Landscape Scale Modeling of the Butte and Colusa Flood Basins to support Ecological Restoration

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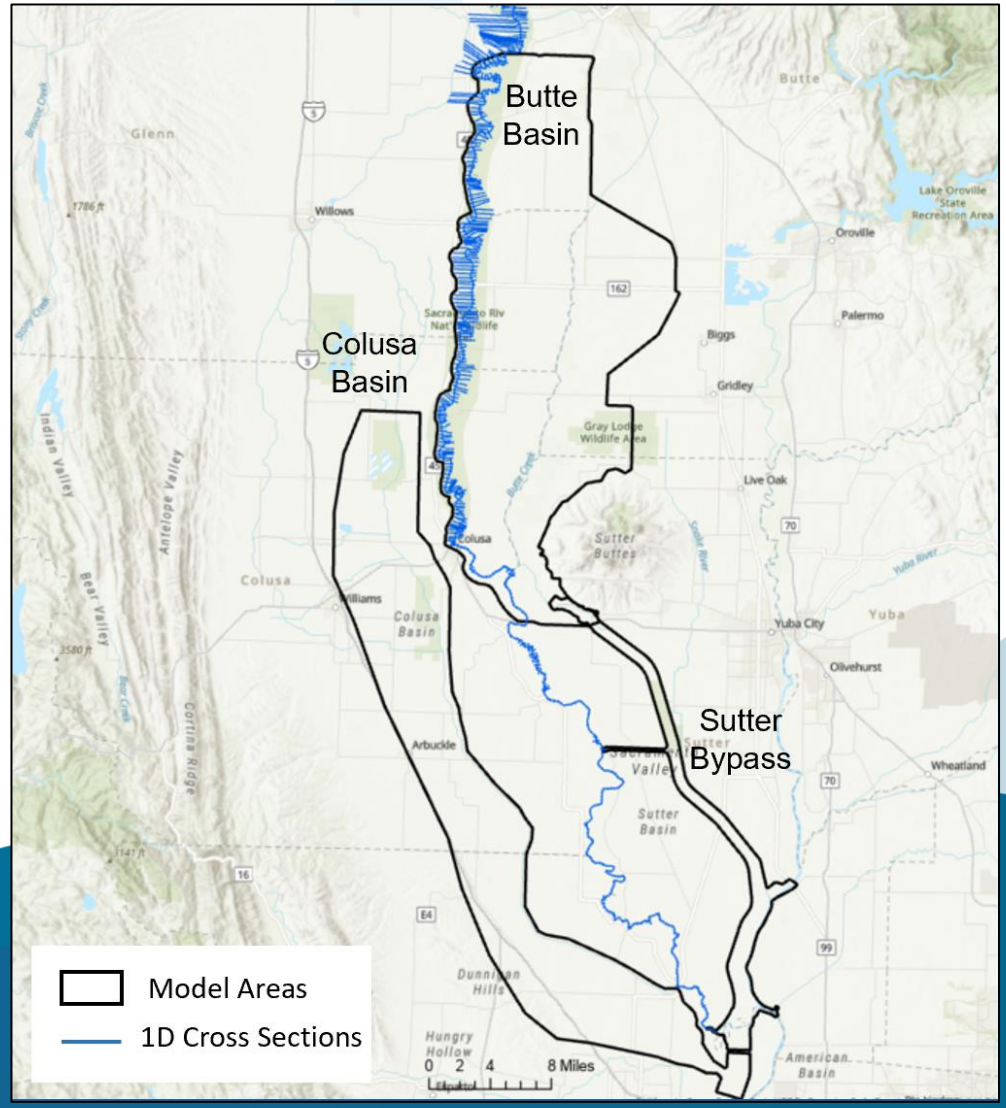
cbec eco engineering

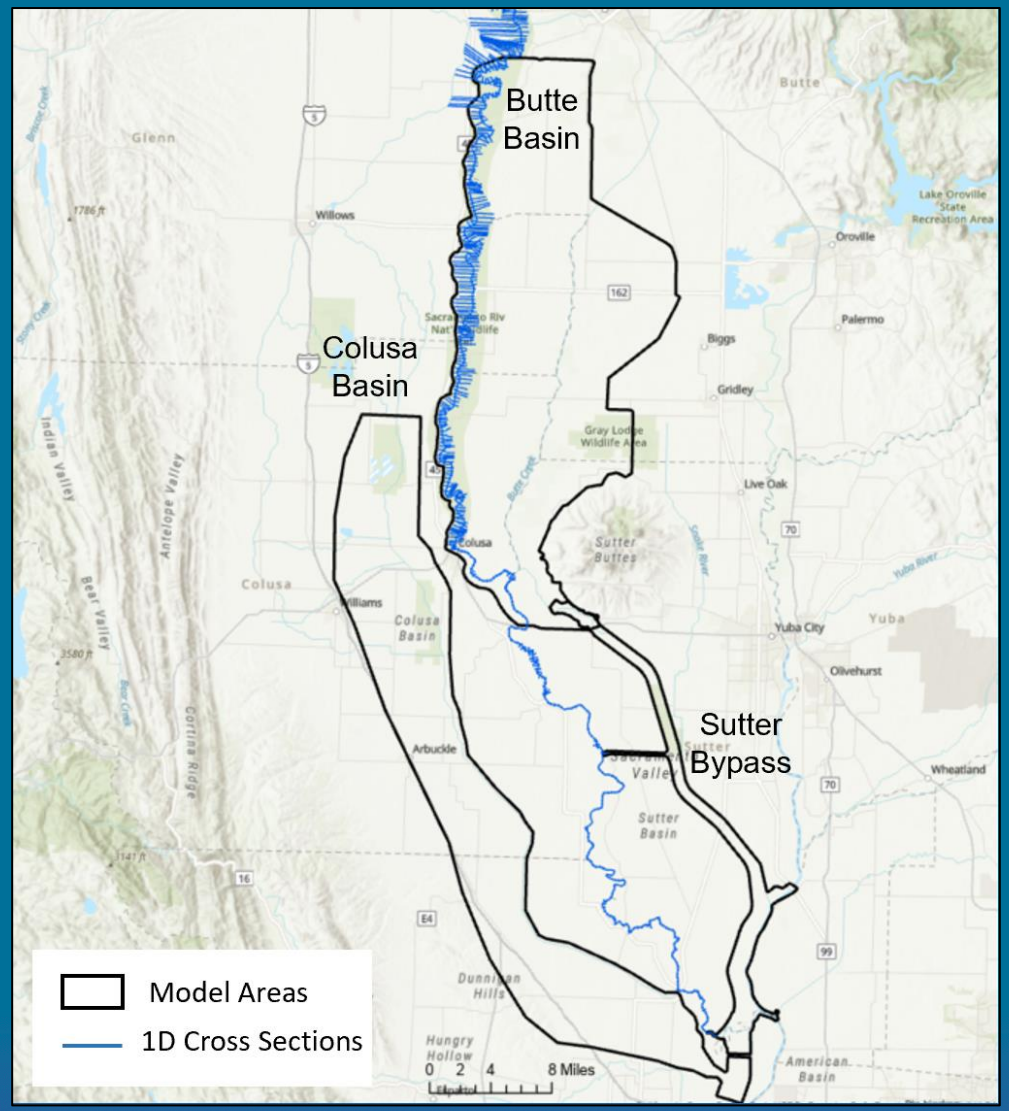
FLOODPLAINS REIMAGINED



April 18, 2023 | 2023 CWEMF Annual Meeting

Presentation Outline

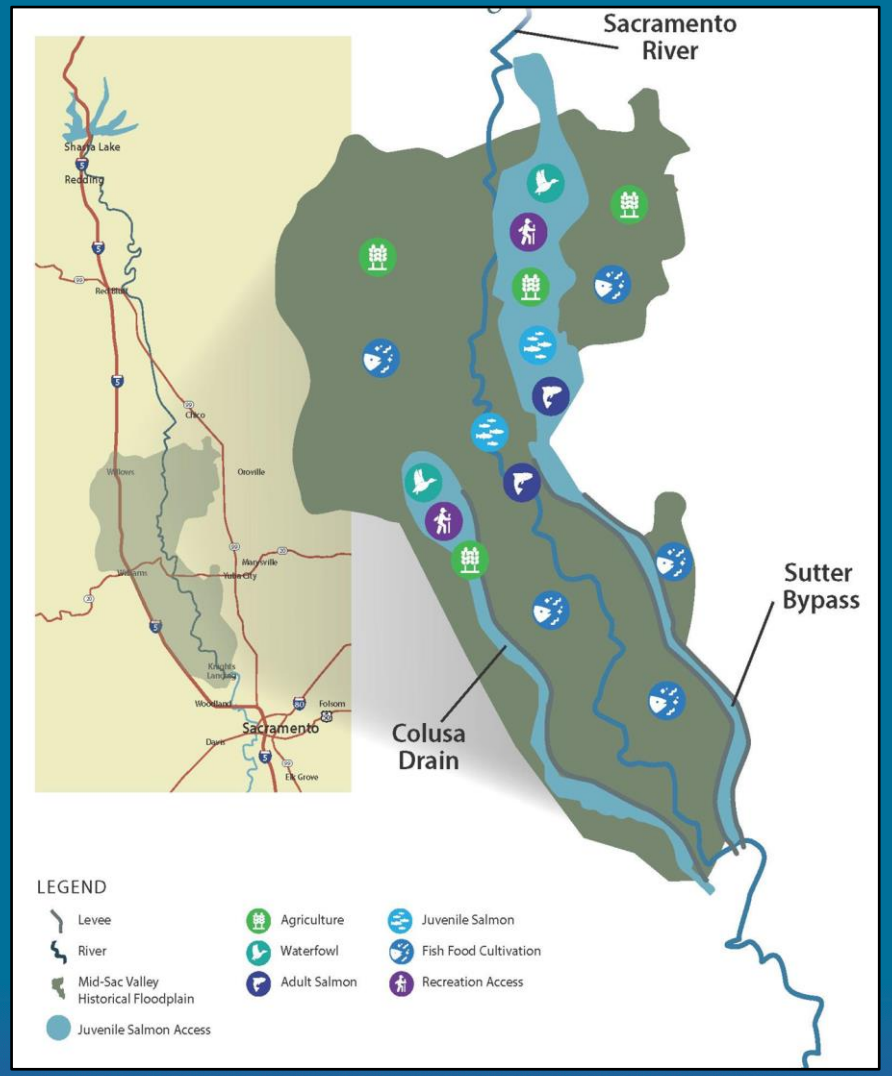
1. Project Background
2. Model Development
3. Model Calibration
4. Scenario Development (ongoing)
5. Acknowledgements



Project Background – Project Goals

Voluntarily increase the frequency and duration of shallow inundation in the winter months through increased connectivity with the Sacramento and Feather Rivers to:

- Improve juvenile salmon migration and access to productive rearing habitat
- Reduce adult fish passage impediments
- Improve Pacific Flyway bird populations
- Improve groundwater recharge
- Respect flood management functions
- Protect existing property and water rights



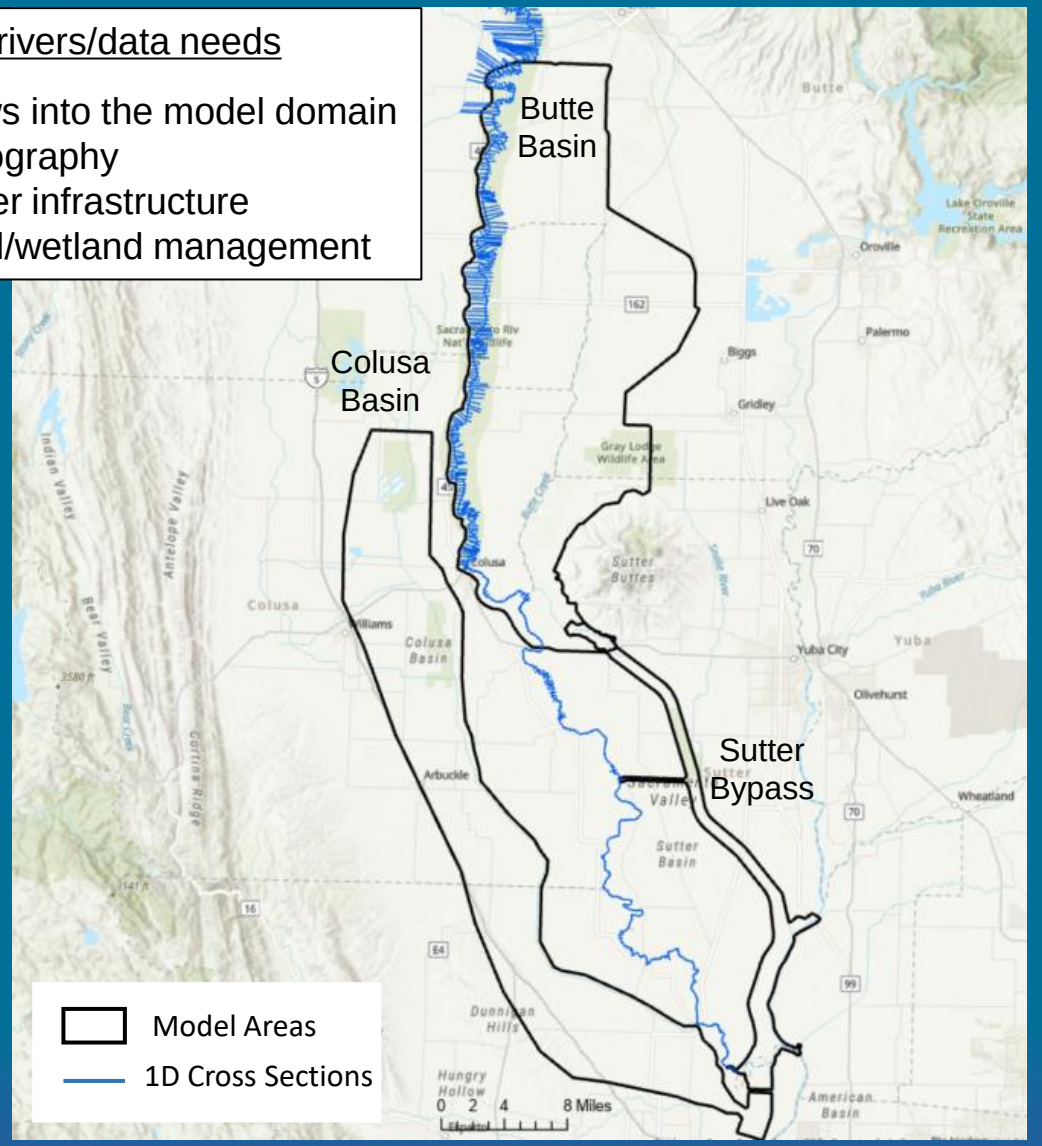
Model Development – Model Domains

Model Domains

- Colusa Basin, Butte Basin, Sutter Bypass
- Based on 2017 CVFED Modeling Effort
- Butte Basin and Colusa Basin modeling approach and technical methodologies based on a foundation of work developed for the Sutter Bypass Management Plan
- 1D (channel) and 2D (floodplain) linked hydrodynamic models
- Models predict depth and velocity in grid cells with sizes ranging from 25 – 400 feet
- Depth and velocity info supports habitat quantification, ecological modeling, and other assessments (water use, conveyance, recharge)
- Simulating 1997 to 2020, October 1st to July 1st
- Butte model overlaps with Sutter Bypass model

Model drivers/data needs

- Flows into the model domain
- Topography
- Water infrastructure
- Field/wetland management



Model Development

Boundary Condition Development

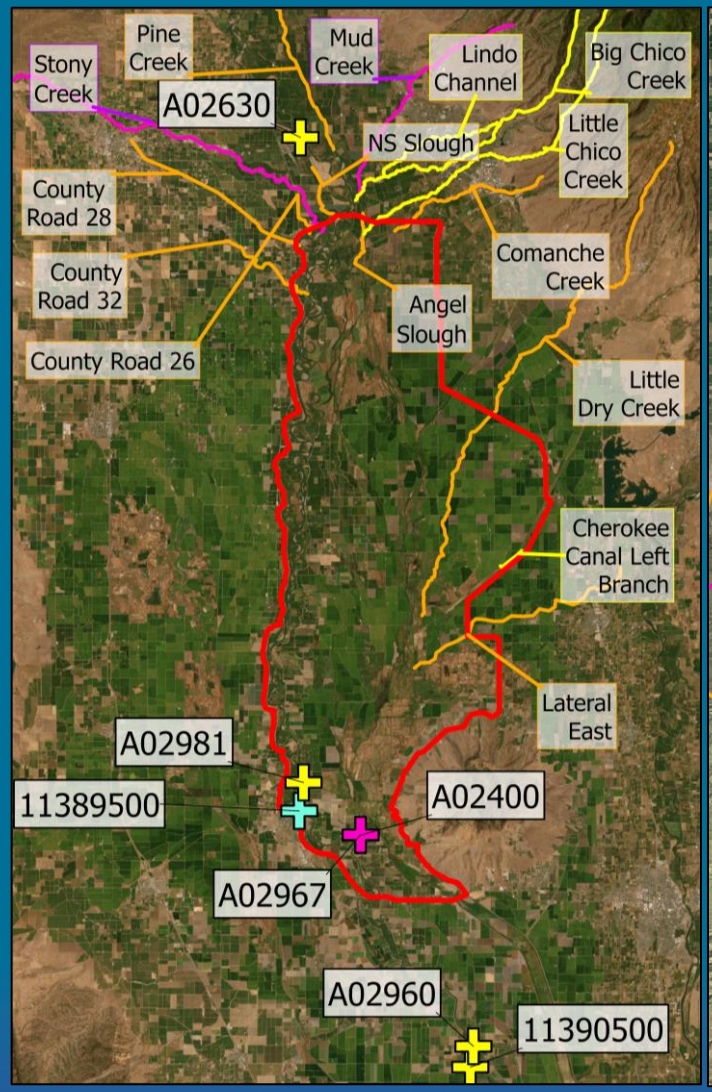
- Colusa Basin: Continuous HEC-HMS rainfall-runoff model
- Butte Basin: Flow gage analysis and watershed scaling

Field Data Collection

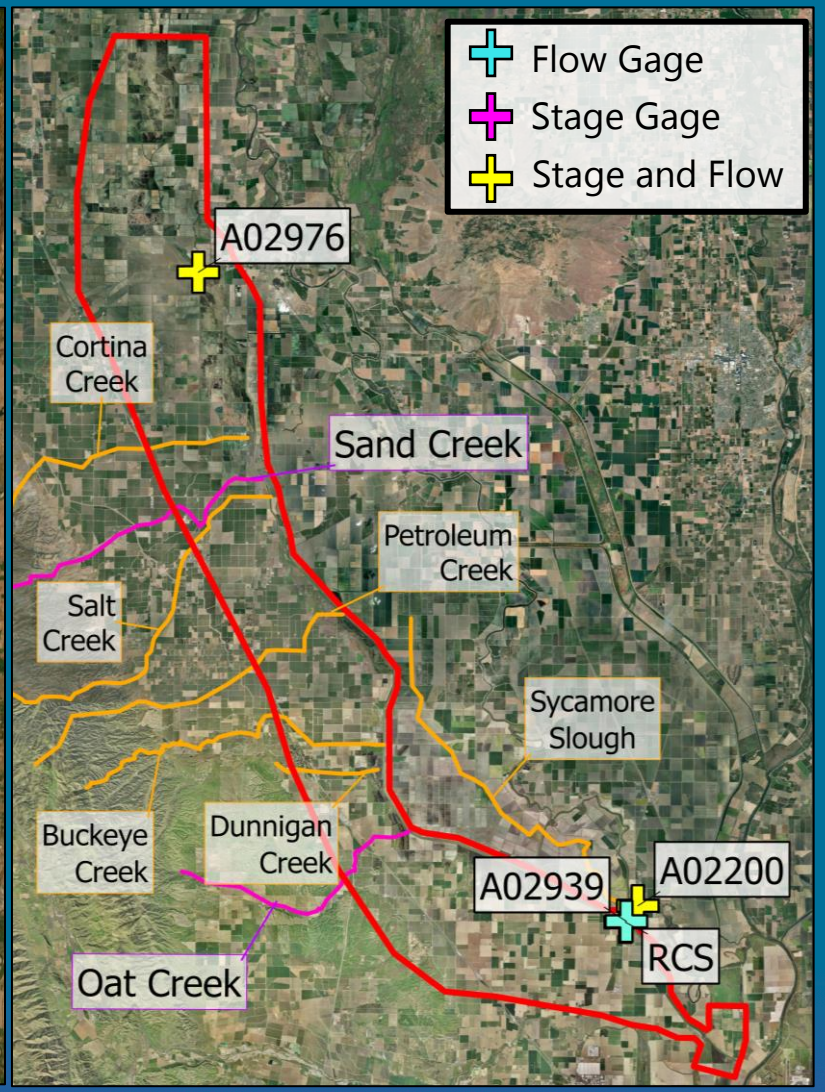
- Supplementary elevation surveys
- Water management structure specifications
- Discharge measurements

Model Development - Flow and Stage Data

Butte Basin



Colusa Basin



- Flows into the model are derived from the available gaging network
- For the ungaged tributaries in the Butte Basin Little Chico Creek and Little Dry Creek, a watershed scaling approach with Butte Creek was used.
- For ungaged tributaries in the Colusa Basin, rainfall-runoff modeling is used to estimate inflows
- Stage data from the gaging network are used for model calibration

Tributary from 2017 CVFED model (Steady Flow)

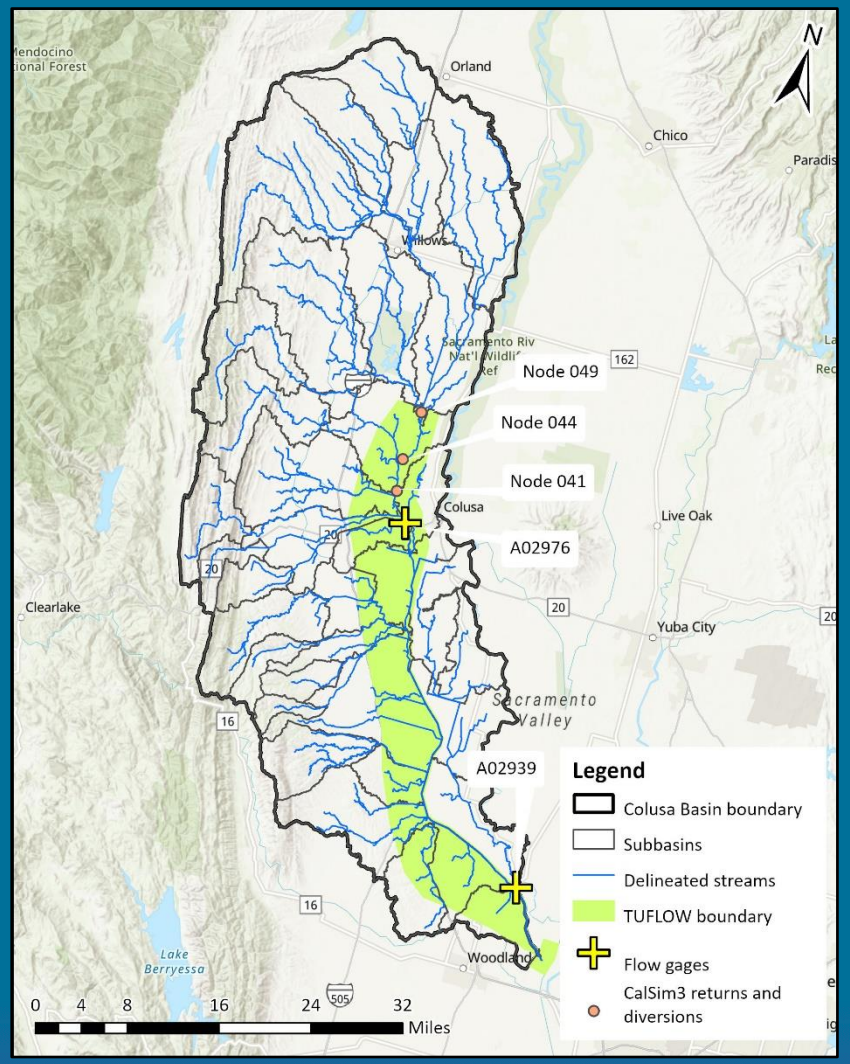
Tributary from 2017 CVFED model (Unsteady Flow)

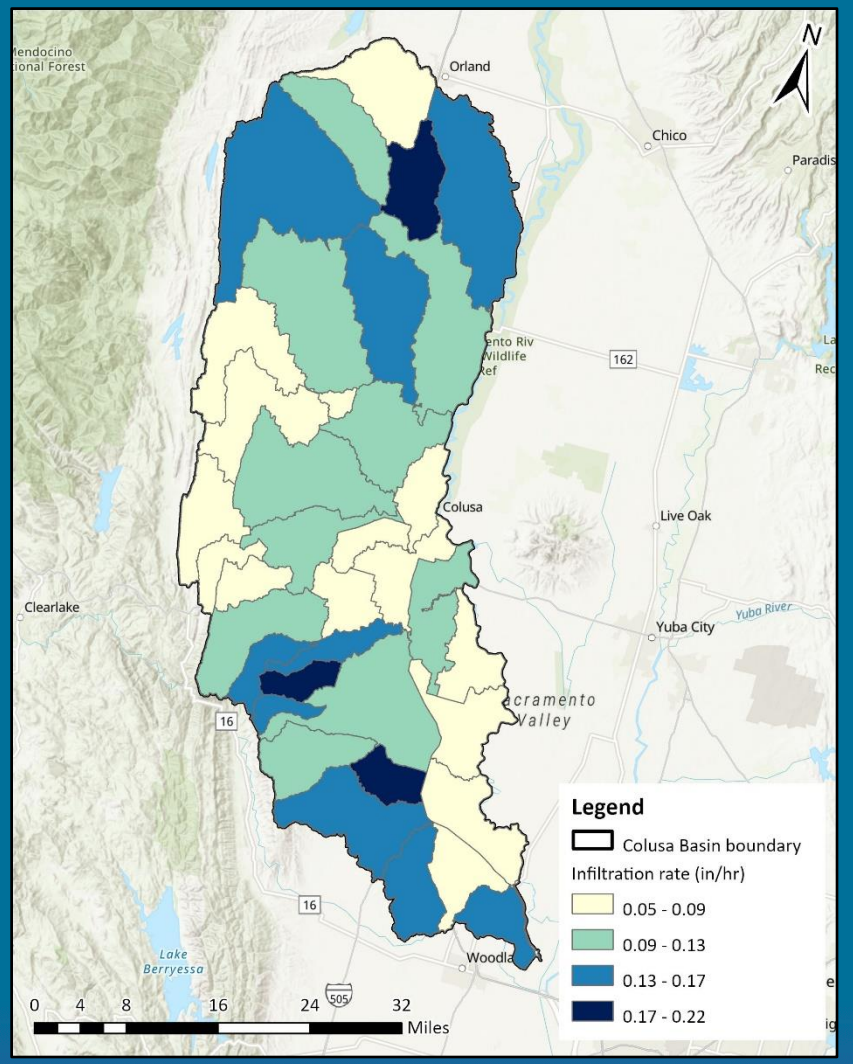
Tributary not included 2017 CVFED model

Model Development - Colusa Basin HEC-HMS Model

Model Development

- Updated event-based USACE model to run continuously for the duration of the study period (1997 – 2020)
- Incorporated agricultural practices that impact hydrology from CalSim3
- Evaluated soil properties using SSURGO data and updated methodology to allow soil to drain and fill continuously





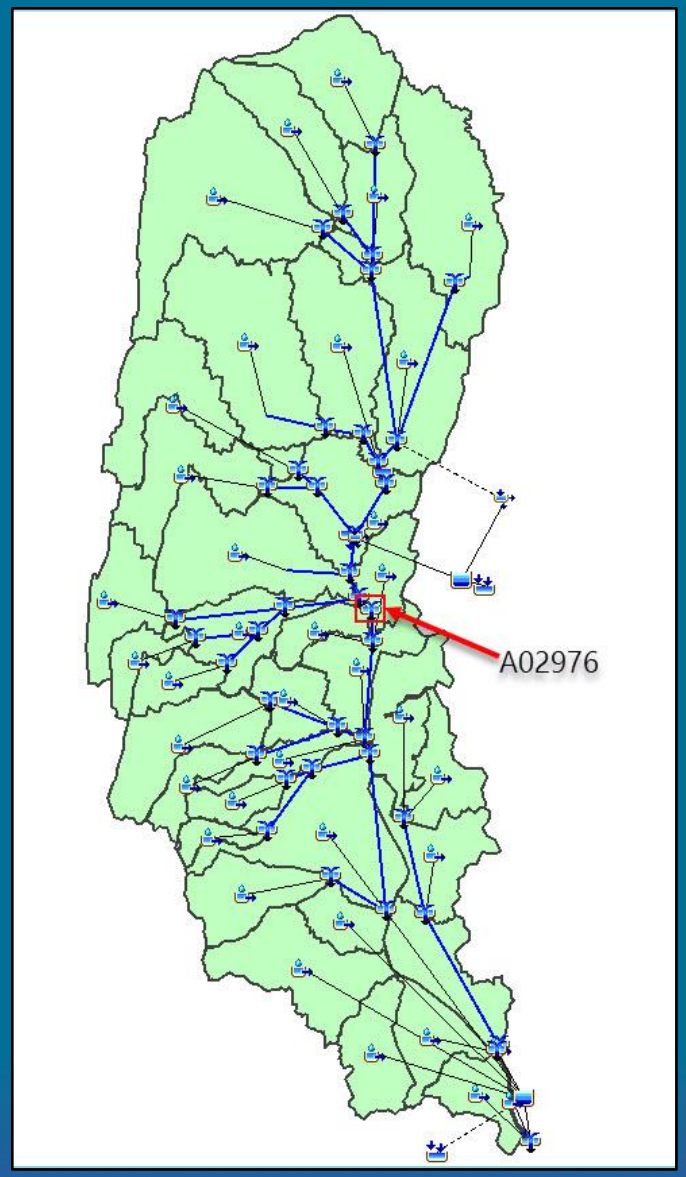
Model Development - HEC-HMS Calibration

Observed Data

- Flow gage A02976 (Colusa Drain at Highway 20) in Water Data Library

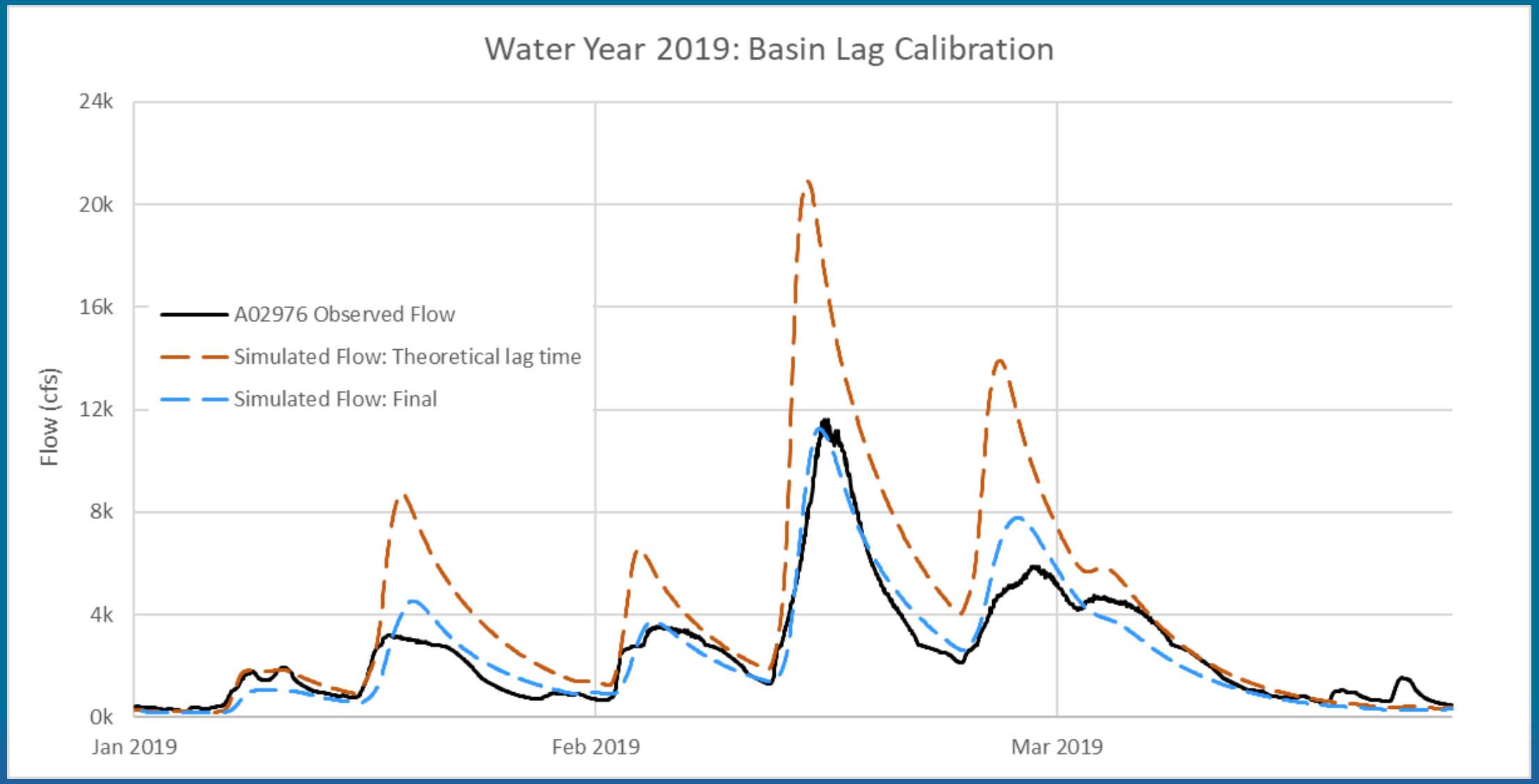
Calibration Parameters

- Basin lag time
- Reach routing
- Soil infiltration parameters
  - Maximum / Initial Deficit
  - Constant loss rate



	Subbasin
	Reach
	Junction
	Source
	Sink
	Reservoir
	Diversion
	Hydrologic Connection

Model Development - HEC-HMS Calibration



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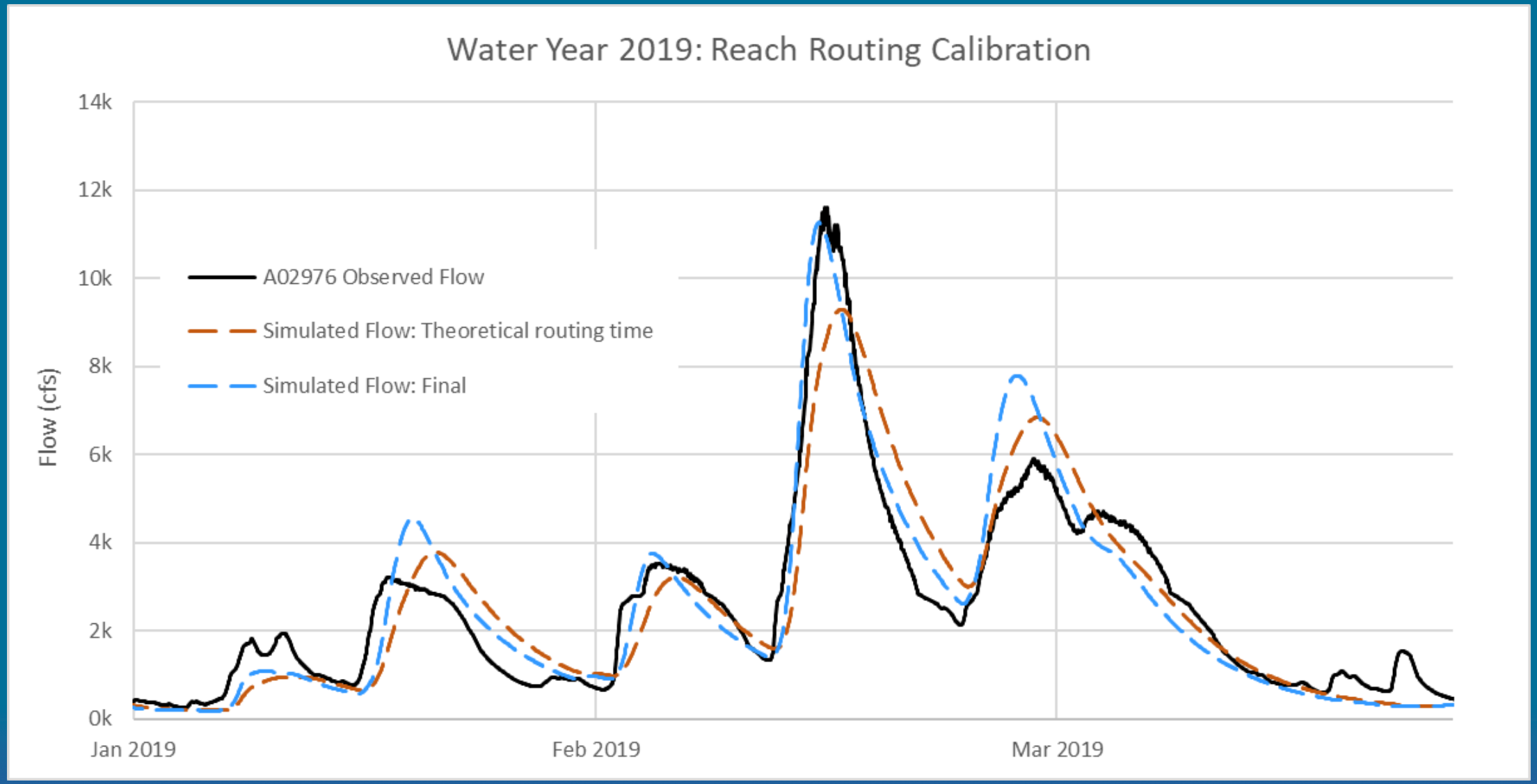
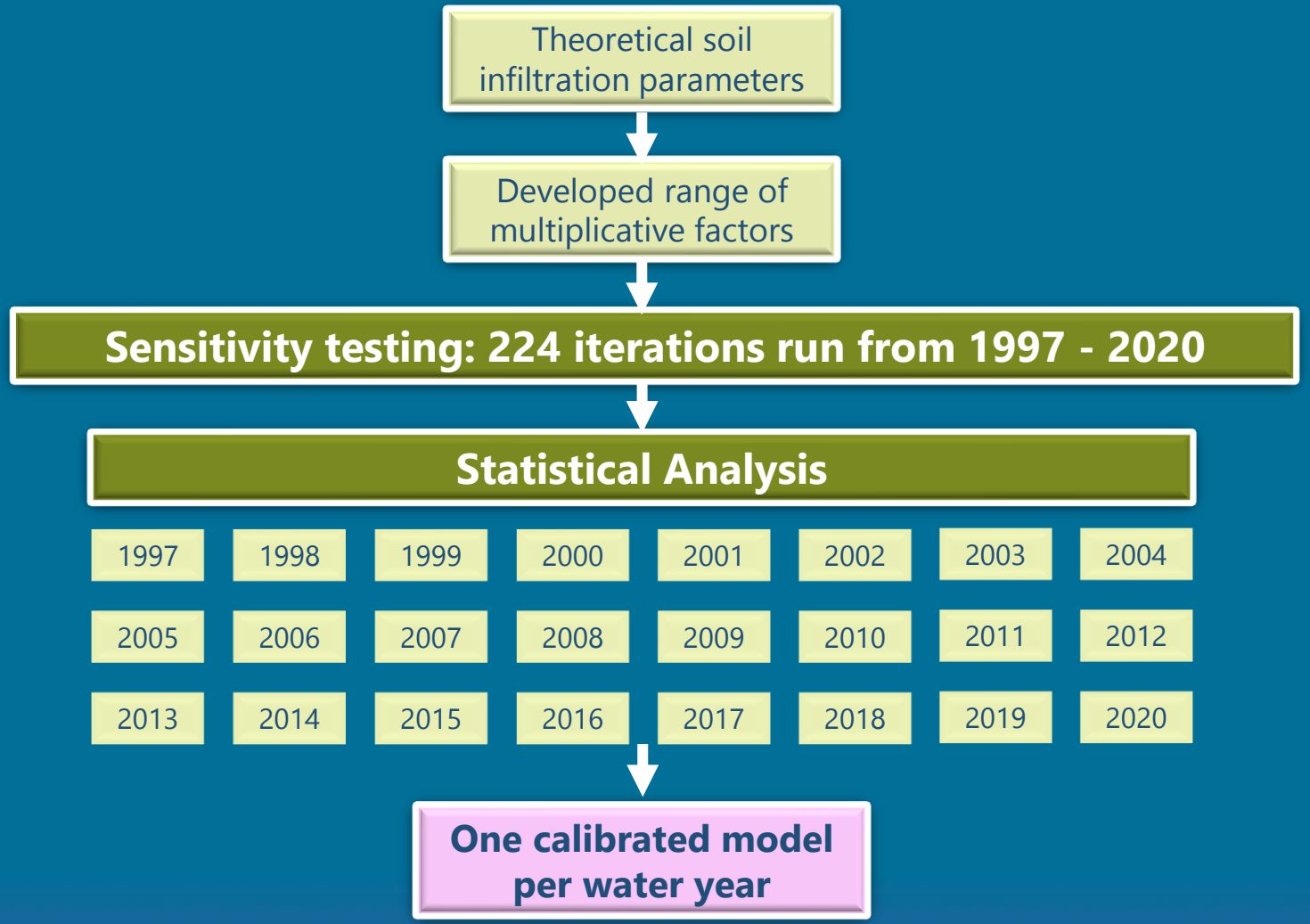
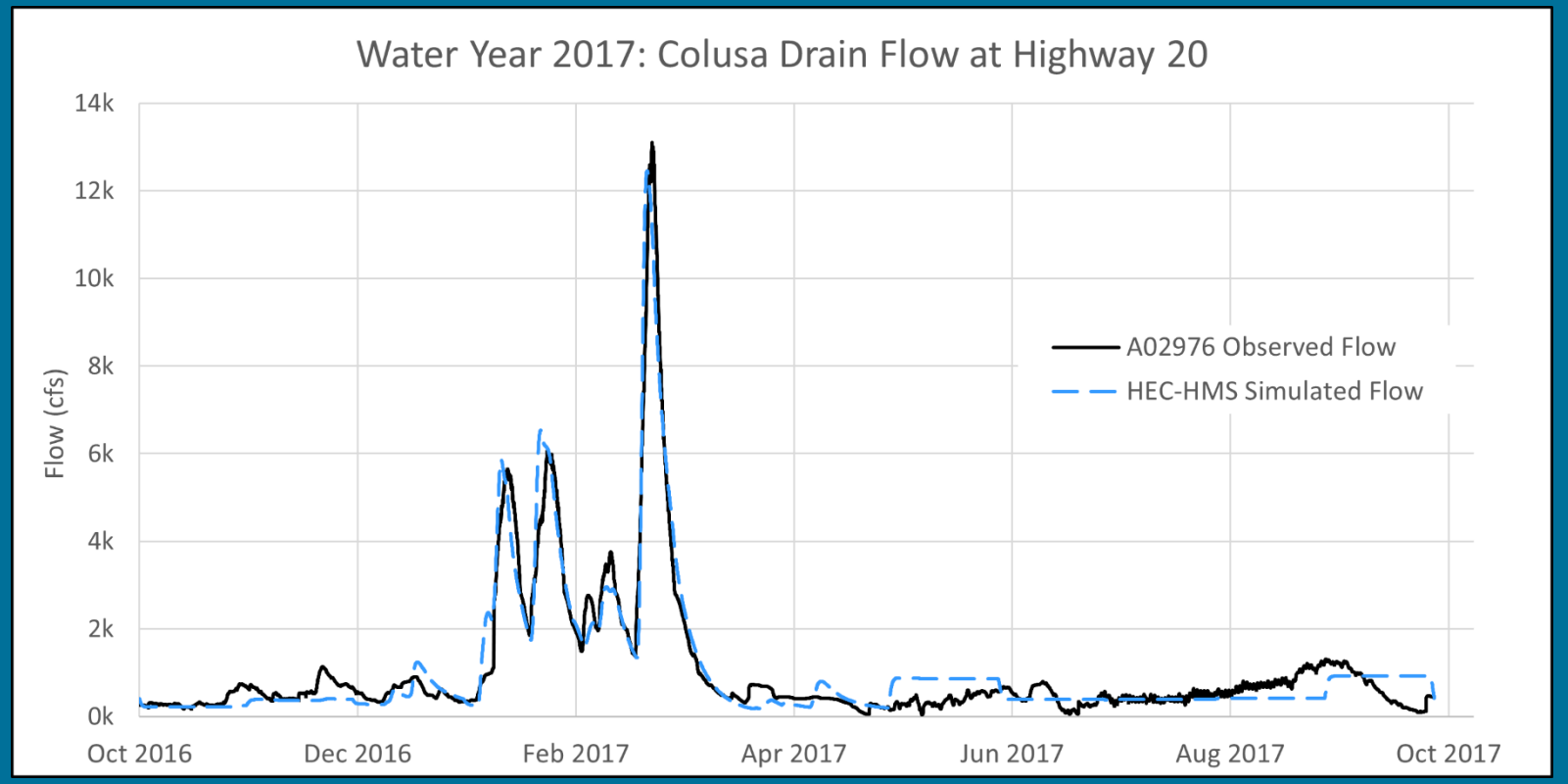


Model Development - HEC-HMS Calibration



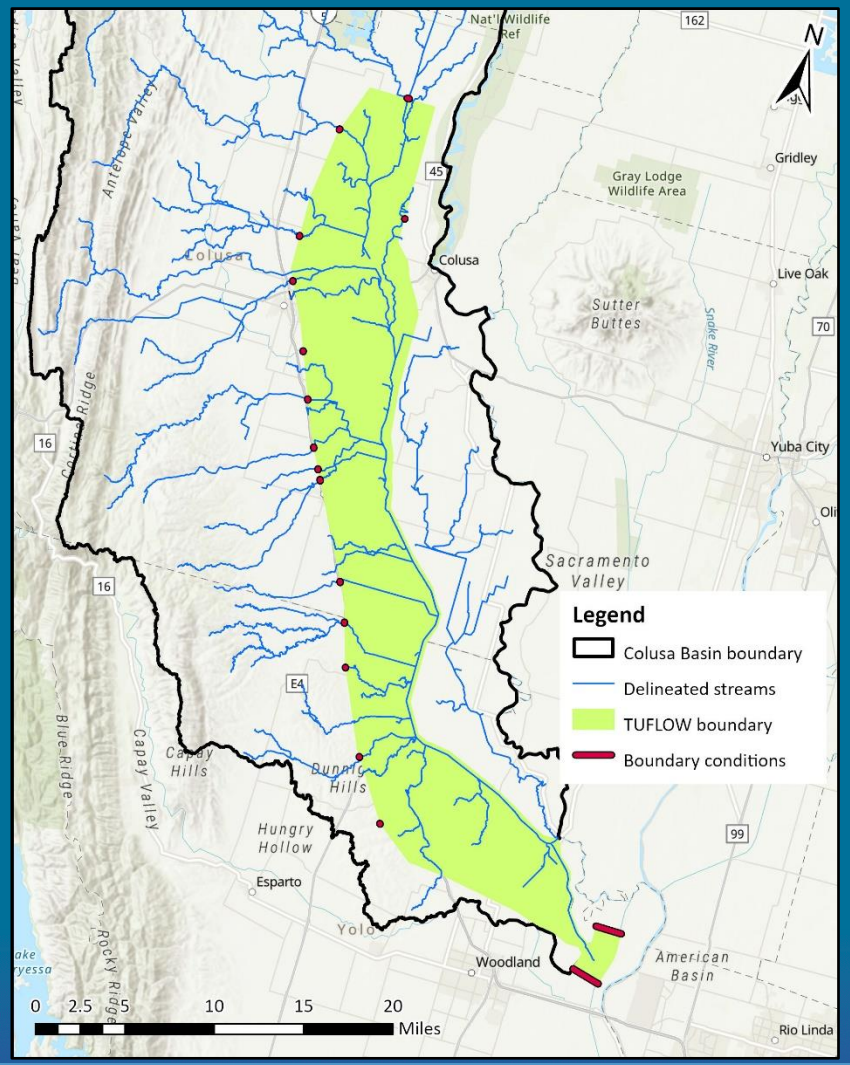
Model Development - HEC-HMS Calibration Results



Water Year	Calculation Period	Percent Error	Nash-Sutcliffe Efficiency	Root Mean Square Error (cfs)	Mean Absolute Error (cfs)
2017	Jan 1 - Mar 15	1.73	0.906	800.3	536.7

Model Development - HEC-HMS Implementation

Boundary Condition Locations



Boundary Condition Placement

- Hydrologic boundary conditions placed along delineated streams modeled in HEC-HMS
- Modeled subbasin outflow used for locations with no delineated streams
- Yolo Bypass flow through model represented at downstream end

Implementation

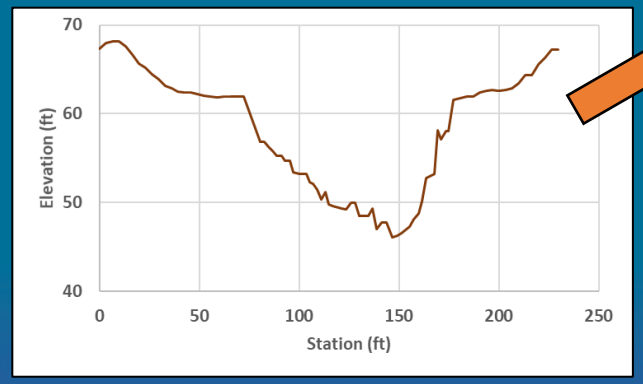
- Input to hydrodynamic Colusa model in TUFLOW
- Flow extracted at marked locations at 1-hour timestep from October – June in water years 1997 – 2020

Model Development – Field Surveys

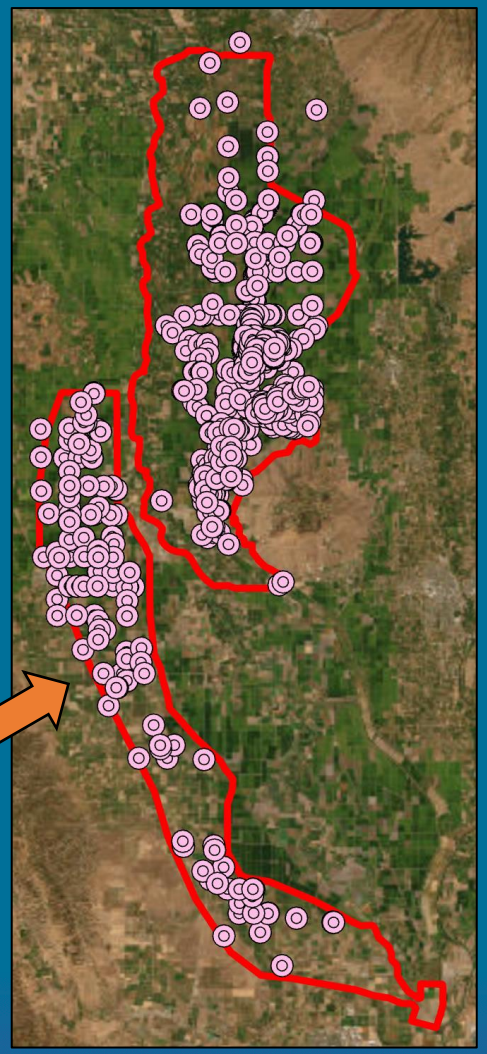
Topography Sources

- 2008 CVFED and 2018/19 USGS LiDAR
- On-the-ground surveys of channels where LiDAR data insufficient
- 1D cross-sections from CVFED
- Merged to create a seamless DEM

Cross-section surveys

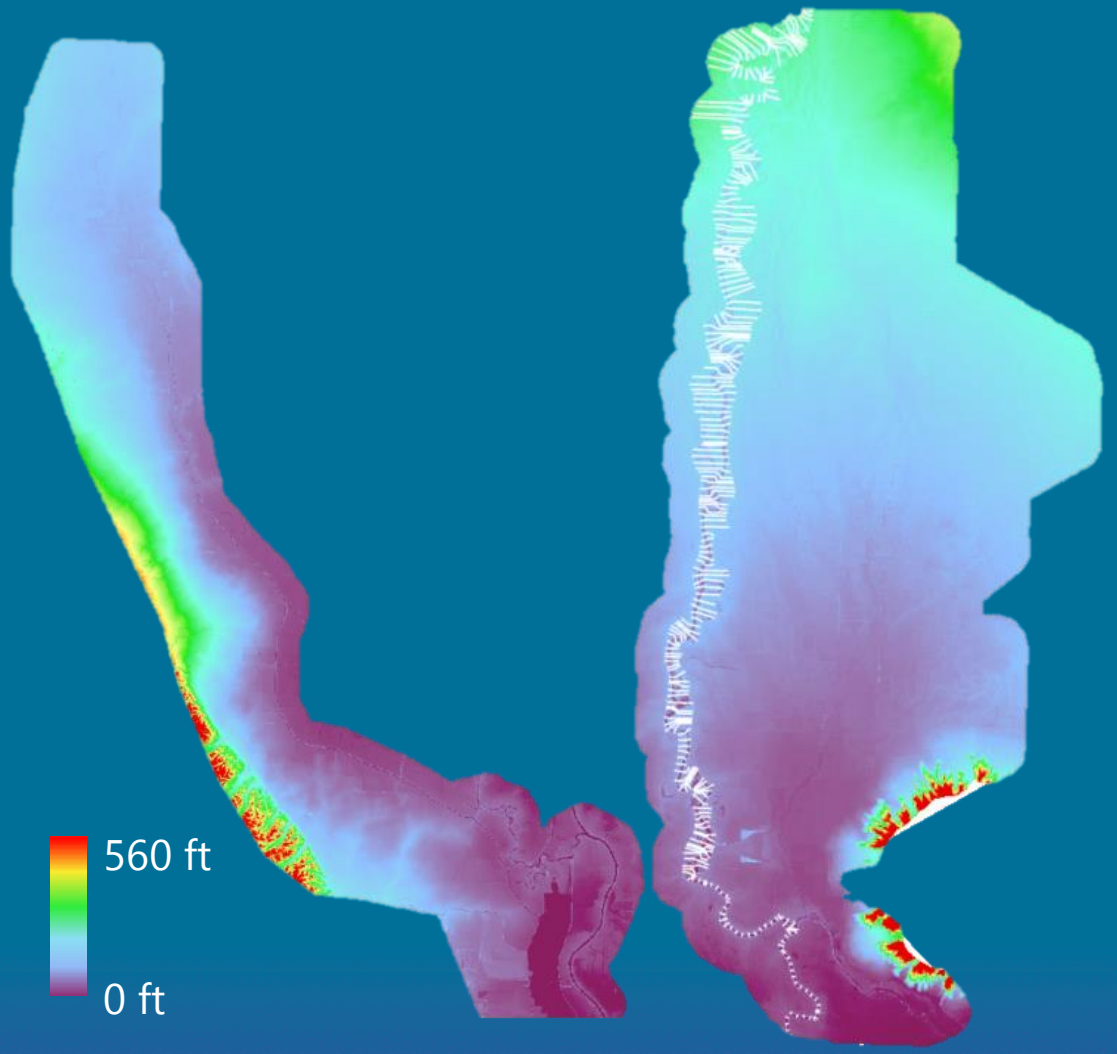


Cross-section surveys



Colusa Basin LiDAR

Butte Basin LiDAR



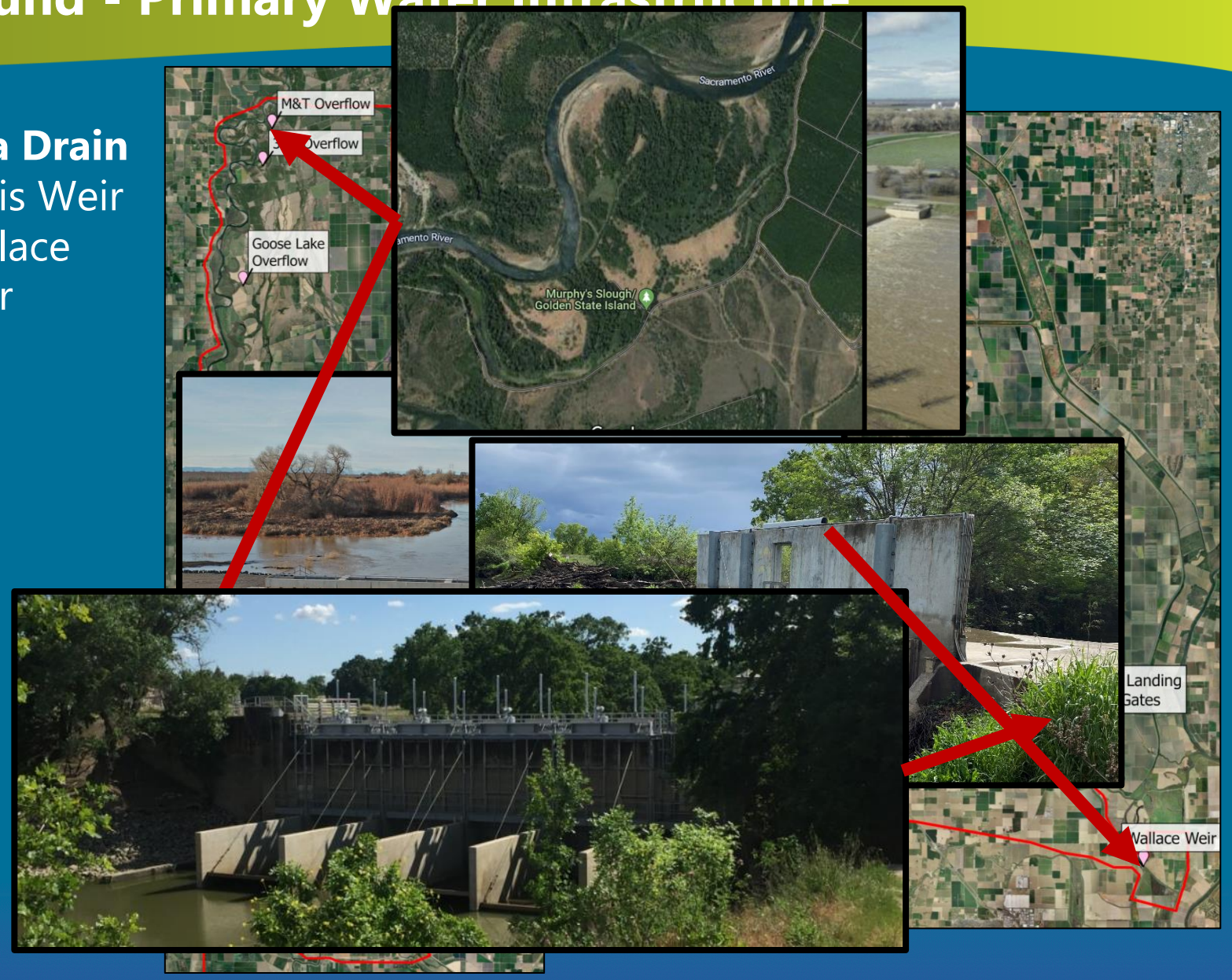
Project Background - Primary Water Infrastructure

Sacramento River overflows
- M&T, 3Bs, Goose Lake
- Moulton Weir
- Colusa Weir

Colusa Drain
- Davis Weir
- Wallace Weir

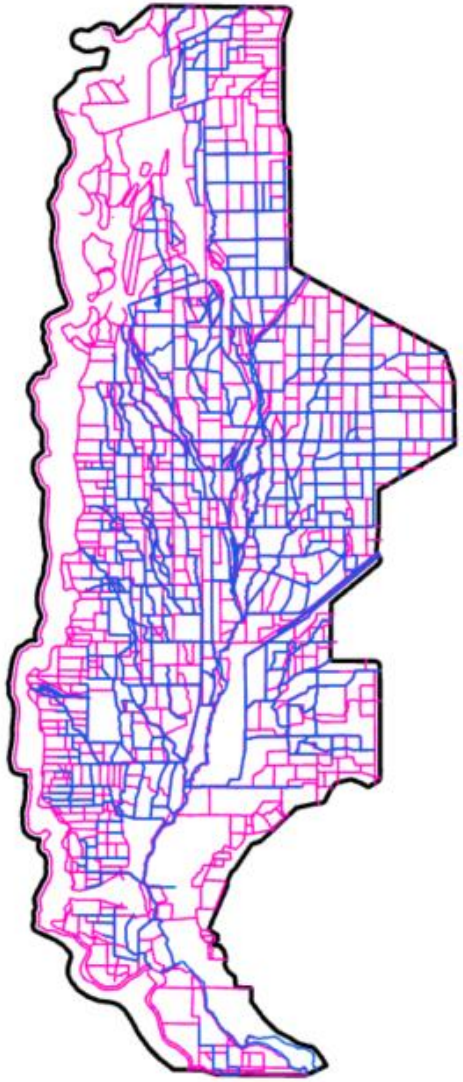
Outfalls to Sacramento River
- Butte Slough Outfall Gates
- Knights Landing Outfall Gates

Butte Sink wetlands
- Bifurcation Structure
- White Mallard Dam
- Five Points Dam, Drumheller Slough Diversion Weir
- North, End, Morton, Driver's Cut, and Colusa Shooting Weirs/Outfalls



Model Development - Berm and Field Drain Network

Butte Basin

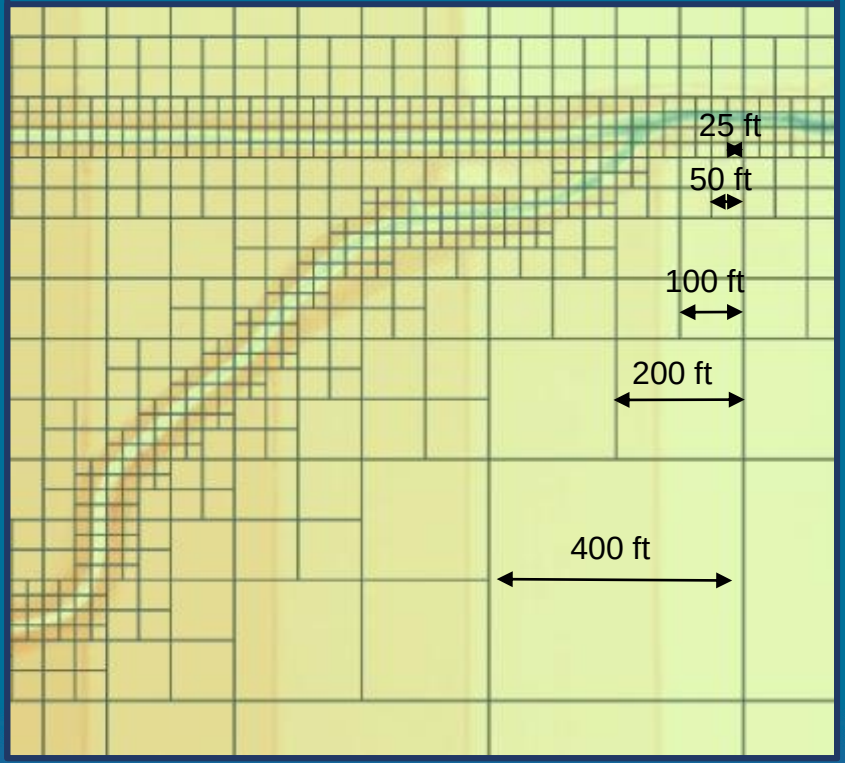


Colusa Basin

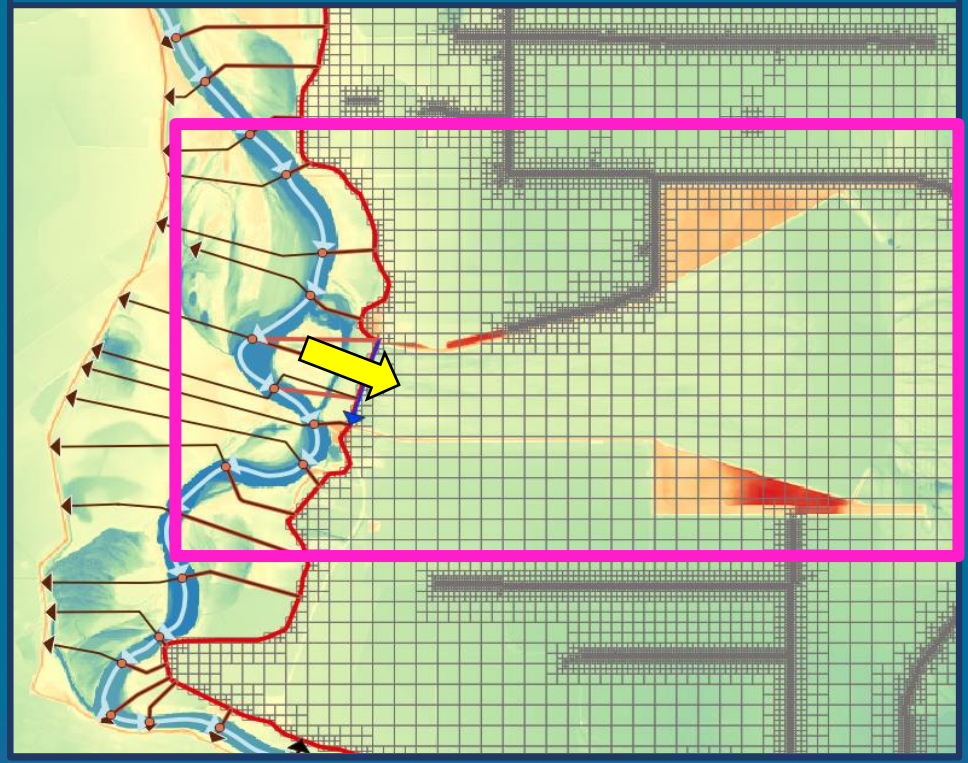
Model Development - Model Grid

"Nested" model grid to provide refinement locally where needed
Large grid cells in flat areas

Quadtree Grid Refinement
400 ft cells for open area and
25 ft cells along the streams and canals



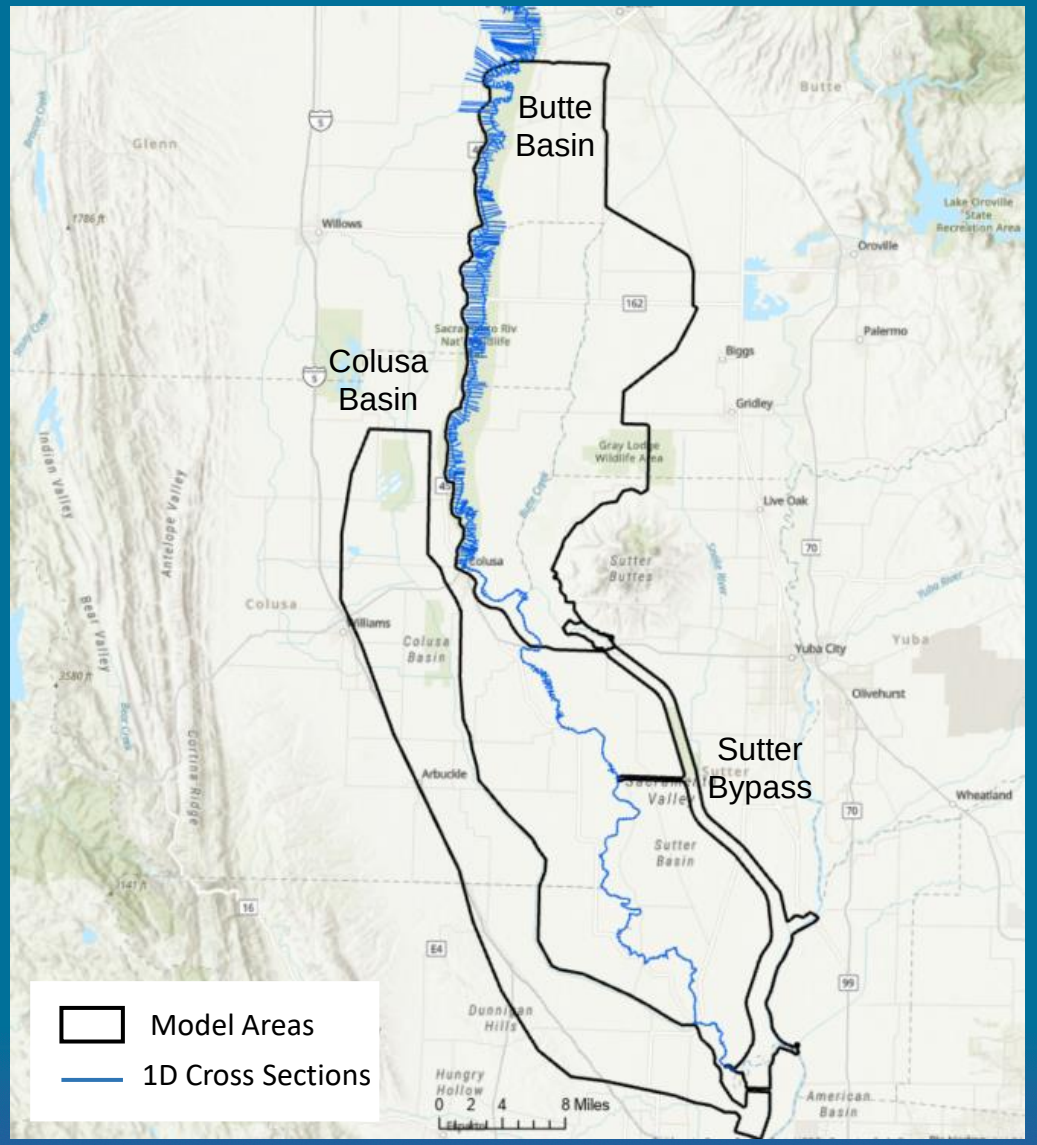
Colusa Weir 1D/2D Connection
Sacramento River in 1D
laterally spills into 2D floodplain



Model Development - Sacramento River Cross Sections

Cross Sections

- Obtained from 2017 CVFED Modeling Effort
- Surveyed in 2010 via Single Beam Survey
  - Accuracy: +/-3-feet to +/-6-feet horizontally
  - +/-0.5-feet to +/-1.0-feet vertically depending on the depth of water
- Initial Main Channel Manning's n values formulated utilizing:
  - Sediment grain size data from "Downstream patterns of bed material grain size in a large, lowland alluvial river subject to low sediment supply" (Singer 2008).
  - Manning's n - grain size relationship from "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains", Paper 2339, Table 1, USGS Report
  - Channel sinuosity
- Adjusted Manning's n values for low (1998) and high flow events (1997 & 2006)
- Formulated a depth variable Manning's n for each cross section



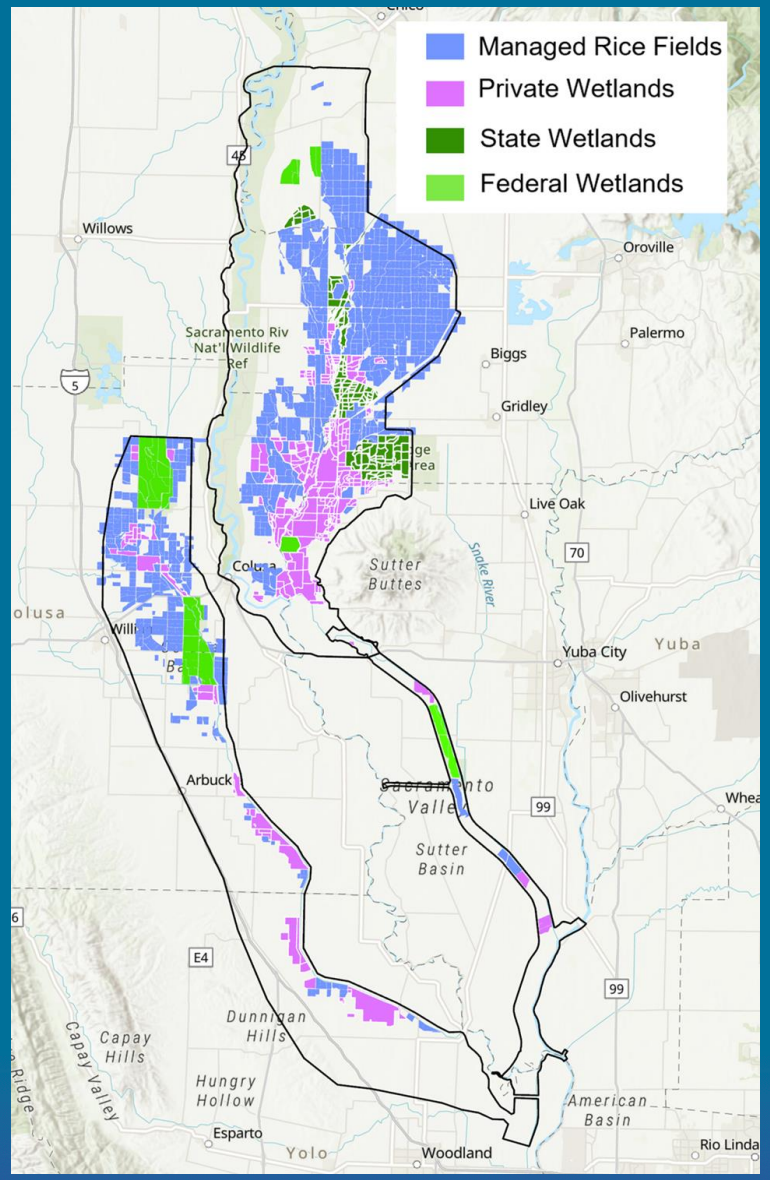
Model Development - Field Management

Maintaining managed water levels on fields/wetlands during winter

- Managed Rice fields
- Private Wetlands
- State and Federal Wetlands

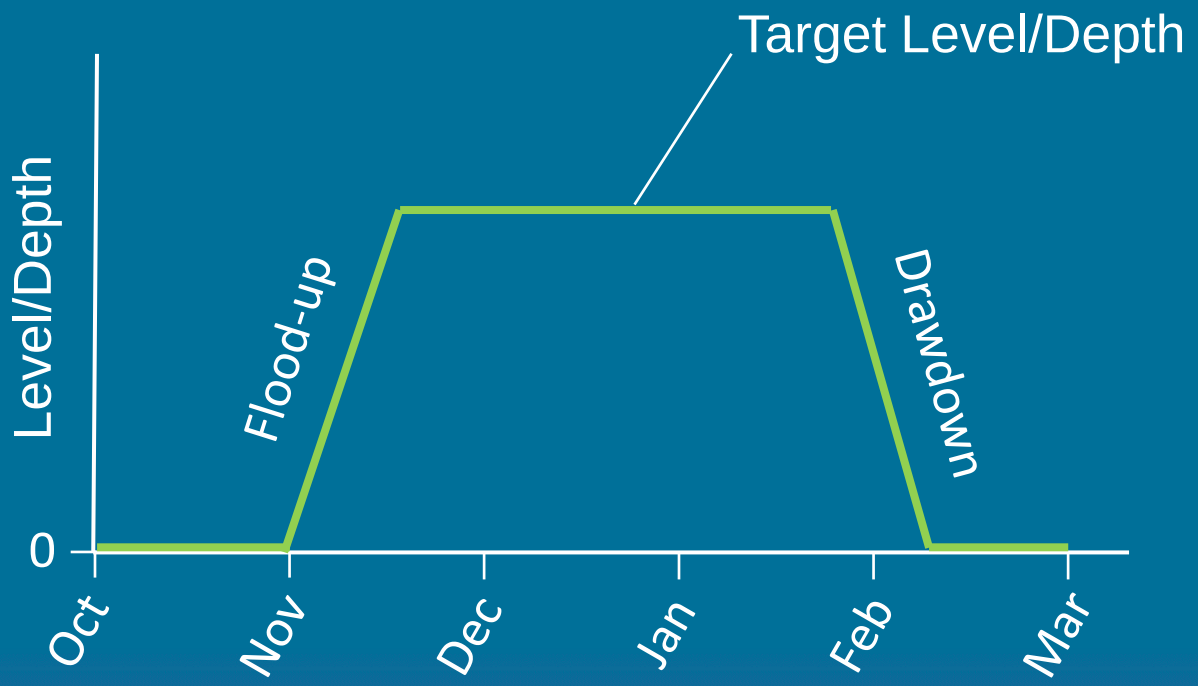
Managed fields represent typical inundation conditions derived from remotely sensed data

Not representing year-to-year variability in managed inundation extents due to water availability

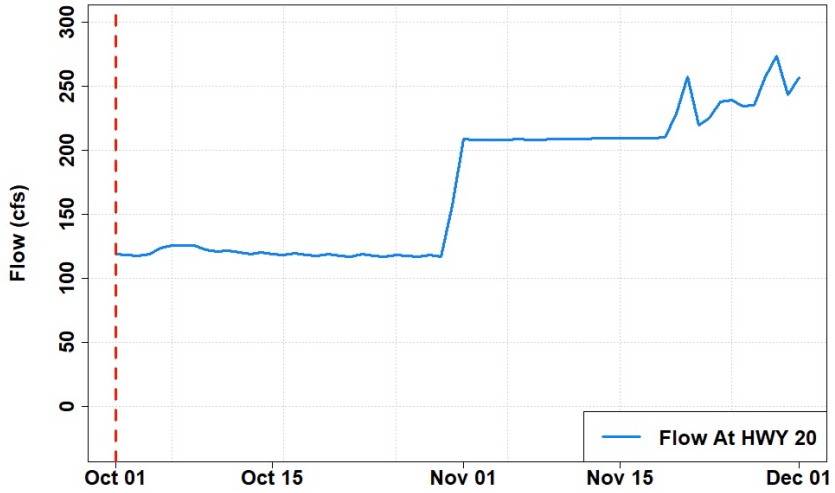


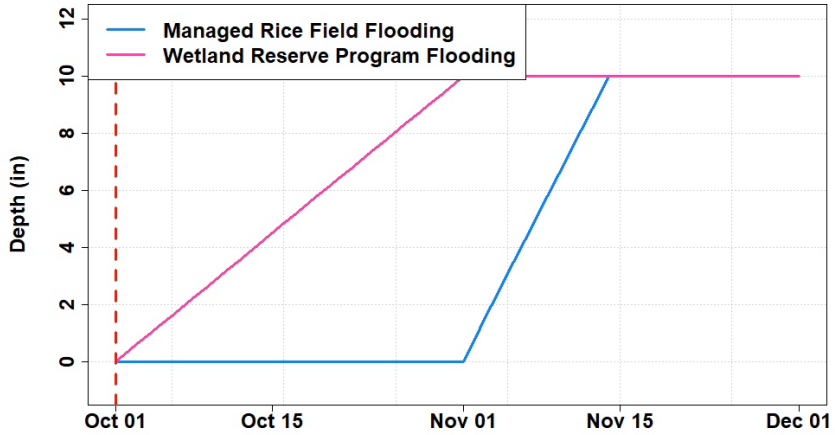
Model Development - Field Management

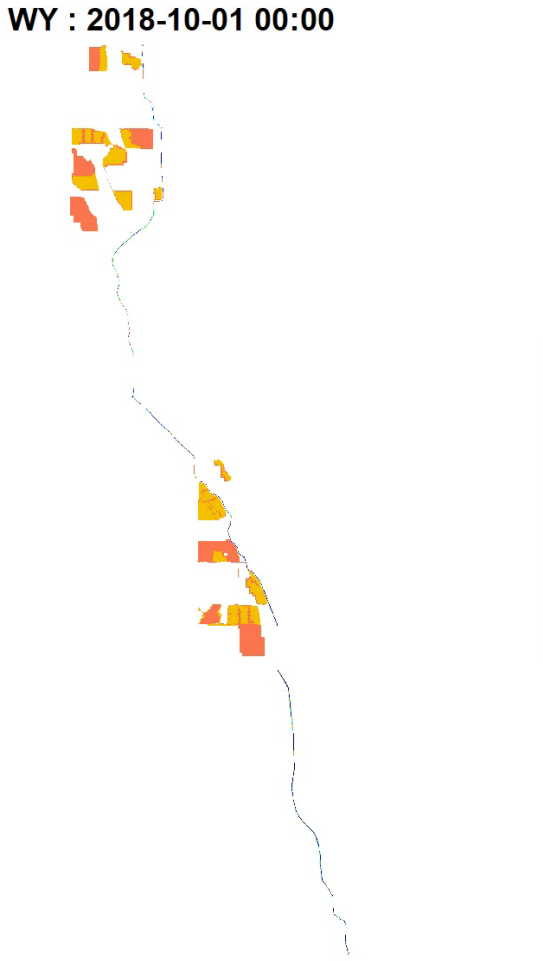
- Specify typical flood-up and drawdown schedules for all wetland types
- Specify target depths and/or water levels

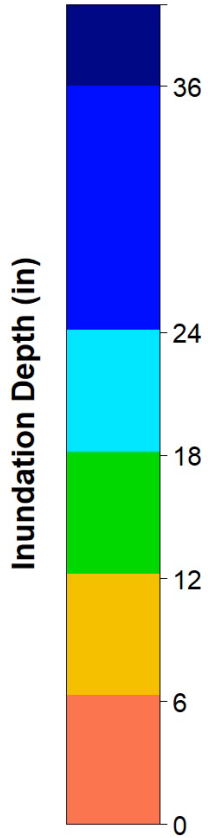


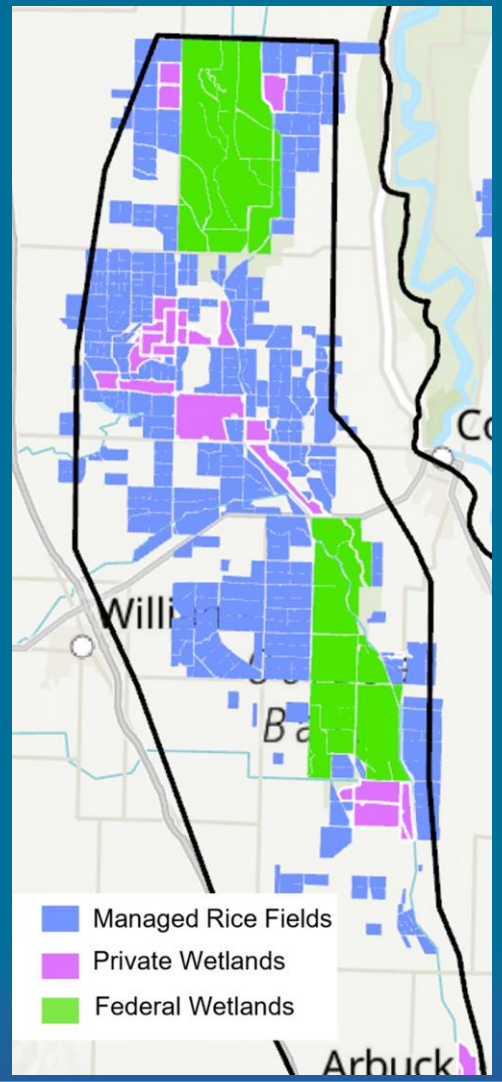
Model Development - 2019 Field Management – Colusa Basin Flood Up



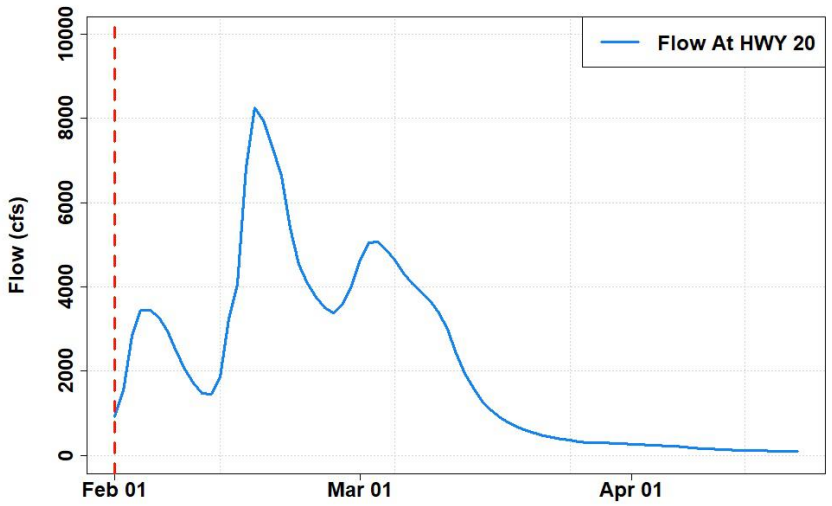


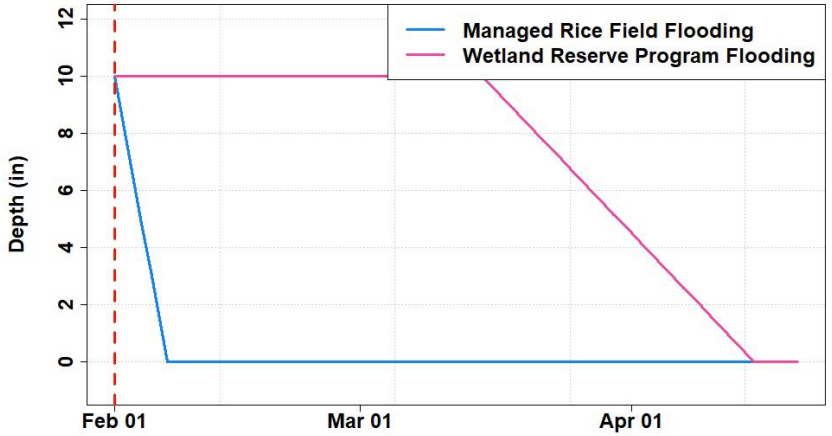


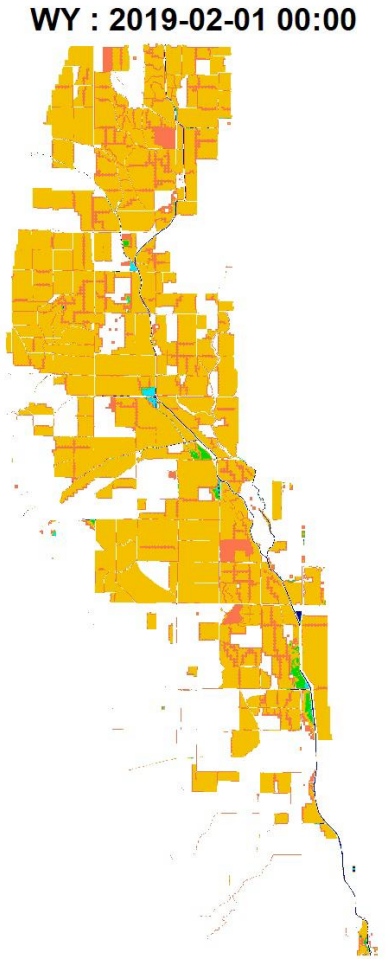


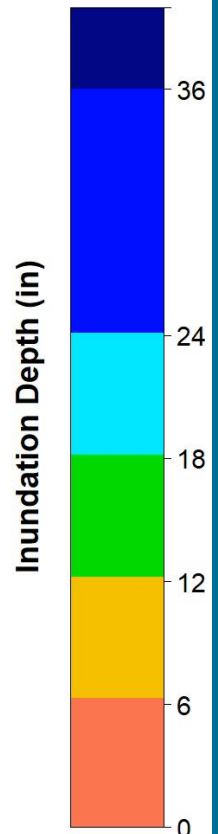


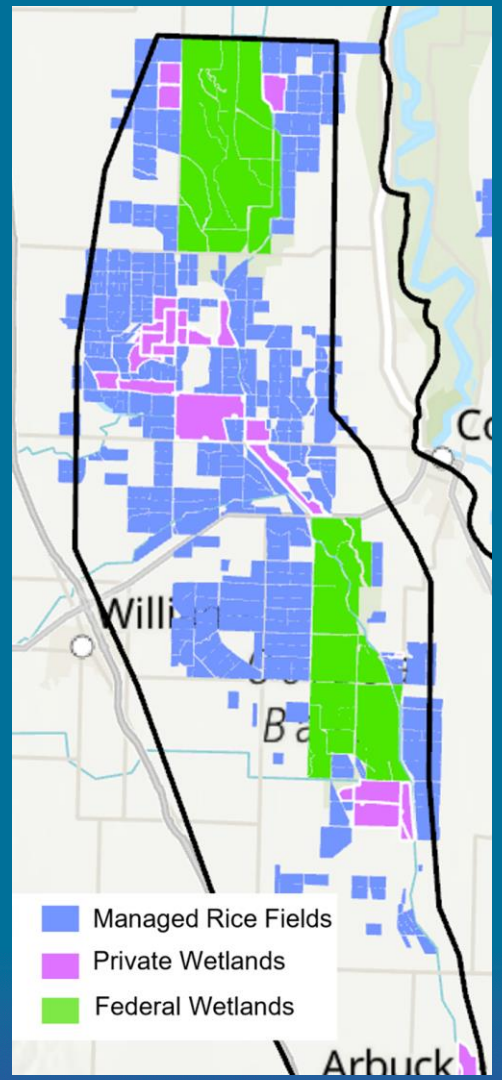
Model Development - 2019 Field Management – Colusa Basin Flood Drawdown











Hydrodynamic Model Calibration

Mainstem Sacramento River Calibration

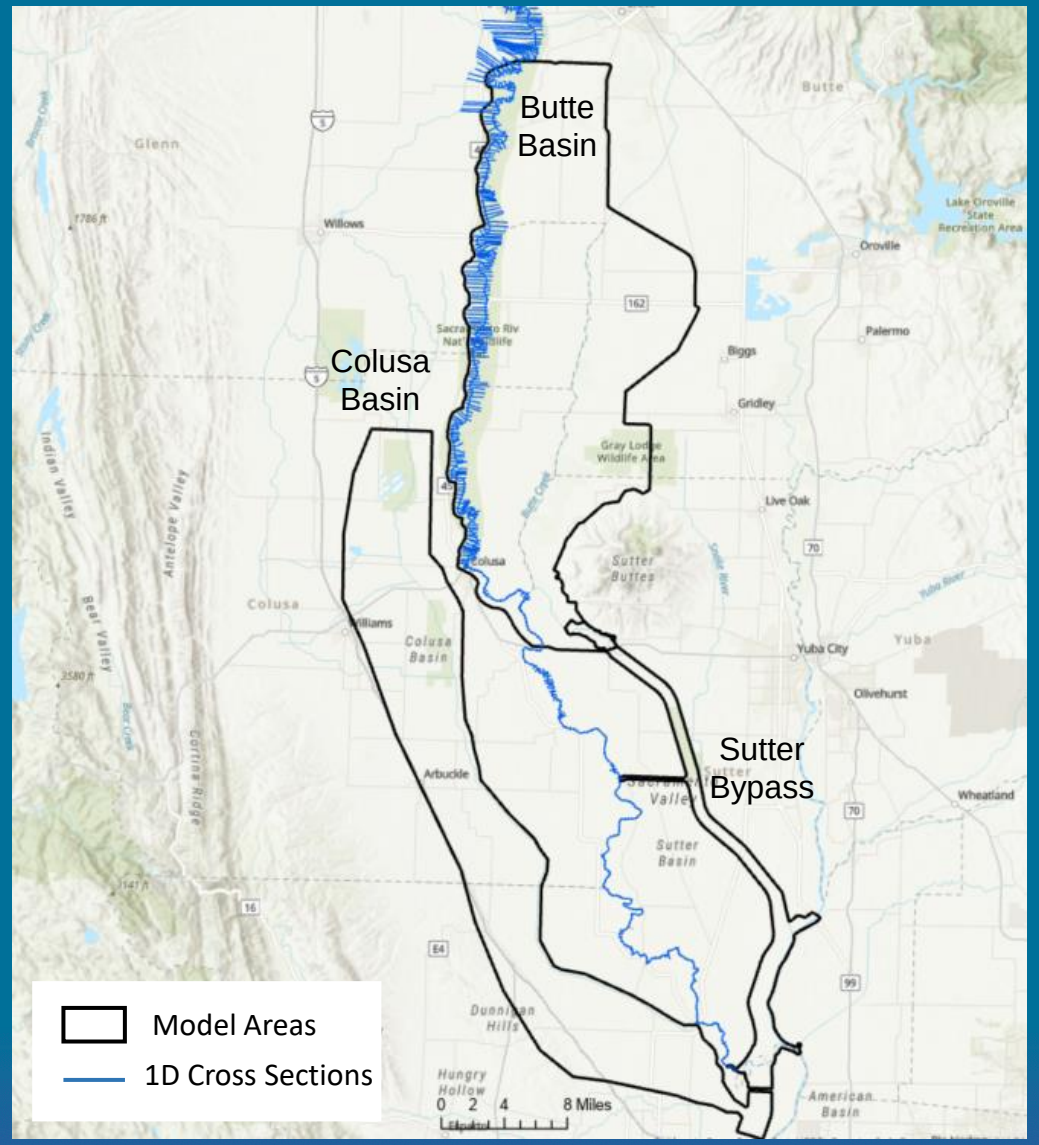
- Mainstem Sacramento River and Overflows
- 1997, 1998, 2006, 2019

Butte Basin Interior Calibration

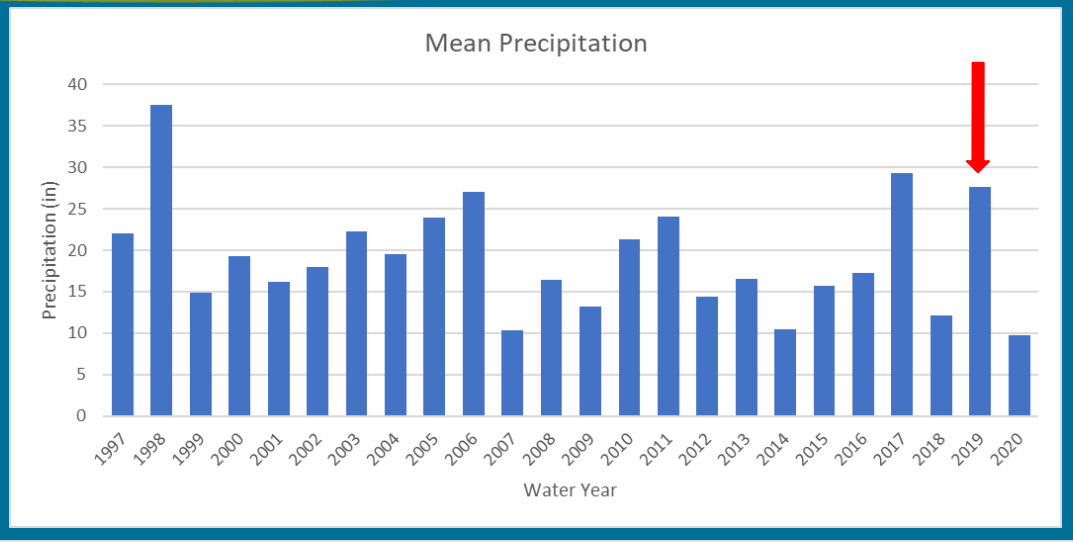
- 2019 water year
- Field Management

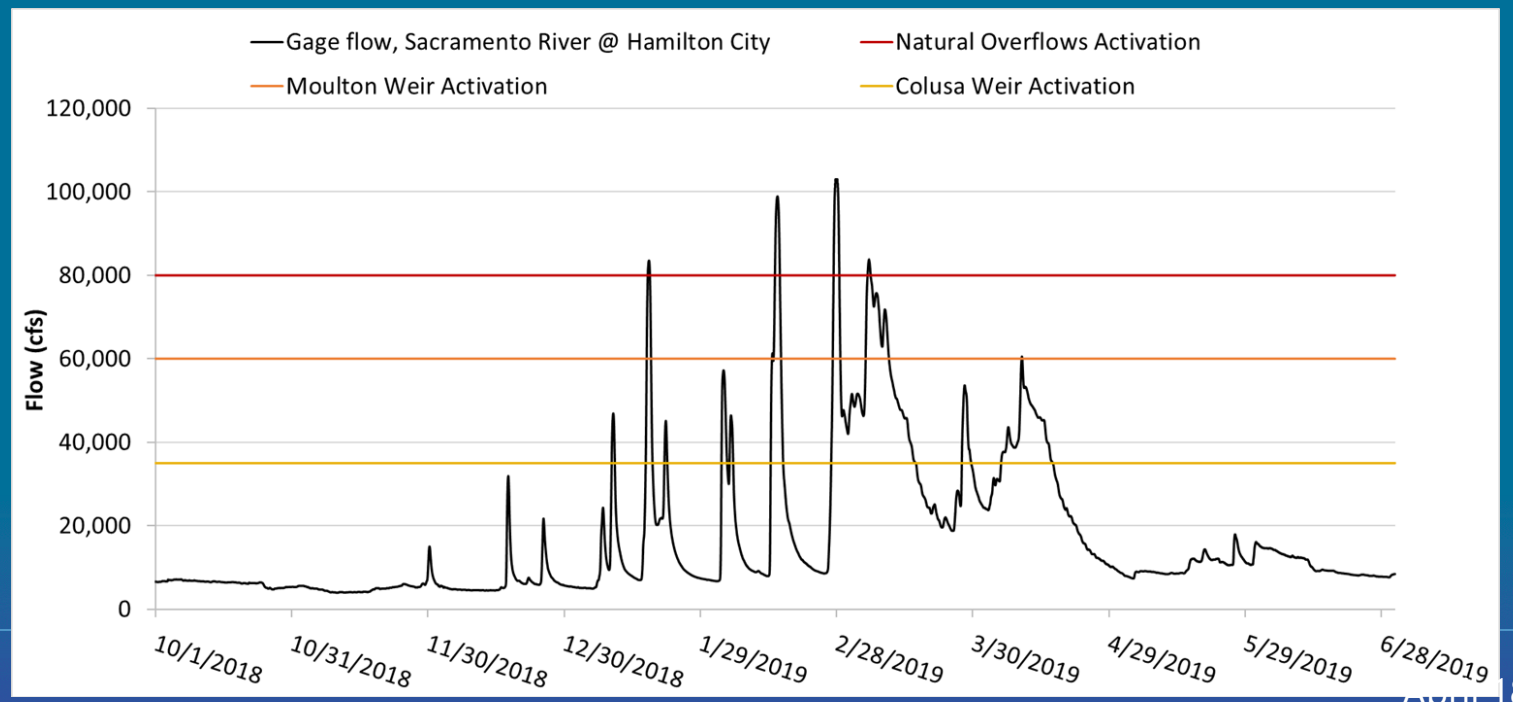
Colusa Basin Calibration

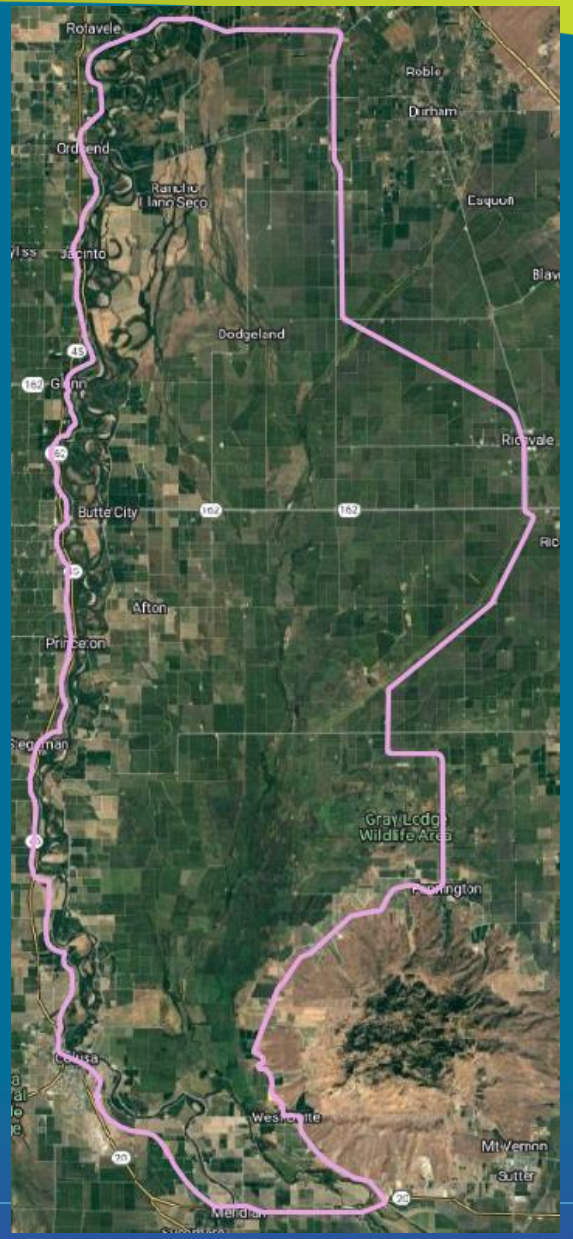
- 2019 water year
- Field Management



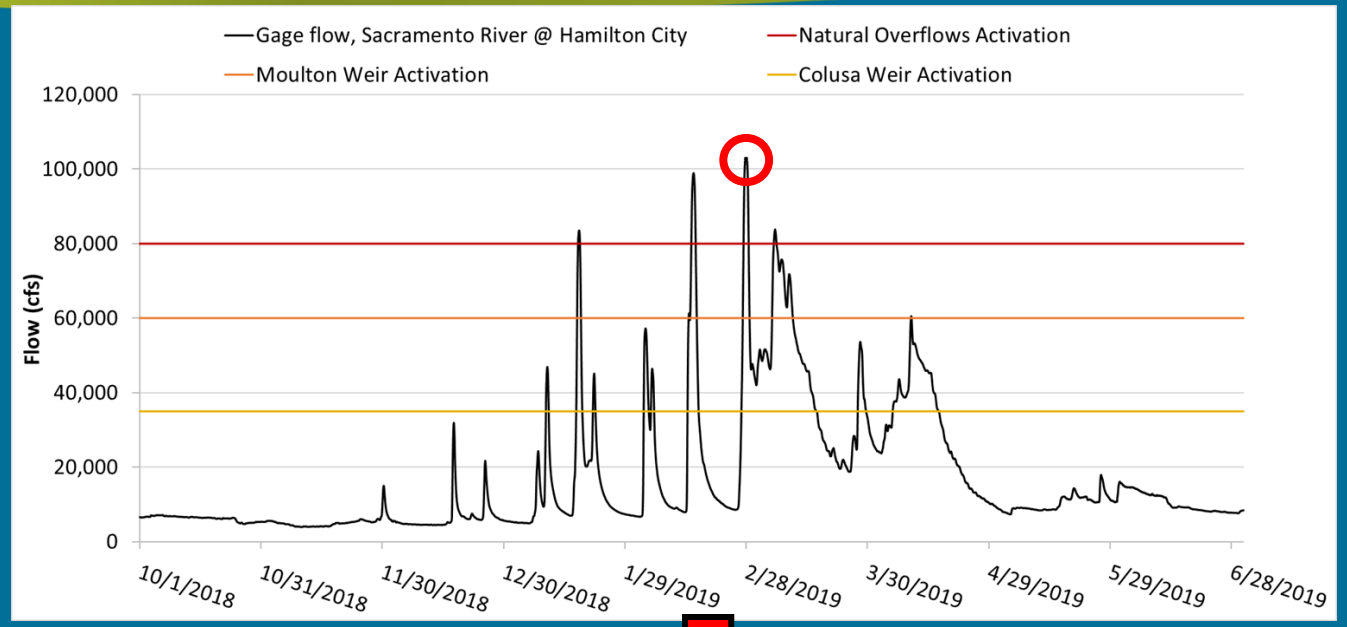
Hydrodynamic Model Calibration – Butte Basin WY2019

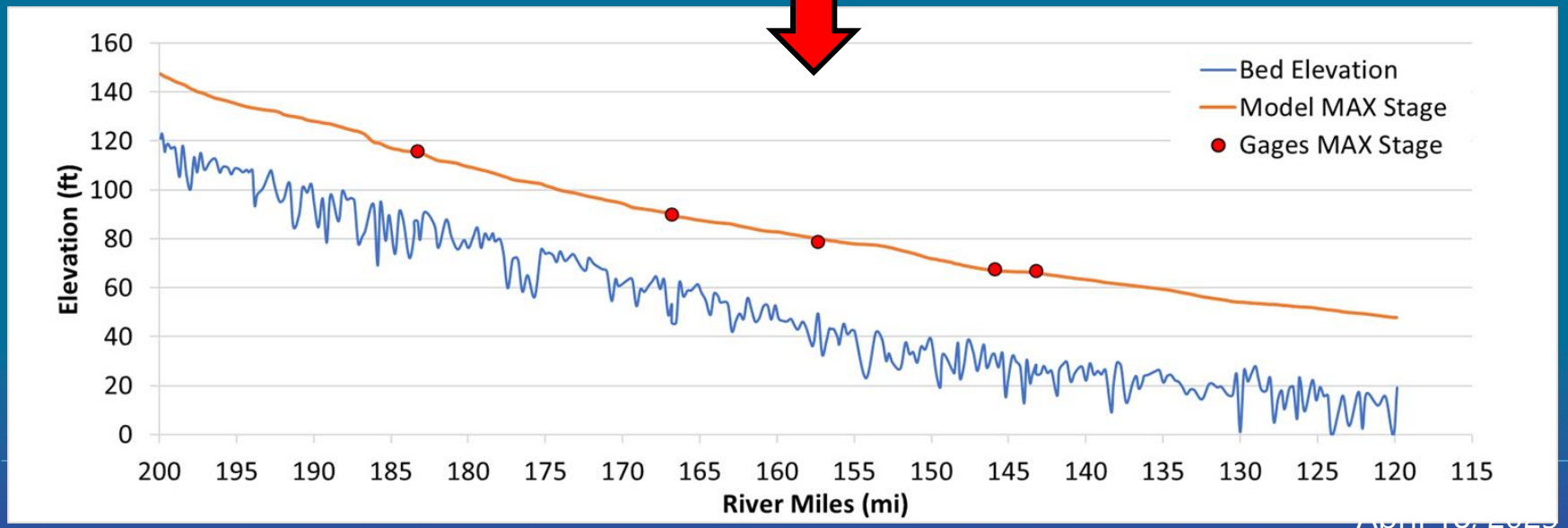


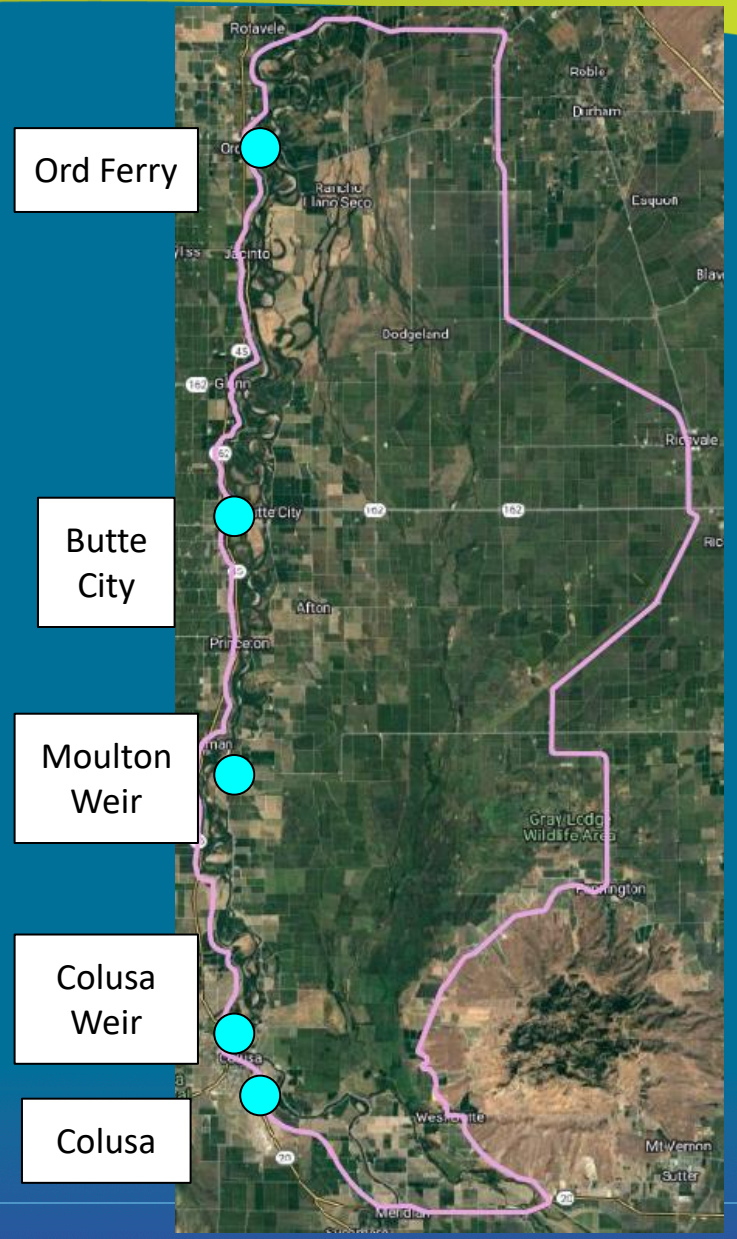




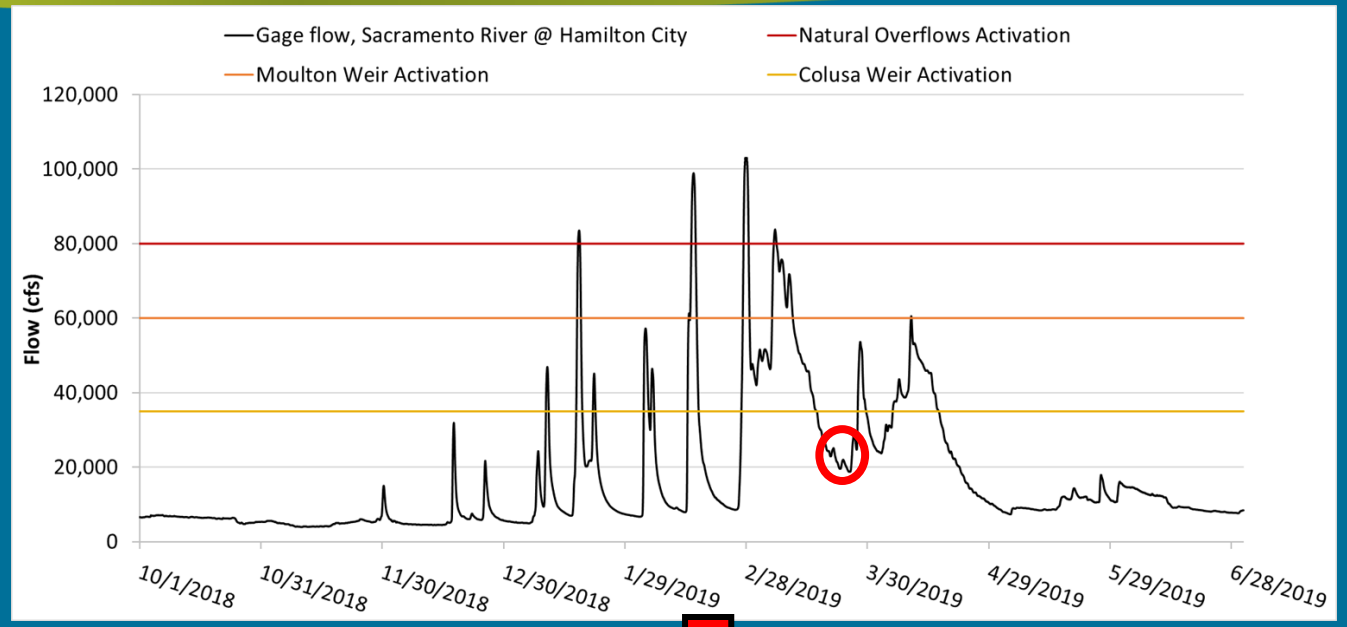
Hydrodynamic Model Calibration – Butte Basin WY2019 MAX Stage

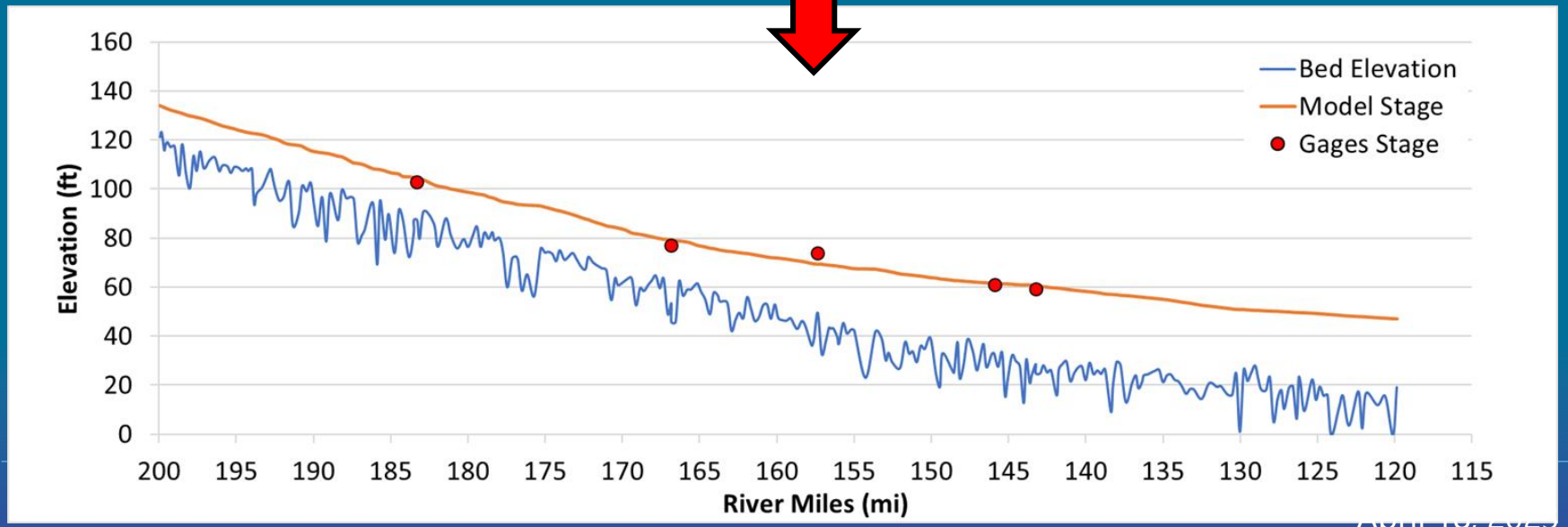


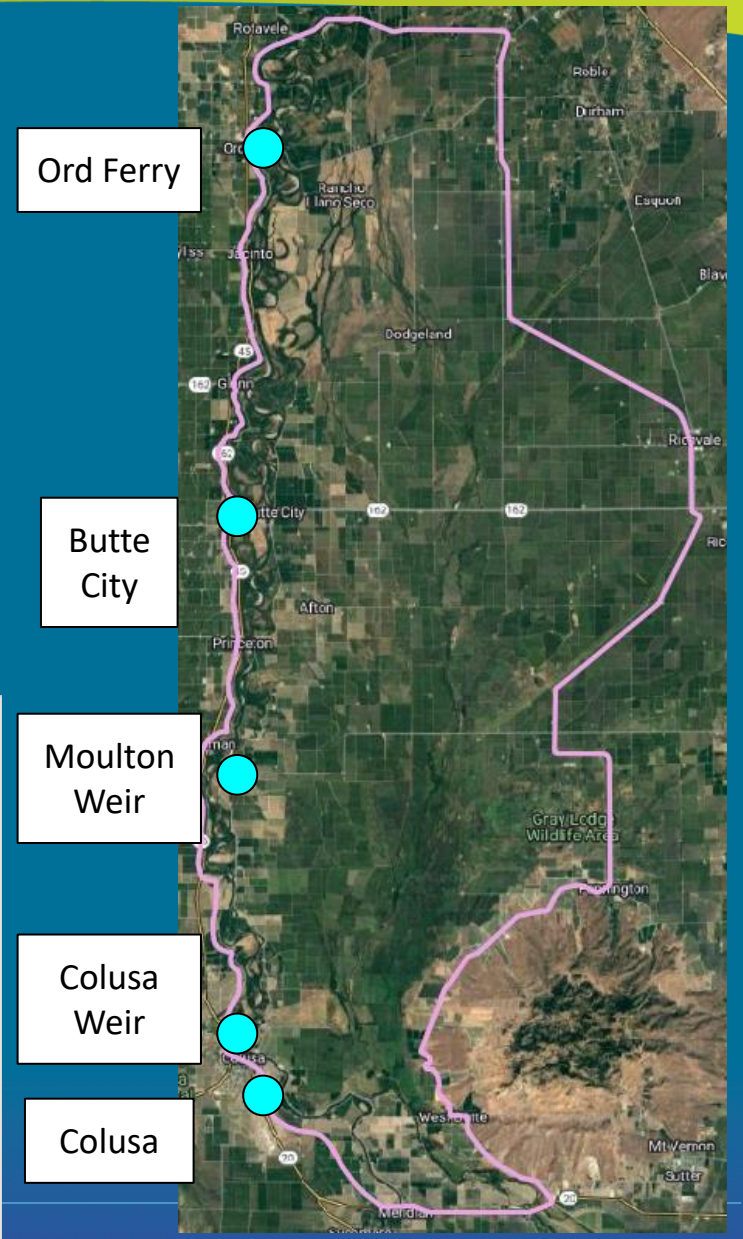




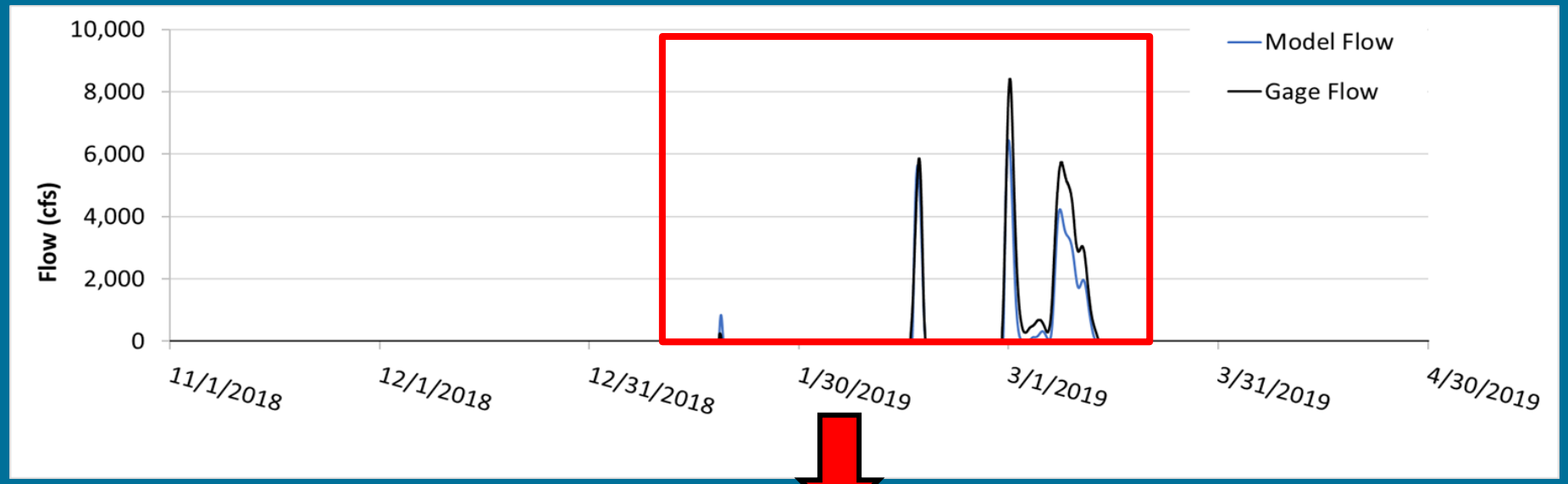
Hydrodynamic Model Calibration – Butte Basin WY2019 3/24/2019 00:00

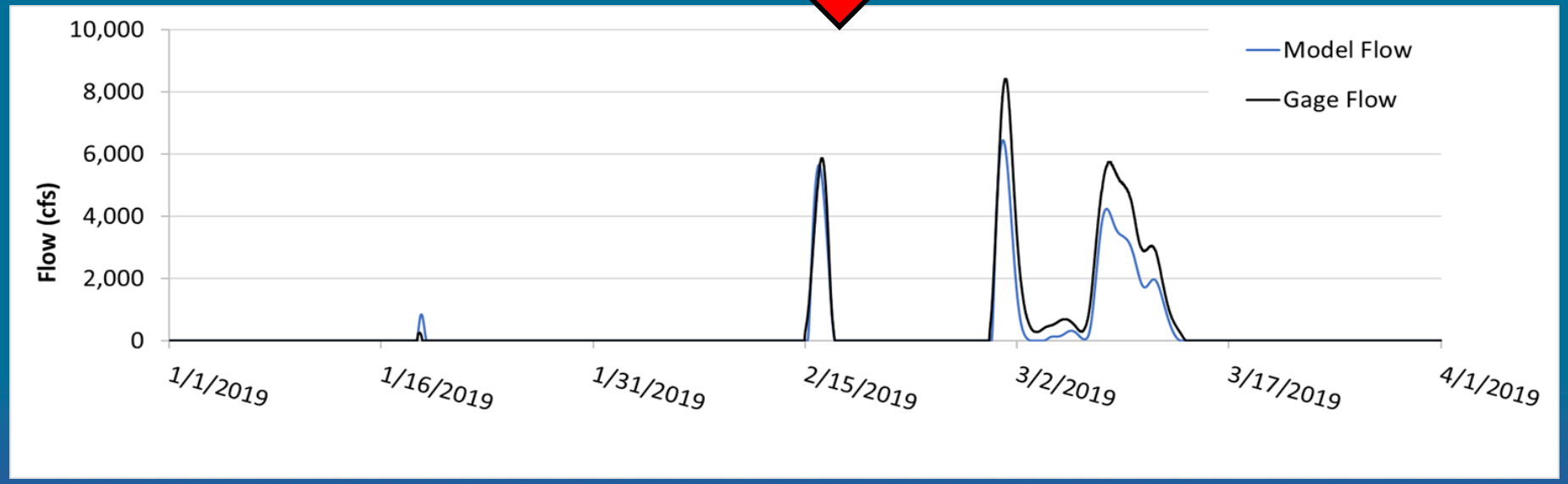


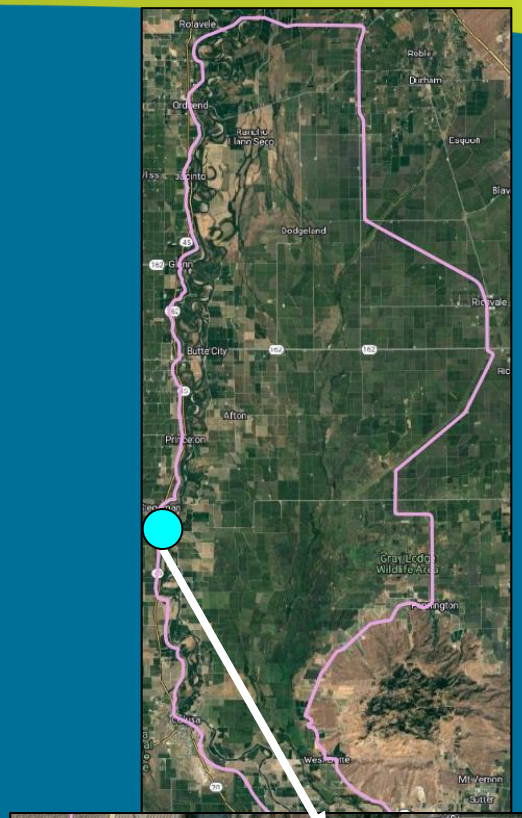


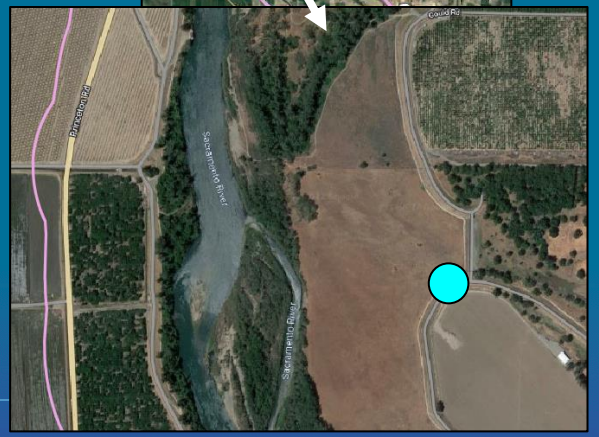


Hydrodynamic Model Calibration – Butte Basin Moulton Weir

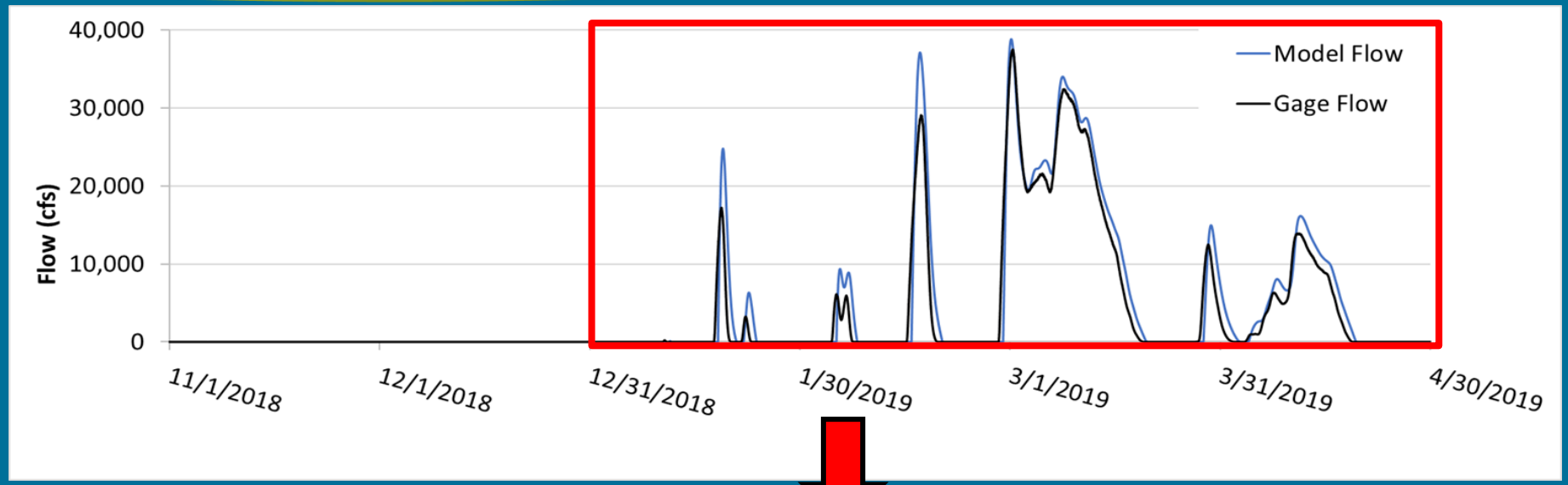


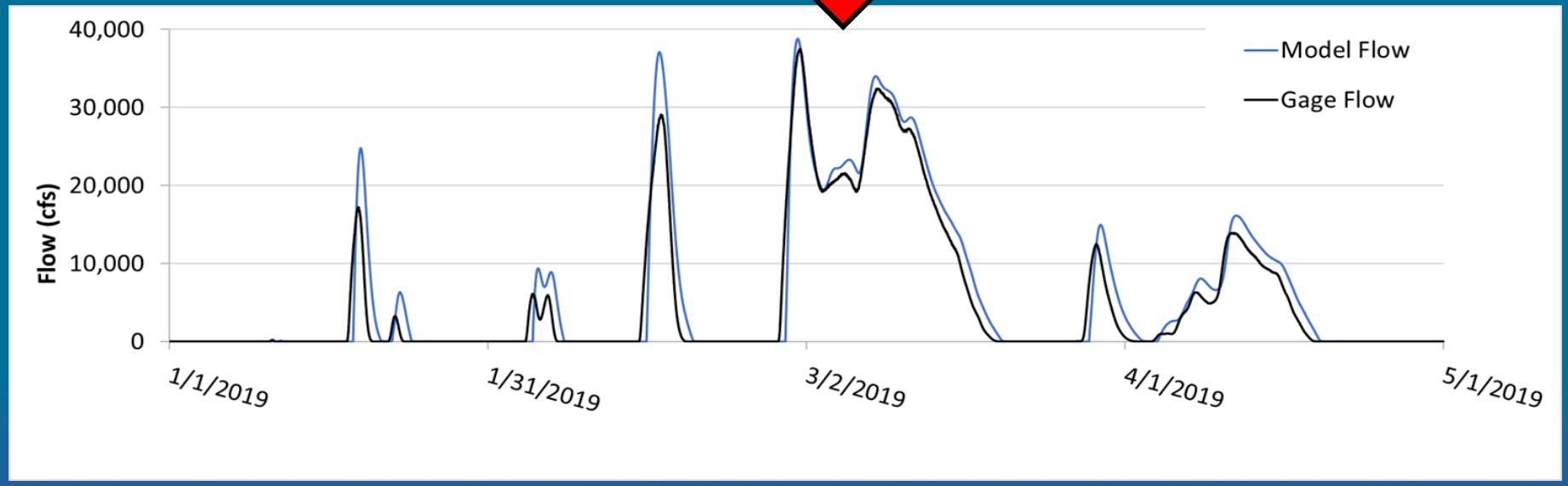


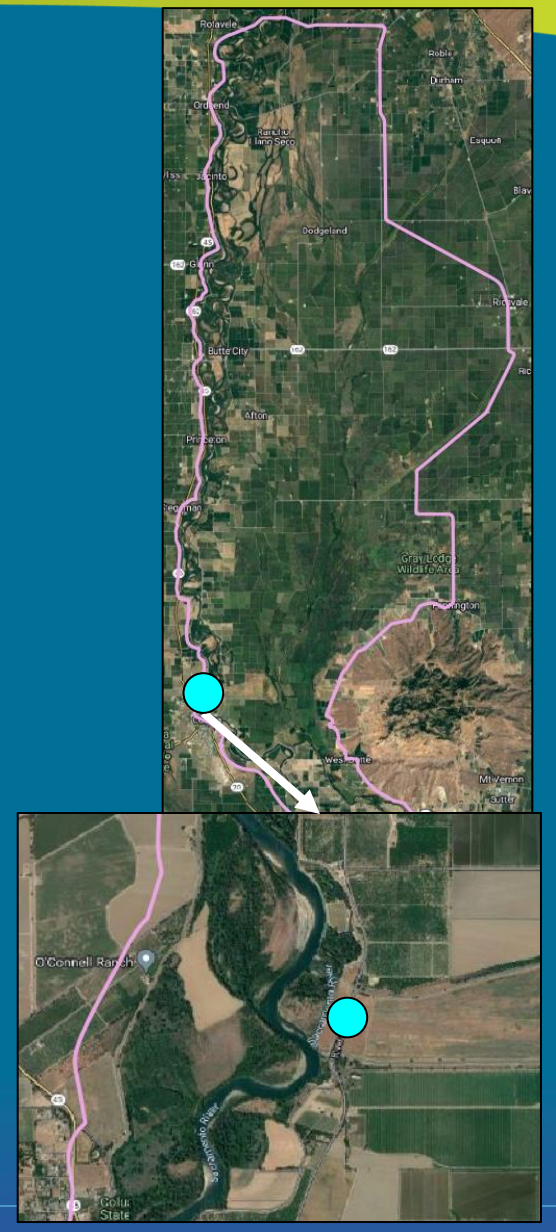




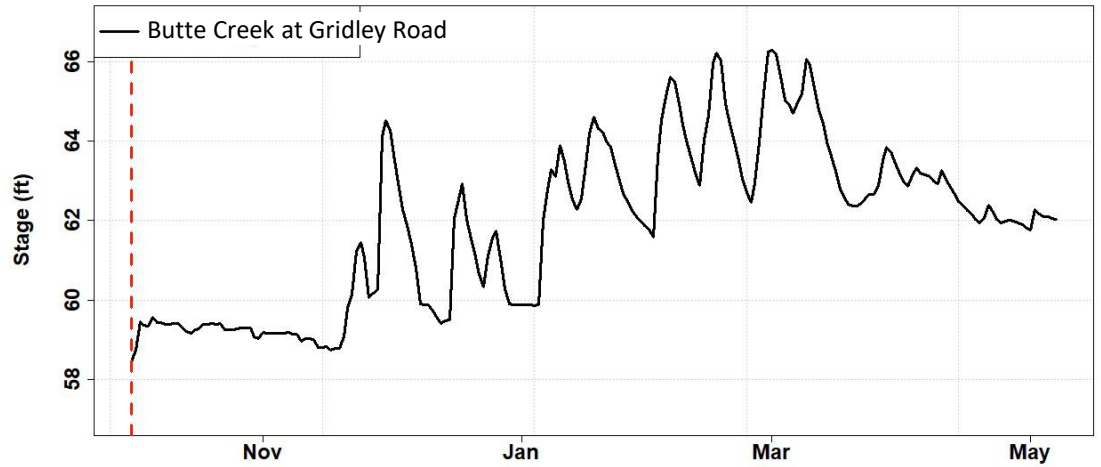
Hydrodynamic Model Calibration – Butte Basin Colusa Weir

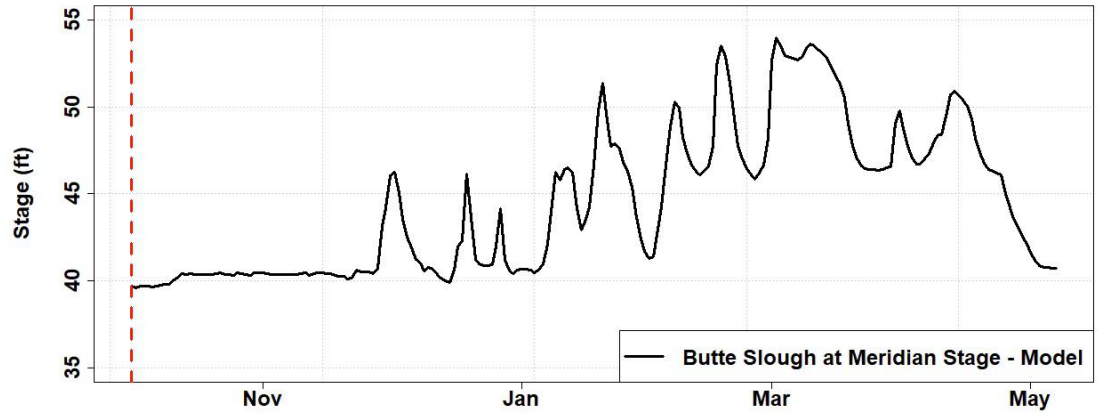


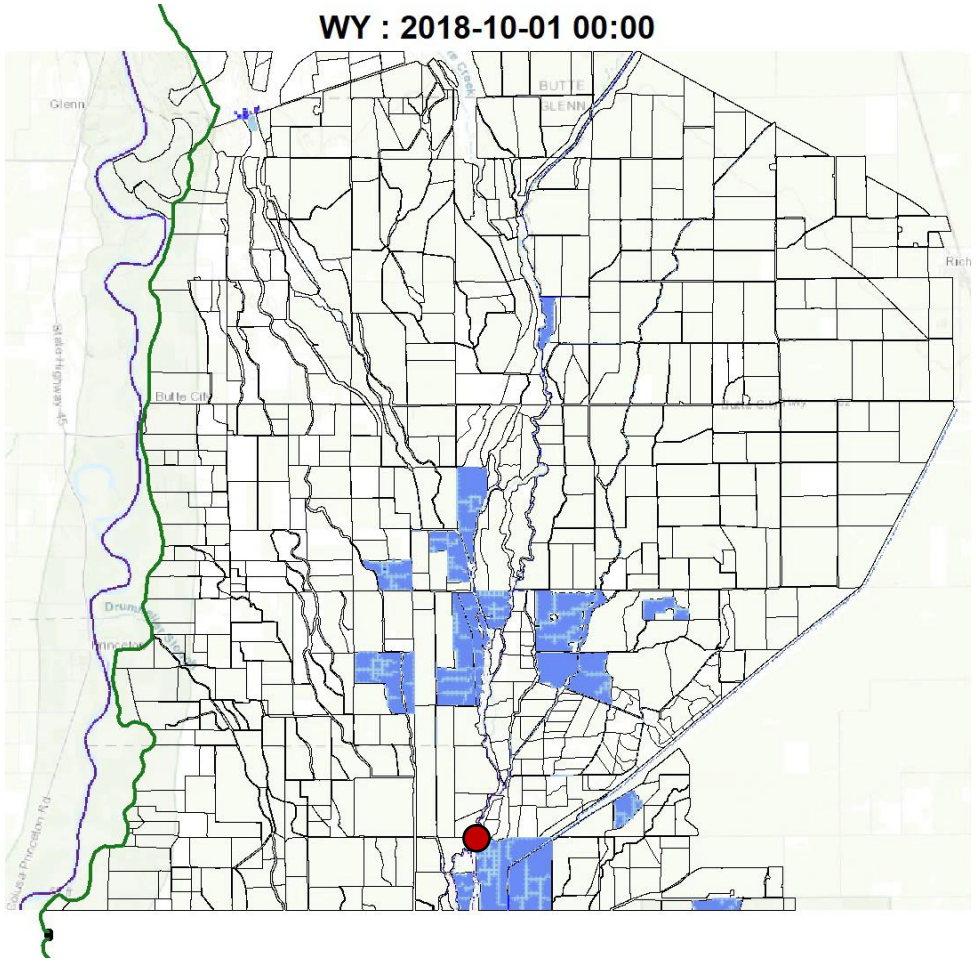




Hydrodynamic Model Calibration – Butte Basin WY2019



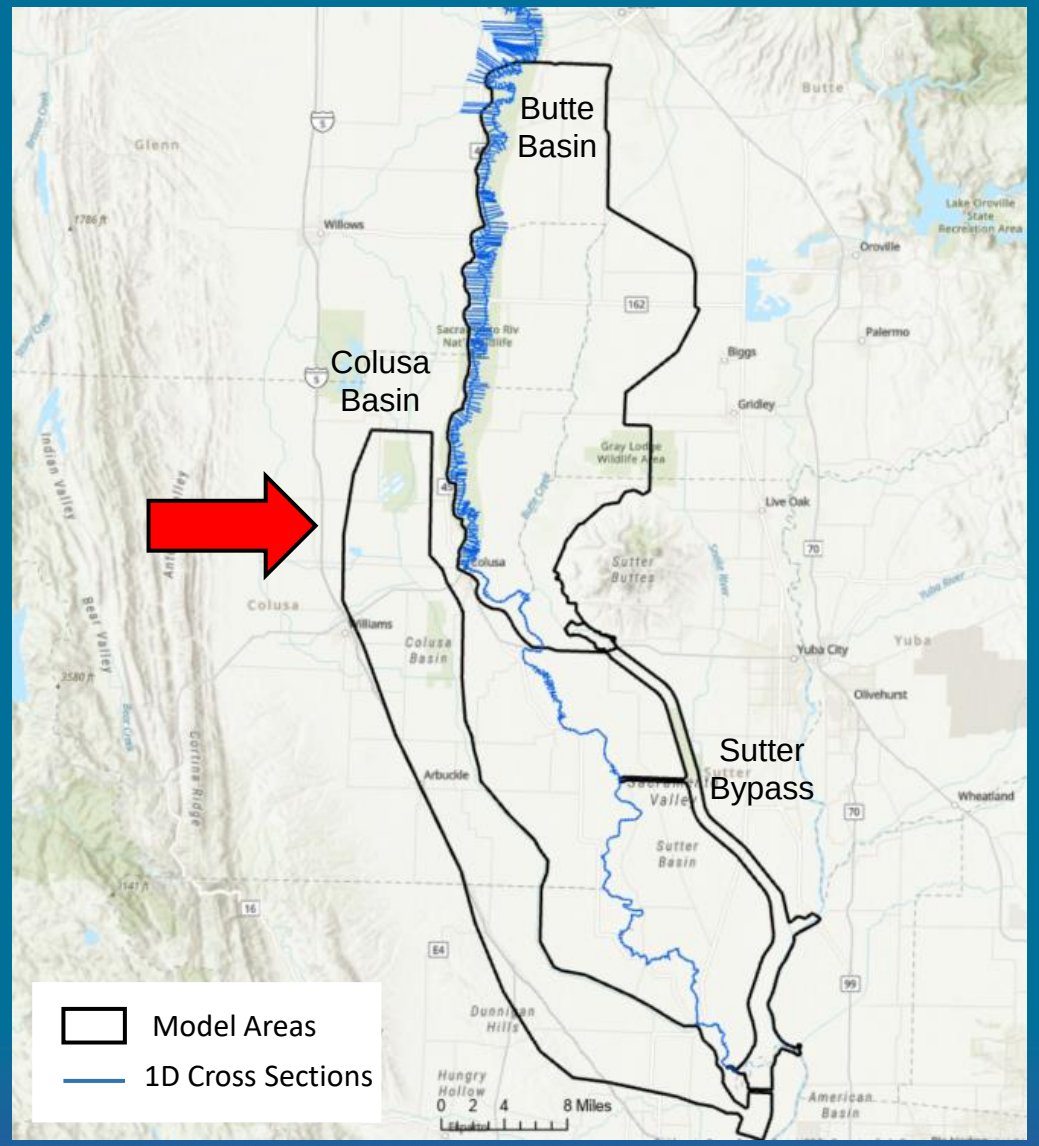




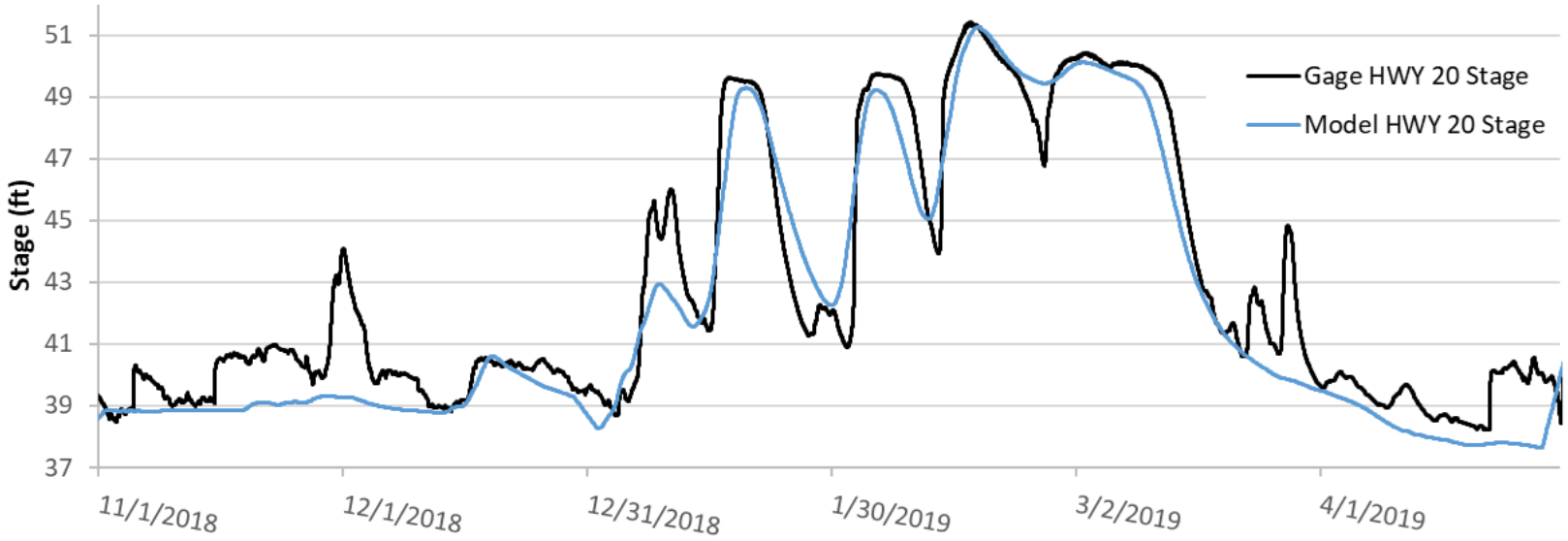
Hydrodynamic Model Calibration – Colusa Basin

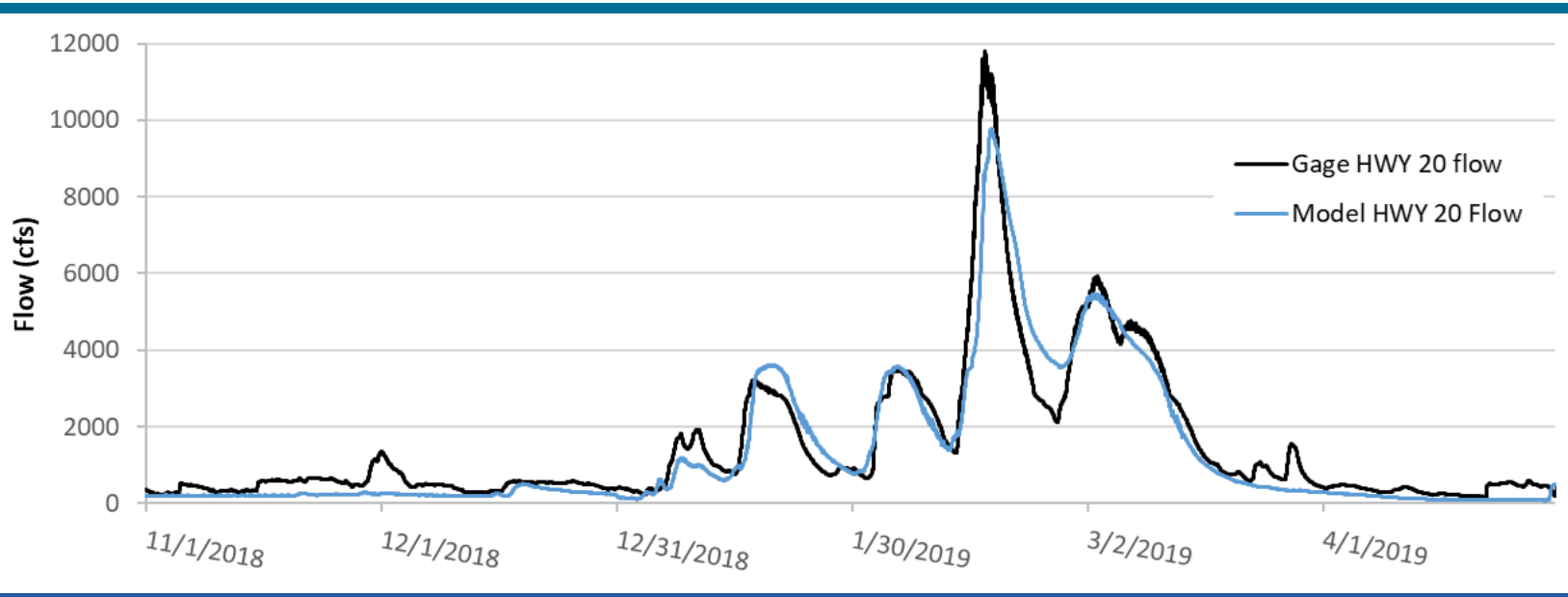
Colusa Basin Calibration

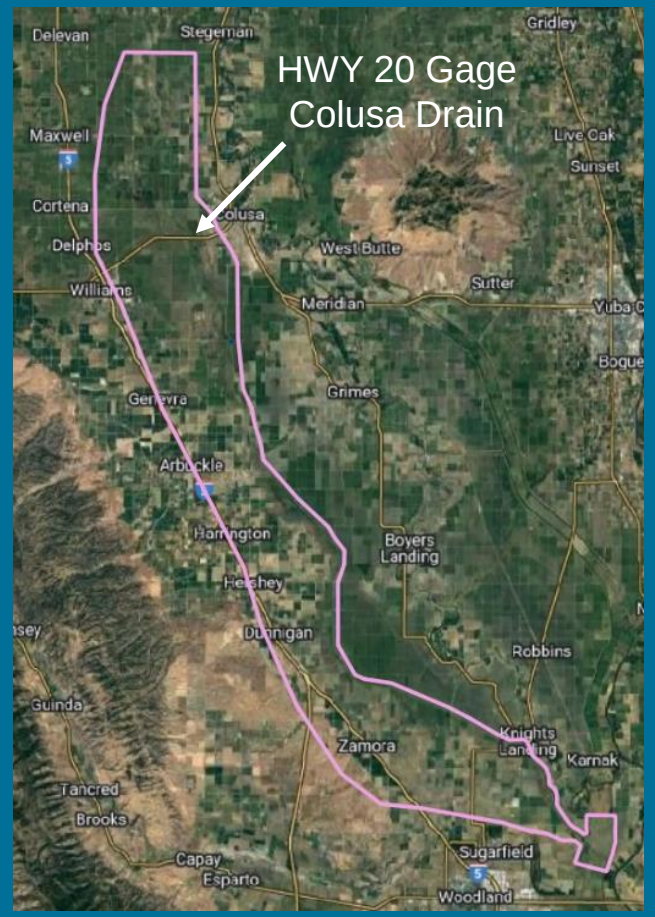
- 2019 water year



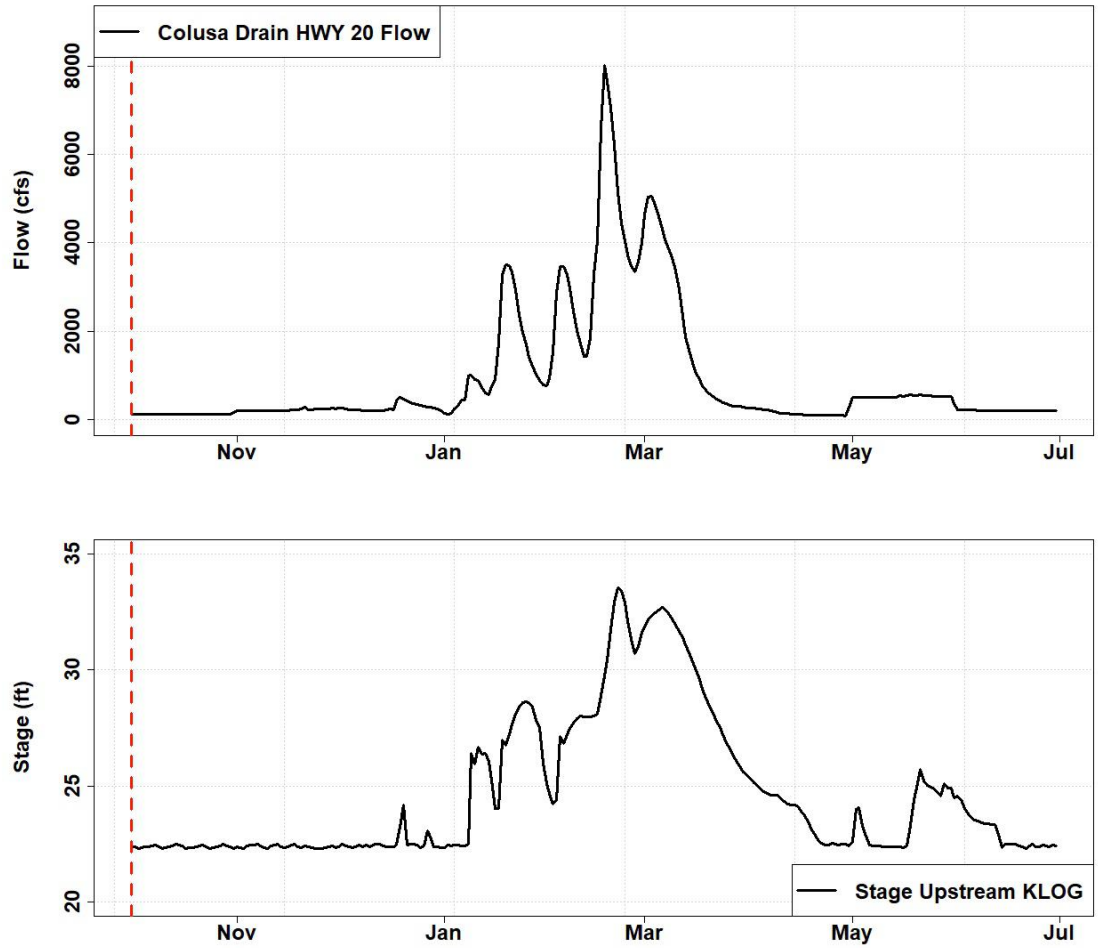
Hydrodynamic Model Calibration – Colusa Basin at HWY 20

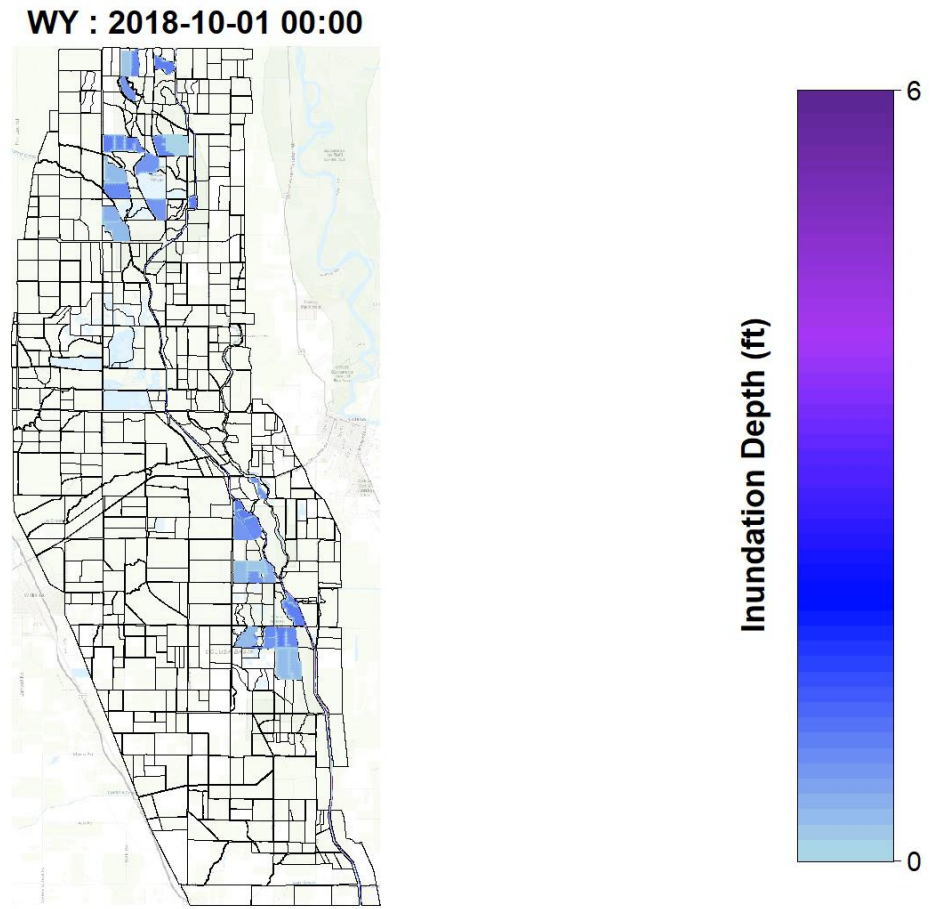




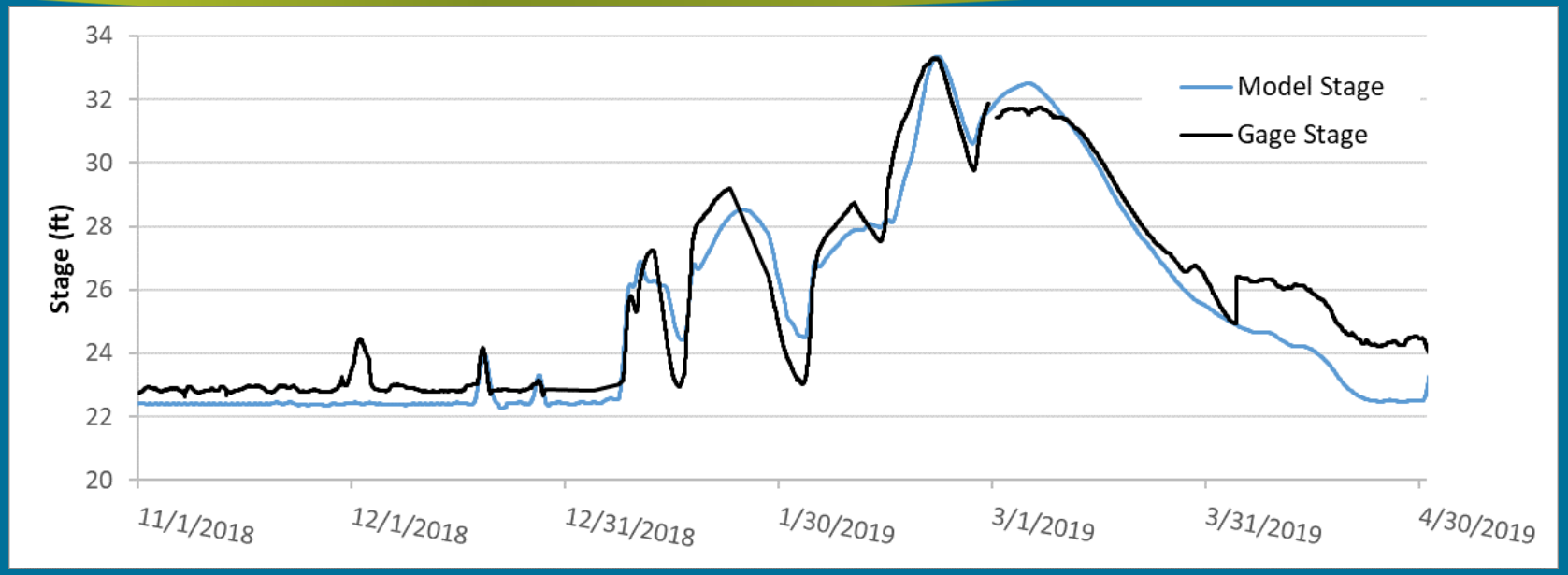


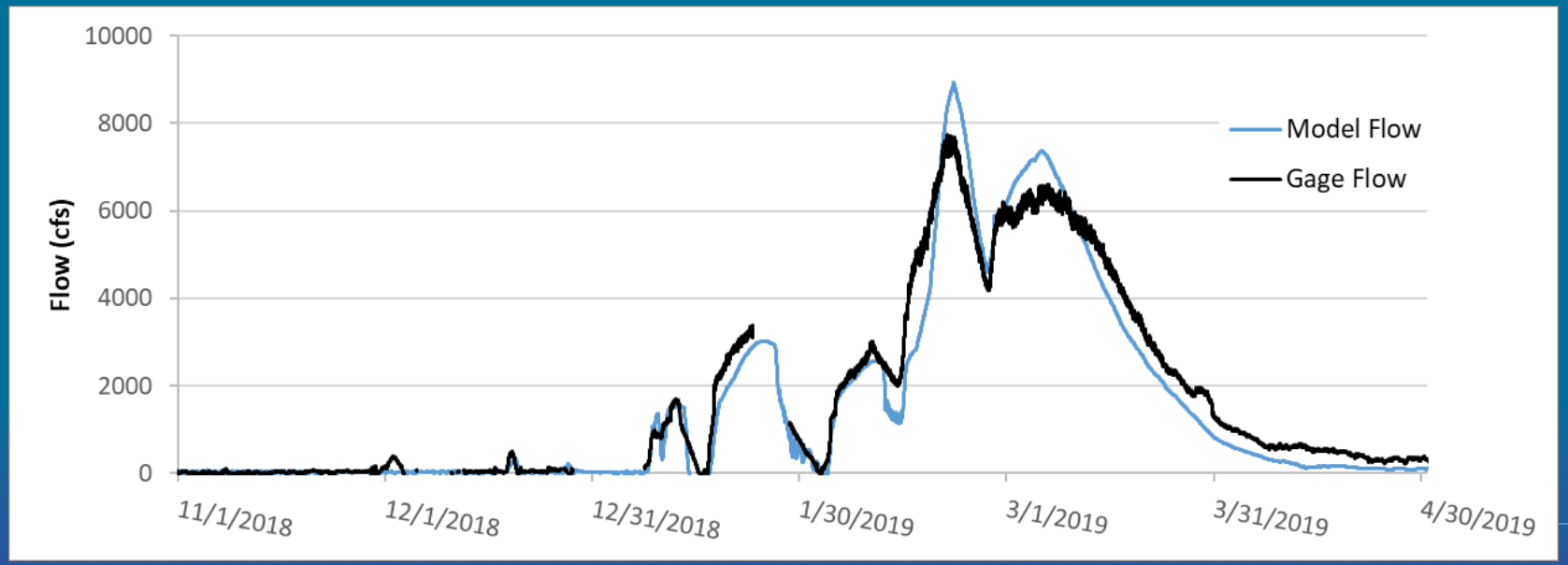
Hydrodynamic Model Calibration – Colusa Basin Animation



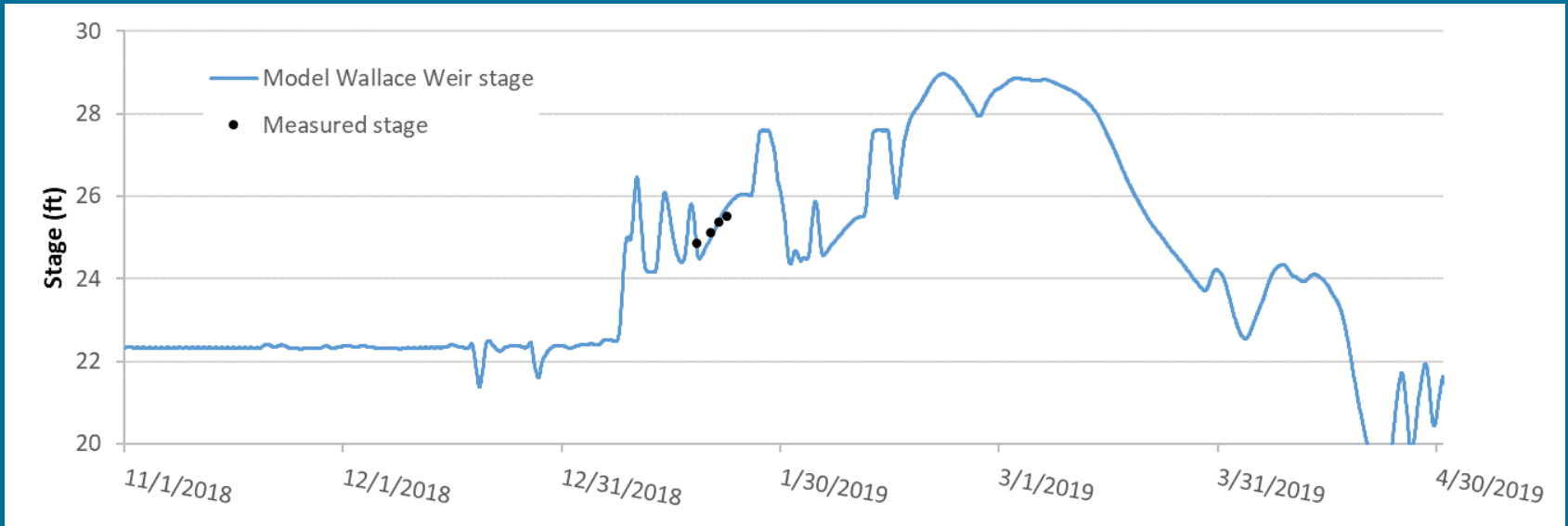


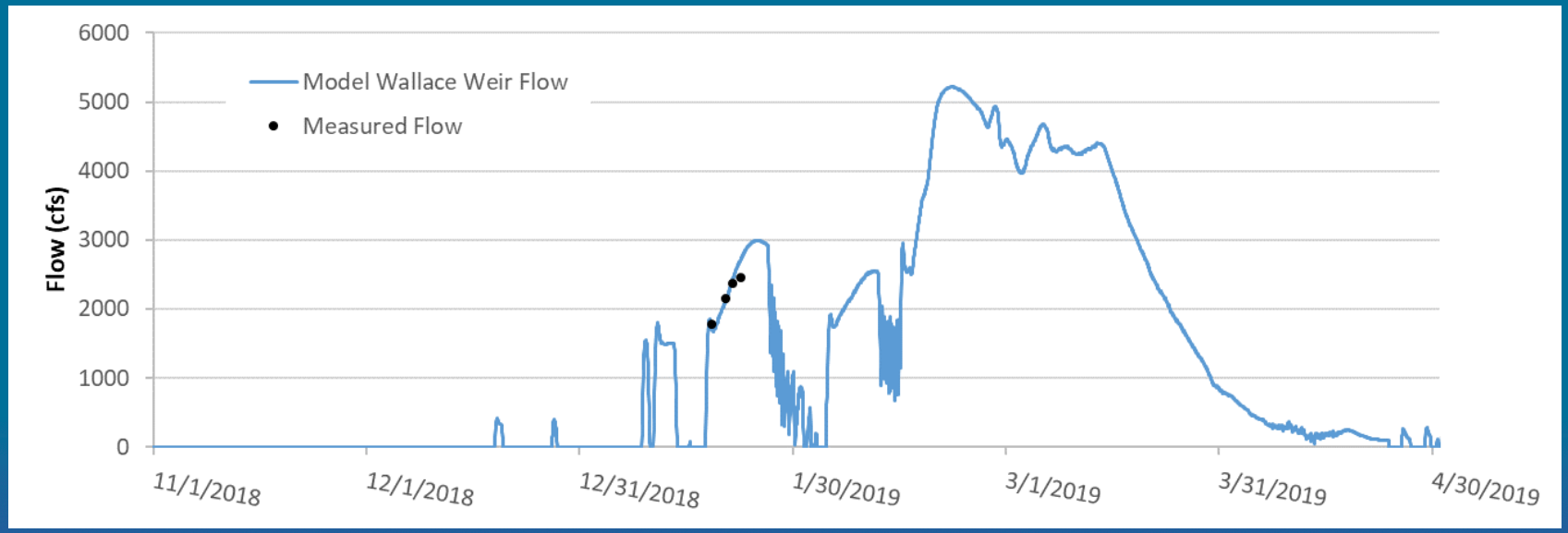
Hydrodynamic Model Calibration – Colusa Basin at Knights Landing Ridgecut





Hydrodynamic Model Calibration – Colusa Basin at Wallace Weir

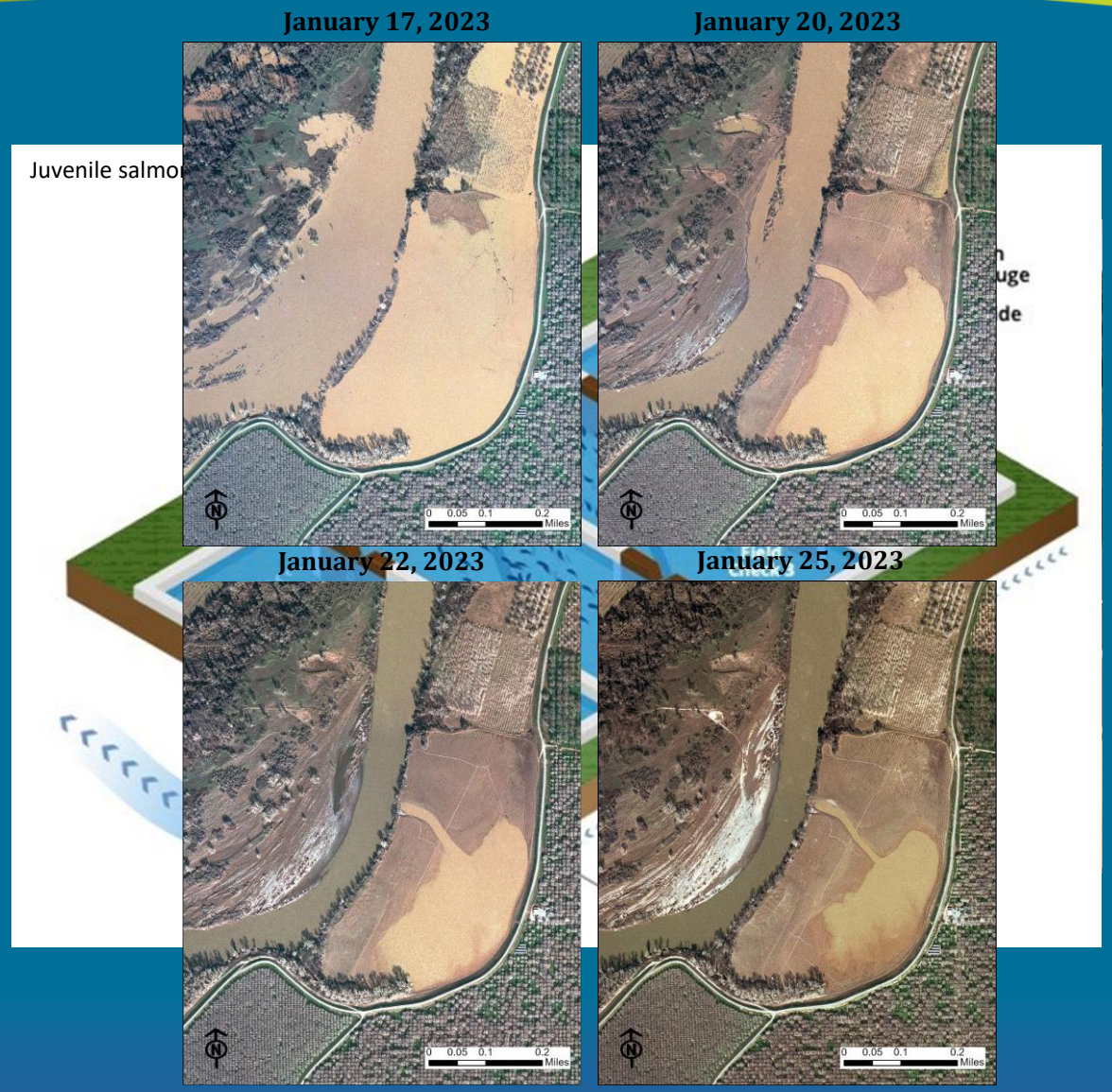




Scenario Development – Suite of Possible Actions

Types

- River Connections
  - Notch overflow and flood weirs
  - Modify outfall gates
  - Modify water management
  - Modify existing or add new diversions
  - Improve fish passage
  - Manage water on the field unit
- Habitat Restoration
  - Juvenile salmon rearing & fish food
  - Juvenile rearing
  - Bird habitat
  - Reduce stranding
  - Groundwater recharge
  - Riparian restoration
  - Fish friendly passage
  - Fish screens
- Habitat Restoration



Acknowledgements

FLOODPLAINS REIMAGINED

https://floodplainsreimagined.org/

Project Funding

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  - Phase I is scheduled for August 2012 – December 2023

Program Partners

- **Reclamation District 108**
  - Program director and grant recipient
- **Kjeldsen Sinnock Neudeck (KSN)**
  - Project manager and engineering support
- **Kearns & West**
  - Stakeholder involvement and facilitation services
- **Larsen Wurzel & Associates**
  - Process advisors
- **cbec eco engineering (cbec)**
  - Technical Team lead for hydrology, hydraulics, and multi-benefit analysis with support from:
    - SFEI (habitat suitability)
    - Cramer Fish Sciences and Aquatic Resources Consulting Scientists (fish)
    - Point Blue and Ducks Unlimited (birds)

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Thank You!

Questions?

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