Using CVFED hydraulic models to inform the C2VSim groundwater-surface water model

Holly Canada, PE
David Ford Consulting Engineers, Inc.

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Collaborators

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- Ali Taghavi (RMC).
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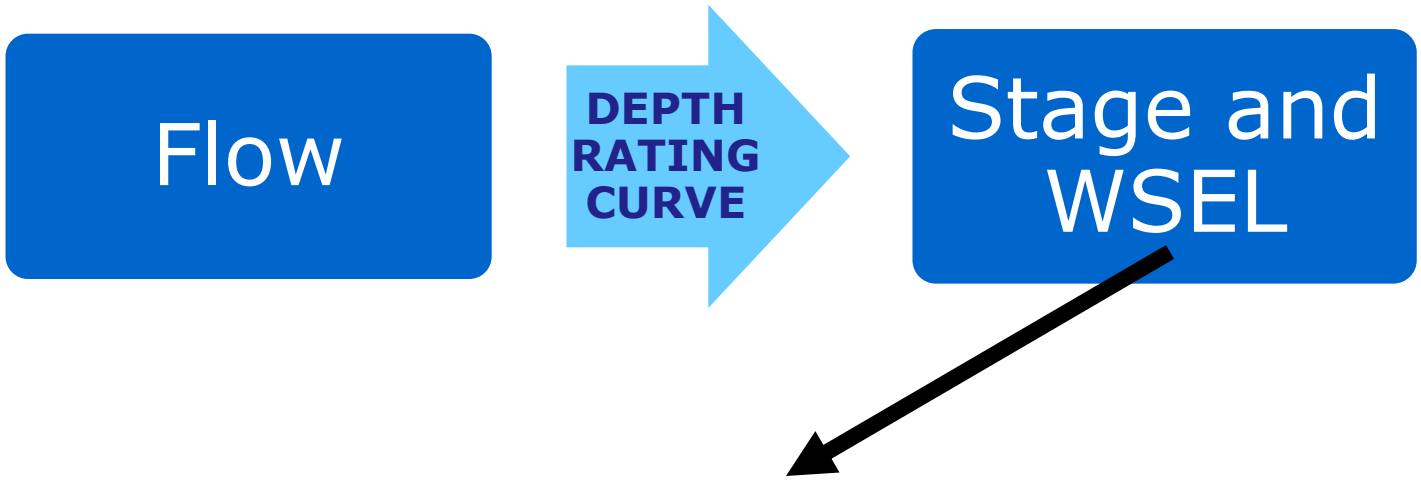
Why?

- To verify and refine the C2VSim channel depth rating curves.



Groundwater – surface water interaction

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Outline

- C2VSim model
- CVFED HEC-RAS models.
- Verify C2VSim coarse grid parameters.
- Refine C2VSim parameters (fine grid model development)
- Summary.

C2VSim groundwater-surface water model

- Integrated hydrologic model.
- Developed by DWR for Central Valley water management planning.
- Simulates water movement through the interconnected land surface, surface water, and groundwater flow systems.

C2VSim model versions

- Two representations of surface water movement:
  1. Water balance (instantaneous routing).
  2. Kinematic wave routing.

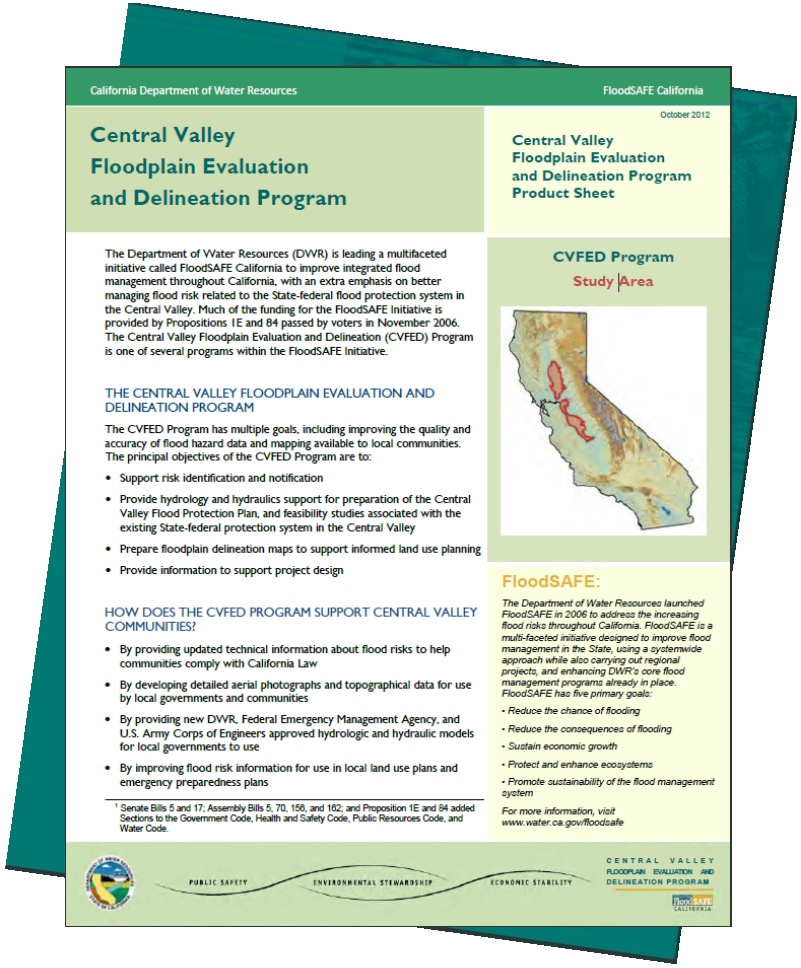
- Two grid size options:
  1. Coarse (1,393 elements).
  2. Fine (+32,500 elements).

What C2VSim models did we use?

- For the **coarse grid** kinematic wave model, we **verified**:
  - Depth-flow rating curves.
  - Velocity-flow rating curves.
  - Cross section geometries.
  - Channel slope values.
  - Manning's n values.
- To aid development of the **fine grid** kinematic wave model, we **refined:**
  - Depth-flow rating curves.
  - Channel invert elevation.

The Central Valley floodplain evaluation and delineation program (CVFED)

- Paterno Decision 2003, DWR White Paper & Hurricane Katrina 2005, Prop 84 & 1E 2006, SB/AB Bills 2007.
- CVFED in 2008.
- $110M Program (Prop. 84 & 1E).
- Three Projects:
  - Project 1 - Topography Acquisition.
  - Project 2 - Riverine and Overland Hydraulic Model Development.
  - Project 3 - Floodplain Mapping.



California Department of Water Resources — FloodSAFE California

October 2012

Central Valley Floodplain Evaluation and Delineation Program

Central Valley Floodplain Evaluation and Delineation Program Product Sheet

The Department of Water Resources (DWR) is leading a multifaceted initiative called FloodSAFE California to improve integrated flood management throughout California, with an extra emphasis on better managing flood risk related to the State-federal flood protection system in the Central Valley. Much of the funding for the FloodSAFE Initiative is provided by Propositions 1E and 84 passed by voters in November 2006. The Central Valley Floodplain Evaluation and Delineation (CVFED) Program is one of several programs within the FloodSAFE Initiative.

THE CENTRAL VALLEY FLOODPLAIN EVALUATION AND DELINEATION PROGRAM

The CVFED Program has multiple goals, including improving the quality and accuracy of flood hazard data and mapping available to local communities. The principal objectives of the CVFED Program are to:

- Support risk identification and notification
- Provide hydrology and hydraulics support for preparation of the Central Valley Flood Protection Plan, and feasibility studies associated with the existing State-federal protection system in the Central Valley
- Prepare floodplain delineation maps to support informed land use planning
- Provide information to support project design

HOW DOES THE CVFED PROGRAM SUPPORT CENTRAL VALLEY COMMUNITIES?

- By providing updated technical information about flood risks to help communities comply with California Law
- By developing detailed aerial photographs and topographical data for use by local governments and communities
- By providing new DWR, Federal Emergency Management Agency, and U.S. Army Corps of Engineers approved hydrologic and hydraulic models for local governments to use
- By improving flood risk information for use in local land use plans and emergency preparedness plans

[1] Senate Bills 5 and 17; Assembly Bills 5, 70, 156, and 162; and Proposition 1E and 84 added Sections to the Government Code, Health and Safety Code, Public Resources Code, and Water Code.

CVFED Program Study Area

FloodSAFE:

The Department of Water Resources launched FloodSAFE in 2006 to address the increasing flood risks throughout California. FloodSAFE is a multi-faceted initiative designed to improve flood management in the State, using a systemwide approach while also carrying out regional projects, and enhancing DWR's core flood management programs already in place. FloodSAFE has five primary goals:

- *Reduce the chance of flooding*
- *Reduce the consequences of flooding*
- *Sustain economic growth*
- *Protect and enhance ecosystems*
- *Promote sustainability of the flood management system*

For more information, visit www.water.ca.gov/floodsafe

PUBLIC SAFETY — ENVIRONMENTAL STEWARDSHIP — ECONOMIC STABILITY

CENTRAL VALLEY FLOODPLAIN EVALUATION AND DELINEATION PROGRAM

Slide credit: Yiguo Liang, PhD, PE (DWR)

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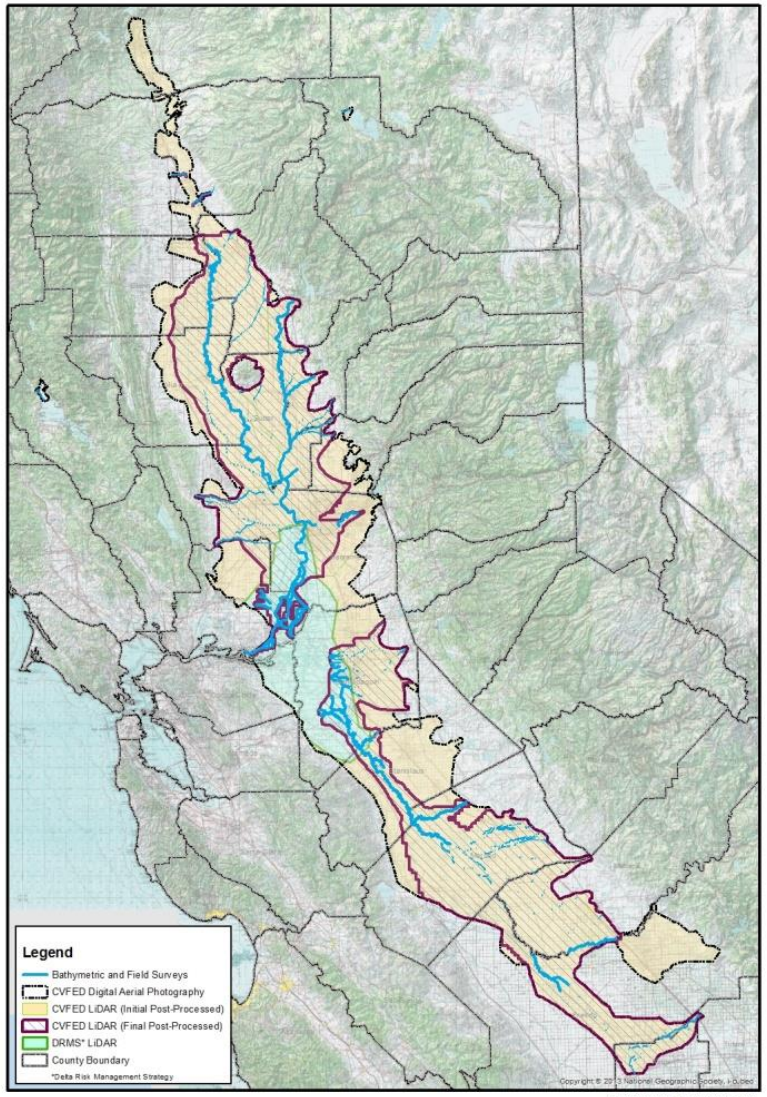
CVFED topography development



- LiDAR
  - Initial post-processing
    - 7,800 sq. mi.
  - Final post-processing
    - 5,800 sq. mi.
  - DRMS LiDAR
    - 1,200 sq. mi.
- Digital Aerial Photography
  - 9,000 sq. mi.
- Field Surveys
  - 3,000 cross-sections
- Bathymetric Surveys
  - 2,500 cross-sections

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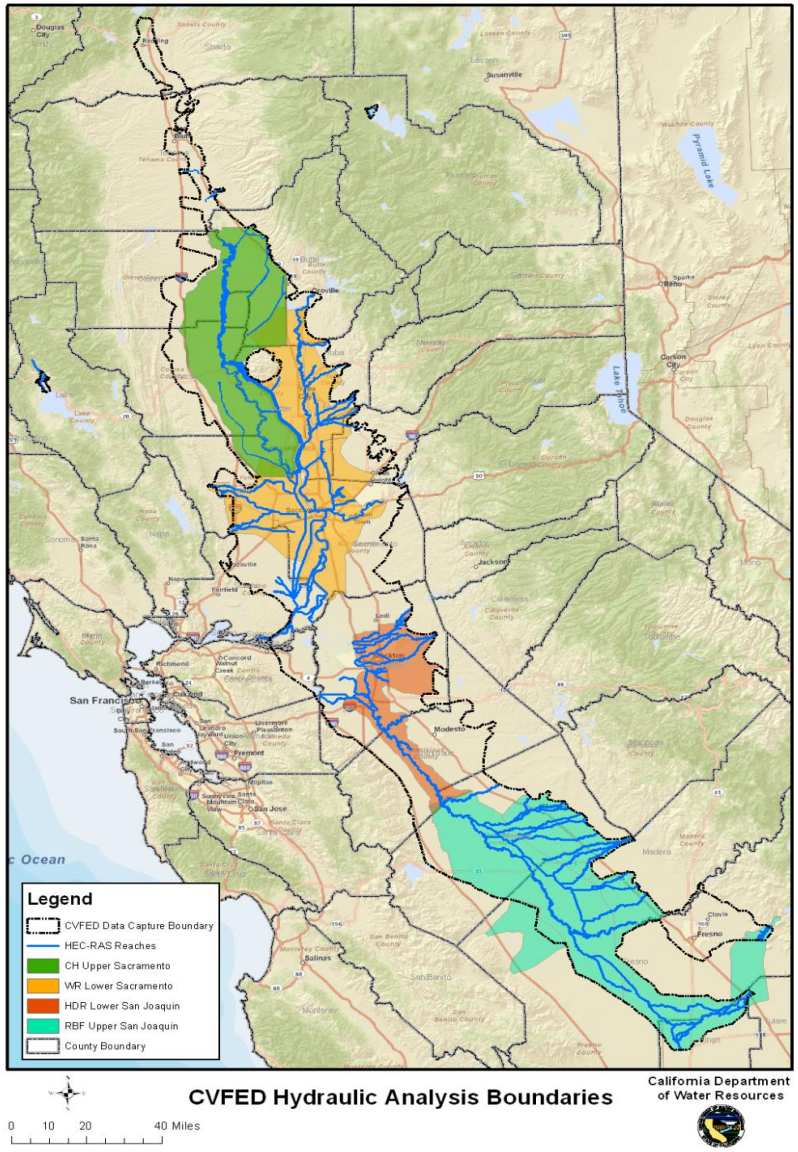
CVFED riverine/hydraulic models



- 1-D riverine models (HEC-RAS)
  - 1,650 miles of streams
- 2-D overland flow models (FLO-2D)
  - 5,950 square miles
- 1-D/2-D riverine/overland models (TUFLOW)
  - Yuba River and Cache Creek

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CVFED hydraulic models

- HEC-RAS hydraulic modeling program.
- Full dynamic wave routing.
- 1-dimensional.
- Unsteady-state.
- Channels, levees, and embankments are based on topography data and existing conditions.
- Sacramento and San Joaquin river systems.

VERIFY C2VSim COARSE GRID MODEL PARAMETERS

Verified model parameters at 8 representative reaches

1. Upper Sacramento River.
2. Feather River.
3. American River.
4. Lower Sacramento River.
5. Lower SJR.
6. Tuolumne River.
7. Upper SJR.
8. Merced River.

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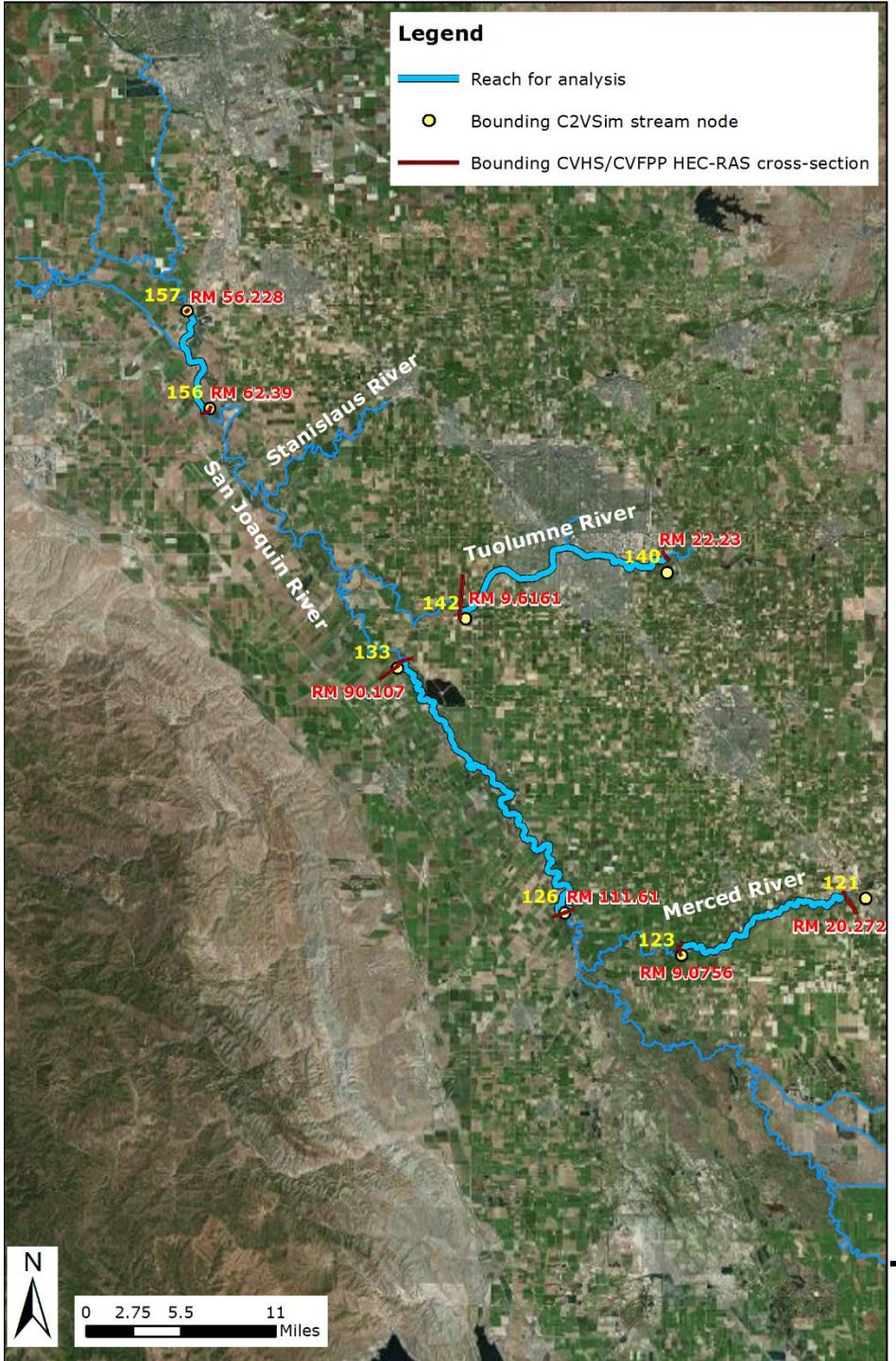

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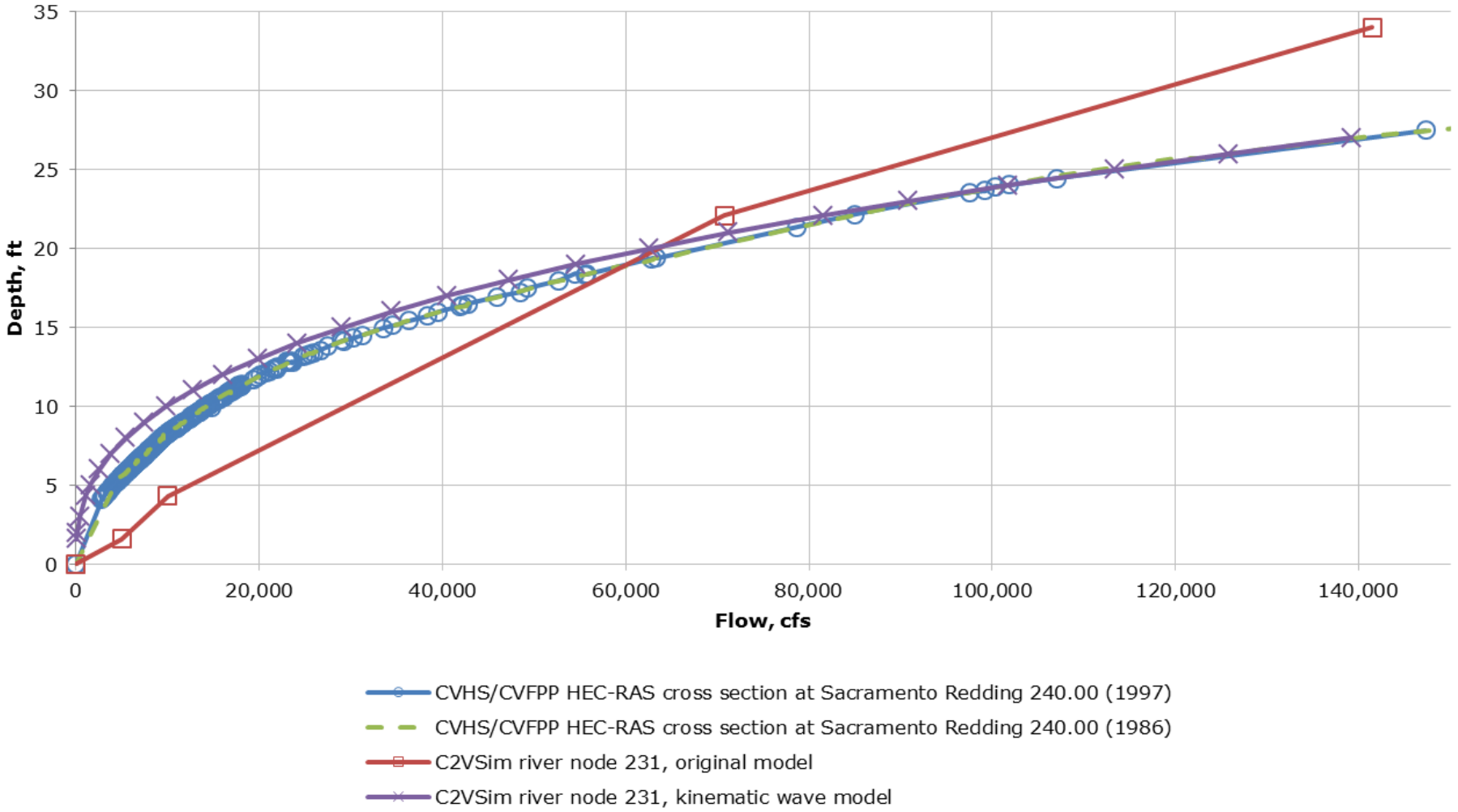
Compared depth-flow rating curves (example location where similar)



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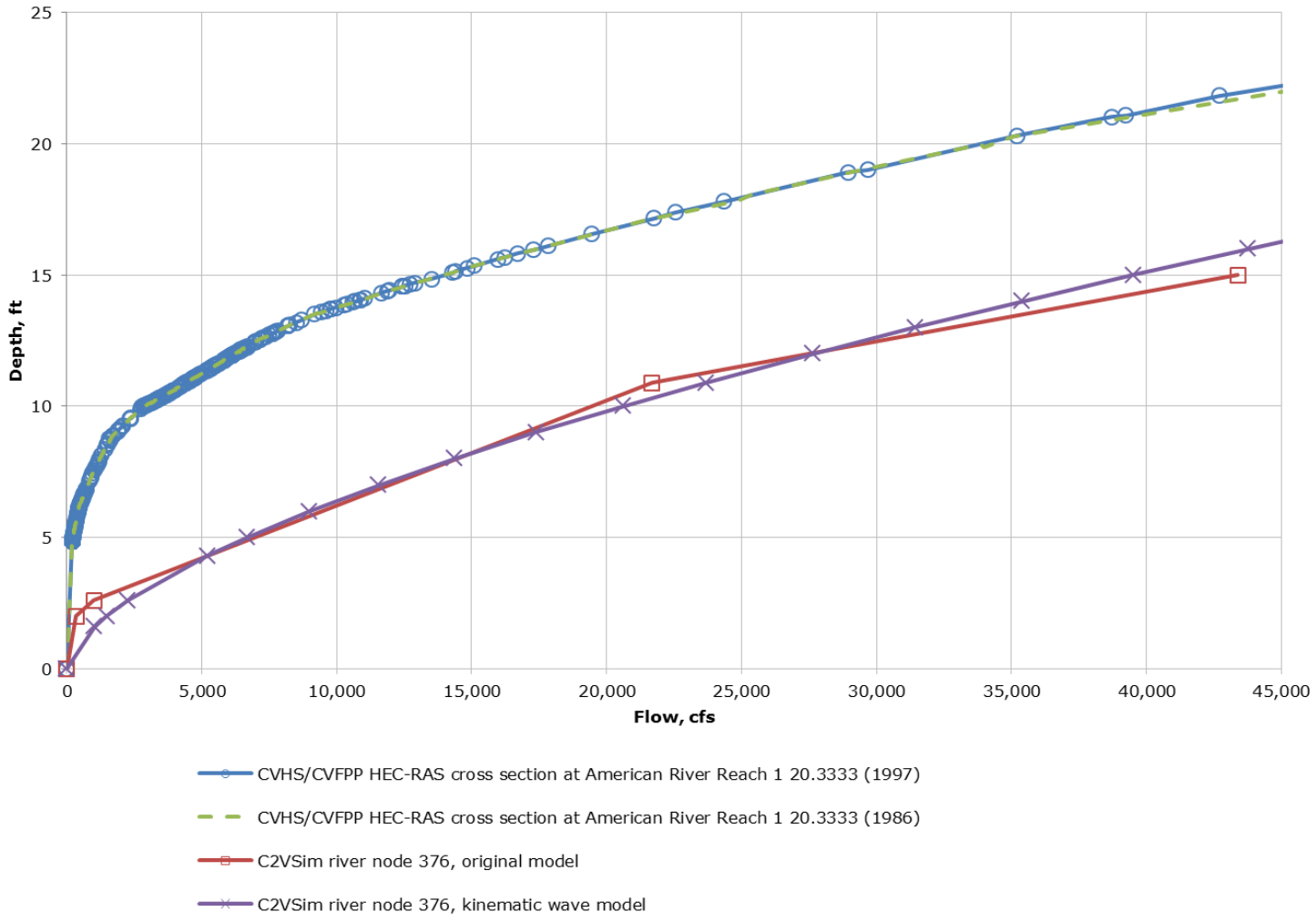
Compared depth-flow rating curves (example location where different)



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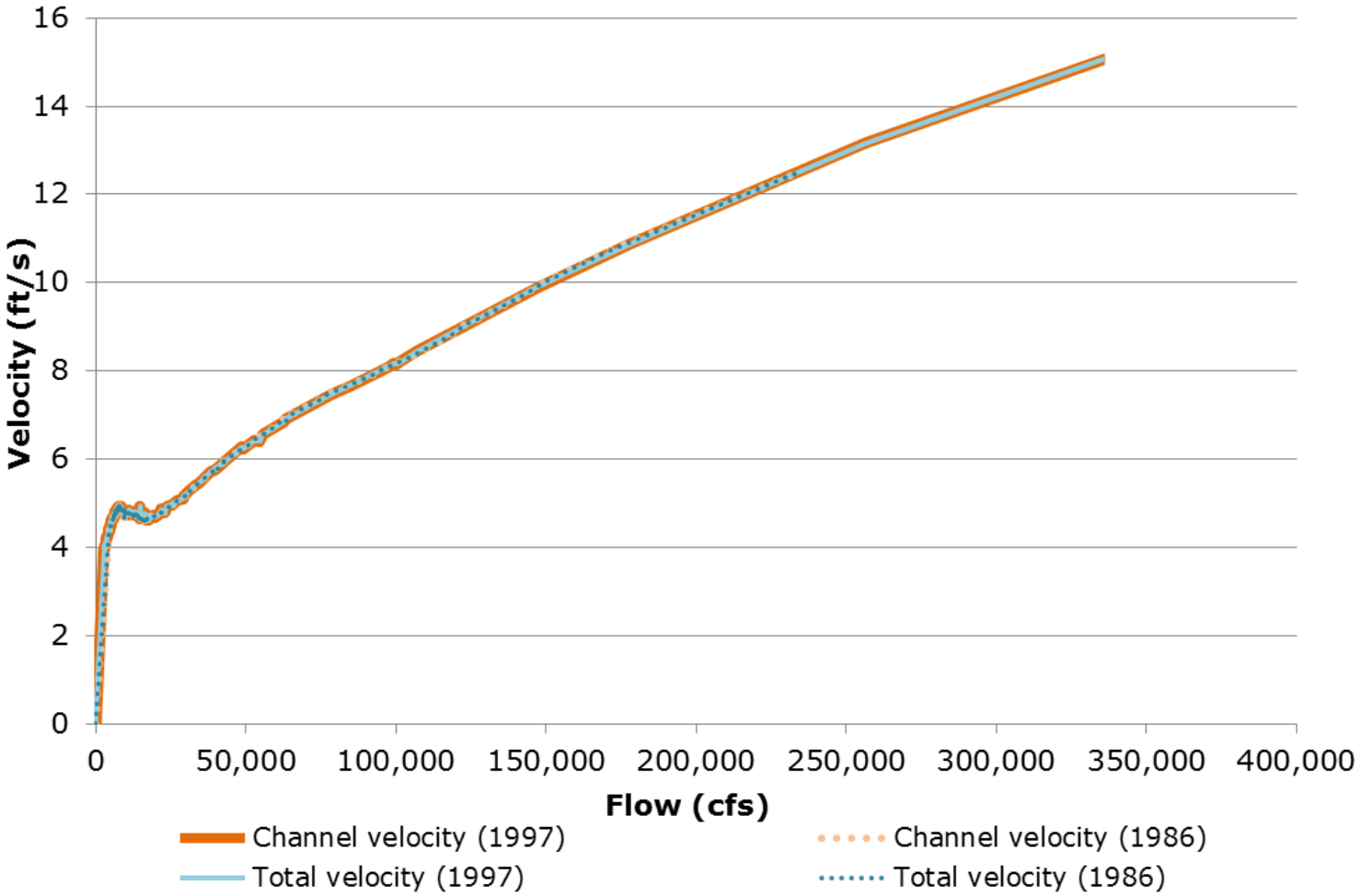
Developed velocity-flow rating curves from HEC-RAS for future comparison



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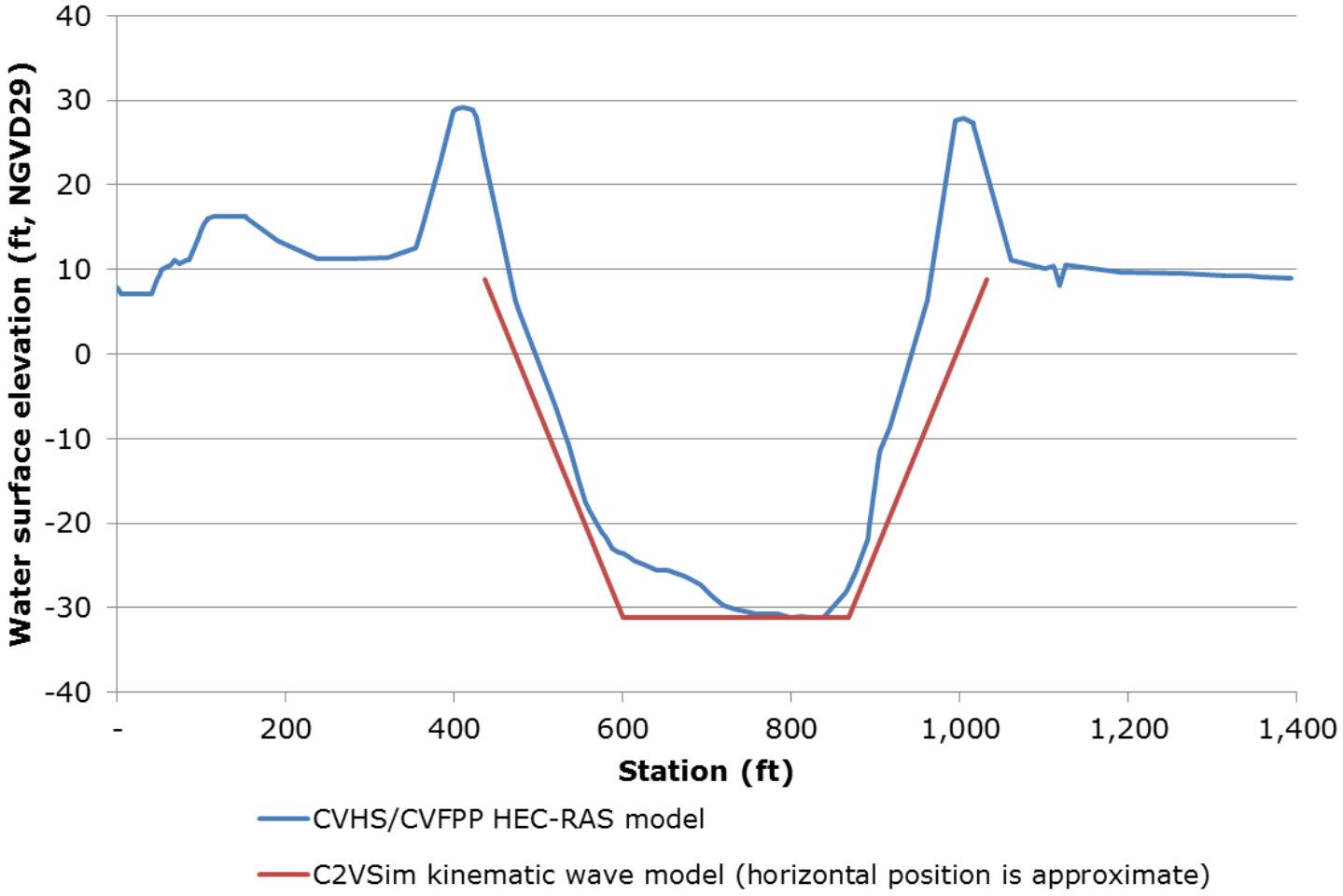
Compared cross section geometries (example location where similar)



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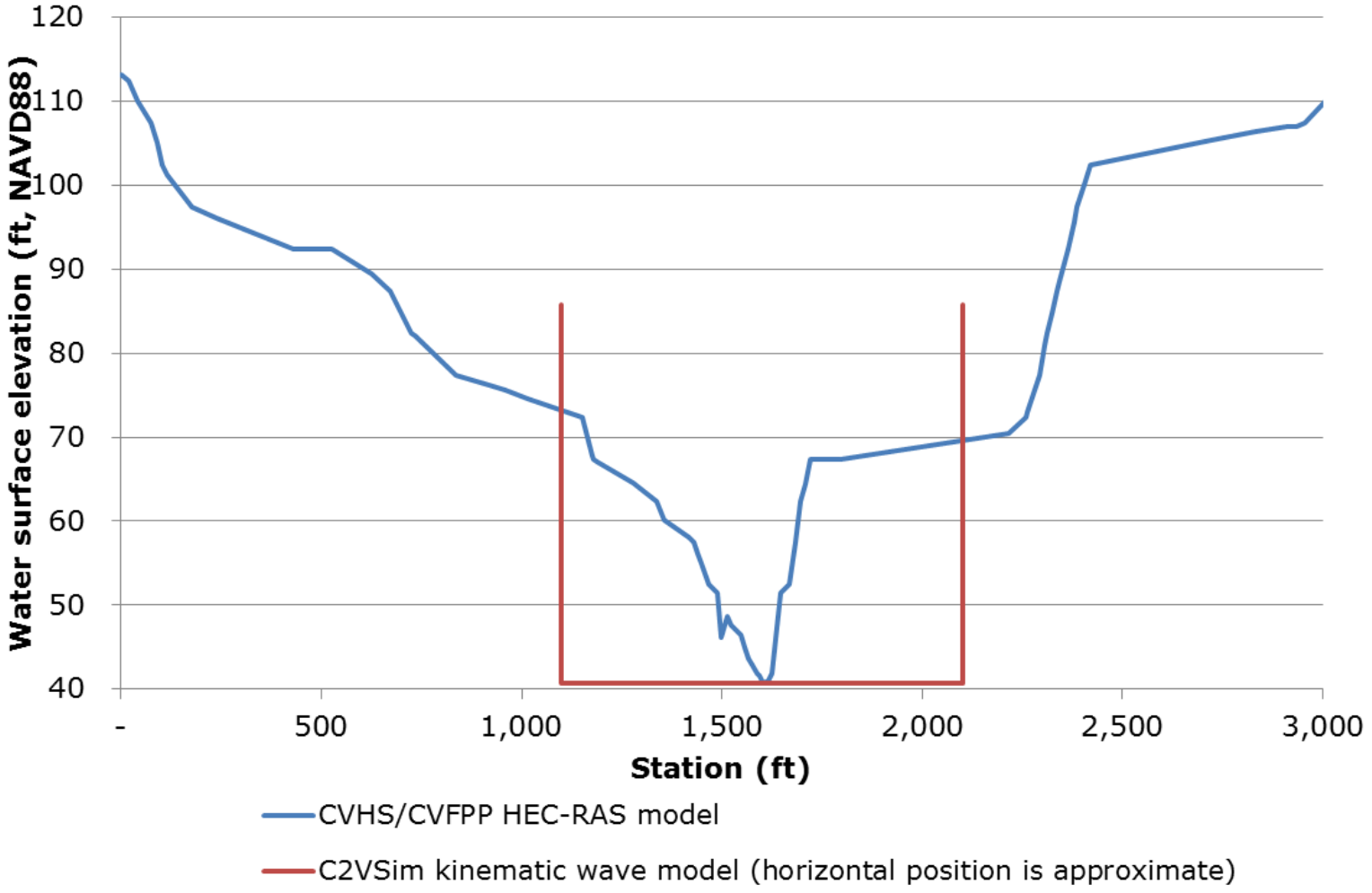
Compared cross section geometries (example location where different)



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Other model parameters

- Channel slope.
- Manning's n.

REFINE C2VSim PARAMETERS (FINE GRID MODEL DEVELOPMENT)

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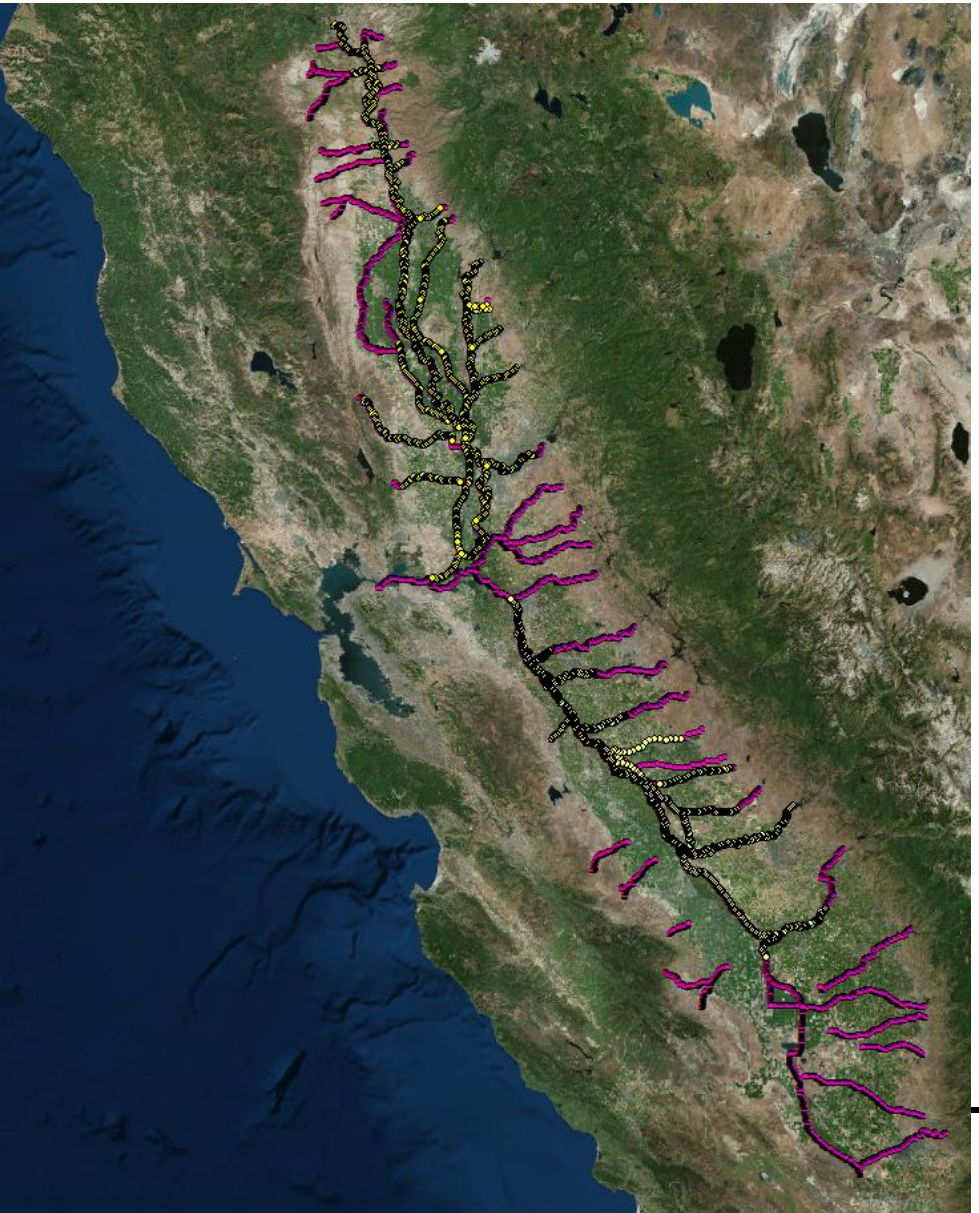
Steps to refine C2VSim parameters for use in the fine grid model



1. Identified C2VSim stream nodes within CVFED model extents.

   2,384 out of 4,569 total stream nodes (52%)

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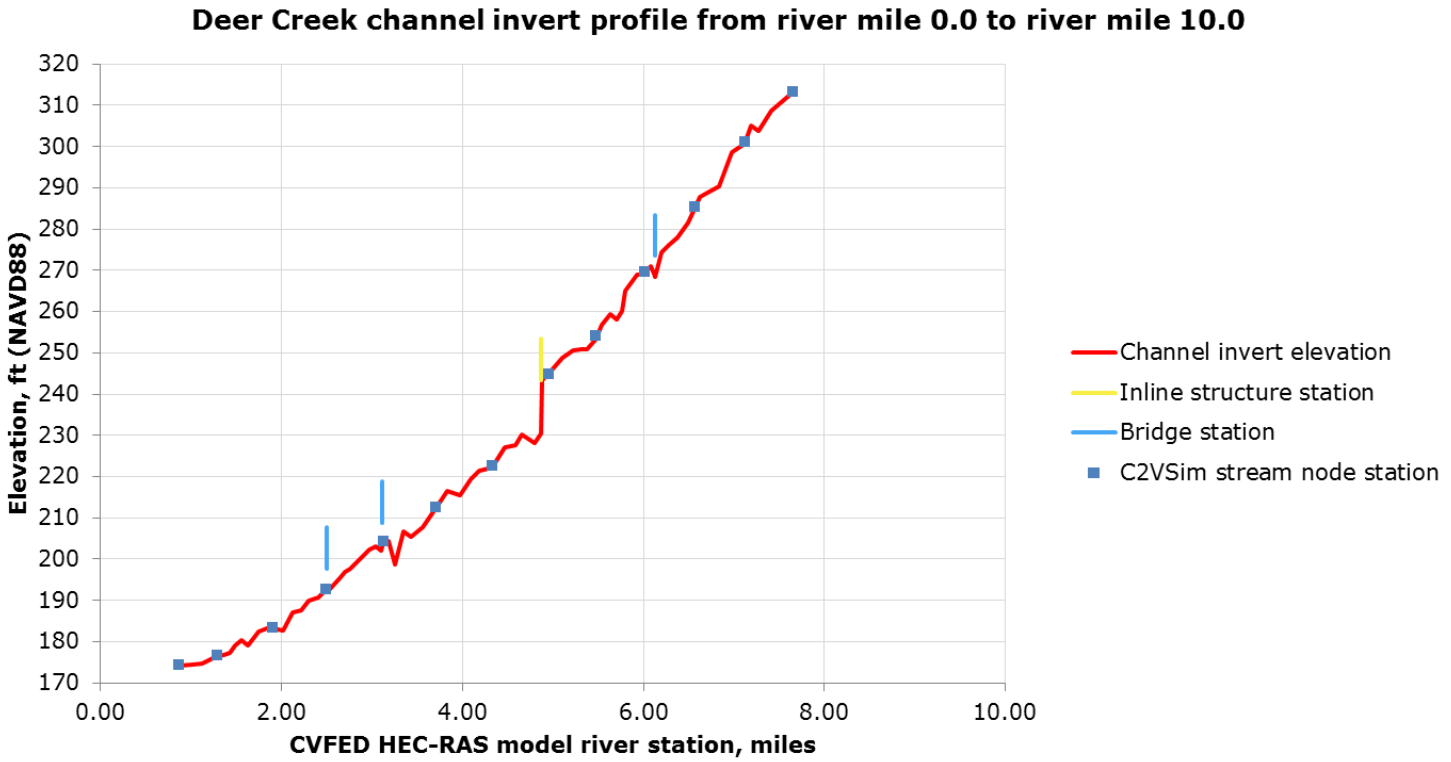
Steps to refine C2VSim parameters for use in the fine grid model

2. Estimated channel invert elevations at C2VSim stream nodes and plotted the channel invert profile along each stream reach.



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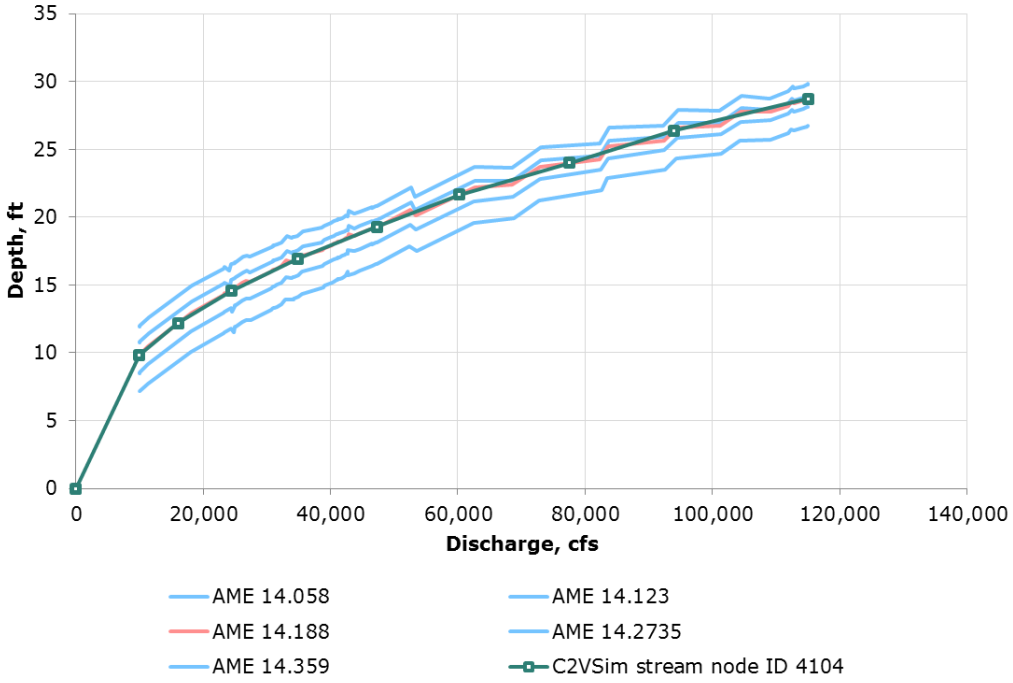
Steps to refine C2VSim parameters for use in the fine grid model

3. Developed depth-flow rating curves:
   1. Identified 195 representative rating curve locations:
      - Beginning of each reach.
      - End of each reach.
      - Near CVHS analysis points.
   2. Selected the 5 nearest CVED HEC-RAS cross sections to each representative rating curve location.
   3. Ran the CVFED HEC-RAS models.
      - Available historical flow events w/ lowest baseflow to populate rating curves.

Steps to refine C2VSim parameters for use in the fine grid model

3. Developed depth-flow rating curves (continued):
   4. Plotted the set of 5 rating curves at each representative rating curve location.
   5. Fitted a 10-point smoothed curve.
   6. Supplemented low-flow ends of rating curves.



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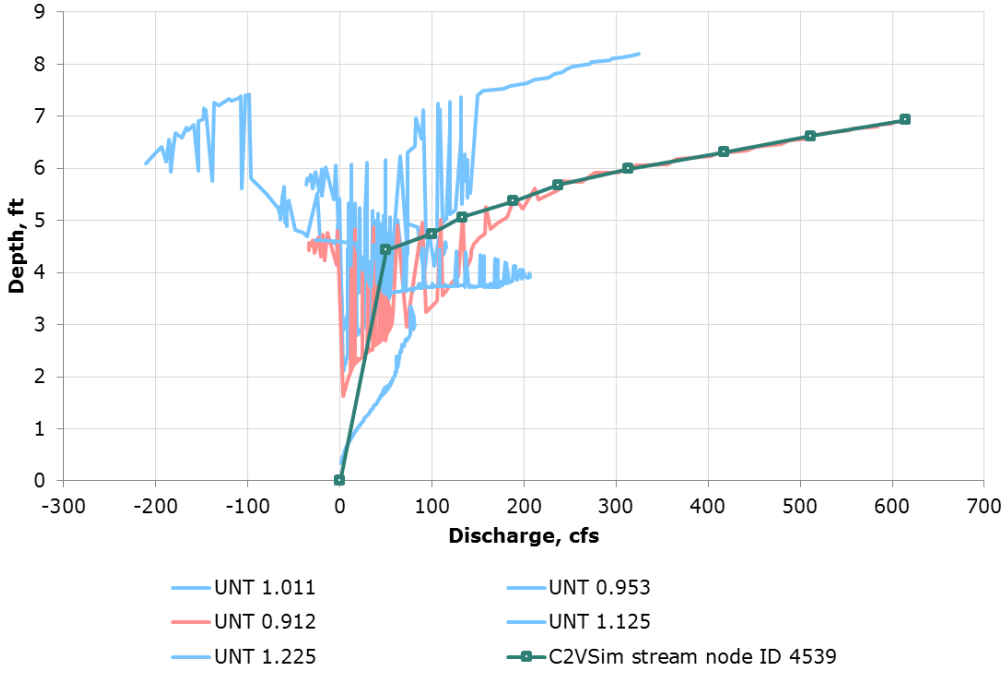
Depth-flow rating curve locations for further analysis

- High backflow or negative flow.
- Limited information at the low-flow end.
- Downstream constant stage boundary influence.



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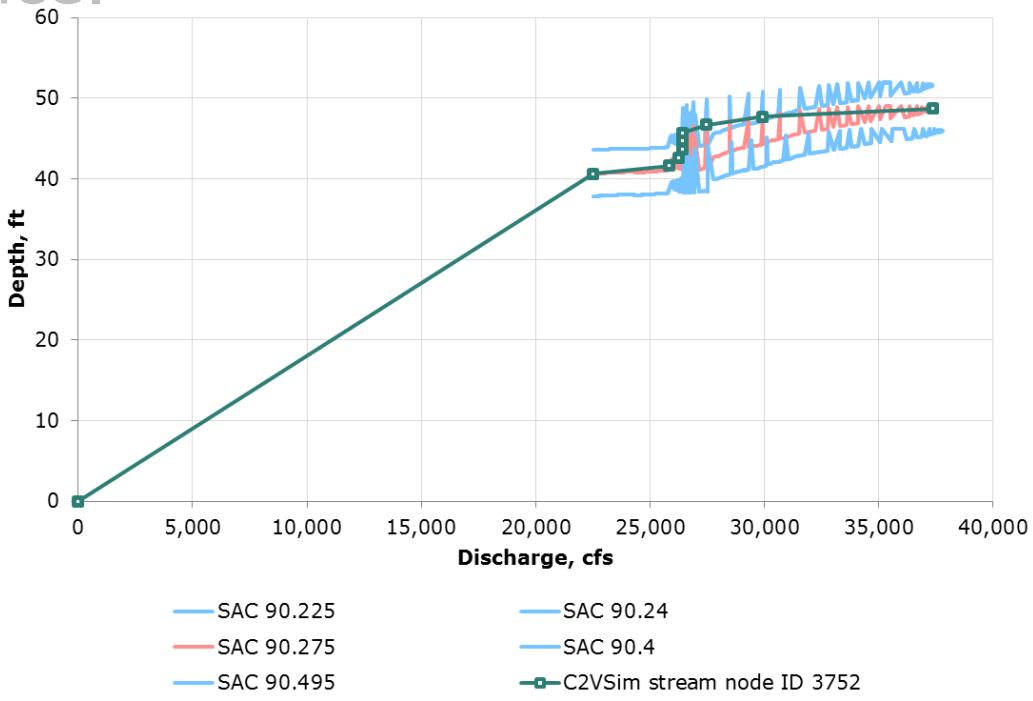

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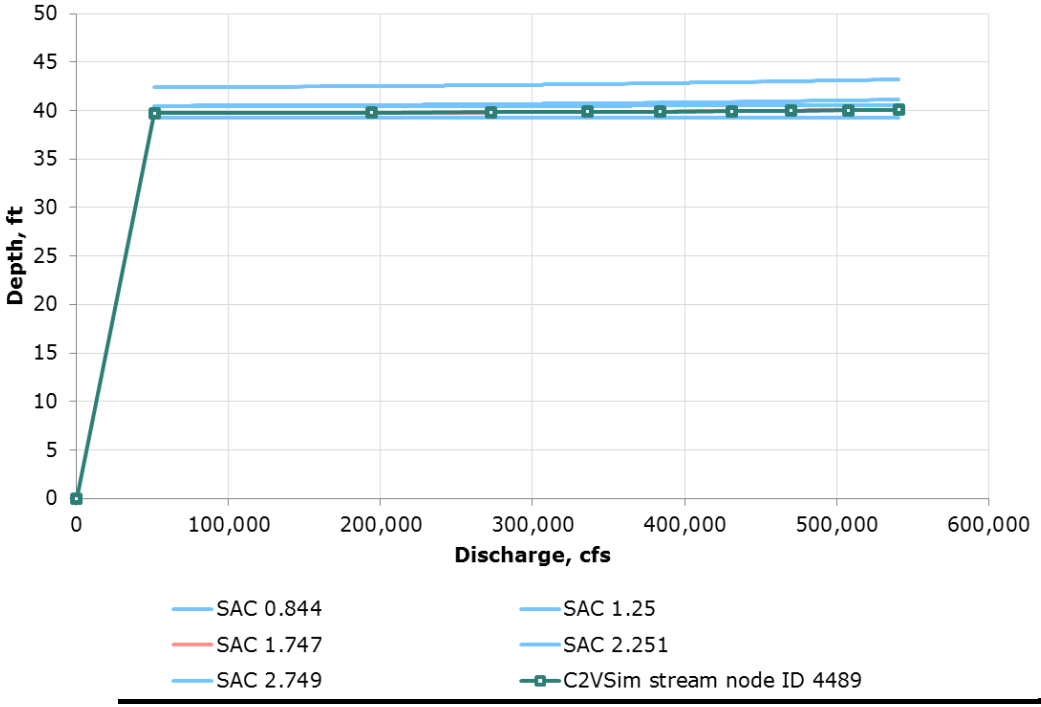

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Summary

- CVFED hydraulic models can help inform C2VSim groundwater-surface water model by:
  - **Verifying** existing C2VSim parameters.
  - **Refining** C2VSim parameters.
- Further analysis necessary at complex areas or C2VSim nodes outside of CVFED model boundaries.

What other synergies can we find with existing California water models?