Application of a New Decision Support Tool for the Rapid Analysis of a Yolo Bypass Widening Scenario

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Presentation Agenda

• Project Goal and Objectives
• Model Platform
• Model Development
• Development of Strategies and Actions
• Model Scenario Selection
• Modeling Results
• Future Applications
The goal of this project was to produce an extremely “rapid” 2D hydrodynamic model for the entire Sacramento Valley to test a variety of “big picture” flood and ecosystem management scenarios. “What if we could start over...?”
Project Objectives

- Project objectives to achieve the project goal included:
  - **Develop, calibrate, and validate** an existing conditions 2D model
  - Identify flood and ecosystem management strategies and actions
  - Compile these strategies and actions in up to five flood and ecosystem management scenarios
  - Adapt the existing conditions hydrodynamic model to simulate the hypothetical flood and ecosystem management scenarios under two flood event conditions
  - Interpret and evaluate the simulation results using ecologic, geomorphic and hydrologic criteria, to identify and prioritize promising strategies and actions to achieve multi-objective flood and ecosystem management objectives

JFlow Model of the Sacramento Valley
Model Platform

- **JFlow+ Model Platform**
  - Solves 2D shallow water equations using finite volume method with gridded mesh
  - First model to make use of GPU technology (2007)
  - Model code recently rewritten (2014) to execute on multiple GPU devices concurrently, to either speed up model runs or increase the model domain size
  - Simulations driven by a terrain model from within a GIS

- **Limitations**
  - Approximations were made for the downstream boundary condition and hydraulic structures

JFlow Model of the Sacramento Valley
Graphics Processing Units (GPUs)

- A CPU consists of a few cores optimized for sequential serial processing while a GPU has a massively parallel architecture consisting of thousands of smaller, more efficient cores designed for handling multiple tasks simultaneously.

- Compute-intensive portions of the application run on the GPU, while the remainder of the code runs on the CPU. From a user's perspective, applications simply run significantly faster.

JFlow Model of the Sacramento Valley

http://www.nvidia.com/
Previous Large Scale Model Applications

- JFlow model applied across 13 European counties primarily for insurance industry flood hazard interests.
Model Development

• Phase 1 – Develop an existing conditions model (FMA 2010 conceptual model; FMA 2012 final model)
  – Define the model domain
  – Identify appropriate hydrology; i.e., 10-yr & 200-yr.
  – Establish model inflow/outflow locations
  – Calibrate/validate model to observed flood events

• Phase 2 – Develop and analyze flood and ecosystem management scenarios (FMA 2014 preliminary model)
  – Modify existing conditions model to simulate conceptual strategies; for example:
    • **New levee setbacks** involved degrading existing levees to adjacent ground elevations and inserting a vertical wall into the DEM along setback levee alignment
    • **New overflow or flood relief weirs** set at a crest elevation to just above the 10-yr existing condition water surface elevation
  – Manning’s roughness values generally changed from 0.030 (agricultural lands) to 0.065 (restored/revegetated floodplain)
Model Domains and Boundary Conditions

JFlow Model of the Sacramento Valley

- 10-meter grid resolution
- 520 million grid cells over 2,000 square miles
- 10-meter grid resolution

Legend:
- JFlow Model Inflows
- JFlow Model Outflows
- New Model Domain
- River Miles
- Levees
Calibration / Validation

• 1997 Calibration:
  – Feather River and tributaries
  – Yolo Bypass
  – Lower Sacramento River

• 1997 Validation:
  – Combined Lower Sacramento River and Yolo Bypass

• 2006 Calibration:
  – Upper Sacramento River
  – Sutter Bypass and Tisdale Bypass

• 2006 Validation:
  – Lower Sacramento River
Development of Strategies and Actions

• Spatial datasets were obtained from public sources
  – Topography, hydrology, flood inundation patterns and extent
  – Soils, vegetation, agriculture
  – Flood control infrastructure, channel capacities

• GIS analyses were performed using these data to identify potential flood and ecosystem management actions: i.e., to assess historical flood basins and Delta wetland habitats (“where did it used to flood?”) and to analyze flood-prone land with non-prime farmlands (“where is it practical to restore floodplains?”)
Development of Strategies and Actions

- A **working group** provided independent input and guidance on the selection of strategies and actions.
- For the purposes of this work, “**strategy**” was defined as a general tactic for achieving a particular goal and “**action**” was defined as a specific effort to support a strategy. Conceptual strategies included:
  - ✓ setting back levees
  - ✓ conveying flood flows
  - ✓ bypassing flood flows
  - ✓ storing flood flows
- The strategies and actions were **“packaged” into five hypothetical scenarios**.
- Scenario modeling showed **relative changes** from existing conditions at key locations (e.g., discharge, water elevation, extent of flooding).
Model Scenario Selection

- Scenario #1 - Implement Selected Actions from Scenarios 2-5
- Scenario #2 - Setback All Non-Urban Levees (NULE) Upstream of the Fremont Weir
- Scenario #3 - Implement Storage/Conveyance Measures Upstream of Fremont Weir
- Scenario #4 - Implement only Sutter Bypass widening actions
- Scenario #5 - Implement only Yolo Bypass widening actions
# Scenario #5 - Yolo Bypass Widening

## Table 2-2. Summary of Proposed Sacramento River Basin Flood and Ecosystem Management Strategies, Actions, and Scenarios (Updated August 12, 2014)

<table>
<thead>
<tr>
<th>Map ID</th>
<th>Basin</th>
<th>Subbasin</th>
<th>Thresholds &amp; Landmarks</th>
<th>Strategy 1</th>
<th>Strategy 2</th>
<th>Action</th>
<th>Map ID</th>
<th>Source</th>
<th>Management Scenarios</th>
<th>Comments on Updates</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adapt</td>
<td>Achieve</td>
<td>Develop all strategies and actions below with consideration for</td>
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<td>JCDEM</td>
<td>Maintain up to 5 scenarios</td>
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<td></td>
<td></td>
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<td>resilience</td>
<td>Adaptation Strategies in DWR 2008 &quot;Managing an Uncertain Future&quot;</td>
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<td>31</td>
<td>Fremont Weir</td>
<td>Convey</td>
<td>--</td>
<td></td>
<td></td>
<td>Expand Fremont Weir</td>
<td>31</td>
<td>SVFEMW</td>
<td></td>
<td>Fremont Weir widened by one mile.</td>
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<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Setback Levees in Levee District 1000</td>
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<td></td>
<td></td>
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<tr>
<td>32a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Construct New Levee Between Southern Colusa Basin and Yolo Basin NE of Woodland and Strengthen Existing Levees to the South</td>
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<td>cbec</td>
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<td>33</td>
<td>Lower Sacramento River Valley</td>
<td>Yolo Basin</td>
<td>Setback /Vegetate Floodplain to n=0.065</td>
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<td>Setback Levees in Levee District 2035 (expand Cache Creek Settling Basin)</td>
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<tr>
<td>33a</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Remove Embankments for Railroad and Hwy 22 East of Woodland</td>
<td>33a</td>
<td>cbec</td>
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<td>Setback Levees in Levee Districts 587, 785, 827</td>
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<td></td>
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<td>Expand Existing Yolo Bypass</td>
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<td>Convey</td>
<td>Expand Sacramento Weir and Bypass</td>
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<td>SVFEMW</td>
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<td>Sacramento Bypass widened by 1000-feet</td>
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<td>37a</td>
<td>Sacramento River Delta</td>
<td>West Sacramento</td>
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<td>Construct Closure Structure and Overflow Weir to Add Conveyance Capacity to Ship Canal</td>
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<td>Widen Yolo Bypass at Little Egbert Tract (RD 2084)</td>
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SVFEMW = Sacramento Valley Flood & Ecosystem Management Workgroup

JFlow Model of the Sacramento Valley
Modeling Results: Scenario 5
Yolo Bypass Widening and 200-Year Flood Event

JFlow Model of the Sacramento Valley
### Flow and Stage Summary for 200-Year Event

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<td>15785</td>
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Key: “Line” refers to monitoring lines in the 2D inundation maps; FRE = Fremont Weir; VON = Verona

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**JFlow Model of the Sacramento Valley**

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- Line 11: +1.4%
Summary

• **The big picture** – It is very informative to “see” flood simulations from a 30,000-foot level; there are benefits for stakeholder/public involvement.

• **Rapid modeling** - Model scenario run times were about 100 hours for this 2,000 square mile, 520 million grid cell GPU-based model; comparable runs on CPU devices may be 10-100 times longer.

• “**What if...**” – The ability to rapidly model various scenarios can accommodate creative thinking to explore well planned (or even “wild & wacky”!) ideas for flood and ecosystem management.

• **The future** – There are many future applications.
Future Applications

- Refine design concepts prior to “detailed” modeling
- Support flood hazard mapping/evacuation planning
- Refine depth-velocity-damage relationships
- Establish expected Annual Habitat (EAH) - Agricultural Flood Easements
- Explore reservoir re-operation strategies
- Assess floodplain ecosystem values
- Evaluate extreme flood scenarios (ARkStorm)
- Evaluate down-scaled climate change data
- For federally funded projects under the new Executive Order 13690, determine vertical flood elevations and floodplains using prescribed approaches: e.g., climate-informed science; freeboard value; 0.2-percent annual chance flood; or, other methods

JFlow Model of the Sacramento Valley
Acknowledgements

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  – Funders: DWR FESSRO and Resources Legacy Fund
  – Working Group: Ray McDowell, Stacy Cepello, Kristin Brainerd, Joe Countryman, Joe Bartlett, John Cain, Mark Tompkins, Pete Ghelfi, Renee Henery, Steve Greco, Lester Snow
  – Friendly advice: Todd Bernardy, Mary Jiminez, Tim Washburn, Ted Frink, Craig Williams, Stefan Lorenzato

• Due to the spatial extent and complexity of this modeling, this project helped to drive global advances in large-scale hydraulic modeling

• Questions?