Addressing RISK in a Changing Watershed
Understanding Model Calibration Before Model Use

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Project Background

• California Department of Water Resources – Sacramento River Watershed HEC-RAS Modeling

• 900+ River/Stream Miles
  – Major/Minor Confluences
  – Major/Minor Diversions and Bypasses

• Calibration Effort – 1997/2006 Storms
RISK Redefined

- **Resiliency, Integration, Sustainability, and Knowledge**
- Assess the Probability and Magnitude of the Hazard and the Cost of the Consequences
- Prevention of Future Damages are Benefits
- **Everything Hinges on the Hazard Assessment**
Defining the Hazard

• **The Flooding Conditions**
  – Flow – Rarely Directly Measured – Usually Calculated Based on Assumptions with Fixed Parameters
  – Roughness – Usually Modeled as a Single Value for all Flows
  – Both Parameters Affect Measured Stage in an Interdependent Manner
    • Higher Flow with Lower Roughness can Equal Lower Flow with Higher Roughness

• **Nothing is Really Fixed (Constant)**
What is Calibration?

• Implies Precision or “Truthing”
• Ideally a “Known” Quantity is Being Utilized to Test/Adjust the Model Settings to Get Simulated Results to Match the Measured Event
• Assumes Storm Event Data is Trustworthy and Accurate (Gages Work Correctly and Published Data is Complete)
The Reality

• Systems Can Fail During Floods
• Gage Coverage (Spatially and Temporally) Can Have Gaps and Require Forensic Analysis
• Gage Documentation Can Be Unavailable or Non-Existent
• Gage Assumptions May Not Apply to Today’s Conditions or Event Conditions
• Stream Surveys May Not Reasonably Reflect Geometry during the Calibration Event
Calibration is a Mosaic Process
(Taking Broken Pieces and Creating a Picture)

• Validate Gage Data
  – Evaluate the Basis of Data (Measured or Calculated)
  – Evaluate the Gage Data with Model Results
  – Evaluate Gages Together
  – Fill in Missing Data and Re-Evaluate

• Evaluate Hydraulic Properties (Fixed vs. Dynamic)

• Determine if Modeling Limitations Prevent Realistic Data Interpretation

• Question Everything
Example 1 – Gage Malfunction?
Simple Math
Diversion Operation

- Upper Butte Creek Flow – UB
- Lindo Channel Flow – L
- Sycamore Channel Flow – S
- Lower Butte Creek Flow – B
- UB Approximately Equal to L + S + B
What Happened?

• Upstream Gage Stopped Working at the Beginning of the Storm
• Downstream Flows were Disproportionate – Not Following Gate Rules
• Conclusion – The Gates did Not Operate as Planned
• Likely Cause – Debris – Took out Upstream Gage and Blocked Downstream Gates
Example 2 – Feather River (Several River Flow Data Points)
Life is Good
Storm Clouds May Be Forming
Things Change in High Flow

• Reported Total Flow at Thermalito was Too High and Did Not Make Sense

• Reported Flow at Thermalito Required Increasing Upstream Inflow Which Resulted in More Flow Than Measured at Upstream or Downstream Gages
Conclusion?

• Reported Total Feather River Flow at Thermalito is a Simple Summation of Thermalito Outflow and Upstream Feather River Flow

• Assumes All Flow Reaches Thermalito without Spilling through the Wildlife Refuge

• Likely Based on Reservoir Operations for Water Supply Releases
Example 3 - Missing Inflow?
More Examples – Not Enough Time

• Basis of Rating Curves Unavailable
• Rating Curve Not Matching Surveyed/Modeled Conveyance
• Gage Measurements Affected by Bridges
• 1D Model Results Could Not Represent Actual Flow Conditions
  – N-values, 2D Flow Conditions, etc.
“Real” Measured Events Inform Hypothetical Events

• Statistics for Flow and Stage Frequency are Often Based on Data Measured/Reported at these Gages and from Calibrated Models, and Often Assume Unchanging Stream Bed and Cross Section Geometry, Constant Upstream Watershed Conditions and Climate Stationarity
The Future is Still a ...
Current Approaches

• Quantify Uncertainty
  – Statistical Confidence Bands (Deviations from Assumed Patterns or Limits of Record)
  – USACE Risk and Uncertainty (Assumed Range of Variability of Parameters)

• Include Freeboard or Increase Strength of Resistance in Our Designs
What More Can Be Done?

• Study System Model Uncertainty Potential – Watershed-wide Gage Assessment
• Account for Realistic System Failure Scenarios to Identify Overflows and Where Redundancy is Needed
• Identify Blockage Potential and Prevention Measures
• Don’t Be Afraid to Ask “What if?”
• As Much as Possible, Make “Unknowns” into “Knowns”
• More Gages – RECORD, RECORD, RECORD
Remember

• Whenever a Story is Lacking Detail People Must Fill in the Blanks to have a Finished Story

• Tools Cannot Make Up for a Lack of Data (One Cannot Build without Materials)

• A Picture is Worth a Thousand Cross Sections
S____ Will Happen
(But Remember to Document)
QUESTIONS

• ???