Photo credit: John Hannon, Reclamation

2024 CWEMF Annual Meeting: Session 7: CVP WTMP, Chapter 3

Presentation: What We Have Done

Moderator: Yung-Hsin Sun, Sunzi Consulting

Session 7: CVP WTMP, Chapter 3

3:30 Introduction
Moderator: Yung-Hsin Sun (Sunzi Consulting LLC)

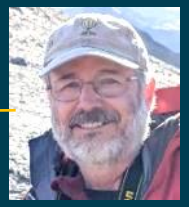
3:40 Presentation: What We have Done

- 3:40 Design with Users and Durability in Mind
- 3:57 Enabling Platform with Capacity and Flexibility
- 4:14 Community Engagement and Institutional Knowledge Development
- 4:21 Peer Review and Rollout Preview
- 4:31 Q&A

4:40 Reclamation Panel Discussion with Q&A:
The End is the Beginning

5:15 Adjourn

Mike Deas, PhD, PE
Watercourse Engineering
(Consultant Team Lead)



John DeGeorge, PhD, PE
Resource Management Associates

Yung-Hsin Sun, PhD, PE, BC.WRE
Sunzi Consulting

Randi Field
Bureau of Reclamation, CVO
(Reclamation Project Lead)

All of You

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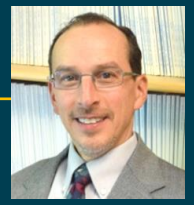

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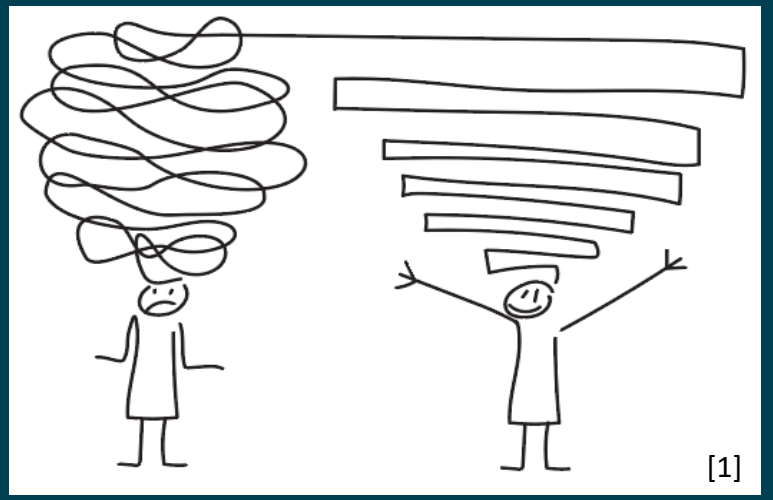
Typical Simulation Modeling Challenges

- Disparate data sources
  - Data acquisition
  - Data QA and metadata
  - Data storage and access
- Model input development
  - File construction
  - File/study management
  - Consistent boundary conditions
- Model and Model Simulation
  - Model management
  - Multiple model handshake
  - Unique features
  - Calibration/Recalibration
  - Simulation types (e.g., Forecast, Hindcast, Operations, etc.)
- Post processing
  - Consistent tools
  - Adaptable repeatable reporting
- Model development documentation
- Transparency


[1]

Water Temperature Modeling Platform: Next Generation Tools

WTMP Items	Highlights of Unique Features
Data Management System	Improve flexibility for data access and quality of data
Model Domain	Consistent with operations that influence downstream water temperature
Model Framework	Addresses multi-model simulations/different spatial-temporal scales + uncertainty
Temperature Models	Representations capture reservoir stratification and cold-water pool dynamics and longitudinal river temperature gradients
Key Code Modifications	Enhanced modeling considerations for unique facility components
Communications/Transparency	Modeling Technical Committee and project documentation Planned model distribution (Web access/RISE)

WTMP Framework and Models

Framework: HEC-WAT

Hydrologic Engineering Center (HEC) Watershed Analysis Tool

Data Acquisition

Database

DMS

Automated data acquisition

QA procedures

Model-ready-data

Models

RES-SIM

HEC Reservoir System Simulation:

Reservoir (1-D vertical)

River reaches (1-D longitudinal)

CE-QUAL-W2

Reservoir (2-D vertical and longitudinal)

Automated Reporting Data Drop

Outcomes

- Facilitate standard data management approaches
- Automate repetitive modeling tasks
- Standardized and automated reporting
- Overall reduced modeling activities time
- Facilitate training for new staff


[2]

- Enhanced efficiency, consistency, adaptability, and transparency to address current and future modeling activities to support temperature management actions

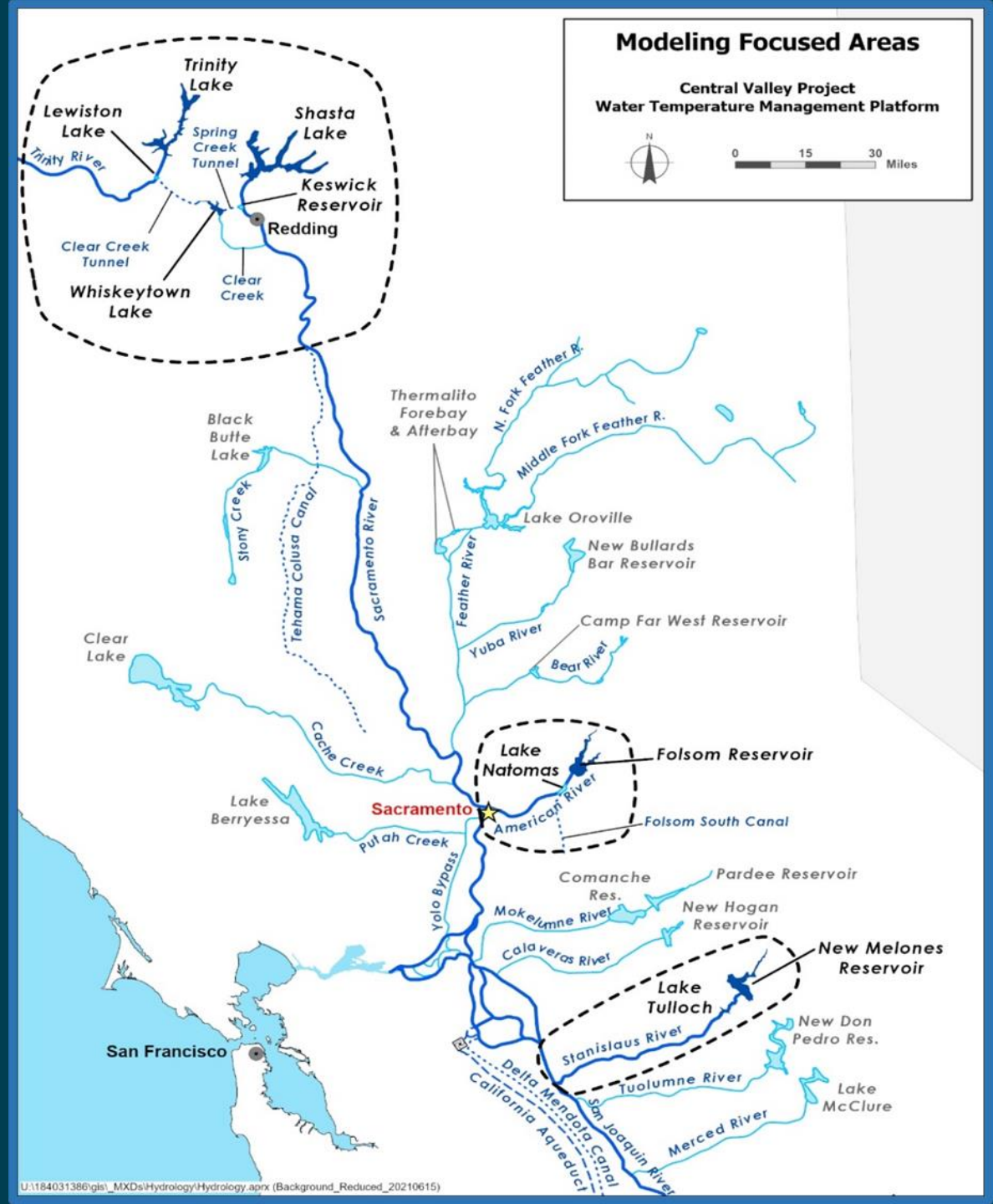
Outcomes

- Facilitate standard approaches for data management
- Automate repetitive modeling tasks
- Standardized and automated reporting
- Overall reduced time to carry out modeling activities
- Facilitate training for new staff

- Overall enhanced efficiency, consistency, adaptability, and transparency in modeling to support temperature management activities

WTMP Domain

- Sacramento and Trinity Rivers
- American River
- Stanislaus River

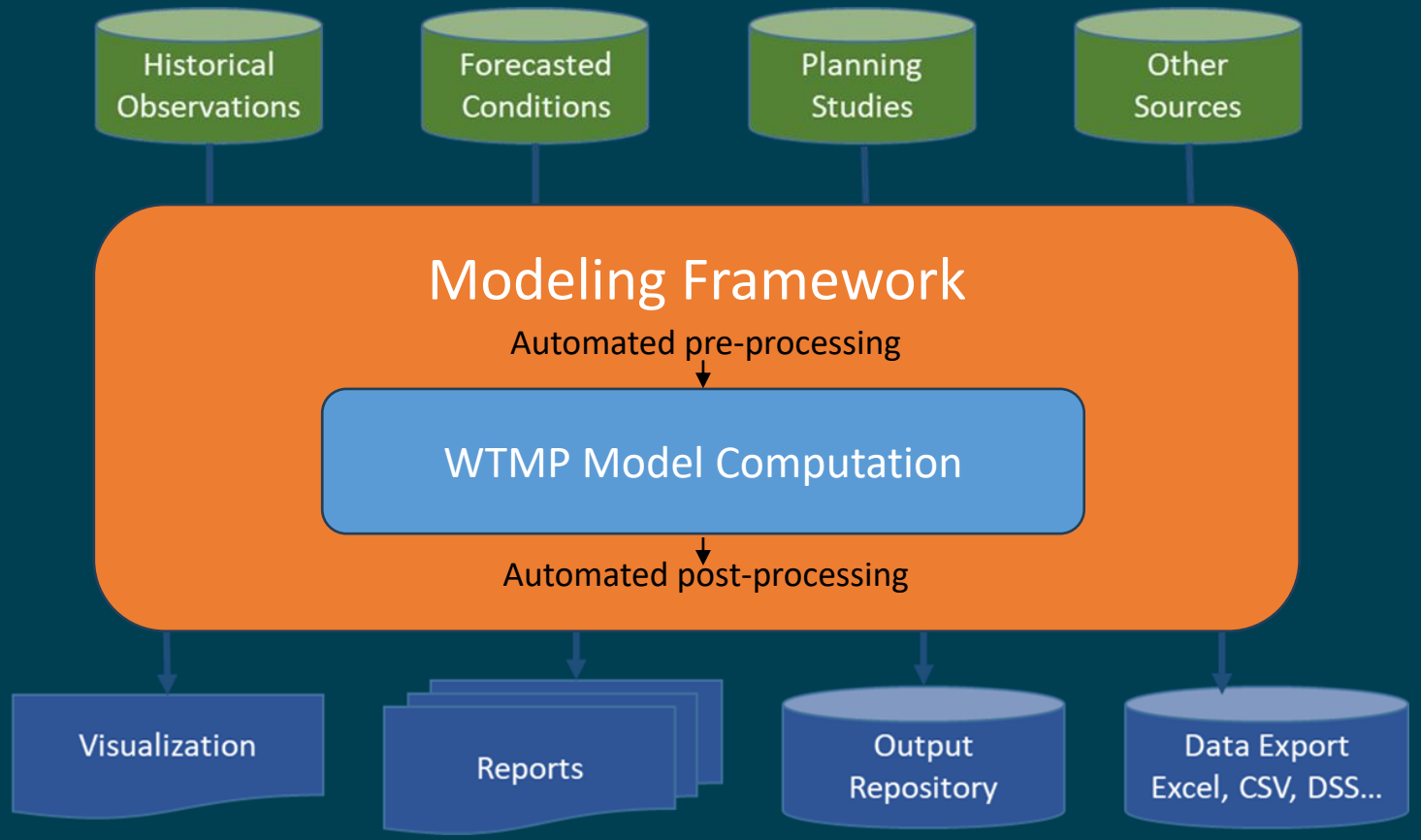


WTMP Analytics Framework - Basics

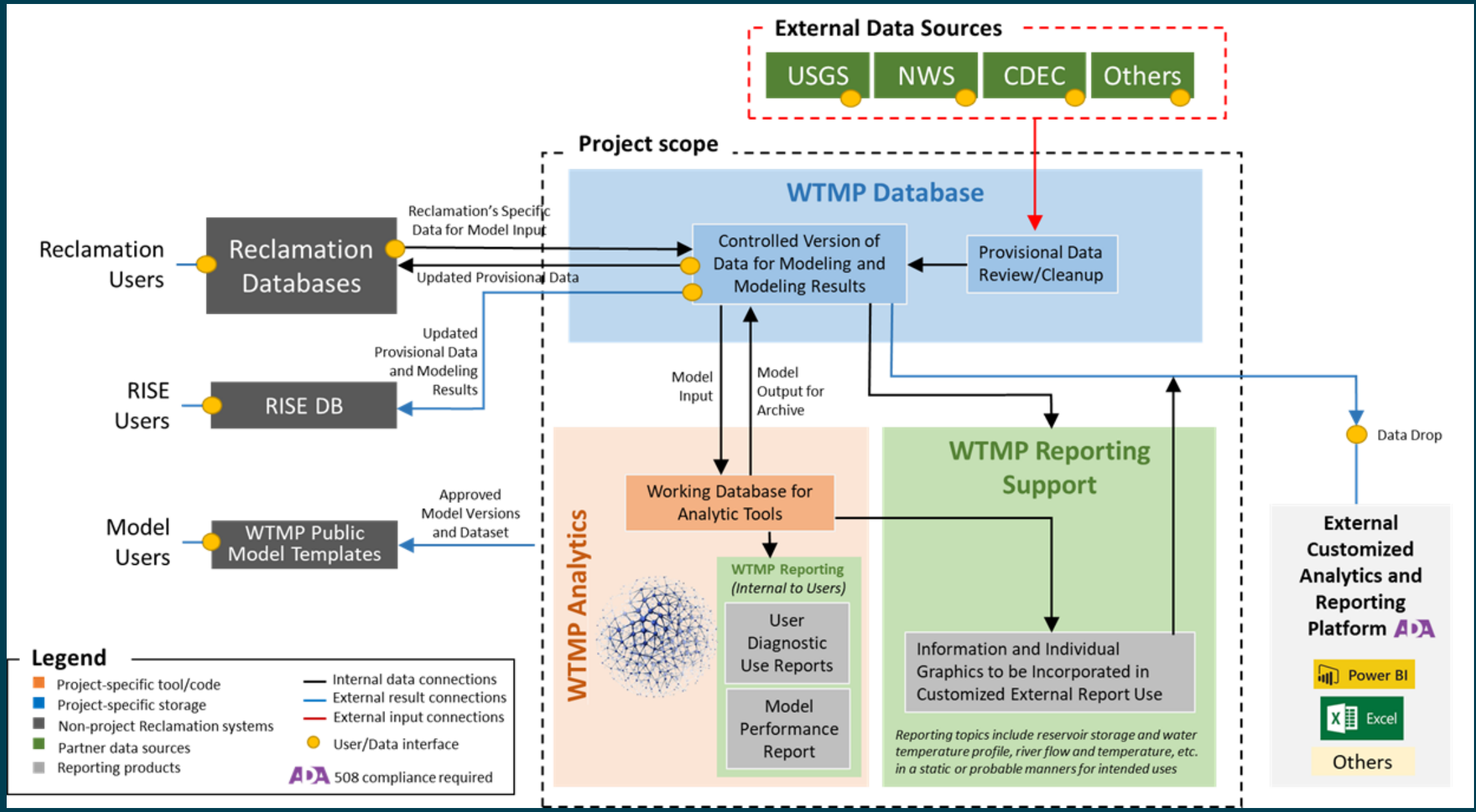
Modeling Study Data (input)

WTMP Models (ResSim, W2)

Modeling Study Output

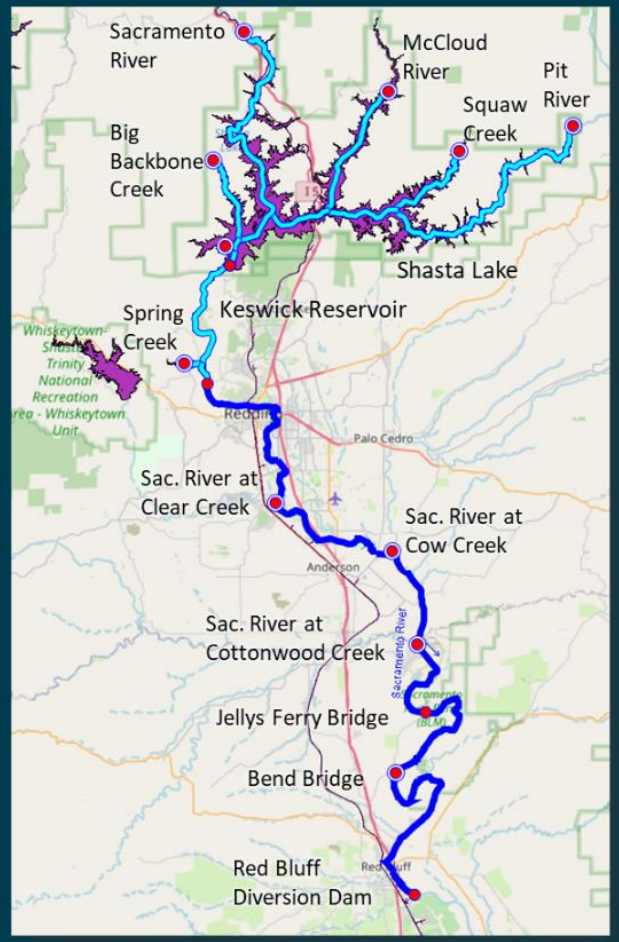


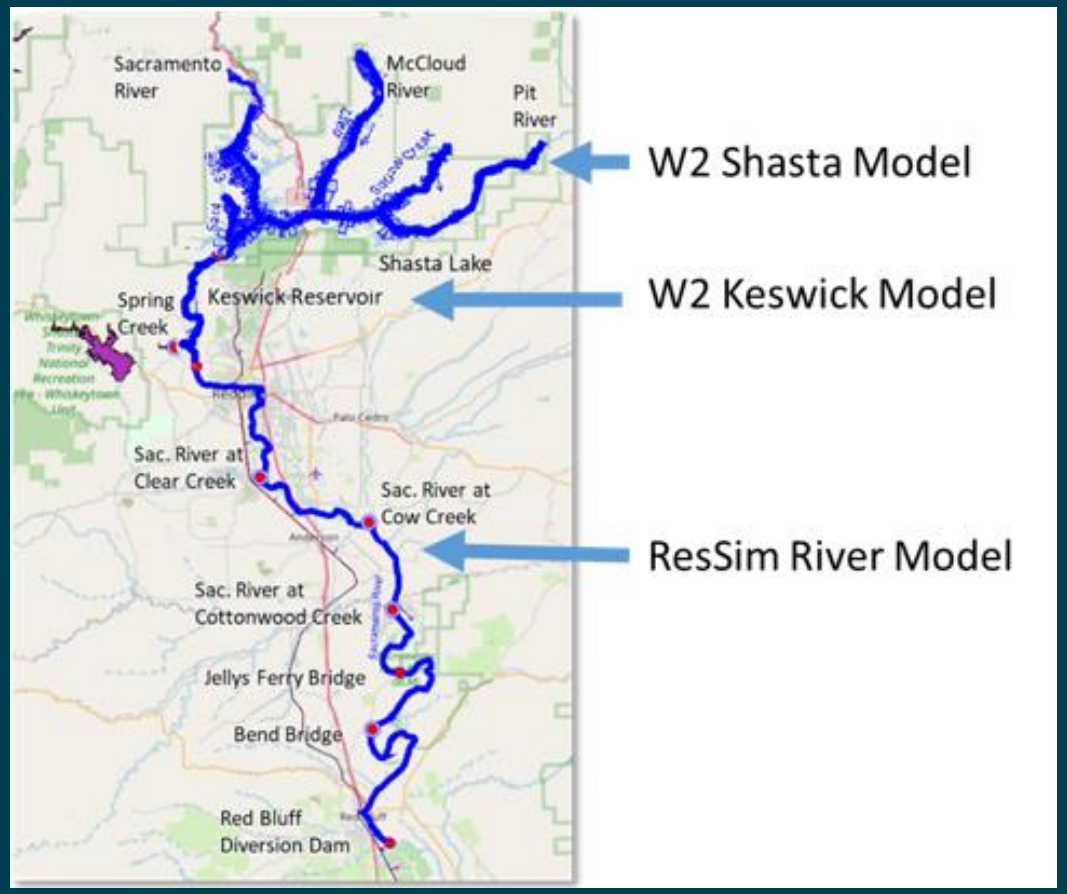
WTMP Analytics Framework - Details



HEC-WAT Framework Using W2 and ResSim

- Shasta-Keswick-Upper Sacramento River
  - ResSim Only
  - Combined W2 and ResSim





Model Performance

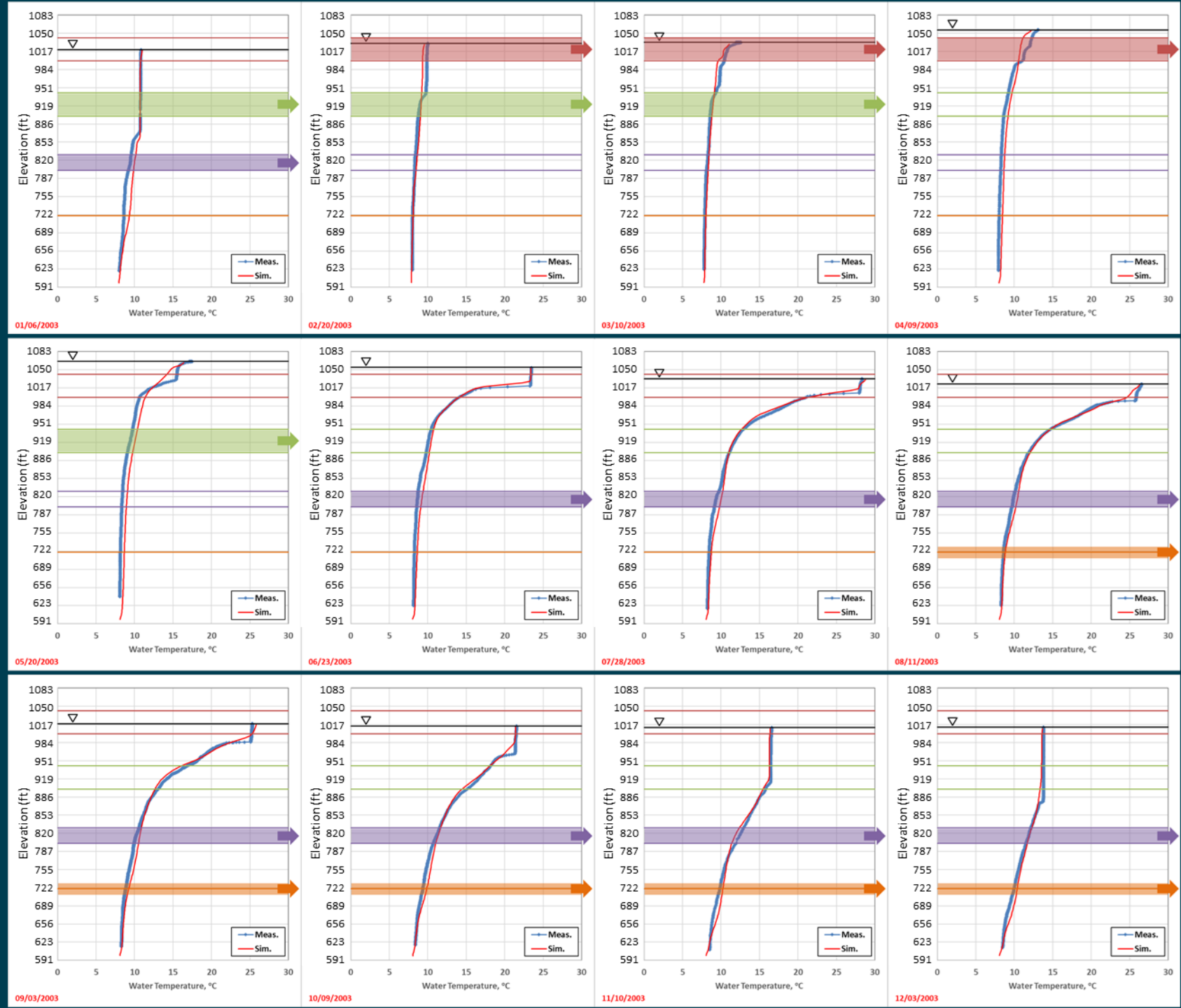
- CWEMF Protocols and Peer Review Support
- Extensive model testing and assessment
  - 2000-2021 (where data available)
  - Objective-driven model performance metrics
  - Calibration and validation metrics (statistical, graphical)
  - Temperature signatures of seasonally stratified reservoirs: profile and outflow temperatures
  - Temperature signatures of rivers and small reservoirs: time series
  - Sensitivity analysis
- Outcome:

  Robust, durable tool

Parameter	Mean Bias	MAE	RMSE	NSE
Stage	±0.5 ft (0.15 m)	≤1.0 ft (0.3 m)	≤1.5 ft (0.45 m)	≥0.65
Flow	±150 cfs (4.2 cms)	≤300 cfs (8.4 cms)	≤500 cfs (14.2 cms)	≥0.65
Water Temperature	±1.3°F (0.75°C)	≤1.8°F (1.0°C)	≤2.7°F (1.5°C)	≥0.65

Sacramento River Basin - Shasta Lake

- CE-QUAL-W2
- Shasta Lake water temperature profile
- Active TCD gate settings
- 2003 Results



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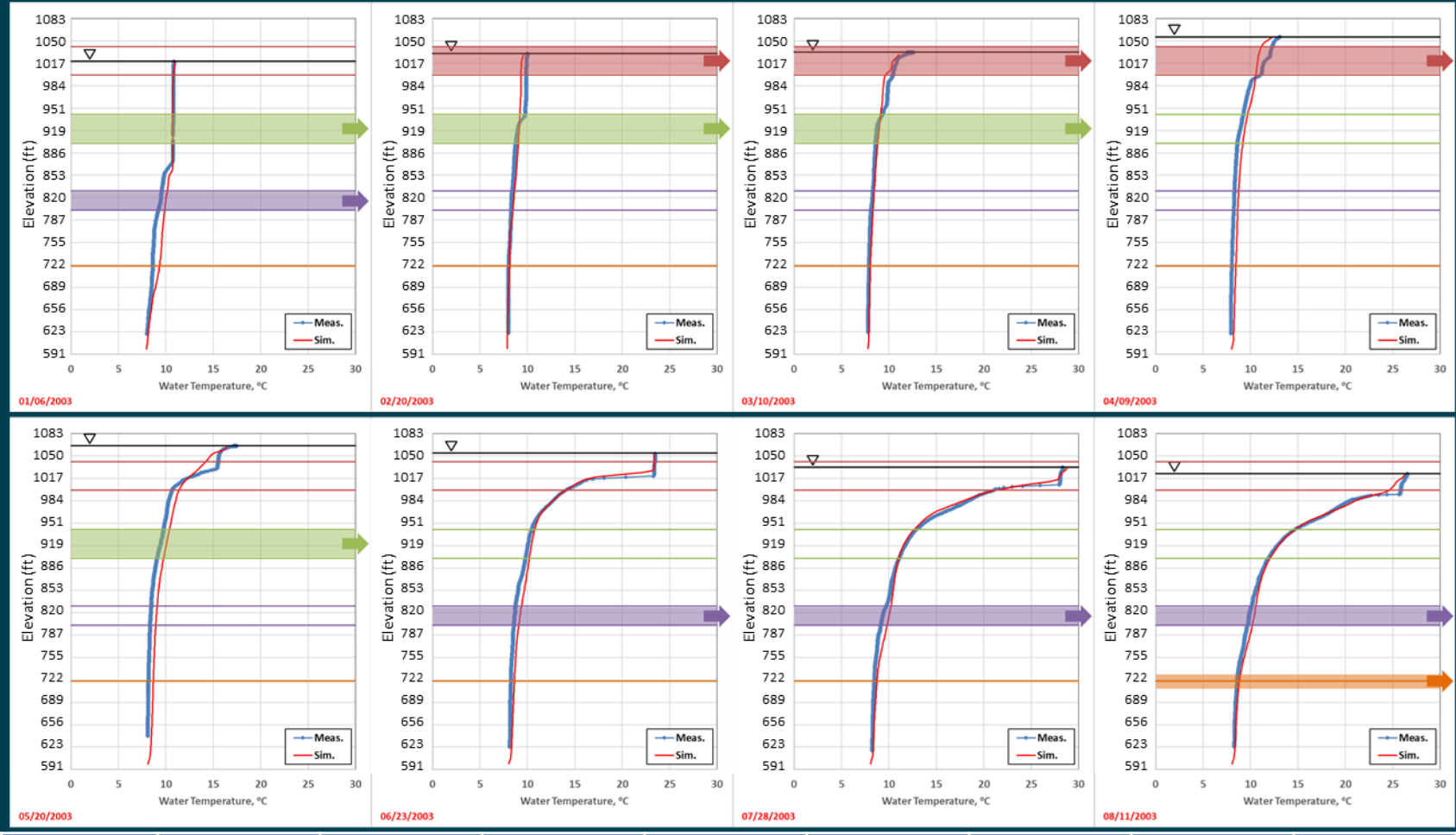
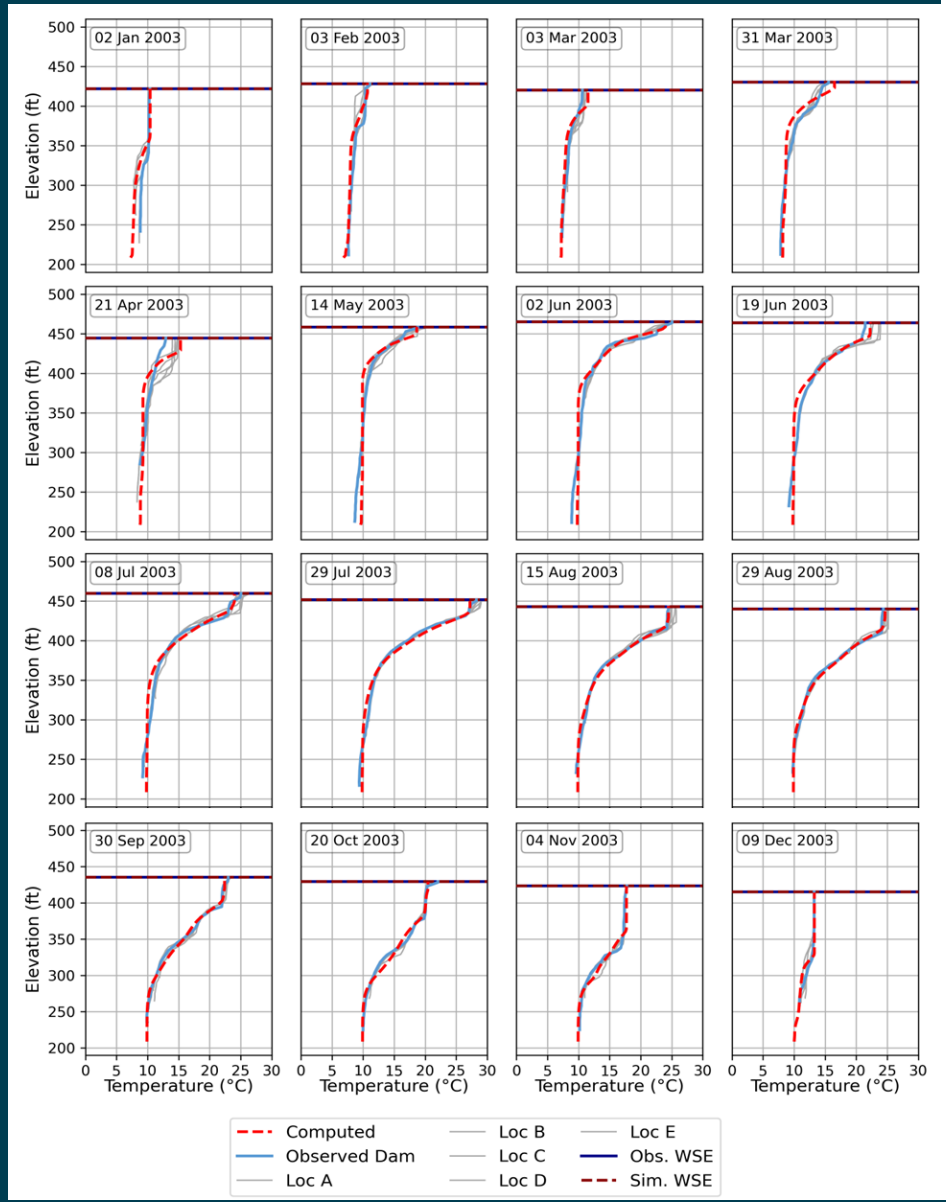
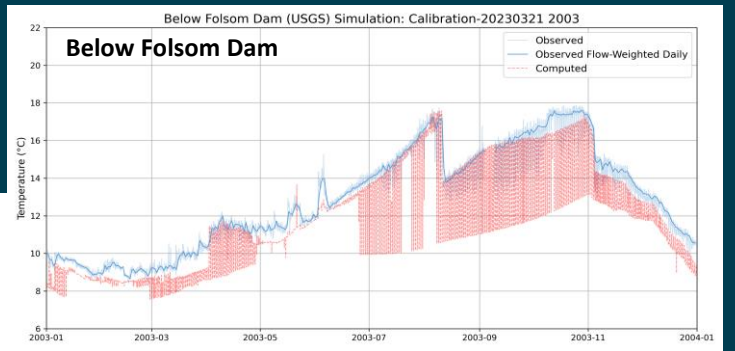


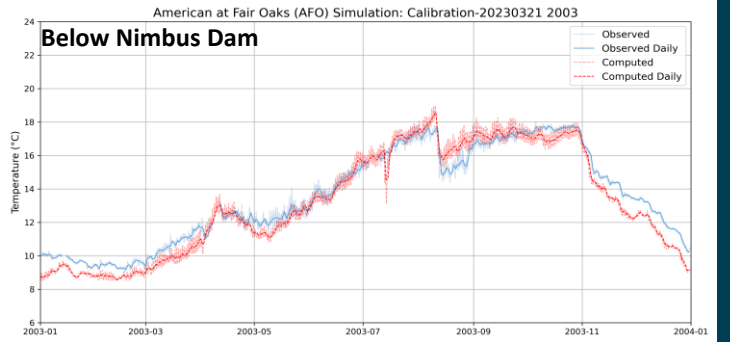
Statistic	01/06	02/20	03/10	04/09	05/20	06/23	07/28	08/11	09/03	10/09	11/10	12/03
Mean Bias (°C)	0.33	-0.04	0.02	0.27	0.43	0.25	0.11	0.16	0.12	0.07	-0.03	0.07
MAE (°C)	0.36	0.23	0.23	0.50	0.62	0.40	0.37	0.31	0.39	0.32	0.30	0.28
RMSE (°C)	0.48	0.30	0.28	0.53	0.66	0.59	0.51	0.40	0.48	0.40	0.35	0.33
NSE	0.79	0.82	0.91	0.83	0.90	0.98	0.99	0.99	0.99	0.99	0.99	0.97

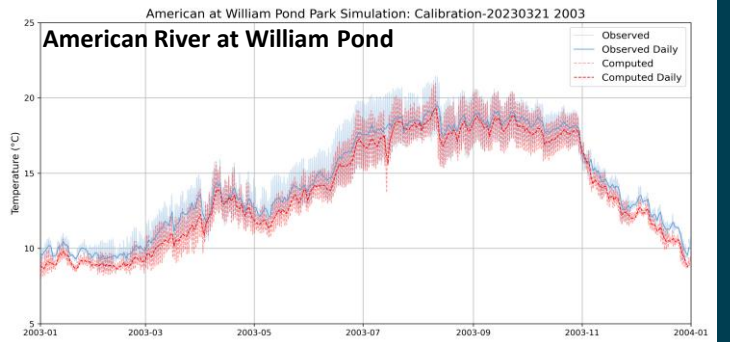
American River Basin – American River

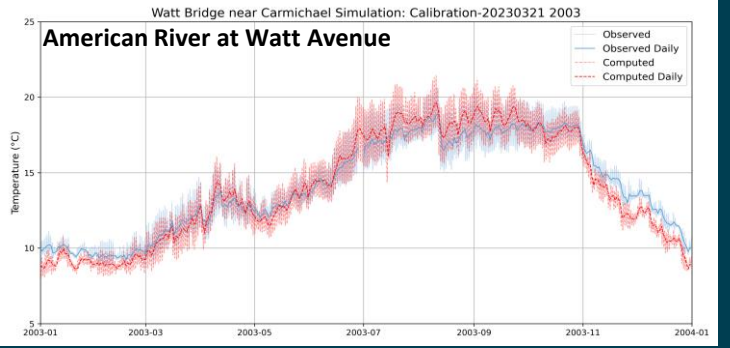
- HEC-ResSim
- Folsom Lake
  - Water temperature profile
  - Outflow temperature
- Nimbus Dam
- American River
  - At William Pond
  - At Watt Avenue
- 2003 results





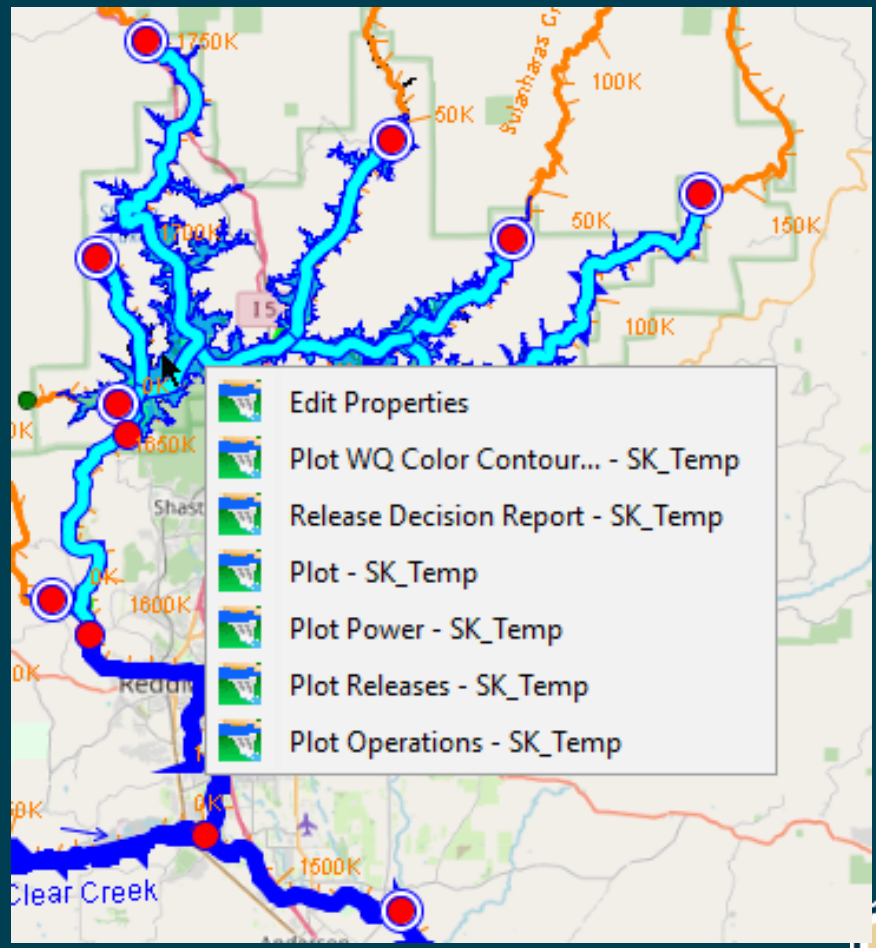






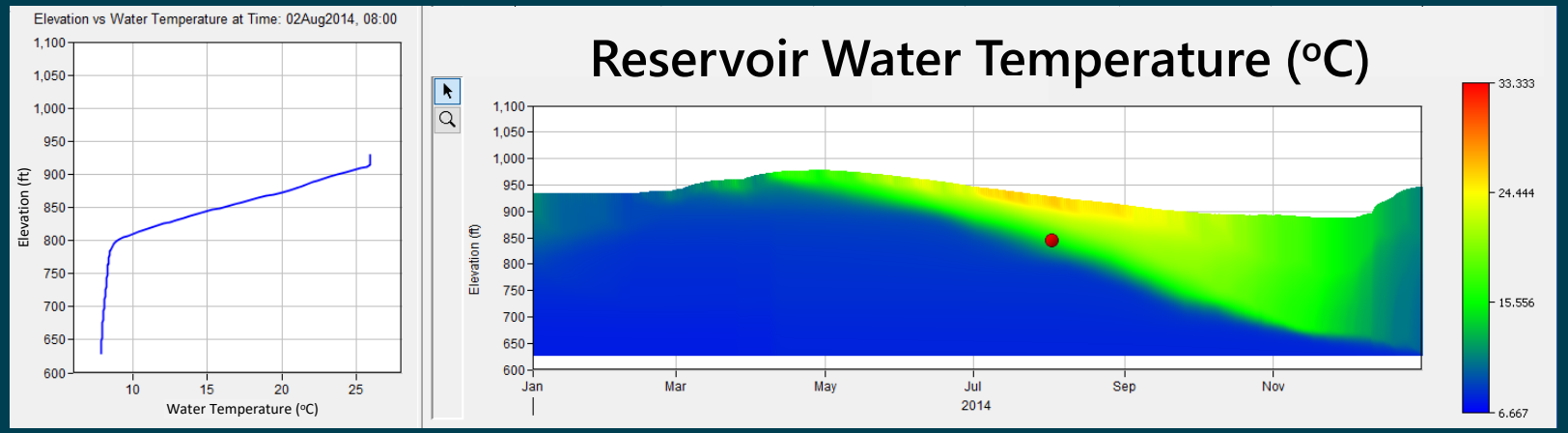
Graphical User Interface

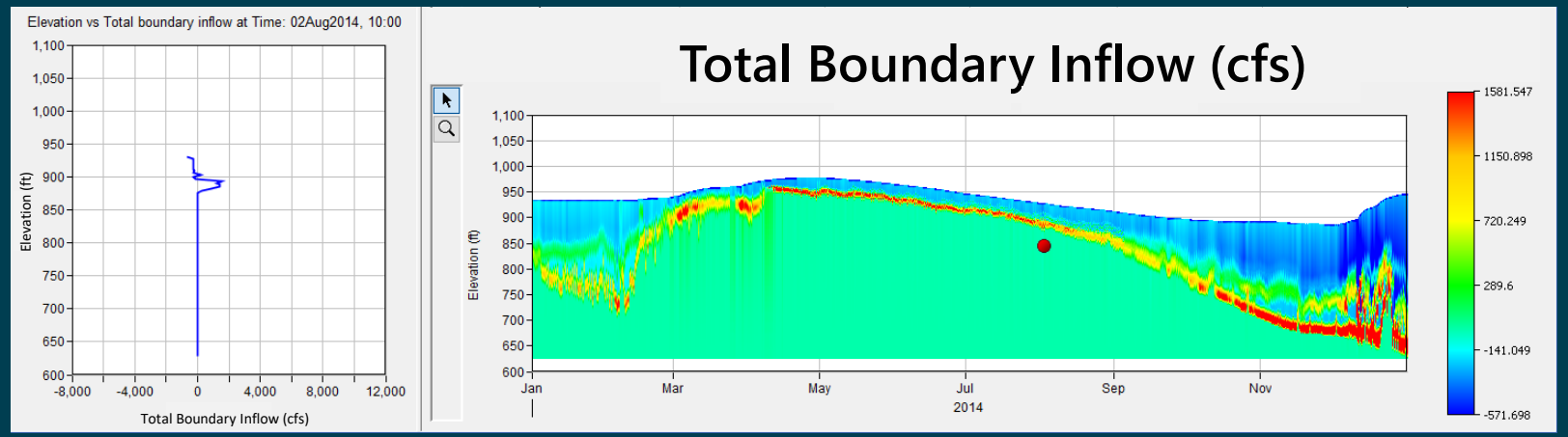
- Display editors
- User interface system schematic-based elements (clickable)
- Plots
- Tables
- Extending tools to CE-QUAL-W2

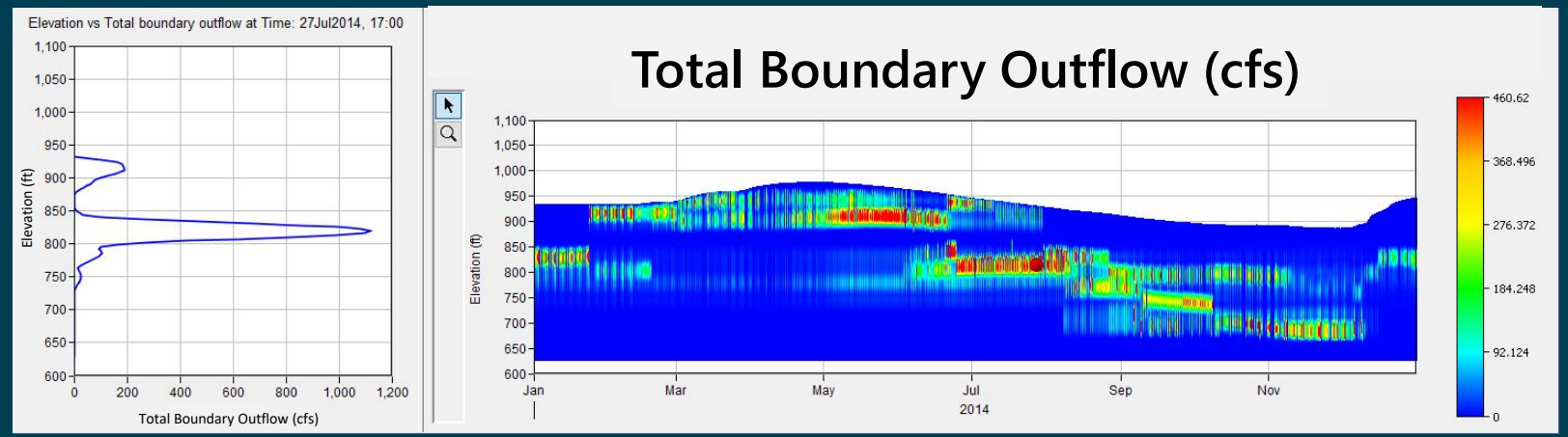


Contour Plots: Reservoirs (HEC-ResSim)

Shasta Lake







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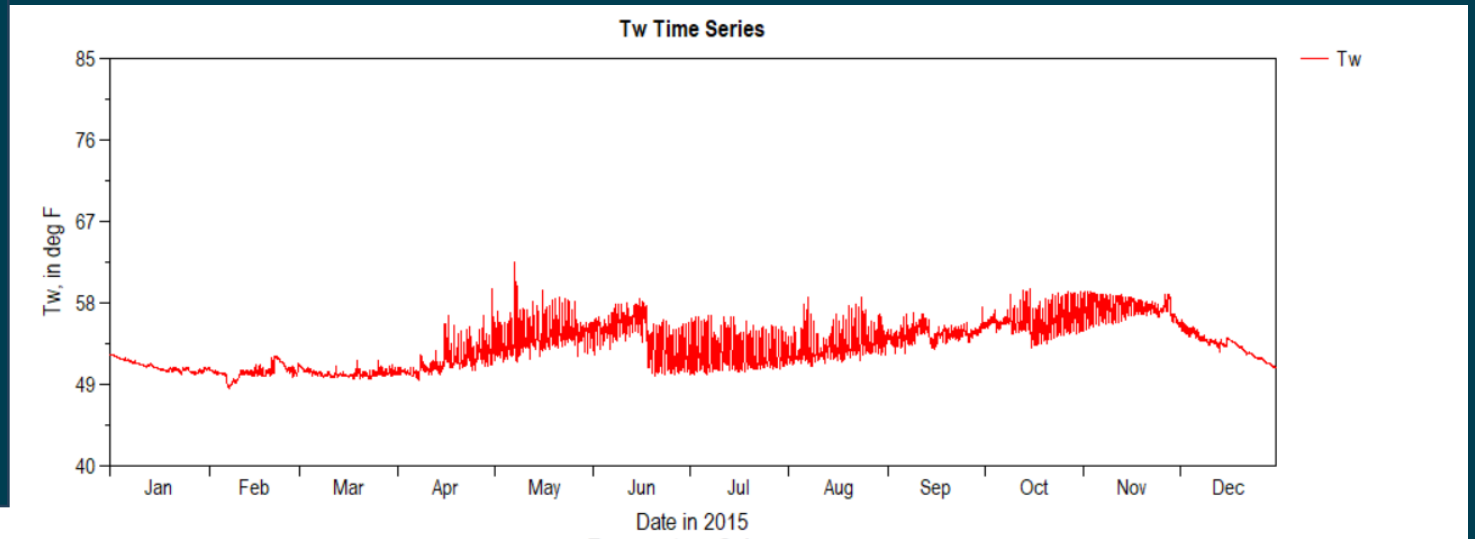
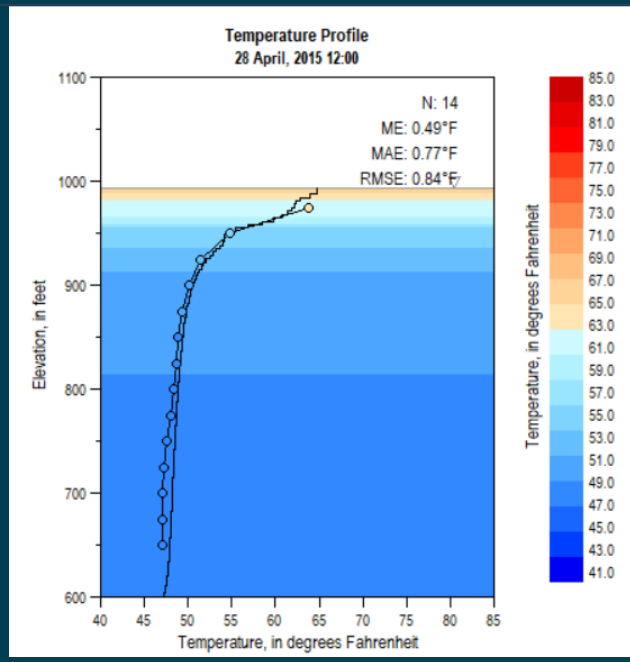
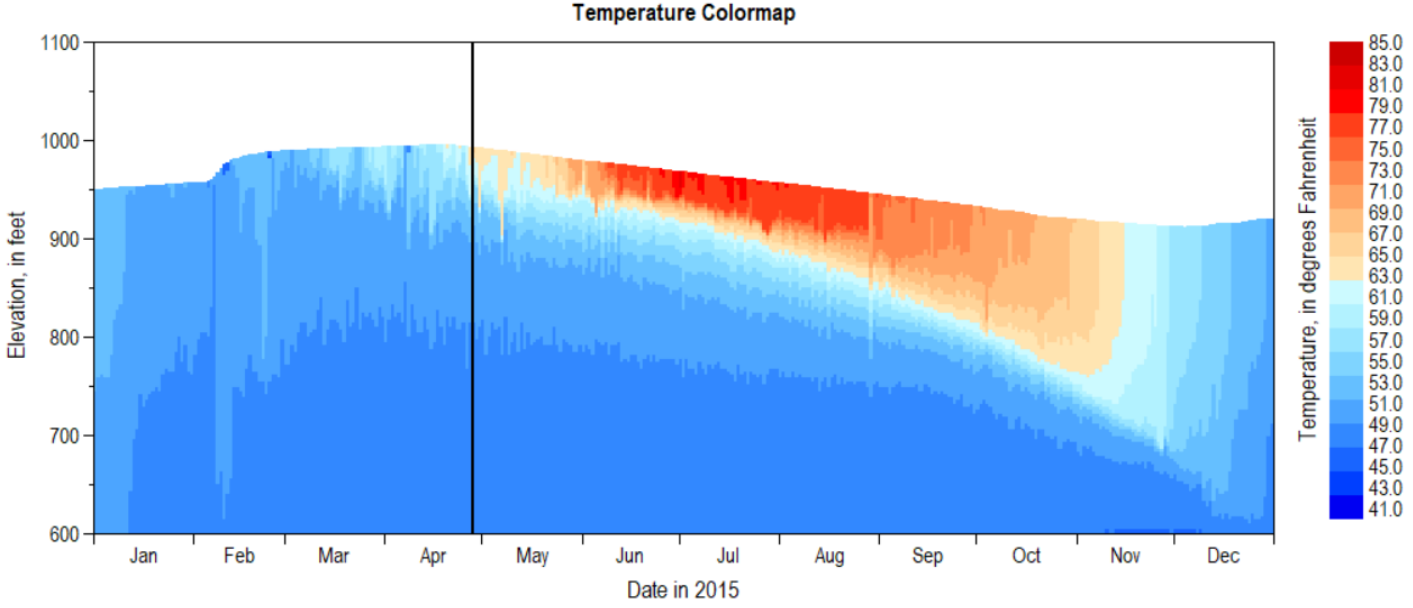
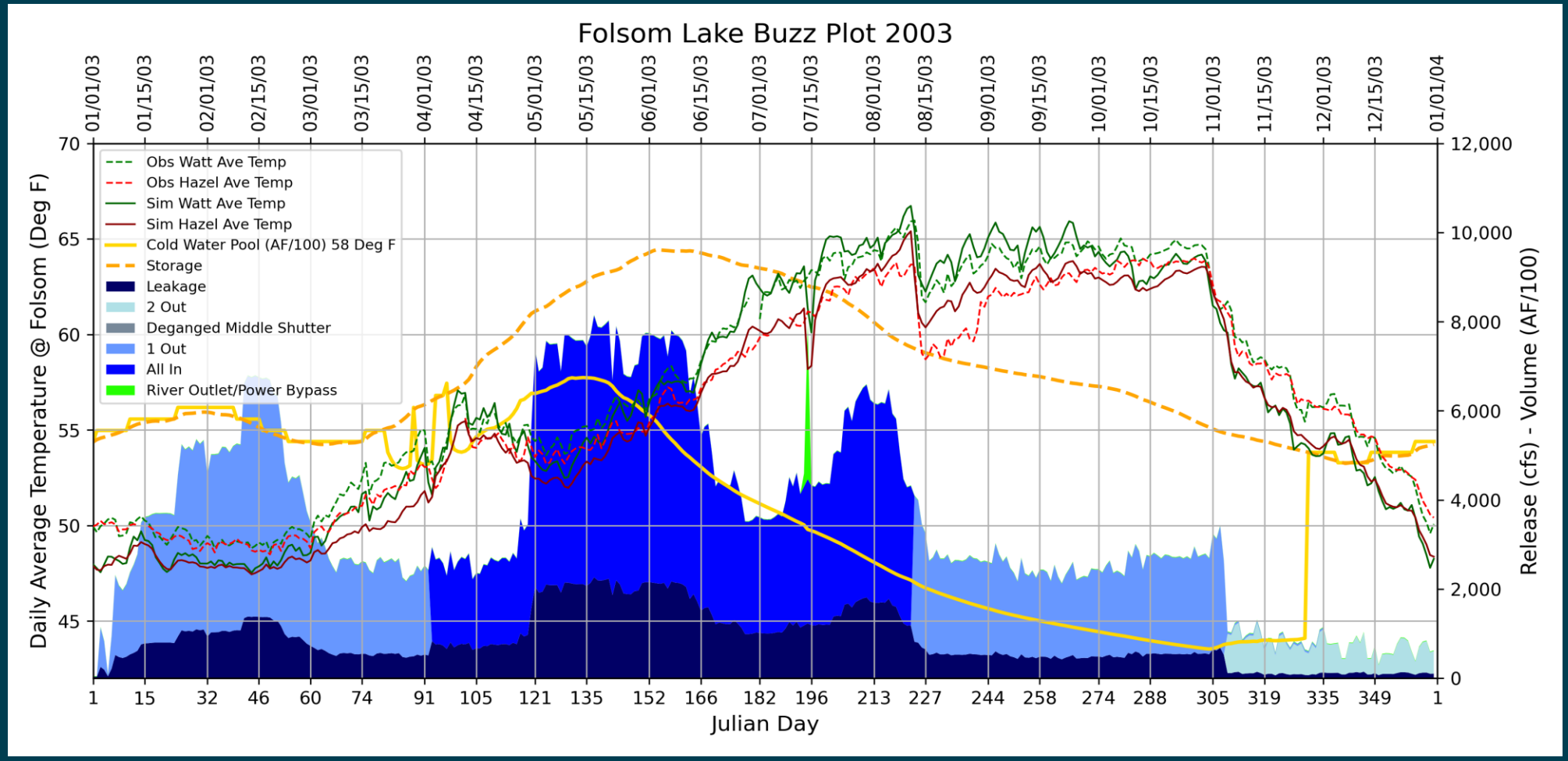






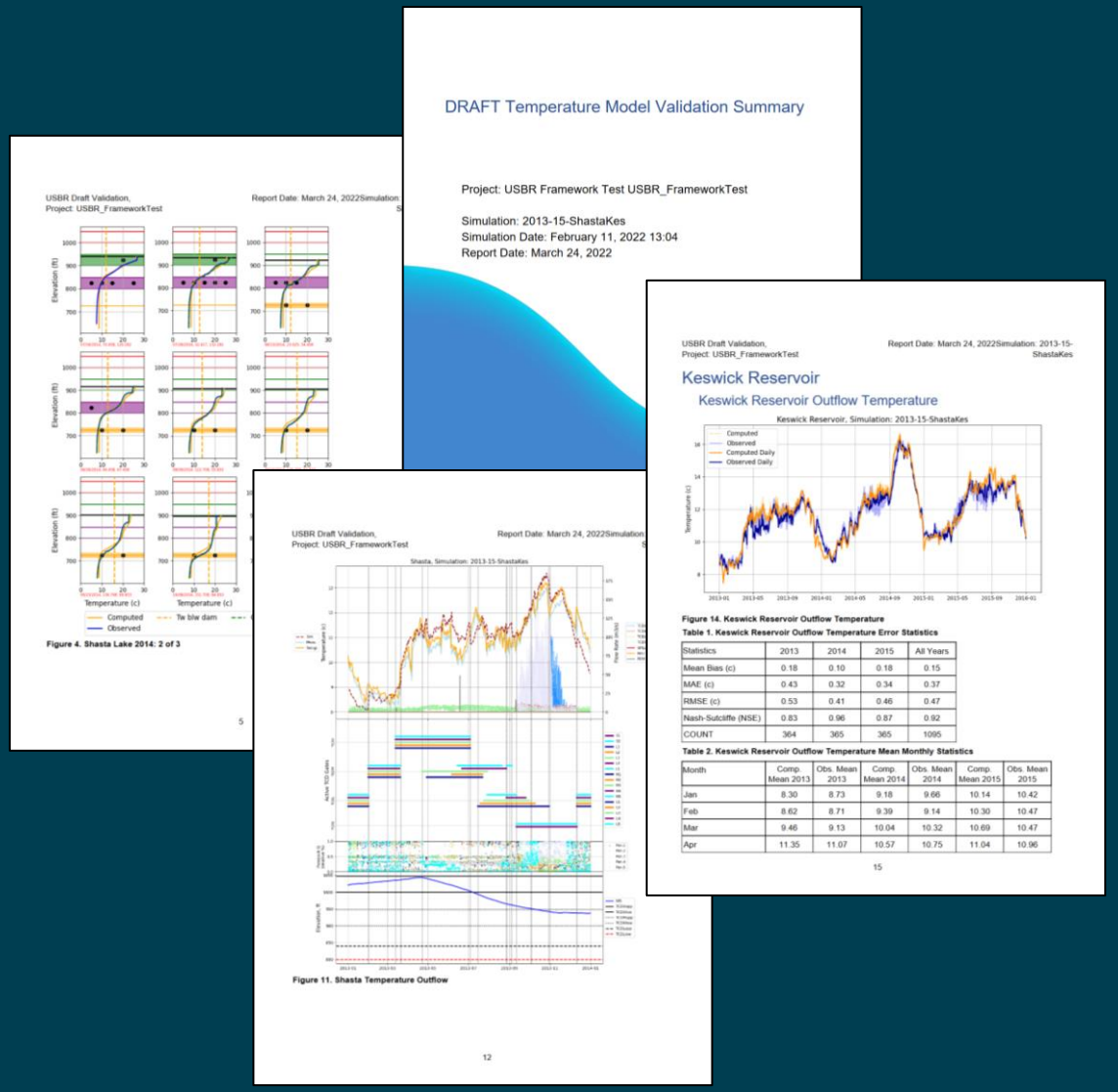
Customized Plots - American River

- Folsom 2003 results



Automated Plotting and Tabulation of Results

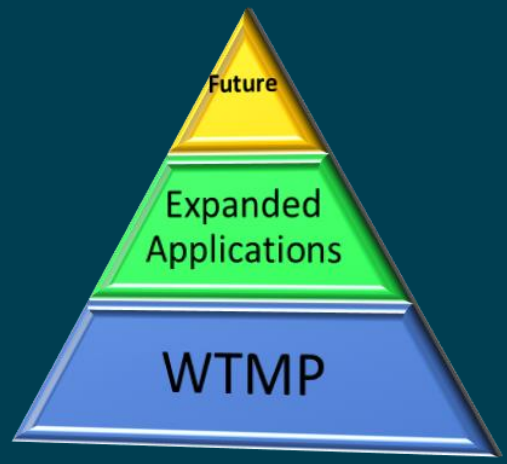
- Rapid creation of key output tables and graphics to facilitate results review by modelers
- Calibration Reports
- Creation of tables and graphics that could be incorporated in other reporting and presentation products



The WTMP Looking Forward

- Continued refinement of WTMP project elements (multi-year project)
- Extending modeling workflow processes (e.g., LTO, automated recalibration, developing multi-scenarios studies)
- Ongoing training of Reclamation's diverse technical staff (CVO, BDO, TSC)
- Installation of the Data Management System and WTMP within Reclamation's internal network
- Develop data sharing protocols and processes via Reclamation Information Sharing Environment (RISE)[3]

- WTMP framework provides foundational components and establishes processes/protocols that accommodates technological advancements that can be used repeatedly into the future



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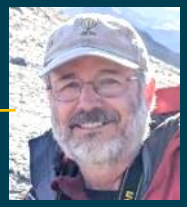


John DeGeorge, PhD, PE
Resource Management Associates

4:40 Reclamation Panel Discussion with Q&A:
The End is the Beginning

5:15 Adjourn

WTMP Objectives

Enhance Efficiency, Consistency, Adaptability and Transparency

- Ease model application and output interpretation
  - Reduce requirement for training on file editing and information flow
  - Reduce the time it takes to carry out modeling activities
  - Facilitate standard approaches for data management and reporting
  - Automate repetitive modeling tasks
- Facilitate the use of multiple models individually or in a sequence
- Managing updates and addition of new features
- Reducing input error and errors in general!

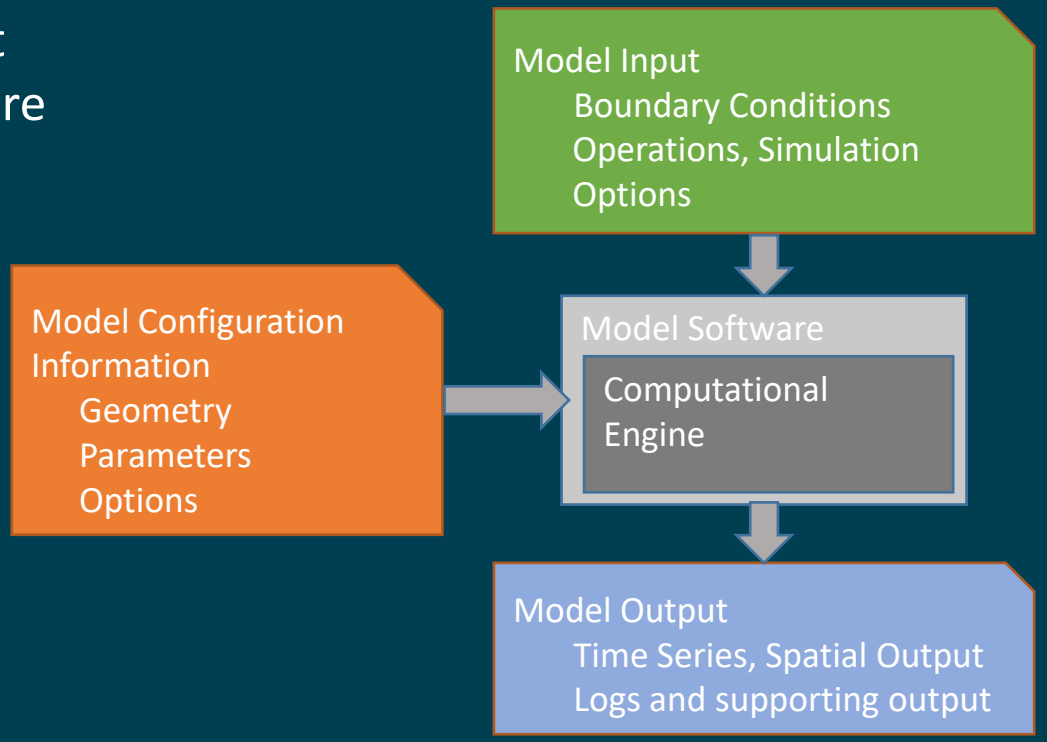
Framework Functions for Team Members with Different Roles

- **Model Operator:** Carries out modeling studies
- **Power User:** Configures automated processing for pre- and post-processing, designs reports, manages model linkages
- **Expert Modeler:** Responsible for configuration and calibration of a model for a particular system
- **Model Developer:** Responsible for the development and maintenance of a model's computational engine
- **IT Support:** Manages the IT infrastructure to facilitate team modeling and provide connectivity to web data sources

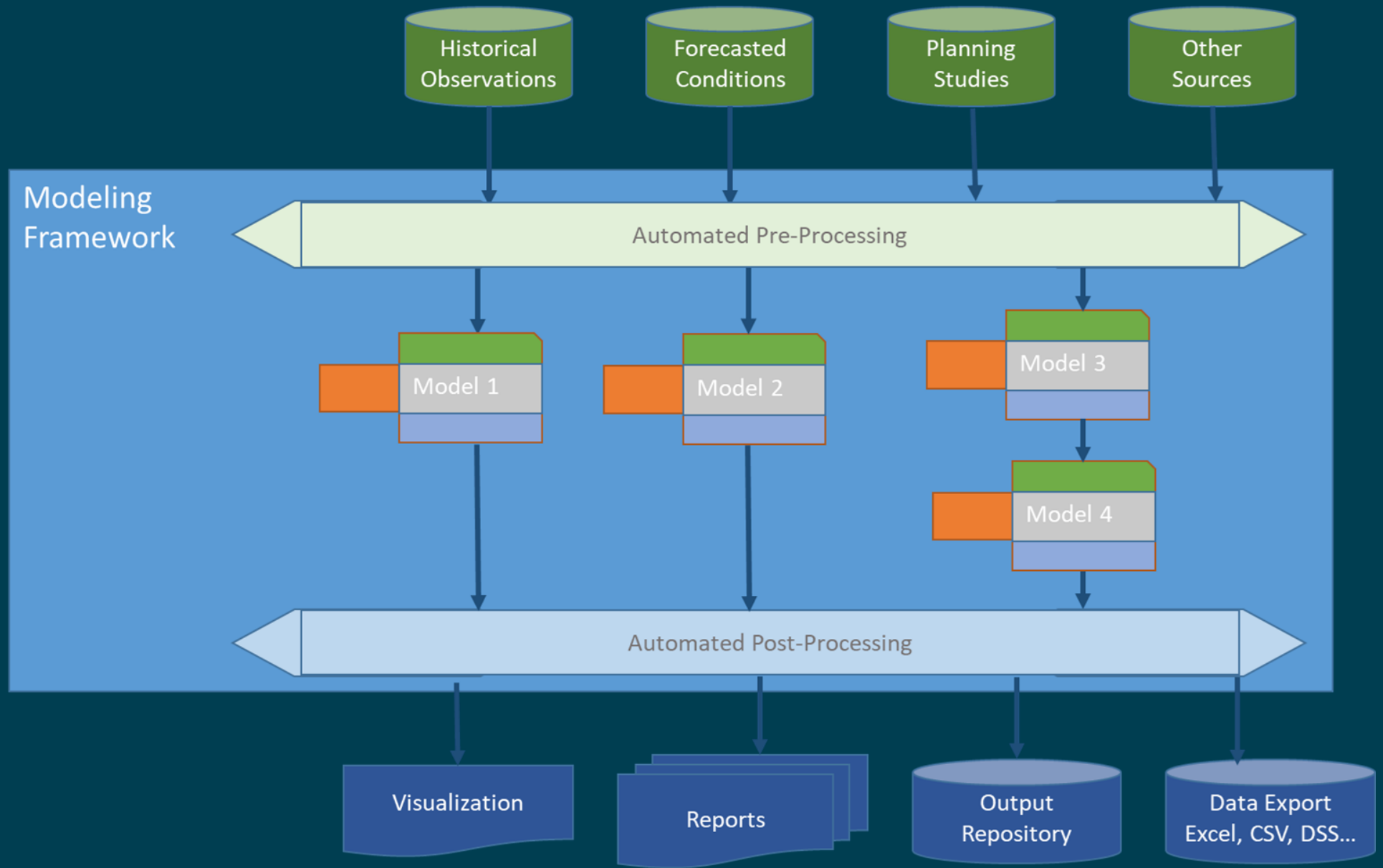
Model, Configuration, Input and Output

"Model Software" in this context refers to a computational software program, for example:

CE-QUAL-W2
HEC-5Q
HEC-ResSim
CALSIM II
DSM2
…



WTMP Analytics Framework

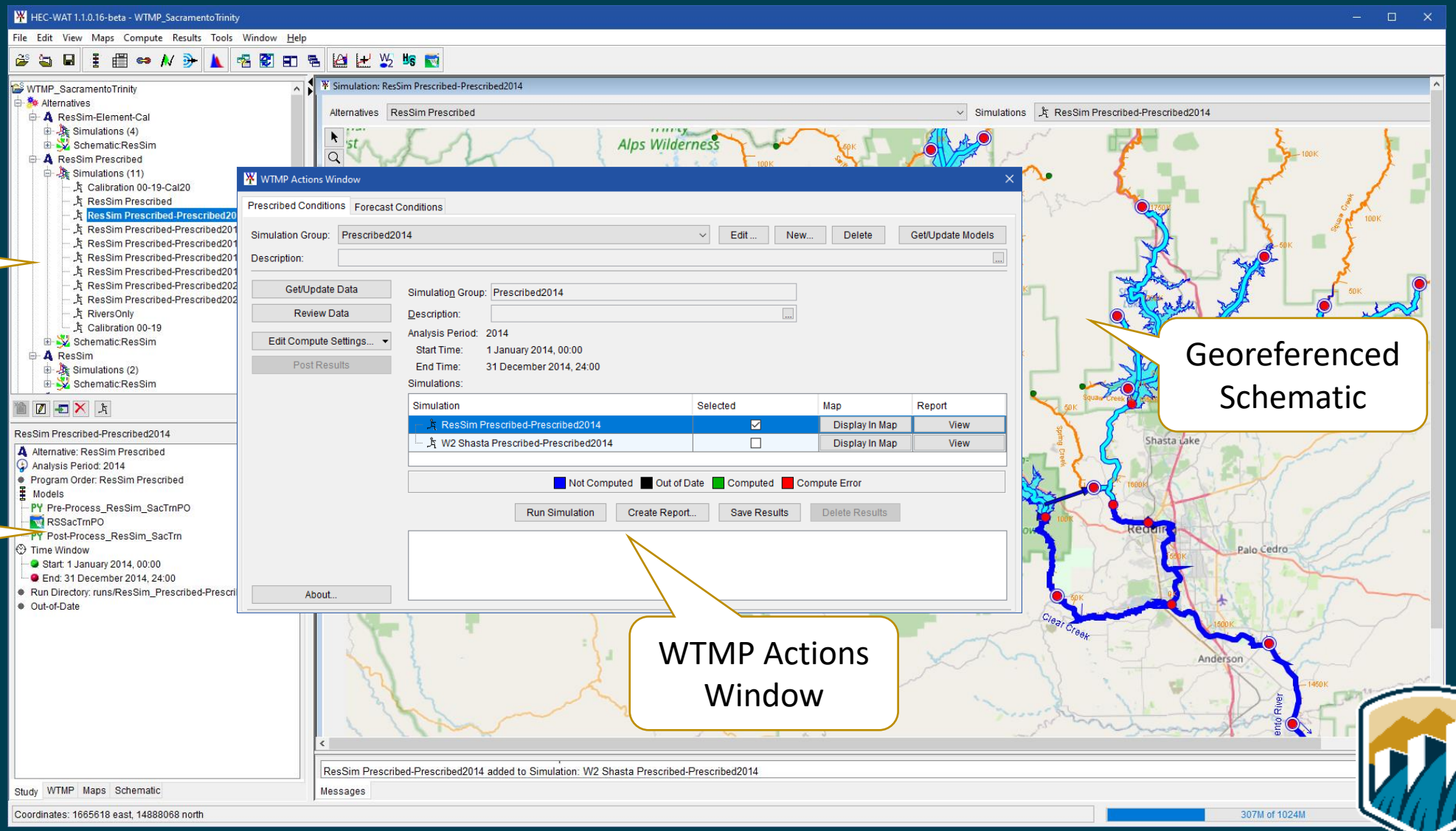


WTMP Modeling Framework User Interface

Menus and Toolbar Buttons

Study Tree

Study Element Details



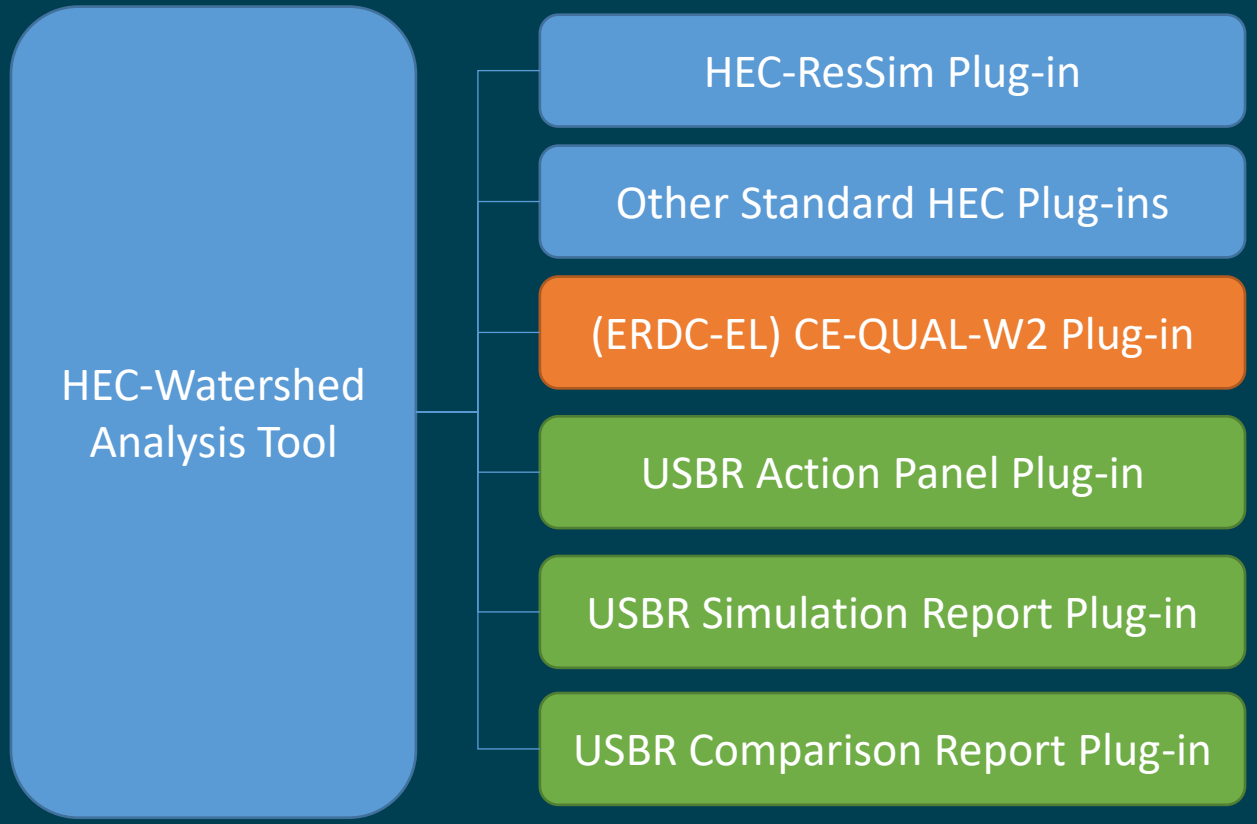
Georeferenced Schematic

WTMP Actions Window

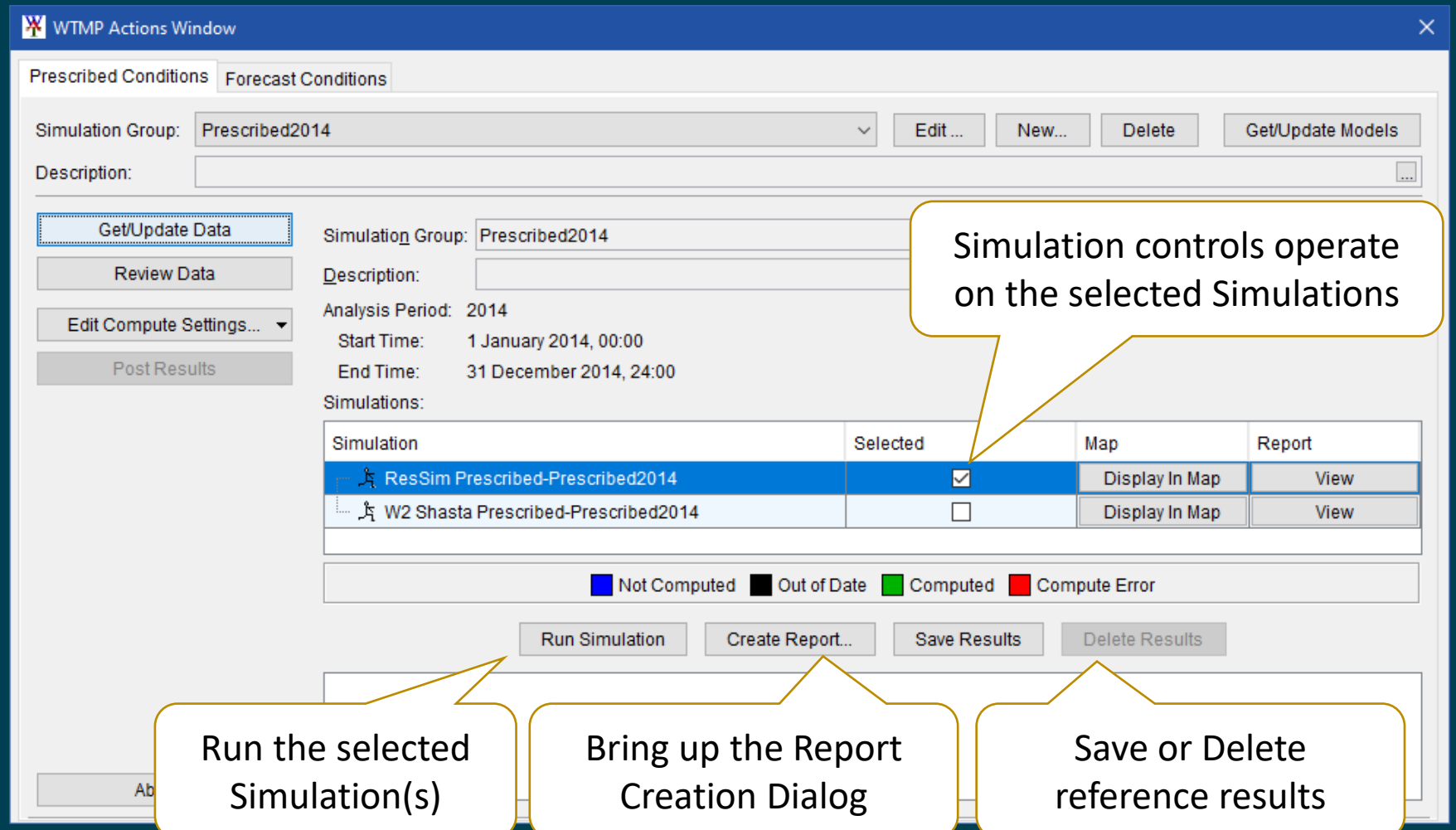
HEC-WAT and WTMP Software Plug-ins

- USBR WTMP Modeling Framework is based on the USACE Hydrologic Engineering Center's HEC-WAT product.
- HEC-WAT is designed to support customization through software plug-ins

https://www.hec.usace.army.mil/software/hec-wat/



Simulation Controls in the User Interface



Forecast Modeling Overview

- Differences from Hindcast
  - Hindcast is about testing model performance once all boundary conditions are known
  - Forecast is about testing temperature management plans against possible future conditions
- Hydrologic Conditions from Operations Forecasts
- Meteorological Conditions from Historical Experience and/or Climate Forecasts
- Objective is to select the best seasonal temperature targets for management of cold water resources
- Consider a range of possible futures through ensemble simulation

Ensemble Simulation

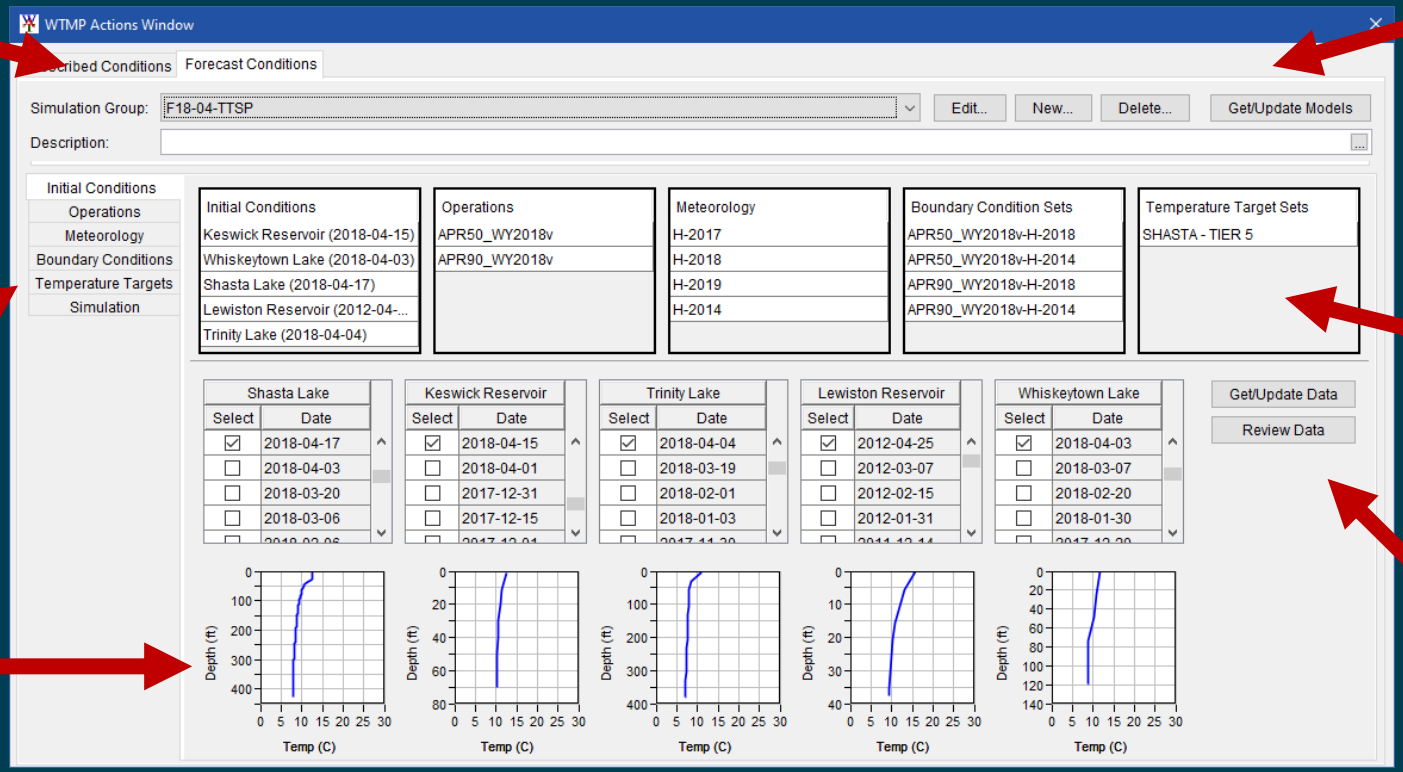
- Variability
  - Future Hydrology and associated Reservoir Operations
  - Future Meteorology
  - Temperature Management Plan
- Hydrology + Operations and Meteorology combine to form a set of model Boundary Conditions
- A Boundary Condition Set combined with a Temperature Target Time Series and Initial Conditions provide the inputs required for a single simulation run
- Ensemble simulation can be used to explore the impact of the these forms of variability individually or together

WTMP Forecasting User Interface Concept

Tabs to choose between Prescribed (Hindcast) and Forecast Simulation

Side tabs to move between data preparation panels

Provide visualization of data to facilitate QA



Keep Simulation Group controls at the top of the screen

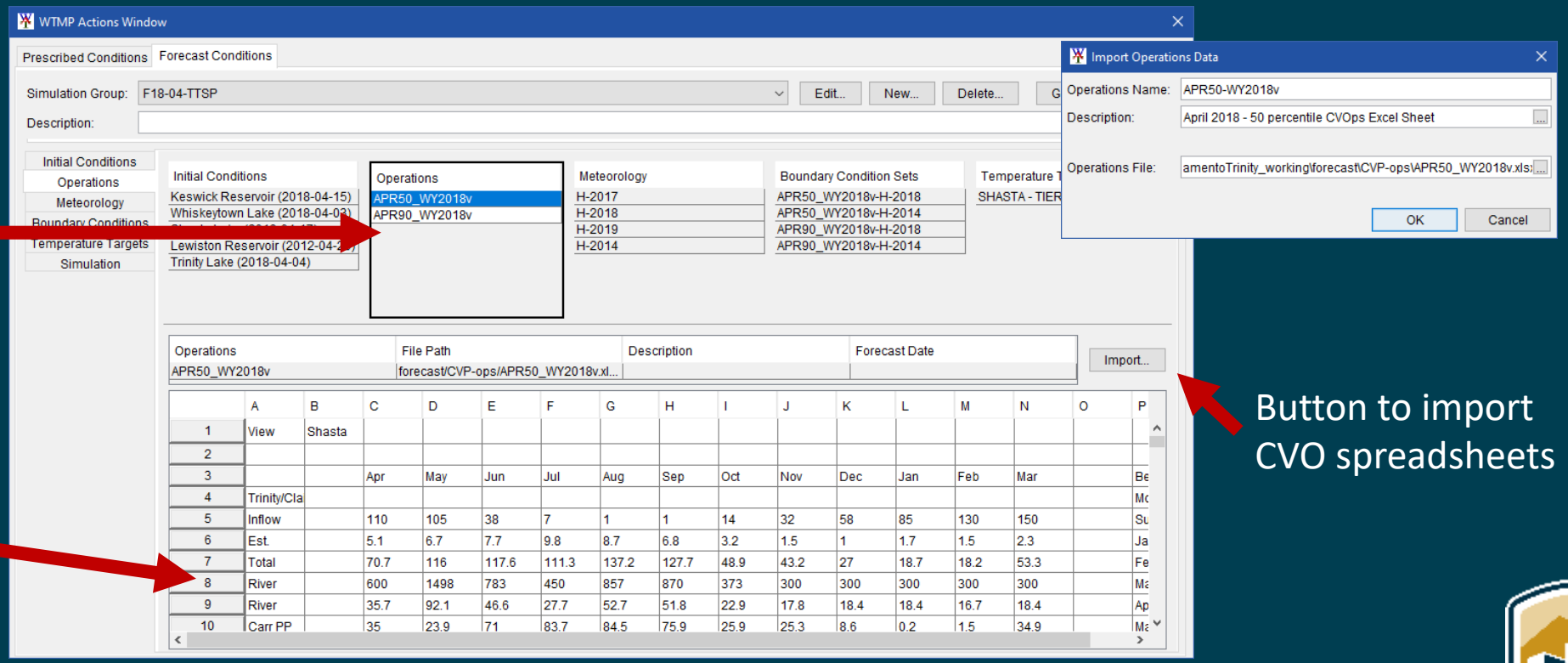
Summarize the information collected for each primary data set

Buttons to trigger data import, processing, and review actions

Preparing Data for Forecast Simulation: Operations

Table shows list of imported operations

Data for operation highlighted in upper table



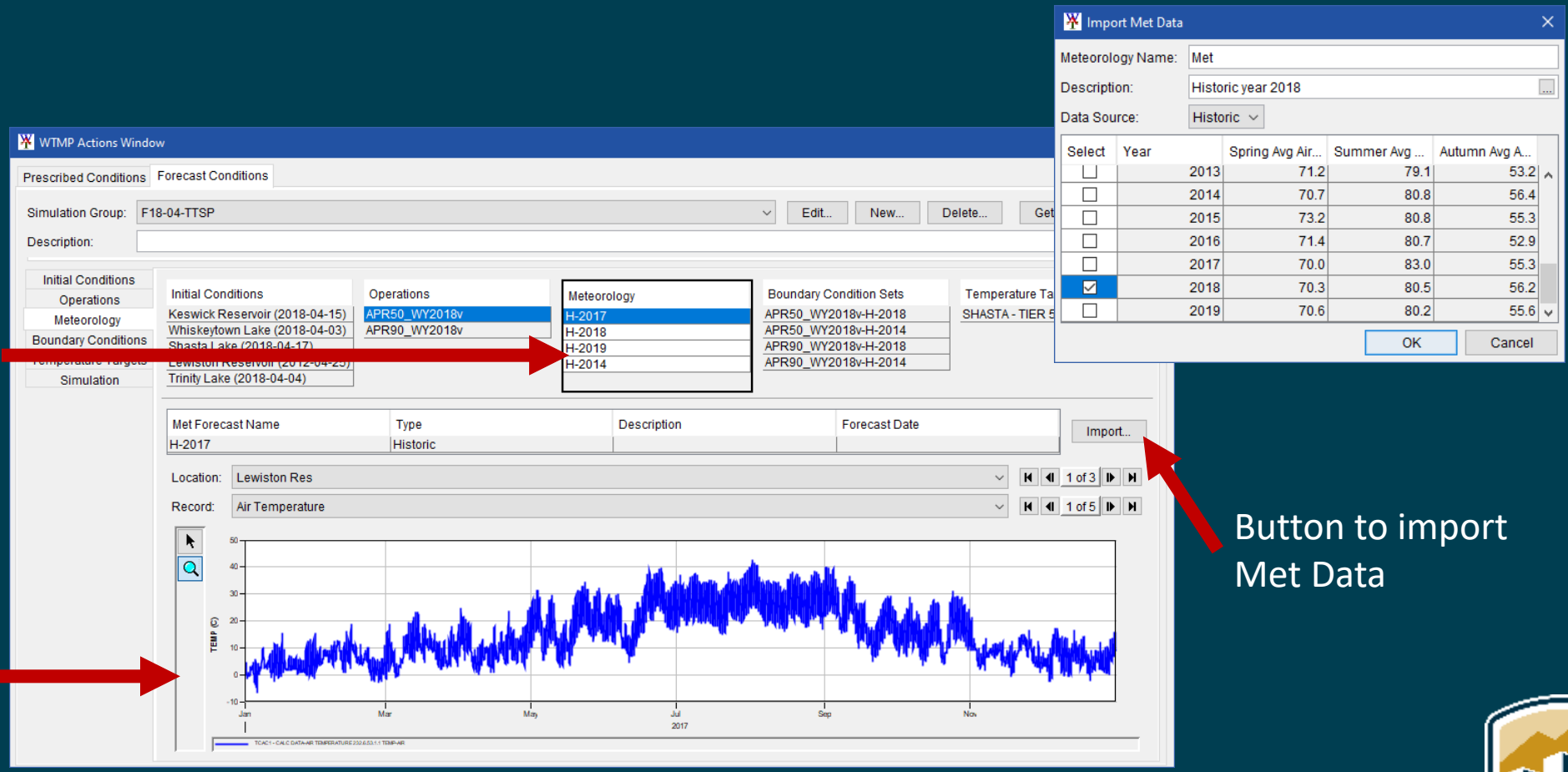
Button to import CVO spreadsheets

Preparing Data for Forecast Simulation: Meteorology

Table shows list of imported operations

Met Data for highlighted set in upper table

Button to import Met Data

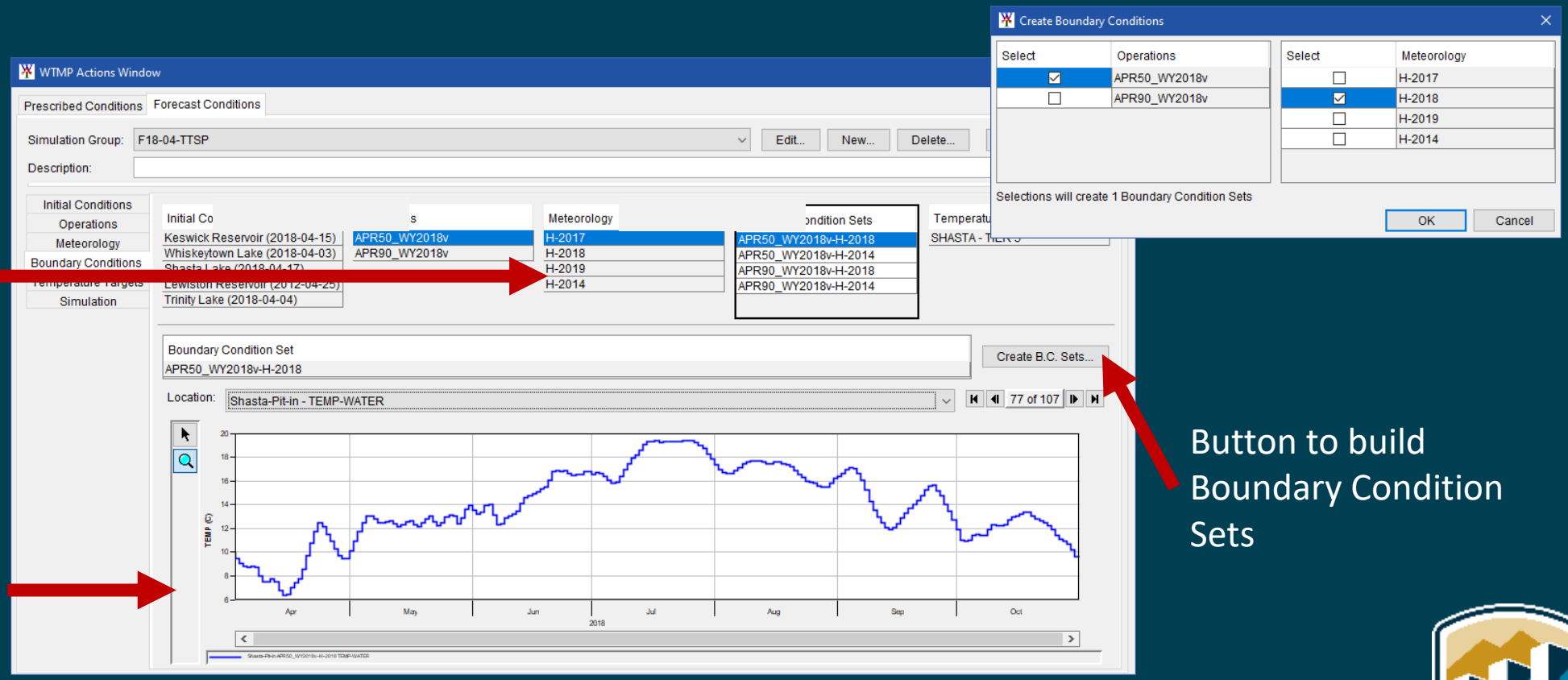


Preparing Data for Forecast Simulation: Boundary Conditions

Table shows list of Boundary Condition Sets

BC Data for highlighted set in upper table

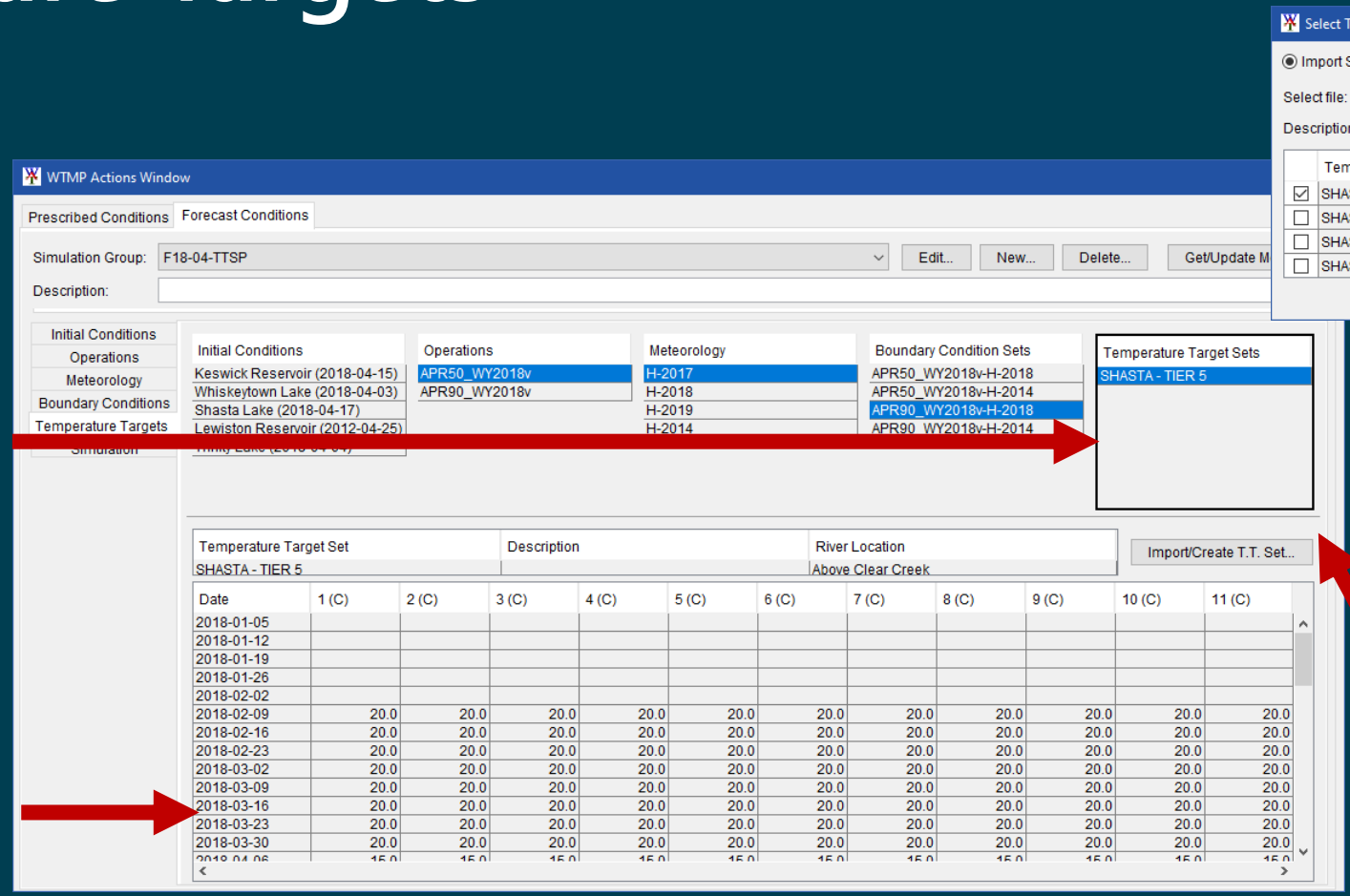
Button to build Boundary Condition Sets

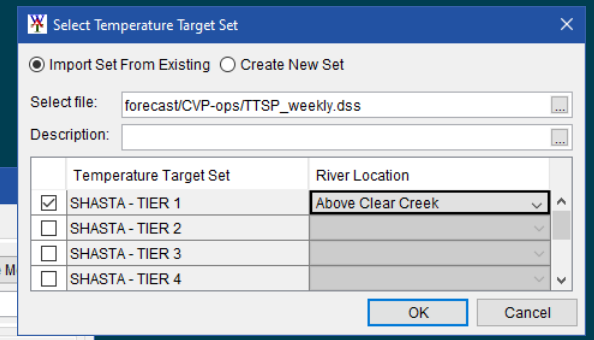


Preparing Data for Forecast Simulation: Temperature Targets

Table shows list of imported Temp Target Sets

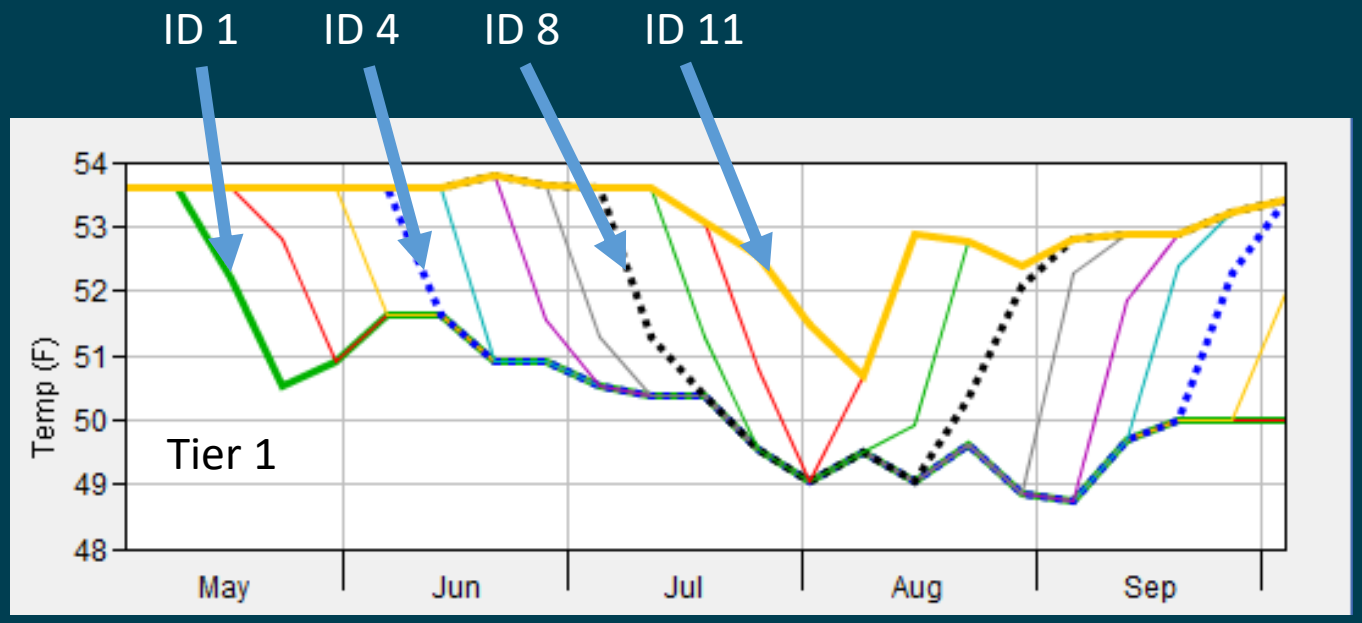
Temp Target Set highlighted in upper table

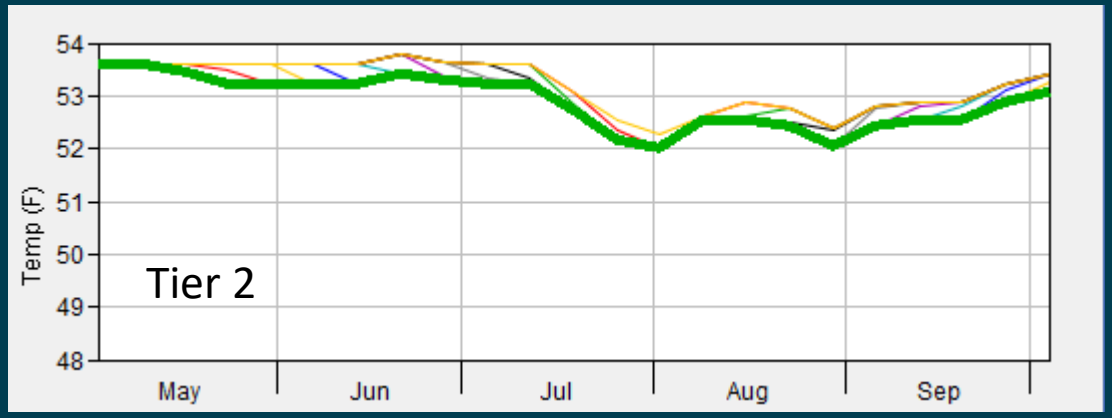


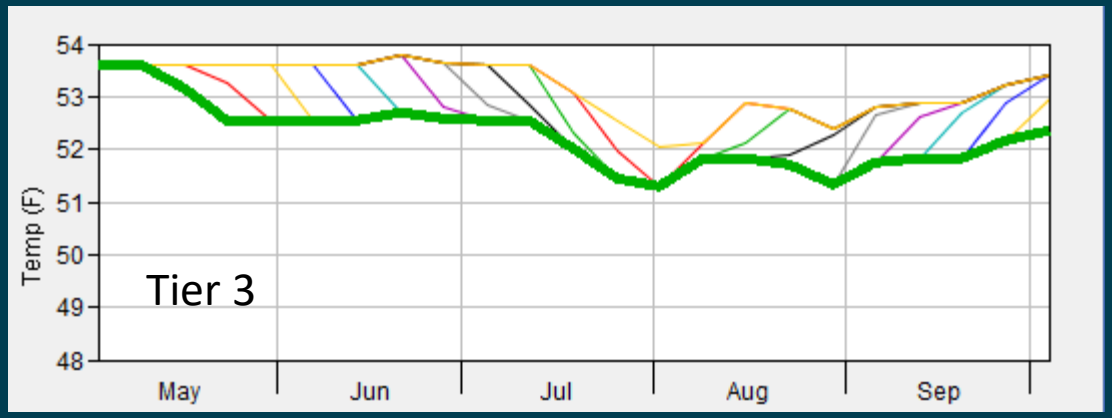


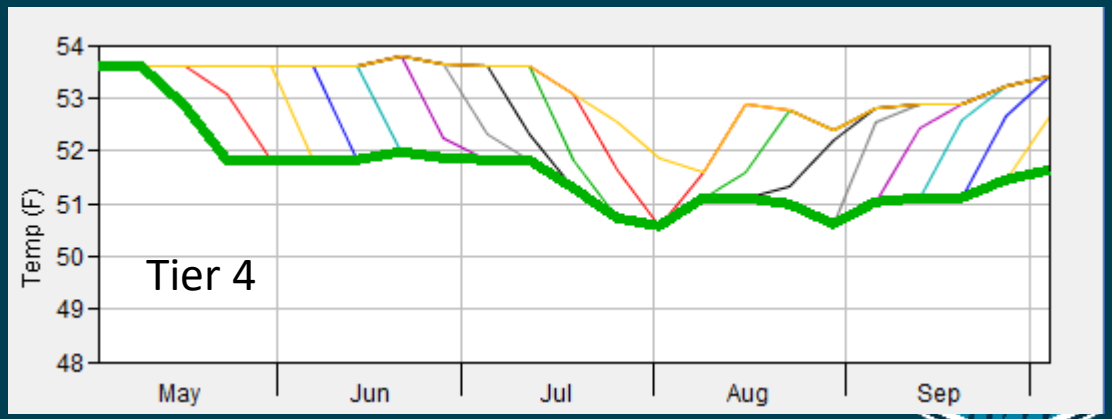
Button to import Temperature Target Sets

Temperature Target Sets
TTSP Spreadsheet (Example)





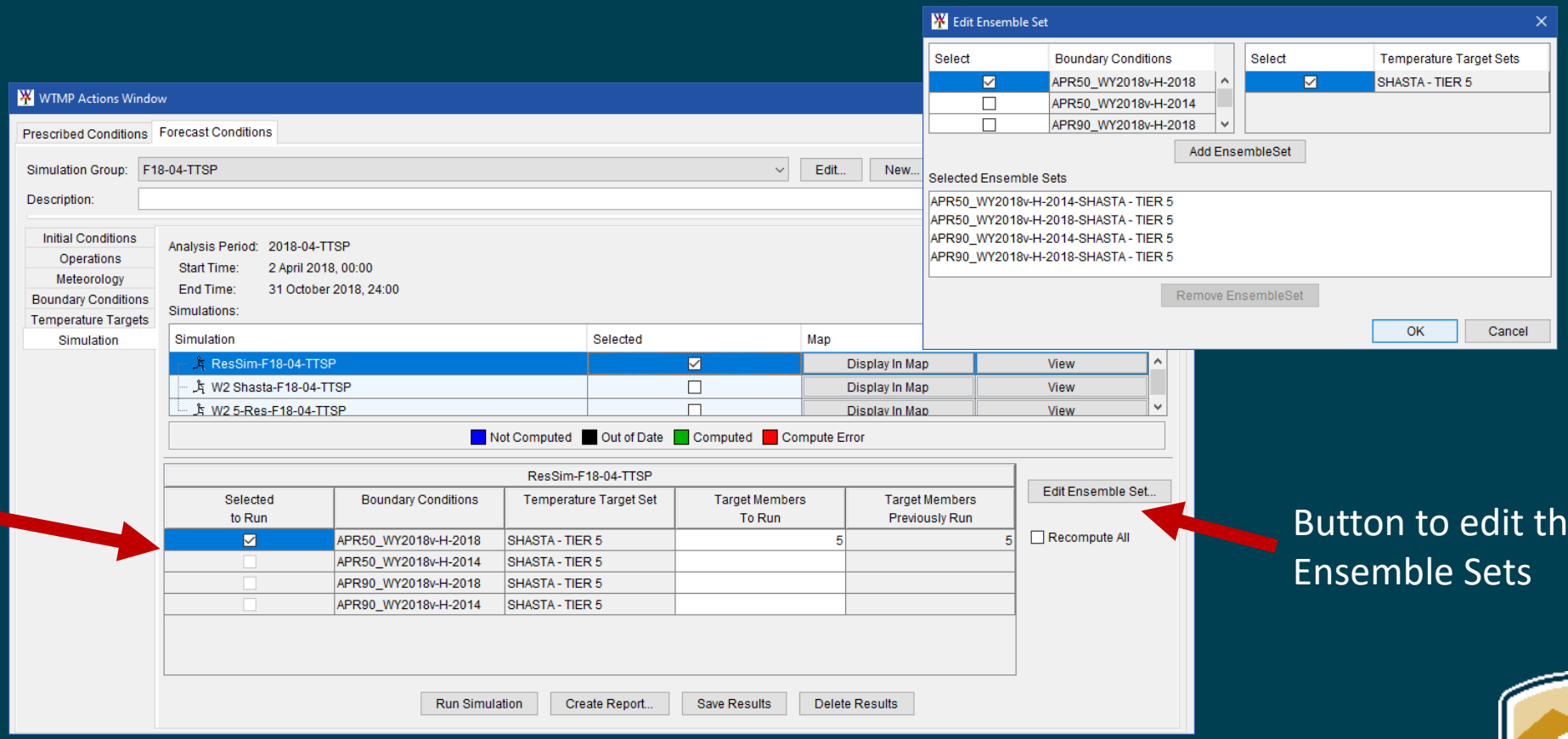




Preparing Data for Forecast Simulation: Selecting Data for Simulation

List of Ensemble Sets ready to run

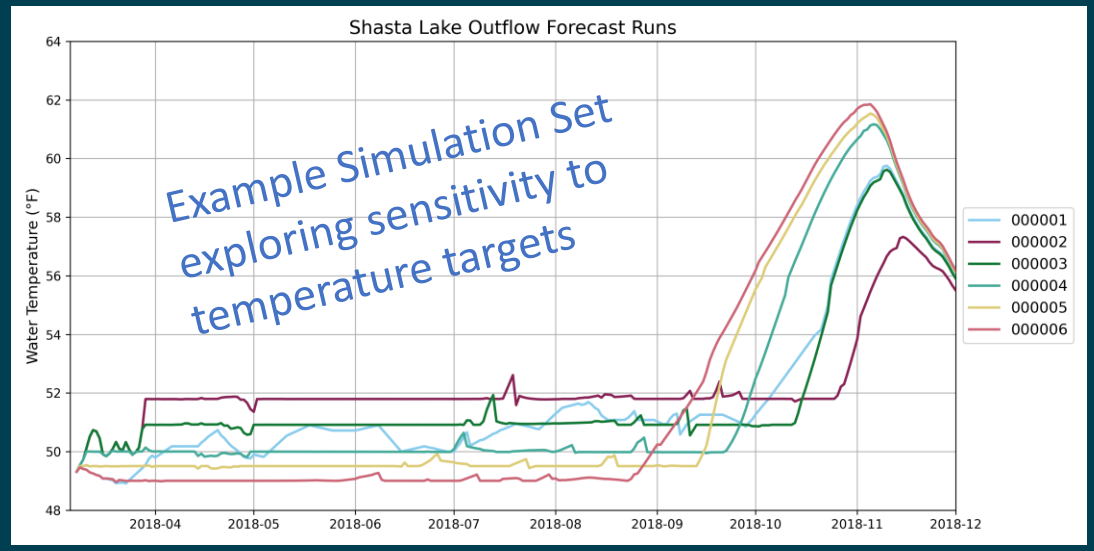
At least one Temp Target member must identified before row can be selected for simulation

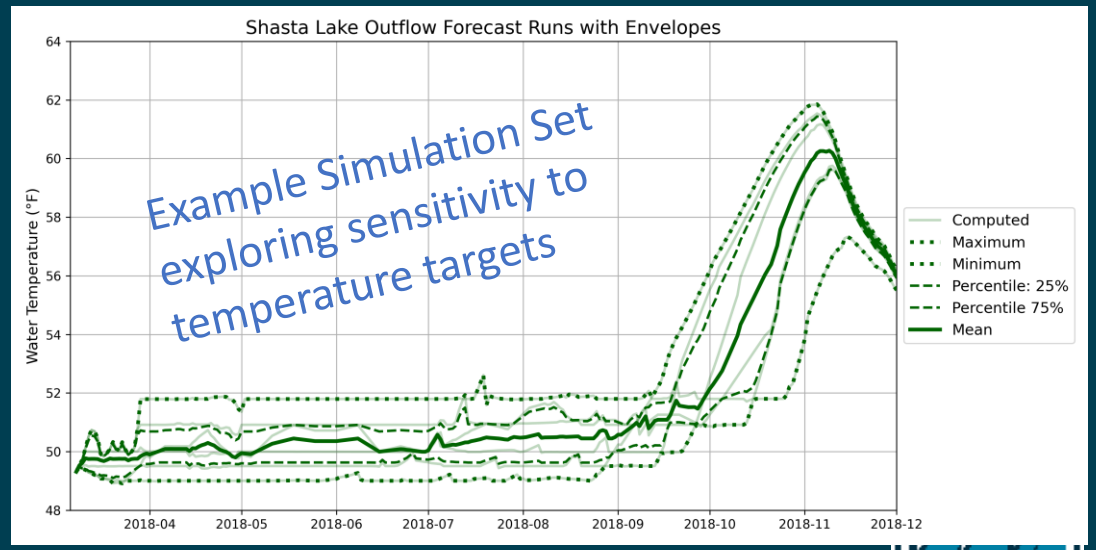


Button to edit the Ensemble Sets

Results Reporting

- Plotting Individual Ensemble Members
  - Demonstrates differences between specific simulations
  - Most useful for a small set of simulations
- Exceedance Plots
  - Demonstrates the distribution possible outcomes
  - Most useful for larger sets of simulations where each results is equally likely
- UI supports filtering results to examine sensitivity to specific inputs





Session 7: CVP WTMP, Chapter 3

3:30 Introduction
Moderator: Yung-Hsin Sun (Sunzi Consulting LLC)

3:40 Presentation: What We have Done

- 3:40 Design with Users and Durability in Mind
- 3:57 Enabling Platform with Capacity and Flexibility
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4:40 Reclamation Panel Discussion with Q&A:
The End is the Beginning

5:15 Adjourn

Yung-Hsin Sun, PhD, PE, BC.WRE
Sunzi Consulting

Model Technical Committee

- The primary mechanism for Reclamation's engagement process in addition to project website, mailing list, etc. .
- A community approach for *collaborative model development*
  - Focusing on technical discussions to advance water temperature modeling tools and analytical methods,
  - Leveraging collective expertise for progressive review of model and platform development to improve overall outcomes, and
  - Maintaining an open and transparent environment for information sharing and cooperation.

Model Technical Committee

- 10 quarterly MTC meetings from 7/21 through 10/23
  - 3 hours in length
  - Materials and summary available on Reclamation's project website

- Participants:
  - Technical staff (especially modeling specialists) and managers from resource management agencies, federal/state/local agencies, organizations, consulting practitioners, and supporting staff of adjacent programs and processes.
  - Relative consistent participation throughout the 2.5-year process.

MTC Agenda Designed to Match Platform Development Progression

Topic	7/1/21	10/7/21	1/6/22	4/7/22	7/7/22	10/6/22	1/5/23	4/6/23	7/6/23	10/5/23
MTC Orientation	1/2/3	-	-	-	-	-				
Project Purposes, Goals, Anticipated Outcomes	1/2/3	3	-	-	-	-				
Modeling Framework Selection	1	2	3	-	-	-				
Water Temperature Model Selection	1	2	3	-	-	-				
Consistency between System Model and Detailed Models	-	1	2	3	-	-				
Common Model Preparation and Considerations	-	1	2/3	-	-	-				
Sacramento/Trinity River Water Temperature Model	-	-	1	2	2/3	3	-	-	-	-
American River Water Temperature Model	-	-	-	1	2	2/3	-	-	-	-
Stanislaus River Water Temperature Model	-	-	-	-	1	2	3	-	-	-
Modeling Framework Implementation	1	-	2	-	-	-	2/3	-	3	-
Mid-term Peer Review Outcomes	-	-	-	-	-	1/2/3	-	-	-	-
Phase II Activities (Introduction only)	-	-	-	-	1/2/3	-	-	-	-	-
Follow-up Model Discussions (as needed)							1	2	3	-
Characterization of Model Uncertainty							1	2	3	3
Communication of Model Uncertainty							1	1/2	2/3	3
Output and Visualization							-	1	2	3
Final Peer Review Outcomes							-	-	-	1/2/3
Celebration							-	-	-	1/2/3

Key: 1 – Introductory Presentation; 2 – Comments and Discussion; 3 – Closure Discussion.

Reclamation's Institutional Knowledge Development

- Reclamation will own and implement the WTMP.
- Develop and retain institutional knowledge is the key to success.
  - Integrated team structure
  - Develop solutions with active participation by Reclamation staff
  - Collaborative development with hand-on opportunities
  - Regular team meetings with paced incremental reviews to establish shared experience in problem solving
  - Milestone workshops with Reclamation for enhanced learning experience and on-boarding
  - Documentation, documentation, and documentation
- Validation: Reclamation team's stella performance in the final peer review.

What is Next for Engagement and Institutional Knowledge Development

- *Stay on the path that works.*
- Maintain the same integrated team with Reclamation for continued fostering organization capacity growth and long-term implementation
- Maintain the same principles for engaging modeling community and interested parties (more in the rollout preview)
  - Engaging currently established technical groups for facilitated adoption
  - Forming a WTMP User Group

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Randi Field
Bureau of Reclamation, CVO
(Reclamation Project Lead)

WTMP Final Peer Review

- What did the Review cover?
  - Tested the technical merits/methods of the model
  - Model development process
  - Evaluation of model performance
  - Documentation and support material
  - Application and adequacy of the models
- What was Feedback?
  - Model elements were found to be appropriately represented and consistent with project objectives
  - Extremely positive feedback and responses from the Peer Review Panel
- What was the outcome?
  - Built confidence in technical adequacy for application
  - WTMP performed documentation enhancements based on feedback
  - Team transition to testing and facilitated adoption

Response to Peer Review Comments

- Addressed comments in documentation:
  - Polished diagrams, maps, and graphics
  - Enhanced text content including section overviews
  - Reformatted model performance to arrange results by year type
  - Identified specific ranges of meteorological conditions where were calibrated
  - Enhanced tables and plots of reservoirs including water year type classification, volumes, and min/max release

Quote from the Peer Review Final Report

"The WTMP Project Team has taken important and commendable steps to position the modeling framework along an adequate path. These steps include:

1. engagement with scientific community working on climate forecasts and downscaling,
2. engagement with stakeholders,
3. modeling's and data sharing,
4. sharing documentation on modeling approach and performance,
5. system monitoring,
6. hinder approach for continuing model performance evaluation, and
7. building the system framework to operate within a Monte Carlo framework."

WTMP Peer Review Panel: Features to Commend

Items externally perceived as laudable practice and a significant complement to CWEMF Modeling Guidelines:

- Model development transparency
- Open software/free
- Data management
- Data quality
- Data availability
- Stakeholder engagement through open science
- Model dissemination to build community capability in-house and within stakeholder communities

WTMP Peer Review Panel: Suggestions

Additional Areas of Future Work:

- Incorporate future 3-to-5-day meteorologic forecast uncertainties
- Continue investigating forecast uncertainty
- Explore Water Data Markup Language (WaterML)
- Investigate additional data gap filling methodologies
- Improve areas in the model where parameterization was applied
- Craft future work plan

Next Peer Review

Independent peer reviews complement Reclamation's commitment to quality and integrity of analytical tools to support Project operations:

- HEC-ResSim model independent scientific review
  - In the context of WTMP use
  - Water quality module for water temperature modeling applications
- Reclamation is partnering with USACE, Hydrologic Engineering Center
- Review host is the Delta Stewardship Council, Delta Science Program
- Tentative review date is January 2025

Rollout Update!

- Facilitated Adoption to begin in Spring 2025
- WTMP tools to be available for distribution in Fall 2025

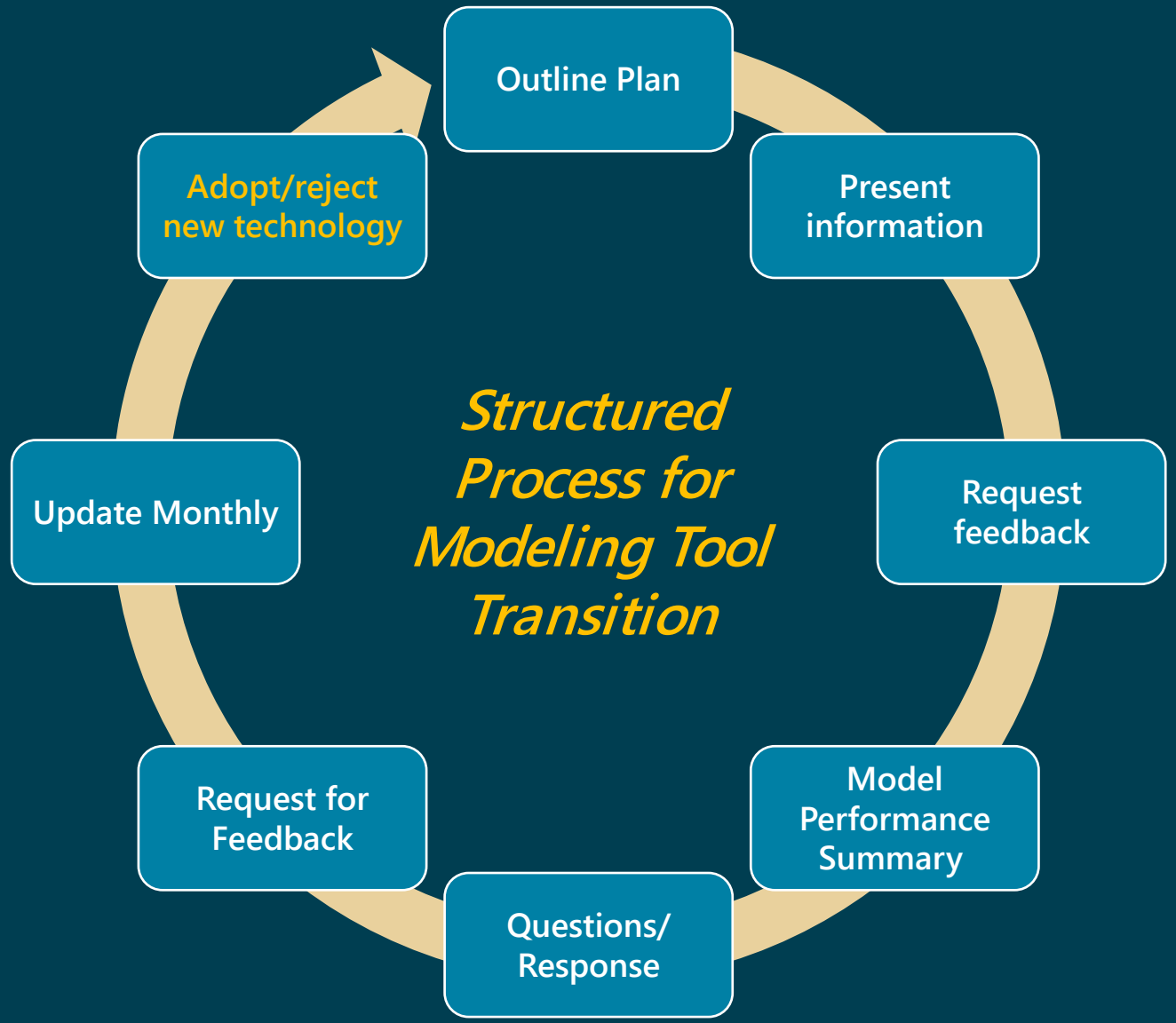
- Why the new approach?
  - Logistical challenges - Institutional security requirements
  - Facilitated adoption – Expansion/more frequent interaction
  - Testing - Additional time to address project scope, data magnitude, and level of technical detail
  - Preparation – New media elements

Facilitated adoption including migration, onboarding, and education, aiming at empowering users with success from the beginning. More details to come.

What will happen Spring 2025?

- Facilitated Adoption for the WTMP:
  - Opportunity to engage with WTMP teams/stakeholders
  - Initiate the setup of the Seasonal Temperature Management Plan
  - Present parallel performance comparisons of new and legacy tools
  - Offer consistent monthly updates May through October
  - Comprehensive seasonal hindcast evaluation complete late November/early December

What is Facilitated Adoption?



What are the benefits of Facilitated Adoption?

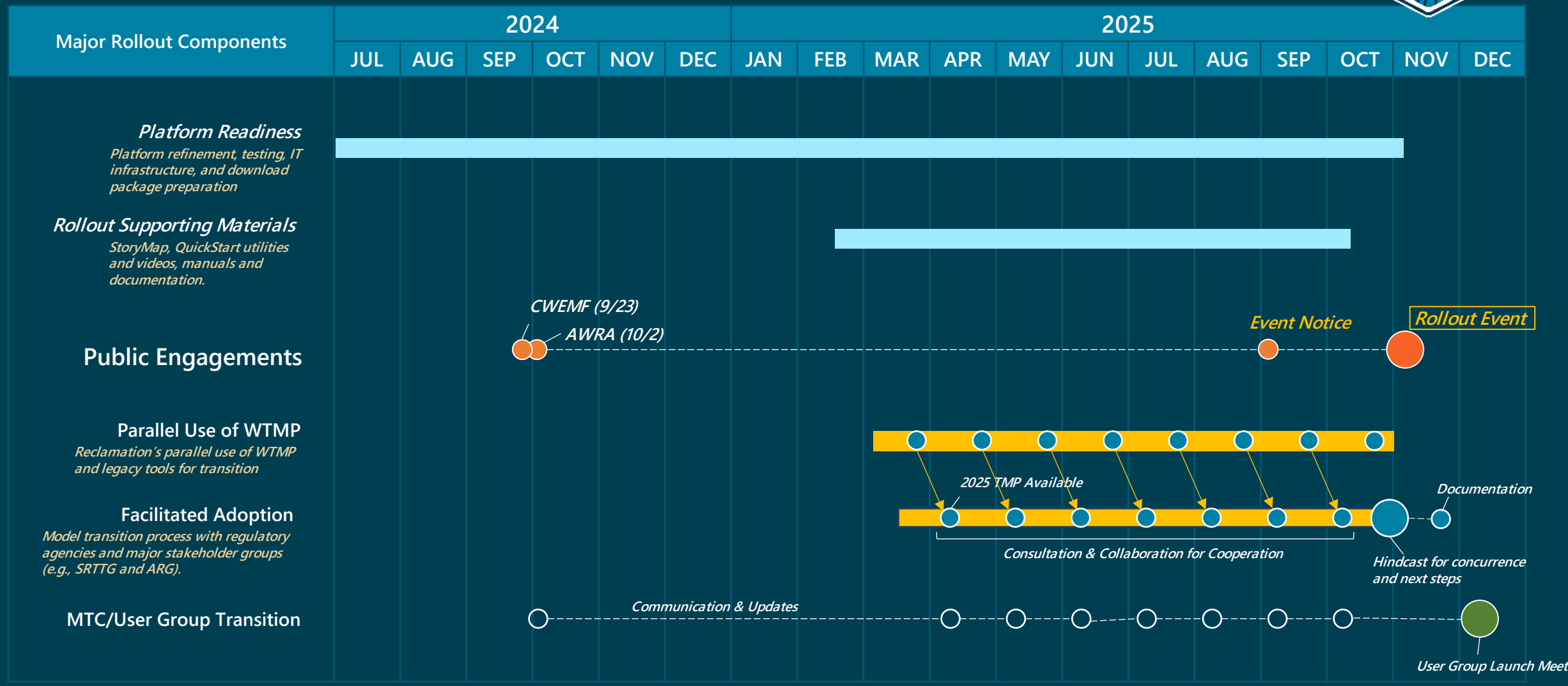
- Gradual and stepwise introduction of:
  - Tools
  - Inputs and Assumptions
  - Results
  - Analysis
  - Processes
- Greater opportunities for community feedback:
  - Information presentation - Graphic/tabular displays
  - Performance assessment
  - Workflow process testing

What to Expect at the Fall 2025 Rollout?

- A celebration event that you do not want to miss.
- Access to the WTMP tool package with links for downloading:
  - Model Documentation
  - Model Software Packages
  - RISE data
  - QuickStart Videos
  - WTMP StoryMap

- Launch the Water Temperature Modeling User Group:
  - Voluntary recruiting process and sign-up information
  - First meeting will follow approximately a month after the Rollout event

WTMP Rollout Schedule



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All of You

Photo credit: John Hannon, Reclamation

2024 CWEMF Annual Meeting: Session 7: CVP WTMP, Chapter 3

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