BUREAU OF RECLAMATION

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Central Valley Project Water Temperature Modeling Platform

California Water and Environmental Modeling Forum

Session 12

April 5, 2022; 8 - 9:45 a.m.

Session 12: Central Valley Project (CVP) Water Temperature Modeling Platform (WTMP)

8:00	Introduction	Yung-Hsin Sun (Stantec)
8:05	Purposes and Goals	Randi Field (Reclamation)
8:20	Design of the WTMP	John DeGeorge (RMA)
8:40	Approach to the WTMP	Mike Deas (Watercourse)
8:55	Status and Accomplishments	Mike Deas (Watercourse) & Jeff Schuyler (Eyasco)
9:20	Stakeholder Engagement	Yung-Hsin Sun (Stantec) & Randi Field (Reclamation)
9:30	Q&A	All
9:45	Adjourn	

Session 12: Central Valley Project (CVP) Water Temperature Modeling Platform (WTMP)

Moderator/Panelist	Panelist	Panelist	Panelist	Panelist
				
Yung-Hsin Sun, PhD, PE, D.WRE **Stantec Consulting Services Inc.**	**Randi Field** **Central Valley Operations Office,** **US Department of the Interior,** **Bureau of Reclamation**	**John DeGeorge, PhD, PE.** **Resource Management Associates**	**Mike Deas, PhD, PE** **Watercourse Engineering, Inc.**	**Jeff Schuyler** **Eyasco, Inc.**
	Reclamation Project Lead		**Consultant Team Lead**	

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WTMP Purposes and Goals

- Project Needs and Anticipated Outcome

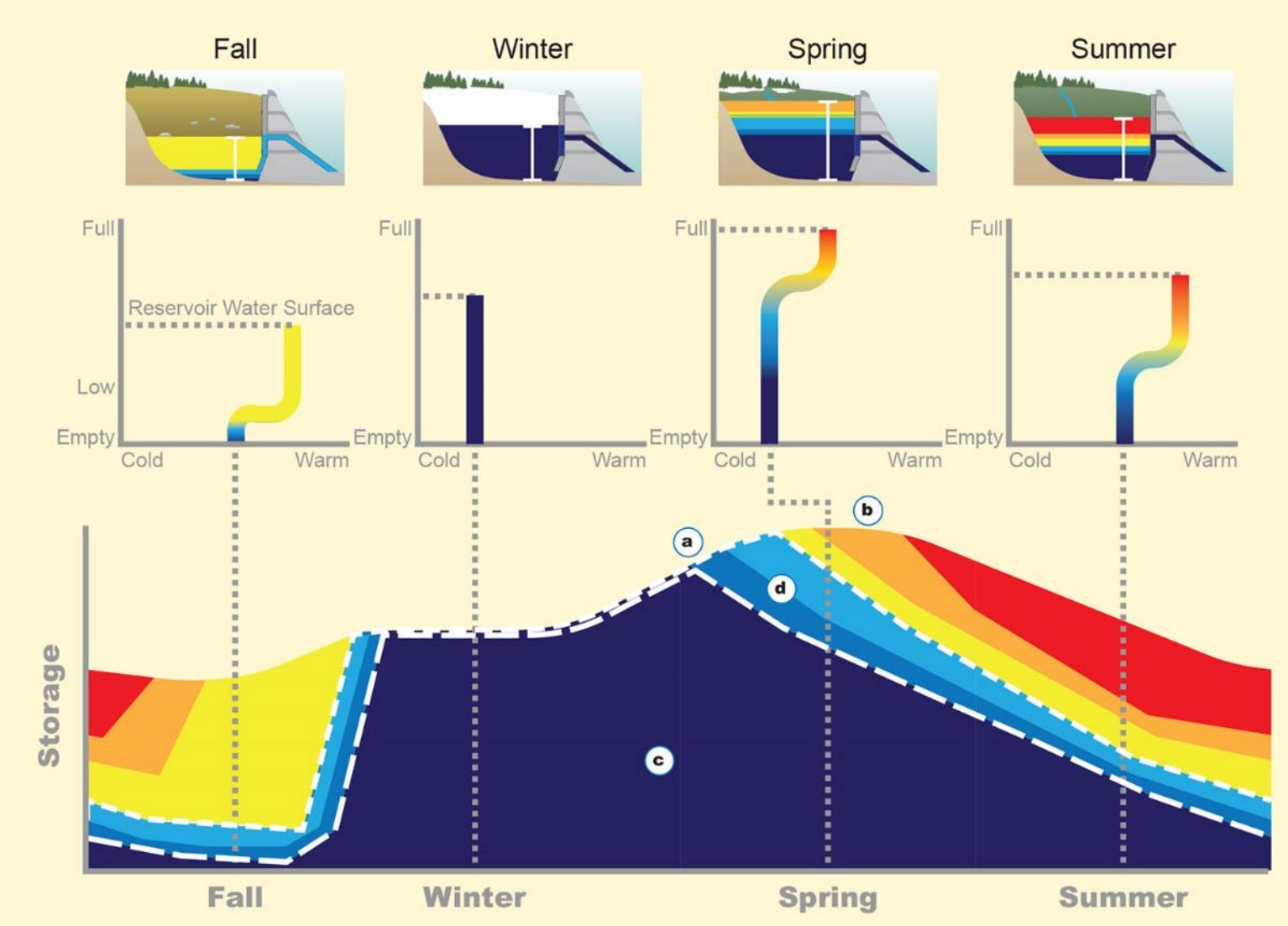
Randi Field, Civil (Hydrologic) Engineer, CVO

Active Temperature Management serves Downstream CVP Goals

- Environmental Goals: Fishery habitat objectives

- How?
  - Reservoir Stratification and Cold-Water Pool Resources
  - Facility Infrastructure and Systemwide Operations
  - Computational tools
  - Seasonal, Real-Time, and Long-Term Planning Products

Water Temperature Management Story



Elements of Temperature Management

The Why

1. **Environmental Objectives:** Defining management criteria (e.g., target species' seasonal temperature requirements and their distribution in downstream river reaches).

The Resources

2. **Total Reservoir Storage:** Defining cold water volume through reservoir storage.

3. **Reservoir Water Temperature Profile:** Defining cold water volume through thermal profile characterization.

The Means

4. **Selective Withdrawal:** Assessing selective withdrawal facilities and strategies.

5. **Tail Bay Water Temperature Management:** Determining reservoir tail bay temperatures.

The Factors

6. **Meteorological Conditions:** Determining heat gain from the reservoir to downstream river management locations to inform decision-making processes.

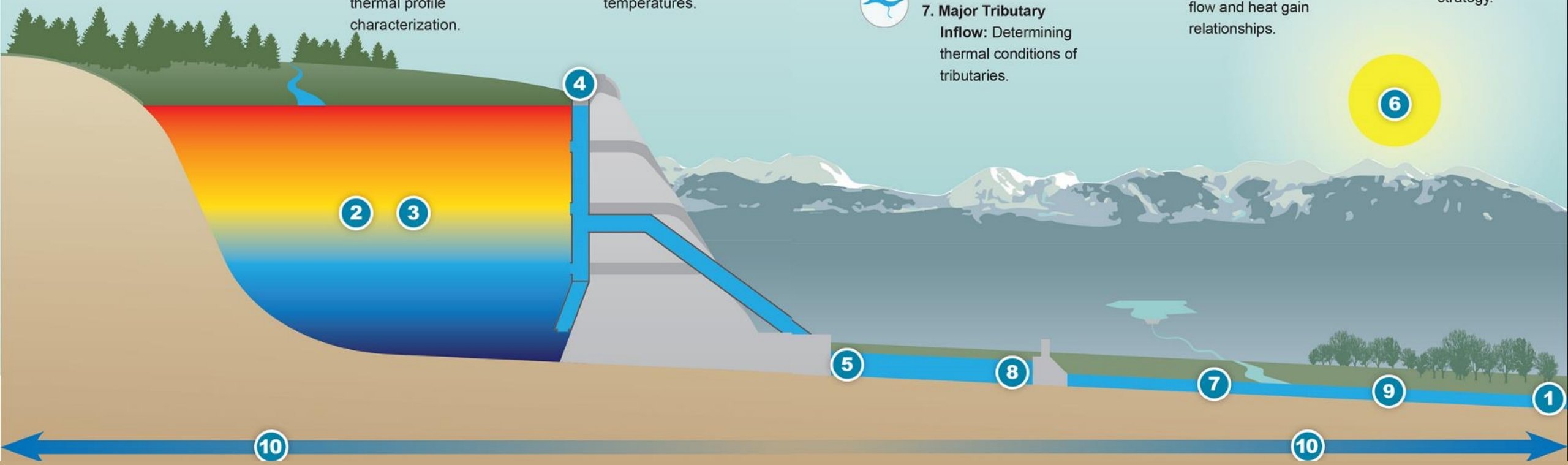
7. **Major Tributary Inflow:** Determining thermal conditions of tributaries.

8. **Regulating Reservoirs:** Characterizing re-regulating reservoir conditions and river release temperatures.

9. **River Flow Heat Gain Relationship:** Employing river flow and heat gain relationships.

The Methods

10. **Monitoring:** Using system-wide monitoring network information to assess conditions and adapt the selective withdrawal strategy.



Reference: Reclamation, 2017. Water Temperature Management in Reservoir-River Systems through Selective Withdrawal, Reference Technical Memorandum for Central Valley Project Operation, California. September.

Existing Modeling Capabilities

- Current Tools:
  - HEC-5Q – Shasta, Trinity, Whiskeytown
  - iCPMM – American
  - HEC-5Q – Stanislaus
  - Reclamation Temperature Models – Trinity, Whiskeytown, Shasta, Folsom, New Melones, and Tulloch
- Seasonal and long-term planning applications
  - Historical time-series and forecasting modes

Temperature Modeling Challenges

- Software is not supported by developer
- Documentation does not satisfy today's mindset
- Solution methods are inefficient
- Structure doesn't support:
  - multi-model comparisons
  - sensitivity/risk/uncertainty evaluations
  - leveraging data wealth
- Processing workflow is cumbersome and tedious

General Modeling Development Needs

- Modernize Tools to Support the CVP Operations
  - Expect high quality
  - Build trust and confidence with transparency and consistency
  - Optimize flexibility/adaptability
  - Design for compatibilities/efficiencies
  - Plan for long-term horizon
  - Enhance within agency expertise

Water Temperature Modeling Needs

- What are the needs?
  - Address spatial/temporal tiering needs for biological modeling
  - Software support: Transition to supported software products
  - Efficient use of time:
    - Options for computational run-time
    - Automate tasks that don't require decision-making
    - Streamline model data preparation and reporting
  - Incorporate quality assurance and control:
    - Build-in checking and error reduction capabilities

Water Temperature Modeling Needs (cont.)

- Enhance model comparison and reporting capabilities
- Streamline testing/tuning capabilities: Performance assurance
- Address Uncertainty: Evaluation and communication
- Flexibility: Respond to changing environment - physical structure, regulatory requirements, climate variability
- Documentation: Robust and transparent

Vision for WTMP Project

Goal: Deliver quality products to support Reclamation's mission – predict water temperature to support CVP operations

- Modernize Systemwide Water Temperature Modeling and Analytics
- Develop to Professional Standards – foster collaboration and transparency
- Consistency cross uses: Real-Time, Seasonal, and Long-term Planning
- Design for flexibility
- Leverage technological advancements
- Build expertise

Anticipated Outcome

- Address modeling needs and challenges via WTMP development effort
- Modeling Technical Committee (MTC) - Ongoing, quarterly meetings
- Distributable model platform and data – Project Completion 2023

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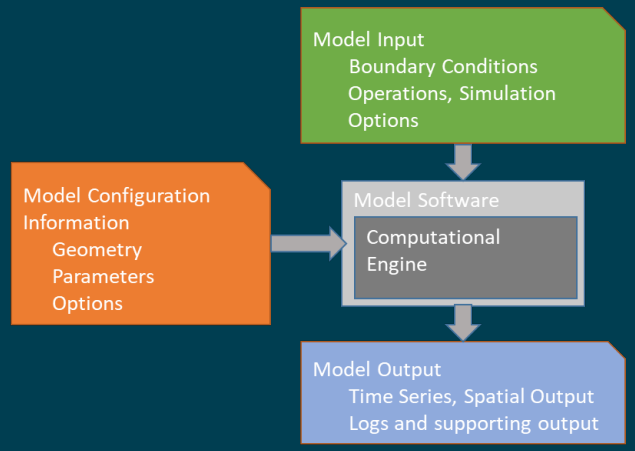
WTMP Design

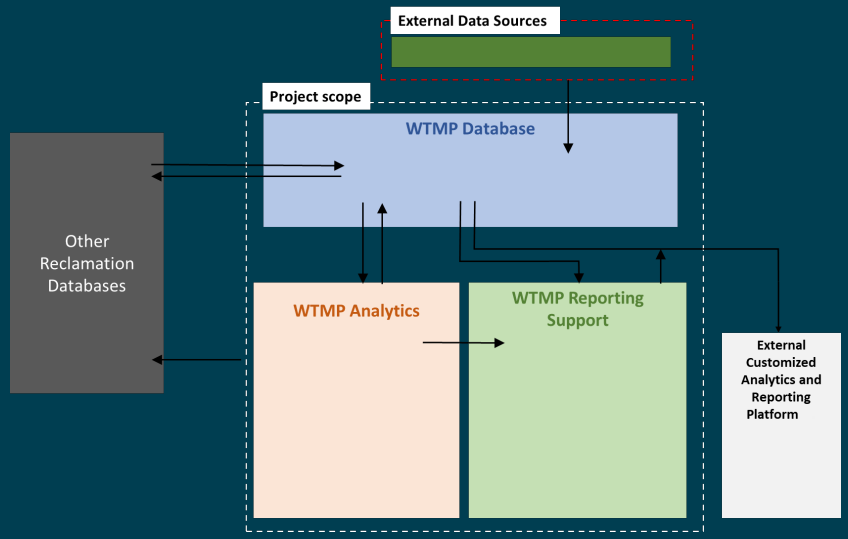
- Facilitating Production use of Temperature Models

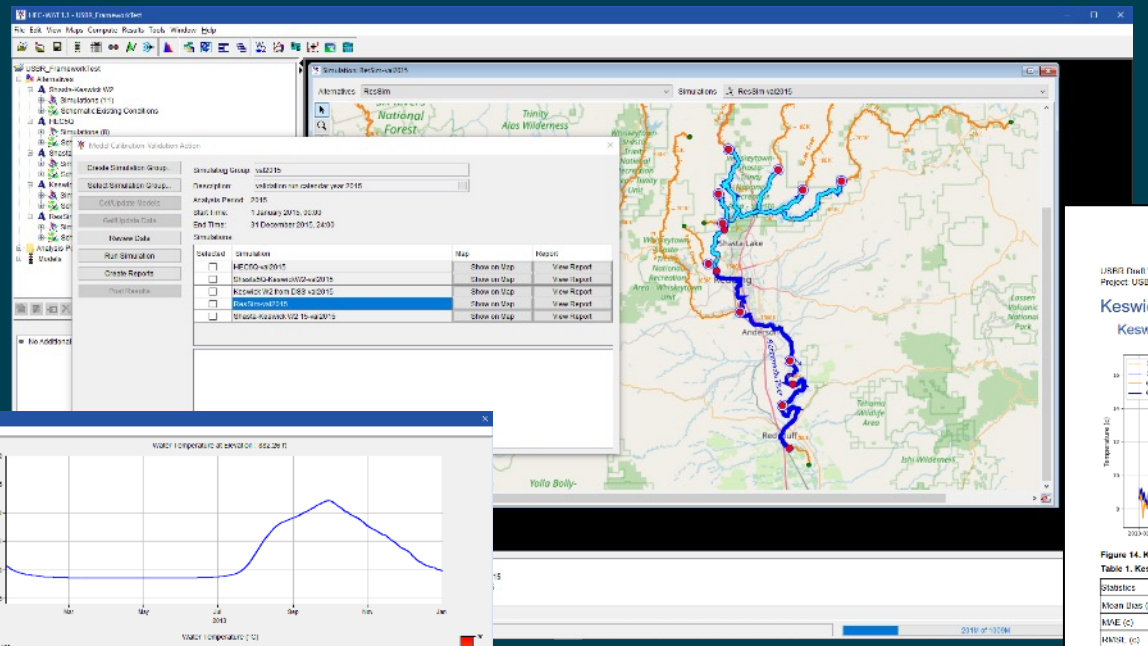
John DeGeorge Ph.D., P.E., Resource Management Associates, Inc.

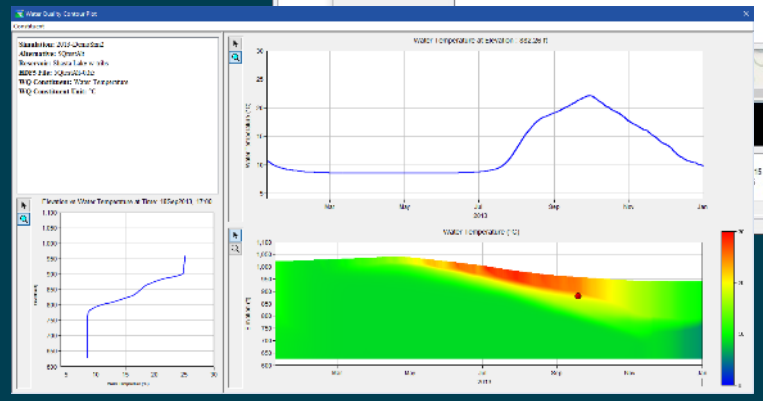
Overview

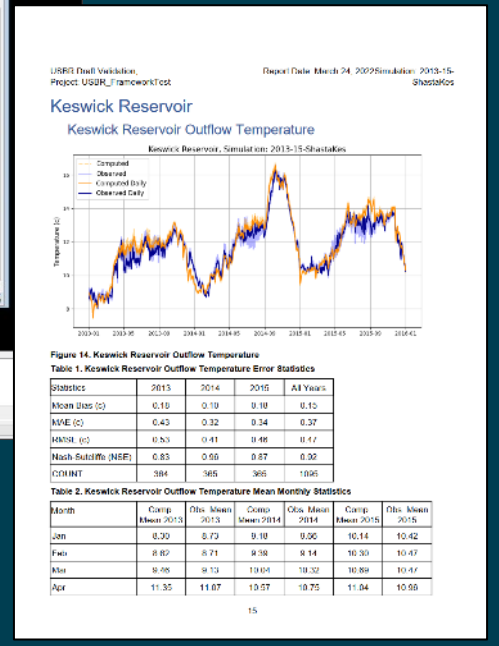
- Objectives
- Data Flow
- Design
- Progress To Date











WTMP Objectives

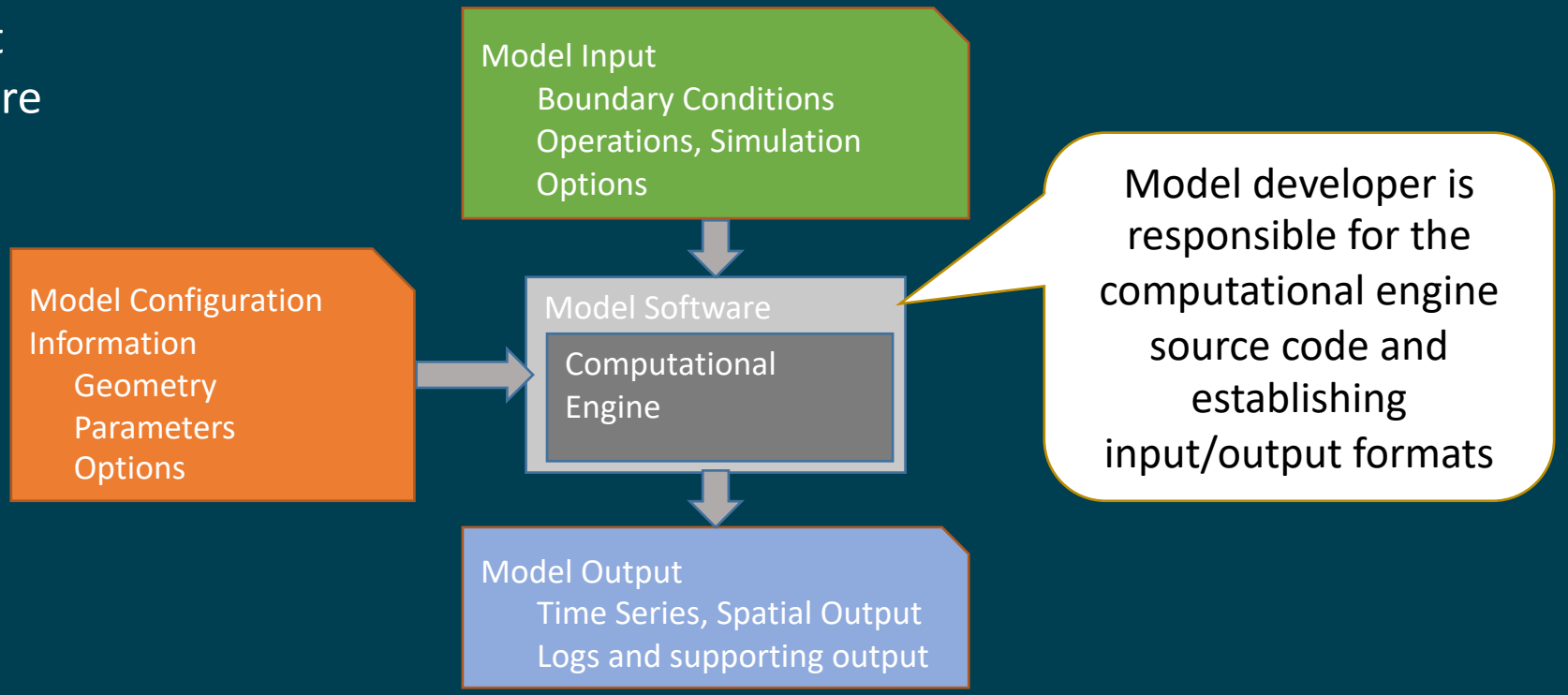
Enhance Efficiency, Consistency, Adaptability and Transparency

- 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!

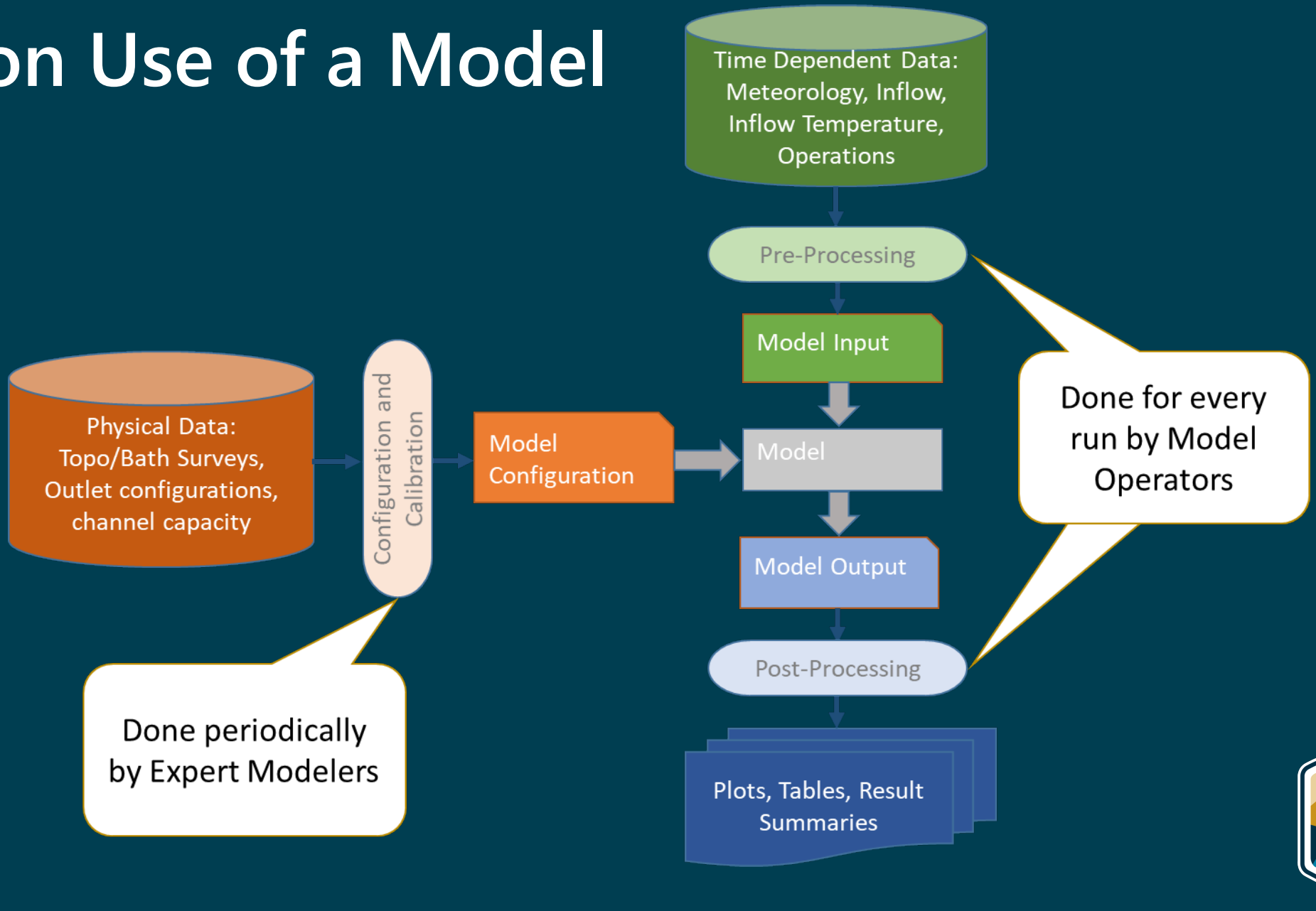
Model, Configuration, Input and Output

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

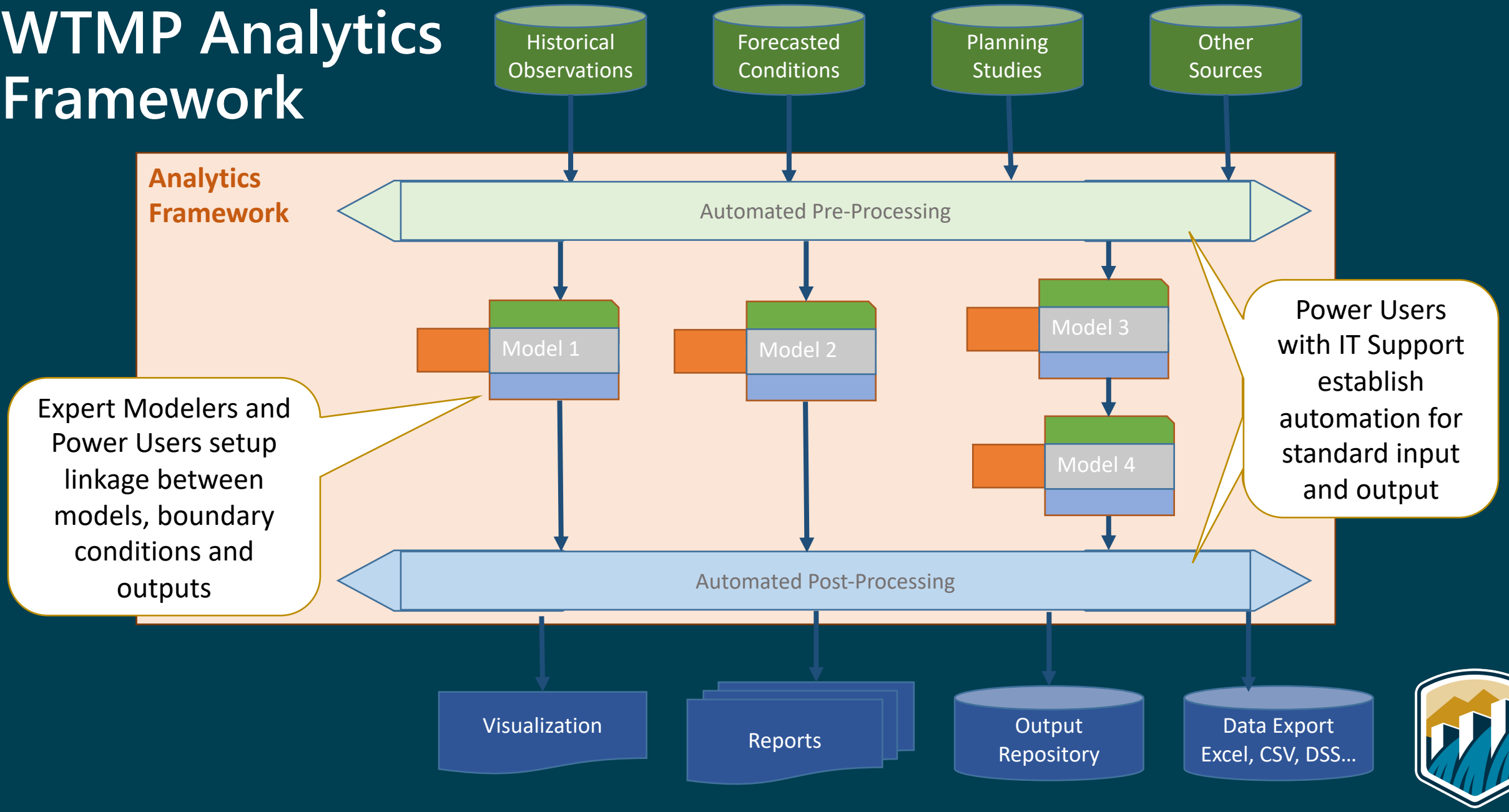
- CE-QUAL-W2
- HEC-5Q
- HEC-ResSim
- CALSIM II
- DSM2
- …



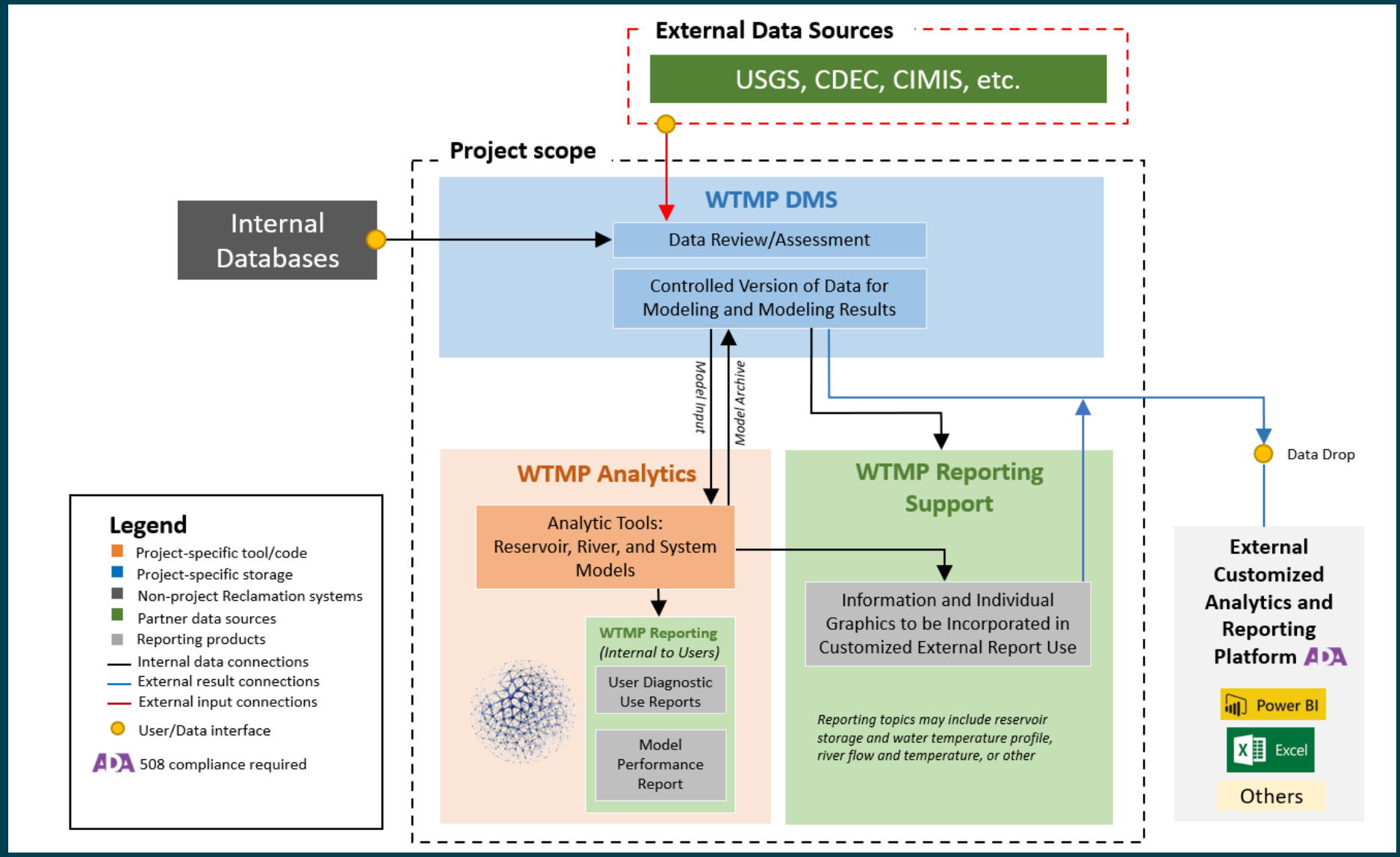
Production Use of a Model



WTMP Analytics Framework



WTMP Data Flow



Framework Functions for Team Members with Different Roles

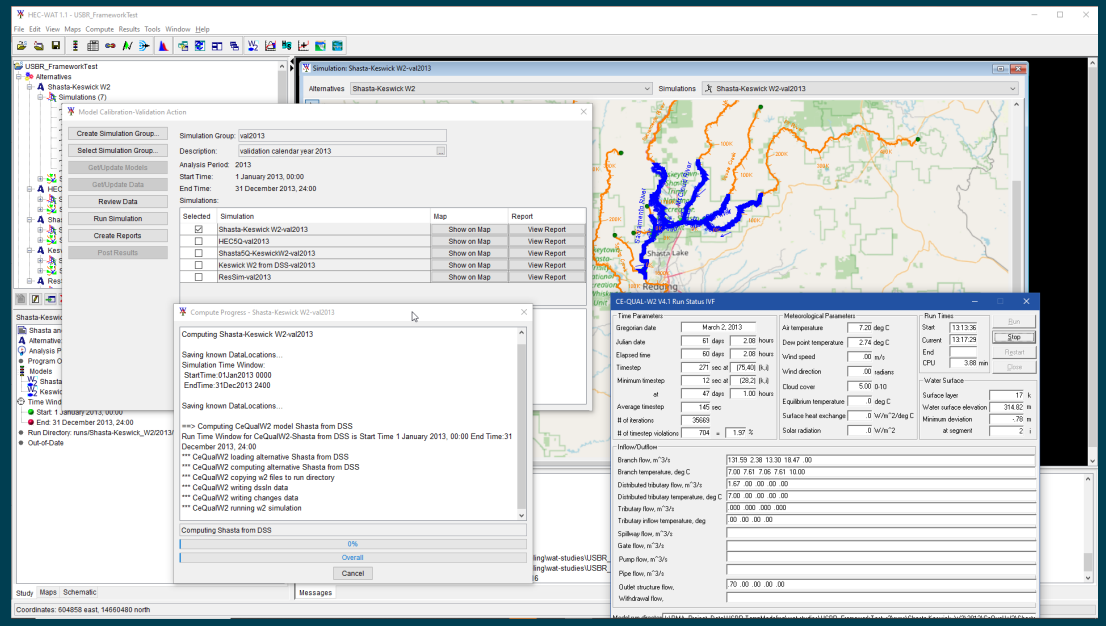
- **Model Developer:** Responsible for the development and maintenance of a model's computational engine
- **Expert Modeler:** Responsible for configuration and calibration of a model for a particular system
- **Power User:** Configures automated processing for pre- and post- processing, designs reports,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

Design Criteria

- Initial focus on Desktop Modeling with eventual expansion to distributed/cloud computation
- Support target model software
- Support linking a sequence of models
- Utilize common data source for boundary conditions
- Provide output in common formats
- Support periodic upgrades to modeling software and configuration
- Publicly distributable
- Team collaboration

HEC-WAT selected for Analytics Framework

- HEC-Watershed Analysis Tool (HEC-WAT)
  - Product of the USACE Hydrologic Engineering Center
  - Freely Distributable
  - Supports local and Cloud based computation
  - Existing support for CE-QUAL-W2, HEC-ResSim, and HEC-RAS
  - Plug-in Application Programming Interface (API) for extension of modeling capabilities
    - Data Management
    - User Interface
    - Computational Model Support
    - Reporting



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

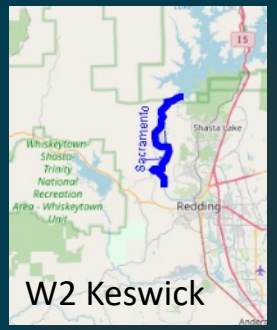
Enhancement to WAT Capabilities
using HEC-WAT Plugin Technology

- Use of Remote Data Source (extract and post from/to web data service)
- Interface to Facilitate Production Use Cases
- Automated Report Generation
- Version Management for model computational code and configuration data sets

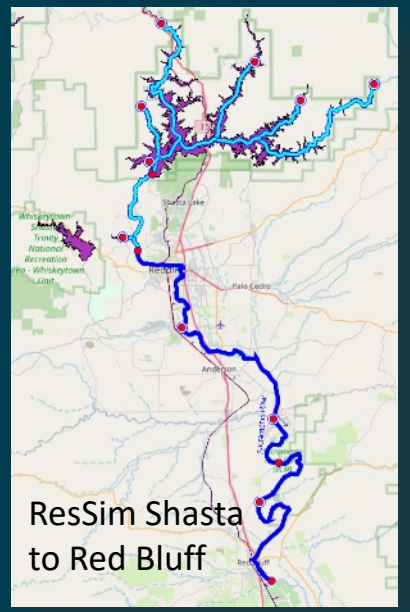
Models

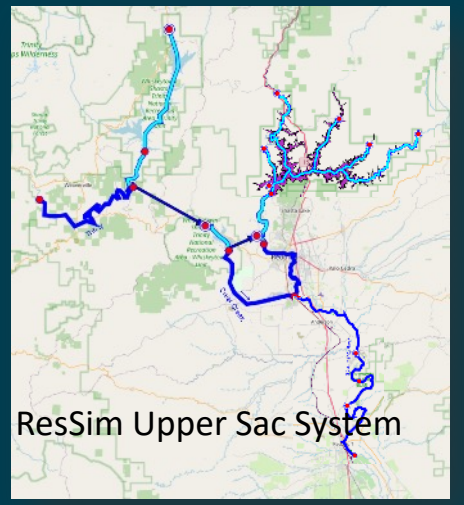
- HEC-ResSim
  - 1D Rivers and Reservoirs
  - Rapid System Simulation
- CE-QUAL-W2
  - 2D Laterally Averaged Reservoirs
  - Detailed Reservoir Simulation
- Other models can be supported in the future
  - HEC-RAS through existing plugin
  - General scripted processes
  - New plugins for additional physical process or statistical models


W2 Shasta



W2 Keswick

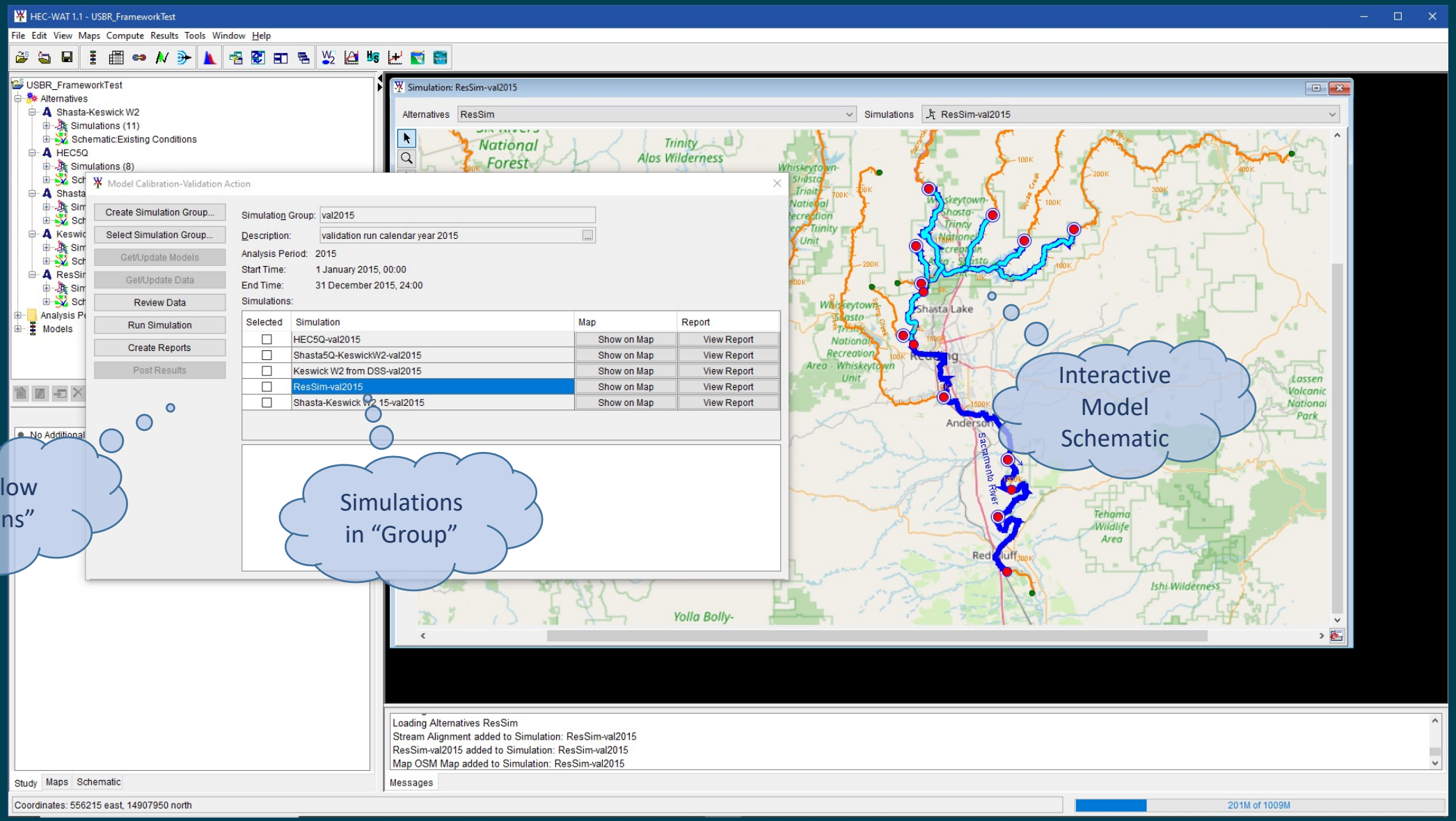

ResSim Shasta to Red Bluff


ResSim Upper Sac System

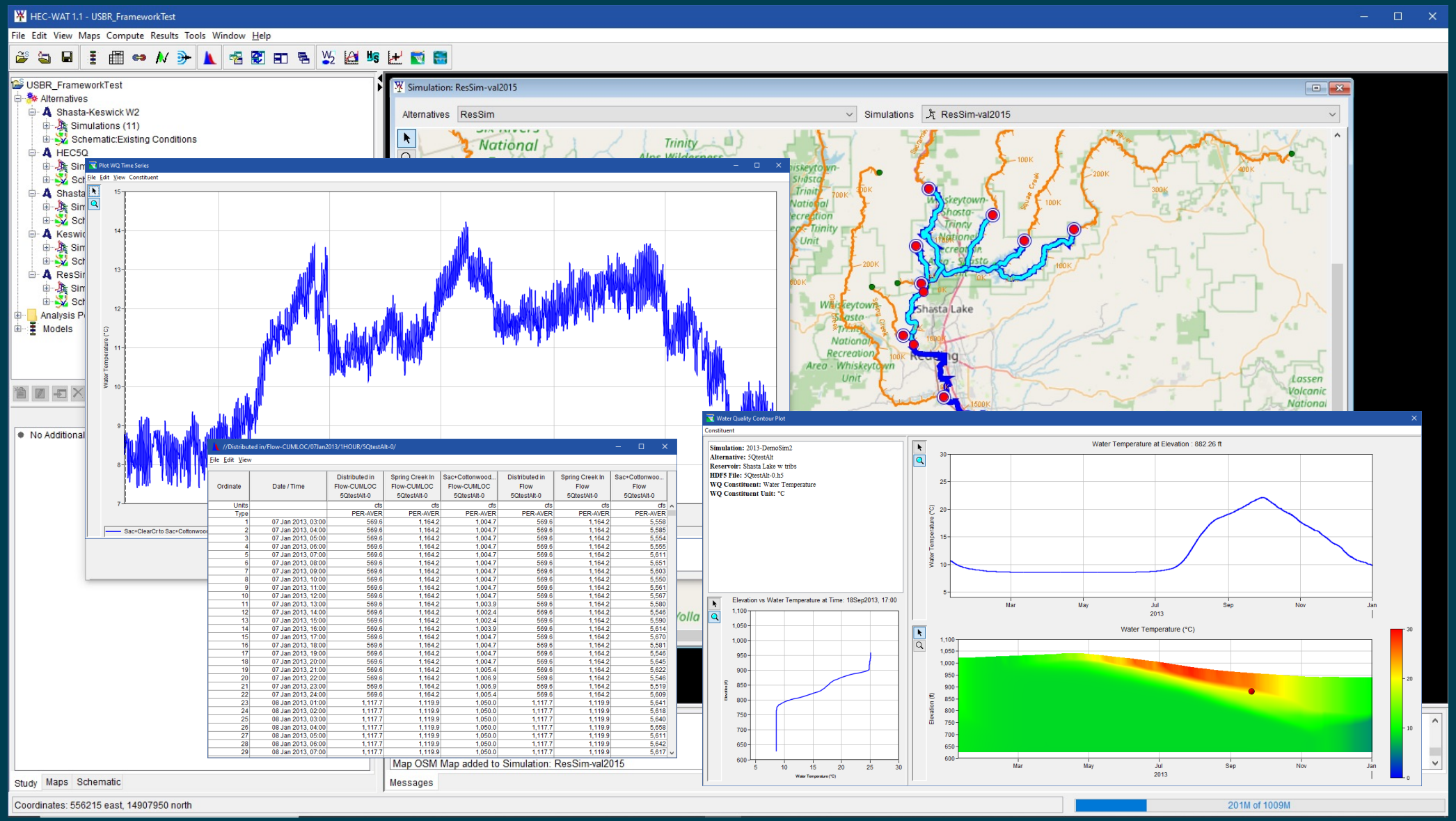
Use Cases

- Calibration/Validation
- Sensitivity and Uncertainty Analysis
- Ensemble Simulation
- Temperature Management Plan Development
- Planning Analysis

Demonstration Screens – ResSim Model Displayed



Interactive Visualization



Automated Reporting

DRAFT Temperature Model Validati

Project: USBR Framework Test USBR_Framew

Simulation: 2013-15-ShastaKes
Simulation Date: February 11, 2022 13:04
Report Date: March 24, 2022

USBR Draft Validation,
Project: USBR_FrameworkTest

Report Date: Mar

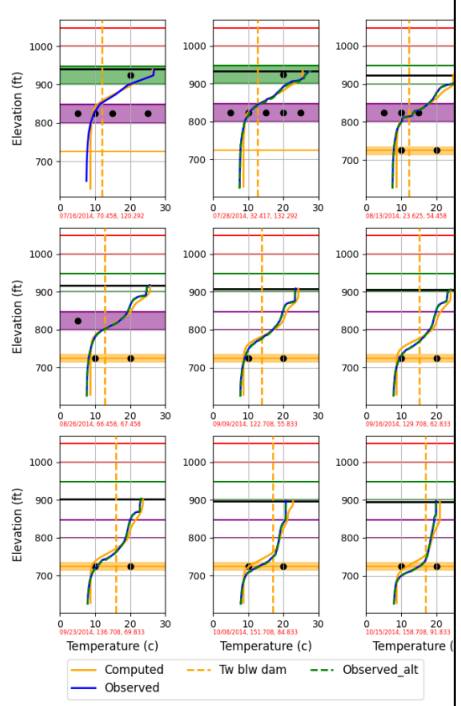


Figure 4. Shasta Lake 2014: 2 of 3

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USBR Draft Validation,
Project: USBR_FrameworkTest

Report Date: Mar

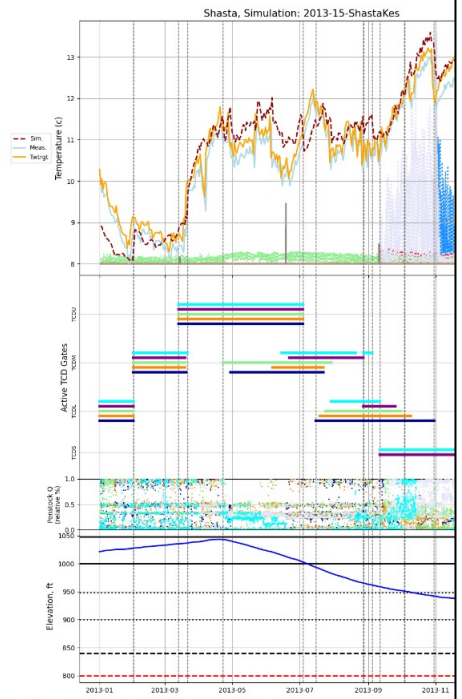

Figure 11. Shasta Temperature Outflow

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USBR Draft Validation,
Project: USBR_FrameworkTest

Report Date: March 24, 2022Simulation: 2013-15-ShastaKes

Keswick Reservoir

Keswick Reservoir Outflow Temperature

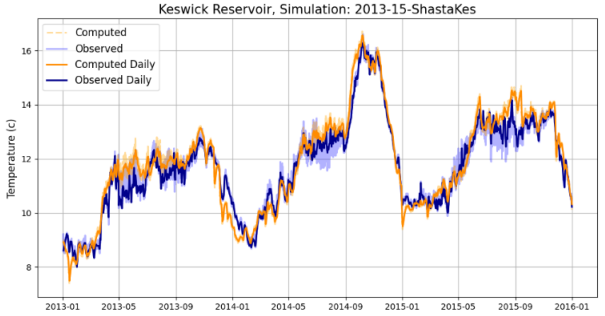

Figure 14. Keswick Reservoir Outflow Temperature

Table 1. Keswick Reservoir Outflow Temperature Error Statistics

Statistics	2013	2014	2015	All Years
Mean Bias (c)	0.18	0.10	0.18	0.15
MAE (c)	0.43	0.32	0.34	0.37
RMSE (c)	0.53	0.41	0.46	0.47
Nash-Sutcliffe (NSE)	0.83	0.96	0.87	0.92
COUNT	364	365	365	1095

Table 2. Keswick Reservoir Outflow Temperature Mean Monthly Statistics

Month	Comp. Mean 2013	Obs. Mean 2013	Comp. Mean 2014	Obs. Mean 2014	Comp. Mean 2015	Obs. Mean 2015
Jan	8.30	8.73	9.18	9.66	10.14	10.42
Feb	8.62	8.71	9.39	9.14	10.30	10.47
Mar	9.46	9.13	10.04	10.32	10.69	10.47
Apr	11.35	11.07	10.57	10.75	11.04	10.96

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Summary

- The WTMP's objectives are to enhance efficiency, consistency, adaptability and transparency of the temperature modeling process
- Primary components are the data management system and analytics framework
- HEC-WAT has been selected for as the foundation of the analytics framework with customization for the WTMP with "plugins"
- CEQUAL-W2 and HEC-ResSim will be the primary model software for initial implementation; build-in flexibility to add other models in the future
- The WTMP is in use during configuration and calibration of the models for the Sacramento/Trinity, American, and Stanislaus Rivers
- Target use cases, including sensitivity/uncertainty analysis, for real-time, seasonal and long-term planning purposes

Photo credit: John Hannon, Reclamation

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Approach to CVP WTMP Development

Mike Deas, PhD, PE, Watercourse Engineering, Inc.

Presentation Overview

- Project Team
- Technical Charge
- WTMP Development Approach
- Project Schedule

Project Team

- Watercourse Engineering, Inc.
- Resource Management Associates, Inc (RMA)
- Cardno, now part of Stantec
- Eyasco, Inc.
- Stantec Consulting Services Inc. (Stantec)
- Tom Camara Graphics

Technical Charge

- Develop tools to support Reclamation's water temperature management activities
  - Data management
  - Model development
  - Model management (framework)
  - Model reporting
  - Documentation
  - Other
- Representative, Useful, Relevant, Longevity

WTMP Development Approach

- Phase I
  - Modeling domain
  - Modeling framework
  - Models
  - Data management
  - Calibration/validation
  - Model development
  - Documentation
- Phase II
  - Model implementation/application
  - Sources of uncertainty
  - Documentation

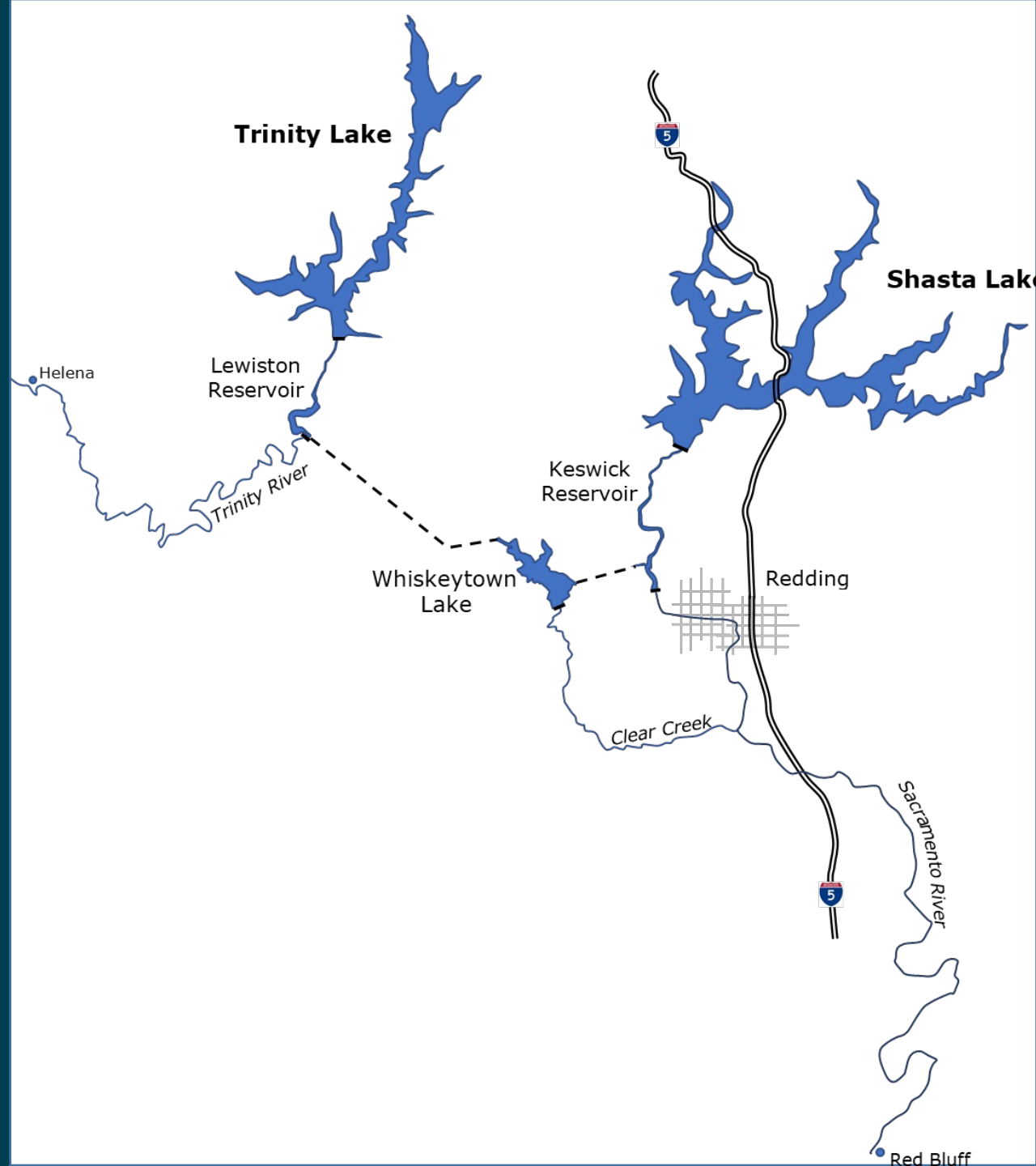
Project Tasks

Workplan (Phase I)	Stakeholder Outreach	Institutional Knowledge	Data Management
Model Framework	Model Selection	Data Development	Source of Uncertainty
Model Calibration/ Validation	Model Development	Workplan (Phase II)	Model Implementation
Model Documentation (Phase I)	Output Communication	Phase II Documentation	Peer Review Support

Phase I | Phase II | Peer Review

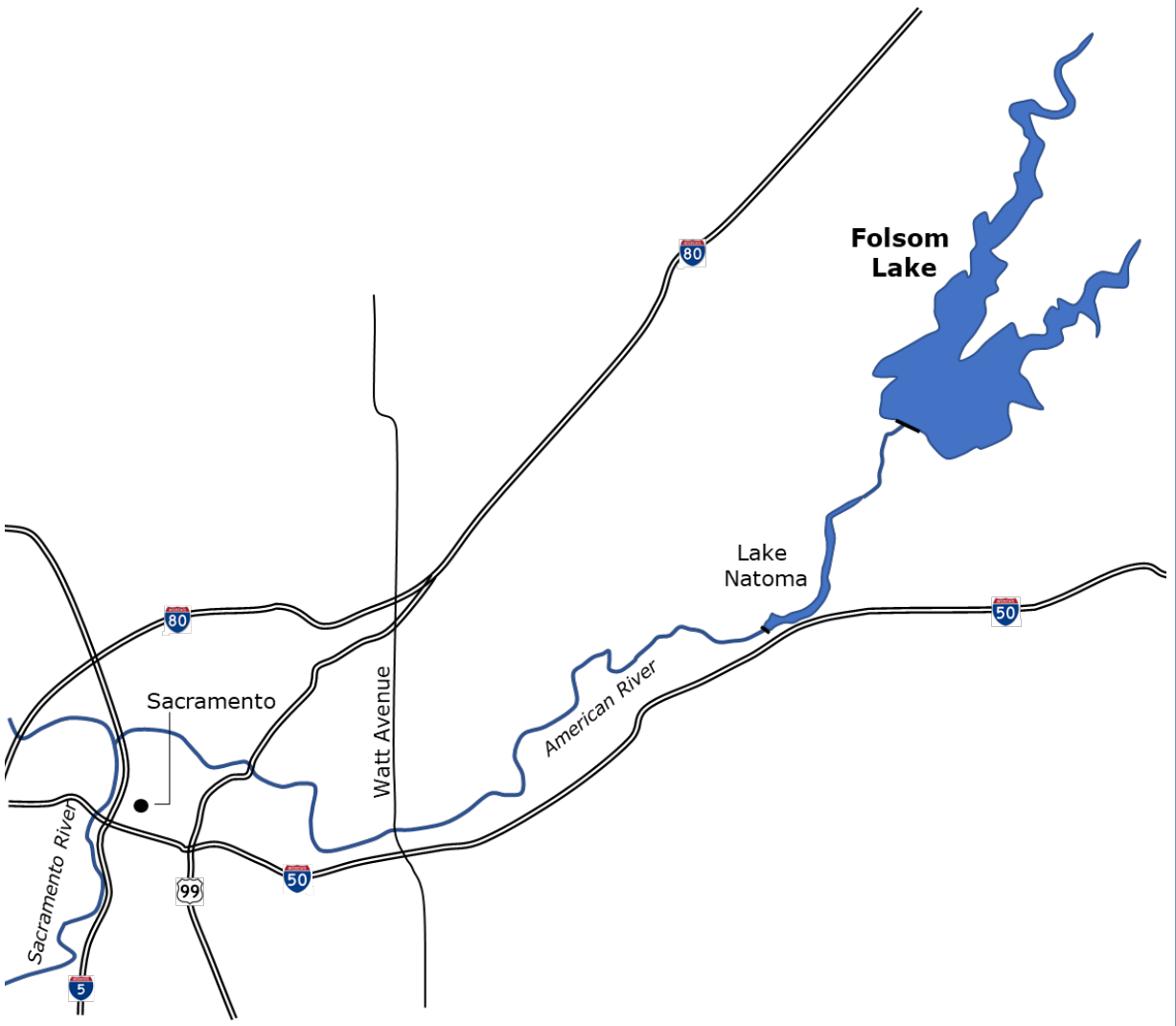
WTMP Domain

- Sacramento River and Trinity River basins
- Facilities:
  - Sacramento
    - Shasta Lake, Keswick Reservoir
    - Sacramento River (to Red Bluff)
    - Whiskeytown Lake
    - Clear Creek (to Sacramento River)
  - Trinity
    - Trinity Lake
    - Lewiston Lake
    - Trinity River (to North Fork)



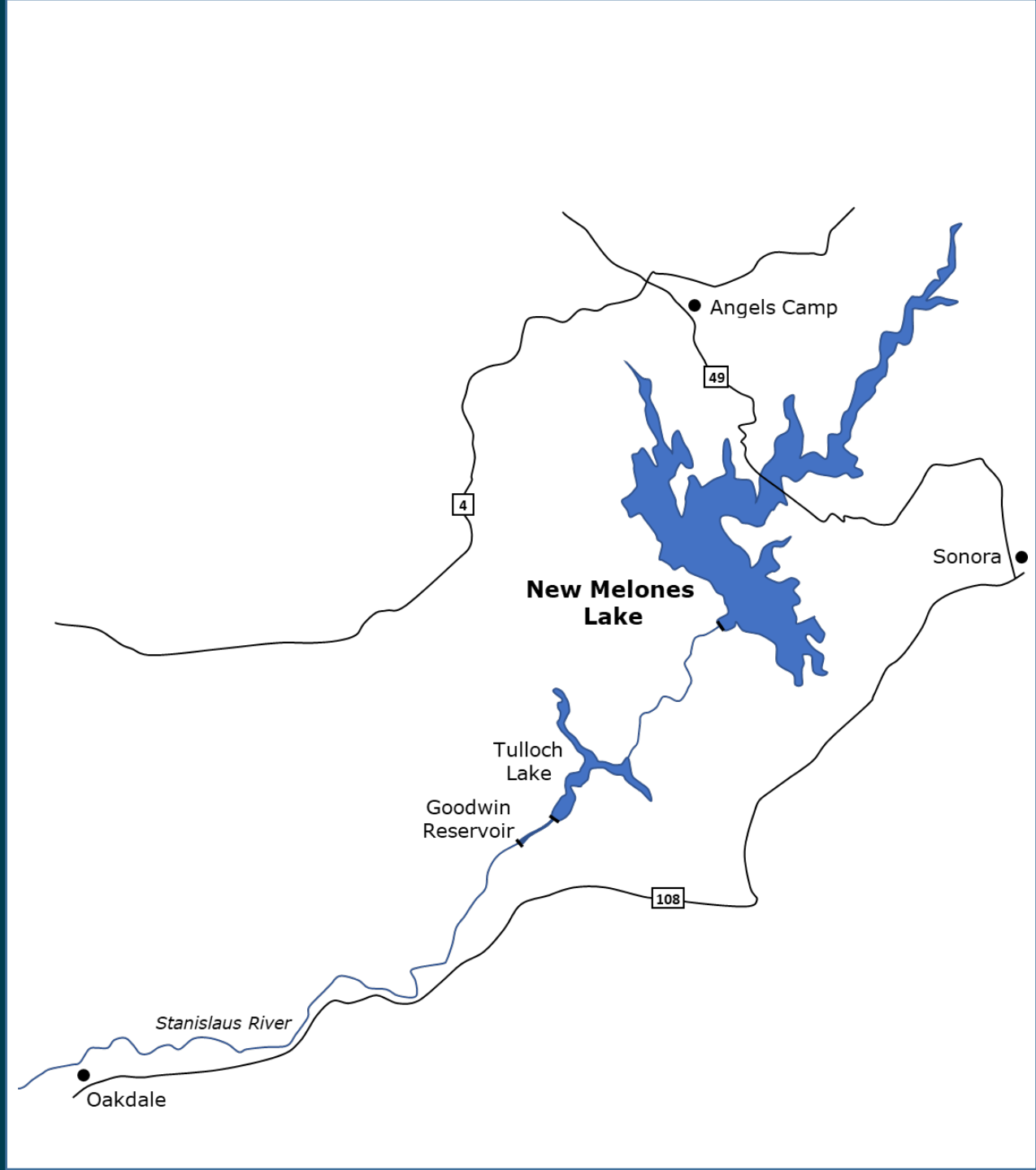
WTMP Domain

- American River basin
- Facilities
  - Folsom Lake
  - Lake Natomas
  - American River (to Sacramento River)



WTMP Domain

- Stanislaus River basin
  - Facilities
    - New Melones Lake
    - Tulloch Lake
    - Goodwin Dam
    - Stanislaus River (to Tuolumne River)

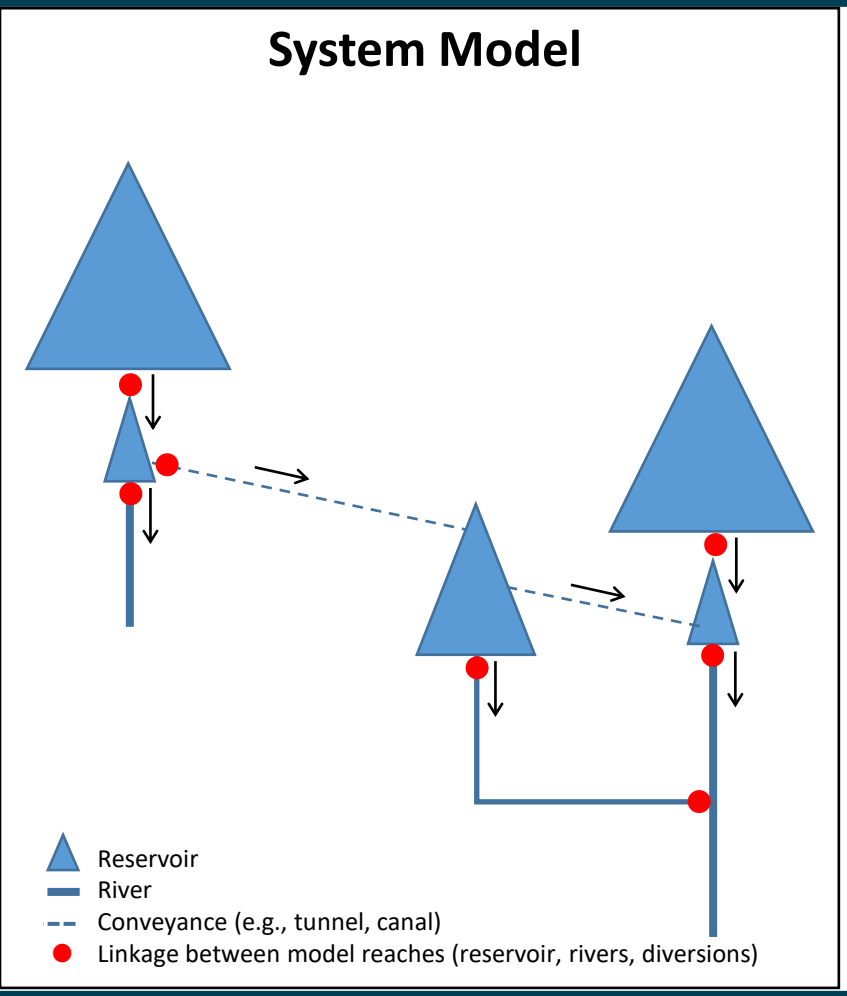


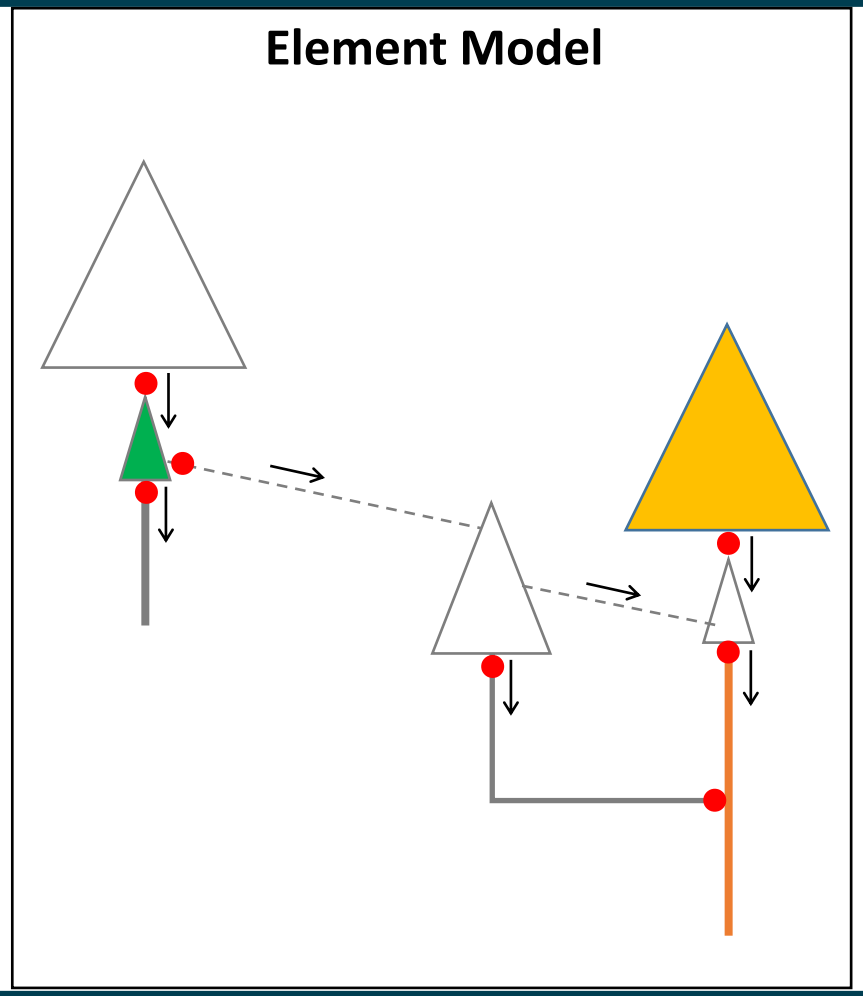
WTMP – Modeling Framework

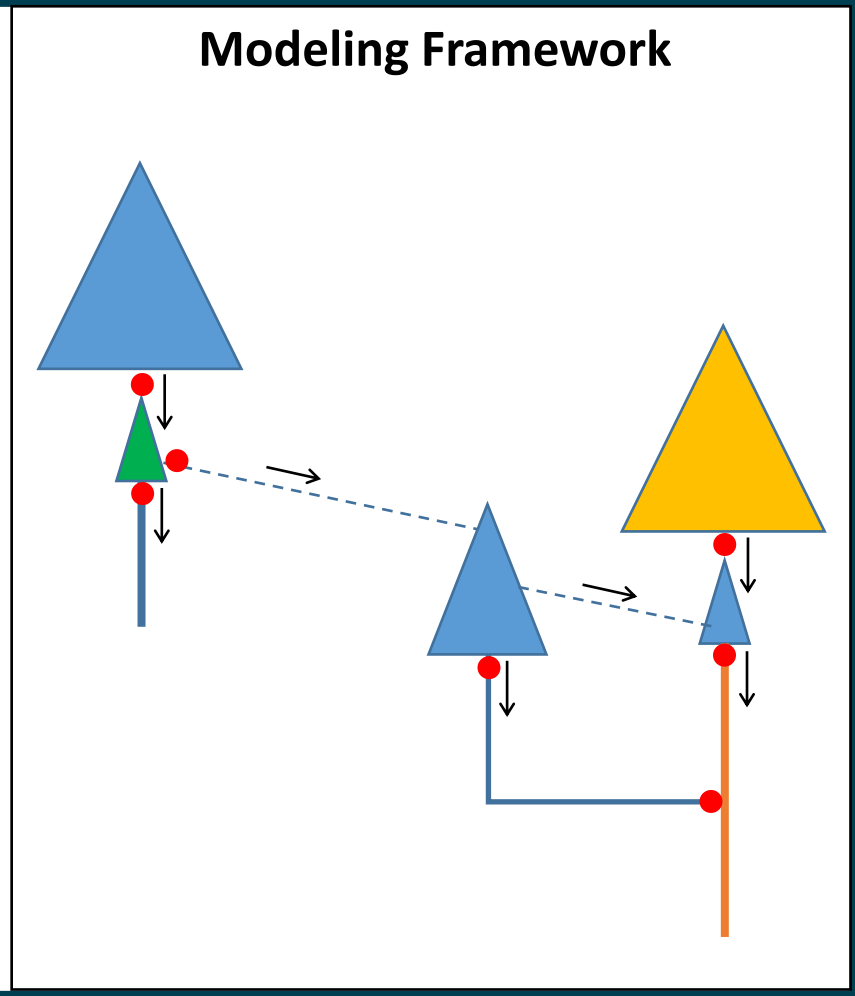
- Framework
  - Criteria development
  - Selection
- Models
  - Criteria development
  - Selection

- Data Management

Model Types/Definitions







Modeling Framework

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 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, data manipulation errors, and errors in general

General Requirements

- Efficiently use several models, individually or in a sequence
- Support work flows for several typical modeling activities
- Utilize common boundary conditions and operational controls across models
- Create reports using common formats across models
- Manage updates of model executable programs and configuration data sets
- Allow for introduction of new modeling tools over time
- Focus on the efficiency of production modeling activities

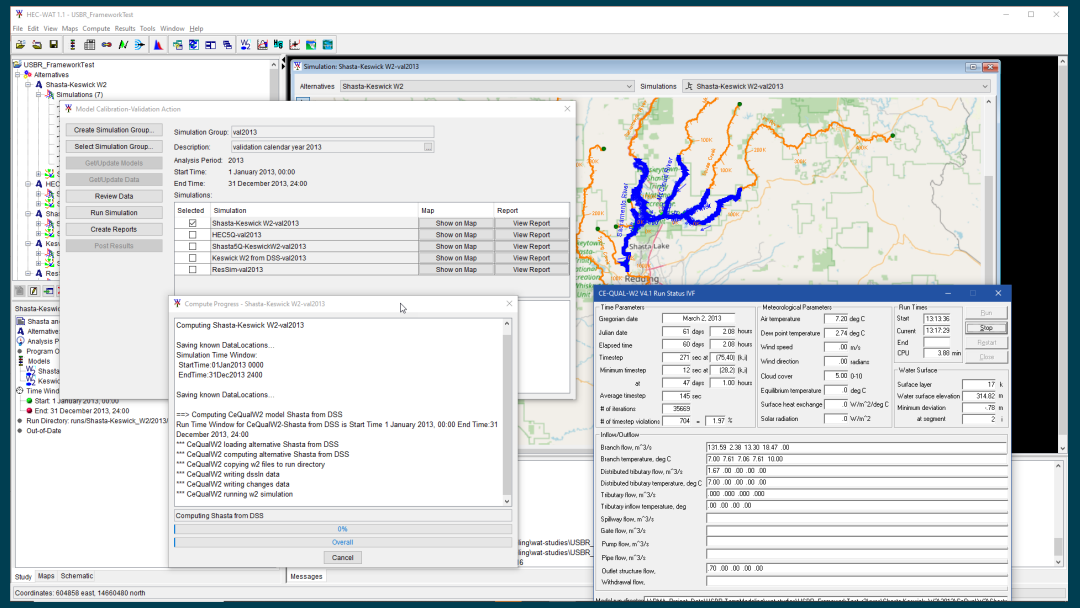
Candidate Frameworks

Framework	Sponsor	Description
Application Programming Interface	OpenMI	Open Modeling Interface
Application Programming Interface	BMI	Basic Model Interface
Software Platform	OMS3/CSIP	Object Modeling System
Software Platform	ESMF	Earth System Modeling Framework
Software Platform	HydroCouple	-
Software Platform	CSDMS	Community Surface Dynamics Modeling System
Software Platform	Delft-FEWS	Flood Forecasting System
Framework Software with User Interface	Delta Shell	-
Framework Software with User Interface	HEC-WAT	Watershed Analysis Tool
Framework Software with User Interface	HEC-RTS	Real Time Simulation

Recommended Framework

- HEC-Watershed Analysis Tool (HEC-WAT)
  - Product of the USACE Hydrologic Engineering Center
  - Freely Distributable
  - Supports local and Cloud based computation
  - Existing support for CE-QUAL-W2, HEC-ResSim, and HEC-RAS
  - Plug-in Application Programming Interface (API) for extension of modeling capabilities
    - Data Management
    - User Interface
    - Computational Model Support
    - Reporting

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



Model Selection Criteria: Subcategories

- Numerical Model Criteria – representation of physical system in a model
- Linkage – addresses if models are discrete (reach specific) or system-wide and if framework compatible
- Input/Output (I/O) – model pre- and post-processors and data structures
- Support – user specific information
- CVP Features – ability to represent specific features CVP
- Qualitative – additional qualitative criteria

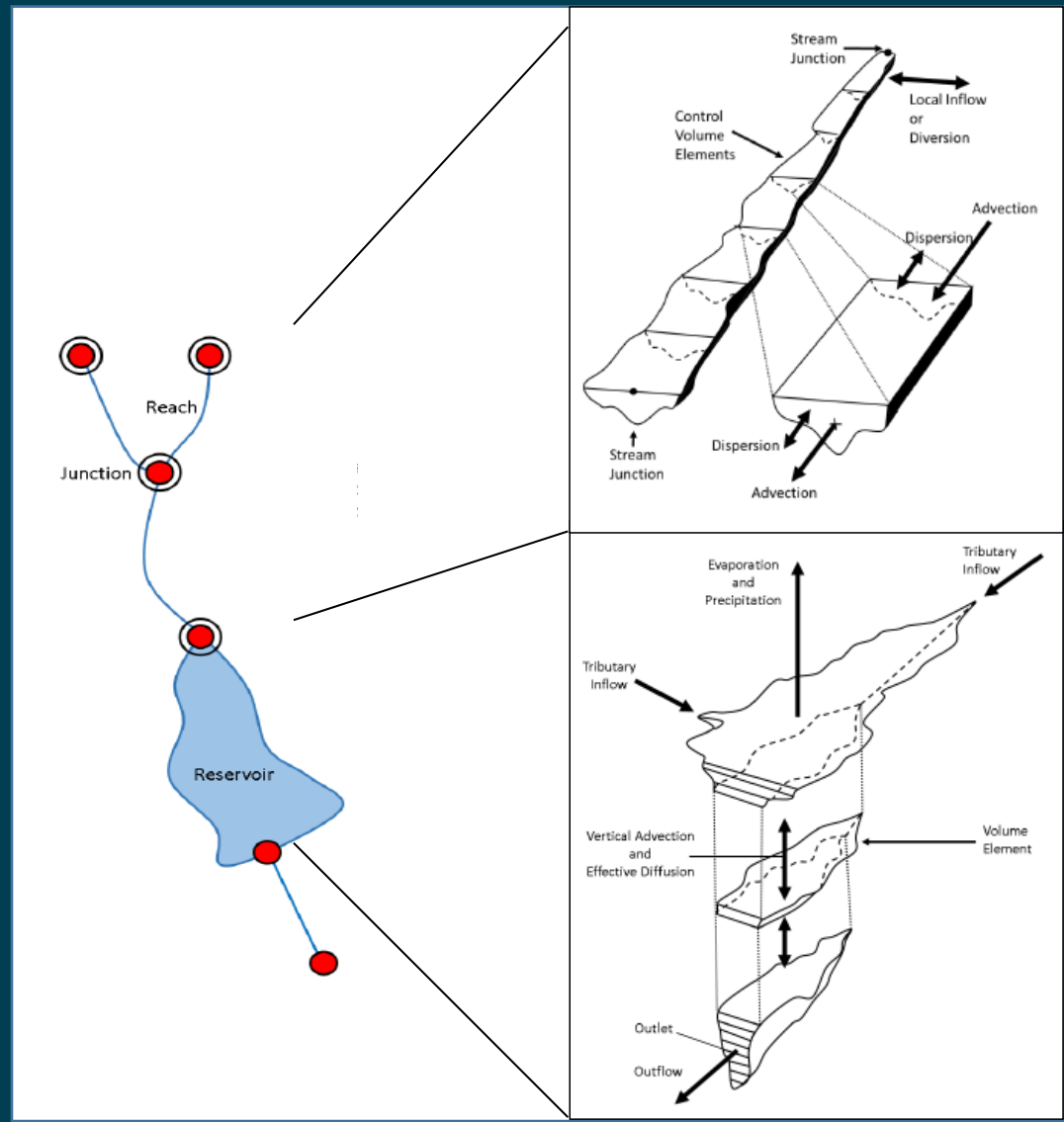
Candidate Flow and Temperature Models

Model	Sponsor	Type
CE-QUAL-W2	PSU, USACOE	Reservoir
DYRESM	CWR-UWA	Reservoir
HEC-5Q	USACOE	System/River
HEC-ResSim	USACOE	System/River
Riverware	CADSWES	System/River
CE-QUAL-RIV1	USACOE	River
EPD-RIV1	GEPD	River
Heat Source	ODEQ	River
HEC-RAS	USACOE	River
QUAL2K	Tufts Univ., USEPA, WDOE	River

CADWES: Center for Advanced Decision Support for Water and Environmental Systems
CWR-UWA: Center for Water Resources, University of Western Australia
PSU: Portland State University
USACOE: US Army Corps of Engineers
GEPD: Georgia Environmental Protection Division
ODEQ: Oregon Department of Environmental Quality
USEPA: US Environmental Protection Agency
WDOE: Washington Department of Ecology

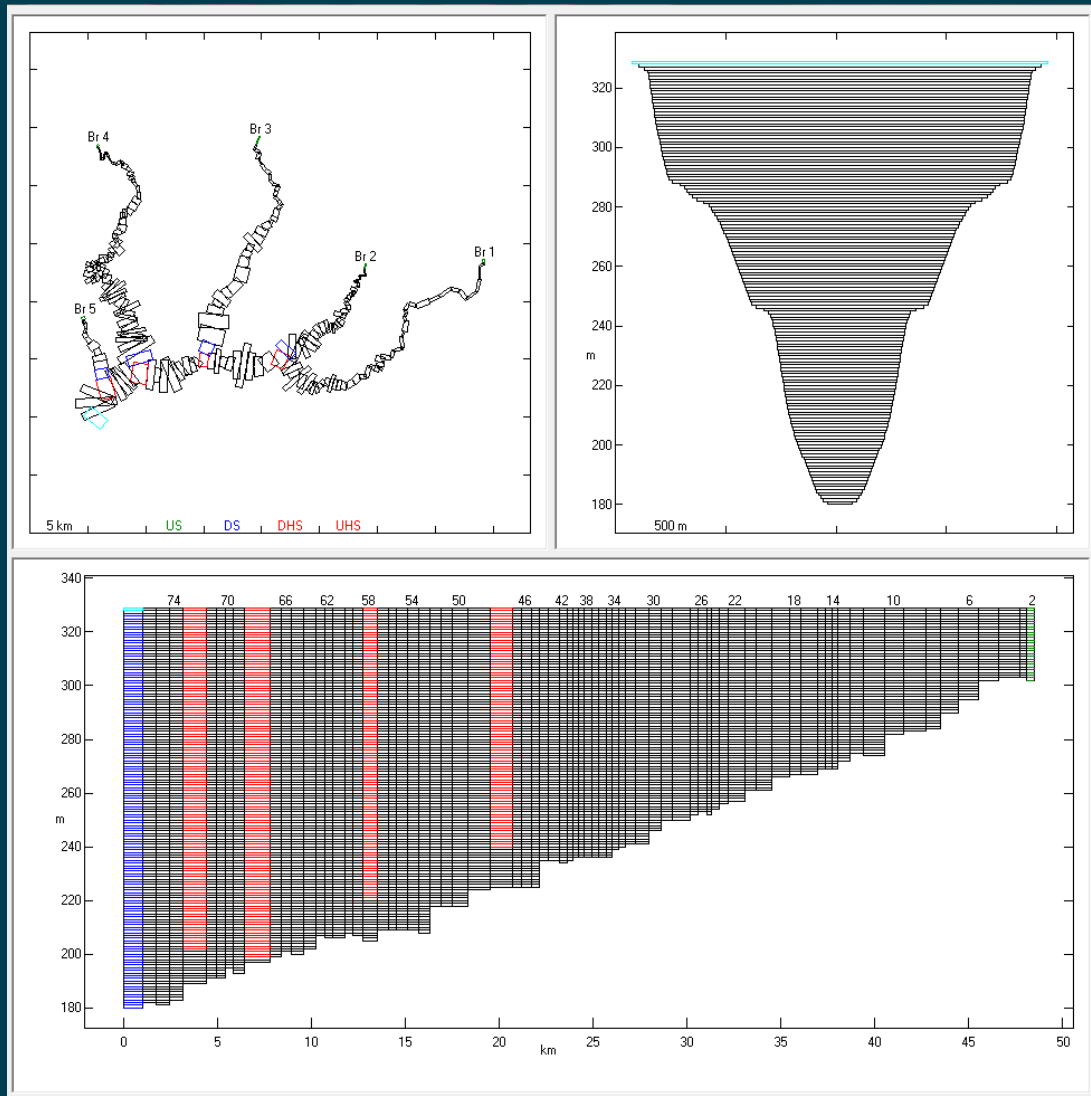
System and River Model: HEC-ResSim

- Non-uniform flow, non-steady state flow
- Full heat budget
- Selective withdrawal (tailbay target)
- Sub-daily time step
- Monte Carlo and Ensemble analyses
- Incorporate new logic via “plug-ins”
- Interface with other models (e.g., CE-QUAL-W2)
- Operate as a stand-alone model or as part of a modeling framework
- One-dimensional (Reservoir Z, River X)
- Pre- and post-processors
- Comprehensive documentation (model, pre- and post-processors)
- Active support (model, pre- and post-processors)
- Access to the model developers, collaboration
- User groups, training

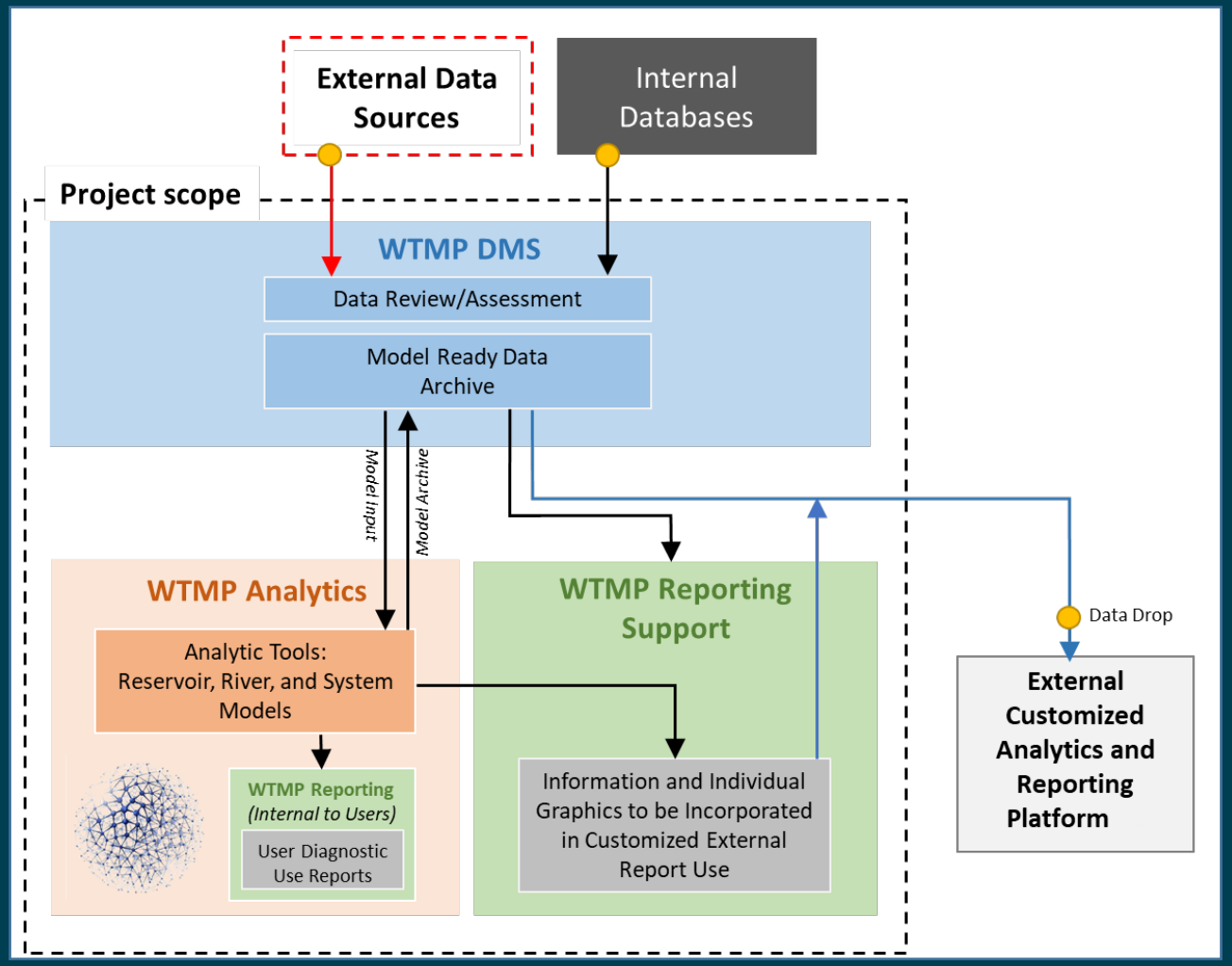


Reservoir Model: CE-QUAL-W2

- Non-uniform flow, non-steady state flow
- Full heat budget
- Selective withdrawal (tailbay target)
- Sub-daily time step
- Operate as a stand-alone model or as part of a modeling framework
- Two-dimensional representation (X-Z)
- Supports branching networks (e.g., dendritic nature of reservoir)
- Existing applications (Shasta, Keswick, Lewiston, Folsom, Natomas)
- Pre- and post-processors
- Comprehensive documentation (model, pre- and post-processors)
- Active support (model, pre- and post-processors)
- Access to the model developers, collaboration
- User groups, training



WTMP Data Management



Model Documentation/Peer Review

- Phase I
  - Technical Memoranda (task-specific)
  - Modeling Report
- Phase II
  - Technical Memoranda (task-specific)
  - Phase II Report

- Peer Review
  - Interim – Phase I (summer 2022)
  - Final – Phase II (summer 2023)

Project Schedule

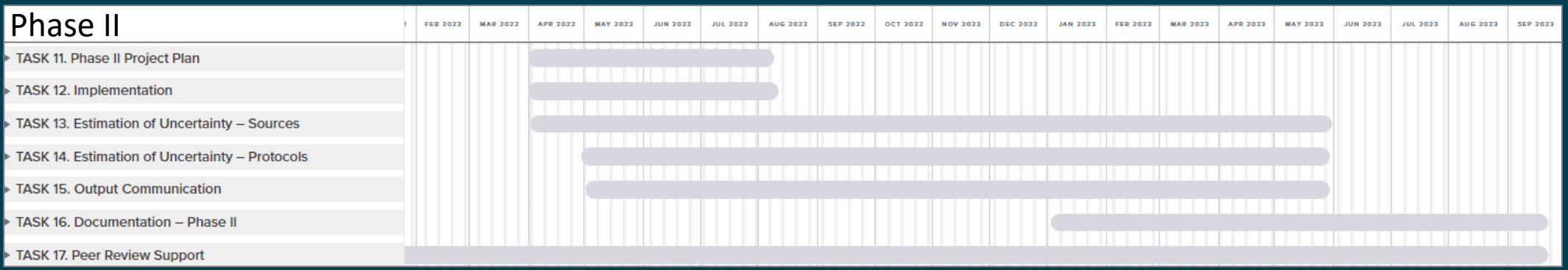


Photo credit: John Hannon, Reclamation

CWEMF

Development of CVP WTMP

- Accomplishments to date

Mike Deas, PhD, PE, Watercourse Engineering, Inc.

Jeff Schuyler, Eyasco, Inc.

Presentation Overview

- WTMP Model Representations
- Data Development and Data Base Management
- Model Implementation and Model Calibration/Validation

WTMP Model Representations: Reservoirs

- Reservoir Attributes
  - Vertical temperature gradient
  - Longitudinal gradient (e.g., afterbays)
  - Cold water pool representation through time
  - Reservoir operations/release temperatures (selective withdrawal)
  - Management actions
- Reservoir Models
  - HEC-ResSim (1-D vertical)
  - CE-QUAL-W2 (2-D vertical and longitudinal)

WTMP Model Representations: Rivers

- Key River Attributes
  - Longitudinal temperature gradient
  - Inflows (e.g., tributaries) and outflows (e.g., diversions)
  - Key in-river reporting locations
  - Management actions
- River model
  - HEC-ResSim (1-D longitudinal)

Data Development

- Model Data Needs
  - Geometry (reservoir and river morphology, facilities descriptions)
  - Boundary Conditions (BC)
    - Flow, stage
    - Temperature time series and vertical profiles (as initial conditions (IC))
    - Meteorology
  - Calibration/Validation data (Cal/Val)
    - Flow, stage
    - Temperature time series and vertical profiles
- Data Sources
  - Many

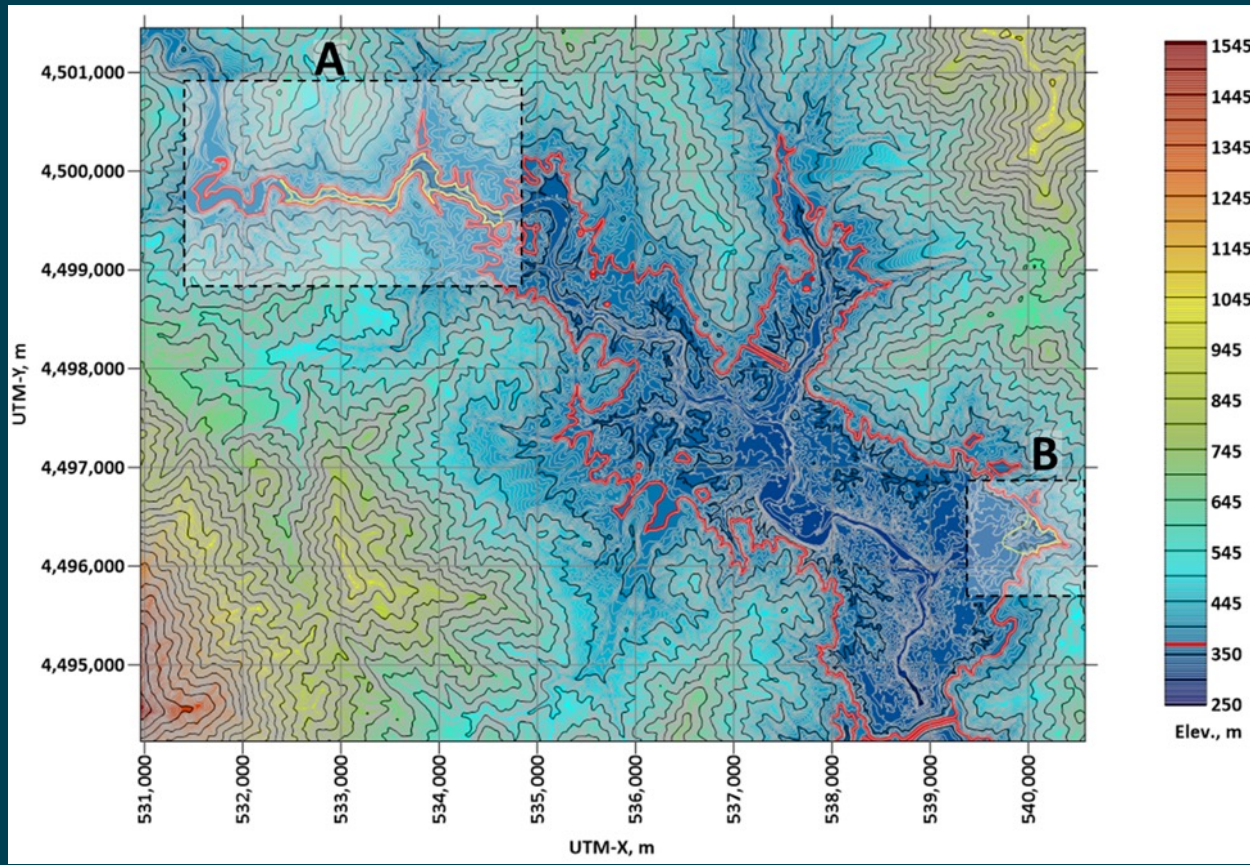
Geometry

- Reservoir Bathymetry and River Morphology (course, cross section, bathymetry)
- Facilities Descriptions
- Selective Withdrawal (Temperature Control) Facilities

Geometry -

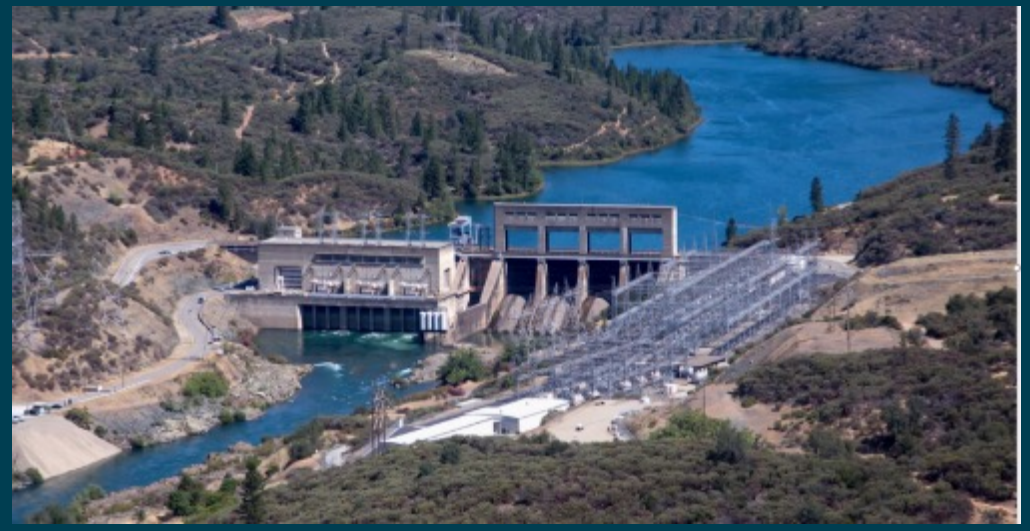
- Existing Information

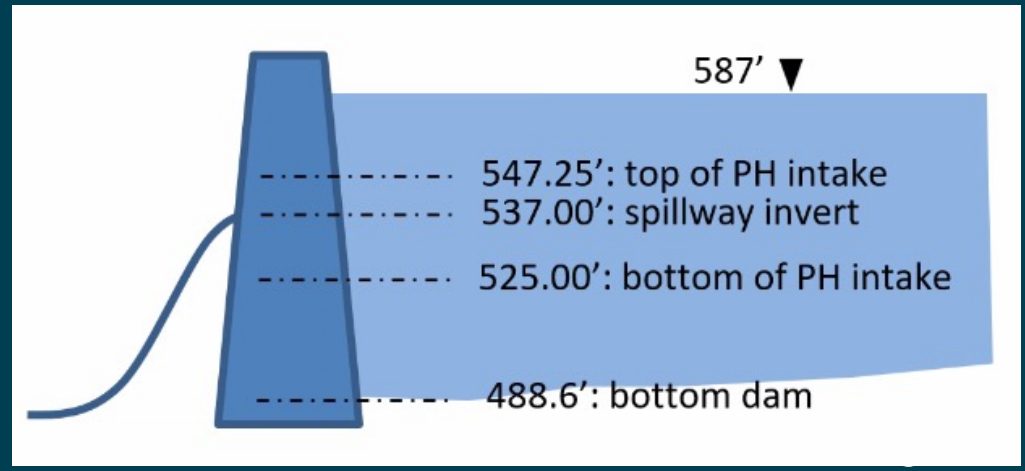
- Additional Geometry Development
  - Whiskeytown Lake bathymetry
  - Trinity Lake bathymetry
  - Sacramento River bathymetry
  - Clear Creek stream alignment, gradient, cross sections



Geometry - Facilities Descriptions

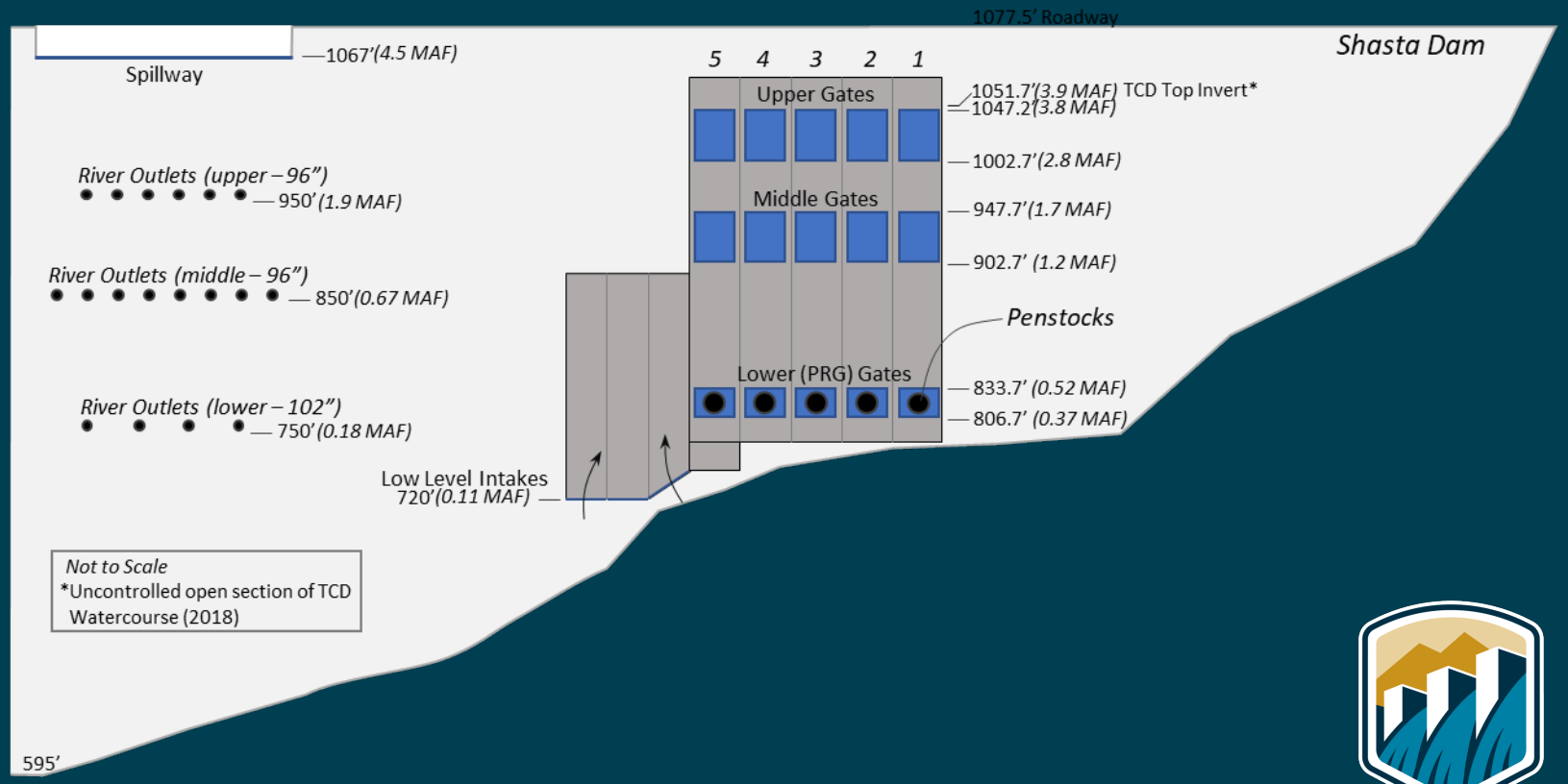
- Elevation
- Capacity
- Operations (and constraints)
- Changes through time
- Unique features
  - Temperature control curtains
  - Submerged dams





Geometry - Selective Withdrawal Facilities (Temperature Control)

- Shasta Dam Temperature Control Device
  - Selective withdrawal
  - Key features
    - Gate size
    - Hydraulic constraints
    - Side gate
    - Leakage
  - Model representation



Data Development – BC, IC, Cal/Val

Abbreviation	Name
SHA	Shasta Lake
KES	Keswick Reservoir
Sac R	Sacramento River (Keswick Dam to Red Bluff)
TRN	Trinity Lake
LEW	Lewiston lake
Trin R	Trinity River (Lewiston Dam to NF Trinity River)
WHI	Whiskeytown Lake
Clear Ck	Clear Creek (Whiskeytown Dam to Sacramento River)
FOL	Folsom Lake
NAT	Lake Natomas
Amer R	American River (Nimbus Dam to Sacramento River)
NML	New Melones Lake
Tulloch	Tulloch Lake
GDW	Goodwin Dam
Stan R	Stanislaus River (Goodwin Dam to San Joaquin River)

SHA – Shasta Lake

Abbr.	SHEF	Title	Description	Parameter	Frequen	Time Zone	Source
SHA	QG1	GENERATION RELEASE, CFS	Shasta Dam Powerhouse, Unit 1	Flow	Hourly	PST/PDT	USBR
SHA	QG2	GENERATION RELEASE, CFS	Shasta Dam Powerhouse, Unit 2	Flow	Hourly	PST/PDT	USBR
SHA	QG3	GENERATION RELEASE, CFS	Shasta Dam Powerhouse, Unit 3	Flow	Hourly	PST/PDT	USBR
SHA	QG4	GENERATION RELEASE, CFS	Shasta Dam Powerhouse, Unit 4	Flow	Hourly	PST/PDT	USBR
SHA	QG5	GENERATION RELEASE, CFS	Shasta Dam Powerhouse, Unit 5	Flow	Hourly	PST/PDT	USBR
SHA	QG	GENERATION RELEASE, CFS	Shasta Dam Powerhouse Total (QG = Σ(QGi, i=1,5)	Flow	Hourly	PST/PDT	USBR
SHA	QS1	SPILL RELEASE, CFS	Shasta Dam Spill, Gate 1	Flow	Hourly	PST/PDT	USBR
SHA	QS2	SPILL RELEASE, CFS	Shasta Dam Spill, Gate 2	Flow	Hourly	PST/PDT	USBR
SHA	QS3	SPILL RELEASE, CFS	Shasta Dam Spill, Gate 3	Flow	Hourly	PST/PDT	USBR
SHA	QS	SPILL RELEASE, CFS	Shasta Dam Spill Total (QG = Σ(QSi, i=1,3)	Flow	Hourly	PST/PDT	USBR
SHA	QU7501	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 750 ft #1	Flow	Hourly	PST/PDT	USBR
SHA	QU7502	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 750 ft #2	Flow	Hourly	PST/PDT	USBR
SHA	QU7503	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 750 ft #3	Flow	Hourly	PST/PDT	USBR
SHA	QU7504	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 750 ft #4	Flow	Hourly	PST/PDT	USBR
SHA	QU8501	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 850 ft #1	Flow	Hourly	PST/PDT	USBR
SHA	QU8502	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 850 ft #2	Flow	Hourly	PST/PDT	USBR
SHA	QU8503	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 850 ft #3	Flow	Hourly	PST/PDT	USBR
SHA	QU8504	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 850 ft #4	Flow	Hourly	PST/PDT	USBR
SHA	QU8505	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 850 ft #5	Flow	Hourly	PST/PDT	USBR
SHA	QU8506	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 850 ft #6	Flow	Hourly	PST/PDT	USBR
SHA	QU8507	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 850 ft #7	Flow	Hourly	PST/PDT	USBR
SHA	QU8508	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 850 ft #8	Flow	Hourly	PST/PDT	USBR
SHA	QU9501	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 950 ft #1	Flow	Hourly	PST/PDT	USBR
SHA	QU9502	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 950 ft #2	Flow	Hourly	PST/PDT	USBR
SHA	QU9503	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 950 ft #3	Flow	Hourly	PST/PDT	USBR
SHA	QU9504	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 950 ft #4	Flow	Hourly	PST/PDT	USBR
SHA	QU9505	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 950 ft #5	Flow	Hourly	PST/PDT	USBR
SHA	QU9506	OUTLET RELEASE, CFS	Shasta Dam Outlet Release 950 ft #6	Flow	Hourly	PST/PDT	USBR
SHA	QU	OUTLET RELEASE, CFS	Shasta Dam Outlet Release Total (QU = ΣQU750i+ΣQU850j+ΣQU950k, i=1,4, j=1,8, k=1,6	Flow	Hourly	PST/PDT	USBR
SHA	QT	TOTAL RELEASE, CFS	Shasta Dam Total Release (QT = QG+QS+QU)	Flow	Hourly	PST/PDT	USBR
SHA	QE	EVAPORATION, CFS	Shasta Lake evaporation (Calculated)	Flow	Daily	n/a	USBR

SHA – Shasta Lake

Abbr.	SHEF	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
SHA	QG1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QG2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QG3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QG4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QG5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QG	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QS1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QS2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QS3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QS	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU7501	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU7502	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU7503	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU7504	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU8501	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU8502	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU8503	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU8504	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU8505	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU8506	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU8507	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU8508	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU9501	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU9502	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU9503	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU9504	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU9505	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU9506	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QU	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
SHA	QE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

TRN – Trinity Lake

Abbr.	SHEF	Title	Description	Parameter	Frequency	Time Zone	Source
TRN	QG1	GENERATION RELEASE, CFS	Trinity Dam Powerhouse, Unit 1	Flow	Hourly	PST/PDT	USBR
TRN	QG2	GENERATION RELEASE, CFS	Trinity Dam Powerhouse, Unit 2	Flow	Hourly	PST/PDT	USBR
TRN	QG	GENERATION RELEASE, CFS	Trinity Dam Powerhouse, Total (QG1+QG2)	Flow	Hourly	PST/PDT	USBR
TRN	QS	SPILL RELEASE, CFS	Trinity Dam Spill	Flow	Hourly	PST/PDT	USBR
TRN	QU1	OUTLET RELEASE, CFS	Trinity Dam Release Gate 1	Flow	Hourly	PST/PDT	USBR
TRN	QU2	OUTLET RELEASE, CFS	Trinity Dam Release Gate 2	Flow	Hourly	PST/PDT	USBR
TRN	QU3	OUTLET RELEASE, CFS	Trinity Dam Release Gate 3	Flow	Hourly	PST/PDT	USBR
TRN	QU	OUTLET RELEASE, CFS	Trinity Dam Release Gate Total (QU1+QU2+QU3)	Flow	Hourly	PST/PDT	USBR
TRN	QT	TOTAL RELEASE, CFS	Total Trinity Dam Release (QG+QS+QU)	Flow	Hourly	PST/PDT	USBR
TRN	HL	RESERVOIR ELEVATION, FT	Trinity Lake Stage	Stage	Hourly	PST/PDT	USBR
TRN	LS	RESERVOIR STORAGE, AF	Trinity Lake Storage	Storage	Hourly	PST/PDT	USBR
TRN	ES	EVAPORATION, CFS	Trinity Lake Evaporation	Flow	Daily	n/a	USBR
TRN	EV	EVAPORATION, INCH	Trinity Lake Evaporation	Inch	Daily	n/a	USBR
TRN	PP	PRECIPITATION, INCH	Trinity Lake Precipitation	Inch	Daily	n/a	USBR
TRN	QI	COMPUTED INFLOW, CFS	Trinity Lake Inflow, Computed	Flow	Daily	n/a	USBR
11523200	n/a	Trinity River nr Coffee Creek nr Trinity Center, CA	https://waterdata.usgs.gov/usa/nwis/uv?site_no=11523200	Flow	15-minute	PST/PDT	USGS
n/a	n/a	Coffee Creek	Coffee Creek Water Temperature	Temp	Hourly	PST/PDT	USFWS
n/a	n/a	Swift CreekCreek	Swift Creek Water Temperature	Temp	Hourly	PST/PDT	USFWS
n/a	n/a	Stuart Fork	Stuart Fork Water Temperature	Temp	Hourly	PST/PDT	USFS
n/a	n/a	Trinity Dam Release	Trinity Dam Release Temperature	Temp	Hourly	PST/PDT	USBR
Trinity Lake	TP1	Log Boom	Trinity Lake Vertical Profile	Temp	week/month	PST/PDT	USBR
TNC	TNC	Trinity Camp - Meteorology (primary)	https://wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCTRI	S,Ta,Tw,W(v,d),P*	Hourly	PST/PDT	WRCC
TNC	TNC	Trinity Camp - Meteorology (secondary)	https://cdec.water.ca.gov/dynamicapp/staMeta?station_id=TNC	S,Ta,Tw,W(v,d),P*	Hourly	PST/PDT	CDEC
LFH	LFH	Lewiston Fish Hatchery	https://cdec.water.ca.gov/dynamicapp/staMeta?station_id=LFH	S,Ta,Tw,P*	Hourly	PST/PDT	CDEC

TRN – Trinity Lake

Abbr.	SHEF	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
TRN	QG1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	QG2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	QG	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	QS	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	QU1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	QU2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	QU3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	QU	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	QT	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	HL	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	LS	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	ES	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	EV	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	PP	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TRN	QI	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11523200	n/a	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
n/a	n/a	X	X	X	X	X	X	X	X	X	X	Y	X	X	X	X	X	X	X	X	X	X	X
n/a	n/a	X	X	X	Y	X	Y	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
n/a	n/a	Y	X	Y	Y	X	Y	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
n/a	n/a	1/01-4/2	3/19-12/	8/05 -10	2/25-6/	1/06-11/	Y	8/29-12	X	X	1/01-4/1	Y	Y	Y	Y	4/02-12	1/01-4/1	4/26-12	3/16	1/31-6/2	Y	8/13-12/	X
Trinity Lake	TP1	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	X	X	X
TNC	TNC	Y	40	77	25	80	14	25	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
TNC	TNC	Y	40	77	25	80	14	25	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
LFH	LFH	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	X	X	X	X	X

FOL – Folsom Lake

Abbr.	SHEF	Title	Description	Parameter	Frequency	Time zone	Source
FOL	QG1	GENERATION RELEASE, CFS	Folsom Dam Powerhouse, Unit 1	Flow	Hourly	PST/PDT	USBR
FOL	QG2	GENERATION RELEASE, CFS	Folsom Dam Powerhouse, Unit 2	Flow	Hourly	PST/PDT	USBR
FOL	QG3	GENERATION RELEASE, CFS	Folsom Dam Powerhouse, Unit 3	Flow	Hourly	PST/PDT	USBR
FOL	QG	GENERATION RELEASE, CFS	Folsom Dam Powerhouse Total (QG = Σ(QGi, i=1,3)	Flow	Hourly	PST/PDT	USBR
FOL	QS1	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 1	Flow	Hourly	PST/PDT	USBR
FOL	QS2	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 2	Flow	Hourly	PST/PDT	USBR
FOL	QS3	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 3	Flow	Hourly	PST/PDT	USBR
FOL	QS4	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 4	Flow	Hourly	PST/PDT	USBR
FOL	QS5	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 5	Flow	Hourly	PST/PDT	USBR
FOL	QS6	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 6	Flow	Hourly	PST/PDT	USBR
FOL	QS7	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 7	Flow	Hourly	PST/PDT	USBR
FOL	QS8	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 8	Flow	Hourly	PST/PDT	USBR
FOL	QS9	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 9	Flow	Hourly	PST/PDT	USBR
FOL	QS10	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 10	Flow	Hourly	PST/PDT	USBR
FOL	QS11	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 11	Flow	Hourly	PST/PDT	USBR
FOL	QS12	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 12	Flow	Hourly	PST/PDT	USBR
FOL	QS13	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 13	Flow	Hourly	PST/PDT	USBR
FOL	QS14	SPILL RELEASE, CFS	Folsom Dam Spill, Gate 14	Flow	Hourly	PST/PDT	USBR
FOL	QS	SPILL RELEASE, CFS	Folsom Dam Spill Total (QG = Σ(QSi, i=1,14)	Flow	Hourly	PST/PDT	USBR
FOL	QU1	OUTLET RELEASE, CFS	Folsom Dam Outlet Release Gate 1	Flow	Hourly	PST/PDT	USBR
FOL	QU2	OUTLET RELEASE, CFS	Folsom Dam Outlet Release Gate 2	Flow	Hourly	PST/PDT	USBR
FOL	QU3	OUTLET RELEASE, CFS	Folsom Dam Outlet Release Gate 3	Flow	Hourly	PST/PDT	USBR
FOL	QU4	OUTLET RELEASE, CFS	Folsom Dam Outlet Release Gate 4	Flow	Hourly	PST/PDT	USBR
FOL	QU5	OUTLET RELEASE, CFS	Folsom Dam Outlet Release Gate 5	Flow	Hourly	PST/PDT	USBR
FOL	QU6	OUTLET RELEASE, CFS	Folsom Dam Outlet Release Gate 6	Flow	Hourly	PST/PDT	USBR

FOL – Folsom Lake

Abbr.	SHEF	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
FOL	QG1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QG2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QG3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QG	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QS1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QS2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QS3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QS4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QS5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QS6	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QS7	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QS8	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QS9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	12/15-	Y	Y	Y	Y
FOL	QS10	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	12/15-	Y	Y	Y	Y
FOL	QS11	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	12/15-	Y	Y	Y	Y
FOL	QS12	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	12/15-	Y	Y	Y	Y
FOL	QS13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	12/15-	Y	Y	Y	Y
FOL	QS14	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	12/15-	Y	Y	Y	Y
FOL	QS	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QU1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QU2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QU3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QU4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QU5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
FOL	QU6	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Data Management System (DMS)

- Objective
- Data Types
- Data Attributes
- Data Processing
- Metadata
- WTMP Interface
- Other Output

DMS Objectives

- Data acquisition – consolidate time series data from different sources
- Data integrity – track changes made to prepare "model-ready" data
- Data management – make data easy to access, interpret, analyze

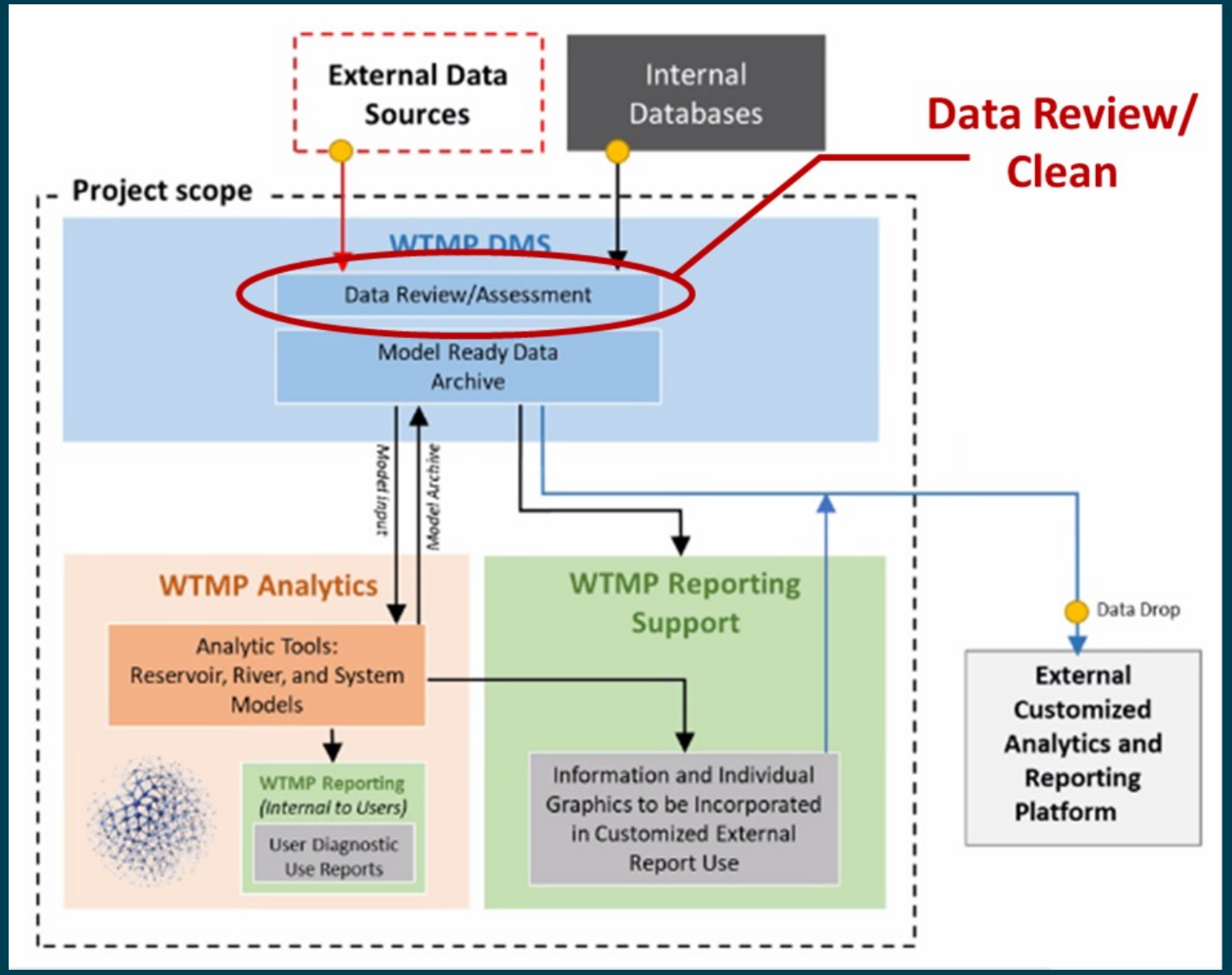
DMS Data Types

- Time Series (most of the data)
  - Flow and Temperature used for boundary conditions and forecasting
  - Temperature Profiles
- Physical
  - Reservoir and river geometry, reservoir intake descriptions, conveyance capacities
- Operational
  - Reservoir operating rules, TCD management protocols, minimum instream flows

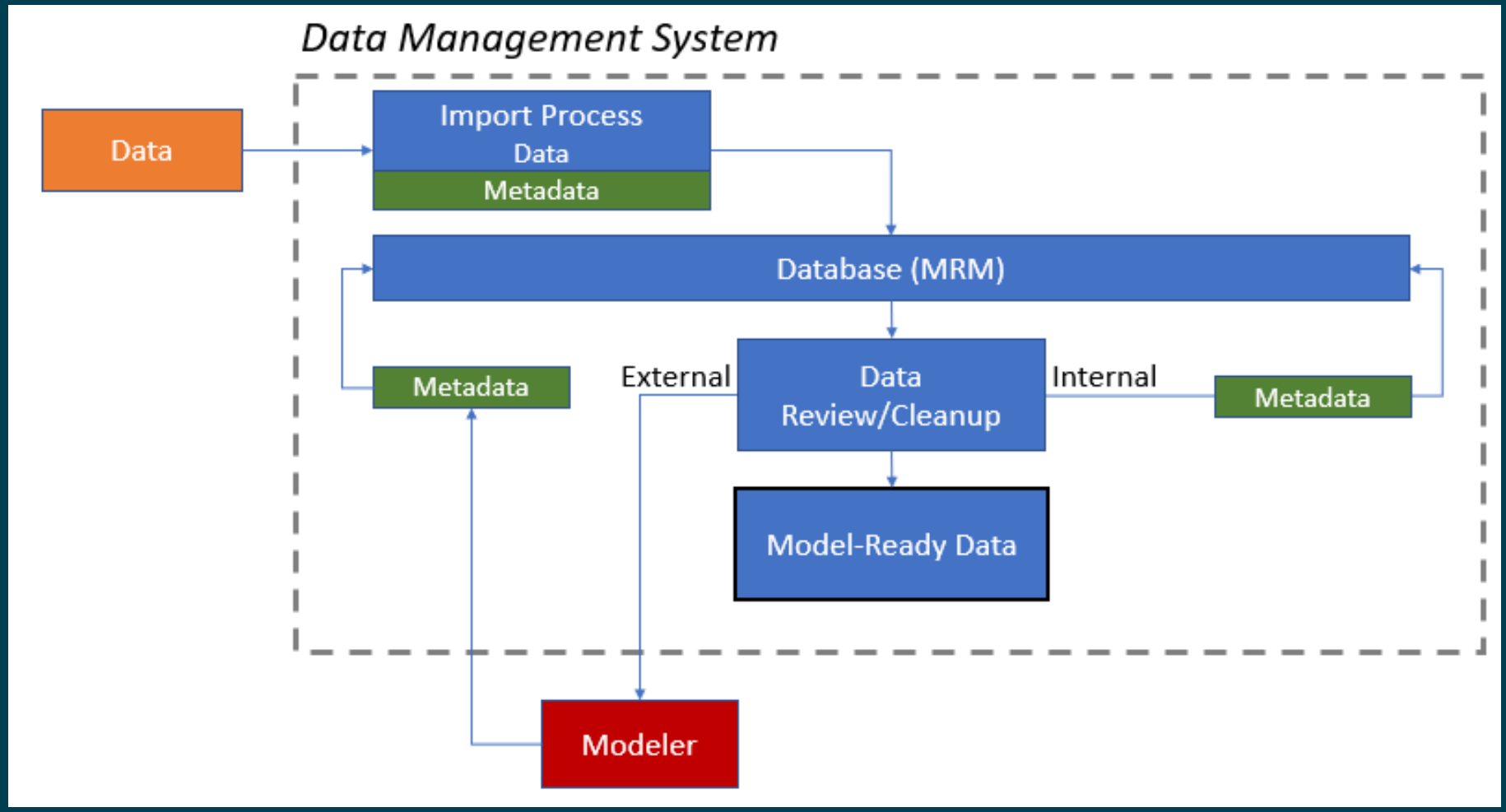
DMS Data Attributes

- Apply rules for organizing time series data
- Data Import:
  - Automate collection from sources
  - Develop import processes and manual entry methods
- Collect and store metadata that tracks the data source, data quality and data revisions
- Provide visualization tools for post-processing source data (QA/QC, gap-filling, etc.)
- Provide a means for on-demand delivery of model ready time series data to the WTMP
- Keep track the relationship between model input series and model output for rapid comparison and report preparation

Data Processing – Data Review/Clean-up



Data Processing – Data Review/Clean-up

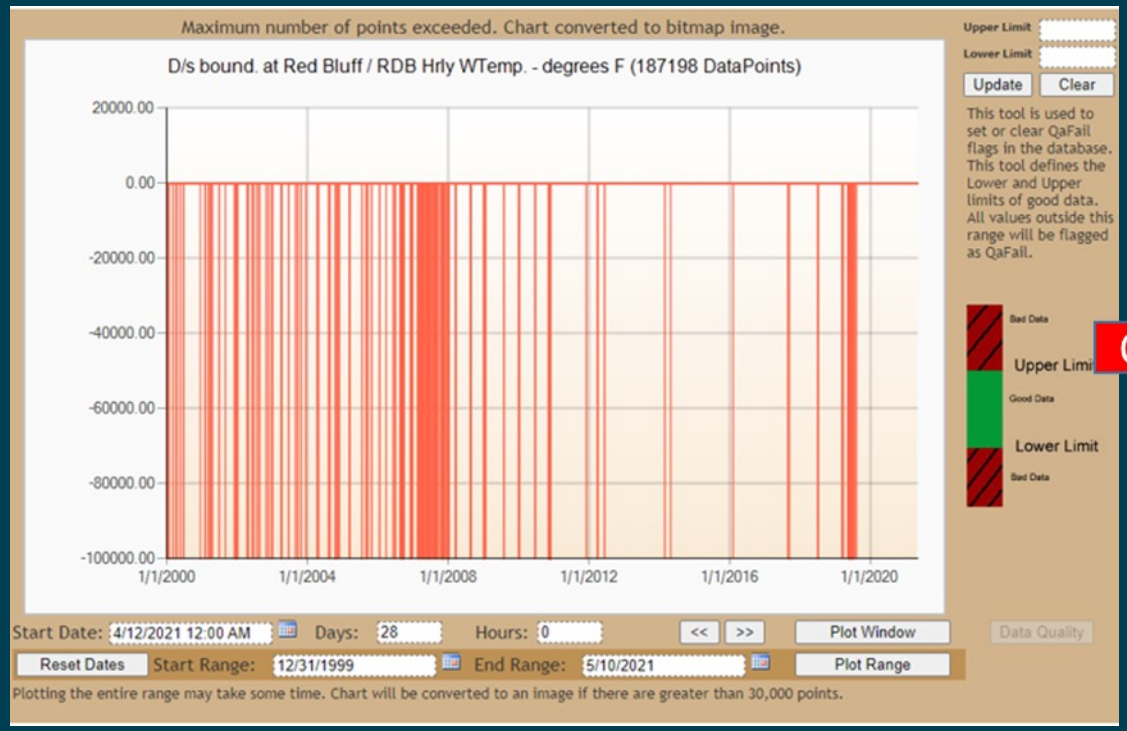


Data Processing

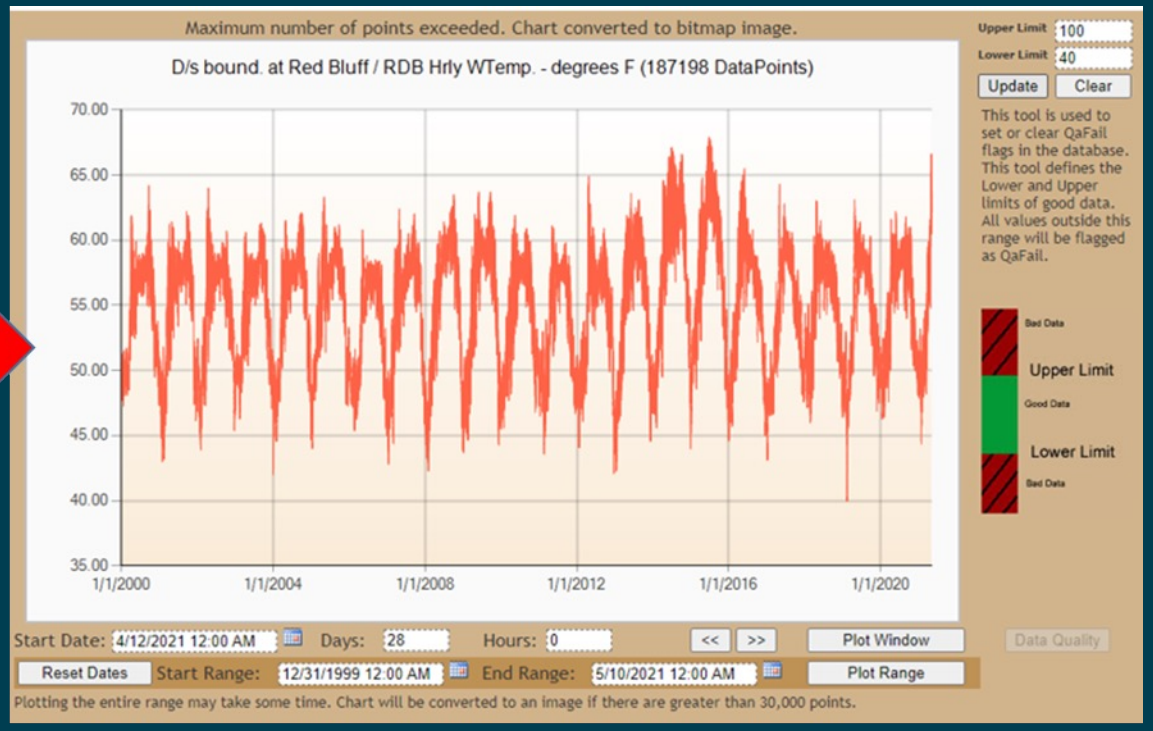
- Filter to allow/deny provisional data
- Apply scale factor and offset (e.g., change units)
- Flag data that falls out of acceptable range
- Fill gaps
- Normalize time steps
- Always retain raw data

Data Processing: QA/QC

The import process can apply linear thresholds to flag data which is outside normal operating limits in order to improve visualization and speed up the process of producing model ready data.



QA/QC

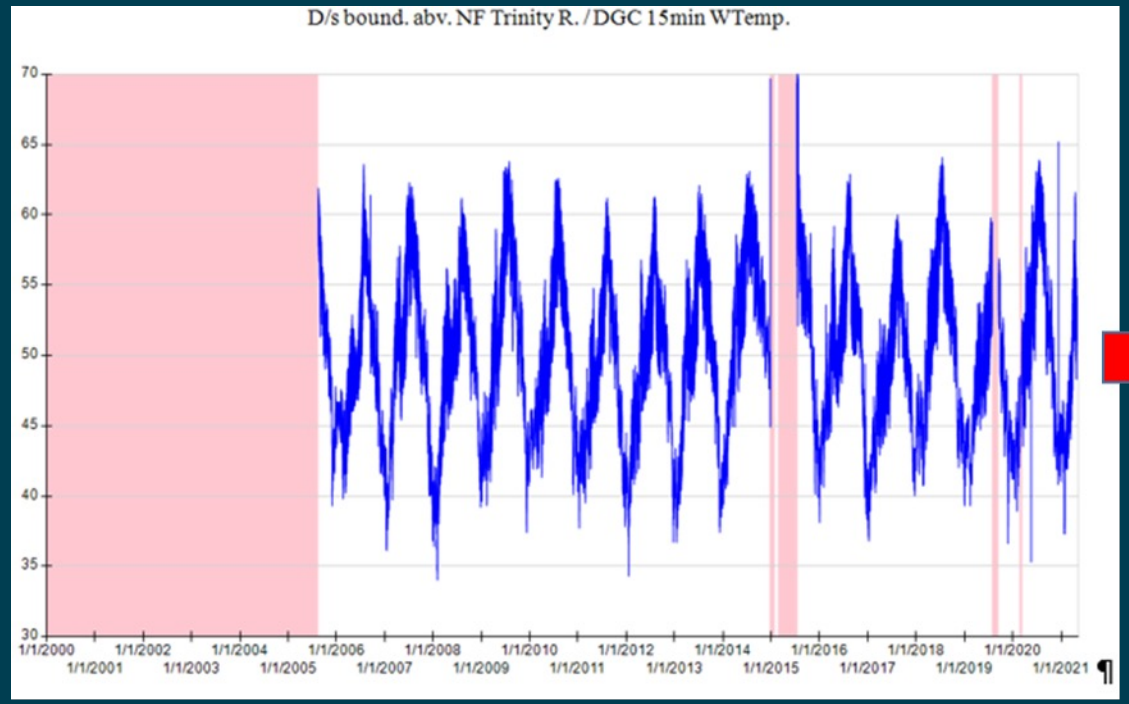


Data Processing: Fill Gaps

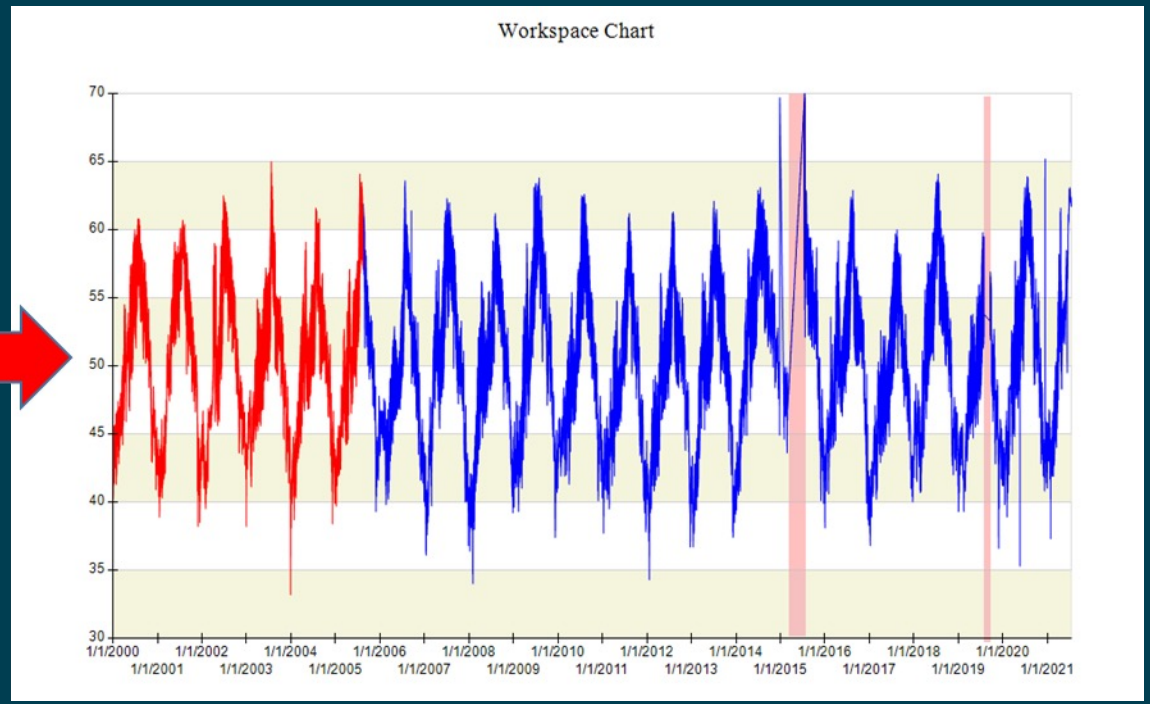
Gap filling may be completed inside or outside the DMS depending on size of gap and complexity of model required to adequately represent the physical process.

- Minor gap filling (e.g., PDT to PST)
- Major gap filling (Modeler)

- The DMS includes tools for rapid identification and display of data gaps



Fill

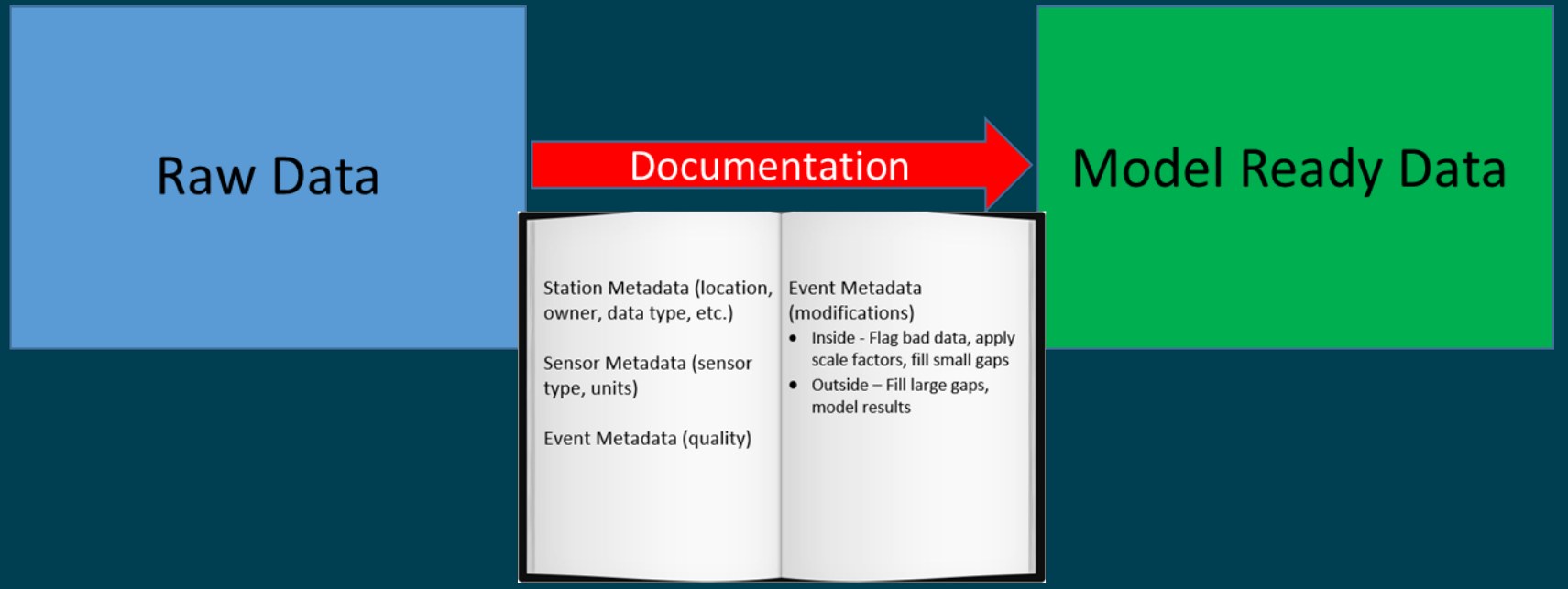


Metadata

- Station Metadata (location, owner, data type, etc.)
- Sensor Metadata (sensor type, units)
- Event Metadata (quality, source)
- Event Metadata (modifications)
  - Internal - Flag bad data, unit conversion, time steps, fill small gaps
  - External – Fill large gaps, model results

Metadata –Model Ready Data

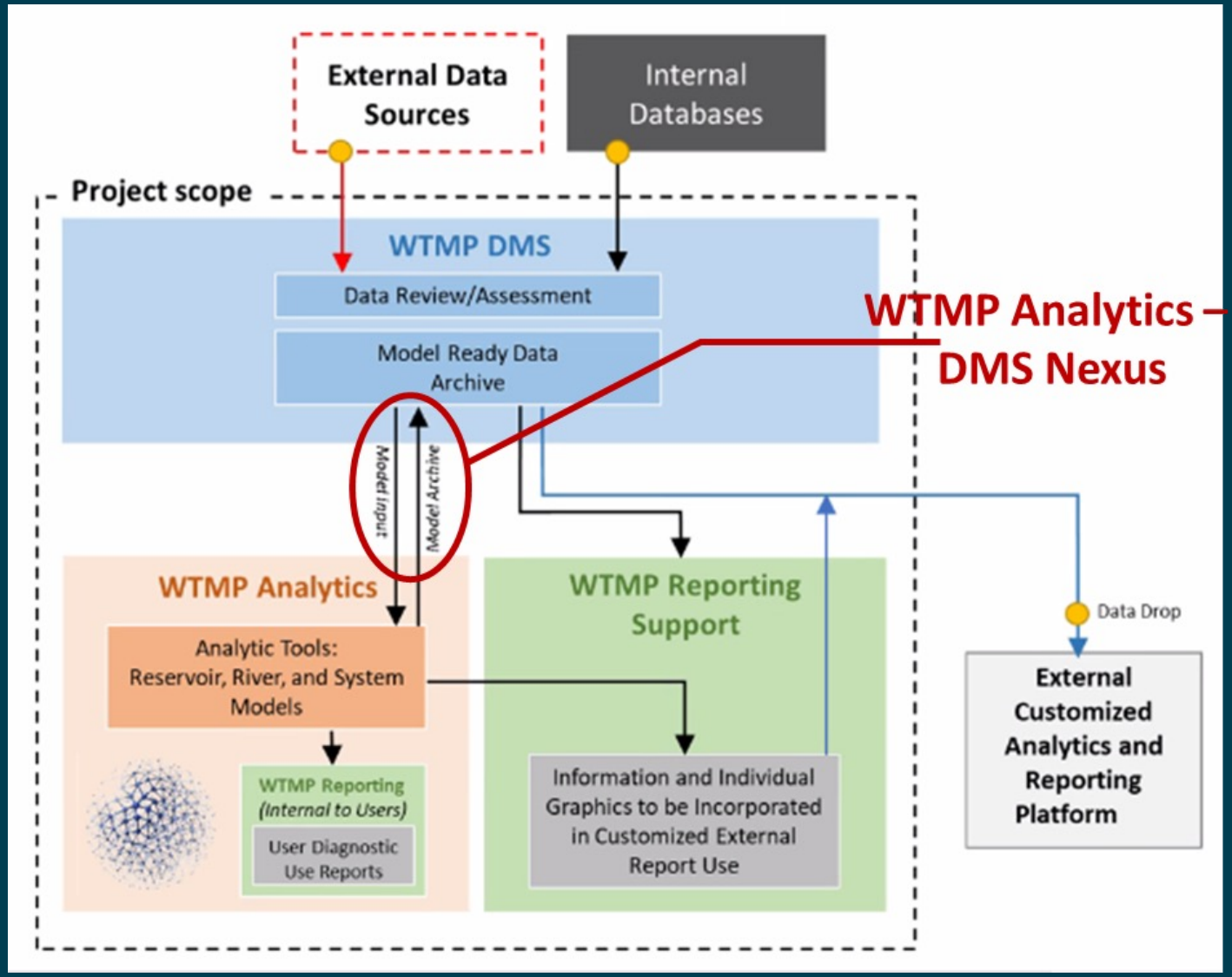
The goal of data processing is not only to produce "Model Ready Data", but to track changes to and maintain a connection to raw data by using metadata applied at the appropriate place in the DMS.



WTMP Analytics-DMS Nexus

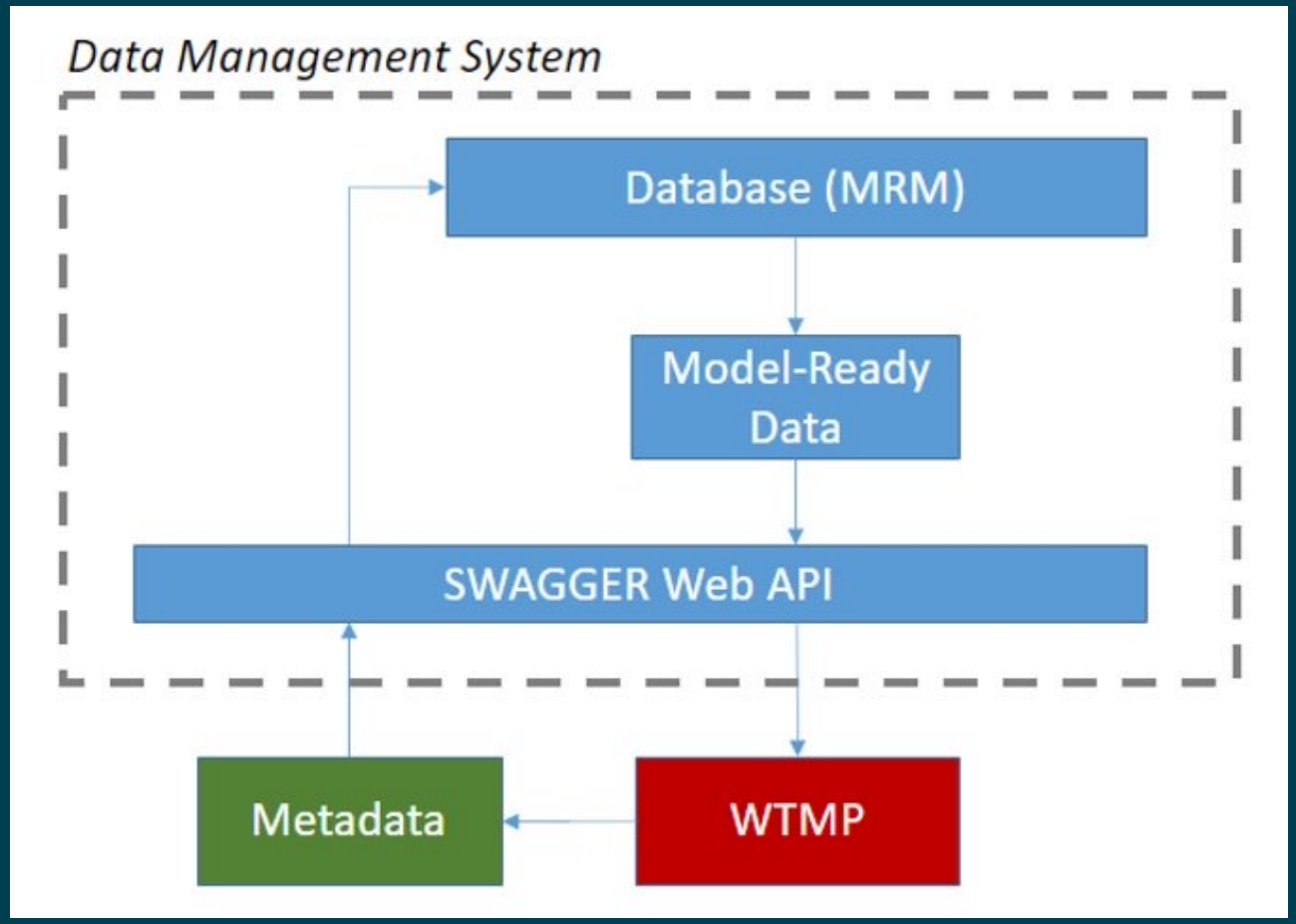
- Model Ready Data includes:
  - Data that can be used directly in the WTMP
  - Metadata
    - Station
    - Measurement
    - Event
    - Revision history
- Model Results
  - Selected model results
  - Metadata

WTMP Analytics-DMS Nexus Diagram



WTMP Analytics-DMS Nexus Flow

- Information Flow



Other Output

- SQL Reporting
- Data Export – Normalized, Pivot
- Data link to RISE
- Data Gateway for PowerBI

Flexibility in Deployment

- Options (TBD, in discussion with Reclamation for security and other administrative considerations)
  - Single server
  - Virtual server(s)
  - Cloud services

- RISE will be the interface for data sharing with external parties

Model Implementation Status

System Element	Model	Status
Shasta Lake	ResSim, CE-QUAL-W2	Cal/Val
Keswick Reservoir	ResSim, CE-QUAL-W2	Cal/Val
Sacramento River	ResSim	Cal/Val
Whiskeytown Lake	ResSim, CE-QUAL-W2	Implementation
Clear Creek	ResSim	Testing
Trinity Lake	ResSim, CE-QUAL-W2	Implementation
Lewiston Lake	ResSim, CE-QUAL-W2	Testing
Trinity River	ResSim	Implementation
Folsom Lake	ResSim, CE-QUAL-W2	Cal/Val
Lake Natomas	ResSim, CE-QUAL-W2	Cal/Val
American River	ResSim	Implementation
New Melones Lake	ResSim, CE-QUAL-W2	Data gathering
Tulloch Reservoir	ResSim, CE-QUAL-W2	Data gathering
Stanislaus River (inc. Goodwin)	ResSim	Data gathering

Model Calibration/Validation

- Target Period of Model development
  - 1/1/2000 – 12/31/2021
- Calibration/Validation
  - Calibration: 1/1/2000 – 12/31/2017
  - Validation: 1/1/2018 – 12/31/2021
  - Similar range of hydrology, meteorology, and operations (including critical dry years and low storage)
- Model performance metrics
- Reach-scale and system performance

Next Steps

- Data acquisition and processing early complete (except Stanislaus)
- Data management system is being populated
- Model development and calibration proceeding on multiple systems with multiple models
- WTMP is being used for calibration and validation, providing model reports (graphical and tabular results, and model performance statistics)
- Model reporting completed coincident with model development

Photo credit: John Hannon, Reclamation

Stakeholder Engagement for CVP WTMP

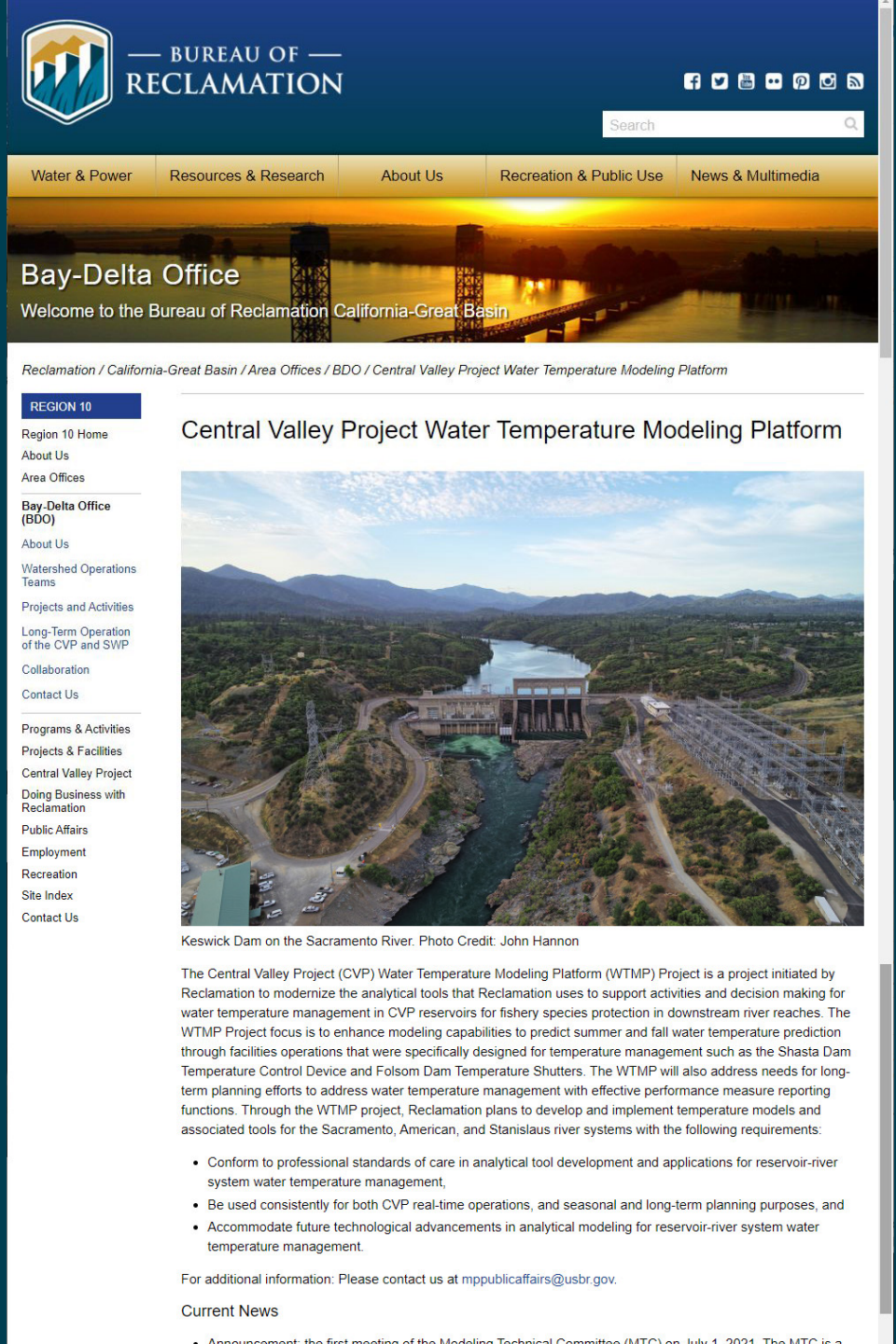
Yung-Hsin Sun, PhD, PE, D.WRE, Stantec Consulting Services Inc.
Randi Field, CVO, US Dept. of the Interior, Bureau of Reclamation

Principles for CVP WTMP Development

- Focusing on technical improvement to advance water temperature modeling tools and analytical methods
- Using a collaborative model development approach with stakeholders and interested parties
- Maintaining an open and transparent environment for information sharing and cooperation.

WTMP Communication and Engagement Channels

- Project contract: mppublicaffairs@usbr.gov
- **Project Website** https://www.usbr.gov/mp/bdo/cvp-wtmp.html
  - Best for getting updates, meeting materials, work products, and more
- More…



WTMP Communication and Engagement Channels (cont'd)

- Project contract: mppublicaffairs@usbr.gov
- Project Website: https://www.usbr.gov/mp/bdo/cvp-wtmp.html
- Modeling Technical Committee (MTC) – Quarterly; from 1 to 4 pm, on first Thursday of the first month of each quarter
- Email communication with MTC and interested parties (mailing list > 350 individuals)
- In addition, Scientific Peer Reviews in collaboration with Delta Stewardship Council

Modeling Technical Committee (MTC)

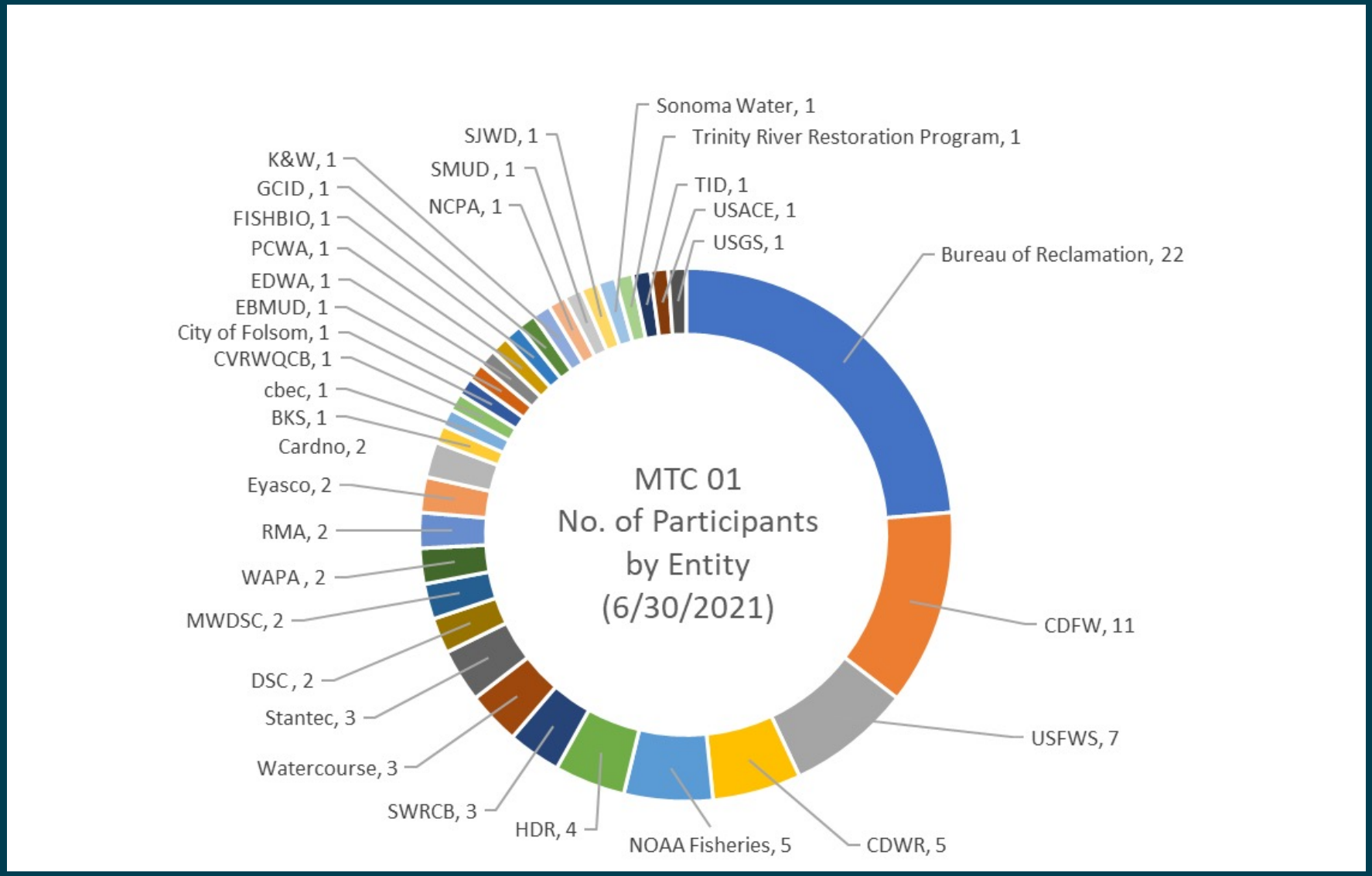
- Despite of its name, it is more an open forum for collaborative model development.
- Technical focused discussions centering around water temperature modeling tools, data and applications.
  - Topic-specific or watershed-specific subgroups to be established as needed; the results of a subgroup discussion to be reported to the full MTC in the subsequent meeting
- Scheduled quarterly meetings – First Thursday (1 – 4 pm) of the first month of each calendar quarter till the end of 2023.
  - In-person meetings are possible in the future (TBD); online participation is always provided.
  - Interest and feedback: Yung-Hsin Sun, yung-hsin.sun@stantec.com

Agenda Topics for the MTC Meetings (Subject to Change)

Topic	7/1/2021	10/7/2021	1/6/2022	4/7/2022	7/7/2022	10/6/2022	2023
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	-
Modeling Framework Implementation	1	-	2	-	-	3	
Phase II Activities	-	-	-	-	TBD	TBD	TBD
Peer Review Outcomes	-	-	-	-	1/2/3	-	TBD

Key: 1 – Introductory Presentation; 2 – Comments and Discussion; 3 – Closure Discussion; TBD – To be determined

Registration for MTC 01



Registration Poll for MTC 01

- What is your primary interest in joining the MTC meetings?

Scientific Peer Reviews

- Goal: Provide an external, independent review of the critical assumptions, technical approach and resulting products of the WTMP Project

- Reclamation is partnering with Delta Stewardship Council and hosting:
  - Mid-Term Review: Summer 2022
  - Final Review: Summer 2023

- More information to be posted on WTMP website

Independent Peer Review Strategy

- The Mid-Term Peer Review:
  - Evaluate the development, methods, and performance of the Shasta-Keswick-Sacramento River temperature models
- Feedback from the Mid-Term review will guide the continued WTMP development
- The Final Peer Review:
  - Evaluate all model representations, applications, framework design, uncertainty, and testing

- Anticipated outcome: Improved robustness and transparency

Photo credit: John Hannon, Reclamation

CWEMF

CVP WTMP: Q&A

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- John DeGeorge: jfdegeorge@rmanet.com
- Jeff Schuyler: jeff@eyasco.com
- Yung-Hsin Sun: yung-hsin.sun@stantec.com