Model Framework Selection

Drew Allan Loney, PhD, PE
Reclamation, Denver Technical Services Center

Philosophy

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 and Foster Transparency
- Consistent Use: Real-time, Seasonal, and Long-term Planning
- Accommodate Continued Technological Advancements

BUREAU OF RECLAMATION

Modeling Framework

Software application or set of applications that can be used to streamline model use and automate repetitive tasks, making the modeling process more efficient and more robust

WTMP: Modeling Framework and Models

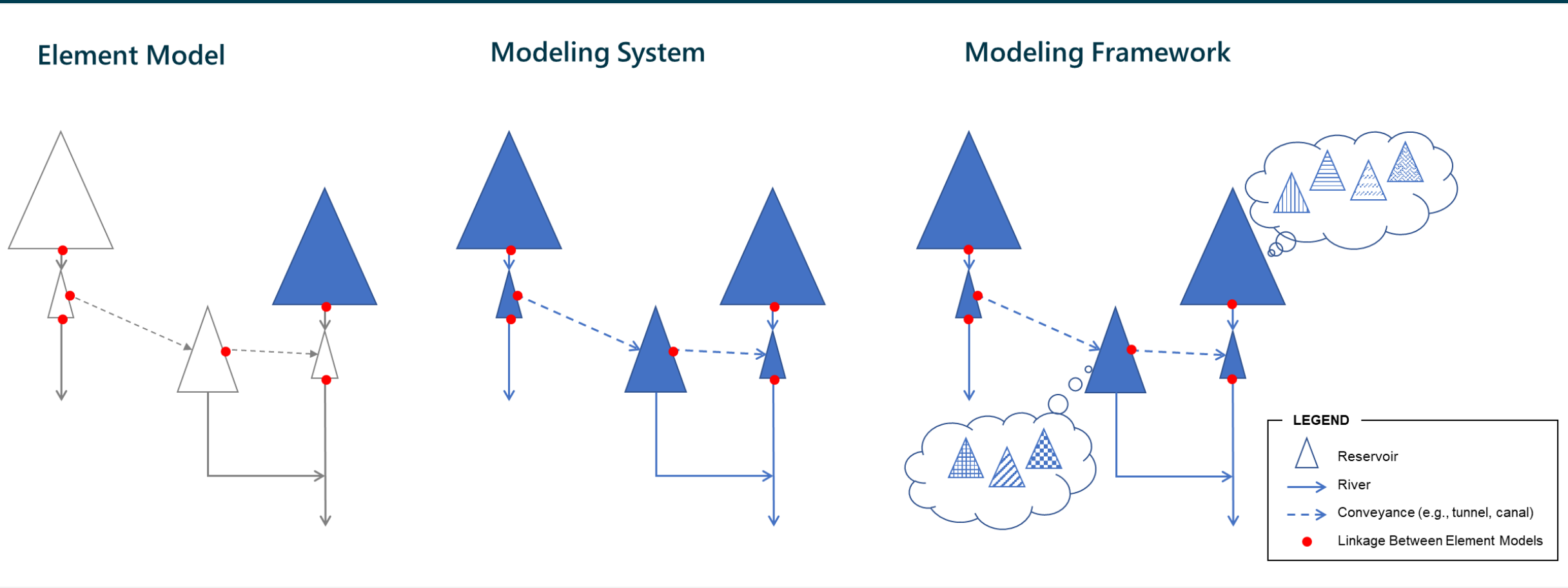


Photo credit: John Hannon, Reclamation

Modeling Framework Selection for WTMP

WTMP Modeling Framework 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

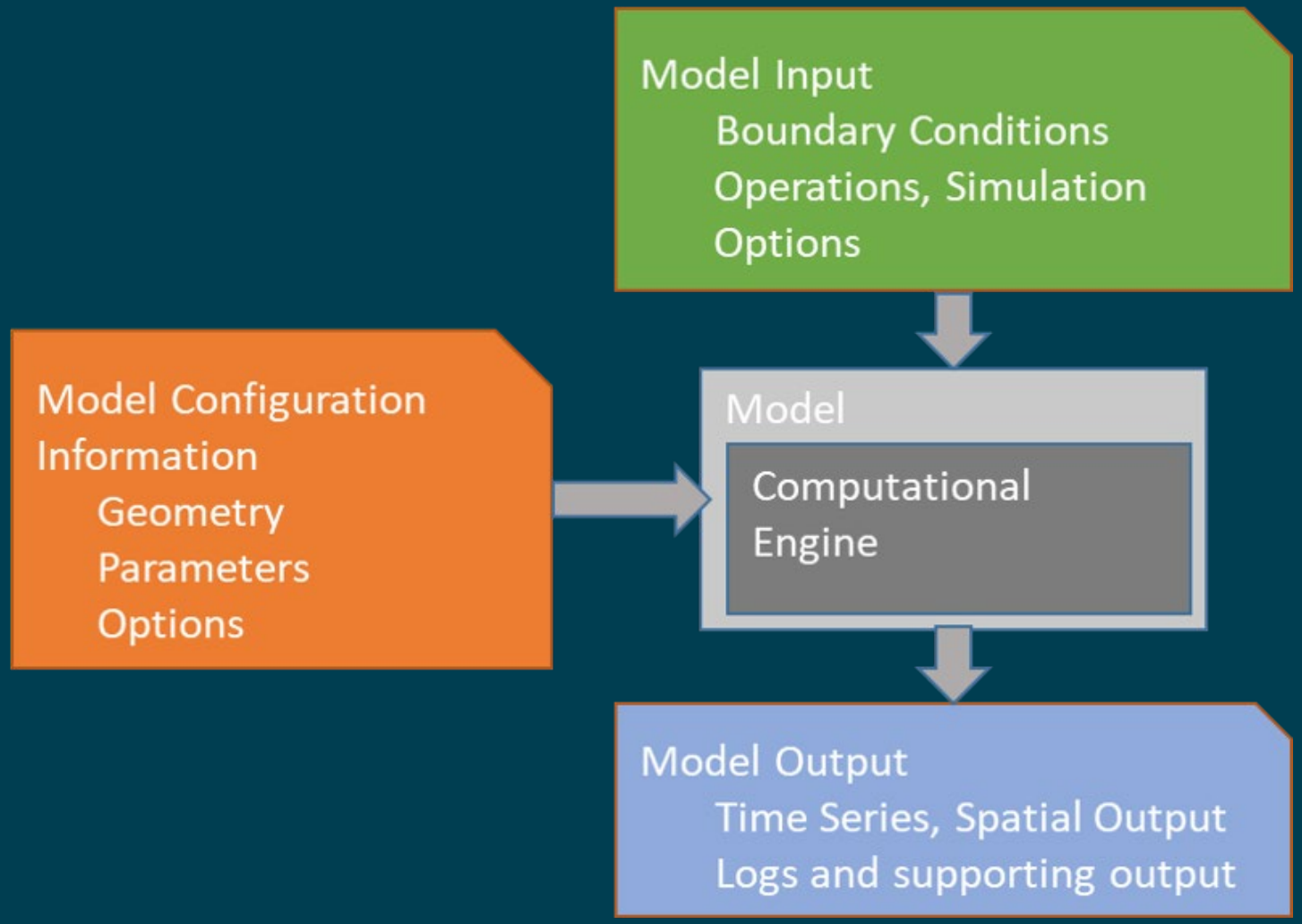
Modeling Framework Selection and Design

- Technical Memorandum
- Segments for each of four questions:
  - Needs of the WTMP modeling framework
  - Selection criteria
  - Candidate frameworks
  - Framework evaluation and comparison
- Selection and proof of concept

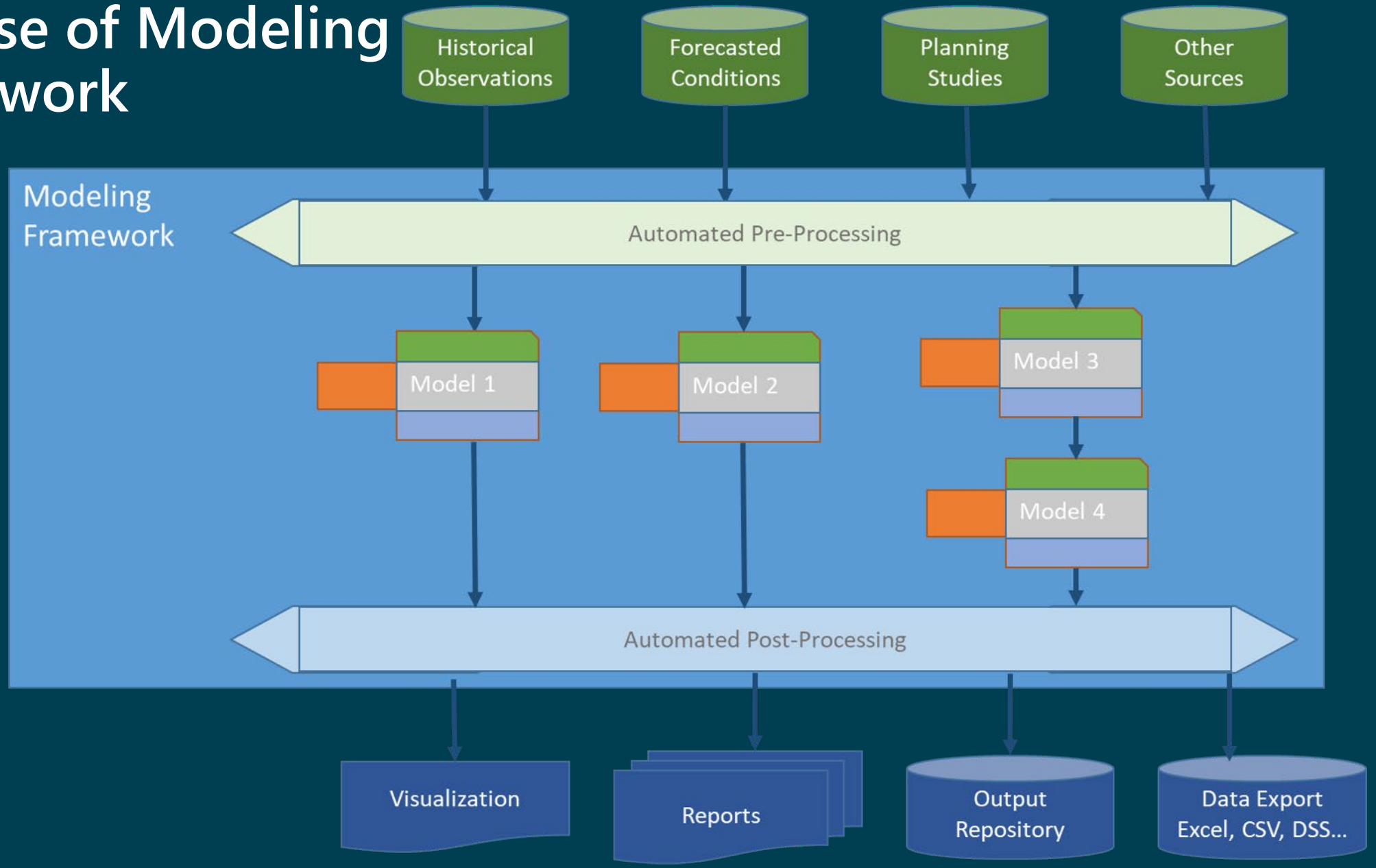
Model, Configuration, Input and Output

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

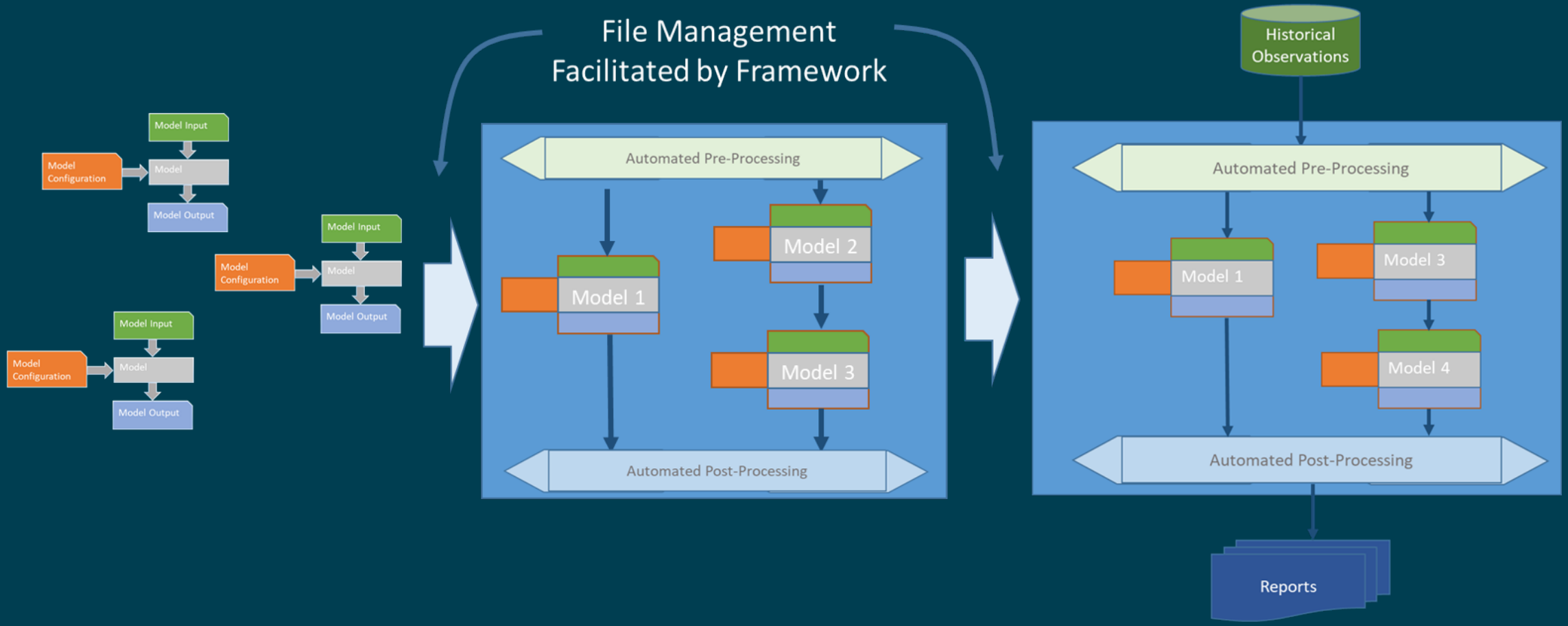
- **CE-QUAL-W2**
- **HEC-5Q**
- **HEC-ResSim**
- **CALSIM II**
- **DSM2**



Purpose of Modeling Framework



Model Data Management



Configuration and Initial Calibration outside of Modeling Framework

Model Linking within the Framework ("Base Simulations")

Production runs supporting a Use Case

Framework Requirements

- Efficiently use several models, individually or in a sequence
- Support workflows 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

Modeling Framework Selection Criteria (TM)

- Model Compatibility (Table 4.1)
- Model Coupling (Table 4.2)
- Workflow (Table 4.3)
- Model Configurations and Data Management (Table 4.4)
- User Interface (Table 4.5)
- Data Storage Service Location (Table 4.6)
- Computation Service Location (Table 4.7)
- Modeling Software Interface Service Location (Table 4.8)

Candidate Modeling Frameworks

- Object Modeling System/Cloud Services Integration Platform (OMS3/CSIP), Colorado State University
- Earth System Modeling Framework (ESMF), NASA, NOAA, NCAR, DoD
- HydroCouple, University of Utah
- Community Surface Dynamics Modeling System (CSDMS), University of Colorado
- Delft FEWS, Deltares
- Delta Shell, Deltares
- HEC-Watershed Analysis Tool (HEC-WAT), USACE Hydrologic Engineering Center
- HEC-Real-Time Simulation (HEC-RTS), USACE Hydrologic Engineering Center

Evaluation of Candidate Frameworks (TM)

- Model Compatibility (Table 5.1)
- Model Coupling (Table 5.2)
- Workflow (Table 5.3)
- Model Configurations and Data Management (Table 5.4)
- User Interface (Table 5.5)
- Data Storage Service Location (Table 5.6)
- Computation Service Location (Table 5.7)
- Modeling Software Interface Service Location (Table 5.8)
- Primary Development Language (Table 5.9)

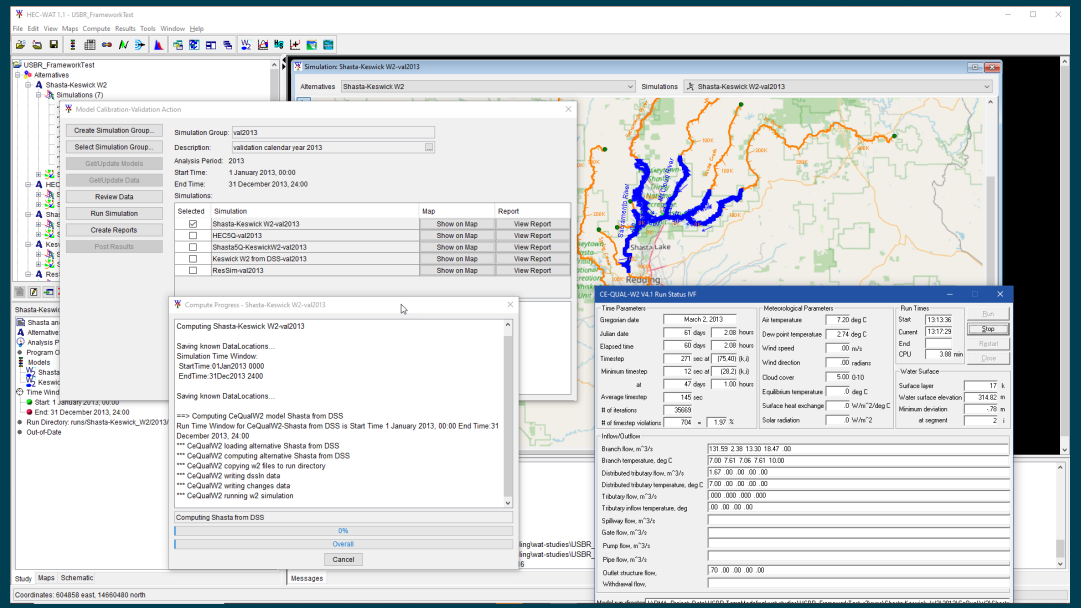
(Example) Table 5 1. Model types that may be utilized in the WTMP modeling framework

Criterion	Importance	OMS3/CSIP	ESMF	HydroCouple	CSDMS	Delft-FEWS	Delta Shell	HEC-WAT	HEC-RTS
CEQUAL-W2	Must	C3	C3	Y*	C3	C3	C2	Y	C2
HEC-5Q	Prefer	C3	C3	C3	C3	C3	C2	C2	C2
HEC-ResSim	Prefer	C3	C3	C3	C3	Y	C2	Y	Y
HEC-RAS	Prefer	C3	C3	C3	C3	Y	C2	Y	Y
General command line models	Must	C3	C3	C3	C3	C2	C2	C2	C2
General GUI based models	Prefer	C3	C3	C3	C3	C3	C3	C3	C3
Scripted processes	Must	C3	C3	C3	C3	C2	C2	C1	C1
Excel worksheets	Prefer	C3	C3	C3	C3	C3	C3	C3	C3

Key - Y indicates the framework provides good suitability for WTMP; Y* indicates the framework meets WTMP needs with some adjustment; C1, C2, and C3 indicate the framework can be customized to meet WTMP needs with relatively low, moderate, and high level, respectively, of effort of customization and coding.

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



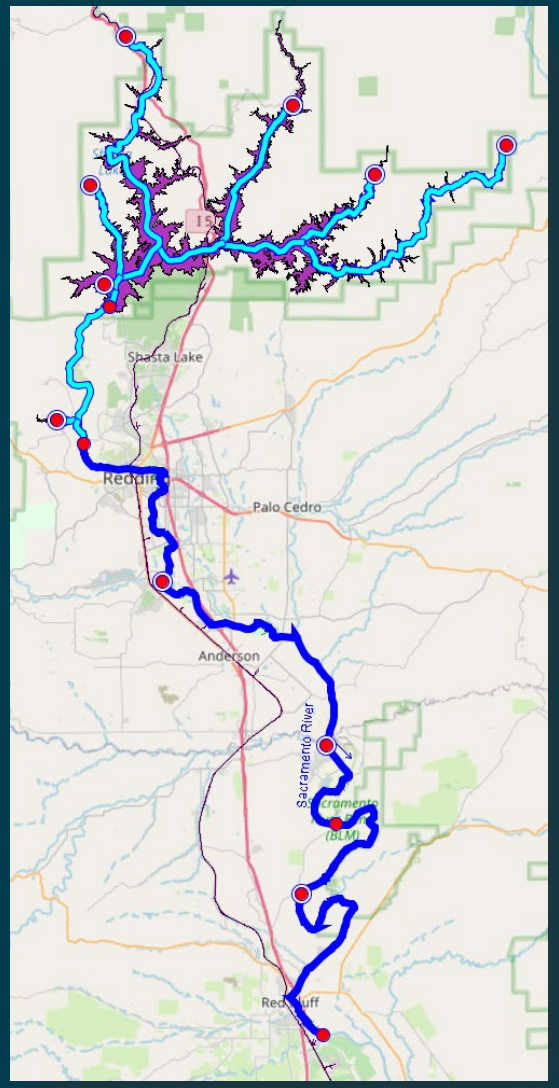
https://www.hec.usace.army.mil/software/hec-wat/

Photo credit: John Hannon, Reclamation

Framework Design with HEC-WAT

WTMP Modeling Framework: Proof of Concept

- Findings:
  - The HEC-WAT can link and execute both system and detailed models successfully.
    - HEC5Q (Legacy Model Test)
    - CE-QUAL-W2
    - HEC-ResSim
  - Initial development of a use case workflow plug-in for HEC-WAT was successful.
  - Initial implementation of common reporting was successful.



Linkage and Consistency between the System Model and Detailed Models

- Key objective is to support both rapid simulation of system operations as well as high-resolution simulation of critical system components
- Requires
  - Consistent representation of physical and operational characteristics
  - Common time dependent boundary conditions and operational controls
  - Standard linkages for passing information between models
  - Standard reporting formats for comparison of output from multiple models

Managing Model Configuration and Time Dependent Data

- Data Management
  - Gathering and QA for time dependent observations
  - Derived time series (e.g., daily min, max, average from instantaneous observations)
  - Archiving of source data used in construction of model data sets
  - Archiving of model data sets
- Modeling Framework
  - Managing metadata associated with model runs
  - Automated pre-processing to prepare model input from common boundary conditions