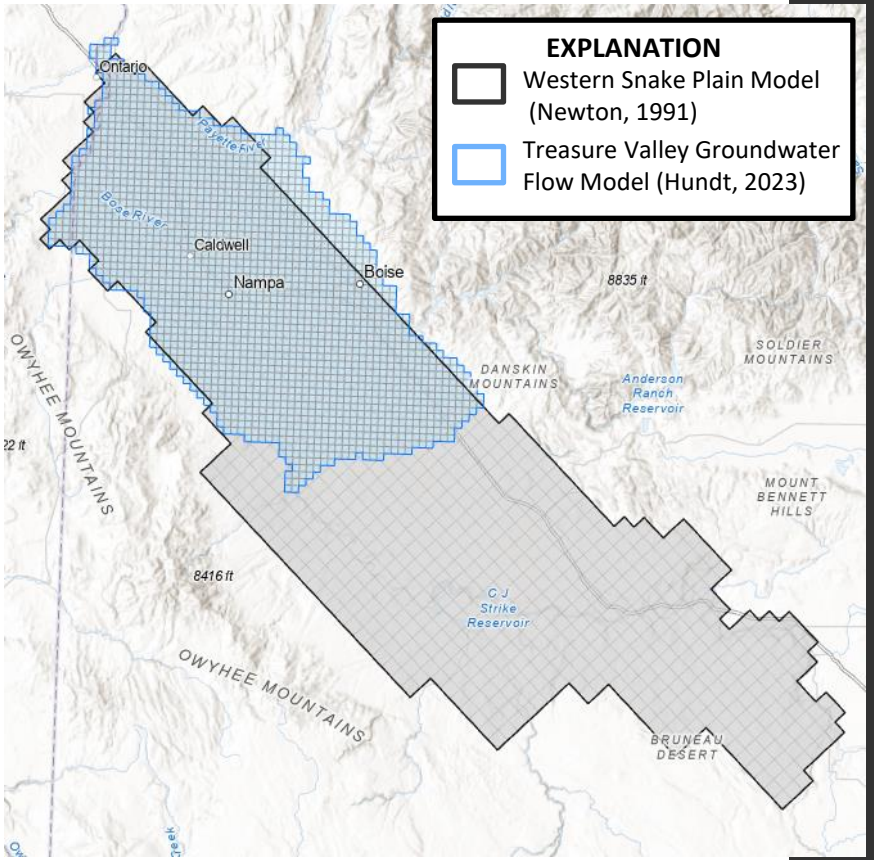

Model Development Process

Jake Knight
USGS
August 26, 2025

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Goal of this talk

(Re)introduce ourselves

Explain how we intend to work on the model and how we hope to interact with the MTAC

Get your feedback

USGS team

Paul Thomas; pthomas@usgs.gov
hydrologist in Boise, Idaho
project lead; admin; communication; modeling

Jacob Knight; jknight@usgs.gov
hydrologist in Tucson, Arizona
lead modeler;

Scott Ducar; sducar@usgs.gov
hydrologist in Boise, Idaho
data analysis; modeling

Project Basics

Timeline

Now – October 2028

Products

Groundwater flow model

Details to be decided and discussed with MTAC

Two Scenarios

Details to be decided and discussed with MTAC

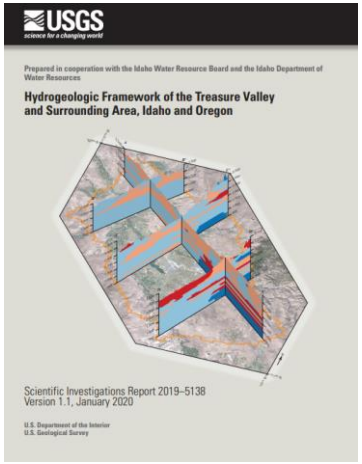
Model Report

USGS Scientific Investigation Report (SIR)

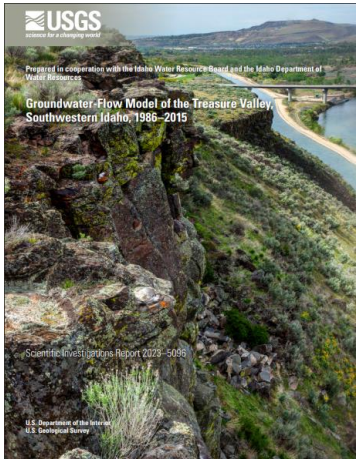
Data Release

USGS *ScienceBase* web page (*www.sciencebase.gov*)
Model
Scenarios
Input data
Scripts and tools for pre and post processing
Software tools for running scripts and other tools

Recent USGS Work

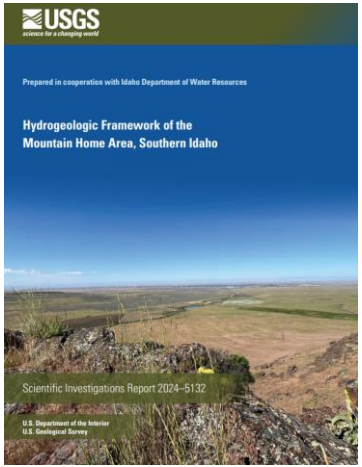


Hydrogeology of the Treasure Valley
Bartolino, USGS



Treasure Valley Groundwater Flow Model
Hundt & Bartolino, USGS

2023 Groundwater Budget of the Mountain Home area
Thomas, USGS



Hydrogeology of the Mountain Home area
Zinsser & Ducar, USGS

Our Proposed Approach

1. Workflow
2. Model Design

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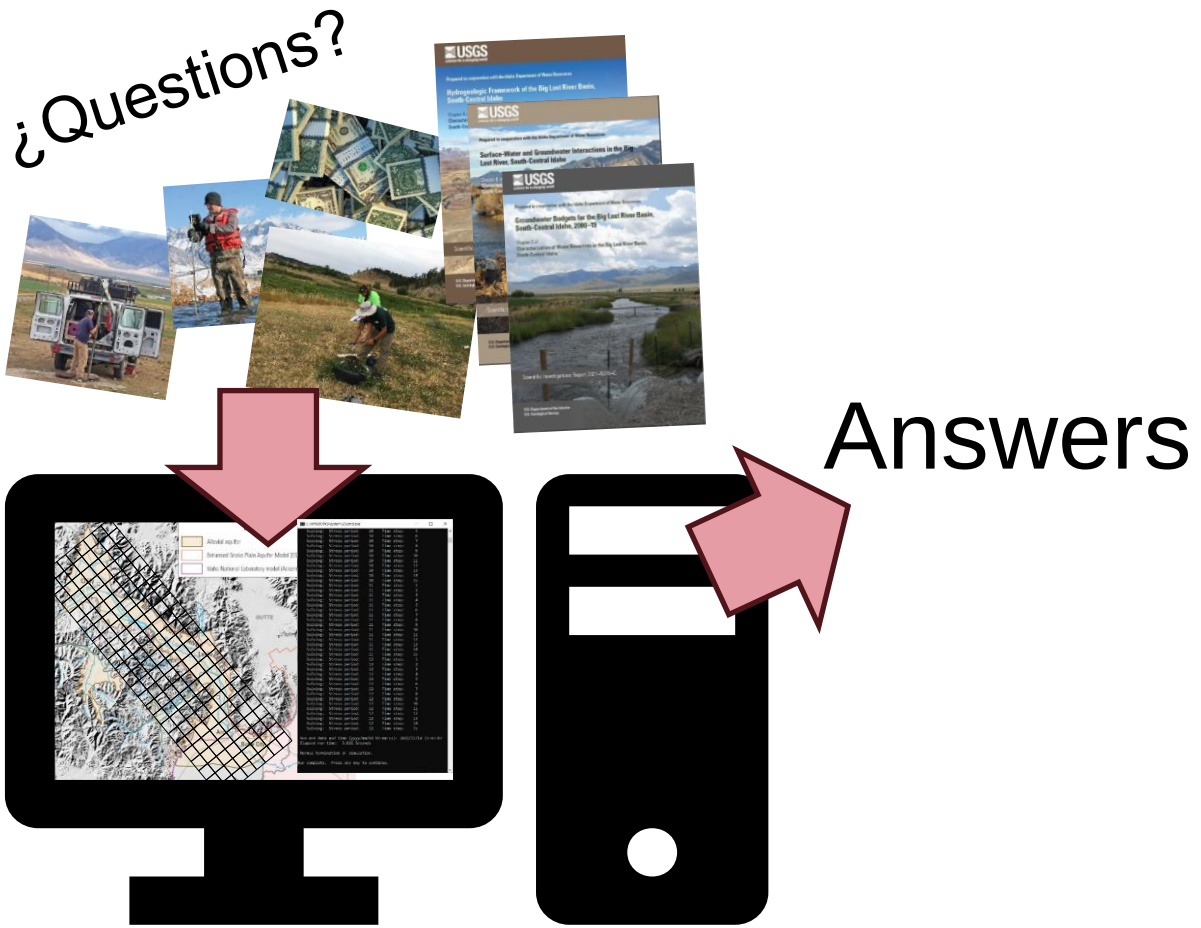
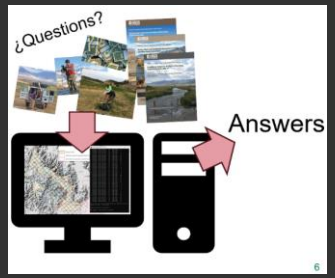
We want to build a model, but how?



The modeling process



Define problem
- Talk to stake-holders
- Literature review
- Preliminary analyses
- Data collection

Develop conceptual model
- Processes/ budget
- Boundary conditions
- Hydro-geologic framework
- Data collection

Develop mathematical model
- Choose model code
- Choose how to represent processes and boundary conditions
- Construct the model

Parameter Estimation
- History matching
- Sensitivity & uncertainty analysis
- Data collection

Assessment of problem using model

Present results

Re-evaluation of the problem and objectives based on simulation results

Project completion

After Reilly (2001) TWRI 3,B8

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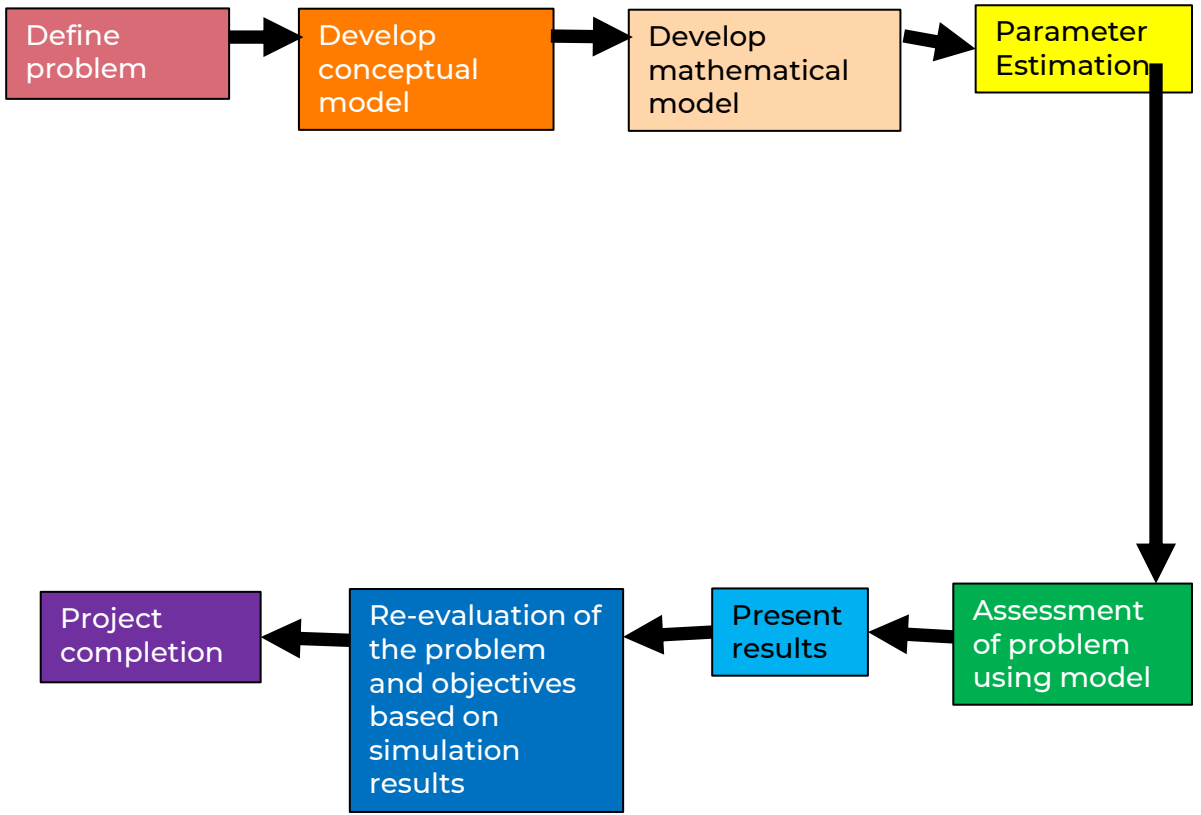
Sequential Development



After Reilly (2001) TWRI 3,B8

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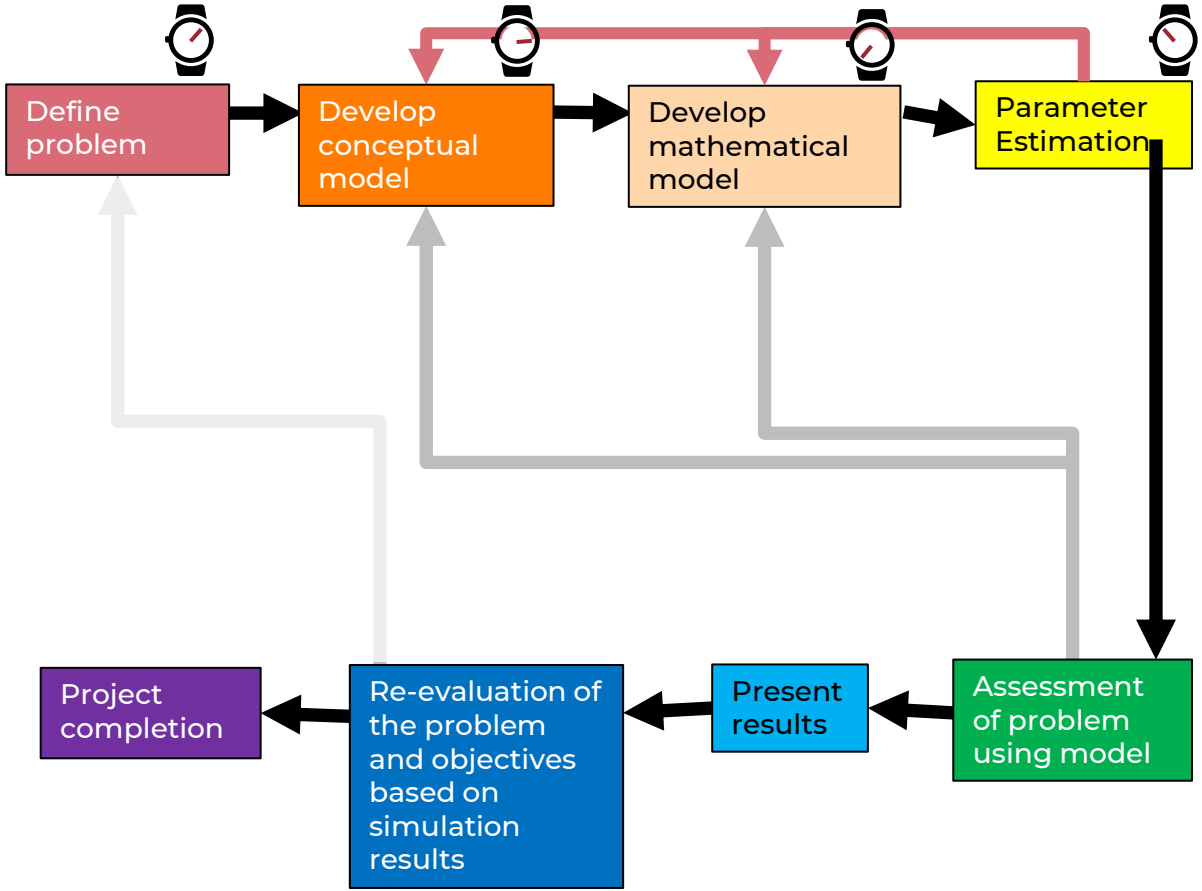
Sorta - Iterative Development

Run out of time to reevaluate problem and adjust conceptual and mathematical model

Difficult to notice and track down errors

Hard to assess the importance of different model features (especially if they don't include parameters for sensitivity analysis)

Less familiar with 'results' -> less insightful documentation



After Reilly (2001) TWRI 3,B8

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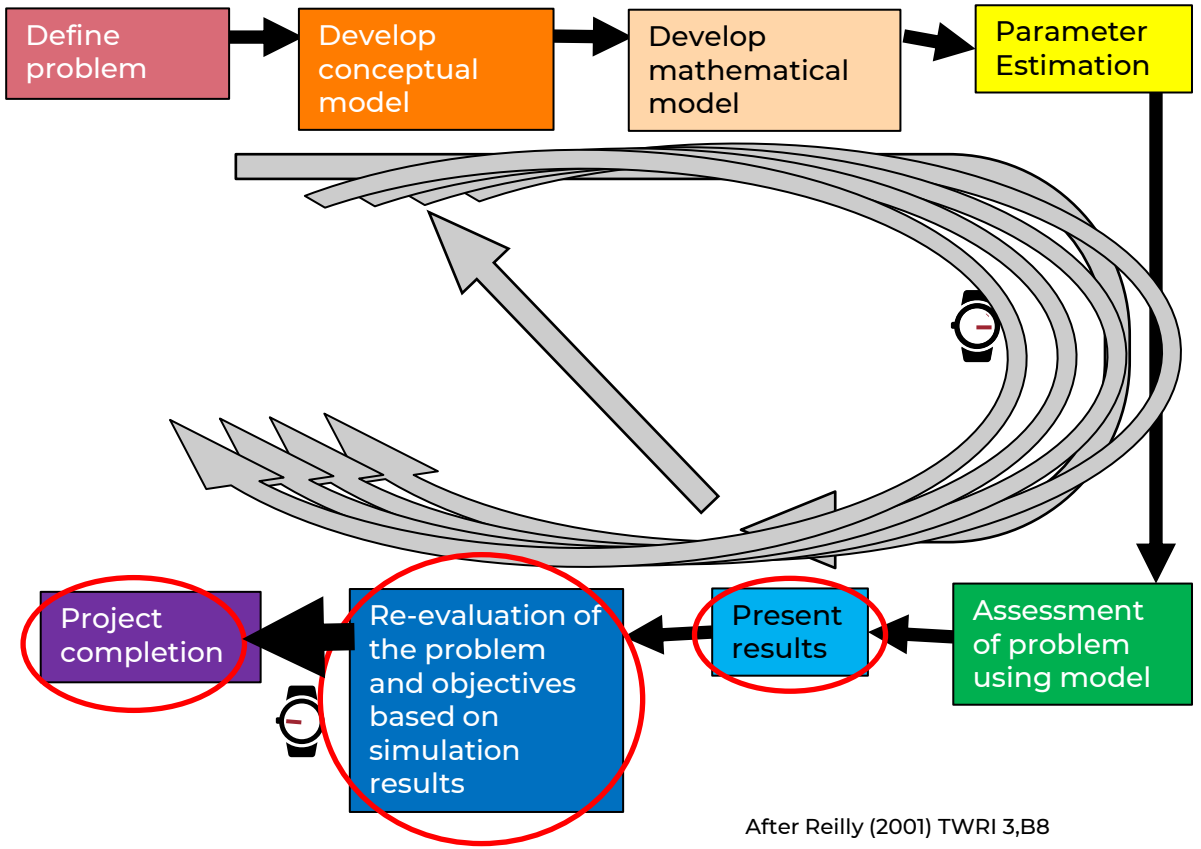
How to get to truly iterative model development?



After Reilly (2001) TWRI 3,B8

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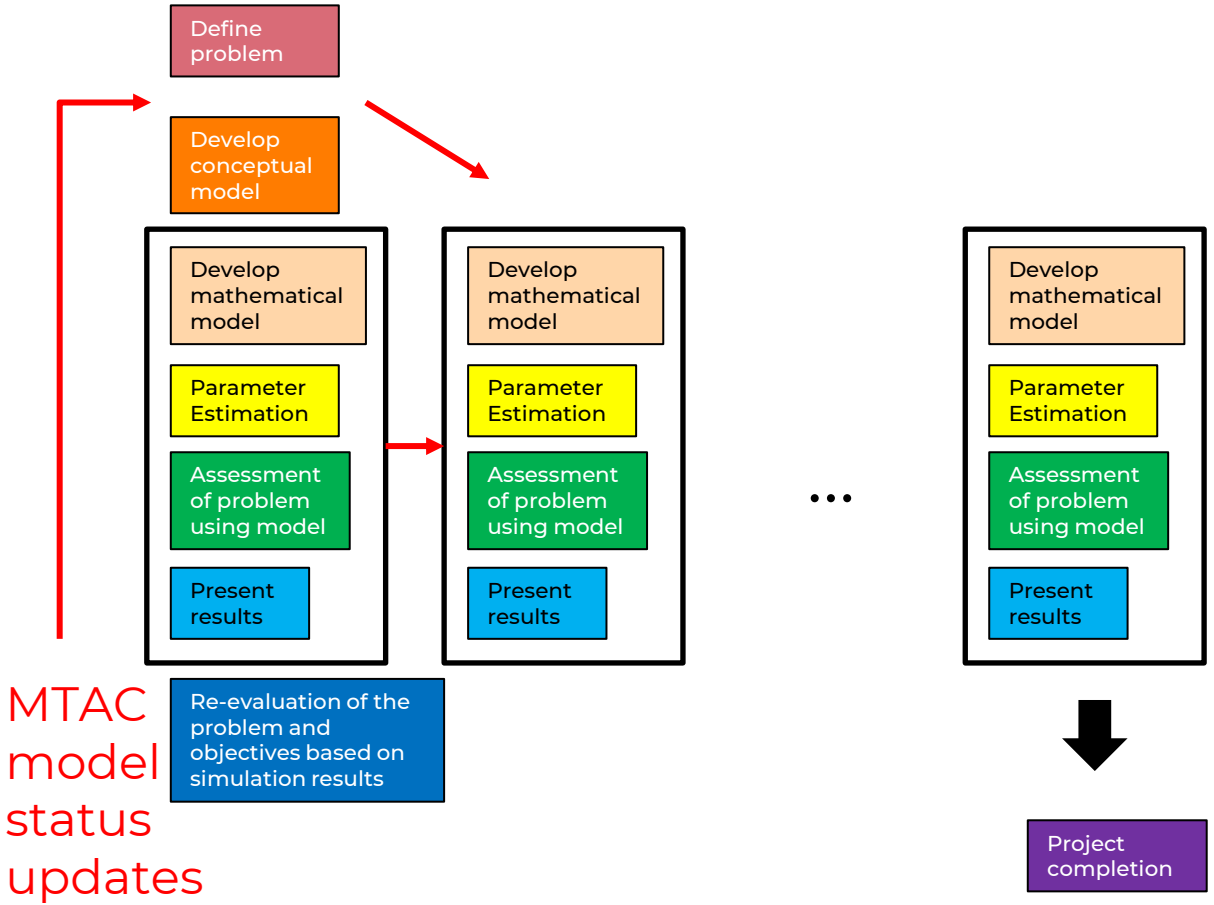
Approach in summary

Build scripts that automatically complete all steps from data retrieval through running and plotting scenario output

Get rudimentary version working and incrementally step through working versions from there

The “results” will include history-matching, parameter estimates, scenario output, and other model metrics **and will be presented at every MTAC**



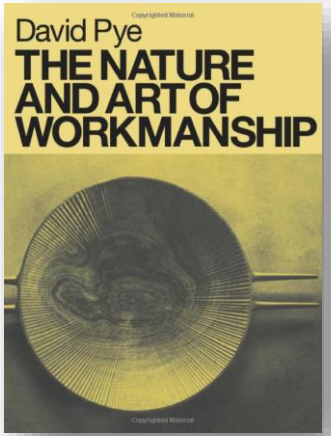
Script-based model development

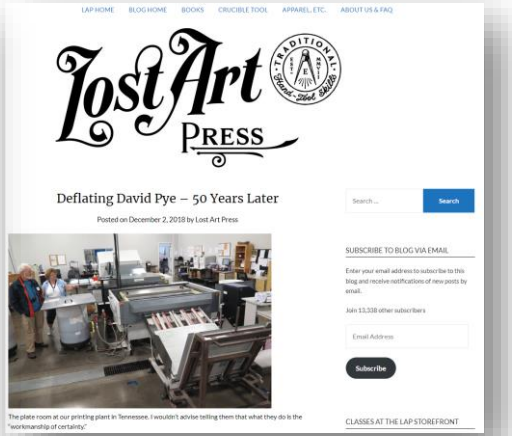
Risk vs. Certainty

From "The Nature and Art of Workmanship" - David Pye (1968)

The most typical and familiar example of the workmanship of risk is writing with a pen, and of the workmanship of certainty, modern printing…

…But all this judgment, dexterity and care has been concentrated and stored up before the actual printing starts. Once it does start, the stored up capital is drawn on and the newspapers come pouring out in an absolutely predetermined form with no possibility of variation between them…





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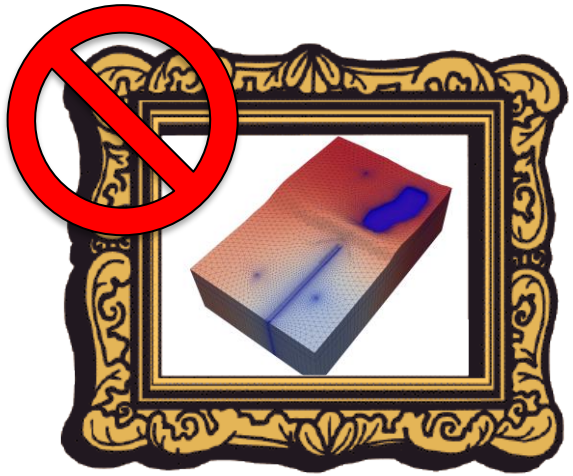
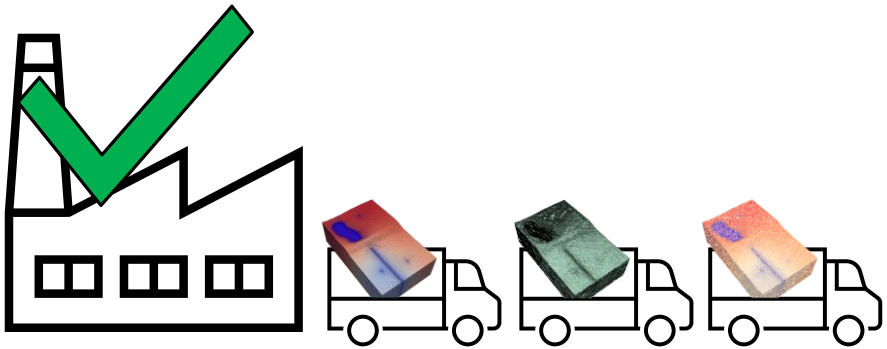
Script-based model development

Don't build a model, build a model factory.



Leverage scripts to:

- **Survive in the realm of "the ubiquity of error"**
- **"Concentrate and store up" your modeling "judgement, dexterity, and care."**
- **Automate input/output generation**
- **Execute *Plan-Do-Check-Act* cycles to move forward in short, quick steps**
- **Maintain flexibility to change decisions**



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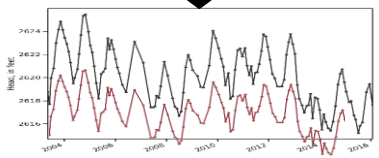
We'll build fully working versions as we go

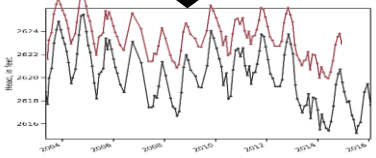
v0.01

- uniform recharge
- Snake as DRN
- uniform K values



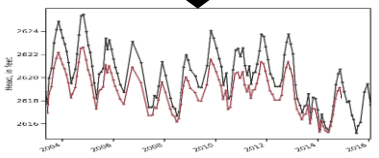
v0.02

- uniform recharge
- Snake as RIV
- variable K values
- tributary underflow



v0.03

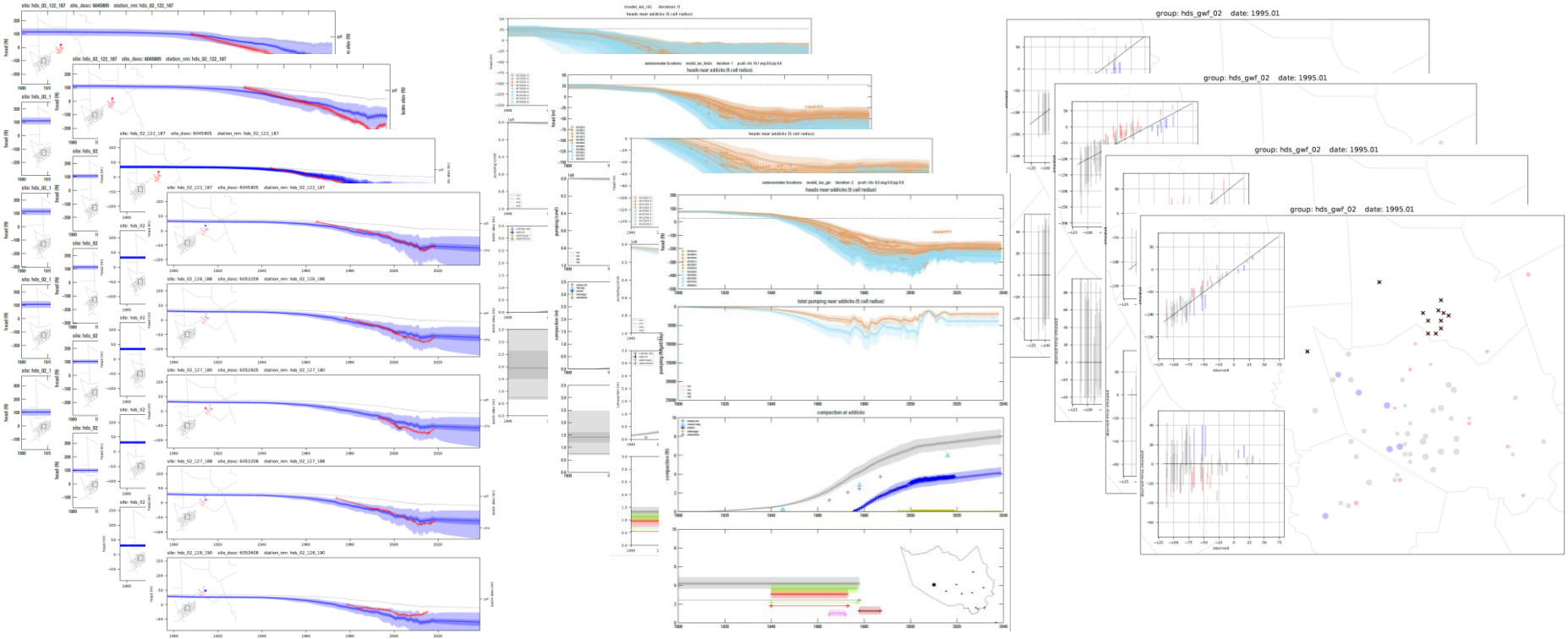
- ag recharge
- Snake as SFR
- variable K values
- tributary underflow



...

The GULF Model

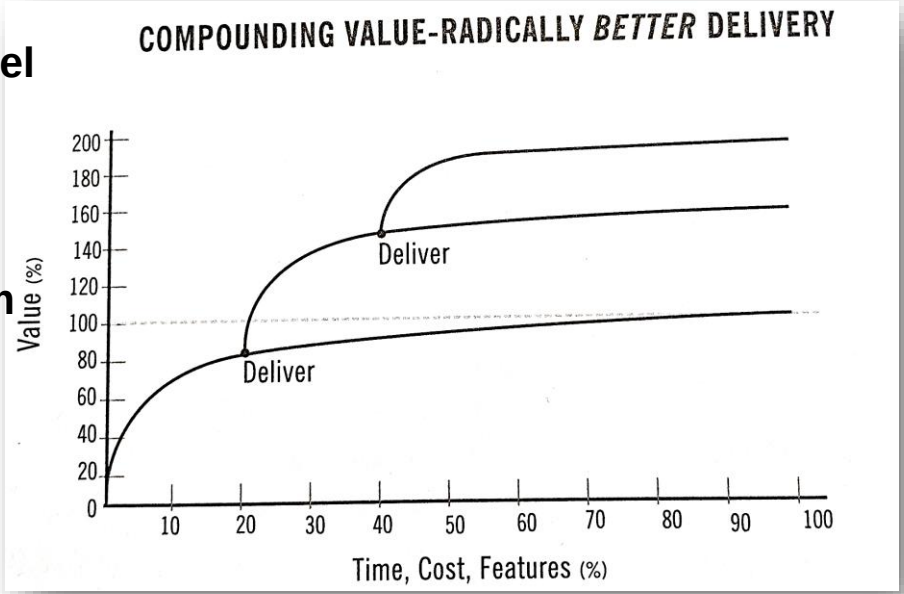
Project Workflow



The BLRM Model

Getting Started

- **Each MTAC meeting is an opportunity for a "product delivery"**
  - **Review added features, improved model performance w.r.t. objectives**
  - **Discuss model shortcomings, challenges**
- **Feedback at each MTAC meeting will inform a refreshed list of target features and abilities to aim for before the next MTAC meeting**
- **Repeat, Repeat, Repeat, until…?**



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Communication with MTAC

Show newest working version

Specific results to facilitate feedback

Act on MTAC feedback

Proposed format for USGS updates

- **Review objectives**
- What you told us last time
- What we've done since last time
- What the model does
- RESULTS
- What the model doesn't do
- What the model should do next

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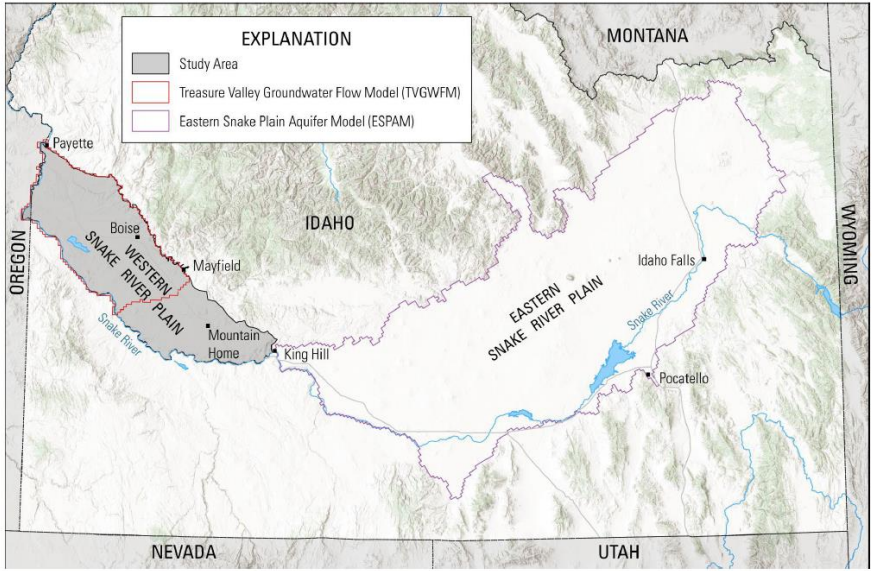
Proposed Model Development Approach



Starting point:

TVGWFM too coarse for Mayfield-area objectives

SE boundary based on GW divide (hydraulic, but not physical barrier to flow)

Mountain Home area not covered by a current model

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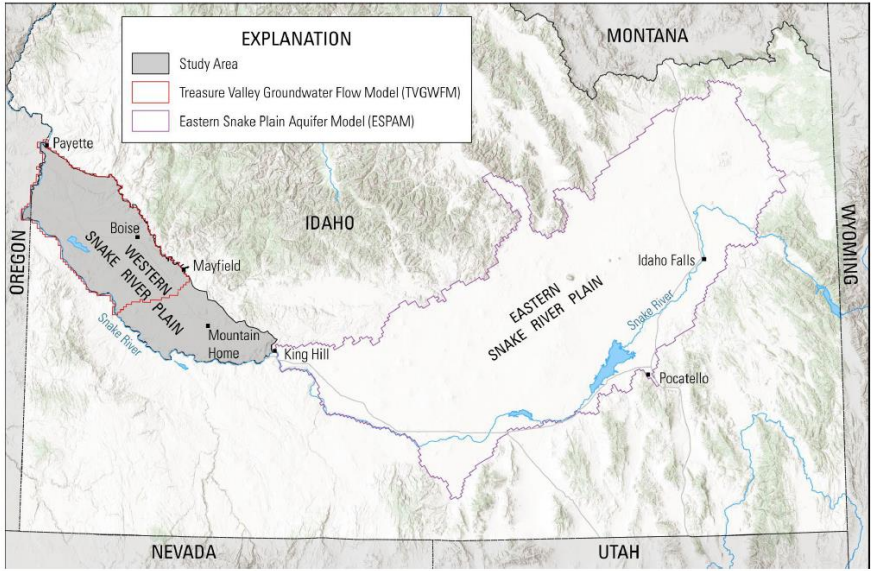
Proposed Model Development Approach



Problems associated with building new, separate models:

Redundant coverage
Potentially conflicting results
Increased maintenance burden

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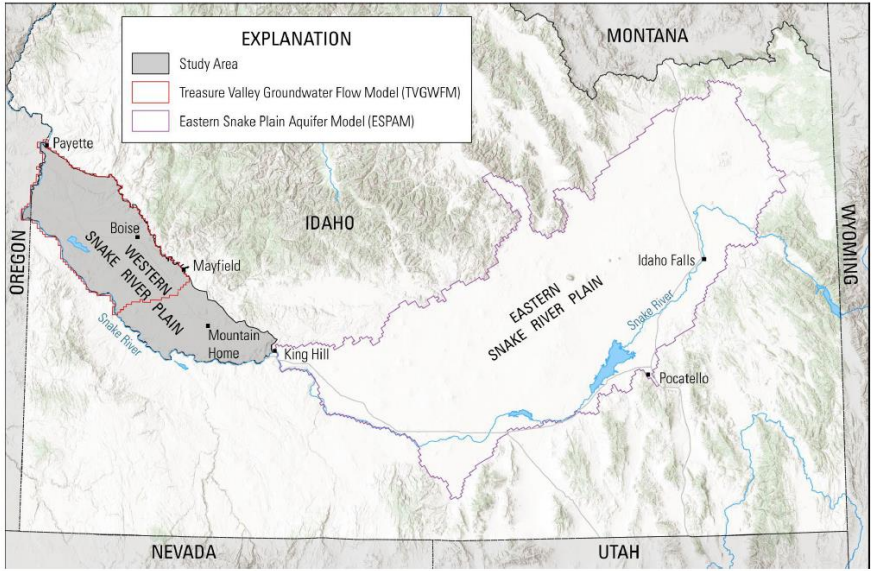
Proposed Model Development Approach



Problems associated with building new, single model for entire WSRP:

Computational burden
Inflexible design

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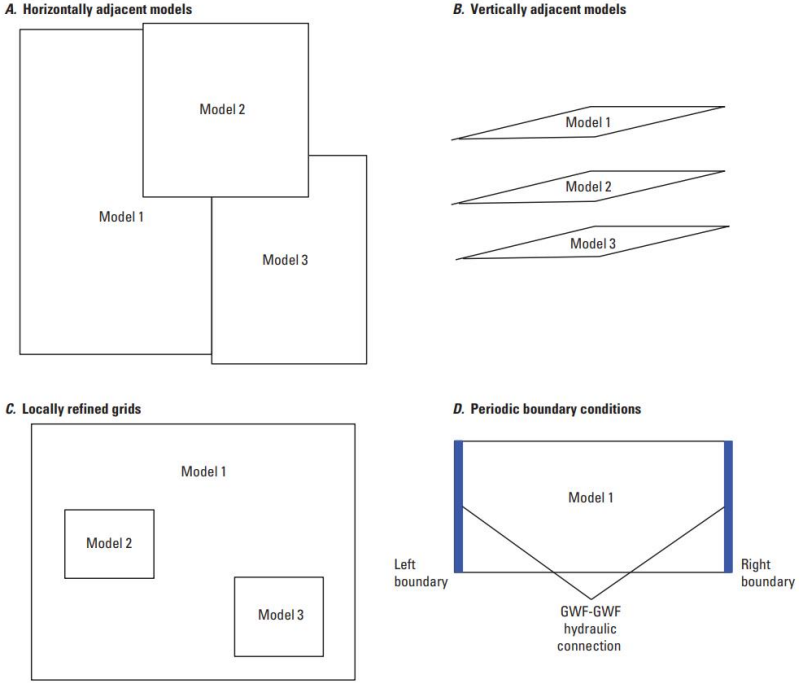

Figure 8–1. Diagram showing model configurations where the Groundwater Flow Exchange (GWF-GWF) may be used to hydraulically connect two different Groundwater Flow Models. *A*, horizontally adjacent models; *B*, vertically adjacent grids; *C*, locally refined grids; and *D*, periodic boundary conditions.

Proposed Model Development Approach

Tightly-coupled multiple model simulation using MODFLOW 6 GWF Model Exchange

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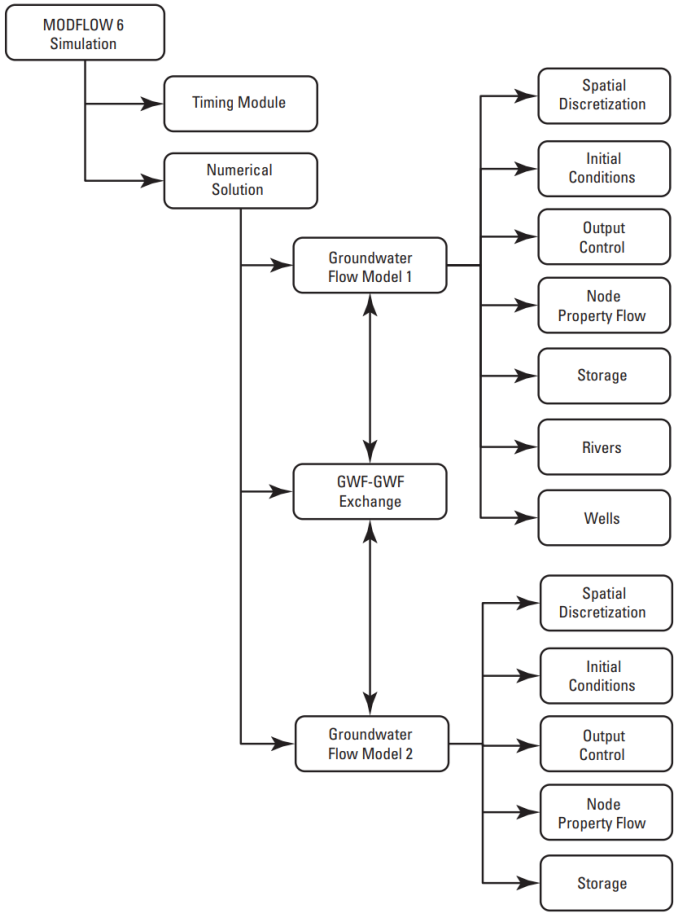

Figure 1–2. Diagram showing the MODFLOW 6 components for a simulation with two Groundwater Flow Models.

Proposed Model Development Approach

MF6 and 'GWF Exchange' functionality

Multiple models coupled at the matrix level and solved simultaneously

Faster and more stable than interatively coupled models

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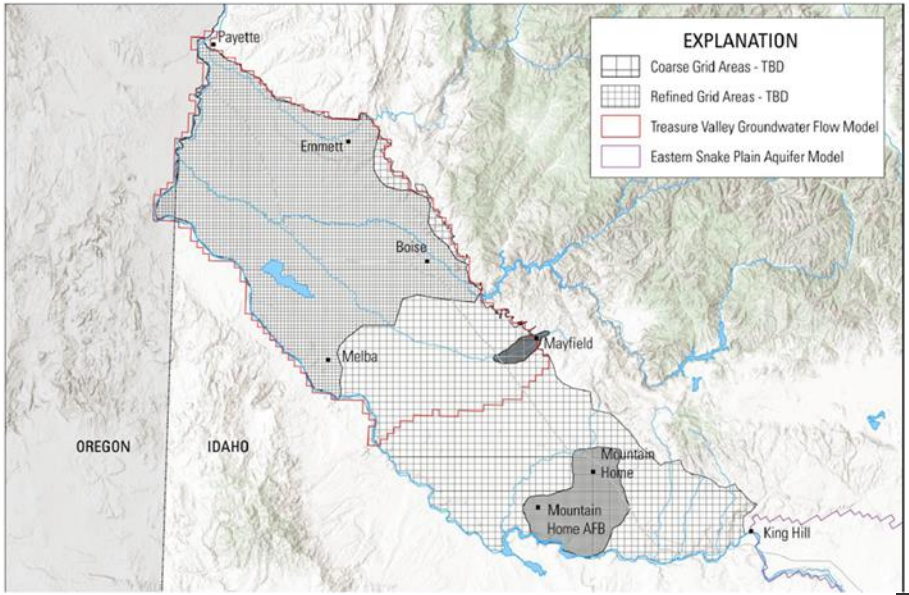
Proposed Model Development Approach



Regional scale: Physically-based boundaries, unified simulation of entire WSRP for management needs

Local scale: higher resolution child models fully-coupled to simulated heads and flows in surrounding regional-scale model cells

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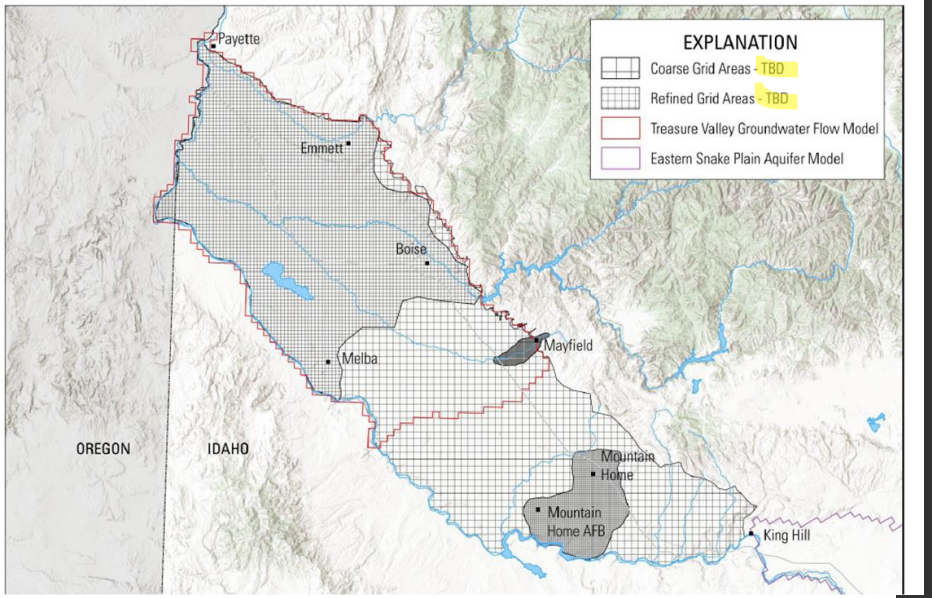
Proposed Model Development Approach



Modular design: child models can be deployed independently of each other

Model design choices can be made independently between child models, to suit **model objectives**

Ability to add/refine child models extends model lifespan

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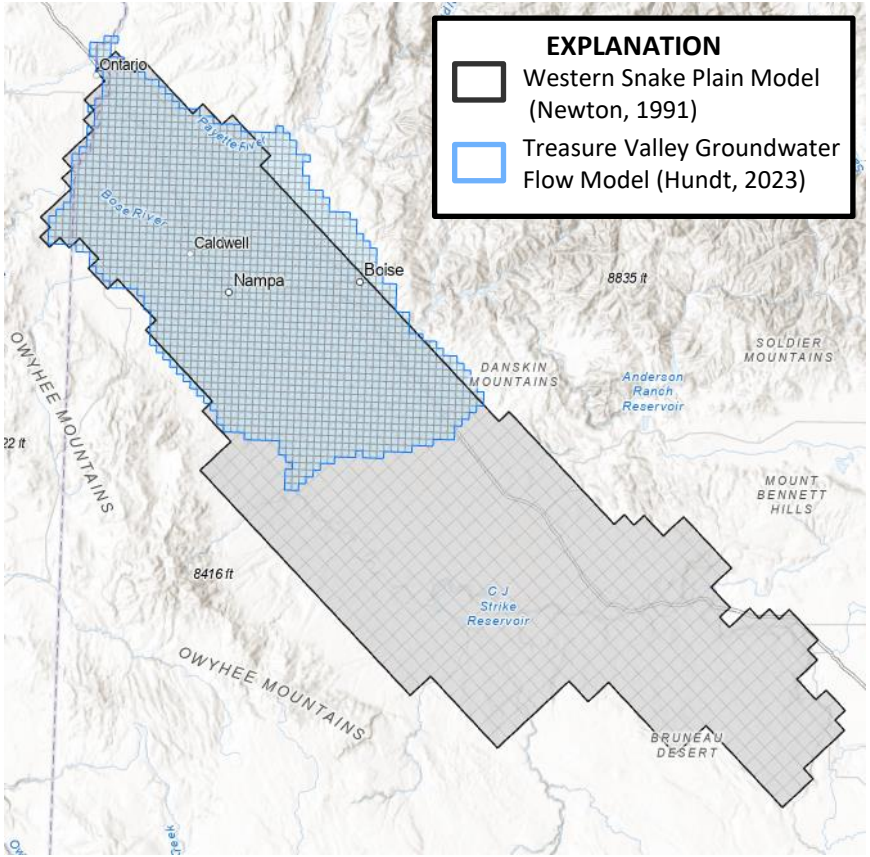

Proposed Model Development Approach

Currently testing tightly-coupled approach.

Parent: WSPM (Newton, 1991)

Child: TVGWFM (Hundt, 2023)

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Thank you!

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