USGS
science for a changing world

# Investigation of the Groundwater System of the Harney Basin, Oregon

**Stephen B. Gingerich**

**For the**
**Greater Harney Valley Groundwater Study Advisory Committee**
**October 20, 2016**

**Burns, OR**

U.S. Department of the Interior
U.S. Geological Survey

Image from Google Earth

# Study Objectives

- Develop a quantitative conceptual understanding of the groundwater-flow system of the Harney Basin using field data and fundamental hydrologic principles.

- Develop tools to test the conceptualization of the groundwater-flow system and accurately simulate its response to current conditions and proposed groundwater development.

- Describe the groundwater-flow system through reports and presentations.

USGS

# Study Information

- 6-yr cooperative study using State and Federal money
- Work elements will be shared by USGS and OWRD
- Stakeholder involvement critical to long-term success of the study for proper aquifer management
- Final reports will be peer-reviewed USGS publications
- USGS modeling reports will not recommend any specific course of action but can describe the impacts of various scenarios that have been designed with stakeholder input

# Some questions to be addressed

- How much water enters the Harney Basin (recharge)?
- How much water leaves the Harney Basin (discharge)?
- How might water-level declines progress in the future?
- How can water-level declines be managed?
- How does pumping affect surface-water discharge?
- To what degree are different parts of the basin hydrologically connected?

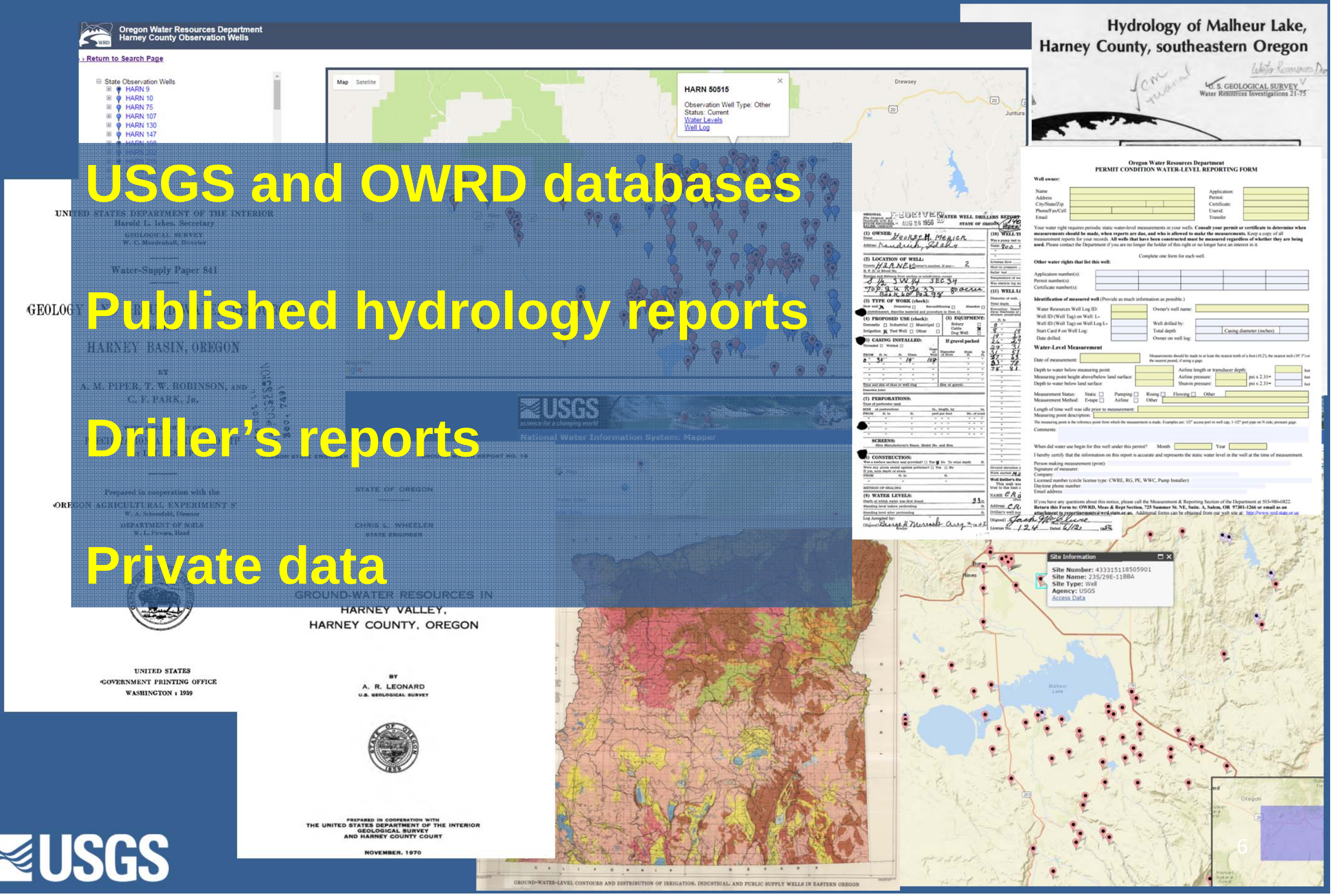
USGS

# Study Approach

- Compile, review, and analyze existing hydrologic data
- Develop an understanding of the groundwater-flow system
- Collect additional hydrologic data in areas with gaps
- Develop hydrologic budget to estimate water flow in and out of the system
- Develop a numerical groundwater flow model to test our understanding of the flow system and evaluate management options

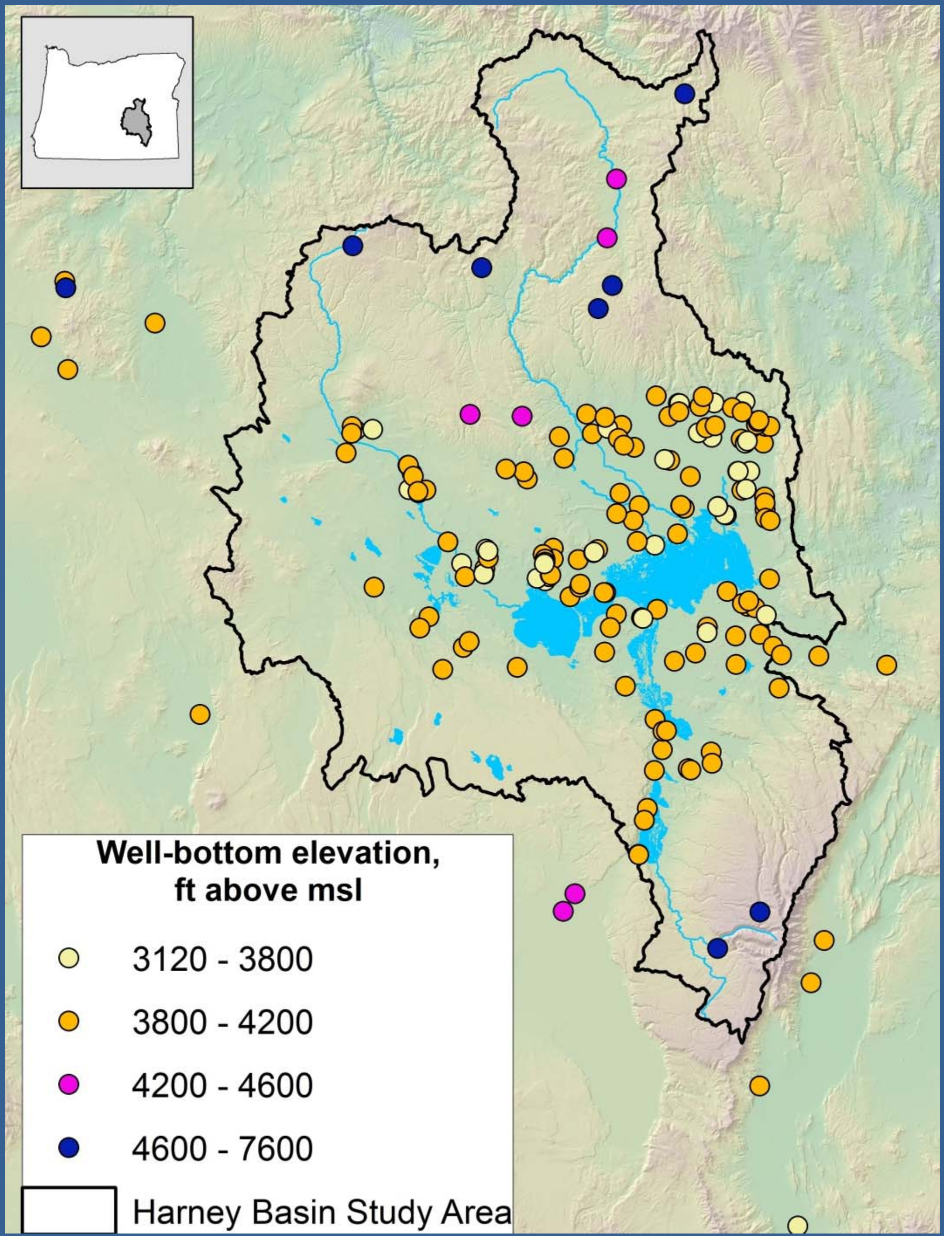
USGS

# Compile existing hydrologic data



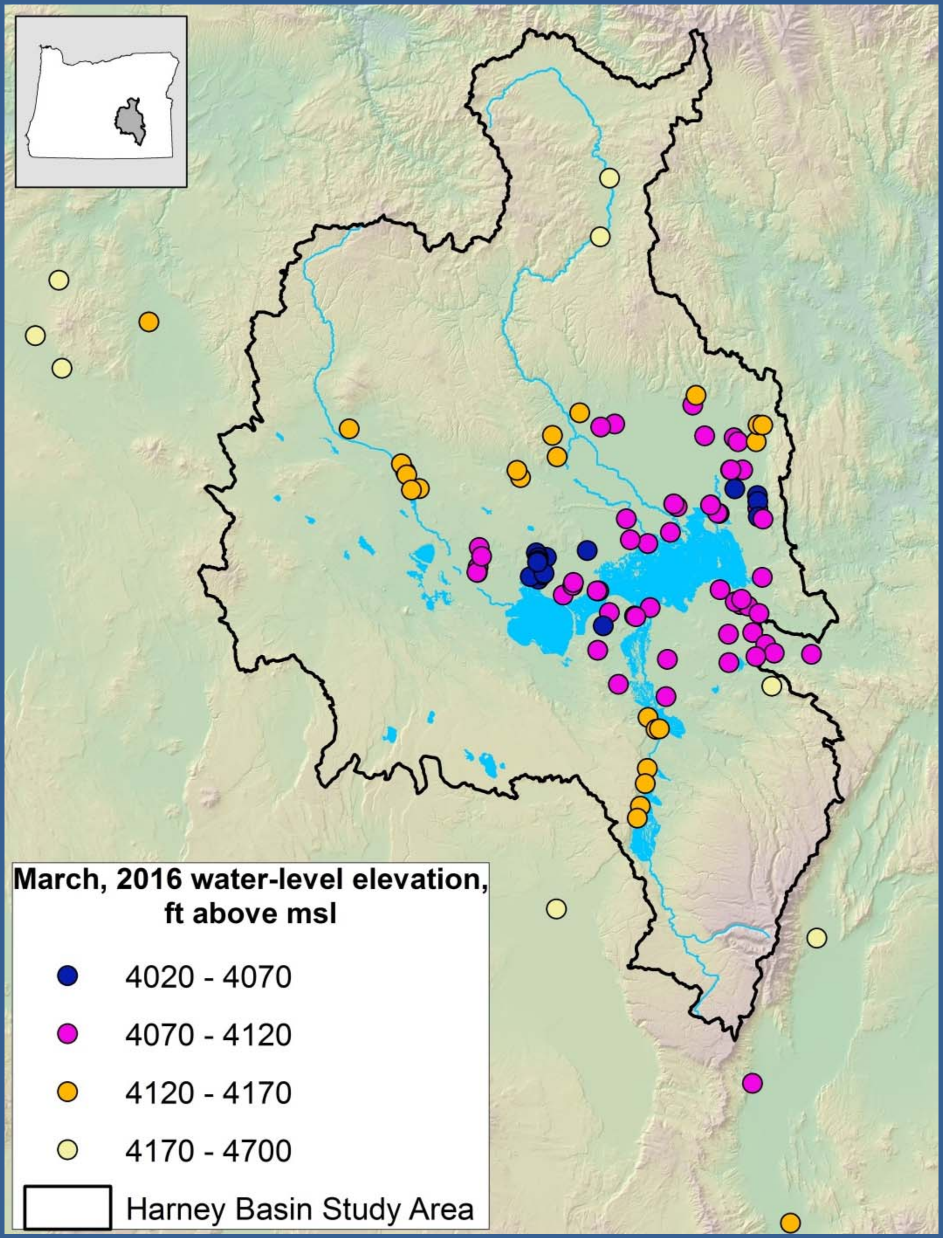

- USGS and OWRD databases
- Published hydrology reports
- Driller's reports
- Private data

# Monitoring well elevations




Data from OWRD well database

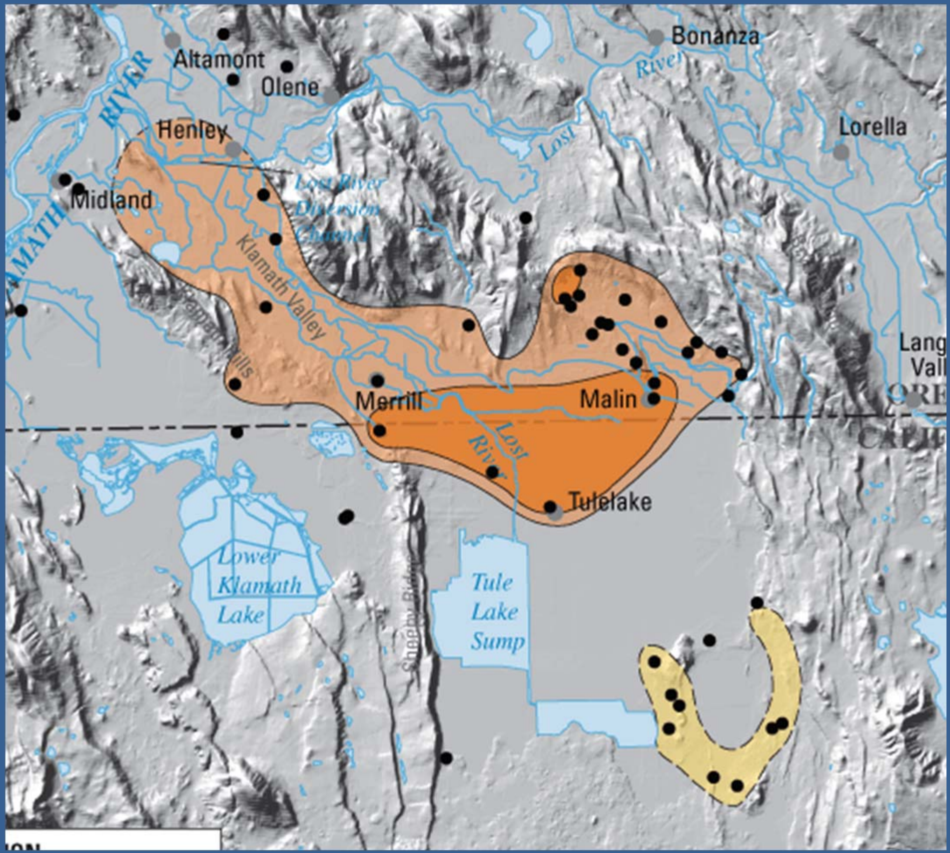
# March 2016 water levels



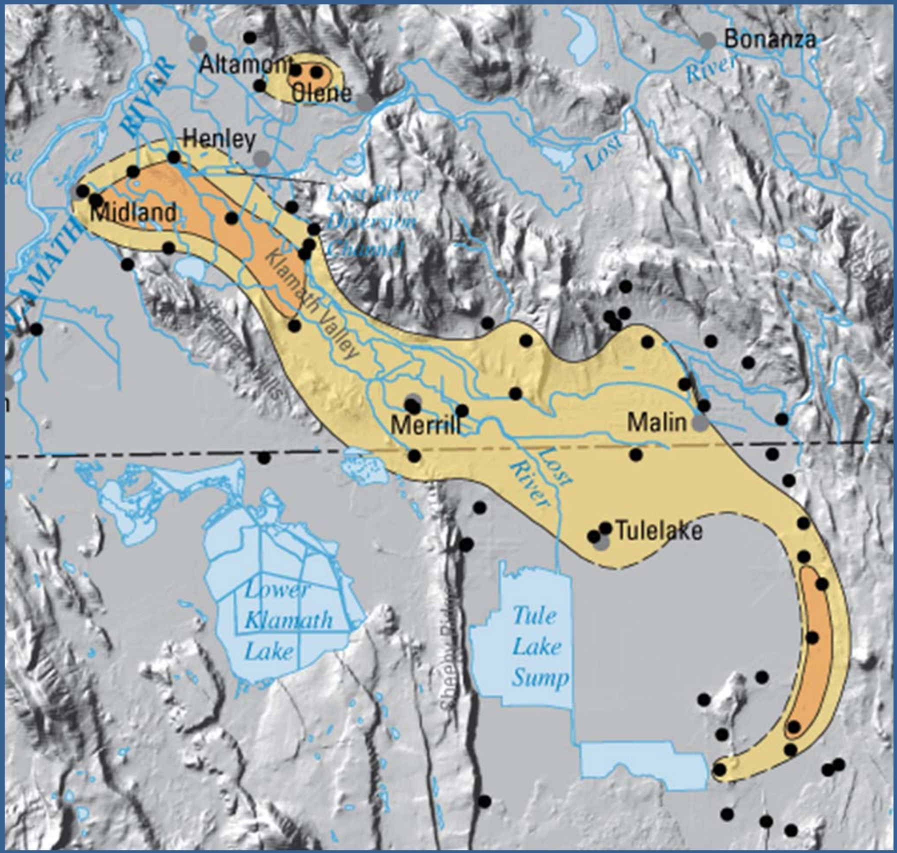

Data from OWRD well database

USGS

# Example of water-level decline maps




Year-to-year

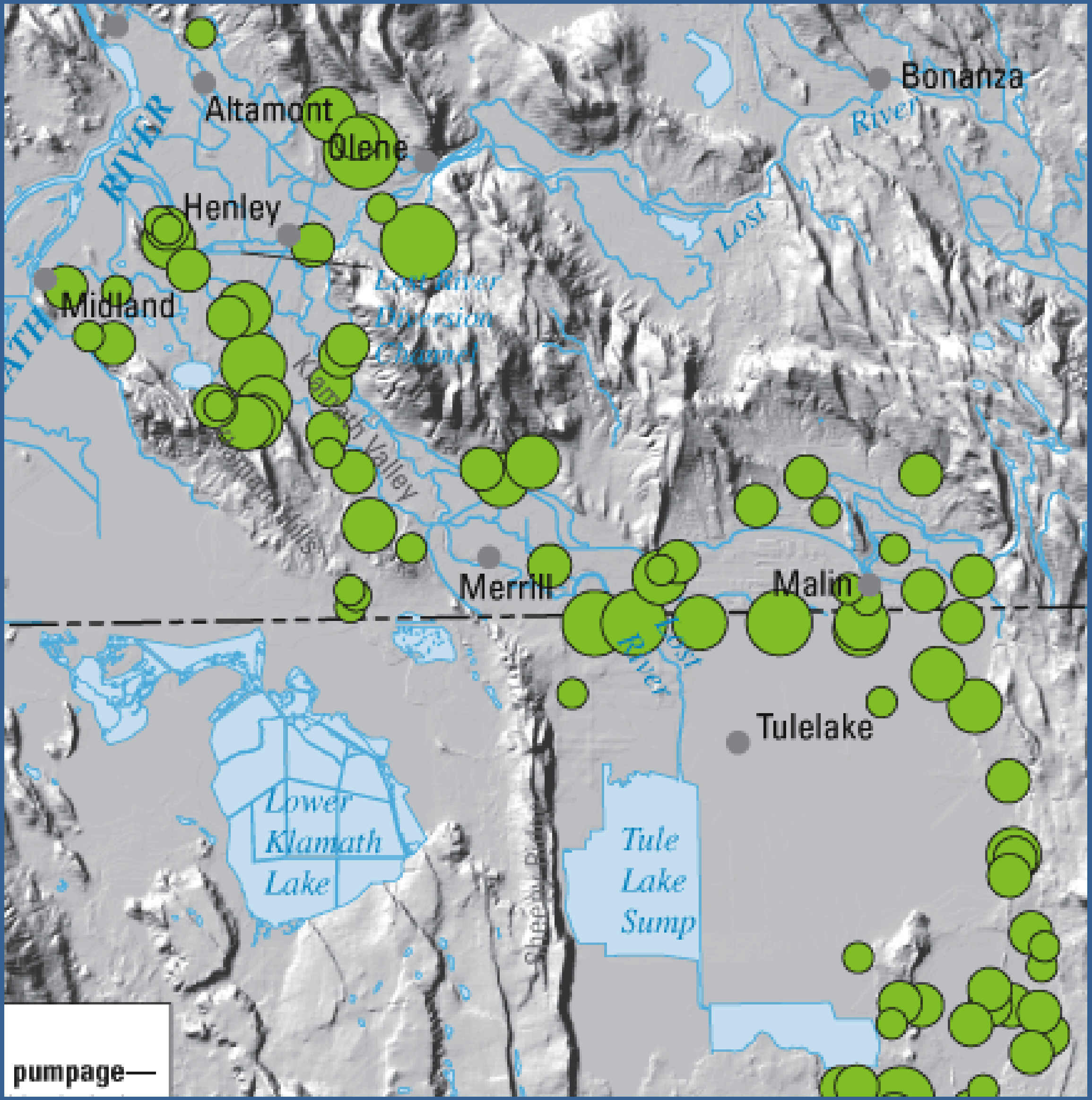



Spring-to-fall

USGS

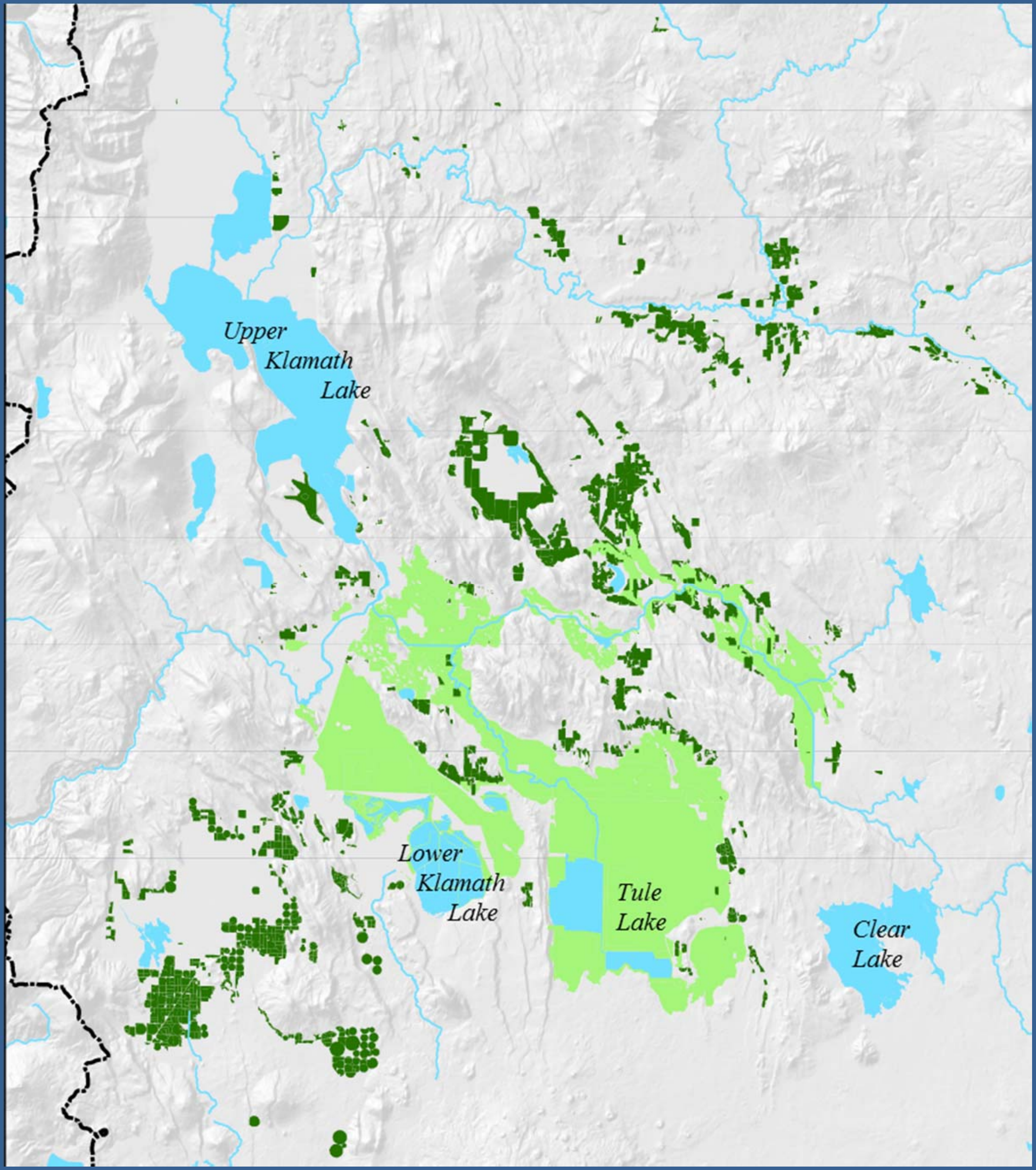
Gannett and others, 2007

# Example of groundwater pumping map




Gannett and others, 2007

# Example of irrigation map



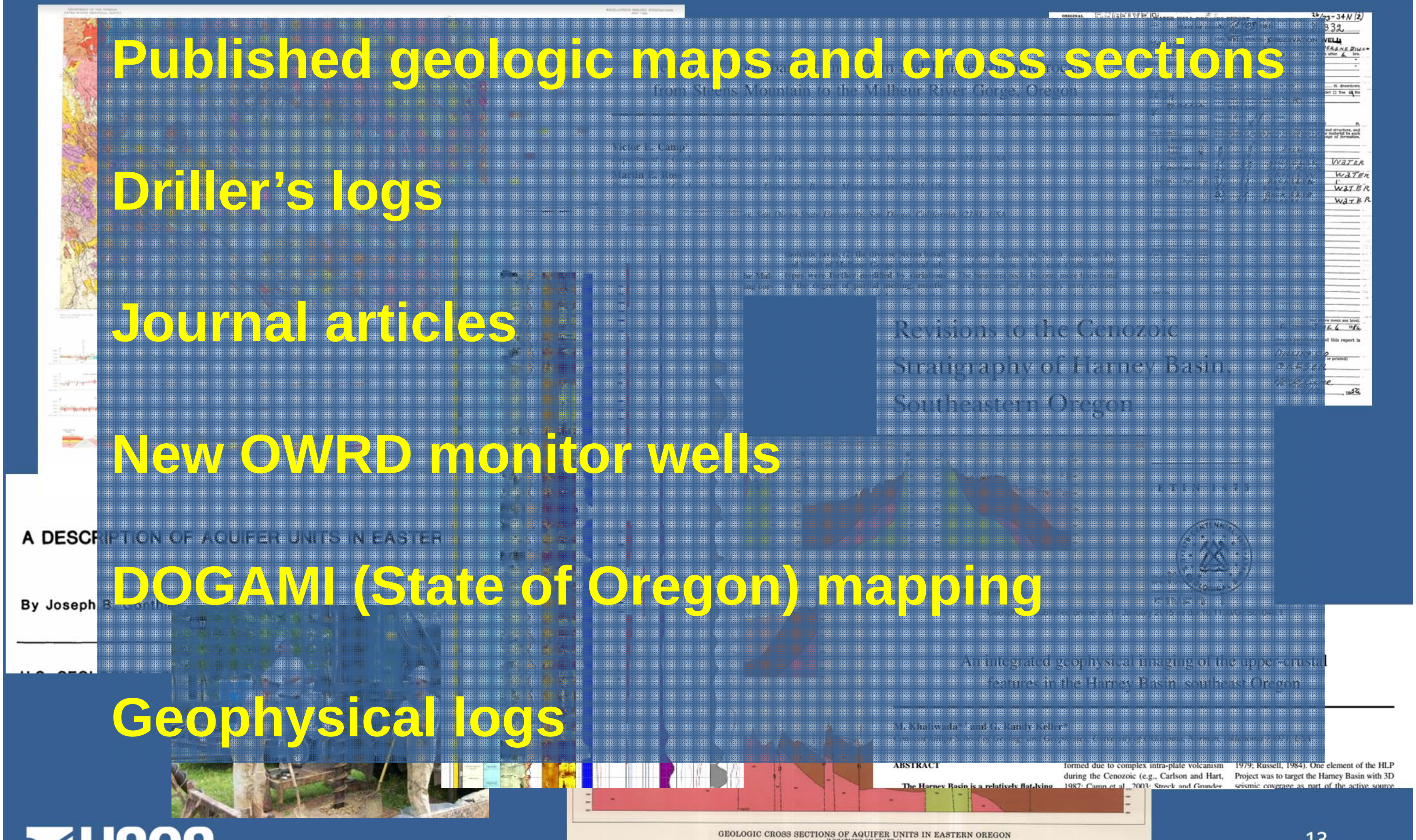

Gannett and others, 2007

# Describe geologic framework

- Determine the thickness, extent, and boundaries of the hydrogeologic units in the Harney basin

USGS

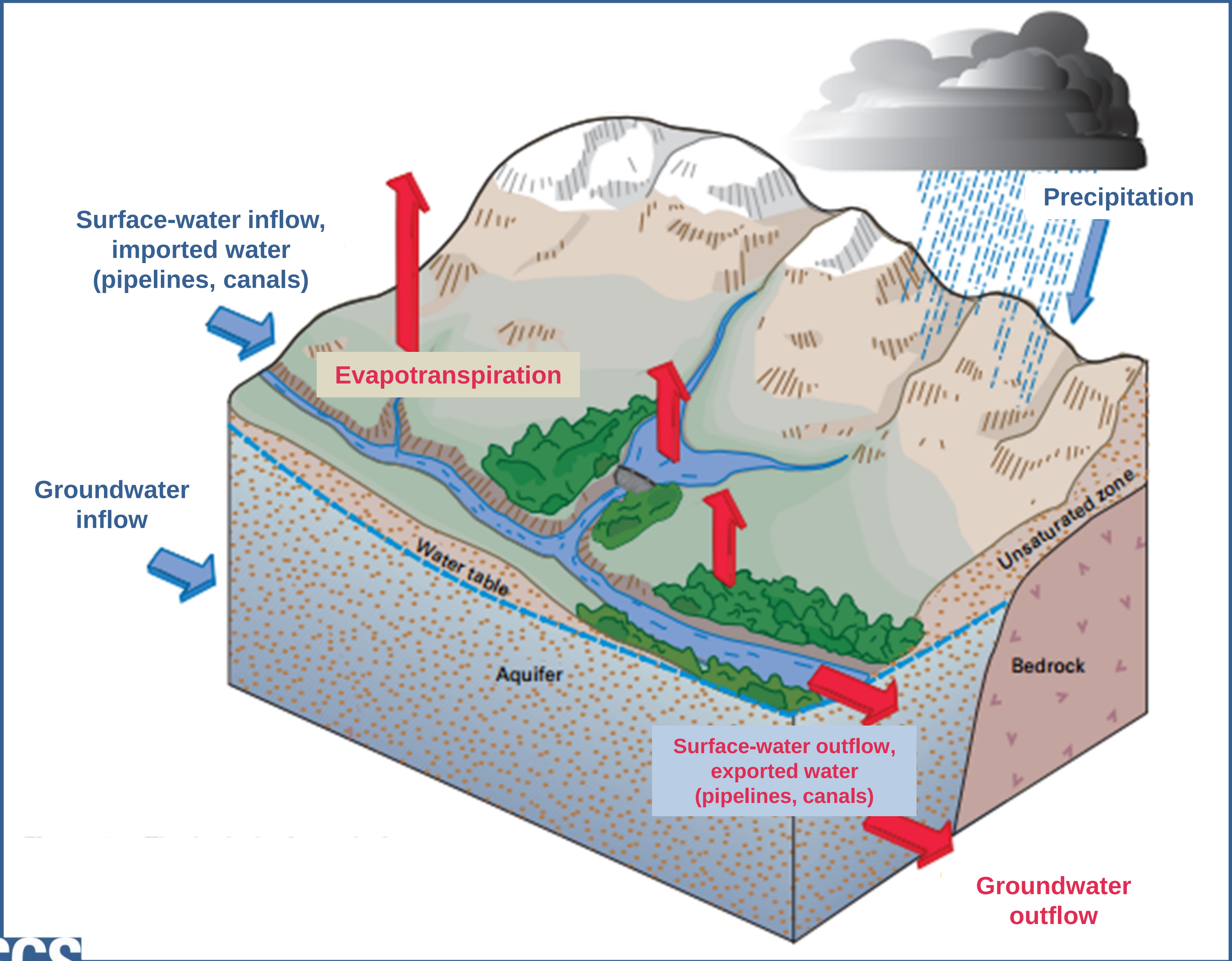
# Compile geologic information




- Published geologic maps and cross sections
- Driller’s logs
- Journal articles
- New OWRD monitor wells
- DOGAMI (State of Oregon) mapping
- Geophysical logs

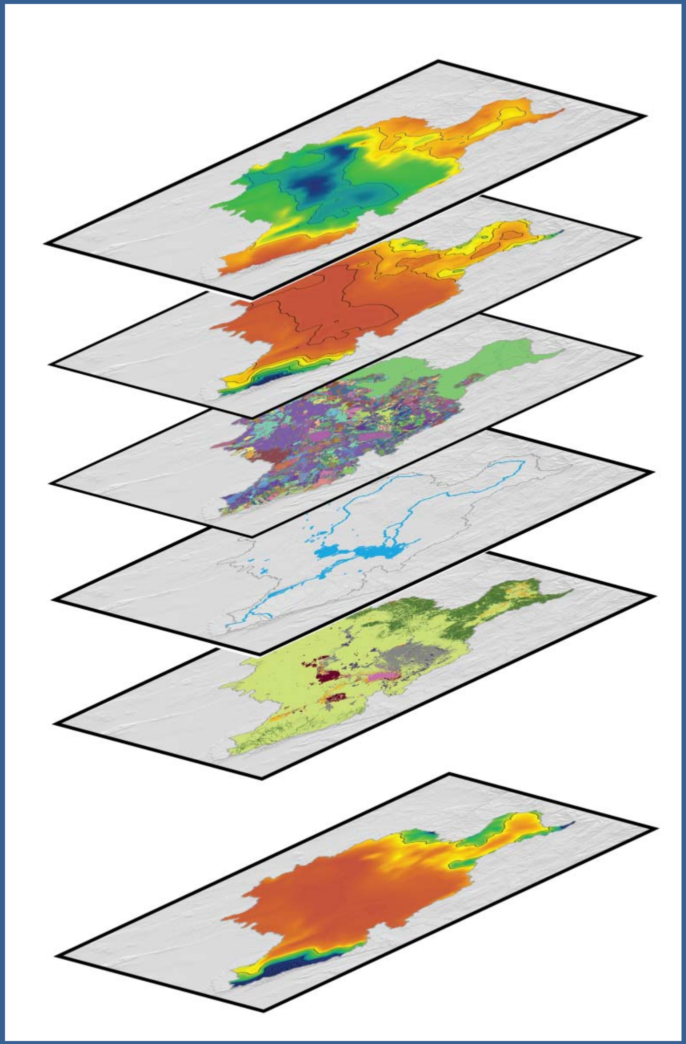
USGS

# Determine water budgets for groundwater and surface-water systems




Healy and others, 2007

# Recharge components



Precipitation

Evapotranspiration

Soils

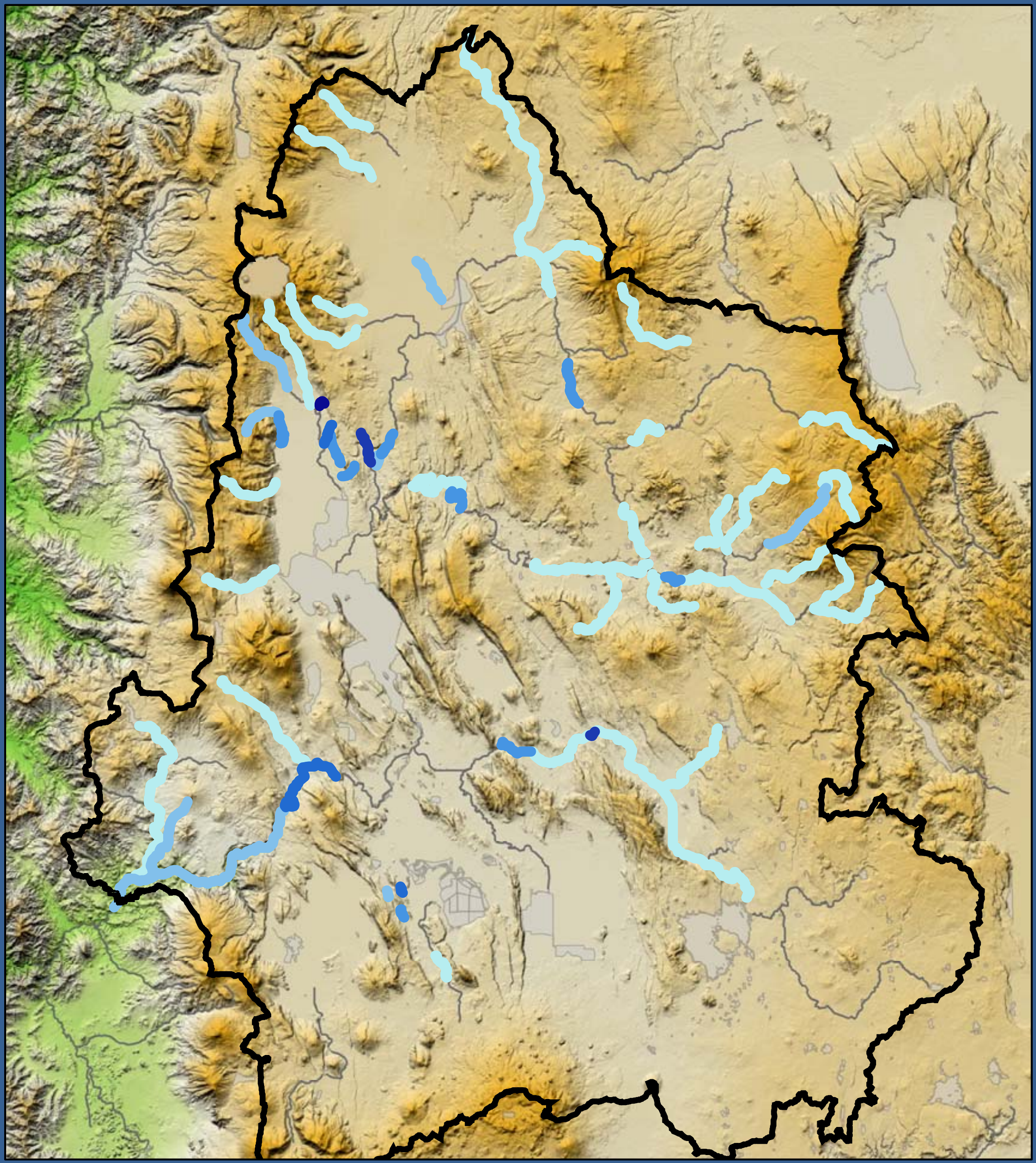
Runoff

Land use

↓

Recharge

# Groundwater Discharge to Streams in the Upper Klamath Basin



**Explanation**

**Groundwater Discharge**

**CFS per mile**

- 0.1 - 2.2
- 2.3 - 5.2
- 5.3 - 13.0
- 13.1 - 27.8
- 27.9 - 71.3
- 71.4 - 195.4

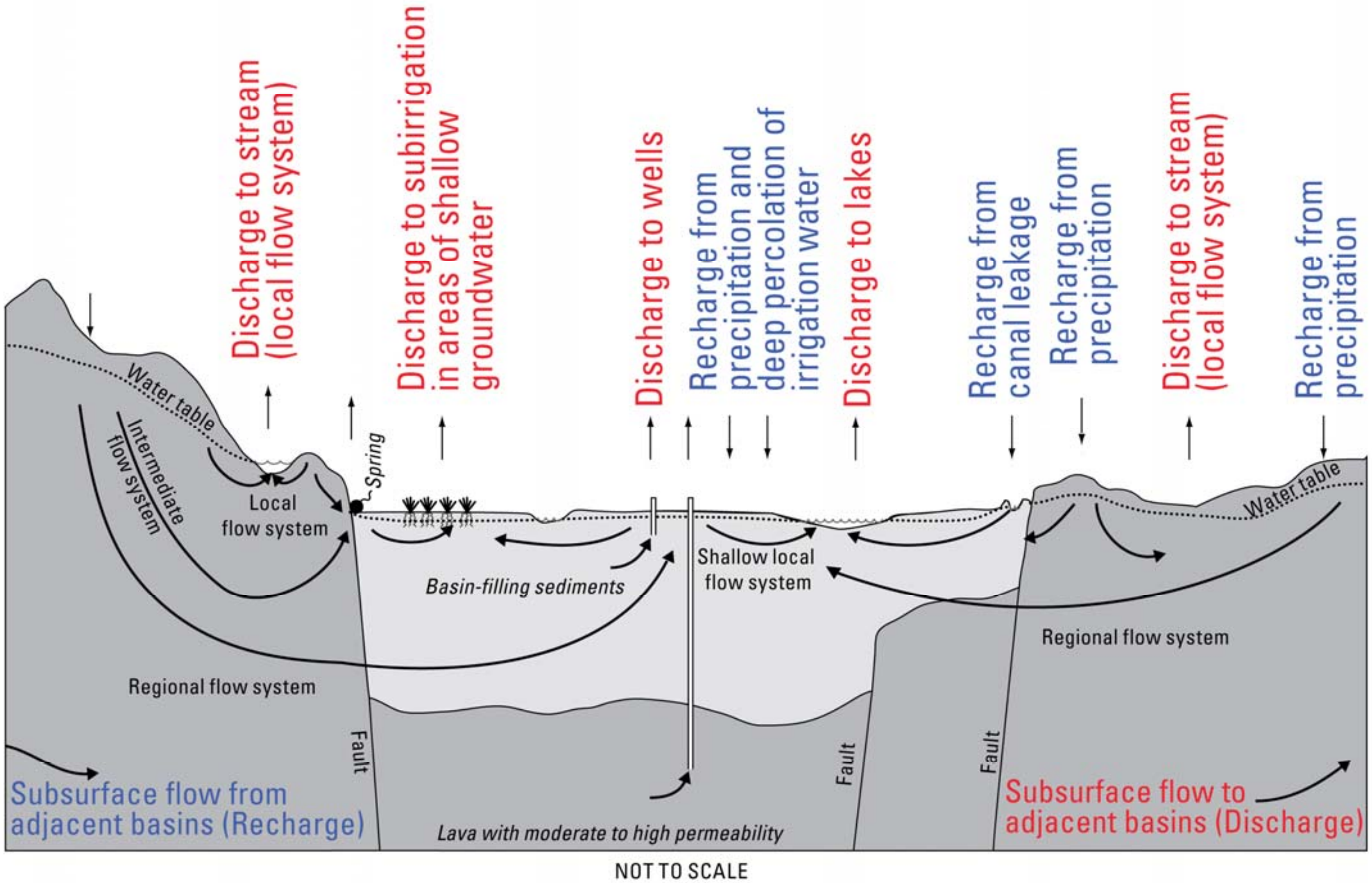
Gannett and others, 2007

# Determine aquifer properties

- Hydraulic conductivity (how fast water moves)
- Storage coefficient (how much water can it hold)
- Historical and new aquifer tests
- Specific capacity of existing wells

USGS

# Describe the flow system (conceptual model)




**RECHARGE = DISCHARGE ± CHANGE IN AQUIFER STORAGE**

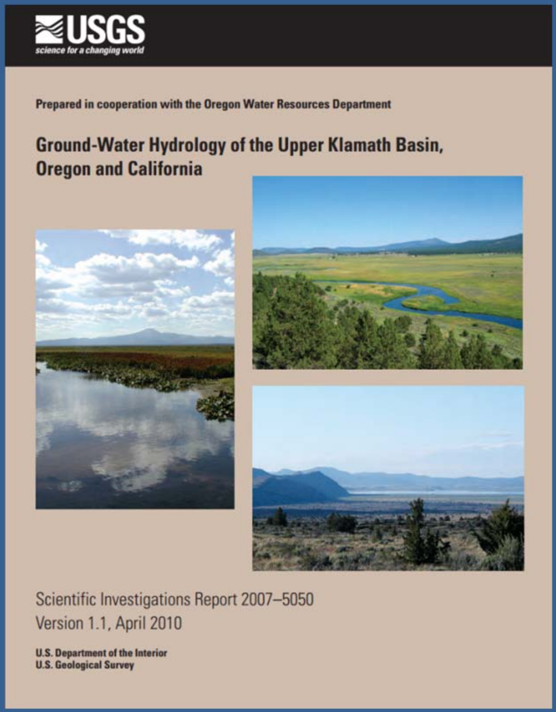
Schematic representation of sources of groundwater recharge, flow paths, and mechanisms of groundwater discharge in the Harney Basin, Oregon.

USGS

Modified from Gannett and others, 2007

# At the end of 2019, a USGS report describing the hydrologic flow system will be published

- Report will provide answers to some of the questions shown earlier and allow OWRD to begin making decisions about water allocation in the Harney Basin




Example: Gannett and others, 2007

USGS

# Phase 2

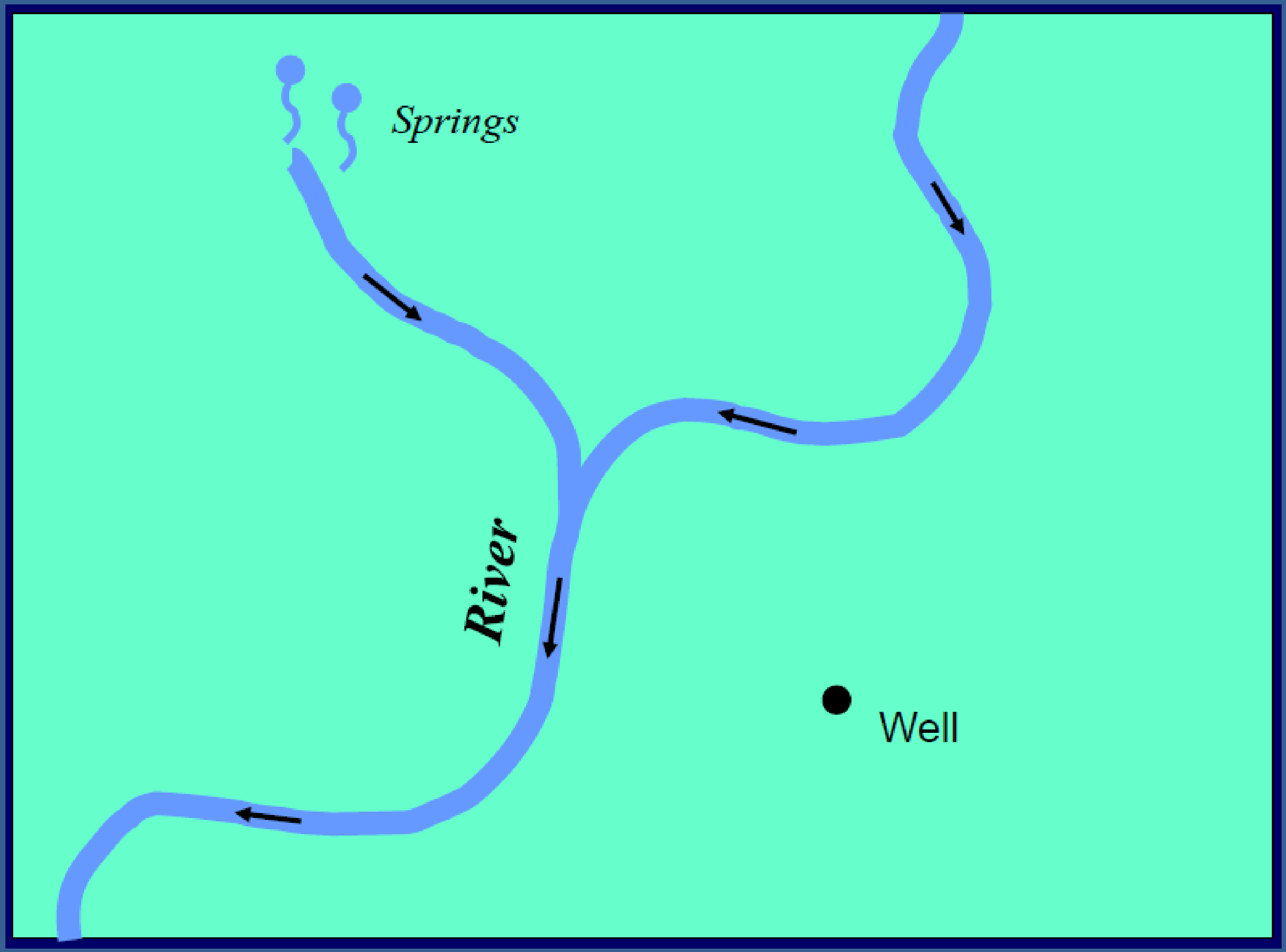
- Synthesize understanding of the flow system into a numerical groundwater-flow model

- Match model to historical water levels and groundwater discharge (calibration)

- Test hydrologic understanding and future pumping scenarios with the model

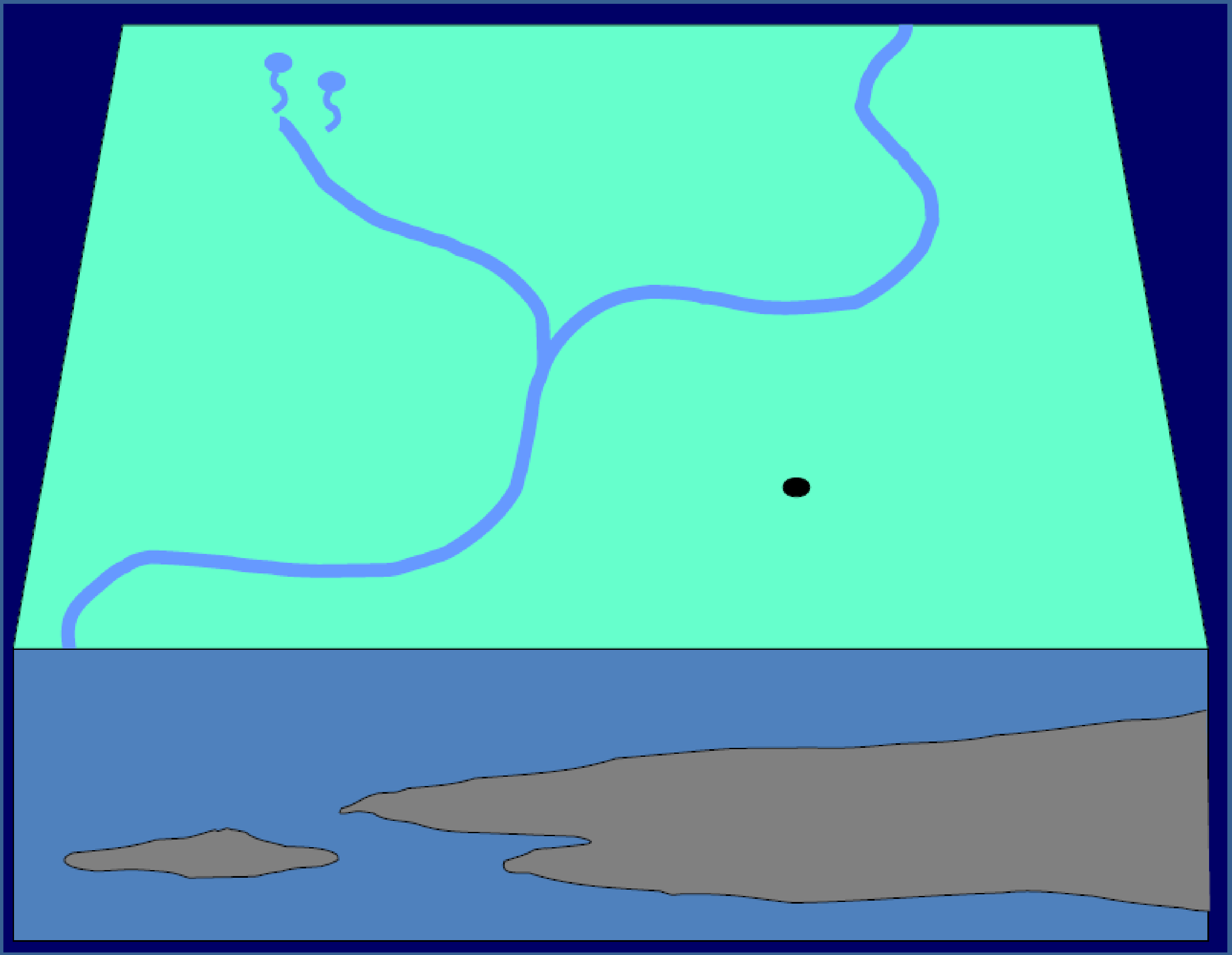
USGS

# Numerical Model Basics

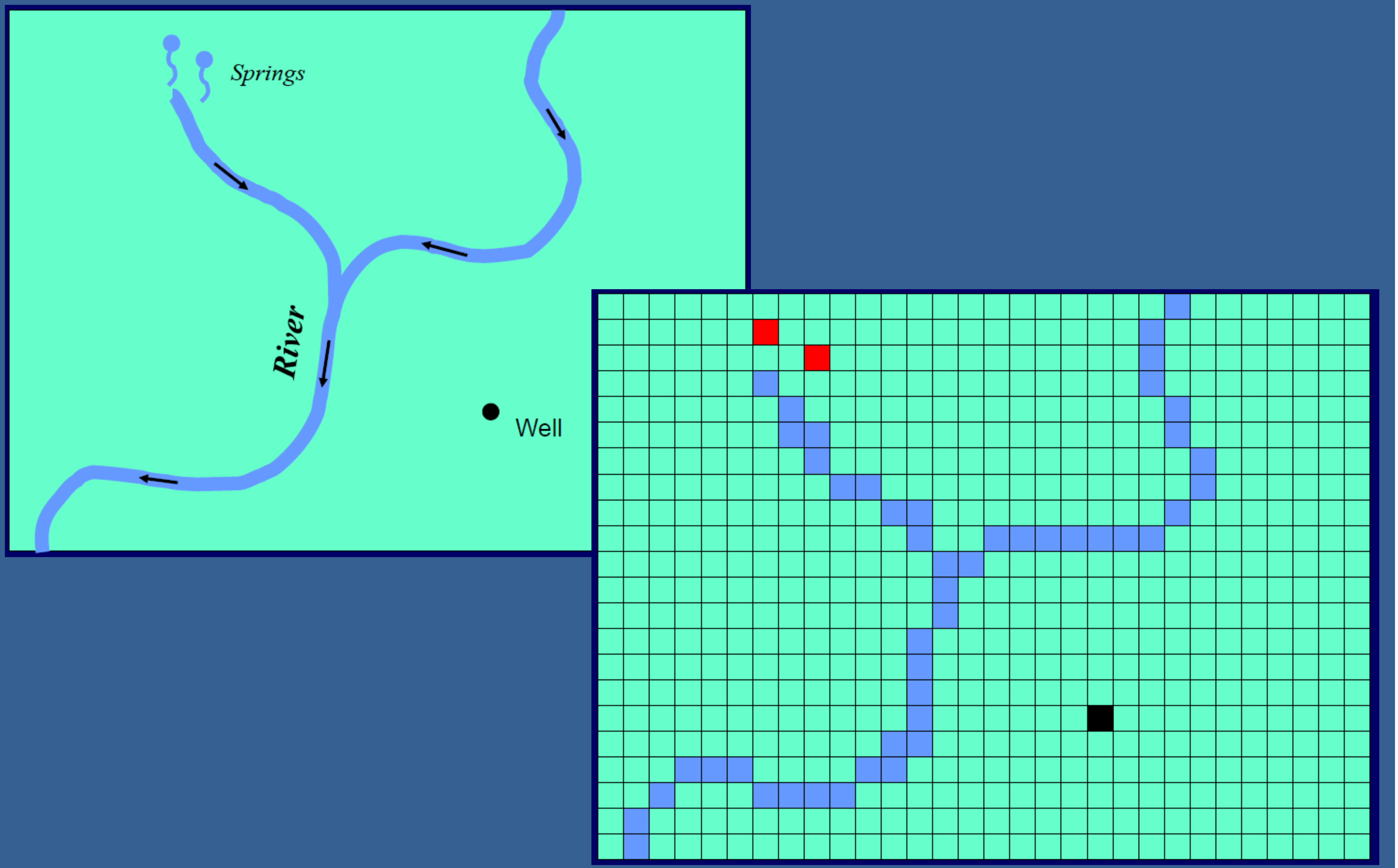


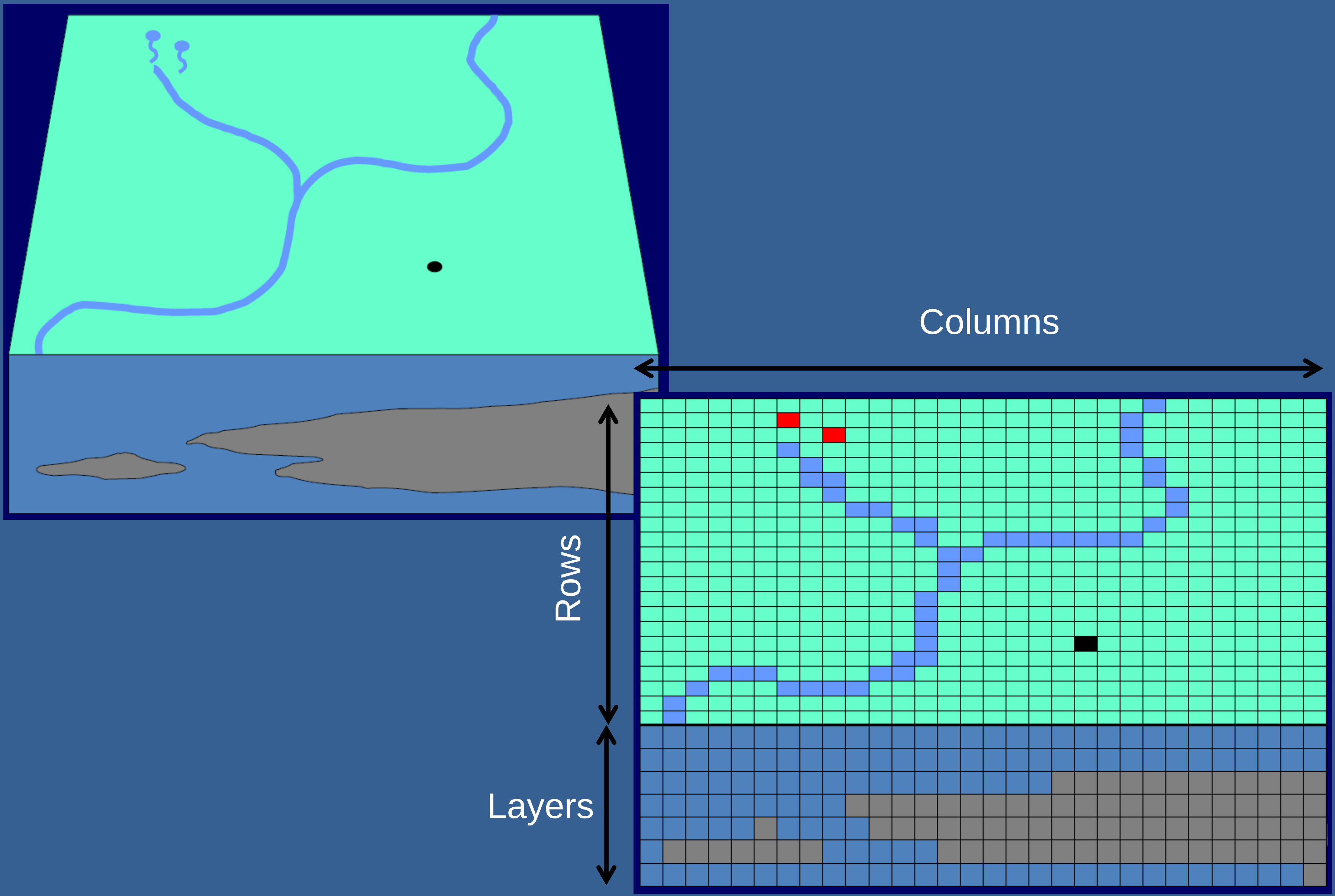

The complexities of natural systems make answering simple quantitative questions about groundwater very difficult.

The geology introduces complexity in the third dimension.



In computer modeling, the system is divided into discrete regions called *cells*. Conditions in each cell are considered homogeneous, so the math becomes simple. Cells can be formulated to act as streams, well, springs, etc.

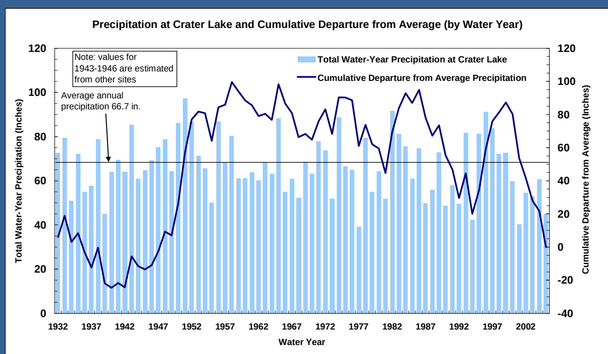




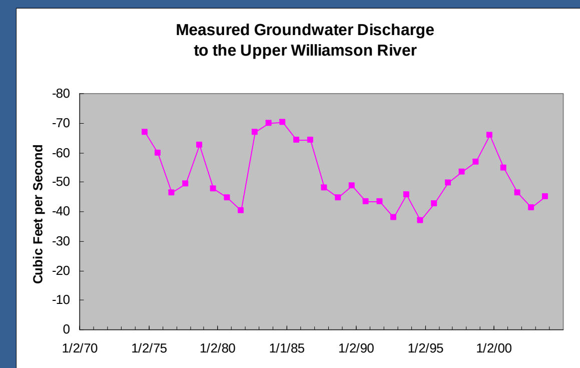

The computer calculates the groundwater flow and head in each cell, as well as the movement of water to boundaries such as streams and springs.

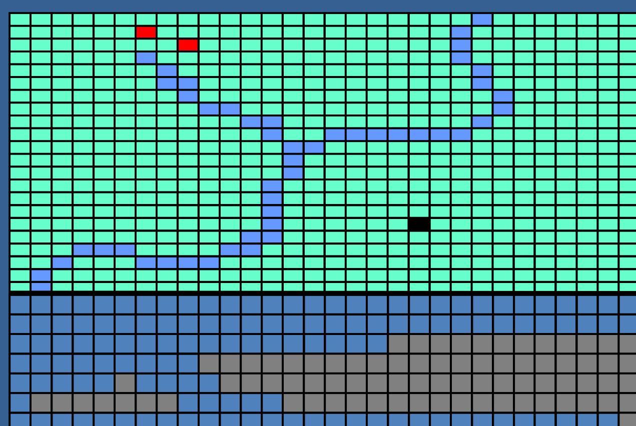
In order to have predictive capability or to provide useful insights, a model should be able to accurately simulate the observed behavior of the groundwater system.

## Measured External Stress

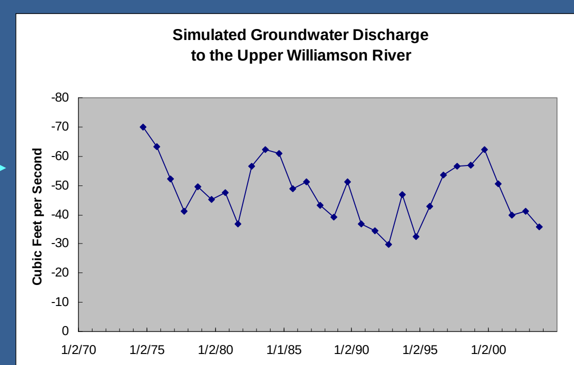



## Measured Response



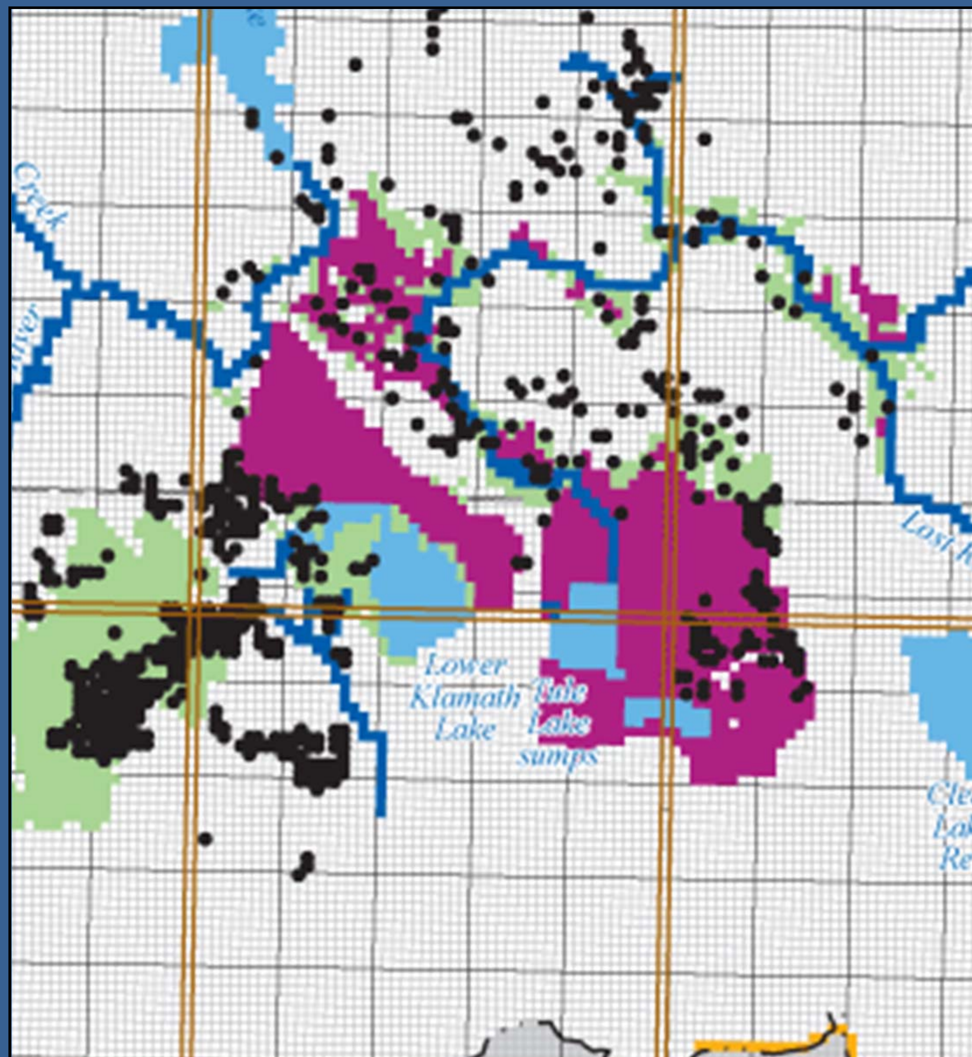



## Simulated Response




A model that can simulate actual observed conditions is said to be *calibrated*.

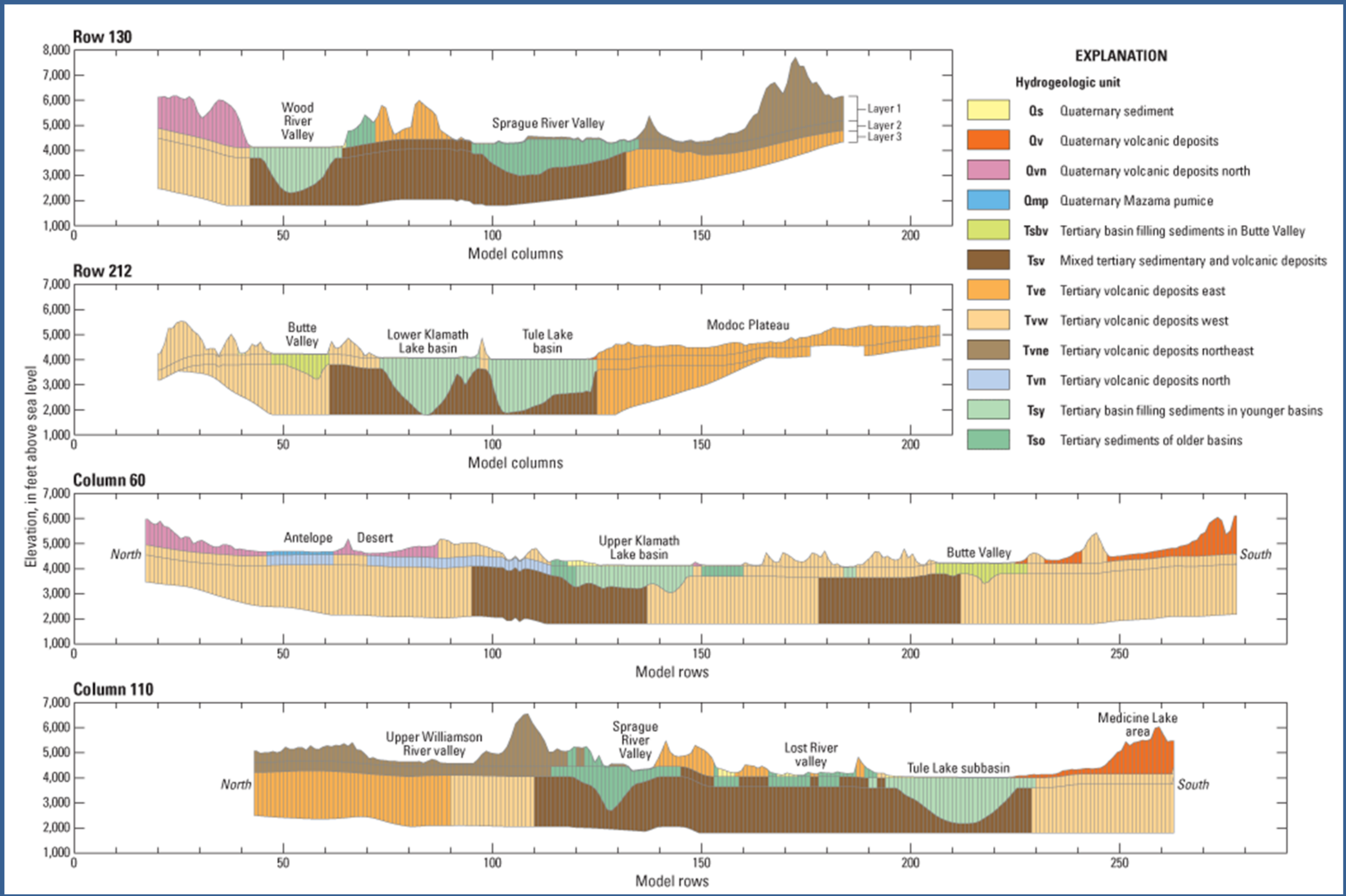
# Example groundwater model grid




Gannett and others, 2012

USGS

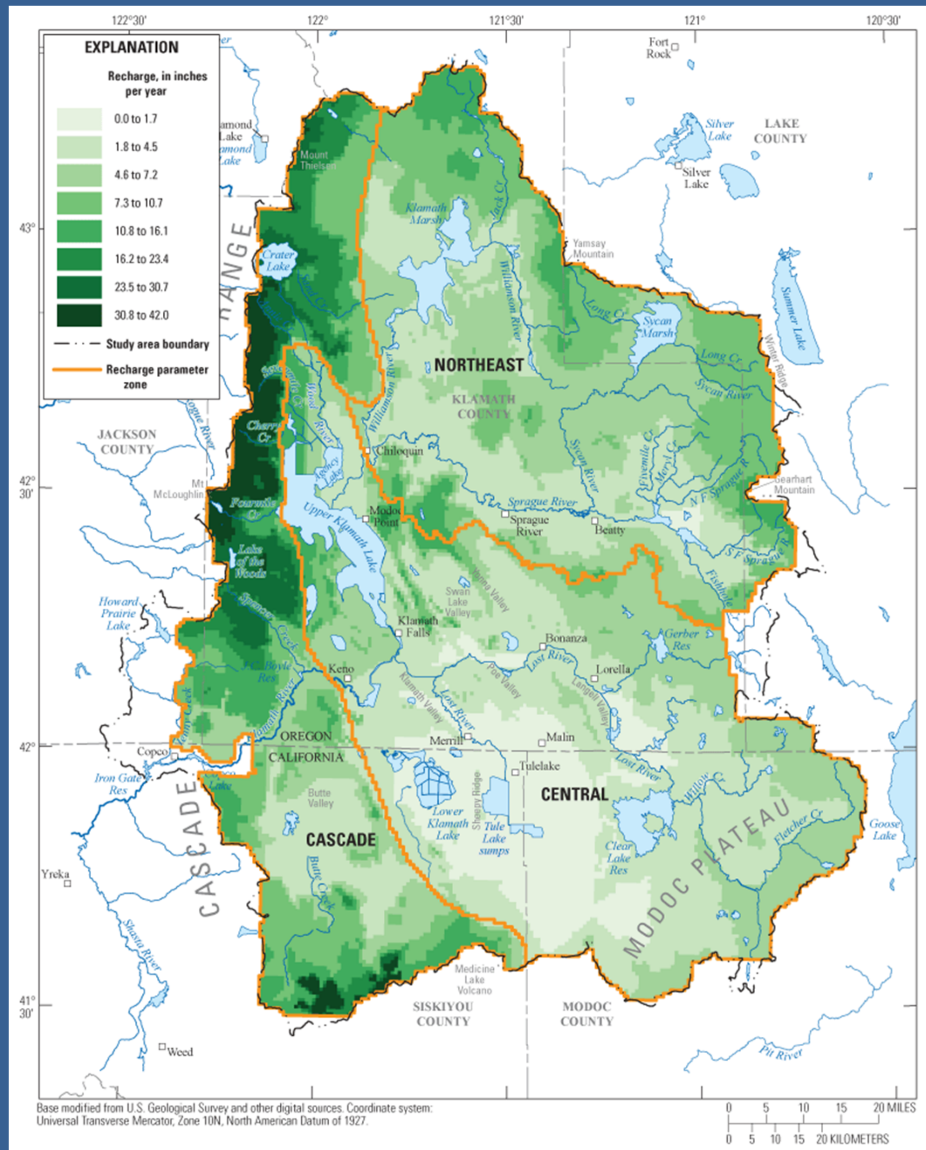
# Example groundwater model grid




USGS

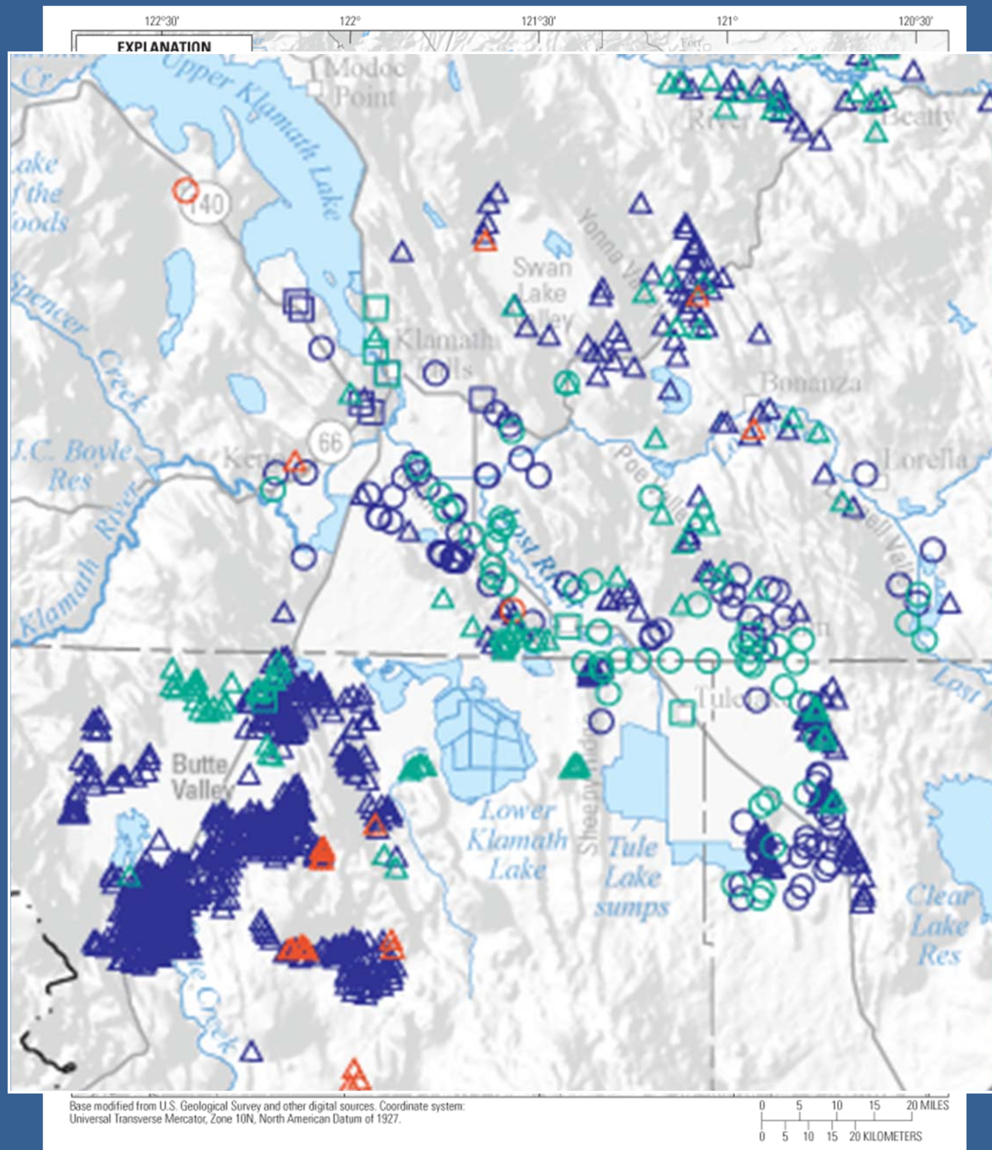
Gannett and others, 2012

# Example recharge distribution



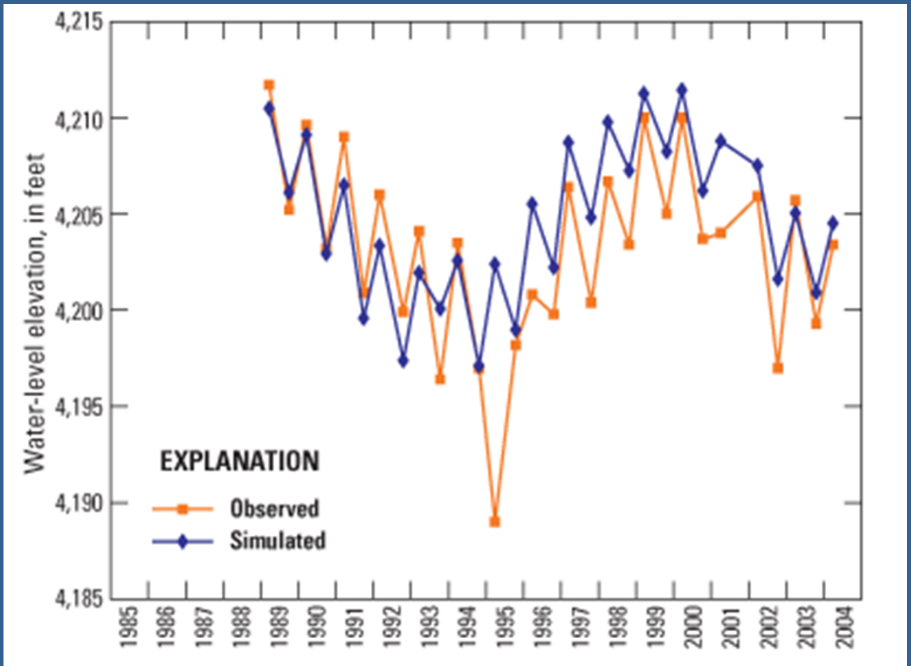

Gannett and others, 2012

# Example pumping distribution

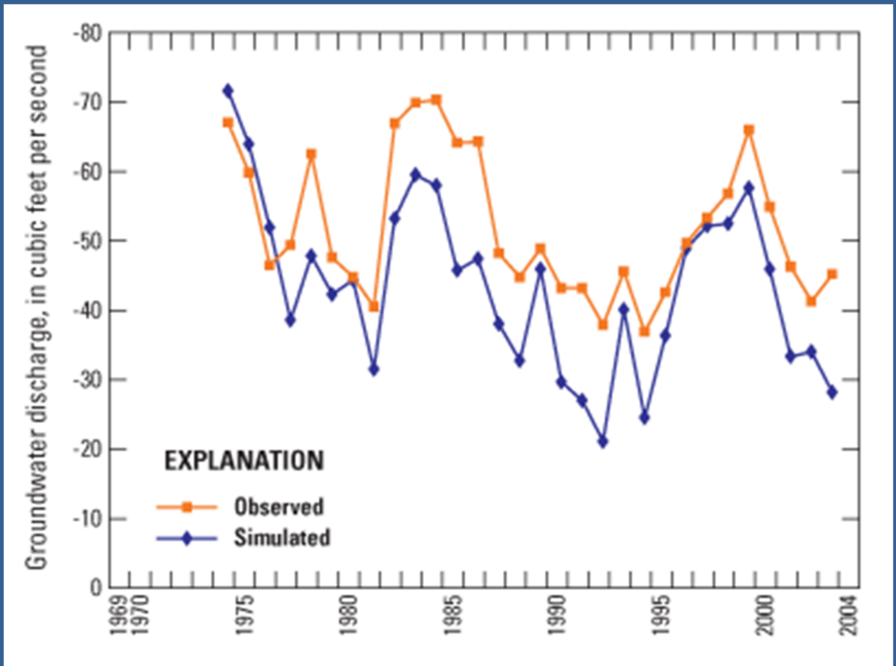



Gannett and others, 2012

# Match model to measured hydrologic data




Water levels

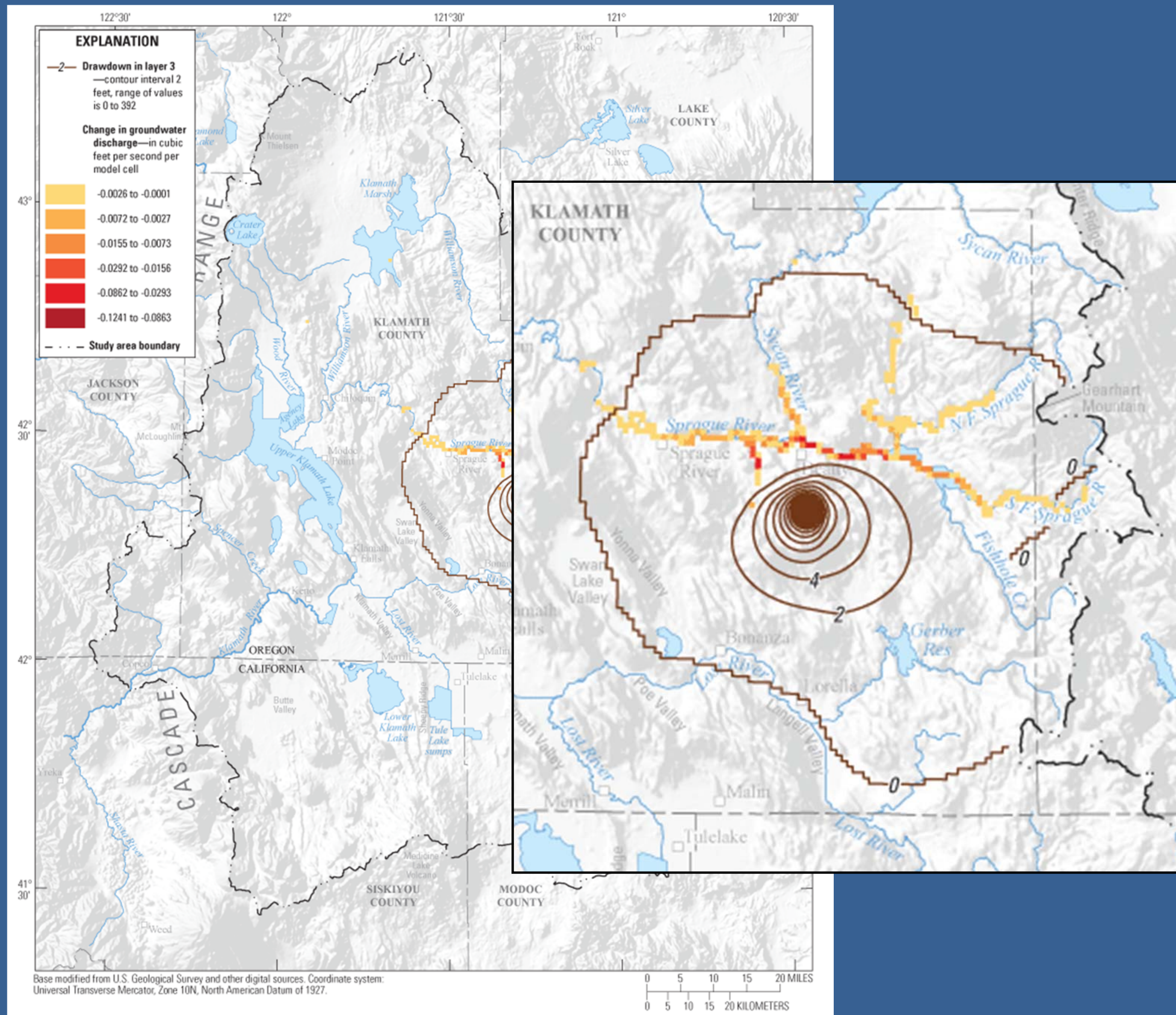



Stream and river discharge



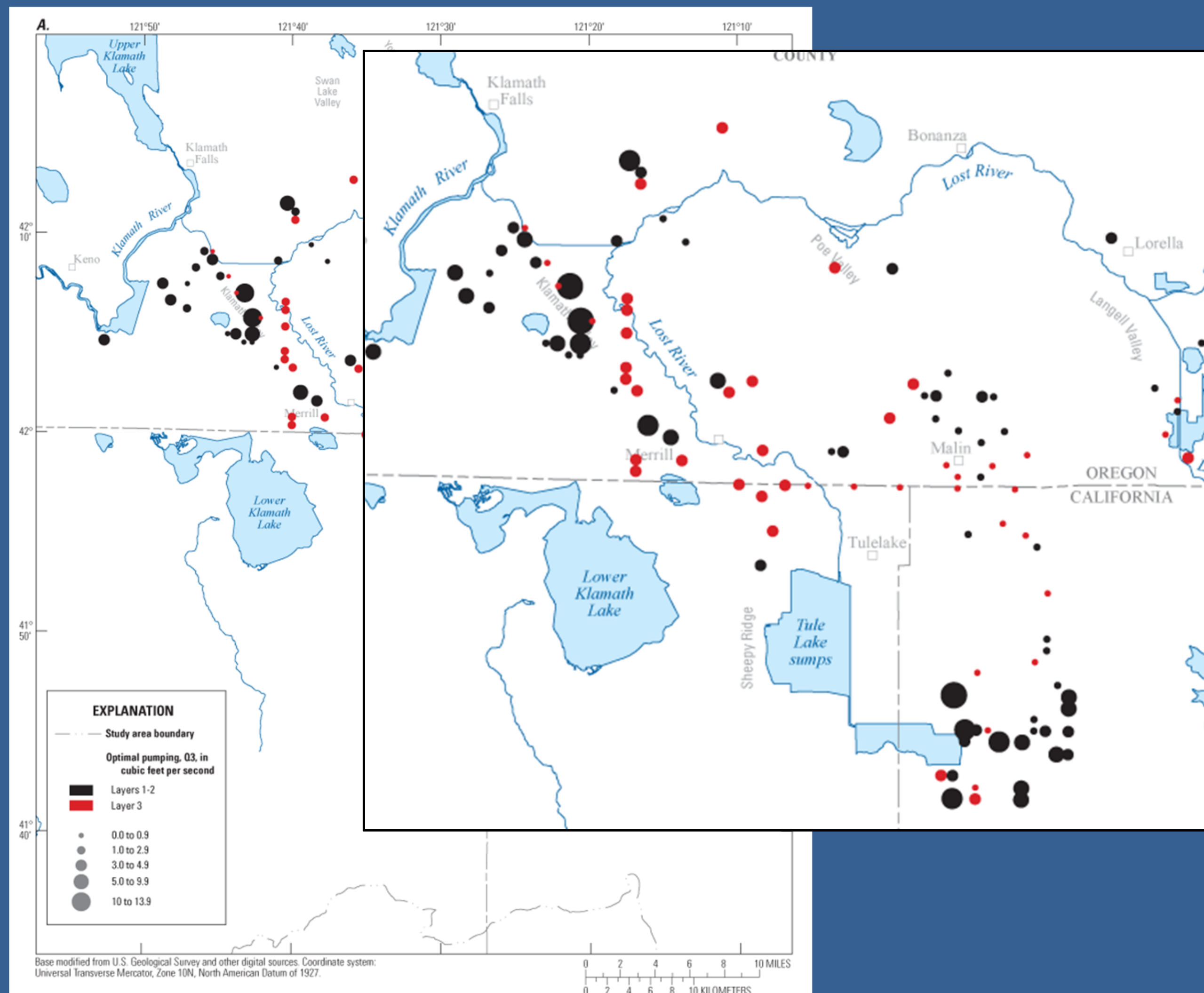
Gannett and others, 2012

# Test pumping scenarios with model



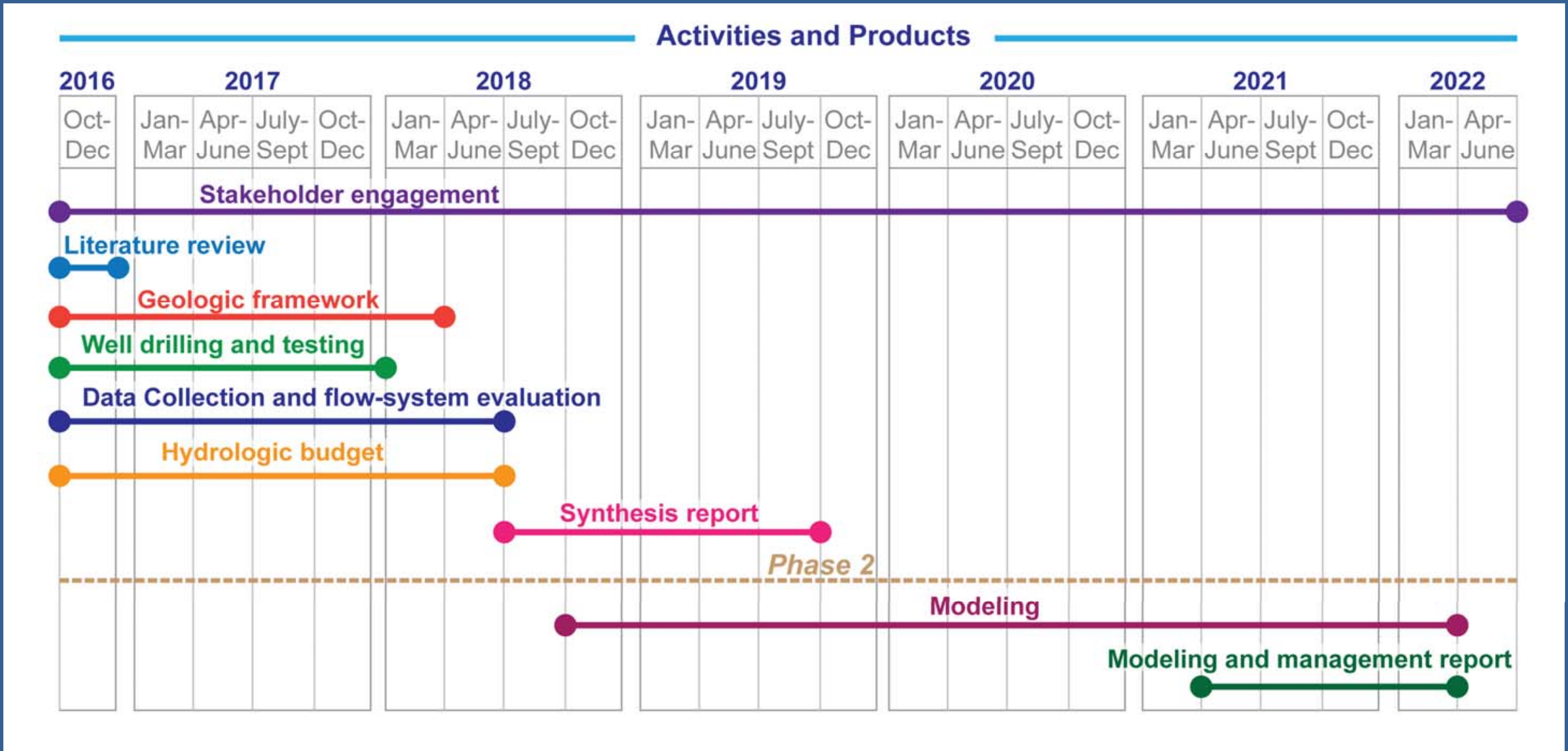

Gannett and others, 2012

# Test pumping scenarios with model




Gannett and others, 2012

# Project timeline




USGS

# References


- Gannett, M.W., Lite, K.E. Jr., La Marche, J.L., Fisher, B.J., and Polette, D.J., 2007, Ground-water hydrology of the upper Klamath Basin, Oregon and California: U.S. Geological Survey Scientific Investigations Report 2007-5050, 84 p.

- Gannett, M.W., Wagner, B.J., and Lite, K.E., Jr., 2012, Groundwater simulation and management models for the upper Klamath Basin, Oregon and California: U.S. Geological Survey Scientific Investigations Report 2012–5062, 92 p.

- Healy, R.W., Winter, T.C., LaBaugh, J.W., and Franke, O.L., 2007, Water budgets: Foundations for effective water-resources and environmental management: U.S. Geological Survey Circular 1308, 90 p.

- Oregon Water Resources Department Database at http://www.oregon.gov/owrd/pages/gw/well_data.aspx


USGS