GSFLOW Coupled Groundwater/Surface-Water Model: Background and Possible Applications in the Great Valley

Great Valley Water Resources Science Forum

October 7, 2009

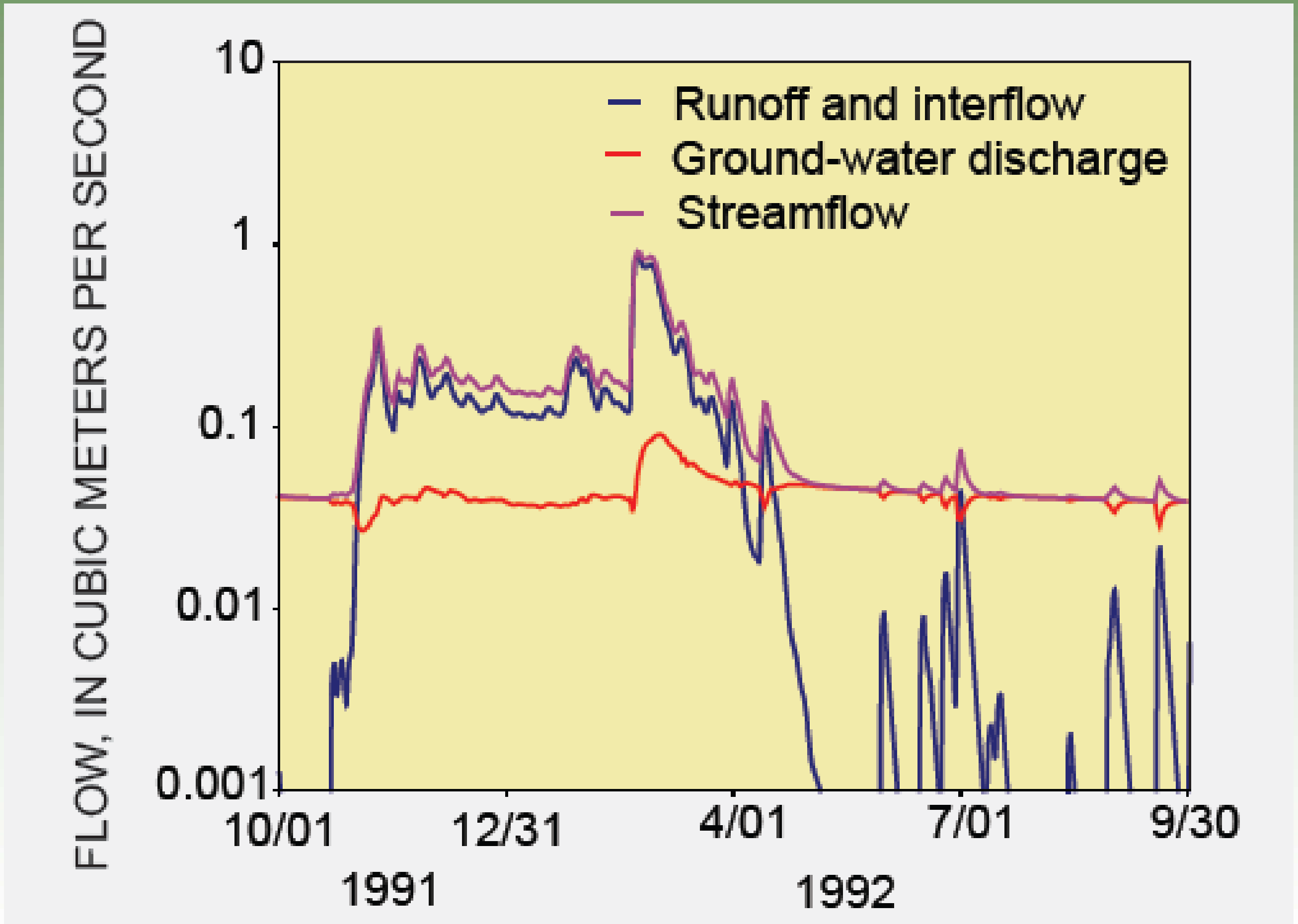
Why was GSFLOW developed?

- To improve our ability to simulate and understand
  - Watershed hydrologic processes and water availability
  - Links between hydrologic processes and climate, vegetation, land uses, water-supply development, and ecology

Uses of GSFLOW

- Determine flow rates and storage volumes of water throughout a watershed—from the tree canopy to deep aquifers:
  - Evaporation and plant transpiration
  - Soil infiltration and interflow
  - Snowpack generation and depletion
  - Groundwater recharge
  - Streamflow generation

Components of Streamflow for a Year of Below-Average Precipitation, Sagehen Creek, Truckee, CA



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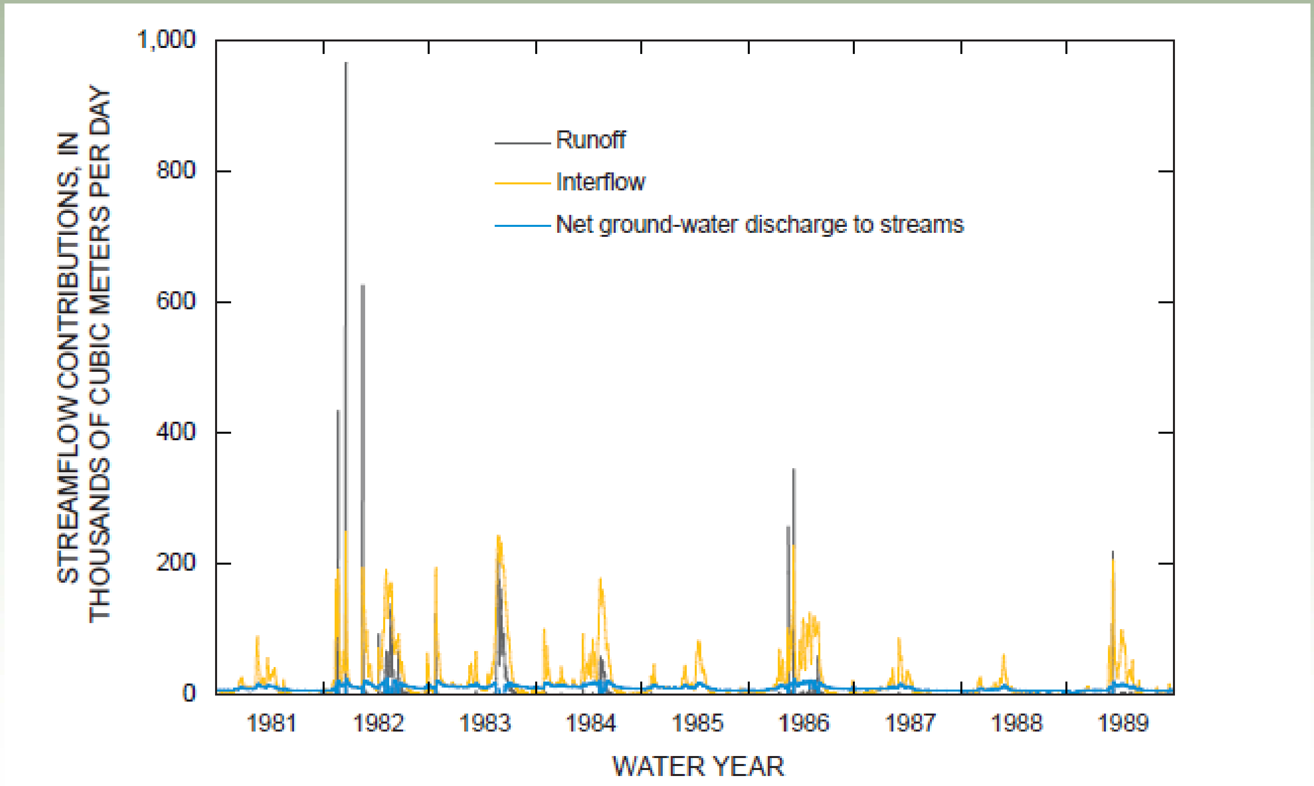
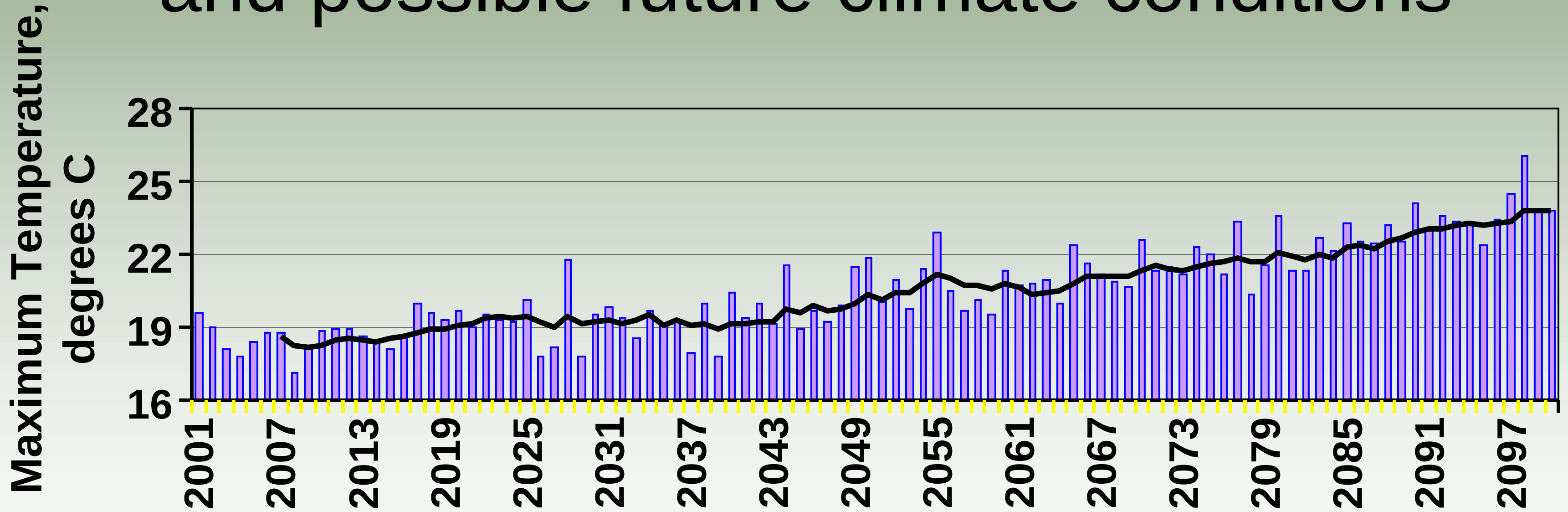
Uses of GSFLOW

- Simulate both low-flow (baseflow and drought) and high-flow (storm) conditions within a watershed



Uses of GSFLOW

- Simulate hydrologic response to changing land uses, population growth, and possible future climate conditions



Projected average maximum daily temperature, Tahoe Basin, California and Nevada

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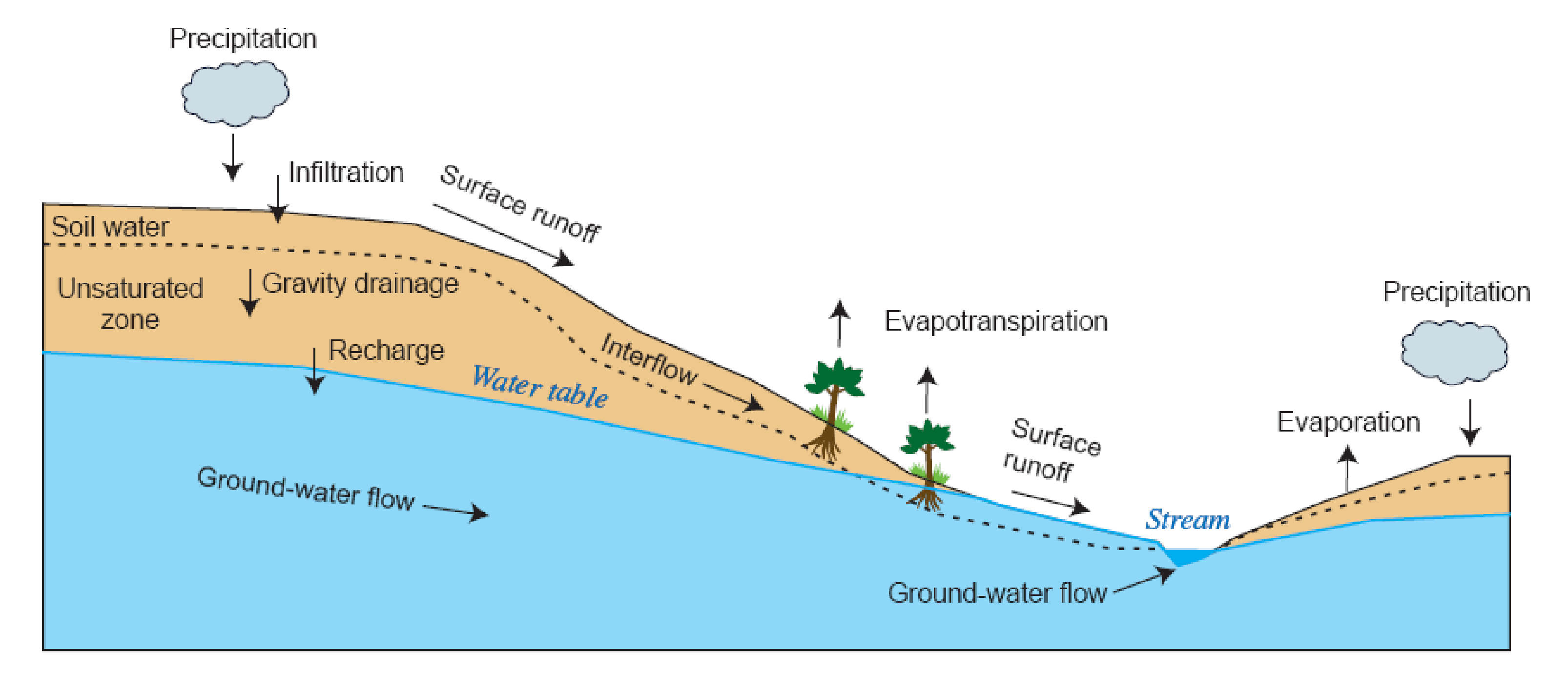
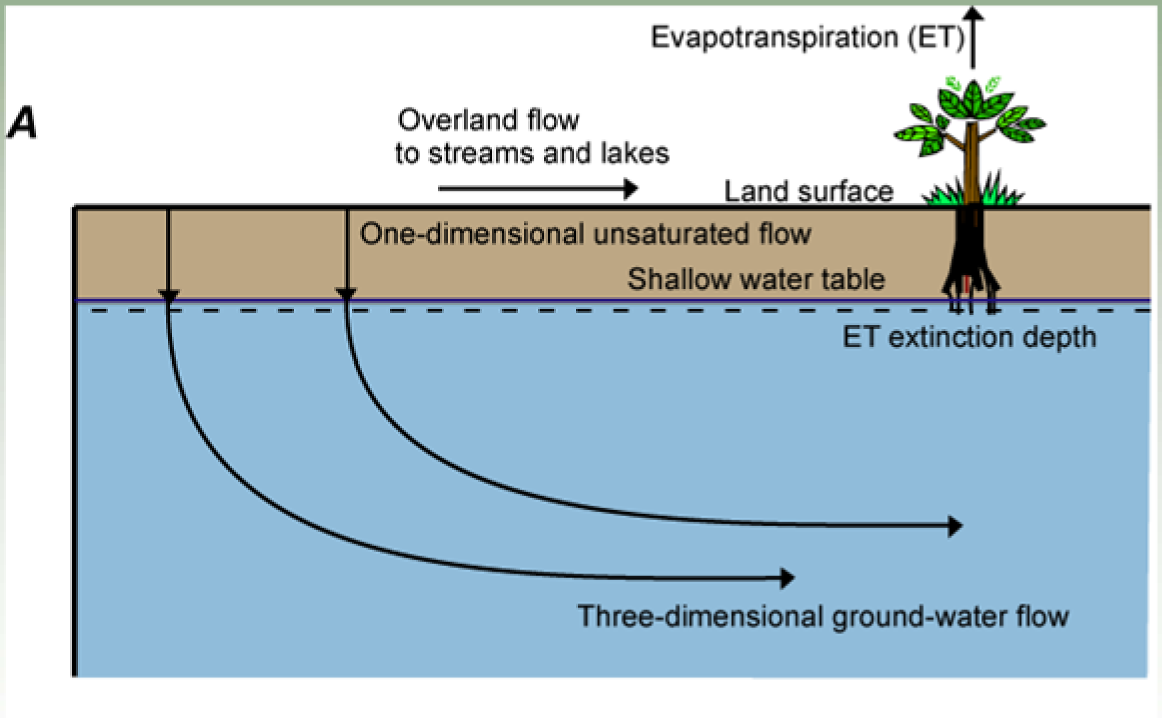
What is GSFLOW?

A Basin-Scale Model Based on the USGS PRMS Watershed Model and MODFLOW Groundwater Flow Model



Enhanced Modeling Capabilities Developed for GSFLOW

- Unsaturated-zone flow below soils, streams, and lakes



Flow, storage, and ET in the unsaturated zone and recharge to the water table in response to infiltration at land surface

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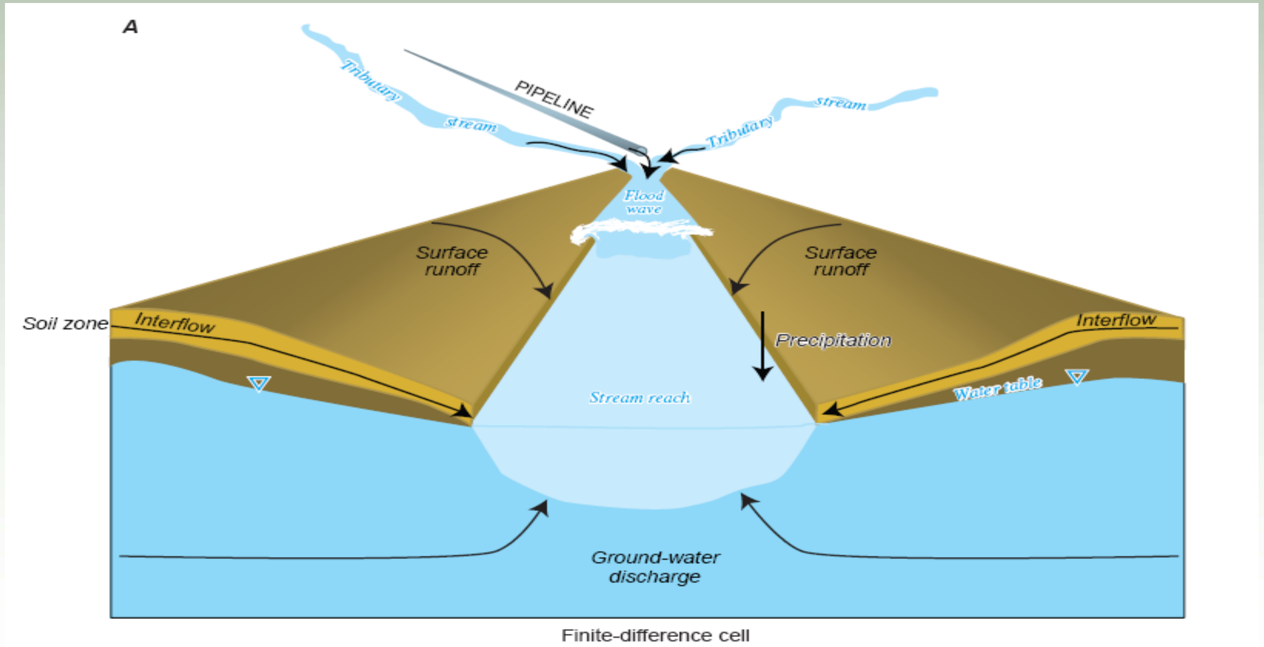
Enhanced Modeling Capabilities Developed for GSFLOW

- Enhanced soil-zone dynamics (capillary, gravity-flow, and preferential-flow reservoirs)
- Enhanced streamflow simulation



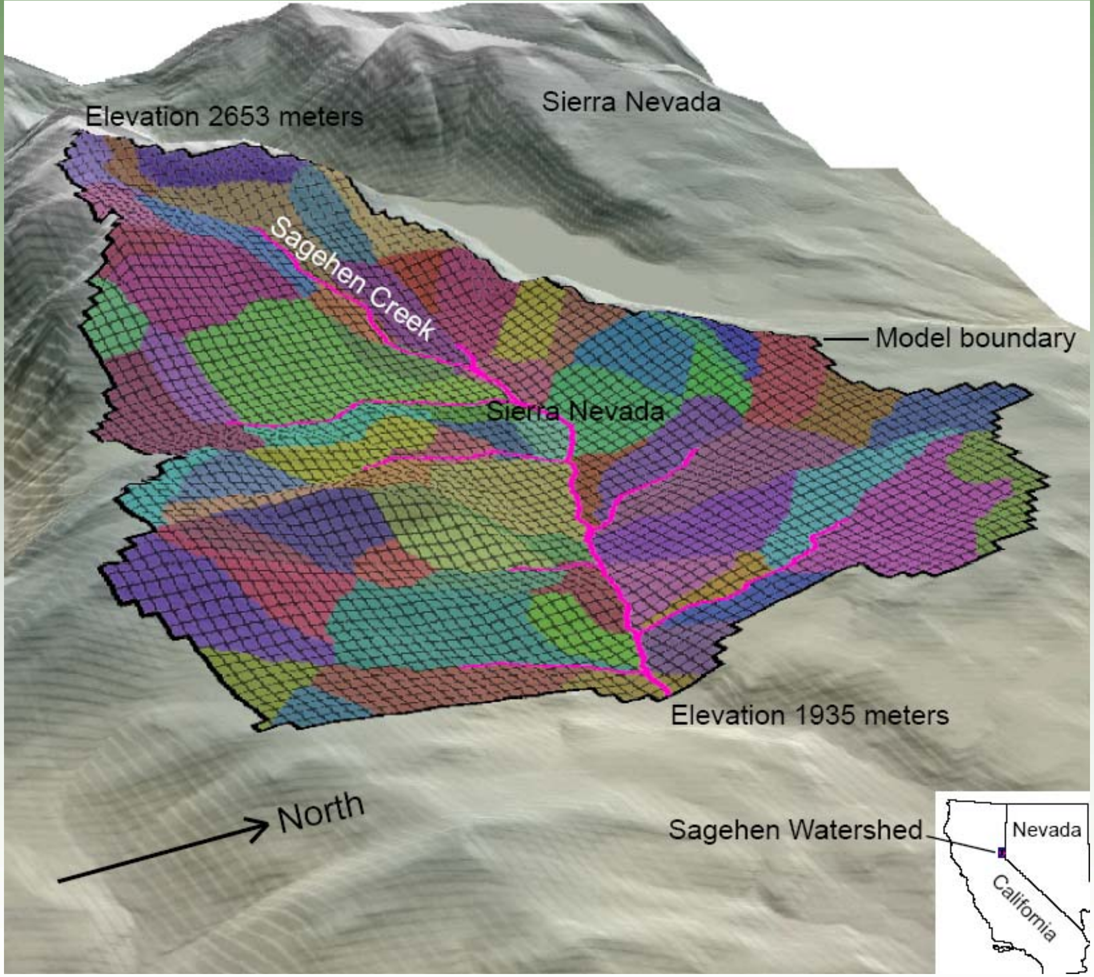
Some of the Hydrologic Processes Simulated

- Potential ET
- Canopy interception
- Snowpack accumulation, melting, sublimation
- Surface-water runoff
- Interflow
- Infiltration to soil zone
- ET within soil zone
- 1-D Unsaturated-zone flow, storage, and ET
- 3-D Groundwater flow
- Streamflow
- Lakes

Climatic and Hydrologic Drivers

- Precipitation
- Air Temperature
- Solar radiation
- Groundwater withdrawals
- Groundwater flow and water-level conditions along boundary of simulated area

Spatial Discretization—PRMS hydrologic response units (HRUs) are intersected with MODFLOW finite-difference cells



Sagehen Creek watershed, Truckee, CA

Some Important Design Criteria for GSFLOW Development

- Calculate and provide detailed water-budget information for the various hydrologic processes in both space and time
- Ensure that the model conserves mass
- Allow simulations using only PRMS or MODFLOW to facilitate initial calibration of model parameters prior to a full GSFLOW (coupled-model) simulation

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Initial GSFLOW Applications by the USGS

- Trout Lake Watershed, WI
- Black Earth Creek Watershed, WI
- Spring Creek Watershed, PA
- Incline Basin near Lake Tahoe, Nevada
- Walker Lake Watershed, NV
- Santa Rosa Plain, northern CA
- Rialto-Colton Basin, southern CA

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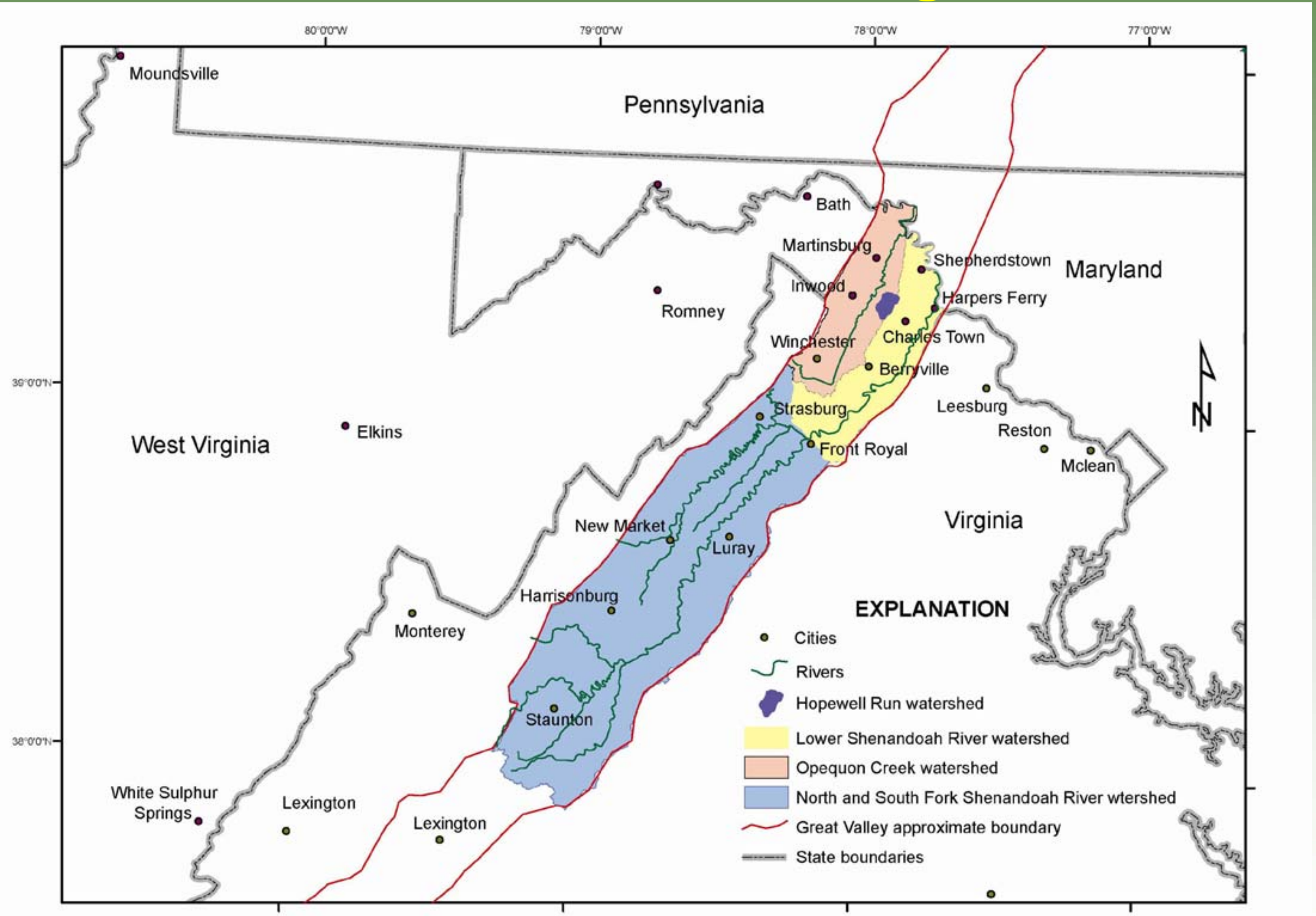
Possible Applications in the Great Valley



Map showing existing and proposed ground-water flow models developed for the Shenandoah Valley.

Opequon Creek Watershed

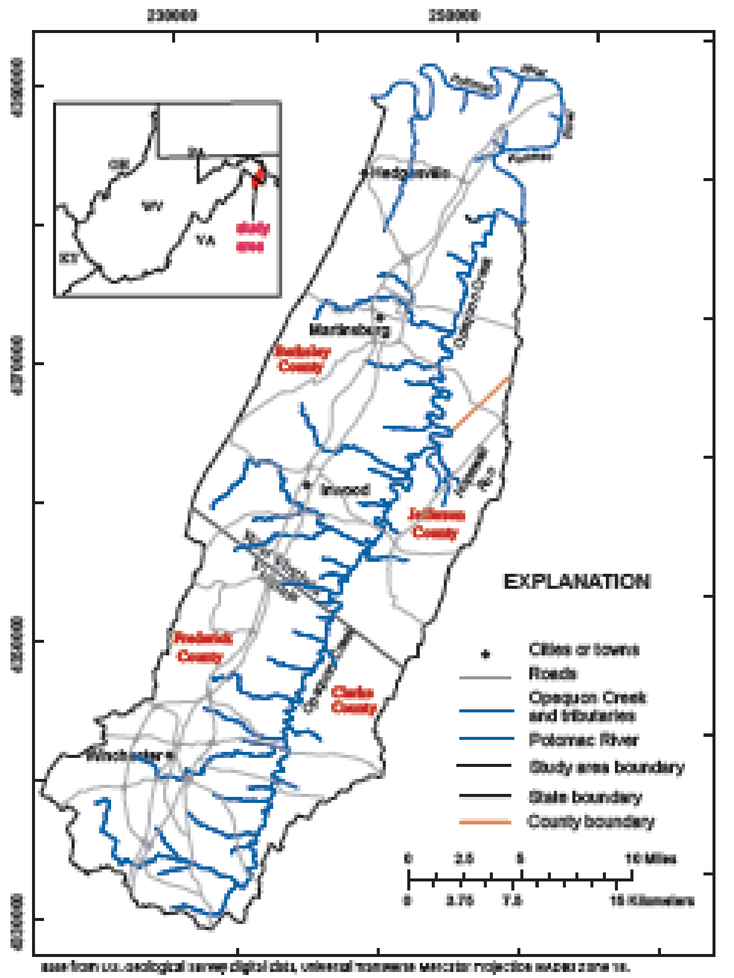


Figure 1. Location of the Opequon Creek Watershed area and in Virginia and West Virginia.

Link the transient groundwater-flow model of Opequon Creek watershed with a PRMS model

Opequon Creek

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Benefits

- Improved representation of hydrologic processes in the watershed and links among land-surface, subsurface, and surface-water hydrologic systems
- Improved water budgets throughout all hydrologic components of the watershed

Data Considerations

- ❖Climate inputs:
  - ❖Daily precipitation and air-temperature data
- ❖Land-surface processes:
  - ❖Evapotranspiration
  - ❖Canopy interception
  - ❖Snowpack dynamics
  - ❖Surface runoff
  - ❖Soil-zone processes

Data Considerations

- ❖Streamflow and Springs
- ❖Subsurface processes:
  - ❖Unsaturated-zone flow
  - ❖Groundwater flow, including wells

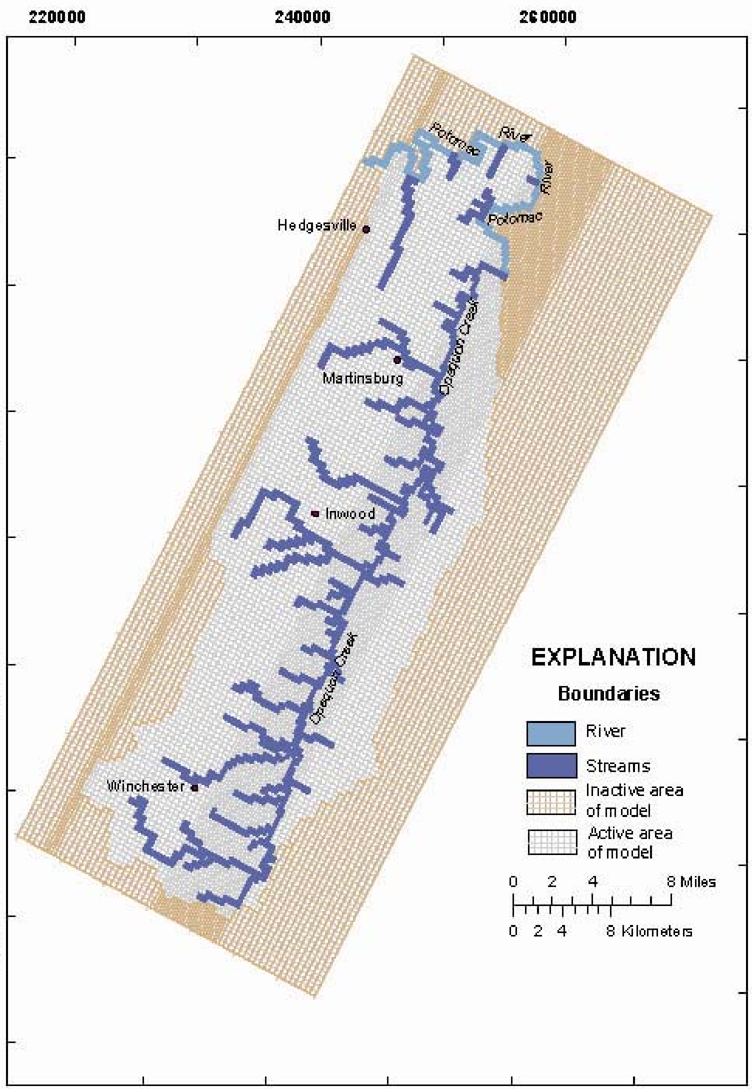

Figure 10. Map showing boundary conditions and the active and inactive model grid of the ground-water flow model developed for the Opequon Creek watershed, Virginia and West Virginia.

Discretization of Watershed:

PRMS HRUs could be coincident with MODFLOW cells, but not required

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Calibration Considerations

- A multistep process:
  - PRMS transient (daily) calibration
  - MODFLOW steady-state calibration
  - Coupled GSFLOW transient (daily) calibration
- Calibration data:
  - Streamflow
  - Groundwater levels

GSFLOW Code and Documentation Report Available online:

- USGS Water Resources Groundwater Software webpage
  - **http://water.usgs.gov/software/lists/groundwater/**

USGS

Questions?