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science for a changing world

Ground-Water Modeling:

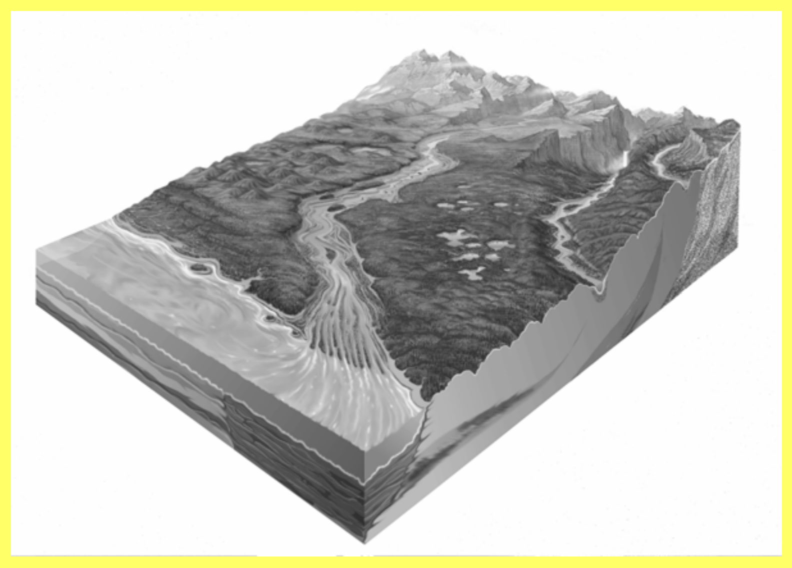
Synthesizing Hydrogeologic Information for Water Resources Management

Allen M. Shapiro

U.S. Geological Survey

Reston, Virginia

Water Resources Management



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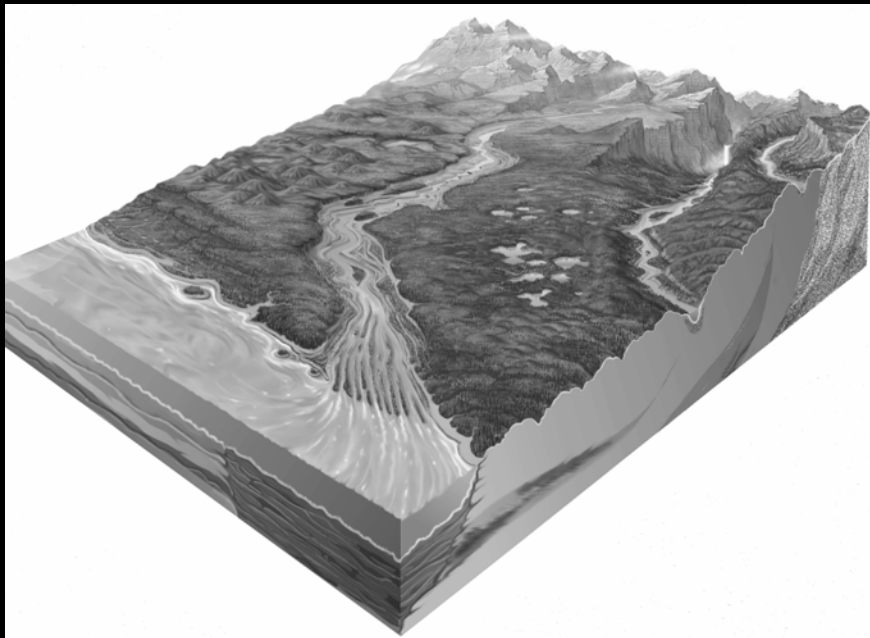
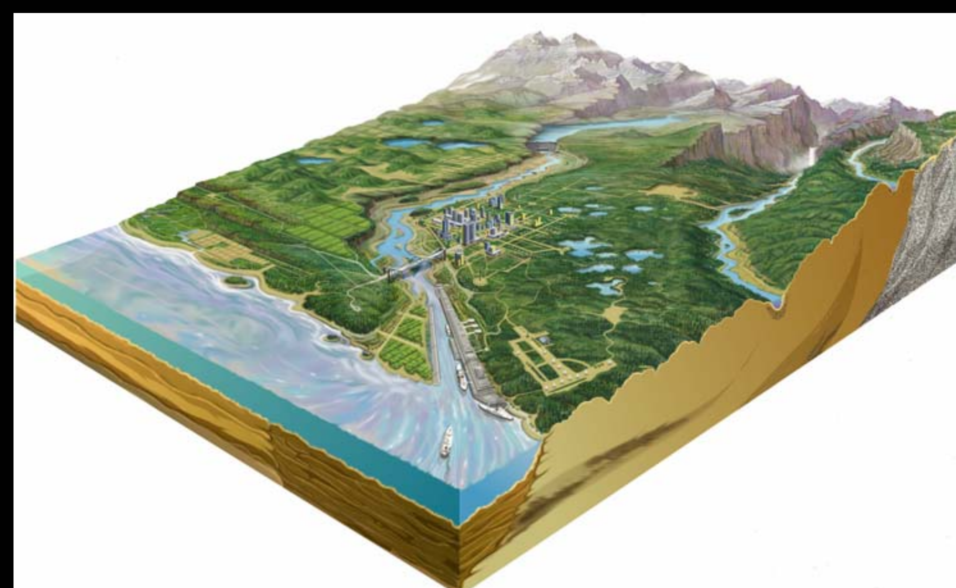


How will water-resources management scenarios effect ground-water and surface water ?



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Physical Model – Sand Box

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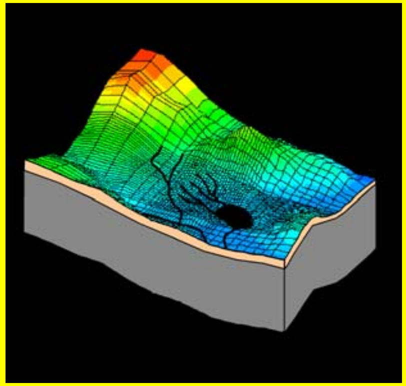
The Underlying Concept in Ground-Water Modeling

change in volume in Δt

$$V_{t+\Delta t} - V_t = \sum_i \left[Q_i(t) \right] \Delta t$$

summation of sources and sinks in Δt



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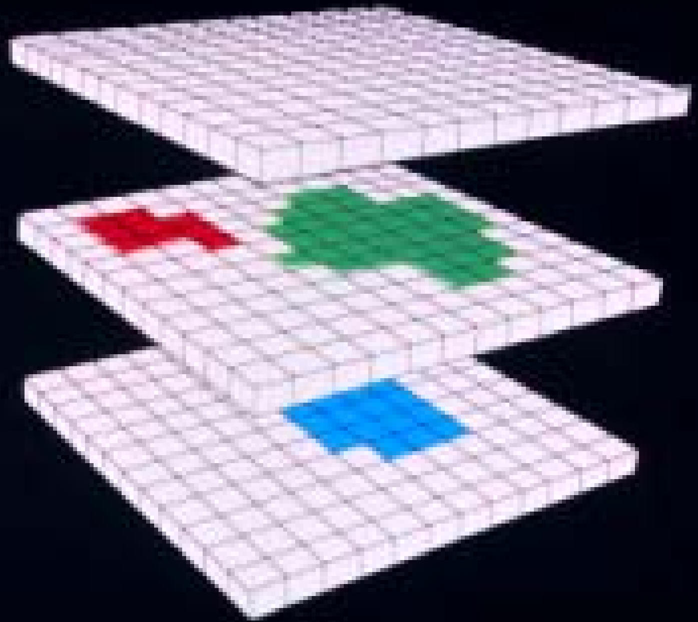
Also applicable to smaller volumes of aquifer material. . .

change in volume in Δt

$$V_{t+\Delta t} - V_t = \sum_i \left[Q_i(t) \right] \Delta t$$

summation of sources and sinks in Δt



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Mathematical Ground-Water Flow Model

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Mathematical models of ground-water flow have been successfully applied to fractured-rock aquifers. . .

Granite and schist,
Mirror Lake watershed,
Grafton County, NH

Madison Limestone,
Rapid City, SD

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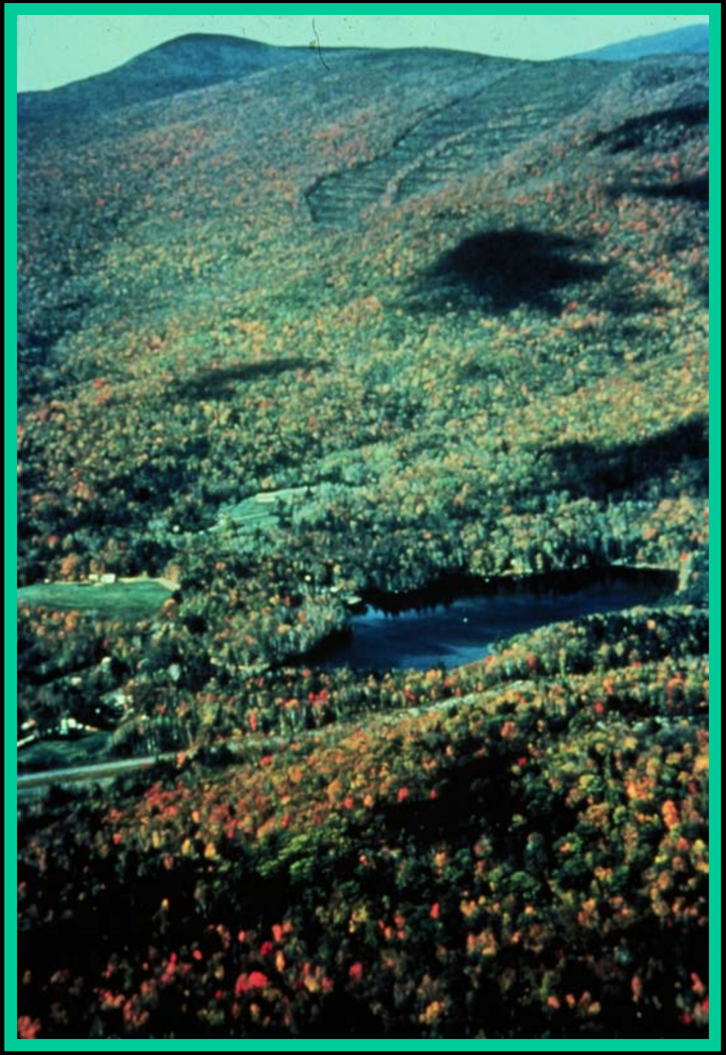
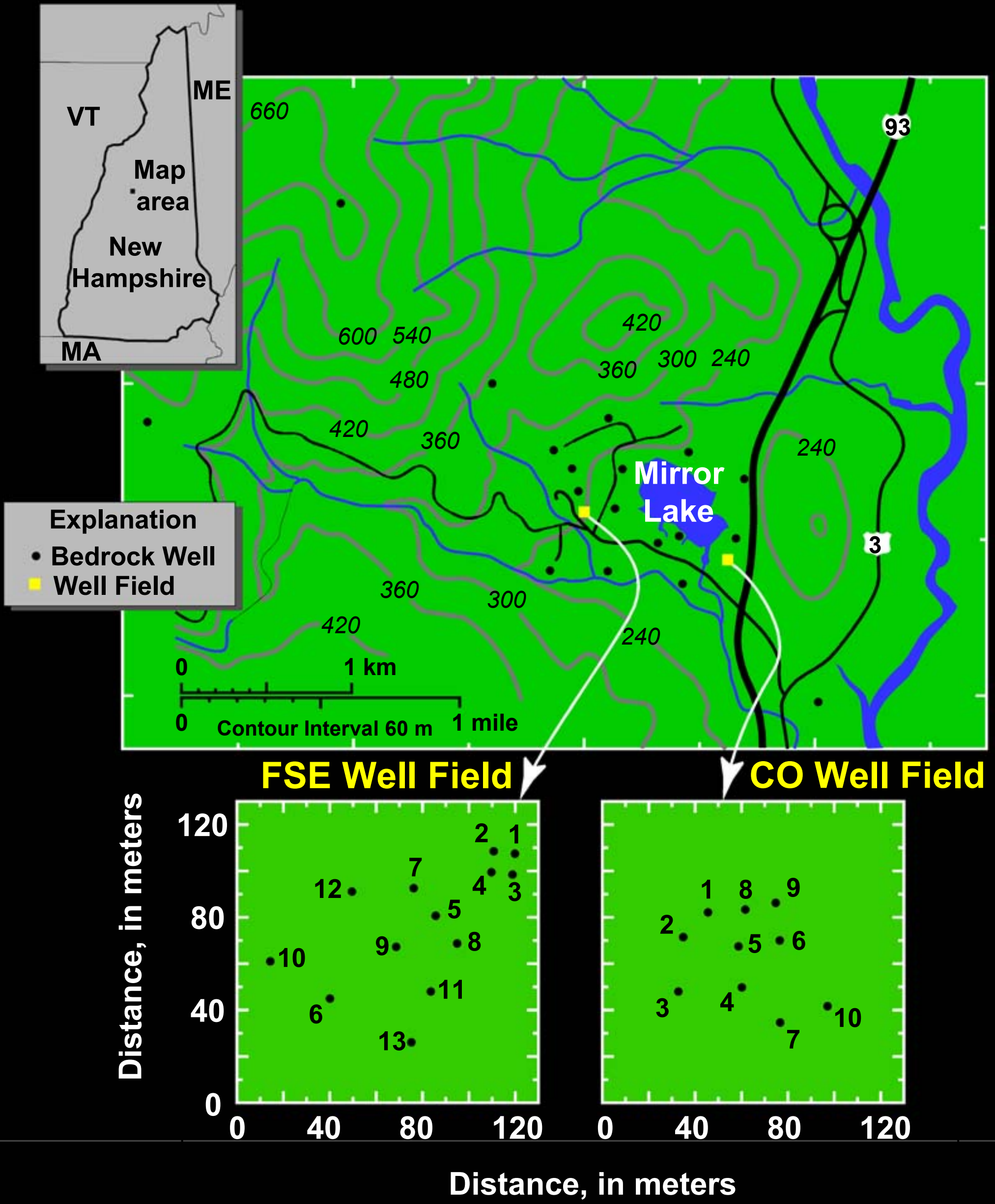
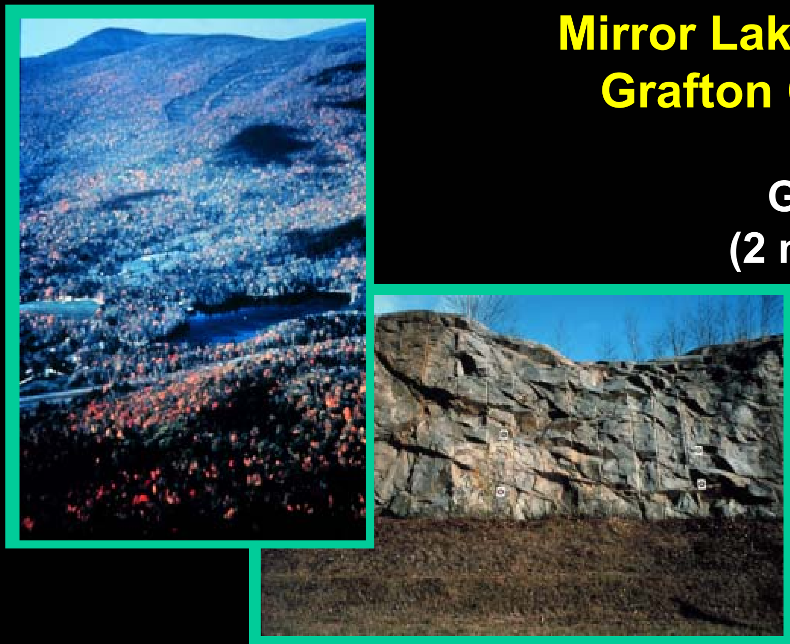
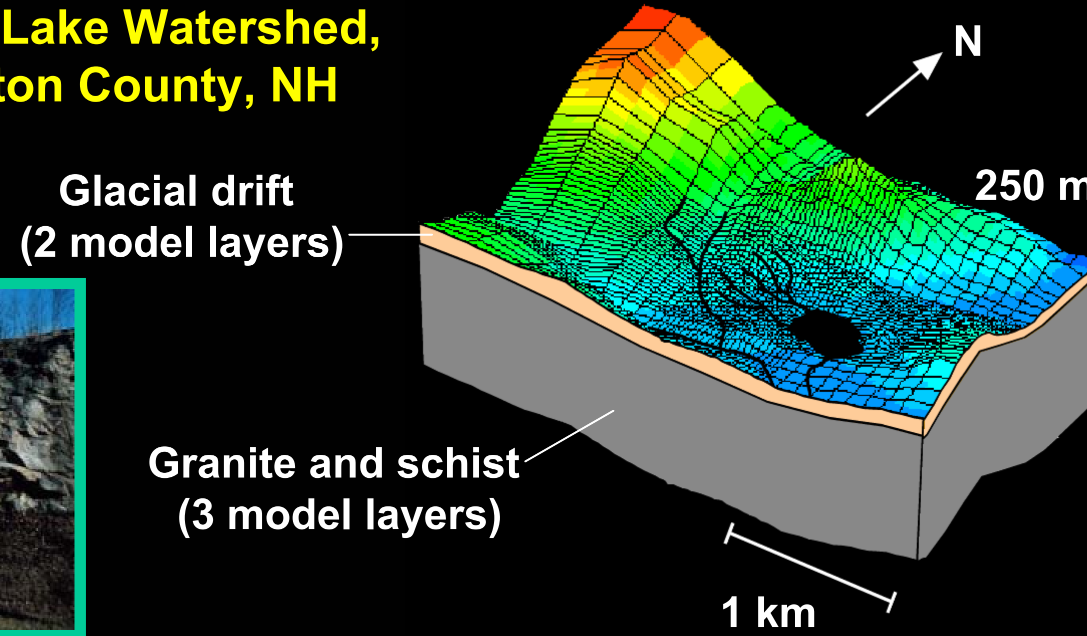


Mirror Lake Watershed,
Hubbard Brook Experimental Forest

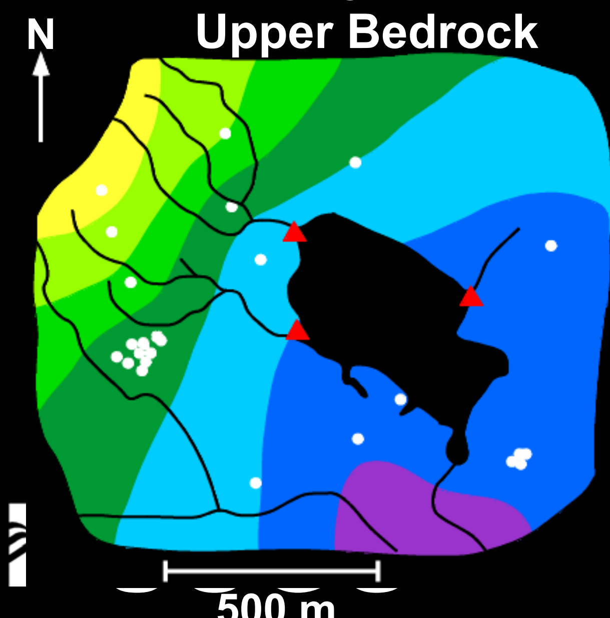


Mirror Lake Watershed, Grafton County, NH

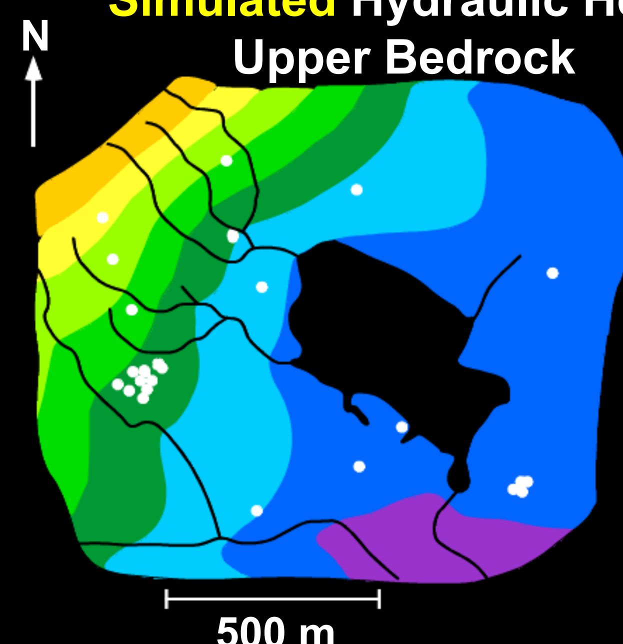


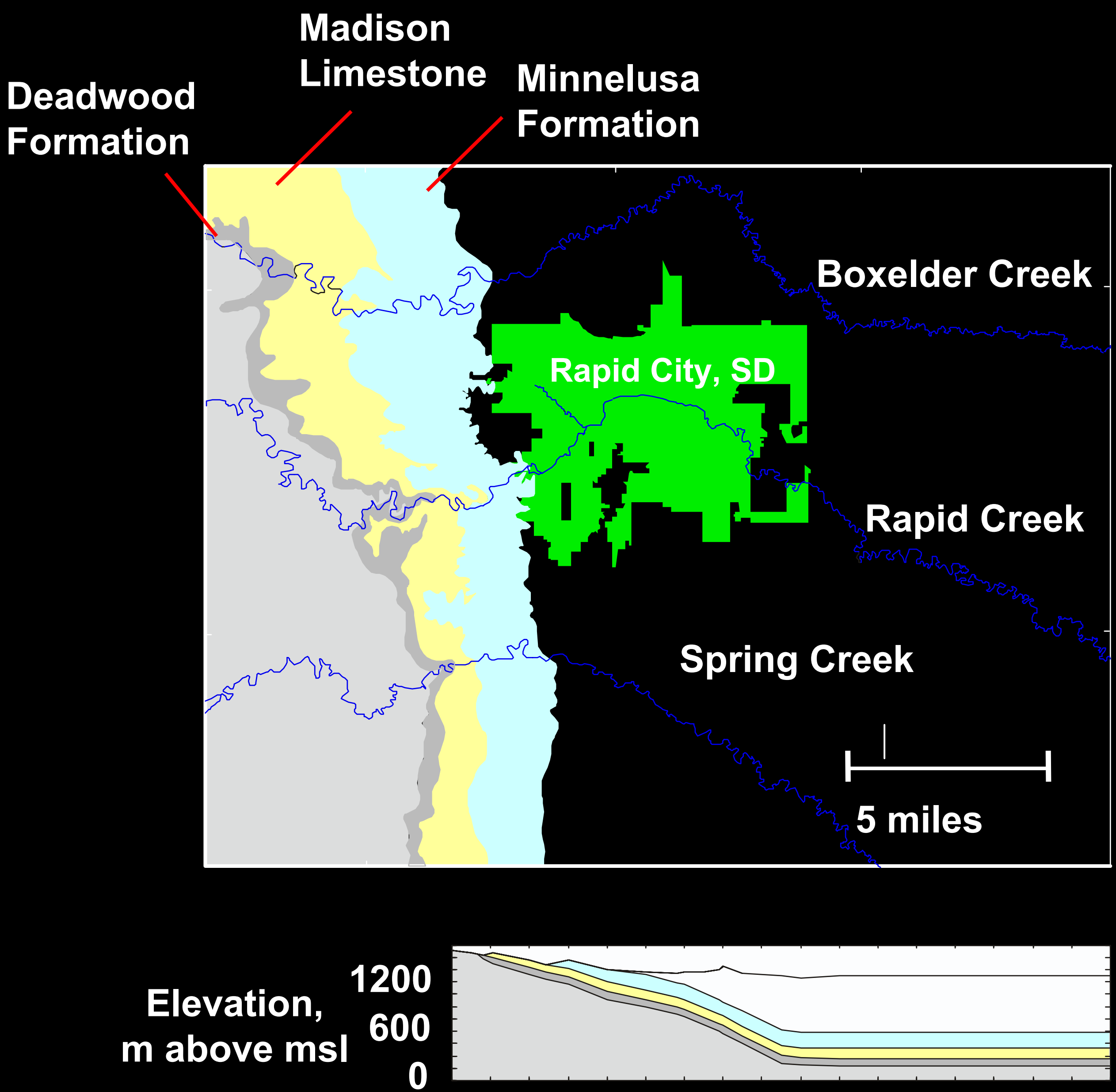


Observed Hydraulic Head
Upper Bedrock

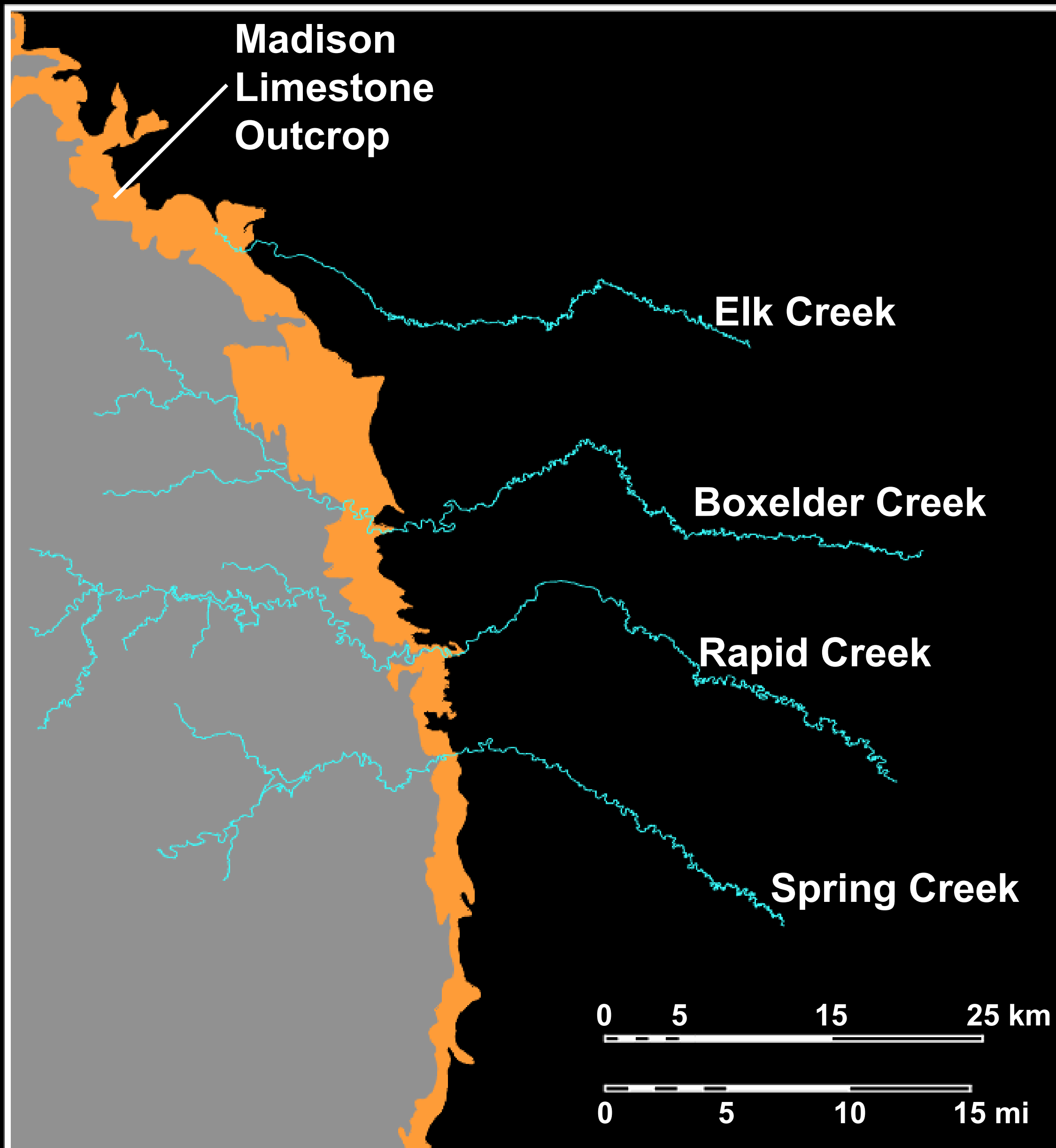


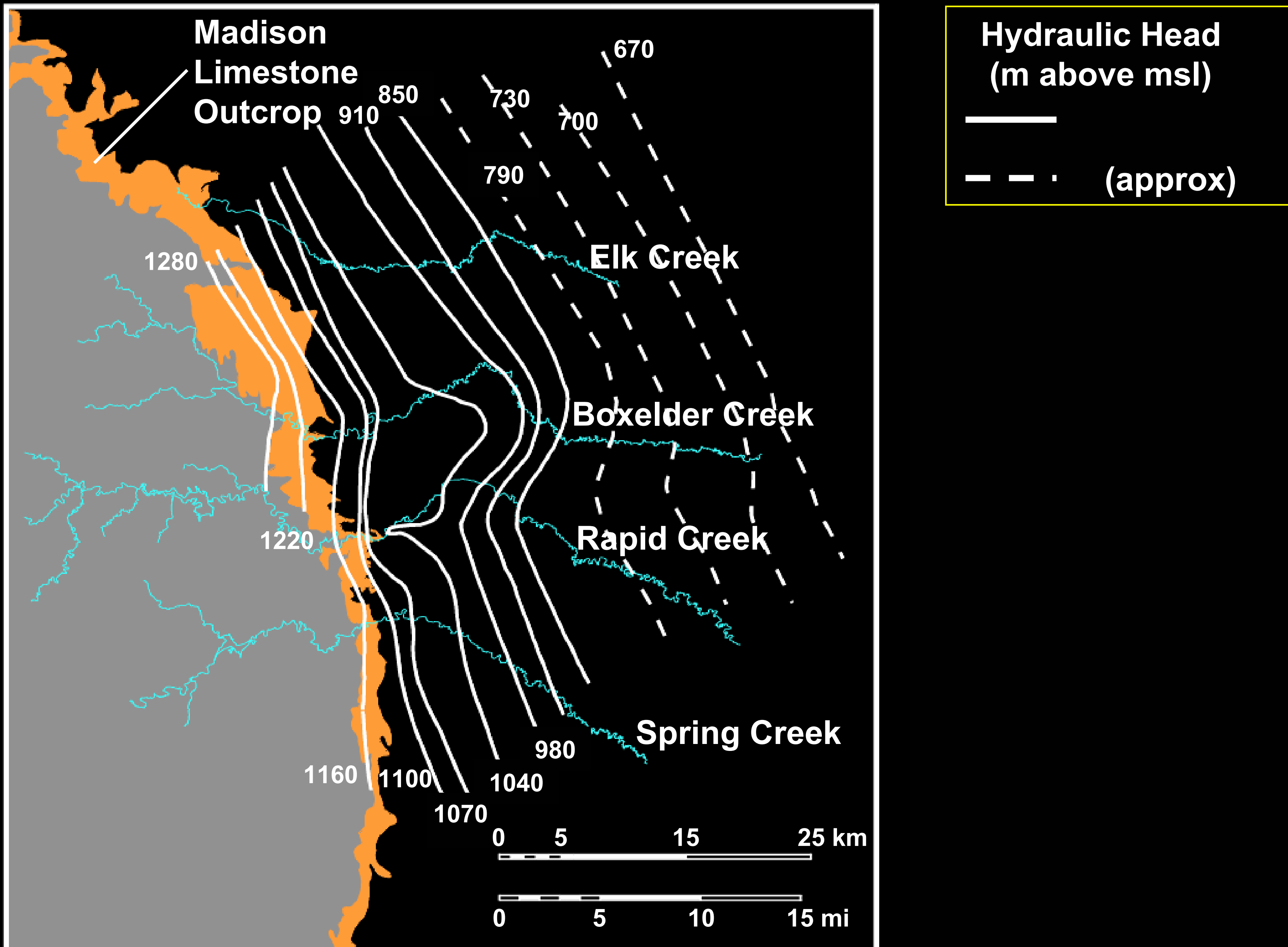
Simulated Hydraulic Head
Upper Bedrock



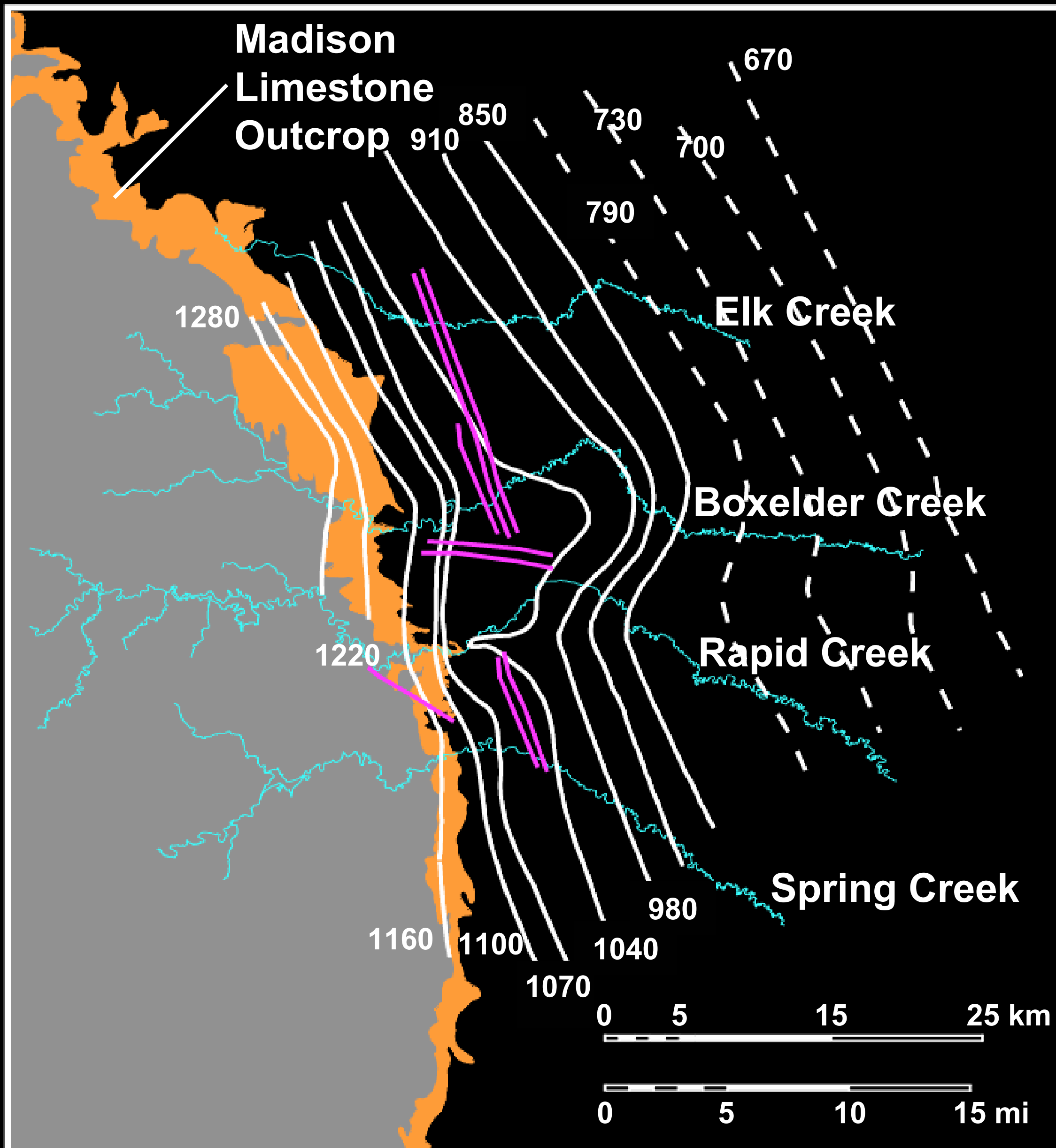


Madison Limestone, Rapid City, SD


Madison Limestone Outcrop
Elk Creek
Boxelder Creek
Rapid Creek
Spring Creek
0 5 15 25 km
0 5 10 15 mi



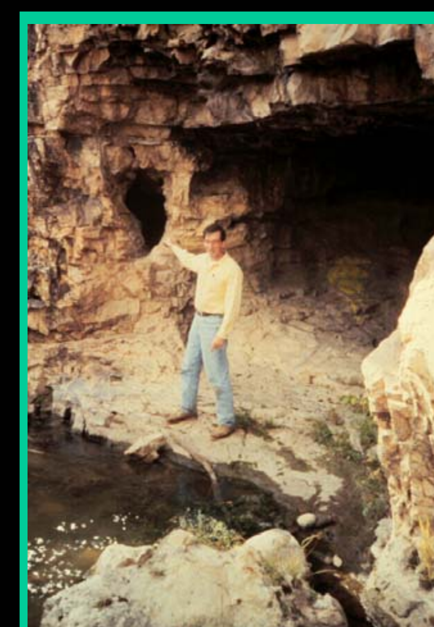
Madison Limestone Outcrop
670
850
730
910
700
790
Elk Creek
1280
Boxelder Creek
1220
Rapid Creek
Spring Creek
980
1160
1100
1040
1070
0 5 15 25 km
0 5 10 15 mi
Hydraulic Head (m above msl)
(approx)

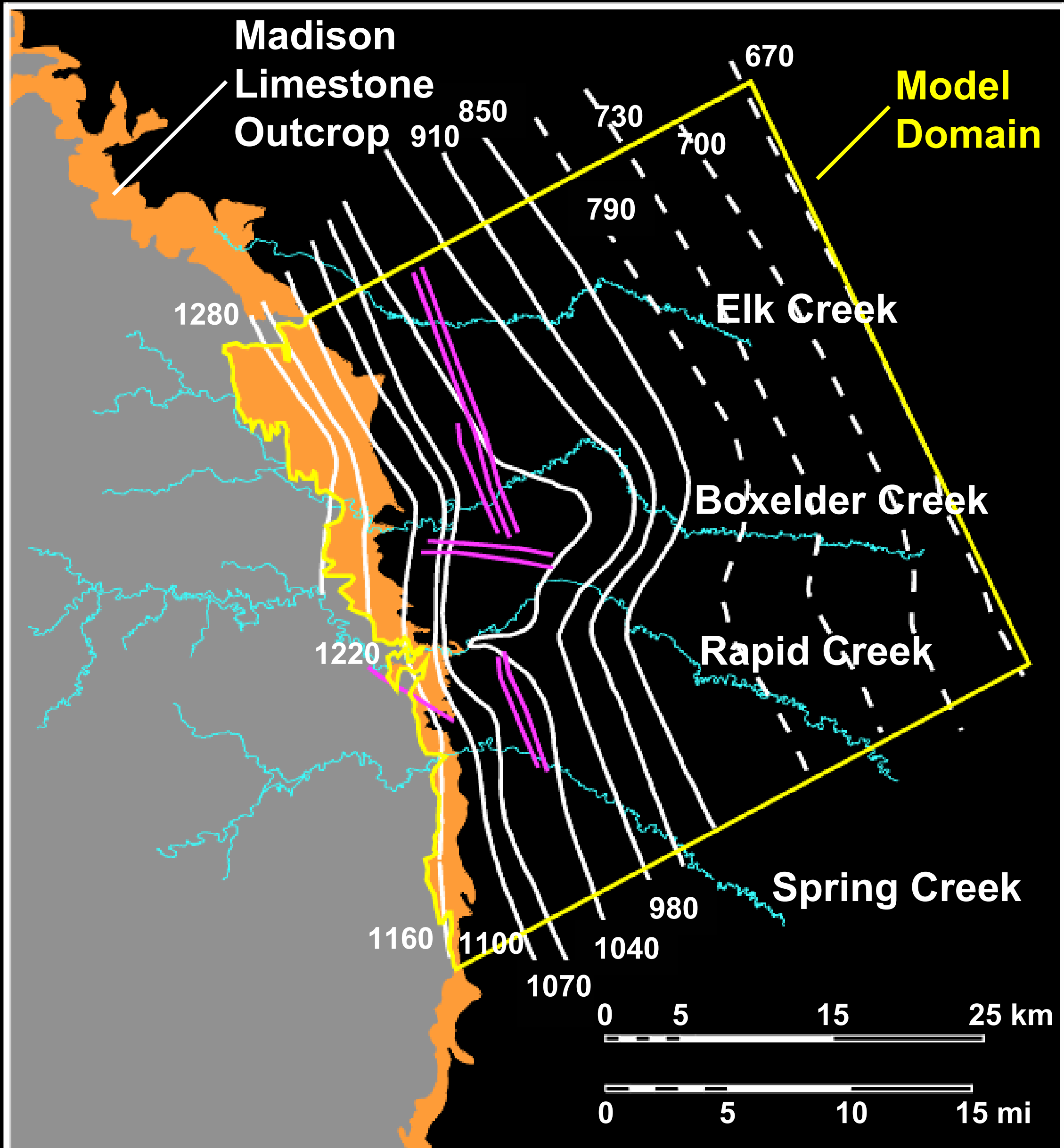


Hydraulic Head
(m above msl)

(approx)

Regional Structure

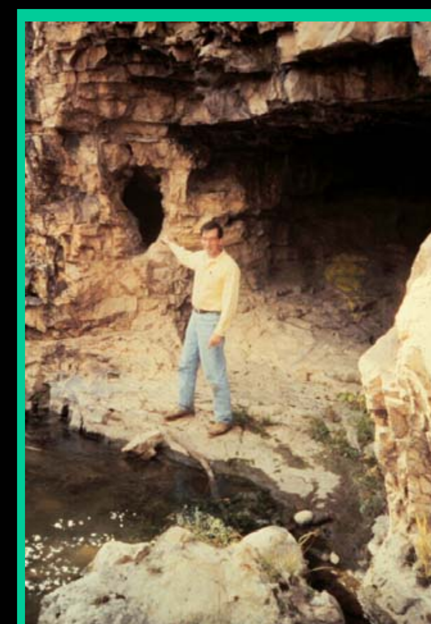




Hydraulic Head (m above msl)

(approx)

Regional Structure



Ground-water modeling of fractured-rock aquifers over the well field dimensions. . .

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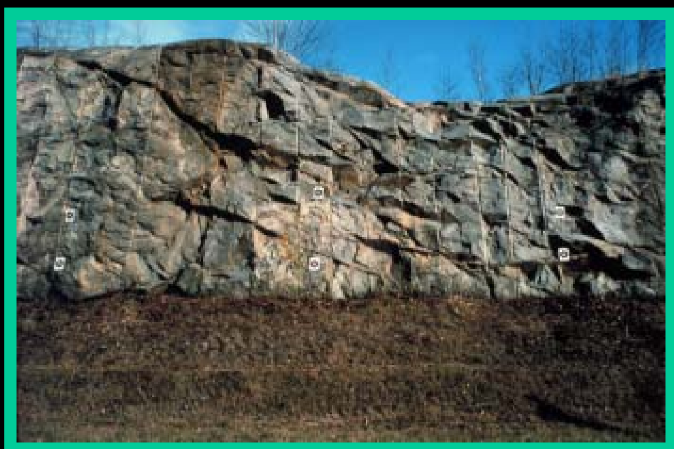
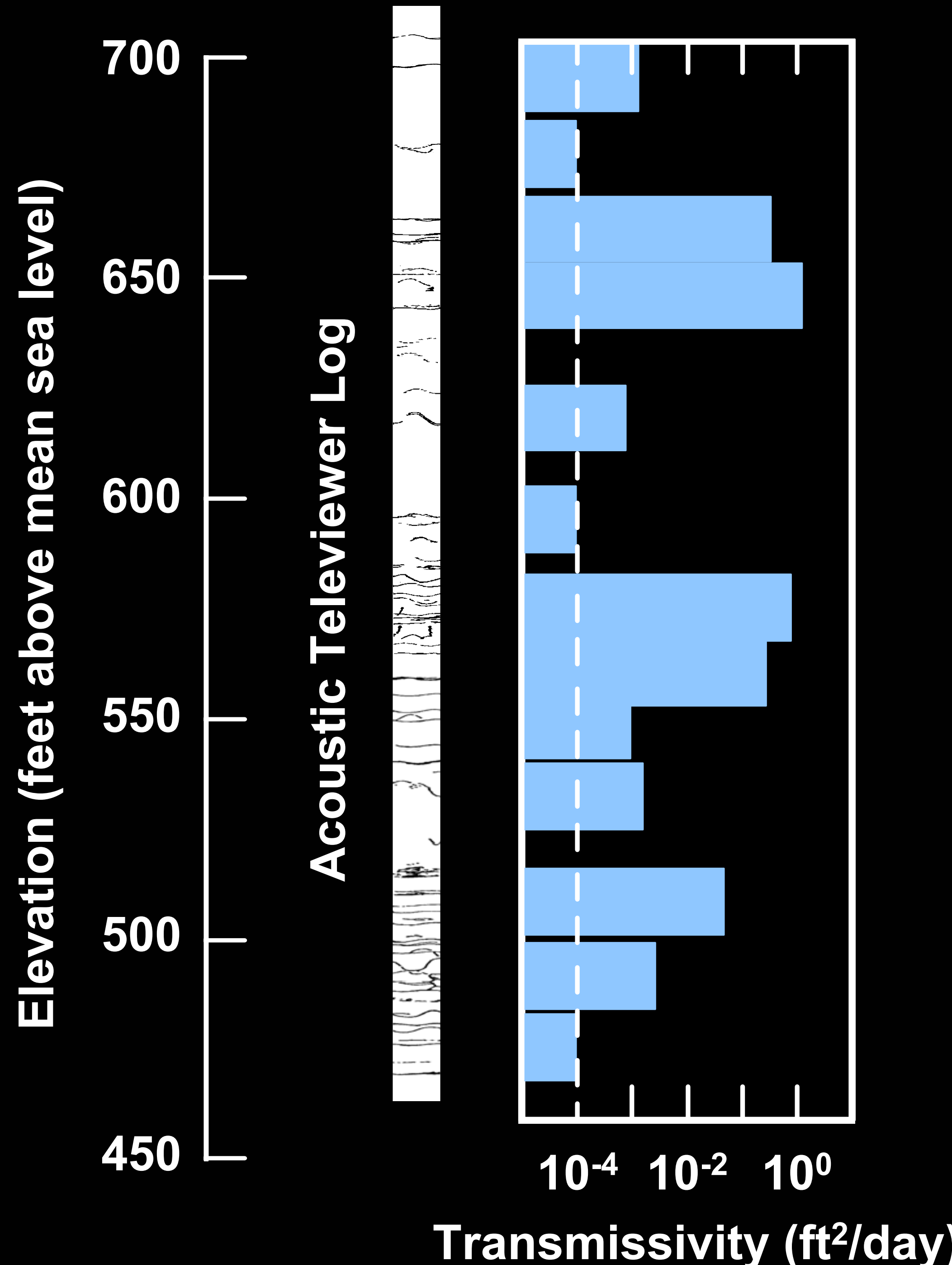
Borehole H1 - Mirror Lake Watershed

Grafton County, New Hampshire





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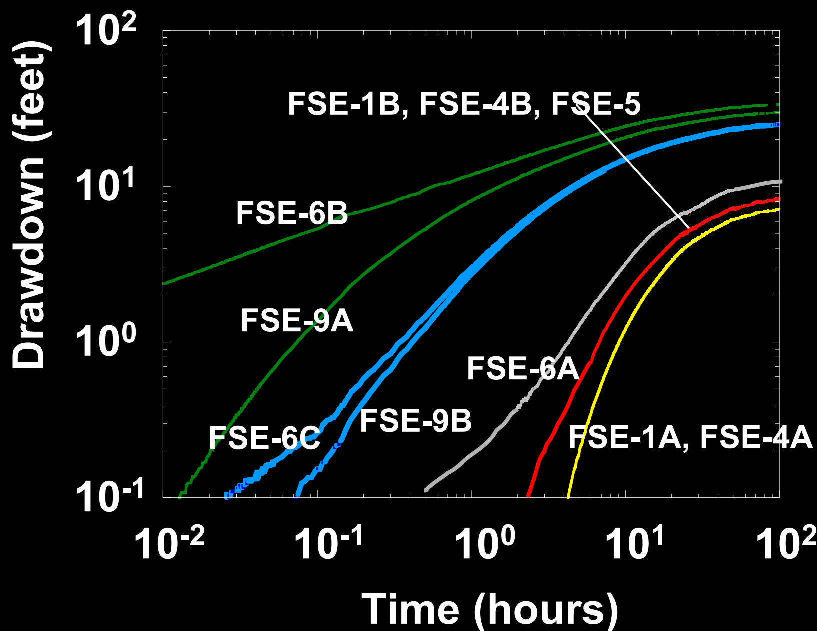
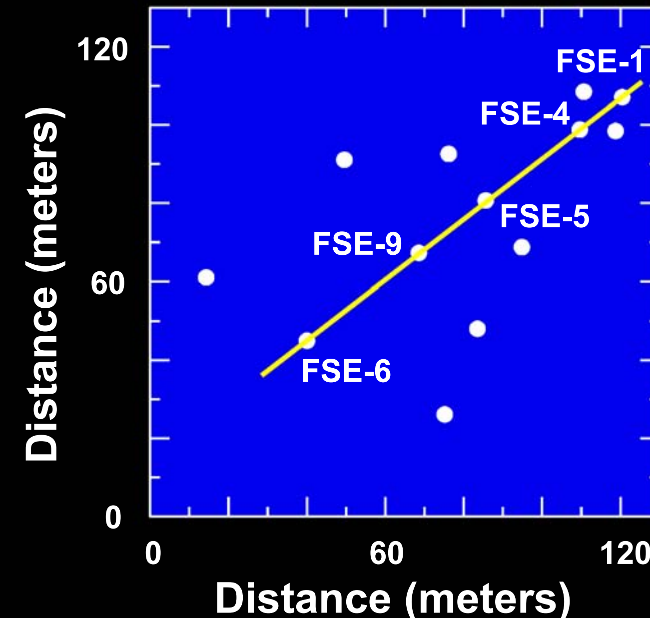
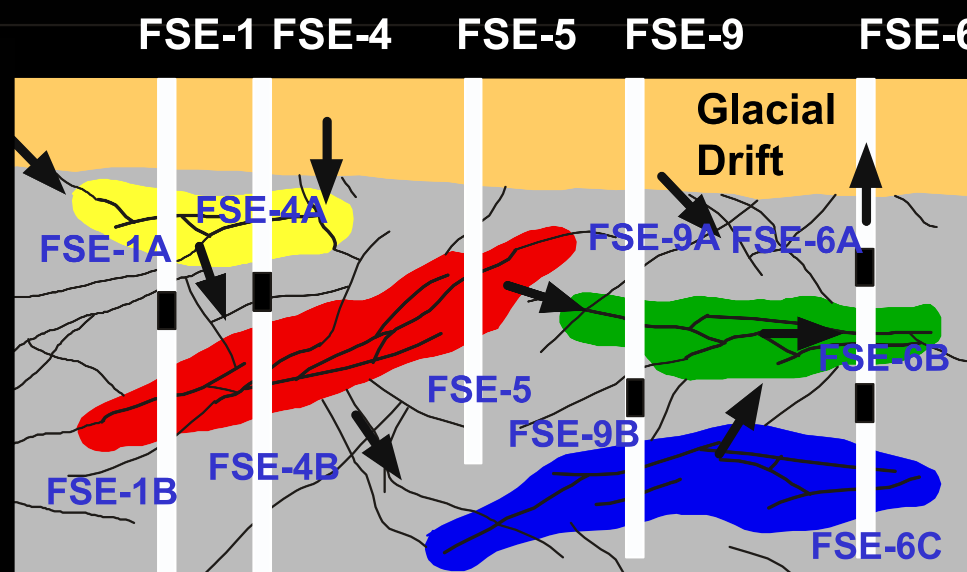


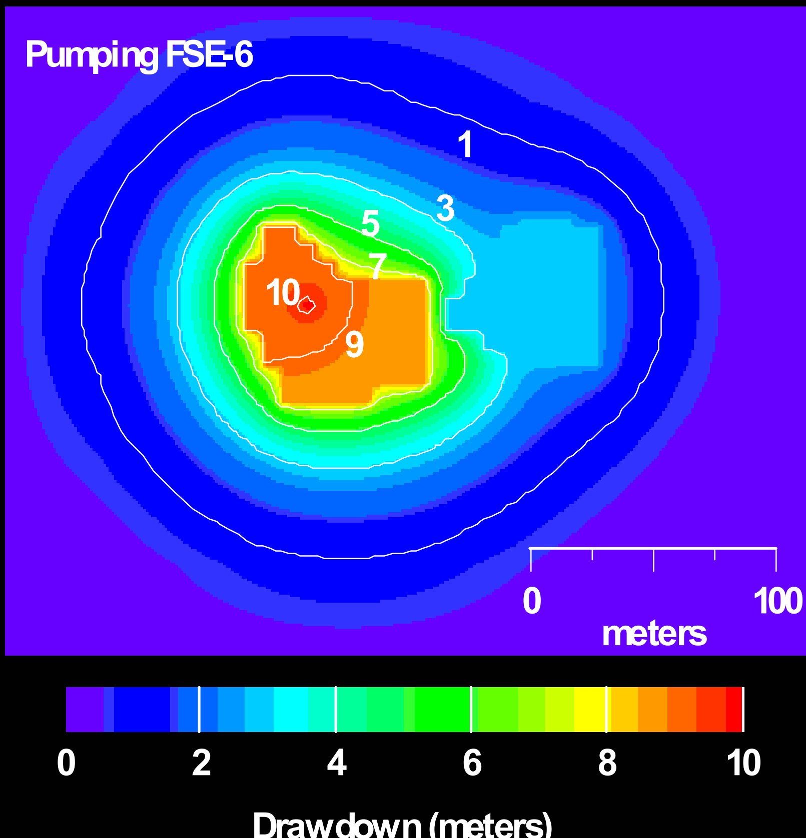


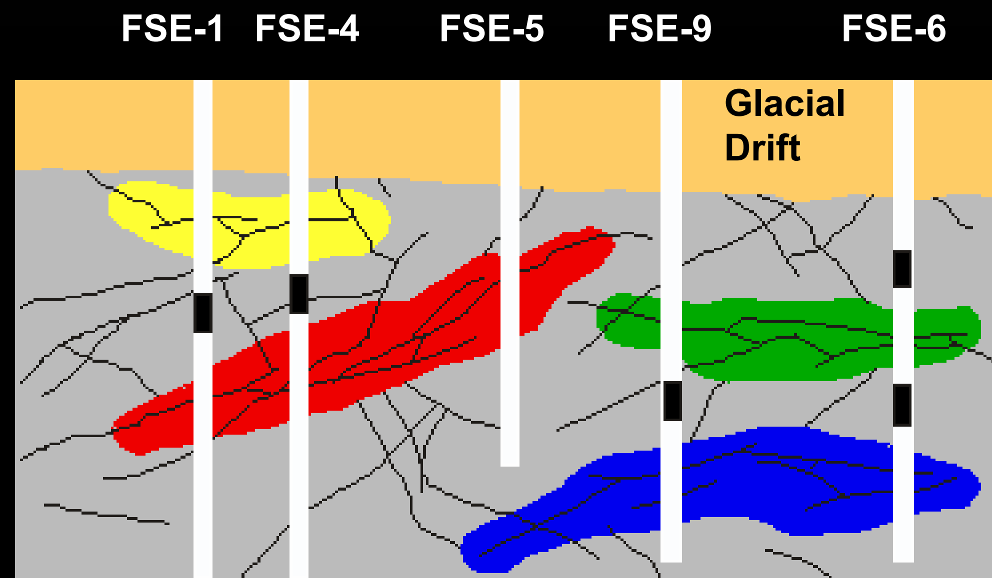
Aquifer Test - FSE Well Field
Mirror Lake, New Hampshire



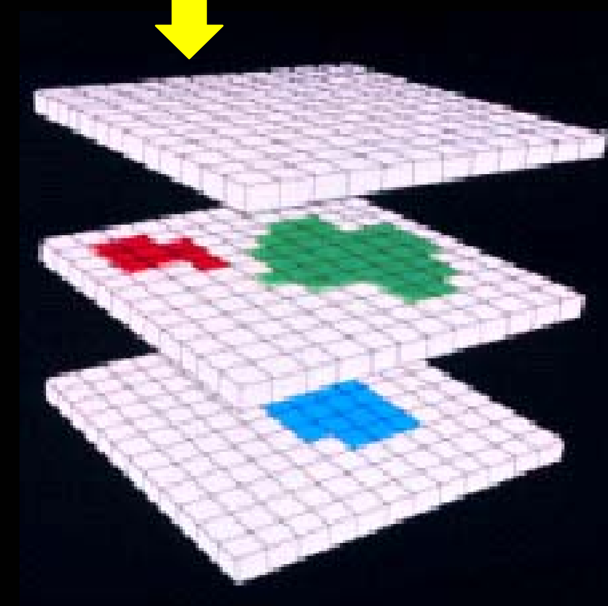
30 meters

Simulated Drawdown





Conceptual Model of Aquifer Heterogeneity



Finite-Difference Model for Ground-Water Flow

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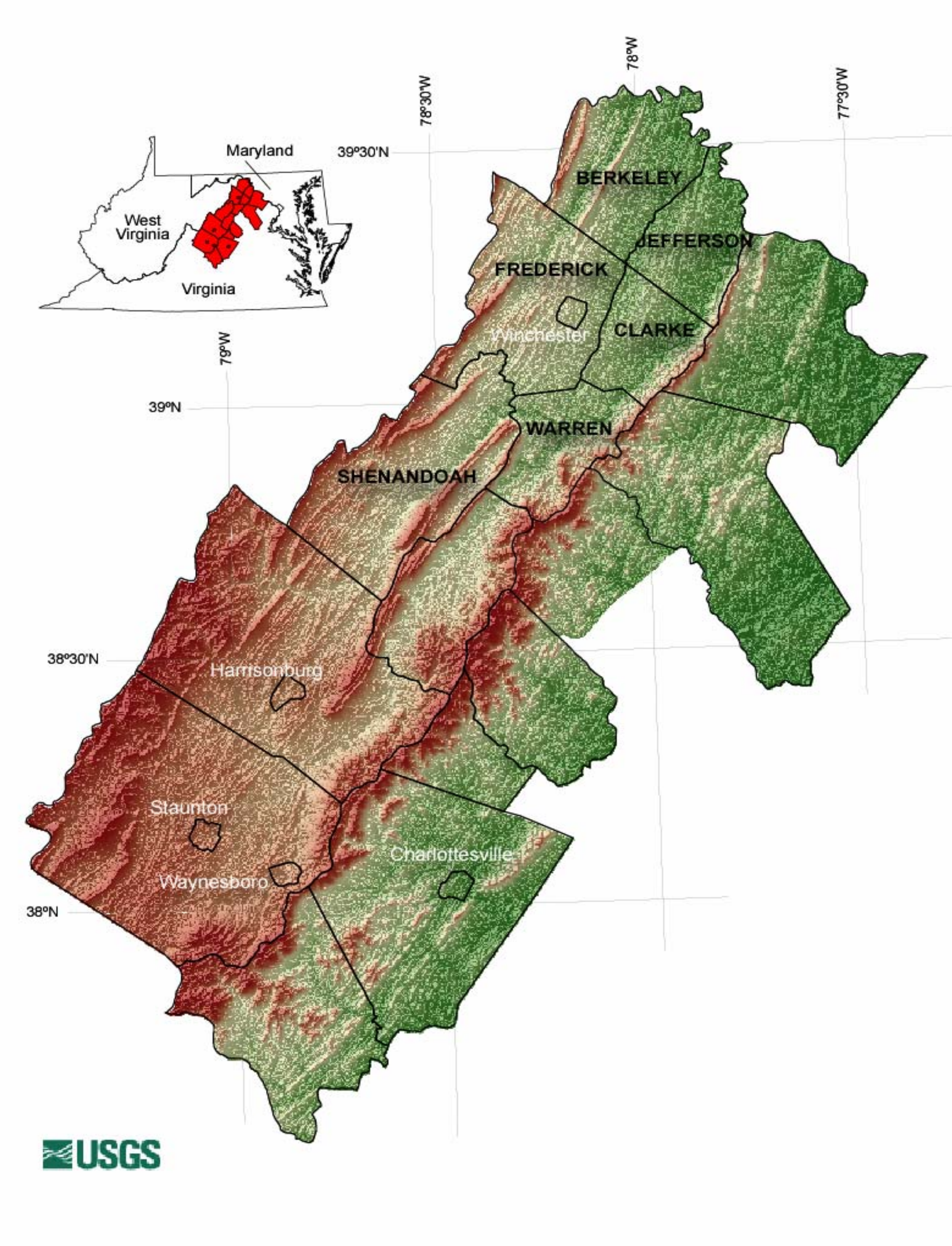

Ground-Water Modeling in the Shenandoah River Valley

Objectives:

- Quantify ground-water elevations and stream discharge subject to known or assumed natural and anthropogenic constraints

- Consider scales of model investigations from small drainages (several sq. miles) to regional drainages (100's of sq. miles)

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Ground-Water Modeling in the Shenandoah River Valley

Data Requirements:

- **Geologic structure**

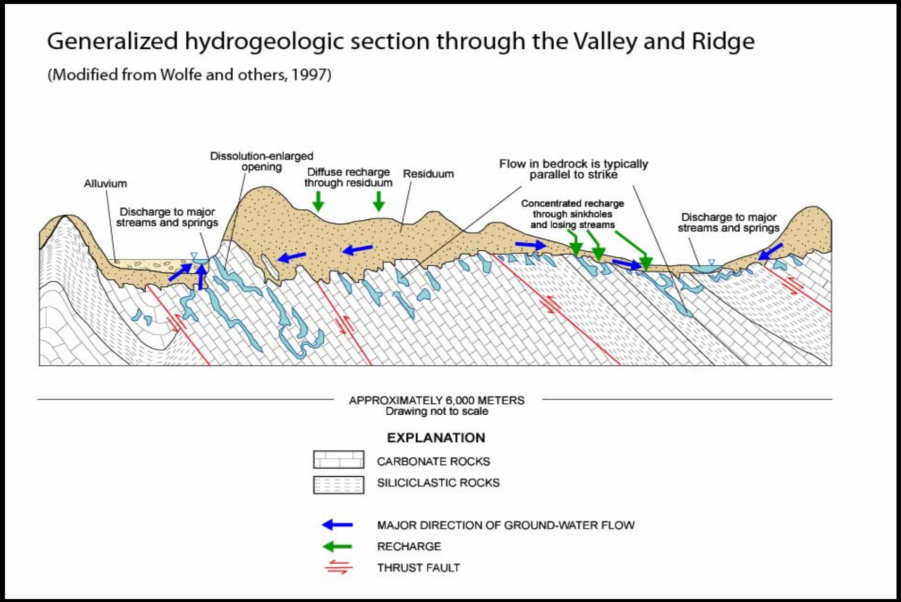
  Stream flows

  Ground-water elevations

  Significant sources and sinks of water

  Aquifer properties - heterogeneity

  Recharge – spatial distribution



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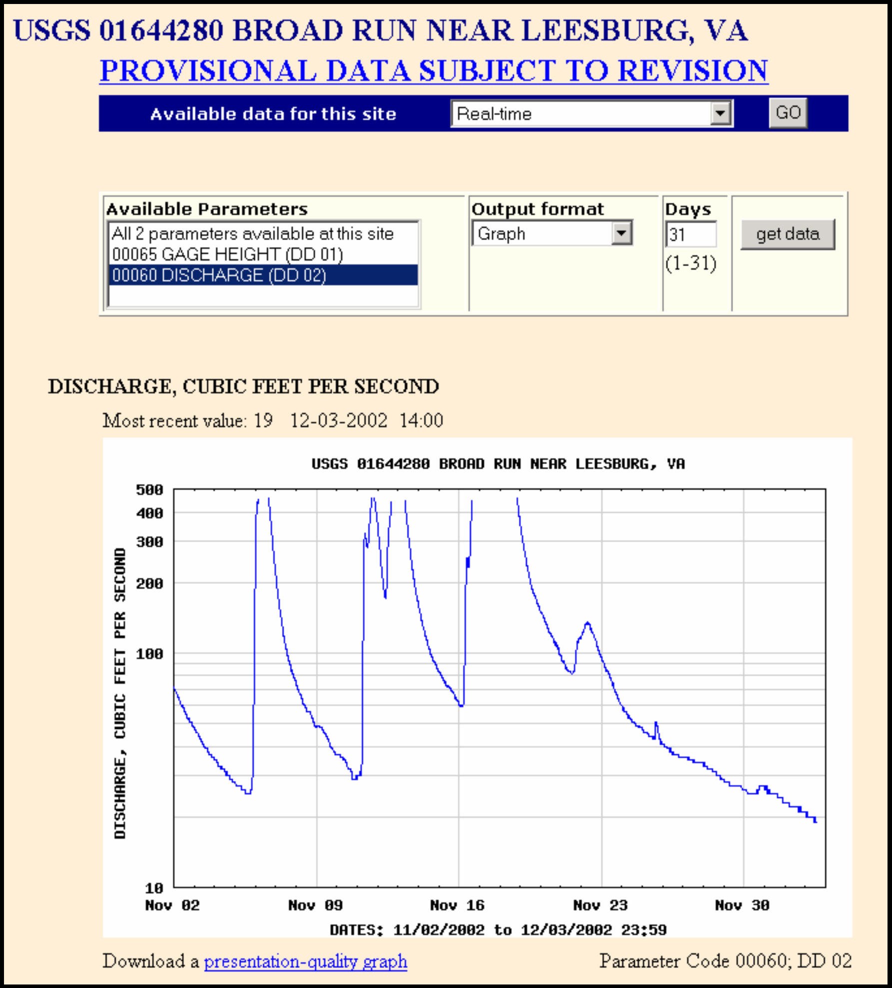
Ground-Water Modeling in the Shenandoah River Valley

Data Requirements:

- Geologic structure
- Stream flows
- Ground-water elevations
- Significant sources and sinks of water
- Aquifer properties - heterogeneity
- Recharge – spatial distribution



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Ground-Water Modeling in the Shenandoah River Valley

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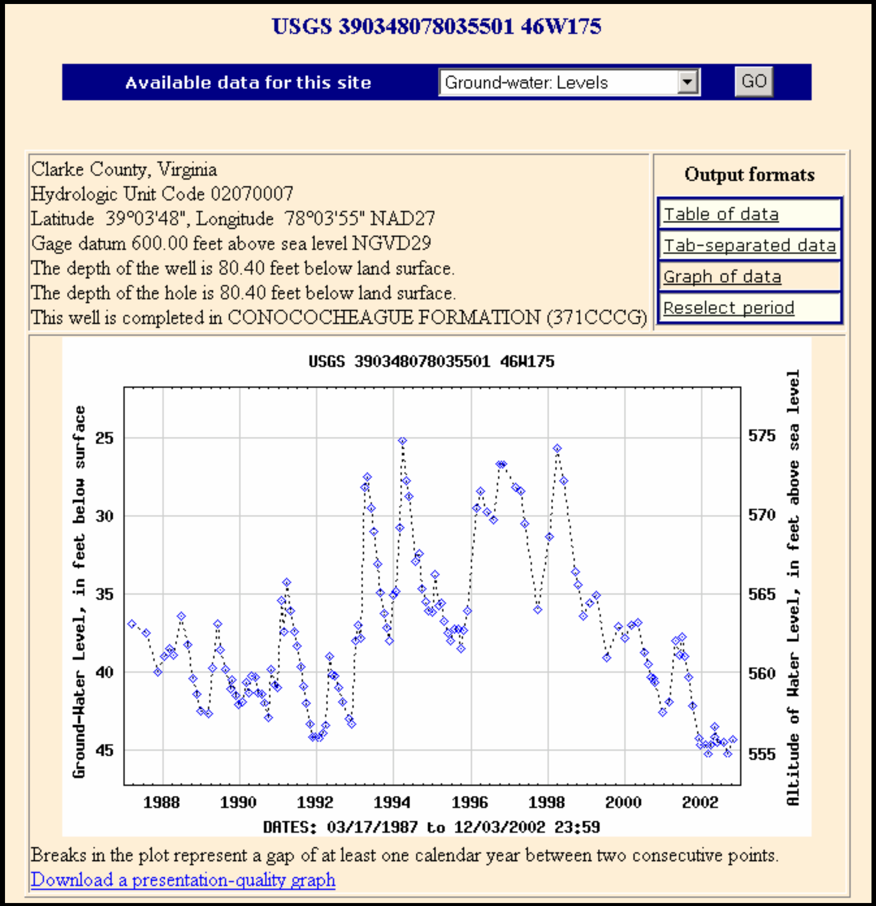

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Ground-Water Modeling in the Shenandoah River Valley

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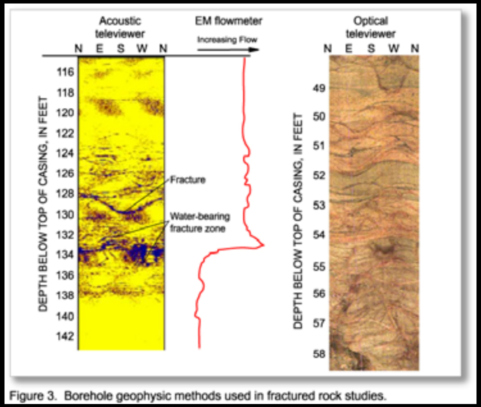
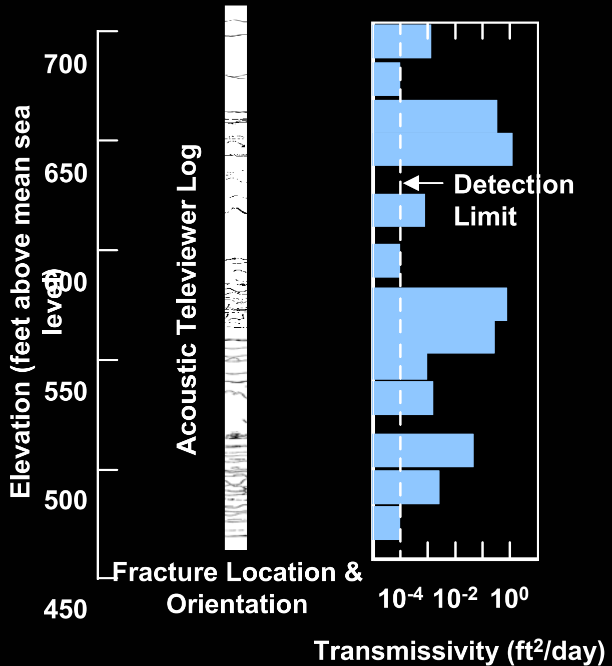


Figure 3. Borehole geophysic methods used in fractured rock studies.



Borehole H1
Mirror Lake Watershed, NH

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Ground-Water Modeling in the Shenandoah River Valley

Data Requirements:

Geologic structure

Stream flows

Ground-water elevations

Significant sources and sinks of water

Aquifer properties - heterogeneity

- **Recharge – spatial distribution**

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Ground-Water Modeling in the Shenandoah River Valley

- **Hydrogeologic conceptual model – an iterative process**

Initial hydrogeologic conceptual model

↓

Mathematical model

↓

Evaluate results

↓

Revise/Evaluate hydrogeologic conceptual model

↓

Data collection

- **Improve/Focus data collection efforts**
- **Ground-water, surface-water resources management**

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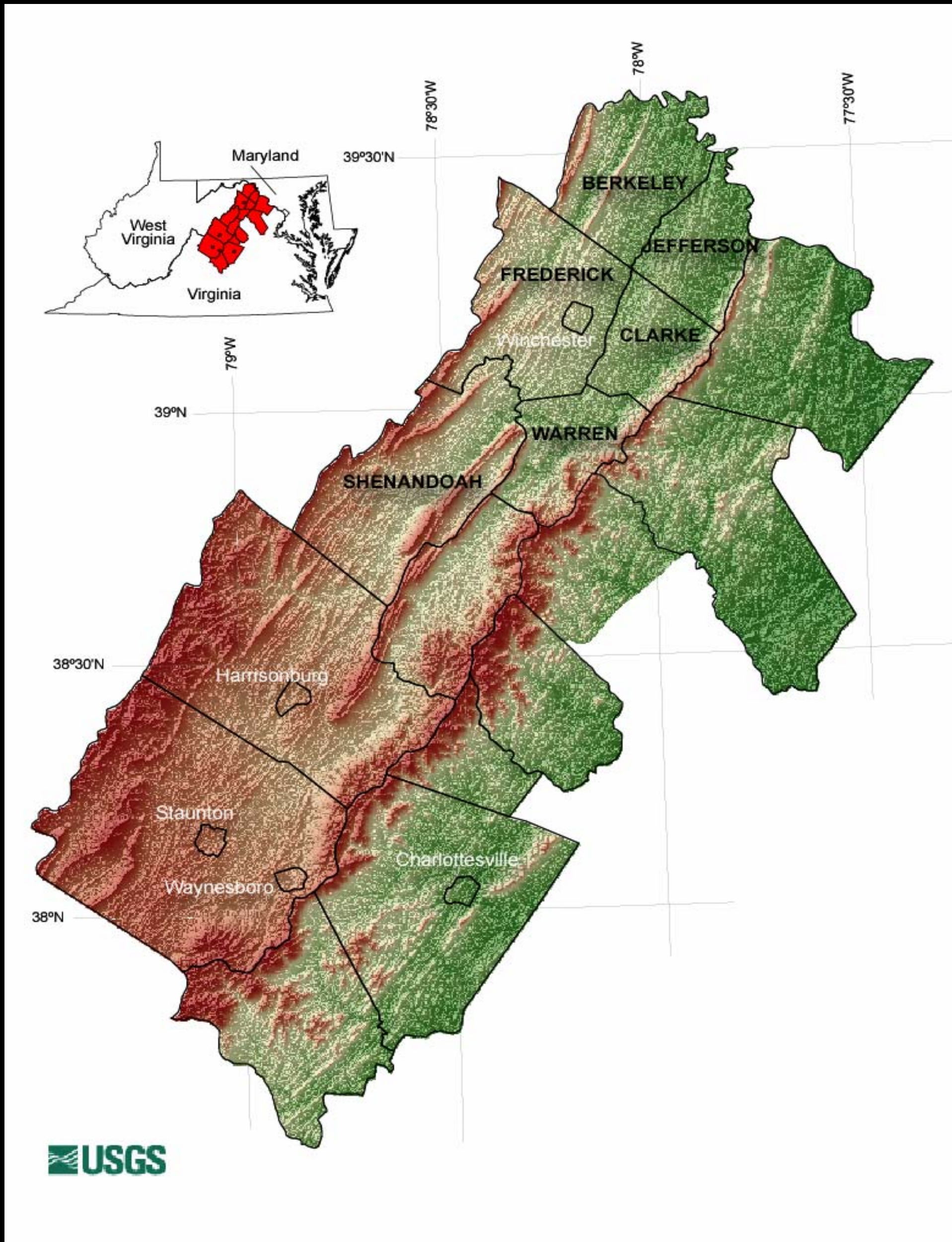
Ground-Water Modeling in the Shenandoah River Valley

- **Time line of events**

  2003: Preliminary regional ground-water flow model
  Identify smaller drainages for model investigation
  Identify data deficiencies

  2004 - 2005: Revise regional model & selected smaller drainages

  2006 – 2008: Revise regional model, additional smaller drainages, conduct post-audit



Ground-Water Modeling in the Shenandoah River Valley

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