Northern Shenandoah Valley Water Resources Initiative

Frederick County Board of Supervisors and Planning Commission
May 25, 2005
Winchester, VA
Water Balance

Hydrologic Cycle

- Atmospheric Moisture
- Precipitation
- Evapotranspiration
- Consumptive Use
- Evaporation
- Streamflow
- Recharge
- Water Table
- Fresh Ground Water
- Interface
- Saline Ground Water
- Ocean

USGS
Aquifer Material

<table>
<thead>
<tr>
<th>Sand</th>
<th>Crystalline rock</th>
<th>Carbonates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell material</td>
<td>Sedimentary rock</td>
<td>Coal</td>
</tr>
</tbody>
</table>

Shenandoah Valley
Ground-Water Flow in Karst
Long Term Monitoring—Ground Water Levels

46W175 Blandy Farm Observation Well

MINIMUM (Highest)

DAILY VALUES

AVERAGE

MAXIMUM (Lowest)

As of Oct. 4, 2004

Statistics based on period of record from WY 1988 to WY 2004

PROVISIONAL DATA SUBJECT TO REVISION

Internet Access:
01634500 Cedar Creek near Winchester, Va.
103 square miles

EFFECTIVE RECHARGE, IN INCHES PER YEAR

1939-2002
7.6 in/yr

2000-2002
5.8 in/yr

8.7 Mgal/d
Foundation Projects:

• Shenandoah River Minimum Instream Flow Investigation:
  – Main Stem – 1999
  – North Fork – 2004
  – South Fork – 2005 start

• County Studies
  – Frederick County – 2001
  – Warren County – 2002
  – Clarke County – 2002
  – Berkeley County – 2002
  – Jefferson County – 2004

• Leetown Science Center Assessment – 2002

[Image: USGS logo]
Study Approach
Karst Springs
Real-Time Water-Data Network

EXPLANATION
- NEW WELL
- EXISTING WELL
- NEW STREAMGAGE
- PROJECT STREAMGAGE
- EXISTING STREAM GAGE
Borehole Geophysical Logging

Figure 3. Borehole geophysical methods used in fractured rock studies.
Frederick County – Well 45W 21 near Stephens City

Vertical Profile          Deviation Log           Plan View

14.1 feet
Generalized hydrogeologic section across the Frederick County carbonate aquifer system
Multidisciplinary Assessment of the Northern Shenandoah Valley in Virginia and West Virginia

• The objective of this first integrated regional assessment is to better characterize the aquifer systems in the Northern Shenandoah Valley and provide relevant hydrogeologic information that can be used to guide the development and management of these water resources.

• This regional study of the karst and fractured-rock aquifer systems will use hydrologic, geologic, cartographic, and biologic information to improve the understanding of the aquifer systems, their relationship to surface features, and potential hazards over a multi-county area of Virginia and West Virginia.
Study Approach for Regional System:

- Characterize karst and fractured-rock aquifer systems
- Characterize ground-water/surface water interactions
- Develop numerical models to simulate the regional and local ground-water-flow systems
- Characterize water quality and sources of degradation
- Assess implications of water resources management decisions on aquatic ecosystems
Project Elements:

• Interdisciplinary Assessment – late 2003
  – 10-Meter digital elevation models
  – Sinkhole mapping
  – GIS mapping

• Regional Ground-Water-Flow Model – 2004

• Interdisciplinary Assessment – late 2004
  - Ground-water age-dating
  - Opequon ground-water model

• Interdisciplinary Assessment - 2005
  - Geophysical Surveys
    - Seismic imaging
    - Electrical resistivity
Sinkhole Mapping

Sinkholes
(789,345 sq meters, 0.5% of area)

Area drained by sinkholes
(9,017,287 sq meters, 5.86% of area)
Ground-Water Age Dating

EXPLANATION
- COUNTY
- VIRGINIA AQUIFER SUSCEPTIBILITY
- SHENANDOAH NATIONAL PARK
- CHESAPEAKE BAY ECOSYSTEM
Ground-Water-Age Dating:
Perry Spring

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tritium ($^3$H)</td>
<td>7.5 ± 0.5 TU</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helium (2.1)</td>
<td>4.3</td>
<td></td>
<td>NanoMol/L</td>
</tr>
<tr>
<td>Hydrogen (0.4)</td>
<td>2.4</td>
<td></td>
<td>NanoMol/L</td>
</tr>
<tr>
<td>Neon (9)</td>
<td>12.2</td>
<td></td>
<td>NanoMol/L</td>
</tr>
<tr>
<td>Deuterium</td>
<td>-53.1</td>
<td></td>
<td>per mil</td>
</tr>
<tr>
<td>Oxygen-18</td>
<td>-8.4</td>
<td></td>
<td>per mil</td>
</tr>
<tr>
<td>$d$Excess</td>
<td>13.8</td>
<td></td>
<td>per mil</td>
</tr>
<tr>
<td>Oxygen, diss.</td>
<td>5.2</td>
<td></td>
<td>mg/L</td>
</tr>
<tr>
<td>pH</td>
<td>6.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Cond.</td>
<td>659 uS/cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water Temp</td>
<td>12.5 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recharge Temp</td>
<td>9.5 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excess air</td>
<td>5.2 cc STP/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recharge Elev</td>
<td>560 ft above Sea Level</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Binary Mixture:**
85% - 2 year water
15% - pre-CFC water

**USGS**
Ground-Water-Flow Model of the Shenandoah Valley

Richard Yager
USGS
Ithaca, New York

Objectives:

- Compute water budget
- Estimate bulk hydraulic properties
- Identify data requirements

Model Area = about 2,900 mi²

*Model depth = 16,000 ft
Mesh

Hydraulic connections along bedding planes within the rocks will be represented by model layers that conform to the generalized dip of the bedding. How?? SUTRA3D will allow this!
Opequon Creek Ground-water Simulation Model

West Virginia & Virginia

Jack Eggleston
USGS, Richmond, VA
Goals of Study

Better understand the regional hydrologic system:

• What is the available ground-water supply?
• How do streams and groundwater interact?
• How does drought affect streams/springs/gw?
• How will population growth affect hydrology and water availability?
Opequon Stream Network

- WV (West Virginia)
- VA (Virginia)
- MD (Maryland)
- Potomac River

Map showing the Opequon Stream Network in WV, VA, and MD, with the Potomac River in the background.
Opequon Streamflow

- Base flow is the portion of stream flow that comes from groundwater discharge

- 68% of Opequon Creek flow is base flow (Martinsburg WV gage, annual average 1948-2002)

- The groundwater model will simulate base flow in streams.

- The model will be calibrated using base-flow data from the five stream-gaging stations.
Model Grid

100 meter grid spacing
Internet Sites

• **Water Resources of Virginia**
  http://va.water.usgs.gov/
  • **Frederick County Project**
    http://va.water.usgs.gov/projects/va134.html
  • **Clarke County Project**
    http://va.water.usgs.gov/projects/va146.html
  • **Warren County Project**
    http://va.water.usgs.gov/projects/va142.html
  • **Shenandoah River Minimum Instream Flow Project**
    http://va.water.usgs.gov/projects/va111.html

• **Great Valley Water-Resources Science Forum**
  http://va.water.usgs.gov/GreatValley/Index.htm