Water Availability in the Upper Monocacy Basin – Existing Estimates from Water Budget and Ground Water Modeling Studies

September 30, 2008

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Interstate Commission on the Potomac River Basin (ICPRB)
Location of Upper Monocacy Basin

Legend
- Blue: Potomac River
- Light blue: Potomac tributaries
- Gray: State boundaries
- Green: Monocacy River Basin
- Yellow: Upper Monocacy Basin
- Gray: Adams County
Water Availability: Considerations

- Spatial scale
- Interconnection between ground water and surface water resources
- Seasonal variations in water availability
- Importance of data
Water Availability Estimates from ICPRB

- Annual recharge estimates for the Monocacy River basin by hydrogeomorphic region
- Seasonal water availability estimates in 4 watersheds of the Monocacy basin using stream flow recession analyses
- Ground water/stream flow model of upper Monocacy basin, estimating of impact of ground water withdrawals on stream flow
Annual Recharge Estimates

- For Monocacy/Catoctin drainage area
- Uses annual baseflow statistics:
  annual recharge ~ annual stream base flow
- Data from 34 stream gages
- Spatial regression analysis, with explanatory variables:
  - Drainage area
  - % watershed in each of 4 hydrogeomorphic regions
    (Chesapeake Bay Program)

See Annual and Seasonal Water Budgets for the Monocacy/Catoctin Drainage Area, ICPRB, 2004
### Annual Recharge Estimates

<table>
<thead>
<tr>
<th>Hydrogeomorphic Regions (CBP)</th>
<th>2-year</th>
<th>10-year</th>
<th>20-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Ridge (BR)</td>
<td>12.2</td>
<td>7.8</td>
<td>6.8</td>
</tr>
<tr>
<td>Mesozoic Lowland (ML)</td>
<td>5.3</td>
<td>2.9</td>
<td>2.4</td>
</tr>
<tr>
<td>Piedmont Carbonate (PCA)</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Piedmont Crystalline (PCR)</td>
<td>8.5</td>
<td>5.8</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Legend

- **Blue Ridge (BR)**
- **Mesozoic Lowland (ML)**
- **Piedmont Carbonate (PCA)**
- **Piedmont Crystalline (PCR)**
Seasonal Water Availability Estimates

- For 4 Monocacy/Catoctin watersheds
- Study period: 1960 - 2002
- Analyses based on:
  - Mean seasonal baseflow
  - Baseflow recession coefficients
- Results include time series of seasonal estimates for:
  - Base flow (BF)
  - Storm flow (SF)
  - Evapotranspiration (ET)
  - Net recharge (R)
  - Storage (S) (above zero-flow level)
# Seasonal Water Availability Estimates

Long-term averages of estimated seasonal water budget components, Marsh/Rock/Alloway Creek watershed (inches per quarter)

<table>
<thead>
<tr>
<th></th>
<th>Precip</th>
<th>SF</th>
<th>BF</th>
<th>ET</th>
<th>R</th>
<th>ΔS</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 (J,F,M)</td>
<td>10</td>
<td>4.5</td>
<td>2.9</td>
<td>2.3</td>
<td>3.1</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>Q2 (A,M,J)</td>
<td>12</td>
<td>2.5</td>
<td>1.7</td>
<td>8.2</td>
<td>1.3</td>
<td>-0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Q3 (J,A,S)</td>
<td>11.5</td>
<td>1</td>
<td>0.4</td>
<td>10.1</td>
<td>0.4</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>Q4 (O,N,D)</td>
<td>9.9</td>
<td>2.2</td>
<td>1.2</td>
<td>6.2</td>
<td>1.5</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Annual</td>
<td>43.4</td>
<td>10.3</td>
<td>6.2</td>
<td>26.8</td>
<td>6.3</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

From *Annual and Seasonal Water Budgets for the Monocacy/Catoctin Drainage Area*, ICPRB, 2004
# Seasonal Water Availability Estimates

## Annual water budget
- Based on estimates of annual recharge
- Assumes no annual change in storage

## Seasonal water budget
- Based on estimates of recharge and recession
- Estimates seasonal changes in storage

<table>
<thead>
<tr>
<th>Station</th>
<th>Annual Recharge (gpd/acre)</th>
<th>Seasonal Summer recharge + summer storage (gpd/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median</td>
<td>1 in 10-year</td>
</tr>
<tr>
<td>Catoctin Creek (01637500)</td>
<td>350</td>
<td>210</td>
</tr>
<tr>
<td>Upper Monocacy (01639000)</td>
<td>230</td>
<td>120</td>
</tr>
<tr>
<td>Big Pipe Creek (01639500)</td>
<td>350</td>
<td>460</td>
</tr>
<tr>
<td>Bennett Creek (01643500)</td>
<td>390</td>
<td>420</td>
</tr>
</tbody>
</table>
Upper Monocacy Basin Ground Water/Stream Flow Model

- **Objective**: investigate impact of ground water withdrawals on summertime stream flow
- **Scale**: regional (309 mi$^2$)
- **Study period**: 1960 to 2002
- **Funding**: National Fish and Wildlife Foundation/ICPRB
Available Stream Flow Data

- Daily flow data:
  - Monocacy R at Bridgeport, MD
  - Piney Cr near Taneytown, MD
  - Toms Cr at Emmitsburg, MD

- Six flow measurements made for project on Marsh Cr & Rock Cr (USGS)
Available Well Data

- Data at 361 wells in 43-year study period
- 59% of wells had only 1 measurement
- 92% of wells had 3 or less measurements
Classification of Summertime Conditions

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<th>Condition</th>
<th>Summertimes</th>
<th>Mean summertime baseflow at 01639000 (cfs)</th>
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Available summertime well data by hydrologic condition

Summer well data
- Red: Dry
- Orange: Average-dry
- Yellow: Average
- Green: Average-wet
- Light blue: Wet
Model Grid

- 500 m x 500 m horizontal grid cells
- 10 layers each 10 m
- 271 stream miles
Hydraulic Conductivity Zones

Rock type:
- Blue Ridge crystalline
- Mesozoic Lowland sedimentary
- Mesozoic Lowland diabase
- Piedmont crystalline
Model recharge inputs represent “net” recharge - include impact of ground water withdrawals

Recharge inputs based on means summer baseflow, by hydrologic condition.
Model Aquifer Level Predictions - Calibration

Average Summer

Simulated (m)

Observed (m)
Model Aquifer Level Predictions - Verification

Dry Summer

![Dry Summer Regression Plot]

Average-Dry Summer

![Average-Dry Summer Regression Plot]
Model Aquifer Level Predictions - Verification

![Graphs showing observed vs simulated aquifer levels for average-wet and wet summer conditions.](image-url)
Model Predictions of Dry & Losing Stream Reaches

Legend
- % Dry stream miles
- % Dry or losing stream miles

Simulated flow at 01639000, mgd

Upper Monocacy Basin
Model stream flow predictions
- Gaining stream reach
- Losing stream reach
- Dry stream reach
- Other grid cell
Upper Monocacy Ground Water/Stream Flow Model – Conclusions

- Model limitations:
  - Regional model, so predictions not likely reliable at local scale
  - Ground water withdrawals simulated as uniform reduction in net recharge
  - Needs further verification – with stream observations

- Model capabilities:
  - Fairly good simulation of typical summertime aquifer levels
  - Indicates that additional ground water withdrawals of ~ several mgd will likely have significant impact on basin streams