Middle Potomac River Watershed Assessment

Human uses of water

Current and future demands in the Potomac River Basin

Second of a six-part webinar series

May 10, 2011

The webinar will start momentarily.

Audio feed is by telephone

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Middle Potomac Watershed Assessment
Webinar 1: Technical Overview

Speakers

Andrew Roach, U.S. Army Corps of Engineers, Baltimore District

Olivia Devereux, Environmental Scientist, Interstate Commission on the Potomac River Basin (ICPRB)
Study Area

Middle Potomac Watershed Study Area

5/10/2011
This project’s objectives

1) Estimate current and future human water withdrawals and their impacts on flows.

2) Characterize flows needed to support healthy stream biotic communities.

3) Provide baseline information and analyses to support water use decision making.

5/10/2011
### Webinar Series

- Technical details on methodology for small streams
- Obtain feedback from stakeholders
- Prepare for concluding workshop: focus on management applications

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**Flow Ecological Response Workshop at NCTC**

5/10/2011
Purpose of the Future Scenarios Task

1. To develop inputs for modeling future steam flow scenarios and estimating impacts on flow.

2. Follow-up to the 2000 ICPRB Water Supply Demands and Resource Analysis study.

Information about the Middle Potomac River Watershed Assessment is available at: PotomacRiver.org/sustainableflows
Determining Potomac Basin Quantitative Flow-Ecology Relationships / Implementation

**Hydrologic Foundation**
- Build hydro model, delineate watersheds

**Flow Alteration**
- Baseline-to-current and current-to-future flow alteration

**River Classification**
- Select (first cut) river types based on natural and anthropogenic factors
- Final river types

**Flow-Ecology Relationships**
- Explore relationships between biometrics, stream habitat, and land/water uses
- Subset of biometrics most sensitive to flow alteration
- Flow alteration - ecological response relationships for each river type

**Decision Making**
- Recommendations for Environmental Flow Standards
- Acceptable Ecological Conditions
- Societal Values and Mgmt Needs

**Implementation**

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Outline

• Study area

• Forecasting water demand and apportioning to a spatial and temporal scale for use in the models

• Six scenario designs and results

• Comparison with other studies

• Conclusions

5/10/2011
Withdrawal sites and drainage to mainstem stream gage sites
Largest withdrawals (>100 MGD)

Mt. Storm Power Station
Allegheny Energy
Mirant Mid-Atlantic
WSSC
Washington Aquaduct
Mirant Dickerson
Mirant Morgantown
Dominion Generation Plant
Mirant’s Morgantown Plant
Approximately 25% of all water withdrawal
Forecasting water demand and consumption


2. Water use sectors
   - Mining
   - Thermo-electric power
   - Industrial
   - Agricultural (livestock and irrigation)
   - Domestic and Public Supply

3. Geography: for point locations, based on projections from a county scale

4. Water sources: groundwater and surface water

5. Scenarios
   - Three scenarios that provide a high, medium, and low estimates for domestic and public supply
   - Hot and dry
   - Climate Change
   - Power generation

5/10/2011
## Water use sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining (MI)</td>
<td>Water used for the <strong>extraction</strong> and on-site <strong>processing</strong> of naturally occurring <strong>minerals</strong> including coal and ores.</td>
</tr>
<tr>
<td>Thermo-electric Power (PO)</td>
<td>Water used in the generation of <strong>electric power from</strong> the following fuels: fossil, nuclear, biomass, solid waste, or geothermal energy.</td>
</tr>
<tr>
<td>Industry (IN)</td>
<td>Water used to <strong>manufacture products</strong> such as steel, chemical, and paper, as well as water used in petroleum and metals refining.</td>
</tr>
<tr>
<td></td>
<td>Includes water used as process and production water, boiler feed, air conditioning, cooling, sanitation, washing, transport of materials, and steam generation for internal use.</td>
</tr>
<tr>
<td>Sector</td>
<td>Definition</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Livestock (LV)</td>
<td>Water used to raise cattle, sheep, goats, hogs, and poultry.</td>
</tr>
<tr>
<td></td>
<td>Animal specialty water use, which includes horses, are included.</td>
</tr>
<tr>
<td></td>
<td>Aquaculture is also included. Includes drinking water for the animals and wash water.</td>
</tr>
<tr>
<td>Irrigation (IR)</td>
<td>Includes all water artificially applied to farm, orchard, pasture, and horticultural crops.</td>
</tr>
<tr>
<td></td>
<td>Turf farms and golf courses are included in this category.</td>
</tr>
<tr>
<td>Domestic and Public Supply (DP)</td>
<td>Water withdrawn by public and private water suppliers and delivered to users, typically used for household purposes such as drinking, food</td>
</tr>
<tr>
<td></td>
<td>preparation, bathing, washing clothes and dishes, flushing toilets, car washing, and watering lawns and gardens.</td>
</tr>
<tr>
<td></td>
<td>This category also includes ski resorts.</td>
</tr>
</tbody>
</table>
## Sources and characteristics of forecasted data

<table>
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<tr>
<th>Water use sector</th>
<th>Forecasted data source</th>
<th>Spatial Resolution of Forecasted data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic + public supply</td>
<td>CBP Population projection</td>
<td>FIPS</td>
</tr>
<tr>
<td>Irrigation</td>
<td>NASS FRIS, CBP land use projection</td>
<td>FIPS</td>
</tr>
<tr>
<td>Livestock</td>
<td>NASS and CBP Ag Census, CBP land use projection</td>
<td>FIPS</td>
</tr>
<tr>
<td>Mining</td>
<td>US-EIA forecasts</td>
<td>northern and central Appalachian regions</td>
</tr>
<tr>
<td>Thermo-electric power</td>
<td>US-EIA forecasts</td>
<td>average for the entire nation</td>
</tr>
<tr>
<td>Industrial</td>
<td>US-EIA forecasts</td>
<td>average for the entire nation</td>
</tr>
</tbody>
</table>
Scaling water demand forecasts

• A rate of increase was applied to the county-scale USGS *Estimated Use of Water in the U.S. 2005* data

• The forecasted county-scale water use was then allocated to point locations based on the states’ reported 2005 withdrawals
  – Groundwater and surface water
  – Monthly

• Next, point data summed to river-segment scale for input to the models

• Data also summed to 8 specific gage sites
# Historical consumptive use

<table>
<thead>
<tr>
<th>Sector</th>
<th>Year</th>
<th>% consumptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic and public supply</td>
<td>1985</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Avg.</td>
<td>11</td>
</tr>
<tr>
<td>Irrigation</td>
<td>1985</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Avg.</td>
<td>82</td>
</tr>
<tr>
<td>Livestock</td>
<td>1985</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>Avg.</td>
<td>78</td>
</tr>
<tr>
<td>Industrial</td>
<td>1985</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>10</td>
</tr>
<tr>
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<td>Avg.</td>
<td>9</td>
</tr>
<tr>
<td>Mining</td>
<td>1985</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Avg.</td>
<td>15</td>
</tr>
<tr>
<td>Power</td>
<td>1985</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>1990</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Avg.</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: Consumptive = 100% for the domestic and public supply and industrial sectors, in those counties that are included in the Blue Plains service area.
Scenarios that provide a high, medium, and low estimates for the domestic and public supply sector

- High scenario
  - Domestic and public supply change in per capita use = 4.38% annual increase
- Medium scenario
  - Domestic and public supply change in per capita use = 1.82% annual increase
- Low scenario
  - Domestic and public supply change in per capita use = 0.0% annual increase

Hot and dry
  (built from Medium scenario)

Climate Change
  (built from High scenario)

Power generation changes
  (built from Medium scenario)

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“Medium” domestic and public supply scenario results

- Agriculture
- Domestic, Public Supply
- Industrial
- Mining
- Power

MGD

--- | --- | --- | --- | --- | --- | --- | ---
[Graph showing MGD consumption from 2005 to 2030 across sectors]

- Groundwater Consumptive
- Surface Water Consumptive
- Groundwater WD
- Surface Water WD

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Causes of domestic and public supply sector increases
Primarily because of per capita withdrawal
Secondarily due to population increase
Impact of per capita rates of growth in the domestic and public supply sector

In 2005, withdrawal was 730 MGD and consumption was 361 MGD.

<table>
<thead>
<tr>
<th>Scenario (per capita annual rate of increase)</th>
<th>Withdrawal (MGD)</th>
<th>Consumption (MGD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High (4.38%)</td>
<td>3,112</td>
<td>1,334</td>
</tr>
<tr>
<td>Medium (1.82%)</td>
<td>1,676</td>
<td>718</td>
</tr>
<tr>
<td>Low (0.0%)</td>
<td>1,068</td>
<td>458</td>
</tr>
</tbody>
</table>

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Climate change scenario design

Built on the High Scenario, Year=2030

Temperature adjustments
- Global temperature change
- Temperature increase by 0.4°C globally by 2030

Precipitation adjustments
- No annual precipitation change
- Variable precipitation patterns result in changes in human decision making

Agricultural sector
- Climate change will not result in any changes to the livestock sector
- Transpiration is assumed to not have an effect on the aggregated crop type used in this scenario
- Irrigated land increases by 50%

Thermo-electric power sector
- Increase power demand by 0.8% in summer months (May to Sept.); assumes a linear relationship between power production and water withdrawal by thermo-electric power plants.

Domestic and public supply sector: Increase water demand 5% for DP in summer months (May to September)

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Climate change scenario design

- Impact only to irrigation, domestic and public supply and power
- No change to mining, livestock, or industry

↑ Temperature 0.4°C by 2030

Variable precipitation
Integrated climate change causal link model

- **Climate Change**
  - ↑ Temperature – 0.4°C by 2030
  - Variable precipitation
  - Global agricultural production changes
    - ↑ Fruit and vegetable production in Chesapeake Bay region
  - Insecurity about rainfall
    - ↑ rate of plant growth
    - ↑ outdoor water use for lawn and garden watering (May-September)
    - ↑ watering of crops, lawns, and gardens
    - ↑ Irrigation
  - ↑ home and building cooling
    - ↑ power generation May-September
    - ↑ water withdrawal (May-September)

- **Industry**
  - Mining
  - Livestock

- **Human Adaption**
  - ↑ Plausible policy interventions
How does climate change impact water demand?
Hot and Dry scenario, based on the Medium Scenario

- Domestic and public supply withdrawals increased by 15.21% for the months April– August

- Power withdrawals increased 6.15% for the months May– October

- Irrigation withdrawals increased per acre by 283.9% for the months May– October

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Temperature increased by the difference between 1930 and 2005 leads to:

- More demand for air-conditioning (May-September)
- More power generation to meet demand (May-September)
- More water withdrawal for power plant cooling operations (May-September)
- Precipitation decreases
  - Increased outdoor water use for lawn and garden watering (April-August)
- Increased water withdrawal
  - Increased water withdrawal of crops by farmers with irrigation equipment
  - Increased water withdrawal due to human adaptation
  - Increased water withdrawal due to plausible policy interventions
Hot and dry comparison with Medium Scenario

- Withdrawal
  - 2005 Medium
  - 2030 Medium
  - 2030 HotDry

- Consumption
  - 2030 Medium
  - 2030 HotDry
Power generation scenario design

Power generation scenario, based on Medium Scenario

- Retrofitted Plants are:
  - Dickerson
  - Potomac-Mirant
  - R. Paul Smith

- Retrofits result in decreased withdrawal of 98.7% and increased consumptive use from 3% to 87%.
Power generation sector scenario design

Retrofits for cooling (conversion to closed-loop)

↓ withdrawal

↑ Consumption
## Power generation scenario comparison with Medium scenario
### Power sector - 2030

<table>
<thead>
<tr>
<th></th>
<th>Medium Scenario (MGD)</th>
<th>Power Generation Scenario (MGD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Withdrawal</td>
<td>3,899</td>
<td>2,823</td>
</tr>
<tr>
<td>Consumption</td>
<td>117</td>
<td>96</td>
</tr>
</tbody>
</table>

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How does changing to closed loop cooling systems impact water withdrawals and consumption?
The y-axis is % of annual withdrawal. The x-axis is month.

5/10/2011
Cumulative withdrawal to stream gages
Medium Scenario

5/10/2011
Cumulative consumption to stream gages
Medium Scenario

5/10/2011
Summary and results

1. Forecasts were primarily business-as-usual; avoid predicting human behavior or public policy

2. Rates of change
   - Power, industry, and mining- slight increase in rate of change, all less than 1.5%
   - Irrigation, livestock, and domestic and public supply-changes based on population and land use projections.
     - Domestic and public supply increased per capita use

3. Over time
   - Agriculture decreased because of land use change
   - Domestic and public supply increased mostly because of per capita use, some due to population increase
   - Industry, mining and power slight increases

4. Most water is withdrawn by the power sector, most consumed by domestic and public supply in all years and scenarios

5. Per capita use makes a difference, and one that public policy can impact
6. Monthly variation-water use is fairly evenly balanced throughout the year.

7. Counties with the largest growth in withdrawal from 2010 to 2030 were near DC and south.

8. Hot and Dry had ~ 17% increase.

9. Power sector is the biggest growth in withdrawals
   1. Population growth increases power demand
   2. Power plant siting makes a big difference in withdrawal and consumption.

10. Climate change has little impact on water use, huge water quality impact due to greater intensity storms, increased erosivity, sediment delivery and associated phosphorus.
## Comparison of results to CO-OP

<table>
<thead>
<tr>
<th>Data</th>
<th>Year</th>
<th>CO-OP (MGD)</th>
<th>Potomac (MGD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WSSC production data and Potomac Basin actual for WSSC</td>
<td>2005</td>
<td>123</td>
<td>126</td>
</tr>
<tr>
<td>Observed for WSSC Potomac + Little Falls + Great Falls + Fairfax Water-Potomac</td>
<td>2005</td>
<td>383</td>
<td>383</td>
</tr>
<tr>
<td>CO-OP Scenario 1 including Rockville -2010. Potomac Basin for the same sources, Low Scenario</td>
<td>2010 (Projected)</td>
<td>502.7</td>
<td>407.1</td>
</tr>
<tr>
<td>CO-OP Scenario 1 including Rockville -2030. Potomac Basin for the same sources, Low Scenario</td>
<td>2030 (Projected)</td>
<td>593.3</td>
<td>516.6</td>
</tr>
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Comparison of withdrawal sites in CO-OP demand study and the Potomac Study
Comparison of Medium Scenario results to MDE Wolman report (2008)

Wolman, et al. report was for the entire state of Maryland, as opposed to just the Potomac portion. Therefore, the specific water demands are not directly comparable.

Agriculture
- Wolman, et al. showed an increase that was more than double the current withdrawal.
- ICPRB projections for the Potomac show a decrease in agriculture, primarily due to land use change.
- It is likely that the increase projected in the Wollman report is likely to occur on the Eastern Shore, which is outside the Potomac River Basin.

Domestic and public supply
- Wolman, et al. showed a modest increase.
- ICPRB Medium Scenario shows a substantial increase.
- Difference may be due to multiple factors, one of which is our data considers Washington, DC demand as part of Maryland, since DC’s water is withdrawn in Maryland. Other differences might be due to population projections or the projected amount of per capita water use.

Power sector
- Wolman, et al. showed a 14% increase in withdrawal.
- ICPRB shows a 24% increase in the Medium Scenario and a 19% increase in the PO scenario without the new plant.

Overall, the reports were difficult to compare given the different geographical scale and sectors analyzed. The Wolman report provided a helpful framework for considering the issues affecting future demands.
Next steps: Calculate flow alteration

• Determine the future scenarios’ impact on stream flows
  • For subwatersheds that drain to biological monitoring stations (more than 700)

• Final report for Middle Potomac Watershed Assessment will be available in 2012
  • Includes an update to the ICPRB 2000 Water Supply Demands and Resource Analysis Report

• Consumptive use upstream of the Washington Metropolitan Area will be used to update the PRRISM model
Webinar Series

- Technical details on methodology for small streams
- Obtain feedback from stakeholders
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Nov 29-Dec1  Flow Ecological Response Workshop at NCTC
Questions?

- Raise your hand clicking on the button on the webinar menu.
- Please remain muted until the conference organizer calls on you.
- Once called upon, unmute your phone by selecting *7.
- Afterward, you may mute your phone by selecting *6 again.