Science of Source Water Workshop
Summary

June 18, 2013
Delaware Valley Regional Planning Commission
Philadelphia, PA

Background
Everyone who depends on and lives within the Delaware River Basin needs a better understanding of the risks they may face due to ongoing forest loss and related changes (e.g. flooding, reliability related to drought, and key water quality parameters such as temperature and turbidity). Although there are many studies and models looking at these issues in the Delaware, there remain important information gaps and needs for integration. Information on future impacts of land use change and climate change in the Delaware Basin, economic aspects of these impacts, and the value of ecosystem services provided by the headwaters forests is especially lacking. With efforts underway to invest in “green infrastructure” as an alternative to conventional stormwater and drinking water infrastructure, it is even more important to determine the costs and benefits associated with the range of options for dealing with future water-related issues across the Basin.

Through discussions with policymakers and water users throughout the Basin, the Pinchot Institute and Common Waters partnership learned of the shared interest to bring together everyone working on these questions and discuss a research agenda that would meet our collective needs. For some time Common Waters had discussed the value of convening scientists and technical experts from agencies, universities, companies, and NGOs with expertise on watershed hydrology, modeling, water quality, land use change, etc.

The primary goal of the workshop was to identify the top information needs of water users and other stakeholders that are critical to managing future water-related risks in the Basin but are not being met by existing studies or models. The charge of the consortium going forward will be to:
1. Review existing data and studies underway on changes in land use and climate, and how this will impact water quality, floods, and droughts;
2. Develop an agenda for short-term research to answer water users’ concerns and needs (e.g. modeling, cost-benefit analyses, etc.); and,
3. Pinpoint additional long-term research needs for companies and other stakeholders and identify appropriate parties to carry out this research in collaboration with others.

This workshop was an effort to share and assess current information and identify additional information needs that will help direct efforts to protect green infrastructure and manage water-related risks. It included presentations from experts with knowledge on a
wide range of topics important to understanding the hydrology, chemistry, economics, demographics, and ecology of the Delaware River Basin. The intent was that these presentations would improve our shared understanding of what is already known about the Delaware River from decades of science and management. As we recall, they did so admirably—with plenty of questions along the way. The series of presentations and discussions that followed addressed different aspects of the scientific and economic challenge of assessing the need for source water protection.

Meeting Agenda

**Overview.** Common Waters & Source Water Protection – Will Price, Pinchot Institute

**Discussion.** Key Questions – Science Scoping

**Hydrology, Water Quality, Land Cover**
- Water supply & water quality in the Delaware Basin – Kenneth Najjar, Ph.D., Delaware River Basin Commission
- Flooding in the Delaware Basin – Thomas Suro, U.S. Geological Survey
- Land cover change trends in the Delaware Basin – Gerald Kauffman, Ph.D., Univ. of Delaware

**Uses and Value of Water**
- Factors influencing water use for energy – Kimberly Long, Exelon Generation
- Floodplain conservation & development cost-benefit analysis – Margaret Walls, Ph.D., Resources for the Future
- Overview of economic studies & tools – Stephanie Dalke, Pinchot Institute

**Uncertainties**
- Climate change and the Delaware Basin – Raymond Najjar, Ph.D., Penn State Univ.
- Change in land cover in the Upper Basin – Claire Jantz, Ph.D., Shippensburg Univ.

**Science Scoping Discussion**
For source water protection, water quality & quantity:
1. What do we know?
2. What are we now learning?
3. What do we still need to know?

Summary of Presentations

*Advancing the Science of Source Water*
Will Price, Pinchot Institute for Conservation

Will kicked off the meeting with a presentation on who the Common Waters partnership is and on the impetus behind asking everyone to convene in Philadelphia. The partnership for some time has been advocating for source water protection in the region above the Delaware Water Gap and below the New York City reservoirs—an area that is mostly privately owned and is losing forests. The work of Common Waters to date has included priority areas mapping, a Marcellus best management practices guide, a land use planning education course, and a program of land protection that now has 50,000 acres enrolled. In the meantime Common Waters has reached out to water users of all kinds in the Basin, focused on understanding how source water protection may help reduce the risks posed by changes in the hydrology and water quality in the Basin. A central tenet of these meetings...
has been the need to better understand the magnitude and implication of the changes that could occur due to loss of forests. In other words, what will result from the failure to protect forestland? Who will be affected and how?

**Water Quality and Water Supply in the Delaware Basin**
Kenneth F. Najjar, Ph.D., Delaware River Basin Commission

Ken’s presentation provided a detailed overview of water use and water quality in the Basin, and the issues on which the DRBC is focused to maintain the currently high levels of water quality in the River. He presented information on water consumption and use, how it has changed, and how it is projected to change. The presentation also covered how the DRBC approaches monitoring and management of Special Protection Waters (SPW), and the importance of SPW areas to long-term water quality. His final points on the “drivers” of changes in the Basin were followed by a discussion on the need to learn more about the link between changes in land use and land cover (LULC) and water quality, and what models are available to help make this connection.

**Flooding in the Delaware Basin: Brief Description of USGS Monitoring and Documentation**
Thomas Suro, U.S. Geological Survey

Tom’s presentation described how the USGS monitors flows in the Delaware River Basin, what they have been able to learn over the decades on how the River responds to different flood events, and how that has impacted communities around the Basin. With the earliest gage (the spelling invented by USGS) placed in the Delaware River Basin in 1903 (Port Jervis), there is a long-term record of flows and flooding going back more than a century. He reminded us that there are many uses for this information, including to: relate floods to forecasts, build safer structures crossing or near the River, calculate pollutant loadings, understand trends, and help boaters and fisherman plan their week. The data he shared on 14 different floods from 1902 to 2011 showed the variability in timing and magnitude of flows depending on where it occurred (upbasin, downstream, above a reservoir, etc), why it occurred (rainfall vs. snowmelt) and pre-existing conditions. A good ensuing discussion focused on whether there is a “new normal,” the difficulty of disentangling the effects of land use change with variables shaping each event, and what any changes in flooding patterns may mean to communities located within floodplains.

**Demographics of the Delaware Basin**
Gerald Kauffman, Ph.D., University of Delaware, Water Resources Agency.

Jerry provided a bird’s-eye flyover of the entire Delaware River Basin, describing its population and land cover and how they have changed, as well as the value of the River to residents. The many facts and figures he shared about the Delaware River Basin included: it would be the 11th most populous state; it provides 5% of the nation’s drinking water; and, its forests are worth $8.6 billion a year. The demographic and land use change information he presented shows growth in most of the nine major subwatersheds and all but six of the 42 counties in the Basin. Associated with this growth is forest loss. Discussion focused on how to understand the relationship between historic forest loss and water quality (which would require better data and hours spent with aerial photos), and a way to focus on recent changes using selected watersheds.
Urban Growth Trends in the Upper Delaware Basin, 1984 - 2030
Claire A. Jantz, PhD, Shippensburg University

Claire shared the results of a detailed study to predict the long-term change in land use in the upper Delaware River Basin. Her analysis used the SLEUTH model to project several scenarios of urbanization in the region that includes eight counties encompassing the headwaters region in New York, Pennsylvania, and New Jersey. The analysis included scenarios for different rates of urbanization (e.g. as Business as Usual (BAU), 25%, and 50% above existing trends), and different policy responses (smart growth and other land use planning approaches). The models project through 2030, using what has happened in the past to calibrate how development occurs in the region and then depict where urbanization is mostly likely to occur. The maps she presented show areas that are more likely to “attract” development in the coming decades—and how this would translate to urbanization, impervious surface, and forest loss. Discussion focused on how the projections relate to what has been observed, and also how they are useful to understand relative likelihood of development and inform future studies and conservation strategies.

Water Issues Facing Electric Generation in the Basin
Kimberly Long, Exelon Generation

Kim’s presentation focused on how Exelon Generation uses water in the Basin, the ways in which this usage will change, and aspects of water management that are important to electrical generation. Right now Exelon is one of the major water users in the Basin (694 mgd), but not one of the largest consumers, as less than 5% of the water withdrawn is actually consumed. She shared that over the coming years Exelon’s use will decline with retirement of facilities—principally due to cost considerations related to the balance between peak and baseload generation. Her presentation also addressed the importance of water use intensity of different types of facilities across their “fleet” (coal vs. gas vs. nuclear) and their efforts to reduce consumptive use, thermal discharges, and effluent loading. The close of the presentation and the ensuing discussion focused on the management challenges and uncertainties associated with climate change, especially salinity and low flows.

Science of Source Water: Economic Studies and Tools
Stephanie P. Dalke, Pinchot Institute for Conservation

Stephanie highlighted questions about the economic impacts of forest loss and climate change on water users and other stakeholders throughout the Basin, and gave an overview of some studies and tools that could be applied in the Basin to help give us better information on these impacts. There is growing interest locally and globally in “green infrastructure” – ecosystems that provide services to humans, such as wetlands and forests – but we still lack detailed information on the costs and benefits of investing in green infrastructure instead of traditional “grey” approaches such as dams and filtration plants. Because the Delaware River is in relatively good shape, and there are so many different sectors and communities using water from the river, it is more difficult to envision the problems we could face from failing to protect an adequate amount of our green
infrastructure. At the same time, we are still not sure what constitutes an “adequate” amount of forest protection in the headwaters of the Basin. Some recent studies and new tools and frameworks may be useful to fine-tune our understanding of the economic value of green infrastructure in the Basin, as well as the potential risks we will face in the future, to different sectors and communities. Discussion focused on how these studies and tools could be adapted to provide us with better economic information on top of other studies to look at land use change and climate change impacts.

*Using Economics in the Study of Conservation Lands and Ecosystem Services*
Margaret Walls, Ph.D., Resources for the Future

Margaret gave an overview of the benefits humans receive from nature, such as flood protection and provision of clean drinking water, and of the important questions that accompany efforts to protect the natural systems that provide us with these benefits. Economic analysis can help answer these questions, such as what are the costs and benefits of an approach and its alternatives, and can help evaluate and design the best approaches to achieve goals for issues such as flood mitigation or source water protection. Economic analyses can be particularly beneficial for discovering the most cost-effective solution to an issue, and when coupled with GIS, for doing spatial targeting of on-the-ground projects. Resources for the Future (RFF) has conducted several studies to quantify the costs and benefits of land conservation and evaluate optimal scenarios, such as in the Lower Fox River Basin in Wisconsin, St. Louis County, Missouri, and the Florida Ranchlands Environmental Services Project. The following discussion included the difficulty of quantifying the *avoided costs* of forest loss and communicating that information to stakeholders in a way they can take action on.

*Climate Change and the Delaware River Basin*
Raymond Najjar, Ph.D., The Pennsylvania State University

Ray presented the latest models showing how climate change may impact the Delaware River Basin, based on analyses by him and colleagues at Penn State. He started by sharing findings from a comprehensive analysis of changes in climate within the Delaware River Basin through 2010, including: days below 32 degrees F (fewer); days with heavy rainfall (more); and, five-day maximum precipitation (more). Looking forward using the array of different GHG emissions scenarios (present day emissions are surpassing the higher scenarios) predicts that temperature and precipitation will increase. By mid-century the summer heat index for the Delaware River Basin region might resemble that of the Neuse River Basin in North Carolina, and by late century the Chattahoochee River basin in Georgia. Winter precipitation increases by around 5% early century, 7% mid-century, and as high as 15% late century. Though more variable in the models, summer precipitation and streamflow appear to decrease and will have important effects on salinity lower in the Basin, especially when combined with the effect of sea level rise. Discussions focused on the how model findings capture and interact with other kinds of changes in the Basin, such as increases in population and land use, and how to relate findings to water quality. Salinity, for example, is not likely to be influenced as much by development as by the trends in flow volume and sea level rise, just due to scale. We also discussed the how the models are more reliable for forecasting overall trends and the probabilities of some events, but are less appropriate or accurate for trends in large events such as hurricanes.
Key research questions
Each of the presentations lead to discussions of, among other things, how available information can be used for understanding potential changes in water quality and flows in the Delaware Basin, as well as what still needs to be learned. Overall, this is a data-rich basin that is benefitting from ongoing and increased focus on understanding how the river will change in the decades to come. However, discussions also highlighted the need for greater focus and coordination on certain key questions that need more study. Discussions during the workshop surfaced the following questions, not all of which can be addressed, but which hopefully can contribute to future discussions, help develop priorities, and lead to partnerships for future work:

Land use and Water Resources

- How will land use change affect:
  - Peak flows, low flows, the salt line?
  - Water quality?
    - From impervious surfaces/increased runoff
    - From new land uses (e.g. lawns, agriculture, construction)
    - From new WWTPs, additional road salt usage
  - Would it be possible to do a retroactive study using historical land use data combined with flow data?
  - What is “the threshold” for impervious surface area in the Delaware Basin?
- What is best source of land use data?
  - NOAA CSC (nearly updated for region);
  - NLCD (easily available and often used); or,
  - DRBC’s one-meter resolution datasets (soon to be ready).
- What characteristics of forests are most critical for water quality & flow regulation?
  - How important are they for maintaining baseflow, and in general what is the role of forests in drought?
  - Are other habitat types important for water quality and flows? (e.g. grassland, shrub/scrub, worthwhile to replace lawns with more natural vegetation?)
  - How can soils be incorporated into models? (e.g. USGS-USDA NRCS collaboration)
- How will demographic changes and changing patterns of land use impact the predicted growth patterns in the upper Basin?

Climate Change

- How will climate change affect:
  - Peak flows, low flows, salt line? *We will need climate scenarios for increased precipitation and runoff to combine with USGS data to predict changes to peak flows, total volume, etc.*
  - Water quality? *Climate models consider timing and amount of precipitation, allowing for modeling hydrology, but not yet for associated water quality changes.*
  - Merrill Creek reservoir? *Climate change impacts have not been incorporated into the management plan for the reservoir.*
- How will land use change interacting with climate change affect:
  - Peak flows, low flows, salt line?
○ Water quality?

● How will climate change impact forests and their ability to provide ecosystem services?

● How do we plan for extremes?
  ○ Ultimately what type of extremes matter most?
  ○ What is the role of headwaters forests in mitigating extremes, esp. downstream?

Geographic Scale

● At what scale(s) do we need to consider (and what scales can we consider):
  ○ The relationships between land cover, water resources, and climate change?
  ○ Setting goals for restoration and protection? (e.g. connectivity of restoration work)
  ○ Measuring the results? (e.g. location and detectability)
  ○ Cumulative impacts? (e.g. suite of changes happening in upper portion of Basin)

Economics

● What is the best method to value and communicate the impacts of land use change and climate change on water quality & quantity? Ideas include:
  ○ Attach economic data to existing models;
  ○ Disseminate and update the Trust for Public Land (TPL) study on land use impacts on treatment costs;
  ○ Evaluate floodplain protection / restoration costs & benefits. Will the insurance industry support a study and eventually conservation work?: and,
  ○ Need to better communicate flood risks to public.

● What are the optimal conservation scenarios (i.e., cost effectiveness)?
  ○ Compare NYC watershed vs. United Water’s approach in Hackensack, NJ (land in source watershed sold & developed)

Next steps

Common Waters and the Pinchot Institute sincerely appreciate the interest, participation, and support that made the workshop happen and hope that our dialogue can continue. We look forward to:

● Prioritizing and further defining research questions;
● Identifying studies underway (or planned) that may answer these questions and work to incorporate these questions into projects where possible (We are developing a clearinghouse at www.commonwatersfund.org/science); and,
● Identifying partnerships and sources of support to launch new studies targeted to these questions.

This workshop and discussions that may follow are just one part of the increased attention to the Delaware River and all the services it provides within and beyond the Basin. Going forward, we hope to collaborate with you all to launch work that can answer the questions we share and that complements other like-minded initiatives and activities in the Delaware River Basin.
# Participants

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy Miller</td>
<td>Delaware Valley Regional Planning Commission</td>
</tr>
<tr>
<td>Andrew Homsey</td>
<td>University of Delaware</td>
</tr>
<tr>
<td>Chuck Kanetsky</td>
<td>U.S. Environmental Protection Agency</td>
</tr>
<tr>
<td>Claire Jantz</td>
<td>Shippensburg University</td>
</tr>
<tr>
<td>David Refkin</td>
<td>GreenPath Sustainability Consultants</td>
</tr>
<tr>
<td>Diane Rosencrance</td>
<td>Natural Lands Trust</td>
</tr>
<tr>
<td>Donna Murphy</td>
<td>USDA Forest Service, State &amp; Private Forestry</td>
</tr>
<tr>
<td>Elizabeth Couillard</td>
<td>Philadelphia Water Department</td>
</tr>
<tr>
<td>Gerald Kauffman</td>
<td>University of Delaware</td>
</tr>
<tr>
<td>Greg Westfall</td>
<td>USDA Natural Resources Conservation Service, NJ</td>
</tr>
<tr>
<td>Jennifer Adkins</td>
<td>Partnership for the Delaware Estuary</td>
</tr>
<tr>
<td>Jessica Sanchez</td>
<td>Delaware River Basin Commission</td>
</tr>
<tr>
<td>Kelly Anderson</td>
<td>Philadelphia Water Department</td>
</tr>
<tr>
<td>Kenneth Najjar</td>
<td>Delaware River Basin Commission</td>
</tr>
<tr>
<td>Kimberly Long</td>
<td>Exelon Generation</td>
</tr>
<tr>
<td>Luc Claessens</td>
<td>University of Delaware</td>
</tr>
<tr>
<td>Margaret Walls</td>
<td>Resources for the Future</td>
</tr>
<tr>
<td>Michelle Kondo</td>
<td>USDA Forest Service &amp; Univ. of Pennsylvania</td>
</tr>
<tr>
<td>Mingkai Jiang</td>
<td>Lehigh University</td>
</tr>
<tr>
<td>Nathan Boon</td>
<td>William Penn Foundation</td>
</tr>
<tr>
<td>Raymond Najjar</td>
<td>Pennsylvania State University</td>
</tr>
<tr>
<td>Roland Wall</td>
<td>Philadelphia Academy of Natural Sciences</td>
</tr>
<tr>
<td>Russ Furnari</td>
<td>PSEG</td>
</tr>
<tr>
<td>Stefanie Kroll</td>
<td>Philadelphia Academy of Natural Sciences</td>
</tr>
<tr>
<td>Stephanie P. Dalke</td>
<td>Pinchot Institute for Conservation</td>
</tr>
<tr>
<td>Thomas Suro</td>
<td>U.S. Geological Survey</td>
</tr>
<tr>
<td>Vicky Binetti</td>
<td>U.S. Environmental Protection Agency</td>
</tr>
<tr>
<td>Will Price</td>
<td>Pinchot Institute for Conservation</td>
</tr>
</tbody>
</table>