INVESTING IN STRATEGIES TO ACCELERATE CONSERVATION AND MEASURE IMPACT IN THE DELAWARE RIVER WATERSHED

A Report of the Open Space Institute, the Academy of Natural Sciences of Drexel University and the William Penn Foundation

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1 EXECUTIVE SUMMARY

The Delaware River watershed provides drinking water to over 15 million people, critical habitat for plants and animals, including many threatened and endangered species, and recreational and economic enterprise valued at $10 billion per year in direct wages. Water quality and associated economic, environmental and social values have improved dramatically since the 1950s when the lower portion of the river was declared a dead zone during parts of the summer due to excessive inputs of domestic and industrial waste. The question today is how to ensure that progress continues in the face of persistent and growing threats to water quality.

Recognizing the challenges facing the watershed, over 40 of the leading conservation groups in this 13,000 square mile region are pursuing a 10-year strategic initiative focused on water quality through the Delaware River Watershed Initiative, a conservation program advancing a combination of place-based work in watershed protection, restoration, education, collaboration and innovation through collective impact.

This paper serves as an invitation for broader strategic investment to accelerate watershed protection and restoration; it also is a springboard for stakeholders to set an agenda for ensuring that the Delaware River watershed delivers clean water for humans, plants and animals. The paper identifies eight "clusters" of subwatersheds, constituting approximately 25 percent of the total Delaware Basin, where analysis has shown that investment in water quality could deliver significant returns. Diverse geology, land use, development patterns, population density and environmental stressors are present throughout these subwatershed clusters. Focusing conservation actions in these places contributes directly to local water quality, and by fostering experimentation and innovation, it also cultivates a wide range of effective approaches for scaling up investment across the Delaware River watershed and beyond.

This paper emphasizes five strategies for investing in protection of high quality waters and restoration of impaired waters:

1. protect forested headwaters to maintain high water quality;
2. manage agricultural lands to reduce polluted runoff and increase groundwater infiltration;
3. implement best practices and new financial incentives to reduce urban stormwater pollution through natural processes;
4. increase the evidence base for watershed protection by monitoring trends in water quality and assessing project impacts;
5. improve policy and practice through applied research focused on water quality outcomes.

These strategies demand place-based work, and the Delaware River Watershed Initiative will focus on advancing these efforts through the cooperation of organizations located in the eight distinct watershed clusters. Proceeding downstream from the headwaters, the eight landscapes are:

- Pocono Mountains and Kittatinny Ridge
- New Jersey Highlands
- Upper Lehigh River
- Middle Schuylkill River
- Schuylkill Highlands
- Brandywine and Christina Rivers
- Upstream Suburban Philadelphia
- Kirkwood-Cohansey Aquifer (comprising New Jersey's Bayshore and Pine Barrens)

These clusters bring together many of the most ecologically valuable and significantly impaired areas of the watershed. They are strategically located where strong organizations and critical natural values provide measurable opportunities for advancing local water quality while having regional impact.

The selection of areas and strategies was based on research and planning undertaken by the Open Space Institute (OSI) and the Academy of Natural Sciences of Drexel University (ANSDU) with support from the William Penn Foundation. Researchers at OSI and ANSDU were joined by the National Fish and Wildlife Foundation (NFWF) in engaging over 40 organizations working across the eight subwatershed clusters to develop collaborative plans for implementing and measuring local conservation strategies essential to the long-term health and vibrancy of the region. These implementation plans tackle major threats to water quality and include strategies to track progress and share lessons learned. The plans provide a framework for public agencies and philanthropic funders seeking to pursue targeted watershed protection outcomes supported by monitoring, technical assistance and ongoing communications.

Organizations large and small, public and private, are invited to read this paper and consider this program as an opportunity to align investment for greater impact and help ensure a bright future for the Delaware River watershed.

2 INTRODUCTION

The Delaware is an iconic river of the United States and a historically and ecologically important tourist destination (Dale, 1996). However, the Delaware River and its many tributaries remain underappreciated and insufficiently protected considering their importance as a source of drinking water, habitat for commercially and ecologically significant wildlife and numerous other public benefits. Water quality has received attention by policymakers and scientists, and public awareness about the watershed as part of our cultural identity is increasing, but there is a need for continuing work toward maintaining ecosystem quality, measuring the success of investments and increasing public stewardship of the watershed. As urban development, suburban sprawl, industrialized agriculture, energy infrastructure and other development continue to adversely affect the environment from New York to Delaware, the region's need for a comprehensive approach to protecting and restoring its most precious resource – water – has become increasingly self-evident. Fishermen cannot eat the fish they catch; swimmers cannot swim in rivers and streams; boaters must avoid certain areas; children are told to stay out of the water at beaches; some rivers cannot sustain marine life; drinking water intakes are just downstream of dangerously polluted waters; the list goes on (Kauffman et al., 2008). Clean water is the lifeblood of industry, economic opportunity and health. While it is possible for us to have healthy waterways in the Delaware River watershed, we must find new ways to drive successful stewardship of this region which provides drinking water to over 15 million people and supports $25 billion in annual economic activity from recreation, water quality, water supply and other sources (Kauffman, 2011).

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By the mid-1880s, fouled water, factory waste, coal byproducts and agriculture and urban runoff were draining into the waters of the Delaware Basin at an alarming rate (Towne, 2012). In the first half of the 20th century, the lower Delaware River was infamous for its 20-mile summer dead zone, a stretch of river so polluted at times almost nothing could survive in it (Sharp, 2010). This spurred early efforts to clean up the Delaware, starting with the 1936 formation of the Interstate Commission on the Delaware Basin (INCODEL), a succession of state and federal legislation to reduce point source pollution, eventually leading to the U.S. Environmental Protection Agency's development of the Clean Water Act in 1972 and amendments in 1977 and 1987. We saw clear progress from these command-and-control regulatory initiatives as the establishment of water quality standards and permit systems for pollution discharges led to raised levels of dissolved oxygen and the return of significant populations of American shad and other aquatic life (Delaware River Basin Commission [DRBC], 2008).

But it's not enough.

Since the first Earth Day in 1970, new contaminants have emerged to threaten environmental and public health even as American industries have relocated major sources of pollution to foreign shores (Kauffman, 2010). During this same period of decline in American manufacturing, an ever-increasing population has given rise to new environmental threats from the industrialization of agriculture, suburban sprawl and the development of unconventional fossil fuels (Kennedy, 2010). With intensified agriculture, unsustainable groundwater withdrawals, forest clearing and the proliferation of impervious cover, improvements in important measures of water quality, like dissolved oxygen, have stagnated or even reversed in recent years (DRBC, 2013; Sharp, 2010).

The regulatory structures currently in place are essential to the region's water quality, but their effectiveness can depend on inspection and enforcement by public agencies stretched thin by overwhelming responsibilities and a tough fiscal climate (National Oceanic and Atmospheric Administration [NOAA] & DRBC, 2012). Regulators are challenged to address sources of pollution that are widely distributed across the landscape and cannot be traced back to a single end-of-pipe discharge point or point source. There are over 1,000 permitted and controlled point sources of pollution spread across the Delaware River watershed, but there are hundreds of thousands of distributed, or non-point, pollution sources (DRBC, 2014). Non-point source pollution is the watershed's dominant source of critical environmental contaminants like sediment, nutrients and bacteria. It includes major contributions from forest clearing for housing developments and new energy infrastructure; contaminated stormwater washing off oil-stained roads and open construction sites; and agricultural runoff leaving chemically treated crop fields and manure-laden livestock yards (Environmental Protection Agency [EPA], 2005; Whitall et al., 2007).

Less than one percent of the watershed's non-point sources are permitted and subject to regulation, but all of them threaten water quality and remain exceedingly difficult to monitor and control (DRBC, 2014). The threat transcends traditional social and political boundaries, challenging communities to forge new relationships in the context of watershed dynamics. In the Delaware River watershed, upstream communities in the forested headwaters rely on urban centers downstream to support a local tourism economy worth just over $3 billion annually and to sustain markets for locally produced quarried stone, farm goods and forest products (Pocono Mountains Visitors Bureau, 2013; Wayne County, 2010). In turn, the downstream communities rely upon the forested headwaters of these same upstream communities for a steady supply of clean drinking water also worth just over $3 billion annually (Kauffman, 2011). Even within these communities, families living uphill from their local waterways rely on their downhill neighbors along the banks for river access and recreational opportunities such as fishing, boating and riverside trails; while the downhill residents rely on their upstream neighbors to soak up and slow down stormwater that otherwise runs off impervious roofs and driveways, rushing into nearby waterways and contributing to destructive flooding. This equal exchange of goods and services is singularly dependent on continued conservation of natural watershed assets like intact forests and functioning wetlands.

"Where stakeholders can embrace a common interest in the landscapes, habitats and livelihoods that depend upon clean water, the natural dynamics of the watershed system can span traditional disciplines and bring new partners together."

Where stakeholders can embrace a common interest in the landscapes, habitats and livelihoods that depend upon clean water, the natural dynamics of the watershed system can span traditional disciplines and bring new partners together. Given the scale and ubiquity of non-point source pollution, a strategically targeted approach may be necessary to effect measurable change on a meaningful scale. Focused investment within a representative selection of priority landscapes could be used to test new approaches for the restoration of degraded landscapes and the protection of pristine areas. Coupled with integrated monitoring to track and evaluate progress, this work could build a body of evidence for more effective conservation. Align the work of all stakeholders—watershed groups, land trusts, funders, university hydrologists, ecologists, land-use planners, water utilities, regulatory agencies—and each targeted investment could magnify and accelerate positive impacts, making the most of every available dollar.

This requires all stakeholders to think across boundaries and test a range of strategies. Where traditional restoration work focuses downhill along stream banks eroded by high flows, investment in infiltration practices should follow to slow the flow from the suburban yards uphill; where one partner is committed to protecting

wildlife and another is focused on adapting to climate change, aligned land protection should capitalize on shared priorities where critical habitat overlaps with flood mitigation areas like floodplains and wetlands. Stakeholders must press for new protections and stringent enforcement of existing regulations while exploring ways to harness the market to create effective, low-cost solutions that complement the government's role in ensuring water quality and then inspire citizens to support the efforts. For these interventions and all others, scientific data should be collected, shared and put to work to inform the public, to inform policy and to inform the professional practice of watershed conservation.

The strategies are complex and the stakes are high. The Delaware River basin provides drinking water to 15 million people through service to New York City and Central New Jersey through the Delaware and Raritan Canal, and to residents of the Delaware Basin by way of over 800 community water systems based on both groundwater and surface water (EPA, 2013). The water resources of the basin are also hydraulically connected to the groundwater resources of the Kirkwood-Cohansey aquifer, which provides drinking water to an additional population of approximately 1 million people (New Jersey Department of Environmental Protection [NJDEP], 1988) and underlies the 1.1 million acre Pine Barrens, a globally significant biosphere reserve designated by the United Nations Educational, Scientific and Cultural Organization (UNESCO) (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2014). This combined landscape holds vital drinking water supplies, critical habitat for endangered and threatened plants and animals, and supports economic enterprise and ecosystem services valued at almost half the gross domestic product of the entire state of Delaware.

Collaborative and collective action will be the key to continued progress in achieving water quality goals. Through this document, we propose a new framework for accelerating action on behalf of the Delaware River watershed and invite practitioners, foundations and public officials to participate and help secure measurable positive impacts on water quality and availability for all watershed communities.

IN THIS PAPER

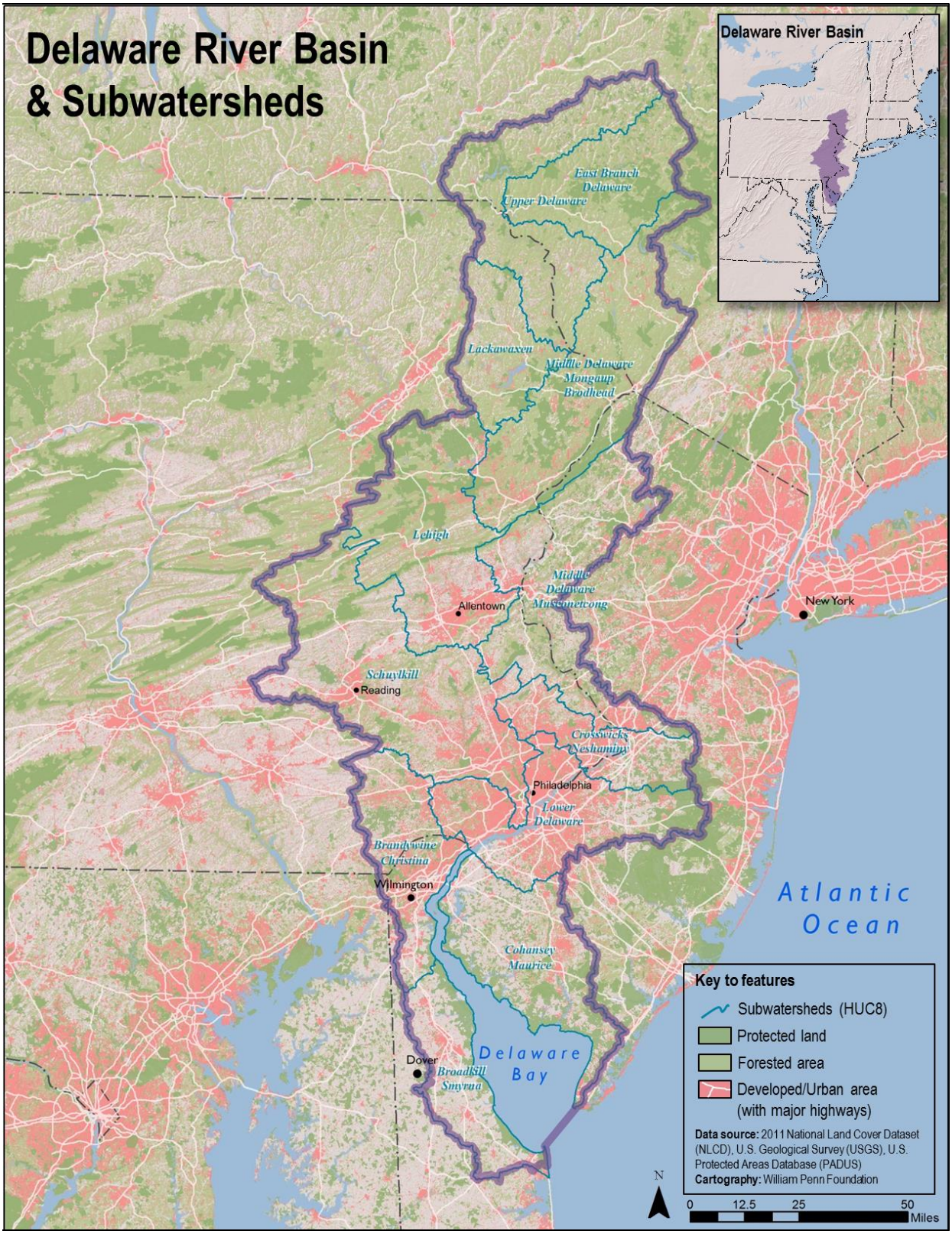
SECTION 3: Reviews several major stressors affecting the watershed and considers the policy context for making water quality improvements

SECTION 4: Describes the selection of places where progress is being targeted and looks at the protection and restoration strategies and monitoring needed to achieve success

SECTION 5: Examines cross-cutting opportunities for investment that were suggested during the research

SECTION 6: Invites partners to help define the future of the Delaware River watershed

2.1.1 MAP: Delaware River Basin & Subwatersheds



3 BACKGROUND

Upstream-downstream connections demand an integrated approach to protecting the Delaware River watershed. Integrated water resource management was the impetus for the 1936 creation of what was then called the Interstate Commission on the Delaware River (INCODEL), with the premise that watershed management required a regional approach (Albert, 1988; Bateman & Rancier, 2012). Evolved from INCODEL, today's Delaware River Basin Commission conducts comprehensive planning that encompasses water quality, supply and conservation (Mandarano, Featherstone, & Paulsen, 2008). The Commission also helps coordinate and fund regional and local partnerships throughout the watershed. With a long history of promoting cooperation to reach a common goal, the Commission serves as a model for non-governmental organizations as well as federal, state and local governments. These efforts at multi-jurisdiction, basin-scale management are founded on due consideration for the watershed's richly varied geography and wealth of natural resources.

Over 450 miles of the watershed's total 23,000 stream miles have special-use designations as a National Wild, Scenic or Recreational River Area. The main stem of the Delaware River is the longest undammed major watercourse—at 330 miles—east of the Mississippi. The headwater regions, in New York and Pennsylvania, offer rolling farmland, extensive forests, freshwater wetlands and exceptional value streams that support wild trout and draw anglers and paddlers from all around. The geology and geography of the basin give rise to ecosystems and habitats that support diverse wildlife, including freshwater mussels, rare bog turtles and the Louisiana Waterthrush, a specialist wood warbler that depends on intact forest streams (Map 3.1.4). Downstream, the saltwater tidal region—one of the largest in the world—has high primary productivity and biodiversity and provides nursery habitat for fish, horseshoe crabs, migratory birds and oysters (DRBC, 2008).

Rivers of the United States have been classified according to their use for drinking water, ecological and recreational importance, as well as whether or not they meet water quality standards. These classifications have been established by federal and state legislation:

> **National Wild and Scenic Rivers Act:** "Scenic River Area" designates rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads. "Recreational River Area" designates rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines and that may have undergone some impoundment or diversion in the past.
>
> **U.S. Magnuson-Stevens Act:** "Essential Fish Habitat" areas include all types of aquatic habitat—wetlands, coral reefs, seagrasses, rivers—where fish spawn, breed, feed or grow to maturity and are subject to protections from adverse impacts under international law.
>
> **Federal Clean Water Act, Sections 305(b) and 303(d):** "Attaining" with "Good" status is given to streams attaining designated use (e.g. public water supply, protection of fish, shellfish and wildlife, and for recreational, agricultural, industrial and navigational purposes). "Attaining" with "Threatened" status goes to streams at risk of not attaining designated use. "Impaired" status is reserved for streams that do not support designated water uses and can trigger additional requirements for restoration.
>
> **Delaware River Basin Commission** (DRBC, 2010)**:** Special Protection Waters (SPW) protect existing high water quality in areas of the Delaware River basin deemed to have exceptionally high scenic, recreational, ecological and/or water supply values.

Regulatory requirements promoting watershed protection are also triggered by the various designated uses for each of the four basin states:

Pennsylvania Clean Streams Law (Pennsylvania Department of Environmental Protection [PADEP], 2013):

- Aquatic Life (e.g. CWF: Cold Water Fisheries)
- Water Supply (e.g. PWS: Potable Water Supply)
- Recreational and Fish Consumption (e.g. F: Fishing)
- Special Protection (HQ: High Quality Waters, EV: Exceptional Value Waters)

New York Environmental Conservation Law (New York State Department of Environmental Conservation [NYSDEC], 2013):

- Class AA or A: Waters used as a source of drinking water
- Class B: Best usage for swimming and other contact recreation, but not for drinking water
- Class C: Waters supporting fisheries and suitable for non - contact activities
- Class D: Lowest classification
- Classes A-C may also be classified as (T): Supporting a trout population or (TS): May support trout spawning

New Jersey Surface Water Quality Standards (NJDEP, 2011):

- FW1: Not subject to any man-made wastewater discharges
- FW2: All other freshwaters
- Trout status: Trout production (FW2-TP), Trout maintenance (FW2-TM) and Non-trout (FW2-NT).
- Anti-degradation designations: Outstanding National Resource Waters (ONRW), Pinelands waters (PL), Category One (C1) and Category Two (C2)

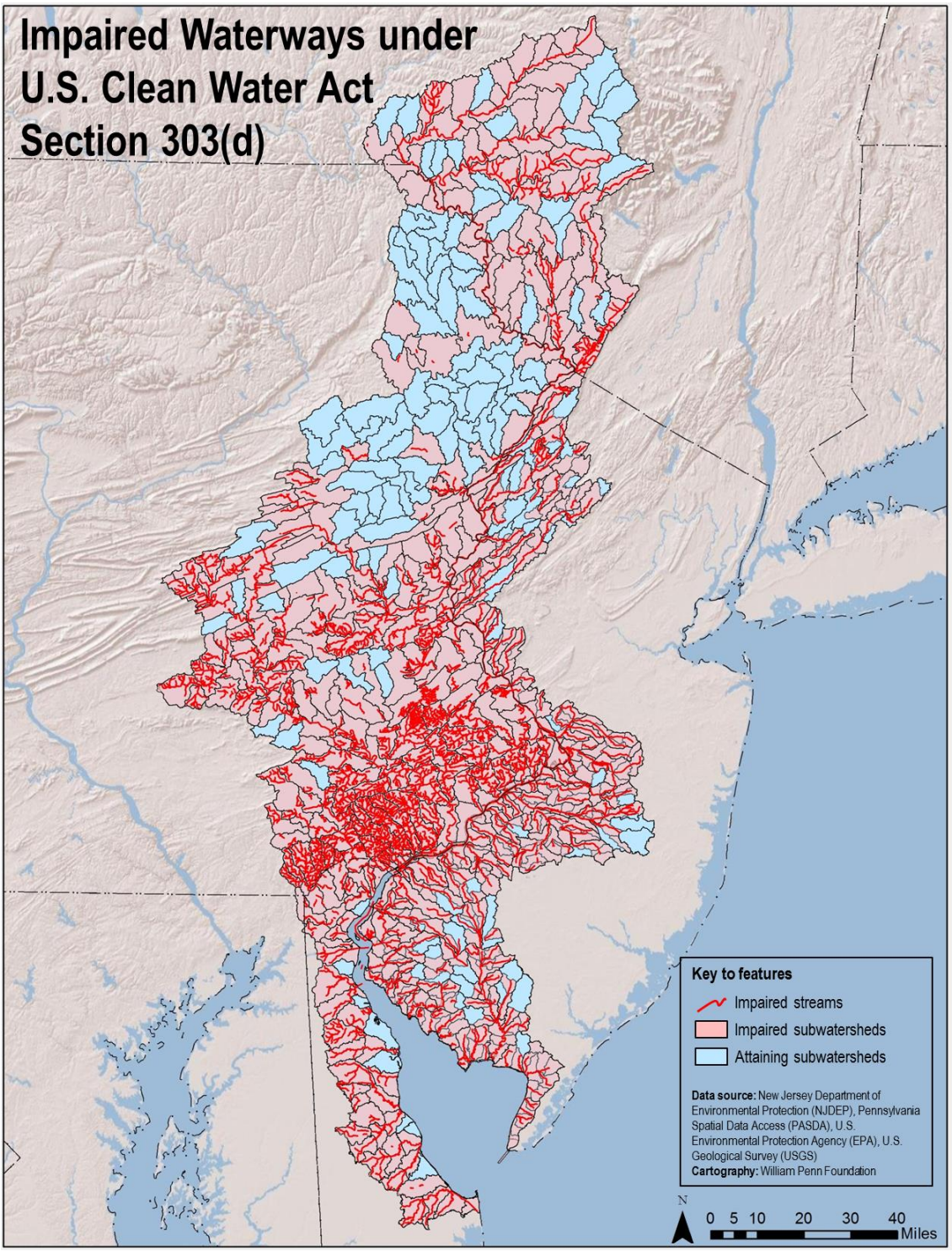
Delaware Surface Water Quality Standards (Delaware Department of Natural Resources and Environmental Control, 2004):

- Public Water Supply (acceptable for drinking water following treatment)
- Industrial Water Supply
- Secondary Contact Recreation (Wading, restricted bacteria levels)
- Primary Contact Recreation (Swimming, restricted bacteria levels)
- Fish Aquatic Life and Wildlife (prohibitions on acute or chronic toxicity)
- Cold Water Fish (restrictions on human-induced temperature increase and minimum dissolved oxygen)
- Agricultural Water Supply
- Harvestable Shellfish Waters (restricted levels of total coliforms)
- Exceptional Recreational of Ecological Significance (ERES, highest level of protection)

3.1 Threats and Stressors

A close examination reveals that the Delaware River basin is beset by numerous stressors, putting both economic and ecological values at risk despite improved pollution control measures. As of 2010, the U.S. Environmental Protection Agency (EPA) ATTAINS database listed 2,762 miles (12 percent) of the watershed's streams as impaired for their designated uses, leading to economic losses from boating and navigation, commercial and recreational fishing, swimming and drinking water (Map 3.1.1). These stressors include energy extraction and mining, agriculture, flow regulation by dams and development-related activities, including increased impervious surfaces, loss of forests and overexploitation of surface and groundwater resources due to increasing demands.

3.1.1 MAP: Impaired Waterways Under U.S. Clean Water Act Section 303(d)



Over 8,000 miles of streams across the Delaware River watershed are listed as impaired (depicted as red lines above). Streams are impaired for uses that include agricultural and industrial as well as public water supply, aquatic habitat, fish consumption and recreation. The majority of impairments are associated with non-point sources of pollutions. In Pennsylvania, for example, of all sources of impairment, 45 percent are due to urban, road and residential runoff or storm sewers, 12 percent are associated with agriculture; and less than six percent are associated with municipal or industrial point sources. Unknown sources account for an additional 12 percent of impairments; four percent are from abandoned mine drainage, with the remainder attributed to a variety of development activities.

A number of stream impairments reflect historic point source pollution, others reflect metal contamination and acid mine drainage, while many impairments result from land uses which affect stream flows and inputs of nutrients, bacteria and sediment. These stressors have long histories, but until relatively recently, their effects had been overshadowed by point source pollution like untreated industrial and municipal effluent.

Now, as the effects of diffuse stressors are becoming more apparent, new problems are emerging. Veterinary and human pharmaceuticals are reaching detectable levels, while hundreds of other chemicals remain untracked (USGS, 2004). Contaminated sediments and nutrient inputs in water courses continue to degrade habitat even as farming practices improve (Lyerly, Hernández, Foreman, & Dennison, 2013). Energy resource extraction would withdraw vast quantities of water from the hydrologic system and transfer the water to other watersheds, representing a net loss to the Delaware Basin, or return water of uncertain quality (Kauffman & Homsey, 2012). Infrastructure for gas drilling could fragment some of the watershed's best natural areas (Johnson et al., 2010). Climate change is expected to intensify problems if severe storms flush nutrients, contaminants and sediment into watercourses and degrade habitat, while higher temperatures have been related to lower dissolved oxygen levels (Baron et al., 2013). Rising sea levels, combined with increased water withdrawals for human use, push the salt line upstream and cause flooding inland (Kreeger et al., 2010). These changes will inevitably lead to changing communities and more disturbance-tolerant wildlife, while reducing the amount of available habitat and opening the door for invasive species (Bellard, Bertelsmeier, Leadley, Thuiller, & Courchamp, 2012).

Changes to water's chemical and physical attributes have broad consequences for wildlife habitat and drinking water quality—changes that reverberate throughout local and regional economies. Perhaps more than any other resource, water forces us to recognize our role as part of the natural system, sharing its resources and benefits but also the repercussions of overuse and misuse. Increasing landowner, practitioner and public involvement in the basin's ecological health is therefore essential to the well-being and prosperity of our region, and the Delaware Basin is an excellent laboratory for making investments in different conservation strategies. The Delaware River Watershed Initiative provides the data-driven framework and catalytic resources to accelerate conservation in targeted geographies of the Delaware River watershed by aligning priorities for land protection and restoration projects; extensively assessing water quality impacts at hundreds of sites; and amplifying effectiveness by sharing results within and among clusters, as well as more broadly.

"Perhaps more than any other resource, water forces us to recognize our role as part of the natural system, sharing its resources and benefits but also the repercussions of overuse and misuse."

As a first task for developing a focused investment strategy for addressing water quality, researchers from OSI and ANSDU sought to delineate which stressors would and would not be targeted. Although point sources such as acid mine drainage and the release of pesticides, zinc and other contaminants from manufacturing and wastewater treatment plants are important, these issues have been set aside to allow greater focus on advancing progress on non-point sources. Except where their removal is necessary for the advancement of water quality, the ecological impacts and economic role of dams are not a focus of this work. Species, populations and aquatic habitat are evaluated as valuable indicators of water quality trends, though are not targets for restoration and protection on their own within this effort.

Intertwined with water quality and the concentrations of pollutants is water quantity. When flow is reduced, higher concentrations are often present for chemicals that are toxic to humans and aquatic life. Water quantity is a critical issue and depends on both surface and groundwater resources. Researchers focused on water quantity relative to stormwater and groundwater infiltration in more urbanized areas as well as unsustainable groundwater withdrawals from the Kirkwood-Cohansey aquifer of southern New Jersey. Below is a review of the stressors that targeted investment can address through this watershed initiative.

Population growth: The region's human population is currently over 8 million and growing, and conversion of undeveloped land continues to grow with it. Population growth and redistribution across the landscape at lower densities along patterns of urban and suburban sprawl are driving significant impacts to the watershed. Map 3.1.2 shows how the watershed's population has changed over the past half-century – with an especially high rate of growth in Sussex County, New Jersey, and Pike and Monroe counties, Pennsylvania – places where water quality has been good but is now at risk from stressors associated with development. The scenic landscapes and lifestyle values of these rural counties have always drawn tourists; today they also attract new residents who have moved from the big metropolitan centers to the east.

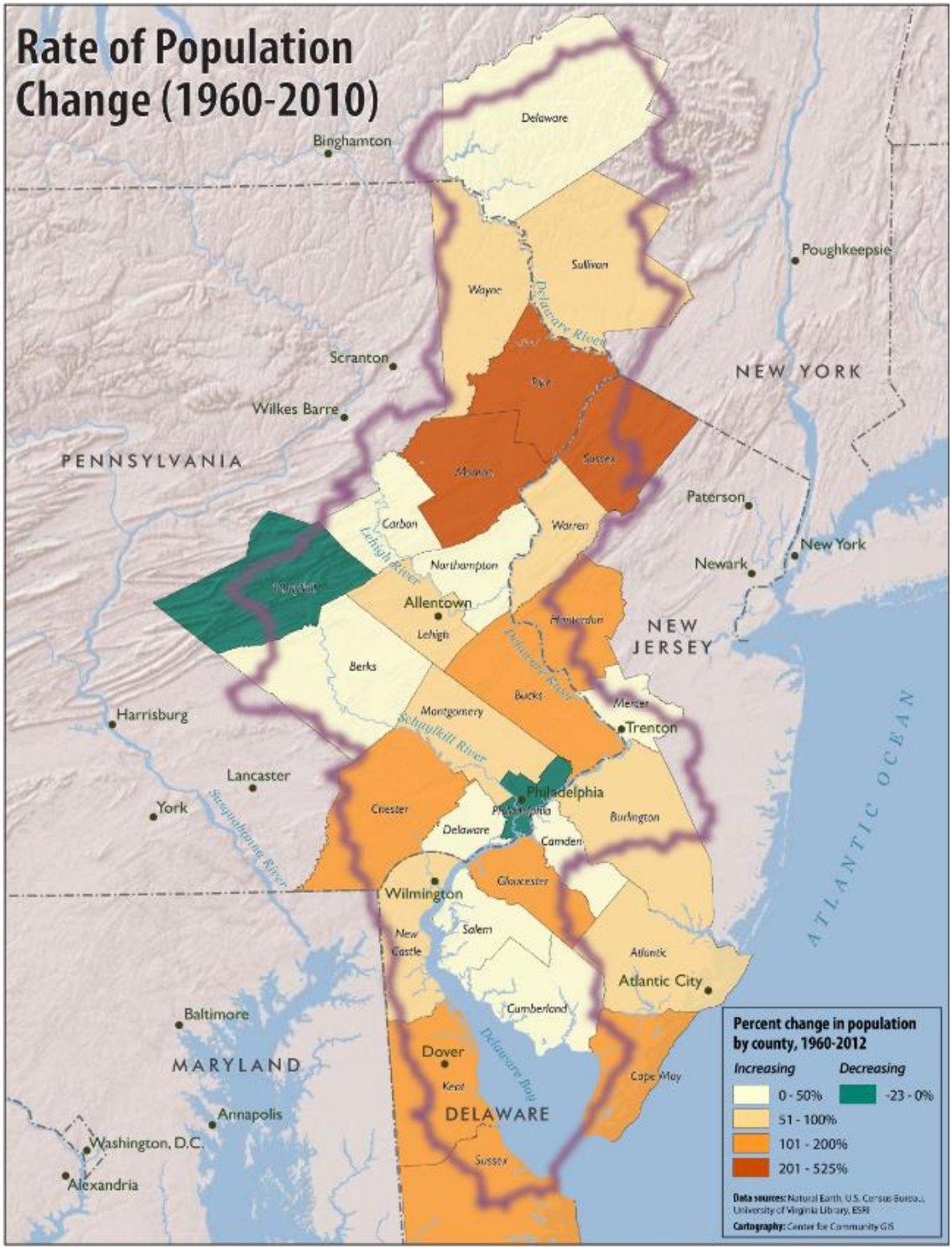
"Population growth and redistribution across the landscape at lower densities along patterns of urban and suburban sprawl are driving significant impacts to the watershed."

Between 1960 and 2010, the U.S. Census Bureau reported that Delaware, New Jersey, New York and Pennsylvania averaged statewide population increases of 20 percent, but most counties in the Delaware Basin experienced an increase of 50 percent or more. A growing population has clear implications for water use and water quality, implications that are associated with development of forested land, increased impervious surfaces and stormwater problems, and all the ramifications of greater demand for the basic necessities of food, water and energy. While population change itself would not be addressed through this initiative directly, with population growth comes an increased responsibility to manage impacts and educate and build constituencies for the conservation of the Delaware River and its many tributaries.

Loss of forest cover: The expansion of developed land to accommodate new residents in recent decades has come at the expense of all other land uses, but especially forested lands and the natural processes of water filtration and purification these lands provide (DRBC, 2008). Map 3.1.3 indicates how suburban development around the region's major cities is shrinking and fragmenting forests. Map 3.1.4 shows the division of the watershed into the highly developed Atlantic Coastal Plain and Piedmont versus the largely intact headwaters across the Ridge and Valley Province and the Appalachian Plateau, which is separated by the Kittatinny Ridge, part of the Atlantic Highlands. Agriculture once dominated the lower basin's valleys and plains, and many abandoned farmlands have been converted to forests. These reclaimed lands must be protected from suburban sprawl.

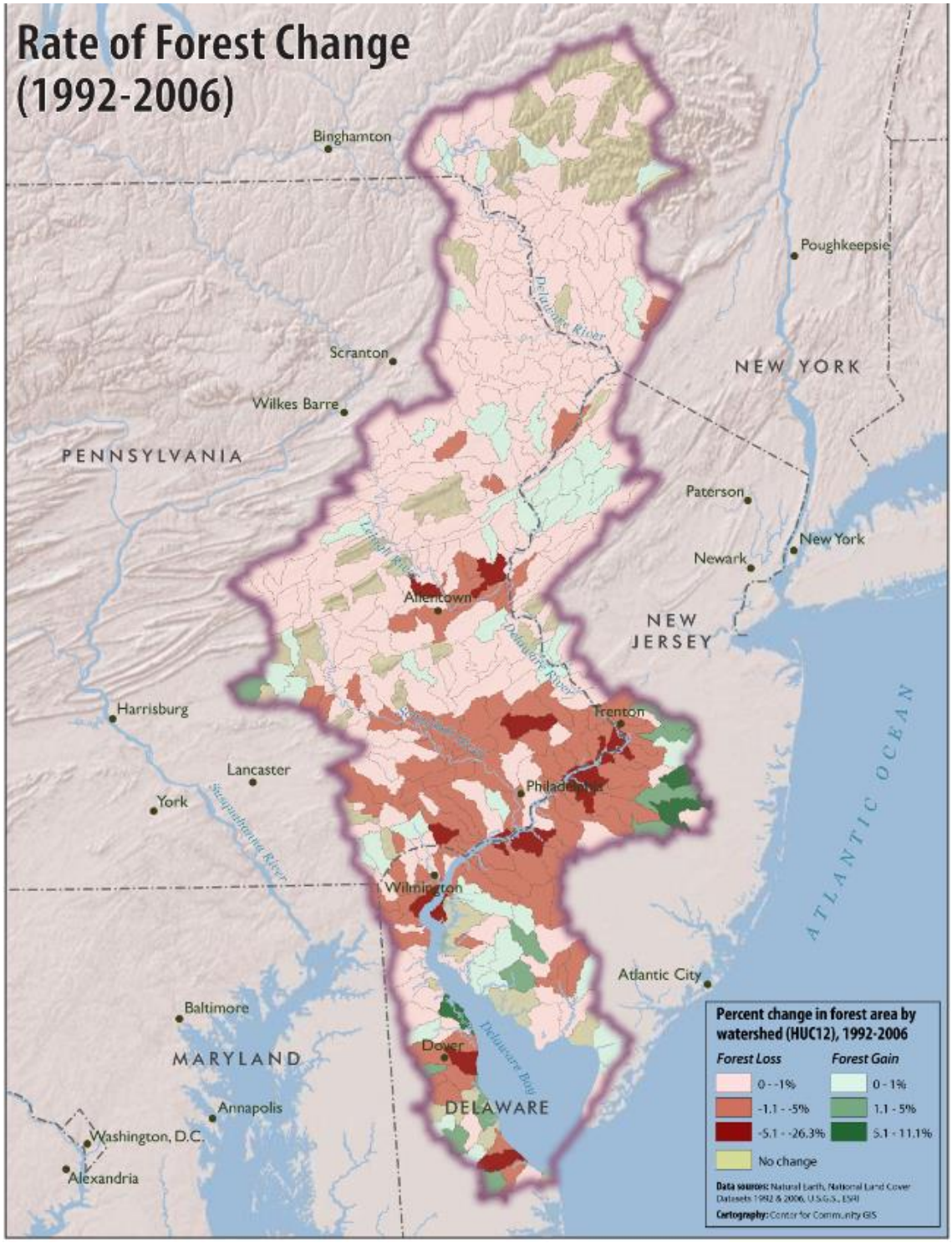
Impervious surface, stormwater, flooding and sewer overflows: Although the ridges and plateau have seen less development and continue to offer spectacular scenery and outdoor experiences, the increase in impervious cover (e.g. concrete, asphalt) that accompanies development elsewhere can intensify flood peaks through reduced soil infiltration (Philadelphia Water Department, 2011). Inadequate sewer systems and increased flooding have led to combined sewer overflows in older cities, which are significant point sources of contaminants during large storm events. Runoff from impervious surfaces is also the source of particulate pollutants, motor oil, chemicals and other contaminants in stormwater and is one of the largest sources of nutrient loading in suburban and urban watersheds (DRBC, 2008; EPA, 2003). Nutrients, sediment, agricultural toxins and emerging contaminants introduced by stormwater and agricultural runoff have become more apparent as end-of-pipe effluent has decreased (Brown & Froemke, 2012). This non-point source pollution is generated in suburban backyards and roadways as well as on the farms that feed this populous region (Map 3.1.5). Stormwater control requires citizen engagement, new strategies involving both regulations and incentives, holistic water resource planning, and working across political and professional boundaries.

3.1.2 MAP: Rate of Population Changes (1960-2010)



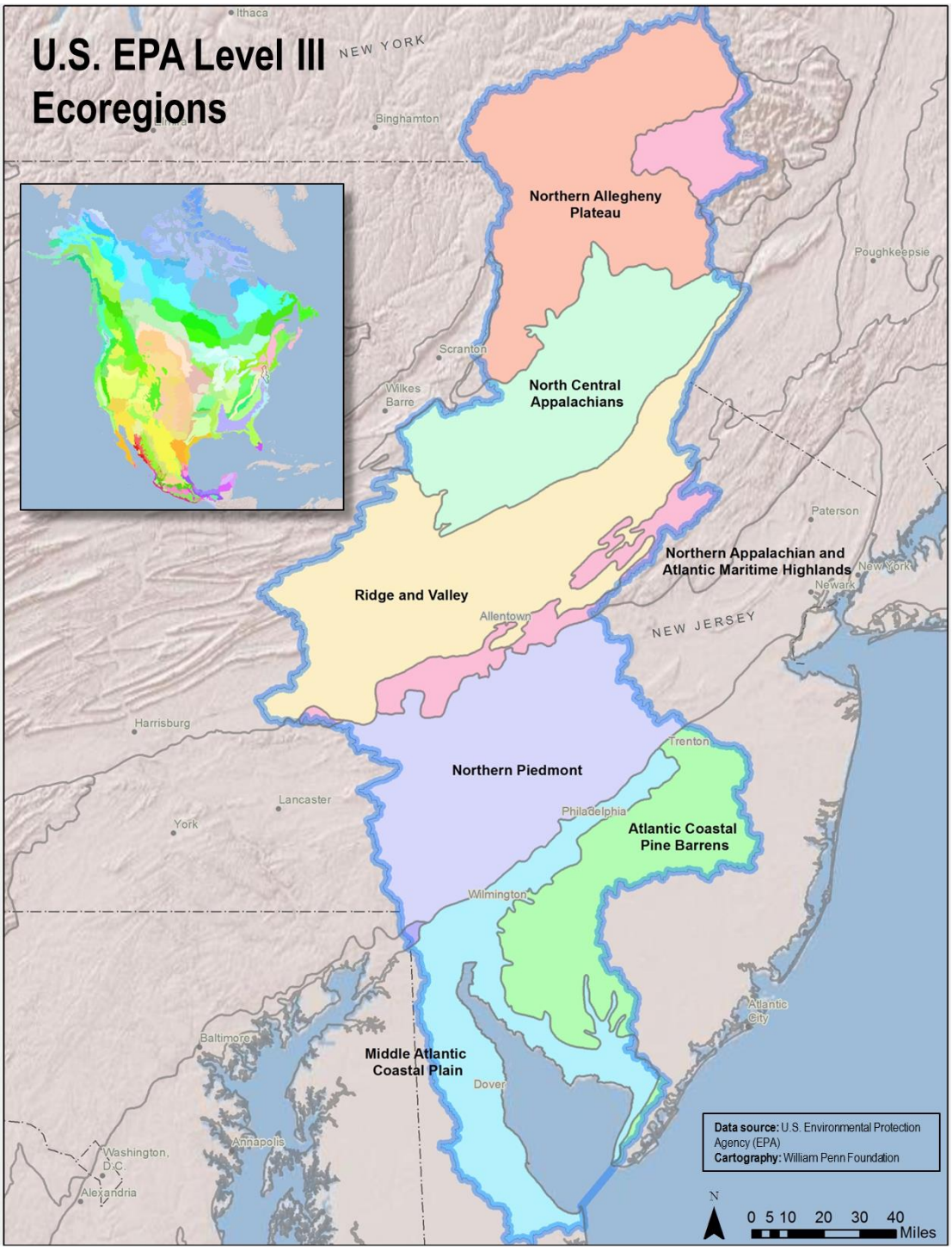
Population growth is directly linked to increasing non-point sources of pollution. In the forested landscapes of the upper basin in Monroe, Pike and Sussex counties, high population growth associated with New York City bedroom communities and tourism destinations has contributed to significant forest loss with over 100,000 acres of forest lost each year between 2006-2011.

3.1.3 MAP: Rate of Forest Change (1992-2006)



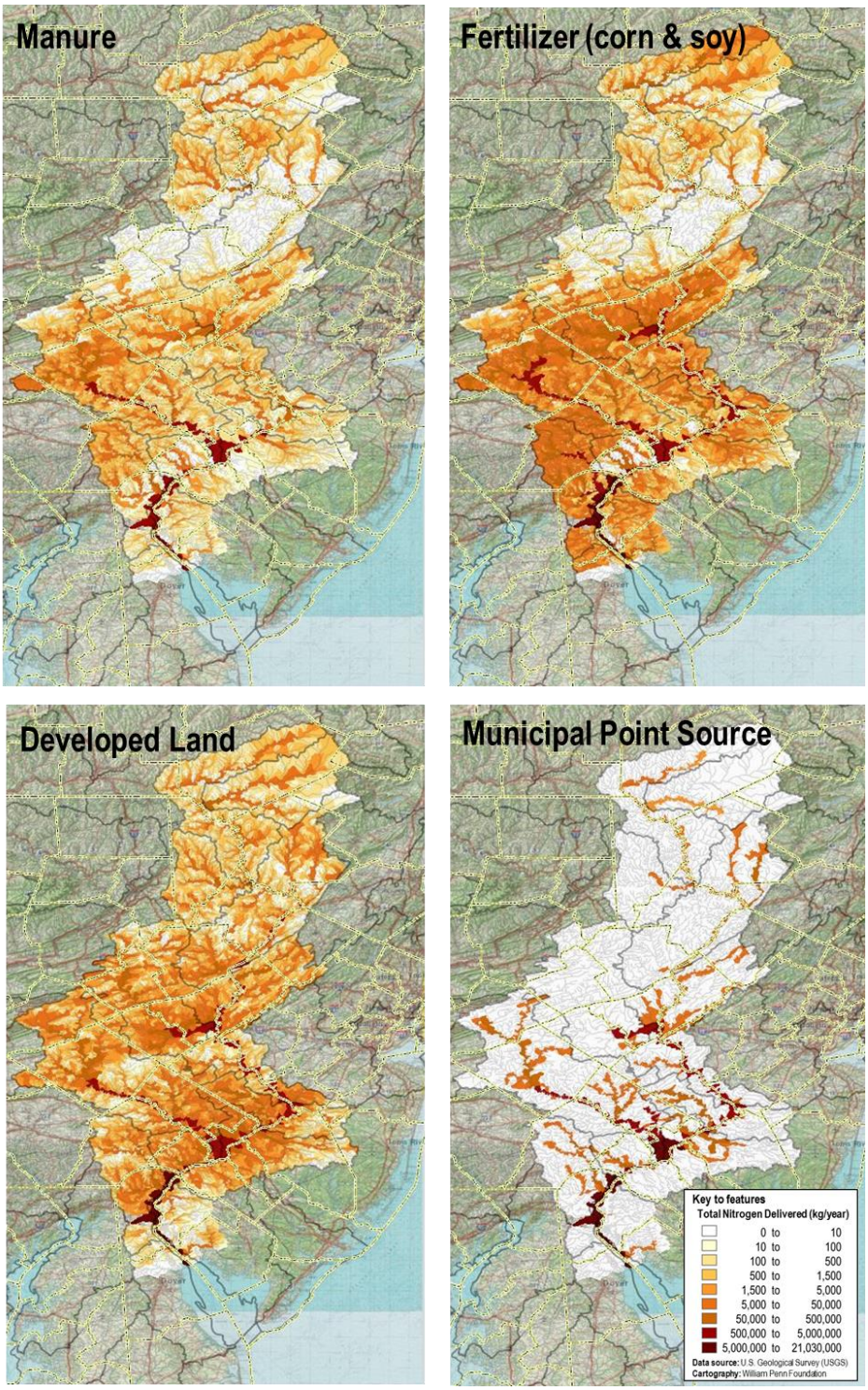
In more recent decades, suburban sprawl concentrated around major urban areas has accelerated loss of forested land cover, increasing the vulnerability of surface waters to contamination from non-point sources. These same urban populations are also among those most reliant on the surface waters of the Delaware River basin for drinking water. Areas of increased forest cover in New Jersey largely correspond to the landscapes of the Highlands and Pinelands. These two special planning and management areas are subject to strong regulatory protections as important sources of drinking water for the state.

3.1.4 MAP: U.S. EPA Level III Ecoregions



The Delaware River watershed is unique for the richness and diversity of its landscape, comprising seven ecoregions. Ecoregions are relatively large units of land or water containing a distinct assemblage of natural communities that share a large majority of species, dynamics and environmental conditions (Omernik, 1995). They are recognized as important tools for conservation by organizations like the U.S. Environmental Protection Agency and World Wildlife Fund. At 13,000 square miles, the Delaware River watershed traverses more ecoregions than any other hydrologic subregion in the country. There are 222 hydrologic subregions across the U.S. with an average area of 16,800 square miles. A hydrologic subregion (as defined by the U.S. Geological Survey Hydrologic Unit Code classification) includes the area drained by a river system, a reach of a river and its tributaries in that reach, a closed basin(s), or a group of streams forming a coastal drainage area.

3.1.5 MAP: Sources of Nitrogen Pollution to the Delaware River Estuary



The nitrogen pollution load delivered to the Delaware River Estuary amounts to 47.5 million kilograms each year. Agricultural runoff from non-point sources, including manure (top left) and fertilizer (top right), accounts for 29 percent of the total. Non-point source contributions from stormwater running off developed land are also significant (14 percent, bottom left). Point sources like treated sewage (bottom right) represent the single largest source category, responsible for approximately 46 percent of all nitrogen pollution delivered to the head of the estuary. The remainder is attributed to atmospheric deposition. Source: 2011 U.S. Geological Survey SPARROW watershed model.

Agricultural pollution: Farms in the watershed can contribute to loss of riparian buffers and to pollution through runoff containing bacteria, pesticides, nutrients and sediment (Map 3.1.5). The Delaware River has higher concentrations of effluent and nitrogen than many other major rivers of the Mid-Atlantic and the Northeast. Surprising to most, the concentration or intensity of nutrient loads coming into the Delaware River estuary, measured as load per unit volume of the receiving waterbody, is greater than what flows into the neighboring Chesapeake Bay (Moore, Johnston, Smith, & Milstead, 2011). The Delaware Bay is spared the eutrophication and hypoxia that afflict the Chesapeake only because nutrients are more quickly and easily flushed out of the Delaware tidal zone (Bricker et al., 2007; Sharp et al., 2009).

Declines in aquifer water levels: Water withdrawals for agriculture, drinking water and industry draw down aquifers and increase the concentration of pollutants in watercourses' remaining flow. New Jersey's shallow aquifer, the Kirkwood-Cohansey, feeds the headwaters of many Delaware tributaries along with heavy industrial and residential users, and the current rate of groundwater withdrawals are unsustainable, reducing stream flows and dewatering wetlands (Pinelands Preservation Alliance, NJDEP, & U.S. Geological Survey, 2012). The Delaware River Basin Commission has identified two areas of critical concern in the upper estuary—southeastern Pennsylvania and south-central New Jersey—where additional withdrawals must be limited or prohibited if long-term yields of water are to be sustainable.

Loss of riparian buffers: The area adjacent to a stream, the riparian zone, is essential for maintaining stable stream banks. This zone also acts as a filter to water flowing from the surrounding land, which contains contaminants and nutrients that are carried to the stream in runoff (Sweeney, 2004). Forested riparian areas have been found to filter a significant portion of the runoff generated by human activities on surrounding land and provide essential protection for water quality (Newbold, Herbert, Sweeney, Kiry, & Alberts, 2010). In the past, land development for urban and agricultural uses included vital streamside habitat.

"The growing climate crisis is an important context for all work in the watershed … Projected changes in the Delaware Basin include higher temperatures, especially in winter, and more intense rainfall events with greater dry periods between them."

Climate change: The growing climate crisis is a major intensifying factor of the stressors described above and an important context for all work in the watershed. Projected changes in the Delaware Basin include higher temperatures, especially in winter, and more intense rainfall events with greater dry periods between them (Kreeger et al., 2010). Predictive modeling has shown that climate change affects water quality and quantity in a watershed. Climate change reduces snowfall, decreases the snow-pack volume and increases the rate of evapotranspiration, thus reducing the year-round water storage volume of a watershed and causing fluctuations in flow, especially during high water demand times. Higher temperatures also increase the percentage of winter precipitation in the form of rain (rather than snow). This, in addition to climate change-related early snowmelt, increases runoff and causes fluctuations in water level and flow that deviate from the natural cycles. This extra runoff also changes the timing and magnitude of sediment loading (by up to 50 percent) and is responsible for disruptions of nutrient cycles and ratios that can lead to increased algae and plant biomass and eutrophication (Marshall & Randhir, 2008).

Energy development: The region is attracting an estimated $2 billion in energy pipelines that will cross the landscape (Messersmith, 2014). Should the Delaware River Basin Commission lift its moratorium, extraction of oil and gas from Marcellus Shale and other sources will involve construction of new

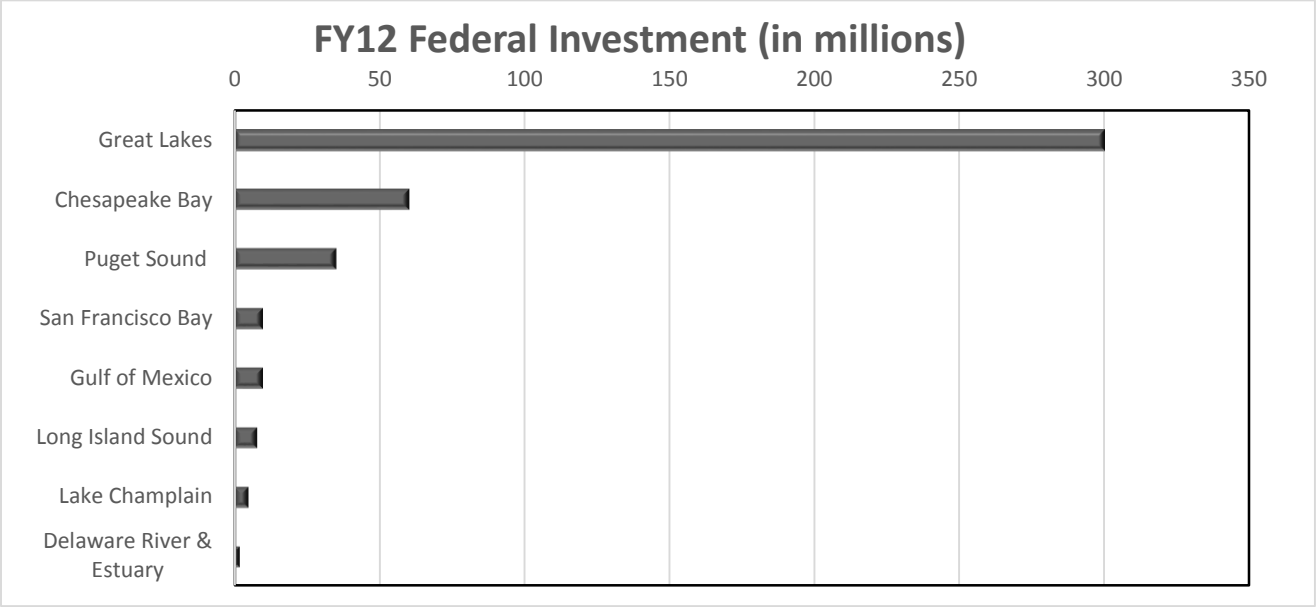
pipelines, forest clearing, large withdrawals of water, high volumes of chemical brine wastewater, stormwater runoff from drilling sites and roads, and potential spills and accidents that could directly threaten drinking water quality (Johnson et al., 2010; Vidic, Brantley, Vandenbossche, Yoxtheimer, & Abad, 2013). Some of the chemicals found in natural gas wastewater are not governed by existing water quality regulations, precluding regulators from issuing permits that could safeguard water quality.

3.2 Policy Context

Although non-point source pollution can at times seem intractable, it is the cultural, economic, political and regulatory context behind everyday behaviors that need attention in order to accelerate progress. People's perception that they, as individuals, are separate from the natural ecosystems that support them represents a major barrier for more effective natural resources management.

Where federal environmental agencies remain committed to investing in stream restoration projects, budget cuts have constrained funding for land protection, monitoring and environmental enforcement (EPA, 2011). Watershed groups lack sufficient resources to counter the notion that, in lean economic times, the environment is an area for reduced discretionary spending. Although the DRBC and the four states that share the Delaware Basin's resources work collaboratively, the process of improving the quality of the basin is slow-moving. In other large watersheds, such as the Great Lakes or Chesapeake Bay, problems like these sparked regulatory action by the federal government leading to ambitious new policies and funding programs (Kauffman, 2014).

3.2.1 GRAPH: FY12 Federal Investment



This chart depicts federal funding allocated during fiscal year 2012 through the U.S. Environmental Protection Agency's geographic programs, including the Great Lakes, Chesapeake Bay, Long Island Sound and the Delaware River watershed. The small amount of funding shown for the Delaware Basin is from the National Estuary Program. It totaled less than $600,000 and that amount is generally on a downward trend. While the watershed also gets limited funding through the Department of the Interior (i.e. National Park Service, Fish and Wildlife Service, and Natural Resource Conservation Service), the other watersheds do so as well, and the significant gap in funding remains. Source: Coalition for the Delaware River Watershed.

The Delaware has not received significant federal funding, and in the current economic environment, it will take a bold vision and strong interstate political will to affect federal policy and attract federal funds. Despite fiscal

challenges, emerging approaches to environmental problems have potential to deliver real returns in water quality, and new, collaborative thinking is taking a fresh look at old problems. Water quantity and flow analysis conducted by The Nature Conservancy (The Nature Conservancy, Partnership for the Delaware Estuary, & Natural Lands Trust, 2011) is yielding rich, new insights on how to manage water resources in the Delaware more efficiently. The EPA is seeking a more integrated approach to ensuring healthy watersheds, recognizing that "fixing" problems is not enough; preventing a system from being degraded in the first place may be a more effective and efficient use of scarce resources (EPA, 2011).

Underlying any advancement is the recognition that clean water is an economic, social and natural asset, and its loss has implications across all three spheres. Understanding this threefold value, or "triple bottom line," is critical for incentivizing water quality protection. The ideas briefly described below have the potential to catalyze action and demonstrate that public and private investment can ensure sustainable communities.

"Underlying any advancement is the recognition that clean water is an economic, social and natural asset, and its loss has implications across all three spheres."

Green infrastructure: The City of Philadelphia's Green City, Clean Waters initiative is a 25-year, $3 billion plan to reduce combined sewer overflows through green infrastructure (Philadelphia Water Department, 2011). It is based on the premise that parks, swales and rain gardens will ultimately be cheaper and more effective in reducing stormwater overflow than gray infrastructure—wastewater treatment plants, pipes, storm sewers and concrete—especially when considering full economic, social and environmental values. The hypothesis is that full-cost accounting for the environment ultimately pays off. The program is using a mixture of incentives and penalties, pegging the water utility rate structure to the amount of impervious surface on a property, thus making explicit the link between the environment and economics. It creates incentives by reducing fees for property owners that build green infrastructure and thus generate stormwater credits. It encourages participation by offering financial assistance. It seeks to develop new sources of financing for stormwater management by enabling investors to fund green infrastructure projects and realize returns through the utility bill savings.

The critical link between upstream communities and the city's downstream needs requires promotion of projects in upstream areas to lessen stormwater flows and flooding that affect Philadelphia. Success would demonstrate the alignment of environmental health with economic development and prove that enhancing the quality of life is an economically viable proposition, not an either-or choice, on a large scale. Such initiatives could catalyze a new paradigm for watershed protection and restoration.

The municipal separate storm sewer system: MS4 regulations apply to a new, previously exempt class of stormwater generators; they give municipalities more flexibility than command-and-control regulations and encourage town and city leaders to engage citizens in reducing runoff from their own homes and businesses. They must be enforced, of course, but the MS4 approach serves as an example of innovation and advancement that can be paired with local constituency building and ground-up action.

Mitigation funding: Mitigation offers opportunities to leverage private investment where efforts to avoid or reduce impacts have failed. Mitigation can be federally or state mandated for the regulated loss of a natural resource or can be a voluntary offering of protection or restoration funds in order to offset public perception. The Palmerton Trust, for example, is a $1.5 million fund designed to offset damage caused by a zinc plant in the Lehigh River valley; the trust has provided critical funding for several important restoration projects in the region (Trustees of the Palmerton Zinc Pile Superfund Site, 2011). Federal

wetlands banking has been well established for the mitigation of impacts from wetlands loss (McElfish & Brooks, 2012). Mitigation from gas pipelines, described more fully below, may also offer another opportunity for financing land protection with private funds.

Adaptation to climate change: The magnitude of Hurricane Sandy and the amount of money available for relief have put a spotlight on resilience, adaptation and preparedness. Adaptation planning in the Delaware River basin lends itself naturally to watershed approaches because it involves issues of both water quantity and water quality. It will require multiple efforts on multiple fronts – from water conservation to smart growth, from traditional land protection to new partnerships with industry, utilities and municipalities – with each effort conducted in the place where it will have the greatest benefit.

Grass-roots action: Although market incentives and innovative tools have exciting potential, tried and true grass-roots advocacy and constituency building will remain critical to attracting support for the river, its tributaries and enforcement of regulations to ensure water quality. Accelerating grass-roots impact will require all environmental leaders in a watershed to have a broad perspective and a common purpose. In watersheds where restoration plans have succeeded, local and national groups have networked to coordinate advocacy, mobilize members and focus on the decision-makers who matter.

Federal action: One effort that might help Delaware stakeholders strengthen their networks and coordination is greater federal recognition. This recognition could come about through a number of different forms, be it through Executive Order, regulatory action or new legislation. Previous examples of such wide-reaching efforts include work on the Delaware River Basin Conservation Act (HR 644). Initially introduced in 2011 and revived in 2013 and 2014, the Northeast Midwest Institute reports that the Act calls the Delaware River basin a "national treasure of great cultural, environmental and ecological importance" that provides essential ecosystem services but is vulnerable to further degradation. The Act would establish the Delaware River Basin Restoration Program to coordinate funding at federal, state, regional and local levels. Another expected outcome is that conservation partners would be involved in defining an investment strategy of cost-effective conservation targets with multiple, measurable benefits. Such broad-reaching federal action could both sustain and enhance conservation efforts currently underway, such as habitat restoration and protection, water management for stream flow, land-use planning for environmentally sensitive development, public outreach and education through resources like competitive matching grants and technical assistance to conservation partners.

National recognition: The Delaware Basin has the foundation for the coordination of local action envisioned in the federal bill, and stakeholders have the body of knowledge and best practices necessary to catalyze an unprecedented level of conservation impact. The river's headwaters are intact, and no dams obstruct its mainstem. Strong organizations – Delaware River Basin Commission, Delaware Riverkeeper Network, Partnership for the Delaware Estuary, Coalition for the Delaware – are already coordinating collective efforts. These conditions help to raise the watershed's national profile and attract the additional resources that often follow. In 2013, the region and its community of conservation practitioners received notable recognition with the federal designation of the Delaware River as one of a select few locations for an Urban Waters Federal Partnership. Led by the U.S. Forest Service, U.S. National Parks Service and the U.S. National Oceanic & Atmospheric Administration, this multi-agency initiative is improving coordination among federal agencies and community-led revitalization efforts to improve the waters of the Delaware River basin and promote their economic, environmental and social benefits. Greater recognition of the basin's importance by other national institutions, from both the public and private sectors would further accelerate conservation efforts for the region.

4 PLACE-BASED STRATEGIES

Decades of intervention by public and private funders suggest that regional research and policy advocacy cannot succeed without local stakeholders' efforts. It is on the ground that the work gets done – whether it is gaining the trust of local farmers, working with the town planning board or installing rain barrels to capture stormwater runoff. Such place-based strategies can target specific subwatersheds, test innovative approaches and refine best practices. With well-chosen strategies and careful monitoring, specific places can become laboratories and the solutions can be scaled up. Because water quality improvements are largely incremental and resources are finite, it is imperative to focus investment.

To select locations for the place-based investment, ANSDU researchers studied land cover and water quality data and developed an index for prioritizing restoration of subwatersheds with degradation from urban and agricultural activities as well as areas optimal for land protection. Next, to identify groups with the capacity to participate in these collaborative restoration and protection projects, OSI reviewed stressors, strategies and institutional capacity. The study involved more than 50 interviews and a review of reports and data from across the 13,000 square miles of the watershed, covering four states and many local jurisdictions. The goal was to identify places at the intersection of science and practice—that is, where investment in water quality would have the highest potential for significant returns and where practitioners had the capacity to effect measurable change, whether through protection of intact waters or restoration of degraded streams.

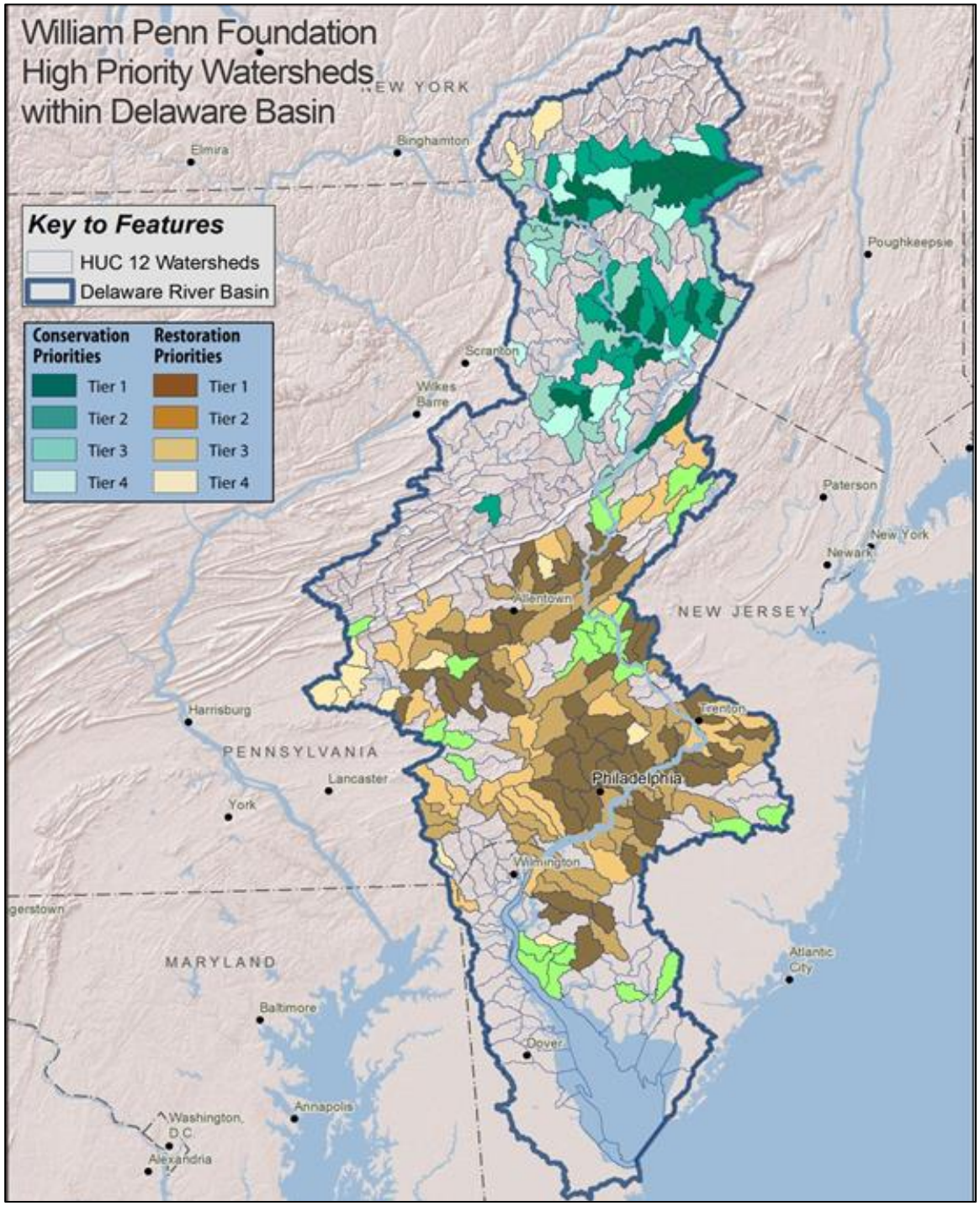
4.1 SELECTION OF AREAS FOR INVESTMENT

The first step was identifying and mapping stressors and areas with important ecological resources. To locate the stressors across the Delaware River basin, ANSDU sought to consistently evaluate the subwatersheds on a scale from ecologically intact to the most compromised. Stream drainage areas designated by the U.S. Geological Survey as hydrological unit code 12 (HUC-12) with areas that range from 15 to 62 square miles were considered the scale for regional analysis of over 400 subwatersheds. Each subwatershed was evaluated according to water quality and biological indicator data; impaired, high quality or exceptional value stream classifications; species of special concern; land cover, including protected areas; agriculture, by type; impervious surface; forested land; riparian forest; and wetlands. Biological data for the assessment were drawn from the following sources, which provide relatively consistent and reliable information across the four-state region:

- Natural Heritage Program's Aquatic Communities Classification for Pennsylvania (not available for other states);
- New Jersey's macroinvertebrate index of biological integrity, surface water quality standards and list of impaired streams;
- New York's designated stream uses and list of impaired streams; and
- Pennsylvania's designated stream uses and list of impaired streams.

Using mapping analysis, researchers then developed land cover-derived indices to identify the best and worst watersheds out of all 400-plus subwatersheds of the Delaware according to their potential to contribute to water quality or impairment. Based on this integrated land cover and biological assessment, about 100 subwatersheds were identified as either highest quality or degraded with potential to effect change. Some subwatersheds were eliminated when their sources of impairment (point source and abandoned mine drainage) were outside the scope of this program. In some cases, subwatersheds met the criteria for high value (e.g. trout fisheries) but also had degraded areas. These hybrid areas demonstrate the importance of integrated approaches to protection and restoration projects.

4.1.1 MAP: William Penn Foundation High Priority Watersheds within Delaware Basin



Top-tier watersheds represent those that are the most degraded and those of the highest quality. The bright green color designates those subwatersheds with unique ecosystem features, such as rare habitat and threatened species. This analysis was used to identify those geographic areas where systems were at the tipping point, i.e. those areas between intact and degraded conditions where strategic protection efforts might stop a backslide toward degraded quality or where restoration could catalyze or accelerate improvement.

With the ANSDU analysis as a starting point, OSI then sought to identify places where progress could be made and where stressors demanded immediate action. Such places would not only have specific impairments or stressors that could be mitigated by targeted investment, but also have stakeholders who could take action to protect or restore those areas and then measure the benefits.

Capacity comprises ability and resources, and the analysis sought to identify places where a diversity of groups working on water quality could combine resources, align strategies and address the full range of stressors through public-private collaboration. The ideal situation would be a healthy mix of federal, state and county investment in the area combined with strong advocacy, land protection and restoration organizations that had demonstrated effectiveness. A mix of public and private investment indicates commitment that can withstand budget cuts and organizational change and facilitates broader concern for a combination of social, ecological and economic issues related to water quality. The scale and importance of the issues require a fusion of grass-roots action, governmental involvement and capital funding to effect meaningful change.

The capacity analysis also looked at existing watershed plans, notable parks, state-designated heritage areas and other planning tools. Examining the geographic distribution of the priority subwatersheds suggested clusters or groupings of areas with similar characteristics. To integrate ecological and capacity issues, the following criteria were used in selecting the final clusters recommended to the William Penn Foundation:

- the severity of current and potential stressors;
- the existence of strategies for effective action;
- organizational capacity;
- cost, feasibility and opportunities to leverage investment;
- potential for significant benefits; and
- ability to measure outcomes.

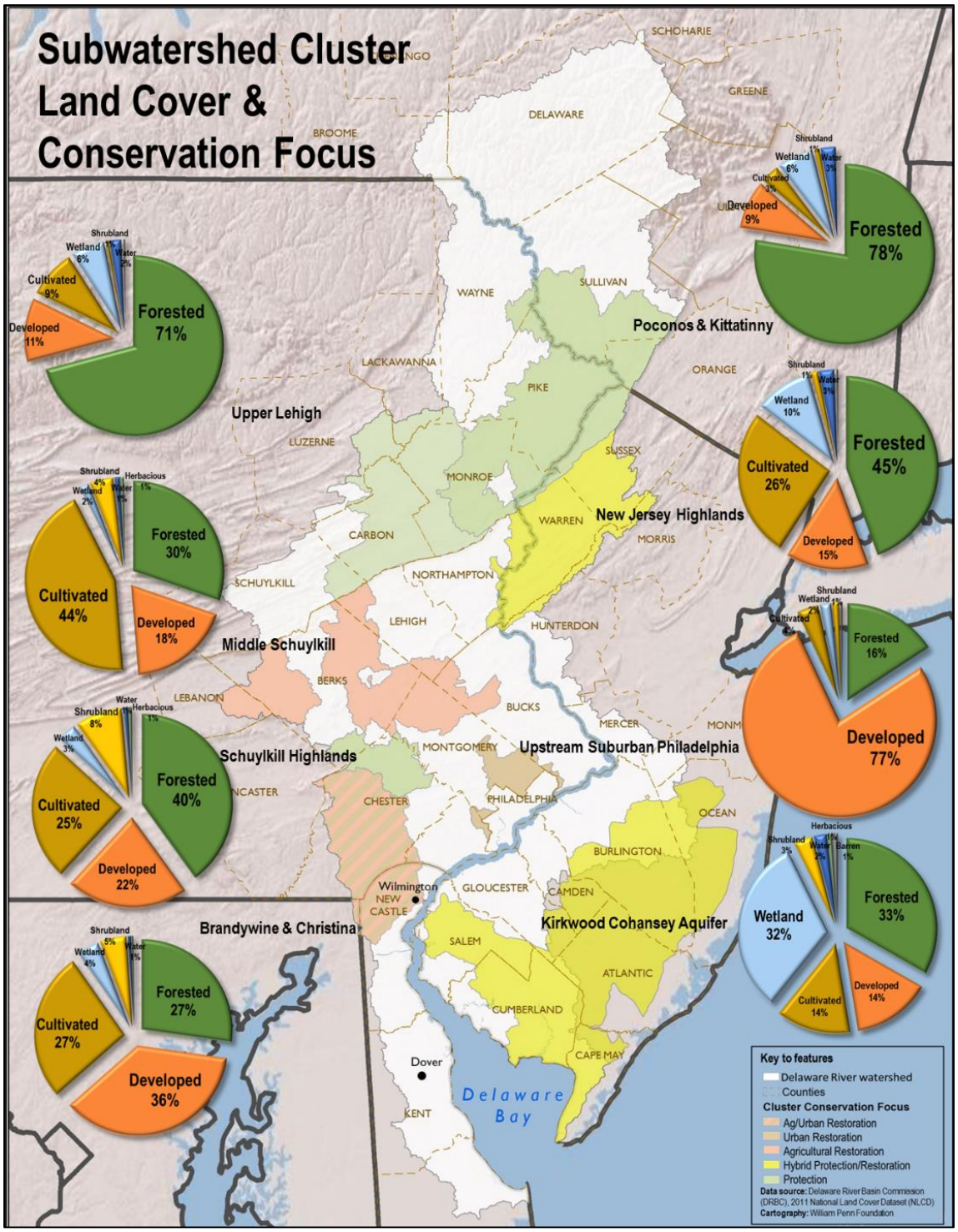
OSI also sought to ensure the final places for investment would provide approaches to a representative mix of stressors across the Delaware Basin. The following three categories of places were selected:

- **Suburban restoration:** dealing with impervious surface, flooding, stormwater and wastewater;
- **Agricultural restoration:** nutrient and sediment loading in runoff, stream bank destabilization from grazing, and overwithdrawal from aquifers; and
- **Protection of intact forestland and wetlands:** areas with potential for loss of total forested areas and wetlands in addition to fragmentation due to population growth and possible energy extraction.

The final result of this work identified eight clusters of subwatersheds, representing approximately 25 percent of the total Delaware Basin, that embody a range of stressors, threats, organizations and potential strategies; places where coordinated action among diverse stakeholders could lead to tangible improvements in water quality and quantity (see map 4.1.2). Together, these eight clusters concentrate many of the Delaware Basin's major ecological values and impairments and highlight opportunities for advancing water quality. They are thus laboratories for testing what works and why, and under what conditions, yielding lessons that can be shared and replicated in other places across the watershed and elsewhere. The eight watershed clusters were identified as the following types:

- **Suburban restoration:** the suburbs upstream of Philadelphia;
- **Agricultural restoration:** the Middle Schuylkill River and Brandywine and Christina Rivers
- **Protection of intact forestland:** the Poconos and Kittatinny region, Upper Lehigh River and the Schuylkill Highlands.
- **Hybrids of both restoration and protection:** the New Jersey Highlands and the Kirkwood-Cohansey aquifer

4.1.2 MAP: Subwatershed Cluster Land Cover & Conservation Focus



Colors denote the conservation priority for each targeted cluster of subwatersheds, which are influenced by land cover and the balance between natural land uses that benefit water quality (forest and wetland) and developed uses (agriculture/cultivated and urban/developed) that introduce threats to water resources. Conservation priorities include the protection of intact forests and wetlands (green), the restoration of degraded agricultural landscapes (red), the restoration of degraded urban landscapes (brown) and hybrids of both protection and restoration (yellow).

In June of 2013, OSI and ANSDU presented these watershed clusters to leaders from public and nonprofit agencies at a meeting held at the William Penn Foundation's offices (see appendix 7.1 for the participant list). The group reviewed and confirmed these sites as critical locations for public and private investment, noting the importance of focusing on protection of forested headwaters as well as restoration of degraded agricultural districts and the communities upstream of Philadelphia. Participants also emphasized the alignment of several clusters with federal and state funding priorities.

4.2 Place-based Strategies for Success

Through OSI's review of the myriad strategies organizations were involved in across the watershed, four place-based strategies emerged as critical issues for the Foundation to support. These strategies are briefly described below.

Conserving forested headwaters to maintain water quality: Keeping the headwaters intact is one of the most cost-effective ways to target water quality. It is no coincidence that the City of Philadelphia's source water plan lists protection of forested headwaters—the Schuylkill Highlands, the Upper Lehigh, the New Jersey Highlands, the Poconos and Kittatinny and the Upper Delaware River region—as a priority. Amassing the political and financial capital needed to protect these areas before they become fragmented and impaired will avoid future restoration costs. Scientific analysis and mapping are needed to pinpoint the most important parcels to conserve, and further research can help stakeholders understand more clearly how intact forests contribute to water quality and, conversely, at what point their fragmentation begins to degrade it (Mancini, et al., 2005). Equally important, conservationists need to employ the full suite of protection tools – purchase of land and easements, land-use planning and improved land management – and not rely on regulation. Creative sources of conservation finance will include public and philanthropic dollars, corporate support, carbon credits and, assuming that energy infrastructure cannot be installed on less sensitive lands, potential mitigation funding from the construction of pipelines and power transmission corridors.

Improving management of agricultural lands to reduce nutrient loads: Agricultural Best Management Practices (BMPs) can reduce contaminant, nutrient (phosphorus and nitrogen) and sediment run-off from farmland into streams. These BMPs include reduced use of pesticides, relocation of manure pits, restoration of wetlands and installation of riparian buffers, to name a few. Efforts

Professional Modeling for Citizen Stakeholders

The science of hydrology is ahead of the application of hydrologic data to inform practical decision-making about land protection and restoration. The complexities of the science must be translated into accessible forms that can drive water quality policy and investment. That is the goal of Model My Watershed, a web-based hydrologic model that the Stroud Water Research Center created with support from the National Science Foundation to help communities understand threats to their local water resources. Model My Watershed enables users to visualize future land cover change scenarios driven by development or conservation and instantly model and display changes in the natural water cycle including contributions to stormwater runoff.

For community stakeholders and planners looking to address questions about water availability for both human needs and ecological flow requirements, the U.S. Geological Survey (USGS) is developing the Water Availability Tool for Environmental Resources, or WATER, for the Delaware River watershed. Users interested in flows for a particular creek will point-and-click a stream reach to generate daily flow time series, which is useful for building hydrologic flow models to meet various conservation and regulatory objectives. The model will integrate data from a number of existing programs and be capable of looking back to show trends over the past 30 years. WATER will be publicly available and is scheduled for release in 2015, with initial USGS research findings to be formally published in 2016. Both WATER and Model My Watershed provide examples of how synthesizing already accessible data can increase awareness of what is working and why and indicate how success may be scaled up and replicated.

Upstream-Downstream Connections

All the critical issues require watershed-wide, creative strategies that cut across traditional protection and restoration silos. Isolated protection and restoration projects will not be sufficient to solve the intractable problems posed by non-point source pollution.

EXAMPLE: Watershed health in the upper Lehigh depends on filling gaps in protected land to secure the success of past efforts. But land protection will not resolve the problems unless planners address stormwater management in the middle and lower Lehigh.

EXAMPLE: Land protection in New Jersey's Pinelands National Reserve will enhance the recharge of the Kirkwood-Cohansey aquifer. But approximately 40 towns on the western border of the reserve will not be able to withdraw sufficient water from that effort unless water conservation is part of the solution.

EXAMPLE: Farmland in the middle and lower Musconetcong watershed of the New Jersey Highlands has been targeted for restoration. But ongoing loss of forest cover will negate the restoration benefits for coldwater streams and aquifer recharge areas.

EXAMPLE: Philadelphia's Green City, Clean Waters initiative requires vast resources to build and maintain green infrastructure. But the money—and opportunity to set a precedent—will be wasted if suburban storm runoff overwhelms the city's progress.

to employ these effective practices should target degraded areas where agriculture is a major land use, such as portions of the Brandywine watershed, the Middle Schuylkill, sections of the New Jersey Highlands and New Jersey's Delaware Bayshore Region. Agricultural districts are also sites for easements and tighter regulation. Creative approaches to funding might include leveraging the Farm Bill and state and local government programs; developing new public funding sources, including use of water rate surcharges, water allocation fees and stormwater authorities; and creating incentive-based systems, such as nutrient trading or a water quality trading bank, whereby stakeholders can purchase and sell credits for reducing pollutants from farms into streams (Kauffman, 2009; University of Maryland Environmental Finance Center, 2008). By targeting efforts in defined locations, public and nonprofit practitioners can increase the likelihood of achieving reductions in pollutants.

Demonstrating successful approaches to stormwater reduction: Philadelphia's green infrastructure initiative provides a platform for creative, effective, philanthropic investment. Private investors can help incubate the city's program, strengthen the scientific and economic research base, support the education and engagement of citizens, as well as fund monitoring and applied research to evaluate gains and facilitate replication. Other opportunities include financing research and stormwater reduction practices through both debt and equity vehicles, as well as piloting green infrastructure projects in upstream towns, which must reduce their stormwater runoff if Philadelphia is to achieve these ambitious goals.

Increasing organizational knowledge through monitoring and modeling: The nature of non-point source pollution—multiple stressors, diffuse origins—makes it difficult to identify the particular cause of impairment and to measure progress in reducing non-point inputs. For this reason, watershed models and monitoring that help to connect sources and impacts are critical to advancing water quality goals. For the William Penn Foundation, it was necessary that grant recipients committed to supporting monitoring, adjusting strategies based on feedback and communicating both progress and failures to improve implementation within and beyond the basin. Feedback will be critical to understanding where land protection can improve or maintain water quality most effectively, what nutrient reduction strategies are most cost-effective and what indicators of water quality are most reliable. For local monitoring of known stressors, the indicator (e.g. turbidity) can offer a direct measurement of the stressor itself (erosion). For measuring overall conditions across larger scales of analysis, other indicators, such as patterns in land-use and land-cover data, are also effective. Led by ANSDU, monitoring of progress toward William Penn Foundation goals is intended to advance integrated management and collaboration between upstream and downstream communities and between land trusts and water protection groups.

4.3 Voices from the Field

Partnership is critical for making water quality improvements in the Delaware Basin. The voices of diverse leaders, both at the local level and at the state or regional scale, will define success. Over the course of the planning phases for the William Penn Foundation strategy, OSI, ANSDU and the Foundation heard from many of these voices. Although many of their ideas are integrated into this document, the quotes below present feedback on what is needed to ensure a bright future for the Delaware River basin.

> "Stream flow keeps the concentrations of contaminants (particularly nutrients) below the levels where they start to change the aquatic ecosystem. If you reduce stream flow, it's like adding your usual teaspoon of sugar but to only half a cup of tea. We need to keep making the point that stream flow and water quality are intimately related from a long-term sustainability perspective, and the way to maintain healthy stream flows is by monitoring ground and surface water withdrawals."
>
> **—Rich Bizub, Pinelands Preservation Alliance, New Jersey**

> "In some communities, a stormwater tax would be used just to perpetuate the same old gray infrastructure, rather than to restore watersheds and install green infrastructure. The economic incentive of a stormwater tax needs to be accompanied by a strong, progressive stormwater policy covering new development."
>
> **—Maya K. van Rossum, Delaware Riverkeeper Network**

> "I believe there are three things we need to do to restore and protect water into the future. One, we have to do more of what we know works. Some solutions, like riparian buffers, are effective but we haven't done enough of them. Two, we have to try new things, including some we have yet to imagine. We need new options to address new challenges or get better results. Three, we have to monitor. We are asking questions and posing solutions, but we aren't going back and seeing if we got what we wanted."
>
> **—John Jackson, Stroud Water Research Center, Pennsylvania**

> "The many conservation organizations in the river basin have compatible goals—sediment management, flood mitigation, water quality protection, forest health, recreation, habitat restoration—but often don't leverage their work because of their singular focus. Setting up a list-serve or social networking site and getting all of the partners participating, as well as having quarterly face-to-face or web meetings to update each other on actions and emerging issues, could improve collaboration."
>
> **—Greg Westfall, Natural Resources Conservation Service, New Jersey**

> "It doesn't take a lot of money to support a good staff person who can bring people together and motivate them. Grass-roots work is slow, messy, not glamorous. But what's more powerful than people who live in the area and care about their stream?"
>
> **—Cindy Adams Dunn, Pennsylvania Department of Conservation and Natural Resources**

"Grass-roots effort is the key. We're a small local organization, but we have boots on the ground all over: people keep an eye on the river and report problems, big and small. They have a sense of stewardship because they are attached to the resource."

—Beth Styler Barry, Musconetcong Watershed Association, New Jersey

"All the science and monitoring in the world does no good unless strong advocates use the information to ensure good decisions and affect change."

—Maya K. van Rossum, Delaware Riverkeeper Network

"Even in the Pinelands, there are many neighborhoods that need revitalization and could absorb a great deal of demand for housing and commercial development, but it is much cheaper to build on a forest or farm field. We need incentives for compact, multi-use development, redevelopment and low-impact designs."

—Jaclyn Rhoads, Pinelands Preservation Alliance, New Jersey

"We want to make conservation part of every decision—whether it's roads or development—and get it on the checklist for everything local officials do. Our approach is to use source water plans to reach drinking water suppliers, because the suppliers take water quality seriously. We help them, and some give us funding to do agricultural BMPs and forest stewardship planning. To get something done, you need to be involved so that the source water protection plans take the conservation angle."

—Larry Lloyd, Berks Conservancy, Pennsylvania

"We put a priority on bringing education programs into schools. We have to connect young people not with a tropical rainforest thousands of miles away but with their own watershed. We have to make that local connection because people will not protect what they do not love, and the connection starts with kids."

—Beth Styler Barry, Musconetcong Watershed Association, New Jersey

"We recently met with a large developer and explained why their water management approach was not in the best interest of the headwaters streams. They knew we were willing to pursue the matter—we're small but we have litigated on occasion—and they really listened. The revised plan incorporates everything we suggested, and the county gets the economic development and water quality protection."

—Theresa Merli, Brodhead Watershed Association, Pennsylvania

5 Cross-Cutting Innovation

Investments can pilot potential models and catalyze regional efforts, but their success is often compromised by larger forces. Energy development, climate change, exurban sprawl and acid rain are examples of stressors that cut across ecological and government boundaries and may require a regional response. In a basin as large and complex as the Delaware Basin, with its combination of point and non-point sources, the array of threats and potential responses can be daunting. A complicating factor is the patchwork of sometimes conflicting, or at least inconsistent, regulations at the intersection of federal, state and regional governance. A case in point is the divergent approaches to hydraulic fracturing ("fracking"), from Pennsylvania's aggressive support to New York's more cautious stance to the Delaware River Basin Commission's struggle to find the balance between political and natural resource considerations. In desk research and interviews with key stakeholders, the authors found significant differences in basin-wide knowledge and policy, identifying gaps and a need to coordinate within the public and nonprofit sectors on how best to fill them.

5.1 Scientific Background and Research Opportunities

Historically, long-term benchmarks of river health were evidenced in records of fish caught in the main stem of the Delaware, and especially in the estuary. Benjamin Franklin worked to regulate pollution of Philadelphia's waterways in the 1700s, while water quality monitoring arose as a consequence of the river's extensive pollution and resulting sulfur stench of the 1940s (Kauffman, 2010). The past century has seen the development of an extensive body of literature in freshwater science, with many study results on the impacts of human activities on water quantity and quality.

Although the stressors listed above are not new arrivals in the discipline of freshwater science, new research questions arise that can be applied to better understanding the interactions between human activities and water quality in specific locations, the amount of measurable effect of restoration and protection actions, and the contributions to ecosystem theory using examples from the Delaware Basin.

"Traditionally, when funding is provided for restoration and protection, practitioners overlook the need to continue to monitor stream health throughout these processes. Monitoring and analysis are essential for detecting improvements or declines in ecosystem…"

Biological monitoring: Monitoring streams' ecosystem health using organisms as indicators has been shown to be an effective approach to measuring the effects of stress caused by human activities (Patrick, 1956; Jackson & Resh, 1992). Fish, macroinvertebrates, algae and salamander communities often exhibit different responses to stressors including urban and agricultural land use, riparian forest condition, flow regulation and flooding. These residents of our waterways give more information on habitat suitability over the long term than one-time chemical samples do. Traditionally, when funding is provided for restoration and protection, practitioners overlook the need to continue to monitor stream health throughout these processes. Monitoring and analysis are essential for detecting improvements or declines in ecosystem integrity after a project has been implemented.

Government agencies tasked with monitoring rivers across the nation, including those of the Delaware River watershed's states, have thinly stretched resources that must characterize expansive geographies but remain constrained to a specific number of data collection sites and limited sampling periods. Each data collection site may be needed to assess impaired areas or to check for compliance with regulatory actions, and the time period for data collection is often cut short as many bodies of water are no longer sampled once they attain their designated use. For drinking water regulations, large rivers are often the only sites chosen for monitoring.

County and state organizations have distributed efforts throughout smaller tributaries but tend to visit sites on a rotating basis. Simply put, there are more rivers than aquatic ecologists, and the work of agencies must be complemented by universities, private firms and volunteer groups. In addition to adding capacity, the involvement of other non-governmental parties helps improve the science of monitoring by including protocols designed for a broad spectrum of streams, and not simply determining whether streams are attaining their designated use. A combination of professional and volunteer monitoring with the involvement of community groups, schools, universities and watershed associations integrates research and environmental stewardship with community involvement and therefore amplifies the impact of a project through citizen ownership of their watershed and personal connections to water quality issues.

The science of restoration and protection: Restoration ecology became a discipline of its own in the 1980s, and projects were planned with a strong foundation in ecological theory. However, the concept of *measurable success* in ecological restoration was largely overlooked. In 2005, the University of Maryland's Margaret Palmer and more than twenty of her colleagues in restoration ecology issued a "call to arms" for the scientific community to study whether the restoration projects were actually benefitting ecosystems as they were intended (Palmer et al., 2005). Studying the aquatic ecosystems of the eight subwatershed clusters as they are now, and throughout the processes of protection and restoration, is the key to measuring the success of investments as they translate to water quality. Moreover, this research will contribute to the discipline of restoration ecology and provide models for projects in any region of the world.

Another important area of research that has received some attention but lacks defined relationships is how the size and location of preserved lands affect water quality. This program is expected to provide a solid dataset for continuing work on this important question.

5.2 Developing a Shared, Applied Research Agenda

Academic research – past, present and future: Utility companies typically monitor the quality of drinking water, while government-based agencies often assess waterways in terms of designated uses. Much effort has been put into monitoring the main stem of the Delaware and source waters for municipal drinking supplies (DRBC, 2008). Studies in parts of the Delaware Basin have focused on a variety of important aspects of ecosystem structure and function, such as fish community composition (van Snik, Ross, & Bennett, 2005) and changes over time (Fairchild, Horwitz, Nieman, Boyer, & Knorr, 1998), the development of indices of biological integrity (IBI) and erosion (Daniels, Riva-Murray, Halliwell, Vana-Miller, & Bilger, 2002; Paul, 2006; Sun, Natter, & Lacombe, 2008).

Research on human impacts to the basin include overall trends in water quality (Fischer et al., 2004), the ecological effects of dam removal (Velinsky, Bushaw-Newton, Kreeger, & Johnson, 2006; Fairchild et al., 1998), the effects of riparian buffer restoration (Newbold et al., 2010), fecal coliform source tracking, the impacts of land use changes (especially deforestation associated with natural gas exploration and extraction) on water chemistry and macroinvertebrate communities (Jackson & Sweeney, 2010) and the use of surface water in combination with groundwater to meet the area's water consumption demands (Featherstone, Fielding, & Hull, 1983). Several studies have focused on climate change and its observed and predicted impacts (Barnett & Dobshinsky, 2008; Wolock, McCabe, Tasker, & Moss, 2007; Najjar et al., 2000; Neff et al., 2000). Much research has translated to knowledge about waterways:

- Many point sources have been removed, while progress continues through enforcement of non-point source management at federal and state levels. Work is needed to further reduce non-point source inputs.

- Although the water quality of the Delaware Estuary is better than it has been since the Industrial Revolution (Partnership for the Delaware Estuary, 2012; Sharp, 2010), there is substantial work to be done restoring fish and other aquatic communities.
- Phosphorus levels have declined due to secondary wastewater treatment and reductions in fertilizer use but should continue to be reduced to improve ecosystem health.
- Land development caused continuous increases in sediment delivery to the basin, and strategic areas were periodically dredged to keep reservoirs and channels from filling in. There is evidence that this sedimentation has decreased significantly in the last decade.
- PCBs and other toxic pollutants in fish tissue have also declined over the last 40 years, but fish consumption advisories remain in effect for the Delaware River and most major tributaries (PADEP, 2013).

Ongoing research in the basin will be most effective when there is alignment among researchers so that applied knowledge can drive policy and practice. Examples of gaps in knowledge include the following:

Cumulative impact: Throughout the basin, practitioners are interested in understanding how multiple human activities affect water resources. The combinations include development, non-point source pollution, climate change, energy-related activities, dam and reservoir management and water withdrawals.

Energy development: In the upper basin, Delaware River Basin Commission officials and nonprofit practitioners are trying to predict the effects of cumulative stressors with a strong focus on the interactions with hydraulic fracturing. "Fracking" poses particular challenges to regulators, and the current legislation reflects the need for more information on the indirect effects on human health due to contamination of surface water and groundwater. In addition, research is needed on how sedimentation associated with installation of drill pads, roads and related infrastructure along with deforestation and forest fragmentation affect water quality and wildlife.

"Ongoing research in the basin will be most effective when there is alignment among researchers so that applied knowledge can drive policy and practice."

Green infrastructure: To what extent can green infrastructure benefit the economy, society and natural systems or a "triple bottom line" as proclaimed by the City of Philadelphia? Are such investments economically efficient, environmentally sustainable and equitable? How can studying stormwater BMPs before and after installation lead to improvements in their design? How much pollution does stormwater transport into the basin? When is this transport greatest: on the scales of a single storm, by season, or with annual and decadal variations in precipitation?

Relationships between protection and restoration: Many land parcels converted to conservation easements are retired farmland. Although current activities do not contribute to increased impacts, these lands may have compacted soils or degraded riparian areas which are not being fully exploited by native wildlife. They may also have legacy sediment loads and changes in topography. How should investments be made to acquire easements and optimize the effectiveness of reclaimed farmland?

Forest protection for water quality and savings: After years of using traditional restoration techniques to address total maximum daily loads (TMDLs), EPA and the Chesapeake Bay Commission are asking what role the protection of intact forested land plays in restoring the water quality of a degraded resource and

about implications for regulatory compliance. On a policy side, can communities receive credit for preserving open space that prevents development that might have otherwise required restoration? Can this be modeled in a credible way so that research informs investments and policies?

Relationships between impervious surface and water quality: At what point does increased impervious surface compromise water quality in the Delaware Basin? Research around the world indicates the amount of impervious cover that impacts aquatic ecosystem health varies by geography. Seminal studies have flagged 10 percent impervious cover as a critical threshold, but other work finds significant degradation at lower or much higher percentages (Arnold & Gibbons, 1996; Schueler & Holland, 1994). Many of these studies have used impervious cover estimates of questionable accuracy. Currently, new technology providing high quality images of land surfaces are being produced to give more accurate numbers for land cover estimates. Using this new information, thresholds must be assessed specifically for the Delaware Basin.

Emerging contaminants: Do new pollutants, such as pharmaceuticals, health care products, cosmetics and sewage from hospitals, require new regulations at the state and regional levels? What threat do they pose, and how should regulators and policy-makers respond?

How can land preservation have the greatest impact? Land protection often must occur where landowners are willing to participate in easements. However, targeting specific parcels for their size, location in the watershed and soil and forest qualities may be essential to protecting water quality. Currently, the tools InVEST (Sharp et al., 2014) and RIOS, developed by the Natural Capital Project, have advanced the study of economic return on land protection for water quality. Such tools must be adapted for the Delaware Basin and a wider audience of users.

How much can forested riparian buffers affect water quality? Continued progress in reforesting riparian forests will be useful in determining whether preservation of land along the rivers, in the riparian buffer, provide greater services, or if larger areas throughout the drainage basin are better investments. How much can a riparian forest buffer improve water quality in areas dominated by agricultural and urban lands? Work to continue planting riparian buffers along farmed and non-farmed land is beginning to show changes in the aquatic communities around Stroud Water Research Center projects in Chester County, although the biota are not yet showing full ecosystem recovery. In addition to the economic benefits of increasing water quality, these projects have the potential to improve fish habitat. Can installation of forested riparian buffers reduce stream temperature enough to restore trout populations?

BMPs with the best results: Although BMPs such as riparian buffer strips, water-conserving drip irrigation systems, land terracing, cattle exclusion and proper manure and fertilizer management have demonstrated decreased nutrient and sediment inputs, which combination of these practices yields the greatest positive impact? Where fecal coliforms are detected, determining the source of these bacteria will allow for improvement of BMPs and work with specific farms that contribute to water pollution. In addition, aligning BMPs with more sustainable use of groundwater and surface water may have a compounded, positive effect.

Stewardship and monitoring: Public outreach and education are key elements in these initiatives, and watersheds around the world have benefitted from volunteer stream monitoring. In the Delaware, how can the use of citizen stream monitors increase awareness about the status of our waters and increase public awareness and participation in preserving our waterways? Combined with traditional approaches

for outreach, new technologies engage the public through interaction, and assessing their effectiveness and applicability can allow watershed groups to reach larger audiences.

Increasing understanding about what works: As the beneficiary of advances in water quality over the past four decades, the Delaware River watershed is a living laboratory for knowledge about what works and what doesn't. That creates opportunities to accelerate the collection, dissemination and application of knowledge and improve decision-making about restoration and protection. Citizens can gain a better understanding of the health of their waterways and the consequences of their actions and decisions through public communication and greater access to resources like monitoring data. Improvements in monitoring can greatly increase knowledge about effective practice and thereby increase the effectiveness and efficiency of investment.

5.3 Creating New Models of Sustainable Watershed Finance

Reducing non-point source pollution is essential to increasing economic viability and quality of life, but it requires experimentation and innovation. Mitigation funding, source water protection plans, nutrient trading, water funds and transfer of development rights have the potential to advance protection and restoration efforts and establish the Delaware Basin as a leader in water quality protection.

The first priority is to avoid harmful development, then reduce its effects, and only then pursue compensation for the negative impacts of development or demand "mitigation funds." One potential opportunity involves pipeline projects. Although power line mitigation is regulated, a pipeline company is not required to mitigate environmental impacts unless wetlands are involved. Nonetheless, for public relations benefit and perhaps to forestall potential regulatory action, some companies have initiated voluntary projects elsewhere in the nation. With billions being invested in pipeline projects across the Delaware River basin, coordinated action could extract significant funding in voluntary mitigation for land protection. Fracking, if approved by the DRBC, may generate millions more in mitigation dollars. One major task is determining standards for mitigation for incursions into the watershed.

"The first priority is to avoid harmful development, then reduce its effects, and only then pursue compensation for the negative impacts of development…"

Nutrient trading is an innovation that has yet to realize its potential, particularly in the Delaware watershed. However, MS4 permits and legislation for the creation of fee-collecting municipal stormwater authorities could renew interest in using voluntary market mechanisms to finance less costly rural restoration. Regulated communities downstream would thus gain some flexibility in meeting legal requirements for reducing stormwater flows. Currently, Pennsylvania's nutrient trading scheme is limited to the Susquehanna and Potomac watersheds, and critics of the program say bureaucracy is limiting its effectiveness. Designing and implementing effective pilots with nutrient trading could highlight the problems and potential solutions and indicate how to enlarge the scale of trading and thus its potential benefits.

Another tool for protecting environmental resources is the transfer of development rights (TDR) from owners of farmland, intact forests, aquifer recharge areas or other open space to owners of land in areas designated for development. TDRs enable landowners to receive compensation for restrictions on the development potential of their properties. The sale of TDR credits began in New Jersey in 1981 with the Pinelands Development Credit program, which is part of the comprehensive management plan that regulates land use in the Pine Barrens. As of 2006, more than 49,000 acres had been preserved through the program, and the price of a certified credit had

risen from less than $10,000 to as much as $160,000. While TDR programs exist in some Pennsylvania communities and are envisioned on a grand scale in the New Jersey Highlands, the challenges lie in their design and bringing them to scale.

5.4 Deepening and Broadening Public Support

An informed citizenry can ensure that public officials enforce existing regulations and, when necessary, write new ones. At a gathering of the region's funders on June 5, 2013, representatives from Natural Resources Conservation Service offices, state land protection programs, farmland conservation programs and private foundations agreed, overwhelmingly, on the need for constituency building. This theme carried through the discussion on the following topics:

- The triple bottom line – encompassing economic, natural resource and social factors – needs to be considered when making water management decisions for the long term.
- Build-out scenarios are a critical tool for helping towns and citizens assess water quality impacts.
- Major weather events may provide an opportunity to help the public understand the connection between human activities, climate change and water management, which could lead to the political leverage to finance stormwater management.
- Branding the Delaware River watershed is key to promoting a strong sense of place and identity that can build interest and engagement in the conservation of the watershed.
- Water quality certification could be used to advertise good river practices and offer certainty to farmers.

5.5 Protecting Source Water

Source water protection plans may be another opportunity, even though the vast majority have no regulatory teeth. The city of Wilmington has paved the way, earmarking small amounts of funding for watershed protection in the headwaters of the upper Brandywine River (Crockett Consulting, 2010). Private and public water utilities charge their customers to maintain water quality, opening the door to leveraging markets for water quality – either the companies protect watersheds directly or they charge customers fees that could be pooled for this purpose. More work is needed to understand tipping points for individual water utilities. The water utility in Bethlehem, Pennsylvania, is working with The Nature Conservancy to protect its water source through the Working Woodlands Program by conserving the watershed forest and achieving third-party certification for sustainable forest management. In the process, the city is also obtaining revenue from carbon credits. Knowing when increased impervious surface area raises filtration costs beyond acceptable levels would enable conservation stakeholders to leverage water utilities' interests. Also important is information on the land holdings of utilities – their extent, conservation values, availability for sale or easement – and the interests and constraints of the utility owners.

6 INVITATION TO SHAPE THE FUTURE OF THE DELAWARE

From June through August 2013, over 40 organizations that are invested in the future of the Delaware River basin participated in the development of eight detailed implementation plans that define strategies for ensuring a promising future for the Delaware River, its tributaries and the people, industry, community and lands that shape both the morphology and quality of those streams.

Together, these eight plans represent one of the greatest investments of time, intellect and private support to develop a collaborative approach to protection and restoration in critical subwatersheds in the Delaware Basin. This not only links work done locally within the clusters through collaboration across the spectrum of restoration and protection needs for the first time, but it also links organizations working in the headwaters of the Delaware with groups working downstream.

"…we aspire to maximize positive impact from all sources, as we work towards greater health, sustainability and resiliency for this essential and irreplaceable resource."

The plans, often 50 to 100 pages each, offer detailed approaches to the stressors and strategies discussed in this paper. These strategies are paired with approaches to tracking progress and failures for potential mid-course correction. In essence, the plans provide a blueprint for public and philanthropic funders seeking to pursue these themes in a framework supported by monitoring, technical assistance and communication.

The William Penn Foundation anticipates supporting four major areas of investment across these eight geographies.

Cross-cutting innovation through financial support of policy, research and market development that furthers restoration and protection across the Delaware River watershed. This work will include a mixture of investments in organizations in specific watershed clusters that are working on issues with broader implications and intermediaries that are providing assistance across the clusters.

Restoration activities will include activities such as stormwater control measures, stream bank stabilization, agricultural best management practices and other capital intensive projects. The watershed cluster plans identified a need of approximately $75 million over the next three years. The William Penn Foundation will seek to support a portion of this work through establishment of a capital fund that will distribute funds for exemplary projects through a competitive grant process.

Protection activities will include direct acquisition of land and easements that make the greatest contribution to maintaining water quality and avoiding future degradation. The watershed cluster plans identified protection needs totaling over $87 million over the next three years to protect critical high quality streams, headwaters and flood plains that might otherwise be converted out of natural use. The William Penn Foundation will seek to support conservation through establishment of a capital fund that will distribute money for the best projects through a competitive grant fund.

Additional needs covering **monitoring and constituency building** were identified in the plans, totaling $16 million in funding requests. The William Penn Foundation has already begun investing in monitoring of the watershed with an initial investment with ANSDU and will continue to work with thought leaders in

research and applied science to ensure technical assistance and high-quality monitoring across the Delaware Basin, as well as the direct application of research findings towards more effective practice.

In total, the plans identify over $230 million of costs for protection, restoration, constituency building and monitoring to make measurable headway on water quality over the next three years. They represent the work of strong and knowledgeable nonprofit groups – including large global organizations as well as small citizen watershed groups – working in partnership with key public agencies around shared goals and priorities. While these plans inform investment by the William Penn Foundation, they also identify opportunities for investment that are many times larger than the scope of the Foundation's resources. Partnership from both the private and public sector will be critical to success. The Foundation's commitment to supporting local and watershed-wide monitoring to ensure measurable results and adaptive management, offers other investors a valuable opportunity for learning as well. In this way we aspire to maximize positive impact from all sources, as we work towards greater health, sustainability and resiliency for this essential and irreplaceable resource.

7 APPENDICES

7.1 ATTENDEES TO THE JUNE 2013 GATHERING AT THE WILLIAM PENN FOUNDATION

Bob Lueckel	U.S. Department of Agriculture - Forest Service
Michael Leff	U.S. Department of Agriculture - Forest Service
Carrie Mosley	U.S. Department of Agriculture - Natural Resources Conservation Service
Christine Hall	U.S. Department of Agriculture - Natural Resources Conservation Service
Denise Coleman	U.S. Department of Agriculture - Natural Resources Conservation Service
Richard Sims	U.S. Department of Agriculture - Natural Resources Conservation Service
Susan Fox Marquart	U.S. Department of Agriculture - Natural Resources Conservation Service
Simeon Hahn	National Oceanographic and Atmospheric Administration
Eric Schrading	U.S. Department of the Interior - Fish & Wildlife Service
Gregory Breese	U.S. Department of the Interior - Fish & Wildlife Service
Paul Phifer	U.S. Department of the Interior - Fish & Wildlife Service
David Lange	U.S. Department of the Interior - National Park Service
Jeff Fischer	U.S. Department of the Interior - U.S. Geological Survey
Richard Balla	U.S. Environmental Protection Agency Region 2
Jon M. Capacasa	U.S. Environmental Protection Agency Region 3
Doug Wolfgang	PA Bureau of Farmland Preservation
Cindy Dunn	PA Department of Conservation and Natural Resources
Lauren Imgrund	PA Department of Conservation and Natural Resources
Rhonda L. Manning	PA Department of Environmental Protection
Leroy Young	PA Fish and Boat Commission
Carl G. Roe	PA Game Commission
Dave McPartland	NJ Department of Environmental Protection 319 Grant Program
Curt Gellerman	NJ Department of Environmental Protection Green Acres
Robert Piel	NJ Department of Environmental Protection Watersheds
Nancy B. Wittenberg	NJ Pinelands Commission

Cindy Roberts	NJ State Agriculture Development Committee
Susan Payne	NJ State Agriculture Development Committee
Frank Piorko	DE Department of Natural Resources and Environmental Conservation
Carol Collier	Delaware River Basin Commission
Ken Najjar	Delaware River Basin Commission
Chris Crockett	Philadelphia Water Department
Howard Neukrug	Philadelphia Water Department
Andrea Bretting	Claniel Foundation
Bruce Melgary	Lenfest Foundation
Jamie Horwitz Fram	Philanthropic Advisor
Brian Hill	R.K. Mellon Foundation
Kurt Zwikl	Schuylkill River Restoration Fund
Rich Horwitz	Academy of Natural Sciences
Roland Wall	Academy of Natural Sciences
Stef Kroll	Academy of Natural Sciences
Amanda Bassow	National Fish and Wildlife Foundation
David O'Neill	National Fish and Wildlife Foundation
Kristen Saacke Blunk	National Fish and Wildlife Foundation
Abigail Wienberg	Open Space Institute
Bill Rawlyk	Open Space Institute
Peter Howell	Open Space Institute
Andrew Johnson	William Penn Foundation
David Schwartz	William Penn Foundation
Laura Sparks	William Penn Foundation
Nathan Boon	William Penn Foundation
Rashanda Perryman	William Penn Foundation

7.2 SUBWATERSHED CLUSTER TEAMS

Kirkwood-Cohansey Aquifer

- ***New Jersey Conservation Foundation***
- American Littoral Society
- Pinelands Preservation Alliance
- The Nature Conservancy NJ
- Natural Lands Trust
- Trust for Public Land
- D&R Greenway Land Trust
- NJ Audubon Society
- Association of NJ Environmental Commissions
- Partnership for the Delaware Estuary

Brandywine and Christina

- ***Brandywine Conservancy***
- Brandywine Valley Association
- University of Delaware – Water Resources Agency
- Natural Lands Trust
- The Nature Conservancy DE
- Stroud Water Research Center

Upstream Suburban Philadelphia

- ***Pennsylvania Environmental Council***
- Natural Lands Trust
- Temple University - Center for Sustainable Communities
- Villanova University - Center for the Advancement of Sustainability in Engineering
- Tookany/Tacony-Frankford Watershed Partnership
- Lower Merion Conservancy
- Pennypack Ecological Restoration Trust
- Wissahickon Valley Watershed Association
- Friends of the Poquessing Watershed

Upper Lehigh

- ***Wildlands Conservancy***
- Natural Lands Trust
- National Audubon Society PA
- The Nature Conservancy PA
- Pocono Heritage Land Trust
- North Pocono CARE

Schuylkill Highlands

- ***Partnership for the Delaware Estuary***
- Natural Lands Trust
- Berks County Conservancy
- French and Pickering Creeks Conservation Trust
- National Audubon Society PA
- Green Valleys Watershed Association
- Stroud Water Research Center
- Chester County Water Resources Authority

Middle Schuylkill

- ***Berks County Conservancy***
- Partnership for the Delaware Estuary
- Stroud Water Research Center

New Jersey Highlands

- ***The Nature Conservancy NJ***
- NJ Conservation Foundation
- Land Conservancy of NJ
- Hunterdon Land Trust
- Musconetcong Watershed Association
- NJ Highlands Coalition
- Association of NJ Environmental Commissions
- New Jersey Audubon Society
- North Jersey Resource Conservation and Development Council
- Trout Unlimited
- Wallkill River Watershed Management Group

Poconos and Kittatinny

- ***Pinchot Institute for Conservation***
- The Nature Conservancy PA
- Natural Lands Trust
- Trust for Public Land
- Pocono Heritage Land Trust
- Delaware Highlands Conservancy
- East Stroudsburg University
- Brodhead Watershed Association

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