



June 8, 2018

Hon. Daryl D. Metcalfe, Majority Chair
Pennsylvania House State Government Committee
144 Main Capitol Building
PO Box 202012
Harrisburg, PA
Pam Neugard, Pneugard@pahousegop.com
Sharon at Houssou@pahouse.net

Re: Written Testimony submitted for the Public Hearing of Pennsylvania House State Government Committee regarding Delaware River Basin Commission, June 11, 2018

Dear Mr. Metcalfe,

Delaware Riverkeeper Network (DRN) submits this comment to the Public Hearing of the Pennsylvania House State Government Committee that is scheduled for June 11. The hearing is to receive testimony regarding the Delaware River Basin Commission (DRBC) policies and actions on business growth and economic vitality in the basin and the rights of property owners within the basin.

DRN is a non-profit organization established in 1988 to protect and restore the Delaware River, its associated watershed, tributaries, and habitats. In its efforts to protect and restore the watershed, DRN organizes and implements stream, wetland and habitat restorations, a volunteer monitoring program, educational programs, environmental advocacy initiatives, recreational activities, and environmental law enforcement efforts throughout the entire Delaware River Basin. DRN is a membership organization headquartered in Bristol, Pennsylvania, with more than 20,000 members with interests in the health and welfare of the Delaware River and its watershed. DRN is uniquely qualified as a stakeholder to comment on and provide relevant information concerning the Delaware River Basin Commission's policies and actions, which directly impact its members and the Delaware River Watershed.

The Upper Delaware River is a federally designated "Scenic and Recreational River" administered by the National Park Service. The National Wild and Scenic Rivers System also includes large portions of the Lower Delaware and the Delaware Water Gap. The Lower, Middle and Upper Delaware River have high water quality and are subject to Delaware River Basin Commission Special Protection Waters Designation. The Basin and River are home to a number of federal and state listed endangered or threatened species

DELAWARE RIVERKEEPER NETWORK
925 Canal Street, Suite 3701
Bristol, PA 19007
Office: (215) 369-1188
fax: (215) 369-1181
drm@delawareriverkeeper.org
www.delawareriverkeeper.org

including, but not limited to, the dwarf wedgemussel, Indiana bat, Timber Rattle snakes, bog turtle, Northeastern bulrush. Over 200 species of migratory birds have been identified within the drainage area of the Upper Delaware River within the Basin, including the largest wintering population of bald eagles within the Northeastern United States. The ecologically, recreationally and economically important American Shad population migrates up through the nontidal portions of the Delaware River to spawn, American Shad populations in the Delaware River are currently at depressed numbers. Migratory birds breed in or migrate through the high quality riparian corridors of the Basin. The Delaware River is also home to dozens of species of commercially and recreationally important fish and shellfish species. These attributes provide important economic value to the Delaware River Watershed and, when sustained, contribute daily to the economic viability of the basin's resources. This comment provides specific information regarding the benefits of the Delaware River Basin's water supplies, ecosystems and natural resources, and the irreplaceable value of a healthy river.

The Delaware River's waters are protected under the terms of the Delaware River Compact, the DRBC's Special Protection Waters Program, and regulations adopted in its Comprehensive Plan and Rules of Practice and Procedure. Attached is DRN's written comment submitted to the DRBC regarding recent proposed rulemaking "Proposed New 18 CFR Part 440 - Hydraulic Fracturing in Shale and Other Formations; Proposed revisions and additions to section 18 CFR 401.35 relating to project review classifications", available at

<http://www.delawariverkeeper.org/sites/default/files/DRN%20Comment%20on%20DRBC%20Draft%20Regulations%20w%20Attachments%20%282018-03-30%29.pdf>. Pages 5 through 12 of the comment address in detail the legal framework from which the State Government Committee's inquiry should be conducted.

The economic value of the Delaware River's resources have been recognized by Congress through its designation of the Delaware as a Wild and Scenic River and the specific recognition of its outstanding and profitable recreational values. The living resources and commercial importance of the Delaware Estuary and Bay are recognized by the inclusion of the Delaware in the federal National Estuary Program. The economic value of the water supplied each day to 15 to 17 million people, including Philadelphia and regions outside of the Basin in New York City and New Jersey, is also recognized by the U.S. Environmental Protection Agency, all four of the Basin states (Pennsylvania, New York, New Jersey and Delaware) and by studies and academic research over many decades.

Dr. Gerald Kauffman of the University of Delaware published a seminal analysis in 2011 entitled "[Socioeconomic Value of the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania](#)", attached to this comment. The report examines the Basin's annual economic activity, ecosystem services, and jobs and wages of the Delaware River. These are included in the resources that the DRBC is responsible for in its administration of its policies and actions.

The Executive Summary explains:

What do the Guggenheim Museum, Boeing, Sunoco, Campbell's Soup, DuPont, Wawa, Starbucks, Iron Hill Brewery, Philadelphia Eagles, Camelback Ski Area, Pt. Pleasant Canoe Livery, Salem Nuclear Power Plant, and United States Navy all have in common? They all depend on the waters of the Delaware River Basin to sustain their business. **The Delaware River Basin is an economic engine that supplies drinking water to the 1st (New York City) and 5th (Philadelphia) largest**

metropolitan economies in the United States and supports the largest freshwater port in the world. (*Emphasis added*) The Delaware Basin's water supplies, natural resources, and ecosystems in Delaware, New Jersey, New York, Pennsylvania and a small sliver of Maryland:

- Contribute \$22 billion in annual economic activity from recreation, water quality, water supply, hunting/fishing, ecotourism, forest, agriculture, open space, and port benefits.
- Provide ecosystem goods and services (natural capital) of \$21 billion per year in 2010 dollars with net present value (NPV) of \$683 billion discounted over 100 years.
- Are directly/indirectly responsible for 600,000 jobs with \$10 billion in annual wages. (Kauffman 2011, p.1)

The values of the Delaware River are examined in a report published by DRN in 2010 “RIVER VALUES, The Value of a Clean and Healthy Delaware River” found at http://www.delawariverkeeper.org/sites/default/files/River_Values_Report_0_0.pdf. The report is attached. The report examines economic aspects of the Basin such as the value of clean water, property values, environmental health, waterfront businesses, recreational assets, employment, and cultural and historic values such as current Native American communities and cultural heritage, historic settlement of the region, and scenic values. It also explains that while restoration of the river’s quality has made its comeback from a polluted waterway incapable of supporting life to a vibrant, highly valued Watershed, it is the work of dedicated individuals, communities and organizations, the investment of billions of dollars over many decades and the implementation of environmental laws and action by local, state and federal agencies, and most importantly the DRBC, that has made its renaissance possible. The DRBC’s implementation of the Watershed approach to environmental quality makes it possible to provide the locally-based information, data and scientific and technical knowledge that can help avoid damage and the level of disregard that resulted in the river’s decline by the mid-20th Century. Once damage has been done, it is extremely costly and difficult to undo, making it both economical and environmentally beneficial to prevent the harm before it occurs through informed, integrated planning, community-driven initiatives, and protective regulation.

The Forward by the Delaware Riverkeeper Maya van Rossum discusses the significance of the Delaware River Watershed’s remarkable assets:

The rich ecological history of the river region, still evidenced today, has not only been critical to the success of the recreational uses and associated ecotourism, but has been the foundation upon which the region’s culture and sense of identity has evolved. Historic and ongoing community vigilance has preserved unique cliff formations overlooking the River; natural islands, rapids, a remarkably well-established green riparian buffer including wetlands, and magnificent and unparalleled ecological phenomena including the arrival of hundreds of thousands of migratory shorebirds coming to feast on the eggs of the Horseshoe Crab, a species that has lived and spawned in our Delaware Bay since before the dinosaurs. (DRN 2010, p. v)

Access to pure, life-sustaining water that supports diverse and healthy aquatic communities is an inalienable right of all beings, and of the Delaware River itself. The Delaware River and the watershed it supports is our opportunity to receive the benefits of this inalienable right. No one entity, person, corporation, industry, town, county or state, has the right to use the Delaware River or any of the streams that feed it in a way that harms others or infringes on this right.

Protecting, respecting and restoring a clean, healthy and free flowing Delaware River provides the greatest level of protection, healthy growth and quality of life to our communities. A healthy Delaware River including floodplains, flows, tributaries, aquifers and habitats protects our communities from flood damages and drought, provides clean and abundant drinking water at a sustainable level to our communities, supports growing businesses of all types, supports healthy commerce, encourages both commercial and recreational fisheries providing safe food, creates vibrant recreation, encourages growing ecotourism, increases the marketability and market value of our homes, and makes our communities more desirable places to live and be. (DRN 2010, p. vi)

The prevention of environmental degradation, pollution, and community harm is an essential consideration for all actions in the Delaware River Basin. High volume hydraulic fracturing (“fracking”), the processing, storage and discharge of wastewater produced by fracking, and the withdrawal of water for fracking are activities being considered by the DRBC at this time in their proposed rulemaking, “Proposed New 18 CFR Part 440 - Hydraulic Fracturing in Shale and Other Formations; Proposed revisions and additions to section 18 CFR 401.35 relating to project review classifications”, available at <http://www.nj.gov/drbc/programs/natural/>. The most comprehensive collection of scientific literature on high volume hydraulic fracturing, and its impacts is the [Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking, 5th Edition](#), available at <http://concernedhealthny.org/compendium/>. The Fifth Edition of this authoritative report started in 2014 examining the impacts of fracking on the environment and public health was published March 2018.

The health professionals who reported and analyzed over 1,200 peer reviewed research articles for the Compendium concluded in the report: The “...findings to date from scientific, medical, and journalistic investigations combine to demonstrate that fracking poses significant threats to air, water, health, public safety, climate stability, seismic stability, community cohesion, and long-term economic vitality. Emerging data from a rapidly expanding body of evidence continue to reveal a plethora of recurring problems and harms that cannot be sufficiently averted through regulatory frameworks. There is no evidence that fracking can operate without threatening public health directly or without imperiling climate stability upon which public health depends.” (psr.org/resources/fracking-compendium.html, p. 266.)

Another related report is a literature review that examines literature compiled on fracking impacts for an earlier edition of the Compendium. The report concludes that the body of scientific evidence demonstrating the negative environmental and human health effects from unconventional natural gas development (UNGD) is very strong. The authors of a 2016 study evaluated peer-reviewed literature published between January 1, 2009 and December 31, 2015 as they related to the potential impacts of UNGD on public health, water quality, and air quality. The boundaries of the assessment included scientific literature on hydraulic fracturing and the associated operations and ancillary infrastructure required to develop and distribute unconventional natural gas. (Hays, J. & Shonkoff, S.B.C. (2016). Toward an Understanding of the Environmental and Public Health Impacts of Unconventional Natural Gas Development: A Categorical Assessment of the Peer- Reviewed Scientific Literature, 2009-2015. *PLoS ONE*, Vol. 11, No.4. Retrieved from <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154164>) The results indicated that at least 685 papers have been published in peer-reviewed scientific journals that are relevant to assessing the impacts of UNGD. (Hays and Shonkoff, 2016)

A portion of these papers covering each category (public health, water quality, and air quality) was selected by the authors to review. Of the 31 studies selected for public health, 26 (84%) contained findings that indicate public health hazards, elevated risks, or adverse public health outcomes from UNGD. (Hays and Shonkoff 2016) Of the 58 studies related to water quality, 40 (69%) had findings that indicated potential, positive association, or actual incidence of water contamination from UNGD. (Hays and Shonkoff, 2016) Finally, of the 46 studies associated with air quality, 40 (87%) had findings that indicated that UNGD increased air pollutant emissions and/or atmospheric concentrations. (Hays and Shonkoff, 2016) This study demonstrates that the weight of the findings in the scientific community indicates hazards and elevated risks to human health as well as possible adverse health outcomes associated with UNGD.

The development of the infrastructure required by natural gas development also requires extensive analysis to prevent environmental degradation, pollution, and community harm in the Basin. Communities across America are being abused by the use and misuse of powers granted to the Federal Energy Regulatory Commission (FERC) pursuant to the Natural Gas Act. An extensive analysis that documents the lack of needed environmental protection available is a dossier reviewing the Federal Energy Regulatory Commission (FERC): *People's Dossier: FERC's Abuses of Power and Law* available at <http://bit.ly/DossierofFERCAbuse> The dossier demonstrates the repeated examples of FERC's misuse of the law to strip people of their legal and constitutional rights; to strip the legal authority of states; to undermine the authority of other federal agencies; to prevent fair public participation in the pipeline review process; to ignore the mandates of the Clean Water Act and the National Environmental Policy Act; to take from residents and citizens their private property rights; to take from communities the protection of public parks, forests and conserved lands that they have invested heavily in protecting; to take jobs and destroy small businesses; to inflict on our communities health, safety and environmental harms ... all for the benefit of the pipeline industry seeking to advance its own corporate profits and business edge over its competitors.

The authority of the DRBC extends to decision making that can affect water resources, land use, ecosystems and other watershed assets. The House State Government Committee is examining private property rights as part of this Hearing. Attached is a Legal Memorandum addressing the "takings" issue that was submitted by DRN to DRBC explaining why leaseholders do not have a regulatory takings claim against them for their enactment of a moratorium on shale gas drilling. While the memo addressed specific statements by landowners in 2013, it applies to the broader issue of private property rights and "takings".

The CONCLUSION states:

Over fifteen million people benefit from the unfiltered drinking water supplied by the Delaware River Watershed. Clean drinking water is a quintessential public good that benefits everyone in the population. The burdens to the landowners, by contrast, are small and consist of no more than what any landowner must submit to in order to secure "the advantage of living and doing business in a civilized community." *Andrus v. Allard*, 444 U.S. at 67, 100 S. Ct. at 328 (quoting *Pennsylvania Coal Co.*, 260 U.S. at 422, 43 S. Ct. at 163 (Brandeis, J., dissenting)). The regulation of gas drilling has long been concerned with environmental protection, including the protection of drinking water supplies. The aim is not to conserve wild land in its natural state—this is a law specifically focused on drilling for natural gas. A narrowly drawn regulation focused precisely on the injury to be prevented is one for which the burden should "in all fairness and justice" be borne by the property owner *alone* because he holds his property subject to reasonable regulation and the implied obligation not to use property in a way injurious to the community. *See Mugler v. Kansas*, 123 U.S. 623, 665, 8 S. Ct. 273, 299 (1887).

For the aforementioned reasons, leaseholders in the Delaware River Basin likely do not have an actionable taking claim. (DRN Legal Memo “Regulatory Takings: Northern Wayne Property Owners Alliance Letters to DRBC”, 2010, p. 15-16)

Finally, DRN points out the very limited and unstable economic footing of shale gas development. There are numerous analyses, including reports and articles by oil and gas industry experts, which question the viability and longevity of shale gas with an economic benefit, particularly due to the “boom and bust” nature of its development and also due to the manifestation of the stronger long-term economic engine of renewable energy and energy efficiency.

Of note are studies addressing the economics of shale gas development by Janette Barth, president of J.M. Barth & Associates Inc. and founder of Pepacton Institute LLC, with 35 years of experience in economic modeling and forecasting. An article that summarizes her conclusions is available at <https://www.enr.com/articles/20867-hydrofracking-offers-short-term-boom-long-term-bust> and a report is available at: <http://www.state.nj.us/drbc/library/documents/dockets/stone-energy/Barth-Study-Economics032710.pdf> Dr. Barth concludes that the negative economic impacts of shale gas development may likely outweigh any positive economic gain. She states that “...the likelihood is that gas drilling would adversely affect other economic activities such as tourism and sport fishing and hunting. To some extent gas drilling and these other industries are likely to be mutually exclusive. The net effect is what must be considered.” (“Unanswered Questions About The Economic Impact of Gas Drilling In the Marcellus Shale: Don’t Jump to Conclusions”, J. Barth, 2010, p. 14) She concludes: “As decisions regarding gas drilling in the Marcellus Shale have potentially severe and in some cases irreversible consequences in the form of health, environmental and infrastructure degradation, it is imperative that all of the possible economic impact outcomes be fully understood.” (J. Barth, 2010, p. 15)

The problematic boom and bust cycle of shale gas development is examined in a published report authored by Susan Christopherson, Professor, Department of City & Regional Planning, Cornell University.

The cycle is described by Dr. Christopherson:

The extraction of non-renewable natural resources such as natural gas is characterized by a “boom-bust” cycle, in which a rapid increase in economic activity is followed by a rapid decrease. The rapid increase occurs when drilling crews and other gas-related businesses move into a region to extract the resource. During this period, the local population grows and jobs in construction, retail and services increase, though because the natural gas extraction industry is capital rather than labor intensive, drilling activity itself will produce relatively few jobs for locals. Costs to communities also rise significantly, for everything from road maintenance and public safety to schools. When drilling ceases because the commercially recoverable resource is depleted, there is an economic “bust” -- population and jobs depart the region, and fewer people are left to support the boomtown infrastructure. (Susan Christopherson, “The Economic Consequences of Marcellus Shale Gas Extraction: Key Issues, A Research Project sponsored by the Cornell University Department of City & Regional Planning, CaRDI Reports, 2011, p. 4 www.cardi.cornell.edu)

The lack of profit being made by the fracking industry undermines its ability to fuel economic growth. The over-inflation of job estimates and the shaky nature of the market, as explored by recent Wall Street Journal articles referenced in a May 12, 2018 article by S. Tom Bond, an industry analyst, has fooled many investors. The article points out that fracking just isn’t profitable and it has many negative impacts with long term damaging economic impacts. Available at: <http://www.frackcheckwv.net/2018/05/12/fracking->

[companie-are-drilling-more-and-enjoying-it-less/?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+frackcheckwv+%28Frack+Check+WV+%29.](#)

The expansion of renewable energy sources and the jobs and economic gains that this growing sector is producing have been the subject of many articles and reports over the last few years. A Bloomberg article by Tom Randall “Wind and Solar Are Crushing Fossil Fuels” discusses the growth of renewables and the decline of fossil fuels, including natural gas. Available at: <https://www.bloomberg.com/news/articles/2016-04-06/wind-and-solar-are-crushing-fossil-fuels>

An in-depth report shows that jobs and positive economic benefits accompany regulation.

(“Abel Russ and Eric Schaeffer, “DON’T BELIEVE THE “JOB KILLER HYPE: *Decades of Economic Research Show that Environmental Regulations are Good for the Economy*”, Environmental Integrity Project, January 16, 2017. <http://www.environmentalintegrity.org/wp-content/uploads/2017/01/Jobs-and-environment-report.pdf>)

The report states:

A large body of evidence accumulated over the past 30 years shows that regulations, and in particular environmental regulations, tend to create jobs, not kill them.” (Russ and Schaeffer, 2017, p. 1); and

The evidence also shows that environmental regulations do not hamper productivity growth. A 2014 review paper from the London School of Economics concluded that the effect of environmental regulations on competitiveness is “negligible compared to other factors such as market conditions and the quality of the local workforce. This is true at the national level, at the state level, and at the industry level.

- A 2014 report from the Organization for Economic Cooperation and Development (OECD) found that stronger environmental policies lead to short-term gains in productivity growth, resulting in permanently higher levels of productivity.” (Russ and Schaeffer, 2017, p. 2)

An article by economist Deborah Lawrence examines the financial gains being made by renewable energy sources over fossil fuels, including coal and gas. (Deborah Lawrence, “Shales vs. solar: An investment perspective”, [Energy Policy Forum](#), 2014 <http://www.resilience.org/stories/2014-07-29/shales-vs-solar-an-investment-perspective>)

Ms. Lawrence quotes McKinsey and Company’s explanation of the phenomenon of renewables ascending financially:

“The heat-rate efficiency of the average coal-fired power plant has not significantly improved in more than 50 years...Underutilization and chronic inefficiency cannot be solved by financial engineering or offshoring labor. Something more fundamental is required. We see such challenges as emblematic of an unprecedented opportunity to produce and use resources far more imaginatively and efficiently, revolutionizing business and management in the process. Indeed, rather than facing a crisis of resource scarcity, the world economy will be revitalized by an array of business opportunities that will create trillions of dollars in profits.” (D. Lawrence, Energy Policy Forum 2014)

A review of the U.S. Labor Statistics regarding job growth nationally recognizes that the renewable energy sector is growing twice as fast as any other industry. (<https://qz.com/1111998/renewable-energy-is-creating-us-jobs-twice-as-fast-as-any-other-industry/>) and other reports on the growth of jobs in this sector continue. An article at <https://insideclimatenews.org/news/26052017/infographic-renewable-energy-jobs-worldwide->

[solar-wind-trump](#) reports that renewable energy jobs are growing, twice as many Americans now work in the wind industry as in coal mining, and solar employs many more than that. 9.8 million people are now employed in the renewable energy industry globally, and the numbers are increasing.

DRN supports protective action by the DRBC and recognizes its authority to take that action. DRN supports DRBC's proposal for the prohibition of fracking throughout the Delaware River Watershed. DRN opposes the diversion, transfer or exportation of water from sources within the Basin for utilization in fracking of hydrocarbon carbon bearing rock formations outside the Basin as proposed at Section 440.4 in their proposed rulemaking. DRN opposes the importation, transfer, treatment, storage, disposal, or discharge in the Basin of produced water and Centralized Waste Treatment (CWT) wastewater generated by fracking operations, as proposed at Section 440.5. DRN asserts that a ban on fracking and its activities as described here will provide economic stability and viability that supports the Delaware River Basin's resources, assets, and well-being. A complete ban by the DRBC is within their authority and would serve to fulfill their responsibility to protect the water resources of the Delaware River Basin.

Truly sustainable economic growth and stability requires a healthy river, clean water and air, and a thriving Watershed and it is Delaware Riverkeeper Network's goal to assure that this is achieved today and for future generations.

Respectfully submitted,



Maya K. van Rossum
the Delaware Riverkeeper
keepermaya@delawariverkeeper.org



Tracy Carluccio
Deputy Director
Delaware Riverkeeper Network
tracy@delawariverkeeper.org

CC: Hon. Matthew D. Bradford, Democratic Chair
Pennsylvania House State Government Committee
Bridget M. Lafferty, Executive Director, House State Government Committee
Steve Tambini, Executive Director, Delaware River Basin Commission
Pam Bush, Commission Secretary and Assistant General Counsel, Delaware River Basin Commission

Attachments:

DRN's written comment submitted to the DRBC regarding recent proposed rulemaking, d. 3.30.18
"Socioeconomic Value of the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania", Dr. Gerald Kauffman

“RIVER VALUES, the Value of a Clean and Healthy Delaware River”, Delaware Riverkeeper Network, April, 2010.

Legal Memorandum Re: Regulatory Takings: Northern Wayne Property Owners Alliance Letters to DRBC, Delaware Riverkeeper Network, 2013

RIVER VALUES

The Value of a Clean and Healthy Delaware River



Delaware RIVERKEEPER® Network

April 2010

RIVER VALUES

The Value of a Clean and Healthy Delaware River

Delaware RIVERKEEPER® Network

April 2010

Printed on Recycled Paper

Delaware RIVERKEEPER® Network



The Delaware Riverkeeper is an individual who is the lead voice for the Delaware River, championing the rights of the Delaware River and its streams as members of our community.

The Delaware Riverkeeper is assisted by seasoned professionals and a network of members, volunteers and supporters. Together they are the Delaware Riverkeeper Network, and together they stand as vigilant protectors and defenders of the River, its tributaries and watershed.

Established in 1988 upon the appointment of the Delaware Riverkeeper, the Delaware

Riverkeeper Network (DRN) is the only advocacy organization working throughout the entire Delaware River Watershed. DRN is committed to restoring the watershed's natural balance where it has been lost and ensuring its preservation where it still exists.

The Delaware Riverkeeper Network's focus is the ecological health and integrity of the river ecosystem recognizing we best protect ourselves only when we best protect our River.

The Delaware Riverkeeper Network works to:

- ✓ Protect and defend the Delaware River through advocacy and enforcement;
- ✓ Inform, organize, activate and strengthen citizens and communities that appreciate and rely upon the River, its tributaries and watershed and want to get involved for their protection and restoration;
- ✓ Monitor the health of the River and tributary streams – gathering reliable data that is then used to bring about meaningful change;
- ✓ Secure and enforce strong legal protections for waterways and associated ecosystems;
- ✓ Restore damaged streams and ecosystems; and
- ✓ Ensure that the voice of the River is heard and its needs are given highest priority in all decision making.

To learn more about the Delaware Riverkeeper Network, to support our work, and/or to become an active member visit our website or contact our office.

Delaware RIVERKEEPER Network
Bristol, PA 19007
(215) 369-1188
www.delawareriverkeeper.org



Table of Contents

Table of Contents

Forward by Maya K. van Rossum, the Delaware Riverkeeper.....	v
Property Values	1
Clean Rivers Increase Property Values.....	1
Healthy Environments Protect Our Communities.....	2
Businesses Benefit from Attractive Waterfronts.....	9
River Recreation	12
The Broad Array of Recreation on the Delaware River	12
Diverse Boating for Recreation and Sport.....	14
Swimming and Biking Along the Delaware.....	21
Leisure Fishing.....	22
Birding and Wildlife Watching.....	27
Parks and Wildlife Refuges.....	35
Community Attractions Focused on Enticing Ecotourism	43
The River as an Employer.....	45
Commercial Fisheries as Employers.....	45
Agriculture and the River.....	49
Where our Drinking Water Comes From.....	52
Industry on the Delaware.....	56
Water and Commercial Use.....	59
Delaware River Ports.....	59
Cultural and Historic Values.....	62
Native Americans.....	62
European movement and American Independence.....	63
Historical Sites and Reenactments.....	64
The Importance of Clean Water.....	65
We Need Your Help.....	67
Special Thanks	67
List of Figures	
Figure 1 Hotel Prices with and without a River View	11
Figure 2 Water Recreation Revenue in PA, NY, & NJ	13
Figure 3 Canoe Liveryes along the Delaware River main stem	18
Figure 4 Number of Fishing Licenses Sold in 2003 in Basin States	26
Figure 5 Delaware River Significant Species List	34
Figure 6 Nationally Significant Parks in the Watershed	36
Figure 7 Campgrounds Bordering the Delaware River	42
Figure 8 Sectors that Consume Delaware River Surface Water	56
Figure 9 Biggest Water Consumers on the Delaware	57
Figure 10 Historical Sites and Public Reenactments	64
Cited Sources.....	69

Forward Maya K. van Rossum the Delaware Riverkeeper

The Delaware River is the last major free-flowing River in the eastern United States. It flows for 330 miles through 4 states, 42 counties and 838 municipalities. Rather than serving as a dividing line among these communities, the Delaware River is a unifying element in the landscape. Throughout history and today, communities within the region regardless of political boundaries have been drawn together by this River, recognizing it as a living resource that supports their lives.

Recreationally, there is no off-season for the Delaware. In the warmer months you can find folks enjoying the River at all hours of the day or night -- fishing, boating, swimming, birding or just idly sitting on its banks and watching it flow by. Even in the coldest winter months kayakers and die-hard anglers are out there enjoying the River and its Bay. Preserving and enhancing the health of the River is critical for sustaining these recreational uses and protecting the local economies that rely on them.



The rich ecological history of the river region, still evidenced today, has not only been critical to the success of the recreational uses and associated eco-tourism, but has been the foundation upon which the region's culture and sense of identity has evolved. Historic and ongoing community vigilance has preserved unique cliff formations overlooking the River; natural islands, rapids, a remarkably well-established green riparian buffer including wetlands, and magnificent and unparalleled ecological phenomena including the arrival of hundreds of thousands of migratory shorebirds coming to feast on the eggs of the Horseshoe Crab, a species that has lived and spawned in our Delaware Bay since before the dinosaurs.



Many reaches of the River are still graced with the presence and history of the Native Americans. It is well documented that the Lenape and Minisink lived, fished, travelled and traded along the banks of the Delaware River.

Additionally, the Delaware River holds a special place in the European history of this country and is viewed by many as the place where America was born. Washington crossed the Delaware River and fought the Battle of Trenton on the banks of the Delaware. It was this battle which was the turning point for the American Revolution and the birth of our nation.

The sense of community created by the Delaware River has harmonized otherwise diverse and disparate voices in support of the River's protection and restoration. Still, more needs to be done.

There was a time in the mid-20th century when the Delaware River had become so polluted that it prevented migration of the historically important Shad upriver to spawn. Implementation of environmental laws and concerted action by concerned citizens and communities restored the River's water quality and ecosystems and supported the return of the Shad to the Delaware River.

While the pollution-induced fish block is now gone, the Delaware River today suffers different problems than in the past. Toxic and other legal and illegal pollution discharges to the River continue; damaging development that floods our communities, pollutes our waterways, and destroys sensitive and important ecosystems continue and are on the rise; the funding of structural flood control options and allowing communities to build, remain and grow in floodplains and in the path of dangerous floods are still the norm; the use of outdated technologies that degrade our clean water or needlessly kill billions of fish is still accepted; the proliferation of industrial activities such as natural gas extraction threatens water resources; overharvesting species, spoiling habitats, and scouring river bottoms continue – all this to accomplish goals that could be better achieved in other ways without such irrevocable harm. In short, many continue to treat our River and its ecological communities as though they are disposable.

But our River is not disposable, it is priceless and irreplaceable.



Access to pure, life-sustaining water that supports diverse and healthy aquatic communities is an inalienable right of all beings, and of the Delaware River itself. The Delaware River and the watershed it supports is our opportunity to receive the benefits of this inalienable right. No one entity, person, corporation, industry, town, county or state, has the right to use the Delaware River or any of the streams that feed it in a way that harms others or infringes on this right.

Protecting, respecting and restoring a clean, healthy and free flowing Delaware River provides the greatest level of protection, healthy growth and quality of life to our communities. A healthy Delaware River including floodplains, flows, tributaries, aquifers and habitats protects our communities from flood damages and drought, provides clean and abundant drinking water at a sustainable level to our communities, supports growing businesses of all types, supports healthy commerce, encourages both commercial and recreational fisheries providing safe food, creates vibrant recreation, encourages growing ecotourism, increases the marketability and market value of our homes, and makes our communities more desirable places to live and be.

This report is designed to document and demonstrate many of the unrecognized values and benefits that a healthy Delaware River brings to our communities, to help people make River protection among their highest priorities, and to expand and enhance appreciation for the beauty and the power of a healthy Delaware River.

The most important take-away from this report is that the Delaware River is a living ecosystem rich in beauty, culture, and community that needs to be protected and, where necessary, restored to continue to be the vibrant and contributing member of our community we all desire and need.

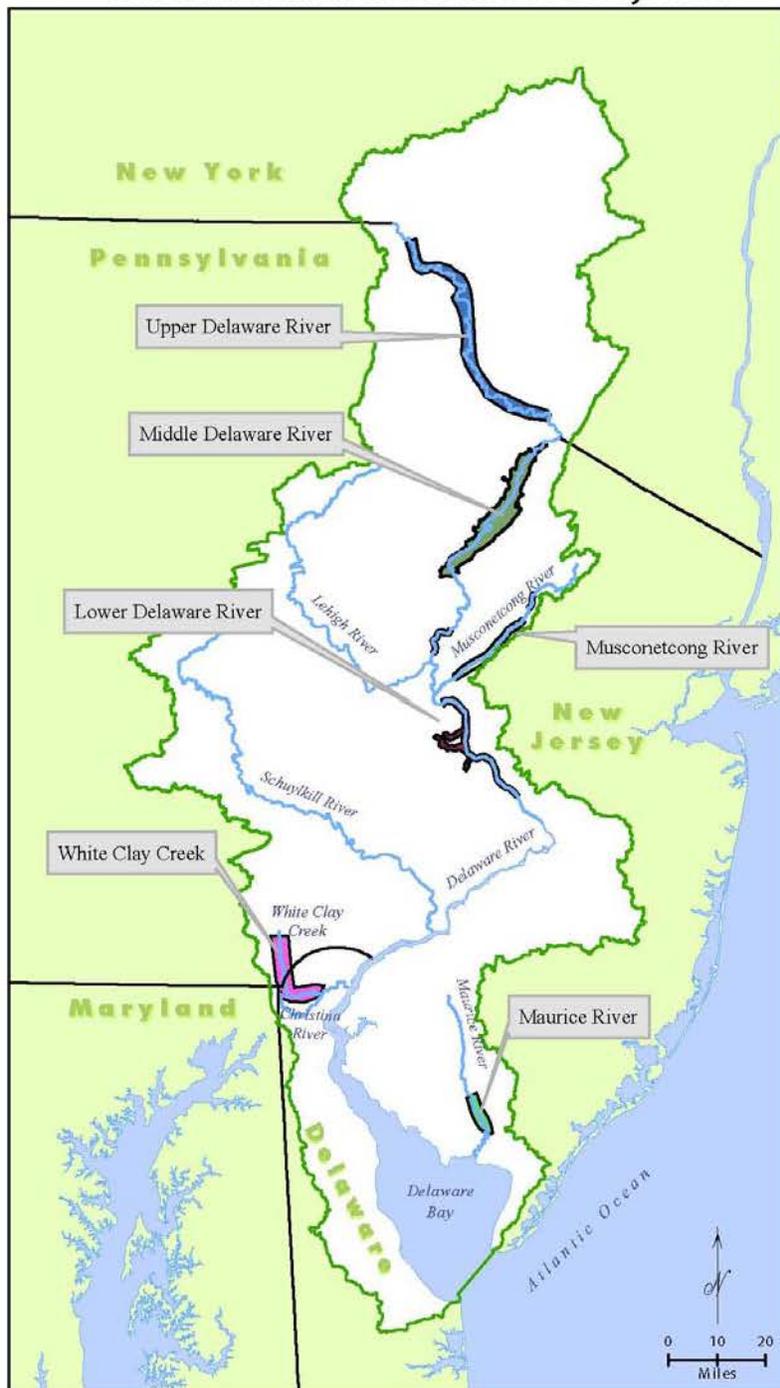
Thank you for your role in appreciating, protecting and restoring the Delaware River, its streams and watershed. It is your care, your voice and your action to Remember the River every day and in all you do that will make the difference.

***Maya K. van Rossum
the Delaware Riverkeeper***

River Values: The Value of a Clean and Healthy Delaware River

Delaware Riverkeeper Network

Stretches of the Delaware River and its Tributaries Included in the National Wild and Scenic Rivers System



WWW.DRBC.NET
 P.O. BOX 7360
 WEST TRENTON, NJ 08628
 (609) 883-9500

Property Values Property Values

- ❖ Clean Rivers Increase Property Values
- ❖ Healthy Environments Protect Our Communities
- ❖ Businesses Benefit from Attractive Waterfronts

❖ Clean Rivers Increase Property Values

A healthy River, free flowing and free from pollution, enhances the economic value of homes, businesses and communities by and through which it flows. An injured system does the opposite. It creates damage and decreases values. River communities need to grow and thrive in a way that protects and maintains healthy river systems to ensure maximum economic and personal benefit.

From the late 16th century throughout the early 20th century, decades of industrial and residential waste dumped directly into the Delaware River began taking its toll on the population. Water pollution in the Delaware River caused outbreaks of dangerous and deadly diseases including cholera and yellow fever.¹ The pollution became unsightly causing pungent and sickening odors. The many cities and towns lining the Delaware misused the River by using it as their personal and commercial sewer line.²

Because of this River abuse, people who could afford it began building country estates and vacationing spots outside of populated cities. Communities such as Washington Crossing, Pennsylvania and Riverton, New Jersey began as summer retreat villages founded by city dwellers from Philadelphia, Trenton, Camden, and New York who wanted to have a Delaware River summer home partially to avoid the risk of waterborne illness which was at its highest in the summer months.³ Some of the oldest and more glamorous 19th century homes along the Delaware River have become privately owned Inns and restaurants that are still used today.⁴

In recent years, as the pollution in the Delaware has declined, communities are starting to turn back to the River for its beauty, recognizing that life by a clean river is not only desirable but can be economically valuable. Maintaining natural areas, trees, wildlife, and a healthy streamside helps to increase property values by reducing pollution, lessening the threats and impacts of flooding and by increasing property and community aesthetics.



RIVERTON, NJ HISTORIC MANSIONS WERE BUILT FACING THE RIVER RATHER THAN THE STREET. MOST OF THESE STATELY HOMES ARE STILL INHABITED OR HAVE BECOME INNS AND RESTAURANTS TAKING ADVANTAGE OF THE RIVER VIEW.

While the property value of a home or business is dependent upon several factors, it is largely influenced by the features either on or nearby the site. A *Money* magazine survey found that clean water and clean air are two of the most important factors Americans consider in choosing a place to live.⁵ Living near a stream, creek or river increases property value. "Ocean, lake, and riverfront properties often sell or rent for several times the value of similar properties located inland."⁶ A case study from the Maine Agricultural and Forest Experiment Station compared property values for homes facing clean water versus water

considered dirty or unclean. The study shows that property located near a high quality water body has a higher market value than if the water body has lower water quality and that in some cases the entire market value premium (increase) resulting from the waterfront location can be lost as the result of declining water quality.⁷

Many waterfront properties have benefited from measures to clean up the Delaware River and its tributaries including the tidal stretch. For example, the Residences at Dockside in Philadelphia and Christiana Landing in Wilmington are selling condominiums featuring a waterfront view for up to \$1.5 million.⁸ In downtown Wilmington, the waterfront has been completely modernized with new town homes, restaurants, museums, and shopping in an effort to stimulate a city renaissance providing access to the River.⁹ These are big changes in cities where only a few decades ago the River was blocked off and primarily used by industries and port operations. Aesthetically appealing and clean rivers are an asset to property values along the Delaware.

❖ Healthy Environments Protect Our Communities

Trees, shrubs and naturalized lands, whether along a water body or inland, provide a number of benefits in addition to increased market value and marketability of properties. They provide critical protections to the health of our streams and rivers as well as to our communities through pollution filtering, flooding and natural disaster protection, and erosion prevention.

Healthy Environments are Pollution Filters

Vegetation such as trees, shrubs, and deep rooted plants, filter pollution out of water runoff, protecting our streams from potential contamination and our communities from the cost of cleanup. Sediment and pollutants are trapped by the structure of a forest floor and by plant communities. The natural vegetation slows the flow of runoff, allowing a greater opportunity for sediment and pollutants to settle and/or be absorbed by plants and soils, before the runoff enters a stream, wetlands or other waterway. At the same time, plants via their root systems take up pollutants.¹⁰ Nitrogen, phosphorous, pesticides, sediment, sulfates, calcium, magnesium, and herbicides are among the many contaminants that healthy plant communities can remove from runoff before it is allowed to pollute our streams and water supplies.¹¹ Trees absorb air pollution and help maintain air quality. The shade provided by trees reduces heat, which reduces cooling costs for property owners and protects aquatic life.



BUFFER. VEGETATED STREAMS PROVIDE POLLUTION FILTERS, FLOOD PROTECTION, AND EROSION PROTECTION TO MAINTAIN STABLE BANKS

VEGETATED BUFFER

Vegetated buffers are the banks and adjacent lands of waterways and wetlands with trees, shrubs, and deep rooted plants that act to prevent erosion and trap sediment, while providing habitat, food, and shade for aquatic life and animals, acting as natural filters for pollutants, absorbing floodwaters and providing distance needed to protect communities from flooding

Whether you live along a body of water or inland, naturalizing your property to receive all of these benefits also increases the value of your home and property. In a survey conducted by the National Association of Home Builders, 43% of home buyers paid a premium of up to \$3,000, 30% paid premiums of \$3,000 to \$5,000, and 27% paid premiums of over \$5,000 for homes with trees.¹² "Two regional economic surveys documented that conserving forests on residential and commercial sites enhanced property values by an average of 6 to 15% and increased the rate at which units were sold or leased."¹³

Living nearby healthy plant ecosystems also increases property values. One study found that homes within 1,500 feet of a park sold for \$1,600 more than properties further away from naturalized areas.¹⁴ Similarly, the study found that property values go up for homes within 1,500 feet of a wetland by an average of \$37 per acre.¹⁵ "Pennypack Park in Philadelphia is credited with a 38% increase in the value of a nearby property."¹⁶

Not only are homeowners economically benefitted when they plant trees on their properties, but the host communities are too. "It has been conservatively estimated that over \$1.5 billion per year is generated in tax revenue for communities in the U.S. due to the value of privately-owned trees on residential property."¹⁷

Healthy Environments Protect Us from Natural Disasters

Flooding in the watershed causes significant damage to public property, private property, and measurable economic injury for towns and cities. Hurricanes, severe thunderstorms, heavy rains, and snowstorms affect the Delaware River watershed and its residents. In areas lacking proper floodplain protection and riparian buffers, high water levels can create dangerous situations that are devastating emotionally, physically and financially, while resulting in damage to residents, communities, the River and all who rely upon it.

Vegetated areas encourage the infiltration of rainfall, protecting the region from the impacts of flooding and drought. The infiltrated water replenishes groundwater, which in turn provides healthy base flow to streams and the River, and feeds drinking water aquifers. Soaking this water into the ground also means it does not turn into non-natural stormwater runoff that contributes to flooding. Using manmade structures to try to prevent stormwater runoff and flooding is costly and much less effective than supporting the same action by nature.



NEW HOPE, PA CONDOMINIUMS INUNDATED DURING THE JUNE 2006 FLOOD. THESE RESIDENCES WERE BUILT BETWEEN THE DELAWARE CANAL AND RIVER, IN A FRAGILE ENVIRONMENT SURROUNDED BY WATER WITH NO RIPARIAN BUFFERS OR PROTECTION FROM OR FOR THE RIVER.

"Floods have been, and continue to be, the most destructive natural hazard in terms of economic loss to the nation, as well as the cause of hundreds of deaths in communities across the nation"

..... testimony from William O. Jenkins, Director of Homeland Security and Justice, 2004

Flood response and emergency services costs are of increasing concern to our region and nation. In its long history, Delaware River flooding has not only cost homeowners and municipalities millions of dollars, but the taxpayers of the entire state and nation pay the price. Responding to a flood requires a variety of emergency service operations and personnel including police and fire departments, local and county municipal services, and cleanup efforts. After a flood, communities must be provided temporary housing, food, and water. There must also be an investment of time and resources in providing ongoing information and assistance to flooded communities. Clean up after a flood often requires "hundreds of workers to renovate and repair, or tear down and dispose of, damaged or destroyed structures and materials."¹⁸ Flooding destroys public and private utilities. Repairing damaged power lines, roads and bridges, gas pipelines, water treatment and storage facilities, and heating and cooling systems can make the cost of clean-up insupportable.



NOT ONLY DOES PROPERTY SUFFER DURING FLOOD EVENTS, BUT THE RIVER SUFFERS AS WELL. ALTHOUGH FLOODS ARE A NATURALLY OCCURRING PROCESS FOR RIVERS, NON NATURAL STRUCTURES, LITTER, AND ANYTHING THAT FLOOD WATERS COME IN CONTACT WITH IS CARRIED INTO THE RIVER, POLLUTING IT.

Other often unrealized expenses include health threats, and the cost of lost food and polluted drinking water. Repair, renovation and demolition operations that must occur in the wake of a flood often generate airborne asbestos mineral fiber that can cause chronic lung diseases or cancer.¹⁹ Inhalation of asbestos can cause lung disease that can be fatal.²⁰ Lead is another dangerous toxin that can be released during repair, renovation or demolition operations. If inhaled or ingested, lead can cause damage to the nervous system, to the kidneys, to blood forming organs and to the reproductive system.²¹

After a flood, it is recommended that foods that came into contact with flood waters be discarded, and that all water should be considered unsafe until communities have been notified otherwise. These can be costly hardships for communities recovering from a flood.²² Flooding can result in the growth and

transmission of fungi such as mildew, mold, rusts and yeasts which can cause illnesses.²³ Some forms of the fungi can cause skin, respiratory and other disorders.²⁴ Waterborne illnesses caused by bacteria, viruses and protozoa in drinking water are additional concerns in the wake of a flood.²⁵

Flooding pollutes rivers with accumulated chemicals and debris from roadways and cities. Thunderstorms and hurricanes often lead to “Boil Water Advisories” as the result of sewage overflows at water treatment facilities. It is recommended that people boil all water for at least three minutes before consuming, making ice, feeding pets, washing dishes, brushing teeth, or rinsing food. These advisories can be expensive, as well as the added cost of having to buy treated/filtered water. When flooding occurs, recreation is halted and ecotourism harmed. The loss of business to a community or region can be significant.

In developed areas, rainwater rushes off impervious surfaces such as parking lots, roads, rooftops, hard-packed and chemically treated turf lawns, playing fields, golf courses and unstable farm fields into detention basins and storm systems that dump it, generally untreated, directly into streams, wetlands, lakes, and rivers and onto downstream communities. As development increases, the volume of stormwater increases and flooding worsens.

In natural forests and meadows, rainwater is absorbed into vegetated soils, feeding plant life, recharging aquifers and wetlands and maintaining stream base flow and waterway health. The volume of stormwater runoff is reduced. Naturally vegetated areas protect communities from increasing flood damages, the need for flood response services, and the need for flood damage payouts.

HIDDEN COSTS OF FLOODING

Floods bring serious emotional harm to affected homeowners and communities in crisis. Following a flood disaster, people are engaged in the response and helping one another to cope. Later, feelings of panic, anger, anxiety, disorientation, and despair emerge. The full force of emotions often hit after the flood waters have receded. Exhaustion, grief, desperation and depression can then set in.

The prolonged stress caused in the wake of a flood can lead to difficulty sleeping, irritability and outbursts of anger, difficulty concentrating, painful emotions, or post traumatic stress disorder.

Children can be more deeply affected than adults, experiencing nightmares, fear, anxiety, increased physical pain such as headaches and stomach aches, a decline in their academic performance, difficulty sleeping, even suicidal tendencies.

Accessed June 9, 2008 West Virginia Division of Homeland Security and Emergency Management www.wvdhsem.gov



TINICUM, PA DRN RECEIVED FUNDING TO DEVELOP RESTORATION AND MANAGEMENT PLANS FOR 2 MILES OF TINICUM AND RAPP CREEK. THE PLANS WILL ADDRESS INCREASES IN STORMWATER RUNOFF, FLOODING, STREAM BANK EROSION AND THE LOSS OF RIPARIAN BUFFERS. TREES AND WOODY SHRUBS NATURALLY PROVIDE FLOOD FLOW REDUCTION.

A loss of tree cover over a 15 year period (1985 to 2000) in Bucks, Montgomery, Delaware, and Chester Counties, Pennsylvania and Mercer, Burlington, Camden and Gloucester Counties, New Jersey, reduced the ability of the Delaware watershed region's urban forests to "detain almost 53 million cubic feet of stormwater, a service valued at \$105 million."²⁶ Despite that diminishment, this same region "stored 2.9 billion cubic feet of stormwater in 2000, valued at \$5.9 billion."²⁷

Existing tree cover was found to prevent 65 million cubic feet of stormwater runoff in the Big Timber Creek watershed (New Jersey) saving the community \$3.3 billion in stormwater infrastructure. In the Cobbs Creek watershed (Pennsylvania) existing tree cover prevented 20 million cubic feet of stormwater runoff saving the community \$1 billion in stormwater infrastructure.²⁸

In the Mill Creek watershed (New Jersey) existing tree cover prevented 6.7 million cubic feet of stormwater runoff saving the community \$350 million in stormwater infrastructure. And in the Frankford-Tacony watershed (Pennsylvania) existing tree cover prevented 38 million cubic feet of stormwater runoff saving the community \$2 billion in stormwater infrastructure. This tremendous savings translates into \$176,052,455 per year of benefit/savings for this part of the Delaware River watershed community.²⁹



VALLEY CREEK, CHESTER COUNTY, DRN ASSISTED OPEN LAND CONSERVANCY AND RESTORED THIS STREAM REACH WHICH HAD BEEN DEVASTATED BY EROSION.

FLOODPLAIN

The floodplain is the low, flat, periodically flooded area adjacent to rivers, lakes, and oceans. Natural floodplains absorb water, filter it, and help it to infiltrate the soil rejuvenating groundwater aquifers for drinking water.

Calculating the benefits of trees on a site-by-site basis further demonstrates that healthy, vegetated watersheds can provide dramatic cost savings for communities. A 3.41 acre commercial site in the Tacony watershed (Pennsylvania) with 2% tree cover and 97% impervious cover provides no stormwater benefits. By comparison, a single family site, 3.19 acres, with a 30% tree cover “provides \$5,454 in stormwater savings”.³⁰ In communities serviced by combined sewer and stormwater systems, where the cost to build additional stormwater infrastructure storage costs approximately \$52 per cubic foot (as compared to areas served by separate stormwater systems where the cost ranges at \$2 per cubic foot for stormwater construction), a 30% tree canopy on a 5 acre residential development site can save over \$308,000.³¹

To reap the benefits of living near a water way, it is important not to encroach on it. While locating homes and certain businesses (such as restaurants, hotels, etc.) with a water view enhances their value, placing them too close to the water does the opposite. Buildings and other structures located too close to our waterways are at risk of flooding and resulting flood damages.

Houses located within the floodplain have lower market values than equivalent houses located outside the floodplain.³² The reduction in value between the two can be as much as 4 to 12% with an average 5.8% reduction in value.³³ Recent flooding creates an even greater reduction in property values.³⁴

A location in the floodplain reduces the value of the home for the seller, and also increases the costs for the buyer. Homeowners located in the floodplain are required to purchase flood insurance. They are also responsible for uncovered expenses associated with cleanup after a flood, and the costs of having to relocate after a flood, temporarily or long term.

Homes and businesses located in the floodplain increase polluted runoff because of this proximity to the waterway. The removal of native vegetation and the creation of impervious surfaces increases runoff that carries into the water every contaminant found there. For instance, homes that meet the minimum standards for floodplain construction can still place an unoccupied garage, driveway, and parking lot in the floodplain. Every time it rains, grease, oil, and any chemicals stored or used in a garage are washed into the river. And in floods, motor vehicles, lawn mowers, and other typical equipment kept in a garage or shed are swept in the floodwaters, sometimes taking the shed along as well.

Infringement on the floodplain reduces river values. Downstream and neighboring communities and businesses lose the enjoyment of beautiful, healthy and clean streams and their risk of flood damage is increased.

While avoiding construction in the floodplain will reduce flood damages and while reducing development impact through effective stormwater management and less impervious surface will reduce the volume of runoff, rivers and streams will always flood their floodplains. As part of the river system natural flood plains provide immense value by allowing river flooding to occur as part of the normal life cycle of a waterway.



BUCKS COUNTY, PA. BANK EROSION FROM EXCESSIVE RUNOFF IN TINICUM CREEK. THE SEDIMENT FROM THIS BANK RUNS DOWNSTREAM MUDDYING THE WATER, SMOTHERING STREAM BOTTOM HABITAT, AND SUFFOCATING FISH, MUSSELS AND OTHER AQUATIC LIFE.

Flood damage claims for three major flood events in the Delaware River Watershed

September 2004: 1,313 claims totaling \$46 million

April 2005: 1,977 claims totaling \$73 million

June 2006: 3,045 claims totaling \$107 million

http://www.state.nj.us/drbc/Flood_Website/floodclaims_home.htm

Healthy Environments Prevent Erosion

Naturalized areas along a water body help prevent the erosion of public and private lands, including the undermining of bridges and roadways. Protection of our streams is much more cost effective than having to restore them once damage is done.

Streams are formed over time by the forces of nature. A stream's physical structure shifts naturally over time but often is forced to change more dramatically or unnaturally due to human intrusion such as increased water runoff, roads, dams, levees, or floodplain disturbance. A vegetated buffer along a waterway protects and supports the banks and other critical parts of a stream's make-up, allowing it to resist erosive forces and remain stable. Forested buffers are the glue that holds together nature's design. The roots hold the riparian lands in place, maintaining the hydraulic roughness of the bank, slowing flow velocities in the stream near the bank.³⁵ Also, the absorption ability of a vegetated buffer, especially when it contains a mix of woody shrubs and trees, slows down the water in high stream flows and soaks up water, reducing in-stream channel velocity and volume during storm events thereby reducing damage to the stream and preventing non-natural erosion.³⁶

In Ohio, the Department of Transportation found that on average it costs between \$3-\$10 per linear foot to preserve a stream, while it costs almost \$300 per linear foot to restore it.³⁷ Protecting our floodplains and buffer areas keeps people from building in the floodplain where they are vulnerable to floods and flood damages while at the same time protecting our public and private lands from being literally washed away.



WETLANDS ARE FILTERS AND BUFFERS FOR RISING WATER LEVELS. THIS AREA IS ALONG BEAVER CREEK, A TRIBUTARY OF OLDMANS CREEK, A NEW JERSEY TRIBUTARY OF THE DELAWARE RIVER.

Protection from the Effects of Global Climate Change

Global climate change is a major threat to our region, nation, and earth. A recent report entitled "Confronting Climate Change in the U.S. Northeast" and an associated New Jersey specific *Executive Summary* found that under one conservative emissions scenario, by the end of the century New Jersey is expected to lose virtually all of its snow cover; that "the frequency and severity of heavy rainfall events is expected to rise"; and that the frequency of short term drought (one to three months) is projected to increase.³⁸ In addition, global climate change is expected to dramatically increase the number of days over 100 degrees communities in our region experience. In the coming decades, communities nearby Philadelphia will begin to experience in the range of 10 days to 30 days that are over 100°.³⁹

Scientists have determined that carbon dioxide, a major greenhouse gas, contributes significantly to global climate change.⁴⁰ Trees are an important part of the solution. Trees store carbon in their leaves, stems, branches, and roots.⁴¹ Other plants, dead plant material, and the organic matter found on the forest floor and in forest soils also store carbon.⁴² Protecting our forests to protect our rivers also helps protect us from global climate change.

A forest which has not been previously logged and has a closed canopy, stores about 250 tons of carbon per hectare in its vegetation and soil.⁴³ Rather than acting as a sink for carbon, this same area if converted to agriculture becomes a source of carbon, releasing about 200 tons of carbon per hectare.⁴⁴ Forests with an open canopy store about 115 tons of carbon per hectare. The same forests release about 29 to 39 tons per hectare if converted to agriculture.⁴⁵ The social costs of emitting carbon (calculated as damage avoided) is about \$34 per ton.⁴⁶ The US Forest Service Northeastern Research Station estimated that forest carbon storage in New Jersey at approximately 38.3 tons per hectare. This means that the 126,606 hectares of NJ State Parks and Forests store 4,849,009 tons of carbon⁴⁷ which would, at the \$34 per ton figure, provide over \$164 million in damage avoidance.

Restoring our floodplains by creating forested buffers along our rivers and streams protects communities from the expected increase in flooding that will accompany changing weather patterns and increased rise of sea level that will result from global climate change. At the same time it provides the quality of vegetation that can be part of the solution for reducing the advance of global climate change by sequestering carbon and filtering air pollution.



NATIVE RIPARIAN PLANTS, GRASSES, AND TREES HELP TO RESTORE DAMAGED STREAMS STRENGTHENING THE BANKS AND CREATING ROOT SYSTEMS.

❖ Businesses Benefit from Attractive Waterfronts

A clean and healthy Delaware River increases the appeal of commercial properties and businesses that benefit from the River as an attraction. On a nice day, people are drawn to the River; riverfront businesses gain an increase in customers and foot traffic based on their location. Riverfront restaurants, art galleries, inns, Bed and Breakfasts, charter fishing boats, coffee shops, and retail shops all benefit from a proximity to the River and parks when they are clean and attractive.

Restaurants

At the riverfront in downtown Philadelphia, Moshulu has transformed a historic four masted sailing ship from the early 20th century into a fine dining restaurant docked at Penn's Landing. The restaurant is one of many fine dining experiences that may be enjoyed along the Delaware River. The Spirit of Philadelphia is a riverboat cruise that combines the beauty of the River, the spirit of the City, and a buffet dinner and a show for around \$65 per person. River cruises like this one are not uncommon to the Delaware River.⁴⁸ The Liberty Belle docked in the Navy Yard offers a similar experience and can be rented out for weddings or other large events for up to 600 people; people pay more than \$6,000 for this Mississippi style riverboat to enjoy their evening on the River.⁴⁹



NEW HOPE, PA. THE LANDING RESTAURANT FEATURES RIVERSIDE DINING WITH VIEWS OF LAMBERTVILLE, N.J AND THE DELAWARE RIVER.



NEW HOPE-LAMBERTVILLE BRIDGE. PEDESTRIANS CAN WALK OVER THE DELAWARE RIVER FOR SHOPPING AND DINING ON EITHER SIDE OF THE RIVER. GOURMET RESTAURANTS, ANTIQUE SHOPS, CRAFT GALLERIES, SALON BOUTIQUES, AND UNIQUE JEWELRY STORES BENEFIT FROM A STEADY FLOW OF CUSTOMERS.

Along the lower Delaware the Bucks Bounty, Bridge Café, Landing Restaurant, Indian Rock Inn, and Center Bridge Inn are all restaurants that people drive to from miles away to enjoy the views of the River, the sounds of the water, and the aesthetics of nature and history.⁵⁰ Restaurants along the Delaware River in Lambertville and New Hope are able to attract visitors throughout the region for the scenic river views, walkable bridge, and historic towns.

Rojo's Roastery in Lambertville brews organic and fair trade coffee for pedestrians that stroll in from walking along the River and through town. The River Horse Brewery in Lambertville uses water directly from the Lambertville Reservoir of Swan Creek, a tributary of the Delaware River. The microbrewery has been located along the banks of the Delaware River since 1996 and distributes all natural beer throughout the northeast, Delaware, and Maryland.⁵¹



Case Study: The Delaware River Art Gallery Yardley, PA

The Delaware River Art Gallery holds exclusive and historic pieces of artwork that focus on the life and beauty of the Delaware River, mostly by local artists. Located in historic Yardley, Pennsylvania the Gallery celebrates life on the Delaware as well as the beauty of the River itself.

Dale Woodward, owner of the Delaware River Art Gallery says that although much of the business comes from people strolling along the River through Yardley who decide they want to

remember the view of the Delaware through art, even more business comes from the people who actually live in the area. Residents of Yardley enjoy daily views of the Delaware, a River many of them have grown up on, and artwork of the River is a prized possession.

Inns and Hotels

The Black Bass Inn was one of the first taverns in Bucks County. It is located in the river town of Lumberville.⁵² Currently, the Black Bass resides as an upscale restaurant and inn.⁵³ Situated close to the Delaware, people come to the restaurant for the views of the River below. The Lumberville footbridge connects the town to Bulls Island State Park for an after dinner stroll or as a take out for kayakers and canoeists wanting a good meal.⁵⁴

Chestnut Hill Inn on the Delaware consists of two romantic Victorian houses overlooking the scenic river in Milford, Hunterdon County, NJ.⁵⁵ The guest rooms exude a sense of warmth and romance no matter what season you visit. All rooms have access to the beautiful riverfront terraced gardens, deck, and dock. River access is nearby so guests can bring their boat, canoe, kayak or tube. Many guests enjoy bringing their lunch or dinner back to the Inn to dine along the River's edge.

The Bucks County Bed and Breakfast Association of Pennsylvania is supported by many Delaware River bed and breakfasts throughout Bucks County. Most of the inns and restaurants are restored homes built in the 19th century and contain the river charm people seek for getaways, retreats, and important events.⁵⁶

The Lambertville Station Inn located along the Delaware River in Lambertville, New Jersey offers waterfront lodging, dining, activities, and a ballroom ideal for weddings and receptions.⁵⁷ Every room located at the Inn has a scenic waterfront view. The ballroom is made of three glass walls offering river observation from every angle, giving the inside an impression of the outdoors.



CHESTNUT HILL INN ALONG THE DELAWARE RIVER IN MILFORD, NJ INNS LIKE CHESTNUT HILL ARE APPEALING BECAUSE OF THEIR PROXIMITY TO THE RIVER AND THE BEAUTY AND ACTIVITIES THE RIVER PROVIDE. PHOTO

Among the many hotels, lodges, and inns throughout the watershed, accommodations along the River with a waterfront view are priced higher than hotels without. (see figure: 1)



Figure 1: Hotel Room Prices With and Without a River View

Figure 1 shows a range of hotels along the Delaware River that offer both views of the riverfront and rooms without views of the riverfront. The range between the two demonstrates that people are willing to pay more for a view of the River. At the Cape May Grand Hotel located near the mouth of the Delaware Bay, a room with a waterfront view costs \$227 per night, while a view on the opposite side of the same hotel costs only \$192 for the same night.⁵⁸ The Hyatt Regency in Philadelphia also increases the price on rooms with a view, charging \$247 for a king size bedroom without a River view as compared to \$282 for a king size bedroom on the waterfront.⁵⁹ Up river at the Bridgeton House in Upper Black Eddy, prices can be found for nearly \$100 more with a Delaware River view.⁶⁰ And the historic Penn's View hotel in Philadelphia charges \$289 for its rooms with a Delaware River view, which are also suite style rooms; the lower level rooms can be purchased for as low as \$145 per night; a difference of \$144.⁶¹

River Recreation

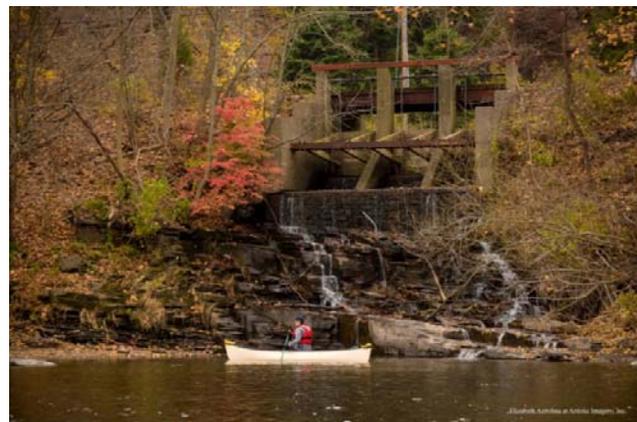
River Recreation

- ❖ The Broad Array of Recreation on the Delaware River
 - ❖ Diverse Boating for Recreation and Sport
 - ❖ Swimming and Biking Along the Delaware
 - ❖ Leisure Fishing
 - ❖ Birding and Wildlife Watching
 - ❖ Parks and Wildlife Refuges
- ❖ Community Attractions Focused on Enticing Ecotourism

❖ The Broad Array of Recreation on the Delaware River

Recreation is fundamental to individual, family and community quality of life. Recreation provides jobs, stimulates and supports the economy, brings tourists and outside revenue into the region, and it enhances the quality of life of those enjoying it.

On the Delaware River recreational possibilities abound and include all types of boating, fishing, bird watching, hiking, biking, tubing, jogging, swimming, camping, and wildlife viewing. Keeping the river healthy, and restoring health where it has been lost, will allow these recreational activities to prosper.



PADDLER CROSSING A DELAWARE RIVER CANAL OVERFLOW IN SMITHFIELD, PA ON THE DELAWARE RIVERKEEPER NETWORK'S NOVEMBER 2008 BUSINESSMAN'S CANOE TRIP. PHOTO CREDIT: ELIZABETH AZZOLINA 2007

Outdoor recreation keeps people physically and mentally healthy and productive, enhancing the body and the mind. In a survey of Delaware River Valley visitors,⁶² almost all recreationists stated that the River provided a source of mental and physical refreshment.

RECREATION

Recreation along the Delaware River includes boating, fishing, bird watching, hiking, biking, tubing, jogging, swimming, camping, and wildlife viewing.

Many rural river towns are supported by seasonal tourist revenue.⁶³ Recreation is a \$730 billion annual contribution to the United States economy.⁶⁴ In New York, New Jersey, and Pennsylvania alone, the total economic contribution of outdoor recreation exceeds \$38 million annually, generating over 350 thousand jobs and adding additional economic sales and tax revenues of more than \$32 million.⁶⁵



CANOING THE DELAWARE RIVER AT FRENCHTOWN, NJ DRN HOLDS AN ANNUAL BUSINESSMAN'S CANOE TRIP IN THE FALL FOR MEMBERS AND STAFF TO ENJOY THE RIVER BEFORE WINTER AND WHILE THE LEAVES ARE BRIGHT AND COLORFUL. PHOTO CREDIT: ELIZABETH AZZOLINA 2007

According to the Outdoor Industry Foundation, “more Americans paddle (canoe, kayak, raft) than play soccer”, and “more Americans camp than play basketball”.⁶⁶ The U.S. Fish & Wildlife Service reports that in 2006 fishing was the “favorite recreational activity in the United States” with 13% of the population 16 and older (29.9 million anglers) spending an average of 17 days fishing in that year alone.⁶⁷ As a result, in 2006, “anglers spent more than \$40 billion on trips, equipment, licenses and other items to support their fishing activities.”⁶⁸ Of this, 44% (\$17.8 billion) was spent on items related to their trips, including food, lodging and transportation.⁶⁹

These national trends and figures are consistent in the Delaware Valley. According to the New Jersey Department of Fish and Wildlife, New Jersey state parks received 12 million visits in one year (1994) statewide, with wildlife recreation, fishing and hunting responsible for 75,000 jobs and generating \$5 billion in retail sales.⁷⁰ Valley Forge Historical Park, through which the Schuylkill River and tributary streams flow, created 1.23 million recreation visits in 2001 with park visitors spending “\$33.3 million dollars within an hour’s driving distance of the park, generating \$10.4 million in direct personal income (wages and salaries) for local residents and supporting 713 jobs in the area.”⁷¹



Figure 2 Water Recreation Revenue in PA, NY, & NJ

For many, the Delaware River evokes a “strong feeling of affection, loyalty, and attachment”.⁷² Visitors are attracted to the Delaware River for recreation because of its vicinity to major eastern metropolitan areas as well as its “clean river water, exceptional trout, shad, and eel fisheries, and wildlife to observe.”⁷³

The most popular River activities include boating, fishing, and bird watching. The total economic contribution of fishing in Pennsylvania, New York, and New Jersey exceeds \$3 million.⁷⁴ Another \$2.5 million is supplied from paddle based boating.⁷⁵ Nearly \$2 million is spent on the gear to support these industries with another \$3 million generated from related travel.⁷⁶ In addition, nearly \$750,000 is generated in state and federal taxes on all of these water recreation income streams.⁷⁷ **Figure 2** shows how the amount of money spent on recreation purposes breaks down specifically in the tri-state area.

❖ Diverse Boating for Recreation and Sport

- ***The Delaware is the longest un-dammed river east of the Mississippi, extending 330 miles from the confluence of its East and West branches at Hancock, New York to the mouth of the Delaware Bay where it meets the Atlantic Ocean. Because the Delaware is undammed, it is ideal for popular recreational activities such as canoeing and kayaking. The River is fed by 216 tributaries, the largest being the Schuylkill and Lehigh Rivers in Pennsylvania and the Musconetcong in New Jersey. Boating options throughout the watershed include canoeing, kayaking, rafting, jet skiing, motorboats, paddleboats, different types of historic riverboats and sailing. Even in urban areas, such as the Philadelphia and Camden waterfronts, the popularity of paddle sports is increasing as evidenced by the recent creation of the Tidal Water Trail maps series, public access points, and points of interest.***

Rowing on the Schuylkill

Boating recreation has a recognized history in the watershed. For example, the Schuylkill River traces its rowing culture as far back as the 1830's.⁷⁸ Each year the Schuylkill Navy hosts numerous regattas along the Schuylkill including the Dad Vail, the largest collegiate rowing event in the nation.⁷⁹ In response to the atmosphere of professional rowing of the 19th century, and the gambling and corruption that plagued the sport, the Schuylkill Navy was formed in 1858 to promote amateur rowing and establish rules of behavior.

Today, the Schuylkill Navy is the oldest amateur athletic governing body in the United States and is made up of ten clubs on Boathouse Row as well as high school and college rowing programs.⁸⁰ In 1938, Philadelphia Girls' Rowing Club, the first boat club on the Schuylkill for women, was organized.⁸¹ The first Schuylkill men's club to organize a women's rowing team was Vesper in 1970.⁸²



DINGMANS FERRY, PA AMERICAN CANOE ASSOCIATION HELPING DRN ORGANIZE THE ANNUAL UNITED NATIONS INTERNATIONAL SCHOOL FRESHMAN CLASS CANOE AND CAMPING TRIP ON THE DELAWARE.



PHILADELPHIA, PA ST. JOSEPH UNIVERSITY WOMEN'S ROW TEAM SCHUYLKILL RIVER. ROWING HAS A LONG HISTORY ON THE MAIN STEM SCHUYLKILL RIVER. PHOTO CREDIT: PATRICK CONOLLY 2007

The presence of the Schuylkill Navy and the clubs along Boathouse Row nurtured excellence in amateur rowing for decades. Vesper Boat club, organized in 1865, won gold medals in the eight-oared shell event at the 1900, 1904 and 1964 Olympics.⁸³

Elite level rowers and world class coaches continue to be attracted to the Schuylkill to train. Rowers training in Philadelphia are earning spots on national and Olympic teams including the 5 Philadelphia-area rowers who represented the United States at the 2008 Olympics in Beijing.⁸⁴

In addition to dual competitions among local college crews, more than 20 regattas are held on the Schuylkill each year from April through November.⁸⁵ These regattas include the

Independence Day Regatta, the largest summer club regatta in the United States (over 1,400 competitors in 2008)⁸⁶; the Dad Vail, the largest collegiate rowing event in the nation (over 3,000 competitors in 2008)⁸⁷; and the Stotesbury Cup, the largest high school regatta in the world (over 5,000 competitors from 177 high school teams in the United States and Canada in 2008).⁸⁸ With thousands of competitors coming to the region for multiple day visits, these regattas result in a significant economic impact for the Philadelphia area. Rowing has become such a strong force in the region that clubs and competitions have expanded to other Delaware River tributaries with regattas now being held on the Cooper River in New Jersey and the Christina River in Delaware.



PHILADELPHIA, PA BOATHOUSE ROW THE SCHUYLKILL REMAINS HEAVILY USED FOR COMPETITIONS INCLUDING NATIONAL REGATTAS AND OTHER ROWING EVENTS. PHOTO CREDIT: GREGORY MELLE

The boat clubs that comprise Boathouse Row have been registered as a National Historic Landmark since 1987.⁸⁹ Boathouse Row has become an iconic image for the City of Philadelphia and tours offering a glimpse into the competitive world of Philadelphia rowing have become an important component of Philadelphia tourism.⁹⁰

Whitewater Kayaking

Those who enjoy whitewater particularly enjoy the Delaware River's upper reaches. In 1986 the Upper Delaware attracted 232,000 whitewater paddlers who spent \$13.3 million, adding \$6.2 million to the local economy and supporting 291 jobs.⁹¹ The Water Gap is a tremendous resource for whitewater paddlers. In 1986 this reach of the River was responsible for attracting 135,400 whitewater paddlers who spent \$6,929,000, contributing \$3,695,200 of local economic value and supporting 156 jobs.⁹²



BUCKS COUNTY, PA TWICE A YEAR RELEASES FROM NOCKAMIXON LAKE TO TOHICKON CREEK CREATES A GREAT WHITEWATER EXPERIENCE THAT IS A FAVORITE AMONG WHITEWATER PADDLERS AND CANOEISTS.

Canoeing on the Delaware

There are more than 20 canoe liveries along the Delaware River, some of which employ over 200 people and have annual attendances of around 60,000-70,000 people.⁹³ The liveries offer a variety of options including canoeing, kayaking, tubing, and rafting. Tubing at Bucks County River Country costs \$18 a trip and whole families can go rafting for \$40-\$50 a day (2006).⁹⁴ With an annual attendance of 60,000 people,⁹⁵ this creates estimated gross revenue of between \$648,000 and \$3 million.

Canoe liveries throughout the watershed cater to family fun. There are few other full day activities that families may experience together for as little as \$50. These activities allow for education and appreciation of the River while relaxing, fishing, reading, and sunbathing.

Clean and healthy water is essential for the survival of canoeing businesses. The threat of pollution or contaminated water turns many families away for health and safety reasons. When it was learned that the Village of Deposit was discharging 450,000 gallons per day of chlorinated raw sewage into the Delaware River during the summer months (July-August), 2006, it was recognized immediately as a threat to recreation along the River. An alert about the discharge from the Delaware Riverkeeper Network inspired numerous calls for immediate action. Calls to regulatory agencies, letters from the community, and news

articles about the discharge and its threat to the community and recreation prompted swift action from the agencies to stop the discharge. This type of pollution incident can damage the river's reputation even after the event is abated.

Flooding along the Delaware River in recent years has closed down canoe and boating liveries for weeks at a time. Peak livery operations last only 3 months out of the year, so summer flooding threatens these small businesses with relatively small profit margins.⁹⁶ High waters can be dangerous for boaters and swimmers by causing rapid water flow and adding obstacles and debris to the current.

Keeping the riversides and a campgrounds clean are important in attracting tourists to the region. Recognizing this Kittatinny Canoes near the Delaware Water Gap National Recreation Area hosts an annual river litter clean up that brings in people from all over the watershed to pull tires, paper, plastic bottles, and roadway trash from the River.



DELAWARE WATERGAP FOR THE PAST 18 YEARS, DELAWARE RIVERKEEPER NETWORK HAS ORGANIZED A 3 DAY CANOE AND CAMPING TRIP FOR THE FRESHMAN CLASS OF THE UNITED NATIONS INTERNATIONAL SCHOOL FROM NYC. FOR MANY IN THE GROUP OF 100+, IT IS THEIR FIRST TIME IN A CANOE OR CAMPING IN THE WOODS.

Location	Canoe Liveries
Pennsylvania	Adventure Sports Canoe & Raft Trips Bucks County River Country Chamberlain Canoes Kittatinny Canoes Pack Shack Adventures Portland Outfitters River Country Shawnee Canoe Trips Shohola Campground Soaring Eagle Campgrounds Sylvania Tree Farm Camping Two River Junction
New Jersey	Delaware River Rafting & Canoeing Delaware River Tubing GreenWave Paddling Lazy River Outpost Paint Island Canoe & Kayak Phillipsburg River Outpost
New York	Ascalona Campground Catskill Mountain Canoe and Jon Boat Rentals Cedar Rapids Kayak & Canoe Outfitters Inc Deer Run Rustic Campground Delaware River Trips Indian Head Canoes & Rafts Jerry's Three River Campground and Canoes Landers River Trips Red Barn Family Campground Silver Canoe Rentals Upper Delaware Campgrounds, Inc. Whitewater Willies Raft & Canoe Rentals, Inc. Wild & Scenic River Tours & Rentals

Figure 3: Canoe Liveries Along the Delaware River Main Stem⁹⁷

Whitewater clubs and paddling clubs throughout New York take advantage of the nearby river attractions. The Canoe and Kayak Club of New York plans trips almost every weekend of the fall, spring and summer through Upper Delaware tributaries and headwater streams.⁹⁷ The Mongaup and Lehigh Rivers are favorites for clubs that frequent both the Delaware and Hudson River watersheds.⁹⁸

To the delight of Whitewater enthusiasts, Lake Nockamixon makes 2 whitewater releases each year into the Tohickon Creek at Ralph Stover State Park in Bucks County, Pennsylvania.⁹⁹ The course can be challenging for even the most avid kayakers. The creek contains several drop-offs, high rock cliffs, class III and IV rapids, and some of the most beautiful landscapes in southeastern Pennsylvania.¹⁰⁰ Boundless Philadelphia, a Philadelphia based tourism website warns, “don’t be surprised to find the water somewhat crowded.” “This is a favorite among paddlers all over the Northeastern US.”¹⁰¹

Kayakers and paddlers take advantage of the still water reservoirs in New York and the upper Delaware. The Swinging Bridge reservoir and Mongaup Falls reservoir together span almost 1000 acres.¹⁰² These recreational hot spots are free to paddlers and hikers; anglers can catch Largemouth Bass, Chain Pickerel, and Panfish.¹⁰³ The Mongaup Falls reservoir is trout stocked.¹⁰⁴ The Mongaup Falls Reservoir Park is known as a prime location for Bald Eagle watching and contains designated bird observation areas.¹⁰⁵

Boating of all types is important for residents of the watershed and tourists. Tourists are attracted to the region; historic attractions are maintained; jobs are created; and valued recreation, vacation, environmental education and family interactions are nurtured along the River.



Case Study: Canoe Designer and Photographer Harold Deal

Harold Deal's ancestors have been residents of the Delaware River for centuries. One of those ancestors, Daniel Bray, collected Durham boats for General Washington's army allowing them to cross the Delaware River aiding in our country's independence. Harold has grown up on the Delaware and knows its ebbs and flows in all seasons. He once continuously paddled the 200 miles from Hancock to Trenton without any sleep or rest. This intimate knowledge gained from the flow of the Delaware River and its tributaries enabled him to become a semi-professional paddler, designing and building prototype models for performance canoes and paddles used for recreational paddling and racing. Harold's whitewater skills led to 24 first-place finishes at Whitewater Open Canoe National Championship events held around the United States.

“After so many years of paddling, I know how a canoe's shape will respond in the dynamics of a flowing river. My relationship with boating manufacturers from recreational paddling and whitewater racing over the years allowed me to develop and market my own concepts for canoes and paddles that are being produced today”, said Deal.

Deal lives along the Delaware River in Upper Mount Bethel Township with his wife Bets. He is able to keep an eye on the river and regularly frequents his favorite sections of the Delaware and its tributaries year round. “Living in close proximity to the river has allowed me to immerse myself in a way of life that is connected with the water. Bets and I have a deep appreciation for wildlife and the natural outdoors, and the importance of preserving a clean and healthy watershed system”.





BRISTOL, PA THE BRISTOL RIVERBOAT QUEEN DOCKED ALONGSIDE THE DELAWARE RIVERFRONT IS A REPLICA STEAMBOAT THAT TOURS THE MANSIONS OF BRISTOL AND BURLINGTON, NJ

Historic Riverboats

Riverboats are a part of the Delaware River's history and offer another kind of boating attraction. Canal boat tours in New Hope and Easton, Pennsylvania keep that history alive. Wells Ferry in New Hope, Pennsylvania offers scenic, narrated tours of the Delaware River's history.¹⁰⁶ Coryell's Ferry, also in New Hope offers narrated tours on a boat with a paddlewheel that departs every 45 minutes in May through October.¹⁰⁷

In Burlington, New Jersey, county officials have attempted to spark tourism through offering a historical riverboat tour on the Bristol Riverboat Queen, a replica steamboat.

What began as a one day event has transformed into a regular summertime weekend adventure. More than 1,500 people showed interest in the tour of the Burlington and Bristol mansions and factories that can only be viewed from the River itself.¹⁰⁸ The boat holds 100 people, and every trip is filled to capacity.¹⁰⁹

The Bucks County Riverboat Company offers a 52-foot long pontoon boat for scenic and historic rides along the Delaware while serving dinner for more than 70 guests at a time. The pontoon boat can be chartered for special events at a cost of \$1,375 for four hours.¹¹⁰ It is rented out regularly on weekends throughout the summertime months. This riverboat and the Delaware River Steamboat floating classroom offer environmental education seminars for local public and private schools, families, college students, and youth groups.¹¹¹

❖ Swimming and Biking along the Delaware

The Delaware is a safe and fun haven for swimmers and the canal towpaths create perfect biking trails. Swimmers enjoy Delaware River and tributary waters at a number of locations that may not be official access points, but community-made put-ins where kids and adults can appreciate the cool water during the hot summer.



CAPE HENLOPEN, DE KIDS SWIMMING DURING DELAWARE RIVERKEEPER NETWORK'S ANNUAL MEMBERS DAY AT THE BAY DAY AT THE BEACH. THE BAY OFFERS MORE SECLUSION THAN THE JERSEY SHORE, WITH JUST AS MUCH FUN.

Some popular Delaware River swimming holes are located at Bulls Island just north of New Hope and Lambertville, Farview in Stroudsburg, Flatbrook and Milford swimming holes in Milford, and at the Trestle Bridge in Columbia, New Jersey.¹¹² Popular swimming lakes include Crater Lake and Highlands Natural Pool.¹¹³ Creeks and brooks with reportedly good swimming spots are at the Devils Pool on Cresheim Creek in Mt. Airy Pennsylvania, the Brandywine in Chadd's Ford, and Otter Hole in the Posts Brook in New Jersey.¹¹⁴ The Musconetcong Wild and Scenic River enters the Delaware at Riegelsville, New Jersey and plays host to popular swimming holes throughout its length. Some of these lakes and swimming holes are in the most beautiful secluded spots of the watershed. Many have warnings about jumping from high up into shallow water and watching out for dams or big rocks.¹¹⁵ After

heavy rain, due to polluted runoff, many areas are better left off limits for swimming and other water contact recreation for approximately two days to allow water quality to clear up.

Besides swimming holes, there are also a few remaining Delaware River beaches where swimming continues. Historically, swimming in the River was a popular summertime activity. Smithfield Beach and Milford Beach in Milford, Pennsylvania maintains a lifeguard on duty during the summer months. In the Delaware Bay, Cape Henlopen, Dewey Beach, Cape May, and several other spots are popular for tidal salt water beaches without the crowds of the Jersey Shore or Delaware beach hotspots. To many towns, beaches are a vital part of the local economy.

Bicyclists have a number of scenic options that take them close to water. The Delaware and Raritan Canal trail is a perfect bicycling adventure. It travels along the historic Delaware River canal towpath for 27 miles from Frenchtown to Trenton, New Jersey.¹¹⁶ The canal on the Pennsylvania side of the River offers a similar experience close to the water for over 60 miles from Easton to Bristol.¹¹⁷ Bikers, runners, and families with strollers, appreciate the trails. The River to River scenic Bicycle tour from Montgomery County to Bucks County, Pennsylvania offers both recreational and professional cyclists with 25-, 50-, or 100-mile cycling routes along roads through scenic old towns, rivers, and parks.¹¹⁸

The Delaware River Scenic Byway is a scenic driving experience traveling along Route 29 between Trenton and Frenchtown, New Jersey, and along Route 32 that parallels the River through Bucks County in Pennsylvania. Motorcyclists and bicyclists also enjoy the scenic rides and views¹¹⁹ and cycling opportunities continue to expand from the Poconos (the MacDade Trail) to the Camden City Waterfront (Camden Greenway Trails).

❖ Leisure Fishing

The Delaware River is known for its world class fisheries. Both commercial and recreational fishing abound on the River and help support local economies. Fish commonly found in the Delaware River include Striped Bass, Trout, and Large and Smallmouth Bass. Other fish present in the River include Weakfish, American Shad, Sturgeon, Catfish, Pike, Bullhead, Perch, Walleye, and Sunfish. A 1996 survey found that 31,390 anglers spent 265,970 days fishing just the New York reaches of the Delaware River.¹²⁰

Shad Fishing

The American Shad is deeply rooted in the foundation of the cities and towns throughout the Delaware River watershed. The Shad is a “major part of the river’s ecology and has played an important role in the river’s early commercialization, development, and tourism.”¹²¹ American Shad are born in freshwater. After hatching in spring, they feed on plankton and aquatic insects before migrating towards the ocean.¹²² After four to seven years in the ocean the Shad return to their place of birth to spawn in the fresh waters of the Delaware River and upriver tributaries.¹²³



JUVENILE SHAD SEINING. PHOTO CREDIT: NJ DIV. OF FISH & WILDLIFE

The American Shad are celebrated in several cities throughout the watershed during their spring spawn including Fishtown in Philadelphia, Easton, Pennsylvania and Lambertville, New Jersey bringing in people from all over the basin. The annual Shad fishing tournament held each year following the Easton Shadfest charges a \$20 entry fee, and with over 1000 competitors in 2006, the tournament raised \$20,000 in proceeds.¹²⁴ Lambertville’s Shadfest has been an annual part of the community for 26 years, attracting 30,000 to 35,000 visitors during the two day event.¹²⁵ The Shad population has rebounded from decades ago because of renewed efforts to maintain water quality allowing the Shad to make the spawning journey up the Delaware.¹²⁶



LAMBERTVILLE, NJ DELAWARE RIVERKEEPER NETWORK BOOTH FEATURING A REAL AMERICAN SHAD, MERCHANDISE, AND EDUCATIONAL MATERIAL . PHOTO CREDIT: A. WALSH

Shad enthusiasts express their passion for shad fishing through many avenues. The Delaware River Shad Fisherman’s Association actively supports “all things shad”, from tournaments to school education, advocacy and lots of fun events. Find them at <http://mgfx.com/fishing/assocs/drsfa/> or DRSFA, 3907 Boswell Court, Bethlehem, PA.

Trout Fishing

Trout are a world class Delaware River recreational fishery. While there are no dams on the main stem of the Delaware River, there are significant dams on tributaries. Most notable are a series of three dams on headwater streams to the River. Cannonsville Reservoir Dam is on the West Branch of the Delaware, Pepacton Reservoir Dam is on the East Branch of the Delaware, and the Neversink Reservoir Dam is located on the Neversink River; an Upper Delaware tributary.

These reservoirs were constructed to provide drinking water to New York City (located in the Hudson River Watershed). The tailwaters (the water just below the dam) receiving cold water from Cannonsville and Pepacton are widely known for their Brown and Rainbow Trout populations. While brook trout have been present on these headwater streams well before construction of the dams and historically were abundant on the East and West branches, tributaries and upper main stem Delaware River¹²⁷, the trout fishery in the region regained attention in the 1980s “when improved water releases from the water supply reservoirs enhanced the fishery value of these waters.”¹²⁸ Today there is great debate over how to best manage the releases from the reservoirs in order to best support the trout, and while more can be done to benefit the trout, the fishery maintains its national reputation.

It has been determined that in the Upper Delaware, wild trout fishing resulted in \$17.69 million for local business revenue in 1996, that there was \$7.25 million of spending by anglers in Delaware County, New York alone, and that about 41% of this spending remained in the local communities surrounding the tail water fisheries area (Hancock, Deposit, Walton, and Village of Downsville).¹²⁹ The cycling of this 41% of angler expenditures in the region ultimately results in \$29.98 million in local economic activity.¹³⁰ Research has also shown that revenues generated by anglers in this region supported 348 jobs with total wages of \$3.65 million; and provided \$719,350 in local taxes.¹³¹ Other research has shown that multiple towns in the New York reaches of the Delaware River Watershed are benefiting from the clean water and resulting healthy fish populations found in tributary streams.

The Beaverkill and Willowemoc Rivers are credited with providing towns such as Roscoe and Livingston Manor with \$10 million in annual expenditures from their sport fishery.¹³² Friends of the Upper Delaware have reported that the world famous upper Delaware River is a dynamic tourism and economic engine that has not yet reached its potential.¹³³ They estimate that fly-fishing in the region could generate \$58 million per year in economic activity, creating new jobs with virtually no infrastructure or environmental threat, for which there is already a trained work force and where control would remain local.¹³⁴



VALLEY CREEK, PA DRN RESTORATION STAFF COME ACROSS BROOK TROUT AND OTHER WILDLIFE WHILE ASSESSING STREAMS AND CONDUCTING RESTORATION PROJECTS. PHOTO CREDIT: DAVE WILLIAMS

IMPORTANT SPECIES HIGHLIGHT

Dwarf Wedge Mussel (federal endangered)

The mussel is an interesting species. Mussels are *mini filters* cleaning our rivers as the water travels ovetop of the rocks and riffles where they hide. The Dwarf Wedge Mussel is special in particular, because it is now *endangered* due to *poor water quality* and *dams* throughout the eastern US. It can only live in *very clean* streams with little *sediment*, *chemicals*, and a good supply of *coldwater flows* to keep the temperature low even in summer months. The *largest remaining population* of Dwarf Wedge Mussels exists in the Upper Delaware watershed which is good news for *trout anglers*. Not only does mussel presence indicate clean healthy water, but their status as endangered helped remove a dam along the Neversink that threatened their population and continues to protect the waterways from future threats where both species coexist.



Delaware Estuary and Bay Fishing

Fishing in the lower reaches of the Delaware River and Bay is an important aspect of the River and its connection with the community. Children along the docks go crabbing and fish for Herring during the Herring run. Recreational fishermen catch Mackerel, Drumfish, Weakfish, Flounder, Sea Bass, and Striped Bass seasonally in the Delaware Bay.

Urban fishing throughout Philadelphia, Camden, Wilmington and Trenton is a common sight along the River because of available public access and desire from community residents. In 2006, Ron Swegman authored *Philadelphia on the Fly: Tales of an Urban Angler*, a book about the popularity of fly fishing in the Philadelphia area.¹³⁵ In it, Swegman tells stories of different rivers and tributaries where he has successfully been fly fishing. Swegman continues to write about urban fishing spots throughout Pennsylvania in his personal blog and Pennsylvania angler forums.¹³⁶

Urban anglers use spots like naturalized piers and docks throughout Philadelphia, as well as urban parks and bridges to go fishing on both the Delaware and its major tributary there, the Schuylkill. Greenways along major roadways and new parks in urban areas like Trenton attract anglers providing them with a relatively inexpensive meal each trip. (see "FISH ADVISORIES" box)



DELAWARE BAY, DE THESE ROCKY OUTCROPS JUTTING INTO THE BAY MAKE A PERFECT FISHING PLATFORM FOR KIDS AND ADULTS WANTING TO CATCH SOME FISH FOR DINNER OR JUST HAVE SOME FUN.

Figure 4 shows the revenue generated from the sale of state fishing licenses within each of the four basin states. In Delaware, the state with the lowest price for a fishing license, revenue of nearly \$200,000 was generated in 2003. In Pennsylvania, the state earned nearly \$19 million in fishing license revenue from resident and non-resident purchases of fishing licenses. This is not counting all of the 1, 3, and 7 day-passes, or any of the passes simply given away to children at local parks and events. (In Pennsylvania, fishing activities are credited with generating \$4.7 billion per year in revenue and supporting 43,000 jobs.¹³⁷) New Jersey brought in almost \$4 million in revenue statewide from fishing license sales, and New York, with the highest number of out of state fishing licenses sold, brought in almost \$32 million in state revenue.

FISH ADVISORIES

State and National agencies put fish advisories in place in response to contamination found in the fish tissue, generally accumulated from the waters where they live. Because the various responsible agencies do not coordinate or join forces in crafting and releasing fish advisories, in several reaches of the Delaware one side of the River is under advisory for a species while the other is not. Fish advisories impact the perceptions of our River and region and as a result can affect tourism, recreation, and associated commercial activities like dining, overnight stays, and the purchase of associated goods and services. Advisories should be consistent from state to state to both better protect public health and the economies the fish advisories impact. For further rating on fish consumption and the best and worst choices of fish considering environmental factors go to

<http://www.edf.org/home.cfm>



PHILADELPHIA, PA URBAN FISHERMAN OUTSIDE OF VACANT PHILADELPHIA ELECTRIC COMPANY ON DELAWARE AVE AT PENN TREATY PARK. FISHERMAN CAN ALMOST ALWAYS BE FOUND AT THIS SPOT.

STATE	# Fishing Licenses Sold in 2003	Resident Cost	Non-Resident Cost	Total Revenue (Million)
Delaware 138	R: 17,233 NR: 3,331	\$8.50	\$15.00	\$196,445
Pennsylvania 139	R: 777,089 NR: 49,957 O: 67,992	\$21.00	\$51.00	\$18,866,676 (w/o O sales)
New Jersey 140	R: 155,764 NR: 6,763 O: 4,181	\$22.50	\$34.50	\$ 3,738,013 (w/o O sales)
New York 141	R: 842,966 NR: 156,726	\$19.00	\$40.00	\$ 31,882,588

R: Resident NR: Non-Resident O: Other, including lifetime, 3-day, 7-day, and free fishing licenses.

Figure 4: Number of Fishing Licenses Sold in 2003 in Delaware River Basin States

Clean Water for our Food Supply

Fishing the Delaware River is valuable commercially, recreationally and for those families that simply need it to eat. Clean water is critical for supporting the life cycle of fish. But also, it is critical for ensuring that the fish caught from our Rivers are safely edible. Pollutants accumulate in the fat and/or tissue of fish, in some cases building up and increasing in concentration over time. Persistent pollution problems can and do contaminate fish, in some cases making them unsafe to eat.

On the main stem Delaware River there are advisories on more than 9 species of fish.¹⁴² In some sections of the River all fish are subject to advisories.¹⁴³ Fish advisories set limits on the amount of contaminated fish species that should be eaten in order to protect individual and community health. Often elderly persons, children and pregnant women are subject to more stringent limits because of their increased vulnerability to contamination. Exposure to the toxins contained in fish tissue, including methyl mercury, PCB's, chlorinated pesticides and dioxins are colorless, odorless, and can not be revealed through appearance of the fish – therefore knowledge and compliance with fish advisories is critical.¹⁴⁴ Before consuming fish from the Delaware River and Bay, it is important to be aware of the current fish consumption advisories for each state. Many fish in the River are unsafe for pregnant women and the elderly because of contaminants that are still making their way into our streams and rivers. Contact your state's environmental protection agency for the most current advisories and warnings.

"United for The River"



The Delaware River Fisherman's Association is an active, fish-loving membership organization for both NJ and PA fisherman. For their many activities and great reports go to:
www.drfishermen.com/

Or

To learn about some popular fishing spots in the Delaware River Watershed go to
www.delawariver.net/fishing.

If we were able to eliminate pollution to the level that there were no advisories on the Delaware, not only would we be protecting the health of our communities, but we would be enhancing the fisheries of the Delaware and all who rely on them. It is important to note, the issue isn't just reality, it is also perception. Multiple fish advisories create the perception that the Delaware is not clean or safe – the result could be to impact the desirability of the Delaware as a tourism, recreation or home buying destination, and can affect associated commercial activities like dining, overnight stays, and the purchase of associated goods and services.

❖ Birding and Wildlife Watching

The Delaware River and Bay are home to populations of birds, mammals, reptiles, amphibians, fish, insects, and shellfish surviving and thriving in the functioning ecosystems of the region. The plants and animals within the River and its corridor are a major draw bringing tourists from near and far to vacation and experience the beauty of our River and its natural communities. Many Delaware River plants and animals are nationally significant for health, historical, and economic reasons. All of the species within the River deserve to be respected, protected and preserved if they are to continue to exist for future generations.

Because of the River's free flows, its captivating beauty, its vast natural resources, historical significance, high water quality, premier recreation, and natural open space, in 1978 a majority of the non-tidal Delaware River (73 miles extending from Hancock, New York to Milford, Pennsylvania and 40 miles from just south of Port Jervis, New York to the Delaware Water Gap) was Congressionally designated a National Wild and Scenic River of the United States.¹⁴⁵ In 2000, the Lower Delaware from the Water Gap to Washington Crossing, a stretch of 76 miles, was also granted Wild and Scenic designation due to its extraordinary beauty and health. The abundant wildlife and bird watching opportunities within this nationally significant corridor generate a tremendous volume of ecotourism and related business. Many of the species inhabiting the Lower and Upper Delaware are designated as threatened or endangered, demonstrating the fragility and vulnerability of the ecosystems and ecological communities dependent upon the area. **Figure 5** lists some of the diverse species found here. This table is just a sampling of the interesting and valuable species that can be found in the Delaware River Watershed. (Figure is at the end of this section)

In 2006, over 71 million Americans participated in wildlife watching including photography and observation, spending nearly \$45 billion dollars on travel, equipment, food, and lodging.¹⁴⁶ Twenty-three million of the 71 million traveled away from home (more than a mile) to engage in wildlife watching activities.¹⁴⁷ In New Jersey, it has been determined that watchable wildlife attracted 1.9 million participants in a single year.¹⁴⁸

Wildlife viewing creates nearly 500 thousand jobs nationally, and generates \$2.7 billion in federal and state taxes.¹⁴⁹ In Pennsylvania, New York and New Jersey, 31% of the population participates in some form of wildlife viewing.¹⁵⁰ These activities generated an estimated \$1 million in retail supply sales, \$623 million in trip related sales, \$217 million in federal and state taxes, and supported 35,000 jobs.¹⁵¹



KEMPTON, PA BIRD WATCHING FROM WITHIN THE HAWK MOUNTAIN SANCTURAY. BIRD WATCHING IS ONE OF THE FASTEST GROWING FORMS OF RECREATION. PHOTO CREDIT: HAWK MOUNTAIN SANCTUARY

The total economic contribution of wildlife viewing in the tri-state area exceeded \$3 million in the year 2002.¹⁵² The Outdoor Recreation Alliance estimates that New Jersey alone generated nearly \$4 billion from wildlife-related recreation in 2006, and reports that New Jersey ranks number six in the amount of economic activity created by in-state wildlife viewing activities.¹⁵³

Celebrating Birds is a Lucrative Business

Bird watching has become one of the most lucrative forms of recreation in the watershed because of the avian diversity and wealth of attractive viewing areas. Bald Eagles, Ospreys, Red-Tailed Hawks, and migrating shorebirds such as Sanderlings and the Red Knot *rufa* can all be viewed within the watershed. In addition to being among the most lucrative activities for our region, birding is also among the fastest growing. The Center for Rural Pennsylvania issued a report on nature-based tourism in 2003 which listed bird watching up 155% in Pennsylvania; a greater percentage increase than every other form of recreation measured.¹⁵⁴



ONE OF MANY RAPTORS THAT CAN BE SEEN FROM HAWK MOUNTAIN AND OTHER LOCATIONS IN THE DELAWARE VALLEY. RAPTOR POPULATION DECLINES ARE OFTEN DUE TO HABITAT FRAGMENTATION, OR BUILDING HOMES, ROADS, AND RETAIL SPACES ON FORMERLY FORESTED LAND. PHOTO CREDIT: GEORGE WILLIAMS

Hawk Mountain in Kempton, Pennsylvania is a wildlife sanctuary for raptors in the Delaware River Watershed (Lehigh River) eastern Pennsylvania. The preserve is the largest protected tract of contiguous forest in Pennsylvania with 13,000 acres of private and public lands.¹⁵⁵ Mountaintop vistas, hiking trails, and over 25,000 Hawks, Eagles, and Falcons bring visitors year round.¹⁵⁶ The Hawk Mountain sanctuary brought in over \$850,000 in 2005 from visitor fees, memberships, and retail.¹⁵⁷



HAWK MOUNTAIN SANCTUARY KEMPTON, PA NOW HAS 13,000 ACRES OF CONTIGUOUS FOREST PROTECTED FOR RAPTORS AND OTHER WILDLIFE. PHOTO CREDIT: HAWK MOUNTAIN SANCTUARY



Case Study: Nature Photographer Mike Hogan

Michael Hogan,
Professional Nature
Photographer, has
spent decades taking

pictures of the Delaware Bay and Pinelands region. His pictures help in tracking invasive species; producing photographic natural resource inventories for counties and municipalities; and using Geographic Integrated Systems (GIS) technology to document where endangered species exist such as Swamp Pink, a gorgeous flowering wetland plant that remains in only a few remote locations throughout New Jersey. Working with the South Jersey Land and Water Trust and the Rutgers Water Resources Program, and using the USDA Stream Visual Assessment Protocol, Michael has visually assessed 300 stream segments in southern New Jersey for stream health and quality.

Nature photography in the region has led Hogan to become an advocate and active environmentalist for preserving open space in New Jersey. "The habitats and ecosystems within New Jersey are keeping my career afloat. If I wasn't helping to preserve land and wildlife in New Jersey through education, book illustrations, visual stream assessments, and art, I don't know what I'd be doing right now," said Hogan.

Michael's large format, landscape photographs are in public, private, and corporate art collections. In addition, Michael has donated his work to various local nonprofit organizations including the Delaware Riverkeeper Network to help them in their fundraising. In 2005, Michael Hogan partnered with author Robert Peterson to create an illustrated book called "The Natural Wonders of Jersey Pine and Shore." "This book combines years of photographs and prose into one source so that people from all over can see what I see when I'm hiking in the Pinelands or relaxing on the Bay shore" says Hogan. The book was the last from author Robert Peterson who passed away in 2003 just after viewing the final text of the book.

When asked how important southern New Jersey is to him Michael Hogan replied "It's where I live, it's what I care about, and it's my livelihood".

There are many careers supported by the nature and wildlife of the Delaware River Valley. Michael's work can be viewed on his website www.hoganphoto.com.

The Bald Eagle, an emblem of American freedom, spirit, and pursuit of excellence, currently lives and thrives along the protected Upper Delaware River. Explicit Bald and Golden Eagle protection laws, conservation of Eagle habitat, and the banning of DDT and other poisons have been successful in protecting Upper Delaware Eagles.¹⁵⁸ In the United States, Bald Eagle populations have increased from less than 500 nesting pairs in the 1960's to more than 5,000 currently.¹⁵⁹

To celebrate the remarkable comeback of the Bald Eagle, Eagle Fest is an annual winter festival held in Narrowsburg, New York along the scenic Upper Delaware River. The festival draws between 1,500 and 2,500 people from around the region, including residents from New York, Pennsylvania and New Jersey. The local fire Department uses the festival as a successful fundraiser, selling hot dogs and hamburgers; local churches and the Chamber of Commerce help run the event and set up tables for fundraising.

For many local businesses, Eagle Fest brings tourists and visitors to the region in the middle of winter when tourism is relatively low. Festival attendees learn about Bald Eagles and their recovery while they try and catch a glimpse of one flying over the often frozen Delaware River. To broaden appeal, Eagle Fest holds multiple events including lectures, art shows, a live raptor show, Eagle educational exhibits, food, and environmental films. Conservation groups are also invited to participate and share information about their organizational mission and efforts. Ice carvers, wood carvers and other artists are able to exhibit their handy work. Local shops featuring gifts, clothing, antiques, art stores, and even furniture stores not only see greater sales during the event, but see return visitors throughout the year who first came during Eagle Fest. For many local businesses, Eagle Fest brings the best or second best sales day of the year.¹⁶⁰

In New Jersey, the Cape May Bird Observatory holds a Spring Weekend every year offering guided walks, boat rides, nature tours, book signings, movies, speakers, and birding. At the end of the three-day weekend they hold a World Series of birding to discover how many birds each person has counted over the weekend. More than 200 birds have been spotted flying throughout the nature center's premises.¹⁶¹ Bird watchers wishing to enter as a single person or team obtain sponsorships where they receive money for every bird they view and proceeds go to the conservation fund of their choice. The event raises more than \$500,000 annually to support bird conservation efforts and attracts bird enthusiasts from all over the world.¹⁶²



THE AMERICAN EAGLE THE UNITED STATES EMBLEM WAS NEARLY EXTINCT AFTER THE DECADES OF HEAVY PESTICIDE USE AND DECREASING WATER QUALITY IN WATERWAYS LIKE THE DELAWARE RIVER. ITS REMARKABLE RECOVERY IS AN IMPORTANT SUCCESS; ONE THAT SHOULD BE REPLICATED FOR THE MANY OTHER BIRD SPECIES CURRENTLY IN PERIL THROUGHOUT THE US. PHOTO CREDIT: DOUGLAS NORTON 2007



BOWERS BEACH, DE DELAWARE BAY IS HOME TO THE WORLDS LARGEST SPAWNING POPULATION OF HORSESHOE CRABS IN THE WORLD. THE HORSESHOE CRAB IS AN ANCIENT SPECIES DATING BACK OVER 350 MILLION YEARS.



RED KNOT PHOTO TAKEN DURING THE 2008 RED KNOT MIGRATION. RED KNOTS WERE BEING BANDED SO THAT SCIENTISTS COULD TRACK THEIR QUALITY OF HEALTH AND WEIGHT TO BETTER UNDERSTAND THEIR SURVIVAL.

Protecting Birds, Food and Habitats

Delaware Bay is home to the largest spawning population of Horseshoe Crabs in the world. The Horseshoe Crab is an ancient species, dating back over 350 million years. Delaware Bay is also critical habitat to more than 400 species of birds and migrating shore birds.¹⁶³ Each spring, at least 11 species of birds stop over on the Delaware Bay shore to feed on the eggs of the Horseshoe Crab and thereby fuel their annual spring migration, including the Sanderling, Sandpiper, Red Knot, and Ruddy Turnstone.¹⁶⁴

It is estimated that between 425,000 and 1,000,000 birds stop in the Delaware Bay as part of their 3,000 to 4,000 mile migratory journey from their wintering grounds in

South America to their breeding grounds in the Arctic.¹⁶⁵ The bird stop over is ecologically timed to coincide with the spawning of the Horseshoe Crabs, their eggs being a critical food source.¹⁶⁶ The eggs of the Horseshoe Crab are so critical that recent declines in their abundance threaten the survival of the Red Knot (*Calidris canutus*).

In 1982, 95,530 Red Knot were counted on the shores of the Delaware Bay. In 2006 only 13,445 were observed during the same time period¹⁶⁷ and a more recent study continues to show declines and low weight gain for the birds that do arrive to feed on Horseshoe Crab eggs. The Red Knot is now predicted to go extinct because declines in the Horseshoe Crab and



MOORE'S BEACH NJ INTERESTED VOLUNTEERS AND AREA VISITORS WATCH THE ARRIVAL OF THE BIRDS WITH BINOCULARS.

their eggs.¹⁶⁸

Other shorebirds that rely on Horseshoe Crab eggs, such as Ruddy Turnstone (*Arenaria interpres*), Semipalmated Sandpiper (*Calidris pusilla*), Sanderling (*Calidris alba*), Dunlin (*Calidris alpina*) and Short-Billed Dowitcher (*Limnodromus griseus*), have also declined in numbers on the Delaware Bay migratory stop over. These species and Red Knot make up 99 percent of the shorebird concentration in the Delaware Bay and all are primarily dependent upon Horseshoe Crab eggs for their diet.¹⁶⁹

The arrival, feasting and migration of the shorebirds supports a multi-million dollar ecotourism industry. Birding and outdoor enthusiasts from all over the world flock to the Delaware Bay shore to watch the spectacular

feeding frenzy. During their visit they buy recreational-related goods and services, stay in the region's hotels, and visit parks and patronize restaurants and local shops.¹⁷⁰ According to one report, Horseshoe Crab dependent ecotourism generates between approximately \$7 million and \$10 million of spending in Cape May, New Jersey alone, and creates 120 to 180 related jobs providing an additional \$3 million to \$4 million in social welfare value.¹⁷¹ According to a New Jersey Department of Fish and Wildlife report, the economic value of the Horseshoe Crab and migratory bird phenomenon seasonally for the Delaware Bay shore area is over \$11.8 million with over \$15 million of economic value generated if other beneficiaries beyond New Jersey are included. Annually, it provides \$25 million in benefits to the Delaware Bay shore region and \$34 million regionally.¹⁷² Because most of these expenditures occur in the "off-season", it is particularly valuable to local economies.

The fishery use of Horseshoe Crabs as bait for whelk, eel and conch, is highly controversial. Decades of overharvesting and abuse have resulted in a decline in the Horseshoe Crab population to such a level that the Red Knot is predicted to go extinct because of a lack of Horseshoe Crab eggs needed to fuel their annual migration.¹⁷³ Since 1989 Horseshoe Crabs in the Delaware Bay have shown a steady decline with the lowest counts taking place in most recent years.¹⁷⁴ To combat this ecological crisis, many are calling for a moratorium on the bait harvest of Horseshoe Crabs in order to allow the Crabs, the eggs and

the birds to replenish and restore so that all dependent industries can be supported in the future. New Jersey issued regulations that established a moratorium for 2006 and 2007; and in 2008 passed legislation to keep the moratorium in place until the Red Knot population is restored and stable.

INDICATOR SPECIES

Protecting bird species throughout the basin is important for several reasons. Not only is bird watching one of the most popular and lucrative forms of recreation, bringing in tourists from all over the world, but birds are an *indicator species*. Indicator species represent the overall health status of an area through their population numbers and habitats. Healthy rivers are habitat for healthy bird populations. If bird populations begin declining, it can mean that the over all quality of life for an area may be declining as well. Abundance in bird species is a good sign that land condition and air quality are high enough to support ample birds and bird watchers alike.

The continuing existence of the Horseshoe Crab and migrating shorebird phenomenon are vital for the related ecotourism industry. Of those surveyed, only 6.6% said that the Horseshoe Crab and shorebird phenomenon was unimportant to their visitor satisfaction. On average those surveyed said they would be willing to pay as much as \$212.45 (in decreased annual household income) annually for a program to protect these resources; and that they would "be willing to tolerate no more than 50.7% decline in Horseshoe Crabs and migrant shorebirds

before they would cease visiting the Delaware Bay shore area.”¹⁷⁵

Wildlife for Health Protection

Protecting healthy wildlife and aquatic life populations that live in the River provides critical health protections to humans, protections that have economic and social value. A good example is the Horseshoe Crab. The Horseshoe Crabs in Delaware Bay are irreplaceably important to the biomedical industry. In the late 1960's, researchers at Johns Hopkins University demonstrated that special blood properties from Horseshoe Crabs could be used to detect endotoxins.¹⁷⁶ As a result, the U.S. Food and Drug Administration now requires that many intravenous drugs and medical implants be tested for endotoxins using Limulus Amebocyte Lysate (LAL), found exclusively in the blood of Horseshoe Crabs.¹⁷⁷ In addition, LAL is used for detecting diseases including spinal meningitis.¹⁷⁸ No artificial alternatives to the LAL test currently exist.¹⁷⁹ To obtain the blood the Horseshoe Crabs are bled non-lethally,¹⁸⁰ although it has been estimated that between 10 and 15% may die once the Crabs have been returned to their natural environment.¹⁸¹

The U.S. Fish and Wildlife Service valued annual revenues associated with the LAL industry at \$60 million with the social welfare value at \$150 million. One pint of Horseshoe Crab blood is worth \$15,000 to the bio-medical industry,¹⁸² and the industry creates between 145 and 195 jobs in each of the regions it operates (Falmouth, Massachusetts, Walkersville, Maryland and Charleston, South Carolina), contributing \$73 million to \$96 million total to these local economies.¹⁸³ Furthermore, the industry is expected to grow between 8-10% annually.¹⁸⁴ The ecotourism and biomedical benefits of Horseshoe Crabs dwarfs their value as bait in the fishing industry in dollars and number of jobs.



BOWERS BEACH, DE. FEMALE HORSESHOE CRAB MAKING ITS WAY BACK TO THE SHORE FROM THE OCEAN. FEMALE HORSESHOE CRABS ARE LARGER THAN MALES BECAUSE THEIR BODIES HAVE GROWN OVER TIME ALLOWING THEM TO CAPTURE MORE SPERM DURING MATING SEASON. HORSESHOE CRAB EGGS ARE THE PRIMARY FOOD SOURCE FOR MANY MIGRATING SHOREBIRDS IN THE DELAWARE BAY.

SPECIAL SPECIES HIGHLIGHT

American Eel meets the Elliptio companata mussel

The American eel deserves recognition for the journey it makes and the impact it has on the Upper Delaware River. Born in the Sargasso Sea (northern Caribbean-Bermuda region), the American eel travels across the Atlantic Ocean, into the Delaware Bay, and up the undammed Delaware River, which retains one of the largest eel populations in the nation.

Not only does the eel perform this epic journey, but it also supports one of the largest mussel populations in the Upper Delaware, the *Elliptio companata*, mussel which relies on the eel for particular components of reproduction. The *Elliptio* can be found in the millions in the Upper Delaware because of the presence of the American eel.

These mussels have an enormous filtration capacity and are able to filter six times the Delaware's average daily summer flow. With almost 2 million mussels per mile, the clean water benefits we receive from this species interaction are invaluable.



SWAMP PINK IS AN ENDANGERED AND SIGNIFICANT SPECIES IN THE DELAWARE VALLEY. IT CAN BE FOUND IN THE SWAMPS AND MARSHES OF THE PINELANDS REGION OF NEW JERSEY. PHOTO CREDIT: MIKE HOGAN WWW.HOGANPHOTO.COM



JUVENILE AMERICAN EEL MAKE THE JOURNEY TO THE UPPER DELAWARE RIVER FROM THE SARGASSO SEA AND BECOME THE HOST SPECIES ENABLING THE *ELLIPTIO* MUSSEL TO SURVIVE. MUSSELS IN THE UPPER DELAWARE FILTER 6 TIMES THE AVERAGE FLOW PER DAY. PHOTO CREDIT: DOUG AND TIM WATTS WWW.GLOOSKAPANDTHEFROG.COM

<p>Amphibians and Reptiles</p>	<p>Bog turtle (E) Coastal plain leopard frog (E) Eastern mud turtles Loggerhead sea turtle (E) Long-tailed salamander (T) Map turtle Marbled salamander New Jersey chorus frogs (E) Northern diamondback terrapin Red-bellied turtle (T) Timber rattlesnake (E) Wood turtle</p>	<p>Invertebrates and Insects</p>	<p>American Oyster Blue Crab Brook Floater (E) Dwarf Wedgemussel (E) Eastern Pearlshell Eastern Pondmussel (E) Horseshoe Crab Mottled Duskywing Northeastern beach tiger beetle (T) Regal fritillary Tawny crescent</p>
<p>Birds</p>	<p>American Bittern (T) Bald Eagle Barred Owl (T) Bobolink (T) Cerulean warbler Cliff Swallow (T) Common Snipe (T) Common nighthawk Coopers Hawk (E) Grasshopper Sparrow (T) Great Blue Heron (T) Least Bittern (T) Louisiana Waterthrush Northern Harrier (T) Northern Goshawk (E) Osprey (E) Peregrine Falcon (E) Red Headed Woodpecker (T) Red Shouldered Hawk (T) Savannah Sparrow (T) Short Eared Owls Upland Sandpiper (T) Yellow-bellied Flycatcher (T) Prairie Warbler Ruffed Grouse Marsh Wren</p>	<p>Plants</p>	<p>American Purple Vetch Atlantic Sedge (T) Basil Bee-Balm Basil Mountain Mint Bog bluegrass (T) Bush's sedge Eared false-foxglove (E) Grass of parnassus Great St. John's-wart Hemlock Lobelia Lowland brittle fern Missouri goosefoot Nebraska sedge Northern pondweed (E) Pale Indian plantain Prickly pear cactus Rhododendron Serpentine aster (T) Shadblow serviceberry Spreading globeflower (E) Skunk currant (E) Spring coral root Swamp pink (E) Variable sedge (E) Wood aster</p>
<p>Fish</p>	<p>American Shad (T) Alewife American Eel Atlantic Sturgeon (T) Banded Sunfish (E) Bridle Shiner (E) Hickory Shad (E) Ironcolor Shiner (E) Largemouth Bass Muskellunge River Herring Slimy Sculpin Sheild darter Shortnose Sturgeon (E) Smallmouth Bass Striped Bass Tadpole Madtom (E) Threespine Stickleback (E) Trout Walleye Pike White Perch</p>	<p>Mammals</p>	<p>Beaver Blackbear Blue whale Bobcat Canada lynx (E) Delmarva fox squirrel (E) Eastern red bat Eastern woodrat (E) Fin whale Harbor porpoise Hoary bat Humpback whale Indiana bat (E) Keen's bat (E) Least shrew (E) Marsh rat Northern long-eared bat (E) Northern right whale River otter Small-footed bat (E) Sperm whale</p>

(T) Federal or State (PA, DE, NJ, NY) Threatened Species (E) Federal or State Endangered Species

Figure 5: Delaware River Significant Species List¹⁸⁶

❖ Parks and Wildlife Refuges

The Delaware River spans four states. In order to maintain animal habitat, recreational access, and special or significant pieces of land, federal, state and local governments operate and maintain a spectacular array of parks, forests, and wildlife refuges. The national, state, county and local park systems are key elements in the ecotourism businesses and attractions that grace the Delaware River Watershed. The parks provide a public place to view wildlife, canoe, fish, hike, and much more -- they enhance the quality of life for the community, providing job opportunities, and recreational and family activities.

National Parks

Dozens of parks line the banks of the Delaware, with the region's largest federal parks known all over the world. **Figure 6** lists the parks within the Delaware River watershed designated as nationally significant. This includes the nationally recognized Appalachian Trail which stretches from Georgia to Maine, and crosses the Delaware River at the Delaware Water Gap National Recreational Area (DWGNRA.) This crossing of the Delaware River is a "favorite" among the hundreds of people each year who hike the trail from start to finish.¹⁸⁵ The watershed is also home to four national historic sites and two national historic parks and memorials.¹⁸⁶ The United States Department of Agriculture's (USDA) Forest Service has determined that water enhances the value of National Forest Lands nationwide by more than \$3.7 billion a year, not including a number of key economic benefits including maintaining the value of fish species or the savings to municipalities with reduced filtration costs as a result of the protected lands.¹⁸⁷

The Delaware Water Gap National Recreation Area is 67,000 acres and was first acquired by the U.S. Army Corps of Engineers in the 1950's to support construction of the Tocks Island Dam.¹⁸⁸ The dam proposal was defeated after decades of protest and analysis.¹⁸⁹ The land was then transformed into a national recreation area which contains waterfalls, ponds, mountains, river bends, and animals such as Bald Eagles, Black Bears, Timber Rattlesnakes, and Peregrine Falcons.¹⁹⁰ There are a variety of plant species present including Hemlock, Rhododendron, Andropogon gerardii (big bluestem grass) and Prickly Pear Cactus. Water quality in the Delaware River as it flows through the DWGNRA is exceptional, encouraging swimming, fishing, boating, hunting, and hiking.¹⁹¹



THE WILD AND SCENIC DELAWARE RIVER. THE DELAWARE RIVER HAS BEEN AWARDED SPECIAL PROTECTION WATERS STATUS BY THE DELAWARE RIVER BASIN COMMISSION. THE HIGHEST LEVEL OF PROTECTION FOR BEING A CLEAN AND VALUABLE RIVER FROM ITS HEADWATERS THROUGH THE WATER GAP AND BELOW FOR 176 MILES. NO OTHER RIVER IN THE U.S. HAS THIS DESIGNATION FOR A LONGER STRETCH. PHOTO CREDIT: PAUL CARLUCCIO

National Park	Park Type	Location
Delaware Water Gap National Recreation Area	National Recreation Area	Bushkill, PA and New Jersey
Independence National Historic Park	National Historic Park	Philadelphia, PA
Valley Forge National Historic Park	National Historic Park	Valley Forge, PA
Upper Delaware Scenic and Recreational River	Scenic and Recreational River	Pike and Wayne, PA Delaware, Orange, and Sullivan, NY
Thaddeus Kosciuszko National Memorial	National Memorial	Philadelphia, PA
Appalachian National Scenic Trail	National Scenic Trail	GA, CT, MA, MD, ME, NC, NH, NJ, NY, PA, TN, VA, VT, WV
Hopewell Furnace National Historic Site	National Historic Site	Elverson, PA
Gloria Dei Church National Historic Site	National Historic Site	Philadelphia, PA
Deshler-Morris House	National Historic Site	Philadelphia, PA
Edgar Allen Poe National Historic Site	National Historic Site	Philadelphia, PA

Figure 6: Nationally Significant Parks in the Delaware River Watershed¹⁹²

The Delaware Water Gap National Recreation Area is one of the most heavily used parks on the East Coast visited by more than 3 million annually.¹⁹³ Shared by Pennsylvania and New Jersey, DWGNRA has been home to native people for centuries prior to European settlement. Since about 1988 more than 113,000 historical and aboriginal artifacts have been uncovered.¹⁹⁴ Archaeological sites currently located within DWGNRA help today's archaeologists learn more about the culture and history of the Minisink and other native people as well as the natural history of the region.



CANOEING AT THE DELAWARE WATER GAP. THE WATER IS CLEAN, THE AIR IS FRESH, AND CLIFFS APPEAR THROUGHOUT THE LANDSCAPE. WILDLIFE IS ABUNDANT THROUGHOUT THIS STRETCH MAKING IT THE PERFECT OUTDOOR EXPERIENCE FOR PEOPLE FROM NEW YORK, PHILADELPHIA, AND BEYOND.

In 2007, in recognition of the beauty of the DWGNRA and its 40.6 mile water trail, the Delaware Water Gap National Recreation Area was designated a National Recreation Trail by the Secretary of the Interior.¹⁹⁵ The trail is valued for connecting people with the beauty and values of nature, introducing them to geological formations and a diverse set of wildlife habitats. It is the largest recreation area in the eastern U.S. bringing in revenue to local communities and economies in both Pennsylvania and New Jersey.¹⁹⁶

National Wildlife Refuges are a special class of parkland set aside specifically to protect animal and plant habitats. Several wildlife refuges exist throughout the watershed. Just south of Philadelphia, the John Heinz National Wildlife Refuge at Tinicum has been set aside to protect the last 200 acres of freshwater tidal marsh in Pennsylvania. It is currently home to over 280

species of birds and is the only place where the “state endangered Red-Bellied Turtle and Southern Leopard Frog can be found”.¹⁹⁷ A great amount of effort has been invested in preserving and restoring this natural area which is located in a densely populated region of the watershed.¹⁹⁸ The wildlife preserve allows urban communities to access native plants, wetlands, and aquatic habitats. It also connects urban residents with their natural community. The marshes of the John Heinz Wildlife Refuge capture rainfall and stormwater while filtering out pollution, absorbing flood waters, helping to defend against drought, and providing water quality benefits to the River.¹⁹⁹

The Cape May National Wildlife Refuge, Delaware Bay Division, protects a large variety of habitat including “salt marsh, forested uplands, forested wetland and vernal pools, shrub/scrub, and grassland”²⁰⁰ Supawna Meadows National Wildlife Refuge in Pennsville, NJ is part of the Cape May Refuge. It includes 3,000 acres of protected wetlands, mainly for shorebirds, warblers and other migrating birds which use the upland area as valuable resting and feeding habitat.²⁰¹

Bombay Hook is a National Wildlife Refuge in Delaware encompassing 15,000 acres in the Delaware estuary.²⁰² This refuge connects parts of the Atlantic Flyway, an avian migratory route of global ecological importance. It provides an important resting point and breeding ground for a variety of species including migrating waterfowl, Bald Eagles, Canada Geese, and several species of duck.²⁰³ Bombay Hook is an important home to White-Tailed deer, Woodchucks, Horseshoe Crabs, Bullfrogs, and Tulip Trees.²⁰⁴ Prime Hook National Wildlife Refuge, located near the western shore of the Delaware Bay, is a 10,000 acre sanctuary for migrating birds. Outstanding wetlands provide rare habitat for many species of birds and other wildlife, including threatened and endangered species.²⁰⁵

The Delaware Estuary’s Pea Patch Island is a refuge ideal for wading bird populations and waterfowl, including 2,300 nesting pairs of Heron.²⁰⁶ The Delaware Bay as a whole is the second largest stopover for migratory birds in the western hemisphere, visited each year by over one million birds.²⁰⁷



WORTHINGTON STATE FOREST, NJ WATERFALL ON A TRIBUTARY TO THE MIDDLE DELAWARE WILD AND SCENIC RIVER. PHOTO CREDIT: PAUL CARLUCCIO

State and County Parks

State and county managed parks are also prominent in the watershed. State parks and campgrounds are used regularly by tourists and local residents and are home to a variety of wildlife, trees and plants. “A walk along the 60-mile towpath of the Delaware Canal is a stroll into American History. The Delaware Canal is the only remaining continuously intact canal of the great towpath canal building era of the early and mid-19th century.”²⁰⁸ Before railroads, the canal was a means of transporting people and goods from Pennsylvania to New York and back.²⁰⁹ Today, 60 miles of the canal has been restored and converted into a nature trail for joggers, bikers, birders and historians.²¹⁰ The Delaware Canal State Park, stretching from Easton to Bristol, PA, has protected the riverfront for everyone to enjoy. The Pennsylvania Canal State Park attracts on average nearly 835,000 visitors annually.²¹¹

On the New Jersey side, the Delaware and Raritan Canal State Park begins at Bulls Island Recreation Area and travels through Washington Crossing State Park linking Frenchtown with New Brunswick.²¹² “The 70-mile Delaware and Raritan Canal State Park is one of central New Jersey’s most popular recreational corridors for canoeing, camping, jogging, hiking, bicycling, fishing and horseback riding. The canal and the park are part of the National Recreation Trail System. This linear park is also a valuable wildlife corridor connecting fields and forests. A recent bird survey conducted in the park revealed 160 species of birds, almost 90 of which nested in the park.”²¹³

INTRINSIC VALUE

Intrinsic value is the value of something for more than its measurable qualities. Instead of valuing fish for their ability to be caught or eaten, intrinsic value is the value of the fish simply for existing and not for its services to humans. Intrinsic values and existence values are important to keep in mind when thinking about the importance of biodiversity throughout the watershed. Biodiversity not only has a dollar sign attached to the term, but is important to maintain intrinsically, simply because nature has a right to exist.



FISHTOWN, PA PENN TREATY PARK IS A HAVEN IN CENTRAL PHILADELPHIA. A NATURAL RIVER'S EDGE, VIEWS OF THE BEN FRANKLIN BRIDGE AND PETTY'S ISLAND, EASY ACCESSIBILITY FOR PEDESTRIANS AND MASS TRANSIT, MEANS THAT THE PARK IS ALWAYS BUSY.

New Jersey State Parks and Forests attract 15 million visitors each year. It is estimated that New Jersey's Parks and Forests generate \$807 million a year with park fees accounting for \$6 million. Stokes State Forest is located within the New Jersey Sky lands and includes over 15,000 acres of mountains, streams, trails and wildflowers; and is home to a variety of fish, birds, and wildlife.²¹⁴ New Jersey Worthington State Park is situated along the Delaware River at the Delaware Water Gap National Recreational Area and has widespread appeal with camping, canoe and boat launches, waterfalls, and forested river refuges.²¹⁵

In Philadelphia, it is estimated that annually, parks provide the city with revenue of \$23.3 million for the residents and government of Philadelphia.²¹⁶ This methodology for valuing the city parks includes the value of property value, tourism, direct use, health, community cohesion, clean water, and clean air.²¹⁷

Some of the most visited parks in Philadelphia include Fairmount Park, home of Philadelphia's first water treatment reserve.²¹⁸ Philadelphia's yellow fever epidemic of the 1790's left City Hall with a need to protect its water supply by purchasing land and setting aside public areas that would protect the Schuylkill River and surrounding land from development.²¹⁹ The park is now 92,000 acres providing drinking water protection, as well as an enhanced opportunity for events, public recreation, and environmental education.²²⁰ Historical records indicate that Penn Treaty Park along the Delaware River in Philadelphia is the site where William Penn may have signed a peace treaty with the Lenape Indians, but where we know they met in a peaceful and respectful way in the 17th century.²²¹ The Park remains today reminding us of the peaceful relationship between the two peoples at that time.

Numerous small city parks throughout Philadelphia provide naturally green areas that benefit the urban community in a variety of ways. Some have become city gardens, teaching kids how to plant, nurture and cultivate the earth. Others are just a nice place to rest, play with your pets, or enjoy time with the family. These small urban parks are vital for communities to retain a connection with nature that enhances quality of life amidst the city land.

Native plants, like wildlife, are themselves an attraction to our parks and region generating interest and visitors. The Prickly Pear cactus is a notable Delaware River species. It is most often found in desert ecosystems like the Mojave; however it can also be found on some of the south facing cliffs in the Delaware River region, while the northern face of the same cliff can be covered in flora and fauna typically found in arctic-alpine climates. The differences in landscape between the northern and southern sections of the same cliff are an attraction bringing visitors to local parks on foot and by boat.



PRICKLY PEAR CACTUS IN BLOOM IN NEW JERSEY. THE CACTUS CAN BE FOUND THROUGHOUT THE DELAWARE RIVER WATERSHED FROM THE PINES BARRENS TO THE JOHN HEINZ WILDLIFE NATIONAL REFUGE TO CLIFFS ALONG THE UPPER REACHES OF THE RIVER.



DEPUE ISLAND IN THE DELAWARE WATER GAP, RIVER MILE 215. OVER 100 ISLANDS EXIST IN THE DELAWARE, SOME DEVELOPED AS GOLF COURSES, ONE AS A BOY SCOUT CAMP, BUT MOST ARE UNDEVELOPED FORESTS AND HABITAT PERFECT FOR A LUNCH BREAK STOP DURING A PADDLE.

“GIMME SOME SPACE”

The value of open space from a wildlife, recreation and quality of life perspective has fueled local efforts to purchase and protect natural lands from development. From 1961 to 1995, the New Jersey Green Acres program set aside \$1.4 billion for land acquisition and park development for open space and wildlife. Since 1998, funding was guaranteed for the program, set aside by the Garden State Preservation Trust Act. The Trust was depleted in 2009, but a new Bond or other stable source of funding is being developed in the state. NJ officials have also recognized the importance of protecting riparian lands for ecosystem services including water quality and flood protection. The state has approved a Blue Acres program which would invest funds in protecting open space along the Delaware and other river systems.

In Bucks County Pennsylvania, voters overwhelmingly approved spending \$59 million towards preserving open space throughout the county in 1997. Since then, more than 15,000 acres have been protected establishing new parks, preserving agricultural land, providing natural habitat for wildlife, improving historical buildings and grounds, and rejuvenating the Delaware River waterfront.

Other public land preservation programs are active in all the River's Watershed States. In addition, private non-profit conservation organizations dedicate millions towards preserving land from development.

For more information on the benefit of open space go to:

The Benefit of State Investments in Preservation Programs, April 15, 2009.

<http://njkeepitgreen.org/resources.htm>

Community Benefits of Open Space, The Trust for Public Land <http://www.njkeepitgreen.org/>

Economic Benefits of Conserved Rivers: An Annotated Bibliography, National Park Service June, 2001



CAPE HENLOPEN STATE PARK DELAWARE BAY AT SUNSET. VISITORS CAN CAMP ON THE BEACH AND WATCH WATERFOWL WHILE THE SUN SETS.

The State of Delaware is home to 18 parks including historical parks, nature preserves, state forests, and scenic vistas.²²² Delaware is known for its unmatched wading bird populations. Marshes, wetlands, and the Delaware River estuary provide habitat to rare bird species specific to the Delaware region.²²³ Delaware visitors can experience beaches, rivers, nature trails, greenways, and farms. State parks in Delaware include activities such as whale and dolphin watching.²²⁴ Cape Henlopen State Park, which borders the Delaware Bay, allows visitors to camp on its beaches and visit the nature center which provides activities year round.²²⁵ Each year Delaware's Cape Henlopen attracts over 1 million visitors.²²⁶

Catskill State Park is a vast 300,000 acres spanning Sullivan, Ulster, Delaware, and Greene Counties in New York.²²⁷ Its size has grown considerably since its founding in 1894 at 30,000 acres.²²⁸ The park contains ponds, waterfalls, meadows, streams, cliffs, and 98 mountain peaks over 3,000 feet high forming an "impressive skyline."²²⁹ Catskill State Park is a great place to visit for hiking with hundreds of miles of trails and abandoned roads. "Today, it serves as watershed, recreation area, and ecological scenic reserve."²³⁰

The Catskill Mountains in New York are the headwaters of the Delaware River. Catskill

Campgrounds along the Delaware River provide access to river resources and recreation including rafting, canoeing, kayaking, fishing and wildlife viewing. Natural, low impact campgrounds retain the atmosphere and essence of nature that many campers seek. Campgrounds throughout the watershed range in size and amenities, and are an important part of the ecotourism experience. RV campsites generally have hook ups to electricity, increasing the amount of amenities campers have while enjoying the outdoors. For example, Lander's River Trips and Campground has four different campgrounds to choose from, allowing for all types of campers. Some enjoy the peaceful quiet sounds by the campfire, while others want restaurants and amenities after a long day on the River. Dingmans and Kittatinny campgrounds both offer whitewater rapids within their stretch of the River ideal for kayakers. Sylvania Tree Farm is a secluded 1,200 acre estate in the Upper Delaware Wild and Scenic stretch of the River,²³¹ and within the Wild & Scenic River corridor. It offers a nature campsite right on the River where one can enjoy the peaceful flowing water all night and come across interesting wildlife including bears. There are also secluded cabins set back in the woods away from the River's edge.²³² Bull's Island Recreation Area, located on Route 29 (River Road) in Hunterdon County, NJ, and within the Delaware and Raritan State Park, offers 43 rustic campsites on the Island, each with a fire ring and picnic table open April 11–October 31. With a boat ramp on the Island, the site is perfect for overnight canoe-campers.²³³



DELAWARE RIVER CAMPSITE ALONG THE DELAWARE. THE NATIONAL PARK SERVICE HAS CREATED FIRST COME FIRST SERVE CAMSITES THROUGHOUT MANY OF THEIR PARKS FOR HIKERS AND BOATERS TO REST.

Campground	Location	Price	Nearby Attraction	Amenities
Dingman's Campground	Dingman's Ferry, PA	\$28/ Night	Waterfalls, Appalachian Trail	Hiking, Nature and Biking Trails, Fishing, Canoeing ²³⁴
Worthington State Forest	Warren County, Old Mine Road Delaware Water Gap	\$15/ Night	6,000 acres within the DWGNRA, Sunfish Pond, Old Copper Mine Trail	Fishing and Boating, Hiking the Appalachian Trail, Picnicking ²³⁵
Lander's River Trips and Campground	Narrowsburg, NY	\$16/ Night	4 campgrounds with River Views, Fort Delaware, Skinner's Falls (waterfalls)	Boating, Fishing, Hiking, Kayaking, Rafting, Playgrounds ²³⁶
Kittatinny Campground	Barryville, NY	\$10/ Night	Mountains, Delaware River Whitewater	Whitewater Rafting, Kayaking, Trout Fishing, Hiking, Horseshoes, Volleyball ²³⁷
Cape Henlopen	Lewes, DE	\$31/ Night	Six miles of beach, WWII Observation Tower, Lewes Ferry	Beach Camping, Bike Trails, Bird Watching, Swimming, Disc Golf, Ferry Service ²³⁸
Sylvania Tree Farm	Lackawaxen, PA	\$25/ Night	Skiing, Horseback riding, Balloon rides, Delaware River Whitewater	Fishing, Hiking, Camping, Swimming ²³⁹
Bull's Island Recreation Area	Stockton, NJ	\$20/ Night	Borders river and canal, lush vegetation on the Island. Nearby towns Lambertville, NJ and New Hope, PA	Fishing, River and Canal access, Swimming, Historic foot bridge to PA

Figure 7: Campgrounds bordering the Delaware River

❖ Community Attractions and Ecotourism

Enhancing the natural assets of a community to increase ecotourism can be a low-cost, high-benefit solution for bringing in extra people and dollars to an area. Several communities in the watershed have already been successful in this endeavor, while others are just beginning.

In Pennsylvania, Bucks County is distinguishing itself as an ecotourism destination. Wineries, breweries, local coffee houses, nature parks, historic hotels, museums, bed and breakfasts and Delaware River access points all bring visitors to the area.²⁴⁰ Places like the Bowman's Hill Wildflower Preserve, 1000 acres with over 134 native plant species near New Hope provide opportunities for day trips as well as complementing longer stays.²⁴¹ Visitors to the area supply revenue to local businesses and keep the importance of preservation and conservation of resources at the forefront of county planning.²⁴²

The State of Delaware has attracted tourists through creative activities such as the "Biking Inn to Inn" – an excursion that combines recreation, wildlife viewing, exercise, and Delaware's history on a 30-45 mile biking tour.²⁴³ The trip stops at three different historic Delaware Bed and Breakfasts along countryside back roads. Other Delaware ecotourist adventures include bird-watching along the Atlantic Flyway, sport-fishing, horseback riding, antique shopping, arts and culture, fine dining, shopping, and visits to historic locations.²⁴⁴



BLUE TORTILLA RESTAURANT IN NEW HOPE, PA THE HISTORIC BUILDINGS, PEDESTRIAN FRIENDLY WALKWAYS, AND RIVERFRONT ACCESS ALL BRING TOURISTS TO THE AREA FOR SHOPPING, DINING, AND RECREATION.

Small river towns throughout the watershed bring in visitors each year to celebrate the river. In Frenchtown New Jersey, "River Fest" first started to commemorate the role of the Delaware River in local history, and to support the preservation of the river and the surrounding environment.²⁴⁵ River Fest, sponsored by the Frenchtown Business and Professional Association is considered Frenchtown's largest annual event.²⁴⁶ In Knowlton, New Jersey, River Fest is "an annual Musical Event that celebrates music and nature next to the

Delaware River."²⁴⁷ In Narrowsburg, New York, River Fest is about promoting the Arts and Environment, featuring speakers that promote river conservation education. Lambertville's Shad Fest brings 30,000-35,000 visitors each year to the small historic river town. In Easton, Pennsylvania the Annual Forks of the Delaware Shad Fishing Tournament and Festival is held every year in Scott Park, attracting enthusiastic shad lovers from all around.

Peters Valley, a small village tucked away in Sussex County, is an art retreat for artisans and crafters.²⁴⁸ The Peters Valley Craft Center has 8 art studios which include blacksmithing, ceramics, structural fibers, metals, photography, and woodworking.²⁴⁹ Once a year they hold an annual craft fair in September featuring local crafters using inspiration from the Valley's surroundings.²⁵⁰

ECOTOURISM

Ecotourism is responsible travel to natural areas that helps conserve the environment and improve the welfare of local residents. Ecotourism is a major component of each of the basin states economy. Ecotourism supports local economies through retail sales, restaurants, lodging, and services provided. Ecotourism is the fastest growing sector of the travel industry, and therefore countries all over the world and states throughout the U.S. are quickly changing marketing systems to promote their remaining natural and historical areas.

The Delaware County Riverfront Ramble is a weekend long festival featuring music, canoe racing, environmental education, and pirate and fishing shows for families and people of all ages.²⁵¹ Riverfront Ramble promotes the Delaware River as a destination location. In 2007, after only 3 years, the event attracted approximately 22,000 people and was expanded to cover 2 days in order to attract overnight visitors and therefore increased proceeds for participating communities.²⁵² In 2008 the Riverfront Ramble had events in 6 locations lining the Delaware shore including Market Square Memorial Park in Marcus Hook, Delaware, John Heinz National Wildlife Refuge, and the Governor Printz Park in Tinicum, Pennsylvania and several other Delaware River shore stops. Ferry and free boat rides connect the 6 locations with shuttle services to get you back to your start.

Big cities benefit from the draw and beauty of a clean and healthy Delaware River. Philadelphia is home to a variety of events that boast its river areas as an attraction. Boating events include the Philadelphia Canoe Club's 'Philadelphia Fall Classic', a 10,000 meter canoe, kayak, outrigger and surf ski race²⁵³ and the Philadelphia International Dragon Boat Festival featuring more than 100 teams racing fiberglass dragon boats on the Schuylkill River.²⁵⁴

Maintaining the nature and history of towns along the Delaware River makes them tourist locations that bring in additional revenue for the entire community. This idea is what led to Cumberland County New Jersey publishing a "Vision & Implementation Strategy for Economic Development & Conservation" in 1996. The report "was born out of a need to find a common agenda; one that would provide both economic development opportunities and preserve the County's natural heritage. Eco-tourism is here. It is happening today in Cumberland County. It is one way to expand the economy, create jobs, and protect



WASHINGTON CROSSING STATE PARK. PA. ECOTOURISM, SUCH AS WILDLIFE OBSERVATION INCLUDING THIS EASTERN TIGER SWALLOWTAIL BUTTERFLY. BRING ECOTOURISTS INTO A REGION REQUIRING MASSIVE INFRASTRUCTURE, ROAD BUILDING, OR HIGH RISE HOTELS. THE KEY IS PROPERLY MARKETING THE UNIQUE AND VALUABLE NATURAL RESOURCES AN AREA ALREADY CONTAINS.

THREATS TO ECOTOURISM

Improper handling and treatment of sewage, inappropriate and uncontrolled development, industrial air pollution, and water pollution from all sources including industry, roads, farms, cities, and neighborhoods threaten regional ecotourism opportunities for small towns and counties. A recent university study found that illnesses associated with swimming in contaminated water costs the public more than \$3 million per year through the loss of tourism dollars as well as health care related costs, legal fees, and cleanup. Poor environments diminish the public's ability to fish, swim, bird watch, canoe, and experience our public parks and reserves.

the natural resource base that is so important to the area's quality of life."²⁵⁵ Other communities have published similar reports, created brochures, or are developing strategies to enhance the natural and cultural assets already existing within their borders.

Recognizing the value of recreation to our communities, and its dependence on clean water, beautiful and scenic vistas, and natural areas, it is important that we take action to protect the quality of our river water, our river corridors, and the natural areas in the watershed. Clean water increases park attendance and recreation revenue. Every type of river recreation is diminished if the health of the Delaware River diminishes. With the jobs and economy supported by recreation and ecotourism, it is vital that the community place a high value on the protection and restoration of the River and its surroundings.

The River as an Employer

The River as an Employer

- ❖ Commercial Fisheries as Employers
 - ❖ Agriculture and the River
- ❖ Where our Drinking Water Comes From
 - ❖ Industry on the Delaware
 - ❖ Water and Commercial Use
 - ❖ Delaware River Ports

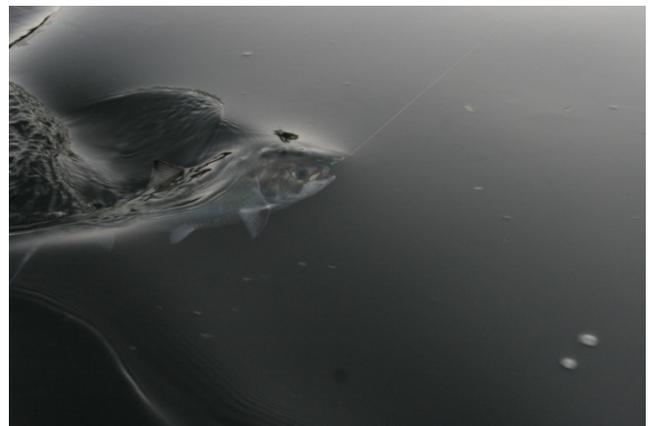
❖ Commercial Fisheries as Employers

The Delaware River watershed supports diverse interests and purposes. A clean and healthy Delaware River creates and supports. To support the diversity and quality of jobs the Delaware needs to be clean, healthy and free-flowing.

“In 1991, over 9 billion pounds of fish and shellfish with a value of over \$3 billion were harvested by commercial fishermen in the United States.”²⁵⁶ This commercial catch includes freshwater species as well as ocean catches, but it is estimated that nearly three-quarters of all commercially harvested fish and shellfish depend directly on coastal estuaries and river basins for spawning grounds or nurseries. The Delaware River and Bay provide temporary home and spawning ground for species that are later harvested for use all over the eastern U.S. In the late 19th century, the Delaware River had the largest annual commercial fish catch of any river on the Atlantic coast. But over-fishing and/or pollution has often threatened the fish of the Delaware River including Shortnose Sturgeon, Atlantic Sturgeon, River Herring (including Blueback and Alewife), Striped Bass, and American Shad.²⁵⁷

Early European settlers wrote letters home telling their families and friends about the bounties of fish within the Delaware River and tributaries, at sizes often much larger than typically found in Europe.²⁵⁸ Tales of almost effortless fishing and brush netting fish into crates became well known in the Delaware River Valley.²⁵⁹

By the mid-20th century, a combination of an increasing human population, loss of natural forest wetlands, and inadequate sewage and industrial waste treatment created an ecological barrier, a 20-mile oxygen dead zone that impeded the ability of fish to migrate upriver to spawn in the Philadelphia/Camden portion of the River.²⁶⁰ Improved technologies and laws that required their use, including the Federal Clean Water Act of 1972, forced the cleanup of a variety of pollution sources to the River. As a result, the nutrient pollution which was the primary cause of the River's oxygen problem was largely abated, allowing fish to once again migrate upstream from the ocean and lower stretches of the estuary.



SHAD ARE MAKING THEIR WAY BACK UP THE DELAWARE AND ITS TRIBUTARIES AGAIN BECAUSE CLEAN WATER IS ALLOWING THEM TO RETURN TO THEIR SPAWNING GROUNDS AFTER A LIFE IN THE ATLANTIC OCEAN. PHOTO CREDIT: ART EASTON 2008



SHAD FISHING: LUMBERVILLE, PA
PHOTO CREDIT: ART EASTON 2008

Today, a viable commercial fishery is still maintained along the Delaware River and Bay. In 1998, statewide, New Jersey's commercial fisheries harvested 196 million pounds at a value of \$90.9 million statewide; New York harvested 57.5 million pounds at a value of \$84.3 million; and Delaware harvested 7.8 million pounds at a value of \$5.6 million.²⁶¹ According to New Jersey's Department of Fish and Wildlife, efforts to clean up rivers and reservoirs have created the best trout fishery New Jersey has ever had.²⁶² Striped Bass has been declared recovered in the Delaware River by the Atlantic States Marine Fisheries

Commission compared to historic levels.²⁶³ American Shad have also recovered enough to support commercial fishing in the Delaware River, although not enough to supply the current demand.²⁶⁴ Other species commercially caught from the Bay and tributary waters include Alewife, Atlantic Croaker, Blueback Herring, Carp, Spot, Striped Bass, White Perch and Blue Crab.²⁶⁵

Lewis Shad Commercial Fishery

The Lewis Shad commercial fishery has survived in the Delaware River for over 108 years. A family run business located above the head of tide in Lambertville, NJ, the Lewis Shad fishery is the oldest commercial shad fishery on the Delaware River.²⁶⁶ Although its annual shad catches no longer support commercial demand in the Philadelphia and New York markets, this family fishery remains in operation, still using the same fishing methods and practices it used when it first began.²⁶⁷ The Shad catch is very low, but the family continues their traditions to keep Shad fishermen trained and ready for when the Shad return in greater numbers.²⁶⁸ The traditional practices used by the Lewis Shad fishery are demonstrated every year at the Lambertville Shad Fest and are a big draw for those in attendance. Each year Shad make the journey up river from the ocean with the fishery improving as water quality and obstacles to migration improve in the Delaware River.²⁶⁹

Lewis' approach to the shad market demonstrates a strong conservation ethic. "We don't try to catch enough even to sell to the markets of Philadelphia and New York," said Lewis. "We try not to catch more than we can sell right here. For the price you get in the markets, the fish are more valuable going up the river. A shad roe that you might get 50 cents a pound for in the market, might spawn 150,000 eggs; big difference in value there."²⁷⁰

Shellfisheries

Shellfish are also part of the economy sustained by the Delaware River. In 1880, the Delaware Bay brought in a harvest of 2.4 million bushels of oysters. In the 1930's, more than 1 million bushels were harvested. Numbers decreased as natural surfaces in the Bay were reduced, limiting the places where oysters can attach and grow. In the late 1950's, MSX (Multinucleated Sphere unknown affinity X), a deadly shellfish disease, depleted 90-95% of the oyster population in the Bay.²⁷¹ After minimal recovery and decades of building resistance to the disease, Dermo (Perkinsus marinus), a second shellfish parasitic disease, again decimated the oyster population in 1980.²⁷²

While Dermo continues to plague the adult oyster population, the Delaware Bay Oyster Restoration Task Force (a total of 12 public and private agencies from NJ and DE including representatives from Rutgers University, the New Jersey Department of Environmental Protection, the Delaware Department of Natural Resources and Environmental Control, the Delaware River Basin Commission, and the Delaware River Bay Authority) have invested heavily in efforts to restore the Bay's oyster populations and the oyster industry. Since 2005, as much as \$5 million of federal funds have been invested to restore the oyster beds of the Delaware Bay.²⁷³ In 2004, \$1.55 million worth of oysters were landed on the New Jersey side

of the Bay.²⁷⁴ In 2006 it was reported that oyster harvesting generated \$535,000 of income for harvesters, and a total \$3 million of economic benefit locally.²⁷⁵ Numbers of oysters and successful shell placement and economic benefits continue to markedly increase. The estimated overall economic impact to the industry for 2007 is estimated at \$80 million.



OYSTER LARVAE REQUIRE A CLEAN, HARD SURFACE UPON WHICH THEY CAN ATTACH OR "RECRUIT." DUE TO A STORAGE OF THESE NATURAL RESOURCES, THE DELAWARE BAY OYSTER RESTORATION TASK FORCE HAS "PLANTED" SURF CLAM, OCEAN QUAHOG, AND MARYLAND OYSTER SHELL IN AN EFFORT TO REVITALIZE THE DELAWARE BAY OYSTER POLLUTION. PHOTO CREDIT: BAYSHORE DISCOVERY PROJECT.

Case Study: Backwoods Angler Fishing Guides

Blaine Mengel Jr. and Associate Guide Chris Gorsuch know the Delaware River up and down. Both are Delaware River fishing guides for a company called The Backwoods Angler, a fishing guide service owned and operated by Blaine. In operation since 2000, this guide service is based on a healthy catch & release smallmouth bass fishery. Their range spans from Belvidere, NJ north and south.

People come from Pennsylvania, New Jersey, New York, and all over the U.S. to experience the Delaware River. "People are amazed to find such a clean and scenic valuable resource within such a close distance to a metropolis like NYC" said Chris Gorsuch, Associate Guide. The Backwater Angler offers both kayaking trips and jet boat trips from 4-8 hours long for groups of 1-2 people. "We regularly see a variety of turtles, beaver, deer, eagles, osprey, great blue heron and other water fowl; we have even had a number of black bear sightings in the past few years along the banks of the Delaware," Gorsuch reports.

As Gorsuch explains, "Our business is truly sustained by the River and its ecosystem. It is a delicate balance, the aquatic plants, insects and invertebrates all thrive in clean water. These insects and other minnows such as darters, provide the forage that sustains a healthy smallmouth bass population. Without a healthy fish population, there are no eagles, no osprey, no blue heron, and without a quality fishery there are no fishing guides. We have to be able to take people to where the fish are, and understand what parts of the river offer the best fishing opportunities depending on the time of year and the water flow. A healthy Delaware is vital to our being able to do this. Without clean water, we don't have jobs".

There are only a handful of fishing guides along the Delaware; most are trout guides in the West Branch Delaware River. Backwoods Angler operates 7 days a week 12 months out of the year, and successfully gets about 500-600 people out on the River annually. To learn more about the Backwoods Angler Fishing Guide Service, visit their website at www.backwoodsangler.com



Dylan Hechendorf and his father Darin booked the Backwoods Angler guide service in early August. This was Dylan's first Delaware River Smallmouth. His dad says; "Dylan's hooked for life!"

Additional Commercial Businesses

Many businesses throughout the watershed are supported by the River, but aren't directly along its banks. The Crab Connection in Little Creek, Delaware sells fresh seasonal seafood as well as bait for Delaware Bay fishermen.²⁷⁷ In Easton, Pennsylvania Lani Abraham has created a Pocket Guide to tourism in the area and along the River, and runs a tourist shop in the downtown district providing information to recreationists and visitors to the River and City of Easton from throughout the region.²⁷⁸



BOWERS BEACH, DE RUSSELL'S CHARTER FISHING BOAT MISS SHYANNE TAKES A GROUP OUT ON A FISHING TOUR ON THE DELAWARE.

Charter boats and charter fishing companies thrive in all seasons along the Delaware Bay. Russell's Charter Fishing, Inc. in Bowers Beach, Delaware takes tourists and locals out into the Bay to fish for whatever is in season. Captain Sonny Sullivan owns a bait and tackle shop in Bowers Beach supplying the necessities to Charter fishing boats while also using his own boat to catch bait for sale at his shop.



BOWERS BEACH, DE CAPTAIN SONNY SULLIVAN CUTTING BAIT FOR SONNY'S BAIT AND TACKLE SHOP THAT CATERES TO RECREATIONAL AND COMMERCIAL FISHERIES.

The Philadelphia seafood market, located in the Italian Market at 9th and Washington, is "the oldest and largest working outdoor market in the United States". The outdoor market supplies seasonal fresh fish and shellfish from the Delaware River and Bay, as well as from other waterways around the world.²⁷⁹ Similarly the Reading Terminal Market in downtown

Philadelphia brings thousands out each weekend to buy locally grown produce, fresh meats, and fish from the Delaware River.²⁸⁰

The Delaware's commercial fishery doesn't just provide jobs, it supports a way of life. It is a historic and present day culture that is unique unto itself and worthy of respect and protection, not only for the dollars it generates, but for the culture it brings.

❖ Agriculture and the River

Agriculture has a long history in the Delaware River Valley. Pennsylvania is known for its dairy; New Jersey for its peaches, tomatoes, cranberries and blueberries; New York homesteads for their maple syrup, sheep, eggs, and dairy cows; and Delaware State for its poultry.

Farming Culture

There are thousands of farms throughout the basin providing local restaurants and farm markets with an abundance of local produce, vegetables, grass-fed meat, eggs, dairy products, and more. In New Jersey, "Jersey Fresh" has become emblematic of family farming and marketing throughout the state. Water



BEDMINSTER, BUCKS COUNTY, PA PRESERVED FARMSTEAD, ONE OF 917 FARMS IN BUCKS COUNTY PRESERVED TO ENSURE THE RURAL HERITAGE AND FARMING TRADITIONS OF THE REGION.

provided by the Delaware River system and the unique river valley soils throughout the basin have supported the farming tradition in each of the basin states producing a wide variety of foods, goods, and jobs.

In 2006, the Bucks County Open Space Task Force celebrated preserving its 100th farm. Today, Bucks County, Pennsylvania, has over 917 farms containing more than 76,000 acres and generating over \$60 million in agricultural products.²⁸¹ Preserving farmland provides a sense of identity for the county. Historic barns and outbuildings, grazing livestock, and open fields continue to define the character of the county while, when managed appropriately, helps to maintain meadowlands, streambeds, and forests for natural habitat.²⁸²

Monmouth County, New Jersey recently preserved its 10,000th acre of farmland, and is the seventh county in the state to do so. The Gerald Rottkamp Farm in Cumberland County, New Jersey produces sweet corn, tomatoes, peppers, melons, and blueberries, and uses 2,200 gallons of water per day from the Delaware River. Likewise, other farms throughout the state and the basin rely on the Delaware River its tributaries and agriculture to provide irrigation and to sustain farming traditions.²⁸³



NEW JERSEY FARM MARKET RT 48 SALEM COUNTY. "JERSEY FRESH" HAS BECOME EMBLEMATIC OF NEW JERSEY AGRICULTURE THROUGHOUT THE STATE.

Buying Local

Agriculture close to or within urban areas is also uniquely valuable and important. It creates green spaces for trees and water filtration, while providing a local food supply to urban residents. Local farms provide educational opportunities for children and decrease the amount of transportation needed to supply homes, local groceries, restaurants, stores and markets with fresh produce.

In agriculture, contamination of water sources could lead to sickness and infection of both humans who consume the food and to livestock that use the water for drinking. Pre-treating irrigation water is a costly endeavor.

Current methods of irrigation take in water from the River and apply it directly onto agricultural fields. Many agricultural fields use ground water wells for irrigation rather than direct surface water intakes, but contamination can still happen. The importance of clean water in irrigation was proven in the fall of 2006 when over one hundred people became sick after consuming spinach that was irrigated with contaminated water in California. The irrigation sources were infected from fertilizer runoff and animal waste.²⁸⁴



JERSEY FRESH RED POTATOES SOLD IN SALEM COUNTY FOR \$2.50 A BOX

For a great guide to New Jersey food, see [Edible Jersey](http://www.ediblejersey.com), a quarterly magazine that celebrates "local foods from the Garden State, Season by Season." (www.ediblejersey.com)

Livestock and Factory Farming

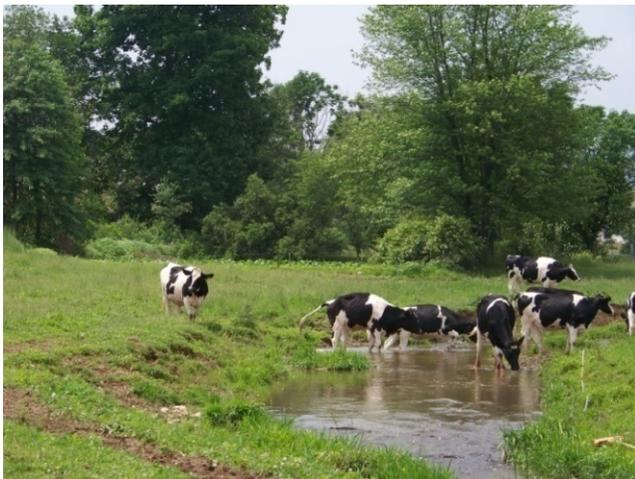
Agriculture is a significant part of the Delaware River watershed economy and culture. While watershed farmers need to do their part to protect the streams and rivers of the watershed; the watershed community needs to do its part to support local farmers with clean water and community support.

Many livestock and farm animals drink from the water provided by the Delaware River and its tributaries. Clean water is needed in order for them to stay healthy and sanitary. "High levels of sulfates in drinking water can contribute to decreased egg production in chickens."²⁸⁵ "Many species of animals are susceptible to nitrate poisoning, especially cattle", which has been associated with miscarriage and other reproductive problems, anorexia, lower blood pressure, and reduced lactation for dairy cattle."²⁸⁶



CONFINED ANIMAL FACTORY FARM BEING INUNDATED WITH FLOOD WATERS. THE FARM'S LAGOONS CONTAIN MANURE AND CONTAMINANTS THAT, WHEN FLOODED OR OVERTOPPED, POLLUTE THE NEARBY WATERWAY.

And agriculture must take due care to ensure that it does not itself become a source of pollution to waterways in the watershed. Animal agriculture produces byproducts like manure and chemical waste that should be properly treated, recycled as fertilizer or compost and kept away from waterways. Rain washes livestock waste containing bacteria and pathogens into water sources. Excessive nutrients from animal byproducts destroy river habitats by creating excessive algal blooms resulting in reduced oxygen levels that suffocate fish and impact wildlife. Livestock should always be kept away from streams and rivers.



WITHOUT FENCING, EVEN SMALL ANIMAL OPERATIONS CAN DEGRADE STREAM QUALITY.

Every effort should be made to avoid the operation of confined animal feeding operations (CAFO's) or factory farms in our watershed and communities. Factory farms introduce a variety of chemicals, pharmaceuticals, growth hormones, antibiotics, bacteria and contaminants onto the land and into the nearest waterway.²⁸⁷ Factory farms create water, noise and odor pollution, and they inflict morally reprehensible abuse on the animals they house. Preventing the construction and operation of factory farms is one important strategy for protecting drinking water supplies, the environment and communities.

❖ Where our Drinking Water Comes From

A clean and healthy Delaware River, including the River's corridor, provide for our basic human needs: water, food, safety and health. About 5 percent of the U.S. population or 15 million people rely on the Delaware River for their drinking water supply. Major cities and small communities alike drink from the River.



NEVERSINK RIVER, NY THE NORTHERN REACHES OF THE DELAWARE RIVER WATERSHED HELP TO SUPPLY MILLIONS OF NEW YORKERS. PHOTO CREDIT: DAN L. PERLMAN/ECOLIBRARY.ORG

The Philadelphia Water Department has three drinking water treatment plants that draw water from the Delaware and Schuylkill Rivers. The Baxter plant, which draws an average of 200 million gallons a day from the mainstream Delaware, provides drinking water to 60% of Philadelphia's population, as well as serving a portion of lower Bucks County. The Belmont and Queen Lane treatment plants together draw an average of 110 million gallons per day (40 MGD and 70 MGD respectively) from the Schuylkill River to support the other 40% of Philadelphia's drinking water needs.²⁸⁸ Not all of the 15 million people drinking Delaware River water live in the watershed, in fact a large portion live in other River basins. Residents of central New Jersey reside in the Raritan River Basin, and New York City residents are in the Hudson River Basin – yet both drink water supplied by the Delaware River.

Clean Drinking Water

Clean Delaware River water, free from toxins, bacteria, pathogens, mercury, PCB's, and various other known and unknown chemicals is critical for supporting a healthy drinking water supply for residents throughout the watershed as well as business and commercial uses. The health impacts of water contamination for both humans and wildlife range from acute illness, to diseases such as cancer and metabolic disorders. Waterborne diseases are a major problem in surface water. Gastroenteritis, acute respiratory symptoms, and dermatitis are among the acute illnesses that can result from contaminated drinking water.²⁸⁹ Both ground and surface water can become polluted with pesticides, petrochemicals, bacteria, nutrients, synthetic organics, acidification, heavy metals, chemicals (manmade and naturally occurring), and waste products. Toxins and contaminants have serious health consequences when consumed. Accidental pollution releases, legally permitted pollution discharges, illegal discharges, as well as pollution washed from the land during rain events are all potential sources of contamination of our drinking water supply.

In 2008, The Associated Press reported that 56 pharmaceuticals or byproducts have been found in Philadelphia's drinking water supply.²⁹⁰ According to authorities this issue may not be a major issue now, but over time and without fully understanding where the byproducts are originating, it could be a substantial threat.²⁹¹

Cleaning Dirty Water: Water Treatment

The cost of water treatment is high. Maintaining our drinking water supplies to the highest specifications of water safety and cleanliness not only provides health and quality of life benefits but it also ensures a more cost effective source of drinking water. In New York, residents have long enjoyed the untreated, high quality waters from the upper Delaware River system. In 1996, New York City faced the choice of building a water filtration plant to filter its water supply, or of protecting the watershed that drains to the City's drinking water reservoirs in order to maintain its high quality drinking water. Economically, the decision was an easy one. The cost of building and operating a water filtration plant would cost the City \$6 to \$8 billion at that time.²⁹² Rather than invest in a water filtration facility, New York City, with the support of the U.S. Environmental Protection Agency (EPA), entered into its Watershed Memorandum of



NEW YORK CITY DECIDED TO PRESERVE RIPARIAN LAND IN THE UPPER DELAWARE TO MAINTAIN CLEAN WATER VS. BUILDING A MULT- BILLION WATER FILTRATION PLANT. PHOTO CREDIT: JON NAIL

Agreement in 2007. The Watershed Plan that was created invested in protecting riparian buffer zones and watershed lands around their City's reservoirs in order to help protect their water source from non-point source pollution, including nutrients and pesticides resulting from stormwater runoff, septic tanks and agriculture.²⁹³ The City invested in repairing and installing community sewage treatment plants throughout the counties that drain to their reservoirs. Protecting the watershed was estimated to only cost the City around \$1 to \$1.5 billion dollars with \$250 million invested in acquiring land and setting aside special protection areas.²⁹⁴ This land purchase has been complemented by regulatory protections (New York City's Rules and Regulations for the Protection from Contamination, Degradation, and Pollution of the NYC Water Supply and its sources Chapter 18 and landowner incentives for land protection.²⁹⁵

The watershed program choice has not only provided New York City with some of the cleanest and best tasting water nationwide, but it has provided tremendous benefits to the Delaware River as a whole, reducing the level of pollution that is dumped into the system from deforestation and development.

Today it is estimated that building a water filtration plant could total as much as \$10-20 Billion; New York City residents' annual water bills would increase by at least 11.5%. This would make the average water bill \$699, annually.²⁹⁶ Protecting the watershed is still the most cost effective and attractive solution for the City.

***“...clean water is the fuel
that powers the nation’s
economic engine.”***



Researchers in other communities recognize the benefits of watershed protection from a community water supply and pollution prevention perspective, finding that every \$1 invested in watershed protection could save between \$7.50 and \$200 in costs for new filtration and water treatment facilities.²⁹⁷ “In 1991, the cost of treating contaminated water was estimated to be \$10-\$15 per month for a family of three.”²⁹⁸ Communities in Washington D.C. spend as much as \$3 to \$5 per pound to remove nitrogen from wastewater, a process that forested buffers provide naturally.²⁹⁹



NEW YORK CITY'S WATER SUPPLY SYSTEM



The map above shows some of the water storage reservoirs along the Delaware. These reservoirs hold the public supply of water used for drinking, cleaning, lawn care, and for industries such as food production and automobile manufacturing. Several communities manage their own water supply through reservoir operations including Wilmington and Newark in Delaware, Bethlehem, Pennsylvania, and the largest water user from our basin, New York City, which exports water from the headwaters of the Delaware River. Other communities in addition to Philadelphia take in water directly from the River including: Morrisville, Trenton, Burlington, and Bristol.

❖ Industry on the River

Although industry has changed along the Delaware River over the years, the River has always been a fundamental resource for the economy that spurred the growth of Philadelphia, Camden, Wilmington, Trenton, and even New York City. Industries throughout the watershed continue to bring young talented professionals and families into the region, but the River is what keeps that industry viable and its employees' quality of life high.

Industrial Beginnings

Starting in the 1760's, timber rafting was a way of transporting thousands of harvested trees from the Upper Delaware forests of New York, Pennsylvania, and New Jersey into Philadelphia and Camden. Timber from the valley fueled shipbuilding, one of the first major Delaware River industries.³⁰⁰ Other historical Delaware River industries include lumber and paper mills, tanneries, stone quarries, especially bluestone, cement-making, iron, and rubber. Many of these industries relied primarily on the River and estuary for transportation, including coal which traveled down the Lehigh into the Port of Richmond just north of Philadelphia.³⁰¹ The anthracite coal industry began in the early 19th century in the headwaters of the Schuylkill River to fuel the industrial revolution.

Many historic Delaware River industries played a large part in the demise of water quality between Trenton and Philadelphia, the decline reached its peak in the 1940's and 50's.

In the Mid to late 1800's upper Delaware River timber harvesting and tanneries that stripped tannic acid from the bark of the region's mature trees devastated the River. What was once an idyllic intact forest brimming with trout-filled streams was transformed into a logged wasteland with a river polluted by acid and choked with sediment. Many tributary streams were utterly destroyed.

Declining quality made the River an unreliable source of water. Federal laws and a greater appreciation of the River for multiple purposes resulted in the cleaning up of the Delaware River, which revived industrial reliance for water supply on the Delaware, leading to greater job security and better health for its many workers. The industries that dominate the River's edges have changed over the decades.

Sectors that Consume Delaware River Surface Water

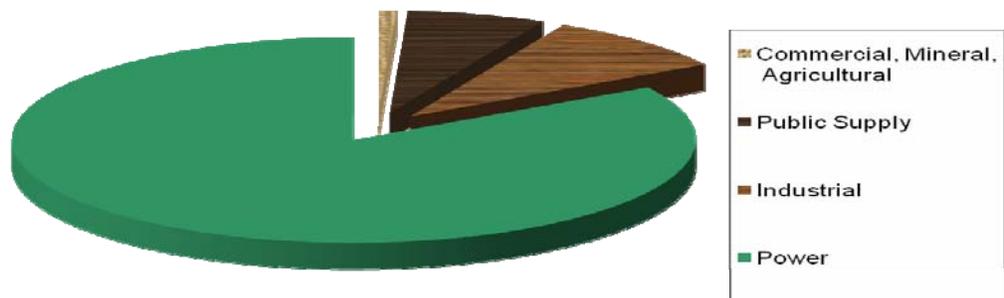


Figure 8: Sectors that Consume Delaware River Surface Water

Today's River Industries

Today, water is an essential factor in industrial production, productivity and transport. The largest water consumers on the Delaware today are electricity generation facilities, or the power industry. The power industry takes in three times more water than all other major water consumers combined, including public water supply, agriculture, and commercial businesses. **Figure 8** lists the four sectors of commercial Delaware River surface water consumers.³⁰²

The power industry consumes approximately 5.674 billion gallons per day of Delaware River surface water,³⁰³ primarily used for cooling purposes. Because most power generating facilities along the Delaware River intake water through underwater pipes, it is important that the water remain clean and clear of unnatural debris.

In April of 2007, a cooling water intake at PSE&G was forced to shut down after screens on its water intake system became clogged with assorted River debris.³⁰⁴

PSE&G is a native New Jersey electric service provider that supplies electricity for over 75% of New Jersey from Bergen, to Gloucester Counties. PSE&G employs over 10,500 people throughout its state wide service area, providing jobs for highly skilled engineers and nuclear technicians as well as hourly positions of all kinds.³⁰⁵ PSE&G takes in more than three billion gallons of water per day from the Delaware River for cooling purposes.³⁰⁶

Exelon takes in over one billion gallons per day from the Delaware River and employs thousands of men and women throughout the region.³⁰⁷ Power companies strategically locate themselves along bodies of water. A dependable flow of water is essential for power plants to remain viable.

Figure 9 shows the five largest Delaware River consumers; four of which are power companies.³⁰⁸ Conectiv, Exelon, PSE&G, and Reliant are all power companies with a combined water intake of more than 55 billion gallons of water per day.³⁰⁹ Premcor is an oil refining facility that takes in 355 million gallons per day of Delaware River surface water.³¹⁰

Every year the Salem Nuclear Generating Station kills over 3 billion Delaware River fish including:

- Over 59 million Blueback Herring
- Over 77 million Weakfish
- Over 134 million Atlantic Croaker
- Over 412 million White Perch
- Over 448 million Striped Bass
- Over 2 billion Bay Anchovy

The US Fish and Wildlife Service, in a letter dated January 10, 2001, characterizes the loss of aquatic organisms at Salem as "ecologically significant. In addition, conditional mortality rates for some Representative Important Species (RIS) are high enough to be of serious concern."

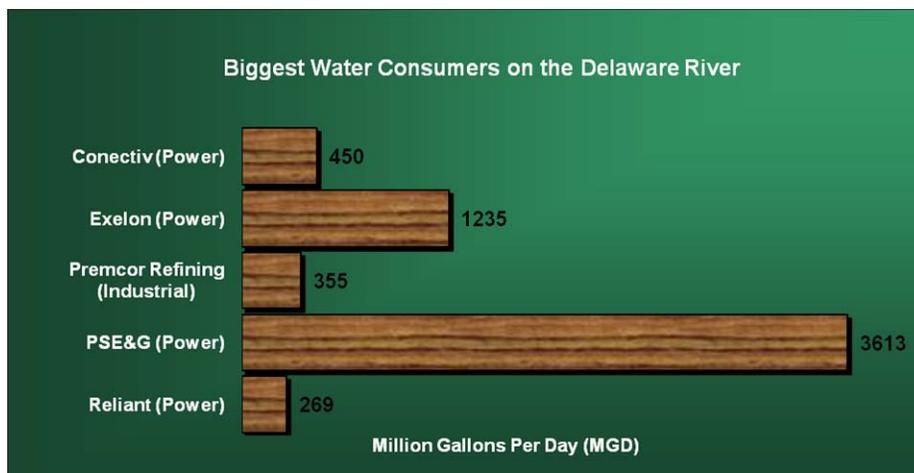


Figure 9: Five Largest Delaware River Consumers

Being the biggest water consumers on the Delaware brings with it a high level of responsibility, ensuring that their use of the River water is done so as to minimize any adverse impacts they might have on the ecosystem or others who rely on the River. PSE&G's Salem facility kills over 3 billion Delaware River fish a year including Weakfish, Bay Anchovy, Shad, and more. If PSE&G were to change the cooling water technology at the facility it could reduce those fish kills by over 95% and use 95% less Delaware River water. In addition to the ecological impacts, the commercial and recreational fishing industries and workers are forced to compete with electric generating stations for their livelihood — a day's catch. Fishing industries are dependent on a healthy and growing fish population in the Delaware Estuary and Bay and it is incumbent on PSE&G, Exelon and all other power companies to respect the right and need of others who mutually rely on the River.

Other industries that today rely on Delaware River surface water include steel manufacturing, chemical companies, paper mills, cement production facilities, and oil refineries. Chemicals are manufactured at DuPont with locations in New Jersey and Delaware. Although clean water is an essential component of DuPont's operations, DuPont's Chamber Works facility in Deepwater New Jersey is the single largest discharger of hazardous waste effluent in New Jersey.³¹¹ Industries like this do not help the River or region, but actually hurt the long term growth of the environment and economy. Rohm and Haas (now Dow Chemical) is a chemical company based out of Philadelphia. According to the industry, chemical manufacturing and research requires a reliable water source: "Water is the single most important chemical compound".³¹² The higher the level of initial contamination of the water, the more effort that must be applied before research and production can begin.



INDUSTRIAL TOWERS IN THE BACKGROUND OF A SCENIC RIVER VIEW.

Water is a basic and essential component to the local production of paper towels, tissues, copy paper and notepads. Companies such as Scott paper operating on the Delaware River since the mid 1800's rely on plentiful, good quality water.

Why Industry Needs Clean Water

"Contaminated water can increase industrial expenses as it causes steam electric power plants to operate less efficiently, clogs cooling equipment, corrodes pipes, and increases the rate at which pumps and other equipment wear out".³¹³ In November of 2008, industries along the Monongahela River flowing through Pittsburgh, Pennsylvania noticed "significantly higher water treatment costs" after microscopic contaminants, Total Dissolved Solids (TDS), were found at high levels.³¹⁴ The Pennsylvania Department of Environmental Protection said it

received several reports from industries about equipment problems and increased filtering costs to protect expensive steam boilers and turbines as well as drinking water filtration plant problems that led to water so high in TDS that it couldn't be effectively filtered. 325,000 consumers were advised to switch to bottled water for weeks and again for a period in 2009. A power industry spokesman said utility treatment costs increased because very clean water is needed for power generating facilities.

Many industries and businesses depend on the River for transportation today. Approximately 3000 cargo vessels travel the River annually.³¹⁵ About 85% of the east coast oil imports come up through the Delaware Bay and River³¹⁶. Debris impairs the ability of ships for these and other industries located along the river to safely transport and deliver their cargo, making it important to keep damaging debris out of the water.

In Philadelphia and South Jersey, the Delaware River Port Authority (DRPA) launched a “Green Ports” program with South Jersey Port Corporation (SJPC) and the Philadelphia Regional Port Authority (PRPA). The DRPA is a regional transportation and development agency that owns and operates the Benjamin Franklin, Walt Whitman, Commodore Barry and Betsy Ross bridges, PATCO, the Philadelphia Cruise Terminal and the RiverLink Ferry.³¹⁷ Initiatives to “green the ports” in several U. S. port cities have led to success economically and environmentally. Los Angeles, Mayor Antonio Villaraigosa and the mayor of neighboring Long Beach, launched a campaign to clean up port activities and reduce air emissions and water pollution. “We believe the only way to grow the port is to green the port,” says Villaraigosa. “And the only way to green the port is to grow the port....”³¹⁸

❖ Water and Commercial Use

Other commercial users of Delaware River surface water include the small businesses of the watershed like restaurants and hotels.

Hotels, restaurants, small businesses, and real estate operations rely on the Delaware River for their drinking water, wash water, maintaining their landscaping and grounds and to support onsite recreational uses including filling and maintaining swimming pools. Clean water is also fundamentally important for real estate in order to sell properties. Either real or perceived contamination, litter, garbage, or murky river conditions can influence buyer interest and the final selling price of property.

Some of the largest private consumers of Delaware River water are Waterworks Condominiums in Philadelphia, USS Real Estate owned by U.S. Steel, and River Winds in West Deptford Township, New Jersey.³¹⁹ Even the Philadelphia Airport takes in water to maintain the grounds, keep runways and airplanes clean, provide bathroom facilities for thousands of people moving throughout the airport each day, and to run the many restaurants and kitchens located within the facility.

As with all users of the River, it is important that commercial sources that benefit from a clean and healthy Delaware River do their part to protect and restore that same clean water. Their ability to do so is all about the choices they make for their day to day operations.

❖ Delaware River Ports

The ports of Philadelphia and Camden make up the busiest freshwater port in the world with annual revenue of \$19 billion.³²⁰ Over 70 million tons of cargo per year move through the ports at Philadelphia, PA; Camden, Gloucester City, and Salem, NJ; and Wilmington, DE Historically, cities such as Philadelphia and Trenton were created and supported by the products supplied through the ports. Raw timber and coal went out, and processed goods came in.

“Delaware River ports employ 4,056 workers who earn \$326 million.”³²¹ When one looks at the additional jobs and worker spending associated with these jobs the Delaware River ports are said to support “12,121 jobs and \$772 million in labor income, generating \$2.4 billion in economic output.”³²² The ports are well known for staple products like fruits, cashews, and cocoa beans, and contain the number one perishables port on the east coast. Oil comes in from the Middle East and meat comes in from Chile, Argentina, and Australia. Delaware River ports make up the largest North American port for steel, paper, and meat imports as well as the largest importer of cocoa and fruit on the east coast.³²³ The Port of Wilmington is one of the busiest container ports on the Delaware River handling Dole and Chiquita.³²⁴

A deepened main navigation channel is not needed to support this vibrant port, or new business. The success of the Delaware River ports lies in developing them as a strong niche port. In recent years record growth has been reported for the Delaware River ports, without the prospect of a deepened channel.³²⁵ While deepening the Delaware is not needed for a vital and growing port, it would threaten the other uses of the River with contamination, losing jobs and income, as well as diminishing the health of the River for others, including the people who drink and eat from it.



VIEW OF THE NAVY SHIPYARD AT SUNSET. THE PORTS ARE SHIPPING AND RECEIVING CORRIDORS FOR INTERNATIONAL TRADE AND COMMERCE. MOSTLY OIL TANKERS, WE ALSO RECEIVE PERISHABLE FOODS AND CONSUMER GOODS.

Why it Needs to be Clean Water

In the 1940's and 1950's the Delaware River was filled with sewage and garbage that clogged boat engines of incoming and outgoing ships peeling the paint from their sides, hindering traffic and port employment.³²⁶ In 2004, a large oil tanker carrying thick Venezuelan crude oil hit two submerged objects lying on the River's bottom: an old anchor and pipe. The objects ripped two gashes in the tanker's hull resulting in an oil spill of 265,000 gallons. The Athos I oil spill forced the ports to completely shut down for a period of days. The Coast Guard and others were forced to invest more than \$84 million dollars to clean up the toxic crude which impacted 115 miles of River and 280 miles of shoreline with oil, as well as over 16,500 birds and other wildlife.³²⁷

Keeping the ports healthy and functioning is important to the region's economy. The supplies that come into the ports provide jobs for watershed residents, overseas manufacturers, ship captains and their workforce, port receiving and distribution, inland transportation like truckers and railroad personnel, and all of the local suppliers relying on the products like restaurants, Hershey's chocolate factory, steel manufacturers, and more. It is important that we keep our river clean so we do not jeopardize job security or the health of these workers. Accidents and fuel or cargo spills cause injuries, death, damage to public health and the environment, and serious economic harm. It is critical that all policies, procedures and steps be taken to avoid short term catastrophic events as well as long term degradation and harm. Maintaining our port as a source of reliable employment for hundreds of thousands of workers is a priority for the region and requires a clean and healthy River.

In Philadelphia and South Jersey, the Delaware River Port Authority (DRPA) launched a "Green Ports" program with South Jersey Port Corporation (SJPC) and the Philadelphia Regional Port Authority (PRPA). The DRPA is a regional transportation and development agency that owns and operates the Benjamin Franklin, Walt Whitman, Commodore Barry and Betsy Ross bridges, PATCO, the Philadelphia Cruise Terminal and the RiverLink Ferry.³²⁸ Initiatives to "green the ports" in several U. S. port cities have

led to success economically and environmentally. Los Angeles, Mayor Antonio Villaraigosa and the mayor of neighboring Long Beach, launched a campaign to clean up port activities and reduce air emissions and water pollution. "We believe the only way to grow the port is to green the port," says Villaraigosa. "And the only way to green the port is to grow the port...."³²⁹



ABOVE LEFT: AFTER THE ATHOS I OIL SPILL TEAMS FROM ALL OVER THE REGION TOOK PART IN THE CLEAN UP EFFORTS TO WASH BIRDS AND STOP THE FLOW OF OIL FROM THE SPILL SITE. PHOTO CREDIT: DAVID SWANSON PHILADELPHIA INQUIRER: ABOVE RIGHT: ATHOS I PHOTO CREDIT: DANIELLE DEMARINO BOTTOM RIGHT: OIL SOAKED GOOSE FROM ATHOS 1 SPILL PHOTO CREDIT: DAN PRAN/THE NEW YORK TIMES

Cultural & Historic Value

Cultural & Historic Value

- ❖ Native Americans
- ❖ European Movement and American Independence
- ❖ Historical Sites and Reenactments

❖ Native Americans

The Delaware River holds a spiritual and cultural significance to those living within the watershed and beyond. Native Americans from the valley continue to meet and spread their stories and history to the community.

Pre-dating European settlement, Native Americans, the Lenape, inhabited the land along the Delaware River and Bay. Their “Lenapehoking” (land of the Lenape) encompassed southern Connecticut, New York, all of New Jersey, eastern Pennsylvania, and Delaware.³³⁰ The Lenape made canoes and used the Delaware River for both transportation and sustenance.³³¹

Today, archaeologists from American University’s Department of Anthropology have found more than 55,000 Lenape artifacts from 25% of what is believed to be the total site area in the upper Delaware River Valley region. Archeological evidence of the region’s native people and their settlements have been found up and down the River and its Watershed. There has even been some findings that may prove ancient cultures that pre-date the Lenape.



More recently, prehistoric Native American artifacts were found along the Delaware River in Philadelphia, at the site of the proposed Sugar House casino. Common artifacts found at Native American archaeological sites include arrowheads and other tools used during the time the Lenape inhabited the area.³³² Museums throughout the Basin describe Lenape history and culture. The Delaware River still holds a very spiritual and cultural connection to their descendents. The River is a link to the life and spirit cherished by the Lenape.

ED FELL SERVED AS PRESIDENT OF THE NATIVE AMERICAN ALLIANCE OF BUCKS COUNTY FOR MANY YEARS UNTIL HIS PASSING IN 2009. THE ALLIANCE CONTINUES TO HOLD REGULAR MEETINGS EDUCATING OUR YOUTH ABOUT NATIVE CULTURES OF THE PAST AND ENSURING NATIVE AMERICAN CULTURE LIVES ON IN THE DELAWARE VALLEY.

❖ European Movement and American Independence

With such a long history, the Delaware River valley holds significant opportunities for people looking to rediscover events of the past. From the formation of the River to the first human settlement, its colonial history, the revolutionary war, and more recent accomplishments, several places of interest bring in visitors year round. Many historic sites are located along the Delaware River or one of its tributaries. Keeping the water clean as it flows past and through these sites entices people to continue visiting them. A bad smell, dirty water, or degraded streams detract from the historic presence of a site.

Henry Hudson was the first European to discover the Delaware River when he and the crew of the Dutch Half Moon entered the mouth of Delaware Bay on August 28, 1609. They quickly ran aground in the Bay, making a u-turn that allowed Lenapes to enjoy a little more time before settlers intruded.³³³ The English discovered the Delaware the following year, and Dutch, Swedish, Finnish, German and other settlers from Europe followed over the next 166 years.³³⁴



BATTLE OF TRENTON REENACTMENT. PHOTO CREDIT: PAUL CARLUCCIO

Today, the site where George Washington crossed the Delaware on December 25th 1776, is one of the most heavily visited locations on the River, particularly on Christmas Day when this event is reenacted. On the other side of the River in Trenton, NJ, there are annual reenactments of the Battle of Trenton which ensued on Christmas night, and the second Battle of Trenton that occurred seven days later. These reenactments and Revolutionary War reenactments attract reenactors and visitors from all over the country.

History Telling

Valley Forge Park along the Schuylkill River is also a heavily visited site. Valley Forge housed Washington's army during the harsh winter of 1777.³³⁵ Historic details mixed with recreational possibilities and nature centers, provide people of all ages and interests with an exciting day-long outing. People come from all over to visit many of the historic sites where reenactments occur, and where markers describe the event and its significance.



OLD BARRACKS MUSEUM, TRENTON N.J. BATTLE OF TRENTON REENACTMENT. PHOTO CREDIT: PAUL CARLUCCIO

In the Estuary portion of the River, Fort Delaware is a famous historic site located on Pea Patch Island claimed to have grown from a cargo of peas that was lost overboard by the Dutch. Pea Patch Island today offers historic reenactments from the days when it was used as a Union prison during the Civil War.³³⁶ In addition, the Island offers ferry rides, hiking trails, and an observation platform from which to view nine different species of birds, including Herons, Egrets, and Ibis.

Historic Sites and Reenactments	Where	Details
Minisink Archaeological Site	Bushkill, PA	Archaeologists have been making discoveries at this site for decades. More than 55,000 artifacts have been found in only 25% of the total site area. Arrowheads, relics, and details of early people continue to bring out new questions about the area's history. ³³⁷
Valley Forge National Park	Forge, PA	Visit the encampment where Washington's army rested through the winter of 1777 during the Revolutionary War ³³⁸
Washington Crossing the Delaware	Washington Crossing, PA	This famous site hosts annual reenactments of General George Washington crossing the Delaware River toward Trenton during the Christmas holiday bringing thousands of visitors ³³⁹
Battle of Trenton	Trenton, NJ	The Battle of Trenton reenactments feature soldiers dressed in Revolutionary War era uniforms and traditional weaponry marching along the streets of Trenton, New Jersey. ³⁴⁰
Pea Patch Island	Fort Delaware, DE	This well known site holds reenactments of the days when the island was used as a prison during the Civil War. Today it is also home to a protected wildlife preserve for numerous waterfowl species ³⁴¹

Figure 10: Historic Sites and Public Reenactments along the Delaware River

Historic Figures from the Delaware Valley

After becoming famous, Zane Grey, one of the nation's favorite Western authors from the early 20th century, moved with his wife Dolly to Lackawanna County, Pennsylvania from New York City.³⁴² The convergence of the Lackawanna and Delaware Rivers was one of Grey's favorite spots and is where he settled with his family around 1905.³⁴³ The home and farmstead remain at this unique and gorgeous location as a museum for travelers and locals. The museum contains Grey's library and office full of the photos, writings, and books he used while authoring his more than 40 books and essays, the first being "A Day on the Delaware" published in *Recreation Magazine* in 1905.³⁴⁴

Another historic attraction in the same reach of the Delaware River is the Roebling Aqueduct. In 1847, John Roebling, future engineer of the Brooklyn Bridge, designed and helped to construct several aqueducts along the Delaware and Hudson canal.³⁴⁵ The D&H Canal was vital in transporting coal from Pennsylvania mines to New York City, where it helped to fuel the industrial revolution.³⁴⁶ The only remaining aqueduct of Roebling's is along the Delaware, because of its adaptation to a car bridge in the

early 20th Century.³⁴⁷ Almost all of the original ironwork, cables, and structures, remain on the Delaware Aqueduct, and other characteristics of the time have been reconstructed so that visitors can see exactly how early transportation by mule labor and water gravity occurred.³⁴⁸

In order to maintain the region's history and keep visitors coming to these sites, it is important to keep the neighboring streams and rivers clean. The Delaware River Watershed is a part of America's history. Maintaining this history for future generations to experience is an important aspect in understanding our past and our country's foundation. Keeping the river clean, with a goal of restoring it to the conditions our prehistoric and long-ago ancestors experienced, and ensuring that it is a complement and enticement for viewing and experiencing the local economic historic and cultural offerings of our region is important for education, ecotourism, cultural values, and local economies.

Importance of Clean Water Importance of Clean Water



“When we best protect and restore the Delaware River is when we best protect and restore ourselves.....”

Maya K. van Rossum, the Delaware Riverkeeper

The Delaware River watershed is home to 8 million people and provides drinking water for approximately 15 million. It is a revered recreational resource to boaters, fishers, birdwatchers, nature hikers, swimmers, and sight-seers of all kinds. It is a means of transportation for port industry, and a steady reliable source of water for commercial and industrial operations. The riverbanks serve as

habitats for rare and endangered species. The River is an ecosystem to thousands of plant and animal species that have called it home for millions of years. When the River is healthy it helps to protect us from floods, droughts and illness.

A clean Delaware River reduces the cost of water treatment and increases property values for homes and businesses. By protecting and restoring our River we earn tremendous economic and ecological benefits while the quality of life for residents throughout the Delaware River watershed increases.

Once damage has been done to the natural ecosystems of the Delaware River it can be difficult and costly to undo. It has been estimated that restoring the ecosystems necessary to replace the billions of fish and aquatic organisms killed by the Pilgrim Nuclear Generating Station located in Massachusetts would cost at least \$140 million.³⁴⁹



It is often the case that the cost of the restoration is far less than the value of the natural resource to the community.³⁵⁰ While the investment may be worth it, it would still have cost far less both in the direct cost of restoration and the opportunity costs during the period of harm, had the resource simply been protected in the first place.

The River is a resource and a member of our community which needs to be preserved for the children and grandchildren of the watershed. It is critical that the Delaware River remain valued so that the entire watershed may benefit ecologically, economically, culturally, and spiritually for decades to come.

One of the most important ways to protect all of the values of the streams and River discussed in this report is to protect the watershed in as natural a condition as possible. This includes protecting and restoring its floodplains in a forested state, protecting its upland forests and terrain, as well as its wetlands and soils. When we protect the watershed to protect the River we see the tremendous community-wide benefits that are received.

This report ends where it began. The most important take away from this report is that the Delaware River is a living ecosystem rich in beauty, culture, and community that needs to be protected and restored in order to continue to be the respected and contributing member of our community we all need and enjoy.



We Need Your Help We Need Your Help

From its headwaters in the Catskills, the Delaware River flows 375 miles to the Delaware Bay. Its watershed encompasses over 13,539 square miles in the backyard of the most densely populated area of the country. When George Washington crossed the Delaware, he could not have imagined the insults this great river would suffer 200 years later - catastrophic oil and pollution spills, ongoing pollution inputs, the threat of dams and invasive dredging, and many species on the brink of extinction.

Rivers cannot defend themselves, but **the Delaware River does have a voice through the Delaware Riverkeeper and the Delaware Riverkeeper Network.** It is our responsibility and privilege to champion the Delaware River and its streams as members of our communities.

Led by the Delaware Riverkeeper, the Delaware Riverkeeper Network is **a dedicated team of staff and volunteers who defend the River and its tributaries.** For over 20 years, we've watched over the River and its tributaries, combating threats to its health and taking on challenges that endanger the environment our children will inherit. **We are the only river advocacy organization working throughout the Delaware River Valley, and we are making a difference.**

Members make up the backbone of the Delaware Riverkeeper Network, providing strength and resolve for all of our efforts and accomplishments. **Become a member and become part of our efforts to leave a legacy of healthy, vibrant rivers and the communities they support.**

As a member, you will have the satisfaction of knowing your donation is being put to work right here in the Delaware River watershed protecting local streams. You will receive email notices keeping you informed of breaking river protection news as well as opportunities to take action. You will also receive a special river keepsake, a 10% discount at our annual Native Plant Sale held the first weekend in May each year, and invitations to special members-only events.

As a citizen-supported and watershed-based organization, every membership has a profound impact on our ability to support our many successful programs. **Every member really does make a difference in ensuring that the voice of the River is heard.** Every dollar donated expands the number of threats to the River we are able to take on, so please join today. **By joining the Delaware Riverkeeper Network, you will be investing in a healthier future.**

Your membership strengthens us and ensures the voice of the Delaware River and its tributary streams is heard. To become part of the Delaware Riverkeeper Network, join online at www.delawareriverkeeper.org or by calling our office at 215-369-1188.

Special Thanks Special Thanks

Special Thanks to all who provided photos within the report

Elizabeth Azzolina
Bristol Riverboat Queen
Paul Carluccio
Harold Deal
Art Easton
Mike Hogan
Blaine Mengel Jr. and Chris Gorsuch
Jon Nail
Douglas Norton
Dave Williams
George Williams
Richard Albert
Ann Bidwell

All Additional Photos provided by DRN Staff

Shannon Blankinship
Elizabeth Koniers-Brown
Tracy Carluccio
Carole Glessner
Emma Gutzler
Fred Stine
Maya van Rossum

Contributing Authors

Maya K. van Rossum, the Delaware Riverkeeper
Tracy Carluccio, Deputy Director, Delaware Riverkeeper Network
Shannon Blankinship, Executive Assistant, Delaware Riverkeeper Network

Technical Expertise & Editing

Richard Albert
Mary Ellen Noble
Chari Towne
Faith Zerbe
Stefanee Magill
Fred Stine

Sponsors of *The Value of a Clean and Healthy Delaware River*

Bucks County Riverboat and Trolley Company
Delaware River Experience
Kistlers Minuteman Press
Zephyr Printing

Cited Sources

- ¹ Albert, Richard C. "The Historical Context of Water Quality Management for the Delaware Estuary." *Estuaries* June 1988. Vol. 11, No. 2 p 99-107 citing (Webster et al 1914)
- ² Ibid
- ³ Ibid
- ⁴ Ibid
- ⁵ Money. *Best Places to Live 2000*. Money Magazine: 2001.
- ⁶ EPA Office of Water. *EPA Liquid Assets 2000: America's Water Resources at a Turing Point*. US EPA, May 2000.
- ⁷ Bouchard, Roy, Kevin J. Boyle, Holly J. Michael. *How Water Quality Affects Property Prices: A Case study of Selected Maine Lakes*. Maine Agricultural and Forest Experiment Station. Misc Report 398. February 1996.
- ⁸ "The DePaul Grp.'s 242 unit condo extends program." NJPA Real Estate Journal. April 13-26 Vol.19 Issue 7
- ⁹ "Citizens Bank finances first housing development project along Wilmington, DE Riverfront: Townhouses will spur new housing and renaissance of city." *Citizens Bank Press*. 3 March 2004 <www.citizensbank.com> accessed 10 December 2006
- ¹⁰ DNREC and Brandywine Conservancy, *Conservation Design for Stormwater Management: A Design Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use*, September, 1997, pgs. 1-25
- ¹¹ David Welsch, Forest Resources Management, USDA Forest Service, "Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources", NA-PR-07-91; NJAC 7:8 NJDEP Agency Proposal Document at NJAC 7:8-5.5(h) pg. 76
- ¹² Kollin, Cheryl. "Designing with Nature and Showing the Benefits", *Land Development*, National Association of Home Builders, Winter, 1997.
- ¹³ Center for Watershed Protection, *Better Site Design: A Handbook for Changing Development Rules in Your Community*, August 1998 (citing two studies by Morales and Weyerhauser)
- ¹⁴ Lutzenhiser, M. and N.R. Netusil. "The Effect of Open Spaces on a Home's Sale Price" *Contemporary Economic Policy* 19.3 (2001): 291-298.
- ¹⁵ Ibid
- ¹⁶ Center for Watershed Protection, *Better Site Design: A Handbook for Changing Development Rules in Your Community*, August 1998, pg. 134
- ¹⁷ Ibid
- ¹⁸ US Dept of Labor: Occupational Safety and Health Administration. *Flood Cleanup Alert: How to Protect Yourself from Asbestos Hazards*, Bulletin 4. <http://www.osha.gov/OshDoc/data_FloodFacts/Bulletin4.pdf> accessed 20 June 2008
- ¹⁹ Ibid
- ²⁰ Ibid
- ²¹ US Dept of Labor: Occupational Safety and Health Administration. *Flood Cleanup Alert: How to Protect Yourself from the Hazards of Lead Poisoning*, Bulletin 5. <http://www.osha.gov/OshDoc/data_FloodFacts/Bulletin5.pdf> accessed 20 June 2008
- ²² West Virginia Division of Homeland Security and Emergency Management. *Facts About Food and Floods* Disaster Resource. <www.wvdhsem.gov> accessed 9 June 2008
- ²³ US Dept of Labor: Occupational Safety and Health Administration. *Flood Cleanup Alert: How to Protect Yourself from Fungal Disease*, Bulletin 3. <http://www.osha.gov/OshDoc/data_FloodFacts/Bulletin3.pdf> accessed 20 June 2008
- ²⁴ Ibid
- ²⁵ West Virginia Division of Homeland Security and Emergency Management. *Preventing Waterborne Illness*. Disaster Resource. www.wvdhsem.gov accessed 9 June 2008.
- ²⁶ American Forests. 2003. "Urban Ecosystem Analysis Delaware Valley Region: Calculating the Value of Nature." March 2003 (The value attributed to these natural systems is based upon what it would have cost the region to construct basins and other solutions for intercepting the runoff.)
- ²⁷ Ibid
- ²⁸ Ibid
- ²⁹ American Forests. 2003. "Urban Ecosystem Analysis Delaware Valley Region: Calculating the Value of Nature." March 2003.
- ³⁰ Ibid (These are communities with separate stormwater sewer management systems.)
- ³¹ Ibid
- ³² Okmyung Bin & Stephen Polasky. 2003. "Effects of Flood Hazards on Property Values: Evidence Before and After Hurricane Floyd", August 2003.
- ³³ Ibid
- ³⁴ Ibid
- ³⁵ Water, Science, and Technology Board, Board of Environmental Studies and Technology, "Riparian Areas: Functions and Strategies for Management" 2002 (citing Swanson, et al.)
- ³⁶ J. Toby Tourbier, "Open Space Through Stormwater Management, Helping to Structure Growth on the Urban Fringe"
- ³⁷ U.S. Department of Transportation Federal Highway Administration. Environment: Results of the FHWA Domestic Scan of Successful Wetland Mitigation Programs: Ohio. <<http://www.fhwa.dot.gov/environment/wetland/scanrpt/oh.htm>> accessed 23 June 2008
- ³⁸ Union of Concerned Scientists, *New Jersey, Confront climate change in the U.S. Northeast*, 2007, a summary based on *Confronting Climate*

Change in the U.S. Northeast: Science, Impacts and Solutions, by the Northeast Climate Impacts Assessment, 2007.

³⁹ Ibid

⁴⁰ *The Economic Value of New Jersey State Parks and Forests*, NJDEP Division of Science, Research and Technology, June 2004 pg. 14

⁴¹ Ibid

⁴² Ibid

⁴³ Ibid

⁴⁴ Ibid

⁴⁵ Ibid

⁴⁶ Ibid

⁴⁷ New Jersey Department of Environmental Protection. Division of Science, Research, and Technology. *The Economic Value of New Jersey State Parks and Forests*. June 2004 pg. 15

⁴⁸ For more information go to: <<http://www.spiritofphiladelphia.com/ph/index.jsp>> 2007 rates quote

⁴⁹ For more information go to: <<http://www.libertybelle.com/>> 2007 rates used

⁵⁰ Ibid

⁵¹ River Horse Brewery website. *About Us*. 2008 http://www.riverhorse.com/about_us/index.html accessed 6 August 2008

⁵² Frenchtown.com. 2008. "Black Bass Inn Restaurant and Hotel Sold March 10, 2008." Frenchtown: A Collaborative Travel and Lifestyle Magazine. <<http://www.frenchtown.com/Black-Bass-Restaurant-and-Hotel-Sold-March-10-2008.html>> accessed 27 June 2008

⁵³ Ibid

⁵⁴ New Jersey Great Northwest Skylands. January 2008. "Bicycle Trails." <<http://www.njskylands.com/odbike.htm>> accessed 30 June 2008

⁵⁵ Chestnut Hill on the Delaware. Rob Castagna Phone Interview. July 2008.

⁵⁶ Bucks County Bed and Breakfast Association. "Restaurants." 2007. <www.visitbucks.com/restaurant/> accessed March 2007.

⁵⁷ Lambertville Station Inn. *Weddings*. 2007. <<http://www.lambertvillestation.com/>> accessed 5 June 2007.

⁵⁸ Cape May Grand Hotel. *Rates* 16 July 2007 <<http://www.grandhotelcapemay.com/rates/room1.htm>> accessed 10 August 2007

⁵⁹ Hyatt Corporation. 2007. *Reservations* <<http://pennslanding.hyatt.com/hyatt/reservations/flow6/propSelectedHotelRates.jsp>> accessed 10 August 2007

⁶⁰ Bridgeton House. 2007. *Lodging on the Delaware* <bridgetonhouse.com/rates.htm> accessed 10 August 2007

⁶¹ Penn's View Hotel. *Rates*. <http://www.pennsviewhotel.com/hotel_accommodations/index.aspx> accessed 26 July 2007

⁶² Pawelko, K. E.B.; Drogin, A.R. Graefe; and D.P. Huden. 1995. "Examining the nature of river recreation visitors and their recreational experiences on the Delaware River." Pg. 46

⁶³ The Outdoor Industry Foundation. "The Active Outdoor Recreation Economy: A \$730 Billion Annual Contribution to the U.S. Economy." Fall 2006

⁶⁴ Ibid

⁶⁵ Ibid

⁶⁶ Ibid

⁶⁷ US Fish and Wildlife Service. "2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, National Overview." (Preliminary Findings) May 2007. Pg. 5

⁶⁸ Ibid

⁶⁹ Ibid

⁷⁰ Eubanks, Ted; Stoll, Paul Kerlinger. 2000 "Wildlife-associated Recreation on the New Jersey Delaware Bayshore, The Economic Impact of Tourism Based on the Horseshoe Crab-Shorebird Migration in New Jersey". 16 February 2000. Prepared for the New Jersey Department of Environmental Protection.

⁷¹ Michigan State University. 2003. "Impacts of Visitor Spending on the Local Economy: Valley Forge National Historical Park, 2001." Prepared for National Park Service Social Science Program and Department of Parks, Recreation and Tourism Resources

⁷² Pawelko, K. E.B. Drogin, A.R. Graefe, and D.P. Huden. 1995. "Examining the nature of river recreation visitors and their recreational experiences on the Delaware River." Pg. 45

⁷³ Pawelko, K. E.B. Drogin, A.R. Graefe, and D.P. Huden. 1995. "Examining the nature of river recreation visitors and their recreational experiences on the Delaware River." Pg. 46

⁷⁴ Ibid

⁷⁵ Ibid

⁷⁶ Ibid

⁷⁷ Ibid

⁷⁸ Schuylkill River National State & Heritage Area. "Philadelphia". <www.schuylkillriver.org/philadelphia.aspx> accessed 7 August 2007

⁷⁹ Ibid

⁸⁰ Living places by The Gombach Group. "Boathouse Row."

<http://www.livingplaces.com/PA/Philadelphia_County/Philadelphia_City/Boathouse_Row.html> accessed 29 July 2008

⁸¹ Philadelphia Girls' Rowing Club. Club History. <<http://www.boathouserow.org/clubs/history.html>> accessed 29 July 2008

⁸² Vesper Boat Club. "Vesper: A Brief History" <<http://www.vesperboatclub.org/AboutVesper.html>> accessed 29 July 2008

⁸³ Ibid

⁸⁴ Philadelphia Inquirer. Compiled By The Inquirer Staff. "U.S. Olympic rowing team has Philadelphia flavor"

<http://www.philly.com/inquirer/sports/20080628_U_S_Olympic_rowing_team_has_Philadelphia_flavor.html> accessed 29 July 2008

⁸⁵ Schuylkill Navy. "Regattas" <<http://www.boathouserow.org/sked08.html>> accessed 29 July 2008

⁸⁶ Schuylkill Navy. "Independence Day Regatta" <<http://www.boathouserow.org/reg08/idr08.html>> accessed 29 July 2008

⁸⁷ Dad Vail Regatta. "News and Information" <<http://www.dadvail.org/?News>> accessed 29 July 2008

⁸⁸ Philadelphia Inquirer. Bill Iezzi, Inquirer Staff Writer. "Rowers off to fast start at Stotesbury"

<http://www.philly.com/inquirer/home_top_left_story/7587402.html> accessed 29 July 2008

⁸⁹ Living places by The Gombach Group. "Boathouse Row."

<http://www.livingplaces.com/PA/Philadelphia_County/Philadelphia_City/Boathouse_Row.html> accessed 29 July 2008

⁹⁰ Gophila.com, Official Visitor Site for Greater Philadelphia. "Rowing Adventures on Boathouse Row"

<http://www.gophila.com/C/Your_Philadelphia/14/Family_friendly_Philadelphia/264/Family_friendly_Tours/286/U/Rowing_Adventures_on_Boathouse_Row/1951.html> accessed 29 July 2008

⁹¹ American Whitewater. 2006. *River Stewardship Toolkit. "Paddlers Footprint: The Economic Impacts of River Recreation"* <www.americanwhitewater.org> accessed 16 June 2008 (summarizing data from Charles Simms 2002)

⁹² Ibid

⁹³ Jones, Dave (Kittatinny Canoes). Telephone Interview. 14 November 2006

⁹⁴ Bucks County River Country. "Prices" <<http://www.rivercountry.net/index0.html>> accessed 31 July 2007

⁹⁵ Breen, Dan (Bucks County River Country). Telephone Interview. 21 February 2007

⁹⁶ Jones, Dave (Kittatinny Canoes). Telephone Interview. 14 November 2006.

⁹⁷ Canoe and Kayak club of New York. 2008 "Homepage". <<http://www.kccny.com/Default.aspx>> accessed 19 June 2008

⁹⁸ CanoeKayak.com. 2008 "Clubs" <<http://www.canoeKayak.com/paddlers-portal/clubs/>> accessed 19 June 2008

⁹⁹ Pennsylvania Department of Conservation and Natural Resources. Pennsylvania State Parks: Ralph Stover State Park.

<<http://www.dcnr.state.pa.us/stateparks/parks/ralphstover.aspx>> accessed 19 June 2008

¹⁰⁰ Greater Philadelphia Tourism and Marketing Corporation. 1998-2008. *Boundless Philadelphia: Lake Nockamixon Whitewater Release*. <http://www.gophila.com/C/Countryside/382/Bucks_County/241/U/Lake_Nockamixon_Whitewater_Release/2134.html> accessed 19 June 2008

¹⁰¹ Ibid

¹⁰² Sportsman Connection. "Lake Info: Mongaup Falls Reservoir" <http://www.sportsmansconnection.com/lakeinfo/11382-Mongaup_Falls_Reservoir/> accessed 19 June 2008; Sportsman Connection. "Lake Info: Swinging Bridge Reservoir."

<http://www.sportsmansconnection.com/lakeinfo/11425-Swinging_Bridge_Reservoir/> accessed 19 June 2008

¹⁰³ Interactive GEO GuideBook Inc. 2007. "Swinging Bridge Reservoir: Description" <<http://www.activityguidebook.com/destination/3697>>

accessed 19 June 2008

¹⁰⁴ New York State Department of Environmental Conservation. 13 June 2008. Southeastern New York Fishing Hotline. Press Advisory.

¹⁰⁵ Eagle Institute. 2008. "Data Collection". <<http://www.eagleinstitute.org/datacollection/datacollection.php>> accessed 19 June 2008

¹⁰⁶ Wells Ferry. "Homepage" <<http://www.wellsferry.com/>> accessed 31 July 2007

¹⁰⁷ Gerenser, Robert. *Coryell's Ferry Boat Rides*. <<http://www.spiritof76.biz/ferry.html>> accessed 27 July 2007

¹⁰⁸ Laughlin, Jason. Courier-Post. "Burlco considers more riverboat tours". 30 July 2007

¹⁰⁹ Ibid

¹¹⁰ Keller, David (Bucks County Riverboat Co.). Telephone Interview. 22 February 2007. 2007 Prices.

¹¹¹ Delaware River Steamboat Floating Classroom. <<http://steamboatclassroom.org/step2/>> accessed 19 June 2008

¹¹² SwimmingHoles.org. 2007. "Swimming Holes in NJ; Swimming Holes in PA; Swimming Holes in DE."

<<http://www.swimmingholes.org/nj.html>> accessed 19 June 2008

¹¹³ Ibid

¹¹⁴ Ibid

¹¹⁵ Ibid

¹¹⁶ New Jersey Department of Transportation. *D&R Canal Towpath Ride: A Tour Guide for Cyclists*. October 2002

<<http://www.state.nj.us/njcommuter/pdf/dr canal.pdf>> accessed 26 July 2007

¹¹⁷ Pennsylvania State Parks. *Delaware Canal State Park*. <<http://www.dcnr.state.pa.us/stateparks/parks/delawarecanal.aspx>> accessed 31 July 2007

¹¹⁸ Holmes, Kristen. Bucks County News In Brief: Bicycle Tour to Explore. Philadelphia Inquirer. 13 July 2008

¹¹⁹ Delaware River Scenic Byway. *Delaware River Scenic Byway: Corridor Management Plan Update*. 2007

<www.delawareriverscenicbyway.org/about.html> accessed 28 March 2007

¹²⁰ Maharaj, Vishwanie, Joseph McGurrin and Janet Carpenter, *The Economic Impact of Trout Fishing on the Delaware River Tailwaters in New York*, Report prepared for American Sportfishing Association and Trout Unlimited, October 1998.

¹²¹ Keller, David. *Delaware River Experience: Unique Educational Programs on the Delaware River*. 2006

22 February 2007 <<http://www.delawareriverexperience.org/DREPresentation.pdf>>

¹²² Delaware River Basin Commission. *American Shad Fact Sheet*. 2007

¹²³ Ibid

¹²⁴ Forks of the Delaware Shad Fishing Tournament and Festival. 2007 <http://shadtournament.com/Directions_Contacts.html> accessed June 2007

¹²⁵ Pineno, Ellen (Lambertville Chamber of Commerce). Shadfest Organizer. Telephone Interview. 18 September 2007

¹²⁶ The Shad Foundation. *Shad Journal*. Vol 1:1 Seattle, WA: November 1996

¹²⁷ Karas, Nick, "Brook Trout", Lyons Press, 1997, p.164.

¹²⁸ Maharaj, Vishwanie, Joseph McGurrin and Janet Carpenter, *The Economic Impact of Trout Fishing on the Delaware River Tailwaters in New York*, Report prepared for American Sportfishing Association and Trout Unlimited, October 1998.

¹²⁹ Ibid

¹³⁰ Ibid

¹³¹ Ibid

¹³² Ibid.

¹³³ Findley, Craig. Friends of the Upper Delaware River. "Adequate and Constant Releases - Equal's a Growing Economy." 8 April 2007

¹³⁴ Ibid

¹³⁵ Swegman, Ron P. 2005. Philadelphia on the Fly. Frank Amatto Publications: Portland, OR

¹³⁶ Ron p. Swegman blog. 2008. <<http://www.ronpswegman.com/>> accessed 6 August 2008

¹³⁷ PA Clean Water Campaign. *Who We Are*. 2007. 30 January 2007 <<http://www.pacleanwatercampaign.org>>

¹³⁸ Delaware Department of Fish and Wildlife. *License Statistics*. 2007. <<http://www.fw.delaware.gov/info/licensestats>> accessed 6 November 2006

¹³⁹ Pennsylvania Fish and Boat Commission. *Fishing Licenses*. 2007.

<http://sites.state.pa.us/PA_Exec/Fish_Boat/images/admin/lars/fishlice_county2003.htm> accessed 6 November 2006

¹⁴⁰ New Jersey Department of Fish and Game. 6 November 2006 *Calendar Year License Sales: 2001-2005*

-
- ¹⁴¹ New York Department of Environmental Conservation. 19 December 2006 *Fishing License Sales 2000-2005*. Excel Spreadsheet.
- ¹⁴² Delaware Riverkeeper Network. “*Eating Fish from the Delaware River Watershed: Know Which Fish Are Safe To Eat And How To Prepare Them.*” Data compiled from each state’s 2003 fish advisories.
- ¹⁴³ Ibid
- ¹⁴⁴ Ibid
- ¹⁴⁵ National Park Service. *Lower Delaware River National Wild and Scenic Study Report, Section II: Description of the Study Area Resources*. 2006. <<http://www.nps.gov/phso/sp/finalsect2.pdf>> accessed 30 March 2007; Delaware River Basin Commission web site, <<http://www.state.nj.us/drbc/>>, accessed March 2008
- ¹⁴⁶ US Fish and Wildlife Service. “2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, National Overview.” (Preliminary Findings) May 2007 pg. 5
- ¹⁴⁷ Ibid
- ¹⁴⁸ New Jersey Department of Environmental Protection. Division of Science, Research, and Technology. *The Economic Value of New Jersey State Parks and Forests*. June 2004 pg. 13
- ¹⁴⁹ The Outdoor Industry Foundation. “*The Active Outdoor Recreation Economy: A \$730 Billion Annual Contribution to the U.S. Economy.*” Fall 2006.
- ¹⁵⁰ Ibid
- ¹⁵¹ Ibid
- ¹⁵² Ibid
- ¹⁵³ Outdoor Recreation Alliance. *The Economic Impacts of Wildlife-Related Recreation in New Jersey*. Fact Sheet. <<http://www.outdoorrecreationalliance.com/pdf/economicbenefits.pdf>> accessed 26 July 2007
- ¹⁵⁴ Shafer, E.L. and Youngsoo Choi. *Nature-Based Tourism Policy*. Center for Rural Pennsylvania. Harrisburg, PA: November 2003
- ¹⁵⁵ Hawk Mountain Sanctuary. *Annual Report 2005*. April 2007 <www.hawkmountain.org> accessed June 2007
- ¹⁵⁶ Ibid
- ¹⁵⁷ Ibid
- ¹⁵⁸ American Eagle Foundation. *Bald Eagle: The U.S.A.’s National Symbol*. 2007. <<http://www.eagles.org/moreabout.html>> accessed 5 June 2007
- ¹⁵⁹ Ibid
- ¹⁶⁰ DiGiorgio, Yoke. (Eagle Fest organizer) Telephone Interview. 11 December 2007
- ¹⁶¹ New Jersey Audubon Society. 2007. Welcome to Birding’s Premier Event: World Series of Birding, 2007 <<http://www.njaudubon.org/WSB/>> accessed 2 August 2007
- ¹⁶² World Series of Birding, Raising Funds for Bird Conservation, <www.birds.cornell.edu/wsb/what-is-wsb> accessed 12 September 2007
- ¹⁶³ New Jersey Audubon Society. 2007 “*Cape May Bird Observatory: Recreational Birding*” <<http://www.njaudubon.org/Centers/CMBO/RecBird.html>> accessed 2 August
- ¹⁶⁴ Walls, Berkson & Smith. “*The Horseshoe Crab, Limulus polyphemus: 200 Million Years of Existence, 100 Years of Study*” *Reviews in Fisheries Science*, 2002
- ¹⁶⁵ Ibid
- ¹⁶⁶ Ibid
- ¹⁶⁷ New Jersey Department of Environmental Protection, *Status of the Red Knot (Calidris canutus rufa) in the Western Hemisphere*. Trenton: New Jersey, 2007, pg. 139
- ¹⁶⁸ Niles et. al., Status of the Red Knot (*Calidris canutus rufa*) in the Western Hemisphere, prepared for US Fish and Wildlife Service, May 2007.
- ¹⁶⁹ Dey, Amanda D., Niles, L.J., H Sitters. Report on Delaware Bay Shorebird Project 2008; Chandra, David. Director of NJ Division of Fish and Wildlife. From letter dated 27 December 2007.
- ¹⁷⁰ Eubanks, Ted; Stoll, Paul Kerlinger. 2000 “*Wildlife-associated Recreation on the New Jersey Delaware Bayshore, The Economic Impact of Tourism Based on the Horseshoe Crab-Shorebird Migration in New Jersey*”. 16 February 2000. Prepared for the NJ Dept of Environmental Protection.
- ¹⁷¹ Walls, Berkson & Smith, The Horseshoe Crab, *Limulus polyphemus: 200 Million Years of Existence, 100 Years of Study*, *Reviews in Fisheries Science*, 2002.
- ¹⁷² Eubanks, Ted; Stoll, Paul Kerlinger. 2000 “*Wildlife-associated Recreation on the New Jersey Delaware Bayshore, The Economic Impact of Tourism Based on the Horseshoe Crab-Shorebird Migration in New Jersey*”. 16 February 2000. Prepared for the NJ Dept of Environmental Protection.
- ¹⁷³ Niles et. al., Status of the Red Knot (*Calidris canutus rufa*) in the Western Hemisphere, prepared for US Fish and Wildlife Service, May 2007
- ¹⁷⁴ Niles, Larry Ph.D., Amanda Dey, Ph.D, NJ Division of Fish and Wildlife; Humphrey Sitters, Ph.D International Wader Study Group, United Kingdom; Clive Minton, Ph.D, Victoria Water Study Group, Australia. *Report on the Status of Red Knots on the Delaware Bay with Recommendations for the 2005 Field Season*.
- ¹⁷⁵ Eubanks, Ted; Stoll, Paul Kerlinger. 2000 “*Wildlife-associated Recreation on the New Jersey Delaware Bayshore, The Economic Impact of Tourism Based on the Horseshoe Crab-Shorebird Migration in New Jersey*”. 16 February 2000. Prepared for the NJ Dept of Environmental Protection.
- ¹⁷⁶ Sargent, William. *Crab Wars: A Tale of Horseshoe Crabs, Bioterrorism, and Human Health*. Lebanon, NH: University Press of New England, 2002.
- ¹⁷⁷ Ibid
- ¹⁷⁸ Ibid
- ¹⁷⁹ Walls, Berkson & Smith, The Horseshoe Crab, *Limulus polyphemus: 200 Million Years of Existence, 100 Years of Study*, *Reviews in Fisheries Science*, 2002
- ¹⁸⁰ Sargent, William. *Crab Wars: A Tale of Horseshoe Crabs, Bioterrorism, and Human Health*. Lebanon, NH: University Press of New England, 2002
- ¹⁸¹ Walls, Berkson & Smith, The Horseshoe Crab, *Limulus polyphemus: 200 Million Years of Existence, 100 Years of Study*, *Reviews in Fisheries Science*, 2002
- ¹⁸² Nature PBS Special. 2008. Crash: A Tale of Two Species
- ¹⁸³ Ibid

- ¹⁸⁴ Manion, M., R. West and R. Unsworth. 2000. Economic assessment of the Atlantic coast horseshoe crab fishery. Prepared for the Division of Economics, U.S. Fish and Wildlife Service, Arlington, VA, by Industrial Economics, Inc., Cambridge, MA.
- ¹⁸⁵ Bryson, Bill. *A Walk in the Woods: Rediscovering America on the Appalachian Trail*. Black Swan, 1998
- ¹⁸⁶ National Park Service. National Park Guide: Geographic Search; PA, NY, NJ, DE. <<http://home.nps.gov/applications/parksearch/state.cfm?st=pa>> accessed 26 July 2007
- ¹⁸⁷ New Jersey Department of Environmental Protection. 2004 “*The Economic Value of New Jersey State Parks and Forests*”. NJDEP Division of Science, Research and Technology. June 2004 pg. 12
- ¹⁸⁸ Albert, Richard C. *Damming The Delaware: The Rise and Fall of Tocks Island Dam*. University Park, PA: Pennsylvania State University Press, 1987.
- ¹⁸⁹ Ibid
- ¹⁹⁰ National Park Service. *Lower Delaware River National Wild and Scenic Study Report, Section II: Description of the Study Area Resources*. 2006. <<http://www.nps.gov/phso/sp/finalsect2.pdf>> accessed 30 March 2007
- ¹⁹¹ Ibid
- ¹⁹² National Park Service. National Park Guide: Geographic Search; PA, NY, NJ, DE.
- ¹⁹³ Guest Services, Inc. 2008 New Jersey’s Great Northwest Skylands: Delaware Water Gap National Recreation Area. <<http://www.njskylands.com/pkdwgnra.htm>> accessed 8 August 2008
- ¹⁹⁴ Ibid
- ¹⁹⁵ *DWGNRA designation National Recreation Trail*, Pocono News.Net, June 4, 2007
- ¹⁹⁶ Ibid
- ¹⁹⁷ Fish and Wildlife Service. *John Heinz National Wildlife Refuge at Tinicum: Conserving the Nature of America*. 2007. <<http://www.fws.gov/northeast/heinz/>> accessed 09 February 2006
- ¹⁹⁸ Delaware Riverkeeper Network. “*Restoration Plan for the Lower Darby Creek with Recommendations to the John Heinz National Wildlife Refuge*”. Washington’s Crossing, PA: May 2006
- ¹⁹⁹ Ibid
- ²⁰⁰ www.fws.gov/northeast/capemay/abouttherefuge
- ²⁰¹ <http://northeast.fws/nj/spm.htm>
- ²⁰² U.S. Fish and Wildlife Service. *Bombay Hook National Wildlife Refuge: Welcome*. <<http://www.fws.gov/northeast/bombayhook/>> accessed 26 July 2007
- ²⁰³ Ibid
- ²⁰⁴ Ibid
- ²⁰⁵ www.primehook.fws.gov
- ²⁰⁶ Delaware Department of Natural Resources and Environmental Control. 2003. “*DNREC NEWS: Pea Patch Island Heronry is Off Limits to Everyone but the Birds*”. 1 April 2003
- ²⁰⁷ The Nature Conservancy. 2008. “*Delaware Bayshore: The Epicenter of Horseshoe Crab Habitat*.” <<http://www.nature.org/wherework/northamerica/states/delaware/preserves/art10713.html>> accessed 20 June 2008
- ²⁰⁸
- ²⁰⁹ Pennsylvania State Parks. *Delaware Canal State Park*. <<http://www.dcnr.state.pa.us/stateparks/parks/delawarecanal.aspx>> accessed 31 July 2007
- ²¹⁰ Ibid
- ²¹¹ DCNR park attendance figures 1956 – 2006.
- ²¹² Delaware and Raritan Canal State Park. 2008. “*General Information*.” <http://www.dandrcanal.com/gen_info.html> accessed 20 June 2008
- ²¹³ Delaware and Raritan Canal Commission. “*General Information*”. 2009. <http://www.dandrcanal.com/gen_info.html> accessed 13 May 09
- ²¹⁴ Johnson, Kent. “*Family Hiking in Stokes State Forest*.” New Jersey Skylands website. <<http://www.njskylands.com/pkstokes2.htm>> accessed 31 July 2007
- ²¹⁵ StateParks.com. Worthington State Forest. USA- New Jersey. <<http://www.stateparks.com/worthington.html>> accessed 31 July 2007
- ²¹⁶ The Trust for Public Lands and Philadelphia Parks Alliance. June 2008. “*How Much Value Does the City of Philadelphia Receive from Its Park and Recreation System?*”
- ²¹⁷ The Trust for Public Lands and Philadelphia Parks Alliance, 2009. “*Measuring The Economic Value of a City Park System*”
- ²¹⁸ Fairmount Park. “*Welcome to Fairmount Park: Philadelphia’s Park System*.” <<http://www.fairmountpark.org/HistoryMain.asp>> accessed 6 August 2008
- ²¹⁹ Ibid
- ²²⁰ Ibid
- ²²¹ Explore PAHistory.com. 2003. Penn Treaty Park. <<http://www.explorepahistory.com/hmarker.php?markerId=41>> accessed 8 August 2008
- ²²² Delaware Division of Natural Resources and Environmental Conservation: Parks and Recreation. “*Overview of Delaware State Parks*”. <<http://www.destateparks.com/places/overview.htm>> accessed 31 July 2007
- ²²³ Ibid
- ²²⁴ Ibid
- ²²⁵ Ibid
- ²²⁶ Email communication with DNREC, July 27, 2007 (Actual figure provided 1,123,900)
- ²²⁷ State Parks.com. “*Catskill State Park*”. <<http://www.stateparks.com/catskill.html>> accessed 20 June 2008
- ²²⁸ Ibid
- ²²⁹ Ibid
- ²³⁰ Ibid
- ²³¹ Sylvania Tree Farm. 2005. *About Us and Campsites*. <<http://www.sylvaniatreefarm.com/aboutus.htm>>
- ²³² Ibid
- ²³³ www.dandrcanal.com/camping.html

- ²³⁴ Dingmans Choice Outdoors. *Dingmans Campground: "Welcome to Dingman's Campground 2007 Season."* <<http://www.dingmancampground.com/>> accessed 2 August 2007
- ²³⁵ StateParks.com. Worthington State Forest. USA- New Jersey. <<http://www.stateparks.com/worthington.html>> accessed 31 July 2007
- ²³⁶ Lander's River Trips. 2007. "Lander's River Trips: 2007 Rates" <<http://www.landerrivertrips.com/rates.htm>> accessed 2 August 2007
- ²³⁷ Kittatinny Canoes. 2004. *Camping Rates*. <http://www.kittatinny.com/pages/camping_rates.php> accessed 2 August 2007
- ²³⁸ Delaware Division of Natural Resources and Environmental Conservation: Parks and Recreation. "Cape Henlopen" <<http://www.destateparks.com/chsp/chsp.htm>> accessed 31 July 2007
- ²³⁹ Sylvania Tree Farm. 2005. *About Us and Campsites*. <<http://www.sylvaniatreefarm.com/aboutus.htm>>
- ²⁴⁰ Bucks County Conference and Visitors Bureau, Inc. 2007 *Visitors Guide*. Bucks County Pennsylvania: 2007
- ²⁴¹ Solebury Township, Bucks County, PA. 2005-2008. "Solebury: A natural choice to live. Community Organizations" <<http://www.soleburytpwp.org/page.aspx?p=33>> accessed 18 June 2009
- ²⁴² Ibid
- ²⁴³ Southern Delaware Tourism. "Welcome to Southern Delaware: Discover our Treasures". <<http://www.visitsoutherndelaware.com/outdoors.htm>> accessed 2 August 2007
- ²⁴⁴ Southern Delaware Outdoor Guide. Georgetown, DE: Southern Delaware Tourism, 2001.
- ²⁴⁵ Frenchtown Website. Travel and Lifestyle Guide to Hunterdon & Bucks County and Beyond. *Festivals*. 2006 <<http://www.frenchtown.com/frenchtown-nj/river-fest-2006.html>> accessed 4 June 2007
- ²⁴⁶ Press Release, River Fest Sept 1-3, Frenchtown, NJ, Aug 2, 2007.
- ²⁴⁷ Knowlton-Fest Website. 2007 <<http://www.knowlton-fest.com/>> accessed 04 June 2007
- ²⁴⁸ Peters Valley Craft Center. 2008. "Peters Valley: About Us." <<http://www.petersvalley.org/about.htm>> accessed 20 June 2008
- ²⁴⁹ Ibid
- ²⁵⁰ Ibid
- ²⁵¹ River Front Ramble website. "Home, Map, Activities" <<http://www.riverfrontramble.org/index.html>> accessed 28 July 2008
- ²⁵² Mahon, Ed. *Riverfront Ramble expands to a two-day extravaganza*. Philadelphia Inquirer. August 12, 2007
- ²⁵³ For more information, go to www.philacano.org
- ²⁵⁴ For more information, go to www.philadragonboatfestival.com
- ²⁵⁵ Cumberland County. "Cumberland County Ecotourism Plan: A Vision & implementation Strategy For Economic Development & Conservation". February 1996
- ²⁵⁶ Klapproth, Julia C. and James E. Johnson. Understanding the Science Behind Riparian Forest Buffers: Benefits to Communities and Landowners. 2001. Virginia Cooperative Extension. Blacksburg, VA: pg. 6 (citing EPA 1995)
- ²⁵⁷ Delaware Bay and Estuary Assessment Report, DNREC and EPA, August 2005.
- ²⁵⁸ Scholl, Dennis. 1997. History of Shad in the Lehigh River. <<http://mgfx.com/fishing/assocs/drsfa/history.htm>> accessed 31 July 2008
- ²⁵⁹ Ibid
- ²⁶⁰ Delaware River Basin Commission. *American Shad Fact Sheet*. 2007
- ²⁶¹ NOAA/National Marine Fisheries Service, Northeast Region, Press Release: Commercial Fisheries and Mariculture Revenues for Northeast Coastal States Hit \$957 million in 1998; July 8, 1999
- ²⁶² Sciascia, Jim. "Trout Fishing in New Jersey- The Good 'Ole Days are Now." *New Jersey Outdoors*, Spring 2001
- ²⁶³ Beal, Robert. 2000. Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Atlantic Striped Bass (*Morone saxatilis*). 21 November 2000
- ²⁶⁴ The Shad Foundation. *Shad Journal*. Vol 1:1 Seattle, WA: November 1996
- ²⁶⁵ Ibid
- ²⁶⁶ Ibid
- ²⁶⁷ Ibid
- ²⁶⁸ Ibid
- ²⁶⁹ Ibid
- ²⁷⁰ The Shad Foundation. *Shad Journal*. Vol 1:1 Seattle, WA: November 1996
- ²⁷¹ Army Corps of Engineers Philadelphia District. 2006 Delaware Bay Oyster Restoration Project: Delaware and New Jersey. Final Environmental Impact Statement. April 2006.
- ²⁷² Ibid
- ²⁷³ News from The Delaware Department of Natural Resources and Environmental Control Vol. 39, No. 402, Oct. 8, 2009.
- ²⁷⁴ Moore, Kirk. "Delaware Bay Oysters Thrive on Clam Shells" Home News Tribune. 29 January 2006
- ²⁷⁵ Bauers, Sandy. "Clams Give Jersey Oysters a Leg Up." Philadelphia Inquirer. 29 January 2007
- ²⁷⁶ News from The Delaware Department of Natural Resources and Environmental Control Vol. 39, No. 402, Oct. 8, 2009.
- ²⁷⁷ Crab Connection. Personal Communication. July 2008
- ²⁷⁸ Laini's little pocket guide to Easton PA. Launch Party Invitation. July 16, 2007.
- ²⁷⁹ Philadelphia Italian Market website. <<http://www.phillyitalianmarket.com/market/9thstreet.htm>> 5 June 2007
- ²⁸⁰ Reading Terminal Market. *Welcome to the Reading Terminal Market*. January 2007 <http://www.readingterminalmarket.org/pdf/RTM_dir_2007.pdf> accessed 5 June 2007
- ²⁸¹ Bucks County Open Space Task Force. *Report of the Bucks County Open Space Task Force*. 20 June 2007 pg. 3
- ²⁸² Ibid
- ²⁸³ Delaware River Basin Commission. *Surface Water Intakes Spreadsheet*. February 2007
- ²⁸⁴ Hood, James R. "Second Company Named in Contaminated Spinach Outbreak: Consumers warned to Avoid All Fresh Spinach." *ConsumerAffairs.com*. 19 September 2006
- ²⁸⁵ Klapproth, Julia C. and James E. Johnson. Understanding the Science Behind Riparian Forest Buffers: Benefits to Communities and Landowners. 2001. Virginia Cooperative Extension. Blacksburg,

- VA: pg. 6 (citing Veenhuizen and Shurson 1992)
- ²⁸⁶ Klapproth, Julia C. and James E. Johnson. Understanding the Science Behind Riparian Forest Buffers: Benefits to Communities and Landowners. 2001. Virginia Cooperative Extension. Blacksburg, VA: pg. 6 (citing Johnson 1994 and Overcash 1983)
- ²⁸⁷ U.S. EPA. Private Drinking Water Wells: Human Health. <<http://www.epa.gov/safewater/privatewells/health.html>> accessed 20 June 2008
- ²⁸⁸ City of Philadelphia. 2006. City of Philadelphia website <www.phila.gov> accessed 4 January 2008
- ²⁸⁹ US Waterborne Outbreaks 2003-2004, *Hresidentealth Stream* the Public Health Newsletter of the Cooperative Research Center for Water Quality and Treatment, March 2007.
- ²⁹⁰ Mendoza, Martha. "Pharmawater-Secrecy, Water provides, researchers rarely release full test results". Metrowest Daily News. 11 March 2008
- ²⁹¹ House, Khara. "Cotinine, Other Prescription Drugs, Found in U.S. Drinking Water". AC Associated Content, March 10, 2008
- ²⁹² Barbier, Edward B. and Geoffrey M. Heal. "Valuing Ecosystem Services". The Berkeley Electronic Press, February 2006
- ²⁹³ Natural Resource Council: Committee on Assessing and Valuing the Services of Aquatic and related Terrestrial Ecosystems. 2004 Valuing Ecosystem Services: Toward Better Environmental Decision-making, The National Academies Press. pg. 157
- ²⁹⁴ Barbier, Edward B. and Geoffrey M. Heal. "Valuing Ecosystem Services". The Berkeley Electronic Press, February 2006. NY Department of Conservation land purchases have been of undeveloped land from willing sellers, as opposed to condemnation or eminent domain acquisition. Valuing Ecosystem Services, Toward Better Environmental Decision-making, National Research Academy, The National Academies Press, www.nap.edu (2004), p. 157.
- ²⁹⁵ Natural Resource Council: Committee on Assessing and Valuing the Services of Aquatic and related Terrestrial Ecosystems. 2004 Valuing Ecosystem Services: Toward Better Environmental Decision-making, The National Academies Press. pg. 158
- ²⁹⁶ DePalma, Anthony. "New York City Water Rates Expected to Rise 11.5 Percent." *New York Times*. 11 April 2007
- ²⁹⁷ New Jersey Department of Environmental Protection. Division of Science, Research, and Technology. 2004 "*The Economic Value of New Jersey State Parks and Forests*". June 2004
- ²⁹⁸ Klapproth, Julia C. and James E. Johnson. Understanding the Science Behind Riparian Forest Buffers: Benefits to Communities and Landowners. 2001. Virginia Cooperative Extension. Blacksburg, VA: Pg. 4 (citing Welsch 1991)
- ²⁹⁹ Klapproth, Julia C. and James E. Johnson. Understanding the Science Behind Riparian Forest Buffers: Benefits to Communities and Landowners. 2001. Virginia Cooperative Extension. Blacksburg, VA: Pg. 4 (citing Palone and Todd 1997)
- ³⁰⁰ Dale, Frank. Delaware Diary: Episodes in the Life of a River. New Brunswick, NJ: Rutgers University Press, 1996
- ³⁰¹ Ibid
- ³⁰² Delaware River Basin Commission. Surface Water Intakes Spreadsheet. February 2007
- ³⁰³ Ibid
- ³⁰⁴ "State's largest utility shut down nuclear plant." *Associated Press* 25 April 2007
- ³⁰⁵ Yahoo Finance. *Exelon Corp (PSEG): Direct Competitor Comparison*. <<http://finance.yahoo.com/q/co?s=PSEG>> accessed 5 July 2007
- ³⁰⁶ Delaware River Basin Commission. Surface Water Intakes Spreadsheet. February 2007
- ³⁰⁷ Yahoo Finance. *Exelon Corp (EXC): Direct Competitor Comparison*. <<http://finance.yahoo.com/q/co?s=EXC>> accessed 5 July 2007
- ³⁰⁸ Delaware River Basin Commission. Surface Water Intakes Spreadsheet. February 2007
- ³⁰⁹ Ibid
- ³¹⁰ Ibid
- ³¹¹ <http://www.epa.gov/cgi-bin/broker?>
- ³¹² Dow Chemical. Dow News Center. 2006. <www.news.dow.com/corporate/2006/200607250.htm> accessed 20 June 2008
- ³¹³ Klapproth, Julia C. and James E. Johnson. Understanding the Science Behind Riparian Forest Buffers: Benefits to Communities and Landowners. 2001. Virginia Cooperative Extension. Blacksburg, VA: Pg. 10 (citing Ribaldo 1986)
- ³¹⁴ Hopey, Don. 17 November 2008 "*Monongahela River Solids and a Threat to Machinery but not Health*". Pittsburgh Post-Gazette. Pittsburgh: PA. <<http://www.ceoe.udel.edu/oilspill/shipping.html>>
- ³¹⁵ Ibid
- ³¹⁶ <http://www.drpa.org/projects/green.html>
- ³¹⁷ Andrew Murr. PROJECT GREEN, Shipping News, "The 'greening' of America's two biggest ports", Newsweek Web Exclusive, Sep 9, 2008, <http://www.newsweek.com/id/158126>
- ³¹⁸ <http://www.ceoe.udel.edu/oilspill/shipping.html>
- ³¹⁹ Delaware River Basin Commission. Delaware River Basin Facts. <<http://www.state.nj.us/drbc/thedrb.htm>> accessed 30 November 2006
- ³²⁰ Maritime Commerce in Greater Philadelphia, Assessing Industry Trends and Growth Opportunities for Delaware River Ports, July 2008 p.3
- ³²¹ Ibid
- ³²² Delaware River Basin Commission. Delaware River Basin Facts. <<http://www.state.nj.us/drbc/thedrb.htm>>
- ³²³ 30 November 2006
- ³²⁴ Pappas, Leslie A. "Study: Growth coming if ports plan for it." *The News Journal*. 23 March 2007
- ³²⁵ For more detailed information see: Delaware Riverkeeper Network & National Wildlife Federation, Delaware River Deepening Dumped Again, March 2007; Delaware Riverkeeper Network & National Wildlife Federation, Strike Three ... The Corps Fails Again to Justify the Delaware River Deepening, July, 2003
- ³²⁶ Albert, Richard C. "The Historical Context of Water Quality Management for the Delaware Estuary." *Estuaries* June 1988. Vol 11, No. 2 pg 99-107
- ³²⁷ Coast Guard <www.house.gov/transportation/cgmt/01-18-05/01-18-05memo.html>
- ³²⁸ <http://www.drpa.org/projects/green.html>
- ³²⁹ Andrew Murr, PROJECT GREEN, Shipping News, "The 'greening' of America's two biggest ports", Newsweek Web Exclusive, Sep 9, 2008, <http://www.newsweek.com/id/158126>

-
- ³³⁰ Lenape Lifeways. 2002. "Who were the Lenapes?" <<http://www.lenapelifeways.org/lenape1.htm#lenapes>> accessed 3 August 2007
- ³³¹ Dale, Frank. *Delaware Diary: Episodes in the Life of a River*. New Brunswick, NJ: Rutgers University Press, 1996.
- ³³² American University. Department of Anthropology. " *Shawnee Minisink: New Dates on the Paleoindian Component*" <http://www.american.edu/cas/anthro/shawnee_minisink_2.html> accessed 2 August 2007
- ³³³ Albert, Richard C. *Damming The Delaware: The Rise and Fall of Tocks Island Dam*. University Park, PA: Pennsylvania State University Press, 1987.
- ³³⁴ Ibid
- ³³⁵ Ibid
- ³³⁶ Delaware River Basin Commission. *Pea Patch Island Fact Sheet*. 2007
- ³³⁷ American University. The Department of Anthropology. " *Shawnee Minisink: New Dates on the Paleoindian Component*" <http://www.american.edu/cas/anthro/shawnee_minisink_2.html> accessed 2 August 2007
- ³³⁸ National Park Service. 2007. " *Valley Forge: History and Culture*". <<http://www.nps.gov/vafo/historyculture/index.htm>> accessed 2 August 2007
- ³³⁹ Pennsylvania Historical and Museum Commission. U.S. History.org. *Washington Crossing Historic Park*. <<http://www.ushistory.org/washingtoncrossing/>> accessed 31 July 2007
- ³⁴⁰ Pennsylvania Historical and Museum Commission. U.S. History.org. *Washington Crossing Historic Park: Timeline* <<http://www.ushistory.org/washingtoncrossing/history/timeline.htm> > accessed 2 August 2007
- ³⁴¹ Delaware River Basin Commission. *Pea Patch Island Fact Sheet 2007*
- ³⁴² National Park Service. 2006. *Upper Delaware Scenic and Recreational River: Zane Grey*. <<http://www.nps.gov/upde/historyculture/zanegrey.htm>> accessed 31 July 2008
- ³⁴³ Ibid
- ³⁴⁴ Ibid
- ³⁴⁵ National Park Service. 2006. Upper Delaware Scenic and Recreational River. Roebling's Delaware Aqueduct. <<http://www.nps.gov/upde/historyculture/roebningbridge.htm>> accessed 31 July 2008
- ³⁴⁶ Ibid
- ³⁴⁷ Ibid
- ³⁴⁸ Ibid
- ³⁴⁹ R. Bruins & M. Heberling, *Economics and Ecological Risk Assessment, Applications to Watershed Management*, Chapter 15, p. 415
- ³⁵⁰ R. Bruins & M. Heberling, *Economics and Ecological Risk Assessment, Applications to Watershed Management*, Chapter 15, p.



Re: Regulatory Takings: Northern Wayne Property Owners Alliance Letters to DRBC

QUESTION PRESENTED

Whether a gas rights leaseholder has a claim for uncompensated regulatory takings due to the Delaware River Basin Commission temporary moratorium on shale gas development? Would a leaseholder have a claim if the moratorium were permanent?

BRIEF ANSWER

Leaseholders likely do not have a taking claim because the DRBC’s moratorium on drilling within the Delaware River Basin pending the promulgation of final regulations constitutes neither a total taking under the *Lucas* Test, nor a partial taking under the factors articulated in *Penn Central*. Furthermore, it is likely that this case is not ripe for consideration as no “unreasonable delay” in promulgating final regulations on DRBC’s part can be established.¹

The DRBC should, of course, perform its own legal research and analysis on the issues.

REGULATORY TAKINGS OVERVIEW

The Takings Clause of the Fifth Amendment to the Constitution states that private property shall not be “taken for public use, without just compensation.” U.S. Const. Art. 5. Ultimately, the “purpose of the Takings Clause . . . is to prevent the government from ‘forcing some people alone to bear public burdens which, in all fairness and justice, should be borne by

¹ This analysis does not include a review of two recent Supreme Court cases decided in June of 2013: *Nollan v. California Coastal Commission*, and *Dolan v. City of Tigard*. While these decisions may expand a property-owner’s ability to challenge local land use regulation, it is not clear whether this expansion will result in more successful legal challenges.

the public as a whole.” *Palazzolo v. Rhode Island*, 533 U.S. 606, 617-18, (2001) (quoting *Armstrong v. United States*, 364 U.S. 40, 49 (1960)). A disproportional burden borne by the property owner does not automatically indicate a taking. *See Penn Central Transp. Co. v. New York City*, 438 U.S. 104, 124 (1978) (stating that there is no “set formula” to determine *when* the imposition of a disproportional burden requires compensation). Instead, “[t]he Takings Clause [] preserves governmental power to regulate, subject only to the dictates of ‘justice and fairness.’” *Andrus v. Allard*, 444 U.S. 51, 65 (1979) (quoting *Penn Central Transp. Co.*, 438 U.S. at 124) (emphasis added).

Takings jurisprudence “aims to identify regulatory actions that are *functionally equivalent to the classic taking* in which government directly appropriates private property or ousts the owner from his domain.” *Lingle v. Chevron U.S.A. Inc.*, 544 U.S. 528, 539 (2005) (emphasis added). Additionally, the Supreme Court has denied takings challenges “in a wide variety of situations when the challenged governmental action prohibited a beneficial use to which individual parcels had previously been devoted and thus caused substantial individualized harm.” *Penn Central Transp. Co.*, 438 U.S. at 125. A taking stemming from a moratorium is known as a “regulatory taking” and was first acknowledged in *Pennsylvania Coal Co. v. Mahon*. 260 U.S. 393 (1922). Given a protected property interest, the types of regulations that constitute total or partial takings fall into three categories: a regulation requiring a physical intrusion onto the owner’s property, a regulation that totally eliminates any productive use for the property, and a regulation that does not wholly eliminate the property’s productive use but is found to be severe in light of a balance of relevant factors. *Lingle*, 544 U.S. at 538-39.

In non-appropriation/non-physical invasion cases, such as a regulatory taking case, there are two different tests to determine whether a taking has occurred: the first test addresses the

“relatively rare” situation in which a land use regulation deprives the owner of all use of his or her property. *Lucas v. South Carolina Coastal Council*, 505 U.S. 1003, 1017, 112 S.Ct. 2886, 120 L.Ed.2d 798 (1992). The second “test” is the more traditional takings analysis, which becomes applicable if the regulation does not rise to the level of a *Lucas* taking, known as the *Penn Central* test. *Penn Central*, 438 U.S. at 124.

Lucas stands for the proposition that regulations that deprive an owner of “all economically beneficial or productive use of land” are takings unless the use constitutes a public nuisance or are caused by the nature of the use and the owner could have expected that the government might prohibit it. *Lucas*, 505 U.S. at 1027-1029, 112 S.Ct. 2886. Therefore, to conduct a *Lucas* analysis, courts determine whether the subject regulation “deprives a landowner of all economically beneficial” use of his or her property. If so, the regulation will constitute a taking unless state property law independently prohibits the use. *Id.* at 1027. More recently, in *Lingle v. Chevron U.S.A. Inc.*, the Supreme Court again noted that one of the situations “that generally will be deemed *per se* takings for Fifth Amendment purposes” occurs when a regulation or regulatory action “completely deprive[s] an owner of ‘all economically benefit us[e]’ of her property.” 544 U.S. 528, 538 (2005). Courts have denied *Lucas*-type takings claims when the regulation at issue left the claimant with beneficial uses. *Palazzolo*, 533 U.S. at 630-31, 121 S. Ct. at 2464 (claimant could build a “substantial residence”); *Keystone Bituminous Coal Assn. v. DeBenedictis*, 480 U.S. 470, 501, 107 S. Ct. 1232, 1250 (1987) (claimants retained right to mine mineral estates, and only some of the support estates were restricted under the challenged statute); *Briarcliff Associates, Inc. v. Town of Cortlandt*, 272 A.D.2d 488, 491 (2d Dep’t 2000) (claimant retained right to operate emery mine as legal nonconforming use; residential development remained a possibility).

In the absence of a physical, *per se* takings claim, the claimant may fall back on the default rule laid out in *Penn Central*. *Lingle*, 544 U.S. at 538, 125 S. Ct. at 2081; *Friedenburg v. DEC*, 3 A.D.3d 86, 95, 767 N.Y.S.2d 451, 458 (2d Dep’t 2003). The analysis “necessarily entails complex factual assessments of the purposes and economic effects of government actions.” *Tahoe-Sierra Preservation Council*, 535 U.S. at ____, 122 S. Ct. at ____ (quoting *Yee v. Escondido*, 503 U.S. 519, 523, 112 S. Ct. 1522, 1526 (1992)). In *Penn Central*, the Court decided there was no taking when a Landmarks Preservation Law prohibited the owner of Grand Central Terminal from building a multistory office structure on top of the terminal. Since the regulation did not deprive the owner of all economically beneficial use, the Court used a three-pronged analysis that included the economic impact of the regulation, the interference with reasonable investment-backed expectations, and the character of the government action in coming to this decision. *Palazzolo*, 533 U.S. at 617, 121 S. Ct. at 2457 (citing *Penn Central Transp. Co.*, 438 U.S. at 124, 98 S. Ct. at 2659). The third factor is explained as whether the action resembles a physical intrusion into the property interest or whether it more resembles a “public program adjusting the benefits and burdens of economic life to promote the common good.” *Penn Central Transp. Co.*, 438 U.S. at 124, 98 S. Ct. at 2659; *see also Lingle*, 544 U.S. at 539, 125 S. Ct. at 282.

THE DENOMINATOR PROBLEM

Pursuant to either analysis, there is a threshold question, frequently referred to as the “denominator problem,” which must be answered: what is the parcel against which the takings tests are applied? *See Keystone*, 480 U.S. 470 at 479, 107 S.Ct. 1232, 94 L.Ed.2d 472. If the area is defined broadly, almost no government action—no matter how intrusive—will be found to be a taking. *See John E. Fee, Unearthing the Denominator in Regulatory Takings Claims*, 61 U. CHI.

L.REV. 1535, 1536 (1996). Similarly, if we define the land too narrowly, virtually all government action that affects private property will be a taking that requires compensation and government will be inhibited from enacting necessary legislation. *Id.*

Because property is conceptualized as a “bundle” of “property rights.” *see Loretto v. Teleprompter Manhattan CATV, Corp.*, 458 U.S. 419, 435, 102 S.Ct. 3164, 73 L.Ed.2d 868 (1982), courts have had to struggle with what has been referred to as “severance” issues in defining the relevant parcel. See Marc R. Lisker, *Regulatory Takings and the Denominator Problem*, 27 RUTGERS L.J. 663, (Spring 1966) (“the Lisker Article”). In other words, the courts have been called upon to consider whether some of the property rights in the bundle may be severed from the others and viewed separately as the relevant parcel. Severance issues have involved the following: (1) the horizontal, physical division of property - is the relevant parcel all the land in a given geographic area that one owns or some smaller portion of that acreage? *See, e.g., Florida Rock Industries v. United States*, 791 F.2d 893 (Fed.Cir.1986); (2) the vertical division of property - can the parcel be divided among air rights, surface rights, and mineral rights? *See Penn Central*, 438 U.S. at 130, 98 S.Ct. 2646 and *Keystone*, 480 U.S. at 470, 107 S.Ct. 1232; or (3) the temporal division of property - can the property be viewed in discrete temporal units? *See Tahoe-Sierra Pres. Council Inc. v. Tahoe Reg. Planning Agency*, 535 U.S. -- --, 122 S.Ct. 1465, 152 L.Ed.2d 517 (2002).

When a regulatory takings claim involves the ownership of a fee simple estate in land, it is well established that the owner cannot break that fee estate into segments in order to establish a taking of the regulated segment. *E.g., Penn Central Transp. Co. v. City of New York*, 438 U.S. 104, 130-31 (1978) (“Takings’ jurisprudence does not divide a single parcel into discrete segments and attempt to determine whether rights in a particular segment have been entirely

abrogated”); *Andrus v. Allard*, 444 U.S. 51, 65-66 (1979) (“At least where an owner possesses a full ‘bundle’ of property rights, the destruction of one ‘strand’ of the bundle is not a taking, because the aggregate must be viewed in its entirety”); *Keystone Bituminous Coal Ass’n v. DeBenedictis*, 480 U.S. 470, 500 (1987) (rejecting plaintiff’s attempt to vertically define the relevant parcel as only its “support estate” even though that segment was recognized as a legally distinct property interest under state law). From 1978 until recently, the lower federal courts and state courts have generally utilized the whole-parcel analysis, usually to defeat a taking claim. *Appolo Fuels, Inc. v. U.S.*, 54 Fed. Cl. 717, 56 Env’t. Rep. Cas. (BNA) 1393 (2002); *Naegele Outdoor Adver. v. City of Durham*, 803 F. Supp. 1068 (M.D.N.C. 1992); *Ciampitti v. United States*, 22 Cl. Ct. 310 (1991); *Dufau v. United States*, 22 Cl. Ct. 156 (1990), *Zilber v. Town of Moraga*, 692 F. Supp. 1195 (N.D. Cal. 1988); *Moore v. City of Costa Mesa*, 678 F. Supp. 1448 (C.D. Cal. 1987); *Jentgen v. United States*, 657 F.2d 1210 (1981); *Deltona Corp. v. United States*, 657 F.2d 1184 (1981); *Palazzolo v. State ex rel. Tavares*, 746 A.2d 707 (R.I. 2000).

The U.S. Supreme Court recently reaffirmed the validity of the property as “a whole rule.” *Tahoe-Sierra Preservation Council v. Tahoe Reg. Planning Agency*, 535 U.S. ----, 122 S.Ct. 1465, 1480-81, 152 L.E.2d 517 (2002). In *Tahoe-Sierra*, Petitioners sought to divide their interests in land into temporal parts to claim that the statute, which imposed a temporary moratorium on development of private property surrounding Lake Tahoe, caused the restricted temporal portion of their property to become valueless. *Id.* at 1482-83. The Court declined to allow Petitioners to so divide their property. *Id.* It held that the moratorium did not constitute a *Lucas* taking because a fee simple interest in property may not be temporally divided for the purpose of takings analysis. *Id.* at 1482-84. The Court held that, when viewed as a whole the

properties at issue retained value and that the temporary development prohibition did not rise to the level of a *Lucas* taking. The Court explained:

Petitioners' "conceptual severance" argument is unavailing because it ignores *Penn Central's* admonition that in regulatory takings cases we must focus on "the parcel as a whole." We have consistently rejected such an approach to the "denominator" question.... Thus, the District Court erred when it disaggregated petitioners' property into temporal segments corresponding to the regulations at issue and then analyzed whether petitioners were deprived of all economically viable use during each period....

Pin cite.

In some courts, a trend contrary to *Tahoe-Sierra* has appeared, arising principally from decisions of the Court of Federal Claims under the statute known as the Tucker Act, which governs tort claims against the federal government. In *Loveladies Harbor, Inc. v. United States*, the court held that the denial of a United States Army Corps of Engineers permit for the development of the last 12 acres of what had been a 250-acre subdivision was a taking; the court permitted analysis of the 12-acre parcel instead of the entire parcel as it had been developed during more than 20 years. *Loveladies Harbor, Inc. v. United States*, 28 F.3d 1171 (Fed. Cir. 1994). Rather than adopting a firm rule, however, the court held that each case would have to be reviewed on its own facts in order to determine what the proper numerator and denominator of the takings analysis should be. *Id.*

Less than eight months after the United States Supreme Court decision in *Tahoe-Sierra*, supporting the "parcel as a whole" rule, the Ohio Supreme Court rejected the rule in *State ex rel. R.T.G., Inc. ("R.T.G.")*. *State ex rel. R.T.G., Inc. v. State*, 98 Ohio St. 3d 1 (2002). The court concluded that mineral rights were separate property interests from land surface rights. In segmenting the property interests, the court concluded that the restriction of coal mining on a portion of the property constituted a taking of that particular piece of property. In rendering its decision, the Ohio Supreme Court acknowledged that the U.S. Supreme Court had twice rejected

this kind of segmentation, but it ignored these precedents by claiming certain Supreme Court justices had questioned the application of the parcel-as-a-whole rule. However, in the same year that *R.T.G.* was decided, the Pennsylvania Supreme Court in *Machipongo Land and Coal Co., Inc. v. Com.* reached the opposite conclusion on similar facts as *R.T.G.* The Pennsylvania Supreme Court has consistently relied upon the decisions of the U.S. Supreme Court when considering takings issues, and as such, flatly rejected the argument that surface rights could be segmented from mineral rights, thereby supporting the parcel-as-a-whole rule. *See Machipongo Land and Coal Co., Inc. v. Com.*, 569 Pa. 3, 799 A.2d 751, (2002) (court examined the whole parcel in light of the individual portions of the property subject to logging restrictions and found no taking).

Ultimately, while there has been some dissension, the Supreme Court has refused to allow: vertical severance of the mineral estate in *Keystone*; vertical segmentation of air and surface rights in *Penn Central*; or temporal division of property in *Tahoe-Sierra*. Thus, the relevant parcel cannot be segmented, and must be defined to include both the surface and mineral rights.

ANALYSIS: LANDOWNERS DO NOT HAVE A TAKING CLAIM

To properly bring a successful takings claim, first the claimant must identify the property interest allegedly taken. *Northwest La. Fish & Game Pres. Comm'n v. United States*, 79 Fed. Cl. 400, 408 (2007). A Leaseholder has a recognized property right, lease rights, subject to 5th Amendment takings clause. *Love Terminal Partners v. United States*, 97 Fed. Cl. 355, 371 (2011). “As a general proposition, a leasehold interest is property, the taking of which entitles the leaseholder to just compensation for the value thereof.” *Sun Oil Co. v. United States*, 215 Ct. Cl.

716, 769 (1978) (Sun Oil held lease for oil and gas rights from Department of Interior). The property interest allegedly taken through the DRBC moratorium is a natural gas leasehold.

As indicated in the February 2012 letter provided by NWPOA landowners to the DRBC, “all of NWPOA’s members owned unsevered natural gas rights.” Therefore, the “denominator” is unquestionably the entire parcel – both surface and subsurface rights. As such, NWPOA landowners likely do not have a taking claim because the moratorium on drilling constitutes neither a total taking under the *Lucas* Test, nor a partial taking under the factors articulated in *Penn Central*. Under *Lucas*, landowners retain other reasonable uses of their land, and therefore have not been deprived of “all economically beneficial or productive use of land.” *Lucas*, 505 U.S. at 1027-1029. In fact, in NWPOA’s June 2013 letter it is made abundantly clear that landowners may “timber their lands or subdivide them and open the subdivisions to development so they and their families can keep going financially.” Under the *Penn Central* analysis, the economic impact is mitigated by the potential use of the properties for other reasonable purposes. Additionally, the investment backed expectations of the landowners are in a heavily regulated arena and are not derived from traditional long-protected land uses. Lastly, the rare circumstance of extraordinary delay and bad faith are not supported by the DRBC’s crafting of a series of complex, permanent regulations that have the potential to impact the drinking water of over 15 million people.

LUCAS TEST:

Under the test in *Lucas*, the prohibition of particular uses does not constitute a taking if other uses are allowed. *Andrus v. Allard*, 444 U.S. 51, (1979); *Thompson v. City of Red Wing*, 455 N.W.2d 512 (Minn. App. 1990) (prohibition on gravel mining not taking where other economic uses remain); *see also Adolph v. Federal Emergency Management Agency*, 854 F.2d

732 (5th Cir. 1988) (FEMA floodplain regulations not taking because they only require elevation and floodproofing, and thus do not prevent all reasonable uses of land) *Miller & Son Paving, Inc. v. Plumstead Township*, 552 Pa. 652, 717 A.2d 483 (1998) (A taking does not result merely because a regulation ... deprive[s] the owner of the most profitable use of his property). For landowners who own drilling rights as part of their estate, the banning of mining activities does not extinguish all economic use of their property. *William C. Haas & Co. v. City & County of San Francisco*, 605 F.2d 1117 (9th Cir. 1979) (zoning ordinance valid even though reduced property value by more than 90%); *see also Hadacheck v. Sebastian*, 239 U.S. 394, 36 S. Ct. 143, 60 L. Ed. 348 (1915); *Pace Resources Inc. v. Shrewsbury Tp.*, 808 F.2d 1023 (3d Cir. 1987) (In measuring diminution of value, as noted by the court in *Pace Resources*, the owner's loss of highest and best use is not the controlling factor).

Landowners here retain other reasonable uses of their land, such as for the construction of residences, farming, timber sales, conventional natural gas extraction, and mining. The Supreme Court has repeatedly criticized defining the property interest taken in terms of the regulation challenged as “circular.” *Tahoe-Sierra Preservation Council*, 535 U.S. at 331, 122 S. Ct. at 1483. The Court looks instead to the parcel as a whole. *Id.* Therefore, NWPOA’s claim that “the value of natural gas development would dwarf the value of the surface estate,” is irrelevant. Under *Lucas*, landowners here simply do not have a total taking claim.

PENN CENTRAL TEST:

Turning now to the Penn Central test, the landowners regulatory takings claim here fail as well. Regulatory takings jurisprudence under Penn Central is characterized by “essentially ad hoc, factual inquiries,” designed to allow “careful examination and weighing of all the relevant circumstances,” *Palazzolo v. Rhode Island*, 533 U.S. 606, 636 (2001) (O’CONNOR, J.,

concurring). The Supreme Court has “identified several factors ... that have particular significance: ‘the economic impact of the regulation, its interference with reasonable investment backed expectations, and the character of the governmental action.’” *Eastern Enters. v. Apfel* at 521 (citing *Penn Central Transp. Co.* at 124).

a) Economic Impact

Similar to the focus in the *Lucas* test, in evaluating the economic impact of a regulation on a plaintiff, a court focuses on the nature and extent of the interference with a plaintiff's rights in the parcel as a whole. *Tahoe-Sierra Pres. Council Inc. v. Tahoe Regional Planning Agency* at 327; *Andrus v. Allard* at 51, 66. The Supreme Court found a 94 percent diminution in value to leave more than “a token interest” that did not leave the property “economically idle.” *Palazzolo v. Rhode Island* at 631. Similarly, a 91 percent reduction in value was found not to be a categorical taking. *Rith Energy Inc. v. United States*, 270 F.3d at 1349. Recently, the Federal Circuit found losses of 92 percent and 78 percent to be “manifestly insufficient” to establish a taking. *Appollo Fuels Inc. v. United States* at 1347; *see also Village of Euclid v. Ambler Realty Co.*, 272 U.S. 365, 384 (1926) (approximately 75 percent diminution in value); *Hadacheck v. Sebastian*, 239 U.S. 394, 405 (1915) (92.5 percent diminution); *Lucas v. South Carolina Coast Council* at 1019-1020 n.8 (suggesting that a 95 percent diminution in value would not constitute a categorical taking); *Maritrans Inc. v. United States* at 1358 (13 percent reduction in value does not constitute a taking); *Brace v. United States* at 337, 357 (14 percent diminution in value does not have the effect of a taking). However much a gas drilling moratorium diminishes the value of mineral rights, a court cannot find a taking unless the other *Penn Central* factors weigh heavily in favor of a taking, which they do not.

b) Investment Backed Expectations

In determining whether there has been a regulatory taking, it is well settled that courts must evaluate the extent to which the challenged governmental action has interfered with the reasonable investment-backed expectations of the property owner. *Keystone Bituminous Coal Ass'n v. DeBenedictis* at 495. NWPOA landowners have little reason for investment-backed expectations. No permit has ever been granted in Pennsylvania for the practice of horizontal high-volume hydraulic fracturing in the Delaware River Basin. Courts consider three factors for property that was acquired prior to regulation: (1) is it a highly regulated industry or activity; (2) was the plaintiff aware of the problem that spawned regulation when the property was acquired; and (3) could the regulation have been reasonably anticipated?

Gas development is a heavily regulated field everywhere in the United States and subject to a rigorous permitting process. In the area of mineral interests, such expectations are necessarily shaped by the fact that the development and extraction of natural resources through mining or drilling has a long history of heavy regulation due to the adverse environmental impacts that can result. *See District Intown Props., Ltd. v. District of Columbia*, 198 F.3d 874, 884 (D.C. Cir. 1999) (“[b]usinesses that operate in an industry with a history of regulation have no reasonable expectation that regulation will not be strengthened to achieve established legislative ends.”). Because hydrocarbon extraction and development is such a heavily regulated field, any landowner who acquired property in the Delaware River Basin for the purpose of resource extraction, as well as any gas driller, should be well aware that the economic prospects may be limited by regulations. However, since high-volume horizontal hydrofracking is a relatively new process for extracting gas, many landowners in the Marcellus Shale may have just recently discovered the profitability of their property for gas development. The third prong of the analysis addresses this situation by considering whether regulation could have reasonably been

anticipated when the industry introduced a new practice. Because hydrofracking is more invasive and resource intensive than previous methods used to extract gas, imminent regulation should have been anticipated. This is especially true in the Delaware River Basin where dangers to surface waters have been targeted for rigorous regulation by the DRBC since the 1950s. A landowner can change the economic expectations of his or her property once a new practice is introduced that can suddenly change the land's profitability, but those expectations will only be considered in the context of the overall regulatory regime in place.

This case does not deal with traditional, long-protected land uses. Natural gas from mile deep shale formations is considered an “unconventional” fuel source. In turn, natural gas extraction by high volume slick water fracturing is an unconventional land use. Under these circumstances, fairness requires giving agencies with proper jurisdiction, such as the DRBC, the chance to determine the legal limits of the property interest associated with the new technology, before courts step in to require compensation for denying the exploitation of that interest.

c) Character of Government Action

An evaluation of the character of the government's action involves an inquiry into “the public purposes served by the [g]overnment's regulatory actions. ...” *Bass Enterprises Prod. Co. v. United States*, 381 F.3d at 1369-1370. The assessment includes an analysis of “[t]he purposes served, as well as the effects produced, by a particular regulation,” *Palazzolo v. Rhode Island* at 633, and the “purpose and economic effect” of the government's actions. *Tahoe-Sierra Pres. Council Inc. v. Tahoe Regional Planning Agency* at 323. A government's traditional regulatory actions, such as those involving zoning, permits, moratoriums, and other land use provisions, as well as those affecting safety, often do not constitute takings if the duration of the regulatory restriction is within reasonable time limits. *Id.* at 329.

The Federal Circuit first observed that neither a permitting process alone nor the mere assertion of regulatory jurisdiction, without more, can constitute a taking; nor can mere fluctuations in value during the decision-making process, absent extraordinary delay. *Id.* at 1098-99 (citing *Agins*). *see also Cooley*, 324 F.3d at 1307 (“The length of the delay is not the only or necessarily the critical factor for finding a taking by extraordinary governmental delay.”); *see also Williamson County Reg'l Planning Comm'n v. Hamilton Bank of Johnson City*, 473 U.S. 172, 105 S.Ct. 3108, 87 L.Ed.2d 126 (1985) (eight years is insufficient delay to effect a taking); *Bass Enters.*, 381 F.3d at 1367 (45 months' delay is not extraordinary); *Wyatt*, 271 F.3d at 1098 (nearly ten-year permitting process including seven years' delay is not extraordinary); *1902 Atlantic Ltd. v. United States*, 26 Cl.Ct. 575 (1992) (five years' delay not extraordinary); *Dufau v. United States*, 22 Cl.Ct. 156, 162-63 (1990) (16 months' delay is not extraordinary). The Federal Circuit explained that it is not the *length* of the delay alone that makes it “extraordinary,” but rather, the *reasons* for delay and the nature of the permitting process will determine whether a delay is extraordinary. *Id.* at 1099. The nature of the regulatory scheme is especially critical when the permitting process requires detailed technical information necessary to determine environmental impacts. *Id.* at 1098. If no extraordinary delay is found, this issue would be dispositive on grounds of ripeness. Courts have latched onto extraordinary delay as the trigger that, absent a “final” decision, ripens a takings claim. *McGuire v. United States*, 2011 WL 576060 at *7 (Fed. Cl. Feb. 18, 2011).

What is more, the Federal Circuit cautioned that only in rare circumstances can a delay be extraordinary without a finding of bad faith on the part of the government. *Id.*; *see also Bay-Houston Towing Co. v. United States*, 58 Fed. Cl. 462, 477-78 (2003) (holding that eleven-year dispute over whether the plaintiff was entitled to a CWA § 404 dredge and fill permit for mining

peat did not amount to bad faith or unreasonable delay, so no temporary taking occurred). In order for bad faith to be established the delay would need to be “so objectively unreasonable as to give rise to the inference” that the government was acting “solely for purposes of delay or some other illegitimate reason.” *Landgate, Inc. v. Cal. Coastal Comm'n*, 953 P.2d 1188, 1200 (Cal. 1998). The Court in *Tahoe-Sierra* offered very little on what may constitute bad faith. In *dicta*, the court included a sentence implying that had the agency not “acted diligently and in good faith” but had instead been “stalling,” such facts “arguably could support” a “bad faith” takings claim. However, this is a difficult burden to carry as the government is entitled to the presumption that its actions were lawful and authorized. That is because, in a takings case, “we assume that the underlying governmental action was lawful.” *Appolo Fuels Inc. v. United States* at 1351 n.7, citing *M & J Coal v. United States* at 1154. Furthermore, the DRBC could rightly claim it is justified using a moratorium to craft complex, wise, permanent regulations that have the potential to have a significant impact on a significant number of people.

CONCLUSION

Over fifteen million people benefit from the unfiltered drinking water supplied by the Delaware River Watershed. Clean drinking water is a quintessential public good that benefits everyone in the population. The burdens to the landowners, by contrast, are small and consist of no more than what any landowner must submit to in order to secure “the advantage of living and doing business in a civilized community.” *Andrus v. Allard*, 444 U.S. at 67, 100 S. Ct. at 328 (quoting *Pennsylvania Coal Co*, 260 U.S. at 422, 43 S. Ct. at 163 (Brandeis, J., dissenting)). The regulation of gas drilling has long been concerned with environmental protection, including the protection of drinking water supplies. The aim is not to conserve wild land in its natural state—this is a law specifically focused on drilling for natural gas. A narrowly drawn regulation

focused precisely on the injury to be prevented is one for which the burden should “in all fairness and justice” be borne by the property owner *alone* because he holds his property subject to reasonable regulation and the implied obligation not to use property in a way injurious to the community. *See Mugler v. Kansas*, 123 U.S. 623, 665, 8 S. Ct. 273, 299 (1887). For the aforementioned reasons, leaseholders in the Delaware River Basin likely do not have an actionable taking claim.



March 30, 2018

Commission Secretary
Delaware River Basin Commission
P.O. Box 7360
25 State Police Drive
West Trenton, NJ 08628-0360

Re: Proposed New 18 CFR Part 440 - Hydraulic Fracturing in Shale and Other Formations;
Proposed revisions and additions to section 18 CFR 401.35 relating to project review
classifications

Dear Commission Secretary and Commissioners,

The Delaware Riverkeeper Network (DRN) submits these comments regarding the Proposed New 18 CFR Part 440 - Hydraulic Fracturing in Shale and Other Formations; Proposed revisions and additions to section 18 CFR 401.35 relating to project review classifications (“Proposed Rules”) that were publicly noticed by Delaware River Basin Commission (DRBC) on November 30, 2017.

I. THE DELAWARE RIVERKEEPER NETWORK

DRN is a non-profit organization established in 1988 to protect and restore the Delaware River, its associated watershed, tributaries, and habitats. This area includes 13,539 square miles, draining parts of New Jersey, New York, Pennsylvania and Delaware, and it is

DELAWARE RIVERKEEPER NETWORK
925 Canal Street, Suite 3701
Bristol, PA 19007
Office: (215) 369-1188
fax: (215) 369-1181
drm@delawareriverkeeper.org
www.delawareriverkeeper.org

within this region that a portion of the Project's construction activity and operations will take place.

The Upper Delaware River is a federally designated "Scenic and Recreational River" administered by the National Park Service. The National Wild and Scenic Rivers System also includes large portions of the Lower Delaware and the Delaware Water Gap. The Lower, Middle and Upper Delaware River have high water quality and are subject to Delaware River Basin Commission Special Protection Waters Designation. The Basin and River are home to a number of federal and state listed endangered or threatened species including, but not limited to, the dwarf wedgemussel, Indiana bat, Timber Rattle snakes, bog turtle, Northeastern bulrush. Over 200 species of migratory birds have been identified within the drainage area of the Upper Delaware River within the Basin, including the largest wintering population of bald eagles within the Northeastern United States. The ecologically, recreationally and economically important American Shad population migrates up through the nontidal portions of the Delaware River to spawn, American Shad populations in the Delaware River are currently at depressed numbers. Migratory birds breed in or migrate through the high quality riparian corridors of the Basin. The Delaware River is also home to dozens of species of commercially and recreationally important fish and shellfish species.

In its efforts to protect and restore the watershed, DRN organizes and implements stream, wetland and habitat restorations, a volunteer monitoring program, educational programs, environmental advocacy initiatives, recreational activities, and environmental law enforcement efforts throughout the entire Delaware River Basin. DRN is a membership

organization headquartered in Bristol, Pennsylvania, with more than 20,000 members with interests in the health and welfare of the Delaware River and its watershed. DRN is uniquely qualified to comment on and provide relevant information concerning associated impacts to human health and the environment.

These comments include and reflect the findings of technical experts engaged by DRN to analyze and comment on the Proposed Rules. All reports are submitted with these comments and are appended to this document.

Delaware Riverkeeper Network supports DRBC's proposal for the prohibition of high volume hydraulic fracturing (HVHF) in hydrocarbon bearing rock formations within the Delaware River Basin ("the Basin"). We provide more detail and additional recommendations regarding the prohibition under DRN's Section 440.3 comments and the proposed revisions and additions to section 18 CFR 401.35 relating to project review classifications under Section 3.8 of the Compact. These comments conclude that the prohibition is essential to provide needed protection to the Delaware River Watershed, but that it must go further.

DRN opposes the diversion, transfer or exportation of water from sources within the Basin of surface water, groundwater, treated wastewater or mine drainage water for utilization in hydraulic fracturing ("fracking") of hydrocarbon carbon bearing rock formations outside the Basin as proposed at Section 440.4. These comments conclude that the water export proposal constitutes a failure of the DRBC to protect the water resources of the Delaware River Basin. We provide more detail and additional recommendations regarding the prohibition under DRN's Section 440.4 comments.

DRN opposes the importation, transfer, treatment, storage, disposal, or discharge in the Basin of produced water and Centralized Waste Treatment (CWT) wastewater generated by fracking operations, as proposed at Section 440.5. These comments conclude that the wastewater proposal constitutes a failure of the DRBC to protect the water resources of the Delaware River Basin. We provide more detail and additional recommendations regarding the prohibition under DRN's Section 440.5 comments.

DRN respectfully requests the DRBC remove all reference to the allowance of water exports from the Basin for fracking and the import and storage, processing, disposal and discharge of CWT wastewater and produced water from fracking in the Basin, as described at Sections 440.4 and 440.5. DRN also requests that Section 440.3(b) is expanded to include prohibition of the activities related to fracking, specifically including the export of water and water resources out of the Basin for fracking elsewhere and the prohibition of the importation, transfer, treatment, storage, disposal, or discharge in the Basin of produced water and Centralized Waste Treatment (CWT) wastewater generated by fracking operations.

The Delaware River's waters are protected under the terms of the Delaware River Compact, the DRBC's Special Protection Waters Program, and regulations adopted in its Comprehensive Plan and Rules of Practice and Procedure. The Proposed Rules at Sections 440.4 and 440.5 fail to ensure protective management of the water resources of the Delaware River. DRN supports a complete ban on fracking and its activities, including a ban on water export out of the Basin for fracking and the import and storage, processing, disposal, and discharge of wastewater produced by fracking in the Basin.

DRN engaged six experts to review and assess the Proposed Rules, develop conclusions and make recommendations. These comments incorporate and rely upon the comments, recommendations and conclusions of these expert reports. The expert reports are submitted as Attachment 1. The curriculum vitae for these experts are collectively submitted as Attachment 2. DRN also relied upon information referenced in DRN’s comment letter, documented by Endnotes and References.

LEGAL FRAMEWORK

a. Delaware River Basin Compact

Under the Delaware River Basin Compact of 1961, the DRBC is charged with conserving and managing the water resources of the Delaware River and its watershed.

Article 13, Section 13.1 of the Compact provides for the development and adoption, and periodic review and revision, of a Comprehensive Plan “for the immediate and long range development and use of the water resources of the basin. The plan shall include all public and private projects and facilities which are required, in the judgment of the commission, for the optimum planning, development, conservation, utilization, management and control of the water resources of the basin to meet present and future needs.”

The DRBC implements the Compact’s directives and objectives and the Comprehensive Plan through the Water Code and the Administrative Manual: Rules of Practice and Procedure (“RPP”) (codified at 18 CFR §§ 401.81–90).

Article 3, Section 3.8 of the Delaware River Basin Compact requires that

No project having a substantial effect on the water resources of the basin shall hereafter be undertaken by any person, corporation, or governmental authority unless it shall have been first submitted to and approved by the commission, subject to the provisions of Sections 3.3 and 3.5. The Commission shall approve a project whenever it finds and determines that such project would not substantially impair or conflict with the Comprehensive Plan and may modify and approve as modified, or may disapprove any such project whenever it finds and determines that the project would substantially impair or conflict with such Plan. The Commission shall provide by regulation for the procedure of submission, review and consideration of projects, and for its determinations pursuant to this section. Any determination of the Commission hereunder shall be subject to judicial review in any court of competent jurisdiction.

See also 18 C.F.R. § 401.32.

b. Comprehensive Plan

Sections 3.2 and 13.1 of the Compact require the creation of a Comprehensive Plan, which binds private parties and agencies to the Commission’s vision for immediate and long term development within the Basin. Compact §§ 3.2, 13.1. The Commission has created a Comprehensive Plan which seeks to optimize the conservation, control, and management of the Basin’s limited water resources and determine what type of development is consistent with the public interest. DRBC, *Comprehensive Plan* § I.A.b.; I.A.d. (July 2001). Activities which may have a substantial impact on the Basin are examined in the context of this Plan, and in order for a project to be approved by the DRBC, the Commission must determine that the project “provide[s] beneficial development of the water resources in a given locality or region,...the project conforms with accepted public policy,” and the project does “not adversely influence the development of the water resources of the basin.” *Id.* § I.A.d.

DRBC’s duties under the Comprehensive Plan require the Commission to consider whether and where an activity, as a whole – such as unconventional gas development – fits
Page 6 of 145

in the Basin, and its cumulative impacts. The Commission must also consider if there are particularly fragile areas of the Basin, such as Special Protection Waters, where a particular activity should *not* occur. *Wayne Land & Mineral Grp., LLC v. Delaware River Basin Comm'n*, No. 3:16-CV-00897 (M.D. Pa. Mar. 23, 2017), ECF No. 22-1.

c. The Water Code

DRBC's Water Code requires the conservation of the Basin's water resources, a consideration of present and future public interest when planning groundwater withdrawal projects, and the maintenance of basin water quality, *inter alia*. See, e.g., Water Code §§ 2.20.2, 2.20.3, 2.20.5, 2.200.1; 18 C.F.R. § 410.1.

Section 3.40 of the Water Code regulates groundwater quality and requires its maintenance "in a safe and satisfactory condition..." Water Code § 3.40.3A. Section 3.40.4(B) explains that "[i]t is the policy of the Commission to prevent degradation of ground water quality" and that "[n]o quality change will be considered which...may be injurious to any designated present or future ground or surface water use." *Id.* §§ 3.40.4.

Similarly, Sections 2.20.2 and 2.20.3 of the Water Code authorize and require the DRBC to preserve and protect underground water-bearing formations, and to safeguard the public interest from projects that withdraw underground waters. *Id.* §§ 2.20.2, 2.20.3.

The Water Code also protects the areas of the Delaware River and its tributaries that have exceptionally high water quality, known as Special Protection Waters. *Id.* § 3.10.3.2 *et seq.* Marcellus Shale natural gas deposits in the Basin are found *exclusively* within the area designated as Special Protection Waters. *Wayne Land & Mineral Grp., LLC v. Delaware River*

Basin Comm'n, No. 3:16-CV-00897 (M.D. Pa. Mar. 23, 2017), ECF No. 22-1. Section 3.10.3A.2.b. of the Water Code protects these waters “at their existing water quality.” *Id.* § 3.10.3A.2.b. Additionally, the Water Code recognizes the need to protect water quality for other, nonhuman users, stating that “[t]he quality of the Basin waters shall be maintained in a safe and satisfactory condition for...wildlife, fish, and other aquatic life.” *Id.* § 2.200.1.

Natural gas extraction and its related activities have the potential to negatively affect ground and surface water, and as such, are subject to regulation under the DRBC’s Water Code.

d. Rules of Practice and Procedure

Section 1.2(g) of the Compact defines a “project” as including any work or activity identified by the Commission. Compact § 1.2(g). The DRBC’s Rules of Practice and Procedure (“RPP”), published at 18 C.F.R. Part 401, establish thresholds under which Compact Section 3.8 project reviews take place. The following are sections of the RPP which grant DRBC the authority and duty to review natural gas development activities.

A project is subject to Commission review when the Executive Director “specially direct[s] by notice to the project sponsor or land owner as having a potential substantial water quality impact on waters classified as Special Protection Waters.” *Id.* § 401.35(b)(18). The Executive Director has determined that *all* natural gas development projects may have a substantial effect on water resources of the Basin.

Additionally, RPP Sections 2.3.5A and 2.3.5C allow federal agencies such as the U.S. Fish and Wildlife Service and the National Park Service to refer projects to the Commission

for review. 18 C.F.R. §§ 401.35(a), (c) (RPP §§ 2.3.5.A, C). Citing the need to protect the Basin's water quality and natural gas development's potential adverse effects, both the U.S. Fish and Wildlife Service and the National Park Service referred all projects that involve the development of natural gas wells to the DRBC for project review. *Wayne Land & Mineral Grp., LLC v. Delaware River Basin Comm'n*, No. 3:16-CV-00897 (M.D. Pa. Mar. 23, 2017) ECF No. 33-1, 2. The Commission *must* take action under Section 3.8 of the Compact once it receives such a referral. 18 C.F.R. § 401.35(c).

In addition to the DRBC's need to review natural gas well development when referred by an agency such as the U.S. Fish and Wildlife Service or the National Park Service, the Commission must review projects that "have or may have a substantial effect on the water resources of the basin" or that result in the discharge of pollutants into surface or ground waters of the Basin. *Id.* §§ 401.35(b), (b)(6).

Some natural gas development activities are also explicitly subject to Commission review; natural gas transmission lines and appurtenances are reviewed when "they would pass in, on, under or across an existing or proposed reservoir or recreation project area as designated in the Comprehensive Plan; [or] such lines would involve significant disturbance of ground cover affecting water resources;..." *Id.* § 401.35(a)(12). Natural gas pipelines are also subject to review under § 401.35(b)(7). *Id.* § (b)(7). In these instances the Commission directly recognizes that the disturbance of ground cover affects water resources.

Both water quantity and water quality are indisputably at issue with natural gas development.

e. DRBC's Special Protection Waters Program

The Delaware Riverkeeper Network petitioned the Delaware River Basin Commission (DRBC) in 1990 to develop a program to protect the exceptional water quality and outstanding resources of the designated Wild and Scenic Delaware River pursuant to the Outstanding Natural Resource Waters (ONRW) provision of the federal Clean Water Act.

In response, the DRBC amended its Water Code to include its unique version of ONRW, the Special Protection Waters program. In 1992 the DRBC granted the Upper and Middle Delaware Wild and Scenic River segments Outstanding Basin Waters status under their Special Protection Waters (SPW) program.

In 2001, after the Lower Delaware River was designated by Congress as Wild and Scenic, DRN again petitioned DRBC to classify the Lower Delaware River as SPW. As a result of DRN's efforts, the DRBC permanently designated the Lower Delaware River as Significant Resource Waters, a type of SPW, in July 2008.

The entire non-tidal Delaware River is protected by Special Protection Waters anti-degradation regulations. This designation requires strict regulation to protect the water quality of all SPW waters, which is documented as "exceptional" through regular water quality testing by the DRBC. The agency must maintain the high existing water quality so that there is "**no measurable change**" except towards natural conditions. Water Code § 3.10.3 *et seq.* codifies the anti-degradation program of the DRBC's Special Protection Waters program. (DRBC Resolution Nos. 70-3, 92-21, 94-2, 2008-9); *see also* 18 C.F.R. Part 410; Water Code §2.200.1(Resolution No. 67-7)("[t]he quality of Basin waters shall be

maintained in a safe and satisfactory condition for...wildlife, fish and other aquatic life”); Water Code §2.20.2 (“[t]he underground water-bearing formations of the Basin, their waters, storage capacity, recharge areas, and ability to convey water shall be preserved and protected”); Water Code §2.20.5 (“[n]o underground waters, or surface waters which are or may be the sources of replenishment thereof, shall be polluted in violation of water quality standards duly promulgated by the Commission or any of the signatory parties”); Water Code §3.40.4.B (“[i]t is the policy of the Commission to prevent degradation of ground water quality....No quality change will be considered which, in the judgment of the Commission, may be injurious to any designated present or future ground or surface water use”).

The Draft Regulations fail to ensure that there will be no measurable adverse change to the quality of the Basin’s water resources.

f. National Environmental Policy Act

The National Environmental Policy Act (“NEPA”), the nation’s bedrock environmental law, seeks to ensure sound policy making by requiring that federal agencies evaluate the potential adverse impacts of their proposed activities before undertaking them. To achieve this goal, NEPA requires the preparation of an environmental impact statement for all “major Federal actions significantly affecting the quality of the human environment.” 42 U.S.C. § 4332(2)(C). There can be no doubt that the DRBC is a federal agency subject to the requirements of NEPA. The language of the DRBC Compact itself provides that the Commission is a federal agency and thus subject to NEPA, stating that the “compact shall

not enlarge the authority of any federal agency other than the commission.” DRBC Compact, §15.1(o) (emphasis added). The Council on Environmental Quality’s (“CEQ”) regulations for NEPA also recognize DRBC as one of the “federal or federal-state agencies with jurisdiction by law” over NEPA issues, alongside the United States Environmental Protection Agency and numerous other federal agencies. NEPA Implementation Procedures, Appendix II, 49 Fed. Reg. 49750 (December 21, 1984).

Further, the issuance of regulations governing hydraulic fracturing activities within the Delaware River Basin is plainly a major federal action for purposes of NEPA. The CEQ regulations define a “major federal action” as an action “with effects that may be major and which are potentially subject to Federal control and responsibility,” and such an actions involve “new and continuing activities, including projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies; new or revised agency rules, regulations, plans, policies, or procedures . . .” 40 C.F.R. § 1508.18. By this definition, the issuance of these regulations is clearly a major federal action because it creates a new program that adopts new agency rules and regulations, and is partly financed, regulated and approved by the DRBC and by the Army Corps of Engineers, the DRBC’s federal member.

Moreover, for all the reasons set forth below and in the accompanying expert reports, the regulation of hydraulic fracturing within the Delaware River Basin is an activity that has the potential to have significant environmental effects. As such, it is evident that the DRBC is bound, subject to NEPA, to prepare a full environmental impact statement (“EIS”)

evaluating the range of potential adverse environmental impacts of its proposed regulatory program before issuing new regulations governing gas development within the Basin. 42 U.S.C. § 4332(2)(C); 40 C.F.R. §§ 1502.4, 1508.18. Nonetheless, the DRBC has issued its draft regulations without undertaking any NEPA environmental review measures whatsoever.

The purpose and benefits of NEPA's requirements are clear. NEPA's EIS requirement aims "to ensure both that an agency has information to make its decision and that the public receives information so it might also play a role in the decisionmaking process." *Dep't. of Transportation v. Public Citizen*, 541 U.S. 752 (2004). The statute is intended to insure that environmental concerns are integrated into the very process of agency decision-making. *Andrus v. Sierra Club*, 442 U.S. 347 (1979); *Lower Alloways Creek Tp. v. Public Service Elec. & Gas Co.*, 687 F.2d 732 (3d Cir. 1982). When the federal government conducts an activity, NEPA imposes procedural requirements to ensure that in making decisions, an agency will have available, and will carefully consider, detailed information concerning environmental impacts. To issue detailed regulations for new gas development in the Delaware River Basin without having reviewed the potential environmental impacts that may result therefrom is not only short-sighted but unlawful, and is likely to result in flawed and incomplete regulation of this risky industrial activity.

g. Cumulative Impacts Analysis

Adequate regulations based on a comprehensive environmental assessment are essential to protect the water supply for over 15 million people and to assure that the

Delaware River's Special Protection Waters (SPW) and all the Basin's water resources are protected from pollution and degradation. The Commission's Draft Regulations do not achieve the goal of preventing pollution, avoiding degradation, and helping to improve where needed the water resources of the Basin.

The Commission recognized the potential cumulative impacts of hydraulic fracturing activities on the water resources of the Basin to be so significant that the Commission applied for federal funding for a cumulative impact study. The U.S. House of Representatives Appropriations Committee Subcommittee on Interior, Environment, and Related Agencies approved \$1 million for the U.S. Geological Survey (USGS) and the Commission to conduct that study but due to the lack of needed action on the federal budget, these funds were not granted in the Congressional session. The foresight the Commission has shown in seeking these funds is exemplary. We are in full support of this effort and have continued to seek funding sources for the Commission ourselves.

The Commission's Water Resources Program FY2010-2015 (WR Program) calls for the Commission to "Perform Cumulative Impact Analysis on water supply 2011-2012 Funding permitting" (DRBC 2010b, p. 17) under its Natural Gas Development regulation program. The lack of a cumulative impact analysis undermines the Commission's ability to implement effective and sufficiently protective regulations. The Commission's WR Program states that "Additional demand for use in energy exploration, e.g. natural gas drilling, is increasing, although the full effect of this demand sector has yet to be identified" (DRBC 2010b, p.4) and "There will need to be more analysis of the water needs for energy projects

and energy needs for water treatment as well as an evaluation of the carbon and water footprints” (DRBC 2010b p.11).

The impacts of hydraulic fracturing activities on the subsurface geology and ground water resources in the Delaware River Watershed are unknown and have not been studied or modeled by the Commission or any other agency. A cumulative impact analysis or environmental study should be completed to assess the subsurface changes that would occur and the resulting environmental impacts.

There is tremendous debate over the safety of hydraulic fracturing activities. The large number of incidents of pollution, methane gas migration, blowouts and other problems throughout Pennsylvania is well documented by PADEP. (*see* www.dep.state.pa.us/dep/deputate/minres/oilgas/OGInspectionsViolations/OGInspviol.htm).

One of the most disturbing aspects of the Draft Regulations is the obvious lack of information about the watershed and the lack of data about the expected impact. This information, gathered through an impact analysis, would serve as a foundation for the decision-making process and regulations. It is surprising that, in an area of high ecological importance and the presence of powerful economic interests (New York City, Philadelphia, utilities and the mining industry), there is no comprehensive model of the watershed allowing for the simulation of future scenarios.

Unfortunately, the Commission issued draft natural gas regulations without the benefits of the findings of such a study. In our opinion, a cumulative impact analysis of the potential effects of natural gas development on the Basin’s resources is essential to

developing appropriate rules that will fulfill the DRBC's mandates. We consider the Draft Regulations lacking in the critical limits and management policies that this analysis would provide. In addition to specific deficiencies detailed in this comment, this is an inescapable fatal flaw in the Draft Regulations.

Proposed Regulatory Changes Sections 403.3, 440.4, and 440.5

This comment submission examines the proposed regulatory changes in three parts:

- the prohibition of high volume hydraulic fracturing (HVHF) in hydrocarbon bearing rock formations within the Basin;
- the export of water and water resources outside of the basin for fracking elsewhere;
- the import and storage, processing, disposal, and discharge of wastewater produced by fracking in the Basin.

Comment in Support of the Prohibition of HVHF at Section 440.3 (a) and (b)

DRN supports the complete prohibition of fracking throughout the Delaware River Watershed.

Marcellus and Utica Shale geologic formations underlie approximately 40% of the Basin, primarily in Pennsylvania and New York (a small portion of the Utica underlies the northwestern corner of New Jersey). These shales are considered the largest petroleum-producing deposits in the nation; approximately 5% of the total area of the Marcellus underlies the Delaware River Basin. (Schmid & Company, Inc., "Comments on Proposed

Regulations of the Delaware River Basin Commission Concerning High Volume Hydraulic Fracturing to Produce Oil and Gas, 3.18.2018). New Jersey and Pennsylvania also contain the South Newark Basin gas-bearing rock formation, identified by the U.S. Geologic Survey as potentially productive, although it is not being developed at this time. The potential for substantial adverse impacts from development of shale gas within the Basin is enormous.

The entire non-tidal Delaware River is protected by Special Protection Waters (SPW) anti-degradation regulations due to the exceptional values of the River. The strict regulations adopted by DRBC to protect the water quality of SPW waters requires that the existing high existing water quality be maintained so that there is **“no measurable change”** except towards natural conditions. Approximately 50% of SPW are located in Pennsylvania, 35% in New York, and 15% in New Jersey. (Schmid) Of the SPW sections of the Basin, approximately 98% is underlain by Marcellus Shale in New York and 67% of the area in Pennsylvania. (Schmid). SPW designation applies to the entire watershed regions that drain to SPW waters. The anti-degradation provision of these waters would be unattainable if fracking were to occur in these regions due to the adverse impacts that accompany it.

Surface Development of Fracking Well Sites

The use of hydraulic fracturing to extract and develop natural gas from shale formations include several phases of the fracking process. The first stage is the development of the well site and adjacent operations which require the removal and clearing of vegetation and the reforming of the natural landscape. At this stage impacts include: destruction of vegetation; forest loss and forest fragmentation; soil compaction and destruction of the

natural soil mantle and land contours; watershed drainage pattern alterations, and disruption of local hydrologic systems such as wetlands and vernal ponds.ⁱ

These impacts are part of the process of developing a gas well and are unavoidable, as found in a study of the potential impacts of fracking, based on the industry's practices since the modern shale boom began. "Disturbing the land is an unavoidable part of the fracking process to extract gas and move it to market. Specifically, well pads (generally taking up between 1-3 hectares) are needed to support equipment needed for drilling and fracking, access roads are required to bring equipment to the well pad, and gathering pipelines are needed to bring the gas from the well pad to an existing portion of the natural gas pipeline network."ⁱⁱ

The areas disturbed include the well pad; storage and ancillary equipment areas; freshwater basins or tanks and tanks or pits to store fracking fluid chemicals, flowback, produced water, fuel, and re-used or reusable frack fluids; containers to store proppants such as sand; driveways or access roads to the site; gathering pipelines, local compressors and related equipment to carry gas to a market pipeline; and in some instances, quarries for mining gravel for driveways and well pad pavement, and water lines, buried or on surface. The impacts of this activity can continue at varying levels during well drilling, stimulation, development, and production. Upon completion of construction activity, the invasion of non-native invasive species of plants into disturbed and cleared land and the transfer of destructive insects and pathogens result from the land use changes that have occurred at the

well site. Compacted soil at the finished site can have a runoff coefficient close to concrete and the destroyed soil mantle can permanently retard the absorption and normal infiltration of precipitation. Accelerated runoff, both in volume and rate, is the consequence of this changed land condition, leading to the continuation of negative impacts on groundwater and receiving waterways.

Stormwater NPDES permits are generally not required for unconventional gas well pads. Only flowback from the well is regulated by the NPDES program.ⁱⁱⁱ Due to inadequate regulation of stormwater from well sites, including the current practice by DRBC to use host state stormwater regulations to manage stormwater, polluted runoff, erosion and sediment loading to adjacent waterways from well sites causes several negative stream impacts. These include adverse impacts to water quality, the rate and volume of water flow, stream morphology, riparian buffers and vegetation, the loss of groundwater infiltration and recharge of aquifers, and the reduction of healthy base flow of streams. In turn, aquatic and riparian habitats and the flora and fauna species that rely on them are negatively impacted. Overall, the land is transformed from its current condition to an industrial site.

In a peer reviewed journal paper that examines the footprint of Marcellus shale gas and wind through scenario analysis, upwards of 1 ¼ million acres of new impervious surface can be expected across the Marcellus from gas well development. This has direct adverse impacts on water quality and water supplies, the maintenance of biological life in streams and causes increased polluted stormwater runoff, sedimentation and flooding to waterways.^{iv} The report points out that much of the land is now forested (about 70% of the entire

Marcellus Shale play), that forests provide important water quality benefits and the loss of forested land increases the cost of providing safe drinking water to the urban areas that rely on it.^v This is of particular importance to the downstream developed areas in the Delaware River Watershed and in communities outside of the Basin that use the Delaware River for drinking water.

The economic hardship caused by diminished water quality and supply must be considered in assessing the potential impacts of fracking. In the Delaware River Watershed, water supplies contribute 3.82 billion dollars in annual value to the regional economy and water quality brings \$2.5M in annual economic benefit to the Basin, according to a study out of the University of Delaware.^{vi} When water is depleted, it has real economic impacts for the source watershed that has lost the value of that water and can force externalized costs on to the consumer.

A study that examined the location and footprint of gas well sites found substantial land clearing and forest fragmentation in Pennsylvania's Marcellus Shale regions and reported on impacts to fauna and flora. "In a study of 242 drilling pads on the Marcellus Shale in Pennsylvania, half were located in forested areas and an average of 8.8 acres of forest was cleared for each drilling pad with its roads and other infrastructure."^{vii} "Assuming an ecological edge effect of 330 feet extending into intact forest from cleared areas, each drilling installation affected 30 acres of forest. Black-throated blue warblers, scarlet tanagers, ovenbirds, and other forest songbirds are adversely affected by fragmented forests because they avoid open areas."^{viii} The openings in the forest canopy also increase exposure

to predation and nest parasitism for these species. Other organisms that can be negatively affected by forest fragmentation include woodland pool-breeding amphibians, forest floor wildflowers with ant-dispersed seeds, and plants whose pollinators or herbivores are affected.”^{ix}

The amount of acreage disturbed is now trending upwards in size due to oversized wells with longer well bores. Mega-sized well pads are the trend, starting in 2016 and becoming more common in 2017. Therefore, the impacts will be greater as the disturbance and actively used areas of a well site expands. This is discussed in more detail in this Comment on page 24.

The documented benefits of forest ecosystem services to water purification are discussed in a U.S. Forest Service report; the loss of these services can degrade water quality.^x Scientific literature explains the clear link between forests and water quality, verifying that reductions in forest cover correlate with negative changes in water chemistry, such as increased levels of nitrogen, phosphorus, sodium, chlorides and sulfates as well as reduced levels of macroinvertebrate diversity.^{xi} Approximately 85% of the lands underlain by Marcellus Shale in the Delaware River Basin is forested. (Schmid) Approximately 85% of the Appalachian Basin in the Delaware River Watershed is forested.^{xii}

Researchers at the Academy of Natural Sciences have discovered that where high density of natural gas wells occur, adjacent streams in Pennsylvania’s Marcellus are experiencing decreased water quality as demonstrated by lower macroinvertebrate density and higher levels of specific conductivity and total dissolved solids.^{xiii} A publication of the

Proceedings of the National Academy of Sciences found streams adjacent to gas wells are negatively impacted by runoff and sedimentation (Total Suspended Solids), harming benthic life, fish and wildlife and causing streams to be eroded and destabilized.^{xiv}

According to a peer reviewed paper assessing stream vulnerability to unconventional oil and gas development, approximately 79% of assessed U.S. river and stream miles have degraded environmental conditions with significantly altered biological communities.^{xv}

Common stream stressors that degrade water quality are excess nitrogen and phosphorous, metals, sediment, and other contaminants from agriculture, urbanization, and wastewater.^{xvi}

Development for energy sources such as mining has had large impacts on stream quality over the years. Today, unconventional oil and gas extraction (UOG) from shale has the potential to alter streams through land development, spills, water withdrawals, and wastewater production.^{xvii} The report states that adding these impacts to the existing

stressors will have an unknown level of impact. The study developed indices to describe watershed sensitivity and exposure to disturbances and compared various shale plays.

Catchments in the Barnett and Marcellus-Utica were naturally sensitive from more erosive soils and steeper catchment slopes.^{xviii} These catchments also encompassed areas with

greater UOG densities and urbanization.^{xix} These findings document that development of shale gas in the Delaware River Basin can be expected to have negative impacts due to the natural conditions of the watershed and that as intensity of development increases, so do the adverse impacts.

Wetlands are located throughout the portions of the Basin underlain by gas-bearing shales. Forested wetlands are characteristic of these regions. However, DRBC has not developed detailed maps of regulated wetlands in the Basin. (Schmid)

“There are no detailed maps of regulated wetlands in the Basin. Existing National Wetland Inventory maps show the general location of wetlands recognizable from aerial photographs, but omit many forested wetlands, which are characteristic in the Special Protection watersheds of the Basin, and which offer special habitat values over and above other kinds of wetlands in this biome (Schmid& Co., Inc. 2014).”^{xx}

Wetlands are sensitive to development activities and are documented to have been degraded by oil and gas development. There is substantial potential for destruction and loss of wetlands if fracking were to occur in the Basin. (Schmid)

“Wetlands are among the most threatened ecosystems on the planet. They are degraded and converted to human uses more rapidly than any other ecosystem, and the status of freshwater species is deteriorating faster than any other species. Since wetlands are essentially characterized by hydrologic conditions, changes in water volumes and timing of flows are major threats, as are discharges of various pollutants.”^{xxi}

A report on frack well sites documents the harmful impacts to wetlands and wetland species. “Brackish (salty) wastewater released at a wellsite can pollute streams and wetlands, rendering them unsuitable for many salt-sensitive freshwater organisms including frogs, salamanders, fishes, and many freshwater plants.”^{xxii} Plants are also adversely affected. “Brackish wastewater spilled or leaked onto soil would render the habitat

unsuitable for many common and rare woodland plants including some trees, as well as many soil invertebrates.”^{xxiii}

A report from New Jersey Department of Environmental Protection concludes that less than half the wetlands mitigated over time were successful; only 48% concurred with their design specifications on average, leaving most sites without the mitigation goals accomplished.^{xxiv} A report from the New Hampshire Office of Energy and Planning warns that there is a lack of scientific evidence that documents the success or failure of mitigating adverse impacts through wetlands creation or expansion; contracted wetlands are not necessarily successfully providing environmental benefit.^{xxv} In other words, mitigation is a leap of faith not founded on scientific evidence.

The U.S. Council on Environmental Quality states that impacts should be avoided altogether by not taking a certain action or parts of a certain action and includes as options to minimize, reduce, rectify and compensate for adverse impacts of development.^{xxvi} Once a natural system such as a wetland is damaged or destroyed, it is very difficult to restore that resource’s full function or to replace those lost ecosystem functions with another. The far better policy is to prevent the damage rather than try to repair or replace after the intact natural system is diminished.

Examining the trend in shale gas development today, the size of well pads is expanding as horizontal well bores extend further (up to 4 miles in Pennsylvania’s Marcellus Shale) and the geometry of drilling adjusts to allow more horizontal well bores to each vertical bore.^{xxvii} Supersized well pads or “mega-pads” are the trend, starting in 2016 and

becoming more common in 2017. DRBC's Supplementary Information states that the average total disturbance for a single well pad is 7.7 acres including access roads and gathering lines.

This estimated area to be disturbed for a fracking well site is now out of date. Companies such as EQT – the largest natural gas producer in the nation with offices in Pittsburgh - Range Resources and industry investor reports are touting the new “supersize” wells as the wave of the future, maximizing the investment of up to a half billion dollars on well pads with up to 20 wells. Some pads in the southwestern Pennsylvania area have up to 37 wells permitted.^{xxviii} In the Permian Basin in Texas, one pad has 64 wells.^{xxix}

The size of the well pad today is trending to be at least 10 acres in the Marcellus and Utica shale regions for these supersize wells, without considering the associated disturbances for access, pipelines, water basins, and other industrial activities required for well development. This translates into more impervious surface, more runoff, and more intense use of each site. It also means that industrial scale operations to develop the wells on a mega-pad will last longer, at least 3 years rather than the previously typical one year time frame.^{xxx}

This means prolonged impacts on land and streams while wells are being constructed. This also provides more time for pollution events, spills, leaks and stormwater impact to occur, exposing the environment, waterways and the public to more risk for longer periods of time. And it prolongs the period of time that humans and wildlife are impacted by local air, noise, and light pollution, traffic impacts and other disturbances. For instance, the

number of truck trips to transport water into a frack well site and to transport the waste out of the property also increases; typically 1400 truck trips are required to deliver the average 4.5 million gallons of water to frack a well. However, since water use has now more than doubled, the local truck traffic and the air emissions that are released by the diesel trucks can also be expected to increase by at least double.

Fracking Fluids, Injection, and Gas Production Impacts

The next phase of gas development involves the storage, handling, and use of chemicals and additives for extraction and stimulation of gas, the drilling and fracking of the gas well, and the release of gas from the geologic formation. The impacts of the production of flowback and produced fluids will be addressed in this comment under Section 440.5.

The two primary pathways for pollution to reach waters of the Basin from fracking and drilling operations are across the ground surface and through groundwater. (Tom Myers, “Technical Memorandum: Review of Proposed Natural Gas Regulations as Proposed by the Delaware River Basin Commission”, March 12, 2018)

“There are two primary pathways for contaminants to reach waters of the Delaware River Basin –across the ground surface and through groundwater. The primary source of contaminants on the ground surface is spills from operations or transportation.”^{xxxix}

Spills or leaks

The potential for contamination of ground and surface water from spills at a gas well site is substantial and presents a significant threat. Studies show that spills and leaks are among the most likely means of contamination from gas and oil wells. (Myers) Examination

of data from four states, including Pennsylvania, found the occurrence of one spill per every 3.2 wells. (Myers)

“Contamination can reach surface water near a gas well by flowing across the ground surface through small drainages to streams downhill from the source. The potential for spills or leaks to follow such a path is clear, but there is little specific research. Lefebvre (2017) found that spills or other surface releases represent the most probable mechanism leading to groundwater contamination. Most research concerning spills of fluids associated with O&G development focuses on well pad spills. For example, EPA’s review of fracking-related spills was limited to spills near the pad (EPA 2015). In a substantial review paper concerning the impact of shale gas on regional water quality (Vidic et al. 2013), the authors cited just one report from grey literature (Considine et al. 2012) regarding spills and one journal article from the early 1980s regarding spills transporting through shallow groundwater (Harrison 1983). A more recent article (Maloney et al 2017) summarized details of the threats of spills at the well site harming nearby streams.

Considering O&G development in four states, Pennsylvania, Colorado, New Mexico, and North Dakota, Maloney et al (2017) reviewed data from 6622 spills that occurred for 21,300 unconventional wells, a ratio of one spill for every 3.2 wells.”^{xxxii}

Of the four states examined in Maloney et al (2017) Pennsylvania had the closest proximity of wells to streams. (Myers) This means a more rapid delivery of pollutants to surface water and more difficult management of pollution incidents. Over the four states,

5.3% of the reported spills in Pennsylvania were within 100 feet of a surface waterway.

(Myers) Since Pennsylvania regulations only require a 100 foot separation from the edge of a well pad to a stream, compliance with those regulations will not prevent contamination from spills. These statistics show that to prevent gas well spills from causing pollution, prohibiting fracking is the best course.

“The proximity to streams was smallest in Pennsylvania, with an average distance of 268 meters (Id.). This could be due to the higher density of streams in a humid-regions state like Pennsylvania as compared to the other states. Over the four states, 7% of spills were within 100 feet of a stream, and 5.3% of the spills in Pennsylvania were within this distance. Maloney et al (2017) reported that the required setback in Pennsylvania is 100 feet, so decisionmakers should not rely on compliance with regulations to protect streams. The statistics regarding spills shows that DRBC is correct to ban fracking within the DRB to protect streams within the basin.”^{xxxiii}

Groundwater contamination occurs when pollutants are spilled onto the ground surface and are infiltrated to shallow groundwater. This contamination can then easily be transported to surface water. (Myers) The likelihood of water contamination from fracking is great due to the vulnerable nature of the headwaters regions of the basin, supporting the prohibition of fracking as the most effective means of preventing the spread of contamination from spills. (Myers)

“A groundwater flow pathway unique to headwaters regions within the DRB is shallow transport from spills or leaks of surface storage. The distance from any point on a

drainage basin to a first-order stream is short, on the order of a few hundred to perhaps a thousand feet. Shallow aquifers especially on ridges are thin (Taylor 1984) and the water table follows the topography. Thus, spills would move as interflow from the source to streams relatively quickly, on the order of days.”^{xxxiv}

Spills or leaks at fracking well sites contain very dangerous chemicals and hazardous substances. For instance, hydrocarbons, petroleum distillates, and diesel range organic chemicals (DRO) have been found in soils and shallow groundwater near spill locations at well sites. (Myers) These are very difficult to clean up and remain 25 times longer in the clay-rich soils found in the Basin, making prevention rather than mitigation the preferred approach to water resource protection. (Myers) Radioactive materials are also more likely to be found at spill locations at fracking sites; radioactive properties are also extremely long-lived (the half-life of radium 226 is 1600 years).

“Spills of fracking fluids include hydrocarbons and petroleum distillates which linger in the soils and are difficult to clean up (Maloney et al 2017), regardless of whether the spill is at the pad or during transportation. Ripendra (2016) found contamination by wastewater disposal and accidental leaks and spills of wastewater and chemicals used during drilling and the hydraulic fracturing process to be two of the four primary threats to water quality posed by fracking, with the other two being well integrity related.

Drollette et al (2015) found in the Marcellus region an elevated concentration of diesel range organic chemicals linked to hydraulic fracturing fluid within shallow

groundwater. They associated it with spills, primarily at the well sites, by correlating DRO concentration with distance from wells. They did not test for distance from other types of spills, presumably because the location of those spills is not available in the data base. In addition to showing potential for long-term contamination near well sites, these results suggest there would be long term DRO contamination near all spill sites. The contamination from spills into clay-rich soils is likely to linger as much as 25 times longer than for gravelly soils (Cai and Li 2017). The contamination is also likely to contain higher concentrations of various radioactive substance (Lauer and Vengosh 2016).”^{xxxv}

Complicating the problem of spills at fracking sites is that much is not known. This is due to lack of routine monitoring that could catch unreported releases or the accumulation of smaller spills, inadequate reporting and enforcement systems, and the use of hazardous materials that are unidentified or are protected by trade secret laws. “Little information is available on the potential impacts of some fracking chemicals on streams, wetlands, or upland soils. Because some of these chemicals are known to be endocrine disruptors or carcinogens, these substances would undoubtedly cause harm to many stream, wetland, and forest wildlife species.”^{xxxvi}

The Fracking Process

Contamination of groundwater aquifers by fracking occurs underground and involves at least three different substances – natural gas, formation brine, and fracking fluid. The

contaminants can follow natural fractures and faults in the subsurface rock formations or can travel from a poorly constructed gas well and/or through abandoned wells. (Myers)

“The most complex transport pathways for contaminants from fracking to reach Watershed lands occur underground, between the point of fracking and shallow groundwater or surface water. At least three different substances released by fracking can reach shallow groundwater or surface in the DRB – natural gas (shallow biogenic and deep thermogenic gas), formation brine, and fracking fluid. All would be part of produced water as defined by the proposed regulations if they transported up the well bore to shallow groundwater or surface water. These contaminants can follow pathways through natural faults and fractures, through abandoned wells or poorly constructed gas well, or a combination of both.”^{xxxvii}

Natural gas is a mixture of carbon-chain gases, with methane (CH₄) being the dominant. (Myers) There are many studies that have documented increased concentrations of thermogenic (from deep geologic formations) CH₄ within one kilometer of fracked wells. (Myers) Valley locations along faults have also collected CH₄ and fractures caused by faulting is considered to provide pathways to the surface. (Myers)

A peer reviewed study by Tom Myers explained several ways that shallow groundwater can become concentrated with CH₄ including: microbial methane production; natural migration over time; vibrations from drilling activities that drive natural gas towards shallow groundwater; leakage from target or intermediate-depth formations through a poorly cemented well annulus; leakage from target formations through faulty well casings;

migration of gas from deep formations along natural faults, joints, or fractures; migration of deep formation gas through faults or fractures caused by drilling or fracking; migration of deep or intermediate gas through abandoned or orphaned wells. Earthquakes may also cause vibrations that cause gas to be released and earthquakes may also be associated with increased fracking. Gas migration into groundwater can affect water wells. (Myers)

“Darrah et al. (2014) listed the following scenarios that can lead to higher methane concentrations in shallow groundwater:

- (i) in situ microbial methane production;
- (ii) natural in situ presence or tectonically driven migration over geological time of gas-rich brine from an underlying source formation or gas-bearing formation of intermediate depth (e.g., Lock Haven/Catskill Fm. Or Strawn Fm.);
- (iii) exsolution of hydrocarbon gas already present in shallow aquifers following scenario 1 or 2, driven by vibrations or water level fluctuations from drilling activities;
- (iv) leakage from the target or intermediate-depth formations through a poorly cemented well annulus;
- (v) leakage from the target formation through faulty well casings (e.g., poorly joined or corroded casings);
- (vi) migration of hydrocarbon gas from the target or overlying formations along natural deformation features (e.g., faults, joints, or fractures) or those initiated by

drilling (e.g., faults or fractures created, reopened, or intersected by drilling or hydraulic fracturing activities);

(vii) migration of target or intermediate-depth gases through abandoned or legacy wells”^{xxxviii}

Also documented by studies using tracers during fracking, gas can move quickly from the well into the surrounding environment and can move between rock layers under the ground. (Myers) This means that the release of CH₄ is difficult to control and can be difficult to mitigate.

“Gas tracers released during fracking were found at production wells 750 feet away from the source within days (Hammock et al 2014). They also found evidence of gas migration to a sandstone formation 3000 feet above the Marcellus shale (Id., Figure 33). A model study based on conditions found at the southwest Pennsylvania site used in Hammock et al. estimated that gas can flow from a well bore leak through a sandstone rock matrix to a well 170 m away in times ranging from 89 days to 17 years depending on conditions (Zhang et al 2014). Darrah et al. (2014) found several gas wells within one kilometer of fracked wells that experienced large increases in gas concentration between annual sampling events which suggests that gas transport of up to a kilometer occurred in a time period of less than a year.

Additional evidence of gas movement along faults through the earth’s crust to shallow groundwater may be seen through studies concerning CO₂ sequestration. Shipton et al.

(2004) found that fluids (liquid and gas) can move vertically through low permeability faults, including those otherwise considered to be sealed with calcite.”^{xxxix}

The movement of gas through various faults and pathways is also extremely variable and hard to predict. (Myers) But the evidence of the ability of gas released by drilling and fracking from deep formations to reach shallow groundwater and water wells, springs and streams is scientifically affirmed. (Myers) The effects of CH₄ concentrations in streams and on aquatic life can be devastating.

“It is common to ignore the presence of methane in streams. Methane degases from surface water, but without sufficient aeration, the methane decreases the dissolved oxygen in the surface water which would have severe aquatic effects. Essentially, methane discharges to streams increase the dissolved methane content of the stream thereby decreasing the dissolved oxygen content for areas near the methane source. This can lead to dead zones just as anything else that depletes oxygen.”^{xl}

The forces that cause the release are many and complex, are not usually understood or required to be analyzed prior to drilling and fracking a well and are not uncommon. To avoid CH₄ contamination, prevention is the most effective approach.

Formation brine, under natural forces, moves from deep rock formations to shallow groundwater through natural faults and fractures. (Myers) Reports point out that these same pathways are available for fracking fluids to shallow groundwater. Studies have proven that fracking fluid has reached drinking water wells and that transport has occurred between the

gases well and shallow groundwater. The flow of deep brine to the surface and between shale layers is well documented in scientific literature over the years. (Myers)

“Formation brine naturally flows through faults and fractures from the Marcellus (Warner et al. 2012) or other deep Appalachian basins to shallow groundwater (Llewellyn 2014) based on geochemical and isotopic evidence. Both papers warn that these connections could allow more rapid brine flow or portend the flow of fracking fluid to shallow groundwater due to increased pressure or enhanced connections due to fracking. At least three published studies have documented fracking fluid reaching drinking water wells (Llewellyn et al 2015, DiGiulio et al. 2011; EPA 1987) and litigation settlements have prevented disclosure of the facts in similar circumstances. Llewellyn et al (2015) documented transport between a fault plane/well intersection 1600 feet BGS and a shallow aquifer.

Model studies for years have simulated the potential for deep brine to circulate to the surface naturally (Deming and Nunn 1991; Person and Baumgartner 1995) or in conjunction with deep waste or CO2 injection (Birkholzer and Zhou 2009)). The role of fractures to allow flow through shale layers has also been known for years, with Bredehoeft et al. (1983) finding that at a field scale, the vertical conductivity of shale is up to three orders of magnitude greater than the conductivity estimated from a column in a laboratory.”^{xli}

Marcellus Shale has been modeled to show that deep brine and fracking fluids can be transported from the Marcellus to shallow aquifers over a period of ten years to more than a

thousand years. (Myers) Numerous modeling studies show that these fluids can move from deep formations (where fracking occurs) to drinking water and surface waters. Two studies that countered these findings have serious flaws that have been exposed. (Myers)

“Myers (2012) found that transport from the Marcellus to shallow aquifers could occur over a period from 10 to more than a thousand years, depending on the conductivity assumed to result from fracking -- his model had the horizontal gas well intersecting a vertical fault connecting the shale to the near-surface. Gassiat et al. (2013) modeled a high permeability, continuous, 10-m wide fault zone from the shale to the shallow groundwater with fracking simulated as a change in permeability over a 2-km long, 150-m thick zone. Kissinger et al. (2013) simulated a continuous 30-m thick vertical fault with a head drop of up to 60 m to drive a plume of fracking fluid into the lower aquifer. After 30 years under this scenario, simulated fracking fluid had reached the shallow aquifer. Lateral migration of contaminants occurred at rates up to 25 m/y (Lange et al. 2013). Chesnauw et al. (2013) modeled flow along a fracture pathway between a target shale zone and surface aquifer in a two-dimensional framework, 3000-m long by 3000-m deep and 1 m thick. The modeling studies utilized generic stratigraphic and topographic cross-sections with idealized formation properties due to a lack of specific aquifer data. Also, they considered flow through a fault, but likely underestimated the potential for preferential flow through small but highly permeable fractures even within a preferential flow zone. Taherdangkoo et al (2017) found that upward fluid migration to a shallow aquifer depended on the characteristics of the fault, but argued the

probability remained small; they did not consider out-of-formation fractures intersecting the fault or a natural upward gradient in the fault zone due to common basin topographic circulation (Deming and Nunn 1991). Wilson et al (2017) used model simulations to show that fracking fluid could reach shallow aquifers through fault zones from a target shale greater than 2000 meters bgs. Travel time was quicker for increased induced fracture extent (out of formation fractures), absence of deep high hydraulic conductivity strata, and low fault hydraulic conductivity. The authors found that high conductivity horizontal formations intersecting the fault and high conductivity faults allowed fluids to leak off thereby reducing the mass reaching shallow groundwater.”^{xliii}

Brine from the Marcellus Shale uses pathways that are opened or expanded by fracking, allowing the free water that is contained in fracture zones to travel upwards. The fact that brine dominated the flowback after the initial flowback carried the nearest fluids – the fracking fluids – up the well bore, proves that there is free water in the deep formations and it is agitated, released, and transported by fracking. (Myers) The highly contaminated properties of this brine, including TDS, various salts, hydrocarbons, heavy metals, and naturally occurring radioactive materials (NORM) poses tremendous threat to the quality of groundwater, drinking water wells, and surface water in the Delaware River Basin. (Myers)

“Fracking provides a pathway for Marcellus brine, the free water, to flow to the gas well, probably becoming dominant after the fracking fluid remaining most closely near the well goes back up the well as flowback.

Haluszczak et al (2012) showed that brine dominated the flowback, based on the rapid increase in concentrations of various constituents, including TDS, Cl, Br, Na, Ca, Sr, Ba, and Ra, in the flowback to levels several times that of seawater. Flowback was not fracking fluid that had dissolved rock minerals from the shale as claimed by Engelder et al. Kohl et al. (2014) used strontium isotope ratios found in flowback to isolate the source formation; the strontium signatures would not be as representative of the source formation if its presence was due only to high velocity dissolution during fracking. Rowan et al. (in press, abstract, emphasis added) conclude that the “ $\delta^{18}\text{O}$ values and relationships between Na, Cl, and Br, provide evidence that the water produced after compositional stabilization is **natural formation water**, whose salinity originated primarily from evaporatively concentrated paleoseawater”.”^{xliii}

Because this movement of contaminants cannot be controlled underground, there is effectively no way to avoid the contamination it causes. The only way to avoid this substantial risk of pollution is to prevent it by prohibiting fracking within the Watershed.

“The proposed regulations properly prohibit fracking within the Delaware watershed. This section has described how fracking has been shown to cause pollution or how it is likely to do so in the future, both through the actual process of fracking and from well bore leaks. The potential for contaminants to reach groundwater through these pathways is a good reason for banning the process within the watershed. DRBC is correct in doing so.”^{xliv}

Scientific reports examine the competence of the cement that is used to seal the gas well bores that access gas and the steel that is used to encase the produced gas in the well bore. One report investigated many industry and technical reports on these issues and provides ample evidence of the substandard well construction and plugging and abandonment regulations that are in place. Well casings, cementing, and cement plugs are not regulated to protect aquifers and will lead to pollution, either in the short term or as they degrade. “Because hydraulic fracturing opens joints well beyond the borehole, plugging and abandonment practices may do little to protect the environment after chemical additives are repeatedly injected into bedrock formations under high pressure. Also, presently used cement mixtures and other materials do not achieve zonal isolation in each well, allowing for gas migration and the escape and comingling of fresh and contaminated subsurface waters.”^{xlv} The report concludes that the implications of short term cement failure on long term aquifer water quality protection are extremely significant. As stated in the report^{xlvi}:

“Aquifer protection requires the use of downhole methods and materials that, like aquifers, will stand the test of time and harsh physical conditions. Current state-of-the-art cement materials used in well completion and plugging and abandonment operations do not have a documented long-term history of durability. Cement mixtures or alternate sealant materials must be capable of maintaining the long-term hydrologic integrity of freshwater aquifers separate from deep underlying geologic formations that contain saline water enriched with natural gas, radioactive elements, and hydrofracture-related chemicals. Inherent in permitting and the regulation of gas wells is the concept that

groundwater quality will be maintained and will be available as a potable water source in perpetuity.

Freshwater aquifers have taken millions of years to form. As geologic layer after geologic layer was deposited, buried, and eventually lithified over time, many became physically isolated from overlying strata. Some of the deeper bedrock horizons contain old, brine-rich, connate waters that are present in the pores of the bedrock. This saline water was either trapped in bedrock pores when the rock units were formed or became highly saline later in time through mineralization due to stagnant flow conditions (Fetter, 1994). Under natural conditions, this pore water is not encompassed by the hydrologic cycle. Gas drilling activities provide a mechanism whereby deep formation waters now have an avenue to commingle with overlying freshwater aquifers if failure of zonal isolation materials occurs.”

“The oil and gas industry has long recognized the need to maintain the long-term integrity of boreholes that breach bedrock formations that have naturally and effectively isolated freshwater aquifers from deep connate waters for millions of years. Research continues in efforts designed to lead to better practice and better cement formulations, including some self-sealing mixtures that are newly developed but have not been tested for years in the harsh downhole environment.”

“Cement shrinkage, debonding, and failure can result from a variety of causes including too high a water content, water expulsion, shrinkage after setting and during hardening, radial cracking, tensile failure, compressional failure, traction, cement dehydration,

osmotic dewatering in the presence of high salt content formation brines, corrosive gases, high formation pressures and temperatures, changes in temperature and pressure, sustained casing pressure (SCP), poor cement blends, pressure testing, gas and water channeling, gas migration through setting cement, influx via mud channels, internal and external microannulus development, cement shattering, and cement plastic deformation (e.g., Dusseault et al. 2000; Heathman and Beck 2006; Brufatto et al. 2003; Kellingray 2007; Lecolier et al. 2006; Newhall 2006; Mainguy et al. 2007; Teodoriu et al. 2010; Ladva et al. 2005; Moroni et al. 2007; Ravi et al. 2002; Gray et al. 2007; Reddy et al. 2007; Darbe et al. 2009; Bellabarba et al. 2008; Daneshy, 2005; Crook and Heathman 1998; Boukhelifa et al. 2005; Tahmourpour et al. 2008).

Problems with the integrity of well cement are well known in oil and gas fields. For example, twenty-five to thirty percent of wells in one shelf study area were estimated to have annular pressure problems (SCP) in five to six years, reaching 60 percent in 27 years (Kellingray 2007). Fractured shales of the Appalachian Basin may present problems when cementing wells (Newhall 2006).”

“Assorted researchers are evaluating the service-life of reinforced concrete structures susceptible to chloride corrosion (e.g., Trejo and Pillai 2003). Similarly, Shiu (2011), of Walker Restoration Consultants, states that reinforced concrete structures generally have a service life of 30 to 40 years. Their work may help assess the maximum potential service life of concrete under various conditions. Research to date indicates that the life of concrete in both above ground and downhole conditions, under the best of

circumstances, may be less than 100 years. Even if this preliminary assessment is in error by an order of magnitude and the life of concrete is 1,000 years, this time frame for the design life of concrete very quickly results in jeopardizing the useful life of Delaware River Basin aquifers in far less than 1,000,000 years – in only 0.1 percent of the conservatively estimated life of aquifers.”^{xlvii}

Considering groundwater flow, time, and the corrosive downhole environment created by gas extraction processes, including the lack of durability of the cement sealant and steel well casings, aquifers and surface waters are not sufficiently isolated from the gas, toxic fluids and deep geology pollutants that are distributed by drilling and fracking.^{xlviii} Aquifers could be impacted quickly, such as when there is a faulty cement seal or casing during construction, or over time. But it is certain that the life of the cement and/or steel (up to 100 years under good conditions) is less than the life of the aquifer - so even if there is no evidence in the near term, the eventual pollution is likely occur in less than a century.^{xlix} It is not a matter of “if” these wells will fail, but a matter of “when”.¹ And when that does occur, water sources are ruined for the generations to come. This is not an acceptable legacy for DRBC and this unavoidable problem supports a ban on fracking.

Fracking is responsible for a plethora of environmental and public health problems where it is occurring, including in the Marcellus and Utica Shales in Pennsylvania. The harms are documented in a growing body of scientific literature and in data being produced by agencies and reporting mechanisms such as FracTracker

(<https://www.fractracker.org/map/us/pennsylvania/>) SkyTruth (<https://www.skytruth.org/>)

and industry sites such as FracFocus.

SkyTruth uses technology to identify and monitor threats to the natural environment.^{li} As part of that work, SkyTruth collects violations of permits for oil and gas development for subscribers. Attached as **Attachment 3** is an excel document that contains all the violation SkyTruth collected from PADEP's website (<http://www.dep.pa.gov/Pages/default.aspx>) since May 2012, a total of 2765 reported violations. These may not include all of the violations since the information varies depending on time of inspection and issuance of violation, follow-up actions, and other details, according to SkyTruth staff.^{lii}

Arguably the most comprehensive collection of scientific literature on fracking and its impacts is the [Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking, 5th Edition](#).^{liii} The Fifth Edition of this authoritative report started in 2014 examining the impacts of fracking on the environment and public health was published March 13. DRN has submitted the entire Compendium through the DRBC's web portal as comment on the Draft Regulations in a separate submission from this Comment.

The health professionals who reported and analyzed over 1,200 peer reviewed research articles for the Compendium concluded in the report: The "...findings to date from scientific, medical, and journalistic investigations combine to demonstrate that fracking poses significant threats to air, water, health, public safety, climate stability, seismic stability, community cohesion, and long-term economic vitality. Emerging data from a

rapidly expanding body of evidence continue to reveal a plethora of recurring problems and harms that cannot be sufficiently averted through regulatory frameworks. There is no evidence that fracking can operate without threatening public health directly or without imperiling climate stability upon which public health depends.”^{liv}

Another related report is a literature review that examines literature compiled on fracking impacts for an earlier edition of the Compendium. The report concludes that the body of scientific evidence demonstrating the negative environmental and human health effects from unconventional natural gas development (UNGD) is very strong. The authors of a 2016 study evaluated peer-reviewed literature published between January 1, 2009 and December 31, 2015 as they related to the potential impacts of UNGD on public health, water quality, and air quality. The boundaries of the assessment included scientific literature on hydraulic fracturing and the associated operations and ancillary infrastructure required to develop and distribute unconventional natural gas.^{lv} The results indicated that at least 685 papers have been published in peer-reviewed scientific journals that are relevant to assessing the impacts of UNGD.^{lvi}

A portion of these papers covering each category (public health, water quality, and air quality) was selected by the authors to review. Of the 31 studies selected for public health, 26 (84%) contained findings that indicate public health hazards, elevated risks, or adverse public health outcomes from UNGD.^{lvii} Of the 58 studies related to water quality, 40 (69%) had findings that indicated potential, positive association, or actual incidence of water contamination from UNGD.^{lviii} Finally, of the 46 studies associated with air quality, 40

(87%) had findings that indicated that UNGD increased air pollutant emissions and/or atmospheric concentrations.^{lix} This study demonstrates that the weight of the findings in the scientific community indicates hazards and elevated risks to human health as well as possible adverse health outcomes associated with UNGD.

Another important source of data about the impacts of gas development is the website of the Pennsylvania Department of Environmental Protection (PADEP). PADEP has determined that there are 307 cases of private water well contamination caused by oil and gas operations in the Commonwealth, as of 3.23.18.^{lx} This number does not include ongoing investigations or cases that were settled and are now subject to a non-disclosure agreement. The number also represents “cases”, as many as 16 water wells and, in the case of Dimock, PA, nine square miles of aquifer were contaminated but the contamination was counted as one “case”. There are also cases that were not found to meet PADEP’s requirements to be determined as definitely caused by oil and gas operations that are still unresolved by well owners. It is important to also recognize that PADEP uses data collected pursuant to oil and gas regulations which have limited zones of influence around the gas well that can be considered, limited periods of time in which contamination can be considered, and a limited number of contaminants for which sampling is done. For instance, methane migration into water wells caused by fracking is not being counted by PADEP as a pollution incident^{lxi} and yet it can render a water well unusable and has health and safety impacts for the residents.

For instance, if contamination occurs after the period of time that a water well in proximity to a gas well is required to be monitored, the contamination may not be considered

as legitimate. Further, because the sampling of water wells within the zone of presumption is compared to current background water quality, pollution events can be masked by prior contamination of an aquifer, leaving the well owner without the proof needed to receive a positive letter of determination from PADEP. It also means that because background concentrations are used as the standard to which groundwater must be cleaned under Pennsylvania's Act 2, aquifers where fracking contamination has occurred but had not been discovered will be condemned to a downward spiral of water quality as the "new normal" becomes the contaminated condition.

Therefore, the 307 cases – in itself representing an unacceptable loss of residents' well water quality and clean drinking water - that have been "positively determined" by PADEP are more than likely an under-representation of the total number of private water wells that have been contaminated by oil and gas operations in Pennsylvania. Since the number of "positive determinations" continues to rise as new cases are resolved, it is clear that private water wells and the aquifers of Pennsylvania are not protected from degradation by gas and oil development and fracking, regardless of the adopted regulations.

The Delaware River Basin would be exposed to this same risk. Over 4,400 water complaints related to oil and gas have been filed by the public with PADEP. Between 2004 and 11.2016, PADEP lists a total of 9,443 public complaints about environmental problems in shale gas drilling areas.^{lxii} As fracking has progressed in Pennsylvania, instead of practices improving and the adoption of new regulations by PADEP reducing gas and oil operation-related complaints, the ratio of complaints has increased.^{lxiii}

Finally, the U.S. Environmental Protection Agency's (EPA) Hydraulic Fracturing study issued in 2016 after seven years of research provides scientific evidence that fracking activities can impact and have impacted drinking water resources.^{lxiv} EPA also has published an analysis of oil and gas industry spills.^{lxv} The false claim that fracking has not contaminated water supplies cannot be made with a straight face; EPA and other reports (see "Compendium" and other references in these comments) have proven it has and that water pollution incidents can be expected to continue.

It is also important to recognize the shortcomings of some analyses, especially if the results are being mischaracterized. Some members of the public have been describing a report issued by the Susquehanna River Basin Commission (SRBC) as concluding that there are no adverse impacts from fracking to the water resources of the Susquehanna River Basin. In fact, the U.S. Geologic Survey and Northeast-Midwest Institute conducted a review of the SRBC report and concluded that the existing water quality data in the Susquehanna River Basin are inadequate to assess whether the increase of shale gas development activity in the Susquehanna River Basin is causing adverse changes in water quality.

The report states that the rapid growth of high-volume hydraulic fracturing (HVHF) in the Susquehanna River Basin has raised concerns about the potential for degraded surface-water quality and potential impacts on drinking water aquifers throughout the basin. USGS and the Northeast-Midwest Institute outlined the key elements necessary to assess the impacts of shale gas development in the Susquehanna Basin. First, it is necessary to collect

sufficient water-quality monitoring data. The cumulative effects of shale gas development are more subtle to detect and water-quality monitoring is the only path to identifying low level and long-term changes. Without water-quality data, the long-term cumulative effects of shale gas development on water quality will be unknown.^{lxvi} The report concludes that existing surface-water quality data in the Susquehanna River Basin are insufficient to detect water-quality change related to shale gas development.^{lxvii} The key steps to generating the needed data include increased monitoring at a subset of priority monitoring sites that includes increased sampling frequency, sampling for additional priority parameters and streamflow, and commitment to long-term monitoring.^{lxviii}

The report explains that surface water monitoring sites should be located in each of the four ecoregions with active or planned shale gas development, because stream chemistry in each ecoregion is unique and will respond differently to disturbances or changes in land use.^{lxix} Monitoring sites must be located in watersheds with fracking wells and in reference watersheds in each ecoregion (areas with no fracking well development). Monitoring sites in both types of watersheds allow for the detection of water-quality changes that can be compared to identify whether these changes are resulting from natural gas development.

The report states that water-quality and streamflow data at these monitoring sites must be available with sufficient sampling frequency and duration to evaluate trends in concentration over time.^{lxx} It also states that data on shale gas development, geology, climate, and other changes in land use throughout the monitored watershed must be available to correlate water-quality change with shale gas development activity. Without this

information, the relationship between shale gas development and water quality cannot be evaluated.^{lxxi}

The report further states that networks of groundwater sampling sites are also needed with each sampling site located within 1 mile of a fracking well. Water quality data collected before and after shale gas development are necessary in order to detect groundwater quality change. Information on the shale gas development, geology, other changes in land use, and climate near those sampling sites must be available to compare water-quality change with shale gas development activity.^{lxxii} Next, a suite of water quality parameters is needed to determine if contamination from the cumulative impact of shale gas development activities has occurred in the Susquehanna River Basin. The suites of priority parameters for surface water and groundwater should be based on the specific hydrology, geology, past and current land use, and other environmental concerns expressed in the Susquehanna River Basin.^{lxxiii}

The report says that monthly sampling frequency is needed to detect changes in water quality year-round and to minimize the time needed to detect statistically significant water-quality change at each monitoring site. A minimum of eight surface-water monitoring sites are needed: one monitoring site in a watershed with fracking wells and one reference watershed monitoring site is needed in each of the four ecoregions with active or predicted shale gas development.^{lxxiv}

According to the report, the magnitude of water quality change that could occur from contamination related to shale gas development is unknown, but it would take 3-6 years of

monthly monitoring to detect a 20% change in median specific conductance or total barium in the Susquehanna River Basin.^{lxxv} Only 4 of 22 surface-water monitoring sites in the Susquehanna River Basin with enough existing data for a water-quality trend analysis for barium or specific conductance are located in watersheds with active fracking wells, and few of the 26 recommended surface-water monitoring parameters are available for those sites.^{lxxvi} Only one of those monitoring sites is in a watershed with a fracking well density greater than 0.5 wells per square mile.^{lxxvii} The existing surface-water data in the Susquehanna data set are not sufficient to detect whether the cumulative effects of shale gas development are resulting in water-quality change.^{lxxviii}

The report states that there is no systematic, large-scale, long-term monitoring effort underway to assess the effects of shale gas development on groundwater quality in the Susquehanna River Basin. The groundwater sampling sites with existing data are rarely located within 1 mile of a fracking well, but even when they are in the right locations the sites lack data for most of the priority groundwater parameters.^{lxxix} In addition, the available groundwater data lack the sampling frequency needed for a water-quality trend analysis and lack the number and location of sampling sites needed for a spatial water-quality network analysis.^{lxxx} Targeted, robust monitoring networks for both surface water and groundwater are critical for identifying whether the increase of shale gas development activity in the Susquehanna River Basin is causing adverse changes in water quality. The report thus concludes that the existing water quality data in the Susquehanna River Basin are inadequate to serve this purpose.

The findings of the USGS/Northeast-Midwest Institute analysis of the SRBC report were also reported in the USEPA's 2016 Hydraulic Fracturing Study.^{lxxxix}

Air Pollution and Greenhouse Gas Emissions from Fracking

In the both development and production phases, natural gas has significant negative air quality and greenhouse gas impacts. While DRBC is responsible for protecting the water resources of the basin, it is known that air emissions effect water and ecological systems. When contaminants disperse to the air they eventually settle downwards, affecting water, soil, vegetation, species, and surfaces. The impact can be substantial, depending on the concentrations and dispersal pattern of the pollution. Many factors influence the effects of air emissions, including weather, climate, atmosphere and anthropomorphic influences.

Scientific reports have confirmed that air quality is impacted by natural gas operations. Air monitoring is not uniform or required in most instances, leaving large data gaps. However, studies have been done of air near gas activities and unhealthy conditions and increases in related illnesses have been discovered.

For example, Colborn et al. conducted an exploratory study in western Colorado where residences are in close proximity to natural gas wells and development.^{lxxxix} The study was designed to explore the presence of volatile organic compounds (VOCs), many of which are associated with the production of natural gas, in this rural natural gas production area for one year. The sampling period spanned the timeframe before, during, and after development of a natural gas well pad. Development included drilling, hydraulic fracturing, and production operations. Baseline and weekly air samples were collected between July, 2010,

and October, 2011, from a fixed sampling station near a well pad on which 16 vertical (directional) gas wells had been drilled, hydraulically fractured, and put into production during the course of the study.^{lxxxiii}

Among the VOCs, four chemicals were detected in every sample: ethane, methane, toluene, and propane. Chemicals with the highest mean values across the sampling period were, in order of mean value: methane, methylene chloride, ethane, methanol, ethanol, acetone, and propane.^{lxxxiv} Regarding the carbonyls, acetaldehyde and formaldehyde were detected in every sample. The highest values were for formaldehyde and crotonaldehyde.^{lxxxv} Naphthalene was the only polycyclic aromatic hydrocarbon (PAH) detected in every sample and it was also found at the highest concentration among the PAHs detected.^{lxxxvi} The most chemical detections occurred during the first four months of drilling, at a time when only one fracturing event occurred. Notably, the highest percentage of detections occurred during the initial drilling phase, prior to hydraulic fracturing on the well pad, and did not increase during hydraulic fracturing.^{lxxxvii}

The study found that methylene chloride, a toxic solvent not reported in products used in drilling or hydraulic fracturing, was detected 73% of the time.^{lxxxviii} This also stood out due to the extremely high concentrations in some of the samples, including one reading of 1730 ppbv, and three other readings more than 563 ppbv during the period of well development. In contrast, after activity on the pad came to an end and the wells went into production, the highest level of methylene chloride detected was 10.6 ppb.^{lxxxix} Residents and gas field workers have reported that methylene chloride is stored on well pads for

cleaning purposes.^{xc} A literature search of the health effects of non-methane hydrocarbons revealed that many had multiple health effects, including 30 that affect the endocrine system, which is susceptible to chemical impacts at very low concentrations, significantly less than government safety standards.^{xcii}

The study also found that selected PAHs were at concentrations greater than those at which prenatally exposed children in urban studies had lower developmental and IQ scores.^{xciii} While natural gas development and production continues to spread across the land it is moving closer to schools, homes, and places of business. The authors warned that at the same time more and more raw gas will be released into the atmosphere on a steady, daily basis. The report recommended that in order to determine how to reduce human exposure for both those who work on the well pads and those living nearby, systematic air quality monitoring of natural gas operations must become a regular part of permitting requirements.

This report covers many of the air impacts that accompany gas development and fracking. It shows that the various stages of drilling and fracking have impacts, that there are many toxic contaminants that are released by the drilling and fracking process and that many of them have significant adverse health effects upon exposure. The information contained in this report supports a complete prohibition of fracking and drilling and a prohibition of related activities. There are many other scientific reports and articles that are included in the “Compendium”, submitted by DRN to the public record for DRBC’s comment period on the Draft Regulations and discussed earlier in this Comment. Also, reports from the Southwest Pennsylvania Environmental Health Project^{xciiii} document air

emission-related health problems in the vicinity of shale gas operations and facilities. Some of the data and reports from that Project are included in the Compendium.

In addition to problems associated with harmful air emissions from fracking and gas operations, odors are also a problem related to the storage, management, and treatment of fracturing fluids and in flowback produced by fracking. Odors are not just a nuisance, they can be a serious human health issue and can greatly affect the quality of life near a well site. Hydrogen sulfide is an example of an odorous gas that is nauseating (the “rotten egg smell”) and is highly toxic. (Glenn C. Miller, Ph.D., “Review of the Draft Delaware River Basin Commission’s Regulations on Hydraulic Fracturing in Shale and Other Formations”, March 20, 2018) It can cause illness and even death. There are other toxic odors as well released by fracking operations. (Miller)

“Odors are a particular problem for management/storage/treatment of HF waters, and a variety of chemicals are present in hydrocarbon formations that can present a serious odor problem, which can be both a serious human health issue and can affect the quality of life of persons living near these sites. A very common, but toxic, constituent is hydrogen sulfide, characterized by a rotten egg smell. Other organic sulfides can also be present, including a variety of alkyl sulfides. Odors are very difficult to regulate, due to the vagaries associated with odor detection, acclimation, and differential effects on different persons. The severity of an odor is in the nose of the beholder. Odors are particularly bothersome to persons living downwind, and storage of HF waters in the Basin can very likely lead to complaints, which should be taken seriously.”^{xiv}

Radon is another dangerous gas that can be released in toxic amounts by fracking, due to the radioactivity of Marcellus Shale.^{xcv} Radon is a radioactive decay product of radium and is a known carcinogen.^{xcvi} Dr. Marvin Resnikoff states, “We support section 440.3 which prohibits fracking within the Delaware River basin. This is important, not only for the potential release of drilling fluids and contaminated water into aquifers but also for minimizing the potential release of the radioactive inert gas radon”.^{xcvii}

According to a report that examined the potential impacts from fracking on the Delaware River Watershed, the development of shale gas wells could as much as double nitrogen oxides (NOx) emissions, compared to current air conditions in the Marcellus Shale counties of the basin.^{xcviii} The release of the NOx is not expected to be short term, during fracking or construction like some of the air pollution associated with fracking operations.^{xcix} But the gathering lines require compressor stations to move the gas from the well to market pipelines and those compressor stations are permanent necessity as long as the gas well is producing. So the air quality degradation and unhealthy condition created by the NOx is long-lived and unavoidable throughout the life of the producing gas well.^c NOx and VOCs are precursors to ozone, or smog, which is known to cause respiratory illness.^{ci} Other air pollutants are released by fracking and during all stages of gas development, including sulfur oxides, particulate matter, and volatile organic compounds such as formaldehyde, benzene, toluene, ethylbenzene, and xylene.^{cii}

In the same study that examined the potential impacts from fracking on the Delaware River Watershed, health impacts from air emissions and other pollution from fracking was

examined.^{ciii} The report mapped the likely location of well pads in the Delaware River Watershed's Marcellus Shale region and estimated that 45,000 people live within 1 mile of a projected well pad, virtually the entire population of the location where fracking is most likely to occur.^{civ} The study reported that scientific literature documents that some health risk factors are related to the distance from a well pad to a person's home.^{cv} 60% of the health of Wayne County's population could be affected by close proximity to a well pad.^{cvi} The study examined the pollutants that people would be exposed to, based on scientific studies (CNA, Table 12).^{cvii} These findings make very clear that the effects of gas development and fracking on the air and the health of the people of the region are inescapable due to the proximity of projected well pad locations to the population. It is unacceptable to sacrifice the air quality and health of the people of the Marcellus Shale region in the Delaware River Basin so that shale gas can be developed. The only protective option is to prohibit fracking and gas development completely.

Methane pollution and greenhouse gas releases from natural gas development significantly contribute to air degradation from natural gas, whether during stimulation and production or during transport when pipeline leakage is a mounting problem. Methane is an ozone precursor.^{cviii}

Natural gas is primarily methane, a greenhouse gas 86 times more efficient at warming the atmosphere than carbon over a 20 year time frame^{cix} and its effects persist for hundreds of years^{cx}. The well documented vented and fugitive losses from natural gas systems contribute to atmospheric warming; current technology and practices have not

controlled these releases. The emissions from shale gas development are so great that it is projected that their release from the build out of Pennsylvania's Marcellus shale will prevent the achievement of global warming goals in the state, accelerating climate change.^{cxix}

Climate change impacts on the Basin's water resources include changes in precipitation and runoff that increase flooding and drought, impairment of habitats and water quality (including salt water intrusion to Delaware River Estuary water supplies, the drinking water source for millions of people) and sea level rise^{cxii}.

Again looking at the study referenced above that examined the potential impacts from fracking on the Delaware River Watershed, the amount of leakage from natural gas development in the Watershed was estimated to be approximately at least an additional 0.5 to 2.2% per year, which would be added to the current releases from the Marcellus Shale play in Pennsylvania and West Virginia.^{cxiii} Considering the potency of methane as a greenhouse gas, this burden adds to the growing problem of atmospheric warming from methane, fueling the advance of climate change for the planet. This is an adverse impact of fracking should be considered by DRBC because of the environmental and water-related problems that are caused by climate change and global warming, as discussed above.

The adverse water resource and health impacts caused by methane being released to the atmosphere are another of the impacts of fracking that cannot be eliminated; the leaked and vented gas is part of the fracking process and, even with attempts to develop performance standards to reduce or control leaks and venting, the effort has been ineffectual. As stated in a review of the Center for Sustainable Shale Development Standards, Dr. Robert

Howarth rejects what was touted as a new “gold standard” from industry practices that could reduce methane emissions substantially as full of loopholes and too vague to be effective.^{cxiv}

In fact, the sources of methane emissions from components that make up fracking operations in the Marcellus Shale region are largely unavoidable, extremely difficult and/or expensive to control in terms of methane emissions, including: gathering lines; compressors for gathering lines; the use of under-balanced drilling and the presence of “faults” such as those found where mining has occurred (such as would be found in the anthracite coal mining areas of the western portion of the Delaware River Upper Basin); and the venting of gas, including “non-pipeline quality” or “low flammability” gas, venting during completion of a well, venting from exploratory wells that are not equipped to flare and on-site “de minimis” venting.^{cxv}

Methane is a very difficult gas to control and it is so potent that its effects are outpacing the global effort to control the warming of the earth’s atmosphere. Studies are showing that methane emissions are rising, even as carbon emissions are just beginning to slow. As stated in a news article about a new study that reveals the huge negative impacts of methane: "What’s true for carbon dioxide is not at all true for methane, the second most important greenhouse gas. Atmospheric concentrations of this gas — which causes much sharper short-term warming, but whose effects fade far more quickly than carbon dioxide — are spiking, a team of scientists reports in an [analysis published Sunday](#) in the journal *Environmental Research Letters*."^{cxvi}

As Dr. Robert Howarth of Cornell University eloquently explains, “We need to reduce carbon dioxide. We’ve already put 90% of the carbon dioxide we can into the atmosphere and keep the earth well below 2 degrees Celsius, so we can’t afford to put much more carbon dioxide up there. But no matter what we do for carbon dioxide over the coming years and decades, the planet will continue to warm to 1.5 degrees [Celsius] in 12 years and to 2 degrees [Celsius] in 35 years unless we cut methane emissions. The planet responds much much faster to methane than to carbon dioxide. There was a lot of talk at COP21 that yes, we need to start looking at these short-lived climate pollutants. We need to focus attention on them. We need to do it internationally within the next 2 or 3 years. So, we need to cut methane. Where is methane coming from? The major source in the United States is the natural gas industry. There’s no question about that. And there’s good evidence that shale gas development has accelerated that and perhaps doubled the methane emissions for the natural gas industry because of that. So this completely undercuts the idea that natural gas is a bridge fuel. It cannot be a bridge fuel for it to meet the COP21 targets.”^{cxvii} The fact is, methane is a major part of the global warming problem and it is essential that action be taken wherever possible to prevent its release.

Methane emissions are so large they can now be seen from outer space.^{cxviii} These findings support the prevention of methane releases to the atmosphere by the complete prohibition of fracking in the Delaware River Watershed.

Comments in opposition to the export of water and water resources out of the basin for fracking at Section 440.4

DRN opposes the Draft Regulations at Section 440.4 that would allow the diversion, transfer or exportation of surface water, groundwater, treated wastewater or mine drainage water from the Delaware River Basin to support fracking outside the basin. DRN requests that this Section 440.4 as written be removed from the draft regulations. Despite a statement by the DRBC that this practice is “discouraged”, the regulations lay a road map for drilling companies showing how to successfully receive DRBC approval. Due to trends in industrial practices over recent years and the proximity of high-producing gas wells in adjacent Susquehanna County and other portions of the Susquehanna River Basin, it is more than likely that drillers would take advantage of the opportunity to withdraw water from the Delaware River Watershed for fracking.

The management, protection, and conservation of water resources is DRBC’s *raison d’être*. One of the few regions to be governed by a Compact based on watershed boundaries, predating our federal environmental laws and bureaucracies, DRBC is in a unique and powerful position to make watershed-based decisions from which the Basin states have richly benefited since 1961. Indeed, little is being done regarding proper management and protection of water nationally or on a global scale, evidenced by the high water consumption and out of date planning that dominates the world’s approach to water.

Examining the demand for water worldwide, a report published in August in *Nature* concludes that we are overexploiting our aquifers, estimating that the global groundwater footprint is about 3.5 times the actual size of aquifers where almost one quarter of the

Page 60 of 145

world's population lives (1.7 billion people).^{cxix} An article in the Harvard Business School's Working Knowledge points out that by 2050, the Earth's population will likely exceed 9 billion people, many expected to live in cities yet in terms of urban planning, "Water is often planned last and gets short shrift," said John Briscoe, a professor at the Harvard School of Engineering and Applied Sciences, who participated in a panel a session dedicated to water. "Water is absolutely the poor cousin of the utilities."^{cxx}

Water used for fracking, particularly in deep geologic formations, is a depletive use and is defined as depletive by DRBC. This depletion is fundamentally different than evaporative losses for agriculture, electricity generation, and recreational uses like golf courses, which essentially recycle the water used into the atmosphere where it returns as precipitation. In fracking, the water used is not only removed from its source, but is locked away in the rock formations where it was injected. In the Marcellus Shale, approximately 90% or more of the water stays below the ground and the remainder (10% or less) travels back up the well bore during the fracking process as "produced water". That produced water has been transformed from its natural quality to a polluted state that essentially renders it useless as a water source, and becomes wastewater that is required to be disposed of under Clean Water Act regulations. The majority of the water injected for fracking is locked away from the earth's natural hydrologic cycle, a total loss that simply doesn't return to the atmosphere, except perhaps over geologic time frames, in a highly polluted condition.

The ecological and socio-economic implications of this true depletive loss have not been studied or quantified, but considering the finite nature of potable water and our

expanding consumption rate, this must be recognized by DRBC as a key element in assessing fracking's water footprint and how it impacts the Basin's water "balance sheet". Very little data exists to quantify groundwater in many aquifers^{cxxi}, even within the relatively well-studied Delaware River Basin, so that accurate water footprint accounting and its implications for meeting existing and future water demands while maintaining water quality standards just isn't available. This should be a huge caution sign for DRBC that supports a total prohibition on this depletive use.

The amount of water used to frack a shale gas well in Pennsylvania has more than doubled since 2011. In 2017, the average amount of water used was 11.4 million gallons per Marcellus Shale well in Pennsylvania. (FracTracker Alliance, "Potential Impacts of Unconventional Oil and Gas on the Delaware River Basin", March 20, 2018)

"Water usage for Marcellus wells in Pennsylvania have increased from an average of 4.3 million gallons in 2011 to 11.4 million gallons in 2017, while water use in the deeper Utica formation has increased from 5.8 million to 13.5 million gallons per well over the same time frame. The reason for this increase is twofold. First, drillers are using increasingly longer bore holes in the Appalachian basin, the lateral portion of which is starting to exceed 4 miles in some cases. The resulting effect is more surface area to stimulate (which inherently uses more water). And second, operators in the Appalachian basin are using significantly more water per lateral foot than in years past."^{cxxii}

The lengthening of horizontal well bores due to advances in drilling technology has created a trend in the drilling industry that has dramatically changed the water footprint of

fracking in the Marcellus and Utica Shales. The DRBC estimate in its Supplementary Information of an average 4.3 million gallons per well per fracturing event based on SRBC data from 2008 and 2013 and a median 4.18 million gallons reported by EPA for Pennsylvania between 2011 and 2013, are now out of date. DRBC states that EPA also reported that in at least 10% of the cases, 6.6 million gallons was used per well in Pennsylvania. DRBC states that the longer well bores that began in 2016 increased the average water use per fracturing event to approximately 5.1 to 6.5 million gallons. The current data shows an even greater average use per Marcellus well in Pennsylvania than DRBC's estimates – 11.4 million gallons of water on average per fracked Marcellus shale well. (FracTracker) This is a sea change in terms of potential water resource impacts.

News articles are reporting large well pads with wells that have longer and more well bores in western Pennsylvania's Marcellus Shale region, with horizontal bores traveling up to four miles and curving away from the vertical well bore at shallower depths and less radical curvatures to allow for more horizontal bores that won't interfere with each other, multiplying the capacity of each well.^{cxxiii} Industry reports consider the longer well bores and supersized pads to be a better investment and the direction that shale gas well development is going.^{cxxiv}

The amount of water used today to frack a shale well in the Appalachian basin also has been calculated to use significantly more water per lateral foot. (FracTracker) This phenomenon is being reported in industry filings but the reasons have not been analyzed publicly. This is another important change, however, that could increase the amount of

water used for fracking shale gas wells and should be considered as a driver for demand.

Overall, the potential impact of water depletion to meet this demand has at least doubled and the trend is for the demand to continue to increase per well drilled, making the impacts greater.

Another factor that influences the amount of water needed by drillers to develop shale gas wells is the induced expansion of the market for gas due to the buildout of infrastructure such as pipelines and end uses that include the export of gas and gas liquids and the consumption of natural gas at new gas-fired electric generating stations and petrochemical processing facilities.

The U.S. Energy Information Administration reported in March 2018 that the nation's liquefied natural gas (LNG) exports quadrupled in 2017. "The increase in LNG exports over the past two years is the result of the continuing expansion of U.S. LNG export capacity. Two LNG projects—Sabine Pass in Louisiana and Cove Point in Maryland—have come online since 2016, increasing U.S. LNG export capacity to 3.6 Bcf/d. [Four more projects are scheduled to come online](#) in the next two years: Elba Island LNG in Georgia and Cameron LNG in Louisiana in 2018, then Freeport LNG and Corpus Christi LNG in Texas in 2019. Once completed, U.S. LNG export capacity is expected to reach 9.6 Bcf/d by the end of 2019. As export capacity continues to increase, the United States is projected to become the third-largest LNG exporter in the world by 2020, surpassing Malaysia and remaining behind only Australia and Qatar."^{CXXV}

This illustrates the expansion of the LNG market which is spurring new fracked gas well starts in Pennsylvania as well as other states. The proximity of Pennsylvania to the Cove Point LNG export facility in Maryland (in the Chesapeake Bay) will increase close-by demand for more gas. Also, demand for gas to be processed and marketed as natural gas liquids (NGL) at export facilities will grow as well. An example is the expanding Sunoco Logistics export terminal in Marcus Hook, Pennsylvania south of Philadelphia on the Delaware River; a second Market East pipeline is under construction to bring more natural gas liquids from the Mark West processing facility in southwestern Pennsylvania to the Delaware River terminal for export. There is also an active application to build a new NGL export facility in Greenwich Township, Gloucester County, New Jersey on the Delaware River, across from Philadelphia. PADEP has permitted 49 new natural gas-fired power plants in the Commonwealth in recent years which will also increase demand for fracked gas wells. DRN received documentation of the number of permitted natural gas power plants from PADEP in late 2017 through a Right to Know Law request and the excel sheet provided by PADEP in response is linked in the Endnotes.^{cxxvi}

The number of shale gas wells drilled in 2017 increased by 35 over the year prior in Pennsylvania and, as delivery systems and markets grow, the price of gas will go up, making it more profitable to drill new wells. (Fractracker)

“In all, we estimate that the industry used 51.4 billion gallons of water to stimulate 7,721 Unconventional wells in Pennsylvania in the seven-year period from 2011 through 2017.”^{cxxvii}

All of this activity means an increased demand for water for fracking in Pennsylvania. Looking at 2017 alone, 6 billion gallons of fresh water was used in Pennsylvania to frack wells. (FracTracker). That is approximately 16.5 million gallons of water per day, a depletive use. If the amount were to remain steady (rather than increase per well as the trend expects) the fracking industry will be looking for fresh water sources to fill their need and can be expected to look to the Delaware River Basin, especially for the areas in proximity to high-producing wells such as those located near the Delaware River Watershed in northeast Pennsylvania. The amount of water demand for fracking from nearby wells could easily dwarf the current depletive water use of fresh water in the Upper Delaware River Basin.

“In an industry expecting to drill roughly 45,000 more wells just in the Interior Marcellus Formation of PA through 2045,²⁴ the pressure to find new water sources and waste disposal sites will be ongoing in the coming decades, including within the Delaware River Basin. This will require over half a trillion gallons of water to stimulate, assuming that the per-well water consumption does not continue to increase beyond 2017 figures.”^{cxxviii}

“Currently, none of the Pennsylvania O&G related surface or ground water withdrawal sites are in the Delaware River Basin, although with such an increasing demand for fresh water, drilling operators would likely make extensive use of hydrological resources there.”^{cxxix}

Water withdrawals from surface and groundwater have substantial impacts on water resources, ecosystems, and stream habitats. Human activities that effect these resources

have severely altered the natural environment and continue to do so. 30-35% of all freshwater fish species are believed by scientists to be already extinct, with 93% of those reductions occurring in the last 50 years. This shows an accelerating trend towards extinction. Freshwater mussels is one of the most imperiled animal groups in North America. The dwarf wedgemussel, a federally endangered species, has established populations in the Upper Delaware River Watershed (Piotr Parasiewicz, PhD, A.Prof., “Ecological review of the DRBC Draft 18 CFR Parts 401 and 440 Proposed Amendments to the Administrative Manual and Special Regulations Regarding Natural Gas Development Activities,” February 2018)

“The dramatic impact of human-induced alterations on freshwater flora and fauna is widely reported (Gleick et al., 2001; UNEP, 1999). Running water ecosystems belong to the most severely human-impacted habitats on Earth (Nilsson et al., 2005; Malmqvist and Rundle, 2002). Of more than 3,500 species currently threatened with extinction worldwide, one-quarter are fish and amphibians.

In freshwaters, the projected decline in species diversity is about five times greater than in terrestrial ecosystems (Pimm et al., 1995). This rate is similar to that of great prehistoric extinctions (Malmqvist and Rundle, 2002).

It has been suggested that some 30-35% of all freshwater fish species are already extinct or in serious decline worldwide (Stiassny, 1999). Ninety-three percent of these

reductions occurred during the last 50 years, indicating extinction of freshwater fishes is a serious and accelerating global trend (Harrison and Stiassny, 1999).

The freshwater mussel is one of the most imperiled animal groups in North America with only 25% of the existing species having stable populations (Williams et al., 1995). Freshwater mussels fulfill many crucial ecosystem services such as the filtering of large amounts of water, which removes pollutants from the water. Hence, healthy assemblages of mussels are necessary to maintain high water quality standards.”^{xxxx}

Urbanization is playing a large part in the destruction of natural flow patterns in streams and habitat loss. Excessive water withdrawals and deforestation that alter hydrograph runoff patterns that increase peak flows and decrease base flows of streams are a large part of the changes accompanying urbanization that are causing species extinction and destabilization. (Parasiewicz)

“Historical and ongoing urbanization of our landscape intensifies floods and droughts, causing damage to human property and stressing the fauna. Excessive water withdrawals due to human and industrial demands dry up rivers with increasing frequency.

The process of urbanization alters seasonal hydrographs by increasing peak flows and decreasing base flows (e.g., Bedient and Huber, 1988; Dunne & Black, 1970; Parasiewicz and Goettel, 2003; Petersen, 2001). In the Northeastern United States, this hydrological pattern appears to be a regional phenomenon and a lasting legacy of historic deforestation. Even in areas such as the Catskill Mountains that superficially

appear to have recovered from the historical impacts of earlier timber harvests, similar effects can still be observed (Parasiewicz et al., 2010).”^{cxviii}

Reduced base flows that result from these changes warm up the water in a river or stream more quickly. Groundwater withdrawals translate into less cold water being expressed to the surface and to waterways. Summer temperatures in excess of 89 degrees F are now being recorded in “long stretches of coldwater streams.” (Parasiewicz) These impacts harm species and also degrade water quality. Scientists are warning that, coupled with climate change impacts that are causing higher summer temperatures, longer warm seasons, lower river flows, and more frequent and more severe flooding, the risk of further degradation and extinctions are so great that water withdrawal management must be a priority. (Parasiewicz) A species such as the dwarf wedgemussel, which is sedentary, is particularly vulnerable to habitat changes that can result from water withdrawals at sensitive times or rapid fluctuations in flow. (Parasiewicz)

“The water in these reduced flows tends to warm up more quickly in rivers that have been widened by previous floods and historical logging operations. Shallow ponds, created by thousands of small dams, serve as natural solar collectors. Additionally, less cold water is entering the rivers from base flow because of increased ground water withdrawals. We are frequently now measuring summer water temperatures in excess of 80°F in long stretches of “coldwater” streams (e.g. Ballestero et al., 2007, Parasiewicz et al., 2007).

The change in our global climate further contributes to this impact by causing higher summer air temperatures, a longer summer season, and lower minimum river flows together with more frequent and severe flooding (Faloon and Betts, 2006).

Consequently, the habitat conditions are quite unstable and high water temperatures have caused fish die offs and potentially reduced mussel populations in the past. As documented by an investigation of dwarf wedgemussel habitat, the existing populations are limited to a few locations that maintain hydraulic stability. The sedentary organisms like freshwater mussels are particularly vulnerable to the habitat reduction due to the lack of water than can be caused by water withdrawals or rapid fluctuations.”^{cxxxii}

Water withdrawal management, however, is not a simple matter that can be addressed effectively by setting minimum flow levels based on the Q7-10 (the flow which occurs for a period of seven consecutive days one time in 10 years – considered “drought flow”) or simply managing the scheduled releases from reservoirs and dams. (Parasiewicz) Scientists have discovered that the hydrologic pattern of a flowing water body are critical and if disrupted can be detrimental to aquatic life. (Parasiewicz) Preserving the natural or ecological flow regime of a waterway is of utmost importance in terms of stream health, habitats, water quality and species and must be the basis of decisionmaking regarding water withdrawals if these are to be adequately protected.

“Silk et al. (2000) eloquently suggests that “The natural ecosystem of any river is the product of millions of years of adaptation and evolution, which have created a myriad

of variables and subtleties more complex than we can imagine.” Due to this complexity and continuing conflicts of interest among competing water uses, a very precise planning and evaluation of potential development impacts is required.

Water allocation issues are not new, and many techniques have been developed in recent decades to address these problems (Stalnaker, 1995; Dunbar et al., 1998). Only recently we learned to recognize that not only is the quality and quantity of water released below a hydro-power or irrigation dam important, but also that modifications of hydrological patterns can have detrimental effects on aquatic life (Richter et al 1997).”^{cxxxiii}

In the Delaware River Basin, the Upper Delaware’s Catskills and Pocono Mountains are generally rural with steep areas that have shallow soils overlaying bedrock. (Parasiewicz) Severe erosion can occur when there are high flows in a stream, eroding stream banks and widening the stream to unnatural widths. The adverse changes in stream morphology are exacerbated when woody debris is removed or high flows scour debris away. (Parasiewicz)

“The Catskill Mountains’ and Poconos watersheds are generally rural, topographically steep areas with shallow, permeable soils overlaying restrictive bedrock or fragipans. Heightened flow peaks cause severe erosion, leading to the down-cutting and overwidening of river corridors (Parasiewicz et al., 2010). The notable lack of woody debris structure documented in the Stony Clove Creek study in the Catskill Mountains (Parasiewicz et al., 2003) was partially a consequence of increased flow peaks removing log jams before they can stabilize, but also due to frequent “cleanups” of woody debris as a flood protection and beautification measure.”^{cxxxiv}

Shallower, wider and straightened streams add to the factors that heat up waterways. Anchor ice also tends to form in winter in shallower streams, sticking to the bottom and damaging aquatic fauna and forcing fish to move, increasing mortality. This becomes a downward spiral for the life of a stream when reduced base flow and groundwater levels caused by excessive and poorly timed water withdrawals disrupt critical natural flow patterns. (Parasiewicz)

“These changes, in combination with reduced stream flows and groundwater levels, increase summer water temperatures and can cause creation of anchor ice in the winter. Anchor ice is an ice forming at the bottom of the river that can create considerable damage to the aquatic fauna by forcing fish movements and increasing their mortality. In addition, many river corridors, especially those in urbanized areas, have been physically modified (e.g., straightened, widened, dredged or impounded), altering the character of the corridor (e.g. from braided to straightened) and leading to further modifications in the hydrological regime (Hewlett and Hibbert, 1967).”^{cxxxv}

One of the results of the hydrologic pattern changes, the disruption of the natural flow regime, is the loss of species that were adapted to the unique habitat conditions that allowed them to live in a location. More generalized species move in that can adapt to the changed conditions, as documented in northeastern rivers. (Parasiewicz)

“The most apparent consequences of such changes in hydrological patterns are a reduction in fish densities and modification of the fish community structure from specialized riverine species towards more generalized species. This phenomenon has

been documented in several recent studies in the Northeast Region (e.g. Parasiewicz and Goettel, 2003; Armstrong et al., 2001).”^{cxxxvi}

DRBC does not explain how the measures it expects to “discourage” water withdrawals will be carried out. The lack of detail about how biocriteria will be assessed and used to protect flows and species is not disclosed in the draft regulations but must be in order for the public to understand and comment on the draft regulations. (Schmid)

“DRBC has not explained how it intends to implement the requirements of its *Water Code* and *Water Quality Regulations* when authorizing stream water withdrawal for HVHF uses. In particular, it does not indicate how it will assure compliance with its adopted biocriteria. Those biocriteria appear not to be addressed by other agencies. DRBC has offered no detailed regulations or technical guidance specifying how such assessments will be made and reported in order to fill the current regulatory gap.”^{cxxxvii}

DRBC proposes to allow out-of-basin water withdrawals for fracking, despite its “discouragement” of out of basin transfers and its recognition and regulation of such withdrawals as depletive. DRBC implies that its low-flow and pass-by flow policies for water withdrawal dockets will sufficiently protect the Watershed’s streams and rivers. This is not so. DRBC regulates withdrawals from streams with the use of a “pass-by flow” that limits the amount of water that can be withdrawn to protect streams from being overdrawn. However, a pass-by flow that is based on using the Q7-10 (the flow which occurs for a period of seven consecutive days one time in 10 years – considered “drought flow”) is not

adequate to protect waterways and the life that depends on them^{cxxxviii} and can be expected to cause direct harm to the habitats and water quality of the stream.^{cxxxix}

Using the Q7-10 allows the stream's flow to be artificially "flattened" because the natural flow regime and seasonality will be disrupted and potentially eliminated. An ecological flow analysis of the waterway is required to measure the natural variation of the waterway's flows in terms of volume, rate, temperature, stream structure, and quality. This analysis should be completed before any withdrawal of surface water in order to provide an ecologically-based flow regime that will give needed protection to the habitats, species and water quality of that particular stream. Once a comprehensive assessment is complete, reliable models can be used to forecast changes should withdrawals for any purpose be contemplated. (Parasiewicz) Ecologically-based flow requirements, stream channel restoration projects and mitigation projects, will then be able to be designed to retain the habitats needed by the River's species. (Parasiewicz) This is essential to protect habitats and to ensure water quality that will support the river's uses and values.

"Before contemplating any option associated with potential water withdrawals of any kind it would be necessary to conduct a comprehensive assessment of habitats and species in tributaries and main stem and to develop watershed models to forecast potential cumulative impacts. Such models need to inform the decision not only with regard to the possibility of water withdrawals, but also about necessary mitigation and compensation measures such as by-pass flows or channel improvements. Such documentation and models do not exist yet."^{cxl}

Water withdrawals from surface waterways also have the potential to deplete downstream groundwater resources if set based on pass-by flows that do not take seasonality into account, including local benefits of high flows such as springtime flows or heavy precipitation events. Such a withdrawal may downstream cause some additional discharge from the aquifer to make up the loss of stream flow. This additional base flow will be contributed by shallow groundwater downstream of the withdrawal site, impacting aquifers. This presents the potential for loss of groundwater reserves that will discharge to the stressed waterway to attempt to maintain base flow that was lost to the withdrawal.^{cxli}

The Delaware River is an exceptionally healthy river that supports the federally endangered dwarf wedgemussel and several other freshwater mussels, and many migratory fish that travel to the upper reaches of the river, including the American eel and American shad. (Parasiewicz) These are iconic species for the Delaware that define its nature and distinguish it as unique and of national importance, enabled by the river's free flowing main stem, the longest free-flowing river east of the Mississippi. The river is enjoyed by millions due to the nearby New York and Philadelphia metropolitan regions that can drive there on a tank of gas. Fly fishing in the coldwater creeks and streams are famous and beloved for generations. (Parasiewicz)

The river has been recognized by Congress as a Wild and Scenic River, among the early rivers to receive this merit, due to its outstanding natural features and scenic and recreational values. The National Park Service protects the Upper Delaware and the

Delaware Water Gap National Recreation Area, one of the most frequently visited in the nation.

But the Upper Delaware's streams still show the imprint of human activity in the long-lasting effects of historic deforestation and heavy industrial practices from the last centuries on its creeks and streams that are shallow, wide, and flashy, exhibiting dramatically altered hydrologic patterns due loss of natural flow regimes. (Parasiewicz) The export of water from the Upper Delaware for drinking water in New York City has indelible impacts. (Parasiewicz)

“However, the legacy of deforestation and an industrial past is still visible in its overwidened, shallow river channels and flashy hydrology with rapidly changing flows from very low to very high. The watershed is also under pressure for hydropower use and as a drinking water supply for New York City (Parasiewicz et al., 2010).”^{cxlii}

Water withdrawals of freshwater totaled about 4,130 Mgal/d in 2010, with New York City withdrawing an average 574 million gallons per day.^{cxliii} Up to 17 million people receive their drinking water from the Delaware River, varying between 15 and 17 million on any given day depending in large effect on how much is exported to New York City through the reservoir and aqueduct system.

Pumping of aquifers to remove water for depletive/consumptive use can diminish surface water supplies by reducing natural shallow groundwater flows to streams and reservoirs. It also has the potential to disrupt the flow of groundwater that feeds existing water supply wells on which millions within the Basin rely for drinking water and other

local uses. It can also diminish and/or disrupt available groundwater that supports forests and other vegetation, including agriculture, harming existing uses. Natural resources such as wetlands, seeps, and springs, are also diminished or seasonally depleted by depletive water withdrawals.

Managing the Delaware River flows downstream of the major reservoirs on its tributaries is a complex and difficult task. The Supreme Court Decree that prescribes the division of water among the four states, the minimum flow targets that must be maintained in the main stem river, and the Court's mandate to repel the salt line in the tidal river to protect drinking water intakes in Philadelphia and southern New Jersey as well as the flow regimes that are required to protect fish and aquatic life in the Upper Delaware, all present challenges that sometimes lead to unstable water temperatures and fish die-offs as well as threatening the river's dwarf wedgemussel populations. (Parasiewicz)

“The flows in the river are strongly influenced by releases from upstream reservoirs: Cannonsville on the West Branch, Pepacton on the East Branch, Wallenpaupack on the Lackawaxen River, Mongaup on the Mongaup River and Neversink on the Neversink River. A Supreme Court decree was needed to manage the downstream salt wedge in Philadelphia by mandating the minimum flow releases. Due to complex management objectives, the current flows in the river can be erratic and unpredictable.

Consequently, the habitat conditions are quite unstable and high water temperatures have caused fish die offs and potentially reduced mussel populations in the past. As

documented by an investigation of dwarf wedgemussel habitat, the existing populations are limited to a few locations that maintain hydraulic stability.”^{cxliv}

The Flexible Flow Management Plan, a major agreement between the Decree Parties, is an ongoing plan that has recently been renewed after intense negotiations; it is a crucial endeavor that requires further work to develop adaptive management strategies to protect life in the streams and Upper River. (Parasiewicz)

“In consequence of a multiyear collaborative efforts the next Flexible Flow Management Plan including measures to protect federally endangered species such as the dwarf wedgemussel has been recently extended for another 5 years. It is a complex effort and intensive endeavor aiming towards managing numerous users and protecting the river ecology. During this time the DRBC and involved parties committed to continue investigations of the consequences of plan introduction searching for adaptive management options.”^{cxlv}

All water withdrawal decisions must be informed by the Flexible Flow Management Plan and the methods that are developed to manage the river’s flows to protect the Watershed’s habitat and species. The depletive removal of water from the river jeopardizes the competence of the plan and the protections it is supposed to provide. (Parasiewicz)

“HVHF requires high volumes of water (between 4 to 11 million gallons per fracturing event on one well only). Such withdrawals could easily destabilize the carefully crafted web of Flexible Flow Management Plan and other protective regulations.”^{cxlvi}

The proposal to allow water to be exported from the Basin for fracking does not sufficiently take into account the water scarcity that DRBC describes in times of drought and low rainfall. Well pads outside of the Basin will likely be encouraged in close proximity to the Delaware River Watershed boundary to take advantage of the availability of water, especially when new sources are sought for fracking in regions already being heavily tapped. (Parasiewicz)

Managing the water flows and protecting the outstanding values and living systems that make up the Delaware River is complex and DRBC is just now beginning to take up the development of adaptive strategies and ecological flow consideration in its Flexible Flow Management Plan work and the research that the Regulated Flow Advisory Committee and Subcommittee on Ecological Flows (SEF) will be doing. The fluctuations of weather and the added stresses of climate change such as increased frequency and intensity of storms and the environmental degradation that results, demand more comprehensive and ecologically-based management strategies. It is counterproductive to allow water exports that will impact flows, groundwater reserves, and stream stability by permitting further depletive uses. This fracking-related activity must be avoided to achieve success in the endeavor to both protect and manage the river and its ecosystems. (Parasiewicz)

“A thorough review of existing information made it clear that complete prohibition of shale gas extraction is an appropriate decision for protection of public health and resources in the Delaware River Basin. This prohibition, however should also include water exportation from and wastewater imports to the Watershed. Offering permitting

options will encourage development of extraction wells in near proximity of the Delaware Watershed imposing the public and wildlife to associated risks. Particularly the substantial uncertainty with long term effects of the pollutants in produced water and our ability of stopping them from entering into the waters of the area calls for very strict regulation without permitting options.”^{cxlvii}

“However, the Commission is willing to consider permitting *water exports* for utilization in hydraulic fracturing. Although the Commission requires also alternative analysis, in face of the ample evidence of water scarcity in the Delaware River Watershed this consideration seems to be inconsistent with declared policy of discouraging the exports.”^{cxlviii}

“The Upper Delaware River Watershed is a precious resource with a multitude of outstanding characteristics and users. The maintenance of the watershed’s ecological integrity requires careful and wise management. Such management is under development and measures that prevent degradation of aquatic fauna under climate change scenarios are not in place yet.

At this point adding more complexity and additional risks before such a program is in place is counterproductive, as obviously more time and resources are necessary to complete ongoing scientific efforts and take control over current issues in a way that will allow the protection and enhancement of ecological integrity.

Therefore, I recommend that Natural Gas Development should be fully banned without encouraging HVHF activities, especially in the proximity of the Delaware River

Watershed. This includes complete prohibition on water exports and wastewater imports for the purpose of natural gas mining as an unnecessary risk to the wellbeing and health of millions of citizens and the Delaware River Watershed's water resources and natural ecosystems, including the species that live there.”^{cxlix}

DRN recommends that a change be made to the text of Section 440.3 (b) to include all gas drilling and fracking regardless of whether it is High Volume Hydraulic Fracturing (HVHF), as defined at Section 440.2, or not. DRN bases this recommendation on the fact that “conventional” gas drilling, as defined by Pennsylvania Department of Environmental Protection, has substantial adverse impacts on water, the environment, and public health, where it is occurring today, as discussed in the review of scientific reports in this Comment. Furthermore, fracking and drilling that uses less than 300,000 gallons of water still has the potential for a substantial effect on the water resources of the Basin due to the toxic and radioactive properties of the fluids that are injected and the produced water or flowback that is generated by all drilling and fracking carried out to develop natural gas.

Comment Opposing Wastewater Transfer, Treatment, Storage, Disposal and Discharge of Produced Water and CWT Wastewater Produced by Fracking as Proposed at Section 440.5

DRN opposes the importation, transfer, treatment, storage, disposal, or discharge in the Basin of produced water and Centralized Waste Treatment (CWT) wastewater generated by fracking operations, as proposed at Section 440.5. DRN supports the complete prohibition of these proposed activities.

DRBC has recognized many of the problems posed by the wastewater produced by fracking in its Supplementary Information. However, the draft regulations do not provide protection and effective management of the water resources of the Delaware River Basin. The only option that will allow DRBC to meet its obligation to protect the water resources of the Basin is to prohibit these wastewaters and produced waters from being stored, processed, treated, disposed or discharged within the Basin.

There is ample evidence that supports a complete prohibition of the storage, processing, treating, disposal or discharge of produced water and CWT wastewater within the Basin.

The highly toxic nature of frack waste is widely recognized. According to the GAO, produced water is “generally of poor quality, with levels of contaminants varying widely”.^{cl} Fracking can yield poorer quality produced water than other extraction processes.^{cli} A previous study from the U.S. Department of Energy concludes that produced water from gas drilling is 10 times more toxic than those from off shore oil drilling.^{clii} Adding to pollution dangers posed by the reuse and recycling of frack fluids mixed with flowback or produced water, Marcellus Shale contains radionuclides including uranium-238, thorium-232, and their decay products. Radioactive concentrations in the Marcellus Shale formation are at concentrations 20 to 25 times background, making shale gas wastewater extremely radioactive.^{cliii} The produced water from Marcellus Shale has higher levels of radionuclides than water from Barnett Shale wells, according to the GAO.^{cliv} Sampling and data-gathering by New York State detected radiological parameters in Marcellus Shale flowback, including

Radium-226^{clv}, the longest lived isotope of radium with a half-life of 1600 years. Radium 226 can cause lymphoma, bone cancer and blood formation diseases such as leukemia and plastic anemia. Gross Alpha, Gross Beta, Total Alpha Radium and Radium-228 were also found.^{clvi}

New York's DSGEIS contained a list of constituents in Marcellus Shale wastewater from Pennsylvania and West Virginia.^{clvii} Many are hazardous, some have known harmful health impacts, and some are carcinogenic. New York tested flowback from these shale gas extraction operations in Pennsylvania and West Virginia and found 154 parameters.^{clviii} DRBC proposes to require Treatability Studies for the treatment of frack wastewater at Centralized Wastewater Treatment Facilities that plan to discharge to the Watershed. These studies are supposed to show that the "Pollutants of Concern" are treated, using USEPA Tables from the agency's technical document on oil and gas waste discharges to define the "Pollutants of Concern".^{clix} There are 78 pollutants listed but those are not all the toxic and/or hazardous pollutants contained in frack wastewater. For instance, Tables C -11, C-13, C-15, C-17, and C-19 don't include all the 154 parameters that New York discovered in their sampling. We know from DRBC and many other sources that over 1000 additives are in the fluids used to frack wells today,^{clx} and many, according to U.S. EPA and other authorities, are carried into the frack wastewater produced by the well.

Wastewater produced by fracking contains many dangerous and toxic constituents and properties including: Total Dissolved Solids (TDS), Total Kjeldahl Nitrogen (TKN), Ammonia Nitrogen, Nitrate-N, Chloride, Bromide, Sodium, Sulfate, Oil and Grease, BTEX

(benzene, toluene, ethylbenzene, xylene), VOC (volatile organic compounds), Naturally Occurring Radioactive Materials (NORM), Barium, and Strontium, according to a report by Natural Resources Defense Council.^{clxi} Some are carcinogenic, some have known health effects, and some are toxic to aquatic life and plant life.

Yale University School of Public Health, in a study of chemicals used in fracking, found that of the 119 compounds with sufficient data to classify them in terms of carcinogenicity (only 20% of chemicals in use had sufficient data – a problem in itself), “44 percent of the water pollutants and 60 percent of air pollutants were either confirmed or possible carcinogens.”^{clxii} Fifty five unique compounds with carcinogenic potential could be released to both water or air and 20 chemicals had evidence of increased risk for leukemia or lymphoma specifically.^{clxiii}

In its national study of fracking and drinking water, EPA identified 1,606 chemicals in fracking fluid or drilling wastewater including 1,084 identified in fracking fluid and 599 identified in wastewater, yet only 173 had toxicity values from sources that met EPA’s standards for conducting risk assessments. “This missing information represents a significant data gap that makes it difficult to fully understand the severity of potential impacts on drinking water resources.” However, EPA also reported that “health effects associated with chronic oral exposure to these chemicals include carcinogenicity, neurotoxicity, immune system effects, changes in body weight, changes in blood chemistry, liver and kidney toxicity, and reproductive and developmental toxicity.”^{clxiv} It is instructive to note that EPA did not mention that the agency’s own failure to request health testing for

new chemicals proposed for oil and gas drilling and regulated by EPA under the Toxic Substances Control Act contributed to the lack of information about chemical risks.^{clxv}

EPA officials could not be certain about the accuracy of their list of chemicals found in fracking fluid and wastewater in part because the list did not include confidential chemicals used by drilling companies for hydraulic fracturing. Drilling companies have withheld fracking chemical identities from the public as confidential thousands of times.

Two Harvard researchers found that 92 percent of the well-by-well fracking chemical disclosures submitted to the non-governmental organization FracFocus between approximately March 2011 and April 2015 included at least one chemical identity withheld from the public as confidential business information (CBI).^{clxvi} FracFocus is the nation's leading repository of fracking chemical disclosure information and currently contains disclosures from more than 127,000 wells.^{clxvii} EPA commented that, "when chemicals are claimed as CBI, there is no public means of accessing information on these chemicals. Furthermore, many of the chemicals and chemical mixtures disclosed, or those detected in produced water, lack information on properties affecting their movement, persistence, and toxicity in the environment should they be spilled."^{clxviii}

There may be constituents in flowback and produced waters from gas development that are not regulated under the Safe Drinking Water Act even though they have human health risks and ecosystem/environmental impacts. Some substances are chemicals that are unregulated and for which there is no maximum contaminant level (MCL) yet set by U.S. Environmental Protection Agency (EPA) or the State for drinking water quality. Many of

these are known as “emerging contaminants” and have known harmful human health effects but standards are still in the process of being developed. These pose additional unacceptable risks because they may be released into the environment without detection or any requirement for monitoring, detection, or treatment. Some of these are endocrine disruptors (EDC) or pharmaceuticals that may occur in gas drilling wastewater.^{clxix}

EDCs used in hydraulic fracturing fluids and found in flowback are of special concern due to the biological effects of these constituents at extremely low concentrations.

Suspected EDC’s found in gas drilling wastewater include arsenic and selenium; hydraulic fracturing fluids may contain others such as 2BE, 2-Ethylhexanol, and Crystalline Silica. Scientists and health professionals are beginning to analyze these materials and measure their impacts on human health in a different way, testing these compounds at very low levels in the range of human exposures and at various endpoints.^{clxx}

In an effort to protect human health from these very dangerous materials, scientists are concluding that there are no safe doses for endocrine disruptors; the fact that they have biological effects proves that EDC’s have biological activity – what the induced effects are is the question.^{clxxi} As stated by Linda Birnbaum, Director, National Institutes of Health, “It is time to start the conversation between environmental health scientists, toxicologists, and risk assessors to determine how our understanding of low-dose responses influence the way risk assessments are performed for chemicals with endocrine-disrupting activities. Together, we can take appropriate actions to protect human and wildlife populations from these harmful chemicals and facilitate better regulatory decision making”.^{clxxii}

There are other problems that make it impossible to accurately test for and remove toxic constituents of wastewater and produced water generated by fracking. According to a report that the Partnership for Policy Integrity published in 2016 based on a Freedom of Information Act (FOIA) request filed with EPA, between 2009 and 2014, EPA reviewed 105 new chemicals proposed for drilling and fracking for health and environmental risks under the New Chemicals program.^{clxxiii} EPA had health concerns about 88 of the chemicals ranging from irritation to skin, eyes, and mucous membranes; lung effects; neurotoxicity; kidney toxicity; and developmental toxicity.^{clxxiv}

Nevertheless, EPA allowed 98 of the 105 to go into commercial production, often without health testing data that could have more conclusively determined health risks; more than half of these chemicals went into commercial production and use.^{clxxv}

Chemical manufacturers frequently withheld as trade secrets information about the chemicals' identities including Chemical Abstracts Service Numbers, chemical names, and trade names. This confidentiality makes it very difficult to know where these chemicals have been used but we do know they are used in Pennsylvania's Marcellus Shale wells.^{clxxvi}

It is likely that drilling companies would use secret and potentially dangerous chemicals if drilling and fracking were allowed in the Basin. And it is likely if wastewater discharges are allowed, these secret chemicals will enter the Watershed's environment and contaminate its water.

The EPA has found that fracking wastewater can contain chemicals injected in fracking. Therefore, if fracking wastewater is allowed in the basin, it is likely that treatment

facilities will be handling and discharging unknown and potentially toxic contaminants that not only are not identified in the permit or docket as requiring treatment but may not even be sampled for.

This opens a pathway of pollution that is extremely dangerous because the presence of the chemical and its concentration in effluent would be unknown, allowing it to slip past treatment and enter receiving waterways as well as potential air emissions or sludge residues. If the facilities don't know what they're trying to remove from the water, they are unlikely to remove it.

The end result will risk contamination of the Basins' water resources, including drinking water supplies. The only way to eliminate the outsized risk of exposing people, wildlife, and the environment to this contamination in drinking water and through other environmental pathways is to prohibit its storage, treatment, processing, disposal, and discharge in the Watershed. (Miller)

“The range of hydraulic fracturing additives is very large, and difficult to assess from a risk perspective, since the list is almost certainly incomplete, specific information on the chemicals is lacking, and the specific rate of usage is not offered. Thus, not knowing the composition of the specific additives and the amounts provides effectively no basis for estimating the risk of these components on the biota of the receiving water. A mere laundry list of these components does not meet requirements for analysis of their potential impacts. The list is so long, and the data on each component so meager, that it falls far short of an analysis of risk. Additionally, many additives used are given

proprietary trade names, and while the regulators may have information on the constituents in those products, the public does not, and thus the public cannot legitimately understand the risk of these products. Additionally, treatment of those proprietary compounds, even in a CWT, is not understood and ultimate disposal in a surface water constitutes a risk that can be avoided entirely by requiring deep well disposal in a permitted facility outside of the Basin.”^{clxxvii}

DRBC’s claim that they can address the pollutants in produced water and frack wastewater from Centralized Wastewater Treatment (CWT) Facilities by “treating” the EPA’s Table of Pollutants of Concern and by requiring that water quality standards be met for contaminants that have them, is not supported by the facts. As discussed above, there are contaminants that pose significant hazards to human health and flora and fauna, including aquatic life, that are not included in EPA’s Table; that do not have water quality standards established or other regulatory limits on exposure but have known adverse human health effects and/or ecological impacts; that do not have information developed that allows them to be used in a risk assessment; or that are kept unidentified as trade secrets by industrial operators. This is an untenable situation, much different than other wastewater that DRBC regulates, and it simply cannot be remedied by DRBC’s efforts.

In attempting to address the treatment of produced water and CWT wastewater, DRBC has left important and some of the most dangerous issues unaddressed or vaguely addressed with opportunities for substantial and long term contamination to occur, even if the methods in the draft regulations were to be followed. “The flowback and produced water

that flows back up the wells following hydraulic fracturing is heavily contaminated, primarily with the Marcellus formation contaminants. The produced brines that are released during gas production are complex and contain a variety of problematic contaminants and represent a serious chemical contamination potential.” (Miller, p. 2)

“The Commission clearly recognizes the problems with contaminants in HF waters, particularly in the non-tidal portions of the Delaware River. However, further efforts are required for understanding all of the contaminants in the flowback and produced water, their management and disposal. Four problematic components of the flowback water and produced brines include (1) the inorganic salts (including bromide), metals and metalloids, (2) the radioactive component (NORM), (3) the organic substances (from the hydrocarbon formation) and, (4) the chemical additives that increase the efficiency of gas recovery.”^{clxxviii}

The largest component in the formation water by mass is salts and other organic constituents. (Miller) Disposal of the large volume of highly contaminated water is the biggest management problem. (Miller)

“The associated EPA study (EPA, 2016) on management of HF water shows that produced waters containing the formation water are variable in chemical composition, but include not only simple salts (e.g. sodium, potassium, chloride, bromide, sulfate, fluoride etc.) but also a variety of metals with varying frequency (cadmium, mercury, cobalt, nickel) and metalloids (arsenic, selenium, boron). Some of the constituent concentrations are very high, particularly sodium chloride, which has a mean

concentration of on the order of 10% by weight. Some samples had over 30% by weight of simple salts plus other contaminants. The extreme contamination of these wastewaters, and the high variability of contaminant levels, make these waters complicated for treatment and potential reuse, as well as for tracking and disposal. If improperly managed and released to surface or groundwater, potentially severe contamination is likely. In particular, if this contaminated water intercepts domestic groundwater or surface water used as a drinking water source, the potential exists that these sources of water may need to be removed as a domestic source. While the proposed regulations effectively may not allow discharge of these waters into a surface stream that can be used as drinking water, that appears to not be the case for the more saline portions of the Basin.

While recognizing the problems with management of this water, the Commission fails to clearly state how this water will be either disposed in a manner that protects human health and the environment, or otherwise treated to remove the contaminants. While a range of alternatives potentially exist, effectively none of these is likely to be accomplished in even a centralized waste treatment facility, and simply eliminating these waters from the Basin is the prudent alternative.”^{clxxix}

One of the most difficult constituents to treat in Pennsylvania’s fracking wastewater is bromide. (Miller) PADEP acknowledges that bromide is a key parameter of concern in the effluent because it can form brominated disinfection by-products (DBP’s) in water

supplies.^{clxxx} These are a drinking water hazard because of the propensity for the brominated DBP's to form trihalomethanes and haloacetic acid, which can cause cancer.^{clxxxii}

An example of how difficult it is to control bromides and the far-reaching effect high concentrations can have is the Monongahela River in Pennsylvania in 2010–2011. Bromide concentrations increased significantly, leading to increases in trihalomethane and haloacetic acids from mixing with drinking water supply disinfectants. This drinking water crisis affected the drinking water for millions of people in the Pittsburgh region; see “Bromide levels in Monongahela River rose in 2010, remain high” Pittsburgh Post-Gazette^{clxxxii} and “Bromide pollution persists in Allegheny River in Western Pa.,” Associated Press.^{clxxxiii}

Despite “treatment” that is supposed to remove this dangerous constituent and the problems it causes in drinking water, it persists as a problem. The result is that carcinogens have entered people’s drinking water and preventing this exposure is not consistently achieved by today’s water treatment facilities. This problem is so risky and could expose so many people to carcinogenic substances that DRBC should prohibit fracking wastewater to enter the Basin. Miller states:

“A particular constituent that has been problematic in Pennsylvania waters receiving partially treated hydraulic fracturing water is bromide. When water is taken in to be treated as a drinking water, normal disinfection processes (chlorine and chloramine) convert bromide ion to bromide radical, which reacts with naturally occurring organic matter to produce the probable carcinogenic brominated trihalomethanes (THM).

Because of the higher molecular weight of the brominated trihalomethane, the drinking

water can violate drinking water for trihalomethanes (Chowdhury, et al., 2010; EPA, 2016) Use of ozone as a disinfectant can generate bromate, a known carcinogen (Fellet, 2014).”^{clxxxiv}

A highly toxic component in frack wastewater with an extremely long life is radioactive material. Yet DRBC poses no means of addressing the disposal of naturally occurring radioactive materials (NORM). (Miller)

“The Commission also certainly recognizes the issues associated with management of NORM that comes to the surface either in the flowback or the production brines. However, similar to the salt problem discussed above, no indication on how treatment to remove these materials will be conducted.

Examples of NORM concentrations are presented from flowback in the EPA study (EPA, 2016).

The level of radioactivity as gross alpha is very high, from about 18,000 pCi /L to 123,000 pCi/L. The drinking water standard is 15 pCi/L (gross alpha).

What is to be done with these waters, and what is to be done with the residual NORM, if it is removed from the produced water and the flowback water? Dilution of the brines to a drinking standard of 15 pCi/L (gross alpha) will require 1000x to 10,000x dilutions, and is unlikely to be acceptable in nearly all jurisdictions, particularly when the components that are causing the radioactivity are not specified.

Ultimately, these radioactive materials will need to be removed offsite. Where will these radioactive materials be disposed, and will they be included with the very large

tonnage of salts that results from an evaporation-crystallization treatment, or will they be separated into a metal/radioactive fraction by some (unknown?) chemical precipitation process? These issues are critical for an analysis of the potential impacts of management of these materials, and the lack of a thorough analysis presents a serious problem when assessing the risk of these substances. There is effectively no discussion of how these materials will be disposed, other than a general suggestion that they would be “treated” in a centralized treatment facility. In fact, there is no demonstrated economic and chemically efficient method for disposal of these wastes which is why most of this waste is transported to a deep well disposal site.”^{clxxxv}

It is well known and long understood that the Marcellus Shale formation is radioactive.^{clxxxvi} USGS investigated and verified high concentrations of uranium in the Marcellus. (Marvin Resnikoff, “Memorandum, DRBC Draft Regulation Comments”, Radioactive Waste Management Associates, February 19, 2018) The naturally occurring radioactive material (NORM) found in frack wastewater is unavoidable - it is released through the fracking process into the flowback that comes back to the surface through the well bore as a result of a fracking event. (Resnikoff)

One of the most commonly found in frack wastewater is Radium-226, which has a half-life of 1,600 years, so it will be present in the environment for thousands of years.^{clxxxvii} It is also water soluble, meaning it easily travels with water.^{clxxxviii} Radium 228 and other decay products of uranium are also found in the Marcellus and its waste products. (Resnikoff)

New York State sampled and verified the presence of Gross Alpha, Gross Beta, and Total Alpha Radium in addition to Radium 226 and 228.^{clxxxix} A Duke University study of a stream in Pennsylvania below a frack wastewater plant found radium 226 levels in stream sediments at the point of discharge were ~200 times greater (544–8759 Bq/kg) than upstream sediments and background sediments (22–44 Bq/kg) and above radioactive waste disposal threshold regulations.^{cx}

Interstitial or formation water (the brine in the shale formation) can be highly radioactive (as concentrated as 15,000 pCi/L), so each time the water is reused, the radium is concentrated. This will result in TENORM, or Technically Enhanced Naturally Occurring Radioactive Materials.^{cxci} Frack wastewater containing TENORM is not properly regulated by the federal government or the states due to lack of requirements for monitoring/testing for TENORM at crucial junctures in the waste stream where it should be targeted for detection and removal. For instance, the concentrated residuals that are filtered from wastewater at treatment plants can occur at levels that are so dangerous they would need to be removed to a specially designed storage facility, such as those used for nuclear waste.

DRBC states in the proposed regulations that residuals from wastewater treatment should not be affected by the treatment process but radioactive properties inevitably pose a treatment challenge that will affect both the waste liquids and solids, including residuals; the radioactivity doesn't just disappear. (Resnikoff) In addition, the lack of testing at the well site and related lack of truck signage (“placarding”) that accurately reflects the level of radioactivity of the wastewater that is transported^{cxcii} adds great risk to the transport of the

untreated, toxic produced water or flowback from wells outside of the Basin to the Delaware River Watershed for storage, treatment and disposal.

One of the most important distinguishing problems with produced water and CWT water produced by fracking is that it contains toxic concentrations of radioactive materials that cannot be destroyed. The result is that by attempting to set standards for its treatment in the Delaware River Basin, DRBC is not controlling its release or its effects on human health and the environment but is allowing it to enter the Watershed and its drinking water at concentrations DRBC has decided are acceptable. The radioactive materials can be released as flowback, as treated effluent from a CWT plant, in drill cuttings and other solids, in residues that result from processing or treatment, and as an inert gas, radon, which is the second highest cause of lung cancer in the United States. (Resnikoff)

This is far too great a risk for DRBC to take. This potent toxicity and long lived properties of radioactive materials alone is reason enough to prohibit frack wastewater from entering the Watershed's environment. In the SPW portions of the River, the release of radioactive elements are categorically inconsistent with the "no measureable change" requirement. (Resnikoff)

"To review, the process of hydraulic fracturing consists of drilling a well down to the Marcellus shale formation 4000 to 8000 feet below ground and then extending the well horizontally in the shale formation for up to a mile. Casings are constructed and the wells are placed under hydraulic pressure. Explosives shatter the shale formation and proppants maintain open the shattered shale formation. When the hydraulic pressure is

released much of the contaminated water, consisting of drilling fluid and interstitial water along with rock cuttings (with the consistency of coarse sand) comes to the surface. This contaminated water is stored in an adjacent pond or in tank cars. After approximately two weeks' time, natural gas continues to come up with some of the remaining water. This salty water (brine) is highly radioactive and is separated from natural gas at the surface and placed into condensate tanks or trucks. This produced water or brine contains high concentrations of total dissolved solids (TDS). As shown in the table below, the TDS concentrations increase over time. The TDS concentrations can range up to 345,000 mg/L by day 90 after the well is placed into production. At the present time flowback and production water is transported to a centralized water treatment facility (CWT). After processing, the rock cuttings and sludge are disposed in sanitary landfills and processed water is released to the environment. Under the proposed regulations the rock cuttings, sludges and processed water can be transported to the Delaware River basin and may be released to accessible waterways. The proposed DRBC regulations do not prohibit disposal of rock cuttings into landfills within the basin.

It has been known for over 50 years that the Marcellus shale formation is radioactive. In the late 1970s the USGS investigated the Marcellus shale for high concentrations of uranium. So clearly what is radioactive below ground does not become non-radioactive above ground; this is not alchemy where the radioactivity simply disappears. This radioactivity, consisting of radium-226 and 228 and decay products, is a problem faced

by the DRBC in establishing regulations. Because all this radioactivity must go somewhere, the DRBC is essentially establishing regulations that set the radioactive concentrations that can enter the environment within the Delaware River Watershed.

We support some sections of the proposed regulations. We support section 440.3 which prohibits fracking within the Delaware River basin. This is important, not only for the potential release of drilling fluids and contaminated water into aquifers but also for minimizing the potential release of the radioactive inert gas radon. We also support the policy of the commission, section 440.5, that there be no measurable change in existing water quality and that the release should not create a menace to public health and safety at the point of discharge. Based on this policy, it is inconsistent that the commission will allow produced water and wastewater from central waste treatment facilities, even under regulated conditions.”^{cxiii}

The removal of radioactive elements from flowback and produced water is difficult and poorly carried out by treatment facilities today. DRBC presents no method for doing this in the draft regulations. (Resnikoff) Also, DRBC’s stated goal of meeting drinking water standards for the discharged effluent from CWTs is essentially not practically achievable; the safe drinking water standard for combined radium 226 and 228 is 5pCi/L. (Resnikoff) Concentrations as high as 25,000 pCi per liter can be contained in produced water generated by fracking in the Marcellus Shale. (Resnikoff)

“Centralized waste treatment facilities are not a panacea. Studies by the Pennsylvania Department of Radiation Protection show that concentrations of dissolved radium that

enter a CWT are approximately equal to concentrations that leave a CWT¹ (Though there are methods for removing radium from water - methods have been used extensively in uranium mills), the process is more expensive than simply releasing this contamination to the environment or into a deep well. Even if CWT's were effective, what would be the final disposal solution for sludges and solids that were created? Essentially the radium dissolved in water would be converted to a solid that can be filtered. And what would be the final disposal solution for the rock cuttings? The radioactive content of the rock cuttings ranges from 30 pCi per gram to 204 pCi per gram (the radioactive concentration of rock cuttings that were sent to the Allied landfill in Niagara County New York)². Released to waterways, Duke University scientists have measured radium concentrations and stream sediments at the point of discharge 200 times greater than upstream and background sediments and above radioactive waste disposal threshold regulations. So we are mystified by what the commission is going to find in these treatability studies required in section 440.5.”^{cxciv}

“The commission also states that effluent shall not exceed the more stringent of EPA or the host states primary drinking water standards. For combined radium 226 and 228, the drinking water standard is 5 pCi per liter. Produced water can contain concentrations up to 25,000 pCi per liter. It will be difficult to reach concentrations as low as 5 pCi/L.”^{cxcv}

¹ The DEP study showed that high Ra-226 effluent releases from CWT's were 26,000 pCi/L (DEP,ES-22) equal to the high Ra-226 concentrations into the CWT's and indicating that Ra-226 was not removed at the CWT's.

² NYSDEC, Division of Environmental Remediation, August 2012, re. Allied Landfill, Niagara County.

The release of produced water and CWT wastewater produced by fracking into the waters of the Delaware River Basin will release radioactive materials. Even if discharged at established drinking water standards, radioactive materials can build up over time in the environment, as is shown by scientific literature and reported data. Furthermore, since the Estuary and Bay portions of the Basin are not designated as drinking water supply, these radioactive materials can be discharged at any level set by DRBC in docket. The public will be inevitably exposed to increased concentrations of radioactive elements over the current backgrounds. This could happen with one discharge to the air or water or it could happen as radioactivity accumulates in sediments or other environmental features in the Watershed. This exposure of the public to radioactive materials will result in an increased risk of cancer.^{cxcvi} The only way to avoid this inevitable health risk is to prohibit produced water and wastewater from fracking to be stored, treated and/or discharged in the Watershed.

Resnikoff states:

“While I support the Delaware River Basin Commission’s (DRBC) prohibition on high-volume hydraulic fracturing (fracking), I do not support the proposed regulations of Part 440 that allow the import of radioactive waste and solids from fracking into the basin. To be clear, the oil and gas industry has a problem in disposing of fracking water and rock cuttings. To frack a well, approximately 5 to more than 11 million gallons of water are required; in 2017 the average volume of water used to frack a Marcellus Shale well in Pennsylvania was 11.4 million gallons. That is primarily because of the longer well bores, increased now from 1 - 2 miles to 4 miles or more in some areas. Some of this

drilling fluid can be recycled. But there are not enough deep disposal wells to accommodate the demand for the volume of fracking water produced. As a result, the oil and gas industry has pressured the DRBC to accept this contaminated water. Under Parts 400 the DRBC has proposed regulations for the acceptance of water from fracking and placed conditions on that acceptance. Just to be clear the DRBC could simply ban the importation of fracking water and rock cuttings, but instead have established regulations that allow that to proceed. The following specific comments are in support of some of the regulations DRBC has proposed and opposes others.

We support the commission's policy of no measurable change in existing water quality. But we strongly oppose approving centralized water treatment facilities.”^{cxcvii}

Hydrocarbons are contained in flowback and produced water from fracking. But they are only part of the known components such as heterocyclic amines and sulfur containing compounds and the array of unknown compounds that are routinely produced. Without knowing all components, effective treatment can't be achieved. The safe option is to prohibit the discharge to surface waters of the wastewater produced by fracking.

“Hydrocarbons present in the flowback and produced water are characteristic of fuel hydrocarbons, and are represented by (a) compounds that, in some cases, are carcinogenic (e.g. benzene, benzo(a)pyrene), (b) common solvents (e.g. toluene, ethylbenzene), and (c) the primary fuel components of natural gas, particularly methane. But, these components are only part of the mix that is contained in fracking water. Other components include heterocyclic amines, sulfur (odor) containing compounds,

and an array of unknown compounds that have not yet been identified from specific wells. The characterization of these constituents before and after treatment has not been completed. Without knowing what these chemicals are, and the toxicity of each of them, it is difficult to know how to treat them. The associated risk is primarily ecological, and, again, simply eliminating discharge of HF waters is the safe option.”^{xcviii}

The draft regulations are written to allow discharges of produced water from fracking and CWT wastewater to be discharged under certain conditions. For the tidal zones of the Delaware River, there are several loopholes built into the regulations that will allow the standards that are mentioned for certain contaminants to be used as goals or guidelines and not as enforceable standards. Because the application of much of the protective measures do not apply in the Estuary where drinking water is not a protected use and because mixing zones are allowed in the Estuary and Bay, these regions of the River are open to degradation of water quality, increased concentration of toxics and emerging pollutants, and the destruction of aquatic life and species that are already at great risk due to other stresses and conditions ongoing in this part of the Basin.

This is true for contaminants that would be controlled based on Background Concentrations as well. DRBC proposes, in certain circumstances, to use the “background concentration” of a pollutant, or the measurement of the existing level of a pollutant in a waterway, as the amount that a discharger of effluent must not exceed. This could protect a part of the river where there is no or a very low concentration of a given contaminant but

where there are already high concentrations of a pollutant, the waterway will, effectively, be doomed to maintaining that concentration of a pollutant if the effluent discharged simply meets the background; the waterway won't have a chance to become cleaner. In the Estuary parameters such as Total Dissolved Solids and some toxics already far exceed healthy conditions and are in need of improvement.

DRBC and the states, under federal EPA regulatory requirements such as the Clean Water Act, work regularly on plans to minimize pollution and billions of public and private funds have been spent to implement pollutant minimization plans and total maximum discharge limits (TMDL) to restore healthy water quality. The background concentration method undermines those efforts, both in current DRBC permitting practices and as proposed in the Draft Regulations. Fracking wastewater discharges that meet background concentrations in already contaminated waters, will spell doom for water quality and could harm aquatic life. The DRBC should completely prohibit the discharge of wastewater produced by fracking.

Another problem is that DRBC says they have not yet developed the analytical methods, method detection limits, and quantification limits that a discharger must use to define the background concentration of a pollutant so there is no certainty about its accuracy or reliability. This is another compelling reason not to move ahead with the draft regulation.

DRN opposes the Total Dissolved Solids (TDS) standard in the draft regulations. TDS is extremely high in frack wastewater and constitutes, by sheer mass, the largest pollutant. TDS contains potent salts that must be kept below strict levels to protect water

quality and aquatic life. (Miller) In such huge amounts, TDS is very difficult to keep under control. (Miller) DRBC proposes a limit of 500 mg/l of TDS, or not to exceed background, for zones of the river as far south as River Mile 95, located roughly at the southern part of the Philadelphia region. However, 500 mg/l is not protective of aquatic life. For instance, 350 mg/l TDS reduced spawning of Striped bass (*Morone saxatilis*) in the San Francisco Bay-Delta region, and concentrations below 200 mg/l promoted even healthier spawning conditions for fish.^{ccix} And in the Truckee River, the EPA found that juvenile Lahontan cutthroat trout were subject to higher mortality when exposed to thermal pollution stress combined with high total dissolved solids concentrations.^{cc}

DRN opposes the standards and methods proposed in the Draft Regulations regarding TDS in the Estuary and Bay. In Zones 4 to 6,^{cci} encompassing most of the Estuary south to the Bay and Ocean, DRBC is allowing a TDS standard of “not to exceed 1,000 mg/l” “or a concentration established by the Commission that is compatible with designated water uses and stream quality objectives”. There is too much discretion given to the agency to establish the concentration and 1000 mg/l has been shown to not sufficiently protect aquatic life, as discussed above. It is not possible for DRN or the public to comment on a concentration that is unknown and proposed to be decided by DRBC on a case by case basis. Furthermore, DRBC has not committed to monitoring and reporting of numeric effluent limits; in the draft regulations, this essential oversight tool only “may” be required. These regulations should be withdrawn as incomplete as well as not protective of water quality and aquatic life.

The record of how DRBC currently calculates and sets TDS concentrations for dockets is instructive. This practice by DRBC is not reliable or protective, as shown by variances allowed by DRBC for TDS loadings from wastewater into these areas now. DRBC even has a form that a discharger fills out to explain why they can't meet TDS limits and why they need a mixing zone – it is that customary a practice. Examples of specific approvals for permits where DRBC has been lax in applying TDS limits are Global Advanced Metals Industrial Wastewater Treatment Facility, Schuylkill River, Perkiomen Creek, Swamp Creek, PA^{ccii} (TDS of 15,000 mg/l) and JBS Souderton Industrial Wastewater Treatment Facility for a meat packing plant, Schuylkill River, Perkiomen Creek, Skippack Creek, PA^{cciii} (TDS of 3,100mg/l).

Even when it is known that a discharger could not possibly meet required standards throughout the year due to high levels of pollution in the wastewater, DRBC currently bends the rules by allowing open lagoons to temporarily store wastewater that at certain times cannot be discharged due to conditions in the receiving waterway, such as low flows. So not only are the regulations not strict enough but DRBC already goes around the rules and allows TDS to contaminate the Estuary at damaging concentrations. To add new sources of these damaging salts is not acceptable and cannot be allowed. The only way to protect water quality, fish, other aquatic life and wildlife is to prohibit discharges of wastewater from fracking throughout the Basin.

DRBC allows broad discretion by allowing mixing zones and employing a non-standard such as “or a concentration established by the Commission that is compatible with

designated water uses and stream quality objectives”. (Miller) Considering that existing discharges already provide sources of contaminants that stress the quality of the Estuary, organic compounds and radioactive elements can provide unacceptable risks to species and the ecosystems of the Basin. (Miller) Miller states:

“From my read of the proposed regulations, it appears that disposal of HF waste water will be effectively prohibited through even a centralized water treatment (CWT) facility in areas where the receiving water can potentially be a drinking water, and in the areas designated as Special Protection Waters. With a TDS limit of 500 mg/L limit, the salt load in these HF waters would effectively preclude any reasonable treatment (other than a membrane treatment) for discharge.

However, on a closer reading this may not be the case for the tidal waters that have a higher TDS limit. The language in the 440.5(f) section contain words that allow a broad discretion on whether a facility can be sited in the saltier sections of the River, with discretionary terms such as “mixing zone” or “or a concentration established by the Commission that is compatible with designated water uses and stream quality objects”. Existing discharges to the lower portion of the basin, from POTW and other industrial discharges already provide a source of contaminants that are of concern. While the Delaware River water quality has improved through dedicated efforts of the Commission, the lower stretch of the Delaware River Basin already receives discharges from other industries. While a pure sodium chloride discharge may not have a major negative impact on the biota of the Basin, the other constituents in HF water, including

organic compounds and the radioactivity can still provide an unacceptable risk to the ecological integrity of the Basin.”^{cciv}

In the Estuary drinking water is not a protected use, so safe drinking water standards don't apply, allowing less strict pollution controls. DRBC also allows “mixing zones” there, allowing pollution in wastewater that doesn't meet clean water standards to be mixed, or diluted by the waterway, before meeting a required standard. Allowing this practice with the highly toxic wastewater produced by fracking jeopardizes species that live there, including threatened and endangered species that are already under great stress and important forage fish.

This is harmful specifically for this region, affecting the Estuary resources of Pennsylvania, New Jersey and Delaware, threatening all life in these zones of the Estuary and Bay. And since the tides carry pollutants, including increased salinity, upstream and into tributaries, areas that do provide drinking water (including the State of Delaware's tributary drinking water intakes, and Philadelphia and south Jersey drinking water intakes serving millions of people) and upstream river zones that are tidally influenced will all be negatively impacted to some degree. Risking the viability of species and water quality is a chance too great to take; the discharge of wastewater from fracking should be prohibited altogether.

Whole Effluent Toxicity (WET) testing is relied upon in DRBC's draft regulations as a method that will assure that effluent is not toxic. But WET testing is not a panacea. It should only be the first stage in a risk assessment; WET testing identifies a hazard(s), not

how much risk is associated with that hazard. WET testing used to assess the effect of all pollutants in a facility's effluent is not conclusive.^{ccv} DRBC should not rely on WET testing to predict toxic effects. As discussed earlier in this comment, many of the chemicals, including some with known adverse human health effects, used in fracking fluids do not have enough known about them to allow them to meet the requirements of EPA to be tested through a risk assessment and some are kept confidential as Trade Secrets. WET testing faces similar limits when chemicals are not disclosed or when the chemical's properties are not fully understood or known. This is a flawed approach that cannot be trusted when applied to frack wastewater, providing another reason why frack wastewater must be prohibited to prevent water resource damage.

It is unclear how treatment would be accomplished because DRBC does not propose treatment options. Discharging CWT wastewater to the surface waters of the Basin without causing significant contamination that threatens the drinking water and the Watershed's water resources throughout the Basin and without causing measurable negative change in the nontidal River, is not a viable option. This is especially true considering economic cost and partial administration of such a program. (Miller) Miller states:

“Permissible treatment of the flowback and the produced water is not well defined. It is unclear how the post-treatment residual salts and radioactivity will be managed. There does not appear to be any complete treatment of these waters that will allow discharge of the water in any surface water of the Delaware River Basin.

In my opinion, there are no treatment options that can remove the contaminants in a cost effective manner, and suggest that until such a process is developed, discharge of HF water should simply be banned within the basin to avoid the unreasonable risk of the contamination and loss of drinking water resources. This is particularly the case for drinking water sources, but also for lower basin waters, primarily associated with ecological risk. Some of the membrane processes (e.g. reverse osmosis, nanofiltration) may meet the standards in some cases for a portion of the water, although the reject water will still need to be disposed out of the basin and will contain higher concentrations of all of the contaminants. Effectively, there is no reasonable cost alternative to simply transporting the HF waters to regions where deep well disposal is permitted, which is the way those waters are being managed to date.

The methods for treatment of the water for discharge to a surface water are not considered, and how specific requirements for discharge could be met by various treatment processes (e.g. membrane, ion exchange or evaporative processes) are not mentioned. The residual contaminants removed by evaporative or membrane processes, and thus concentrated to form even more contaminated water, were not discussed, other than to indicate that the residual salts, or concentrated brine will require “further treatment or disposal”. For flowback or brine containing 7% (70,000 mg/L) salts, upwards of 300 tons of salts will exist in every million gallons of water, plus the concentrated NORM as well as a portion of the hydrocarbons. The source of the alpha emitters also will need to be identified. If, as is suspected, polonium is present in the

flowback water, it represents an additional management burden of the flowback and produced water.

The best option is simply to prohibit storage or treatment of HF water in the Delaware River Basin entirely.”^{ccvi}

No federal standards have been issued to guide DRBC on the design and regulation of the treatment of wastewater produced by fracking. DRBC attempts to fill that void but fails to do so. The wastewaters produced by fracking are complex and variable, to the extreme of each truckload produced at a frack site varying from other truckloads due to the uncontrollable nature of the fluids injected and released by the deep geologic formations. Chemicals are injected by drillers that are protected as Trade Secrets and, in Pennsylvania we know this has prevented the disclosure of the contents of these fluids, which are also found in the wastewater or produced water that fracking generates.

These complexities and unknowns make the wastewater unpredictable while also being highly toxic and dangerous to human health and the environment. This is fundamentally different than other types of wastewater for which DRBC now issues dockets. It is not reasonable to expect any agency to perform the vigilance needed to handle this waste. The means of control are prohibition, to “remove the option of disposal”. (Miller)

“I have examined many of the chemical and toxicological issues, particularly related to potential treatment and discharge into the Delaware River Basin of waters associated with hydraulic fracturing, primarily produced and flowback (formation) water. This issue has confronted the Delaware River Basin Commission for several years now, and

I appreciate the thought that has gone into these regulations. I feel strongly that, due to the chemical complexity of these highly contaminated waters, the best solution is to simply remove the option of disposal of any hydraulic fracture (HF) associated waters to any surface water in the Delaware Basin. The areas of the river designated by the Commission as Special Protection Waters (the nontidal river) cannot maintain adopted or proposed water quality standards nor meet the “No measurable change” requirement enforced by the Commission if the waters produced by hydraulic fracturing are discharged to the Basin’s waterways, particularly if the HF waters are not treated to remove metals, salts and norm. The region below Philadelphia already receives a variety of discharges, and potentially adding a major load of a complicated array of contaminants from HF water should simply be prohibited.”^{ccvii}

The importation, treatment and discharge of produced water from fracking is contrary to the DRBC’s stated goals of protection of water resources and the health of aquatic life and the public. The management challenges are not sufficiently met or assessed by the proposed regulations. (Parasiewicz) The methods of defining background concentrations for contaminants and the characterization of all contaminants in the wastewater stream are not developed or explained in the regulations. (Parasiewicz) Freshwater mussels such as the federally endangered dwarf wedgemussel are water filtering organisms that may be vulnerable to the toxic substances in CWT wastewater or produced water through long-term bioaccumulation but this is not addressed and must be. (Parasiewicz)

The cumulative impacts on species, habitats and water quality is not planned for but must be. The possible development of storage basins or tanks within the Watershed of highly toxic materials that cannot be sufficiently processed to meet discharge permit standards is not assessed or addressed in terms of management to avoid leaks, accidents, and spills of untreated produced water, concentrated residuals, or contaminated fluids and must be. (Parasiewicz)

It is documented in DRBC records that DRBC does already allow open lagoons and/or tanks within the Basin to temporarily hold materials too polluted to discharge into surface water due to conditions such as low flow; these dangerous materials that do not meet water quality standards for discharge are stored until they can be worked into the treatment system, risking accidental exposure to the environment and air emissions that could be harmful.

The obvious dangers of transport, accidental leaks and spills, and the inducement of development of HVHF in proximity to the Watershed by allowing the fracking-related activities of wastewater importation and water exportation, threatening additional impacts to the Basin, is not examined but must be. (Parasiewicz) Parasiewicz states:

“Despite the requirement of alternatives analysis this proposition is also in contrast with the declaration of protection of public health and aquatic life, because:

- a. Many of the toxic substances occurring in the produced water of Marcellus Shale require special treatment with expensive technologies.
- b. Safe concentration of some of these substances (total dissolved solids, barium, bromide, radium and strontium) are not yet regulated and

treatability studies are still required even to characterize the pollutant loads in the produced water.

- c. The long term bioaccumulation effects of these substances on biota is not well known. Water filtering organisms such as freshwater mussels may be particularly vulnerable to such toxic substances.
- d. Similarly background concentrations that are required to be maintained according to the rule are yet to be determined.
- e. Due to the fact that the produced water dissolves substances from target rock formation, it is conceivable that their concentration as well as their chemical composition may vary uncontrollably potentially exceeding the capacity of the treatment plant. Attempting to mitigate that would require toxic storage reservoirs with all associated and unacceptable risks of accidental breaching or leaching.
- f. Transportation and handling of such substances is prone to accidental leaks, which are very difficult to control and account for.
- g. It encourages the development of HVHF operations in the proximity of the Delaware Watershed with all the consequences described above.”^{ccviii}

Addressing what to do with all the waste produced by modern day fracking has been a formidable challenge. The trend in the increased volume of water used and, in turn, the increased volume of wastewater produced and discharged by fracking is making the challenge even more difficult. It has been consistently documented by agencies that

unconventional wells (defined by geologic formation depth by PADEP; essentially these are shale gas wells that use HVHF) use more water than conventional wells (drilled into shallower depth rock formations as defined by PADEP), as illustrated by a comparison of waste generated in Pennsylvania. (FracTracker)

The number of conventional wells outnumber the unconventional wells by 3 to 1 in 2016-2017 but the cumulative volume of liquid waste produced by unconventional wells was more than 10 times than that of conventional wells. (FracTracker) Statistics from PADEP Oil and Gas Production Reports show the amounts in millions of barrels. (FracTracker Figure 4 and Tables 2 and 3) Solid waste in tons is also documented; 93% is disposed at landfills. (FracTracker, Table 4) Matt Kelso of FracTracker states:

“Dealing with such large quantities of liquid waste has been problematic in Pennsylvania in recent years. Originally, much of this liquid O&G waste was treated in publicly owned treatment facilities, but due to rising contaminant levels in the rivers, the Pennsylvania DEP requested a voluntary cessation of the practice in April 2011, a move that was later made compulsory. However, other surface treatment facilities were not affected by this decision.

Many other states rely heavily on oil and gas wastewater disposal wells to avoid surface treatment. This practice has created a number of problems as well, however, including aquifer contamination and induced seismic activity. In Pennsylvania, much of the geology has been deemed unsuitable for underground injection, although there are recent efforts to expand this program¹⁶ due to the immense volume of liquid waste now

being generated by the industry. In March 2018, the US Environmental Protection Agencies issued permits for two more of these disposal wells, including facilities in Allegheny and Elk counties. The industry does try to reuse some of this produced fluid, but there are limits to what they can do in that regard.

Solid waste disposal is also a concern for water quality, as there is the potential for toxic, radioactive contaminants such as Radium-226 to enter the water cycle via landfill leachate. Landfills in Pennsylvania have monthly radiation quotas, the limits of which were reached 87 times in 2015 due to oil and gas waste.”^{ccix}

The Delaware River Basin already receives some waste generated by unconventional oil and gas wells in Pennsylvania. These facilities are located in Reading, Berks County; Hatfield, Montgomery County; and Myerstown, Lebanon County. (FracTracker) While the definitions of liquid and solid wastes are blurred due to the nature of these wastes that can vary from liquids, to sludge material, to loose solids, to dry cake, and the descriptive terminology is not consistent in reporting, it is important to document that some produced wastewater or solid waste is being handled and processed within the Basin now. (FracTracker, Figure 5 and Table 5.)

The pressure to dispose of waste from the rest of Pennsylvania is already occurring within the Basin and can be expected to expand if the draft regulations are adopted, providing the road map drillers need to find much needed new locations for disposal of the enormous volumes of waste being generated by fracking in the Commonwealth. Matt Kelso of FracTracker states:

“Although just a small fraction of the statewide O&G waste management picture, the waste accepted by facilities in the Delaware River Basin is significant, especially the more than 34,000 tons of drill cuttings disposed of at the Republic Environmental Systems facility. With waste haulers being willing to drive as far as Michigan to dispose of some Pennsylvania’s waste, the economic pressure of finding closer destinations is likely considerable.”^{ccx}

The pressure to find locations for wastewater from fracking will grow as shale gas wells are drilled and fracked. The 45,000 wells that are forecasted to be drilled in the Interior Marcellus by 2045 will require even more water than prior projections expected due to the dramatic increase in the volume of water used per fracked well, as discussed earlier, and it will also translate into much larger volumes of wastewater (and solids) that must be disposed of. (FracTracker) “In an industry expecting to drill roughly 45,000 more wells just in the Interior Marcellus Formation of PA through 2045, the pressure to find new water sources and waste disposal sites will be ongoing in the coming decades, including within the Delaware River Basin. This will require over half a trillion gallons of water to stimulate, assuming that the per-well water consumption does not continue to increase beyond 2017 figures. If waste figures also hold steady, we will see 1.4 billion barrels (60 billion gallons) of toxic liquid waste and 28.5 million tons of solid waste that will need to be processed in the coming years.”^{ccxi} (FracTracker) Considering the advances in well boring technology and equipment, the volumes could reasonably be expected to increase to even greater levels. Matt Kelso of FracTracker states:

“The de facto moratorium on unconventional oil and gas development put in place by the Delaware River Basin Commission has afforded the region significant protections from serious impacts in recent years that the Susquehanna River Basin and Ohio River Basins have not been provided. Through 2017, the oil and gas industry in PA drilled 10,652 unconventional wells; caused 7,956 incidents receiving violations. In 2017 alone, the industry required over 6 billion gallons of fresh water in Pennsylvania and generated 53 million barrels (2.2 billion gallons) of liquid waste and 1.1 million tons (2.1 billion pounds) of solid waste, despite being a relatively light year in terms of the total number of wells drilled.

With its proposed ban as written, the Delaware River Basin Commission looks to protect the basin from the direct impacts of drilling, but if the ancillary industries of water withdrawals and waste disposal are permitted, such activities will have an adverse effect on the waters within the basin.

In an industry expecting to drill roughly 45,000 more wells just in the Interior Marcellus Formation of PA through 2045, the pressure to find new water sources and waste disposal sites will be ongoing in the coming decades, including within the Delaware River Basin. This will require over half a trillion gallons of water to stimulate, assuming that the per-well water consumption does not continue to increase beyond 2017 figures. If waste figures also hold steady, we will see 1.4 billion barrels (60 billion gallons) of toxic liquid waste and 28.5 million tons of solid waste that will need to be processed in the coming years. The actual figure is likely to be much more than that, however, as the

current waste figures are based on the output of just 8,000 wells – if the industry drills 45,000 more, there will likely be times where there are tens of thousands of active unconventional wells generating immense volumes of waste simultaneously.

We expect substantial pressure will be placed on the basin to help shoulder the burdens of O&G water withdrawals and waste disposal in the coming decades. By ignoring these ancillary industries in its proposed ban of unconventional drilling, the Delaware River Basin Commission is taking a half-measure towards protecting the waters in its jurisdiction from substantial impacts in the years ahead.”^{ccxii}

Comment on Proposed Revision to Section 18 CFR 401.35(a) and (b) Classification of projects for review under Section 3.8 of the Compact

Section 401.35 (a) currently reads: “Except as the Commission may specially direct by notice to the project owner or sponsor, or as a state or federal agency may refer under paragraph (c) of this section, a project in any of the following classifications will be deemed not to have a substantial effect on the water resources of the basin and is not required to be submitted under Section 3.8 of the Compact:”

Section 18 CFR 401.35(a) (15)

DRN recommends changes to the proposed text at Section 18 CFR 401.35(a) (15) which reads: “Draining, filling, or otherwise altering marshes or wetlands when the area affected is less than 25 acres; provided; however, that areas less than 25 acres shall be subject to Commission review and action where neither state nor a federal level review and permit system is in effect”.

DRN recommends: “All alterations to wetlands or marshes, including areas less than 25 acres, and regardless of whether a state or a federal level review and permit system is in effect, shall be subject to Commission review and action”.

DRN considers DRBC to have more local and immediate information, data, and knowledge of wetlands than the state or federal agencies. Even though DRBC does not currently have detailed maps of all wetlands within the Basin, this research can be carried out more thoroughly under DRBC than under the more distant agencies that have less data and local knowledge on wetlands and marshes within the Basin. DRN considers DRBC to have the potential for more comprehensive and accurate assessment of proposed disturbances in wetlands and marshes within the Basin than state or federal agencies and therefore supports DRBC review of these activities.

DRN does not consider the 25 acre threshold for review that is currently in place and used as a threshold in the Draft Regulations to be scientifically-based. There is no justification that DRBC has produced to support the arbitrary threshold of 25 acres. DRN objects to 25 acres being used as a threshold for substantial impact.

Wetlands are located throughout the Delaware River Watershed and constitute a critical natural feature and a keystone ecosystem. Wetlands are sensitive to development activities and are documented to have been degraded by oil and gas development. Thorough and comprehensive oversight and review of all disturbance of wetlands and marshes is required to provide needed protection for the integrity of these ecosystems and the water resources of the Basin.

Miller states that “Wetlands are among the most threatened ecosystems on the planet. They are degraded and converted to human uses more rapidly than any other ecosystem, and the status of freshwater species is deteriorating faster than any other species. Since wetlands are essentially characterized by hydrologic conditions, changes in water volumes and timing of flows are major threats, as are discharges of various pollutants.”^{ccxiii}

Section 18 CFR 401.35(a) (18)

DRN recommends a change in the text at Section 18 CFR 401.35(a) (18) which is proposed in the Draft Regulations as: “Except as provided at 18 CFR401.35(b) (18), the diversion or transfer of wastewater into the Delaware River basin (importation) whenever the design capacity is less than a daily average of 50,000 gallons”.

DRN recommends the text be changed to read: “Except as provided at 18 CFR401.35(b) (18), the diversion or transfer of wastewater into the Delaware River Basin (importation)”.

DRBC has more information about the potential impacts of wastewater, excluding wastewater produced by fracking which must be wholly prohibited, on the resources of the Basin and can potentially provide better oversight and review than the host state from where the wastewater is originating. For the myriad of reasons discussed in this Comment, the water resources of the basin are at risk of degradation by toxic discharges and should be under the jurisdiction of the DRBC no matter the volume of the wastewater.

Section 18 CFR 401.35(a) (19)

DRN recommends a change in the text at Section 18 CFR 401.35(a) (19) which is proposed in the Draft Regulations as: “To the extent allowed in the basin (see prohibition at 18 CFR440.3(b)), projects involving hydraulic fracturing, unless no state-level review and permit system is in effect;”.

DRN recommends Section 18 CFR 401.35(a) (19) be deleted and that NO hydraulic fracturing be allowed within the Basin, regardless of the state-level review and permit system that is in effect.

Considering the reasons provided in this Comment, DRN opposes all drilling and fracking for gas and oil within the Delaware River Basin.

Section 401.35 (b) currently reads: “All other projects which have or may have a substantial effect on the water resources of the basin shall be submitted to the Commission in accordance with these regulations for determination as to whether the project impairs or conflicts with the Comprehensive Plan. Among these are projects involving the following (except as provided in paragraph (a) of this section:”

Section 18 CFR 401.35(b) (14)

DRN recommends changes to Section 18 CFR 401.35(b) (14) that is proposed in Draft Regulations as: “Leachate treatment and disposal projects associated with landfills and solid waste disposal facilities in the basin”.

DRN recommends the text be changed to read: “Leachate treatment and disposal projects associated with landfills and solid waste disposal facilities in the basin, landfills and solid waste disposal facilities affecting the water resources of the basin”.

DRN agrees that leachate associated with landfills and solid waste facilities must be included in this Section because of the potential for substantial effect on the water resources of the Basin. DRN recommends the above text change based on the fact that toxic and radioactive waste generated by fracking is currently being imported to the basin, as discussed in this Comment, so it is a known threat but DRBC may not have any knowledge of this ongoing activity. DRBC cannot effectively carry out its responsibilities or implement its regulations that protect the water resources of the Basin unless it has information about the importation of wastes from fracking.

Landfills and solid waste disposal facilities are likely to continue to receive waste generated by fracking and drilling as gas development continues in the hydrocarbon bearing rock formations in the host states and beyond. We know, as discussed in this Comment, that landfill radioactivity monitors have been set off hundreds of times by drilling and fracking waste; there is no change in the radioactive properties of waste generated by fracking that has changed or can reasonably be expected to change. Therefore, the threat of radioactive and toxic materials generated by fracking will remain, requiring DRBC to have review and regulatory authority over these activities. Based on the information contained in this Comment, DRN recommends that all fracking-related waste materials be prohibited from importation, storage, processing, treatment, disposal, and discharge within the Delaware River Basin.

II. INTERSTATE COMMERCE CLAUSE DOES NOT PREVENT A BAN ON IMPORTATION, STORAGE, PROCESSING, AND DISCHARGE OF OIL AND GAS WASTEWATER

The Interstate Commerce Clause of the United States Constitution **does not** prevent the Delaware River Basin Commission (“DRBC”) from imposing a ban on the importation, storage, processing and discharge of oil and gas wastewater in the Basin. The ban would not prohibit transportation of wastewater through the Basin.

a. DRBC’s Current and Proposed Oversight of Oil and Gas Wastewater

The DRBC has described its current oversight of oil and gas wastewater as follows:

In some but not all cases, DRBC docket approvals for wastewater discharges include a condition expressly providing that the docket does not constitute an approval to import wastewater from *hydraulic fracturing activities*, and stating that if the docket holder proposes to import and treat such wastewater, it must first apply for and obtain Commission approval for this activity. Such docket conditions do not constitute a moratorium.

DRBC, FAQ - Revised Draft Rules Addressing Hydraulic Fracturing Activities within the Delaware River Basin, at p.6 (emph. added). The DRBC has proposed new regulations that would “require Commission approval for the importation into the Basin and treatment and discharge within the Basin of wastewater from hydraulically fractured oil and gas wells.” Id. at p.1.

The proposed rules would address more than simply fracking wastewater. The proposed rules deal with “produced water” and “CWT wastewater.” “Produced water” is very broad:

the water that flows out of an oil or gas well, typically including other fluids and pollutants and other substances from the

hydrocarbon-bearing strata. Produced water may contain “flowback” fluids, fracturing fluids and any chemicals injected during the stimulation process, formation water, and constituents leached from geologic formations. For purposes of §§ 401.35(b)(18) and 440.5, the term “produced water” encompasses untreated produced water, diluted produced water, and produced water mixed with other wastes.

“CWT wastewater” is “any wastewater or effluent resulting from the treatment of produced water by a CWT [centralized waste treatment facility, as defined in the proposed regulations].”

Thus, the DRBC proposes to address more than fracking wastewater, potentially affecting all oil and gas wells. At the present time, according to available data, there are almost no oil and gas wells in New York or Pennsylvania in the Basin area – unconventional or conventional.

b. Standards and Analysis

The Interstate Commerce Clause and the “Dormant Commerce Clause”

Article I, sec. 8, cl. 3 of the United States Constitution is what is known as the Interstate Commerce Clause. It states, “[The Congress shall have Power] To regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes.” Case law has developed over time to address what is known as the Dormant Commerce Clause (“DCC”), which is an implied reading of the Interstate Commerce Clause designed to prevent states from erecting barriers to or otherwise interfering with interstate commerce. “[T]he Commerce Clause is designed to eliminate protectionist restrictions on interstate trade which typically characterize international trade, such as embargoes, quotas, and

tariffs.” *Norfolk Southern Corp. v. Oberly*, 822 F.2d 388, 399 (3d Cir. 1987). Such state-versus-state provisions were common prior to the U.S. Constitution, during the period in which the Articles of Confederation governed. Id. A simple example of a protectionist restriction is a tariff that applies solely to out-of-state goods. “The Supreme Court has recognized a . . . Commerce Clause interest in federal uniformity in cases addressing state regulation of the means of interstate transportation.” Id.

The DCC was central to a number of “flow control” challenges, in which states such as New Jersey had enacted bans on importation of out-of-state waste in order to preserve in-state landfill space for in-state waste. *See, e.g., Phila. v. N.J.*, 437 U.S. 617 (1978). Such preferential treatment for in-state waste was deemed discriminatory; however, the Court of Appeals left open the option that the state could have enacted other regulations to preserve landfill space that treated in-state and out-of-state waste alike. *Norfolk Southern Corp.*, 822 F.2d at 401.

In other cases, environmental regulations blocking the importation of certain out-of-state goods have been upheld where the state was able to specifically identify with scientific evidence reasons why importation of certain goods (i.e. live baitfish) posed a threat that the state could only truly address through a ban on the out-of-state goods. Maine v. Taylor, 477 U.S. 131 (1986).

The U.S. Court of Appeals for the Third Circuit has explained:

In general terms, the Supreme Court has invalidated under the dormant Commerce Clause state laws falling into three categories:
1) laws that purposefully or arbitrarily discriminate against interstate commerce in favor of in-state interests . . . ; 2) laws that

impose incidental burdens on interstate and foreign commerce that are clearly excessive in comparison to the putative local benefits . . . ; and 3) laws that undermine the federal need for uniformity among the states in particular areas, such as foreign trade and interstate transportation.

Norfolk Southern Corp., 822 F.2d at 398.

The DCC case law is often inconsistent. At times, the line between an improper regulation and a valid one is fuzzy, particularly when determining whether a law's discriminatory effects are such that it discriminates against out-of-state entities, or whether it merely incidentally burdens interstate commerce, and thus a lower standard of scrutiny would apply.

The Third Circuit summarized three categories of cases and thus varying levels of scrutiny to apply to challenges to state regulations that purportedly affect or impair interstate commerce.

Three standards of review are applied in performing dormant Commerce Clause analysis: 1) state actions that purposefully or arbitrarily discriminate against interstate commerce or undermine uniformity in areas of particular federal importance are given heightened scrutiny; 2) legislation in areas of peculiarly strong state interest is subject to very deferential review; and 3) the remaining cases are governed by a balancing rule, under which state law is invalid only if the incidental burden on interstate commerce is clearly excessive in relation to the putative local benefits.

Id. at 398-99.

For Category 1 cases, "Discrimination against interstate commerce in favor of local business or investment is *per se* invalid, save in a narrow class of cases in which the municipality can demonstrate, under rigorous scrutiny, that it has no other means to advance

a legitimate local interest.” *C & A Carbone, Inc. v. Town of Clarkstown, NY*, 511 U.S. 383, 393 (1994)(citing *Maine v. Taylor*, 477 U.S. 131 (1986)).

Category 1-type cases are those like *Phila. v. N.J.* and *Maine v. Taylor*, in which there is a difference in treatment – whether facially or in effect – between in-state and out-of-state entities. The standard explained in Category 2 does not apply to “nondiscriminatory environmental statutes.” *Norfolk Southern Corp.*, 822 F.2d at 398, 405.

Category 3 cases involve statutes that treat in-state and out-of-state entities alike, but still impose some burden on interstate commerce. For example, in *Norfolk Southern Corp.*, the Third Circuit upheld Delaware’s ban on new industrial activity in the coastal zone. It found no difference in burden between in-state and out-of-state entities as far as being restricted from building in the coastal zone, and no burden that was excessive; this obviated the need to review the state’s conclusion that industrial activity of the type proposed would endanger the coastal zone through pollution. *Norfolk Southern Corp.*, 822 F.2d at 406-07; *see also Huron Portland Cement, Inc. v. Detroit*, 362 U.S. 440 (1960). In contrast, the U.S. Supreme Court invalidated a state law pertaining to fruit packaging that would have required an in-state entity to invest a substantial amount of money to build an in-state packing facility, rather than continuing to ship its melons to another state for packing. *Pike v. Bruce Church, Inc.*, 397 U.S. 137 (1970). It found this burden to be excessive in comparison to the state interest, which was “to protect and enhance the reputation of growers within the State.” *Id.* at 143.

The Dormant Commerce Clause Case Law Does Not Apply to the DRBC

The DCC does not apply to the DRBC because the DRBC is an interstate entity. Courts have repeatedly found that construction of an interstate compact is a question of federal law, not state law, and that compacts are to be construed in the same manner as contracts. *Tarrant Reg'l Water Dist. v. Hermann*, 569 U.S. 614, 628 (2013); *Texas v. New Mexico*, 482 U.S. 124, 128, (1987); *Cuyler v. Adams*, 449 U.S. 433, 438 (1981); *Petty v. Tenn.-Missouri Bridge Comm'n*, 359 U.S. 275, 278-79 (1959). The DRBC also has, as one of its members, the federal government, and Section 2.1 of the Compact specifically identifies the DRBC as “an agency and instrumentality of the governments of the respective signatory parties,” including the federal government. Thus, the Dormant Commerce Clause should not apply at all because there is no state entity here – it is an interstate or federal agency exercising powers beyond the boundaries of any one state.

c. Even if the Dormant Commerce Clause Applies to DRBC Actions, It Only Applies When Those Actions Are Based on State Boundaries, not Basin Boundaries

Industry may attempt to argue that the Dormant Commerce Clause applies by pointing to Section 1.4 of the Compact, which states:

Nothing in this compact shall be construed to relinquish the functions, powers or duties of the Congress of the United States with respect to the control of any navigable waters within the basin, *nor shall any provision hereof be construed in derogation of any of the constitutional powers of the Congress to regulate commerce among the states* and with foreign nations.

(emph. added); *see also* Section 15.1(s), (t). Thus, although the Compact itself is federal law, and the federal government is a member, there is also a provision stating that the

Interstate Commerce Clause still has some impact on the DRBC. However, we have not yet
Page 128 of 145

found a case challenging an interstate agency’s exercise of authority on the basis of the Dormant Commerce Clause to determine precisely what that impact would be. Practically, the federal government’s interest in and authority over the free flow of interstate commerce is protected in part by its membership on the DRBC. *Cf. W.Va. ex rel. Dyer v. Sims*, 341 U.S. 22, 26-28 (1951) (discussing the Ohio River Valley Water Sanitation Compact and that the “national interest” was safeguarded both by Congressional consent under the Compact Clause, and by the federal government’s membership in the compact agency); *see also Cuyler*, 449 U.S. at 438 (Congressional consent under the Compact Clause allows Congress to “maintain ultimate supervisory power over cooperative state action that might otherwise interfere with the full and free exercise of federal authority”).

One way to read Section 1.4 is that it provides a backstop against a majority vote of the DRBC to engage in specific actions that would interfere with or impair interstate commerce across state lines in the same fashion that state regulation is not allowed to do. For instance, if the DRBC voted to prohibit the importation of waste into New Jersey from the Pennsylvania portion of the Basin, this would be very similar to the fact pattern in *Phila. v. N.J.*, 437 U.S. 617 (1978), and would likely be found improper. Given the contentious history of water allocation between DRBC signatory states, it is possible that preventing discrimination against particular states (commerce across state boundaries, rather than basin boundaries) is one reason for the provision – to provide one more check against abuse of authority to benefit or harm certain signatory states over others.

If that is the case, that concern does not arise in regard to a ban on the importation of fracking wastewater into the Basin because it would not result in discrimination on the basis of state borders. While it is true that Pennsylvania currently has the most shale gas activity, the proposed regulation does not distinguish between shale gas and other wells. Likewise, a proposed regulation applies to brines, which can come from any type of oil or gas well regardless of whether shale gas development is allowed in the state or not. The proposed regulations are, on their face, concerned with watershed boundaries, not state boundaries. Viewed in this light, it is clear that the proposed regulations would not discriminate on the basis of state boundaries. As a result, the Category 3 standards from *Pike v. Bruce Church, Inc.* would apply, and the analysis would revolve around whether the incidental burden on commerce across signatory state lines in the Basin is clearly excessive relative to the local benefits from the wastewater ban. *Norfolk Southern Corp.*, 822 F.2d at 398-99.

As will be discussed further below, there is significant scientific evidence to support the harms associated with improperly treated produced water and CWT wastewater, and the difficulty of achieving proper treatment that justify the prohibition on bringing these types of wastewater into the Basin, including across signatory state lines. As for the incidental burden, wastewater from oil and gas operations already has to be shipped long distances because facilities capable of handling the wastewater are limited in number. Thus, prohibiting wastewater from coming into the Basin and across signatory state lines does not carry with it the same weight if the wastewater were more easily treatable in closer distances. Also, the sparse history of oil and gas development in the Basin means a far less

likely chance that anyone would even need to send wastewater into the Basin and across signatory state lines for storage, processing, treatment and discharge due to the lack of facilities.

Industry may go further to claim that the Compact language in Section 1.4 is designed to avoid in-Basin/out-of-Basin discrimination that impacts interstate commerce, as if the DRBC were itself a state, and the boundaries of the Basin were equivalent to state borders. This perspective would favor application of DCC case law to the DRBC in a way that recognizes DRBC as an interstate entity whose actions could be construed as impeding commerce flow across Basin borders. Even assuming, arguendo, that this view of Section 1.4 prevailed, it would not change the result, as explained further below.

d. Even if the Ban on Importation Based on Basin Boundaries Is Viewed as the Equivalent of a Ban that is Based on State Boundaries, It Would Still Survive Challenge

Below we apply the Category 1 and Category 3 standards to a potential DRBC oil and gas wastewater ban. For the purposes of this analysis, we assume a potential industry view that would equate “in-Basin” and “out-of-Basin” to “in-state” and “out-of-state” to apply the relevant case law.

Category 1: Differential Treatment Between In-Basin and Out-of-Basin Entities/Blocking Commerce Flow at Basin Borders and Heightened Scrutiny

When a regulation discriminates against interstate commerce (either on its face or through its effects), the burden is on the “State to demonstrate both that the statute ‘serves a legitimate local purpose,’ and that this purpose could not be served as well by available

nondiscriminatory means.” *Maine*, 477 U.S. at 138 (quoting *Hughes v. Okla.*, 441 U.S. 322, 336 (1979)). It could theoretically be argued that a ban on importation of produced water and CWT wastewater into the Basin while placing no restrictions on in-Basin produced water and CWT wastewater would trigger this level of heightened scrutiny because it facially discriminates against out-of-Basin-generated produced water and CWT wastewater.

Assuming that there is no storage, processing, treatment, and discharge of in-basin-generated produced water or CWT wastewater, the DRBC could argue that there is no discriminatory treatment because no such in-Basin activities, posing the same threats, are occurring while the out-of-Basin entities are barred from doing so (and thus, there can be no discrimination between in-Basin and out-of-Basin occurring). *Norfolk Southern Corp.*, 822 F.2d at 401-02; *Exxon Corp. v. Md.*, 437 U.S. 117, 125 (1978).

Even if the ban were to trigger the highest level of scrutiny, a DRBC ban should survive heightened scrutiny. Although heightened scrutiny has invalidated many laws, the DRBC ban situation can be distinguished from *Phila. v. N.J.*, and analogized to *Maine v. Taylor*, a case in which the local law was upheld.

First, the ban serves a “legitimate local purpose” in protecting Basin waters and the uses that rely on those waters from the well-documented impacts of poorly-treated oil and gas wastewater. Science has strongly established the harms associated with inadequately-treated oil and gas wastewater in Pennsylvania streams and rivers. This includes streams whose sediments are now radioactive due to the discharges from certain centralized waste treatment facilities, and streams whose ecology was turned to that of a saltwater

environment. Inadequately-treated oil and gas wastewater can negatively affect public drinking water supplies, in addition to harming aquatic life and changing the salinity of the aquatic environment. Protecting Basin water resources from the threat of produced water and CWT wastewater based on this science demonstrates that there is a legitimate local interest at play. In comparison, in Maine, state experts “testified that live baitfish imported into the State posed” threats of parasites and nonnative species to Maine’s wild fish and aquatic ecology, which the Court found to meet the legitimate local interest requirement. 477 U.S. at 140-41.

Second, even if one concluded that there was discrimination, protecting Basin waters and the uses they support would not be “served as well by available nondiscriminatory means.” *Maine*, 477 U.S. at 138. Although the DRBC proposed regulations seem to suggest that the DRBC thinks such means exist, the science says otherwise. For example, full disclosure of all potential pollutants requiring treatment in produced water and CWT wastewater is impossible when fracking has been employed because the industry uses undisclosed “trade secret” constituents that will be present in the wastewater. This hampers proper treatment of the wastewater, exposing Basin waters, users, and the aquatic ecology to significant uncertainties and risks. *Cf. Maine*, 477 U.S. at 148 (“Maine has a legitimate interest in guarding against imperfectly understood environmental risks, despite the possibility that they may ultimately prove to be negligible”).³

³ See also *id.* quoting the District Court’s opinion in 585 F.Supp. 393, 397 (D.Mn. 1984) (“[T]he constitutional principles underlying the commerce clause cannot be read as requiring the State of Maine to sit idly by and wait until potentially irreversible environmental damage has occurred or until the scientific
Page 133 of 145

If industry were to argue that there should be an allowance of some oil and gas wastewater (e.g. wastewater with fracking fluids in it versus others), there is no easy way to distinguish different types of oil and gas wastewater from one another except via sampling every load and determining if it should be allowed into the Basin. *Cf. Maine*, 477 U.S. at 141-42 (state experts testified to “no satisfactory way to inspect shipments of live baitfish for parasites or commingled species,” that it would be a “physical impossibility,” and that “no scientifically accepted procedures” for certifying a shipment as parasite-free “were [not] available for baitfish.”). That is a high administrative burden that the DRBC need not take on to protect the waters of the Basin from a known threat. *Cf. id.* at 147 (state not required to “develop new and unproven means of protection at uncertain cost”).⁴

Category 3: Nondiscriminatory Environmental Standards and a Balancing Test

For Category 3 cases, “the extent of the burden that will be tolerated will . . . depend on the nature of the local interest involved, and on whether it could be promoted as well with a lesser impact on interstate activities.” *Pike v. Bruce Church, Inc.*, 397 U.S. 137, 142 (1970). Because a ban can pass the stricter standard set forth above, it can pass the balancing test as well. The same evidence described above would be useful to defend the ban under this standard.

community agrees on what disease organisms are or are not dangerous before it acts to avoid such consequences.”)

⁴ In practice, a significant amount of wastewater goes to places capable of deep injection, such as Ohio, thus, wastewater generators and transporters already have a substantial burden to bear as far as transport in comparison to what the DRBC would be doing.

e. Applying the Standards to a Potential Ban If In-Basin Produced Water and CWT Wastewater Storage, Processing, Treatment, and Discharge Exists

This analysis assumes that there is no produced water or CWT wastewater being generated, processed, treated, stored, and discharged in the Basin currently. A stronger approach that would account for any such in-Basin activities that might exist or that might begin in the future would be for the DRBC to ban processing, storage, treatment and discharge of produced water and CWT wastewater *regardless of origin*, whether in-Basin or out-of-Basin. Such an approach would avoid the pitfall inherent in New Jersey's trash importation ban, which "impose[d] on out-of-state commercial interests the full burden of conserving the State's remaining landfill space." 437 U.S. at 628.

To further strengthen this approach, we recommend that the DRBC include in the definition of "produced water" the liquid fraction of otherwise-solid waste, such as drill cuttings. For instance, some loads of drill cuttings that arrive at waste facilities are highly saturated with oils and other fluids. That liquid fraction can separate out and remain in the bottom of the waste container, requiring the receiving facility to do something with that waste fluid. That waste fluid may contain brine-type material, radioactive materials, drilling mud, or other chemical constituents that need proper treatment. Other facilities may bring in wastewater, separate out the solids in the wastewater for disposal in a landfill, and return the wastewater to the operator. The DRBC's current regulations do not account for this liquid waste or these types of scenarios, even though these activities pose threats to the health of

Basin waterways that are similar to the threats posed by the other oil and gas wastewater the DRBC is proposing to regulate.

If the DRBC took the approach of banning activities regardless of the wastewater's origin, the mere fact that the majority of oil and gas wastewater would come from outside of the Basin would likely not change the fact that both in-Basin and out-of-Basin entities were subject to the same standards. 822 F.2d at 402; *Exxon Corp. v. Md.*, 437 U.S. 117, 125 (1978).⁵ Such an across-the-board ban would support the conclusion that the ban is based on environmental protection, in contrast to economic protectionism. *Cf. id.* at 403-04. A ban that treated in-Basin and out-of-Basin entities alike would be subject to the Category 3 standard, under which “state law is invalid only if the incidental burden on interstate commerce is clearly excessive in relation to the putative local benefits.” *Id.* at 398-399. As already noted, the available science and knowledge of how difficult oil and gas wastewater is to treat – regardless of fracking fluid presence or not – would support the immense local benefits to keeping such wastewater out of Basin water resources. Also, it is common for oil and gas wastewater to be transported long distances to facilities for treatment. This differs from *Pike v. Bruce Church, Inc.*, in which the local benefits of melon packaging were far

⁵ Although the DRBC could take the route of including a grandfather clause for facilities currently accepting to-be-prohibited waste streams, which would not affect the Commerce Clause analysis, the need for such a clause is not apparent because any facilities currently accepting waste do not appear to be solely dependent on oil and gas waste fluids and wastewater for their business. *Norfolk Southern Corp.*, 822 F.2d at 404. Thus, banning certain waste streams would not result in the facility shutting down, lowering the risk of a regulatory takings claim that might otherwise warrant a grandfathering clause.

less than the burden on a company to invest thousands of dollars to build an in-state packaging plant.

Conclusion

Delaware Riverkeeper Network supports DRBC's proposal for the prohibition of high volume hydraulic fracturing (HVHF) in hydrocarbon bearing rock formations within the Delaware River Basin ("the Basin"). DRN opposes the diversion, transfer or exportation of water from sources within the Basin of surface water, groundwater, treated wastewater or mine drainage water for utilization in hydraulic fracturing ("fracking") of hydrocarbon carbon bearing rock formations outside the Basin as proposed at Section 440.4. DRN opposes the importation, transfer, treatment, storage, disposal, or discharge in the Basin of produced water and Centralized Waste Treatment (CWT) wastewater generated by fracking operations, as proposed at Section 440.5. DRN requests the DRBC remove all reference to the allowance of water exports from the Basin for fracking and the import and storage, processing, disposal and discharge of CWT wastewater and produced water from fracking in the Basin, as described at Sections 440.4 and 440.5. DRN also requests that Section 440.3(b) is expanded to include prohibition of the activities related to fracking, specifically including the export of water and water resources out of the Basin for fracking elsewhere and the prohibition of the importation, transfer, treatment, storage, disposal, or discharge in the Basin of produced water and Centralized Waste Treatment (CWT) wastewater generated by fracking operations.

Respectfully submitted this 30th day of March 2018,



Maya K. van Rossum
the Delaware Riverkeeper
keepermaya@delawariverkeeper.org



Tracy Carluccio
Deputy Director
Delaware Riverkeeper Network
tracy@delawariverkeeper.org

/s/ Aaron Stemplewicz
Aaron Stemplewicz
Delaware Riverkeeper Network
925 Canal Street, Suite 3701
Bristol, PA 19107
Phone: 215.369.1188
Fax: 215.369.1181
aaron@delawariverkeeper.org

Counsel for: *Petitioners Delaware Riverkeeper Network and the Delaware* March 28, 2018

Attachments:

Attachment 1: Expert reports

1. Tom Myers, “Technical Memorandum: Review of Proposed Natural Gas Regulations as Proposed by the Delaware River Basin Commission”, March 12, 2018
2. Glenn C. Miller, Ph.D., “Review of the Draft Delaware River Basin Commission’s Regulations on Hydraulic Fracturing in Shale and Other Formations”, March 20, 2018

3. FracTracker Alliance, “Potential Impacts of Unconventional Oil and Gas on the Delaware River Basin”, March 20, 2018
4. Schmid & Company, Inc., “Comments on Proposed Regulations of the Delaware River Basin Commission Concerning High Volume Hydraulic Fracturing to Produce Oil and Gas, 3.18.2018
5. Piotr Parasiewicz, PhD, A.Prof., “Ecological review of the DRBC Draft 18 CFR Parts 401 and 440 Proposed Amendments to the Administrative Manual and Special Regulations Regarding Natural Gas Development Activities,” February 2018
6. Marvin Resnikoff, “Memorandum, DRBC Draft Regulation Comments”, Radioactive Waste Management Associates, February 19, 2018

Attachment 2: Curriculum Vitae for Experts

1. Kunz (Schmid and Co.)
2. Schmid
3. Parasiewicz
4. Resnikoff
5. Kelso (FracTracker)
6. Myers
7. Miller

ⁱ Michele Adams, “Unsafe and Unsustainable,” Delaware Riverkeeper Network, 2014, p. 15-16
http://www.delawariverkeeper.org/Documents/DRN_Report_Unsafe+Unsustainable_fr.pdf

ⁱⁱ Hanson, L., Habicht, S., Daggupati, P., Srinivasan, R., & Faeth, P. (2017). Modeling changes to streamflow, sediment, and nutrient loading from land use changes due to potential natural gas development. *Journal of the American Water Resources Association*, Vol.53, No. 6, 1293 – 1312. Retrieved from
<https://onlinelibrary.wiley.com/doi/full/10.1111/1752-1688.12588>

ⁱⁱⁱ Michele Adams, “Unsafe and Unsustainable,” Delaware Riverkeeper Network, p. 15-16, 2014,
http://www.delawariverkeeper.org/Documents/DRN_Report_Unsafe+Unsustainable_fr.pdf page 10.

^{iv} Evans, Kiesecker, “Shale Gas, Wind, and Water: Assessing the Potential Cumulative Impacts of Energy Development on Ecosystem Services within the Marcellus Play”, PLOS/One, DOI: 10.1371/journal.pone.0089210, February 19, 2014.

^v Ibid.

^{vi} Gerald J. Kauffman, Socioeconomic Value of the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania”, University of Delaware, 10.11.11, p. 26.

- vii Kiviat, E., & Schneller-McDonald, K. (2011). Fracking and Biodiversity: Unaddressed Issues in the New York Debate. *News from Hudsonia*, Vol. 25, No. 1 & 2. Retrieved from <http://hudsonia.org/wp-content/uploads/2012/01/nfh-Fracking-biodiversity-best.pdf>
- viii Ibid.
- ix Ibid.
- x Robert A. Smail & David J. Lewis, Forest Service, U.S. Dep't of Agric., Forest Land Conversion, Ecosystem Services, and Economic Issues for Policy: A Review 12 (2009), www.fs.fed.us/openspace/fote/pnw-gtr797.pdf
- xi Jackson, J.K. & Sweeney, B.W., "Expert Report on the Relationship Between Land Use and Stream Condition (as Measured by Water Chemistry and Aquatic Macroinvertebrates) in the Delaware River Basin," Stroud Water Research Center, Avondale, PA.
- xii Hutson, S.S., Linsey, K.S., Ludlow, R.A., Reyes, Betzaida, and Shourds, J.L., 2016, Estimated use of water in the Delaware River Basin in Delaware, New Jersey, New York, And Pennsylvania, 2010: U.S. Geological Survey Scientific Investigations Report 2015–5142, 76 p., <http://dx.doi.org/10.3133/sir20155142>, Table 1, Introduction, p. 4.
- xiii Academy of Natural Sciences of Drexel University, "A Preliminary Study of the Impact of Marcellus Shale Drilling on Headwater Streams," available at <http://www.ansp.org/research/pcer/projects/marcellus-shale-prelim/index.php>
- xiv Olmstead, et.al. "Shale gas development impacts on surface water quality in Pennsylvania", *Proc Natl Acad Sci U S A*. 2013 Mar 26; 110(13): 4962–4967. Published online 2013 Mar 11. Doi: [10.1073/pnas.1213871110](https://doi.org/10.1073/pnas.1213871110), PMID: PMC3612605 <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3612605/>
- xv Entreken, S.A., Maloney, K.O., Kapo, K.E., Walters, A.W., Evans-White, M.A., & Klemow, K.M. (2015). Stream Vulnerability to Widespread and Emergent Stressors: A Focus on Unconventional Oil and Gas. *PLoS ONE* 10(9): e0137416. Retrieved from <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0137416>
- xvi Ibid.
- xvii Ibid.
- xviii Ibid.
- xix Ibid.
- xx Schmid & Company, Inc., "Comments on Proposed Regulations of the Delaware River Basin Commission Concerning High Volume Hydraulic Fracturing to Produce Oil and Gas, 3.18.2018, p. 12.
- xxi Ibid. p. 11
- xxii Kiviat, E., & Schneller-McDonald, K. (2011). Fracking and Biodiversity: Unaddressed Issues in the New York Debate. *News from Hudsonia*, Vol. 25, No. 1 & 2. Retrieved from <http://hudsonia.org/wp-content/uploads/2012/01/nfh-Fracking-biodiversity-best.pdf>
- xxiii Kiviat, E., & Schneller-McDonald, K. (2011). Fracking and Biodiversity: Unaddressed Issues in the New York Debate. *News from Hudsonia*, Vol. 25, No. 1 & 2. Retrieved from <http://hudsonia.org/wp-content/uploads/2012/01/nfh-Fracking-biodiversity-best.pdf>
- xxiv <http://www.state.nj.us/dep/dsr/wetlands/final.pdf>
- xxv New Hampshire Office of Energy and Planning, "Wetlands Mitigation/Restoration Issues", Technical Bulletin 2, spring 1988.
- xxvi <http://www.gpo.gov/fdsys/granule/CFR-2012-title40-vol34/CFR-2012-title40-vol34-sec1508-20/content-detail.html>
- xxvii <http://www.post-gazette.com/powersource/companies/2018/01/15/These-days-oil-and-gas-companies-are-super-sizing-their-well-pads/stories/201801140023>
- xxviii <http://www.post-gazette.com/powersource/companies/2018/01/15/These-days-oil-and-gas-companies-are-super-sizing-their-well-pads/stories/201801140023> AND <http://www.post-gazette.com/powersource/companies/2018/01/15/These-days-oil-and-gas-companies-are-super-sizing-their-well-pads/stories/201801140023>
- xxix Ibid.
- xxx Ibid.
- xxxi Tom Myers, "Technical Memorandum: Review of Proposed Natural Gas Regulations as Proposed by the Delaware River Basin Commission", March 12, 2018, p.1.
- xxxii Ibid. p. 3.
- xxxiii Ibid. p. 3.
- xxxiv Ibid. p. 2.
- xxxv Ibid. p. 4.
- xxxvi Kiviat, E., & Schneller-McDonald, K. (2011). Fracking and Biodiversity: Unaddressed Issues in the New York Debate. *News from Hudsonia*, Vol. 25, No. 1 & 2. Retrieved from <http://hudsonia.org/wp-content/uploads/2012/01/nfh-Fracking-biodiversity-best.pdf>
- xxxvii Tom Myers, "Technical Memorandum: Review of Proposed Natural Gas Regulations as Proposed by the Delaware River Basin Commission", March 12, 2018, p.5-6.
- xxxviii Ibid. p. 6.
- xxxix Ibid. p. 7-8.

-
- xi Ibid. p. 9.
- xii Ibid. p. 9-10.
- xiii Ibid. p. 10-11.
- xiiii Ibid. p. 12-13.
- xlv Ibid. p. 13.
- xlv Paul Rubin, Report for the Delaware River Basin Commission on Natural Gas Development Regulations December 9, 2010, Article 7 of Part III – Basin Regulations, 2011, p. 3-4.
- xlvi Paul Rubin, Report for the Delaware River Basin Commission on Natural Gas Development Regulations December 9, 2010, Article 7 of Part III – Basin Regulations, 2011, p. 10-29.
- xlvii Ibid.
- xlviii Rubin, Paul, 2014. “Unsafe and Unsustainable”, Delaware Riverkeeper Network, p. 27.
- xlix Rubin, Paul, 2014. “Unsafe and Unsustainable”, Delaware Riverkeeper Network, p. 36, 38 and 39.
- I Ibid.
- li <https://www.skytruth.org/about/> “SkyTruth uses the view from space to motivate people to protect the environment. We utilize [technology](#) to identify and monitor threats to the planet’s natural resources such as offshore drilling and oil spills, urban sprawl, fracking, mountaintop removal mining, and overfishing of the oceans.” Accessed 3.28.18.
- lii Personal communication with excel sheet attachment, Dan Cogswell daniel.cogswell@skytruth.org to Tracy Carluccio, tracy@delawareriverkeeper.org, Fri 3/23/2018 5:32 PM.
- liii Concerned Health Professionals of New York & Physicians for Social Responsibility. (2018, March). Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction) (5th ed.). <http://concernedhealthny.org/compendium/>
- liiv psr.org/resources/fracking-compendium.html, p. 266.
- lv Hays, J. & Shonkoff, S.B.C. (2016). Toward an Understanding of the Environmental and Public Health Impacts of Unconventional Natural Gas Development: A Categorical Assessment of the Peer- Reviewed Scientific Literature, 2009-2015. *PLoS ONE*, Vol. 11, No.4. Retrieved from <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154164>
- lvi Ibid.
- lvii Ibid.
- lviii Ibid.
- lix Ibid.
- lx http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/Determination_Letters/Regional_Determination_Letters.pdf
- lxi <http://www.nationofchange.org/2017/01/31/9442-citizen-reported-fracking-complaints-reveal-12-years-suppressed-data/>
- lxii <https://stateimpact.npr.org/pennsylvania/2017/01/31/data-trove-offers-new-details-on-complaints-to-dep-during-shale-boom/> and https://docs.google.com/spreadsheets/d/1_tg1zTCA-xTmFk4erdcYJt4zqmQZ9x89qliQg55zekg/edit#gid=1060152199 and <https://maps.fractracker.org/latest/?appid=f973714e27c14e1ebee222d2560f8cb0>
- lxiii <http://publicherald.org/hidden-data-suggests-fracking-created-widespread-systemic-impact-in-pennsylvania/>
- lxiv USEPA (U.S. Environmental Protection Agency). 2016. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. Office of Research and Development, Washington, DC. EPA-600-R-16-236Fa. Available at: www.epa.gov/hfstudy; Hein 2012, p. 2. <https://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=332990>
- lxv https://www.epa.gov/sites/production/files/2015-05/documents/hf_spills_report_final_5-12-15_508_km_sb.pdf
- lxvi Betanzo, E.A., Hagen, E.R., Wilson, J.T., Reckhow, K.H., Hayes, L., Argue, D.M., and Cangelosi, A.A. (2016). Water data to answer urgent water policy questions: Monitoring design, available data and filling data gaps for determining whether shale gas development activities contaminate surface water or groundwater in the Susquehanna River Basin. Northeast-Midwest Institute and U.S. Geologic Survey, 2016.
- lxvii Ibid.
- lxviii Ibid.
- lix Ibid.
- lxx Ibid.
- lxxi Ibid.
- lxxii Ibid.
- lxxiii Ibid.
- lxxiv Ibid.
- lxxv Ibid.
- lxxvi Ibid.
- lxxvii Ibid.

-
- lxxviii Ibid.
- lxxix Ibid.
- lxxx Ibid.
- lxxxi USEPA (U.S. Environmental Protection Agency). 2016. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. Office of Research and Development, Washington, DC. EPA-600-R-16-236Fa. P. 8-74, 75.
- lxxxii Colborn, T., Schultz, K., Herrick, L., & Kwiatkowski, C. (2012). An Exploratory Study of Air Quality near Natural Gas Operations. *Human and Ecological Risk Assessment: An International Journal*, Volume 20, Issue 1.
- lxxxiii Ibid.
- lxxxiv Ibid.
- lxxxv Ibid.
- lxxxvi Ibid.
- lxxxvii Ibid.
- lxxxviii Ibid.
- lxxxix Ibid.
- xc Ibid.
- xcI Ibid.
- xcii Ibid.
- xciii Southwest Pennsylvania Environmental Health Project at <http://www.environmentalhealthproject.org/>
- xciv Glenn C. Miller, Ph.D., "Review of the Draft Delaware River Basin Commission's Regulations on Hydraulic Fracturing in Shale and Other Formations", March 20, 2018, p. 6.
- xcv Marvin Resnikoff, Ph.D., Radioactive Waste Management Associates, "Comments on Marcellus Shale Development", October 2011.
- xcvi <http://www.epa.gov/radiation/radionuclides/radium.html#inbody>
- xcvii Marvin Resnikoff, "Memorandum, DRBC Draft Regulation Comments", Radioactive Waste Management Associates, February 19, 2018, p. 2.
- xcviii Steven Habicht, Lars Hanson and Paul Faeth, "The Potential Environmental Impact from Fracking in the Delaware River Basin", August 2015, p. 53 - 61.
- xcix Ibid.
- c Ibid.
- ci Ibid.
- cii Ibid.
- ciii Ibid. p. 63 - 72.
- civ Ibid.
- cv Ibid.
- cvi Ibid.
- cvi Ibid.
- cvi Ibid.
- cviii [Eric A. Kort](#), [Christian Frankenberg](#), [Keeley R. Costigan](#), [Rodica Lindenmaier](#), [Manvendra K. Dubey](#), [Debra Wunch](#) "Four corners: The largest US methane anomaly viewed from space", First published: 9 October 2014. <http://onlinelibrary.wiley.com/enhanced/doi/10.1002/2014GL061503/>
- cx Intergovernmental Panel on Climate Change (IPCC). 2013. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. <http://www.pnas.org/content/early/2017/01/03/1612066114.full>
- cxI PSE Healthy Energy, "Lifecycle Greenhouse Gas Emissions Associated with Projected Future Marcellus Development", 2017.
- cxii <https://www.epa.gov/climate-impacts/climate-impacts-water-resources>
- cxiii Steven Habicht, Lars Hanson and Paul Faeth, "The Potential Environmental Impact from Fracking in the Delaware River Basin", August 2015, p. 59 - 61.
- cxiv Robert W. Howarth Ph.D., "CSSD Performance Standards: Impact on Greenhouse Gas Emissions", *Unsafe and Unsustainable*, Delaware Riverkeeper Network, 2014.
- cxv Ibid. p. 19-23.
- cxvi https://www.washingtonpost.com/news/energy-environment/wp/2016/12/11/atmospheric-levels-of-methane-a-powerful-greenhouse-gas-are-spiking-scientists-report/?utm_term=.445d31cff224
- cxvii Robert Howarth: The David R. Atkinson Professor of Ecology and Environmental Biology, Cornell University, "COP21 Reflections on the Historic Paris Climate Agreement", Tompkins Public Library, New York (transcript), February 3, 2016.
- cxviii [Eric A. Kort](#), [Christian Frankenberg](#), [Keeley R. Costigan](#), [Rodica Lindenmaier](#), [Manvendra K. Dubey](#), [Debra Wunch](#) "Four corners: The largest US methane anomaly viewed from space", First published: 9 October 2014. <http://onlinelibrary.wiley.com/enhanced/doi/10.1002/2014GL061503/>

-
- cxix Tom Gleeson, et.al, “Water balance of global aquifers revealed by groundwater footprint”, published on line 6.1.12.
- cox Carmen Nobel, “Water, Electricity, and Transportation: Preparing for the Population Boom”, *Working Knowledge*, 3.14.11.
- cxxi Tom Gleeson, et.al, “Water balance of global aquifers revealed by groundwater footprint”, published on line 6.1.12.
- cxixii FracTracker Alliance, “Potential Impacts of Unconventional Oil and Gas on the Delaware River Basin”, March 20, 2018, p. 6.
- cxixiii <http://www.post-gazette.com/powersource/companies/2018/01/15/These-days-oil-and-gas-companies-are-super-sizing-their-well-pads/stories/201801140023>
- cxixiv <http://investordiscussionboard.com/boards/ind-energy/these-days-oil-and-gas-companies-are-super-sizing-their-well-pads>
- cxixv U.S. EIA, <https://www.eia.gov/todayinenergy/detail.php?id=35512>, accessed 3.28.2018.
- cxixvi Excel sheet document provided by PADEP: <https://bit.ly/2J22o59>
- cxixvii Ibid. p. 7.
- cxixviii Ibid. p. 13.
- cxixix Ibid. p. 7.
- cxixxx Piotr Parasiewicz, PhD, A.Prof., “Ecological review of the DRBC Draft 18 CFR Parts 401 and 440 Proposed Amendments to the Administrative Manual and Special Regulations Regarding Natural Gas Development Activities,” February 2018, p.5-6.
- cxixxxi Ibid. p.6.
- cxixxxii Ibid. p. 6-7.
- cxixxxiii Ibid. p. 7.
- cxixxxiv Ibid. p. 7.
- cxixxxv Ibid. p. 7-8.
- cxixxxvi Ibid. p.8.
- cxixxxvii Schmid & Company, Inc., “Comments on Proposed Regulations of the Delaware River Basin Commission Concerning High Volume Hydraulic Fracturing to Produce Oil and Gas, 3.18.2018, p. 9.
- cxixxxviii Instream Flows for Riverine Resource Stewardship, Instream Flow Council, Cheyenne, Wyoming, 2004, page 178.
- cxixxxix Instream Flows for Riverine Resource Stewardship, Instream Flow Council, Cheyenne, Wyoming, 2004, p.178-179
- cxli Piotr Parasiewicz, PhD, A.Prof., “Ecological review of the DRBC Draft 18 CFR Parts 401 and 440 Proposed Amendments to the Administrative Manual and Special Regulations Regarding Natural Gas Development Activities,” February 2018, p. 14.
- cxlii “Review of XTO Energy Oquaga Creek Withdrawal, DRBC Docket D-2010-022-1”, Peter Demicco, Demicco and Associates, 5.9.11.
- cxliicxliii Piotr Parasiewicz, PhD, A.Prof., “Ecological review of the DRBC Draft 18 CFR Parts 401 and 440 Proposed Amendments to the Administrative Manual and Special Regulations Regarding Natural Gas Development Activities,” February 2018, p. 8-9.
- cxliiii Hutson, S.S., Linsey, K.S., Ludlow, R.A., Reyes, Betzaida, and Shourds, J.L., 2016, Estimated use of water in the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania, 2010: U.S. Geological Survey Scientific Investigations Report 2015–5142, 76 p., <http://dx.doi.org/10.3133/sir20155142>. P. 30, et seq.
- cxliiv Ibid. p. 9.
- cxliv Piotr Parasiewicz, PhD, A.Prof., “Ecological review of the DRBC Draft 18 CFR Parts 401 and 440 Proposed Amendments to the Administrative Manual and Special Regulations Regarding Natural Gas Development Activities,” February 2018, p.9-10.
- cxlvii Ibid. p. 11.
- cxlviii Ibid. p. 2.
- cxlvix Ibid. p. 12.
- cxlix Ibid. p.13-14.
- cxli US General Accountability Office, ***Information on the Quantity, Quality, and Management of Water Produced During Oil and Gas Production***, GAO-12-56, January 2012.
- cxlii Ibid.
- cxliii U.S. Dept. of Energy, Argonne National Laboratory, “A White Paper Describing Produced Water from Production of Crude Oil, Natural Gas, and Coal Bed Methane”, January 2004.
- cxliiii Marvin Resnikoff, Ph.D., Radioactive Waste Management Associates, “Comments on Marcellus Shale Development”, October 2011.
- cxliiv US General Accountability Office, ***Information on the Quantity, Quality, and Management of Water Produced During Oil and Gas Production***, GAO-12-56, January 2012.

- clv New York State Department of Environmental Conservation, **Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas, and Solution Mining Regulatory Program, Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and other Low-Permeability Gas Reservoirs**, September 2011. <http://www.dec.ny.gov/data/dmn/rdsgeisfull0911.pdf>
- clvi Ibid.
- clvii NYSDEC Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas, and Solution Mining Regulatory Program (DSGEIS), 2009, Tables 5-8 and 5-9, p. 5-109 .
- clviii New York State Department of Environmental Conservation, **Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas, and Solution Mining Regulatory Program, Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and other Low-Permeability Gas Reservoirs**, September 2011, Table 5.9.
- clix USEPA Technical Development Document for the Effluent Limitations Guidelines and Standards for the Oil and Gas Extraction Point Source Category (2016), Tables C -11, C-13, C-15, C-17, C-19.
- clx USEPA, Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States”, EPA-600-R-16-236Fa, December 2016 www.epa.gov/hfstudy AND New York State Department of Environmental Conservation, Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas, and Solution Mining Regulatory Program, Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and other Low-Permeability Gas Reservoirs, September 2011, Table 6.1.
- clxi NRDC Document, “In Fracking’s Wake: New Rules are Needed to Protect Our Health and Environment from Contaminated Wastewater”, May 2012 d:12-05-A, Table 1.
- clxii Yale University School of Public Health, <https://publichealth.yale.edu/news/article.aspx?id=13714>.
- clxiii Ibid.
- clxiv U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at ES-45 to ES-46 and 9-1. EPA Report # 600/R-16/236F. See <https://www.epa.gov/hfstudy>.
- clxv Dusty Horwitt, Environmental Issues Concerning Hydraulic Fracturing, Volume 1 (Kevin A. Schug and Zachariah L. Hildenbrand, eds.), at 101 (2017).
- clxvi U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at 9-1, 10-25. EPA Report # 600/R-16/236F. See <https://www.epa.gov/hfstudy>.
- clxvii FracFocus. See <http://fracfocus.org/>.
- clxviii U.S. Environmental Protection Agency. Hydraulic fracturing for oil and gas: impacts from the hydraulic fracturing water cycle on drinking water resources in the United States. Washington, DC: Office of Research and Development; 2016, at 9-1, 10-25. EPA Report # 600/R-16/236F. See <https://www.epa.gov/hfstudy>.
- clxix 2010 NWRI Final Project Report on "Source, Fate, and Transport of Endocrine Disruptors, Pharmaceuticals, and Personal Care Products in Drinking Water Sources in California", May 19, 2010. <http://www.nwri-usa.org/pdfs/cecresearchprofile.pdf>
- clxx Vandenberg et. al., “Hormones and Endocrine-Disrupting Chemicals: Low-Dose Effects and Nonmonotonic Dose Responses”, The Endocrine Society, doi:10.1210/er.2011-1050, 3.14.12.
- clxxi Laura Vandenberg, Tufts University, “There Are No Safe Doses for Endocrine Disruptors”, Environmental Health News, 3.12.
- clxxii Linda S. Birnbaum, Director, NIEHS and NTP, National Institutes of Health, U.S. Department of Health and Human Services, “Environmental Chemicals: Evaluating Low-Dose Effects”, doi:10.2189/ehp.1205179, Environmental Health Perspectives, Vol. 120, Number 4, April 2012.
- clxxiii Partnership for Policy Integrity, **Toxic Secrets: Companies Exploit Weak US Chemical Rules to Hide Fracking Risks**, April 7, 2016. <http://www.pfpi.net/toxic-secrets-companies-exploit-weak-us-chemical-rules-to-hide-fracking-risks>
- clxxiv Ibid.
- clxxv Ibid.
- clxxvi Ibid.
- clxxvii Glenn C. Miller, Ph.D., “Review of the Draft Delaware River Basin Commission’s Regulations on Hydraulic Fracturing in Shale and Other Formations”, March 20, 2018, p. 5.
- clxxviii Glenn C. Miller, Ph.D., “Review of the Draft Delaware River Basin Commission’s Regulations on Hydraulic Fracturing in Shale and Other Formations”, March 20, 2018, p. 2.
- clxxix Ibid. p. 3.
- clxxx PADEP “Permitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges”, April 11, 2009.
- clxxxi <http://www.duq.edu/academics/schools/natural-and-environmental-sciences/academic-programs/environmental-science-and-management/3-rivers-quest>;

clxxxii <http://www.post-gazette.com/local/south/2011/11/04/Bromide-levels-in-Monongahela-River-rose-in-2010-remain-high/stories/201111040150>.

clxxxiii <http://www.record-courier.com/news/20121113/bromide-pollution-persists-in-allegheny-river-in-western-pa>

clxxxiv Glenn C. Miller, Ph.D., “Review of the Draft Delaware River Basin Commission’s Regulations on Hydraulic Fracturing in Shale and Other Formations”, March 20, 2018, p. 3-4.

clxxxvclxxxv Ibid. p. 4.

clxxxvi Swanson, VE, “Oil Yield and Uranium Content of Black Shales,” USGS paper 356-A, 1960.

clxxxvii Resnikoff, Marvin, “Review of Pennsylvania Department of Environmental Protection Technologically Enhanced Naturally Occurring Radioactivity Materials (TENORM) Study Report”, Dec. 2015.

clxxxviii Ibid.

clxxxix New York State Department of Environmental Conservation, Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas, and Solution Mining Regulatory Program, Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and other Low-Permeability Gas Reservoirs, September 2011, Table 5.24.

cx c Nathaniel R. Warner*, Cidney A. Christie, Robert B. Jackson, and Avner Vengosh, “Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania”, Division of Earth and Ocean Sciences, Nicholas School of the Environment, Duke University, Durham, North Carolina 27708, United States, Environ. Sci. Technol., 2013, 47 (20), pp 11849–11857, DOI: 10.1021/es402165b <http://pubs.acs.org/doi/abs/10.1021/es402165b>

cxci Marvin Resnikoff, Ph.D., Radioactive Waste Management Associates, “Comments on Marcellus Shale Development”, October 2011.

cxcii Marvin Resnikoff, Ph.D., “Review of Pennsylvania Department of Environmental Protection Technologically Enhanced Naturally Occurring Radioactivity Materials (TENORM) Study Report”, Dec. 2015.

cxciiii Marvin Resnikoff, “Memorandum, DRBC Draft Regulation Comments”, Radioactive Waste Management Associates, February 19, 2018, p. 2.

cxciiv Ibid. p. 3.

cxci v Ibid. p. 4.

cxci vi Marvin Resnikoff, Ph.D., “Review of Pennsylvania Department of Environmental Protection Technologically Enhanced Naturally Occurring Radioactivity Materials (TENORM) Study Report”, Dec. 2015.

cxci vii Marvin Resnikoff, “Memorandum, DRBC Draft Regulation Comments”, Radioactive Waste Management Associates, February 19, 2018, p.1.

cxci viii Glenn C. Miller, Ph.D., “Review of the Draft Delaware River Basin Commission’s Regulations on Hydraulic Fracturing in Shale and Other Formations”, March 20, 2018, p. 3-4.

cxci ix Kaiser Engineers, California, Final Report to the State of California, San Francisco Bay-Delta Water Quality Control Program, State of California, Sacramento, CA (1969).

cc C.M. Hogan, Marc Papineau et al. Development of a dynamic water quality simulation model for the Truckee River, Earth Metrics Inc., Environmental Protection Agency Technology Series, Washington D.C. (1987).

cci DRBC Water Quality Regulations, 18 CFR, Part 410 <http://www.state.nj.us/drbc/library/documents/WQregs.pdf>

ccii <http://www.state.nj.us/drbc/library/documents/dockets/interactive-map/1970-072-5.pdf>

cciii <http://www.state.nj.us/drbc/library/documents/dockets/interactive-map/1996-021-4.pdf>

cciv Glenn C. Miller, Ph.D., “Review of the Draft Delaware River Basin Commission’s Regulations on Hydraulic Fracturing in Shale and Other Formations”, March 20, 2018, p. 6-7.

ccv PETER M. CHAPMAN, “WHOLE EFFLUENT TOXICITY TESTING—USEFULNESS, LEVEL OF PROTECTION, AND RISK ASSESSMENT”, Environmental Toxicology and Chemistry, Vol. 19, No. 1, pp. 3–13, 2000, q 2000, SETAC, 0730-7268/00.

ccvi Glenn C. Miller, Ph.D., “Review of the Draft Delaware River Basin Commission’s Regulations on Hydraulic Fracturing in Shale and Other Formations”, March 20, 2018, p. 5.

ccvii Glenn C. Miller, Ph.D., “Review of the Draft Delaware River Basin Commission’s Regulations on Hydraulic Fracturing in Shale and Other Formations”, March 20, 2018, p. 2.

ccviii Piotr Parasiewicz, PhD, A.Prof., “Ecological review of the DRBC Draft 18 CFR Parts 401 and 440 Proposed Amendments to the Administrative Manual and Special Regulations Regarding Natural Gas Development Activities,” February 2018, p. 12-13.

ccix FracTracker Alliance, “Potential Impacts of Unconventional Oil and Gas on the Delaware River Basin”, March 20, 2018, p. 9-11.

ccx Ibid. p. 13.

ccxi Ibid. p. 13.

ccxii Ibid. p. 13.

ccxiii Ibid. p. 11