March 30, 2018

Delaware River Basin Commission
25 Cosey Road
P.O. Box 7360
West Trenton, NJ 08628-0360

Re: Comments on the Delaware River Basin Commission's Proposed Amendments to the Administrative Manual and Special Regulations Regarding Hydraulic Fracturing Activities and Additional Clarifying Amendments

Dear Commissioners:

Thank you for the opportunity to comment on the Delaware River Basin Commission's (the "Commission") Proposed Amendments to the Administrative Manual and Special Regulations Regarding Hydraulic Fracturing Activities ("draft regulations").[1] These comments are submitted on behalf of the Natural Resources Defense Council ("NRDC") and its over half a million members across the country. In brief, NRDC writes to urge the Commission to enact a full ban on fracking in the River Basin—including drilling, a ban on the treatment and disposal of fracking wastewater, and a ban on the withdrawal and export of Basin water for fracking elsewhere.

NRDC is a national, nonprofit, nonpartisan environmental advocacy organization with its principal office located in New York City. NRDC has a long history of litigating and advocating for clean water at both the federal level and in New York State. In 1972, for example, it helped enact the Clean Water Act, America's bedrock water-protection law, and most recently, in 2015, NRDC was a principal advocate for the issuance of the Clean Water Rule, which returned guaranteed protections under the Clean Water Act to hundreds of thousands of miles of streams and tens of millions of acres of wetlands across the country.

NRDC also has deep expertise on the issue of fracking. Among other work, NRDC launched the Community Fracking Defense Project to provide communities with policy, legal, and technical tools to protect themselves from the risks of fracking, including groundwater contamination; air, climate, noise and light pollution; toxic chemical and wastewater spills;

[1] Notice of Rule and Public Hearing, Administrative Manual and Special Regulations Regarding Natural Gas Development Activities; Additional Clarifying Amendments, 83 Fed. Reg. 1586 (proposed Jan. 12, 2018) [hereinafter "Proposed Regulations"].

induced seismicity; and the risk of catastrophic accidents, such as wellsite explosions. As part of this effort, NRDC and other stakeholders successfully advocated for the prohibition of high-volume hydraulic fracturing ("fracking") activities in New York State, activities that the State found in 2015 significantly threatened New York's water resources.

As the Commission is well aware, the Delaware River Basin helps provide drinking water for over 17 million people in the Northeast. Yet the basin — which extends from the Catskills in New York to parts of New Jersey, Pennsylvania, Delaware, and Maryland — has been at risk of fracking for over ten years. Recently, the Commission, composed of governors from New York, New Jersey, Delaware, and Pennsylvania, and one federal representative from the Army Corps of Engineers, released draft regulations banning fracking in the entire watershed.

But these new rules do not go far enough. While the draft regulations are an important step in the right direction, they could still open the watershed to the storage, treatment, and disposal of contaminated fracking wastewater—a toxic mix of water, sand, and as many as 1,000 chemicals. And they could also allow companies to draw freshwater from the watershed for use in fracking elsewhere. This will not fully protect public health and the environment. It is critical that the Commission also advance regulations that permanently ban fracking *and* protect the watershed and surrounding communities from all fracking-related activities.

We raise three main points in our comments. First, given the known risks of fracking on water quality, we strongly support the Commission's proposal to ban fracking in the region. Second, while a ban on fracking is necessary to protect the River Basin from the harms of fracking, it is not sufficient on its own—a ban on fracking wastewater is necessary to ensure that the water quality, economy, and health of the residents of the River Basin are protected from the full harms of fracking. Finally, in order to protect the Delaware River Basin's already historically low water levels,[2] we request that the Commission also ban the export of basin water for use for fracking elsewhere.

In support of these points, our comments are divided into five parts. Part I provides the background necessary to understand why fracking and its associated activities can and should be banned in the River Basin. Part II sets forth why fracking should be banned in the River Basin. Part III explains why a ban on the treatment and disposal of fracking wastewater is necessary to achieve the ends sought by the fracking ban. Part IV sets forth why water withdrawals for fracking purposes should also be prohibited in the River Basin. Finally, Part V explains how the bans we request would not violate the limitations on state activity set forth in the dormant Commerce Clause.

---

[2] Bruce Shipkowski, *Low Levels in Delaware River Could Keep Re-Enactors on Land*, U.S. News & World Report, Dec. 17, 2017, https://www.usnews.com/news/best-states/new-jersey/articles/2017-12-17/low-levels-in-delaware-river-could-keep-re-enactors-on-land.

For years, NRDC has been studying the harms of fracking wastewater on water quality and human health.[3] As part of this effort, we have retained an expert consultant, Judith Schreiber, Ph.D., former Chief Scientist at the Environmental Protection Bureau of the New York State Office of the Attorney General and former Section Chief of Environmental Research at the New York State Department of Health, to summarize the existing scientific research on this subject. Attached to this letter is a report prepared by Dr. Schreiber on this matter.[4] Dr. Schreiber's report has formed the basis for the recommendations regarding fracking wastewater that are contained in this letter.

Finally, we thank the Commission for extending the comment period on the draft regulations from February 28, 2018 to March 30, 2018. This extension was helpful in allowing NRDC and many other members of the public to review the proposal in more detail and to comment more meaningfully on this enormously important set of new regulations.

I. Background

a. The Delaware River Basin

The Delaware River Basin is the catchment area of the United States' longest free-flowing river east of the Mississippi. It is remarkable for its pristine character, geographic scope, and singular utility to the Nation's most densely populated region, the Mid-Atlantic. From the headwaters in the Catskill Mountains to the mouth in the Delaware Bay, the Delaware River spans 330 miles, draws from 216 tributaries, and drains surface water from approximately 13,000 square miles across 42 counties in five U.S. states: 6,465 square miles in Pennsylvania, 2,969 square miles in New Jersey, 2,363 square miles in New York, 968 square miles in Delaware, and 8 square miles in Maryland. North to south, the Basin encompasses five, distinct physiogeographic provinces (Appalachian Plateaus, Valley and Ridge, New England, Piedmont, and Coastal Plain), which range in altitude from over 4,000 feet down to sea level.

The Delaware River Basin is also home to bass, spawning shad, trout, and one of the healthiest American eel populations in our country, and sits on top of the Marcellus Shale, the largest natural gas field in the United States.[5] The Marcellus shale formation underlies about 36 percent of the Delaware River Basin,[6] and spans six states: New York, Pennsylvania, Ohio, Maryland, Virginia, and West Virginia. To date, the reach of shale under the Delaware River

---

[3] *See, e.g.,* NRDC, *In Fracking's Wake: New Rules are Needed to Protect Our Health and Environment from Contaminated Wastewater* 6 (2012), https://www.nrdc.org/sites/default/files/Fracking-Wastewater-FullReport.pdf [hereinafter "NRDC, *In Fracking's Wake*"].

[4] Judith S. Schreiber, *Synopsis of Public Health and Environmental Risks Associated with Fracking Wastewater* (2018).

[5] U.S. Department of Energy, *Modern Shale Gas Development in the United States: A Primer* 17 (2009), http://www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf.

[6] Delaware River Basin Commission, Natural Gas Drilling Index Page, http://www.state.nj.us/drbc/programs/natural/ (Mar. 29, 2018).

Basin has remained untouched by fracking, preserving clean and safe water and a natural environment in a region that relies on these features for its livelihood.

b. The Environmental, Drinking Water, and Recreational Resources of the Delaware River Basin

The Lower Delaware is one of the most important shad, striped bass, and river herring fisheries in the east. Additionally, the Middle and Upper Delaware represent an unmatched blend of habitats for roaming striped bass, spawning shad, smallmouth bass, trout, and one of the healthiest American eel populations in our country. The Delaware's drainages and surrounding environs also encompass a substantial oak hickory forest, northern mixed hardwoods, and isolated spruce fir zones that includes bog and fen habitats. And the Basin provides sanctuary to rare and endemic species of plants and animals including bears, bald eagles, native trout, and endangered timber rattle snakes.

The River Basin's undeveloped, bucolic nature holds tremendous ecological and economic value. Altogether, approximately 17 million people (5% of the total U.S. population) depend on the Delaware River Basin for clean drinking water.[7] This figure includes 8 million individuals who reside within the Basin,[8] along with 7 million residents of New York City and Philadelphia, the first and seventh largest metropolitan economies in the United States, respectively.[9]

New York City gets nearly half of its water from three large reservoirs located on the tributaries to the Delaware.[10] Due to the very high quality of drinking water from the Delaware River Basin, New York City is one of only five large cities in the country with a surface drinking water supply that does not need to filter their water prior to consumption, a measure that saves the City $10 billion per year.[11] Philadelphia gets 100 percent of its water supply directly from the Delaware and Schuylkill Rivers.[12]

A clean and protected River Basin also contributes to the regional economy by supporting approximately 600,000 jobs (more than $12 billion in annual wages) in the coastal,

---

[7] Gerald J. Kauffman, Socioeconomic Value of the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania, Executive Summary (2011), http://www.state.nj.us/drbc/library/documents/SocioeconomicValueDRB-UDEL-FinalRpt.pdf [hereinafter "Kauffman"].

[8] *Id.*

[9] New York City Dept. of Env. Prot., *New York City 2016 Drinking Water Supply and Quality Report* (2016), http://www.nyc.gov/html/dep/pdf/wsstate16.pdf.

[10] U.S. Govt. Accountability Office, *Interstate Compacts: An Overview of the Structure and Governance of Environment and Natural Resource Compacts* 38 (2007), https://www.gao.gov/assets/260/258939.pdf.

[11] New York City Dept. of Env. Prot., *Final Impact Assessment Report: Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed* 51 (2009), http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/12_23_2009_final_assessment_report.pdf [hereinafter "NYC Assessment"].

[12] U.S. Govt. Accountability Office, *supra* note 10, at 38.

ecotourism, recreation, and water industries.[13] Factoring in ecosystems services, the Basin's annual contribution to regional and local economies totals at least $16 billion[14] — nearly five times the potential annual value of the natural gas industry (a mere $3.3 billion).[15]

Congress has repeatedly recognized the Delaware River Basin's unique status, taking action to protect it on at least four occasions. First, in 1965, Congress authorized the Delaware Water Gap National Recreation Area, a 104-square mile protected area and park encompassing the Delaware River's middle passage, from just below the start of the River's main stem down to the Water Gap at the New Jersey-Pennsylvania state line.[16] Second, between 1978 and 2006, Congress added over two hundred miles of main-stem Delaware and tributaries to the National Wild and Scenic Rivers System.[17] Third, in 1996, Congress added the Delaware Estuary to the National Estuary Program.[18] Finally, in 2016, Congress passed the Delaware River Basin Conservation Act, establishing the Delaware River Basin Restoration Program to promote conservation, water management, and recreational opportunities in the Basin.[19]

c. The Delaware River Basin Commission

The Delaware River Basin Commission was formed in 1961 by an interstate compact between New York, New Jersey, Pennsylvania and Delaware, signed by President Kennedy, and ratified by Congress.[20] The Commission was formed to coordinate the overlapping water management concerns of the four states.[21] It is the only Federal-state basin compact with authority in all areas of water supply, water quality, flood mitigation, and watershed management.[22]

---

[13] Kauffman, *supra* note 7, at T.E1, T.E3. These figures exclude jobs and wages generated from wastewater utilities.
[14] *Id.*
[15] *Id.*
[16] An Act to Authorize Establishment of the Delaware Water Gap National Recreation Area, and for Other Purposes, Pub.L. 89-158, 79 Stat. 612 (1965).
[17] These include the 73.4-mile long Upper Delaware Scenic and Recreational River, the 40-mile long Middle Delaware National Scenic and Recreational River, the 38.9-mile long Lower Delaware National Scenic and Recreational River, the 24.2-mile long Musconetcong National Wild and Scenic River, and the 14.7, 10.7, and 3-mile long Tinicum, Tohickon, and Paunacussing Creeks. National Park Service, *Delaware River Basin Wild and Scenic River Values* 7, 11 (2012), http://www.delawareriverkeeper.org/sites/default/files/resources/Reports/DelawareRiverBasin_Sept2012.Wild%20and%20Scenic%20River%20Report.NPS.pdf.
[18] Gerald J. Kauffman, Partnership for the Delaware Estuary, Inc., *Economic Value of the Delaware Estuary Watershed Comprehensive Report* 12 (2011), http://www.ipa.udel.edu/publications/DelEstuaryValueReport.pdf.
[19] Water Infrastructure Improvements for the Nation Act, Pub. Law No. 114-322, 130 Stat. 1628 (2016).
[20] Delaware River Basin Compact, Pub. L. No. 87-328, 75 Stat. 688 (1961) [hereinafter "Compact"]. The compact also is codified at N.Y. Envtl. Conserv. Law §§ 21-0701 to -0723; 53 Delaware Laws, Chapter 71; New Jersey Laws of 1961, Chapter 13; Pennsylvania Acts of 1961, Act No. 268.
[21] *New Jersey v. New York*, 347 U.S. 995 (1954).
[22] Gerald J. Kauffman, *Governance, Policy, and Economics of Intergovernmental River Basin Management*, 29 Water Resource Management 5689 (2015), http://www.wrc.udel.edu/wp-content/uploads/2016/09/GovernancePolicyandEconomicsofIntergovernmentalRiverBasinManagementGJKauffman2015.pdf.

Significantly, the Compact states:

> The commission may assume jurisdiction to control . . . pollution . . . in the waters of the basin, whenever it determines . . . that the effectuation of the comprehensive plan so requires. The standard of such control shall be that pollution by sewage or industrial or other waste originating within a signatory state shall not injuriously affect waters of the basin as contemplated by the comprehensive plan. . . . [T]he commission may adopt and from time to time amend and repeal rules, regulations and standards to control such future pollution and abate existing pollution, and to require such treatment of sewage, industrial or other waste . . . as may be required to protect the public health or to preserve the waters of the basin for uses in accordance with the comprehensive plan.[23]

The Compact also states:

> The commission may regulate and control withdrawals and diversions from surface waters and ground waters of the basin.24

The Commission is composed of five members:[25] the governors of the four Basin states (New York, New Jersey, Pennsylvania, and Delaware), and the commander of the North Atlantic Division, U.S. Army Corps of Engineers.[26] Decisions of the Commission are made by vote of a majority of the membership.[27] Each Commissioner is entitled to one vote.[28]

All proposed "projects"[29] having a "substantial effect" on the water resources of the basin require approval from the Commission.[30] With respect to natural gas drilling in the Marcellus Shale formation, the Commission has appropriately asserted authority to regulate several aspects of operations:[31]

1) Water withdrawal permitting, from both surface and ground water diversions;[32]

---

[23] Compact § 5.2.
[24] *Id.* at § 10.1.
[25] *Id.* at §§ 2.2 and 2.3.
[26] *Id.* at § 2.2.
[27] *Id.* at § 2.5.
[28] *Id.*
[29] A "project" is defined as "any work, service or activity which is separately planned, financed, or identified by the commission, or any separate facility undertaken or to be undertaken within a specific area, for the conservation, utilization, control, development, or management of water resources which can be established and utilized independently or as an addition to an existing facility, and can be considered a separate entity for the purposes of evaluation. *Id.* at § 1.2(g).
[30] *Id.* at § 3.8.
[31] Del. River Basin Comm'n, *Natural Gas Drilling in the Marcellus Shale Formation* 2 (2008), http://www.state.nj.us/drbc/NaturalGas10-24-08.pdf.
[32] Authority to manage ground and surface waters is conferred by article 4 of the Compact, and regulated under sections 2.10 and 2.20 of the Delaware River Basin Water Code, *available at* http://www.state.nj.us/drbc/regs/watercode_071608.pdf. Withdrawals exceeding 100,000 gallons daily require DRBC approval. 18 C.F.R. § 401.35(a)(2).

2) On-site pollution control, to the extent that drilling operations could add, discharge or cause the release of water pollutants;[33] and
3) Treatment and disposal of recovered wastewater.[34]

The Commission has made it clear that no project may begin water withdrawal, drill any well, construct any impoundment, or discharge to the ground or surface waters without approval from the Commission.[35]

d. The Draft Regulations

In September 2017, the Commission passed a resolution announcing that they would re-open a process that may lead to banning fracking in the watershed.[36] In November 2017, the Commission issued draft regulations,[37] which include:

- A prohibition on fracking;[38]
- A permit review process for the treatment, storage, and disposal of fracking waste;[39] and
- A permit review process for the withdrawal of water for fracking purposes.[40]

Permanently banning fracking in the watershed would benefit millions of Americans, especially those who live in the basin states of New York, New Jersey, Pennsylvania, Delaware, and Maryland. But if the Commission moves forward with regulations opening the area up to fracking wastewater or to the export of water for fracking uses, the Delaware River would be vulnerable to water contamination, among many other harms, and would be poised to be the epicenter of the next national fracking fight.

e. The Movement Against Fracking in the Delaware River Basin

For over seven years, NRDC and our allies have advocated for a fracking ban in this important region. And since 2011, there has been a *de facto* moratorium on fracking and its associated activities, including the treatment, storage, and disposal of fracking wastewater.

Since then, the movement to ban fracking has grown—fracking is currently banned in New York, Vermont, and Maryland, and in municipalities in fifteen other states. Now, a wide and diverse coalition of environmental, community, and business groups across all five Basin

---

[33] *Id*.
[34] The Commission has authority to control water pollution under article 5 of the Compact. Regulations concerning pollution control are set out in article 3 of the Delaware River Basin Water Code, *supra* note 32.
[35] Del. River Basin Comm'n, *supra* note 31, at 2.
[36] Del. River Basin Comm'n, Resolution for the Minutes (Sept. 13, 2017), *available at* http://www.state.nj.us/drbc/library/documents/ResforMinutes091317_natgas-initiate-rulemkg.pdf.
[37] Proposed Regulations, 83 Fed. Reg. 1586.
[38] *Id.* at 1590.
[39] *Id*. at 1591.
[40] *Id.*

states has organized together to push for a ban on fracking in the Delaware River Basin.[41] This summer, members of the public submitted over 63,000 comments to the Delaware River Basin Commission, an interstate agency that is responsible for regulating water quality in the Delaware River, asking for a fracking ban in the watershed.[42] This included over 10,000 NRDC member comments demanding a full ban.

II. The Commission Rightly Proposes a Ban on Fracking in Order to Protect the Region's Environment and Economic Livelihood

We thank the Commission for proposing a ban on fracking in the watershed.[43] As you know, there is a substantial body of scientific evidence documenting the harms that natural gas development presents to both water quality and the regional economy. Indeed, fracking activity can and has destroyed natural habitats and contaminated water. These, combined with fracking's effects on local air quality and human health, have the potential to significantly harm a regional economy that relies on a healthy population, scenic wilderness, and robust tourism for its livelihood.

a. Fracking Would Significantly Alter Land Use in the River Basin

The most sweeping effect fracking would have in the River Basin would likely result from changes in land use, specifically, the conversion of forested ecosystems into roads, wells, and pipelines for extracting and exporting fracked gas.[44] Fracking-related development can and has harmed wildlife habitat, sensitive lands, and communities, as it tears up forest and pasture land and converts it to gravel and other unnatural and less permeable surfaces, for roads, well pads, and other fracking infrastructure. This activity contributes to habitat fragmentation, and increases stormwater runoff and erosion potential.[45] Fracking also requires heavy truck traffic, and generates noise and light pollution, among other things. Combined, these activities harm natural habitats and the living organisms that depend upon them.

The construction of fracking infrastructure in the River Basin would displace natural habitats. If fracking in the Delaware River Basin were to follow the pattern of shale development in the rest of Pennsylvania, the upper Delaware watershed might experience 2,000

---

[41] Organizations that have publicly opposed fracking in the Delaware River Basin include: Berks Gas Truth, Bucks County Environmental Action, Catskill Mountainkeeper, Clean Water Action New Jersey, CREDO, Delaware Riverkeeper Network, Environment New Jersey, Food and Water Watch, Frack Action, Natural Resources Defense Council, Sierra Club Delaware Chapter, Sierra Club New Jersey Chapter, Sierra Club New York Chapter, Sierra Club Pennsylvania Chapter, 350 Bucks County. Press Release, Delaware Riverkeeper Network, Petitions for a Fracking Ban in Delaware River Watershed to be Submitted to Governors of Four States and the Army Corps of Engineers (July 27, 2017), http://www.delawareriverkeeper.org/sites/default/files/MEDIA ADVISORY.Petition.del_FEDlead7.17.pdf.

[42] Morgan McKay, *Petition Against Fracking Delivered to Gov. Cuomo*, News 10 ABC, Jul. 24, 2017, http://news10.com/2017/07/24/petition-against-fracking-delivered-to-gov-cuomo/.

[43] Proposed Regulations, *supra* note 1.

[44] Steven Habicht, et al., *The Potential Environmental Impact from Fracking in the Delaware River Basin* (2015), https://www.cna.org/CNA_files/PDF/IRM-2015-U-011300-Final.pdf.

[45] NYC Assessment, *supra* note 11, at 32.

wells on 300 to 600 well pads, with 17 to 23 acres of land cover disturbance each, the equivalent of building as many as 840 Walmart Supercenters in an area that is predominantly forest cover.[46]

i. Impacts on Water Quality

It is well-established that land use significantly influences water quality throughout a watershed.[47] Indeed, construction impacts on natural resources such as the clearing of vegetation, erosion of land, compaction of soil, and destruction of forests all have the potential to degrade water quality. These activities can increase both stormwater runoff (i.e., water that 'runs off' the land instead of seeping into the soil) and soil erosion, which together can exacerbate the turbidity and sedimentation in nearby waterbodies, undermining the waterbodies' uses as suitable habitat or spawning area for fish and other aquatic species.[48]

Soil compaction has well-established links to water quality. Compaction occurs at many stages during the construction process—whenever land is graded, or soil is excavated and stored, or when heavy construction equipment is driven over the soil, soil is compacted. Compaction, in turn, harms the ability of soil to absorb precipitation,[49] it also impedes plants from growing or regenerating.[50] When soil absorbs less water, and this effect is compounded by the presence of fewer plants to absorb water, stormwater runoff and erosion intensifies, and turbidity increases in nearby waterbodies.[51] These are not short-term effects. Once soil is compacted, it is very difficult to restore it so that the absorption of surface water or the regrowth of healthy vegetation matches the rates that existed before construction.[52]

While turbidity naturally occurs in rivers during storm events or spring melt, artificially high levels can directly harm fish, plants, and other organisms that dwell in the water.[53] Indeed, while natural erosion produces nearly 30 percent of the total sediment in the United States, human-caused erosion generated by changes in land use accounts for the remaining 70 percent.[54]

---

[46] Habicht, et al., *supra* note 44, at 18, 25.
[47] *See, e.g.,* U.S. Geological Survey, *Does Land Use Affect Our Streams?* (2002), *available at* https://goo.gl/CtsSDx [hereinafter "USGS"].
[48] New York State Dept. of Env. Conservation, Final Supplemental Generic Environmental Impact Statement of Regulatory Program for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs 6-14–15, 51 (2015), *available at* https://goo.gl/EzY83S [hereinafter "NYS SGEIS"].
[49] Meliora Environmental Design, Professional Review & Comment on DEIS 11 (2014), *available at* https://goo.gl/L1jK46 [hereinafter, "Meliora"].
[50] Penn State College of Agriculture Sciences, *Effects of Soil Compaction* (2004), *available at* https://goo.gl/ULQeHq.
[51] Meliora, *supra* note 49, at 11.
[52] *Id.* at 9–10.
[53] John Sigler, et al., *Effects of Chronic Turbidity on Density and Growth of Steelheads and Coho Salmon,* 113 Transactions of the Am. Fisheries Soc'y 142 (1984), *available at* https://goo.gl/sxTMAS.
[54] Mid-America Regional Council, *What is Sediment Pollution?* 2, *available at* https://goo.gl/1nTU7Q (last visited Aug. 8, 2017) [hereinafter "Mid-America Regional Council"].

ii. Impacts on Terrestrial Ecosystems

Vegetation holds soil in place and absorbs precipitation—when it is removed, it can no longer protect soil from the effects of wind and rain, increasing the volume and intensity of stormwater runoff, in turn increasing the potential for soil erosion.[55] The eroded soil then runs into waterbodies, a process known as sedimentation, which contributes to increased turbidity and possibly flooding and habitat loss.[56]

Fracking is especially harmful when it takes place in forests, which must be cleared for roads and other fracking infrastructure. It is well-established in the scientific literature that forest cover is closely linked with nearby water quality—they filter contaminants, regulate stream temperatures, and limit flow after a storm.[57] According to one study, opening the River Basin to fracking could lead to a 1 to 2 percent loss of total forest land in fracking areas, and between 5 and 10 percent loss of core forest,[58] or the loss of up to 40,000 acres of forest.[59] In addition to increased turbidity, reductions in forest cover provoke increases in nitrogen, phosphorus, sodium, chlorides, and sulfates in water.[60] In the River Basin, dense forest cover provides the region with a variety of ecosystem services, such as carbon sequestration, clean air, aquifer recharge, and recreation/eco-tourism.[61] The forests also play a key role in maintaining the water quality of the Delaware River, which, as noted, supplies drinking water to over 17 million people.[62]

iii. Impacts on Organisms

As water quality deteriorates, aquatic species, such as plants, fish, mollusks, crustaceans, and insects, may suffer—both in the short and long-term.[63] Fish, plants, and other aquatic species have evolved to thrive in habitats with particular characteristics. Aquatic species require narrow ranges of water temperatures, certain natural features for feeding and spawning, and particular levels of turbidity. Changes to any of these characteristics can significantly harm populations of fish, plants, and other organisms that rely on these qualities for survival.

For example, healthy streams typically have gravel bottoms and cobble bars free of mud and sediment. These provide fish and other aquatic animals with spawning areas.[64] They also provide benthic invertebrates, such as mussels and crustaceans, space for attachment, protection,

---

[55] *Id.*
[56] *Id.*
[57] *See, e.g.,* Delphine Brogna et al., *Linking Forest Cover to Water Quality*, 9 Water 176 (2017), *available at* https://goo.gl/dwzc6i; U.S. Forest Services, Watershed Services: The Important Link Between Forests and Water (2007), *available at* https://goo.gl/Sm7WDi.
[58] Habicht, et al., *supra* note 44, at 17.
[59] *Id*. at 18.
[60] *Id.*
[61] *Id.* at 19.
[62] *Id.*
[63] J. M. Castro et al., *Risk-Based Approach to Designing and Reviewing Pipeline Stream Crossings to Minimize Impacts to Aquatic Habitats and Species*, 31 River. Res. & Application 767, 767 (2015), *available at* https://goo.gl/5gtBgx [hereinafter "Castro"].
[64] Meliora, *supra* note 49, at 13.

feeding, and oxygen consumption.[65] When sediment settles, it smothers fish eggs, destroys the primary habitat for many benthic invertebrates, and deprives fish of a key food source (i.e., invertebrates).[66]

Increased sedimentation and turbidity can also lead to increased water temperatures.[67] Compounding this effect, the loss of vegetation near streams can remove shade cover and increase water temperatures.[68] Warmer waters can damage habitat for aquatic animals, rendering their habitats unlivable.[69] For instance, trout, a type of fish known to populate streams and rivers of the River Basin,[70] require clean, cold, fast-flowing water for survival.[71] Activities such as the removal of upland forest can easily convert the natural habitat into "still, warm, silty waterways incapable of supporting trout."[72] Sedimentation hurts trout population in many ways—for example, trout rely on riffles for propagation.[73] And, as mentioned earlier, sedimentation, combined with the removal of protective vegetative cover, leads to increased water temperatures,[74] which is detrimental to trout populations in a number of ways—brook trout, for example, grow more slowly,[75] and are more likely to die of proliferative kidney disease, a parasitic infection, in higher water temperatures.[76] Additionally, as water temperatures rise, the level of dissolved oxygen decreases, depriving trout of oxygen needed to respire.[77]

Fracking can also harm some song birds populations. In one study of the effect of fracking operations on songbird populations in Canada, researchers found that regional declines of some songbird species, especially sagebrush-obligates.[78] Decreases in certain songbird populations have been attributed to the introduction and spread of invasive species, like crested

---

[65] Lucie Levesque & Monique Dube, *Review of the Effects of In-Stream Pipeline Crossing Construction on Aquatic Ecosystem*s, 132 Envtl. Monitoring & Assessment 395, 400 (2007), *available at* https://goo.gl/N2soGd [hereinafter "Levesque"].
[66] *Id.* at 400–02.
[67] Meliora, *supra* note 49, at 13.
[68] Heidelinde Trimmel, et al., *Can Riparian Vegetation Shade Mitigate the Expected Rise In Stream Temperatures Due to Climate Change During Heat Waves In a Human-Impacted Pre-Alpine River?*, 22 Hydrol. Earth Syst. Sci., 437, 437 (2018), https://doi.org/10.5194/hess-22-437-2018.
[69] U.S. Fish and Wildlife Service, *Habitat Suitability Information: Rainbow Trout* 4 (1984), *available at* https://goo.gl/7FMk6u [hereinafter "FWS"].
[70] Trout Unlimited, Upper Delaware Watershed Home Rivers Initiative, https://www.tu.org/tu-projects/upper-delaware-watershed-home-rivers-initiative (last visited Mar. 30, 2018).
[71] DEC, *Trout*, https://goo.gl/Eaj8XG (last visited Aug. 8, 2017) [hereinafter "DEC Trout"].
[72] *Id.*
[73] FWS, *supra* note 69, at 4.
[74] Meliora, *supra* note 49, at 13.
[75] Cailin Xu et al., *Context-Specific Influence of Water Temperature on Brook Trout Growth Rates in the Field*, 55 Freshwater Biology 2253 (2010), *available at* https://goo.gl/iu67kE.
[76] K. Bettge et al., *Proliferative Kidney Disease (PKD) of Rainbow Trout: Temperature- and Time-Related Changes of Tetracapsuloides Bryosalmonae DNA in the Kidney*, 136 Parasitology 615 (2009), *available at* https://goo.gl/MHkiQq.
[77] FWS, *supra* note 69, at 6.
[78] Michelle M. Gilbert & Anna D. Chalfoun, *Energy Development Affects Populations Of Sagebrush Songbirds In Wyoming*, 75 The Journal of Wildlife Management 816 (2011), https://doi.org/10.1002/jwmg.123.

wheatgrass, and the creation of access trails to well pads, which can fragment native species' habitats.[79]

This new construction for fracking also encourages the growth and spread of invasive species. In a study of Pennsylvania forests that overlay the Marcellus and Utica shale formations, researchers found invasive plant species in over half of the new well pads constructed.[80]

Finally, for people living near fracking operations, residents complain of continuous noise and light pollution that is sustained for months.[81] Financial and other strains on municipal services include those on law enforcement, road maintenance, emergency services, and public school administration have been reported. Drilling and fracking operations pose an inherent conflict with mortgage and property insurance due to the hazardous materials used and associated risks,[82] and therefore may have a negative financial impact on homeowners.

b. Fracking Can and Has Contaminated Water

Fracking can and has harmed local water quality, including drinking water. The fracking process utilizes over 1,000 chemical additives, many of which are toxic and potentially carcinogenic.[83] Stray gas can also move into groundwater supplies, rendering drinking water flammable. Indeed, fracking's potential to harm surface and groundwater is one of the most harmful aspects of the fracking process, and as explained in Part III, can harm people and habitats far from the fracking well.

i. Fracking Fluid

The fracking process involves pumping fracking fluid, a mixture of water and other additives, into a fracking well in order to free methane trapped in the rock.[84] The ingredients used in fracking fluid consist primarily of fresh or recycled water, along with chemicals used to modify the water's characteristics (for example, to reduce friction or corrosion) and sand or other agents that hold open the fractures in a shale formation as gas is extracted.[85] Of the fracking fluid that is used at a fracking well, approximately 10 to 50 percent or more of it returns to the

---

[79] Sarah M. Ludlow, et al., *Oil and Natural Gas Development Has Mixed Effects on the Density and Reproductive Success of Grassland Songbirds*, 117 The Condor 64 (2015), https://doi.org/10.1650/CONDOR-14-79.1.
[80] Barlow et al., *Unconventional Gas Development Facilitates Plant Invasions*, 202 Journal of Environmental Management, 208 (2017).
[81] Concerned Health Professionals of New York & Physicians for Social Responsibility, *Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction), Fifth Edition* 126 (2018), http://concernedhealthny.org/compendium/.
[82] *Id.* at 224.
[83] Elise G. Elliott, et al., *A Systematic Evaluation of Chemicals In Hydraulic-Fracturing Fluids and Wastewater for Reproductive and Developmental Toxicity*, 27 Journal of Exposure Science and Environmental Epidemiology 90 (2017).
[84] NYC Assessment, *supra* note 11.
[85] Schreiber, *supra* note 4, at 1.

surface.[86] This water is then trucked offsite for treatment and disposal—approximately 600 to 865 truck trips per fracking well are used for the transport of water and wastewater alone.[87]

Because each fracking event requires between 80 and 300 tons of chemicals,[88] fracking generates massive amounts of polluted wastewater that threaten the health of our drinking water supplies, rivers, streams, and groundwater. And threats to water quality are present not only at the fracking well—the transportation, treatment, and disposal of fracking wastewater can also degrade source water quality, impair long-term watershed health, and expose watershed residents to chronic low levels of toxic chemicals.[89]

ii. Fracking Wastewater Composition

The fracking process generates two types of wastewater: "flowback" (the fracturing fluid injected into a gas well that returns to the surface during or closely after the time of drilling) and "produced water" (all wastewater emerging from the well after completion of drilling operations, much of which is brine contained within the shale formation).

A wide variety of chemicals are known to be used for fracking fluid, and can make up to 0.5 to 2 percent of the entire solution.[90] And while the relative proportion of chemicals in fracking fluid as compared to water or sand is low, the total amount of chemicals used is still very large, and just a small concentration of chemicals is sufficient to harm the health of water bodies. Assuming about 4 million gallons are used per fracking well, this means about 80 to 300 tons of chemicals are used per well.[91]

Because fracking companies can conceal the exact composition of their fracking fluid, the exact chemical composition of fracking wastewater that would be treated in the basin is unknown. Even if it were known, there is "very limited" compound-specific toxicity data for many of the over 1,000 chemicals present in fracking wastewater.[92] This dearth of information makes it extremely difficult to know for certain what effect fracking wastewater will have on human health and the environment.[93]

Generally speaking, however, the major constituents of concern that are present in wastewater are (1) salt, including metals, (2) organic hydrocarbons (sometimes referred to as "oil and grease"), (3) inorganic and organic additives, and (4) naturally occurring radioactive material (NORM). These pollutants can be dangerous if they are released into the environment or if

---

[86] NYC Assessment, *supra* note 11, at 6.
[87] *Id.* at 33.
[88] *Id.*
[89] *Id.* at ES-3.
[90] *Id.* at 5.
[91] *Id.* at 33.
[92] *Id.* at 36.
[93] Matthew McFeeley, *NRDC Issue Brief: State Hydraulic Fracturing Disclosure Rules and Enforcement: A Comparison* (2012), https://www.nrdc.org/sites/default/files/Fracking-Disclosure-IB.pdf. As of March 2017, Pennsylvania requires fracking operators to complete and submit a list of chemicals used during the fracking process on the website, FracFocus.org. However, operators are allowed to withhold these chemicals from public disclosure if they consider a chemical or the concentration of a chemical to be a trade secret. 58 Pa.C.S.A. § 3222.1.

people are exposed to them. Some contaminants (e.g., benzene, toluene, ethylbenzene, and xylenes) can be toxic to humans and aquatic life, radioactive, or corrosive.

iii. Fracking Wastewater Is Harmful to Human Health

While the components of fracking wastewater vary from well to well, a number of chemical additives commonly used in fracking have been associated with negative health effects. One study found that more than 75 percent of the chemicals used in fracking are associated with adverse effects on the skin, eyes, respiratory and gastrointestinal systems, about 40 percent could have effects on the brain/nervous system, immune and cardiovascular systems, the kidneys and endocrine system, and 25 percent are associated with cancer and mutations.[94] Even very low doses of certain chemicals in drinking water, especially known or suspected carcinogens and endocrine disrupting compounds, can be dangerous to human health.[95] To date, no one has compiled a comprehensive inventory of all the components of fracking wastewater and their associated health risks.

A 2011 report by the Minority Staff of the U.S. House of Representatives Committee on Energy and Commerce identified at least 29 chemical additives known to be present in wastewater that are (1) known or possible human carcinogens (such as naphthalene, benzene, and acrylamide); (2) regulated under the Safe Drinking Water Act for their risks to human health (such as toluene, ethylbenzene, and xylenes, which can damage the central nervous system, liver, and kidneys[96]); or (3) listed as hazardous air pollutants under the Clean Air Act.[97] That list, while significant, is just a portion of the chemicals in wastewater that are known to harm humans.

Significantly, the report omitted chemicals that have been associated with non-cancer health effects but that are not regulated by the Safe Drinking Water Act or the Clean Water Act. For example, the list does not include contaminants that are on EPA's Candidate Contaminant List, a list of unregulated contaminants that are known or anticipated to occur in public water systems and that may require regulation under the Safe Drinking Water Act.[98] At least 8 chemicals on the Candidate Contaminant List—1-butanol, acetaldehyde, benzyl chloride,

---

[94] T. Colborn, et al., *Natural Gas Operations from a Public Health Perspective*, 17 Human and Ecological Risk Assessment: An International Journal 1039 (2011), http://dx.doi.org/10.1080/10807039.2011.605662.
[95] NYC Assessment, *supra* note 11, at 36.
[96] EPA, *Basic Information about Toluene in Drinking Water, Basic Information about Ethylbenzene in Drinking Water, and Basic Information about Xylenes in Drinking Water*, http://water.epa.gov/drink/contaminants/basicinformation/index.cfm (accessed Oct. 14, 2010).
[97] These include: Methanol (Methyl alcohol), Ethylene glycol (1,2-ethanediol), Diesel, Naphthalene, Xylene, Hydrogen chloride (Hydrochloric acid), Toluene, Ethylbenzen , Diethanolamine (2,2-iminodiethanol), Formaldehyde, Sulfuric acid, Thiourea, Benzyl chloride, Cumene, Nitrilotriacetic acid, Dimethyl formamide, Phenol, Benzene, 3 Di (2-ethylhexyl) phthalate, Acrylamide, Hydrogen fluoride (Hydrofluoric acid), Phthalic anhydride, Acetaldehyde, Acetophenone, Copper, Ethylene oxide, Lead, Propylene oxide, and p-Xylene. U.S. House of Representatives, Committee on Energy and Commerce, Minority Staff, *Chemicals Used in Hydraulic Fracturing* 8-9 (2011), *available at* http://www.conservation.ca.gov/dog/general_information/Documents/Hydraulic%20Fracturing%20Report%204%2018%2011.pdf.
[98] 42 U.S.C. § 300g-1(b)(B)(i)(I).

ethylene glycol, ethylene oxide, formaldehyde, methanol, n-methyl-2-pyrrolidone—are known to have been used in fracking fluid.[99] In addition, chemicals like 2-butoxyethanol (2BE), which is also not included, has been shown to cause hemolysis (destruction of red blood cells) and damage to the spleen, liver, and bone marrow, and is easily absorbed and rapidly distributed in humans following inhalation, ingestion, or dermal exposure.[100]

The following section provides just a small sample of the known components of fracking waste and their associated health risks:[101]

Acetone. In several studies, workers exposed to very high levels of acetone via inhalation complained of headache, lightheadedness, unsteadiness and confusion.[102] Animals exposed to large amounts by ingestion had bone marrow hypoplasia (fewer new cells being produced), degeneration of the kidneys, increased liver weights, and listlessness.[103] Pregnant mice that swallowed acetone had lower body weights and produced fewer newborn mice.

Benzene. Eating foods or drinking liquids containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, coma, and death.[104] Benzene causes effects on normal blood production and can lead to a decrease in red blood cells (anemia).[105] Excessive exposure to benzene can be harmful to the immune system, increasing the chance of infection and perhaps lowering the body's defense against cancer. Long-term exposure to benzene can cause cancer of the blood-forming organs (leukemia).[106] In addition, benzene may be harmful to reproductive organs and the developing fetus.[107]

Cyanide. Cyanide enters air, water, and soil from both natural processes and industrial activities.[108] Many are powerful and rapid-acting poisons, affecting the nervous system and capable of causing death at high concentrations.[109] As the cyanide goes through the body, it can affect the thyroid gland, reducing the ability of the gland to produce hormones that are necessary for the normal function of the body.[110]

---

[99] U.S. House of Representatives, *supra* note 99, at 8-9; Drinking Water Contaminant Candidate List 4—Final, 81 Fed. Reg. 81099-01.
[100] EPA, *Toxicological Review of Ethylene Glycol Monobutyl Ether* 4 (2010), https://cfpub.epa.gov/ncea/iris/iris_documents/documents/toxreviews/0500tr.pdf. *See also* U.S. House of Representatives, *supra* note 99, at 7.
[101] Schreiber, *supra* note 4, at 9 – 14.
[102] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, *Toxicological Profile For Acetone* (1994), https://www.atsdr.cdc.gov/toxprofiles/tp21.pdf.
[103] *Id.*
[104] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, *Toxicological Profile for Benzene* (2007), https://www.atsdr.cdc.gov/toxprofiles/tp3.pdf.
[105] *Id.*
[106] *Id.*
[107] *Id.*
[108] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, Toxicological Profile for Cyanide (2006), https://www.atsdr.cdc.gov/toxprofiles/tp8.pdf.
[109] *Id.*
[110] *Id.*

Total Trihalomethanes (TTHMs): Bromoform, Chloroform, Dichlorobromomethane and Dibromochloromethane. The main effect of swallowing or breathing large amounts of bromoform is a slowing of normal brain activities, resulting in sleepiness or sedation, which tends to subside after exposure ceases.[111] Some studies in animals indicate that exposure to high doses of bromoform or dibromochloromethane may also lead to liver and kidney injury, and can cause liver and kidney cancer. [112] The EPA classified bromoform as a probable human carcinogen and dibromochloromethane as a possible human carcinogen.[113]

Ethylbenzene. Exposure to high levels of ethylbenzene in air can cause eye and throat irritation, vertigo and dizziness.[114] Relatively low levels of ethylbenzene in air resulted in potentially irreversible damage to the inner ear and hearing of animals.[115] Rats exposed to large amounts of ethylbenzene by mouth had severe damage to the inner ear.[116] There is also limited information suggesting minor birth defects and low birthweight in newborn animals whose mothers were exposed air containing ethylbenzene.[117]

Phenols. Ingestion of liquid products containing concentrated phenol can cause serious gastrointestinal damage and even death.[118] Inhalation of high levels of phenol has caused irritation of the respiratory tract and muscle twitching in animals.[119] Longer term inhalation exposure to high levels of phenol caused damage to the heart, kidneys, liver, and lungs in animals.[120] Drinking water with extremely high concentrations of phenol has caused muscle tremors, difficulty walking, and death in animals.[121]

Radium. The Marcellus Shale is also known to have high uranium content, which produces a decay product radium-226, at levels that can exceed 10,000 picocuries per liter (pCi/L) in the concentrated brine. As a result, radionuclides are present in drilling waste.[122]

---

[111] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, *Toxicological Profile for Bromoform and Dibromochloromethane* (2005), https://www.atsdr.cdc.gov/toxprofiles/tp130.pdf.
[112] *Id.*
[113] U.S. Env. Prot. Agency, Fact Sheet: Bromoform (2016), https://www.epa.gov/sites/production/files/2016-09/documents/bromoform.pdf; U.S. Env. Prot. Agency, Integrated Risk Information System (IRIS): Dibromochloromethane (1992), https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0222_summary.pdf#nameddest=woe.
[114] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, *Toxicological Profile for Ethylbenzene* (2010), https://www.atsdr.cdc.gov/toxprofiles/tp110.pdf.
[115] *Id.*
[116] *Id.*
[117] *Id.*
[118] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, *Toxicological Profile for Phenol* (2008), https://www.atsdr.cdc.gov/toxprofiles/tp115.pdf.
[119] *Id.*
[120] *Id.*
[121] *Id.*
[122] Schreiber, *supra* note 4, at 12 – 13. (citing A. Nelson, et al., *Understanding the Radioactive Ingrowth and Decay of Naturally Occurring Radioactive Materials in the Environment: An Analysis of Produced Fluids from the Marcellus Shale,* 123 Environ. Health Perspect.689 (2015); V. Brown, *Radionuclides in Fracking Wastewater: Managing a Toxic Blend.*, 122 Environ. Health Perspect. A50 (2014).

Evaluation of drill cuttings and produced waters from Marcellus wells confirms that elevated levels of radioactivity are not uncommon for wastewaters associated with Marcellus Shale development.[123] While radium is naturally present in the environment, it is usually present at very low levels. At more elevated levels, radiation has been shown to cause adverse health effects such as anemia, cataracts, fractured teeth, cancer and death. Although there is some uncertainty as to how much exposure to radium increases your chances of developing a harmful effect, the greater the total amount of your exposure to radium, the more likely you are to develop one of these diseases.[124]

Toluene. Toluene may have an effect on the nervous system (brain and nerves) after exposure; these effects may be temporary, such as headache, dizziness, or unconsciousness.[125] However, some effects such as incoordination, cognitive impairment, and vision and hearing loss may become permanent with repeated exposure, especially at high concentrations.[126] High levels of toluene exposure during pregnancy, such as those associated with solvent abuse, may lead to retardation of mental abilities and growth in children.[127] Other health effects of potential concern may include immune, kidney, liver, and reproductive effects.[128] Some studies in people have sown reproductive effects, such as an increased risk of spontaneous abortions, from high levels of toluene in the workplace.[129] Additionally, exposure to high levels of toluene could possibly cause liver and kidney damage.[130]

Total Petroleum Hydrocarbons. Total Petroleum Hydrocarbons (TPH) is a term used to describe a broad family of several hundred chemical compounds that originally come from crude oil. Some of the TPH chemicals, such as the smaller compounds benzene, toluene and xylene (which are present in gasoline) can affect the human central nervous system, blood, immune system, liver, spleen, kidneys, developing fetus, and lungs.[131]

Xylenes. There are three forms of xylene, with very similar effects on health. Short-term exposure to high levels of xylenes can cause irritation of the skin, eyes, nose and throat; difficulty breathing; impaired function of the lungs; delayed response to a visual stimulus; impaired memory; stomach discomfort; and possible changes in the liver and kidneys.[132] Both short-term and long-term exposure to high levels of xylenes can cause effects on the nervous

---

[123] Marvin Resnikoff, et al., Residents for the Preservation of Lowman and Chemung (RFPLC), *Radioactivity in Marcellus Shale* (2010), http://www.rwma.com/Marcellus%20Shale%20Report%205-18-2010.pdf.
[124] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, *Toxicological Profile for Radium* (1990), https://www.atsdr.cdc.gov/toxprofiles/tp144.pdf.
[125] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, *Toxicological Profile for Toluene* (2017), https://www.atsdr.cdc.gov/toxprofiles/tp56.pdf.
[126] *Id.*
[127] *Id.*
[128] *Id.*
[129] *Id.*
[130] *Id.*
[131] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, *Toxicological Profile for Total Petroleum Hydrocarbons (TPH)* (1999), https://www.atsdr.cdc.gov/toxprofiles/tp123.pdf.
[132] Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services, *Toxicological Profile for Xylene* (2007), https://www.atsdr.cdc.gov/toxprofiles/tp71.pdf.

system such as headaches, lack of muscle coordination, dizziness, confusion, and changes in one's sense of balance.[133] The results of animal studies indicate that large amounts of xylenes can cause changes in the liver and harmful effects on the kidneys, lungs, heart, and nervous system.[134] Long-term exposure of animals to low concentrations of xylenes has not been well studied, but there is some information that long-term exposure of animals can cause harmful effects on the kidney (with oral exposure) or on the nervous system (with inhalation exposure).[135]

iv. Fracking Wastewater Is Harmful to the Environment

In addition to adverse effects on human health, fracking wastewater has also been found to harm the environment. Certain chemicals found in fracking wastewater, such as ammonia, can damage ecosystem health by depleting oxygen or causing algal blooms, or they can interact with disinfectants at drinking water plants to form cancer-causing chemicals.[136] Some others are a concern because they can affect the beneficial use of the water downstream (e.g., sulfate, which can make drinking water taste bad), and still others can disrupt ecosystems (e.g., chloride, which alters fish reproduction).[137]

Fracking wastewater has also been found to increase plant mortality and lower streambed diversity.[138] Exposure to wastewater has been shown to increase plant mortality of terrestrial plants, reduce juvenile mussel survival rates, and lower streambed microbial diversity.[139] Spills or intentional discharges of fracking waste into streams has adversely affected the ecology and aquatic biodiversity and populations of sensitive fish species, such as brook trout,[140] and the quantity and quality of aquatic, wetland, and terrestrial habitats and the biota that they support.[141]

Discharges of Total Dissolved Solids (TDS), sulfates, and chlorides into the receiving surface water are the primary cause of harm to aquatic species.[142] Brine and fracking wastewater have high concentrations of TDS, which increase salinity and can rebond with other more toxic metals, increasing the toxicity of the receiving waters.[143] Several studies on the potential effect of discharges of TDS into water have found that the discharge of TDS lead to decreases in existing

---

[133] *Id.*
[134] *Id.*
[135] *Id.*
[136] NRDC, *In Fracking's Wake*, *supra* note 3, at 6.
[137] *Id.*
[138] Schreiber *supra* note 4, at 20 – 21.
[139] Kelly O. Maloney, et al., *Unconventional Oil and Gas Spills: Materials, Volumes, and Risks to Surface Waters in Four States of the U.S.*, 581-582 Science of the Total Environment 369 (2017).
[140] Concerned Health Professionals of New York & Physicians for Social Responsibility, supra note 81, at 48.
[141] New York State Dept. of Health, A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development (2014), https://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf.
[142] Pennsylvania Dept. of Env. Prot., P*ermitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges* (2009), http://files.dep.state.pa.us/Water/Wastewater%20Management/WastewaterPortalFiles/MarcellusShaleWastewaterPartnership/high_tds_wastewater_strategy_041109.pdf.
[143] *Id.*

freshwater organisms in the receiving waters, and an increase in brackish water organisms, indicating a shift in biotic communities.[144]

Moreover, salts, metals and organics are core components of most fracking wastewater, and are all known to induce oxidative stress in fish.[145] Other studies have also shown changes in fish gill morphology in response to waterborne metals, organic toxicants, and elevated salts.[146] In fact, acute exposure of fracking wastewater to rainbow trout was found to generate oxidative stress in the gills and liver, and morphological changes in the gills.[147]

Given the known harms associated with fracking wastewater on plant survival, it is not a surprise that fracking wastewater has also been found to hurt farms. Soil quality, if contaminated or compacted by drilling or infrastructure, can reduce crop yield and quality.[148] Studies and case reports from across the country have also found instances of deaths, neurological disorders, aborted pregnancies, and stillbirths in animals that have come in contact with wastewater.[149]

In California, farmers who used fracking wastewater for crop irrigation and livestock watering reported damage to the timber sector.[150] When studied, the wastewater in question was found to contain at least ten known or suspected carcinogens, as well as over a dozen chemicals with no available toxicological data, and many unidentified compounds currently classified as "trade secrets."[151] Changes in the number of working farms, as a result of drilling or contamination, was found in a Pennsylvania study where dairy farmers sold their property and moved.[152]

Understandably, farmers have concerns that the fracking process and wastes could invalidate organic certification.

v. Wherever There is Fracking Fluid, There are Spills

Fracking fluid can spill into surface water bodies at every stage before, during, and after the fracking process—during transportation of the fracking fluid to the well site, during storage and handling of the fluid at drill sites, and afterwards, when fracking wastewater is being trucked from well pads for treatment and disposal.[153] Spills or releases can result from tank ruptures, piping failures, equipment or surface impoundment failures, overfills, vandalism, accidents (including vehicle collisions), ground fires, drilling and production equipment defects, or

---

[144] *Id.*
[145] V. I. Lushchak, *Environmentally Induced Oxidative Stress in Aquatic Animals,* 101 Aquat. Toxicol. 13 (2011).
[146] *Id.*; Blewett, et al. *The Effect of Hydraulic Flowback and Produced Water On Gill Morphology, Oxidative Stress and Antioxidant Response in Rainbow Trout (Oncorhynchus Mykiss)*, 7 Scientific Reports 2 (2017), https://www.nature.com/articles/srep46582.
[147] *Id.*
[148] Delaware Riverkeeper Network, *Docket #PF14-8: Scoping Comment for the EIS for William's Atlantic Sunrise Project* (2014), https://goo.gl/LH1TEP.
[149] Concerned Health Professionals of New York & Physicians for Social Responsibility, supra note 81, at 164.
[150] *Id.* at 163.
[151] *Id.*
[152] Delaware Riverkeeper Network, *supra* note 148, at 14.
[153] NYS SGEIS, *supra* note 48, at 6-14.

improper operations. From there, spilled, leaked, or released fluids could flow to a surface water body or infiltrate the ground, reaching subsurface soils and aquifers.[154] These chemicals can move beyond the fracking zone to groundwater, streams, reservoirs, and eventually water supplies.

The opportunities for spills are not theoretical. Spills have occurred wherever fracking or transport of fracking fluid or wastewater has occurred. In 2009, EPA conducted a study evaluating the impact of fracking on the water cycle, and found that fracking activities have caused contamination of water resources.[155]

Indeed, spills and leaks account for many of the environmental violations cited in connection with shale gas development by the Pennsylvania Department of Environmental Protection.[156] According to EPA, between May 2009 and April 2013, there were eight reported spills of fracking wastewater in Pennsylvania, ranging from more than 4,000 gallons to more than 57,000 gallons reached surface water resources. The spills were reported to have resulted in local impacts to environmental receptors, requiring remediation and monitoring. The number of reported spills is likely an underestimate. Legal action in Pennsylvania alleging long-term illegal dumping raises questions about the difficulty of detecting this behavior and quantifying it on a regional basis.[157]

In another study of spills related to fracking activities across Colorado, New Mexico, North Dakota and Pennsylvania, from 2005 through 2014, 6,622 spills were reported in an area that contained 21,000 fracking wells, amounting to a 32 percent spill rate over the period.[158]

In the province of Alberta, Canada, an estimated 2,500 fracking wastewater spills occurred from 2005 to 2012, with more than 113 of those spills entering directly into freshwater lakes and streams.[159]

---

[154] *Id.* at 6-15. Spills or releases can occur as a result of tank ruptures, piping failures, equipment or surface impoundment failures, overfills, vandalism, accidents (including vehicle collisions), ground fires, drilling and production equipment defects, or improper operations. Spilled, leaked or released fluids could flow to a surface water body or infiltrate the ground, reaching subsurface soils and aquifers.
[155] U.S. Env. Prot. Agency, *Hydraulic Fracturing for Oil and Gas: Impacts from Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States* (2016), www.epa.gov/hfstudy.
[156] *See, e.g.*, *3,400 Gallons of Frack Water Spilled in Accident*, Lockhaven Express, Feb. 22, 2011, http://www.lockhaven.com/page/content.detail/id/529606/3-400-gallons-of-frack-water-spilled-in-accident.html; *see also* New York State Water Resources Institute, *Spills and Leaks Associated with Shale Gas Development* 4 (2011), http://wri.eas.cornell.edu/gas_wells_20_690970228.pdf.
[157] Jonathan D. Silver, *State Charges Local Company for Dumping Wastewater and Sludge*, Pittsburgh PostGazette, Mar. 18, 2011, http://www.post-gazette.com/pg/11077/1132812-454.stm; Kaitlynn Riely, *Greene County Man Pleads Guilty to Illegally Dumping Liquid Waste*, Pittsburgh Post-Gazette, Feb. 11, 2012, http://www.post-gazette.com/pg/12042/1209625-503.stm.
[158] Kelly O. Maloney, et al., *Unconventional Oil and Gas Spills: Materials, Volumes, and Risks to Surface Waters in Four States of the U.S.*, 581-582 Science of the Total Environment 369 (2017).
[159] D. S. Alessi et al., *Comparative Analysis of Hydraulic Fracturing Wastewater Practices in Unconventional Shale Development, Water Sourcing, Treatment, and Disposal Practices*. 42 Can. Wat. Resour. J. 105 (2016).

The effects of fracking wastewater spills are not abstract. In 2004, gas and other contaminants were found to have leaked from a nearby fracking wellbore into the drinking water of residents of Garfield County, CO. The drinking water was found to be contaminated with methane and BTEX compounds. Some domestic water wells were also found to have concentrations of arsenic that exceeded health-based standards and concentrations of chloride, iron, manganese, and/or total dissolved solids (TDS) which exceeded aesthetic-based standards.[160]

In 2009, over the span of less than one week, three significant spills of hydraulic fracturing fluid occurred at the same natural gas well pad in Dimock, totaling 8,000 gallons. The leaks resulted from faulty supply pipes, and seeped into wetlands and a stream, killing fish. The fracking fluid included a liquid gel produced by Haliburton known as, "LGC-35," which can lead to skin cancer and may cause headaches, dizziness, and other central nervous system effects. As a result of multiple accidents in Dimock, residents reported their water turning brown, suffering from headaches and skin sores from showering, and observing hair and fur loss in horses and pets.[161]

In 2013, a natural gas well pad operated by Carrizo Gas Company burst in Tunkhannock, Wyoming County, releasing thousands of gallons of fracking fluid into the local environment and nearby wetlands, and causing the evacuation of several nearby homes. The spill occurred because bolts within the wellhead were too loose and became unfastened, allowing a liquid mixture of water, sand, hydrochloric acid and other hazardous chemicals to flow out. At one point, 800 gallons of fluid were spewing out per minute, and the overall rate was between 25,000 and 35,000 gallons per hour. The flow lasted for as long as 18 hours, during which the road leading to the site was blocked off and several families were asked to evacuate for fear that methane gas could escape the well and explode.[162]

In 2015, a four-inch pipeline operated by Summit Midstream Partners LP burst north of Williston, North Dakota, leaking almost 3 million gallons of saltwater brine, a byproduct of hydraulic fracturing.[163] The fracking brine spilled into Blacktail Creek, which flows into the

---

[160] Briana Mordick, *Risks to Drinking Water from Oil and Gas Wellbore Construction and Integrity: Case Studies and Lessons Learned,* https://www.epa.gov/sites/production/files/documents/riskstodrinkingwaterfromoilandgaswellboreconstructionandintegrity.pdf (last accessed Mar. 28, 2018).

[161] Amy Mall, *Dimock, Pennsylvania: A Community Paying the Price for Natural Gas Production With Hydraulic Fracturing Fluid Spills*, NRDC Expert Blog, Sept. 23, 2009, https://www.nrdc.org/experts/amy-mall/dimock-pennsylvania-community-paying-price-natural-gas-production-hydraulic; Press Release, Pennsylvania Dept. of Env. Prot., DEP Orders Cabot Oil and Gas to Cease All Gas Well Fracking in Susquehanna County (Sept. 25, 2009) http://www.uppermon.org/news/Other/PA-DEP-DEP_Orders_Cabot_2_Cease_Fracking-25Sept9.html; Press Release, Pennsylvania Dept. of Env. Prot., Company Must Properly Clean Up Susquehanna County Gel Spill (Sept. 23, 2009), http://www.uppermon.org/news/Pgh-Alleg/PA-DEP_Release_Cabot_Spill-23Sept09.html.

[162] Marie Cusick, *After Fracking Wastewater Spill, Residents and Regulators Believe Water Is Safe*, State Impact, Mar. 19, 2013, https://stateimpact.npr.org/pennsylvania/2013/03/19/after-fracking-wastewater-spill-residents-and-regulators-believe-water-is-safe/.

[163] Rebecca Jacobson, *Fracking Brine Leak In North Dakota Reaches Missouri River, Prompts State Democrats to Call For More Regulation*, PBS News Hour, Jan 26, 2015, https://www.pbs.org/newshour/nation/fracking-brine-leak-north-dakota-reaches-missouri-river-prompts-state-democrats-call-regulation.

Missouri River, the drinking water source for Williston.[164] Later that month, officials found chloride concentrations in the creek to be as high as 92,000 mg/L, much higher than normal concentrations of about 10 to 20 mg/L.[165] In samples taken a year later, soil and sediment downstream of the spill site had radium concentrations up to 100 times as great as in samples upstream.[166]

In 2009, after conducting a thorough assessment of the environmental impacts of fracking, New York City concluded that "[i]t is reasonable to expect that development of natural gas resources in the watershed will be accompanied by an increased frequency of chemical, wastewater and fuel spills at or near wellpads."[167] And strict regulations are not enough to prevent these spills—"Even with appropriate BMPs and regulations . . . mechanical failures, human errors, and accidents are inevitable."[168] In the end, New York City determined that fracking was "incompatible" with its reservoir system, and that it would pose "unacceptable risks" to the city's drinking water supply.[169]

The list goes on, and would invariably include accidents in the River Basin if tracking were permitted there.

c. Fracking Pollutes the Air

In accordance with the Compact, the Commission is empowered to regulate water flow and quality in order to, among other things, protect the public health in the region.[170] As explained below, air pollution generated from fracking activities can and has directly harmed human health. Indeed, there are 143 air pollutants released by the fracking process and from fracking wastewater. Fracking emits PM and ozone, two of the six "criteria pollutants" regulated by the EPA because of their harmful effects on health and the environment. In 2014, NRDC released a report detailing the harmful effects of fracking on air quality and public health.[171] In short, it found that the fracking process emits airborne pollutants at and near fracking sites that are known to cause cancer and harm the nervous, respiratory, and immune systems.

---

[164] *Id.*
[165] Katie Valentine, *Nearly 3 Million Gallons Of Drilling Waste Spill From North Dakota Pipeline*, Think Progress, Jan. 22, 2015, https://thinkprogress.org/nearly-3-million-gallons-of-drilling-waste-spill-from-north-dakota-pipeline-3690ea16c937/.
[166] Deirdre Lockwood, *Toxic Chemicals From Fracking Wastewater Spills Can Persist For Years*, Chemical & Engineering News, May 20, 2016, https://cen.acs.org/articles/94/web/2016/05/Toxic-chemicals-fracking-wastewater-spills.html.
[167] NYC Assessment, *supra* note 11, at 39.
[168] *Id.*
[169] New York City, (2009), http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/nycdep_comments_final_12-22-09.pdf; *see also* NYC Assessment, *supra* note 11.
[170] Compact, at 2, §§ 4.2, 5.2.
[171] Tanja Srebotnjak and Miriam Rotkin-Ellman, Natural Resources Defense Council, Fracking Fumes: Air Pollution from Hydraulic Fracturing Threatens Public Health and Communities (2014), https://www.nrdc.org/sites/default/files/fracking-air-pollution-IB.pdf [hereinafter "NRDC, *Fracking Fumes*"].

Fracking sites release a toxic stew of air pollution that includes chemicals that can cause severe headaches, eye, nose, and throat irritation, asthma symptoms and other respiratory illnesses, cancer such as childhood leukemia, central nervous system damage, cardiac problems, birth defects, and premature death.[172] Indeed, people and communities in areas with many hydraulically fractured wells report health problems consistent with these types of exposures.[173] Toxic air pollutants originate from direct and fugitive emissions of hydrocarbons at the well and from associated infrastructure such as condensate tanks, dehydrators, wastewater impoundment pits, and pipelines.[174]

The fracking process involves dozens of chemicals and the process returns gas, fracking chemicals, formation brines, and mobilized compounds, including heavy metals and naturally occurring radioactive materials (NORM) to the surface. Hydrogen sulfide (H_2S) is a toxic and explosive gas that may be present in oil and gas formations and is produced along with the hydrocarbons. It is damaging to the central nervous system and can be lethal at higher concentrations (~1000 ppm).[175]

Benzene, toluene, ethylbenzene, and xylene (BTEX) and other toxic hydrocarbons, such as formaldehyde, released from gas operations and equipment can lead to health impacts ranging from irritation of eyes, nose, mouth, and throat to aggravated asthma and other respiratory conditions, blood disorders, harm to the developing fetus, immune system-related diseases, and cancer (e.g., leukemia, non-Hodgkins lymphoma).[176]

Silica—the main component of 'frac sand'—is used widely and in large quantities to hold open the fractures created during the fracking process.[177] Inhalation of respirable silica can cause

---

[172] Adgate et al., *supra* note 182.

[173] Elizabeth Ridlington, John Rumpler, Environment America Research & Policy Center and the Frontier Group, *Fracking by the Numbers: Key Impacts of Dirty Drilling at the State and National Level* (2013); Charles W. Schmidt, *Estimating Wastewater Impacts from Fracking*, 121 Env. Health Persp. 4 (2013); Roxana Z. Witter et al., *Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003- 2008)* (2008), http://www.aph.gov.au/DocumentStore.ashx?id=d4314bfd-05e6-493c-942b-3c5ebf065f74; Roxana Z.Witter, et al., *Health Impact Assessment for Battlement Mesa, Garfield County Colorado, Aurora, CO* (2010), https://goo.gl/qgHBEz; Peter M. Rabinowitz, et al. *Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania*, 123 Environmental Health Perspectives 21 (2014), https://goo.gl/Tq5q1F.

[174] The Wyoming Department of Health identified 15 different fracking processes and sources—including the drilling process, wastewater, and condensate tanks—that can release air contaminants. Wyoming Dept. of Health, *Associations of Short-Term Exposure to Ozone and Respiratory Outpatient Clinic Visits — Sublette County, Wyoming, 2008–2011* (2013), https://fossil.energy.gov/app/DocketIndex/docket/DownloadFile/162.

[175] Eric J. Esswein, et al., *NIOSH Field Effort to Assess Chemical Exposures in Oil and Gas Workers: Health Hazards in Hydraulic Fracturing* (2012), https://www.cdc.gov/niosh/docs/2010-130/pdfs/2010-130.pdf.

[176] NRDC, *Fracking Fumes*, *supra* note 171 at 18.

[177] According to industry representatives, hydraulic fracturing companies use up to 10,000 tons of silica sand to hydraulically fracture a single well. *See* Kanika Sikka & Sneha Banerjee, U*.S. Silica Sees Sand Demand Piling up as Fracking Goes Super-Sized*, Reuters, Sept. 19, 2014, https://goo.gl/KauDom.

silicosis, an irreversible lung disease,[178] as well as lung cancer in miners, sandblasters, and foundry workers.[179]

Fracking-related processes and other stages of the oil and gas production process release nitrogen oxides and VOCs, which react in the presence of sunlight to form ozone ('smog'). Exposure to ozone is associated with a variety of respiratory and cardiovascular effects, including shortness of breath, reduced lung function, aggravated asthma and chronic respiratory disease symptoms, inflammatory processes, and premature death.[180] For example, in many rural areas, the boom in oil and gas activity has been linked to unhealthy spikes in ozone concentrations.[181]

Exhaust from diesel engines, which are used in heavy trucks and machinery used during well site preparation, drilling, and production, contains hundreds of toxic chemicals. Of greatest concern is the fine diesel soot particles, which can lodge deep within the lungs, increasing health risks including: emergency room visits, hospital admissions, asthma attacks, cardiopulmonary disease (including heart attack and stroke), respiratory disease, adverse birth outcomes, and premature death (from pneumonia, heart attack, stroke and lung cancer).[182] Indeed, truck impacts from fracking activity is quite significant—the total travel distance by trucks ranges from about 9,600 miles to 22,000 miles per well.[183]

While it is difficult to measure actual exposures to pollutants from nearby fracking operations and establish clear links to adverse health outcomes, some studies found associations between air pollutants that are present at oil and gas production sites and health impacts observed in nearby communities.[184] In 2008 and 2011, increased ozone concentrations in Wyoming's Sublette County were associated with subsequent increases in outpatient clinic visits for respiratory problems.[185]

And in Colorado, an evaluation of birth defects in areas with high concentrations of oil and gas activity found that mothers who lived near many oil and gas wells were 30 percent more

---

[178] Long-term exposure can lead to chronic silicosis, while short-term exposure to very large amounts of silica can cause acute silicosis.
[179] OSHA, *Silica, Crystalline*, https://www.osha.gov/dsg/topics/silicacrystalline/ (Mar. 30, 2018).
[180] U.S. Env. Prot. Agency, *Health Effects of Ozone in the General Population*, https://www.epa.gov/ozone-pollution-and-your-patients-health/health-effects-ozone-general-population (Mar. 30, 2018).
[181] Detlev Helmig et al., *Highly Elevated Atmospheric Levels of Volatile Organic Compounds in the Uintah Basin, Utah*, 48 Environmental Science & Technology 4707 (2014).
[182] Seth B. Shonkoff et al., *Environmental Public Health Dimensions of Shale and Tight Gas Development,* 122 Environmental Health Perspectives 787 (2014), https://ehp.niehs.nih.gov/wp-content/uploads/122/8/ehp.1307866.pdf; John L. Adgate et al., *Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development*, 48 Environmental Science and Technology 8307 (2014).
[183] U.S. Env. Prot. Agency. *Hydraulic Fracturing for Oil and Gas*, supra note 155, at E-81.
[184] Lisa M. McKenzie et al., *Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources*, 424 Science of the Total Environment 79 (2012); Lisa M. McKenzie et al., *Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado*, 122 Environmental Health Perspectives 412 (2014), https://ehp.niehs.nih.gov/wp-content/uploads/122/4/ehp.1306722.pdf.
[185] Wyoming Dept. of Health, *supra* note 174.

likely to have babies with heart defects.[186] Similarly, preliminary results from a study in Pennsylvania show impacts among newborns that could be linked to air pollution such as increases in low birth weight.[187] Researchers who looked at air pollution levels near fracking sites in Colorado also found an increased risk of chronic and sub-chronic effects mainly stemming from oil and gas related pollutants, which can harm the respiratory and neurological systems and lead to symptoms like shortness of breath, nosebleeds, headaches, dizziness, and chest tightness.[188]

Indeed, it cannot be reasonably disputed that fracking has made people sick. If the Commission were to permit fracking in the River Basin, it has been estimated that up to 45,000 residents in the River Basin could also face air quality issues,[189] or sixty percent of the population would have their health harmed by drilling and fracking in their communities.[190]

III. The Commission Should Ban the Treatment and Disposal of Fracking Wastewater

In proposing a ban on fracking, the Commission states that advances this proposal to "control future pollution."[191] But this goal cannot be achieved without also banning the treatment and disposal of fracking wastewater.

Under the Commission's draft regulations, fracking wastewater would be allowed to be transferred to, treated by, and discharged from new or existing centralized waste treatment facilities (CWTs) within the Delaware River Basin provided that the facility is issued a docket by the Commission, or the facility is operating in accordance with a state permit issued pursuant to an administrative agreement between the Commission and a host state.[192] While the draft regulations also provide for additional effluent limitations for total dissolved solids (TDS), whole effluent toxicity (WET), as pollutants of concern as listed by the EPA in the *Technical Development Document for the Effluent Limitations Guidelines and Standards for the Oil and Gas Extraction Point Source Category*,[193] this is insufficient to protect the watershed from the harmful chemicals present in fracking wastewater.

As explained above in Part II.b., fracking generates massive amounts of polluted wastewater that threaten the health of our drinking water supplies, rivers, streams, and groundwater. And these threats to water quality are present well beyond the footprint of the fracking well, even into areas where fracking itself is banned. The transportation, treatment, and

---

186 McKenzie et al., *Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado*, *supra* note 184.
187 Adgate et al., *Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development*, *supra* note 182.
188 Wyoming Dept. of Health, *supra* note 174.
189 Habicht, et al., *supra* note 44, at 75.
190 *Id*.
191 Proposed Regulations, *supra* note 1.
192 *Id*.
193 U.S. Env. Prot. Agency, *Technical Development Document for the Effluent Limitations Guidelines and Standards for the Oil and Gas Extraction Point Source Category* (2016), https://goo.gl/MxRwGL.

disposal of fracking wastewater, even without fracking wells nearby, can also degrade source water quality, impair long-term watershed health, and expose watershed residents to chronic levels of toxic chemicals.[194] Indeed, a fracking ban alone, without a complementary ban on fracking wastewater, is not sufficient to protect the River Basin. For this reason, the Commission should also ban the treatment and disposal of fracking wastewater in the River Basin.

a. Transportation, Treatment and Disposal of Wastewater Can and Has Contaminated Water Bodies

Even where fracking is banned outright, the handling, storage, and transport of wastewater can and has led to spills and other releases of pollutants that contaminate land and water with toxic or radioactive material. At any of the locations where produced water is handled, the potential exists for releases due to accidents, inadequate facilities management or staff training, or illicit dumping.[195]

Water used in the fracking process is typically taken from surface water bodies and trucked to the drill site.[196] After the fracking wastewater returns, the produced water is generally trucked off-site for treatment or disposal.[197] This hauling of water and wastewater to and from the drill site can require between 600 and 865 truck trips per well.[198] It is this practice—the transportation of produced water to and from the fracking site hundreds of times per well—that has the most significant potential to pollute water bodies.[199] As such, the greatest risk pathway for water contamination occurs not at the fracking site, but where produced water is transported, including in areas where fracking itself is banned.[200]

Wherever produced water is being transported, pollutants in wastewater can be unintentionally released directly to the environment, either with or without appropriate treatment and safeguards to limit pollution discharges. These spills may result from accidents, from inadequate management or training, or from illicit dumping. Like the risks of fracking wastewater near the wellsite, the risks posed by the transportation, treatment, and disposal of fracking wastewater are not theoretical.

In 2010, a truck carrying oil and gas wastewater overturned in the small Ohio town of Barnesville. It spilled 5,000 gallons of wastewater into a stream only a few hundred yards from where the stream runs into a drinking water reservoir. While it is unclear whether the wastewater was produced water from a producing well, rather than fracking wastewater, both can

---

[194] NYC Assessment, *supra* note 11, at ES-3.
[195] Charles G. Groat & Thomas W. Grimshaw, *Fact-Based Regulation for Environmental Protection in Shale Gas, report prepared for the Energy Institute* (2012) 25, http://energy.utexas.edu/images/ei_shale_gas_regulation120215.pdf; *see also* NYC Assessment, *supra* note 11, at 35.
[196] NYC Assessment, *supra* note 11, at ES-1.
[197] NRDC, *In Fracking's Wake*, *supra* note 3, at 6, 58.
[198] NYC Assessment, *supra* note 11, at 33.
[199] NRDC, *In Fracking's Wake*, *supra* note 3, at 6, 58.
[200] *Id.*

contain materials quite toxic to human health, including radioactive materials, heavy metals, and hydrocarbons.[201]

In 2014, two fracking water tankers were rear-ended by a third, larger tanker truck carrying diesel fuel in West Virginia. Fracking water and diesel fuel both spilled onto the road. About 1,300 gallons of diesel fuel and 400 gallons of fracking water leaked into Chartiers Creek and the sewer drains. The spill was a concern to aquatic life in the creek, and required HAZMAT crews, DEP, and town officials to clean up.[202]

Based on its review of the risk of spills generated from truck trips alone, New York City concluded in its 2009 report, that "acute spill scenarios are realistic and should be expected."[203]

b. Even Industrially-Treated Wastewater Can Harm Water Quality

Even fracking industrially-treated fracking wastewater poses threats to humans and the environment, as centralized waste treatment facilities do not adequately remove all dangerous contaminants from wastewater. As New York City has observed, "the development of natural gas resources will present a significant waste disposal challenge for which there is no clear or viable solution evident at this date."[204]

If fracking wastewater is to be discharged into surface waters, it must first be treated at dedicated brine or industrial wastewater facilities, also called centralized waste treatment (CWT) facilities.[205] These plants use many of the same treatment processes that are found in municipal sewage treatment plants (also known as publicly owned treatment works, or POTWs), which are designed to treat pollutants found in municipally-generated, not industrial, wastewater. CWTs may also add coagulation and precipitation techniques to remove dissolved solids. However, while CWTs may be designed to remove more pollutants from wastewater than POTWs do, their discharges may still contain high levels of pollutants that are harmful to both people and the environment.

CWTs are subject to federally established effluent limitation guidelines (ELGs) limiting the pollutants that they may discharge.[206] However, these ELGs are out of date; they were

---

[201] Amy Mall, *Drinking Water Reservoir Contaminated by Oil and Gas Wastewater in Ohio*, NRDC Expert Blog, Mar. 11, 2016, https://www.nrdc.org/experts/amy-mall/drinking-water-reservoir-contaminated-oil-and-gas-wastewater-ohio.

[202] Christine D'Antonio, *HAZMAT Crews Called To Wash. Co. Tanker Crash*, CBS Pittsburgh, Apr. 21, 2014, http://pittsburgh.cbslocal.com/2014/04/21/hazmat-crews-called-to-wash-co-crash/; Jackie Cain, *3 Tanker Trucks Crash In Canton Township, Spilling Fracking Water, Diesel Fuel*, Pittsburgh's Action News 4, Apr. 21, 2014, http://www.wtae.com/article/3-tanker-trucks-crash-in-canton-township-spilling-fracking-water-diesel-fuel/7465904.

[203] NYC Assessment, *supra* note 11, at 37.

[204] *Id.* at 48.

[205] 40 C.F.R. § 435.33.

[206] 40 C.F.R. Pt. 437.

developed prior to the emergence of hydraulic fracturing methods of shale gas extraction and do not address all pollutants of concern in the wastewater generated by such operations.[207]

While the Commissions' draft regulations propose regulating some of these contaminants, an unknown number of contaminants may be released in the River Basin without regulation. As mentioned earlier, the absence of regulatory attention to a chemical does not guarantee safety. Only some of these chemicals are regulated by laws such as the Clean Water Act and the Safe Drinking Water Act, and as more evidence demonstrating the harms associated with fracking chemicals increases and as public health concerns associated with these same chemicals continues to grow, the number of contaminants known to harm human health and the environment will expand. For example, 1,4-dioxane, a chemical identified by EPA as a "likely carcinogen,"[208] has been found in fracking fluid and fracking wastewater,[209] and is currently not regulated under the Safe Drinking Water Act.

Because fracking wastewater contains many chemicals that are known to harm human health and the environment, because untreated wastewater can and has been inadvertently released into local waterbodies, and because even wastewater treated by CWTs contain chemicals that can adversely affect the River Basin and its residents, in order to fulfill the Compact's directive to "control future pollution and abate existing pollution in the waters of the [Delaware River] basin,"[210] the Commission should ban the treated or discharged in the River Basin.

IV. The Commission Should Ban Water Withdrawal for Fracking Use

Water withdrawals that total less than an average of 100,000 gallons per day (per 30-day period) do not currently require a Commission permit. The proposed regulations would eliminate this loophole, requiring all water withdrawals for oil and gas extraction to first obtain Commission review and approval. While this change helps to regulate a harmful, and previously unregulated, activity, it would still allow the Delaware River Basin's freshwater to be used for fracking where it is permitted.[211] Water exports would also exacerbate the risk of droughts and

---

[207] The ELGs were adopted in 2000 and revised in 2003, yet large-scale shale gas extraction was not practiced at all until 1997 and did not become common until the mid-2000s. Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards for the Centralized Waste Treatment Point Source Category; Final Rule, 65 Fed. Reg. 81,241 (Dec. 22, 2000) (codified at 40 C.F.R. Pt. 437); Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards for the Centralized Waste Treatment Point Source Category, 68 Fed. Reg. 71,014 (Dec. 22, 2003) (codified at 40 C.F.R. Pt. 437). *See generally* U.S. Department of Energy, National Energy Technology Laboratory, Shale Gas: Applying Technology to Solve America's Energy Challenges, March 2011, 3, http://www.netl.doe.gov/technologies/oilgas/publications/brochures/Shale_Gas_March_2011.pdf (summarizing the history of shale gas development).

[208] U.S. Env. Prot. Agency, Technical Fact Sheet—1, 4-Dioxane (2017), https://www.epa.gov/sites/production/files/2014-03/documents/ffrro_factsheet_contaminant_14-dioxane_january2014_final.pdf.

[209] NYS SGEIS, *supra* note 48, at 6-20, T. 6-1.

[210] Compact § 5.2.

[211] Proposed Regulations, *supra* note 1.

other harmful events across the region. As such, the Commission should ban the export of freshwater for fracking entirely.

The removal of water for fracking would cause irreparable harm. Fracking is a highly water-intensive process that requires between three and eight million gallons of water per well in the Marcellus region.[212] And unlike other activities in the Delaware River Basin, such as domestic and commercial use, where 90 percent of water is returned, fracking results in 70 to 90 percent of the water used to be permanently removed from the water cycle.[213] For example, in the nearby Susquehanna River Basin, approximately 96 percent of the water withdrawn by the gas industry is not returned to its source.[214] Such a removal from the Delaware River Basin would disrupt its natural hydrologic cycle, since water used for fracking would be exported out, and not returned to the River Basin.

According to the Delaware River Basin Water Code, "the waters of the Delaware River Basin are limited in quantity and the basin is frequently subject to drought warnings and drought declarations due to limited water supply storage and streamflow during dry periods. Therefore, it shall be the policy of the Commission to discourage the exportation of water from the Delaware River Basin."[215] The Commission should follow the policy of its own code and not allow the withdrawal of water for fracking. Given the highly variable and limited freshwater supply in the Basin, it should ban the exportation for water to be used for fracking.

Moreover, the Commission has proposed banning fracking from the basin because it has rightly deemed it to be unsafe. As the Commission well knows, fracking is dangerous and harmful. It causes health problems and risks to water quality.[216] Fracking's risks are the same whether it occurs in the Basin or elsewhere, and the Basin should not facilitate other areas to take on this risk where it has deemed fracking to be wrong for its own environment.

a. Exporting Water for Fracking Would Harm the Watershed

Withdrawing Delaware River Basin freshwater would be devastating to a region that relies on a clean and healthy watershed for its livelihood.

First, these exports can create low-flow conditions, which have been linked to increased water temperature, decreased dissolved oxygen and decreased biodiversity, which would in turn harm aquatic habitats, including sensitive wetlands.[217] For example, low-flow conditions reduce

---

[212] B. Wright, et al., *Impact Assessment of Natural Gas Production in the NYC Water Supply Watershed* 5 (2010).
[213] Proposed Regulations, *supra* note 1; U.S. Env. Prot. Agency, *Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States* 12 (Fig. ES–4(a)).
[214] J. Richenderfer, et al., *Water Use Associated with Natural Gas Shale Development: An Assessment of Activities Managed by the Susquehanna River Basin Commission July 2008 through December 2013*, 38 (2016).
[215] Delaware River Basin Water Code, DELAWARE RIVER BASIN COMMISSION, § 2.30.2. http://www.nj.gov/drbc/library/documents/watercode.pdf.
[216] Delaware River Basin Commission, *Frequently Asked Questions (FAQs) Revised Draft Rules Addressing Hydraulic Fracturing Activities within the Delaware River Basin*, http://www.state.nj.us/drbc/library/documents/HydraulicFracturing/FAQ_HydraulicFracturingPRM_012218.pdf.
[217] Robert J. Rolls, et al., *Mechanistic Effects Of Low-Flow Hydrology On Riverine Ecosystems: Ecological Principles And Consequences Of Alteration*, 31 Freshwater Science, 1163, 1170 (2012).

the capacity of a waterway to transport silt and fine sediment, leading to sedimentation and the smothering of benthic habitat.[218] Low-flow conditions have also been documented to lead to decreased insect biomass due to limited habitat, which has implications for fish communities and other species which rely on insects for food.[219]

Effects on native trout fisheries in the upper Delaware, which rely on upstream releases of cold water from reservoirs in New York State, would be particularly troubling. In 2010, trout fisheries in the Delaware River generated more than $29 million in economic activity across the region while at the same time supporting an intricate web of life throughout the watershed.[220] But example, low-flow conditions and corresponding increases in temperature have led to increased competition for food and reduced body mass among trout populations.[221] Exporting water out of the watershed would lead to a decline in the availability of upstream freshwater releases, which would irreparably harm the trout fisheries and all that depend on them.

Second, a decrease in the supply of freshwater in the Delaware River would reduce the waterway's ability to dilute and assimilate pollutants. When water enters a waterway through tributaries, it helps naturally dilute point sources of pollution (for example, a sewage outfall). In China, for example, where access to water is highly variable, pollution loads have exceeded the natural assimilative capacity of certain waterways, meaning the rate by which waterways can naturally dilute pollution has decreased.[222] Should freshwater be extracted from the Delaware River Basin, there will be a decreased supply of freshwater to assimilate downstream sources of pollution. A decline in the ability of a waterway to dilute pollutants may lead to an increased number of water quality impairments.[223]

Third, and most critically, removing freshwater for fracking would threaten regional drinking water security. As mentioned in Part I, the Delaware River Basin provides drinking water for over 17 million Americans, including residents of Philadelphia and New York City. Removing water from the basin would decrease the amount of water available for drinking, especially during seasonal droughts. DRBC acknowledged this risk, stating that "withdrawals from surface and groundwater in the amounts required for [fracking] may adversely affect aquatic ecosystems and river channel and riparian resources downstream, including wetlands, and may diminish the quantity of water stored in an aquifer or a stream's capacity to assimilate pollutants."[224] These risks are not nearly worth the potential rewards.

---

[218] *Id*. at 116.
[219] Annika Walters & David Post, *How Low Can You Go? Impacts Of A Low Flow Disturbance On Aquatic Insect Communities.*, 21 Ecological Applications 163, 172 (2011).
[220] Gerald J. Kauffman, *Economic Value of Nature and Ecosystems in the Delaware River Basin*, 158 Journal of Contemporary Water Research & Education 98, 108 (2016), https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1936-704X.2016.03222.x.
[221] The Nature Conservancy, *Ecosystem Flow Recommendations for the Delaware River Basin*, 26 (2013), http://www.state.nj.us/drbc/library/documents/TNC_DRBFlowRpt_dec2013.pdf.
[222] Dabo Guan, et al. *Lifting China's Water Spell,* 48 Environmental Science and Technology, 11048 (2014).
[223] *Proceedings of the 2007 Georgia Water Resources Conference*, held March 27–29, 2007, at the University of Georgia, http://www.gwri.gatech.edu/sites/default/files/files/docs/2007/5.2.3.pdf.
[224] Proposed Regulations, *supra* note 1.

New York City plays a critical role in managing regional fresh water supply through three Delaware watershed reservoirs: the Pepacton, Cannonsville, and Neversink Reservoirs ("City Reservoirs").[225] The City Reservoirs supply approximately 50 percent of the New York City's daily water needs and are cooperatively managed by the Flexible Flow Management Program (FFMP), an agreement between New York City and New York State, New Jersey, Pennsylvania and Delaware.[226] The FFMP was developed to manage New York City's large water needs and release excess water to downstream states. These releases underscore the Delaware Basin's role in meeting the region's water needs.

Should the Commission allow the exportation of water for fracking, upstate surface water withdrawals could reduce flow to the City Reservoirs and decrease the probability that those reservoirs refill, especially during seasonal droughts.

Additionally, groundwater withdrawals could deplete freshwater aquifers, threatening streams and wetlands throughout the watershed, and downstream withdrawals could require upstream reservoirs to release additional water to meet in-stream flow and release requirements.[227] Understanding the unique and delicate hydrologic relationship between surface and groundwater resources is essential as the Commission considers opening the Basin up to exports of water for fracking where it is permitted. In 2008, streams in Washington County, Pennsylvania were pumped dry to provide water for drilling in the Marcellus shale.[228] Opening the Delaware River Basin to exports of fracking water could create conditions by which New York City and the entire region's drinking water supply could be similarly constrained.

b. Climate Change Will Exacerbate Impacts of Water Exports

The harms of decreased water supply due to the exportation of water for fracking are further heightened by the threat of anthropogenic climate change. Studies show that climate change will cause unpredictable precipitation and increased temperatures, resulting in loss of snowpack, prolonged droughts and sea-level rise.[229] The combination of average temperatures increasing, loss of upstream water supply due to decreased snowpack and sea-levels rising will facilitate an increase in the rate of saltwater intrusion into inland water supplies.[230]

In the Delaware River, the "salt line," the invisible zone dividing freshwater and seawater, fluctuates based upon tidal activity and upstream reservoir water releases. Although the

---

[225] United States Geologic Survey (USGS), *Agreement of the Parties to the 1954 U.S. Supreme Court Decree Effective June 1, 2012*, 3 (2012), https://water.usgs.gov/osw/odrm/documents/FFMP_FINAL.pdf.
[226] City of New York, *NYC's Reservoir System*, http://www.nyc.gov/html/nycwater/html/drinking/reservoir.shtml (Mar. 30, 2018); USGS, *Agreement For A Flexible Flow Management Program* (2017), https://water.usgs.gov/osw/odrm/ffmp/FFMP2017.pdf.
[227] NYC Assessment, *supra* note 11, at 33.
[228] *Team 4: PA Streams Drained Dry By Drillers*, Damascus Citizens for Sustainability, Nov. 13, 2008, http://www.damascuscitizensforsustainability.org/2008/11/team-4-pa-streams-drained-dry-by-drillers/.
[229] R. Horton, et al., *The Third National Climate Assessment: Climate Change Impacts in the United States*, ch. 16 (2014), https://goo.gl/mUWpiB.
[230] Atlantic Climate Adaptation Solutions Association, *Saltwater Intrusion and Climate Change* 11 (2011), http://www.gov.pe.ca/photos/original/cle_WA1.pdf.

salt line typically hovers around Wilmington, Delaware, during the "drought of record" in 1963, it pushed to just south of Philadelphia's drinking water intakes.[231] In a climate-disrupted future, as upstream supply of freshwater decreases due to decreased snowpack in New York, and sea-levels increase, the salt line will move upstream, risking impairment of drinking water intakes and infrastructure throughout the watershed. This hydrologic dynamic would be exacerbated further by water exports, as there would be reduced supply to push the "salt-line" toward the sea.

V. Neither a Fracking Wastewater Ban Nor a Ban on Water Withdrawal for Fracking Purposes Would Violate the Dormant Commerce Clause

Finally, neither a ban on fracking wastewater nor on water withdrawals for fracking purposes would violate the dormant Commerce Clause. First, the Commission, as a state/federal agency acting in accordance with a Congressionally-approved interstate compact, may not even be subject to the dormant Commerce Clause. But even if it is, such bans would not run afoul of the dormant Commerce Clause, as the bans would not discriminate against interstate commerce, and the public interest in such a ban outweighs any burden on interstate commerce.

In 2014, Governor Christie vetoed a New Jersey bill proposing to ban fracking wastewater, claiming that such a ban would have violated the dormant Commerce Clause.[232] Several legal experts and scholars have explored the credibility of his claim, all ultimately concluding that a ban on fracking waste would not violate the dormant Commerce Clause.[233] This section serves to just briefly expand these analyses to the case of the Delaware River Basin.

The dormant Commerce Clause is rooted in Article 1 of the Constitution, which states that "Congress shall have Power . . . [t]o regulate Commerce with foreign Nations, and among the several States."[234] While this language explicitly provides Congress an affirmative grant of regulatory power over states, it has "long been understood to have a 'negative' aspect," known as the "dormant" Commerce Clause, that prohibits states from unjustifiably discriminating against or burdening the interstate flow of articles of commerce.[235] The Supreme Court has found that the dormant Commerce Clause prohibits states from passing laws that economically isolate or arbitrarily discriminate against articles of commerce from outside its borders.[236] The purpose of this prohibition "reflected a central concern of the Framers . . . the conviction that in order to

---

[231] Jon Hurdle, *As Drought Persists, DRBC Steps Up Efforts to Repel Salt Front In Delaware River,* NPR, Nov. 28, 2016, https://stateimpact.npr.org/pennsylvania/2016/11/28/as-drought-persists-drbc-steps-up-efforts-to-repel-salt-front-in-delaware-river/.

[232] Brent Johnson, *Christie Vetoes Bill Aiming To Ban Fracking Waste in N.J.*, NJ.com, Aug. 8, 2014, http://www.nj.com/politics/index.ssf/2014/08/christie_vetoes_bill_aiming_to_ban_fracking_waste_in_nj.html.

[233] Eric Michel, *Discrimination in the Marcellus Shale: The Dormant Commerce Clause and Hydraulic Fracturing Waste Disposal,* 88 Chi. Kent. L. Rev. 213, 228 (2012); Stephen Miller, *Hydraulic Fracturing and the Emergent Dormant Commerce Clause*, 9 American Bar Association Section of Environment, Energy, and Resources Constitutional Law Committee Newsletter 6 (2013); Letter from Albert Porroni, Legislative Counsel, New Jersey State Legislature Office of Legislative Services, to Bob Smith, New Jersey State Senator (Mar. 19, 2012), *available at* https://goo.gl/1GBPsc.

[234] U.S. CONST. art. I, § 8, cl. 3.

[235] *Or. Waste Sys. V. Dep't of Envtl. Quality*, 511 U.S. 93, 98 (1994).

[236] *Lewis v. BT Inv. Managers, Inc*., 447 U.S. 27, 36 (1980); Eric Michel, *Discrimination in the Marcellus Shale: The Dormant Commerce Clause and Hydraulic Fracturing Waste Disposal*, 88 Chi. Kent. L. Rev. 213, 228 (2012).

succeed, the new union would have to avoid the tendencies toward economic Balkanization that had plagued relations among the Colonies and later among the States under the Articles of Confederation."[237]

As a preliminary matter, because the Delaware River Basin Commission would be acting to implement an interstate compact ratified by Congress, it could be argued that any act taken pursuant to the Compact, such as a ban on fracking wastewater or water withdrawals for fracking purposes, would be insulated from the limitations of the dormant Commerce Clause. In 1945, the Supreme Court recognized the "undoubted" power of Congress to "permit the states to regulate the commerce in a manner which would not otherwise be permissible" under the dormant Commerce Clause.[238] In *Cuyler v. Adams*, the Supreme Court found that a Congressionally approved interstate compact falling within the Compact Clause of the U.S. Constitution *is* federal law.[239] Therefore, while state actions are generally subject to the limits of the dormant Commerce Clause, "congressional approval of a compact eliminates the concern over a dormant commerce clause challenge to state water policy, since any affect [sic] on interstate commerce has been sanctioned by the federal government."[240] One need not reach that analysis, however, because even if the Commission's actions are subject to the dormant Commerce Clause, bans on fracking wastewater and on water withdrawal for fracking purposes would still not run afoul of state's limits on interstate commerce.

To determine whether a state law runs afoul of the dormant Commerce Clause, courts undertake a two-step analysis, as outlined by the Supreme Court in *United Haulers Association v. Oneida-Herkimer Solid Waste Management Authority*.[241] First, the court looks to the text of the law to determine whether it facially discriminates against interstate commerce.[242] If the court finds that the state law provides for "differential treatment of in-state and out-of-state economic interests that benefits the former and burdens the latter,"[243] the law is struck down unless the state shows that there is a legitimate local purpose that cannot be achieved without discrimination.[244] For example, a New Jersey law that prohibited the importation of garbage that originated outside the state was determined to be facially discriminatory and was struck down by the Supreme Court.[245]

---

[237] *Hughes v. Oklahoma*, 441 U.S. 322, 325 – 26 (1979).
[238] *S. Pac. Co. v. Arizona,* 325 U.S. 761 (1945). .
[239] 449 U.S. 433, 440 (1981); *see also Texas v. New Mexico*, 482 U.S. 124, 128 (1987). The Compact Clause provides: "No State shall, without the Consent of Congress ... enter into any Agreement or Compact with another State." U.S. Const. art. I, § 10, cl. 3; *see also Tarrant Reg'l Water Dist. v. Herrmann*, 656 F.3d 1222, 1235 (10th Cir. 2011), *aff'd*, 569 U.S. 614 (2013)
[240] Noah D. Hall, *Toward A New Horizontal Federalism: Interstate Water Management in the Great Lakes Region*, 77 U. Colo. L. Rev. 405, 452 (2006).
[241] *United Haulers Ass'n v. Oneida-Herkimer Solid Waste Mgmt. Auth.,* 550 U.S. 330, 338 (2007). Note that this test for facial discrimination emerged long before this case.
[242] *Id.* at 138.
[243] *United Haulers Ass'n, Inc. v. Oneida-Herkimer Solid Waste Mgmt. Auth*., 550 U.S. 330, 338, 127 S. Ct. 1786, 1793, 167 L. Ed. 2d 655 (2007)
[244] *See Maine v. Taylor*, 477 U.S. 131, 151.
[245] *Philadelphia v. New Jersey*, 437 U.S. 617 (1978).

Second, for laws that are found not to be facially discriminatory, courts undertakes a "*Pike"* balancing test, whereby the law is upheld "unless the burden imposed on the course of interstate commerce outweighs the state regulatory concern."[246] Under this test, a law does not violate the dormant Commerce Clause if it: (1) is an even-handed regulation drafted to protect a legitimate public interest; (2) its effects on interstate commerce are merely incidental; and (3) the burden imposed on interstate commerce is clearly not excessive as compared to the local benefits that result.[247] This is an extremely fact-dependent analysis. However, courts approach burden review with considerable deference, and few laws are struck down under this prong of the analysis unless the stated public interest seems nearly unconnected to the challenged rule.[248] For example, the U.S. Supreme Court invalidated an Iowa state law that excluded trucks beyond a certain length from its highways after Iowa was unable to muster any serious evidence that its law promoted safety.[249]

NRDC believes a proposed ban on fracking wastewater in the Delaware River Basin would pass the two-part test. First, such a ban would not on its face discriminate against interstate commerce, as *all* wastewater, produced in any state, would be prohibited in the Delaware River Basin. While it may be true that, in the case of New York, New Jersey, and Delaware, because fracking does not take place in these states, all wastewater would necessarily originate from out of the state, the Supreme Court has previously found the mere fact that only out of state businesses are affected by the law does not, by itself, establish facial discrimination.[250] A ban on fracking wastewater would also satisfy the second part of the two-part test, since, as explained in Parts II.b. and III, fracking wastewater is harmful to both public health and the environment, and a ban would serve to protect those interests. Finally, the burden on interstate commerce would not be significant.

Additionally, a proposed ban on water withdrawals in the Delaware River Basin for fracking purposes would also pass the two-part test. First, such a ban would not on its face discriminate against interstate commerce, as water withdrawals for fracking in any state would be prohibited. While it may be true that, states where fracking does not place, such as New York, New Jersey, and Delaware, would not be limited by this regulation, as explained above, the Supreme Court has previously found the mere fact that only out of state businesses are affected by the law does not, by itself, establish facial discrimination.[251] A ban on water withdrawal would also satisfy the second part of the two-part test, since, for the reasons explained in Part IV, water withdrawals for fracking could harm both human health and the environment, and a ban in water withdrawals for fracking would serve to protect those interests.. Finally, the burden on interstate commerce would not be significant.

---

[246] *Pike v. Bruce Church, Inc.*, 397 U.S. 137, 142 (1970).
[247] *Id.*
[248] *See* Daniel Francis, *The Decline of the Dormant Commerce Clause*, 94 Denv. L. Rev. 255, 266 (2017).
[249] *Kassel v. Consolidated Freightways Corp. of Delaware*, 450 U.S. 662, 671-74 (1981) (plurality opinion).
[250] *Exxon Corp. v. Governor of Maryland*, 437 U.S. 117, 125 (1978) (upholding a law barring petroleum producers from owning gas stations where no producers operated in the state).
[251] *Exxon Corp. v. Governor of Maryland*, 437 U.S. 117, 125 (1978) (upholding a law barring petroleum producers from owning gas stations where no producers operated in the state).

For the reasons stated above, neither a ban on fracking wastewater, nor a ban on water withdrawal for fracking purposes would violate the dormant Commerce Clause.

Conclusion

NRDC thanks the Commission for proposing a ban on fracking in the watershed. While an important step, a ban on drilling alone is insufficient to fully protect the Delaware River Basin. For the reasons stated above, we request that the Commission enact a full ban on fracking in the River Basin that is inclusive of a ban on the treatment and disposal of fracking wastewater and on the withdrawal and export of water from the River Basin for fracking purposes.

Sincerely,

Mark A. Izeman
New York Regional Director
Senior Attorney

Kimberly Ong
Staff Attorney

Robert H. Friedman
Policy Advocate

SYNOPSIS OF PUBLIC HEALTH AND ENVIRONMENTAL RISKS ASSOCIATED WITH FRACKING WASTEWATER

prepared on behalf of the

NATURAL RESOURCES DEFENSE COUNCIL[1]

By

Judith S. Schreiber

Schreiber Scientific, LLC

March 30, 2018

[1] *This report was funded by the Natural Resources Defense Council (NRDC). The views contained herein are those of the author and do not necessarily reflect those of NRDC.*

INTRODUCTION

High-volume hydraulic fracturing, commonly called "fracking," is a technique used to increase natural gas production from underground rock formations by injecting fluids containing water, chemicals and sand or other material under pressure. As recognized by many health and environmental regulators, the process has the potential to contaminate groundwater and surface water, and presents waste disposal concerns from contaminated water from fracking operations. In addition, the large amounts of water used in these operations have environmental impacts on resource allocation because of large scale withdrawals of water from freshwater resources. Waste disposal issues are key, as the large scale aqueous wastes must be properly handled, transported to off-site locations, and disposed of in an environmentally sound manner, protective of public health.

I. FRACKING WASTES: CHEMICAL COMPOSITION

It is widely acknowledged that many chemicals are used in the process of fracking. However, there are no uniform requirements for the disclosure of chemicals used in fracking operations, resulting in the largely unknown nature of the chemicals' potential impact on health and the environment. Wastewater from fracking operations is a result of both 'flowback' (water that originated from the water and chemicals added during the extraction) and from 'produced water' (additional water that is released with brines, organic chemicals, and materials from the geological and water-bearing strata). Both flowback and produced water are sources of wastewater that include contaminants of concern.

Fracking fluids contain water and a mixture of chemicals that vary by company and by site. Sand (silicates) or other proppants are used to keep the fractured shale rock open. Millions of gallons of these fluids are injected into each well at high pressure to fracture the shale-containing rock, and millions of gallons of wastewater (flowback and produced water) return to the surface. These wastewater fluids contain heavy metals such as barium, manganese and iron; radioactive materials such as radium; and organic compounds such as benzene, toluene, xylenes, oil and grease (Finkel et al., 2013; Wilke and Freeman, 2017).

Several reports have presented detailed chemical composition of fracking fluids (USEPA, 2016; NYSDOH, 2014; PSR, 2018). Due to the proprietary nature of the materials used, regulators have faced challenges in determining the chemicals of concern and reliable monitoring to detect them. In a comprehensive review, over 600 chemicals were identified as ingredients of more than 900 products used during natural gas fracking (See Tables 2 and 3, Colborn et al., 2011). Only 14% of the product information included specific chemicals used in the fluids, while 43% of the products had less than 1% of the total product composition available (Colborn et al., 2011).

New York State Department of Environmental Conservation (NYSDEC) Division of Mineral Resources reported that fracking fluid is made up primarily by water (90%), sand or proppant (9.5%), and 0.5% chemical additives (Gill et al., 2017). Variability of geology, watersheds, and hydraulic fracturing processes makes it difficult to generalize whether or not fracking contributes to groundwater contamination or depletion of freshwater resources (Gill et al., 2017), and because of the dearth of disclosure requirements, without adequate monitoring and assessment, the levels of contaminants and the impact on water resources cannot be well characterized. However, there are reports adequate to ascertain that fracking wastes can and do affect water quality in surface water, groundwater, and drinking water supplies (USEPA, 2016).

In general, additives to fracking fluids include acids to help dissolve minerals and rocks (such as hydrochloric or muriatic acids), antibacterial agents (such as gluteraldehyde), corrosion inhibitors (such as n,n-dimethyl formamide), friction reducers (such as petroleum distillates), scale inhibitors (such as ethylene glycol), solvents (such as stoddard solvent, aromatic hydrocarbons), and surfactants (such as isopropanol), among others (Adgate et al., 2014). In addition to additives, naturally occurring materials in the earth's crust (including petroleum hydrocarbons and uranium) are brought up during the extraction process and are released as produced water. The Marcellus Shale is known to have high uranium content, which produces a decay product radium-226, at levels that can exceed 10,000 picocuries per liter (pCi/L) in the concentrated brine. As a result, radionuclides are present in drilling waste, brought up from natural underground sources (Nelson et al., 2015; Brown, 2014).

In a comprehensive evaluation of potential environmental impacts, NYSDEC in 2009 published a Draft Supplemental Generic Environmental Impact Statement (NYSDEC, 2009) which presents the array of chemicals present in fracking flowback water and typical concentrations of flowback constituents (see Table 6.2 and Table 6.3 for a full dataset). Components of greatest environmental concern are gelling agents, surfactants and chlorides in flowback and process wastewater, in addition to dissolved solids, metals, biocides, organics and radionuclides, because of adverse effects on groundwater and surface water (and their ecology), and the potential for human health effects via consumption of contaminated drinking water. The metals in fracking wastewater have been found at levels exceeding drinking water standards, and have been extensively reviewed (NYSDEC, 2009).

Among the reported chemicals found in flowback are:

Organic chemicals:

- 1,1,1-Trifluorotoluene
- 1,4-Dichlorobutane
- 2,4,6-Tribromophenol
- 2,5-Dibromotoluene
- 2-Fluorobiphenyl
- 2-Fluorophenol
- 4-Nitroquinoline-1-oxide
- 4-Terphenyl-d14
- Acetone
- Benzene
- Bis(2-ethylhexyl)phthalate
- Bromoform
- Chlorodibromomethane
- Cyanide
- Dichlorobromomethane
- Ethylbenzene
- Methyl Bromide
- Methyl Chloride
- Naphthalene
- Nitrobenzene-d5
- O-Terphenyl
- Petroleum Hydrocarbons
- Phenols
- Surfactants
- Tetrachloroethylene
- Toluene
- Xylenes

Metals:

- Aluminium
- Antimony
- Arsenic
- Barium
- Barium Strontium
- Boron
- Cadmium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Lithium
- Magnesium
- Manganese
- Molybdenum
- Nickel
- Phosphorous
- Potassium
- Selenium
- Silver
- Strontium
- Thallium
- Zinc
- Zirconium

Salts and other components:

- Carbonate (alkalinity)
- aqueous ammonia
- Fluoride
- Nitrogen (as total N)
- scale inhibitors
- oil and grease

Also noted are other impacts on water quality such as pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Specific Conductivity, Total Dissolved Solids (TDS), Total Organic Carbon, and Total Suspended Solids.

The Table below summarizes data selected from EPA (USEPA, 2016(b)), and DEC (NYSDEC, 2009, Tables 6.1 and Table 6.2) which presents an array of "Typical concentrations of flowback constituents based on limited samples from Pennsylvania and West Virginia, and regulated in NY," [we excluded data that only has one sample or one sample detected]. While these samples are from fracking wastewater originating from Pennsylvania and West Virginia, they are representative of what is expected from other Marcellus Shale locations. Some parameters such as benzene, ethylbenzene, cyanide and radium exceed Maximum Contaminant Limits (MCLs) for those chemicals in drinking water.

Table: Selected Organic Chemical Constituents in Fracking Wastewater reported by NYS DEC and U.S. EPA[2, 3]							
Chemical constituent or surrogate parameter	NYSDEC Data			EPA Data[4]		Maximum Contaminant Level (MCL)	Comments
	Number of samples (number detected)	Range	Median	Range	Median		
4-Nitroquinoline-1-oxide	n=24 (24)	1,422-48,336 mg/L	13,908 mg/L			N/A	
Acetone	n=3 (1)	ND-681 ug/L	681 ug/L			N/A	
Cyanide	N=7 (2)	6-12.5 mg/L	19 mg/L			0.2 mg/L	MCL based on nervous system effects and thyroid problems.
Di(2-ethylhexyl) phthalate	n=23 (2)	10.3-21.5 ug/L	15.9 ug/L			6 ug/L	MCL based on reproductive and liver effects, and increased cancer risk.
Ethylbenzene	n=29 (14)	3.3-164 ug/L	53.6 ug/L	7.6-650 ug/L	42 ug/L	70 ug/L	MCL based on kidney and liver effects.
Oil and grease	n=25 (9)	5-1470 mg/L	17 ug/L			N/A	
Phenols	n=25 (5)	0.05-0.44 mg/L	0.191 mg/L			N/A	
BTX (benzene, toluene, xylene)					1,102 ug/L		
Benzene	n=29 (14)	15.7-1950 ug/L	479.5 ug/L	5.8-2,000 ug/L	220 ug/L	5 ug/L	MCL based on anemia, decreased blood platelets, and increased cancer risk.
Toluene	n=29 (15)	2.3-3190 ug/L	833 ug/L	5.1-6,200 ug/L	540 ug/L	1,000 ug/L	MCL based on nervous system, kidney and liver effects.
Xylenes	n=22 (14)	16-2670 ug/L	487 ug/L	15-6,500 ug/L	300 ug/L	10,000 ug/L	MCL based on nervous system effect.
TTHMs (Total Trihalomethanes)						80 ug/L	MCL based on liver, kidney, central nervous system and increased cancer risk.
Bromoform	n=29 (2)	34.8-38.5 ug/L	36.65 ug/L			80 ug/L	TTHM, Total
Chlorodibromomethane	n=29 (2)	3.28-4.06 ug/L	3.67 ug/L			80 ug/L	TTHM, Total
Radium					10,000 pCi/L	5 pCi/L	MCL based on increased cancer risk.

[2] NYSDEC, 2009. New York State Department of Environmental Conservation. Draft Supplemental Environmental Impact Statement, Chapter 6: Potential Environmental Impacts. See Table 6.1 and 6.2 for full dataset.
[3] USEPA, 2016 (b). United States Environmental Protection Agency. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States: Appendices. December 2016. EPA-600-R-16-236Fb. www.epa.gov/hfstudy
[4] Number of samples not reported.

With increasing attention and interest in fracking contamination, the USEPA, state governments, and researchers will undoubtedly produce more data on impacts on groundwater, surface water and drinking water supplies focused on detecting specific constituents at low levels of detection. Evaluating the result of fracking wastewater spills during transportation would provide useful information.

II. HEALTH EFFECTS OF CONTAMINANTS IN FRACKING WASTEWATER

Of the multitude of chemicals identified in fracking wastewater, many are associated with adverse effects on health and the environment. Colborn et al., 2011, found that more than 75% of these chemicals are associated with adverse effects on the skin, eyes, respiratory and gastrointestinal systems; about 40% could have effects on the brain/nervous system, immune and cardiovascular systems, the kidneys and endocrine system; and 25% are associated with cancer and mutations.

Toxicological appraisals are generally conducted based on higher levels of exposure mainly from occupational studies or animal studies, from which 'safe' levels of exposure are derived. The Agency for Toxic Substances and Disease Registry (ATSDR) has appraised toxicity of a wide array of chemicals found in the environment, including some of those associated with fracking wastes. The Maximum Contaminant Limit (MCL) derived by EPA for drinking water is developed to protect the public with an adequate margin of safety. MCLs are based on toxicological information and application of uncertainty factors to derive a drinking water concentration that is protective of public health. Some of the toxicology appraisals and MCLs are summarized below.

A. Acetone

Most of the information on acetone effects comes from examination of effects on workers, and evaluation of adverse effects in experimental animal studies. Workers exposed by inhaling acetone at very high levels complained of headache, lightheadedness, unsteadiness and confusion. Animals exposed to large amounts by ingestion had bone marrow hypoplasia (fewer new cells being produced), degeneration of the kidneys, increased liver weights, and listlessness. Pregnant mice that swallowed acetone had lower body weights and produced fewer newborn mice (ATSDR, 1994). An MCL has not been provided by EPA for acetone (USEPA, 2009).

B. Benzene

Eating foods or drinking liquids containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, coma, and death. The health effects that may result from exposure to lower levels of benzene are not well known. Benzene causes effects on normal blood production and can lead to a decrease in red blood cells (anemia). Excessive exposure to benzene can be harmful to the immune system, increasing the chance of infection and perhaps lowering the body's defense against cancer. Long-term exposure to benzene can cause cancer of the blood-forming organs (leukemia). Benzene is classified as carcinogenic to humans (can cause cancer). In addition, benzene may be harmful to reproductive organs and the developing fetus (ATSDR, 2007). EPA calculated an MCL of 5 micrograms per liter (ug/L) for benzene based on its effects on blood platelets, anemia, and increased cancer risks (USEPA, 2009).

C. Cyanide

Cyanide is a chemical group consisting of carbon bonded to nitrogen, which can occur naturally or produced synthetically. Cyanide has been found in almost 500 of some 1,662 former or current National Priorities List site for clean-up activities. Cyanide enters air, water, and soil from both natural processes and industrial activities. The half-life of cyanide in water is not known. Cyanide is a powerful and rapid-acting poison, affecting the nervous system and capable of causing death at high concentrations. As the cyanide goes through the body, it can affect the thyroid gland, reducing the ability of the gland to produce hormones that are necessary for the normal function of the body (ATSDR, 2006). EPA established an MCL for cyanide of 0.2 mg/L (200 ug/L) based on effects on the nervous system and thyroid problems.

D. Total Trihalomethanes (TTHMs): Bromoform, Chloroform, Dichlorobromomethane and Dibromochloromethane

Total Trihalomethanes (TTHMs) are the group of four chemicals noted above. They are byproducts of chlorination of water supplies, and also formed from brines containing chlorine and other salts containing bromine. The main effect of swallowing or breathing large amounts of bromoform is a slowing of normal brain activities, resulting in sleepiness or sedation, which tends to subside after exposure ceases. Some studies in animals indicate that exposure to high doses of bromoform or dibromochloromethane may also lead to liver and kidney injury, and can cause liver and kidney cancer. The EPA classified bromoform as a probable human carcinogen and dibromochloromethane as a possible human carcinogen (ATSDR, 2005). The MCL for TTHMs is 80 ug/L based on effects on the liver, kidneys, central nervous system, and increased cancer risk (USEPA, 2009).

E. Ethylbenzene

Exposure to high levels of ethylbenzene in air can cause eye and throat irritation, vertigo and dizziness. Relatively low levels of ethylbenzene in air resulted in potentially irreversible damage to the inner ear and hearing of animals. Rats exposed to large amounts of ethylbenzene orally had severe damage to the inner ear. There is limited information suggesting minor birth defects and low birthweight in newborn animals whose mothers were exposed air containing ethylbenzene. Information on potential effects on children or whether ethylbenzene causes birth defects in people is not available (ATSDR, 2010). The MCL for ethylbenzene is 700 ug/L based on kidney and liver effects (USEPA, 2009).

F. Phenols

As with other chemicals, the degree of exposure will influence the likelihood of adverse health effects. Ingestion of liquid products containing concentrated phenol can cause serious gastrointestinal damage and even death. Inhalation of high levels of phenol has caused irritation of the respiratory tract and muscle twitching in animals. Longer term inhalation exposure to high levels of phenol caused damage to the heart, kidneys, liver, and lungs in animals. Drinking water with extremely high concentrations of phenol has caused muscle tremors, difficulty walking, and death in animals (ATSDR, 2008). While an MCL for phenols is not available, EPA has set a lifetime health advisory for phenols at a concentration of 2 mg/L (ATSDR, 2008).

G. Radium

Radium is naturally present in the environment, usually at very low levels, and we are all exposed to small amounts of radiation. Radiation has been shown to cause adverse health effects such as anemia, cataracts, fractured teeth, cancer and death. The relationship between the amount of radium that you are exposed to and the amount of time necessary to produce these effects is not known. Although there is some uncertainty as to how much exposure to radium increases your chances of developing a harmful effect, the greater the total amount of your exposure to radium, the more likely you are to develop one of these diseases (ATSDR, 1990). The EPA derived an MCL for radium of 5 picocuries per liter based on increased cancer risk (USEPA, 2009).

H. Toluene

Toluene may have an effect on the nervous system (brain and nerves) after exposure; these effects may be temporary, such as headache, dizziness, or unconsciousness. However, some effects such as incoordination, cognitive impairment, and vision and hearing loss may become permanent with repeated exposure, especially at high concentrations. High levels of toluene exposure during pregnancy, such as those associated with solvent abuse, may lead to retardation of mental abilities and growth in children. Other health effects of potential concern may include immune, kidney, liver, and reproductive effects. Some studies in people have sown reproductive effects, such as an increased risk of spontaneous abortions, from high levels of toluene in the workplace. Additionally, exposure to high levels of toluene could possibly cause liver and kidney damage (ATSDR, 2015). The EPA derived an MCL for toluene of 1,000 ug/L based on effects on the nervous system, liver and kidneys (USEPA, 2009).

I. Total Petroleum Hydrocarbons

Total Petroleum Hydrocarbons (TPH) is a term used to describe a broad family of several hundred chemical compounds that originally come from crude oil. In this sense, TPH is really a variable mixture of chemicals. Some of the TPH chemicals, such as the smaller compounds benzene, toluene and xylene (which are present in gasoline and other petroleum products) can affect the human central nervous system, blood, immune system, liver, spleen, kidneys, developing fetus, and lungs (ATSDR, 1999). An MCL for Total Petroleum Hydrocarbons is not available.

J. Xylenes

There are three forms of xylene, with very similar effects on health. Short-term exposure to high levels of xylenes can cause irritation of the skin, eyes, nose and throat; difficulty breathing; impaired function of the lungs; delayed response to a visual stimulus; impaired memory; stomach discomfort; and possible changes in the liver and kidneys. Both short-term and long-term exposure to high levels of xylenes can cause effects on the nervous system such as headaches, lack of muscle coordination, dizziness, confusion, and changes in one's sense of balance. The results of animal studies indicate that large amounts of xylenes can cause changes in the liver and harmful effects on the kidneys, lungs, heart, and nervous system. Long-term exposure of animals to low concentrations of xylenes has not been well studied, but there is some information that long-term exposure of animals can cause harmful effects on the kidney (with oral exposure) or on the nervous system (with inhalation exposure) (ATSDR, 2007). The EPA derived an MCL for xylenes of 1,000 ug/L based on nervous system effects (USEPA, 2009).

III. POTENTIAL TO CONTAMINATE WATER RESOURCES: RELATIONSHIP BETWEEN FRACKING ACTIVITY AND WATER QUALITY

There is mounting evidence of the adverse impact of fracking operations and waste transport on water quality. Although analytical data on water impacts is often unavailable or incomplete, there is adequate information to conclude that fracking activities and waste transport can adversely affect groundwater, surface water and drinking water supplies (PSR, 2018; Hays and Shonkoff, 2016; Myers, 2012).

The EPA' s study evaluating the impact of fracking on the water cycle (USEPA, 2016), found that fracking activities have caused contamination of water resources, and looked at the various routes that drinking water can be affected. The EPA documented cases of drinking water contamination that have resulted from spills of fracking fluid and fracking wastewater; the discharge of fracking fluids into rivers and streams, as well as the underground migration of fracking chemicals, including gas (methane), into drinking water wells (PSR, 2018 at page 53). About 5% of all fracking waste is lost to spills, often during transport (PSR, 2018 at page 48).

The potential for communication between the drilled fracking wells and the water aquifer has been a topic of increasing concern as contaminants are identified that originated from fracking fluids. Near these wells, potential pathways for vertical transport of gases and fracking fluids include transport through sedimentary rock, fractures and faults, and abandoned wells or open boreholes. Open boreholes and improperly sealed water and gas wells can be conductive pathways among aquifers (Myers, 2012).

There are several above ground and below ground mechanisms by which hydraulic fracturing could affect drinking water resources. Above ground activities such as spills of hydraulic fluid and chemicals, spills of flowback and produced wastewater, and inadequate treatment or discharge of fracking wastewater can affect ground and surface water resources. Below ground mechanisms include movement of liquids and gases via the production well into underground drinking water resources, and movement from the fracture zone (Gill et al., 2017).

Below ground movement of fluids, including gases, most likely via the production well, has contaminated drinking water resources (Gill et al., 2017).

Reports of contamination have been identified where spills of hydraulic fracturing fluid and produced water in certain cases have reached drinking water resources, both surface and groundwater. Discharge of treated hydraulic fracturing wastewater has increased contaminant concentrations in receiving surface waters (PSR, 2018).

Wastewater from fracking may potentially impact groundwater, surface water and drinking water when wastewater is transported from one location (where it is generated), to other locations where it will be treated and or disposed. Information on the total volumes of fracking wastewater produced is lacking; information on treatment and disposal procedures are elusive. While the number of events may be small (and this itself is not known), even one spill near a sensitive water receptor could have catastrophic impacts on groundwater, surface water and drinking water supplies.

Risks to surface water from spills related to fracking activities in four states (Colorado, New Mexico, North Dakota and Pennsylvania) were evaluated by Maloney et al., 2017. Across all four states, 21,000 fracking wells were identified with 6,622 spills reported during the period 2005 through 2014, amounting to 32% spill rate over the period. The authors evaluated the materials spilled, reasons for the spills, and volumes of spilled materials. They found that spill reports are often short on detail precluding a thorough assessment. Wastewater and crude oil were two of the most frequently spilled materials; Pennsylvania was found to have watersheds highly important to drinking water sources, and they infer that freshwater resources in this state may be at higher risk (Maloney et al., 2017).

Regarding potential impacts on water quality, an assessment of 58 studies relevant to shale gas development found that of 46 original research studies, 40 (69%) found potential association or actual incidence of water contamination associated with fracking activities (Hays and Shonkoff, 2016).

USEPA (2016(b) at E.5) reports that in Pennsylvania, based on notices of violation, between May 2009 and April 2013, eight spills of flowback and produced water ranging from more than 4,000 gallons to more than 57,000 gallons reached surface water resources. The spills were reported to have resulted in local impacts to environmental receptors, requiring remediation and monitoring.

A. Wastewater Transportation and Disposal

The large volumes of fracking wastewater produced pose a waste disposal dilemma.

Fracking fluids amount to between 2 and 13 million gallons of water per well, which include some portion of the chemicals added, and natural materials brought up from the shale and rock formations as produced wastewater (Vengosh et al., 2014; Schmidt, 2013). The amount of injected fluid that returns to the surface as flowback and produced water after fracking is estimated to range from 9% to 34% of the injected fluid, resulting in 0.18 to 4.42 million gallons per well that is released as wastewater. The remainder stays underground. (Myers, 2012).

Where does this contaminated wastewater go after it comes up from a fracking well?

As discussed by Wilke and Freeman, 2017, the flowback can be handled in various ways: it can be reused or recycled, evaporated in surface pools, or transported and injected into deeper disposal wells. It is estimated that as much as 95% of the wastewater generated by fracking is injected into disposal wells. They note that it is important to monitor the depth and geological location of these disposal wells for future potential impacts. In just Pennsylvania, more than 180,000 fracking wells had been drilled prior to any requirement for documenting their location, leaving many locations unknown including abandoned wells (Myers, 2012).

Gas producers in Pennsylvania traditionally sent their wastewater to municipal water sewage treatment plants for treatment and then discharge into rivers. However, environmental concerns have grown, and in April 2011, the Pennsylvania Department of Environmental Protection (DEP) called on the Marcellus Shale industry to cease wastewater delivery to municipal sewage treatment plants (Schmidt, 2013).

The loss of municipal treatment for fracking water waste in Pennsylvania resulted in the need for removal of the wastewater to be trucked for disposal to other areas, and sequestered via underground injection. Some of these wastes are transported to Ohio, estimated to have increased from about 26 million gallons in 2010 to 106 million gallons in 2011 (Schmidt, 2013).

The chances of an accident during transportation of fracking waste has been assessed by EPA. (USEPA, 2016(b) at E-8). EPA based their estimates using available information on estimated volumes, disposal distances, truck sizes, and accident rates. The total travel distance by trucks ranges from about 9,600 miles to 22,000 miles per well (see Page E-81). Each truck is assumed to carry 5,440 gallons of waste. The accident rate was assumed to be 3.4% from truck crashes and an accident rate of 28 crashes per 100 million miles travelled. The results show that the expected number of releases is relatively low. However, we note that if a spill does occur near groundwater, surface water or drinking water resources, it can seriously impact the chemical composition of the receiving water.

An article published by the American Public Health Association (Krisberg, 2017), points out that EPA concluded that fracking can affect drinking water under some circumstances. Among the factors and events that can harm drinking water are spills of fracking fluids and chemicals, the injection of fracking fluids into defective wells, the discharge of inadequately treated fracking wastewater into surface water and the disposal of fracking wastewater into unlined pits that may leak into nearby groundwater. The report notes that due to large data gaps, the EPA was unable to estimate how often activities impact drinking water sources.

An analysis of spill data suggests that the commonly reported pathways where spills of fracking wastewater occurred included blowouts at the wells, drilling equipment, completion equipment, tanks, pits, flowlines, heater treaters, stuffing boxes, pumps, transportation, leaks around the wellhead, and unknown. For the state data analyzed (Colorado, New Mexico, North Dakota, and Pennsylvania), between 93% to 98% were attributed to one of these pathways (Patterson et al., 2017).

Spills related to fracking were associated with equipment failure, human error, failure of container integrity, and other (vandalism and weather). More than 30% of spills characterized by the USEPA came from fluid storage units such as tanks, totes, and trailers (USEPA, 2016(b) at A-11).

B. Ecological Impacts

In addition to potential adverse effects from drinking contaminated water, there are also significant potential impacts on the general environmental ecosystem that have been assessed and reported in many review documents and research. When spills of wastewater reach a stream or other receptor, the volume of the wastes is an important determinant of the potential impact on the receiving water. In an evaluation of fracking spills in four states (Colorado, New Mexico, North Dakota, and Pennsylvania), 21,300 fracking wells were identified, and 6,622 spills were reported. The spilled amounts ranged from 100 to 10,000 liters. Produced waters from fracking wastewater generally have much higher salinities (from salt brines) than surface waters, and even small inputs can impact freshwater quality (Vengosh et al., 2014).

Wastewater, crude oil, drilling waste, and hydraulic fracturing fluid were the materials most often spilled. The report notes that Pennsylvania spills occurred in watersheds with a higher relative importance to drinking water sources (Maloney, 2017).

i. Aquatic Life

Primary impacts on aquatic life are often due to discharges of Total Dissolved Solids (TDS), sulfates and chlorides in the receiving surface water (PA DEP, 2009). Brine and fracking wastewater have high concentrations of TDS which causes toxicity through increases in salinity, changes in ionic composition of the water, and toxicity of the individual ions. Several studies on the potential impact to aquatic life from large TDS discharges found that there was a clear transition of freshwater organisms to brackish water organisms in the receiving water, indicating a shift in biotic communities (PA DEP, 2009).

ii. Streambed and Biota Diversity

Increased plant mortality and lower streambed diversity have been reported as a result of receiving fracking wastewater. Exposure to wastewater has been shown to increase plant mortality of terrestrial plants, reduce juvenile mussel survival rates, and lower streambed microbial diversity (Maloney et al, 2017). Spills or intentional discharges of fracking waste into streams has impacted the ecology and aquatic biodiversity and populations of sensitive fish species, such as brook trout (PSR, 2018 at page 48). Adverse impacts to quantity and quality of aquatic, wetland, and terrestrial habitats and the biota that they support have been reported (NYSDEC, 2009; NYSDOH, 2014).

iii. Agriculture

Threats to agriculture have been evaluated in California where damage to the timber sector and farmers using fracking wastewater for crop irrigation and livestock watering were identified. The wastewater contained at least ten known or suspected carcinogens, as well as over a dozen chemicals with no available toxicological data, and many unidentified compounds currently classified as 'trade secrets' (PSR, 2018, at p 163).

Studies and case reports from across the country have found instances of deaths, neurological disorders, aborted pregnancies, and stillbirths in animals that have come in contact with wastewater. Additionally, farmers have concerns that the fracking process and wastes could invalidate organic certification (PSR, 2018, at page 164).

Impacts on agriculture and soil from spills of wastewater have been found (Delaware Riverkeeper Network, 2014). Soil quality, if contaminated or compacted by drilling or infrastructure can reduce crop yield and quality. Changes in the number of working farms, as a result of drilling or contamination, was found in a Pennsylvania study where dairy farmers sold their property and moved (DRN, 2014 at page 14).

Land use changes and transport of invasive species by drilling and fracking operations have led to documented ecological and monetary harm to soils, forests, and natural areas which are presented in the PDR 2018 Compendium (PDR, 2018 at p 164).

iv. Demand on Water Resources

Increased demand for water resources and availability of water for other uses due to high water usage for fracking has been an increasingly important aspect for resource allocation (Pacific Institute, 2012). Watershed withdrawals to conduct fracking operations use an estimated 2.3 to 3.8 million gallons of water per well, which may underestimate and be more variable than reported previously, and put stress on an already taxed groundwater aquifer system. Concerns over water availability have been seen across the US (Pacific Institute, 201 at p 16). There are competing interests for water acquisition – for drinking water, for agriculture, for commerce, and surface and groundwater sufficiency, and so on. Reduced streamflow due to water withdrawals, insufficient supplies for downstream uses such as public water supply has been reported (NYSDOH, 2014).

IV. SUMMARY

Hydraulic fracking is well-recognized to cause effects on water quality as a result of the use of a variety of chemicals in the process, handling, transportation, and disposal of fracking wastewater. The wastewater contains toxic chemicals which sometimes contaminate surface water, groundwater and drinking water supplies if mishandled or spilled. In addition, adverse effects on aquatic life, streambed diversity, agriculture, and water resources are known to occur.

REFERENCES

Adgate, J., et al. 2014. Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development. Environ Sci and Tech, Vol 48, 8307-8320.

ATSDR, 1994. Agency for Toxic Substances and Disease Registry. Toxicological profile for Acetone. Public Health Statement. US Department of Health and Human Services, Public Health Service.

ATSDR, 2007. Agency for Toxic Substances and Disease Registry. Toxicological profile for Benzene. Public Health Statement. US Department of Health and Human Services, Public Health Service.

ATSDR, 2005. Agency for Toxic Substances and Disease Registry. Toxicological profile for Bromoform and Dibromochloromethane. Public Health Statement. US Department of Health and Human Services, Public Health Service.

ATSDR, 2006. Agency for Toxic Substances and Disease Registry. Toxicological profile for Cyanide. Public Health Statement. US Department of Health and Human Services, Public Health Service.

ATSDR, 2010. Agency for Toxic Substances and Disease Registry. Toxicological profile for ethylbenzene. Public Health Statement. US Department of Health and Human Services, Public Health Service.

ATSDR, 2008. Agency for Toxic Substances and Disease Registry. Toxicological profile for Phenol. Public Health Statement. US Department of Health and Human Services, Public Health Service.

ATSDR, 1990. Agency for Toxic Substances and Disease Registry. Toxicological profile for Radium. Public Health Statement. US Department of Health and Human Services, Public Health Service.

ATSDR, 2015. Agency for Toxic Substances and Disease Registry. Toxicological profile for Toluene. Public Health Statement. US Department of Health and Human Services, Public Health Service.

ATSDR, 1999. Agency for Toxic Substances and Disease Registry. Toxicological profile for Total Petroleum Hydrocarbons. Public Health Statement. US Department of Health and Human Services, Public Health Service.

ATSDR, 2007. Agency for Toxic Substances and Disease Registry. Toxicological profile for Xylene. Public Health Statement. US Department of Health and Human Services, Public Health Service.

Brown, V., 2014. Radionuclides in Fracking Wastewater: Managing a Toxic Blend. Environ. Health Perspect. Vol 122(2): A50-55.

Burgos, W., et al., 2017. Watershed-scale Impacts from Surface Water Disposal of Oil and Gas Wastewater in Western Pennsylvania. American Chemical Society, Environmental Science and Technology, DOI: 10.1021/acs.est.7b01696.

Colborn, T., et al., 2011. Natural Gas Operations from a Public Health Perspective. Human and Ecological Risk Assessment: An International Journal, http://dx.doi.org/10.1080/10807039.2011.605662

DRBC, 2017. Delaware River Basin Commission, Proposed Amendments to the Administrative Manual and Special Regulations Regarding Natural Gas Development Activities; Additional Clarifying Amendments. 18 CFR Parts 401 and 440.

DRN, 2014. Delaware Riverkeeper Network, 2014. Docket #PF14-8: Scoping Comment for the EIS for William's Atlantic Sunrise Project. August 16, 2014.

Finkel, M., et al., 2013. Modern Natural Gas Development and Harm to Health: The Need for Proactive Public Health Policies. ISRN Public Health, Volume 2013, Article ID 408658, http://dx.doi.org/10.1155/2013/408658

Gill, A., et al., 2017. Critical Review of Risks to Water Resources from Hydraulic Fracturing. International Journal of Advance Research, Ideas and Innovations in Technology. Volume 3, Issue 6.

Hays, J. and Shonkoff, S., 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 11(4): e0154164. https://doi.org/10.1371/journal.pone.0154164

Krisberg, K., 2017. EPA: Fracking activities can put drinking water at risk due to toxicity. American Public Health Association (APHA), The Nation's Health, February/March 2017, Vol 47, no. 1.

Konschnik, K. and A. Dayalu, 2016. Hydraulic fracturing chemicals reporting: Analysis of available data and recommendations for policymakers. Energy Policy Vol 88, 504-514.

Llewellyn, G., et al. 2015. Evaluating a groundwater supply contamination incident attributed to Marcellus Shale gas development. PNAS, Vol 112 (20), 6325-6330.

Maloney, K., et al., 2017. Unconventional oil and gas spills: Materials, volumes, and risks to surface waters in four states of the U.S. Science of the Total Environment, Vol 581-582, 369-377.

MSI, Michigan Sustainability Institute. 2015. High Volume Hydraulic Fracturing in Michigan. Integrated Assessment Final Report. September 2015.

Montague, J. and G. Pinder, 2015. Potential of hydraulically induced fractures to communicate with existing wellbores. Water Resources Research, 51:8303-8315, doi:1002/2014WR016771

Myers, T., 2012. Potential Contaminant Pathways from Hydraulically Fractured Shale to Aquifers. Ground Water, National Ground Water Association, NGWA.org, doi: 10.1111/j.1745-6584.2012.00933.x

Nelson, A., et al., 2015. Understanding the Radioactive Ingrowth and Decay of Naturally Occurring Radioactive Materials in the Environment: An Analysis of Produced Fluids from the Marcellus Shale. Environ Health Perspect 123(7): 689-696.

NRDC Issue Brief, 2012. Natural Resources Defense Council, State Hydraulic Fracturing Disclosure Rules and Enforcement: A Comparison. July 2012 IB: 12-06-A. Author M. McFeeley.

NYSDEC, 2009. New York State Department of Environmental Conservation. Draft Supplemental Environmental Impact Statement, Chapter 6: Potential Environmental Impacts.

NYSDOH, 2014. New York State Department of Health. A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development.

Pacific Institute, 2012. Hydraulic Fracturing and Water Resources: Separating the Frack from the Fiction. H. Cooley and K. Donnelly, June 2012.

Patterson, L. et al., 2017. Unconventional Oil and Gas Spills: Risks, Mitigation Priorities, and State Reporting Requirements. Environ Sci and Tech. Accessed on line 2/16/17. DOI: 10.1021/acs.est.6b05749.

PA DEP, 2011) Pennsylvania Department of Environmental Protection. Permitting Strategy for High Total Dissolved Solids (TDS) Wastewater Discharges, April 11 2009.

PSR, 2018. Physicians for Social Responsibility, Concerned Health Professionals of NY, Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction), Fifth Edition, March 2018.

Schmidt, C., 2013. Estimating Wastewater Impacts from Fracking. Environ. Health Perspect. 121(4): a117. PMCID: PMC3620738.

Schneiderman, E., 20XX. Plaintiff State of New York, US District Court, Eastern District of New York.

Stanberry, K. and Stanberry, C., 2017. The Fracking Controversy: Can Environmental Concerns be Resolved? International Journal of Applied Science and Technology. Volume 7, No. 2, June 2017.

USEPA, 2009. National Primary Drinking Water Regulations. May 2009. EPA 816-F-09-004.

USEPA, 2016 (a). United States Environmental Protection Agency. Hydraulic Fracturing for Oil and Gas: Impacts from Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. Dec 2016. EPA-600-R-16-236ES. www.epa.gov/hfstudy

USEPA, 2016 (b). United States Environmental Protection Agency. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States: Appendices. December 2016. EPA-600-R-16-236Fb. www.epa.gov/hfstudy

Vengosh, A., et al., 2014. A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States. Environ Sci and Tech., Vol 48, 8334-8348.

Wilke, R. and Freemen, J., 2017. Potential Health Implications Related to Fracking. American Medical Association, Published online October 16, 2017. doi:10.1001/jama.2017.14239.

JUDITH S. SCHREIBER, Ph.D.

Dr. Schreiber earned a Bachelor of Science degree in Chemistry from the State University of New York at Albany (1972), as well as a Master of Science degree in Chemistry (1978), and a Doctoral degree in Environmental Health and Toxicology from the School of Public Health of the State University of New York at Albany (1992).

Her career has been dedicated to assessing public health impacts of human exposure to environmental, chemical and biological substances. She was employed by the New York State Department of Health for over 20 years in varying capacities conducting investigations and risk assessments. She joined the New York State Office of the Attorney General in 2000, where she evaluated environmental and public health risks of importance to the State of NY. Dr. Schreiber retired from public service in 2012.