Impact of *Executive Order (2014-03): Leasing of State Forest and State Park Land for Oil and Gas Development* by Governor Corbett on the State Lands and Parks of the Commonwealth of Pennsylvania

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I - INTRODUCTION

In Spring 2014, the Governor's Office of the Commonwealth of Pennsylvania issued an executive order allowing, under certain conditions, the leasing of state forest and state park land for oil and gas development, including shale gas extraction through high volume horizontal fracturing [HVHF], which includes water withdrawals, deforestation, heavy equipment use, drilling pad installation, noise, and the injection of water, sand, and fracking fluid (hereafter referred to as hydrofracking) as a means to extract natural gas resources in the Marcellus shale of Pennsylvania, as well as other locations in the State of Pennsylvania where natural gas resources have or will be identified.

In particular, according to a news release from the Governor's office from May 23, 2014 (see Appendix A), the order **will allow gas to be extracted horizontally through wells located on adjacent private lands or previously leased areas of the state forest.** This order is therefore likely to increase the numbers of shale gas extraction permits on land immediately adjacent to state land, or in state lands where a lease was previously issued.

The first part of this document (Section A) discusses the implication of this order with respect to surface water / groundwater interactions, forest hydrology (water quantity, water quality), subsurface hydrology (water table height, groundwater contamination), and to a limited extent the impact of surface operations on wildlife and recreation.

The second part of this document (Section B) presents a possible framework that could be implemented as a tool to identify places in the landscape where the impact of surface and subsurface operations on the landscape would have the least impact. To this end, four actionable recommendations that could easily be incorporated in a permitting process are presented.

The third part of this document (Section C) synthesizes a lot of the information presented in Sections A and B to answer key questions associated with the constitutionality of Executive Order 2014-03, as related to: 1) The fact that the Commonwealth must protect the environment for future generations; 2) How one should design a review process to minimize negative environmental impacts of any future shale gas extraction operations, 3) The type of information, studies, or investigation needed prior to any new drilling approvals, 4) The potential for Executive Order 2014-03 to cause unreasonable degradation of our natural resources, and 5) Conditions that should be imposed on new drilling sites to reduce impacts.

The purpose of this document is not to take a position for or against hydrofracking, but instead to discuss the implications of Executive Order 2014-03, especially with respect to surface water impacts vs. groundwater impacts. I am therefore not addressing in details some general issues associated with hydrofracking such as the recycling and/or disposal of "fracked" water, site remediation/restoration, or the inadequacy of alert systems should contamination occur (Lautz et al. 2014).

II - SECTION A

IMPLICATIONS OF EXECUTIVE ORDER 2014-03 ON STATE FORESTS AND PARK LANDS

II.1. Surface water and groundwater: A single resource

The language used in Executive Order 2014-03 issued by Governor Corbett in Spring 2014 (hereafter referred to as the Executive Order) clearly focuses the debate on surface disturbance:

> … oil and natural gas development which results in no additional surface disturbance to state park and forest lands managed by[the Pennsylvania Department of Conservation and Natural Resources] is consistent with ensuring the stewardship and protection of such lands for the benefit of all the citizens….

Although surface disturbance is important, **it is not possible to separate surface disturbance from subsurface disturbance that occur when a well is installed, and when fracking fluid is injected into the subsurface.** In particular, although it is understood that colloquially it is convenient to separate surface water resources from groundwater resources, it is incorrect to assume that these resources are separate from one another.

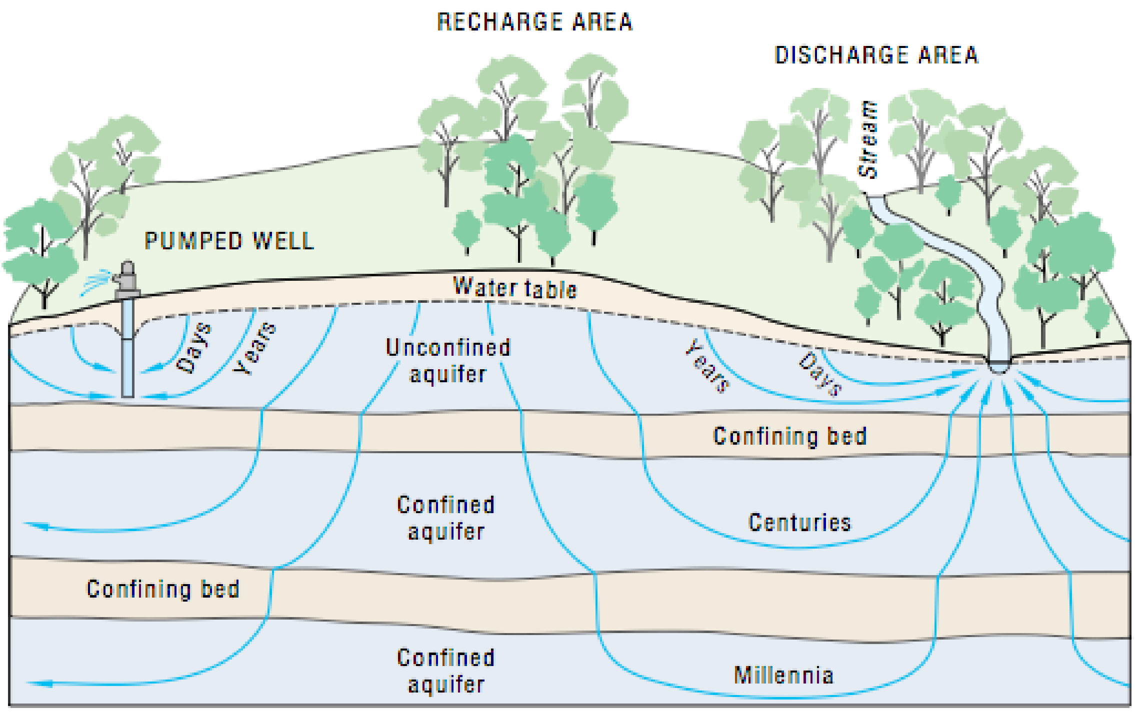
In 1998, the US Geological Survey (USGS) released USGS Circular 1139 *Groundwater and Surface Water: A Single Resource* (Winter et al. 1998). The foreword for this document, written by Robert Hirsch, Chief Hydrologist at the USGS, crystalizes the key points of this document:

> Traditionally, management of water resources has focused on surface water or ground water as if they were separate entities. As development of land and water resources increases, it is apparent that development of either of these resources affects the quantity and quality of the other. Nearly all surface-water features (streams, lakes, reservoirs, wetlands, and estuaries) interact with ground water. These interactions take many forms. In many situations, surface-water bodies gain water and solutes from ground-water systems and in others the surface-water body is a source of ground-water recharge and causes changes in ground-water quality. As a result, withdrawal of water from streams can deplete ground water or conversely, pumpage of ground water can deplete water in streams, lakes, or wetlands. Pollution of surface water can cause degradation of ground-water quality and conversely pollution of ground water can degrade surface water.

Since this circular was released to the public, recent research has continued to illustrate the connectivity between surface water and groundwater resources. As indicated in Circular 1139, groundwater flow path may vary greatly in length, depth, and travel time from points of recharge (i.e. surface water entering the ground) and points of discharge (i.e. groundwater re-entering the surface water system). In particular, geological layers affect the groundwater residence time. However, no geological layer truly isolates a water source from the surface, so **the assumption that groundwater disturbances do not impact surface water resources, or that only surface operations have an impact on surface water resources is erroneous at best, and certainly misleading to a general audience not well versed in the connection between surface water and groundwater systems.**

My own research documenting surface water – groundwater interactions around streams in a variety of landscapes support this argument that surface water and groundwater are one resource and should not be separated when discussing the impact of fracking activities on state forests and parks (Vidon et al. 2013; Vidon and Smith 2007; Vidon and Hill 2006; Vidon and Hill, 2004).

Figure 1: Ground-water flow paths vary greatly in length, depth, and travel time from points of recharge (i.e. surface water entering the ground) and points of discharge (i.e. groundwater re-entering the surface water system) in the ground- water system. However, even across poorly conductive geological layers (confining beds on the figure below), surface water and groundwater resources remain connected. Reproduced from USGS Circular 1139, page 5: http://pubs.usgs.gov/circ/circ1139.



II.2. Forest Hydrology

II.2.1: Water Quantity

The volume of water generated by first-order catchments (catchment with one stream but no tributaries) has far reaching impact on the quantity of water flowing downstream. In the Northeastern US, which includes Pennsylvania, 70% of the water volume in second order streams (streams with at least one tributary) originate from first-order streams (Alexander et al. 2007). Moreover, the flow contributions of headwater catchments to the mean water volume in downstream reaches decline only marginally to about 55% in fourth- and higher-order streams (Alexander et al. 2007).

In their synthesis efforts of the role of headwater streams on water quantity and water quality downstream, Alexander et al. (2007) also stress that because of the intrinsic connection between headwater streams and landscape processes and downstream waters, headwater streams impact the supply, transport, and fate of water in whole watersheds, regardless of size.

When fracking occurs, huge volumes of water are pumped into the ground. This water is generally sourced locally to reduce transport costs, and is therefore often collected from first, second, or third order catchments and streams where most fracking operations occur in the Marcellus Shale area of Pennsylvania.

It is challenging to accurately estimate the volume of water used during fracking operations because this amount is often self-reported by energy companies. The amount of water needed per well also varies based on the characteristics of the geological formation where the natural gas is located (e.g., shale vs. siltstone), as well as the extent of the well. However, in a recent study, Macy et al. (2014) estimate that the hydrofracking of one well typically requires between seven and 19 million liters of water.

One might argue that the long-term impact of removing these amounts of water from a stream, assuming this volume is removed at a steady pace over a 12-month period may be limited. Indeed, in a stream with an average annual flow of 100 L/s (typical for an first-order stream) or 1000 L/s (typical for a second order stream), pumping 19 million liters of water out of the stream represents approximately 0.6% and 0.06% of the annual flow, respectively. If seven million liters are pumped out the stream for one well, these numbers drop to 0.22% and 0.02% respectively. This is usually the way many people with limited understanding of fracking operations and stream hydrology argue that using stream water from headwater streams (where most fracking will take place) will likely have only a limited impact on stream flow. Although mathematically correct, these calculations are conceptually wrong.

Indeed, water for fracking is never pumped at a steady pace over a 12-month period. In an extensive study of the impact of the carbon footprint analysis of source water for hydrofracking, Macy et al. (2014) indicate that pumping 19 million liters of water typically takes 125 hours (5.2 days). Pumping such a huge amount of water over such a short amount of time can have drastic effects on stream flow.

Of course, stream flow varies a lot depending on time of year, so the impact of pumping such a huge amount of water over such a small amount of time can be minimized if pumping occurs during high seasonal flow in the US Northeast (e.g. late winter – early spring). However, the numbers remain really high. For instance, Table 1 (at right) indicates the impact of pumping 19 million liters of water over a 5 day period on the weekly, monthly, and seasonal (three months) flow of stream with average weekly, monthly, and seasonal flow of 100, 1000, and 2500 L/s, where 2500 L/s represents the typical spring baseflow of third order streams.

Table 1: Stream flow reduction (%) associated with the pumping of 19 millions L of water (one well) calculated based on a weekly, monthly, or seasonal (three months) time frame based on ONE well only.			
Average stream flow	**Volume pumped**	**Calculation Basis**	**Stream flow reduction**
100 L/s	19 millions L	1 week	31.33%
1000 L/s	19 millions L	1 week	3.13%
2500 L/s	19 millions L	1 week	1.25%
100 L/s	19 millions L	1 month	7.23%
1000 L/s	19 millions L	1 month	0.72%
2500 L/s	19 millions L	1 month	0.29%
100 L/s	19 millions L	3 months	2.41%
1000 L/s	19 millions L	3 months	0.24%
2500 L/s	19 millions L	3 months	0.10%

When more than one well are installed, as is often the case when high volume horizontal fracturing occurs, the impact on streams is proportionally higher. Indeed, depending on sources, between eight and 12 wells are generally installed in one drilling pad.

When put in context, these numbers indicate that the Executive Order is likely to significantly impact not only stream flow in state forests and parks, but also the health of sensitive ecosystems dependent on stream flow. Ecosystems have evolved over thousands of years to adapt to local hydrological conditions. In particular, native vegetation has evolved to develop root systems just deep enough to access water in the local water table fluctuation zone. Similarly, the water balance of sensitive wetland ecosystems is by nature very sensitive to changes in groundwater input.

It is also important to understand soil and aquifer structure when discussing the impact of the flow reduction figures on water table levels. Most soils contain (depending on texture) between 35% and 55% pore space. Even when the soil is unsaturated, a fraction of that pore space contains water trapped in small pores, especially immediately above the water table where the soil is generally at field capacity (Dingman et al 2002). A change in the amount of water recharging an aquifer (e.g. equivalent to 10 cm of water at the surface), can translate in a drop in water table by 70 or 90 cm, which makes it virtually impossible for native plants to survive (time frame too short for adaptation), and puts in jeopardy wetland systems and associated ecosystems (see calculation below).

Example of calculation of the impact of recharge rate on water table height:

For a clay loam soil, the typical porosity by volume is 45%, while the field capacity is 30% (Dingman et al. 2002). This means that in the area of the soil profile immediately above the water table, which remains at field capacity most of the time, the difference between saturation and field capacity is only 15% of the volume of the soil. Should recharge increase by 10 cm at the soil surface, this increase in recharge would translate into a water table rise of 67 cm [(100/15) x 10 cm]. Conversely, a drop in water recharge equivalent to 10 cm of water at the soil surface would translate into a drop of the water table by 67 cm or approximately 70 cm. Depending on the soil texture, this number can be as high as 90 cm (for some silt loam to clay loam soils) or, although rarely, as low as 40 cm (some fine sand soil). This is why very quick changes in water table level are observed in soils, even when inputs only change minimally (Vidon 2012; Jung et al 2004) [Note: Soil porosity and field capacity figures used in these calculations were obtained from Figure 6.4 in Dingman et al., 2002]

Furthermore, many ecosystems of the US northeast are already under a variety of stressors tied to water quantity. For instance, many climate change models predict an increase in the intensity and frequency of high intensity storm events, a reduction of moderate intensity storm events, and drier dry periods (Karl and Knight, 1998; Milly et al., 2005). In terms of stream flow, this translates into higher high flows and lower low flows. An increase in the variability of flow conditions, and especially lower low flows can drastically impact groundwater recharge. In addition, during storms (high flows), stream flow velocity increases, which reduces the potential for interaction between surface water and groundwater at headwater locations. This is therefore not a zero-sum game for groundwater; changes in climate will inevitably lead to lower groundwater levels in many regions including the northeast. Many wetlands, first and second order streams, and their associated ecosystems are already affected by lower low flows, even in the US northeast where people feel like water quantity is not an issue.

Most forested locations where shale gas development is occurring are located in first, second, and third-order watersheds where the impact of stream flow reductions are likely to be drastic at locations where high volume horizontal fracturing will occur, and where many wells will be installed (see above and Table 1). As many state parks and forests contain sensitive wetland environments, activities leading to a reduction of stream flow in forested environments immediately adjacent to state parks and forest are likely to impact the water supply and associated recharge in wetlands at downstream locations located in state forests or state parks. Wetland systems are already stressed due to changes in precipitation patterns, and any changes in flow entering these systems owing to upstream shale gas extraction activities will likely have deleterious effects on these already stressed systems.

Because state parks and state forests often contain sensitive wetlands, and are dependent upon an unaltered input of water from upstream locations, allowing drilling on land immediately adjacent to state parks and forests is likely to affect the flow of water in the streams and aquifers connected to state lands in a negative way.

Although there might be some cases where water quantity issues may be limited, allowing high volume shale gas extraction and associated impacts on land adjacent to state parks and forests will certainly negatively impact state lands and associated streams and aquifers.

II.2.2. Water quality

This section on water quality presents some critical information on the concentrations of active chemicals used in fracking fluids, and subsequently on their impact on water quality. A specific discussion of the potential impact of fracking fluid contamination and diesel fuel contamination of aquifer systems is presented in Section III.1. Subsurface hydrology.

Although much of the details on the composition of fracking fluids is proprietary, much is known about the classes of chemicals used in fracking fluid. For instance, it is well established that approximately 90% of fracking fluid is water, 9.5% is sand, and 0.5% are chemicals of various sorts (http://www.energyfromshale.org/hydraulic-fracturing/hydraulic-fracturing-fluid).

Although the list of chemicals commonly used in fracking fluids is available (see http://fracfocus.org/chemical-use/what-chemicals-are-used), the actual proportion of each chemical in the 0.5% mentioned above is generally not made available to the public.

Table 2 (below) contains a list of some of the exposure symptoms associated with a few of the chemicals commonly used in fracking fluids, according to the OSHA/EPA Occupational Chemical database.

The low percentage of these chemicals (0.5% of the total amount of fracking fluid injected into the ground during fracking operations) is very misleading to the general public. Combined with the lack of toxicology information for many of them, it is very difficult to make a direct assessment of the critical concentration thresholds needing to be met for negative environmental impacts to be seen. However, current scientific knowledge provides enough information to show the risk associated with the release of these chemicals in the environment, even at very low doses.

We know that extremely low concentrations of chemicals in the environment can have deleterious effects on human and environmental health. For instance, the US Environmental Protection Agency (USEPA) recommends that water with any pesticide concentration in excess of 3 μg/L be classified as non-potable water. A concentration of 3 μg/L is equivalent to 3.10^{-6} g/L. Considering that 1 L of water weighs 1000 g, any water containing 3.10^{-6} g of pesticides/1000g of water or 3.10^{-9} g of pesticide per gram of water should be considered unfit for human consumption. This equates to saying that water containing approximately 3.10^{-7}%, or 0.0000003% of pesticides is unfit for human consumption. Although pesticides may not be commonly used in fracking fluid composition, they are chemicals with toxicity (carcinogenic, endocrine distruptors….) equal to or lower than the chemicals, presented in Table 2 below, that are used in fracking. They therefore offer a good comparison for understanding the water quality impacts and health threats of fracking chemicals used.

When it comes to impacts on the environment, phosphorus concentrations of less than 0.1 part-per-million (0.00001%) have been tied to massive algae blooms in Lake Erie and other freshwater systems (Carpenter et al. 1998; David et al., 2000; Tedesco et al. 2005).

Concentrations of phosphorus or pesticides between 0.00001% and 0.0000003% of an aqueous solution can have deleterious effects on ecosystems and human health.

Although pesticides and phosphorous are not the direct equivalent of the chemicals listed below in Table 2, they are similarly or even likely less toxic to the environment than many of the chemicals listed in Table 2.

As indicated above, when looking at the composition of fracking fluids, these typically contain 0.5% of active chemicals, most of which are

Table 2: Common chemicals used in fracking fluid formulation and associated exposure symptoms. A list of the abbreviations used under the Exposure Symptoms column can be found at https://www.osha.gov/chemicaldata/abbrev.html.		
Chemical name	**CAS #**	**Exposure Symptoms**
Hydrochloric Acid	007647-01-0	Irrit nose, throat, larynx; cough, choking; derm; solution: eye, skin burns; liquid: frostbite; in animals: lar spasm; pulm edema
Glutaraldehyde	000111-30-8	Irrit eyes, skin, resp sys; derm, sens skin; cough, asthma; nau, vomit
Tetrakis Hydroxymethyl-Phosphonium Sulfate	055566-30-8	No Results on OSHA/EPA Occupational chemical database. The Material safety data sheet (MSDS) indicates: Acidic liquid. Contact with the eyes may cause significant irritation or burns. May be harmful if absorbed through the skin, may cause skin sensitization. May be harmful if inhaled. Harmful if swallowed.
Ammonium Persulfate	007727-54-0	No Exposure Symptoms information on OSHA/EPA Occupational chemical database. The MSDS indicates: Potential Acute Health Effects: Hazardous in case of skin contact (irritant, sensitizer), of eye contact (irritant), of ingestion, of inhalation (lung irritant, lung sensitizer). Prolonged exposure may result in skin burns and ulcerations. Over-exposure by inhalation may cause respiratory irritation. Potential Chronic Health Effects: CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. The substance may be toxic to upper respiratory tract. Repeated or prolonged exposure to the substance can produce target organs damage.
Isopropanol	000067-63-0	Irrit eyes, nose, throat; drow, dizz, head; dry cracking skin; in animals: narco
Acetaldehyde	000075-07-0	Irrit eyes, nose, throat; eye, skin burns; derm; conj; cough; CNS depres; delayed pulm edema; in animals: kidney, repro, terato effects; [carc]
Potassium Metaborate	013709-94-9	No Results OSHA/EPA Occupational chemical database. The MSDS indicates: Acute toxicity: Primary irritant effect: on the skin: Irritant to skin and mucous membranes. on the eye: Irritating effect. Sensitization: No sensitizing effects known. Subacute to chronic toxicity: The toxicity of potassium compounds is generally due to the anion. Subacute to chronic toxicity: Boron affects the central nervous system. Boron poisoning causes depression of the circulation, persistant vomiting and diarrhea, followed by profound shock and coma. The temperature may become subnormal and a scarletina form rash may cover the entire body. Additional toxicological information: To the best of our knowledge the acute and chronic toxicity of this substance is not fully known.
Ethylene Glycol	000107-21-1	Irrit eyes, skin, nose, throat; nau, vomit, abdom pain, weak; dizz, stupor, convuls, CNS depres; skin sens
Sodium Erythorbate	006381-77-7	No Results OSHA/EPA Occupational chemical database. MSDS indicates: Routes of Entry: Eye contact. Inhalation. Ingestion. Toxicity to Animals: LD50: Not available. LC50: Not available. Chronic Effects on Humans: Not available. Other Toxic Effects on Humans: Hazardous in case of skin contact (irritant), of ingestion, of inhalation. Special Remarks on Toxicity to Animals: Not available. Special Remarks on Chronic Effects on Humans: Not available. Special Remarks on other Toxic Effects on Humans: Not available.
Naphthalene	000091-20-3	Irrit eyes; head, conf, excitement, mal; nau, vomit, abdom pain; irrit bladder; profuse sweat; jaun; hema, hemog, renal shutdown; derm, optical neuritis, corn damage
2-Butoxyethanol	000111-76-2	Irrit eyes, skin, nose, throat; hemolysis, hemog; CNS depres, head; vomit

extremely dangerous to the environment and human health. Should any of these chemicals come in contact with groundwater or stream water, either through well leakage, return of fracking fluid to the surface, or the accidental release of fracking fluid, the environmental consequences, both short-term and long-term could be dramatic owing to the toxicity of the chemical in questions.

Based on a 0.00001% and 0.0000003% risk threshold, the cocktail of chemicals in fracking fluid (0.5% of total volume) are between 50,000 and 1,700,000 times more concentrated than the likely concentration thresholds to affect either human health or drinking water resources. The speculative nature of this statement owing to 1) the impossibility of knowing the exact concentration of each individual chemical in fracking fluid, and 2) the lack of data on the environmental toxicology of these chemicals should not be grounds to belittle the potential risk associated with the potential release of these chemicals in the surface water and groundwater resources connected to state forests and parks. Indeed, it is my expert opinion that, based on US Department of Labor toxicity information which indicates that most of the chemicals commonly used in fracking are much more toxic than phosphorus or most pesticides, concentrations as low as 0.0000003% for some of these chemicals (e.g., acetaldehyde, potassium metaborate, petroleum distillate, See Table 2) could have deleterious effects on ecosystems.

Potential concentration of individual chemicals in fracking fluid:
According to the oil and gas industry, there are dozens to hundreds of chemicals used in fracking (http://fracfocus.org/chemical-use/what-chemicals-are-used). If the 0.5% of active chemical is made up of 100 chemicals in equal proportion, then the concentration of each chemical in fracking fluid would be 0.005% of the total volume, or still 16,666 times the 0.0000003% threshold identified above. Using 19 million liters for the volume of water to be injected in one well (as is common in the Marcellus shale of Pennsylvania), 0.5% by volume corresponds to 95,000 Liter of toxic chemicals.

Until more information is available on the short-term and long-term toxicity of the chemicals found in fracking fluid on the environment, banning the use of these chemicals in and around state forests and lands is the only way to guarantee that the Executive Order will not endanger state forest and state lands.

Requiring energy companies to disclose not only the chemicals used in fracking, but also their actual concentration would allow experts like me to refine their understanding of the impact fracking fluids could have on state forests and state parks. Until then, the most reasonable assumption to make is that toxic chemicals represent 0.5% of the total volume of fracking fluids, and that the average toxicity of these chemicals is equivalent or higher than those of pesticides.

II.2.3. Fracking chemicals as endocrine disruptors

It is also important to note that besides acute toxicity concerns (Table 2), many chemicals used in fracking fluids (petroleum distillate, methanol, etholxylated nonylphenol) are categorized as endocrine disruptors. The endocrine system regulates hormone concentrations levels in the body, and disruptions of the endocrine system have been tied to infertility, diabetes, obesity, cardiovascular disease, and various metabolic issues. Within the context of the Executive Order, it is unconstitutional for the Commonwealth of Pennsylvania to take actions that endanger either the health of the environment or the people using state forests and parks.

The body of scientific evidence so far is that even at very low doses (part-per-trillion = 0.0000000001%), endocrine disrupting chemicals may have real effects on both the living resources of the environment (fish, amphibians, reptiles, birds, and mammals) and the people exposed to low doses of these chemicals (Vandenberg et al. 2014). More importantly, acute exposure studies are inadequate to assess the real environmental and health risks associated with these chemicals because low dose effects often disappear at higher doses, giving a false illusion of safety (Vandenberg et al. 2014).

Should some of these chemicals be degraded over time, it is uncertain at what rate this would occur, if at all, and whether the byproducts of degradation would be less toxic than the chemical themselves.

Considering the importance of state forests and parks to the people of Pennsylvania, it appears that allowing the use of fracking fluids containing endocrine disrupting chemicals in parcels of land immediately adjacent to state land would jeopardize the long-term health of the environment in state lands and potentially affect the health of the people and other living organisms using these resources.

II.3. Subsurface Hydrology

As indicated in Section II.1. Surface water and groundwater: A single resource,_surface water and groundwater (subsurface) are a single, connected resource.

However, there are specific characteristics of groundwater systems that make them especially sensitive to the kind of contamination that commonly happens when high volume horizontal fracturing occurs. Lautz et al. (2014) indicate the type of contamination that commonly happens during fracking operations:

> During gas-drilling operations, saline "flowback" and produced water may be introduced into the environment through migration of injection fluids and formation waters to shallow aquifers and/or discharge of the water to the environment during transport and disposal (e.g., surface spills of produced water or leaking impoundment ponds). Failed well casings and defective cement have also been implicated as causes of brine contamination in shallow aquifers. Produced and flowback waters typically include two sources of potential contamination: additives used to create optimal fluid consistency for well stimulation and the metals, dissolved solids, and radionuclides introduced to flowback water from naturally occurring basin brines.

Although it is understood that contamination of surface water systems and shallow groundwater systems is not supposed to occur under normal gas recovery operations, as Lautz et al. (2014) indicate, contamination is both possible and likely through a number of pathways. Because I am not an expert in drilling operations, I cannot specifically comment on the odds of such events occurring. However, it is well established that contamination risks of subsurface aquifer systems cannot and will never be completely eliminated.

Even if the risk of groundwater system contamination by fracking fluid were low, remediation techniques available today are inadequate to guarantee that the spill could be successfully contained, and that no long-term toxicity impact will occur – and therefore, when an event does happen the harm to the environment can be both significant and enduring. Indeed, the residence time of water in groundwater systems can vary from a few days to one hundred, or even thousands of years. It all depends on the soil or sediment hydraulic conductivity, the flowpath length to the surface, and the subsurface hydraulic gradient (See Figure 1 and Section II.1. Surface water and groundwater: A single resource). From a contamination standpoint, this is a great challenge, as a contaminated groundwater system will remain contaminated for a time much greater than the residence time of water in the system.

Even if the long residence time of water in groundwater systems (compared to surface water systems) offers some time to develop remediation strategies, actual remediation efforts are often not implementable unless the contamination is extremely localized. Indeed, once a plume of contaminant is in the groundwater, the contaminant will diffuse (spread) laterally and down gradient, making it very difficult to contain, especially in the case of toxic chemicals acting at the part-per-trillion or part-per-billion level.

In addition, it is virtually impossible to "rinse" an aquifer, or remove the contaminated water and replace it with clean water. Aquifers contain pores of various sizes capable of retaining water (including contaminated water). The smaller the pore, the more tightly water is held, and the harder it is to access that water (and clean it). Contaminated aquifers therefore have the potential of releasing solutes (i.e. contaminants) over many years after the contamination has occurred.

Although studies of this issue within the context of hydrofracking are lacking, several studies in other contexts very well illustrate this fact. For instance, in a long-term study (1985-1999), Kladivko et al. (2004) show that it takes several years for nitrate contamination levels in the subsurface to go down even following a reduction of surface nitrate input. Elsewhere, Ledford and Lautz (2014) show that groundwater systems contaminated with de-icing salt in winter release high concentrations of contaminated water to streams throughout the summer, months after contamination occurred. Many other examples of contaminated groundwater releasing to streams have been reported in the literature (see Vidon et al. 2006).

Within the context of the Executive Order, should contamination of an aquifer hydrologically connected to state land occur, it is certain that a full contaminant remediation would be impossible, and that contamination of the associated surface water would ensue and endure,

whether immediately or in the years to follow the contamination event, and ultimately endanger the natural resources found on and flowing through the nearby state lands.

> **The glass and sponge analogy:**
> It is much more difficult to clean a contaminated groundwater aquifer (sponge) than a surface water reservoir (glass). Take a glass of water and a wet sponge; add some green food coloring to the glass of water; the water turns green. Empty the glass and add fresh water. After you repeat this operation a few times, the water in the glass will be clear. Now, take a sponge and add some green dye to the sponge until it is fully saturated with green dye. Rinse the sponge with clean water repeatedly, as done with the glass. Even with repeated rinsing it will be virtually impossible to remove the green hue from the sponge, mainly because some green water will remain trapped in the small cavities (equivalent to soil or sediment pores) in the sponge.

II.4. Impact of drilling operations on recreation and wildlife

David and Robinson (2012) conducted an extensive study of the potential ecological impacts of natural gas recovery in the Marcellus shale and indicated that the average size of a drilling pad was approximately 2.57 km^2. Sawyer et al (2009) showed that mule deer (in Wyoming) avoided all types of well pads (i.e., wells with and without a liquids gathering system, and wells with active directional drilling) as well as areas away from the well pad itself with high levels of traffic. Elsewhere in Wyoming, Gilbert and Chalfoun (2011) found that well density was associated with significant decreases in various sparrow species abundance.

Overall, there are several studies documenting the impact of drilling operations under a variety of settings on wildlife and recreation. Although most research on the impact of drilling pads on the environment has mainly focused on water quality and water quantity impacts, studies documenting the impact of drilling operations for natural gas on recreation and/or the ecology of surrounding systems generally show a negative impact.

The impacts of drilling operations (scenery, noise) on the natural and recreational uses of state forest and parks with the presence of a drilling pad immediately adjacent to forest lands would inevitably impact natural resources and recreation in a negative way.

The existing research suggests that both wildlife and recreation will be negatively impacted by an executive order allowing drilling adjacent to state forests and parks.

III. Section B

A FRAMEWORK TO REDUCE IMPACTS OF SHALE GAS EXTRACTION ON STATE LANDS

As indicated in Section A, there are several issues associated with hydrofracking that make this practice unsafe to use in and around state forests and parks. These include:

- The inherent connection between surface water and groundwater. Although these are often considered as two separate resources, they are in fact a single resource, and the quantity and quality of one will eventually affect the quantity and quality of the other.
- The volume of water to be collected for fracking operations for one well can be significant in places where the water is collected in first-, second-, and third-order streams (see Table 1), especially if more than one well is installed on one drilling pad as is generally the case where high volume horizontal fracturing occurs.
- The chemicals used in fracking are known to be extremely toxic. At very low doses, many are endocrine disruptors. For many of them (see Table 2), little information on low dose or high dose toxicity is available. Until the actual concentrations of each chemical used in fracking fluid are made public, it is impossible for third party water quality experts to say that the concentrations are too low to be dangerous.
- Even if individual concentrations of individual chemicals are low, fracking fluid contains on average 0.5% of chemicals. The concentrations of the cocktail of chemicals used in fracking fluids (0.5% of total volume) are between 50,000 and 1,700,000 times more concentrated than the likely concentration threshold to affect either human health or drinking water resources.
- Should a leak of toxic chemicals (either diesel fuel or fracking fluid) occur either at the surface or underground and contaminate groundwater, it is very unlikely that the aquifer could be cleaned appropriately because of the inherent nature of an aquifer at trapping chemicals in soils and sediment pores.
- Although limited information exists on the actual impact of drilling pads on system ecology, all studies suggest that wildlife will generally avoid areas in and around drilling pads.

Scientific research is clear, drilling and fracking will directly and adversely impact the health of the environment, people, wildlife habitat, and recreation in state forests and parks, should such activities take place in or immediately adjacent to state lands.

The Executive Order allows for the development of shale gas extraction operations in, around and under state lands. And yet, the Executive Order fails to ensure that even minimum measures be taken to reduce or avoid harms to state lands, and the health of our environment for current and future generations such as the following.

<u>Minimum Measure #1:</u> Any drilling operation should not be allowed to occur if located upstream of state forests and state lands, or if the groundwater system susceptible to be affected by fracking operations is connected to state lands.

For many years, the USGS and the USEPA, in their efforts to manage the quantity and quality of our nation's waters, have recognized that political boundaries (state, county, city and park limits, state vs. private land boundaries…) are inadequate for managing water resources.

The USGS and the USEPA have therefore adopted management strategies based on watershed boundaries as opposed to political or other artificial boundaries. The USGS indicates [http://water.usgs.gov/GIS/huc.html] that

> The United States is divided and sub-divided into successively smaller hydrologic units which are classified into four levels: regions, sub-regions, accounting units, and cataloging units. The hydrologic units are arranged or nested within each other, from the largest geographic area (regions) to the smallest geographic area (cataloging units). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system.

The rationale for this division of the country in successively smaller units is that the water quality of streams at downstream locations is hugely influenced by the quantity and quality of water in headwater streams. As indicated previously, the volume of water generated by first-order catchments (catchment with one stream but no tributaries) has far reaching impacts on the quantity of water flowing downstream. In the Northeastern US, which includes Pennsylvania, 70% of the water volume in second-order streams (stream with at least one tributary) originates from first-order streams (Alexander et al. 2007). Moreover, the flow contributions of headwater catchments to the mean water volume in downstream reaches decline only marginally to about 55% in fourth- and higher-order streams (Alexander et al. 2007).

To identify groundwater connectivity, an intimate knowledge of subsurface geology and groundwater levels must be obtained, so hydraulic gradients and flow direction can be accurately calculated. Often, groundwater surface topography does not mirror surface topography, so an assessment of the connections of aquifers susceptible to be affected by fracking operations should be done in order to identify connectivity issues.

Placing a drilling pad upstream from a state forest or park will guarantee that negative impacts will be observed on these lands. In order to minimize potential impacts, it is therefore critical to not allow any drilling operations to take place if located upstream of state forests and state lands, or if the groundwater system susceptible to being affected by fracking operations is connected to state lands.

__Minimum Measure #2:__ **The total amount of water used for fracking operations that is collected from local streams should not exceed 1% of the total flow of the stream over a 1-month period or 10% of the total flow of the stream over a one-week period.**

Ecosystems rely on a consistent water supply. Even in the US Northeast where water is not considered to be scarce, ecosystems (e.g., wetlands, tree root systems) have evolved over millennia to optimize their usage of water based on current water levels. Further, small drops in groundwater recharge rates can turn into huge changes in water levels, as explained in Section II.2.1. Although many organisms can survive short term drops in water quantity (one week or less), significant impacts occur (e.g., wetland desiccation, loss of habitat, ….) when longer drops (one month or more) in flow occur.

In order to preserve ecosystems from permanent negative impacts associated with short-term reductions in flow, it is therefore critical to limit the total amount of water to be removed from streams for all the wells installed in one watershed to less than 1% of the total flow of the stream over a 1-month period or 10% of the total flow of the stream over a one-week period.

__Minimum Measure #3:__ **Energy companies should be required to disclose the list of chemicals used in fracking operations as well as the exact concentration of each chemical in the 0.5% of fracking fluid that contain toxic chemicals.**

Many of the chemicals used in fracking are at least as toxic as many pesticides, whose concentration in drinking water must be less than 3 μg/L or 0.0000003% of the water volume. Many of the chemicals used in fracking are also endocrine disruptors that can affect ecosystem and human health at the part-per-trillion level or 0.0000000001% of the water volume. Should a contamination event occur, it is very unlikely that dilution would bring these chemicals to safe levels.

Should some of these chemicals be degraded over time, it is also uncertain at what rate this would occur, if at all, and whether the byproducts of degradation would be less toxic than the chemical themselves.

Further, there is a huge lack of information on low dose toxicity for many of the chemicals used in fracking.

Until an exact list along with exact concentrations of each of the chemicals used in a fracking well that would impact state lands are disclosed, and long-term toxicity studies on the low-dose exposure to these chemical are achieved, allowing the development of fracking operations in and around state lands is highly risky for the health of the environment and the people recreating in state forests and parks.

__Minimum Measure #4:__ **A 10 mile buffer between the drilling pad and the boundary of individual state forests and parks should be mandatory to minimize the impact on wildlife and recreationists if Minimum Measure #1 cannot be met.**

Until a better understanding of the low dose toxicity of the chemicals used in fracking, and of the direct and indirect impacts on wildlife and recreationists are better understood within the context of hydrofracking, I recommend that a 10 mile no-fracking zone buffer be instated between a drilling pad and the boundary of any state land to minimize the negative impacts of fracking operations on state land. It is indeed my expert opinion that if Minimum Measure #1 cannot be met, using a 10 mile buffer approach would reduce the risk of acute water quantity and quality impacts on state forests and parks, as well as other disturbances such as noise, wildlife habitat loss, and "viewshed" degradation.

Consistent with this recommendation, Burton et al. (2014) state that

> Generally, the closer geographical proximity of the susceptible ecosystem to a drilling site or a location of related industrial processes, the higher the risk of that ecosystem being impacted by the operation. The associated construction of roads, power grids, pipelines, well pads, and water- extraction systems along with increased truck traffic are common to virtually all HVHF [*high volume horizontal fracturing*] operations. These operations may result in increased erosion and sedimentation, increased risk to aquatic ecosystems from chemical spills or runoff, habitat fragmentation, loss of stream riparian zones, altered biogeochemical cycling, and reduction of available surface and hyporheic water volumes because of withdrawal-induced lowering of local groundwater levels.

Figure 2: List of potential impact of hydraulic fracturing in the environment (1 = low impact potential, 3 = high impact potential)(Source: Burton et al. 2014).

Criteria air pollutants	3	2	1			
Chemical additives		2	2-3	2-3	1-2	
Organic & inorganic water contamination (incl. NORM)	1		1-3	1-2	1	
Water withdrawals	1	1-3	1-3	1	1-2	
Habitat alteration	1-3	1	1-2	1-3	1-2	1
Sedimentation	1-3	1	1	1-2	1	1
Nutrient enrichment	1-3	1	1	1	1	1

IV. Section C

ADDRESSING SOME KEY QUESTIONS OF INTEREST TO VARIOUS STAKEHOLDERS

__Question #1:__ **Under the Environmental Rights Amendment to the Pennsylvania Constitution, the Commonwealth should not approve any project that would cause an unreasonable degradation of our air, water, or the other elements of a healthy environment. The Commonwealth must protect the environment for future generations. Is this Executive Order compatible with these rights?**

As indicated in Sections A and B, allowing the development of shale gas extraction by hydrofracking on land immediately adjacent to state lands will certainly negatively impact water quantity (reduce stream flow, increase wetland dessication risks, loss of habitat), water quality (surface and subsurface water contamination), and negatively affect wildlife and recreation in state forests and parks. It is my expert opinion that allowing the development of shale-gas extraction through fracking in or around state forests and parks would most certainly cause an unreasonable degradation of air, water, and other elements of a healthy environment. Considering that the Commonwealth of Pennsylvania must protect the environment for future generations, including not endangering the health of the environment and of the people in state forests and parks, it is my opinion that the Executive Order runs counter to these rights.

__Question #2:__ **How should one design a review process to minimize negative environmental impacts of any shale gas extraction operations?**

One of the primary issues with allowing fracking operations to take place in or near state land is that state forests and parks are part of the broader watershed in which they are located. As development projects for shale gas development around state lands and in the subsurface of state lands are proposed, I believe that the first step needed to assure that minimum harm to state land is done is to not allow development at locations upstream or up-watershed of state land.

For projects proposing to develop well fields near state lands and allowing horizontal drilling to take place in the subsurface under state lands, the state should require energy companies to disclose the exact chemicals and their concentrations used in fracking fluids AND allow unbiased third parties to test fracking fluid composition in certified independent laboratories for verification purposes. Only then will we be in a position to more fully assess the potential impact of individual hydrofracking operations on our environment.

The state should also act as an intermediary to hire third party external, unbiased contractors to measure the actual amount of water withdrawn and utilized by energy companies from local streams to better understand the impact of fracking operations on water resources.

The state should also prohibit pumping of stream water to levels that would not meet Minimum Measure #2 (see above) and therefore compromise the health of wetlands, forests, and other sensitive ecosystems in and around state forests and parks (see details in Section B – Minimum Measure #2, and in Section A. II.2.1. Water Quantity).

Finally, the science behind high volume shale gas extraction is constantly evolving as more and more studies from major universities become available. In order to insure that all measures are taken to minimize harm on the environment, the permit approval program should be re-evaluated every three years to incorporate new findings associated with lose-dose toxicity of chemicals used in fracking fluid, the impact of drilling operation on wildlife and recreation, and any new scientific findings associated with well drilling operation impacts on our environment: surface water, groundwater, wildlife, and recreation.

In summary:

1. Well pads must be located downstream of sensitive state forests and parks.
2. Energy companies must disclose the concentration of each of the chemicals used in fracking fluid when development is to occur near park boundaries.
3. The state must act as an intermediary to hire a third party independent contractor not subjected to the pressure of the energy companies to measure the quantity of water used during fracking operations.
4. 4) The state should prohibit pumping of stream water to levels that would not meet Minimum Measure_#2 (see above) and therefore compromise the health of wetlands, forests, and other sensitive ecosystems in and around state forests and parks
5. The permit approval program should be re-evaluated every three years to incorporate new findings associated with lose-dose toxicity of chemicals used in fracking fluid, the impact of drilling operation on wildlife and recreation, and any new scientific findings associated with well drilling operation impacts on our environment: surface water, groundwater, wildlife, and recreation.

Although implementing these permitting requirements would not eliminate the risk of negative impacts on state forests and parks, it would greatly reduce them, and allow for the introduction of new standards for drilling permit approvals as new science becomes available.

<u>Question #3:</u> Can any shale gas development meet this standard with any degree of probability?

Using the best science available today, it appears reasonably certain that most shale gas extraction drilling operations to take place near state forests and parks boundaries under the Executive Order will lead to an unreasonable degradation of our air, water, and other elements of a healthy environment.

Scientific evidences in support of this statement are provided in Section A of this document.

<u>Question #4:</u> What information, studies, or investigations should be required prior to any drilling approvals?

Thinking cumulatively about high volume shale gas extraction operations in general, I believe that much more information should be made available to the public, through independently funded research, on the following issues:

To my knowledge, there exists no proven technology capable of "cleaning" a contaminated aquifer fully, whether in the context of hydrofracking or not. However, as indicated by Lautz et al. (2014):

> During gas-drilling operations, saline "flowback" and produced water may be introduced into the environment through migration of injection fluids and formation waters to shallow aquifers and/or discharge of the water to the environment during transport and disposal (e.g., surface spills of produced water or leaking impoundment ponds). Failed well casings and defective cement have also been implicated as causes of brine contamination in shallow aquifers. Produced and flowback waters typically include two sources of potential contamination: additives used to create optimal fluid consistency for well stimulation and the metals, dissolved solids, and radionuclides introduced to flowback water from naturally occurring basin brines.

There is also a critical need to improve technologies to reuse and/or dispose of "fracked" water (i.e., water to which fracking material has been added). To date, there is very little understanding of the long-term effects of strategies used to dispose or reuse "fracked" water, be it through reuse of frack water in drilling operations, disposition of fracked water in open vats or injection into deep wells.

Finally, better alert systems must be developed to identify potential accident occurrences whereby fracking fluid has leaked into the environment. Although a lot of the chemicals used in fracking are known (see Table 2), these cannot be routinely measured, and certainly not fast enough to be used as an early warning system for fracking fluid contamination. Early warning systems capable of showing the presence of deep groundwater in surface water are still being developed (Lautz et al. 2014).

Thinking more locally at the scale of individual projects, information critically needed before any permit is approved should include (as discussed above): 1) the location of the well field relative to sensitive state land (Minimum Measures #1 and #4); 2) the amount of water that will be used in relation to the flow of the stream where the water will be collected (Minimum Measure #2); and 3) the exact concentration of each chemical used in fracking fluid (not just the list of chemicals) (Minimum Measure #3).

Finally, thoroughly investigating the cumulative impact of shale gas extraction operations on the watershed where activities occur, not only on the subsurface or surface water quality, but also on noise, viewshed alteration, wildlife habitat disruption, and so on is critical to be able to make informed decisions about both the short-term and long-term impact of such operations on our environment for present and future generations.

Considering the environmental risks associated with high volume horizontal fracturing operations, especially within the context of the Executive Order, it appears unreasonable to allow drilling for shale gas to occur near state forests and parks without jeopardizing the health of our water and other ecosystem components (e.g., soil, habitat for wildlife…). Regardless, much more research is needed on the issues listed above to more directly quantify, under a variety of situations, the impact of fracking operations on our environment.

<u>Question #5:</u> How likely is it that shale gas development, as it would proceed under the Executive Order, would cause an unreasonable degradation of our natural resources?

Based on the scientific evidences presented in this document (water quantity, water quality, subsurface hydrology, impact on wildlife and recreation…) and lack of watershed context in the permitting process (well field location relative to state land), it is certain that shale gas development, under the Executive Order, would cause unreasonable degradation of our natural resources. A long list of scientific evidences to support this statement is provided in Section A of this document.

<u>Question #6:</u> If any shale gas development were allowed to proceed, what conditions must be imposed to ensure that such development had the least possible impact?

Section B directly begins to address this question within the confines of my area of expertise. I believe that the four recommendations below would reduce the impact of new shale gas extraction and associated well field on our environment. Of course, there are many other impacts and areas of expertise beyond the scope of this particular analysis and therefore this limited set of minimum measures / recommendations should not be considered complete.

<u>Minimum Measure #1:</u> Any drilling operation should not be allowed to occur if located upstream of state forests and state lands, or if the groundwater system susceptible to be affected by fracking operation is connected to state lands.

<u>Minimum Measure #2:</u> The total amount of water used for fracking operations that is collected from local streams should not exceed 1% of the total flow of the stream over a 1-month period or 10% of the total flow of the stream over a one-week period.

<u>Minimum Measure #3:</u> Beyond disclosing the list of chemicals used in fracking operations, energy companies should be required to disclose the exact concentration of each chemical in the 0.5% of fracking fluid that contain toxic chemicals.

<u>Minimum Measure #4:</u> A 10 mile buffer between the drilling pad and the boundary of individual state forests and parks should be mandatory to minimize the impact on wildlife and recreationists.

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ABOUT THE AUTHOR

Philippe Vidon, Ph.D. is a watershed hydrologist, contaminant hydrologist, and biogeochemist. Born in France in 1973, Dr. Vidon obtained a BSc in Mathematics and Physics (fluid mechanics, thermodynamics) from Pierre et Marie Curie University in Paris, France in 1995, and a Master in Agronomy from the National Institute of Agronomy in Paris, France in 1997. After working for two years as a research associate at the Cemagref (National Institute of Research and Engineering in Agriculture and Environment) (France), Dr. Vidon obtained a Ph.D. in Geography (Hydrology and Biogeochemistry) in 2004 from York University in Toronto, ON, Canada. From 2004 to 2010, Dr. Vidon was an Assistant Professor in the Department of Geology (now Earth Sciences) at Indiana University – Purdue University Indianapolis (IUPUI). Since 2010, Dr. Vidon has been an Associate Professor and Empire Innovation Faculty in the Department of Forest and Natural Resources Management at the State University of New York College of Environmental Science and Forestry (SUNY-ESF), and holds adjunct appointments in the Department of Geology at Syracuse University, and in the Department of Geography and Earth Sciences at the University of North Carolina at Charlotte.

Dr. Vidon's research focuses on the fate and transport of environmental contaminants (e.g. nitrogen, phosphorus, carbon, mercury, methane, nitrous oxide, carbon dioxide, pesticides) in hydrological systems (surface and subsurface) and at the soil-atmosphere interface. Dr. Vidon uses this knowledge to assess the impact of climate change and various land use activities on ecosystem health and water quality, and determine how to best manage water quality and water quantity in watersheds under a variety of stressors.

Since 2004, Dr. Vidon has received either as principal investigator or co-principal investigator more than $2.9 million in funding from the US Environmental Agency, the National Science Foundation, the US Department of Agriculture, the US Geological Survey, among other funding sources. Dr. Vidon is widely published and has presented his work on many occasions at meetings of the American Geophysical Union, the Geological Society of America, the Soil Science Society of America and the American Water Resources Association. Dr. Vidon's work has been cited more than 800 times in more than 600 publications since the beginning of this career.

APPENDIX A

News release from Governor Corbett's office from May 23, 2014 and associated Executive Order 2014-03

News for Immediate Release

May 23, 2014

Governor Corbett Issues Executive Order Protecting State Forests, Parks from Gas Leasing that Involves Surface Disturbance

Harrisburg – Governor Tom Corbett today issued an executive order prohibiting leasing for natural gas development in Pennsylvania's state parks and forests that would result in additional long-term surface disturbance.

The order supports the governor's budget proposal to generate $75 million to help meet critical priorities. Limited leasing will allow natural gas to be extracted from deep beneath the surface only when there will be no additional long-term disturbance on state forest and park lands. The order will only allow gas to be extracted horizontally through wells located on adjacent private lands or previously leased areas of the state forest.

"With this executive order, I am directing that the commonwealth maintain a moratorium on any additional gas leasing of DCNR lands that involves long-term surface disturbance, such as placing well pads, roads or pipelines in the newly-leased areas," Corbett said. "This balanced approach will ensure that the special characteristics and habitats of DCNR lands are conserved and protected, and will also provide for historic investments in conservation programs, our schools and quality health care, without raising taxes on Pennsylvanians."

The governor noted that specific areas and acreage will be analyzed by reviewing interest from oil and gas operators who can access the gas through horizontal drilling without additional disturbance on the surface of DCNR lands.

"Future royalties from these leases will be dedicated to expanding our system by acquiring lands with high conservation value and ecological importance, purchasing privately-held subsurface rights for existing DCNR lands and improving state parks and forests," Corbett said.

The Pennsylvania Chamber of Business and Industry, one of the largest economic advocacy groups in the commonwealth, supported the governor's action. "Balancing our efforts to responsibly develop the state's natural gas resources with the need to preserve our renowned state parks and forest is extremely important to the future of this Commonwealth," Gene Barr, President and CEO of the PA Chamber of Business and Industry said. "We know that we can safely and efficiently protect our state's natural lands while still benefiting from the economic opportunities that come with growing the natural gas industry and making Pennsylvania a world leader in energy production."

"The commonwealth's state forest system has been certified as 'well-managed' longer than any other in the country, and continues to receive that distinction after five years of gas development in the Marcellus shale formation," DCNR Secretary Ellen Ferretti said. "I am confident that DCNR can continue to manage our system for a variety of uses and values, including ecological integrity, outdoor recreation and the environmentally sound extraction of underground resources."

The executive order is effective immediately. To download a copy, visit the Office of Administration's website at www.oa.state.pa.us, select "Records and Directives" and "Executive Orders."

Information about the proposal is included in a fact sheet on the DCNR website at www.dcnr.state.pa.us, choose "Gas Drilling on State Forests" under "Quick Links," then "Policy and Guidelines."

Since the Governor's budget proposal in February, DCNR staff have made presentations for and answered questions from the department's citizens and natural gas advisory committees, as well as environmental organizations.

Governor Corbett's budget also includes the initiative ***Enhance Penn's Woods***, a 2-year, more than $200 million investment in improving state parks and forests that is the largest funding commitment for this purpose in commonwealth history.

"Pennsylvania is home to a world-class state park and forest system, and my proposed budget gives an historic boost to conservation and protection of our natural resources," Corbett said.

Corbett noted that since 2011, Pennsylvania has added almost 8,000 acres to its state park and forest system. ***Enhance Penn's Woods*** would provide funding for an additional 20,000 acres.

Pennsylvania has 120 state parks totaling more than 200,000 acres, and 2.2 million acres in 20 state forest districts. For more information on state parks and forests, visit www.dcnr.state.pa.us.

Media contact:
Valerie Caras, Governor's Office, 717-783-1116
Christina Novak, DCNR, 717-772-9101

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Editor's Note: The text of the Governor's executive order follows:

WHEREAS, the Department of Conservation and Natural Resources (DCNR) is the state agency charged with ensuring the stewardship and protection of state forest and state park lands for the benefit of all citizens; and

WHEREAS, Pennsylvania is home to a world-class state forest and state park system, comprising over 2.2 million acres of state forest land and 200,000 acres of state park land contained within 120 state park and conservation areas; and

WHEREAS, Pennsylvania's award-winning state parks provide opportunities to enjoy healthful outdoor recreation and serve as classrooms for environmental education in a setting where natural, scenic, aesthetic and historical values are preserved for current and future generations while hosting 38 million visitors annually, contributing $1.2 billion annually to the commonwealth's economy and providing more than 13,000 jobs; and

WHEREAS, Pennsylvania's state forest system is managed for a variety of uses and values, including ecological integrity; wild character; drinking water supply protection; recreation; plant and animal habitat; high-quality timber; and the environmentally sound utilization of mineral resources; and

WHEREAS, the international Forest Stewardship Council (FSC) has developed a set of principles and criteria that apply to FSC-certified forests around the world, and FSC forest-management certification confirms that a specific area of forest is being managed in accordance with the FSC principles and criteria; and

WHEREAS, Pennsylvania's state forest system has been independently certified to be in adherence with the gold standard for environmentally and socially responsible forestry established by the FSC, and Pennsylvania's state forest system has been FSC-certified longer than any other state forest system in the United States; and

WHEREAS, in December 2012, after five years of natural gas development in the Marcellus shale formation, the Rainforest Alliance's annual audit of Pennsylvania's conformance with the FSC certification found that certification requirements are being met and recommended maintenance of certification; and

WHEREAS, an independent review of Pennsylvania's state forest system in 2013 by Scientific Certification Systems, a certification body accredited by the FSC, recommended that Pennsylvania's state forest system be awarded FSC certification as a "Well Managed Forest"; and

WHEREAS, the *Conservation and Natural Resources Act* (*Act of June 28, 1995, P.L. 89, No. 18*) authorizes DCNR to enter into leases for the disposition of oil and natural gas when doing so would be in the best interests of the commonwealth; and

WHEREAS, DCNR has the responsibility and expertise to approach shale gas development in a way that efficiently utilizes commonwealth energy resources while balancing the many uses, values and overall sustainability of the state parks and state forest system; and

WHEREAS, the Governor's Marcellus Shale Advisory Commission, in accordance with *Executive Order 2011-01*, unanimously adopted a report and accompanying recommendations on the safe and responsible development of unconventional shale gas resources, and the Commission recommended that any future leasing of state forest land should be limited to agreements which result in no or minimal surface impact to commonwealth-owned land; and

WHEREAS, the Pennsylvania General Assembly enacted the *2012 Oil and Gas Act (Act of Feb. 14, 2012, P.L. 87, No. 13) (Act 13)*, which significantly enhanced the environmental protection standards for shale gas resource development in the commonwealth, including new protections for rivers, streams, water wells and public water supplies, well site inspection and enforcement, public notice and information sharing, remediation standards, and other enhancements; and

WHEREAS, *Article 1, Section 27* of the *Constitution of Pennsylvania*, recognizes the right of citizens to clean water and pure air and establishes the commonwealth's duty to conserve and maintain Pennsylvania's public natural resources for the benefit of all the people; and

WHEREAS, *Executive Order 2010-05, Leasing of State Forest and State Park Land for Oil and Gas Development* issued by Governor Edward G. Rendell on October 26, 2010 ordered that no lands owned and managed by DCNR shall be leased for oil and gas development; and

WHEREAS, oil and natural gas development which results in no additional surface disturbance to state park and forest lands managed by DCNR is consistent with ensuring the stewardship and protection of such lands for the benefit of all the citizens, and with the requirements of *Article 1, Section 27* of the *Pennsylvania Constitution*;

NOW, THEREFORE, I, Tom Corbett, Governor of the Commonwealth of Pennsylvania, by virtue of the authority vested in me by the Constitution of the Commonwealth of Pennsylvania and other laws do hereby direct the following:

1. **DCNR Oil and Gas Leasing.** As of the date of this Executive Order, no state forest or state park land may be leased for oil and natural gas development which would result in additional surface disturbance on state forest or state park lands.

2. **Use of Oil and Gas Royalty Revenue to Buy Oil and Gas and Other Mineral Rights and to Provide Improvements in State Parks and State Forests.** DCNR shall seek, in accordance with applicable laws, to utilize the royalty revenue generated from oil and natural gas leasing and development to:

   a. repair and improve upon the infrastructure and amenities of the state forest and state park systems;

   b. prioritize and acquire high-value inholding lands, indentures and areas of high conservation value or ecological importance; and

   c. prioritize and acquire privately-owned oil, natural gas, and other mineral rights underlying high-value surface lands owned by DCNR.

3. **Effective Date.** This Executive Order shall take effect immediately.

4. **Termination Date.** This Executive Order shall remain in effect until amended or rescinded by the Governor.

5. **Rescission.** Effective immediately, *Executive Order 2010-05* is hereby rescinded.