NEW YORK STATE OF OPPORTUNITY™ | Department of Environmental Conservation

FINAL SUPPLEMENTAL GENERIC ENVIRONMENTAL IMPACT STATEMENT

ON THE OIL, GAS AND SOLUTION MINING REGULATORY PROGRAM

Regulatory Program for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs

Volume 2: Response to Comments

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VOLUME 2 OF 2
RESPONSE TO COMMENTS

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VOLUME 2

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INTRODUCTION

This volume of the Final SGEIS (FSGEIS) summarizes and responds to the substantive comments received on the 2009 Draft SGEIS (dSGEIS) and the 2011 Revised Draft SGEIS (rdSGEIS) (the drafts and the FSGEIS are collectively referred to as the "SGEIS" unless otherwise distinguished). The dSGEIS was released for public comment on September 30, 2009. In 2009, in addition to written comments, the Department received comments electronically through a web-based system and received verbal and written comments at four public hearings held in October and November of 2009. The Department also accepted transcripts from hearings held by legislative and municipal bodies during the public comment period.

The rdSGEIS was released for public comment on September 7, 2011. On September 28, 2011, the Department released for public comment draft regulations concerning high-volume hydraulic fracturing (HVHF) and the SPDES General Permit for Stormwater Discharges from High-Volume Hydraulic Fracturing under the State Pollutant Discharge Elimination System (SPDES) Permit Program. Public hearings were held concurrently on the rdSGEIS, the SPDES General Permit and the draft regulations, and the combined public comment period was held open until January 11, 2012. In total, the Department received over 80,000 public comments on the drafts of the SGEIS and over 180,000 comments on the proposed regulations. This includes comments received by postal mail, through electronic submissions, and from speakers at public hearings held in 2009 and 2011. This level of public comment was unprecedented in the Department's history. Responses to comments received on the draft regulations were issued separately. The draft regulations lapsed as a matter of law on February 27, 2013.

The Department received comments from many diverse groups and individuals including state and local agencies, federal agencies, landowner coalitions, industry representatives, legislators, public health professionals, non-governmental environmental organizations, mineral rights owners and members of the general public. During preparation of the FSGEIS, the Department incorporated suggestions made in the public comments and, where appropriate, provided additional discussion in either the FSGEIS or the Response to Comments to clarify the content of the drafts. Specifically, the Department revised Chapter 7 of the FSGEIS to remove conclusory language with respect to the mitigation proposed to better reflect remaining uncertainty as to the residual environmental and public health risks even after imposition of proposed and considered mitigation measures. The Department specifically examined the adequacy of the mitigation and the degree to which the mitigation would reduce significant public health and environmental impacts and risks associated with HVHF. The Department also revised Chapter 9 to better represent both the benefits and negative consequences of the No Action Alternative. The Executive Summary was also revised to reflect these changes. The Department has revised Chapter 1 to reflect all of the procedural changes and occurrences that have followed from the time of publication of the rdSGEIS for public comment. In Chapter 2, a subsection drafted in 2011 relating to the potential public need and benefit of HVHF was deleted; the subject is addressed more accurately in the Response to Comments, based on subsequent analysis and public comment. Finally, the FSGEIS was modified to reflect some of the additional mitigation measures that the Department considered in response to public comments and based on evolving scientific evaluation and studies of the impacts of HVHF. These changes to the SGEIS do not include the fact that some laws or regulations have changed from the time of the publication of the 2011 rdSGEIS, notably the Water Resources Law and corresponding regulations. In the event that these changes relate to the regulatory requirements that would apply to HVHF, if it were authorized, they are discussed in these Response to Comments. To the extent that there is any inconsistency between the Response to Comments and the text within the chapters and appendixes of the FSGEIS, the Response to Comments represents the Department's most current assessment of the impacts associated with HVHF, the scientific uncertainties regarding impacts to public health and safety and the adequacy of proposed or considered mitigation.

As a general matter the vast majority of comments received were opposed to HVHF in New York State. In this respect, these comments favored the No Action Alternative. Many of the comments raised concerns about potential significant adverse impacts on surface and ground water, forests, wetlands and habitat, state-owned lands, wildlife and air resources, the cost and government capacity for regulatory oversight, local government services and transportation and other related infrastructure. The comments also questioned industry's record of compliance with environmental standards and the socioeconomic benefits, and raised concerns about potential significant adverse impacts to community character and cultural resources. Many comments also focused on potential significant health impacts from activities associated with HVHF. In contrast, there were some comments that supported permitting HVHF. These ranged from allowing it on a limited level with enhanced restrictions and mitigation measures to permitting it with substantially fewer and less stringent restrictions than those proposed in the rdSGEIS. The central theme to these comments was that HVHF would provide an economic benefit to the State of New York.

In September 2012, the Department asked the State Health Commissioner to assess the analysis of potential health impacts in the rdSGEIS. In December 2014, the Acting Commissioner of the New York State Department of Health (NYSDOH), Dr. Howard Zucker issued a "Public Health Review of Shale Gas Development" (attached hereto as Appendix A)(Public Health Review), which considered the current state of science and public health risks regarding HVHF in the United States and internationally. The review encompassed an evaluation of emerging scientific information on environmental public health and community health effects relating to HVHF. The review evaluated whether such information was sufficient to determine the extent of potential public health impacts of HVHF activities in New York, and whether existing mitigation measures implemented in other locations are effectively reducing the risk for adverse public health impacts.

In summarizing the available information assessing HVHF health impacts, the NYSDOH Public Health Review concluded that:

> "… the overall weight of the evidence from the cumulative body of information … demonstrates that there are significant uncertainties about the kinds of adverse health outcomes that may be associated with HVHF, the likelihood of the occurrence of adverse health outcomes, and the effectiveness of some of the mitigation measures in reducing or preventing environmental impacts which could adversely affect public health."

The Department adopts the conclusions issued by NYSDOH in its public health review. The public health and environmental evaluations similarly found significant uncertainties related to the human health and environmental impacts of HVHF development and the emerging science and trends related to the effectiveness of mitigation measures to adequately mitigate such impacts. In addition to the uncertainties expressed by NYSDOH, the Department after reviewing the over 80,000 comments submitted by the public, acknowledges that there remains significant uncertainty as to the adequacy of a potential HVHF permitting program as outlined in the SGEIS. The SGEIS outlined a program that would in many instances effectively mitigate potential significant adverse impacts. However, there are certain instances where impacts are simply unavoidable or where the effectiveness of HVHF-specific mitigation measures proposed (and additional measures considered) is unpredictable. In these instances the potential for significant adverse environmental impacts remains notwithstanding the proposed mitigation measures.

Specifically, the Department accepts that despite the short duration for construction of an individual well on a well pad that would likely accommodate between six to eight wells, and despite the noise and visual mitigation measures set forth in the rdSGEIS, there remains a potential for significant adverse impacts to the elements that constitute community character, particularly from the ancillary activities associated with HVHF. These include anticipated truck traffic, the construction of multiple wells in the same geographic area in combination with a network of pipelines and gathering lines necessary to distribute natural gas harvested from the Marcellus Shale. Likewise, the Department recognizes that these same ancillary activities would cumulatively cause significant impacts to wildlife habitat (forest fragmentation) and state lands (increased truck traffic within the boundaries of state-owned lands). In other areas, although certain mitigation measures would likely be effective in reducing the risk of significant impacts they do not provide a level of certainty that would avoid or minimize impacts to a point of non-significance. For example, setbacks or buffers are used as a measure to reduce risk because even with engineering controls and best management practices in place spills or engineering control failures are possible in activities associated with the unique elements of HVHF operations, such as high pressure injection of proppants and chemicals and the large volume of chemical and waste storage required, and the heavy use of truck transportation. The setback consequently is used as one tool to protect a resource from being impacted from the likely consequences of certain HVHF related activities, such as a spill. However, as explained more fully below, given the increased risk of spills from a range of HVHF related activities, determining the adequacy of a setback on a generic and statewide basis for this particular activity is difficult. Further complicating that determination is the uncertainty and inability to quantify what the ultimate impact of a spill would be to a particular resource or to public health. Here, the Department notes that in its Public Health Review, NYSDOH identified uncertainties as to “the kinds of adverse health outcomes that may be associated with HVHF” and “the likelihood of the occurrence of adverse health outcomes.”

Following the issuance of the 2011 rdSGEIS and faced with ever-increasing information and scientific studies detailing the risks and uncertainties regarding the environmental and public health impacts that could result from HVHF development, the Department considered additional mitigation measures that could further reduce or avoid those impacts. Specifically, the Department considered measures to enhance protections for water resources, expand setbacks to residences, reduce greenhouse gas emissions (GHG), further protect habitat and wetlands, ban any HVHF development in the Catskill Park, and provide for greater disclosure of the chemicals used in HVHF and more opportunity for public comment on specific well permit applications.

With respect to water resources, the Department recognizes that uncertainty remains regarding whether the proposed mitigation would adequately mitigate against significant adverse impacts in all cases. The Department recognizes the importance of protecting New York’s ground and surface waters for drinking water supplies, economic development, agriculture, recreation and tourism. As memorialized in ECL § 15-0105, the Department must require the use of all known available and reasonable methods to protect and preserve the purity and quality of water resources over the long-term in order to serve public health, safety and welfare and to maintain ecological resources. Consequently, the Department considered requiring that operators develop and implement a groundwater monitoring program to detect potential spills and releases around the HVHF well pad and to detect potential contamination in groundwater drawn by nearby drinking water wells before they are impacted (this measure, however, reflects the Department’s on-going concern that impacts could occur either through engineering control failures or through uncontained spills). Additionally, the Department considered extending buffer zones on tributaries to public drinking water supplies. The Department also prohibited use of beneficial-use determinations (BUDs) for roadspreading of brine produced from wells stimulated by HVHF in the Marcellus Shale or other low-permeability formations until additional data on NORM content is available and evaluated by the Department and NYSDOH.

Furthermore, to address concerns about flooding beyond the 100-year floodplain and in recognition of the increasing frequency and intensity of recent and potentially future flood events, the Department considered requiring that, in certain areas, well pads be elevated two feet above the higher of the 500-year flood elevation or the known elevation of the flood of record, should either be known. However, the Department notes that flood risk changes over time and consequently potential impacts could still occur from HVHF as a result of incomplete data.

Finally, in response to concerns raised about infrastructure associated with the Syracuse and New York City watersheds, the Department considered extending its initial 4,000-foot setback from unfiltered drinking water supply watersheds for the siting of HVHF well pads. The setback would encompass a portion of the water supply infrastructure, including tunnels that carry water to the City from upstate reservoirs. Beyond that, the Department also considered prohibiting the placement of any portion of a wellbore less than 2,000 feet from any water tunnel or underneath a tunnel, and requiring enhanced site-specific review plus consultation with the municipality for any wellbore located within two miles of any water supply infrastructure for the Syracuse and NYC drinking water supplies. Consideration of this further measure recognized the existence of scientific uncertainty, disclosed by recent studies, as to the likelihood of HVHF-induced earthquakes, and the potential for impacts to the water supply infrastructure.

Additionally, in order to reduce the potential for contamination of public and private water supplies, the Department considered requiring 3-dimensional seismic surveying prior to commencing HVHF or active microseismicity monitoring during fracturing, where HVHF was to be conducted where the top of the objective formation at any point along any part of the proposed length of the well bore is at a depth less than 3,000 feet below the ground surface.

The Department has also concluded that GHG emissions would increase due to the operation of HVHF wells but that the extent of the potential impact would largely depend on the efficacy of controls on methane releases and other GHGs. With this in mind the Department considered requiring that a Reduced Emission Completion (REC) with minimal venting and flaring, if any, be performed whenever a commercial sales line, interconnecting gathering line and operating compressor station, if necessary, are available to an operator during a high-volume hydraulically fractured completion or recompletion at any HVHF individual well or multi-well pad. The Department also considered requiring a GHG emissions mitigation plan.

In recognizing concerns expressed by the public with respect to chemicals used in the HVHF process, the Department considered expanding the fracturing fluid chemical disclosure requirements to ensure that each chemical, and not merely each product, would be disclosed publicly both before drilling and after completion of each well. The Department also considered requiring that every ECL Article 23 well application proposing HVHF on a new well pad be subject to a fifteen-day public notice period, limited to site-specific issues on the subject application not addressed in the 1992 GEIS or this SGEIS. Similarly, the Department considered requiring operators to produce semiannual forecasts of HVHF and related activities expected to occur within the ensuing three years, revising the forecast every six months. This measure recognizes that local governments, including emergency responders and local and state health workers, could be significantly impacted if HVHF were authorized.

In further recognition that spills or engineering control failures could result in exposure to the potential environmental and health impacts associated with of HVHF, and the potential for noise and lighting impacts from HVHF, the Department considered establishing or expanding further a 500-foot setback from the edge of the well pad to inhabited private dwellings and places of assembly, such as schools and hospitals, unless the Department issues a variance from the requirement with the consent of the owner and any tenants.

In response to concerns raised about impacts to wildlife habitat and wetlands, the Department considered requiring the applicant to address potential impacts to habitat connectivity in cases where a well permit application for HVHF proposes a new access road within the 100-year floodplain or within 50 feet of surface water. The Department also considered expanding the requirement to conduct a site-specific review for well pads located within 300 feet of a federal or state regulated wetland, perennial or intermittent stream, lake, pond, or storm drain.

Finally, the Department recognized that HVHF activities could have a profound impact on community character, especially on those areas that have unique, historic and "special" identities. In this respect the Department considered prohibiting HVHF development on private land within the Catskill Park (outside the NYC drinking water supply watershed) and requiring a site-specific review in state and federally designated historic districts. The Department recognizes that this measure necessarily does not consider other potential "special" areas that could be significantly impacted if HVHF were authorized.

These additional measures that were considered by the Department in response to public comment and scientific studies, further confirm the uncertainties with respect to HVHF's potential impacts, as well as with respect to the effectiveness of the mitigation measures it proposed or considered. The mitigation measures in some instances would likely be effective in substantially reducing the risk of significant adverse public health and environmental impacts, in other instances impacts would only be partially mitigated, and in some instances the Department recognizes that there is insufficient information, or too much uncertainty as to the effectiveness of the mitigation, to determine if the significant adverse impacts could be adequately mitigated at all.

Furthermore, these mitigation measures would further impede the economic viability and reduce the potential economic benefits of developing the Marcellus Shale through HVHF. Indeed, with all the above restrictions, more than 63% of the Marcellus Shale area would not be available for HVHF. Beyond these restrictions there are additional areas that would not be available for HVHF due to setbacks from a multitude of individual water wells, public water supply wells, lakes, streams, ponds, wetlands, residences, schools and other public buildings.

Similarly, the recent New York Court of Appeals decision, *Matter of Wallach v. Town of Dryden and Cooperstown Holstein Corp. v. Town of Middlefield*, will likely further limit the amount of available natural gas that could be extracted through HVHF. In that decision, the Court found that ECL § 23-0303(2) does not preempt communities with adopted zoning laws from entirely prohibiting the use of land for HVHF. Such bans, together with the reductions in availability of natural gas resulting from mitigation measures, would reduce the ultimate economic benefits of allowing HVHF in New York.

Conversely, the proposed mitigation measures and the additional mitigation measures that the Department considered would increase the cost of administering the program. In this regard, the Department estimates that its costs of administering this program under the average development scenario would be approximately $14 million in the first year and would grow to nearly $25 million in the fifth year. These costs do not consider the other substantial costs that would be incurred by other state agencies, which would nearly double the total State costs associated with regulating HVHF, or the costs imposed on local agencies.

The Department has organized the comments and responses by topic. In all there were eight central areas that the Department received comments on: SEQRA and SAPA, Permit Process and Regulatory Coordination, Prohibited Locations, Geology, Potential Environmental Impacts and Mitigation, Cumulative Impacts, Health Impacts, Enforcement, and Other (where comments did not readily fit into a category). Within these categories many discrete issues were raised, particularly within the major category Potential Environmental Impacts and Mitigation. Where the Department could group those issues, categories were further broken down into subcategories. Below, the Department has summarized the comments received for the various categories and subcategories and has responded to all of the substantive issues raised in the comments.

1. SEQRA and SAPA

General SEQRA

Comment: The Department received numerous comments with respect to the adequacy of the Department's SEQRA review and analysis. The majority of these comments contended that the Department failed to take the necessary "hard look" at potential impacts. The comments in the General SEQRA category fit, broadly speaking, into the following general categories:

- The Department should have prepared a "worst-case scenario" or that the Department relied too heavily on worst-case scenarios;
- Applications to conduct HVHF should be reviewed under the Uniform Procedures Act (Article 70 of the Environmental Conservation Law), which governs the processing of many other permits issued by the Department;

- The Department failed to consider cumulative impacts in the 2009 dSGEIS;

- The Department segmented the review of the proposed action in the dSGEIS by excluding consideration of waste disposal, cumulative impacts, induced growth, air quality impacts, pipeline construction, and ancillary infrastructure;

- Multi-well pads are significantly different than what was discussed in the 1992 GEIS and need to be discussed in the SGEIS; and

- The Department improperly used a Generic Environmental Impact Statement for an activity that will have substantially different environmental impacts depending on where it is conducted.

Response: The Department recognizes that if HVHF were authorized there is the potential for significant adverse environmental impacts on a large array of resources. In this regard, consistent with the requirements of SEQRA, the SGEIS considered potential significant adverse environmental impacts, and where appropriate the Department proposed and considered mitigation measures that could reduce those impacts. The SEQRA regulations (at 6 NYCRR 617.10) state that generic environmental impact statements "may present and analyze in general terms a few hypothetical scenarios that could and are likely to occur." Here, the Department applied a "worse case" scenario when analyzing potential significant environmental impacts.

As more fully addressed in the Response to Comments, Community Character, in Potential Environmental Impacts and Mitigation and Cumulative Impacts, there is no basis to pinpoint exactly where and how many wells or well pads may be drilled for HVHF. Moreover, even if the Department could accurately predict the number of wells to be developed by HVHF, it is not possible to predict the timing of each HVHF operation. In the face of the potential full build out of HVHF wells and the density of development, this lack of predictability further complicates the ability of the Department to adequately address potential impacts and provide effective mitigation to prevent significant adverse impacts to public health, natural resources and the environment. Similarly, consistent with SEQRA requirements, potential cumulative impacts from HVHF are discussed throughout the SGEIS. At the programmatic level, it was however difficult to predict where and how many wells or well pads may be drilled. See Response to Comment in Cumulative Impacts.

Despite acknowledging that if HVHF were authorized it would not be possible to determine the precise location of where each well pad would be located, when it would be developed, or how many wells may be located on a given pad, the use of a generic environmental impact statement (EIS) is the most appropriate means to have programmatically examined the potential significant adverse environmental impacts of HVHF on public health and the environment. In this regard, the Department's SEQRA Handbook states:

> Agencies that frequently undertake, fund or approve actions that are essentially similar in nature and effect may find that a generic EIS, which addresses those repetitive actions, may save work by reducing the need for individual EISs or negative declarations. Similarly, a generic EIS may be appropriate when an agency is considering a new, or substantially revised plan, program or policy, that will affect a wide range of resources or geographic areas, and for which an exploration of a range of mitigation measures that would work in various circumstances is needed. A generic EIS may also be the most effective way for an agency to assess potential significant cumulative impacts from a number of small projects that individually do not have a significant impact on the environment.

See http://www.dec.ny.gov/permits/56701.html. The evaluation of the proposed regulatory program governing HVHF squarely fits the foregoing description. While there may be individual, site-specific differences in individual applications, there would also be many commonalities from application to application. Even with a generic EIS, if an application deserves individual treatment, then the Department has the discretion and multiple opportunities to give it such treatment. However, as discussed more fully in the Response to Comments in Cumulative Impacts, it may not be possible to adequately address certain impacts for a state-wide program, such as HVHF, in a site-specific review.

With respect to comments urging the Department to subject well permits authorizing HVHF to the Uniform Procedures Act (UPA), the regulatory programs governed by Environmental Conservation Law (ECL) Article 70 (UPA) are listed in Section 70-0107 of that statute. Oil and gas drilling permits are not among the programs listed by the Legislature in that section. However, if HVHF were authorized, the Department would have required a public comment period prior to permitting the first well on a well pad and combined the review of the HVHF well permit applications with any other applications it received, including those subject to the UPA.

Future SEQRA Compliance

Comment: The Department generally received comments that favored a more extensive regulatory treatment — in other words, increasing the category of applications that would fall outside the thresholds and conditions of the GEIS and have to receive an individual determination of environmental significance under SEQRA. Some comments suggested requiring a supplemental environmental impact statement for every permit application, and separate environmental impact statements for the production phase. The following is a representative comment:

> The Department should require a site-specific State Environmental Quality Review Act review for each well proposed along with consideration of cumulative impacts. Site-specific State Environmental Quality Review Act determinations should be done for every well pad, not only for the first hydraulic fracturing events but for any subsequent re-fracturing as well. By issuing a single environmental impact study for all of New York State with regard to HVHF, the Department is treating the State as one large industrial site instead of the tens of thousands of individual sites it will actually be. There is no way that the Department can say that this activity is safe without an in depth investigation of each proposed drilling site. The rights of individuals to exactly the same water and soil quality, noise level and light level that they enjoyed prior to drilling, should receive equal consideration no matter where the well pad is located.

Additional comments were received requesting further SEQRA treatment for applications within 1,000 feet of any public water supply well, within an area subject to local floodplain regulations, within Critical Environmental Areas and Areas of Special Significance, near hospitals, schools, and nursing homes, any permit application within the New York City watershed or similar sensitive area, and if a road agreement is not entered into with the host municipality.

Response: Under the Department's SEQRA regulations (at 617.10 [d]), "[n]o further SEQR compliance is required if a subsequent proposed action will be carried out in conformance with the conditions and thresholds established for such actions in the generic EIS or its findings." The section then lists various scenarios for additional SEQRA reviews as follows:

- An amended findings statement must be prepared if the subsequent proposed action was adequately addressed in the generic EIS but was not addressed or was not adequately addressed in the findings statement for the generic EIS;

- A negative declaration must be prepared if a subsequent proposed action was not addressed or was not adequately addressed in the generic EIS and the subsequent action will not result in any significant environmental impacts; and

- A supplement to the final generic EIS must be prepared if the subsequent proposed action was not addressed or was not adequately addressed in the generic EIS and the subsequent action may have one or more significant adverse environmental impacts.

In the SGEIS, the Department discussed how applications would be treated if HVHF were authorized— both for applications that met the conditions and thresholds of the GEIS and for ones that did not. This may include thresholds and criteria for supplemental EISs to reflect specific significant impacts, such as site-specific impacts, that were not adequately addressed or analyzed in the generic EIS.

The use of a generic EIS to address common impacts is authorized by SEQRA and is appropriate for analyzing the proposed HVHF permitting program. Although the vast majority of potential impacts are associated with the drilling and completion phase, the SGEIS also addressed the production phase because the activity is likely to result in common impacts most appropriately studied in a generic EIS. A GEIS also allows an agency to look at cumulative impacts of the same class of activity occurring many times within a defined geographic area and assists in the consideration of cumulative impacts of an activity. Furthermore, in the event that HVHF were authorized, all applications for permits to conduct HVHF would be individually reviewed at some level to ensure that environmental concerns are identified and addressed. In the event any particular application would cause significant adverse impacts not previously identified and considered in this SGEIS, a supplemental EIS would be required with regard to such new significant adverse impacts.

If HVHF were authorized, some level of site-specific review should be required for activities in or near sensitive locations, which may include critical environmental areas, areas of special significance, hospitals, schools, and nursing homes. Furthermore, HVHF activities should simply be prohibited from certain areas to protect invaluable resources, such as certain water drinking supplies. See Responses to Comments in Prohibited Areas and in Setbacks in Potential Environmental Impacts and Mitigation.

In addition to these considered prohibitions and site-specific review requirements, the Department recognizes that sensitive receptors such as hospitals, schools and nursing homes would be identified as part of any site-specific noise impact analysis. Proximity of a proposed well pad or access road to a designated Critical Environmental Area (CEA) would be determined and considered during the permitting process. Because specific well locations are not evaluated in the SGEIS, the identification of a potential impairment of the environmental characteristics of a CEA would require a site-specific SEQRA determination and would be one of the criteria for determining significance (i.e., whether or not a supplemental EIS would be needed).

Finally, managing traffic impacts is an area of uncertainty for the Department. If HVHF were permitted to generally proceed, the Department considered requiring a project-specific transportation plan with every well permit application regardless of whether a road use agreement has been obtained. This considered measure to address potential traffic impacts, however, is untested and it is not clear that it would adequately mitigate potential impacts caused by increased traffic.

Alternatives

Comment: The Department received numerous comments that contend that the SGEIS failed to properly consider a wide-enough range of alternatives to satisfy the requirements of SEQRA. Comments also suggested a number of alternatives that should have been considered by the Department. These suggested alternatives included alternatives that would: 1. Prohibit HVHF in special places reflecting the significance of unique cultural and historic resources; 2. A demonstration project that would monitor impacts during a limited and focused demonstration project; 3. Prohibit HVHF where local government has enacted land use restrictions; 4. Prohibit HVHF in areas where the environmental hazard presented by HVHF presents an unduly increased risk; 5. Defer action pending the development of scientific studies demonstrating that HVHF can be done safely; 6. Limit development of HVHF to brownfields: 7. Limit HVHF to areas designated as an industrial zone. Other comments, while not offering any specific alternative, argued that the Department should consider alternatives that would minimize impacts to agriculture, that would require drilling operations without the use of chemicals or require the use of biodegradable or “green” fracturing fluids, that would require the use of propane rather than water to fracture, and that would generally require a closer look at other shale-gas extraction technologies.

The Department also received comments that argued that the Department should consider increased spacing units beyond 640 acres (or at least prohibit the use of spacing units below this threshold) or require forced pooling of well sites in order to reduce environmental impacts. Here, comments contended that current technology enables wellbore laterals to extend to over 5,000 feet, which would mean that a single well pad with multiple wells can tap into four to five square miles or roughly up to 3,200 acres of shale. The comments noted that pooling and larger spacing units reduces environmental impact, and lowers road repair impact, aesthetic impact, and gathering-pipeline impact.

The Department also received a number of comments that asserted that the Department should consider an alternative that deferred to localities and prohibited HVHF where the drilling operation directly conflicts with local land use policy. In this regard, the comments argued that the SGEIS was unclear what the Department would do when HVHF permit requests are made for areas of the Marcellus/Utica Shale where local zoning provisions or land use plans preclude drilling and other heavy industrial activities. To the extent that the comments reflected the belief that the SGEIS would allow the Department to preempt local zoning ordinances, many comments stated that such preemption was inconsistent with longstanding legal principles, which have upheld the right of localities, under the police power, to establish comprehensive land use plans and local zoning ordinances.

The Department also received comments urging the Department to adopt the No Action alternative. In this respect, the comments suggested that HVHF as currently proposed is simply not a safe activity and should be delayed until a safer method can be found to extract natural gas ("delay action" alternative). Many comments suggested that there was still too much uncertainty surrounding the potential impacts from HVHF and that more time was need to fully understand these impacts. The comments also recommended that HVHF be prohibited to prevent the harmful release of greenhouse gases. The comments also suggested that the No Action alternative underestimated the potential risk of significant adverse environmental impacts and failed to address energy conservation and efficiency and the use of alternative sources of energy, especially the use of renewable sources of energy. Finally, some comments indicated that the discussion of the No Action alternative in the 2011 rdSGEIS incorrectly concluded that a prohibition of hydraulic fracturing would violate state law.

Response: The SEQRA regulations state that an environmental impact statement must describe and evaluate "the range of reasonable alternatives to the action that are feasible, considering the objectives and capabilities of the project sponsor" (6 NYCRR 617.9(b)(5)(v)). The description and evaluation of each alternative "should be at a level of detail sufficient to permit a comparative assessment of the alternatives discussed." While the SGEIS considered a reasonable range of alternatives, as required by ECL § 8-0109(2)(d), based on the comments received, the Department has considered additional alternatives many of which were requested by the commenters. Specifically, the Department has considered: the denial of permits to develop the Marcellus Shale and other low-permeability gas reservoirs by HVHF (No-action alternative); permutations of a phased permitting approach to developing the Marcellus Shale and other low-permeability gas reservoirs, including an incremental permitting alternative; a demonstration project alternative that contemplates an initial restriction on gas development using HVHF contingent upon the results of the demonstration project; requiring the use of “green” or non-chemical fracturing technologies and additives, and a “special places” approach that would prohibit or restrict HVHF in areas that have significant environmental features, including hydrological, recreational, aesthetic, ecological, and historical.

The Department considered a host of mitigation features that would at least partially adopt many of the measures outlined in these alternatives. Specifically, the Department proposed a green chemical analysis and where feasible and, the use of alternative additive products that may pose less risk to the environment. As to the use of propane rather than water, this technology would have to be evaluated pursuant to a specific proposal and also may raise other environmental issues not identified or assessed in this SGEIS.

To address “special places,” if HVHF were authorized the Department considered a combination of prohibitions and environmental site-specific reviews in areas of the state that the Department deems particularly sensitive to the proposed development of natural gas resources through HVHF. In this regard, the Department considered applying numerous mitigation measures that would influence the location of HVHF wells, which would also necessarily limit the number of HVHF wells because certain areas of the State would be off limits to surface disturbance, HVHF in its entirety or, at least, less likely to be developed because of regulatory requirements. These mitigation measures would include setbacks (prohibitions or site-specific SEQRA review) from specific water resources and supplies, a prohibition of well pads for HVHF on Department-administered State-owned lands, enhanced site-specific review for critical habitat and agricultural districts, and stormwater controls. The Department would also require mitigation measures for visual and historic resources, and considered including mandatory additional environmental review for any application for HVHF in Historic Districts and the Catskill Park (and considered a complete prohibition within the Catskill Park). The Department would also prohibit the siting of well pads in floodplains if HVHF were authorized. Collectively, these mitigation measures would reduce impacts to ecosystems and wildlife, water resources and community character. While impacts could be reduced, impacts could still be significant (including cumulative impacts based on the anticipated wide scale development of HVHF), and that the only certain way to eliminate the potential for significant adverse impacts is through the adoption of the No Action Alternative.

As to limiting development to previously disturbed areas, including brownfields, the Department notes that the ability to locate commercially producible quantities of natural gas in low-permeability reservoirs is dependent on subsurface geology. It would not be reasonable to limit the siting of wells to areas where surface acreage has been previously disturbed by road building or historical contamination.

Similarly, with respect to pooling or expanding spacing units, the Department agrees that a multi-well pad limits the environmental impacts from well pad and access road construction compared to single well pads, but notes spacing unit sizes are outside the scope of the SGEIS since it would require legislative action. However, due to the anticipated widespread nature of this activity in areas that previously have not been exposed to oil and gas development because of the evolution of the technology that facilitates extraction of natural gas from deep low-permeability shale formations where it was previously not feasible, the footprint on certain areas within the Marcellus formation and the associated impacts would likely be greater than for traditional methods of extraction.

With respect to comments that argue that the Department should consider deferring to municipal zoning regulations, the recent New York Court of Appeals decision in *Matter of Wallach v. Town of Dryden* found that ECL § 23-0303(2) does not preempt communities with adopted zoning laws from entirely prohibiting the use of land for HVHF. In that decision, the Court noted that: "Manifestly, Dryden and Middlefield engaged in a reasonable exercise of their zoning authority … when they adopted local laws clarifying that oil and gas extraction and production were not permissible uses in any zoning districts. The Towns both studied the issue and acted within their home rule powers in determining that gas drilling would permanently alter and adversely affect the deliberately cultivated, small-town character of their communities." In light of the *Dryden* decision, if HVHF were authorized under this SGEIS, communities would have the ability to adopt zoning ordinances that prohibit HVHF.

The Department agrees that the discussion of the No Action alternative too broadly concluded that prohibiting HVHF would contravene the ECL and that reference has been removed from the FSGEIS. Moreover, the No Action alternative has been revised to better reflect the potential impacts from HVHF, if it were authorized, including potential impacts to community character and uncertainty with respect to potential public health impacts. The No Action alternative has also been revised to reflect the costs associated with administering the program as compared to the anticipated economic benefit. The discussion of the No Action alternative also addresses the potential impact associated with greenhouse gases if HVHF were authorized in the context of the state's energy policy. Finally, the Department also agrees that to the extent that uncertainty remains as to the potential environmental and health impacts and the effectiveness of the mitigation, the No Action alternative is a reasonable alternative to consider.

SAPA

Comment: The Department received comments that the conditions and thresholds established through the SGEIS for permitting HVHF were either not enforceable or violated the State Administrative Procedure Act (SAPA) as an improper rulemaking.

Response: If HVHF were authorized, the conditions and proposed mitigation established through the environmental review process would be enforceable as permit conditions that an applicant would be required to abide by. An applicant that did not wish to be bound by such conditions and thresholds would have the choice of undergoing an additional, individual review process to determine whether the proposed activity could be carried out in a way that met the requirements of SEQRA. While permit conditions derived from numerous articles contained in the Environmental Conservation Law and SEQRA are fully enforceable, the Department had proposed regulations that were an outgrowth of the environmental impact statement process in order to solidify the legal foundation for the overall program. That rule-making expired. If high-volume hydraulic fracturing were authorized, the Department would consider proposing new revised regulations.

2. Permit Process and Regulatory Coordination

General – Permit Process

Comment: The Department received numerous comments that addressed the process by which the Department would use a generic environmental impact statement to grant individual permits and the criteria that would be used to make those permitting decisions. Commenters raised questions about the expected interaction among the various federal, state and local governmental organizations involved in approving different aspects of the proposed action and the extent of public involvement planned. Some comments asked for more specificity on the role to be played by the interstate basin commissions for approval of water withdrawals, and other comments requested that other state, county, and local governments either receive direct notification of all permit applications or that they take part in the approval of individual permits or resource-specific plans, such as road use agreements.

Many detailed comments were also received on the proposed environmental assessment form and the various plans that would be required to be submitted as part of a permit application for a well where HVHF is planned, and these comments offered a myriad of suggestions on how such proposed plans and forms should be modified. Overall, public comments received indicated there is much confusion on how a generic impact statement, or this particular impact statement, would be used during permitting review. Some commenters believed the SGEIS was intended to be a one-size-fits-all environmental review that did not take into consideration how specific resources would be affected while other commenters believed the SGEIS was so generic and required so many detailed site-specific plans that the SGEIS served no regulatory or procedural purpose. Several comments questioned how the Department intended to handle the number of expected permits with existing staff and a portion of these comments argued that the proposal to limit the number of permits to available staff is arbitrary. Finally, some comments argued that the plans and mitigation measures proposed for HVHF wells should apply to other wells regulated by the Department. In addition to general comments regarding the permit process, the Department received more specific comments with respect to requirements contained in the Environmental Assessment Form Addendum; the process that the Department proposed to use to review and approve of individual permit applications; and comments either advocated or opposed the use of a phased permitting process to control the pace of development related to HVHF. The comments are addressed individually below, following a general response to the permit process.

Response: The SGEIS does not prescribe a "one-size-fits-all" permitting approach for HVHF wells. Instead, it would have established a process for guiding how permit applications would be developed by well operators and how applications would be reviewed by the Department. The SGEIS required site-specific plans related to specific types of resources (invasive species, roads, visual resources, etc.) and an environmental assessment form addendum that would have disclosed site-specific information about chosen well locations. If HVHF were authorized the Department would use the SGEIS and findings statement to establish the process and the thresholds and conditions under which any applications would be evaluated to determine if the potentially significant adverse environmental impacts at a specific location have been fully assessed and if they were consistent with the conditions and thresholds disclosed and analyzed in the SGEIS.

If the site-specific review of an actual application did not reveal additional significant adverse environmental impacts that were not already disclosed, fully evaluated and subject to mitigation deemed adequate in the findings statement, then, if HVHF were authorized, a permit could be issued with the mitigation measures contained in the generic EIS. However, if a site-specific review of a specific permit application did reveal significant adverse public health and environmental impacts that were not already addressed in the SGEIS, then additional SEQRA determinations would be made, including whether a supplemental EIS is required. The SGEIS also identified, in Chapter 3, some pre-determined locations where a site-specific determination of significance would be required. In addition to those locations identified in the SGEIS, the Department considered requiring a site-specific EIS review for additional resources. See Responses to Comments in State Owned Lands in Prohibited Locations and Flowback Water in Potential Environmental Impacts and Mitigation.

In light of the requirements proposed, including the need for site-specific reviews for many of the likely proposed well sites, the Department acknowledges that administering the program would carry with it very significant costs. The Department's costs of administering this program under the average development scenario would grow from approximately $14 million in the first year to nearly $25 million in the fifth year. These costs do not consider other substantial costs that would be incurred by other state and local agencies. See Response to the Comment in Enforcement.

To the extent that comments suggested the SGEIS process or mitigation measures should apply to all wells regulated by the Department, the Department notes that the proposed action evaluated in the SGEIS pertained to a specific subset of wells regulated by the Department, those which involve HVHF. The SGEIS and the proposed mitigation measures described in the SGEIS do not apply to any other wells regulated by the Department, including oil and gas production wells which do not involve HVHF. The Department also notes that HVHF is defined as the stimulation of a well using 300,000 or more gallons of water as the base fluid for hydraulic fracturing for all stages in a well completion, regardless of whether the well is vertical or *directional,* including horizontal. Well stimulation requiring less than 300,000 gallons of water as the base fluid for hydraulic fracturing for all stages in a well completion are not considered high-volume, and will continue to be reviewed and permitted pursuant to the 1992 GEIS, and 1992 and 1993 Findings Statements.

As discussed in the rdSGEIS, HVHF raises new, potentially significant, adverse impacts that were not studied in 1992 in the Department's previous Generic Environmental Impact Statement (1992 GEIS) on the Oil, Gas and Solution Mining Regulatory Program. HVHF is distinct from other types of well completion that have been allowed in the State under the 1992 GEIS and non-

HVHF permits due to the much larger volumes of water mixed with chemicals used to conduct hydraulic fracturing operations. The use of HVHF with horizontal well drilling technology provides for a number of wells to be drilled from a single well pad (multi-pad wells). Although horizontal drilling results in fewer well pads to develop a given area than traditional vertical well drilling, pads where HVHF is planned are larger and the industrial activity associated with HVHF on the pads is more intense. In addition, the technological capacity to develop low-permeability reservoirs by HVHF has the potential to draw substantial development into large areas of New York that would otherwise be less accessible via conventional development. In this respect, the Department estimated that even under a low development scenario, a total of 7,420 horizontal wells and 840 vertical wells are assumed to be constructed at maximum build-out (year 30)(although this number would likely be further reduced by the various mitigation measures that prohibit development in certain areas). See Response to Comment in Socioeconomic in Potential Environmental Impacts and Mitigation. As a consequence, HVHF poses the hazards identified in the SGEIS. Specifically, the extra water, blended with the additives, that is associated with this type of well completion raises concerns about potential significant adverse impacts relating to water supplies, wastewater treatment and disposal and truck transport to name a few. Horizontal wells also generate greater volumes of drilling waste (cuttings) than vertical wells drilled to the same target depth. Industry projections of the level of drilling, as reflected in the intense development activity in neighboring Pennsylvania, have raised additional concerns relating to air quality, truck traffic, noise, habitat, cultural, historic and natural resources, agriculture, community character and socioeconomics.

If HVHF were authorized, coordination of the various approvals among divisions in the Department and with other interested and involved agencies would be an important element of the overall process. The SGEIS describes the various roles of divisions within the Department and other agencies that would play a role in the approval of a HVHF well, such as the river basin commissions. To assist in the coordination of review, the SGEIS proposed that the Department maintain a publicly available database that could be used to notify local governments of the receipt of permit applications where HVHF is planned. In response to public comments, the Department considered other means available to work with state and local governments on the review of specific locations, such as regular regional meetings attended by government, well operators and the public where the industry would be required to present their long term projections for HVHF development. These regular meetings would generally provide a means for other state and local agencies to plan ahead for applications that may be received. This considered measure sought to address the concern that both the public and the industry would have to interact with several different government bodies, rather than a single or coordinated point of contact. However, such coordination is untested, and therefore it is uncertain as to how effective it would be in reducing impacts. Consequently, while the proposal to continuously update a publicly available database of permit applications would provide interested parties with necessary information to plan, it would not necessarily prevent potential impacts to local resources and the environment. Should HVHF be allowed to proceed generally, the Department also considered providing public notice and an opportunity for public comment on the first ECL Article 23 well application proposing HVHF on a new well pad via a fifteen-day public notice period, limited to site-specific issues on the subject application not addressed in the 1992 GEIS or this SGEIS. See Response to Comments in Cumulative Impacts and Community Character in Potential Environmental Impacts and Mitigation.

Comment on Environmental Assessment Form Addendum

A number of comments received on the SGEIS specifically addressed the Environmental Assessment Form (EAF) Addendum, which lists information the well operators would need to supply with an application to drill a HVHF well. If HVHF were authorized, the EAF Addendum would require well operators to identify, for example, the distance between their proposed well pad and nearby water resources, the types of equipment that may be used on site and details related to well construction. Public comments suggested, among other things, that the EAF Addendum should:

- Require operators to show the distance between well pads and water sources;
- Include a requirement that operators describe how long fluids would be stored on site;
- Include more detailed and prescriptive requirements for the emergency response plan:;
- Require information about potential impacts to infrastructure;

- Require operators to state the distance between private water wells and petroleum bulk storage facilities;
- Mandate an affirmation from the operator that adequate treatment capacity is available for flowback;
- Be required for both re-fracturing and each individual well on a pad;
- Exclude a requirement for an invasive species plan since the risk of transferring invasive plants to an off-site location is the same or similar for all other construction projects;
- Identify how archeological resources would be protected;
- Require operators to have a blowout response plan;
- Apply to all natural gas development, not just HVHF;
- Require operators to submit proof that local landowners have been notified of proposed well sites;
- Include information about state and federally-listed threatened and endangered species;
- Specify whether ultra-low sulfur fuel must be used in all equipment or just stationary equipment;
- Clarify the definitions and wording so they are clearer and do not contradict complementary sections of the SGEIS;
- Require operators to file documents electronically so that assembling and distributing documents would be more efficient;
- Require operators to identify environmental resources or receptor locations over a greater distance from the well pad;
- Require operators to supply proof of a road use agreement with the host community(ies);
- Require operators to identify environmental resources or receptor locations over a shorter distance from the well pad; and
- Specify when such plan or reports should be submitted to the Department.

More general comments on the EAF Addendum claimed the list of information required by well operators would not enable the Department to make a site-specific determination of significance and in contrast, those opposed to all or some of the EAF Addendum requirements argued that such measures are excessive, unprecedented and are founded upon questionable regulatory or statutory authority.

Response to Comment on the EAF Addendum

The SGEIS discusses many different submission requirements, covering a wide array of environmental considerations, for an applicant seeking a Permit to Drill an ECL Article 23 well that will be completed using HVHF. As stated above, if HVHF were authorized, these requirements would apply to every well on the well pad and an operator who seeks to drill additional wells beyond the initially-permitted well(s) on a multi-well pad would be required to submit supporting documentation with an EAF Addendum. This documentation would need to reflect current and proposed site conditions, and as with all submitted applications, a pre-site inspection would be performed by Department staff after the application is submitted.

As a general matter, redundant or contradictory sections of the SGEIS should be corrected and the process for submittal and approval of various plans should be transparent. To the extent possible, if HVHF were authorized, the Department would take steps to make sure the regulatory process is clear, including a description of how SEQRA would be used as a guide to decision making.

Also, if HVHF were authorized, compliance with the State Historic Preservation Act would be an important element of the permitting process, and OPRHP would routinely be incorporated in the permit review process. The Department considered additional mitigation measures that would likely further reduce impacts to historic properties if HVHF were authorized. See Response to Cultural Resources Comment in Potential Environmental Impacts and Mitigation for additional measures considered.

In response to some of the more specific comments on the EAF Addendum, if HVHF were authorized:

- The SGEIS would require an invasive species plan as part of a permit application. Although most of the traffic associated with HVHF sites is not part of any surface-disturbing activities, the number of vehicle trips associated with HVHF creates the potential for transfer of invasive terrestrial species.

- Staff would review all submitted documentation.

- The Department agrees that applicants should provide information on endangered and threatened species, as it is an existing requirement of the Department's EAF. The EAF Addendum is specific to HVHF and is meant to supplement the existing EAF rather than serve as a replacement;

- All fueling tanks used at the well site, regardless of volume, must meet all the requirements - including SPOTS 10 - set forth in the SGEIS;

- The use of ultra-low sulfur fuels for all engines has been identified as a mitigation measure by the industry;

- The Department agrees electronic submissions would be more efficient and would encourage the use of e-filing;

- The Department would encourage road-use agreements with local governing but does not engage in the development or approval of specific road-use agreements; that authority has been granted by the Legislature to local governing bodies (See, ECL § 23-0303(2)).

- The Emergency Response Plan (ERP) discussion in the SGEIS is intended to convey the essential elements of an ERP, as well as the importance of tailoring a given ERP to a specific site. It is not intended to provide an all-inclusive list of emergencies (or other non-routine incidents) and their corresponding responses.

- Blow-out preventer (BOP) testing performed in conformance with industry standards and the proposed BOP Use and Test Plan is an important component of overall well design and planning; and

- The scope of the SGEIS is limited to wells to be completed by HVHF and therefore any mitigation proposed by the Department is specific to this SEQRA action, and should not be assumed to be applicable to other regulated wells.

Comment on Approval of Plans and Permits

In addition to comments on the permitting process in general and the EAF Addendum, public comments also focused on the process used to review and approve of individual permit applications. The SGEIS did discuss how individual permit applications would be reviewed and the standards for permit issuance under the Environmental Conservation Law and SEQRA, if HVHF were authorized, and the EAF Addendum described the requirements necessary to submit a complete application. Public comments suggested that a permit to drill should not be approved unless:

- the well operator had a clean record of compliance;
- gas companies bring local roads up to standards needed for volume and weight of traffic associated with HVHF;
- the Department verifies information submitted by applicants (e.g., distance from setbacks, depth to groundwater resources, etc.);
- closed-loop drilling is required;
- reserve pit specifications are clear and additives that may be placed in pit are identified;
- all best management practices in the SGEIS related to invasive species are adhered to;
- all plans required by the EAF Addendum are shared with the public;
- all plans required by the EAF Addendum are incorporated by reference into the permit;
- regulations are updated to reflect mitigation measures identified in the SGEIS;
- all well permit applications are vetted through a quasi-judicial proceeding; and
- a site-specific EIS is completed for every well.

Some commenters asked for a well-defined time frame for review including some form of uniform procedures for review of applications to drill HVHF wells, since the UPA does not apply to ECL Article 23 permits. Some commenters were also confused about the timing of the review of plans required by the EAF Addendum relative to the start of drilling or construction of the well pad.

Response to Comment on Approval of Plans and Permits

Except for a road use agreement between the operator and a local municipality and a copy of the emergency response plan, the EAF Addendum would require all listed plans and information to be submitted at the time of permit application. Specific time frames for the review of such information are based on site-specific and well-specific considerations. Timeframes cannot be offered for permit decisions, as they would necessarily be based on the assumption that all information submitted as part of an ECL Article 23 application is complete and standards met. Department experience has shown that many applications require additional information and/or clarification based on the originally-submitted information.

In the review of individual permit applications, the Department does consider the compliance history of an applicant as described in the Department's existing Record of Compliance policy. Moreover, although permit applications would generally be considered public information and the Department would take steps to make public information available, the disclosure of Department records to the public does not mitigate potential environmental impacts. If HVHF were authorized, the Department would consider providing public notice and an opportunity for public comment on the first ECL Article 23 well application proposing HVHF on a new well pad via a fifteen-day public notice period, limited to site-specific issues on the subject application not addressed in the 1992 GEIS or this SGEIS. However, a quasi-judicial proceeding to review individual applications is not necessary since the SEQRA process sufficiently addresses the need for public involvement. Under the Department's Uniform Procedures Act (UPA) policies, if other permits were required that mandated public hearings or a 30-day comment period, e.g., a "major" Freshwater Wetlands permit, the Department, pursuant to 6 NYCRR Part 621.3(a)(4), would process the permit applications simultaneously, such that the HVHF permit public notice and comment would be conducted under the UPA process.

In response to some of the specific comments on how permits should be approved, if HVHF were authorized:

- The Department does not believe it would be necessary to include all the BMPs contained in Section 7.4.1.1 of the SGEIS in every well drilling permit. Rather, the Department would use site-specific information to condition the well drilling permit and would only include BMPs deemed appropriate for that individual well site.

- Closed-loop systems provide environmental and economic benefits during various phases of the development of natural gas wells and would be required, as indicated in Proposed Supplementary Permit Conditions. If oil-based mud or polymer-based with mineral oil lubricant mud is used the operator would be required to utilize a closed-loop tank system rather than a lined reserve pit. A reserve pit would only be permitted in certain circumstances, such as when used for temporary containment of cuttings and fluids generated during drilling on mud, water or other fluid, including air, without additives.

All submitted information would be reviewed by Department staff. Department staff already routinely conduct pre-site inspections, after an application is received, and post-site inspections, after drilling and (non-high-volume) fracturing but before production, to verify regulatory setbacks and confirm that wells are constructed as approved. Should HVHF be allowed to proceed, pre-site and post site inspections would be used to verify compliance with buffers, as well as any other site-specific information contained in an HVHF well permit application.

Comment on Phased Permitting

A significant number of comments suggested that the Department should control the pace of development related to HVHF. Those in favor of phased permitting offered a range of suggestions that included: a complete moratorium on permitting until the impacts of HVHF in other states could inform decision making in New York; a specific number of permits that could be used as a demonstration project; or issuance of a specific number of permits each year. In response to the phased-permitting alternative discussed in Chapter 9 of the SGEIS some commenters argued it was unclear how the Department would limit permits under the various alternatives discussed and how this would impact pending applications by various operators, including operators facing lease expirations. Comments also offered that there are no standards articulated in the SGEIS for when limits should be imposed, how limits would be imposed or the duration of any limits. Comments argued this creates significant uncertainty for industry, jeopardizes lease holdings and makes New York anti-competitive.

Those in favor of a phased approach to permitting suggested that a phased permitting approach would address concerns about the number of Department inspectors, and other comments suggested that the industry sponsor a demonstration project so the impacts of HVHF can be further studied.

Response to Comment on Phased Permitting

As a general matter, the adoption of a phased permitting approach would allow the Department to limit the scope of its regulatory program while the industry, local governments, the Department, other state agencies and the public gain experience with regulating operations. The SGEIS, in Chapter 9, discusses the inherent difficulties involved in predicting the rate of development that might occur in New York but also recognizes that the pace of development may follow a natural progression. Chapter 9 also explains how the SGEIS would necessarily in essence adopt a phased-permitting approach, if HVHF were allowed to proceed, since the SGEIS would pre-determine which sites would automatically require a site-specific SEQRA determination and would prohibit development by HVHF in certain other locations, such as the City of Syracuse and New York City Watershed. The SGEIS acknowledged that collectively these factors would influence the location of wells, which would also necessarily limit the number of wells drilled, because many areas of the State would be off limits to surface disturbance or drilling in its entirety or at least less likely to be developed because of permitting and/or regulatory requirements. The Department continues to maintain that if HVHF were authorized, the pace of development would also be limited by personnel resources at the Department who are available to review and approve permit applications, conduct site inspections, and enforce permit conditions and regulations. See Response to Comment in Enforcement.

Following public comment, the Department did consider how permitting of HVHF wells could be paced to allow state and local governments to plan for development. However, as indicated above, and in Chapter 9 of the SGEIS, the selection of a specific number of wells on a generic basis could be seen as arbitrary. The site-specific factors of any given HVHF well pad or multiple well pads developed in geographic proximity or regionally, including the number of wells that may be drilled from any given pad, the number of wells that may be developed in any specific county at any given time and the state of leasing are all factors which make it difficult to determine the nature and scope of the cumulative impacts that would result from HVHF and, therefore, determine the measure of mitigation that would be achieved by limiting the number of HVHF wells that should be permitted during any specified time period.

The Department, at any time, can review applicable regulatory requirements to determine whether any adjustments are needed to respond to evolving industry practices, standards, or conditions in the field but those adjustments would not necessarily be adequate to address the cumulative impacts of HVHF development. A phased permitting approach constitutes one method that the Department could employ to address cumulative impacts which would be critical to the Department's program to mitigate such impacts.

With respect to well density and distances, siting several wells on a single multi-well pad has mixed environmental impacts; fewer well pads and access roads are constructed, infrastructure needs are fewer and overall the amount of land disturbance is less than if the same acreage were developed by vertical drilling of single wells. On the other hand, HVHF would allow development to occur across a broad swath of the State on a more frequent basis than would result from conventional extraction methods. This would result in more intense industrial activity occurring in more locations throughout the region with the appurtenant supply chain, product management and transportation and waste disposal impacts. The number of wells sited on a well pad is influenced by several factors including: whether the resource can be effectively recovered; the well operator's lease position; and the siting setbacks and prohibitions that would be imposed by the SGEIS. The uncertainty as to where HVHF wells would be sited if HVHF were authorized, further complicates the Department's ability to assess potential cumulative impacts, as well as impacts to community character and natural resources.

Interagency Coordination

Comment: The Department received numerous comments with respect to the proposed coordination between the Department and other state agencies, the federal government, the Indian Nations and local governmental bodies. The vast majority of these comments favored a heightened degree of coordination. Specifically, a substantial body of comments asked that the Department coordinate with the Department of Health (DOH) in identifying and resolving well water contamination issues that might arise from HVHF. There was significant concern expressed that individual well water contamination complaints would not be addressed. The Department also received a large body of comments on coordination with federal agencies, and with the Public Service Commission regarding natural gas pipelines, the Department of Agriculture and Markets regarding agricultural lands, interstate compact agencies regarding water withdrawals, and the Indian Nations regarding consultation and their reserved water rights.

Response: The Department discussed interagency coordination of permit reviews in Chapter 8 of the rdSGEIS. Table 8.1 of the SGEIS summarized the potential involvement of various divisions or parts of the Department as well as state, federal and local agencies and others, assuming a non-no-action alternative. If a permitting program for HVHF were to be instituted, interagency coordination as discussed below would be necessary to address the significant environmental impacts that would result from this activity given the multiple state and federal agency jurisdictions that apply to HVHF development, production and waste disposal. Establishing an effective regulatory program would have to overcome the hurdles presented by the multi-agency jurisdictional framework given the significant cumulative impacts that would result from this activity.

Coordination with local governments is to a large extent modified by the Court of Appeals' decision in *Matter of Wallach v. Town of Dryden*, which held that ECL § 23-0303(2) does not preempt municipalities from exercising their zoning powers to prohibit the use of land for HVHF. Prior to *Dryden*, the Department considered as part of the overall mitigation that it would respect legally binding local government expressions of community character through, for example, an adopted a town comprehensive plan. For several scenarios the discussion regarding coordination with local governments was predicated on a contrary interpretation of the § 23-0303(2) preemption clause. The following describes how the Department would coordinate with specific state agencies and other interested government bodies.

<u>NYSDOH Coordination</u>

As an initial matter, the Department extensively coordinated and consulted with NYSDOH throughout the HVHF process. The SGEIS considered potential human health impacts in numerous chapters of the SGEIS, including, among others, a review of the toxicity of potential fracturing fluid additives (Chapter 5), potential impacts to drinking water and air (Chapter 6), and mitigation measures to prevent human exposure (Chapter 7). NYSDOH was involved in all issues relating to potential health impacts leading up to its December 2014 Public Health Review of HVHF for Shale Gas Development. That Public Health Review concluded that "… the overall weight of the evidence from the cumulative body of information … demonstrates that there are significant uncertainties about the kinds of adverse health outcomes that may be associated with HVHF, the likelihood of the occurrence of adverse health outcomes, and the effectiveness of some of the mitigation measures in reducing or preventing environmental impacts which could adversely affect public health."

As for well water contamination complaint procedures, if HVHF were authorized: after an initial investigation by local health departments, complaints that are not adequately resolved can be referred to NYSDOH and the Department for further investigation and response. Additionally, the Department would continue to coordinate with NYSDOH and local health departments on how to best handle individual water well complaints as the regulatory program evolved. Currently, NYSDOH and at least some local health departments do not have the resources to conduct such activities under several development scenarios. The Department also considered a requirement for groundwater monitoring wells around well pads and requiring drilling companies to test nearby wells, prior to the commencement of drilling activities, as well as during HVHF and during and after production, at their expense so as to better identify the source of any incidents were they to occur.

<u>Local Governments</u>

ECL § 23-0303(2) states that "[t]he provisions of this article shall supersede all local laws or ordinances relating to the oil, gas and solution mining industries; [sic] but shall not supersede local government jurisdiction over local roads or the rights of local government under the real property tax law." As discussed above, the Court of Appeals held that ECL § 23-0303(2) does not by its terms preempt the home rule authority vested in municipalities to regulate land use so as to prohibit the use of land for natural gas development using the HVHF method of gas stimulation. According to the Court, ECL § 23-0303(2) only preempts municipalities from regulating the operational details of gas drilling (or as the Court phrased it the "how to" of drilling activity). Thus, if HVHF were authorized, towns, villages, and cities would be able to properly exercise their zoning authority over HVHF so long as they did not regulate the operational details or the "how to," in the Court's words, of drilling activity. Local governments also have authority to regulate local roads.

Some towns could exercise their zoning authority in such a way that they would be involved agencies under SEQRA. This means that the Department would be required to coordinate with such governments if the permit required discretionary approvals from the local government (e.g., a special use permit or some other type of zoning approval). See Response to Comment in Community Character in Potential Environmental Impacts and Mitigation for discussion concerning uncertainties as to potential impacts and effectiveness of considered mitigation measures.

For all other local governments and for local government in general, the coordination and notification schemes are discussed in sections 8.1.1 and 8.1.1.3 of the SGEIS.

New York State Department of Public Service

Concerns were expressed that HVHF would likely result in the construction of additional gas pipelines and that the review of these pipelines would be conducted in an uncoordinated fashion. The Public Service Commission (PSC) would be the principal regulatory entity in overseeing the construction of such pipelines. Where the PSC has jurisdiction over intra-state natural gas pipelines (which would be the case for most gathering lines), the agencies have historically coordinated and would continue to coordinate their reviews within the PSC proceedings. The PSC's Article VII proceedings are an analogue of the SEQRA process. The Department is a statutory party to such proceedings and additionally retains Federally delegated or authorized separate jurisdiction over any required air pollution control permits and registrations (usually for associated compressor stations and dehydrators) as well as under the State Pollution Discharge Elimination System (SPDES) for stormwater runoff. The Department concedes that there would be some level of impacts to wildlife habitat from any additional network of pipelines that would accompany HVHF wells if it were authorized. See Response to Comment in Other for discussion of pipelines.

Due to the unique nature of this activity, coordination to overcome the difficult regulatory issues presented by split jurisdictional responsibilities between the PSC and the Department for intrastate pipelines would have to be done in a manner that addresses HVHF's cumulative impacts.

New York State Department of Agriculture and Markets

If HVHF were authorized it would invariably affect agriculture and agricultural lands. As a consequence and because of the strong state policies favoring protection of agricultural lands, the Department would consult with the Department of Agriculture and Markets to develop permit conditions, best management practices (BMP) requirements and reclamation guidelines that would be followed when a proposed disturbance is larger than 2.5 acres on a farm in an Agricultural District. Further, the Department considered a requirement for site-specific review of applications in an Agricultural District. However, it is also recognized that notwithstanding such reviews and dependent upon the level of development, some agricultural land is likely to be lost due to HVHF activities. Furthermore, while the Department would employ a host of measures and restrictions to avoid environmental impacts, the only means of completely eliminating the risk of impacts to farmlands and livestock is to employ the No-Action alternative. The potential significant adverse environmental impacts, specifically those impacts on agricultural land, must be considered within the framework of the goals of Article 14, Section 4 of the New York State Constitution, which specifically states that the policy of the State is to "encourage the development and improvement of its agricultural lands for the production of food and other agricultural products [which]….shall include the protection of agricultural lands." The potential loss or conversion of productive agricultural land is of great importance to the State.

New York State Department of Transportation

Truck traffic from HVHF operations is a major concern with respect to local and cumulative impacts. The SGEIS evaluated the potential significant adverse impacts from increased truck traffic given the nature of HVHF development and its cumulative impacts. Such impacts could occur in locally concentrated areas in communities or in broader areas encompassing more regional road networks. Pursuant to SEQRA, the Department would defer to the NYSDOT and the local governments which have primary jurisdiction over roads and traffic within their respective jurisdictions. Nonetheless, in order to facilitate the exercise of such jurisdiction, the Department considered a requirement that well operators be required to submit a transportation plan that will be reviewed by the Department in consultation with NYSDOT. However, the Department concedes that while such measure may reduce impacts, there is uncertainty as to the ultimate effectiveness of this proposal and whether it would significantly reduce impacts to air quality, infrastructure, community character or impacts to other resources like State-owned lands. Coordination to overcome the difficult regulatory issues presented by fragmented jurisdiction between the NYSDOT, local government agencies and the Department would have to be accomplished in a manner that addresses HVHF's cumulative impacts.

New York State Office of Parks, Recreation and Historic Preservation

HVHF, if it were authorized, would result in potentially significant impacts to cultural, archeological and historical resources. The Office of Parks, Recreation and Historic Preservation (OPRHP) exercises primary jurisdiction over potential impacts to such resources under section 14.09 of the Parks, Recreation and Historic Preservation Law (which is an existing requirement). The Department would consult with OPRHP where appropriate. See Response to the Comment in Cultural Resources in Potential Environmental Impacts and Mitigation.

Federal Coordination

USEPA reviewed the SGEIS and provided comments, but has no direct responsibility for state gas drilling permitting although regulation of HVHF would require the Department to implement federally delegated programs. The Department would primarily regulate HVHF through Article 23 of the ECL (which is the state law on mineral resources), Article 17 of the ECL (which is the state law on water pollution control, and specifically Title 8 of that article, which is SPDES a federally approved law) and Article 19 of the ECL (which is the state law on air pollution). Additionally, through SEQRA, the Department has wide-ranging powers to evaluate the impact of HVHF activities on the environment.

Currently, 'drilling fluids, production brine, and other wastes associated with the exploration, development, or production of crude oil, natural gas or geothermal energy' are excluded from being regulated as a hazardous waste in both federal law and federal and state regulations (42 U.S.C. 6921 (b)(2)(A), 40 CFR 261.4(b)(5), 6 NYCRR 371.1(e)(2)(v)). This is commonly referred to as the 'extraction and production' (E&P) exclusion. This exclusion has existed since the beginning of the federal Resource Conservation and Recovery Act (RCRA) regulatory program and was included verbatim in the New York regulations when USEPA delegated the RCRA program to New York. More recently, the Energy Policy Act of 2005 created an exemption for the underground injection of hydraulic fracturing fluids as used in HVHF from the Safe Drinking Water Act. In this regard, EPA recently finalized regulations for the oil and gas industry which will apply more restrictive air regulations on the industry. If HVHF were authorized, the Department would use these EPA regulations along with restrictions and mitigation measures imposed by the SGEIS to regulate potential air pollution from well activities, off-site compressors and ancillary equipment. The requirements considered by the Department also go beyond federal regulation where necessary to assure compliance with air quality standards in New York. See Response to Comment in Air Quality and Greenhouse Gas Emissions in Potential Environmental Impacts and Mitigation.

If HVHF were authorized, the Department would consult with the appropriate federal agency to develop measures to mitigate visual impacts on federal resources and visually sensitive areas, including, but not limited to, National Historic Landmarks (NHL); properties listed in the National Register of Historic Places (NRHP); National Natural Landmarks (NNL); National Wildlife Refuges; National Park System Units, Recreation Areas, Seashores and Forests, as applicable; National Wild and Scenic Rivers and American Heritage Rivers; and National Scenic, Historic and Recreation Trails, and other resources owned or managed by U.S. Department of the Interior, National Park Service.

Furthermore, the Department recognizes the US Fish and Wildlife Service's expertise in evaluating toxicity of chemicals on fish and wildlife and appreciates US Fish and Wildlife Service's offer to assist in pilot projects.

Indian Nations

As an initial matter, the Department met with Chiefs of the Onondaga, Mohawk, Cayuga, Tonawanda, Seneca and Tuscarora Nations to discuss the comments they submitted on several occasions, and the Department has conferred on other occasions with the attorney who submitted comments on their behalf.

Coordination with Indian Nations is based on Commissioner's Policy 42. CP 42 requires consultation on any proposed action or activity, whether undertaken directly by the Department or by a third party requiring a Department approval or permit, which may have a direct foreseeable, or ascertainable effect on environmental or cultural resources of significance to one or more Indian Nations, whether such resources are located on or outside of Indian Nation Territory. In this respect, the Department recognizes that in addition to CP-42, further measures may be needed to adequately consider potential impacts to the Indian Nations if HVHF were authorized. In this respect, the Department considered requiring contact with an Indian Nation, for the purpose of initiating consultation, for all applications for the construction of a well pad for HVHF within a one-mile zone of that Indian Nation's Territory.

The Department acknowledges the Indian Nations' longstanding and traditional federal reserved water rights. Those rights were established by the United States Supreme Court decision in *Winters v. United States* (207 U.S. 564 [1908]), and extend to water resources beyond the boundaries of the reservations. The doctrine of federal reserved water rights provides that when the United States sets aside an Indian reservation, it impliedly reserves sufficient water to fulfill the purposes of the reservation. The Department has examined the potential for impacts to ground water resources and has identified certain mitigation measures that would likely reduce impacts to those resources. This SGEIS has also identified certain areas of the state where HVHF would be prohibited to reduce the potential for an adverse impact to water and other natural resources. One of the areas identified for this prohibition is in close proximity to the

Onondaga Nation's reservation near Syracuse, New York. Other similar areas where HVHF would be prohibited were selected based on their geographical proximity to all the water resources of the state, and include those protected by the Nations' federal reserved water rights. The No-Action alternative would eliminate the potential for the Indian Nations to be adversely affected by impacts of HVHF activities.

River Basin Commissions

The river basin commissions — namely the Susquehanna River Basin Commission (SRBC) and the Delaware River Basin Commission (DRBC) — play a regulatory role in determining water withdrawals needed for HVHF. The Department would coordinate with the river basin commissions with respect to these withdrawals. See Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation for further discussion on coordination with DRBC and SRBC.

Local Government Notification and Coordination

Comment: The Department received comments asking that local governments be allowed to regulate the impacts of HVHF activities including noise, lighting, and visual impacts and that State preemption was unacceptable. Other comments took the opposite stance. Many comments focused on a paragraph of the SGEIS stating that the applicant would be asked to indicate whether the application was consistent with local land use plans. Some comments focused on what actions, if any, the Department intended to take to notify local governments and others of HVHF applications that are received by the Department. For example, one comment stated: "Local governments must be listed as involved or interested agencies for every gas permit application review. As soon as possible after a drilling permit application is received, the Department must notify local governments, local/county health departments, local emergency response, and all landowners adjoining the land where the well will be drilled. For locations within the Delaware River Basin, the Upper Delaware Council should also be notified. Local governments, planning boards, town engineers, the public, and other agencies must review drilling applications and provide comments to the Department prior to permit issuance. Local governments must have 60 days or more to review the application and should not be expected to use the Department's website to view permit applications received, as some towns have limited or no internet access." Comments also argued that local governments should be involved in the process of identifying environmental impacts. Substantively, at least one comment suggested that local community impacts should extend beyond the "generic" conditions that the SGEIS considers in all cases.

The Department received comments favoring and opposing state preemption of pipelines and compressor stations, which would be ancillary or incidental to any drilling activity. The Department received comments to the effect that local governments should have an opportunity to review highway impacts of gas drilling and that permitting activities need to consider the capacity of local emergency responders to handle accidents and spills. The Department also received numerous comments on federal agency jurisdiction.

Response: With respect to the issue of preemption, ECL § 23-0303(2) states that "[t]he provisions of this article shall supersede all local laws or ordinances relating to the oil, gas and solution mining industries; [sic] but shall not supersede local government jurisdiction over local roads or the rights of local government under the real property tax law." As previously discussed, the Court of Appeals held that ECL § 23-0303(2) does not by its terms preempt the home rule authority vested in municipalities to regulate land use so as to prohibit the use of land for natural gas development using the HVHF method of well stimulation. According to the Court, ECL § 23-0303 (2) only preempts municipalities from regulating the operational details of gas drilling (or as the Court phrased it the "how to" of drilling activity). Thus, if HVHF were authorized, towns, villages, and cities would be able to exercise their zoning authority over HVHF so long as it did not regulate the operational details or the "how to," in the Court's words, of drilling activity – akin to municipal regulation under the Mine Land Reclamation Law. Local governments also have authority to regulate local roads. The Court of Appeals' decision helps to ameliorate concerns that HVHF applications would proceed regardless of local planning in those communities that have chosen to regulate HVHF activities pursuant to the zoning enabling laws. However, as noted below in the Response to Comment in Community Character in Potential Environmental Impacts and Mitigation, the Department recognizes that even were a community to entirely prohibit HVHF, impacts related to HVHF activities, such as truck traffic, could conceivably affect a number of municipalities in the area due to the widespread nature of anticipated HVHF development. This decision does not resolve the issue of ancillary impacts to neighboring communities.

Coordination under SEQRA and Local Government Participation Generally

Notwithstanding the Court of Appeals' recent decision on preemption, the Department considered and proposed additional measures to facilitate local governments' involvement in the permitting process in the event that HVHF were authorized. Initially, if a local government is an involved agency under SEQRA then coordination of review must occur with that government if the action is classified as a Type I action. Whether a local government would qualify as an involved agency under SEQRA is governed by whether it has discretionary jurisdiction by law to approve, fund, or undertake an action or any part of it. This would only be ascertainable at the time a well permit authorizing HVHF is applied for.

Local governments, whether they have adopted zoning to regulate HVHF or not, would be able to participate in the Department's permitting process and identification of impacts through SEQRA where a particular drilling permit needed additional, site-specific review. Along these lines, ECL § 23-0305(13) requires every person granted a permit to drill to notify any affected local government and surface owner prior to commencing operations. If HVHF were authorized, the Department considered requiring public notification of complete applications be provided. In this regard, the Department would likely notify effected local governments of all applications for HVHF, using a continuously updated database of local government officials and an electronic notification system that would both be developed for that purpose. Along these lines, the Department considered the development of a database of local points of contact, who would be notified of receipt of permit applications for wells proposed to be completed by HVHF.

Notification to local government of receipt of an application was proposed to apprise local government of a proposed well. Other resources, such as the Department's online searchable database, already provided a publicly accessible means of obtaining information about the status of a well.

The Department also considered requiring that operators submit three-year forecasts of drilling activity by county twice a year and that the Department hold meetings twice a year with operators and representatives of local governments to discuss those forecasts and the potential local impacts from the activity.

With respect to community and local government involvement, the Department considered providing a mechanism through which the Department could adjust the timing of operations, based on input from local government, to respond to concerns that simultaneous operations are unduly concentrated in a particular location. The Department explored and considered several mitigation measures, including restrictions on timing of construction or imposition of well-spacing requirements and requiring frequent and regular communication among developers, consulting agencies and local officials. In having considered these measures the Department recognized that it is far from certain that specific mitigation measures can address potential cumulative impacts to a particular region, especially in an area where the activity is clearly inconsistent with the overall character of the region.

Department of Public Service and Gas Transmission Lines

It is not possible to fully discuss impacts from the siting and construction of pipelines and compressor stations in this SGEIS because the assessment of impacts from pipeline construction are site-specific and the Department would not know ahead of time whether or where such pipelines and associated infrastructure, such as compressor stations, would be located, the number of pipelines that may be needed, their respective sizes and when they would be constructed. Any attempt to study specific locations would be entirely speculative. Those impacts would be assessed in separate environmental reviews conducted by the Department of Public Service and Public Service Commission pursuant to Article VII if HVHF were authorized. The Department concedes that this uncertainty as to location, coupled with the necessity of pipelines and compressor stations if HVHF were authorized, may lead to unavoidable impacts, including cumulative impacts to wildlife habitat, visual resources and local communities in the vicinity and along the pipeline routes. Consequently, because the SGEIS is a generic SEQRA review of an activity that would be widespread across certain regions and induce the construction of gathering lines, pipelines and compressor stations, the Department may consider, and in fact did consider, the general potential impacts associated with these ancillary activities. The Department recognizes that these considerations are limited where the Department is preempted by federal law (e.g. Surface Transportation Act, Natural Gas Act).

Roads

Local governments have the authority to enter into road use agreements with prospective well operators who intend to utilize HVHF. These agreements would provide an opportunity to minimize road use impacts. Since these agreements are strictly between the locality and prospective well operators, there is no timeframe specified in the SGEIS for how long it may take to negotiate such agreements. The Department considered requiring, as discussed in the SGEIS, that every application for construction of a well pad or well be accompanied by a transportation plan. That plan would require, for example, a description of proposed truck routes and an assessment of the condition of the roads along the proposed routes. However, the Department does not have jurisdiction over local roads; therefore, municipalities are empowered to advance their own needs with respect to the safeguarding of local roads to the extent permitted by law. Briefings of town and county highway departments could be addressed in the road use agreement, although such briefings are not mandated. However, the Department recognizes that despite the mitigation measures identified above, the traffic resulting from well drilling would be difficult to predict and control. For example, truck routes beyond the limits of the transportation plan or not covered in local road-use agreements could adversely impact neighboring regions.

Emergency Response

Spills and other unplanned releases from many segments of the infrastructure supporting HVHF have been reported in other states which have allowed HVHF. While future potential impacts from spills cannot be assessed, it is anticipated that spills from HVHF would occur in New York and due to the nature of the activity could have wide-spread impacts. As one proposed measure to mitigate such impacts, the Department would require well operators to disclose all chemical constituents of additives proposed for use in HVHF to the Department before and after well development. Safety Data Sheets or Material Data Safety Sheets are considered public information and will not be withheld in the event of a request for trade secret protection, and would therefore be available during any emergency response planning. As to the suggestion that local health units be notified within 24 hours of a spill, existing Department regulations require immediate verbal notification of any fire or pollution hazard or the loss of three million cubic feet of gas. Notification of a petroleum spill is also governed by the Navigation Law. Pipeline safety issues are subject to the jurisdiction of the Department of Public Service and would be addressed as part of the permitting for such facility.

The Department also considered requiring applicants to conduct appropriate advance planning for emergencies and to prepare an Emergency Response Plan (ERP) as part of the permit application. Included in the ERP would be the response procedures and necessary on-site equipment to address an emergency involving a release, fire or explosion, as well as the notification procedures. The ERP would need to describe how the operator of the site would respond in emergency situations which may occur at the site, and the availability of company and community assets. Locations and capacity of existing facilities to respond to incidents should also be included. The developer would be required to identify a knowledgeable and qualified individual with the authority to respond to emergency situations and implement the ERP. While the ERP would help contain any spill or accident, or minimize its potential impact, the Department nevertheless recognizes that if a spill were to occur there remains the potential for significant adverse environmental impacts given the nature of HVHF (e.g., the volume of fluids, high-pressure injection and the toxicity of chemicals used) and the widespread development of wells and related activity that would be anticipated.

Economic Impacts on Local Governments

The SGEIS identifies the potential significant adverse impacts on local government services from this activity. See also Response to Comments on Socioeconomic Impacts for a discussion of government expenditures and revenues related to Marcellus drilling. The Department estimates that the cost of administering this program under the average development scenario would grow from approximately $14 million in the first year to nearly $25 million in the fifth year. These costs do not consider other substantial costs that would be incurred by other state agencies that would likely nearly double the costs associated with regulating HVHF or the costs that local agencies would incur. The Department notes that economic considerations represent a factor to be considered under SEQRA in the certification issued by the Department in determining whether HVHF should be authorized. See SEQR Handbook, published on the Department's website at http://www.dec.ny.gov/permits/56832.html.

Hydraulic Fracturing Information

The Department received numerous comments with respect to disclosure requirements for the chemicals used in the hydraulic fracturing process; the timing of disclosure and operator responsibility associated with disclosure. The Department also received comments on the Department's treatment of trade secrets, the requirement for an alternative analysis, and comments that suggested that other fracturing technologies be used in lieu of HVHF. The comments are more fully explained below and responded to.

<u>Comment on Scope of Disclosure</u>

A number of comments addressed the need for well operators to disclose the chemicals used in the hydraulic fracturing process. The extent of disclosure called for varied greatly. Some called for complete chemical disclosure, at the constituent level, to the general public, and some called for all or limited information to be made available to county officials, emergency responders and health professionals, in addition to the Department. Others argued that it should be sufficient for industry to identify the chemicals used at the product level rather than the constituent level, in a publicly available database such as FracFrocus.org, and still others contended that disclosure to the Department is unnecessary in light of disclosure requirements imposed by federal agencies.

Beyond the need to disclose each component of hydraulic fracturing, some comments argued that well operators should also disclose the percent by weight, of each chemical used in the HVHF treatment as a percentage of the total of the fluid used in HVHF. In contrast, other commenters suggested that use of "percent by weight" would not be the most effective way to represent the composition of fracturing fluid since sand, used as a proppant, is the largest non-water component of fracturing fluid and the volume of additives actually used at a well site would appear to be insignificant. While most of the comments focused on the fluids used during well completion, some comments argued for disclosure of all constituents in drilling mud, flowback and produced water.

Response to Comment on the Scope of Disclosure

The SGEIS proposed to require the disclosure of additives at the product Material Safety Data Sheet (MSDS) level. Disclosure would be submitted with the HVHF well permit application, and any additive would not be permitted for use unless the relevant MSDS was on file with the Department. The SGEIS also proposed a requirement that well operators document, at the time of permit application, an evaluation of available alternatives for the proposed additive products that are efficacious, but which exhibit reduced aquatic toxicity and pose less risk to water resources and the environment.

Constituent-level reporting, to the Department or a third-party website, would largely address the concern that the identity of products or chemicals used at a well site would be unknown to either emergency personnel or to regulatory agencies, such as the Department, who must approve of actions under the ECL and SEQRA and respond to spills. Therefore, in response to comments, the Department considered different means to achieve constituent-level reporting through the permitting process, and potentially through regulations for all HVHF operations. More specifically, the Department considered requiring a list of all chemical constituents, by chemical name and CAS Number that were to be intentionally added to the carrier/base fluid to be provided to the Department as part of the EAF Addendum. The Department also considered whether to require the disclosure of the percent by weight of each chemical constituent within a given product or the maximum concentration of each chemical constituent intentionally added to the carrier/base fluid.

Finally, disclosure of hydraulic fracturing additive information to the Department, to any degree, would not result in a taking. The SGEIS would not mandate public disclosure of information qualified and appropriately justified in accordance with existing state law and regulation as a trade secret, and the Department's existing procedures for handling information classified as a trade secret would have prevented such information from reaching the public. See the Response to Trade Secret Procedures section below.

Comment on Timing of Disclosure

Many of the comments both for and against complete disclosure of additive information also addressed the timing of disclosure in relation to initial permit issuance and the need for additional disclosure after a well is drilled. Some argued the requirement to disclose the proposed additives at the time of the well permit application is premature since the well operator may not have selected a service company at the time of permit application or the service company may be changed after a well permit application has been submitted. A change in service companies, it was argued, would thereby change the additives proposed to be used at a particular well. Furthermore, comments noted that a decision regarding which additives to use for a given well may not be feasible until there is adequate information regarding the geology at the particular well site.

Comments also suggested that even once HVHF has commenced, it is not unusual for information gained during the drilling process to result in the introduction of fracturing products that were not originally anticipated to be used and therefore would not have been included in the permit application. Those comments also indicated that the approval process must be nimble enough to enable appropriate changes to be made in response to conditions encountered in the field without cumbersome and time-consuming cycles of review. It was suggested, as an alternative, that disclosure of additives (to the extent that they are known) be made at the time the pre-hydraulic fracturing checklist is submitted and at well completion.

Relative to timing, comments also suggested that when there is a proposed change in fracturing additives, Department review should not be necessary if the additive's composition has already been disclosed to the Department or is in the same chemical family as additives the Department has already approved in other applications or published in the SGEIS.

Comments also reasoned that the timing and mechanics of such disclosure should be implemented in a workable manner which does not restrict the flexibility that is needed to adjust the specific fluid system formulations to respond to conditions that may be encountered after the application or during drilling, completion and hydraulic fracturing, or that will preclude innovation and use of constantly evolving and more environmentally safe technologies that are identified between the time the application is submitted and when drilling/hydraulic fracturing commences.

Finally, other comments on the timing of disclosure noted that disclosure of additive information should also occur after well completion to ensure the chemicals proposed for use were, in fact, used during fracturing operations.

Response to Comment on Timing of Disclosure

As discussed above, the Department considered requiring chemical constituent-level disclosure, at the time of permit application, as part of the EAF Addendum for all HVHF operations. The Department also considered requiring submission of a Pre-Frac Checklist and Certification that would confirm whether the products to be used during hydraulic fracturing would be the same as those identified in the well permit application materials. As proposed, this Pre-Frac Checklist and Certification would be submitted to the Department at least three days prior to commencement of HVHF operations.

The Department acknowledges that additives proposed for use may change based on well-specific information gathered by the well operator but disagrees that the possibility that additives may change in order to optimize the fracturing treatment or maximize the well production is a sufficient reason to delay disclosure until either the checklist is provided or until after completions. However, the Pre-Frac Checklist and Certification form would provide a mechanism for the operator to notify the Department of changes to the proposed hydraulic fracturing products based on information gathered during drilling, while allowing for disclosure to the Department in advance of the commencement of the fracturing operation. The review of additives which have already been approved for use by the Department should not unreasonably delay HVHF well operations.

In addition to disclosure at the time of application and/or Pre-Frac Checklist and Certification submission, the Department also considered requiring disclosure, to the Department and a national chemical disclosure registry, following well completion, concurrent with the filing of the Well Drilling and Completion Report. Enhancements of the proposed requirements for chemical disclosure would allow agencies to be better prepared for exposures (e.g., through better planning), but would not reduce those impacts (e.g., contamination of water resources from spills).

Comment on Persons Responsible for Disclosure

A few comments suggested that the Department should allow an option for service companies, rather than well operators, to provide additive information, since service companies may not disclose the contents of their fluid systems to their customers, the well operators. In order to continue to protect this information, it was suggested that service companies be included among the entities allowed by the SGEIS and any implementing regulations to provide this information to the Department, and that the EAF addendum and the regulations be revised accordingly to permit service companies to do so.

Response to Comment on Persons Responsible for Disclosure

The Department coordinated with service companies and chemical suppliers regarding the submission of product specific SDSs/MSDSs and chemical constituent-level disclosures for the products listed in Chapter 5 of the SGEIS, and anticipates that it would continue to coordinate with similar entities in the future to ensure that the Department has access to the necessary chemical information if HVHF were authorized.

Comment on Trade Secret Procedures

Other comments related to fracturing fluid disclosure questioned how such disclosure should be treated under existing trade secret provisions in the Department's regulations. In this regard, some comments urged the Department to adopt the trade secret framework used in the federal Emergency Planning and Community Right to Know Act and others criticized the notion that anything used during completion activities should be granted trade secret protection when it is reported to the Department. Those opposed to having additive information protected as a trade secret argue that trade secret claims should be accompanied by information substantiating the legitimacy of the trade secret assertion, and that citizens should be allowed to challenge such claims.

Comments related to the Department's trade secret provisions argued that the Department should provide a process for approval of new additives, through submission of information with protection for trade secrets and trade secret information, separate and apart from a well permit application. This process should be defined for operators and service companies in order to provide reasonable timeframes for Department review.

Response to Comment on Trade Secret Procedures

As indicated above, the Department recognizes that hydraulic fracturing additive information, including the names and quantities of specific constituents, may qualify as a trade secret or confidential business information, as defined by existing law and regulations, specifically POL §89(5) and 6 NYCRR 616.7. The Department considered requiring constituent level-disclosure to the Department, along with the submission of an SDS/MSDS for every product proposed for use. However, disclosure to the Department of any such information considered to be trade secret must, under existing law and regulations, be accompanied by an appropriate request and written justification for exception from public disclosure as a trade secret. All such information would then be handled by the Department, in accordance with procedures described in 6 NYCRR 616.7.

All information which is not a trade secret would be available to the public through the Freedom of Information Law. The Department also considered making such information available on the Department's website.

Additionally, the Department considered requiring that non-trade secret information be posted to a national chemical disclosure registry, concurrent with the filing of the Well Drilling and Completion Report with the Department. If the specific identity of a chemical constituent and/or the concentration of a chemical constituent are claimed to be trade secret, the well operator would be required to indicate this on the chemical disclosure registry. Also, if the identity of a specific chemical constituent is claimed to be trade secret on the national chemical disclosure registry, the chemical family or other similar descriptor associated with the chemical would be required to be provided to the chemical disclosure registry.

Comment on Alternatives Analysis

As stated above in the response to comments on the scope of disclosure, the SGEIS proposed a requirement that well operators document, at the time of application, an evaluation of available alternatives for the proposed additive products that are efficacious, but which exhibit reduced aquatic toxicity and pose less risk to water resources and the environment. Comments on this requirement questioned what would constitute an acceptable level of evaluation and contended that such a requirement is unclear and open-ended. Some commenters found that the language used in various sections of the SGEIS to describe the alternative additive analysis was not consistent. Comments that supported the concept of an alternatives analysis argued that the Department should have a bright line test to determine what a "less toxic" alternative is and then prohibit the use of chemicals which pose a significant risk to the environment and human health.

Still other comments questioned how such a requirement would be implemented. These comments suggested the alternatives analysis proposal was an over-simplification of the process since substitution of chemical additives is rare and hydraulic fracturing fluids are complex formulations that take into account the properties and effects of all ingredients together, not just the individual components of the fluid. Substitute ingredients will have different physical properties, different performance parameters and different effects on other ingredients in the formulation. Finally, some comments suggested that an alternative ingredient could be favored primarily on the basis of the hazard posed by the initially proposed ingredient while an alternative additive could result in greater risk because of the need to use a greater concentration of the alternative.

Many comments on the alternative additive analysis also addressed the ability of the Department to incentivize or mandate the use of "green" chemicals. Concerning the identification and use of green chemicals, comments suggested, among other things that:

- a best practices board should be formed or an independent firm should be hired to identify green alternatives to additives;

- applications for well drilling permits that propose the use of environmentally-friendly hydraulic fracturing fluids and additives should be fast-tracked and/or processed ahead of applications that do not;

- bidders for the lease of State lands for oil and gas exploration and production should be given preference if they state that they will only use environmentally-friendly hydraulic fracturing fluids and additives;

- the review of additives for alternative green chemistry with every new permit application is impractical, and only a biennial review should be done by service companies;

- service companies are in a better position to judge the effectiveness of alternatives than operators;

- green additives may not always be the most suitable for a particular fracture treatment based on local geology or other conditions; the universal use of green chemicals that are efficacious, but less efficient could result in reduced well efficiency and less efficient production of the resource; and

- an evaluation of alternatives to the proposed additive products is required, but it is not clear what the Department will do with this information.

<u>Response to Comment on Alternatives Analysis</u>

The Department recognizes that consideration should be given to the effectiveness and economic or technical feasibility of utilizing the evaluated alternative additives, which is why the Department would, if HVHF were authorized, make the use of less toxic alternatives contingent upon an evaluation of their effectiveness and feasibility. The Department generally disagrees with the suggestion that the use of certain chemicals should be mandated or that particular additives should be prohibited. See the Response to the Comment in Fracturing Fluid in Potential Environmental Impacts and Mitigation. Under the Department's proposal, the operator would submit relevant information related to the feasibility of utilizing an alternative product, including the concentration of an alternative ingredient in a hydraulic fracturing fluid needed to achieve equivalent efficacy, or changes in characteristics due to interactions with other ingredients. Also, to the extent that there is ambiguity in the SGEIS related to the alternatives analysis, the terminology used in various sections may not be identical, but the intent of the language was to require well operators to evaluate additive alternatives and document such evaluation to the Department. The Department considered, for use as a mitigation measure, a requirement that additives selected for use should pose no greater level of risk to water resources as available alternatives, but the Department concedes that an acceptable benchmark for making this determination is not available at this time. Therefore, if HVHF were authorized, the

Department would require the well operator to demonstrate to the Department's satisfaction that alternatives were considered.

As to the comment that review of alternative chemicals should be done by a third-party board and should be done on a biennial basis, neither of these suggestions is practical at this time. The creation of a third-party board is outside the scope of the SGEIS, and periodic review of alternatives to fracturing additives would not allow the Department to fulfill its SEQRA obligations on a well-by-well basis. The permitting process the Department proposed to implement is designed to ensure that the best alternatives are used on an ongoing basis.

Comment on Alternative Fracturing Methods

Some of the comments that addressed the composition of hydraulic fracturing additives suggested that the Department more fully consider, and in some instances, mandate the use of technologies that do not require the classes of chemicals identified in the SGEIS. For example, comments suggested that the use of foam fracturing, which has been previously addressed in the 1992 GEIS or nitrogen-based foams should be more fully described and evaluated, including an identification of the chemical make-up of those alternatives and consideration of the potential environmental impacts associated with the use of foam. Other comments suggested that the Department more fully consider the use of liquefied petroleum gas (LPG) in the form of propane as an alternative to the use of water as the base fluid for hydraulic fracturing.

Response to Comment on Alternative Fracturing Methods

Chapter 9 of the 1992 GEIS discusses foam fracturing and Chapter 5 of the SGEIS recognizes that foam fracturing has been proposed for Marcellus Shale development. Foam fracturing uses a gas as part of the fracturing "fluid." The gas is commonly Nitrogen or Carbon Dioxide. The percentage of gas to the base fluid is referred to as Foam Quality. The hydraulic fracturing additive disclosure requirements discussed above would apply to any fracturing operation that meets the definition of HVHF.

Well permit applications that specify and propose the use of propane (or LPG) as the base fluid would be reviewed pursuant to the 1992 GEIS and Findings Statement, which would be supplemented to the extent, if any, that this approach is determined to cause significant adverse impacts not previously reviewed in that document or this SGEIS. LPG's high volatility, low weight, and high recovery potential make it a potentially good fracturing agent. Using propane eliminates the need to obtain source water for hydraulic fracturing, recover flowback fluids to the surface and dispose of the flowback fluids. Although the use of propane may be a viable alternative to the use of hydraulic fracturing, the SGEIS would not propose that well operators be required to use it as an alternative method of fracturing. However, this technology would have to be evaluated pursuant to a specific proposal and also may raise other environmental issues not identified or assessed in this SGEIS.

3. Prohibited Locations

General Prohibitions

Comment: The Department received numerous comments with respect to potential significant adverse environmental impacts from HVHF on a variety of resources. These comments ranged from supporting expansion of the proposed prohibitions on HVHF, and providing a rationale as to why such expansions are necessary, to arguing that prohibitions on HVHF are unnecessary. Comments also argued that a moratorium on HVHF should be in place until any number of specific events take place or particular goals are achieved. Comments also argued that certain activities related to HVHF should be specifically prohibited. The Department has provided responses specific to each of these areas.

The Department received numerous comments that HVHF should be prohibited in a variety of locations, e.g., all watersheds; in sole source aquifers; above unfiltered drinking water supplies; over or within a principal or primary aquifer; in the vicinity of all New York State lakes, rivers, streams, and brooks (all water bodies); anywhere the water table supports a high population density; in watersheds where 5% or more of the private water wells are owned by landowners who request a prohibition; within 4,000 feet of a municipal reservoir or reservoir tributary; within 500 feet of a perennial or intermittent stream; within 2,000 feet of a municipal water supply; within floodplains; within a State or Federally protected wetland; where the top of the target fracture zone at any point along the entire proposed length of the wellbore is less than

1,000 feet below the base of a known freshwater supply; where naturally occurring radioactive material levels are found to be higher than drinking water standards; on State lands; in urban areas; in parks and public recreation lands; within a Forest or Grassland Focus Area or Important Bird Areas; in Central New York; in the Catskill and Adirondack mountain regions; on Onondaga Indian lands; in Delaware, Otsego, Schoharie, Albany, Greene, Sullivan and Ulster Counties; in Tioga, Chemung, and other counties west; in the Ithaca/Danby area; in Allegany State Park; in the Shawangunk Mountains; in the Finger Lake area (e.g., Keuka Lake, Hemlock Lake and Canadice Lake); near Erie Lake; in the Great Lake area; near the Hudson River; in the Upper Delaware River Scenic and Recreational River Corridor; in other National Park System units; above and below carbonate formations, inclusive of no laterals beneath carbonate formations; on private lands to protect neighbors; on school grounds or adjacent to schools; near Canandaigua Lake; when the top of the fracture zone is less than 2,000 feet from the land surface; where topography exceeds an eight percent slope; and in areas where there is a conflict with local zoning.

In support of a prohibition on HVHF in those locations, comments provided diverse rationales (e.g., unknown short and long-term health and environmental effects of HVHF; potential water contamination, generally; risks from handling and treatment of wastewater; potential impacts to drinking water; insufficient water resources; radioactive contamination of ground and surface waters; human error; mechanical failure; immitigable consequences of HVHF; spills; accidents (both vehicle and at the well pad); methane gas leakage; damage to local infrastructure caused by the need to build, repair and maintain local roads to accommodate the industry's heavy machinery and trucks; increased seismic activity; air pollution; noise and light pollution due to 24/7 drilling operations; depressed real estate values of neighboring homes; a myriad of social problems; sensitive ecosystems; community impacts; permit application inadequacy; contribution to climate change; and the point that regional plans that lower greenhouse gas emissions cannot move forward if HVHF is done in New York State).

However, other comments argued that HVHF should be allowed:

- for consistency with the policy mandates of ECL Article 23 to promote recovery of the resource;

- because a ban on HVHF is an unconstitutional taking without compensation and unnecessarily deprives New York State and its residents of the opportunity to acquire significant economic benefits; or

- because the Primary Aquifer prohibition and the many other setbacks proposed will require abandonment of attractive and logical drill sites and cause losses to the operator and the mineral owners of tens to hundreds of millions of dollars.

Comments also argued that a moratorium on HVHF should be imposed until any number of specific events took place or goals were achieved (e.g., Public Health Review by NYSDOH is complete; studies on contamination by EPA have been completed; safe hydraulic fracturing fluids and additives are available or other safe stimulation techniques are developed and ready for use; HVHF is proven to be 100% safe; re-evaluation of buffers from drinking water supplies and associated infrastructure value of the gas resource appreciates over time; resolution of regulatory shortcomings related to safeguards against accidental chemical spills into reservoirs and farmland or underground migration to aquifers, rivers, and streams; final regulations are in place with taxes, penalties, and oversight; full disclosure of chemicals used in HVHF is provided; deficiencies of the SGEIS are addressed regarding birds, other wildlife and their habitats; explanation of why there is a proposed prohibition on HVHF within the NYC and Syracuse unfiltered drinking water supplies but not for other drinking water supplies; the Department has increased staffing; the cumulative effects of water withdrawal are known and addressed; there are mitigation measures for lead, NORM, and radon; leases have been renegotiated to protect property owners from financial impacts; re-evaluation of compulsory integration; all oil and gas wells in New York State which are known or suspected to require plugging have been added to the priority plugging list and every well on that list has been plugged and the area reclaimed; people can vote on HVHF; analysis of the potential environmental impact on the state is completed; the economic impacts of contamination have been defined; risks, their root causes and risk abatement measures have been developed; methods are developed to ensure compliance with the risk abatement measures, including who within the government will perform the inspections and who will fund them; an assessment of the bond that must be provided by the drilling companies that will ensure no financial impact will absorbed by the state or local governments should contamination occur; and concerns regarding impacts are addressed by experts).

Comments suggested that there be a specific moratorium on HVHF in the Great Lakes Basin until adequate regulations on water withdrawal are in place.

Aside from comments in support of a full prohibition on HVHF, comments also suggested that specific activities associated with HVHF be prohibited, including:

- deep-well injection disposal of brine waste;
- gas pipeline networks, pipeline access roads and compressor stations on State and public land;
- surface water withdrawals from any source other than the main-stem of the region's rivers;
- groundwater withdrawal;
- drilling near infrastructure for drinking water supplies (not just a site-specific EIS) including infrastructure for the City of Syracuse; or
- issuance of any State Pollution Discharge Elimination System (SPDES) permits for HVHF.

Response: HVHF and activities associated with HVHF have the potential to cause significant adverse environmental impacts on a variety of resources if not adequately mitigated. In this regard, the SGEIS proposed numerous prohibitions on the location where HVHF could occur to minimize the potential risks related to specific resources (e.g., HVHF well pads within 4,000 feet of an unfiltered drinking water supply; within 500 feet of a Primary Aquifer; within 2,000 feet of public drinking water wells, river or stream intakes and reservoirs; within 500 feet of private water supplies; within 100 feet of an inhabited dwelling (although the Department considered expanding this setback to 500 feet or more); on certain New York State lands; and a 500-foot setback for fuel tanks from a wetland. The Department considered expanding the area off limits to HVHF and setbacks identified in the SGEIS in order to increase public and natural resource protection.

The SGEIS proposed, and the Department considered, prohibitions on HVHF to reduce the potential for significant adverse environmental and health impacts from HVHF on a variety of resources in New York State. After review and consideration of comments submitted, the

Department maintains that prohibitions (within resources and possibly a buffer) are a necessary mitigation measure. However, the Department recognizes the difficulty in determining what specific prohibitions, and the breadth of those prohibitions, would be adequate to protect a specific resource because of the variability related to HVHF (e.g., the number of well pads, volume and variety of chemicals used, duration of the HVHF activity and ancillary activities, and the wide variability in the potential list of chemicals used).

NYSDOH'S Public Health Review concluded that there is insufficient scientific information to assess the public health risk posed by HVHF and associated activities. For the same reason, determining an adequate prohibition to provide a level of assurance that potential risks have been satisfactorily minimized is not possible. To determine whether a prohibition is adequate, it is necessary to understand the risk; without that understanding, the adequacy of the prohibition is necessarily uncertain.

The Department recognizes the potential impacts from contaminated stormwater runoff (i.e., sedimentation) at an HVHF well pad to surface water bodies as well as from any uncontained and unmitigated surface spill, leak, or release of fluids containing chemicals or petroleum. Specifically, risks associated with construction activity, high volumes of truck traffic (i.e., road runoff and accidents), or improper chemical, petroleum or wastewater handling, could result in a degradation of a variety of resources, including both surface and groundwater. If HVHF were authorized, the Department would impose a robust set of engineering controls that, in its best professional judgment, would reduce some of the risk. Even with controls in place, however, many of the risks, including spills and other unplanned events resulting in the discharge of pollutants associated with HVHF, even if relatively remote, would not be eliminated and could have significant consequences. HVHF presents unique challenges, including the industrialization of multiple sites throughout the region each presenting or contributing to the cumulative impacts associated with multiple wells drilled on a single pad and well pads constructed throughout numerous towns and counties of the State. Some of the engineering controls and management practices that would be required are untested under these circumstances for the scale and nature of this activity. Consequently, it remains uncertain whether the engineering controls would be adequate to prevent spills and other unplanned events resulting in the discharge of pollutants associated with HVHF and mitigate adverse impacts if such an event occurs. Compounding this risk, is the current uncertainty identified by NYSDOH as to the level of risk HVHF activities pose to public health.

The SGEIS did not prohibit activities ancillary to HVHF within any of the prohibited areas. The Department recognizes that ancillary activities (e.g., storage of HVHF material), including those that the Department does not have jurisdiction over (e.g., truck traffic), would also present risks (e.g., spills) similar to those risks associated with HVHF itself. Ancillary activities, coupled with the likely widespread development of HVHF, would pose a significant risk to a variety of resources. Indeed, the Public Health Review came to the same conclusion in finding that "[t]he number of well pads and associated HVHF activities could be vast and spread out over wide geographic areas where environmental conditions and populations vary. The dispersed nature of the activity magnifies the possibility of process and equipment failures, leading to the potential for cumulative risks for exposures and associated adverse health outcomes. Additionally, the relationships between HVHF environmental impacts and public health are complex and not fully understood." Public Health Review. While the prohibition of HVHF well pads in certain areas could reduce direct impacts, only the No Action Alternative would prevent ancillary activities from being conducted and eliminate the potential risks. See the Response to Comment in Cumulative Impacts for further discussion on the cumulative impacts from HVHF (e.g., visual, community character, air).

In the event that HVHF were authorized, the Department recognizes that significant costs would be associated with administering the program, including the need for additional staff for permitting and enforcement. See Response to the Comment in Enforcement.

Regarding prohibitions on HVHF near certain water resources, see Responses to the Comments in NYC and Syracuse Watersheds; Other Public Drinking Supplies and 2,000-foot Buffer; Primary Aquifers and 500-foot Buffer; Private Water Wells and 500-foot Buffer; 100-year Floodplains, all in Prohibited Locations. See Responses to Comments in Floodplains; Wetlands; Water Resources; and Setbacks, all in Potential Environmental Impacts and Mitigation. Those responses address prohibitions, development of adequate buffers, uniform protection of all water resources or all drinking water supplies, and vertical separation between potable water and the target zone for HVHF, and subsurface access to gas resources utilizing HVHF. For additional discussion on prohibitions, see also Response to the Comment in State Owned Lands in Prohibited Locations.

In response to the comment that HVHF should be prohibited on school grounds or adjacent to schools, the Department's existing regulations specify a 150-foot setback from any public building including those used for education. Based on the review of comments, the Department considered additional mitigation measures including an increase in the buffer to 500 feet or beyond from places of assembly, including schools and other sensitive receptors.

In response to the rationales provided for prohibition of HVHF, see Responses to Comments in General- Permit Process, Local Government Notification and Coordination, and Hydraulic Fracturing Information, all in Permit Process and Regulatory Coordination; Seismicity, Naturally Occurring Radioactive Materials, and General Geology, all in Geology; Water Resources, Well Construction, Hydraulic Fracturing, Fracturing Fluid, Waste Transport and Disposal, Setbacks, Ecosystems and Wildlife, Air Quality and Greenhouse Gas Emissions, Socioeconomic, Visual Resources, Noise, Transportation, Community Character, all in Potential Environmental Impacts and Mitigation; Health Impacts; Enforcement; and Other.

Regarding comments that a moratorium on HVHF should be imposed until any number of specific events took place or goals were achieved, see Responses to Comments in General- Permit Process, Local Government Notification and Coordination, and Hydraulic Fracturing information, all in Permit Process and Regulatory Coordination; Seismicity, Naturally Occurring Radioactive Materials, and General Geology, all in Geology; Water Resources, Well Construction, Hydraulic Fracturing, Fracturing Fluid, Setbacks, Ecosystems and Wildlife, Air Quality and Greenhouse Gas Emissions, Socioeconomic, Visual Resources, Noise, Transportation, Community Character, all in Potential Environmental Impacts and Mitigation; Health Impacts; Enforcement; and Other. See also Responses to the Comments in NYC and Syracuse Watersheds; Other Public Drinking Supplies and 2,000-foot Buffer; Primary Aquifers and 500-foot Buffer; Private Water Wells and 500-foot Buffer; 100-year Floodplains, all in Prohibited Locations. See Responses to Comments in Floodplains; Wetlands; and Water Resources, all in Potential Environmental Impacts and Mitigation.

Regarding the proposals to prohibit specific activities related to HVHF, see Response to the Comments in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation regarding deep well injection; Other for a discussion of the potential impacts related to pipelines; Water Resources in Potential Environmental Impacts and Mitigation for potential impacts from water withdrawals for HVHF; New York City and Syracuse Watersheds in Prohibited Locations regarding setbacks from drinking water supply infrastructure; and Stormwater in Potential Environmental Impacts and Mitigation for potential stormwater impacts from HVHF.

NYC and Syracuse Watersheds and 4,000-Foot Buffer

Comment: The Department received numerous comments with respect to potential significant adverse environmental impacts on the unfiltered drinking water supply watersheds of New York City and Syracuse from HVHF. These comments ranged from supporting the proposed 4,000-foot buffer, to questioning the buffer's effectiveness, to arguing that the buffer was unnecessary. Comments also raised concerns about the potential impacts from HVHF ancillary activities, including water withdrawals, on these watersheds and potential impacts to the infrastructure that supports the NYC and Syracuse drinking water supplies. The Department has broken down these comments into four areas and has provided a response specific to each of these areas.

a) The Department received comments in support of the proposal in the SGEIS to prohibit HVHF within unfiltered drinking water supply watersheds (i.e., the New York City and Syracuse watersheds) and within the 4,000-foot buffer surrounding those unfiltered drinking water supply watersheds; however, many comments argued that a greater buffer (e.g., 2 miles, 7 miles, 10 miles, 26 miles) is necessary to protect the unfiltered drinking water supplies from contamination and degradation and that horizontal drilling should be precluded under these watersheds. Concerns identified included contamination from exploratory wells, stormwater, wastewater, and chemical use and transport. Additionally, there were comments expressing doubt as to the mechanism by which any buffer could be respected, enforced, and/or monitored. Other comments received stated that the prohibition is not warranted, as well as that the 4,000-foot buffer is excessive. Concerns were also raised that the SGEIS proposed that the prohibition be revisited (e.g., after 2 or 3 years), which could allow for

HVHF within the unfiltered drinking water supply watersheds at some time in the future. Comments suggested that a sunset provision for the prohibition be included in the SGEIS to allow HVHF to commence if the Department does not act. Comments also stated that the distinction between "unfiltered water" and "filtered water" is not supported by scientific facts and that the same mitigation measures should be applicable to all water supplies.

b) Comments recommended that the Department analyze whether there should also be a prohibition on ancillary structures connected to the HVHF well pad within the unfiltered drinking water supply watersheds, such as centralized flowback impoundments, open pits, pipes, transfer stations, containment tanks (e.g., for production brine), other structures, HVHF materials (e.g., bulk additive supplies), diesel fuel, and other drilling-related operations.

c) Concerns were raised related to infrastructure (e.g., tunnels) for the unfiltered drinking water supply watersheds that lie beyond the 4,000-foot buffers to the watersheds. Comments stated that the proposed mitigation in the SGEIS is inadequate to address potential damage by direct penetration of the tunnel and fails to address the other risks that HVHF poses to these critical assets. Technical assessments presented in the comments concluded that there is a risk from the subsurface transmittal of elevated pressures due to HVHF. Concerns were also raised as to the risk from elevated pressure increases as more wells are drilled and stimulated in close proximity to the tunnels and that differential pressures on the tunnel liners could be caused by movement along a fault or from earthquake waves, or movement of fluids or gas. Additionally, comments indicated that while there is a risk of cracks or greater damage to tunnel liners from differential pressure, the consequence of such impacts is likely to be a loss of efficiency in water transmission and a reduction in capacity from leaks, plus any damage from surface expressions of water.

d) The Department received comments that it should analyze the potential threat from water withdrawals needed for HVHF that could affect or occur within the unfiltered drinking water supply watersheds.

Response: The Department recognizes that HVHF and activities associated with HVHF have the potential to cause significant adverse environmental impacts on the drinking water supply watersheds and infrastructure of New York City and Syracuse, if not adequately mitigated. In this regard, the Department proposed and considered additional mitigation measures to protect these critical resources, including a prohibition of HVHF well pads within unfiltered drinking water supply watersheds, as well as within 4,000 feet or beyond of unfiltered drinking water supply watersheds and also applying this setback to the portion of the water supply infrastructure including tunnels that transport water. Additionally, the SGEIS proposed notification to New York City of any HVHF well pads proposed in counties outside of New York City in which infrastructure related to its water supply is located. Finally, under the SGEIS, a site-specific determination of significance would be required for HVHF well pads proposed within 1,000 feet of subsurface infrastructure (e.g., a tunnel or aqueduct) related to New York City's drinking water supply watershed. In this regard, the Department considered prohibiting the positioning of any well bore less than 2,000 feet from any water tunnel or underneath a tunnel and requiring enhanced site-specific review plus a consultation with a municipality for any well bore located within 2 miles of any water supply infrastructure for the Syracuse and New York City drinking water supplies.

a) The SGEIS proposed, and the Department considered, various levels of mitigation and prohibitions to reduce the potential for significant adverse environmental and health impacts from HVHF on unfiltered drinking water supply watersheds. After review and consideration of comments submitted, the Department maintains that a prohibition of HVHF within a buffer, if an adequate buffer can be determined, as well as within the unfiltered drinking water supply watersheds, is necessary because it would reduce the potential for impacts to those water resources, as well as to human health and ecosystems. Therefore, if HVHF were authorized, the impacts and risks would likely remain and as a result the Department does not anticipate allowing the prohibitions to sunset.

   The City of New York and the City of Syracuse are the only two cities in New York State that have an unfiltered drinking water supply and are governed by the terms and conditions of a Filtration Avoidance Determination (FAD), issued by NYSDOH as the primary administrator of the program in New York, in coordination with USEPA and the Department under the Federal Safe Drinking Water Act. As part of the FAD, each city must meet certain objective water quality criteria (e.g., coliform, turbidity), operational criteria (e.g., Giardia), and watershed control criteria (i.e., comprehensive watershed protection programs) to avoid mandatory filtration of its water supply. Approximately 9.4 million residents rely on the NYC drinking water supply: 8.4 million in NYC and 1 million in portions of Orange, Putnam, Ulster and Westchester Counties. The City of Syracuse also has an unfiltered drinking water supply, which serves a population of approximately 145,000. Losing the FAD designation as an unfiltered drinking water supply would mean New York City and Syracuse would be required to spend billions of dollars to build water filtration plants.

The Department agrees with comments received that a buffer from unfiltered drinking water supply watersheds is a necessary mitigation measure. Considerations for determining an adequate buffer are discussed fully in the Response to the Comment in Setbacks in Potential Environmental Impacts and Mitigation. Additionally, buffers for unfiltered drinking water supplies must be consistent with the principles of source water protection and the "multi-barrier" approach. See, e.g., National Research Council Watershed Management for Potable Water Supply: Assessing the NYC Strategy at 97-98 (2000); American Water Works Association, *State Source Water Protection Statement of Principles,* AWWA Mainstream (1997). For a detailed discussion of the potential risks associated with HVHF to drinking water supplies, generally, see Response to the Comment in Setbacks in Potential Environmental Impacts and Mitigation. However, there are some potential risks associated with HVHF that are of particular importance to the protection of unfiltered drinking water supply watersheds. Standard stormwater control, if not properly implemented, would not eliminate the risk of potential significant adverse impacts (e.g., sedimentation, turbidity, disinfection by-products) on drinking water supplies from the increased construction activity associated with HVHF, particularly during peak levels of activity. In this regard, industrial activity associated with well pad development, road construction and other activities associated with HVHF, including such cumulative impacts associated with pipeline development and construction, is inconsistent with the long-term protection of unfiltered drinking water supply watersheds.

b) The SGEIS did not prohibit activities ancillary to HVHF within an unfiltered drinking water supply watershed or a buffer extending from such watershed. The Department recognizes that ancillary activities (e.g., storage of HVHF material), including those that the Department does not have jurisdiction over (e.g., truck traffic), would also present risks (e.g., spills) to drinking water supplies similar to those risks associated with HVHF itself. While the prohibition of HVHF well pads in certain areas could reduce direct impacts, only the No Action Alternative would prevent ancillary activities from being conducted and eliminate the potential risks. See the Response to Comment in Cumulative Impacts for further discussion on the cumulative impacts from HVHF (e.g., visual, community character, air).

c) The SGEIS proposed, and the Department considered, various levels of mitigation and prohibitions to reduce the potential for significant adverse impacts from HVHF to the infrastructure for unfiltered drinking water supply watersheds that lie beyond the buffer. Protection of the infrastructure that stores and delivers drinking water is just as critical as protection of the watershed and the need to protect these critical assets is essential to protecting the unfiltered drinking water supply watersheds. Damage to the infrastructure could put nearby residents in danger and could also seriously impair the ability of a municipality to deliver water to consumers. Risks to the infrastructure for unfiltered drinking water supply watersheds from HVHF include those from direct penetration by drilling, the creation of differential pressures, the inducement of seismic activity, and the migration of fluids and/or gas. This same risk applies to infrastructure associated with any water supply. See Response to Comment in NYC and Syracuse Watersheds and 4,000 Foot Buffer in Prohibited Locations.

   After review and consideration of comments submitted, the Department acknowledges that there remains uncertainty as to what mitigation measures would adequately protect the infrastructure for unfiltered drinking water supply watersheds. "Recent evidence from studies in Ohio and Oklahoma suggest that HVHF can contribute to the induction of earthquakes during fracturing (Holland, 2014; Maxwell, 2013). Although the potential public health consequences of these mild earthquakes is unknown, this evidence raises new concerns about this potential HVHF impact." Public Health Review. The Public Health Review also identified current uncertainty related to potential migration of fluid and/or methane and groundwater contamination, which is more fully discussed in this response above.

See also Response to the Comment in Seismicity in Geology for further discussion of potential impacts to drinking water supplies related to fractures and faults. See also Response to the Comment in Well Construction in Potential Environmental Impacts and Mitigation for further discussion of the potential impacts related to drinking water supplies related to fluid/gas migration. See also Response to the Comment in Other for further discussion of incidents in other states.

d) See Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation for further discussion of the potential impacts of HVHF related to water withdrawals.

Other Public Drinking Supplies and 2,000-Foot Buffer

Comment: The Department received numerous comments with respect to potential significant adverse environmental impacts on municipal and other public drinking water supplies from HVHF. These comments ranged from supporting the proposed 2,000-foot buffer, to questioning the buffer's effectiveness, to arguing that the buffer was unnecessary. The Department has provided responses specific to these comments.

Numerous comments indicated that a buffer of 2,000 feet around municipal and other public drinking water supplies is inadequate. The comments suggested that a greater buffer is necessary to protect public drinking water supplies from contamination (e.g., 4,000 feet, 5,000 feet, 6,000 feet, 20,000 feet, 2 miles, 5 miles, 7 miles, 10 miles, 50 miles). Comments included a variety of bases for increasing the buffers, such as:

- experience of other states;
- earthquakes;
- migration of HVHF chemicals into groundwater;

- inability of water filtration systems to filter out the wide range of chemicals expected to be used in HVHF;

- location of zones with significant vertical permeability such as faults and fractures in the vicinity of public water supplies; and

- potential spills and releases into the water supply.

However, many other comments received argued that the prohibition is not warranted or that the 2,000-foot buffer is excessive.

Comments stated that the distinction between “unfiltered water” and “filtered water” is not supported by scientific facts and that the same mitigation measures should be applicable to both. Additionally, comments were received that springs should be included as part of the 2,000-foot setback from public water supplies.

Concerns were also raised that the SGEIS proposed that the prohibition of HVHF well pads within 2,000 feet of a public drinking water supply be revisited (i.e., 3 years), which could allow for HVHF within those areas at some time in the future. Other comments suggested that a sunset provision for the prohibition should be included in the FSGEIS to allow HVHF to commence if the Department does not act.

Comments also suggested that subsurface access utilizing HVHF should not be allowed under a water supply source.

Response: HVHF and activities associated with HVHF present the potential to have significant adverse environmental impacts on public drinking water supplies, if not adequately mitigated. In this regard, the SGEIS proposed a prohibition for HVHF well pads within 2,000 feet a public drinking water supply (e.g., public water supply wells, river or stream intakes or reservoirs). Additionally, the SGEIS proposed that such restrictions be in place for at least three years after issuance of the first well permit authorizing HVHF and be re-evaluated at that time. The Department’s 1992 GEIS had concluded that issuance of a permit to drill less than 1,000 feet from a municipal water supply well is considered "always significant" and requires a site-specific SEIS to analyze groundwater hydrology, potential impacts and propose mitigation measures. The 1992 GEIS also found that any proposed well location between 1,000 and 2,000 feet from a municipal water supply well requires a site-specific assessment and SEQRA determination, and may require a site-specific SEIS. The 1992 GEIS provides the discretion to apply the same process to other public water supply wells. The SGEIS proposed, and the Department considered, various levels of mitigation and prohibitions to reduce the potential for significant adverse environmental and health impacts from HVHF within a buffer surrounding public drinking water supplies.

After review and consideration of comments submitted, the Department maintains that a prohibition of HVHF well pads within a buffer, if an adequate buffer can be determined, is appropriate to reduce potential impacts to those drinking water supplies, as well as to human health and ecosystems. Therefore, given the nature of the impacts resulting from HVHF and the likelihood that they would continue if HVHF were authorized, the Department does not anticipate allowing the prohibition to sunset.

The total population within the Marcellus Shale play area is approximately 906,000. More than 360,000 people (or roughly 40.9% of the population) in this prospective area are served by individual private wells or public surface water supplies, or community supplies outside of Primary and Principal Aquifer areas. Examples of water supplies not in Primary or Principal Aquifers in the Marcellus Shale play area include: Oneonta with a population served of approximately 15,800; Hornell with a population served of approximately 8,600; Monticello with a population served of approximately 8,000; and Norwich with a population served of approximately 8,000.

The Department agrees with comments received that a buffer from public drinking water supplies is a necessary mitigation measure. Considerations for determining an adequate buffer are discussed fully in the Response to the Comment in Setbacks in Potential Environmental Impacts and Mitigation.

For a detailed discussion of the potential risks associated with HVHF to public drinking water supplies, generally, see Response to the Comment in Setbacks in Potential Environmental Impacts and Mitigation. However, there are some potential risks associated with HVHF that are of particular importance to the protection of public drinking water supplies. For public drinking water supplies that utilize groundwater, in addition to protecting the aquifers themselves, protection of aquifer recharge areas (i.e., the land area where the substrate is permeable enough to allow surface water to infiltrate into and replenish an aquifer) is important.

For public drinking water supplies that utilize ponded surface water (lakes, reservoirs, ponds), the Department considered a 2,000-foot prohibition encircling the entire water body, which means that gas well pads will not be near the tributaries flowing into that impoundment for at least the first 2,000 feet of the tributary. This prohibition distance would provide added time to control a release before it could potentially reach the ponded water should a spill, release or similar event occur. However, while the majority of the surface water intakes in the State are found in ponded systems, some are in flowing water systems. As such, the Department considered prohibiting HVHF well pads within 1,000 feet on each side of the main flowing waterbody and any tributary to that waterbody, both for a distance of 1 mile upstream from the public drinking water supply intake. This proposed supplemental prohibition would provide additional time before contaminants could reach surface water intakes in flowing water, and provide more time to implement actions to minimize or prevent exposures. In addition, if a spill occurred in an area more than one mile from the public drinking water supply intake, there would also be greater dilution of any contaminants that might enter a tributary.

Also, springs can be used as drinking water sources and occur frequently throughout New York, and any buffer, if one could be developed, would apply equally to domestic water supply springs.

In the event that HVHF were authorized, the Department would require a buffer from public drinking water supplies (although the Department acknowledges that the extent of the buffer needed is uncertain) and would enforce and monitor these buffers through permit conditions. See also Response to Comment in Enforcement. The SGEIS did not prohibit activities ancillary to HVHF within any proposed buffer to public drinking water supplies. The Department recognizes that ancillary activities (e.g. storage of HVHF material), including those that the Department does not have jurisdiction over (e.g. truck traffic), would also present risks (e.g., spills) to public drinking water supplies similar to those risks associated with HVHF itself. While the prohibition of HVHF well pads in certain areas could reduce impacts, only the No Action Alternative would prevent ancillary activities from being conducted and eliminate the potential risks. See the Response to Comment in Cumulative for further discussion on the cumulative impacts from HVHF (e.g., visual, community character, air).

See also Response to the Comment in Seismicity in Geology for further discussion of potential impacts to drinking water supplies related to fractures and faults. See also Response to the Comment in Well Construction in Potential Environmental Impacts and Mitigation for further discussion of the potential impacts to drinking water supplies related to fluid/gas migration. See also Response to the Comment in Other for further discussion of incidents in other states.

Private Water Wells and 500-Foot Buffer

Comment: The Department received numerous comments with respect to potential significant adverse environmental impacts on private water supplies (private water wells and domestic supply springs) from HVHF. These comments ranged from supporting the proposed 500-foot buffer, to questioning the buffer's effectiveness, to arguing that the buffer was unnecessary. Comments also raised concerns about the potential impacts from HVHF ancillary activities, including water withdrawals, on these water supplies. The Department has broken down these comments into four areas and has provided responses specific to each of these areas.

a) Comments were received in support of the proposal in the SGEIS prohibiting HVHF within 500 feet of a private water well (i.e., non-public use water source), in addition to comments that a larger buffer is necessary (e.g., 1,000 feet; 1,320 feet; 2,000 feet; 2,640 feet; 3,000 feet; 4,000 feet; 5,000 feet; greater than one mile; a distance significantly exceeding the length of the horizontal lateral; the maximum distance capability of horizontal drilling) to protect private water wells from contamination and degradation. Others commented that no buffer would be adequate to protect private water wells; however, many comments argued that a 500-foot buffer is excessive and that a shorter buffer (e.g., 250 feet) would open up more private land for HVHF. In support of either side, comments suggested that the results of any technical determination or study (e.g., technical analysis of federal law requirements to protect Underground Sources of Drinking Water) supporting a set buffer be made public in a FSGEIS. Comments also indicated that wells utilized for crop irrigation and water for livestock should be protected. Comments also supported the imposition of equal mitigation measures for private water and public water supplies and stated that consideration should be given to the fact that private water wells are not filtered. Additionally, comments were received that domestic use springs should be included as part of the 500-foot buffer from private water wells.

b) Comments recommended that the Department analyze whether there should also be a prohibition on activities ancillary to HVHF within such buffers, such as roadspreading of brine.

c) Comments were received in support of the proposal in the SGEIS for a landowner to waive the prohibition on an HVHF well pad located within 500 feet of their private water well, but some of them suggested that the procedure needs to be more clearly written (i.e., accounting for shared wells, land leases). Other comments were received stating that no waiver should be allowed.

d) The Department received comments that it should analyze the potential threat from water withdrawals needed for HVHF that could affect a private water well.

Response: HVHF and activities associated with HVHF present the potential to have significant adverse environmental impacts on private water supplies (private water wells and domestic supply springs), if not adequately mitigated. In this regard, the SGEIS proposed a prohibition of HVHF within 500 feet of private water wells and domestic supply springs. Provisions for waiver by the landowner of this prohibition were also included in the SGEIS.

a) The SGEIS proposed, and the Department considered, various levels of mitigation and prohibitions to reduce the potential for significant adverse environmental and health impacts from HVHF within a buffer surrounding private water wells and domestic supply springs. After review and consideration of comments submitted, the Department concluded that if an adequate buffer can be determined, a prohibition of HVHF well pads within the buffer is appropriate to reduce potential impacts to private water supplies, as well as to human health and ecosystems. Additionally, the Department considered the level of protection that should be afforded to water wells utilized for livestock consumption or crop irrigation.

The total population within the Marcellus Shale play area is approximately 906,000. More than 360,000 people (or roughly 40% of the population) in this prospective area is served by individual private wells or public surface water supplies, or community supplies outside of Primary and Principal Aquifer areas. Since just 2000, 16,000 new private water wells in the Marcellus Shale play area have been reported to the Department; this averages out to over 1,000 per year.

The Department agrees with comments received that a buffer from private water supplies is a necessary mitigation measure. Considerations for determining an adequate buffer are discussed fully in the Response to the Comment in Setbacks in Potential Environmental Impacts and Mitigation.

For a detailed discussion of the potential risks associated with HVHF to private water supplies, generally, see Response to the Comment in Setbacks in Potential Environmental Impacts and Mitigation. However, there are some potential risks associated with HVHF that are of particular importance to the protection of private water supplies. Unlike public drinking water supplies, the operation of private water supplies is not regulated, either by federal or state regulations. There is no required monitoring of private water supplies to periodically assess the water quality of private water supplies. In addition to protecting the aquifers that supply the private water supplies, protection of aquifer recharge areas (i.e., the land area where the substrate is permeable enough to allow surface water to infiltrate into and replenish an aquifer) is important. Also, springs can be used as private water sources and occur frequently throughout the state of New York, and any buffer, if one could be developed, would apply equally to private water supply springs.

In the event that HVHF were authorized, the Department would require a buffer from private water supplies (although the Department acknowledges that the extent of the buffer needed is uncertain) and would enforce and monitor these buffers through permit conditions. See also Response to Comment in Enforcement.

See also Response to the Comment in Seismicity in Geology for further discussion of potential impacts to drinking water supplies related to fractures and faults. See also

Response to the Comment in Well Construction in Potential Environmental Impacts and Mitigation for further discussion of the potential impacts to drinking water supplies related to fluid/gas migration. See also Response to the Comment in Other for further discussion of incidents in other states.

b) The SGEIS did not prohibit activities ancillary to HVHF within any proposed buffer to private water supplies. The Department recognizes that ancillary activities (e.g. storage of HVHF material), including those that the Department does not have jurisdiction over (e.g. truck traffic), would also present risks (e.g., spills) to private water supplies similar to those risks associated with HVHF itself. While the prohibition of HVHF well pads in certain areas could reduce direct impacts, only the No Action Alternative would prevent ancillary activities from being conducted and eliminate the potential risks. See also Response to the Comment Waste Transport and Disposal for further discussion of roadspreading of brine.

c) The Department considered allowing a landowner to waive a buffer only if the potential impacts from HVHF would be limited to the landowner's private property, including water resources.

d) See Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation for further discussion on mitigation of the potential impacts related to water withdrawals.

Primary Aquifers and 500-Foot Buffer

Comment: The Department received numerous comments with respect to potential significant adverse environmental impacts on Primary and Principal Aquifers and the proposed prohibition of HVHF well pads in Primary Aquifers and the proposed site-specific determination of significance for HVHF well pads in Principal Aquifers. These comments ranged from supporting the proposed 500-foot buffer and urging that well pads be prohibited in both types of aquifers, to questioning the buffer's effectiveness, to arguing that the buffer was unnecessary. The Department has provided responses specific to each of these areas.

The Department received comments in support of the proposal in the SGEIS prohibiting HVHF well pads and ancillary activities in Primary Aquifers and within 500 feet of Primary Aquifers, in addition to comments that a larger buffer (e.g., 1,000 feet; 1,320 feet; 2,000 feet; 4,000 feet; 5,000 feet; greater than one mile; site-specific) is necessary to protect Primary Aquifers from contamination and degradation. Others commented that no buffer would be adequate to protect Primary Aquifers; however, other comments argued that a prohibition and a 500-foot buffer are unnecessary and excessive. In support of either side, comments suggested that the results of any technical determination or study (e.g., geology, topography, and hydrology) supporting a determination of a buffer be made public in an FSGEIS. Additionally, comments suggested that before making any determinations, the Department should have detailed aquifer mapping for the entire play area including updating/revising existing aquifer maps and new mapping where necessary. Comments also recommended that any set buffer be measured from the end of the horizontal lateral to prevent drilling underneath the aquifer, as horizontal laterals have the potential to extend up to one mile or more. Comments also supported the imposition of mitigation measures for Primary Aquifers equal to those for unfiltered drinking water supply watersheds and other public water supplies, including Principal Aquifers, considering that such are also not filtered. Concerns were also raised over revisiting the restrictions on HVHF well pads over Primary and Principal Aquifers and an associated 500-foot buffer, which could allow for HVHF within those areas at some time in the future. Details as to what the Department would consider when revisiting the restrictions should be included. Also, comments suggested that a sunset provision for the restrictions should be included to allow HVHF to commence if the Department does not act. Comments also suggested that subsurface access to gas resources should not be allowed under a water supply source.

Response: The Department recognizes that HVHF and activities associated with HVHF present the potential to have significant adverse environmental impacts on Primary and Principal Aquifers, if not adequately mitigated. In this regard, the SGEIS proposed a prohibition of HVHF well pads over Primary Aquifers and an associated 500-foot buffer, as well as a site-specific determination of significance for HVHF well pads over Principal Aquifers and an associated 500-foot buffer. Additionally, the SGEIS proposed that the restrictions on Primary and Principal

Aquifers be in place for at least two years after issuance of the first well permit authorizing HVHF and then be re-evaluated.

The SGEIS proposed, and the Department considered, various levels of mitigation and prohibitions to reduce the potential for significant adverse environmental and health impacts from HVHF to Primary and Principal Aquifers. After review and consideration of comments submitted, heightened protections are necessary to reduce potential impacts to Primary and Principal Aquifers, as well as to human health and ecosystems. Therefore, if HVHF were authorized the Department does not anticipate allowing the restrictions to sunset.

Aside from the NYC Watershed and water supply system, about half of all New Yorkers rely on groundwater as a source of potable water. In order to enhance regulatory protection in areas where groundwater resources are most productive and most vulnerable, in 1980, the Department of Health identified 18 Primary Water Supply Aquifers (also referred to simply as Primary Aquifers) across the state. These are defined in the Division of Water (DOW) Technical & Operational Guidance Series (TOGS) 2.1.3 as "highly productive aquifers presently utilized as sources of water supply by major municipal water supply systems." Many Principal Aquifers have also been identified and are defined in the DOW TOGS as “highly productive but which are not intensively used as sources of water supply by major municipal systems at the present time.” However, the potential yields (amount of water that can be produced) of Primary and Principal Aquifers are similar. Because they are largely contained in unconsolidated material, the high permeability (which allows rapid movement of groundwater) of Primary and Principal Aquifers and shallow depth to the water table, make these aquifers particularly susceptible to contamination. Protection of aquifers is critical for existing water supply needs, as well as to fulfill future needs for new or expanded water supplies.

There are approximately 1,074 public supply systems that rely on Primary and Principal Aquifers in the Marcellus Shale play area, and the total population served by these combined water supplies is at least 544,740. The total population within the area is approximately 906,000. Therefore, roughly 60% of the population in this prospective area is served by community groundwater supplies that draw from Primary and Principal Aquifer areas. The remainder of the population in this area is served by individual private wells or public surface water supplies, or community supplies outside of Primary and Principal Aquifer areas.

Primary Aquifers currently serve major municipal water supply systems and are highly productive and vulnerable. The Endicott-Johnson City Primary Aquifer, located in Broome County, includes numerous major municipal systems including Johnson City, Endicott, Binghamton, Vestal, and Conklin, serving close to 100,000 people. Principal Aquifers are presently used as sources of municipal water supply systems and known to be highly productive or whose geology suggests abundant potential water supply. The Almond – Alfred area in Allegany Co. has been identified as a Principal Aquifer serving approximately 8,200 people.

Data from the NYS Department of Health shows that, within the Marcellus Shale play area of New York, about 320,000 people are supplied by public water supplies from Primary Aquifers, whereas about 220,000 people are supplied by public water supply systems from Principal Aquifers. In addition, individual water supply systems in Principal Aquifers are serving as many as 16,000 people, whereas only 5 of the 18 municipal water systems in Primary Aquifers are serving more than 16,000 people.

Under the SGEIS, rather than applying an absolute prohibition, as is the case with Primary Aquifers, the siting of a well pad for HVHF over a Principal Aquifer and an associated 500-foot buffer would require a site-specific determination of significance. As part of the site-specific SEQRA review, the appropriateness of placing a well pad in the proposed location would be evaluated and might or might not be permitted based on that site-specific review, which considers the potential impacts versus the potential benefit. If permitted, enhanced mitigation measures would be tailored to the specific application. Among other things, the Department would consider the following factors when considering an application to construct a well pad above a Principal Aquifer or within 500 feet of the boundary of the aquifer: topographical features, such as depressions and overall slope of the land; distance to drinking water supplies and population served; and other uses of the aquifer.

The Department agrees with comments received that a buffer from Primary and Principal Aquifers is a necessary mitigation measure. Considerations for determining an adequate buffer are discussed fully in the Response to the Comment in Setbacks in Potential Environmental Impacts and Mitigation.

For a detailed discussion of the potential risks associated with HVHF to Primary and Principal Aquifers, generally, see Response to the Comment in Setbacks in Potential Environmental Impacts and Mitigation. However, there are some potential risks associated with HVHF that are of particular importance to the protection of Primary and Principal Aquifers. In addition to protecting the aquifers themselves, protection of aquifer recharge areas (i.e., the land area where the substrate is permeable enough to allow surface water to infiltrate into and replenish an aquifer) depending on the circumstances may also be important.

In the event that HVHF were authorized, the Department would require a buffer from Primary and Principal Aquifers (although the Department acknowledges that the extent of the buffer needed is uncertain) and would enforce and monitor these buffers through permit conditions. See also Response to Comment in Enforcement.

Regarding comments on the necessity to revise aquifer maps, the 1988 USGS aquifer maps referred to were digitized by USGS and have been posted on the NYS GIS clearinghouse under the data set name "Unconsolidated Aquifers at 1:250,000." While this may be incomplete in that bedrock aquifers are not included, it represents the best statewide mapping available. However, unlike the Primary Aquifers, not all Principal Aquifers have been delineated at a mapping scale adequate for well-pad site evaluation. The existing State-wide Geographic Information System (GIS) map showing the Principal Aquifers was compiled and digitized in the 1980s at a regional scale of 1:250,000. This mapping is inaccurate for use when projected to the 1:24,000 scale. GIS coverage of Primary Aquifers and selected Principal Aquifers mapped at the 1:24,000 scale are available from the United States Geological Survey (USGS) web page (http://ny.water.usgs.gov/projects/gisunit/Upstate Aquifer Page.html). Delineation of the remaining principal-aquifer boundaries at the 1:24,000 scale using the same mapping criteria is warranted for effective application of any buffer, as well as the potential identification of other Principal Aquifers currently not identified, but that cannot be completed prior to any SGEIS being issued.

The SGEIS did not prohibit activities ancillary to HVHF within Primary and Principal Aquifers or a buffer extending from such aquifers. The Department recognizes that ancillary activities (e.g. storage of HVHF material), including those that the Department does not have jurisdiction over (e.g. truck traffic), would also present risks (e.g., spills) to Primary and Principal Aquifers similar to those risks associated with HVHF itself. While the prohibition of, or requirement to complete a site-specific determination for, HVHF well pads in certain areas could reduce direct impacts, only the No Action Alternative would prevent those ancillary activities from being conducted and eliminate the potential risks.

See also Response to the Comment in Seismicity in Geology for further discussion of potential impacts to drinking water supplies related to fractures and faults. See also Response to the Comment in Well Construction in Potential Environmental Impacts and Mitigation for further discussion of the potential impacts to drinking water supplies related to fluid/gas migration. See also Response to the Comment in Other for further discussion of incidents in other states.

State-Owned Lands

Comment: The Department received numerous comments concerning the potential impacts HVHF would have on State-owned lands. Comments ranged from supporting the proposed prohibition of well pads on State-owned lands and in some cases contending that it was insufficient because it would have allowed subsurface horizontal drilling beneath those lands, to concerns that even the surface prohibition would force the State to forgo potential revenue streams created by leasing opportunities. Despite the proposed prohibition of well pads on State-owned lands, many comments raised additional questions and concerns that the ancillary activities associated with HVHF would have a significant adverse impact on State-owned lands.

Specifically, comments called for the SGEIS to make it clear that the prohibition of surface disturbance within state lands also includes any road construction (new roads, road expansion, widening, increase in bridge carrying weights, etc.) to accommodate the increased traffic due to HVHF. In this regard, comments also questioned the potential impacts associated with truck traffic utilizing roads that access State Forests, State Parks, and Wildlife Management Areas. Similarly, many comments urged the Department to also prohibit subsurface disturbance from adjacent lands to State-owned lands and pointed out that leasing of gas rights underneath certain State-owned lands violates Article XIV of the New York State Constitution.

In this respect, comments argued that the Department should prohibit HVHF immediately adjacent to State-owned lands, because the secondary impacts from drilling on the periphery of State-owned lands upon these reserves' habitat integrity would be significant and unacceptable even if the core is protected. Here, comments argued that leasing of subsurface rights to State forestland may lead to dense development surrounding New York's parks and reserves. A network of well pads and pipelines may cut off migration corridors between protected lands and larger blocks of significant habitat. Increased natural gas development surrounding New York's public lands could lead to secondary environmental degradation of parklands such as decreased air quality, excessive noise and light pollution, contaminated waterways from accidental spills, excessive road kill from migrating animals and increased invasive species vectors. In this regard, there were comments that asked the Department to extend the prohibition of surface disturbance from HVHF on State Forests and Wildlife Management Areas to all public lands (including local, county and Federal lands) and to establish a setback from State-owned lands. Comments also urged the Department to extend the prohibition of drilling activities to the entire Catskill Park.

On the other end of the spectrum, some comments argued that the Department should also make it easier to cross State lands with pipelines associated with HVHF, particularly along existing rights-of-way. Some comments asserted that roads that would necessarily be improved and built for developing gas resources would easily be located in areas that would aid in long-term forest management, including multiple recreational uses. Here, some comments posited that there is no rational basis for differentiating between private and public lands in this context, as both are equally susceptible to resource development and environmental impacts. Therefore, the comments argued, the outright ban on HVHF operations on state-owned lands constitutes a regulatory taking without compensation. Some stated that the prohibitions also would constitute a taking as applied to some operators or situations. These comments, therefore, argued that the Department should reduce or eliminate these prohibitions on State-owned lands altogether.

Response: The SGEIS proposed, and the Department considered, various levels of mitigation and prohibitions to reduce the potential for significant adverse environmental impacts to State-owned lands from activities associated with HVHF. As described in the SGEIS, the prohibition on surface disturbance associated with HVHF on State lands would reduce impacts to public lands and would potentially allow them to be managed for the purposes for which they were acquired, such as open space, public recreation, forestry and wildlife habitat, and in keeping with their respective authorizing statutes. While the prohibition of wellpads on State-owned lands would mitigate direct impacts, ancillary activities associated with HVHF would still have the potential to cause significant adverse environmental impacts. For example, while the Department considered requiring a site-specific review to examine potential transportation impacts to State Forests, State Parks, and Wildlife Management Areas for any proposed drilling on private lands that are embedded within these State-owned lands, such a review necessarily accepted the premise that some level of increased truck traffic would occur on roads within State-owned lands. Moreover, in many instances town and county roads cross over State-owned lands administered by the Department and the State does not have direct jurisdiction over these roads. Moreover, unless the No Action Alternative is selected, the SGEIS would potentially permit subsurface access to gas resources obtained through HVHF under State lands from adjacent private lands, except for those State-owned lands covered by Article XIV of the New York State Constitution (i.e., the Forest Preserve, State Reforestation Areas in forest preserve counties and the State Nature and Historical Preserve). While this would enable the State to receive royalties from such exploration, it would necessarily increase the potential of significant adverse environmental impacts, including visual and noise impacts.

The comments that claim that the prohibition of HVHF activities on State-owned lands constitutes a regulatory taking are without merit. The Department acquires public lands pursuant to the ECL and with public funds that require such public lands to be managed for specified public purposes like public recreation and wildlife habitat. The prohibition of HVHF is a regulation of the type of technology that may be used to extract the mineral resource, and the basis of such regulation is directly tied to the State's interest in preserving these lands for continued public recreation and wildlife habitat. Notwithstanding the prohibition on surface disturbance associated with HVHF, mineral resources under State lands may be extracted using conventional drilling technology other than HVHF. Such legal requirements and use restrictions do not attach to private lands; however, many of the impacts associated with public lands apply equally to private lands, including, but not limited to, impacts to wildlife and habitat. Therefore, a prohibition of this type of technology statewide through the No Action Alternative would also not amount to a regulatory taking, as conventional technology (with fewer associated impacts) could still be used to extract mineral resources. Furthermore, other types of activities, such as farming would still be permissible.

An HVHF well pad is expected to be larger than a conventional drilling well pad, and drilling activities would continue for a longer period of time. It is also anticipated that there would be a significant increase in truck traffic compared to that resulting from conventional hydraulically fractured wells. Historically, the level of disturbance from conventional wells has been minimal, allowing State lands to be managed for the purposes for which they were acquired, as required under ECL § 9-0507. The type and level of activity associated with HVHF is likely to lead to a significant increase in acreage that would be converted to non-forest use in the form of well pads and roads, and the concomitant nighttime lighting, noise and other impacts would collectively be inconsistent with the provisions of the ECL governing these lands. Thus, the type and level of activity associated with HVHF is likely to lead to potentially significant adverse environmental impacts that would be inconsistent with the provisions of the ECL governing these State lands. Indeed, the duration of drilling and the amount of truck traffic expected at a well pad where HVHF is utilized could negatively impact the State's ability to maintain existing large contiguous patches of forest and otherwise maintain State land for the purposes for which it was acquired. In this regard, the SGEIS recognizes that the potential adverse impacts resulting from HVHF activities are significantly greater than those impacts resulting from traditional, non-HVHF activities.

While the SGEIS recognizes the significance of State-owned lands, in the event that HVHF were allowed to generally proceed (subject to certain restrictions and mitigation), the Department has determined that only government entities having jurisdiction over other publicly-owned lands should decide whether or not to prohibit the use of HVHF on those lands. The government entity with jurisdiction over its own public lands has the authority to make and enforce such a determination, subject to any permit conditions imposed by the SGEIS, and it would be most familiar with the management needs, public purposes, and the acquisition funding relating to such public lands. SEQRA does not change the existing jurisdiction of agencies nor the jurisdiction between or among state and local agencies. See 6 NYCRR 617.3(b). Therefore, unless the No Action Alternative is selected, non-State publically owned lands could be directly impacted by HVHF. Similarly, if HVHF were allowed to proceed, the Department considered prohibiting or requiring further environmental review prior to the issuance of any permit authorizing HVHF on private lands inside the boundaries of the Catskill Park, but such mitigation would not prevent potential significant environmental impacts to other unique areas of the State. In this respect, while a site-specific environmental review can potentially provide effective mitigation for a particular site, it is far less certain that it can address potential cumulative impacts to a particular region, especially in an area where the activity – HVHF – is inconsistent with the overall character of the region.

100-Year Floodplains

Comment: The Department received numerous comments with respect to potential significant adverse environmental impacts from HVHF well pads located in floodplains. These comments ranged from supporting the proposed parameters of the prohibition, to questioning the effectiveness of the proposed parameters, to arguing a prohibition is unnecessary. Comments also raised concerns about potential impacts from HVHF ancillary activities located within floodplains. The Department has broken down these comments into three areas and provided responses specific to each of these areas.

a) The Department received comments in support of the proposal in the SGEIS to prohibit HVHF well pads within the 100-year floodplain; however, other comments argued that a ban is not warranted in the 100-year floodplain given the historical record of wells pads in those floodplain areas throughout the country without incident and that it would be sufficient if well pads in these areas employed best management practices and safety precautions. The Department also received comments that it should consider a prohibition of HVHF under floodplain areas. Comments were also received recommending that the prohibition of HVHF well pads within the 100-year floodplain be extended to other flood-prone areas (e.g., to include any areas that have experienced flooding during the past ten years, or the 500-year floodplain). Comments also identified a necessity for buffers (e.g., 500 feet, 1,000 feet, 5,280 feet) from the 100-year floodplain within which HVHF well pads should be prohibited. Additionally, comments received suggested that before issuing any permits for HVHF, the Department should update/revise Flood Insurance Rate Maps and conduct an up-to-date assessment of the flood risks to ensure that HVHF wells in New York will not be subjected to the same kind of natural disasters that recently affected areas of New York State and international locations (i.e., these maps should be reflective of anticipated changes that may result from climate change, namely the increase in frequency and severity of storm events).

b) Comments recommended that the Department analyze whether there should also be a prohibition on ancillary structures connected to the HVHF well pad within such floodplains, such as open pits, pipes, transfer stations, containment tanks (e.g., production brine), other structures, HVHF materials (e.g., bulk additive supplies), diesel fuel, and other drilling-related operations.

c) Comments received suggested that even with a buffer, the Department must issue specifications for structurally anchoring flowback tanks and other infrastructure containing HVHF materials to resist movement during severe floods or freeze-thaw cycles.

Response: The Department recognizes that should HVHF well pads and activities associated with HVHF be located in flood-prone areas, there may be significant adverse impacts if not adequately mitigated. In this regard, the SGEIS proposed a prohibition on HVHF well pads within the 100-year floodplain.

See Response to the Comment in Floodplains in Potential Environmental Impacts and Mitigation.

a) The SGEIS proposed, and the Department considered, various levels of mitigation and prohibitions to reduce the potential for significant adverse environmental and health impacts from HVHF within the 100-year floodplain. After review and consideration of comments submitted, the Department maintains that a prohibition of HVHF within the 100-year floodplain is appropriate. However, implementing such a prohibition may be difficult based on several factors, including:

- Difficulty in maintaining current Flood Insurance Rate Maps (FIRM), which specifically identify flood-prone areas;

- Out-dated assessment of the flood risks, including consideration of climate change; and

- Technical constraints (e.g., topography).

Current flood-prone areas are not clearly and precisely delineated, especially in light of climate change, which makes implementation of mitigation measures uncertain. Every FIRM, which is the legal flood map used by New York State and its municipalities, is a snapshot in time and can become outdated due to changes in the watershed, such as development and changes in precipitation patterns, which can cause changes in flood flows and expected flood elevations. The FEMA mapped Special Flood Hazard Area (i.e., 100-year floodplain) is a representation of a statistical definition of the area that has a one percent or greater chance of being flooded each year. Both larger and smaller floods occur, and as a result the mapped FEMA flood hazard is not the entire area at risk of flooding. There is also uncertainty as to what level of flood-prone areas (e.g., 100-year or 500-year floodplains) the proposed prohibition would protect. In this regard, to address concerns about flooding beyond the 100-year floodplain and in recognition of the increasing frequency and intensity of recent and potentially future flood events, the Department considered requiring that the well pad be elevated two feet above the 500-year floodplain elevation or the known elevation of the flood of record. However, the Department notes that the data as to what constitutes the 500-year floodplain is incomplete and consequently impacts could still occur.

In flood-prone areas beyond the 100-year floodplain, there exists uncertainty as to adverse environmental and health impacts associated with HVHF, as well as the likelihood of occurrences of such adverse environmental and health impacts. Major rain events occurred in the Southern Tier of the State during 2011, changing the course of some waterways and causing widespread damage to property and natural resources (e.g., aquatic ecosystems), well beyond the 100-year floodplain. Siting well pads and other infrastructure in any flood-prone area is a concern because these areas provide riparian habitat and important flood retention capacity, and recharge groundwater. If chemicals and fuels are used in or in close proximity to the flood-prone areas, these functions performed by floodplains could be impaired should a spill or release occur. In flood-prone areas beyond the 100-year floodplain, uncertainties exist as to the ability of measures to mitigate potential impacts of HVHF.

b) The SGEIS did not prohibit activities ancillary to HVHF within the 100-year floodplain. The Department recognizes that ancillary activities (e.g. storage of HVHF material), including those that the Department does not have jurisdiction over (e.g. truck traffic), would also present risks (e.g., spills) similar to those risks associated with HVHF itself. For example, if chemicals associated with HVHF are stored in a 100-year floodplain, and a flooding event were to occur, there could be an overflow causing impacts to water resources in the floodplain. While the prohibition of HVHF well pads within the 100-year floodplain could reduce direct impacts, only the No Action Alternative would prevent those ancillary activities from being conducted and eliminate the potential risks. See the Response to Comment in Cumulative Impacts for further discussion on the cumulative impacts from HVHF (e.g., visual, community character, air).

c) The Department does not expect that a typical freeze-thaw cycle would negatively impact flowback tanks and other infrastructure containing HVHF materials.

4. Geology

General Geology

Comment: The Department received comments with respect to the description of New York State geology contained in the SGEIS. Comments ranged from specific concerns about localized geologic and topographic considerations to general concerns that the SGEIS did not rely on current data, contains certain inaccuracies and fails to adequately consider the overall geological implications associated with HVHF.

A number of comments focused on local geologic considerations. Several comments were directed at the unique geology of the Finger Lakes Region, questioning the safety of fracturing the area between Keuka and Seneca Lake. Another comment pointed to the difficulty in remediating past contamination due to the “difficult geology” of Ithaca’s South Hill and to contend that it would be similarly difficult to remove HVHF-related contamination.

Other comments were directed at more general features of New York's geology. Some comments requested the Department to consider all available information to ascertain the geological conditions relevant to HVHF activities in the Marcellus Shale, including the use of well log data submitted to the Department to pick formation tops, and questioned the use in the SGEIS of statistics from other sites because they do not take into account the unique geological and ecological features of the Marcellus Shale.

Response: Chapter 4 of the SGEIS supplements and expands upon Chapter 5 of the 1992 GEIS as it pertains to gas potential from unconventional gas resources, placing special emphasis on the Utica and Marcellus Shales because of the widespread distribution of these units in New York.

Regarding the broader concerns expressed by several comments, the SGEIS discusses the geology of the Marcellus Shale and the potential impacts to groundwater associated with water withdrawals, well drilling and construction, as well as the potential for hydraulic fracturing-induced seismicity. See Response to Comments in Seismicity in Geology, and Water and Well Construction in Potential Environmental Impacts and Mitigation. To date, the proposals for the use of HVHF that have been submitted to the Department only target natural gas. Furthermore, because of the risks and potential significant adverse environmental impacts associated with HVHF, the SGEIS proposed to prohibit development of well pads associated with HVHF within 2,000 feet of public drinking water supply wells, river or stream intakes and reservoirs, and within 500 feet of a Primary Aquifer. See Response to Comment in Water Resources in Potential Environmental Impacts and Mitigation for discussion of adequacy of prohibitions and buffers.

With respect to specific concerns regarding the Finger Lakes Region, the Department has no records of shallow oil wells in the area between Keuka and Seneca Lakes, but there are a number of natural gas production wells, gas storage wells and solution salt mining wells in that area. The Department is unaware of any topographical issues associated with the Finger Lakes area that would preclude the development of well pads associated with HVHF outside the prohibited areas discussed above. In addition, the figures cited in the SGEIS are generalized, and the statewide maps are not intended to show the level of detail with respect to the Finger Lakes area, or for other potential developable areas.

The issues associated with Ithaca's South Hill involve volatile organic vapor intrusion from a trichloroethene groundwater plume believed to have spread through the city's sewer systems from various local industries. This plume is affecting groundwater in shallow bedrock. If HVHF were authorized, it would not result in a plume of this nature.

Seismicity

Comment: Comments were submitted noting that the SGEIS does not address or identify New York areas prone to higher seismic activity and suggested measures to prevent earthquakes potentially associated with HVHF.

Several commenters stated that the installation of gas and exploratory wells that open pathways between formerly separated geologic horizons pose an environmental risk, particularly because the area is seismically active. Commenters also were concerned that hydraulic fracturing may cause small earthquakes. Comments also claimed that ground motion associated with seismic activity has the potential to shear multiple well casings, degrade cement grout designed to isolate geologic horizons, and thereby open vertical joint and borehole pathways between formerly separated geologic horizons. These comment further contended that while damage on the ground surface is slight, it is likely that damage to casing grout and possibly well casings may occur, potentially compromising the integrity and physical isolation of different bedrock horizons. Comments also indicated that the potential for seismic activity from full build-out of the Marcellus Shale formation should be evaluated.

Comments also stated that the Department must consider the possibility of seismic events before drilling and well development is allowed near aqueducts and other sensitive infrastructure, including nuclear facilities such as Indian Point Nuclear Power Plant. A requirement for seismic monitoring should be included in the SGEIS and an ERP for HVHF should include procedures for earthquakes and seismic events.

A few comments were received stating that the SGEIS, especially Chapter 4, is inadequate (and out-of-date) in its depiction of the faults and related structures known to characterize most of western New York.

Several comments expressed concern regarding seismic activity related to deep-well injection disposal of HVHF wastewater. Some comments stated that an injection well in Dale, New York, may have caused small earthquakes when water was pumped down a deep well to mine brine (Fletcher and Sykes 1977). Similarly, comments identified a deep-well injection associated with a natural gas storage project near Avoca, New York, that may have caused a felt quake in 2001.

A number of comments stated that recent earthquakes in Ohio that are possibly linked to HVHF wastewater injected into the ground for disposal are a cause for concern of possible water contamination from the injected wastewater. Comments also stated that there currently is no sealing system for the injection wells that is capable of withstanding seismic activity and remain viable and intact long term.

Another comment noted that, if hydraulic fracturing is too dangerous in the New York City and Syracuse watersheds, it should be deemed too dangerous for the Western New York area due to the risk of tremors/earthquakes. One commenter stated that the 2009 dSGEIS should include a discussion of New York's current emergency response procedures for earthquakes and/or other seismic events. Another comment expressed concern regarding the effect of faults on NYC water supply tunnels.

Comments also indicated that drilling into existing or planned salt mines or caverns in the Finger Lakes region can cause tremors which may, in turn, result in a wide array of environmental issues. These tremors may create unstable conditions, potentially leading to subsidence and aquifer damage. These comments argued that extensive research and analyses need to be conducted prior to the commencement of drilling in the region.

Response: The Department recognizes that there remains some level of uncertainty as to the degree of potential impacts from HVHF induced earthquakes including frequency, magnitude and risk. While historically, such seismic activity has not caused measurable damage, with the onset of increased HVHF activity, additional evidence indicates that the scope of impacts may not be fully understood. For example, a recent study (Skoumal, 2015) ascribed a series of earthquakes in Poland, Ohio to HVHF operations. Between March 4 and March 12, 2014, 77 earthquakes, ranging between 1.0 and 3.0 in magnitude, were identified and found to be closely related spatially and temporally to hydraulic fracturing operations at a nearby well. After the Ohio Department of Natural Resources ordered the HVHF well to be shut down on March 10, 2014 the rate of incidence decreased until the earthquakes stopped.

Regulation of deep-well injection is outside the scope of the SGEIS; however, it is discussed generally as a disposal option for HVHF wastewater in the SGEIS. The USGS Earthquake Hazard Program has produced the National Hazard Maps depicting the distribution of earthquake shaking levels that have a certain probability of occurrence in the United States. The SGEIS provides the seismic hazard map for New York State (Source - USGS National Seismic Hazard Maps [2008]) and describes the more seismically active areas of New York (seismic risk zones). Much of the Marcellus and Utica Shales underlie areas characterized by the lowest seismic hazard class rating in New York. The active zones occur in the Buffalo, Lake Ontario, Adirondack Mountains and New York City/Long Island areas where the Marcellus Shale is not present and the Utica Shale is relatively shallow. See Response to Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation for further discussion of the use of deep well injection for HVHF wastewater disposal.

As discussed in the SGEIS, the smallest measurable seismic events are typically between 1.0 and 2.0 magnitude. In contrast, seismic events with magnitude 3.0 are typically large enough to be felt by people. Fluid injection of any kind, including fluid injected during HVHF operations, can trigger felt seismic events if the fluid reaches a geologic fault. While induced seismic events from this process are more typically associated with waste disposal or other long-term injections, there have been several instances where induced seismicity has been linked to hydraulic fracturing operations. As concern has recently grown over HVHF and with increased seismic monitoring, induced seismicity has been attributed to hydraulic fracturing over the past several years, including the following events: 2011 local magnitude (M_L) 2.9 in Oklahoma, 2011 M_L 3.8 in British Columbia, Canada, 2011 M_L 2.3 in England, 2013 M_w 2.2 in Harrison County, Ohio and the above-described earthquakes in Poland, Ohio.

Seismic monitoring systems are already in place for New York with forty seismograph locations located in New York and six surrounding states (CT, DE, MD, NJ, PA, and VT). In New York State, sites are located in Albany, NYC, Cobleskill, Lake Ozonia, Binghamton, and two secondary schools, three colleges, and 15 universities. The seismic monitoring is performed by the USGS, Lamont Doherty Cooperative Seismograph Network as well as the New York State Museum.

The Department recognizes that additional studies have been conducted, which indicate the presence of additional faulting across New York State. Figure 4.13 of the SGEIS illustrates mapped faults in New York State, and does not include topographical and tonal linear features (lineaments). The Isachaen & McKendree Landsat study (which Figure 4.13 is based on) remains the only study of lineaments that incorporated the entire state, as well as integrating known faults at the time of the study. Other studies such as the EarthSat (1997) study also used Landsat lineaments, but with more sophisticated algorithms to produce the image from which the lineaments or linear trends were identified. The image in the EarthSat study, which encompassed the Appalachian basin portion of the State, did not integrate all faults known from other data. Note that linear trends are not confirmed to be actual faults without ground-truthing to verify whether or not a lineament is a fault or a fracture. In addition, Dr. Robert Jacobi developed a map in 2002 depicting proposed and/or mapped faults in the Appalachian basin portion of the state.

Both Jacobi's research and the EarthSat study suggest that the basin area is complexly jointed and faulted, but the extent to which some of these faults may or may not connect shale formations to overlying water resources has not been determined. If HVHF were authorized, the Department should require additional evaluation or monitoring to detect and mitigate seismic impacts in instances where HVHF operations could affect a known, significant, mapped fault, such as the Clarendon-Linden fault system.

The likely presence of unknown faults in New York raises concern as to the effectiveness of this and other proposed safeguards. Based on the discussion above, it is unclear whether the operators or the Department could adequately identify these faults prior to HVHF. However, it is noted that the paucity of historic seismic events and the generally low seismic risk level in the fairways indicates that geologic conditions are relatively stable in the Marcellus and Utica fairways. In addition, geologic conditions associated with a fault are generally unfavorable for effective hydraulic fracturing and economical production of natural gas. Nonetheless, the existence of unknown faults presents a potential pathway for migration of contaminants from HVHF. And the potential to increase seismic activity.

Nevertheless, induced seismicity resulting from hydraulic fracturing near a fault has been verified in the United Kingdom and Canada, and has occurred at several locations in the United States including Ohio, Oklahoma and Texas. Although some of these events occurred in areas under more stress and with more active tectonics than the portion of the Appalachian basin in New York State, the recent earthquakes observed in Poland, Ohio, which have been linked to HVHF occurred in an area with the same seismic hazard class rating as those portions of New York with the lowest seismic hazard class rating in the State, much of which overlies the Marcellus and Utica Shales. The documented earthquakes triggered by HVHF treatment near Blackpool, UK also occurred in a region characterized by relatively low seismicity, but where the rocks are under considerably more tectonic stress than those in the northern Appalachian Basin. It would appear that the stress conditions in the northern Appalachian Basin of New York are of considerably less magnitude than those conducive for induced seismicity of the magnitude found in the Blackpool region, UK. Furthermore, the presence of a fault near the site was unknown prior to drilling and HVHF stimulation. The Ohio and UK events illustrate that induced seismicity can occur on previously unknown faults. The possibility of HVHF-induced seismicity on unknown faults have not yet been studied sufficiently to understand the nature of the risk presented by HVHF. This adds to the Department’s uncertainty.

Seismicity associated with deep injection wells is discussed in the SGEIS, including a description of the two incidents regarding injection well seismicity in Dale and Avoca, NY. In the former incident at Dale, New York, fluid was injected for the purposes of solution mining for a period of weeks to months. This type of injection is substantially different both in volume and duration than the short-term, controlled pumping used for hydraulic fracturing. In the latter instance at New Avoca in Steuben County, New York, test injections were being conducted for brine disposal and the likely cause of seismic events was the result of numerous injection events lasting from 6 to 28 days, which is significantly different than short-term pumping used for hydraulic fracturing. The Department recognizes concerns regarding groundwater contamination from the drilling of HVHF wells and the use of deep injection wells for waste disposal. Several studies have linked methane contamination of drinking water wells to HVHF (e.g. Osborn, 2011). Although the most probable mechanism for stray gas contamination is leaking through inadequate cement on casing or through well annulus, these studies have noted that it is possible for a fracture network system to provide a conduit for gas and fluid migration.

With respect to concerns related to drilling into salt formations or caverns in the Finger Lakes region, drilling into a salt formation would not, in and of itself, cause tremors or subsidence. Wellbores drilled to develop formations, such as the Marcellus Shale, located above the salt formations will not intersect salt formations or their caverns, and therefore will not cause subsidence and aquifer damage related to subsidence. Moreover, current regulations (6 NYCRR 552.4) require that any well proposed to be drilled within 660 feet of an underground mining property undergo additional environmental review whereby the mining operator has the opportunity to provide input regarding the well operator's proposed protection of the mined zone. A public hearing is required prior to issuance of the well drilling permit should the Department receive timely objections from the owner, lessee or operator of the underground mine. In addition, over 300 billion cubic feet of gas has been produced from the Black River formation in New York without any indication of subsidence. Gas well development would not result in subsidence similar to what was experienced by coal extraction, whereby large voids were created in the shallow subsurface.

New York's emergency response procedures for earthquakes and/or other seismic events are outside the scope of the SGEIS. For information on earthquake response procedures see FEMA's website at http://www.ready.gov/earthquakes. In addition, the Department recognizes that there are shallow faults that cross the New York City water supply tunnel systems that could potentially impact the subsurface infrastructure. Indeed, a 2011 technical memorandum issued by NYC DEP and prepared by Hager-Richter Geoscience found that joints and faults are not well characterized in the interval between infrastructure for the watershed west of the Hudson and the Marcellus Shale. With respect to potential subsurface impacts, the report noted that "[t]he absence of direct geophysical data from borehole logging and high resolution seismic reflection surveys, and the natural complexity in rock properties all contribute to the uncertainty in understanding the contemporary stress field and the possible presence of critically stressed faults in the vicinity of the WOH NWI (West-of-the-Hudson Non-Watershed Infrastructure) …. At this time, there is not enough known about the state of stress and faulting in the vicinity of the WOH NWI and details about the condition of the unreinforced concrete-lined tunnels of the WOH NWI to determine that the tunnels would not be damaged by an induced seismic event….” These concerns, along with the recent evidence of HVHF-induced seismic events and the lack of geophysical data concerning unknown faults, highlight the uncertainty regarding potential subsurface impacts.

Naturally Occurring Radioactive Materials

Comment: The Department received numerous comments concerning the potential radiological concerns associated with naturally occurring radioactive materials (NORM) extracted or produced in HVHF operations. Comments ranged from concerns regarding the disposal of NORM-contaminated waste to the assertion that baseline testing of NORM concentrations in water wells surrounding a well pad is unnecessary.

Several commenters noted that NYSDOH had communicated to the Department that NORM in the Marcellus could pose public health risks, and disposal could be problematic. Other comments recommended prohibiting well drilling (mostly for oil and gas wells but, in some comments, for any reason including drinking water wells) into any formation containing NORM. Several focused on the radiological regulation of the well sites themselves, and the potential for the concentration of NORM (otherwise referred to as technologically enhanced NORM, or TENORM) in pipe scale within well equipment and pipes. Here, some commenters focused on the perceived inadequacy of the Department of Health radioactive materials licensing criteria for well sites and expressed concern that TENORM-contaminated pipes and equipment could be inadvertently released for use by the general public. References were made to instances of donations of TENORM-contaminated piping from oil and gas development to municipalities in Texas and other states where it was used to construct publically accessible structures, including playground equipment.

Additional comments regarding the regulation of NORM at well sites stated that the proposed cutoff radiation survey dose rate does not adequately allow for control of worker exposures or prevention of release of TENORM-contaminated equipment. In addition, commenters recommended that all wells be licensed as a matter of course. Comments indicated that based on their past experience, any well developed in the formation would develop dose rates of 50 microrem/hour or greater. Other comments expressed concern at a lack of information in the SGEIS specifying what licensing controls will be required and how they will be implemented.

There were numerous comments regarding various aspects of radon (Rn) risks, both in produced gas and in liquid and solid waste streams. These comments ranged from recommendations to reduce Rn levels in shale gas to claims that Rn in Marcellus Shale gas would pose such a grave health risk that the formation should not be developed in any capacity. Specifically, comments expressed concern that Rn in gas from the Marcellus can pose a significant risk to the end users and recommended additional treatment or decay in storage to reduce the Rn content. Others focused their concerns on the potential risks of Rn to workers or future users of solid waste landfills accepting contaminated drill cuttings for disposal or workers at publically-owned wastewater treatment works (POTWs). Several comments claimed that HVHF operations could create pathways for Rn to enter basements of residences and other structures, posing a risk to occupants. Two pathways were proposed: (1) the vertical propagation of fractures from the Marcellus Shale due to HVHF; and (2) leaks from gas well casing failures.

Concerns about potential impacts from NORM in production brine and flowback elicited a multitude of comments. These comments ranged from a general need to protect the public from NORM impacts related to the treatment and disposal of brine to concern that the SGEIS does not adequately address the potential for brine to contaminate drinking water. Specifically, concerns included the potential that unlimited accumulation of waste at a well site could increase risks to local wildlife and water sources. Some commenters asserted that brine or flowback cannot be adequately treated for NORM contaminants, while others pointed to a lack of brine and flowback treatment capacity in New York and argued that such capacity would be necessary before the Department can allow HVHF to proceed. Several comments described concern related to a hypothetical scenario, where repeated reuse of drilling fluids recovered from drill cuttings would present significant risk if cuttings contaminated with such fluid were disposed of in a landfill.

The Department received a number of comments concerning analytical issues and NORM monitoring. Several commenters questioned the adequacy of gamma spectroscopy to determine NORM concentrations in various media, recommending the utilization of alpha spectroscopy for such determinations because alpha radiation from radium poses greater risks than gamma and beta radiation and/or that insufficient detail was provided to justify the chosen analytical methods. In a similar vein, comments claimed that only the use of delayed-neutron analysis could adequately characterize NORM concentrations in various wastes. In addition, other submissions claimed that HVHF of the Marcellus Shale could not safely proceed until NORM content in the formation has been characterized in detail across the entire state.

Several submissions stated that testing of NORM concentrations should occur on a regular basis at drinking water intake facilities. Similarly, others requested that all "batches" of cuttings and flowback be tested before treatment or disposal. In contrast, other comments asserted that well operators should not have to conduct baseline testing of nearby water wells for gross alpha.

Waste disposal comprised the most voluminous category of comments concerning NORM, including numerous comments related to drill cuttings. Comments inquired as to when NORM levels would trigger a hazardous waste determination. Others suggested that the SGEIS does not adequately address the safe handling and disposal of "radioactive byproducts." Several comments referred to the lack of in-state disposal facilities available to accept low-level radioactive waste to argue that HVHF development should not proceed. With respect to NORM remediation, comments suggested that the SGEIS incorporate federal and state guidance/limits for the remediation of NORM-contaminated sites. Comments further suggested that the disposal of cuttings at landfills should adhere to the EPA remedial guidance concentrations for radium-226 of 5 picocuries/gram in surface soils and 15 picocuries/gram in subsurface soils.

In addition, a number of commenters referred to the permit conditions contained in 6 NYCRR Part 360, as they were imposed on a Chemung County landfill operator. Some stated that these permit conditions are adequate precautions for disposal while others rejected the conditions as inadequate for various reasons, including the following:

- Landfills receiving cuttings from Marcellus Shale drilling operations must have radiation monitors;

- Cuttings should be classified as low-level radioactive waste;
- Drill cuttings should be tracked in a system like the federal TRANSCOM system used to track spent nuclear fuel or other high-level waste;
- Surety bonds should be required for landfills accepting cuttings; and
- A cuttings, brine, or general NORM disposal plan should be required.

In addition, some commenters claimed to have conducted computer modeling using the US DOE computer code RESRAD to estimate that future users of a landfill could be exposed to a dose of 300 mrem/year due to crop uptake of radium and consumption by humans.

Several comments also included references to specific events, papers, or recommendations that they argued should have been specifically detailed in the SGEIS. These included references to recommendations on the subject from the Agency for Toxic Substances and Disease Registry, a General Electric technical study of a specific liquid waste treatment process, and an International Atomic Energy Agency study on NORM, amongst others.

Response: The Department recognizes that gamma ray logs from deep wells drilled in New York over the past several decades show the Marcellus Shale to be higher in radioactivity than other bedrock formations including other potential reservoirs that could be developed by HVHF. While it is recognized that significant variability of NORM content within the formation is possible, available data from across the broader formation from within and outside New York indicate that sufficient data exists to reasonably determine the range of potential impacts across the formation. As discussed in the SGEIS, the total volume of drill cuttings produced from drilling a horizontal well may be about 40% greater than that for a vertical well to the same target depth. The potential water resources impact associated with the greater volume of drill cuttings from multiple horizontal well drilling operations would arise from the retention of cuttings during drilling, necessitating a larger reserve pit that may be present for a longer period of time when used for more than one well, unless the cuttings are directed into tanks as part of a closed-loop tank system. Specifically, HVHF activities can bring NORM to the surface in the cuttings, flowback water and production brine, and NORM can accumulate in pipes and tanks. Based upon currently available information it is anticipated that late phase flowback water may contain levels of NORM of significance, and production brine could also contain elevated NORM levels. In addition, the build-up of NORM in pipes and equipment (pipe scale and sludge) has the potential to cause a significant adverse impacts because it could expose workers handling (cleaning or maintaining) the pipe to increased radiation levels.

It should be noted that technologically-enhanced naturally occurring radioactive material (TENORM) must be disposed of at a facility licensed or permitted to accept such waste. Disposal of TENORM in New York State is prohibited, and therefore, it must be disposed of out-of-state in accordance with any applicable regulations in the disposal state. Additionally, wastes from the treatment of flowback water and production brine may contain TENORM. Currently, there are no facilities that have the ability to treat such waste in New York State.

NORM is ubiquitous in the environment, and is present in varying concentrations in all environmental media. It primarily comes from two sources, those radionuclides that were present at the time of formation of the earth as well as their decay products, and radioisotopes created by cosmic ray interactions with the upper atmosphere. Radioactive potassium and uranium, thorium, and their decay products including radium and radon are in the first category.

Some comments characterized NORM concentrations in the Marcellus Shale as "highly radioactive." Specifically, when looked at in the context of the geotechnical sciences, such as in determining geologic formation stratigraphy using down-hole gamma logging, the gamma signature of the Marcellus Shale can be higher relative to the strata above and below it. However, in the context of the radiation protection field, when compared to sources of radiation exposure that are considered to pose a significant radiological health risk, the Marcellus Shale itself would not be considered to be "highly radioactive."

When brought to the surface, flowback water and production brine which contain NORM at elevated levels have the potential to cause significant adverse environmental and health impacts. Therefore, it is essential to ensure proper handling and disposal to reduce risks. See Response to Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation. Furthermore, as more fully explained in the Response to Comment in Health Impacts, exposure to NORM under certain circumstances can pose a health risk.

Low-level radioactive waste (LLRW) is regulated under its own regulatory scheme in part because it has the potential to pose significant health and environmental risks. Wastes that contain NORM at naturally occurring concentrations do not, with few exceptions (for example, high-grade uranium or thorium ore), pose comparable risks to those posed by LLRW. To be clear, the brine that by definition has existed in the formation for millennia has become saturated with the salts of many elements present in the formation, including those of its NORM constituents. Thus, the Marcellus Shale brine has the potential to pose unacceptable health and environmental risks if not adequately managed and regulated. See Response to Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation regarding potential limitations on acceptable treatment and disposal options. In this regard, the SGEIS proposed various mitigation measures along with current regulatory restrictions to reduce risks associated with NORM.

Drilling fluid and hydraulic fracturing fluid (before introduction into the well) are not expected to contain any significant NORM content and do not pose a risk from a radiological perspective, although hydraulic fracturing fluid may present other risks based on the chemicals present. See Response to Comment in Fracturing Fluid in Potential Environmental Impacts and Mitigation for a discussion of the potential significant environmental and health impacts associated with the chemicals used in HVHF. Flowback will initially consist of mostly hydraulic fracturing fluid and a small percentage of formation brine. However, over time the volume of liquid returning to the surface will diminish and at the same time the percentage of the total volume that is brine will increase. Any fluid collected following the commencement of gas production is considered brine, although the ratios of fracturing fluid to brine continues to change (decrease) over time. Regulatory controls, liquid processing requirements, and any needed remedial efforts for NORM content are primarily focused on the brine. However, the same precautions are applied to flowback due to the presence of some brine in this waste stream, although the NORM-associated risks are lower than those presented by the brine alone.

With respect to comments recommending a prohibition of all well drilling into formations containing NORM, the Department acknowledges that there are potential risks posed by NORM constituents from the Marcellus Shale formation that require regulations or other efforts commensurate with such risks. However, as noted above, all environmental media contains

NORM. Therefore, the issue is not whether a formation contains NORM, but rather, the levels of NORM and the corresponding necessary waste management efforts and measures to address potential health and environmental impacts and adequately mitigate potential impacts from media containing significantly elevated levels of NORM. For oil and gas development, the principal radiological concern is properly assessing the concentrations of dissolved NORM constituents in the formation brine, particularly radium.

The described instances in other states where TENORM-contaminated piping was donated to construct structures such as playground equipment are well known in radiation regulatory circles and primarily occurred prior to a recognition of the risk posed by such material. Release of oil and gas-related TENORM-contaminated piping is no longer allowed in other states, and would not be allowed in New York regardless of whether HVHF were allowed to proceed. Nonetheless, the Department recognizes that potential off-site environmental impact could occur due to the removal of materials or equipment with total and/or removable α/β surface radioactivity above guidelines if there is noncompliance with existing regulations prohibiting in-state disposal of TENORM waste.

With respect to concerns regarding the inadequacy of radiation survey dose rate cutoffs, the 50 microrem/hour dose rate proposed by NYSDOH and presented in the SGEIS is not a cutoff for the evaluation of either worker health or possible TENORM-contaminated items. Rather, that dose rate was chosen as a threshold for licensing because any worker exposed to that level for a standard work shift over the course of one year could potentially reach the regulatory dose limit for a member of the general public of 100 millirem/year. Therefore, 50 μRem/hour was proposed as a conservative limit whereby any portion of a well site exhibiting readings at or above this dose rate would serve to demonstrate that TENORM scale buildup is occurring and the site operator would be required to obtain a radioactive materials license from NYSDOH. Such a license would allow for the routine assessment of dose rates at the well site with regard to both occupational safety and TENORM scale buildup. Because TENORM waste is a regulated waste stream under 6 NYCRR Part 380, contaminated equipment may not be released for general use nor disposed of at any solid waste facility in New York. Therefore, TENORM scale buildup could either be removed from such equipment or pipes with proper radiation protection controls by NYSDOH-licensed operators, or the impacted equipment and pipes could be sent out-of-state for cleaning or disposal at facilities regulated for those purposes.

The Department also recognizes that the literature on the subject of expected dose rates is not in full agreement. Although NYSDOH does not expect that all wells will exhibit significant TENORM scale buildup, if data were to show that the majority of wells exhibited evidence of such buildup, NYSDOH would consider the appropriateness of a blanket licensing system. The SGEIS provides a description of the proposed licensing criteria, and also contains an explanation with respect to NYSDOH's requirements and implementation process.

As described in the Response to Comment on Health Risks, natural gas can also contain radon, a potential indoor air contaminant. A screening analysis presented in the NYSDOH Public Health Review suggests that radon exposure levels from Marcellus Shale natural gas could contribute a small fraction to the overall indoor radon levels. There is substantial uncertainty regarding radon levels in shale gas from various geographic locations and formations because of limited monitoring data, especially from the Appalachian Basin, which includes the Marcellus Shale. However, the NYSDOH Public Health Review used EPA data that bounded the highest levels seen in the Marcellus Shale to date, and based on that data, the Department does not expect that there would be any significant radon impacts to end users.

With respect to radon in cuttings and attendant potential risks to workers, or others, from landfills accepting cuttings, the Department does not believe that radon emanation from a landfill would pose a significant risk for the following reasons: (1) the relatively low concentrations of radium in cuttings; (2) concentration limits already incorporated into Part 360 permits for New York landfills accepting Marcellus Shale cuttings; (3) the robust design of solid waste landfills in New York; and (4) the rapid dispersal of any Rn gas reaching the surface of a landfill. In addition, studies completed by the U.S. Department of Energy's (DOE) Argonne National Laboratory support this assessment. Limiting a landfill waste mass to an average concentration of 50 picocuries/gram would keep worker exposure below the regulatory limit of 100 mrem/year. As a conservative measure, New York landfill permits are more stringent by halving this average concentration limit to 25 picocuries/gram. In addition, New York's solid waste landfills are required to be more robust in design than those modeled by DOE. These landfills must install a radiation portal monitor at their weigh stations, maintain a Department approved training program, have an equipment calibration procedure, establish a relationship between radiation monitor readings and radium concentrations in loads of cuttings, set their monitor alarm level well below the allowed concentration, and notify the Department whenever the alarm is set off to ensure adequate evaluation of the cause of that alarm.

Similarly, impacts to POTW operators and their workers from the potential buildup of NORM in sludge produced at these plants would be reduced by the influent concentration limit proposed the SGEIS for facility SPDES permits of 15 picocuries/liter of radium, which is one quarter of the 6 NYCRR Part 380 discharge criteria for radium. The criteria in Part 380 were developed based on several factors, including possible downstream impacts to drinking water sources. By severely limiting the potential for radium buildup in plant sludge, risks to workers due to the generation of radon would be significantly reduced.

The Department acknowledges the commenters concerns for the proposed generation of preferential pathway for Rn infiltration into structures by the fracturing of the Marcellus formation and the failure of casings for wells located near structures. However, due to the short half-life of Rn (3.8 days) and relatively slow transmission rate of gasses through rock and soil, gas migration into a building through postulated preferential pathways would generate no measurable increase in Rn levels above background levels. Radon infiltrates basements from rock and soils in the vicinity of a structure. Even if such pathways for Rn transmission were present, risks of infiltration from the much higher concentration of natural gas would pose a much more significant and immediate risk than the relatively low concentrations of radon.

The Department has also considered and evaluated potential risks posed by the NORM content of Marcellus Shale brine and recognizes the need to require adequate management and control measures, including discharge and disposal criteria to protect public health and the environment. Production brine and much of the flowback could contain NORM in excess of drinking water standards and therefore would need to be properly regulated to protect water supplies. To reduce these impacts the Department considered requiring tanks for on-site storage for all flowback and brine. There would also be time limits for on-site storage, which would limit the accumulation of waste at a given site. The Department further considered imposing testing requirements prior to the removal of liquid wastes from the well site and requiring that all waste be transported by permitted haulers using a manifest tracking system.

With respect to comments raising concern about the lack of treatment capacity for production brine and flowback in New York, there are a number of potential environmental and health impacts that may be associated with the environmentally sound management and disposal of these waste streams. Currently, there are no approved disposal options for HVHF wastewater in New York State. In addition, flowback water and production brine may include a diverse mixture of residual hydraulic fracturing chemicals and naturally-occurring constituents, including NORM, which would require pre-treatment, at a minimum, for the environmentally proper discharge of some waste streams and could potentially affect the efficacy of available treatment technologies. Furthermore, the Department recognizes concerns related to the improper or inadequate treatment of NORM-contaminated wastewater, illustrated by a recent study of a brine treatment facility in western Pennsylvania accepting HVHF wastewater. The study found Radium-226 levels in stream sediments at the point of discharge were approximately 200 times higher than upstream sediments and well above regulatory thresholds, raising concern about the potential risk of radium bioaccumulation in localized areas where production brine and flowback have been disposed. Pennsylvania no longer allows liquids (including those containing NORM) from unconventional well drilling to be disposed of at POTWs. Furthermore, the SGEIS proposed significant restrictions on the level of Radium-226 that can be disposed of at a POTW.

For a summation of the process for wastewater disposal that the Department would implement if HVHF were authorized, see Response to Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation. As noted there, there is uncertainty as to whether the impacts related to NORM generated through HVHF activities would be adequately managed by well pad operators.

With respect to those submissions expressing concern about the lack of available data to characterize NORM in the Marcellus Shale, the Department acknowledges that there was limited analytical data available on NORM content in that formation. While it is recognized that significant variability of NORM content within the formation is possible, available data from across the broader formation within and outside New York has been utilized to outline a range of potential impacts across the formation. If levels of NORM in a portion of the formation were found to significantly exceed the anticipated upper range of concentrations, the proposed requirements to test wastes prior to being transported from a well site, combined with limitations on concentrations for landfill disposal in New York State, influent concentration limits for POTWs, and existing concentration limits for liquid discharges from POTWs would serve to reduce the potential impacts of such an exceedance. Furthermore, in recognition of potential significant adverse environmental and health impacts, the Department prohibited the use of Beneficial Use Determinations (BUDs) for roadspreading of production brine from wells stimulated by HVHF in the Marcellus Shale or other low-permeability formations until additional data on NORM content is available and evaluated by the Department and NYSDOH.

The Department does not agree that gamma spectroscopy is an insufficient method by which to determine NORM concentrations in various media. Gamma spectroscopy is broadly recognized as an efficient and accurate method to quantify radium in environmental samples. Radiological analytical laboratories have been quantifying environmental levels of radium and other NORM constituents successfully using gamma spectroscopy for decades. Claims that alpha spectroscopy or delayed-neutron analysis is required to adequately quantify NORM content are based on a misunderstanding of the difference between a radioactive isotope such as radium-226 and the subatomic radioactive particles it emits. The isotope radium-226 gives off gamma rays, beta particles and alpha particles as it decays. However, none of this emitted radiation is present without the actual radium itself. Such radiation exists for infinitesimally short periods of time before their energies are absorbed into surrounding materials. Therefore, although alpha radiation poses the greatest risk of the various subatomic emissions from radium, the simpler, less costly and faster gamma spectroscopy method is adequate to determine the overall concentration of radium present, and thus the risk posed by all types of radioactive emissions, including alpha particles. Moreover, the discussion of analytical methods in the SGEIS is accurate and sufficient as it employs generally accepted analytical methods for NORM.

The Department proposed requiring that any lab performing tests in support of HVHF waste operations be ELAP-certified because it is the only radiological laboratory certification program under New York State control and provides a level of confidence in overall laboratory capabilities, particularly for labs that are new, or those with which the Department has no working history.

Regarding requests for additional NORM testing or monitoring, both NYSDOH and EPA have existing requirements for routine radiological testing of public drinking water sources. In addition, the Department proposed a requirement to test NORM levels in wastes at a well site before they can be sent off-site for disposal or treatment. The Department disagrees with the assertion that well operators should not have to conduct baseline testing of NORM levels in nearby water wells. The testing of nearby water wells is a prudent requirement, as it provides a baseline for NORM content in those wells in advance of drilling. This not only provides a reference for property owners in the event that they suspect their water quality is negatively impacted by drilling, but could also refute claims of HVHF contamination of wells that were impacted by shallower reservoirs of natural gas prior to the commencement of drilling, which has been shown to occur occasionally in the absence of nearby gas drilling.

Appropriate precautions should be in place to address the potential risks of disposal of Marcellus Shale drill cuttings, including basic protections such as limiting NORM concentrations in the cuttings sent to a landfill, controlling disposal in a landfill, and monitoring landfill leachate for potential increases in NORM content (in line with the “as low as reasonably achievable” (ALARA) principle, a fundamental of radiological protection). In New York, radioactive wastes are regulated separately from hazardous wastes under 6 NYCRR Part 380, and are not considered to be hazardous waste. The Department recognizes that the 2009 dSGEIS needed additional information regarding NORM management, particularly with respect to NYSDOH radioactive materials licensing. Therefore, the Department added additional information and mitigation to the SGEIS, including details about NYSDOH licensing requirements.

New York does not have an operating low-level radioactive waste (LLRW) disposal facility. However, most, if not all, NORM and TENORM wastes generated from development of the Marcellus Shale would not need to be disposed of in such a facility. NORM in solid form could be disposed of in a solid waste landfill, and TENORM could be disposed of in properly permitted out-of-state RCRA C landfills, or in licensed LLRW landfills if concentrations exceed other disposal site acceptance criteria. In addition, controls currently required for solid waste landfills, as well as restrictions the Department has considered on placement locations of the waste within the landfill, limitations on concentrations of radium in the cuttings (no greater than 25 picocuries/gram) and routine testing of landfill leachate for any significant changes in radium concentrations, would significantly reduce potential impacts from NORM content in the cuttings. See above reference to studies by Argonne National Laboratory on oil and gas waste disposal.

The repeated reuse of drilling fluids could potentially generate slight increases in NORM concentration of the fluids, but any increase in concentration would not significantly change the overall NORM content in cuttings being sent for disposal for a number of reasons. First, there is a low amount of liquid allowed in solid waste being disposed of in landfills (minimum 20% solids). Second, the Marcellus Shale is a very "tight" formation with very low permeability and thus low liquid volume per unit of shale. Only a relatively small amount of brine directly in the drill path would be brought up with the drill cuttings. Therefore, the amount of brine present in dewatered cuttings is low in comparison with the liquid component of the drilling fluid as well as the total volume of dewatered cuttings.

As to those comments calling for adherence to EPA remedial guidance concentrations for the disposal of cuttings at landfill, the concentrations that were cited are for cleaning up radium-contaminated sites so that no limits on future use of the sites would exist. These guidance concentrations were, therefore, never intended to apply to a disposal site. In addition, available data shows that radium concentrations of cuttings accepted by New York landfills do fall within those remedial standards. However, applying concentration limits for unrestricted site use is inappropriately restrictive for disposal purposes, particularly when existing or proposed controls would adequately reduce the comparatively low potential risks.

The acceptability of specific regulatory requirements for a single landfill are outside the scope of the SGEIS. However, it can be noted that the SGEIS proposed to require radiation monitors. In fact, permit conditions require landfills accepting Marcellus Shale cuttings to install and properly operate, calibrate and maintain a portal-type radiation monitor located at the weigh scale for incoming trucks. An additional benefit of the requirement is that all incoming waste would be monitored for radiological content.

The imposition of a surety bond requirement for landfills is beyond the scope of the SGEIS. See also above discussion regarding waste classification.

Regarding the estimated radiation exposure to future users of a landfill, the DOE's Argonne National Laboratory has twice modeled the disposal of oil and gas waste in a solid waste landfill. These studies identified landfill worker dose, and not the potential exposure to a future resident farmer, as the limiting exposure pathway. The results indicated that 51 picocuries/gram of radium is the average waste mass concentration that would result in exposure at or in exceedance of the 100 mrem/year limit for a site worker. New York has reviewed these modeling efforts and applies a more conservative average concentration limit of 25 mrem/year in permit conditions for landfills accepting drill cuttings.

5. Potential Environmental Impacts and Mitigation

Water Resources

The Department received numerous comments with respect to the potential impacts from HVHF on water resources (e.g., watersheds, aquifers, fresh groundwater), including specific comments related to water withdrawal for HVHF, stormwater controls, freshwater impoundments, centralized flowback impoundments, and groundwater and water well monitoring. The Department also received comments on the adequacy and availability of disposal options (e.g., publicly owned treatment works, private industrial treatment works, underground injection wells, and roadspreading) for HVHF wastewater, as well as requirements for characterization of HVHF waste. The comments are more fully explained and responded to below.

<u>Comment on General Water</u>

Comments indicated that there have been many serious problems which have already occurred in Pennsylvania and other states and that the results of the contamination caused by HVHF in other states show that the risk is too great to allow practices to go forward. However, other comments argued that the benefits of HVHF outweigh the negative impacts, and therefore, HVHF should be permitted in New York State.

Comments indicated that the SGEIS did not adequately address the potential impacts of HVHF to New York State's watersheds, and that it does not include adequate provisions for the protection of New York State's watersheds. This includes safeguards against: accidental chemical spills into reservoirs and farmland, underground migration to aquifers, rivers, floodplains and streams, and legal and illegal disposal of HVHF waste.

Comments were received indicating that springs serving a residence should be treated as a private water supply and be tested and setbacks be determined to protect all private and public water wells.

Comments indicated that the SGEIS failed to sufficiently evaluate groundwater (including Karst areas) and surface water as potential exposure pathways for injected hydraulic fracturing fluids and mobilized formation waters.

Comments further suggested the need for a thorough surface and groundwater testing program to collect baseline water quality data near proposed shale gas wells before they are drilled.

Comments indicated that the Department should not permit HVHF in New York State until the Environmental Protection Agency has completed its study of the potential impact of HVHF on water resources.

Comments also indicated that the Department should not permit HVHF in New York State due to potential impacts to surface and groundwater resources during high water events.

Additionally, comments expressed the need to consider future climate change. Commenters raised concerns about potential impacts from extreme weather events, including: the risk of spills from areas such as holding ponds for hydraulic fracturing fluids, and limitations on access to well pads, further increasing the risks.

Response to Comment on General Water

Regarding comments on the potential impacts to New York State's watersheds including accidental chemical spills and underground migration, as well as the EPA study, see Responses to the Comments in General Prohibitions; NYC and Syracuse Watersheds; Other Public Drinking

Supplies and 2,000-foot Buffer; and Primary Aquifers and 500-foot Buffer, all in Prohibited Locations. See also Responses to the Comments in Setbacks and Water Resources, both in Potential Environmental Impacts and Mitigation. See Response to the Comment in Well Construction in Potential Environmental Impacts and Mitigation for a discussion of the potential impacts to drinking water supplies related to fluid/gas migration. Regarding the use of springs as a private water supply and the potential impacts from HVHF, see Response to the Comment in Private Water Wells and 500-foot Buffer in Prohibited Locations.

Regarding comments on the potential impacts, including spills, to surface and groundwater resources during high water events see Response to the Comment in 100-year Floodplains in Prohibited Locations, as well as Response to the Comment in Floodplains in Potential Environmental Impacts and Mitigation. See also Response to the Comment in Air Quality and Greenhouse Gas Emissions in Potential Environmental Impacts and Mitigation regarding climate change, generally.

Regarding the appropriateness of monitoring, including groundwater and private water wells, see Response to the Comment in Water Resource in Potential Environmental Impacts and Mitigation.

Regarding incidents in other states, see Response to the Comment in Other.

Comment on Wastewater

The Department received a number of comments indicating that sewage treatment facilities cannot adequately treat flowback water and production brine and that HVHF wastewater impairs the ability of those facilities to adequately treat wastewater. Other comments indicated that New York currently has no facilities, public or private, designed to treat the type and volume of wastewater from HVHF.

The Department received comments indicating that the SGEIS does not adequately describe an environmentally acceptable system for the storage, transport, and disposal of the wastewater from HVHF with the primary concerns including human and environmental exposure to toxic, hazardous or radioactive waste that is stored on-site, transported on public roads and railways, and disposed of at municipal landfills or sewage treatment plants.

A number of comments expressed concern regarding the fact that a percentage of fracturing wastewater does not return to the surface and will be left underground when HVHF is complete, which can potentially contaminate groundwater.

The Department also received comments that indicated that the exact composition of the hydraulic fracturing fluids, flowback, drilling wastewater and production wastewater for each well must be made publicly available.

Response to Comment on Wastewater

Regarding disposal and transport of HVHF wastewater, see Response to the Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation. This response addresses: storage of HVHF wastewater; transport of HVHF wastewater from the well pad; and disposal of HVHF wastewater at either public or private sewage treatment plants.

Regarding potential contamination of groundwater from HVHF fluids not returned to the surface, see Response to the Comment in Well Construction in Potential Environmental Impacts and Mitigation.

Finally, regarding disclosure of the chemicals used in HVHF, see Response to the Comment in Hydraulic Fracturing Information in Permit Process and Regulatory Coordination.

Comment on Definition of Fresh Water and Vertical Separation between the Target Zone and Potable Fresh Water

The Department received numerous comments with respect to potential significant adverse environmental impacts on potable groundwater from HVHF. These comments ranged from supporting the proposed 1,000-foot buffer below the base of a known fresh water supply from HVHF, to questioning the buffer's effectiveness and raising the need for a greater buffer, to arguing that the buffer was unnecessary. Comments also argued that the definition of fresh groundwater utilized in the SGEIS must be revised and expanded to protect groundwater resources recognized at the federal level as potential sources of drinking water from HVHF activities (e.g., the Federal Safe Drinking Water Act (SDWA) definition of an underground source of drinking water (USDW), which indicates 10,000 mg/l total dissolved solids (TDS) is appropriate).

Response to Comment on Definition of Fresh Water and Vertical Separation between the Target Zone and Potable Fresh Water

The SGEIS proposed a site-specific determination of significance for 1) any proposed HVHF where the top of the target fracture zone at any point along any part of the proposed length of the wellbore is shallower than 2,000 feet below the ground surface; and 2) any proposed HVHF where the top of the target fracture zone at any point along any part of the proposed length of the wellbore is less than 1,000 feet below the base of a known fresh water supply. The SGEIS cited existing regulations [6 NYCRR 550.3(ai)], which defined potable fresh water as less than 1,000 ppm TDS or 250 mg/l Chlorides.

The SGEIS proposed, and the Department considered, various levels of mitigation and prohibitions to reduce the potential for significant adverse environmental and health impacts from HVHF on water resources. After review and consideration of comments submitted, the Department has concluded that if HVHF were authorized a separation distance between the depth of the HVHF and the depth of potable groundwater would be appropriate. However, there remains uncertainty as to whether the required separation between the formation and drinking water aquifers proposed in the SGEIS is sufficient; specifically, the current state regulatory definition of fresh groundwater may not be protective of all groundwater resources that may be used as a source of drinking water.

The Department considered requiring specific methodologies for determining the depth to the base of fresh potable water and confirming that all potable freshwater zones are behind the surface casing, including use of geophysical logs in either the uncased surface hole or the drilled intermediate hole up to and including the surface casing seat for the first well on a pad. The Department also considered requiring use of external casing packers on the intermediate string or other means approved by the Department to permanently isolate any potable freshwater zone found below the surface casing seat from deeper, poor-quality water and/or gas-bearing zones.

The Department's water well program includes a database of over 75,000 water wells in New York State. Although rare, there are water wells in the Department's database exceeding 1000 feet in depth. Furthermore, the Department is aware of a number of drinking water wells where the water quality does not meet the regulatory definition of fresh groundwater used in the SGEIS but is used for drinking water. In fact, since 2002, the Department's ambient groundwater monitoring studies, conducted through USGS, have sampled 568 public and private water wells, the majority of which are used for potable supply. Of those, 35 drinking water wells have exceeded one or both of the criteria (TDS and Chlorides) in the definition of fresh groundwater in 6 NYCRR Part 700 - 250 mg/L for Chlorides and 1000 mg/L for TDS. The Department further recognizes that: 1) other states utilize higher values than the definition of fresh groundwater used in the SGEIS; and 2) the SDWA and USEPA define Underground Sources of Drinking Water as those less than 10,000 ppm of TDS. Additionally, only scattered and incomplete information is available on the depth of potable water. In areas of New York State, where the Marcellus Shale play area is shallow, there is uncertainty as to the location of the base of potable groundwater. The potential impacts can be reduced through the imposition of permit conditions requiring an evaluation of the depth of potable groundwater prior to and/or during the initial well drilling at the well pad.

As noted by some commenters, there is also uncertainty regarding the presence of fractures and the extent of the fractures created by HVHF below the base of the potable groundwater. If HVHF were authorized, the Department would require 3-dimensional seismic surveying prior to commencing HVHF or active microseismicity monitoring during fracturing, wherever HVHF was to be conducted in an objective formation the top of which at any point along any part of the proposed length of the well bore is less than 3,000 feet below the ground surface. These mitigation measures would potentially provide the Department with information about the location of existing fractures or abandoned wells and the extent of fractures from HVHF where the impacts to potable water would be more likely.

Unless the No Action alternative is selected, however, the SGEIS would potentially allow subsurface access to gas resources obtained through HVHF under water resources, which could increase the potential of significant adverse environmental and health impacts. There is some uncertainty regarding the possibility that fluids released in the subsurface during horizontal hydraulic fracturing could reach the drinking water aquifers in shallow strata. If these fluids were able to do so, there could be an increase in significant adverse environmental and health impacts. There are several studies currently underway evaluating the potential impacts of HVHF on drinking water resources, but the results of those will not be final for several years. As the Public Health Review concludes "[t]hese major study initiatives may eventually reduce uncertainties regarding health impacts of HVHF and could contribute to a much more complete knowledge base for managing HVHF risks."

Additional information on the potential impacts to groundwater from HVHF can be found in the broader discussion on proper casing and cementing. See Response to the Comment in Well Construction in Potential Environmental Impacts and Mitigation.

There is also uncertainty as to the existence of fractures and/or faults at certain depths within the Marcellus Shale play area. See also Response to the Comment in Seismicity in Geology for further discussion of potential impacts to drinking water supplies related to fractures and faults. See also Response to the Comment in Well Construction in Potential Environmental Impacts and Mitigation for further discussion of the potential impacts related to drinking water supplies related to fluid/gas migration. See also Response to the Comment in Other for further discussion of incidents in other states.

<u>Comment on Water Withdrawals</u>

The Department received numerous comments with respect to potential significant adverse environmental impacts from water withdrawals for HVHF, including the need to use the Natural Flow Regime Method (NFRM) for determining appropriate passby flows in streams. These comments ranged from support for a heightened regulatory program that is widely applied to arguing that water withdrawals should only have to follow the regulations of the Susquehanna and Delaware River Basin Commissions (SRBC and DRBC), in those jurisdictions. The

Department has broken down these comments into three areas and has provided one response to all.

The Department received numerous comments expressing concerns about water withdrawals (surface and groundwater) and depletion of surface and groundwater supplies as HVHF would consume large amounts of water. Comments indicated that increased water withdrawals, including bulk water withdrawals, for HVHF could negatively affect the amount of water available for human, agricultural, industrial, and wildlife uses and that the SGEIS should include a discussion of the potential cumulative impacts on streams and rivers from multiple water withdrawals. Comments further urged that a site-specific EIS be mandatory for all water withdrawals. However, other comments argued that the volume of water for HVHF is insignificant when compared to existing surface water withdrawals for uses such as power generation, agriculture, recreation, and manufacturing. Comments also argued that multiple, large water withdrawals for HVHF from streams would have minimal impact on stream flow and would not deplete water from streams long enough to affect wetlands, fisheries, or downstream users.

Comments questioned how coordination with other jurisdictions (e.g., SRBC and DRBC), which also regulate water withdrawals, would be accomplished. Comments suggested deference to the existing regulations of other jurisdictions, including the identification of appropriate passby flows, is appropriate. However, other comments said New York State should develop its own regulations to address cumulative impacts from groundwater and surface water withdrawals, before permits are issued for drilling, even though the Water Resources Bill was signed into law in 2011. Still other comments questioned how water withdrawals would be regulated outside of the SRBC and DRBC jurisdictions. Additionally, comments stated that New York State should make it a top priority to develop regulatory guidance, as soon as possible, using science-based standards, thresholds, tools, and data to replace reliance on conditions in gas well drilling permits alone.

A number of comments were received questioning the accuracy of the proposed methods (e.g., NFRM) for estimating passby flows at ungaged sites or from water bodies without sufficient historic stream data. Other comments suggested that it would be more appropriate for the

Department to include the NFRM in regulations, as opposed to conditions in gas well drilling permits. Other comments suggested that the New York Streamflow Estimation Tool, which is being developed by USGS, be utilized for permitting water withdrawals, implementing habitat protection, estimating contaminant loads, or determining the potential impact from chemical spills.

Response to Comment on Water Withdrawals

The SGEIS proposed, and the Department considered, various mitigation measures to reduce the potential for significant adverse environmental and health impacts from water withdrawals for HVHF. The SGEIS proposed to require as a condition in gas well drilling permits that applicants identify the source of the water they intend to use in HVHF and report annually on the aggregate amount of water they have withdrawn or purchased. Furthermore, the Department also intended to require that permittees employ the NFRM as a measure to mitigate the potential impacts from water withdrawals for HVHF.

HVHF may have potential significant adverse impacts related to water withdrawals, including bulk water purchased from public water supplies. Water withdrawals from surface water bodies can directly impact aquatic habitats and other water users by the reduction of water volumes and levels. Smaller water bodies will see the greatest visible impact but even small level changes to large water bodies can sometimes be detrimental. Parameters such as stream inflow, usable storage volume, existing withdrawals, evaporation, and precipitation amounts during prolonged drought periods would be used to calculate the amount of water that can be expected to be available for additional withdrawals. This same methodology can be applied to all types of withdrawals, including those to be used for HVHF.

The Environmental Conservation Law and the Department's water withdrawal regulations provide the framework for consideration of the impacts associated with water withdrawal, which could include water withdrawals for HVHF. Application of the regulations and proposed conditions developed for water withdrawal permits, which could include passby flows, would reduce the potential impacts from water withdrawals for HVHF, including cumulative impacts. However, as more fully explained in Response to Comment in Ecosystems and Wildlife in

Potential Environmental Impacts and Mitigation, despite proposed mitigation measures there remains a risk that water withdrawal activities could cause the introduction of aquatic invasive species to particular water bodies. If HVHF were authorized, the Department would require that all water used for HVHF must come from a withdrawal and water source approved by SRBC or DRBC or permitted by the Department. See also Response to Comments on Invasive Species in Potential Environmental Impacts and Mitigation.

New York's Water Resources Law, ECL Article 15, was amended on August 16, 2011 (Laws of New York, Chapter 401) to expand the Department's authority to regulate water withdrawals statewide. The Department adopted water withdrawal regulations in 6 NYCRR Part 601 to implement a water withdrawal permitting program pursuant to the statutory amendments. These regulations became effective on April 1, 2013. These standards and requirements may include: passby flows; fish impingement and entrainment protections; protections for aquatic life; reasonable use; water conservation practices; and evaluation of cumulative impacts on other water withdrawals. Passby flows as determined by methods such as NRFM, are designed to avoid adverse impacts associated with degradation of a water body's best use and reduced stream flow, including impacts to aquatic habitat and aquatic ecosystems. Seasonally variable flows support the needs of the aquatic ecosystem by preserving natural flow patterns throughout the year.

Pursuant to the amended law, the Department has expanded permitting authority for water withdrawal systems with the capacity to withdraw 100,000 gpd or more. This authority applies statewide, including in the Great Lakes Basin. The Great Lakes Compact prohibits, with limited exceptions for public water supply, the diversion of bulk water from the Great Lakes Basin. For example, water in a tanker truck cannot be transported from the Great Lakes Basin to the Susquehanna River Basin.

The Department's water withdrawal regulations include permitting requirements and habitat protection standards that are similar to those imposed by SRBC or DRBC; therefore, the Department proposed to defer to SRBC or DRBC if the withdrawal had already been subject to review and approval by SRBC or DRBC. Several actions would necessitate a water withdrawal permit, including 1) withdrawal from a new or existing source of water or an increase in the volume withdrawn from an existing permitted source, 2) taking or condemning lands for the protection of public water supplies, 3) certain extensions of supply or distribution mains into a new public water supply service area, or 4) non-incidental changes in the use of water withdrawn pursuant to an existing permit. New interbasin diversions that would adversely impact the water quantity of the source basin are prohibited. Through the water withdrawal permitting process, the Department can monitor and protect water quality and quantity by requiring: passby flow; fish impingement and entrainment protections; protections for aquatic life; reasonable use; water conservation practices; aquifer depletion protection; water withdrawal reporting; and evaluation of cumulative impacts on other water withdrawals.

The Department is a voting member of both DRBC and SRBC and is directly involved in the review and approval of all water withdrawals in New York State's portion of the river basins. Through those processes, conditions for water withdrawals are developed and a passby flow is established to mitigate significant adverse impacts to streams faced with the potential degradation of a stream's best use and reduced stream flow, including impacts to aquatic habitat and aquatic ecosystems. The Department adopted water withdrawal regulations at 6 NYCRR Part 601, which allows passby flow requirements to be implemented through permits for water withdrawal outside of the jurisdictions of SRBC and DRBC.

Within the Susquehanna River Basin, water withdrawals require SRBC approval and compliance with a constant-rate aquifer test. Outside of the Susquehanna River Basin, groundwater withdrawals must be approved by DRBC or permitted by the Department. The Department's DOW Recommended Pump Test Procedures for Water Supply Applications (http://www.dcc.ny.gov/lands/5003.html) will be used to evaluate proposed groundwater withdrawals, including those for HVHF. These procedures are equally protective.

<u>Comment on Stormwater</u>

The Department received numerous comments with respect to potential significant adverse environmental impacts from stormwater discharges associated with HVHF. These comments were generally supportive of requiring coverage under a SPDES general permit for stormwater discharges associated with HVHF, but other comments indicated that individual permit coverage is more appropriate, while others argued that no SPDES permit coverage is required at all. Comments also ranged from supporting the proposed stormwater controls for HVHF, to arguing that the proposed controls for HVHF are not adequate, to arguing that the proposed controls for HVHF are unnecessary.

Comments in favor of requiring an individual permit for stormwater associated with HVHF referred to the unprecedented scope and scale of HVHF operations. Others commented that construction of gathering lines, pipelines and compressor stations associated with HVHF should be subject to stormwater controls. Other comments argued that oil and gas extraction-related stormwater discharges are exempt from SPDES requirements (i.e., that no permit should be required), and that the proposed stormwater requirements are too numerous, unnecessarily prescriptive and lacking in flexibility.

Comments suggested that construction associated with HVHF will fragment the landscape, radically reshape land contours, affect surface water networks, increase soil compaction and impervious surfaces, reduce groundwater recharge, alter stream flow, increase stream siltation and water body turbidity and exacerbate flooding. Comments supported the Department's proposed erosion and sediment control measures, and suggested additional stormwater controls be required around drill cutting stockpiles, pit liner spoil areas and chemical storage areas. Other comments stated that the Department's proposed secondary containment, spill prevention and stormwater pollution prevention measures should be included as regulations. Concerns were raised over who would monitor, inspect and enforce the stormwater controls and assess and analyze chemical runoff from HVHF facilities, suggesting there be third-party oversight of all inspections. Comments also suggested that there be a program of surface water quality monitoring in the vicinity of HVHF. Comments recommended justification for the uniform performance requirements for all watersheds, suggesting there ought to be stricter standards for higher quality watersheds. Other comments suggested a catch-all provision to cover unlisted activities conducted as part of HVHF well pad construction.

Response to Comment on Stormwater

HVHF and activities associated with HVHF present significant adverse environmental impacts on water resources if not adequately mitigated. In this regard, the SGEIS proposed the use of a SPDES general permit specific to HVHF (HVHF GP) to reduce the potential risks from both construction and industrial stormwater discharges associated with HVHF.

The SGEIS proposed, and the Department considered, various permit conditions (e.g., best management practices, engineering controls, inspections, monitoring) to reduce the potential for significant adverse environmental and health-related impacts from HVHF on water resources in New York State. After review and consideration of comments submitted, the Department maintains that SPDES permit coverage (either general, if one is in place and the specific activity is eligible, or individual otherwise) is necessary to mitigate the potential impacts from stormwater discharges associated with HVHF, as such activity may be a significant contributor of pollutants to the waters of New York State.

The SPDES permit would address both the construction of well pads and access roads and any associated soil disturbance, as well as provisions to address surface activities associated with HVHF for natural gas development (e.g., gas well drilling, chemical storage). In the SGEIS, the Department proposed SPDES permit conditions, the requirement to develop a Comprehensive Stormwater Pollution Prevention Plan (SWPPP) for the construction and industrial activities, and implementation of both structural and non-structural Best Management Practices (BMPs) to minimize or eliminate pollutants in stormwater.

The Department recognizes the potential impacts that stormwater discharges associated with HVHF may have on water resources. Potential impacts of stormwater associated with the construction of an HVHF well pad include erosion, sedimentation, peak flow increase, contaminated discharge, and nutrient pollution. Potential impacts of stormwater associated with the industrial activities associated with HVHF include contamination from: well drilling and hydraulic fracturing; vehicle and equipment storage/maintenance; vehicle equipment cleaning; fueling and fuel storage; material and chemical storage; chemical mixing, material handling, loading/unloading; and cement blending.

As more fully described in the SGEIS, the Construction SWPPP would address all phases and elements of construction associated with HVHF, including all land clearing and access road and well pad construction. These are all typical construction activities, and as such, if a Construction SWPPP were developed in accordance with the Department's permit conditions and technical standards and adhered to, the potential impacts from stormwater associated with the construction of HVHF well pads would be mitigated. The Department maintains that a SWPPP developed in accordance with these standards, or their equivalent, would ensure erosion controls that are protective of water resources, including related wildlife habitat (to the extent that these standards are properly implemented). However, depending on the level of development, and the unique nature of HVHF, there is a potential, despite these control measures, that there could be cumulative impacts to surface waters where improper implementation leads to sedimentation caused by land disturbances and increased impervious surfaces. See Response to Comment in Cumulative Impacts.

Additionally, the SGEIS explained that the portion of the Comprehensive SWPPP for industrial activities associated with HVHF would address potential sources of pollution which may reasonably be expected to affect the quality of the industrial stormwater discharges associated with HVHF. This would be accomplished through the development and implementation of BMPs and to ensure compliance with the terms and conditions of the SPDES permit. Structural, non-structural and other BMPs would have to be considered in the SWPPP (e.g., secondary containment, good housekeeping, sheltering activities to minimize exposure to precipitation to the extent practicable, preventative maintenance, spill prevention and response procedures, routine facility inspections, employee training and use of designated vehicle and equipment storage or maintenance areas with adequate stormwater controls). Particular monitoring (e.g., visual monitoring and benchmark monitoring and analysis), inspections (e.g., dry weather flow inspections), and recordkeeping associated with HVHF would be required to determine the effectiveness of BMPs and assess SPDES permit compliance.

There are numerous industrial aspects of HVHF, which are exposed to stormwater, that are uncertain in view of the evolving technologies and techniques associated with HVHF, the uncertainties of which are compounded by the fact that, in contrast to construction activities, HVHF has not been conducted in New York State. The Department recognizes the potential impacts from industrial stormwater associated with HVHF to surface water bodies or groundwater from an uncontained and unmitigated surface spill, leak or release of fluids, containing chemicals or petroleum. Specifically, risks associated with improper chemical, petroleum or wastewater handling and transport could result in a degradation of water resources. If HVHF were authorized, the Department would impose a robust set of engineering controls that, in the Department's best professional judgment, would reduce the risk. Even with controls in place, spills and other unplanned events resulting in the discharge of pollutants associated with HVHF, even if relatively remote, would still be likely to occur and could have significant consequences. Given the nature of HVHF, some of the engineering controls and management practices that would be required have not been sufficiently tested for this scale and nature of this activity. Consequently, there remains uncertainty as to whether they would be adequate to prevent spills and other unplanned events resulting in the discharge of pollutants associated with HVHF and mitigate adverse impacts if such an event occurs. Compounding this risk, is the current uncertainty identified by NYSDOH as to the level of risk HVHF activities poses to public health.

In response to the comments received regarding SPDES permit coverage for the construction of gathering lines, transmission pipelines or compressor stations, the SGEIS proposed that the owner or operator of a gathering line, transmission pipeline or compressor station construction project, which disturbs one or more acres of land, be required to obtain SPDES permit coverage, prior to commencing construction. The Department maintains that this is the appropriate regulatory approach. Nonetheless, the cumulative impacts from HVHF development, production and transportation, if HVHF were authorized, and the approval of ancillary pipelines to support HVHF would be significant.

Regarding enhanced requirements for certain watersheds, see Response to the Comment in Water Resources regarding Chesapeake Bay, TMDLs, and other watershed-specific considerations.

Comment on Impoundments

The Department received comments that all freshwater impoundments should be engineered and comply with well-defined requirements, including the Department's existing regulatory programs (i.e., Dam Safety, Protection of Water). Comments also indicated that the Department should consider potential impacts of water lines used to transport water from impoundments to HVHF wells.

The Department also received comments that the use of centralized flowback impoundments should be prohibited in the Susquehanna River Basin.

Response to Comment on Impoundments

Where freshwater impoundments trigger the thresholds for permitting (e.g., construction stormwater, dam safety, protection of waters) in regulations, the Department would require that such permits be obtained prior to the construction of freshwater impoundments. As part of the HVHF GP, the Department proposed detailed requirements for the construction and use of freshwater impoundments. Regarding construction of water lines, see Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation.

Regarding the construction and use of centralized flowback impoundments, see Response to the Comment in Flowback in Potential Environmental Impacts and Mitigation.

Comment on TMDLs

The Department received comments that asserted that HVHF should be prohibited in various watersheds (e.g., New York City, Great Lakes, Upper Susquehanna River, Upper Delaware Scenic and Recreational River, Hudson River, Susquehanna and Delaware River Basins), because of their sensitivity as a drinking water supply, recreational benefits, and/or ecological significance. Comments also argued that the same protections proposed to mitigate potential impacts from HVHF on the unfiltered drinking water supplies should be afforded to other drinking water supplies.

The Department also received comments that the potential impacts (e.g., increased nitrogen, total dissolved solids, and other pollutants) from HVHF in the Susquehanna River Basin, and Chesapeake Bay Watershed area of New York State, were not addressed.

Response to Comment on TMDLs

Regarding setbacks from water resources see Responses to the Comments in General Prohibitions; NYC and Syracuse Watersheds; Other Public Drinking Supplies and 2,000-foot Buffer; Primary Aquifers and 500-foot Buffer; Private Water Wells and 500-foot Buffer; 100-year Floodplains, all in Prohibited Locations. See Responses to Comments in Setbacks; Floodplains; Wetlands; and Water Resources, all in Potential Environmental Impacts and Mitigation. Those responses address prohibitions; development of adequate buffers; uniform protection of all water resources or at the very least all drinking water supplies; vertical separation between potable water and the target formation for HVHF; and subsurface access to gas resources obtained through HVHF.

Regarding potential impacts of stormwater associated with the construction of an HVHF well pad, see Response to Comments on Water Resources in Potential Environmental Impacts and Mitigation. If HVHF were authorized in the portion of the Chesapeake Bay watershed within New York State, the Department would require the design and implementation of enhanced post-construction stormwater management practices in accordance with the Enhanced Phosphorus Removal Standards (Chapter 10) of the New York State Stormwater Management Design Manual.

Comment on Aquifer Protection

The Department received comments in support of protection of all aquifers, whether primary, principal or other, including from subsurface access of natural gas resources. Comments suggested it would be unwise to allow HVHF activities in watersheds with public water supplies. Some suggested upland watersheds be afforded the same protection as hillside areas, and that HVHF activities be banned in tributary watersheds of less than 5 square miles. Others commented that additional studies should be conducted to determine the effects of HVHF on drinking water supplies. Other commenters argued that the 500-foot buffer is arbitrary and that a more scientifically sound approach to aquifer protection is required. Comments suggested that water from aquifers not be allowed for use in HVHF activities. Comments argued HVHF is not unique because any form of energy extraction has the potential to harm the environment. Comments suggested that both the Department of Health and DEC develop effective, comprehensive monitoring programs, and that all water well testing should be publicly available. Comments suggested principal aquifer mapping at 1:24,000 scale be implemented, including mapping of artesian pressure, regional and site-specific fault mapping. Other comments stated that mapping of all abandoned and other wells within a certain radius of a horizontal well bore be required. Comments raised concerns with HVHF operations including: improperly constructed wells; gas migration; problems with disposal of flowback water, drill cuttings, cutting fluids and production brine; accidental spills and pollution of surface waters; repeated road application of production brine; accidents in transport; illegal dumping; well blowouts; and flooding on well pads.

Response to Comment on Aquifer Protection

Regarding protection of water supplies, including Primary and Principal Aquifers, adequacy of buffers, aquifer mapping, and the potential impacts from subsurface access to natural gas resources, see Responses to Comments on General Prohibitions; NYC and Syracuse Watersheds; Other Public Drinking Supplies and 2,000-foot Buffer; Primary Aquifers and 500-foot Buffer; Private Water Wells and 500-foot Buffer, all in Prohibited Locations. See Responses to Comments in Setbacks; and Water Resources, all in Potential Environmental Impacts and Mitigation.

Regarding the potential impacts associated with HVHF within floodplains, see Response to the Comment in 100-year Floodplains in Prohibited Locations, as well as Response to the Comment in Floodplains in Potential Environmental Impacts and Mitigation.

Regarding the potential impacts from water withdrawals associated with HVHF, see Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation.

Regarding the appropriateness of monitoring, including groundwater and private water wells, see Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation.

Regarding disposal of flowback water, see Response to the Comment in Flowback in Potential Environmental Impacts and Mitigation, as well as Response to the Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation.

See Response to the Comment in Well Construction in Potential Environmental Impacts and Mitigation for a discussion of the potential impacts related to drinking water supplies related to fluid/gas migration.

See Response to the Comment in Transportation in Potential Environmental Impacts and Mitigation regarding potential impacts from traffic and accidents.

See Response to the Comment in Hydraulic Fracturing in Potential Environmental Impacts and Mitigation regarding abandoned oil and gas wells.

Comment on Well Testing and Groundwater Monitoring

Comments received by the Department suggested that testing be required for all groundwater, surface water, residential and municipal water sources, and springs used to irrigate crops and water livestock, at distances ranging from 1,000 to 10,000 feet. However, other comments argued that the proposed water well testing program would create inordinate burdens for gas well operators and that water contamination concerns are unreasonable due to lack of evidence linking drinking water contamination to HVHF. Comments suggested that water well testing parameters be expanded to include all chemicals used for HVHF and constituents of HVHF wastewater. Other commenters suggested that monitoring requirements account for abandoned wells in NY State. Comments suggested that regular (e.g., weekly, monthly, quarterly or annually) monitoring of nearby water wells should be conducted during and following HVHF operations (suggested distances included from 1,000 feet to 5,000 feet to 50 miles from edge of well pad). Other comments argued that the newest testing technologies be required when monitoring and that the operator be required to create a contaminant flow path model.

Response to Comment on Well Testing and Groundwater Monitoring

The SGEIS proposed that testing be conducted of private water wells located within 1000 feet of the HVHF well pad for representative parameters associated with HVHF. In this respect, the SGEIS explicitly recognizes the potential for significant impacts from HVHF, including impacts caused by spills, to water resources, such as private water wells. As discussed more fully in Response to the Comment in General Prohibitions in Prohibited Locations and Setbacks in Potential Environmental Impacts and Mitigation regarding aquifer protection, there is uncertainty regarding the level of protection that would be achieved by some of the proposed mitigation measures, as well as buffers. In the event that HVHF were authorized, the Department would require a comprehensive groundwater monitoring program around HVHF well pads, to detect releases of contaminants should they occur, with monitoring requirements reflective of the amounts and types of chemicals used on the HVHF well pads.

In light of the potential for groundwater impacts, groundwater monitoring adjacent to a well pad would reduce the risk associated with HVHF activities. Groundwater monitoring and sampling would provide the Department with one means of obtaining data that can be used to demonstrate the effectiveness of the implementation of any proposed best management practices, provide advance notice of potential exposures, and alert both operators and the Department to the need to take remedial or other response actions promptly. Groundwater monitoring must account for the site-specific hydrology and nearby use of potable water.

See Response to the Comment in Hydraulic Fracturing in Potential Environmental Impacts and Mitigation regarding abandoned oil and gas wells.

See Response to the Comment in Well Construction in Potential Environmental Impacts and Mitigation for a discussion of the potential impacts related to drinking water supplies related to fluid/gas migration.

Regarding disposal of flowback water, see Response to the Comment in Flowback in Potential Environmental Impacts and Mitigation, as well as Response to the Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation.

Well Construction

Comment: The Department received many comments on the SGEIS expressing concerns about potential significant environmental impacts associated with HVHF well construction (e.g., fluid migration from HVHF, abandoned wells, fissures, faults, springs, casing and cement failures, drilling into zones of Hydrogen Sulfide). Comments also were received regarding the number of required well casings, construction of such well casings, adequacy of cement plugs, failure of well casings, and methane leakage underground and into the atmosphere. The most common concern on this topic related to the perceived inability of casings and cement to isolate fully fluids in the well and keep them from entering and harming the environment. Comments also questioned whether 250 ppm sodium chloride or 1000 ppm total dissolved solids should be used to mark the base of fresh water, and about other potential impacts of HVHF on fresh water. Several comments also suggested that the Department require one week or more to pass between the time that cementing has been completed and the commencement of pressure testing.

However, other comments on these issues reflected a belief that the protective measures in existing and proposed regulations, together with other mitigating measures proposed in the SGEIS would provide adequate mitigation of environmental and public safety concerns.

The Department also received comments related to the handling of rock cuttings from drilled wells, some suggesting a closed-loop tank system should be used if it cannot be demonstrated that an acid rock mitigation plan will be effective in mitigating all heavy metals and other toxic substances encountered in the drill cuttings. In this regard, comments argued lined reserve pits should not be used until tests show that there will be no human or environmental impact from NORM or other contents of the drill cuttings or that reserve pits should not be allowed at all. Comments contended that the only means of properly disposing of cuttings was by disposing of them in a Part 360 solid waste facility or a Part 380 (Prevention and Control of Environmental Pollution by Radioactive Materials) radioactive materials management facility. Comments also argued that there should be an analysis of runoff from cuttings brought to landfills.

Comments argued that blow-outs should not be considered “acceptable collateral damage” and raised concerns as to the adequacy of proposed requirements for blow-out preventers.

Comments argued that the Department should address casing perforating and related yield stimulation practices, which involve the use of explosive compounds and processes. Some comments suggested that supplied materials, including sand, must be tested and certified to assure no contaminants are imported into the State.

Comments regarding plugging and abandonment of HVHF wells were also received, including that the Department should impose more stringent procedures than those currently found in regulation, limitations on HVHF well pad size, and a plan for decommissioning an HVHF well/reclamation of the HVHF well pad, and that there should be clarity on the liability for potential damages resulting from an improperly plugged HVHF well. Relatedly, comments suggested that the location and depth of wells, other than those for HVHF, that have been abandoned need to be documented. Also, comments sought further clarity for defining a sufficient basis for temporary abandonment and revisiting such in the circumstances where the mineral rights change hands.

Comments asserted that the location of faults and fissures is unknown, creating a high risk of contamination of water resources from fluid migration from HVHF through these faults and fissures.

Comments also questioned the use of data from the American Petroleum Institute, or other sources, arguing an inherent conflict of interest.

Response: The Department acknowledges that there is the potential for significant adverse environmental impacts stemming from well construction if not done properly and in accordance with stringent standards. In the event that the SGEIS' well construction prescriptions are followed, there is little likelihood of vertical migration of hydraulic fracturing fluids through the wells based on the nature of the activity and geological aspects of the formation being targeted.

Sufficiency of As-Built Wellbore Construction

If HVHF were authorized, it is generally not expected that fluids and gases would migrate upward through existing natural fractures because fractures do not typically extend continuously, without interruption, from the deep shale producing formations to the surface. Migration through natural fractures would be further inhibited as such fractures can be filled with fluid or not likely to be open (have sufficient aperture to transmit fluids) due, in part, to natural mineralization. Nor would there be sufficient pressure at depth to overcome capillary forces. Further, there would be a pressure sink at the well during flowback and production operations; fluids would be drawn toward the wellbore and up the casing to the surface for recovery. Natural gas migration through natural fractures is also unlikely for the same reasons. Natural gas migration from the target formations through boreholes is also unlikely due to stringent casing and cementing requirements. However, as discussed below, notwithstanding the proposed SGEIS' oversight and construction standards, there may be limited circumstances in which the casing does not achieve its desired protections due to improper installation. Thus, in the event that these wellbores are improperly installed and inspected there is a possible increased risk of fluid and natural gas migration. "Studies have found evidence for underground migration of methane associated with faulty well construction." Public Health Review. See Response to Comment in Incidents in NY and Other States in Other for a discussion of incident in the Town of Freedom, NY where human error led to the migration of methane to the shallow subsurface, including nearby water wells.

In light of these risks, the SGEIS proposed and the Department considered numerous mitigation measures. Mitigation measures include setbacks, and wellbore construction requirements. See Responses to the Comments in Setbacks in Potential Environmental Impacts and Mitigation. The SGEIS proposed to require a site-specific SEQR review for: (1) any proposed HVHF well where the top of the target formation at any point along any part of the proposed length of the wellbore would be shallower than 2,000 feet below the ground surface; and 2) any proposed HVHF well where the top of the target formation at any point along any part of the proposed length of the wellbore would be less than 1,000 feet below the base of a known freshwater supply. The Department also considered a requirement for a third cemented string (i.e., intermediate casing) of casing, in most cases, to address concerns over migration of fluids and gas into aquifers, to provide additional pressure control and to provide an additional level of protection. Intermediate casing would not be required if it could be shown that environmental protection and public safety would not be thereby compromised.

All surface, intermediate and production casing run in a well must meet the Department's Casing and Cementing Practices (SGEIS Appendix 8) and conform to American Petroleum Institute Specification 5CT, Specifications for Casing and Tubing (April 2002). If an incident such as flow behind casing is identified, the Department has the authority to require immediate cessation of operations and corrective action. Cement must conform to specifications and standards, including American Petroleum Institute Specification 10A, Specifications for Cement and Material for Well Cementing (April 2002 and January 2005 Addendum). Conformance with American Petroleum Institute Specifications is an accepted well drilling standard.

Current requirements for running centralizers on surface casing would remain in effect if HVHF were authorized. Appendix 10, Proposed Supplementary Permit Conditions, which include a requirement for additional centralizers for certain casing strings, apply to HVHF operations and would be required in addition to current casing and cementing practices for all wells in New York.

Abandoned gas wells in proximity to HVHF wells may have the potential to provide pathways for the migration of fluids and gases from the drilling of HVHF wells nearby. The Department considered enhanced protections for HVHF wells to reduce the conditions that could lead to fluid migration during fracturing. The program depends on accurate identification and evaluation of the existing abandoned wells in the vicinity of HVHF. To the extent that such information is unavailable or infeasible to collect there exists uncertainty as to the adequacy of the proposed enhanced mitigation measures. The SGEIS proposed to require that the operator consult the Department's Oil and Gas database as well as property owners and tenants in the proposed spacing unit to determine whether any abandoned wells are present within the spacing unit (and considered extending this to one mile as a further precaution). If (1) the operator has property access rights, (2) the well is accessible, and (3) it is reasonable to believe based on available records and history of drilling in the area that the well's total depth may be as deep or deeper than the target formation for high-volume hydraulic fracturing, then the SGEIS would require the operator to enter and evaluate the well, and properly plug it prior to high-volume hydraulic fracturing if the evaluation shows the well is open to the target formation or is otherwise an immediate threat to the environment. This protocol was established based on best professional judgment to reduce potential impacts from abandoned wells as uncontrolled pathways between gas bearing formations and aquifers.

To address the concern regarding shallow gas occurrence, the requirement to document all naturally occurring methane during drilling of the conductor and/or surface hole was considered. If HVHF were authorized, prior to the drilling of a well, shallow gas would be delineated by an evaluation of known geology of an area and proximal borings including water wells, and oil and gas wells. Current casing and cementing practices attached as conditions to all existing oil and gas permits would require that surface casing shall not extend into zones known to contain shallow gas. These conditions would apply to HVHF well permits, if HVHF were authorized. In addition, the SGEIS would require the running and cementing of intermediate casing to provide an additional barrier between aquifers and shallow gas-bearing formations. The operator would be required to wait on cement (WOC) until the cement achieves a calculated compressive strength of 500 psig and a minimum of 8 hours before the casing is disturbed in any way. The operator could request a waiver from the WOC time if it had bench tested the cement batch and blend used for the cement job and determined the cement has reached a compressive strength of 500 psig prior to reaching the full 8 hours.

New oil and gas wells are constructed to prevent leakage, and as-built construction would be tested and verified through pressure testing and certain logging techniques, and subsequent analysis prior to HVHF. If HVHF were authorized, the Department would impose a robust set of engineering controls that, in the Department's best professional judgment, would significantly reduce the risks associated with well construction. The Department acknowledges that there is the potential for wells to be constructed improperly or not installed in accordance with all applicable specifications. Consequently, the risk of failure or leakage would not be eliminated and could have significant consequences.

In this regard, the SGEIS discusses non-routine incidents that have occurred. See Response to the Comment in Other regarding incidents/environmental problems in other states. It is recognized that some problems have occurred due to inadequate well construction and fluid control measures, such as gas migration and fracturing fluid release at the surface.

Compounding this risk, is the current uncertainty identified by NYSDOH as to level of risk HVHF activities pose to public health.

However, if HVHF were authorized, operators would be required to monitor well integrity throughout the life of the well and perform work over operations, when needed, to maintain proper well performance. Department staff would also perform post-drilling inspections to assess the condition of casing, the wellhead and other equipment over the life of the well(s) to ensure the integrity of the operation and to protect the environment.

BOPs/Safety

The blowout control system and its use are discussed throughout the SGEIS. If HVHF were authorized, any drilling and /or completion operation would have to be performed in accordance with a Department-approved BOP Use and Test Plan. Pressure testing of the BOP system would have to be conducted in accordance with API Recommended Practice (RP) 53, RP for Blowout Prevention Systems for Drilling Wells. During any operations when a BOP is installed, tested or in use, the operator or operator's designated representative must be on site and have a current well control certification.

Well Pads

The dimensions of the project site, including the access road and well pad, dictate how much topsoil would be disturbed. The average size of a multi-well pad during drilling and hydraulic fracturing is estimated at 3.5 acres. The average production pad size after partial reclamation is estimated at 1.5 acres.

Only a single access road and gas gathering system would serve the multiple-well pad. While it is true that a multi-well pad would mean that the larger footprint of the pad would be maintained longer than a single well pad, the Department considered requiring partial reclamation of the well site after completion of the last well on the pad. See Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation regarding potential adverse environmental impacts from stormwater associated with the construction of well pads for HVHF. In addition, well sites would be reclaimed prior to any re-fracturing, thus reducing impacts associated with the industrialization of landscapes. See Response to the Comment in State Owned Lands in Prohibited Locations regarding impacts of multiple-well pads.

Hydrogen Sulfide

As to the presence of hydrogen sulfide (H_2S) in Marcellus Shale wells in New York, it cannot be predicted accurately because the shale has not yet been developed by HVHF. Nevertheless, based on drilling results in neighboring Pennsylvania, the Department does not expect the occurrence of hydrogen sulfide to be significant. In the event H_2S is detected in any portion of the wellbore, all regulated activities must be conducted by the operator in conformance with American Petroleum Institute Publication API RP49, "Recommended Practices for Safe Drilling of Wells Containing Hydrogen Sulfide."

Cuttings/flowback fluids

A cuttings disposal plan is one of the required attachments specified in the Proposed EAF and must be approved by the Department before issuance of a permit. Leachate from cuttings at a solid waste disposal site would be addressed by Part 360 regulations. See Responses to Comments in Hydraulic Fracturing Information in Permit Process and Regulatory Coordination, as well as Responses to Comments in Waste Transport and Disposal and Flowback Water both in Potential Environmental Impacts and Mitigation.

Drilling and fracturing fluids, mud-drilled cuttings, pit liners, flowback water and production brine are classified as non-hazardous industrial-commercial waste which could be hauled under a New York State Part 364 waste transporter permit issued by the Department. The Department recognizes that horizontal wells produce significantly more drilling and fracturing fluids, cuttings, flowback water and production brine, and result in an increase in the duration of use of pit liners. This increase consequently creates greater waste disposal impacts, including the risk of inadequate disposal options and the likelihood of spills from accidents occurring during the transportation of this waste. See Response to Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation.

If HVHF were authorized, cuttings from drilling processes which utilize only air and/or fresh water could be disposed of at either C&D debris landfills or municipal solid waste (MSW) landfills, while cuttings from drilling processes which utilize any oil-based or polymer-based products with mineral oil lubricant could only be disposed of at MSW landfills. Onsite burial of cuttings would be limited to cuttings drilled using air or fresh water.

If HVHF were authorized, an Acid Rock Drainage (ARD) mitigation plan would be required to address pyrite-rich cuttings from the basal portion of the Marcellus Shale. Pyrite is an iron sulfide mineral, and it is the sulfide component, not the iron (metal), that is the source of potential acidification of groundwater through the creation of sulfuric acid. In addition, the Department would impose other testing requirements on these cuttings on a case-by-case basis, as deemed necessary. Such testing could include verification that levels of radioactivity do not exceed area background NORM levels. The ARD mitigation plan for each HVHF well pad would be provided to the Department prior to permit issuance for review as part of the evaluation of the application. Only ARD mitigation plans that do not require long-term monitoring would be acceptable.

Methane Releases

Duke University released a report showing that there were substantially higher methane levels in wells that were in close proximity to HVHF operations than in areas that were farther away from such operations. The mitigation measures described in the SGEIS and those considered by the Department are expected to reduce this impact.

Abandoned Wells

In cases in which the operator does not own or have access rights to any abandoned well, the mineral interest owner would be responsible for the plugging of the well under ECL § 23-0305(8)(e) and 9(e). The Department would not issue a gas well drilling permit unless it could be demonstrated that no abandoned well is a threat to the environment during nearby HVHF operations. The SGEIS proposed to require that operators determine whether any abandoned wells are present in the proposed spacing unit. However, the exact location and depth of abandoned wells is not fully catalogued and this makes it difficult in some cases to ensure that all abandoned wells are identified, which may lead to significant potential adverse environmental and health impacts.

Plugging and Abandonment

The SGEIS specifically outlines what measures the operator would be required to take when a well's productive life is over. Regulations at 6 NYCRR Part 555, the 1992 FGEIS and Department-issued plugging permits provide for the protection of groundwater, surface water bodies and soil. Reclamation (restoration) of a well site involves the rehabilitation of the disturbed area to make it acceptable for designated uses. This includes re-grading, replacement of topsoil, and re-vegetation necessary to restore the surface. Reclamation and plugging and abandonment are separate operations.

Current regulations and previously proposed changes to 6 NYCRR Part 555, and the 1992 FGEIS include requirements for the plugging of a well. A description of the plan for final reclamation must be submitted and approved by the Department.

See Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation regarding potential adverse environmental impacts from stormwater associated with the construction of well pads for HVHF.

Base of Fresh Water

As discussed in Response to Comment in Water Resources in Potential Environmental Impacts and Mitigation, the Department is aware of a number of drinking water wells where the water quality does not meet the regulatory definition of potable groundwater used in the SGEIS but the well is nevertheless used for potable purposes. Additionally, only scattered and incomplete information is available on the depth of potable water. In areas of New York State, where the Marcellus Shale play area is shallow, there is uncertainty as to the location of the base of potable groundwater, as well as the presence of fractures and the extent of the fractures created by HVHF below the base of the potable groundwater. If HVHF were to proceed generally, the Department considered requiring 3-dimensional seismic surveying prior to commencing HVHF or active microseismicity monitoring during fracturing, wherever HVHF is to be conducted where the top of the objective formation at any point along any part of the proposed length of the well bore is at a depth less than 3,000 feet below the ground surface. These measures would potentially provide the Department with information about the location of existing fractures and the extent of fractures from HVHF and an opportunity to reduce potential impacts to aquifers and potable groundwater from fractures and faults.

Conflicts of Interest

ICF International, under its contract with NYSERDA, analyzed American Petroleum Institute data in its assessment of the risk of hydraulic fracturing fluids reaching underground sources of drinking water. IOGA-NY is an association of independent oil and gas exploration and development companies, and the Department sought their collective experience as well as information from other interested parties–but also relied upon its own experience and the experience of other state regulatory agencies.

Non-routine Incidents

Any non-routine incident such as a blow-out is taken seriously by the Department. Under the existing and the proposed HVHF regulatory program, an operator would be required to file a non-routine incident report within a specified time frame and Department staff would investigate the incident and consider the need to require immediate cessation of operations and corrective action. See Response to Comment in Other regarding incidents and problems in other states.

Hydraulic Fracturing

Comment: The Department received numerous comments related to the process of hydraulic fracturing operations in general, and perceived problems that process would create. Some identified reported problems in other locations where HVHF has been conducted. Some commenters expressed the view that HVHF had generally been conducted safely elsewhere, and could be conducted safely in New York under the measures proposed in the SGEIS.

General

Numerous commenters expressed general concerns about the training of HVHF operators and the potential for accidents. Comments asserted that the process should be covered by a "six sigma," and/or similar, quality process that is used by many industries. Other comments stated that the SGEIS analysis assumes that all of the exposure pathways and potential impacts from hydraulic fracturing chemicals are known, but suggested that this may not be the case. One comment argued that a study of all wells hydraulically fractured since 1821 should be included in the SGEIS.

HVHF Operations

Many comments stated that HVHF operations would have an unacceptably adverse impact on the use of the land surface near wells, as well as on surface and ground waters. Comments contended that operators who apply for a well permit with HVHF proposed should be required, some suggested, to submit detailed rock mechanics calculations that include fluid pressures, hydraulic fracturing fluid composition, fracturing schemes, and anticipated final fracture number and length to the Department before obtaining a permit, and this information should be made available to all landowners who might be affected by it.

One technical comment noted that HVHF pumping rates could vary from well to well; that operators have reported pump rates in excess of 3,000 gpm, while the rdSGEIS was perceived to have used that value as an upper bound. Another noted that the 2009 draft SGEIS mentions distances of 4,000 and 4,500 feet as typical for horizontal wellbores, but that there was no discussion regarding longer wellbores. Some were concerned that it is not clear how the driller would know when the rock has been fractured. Comments contended that fractures resulting from HVHF operations would extend beyond areas intended to be fractured, and that there were insufficient controls on locations of HVHF treatment and seismic monitoring wells.

Many were concerned that HVHF operations would, as a result of the required high pressures, induce seismic events. Some relied on MODFLOW-2000, a computer program that predicted high rates of movement of contamination in the ground. Others desired that the Department require HVHF operators to submit additional information, including about surface logistics at HVHF sites, microseismic monitoring, chemical storage and transport and monitoring wells.

Other States

Many commenters expressed concern about how HVHF operations have been conducted in other states, including Pennsylvania. Others stated that EPA had expressed concerns about certain other states' regulation of HVHF, including the drilling of multiple wells from one pad.

Fluids in ground/flowback

Comments also asserted that the hydraulic fracturing process would likely leave potentially toxic water below ground that could infiltrate private wells and aquifers. Some comments focused on the idea that the timeframe for active monitoring of HVHF operations is only a handful of years, and that very long-term monitoring, perhaps centuries, would be required before an analysis could be relied upon. Other comments encouraged the Department to consider requiring the addition of a tracer on all HVHF wells.

Some commented that the volume of fluids used to stimulate any particular well, as well as the volume of fluids coming out if it, must be subject to more certain and rigorous identification. In this respect, some comments asserted that flowback water disposal should be more precisely delineated, and questioned New York's capacity to handle brine. Other comments urged the Department to require the use of recycled flowback water for future HVHF operations.

Proximity to Mines

Commenters were concerned that HVHF operations near existing mines could result in migration of fluids and contamination to those mines and thence to groundwater and/or the surface.

Secondary Containment/Spills of HVHF Fluids

Some comments suggested that secondary containment requirements proposed in the SGEIS were inadequate to address potential impacts associated with HVHF. Other comments stated that

Large Diesel Fuel Tanks must be subject to the same regulations applied to all stationary fuel tanks.

Response: The Department recognizes that there is the potential for significant adverse environmental impacts from the release of fracturing fluid or production brine if not properly mitigated or avoided.

General

If HVHF were authorized, certain risks posed by HVHF operations would likely be encountered from spills and other potential exposure events. In this regard, if an actual contamination event, such as a spill, were to occur, more specific assessment of health risks would require obtaining detailed information specific to the event. ECL Article 23, the SGEIS and proposed permit conditions include non-routine incident handling requirements. In addition, the operator would be required to provide the Department with an Emergency Response Plan for the reporting of non-routine incidents, including spills.

As further mitigation, the Department considered requiring the well permittee to have a groundwater monitoring program to detect any releases of contaminants. The monitoring of wells would provide the Department with objective data to determine the effectiveness of the mitigation measures. See Responses to the Comments in Enforcement for a discussion of enforcement generally, as well as Water Resources in Potential Environmental Impacts and Mitigation regarding groundwater monitoring. This proposed measure, however, confirms that there is some level of uncertainty surrounding this activity and explicitly acknowledges the potential for releases and their potential impacts. NYSDOH's Public Health Review stated that "at a minimum, there must be sufficient information to understand what the likely public health risks will be" before allowing HVHF to proceed in New York. Applying that principle here, the Department believes that there is insufficient information to fully comprehend the effectiveness of the mitigation measures, and consequently, assessing the level of impacts is equally difficult.

Hydraulic fracturing was developed in the 1950s, and it is estimated that 90% of wells drilled in New York since its use became widespread have been hydraulically fractured. However, the SGEIS pertains to HVHF, which would be new in New York, and therefore reviewing all wells that have been subject to conventional hydraulic fracturing operations in New York would not necessarily provide sufficient information to better understand the likely public health risks associated with HVHF, nor the effectiveness of the proposed mitigation or the potential impacts.

HVHF Operations

Training and certification of drilling personnel is the responsibility of the well operator or their subcontractors. The International Association of Drilling Contractors, among others, provides accredited training programs for drilling crews with a focus on safety and well control. Required pressure testing of hydraulic fracturing equipment would identify leaks and mechanical problems prior to introducing additives to the wellbore. Moreover, if HVHF were authorized, the proposed Supplementary Permit Conditions would require an operator to make and maintain a complete record of the hydraulic fracturing operation, including types and volumes of materials pumped into the well, pumping pressures and flowback rates and volumes. The Department would also require at least two vacuum trucks, each with a capacity specified by the Department to be on standby at the well site. These measures, as well as numerous Supplementary Permit Conditions in the SGEIS, are designed to prevent accidental releases, promptly identify leaks when they occur, and reduce overall risks.

With respect to the development of a well pad and drilling operation, a multi-well pad, where HVHF would be used, is larger than a conventional well pad in order to accommodate fluid storage and equipment needs associated with the fracturing operations. The number of rigs that may be present on the pad at any given time is not a major factor in the design or preparation of the pad. Furthermore, the factors that determine an optimal drilling pattern include formation depth and thickness, production experience in the area, and topography or surface restrictions. The SGEIS recognizes that operators may propose other, longer or more complex patterns. In this regard, the Department did not propose to limit the length of a horizontal wellbore. In Chapter 5, lateral distance drilled normally is described as exceeding 2,000 feet and the chapter also notes that lateral distance would most likely exceed 4,000 feet. The bottomhole assembly of the drill pipe is equipped with sensors that continuously record and report the drill bit's location. In addition, if HVHF were authorized, developing multiple formations from a common well pad should be encouraged, as it reduces the overall surface footprint. However, there is not enough information to estimate the frequency of re-fracturing operations, if HVHF operations were authorized.

HVHF operators would consider various factors such as thickness, depth and the geochemical properties of the shale before making a decision on where to drill. Regardless of the thickness of the target formation, hydraulic fracturing would be designed with the intention to stay within the confines of the gas-bearing reservoir. Throughout the hydraulic fracturing process the service company monitors the pump pressures, volume of fluids and amount of proppant pumped into the well. Once the strength of the formation is exceeded and the rock begins to fracture, the pump pressure decreases. Microseismic monitoring is an analytical tool used to evaluate, guide and control HVHF. The Department notes that it is in the operator's best interest to monitor the hydraulic fracturing operation to ensure the induced fractures are propagated in the desired direction and distance. Indeed, fractures that propagate beyond the target formation would be detrimental to gas recovery operations.

The SGEIS discusses the submission of information pertaining to the hydraulic fracturing procedure. If HVHF were authorized, all operators would be required to report all formations penetrated and depths and estimated flow rates of any fresh water, brine, oil and/or natural gas on the Well Drilling and Completion Report. The operator would also be required to maintain a complete record of the hydraulic fracturing operation and provide such to the Department upon request during the period up to and including five years after the well is plugged and abandoned, or in the case of a multi-well pad, the period up to and including five years after the last well on the pad is plugged and abandoned. The Department currently conducts, and would conduct for HVHF wells, if it were allowed to proceed, a pre-drilling site inspection prior to permit issuance for every well pad site. Permit issuance would be limited to match the Department's resources. Further protections would be afforded through a monitoring system. Monitoring wells can be existing boreholes or new wells. The minimum distance between the treatment well and seismic monitoring well(s) should be no greater than approximately 2,500 feet. Construction standards in the SGEIS and regulations apply to all wells, including seismic monitoring. Moreover, throughout the hydraulic fracturing process the service company monitors the pump pressures, volume of fluids and amount of proppant pumped into the well.

The Department also proposed and considered measures to reduce the risk from chemical and waste transportation. The Department proposed to require that a Drilling and Production Waste Tracking Form be completed and maintained by generators, haulers and receivers of certain wastes associated with activities addressed by the SGEIS. For discussion on potential impacts from waste transportation see Response to the Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation.

The sand (proppant) used in the operation is stored within the enclosed equipment and sand trucks. The sand contained in these steel vessels is never exposed to the outside. Moreover, a discussion of on-site storage and handling of hydraulic fracturing additives is included in the SGEIS. The storage time is generally less than a week and materials are not delivered until fracturing operations are set to commence. The pouring of dry additives into the feeder is of short duration and not likely to pose an airborne risk.

Fracturing chemicals are transported to well sites in totes which are designed to avoid exposure pathways, even during transportation accidents. Totes are accessed by hooking up piping directly to the container, making it unnecessary to handle any of the material in concentrated form, to attempt to eliminate any exposure pathway to the concentrated material. Personal protective equipment worn by service company personnel would help prevent exposure to chemicals during the hydraulic fracturing operations. Safety warnings and emergency response information are contained within the fracturing product Material Safety Data Sheets.

Other States

With respect to concerns expressed about HVHF operations in Pennsylvania, the SGEIS provides a description of the relevant incidents in Pennsylvania and corresponding mitigation measures that New York State would impose. For example, the Casing and Cementing Practices and Supplementary Permit Conditions contain mitigation measures designed to reduce the risk of gas migration as occurred in incidents in Pennsylvania.

As more fully explained in the Public Health Review, EPA's most recent analysis of the potential impacts of HVHF on drinking water resources only began in 2011 and is not expected to be completed, with peer review, until 2016. "[T]he relationships between HVHF environmental impacts and public health are complex and not fully understood." Public Health Review. Further study of operations in other states could provide information that could lead to additional effective mitigation measures. See also Response to the Comment in Other regarding a description of "incidents" in New York and other states.

Fluids in ground/flowback

As discussed above, the Department proposed and considered robust monitoring requirements that would identify leaks or spills. Consequently, the Department did not consider it would be necessary to require a tracer on all HVHF wells if HVHF were allowed to proceed. However, the Department could require the addition of a tracer on a site-specific basis if conditions warrant such a requirement.

A 9 to 35 percent flowback range has been reported by numerous sources reporting on the initial percentage of flowback from Marcellus wells. Recycling and reuse is generally encouraged by the Department and operators have indicated that they planned to maximize reuse of flowback water if HVHF were authorized in New York. However, on-site processing of hydraulic fracturing fluids and reuse may not always be practical. Flowback water returns to the ground surface through the wellbore in a controlled process, and for wells covered by the SGEIS, would be directed to watertight tanks. Fluids would have to be removed no later than 45 days after completion of drilling and stimulation operations at the last well on the pad. Moreover, regardless of the actual volume of production brine, operators will use one or more brine tanks to store the brine until it can be trucked off location. See Response to the Comment in Waste Tracking and Disposal in Potential Environmental Impacts and Mitigation.

Proximity to Mines

Existing regulation, 6 NYCRR 552.4, Permit in Mining Area, contains certain provisions for mine operators to receive advance notice of any oil or gas well operation that may affect the safety of such underground mining operation.

Secondary Containment/Spills of HVHF Fluids

Secondary containment for hydraulic fracturing containers, additive staging areas and flowback tanks is discussed in Chapter 7 of the SGEIS, and would be required by the Proposed Supplementary Permit Conditions. The SGEIS also requires that fluid transfer operations from tanks to tanker trucks be manned at the truck and at the tank if the tank is not visible to the truck operator. However, due to the unique nature of HVHF there is uncertainty as to the degree of protection afforded by such mitigation measures to prevent, contain and discover spills early so that the spills can be addressed before threatening any water resources.

NYSDOH recognizes that exposure to chemicals used in HVHF can present a risk to public health. "The number of well pads and associated HVHF activities could be vast and spread out over wide geographic areas where environmental conditions and populations vary. The dispersed nature of the activity magnifies the possibility of process and equipment failures, leading to the potential for cumulative risks for exposures and associated adverse health outcomes. Additionally, the relationships between HVHF environmental impacts and public health are complex and not fully understood." Public Health Review. See Responses to Comments regarding Health Impacts, as well as the General Prohibitions in Prohibited Locations and Setbacks in Potential Environmental Impacts and Mitigation for further discussion about potential significant adverse environmental and health impacts from spills and/or releases from HVHF.

Fracturing Fluid and Flowback

Comment: The Department received numerous comments that the use, transport, storage, handling, disposal, and injection of HVHF chemicals poses a threat to water, land, air, wildlife, human health, and the community. Comments argued that the Department should prohibit the use of all chemicals or combinations of chemicals which are known or suspected to be toxic, hazardous, acutely hazardous, persistent, bioaccumulative, carcinogenic, mutagenic, endocrine disrupting, or radioactive and that no chemical should be used until the Department and/or the NYSDOH has assessed whether it is protective of human health and the environment. Comments also identified specific chemicals anticipated to be used in HVHF (e.g., diesel) and identified the potential public health impacts and impacts to natural resources associated with these chemicals. Other comments suggested that there was insufficient data both in the 2009 dSGEIS and the 2011 SGEIS regarding the chemicals proposed for use in HVHF, including inadequate Material Safety Data Sheets (MSDSs), and consequently there is an inability to ensure the health, safety and welfare of citizens (e.g., development of an Emergency Response Plan). Comments also contended that the SGEIS failed to adequately address potential exposure, as well as the frequency of accidents and/or catastrophic failures. Additionally, comments argued that the SGEIS failed to distinguish the increased risks posed by HVHF as opposed to conventional gas wells, including an increase in the quantities of chemicals, potential contamination from HVHF chemicals, proper treatment of HVHF waste, and trucking of HVHF waste. The Department also received comments asserting that there should be mandatory public disclosure of chemicals used during HVHF and that the Department should have the authority to deny a gas well permit based on the chemical or product proposed to be used. The Department also received a number of comments that flowback fluids should be considered hazardous or toxic. Additionally, comments identified potential impacts from evaporation from surface impoundments and reserve pits.

Response: Exposure to chemicals found in fracturing fluids and flowback water can present a risk to public health and the environment. In this regard, "[t]he number of well pads and associated HVHF activities could be vast and spread out over wide geographic areas where environmental conditions and populations vary. The dispersed nature of the activity magnifies the possibility of process and equipment failures, leading to the potential for cumulative risks for exposures and associated adverse health outcomes. Additionally, the relationships between HVHF environmental impacts and public health are complex and not fully understood." Public Health Review. See Response to Comments regarding Health Impacts.

Chemicals in products proposed for use in HVHF include some that, based mainly on occupational studies or high-level exposures in laboratory animals, have been shown to cause effects such as carcinogenicity, mutagenicity, reproductive toxicity, neurotoxicity or organ damage. This information only indicates the types of toxic effects these chemicals can cause under certain circumstances but does not mean that use of these chemicals would cause exposure in every case or most cases, or that exposure would cause those effects in every case or most cases. Whether or not people actually experience a toxic effect from a chemical depends on whether or not they experience any exposure to the chemical along with many other factors including, among others, the amount, timing, duration and route of exposure and individual characteristics that can contribute to differences in susceptibility.

The total amount of fracturing additives and water used in for HVHF is considerably larger than for traditional well stimulation. This suggests the potential environmental consequences of an upset condition could be proportionally larger for HVHF.

The approach taken in the SGEIS assumes that all hydraulic fracturing additives, if released into the environment, pose some potential impact that depends on site-specific circumstances. Therefore the mitigation measures proposed, including setbacks, buffers, exclusion areas, secondary containment requirements, baseline water quality monitoring, inspection and preventative maintenance protocols, and well construction requirements, are included as precautionary measures that are intended to reduce the risk of releases and environmental and human exposures. This approach addresses a broader range of potential impacts than attempting to apply a toxicity or hazard characterization to any specific chemicals. Recognizing however that some chemicals pose comparatively greater toxicity than others, the SGEIS was updated to include the proposed requirement that well operators consider and use, if feasible, less toxic alternative products. See Response to the Comment in Alternatives Analysis in the Permit Process and Regulatory Coordination. Moreover, the SGEIS describes the requirements for the disclosure of fracturing additive information at the time of permit application and at the time of completion, and these requirements apply to any product, regardless of whether it is listed in Chapter 5 of the SGEIS. See Response to the Comment in Hydraulic Fracturing Information in Permit Process and Regulatory Coordination regarding scope of disclosure, timing of disclosure, and trade secret protections.

The Department acknowledges the limited nature of the data regarding what chemicals may be found in flowback water and at what concentrations. The data was voluntarily provided to the Department from out-of-state operations over which the Department has no authority and therefore the Department could not control for any of these variables. The Department recognizes that the SGEIS presents flowback water characteristics based on a limited number of analyses from out-of-state operations, without corresponding complete compositional information on the hydraulic fracturing additives utilized at the source wells from which flowback water samples were collected and analyzed.

Based on the limited nature and sources of the data, and the evolving chemical constituents of production fluids there is uncertainty as to the potential composition of flowback water from HVHF operations in New York, if HVHF were authorized. To determine the level of protection afforded by some of the mitigation measures (e.g., handling of flowback water), it is necessary to understand the composition of the flowback water and risks associated with the chemicals used in HVHF. This is particularly true when viewed alongside the list of chemical constituents of fracturing additives that may be used in HVHF in New York.

As a result of the nature of the flowback water data and the number of chemical constituents that may be present within the flowback water, as well as the fact that industry has stated that centralized flowback impoundments will not be used in New York State, the Department would consider numerous mitigation measures including the required use of covered watertight tanks for on-site storage of flowback water, secondary containment requirements for flowback tanks, the removal of flowback water from the well site within specified timeframes, the submittal of a fluid disposal plan, and the requirement that a Drilling and Production Waste Tracking Form be completed and maintained. Additionally, the requirements for characterization of flowback water chemistry for proper disposal of fluids at POTWs, permitted private treatment facilities or disposal wells, and the existing regulatory programs for approving or permitting disposal at these facilities, would reduce potential adverse impacts related to disposal. Currently there are no waste disposal options approved in New York State and the Department has yet to receive any requests for any disposal facilities to accept this source of waste. Additionally, no POTWs in New York State currently have TDS-specific treatment technologies, so the ability to accept this wastewater is limited. The high concentrations of TDS may potentially impact the efficacy of municipal biological treatment and/or other treatment technologies that are not designed to remove pollutants of this nature and could prove to be inhibitory to the efficacy of biological wastewater treatment overall. As such, there is questionable available capacity for POTWs in New York State to accept HVHF wastewater. There may also be potential impacts on sludge disposal due to the high concentration of hydraulic fracturing chemicals and NORM. Potential impacts on receiving waterbodies could also be realized. Due to the nature and scope of HVHF, without assurance that safe waste water and waste disposal can be guaranteed, New York State could be left with waste disposal issues beyond the capacity of the State to address. Failure to identify efficacious waste water treatment options in New York State raises questions regarding whether HVHF should be allowed to proceed without such options in New York State. See Responses to Comments in Flowback Water and Waste Transport and Disposal both in Potential Environmental Impacts and Mitigation.

With respect to diesel fuel, although diesel-based hydraulic fracturing fluids have not been proposed for use in HVHF operations to develop the Marcellus Shale or other low-permeability gas reservoirs in New York, the Department recognizes the concern over the use of diesel fuel-based hydraulic fracturing fluid. The SGEIS (Proposed Supplementary Permit Condition 44) indicated that the use of diesel as a base fluid is not authorized.

Regarding comments about potential significant environmental impacts from evaporation from surface impoundments and reserve pits, see Response to the Comment in Air Quality and Greenhouse Gas Emissions in Potential Environmental Impacts and Mitigation.

Regarding comments about potential significant environmental impacts on water resources from a spill or release related to HVHF, see Response to the Comments in General Prohibitions in Prohibited Locations and Setbacks in Potential Environmental Impacts and Mitigation.

Flowback Water and Other Impoundments

Comment: The Department received numerous comments with respect to potential significant adverse environmental impacts associated with flowback water from HVHF. These comments ranged from support for a prohibition on the construction and use of centralized flowback impoundments, with acknowledgement by the industry that they do not propose to use centralized flowback impoundments at this time. Comments supported the re-use of flowback water. Comments also raised concerns about the potential impacts from the consumption and storage of freshwater for HVHF. The Department has broken down these comments into three areas and provided responses specific to each of these areas.

a) Comments were received that centralized flowback impoundments should be prohibited altogether, in floodplains, or within limiting distances of water supplies and other water resources, or at least a site-specific review should be required. Closed-loop steel tank systems (above-ground) were raised as a better alternative than centralized flowback impoundments. If centralized flowback impoundments are allowed, buffers would need to be developed with consideration for topography and impacts to habitat and ecosystems. A variety of comments identified concerns about the construction and use of centralized flowback impoundments including: liner integrity; potential leakage (including to groundwater); air and/or chemical pollution; radiation and chemical content of flowback water. Comments also suggested adding requirements for: closure (e.g., timing); monitoring wells; a site-specific engineering analysis; design by a licensed New York State engineer; dam safety; controls of stormwater related to the construction of the impoundment (including avoiding steep slopes and unstable soils); obtaining a protection of waters permit; construction of the impoundment to hazardous waste specifications; vertical separation between the bottom of the impoundment and the water table; oversight and inspections to prevent spills; and fencing and/or netting. Comments were received both in support and in objection to size limitations for centralized flowback impoundments.

b) The Department received comments in support of the re-use of flowback water.

c) Comments were received regarding the use of large impoundments to store water for HVHF purposes. These facilities could allow withdrawal from sources during high flows, thereby eliminating the need to impact streams and rivers during low flow periods. These water storage facilities may mean additional access roads and, therefore, potential impacts to fish and wildlife habitat. This would require more truck trips but result in less habitat disturbance overall.

Response: The construction and use of centralized flowback impoundments associated with HVHF present the potential to have significant adverse environmental impacts if not adequately mitigated. In this regard, the construction and use of centralized flowback impoundments would require a site-specific determination of significance review. Any review would consider structural design, leak detection, monitoring, closure, and reclamation. Under the SGEIS, storage of flowback water would have to be on-site in watertight tanks located within secondary containment.

a) The Department considered, various levels of mitigation and prohibitions to reduce the potential for significant adverse environmental and health impacts from centralized flowback impoundments, both for the protection of public health and air and water resources. After review and consideration of the comments submitted, the Department would likely impose a requirement that on-site watertight tanks be used and be located within secondary containment. Therefore, if HVHF were authorized, the Department does not anticipate allowing the construction and use of centralized flowback impoundments. The Department implements regulatory programs and applies protective standards related to dam safety, air resource, water protection, landfill design and construction which would govern the design and construction of impoundments used for holding flowback water and other materials. Moreover, as stated by industry in comments, flowback impoundments are no longer contemplated for storage of flowback water from HVHF. See also Response to the Comment in Enforcement for further discussion of staffing, permit fees, and enforcement.

   The SGEIS proposed to require the use of covered, water-tight tanks, with secondary containment for the on-site storage of flowback water and production brine. Above ground storage tanks have advantages over surface impoundments. Tanks, while initially more expensive, experience fewer operational issues associated with liner system leakage. In addition, tanks can be easily covered to control odors and air emissions from the liquids being stored. Precipitation loading in a surface impoundment with a large surface area can, over time, increase the volumes of liquid needing treatment. Lastly, above ground tanks also can be dismantled and reused.

   See Response to the Comment in Air Quality and Greenhouse Gas Emissions in Potential Environmental Impacts and Mitigation for a discussion on the potential impacts to air resources from flowback water from HVHF.

b) See Response to the Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation for a discussion of beneficial use associated with flowback water and production brine.

c) See Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation regarding freshwater impoundments. The Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation would also address the potential impacts of water withdrawals on streams and rivers during low flow periods, as well as construction impacts (e.g., truck traffic, habitat disturbance), and potential mitigation of those impacts through storage of water.

Waste Transport and Disposal

Comment: The Department received numerous comments on the adequacy and availability of disposal options (e.g., publicly owned treatment works, private industrial treatment works, underground injection wells, roadspreading) for HVHF wastewater. Comments also suggested that the Department should require characterization of HVHF waste and approval of a fluid disposal plan, as well as consider requiring appropriate monitoring associated with any chosen disposal option. Tracking of HVHF waste, in and out of state was also a concern expressed in the comments. Comments also raised concerns regarding the use of reserve pits.

a) Comments suggested that before allowing HVHF activities, the SGEIS should examine wastewater treatment capacity in New York compared to the potential volume (both from HVHF wastewater generated in New York State and out of state) and composition of HVHF wastewater to ensure capacity exists. Numerous comments indicated that New York currently has no facilities, public or private, designed to treat the type and volume of waste from HVHF. Additionally, the Department received a number of comments indicating that sewage treatment facilities, both public and private (even if one were built), cannot adequately treat flowback water and production brine and that HVHF wastewater impairs the ability of those facilities to adequately treat wastewater. Comments were received indicating that on-site recycling of production brine should be mandatory, and that the Department should identify potential impacts and associated mitigation for brine pipelines. Comments were received arguing that a thorough and comprehensive characterization of HVHF wastewater (including whether the wastewater should be treated as a hazardous waste) is needed and should be made public. Comments suggested that any fluid disposal plan be approved by the Department prior to permits being issued for the drilling of gas wells and that toxicity testing prior to disposal should be required. Comments received stated that the Department must develop effluent limitations for pollutants associated with HVHF (e.g., NORM) and incorporate these limits into any permit issued to a facility that accepts HVHF wastewater for disposal. Comments were received stating that the Department needs to assess alternatives for locating, financing, and supervising construction and operations of disposal facilities that can adequately treat the quantity and toxicity of the expected HVHF wastewater. Comments were received stating that surface water and shallow groundwater near disposal facilities should be monitored to ensure that effluent does not impair wildlife or aquatic habitat. A comment stated that regular biological and chemical monitoring of receiving water quality should be required.

Numerous comments argued that deep-well injection of flowback water and brine should be prohibited. Comments stated that if deep-well injections were to be allowed, the Department must provide a technical justification.

b) Comments stated that the Department should include clear protocols for handling, storing, tracking, transporting and processing all HVHF waste, and should require "cradle to grave" tracking. Comments were received stating that waste from HVHF should not be permitted to be transported out-of-state for disposal, and comments were also received that waste from HVHF generated out-of-state should not be permitted to be transported for disposal within New York State. Comments stated that haulers of drilling and fracturing fluids should ensure that all operations associated with the handling and disposal of drilling wastes must comply with all applicable regulations. Comments stated that there should be a mandatory monthly filing of the Drilling and Production Waste Tracking Form with the Department with a requirement for the HVHF well operator to maintain such information for a specified duration of time. Comments were received arguing that a thorough and comprehensive characterization of HVHF waste (including sludge from a disposal facility) is needed and should be made public.

c) Comments were received stating that roadspreading should be prohibited. Comments stated that if roadspreading were to be allowed, the Department should determine safe levels of all the parameters of concern and set standards that will trigger approval or rejection of a Beneficial Use Determination (BUD) petition.

d) Numerous comments asserted that reserve pits when used for temporary containment of cuttings and fluids generated during drilling on mud, water or other fluid, including air, without additives, should be prohibited. However, other comments argued that larger reserve pits would promote water recycling. Comments were received indicating that fluid should not be allowed to sit in a holding pit when drilling is completed for a given gas well. Comments received suggested that pits and impoundments should be covered. Other comments stated that tanks with secondary containment of all storage systems should be required.

Response: Proper treatment, management and disposal of wastewater from HVHF present a number of potential significant adverse environmental and health impacts for which adequate mitigation has not yet been determined.

a) Currently, there are no approved disposal options for HVHF wastewater in New York State. Flowback water and production brine from HVHF (HVHF wastewater) includes a diverse mixture of residual hydraulic fracturing chemicals and naturally-occurring constituents from the rock formation, such as high concentrations of total dissolved solids (TDS) and Naturally Occurring Radioactive Materials (NORM).

The Department proposed that no permit to use HVHF to drill a gas well would be issued without a Department-approved fluid disposal plan. The plan must provide documentation that the operator has a viable disposal option. A demonstration would be required that any SPDES-permitted treatment facility identified in the fluid disposal plan has adequate capacity to accept the HVHF wastewater.

The Department agrees with comments that on-site recycling of flowback water would substantially reduce the need for disposal and if HVHF were authorized, the Department would consider requiring that used drilling mud and reserve pit fluid, flowback water, and production brine be reused and/or recycled to the maximum extent reasonably feasible.

Currently, there are no publicly owned treatment works (POTWs) permitted to accepted HVHF wastewater in New York State, and the Department has yet to receive any requests from any POTW in the State to accept this source of wastewater. Additionally, no POTWs in New York State currently have TDS-specific treatment technologies, so the current technical capacity to accept this wastewater is limited. Furthermore, the high concentrations of TDS may potentially impact the efficacy of municipal biological treatment and/or other treatment technologies that are not designed to remove pollutants of this nature and would prove to be inhibitory to the efficacy of biological wastewater treatment overall. As such, there is currently no available capacity for POTWs in New York State to accept HVHF wastewater. There may also be potential impacts associated with sludge disposal due to the high concentration of hydraulic fracturing chemicals and NORM. Potential impacts on receiving waterbodies if treatment were ineffective may also be realized. As indicated previously, due to the nature and scope of HVHF, without reasonable assurance that environmentally sound waste water and waste disposal can be guaranteed, New York State could be left without adequate waste disposal options for a significant industrial activity. Each wastewater treatment plant owner and/or operator has the discretion to reject wastewater from HVHF for treatment and disposal. Failure to identify and assure the availability of effective environmentally protective waste water treatment options prior to authorizing HVHF raises questions whether HVHF should be allowed to proceed in New York State.

Should a POTW propose to accept HVHF wastewater, due to the large volumes of return water from HVHF, combined with the diverse mixture of chemicals and high concentrations of TDS that may exist in both flowback water and production brine, pretreatment and a headworks analysis would be required in accordance with 40 CFR Part 403 and Department guidance. Both the Department and EPA Region 2 would need to review and approve such an analysis. The POTW must also have an approved pretreatment program, or mini-pretreatment program in order to accept HVHF wastewater. The headworks analysis would be specific to the parameters expected to be present in the HVHF wastewater (e.g., TDS and NORM). The headworks analysis evaluates the pollutants present in the wastewater against the capabilities of the treatment system and assesses any potential adverse impacts to a treatment system process. A headworks analysis for acceptance of HVHF wastewater would require a full disclosure to the Department and full characterization of the HVHF wastewater, including NORM, TDS, metals and all the chemical additives in HVHF. Additional treatment would be required to remove the pollutants of concern to a safe level before the POTW would be permitted to accept the HVHF wastewater if the headwork analysis indicates that the treatment process could be adversely impacted by the pollutants present in the HVHF wastewater, or the HVHF wastewater would not comply with the pass through and interference provisions in 40 CFR 403.5, or the HVHF wastewater may cause a water quality violation in the receiving waterbody.

The cumulative impacts of the discharges from wastewater treatment plants on the receiving waters are taken into account during the water quality review portion of a SPDES permit development process. During this review other discharges to the same receiving waterbody are also taken into account to assure that the assimilative capacity of the receiving waters is not exceeded. If permitted, the SPDES permit for the POTW would include specific discharge limitations and monitoring requirements, including routine reporting of monitoring results, and tracking of these results by the Department. Discharge limitations in SPDES permits are developed based upon the more stringent of aquatic, water source, or technology standards and are set at levels to ensure that the discharges do not impair water quality standards, including those protective of wildlife and aquatic habitat. Additives and other parameters that do not have specified analytical parameters would be evaluated using toxicity testing in accordance with the Department's guidance to ensure that their presence in the wastewater does not cause or contribute to aquatic toxicity or adversely impact treatment plant biology.

At a minimum, influent and effluent limits for TDS would be included in the modified SPDES permits for any treatment facilities that accept HVHF wastewater and these limits would be designed to protect both the treatment systems and the receiving water. With respect to comments regarding NORM, a maximum influent level of 15 pCi/l for radium 226 would also be included in any SPDES permit for a facility that accepts HVHF wastewater to be protective of the receiving water, facility staff, and the infrastructure of the wastewater treatment plant, including sludge disposal.

Currently, there are no privately owned industrial wastewater treatment facilities built to accepted HVHF wastewater in New York State, and the Department has yet to receive any permit applications for such facilities. Privately owned facilities for the treatment and disposal of industrial wastewater from HVHF operate in other states, including Pennsylvania. These facilities can be designed and constructed to treat the parameters specific to HVHF wastewater and may be more effective than POTWs for the treatment, disposal, and potential reuse of this source of wastewater because they can be designed and optimized to remove the parameters specific to this source of wastewater. If similar facilities were to be constructed in New York, discharges from such facilities would require a SPDES permit and an analysis similar to the headworks analysis required for POTWs would be required to be conducted, as well as disclosure to the Department of the characterization of the HVHF wastewater, including NORM, TDS, metals and all the chemical additives in HVHF. If permitted, specific discharge limitations and monitoring requirements would be required through a SPDES permit issued to a private industrial wastewater treatment facility.

Currently, there are no UIC Class II disposal wells permitted to accepted HVHF wastewater in New York State, and the Department has yet to receive any requests for such a well to dispose of HVHF wastewater. Properly constructed and operated UIC Class II disposal wells are a potential option for disposal of HVHF wastewater. Disposal of HVHF wastewater in an injection well would be subject to the requirements for disposal in a Class II injection well, and would require both a Class II UIC well permit from the USEPA and an individual SPDES permit from the Department. The requirements for obtaining a Class II UIC well permit from the USEPA are detailed in 40 CFR Part 146. As in the case of POTWs and privately owned facilities, an analysis similar to the headworks analysis required for POTWs would be required, as well as disclosure to the Department of the characterization of the HVHF wastewater, including NORM, TDS, metals and all the chemical additives in HVHF. Additional geotechnical information regarding the disposal strata's ability to accept and retain the injected fluid would also be required. In addition, the operator of the proposed disposal well would also need to apply to the Department for a well drilling or conversion permit. If permitted, the SPDES permit for an injection well could set effluent limits or monitoring requirements on HVHF-specific parameters where appropriate, and also require monitoring well(s) screened in the lowermost portion of the aquifer system with monitoring requirements to assure that upward migration of the disposed wastewater is not occurring. See Response to the Comment Seismicity in Geology for discussion of the potential for seismic events from the use of an injection well.

New York State currently has six permitted underground disposal wells, three of which are used to dispose of brine produced with oil and/or gas. Use of an existing permitted underground disposal well would require a modification of the existing UIC and SPDES permits for the well to accept either flowback water and/or production brine from a source not included in the existing permits.

Overall, notwithstanding the proposed conditions the Department would place on HVHF development based on wastewater treatment, there is significant uncertainty regarding the disposal of wastewater from HVHF. The absence of existing facilities with recognized capacity to accept large volumes of wastewater raises the potential of significant impacts, including improper or illegal disposal. The Department recognizes the potential impacts associated with the transport and treatment or disposal of HVHF wastewater and that the mitigation measures proposed in the SGEIS to address them may be inadequate since they would be achieved on a case by case basis. After review and consideration of comments submitted, the Department considered a variety of additional mitigation measures but recognizes that there still exists uncertainty as to the adequacy of additional mitigation measures because of the number of wells that may be drilled and the current limited disposal options, as well the anticipated volume and composition of flowback water and production brine.

See Response to the Comment in Hydraulic Fracturing Information in Permit Process and Regulatory Coordination; Naturally Occurring Radioactive Materials in Geology; and Flowback Water in Potential Environmental Impacts and Mitigation.

b) As noted in the SGEIS, waste transport is an integral part of a fluid disposal plan and transportation tracking helps to ensure that fluid wastes are disposed of properly. The SGEIS proposed the use of a Drilling and Production Waste Tracking Form, which would be completed and maintained by generators, haulers, and receivers of all flowback water associated with HVHF. The SGEIS also proposed that this form be used to track production brine removed from the HVHF well pad.

   If HVHF wastewater were proposed to be disposed of at an out-of state facility, the Department would employ a detailed waste tracking program and require a statement from the receiving facility that it will accept the waste. In addition, HVHF operators would need to meet all applicable requirements of the state where wastewater disposal occurs.

c) Roadspreading of HVHF wastes raises potential significant adverse environmental and health impacts. In this regard, the SGEIS proposed a case-by case evaluation for each beneficial use determination under 6 NYCRR Part 360 to determine whether to allow roadspreading of production brine. Under this proposal, the Department would assess potential impacts, including analytical results from an ELAP-approved laboratory of a representative sample for the following parameters: NORM, calcium, sodium, chloride, magnesium, TDS, pH, iron, barium, lead, sulfate, oil and grease, benzene, ethylbenzene, toluene, and xylene. The Department would then establish limits on the volume and frequency of the application.

   The 1992 GEIS makes a distinction between flowback water and production brine for beneficial use noting that flowback water, particularly in its earliest stages, contains *less* of the natural formation brine salts than gas-well production brines considered a beneficial substitute for rock salt or liquid salt in road maintenance. Furthermore, concentrations of fracturing fluid additives are highest in flowback water, and contribute nothing to dust control or de-icing as intended by roadspreading under a BUD. Therefore, the Department considers roadspreading of flowback water to constitute disposal and would not grant a BUD for its use. Production brine, on the other hand, is high in these natural salts, and if potentially harmful constituents are demonstrated to be below concentrations that may adversely affect human health or the environment, can provide a benefit in replacing mined rock salt or commercial liquid salt in road maintenance. Aquifer contamination is a possible hazard of roadspreading of production brine from HVHF, as it is with any highly saline commercial liquid de-icing or dust control agent. See Response to the Comment in Flowback Water in Potential Environmental Impacts and Mitigation.

However, after review and consideration of comments submitted, the Department acknowledges that there is insufficient data on NORM content produced from the Marcellus Shale and other low-permeability formations through HVHF. Consequently, the Department considered additional mitigation measures, such as clarifying that no BUDs would be issued for roadspreading of flowback water and prohibiting roadspreading of production brine. This would result in an increase in the wastewater needing to be treated or disposed of, with the potential impacts of associated with them, as explained in the preceding section.

d) Storage of drill cuttings, wastewater and other materials in open reserve pits may result in significant adverse environmental and health. In this regard, the SGEIS proposed numerous measures to reduce the potential for releases associated with any on-site reserve pit. After review and consideration of comments submitted, the Department acknowledges that the mitigation measures proposed in the SGEIS may be inadequate with respect to reserve pits. In this respect, there is uncertainty as to the level of protection that would be achieved by measures to contain fluids associated with wells to be developed by HVHF within a reserve pit and prevent the contamination of shallow groundwater. For example, there is uncertainty as to the continued integrity of a liner system, what an adequate size and holding capacity of a reserve pit would be, as well as set triggers for removal of cuttings and fluids from reserve pits. In light of the fact that there is insufficient scientific information to quantify the risk posed by open pit storage of HVHF waste materials, the Department considered additional mitigation measures, such as a closed-loop system or enhanced reserve pit specifications and fluid handling and removal requirements.

Regarding the potential impacts on water resources associated with potential spills and leaks associated with HVHF, see Responses to the Comments in NYC and Syracuse Watersheds; Other Public Drinking Supplies and 2,000-foot Buffer; Primary Aquifers and 500-foot Buffer; and Private Water Wells and 500-foot Buffer, all in Prohibited Locations.

See also Responses to the Comments in Water Resources and Setbacks, both in Potential Environmental Impacts and Mitigation, for further discussion of the potential for the contamination of groundwater.

See also Responses to the Comments in 100-Year Floodplains in Prohibited Locations and Floodplains in Potential Environmental Impacts and Mitigation, for further discussion of the potential impacts associated with locating reserve pits in flood-prone areas.

See also Response to the Comment in Flowback Water in Potential Environmental Impacts and Mitigation.

Setbacks

Comment: The Department received numerous comments with respect to potential significant adverse environmental impacts on a variety of resources from HVHF. These comments ranged from supporting the proposed buffers, to questioning the effectiveness of the proposed buffers, to arguing that buffers are unnecessary. Comments also raised concerns about specific criteria that the Department should consider in proposing any buffer. The Department has broken down these comments into three areas and has provided response specific to each of these areas.

a) The Department received comments that setbacks, generally, should be increased (e.g., 660 feet, 1,000 feet, 4,000 feet, 5 miles).

Comments argued that generic buffers are not appropriate and must be site-specific, with consideration given to topographical features, such as depressions and overall slope of the land between the well pad and features desired to be protected.

In support of either increasing or reducing setbacks, comments suggested that the results of any technical determination or study (e.g., geography, noise, EPA recommendations, experience of other regions) supporting a set buffer be made public in a FSGEIS.

Comments also suggested that climate change be considered in determining any increases to the buffers proposed in the SGEIS.

However, the Department also received comments that the proposed setbacks were onerous, should be eliminated, should be reduced, or should be made consistent with those in other jurisdictions. Comments indicated that setbacks are problematic because they:

- limit exploration;
- diminish the economy of scale needed for efficient and economical development of shale gas, as the more contiguous the leased acreage, the more developable it is;
- are likely to cause great difficulty in unitization of the acreage, a critical step in calculating revenues that are used to derive, among other things, royalties for lessors and taxes;
- reduce options to define rational acreage blocks necessary for units and limit the flexibility needed to minimize environmental impacts;
- deny property owners the opportunity to benefit from royalties that would otherwise be available through a more flexible regulatory framework;
- will result in lost revenues from royalties, loss of local and state real property and income taxes; and the inability to efficiently and completely recover the natural gas resources; and
- will likely increase the environmental impacts because more wells will have to be drilled to access the natural gas beneath these areas (e.g., more land disturbance and local impacts such as truck traffic).

Furthermore, comments indicated that the Department should include provisions to allow setbacks to be waived by the Department as appropriate. For the prohibitions or setbacks that the SGEIS proposed to revisit in a given period of time, comments also indicated that it would be far better to have those provisions automatically sunset.

The Department received numerous comments specifically related to increasing the setbacks from water resources, including:

- from any aquifer (e.g., 1,000 feet; 2,000 feet; length of a horizontal lateral; 2,500 to 3,000 feet between any hydraulic fracturing zone and the deepest drinking water aquifer; 1,500 or 2,000 feet, contingent on an analysis of naturally occurring fractures in the rock above the proposed fracture zone);
- from the Finger Lakes (e.g., one mile; 10 miles; at least 20 miles);

- all water sources supplying drinking water (e.g., 4,000 feet);
- from floodplains (e.g., 300 feet);
- from any water well and well head protection areas (e.g., 2,000 feet; 3,000 feet; one mile);
- from wetlands, ephemeral streams, rivers, lakes, private lakes, agricultural ponds/lakes, springs; and
- between the bottom of the aquifer and the target formation (e.g., prepare a vertical gradient map for the formations directly above the shale to show areas where there would be no upward movement of contaminants that leak from the shale).

Comments also supported the imposition of equal mitigation measures for all water resources (e.g., streams, wetlands, storm drains, lakes and ponds should have the same minimum distance requirement as water supplies; public and private water wells).

Comments suggested that before making any determinations of buffers from groundwater resources, the Department should update/revise aquifer maps with a smaller scale.

Comments also suggested that subsurface access to gas resources should not be allowed under a water supply source.

b) The Department received comments related to increasing the setbacks, from features other than water resources, including from:

- drinking water infrastructure;
- known or suspected faults;
- other areas that, because of ecological, hydrological, recreational, and/or historic significance, should also be placed permanently off-limits to gas development;
- a town/local government designated unique/natural area (e.g., 8,000 feet) and requiring that all water wells must be tested within a certain distance (e.g., 2,000 feet, 5,000 feet, and two miles) of the well pad and entire unit; and
- abandoned oil and gas wells, dwellings (e.g., 5,000 feet), public buildings, schools, parks, recreational areas, historic districts, critical environmental areas, vernal pools, and salt mines.

c) The New York Bankers Association also submitted a comment that urged the Department to amend its regulations to provide the minimum setback that would be acceptable to the secondary market and federal and State mortgage loan guarantee agencies.

Response: HVHF and activities associated with HVHF have the potential to cause significant adverse environmental impacts on a variety drinking water supply resources, if not adequately mitigated. In this regard, the Department proposed setbacks (also known as buffers) - to protect these critical resources (e.g., prohibition of HVHF well pads within 4,000 feet of an unfiltered drinking water supply, within 500 feet of a Primary Aquifer, within 2,000 feet of public drinking water wells, river or stream intakes and reservoirs, and within 500 feet of private water supplies; site-specific determination of significance for HVHF well pads within 500 feet of a Principal Aquifer, and where the target fracturing zone is either at least 2,000 feet deep or 1,000 feet below the underground water supply).

HVHF and activities associated with HVHF also have the potential to cause significant adverse environmental impacts on a variety of resources other than drinking water supplies, if not adequately mitigated. In this regard, the Department proposed setbacks (buffers) to protect these critical resources (e.g. site-specific determination of significance for HVHF well pads within 150 feet of a perennial or intermittent stream, storm drain, lake or pond; 100-foot setback from wetlands; 500-foot setback for fuel tanks from a wetland; 100-foot setback from inhabited dwellings).

a) The SGEIS proposed, and the Department considered, various levels of mitigation and prohibitions to reduce the potential for significant adverse environmental and health impacts from HVHF on drinking water supplies. After review and consideration of comments submitted, the Department maintains that prohibitions and buffers are appropriate in certain instances to reduce the potential for impacts to those water resources, as well as to human health and ecosystems.

   The Department agrees with comments received that a buffer from drinking water supplies is a necessary mitigation measure. All drinking water supplies require protection. Any buffer must provide an adequate margin of safety from a broad range of activities, both surface and subsurface, relating to HVHF development and production. Buffers could be based on a variety of considerations, including the number of people served by drinking water supplies (e.g., over 9.5 million people for unfiltered drinking water supplies), vulnerability of the drinking water supply to contamination from spills and releases, availability of alternative water supplies and associated costs, and the variability related to HVHF (e.g., number of well pads, volume of chemicals used, duration of the HVHF activity and ancillary activities, and the wide variability in the potential list of chemicals used). Imposition of a conservative (i.e., large) buffer would make it less likely that activities associated with HVHF, including those extending away from the well pad, would impact drinking water supplies. In the event that HVHF were authorized, the Department would require a buffer from water resources (although the Department acknowledges that the extent of the buffer needed is uncertain) and would enforce and monitor these buffers through permit conditions. See also Response to Comment in Enforcement.

The Department recognizes that the extent of a buffer is an effective limitation that will reduce the risks to the resources, commensurate with their importance and the nature of the risk. "While a guarantee of absolute safety is not possible, an assessment of the risk to public health must be supported by adequate scientific information to determine with confidence that the overall risk is sufficiently low to justify proceeding with HVHF in New York. The current scientific information is insufficient. Furthermore, it is clear from existing literature and experience that HVHF activity has resulted in environmental impacts that are potentially adverse to public health." Public Health Review. However, determining the adequacy of a buffer for HVHF is complicated by a number of factors, including the effectiveness of control measures, the potential for spills and the uncertainty of the risk posed by those spills, the potential risks posed by ancillary activities, and risks posed from the subsurface access to natural gas resources below water resources.

Specifically, the Department recognizes the potential impacts from contaminated stormwater runoff (i.e., sedimentation) at an HVHF well pad to surface water bodies as well as from any uncontained and unmitigated surface spill, leak, or release of fluids containing chemicals or petroleum. Risks associated with construction activity, high volumes of truck traffic (i.e., road runoff and accidents), or improper chemical, petroleum or wastewater handling, could result in a degradation of drinking water supplies, both surface water and groundwater. If HVHF were authorized, the Department would impose a robust set of engineering controls that, in its best professional judgment, would reduce the risk. Even with controls in place, however, many of the risks, including spills and other unplanned events resulting in the discharge of pollutants associated with HVHF, even if relatively remote, would not be eliminated and could have significant consequences. HVHF presents unique challenges, including, the industrialization of multiple sites throughout the region each presenting or contributing to the cumulative impacts associated with multiple wells drilled on a single pad and well pads constructed throughout numerous towns and counties of the State. Some of the engineering controls and management practices that would be required are untested under these circumstances for the scale of this activity. Consequently, it remains uncertain whether the engineering controls would be adequate to prevent spills and other unplanned events resulting in the discharge of pollutants associated with HVHF and whether they would mitigate adverse impacts if such an event occurs. Compounding this risk, is the current uncertainty identified by NYSDOH as to the level of risk HVHF activities pose to public health.

Standard stormwater controls, if not properly implemented, would not eliminate the risk of potential significant adverse impacts (e.g., sedimentation) on drinking water supplies from the increased construction activity associated with HVHF, particularly during peak levels of activity. Industrial activity associated with well pad development, chemical storage, and other activities associated with HVHF, including such cumulative impacts associated with pipeline development and construction, could potentially impact drinking water supplies.

Furthermore, the SGEIS did not prohibit activities ancillary to HVHF within buffers. The Department recognizes that ancillary activities (e.g. storage of HVHF material), including those that the Department does not have jurisdiction over (e.g. truck traffic), would also present risks (e.g., spills) to drinking water supplies similar to those risks associated with HVHF itself. Ancillary activities, coupled with the likely widespread development of HVHF, continue to pose a significant risk to these water resources. Indeed, the Public Health Review came to this very same conclusion in finding that "[t]he number of well pads and associated HVHF activities could be vast and spread out over wide geographic areas where environmental conditions and populations vary. The dispersed nature of the activity magnifies the possibility of process and equipment failures, leading to the potential for cumulative risks for exposures and associated adverse health outcomes. Additionally, the relationships between HVHF environmental impacts and public health are complex and not fully understood." Public Health Review. While the prohibition of HVHF well pads in certain areas could reduce direct impacts, only the No Action Alternative would prevent ancillary activities from being conducted and eliminate the potential risks. See the Response to Comment in Cumulative for further discussion on the cumulative impacts from HVHF (e.g., visual, community character, air).

Moreover, unless the No Action alternative is selected, the SGEIS would potentially allow subsurface access to gas resources by HVHF under drinking water supplies. There is some uncertainty regarding the possibility that fluids released in the subsurface during horizontal hydraulic fracturing could reach the drinking water aquifers (e.g. private or public wells) in shallow strata, e.g., by moving upwards through an abandoned well. The same could be true with respect to potential contamination of the drinking water supplies that use surface water (e.g. reservoirs). If these fluids were able to migrate, there could be an increase in significant adverse environmental and health impacts. There are several studies currently underway that could clarify these potential impacts, but the results of those will not be final for several years. As the Public Health Review concludes "[t]hese major study initiatives may eventually reduce uncertainties regarding health impacts of HVHF and could contribute to a much more complete knowledge base for managing HVHF risks."

In this regard, in the face of increased risk to public health and the environment and because there is insufficient scientific information to quantify the risk from HVHF and associated activities (e.g., number of well pads, volume of chemicals used, duration of the HVHF activity and ancillary activities, and the wide variability in the potential list of chemicals used), determining an adequate buffer to provide a level of assurance that potential risks have been satisfactorily minimized would be difficult.

See Response to the Comments in Future SEQRA Compliance in SEQRA and SAPA regarding the requirement for when a site-specific determination of significance would be required for setbacks, and Air Quality and Greenhouse Gas Emissions in Potential Environmental Impacts and Mitigation regarding climate change.

Responses to the Comments in NYC and Syracuse Watersheds; Other Public Drinking Supplies and 2,000-foot Buffer; Primary Aquifers and 500-foot Buffer, all in Prohibited Locations, discuss the potential sunset of prohibitions. The waiver of setbacks is discussed in Response to Comment in Private Water Wells and 500-foot Buffer in Prohibited Locations.

Regarding setbacks from water resources, see Responses to the Comments in NYC and Syracuse Watersheds; Other Public Drinking Supplies and 2,000-foot Buffer; Primary Aquifers and 500-foot Buffer; Private Water Wells and 500-foot Buffer; 100-year Floodplains, all in Prohibited Locations. See Responses to Comments in Floodplains; Wetlands; and Water Resources, all in Potential Environmental Impacts and Mitigation. Those responses address prohibitions; specific information for the development of adequate buffers; and vertical separation between potable water in the target zone for HVHF.

See also Response to the Comment in Primary Aquifers and 500-foot Buffer in Prohibited Locations for a discussion on aquifer mapping.

The Responses to the Comments in Air Quality and Greenhouse Gas Emissions in Potential Environmental Impacts and Mitigation discuss climate change.

b) The same potential significant environmental and health risks discussed above apply to resources other than water resources. For additional information, see Response to the Comments in New York City and Syracuse Watersheds in Prohibited Locations regarding setbacks from drinking water supply infrastructure; Seismicity in Geology regarding known or suspected faults; General Prohibitions in Prohibited Locations regarding other areas of significance; Local Government Notification and Coordination in Permit Process and Regulatory Coordination regarding local government designations and requirements; and Hydraulic Fracturing in Potential Environmental Impacts and Mitigation regarding abandoned oil and gas wells.

The Responses to the Comments in Air Quality and Greenhouse Gas Emissions, Socioeconomic, Visual, Noise, Transportation, Community Character, Cultural Resources, all in Potential Environmental Impacts and Mitigation, as well as Cumulative Impacts and Health Impacts, may also address concerns with the protection of many of the resources identified in the comments.

c) The potential impact of HVHF on the mortgage market is not an environmental impact and is thus beyond the scope of the environmental review. In the event that HVHF were authorized, increasing the setback for well pads from residences, or inhabited private dwellings, from 100 feet to 500 feet would likely conform to the majority of title insurance and mortgage restrictions. But any increase would not address all the issues identified with title insurance and mortgage restrictions, nor would an increase in the setback protect against all security interests in the secondary mortgage market.

Floodplains

Comment: The Department received numerous comments with respect to potential significant adverse environmental impacts from HVHF well pads located in floodplains. These comments ranged from supporting the proposed parameters of the prohibition, to questioning the effectiveness of the proposed parameters, to arguing a prohibition is unnecessary. Comments also raised concerns about potential impacts from HVHF ancillary activities located within floodplains. The Department has broken down these comments into three areas and provided responses specific to each of these areas.

a) The Department received comments in support of expanding the SGEIS to prohibit HVHF in areas outside of the 100-year floodplain (e.g., 500-year floodplain, and other areas that have experienced flooding in recent years). The Department also received comments that it should also consider a prohibition of HVHF under floodplain areas. Comments also identified a need for riparian buffer areas from the floodplains in which HVHF should be prohibited. Additionally, comments received suggested that before issuing any permits for HVHF, the Department should update/revise Flood Insurance Rate Maps and conduct an up-to-date assessment of the flood risks to ensure that HVHF wells in New York will not be subjected to the same kind of natural disasters that recently affected areas of New York State and international locations (i.e., these maps should be reflective of anticipated changes that may result from climate change, namely the increase in frequency and severity of storm events).

b) Comments recommended that the Department analyze whether there should also be a prohibition on ancillary structures connected to the HVHF well pad within floodplains, such as open pits, pipes, transfer stations, containment tanks (e.g., production brine), other structures, HVHF materials (e.g., bulk additive supplies), diesel fuel, and other drilling-related operations.

c) Comments received suggested that even with a buffer, the Department must issue specifications for structurally anchoring flowback tanks and other infrastructure containing HVHF materials to resist movement during severe floods or freeze-thaw cycles.

Response: HVHF well pads and activities associated with HVHF be located in flood-prone areas there may be significant adverse impacts if not adequately mitigated. In this regard, the SGEIS proposed a prohibition on HVHF well pads within the 100-year floodplain.

See Response to the Comment in 100-year Floodplain in Potential Environmental Impacts and Mitigation.

Wetlands

Comment: The Department received many comments that raised concerns regarding the potential for adverse effects and impacts to wetland systems due to spills or other accidents, sedimentation, changes in groundwater and surface flows, and the potential for the de-watering of waterways due to excessive water withdrawals. In this regard, comments also indicated that the SGEIS notes that, under Article 24 of the ECL, the Department only protects wetlands 12.4 acres and larger or smaller wetlands of unusual local importance. Comments further noted that these categories represent about 6% of the State's wetlands under Department protection. The majority of wetlands in New York State are regulated by the Army Corps of Engineers (ACOE). Thus, comments called upon the Department to provide mitigation and protections to all waters and wetlands regardless of their regulatory authority.

The comments pointed out that wetlands provide a multitude of ecological, economic, and social benefits and that wetlands are worthy of the same protections afforded other surface waters such as perennial and intermittent streams, storm drains, lakes, and ponds. Comments stated that wetlands contain a variety of plant species and provide valuable habitat for fish and wildlife. They went on to say that wetlands are also important landscape features because they hold and slowly release flood water and snow melt, recharge groundwater, act as filters to cleanse water of impurities, recycle nutrients, and provide recreation and wildlife viewing opportunities for millions of people. Comments questioned the effectiveness of the proposed mitigation in preventing significant adverse environmental impact to wetlands. Specifically, some comments called for greater setbacks for drilling activities, including water withdrawals, and stated that the setbacks should entail a prohibition of drilling activities within the prescribed distance rather than simply triggering an additional SEQRA site-specific review.

Some comments also contended that the SGEIS failed to adequately analyze the economic value and other benefits of wetland ecosystems in terms of clean water, clean air, tourism, recreation, and community character. And some comments questioned whether the SGEIS preempted local wetland and floodplain laws.

Response: Freshwater wetlands are important features of a healthy ecosystem. The 1992 GEIS broadly summarized the potential impacts to wetlands associated with interruption of natural drainage, flooding, erosion and sedimentation, brush disposal, increased access and pit location. Those potential impacts are applicable to HVHF. Therefore, the Department agrees that unmitigated HVHF activities have the potential to have significant adverse environmental impacts on freshwater wetlands (both Department-regulated and federal wetlands) and other surface water bodies. In this regard, the Department recognizes that limiting mitigation measures to Department-regulated wetlands may not reduce impacts to all wetlands. Consequently, the Department considered treating state and federal wetlands the same as other waterbodies such as perennial and intermittent streams, storm drains, lakes, and ponds and would apply the same mitigation measures to all these waterbodies, if HVHF were authorized.

In addition to the mitigation set forth in the 1992 GEIS, and other protections afforded by the Department’s Fresh Water Wetlands regulations, the Department considered additional measures to reduce potential impacts on wetlands, if HVHF were authorized. First, the Department acknowledges that a 100-foot setback from wetlands and other waterbodies may be inadequate to protect the resource, and therefore a site-specific SEQRA determination was considered for well pads proposed within 300 feet of waterbodies, including state and federally regulated wetlands. Second, a site-specific SEQRA determination was considered for surface and groundwater withdrawals within 500 feet of a wetland where pump testing determined the withdrawal could have an influence on the wetland. Moreover, all water used for HVHF would need to come from a water withdrawal permitted by the Department pursuant to 6 NYCRR Part 601. The public would be provided notice of the application for a water withdrawal permit, which would include a description of the proposed withdrawal and its location, and the public would be able comment on that application. See Response to Water Resources in Potential Environmental Impacts and Mitigation for a further discussion on water withdrawals for HVHF. Third, additional requirements related to stormwater runoff and surface spills and releases would have been extended to wetlands. Finally, a detailed analysis of impacts on habitat connectivity from new access roads within a 100-year floodplain or within 50 feet of a surface water, including wetlands, was considered. These measures would be in addition to the Department's existing regulatory program that provides protection to many freshwater wetlands.

All of these measures would reduce potential adverse impacts to wetlands, but would not eliminate all potential impacts to wetlands. Indeed, even requiring a 300-foot buffer between HVHF activities and wetlands may not eliminate the potential for significant impacts to wetlands. While setbacks serve as an effective risk management tool and could help prevent impacts, determining an appropriate setback distance that can address all significant environmental impacts from HVHF activities on wetlands on a generic basis is difficult because of the diverse array of impacts and site-specific factors influencing the potential for those impacts. As such, even a 300-foot buffer might not provide enough of a separation from HVHF activities to fully mitigate impacts on wetlands in all locations. For example, a 300-foot setback from wetlands that provide amphibian breeding habitat might not be sufficient to assure long term persistence of the amphibian breeding population dependent upon that wetland. In fact, research suggests that much larger setbacks (greater than 1000 feet) would be required to fully mitigate these impacts. Thus, even fairly robust setbacks may not always adequately address impacts to wetlands from HVHF activities.

Lastly, based on home rule authority, the Court of Appeals has found that ECL § 23-0303(2) does not preempt local zoning laws.

Land Resources

Comment: The Department received comments that concluded that activities associated with HVHF would industrialize rural and semi-rural areas and consequently have a negative impact on community character and the quality of life in those affected regions. Comments contended that this change in land use would have negative impacts on tourism, agriculture, and recreational opportunities. These comments required the Department to analyze the public benefits (economic, social, health, and others) that stem from ecosystem services provided by healthy, natural systems. The comments argued that these benefits include: flood control; generation and maintenance of soils (including arable soils for agriculture); reduction or elimination of erosion; purification of air and water; removal and/or neutralization of toxins and other waste products; nutrient cycling; and crop pollination. In light of these benefits, the comments contended that the analysis should address the potential for disruption to these services arising from drilling and all associated activities and the cumulative effects of potential impacts over time, including the potential expansion into the Utica Shale.

With respect to potential agricultural impacts, the comments emphasized the importance of the reclamation process for well pads in restoring farmlands, and also questioned the effectiveness of reclamation. Comments also argued that New York State Department of Agriculture and Markets should have an official role in the siting, construction, monitoring and reclamation of well pads on agricultural lands. Finally, comments identified the danger of spills impacting farmland production, and the potential for disruption of agricultural activities by the infrastructure associated with HVHF.

The Department also received comments that activities associated with HVHF should not be permitted to undermine local land use laws, especially plans in rural areas that emphasize resource protection, open space, and scenic quality. In this regard, comments urged the

Department to establish appropriate fees to be paid by the gas industry for professional land use planners to work with communities in the Marcellus Shale region to develop or update comprehensive plans, zoning codes and other land use policies to ensure their ability to better guide the development of well pads and related facilities as well as accompanying residential, commercial and industrial development, in a manner that will protect the region's agricultural industry and minimize the conversion of agricultural land.

Response: New York Courts have long recognized that "[t]he power to define the community character is a unique prerogative of a municipality acting in its governmental capacity," and, that, generally, through the exercise of their zoning and planning powers, municipalities are given the job of defining their own character. See *Village of Chestnut Ridge v. Town of Ramapo*, 45 AD3d 74 (2d Dept. 2007). Previous to the Second Department's decision in Village of Chestnut Ridge, Commissioner permitting decisions recognized the authority of local governments to define their character through the comprehensive planning process. See, e.g., *Matter of St. Lawrence Cement*, 2004 N.Y. ENV LEXIS 60 (Second Interim Decision, Sept. 8, 2004), and decisions cited therein. "Community character is defined by all the man-made and natural features of the area. It includes the visual character of a town, village, or city, and its visual landscape; but also includes the buildings and structures and their uses, the natural environment, activities, town services, and local policies that are in place. These combine to create a sense of place or character that defines the area." SEQR Full EAF Workbook, Part 2, Question 18, published on the Department's website at http://www.dec.ny.gov/permits/91813.html**.** Community character reflects a number of factors including but not limited to natural physical features, history, demographics, socioeconomics and culture. The Department agrees that activities associated with HVHF would likely change the character of some communities in or near the areas affected by drilling. Some communities would experience socio-economic changes, visual and noise impacts and impacts from truck traffic.

Impacts on community character are often intertwined with other environmental issues and may be addressed in the context of addressing those issues (for example, visual and noise impacts). With respect to visual and noise impacts arising from HVHF activities, some of the most significant impacts would be temporary; however, cumulatively or regionally significant adverse impacts would be longer lasting because of the wide ranging nature of the activities across the span of a region. The introduction of HVHF could cause a greater change to sparsely populated rural communities than to communities that are more densely populated and are home to other industrial or manufacturing activities. Likewise, the Department can speculate that the introduction of HVHF activities might not cause as great a change in community character in communities that have prior experience with gas drilling in contrast to those communities that have no prior experience with the activity. However, HVHF presents incrementally greater impacts in areas implicated by community character than conventional drilling. Some communities might welcome HVHF, notwithstanding its environmental impacts, because of the purported economic activity that it would create, while other communities would nonetheless reject such change. Recently, the New York Court of Appeals in *Matter of Wallach v. Town of Dryden* and *Cooperstown Holstein Corp. v. Town of Middlefield* found that ECL § 23-0303(2) does not preempt communities with adopted zoning laws from regulating land use that would entirely prohibit the use of land for HVHF. In that decision, the Court noted that: "Manifestly, Dryden and Middlefield engaged in a reasonable exercise of their zoning authority … when they adopted local laws clarifying that oil and gas extraction and production were not permissible uses in any zoning districts. The Towns both studied the issue and acted within their home rule powers in determining that gas drilling would permanently alter and adversely affect the deliberately cultivated, small-town character of their communities." Nonetheless, even were a community to entirely prohibit drilling, the potential pervasive nature of this activity would affect a number of municipalities in the area.

Quality of Life is another factor, which can be affected by changes to community character. As the Public Health Review indicated (at 6) "[t]here are numerous historical examples of the negative impact of rapid and concentrated increases in extractive resource development (e.g., energy, precious metals) resulting in indirect community impacts such as interference with quality-of-life (e.g., noise, odors), overburdened transportation and health infrastructure, and disproportionate increases in social problems, particularly in small isolated rural communities where local governments and infrastructure tend to be unprepared for rapid changes." The Public Health Review concluded that (at 11) "the number of well pads and associated HVHF activities could be vast and spread out over wide geographic areas where environmental conditions and populations vary. The dispersed nature of the activity magnifies the possibility of process and equipment failures, leading to the potential for cumulative risks for exposures and associated adverse health outcomes. Additionally, the relationships between HVHF environmental impacts and public health are complex and not fully understood."

While there are economic benefits to HVHF, there would also be negative economic impacts, particularly in light of the likely magnitude and pervasiveness of the activity. For example, some of the potential negative impacts associated with HVHF operations, including increased traffic, noise, and visual impacts, may affect visitors' experience of traditional tourist destinations. As a result, tourist destination enterprises that are more geared to traditional tourists would under some circumstances experience a loss in visitors, sales, and employment. Traffic impacts may also lead to additional demands for expanded road infrastructure and related improvements.

With respect to protecting land quality, including agricultural lands, the SGEIS provides, and the Department considered significant measures that would reduce impacts of HVHF. The potential significant adverse environmental impacts, specifically those impacts on agricultural land, must be considered within the framework of the goals of Article 14, Section 4 of the New York State Constitution, which specifically states that the policy of the state is to "encourage the development and improvement of its agricultural lands for the production of food and other agricultural products [which]….shall include the protection of agricultural lands."

Indeed, if HVHF were authorized, any activities disturbing more than 2.5 acres on a farm within an agricultural district would be subject to additional site-specific review in accordance with existing SEQRA regulations. Specifically, the Department would consult with Department of Agriculture and Markets to develop additional permit conditions, best management practices and reclamation guidelines when well pads are proposed on agricultural farmlands. The stockpiling of topsoil would be required by permit condition, and other permit conditions would be developed on a site-specific basis in consultation with DAM staff. The implementation of these measures and coordination with DAM staff would help re-establish active agricultural lands. However, it is also recognized that dependent upon the level of development, some agricultural land could be lost due to HVHF activities. Furthermore, while the Department would employ a host of measures and restrictions to avoid environmental impacts, the only means of completely eliminating the risk of impacts to farmlands and livestock is to employ the No-Action alternative.

Ecosystems and Wildlife

Comment: The Department received numerous comments that raised concerns that if HVHF were allowed to proceed in New York the activity would cause significant adverse environmental impacts on ecosystems and wildlife. Comments included a broad array of concerns with much comment directed specifically at habitat fragmentation, impacts to endangered and threatened species, the introduction of invasive species, and impacts on outdoor recreation.

<u>General Comments</u>

Comments identified specific activities associated with HVHF that would have a significant adverse environmental impact on ecological functions, fish and wildlife populations, and habitat, including noise, lighting, the construction of roads, loss of aquatic habitat from water withdrawals, and sedimentation into surface waters from well pad development. Commenters were also concerned that the SGEIS does not include a comprehensive cumulative impacts assessment with respect to habitat. Specifically, the comments indicated that no comprehensive assessment is provided to estimate the total number of acres likely to be impacted directly (i.e., loss of wildlife habitat) or indirectly (i.e., degraded wildlife habitat, e.g., by edge effects) by natural gas drilling and its associated activities. These comments argued that such an assessment must be done and should include the impacts of well pad construction and maintenance, service roads, staging areas, pipelines, storage areas, and other land uses associated with drilling for, extracting, and transporting natural gas. The cumulative impacts analysis, the comments argued, must be comprehensive to help anticipate and mitigate the full potential impacts to also identify the need to ensure that proper reclamation of well pad sites occurred.

While the majority of comments raised concerns that the mitigation proposed in the SGEIS was inadequate, there were some comments that argued that the mitigation proposed to protect habitat and wildlife was too broad and restrictive. In this regard, comments raised concerns that the restrictions contained on the development of wellheads in grasslands are too broad and without significant environmental justification, and do not provide certainty. These comments further argued that the requirements associated with development in Grassland Focus Areas and Forest Focus Areas on both state and private lands exemplify the selective regulation of the oil and gas industry and will prevent the development of large portions of the Marcellus Shale in New York. They also argued that the SGEIS overestimated the level of development, the amount of land disturbance that would occur and the duration of drilling activities at any particular site.

In addition to comments relating to physical alterations to the landscape, some comments expressed concerns relating to impacts to wildlife and fish from releases of hazardous chemicals. In this regard, comments pointed to a lack of information on toxicity of chemicals used in HVHF and the synergistic effects of these chemicals to fish and wildlife. Related comments focused on potential impacts on fish and wildlife from flowback water impoundments and concluded that these impoundments should not be allowed.

Comments Specific to Habitat Fragmentation

With respect to fragmentation concerns, comments stated the need for both pre- and post-construction monitoring to better identify impacts to habitat and wildlife. Comments also indicated the need for, and in many instances the inadequacy of proposed best management practices, for addressing concerns such as "edge" impacts and impacts from removal of tree canopy and from mowing and other maintenance activities at well pads. Comments also identified impacts from gas pipeline corridors, access roads and other ancillary activities associated with HVHF. In this respect, comments identified the potential for significant impacts from extensive vegetative clearing and grading, water and wastewater storage, truck parking, and drilling infrastructure at each well pad. They estimated that installation of each well pad, including necessary utility and road corridors, would result in 7 acres of the total disturbance. The Nature Conservancy (TNC) provided a report and detailed study that identified the following: 56 fragmentation-sensitive species, including 16 Species of Greatest Conservation Need identified in the Comprehensive Wildlife Conservation Strategy and four species that are designated as Species of Special Concern in New York (Blue-spotted Salamander, Cerulean Warbler, Northern Goshawk, and Red-shouldered Hawk), occur within the Marcellus Shale area of New York. In a case study, TNC developed low-, medium- and high-gas-development scenarios for Tioga County, New York. TNC estimated that natural gas development could reduce the remaining forest habitat by 9-16%, or by 18,674-32,341 acres in Tioga County alone and stated that the direct and indirect impact of a 9-16% loss of forest habitat would significantly affect Species of Greatest Conservation Need, as their populations are already under stress and declining. They went on to state that forest fragmentation resulting from anthropogenic landscape modification, such as clearing for construction of large well pads for HVHF, is well recognized within biogeographic theory and conservation biology as a leading cause of local species extinctions (extirpation). In addition, TNC also stated that development associated with HVHF would likely result in dramatic shifts in the floral and faunal composition of woodland communities as well as sub-lethal impacts to flora and fauna (population isolation, reduced genetic fitness and diversity) from disruptions to forest connectivity. Species dependent upon large, intact areas of interior or core forest and those with limited dispersal abilities are at particular risk from forest fragmentation. They argued that a large body of scientific literature associated with neotropical migratory birds clearly links the survival of many of these species to the preservation and restoration of core forest habitat.

Beyond impacts to species requiring large blocks of habitat, several comments stated that maintaining connections between smaller blocks of habitat was critical to the persistence of many species. Particular concern was expressed for the persistence of amphibian populations that depend on the connections between vernal (seasonal) woodland pools and surrounding upland forest habitat. Linear disturbance corridors such as roadways and pipeline right-of-ways can create impermeable barriers to movement and effectively isolate populations of these organisms from alternative breeding sites. Comments stated that isolated populations are at greater risk for extirpation and that the Jefferson salamander, another species of special concern in New York, would be an example of an amphibian that would be at risk in the absence of conditions addressing connectivity of habitat. In light of these potential impacts, commenters concluded that even with site-specific reviews in designated Forest and Grassland Focus Areas, there would be significant impacts to wildlife and ecosystem resources outside of these focus areas that would require additional mitigation.

Comments identified other significant impacts associated with habitat fragmentation. Specifically, habitat fragmentation contributes to the introduction and spread of invasive species;

edge effects that cause higher predation rates for sensitive species, edge impacts that extend further into the habitat fragment, affecting more area, and a higher presence of generalist species that out-compete sensitive species; drainage pattern changes; and water quality degradation. Comments noted that habitat fragmentation will be particularly detrimental to bird species and that roads, drilling pads, pipeline corridors, and other facilities associated with HVHF will create corridors for nest predators and parasitic species of forest interior bird species. In addition, smaller patches of forest will result in reduced productivity for these species. Beyond potential direct impacts to forest and grassland areas, comments raised concerns about protecting connective and riparian corridors. Finally, some comments suggested that the mitigation measures proposed for forest and grassland areas should be expanded to cover forest and grasslands that are less than 150 and 30 acres respectively and to forests and grasslands beyond the designated focus areas. For example, the Environmental Defense Fund provided detailed comment on this point and concluded that the minimum forest matrix block size threshold used by the Department for determining when special protections apply was too large, and the Department should reduce the size threshold significantly. They urged the Department to use a 1,000-acre threshold and not to consider anything larger than a 5,000-acre threshold. In addition to requests for lowering size thresholds, commenters requested that Important Bird Areas (IBAs) receive specific protections similar to habitat focus areas.

Industry comments indicated that the assumptions of the likely development scenarios of HVHF in the discussion of forest focus areas are incorrect and therefore yield overly conservative representations of impact. Specifically, IOGA, on behalf of the oil and gas industry, estimated that 171 rigs would be used in New York to drill up to 1,744 horizontal and vertical wells per year (less than 35,000 wells by 2020). They recommended that the Department adopt IOGA's drilling rate estimate that they stated was based on conservative assumptions of rig availability in the face of competition from other unconventional plays as opposed to the non-technical predictions that were used in the SGEIS. The New York State Petroleum Council also contended that the imposition of ecological assessments in the grassland and forest focus areas would be without merit or statutory authority. They claimed that imposition of this requirement would impede the exploration for shale gas and severely impact the industry economically. Their comment argued that it had been estimated that these ecological assessments would cost between

$250,000 and $500,000 per study (ERM report to Shell Appalachia, October 28, 2011). These comments concluded that requirements proposed in the SGEIS for work in habitat focus areas unfairly and unreasonably pertain only to the gas exploration and production industry and that these ecological assessments would infringe on the rights of the private landowners by delaying their opportunity to share in royalties generated by the wells.

Many other comments pointed out the need for additional specificity regarding requirements associated with Forest and Grassland Focus Areas. Comments from both industry and environmental groups urged the Department to provide more clarity regarding definitions of terms as well as specific requirements associated with the ecological assessments and pre-disturbance studies proposed in the SGEIS.

Comments Specific to Endangered and Threatened Species

With respect to endangered species, comments raised concerns that the SGEIS relied upon outdated databases and programs (including the Natural Heritage Program). Comments argued that these databases and programs do not provide enough site-specific information, which could lead to potentially significant environmental impacts to ecosystems and wildlife not being properly addressed when issuing permits. In addition, comments indicated that the SGEIS should address the potential for impacts to Federally-listed threatened and endangered species from activities associated with HVHF, including cumulative impacts to these species and their habitats. Comments noted that as of 2012 there were a total of 15 species either listed as endangered, threatened, or designated as candidates for listing which are potentially found within the Marcellus and Utica Shale formations. The comments urged the Department to evaluate the potential cumulative loss of Rare, Threatened, and Endangered Species habitat on a reasonable worst-case scenario estimating the number, duration, and location of proposed wells, and propose necessary mitigation measures to address such impacts. These comments called for the SGEIS to prohibit drilling in or near threatened or endangered species habitat, partly because endangered species already suffer greatly from the loss of suitable habitat and damage from lack of biodiversity. They argued that prohibiting HVHF in or near threatened or endangered species habitat would be a good way to protect the entire ecosystem.

Comments Specific to the Introduction of Invasive Species

Comment related to invasive species noted that invasive plant species, such as purple loosestrife, Japanese knotweed, Phragmites, and others will quickly take advantage of the right-of-ways created by HVHF activities and invade new, relatively pristine wetland sites. These comments went on to state that these introductions would jeopardize breeding populations of many species, including State-listed species such as least bittern, pied-billed grebe, and American bittern. In support of the Department's proposal to monitor and remove invasive plant species from gas project sites, the following suggestions were offered: 1) plant removal should take place prior to seed development; 2) equipment wash water should not run off into water bodies or wetlands; 3) surveys should be conducted one and three years after the site has been restored; 4) root material should be sifted out and treated the same way as aboveground material and disposed of in a proper facility; 5) only sterilized soil that is free from any root and seed material should be used for fill; and 6) all equipment should be cleaned inside and outside prior to transport to a new site. Other comments recommended that the SGEIS include the following site-specific requirements: setbacks between the disturbance and a habitat or plant community; complete avoidance of specific habitats or endangered plants; seasonal restrictions on operations; and vegetation surveys. It was noted that land clearing for the many hydraulic fracturing well pads and associated infrastructure (gathering systems and roads) as well as trucking and movement of fill material would open the door for many invasive species to spread widely in New York (using natural and human mechanisms for dispersal) with major long-term consequences for farmlands, residential areas, and forests. Comments also requested that the Department mandate extensive mediation and remediation to protect against invasive species (including mile-a-minute vine, cinnamon vine, Japanese knotweed, kudzu, zebra fish, insects, blights, etc.) including vehicle and worker inspection/decontamination. In addition, there were some comments that question the need for BMPs to address invasive species or the need for preparation of an Invasive Species Mitigation Plan, while others argued that the BMPs were too open-ended.

Industry comments indicated that invasive species requirements represented selective regulation of the oil and gas industry. They argued that other industrial activities occurring in New York, such as timber harvesting, may also result in the introduction of invasive species; however, invasive species management requirements for timber harvesting are not as restrictive as those proposed for the oil and gas industry in the SGEIS. In this respect these comments stated that the SGEIS would require oil and gas developers to develop and gain approval for an Invasive Species Mitigation Plan prior to any development activities and prior to any invasive species issues being detected and argued that these requirements represent selective regulation that is arbitrary and capricious.

Comments Specific to Outdoor Recreation

Several comments expressed concern for impacts on outdoor recreation from HVHF activities, specifically the loss of hunting and fishing opportunities. For these commenters, outdoor recreation is a very important part of New York's economy and they argued that multiple uses such as hunting, angling, and wildlife watching must be considered. In addition, to maintain the quality of the outdoor recreational experiences, they requested that HVHF operations be suspended during certain times of the year, such as the start of hunting seasons, peak periods of wildlife mating and birthing seasons, and periods of low water or high drought risk. Several commenters were also concerned that any reduction in the experience of forest users could damage hunter and angler recruitment, retention, and participation which they stated was vital to maintaining healthy wildlife populations and robust funding for conservation. Comments also argued that the priority landscapes and acquisition parcels identified in the state Open Space Conservation Plan and the State Forest Resource Assessment and Strategy must be carefully considered, and sites where drilling poses too great a risk must be placed off limits to drilling.

Response: HVHF would result in significant adverse environmental impacts to ecosystems and wildlife. However, the SGEIS proposed, and the Department considered, various measures and site-specific evaluations to reduce the potential for these impacts. The mitigation proposed and considered, including buffers and restrictions on drilling activities in sensitive environmental settings, would likely reduce impacts. In some instances the mitigation would likely be effective in substantially reducing the risk of impacts, in other instances impacts would only be partially mitigated, and in some instances the Department recognizes that there is insufficient information, or too much uncertainty as to the degree of protection afforded by the measures contemplated by the Department to determine if the impacts could be adequately mitigated at all. Despite the proposed and considered mitigation, the Department recognizes that the only certain way to effectively avoid or minimize environmental impacts of HVHF on ecosystems and wildlife to a point of non-significance is to select the No Action alternative, as widespread HVHF activities inherently have the potential to have significant adverse environmental impacts on ecosystems and wildlife.

With respect to endangered, threatened and special concern species, the Department believes that if HVHF were authorized, the existing regulatory framework would reduce the risk of potential impacts to these species. Specifically, the SGEIS proposed that potential impacts to endangered, threatened and special concern species would be reviewed for each well pad location on a case-by-case basis. Under the ECL (ECL § 11-0535), if a project of any kind would take threatened or endangered animals the project requires a permit from the Department. A project that would take listed species could not go forward until such time as it obtained the appropriate permit (See 6 NYCRR Part 182). In addition, any determination made by the Department concerning endangered and threatened species does not in any way reduce the authority or ability of the United States Fish and Wildlife Service to request its own assessments for federally listed species or imposing additional conditions on projects that may harm these species. Thus, in the event that HVHF were authorized, the Department believes that potential impacts to endangered and threatened species would likely be avoided or mitigated under existing regulatory requirements contained in 6 NYCRR Part 182.

Likewise, the measures proposed and considered by the Department would likely be effective in significantly reducing impacts caused by the introduction of invasive species as a result of HVHF activities. Specifically, the SGEIS proposed that potential impacts from invasive species as a result of HVHF activities would be addressed through a site-specific Invasive Species Management Plan and use of Best Management Practices (BMPs) to prevent the spread and introduction of invasive species. These BMPs included pressure- washing and cleaning of equipment and trucks. In addition, prior to any ground disturbance, BMPs require the proper removal of invasive plant species and further require the removal of any new invasive species when reclaiming the site. Specifically, one BMP requires sites to be monitored for invasive species following partial reclamation, and another requires an environmental monitor to check all equipment and machinery entering or exiting the site for invasive species. The SGEIS contained Best Management Practices to prevent the introduction and spread of invasive species at all well pads and access roads. These BMPs establish effective monitoring at all sites for the introduction of invasive species. In the event that HVHF were authorized, the Department would have considered incorporation of several additional requirements that would reduce the potential for introduction and/or spread of invasive species. For example, a requirement that invasive species be eradicated from temporary freshwater impoundments before water could be moved to another location would further reduce the potential for introduction of invasive species.

With respect to the potential transfer of invasive species through water withdrawals associated with HVHF, the Department proposed and considered specific best management practices to prevent the spread of aquatic invasive species during water withdrawal operations. These measures include inspection, cleaning, and decontamination of equipment. Unfortunately, there is no way to know for certain that a source of water is uncontaminated with invasive species. Thus, BMPs for aquatics that were proposed, and considered for adoption if HVHF were authorized would reduce the potential for impacts but not eliminate them.

The Department does not anticipate any cumulative impacts from water withdrawals with respect to water quality and quantity. Indeed, the SGEIS recognizes the Department's ability to regulate water withdrawals used for HVHF, and through a permitting process the Department can monitor and enforce water quality and quantity standards by requiring passby flow (Natural Flow Regime Method); fish impingement and entrainment protections; protections for aquatic life; reasonable use requirements; water conservation practices; aquifer depletion protection; water withdrawal reporting; and evaluation of cumulative impacts on other water withdrawals. These measures would reduce significant adverse impacts on species and habitat. See also Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation.

The Department recognized concerns regarding potential unmitigated impacts to terrestrial habitats and included requirements in the SGEIS to protect habitats of utmost concern in New York. The Department primarily focused on reducing impacts in large blocks of forests and grasslands that support declining species. The SGEIS proposed and the Department considered measures designed to reduce significant adverse impacts from fragmentation by preserving existing large blocks of habitats identified in Grassland and Forest Focus Areas. If HVHF were authorized, the Department considered only allowing for a permit to be issued if the findings of a site-specific ecological assessment demonstrated to the Department's satisfaction that the proposed surface disturbance would not likely result in a significant adverse impact to the grassland or forest habitat and/or bird species using these respective habitats. In this respect while a site-specific environmental review can potentially provide more effective in reducing the risk at a particular site, it is far less certain that it can address potential cumulative impacts to a particular region, especially in an area where the activity – HVHF – may be inconsistent with the functionality of the habitat on the landscape, such as breeding habitat that would be compromised by land disturbances that isolate particular wildlife populations.

Most comments on habitat fragmentation requested additional detail and clarification of these requirements and some comments argued that the requirements went too far, as noted above, while many others argued that the requirements did not go far enough. The comments that argued the requirements went too far primarily questioned the fairness of the requirements rather than the environmental impact. However, the comments that argued for further restrictions based their argument on environment impacts and available science. In addressing the potential impacts to terrestrial habitat, the Department considered mitigation measures that were limited to specific focus areas - forest interior or grasslands habitats. While providing measures to protect forest and grassland focus areas could significantly reduce impacts specific to those blocks it does not take into account the importance of maintaining connections between important habitats. With respect to these connections, the Department considered additional measures to address connections between blocks of habitat. These measures included additional restrictions to maintain riparian corridors between habitat patches which serve as travel corridors for wildlife movement by requiring a site-specific SEQRA determination for any access road to be installed within the 100-year floodplain or within 50 feet of a surface water. However, beyond these focus areas and necessary connections between habitats there are countless forests and grasslands that provide important habitat for declining species. In these areas, the type and level of activity associated with HVHF will lead to a significant increase in acreage that would be converted to non-forest use in the form of well pads and roads, and the concomitant nighttime lighting, noise and other impacts. Thus, while these measures collectively would have reduced certain impacts from HVHF activities, the potential for significant adverse environmental impacts would still remain.

With respect to comments from industry that the Department should have used different estimated rates of expected drilling activity, in the event that HVHF were authorized, the Department could have adjusted these estimated rates. However, even accepting the lower projections provided by the industry, and after application of the measures intended to reduce impacts, HVHF activities would still cause significant adverse impacts from habitat fragmentation.

In addition to comments focused on impacts from well pad construction, many comments were received on the impacts from the network of pipelines and gathering lines that would be necessary to carry the gas produced at the wells. Although the Department does not have jurisdiction over the expected pipeline network and gathering lines, the Department's decision whether or not to authorize HVHF triggers wide ranging significant cumulative impacts from the two activities, i.e. HVHF development and pipeline construction. The method for evaluating the significant adverse environmental impacts that will result from the initiation of HVHF thus far has excluded consideration of those impacts. Under PSL Article VII, the Public Service Commission (PSC) would review on a case-by-case basis the potential environmental impacts associated with creating and maintaining a gas pipeline right-of-way. PSC has the authority to dictate the location of a right-of-way, and to condition how construction, site closure and right-of-way maintenance are conducted to reduce the significant adverse environmental impacts. This includes significant adverse impacts that will cause forest fragmentation and loss of grassland and forest habitat. Under the current regulatory framework, these must necessarily be addressed on a case-by-case basis because the PSC has jurisdiction over where a pipeline would be located and, thus, the environmental resources that are affected. In this respect while a site-specific environmental review can potentially provide more effective mitigation for a particular pipeline, it is far less certain that it can address potential cumulative impacts to a particular region, especially in an area where the activity – HVHF – may be inconsistent with the overall character of the region. In addition, one could only speculate as to whether and where any gas pipelines would be located, depending on whether a well is drilled in a particular location, whether a well or wells are productive, as well as a suite of physical and commercial considerations regarding access to the larger commercial gas pipelines that transmit product for distribution and consumption.

Several comments stated there was a lack of data on the toxicity to wildlife of many chemicals used in HVHF. The Department agrees and the SGEIS stated that, "compound-specific toxicity data are very limited for many additives to fracturing fluids..." and believes that additional research on the toxicity of these chemicals and potential synergism of these chemicals is necessary to understand the full scope of the potential impacts on fish and wildlife from the release of these chemicals into the environment. In the event that HVHF were authorized, the Department proposed and considered numerous measures for controlling, containing, and preventing fracturing fluid and flowback water from being released into the environment. However, the Department recognizes that these measures merely reduce the risk of a release of chemicals into the environment and that the only certain way to avoid that risk is to select the No Action alternative.

In addition to the uncertainty surrounding the impacts from toxicity of chemicals on wildlife, the Department has also recognized the limitation of assessing potential impacts on wildlife from artificial light and noise. While the SGEIS included many measures to address these potential impacts, there remains uncertainty as to the extent of these impacts on wildlife. Specifically, the Department considered requiring lighting at well pads to shine downward during bird migration periods. The SGEIS also included noise mitigation for human receptors that, if applied, also would reduce impacts from noise on wildlife. The Department recognizes that some additional requirements might be necessary to further reduce impacts from lighting. In this regard, the Department considered additional Best Management Practices to further reduce direct impacts to wildlife by requiring all lighting to be shielded downward and the use of low-wattage sodium vapor bulbs. However, even with these additional measures, it is unknown what the full extent of impacts would be on wildlife in New York due to artificial light and noise at well pad sites. See also Response to the Comments in Noise and Visual in Potential Environmental Impacts and Mitigation.

Air Quality and Greenhouse Gas Emissions

Comment: The Department received numerous comments that raised concerns regarding potential impacts to air quality from HVHF activities, as well as the potential for increased greenhouse gas (GHG) emissions. The comments in these two areas of concern are addressed individually below.

Comment on Air Quality

The Department received numerous comments concerning potential air quality impacts related to HVHF. Some comments minimized these impacts, alleging that the Department overestimated the potential significant impacts and then recommended burdensome mitigation measures. Others commented that certain air related regulations and analysis had not been addressed such as Part 212, Part 201 major source applicability and ozone attainment. Many commenters claimed that if HVHF were authorized the activity would cause significant adverse environmental impacts on air quality including significant risk to human health. Comments included a broad array of concerns with many comments directed at cumulative air impacts from all emission sources involved in HVHF including emissions of nitrogen oxides (NO_X), volatile organic compounds (VOCs), fine particulates ($PM_{2.5}$), formaldehyde, benzene, toluene, hydrogen sulfide (H_2S), ammonia (NH_3) and polycyclic aromatic hydrocarbons (PAHs), which contribute to the formation of ozone and are known to negatively impact human health.

Comments identified specific activities associated with HVHF that would have a significant adverse environmental impact on air quality and human health if not properly mitigated. Commenters also suggested that the modeling analysis performed for the SGEIS did not accurately reflect realistic operating scenarios although, in this regard, commenters were split. For instance, some believed that the modeling analysis did not consider the reasonable worst case scenario air impacts resulting from simultaneous operations of spatially proximate well sites and underestimated the maximum number of drilling days. Other commenters believed the SGEIS modeling analysis overestimated emissions by including simultaneous emissions from drilling and fracturing operations when evaluating short-term air quality impacts. Furthermore, with respect to modeling, commenters urged the Department to analyze the cumulative air quality impact from all emission sources involved in HVHF at multiple sites including emissions from truck traffic, well pad engines and equipment, impoundments, flaring, and compressor stations and any air quality impacts from neighboring states. The cumulative impacts analysis, the comments argued, must be comprehensive to help anticipate and mitigate potential significant impacts to human health and the environment and to ensure compliance with National Ambient Air Quality Standards ($NAAQ_S$) and ambient thresholds for air toxics.

While many comments raised concerns that the mitigation in the SGEIS was inadequate, there were some comments that argued that the mitigation to protect air quality was too restrictive and preempted by Federal regulation. In this regard, industry raised concerns that the mitigation measures for the non-road drilling and fracturing engines purported to establish standards and requirements and are thus preempted by the Clean Air Act.

Numerous comments were also received concerning greenhouse gas emissions. Those comments are addressed in a separate section of the response to comments.

<u>Comments Specific to Rule Applicability</u>

Comments asked the Department to clearly identify regulations applicable to all HVHF activity including applicability of 6 NYCRR Part 212 and 6 NYCRR Part 201 major source requirements. With respect to major source applicability, comments recommended that the definition of a "major source" be determined according to the regulations and guidance for aggregating sources that are in place at the time of the application and consistent with controlling case law. Comments further suggested corrections to terminology such as the definition of "facility" as it applies to NESHAP Subpart HH.

Comments stressed the need for compliance with EPA's regulations for the oil and gas industry that were finalized on April 17, 2012 and would impose restrictive regulations for well activities, offsite compressors and ancillary equipment. In addition, comments stated that the impact of drilling activities upon compliance with the new NO_2 and SO_2 standards proposed by the EPA must be assessed. Finally, comments on regulatory applicability included a call for the Department to establish and regularly update guidelines for the oil and gas industry that include best available technology for control of air emissions from oil and gas drilling activities in New York State and include these guidelines in the SGEIS.

Comments Specific to the Air Quality Modeling Analysis

With respect to modeling, comments sought clarification on the procedure and emissions data used by the Department. For instance, commenters requested more information about whether the modeling scenarios used by the Department reflect air and emission regulations applicable to the industry; they questioned the validity of the industry data used in the modeling and the meteorological data used to determine the worst-case dispersion conditions. Comments also questioned the Department's method for incorporating background levels, characterizing it as conservative and recommending that more refined methodologies be used.

Furthermore, commenters cast doubt on the modeling by criticizing the use of worst-case assumptions indicating that the resulting air quality assumptions were not reliable and should not be used to prescribe mitigation measures. Again, these comments were split. Some recommended that the Department redo the modeling using more reasonable assumptions to develop more reliable air concentrations. These commenters argued that the engines should be considered intermittent sources and thus, be excluded from the Departments NAAQS modeling consistent with U.S. EPA's Memorandum to Regional Air Division Directors re: Additional Clarifications Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS (March 1, 2011). They argued that this would more accurately assess the probability of exceedance of NAAQSs and determine the need for mitigation measures, if any. Others sought more conservative assumptions that relied on a worst case scenario based on the lowest tier engine models used for drilling and fracturing. These comments also recommended that the Department analyze alternate modeling scenarios to identify and compare air quality impacts.

Some commenters questioned modeling assumptions relating to venting and flaring and asked the Department to explain how it calculated the gas venting and flaring amounts in standard cubic feet per day based on those assumptions. They urged the Department to severely limit venting to minimize VOC and methane emissions and stressed the need for venting controls where "sour" or "wet gas" is encountered and exceedances of the Hydrogen Sulfide (H_2S) 1-hr standard of 14 $\mu g/m^3$ could occur.

Comments asked that the SGEIS consider emissions from other chemicals used in the hydraulic fracturing process such as emissions from retention pits (or impoundments) used to collect drill cuttings and recover high-volume hydraulic fracturing fluids. Comments also asked that the

SGEIS provide additional analysis supporting the assumption that no emissions of criteria pollutants resulting from uncontrolled venting of the gas are expected. The comments urged the Department to give appropriate consideration to the aerial nitrogen deposition that will come from NO_X and catalyzed ammonia (NH_3) in the emissions of engines, compressors, pumps, or other equipment used in the drilling and distribution operations.

Comments identified modeled exceedances and sought clarification concerning how these would be handled. For instance, modeling of the completion venting of H_2S in the 2009 dSGEIS for the potential production of sour gas showed an exceedance of the New York 1-hr standard of 14 µg/m3; modeling of emissions of benzene from glycol dehydrators showed a potential exceedance of the annual guideline concentration (AGC) for benzene; and modeling of formaldehyde emissions from the offsite compressor engine showed a potential exceedance of the AGC for formaldehyde from the 1,725 horsepower (HP) off-site compressor engine. Comments sought clarification that construction and operation of these would be subject to permit requirements and/or site-specific permit review that would consider these emissions.

Comments Specific to Mobile Sources

Commenters were concerned with air quality impacts from mobile sources, including localized impacts to communities proximate to the well pads and sensitive receptors such as on-site workers and environmental justice communities, as well as regional emissions from truck traffic associated with a peak of about 2,200 wells in a year. Commenters suggested that the mobile source impact assessment under-predicts the number of miles that will be driven by heavy equipment to transport supplies to and haul wastes away from drill sites, especially wastewater hauled out of state to treatment and disposal facilities. The comments indicated that modeling for mobile source air impacts resulting from wastewater transport must be consistent with reasonable worst case scenario forecasts of wastewater volume as well as in and out of state disposal options. The comment questioned modeling assumptions that indicated both light and heavy duty trucks would only travel 20-25 miles one way, when out-of-state treatment and disposal facilities may be located several hundred miles away. Furthermore, for rural operations, the commenter stated that it is unlikely that supplies, equipment, specialty contractors, lodging, and other support equipment and personnel will be located within 20-25 miles of the drill site.

Comments expressed concern about how mobile sources would be factored into the modeling analysis and accounted for given that these sources are not subject to permitting activities. Comments recommended that the United States Environmental Protection Agency emissions inventory tools be used to quantify air toxics emissions from this source category.

Comments Specific to Drilling and Fracturing Engines

The most significant comments concerning drilling and fracturing engines focused on characterizing the engines for regulatory applicability and identifying appropriate, cost effective control technology to reduce emissions from the engines to comply with standards.

Industry questioned the Department's authority to mandate the use of cleaner engines and retrofits such as particulate traps and selective catalytic reduction (SCR). Industry argued that these requirements were preempted by the 1990 Clean Air Act amendments which gave the federal government the authority to establish standards applicable to emissions from new non-road engines and new non-road vehicles. Industry pointed out that this statute expressly preempts all states from regulating emissions from new engines smaller than 175 horsepower that are used in construction or farm equipment or vehicles, and from new locomotive engines; and for other non-road engines beyond those expressly reserved to the federal government. Industry commented that CAA 209(e)(1) allows states other than California to adopt and enforce standards relating to control of emissions from non-road vehicles or engines only after meeting certain requirements. Industry argued that New York had not met those requirements and thus could not impose numerical emissions levels with which the engines must comply, or emission-control technology with which they must be equipped. Furthermore, commenters questioned the cost assumptions regarding the addition of selective catalytic reduction to non-road engines, claiming that they are incorrect and greatly underestimate the costs to the regulated community.

Comments Specific to Ozone and Attainment of NAAQSs

Comments noted that the SGEIS failed to directly address the major issue of secondary formation of pollutants such as ozone (O_3) from the increased emissions of VOCs, including benzene, toluene and NO_X that are emitted during drilling and hydraulic fracturing. Commenters pointed out that these compounds mix with emissions from heavy-duty truck traffic and large generators and compressors at well sites to form ground-level ozone that combines with particulate matter to form smog. Commenters also stated that chronic exposure to smog has been linked to various cancers, heart disease, diabetes and premature deaths in adults, and to asthma, premature birth and cognitive deficits in children. Comments sought additional information on how the additional NO_X emissions would affect the area's 8-hour nonattainment classification and overall how these and other emissions would affect relevant State Implementation Plans (SIPs, including SIPs for $PM_{2.5}$, ozone, and regional haze).

Comments Specific to Monitoring

Comments raised the need for comprehensive air quality monitoring to assure that actual air quality experienced does not pose health risks to the community. Comments stated that monitoring should be both at the regional and local level with community air monitoring plans that define the scope for the monitoring program, sampling methodology and frequency and duration, the location of the monitoring sites, and the amount of equipment and personnel needed to run each site, along with the cost. They further stated that monitoring must provide sufficient information to understand the consequences of increased regional NO_X and VOC emissions on the resultant levels of ozone and fine particulates ($PM_{2.5}$); and include information on how the Department will use the air quality monitoring requirements to inform future determinations regarding shale play development. They commented that the information should include actions to be taken in the event that exceedances are identified, such as dust mitigation measures, temporary work stoppage, and installation of emissions control equipment. Additional recommendations suggested that the monitoring address methane leaks, fugitive dust, toxics, and odors; and include mobile and permanent monitors that rely on battery power or land power.

Commenters asked that the monitoring program commence prior to Marcellus Shale gas development to verify background levels and continue until the Department, in consultation with the EPA, can scientifically conclude that data collection is no longer warranted. Finally, comments asked the Department for a definitive answer concerning who will fund and implement the monitoring. Some insisted that the obligation to fund the air monitoring program be borne by industry and clearly tied to a permit condition requirement. Industry questioned the authority to require shale gas companies to bear the costs of an ambient air monitoring program specific to Shale gas. Most comments seem unified in recommending that the Department implement the monitoring program.

Comments Specific to Mitigation Measures

Many comments focused on the mitigation measures in the SGEIS. Similar to comments on other areas of the SGEIS, comments sought clarifications, challenged regulatory authority to require certain mitigation and recommended additional measures to assure compliance with ambient standards. The latter included the use of vapor recovery units to control fugitive emissions from storage tanks, the use of Ultra-Low Sulfur Diesel (ULSD) in engines to control sulfur oxide emissions and Diesel Particulate Filters (DPFs) or bio-fuels to control PM2.5. Comments asked that truck idling restrictions be enforced in accordance with the requirements of 6 NYCRR 217-3 and that mitigation measures be put into place to address potential exceedances of the NO_2 standard and to minimize dust. As noted earlier in the response to comments, mitigation to reduce emissions from temporary non-road combustion engines was challenged as preempted by Federal law. Comments questioned the feasibility of "setback" mitigation such as fence line public exclusion zones and the necessity of minimum stack heights for sweet gas versus sour gas.

Response to Comment on Air Quality

The process of HVHF development, transport and waste management will result in significant impacts to air quality that must be mitigated to protect human health and the environment. Therefore, the Department undertook a comprehensive air quality impact analysis tailored to the proposed HVHF activity. The goal of the air quality impact analysis was to quantify accurately potential emissions and propose mitigation measures that would assure compliance with national ambient air quality standards promulgated to protect human health and the environment.

Revised industry information on well drilling and fracturing operations, new EPA regulations for the oil and gas industry, and public comments on draft versions of the SGEIS prompted a substantive review and reanalysis of air regulations and the air quality impact assessment. Areas that were reviewed or reanalyzed are discussed in this response to public comment and in several new or revised appendices. These appendices include: Modeling of Ozone Impacts from Well

Pad Activities and Associated Truck Traffic and Compressor Stations for Future Peak Well Development Conditions in the Marcellus Shale Area of New York State (attached hereto as RTC App. B)(new); Modeling Input Data (attached hereto as RTC App. C)(new); Evaluation of Particulate Matter and Nitrogen Oxides Emissions Factors and Potential After treatment Controls for Nonroad Engines for Marcellus Shale Drilling and Hydraulic Fracturing Operations (attached to the SGEIS as App. 18A)(revised); and Cost Analysis of Mitigation of NO_2 Emissions and Air Impacts by Selective Catalytic Reduction (SCR) Treatment (attached to the SGEIS as App. 18B)(revised).

Based on the assessments and the results of the regional ozone modeling, a set of revised mitigation measures were considered which, if implemented, and if HVHF were authorized, would have made it more likely that compliance with national ambient air quality standards would be maintained (with the possible exception of the ozone NAAQS, discussed below) and avoided the need for site-specific assessments of air quality impacts. Alternative measures which industry believes achieve compliance with national ambient air quality standards or equivalent levels of emission reductions would have also been considered on either a case-specific or general basis through a demonstration process.

Rule Applicability

The SGEIS includes an expanded list of state and federal regulations which may be applicable when permitting facilities associated with gas drilling in New York. Most of the listed regulations will not apply to well pad activity. That is, most of the pad emission sources at the well pad are small enough to be exempt from air permitting, unless that activity becomes aggregated with off-site activity, such as a compressor station, as a result of a source determination that triggers a major stationary source threshold. These regulations may apply to off-site compressors. Therefore, a determination of regulatory applicability for off-site compressors and any associated equipment at the well pads would be conducted during the case-specific permit review and analysis of an off-site compressor permit application.

The Department reviewed the list of potential federal and state regulations applicable to HVHF activity and updated the list to account for revised operational considerations and new or revised regulations, including EPA's Final Rule on Oil and Natural Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants, promulgated on April 17, 2012. That rule finalized the review of new source performance standards for the listed oil and natural gas source category, including revisions to: 40 CFR 60 Subpart OOOO (NG [natural gas] Production, Transmission, & Distribution), 40 CFR 63 Subpart HH (Oil & NG Production), and 40 CFR 63 Subpart HHH (NG Transmission & Storage). In addition, EPA revised the NSPS for volatile organic compounds from leaking components at onshore natural gas processing plants and the NSPS for sulfur dioxide emissions from natural gas processing plants. EPA also established standards for certain oil and gas operations not covered by the existing standards. In addition to the operations covered by the existing standards, the newly established standards would regulate volatile organic compound emissions from gas wells, centrifugal compressors, reciprocating compressors, pneumatic controllers and storage vessels. This rule also finalizes the residual risk and technology review for the Oil and Natural Gas Production source category and the Natural Gas Transmission and Storage source category. Furthermore, it includes revisions to the existing leak detection and repair requirements and establishes emission limits reflecting maximum achievable control technology (MACT) for certain currently uncontrolled emission sources in these source categories. This rule also includes modification and addition of testing and monitoring and related notification, recordkeeping and reporting requirements. Details of the rule can be found at the EPA webpage (http://www.epa.gov/airquality/oilandgas/actions.html).

The Department reviewed the requirements of the EPA final rule with respect to all air emission sources at the well pad to assure that pertinent sections of the rule were addressed. In all instances, the mitigation measures and the permitting processes that the Department has identified for air emission sources contained in the SGEIS and this response to comments are as restrictive as, or more restrictive than, the EPA requirements. In other instances where EPA's rule requirements do not modify existing regulations for particular sources located at the well pad, the SGEIS mitigation measures are deemed to be as or more restrictive than the existing EPA regulations. For instance, the emission requirements for gas venting and flaring identified by the Department in the SGEIS are more stringent than required by the EPA regulations. Also, EPA's final rule requires the minimization of VOC emissions by techniques which can achieve a

95% reduction in VOC emissions in most instances. Although EPA's proposed regulation identified combustion techniques such as a flare and a vapor recovery unit (VRU) as methods that achieve the necessary reductions, its final rule provides an exception when VOC emissions would be lower than 6 tons/year based on concerns raised by Industry about safety and the higher cost of VRU use versus the flare technique. However, Department review of the documentation related to costs indicates that if the recovered vapor is marketed for reuse and a VRU system is in place for at least a couple of years, the VRUs would be more cost effective. Thus, condensate tanks used in New York would require installation of a vapor recovery system instead of flaring the emissions since the latter creates additional combustion emissions and other potential issues. However, the Department would modify this permit condition for a case specific demonstration of potential safety concern when VOC emissions are lower than 6 tons/year. In such cases, a combustion technique or another method to limit condensate tank emissions would be considered for approval. For off-pad facilities of air emissions, the requirements of the EPA regulations would be applied on a case-by-case permitting basis.

Furthermore, the 1-hour NO_2 and SO_2 NAAQS, which were finalized after the 2009 dSGEIS, were reviewed and considered by the Department in its supplemental modeling and resulting mitigation measures.

Numerous comments were received concerning regulatory applicability for the drilling and fracturing engines. In calculating emissions for rule applicability, the 2009 dSGEIS did not specify whether the drilling and fracturing engines were considered stationary sources because it was not clearly determined by industry at that time whether these engines would be at a well pad for more than a year, which would have qualified them as stationary sources under applicable law and regulations. Subsequently, the Department determined that the drilling and fracturing engines are properly considered non-road engines because they will be at a pad for less than a year, based on the proposed revised limit of drilling only four wells per pad in a single year, and the fact that each well would take approximately a month to drill and fracture. Based on this determination, NO_X Reasonably Available Control Technology (RACT) and New Source Review (NSR) would not apply to these engines. (However, as discussed below, under "Drilling and Fracturing Engines", the Department evaluated requiring engine emission mitigation measures to achieve ambient standards that would control NO_X emissions at or below that which would be imposed by NO_X RACT requirements.) With regard to off-site compressor or gathering stations, source determination and major source rule applicability would be made on a case-by-case basis within the permitting process.

Furthermore, with respect to comments regarding major source applicability, Appendix 18 to the SGEIS discusses the definition of stationary source for the determination of air permit requirements. To assess applicability, the Department must evaluate whether emissions from two or more pollutant-emitting activities should be aggregated into a single major stationary source. The appendix lays out criteria for the evaluation applicable at the time the appendix was prepared. Subsequent to preparation of the appendix, source determination criteria have changed due to evolving case law. In particular, the 6th Circuit Court of Appeals ruling in *Summit Petroleum Corp. v. EPA*, held that EPA could no longer consider the functional interrelationship between two sources in determining whether the sources are located "contiguous" and "adjacent" to one another. *Summit Petroleum Corp. v. EPA*, 690 F.3d 733 (6th Cir. 2010). Although EPA issued a memorandum stating that it would continue to rely on interdependence outside of the 6th circuit, the D.C. Circuit Court of Appeals invalidated that memorandum, holding that EPA cannot treat pollution sources in one region differently from those in others because of an adverse court ruling. *National Environmental Development Association's Clean Air Project v. EPA*, No. 13-1035, D.C. Cir. May 30, 2014. These court rulings require the Department to revisit the applicable criteria as set forth in Appendix 18. Therefore, any source determinations conducted by the Department would rely on regulation and guidance for aggregating sources that are in place at the time of a permit application and consistent with controlling law, assuming HVHF is in general permitted.

As with all of the information submitted by industry, the emission factors and references used to estimate emissions were independently verified by Department staff. Information reflecting particulate matter (PM) emissions as provided by industry present the general level of the criteria pollutants and were not to determine regulatory applicability. This is because these estimates include emissions from activities which are not considered stationary sources. Where the corresponding speciated PM_{10} and $PM_{2.5}$ emissions are necessary to determine regulatory applicability and compliance, the appropriate EPA emission factors or source specific data would be used by the Department.

Modeling

The modeling analysis performed in the SGEIS to address the potential impacts of gas development was used to determine the consequences of the various operations with respect to the health and other air quality impacts near the well pads and an adjacent compressor station. In making the comparisons to acceptable levels, the SGEIS has relied on National Air Quality Standards ($NAAQ_S$) for criteria pollutants and air guideline concentrations for non-criteria/toxic pollutants. The Department has relied on these levels in making similar determinations for various permitting and SEQRA assessments.

In order to assess the air quality impacts associated with the various air pollution sources at the well pad and associated activities such as truck traffic and potential off-site compressor stations, an initial set of modeling analyses were undertaken for the SGEIS. The modeling followed a stepwise process and evolved since the original 2009 dSGEIS to incorporate a set of revisions to the source characteristics and operational restrictions identified by industry, as well as additional assessments performed to address public comments. The additional analysis performed for the SGEIS and to respond to comments did not affect all aspects of the original analysis. Therefore, to the extent that the original modeling analysis results were still valid, albeit conservative, the revised analysis did not revisit these conservative steps.

Some assumptions used in the air modeling in the 2009 dSGEIS were based on information provided by industry, including the particulate matter emission rates for the engines and the possibility of simultaneous operations of drilling and fracturing at a single well pad. Subsequent revisions to these assumptions were provided by industry. Those that were deemed technically appropriate by the Department and which could be imposed by operational restrictions were included in a supplemental modeling analysis. These refinements no longer assume simultaneous operations of the drilling and fracturing equipment at a single well pad, the simulation of each individual drilling and each fracturing engine (instead of combined source representation), and the appropriate $PM_{2.5}$ and PM_{10} fractions of the particulate matter emissions. The effects of these operational changes were considered by the Department where appropriate in supplemental modeling and in considering potential mitigation. Furthermore, industry has indicated that flowback impoundments are not contemplated and the Department indicated that they would not be approved. Thus, toxics from additives used in the fracturing process were not addressed in the air quality modeling and the SGEIS does not address the impacts of these impoundments.

Due to remaining issues with exceedances of the 24-hour $PM_{2.5}$ ambient standard from the original analysis and the adoption of new 1-hour SO_2 and NO_2 standards by EPA since the initial modeling analysis, a supplemental modeling analysis was performed. That assessment incorporated discussions from an industry modeling exercise for $PM_{2.5}$ and PM_{10}, more recent EPA guidance documents on modeling for these pollutants, and information presented by industry and public comments on the modeling results in the SGEIS.

For example, the original analysis for the 2009 dSGEIS was based on industry information which indicated that up to ten wells could be drilled at a well pad in a year and that there was a potential for simultaneous operations of drilling and completion at a single well pad. However, that assumption was revised based on further information from industry indicating that only four wells would be drilled per pad per year and that no simultaneous operations of drilling and completion at a well pad would occur. Since the original assessment was more conservative in its assumptions as it related to both short term and annual impacts, any subsequent modeling performed revisited these results using the new set of conditions only where the original analysis indicated issues with standards compliance or threshold exceedance.

The basic modeling approach reflected in the SGEIS, including the model, the pollutants and emissions, the meteorological input data, background levels and the well pad sources remain essentially the same in the additional modeling exercises. Based on the spatial extent of the Marcellus Shale, six National Weather Service sites within this area were chosen to represent meteorological conditions for the purpose of dispersion modeling of potential well sites. It was judged that these sites would adequately envelope the set of conditions which would result in the maximum impacts from the relatively low-elevation or ground-level sources identified as sources of air pollutants. In addition, EPA and Department modeling guidance recommends the use of five years of meteorological data from a site in order to account for year to year variability. For the current analysis, however, the Department has chosen two years of data per site to gauge the sensitivity of the maxima to these data and to limit the number of model calculations to a manageable set. It was determined that impacts from the relatively low-elevation sources would be well represented by the total of 12 years of data used in the analysis. This analysis is conservative from the standpoint of the number of data years used. Certain public comments[1] recommended that the Department should use the EPA-recommended five years of data for its analysis. However, these comments do not fully recognize the conservative nature of using 12 years of meteorological data to determine the worst case impact for any potential site in the Marcellus Shale play. While the EPA and the Department guidance using five years of data applies to individual meteorological site analysis to account for possible climatological variability at the particular site, the use of 12 years of data from six different sites has a similar conservatism built into it by the end use of the overall maxima for any well pads or compressor stations.

The “worst case” modeling approach in the SGEIS was retained to determine acceptable impacts under a set of source and operational conditions that could be ensured through the well permitting process and minimize the need for site specific analyses and accommodate alternate operational scenarios. For instance, initial modeling in the 2009 dSGEIS was conducted assuming the potential of ten wells being drilled at a pad for a year, even though refined industry information and resulting permit conditions would have limited the well pads to four. Also, for modeling purposes, placement of the various pieces of equipment on a well pad site was chosen such as not to underestimate maximum off-site impacts as well as combined impacts. For the modeling of the 24-hour $PM_{2.5}$ and 1 hour NO_2 impacts for the supplemental modeling, the simultaneous operation scenario was not used. Furthermore, the initial set of modeling in the 2009 dSGEIS used a single source representation for the drilling engines and compressors, while for the fracturing pump engines, five sources were placed next to each other to represent the potential from fifteen engines, three in each source. This scenario was revised for the supplemental modeling by modeling each of the 15 completion equipment engines as individual point sources. In addition, for the NO_2 impacts, the drilling and compressor engines were modeled as individual sources in the supplemental modeling. The rest of the sources are expected to either be a single piece of equipment or are in sets such that representation as a single source was deemed adequate. Additionally, whereas the 2009 modeling accounted for

[1] AKRF Consultants 12/3/2009, p. 2.

“rain capped” stacks that retard the plume rise momentum out of the stack, the supplemental modeling eliminated this flow restriction. Another difference in the supplemental modeling concerned the placement of the engines on the well pad which was further revised for the additional modeling performed for $PM_{2.5}$ and NO_2 and represented a more realistic scenario where engines were not modeled from at the well pad boundary. This of course, resulted in lower emissions at the receptors. If HVHF were authorized, the new configuration would have to be incorporated as a permit condition, and any exceedances addressed with mitigation measures to show compliance with standards.

In their comments on the SGEIS, industry claimed that the completion engines in particular should be treated as “intermittent” sources and should not be explicitly modeled. The Department disagreed with this position and asked EPA Region 2 for concurrence. EPA Region 2 staff agreed with the Department’s conclusion as did staff at the national Model Clearinghouse at Office of Air Quality Planning and Standards (OAQPS). Thus, an explicit modeling analysis to demonstrate standards compliance was performed for the drilling and fracturing engines in concert with the other sources at the well pad.

The Department has performed modeling to address concerns with the originally assumed placement of well pad engines at the edge of the property boundary as well as the cyclical nature of the emissions of $PM_{2.5}$ from the completion engines. See Appendices B and C to the Response to Comments. Results from the supplemental modeling indicate under the operational restrictions in accord with industry’s suggested engine operations and emissions reflecting Tier 2 engines, further control measures to achieve the PM10 and $PM_{2.5}$ $NAAQ_S$ would not be needed. However, the modeling still indicates exceedances of the 1 hour NO_2 standard which could be mitigated by either distance setback measures or the use of emission reduction methods. These mitigation measures were then identified as potential permit restrictions to be used by industry without a need for a site specific modeling assessment if HVHF were authorized. If industry alters the engine operations or does not choose the mitigation identified by the Department to achieve modeled compliance, no assurance can be provided that short term PM and NO_2 standards would be met. In that case, a well pad specific analysis based on a modeling protocol showing compliance with short term PM and NO_2 would have to be submitted to, and approved by, the Department.

Several comments raised concerns about emissions of criteria pollutants from uncontrolled venting. The 2009 dSGEIS considered the emissions of all criteria and toxic pollutants associated with well drilling and hydraulic fracturing operations. Information provided by industry and the Department's consultants identified all pollutants that could be emitted during short term gas venting. This gas is made up of methane and propane, with minor quantities (less than 10 percent) of non-methane Volatile Organic Compounds (VOC_s). These VOC_s do not contain any criteria pollutants. The air quality impacts of all pollutants in the vented gas including H_2S were considered by the Department. Additionally, the Department's modeling assumed the potential impact of very restrictive gas venting requirements, imposed through permitting requirements, that would assure that methane and VOC (such as benzene) would not be released into the atmosphere to any significant degree. In this regard, the Department's modeling also recognized the possibility of encountering "wet gas" in Western New York which could increase VOC_s emissions and analyzed worst case emissions from West Virginia shale gas.

The initial modeling results identified certain pollutant thresholds that were projected to be exceeded due to specific source emission rates and stack parameters provided by industry. Many of these exceedances related to the very short stacks and associated structure downwash effects for the engines and compressors used in the various phases of operations. Thus, limited additional analysis and modeling was undertaken to determine the impact of simple adjustments to the stack height or estimates of distances at which impacts would be reduced below the standards. Based on this analysis the mitigation measures were adjusted for H_2S and for benzene to condition the use of a minimum stack height only in the event that "sour" or "wet" gas, respectively, is encountered. For example, the exceedances of the benzene toxic threshold were due to the dehydrator placed at the well pad. Thus, in order to meet the annual benzene ambient guideline concentration (AGC), the stack height for a dehydrator placed at the well pad would have to be increased to a minimum of 30 feet, in addition to application of a benzene emission limit of 1 Tpy.

Concerns were also raised during public comment that modeling of formaldehyde emissions from the 1,725 horsepower (HP) offsite compressor engine showed a potential exceedance of the AGC annual guideline concentration for formaldehyde. Since the exceedance was not attributed to a source at the well pad, the Department would have modeled formaldehyde from off-site compressors during permitting of each compressor, at which time DEC would consider the imposition of mitigation measures to ensure that ambient thresholds are met, if HVHF in general was permitted.

Some comments assumed that projected exceedances of the toxics thresholds were due to simultaneous drilling, completion, and production. However, this was incorrect.

Emissions of diesel exhaust result in a variety of air pollutants and PAHs represent a subset of diesel particulate. In order to judge the potential effects of pollutants associated with all sources at the well pad in addition to associated truck traffic and compressor stations, the Department has looked at the level of these emissions relative to the baseline emissions and performed regional modeling to assure the goal of NAAQS compliance. To address the concerns raised regarding diesel exhaust emissions from trucks, pumps, condensers, and other heavy equipment, the Department analyzed emissions from trucks using EPA's MOVES emissions model. This analysis indicates that the contribution of the truck traffic to the regional mobile source emissions is less than one percent for all pollutants. The Department has outlined a number of mitigation measures to minimize diesel emissions which would be imposed through well permit conditions if HVHF were authorized. Recent studies estimating PAH species based upon total PM2.5 sampling episodes among traffic sites indicate that PAHs comprise a maximum of 0.13% of total PM2.5. Multiplying the $PM_{2.5}$ annual $NAAQ_S$ of 12 µg/m3 by 0.13 percent yields an estimated PAH concentration of 0.0156, which is below the Department's health based guideline concentration of 0.02 µg/m3 for PAH. Based on these estimates the Department expects that PAH levels would remain below the guideline concentration as long as compliance with the $PM_{2.5}$ $NAAQ_S$ is maintained. Further assurance could be provided by monitoring of a number of pollutants near the well pads and compressor stations, as discussed in the SGEIS and in this response to comments.

In order to address any modeled adverse impacts, the Department has identified in the SGEIS and in this response to comments the potential set of mitigation measures identified under which standards compliance could be demonstrated. However, to the extent that these standards and thresholds are revised, the mitigation would require reassessment to assure compliance.

Mobile Sources

Based on comments received, the Department revisited the vehicle miles traveled (VMT) used to calculate truck traffic emissions. In order to address public concerns with the weighted average VMT values used in the emissions calculations, the MOVES model was rerun by doubling the VMT to determine the sensitivity of the resultant emissions. This doubling of VMT resulted in the emissions being increased by approximately the same factor of two, or up to 1.3 and 1.6% for NO_X and $PM_{2.5}$, respectively, of the total mobile source emissions in the Marcellus Shale counties modeled. These relative emissions as calculated at the time would not significantly affect the results of the assessments such as the regional ozone modeling. 6 NYCRR 217-3 addresses mobile sources emissions which might occur due to diesel trucks idling in that it limits idling to five minutes. The regulation has an exception to the idling limitation when the "engine is being used to provide power for an auxiliary purpose, such as loading, discharging, mixing or processing cargo; controlling cargo temperature; construction; lumbering; oil or gas well servicing …" This exception, however, is limited only to the specific conditions when the motor vehicle is used to provide the auxiliary power. Vehicles not running their engines to provide power for such auxiliary purposes may idle for no more than five minutes per the regulation. In addition, these regulations only apply to the truck traffic and not to the non-road drilling and fracturing engines. For example, if a vehicle's engine is running to power a pump loading flowback water, then the vehicle is not subject to the 5-minute idling limitation. If that same vehicle is running while sitting stationary awaiting entry to the site, then it is subject to the 5-minute limit. Furthermore, 6 NYCRR Subpart 217-5 contains opacity standards applicable to heavy duty vehicles based on engine model years. Opacity meter trained and certified ECOs are authorized to pull over an offending heavy duty vehicle to conduct a test and to fine violators as appropriate.

Drilling and Fracturing Engines

To address emissions from the drilling and fracturing engines, further analysis for the drilling equipment in the revised draft 2011 SGEIS assumed reduced emissions based on retrofitted Selective Catalytic Reduction (SCR) controls on Tier 2 drilling rig, air compressor, and completion equipment engines.

Mitigation measures included using the cleaner engines and retrofits as modeled. Industry objected to this mitigation measure claiming that it amounted to federally preempted regulation of emissions and emission-control technology for non-road engines. However, it appears that industry misinterpreted the intent of the engine emission mitigation. Emissions and impacts from these non-road sources in excess of air quality standards constitute an adverse impact under SEQRA. Therefore, mitigation measures that have been demonstrated by the Department's modeling to show compliance with air quality standards have been recommended as one means of mitigating an adverse air quality impact, although developers would be able to propose alternative mitigation measures.

The Department has also considered alternative mitigation measures. One of these, enlarging the area around the well site that the public is excluded from (for example, by means of a fence), also drew objections from commenters questioning its feasibility. Other alternatives include: newer (Tier 4) diesel engines, use of natural gas spark-ignition engines, and the use of electric equipment for drilling and hydraulic fracturing. In the absence of these mitigation methods identified by the Department, compliance with air quality standards cannot be assured without site specific modeling analyses to demonstrate compliance with air quality standards using other mitigation methods.

Tier 4 diesel engines are certified at significantly lower PM and NO_X emissions levels than the engines that were on the market when the 2009 dSGEIS was first issued. The Tier 4 standards were phased in beginning in 2011, and are fully in force as of 2015 for new engines greater than 750 horsepower (the engine class that accounts for most drilling rig and hydraulic fracturing engines). However, because of the longevity of engines currently in service, it will be several years before the air quality benefits of Tier 4 engines are fully realized.

Natural gas spark-ignition nonroad engines are certified to meet PM and NO_X emission standards that are more stringent than unretrofitted Tier 2 diesel engines. The applicable PM standards are identical to the Tier 4 diesel PM standards for non-generator set engines. The natural gas engine standards for NO_X are more stringent than the Tier 4 diesel standards for non-generator set engines. Natural gas compression-ignition nonroad engines are dual fuel engines that can run on diesel fuel, and are certified to the same standards as diesel engines. Their emission factors would be the same as corresponding diesel engines.

The final Tier 4 nonroad diesel emissions standards set more stringent standards for diesel fueled electric generators greater than 750 horsepower than for other engines in the same size class. Thus, if HVHF were authorized, use of electric powered drill rigs and hydraulic fracturing equipment could mitigate well site emissions, even if the electricity is generated on site.

Ozone and Attainment of NAAQS / State Implementation Plans

In instances where the analysis for the SGEIS did not address issues which were subsequently determined to be pertinent to the air quality assessment results, further modeling was performed. For example, based on data and information which became available from industry after the SGEIS, Department consultants and staff performed an assessment of regional ozone impacts due to well development and associated truck traffic and compressor stations and this assessment is included as Appendix B to the Response to Comments and is summarized below.

New York State is currently designated attainment for all NAAQSs except for ozone (1997 and 2008 NAAQS). The New York City metropolitan area (Suffolk, Nassau, Richmond, Kings, Queens, New York, Bronx, Westchester and Rockland Counties) is the only area in New York State currently monitoring nonattainment for the 1997 8-hour ozone NAAQS. Areas in New York State designated nonattainment for the 2008 ozone NAAQS are the New York City metropolitan area (Suffolk, Nassau, Richmond, Kings, Queens, New York, Bronx, Westchester and Rockland Counties) and Chautauqua County. The Department will revise State Implementation Plans, as necessary, to assure continued compliance with any revised and/or new NAAQS.

Further evaluation of compliance with the ozone NAAQS is described in Appendix B entitled "Modeling of Ozone Impacts from Well Pad Activities and Associated Truck Traffic and Compressor Stations for Future Peak Well Development Conditions in the Marcellus Shale Area of New York State."

This assessment indicated that HVHF development could increase ozone levels by 1 ppb to 3 ppb in areas downwind of the areas of development, including the New York City metropolitan area which currently measures above and is projected to be at or around the current ozone standard of 75 ppb in 2018. Based on methodology used to characterize the impact of emissions in one state on ozone levels in downwind states, EPA has found any contribution to nonattainment in excess of 1 % of the standard (0.75 ppb), as well as contributions that would interfere with maintenance of the standard in excess of 1 % of the standard to be significant. The significance of the HVHF development contribution could increase in the future if EPA finalizes its regulatory proposal to reduce the ozone NAAQS to the range of 65-70 ppb. Other downwind areas, such as Albany-Schenectady-Troy, Poughkeepsie-Newburgh and Greater Connecticut (Hartford), are projected to be at or near the proposed ozone standard once finalized, so HVHF development could impact the ability of these areas to maintain air quality that meets the ozone standard.

It is critical to note that the worst case incremental impacts and the projected total ozone levels detailed in the appendix modeling ozone impacts cannot be used in the form presented at this time to reach any definitive conclusions on issues related to whether these incremental impacts would result in standards compliance or exceedance, for a number of reasons. First, as mentioned above, there are specific EPA established calculation methodologies for ozone compliance demonstrations for future projections which must be performed to make such determinations for SIP purposes. The use of these EPA procedures account for the conservative nature of the CMAQ predictions and provide an adjustment to the “raw” data predictions presented above. However, it is premature to make such calculations at this time without a full understanding of: 1) how well the timeframes and levels of projected emissions from New York’s portion of the well drilling activities, as used in this study, would be actualized; 2) the potential future emissions expected from the full regional emissions associated with gas development, including those from neighboring states such as Pennsylvania and West Virginia, which have to be included in a final regional inventory to be relied upon by OTC states and EPA to make determinations, which could differ from the 2020 inventory used in this analysis; and 3) EPA's proposal to update the air quality standards for ground-level ozone, proposed on November 25, 2014.

However, it is possible to depict the incremental impacts associated with the additional NO_X and VOC emissions due to the gas development relative to the projected total impacts from the full 2020 inventory such that the relative influence on the concentration patterns can be ascertained. One way to depict this relationship is to show the ozone levels with and without the additional emissions from gas development. Since the incremental impacts were found to be larger for the 2020 future inventory and since this time frame better represents the likely future peak well development period, the comparison is made of the 2020 future regional inventory. This inventory, however, is not the final inventory on which future ozone SIP modeling work would be performed for the reasons presented above.

Monitoring

New York currently operates an extensive air monitoring network throughout the state to evaluate compliance with the NAAQS. Some of these monitors are located in shale gas areas. Information about New York's air monitoring network can be found at www.dec.ny.gov. If HVHF were authorized, the Department would supplement the existing monitoring sites by adding another monitoring station in the southern tier of the State.

Similarly, if HVHF were authorized, local impacts could be monitored using mobile monitoring units and other associated portable monitoring equipment at well sites and in the surrounding communities to evaluate the impact of the various stages of shale gas development at a local level, to verify the adequacy of air pollution mitigation measures, and to respond to air quality complaints. Once sited, these instruments would remain in place until adequate data is collected for the site. They would then be relocated to other areas.

The Department acknowledges that air monitoring conducted by the Department, if funding and staff were available, would be more efficient and acceptable to the public than monitoring performed by industry.

Prior to implementing the air quality monitoring program for shale gas development and prior to the beginning of drilling operations, the Department, with input from NYSDOH, would develop a Quality Assurance Project Plan (QAPP) if HVHF were allowed to proceed. The QAPP would also include an action plan that would describe the actions to be taken by the Department if ambient air pollutant levels rise to unacceptable levels, including any additional community air monitoring, if warranted. The QAPP would be available to the public on the Department's website, as would all collected and verified monitoring data. The QAPP would also be periodically reviewed and modified as necessary.

In addition to the monitoring described in this section, if HVHF were authorized operators would be required to develop and implement a methane Leak Detection and Repair (LDAR) Program, including the monitoring of methane concentrations with a simple hand held device. Details of a potential LDAR program are presented in the section on mitigation below.

Mitigation Measures

Revised industry information on well drilling and fracturing operations, new EPA regulations for the oil and gas industry, and public comments on the initial set of mitigation measures in the draft versions of the SGEIS necessitated substantive review and reanalysis of air regulations and air quality impact assessments.

Some of the Department's assessments in the well pad and regional ozone modeling have relied on industry's estimates of operational constraints and emissions. These assumptions, in turn, would have to be incorporated as mitigation measures in the well permitting process reflective of the expected air quality impacts. Four of these potential measures are further explained based on additional information received through the public comments.

The first item relates to the amount of gas that would be allowed to be vented and flared per pad. The emissions of pollutants used in the modeling assessments assumed that venting and flaring of gas during the completion stage would occur for approximately 3 hours and 3 days, respectively, as provided by industry. That report also notes that the maximum amount of gas flow per well would be 10 million cubic feet per day (MMcf/d) or 420,000 standard cubic feet (scf) per hour which was used in the Department's analyses. Using these values, the total well pad venting and flaring gas amounts were calculated to be:

$$3 \text{ hours} \times 420{,}000 \text{ scf/hour} \times 4 \text{ wells/pad-year} = 5.04\ (\approx 5) \text{ MMscf/pad per year and}$$

$$3 \text{ days} \times 10 \text{ MMscf/day} \times 4 \text{ wells/pad per year} = 120 \text{ MMscf/pad per year.}$$

These assumed gas flow rates and pad-based volumetric limits would allow industry the flexibility to adjust the timeframes for venting and flaring per well depending on the actual gas flow during each well operation. In cases where less than four wells per pad are drilled per year, however, these pad-based volumetric limits could result in gas venting and flaring from individual wells in quantities that potentially raise concerns regarding short-term impacts. Therefore, if HVHF were authorized mitigation measures would also have to limit the amounts of gas to be vented and flared on an average per well basis. This combination of conditions would allow for flexibility and would not increase the assumed maximum emissions used for the modeling and the air quality impact analyses.

The second item to be clarified relates to the controls that would be imposed on the condensate tanks which are used when “wet” gas is encountered. There are instances where the SGEIS preferential use of the vapor recovery units (VRUs) might be a safety concern, specifically at low vapor recovery rates. Therefore, in the event that HVHF were authorized, in instances when an operator can demonstrate that the VOC levels would be lower than 6 ton/year, it would have to identify in a permit application a combustion or another technique as an alternative to the VRUs.

The third item deals with the type of control that would be used for NO_X emission reductions from the wellhead compressors. The NO_X control equipment that would be applicable to lean burn engines is SCR and not Non-Source Catalytic Reduction (NSCR), which would be appropriate for rich-burn engines.

The fourth item relates to the use of SCR control systems in order to shorten the 1000-foot fenceline requirement for fracturing engines. DEC reviewed the original capital and operation and maintenance cost estimates for SCR control systems for fracturing engines in light of the comments submitted by industry. As a result of this review, DEC concluded that the costs were underestimated and re-evaluated these costs using a report by the California Air Resources Board as a guide. The revised costs analysis for installing and operating SCR control systems on fracturing engines is presented in Appendix 18B to the SGEIS.

Based on the reviews and assessments described in the SGEIS and above, if HVHF were authorized the following set of mitigation measures were considered for implementation through enhanced procedures and the well permitting process:

1. The diesel fuel used in drilling and completion equipment engines would be limited to ultra-low sulfur diesel (ULSD) with a maximum sulfur content of 15 parts per million (ppm);

2. There would not be any simultaneous operations of the drilling and completion equipment engines at the single well pad;

3. The maximum number of wells to be drilled and completed annually or during any consecutive 12-month period at a single pad would be limited to four;

4. The emissions of benzene at any glycol dehydrator to be used at the well pad would be limited to 1 Tpy as determined by calculations using the Gas Research Institute's (GRI) GlyCalc program. If wet gas is encountered, then the dehydrator would have a minimum stack height of 30 feet (9.1 meters) and would be equipped with a control device to limit the benzene emissions to 1 ton/year;

5. Condensate tanks used at the well pad would be equipped with vapor recovery systems to minimize fugitive volatile organic compound (VOC) emissions. In site-specific well permit applications, industry can propose an alternative technique, such as a flare combustion of the VOC emissions, for conditions associated with safety concerns and total VOC emissions of less than 6 tons/year;

6. During the flowback phase, the venting of gas from each well pad would be limited to an average of 1.25 MMscf per well and a maximum of 5 MMscf during any consecutive 12 month period. If "sour" gas is encountered with detected hydrogen sulfide (H_2S) emissions, the height at which the gas would be vented would be a minimum of 30 feet (ft) (9.1 meters [m]);

7. During the flowback phase, flaring of gas at each well pad would be limited to an average of 30 MMscf per well and a maximum of 120 MMscf during any consecutive 12-month period;

8. Wellhead compressors would be equipped with either Selective Catalytic Reduction (SCR) or Non-Selective Catalytic Reduction (NSCR) controls;

9. For drilling engines, the following mitigation measures have been demonstrated to meet the ambient standards and do not need site-specific assessments:

    - EPA Tier 2 diesel engines, placed as close to the center of the well pad as possible and in sets of two banks of drilling and compressor engines on opposite sides of the drill rig. In addition, public exposure to any area within 150 m (500 ft) measured from the engine locations and in all directions would be imposed by physical barriers or other equivalent methods;

- The same measures as above, except instead of the setback distance, industry can choose to install SCR control for nitrogen oxides (NO_X) on all engines; and

- Any combination of EPA Tier 4, natural gas or electric engines.

For any other engine use or alternative mitigation measure, industry would perform a well pad- specific modeling analysis or a more generic mitigation measure assessment, in accord with a modeling protocol or a mitigation plan submitted to and approved by the Department. The analysis would also contain an assessment of the consequences of the alternative on the regional ozone levels projected as part of the SGEIS.

10. For completion engines, the following mitigation measures have been demonstrated to meet the current NAAQS and do not need site specific assessments:

    - EPA Tier 2 diesel engines, placed as close to the center of the well pad as possible and in sets of two banks of drilling and compressor engines on opposite sides of the drill rig. In addition, public exposure to any area within 300 m (1000 ft) measured from the engine locations and in all directions would be imposed by physical barriers or other equivalent; and

    - Any combination of EPA Tier 4, natural gas or electric engines.

For any other engine use or alternative mitigation measure, industry would perform a well pad-specific modeling analysis or a more generic mitigation measure assessment, in accord with a modeling protocol or a mitigation plan submitted to, and approved by, the Department. The analysis would also contain an assessment of the consequences of the alternative on the regional ozone levels projected as part of Section 6.5.3 of the SGEIS.

11. During well drilling and completion operations, the operator would post a sign at each well pad in accordance with the requirements of 6 NYCRR 217-3 to reduce diesel emissions from truck idling. The sign would be provided by the Department, as available, or would be provided by the operator with equivalent content; and

12. The well permit application would contain a description of a dust control plan.

<u>Comment on GHG Emissions</u>

The Department received extensive comments on issues related to the impacts of GHG emissions from natural gas (both specifically from HVHF and more generally) and the adequacy of mitigation activities proposed in the 2009 dSGEIS and SGEIS. These comments focused on the impacts and mitigation of carbon dioxide (CO_2) and methane (CH_4) as these are the most prevalent GHGs emitted from oil and gas industry operations, including the exploration and development of the Marcellus Shale and other low-permeability gas reservoirs using HVHF.

The Department has reviewed and considered the comments submitted related to GHG emissions. Broadly speaking, the comments and responses fall into the following major categories: GHG emissions and global warming potentials, natural gas and GHG emission reduction goals, and adequacy of mitigation. For the sake of completeness and recognizing that this is a generic EIS for an activity that could have important implications for the State's energy policy, the Department is responding to comments that might ordinarily fall outside the scope of SEQRA review.

Greenhouse Gas Emissions and Global Warming Potentials

The Department received comments that addressed GHG emissions from HVHF production activities at the well site, as well as comments that addressed GHG emissions from other stages of the natural gas life cycle. Many commenters were concerned that HVHF will produce significant amounts of GHG emissions, which in turn will contribute to climate destabilization and exacerbate climate change. Some commenters questioned whether the Department properly considered all possible sources of GHGs at the well site and urged the Department to consider a variety of GHG emission sources at the well site. Commenters indicated that methane and other GHGs may be emitted intentionally and unintentionally during production at the HVHF well site. Commenters also raised numerous concerns with fugitive GHG emissions (or emissions from leaks, venting, and flaring), contending that fugitive emissions are difficult to measure and that more certainty is needed with respect to how much carbon dioxide and methane would be generated from HVHF activities. At least one commenter questioned apparent inconsistencies in GHG estimate values for various activities contained in tables within Appendix 19 of the SGEIS.

When discussing the life cycle or footprint of natural gas, commenters also emphasized that methane and other GHGs may be emitted during transmission, distribution, and combustion beyond the well site. Many commenters urged the Department to consider, for example, GHG emissions associated with the combustion of shale gas by downstream users and methane releases during transport, storage, and distribution of shale gas. This includes fugitive emissions that are difficult to measure, and therefore many commenters suggested that more certainty is needed with respect to how much GHG emissions would be generated from these downstream portions of the natural gas life cycle. Alternatively, commenters in favor of allowing HVHF suggested that recent research on fugitive emissions from HVHF overestimates these emissions and the need for mitigation.

The Department also received many comments that methane released from natural gas operations has a high Global Warming Potential (GWP) that exceeds that of carbon dioxide. This would contribute substantially to the GHG footprint or life cycle emissions of natural gas, whether produced via HVHF or by conventional means. Commenters also questioned the particular 100-year GWP utilized by the Department in the calculation of GHG emissions associated with HVHF, and suggested that the Department use more recent GWP estimates from the Intergovernmental Panel on Climate Change (IPCC) and a 20-year time frame to represent the near-term impacts of methane as a GHG.

Natural Gas and Greenhouse Gas Emission Reduction Goals

Commenters also raised specific concerns that the expansion of shale gas development and HVHF could interfere with the State's overall GHG emission reduction goals, including the goals of the New York State Climate Action Plan, draft 2009 State Energy Plan, and New York's goal to reduce carbon emissions by 80 percent by 2050 (Executive Order 24, 2009). They also contended that, more generally, shale gas drilling perpetuates society's dependence on, and use of, fossil fuels. Many commenters expressed concern that shale gas development might supplement, rather than replace, coal and other fossil fuels. As a result, according to these commenters, HVHF and associated natural gas development could aggravate, rather than ameliorate, global warming.

Many commenters contended that natural gas has a greater footprint or carbon intensity than that for conventional gas or oil. One commenter claimed that GHG emissions from HVHF are 23 times that of conventional gas drilling. Commenters also argued that the drilling process directly contributes to global warming at levels comparable to or worse than coal and that the footprint of shale gas is at least 20% greater than coal. Commenters also stated that coal would have a lower

GHG ‘impact’ than shale gas in the 30 to 40-year time horizon for existing generating facilities when comparing the most efficient technologies for coal and gas-fired generation.

Commenters also stated that the development of Marcellus Shale gas could negatively impact renewable energy development and use in the State. In particular, commenters questioned the premise that natural gas is an important transitional fuel and requested that a full life cycle analysis of natural gas production be performed to justify such a claim, especially because methane is a powerful GHG. This analysis, commenters urged, should include the anticipated timing of when this transitional gas will become available and the extent to which the renewable energy economy would be in place. Commenters noted an abundance of cheap natural gas could interfere with efforts to encourage the development and use of renewable energy resources.

Adequacy of Mitigation

The mitigation of GHGs from HVHF and the natural gas system generated extensive comments. Some commenters argued that the GHG mitigation measures proposed in the SGEIS should be strengthened, that a GHG mitigation plan and/or fund should be implemented, that the Department should review and approve of all GHG mitigation plans, or that mitigation measures should be codified in regulation to ensure accountability and enforceability. Other commenters contended that the Department lacked authority to require or impose mitigation on a generic basis without adopting rules and regulations.

Some commenters suggested specific measures to reduce GHG emissions during HVHF, including requirements for green or Reduced Emission Completions (as opposed to venting or flaring), leak detection and repair, reducing vehicle miles travelled and fuel consumption by drilling equipment, requiring participation in the USEPA Natural Gas STAR program, and encouraging carbon capture and sequestration. Some further argued that the proposed leak detection and repair program should include a GHG mitigation plan and be incorporated into the permit. Many commenters questioned the Department’s proposal to defer the requirement for green completions pending further analysis. Commenters also indicated that GHG emissions would still be significant even after implementing mitigation measures due to the sheer number of wells, notwithstanding the implementation of mitigation measures at each individual well.

Finally, some commenters questioned the adequacy of mitigation given the full life cycle of natural gas and the potential for fugitive emissions.

Response to Comment on GHG Emissions

HVHF activities result in GHG emissions at the well site and in its transport. Uncertainty remains regarding the overall GHG emission impacts associated with other stages of the natural gas life cycle. These responses address comments on GHG emissions relative to the Department's evaluation of a state-wide program pursuant to which individual applications for well permits authorizing HVHF would be considered in New York State. Ultimately, the mitigation measures proposed in the rdSGEIS would reduce, but not eliminate, the GHG emission impacts from HVHF activities, and would not address other GHG emission impacts associated with the use of natural gas. Updated GWP metrics further demonstrate the potential impact of methane emissions on climate change, but do not resolve this uncertainty. While the precise GHG impact of shale gas is uncertain as a fossil fuel, the use of natural gas as an energy source contributes to climate change, both through the leakage of methane and the emission of CO_2 when natural gas is combusted.

The SGEIS focused on emissions of GHGs from HVHF at well pads. However, the Department recognizes that the full life cycle or footprint of natural gas also includes downstream or post-production GHG emissions. Natural gas emission sources include fugitive GHG emissions (from leakage, venting, and flaring) that can occur during upstream and downstream steps in the life cycle, as well as GHG emissions that result from natural gas combustion – such as for home heating and power generation. The mitigation measures that were proposed in the SGEIS addressed GHG emission sources at the well site and are discussed first in the response below. Downstream GHG impacts of the natural gas life cycle are also discussed, although they occur regardless of the source of the natural gas or the manner in which it is produced, and therefore the mitigation measures described in the SGEIS would not limit these GHG emissions.

The Department recognizes that, as raised by at least one commenter, certain GHG estimate values in the Tables contained within Appendix 19 of the SGEIS are inconsistent. These differences were the result of a transcription error. All of the GHG values in Appendix 19 were projected estimates of the GHG emissions associated with certain activities. As discussed in more detail below, many of these estimates are inherently uncertain and contribute to the uncertainty associated with the overall GHG emission impact of HVHF and the natural gas life cycle. Therefore, updating the GHG estimate values in Appendix 19 of the SGEIS or correcting the transcription error among the various tables contained in the Appendix would not change the Department's overall conclusions regarding the GHG emission impacts associated with HVHF and the natural gas life cycle.

Regarding emissions mitigation at the well site itself, the Department recognizes that there is uncertainty regarding the degree that monitoring and emissions control measures would control GHG emissions during HVHF. Mitigation technologies continue to be improved and utilization of the best available technologies to address emissions would reduce them from HVHF. Green completions or Reduced Emission Completions (REC) would reduce GHG emissions in areas where collection lines are available. However, because new collection lines are not available until production is established, RECs may not be an option for initial wells drilled at new well pad areas. Hence, GHGs could be vented or flared from new wells even if REC standards are in place. Furthermore, the proposed Leak Detection and Repair requirements in the SGEIS provide a reasonable program for reducing emissions, but they would allow GHG emissions during the repair evaluation and scheduling phases. While leaks would be reduced, they would not be eliminated.

Because an SGEIS is being used to evaluate all impacts attributable to HVHF development in New York State, uncertainties in HVHF emissions and their mitigation should also be acknowledged within the context of the additional and often greater methane emissions released during the entire natural gas life cycle. Although it is beyond the scope of this SGEIS, life cycle analysis of natural gas production, transport and use would greatly contribute to the understanding of how natural gas fits in the overall effort to reduce GHG emissions. [2] Importantly, the most recent USEPA Greenhouse Gas Inventory (2009-2012) reported greater emissions from transportation, storage, and distribution of natural gas than from production and

[2] e.g., PSC Case 13-G-0031 and Methane Emissions Reduction Collaborative Project

processing.[3] Moreover, although some studies indicate that the EPA estimates of total US methane emissions from all sources are over-estimated, other studies suggest that emissions are under-estimated, including sources at drilling operations (such as wells, compressors, pumps, and other control devices).[4] This suggests substantial uncertainty in the magnitude of fugitive emissions as well as current and future impacts from natural gas extraction in addition to other methane sources. There is also uncertainty as to the degree to which these activities may be regulated in the near future. Various phases of the life cycle, including the production, transportation, storage, and distribution of natural gas, may be subject to new or revised regulations by the federal government.[5] On January 14, 2015, the Obama administration announced a goal to reduce methane emissions from the oil and gas sector by 40-45% from 2012 levels by 2025. As part of the plan to achieve this goal, the EPA announced that it would propose new source performance standards for methane emissions from the oil and gas sector under Section 111(b) of the Clean Air Act in the summer of 2015, and it would finalize such regulations in 2016.

Overall, the Department recognizes that there is uncertainty in the estimation of carbon intensity when considering all aspects of fuel life cycles. Hence, while the combustion of natural gas is less carbon intensive than that of oil or coal, there are additional methane emissions during the production and distribution of natural gas. This creates substantial uncertainty about comparative life cycle emissions. There is also uncertainty as to whether conventional and unconventional (HVHF) natural gas generate similar amounts of GHGs. Some modeling suggested little to no difference,[6] but these models may need to be updated with more recent

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3 EPA 430-R-14-003 Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012: April 5, 2014. http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

4 Miller, Scot M., et al. Anthropogenic emissions of methane in the United States. Proceedings of the National Academy of Sciences 110.50 (2013): 20018-20022. www.pnas.org/cgi/doi/10.1073/pnas.1314392110; Allen, David T., et al. 2013. Measurements of methane emissions at natural gas production sites in the United States. Proceedings of the National Academy of Sciences 110: 17768-17773. www.pnas.org/cgi/doi/10.1073/pnas.1304880110; Brandt, A.R., et al. 2014. Methane leaks from North American Natural Gas Systems. Science 343: 733-735. www.sciencemag.org/content/343/6172/733

5 White House "Climate Action Plan - Strategy To Reduce Methane Emissions" http://www.whitehouse.gov/sites/default/files/strategy_to_reduce_methane_emissions_2014-03-28_final.pdf

6 Weber C. L., and C. Clavin (2012). Life cycle carbon footprint of shale gas: Review of evidence and implications. Environmental Science and Technology 46, 5688 – 5695: Stephenson T., et al, (2011). Modeling the relative GHG emissions of conventional and shale gas production. Environmental Science and Technology 45, 10757 – 10764.

research on potential emission sources from HVHF. The uncertainty in the estimates of GHG emissions attributable to HVHF is particularly important when considering the greater short-term climate impacts of methane as compared to carbon dioxide as shown in the 20-year vs. the 100-year GWP for this gas.

Regardless of uncertainties regarding the GHG emission impacts of HVHF and the overall natural gas life cycle (including various metrics for GWP), the majority of GHG emissions globally and in the State are from the energy system.[7] Because of this, the IPCC considers the decarbonization of the energy system to be key to reducing and stabilizing GHGs in the atmosphere and avoiding the worst effects of climate change.[8] The State has recognized this need through its overall goal to reduce GHG emissions 80 percent by 2050 (Executive Order 24, 2009), as emphasized in the draft State Energy Plan (2014). The Department recognizes that natural gas does have a lower carbon intensity (carbon dioxide equivalent emissions per unit energy) than other fossil fuels during combustion. In fact, GHG emissions from fossil fuel combustion in the State's electricity system have decreased by more than 40% since 2005, due in part to the increased use of natural gas and reduced use of coal. Uncertainties exist, however, regarding the countervailing impact of GHG emissions associated with natural gas production and distribution.

Of additional concern is the impact on this transition of expanded HVHF and shale gas production, which supplies more abundant low-priced natural gas to the energy market. Recent research demonstrates that low-cost natural gas suppresses investment in and use of clean energy alternatives (such as renewable solar and wind, or energy efficiency), because it makes those sources of energy less cost-competitive in comparison to fossil fuels.[9]

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[7] In 2011 fuel combusted for electricity, transportation, and residential use accounted for approximately 70% of NY GHG emissions. NYSERDA 2014. New York GHG Emissions: Sources and Trends

[8] IPCC AR5 WG3 Chapter 7 Energy Sources. IN IPCC, 2014. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer et al. (eds)] Cambridge University Press, Cambridge

[9] Shearer, Christine, et al. 2014. "The effect of natural gas supply on US renewable energy and CO2 emissions." Environmental Research Letters 9: 094008; McJeon, Haewon, et al. 2014. "Limited impact on decadal-scale climate change from increased use of natural gas." Nature 514: 482-485; Davis, Steven J., and Christine Shearer. 2014. "Climate change: A crack in the natural-gas bridge." Nature 514: 436-437.

Socioeconomic

Comment: The Department received numerous comments on the potential socioeconomic impacts that commenters believed would occur if HVHF were authorized in New York State. Some comments highlighted the expected gains in employment, income, tax revenues and economic activity, while other comments expressed concern that the forecasted economic gains were overstated and that negative socioeconomic impacts would result to other industries, such as agriculture and tourism. Some comments argued that if HVHF were not allowed the natural gas industry would be unfairly penalized and would lose millions of dollars spent on pre-existing lease agreements; that the proposed setbacks and restrictions detailed in the Draft SGEIS were too stringent and would make HVHF uneconomical; and finally, that natural gas extraction companies would be forced to relocate out-of-state.

Comments also expressed concern about the adequacy of the economic impact assessment in SGEIS, questioning the underlying assumptions used to forecast the estimated impacts of job growth, income generation, and state and local tax receipts. In particular, these comments questioned the forecasted number of wells to be drilled and the expected magnitude and duration of development. Additionally, the validity of the individual well production profiles and industrywide production profiles used in the SGEIS were questioned, as were the assumptions made about the average productive life of a well.

In addition to these overarching comments on the potential economic impact of HVHF, substantive comments were also received on the following socioeconomic subtopics:

- Labor Market Issues
- Cyclical Nature of the Extractive Industries;
- Housing/Property Values (including mortgage and homeowner’s insurance issues);
- Tourism;
- Agriculture;
- Government Revenue and Expenditures;

- Technical Critiques of the Economic Analysis; and
- Natural Gas Market and the HVHF Industry.

Response: The Department acknowledges that the SGEIS' assessment of the potential positive economic impacts to employment, income, and government finances that could occur if HVHF activities were authorized must be reevaluated in light of substantial changes in the assumptions used in the 2011 economic model. The changed circumstances include the potential wide spread local restrictions on development (upheld in the recent New York Court of Appeals decision in the matter of *Wallach v. Town of Dryden* and *Cooperstown Holstein Corp. v. Town of Middlefield*), and the impact of more protective public health and environmental mitigation measures proposed and considered by the Department in response to increasing information and uncertainty regarding HVHF's impacts. In addition, the field production profiles for the industry used in the SGEIS did not fully reflect "ramp-up" and "ramp down" periods of production. Furthermore, the Department has re-evaluated the potential administrative and technical oversight costs required to regulate this industry and to ensure implementation of the various mitigation measures proposed in the SGEIS.

The Department concurs that the 2011 rdSGEIS economic analysis was based upon what can now be judged to be optimistic assumptions for the rate of well development and the total number of wells that would be drilled, and has revised and recalculated its development scenarios and its corresponding estimates of the economic impact of HVHF. The Department had originally created development scenarios based, in part, on its review of information provided by the Independent Oil & Gas Association of New York (IOGA-NY). IOGA-NY had stated that:

- Approximately 67% of the area covered by the Marcellus and Utica Shale is developable;
- Approximately 90% of wells would be horizontal wells, with an average of 160 acres/well;
- Approximately 10% of wells would be vertical wells, with an average of 40 acres/well; and

- The Marcellus formation would require approximately 30 years to reach full field development; and there would likely be a "ramp up" and "ramp down" period of development.

The Department adapted the information provided by IOGA in order to create development scenarios with more realistic annual well development estimates that would allow a reevaluation of socioeconomic impacts to be quantified. Average and low development scenarios were created to account for the uncertainty associated with development of the Marcellus and other low-permeability reservoirs. In the SGEIS, each development scenario included an estimate of the number of wells developed annually over a 30-year time frame, which included a 10-year period when the production gradually ramps up, followed by a 20-year peak construction period.

The Department considered developing revised projections in which the 20-year peak construction period would be reduced to 10 years to reflect more realistically the development that could be expected, followed by a 10-year gradual decline in production. In order to reach the full build-out potential used in the scenarios, it is assumed that construction employment and new well construction would remain at these levels for 10 years, from Year 11 to Year 20. After Year 20, the number of new wells constructed is expected to decline because of diminishing marginal returns. That is, when a non-renewable resource is extracted, companies will initially place wells where it is easiest to drill and most productive. As an industry matures and as more extraction takes place, it will become more difficult to find those "easy" wells and it will become more difficult to produce the next unit of gas. As it becomes more difficult to extract that next unit of gas, the financial benefits of drilling the well will decrease. As the financial benefits decline, the number of wells drilled will decline.

Under the average development scenario, the Department assumed that the rate of well development during the 10-year peak construction period would match IOGA-NY's average development rate (i.e., 1,484 horizontal and 168 vertical wells). Under the low development scenario, the Department assumed that the rate of peak well development during the 10-year peak construction period would be 25% of the estimated average well development rate provided by IOGA-NY (i.e., 371 horizontal and 42 vertical wells). The Department considered the adaptations made to the IOGA-NY estimates to be more conservative and realistic estimates.

In both scenarios, the maximum build-out of new wells is assumed to be completed in Year 30. Under the low development scenario, a total of 7,420 horizontal wells and 840 vertical wells are assumed to be constructed at maximum build-out (i.e., Year 30). Under the average development scenario, a total of 29,680 horizontal wells and 3,360 vertical wells are assumed to be constructed at maximum build-out (i.e., Year 30). As with its earlier estimates, these development scenarios were designed to provide order-of-magnitude estimates for the socioeconomic analysis and were not meant to forecast actual well development levels in the Marcellus and Utica Shale reserves in New York State. Using these modified well development scenarios, the Department revised the expected impacts on employment and earnings from HVHF that were projected for New York State as a whole. Annual direct construction employment is directly related to the number of wells drilled in a given year. At the maximum well construction rate assumed for each revised development scenario, total annual direct construction employment is predicted to range from 4,408 FTE workers under the low development scenario to 17,634 FTE workers under the average development scenario. These employment figures correspond to the annual construction of 413 horizontal and vertical wells under the low development scenario and 1,652 horizontal and vertical wells under the average development scenario. In order to reach the full build-out potential used in the scenarios, it is assumed that construction employment and new well construction would remain at these levels for 10 years, from Year 11 to Year 20.

The direct production employment under each development scenario is 1,053 production workers under the low development scenario and 4,213 production workers under the average development scenario in the year of maximum total employment (Year 20), when the total workforce has reached its peak. Year 20, however, is not the maximum year of production employment.

In addition to the direct employment impacts described above, the proposed drilling would also indirectly generate additional employment in other sectors of the economy. Indirect employment impacts would be expected to range from an additional 6,425 full- or part-time jobs under the low development scenario to an additional 25,705 full- or part-time jobs under the average development scenario. These annual figures represent the year with the maximum total employment (Year 20). The years before and after this date would have less direct and indirect employment.

In total, at peak employment years, HVHF development in the Marcellus and Utica Shales under these revised scenarios would be expected to generate between 11,886 and 47,552 direct and indirect jobs, which equates to 0.1% and 0.8%, respectively, of New York State's 2010 total labor force, depending on the level and intensity of development that occurs. Total employment levels would be highest in Year 11 through Year 20. Once new well construction ends in Year 31, the direct and indirect employment would be greatly reduced.

The table presented below provides a brief overview of the revised employment figures that would result from the new development scenarios. For comparison sake, the employment projections for the original analysis used in the SGEIS are presented as well. As shown on the table, the revisions to the analysis resulted in an approximate 12% reduction in the total employment impacts at the year of maximum employment. As discussed below, the economic outlook would be further reduced due to local prohibitions and protective measures proposed and considered by the Department.

Maximum Yearly Employment Impacts on New York State under the Original and the Revised Development Scenarios

	Total Employment			
	Original Analysis		**Revised Analysis**	
Scenario	**Low**	**Average**	**Low**	**Average**
Direct Employment Impacts				
Construction Employment	4,408	17,634	4,408	17,634
Production Employment	1,790	7,161	1,053	4,213
Indirect Employment [1]	7,293	29,174	6,425	25,705
Total Employment Impacts	13,491	53,969	11,886	47,552
Total Employment as a Percent of New York State 2010 Labor Force	0.2%	0.7%	0.1%	0.5%

Source: U.S. Bureau of Economic Analysis 2011a; NYSDOL 2010.

[1] Indirect job estimates include both full- and part-time employment impacts. Not all indirect jobs created would be full-time equivalents.

Likewise, estimates of employee earnings were recalculated and revised downward as a result of the modified development scenarios. When well construction reaches its maximum levels (Years 11 through 20), total annual construction earnings are projected to range from $298.4 million under the low development scenario to nearly $1.2 billion under the average development scenario. Employee earnings from operational employment are expected to range from $71.3 million under the low development scenario to $285.2 million under the average development scenario in Year 20. In the same year indirect employee earnings are anticipated to range from $178.2 million under the low development scenario to $713.0 million under the average development scenario. The total direct and indirect impacts on employee earnings are projected to range from $547.9 million to $2.2 billion per year at levels in Year 20. These figures equate to increases of between 0.1% and 0.5% of the total wages and salaries earned in New York State during 2009.

By reducing the total number of wells assumed to be drilled, the revised development scenarios also reduced the estimates of the expected changes in total assessed value and property tax receipts. New estimates found that the total local property tax receipts for the three representative regions studied in the SGEIS would decline to $292 million under the low development scenario and $1.2 billion under the average development scenario.

In total, modifications to the assumptions used in the development scenarios reduced the employment projections (at the year of maximum impact) by 1,605 jobs under the low development scenario and by 6,417 jobs under the average development scenario or by approximately 12%. In addition, projected employee earnings (at the year of maximum impact) decreased by $74 million under the low development scenario and by $295.8 million under the average development scenario. Finally, the projections for property tax receipts (at the year of peak production) declined by nearly 20% or by $72 million under the low development scenario and $286 million under the average development scenario once more realistic well development estimates were utilized.

To be accurate, projections of the expected employment, income, and tax generation impacts that would result from the approval of HVHF would also need to be further reduced to reflect the recent New York Court of Appeals decision in the matter of *Wallach v. Town of Dryden* and

Cooperstown Holstein Corp. v. Town of Middlefield, which found that ECL § 23-0303(2) does not preempt communities with adopted zoning laws from entirely prohibiting the use of land for HVHF drilling. As a result of this ruling, HVHF will be prohibited in communities throughout the state. The decision's practical application to individual town zoning ordinances remains unclear. Within the 4.8 million acres not excluded by state and or local restrictions, approximately 253 towns have zoning and 145 do not have any zoning. Each town with zoning will have to determine whether its current law restricts or even allows HVHF. Those towns without zoning will have to decide whether to allow HVHF virtually anywhere or adopt zoning to prescribe where drilling could occur. The *Dryden* decision will likely result in a patchwork of local land use rules which the industry claims would utterly frustrate rational development of the shale resource.

Additionally, numerous mitigation measures proposed in the SGEIS, and further considered by the Department, limit the amount of area where HVHF could occur, including but not limited to the ban on HVHF operations in:

- The New York City and Syracuse drinking water supply watersheds and within 2000' of related water tunnels or supply infrastructure;
- Primary aquifers;
- Principal aquifers without site-specific environmental review;
- Within 2000' of public drinking water supplies;
- Within 2000' of water intakes;
- Within 1000' of main flowing water bodies and their tributaries;
- Within 500' of private water wells;
- Floodplains;
- Certain state lands; and
- Within 500' of residential structures.

In addition, the Department considered prohibiting access roads within the 100 year floodplain, well pads located within 300' of wetlands (and streams, lakes, ponds and storm drains), and surface disturbances in certain forest patches and grassland patches, without site-specific environmental review Furthermore, to address concerns about flooding beyond the 100-year floodplain and in recognition of the increasing frequency and intensity of recent and potentially future flood events, the Department considered requiring that the well pad be elevated two feet above the 500-year floodplain elevation or the known elevation of the flood of record.

Both the recent New York Court of Appeals rulings and the proposed and considered mitigation measures have the impact of reducing the amount of land in New York State available for the development of HVHF operations. The local ordinances and the potential mitigation measures that were considered under the SGEIS would all have restricted the amount of land available for HVHF operations and would, in turn, have reduced the number of wells that could be drilled. Indeed, IOGA-NY estimated that the measures proposed in the rdSGEIS in 2011 would eliminate 50% of the available acreage, including "significant setbacks and prohibitions proposed that will make it extremely difficult to lay out spacing units and locate well pads. Industry evaluation of actual acreage controlled by several operators reveals that this will have the effect of reducing the available acreage by as much as 50%." (Critical Issues to the Oil and Gas Industry in New York State, submitted by the Independent Oil and Gas Association of New York, January 11, 2012, pg. 1).

IOGA-NY went so far as to question whether industry would apply for many permits if HVHF were authorized: "This [set of proposed mitigation measures] has the impact of making shale gas development in New York economically non-competitive with other neighboring states, which drive out the few remaining players and stifle the return of industry to New York State." (Id., pg. 3)

The Department predicts that the economic effects of the proposed mitigation measures and local bans will be similar to the impacts projected by IOGA-NY. The total land area affected by protective measures proposed and considered by the Department would constitute approximately 31% of the area underlain by the Marcellus Shale (at depths greater than 2000 feet). The total land area covered by current local prohibitions affects approximately 19% of the area underlain by the Marcellus Shale (at depths greater than 2000 feet). After eliminating overlaps between the two areas, the proposed mitigation measures and the local bans, in combination, would result in approximately 42% of the area underlain by the Marcellus Shale (at depths greater than 2000 feet) becoming unavailable for HVHF activities.

Assuming that the number of wells that could be constructed is directly related to the total land area available that is underlain by the Marcellus Shale (at depths greater than 2000 feet) and that the size of the workforce needed to construct the wells is directly proportional to the number of wells being drilled, the number of the construction jobs that would be expected to be created would also be proportionately reduced. Thus, given the constraints associated with the proposed mitigation measures and local bans, the maximum yearly construction employment would now be expected to be 2,567 jobs under low development scenario and 10,227 jobs under the average development scenario.

Production employment will also experience a significant reduction as a result of the expected decrease in the total land area available for HVHF activities and the resulting reduction in the number of wells being drilled. The reduction in production employment would be greater than the reduction in construction employment. Well construction is typically completed within a short time period, usually less than a year. Therefore, there is a direct correlation between the number of wells drilled in a year and the number of construction workers needed. In contrast, it is not unusual for a natural gas well to produce for 30 years. Therefore, the size of the production workforce is a function of the cumulative number of wells drilled in the previous 30 years. If fewer wells are drilled each year, the size of the production workforce would decline geometrically.

Indirect employment would also decline as a result of the proposed mitigation measures, the local bans and the resulting reduction in direct construction and production employment. Indirect employment is correlated with both construction and production employment levels and is, therefore, related both arithmetically and geometrically to the number of wells drilled. However, given the larger size of the construction workforce and the capital-intensive requirements associated with drilling the wells, impacts to the indirect workforce would be more similar in relative magnitude to the decrease of the construction workforce. Calculating estimated job creation in these categories would be complex. However, it is clear that the expected job creation in all these categories would be reduced by the constriction of the land available for the siting of wells due to protective measures of the Department and prohibitions by local governments.

In addition, the Department acknowledges that the *Dryden* decision, as well as the consideration of several mitigation measures and site-specific review requirements would increase the costs of developing New York State's shale gas reserves, which would subsequently slow the pace of development of the natural gas industry if HVHF were authorized in the state. It is understood that the costs associated with the court decisions and implementation of the proposed mitigation measures may make it financially unviable to recover certain natural gas reserves in the state. This is especially true given the current price of natural gas. Since the magnitude of socioeconomic impacts are largely related to the pace and scale of development, in light of the court's actions and the proposed mitigation measures, the expected socioeconomic impacts on employment, income, and tax generation associated with HVHF would be substantially less than originally projected in the SGEIS and as projected under the revised development scenarios presented above.

Finally, the administrative and technical oversight costs that would be associated with ensuring compliance with the proposed mitigation measures as well as any existing statutory and regulatory requirements would be greater than initially assumed. The complexity and multiplicity of reviews and permits required would necessitate that state and local government entities dedicate a substantial amount of manpower and resources to the oversight of HVHF operations. The cost of additional regulatory oversight costs would further reduce the fiscal benefits associated with allowing HVHF operations in the state.

Comment on Labor Market Issues

Numerous comments noted that the majority of the jobs created, particularly the highly-skilled/high-paying jobs, would not be filled by local workers, but would be filled by transient workers from out-of state. These comments further stated that local area unemployment levels and rates would remain unchanged since all of the new jobs would be filled by workers from outside the area. Comments also suggested that existing local industries would have difficulty attracting and retaining workers because the industries would have to compete against the higher wages typically paid by the natural gas industry.

Response to Comment on Labor Market Issues

The Department acknowledges that initially, the majority of the high-skilled jobs in the HVHF industry would be filled by transient workers from out of state. The SGEIS states that initially due to New York State's small existing natural gas industry "no more than 23% of the construction workforce is expected to be hired locally … [and] the remaining 77% of the workforce would have specialized skills that would most likely be unavailable under New York's labor force" during the first year. However, the Department expects that the percentage of local workers would increase as the HVHF industry gains traction in the state. The pool of qualified local workers would expand as local residents gain the requisite skills and/or formerly transient workers permanently relocate to the state. As a way to increase the number of local residents employed in the HVHF industry, jobs training or apprenticeship programs could be developed through the SUNY system to provide the requisite job skills for the natural gas industry.

HVHF operations would also create jobs in other industries that supply the natural gas development industry (i.e. indirect employment). Other local jobs would be created as a result of the extra spending on the part of those employed in HVHF and gas production, of those employed locally in support industries, and of property owners who would receive additional income from royalty and lease payments (i.e. induced employment). While initially 77% of the construction jobs are expected to be filled by transient workers, the indirect and induced employment gains that would be generated by the increased economic activity from HVHF would be filled by local residents. Additionally, all production jobs are expected to be filled by local residents.

As described in the SGEIS, the total number of these indirect and induced jobs as well as the production jobs would be substantially greater than the direct construction jobs. Therefore, even in Year 1 approximately 75% of all total employment gains are expected to be provided to local residents. As the HVHF industry matures, the percentage of local residents holding the newly created direct, indirect, and induced jobs are expected to increase to more than 95% by Year 30.

As a result of this expansion in the number of jobs available to local residents and assuming all else remains the same within the local economy, the local area unemployment rates are expected to decline as current unemployed and underemployed residents take advantage of the additional job opportunities. Further, the Department concurs that the additional job opportunities generated by the HVHF industry may have an effect on the overall labor market by increasing local wages and salaries and requiring existing industries to compete more aggressively for qualified workers. The significance of any loss of workers by local businesses caused by HVHF operations would depend upon the size of the year-to-year change in the number of local workers working in HVHF operations relative to the number of workers employed by local businesses, and by employment in HVHF operations relative to the stock of unemployed and underemployed persons and the mobility of the labor force. Given that the HVHF industry is expected to gradually ramp up construction and employment needs over at least a 10-year time frame, that there currently is substantial slack in the labor market, and that labor mobility is relative high in New York State, these impacts are likely to be minor and gradual. While it is possible that in some instances local businesses may lose valued workers to HVHF operations, the above considerations suggest that the loss of local businesses' workers to HVHF operations would not be a significant adverse impact.

Comment on Cyclical Nature of the Extractive Industries

Numerous comments were submitted on the cyclical nature of the natural gas industry. Fluctuations in economic activity that could result from changes in the price of natural gas could produce a "boom and bust" cycle within the regional economy. The comments stated that rapid expansion would occur during times of high prices and that extreme contraction of the industry in times of low prices would be detrimental to the regional economy.

Response to Comment on Cyclical Nature of the Extractive Industries

In response to comments submitted on the cyclical nature of the natural gas industry and requests that this type of analysis be included in the SGEIS, the Department completed additional analysis and studied economic literature to investigate the possible impacts associated with the so-called "boom and bust cycle of energy extraction" and on the "boomtown impact model." The Department found that economic factors such as the price of natural gas, input costs, the price of other energy sources, changes in technology, and the general economic conditions of the state and nation would all affect the yearly rate of well construction and the overall level of development of the gas reserves. Historically, extractive industries, including the natural gas industry, have been subject to periods of intense activity and growth and periods of depressed activity and growth (i.e., "booms" and "busts"). Using data from the U.S. Bureau of Economic Analysis, the Department found that the output of all industries in the United States (i.e., the GDP or gross domestic product) has risen steadily over time since 1977, with the exception of the downturn in 2009. In contrast, the mining industry as a whole, including the oil and gas exploration industry, has experienced booms in the early 1980s and in the 2000s, peaking in 2008; a prolonged period of stagnation for much of the 1980s and all of the 1990s; and a sharper downturn than the whole economy in 2009. Similarly, using data from the U.S. Bureau of Labor Statistics, the Department found that employment in the oil and gas extraction industrial categories displays greater volatility than total non-farm employment. The Department found relatively depressed economic conditions in areas that were heavily dependent on mineral extraction.

In addition, the Department reviewed a large body of economic literature dedicated to identifying and examining the economic impacts associated with rapid extractive industry development, though most of the studies are based on research relating to small, isolated, rural communities in the western United States that experienced rapid oil and gas development in the 1970s and 1980s. These studies derived most of their data from the period from the early 1980s to the early 2000s when there was a prolonged slump in the extractive industries and included little if any data from the post-2003 period of increased output and employment. Therefore, given the time span covered by these studies, the Department concluded that the results do not prove that it is inevitable that areas that contain HVHF operations will experience slower long-term growth than other areas. However, some of these impacts were deemed possible.

The Department also noted that the natural gas industry displays more variability over time in its scale of operations than many other industries. Operations can vary spatially, when development is first concentrated in some areas and then moves on to other areas. Operations can also vary temporally. In particular, many of the greatest socioeconomic impacts would be associated with the drilling phase of well development, which involves a larger number of workers than the gas production phase and typically lasts only 3 to 4 months. Finally, as with all extractive industries, once the resource begins to be exhausted at the local or regional level, the natural gas industry's economic importance and impact would decline.

It is possible, therefore, that by increasing the relative importance of the natural gas industry in local and regional economies, HVHF operations, if authorized, would increase the volatility in population, employment and income, housing, community services, local government finances, and other social aspects of the affected communities.

The Department also reviewed the "boomtown impact model" of energy development. The "boomtown impact model," which was highlighted in numerous comments as a cause of potential adverse socioeconomic impacts, was based on the experience of communities in the Western part of the country. The Department found that there were important differences between the communities that were used to develop that model and those within the representative regions in New York State. Whereas the Marcellus Shale region consists of rural areas containing small towns interspersed with larger population centers, the western boomtowns were often small, socially and economically isolated communities. Also, in the western areas, the mineral rights were owned by the federal government or a small number of owners, whereas in the Marcellus Shale region the mineral rights are owned by many thousands of individuals. With regard to governance, whereas in the Marcellus Shale region there are numerous layers of local government that share power, in the western areas, county governments tend to be politically powerful relative to local towns and the federal government controls large areas of land. Finally, the Marcellus Shale region, unlike the western communities, has some previous experience of extractive industry, including natural gas development.

The boomtown impact model contends that it is the peak in labor demand associated with drilling and the in-migration of energy workers that causes most of the "socioeconomic problems" associated with boomtowns. The authors of the boomtown impact model conclude that "slowing the pace (i.e., the speed with which an area is developed) and scale (i.e., the geographical or spatial extent) of development can reduce these problems by reducing the number of wells drilled at one time."

Based on existing economic literature, it is apparent that most of the potential negative socioeconomic impacts associated with HVHF operations would be associated with the rapid expansion (i.e., "boom") and a potentially rapid decline in the drilling workforce ("bust") in an area. The transient nature of much of the drilling workforce and the short time period (typically 3 to 4 months) required to drill a HVHF well would make rapid deployment/departure a possibility. If the rate of well development were controlled, however, then many of the potential negative socioeconomic impacts of HVHF operations would also likely be controlled. In particular, if the rate of well development were constrained, the size of the transient population would be smaller relative to an area's population and therefore more manageable. Impacts on housing and temporary accommodations would be reduced, pressure on other industries caused by a general increase in labor or material costs would be lessened, and the additional demand for various community services and facilities, including but not limited to police protection, emergency services, transportation infrastructure, and safety, would be moderated.

In an effort to reduce the possibility that adverse socioeconomic impacts would result from a concentration of well construction activity in a short period of time within a particular area and as a result of the "boomtown" phenomena, if HVHF were authorized, the Department, as needed, could consult with local governments and, where appropriate, place limits on the number of wells and/or well pads that can be constructed in a specific area at a single time.

<u>Comment to Housing/Property Values</u>

Many comments addressed the effects of HVHF on local area property values, residential mortgages and homeowner's insurance policies. Of particular concern was the potential, or the perceived potential, that environmental damage and changes in community character caused by HVHF activities would reduce the desirability of the real estate in an area where HVHF was occurring, resulting in depressed real estate values. Other commenters felt that housing prices would increase with the influx of transient workers to the area, affecting housing availability and affordability for local residents. Several commenters felt that low-income populations would be significantly impacted as the increase in the demand for housing would raise rental/housing prices to a level which would become unaffordable to these populations.

Many comments discussed lending guidelines that put into question the validity of FHA, FNMA, Freddie Mac and VA mortgages for structures within 100' of a natural gas well. Commenters were concerned with the potential impact these riders would have on individual property owners/mortgage holders, homeowner's insurance coverage, and the secondary mortgage market.

Finally, comments expressed concern over potential problems associated with various natural gas lease agreements such as tactics used to by landmen to obtain these leases; the assertion that the lessees can indefinitely extend the lease against the homeowner's wishes; the lack of current, publicly-available lease information; and the allocation of liability in the event of a spill or accident.

Response to Comment to Housing/Property Values

At this level of analysis the SGEIS acknowledges that it is impossible to predict the actual impacts HVHF activities would have on individual property values. However, the influx of workers associated with HVHF and the income to be derived from properties with associated mineral rights is expected to lead to a general increase in property values. As part of this analysis, the Department completed a literature survey of peer-reviewed economic articles that studied the relationship between natural gas development and housing prices. Natural gas development is anticipated to have an overall regional effect of increasing property values; however, not all properties in the region would increase in value, as residential properties located in close proximity to new gas wells would likely see some downward pressure on price.

In response to comments concerning the potential impact to the second home market, the Department completed additional analysis of the issue and concluded that there was the potential for impacts to occur to the second home market; however, the size and direction of this impact would vary by individual location. The analysis found that demand would likely be affected by the location of the second homes, and would be influenced by competing factors such as the effect of negative externalities of HVHF activities within a specific area as well as the influx of workers needing accommodations. As a result of these competing factors and given the generic nature of the SGEIS, it is impossible to accurately predict what the expected impacts will be at this time.

The Department agrees with comments that contend low-income residents may find it difficult to obtain affordable housing due to the expected influx of workers to the region. In areas that would likely experience the most HVHF activity, the SGEIS concludes that “rent increases caused by the increased demand for rental housing could make such housing unaffordable for existing low-income tenants.”

In addition to the real property value concerns discussed above, concerns have been raised that proximity of a well to a residence could adversely affect an individual’s ability to sell, finance or insure his or her privately-owned property. Although these potential impacts are not significant environmental or socioeconomic impacts within the scope of a SEQRA review, the Department did consider how current setback requirements from residential dwellings would impact individual mortgages, homeowner’s insurance, and lease agreements. Due to potential environmental and public health impacts and the uncertainty regarding the degree of protection afforded by setbacks of this nature, the Department considered increasing the setback for a well pad from inhabited private dwellings from 100 feet to 500 feet and beyond if HVHF were authorized. In addition, expanding the setback to residences found support in the several servicing standards, including those from Fannie Mae and Freddie Mac, related to oil and gas development that included minimum setbacks of wells and well pads from residential structures, typically in the range of 200-300 feet and the fact that standard title insurance policies for single-family residential structures in New York may not always protect lenders against common HVHF activities.

If HVHF were authorized landowners desiring to enter into a lease for oil and gas development on their property should be aware that existing mortgages the landowner has on the property could restrict the ability to enter into such a lease. The potential impact of HVHF on individuals via lease agreements is a private legal matter and is not an environmental or socioeconomic impact and is thus beyond the scope of this SGEIS. However, homeowners desiring to enter into an oil and gas lease would need to understand the specific restrictions of their own mortgage and insurance policies as well as their potential liability in the event of an accident.

Comment on Tourism

Many comments suggested the increased truck traffic, noise, air and water releases and industrialization, as well as the aesthetic impacts of HVHF, would reduce the region's desirability as a tourism destination. Other commenters were concerned about how HVHF would adversely impact the second-home market, particularly in the Finger Lakes region.

Additionally, comments argued, the significant adverse environmental impacts of HVHF would impact passive recreational opportunities, which would in turn, affect the tourism industry. Several commenters highlighted the economic importance of tourism to the region, noting the importance of local wineries and breweries, in particular.

Also with respect to tourism, comments argued that the increase in transient workers would fill local accommodations. While these improved occupancy rates would help hotel/motel owners and the hospitality industry, comments noted that these workers would also displace existing clientele and further reduce the number of traditional tourists that visit the area.

Some comments asserted that HVHF would be good for the regional tourism market. These comments stated that the increase in transient workers to the area would attract large-scale hotel chains, improving the range and number of accommodations available and making the region more attractive to tourists. Others stated that the potential increase of hotel chains to an area could lower prices at existing locally-owned (i.e., bed and breakfast) establishments.

Finally, several commenters raised questions about the impact HVHF would have on hotel occupancy tax receipts, expressing concern that local municipalities would lose substantial tax revenues if the existing tourists were displaced by longer-term transient workers, who are exempt from paying bed taxes.

Response to Comment on Tourism

In response to the numerous comments received on the subject, the Department completed additional analysis on the impact HVHF would have on local tourism. As part of this analysis, the Department collected information from other areas of the country where HVHF operations are occurring and wherever possible reviewed academic articles published on the subject. At this level of analysis it is not possible to precisely identify the impacts of HVHF on the tourism industry in a quantitative manner, although both positive and negative impacts are likely to occur. However, based on information collected from other areas, the following impacts are deemed likely to occur if HVHF were authorized:

- *Increase in Occupancy Rates and Gross Revenues at Hotels/Motels.* Hotel/motel occupancy rates and earnings would be expected to increase significantly in areas where natural gas drilling operations occur. Particularly during the exploration and drilling phases, the influx of transient workers would increase the demand for hotel/motel rooms, rental properties, recreational vehicle (RV) sites, and other non-traditional (temporary) housing units. This increase in demand would translate into increased revenues for hotel/motel operators, rental property owners, vacation home owners willing to rent their properties, and RV/campsite operators through increased utilization and higher prices associated with the increased demand. Experiences in Pennsylvania, Colorado, Wyoming, and elsewhere illustrate this trend. For example, in a study of temporary and permanent housing in Sublette County, Wyoming, where large-scale HVHF operations have been occurring, the author found that nearly 100% of the hotel/motel rooms available to transient workers were occupied during peak drilling times. In addition, many of the hotels had exclusive contracts with well pad operators to house their employees for months or years at a time (Jacquet 2006).

- *Increase in Sales at Eating and Drinking Establishments and Retail Outlets.* The additional transient and permanent population would be expected to increase demand at eating and drinking establishments and at local retail outlets. This increase in demand is anticipated to increase sales and earnings at these establishments, which in turn may increase employment in these sectors. In a study by Ward et al., the authors found that sales at 38% of the eating and drinking establishments and 44% of the retail outlets in Bradford County, Pennsylvania, increased as a result of HVHF operations occurring in that area. Similar, though less statistically significant, results were found in Washington County, Pennsylvania (Ward et al. 2011).

- *Change in Types of Visitors and the Possible "Crowding Out" of Traditional Tourists to the Area.* While major components of the tourism industry (i.e., lodging, eating, and drinking establishments, and retail outlets) would be expected to see increases in the demand for their services and, thus, potential increases in the industry's revenues and employment, the type of visitors to the region would likely change. As natural gas development continued, the possibility that traditional tourists would be "crowded out" of the market would increase. The high occupancy rates and increased prices at various hotels/motels, vacation homes, and campsites would make it increasingly difficult and more expensive for traditional tourists to visit an area. In a report that detailed the socioeconomic impacts of oil and gas shale extraction operations in northwestern Colorado, BBC Research & Consulting, Inc. found that traditional tourism was affected by the absence of available hotel/motel accommodations (BBC Research & Consulting, Inc. 2008).

- *Negative Impacts of HVHF Operations May Impact Tourist Destination Enterprises.* Some of the negative impacts associated with HVHF operations, including increased traffic, noise, and visual impacts, would affect the visitor experience of certain traditional tourist destinations, particularly those where tourists seek wilderness or pastoral getaways. As a result, tourist destination enterprises that are more geared to these traditional tourists may experience a loss in attendance, sales, and employment. However, this decline of traditional tourists may be offset by the patronage of transient workers during their leisure hours, as well as the increased use by local residents with increased income as a result of the HVHF operations. Limited economic research has been completed on this subject; however, in one study by Ward et al. (2011), the authors surveyed 31 tourist destination businesses in Washington and Bradford counties, Pennsylvania, to ascertain whether HVHF operations had any significant impacts on their businesses. Tourism destination businesses were defined as tour operators, souvenir stores, tourist attractions, and related retail stores, including bike shops and sporting goods stores (not hotels and motels). Approximately 29% of the tourist destination businesses indicated that total sales had increased since natural gas development began in the region, while the remaining 71% of the businesses indicated that there had been no change in sales. None of the respondents indicated that sales had decreased as a result of HVHF operations in the counties (Ward et al. 2011). However, there is uncertainty about these impacts since the data assembled to date is limited.

- *Expansion of the Number and Types of Accommodations Available.* It is likely that as demand for hotel/motel rooms and other temporary accommodations increases, additional units would be built as the market responds to the increase in demand. In Tioga County, Pennsylvania, the increased demand for hotel/motel and other temporary accommodations has led to the construction, and planned construction, of hotels by three national chains. According to representatives from the Tioga County Visitors Bureau, prior to the commencement of drilling operations in the county, most tourist accommodations were limited to country inns, bed-and-breakfast establishments, independent hotels, and vacation homes. The additional types of hotel/motel rooms available in the county have helped Tioga County better serve a different sector of the tourism market (Spencer 2012).

- *Second Home Market Would Experience Changes in Demand.* The second home market would experience competing factors that would influence demand for these units. If the negative externalities associated with HVHF operations were to reduce an area's desirability as a tourist destination, downward pressure would be placed on the price of second homes and potential increases in vacancy rates. However, at the same time, the expected shortage of temporary and permanent housing resulting from the expected increases in the transient and permanent population would place upward pressure on the price of second homes. In addition, the potential for royalty payments and the general increase in price levels throughout the area could further increase the perceived value of second homes, and thus their price. In a study of the impacts of HVHF operations and the second home market in Sublette County, Wyoming, Jacquet (2006) indicated that the demand for second homes remained high even after natural gas drilling operations expanded in the county. Approximately 20% to 30% of all housing purchases made in the county in 2000 were for second homes.

- *Increase in Labor Costs May "Price-Out" Some Low-Paying Tourism Employment.* In the case of isolated communities, where the labor supply is small and labor mobility is low, the increased employment and economic development associated with HVHF operations could possibly result in a significant increase in labor costs across all industries. These increased labor costs could make some traditionally low-paying jobs no longer economical from an employer's standpoint. As a result, it is possible there would be some contraction in employment in these traditionally low-paying industries, such as tourism. In a study conducted by BBC Research & Consulting, Inc. that analyzed the socioeconomic trends that were occurring in northwestern Colorado due to the rapid increase in oil and gas shale drilling operations, the authors found that in Garfield County, Colorado, between 2001 and 2006, employment in the natural gas industry increased by 76%, whereas employment in the amusement, gambling and recreation industry declined by 1%. The authors proposed that this decline in the entertainment sector may be a result of the general increase in labor costs. However, they further state that, at this point, there is insufficient data to reliably predict the point at which "factor competition" (i.e., the competition between businesses to attract and retain qualified workers or purchase goods/services from suppliers at competitive prices) may reduce the growth in other industries (BBC Research & Consulting, Inc. 2008).

- *Change in the Amount of Hotel Room Occupancy Tax (Bed Tax) Collected.* The increased hotel/motel room occupancy that would result from drilling operations potentially could increase the amount of bed tax collected in local communities. Since local bed taxes traditionally are earmarked to fund tourism promotion activities such as marketing and research efforts, this increase in bed tax could potentially lead to an increase in traditional tourist visits in response to the heightened promotion efforts. For example, increased funding of the Tioga County, Pennsylvania, Visitors Bureau from bed taxes resulting from drilling operations in the county has allowed the bureau to conduct more tourism promotion activities than had been possible before the increased source of funding (Spencer 2012). However, in New York State, individuals and businesses that occupy hotel rooms for 90 consecutive days are exempt from state and local sales tax and local hotel room occupancy taxes (NYSDTF n.d.). Therefore, if drilling companies were to sign long-term leases that covered substantial portions of the available hotel/motel rooms in a community, it is possible that hotel room occupancy tax receipts could be negatively impacted.

In addition to the literature survey and the cases studies discussed above, the Department also attempted to correlate the impact of HVHF with changes in visitor-supported employment and visitor spending in Pennsylvania between 2005 and 2009. All counties in Pennsylvania were divided into categories based on the number of HVHF well permits that had been approved. Using 2005 (pre-HVHF) and 2009 (on-going HVHF) tourism statistics from these different categories, no obvious conclusions could be drawn about the correlation of HVHF operations and visitor expenditures or visitor-supported employment based on Pennsylvania's experience.

However, based on this analysis, Lycoming and Susquehanna counties did appear to have experienced particularly large increases in visitor spending between the 2005 and 2009 while also experiencing heavy HVHF development during the same time period. A large variation in visitor expenditures throughout Pennsylvania in areas both with and without HVHF was observed, illustrating the fact that tourism-related activities are also impacted by numerous factors unrelated to natural gas drilling, including but not limited to local, state, and national economic trends; the effectiveness of tourism marketing efforts; and the competitive nature of the market.

In response to comments on the SGEIS, the Department also attempted to predict the impacts to local wineries and breweries. There has been no body of economic literature that analyzed this issue with regard to HVHF. Moreover, there has been no significant overlap between HVHF operations and grape-growing regions in other parts of the United States, making proposed HVHF development in New York wine country a novel case. Therefore, no research-based conclusions could be made detailing the potential positive or negative impacts HVHF operations would have specifically on wineries or breweries.

Overall, substantial uncertainty remains regarding the impact of HVHF on tourism and, even more so, its possible impact on wineries or breweries. Over time, additional studies of the impact on tourism will no doubt be conducted in states where HVHF development has occurred. It will thus become clearer in the future whether or not the predominant effect of HVHF activities on tourism is negative.

Comment on Agriculture

Numerous comments requested a more detailed analysis in the SGEIS of the impacts of HVHF on the agricultural industry, based on experiences in other states where HVHF is occurring. Some comments argued that HVHF would improve agriculture in the region by providing farmers with an income stream from lease payments that could be reinvested into farming production; others argued that farmers would quit farming if provided with alternative revenue streams. Additionally, comments noted that HVHF activities would fragment farms and remove productive agricultural lands from production. Comments also contended that farmers would face difficulty as a result of increased competition from HVHF for the basic supplies and services needed to successfully grow and market their produce, such as competition for commercial driver's license (CDL) drivers to transport milk and other produce; diesel fuel; and labor. The purported increase in competition for these factor inputs would make it more difficult and costly to hire workers and purchase supplies.

Comments were also concerned with the effect of water and soil contamination from HVHF on produce grown in the same region. Comments expressed concern that consumers would be reluctant to purchase produce grown in areas where HVHF was occurring, forcing farmers to reduce the prices for their goods. This "stigma," the comments suggested, would be particularly strong for organic products, with the potential for organic farmers to lose their organic certifications if HVHF were to occur nearby.

Response to Comment on Agriculture

With respect to comments concerned with the potential impacts to agriculture, the Department completed an additional statistical and literature-based review and determined that the agricultural industry would be affected by a myriad of competing forces if HVHF were authorized. Similar to the analysis of the tourism industry, it is impossible to accurately predict what the precise impacts on the industry would be on individual farms or at the statewide or regional levels if HVHF were authorized. However, experiences from other areas of the country where HVHF or other natural gas and mineral drilling operations are occurring indicates the following types of positive and adverse impacts may occur:

- *Increase in Farm Revenues Due to Royalty and Lease Payments.* The owners of subsurface minerals rights where wells are drilled would experience an increase in income as a result of royalty payments and lease payments. Typically, a landowner receives 12.5% or more of the annual value of a well's production in royalty payments (NYSDEC 2007a). Since a large proportion of the area in New York State that is underlain by the Marcellus and Utica Shale formations is agricultural land, a large proportion of these royalty payments and lease payments would be paid to owners of agricultural land. This increased income could impact the agricultural industry in a variety of ways. Royalty payments may be used for capital improvements and/or operational changes that would result in increased profitability of individual farms and benefit other industries that supply material and equipment to these farms. Given the low profit margins associated with certain types of farming, royalty and/or lease payments may stabilize some farms by providing an additional revenue stream.

- *Increased Price and Decreased Availability of Production Costs (Factor Inputs).* Labor, farmland, heavy equipment rental, and trucking costs are all expected to experience an increase in demand as a result of the proposed HVHF operations. Drilling activities are expected to compete with the agricultural sector for inputs such as labor, land, equipment rental, and trucking. For example, Commercial Driver's License (CDL) drivers are required for both hauling water and hydraulic fracturing fluids to and from drilling sites and for transporting milk to market. By creating additional demand for these inputs, the HVHF operations may increase the price of these factor inputs, resulting in higher input costs for farmers and reduced farm profitability.

- *Loss of Productive Agricultural Land.* HVHF operations would decrease the amount of agricultural land under production in the affected regions, both temporarily and, to a lesser extent, permanently. The construction of well pads, staging areas, impoundments, access roads, and auxiliary facilities such as transmission lines and compressor stations would reduce the amount of land available for agricultural production. However, farming could still continue on adjacent acreage. In addition, most of this land disturbance would be temporary and the land would be restored to agricultural production upon completion of the natural gas wells. However, some land, particularly land associated with well pads and compressor stations, would be permanently removed from cultivation. The space required for hydraulic fracturing operations for a multi-well pad is influenced by a number of factors, but is expected to be approximately 3.5 acres per well pad. During the production phase, a multi-well pad is expected to be reduced to an average size of approximately 1.5 acres, with the excess acreage used in the drilling and fracturing phase being restored to its original use.

In addition to completing an economic literature study on the potential impacts to the agricultural industry from oil and gas drilling activities operations in other parts of the country, the Department also attempted to correlate the impact of HVHF on cash receipts from livestock and crops, land used for agriculture, and agricultural employment levels in Pennsylvania between 2005 and 2009. All counties in Pennsylvania were divided into categories based on the number of HVHF well permits that had been approved. Using 2005 (pre-HVHF) and 2009 (on-going HVHF) agricultural statistics from these different categories as well as statewide data for Pennsylvania, New York, Ohio, West Virginia, Maryland, Delaware, and New Jersey from 2001 to 2010 on agricultural wage rates, the Department found that there was not sufficient data at this time to identify a discernible relationship between HVHF operations and the economic status of agriculture between counties or states with and without HVHF operations, or between pre- and post-HVHF operations in counties.

As noted above, the Department received comments regarding the concern that a potential loss of certification and/or a potential “stigma” would be associated with organic products grown or raised in an area where HVHF are occurring. In response, the Department completed additional analysis on this supposition and found that only limited economic and agricultural statistics about organic farming are available. Because of the newness of the market and the relatively small number of farms engaged in certified organic farming, statistics on organic farming are not published on a countywide basis.

As such, the analysis compared data for the Commonwealth of Pennsylvania with those for surrounding states to determine if, at the state level, the changes in organic farming were markedly different in Pennsylvania than in other states after the commencement of HVHF operations in 2005. The Department found the number of certified organic operations and the acres used for organic farming continued to increase in Pennsylvania after the commencement of HVHF operations, and after 2005 these numbers increased at a rate that is consistent with the rates of increase for the other states and the United States.

In addition it was found that in Pennsylvania, there are certified organic farms that have gas wells or auxiliary facilities such as pipelines or compressor stations located on them. Pennsylvania Certified Organic (PCO), an agency that certifies organic farms within the state, does not take into account the location of a farm during the certification process (Murphy 2012).

According to a representative of Northeast Organic Farming Association of New York Certified Organic LLC (NOFA-NY), the largest organic certifying agency in New York State, the impact of gas drilling on organic certification is reviewed on a case-by-case basis and is primarily dependent on the operation's proximity to a gas well. During the certification process, the certifying agent considers factors such as buffer areas, the potential for chemical spills/leaching, and whether there are access agreements in place. NOFA-NY recommends testing for contamination as part of the certification process, but such testing is not a requirement for certification (NOFA-NY 2012).

With regard to comments concerning the potential stigma that may be placed on organic agricultural grown near HVHF operations, the Department found that the method used to market these products would likely help determine how susceptible the organic farming industry would be to a perceived stigma. Consumers who purchase organic products directly (e.g., on the farm, at pick-your-own facilities, or through community-supported agricultural markets ([CSAs]) may have a stronger attachment to and concern about the actual location where their products are grown. In contrast, consumers who purchase their organic products from large retail outlets, where the products have been acquired by wholesalers for the retail outlets, typically have much less knowledge and/or attachment to the location where the products are grown. Large distributors and large retail operations combine products from numerous growers; consequently, the localities where these products are grown typically cannot be identified. Therefore, little or no stigma would be associated with the locations at which these products are grown. According to the 2008 Organic Production Survey (USDA 2008), the majority (79%) of all of New York State's organic produce is sold in the wholesale market, while 14.9% is sold directly to consumers.

However, as with the other agricultural indicators studied, such as cash receipts from livestock and crops, land used for agriculture, and agricultural employment levels, there are limited data on organic agricultural from which conclusions can be drawn.

Comment on Government Revenues and Expenditures

Numerous commenters were concerned with the impact that HVHF activities would have on the existing community services and facilities. Of particular concern were the impacts to education, fire and emergency services, police protection, water supply and wastewater treatment, medical facilities, and social services from transient and permanent workers. Concerns were also expressed about the potential for increased response time for emergency personnel and inadequacies in required developer-submitted emergency response plans.

Several comments requested a full fiscal analysis that detailed expected oversight costs for DEC, the expected fiscal impacts of HVHF on state and local governments, and potential changes to the existing NYS tax code. Several comments requested that the state levy a tax or impact fee on HVHF developers to compensate for potential infrastructure improvements and road damage. Others wished to change the way natural gas extraction is taxed and/or change the way these revenues are disbursed to local governments. Additionally, numerous comments suggested ways to use the expected increase in local government revenues that would result from HVHF.

Commenters were concerned that local government ad valorem property tax receipts would decline because housing prices and property values would decline due to the externalities associated with HVHF. Other commenters stated that New York State would not experience a noticeable increase in income tax receipts because a large number of the expected workers would be residents of another state.

Other comments were received requesting an analysis of the spatial impacts of HVHF. It was suggested that revenues would go to the communities where the HVHF wells were located, while the negative fiscal impacts would accrue largely in the communities where the production workers would reside and that these locations are not necessarily the same.

Additional comments were received pointing out that there would be a time lag between local government expenditures and revenues associated with HVHF. A vast majority of fiscal costs would occur during well development; however, revenue generation would not occur until after the well was operational. Finally, other comments suggested that early information on the location of expected development be provided to affected local government entities so that these entities could be better prepared to accommodate the expected fluctuations in the expenditure and revenue streams associated with HVHF.

Response to Comment on Government Revenues and Expenditures

Due to the generic nature of the SGEIS, the lack of specific well pad locations, and the multitude of jurisdictions where development could occur and transient and permanent workers could reside, an analysis of the specific expenditures that would be required by local governments would be speculative. However, the Department did complete an expanded generic analysis of the estimated increase in government expenditures associated with the projected increase in population due to HVHF within the three representative regions based on a per capita cost. Per capita costs associated with the provision of education, public safety (including police, fire, and emergency services), health, transportation, social services, economic development, cultural and recreational services, community services, sanitation and general government at various levels of local government were included in the analysis.

The analysis found that some of the largest negative impacts on the local communities would result from the expected increases in the transient and permanent populations. As described in the SGEIS, as the population increases in local communities affected by the proposed HVHF operations, the demand for locally provided services and facilities would expand, thereby increasing both the need for one-time capital expenditures as well as increasing recurring annual operating costs, as more residents would need to be served.

It is impossible to accurately estimate the total increase in expenditures that would be incurred by a specific local government entity given the large uncertainties associated with the locations of drilling operations and the levels of associated development that is expected would occur if HVHF is permitted. However, to provide an estimate of the potential increase in government expenditures, a per capita expenditure was determined for various services and facilities for communities within Regions A, B, and C. The increase in government expenditures associated with HVHF operations could be assumed to equate to an increase in per capita expenditures proportional to the projected increase in population. Based on this assumption, new residents would require and use approximately the same community services and facilities as the existing population. However, local government expenditures vary greatly from year to year, as the needs and priorities of a community change depending on local circumstances and events.

Therefore, the per capita expenditures should be viewed only as order-of-magnitude estimates and not as actual costs for specific communities.

Only the expenditures made by county, city, town, and village governments and expenditures made by local school districts and fire districts were included in the analysis. Expenditures made by other local government entities such as industrial development agencies, housing authorities, and library districts were excluded.

Data analyzed include Fiscal Year 2010 per capita expenditure for services and facilities, by county, in the three representative regions, and the average per capita expenditure for all school districts and fire districts within each county. At a county level, social services, general government, and transportation are some of the largest per capita expenses across all three representative regions and typically accounted for nearly 75% of the county's total spending. School district costs per resident ranged from approximately $2,760 in Chemung County to $3,620 in Sullivan County. Average per capita expenditures by all fire districts within each county ranged from $11 in Broome County to $118 in Sullivan County.

Transportation and general government are typically the largest expense categories for city, town, and village governments. In many cases, particularly in the smaller communities, some services are not provided by local government. In some cases, these services are provided by a larger government entity. For example, public security may be provided by the county sheriff instead of a municipal police department. However, in other cases, these services are not provided at all. For example, homeowners may be expected to transport their solid waste to area landfills.

Based on this assessment, the Department found that local governments, school districts, fire districts, and counties would incur additional costs due to increases in transient and permanent populations associated with the HVHF activities. If the new transient and permanent residents require the same type and amount of community services that the current population requires, then current local government spending patterns may be used as an approximation of the expected costs per new resident.

For community services that are related to the size of the service area rather than the number of participants in the service, the Department found that the per capita expense could actually decrease. This is particularly true in the case of services that are not needed often by the majority of residents. In these cases the increase in population would not change the total costs appreciably and would, therefore, actually reduce per capita costs. Alternatively, in cases where a particular community facility is operating at or near capacity, the increase in population could require a large capital expense to expand or upgrade the facility to meet the additional demand for service.

In addition to the local government expenditures that would be required to serve the increased transient and permanent populations, the Department found that activities directly associated with HVHF could also affect the need for various community services and facilities. Impacts on the local road network from the large number of heavy truck trips required to drill a HVHF well are one of the most significant direct cost items that could be incurred by local governments. The Department considered whether the adoption of road use agreements between local governments and natural gas developers prior to the commencement of drilling would mitigate these impacts. These local road use agreements would detail, among other things, any upgrades and improvements to roads that would be frequently traveled by operators and thus may be reimbursable. Such road use agreements often provide an alternative (private sector) funding source for road construction and repair and would help ameliorate the expected damage to the local transportation infrastructure that could result from the drilling activities, and help return the road network to at least its prior level of service once drilling activities are completed.

With respect to comments received about the potential for increased emergency response times and the adequacies of developer-submitted emergency response plans, if HVHF were authorized, an emergency response plan and road use plan would be required prior to permit approval, as discussed in the SGEIS. These plans would include a review of potential transportation factors that could possibly affect emergency response times. Additionally, the emergency response plans would need to describe how the operator of the site would respond in emergency situations which may occur at the site, and the availability of company and community assets. Training of local personnel is advisable but is not part of the recommended response plan, which is directed at actions that would be taken by the operator in the event of an emergency. Applicants typically have contracts in place with emergency response companies that can respond quickly for large emergency events but they still rely to some degree on local responders for support.

In addition, the SGEIS identifies and provides level-of-magnitude estimates of the amount of ad valorem property tax that would be generated by HVHF development. These additional funds could be used to pay for a variety of public expenditures; however, how these funds are used would be at the discretion of local governments and beyond the scope of the SGEIS.

In an effort to further understand the potential fiscal implications associated with HVHF operations, the Department completed a literature review of technical economic articles concerning the fiscal impacts of HVHF. To date, few economic analyses have been published that empirically assess the fiscal impacts of HVHF on local governments. Those studies that have been completed acknowledge the difficulty in quantifying fiscal impacts given the vagaries of local government finance and the newness of this industry. In a study of the impacts of HVHF development on the municipal finances in Susquehanna and Washington Counties, Pennsylvania, the authors found that, after analyzing the financial accounts of 41 local governments from 2001 to 2009 (which represented periods prior to and during drilling operations), there was no statistically significant change in municipal expenditure patterns that could be attributed to drilling activities (Jacobson and Kelsey 2011). As a follow-up to the analysis, the authors interviewed representatives from 17 of these communities to help determine the validity of these results. The 17 officials stated that most of the additional costs had either been non-monetary or they had been absorbed by the municipality and resources were moved around within the existing funding sources to meet these needs (Jacobson and Kelsey 2011).

In a more detailed analysis of the municipal fiscal impacts of HVHF operations in Pennsylvania, Kelsey et al. (2011) surveyed 494 jurisdictions, which included all townships, boroughs, and cities in Bradford, Clinton, Fayette, Greene, Lycoming, Somerset, Sullivan, Susquehanna, Tioga, Washington, Westmoreland, and Wyoming Counties. The authors collected data directly from municipal governments and gathered information on the presence of HVHF-related development within the governments' jurisdictions. They then correlated this development with changes in the amount of services provided by local governments and the amount of total revenues received and expenditures made by these governments. The study found that of the 131 jurisdictions that indicated HVHF development was occurring within their boundaries, 75% stated that it had not significantly affected their tax or non-tax revenues. Approximately 18% of the jurisdictions responding stated that revenues increased, while 8% responded that revenues declined. At the time this study was completed, local governments in Pennsylvania did not receive any tax revenues directly from natural gas drilling operations. Natural gas extraction is not taxable for ad valorem property tax purposes in Pennsylvania, and impact fees were not assessed on the industry until the passage of Act 13 of 2012 (Unconventional Gas Well Impact Fee) on February 14, 2012. Therefore, all revenue increases reported in this study were generated from additional earned income taxes, real property tax increases unrelated to the actual extraction of natural gas, permit fee collections, and local services taxes (Kelsey et al. 2011).

In addition, approximately 67% of the 131 jurisdictions with areas of HVHF development reported that there was no change in the types or levels of services they provided. Approximately 28% of the jurisdictions with HVHF development reported that the types or levels of services they provided increased, while the remaining 5% of jurisdictions reported that the services they provided actually decreased. All of the municipalities that reported an increase in services identified that roads were impacted (Kelsey et al. 2011).

Finally, 71% of the 131 surveyed jurisdictions with HVHF operations reported that there was no change in their governments' total expenditures caused by the natural gas development. Approximately 26% of the respondents stated that total expenditures in their municipality increased, 2% did not know the effect of natural gas development on total expenditures, and approximately 1% stated that total expenditures declined because of the HVHF operations. The majority of all respondents stating that total expenditures had increased identified road maintenance costs as being a major component of these additional costs. Other additional costs identified included higher expenditures on clerical services, permitting and code enforcement, legal services, and police protection. Data was not collected on the amount of these expenditures or the marginal costs that could be attributed to the natural gas development operations (Kelsey et al. 2011).

In a 2009 study completed by Ecosystem Research Group (ERG) for the Bureau of Land Management (BLM), the authors completed an economic and fiscal impact analysis of Sublette

County, Wyoming, that had been the location of a significant level of HVHF operations. The study analyzed, among other things, the fiscal impacts drilling operations in the county had on the Big Piney, Marbleton, and Pinedale communities, as well as the fiscal impacts on Sublette County from 1995 to 2009. As detailed in the report, per capita operating expenditures increased significantly in all three communities at the same time natural gas drilling operations were occurring. The largest increase in per capita operating expenses occurred in Big Piney. According to the report, per capita operating expenses in Big Piney, which were approximately $580 per resident in 1995, had increased to $1,267 by 2008 (ERG 2009).

Natural gas production in Wyoming is taxable for ad valorem tax purposes; therefore, Sublette County experienced a significant increase in revenues after drilling operations commenced. However, the communities of Big Piney, Marbleton, and Pinedale, which were the largest population centers in the county and were the communities that experienced the greatest negative impacts on infrastructure items such as roads, water lines, and sewer lines, also did not have any natural gas wells within their municipal boundaries. Therefore, these communities saw significant increases in their per capita expenses but did not experience the corresponding increases in their revenues that occurred at the county level (ERG 2009).

Thus, additional local government expenditures are anticipated to be incurred as a result of HVHF operations. The exact amount and type of costs that would occur would vary from community to community and cannot be accurately predicted at this time. Some communities may require significant capital improvement programs to accommodate the additional population, while others may incur very low, if any, additional costs. The existing funding mechanisms for local communities, such as the sales and use tax and ad valorem property taxes, have the potential to generate enough increased revenues to meet and potentially exceed this additional demand for local government expenditures. However, the distribution of the costs amongst various communities may not directly correspond to the physical location of the natural gas wells. Therefore, there is a possibility that costs may be incurred by one community or taxing district while increases in revenues may go to another community or taxing district.

Finally, there is the possibility that the bulk of the local government expenditures associated with HVHF operations may occur during the construction phase, when the majority of the adverse socioeconomic and environmental impacts are most likely to occur, but the bulk of the increased local government revenues would be received during the production phase, when sales and use tax receipts would be dispersed and when ad valorem property taxes would increase due to the natural gas extraction. The potential time lags between local government revenues and expenditures could negatively impact local government entities if not managed correctly.

In response to comments received requesting a full fiscal analysis, due to the generic nature of the proposed action and the lack of information in terms of intensity and location of the expected drilling, the expected cost to New York State and local governments can be enumerated but not quantified.

The numerous comments received concerning potential changes in the New York State tax code, the levy of severance taxes or impact fees, proposed changes in the way the natural gas extraction industry in taxed, and suggestions and requests for how the expected increase in local government should be spent are all beyond the scope of the SGEIS. Potential changes in the tax code are the responsibility and at the discretion of the State Legislature. Additionally, it would be at the discretion of local governments to determine how any increased revenues would be spent and if these revenues would be used to fund current or additional expenditures, reduce existing tax rates, and/or save for a future use.

Additionally, the comments contending that local government revenues would decline as a result of HVHF's negative impact on the property market are somewhat speculative. In its analysis of the impact to the housing market, the Department found no indication that there would be wholesale reduction in housing prices as result of HVHF operations and therefore, there is unlikely to be a wholesale reduction in ad valorem property tax receipts. However, there is some uncertainty regarding what can be expected to occur in New York State.

The Department disagrees with comments contending that transient workers working in New York State would be exempt from State Income Tax. Workers from out-of-state who earn income in New York are required to pay income tax to New York State as nonresidents (see Form IT-203 and its instructions).

Finally, as discussed in the SGEIS, if HVHF were authorized, the Department would be required to notify local governments of all applications for HVHF in the locality. In addition, the Department has considered requiring operators to submit three-year forecasts of drilling activity by county twice a year to facilitate dialogue among operators and local representatives.

Comment on Technical Critiques

The Department received several comments critiquing the assumptions and techniques utilized in the economic analysis presented in the SGEIS. Comments questioned the price of natural gas and the size of the estimated reserves used in the modeling effort. Other comments highlighted the economic analysis' reliance on production data from IOGA-NY, an industry association. Comments were also received questioning why the “high” development scenario found in the Economic Assessment Report was never analyzed and included in the SGEIS. Some commenters were concerned that the Department utilized the “high” development number of wells to analyze the negative environmental impacts but utilized much lower estimates to analyze the positive economic impacts.

Additionally, several comments were received concerning the use of three representative regions to assess the regional socioeconomic impacts. Additional comments were received concerning the selection of the specific counties in these representative regions.

Many comments were received that requested a financial analysis of the natural gas market, a financial analysis of individual natural gas development companies, or a financial feasibility assessment of the HVHF industry. Numerous other comments were received that requested that the Department take various environmental factors into account in the economic analysis and to monetize these non-market goods in a detailed environmental economic cost-benefit analysis.

Several technical economic comments were received on the appropriateness of using the Regional Input-Output Modeling System (RIMS II) to model the economic impacts of HVHF as presented in the SGEIS. Some of these comments questioned the use of this particular model, while others objected to the use of I-O modeling in general. Still others argued over the specifications used in the model.

Other comments requested that the economic impacts of royalty payments be modeled and included in the economic analysis. Also, commenters queried how the assumptions used to calculate the number of transient workers versus permanent workers were made. Finally, several comments requested that the Department analyze the experiences of other states to help quantify the economic impacts, while others felt the Department should analyze the scale and pace of drilling and describe how these factors would affect the severity of impacts.

Response to Comment on Technical Critiques

With respect to comments about the price of natural gas or estimates of the recoverable reserves used in the economic analysis in the SGEIS, the Department did not use either of these factors as direct inputs in the economic modeling presented in the SGEIS. The SGEIS provides an estimate of the employment impacts of HVHF operations based on a range of development scenarios, and the number of persons that would be employed per well. This analysis is based on an assumed number of wells being drilled each year under each development scenario and a given number of labor hours needed for construction and production of each well, not on the price of natural gas. Ad valorem property tax revenues described in the SGEIS also do not use the 2009 price of natural gas or reserve estimates in their estimation process.

In response to comments questioning the appropriateness of using production data provided by IOGA-NY in the economic analysis, the Department consulted IOGA-NY to provide production rate and drilling activity estimates as IOGA-NY has the most experience related to drilling activities in New York State. IOGA-NY provided estimates of both production (or flow) rates and drilling activity (i.e., number of wells) based on experience in Pennsylvania, rig availability and the amount of acreage in New York potentially available for drilling. IOGA-NY also used the Pennsylvania experience to estimate ultimate recovery on a per well basis. The information provided by IOGA-NY was used in the SGEIS for the socioeconomic analysis. IOGA-NY did not estimate recoverable reserves, and the socioeconomic information presented in the SGEIS is not based on reserve estimates. The production rate information provided by IOGA-NY and used in the socioeconomic analysis provide a “low” and a “high” estimate. The calculations in the socioeconomic sections of the SGEIS are based on IOGA-NY’s “low” estimate, consistent with IOGA-NY’s projection that New York production rates would, on average, be lower than they are in Pennsylvania. The calculations are based on a range that uses IOGA-NY's estimate as an "average scenario" and 25% of that estimate as a "low scenario." However, as noted above, the calculations did not consider the effect of restrictions on where the Department would permit HVHF wells or the effect of local bans if HVHF were authorized.

Additional comments were made concerning the exclusion of the high development scenario of SGEIS. This development scenario was detailed and analyzed in the Economic Assessment Report (EAR) but not presented in the SGEIS because circumstances have substantially changed since the assumptions were made and therefore the scenario was considered overly optimistic in its projection of the number of wells to be successfully drilled based on current information.

In response to comments made concerning the use of three representative regions to analyze the socioeconomic impacts of HVHF, the Department utilized this approach as a way to assess the regional implications of HVHF operations. The three representative regions were selected to provide a range of the scale of impacts that may occur. Since the actual location of proposed HVHF wells has not yet been determined, it is impossible to assess the impacts on a more local level. The SGEIS notes that there could be significant variations in impacts at a town/municipal level across the state and within the same representative region.

The Department did not complete a financial analysis of the natural gas market or a financial analysis of individual natural gas development companies, nor did it complete a financial feasibility assessment of the HVHF industry. The Department also did not attempt to monetize various environmental factors and complete a detailed environmental economic cost-benefit analysis because each of these suggestions is beyond the scope of what is required by SEQRA.

In regard to the technical economic comments concerning the use, selection, and specification of the Regional Input-Output Modeling System (RIMS II), the use of the RIMS II model is a well-accepted economic technique used to provide level-of magnitude estimates of economic impacts associated with a proposed action for environmental impact statements. The RIMS II input-output (I-O) model was used for the SGEIS to assess economic impacts in terms of output, employment, and income. Indirect employment and income changes from this model were also used in the SGEIS. Population and housing impacts were estimated at a regional level using the employment impacts derived from information from the Marcellus Shale Education and Training Center on direct employment impacts and the results of indirect employment impacts from this model, not directly from the model itself. Since I-O modeling involves the use of a series of matrices that describe the linkages between various industry sectors, the RIMS II model cannot be used to estimate impacts to ad valorem property taxes or potential negative socioeconomic impacts associated with HVHF operations without making several highly speculative assumptions and/or monetizing non-market goods, in essence moving outside of the modeling.

With regard to questions on how the number of transient workers versus permanent workers were calculated, the Department utilized data from the Marcellus Shale Education and Training Center on the occupational composition of natural gas workforce operating in Pennsylvania in the SGEIS. It was assumed that in the beginning only those occupations that did not require specialized skills could be filled by the local workforce, including timber logging, truck driving (CDL), general office, and land/realtor occupations. Due to the potential long-term presence of the industry, it was also assumed that the local population would gradually obtain the skills needed to be employed in the natural gas industry.

In an effort to be conservative and not to overestimate the economic impacts associated with transient workers' income and the fear that much of this income would be spent out-of-state, the induced impacts (e.g., the positive economic impacts associated with increased workers' income) were not included in the analysis in the SGEIS. Only the direct and indirect economic impacts were quantified.

Finally, in response to the comments that pointed out that income associated with royalty payments and lease payments were not factored into the analysis, the Department found that owners of the subsurface mineral rights where wells are drilled would also experience an increase in income due to lease payments and royalty payments. Lease payments are acquired through delay rentals, bonus bids, and storage fees. Delay rentals are the annual fees that oil and natural gas developers pay to hold a leased property before development occurs. Bonus bids are the amount companies offer the landowner above the delay rental fee for a specific tract. These bonus bids can often be substantially larger than the delay rental fees. Storage fees are fees paid by operators of underground natural gas storage facilities. Royalty payments are payments provided to the mineral rights owner for extraction of the natural gas.

Once the resource is developed the delay rental is waived and the developer pays a royalty payment to the mineral rights owner, which typically amounts to 12.5% or greater of the value of a well's annual production (NYSDEC 2007a) attributable to the leased acreage. Lease payments are subject to individual negotiations between developers and mineral rights owners, are confidential, and are believed to vary widely. Therefore, an analysis of lease payments would be speculative. However, the size of the royalty payments would depend upon the amount of gas produced, the wellhead price of natural gas, and the royalty rate (i.e., the percentage of the value of the gas produced that landowners receive) negotiated with the company operating the gas well (or wells) on their land (NYSDEC 2012). While it is impossible to determine with any certainty the future price of gas or the royalty rates that would be received by landowners, these royalty payments, particularly in the initial stages of well production when natural gas production is at its peak, could result in significant increases in income.

In an effort to quantify the impact of these royalty payments, the Department completed additional analysis and initially found under the low development scenario approximately $642 million in royalty income would be generated in the year of peak production. Likewise, it was initially estimated that approximately $2.6 billion in royalty income would be generated in the year of peak production under the average development scenario. These estimates assumed a wellhead price of natural gas of $4.65 per thousand cubic feet and a royalty rate of 12.5%.

These estimates, however, were based on the revised development scenarios described in detail above. As mentioned previously, these revised development scenarios did not take into account the recent New York Court of Appeals rulings and the proposed and considered mitigation measures which would have the impact of reducing the amount of land in New York State available for the development of HVHF operations and would, in turn, reduce the number of wells that could be drilled. This reduction in the number of wells drilled would reduce the annual output of natural gas in state, and thereby, reduce total royalty payments very substantially.

Additionally, the wellhead price of natural gas in New York State has declined significantly since 2010, when it was $4.65 per thousand cubic feet. Any decline in the wellhead price of natural gas will lead to a direct corresponding decline in the value of royalty payments paid throughout the state.

<u>Comment on Natural Gas Market and the HVHF Industry</u>

Numerous comments were received by the Department stating that HVHF would not benefit consumers as there was no guarantee that the retail price of natural gas would decline if the drilling technique were approved in the state. Many other comments stated natural gas extracted from New York State using HVHF should not be allowed to be sold on the export market. Additionally, several comments indicated that New York State and the Department should encourage energy conservation and/or the development of renewable energy project, instead of allowing HVHF activities. Other comments expressed the opinion that the shale gas reserves should not be exploited at this time of abundance but extraction should wait until natural gas becomes a scarce commodity. Still others commented that HVHF would create short-term economic gains but would generate long-term environmental problems. Finally, some comments stated that HVHF in New York State would help the United States achieve energy independence.

<u>Response to Comment on Natural Gas Market and the HVHF Industry</u>

Many of the general comments received were on issues that were outside the scope of the SGEIS. While they are important policy issues, discussions concerning the natural gas energy market, the export of natural gas, the importance of energy independence, the need for alternative energy sources and energy conservation, and the optimal extraction rate of natural gas were deemed not to be germane within the context of SERQA to the analysis of the environmental and socioeconomic impacts associated with possible HVHF in New York State. Therefore, these subjects were not discussed in the SGEIS.

Visual Resources

Comment: The Department received numerous comments concerning the potential visual impacts of HVHF and associated activities. Comments ranged from concerns about the regional visual impacts associated with the industrialization of picturesque communities to site-specific impacts on designated visual resources such as parks, scenic byways, recreational rivers, and hiking trails, as well as locally recognized visual resources. Most comments attributed visual impacts to the presence of tall rigs, truck traffic, and other industrial equipment standing on-site, continuous construction activity, and nighttime lighting. Comments also noted that the development associated with HVHF activities would fragment rural scenic regions, which would be a long-term impact. These comments argued that the use of the term "temporary" is a misnomer and that operations active longer than one construction season should be considered a long-term operation. Comments were concerned about the effect of lighting and flaring within "dark skies" communities. Comments argued that impacts on visual resources would directly affect users of these specific resources, and indirectly affect tourism, as well as local residents. Comments urged the Department, through its permit process, to not only recognize state-listed visual resources as significant, but to consider other sensitive resources specific to local communities. Along those lines, comments encouraged consultation with local communities and suggested the development of "dark skies" regulations, restriction of construction to specific seasons or times of day, or establishment of specific setbacks.

Comments suggested additional measures to minimize impacts on local communities and resources such as the use of vegetative screening, low-profile structures, and painted/camouflaged water tanks and other features. These comments requested that the Department mandate compliance with various mitigation measures or with local ordinances and regulations. Some comments indicated that the adverse visual and aesthetic impacts resulting from HVHF could neither be adequately mitigated nor enforced by the Department. Further, some comments contended, the Department's Policy Document DEP-00-2 (Assessing and Mitigating Visual Impacts, NYSDEC 2000) appears to address mitigation of a single project in a single location, and is less appropriate in the context of a generic impact statement. These comments asserted that the long-term visual impacts of HVHF activities should be fully evaluated and mitigated.

Comments were also submitted on the adequacy of the analysis in the SGEIS. Some comments noted that the document should have analyzed the impacts of nighttime lighting and flaring on local residences. Others requested that the SGEIS be revised to incorporate best practices for analyzing visual impacts, such as identifying the relevant view groups and landscape zones and presenting photo simulations of well development in various contexts.

Response: Significant adverse visual impacts will result from HVHF activities, although some of these impacts would be temporary and others long term. The magnitude of the impacts and the degree of impact reduction from proposed and considered mitigation measures depends, to some extent, on site-specific conditions such as the type of receptor and the distance of operations from the receptor. The Department also acknowledges that the evaluation of the significance of the visual impacts depends, in part, on the resource being impacted, a community's natural physical features, history, demographics and socioeconomics and culture, as well as the manner in which the community identifies itself, and the perceptions, likes and dislikes of individual viewers. The greatest potential for negative visual impacts on the scenic character of a region from HVHF is typically associated with well pad construction, well drilling and well fracturing phases but long term impacts will occur from other HVHF related activities including construction and operation of gathering lines and pipelines. As stated in the SGEIS, temporary or short-term activities such as on-site well drilling and fracturing would take 4 to 5 weeks to complete; some of these activities could occur intermittently over a three-year period, but they would not be permanent, ongoing, or continual. The Department considers the definitions provided in the SGEIS accurate and adequate for the generic evaluation of visual impacts from HVHF operations. Additionally, the implementation of multi-well pads would result in greater distances between drilling operations, site preparation activities, and access road construction and would thereby reduce the potential for cumulative visual impacts due to simultaneous well drilling operations.

Although some of the impacts will be temporary in nature, as indicated, many will be long term. When activities occur in wooded areas where substantial clearing is required, siting and operation could result in fragmentation of the landscape that could have a long-term impact on the scenic character of the region. Additionally, the Department recognizes that lighting associated with equipment could result in adverse impacts to residents, tourists, sensitive resources, ecological communities that are not temporary. With respect to concerns about dark skies, the Department is aware that there are a number of places in New York State where there is little or no light pollution at night, such that the stars and other astronomic features such as the

Milky Way are readily visible on clear nights. Although these "dark skies" are not resources that are state or federally designated, they can be located within local (county) or state-designated areas such as county or state parks, and the adverse impacts associated with lighting could affect the enjoyment of these resources. In general, lighting would be associated with construction- and drilling-related equipment and it is the Department's position that such lighting would be necessary to ensure the health and safety of workers during the construction and development (drilling and fracturing) phases of HVHF. However, some of the required lighting would be temporary and would be primarily limited to these phases of HVHF.

The Department has considered measures to avoid, minimize or mitigate potential impacts on significant visual resources or visually sensitive areas that contribute to the scenic character of the region. These measures would include limiting the issuance of well permits (geographically and temporally), and requiring restoration of existing vegetation to reduce the long-term impacts on the scenic character of a region. Additionally, if HVHF were authorized, specific design and siting measures such as those identified in the Department's Program Policy DEP-00-2, Assessing and Mitigating Visual Impacts, would serve as the basis for developing visual mitigation measures in a project-specific visual mitigation plan. This policy would be implemented as part of the state permitting process for specific applications to address the impacts of HVHF on the aesthetics of a project location, including impacts associated with lighting and flaring on residences. Specific mitigation measures could include the use of vegetative or other screening, directing stationary lighting in a downward fashion, and the use of non-reflective materials and lighting. See Response to the Comment in Ecosystems and Wildlife in Potential Environmental Impacts and Mitigation for discussion about potential impacts from lighting on wildlife.

Program Policy DEP-00-2 is designed to complement the state permitting process for specific applications, and includes a process for identifying and incorporating the concerns that local jurisdictions may express for local resources or sensitive areas that would contribute to the aesthetics of a proposed project location or would be affected by lighting associated with HVHF. The State's Policy differentiates between state and local concerns regarding potential visual and aesthetic impacts and specifically states in Part I that "there is nothing in this program policy that eliminates or reduces the responsibility of an applicant to local agencies to address local visual or aesthetic concerns." Towns, communities and municipalities are all considered examples of local agencies that are responsible for identifying local visual and aesthetic resources. Part II of Program Policy No. DEP-00-2 states that, in addition to state and federal designations, "recognition of aesthetic resources also occurs at local levels through zoning, planning or other public means." With respect to evaluation of the potential visual or aesthetic impacts on local visual resources or visually sensitive areas, Program Policy No. DEP-002 indicates that the Department would "defer to local decision makers, who are likely to be more familiar with and best suited to address them." Procedurally, applicants likely would be required in the permit application to identify whether the location of the well pad, or any other activity under the jurisdiction of the Department, is inconsistent with local land use laws, regulations, plans, or policies. The Department would conduct a site-specific review in any case where the applicant or the affected local government asserts an inconsistency, and would request additional information in the permit application to determine whether any such inconsistencies with these local land use laws, regulations, plans or policies raise significant adverse environmental impacts that have not been addressed in the SGEIS.

The assessment of potential significant visual impacts and implementation of specific mitigation measures is dependent on a number of site-specific factors that cannot be determined with specificity until precise well pad locations are proposed. However, the SGEIS analysis of generic visual impacts is consistent with the Department's policy, recognizing that the same types of potential impacts resulting from various phases of natural gas development may be applicable to a wide variety of these visual resources or visually sensitive areas and these potential impacts could be mitigated by the same types of measures.

While the Department believes that Program Policy DEP-00-2 provides the appropriate methodology for assessing potential visual impacts, and that it provides sufficient guidance on mitigation to assist in developing mitigation measures, uncertainties remain regarding the potential cumulative visual impacts to a particular region, depending on the number of well pads that would ultimately be constructed or in operation in a particular viewshed, especially in an area where the activity is clearly inconsistent with the overall character of the region.

Noise

Comment: The Department received numerous comments concerning the potential impacts on sensitive receptors and the community at large from the noise associated with HVHF activities. These comments expressed concern with the duration and magnitude of construction; the adequacy of the SGEIS noise analysis; and the effectiveness of any measures to mitigate noise related to construction and operation of wells, associated pipelines and compressor stations, and the associated truck traffic.

Many comments were received regarding the potential for high noise levels at residences and at other sensitive receptors. Commenters considered the noise impacts part of the overall industrialization of rural communities associated with HVHF, and the degradation of the quality of life in those communities. Commenters specifically cited concerns for noise effects on human health, wildlife, and domestic farm animals. These comments noted that the drilling, fracturing and possible refracturing of multiple wells on a single well pad would result in significant noise impacts, and that these activities, according to the comments, would take significantly longer than originally considered. Many comments expressed concerns about truck traffic noise resulting from the HVHF operations, while other comments were concerned with the noise associated with the construction and operation of the wells, and also construction and operation of the pipelines and compressor stations required to transport gas from the HVHF operations.

To address adverse impacts, numerous comments requested that the Department establish specific, quantitative noise limits, and suggested mitigation measures such as stricter setbacks from hospitals, schools, and farms, limits on nighttime construction activities, and restrictions on truck traffic. Numerous comments expressed concerns that HVHF noise levels could not be adequately mitigated, arguing that the noise impacts would be too significant, or that compliance with the Department noise policy could not be enforced. With respect to enforcement, comments indicated both that the Department is not adequately staffed to monitor the noise levels associated with HVHF operations and/or compliance with permit conditions, and that the Department’s lack of standards, regulations or adequate setbacks leaves a void to be filled by communities.

Comments expressed concern with the adequacy of the SGEIS analysis and the legality of the SEQR process, stating that the noise section fails to provide a meaningful analysis of noise impacts; or that the section does not adequately discuss the significance of the construction noise modeling results. Comments noted that the mitigation measures that are not specifically identified in the EAF are not enforceable. Comments also expressed concern that the regulatory standards related to noise, and the associated SGEIS discussion regarding these standards, are not adequate. These comments recommended that the Department review noise studies and regulatory requirements in other states where HVHF operations are ongoing.

Response: HVHF will result in significant adverse noise impacts in and around communities where such activities take place. With respect to the duration and magnitude of impacts, the SGEIS indicates that drilling and fracturing activities associated with HVHF are temporary, with well drilling lasting from approximately 28 to 35 days and hydraulic fracturing of a single well lasting 2 to 5 days. Current information suggests that 6 to 10 wells would likely be drilled and developed per multi-well pad. Because of the close well spacing at the surface, only one drilling rig at a time would be operating on any given well pad. Once these tasks are complete at a location, the remaining wellhead production generates less noise than during construction and fracturing. Additionally, the implementation of multi-well pads would result in greater distances between drilling operations, site preparation activities, and access road construction and would thereby reduce the potential for cumulative noise due to simultaneous well drilling operations depending on the topography and variables relating to noise transmission and perception. However, due to the anticipated widespread nature of this activity and the on-site generators and other machinery and equipment associated with HVHF, the footprint on certain regions within the Marcellus formation and the associated impacts, including noise, would likely be greater than for traditional methods of extraction. Although it is not known at this time what percent of the wells would need to be re-fractured, noise impacts and associated mitigation for re-fracturing would be similar to those for the initial fracturing.

In response to comments on the industrialization of rural communities, the SGEIS indicates that impacts on quality of life or on rural landscapes are dependent on a community's natural physical features, history, demographics and socioeconomics and culture, as well as the manner in which the community identifies itself through its comprehensive plan and/or zoning. The

Department acknowledges that HVHF activities, taken as a whole, including the significant increases in truck traffic, would have significant adverse impacts on residents, commuters and tourists within the affected communities.

With respect to comments about the adequacy of the SGEIS, the SGEIS presented additional analysis of the potentially significant adverse noise impacts associated with HVHF, based on the Department's Program Policy DEP-00-1, *Assessing and Mitigating Noise Impacts*. The SGEIS includes estimated noise levels that would be experienced at various distances from the drilling operation conducted prior to HVHF and contains estimated noise levels at various distances from the fracturing operation. This section demonstrates that whether significant adverse noise impacts occur is highly dependent on site-specific conditions, such as the type of receptor and the distance from operations to the receptor.

If HVHF were authorized, mitigation measures would be required to reduce noise impacts when necessary at any particular site. Permit applicants would be required to utilize the DEP-00-1, which is intended to provide direction to Department staff for the evaluation of sound levels and characteristics generated from proposed or existing facilities. The guidelines contained within this policy indicate that increases ranging from 0 to 3 dB over existing sound levels would have no appreciable effect on receptors, and that increases from 3 to 6 dB have potential for significant adverse noise impact only in cases where the most sensitive receptors are present. As noted in the guidelines, sound pressure increases of more than 6 dB may require additional analysis of impact potential, depending on existing sound pressure levels and the character of surrounding land uses and receptors.

If HVHF were authorized, the Department considered a requirement that a noise evaluation be conducted following DEP-00-1. In that evaluation, noise modeling would have been required once the location and layout of a drilling site has been established and prior to the execution of the drilling project. To further mitigate impacts, the Department also considered imposing stricter setbacks for inhabited private dwellings, places of assembly and other sensitive receptors identified by local communities. Additionally, the Department explored requiring additional mitigation measures such as the imposition of permit application requirements or permit conditions; restrictions on the timing of construction or operational activities; and the establishment of well-siting requirements. For example, the proposed permit requirements could have included requiring applicants to submit noise mitigation plans with their well permit applications authorizing HVHF. Applicants could have been required to develop a site plan and conduct noise modeling for well pads under certain conditions to control noise impacts. Permit requirements also would have included the use of noise reduction equipment, or the restriction of construction or project activities to daytime hours. To address concerns about adequate staffing and enforcement of permit conditions, the Department would have conducted periodic inspections but could have also relied on local government and citizen complaints and observations of possible violations. Additionally, the Department would have limited its issuance of HVHF well drilling permits to the number of permits it could adequately monitor and enforce, based on its level of staffing. The failure of a well operator to adhere to conditions of the permit would have been considered a violation of ECL Article 23. In regard to concerns about noise impacts associated with pipeline construction and the operation of compressor stations, these aspects of HVHF operations/projects would have been reviewed on a site-specific basis as part of the process governed by either the New York State Public Service Commission under Article VII or the Federal Energy Regulatory Commission (FERC) depending on whether the line is intrastate or interstate. See Response to the Comment in Enforcement.

While the Department considered several additional mitigation measures to reduce noise impacts on local communities, until the location and layout of a specific HVHF site has been established and noise analysis has been conducted, it cannot be determined if noise from any particular site could be adequately mitigated. Most important, the Department recognizes that while various measures may be taken to reduce noise impacts, ultimately, these measures may not be sufficient to adequately mitigate noise in particular cases.

Furthermore, the Department recognizes that while the noise impact of drilling and fracturing a single well is limited, the noise impact of drilling and fracturing 6-10 wells on a well pad could have a longer duration that might be continuous or intermittent.

Transportation

Comment: The Department received numerous comments concerning the potential transportation-related impacts of HVHF activities. Comments were concerned with the increase in construction vehicle traffic and traffic associated with an increase in population in local communities; traffic congestion and the increased potential for accidents; the industrialization of communities resulting from HVHF and associated activities; transport of hazardous materials and the potential for environmental damage from spills; and damage to roadways from truck traffic and the costs associated with road improvements and repairs. On the other end of the spectrum, some comments argued that the measures proposed to mitigate the impacts of trucking on local roads were unnecessary and punitive.

Comments argued that HVHF activities would result in increased traffic volume and traffic associated with an increase in workers/population in local communities. Comments argued that this congestion would cause the industrialization of rural communities and affect quality of life, especially associated with the volume of truck traffic, and related noise and air emissions from the trucks. Some comments expressed concerns about traffic issues in specific communities, or near community facilities such as schools, hospitals and other sensitive areas. With the volume of truck traffic, school bus schedules would be affected, as would response times for service vehicles such as ambulances. Comments asserted that the overall increase in traffic congestion also would have adverse impacts on tourism, recommending the prohibition of traffic from specific towns or historic and tourist areas, or during certain times of the year.

Many comments addressed the potential for truck traffic to place extra wear and tear on infrastructure including roadways, bridges, sewer collection infrastructure, and water supply piping. Concerns were expressed that this damage could lead to accidents, spills, and costly damage to infrastructure. Comments also questioned who would construct and maintain site access roads, and who would pay for the cost of these roads and their connection to the highway system. Others raised questions about the cost to upgrade and maintain existing local and state routes either to accommodate the increase in truck traffic, or as the wear and tear in the roadway systems led to deterioration due to heavy use by the heavy-truck traffic. Comments also reported that the region does not support enough road crews to keep up with all the damages that could accrue. The experiences of small communities in Pennsylvania were described, with comments referring to alleged inadequate mitigation and failures to restore infrastructure damaged by trucking.

Many comments regarding increased traffic also discussed the potential concomitant increase in accidents, attributed largely to heavy trucking vehicles on light-duty rural roadways and local roads. Special concerns were raised about large trucks sharing the roads with agricultural vehicles, bicycles, motorcycles, and pedestrians. Sensitive groups, such as senior citizens, may also be particularly impacted. Changes in grade during construction and road repairs were identified as being particularly hazardous for motorcycles and bicycles. Some comments expressed concern that if roadways were improved to accommodate truck traffic, the speeds of local traffic using those rural roadways would increase, indirectly resulting in an increase in the risk and severity of local vehicle accidents.

Comments cited the risk of chemical and hazardous waste spills, often associated with travel of heavy trucks on rural and local roadways, not designed for heavy truck traffic. Comments raised concerns that discharges or releases, either from leaks from the transport vehicles or accidents involving heavy trucks, could contaminate groundwater, surface water, and soils. Some comments also addressed the possibility that waste materials could be illegally dumped in transit to avoid disposal costs. These impacts, they argued, would result in risks to human health and to ecosystems. Some comments recommended that HVHF developers be required to disclose the materials that were being transported, and that chemical information be made available to local communities.

Numerous comments discussed the impacts from the traffic-related noise, increases in air pollution and greenhouse gases from truck exhaust, increases in road kills of wildlife, degradation of wildlife habitat near highways, impacts on cultural resources and community character, and the visual impacts of trucking.

Comments also recommended specific measures to minimize transportation impacts, suggesting the use of pipelines to haul water, or the use of propane as an alternative to water-based hydraulic fracturing fluid as a way to minimize truck traffic, for example. Other comments advised that detailed baseline traffic surveys should be conducted for each permit. Many comments questioned the adequacy or feasibility of specific mitigation measures, arguing that the cost estimating described in the 2011 SGEIS was incorrect; and that small communities, counties, and the Department lack the expertise to assess both baseline traffic and the potential increases in traffic impacts resulting from HVHF activities. Similarly, comments noted that road use agreements would be problematic, indicating that many small municipalities lack the resources to implement and enforce these agreements. Comments also argued that impacts on state highways would extend beyond the jurisdiction of any road use agreements.

With respect to potential mitigation measures raised in the SGEIS, some comments criticized the proposed phasing of permit issuance, arguing that issuing fewer permits over a longer period of time would extend the duration of impacts. Others questioned the criteria the Department would use to determine which operator has precedence. These comments expressed concern about how factors such as lease expiration date, proximity to existing operations, distances to mobilize, and availability of equipment would affect decisions about phasing. There was concern that decisions about phasing the issuance of permits might discriminate against small operators, or cause undue financial impacts from loss of contracted rigs or delayed activity. Some comments stated that the requirement to identify routes for trucks at the early planning stage is unfair and too restrictive. Comments also questioned whether specific damages could be attributed to HVHF operators.

Response: HVHF and associated activities would impact traffic both locally and regionally. As described in the SGEIS, the greatest increase in truck traffic would occur during drilling and fracturing operations. These periods of high activity would be limited, with well drilling lasting from approximately 28 to 35 days and hydraulic fracturing of a single well lasting 2 to 5 days. However, the Department acknowledges that multiple drilling operations and cumulative impacts from nearby drilling could extend these periods of high traffic generation much longer, to periods of several years.

In regard to the comments which requested analysis of traffic impacts on specific routes and regions, the Department's position is that this report is a generic environmental impact statement which addresses HVHF on a programmatic level. As such, the SGEIS selected and analyzed three representative regions to provide a range of the scale of impacts that may occur. As a part of this analysis, it was assumed as a worst case that water would be transported by trucks initially, with some use of pipelines during longer-term production of wells. If pipelines were used for water transport in earlier phases of development, traffic impacts and worker travel would be reduced. Further reductions in traffic impacts could be achieved by using rail to transport large pieces of equipment like drilling rigs and pipelines.

The SGEIS did not assess specific impacts on local traffic and routes throughout New York State since the actual location of HVHF, and the timing of development has not yet been determined. The Department acknowledges that there would be significant variations in impacts at a municipal level across the state and within the same representative region; and that increased truck traffic would result in adverse traffic impacts, congestion at busy intersections, and the disruption of quiet, rural environments, at both a local and regional level. The addition of heavy trucks on rural roads would cause other impacts such as the degradation of roads, bridges, culverts and subsurface infrastructure. These and other impacts would have adverse effects on community character. Even if a community were to entirely prohibit HVHF, the regional impacts from truck traffic related to HVHF activities in nearby communities could affect a number of municipalities in the same area.

To reduce impacts on those communities that would experience adverse transportation-related impacts, the Department explored and considered several mitigation measures including permit requirements and permit phasing. With respect to permit requirements or conditions, if HVHF were authorized, the Department considered requiring applicants to submit with their applications transportation plans or emergency response plans, and considered requiring municipalities to certify that road-use agreements are in place. Likewise, to ensure the safe transport of hazardous materials, the Department considered a requirement for applicants to identify response and mitigation actions in an emergency response plan submitted as part of the application process. Additionally, because the drilling and fracturing of multiple wells could extend the period of heavy traffic beyond three months, increase the intensity of impacts at specific intersections, or cause other cumulative impacts, the Department considered a requirement to phase permit issuance. The decision to phase permits would have been based on a number of factors including information supplied by well operators and a local government entity and the potential for significant operational and safety impacts. The Department could have also requested traffic studies and required further, more specific mitigation measures to avoid cumulative impacts.

The Department in the SGEIS identifies road-use agreements as an important regulatory tool to mitigate impacts. The road-use agreements would rely on local governments to seek to reduce significant adverse impacts by restricting truck traffic to specific haul routes, assuring the maintenance and repair of infrastructure, and establishing a process for arbitration in the event of a dispute. The availability of model road-use agreements, such as those used by other states or for other activities, would have reduced the burden placed on local municipalities to develop these agreements, especially for small local governments that have limited resources. Significant local road, traffic and related infrastructure impacts may fall under the jurisdiction of state, county and local governments. Nonetheless, the Department proposed and considered various measures that would facilitate the mitigation of those impacts including requiring applicants to enter road use agreements with the appropriate government agency.

With respect to enforcement, road use agreements would be enforced by local law enforcement; and enforcement of general rules and regulations relating to commercial trucks would be the responsibility of local and state police and the NYSDOT. With respect to the costs borne by local communities, municipalities would not be expected to bear the costs of site-specific repairs to infrastructure; rather, bonds could be secured from operators to assure the availability of funds for these repairs. However, local government would bear the responsibility to address significant local traffic and road and bridge infrastructure impacts that would result from HVHF. Regarding diffuse impacts from extra traffic beyond the limits of the road use agreements, traffic generated by HVHF would pay assessments based on fuel taxes, tolls, licensing, and other fees that are required for similar vehicles in other industries. These taxes and fees are designed to support road maintenance. Lastly, road improvements or repairs not covered by local road use agreements could be funded by the *ad valorem* tax on the natural gas production.

Road-use agreements typically include or reference a transportation plan that describes limits on the frequency of travel, routes, weight limits, and timing of road use, as well as other conditions. The Department considered reducing potential impacts through the development of a site-specific transportation plan to address the traffic resulting from HVHF construction and operations. The transportation plan would identify whether the applicant has entered into (a) road use agreement(s) with local governments and would be required to disclose the condition of existing roadways and associated infrastructure, disclose the number of anticipated truck trips to be generated, and describe routes, traffic impacts, and potential impacts to roadways. Transportation plans may also include a commitment to use rail to haul equipment, which would lessen the impacts of trucking on the state roadway system. Additionally, depending on existing traffic conditions, the lead agency or the government agency with jurisdiction on the site specific environmental review would be able to require that the plan include a detailed traffic engineering study analyzing the potential for a change in the level of service on specific roadways, and the duration of adverse traffic impacts. If this review indicated that the well development might result in significant impacts or safety hazards, the government agency with jurisdiction could require the establishment of new routes, seasonal limitations on road use, additions of signals or traffic control agents in sensitive areas, and the construction of turning lanes. Additionally, as is typical with construction projects, signage would have been required to mark changes in grade or changes from unpaved to paved surfaces to reduce the risk of accidents.

Despite the above measures, and even with best practices consistently being enforced, traffic accidents do occur in proportion to the amount of traffic. The increased traffic from HVHF would therefore result in more accidents, which is an unavoidable impact of any activity that generates traffic.

Moreover, the Department recognizes that there is uncertainty regarding the effectiveness of the proposed measures given the myriad of local government agencies which have road, traffic and infrastructure jurisdiction. In addition, the traffic resulting from HVHF would be difficult to predict and control, since truck routes beyond the limits of the transportation plan or not covered in local road-use agreements could adversely impact neighboring regions. At the same time, the Department does not have jurisdiction over roads which are the province of local governments and the Department of Transportation. Further, as the comments indicate, the SGEIS is not able to predict with certainty the cumulative impact from trucking materials to and from many wells. Additionally, added traffic can result in increased emissions of air pollutants, greenhouse gases, excess noise, impacts to surface water from erosion on unpaved roads and the potential for spills, impacts to wildlife, visual impacts, and impacts on the character of communities. As these resource areas would be impacted in proportion to the amount of traffic induced by the HVHF activities, mitigation to reduce the traffic can only be partially effective, since an increase in traffic is an unavoidable impact of HVHF. Some unmitigated adverse impacts to these resources are unavoidable.

In summary, HVHF development could potentially represent a large increase in traffic in some areas. Some of these increases would be limited duration, some would persist with HVHF development throughout the areas subject to HVHF development. If HVHF were authorized, some of these impacts could persist for several years because of cumulative impacts. The impacts include the potential for congestion, an increase in accidents in proportion to the increase in traffic, and a low but real risk of spills. Additionally, even were a community to entirely prohibit HVHF, impacts from truck traffic related to HVHF activities in the area could affect the municipalities that had adopted bans. Mitigation could reduce, but not entirely eliminate these potentially significant impacts.

Community Character

Comment: The Department received numerous comments concerning the potential impacts HVHF would have on community character and quality of life. These comments raised concerns about specific impacts of noise, truck traffic, and lighting pollution on quality of life; questions about the extent to which restoration activities would occur once HVHF activities were complete; the Department's ability to enforce rules and regulations that would mitigate community character and other impacts; and the adequacy of the SGEIS analysis. Some comments recommended that local bans on HVHF would alleviate these concerns.

Comments asserted that the SGEIS assessment of community character is inadequate, noting that the analysis of representative regions did not capture the unique qualities of specific communities within New York State, including places such as the Town of Middlefield, the Town of Cooperstown, and the Finger Lakes Region, for example. To that point, some comments advocated the prohibition of development within the areas not analyzed in the representative regional analysis in the SGEIS. Other comments noted that the analysis failed to adequately describe the magnitude of adverse impacts, which include increased truck traffic, visual impacts and lighting pollution, and the loss of agricultural land. Yet other comments asserted that impacts on community character cannot fully be addressed in the context of a generic impact statement and should be addressed on a site-specific, case-by-case basis.

Numerous comments were concerned with the adverse impacts of HVHF activities on a community's sense of place, noting the human connection to the environment, the potential for environmentally and ecologically degraded communities, and the adverse social impacts of development on otherwise serene communities. Specifically, comments were concerned that HVHF activities would create industrial zones through otherwise undisturbed landscapes, introduce unacceptable adverse impacts, and be wholly incompatible with the goals of local communities. Many comments offered examples of the unique qualities of their communities, stating that HVHF could permanently damage the vitality and character of their region in particular, as they suggest has happened in the boroughs of Montrose, Wellsboro and Mansfield, Pennsylvania, where HVHF has been occurring. Examples of adverse impacts, they suggested, include continuous construction activity, noise and visual impacts, and increased crime rates.

Comments were not only concerned with the immediate impacts of HVHF development, but the potential for long-term, permanent impacts, expressing concern about reclamation and restoration of the landscape once drilling and fracturing activities were completed. Overall, comments indicated that HVHF activities would significantly change the character and feel of their communities, surrounding communities, and the region as a whole. With respect to surrounding communities, comments noted that even if HVHF were banned by one community, the impacts of these activities in a surrounding community would result in permanent adverse impacts to the region as a whole.

Some comments encouraged the Department to explore ways to work with local government to protect the character of individual communities, recommending specific mitigation measures such as increased restrictions in agricultural districts and requirements for local hiring. On the other end of the spectrum, comments posited that there are no effective mitigation measures that protect quality of life, which is essential to attract population and economic development. Finally, numerous comments questioned the Department's ability to adequately enforce compliance with mitigation measures and permit conditions, suggesting that local communities should supersede the State's authority and should ban HVHF outright.

Response: Notwithstanding the measures that could be imposed by DEC and other agencies with jurisdiction over HVHF. HVHF and the expected ancillary activities, would result in significant adverse community character impacts, if it were authorized within or near communities whose natural physical features, history, demographics and culture are divergent from the industrial aspects of HVHF. With respect to adequacy of the SGEIS analysis, this report is a generic environmental impact statement which addresses HVHF on a programmatic level. Three representative regions were selected to provide a range of the scale of impacts that may occur. Since the actual location of proposed HVHF throughout the State has not been determined, it is impossible to assess the specific impacts on any particular community. The SGEIS notes that there could be significant variations in impacts at a municipal level across the state and within the same representative region. Although a site-specific analysis of community character impacts within a particular locality is not practicable at this time, the SGEIS provides a description of some of the significant impacts that are likely to occur within a community if HVHF were authorized. Specific impacts to elements of a community, such as the economy, noise levels, and visual resources are described in separate sections of the SGEIS.

In response to comments on the industrialization of specific communities, the change in community character expected to occur from HVHF activities can be dependent on a community's natural physical features, history, demographics and socioeconomics and culture, as well as the manner in which the community identifies itself, for example, through comprehensive planning and zoning. The SGEIS acknowledges that HVHF will likely have significant impacts on the character of communities where HVHF activities occur. Experiences in Pennsylvania and West Virginia do show that wholesale development could lead to changes in the economic, demographic, and social characteristics of the affected communities. On the matter of crime rates, however, there is insufficient evidence to determine whether crime rates, as expressed on a per capita basis, would increase as a result of the HVHF operations. While the Department acknowledges that evidence from Pennsylvania indicates that the total incidents rates would likely increase as a result of HVHF operations, the majority of these additional incidents are expected to be traffic-related, misdemeanors or other non-violent calls. A study completed by the Pennsylvania State University Justice Center for Research shows that there is no consistent trend in the number of arrests made in seven counties that have experienced HVHF operations.

The SGEIS recognizes that each region within the State, and each community within those regions, has its own unique character and identity. The Department acknowledges that introduction of HVHF could cause a greater change in communities that enable or do not constrain HVHF through the exercise of the authority reserved to them by the Environmental Conservation Law. Other communities may exercise their land use authority to limit or constrain areas and conditions under which HVHF may occur. Given the importance of a community's comprehensive plan and zoning as a factor in defining a community's character, the introduction of HVHF may not cause as great a change in community character in communities that have prior experience with gas drilling consistent with their land use plans compared to those communities that have no prior experience.

While the SGEIS points to a wide range of impacts and states that whether or not changes to community character are considered adverse is determined, in large part, by how an individual community defines its character, the Department recognizes that, at a minimum, HVHF will change aspects of the community character and quality of life in the regions in which HVHF could occur.

To reduce impacts on those communities that would experience adverse environmental impacts that make up community character, the Department has explored and considered several mitigation measures, including 1) permit application requirements or permit conditions; 2) restrictions on timing of construction or imposition of well-siting requirements; and 3) requiring frequent and regular communication among developers, consulting agencies and local officials. The proposed permit requirements or conditions could include requiring applicants to submit with their applications transportation plans, noise and visual mitigation plans, and/or plans for reclamation/restoration.

In regard to noise and visual impacts, which contribute to a community's character, the SGEIS demonstrates that determining whether significant adverse impacts will occur is, in part, due to on site-specific conditions, such as the type of receptor and the distance from operations to the receptor. To mitigate potential impacts, if HVHF were authorized, applicants would be required to utilize the Department's guidance document DEP-00-01, Assessing and Mitigating Noise Impacts, and develop a site plan and conduct noise modeling for well pads under certain conditions to control noise impacts. The operator's noise impacts mitigation plan would be provided to the Department along with the permit application, and additional site-specific noise mitigation measures could be added to individual permits, for example, requiring noise measurements during drilling and HVHF operations where well pads are located within 1,000 feet of an occupied residence or place of congregation. Similarly, with respect to visual impacts, specific design and siting measures such as those identified in the Department's Program Policy DEP-00-2, Assessing and Mitigating Visual Impacts, could serve as the basis for developing visual mitigation measures in a project-specific visual mitigation plan. See Responses to Comments in Visual Resources and Noise, both in Potential Environmental Impacts and Mitigation.

With respect to the issues of reclamation and restoration, if HVHF were authorized, the Department has considered requiring well operators to submit a plan for partial reclamation with their application for a permit to drill; Department approval would be required prior to drilling the well. Plugging and abandonment of the well and reclamation of the surrounding site would be required to be conducted by the well operator in accordance with Department-issued plugging permits. See Response to Comment in Water Resources in Potential Environmental Impacts and Mitigation regarding potential significant environmental impacts associated with stormwater discharges from the construction of HVHF well pads.

With respect to local coordination and consistent with the *Dryden* decision (discussed below), if HVHF were authorized, the Department would commit to informing and coordinating with local governments of all applications for HVHF in the locality. In this regard, the Department considered and explored requiring a site-specific review in any case where the applicant or the affected local government asserts an inconsistency with its local land use laws, to determine whether any such inconsistency raises significant adverse environmental impacts that have not been addressed in the SGEIS. The Department also explored the idea of requiring operators to submit three-year forecasts of potential HVHF activity by county, consult with local governments and operators over those forecasts, and where appropriate, place limits on the number of wells and/or well pads that can be constructed for HVHF in a specific area at a single time in order to mitigate potential adverse impacts on community character, tourism and other potential socioeconomic impacts that could result from a concentration of HVHF activity in a short period of time within a particular area. The Department also considered conducting a site-specific review when an applicant proposes to disturb more than 2.5 acres on a farm within an Agricultural District, with the Department committing to consult with the DAM to develop additional permit conditions, best management practice requirements, and reclamation guidelines to be followed. See Response to Comment in Local Government Notification and Coordination in Permit Process and Regulatory Coordination.

In considering the above, the Department recognizes that taken alone, the impacts of HVHF on individual resource areas may be reduced, but that community character is defined as a combination of several factors that contribute to an area's sense of place. While the Department acknowledges that some communities may experience some positive benefits, and that various mitigation measures could be required to address or reduce adverse impacts on individual resource areas that contribute to community character, these measures may not adequately mitigate the transformation of entire regions that could result from HVHF. In this respect, it is far less certain that specific mitigation measures can address potential cumulative impacts to a particular region, especially in an area where the activity is clearly inconsistent with the overall character of the region.

One way to reduce or eliminate impacts, as commenters noted, would be for communities to address HVHF through the land use authority reserved to them by the Environmental Conservation Law. Recently, as described previously, the New York Court of Appeals in the *Matter of Wallach v. Town of Dryden* found that ECL § 23-0303(2) does not preempt communities from exercising their delegated zoning powers to prohibit or restrict the use of land for HVHF. Nonetheless, even were a community to entirely prohibit drilling, impacts from truck traffic or other ancillary activities related to HVHF could conceivably affect a number of municipalities in the area. Indeed, due to the anticipated widespread nature of this activity in areas that have not been previously subject to natural gas or oil extraction and the evolution of the technology that facilitates extraction of natural gas from deep low-permeability shale formations where it was previously not feasible, the associated regional impacts including from the collection and transport of the natural gas would likely be greater than for traditional methods of extraction. In this respect, the No Action alternative represents the only certain means for avoiding or minimizing environmental impacts of HVHF in other communities.

Cultural Resources

Comment: The Department received numerous comments that raised concerns with respect to the potential for significant adverse impacts to historic, cultural and archeological resources. The comments noted that the SGEIS lacked essential information and analysis in many critical areas related to historic resources and argued that it does not provide the requisite substantial evidence and thus fails to take the hard look required by the New York State Environmental Quality Review Act (SEQRA) to identify and address potential significant adverse impacts to New York States historic and cultural resources. Comments identified that the extensive ground disturbing activities associated with drilling, including the construction of well pads, access roads, pipelines, compressor stations and other appurtenant structures would destroy any cultural or archeological resources located in the soil. Furthermore, the comments contended that if HVHF were authorized it would impact community's "sense of place."

Comments argued that the SGEIS substantially undercounts the amount of historically sensitive resources that would be impacted by hydraulic fracturing, and improperly indicates that the Department would only consider an individual application's impact on National Register ("NR") and National Register Eligible ("NRE") properties. Here, comments identified that many historically important sites and landscapes have not been listed on the NR or have not been technically deemed NRE, but could still be impacted by HVHF activities. Furthermore, the comments maintained that the lack of consistent survey documentation and National Registry (NR) listings encompassing vernacular rural landscapes does not indicate a lack of such cultural resources in many areas considered in the SGEIS. Rather, it indicates that so far, planning efforts in many communities - even where comprehensive plans identify "community character" and "sense of place" as characteristics they wish to preserve and enhance have not yet undertaken such review.

In light of these potential impacts to both listed historical resources and unlisted historic, cultural and archeological resources, comments urged the Department to require an archeological survey before any issuing a permit to construct a drill pad, holding pond, or equipment staging area. The comments noted that there should be a process in place to identify, evaluate, avoid or mitigate for impacts to these important resources located throughout the study area and that regulations should be enacted to enforce these provisions. Some comments went so far as to conclude that there should be no HVHF activities in the vicinity of districts designated as historic by the National Register of Historic Places.

Finally, the Department received comments from the Indian Nations that expressed opposition to HVHF as "a demonizing affront" to their deepest spiritual belief systems. The Indian Nations asserted that SGEIS did not recognize the substantial interests of the Indian Nations, nor did it discuss potential impacts on the Indian Nations. For example, these comments expressed concern about the potential impact to human remains and the desecration of Native American graves. The comments also indicated that the Department should be concerned about impacts from HVHF on Native American lands in relation to environmental justice issues.

Response: HVHF may result in significant adverse impacts to historic, cultural, and archaeological resources, however, the level of impacts is not readily identifiable because the location of HVHF development activities has not been identified. The SGEIS included measures that would have required a site-specific review to determine whether HVHF development would result in significant adverse visual and aesthetic impacts including an assessment of these and other impacts on historic and cultural resources of significance. This process would be conducted in accordance with Program Policy No. DEP-00-2, *Assessing and Mitigating Visual Impacts*. The Department also considered additional mitigation measures that if employed would likely further reduce impacts on cultural resources, including historic buildings and archaeological resources (Historic Properties), if HVHF were authorized.

Specifically, the Department recognizes that impacts to historic properties must be ascertained on a case-by-case process through fulfillment of the requirements of State Historic Preservation Act (SHPA). In light of this requirement, the Department considered measures that would identify Historic Properties, including not readily identifiable archaeological resources, and, in the event that Historic Properties are identified, measures to ensure that appropriate mitigation is applied. These measures include consultation with NYS Office of Parks, Recreation and Historic Preservation - an agency that has additional expertise and authority to evaluate the potential significant adverse impacts of well construction on Historic Properties. The submission of a structural archeological assessment form and a Phase 1 Study, Phase 2 Site Evaluation, or Phase 3 Data Recovery, when appropriate. The Department would require an evaluation of the site's environmental characteristics to determine if archeological resources are likely to be present. With respect to Historic Districts, the Department considered prohibiting HVHF within and contiguous to Historic Districts and/or requiring further environmental review to analyze the potential significant adverse impacts unique to those districts prior to issuing any HVHF permits. Statutory and regulatory authority is already in place to enforce these procedures. If HVHF were authorized, it would be conducted only in compliance with statutory, regulatory and permit requirements imposed to protect any identified cultural, historic and archeological resource.

Similarly, in the event that HVHF were authorized, the Department acknowledges that consultation with Indian Nations must be conducted in accordance with the Department's Commissioner Policy 42, Contact, Cooperation and Consultation with Indian Nations ("CP 42"). Furthermore, the Department recognizes that in addition to CP-42 further measures may be needed to adequately consider potential impacts to the Indian Nations if HVHF were authorized. In this respect, the Department considered requiring contact with an Indian Nation, for the purpose of initiating consultation, for all applications for the construction of a well pad for HVHF within this one mile zone of that Indian Nation's Territory.

6. Cumulative Impacts

Comment: The Department received numerous comments that the SGEIS failed to adequately analyze potential significant cumulative adverse environmental impacts from the likelihood of widespread development of this activity, as well as the collective impact from the accumulation and build-out of wells in the Marcellus Shale region. Specifically, comments argued that the SGEIS failed to evaluate potential cumulative impacts as mandated by the State Environmental Quality Review Act (SEQRA) and its implementing regulations. The comments contended that the Department's SEQRA regulations require the preparation of a cumulative impact assessment when, even if no single project's impact is significant, the aggregated impacts from multiple actions may be significant. According to the comments, this is consistent with the principle that all environmental impact statements (EISs) “should deal with the specific significant environmental impacts which can be reasonably anticipated,” including “primary (direct) and secondary (indirect) impacts” as well as “short-term and long-term effects.” Comments emphasized that consideration of cumulative impacts is especially important with respect to generic EISs that encompass broad statewide programs, such as the Department's plan to permit HVHF in the Marcellus shale. Comments concluded that although Marcellus Shale activities have the potential of both local and aggregate risk, they are being regulated solely as individual local point sources. Consequently, some comments recommended that HVHF sources of environmental pollution should be regulated both individually and collectively.

Comments identified ancillary activities and impacts associated with the development of HVHF statewide, including, new pipelines, pumping stations, storage facilities, feeder and collection pipe networks, roads, impoundments for flowback water (including centralized flowback impoundments), construction of new waste water treatment facilities (POTWs), abandoned wells, and other ancillary infrastructure. These activities and infrastructure, the comments argued, would cause significant adverse cumulative impacts to the environment. In this regard, the comments argued that the SGEIS failed to adequately address regional impacts, long-term impacts, health impacts and community character impacts. The comments also contended that the economic analysis was insufficient as it did not address the potential cumulative impact to tourism, agriculture and the costs associated with administering the program.

The comments argued that the SGEIS only studied one well pad and drilling operation at a time without considering the cumulative impacts on the air, climate change, truck traffic on roads, water quality and withdrawal, and forest fragmentation caused by multiple wells spread out over the landscape. One area that the comments focused on was the potential for cumulative impacts associated with stormwater impacts caused by land disturbances and increased acreage of impervious surfaces specifically from the cumulative effect of HVHF activities on erosion, stream turbidity, and sedimentation. Similarly, comments asserted that the Department failed to consider the potential surface water impacts of stream-crossing activity associated with HVHF well pads, most notably, stream crossings associated with gathering lines and access roads (to both well pads and compressor stations). In this respect, comments asserted that the SGEIS failed to properly employ analytical land use tools, data, and models to map and evaluate the density of anticipated land disturbance and proximity to streams and wetlands. Comments also contended that the SGEIS failed to adequately address waste water disposal and waste water treatment plants and the potential of the discharge of "dangerous" chemicals, including flowback water and production brine. Here, according to the comments, the SGEIS failed to include an evaluation of how the mitigation measures proposed for specific resources would offset cumulative impacts. Similarly, comments noted that the volume of drill cuttings would impact landfills.

Comments also identified specific communities and regions that would likely be negatively impacted, including Broome County, lands within the blue line of the Catskill Park and the New York City Watershed, the Delaware River Watershed and Basin, the Upper Susquehanna Scenic and Recreational River Basin, the Finger Lakes Basin, the 900-mile Finger Lakes Trail, the Chemung River Basin, the Genesee River drainage basin, and the Onondaga Lake watershed. Comments argued that the SGEIS improperly delegated the responsibility for regulating and mitigating cumulative impacts from natural gas drilling to local governments and that the Department's offer to consult with local government would not amount to sufficient mitigation because it would be up to the individual permit reviewer in the regional offices to determine if the conflict could or should be resolved.

The Department also received comments that contended that the cumulative impact analysis was inadequate because it did not contain a public health risk assessment nor did it address the cumulative impacts on health costs. In this regard, comments urged the Department to mandate state health agencies and science laboratories to monitor the effects of the industrial operations in areas where drilling activity is already taking place, such as Pennsylvania.

In contrast, some comments suggested that the many provisions in the SGEIS would have a discriminatory effect. Specifically, the combination of setbacks, prohibited areas, and mandatory mitigation make many areas financially prohibitive to drill. Such restrictions, the comments contended would hinder the development of systematically located unit areas for gas extraction. The effect of these restrictions would be stranded and underutilized infrastructure such as gathering lines and roads, inefficient patchwork development, and unrecovered gas. The comments assert that such a program is not in the best interest of landowners, communities, or the State.

Response: The Department recognizes that if HVHF were authorized it would result in significant cumulative adverse impacts which must be considered using both a spatial and temporal framework. In this regard, the SGEIS and the Department considered potential impacts, and where appropriate proposed mitigation that could reduce those impacts. However, despite the numerous proposed mitigation measures that were evaluated, the Department acknowledges that the cumulative effects caused by HVHF development and reasonably foreseeable ancillary development would occur and significantly affect some resources, particularly water and habitat resources, public health and the environmental impacts that constitute community character, if HVHF were authorized. Indeed, due to the anticipated widespread nature of this activity in regions that have not previously experienced oil and gas development and the evolution of the technology that facilitates extraction of natural gas from deep low-permeability shale formations where it was previously not feasible, the footprint on certain regions within the Marcellus formation and the associated impacts, would likely be greater than for traditional methods of extraction. Moreover, in the Department's experience, community character is especially susceptible to delayed effects; cumulative adverse impacts and cross boundary effects that occur away from the source. See Response to Comment in Community Character in Potential Environmental Impacts and Mitigation.

The purpose of a generic environmental impact statement is to consider both the common and cumulative impacts of a drilling program that would authorize development of well pads using HVHF, regardless of where any individual well is located. In this respect, the development of gas well pads has impacts that interact and that are not apparent when examined on an individual well pad basis. These impacts can arise from the accumulation of similar effect as well as the synergistic interaction of different types of effects associated with developing wells and producing gas using HVHF. Therefore, in 2009 the Department concluded that the use of a generic EIS was the most appropriate means to examine the potential significant adverse environmental impacts of HVHF on natural resources, community character, and health. Based upon its experience since 2009, and the comments received concerning the SGEIS, the total effect of HVHF, including both direct and indirect effects, can only be fully evaluated on a generic basis. Further, only a generic EIS enables the Department to analyze and predict development patterns and determine the synergistic interactions expected from HVHF. To the extent that there was a reasonable basis on which to analyze the combined, or cumulative, impacts of drilling more than one well where HVHF is used that analysis was considered by the Department. For instance, the Department considered the cumulative impacts of HVHF well development and associated infrastructure on water resources; ecosystems and wildlife; air quality, including from regional emissions of ozone precursors; greenhouse gas emissions; socioeconomics; visual; noise; transportation; community character; health; historic, cultural, and archaeological resources; and intra-state pipelines.

The proposed action considered in the SGEIS is the issuance of permits to drill, deepen, plug back or convert a well completed by HVHF. Each well requires a separate permit to drill. For wells previously permitted by the Department that were consistent with the 1992 GEIS it was typical for well operators to drill one vertical or horizontal well on a well pad. Inasmuch as the SGEIS considers the impacts of several wells drilled sequentially on the same pad, it is by its scope, a cumulative analysis of the impacts associated with drilling several individual wells from a common location. Although each well pad will have its own geographical and geological circumstances, it is reasonable to anticipate the number of wells on a single or multi-well pad, since ECL § 23-0501, which establishes the acreage assigned to a given well, is predicated on the concept that vertical shale wells will drain approximately 40 acres and several horizontal wells are needed to efficiently develop spacing units between 40 and 640 acres. Because it is not possible to specify the number of wells that would be drilled on any particular well pad, the SGEIS describes, as a range, the anticipated well density for both vertical and horizontal wells. This conceptual site model is used throughout the SGEIS to define the potential impacts of a multi-well pad and the mitigation necessary to reduce those impacts. This range was informed by information provided by potential well operators, who were asked for estimates of the number of wells that may be constructed for each multi-well pad, as well as observations of development patterns in other jurisdictions.

An example of where the Department considered the aggregate effect of drilling several wells from the same well pad is the potential air quality impacts from drilling and completing four wells in a 12-month period. Even though each well would be separately permitted and each well has independent utility, impacts on the air shed are cumulative and the air quality analysis in the SGEIS addressed the potential impacts associated with use of engines needed to drill, fracture and complete several wells. Water resources, including impacts from withdrawals are areas where it is appropriate to consider cumulative impacts of several separate unrelated actions. The Department considered the impacts and mitigation to address reduced stream flow, impacts to aquatic habitats and impacts to wetlands, among other topics, from HVHF. Consideration of cumulative impacts from multiple users of the same water source is the most reasonable approach because the potential impacts on a water source do not depend on where the well pad is located or how many wells would be drilled. Instead, the impact of individual or multiple withdrawals depends entirely on the condition of a water source at the time of the withdrawal(s). Impact mitigation is also tied to the timing of the withdrawal and takes into account multiple users of the same water source. In that regard, the mitigation measures considered by the Department attempted to account for both individual and cumulative withdrawals while taking into account both geographic and temporal considerations. See Response to Comment in Water Resources in Potential Environmental Impacts and Mitigation for further discussion of the potential significant environmental impacts associated with water withdrawals for HVHF.

However, in some cases, without more specific information regarding the actual number of wells proposed in an area, the distribution of such wells statewide and the timing of drilling, it would be too speculative to conduct a cumulative analysis of several wells or well pads or to predict mitigation efficacy. On a regional level, there was insufficient factual basis on which to predict the actual number of wells that may be drilled in a town or county. Nor is it within the Department's means to determine how wells will be distributed statewide. Taking the Marcellus Shale as an example, the SGEIS generally discusses the recoverable reserves that may be present in New York but qualifies those estimates by stating that recoverable reserves are a function of the prevailing technologies and knowledge base associated with a given resource. The Marcellus Shale outcrops in New York and while there is speculation that the "sweet spots" for developing the Marcellus will be close to the Pennsylvania border, there is no basis to pinpoint exactly where and how many wells or well pads may be drilled. Despite not being able to predict the timing, location and number of wells to be drilled, it is possible to conclude that cumulative impacts will generally occur from HVHF. However, this lack of predictability complicates the ability of the Department to adequately quantify these impacts and provide effective mitigation to prevent significant adverse impacts to water and natural resources and community character.

In an attempt to address this uncertainty and the likely significant adverse cumulative impacts, a number of factors must be considered. One is the effect of numerous mitigation measures that the Department proposed and considered that might influence the location and timing of wells. Many of these measures would necessarily limit the number of wells drilled because a number of areas of the State would be off limits to drilling or, at least, less likely to be developed. These mitigation measures include setbacks, prohibitions or a requirement to conduct site-specific SEQRA reviews for well pads for HVHF that are proposed to be located within specified proximities from specific water resources and supplies, a prohibition of well pads associated with HVHF on Department-administered State-owned lands, enhanced site-specific review for critical habitat, stormwater controls, and mitigation measures for historic resources. Furthermore, other mitigation measures, such as requirements to partially and finally reclaim the well site, and the temporal nature of the activity would reduce the potential footprint of HVHF, thereby reducing some long-term and cumulative impacts. Collectively, these mitigation measures would reduce, but not eliminate, cumulative impacts to ecosystems and wildlife, water resources and community character.

The Department also considered the potential cumulative socioeconomic impacts of a certain number of wells drilled in three different regions. This analysis provided order-of-magnitude estimates of potential socioeconomic benefits and was made possible because existing data sources were available on a county basis. The economic benefits of drilling a hypothetical number of wells are not tied to specific drilling locations, whereas a conclusion about potential noise, visual, traffic, etc. impacts depends in part on the location of the well pad, its proximity to other well pads and its surrounding environment. The Department acknowledges that the mitigations measures considered, if HVHF were authorized, would reduce the potential economic benefits. See Response to Comment Socioeconomic in Potential Environmental Impacts and Mitigation. Additionally, the Department recognizes that significant costs would be associated with a variety of municipal and state government obligations associated with administering programs to protect public health and the environment. The Department estimates that cost of administering this program under the average development scenario would grow from approximately $14 million in the first year to nearly $25 million in the fifth year. These costs do not consider other substantial costs that would be incurred by other state and local agencies. See Response to the Comment in Enforcement.

There are economic benefits to HVHF, the extent of which remain uncertain. However, there would also be negative economic impacts. For example, some of the negative impacts associated with HVHF, including increased traffic, noise, and visual impacts, may adversely affect visitors' experience of certain traditional tourist destinations. As a result, tourist destination enterprises that are more geared to traditional tourists may experience a loss in visitors, sales, and employment. Traffic impacts may also lead to additional demands for expanded road infrastructure and related improvements. See Responses to Comments in Visual Resources, Noise, and Transportation, all in Potential Environmental Impacts and Mitigation.

With respect to potential significant adverse impacts to community character, the Department recognizes that each region within the State, and each community within those regions, has its own set of distinctive attributes, authenticity, and identity, and, consequently is susceptible to cumulative impacts from the anticipated widespread development of HVHF in certain regions within the Marcellus formation. The Department acknowledges that introduction of HVHF could cause a greater change in communities that enable or do not constrain HVHF through the exercise of the authority reserved to them by the Environmental Conservation Law. Other communities may exercise their land use authority to limit or constrain areas and conditions under which HVHF may occur. Given the importance of a community's comprehensive plan and zoning as a factor in defining a community's character, the introduction of HVHF may not cause as great a change in community character in communities that have prior experience with gas drilling consistent with their land use plans compared to those communities that have no prior experience. The SGEIS notes that with perceived adverse impacts such as rapid expansion, changed patterns of development, temporary noise and visual impacts, communities may also experience positive benefits such as increased employment, financial gains, and tax revenues. See Response to Comment in Community Character in Potential Environmental Impacts and Mitigation.

In considering the above, the Department recognizes that taken alone, the impacts of HVHF on individual resource areas may be reduced, but that community character is defined as a combination of numerous factors that contribute to an area's sense of place. While the Department acknowledges that some communities may experience some positive benefits, and that various mitigation measures might address or reduce adverse impacts on individual resource areas that contribute to community character, the Department cannot reliably predict that these measures will adequately mitigate potential adverse impacts to community character. In this respect, it is far less certain that specific mitigation measures can address potential cumulative and long-term impacts to local and regional resources, especially in areas where HVHF is inconsistent with the overall character of the region, such as adjacent to state parks and recreation areas, water supplies and infrastructure, wildlife habitat, open space and recreation among other factors. For this same reason, SEQRA reviews of separate applications across the wide geographic area expected to be subject to HVHF, would not be adequate to evaluate the multitude of indirect and cumulative impacts. Specifically, the Department accepts that some indirect and ancillary impacts of HVHF to community character extend far beyond the well pad. As discussed above, if HVHF were authorized it would have diverse and synergistic impacts to community character, including traffic, noise, and visual impacts.

Although municipalities may exercise the authority regarding land use as defined in the recent New York Court of Appeals in *Matter of Wallach v. Town of Dryden* localities still cannot prevent cross boundary cumulative impacts to their respective community character. It is reasonably foreseeable that a community that prohibits HVHF would be adversely affected by indirect impacts from truck traffic and pipelines related to HVHF activities. See Response to Comment in Local Government Notification and Coordination in Permit Process and Regulatory Coordination.

Similarly, while identified mitigation measures to protect forest and grassland focus areas would reduce impacts specific to an individual permit subject site-specific review within those areas, that review would not take into account the potential fragmentation and repetitive effects of future permits and the ancillary activities within those blocks that collectively could impact these resources. Furthermore, beyond these focus areas there are countless smaller forests and grasslands that provide important habitat for declining species that could potentially be negatively impacted both individually and collectively if HVHF were authorized. Thus, while the proposed mitigations measures, including reclamation requirements, would reduce impacts from HVHF activities, significant unavoidable and unmitigated adverse environmental impacts would still remain.

Likewise with respect to collector pipelines, the Department appreciates that while a site-specific environmental review can potentially provide effective mitigation for a particular collector pipeline, it is far less certain that if HVHF were authorized, such a review could address potential cumulative impacts to a particular region, especially in an area where the activity – HVHF – is inconsistent with the many elements of the overall character of the region. In addition, not knowing the precise location of any gas pipelines precludes prediction of the precise location of the significant impacts associated with HVHF although the impacts will result generally from HVHF development. Many of the specific impacts would, depend on whether a well is drilled in a particular location, whether a well or wells are productive, as well as a suite of physical and commercial considerations regarding access to the larger commercial gas pipelines that transmit product for distribution and consumption. HVHF development across the state therefore would likely lead to a network of gathering lines and other infrastructure necessary for the development and transportation of natural gas resulting in significant adverse cumulative impacts. See Response to the Comment in Other regarding pipelines.

Furthermore, the Department recognizes that if wide spread development of HVHF were authorized, including construction of well pads, access roads and ancillary activities, such development would present a risk of increased nutrient loading and sediment loading to water resources. Typical activities associated with natural gas drilling include the installation of a well pad, construction of an access road to reach the well pad and gas collection lines to gather the gas. These activities would necessarily include land clearing, soil disturbance and excavation. Activities like these when undertaken on steep slopes, highly erodible soils and/or in close proximity to streams, reservoirs or other water courses have the potential to significantly increase polluted stormwater runoff, nutrient loading, erosion and sedimentation to water resources (if erosion and sediment control measures are not properly implemented). The rate at which development would occur and the timing of each drilling event is also highly speculative, rendering any analysis about potential loadings estimates to streams and wetlands unreliable.

See Responses to Comments in Water Resources and Wetlands, both in Potential Environmental Impacts and Mitigation.

During the construction phase of well development it is reasonable to assume that storm events will result in some level of erosion and sedimentation, despite measures proposed in the HVHF GP to control stormwater, from noncompliance. Sediment loading from disturbed soils on construction sites is a significant problem. EPA estimates that one unstabilized acre subject to construction activity emits 1,000 to 2,000 times the sediment during a rain event than an acre of forest or natural meadow does. Such eroded sediments often carry adsorbed contaminants and nutrients to the water. Eroded sediments can fill wetlands and silt in the rock cobble that serves as spawning beds for trout. Sediment operates to impair drinking water quality by contributing to the transport of pathogens and interfering with the effectiveness of disinfection. Furthermore, in terms of the impact on the quality of waters in the State, phosphorus is (arguably) the most significant of all pollutants. The adverse economic impacts of polluted runoff are apparent to anyone involved in a vacation or tourist business that has been affected by polluted runoff. New York lists waters that are formally listed as “impaired” – meaning that they can’t be used as they are intended for drinking water, fishing or swimming. Of the waters listed as impaired in New York, 27 percent of those impairments are attributed to polluted runoff (nutrients and silt/sediment).

With respect to air quality, it was possible to do some quantitative cumulative impact analysis because baseline air quality information is available and there are existing models which can be used to predict significant adverse impacts. Moreover, a cumulative air quality analysis is possible because reasonable assumptions can be made about a hypothetical well pad to make up for the lack of site-specific data. In estimating the potential air emissions associated with HVHF, the SGEIS considered several different drilling estimates when determining at what level of activity exceedances of applicable regulatory thresholds might occur. Based on this modeling significant cumulative adverse environmental impacts are not expect to occur to air quality to the extent that air quality standards are not expected to be exceeded. See Response to Comment Air Quality and Greenhouse Gas Emissions.

The Department does not anticipate cumulative impacts to landfills. The SGEIS describes the volume of drill cuttings that can be expected to be generated from a horizontally drilled well. Drill cuttings are a solid waste that, depending on the drilling method utilized, may be disposed of on-site or at a Part 360 solid waste landfill. A HVHF well is expected to generate approximately 217 cubic yards of drill cuttings, or approximately 271 tons assuming a density of 1.25 tons/cy. Municipal solid waste landfills are currently permitted or authorized to accept approximately 220 million tons of solid waste. Based on these calculations, municipal solid waste landfills in New York State could accommodate drill cuttings from more than 810,000 wells. Though selected cuttings can be disposed on-site or at construction and demolition debris landfills, even if all the cuttings from these wells were disposed of in municipal solid waste landfills, they would use a small percentage of the municipal solid waste capacity in New York State. Therefore, the Department believes that there is sufficient disposal capacity in the state to handle drill cuttings that will require off-site disposal.

Finally, the Department recognizes the potential impacts that HVHF may have on a variety of resources in New York State including impacts from contaminated stormwater (i.e., sedimentation) and uncontained surface spills, leaks, or releases of fluids containing chemicals or petroleum. Specifically, risks associated with construction activity, high volumes of truck traffic (i.e., road runoff and accidents), or improper chemical, petroleum or wastewater handling, could result in a degradation of drinking water supplies. It is uncertain and difficult to quantify what combination of existing Department engineering controls and management practices, enhanced to address unique aspects of HVHF, would be required to prevent spills and mitigate adverse impacts if a spill occurs. The Department would impose a robust set of engineering controls that would significantly reduce the risk. Even with controls in place, the risk of spills and other unplanned events resulting in the discharge of pollutants associated with HVHF, even if relatively remote, would not be eliminated and could have significant consequences. The Public Health Review came to the same conclusion in finding that, "[t]he number of well pads and associated HVHF activities could be vast and spread out over wide geographic areas where environmental conditions and populations vary. The dispersed nature of the activity magnifies the possibility of process and equipment failures, leading to the potential for cumulative risks for exposures and associated adverse health outcomes. Additionally, the relationships between HVHF environmental impacts and public health are complex and not fully understood."

The Department has determined that given the identified significant adverse impacts and substantial uncertainty in several environmental areas that even a generic analysis augmented by site-specific review might not effectively mitigate potential cumulative impacts from the wide spread development of the Marcellus Shale using HVHF.

7. Health Impacts

Comment: One of the major subject areas on which the Department received substantive comments was the potential for public health impacts as a result of HVHF.

Comments in this area focused on approximately seven major categories, outlined in brief below:

- Lack of a health impact assessment (HIA) or risk assessment for HVHF, lack of comprehensive health studies on HVHF, and the lack of proof that HVHF would not result in adverse health impacts.
- Potential health impacts from spills, accidents and unforeseen events to both workers and the public;
- Potential adverse health impacts via air and water pathways;
- Potential short-term and long-term health impacts from noise, light, quality of life disruption and psychological impacts, and impacts to local communities, community services, and increased health insurance costs;
- Potential adverse health impacts from naturally occurring radioactive materials (NORM) in drilling wastes and radon in Marcellus Shale gas, and potential adverse health impacts from seismicity;
- HVHF chemical additives, non-disclosure of such additives and their potential toxicity; and
- Lack of a state health registry and a health advisory panel.

Many comments raised general concerns about assessment of health risks or health impacts from HVHF. Some of these comments indicated that a formal Health Impact Assessment (HIA) was not conducted, and that an HIA should be required as part of the SGEIS. Other comments stated that there was not sufficient information to document a lack of health risks from HVHF and that more research was needed, such as evaluating health outcomes in other communities with current HVHF activity. Some comments noted that health studies evaluating epidemiological evidence near current HVHF activity or documenting health outcomes within a 20-mile radius of HVHF wells had not been done and that such evaluations should be done. One comment stated that a controlled experiment should be conducted in one or more communities to measure baseline health outcomes followed by changes in health outcomes after installing HVHF wells in the community. Two comments stated that a health risk assessment conducted by a consulting firm demonstrated HVHF did not pose significant health risks.

Another subject raised by commenters was the possibility of adverse health impacts from accidents and unforeseen events. Potential impacts that were described included worker injuries and fatalities resulting from job-site accidents, increased traffic accidents from greater truck traffic, unforeseen accumulation of methane and other light hydrocarbons in caves posing a toxicity or asphyxiation hazard, toxicity hazards from spills, skin damage in workers exposed to solar radiation without proper sunscreen, and exposure of sand-mining workers and nearby residents to dusts containing silica from sand used in hydraulic fracturing.

Other comments related to public health impacts raised concerns regarding the potential for groundwater and surface water impacts and potential impacts from air pollutant emissions. Specific water-related concerns mentioned included: aquifer and drinking-water well contamination from sub-surface chemical migration; water contamination from chemicals in flowback fluids; the lack of “acceptable levels” of chemical contaminants in drinking water for sensitive receptors (pregnant women, infants and developing children); potential for sub-surface bacteria to contaminate shallow aquifers; and potential impacts to water and land uses from reuse of drilling wastewater. Specific air-related concerns mentioned included: emissions of volatile organic compounds, nitrogen oxides, carbon monoxide, sulfur dioxide, ozone, benzene, particulate matter, and diesel engine exhaust. Potential for health impacts due to water or air contamination that were mentioned include asthma, acute skin and eye irritation, unspecified respiratory health impacts, endocrine disruption, cancer, developmental effects, diabetes, and childhood leukemia. Some comments noted that allowing HVHF would interfere with cancer prevention efforts. One comment stated that asthma rates would be expected to decline as a result of replacing coal-fired electric power generation with gas-powered generation.

Another topic of concern was the potential impacts to human health from indirect effects of HVHF that could adversely affect quality of life and community character. Factors mentioned include: drilling noise, traffic noise, light pollution, dust, truck traffic, visual disruption of the landscape, need for increased response planning for healthcare providers, more affordable medical care, increased public health costs, industrialization, increased commuting times due to traffic congestion, reduced outdoor recreation, lack of health insurance, and health insurance liability of responsible parties in the event of unspecified contamination. Potential health impacts mentioned in these comments include: ruptured eardrums, sleep disruption, vibro-acoustic disease, psychological stress, noise-induced gastric lesions, improved population health in drilling areas, high blood pressure, chronic fatigue, anxiety, cardiovascular disease, childhood cognitive impairment, psychic numbing, low grade depression, and obesity.

Comments also raised concerns about potential impacts from human radiation exposure from radon present in natural gas from the Marcellus formation, and from NORM present in drill cuttings and wastewater. Some comments raised concerns about the potential for earthquakes to be caused by HVHF or by disposal of wastewater into deep injection wells. Some comments specifically mentioned the potential for cancer due to radiation exposure.

Other comments noted that chemical additives used in HVHF may have limited toxicity information, that chemical information obtained from company disclosure requirements should be incorporated into a private chemical toxicity database, and that more information is needed in the discussion of chemical categories and health information. Some comments indicated that non-disclosure agreements regarding alleged health concerns should not be allowed in NYS. Some comments focused specifically on methane, noting that toxicity information on methane is limited, and that a NYS maximum contaminant level for methane in drinking water should be established.

Finally, some comments raised concerns regarding health-related organizational or programmatic oversight activities in the event that HVHF were to be allowed in NYS. Comments included the need for health care professionals on an HVHF advisory panel and the need for the NYSDOH to establish a health effects registry or epidemiological surveillance program designed to document illnesses due to HVHF activity.

Response: While the SGEIS did not have a specific chapter or subchapter dedicated to discussing potential public health impacts, those potential impacts were identified in several areas of the document, including chapters 5 and 6, when describing topics such as water, air, hydraulic fracturing additives, community character, and emergency response to spills and other accidents at well pads. Based on the significant comments raised by the public and health professionals related to public health, at the Department's request, the New York State Department of Health (NYSDOH) produced a Public Health Review of HVHF for Shale Gas Development. That review was published in December of 2014 and it can be found at http://health.ny.gov or http://www.health.ny.gov/press/reports/docs/high_volume_hydraulic_fracturing.pdf. The NYSDOH public health review is specifically incorporated by reference into this responsiveness summary and SGEIS.

In September 2012, the NYSDOH initiated a Public Health Review of the Department's SGEIS. The Public Health Review was later extended beyond the scope of the initial request to consider, more broadly, the current state of science regarding HVHF and public health risks. This required an evaluation of the emerging scientific information on environmental public health and community health effects. This also required an analysis of whether such information was sufficient to determine the extent of potential public health impacts of HVHF activities in New York State and whether existing mitigation measures implemented in other states are effectively reducing the risk for adverse public health impacts.

HIAs that examined public health risks of HVHF have recently been conducted by governments or academic institutions in Maryland (University of Maryland, 2014), Michigan (University of Michigan, 2013), North Carolina (Research Triangle Environmental Health Collaborative, 2013), Nova Scotia (Wheeler, 2014), the National Institute of Environmental Health Sciences (NIEHS; Penning et al., 2014), the Institute of Medicine (IOM, 2014), and the European Commission

(Broomfield, 2012).[10] The results of these assessments were largely qualitative judgments. Specific public health risks that were emphasized in these assessments included the following:

- The European Commission HIA determined that HVHF in Europe will entail "high" cumulative risks of groundwater contamination, surface water contamination, depletion of water resources, releases to air, increased noise, and increased traffic.

- The University of Michigan assessment identified priority issues including silica exposure, intentional-use chemicals, by-product chemicals, transportation, air quality, water quality, habitat and wildlife (impacts on recreational opportunities, cultural/spiritual practices), and public perceptions (causing, e.g., increased anxiety, family quarrels, depression).

- The North Carolina HIA emphasized planning and monitoring including: collecting baseline data on water quality, air quality, and health statistics; developing a comprehensive water and wastewater management plan; adequately supporting coordinated enforcement; and developing and promoting best practices.

- Both the NIEHS and IOM assessments emphasized the potential for water and air pollution that could adversely affect public health as well as the potential for social disruption that could result from local community impacts caused by rapid development of HVHF activities.

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[10] University of Maryland, Maryland Institute for Applied Environmental Health, School of Public Health (2014). Potential Public Health Impacts of Natural Gas Development and Production in the Marcellus Shale in Western Maryland. Retrieved from http://phpa.dhmh.maryland.gov/OEHFP/EH/Shared%20Documents/Reports/MDMarcellusShalePublicHealthFinalReport08.15.2014.pdf.

University of Michigan, Graham Sustainability Institute. (2013).Hydraulic Fracturing in Michigan Integrated Assessment technical reports. Retrieved from http://graham.umich.edu/knowledge/pubs.

Research Triangle Environmental Health Collaborative. (2013). Shale Gas Extraction in North Carolina: Public Health Implications. Retrieved from http://environmentalhealthcollaborative.org/images/2012SummitWorkProduct.pdf.

Wheeler, D., Atherton, F., Bradfield, M., Christmas, K., Dalton, S., Dussealt, M., et al. (2014). Report of the Nova Scotia Independent Panel on Hydraulic Fracturing. Retrieved from http://energy.novascotia.ca/sites/default/files/Report%20of%20the%20Nova%20Scotia%20Independent%20Panel%20on%20Hydraulic%20Fracturing.pdf.

Penning, T.M., Breysse, P.N., Gray, K., Howarth, M., Yan, B. (2014). Environmental Health Research Recommendations from the Inter-Environmental Health Sciences Core Center Working Group on Unconventional Natural Gas Drilling Operations. *Environmental Health Perspectives*, 122.11, 1155-1159.

Institute of Medicine of the National Academies, Board on Population Health and Public Health Practice, Roundtable on Environmental Health Sciences, Research, and Medicine (IOM). (2014) Health Impact Assessment of Shale Gas Extraction: Workshop Summary. Washington (DC): National Academies Press (US).

Broomfield, M. (2012). Support to the Identification of Potential Risks for the Environment and Human Health Arising from Hydrocarbons Operations Involving Hydraulic Fracturing in Europe. European Commission DG Environment publication 07.0307/ENV.C.1/2011/604781/ENV.F1. Retrieved from http://ec.europa.eu/environment/integration/energy/pdf/fracking%20study.pdf.

In summarizing the available information assessing HVHF health impacts, the NYSDOH Public Health Review concluded that:

> "… the overall weight of the evidence from the cumulative body of information … demonstrates that there are significant uncertainties about the kinds of adverse health outcomes that may be associated with HVHF, the likelihood of the occurrence of adverse health outcomes, and the effectiveness of some of the mitigation measures in reducing or preventing environmental impacts which could adversely affect public health."

There are numerous ways that HVHF could result in public health risks. These range from exposure to chemicals used or transported throughout the HVHF process to motor vehicle accidents from increased truck traffic. Specifically, the Department has acknowledged that traffic accidents and unforeseen events would occur if HVHF were authorized, as they do in other types of industrial activities. A recent study from Pennsylvania reports that automobile and truck accident rates in 2010 - 2012 from counties with heavy HVHF activity were between 15% and 65% higher than accident rates in counties without HVHF. Rates of traffic fatalities and major injuries were higher in heavy drilling counties in southwestern Pennsylvania compared to non-drilling counties in 2012 (Graham, 2015).[11] Major potential adverse impacts from increased truck traffic include increased traffic congestion and accidents; more damage to roads, bridges, and other infrastructure; and spills of hazardous materials during transportation.

Community character impacts also have the potential to cause significant public health concerns. In this respect, many historical examples exist of rapid and concentrated increases in extractive resource development (e.g., energy, precious metals) resulting in local community impacts such as interfering with quality-of-life (e.g., noise, odors), overburdened transportation and health infrastructure, and disproportionate increases in social problems, particularly in small isolated rural communities where local governments and infrastructure tend to be unprepared for rapid changes.[12]

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[11] Graham, J., Irving, J., Tang, X., Sellers, S., Crisp, J., Horwitz, D., & Muehlenbachs, L. (2015). Increased Traffic Accident Rates Associated with Shale Gas Drilling in Pennsylvania. *Accident Analysis and Prevention*, 74:203–209.

[12] For a recent example, see: http://headwaterseconomics.org/energy/western-counties-fossil-fuel-development.

Information obtained by NYSDOH in consultation with government agencies and other expert authorities experienced with HVHF activities noted common concerns include air quality impacts, truck traffic impacts, noise, challenges with wastewater management, social disruption associated with rapidly-escalating industrialization in communities, and the cumulative effect of HVHF activities on stress. While these factors are generally recognized, data gaps exist regarding the degree and extent to which HVHF contributes indirectly to human health impacts due to stressors including off-site nuisance odors and visual impacts such as nuisance light pollution.

With respect to potential exposure to chemicals and other harmful byproducts of HVHF, NYSDOH previously developed an analysis of potential adverse health effects associated with exposure to various fracturing chemical additives, based on qualitative health hazard information for 10 chemical categories inclusive of all fracturing additive chemicals from fracturing product information disclosed to the Department by well service companies. Also see response to the Comment in Fracturing Fluid in Potential Environmental Impacts and Mitigation. As indicated by some comments, additional qualitative health hazard information on chemicals that could be used during HVHF shale-gas development continues to be published in the scientific literature. The significance of such qualitative health hazard information for understanding the risk of human health impacts posed by hydraulic fracturing chemicals is uncertain for several reasons. Assumptions are usually needed to extrapolate from high-dose animal toxicity studies to potential low-dose chronic human exposures or from human data in specific populations (e.g., workers) to the general human population. The validity of such assumptions in any specific instance is inherently uncertain. Any assessment of health risks from a given chemical is also highly dependent on understanding the route (ingestion, inhalation, or skin contact), degree, extent, and timing of human exposure (if any) to that chemical. In the absence of data from a specific exposure incident, this would also entail making many uncertain assumptions and extrapolations regarding the exposure conditions under which risks are estimated.

In a critical review of water resource issues associated with HVHF, Vengosh et al. (2014) identified published data on HVHF activities revealing evidence for stray gas contamination, surface water impacts, and the accumulation of radium isotopes in some disposal and spill sites.[13] The National Institute for Occupational Safety and Health (NIOSH) has assessed potential risks to workers associated with chemical exposure at natural gas drilling sites (NIOSH, 2012).[14] In field studies conducted at 11 sites, respirable crystalline silica and diesel particulates were measured at levels with the potential to pose health hazards. NIOSH has proposed several controls and recommended proper use of personal protective equipment to minimize exposures. NIOSH has also reported that the occupational fatality rate among oil and gas industry workers is seven times higher than the average rate for all US industries (Retzer, 2011).[15]

Several risk-assessment studies have been conducted assessing air quality in many areas of the U.S. with HVHF activity (For instance, Colorado Department of Public Health and Environment, 2010; Bunch et al., 2014; Macey et al., 2014).[16] Volatile organic chemicals such as benzene, toluene, formaldehyde, and 1,2 dibromoethane were reportedly detected at levels exceeding some short-term health comparison values in a small percentage of air samples in these studies. A number of factors, including background air quality associated with traffic and other industrial activity make it challenging to attribute observe air levels to certain sources such as gas drilling (Weisel, 2010).[17] A recent West Virginia study determined that vehicle traffic and engine

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[13] Vengosh, A., Jackson, R.B., Warner, N., Darrah, T.H., Kondash, A. (2014). A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States. *Environmental Science & Technology*, 48(15):8334-48.

[14] National Institute for Occupational Safety and Health (NIOSH). (2012). Health Hazards in Hydraulic Fracturing. Presented at Institute of Medicine of the National Academies, Roundtable on Environmental Health Sciences, Research, and Medicine. Health Impact Assessment of Shale Gas Extraction workshop. Retrieved from http://www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30.aspx.

[15] Retzer, K., Hill, R. (2011). Fatal Injuries. WellServicingMagazine.com. Retrieved from http://www.wellservicingmagazine.com/featured-articles/2011/09/fatal-injuries/.

[16] Colorado Department of Public Health and Environment. (2010). Health Consultation: Public Health Implications of Ambient Air Exposures as Measured in Rural and Urban Oil & Gas Development Areas – an Analysis of 2008 Air Sampling Data, Garfield County, Colorado. Retrieved from http://www.atsdr.cdc.gov/HAC/pha/GarfieldCountyColorado2010/GarfieldCountyColoradoHC08262010.pdf.
Bunch, A.G., Perry, C.S., Abraham, L., Wikoff, D.S., Tachivsky, J.A, Hixon, J.G. et al. (2014). Evaluation of Impact of Shale Gas Operations in the Barnett Shale Region on Volatile Organic Compounds in Air and Potential Human Health Risks. *Science of the Total Environment*, 468-469:832-842.
Macey, G.P., Breech, R., Chernaik, M., Cox, C., Larson, D., Thomas, D., & Carpenter, D.O. (2014). Air Concentrations of Volatile Compounds near Oil and Gas Production: A Community-Based Exploratory Study. *Environmental Health*, 13(1), 82.

[17] Weisel, C.P. (2010). Benzene Exposure: An Overview of Monitoring Methods and their Findings. *Chemico-Biological Interactions*, 184(1-2):58-66.

exhaust were the likely sources of intermittently high dust and benzene concentrations sometimes observed at distances of 625 feet and farther from the center of well pads (McCawley, 2013).[18]

Natural gas can also contain radon, a potential indoor air contaminant. A screening analysis presented in the NYSDOH Public Health Review suggests that radon exposure levels from Marcellus natural gas could contribute a small fraction to the overall indoor radon levels. However, there is substantial uncertainty regarding radon levels in shale gas from various geographic locations and geologic formations because of limited monitoring data, especially from the Appalachian Basin (Rowan and Kramer, 2012), which includes the Marcellus Shale.[19]

Beyond potential air quality impacts, Osborne et al. (2011) highlighted the potential for sub-surface methane migration from HVHF activity to affect drinking water wells in Pennsylvania and some recent publications have shed light on the potential for and causes of occasional water pollution incidents around oil and gas wells (for example, see: Satterfield, 2011; Sharma, 2014; Warner, 2014; Zhang, 2014).[20] Darrah et al. (2014) identified groundwater contamination clusters that they determined were due to gas leakage from intermediate depth strata through failures of annulus cement, faulty production casings, and underground gas well failure.[21] Some

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[18] McCawley, M. (2013). Air, Noise, and Light Monitoring Results for Assessing Environmental Impacts of Horizontal Gas Well Drilling Operations. West Virginia University School of Public Health, Morgantown, WV. Retrieved from http://wvwri.org/wp-content/uploads/2013/10/A-N-L-Final-Report-FOR-WEB.pdf.

[19] Rowan, E.L., and Kramer, T.F. (2012). Radon-222 Content of Natural Gas Samples from Upper and Middle Devonian Sandstone and Shale Reservoirs in Pennsylvania: Preliminary Data. US Geological Survey. Open-File Report 2012–1159, 6 p., http://pubs.usgs.gov/of/2012/1159. (Available only online.)

[20] Osborne, S.G., Vengosh, A., Warner, N.R., Jackson, R.B. (2011). Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing. *Proceedings of the National Academy of Sciences* (PNAS), 108: 8172-8176.
Satterfield, P.E., National Environmental Services Center. (2011). Oil and Gas Extraction and Source Water Protection. Tech Brief. Vol. 11, Issue 2. Retrieved from http://www.nesc.wvu.edu/pdf/DW/publications/ontap/tech_brief/TB54_OIlGasExtraction.pdf.
Sharma, S., Mulder, M.L., Sack, A., Schroeder, K., Hammack, R. (2014). Isotope Approach to Assess Hydrologic Connections during Marcellus Shale Drilling. *Groundwater,* 52(3):424-33.
Warner, N.R., Darrah, T.H., Jackson, R.B., Millot, R., Kloppmann, W., Vengosh, A. (2014). New Tracers Identify Hydraulic Fracturing Fluids and Accidental Releases from Oil and Gas Operations. *Environmental Science & Technology,* 48 (21), pp 12552–12560.
Zhang, L., Anderson, N., Dilmore, R., Soeder, D.J., Bromhal, G. (2014). Leakage Detection of Marcellus Shale Natural Gas at an Upper Devonian Gas Monitoring Well: A 3-D Numerical Modeling Approach. *Environmental Science & Technology,* 48(18):10795-803.

[21] Darrah, T.H., Vengosh, A., Jackson, R.B., Warner, N.R., Poreda, R.J. (2014). Noble Gases Identify the Mechanisms of Fugitive Gas Contamination in Drinking-Water Wells Overlying the Marcellus and Barnett Shales. *Proceedings of the National Academy of Sciences* (PNAS), 111(39):14076-81.

preliminary data suggest inadequate HVHF wastewater treatment could contribute to formation of disinfection byproducts in treated surface waters (e.g., Chang, 2001; Parker, 2014).[22] See Response to the Comments in NYC and Syracuse Watersheds; Other Public Drinking Supplies and 2,000-foot Buffer; Primary Aquifers and 500-foot Buffer; and Private Water Wells and 500-foot Buffer, all in Prohibited Locations. See Responses to the Comments in Water Resources and Setbacks, both in Potential Environmental Impacts and Mitigation. All of those responses to comments include a discussion of the importance of those resources and the potential significant environmental and health risks associated with HVHF.

Vengosh (2014) noted that treatment and disposal of HVHF solid waste and wastewater is a significant challenge. Gas wells can bring naturally occurring radioactive materials (NORM) to the surface in the cuttings, flowback water and production brine. NORM consists of uranium and thorium and their decay products. NORM in flowback and production brine can become concentrated on internal surfaces of pipes and tanks (scale). NORM in pipe scale contains predominantly radium. This can cause an external radiation exposure risk to workers who work with this equipment. See Responses to the Comments in Naturally Occurring Radioactive Materials in Geology and Waste Transport and Disposal in Potential Environmental Impacts and Mitigation.

Holland (2014) described one of the first observed cases in Oklahoma of earthquakes triggered by the hydraulic fracturing phase (rather than underground wastewater injection).[23] The earthquakes were large enough to be felt by local residents. In Maxwell's (2013) description of an approach to evaluating HVHF-related seismic events, criteria for confirming events, and existing injection and HVHF seismicity protocols, the author described several seismic events

[22] Chang, E.E., Lin, Y.P., Chiang, P.C. (2001). Effects of Bromide on the Formation of THMs and HAAs. *Chemosphere*. 43:1029-1034.
Parker, K.M., Zeng, T., Harkness, J., Vengosh, A., Mitch, W.A. (2014). Enhanced Formation of Disinfection Byproducts in Shale Gas Wastewater-Impacted Drinking Water Supplies. *Environmental Science & Technology,* 48(19):11161-9.

[23] Holland, A.A. (2014). Imaging Time Dependent Crustal Deformation Using GPS Geodesy and Induced Seismicity, Stress and Optimal Fault Orientations in the North American Mid-Continent. Graduate Thesis. University of Arizona. Retrieved from http://arizona.openrepository.com/arizona/handle/10150/332903.

ranging from low to moderate energy.[24] According to the author, during April and May of 2011 hydraulic fracturing near Preese Hall, United Kingdom, resulted in an event with magnitude ML=2.3 (local magnitude scale) and later another ML=1.5. The author added that, between 2009 and 2011, 38 earthquakes including a ML=3.8 resulted from hydraulic fracturing in the Horn River Basin shale gas reservoir in north-east British Columbia, Canada. Skoumal et al. (in press) documented seismicity associated with HVHF activities in Ohio.[25] The likelihood of HVHF seismic-induced earthquakes remains unclear, consequently predicting the extent of potential impacts – both surface and subsurface infrastructure damage – is difficult. See Response to the Comment in Seismicity in Geology.

Recognizing the current uncertainty with respect to the correlation between HVHF and public health impacts, the Department notes that there are continuing opportunities to amass more scientific information to better understand what the likely public health risks will be. NYSDOH currently participates in the national Environmental Public Health Tracking (EPHT) Program, which conducts routine surveillance of certain environmental hazards and health effects. NYSDOH also has many ongoing standard health outcome surveillance programs that could identify substantial changes in incidence rates of outcomes (e.g., reportable infectious diseases, asthma emergency-department visits) potentially associated with HVHF activity. If HVHF were to be established in New York, the Department through the NYSDOH could also develop other health surveillance tools intended to specifically document rates of potentially HVHF-related health outcomes such as injuries. The Department agrees with NYSDOH's conclusion that "until the science provides sufficient information to determine the level of risk to public health from HVHF to all New Yorkers and whether the risks can be adequately managed … HVHF should not proceed in New York State."

[24] Maxwell, S. (2013). Unintentional Seismicity Induced by Hydraulic Fracturing. Canadian Society for Exploration Geophysics. CSEG Recorder, 38:08. Retrieved from http://csegrecorder.com/articles/view/unintentional-seismicity-induced-by-hydraulic-fracturing.

[25] Skoumal, R., Brudzinski, M.R., and Currie, B.S. (in press). Earthquakes induced by hydraulic fracturing in Poland Township, Ohio. *Bulletin of the Seismological Society*.

8. Enforcement

Comment: The Department received various comments regarding general enforcement considerations, the majority of which raised concerns related to reclamation of well sites, remediation of impacts, monitoring, self-compliance, financial assurance, liability of well operators and landowners, staffing levels and resources for regulators, industry fees, planning requirements, penalties for violations, and the effect of noncompliance on permit issuance.

Some comments expressed concern that the Department has a conflict of interest in regulating the oil and gas industry, since it is charged with both advancing mineral rights development and protecting the environment. Others expressed concern about the Department's exercise of selective enforcement against the oil and gas industry, arguing that New York will fail to realize the benefits of this industry if the Department creates unjustified, excessive and inequitable rules and regulations that go beyond what is required of any other industry in New York State. This included claims of costs ranging from several hundred thousand dollars to $1 million per well. In contrast, comments stated that the Department is incapable of enforcing safe drilling procedures to assure adequate protection of human health and the environment.

A number of comments focused concerns on well pad reclamation as well as mitigation and remediation for areas affected by HVHF activity. Specifically, restoration objectives and planning should focus on restoring disturbed forests and wildlife habitats. Some comments requested that operators attempt to restore the well area, access roads and pipeline corridors 20-40 years from now. Others provided estimates of costs associated with the remediation of specific sites or claimed that cleaning up pollution, including chemical contamination of the water, would outpace any revenue generated by HVHF. Another comment urged the Department to consider the use of environmental mitigation, compensatory mitigation, or mitigation banking.

Several comments requested the inclusion of more independent monitoring oversight, with requests ranging from the establishment of a HVHF monitoring and mitigation unit within the Department to requiring performance bonds for independent environmental monitors or mandating citizen access and monitoring at all sites, with monitoring costs to be borne by the industry for some timeframe after cessation of active drilling (e.g., 30 years, 100 years, unspecified). In this respect, the comments asserted that monitoring should not just occur to determine 'baseline' conditions, but also to identify aggregate human or environmental impacts and measure the effectiveness of mitigation strategies.

Comments further asserted that Department staff must be on location at all times while drilling or hydraulic fracturing operations are taking place or that site inspections must occur daily, while others called for State authority to conduct unannounced inspections, regular sample collection, questioning of workers and inspection of records. Another comment urged the Department to establish a mechanism to accept complaints from other government agencies, not-for-profits and citizens.

A number of comments projected potential negative environmental impacts or pointed out uncertain or uncharacterized risks associated with such impacts to argue that effective regulation and enforcement would be difficult or impossible. In contrast, some comments expressed concern at the lack of statistical analysis of HVHF failures, comparison of estimated failures with proposed mitigations, and/or estimates of short- and long-term cleanup costs. Similarly, comments requested that the SGEIS include a tabulation of the average number of active construction projects each year in New York State, the number of sites inspected by the Department and the number of violations. Others used various estimates or assumptions to express concerns about liability for and recovery of cleanup costs, including the following projection: if there were approximately 80,000 new gas wells in NY and if incidents resulting in significant environmental impacts occurred in 1 out of every 150 wells, there would be about 533 such incidents in NY.

Various comments were directed at self-compliance requirements for operators. One such comment called for operators to self-inspect their operations and certify compliance. In contrast, other commenters raised concerns that the system of self-compliance proposed in the SGEIS would not provide satisfactory oversight. Some comments noted that the Department failed to specify that monitoring, investigative or testing activities be performed by either the Department or an independent testing agency. Other comments urged the Department to require the presence of Department personnel at all Pre-Fracturing checks to ensure accountability. In addition, it was recommended that there be a time-frame for reporting spills and inspection results, which should be made available to the public.

Numerous comments called for operators and/or landowners to deposit funds into an escrow account, obtain insurance policies and/or post bonds of various amounts for a number of years to address a host of concerns, including remediation, reclamation, pollution, earthquake damage, health impacts, demolition, injuries to landowners, and monitoring. Comments regarding insurance policies, bonding and other financial assurances ranged from general requests for coverage for any potential environmental or health impact to specific requests, including coverage for public health impacts that result from hydraulic fracturing, reimbursement for HVHF-related contamination, particular bonding requirements for HVHF in the New York City watershed, impacts to Pennsylvania and New Jersey property owners, and clean water for municipalities whose water supplies may be impacted by hydraulic fracturing contaminants.

Several comments expressed concern that the $5,000 cap on bonding for shallow wells less than 6,000 feet in depth should be raised. In contrast, others argued that the financial security requirements far outweigh the probable restitution costs and put undue financial burden and hardship on the industry. A number of comments also sought specific protection for lessors, including a requirement that drilling companies indemnify and/or provide insurance protection to lessors for all risks of harm, both to property and person, related to fracturing on the leasehold or within a specified distance of the leasehold borders.

The Department also received various comments raising concerns about operator and/or landowner liability. Many focused on potential water contamination, asserting that a company responsible for water contamination should be required to provide an alternate source of drinking water to affected residents and remediate such contamination. Others proposed that drilling companies, transportation companies and/or their executive management should be liable for all impacts, including the following: industrial waste treatment; negative impacts to animals; infrastructure damage; air, water and land pollution; toxic spills and emissions; earthquake damage; and health needs and deaths of residents; punishment of which should include criminal sanctions and/or appropriate fines. In addition, some comments suggested that the Department should be held liable for losses caused by HVHF operations.

Several comments expressed concern that oil and gas companies will use their extensive financial and legal resources to fight responsibility, bankrupting communities and requiring the expenditure of tax revenue to pay for monitoring, investigations and remedial measures. Those comments suggested that strict liability against the operator should be imposed for cleaning up drilling pollution hazards, with the burden of proof placed on gas companies to rebut an assumption that gas drilling has caused of problems that occur after the commencement of drilling. Comments were also directed at subcontractors for gas companies, arguing that gas companies should be held jointly responsible for subcontractor violations.

Numerous comments called for increased fees or funding to both state and local governments for dedicated enforcement, remedial and/or monitoring programs. These included suggestions that the State set up a dedicated, industry-financed fund or tax, similar to the existing Oil Spill Fund and similar funds in other states, to increase fees, issue a tax, and/or levy fines to provide monies for new staff, cover enforcement, remediate road damage, pay for water rights, undertake future repairs, provide funds for renewable energy development, and/or cover damage to the environment and public health. Several comments argued that a full-time Department employee should be assigned to every drill site, while others suggested that the Department should hire contractors or third-party inspectors and/or delegate field inspections to Soil and Water Conservation District staff. In contrast, a number of comments asserted that the Department is adequately funded, staffed and motivated to ensure adequate regulation of HVHF or that HVHF will generate millions of dollars for the economy which will, in turn, generate enough funds for the Department to hire necessary staff to provide adequate oversight and enforcement.

Some comments specified that funds should be provided to specifically mitigate the impacts of gas drilling related to forest fragmentation, the degradation of streams and wetlands, and for public water protection. Others argued that the industry should finance a fund to protect affected landowners and the general public at large from significant impacts.

A number of comments suggested the inclusion of specific planning criteria and disclosure requirements in the SGEIS, including requirements for disclosure of development plans for planning and bonding for bridge and roadway use, emergency plans, plans to replace contaminated drinking water supplies, and plans to identify and protect existing natural resource hubs, buffers around such hubs and corridors of unbroken forest/natural habitat. For local planning purposes, any town or county should have the benefit of a fully-funded land use plan developed prior to drilling.

The Department received several comments concerned about impacts on local governments and communities. General concerns were focused towards the need for stringent regulation and oversight over the industry, as inadequate funding for remediation, cleanup, enforcement and other costs would place these costs on local communities and local communities and governments do not have the resources for enforcement. Others argued for local funding and asserted that municipalities should have the right to enforce local laws such as noise ordinances and to levy and require adequate performance bonds to assure against potential significant impacts.

Comments argued that the Department must have an enforcement plan that includes civil and criminal penalties and that the current language is too vague or "lacks teeth." Various comments argued for strict regulation of HVHF and enhanced penalties. These included calls for specific penalties/fines for environmental degradation, watershed or well contamination, spills, and other violations.

Other comments pointed to low rates of penalty assessment for violations in other States such as Texas and Wyoming to suggest that the Department put into place mechanisms to ensure penalties are sought in a significant number of cases. In addition, the Department should maintain a publicly-accessible database containing complaints and violations to allow for tracking, including the imposition of any penalties.

Several comments expressed concern about the issuance of permits to operators with a past history of environmental non-compliance, including non-compliance in jurisdictions outside of New York State. Similarly, a number argued that operations should be suspended (period unstated or 10 years) or a lifetime ban imposed for companies that commit significant or serious violations. Other comments suggested that, based on recent history, operators will dispense unproductive wells to smaller operators or self-funds "shell" corporations, complicating monitoring and enforcement. Corresponding questions were posed as to who would be responsible for cleanup costs in the event that an operator goes bankrupt.

Response: The Department recognizes that if HVHF were authorized, effective enforcement would be necessary to ensure compliance with the conditions and measures outlined in the SGEIS, and any associated permits or regulations and that it would require the expenditure of significant costs to properly institute this program.

Article 23 of the ECL specifically provides the Department with the power to regulate drilling, casing, operation, plugging, replugging and posting of financial security for wells and the reclamation of surrounding land. While carrying out these responsibilities, the Department acknowledges that it must do so in a manner that fulfills its overarching policy to conserve, improve and protect the state's natural resources and environment and control water, land and air pollution through appropriate controls on the oil and gas industry.

The numerous mitigation measures proposed in the SGEIS, and additional mitigation measures further considered, represent the Department's best professional judgment to reduce risks to the environment and public health. The Department concedes that many of these measures would influence the location of wells and also necessarily limit the number of wells drilled, thereby likely reducing the potential economic benefits of HVHF in New York. However, these measures represent, at a minimum, the Department's best estimation of what mitigation would be necessary should HVHF proceed in New York.

The Department concedes that there are significant costs and other hurdles associated with administering such a complex program. The Department recognizes that the oversight of HVHF would require a substantial increase in state and local resources which could be a limiting factor on the rate of development of proposals for HVHF. Current staffing levels are well below staffing levels in place during peak development of the Trenton-Black River play. At that time the Department could process, permit and inspect several hundred wells annually. Given the amount of detailed technical information that would be required for HVHF, it would take substantially longer to process, coordinate the environmental review, evaluate baseline and ongoing monitoring, prepare for and respond to spills, permit and inspect a well for HVHF compared to a well drilled in the Trenton-Black River formation. Consequently, significant costs would be associated with administering the program, including the need for additional staff and resources to ensure compliance and an adequate level of enforcement. Indeed, the Department estimates that its cost of administering this program under the average development scenario would grow from approximately $14 million in the first year to nearly $25 million in the fifth year. These costs do not consider other substantial costs that would be incurred by other state and local agencies. Furthermore, because the allocation of Department resources, including the use of an industry-financed fund or issuance of a tax to pay for new staff, cover enforcement, remediate road damage, undertake future repairs and cover environmental damage, is outside the scope of the SGEIS, as it would require legislative action, there is uncertainty as to how the Department would effectively fund and administer this complex program. However, if HVHF were authorized, the Department would only permit the number of wells annually that funding will allow to be properly reviewed and monitored. Existing enforcement resources would also likely be reallocated to address additional enforcement responsibilities.

The concerns expressed by those comments requesting independent monitor personnel to oversee cleanup and remediation and for the Department to create a new hydraulic fracturing mitigation unit are also outside the scope of the SGEIS because they would require legislative action. The Department does not have authority to mandate public access to privately-owned land to allow for citizen monitoring. The Department, however, maintains the right to conduct on-site inspections and, further, can respond to citizens' complaints, as well as any information or complaints received from other agencies, concerning any activity occurring in the State that the citizen believes is in contravention of the ECL, the Department's regulations, and/or Department-issued permits. However, if HVHF is authorized, the SGEIS would require monitoring, allow for unannounced inspections and contain conditions that would serve to reduce environmental impacts. See Response to the Comment in Water Resources in Potential Environmental Impacts and Mitigation regarding groundwater monitoring. Moreover, a well operator's failure to adhere to conditions of a drilling permit, including failure to perform required well-testing procedures, would constitute a violation of ECL Article 23.

In addition to Department oversight and inspection, in many instances operators are required to self-inspect and certify compliance. Well operators would be required to complete a Pre-Frac

Checklist and Certification at least three days before commencing hydraulic fracturing. The SGEIS would also require that any non-routine incident of potential environmental or public safety significance, including spills, be verbally reported to the Department within two hours of when the operator knew or should have known of the incident. The operator would also be required to submit a written report of the incident within 24 hours after discovery. Reports of spills and inspection results are documents that can be made available to the public, subject to the Freedom of Information Law (FOIL). Furthermore, failure of a well operator to adhere to conditions of the permit would be considered a violation of ECL Article 23, and the failure of an operator to follow the SPDES regulations would be enforced pursuant to ECL § 71-1929. The Department currently tracks complaints and violations for possible enforcement action, including those related to conventional oil and gas operations, and would do so for HVHF activities. To the extent legally permissible, the Department's record keeping is made available to the public pursuant to FOIL.

The SGEIS would require operators to cease any activity contributing or suspected to be contributing to a non-routine incident. Penalties and other relief would be pursued for violations of this provision of law, when appropriate. In accordance with 6 NYCRR 550.6, any falsification of the information disclosed to the Department by the industry would be punishable by fine and/or imprisonment and would be subject to such civil and criminal penalties as are provided by law. See response to Comment in Fracturing Fluid in Potential Environmental Impacts and Mitigation. There are also penalties associated with falsifying records and submissions associated with SPDES permits (6 NYCRR 750-2.4), which would be required for all HVHF well pads.

The Department would have authority to inspect operations and enforce permit conditions and, if this activity were to go forward, would visit and inspect HVHF operations on a regular basis as it deems appropriate. In addition, although well operators are required to conduct their own evaluation of well operations and report various incidents and events, the conditions and requirements contained in the SGEIS are enforced by the Department, not the operators. With respect to enforcement, the Department notes, just as with any program, those responsible for causing environmental damage would be held accountable through various enforcement mechanisms described in the SGEIS.

Moreover, while the Department has the ability to conduct inspections and enforce permit conditions, it lacks authority to assess new fees or increase maximum fines because fees and fines are specified in statute. In this respect, the Department recognizes that there is the potential, as with any regulated activity, that sanctions and penalties may not adequately address the damages caused by a spill or other permit violation In any case, significant administrative, civil and criminal penalties are available to address violations of Articles 17 and 23 depending on the nature of the violation, including civil penalties of up to $37,500 per day for each violation of ECL § 71-1929 (Article 17 violations (SPDES)) and criminal sanctions pursuant Article 71 of the ECL and the penal law. To the extent that a violator does not pay fines or penalties specified in an agreement or a Department Order, the Department can seek to collect additional fines and penalties through a judgment in an administrative proceeding or judicial proceeding through referral to the Attorney General's Office. Pursuant to the Department's Civil Penalty Policy (DEE-1), the Department also has authority to calculate and recover the economic benefit of non-compliance and authority to revoke permits issued under Articles 17 and 23 for violations of laws, regulations, or permit conditions.

Similarly, those comments seeking specific protections such as indemnification or insurance coverage for lessors are outside the scope of the SGEIS because they would require legislative action. However, if HVHF were authorized, the Department would provide guidance to landowners, lenders, insurers and other individuals navigating property interests within the oil and gas context. See Response to Comment in Socioeconomic in Potential Environmental Impacts and Mitigation.

Nor does current law does authorize the Department to mandate that operators pay into an escrow account or fund, obtain insurance coverage or post bonds to address remediation, pollution and monitoring. The Department, however, does have authority to compel reclamation and recoup environmental damages caused by operators through enforcement, as described in the SGEIS.

ECL Article 23 specifies that financial security requirements for deep wells be set in rules and regulations promulgated by the Department. ECL § 23-0305, and the Department's corresponding regulation, Part 551, require that the operator continuously maintain financial security until the well giving rise to the financial security has been plugged and abandoned to the satisfaction of the Department. Existing regulations cap financial security for plugging and abandoning of wells greater than 6,000 feet in depth at $250,000 for individual wells and $2 million for multiple wells. The Department proposed regulations that would have removed the cap and required operators to post financial security in an amount that reflects the true costs of plugging a deep well. But here too, the lapse of these draft regulations creates significant uncertainty regarding permit issuance, and would limit the amount of financial security regardless of the true cost of plugging the well. The Department agrees that the existing financial security requirements are uncertain.

Regarding comments expressing concern about operators going bankrupt or transferring unproductive wells to smaller operators or shell business entities including the use of LLCs and LLPs, the Department can seek collection of penalties, fines and other liabilities through administrative enforcement proceedings or judicial proceedings, generally through referral to the Attorney General's Office.

Regarding those comments pertaining to the use of New York Environmental Protection and Spill Compensation Fund (Spill Fund) monies, pursuant to Article 12 of the Navigation Law, the Department can use the Spill Fund to clean up releases of petroleum. In such cases, the Department typically attempts to compel responsible parties to pay for remediation costs, but if a discharger is unable or unwilling to pay, the Department can use the Spill Fund to finance clean ups and later sue for recovery of those costs. However, with respect to oil and gas drilling, the Department can only use the Spill Fund to clean up petroleum spills, and therefore, the fund could not be used for emergency measures or the cleanup of spills involving fracturing fluid, chemicals, brine water or flowback water, which constitute significant potential risks for HVHF activities.

To the extent that comments suggest the use of alternative mitigation approaches, such as mitigation banking, which are beyond the Department's regulatory authority, they are outside the scope of the SGEIS. However, the SGEIS provides numerous mitigation measures designed to reduce potential significant adverse impacts on water resources, freshwater wetlands, ecosystems, visual resources, community character resources, historic resources and wildlife.

The Department can compel reclamation and recoup environmental damages caused by operators through enforcement. Regarding those comments specifically directed at restoring forested areas and wildlife habitats, see response to comment in Ecosystems and Wildlife in Potential Environmental Impacts and Mitigation. In the case of a spill or other non-routine contamination event, the Department would use all available financial, technical, and legal resources to remedy such a situation, subject to the limitations discussed above.

With respect to concerns expressed regarding the reclamation of well pads and other affected areas, operators are required to replug wells if the Department finds that plugging and abandonment of the well is not in compliance with Departmental regulations. ECL § 23-0305(8)(e) specifies that primary liability for the expense of such plugging or replugging shall fall on the operator unless a relevant contract places such liability on the owner of another interest in the land on which the well is situated. Furthermore, if HVHF were authorized, the Department would impose permit conditions requiring the operator to reclaim the site in accordance with a plan submitted for Department approval. The Department recognizes that in reintroducing forest to a cleared area it can take many years to return the forest to its previous natural state.

The concern expressed regarding the reclamation of pipelines and associated infrastructure is outside the scope of the SGEIS. However, for a general discussion regarding the construction and siting of pipelines, see response to Comment in Other (Pipelines). The Department notes that gathering lines that would necessarily accompany HVHF if it were allowed to proceed, have the potential to cause significant adverse environmental impact on resources, such as wildlife habitat.

The Department also considered but rejected the use of compensatory mitigation to address residual risks associated with widespread HVHF in certain regions within the Marcellus formation. The Department does not have detailed regulatory provisions which dictate the amount or type of compensatory mitigation required to support ECL Article 23 well permits. Nevertheless, pursuant to SEQRA the Department is required to take a hard look at HVHF and consider whether adverse impacts can be minimized to the maximum extent practicable by incorporating mitigation measures. Because the impacts associated with HVHF are cumulative and widespread and the risks are highly uncertain, the Department concluded that it could not properly evaluate the adequacy of compensatory mitigation.

The Department has considered additional mitigation measures including a requirement that the operator, at its own expense, collect baseline private water well data and groundwater data after drilling has commenced, in order to ensure effective enforcement. Additionally, if HVHF were authorized, in the case of a spill or other unforeseen event, additional environmental data would be collected as soon as possible to aid the Department in an enforcement matter.

Regarding water withdrawals, the water withdrawal law allows the Department to regulate water withdrawals over 100,000 gpd through a permitting program. Violations of permit conditions would be violations of Article 15 of the ECL, resulting in enforcement with penalties. All approved withdrawals would be conditioned to require any necessary stream flow measurement and monitoring if HVHF were authorized. See also response to Comment in Water Resources in Potential Environmental Impacts and Mitigation.

Regarding the comments projecting a failure rate or number of incidents, any analysis trying to predict spills or other non-routine incidents would be subjective. However, the Department notes that many of the mitigation measures proposed, specifically buffers and prohibitions recognize that there is a risk of engineering control failures and resulting spills that could have significant adverse impacts. Specifically, although proposed enhanced mitigation measures, including secondary containment, buffers and setbacks, and emergency response procedures, would serve to reduce significant impacts, an assessment of the risk to the environment and public health must be supported by adequate scientific information to determine with confidence that the overall risk is sufficiently low to justify proceeding with HVHF in New York. See Responses to the Comments in General Prohibitions in Prohibited Locations and Setbacks in Potential Environmental Impacts and Mitigation, as well as the Response to the Comment in Health Impacts.

Funding of local government is outside the scope of the SGEIS. As pointed out above, local governments would bear significant costs associated with providing local services, such as emergency response, if HVHF were authorized. With respect to concern that local governments should be able to levy or require performance bonds for well casing failures, as discussed in the SGEIS, local governments have jurisdiction over local roads and the right to collect real property taxes, while the State regulates and enforces oil and gas development activities. See response in Local Government Notification and Coordination in Permit Process and Regulatory Coordination.

The Department considered various mitigation measures including the development of local transportation plans and encouraging municipalities to enter into Road Use agreements with operators to reduce impacts from truck traffic, which could often address infrastructure costs. Additionally, the Department considered requiring operators have an Emergency Response Plan (ERP) in place to address and correct any environmental damage created by unanticipated events. The procedures outlined in an ERP are intended to provide for the protection of lives, property, and natural resources through advance planning and the use of company and community assets. These measures, however, are untested in this setting and it is unclear whether they would adequately account for the potential local costs associated with HVHF activities.

Regarding concerns that any wastewater disposal plan should be enforceable, the SGEIS lists several disposal options for HVHF wastewater. However, it should be noted that there are no currently permitted disposal facilities for HVHF wastewater in New York, and no pending applications. In addition, the SGEIS makes clear that no permit would be issued without an approved fluid disposal plan specifying how the HVHF wastewater would be disposed of or treated. To the extent that an operator fails to comply with its approved fluid disposal plan, the operator would be subject to enforcement. The Department notes that because there are no currently permitted wastewater disposal options in New York there is a degree of uncertainty as to whether proper waste disposal would be possible if HVHF were authorized. See Response to Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation.

Regarding the enforcement of light and pollution standards, if HVHF were authorized, the SGEIS would require the submission of a visual and noise mitigation plan prior to the issuance of a drilling permit. Furthermore, the requirements set forth in these plans would be enforceable permit conditions. Failure of a well operator to adhere to conditions of the permit would be considered a violation of ECL Article 23, subject to enforcement. See Responses to the Comment in Visual Resources and Noise, both in Potential Environmental Impacts and Mitigation.

Finally, if HVHF were authorized, the Department agrees that an operator's past record of compliance with environmental laws, regulations and permits should be a factor for issuance of well permits authorizing HVHF and would consider an operator's previous environmental compliance record when making determinations on permit applications. If a reasonable basis exists for denying a permit application based on an operator's previous environmental compliance, the Department can deny such applications. Furthermore, 6 NYCRR Part 551 requires the operator to file with the Department a number of reports, including an organizational report, production and purchase reports, completion report, gas-oil ratio report, non-routine incident report, plugging report and secondary recovery and pressure maintenance reports, all of which aid the Department in its oversight and enforcement responsibilities.

9. Other

Beyond the eight broad categories above, the Department received numerous comments on other topics. Those comments are addressed below and consist of the following subcategories: Other States' Regulations; Incidents in New York and Other States; Compulsory Integration; Leases; Alternative Energy; and Pipelines and Compressor Stations.

Other States' Regulations

Comment: The Department received a number of comments regarding the regulation of HVHF in other states. Comments ranged from general claims that the Department has failed to meet its commitment to properly and adequately evaluate the effectiveness of other states' regulations to requests that New York adopt or implement specific regulatory controls employed by other states. In addition, a number of comments argued that regulation in other jurisdictions, such as Pennsylvania, has been ineffective and that the measures proposed in the SGEIS are no different than those in other states.

Several comments requested that New York review and adopt relevant various restrictions or controls required by other states. By way of referencing requirements in other states, these comments argued that New York's regulatory framework should include the following: (1) enhanced or additional setbacks (TX); (2) prohibition of the acceptance of HVHF waste water by wastewater treatment plants (PA); (3) chemical disclosure rules (TX, CO, AK, WY); and (4) the authorization of local regulation of mining operations including setbacks, buffers and hours of operation. In addition, several comments described earthquakes induced by HVHF which led to new regulations in Ohio. Others advised that interstate and/or international regulations or standards apply to the discharge of flowback into interjurisdictional waterways such as the Niagara River, an international boundary water. Questions were also posed regarding the number and length of leases in Pennsylvania.

Response: The Department respectfully disagrees with concerns that the Department has failed to properly or adequately evaluate regulations in other states. The mitigation requirements proposed in the SGEIS, and considered in response to public comments, reflect full consideration of other states' approaches. Moreover, Chapter 10 of the SGEIS assesses selected incidents in Pennsylvania. In order to avoid similar occurrences, this Response to Comments and the SGEIS as a whole describe numerous mitigation requirements that would be required in New York or have been considered as mitigation measures for use if HVHF were authorized.

Specifically, the Department accepts that due diligence, including aggressive regulatory oversight, is critical to guard against surface spills, leaks and the migration of methane and other potential contaminants due to inadequately constructed and cased wells. There must be requirements relating to water withdrawal, well siting, well construction and drilling, stormwater pollution prevention, fluid management, air emissions, greenhouse gas mitigation and habitat protection. If HVHF were authorized, the proposed program would also afford the flexibility to incorporate new approaches when warranted.

Regarding the concern expressed about land use controls, including the use of enhanced and additional setbacks, the SGEIS does provide minimum setbacks from environmentally sensitive resources. However, determining the adequacy of a setback on a generic basis for this particular state-wide activity is problematic, and further complicating that determination is the uncertainty and inability to quantify what the ultimate impact of a spill would be to a particular resource or public health. The Department recognizes the concern expressed regarding the disposal of flowback water in Pennsylvania. The Pennsylvania DEP required Marcellus Shale drillers to cease taking wastewater to facilities that do not remove dissolved salts such as bromide by May 19, 2011. DEP promulgated Chapter 95 regulations to address the remaining treatment facilities which are intended to address the potential cumulative impact of oil and gas wastewater discharges by limiting the discharge of TDS from new or expanded facilities that take oil and gas wastewater to drinking water standards (which will also reduce radium), increasing the use of recycled water, and promoting alternative forms of disposal. Like Pennsylvania, the Department recognizes that there are a number of potential environmental and health impacts that may be associated with the disposal of HVHF wastewater. Currently, there are no approved disposal facilities for HVHF wastewater in New York State. Additionally, flowback water and production brine from HVHF (HVHF wastewater) may include a diverse mixture of residual hydraulic fracturing chemicals and naturally-occurring constituents from the rock formation, such as high concentrations of total dissolved solids (TDS) and Naturally Occurring Radioactive Materials (NORM). See Response to Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation.

With respect to concerns regarding chemical disclosure, constituent level reporting would address the concern that the identity of products or chemicals used at a well site would be unknown to either emergency personnel or to regulatory agencies, such as the Department, who must approve of actions under SEQRA or respond to spills. Therefore, in recognizing concerns expressed by the public with respect to chemicals used in the HVHF process, the Department considered expanding the fracturing fluid chemical disclosure requirements beyond the MSDS-level approach described in the SGEIS to ensure that each chemical constituent, and not merely each product, is disclosed both before drilling and after completion of each well. Under the considered approach to chemical disclosure, the public would have access to CAS-Number level disclosure for all chemicals actually used in a given hydraulic fracturing operation, with the exception of those appropriately justified as trade secrets as determined by the Department. Department staff would have access to full chemical disclosure of the proposed and “as injected” chemical-makeup at the CAS Number level, including any trade secret information. See

Response to Comment in Hydraulic Fracturing Information in Permit Process and Regulatory Coordination.

In response to the several submissions describing earthquakes in Ohio, the Department is aware that on December 31, 2011, the Governor of Ohio placed an indefinite moratorium only on the use of three drilled deep injection wells and one well with a permit pending in the Youngstown area. The affected operation was brine disposal, not HVHF. The Ohio Department of Natural Resources (ODNR) March 2012 "Preliminary Report on the Northstar 1 Class II Injection Well and the Seismic Events in the Youngstown, Ohio Area" explains the circumstances and actions that ODNR is taking to address concerns related to disposal wells and induced seismic activity in Ohio. The Department notes that more recent seismic events in Ohio were linked to the completion of one HVHF well. See response to Comment in *Seismicity* in Geology.

Regarding the suggestions arguing for greater local control over HVHF, the status of local control over oil and natural gas operations is governed by statute and is outside the scope of the SGEIS. See Response to Comment in Community Character in Potential Environmental Impacts and Mitigation. Furthermore, lease terms in either Pennsylvania or New York are also outside the scope of the SGEIS. The Department does not regulate private leasing nor compile information regarding private leases. However, see "Natural Gas Exploration – A Landowners Guide to Leasing Land in Pennsylvania," a publication of the Penn State Cooperative Extension. Similar information can be found on the Department's website at http://www.dec.ny.gov/energy/1553.html.

As to interjurisdictional discharge considerations, 6 NYCRR 750-1.3(f) states that a discharge is prohibited into the waters of the State of New York "(f) [w]hen the imposition of conditions cannot ensure compliance with the applicable water quality requirements of all affected States." This same concept is reflected in federal regulation. 40 CFR 122.4(d). Related to interstate regulations, 6 NYCRR 750-2 states "(d) [i]f the discharge(s) permitted in a SPDES permit originate(s) within the jurisdiction of an interstate water pollution control agency, then the permitted discharge(s) must also comply with any applicable effluent standards or water quality standards promulgated by that interstate agency and as set forth in the permit for such discharge(s)." See also "Other Jurisdictions - Great Lakes-St. Lawrence River Basin Water

Resources Compact," in the SGEIS, which includes references to Canada, and response to Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation.

Incidents in NY and Other States

Comment: Many commenters were concerned that shale drilling in the Marcellus or other shale formations under current technologies could result in incidents such as accidents, spills, failed pipe or casings and illegal waste dumping, and that these incidents could cause negative environmental and health consequences and have fiscal impacts on state and local governments. Commenters questioned whether local authorities would be prepared to handle the wide variety of responsibilities for monitoring and tracking accidents as well as whether local police, firefighters and healthcare institutions would be prepared to adequately respond to emergencies.

Commenters cited previous incidents in New York and in other states to support their concerns. Examples of incidents the Department was specifically asked to address include:

- Acceptance and discharge by a sanitary wastewater treatment plant of more than three million gallons of gas drilling wastewater, which the commenter stated occurred without a state-required headworks analysis or enforcement of local pretreatment requirements;
- Spill information released in 2009 and 2010 that identified incidents involving drill rig fires, homes evacuated due to gas drilling hazards, gas drilling wastewater sills, and concerns about pollution to water supply wells;
- Incidents in Brookfield and Freedom where gas drilling operations were said to have had an impact on water wells;
- A Chautauqua County Department of Health report indicating that three homeowners had alleged that methane contamination of private wells from gas well drilling had occurred in the Town of Poland;
- An incident of drinking water impact (turbidity) that occurred in the Spring of 2009, when a well was drilled near a home in Allegany County;
- Alleged water well contamination after a gas well was drilled 300 feet from a home near Jamestown;
- Alleged road damage in the village of Smyrna as a result of traffic associated with gas drilling activity;

- Nitrogen-fracturing of a Marcellus Shale well in the Town of Maryland, New York, that allegedly resulted in a turpentine-like smell and headaches, nausea, burning throat and dizziness; and
- Collapse of the Retsof salt mine in 1994.

Other comments noted that less than one percent of all documented spills over the last 30 years have been related to oil and gas drilling. Some comments pointed out that most of the reported oil and gas issues are the result of naturally occurring gas-seeps from shallow rock formations and some are related to utility work or home leaks. Officials from Chautauqua, Cattaraugus, and Allegany Counties commented that there has been no water contamination as a result of hydraulic fracturing and gas well drilling.

Response: Chapter 10 of the SGEIS provides a review of selected non-routine incidents that occurred in Pennsylvania, and the measures that have been or were considered for implementation in New York State to attempt to avoid these types of accidents. The Department's existing regulatory program and the SGEIS are designed to reduce or prevent the occurrence of such incidents and, if HVHF were authorized, the Department would continue to adhere to its protocol with local county health departments in the investigation of complaints about water supplies, including those that well owners believe are attributable to oil and gas operations. The Department notes that while it has proposed and considered measures to reduce risks, the potential exists that spills or other failures associated with HVHF, arising from drilling activity, material storage, and truck transportation, may occur.

The gas migration incidents that occurred in Susquehanna and Bradford Counties, Pennsylvania, resulted from inadequate construction of the vertical wellbore, which was first addressed in New York in the 1980s. Construction of a vertical wellbore, potential impacts, and mitigation of those impacts are the same, regardless of whether or not the well will subsequently be drilled horizontally and stimulated by HVHF in the target formation (after the vertical wellbore is cased and cemented). Indeed, the SGEIS proposed casing and cementing requirements, consistent with existing well drilling practices. As discussed in Response to Comment in Well Construction in Potential Environmental Impacts and Mitigation,, there are circumstances in which the casing and wellbore can be compromised, either for engineering control failures or from potential induced seismic activity from the drilling of HVHF wells. Thus, in the event that these wellbores are compromised there is an increased risk of fluid migration. "Studies have found evidence for underground migration of methane associated with faulty well construction." Public Health Review

The following discussion is offered in response to the examples of specific New York incidents presented in the summary of concerns.

New York State has TDS standards for discharges to surface water, including discharges from sanitary wastewater treatment plants, and the SGEIS describes the permitting and approval process for such discharges. The Department is aware that POTWs in the State of New York have previously received wastewater from conventional wells. In December 2008, the Department sent a letter to all POTWs to remind them that they cannot accept any drilling wastewater without approval from the Department. Subsequently, the Department has followed up by providing reminders to POTWs during Department inspections. Currently, the Department is not aware of any POTWs in the State of New York that are continuing to accept wastewater from conventional wells. There are no applications with the Department for any wastewater treatment facility to accept wastewater from HVHF operations. See Response to Comment in Waste Transport and Disposal in Potential Environmental Impacts and Mitigation.

The 2009 and 2010 information described incidents of known or suspected methane migration, water well contamination and surface spills or releases, all of which are acknowledged and addressed as concerns by the Department in the SGEIS and the 1992 GEIS. Most of the reported incidents pre-date the 1992 GEIS and many of them were found to be unrelated to oil and gas drilling. Those that may have been related to drilling were investigated and addressed by the Department. The 1988 draft GEIS provided mitigation measures to address the types of incidents that had been reported prior to that time. These measures have led to fewer incidents since 1988. In this regard, the SGEIS has built upon these measures to reduce the risk of methane migration, water well contamination and surface spills or releases. However, there are two notable incidents that occurred after 1988, as described below.

The Brookfield incident in 2007 specifically, occurred as a result of compressed air intrusion into the aquifer during drilling (the drill bit was stuck and the operator used compressed air in an attempt to free the bit). The compressed air migrated through natural fractures in the shallow bedrock because the well had not yet been drilled to the permitted surface casing seat depth, causing turbidity in nearby water wells. See discussion of the incident in Chapter 2 of the SGEIS. Division of Mineral Resources staff was deployed to the site and the Department shut down the operation. The operator supplied water and food to the affected parties for a substantial period of time and installed filtration systems on some water wells to address the turbidity effects. The Department ordered the well plugged. This event, although it had nothing to do with HVHF activities, demonstrates that despite robust engineering controls, operators may still make mistakes.

The event in the Town of Freedom in 1996 was an underground blowout of natural gas that affected the local community over a period of hours. The well bore became pressurized when a strong gas flow was encountered underground, causing methane migration that affected properties approximately one and a half miles away. Methane detected in the shallow subsurface for a few days after the event, including in residential water wells and a pond, resulted in the evacuation of 12 families from their homes. The well was brought under control and the homes, wells and lands have since returned to the conditions that existed before the well was drilled. In 2005, the Cattaraugus County Supreme Court awarded damages to the affected individuals. Again, the Department concedes that despite engineering control measures incidents can occur that result in significant adverse environmental impacts.

Regarding methane found in three wells in the Town of Poland, Chautauqua County, the private water wells were found to contain methane, but affected landowners refused to provide the well operator with access to the water wells for sample collection in order to test the gas to determine whether the source was naturally occurring Upper Devonian Shale methane or natural gas from the GEIS-consistent hydraulically fractured (low volume treatment) Medina formation found approximately 4,500 feet below the surface. The private water wells were drilled into the gas-bearing Upper Devonian Shale. Because of this refusal of access the Department cannot determine if the methane was a result of the hydraulically fractured well.

The incident at the home in Allegany County involved a shallow oil well that was not stimulated by HVHF. Inspections confirmed that the water supply was cloudy on different occasions, although several tests failed to detect the presence of methane, ethane, or petroleum hydrocarbons. When a well of any type is drilled into a rock aquifer, water in the aquifer that is near the wellbore may become turbid due to the pulverization of rock by drilling. Such a disturbance of a rock aquifer was the likely cause of cloudiness in the homeowner's water.

As to the comment regarding the well in Jamestown, water sampling conducted during the Department's investigation indicated high levels of TDS, sodium and chlorides were present in the water wells surrounding the property prior to drilling of the gas well. The Department's inspections and records suggest that the gas well was constructed properly and that waste fluids were hauled off-site for disposal at a facility in Pennsylvania. The Department has concluded, based upon water test data, inspections and investigations, that the highly mineralized water produced from the water well was not related to drilling or hydraulic fracturing operations.

As a result of road impacts caused by drilling operations, the operator of the active gas well in the Town of Smyrna made payments to the Town to repair affected roads.

Regarding the event in the Town of Maryland, the well was hydraulically fractured with a GEIS-consistent treatment in the Utica Shale (2009) and subsequently in the Marcellus Shale (2010). Nitrogen was pumped downhole for fracturing the shale, but not otherwise discharged into the environment. Since nitrogen is an odorless gas, it could not have created a turpentine-like smell.

With respect to the question of a relationship between hydraulic fracturing and the Retsof mine incident, salt mining is not analogous to HVHF of shale formations. Hydraulic fracturing is a well stimulation technique which consists of pumping an engineered fluid system and a proppant such as sand down a wellbore under high pressure to create fractures in the hydrocarbon-bearing rock. The collapse at the Retsof salt mine was due to the use of yielding pillars in an area in which overlying bedrock layers had been deeply scoured by glaciers, thereby reducing the structural integrity of the layer of unconsolidated material overlying the mine which, in turn, increased the closure rate.

As to emergency preparedness, an applicant would be required to conduct appropriate advance planning for emergencies and prepare an emergency response plan as part of the permit application. The emergency response plan would identify the response procedures, personnel and necessary on-site equipment to address an emergency involving a release, fire or explosion, as well as notification procedures.

Finally, the Department recognizes concerns expressed about the preparation of well pads for natural disaster events, which may become increasingly important over time as New York is expected to experience more significant or extreme events related to climate change. As with other industrial activities, operators and drillers would need to take precautions and actions to secure their equipment and well sites, as they did in Pennsylvania prior to the arrival of the Irene and Lee storms. If HVHF were authorized, the Department could require such preparation through permit conditions, which may be based on both general and site-specific considerations. Specifically, to address concerns about flooding beyond the 100-year floodplain and in recognition of the increasing frequency and intensity of recent and potentially future flood events, the Department considered requiring that the well pad be elevated two feet above the 500-year floodplain elevation or the known elevation of the flood of record, if such data is available. However, the Department notes that the data as to what constitutes the 500-year floodplain is incomplete and consequently impacts could still occur.

Compulsory Integration

Comment: The Department received numerous comments regarding the compulsory integration process. The majority of these comments expressed the following concerns: compulsory integration would violate the sovereignty of the Indian Nations; the process constitutes an unauthorized taking of the property of another; horizontal drilling has unique implications to property rights relative to vertical drilling; and the process should afford additional protections for landowners.

Several comments expressed concern that the practice of compulsory integration would be a violation of treaty rights and sovereignty of the Indian Nations. Therefore, any attempt by the State to permit corporations to drill under the Nation's territory would be a violation of the federal Trade and Intercourse Act, 25 USC 177, which reads in part: "No purchase, grant, lease, or other conveyance of lands, or of any title or claim thereto, from any Indian nation ... shall be of any validity in law or equity, unless the same be made by treaty or convention entered into pursuant to the Constitution."

A number of comments argued that the process of compulsory integration constitutes an unauthorized taking under the Fifth Amendment of the U.S. Constitution or a trespass or fails to provide fair and reasonable compensation to the integrated landowner(s). These included assertions that compulsory integration decreases the value of adjacent property, threatens residential development and mortgages, is not in the public interest, fosters disrespect for the rule of law, promotes civil disobedience and should not be treated as eminent domain. Submissions were also concerned that the use of State-owned lands would force the compulsory integration of neighboring properties and would be contrary to the purposes for which the State acquired such lands. One comment noted (incorrectly) that even if landowners wish not to lease, compulsory integration allows for the taking of subsoil rights as well as land, as gas pipelines crossing lands would require 60-foot gaps in vegetation.

Some comments expressed a related concern about the property rights implications of horizontal drilling relative to vertical drilling. In conventional drilling, the actual drilling process occurs only on and under the leased property, whereas in horizontal drilling the wellbore could be drilled under unleased properties that are possibly owned by individuals vehemently opposed to this type of resource exploitation.

A comment listed additional requirements which should have been included in the compulsory integration law, including the following: (1) mandatory reimbursement (150%) to property owners for negligent operations; (2) mandatory remediation of soil and water, and free medical monitoring; (3) recording of leases and assignments and prohibition of waivers of liability; (4) requiring fracturing companies to sign a Presumption of Causation Agreement with the State and obtain bonding; (5) authorization of local governments to enact and enforce their own permitting process; (6) mandatory disclosure of chemicals used in HVHF; (7) filing of drilling plans; (8) water and soil testing by a third party; (9) adherence to an EIS process similar to the SEQRA process to assess environmental impacts; (10) required disclosure in leases of environmental and health risks associated with HVHF; (11) a longer time period for landowners to make an election

(28 days); and (12) require an increased percentage of acquired mineral rights to apply for a permit (e.g., 70%, 75%, 80%, 100%).

Several comments claimed that the ECL does not authorize the compulsory integration of gas-bearing formations. Here, comments argued that Title 9 of ECL Article 23 only gives a well operator the right to drill from gas fields or pools of integrated landowners and took the position that a gas-bearing shale formation does not constitute either a “field” or a “pool” as those terms are defined in ECL § 23-0102. In addition, the comments argued that Title 9 does not provide authority for the mining or extraction of minerals from shale gas formations.

Response: Compulsory integration is a process established by ECL Article 23 to apportion the rights and responsibilities of well operators and unleased mineral rights owners for a well that has already been permitted by the Department. Chapter 5 of the SGEIS mentions the process in passing as one factor that may influence how a well operator may sequence the drilling of several wells on a multi-well pad. Well operators are required by ECL Article 23 to have at least 60% of the mineral rights within a proposed spacing unit under lease before applying for a permit to drill. In the event that a proposed wellbore would cross unleased acreage in the target formation, the compulsory integration process would need to be completed before an operator could commence operations under a permit to drill. This explains how the integration process, if needed, could affect the timing of drilling operations. The 1992 GEIS found that the pooling of mineral rights under a compulsory integration order does not present any environmental impacts and is not a significant action under SEQRA. The SGEIS, which is a supplement dedicated to the subject of HVHF, does not raise any new issues with respect to compulsory integration. The need for a compulsory integration hearing is based solely on whether there are any unleased mineral rights in an established spacing unit and is unrelated to the method of drilling or completing a well or the formation targeted by the well operator. The compulsory integration process is the means by which the Department protects correlative rights.

The concern expressed that compulsory integration would violate the rights and sovereignty of the Indian Nations is outside the scope of the SGEIS. Neither the SGEIS nor ECL Article 23 purports to change the jurisdictional boundaries between New York State and the Nation’s territory. As such, the compulsory integration hearing process could not lead to the extraction of natural gas under Indian Nations' land, unless explicitly agreed to by those Nations.

With respect to concerns expressed that compulsory integration amounts to an unauthorized taking, compulsory integration is not eminent domain and questions about the constitutionality of ECL Article 23 are outside the scope of the SGEIS. Compulsory integration assures uncontrolled mineral rights owners that they are compensated for their proportionate share of either production revenue or royalties produced from a well permitted by the Department. Compulsory integration addresses subsurface mineral rights and does not grant the well operator surface access to unleased acreage. The Department further notes that the leasing of State-owned land does not guarantee that a permit to drill would be issued for any particular location within a leased tract nor does the act of leasing create a spacing unit which could leverage unleased private mineral rights. Nevertheless, the inclusion of Department-administered State-owned land in a spacing unit that requires compulsory integration is outside the scope of the SGEIS. Also, compulsory integration does not authorize the construction of pipelines. Therefore, the concern that the integration hearing process could lead to the taking of private property for the construction of pipelines is mistaken.

Those comments asserting that horizontal drilling impacts property rights in a fundamentally different way than vertical drilling are incorrect. The presence of oil and natural gas does not follow property boundaries.

Comments calling for certain modifications to the compulsory integration process are outside the scope of the SGEIS because the compulsory integration process was established by statute. Whether ECL Article 23, Title 9 should have been adopted with or without the suggested modifications is a matter of legislative action. Nevertheless, the Department considered two of the concerns expressed (the need for chemical disclosure and the filing of drilling plans and associated records). If HVHF were authorized, the Department would require chemical disclosure and the filing of drilling plans. As to the concern that the statute should be modified to require compliance with SEQRA, that concern is addressed by ECL Article 8 and the existence of the SGEIS. For activities consistent with the SGEIS, well operators would be required to comply with the mitigation measures contained in the SGEIS if HVHF were authorized.

With respect to assertions that the compulsory integration process does not encompass gas-bearing shale formations, Title 9 of ECL Article 23 directs the Department to integrate uncontrolled mineral rights in an established spacing unit regardless of the formation targeted by a well operator. However, the source of the Department's authority to issue a permit to drill a natural gas well is ECL Article 23, Titles 3 and 5, rather than Title 9.

Leases

Comment: The Department received a number of comments regarding leases for mineral rights. These ranged from concern that lease terms generally favor gas drilling companies, to requests for specific protections including mandatory disclosure of the risks associated with HVHF and time limits on the duration of leases.

Many of the comments recommended specific limitations or requirements for leases. These included several comments stating that mandatory disclaimers, warning statements or other disclosures regarding the risk of contamination and potential health effects related to HVHF should be required in lease documents, or if disclosure is not required, a system should be established to ensure fair and reasonable compensation to landowners. Comments also asserted that any landowner signing a lease should also be required to get the consent of his or her neighbor. Some comments requested the Attorney General to rule on lease issues and proposed that the Attorney General or Consumer Affairs regulate private at-home negotiations, with long cooling-off periods. Others sought to prevent gas companies from indefinitely holding rights to an entire parcel when only a small part is being used for drilling, suggesting that leases should expire and be renegotiated following some set time period (10 years, unstated). A comment also recommended that a gas well or lease should only be authorized for transfer to U.S. companies, opining that transfer to foreign companies would be unpatriotic and risk national security. Other comments specifically requested a filing and recording requirement to ensure full disclosure of lease information at the appropriate County Clerk's office. In addition, comments stated that protections should be established to assure that gas is not removed from unleased lands.

Others expressed concern that energy companies will assert force majeure rights as a result of the de facto moratorium on HVHF and attempt to roll expiration dates forward into the future, which would essentially allow them to hold leases indefinitely.

Additional comments related to leases included the following:

- Address speculative practices where leases are purchased to raise funds, not to develop the resource;
- Require meters on wellheads, bypass valves and third-party testing of such meters and valves to protect landowners from being cheated by gas companies;
- Exempt lessors from lawsuits against HVHF companies; and
- Provide requirements specifically for private leases involving the Finger Lakes Trail, including assistance to realize co-benefits to both the landowner and the trail.

Response: Private leases and their contents, such as disclaimers and warning statements, are outside the scope of the SGEIS. An oil and gas lease is a private contract between the mineral rights owner and the operator/leasing company. The Department lacks authority to regulate private oil and gas lease agreements. Mineral rights owners may negotiate the terms of the lease to include or exclude language or to provide additional protections. For example, mineral rights owners may include lease language to include the owner's review of production records. The mineral rights owners can choose whether or not to execute a lease which does not contain the protections or language that they believe to be essential. The Department recommends that if HVHF is generally permitted, any mineral rights owner who is unfamiliar with oil and gas leases seek out legal or other assistance prior to entering into a lease contract. In addition, oil and gas leases are subject to the provisions contained in General Obligations Law §5-333, which provides a three-day oil and gas lease cancellation period. See above under *Compulsory Integration* for a discussion of correlative rights and the compulsory integration process for unleased lands.

Regarding the concern expressed about transfer of gas wells and leases, the Department disagrees that the transfer of a well or lease would be a risk to national security or otherwise inappropriate solely on the basis that such transfer is to a foreign company. However, the

Department must approve the transfer of wells from an operator to a successor and would not do so unless the operator can meet its statutory and regulatory responsibilities.

With respect to the comment raising concerns regarding force majeure rights, the interpretation of private leases is outside the scope of the SGEIS. To the extent that the comments reference a particular private lease agreement, the language regarding primary term, secondary term and force majeure language would have been negotiated between the mineral rights owner (lessor) and the lessee when the lease was negotiated, and are outside the Department's purview.

The selling of leases, meter construction and testing, the terms of gas leases, and the issue of property owner exemption from lawsuits are outside the scope of the SGEIS.

Alternative Energy

Comment: The Department received a number of comments regarding alternative energy sources. Numerous comments broadly asserted that the State should pursue the development of renewable energy sources in lieu of shale gas and other fossil fuels. Others recommended particular alternative energy sources and energy efficiency systems, claiming that they would be safer and better aligned with the State's energy goals than natural gas production.

Several comments also requested that the SGEIS include a comparative analysis of the methods of energy production. Others expressed concern that although natural gas is cleaner than coal, the conversion of coal plants would take years to complete. On the other end of the spectrum, some comments claimed that HVHF fulfils the need for a reliable backup system when solar and wind energy are unavailable.

Response: The Department supports efforts to develop renewable energy sources and green sector industries including hydropower and solar, wind and geothermal energy. The development of green sector industries is an important question, but one that is outside of the scope of the SGEIS. Similarly, while the question of whether incentives for the development of such energy sources and industries should be adopted is an important one, it is outside the scope of the SGEIS. Furthermore, it is beyond the scope of the SEQRA and this SGEIS to conduct a full-blown analysis comparing methods of energy production. The Department recognizes that in order to achieve its overall greenhouse gas (GHG) emission reduction goals, the State must continue to transition from fossil fuels to non-emitting clean energy sources. Increased availability of low-cost natural gas has the potential to reduce the cost-effectiveness of investment in various types of renewable energy and energy efficiency, thereby suppressing investment in and use of these clean energy technologies. While natural gas may serve as a "bridge" or "transitional fuel" towards greater utilization of non-emitting clean energy sources, increased natural gas development could extend the use of fossil fuels, or delay the necessary deployment of clean energy.

Also, see the 2014 draft New York State Energy Plan, which includes a discussion of alternative energy strategies (http://energyplan.ny.gov/Plans/2014).

Pipelines/Compressor Stations

Comment: The Department received various comments concerning potential impacts of gas pipelines and compressor stations. Comments expressing concern ranged from recommendations that the SGEIS analyze potential impacts associated with the siting and construction of pipelines and compressor stations to concerns or suggested revisions to the Public Service Law (PSL) Article VII gas pipeline process. In contrast, other comments expressed support or confidence that pipeline siting and construction are effectively regulated under existing state and federal laws and rules.

Several comments recommended that the SGEIS include an analysis, including cumulative impacts, of the siting and construction of pipelines and compressor stations. A number of these comments pointed out that SEQRA requires state and local agencies to consider all reasonably foreseeable long-term impacts of an action. In this regard the comments identified potential noise, air, habitat fragmentation and invasive species impacts as areas of special concern as well as potential impacts to an area's hydrology and agricultural lands; including soil compaction. For instance, some comments argued that the long-term impacts of pipeline installation with clear cutting to provide rights-of-way, including long-term pipeline maintenance, should be evaluated and included in the 2009 dSGEIS. Some submissions also suggested that the

Department and Public Service Commission (PSC) conduct and present a coordinated analysis, with PSC authoring appropriate sections and involvement by Department of Health as necessary.

A number of comments stated that the Department should have a regulatory role in the routing, construction, and maintenance of all pipelines and compressor stations, and should not delegate these responsibilities to PSC. Therefore, the SGEIS should specify the Department's role in overseeing these activities. One comment asserted that the SGEIS should include Best Management Practices for the placement and maintenance of gathering pipelines or compressor stations.

Comments specifically recommended that the Article VII gas pipeline process evaluate the potential for certain impacts, including negative impacts to forests and agricultural lands, surface and ground waters, air, human health and communities. For example, to reduce negative impacts of pipeline right-of-ways on forests and agricultural lands due to land clearing, comments recommended requiring pipelines to be sited along existing access roads and operators to share pipeline right-of-ways and minimize right-of-way widths. Several comments noted that potential impacts to surface, ground and drinking water may occur due to improper handling of liquid wastes. These comments stated that regulations should also require a check of pipelines for gas leaks. In addition, the comments argued that the Department should require that all installed gathering lines be capable of being located by Global Positioning Systems and ensure that this information be provided to local governments.

Several submissions recommended a prohibition of pipeline networks and associated infrastructure on State lands or the New York City Watershed. Others raised concerns regarding the level of earthquake activity that gas pipelines would be required to withstand and a potential risks of explosions. A number of comments also suggested that the Department work with PSC to expedite the issuance of permits for gathering line construction concurrent with those for well pad construction, so as to facilitate reduced emissions completions.

Response: Gas pipeline and compressor station siting actions undertaken pursuant to PSL Article VII are designated Type II actions by 6 NYCRR 617.5(c)(35) and are therefore not subject to environmental impact analysis under SEQRA and beyond the scope of the SGEIS.

See Response to Comment in Interagency Coordination in Permit Process and Regulatory Coordination.

The potential significant adverse environmental impacts associated with an intra-state gas pipeline or compressor station construction proposal, when proposed for specific locations, undergo a case-specific environmental impact analysis pursuant to Article VII that is analogous to a SEQRA review. It is not possible to fully discuss the cumulative impacts from the siting and construction of HVHF and intra-state gas pipelines and compressor stations in this SGEIS because of both (a) the site-specific nature of any assessment of such impacts, which would be conducted in another forum, and (b) the extensive uncertainty of knowing whether or where such pipelines and associated infrastructure, such as compressor stations, would be located, the number of pipelines that may be needed, their respective size(s), whether new or existing rights-of-way may be used, the lengths and widths of those rights-of-way, when they may be constructed, and how they may be maintained.

The Department notes, however, that there is the potential for cumulative adverse impacts from gathering lines necessary to support HVHF operations and HVHF well development. Specifically, if HVHF were authorized, the Department anticipates that there would be cumulative impacts to wildlife habitat from the construction of a network of gathering lines needed to facilitate HVHF activities. To the extent that these gathering lines potentially impact other natural resources, such as water bodies and wetlands, these impacts could increase resource stresses and/or degradation, particularly if, for instance, water bodies or streams are encountered in more than one instance.

If the determination were made to authorize HVHF, it would trigger environmental review on a case-by-case basis conducted by the Department of Public Service (DPS) and PSC. Section 8 of the SGEIS describes the jurisdictional authority of PSC. It also discusses the manner in which issues relating to pipeline construction have been addressed in past PSC proceedings under PSL Article VII, including the environmental assessment conducted for issues relating to noise, air emissions, and habitat disturbance and fragmentation, as well as potential minimization and mitigation measures. The Department participates as a statutory party in proceedings conducted by PSC under PSL Article VII. PSC must consider the proposed Article VII project's compliance with the substantive provision of the ECL and its regulations, pursuant to PSL §126(1)(f). The Department's role is to ensure that potential impacts with respect to all appropriate environmental media are identified and assessed by PSC so that it makes appropriate environmental findings under PSL §126.

In addition, the Federal Energy Regulatory Commission (FERC) has overriding jurisdiction over the siting of inter-state, not intra-state, pipelines and will conduct a full environmental review pursuant to the National Environmental Policy Act (42 U.S.C. §4321 et seq.). The Department can intervene in FERC inter-state pipeline proceedings to advocate for FERC's consideration of environmental quality and natural resources preservation and protection. In such proceedings the Department has authority pursuant to the Clean Water Act to determine whether an applicant's pipeline proposal can be certified as complying with State water quality standards (6 NYCRR Parts 700 – 706).

Regardless of whether PSC or FERC exercises generally overriding authority to site pipelines and compressor stations, the Department retains two aspects of environmental program jurisdiction over pipelines and compressor stations: (1) pursuant to the Clean Air Act the Department will determine whether to issue a permit for air emissions from the compressor station (see 6 NYCRR Part 201) and (2) the Department imposes its general construction permit for controlling storm water erosion and runoff discharges in order to protect water quality standards (see http://www.dec.ny.gov/docs/water_pdf/gpsconspmt10.pdf). See Responses to comments in Water Resources in Potential Environmental Impacts and Mitigation regarding stormwater erosion and runoff discharges. Air impacts from compressor stations have been included in the air analysis performed for the SGEIS as set forth in Chapter 6 of the SGEIS.

PSC can investigate the circumstances of gathering line proposals in an Article VII proceeding and, if merited, place safety and compliance conditions on constructing and operating gathering lines, such as GPS tagging or pig testing for pipeline integrity. PSC is the New York State entity with authority over intra-state gas pipeline safety, and consideration of the merits for conditions such as GPS tagging would likely be made in the context of pipeline safety requirements. Best management practices for pipeline construction, operation, maintenance and safety are also a subject specifically addressed in PSC Article VII proceedings. PSC requires life-time maintenance and monitoring for all aspects of gas pipeline operation, including environmental mitigation and safety, for which it prescribes best management practices when issuing individual pipeline certificates. Although no two pipelines are the same, an overview of multiple pipeline certificates would illustrate that PSC has established numerous standard conditions to maintain pipeline integrity and safety at industry standards. See the Public Service Commission's regulations set forth at 16 NYCRR Part 255.

PSC also imposes post-installation restoration conditions on an intra-state gas pipeline right-of-way when it determines to issue a specific certification to construct and operate a pipeline pursuant to Article VII of the PSL. PSC typically requires construction site closure so that a portion of the construction right-of-way is maintained in low shrub or grassland vegetation to facilitate access for inspection and monitoring. On-going maintenance over the life of the pipeline and its right-of-way is the subject of a maintenance plan that an Article VII applicant must supply in order to obtain Article VII certificate approval.

Regarding those comments focused on potential water quality impacts, when PSC issues an Article VII certificate to authorize gas pipeline or compressor station construction, it may, after due consideration of potential project impacts to water quality, also issue a Clean Water Act water quality certificate, with conditions if necessary, stating that the project, as proposed, will comply with New York State water quality standards for surface waters (6 NYCRR Parts 700 – 706). Furthermore ECL Article 71 provides the Department with independent authority to address compliance for any violation of the State's water quality standards, including pollution of the State's groundwater from pipeline construction or right-of-way maintenance. Also, during gas pipeline or compressor station construction, a developer must continue to comply with the Department's authority regulating spills of hazardous substances pursuant to ECL Article 27 and for stormwater pollution protection authority pursuant to the Clean Water Act (33 U.S.C. 1251 et seq.) and ECL Article 17.

In a similar vein, as noted above, the Department also has authority to regulate air emissions from compressor stations. In order for a compressor station to be constructed and operated, it must obtain an air pollution control permit or registration, as appropriate, from the Department. The Department may not issue these permits or registrations to an applicant to construct a compressor station that cannot demonstrate compliance with all applicable State and federal air regulations for operations and control technology. This means that in individual cases, a compressor station associated with an intra-state or inter-state gas pipeline may not be constructed unless it demonstrates that all operating conditions will meet air permitting or registration conditions. See 6 NYCRR Part 201, Subparts 201-5 and 201-6.

When the PSC has pipeline siting authority under Article VII, it may determine whether gathering lines can be constructed prior to wells being completed and proven to be productive, given all of the relevant facts and circumstances of a particular Article VII proceeding. Where appropriate, DEC could make a reduced emissions completion a condition to a well permit if a gathering line and a sales line are available during the completion of any individual well or the multi-well pad. The Department, through its participation in Article VII proceedings, can raise such facts and circumstances as are available for the PSC to consider in determining whether a gathering line should be authorized prior to the well completion.

With respect to concerns regarding the siting of pipelines and their associated infrastructure on State lands, the Department requires that a right-of-way for a gas pipeline over State lands be granted only if some of the gas transported in that line is produced from State lands. If a gas pipeline will transport gas that is not at least in part produced from State lands, its right-of-way may not pass over State lands. In addition, with respect to the prospect of potential forest fragmentation, see response to comment in Ecosystems and Wildlife in Potential Environmental Impacts and Mitigation.

PSC's authority to authorize and regulate gas pipeline construction and operation attaches to pipelines that "extend a distance of one thousand feet or more to be used to transport fuel gas at pressures of one hundred twenty-five pounds per square inch or more." If a pipeline proposal falls below this jurisdictional threshold, other local and State permitting authorities would no longer be overridden by PSL Article VII, Section 130, and those authorities would be in a position to consider individual applications pertaining to their relevant authority over pipelines. In the Department's case, depending on the individual pipeline proposal, its authority may include permits for programs regulating natural resources encountered along the pipeline right-of-way but does not include pipeline integrity or safety. For instance, the Department may consider a developer's applications to impact freshwater or tidal wetlands, the beds and banks of streams, or taking state-listed threatened or endangered species. These permits address regulatory programs for which the Department has specific statutory authority under the ECL, and would not include a specific pipeline construction permit. However, because of the anticipated initial producing pressures of wells stimulated by HVHF, it is expected that most pipelines would fall under PSC's jurisdiction. Nevertheless, the Department acknowledges the potential for significant adverse environmental impacts due to the construction of intra-state pipelines and their associated infrastructure, such as compressor stations, for natural gas produced by HVHF, including cumulative impacts to community character and natural resources.

NEW YORK STATE OF OPPORTUNITY. | Department of Environmental Conservation

Appendices to Response to Comments

FINAL
Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program

Regulatory Program for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs

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NEW YORK STATE OF OPPORTUNITY. | Department of Environmental Conservation

Appendix A

Public Health Review of Shale Gas Development

Final

Supplemental Generic Environmental Impact Statement

Response to Comments

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NEW YORK STATE | Department of Health

A Public Health Review of

High Volume Hydraulic Fracturing for Shale Gas Development

December 2014

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NEW YORK
state department of
HEALTH

Howard A. Zucker, M.D., J.D.
Acting Commissioner of Health

Sally Dreslin, M.S., R.N.
Executive Deputy Commissioner

December 17, 2014

Hon. Joseph Martens
Commissioner
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12207

Dear Commissioner Martens:

In September 2012, you asked Dr. Shah, then Commissioner of Health, to initiate a Public Health Review of the Department of Environmental Conservation's draft Supplemental Generic Environmental Impact Statement for High Volume Hydraulic Fracturing (HVHF). I assumed responsibility for this review when Dr. Shah left. It became clear during this assessment that DOH's Public Health Review needed to extend beyond the scope of the initial request to consider, more broadly, the current state of science regarding HVHF and public health risks. This required an evaluation of the emerging scientific information on environmental public health and community health effects. This also required an analysis of whether such information was sufficient to determine the extent of potential public health impacts of HVHF activities in New York State (NYS) and whether existing mitigation measures implemented in other states are effectively reducing the risk for adverse public health impacts.

As with most complex human activities in modern societies, absolute scientific certainty regarding the relative contributions of positive and negative impacts of HVHF on public health is unlikely to ever be attained. In this instance, however, the overall weight of the evidence from the cumulative body of information contained in this Public Health Review demonstrates that there are significant uncertainties about the kinds of adverse health outcomes that may be associated with HVHF, the likelihood of the occurrence of adverse health outcomes, and the effectiveness of some of the mitigation measures in reducing or preventing environmental impacts which could adversely affect public health. Until the science provides sufficient information to determine the level of risk to public health from HVHF to all New Yorkers and whether the risks can be adequately managed, DOH recommends that HVHF should not proceed in NYS.

I appreciate the opportunity to conduct this Public Health Review. It furthers the long history of close collaboration between the two Departments carrying out our shared responsibility to protect human health and the environment.

Sincerely,

Howard Zucker M.D.

Howard A. Zucker, M.D., J.D.
Acting Commissoner of Health

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Errata

A Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development

It has come to the attention of the Department of Health (DOH) that the Public Health Review document posted on the DOH web site on December 17, 2014 contained two errors requiring correction:

1. The following text (enclosed in ‘ ‘) was inadvertently omitted from the beginning of page 41 and has been added back to the document to complete the sentence started at the end of page 40:

   > [ODNR] ‘says that it will develop new criteria and permit conditions for new applications in light of this change in policy. The department will also review previously issued permits for wells that have not been drilled.’

   As a consequence of the omission, the formatting of the next section heading, beginning on page 41, was also incorrect and has been corrected:

   Conclusions – Health and Environmental Literature

2. Endnote 4 listed on page 89 referred to a web link that had been removed from the document before it was finalized. That endnote was deleted, and all subsequent endnotes were renumbered accordingly (i.e., original-endnote 5 became new-endnote 4, etc.).

In addition, a number of minor typographical errors have been corrected in the amended version of the document. These include the following changes:

1. deletion of an additional blank space character following periods: pages 21, 25, 48, and 56;
2. addition of a missing blank space character: pages 23, 25, 32, and 36;
3. addition of a missing period character: pages 21 and 29;
4. correction of acronyms for US EPA and US DOL: pages 5, 7, 35, 36, 104 and, 105;
5. correction of the date from 2012 to 2014 for reference to an IOM report: page 43; and
6. correction of the date of the reference to an US EPA document and addition of a missing closing parenthesis in endnote 4 (originally numbered 5): page 89.

None of these corrections to the Public Health Review document result in any substantive change to the meaning of the document or the document’s conclusions.

2/13/2015

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Table of Contents

| Executive Summary

The New York State Department of Health (DOH) is charged with protecting the public health of New Yorkers. In assessing whether public health would be adequately protected from a complex activity such as high volume hydraulic fracturing (HVHF), a guarantee of absolute safety is not required. However, at a minimum, there must be sufficient information to understand what the likely public health risks will be. Currently, that information is insufficient.

In 2012, the New York State Department of Environmental Conservation (DEC) requested that DOH review and assess DEC's analysis of potential health impacts contained in DEC's draft supplemental generic environmental impact statement (SGEIS) for HVHF. In response to the original request from DEC, DOH initiated an HVHF Public Health Review process. In conducting this public health review DOH: (i) reviewed and evaluated scientific literature to determine whether the current scientific research is sufficient to inform questions regarding public health impacts of HVHF; (ii) sought input from three outside public health expert consultants; (iii) engaged in field visits and discussions with health and environmental authorities in states with HVHF activity; and (iv) communicated with multiple local, state, federal, international, academic, environmental, and public health stakeholders. The evaluation considered the available information on potential pathways that connect HVHF activities and environmental impacts to human exposure and the risk for adverse public health impacts.

Based on this review, it is apparent that the science surrounding HVHF activity is limited, only just beginning to emerge, and largely suggests only hypotheses about potential public health impacts that need further evaluation. That is, many of the published reports investigating both environmental impacts that could result in human exposures and health implications of HVHF activities are preliminary or exploratory in nature. However, the existing studies also raise substantial questions about whether the risks of HVHF activities are sufficiently understood so that they can be adequately managed. Furthermore, the public health impacts from HVHF activities could be significantly broader than just those geographic locations where the activity actually occurs, thus expanding the potential risk to a large population of New Yorkers.

As with most complex human activities in modern societies, absolute scientific certainty regarding the relative contributions of positive and negative impacts of HVHF on public health is unlikely to ever be attained. In this instance, however, the overall weight of the evidence from the cumulative body of information contained in this Public Health Review demonstrates that there are significant uncertainties about the kinds of adverse health outcomes that may be associated with HVHF, the likelihood of the occurrence of adverse health outcomes, and the effectiveness of some of the mitigation measures in reducing or preventing environmental impacts which could adversely affect public health. Until the science provides sufficient information to determine the level of risk to public health from HVHF to all New Yorkers and whether the risks can be adequately managed, DOH recommends that HVHF should not proceed in New York State.

Scope of the Public Health Review

DOH evaluated whether the available scientific and technical information provides an adequate basis to understand the likelihood and magnitude of risks for adverse public health impacts from HVHF activities in New York State. DOH reviewed how HVHF activities could result in human exposure to: (i) contaminants in air or water; (ii) naturally occurring radiological materials that result from HVHF activities; and (iii) the effects of

HVHF operations such as truck traffic, noise, and social changes on communities. DOH also reviewed whether those exposures may result in adverse public health outcomes.

Public Health Review Process

The initial component of the Public Health Review focused on understanding how public health concerns were addressed in the draft SGEIS. Three nationally recognized experts participated as consultants to the initial phase of the review process. The expert consultants reviewed elements of the draft SGEIS and documentation developed by DOH, and provided extensive input through multiple rounds of communication.

As a result of this input, as well as broader consideration, it became clear that DOH's Public Health Review needed to extend beyond this initial assessment to consider, more broadly, the current state of science regarding HVHF and public health risks. This required an evaluation of the emerging scientific information on environmental public health and community health effects. This also required an analysis of whether such information was sufficient to determine the extent of potential public health impact of HVHF activities in NYS and whether existing mitigation measures implemented in other states are effectively reducing the risk for adverse public health impacts.

In addition to evaluating published scientific literature, former Commissioner Shah, Acting Commissioner Zucker, and DOH staff consulted with state public health and environmental authorities to understand their experience with HVHF. Former Commissioner Shah, Acting Commissioner Zucker, and DOH staff also engaged in a number of discussions and meetings with researchers from academic institutions and government agencies to learn more about planned and ongoing studies and assessments of the public health implications of HVHF. In total, more than 20 DOH senior Research Scientists, Public Health Specialists, and Radiological Health Specialists spent approximately 4500 hours on this Review.

Major Findings

Summarized below are some of the environmental impacts and health outcomes potentially associated with HVHF activities:

- **Air impacts** that could affect **respiratory health** due to increased levels of particulate matter, diesel exhaust, or volatile organic chemicals.
- **Climate change impacts** due to methane and other volatile organic chemical releases to the atmosphere.
- **Drinking water impacts** from underground migration of methane and/or fracking chemicals associated with faulty well construction.
- Surface spills potentially resulting in **soil and water contamination**.
- **Surface-water contamination** resulting from inadequate wastewater treatment.
- **Earthquakes** induced during fracturing.
- **Community impacts** associated with boom-town economic effects such as increased vehicle traffic, road damage, noise, odor complaints, increased demand for housing and medical care, and stress.

Additionally, an evaluation of the studies reveals critical information gaps. These need to be filled to more fully understand the connections between risk factors, such as air and water pollution, and public health outcomes among populations living in proximity to HVHF shale gas operations (Penning, 2014; Shonkoff, 2014; Werner, 2015).

Some of the most significant environmental and health-outcome studies are briefly summarized here.

Air Impacts

Studies provide evidence of uncontrolled methane leakage, emissions of other volatile organic chemicals, and particulate matter from well pads and natural-gas infrastructure. State authorities in both Texas and Pennsylvania have documented methane leakage from natural gas infrastructure by the use of infrared cameras. A recent West Virginia study also determined that heavy vehicle traffic and trucks idling at well pads were the likely sources of intermittently high dust and benzene concentrations, sometimes observed at distances of at least 625 feet from the center of the well pad (McCawley, 2012, 2013; WVDEP, 2013). These emissions have the potential to contribute to community odor problems, respiratory health impacts such as asthma exacerbations, and longer-term climate change impacts from methane accumulation in the atmosphere (Allen, 2013; Bunch, 2014; CDPHE, 2010; Macey, 2014; Miller, 2013; Petron, 2012; Weisel, 2010).

Water-quality Impacts

Studies have found evidence for underground migration of methane associated with faulty well construction (Darrah, 2014; US EPA, 2011). For example, a recent study identified groundwater contamination clusters that the authors determined were due to gas leakage from intermediate-depth strata through failures of annulus cement, faulty production casings, and underground gas well failure (Darrah, 2014). Shallow methane-migration has the potential to impact private drinking water wells, creating safety concerns due to explosions.

Other studies suggest additional sources of potential water contamination, including surface spills and inadequate treatment and disposal of radioactive wastes (Warner, 2013). A recent review paper presented published data revealing evidence for stray gas contamination, surface water impacts, and the accumulation of radium isotopes in some disposal and spill sites (Vengosh, 2014). One recent study also suggests that chemical signals of brine from deep shale formations can potentially be detected in overlying groundwater aquifers (Warner, 2012). These contaminants have the potential to affect drinking water quality.

Seismic Impacts

Recent evidence from studies in Ohio and Oklahoma suggest that HVHF can contribute to the induction of earthquakes during fracturing (Holland, 2014; Maxwell, 2013). Although the potential public health consequence of these relatively mild earthquakes is unknown, this evidence raises new concerns about this potential HVHF impact.

Community Impacts

There are numerous historical examples of the negative impact of rapid and concentrated increases in extractive resource development (e.g., energy, precious metals) resulting in indirect community impacts such as interference with quality-of-life (e.g., noise, odors), overburdened transportation and health infrastructure, and disproportionate increases in social problems, particularly in small isolated rural communities where local governments and infrastructure tend to be unprepared for rapid changes (Headwaters, 2013). Similar concerns have been raised in some communities where HVHF activity has increased rapidly (Stedman, 2012; Texas DSHS, 2010; Witter, 2010; WVDEP, 2013).

A recent study from Pennsylvania also reports that automobile and truck accident rates in 2010–2012 from counties with heavy HVHF activity were between 15% and 65% higher than accident rates in counties without HVHF. Rates of traffic fatalities and major injuries were higher in 2012 in heavy drilling counties in southwestern Pennsylvania compared to non-drilling counties (Graham, 2015).

Health Outcomes near HVHF Activity

Although well-designed, long-term health studies assessing the effect of HVHF activity on health outcomes have not been completed, there is published health literature that examines health outcomes in relation to residential proximity to HVHF well pads. One peer-reviewed study and one university report have presented data indicating statistical associations between some birth outcomes (low birth weight and some congenital defects) and residential proximity of the mother to well pads during pregnancy (Hill, 2012; McKenzie, 2014). Proximity to higher-density HVHF well pad development was associated with increased incidence of congenital heart defects and neural-tube defects in one of the studies (McKenzie, 2014).

Several published reports present data from surveys of health complaints among residents living near HVHF activities. Commonly reported symptoms include skin rash or irritation, nausea or vomiting, abdominal pain, breathing difficulties or cough, nosebleeds, anxiety/stress, headache, dizziness, eye irritation, and throat irritation in people and farm animals within proximity to HVHF natural gas development (Bamberger, 2012; Finkel, 2013; Steinzor, 2012). Federal investigators have also reported that sub-standard work practices and deficient operational controls at well pads contributed to elevated crystalline silica exposures among workers during HVHF operations (US DOL, 2012). While this report focused on worker exposures, it highlights a possible exposure concern for residents living close to HVHF operations if silica emissions from onsite operations are not properly controlled.

Substantial Gaps Remain

Systematic investigations studying the effects of HVHF activity on groundwater resources, local-community air quality, radon exposure, noise exposure, wastewater treatment, induced seismicity, traffic, psychosocial stress, and injuries would help reduce scientific uncertainties. While some of the on-going or proposed major study initiatives may help close those existing data gaps, each of these alone would not adequately address the array of complex concerns related to HVHF activities.
For example:

Marcellus Shale Initiative Study

Geisinger Health System, the lead organization in the collaborative Marcellus Shale Initiative, cares for many patients in areas where shale gas is being developed in Pennsylvania. They began pilot studies in 2013 using well and infrastructure data to estimate exposures to all aspects of Marcellus shale development in Pennsylvania. According to the National Institutes of Health (NIH) abstract, they will use these exposure estimates to evaluate whether asthma control and pregnancy outcomes are affected by Marcellus shale development by studying 30,000 asthma patients and 22,000 pregnancies in the Geisinger Health System from 2006-13. Results from this study are not expected to be available for several years.

University of Colorado at Boulder, Sustainability Research Network

A five-year cooperative agreement funded by the National Science Foundation (NSF) under NSF's Sustainability Research Network competition, this program involves a multidisciplinary team of investigators and is intended to address:

> *"the conflict between natural gas extraction and water and air resources protection with the development of a social-ecological system framework with which to assess the conflict and to identify needs for scientific information. Scientific investigations will be conducted to assess and mitigate the problems. Outreach and education efforts will focus on citizen science, public involvement, and awareness of the science and policy issues"* (Univ. Colorado, 2012; Shonkoff, 2014).

Published research has been produced from this program investigating associations between HVHF activity and birth outcomes and potential for methane leakage from natural gas infrastructure. The cooperative agreement extends to 2017.

EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources

Begun in 2011, the purpose of the study is to assess the potential impacts of hydraulic fracturing on drinking water resources, if any, and to identify the driving factors that may affect the severity and frequency of such impacts. The research approach includes: analyses of existing data, scenario evaluations, laboratory studies, toxicity studies, and case studies. US EPA released a progress report on December 21, 2012 and stated that preliminary results of the study are expected to be released as a draft for public and peer review as soon as the end of 2014, although the full study is not expected to be completed before 2016.

Pennsylvania Department of Environmental Protection (PA DEP) Comprehensive Oil and Gas Development Radiation Study

Started in early 2013, PA DEP is analyzing the radioactivity levels in produced and flowback waters, wastewater recycling, treatment sludges, and drill cuttings, as well as issues with transportation, storage, and disposal of drilling wastes, the levels of radon in natural gas, and potential exposures to workers and the public. According to a July 2014 update from the PA DEP, publication of a report could occur as soon as the end of 2014.

University of Pennsylvania Study

A proposed study of HVHF health impacts was announced several months ago. The study is led by researchers from the University of Pennsylvania in collaboration with scientists from Columbia University, Johns Hopkins University, and the University of North Carolina.

Pennsylvania Department of Environmental Protection

Recently proposed community air monitoring will determine concentrations of fine and coarse (silica-sized) particles near a transfer facility that handles hydraulic fracturing silica sand.

These major study initiatives may eventually reduce uncertainties regarding health impacts of HVHF and could contribute to a much more complete knowledge base for managing HVHF risks. However, it will be years before most of these major initiatives are completed.

Other governmental and research institutes have also recently conducted health impact assessments of HVHF (Institute of Medicine, 2014). These include: the European Commission; University of Michigan, Graham Sustainability Institute; Research Triangle Environmental Health Collaborative; Nova Scotia Independent Panel on Hydraulic Fracturing; Inter-Environmental Health Sciences Core Center Working Group on Unconventional Natural Gas Drilling Operations funded by the National Institute of Environmental Health Sciences; and the Maryland Institute for Applied Environmental Health, School of Public Health, University of Maryland. While these assessments identify many of the same potential environmental impacts mentioned above, more importantly, they reiterate that significant gaps exist in the knowledge of potential public health impacts from HVHF and of the effectiveness of some mitigation measures.

Conclusions

HVHF is a complex activity that could affect many communities in New York State. The number of well pads and associated HVHF activities could be vast and spread out over wide geographic areas where environmental conditions and populations vary. The dispersed nature of the activity magnifies the possibility of process and equipment failures, leading to the potential for cumulative risks for exposures and associated adverse health outcomes. Additionally, the relationships between HVHF environmental impacts and public health are complex and not fully understood. Comprehensive, long-term studies, and in particular longitudinal studies, that could contribute to the understanding of those relationships are either not yet completed or have yet to be initiated. In this instance, however, the overall weight of the evidence from the cumulative body of information contained in this Public Health Review demonstrates that there are significant uncertainties about the kinds of adverse health outcomes that may be associated with HVHF, the likelihood of the occurrence of adverse health outcomes, and the effectiveness of some of the mitigation measures in reducing or preventing environmental impacts which could adversely affect public health.

While a guarantee of absolute safety is not possible, an assessment of the risk to public health must be supported by adequate scientific information to determine with confidence that the overall risk is sufficiently low to justify proceeding with HVHF in New York. The current scientific information is insufficient. Furthermore, it is clear from the existing literature and experience that HVHF activity has resulted in environmental impacts that are potentially adverse to public health. Until the science provides sufficient information to determine the level of risk to public health from HVHF and whether the risks can be adequately managed, HVHF should not proceed in New York State.

| Background

In 1992, the NYS Department of Environmental Conservation (DEC) finalized the Generic Environmental Impact Statement (1992 GEIS) on the Oil, Gas and Solution Mining Regulatory Program.[1,2] Conventional natural gas development in NYS – including the use of low-volume hydraulic fracturing – has been permitted by DEC under the GEIS since that time. High-volume hydraulic fracturing (HVHF), which is often used in conjunction with horizontal drilling and multi-well pad development, is an approach to extracting natural gas that raises new, potentially significant, adverse impacts that were not studied in the 1992 GEIS. Therefore, in 2008 DEC began the process of developing a supplement to the GEIS (hereafter the draft SGEIS) specifically addressing natural gas development using HVHF and directional drilling in unconventional formations such as the Marcellus and Utica Shales (collectively referred to here as HVHF shale-gas development).

In 2012, DEC requested that the New York State Department of Health (DOH) review and assess DEC's analysis of potential health impacts contained in DEC's draft supplemental generic environmental impact statement (draft SGEIS[3]) for HVHF. In response to the original request from DEC, DOH initiated an HVHF Public Health Review process. DOH has a long history of working closely with DEC on all DEC programs that have public health components. DOH has extensive expertise in environmental health, including protecting drinking water supplies, environmental radiation protection, toxicology, environmental exposure assessment, occupational health, and environmental epidemiology. DOH also collects, manages, and analyzes extensive public health surveillance data for all of New York State.

DOH is charged with defending the public health of New Yorkers. In order to meet this charge with respect to HVHF, DOH reviewed and evaluated relevant emerging scientific literature that investigated the environmental health and community health dimensions of HVHF. The literature was assessed in terms of the adequacy of the current science to inform questions regarding public health impacts of HVHF. As part of this review, DOH also sought input from three outside public health expert consultants, engaged in discussions and field visits with health and environmental authorities in states with HVHF activity, and held numerous meetings with local, state, federal, international, academic, environmental, and public health stakeholders. The evaluation considered the available information on all potential pathways that connect HVHF activities and environmental impacts to human exposure and the risk for adverse public health impacts.

HVHF shale-gas development is a large-scale, complex issue that potentially could affect a significant portion of New York State. In order to make an informed assessment of the potential public health consequences of HVHF in New York, the totality of available information from relevant sources has to be evaluated collectively. A single study or isolated piece of information will not provide a complete public health picture for such a complex activity. In assessing whether public health would be adequately protected when allowing a complex activity such as HVHF to go forward, a guarantee of absolute safety is not required, but there must be sufficient information to understand what the likely public health risks will be. Ultimately, in conducting this Public Health Review, DOH evaluated the relevant lines of available evidence collectively, and made a judgment on whether the scientific information was adequate to determine the level of public health risk.

Scope of the Review

DOH evaluated whether the available scientific and technical information provides an adequate basis to understand the likelihood and magnitude of risks for adverse public health impacts from HVHF activities in New York State. The evaluation reviewed how HVHF activities could result in human exposure to: (i) contaminants in air or water; (ii) naturally occurring radioactive materials that result from HVHF activities; and (iii) the effects of HVHF operations such as truck traffic, noise, and social changes on communities. The evaluation also reviewed whether those exposures may result in adverse public health outcomes.

Public Health Review Process

The initial component of the Public Health Review focused on understanding how public health concerns were addressed in the draft SGEIS. Three nationally recognized experts also participated as consultants to the initial phase of the review process. The expert consultants reviewed elements of the draft SGEIS and documentation developed by DOH, and provided extensive input through multiple rounds of communication.

As a result of this input, as well as broader consideration, it became clear that DOH's Public Health Review needed to extend beyond this initial assessment to consider, more broadly, the current state of science regarding HVHF and public health risks. This required an evaluation of the emerging scientific information on environmental public health and community health effects. This also required an analysis of whether such information was sufficient to determine the extent of potential public health impact of HVHF activities in NYS and whether existing mitigation measures implemented in other states are effectively reducing the risk for adverse public health impacts.

One major component of the Public Health Review was an objective evaluation of the emerging scientific information on environmental impacts and public health effects of HVHF activity. Scientific studies reporting relationships between HVHF and public health outcomes were the main focus of this evaluation, but relevant literature that was only focused on HVHF and effects on environmental media was also reviewed. Additional literature was reviewed and considered supplemental to the main Public Health Review (see Appendix 1). More than 20 DOH senior Research Scientists, Public Health Specialists, and Radiological Health Specialists contributed to the review under the direction of former Commissioner Shah and Acting Commissioner Zucker. The entire Public Health Review process involved more than 4500 hours of combined effort.

In addition to evaluating published scientific literature, former Commissioner Shah, Acting Commissioner Zucker, and DOH staff held multiple discussions and meetings with public health and environmental authorities in several states to understand their experience with HVHF. Former Commissioner Shah, Acting Commissioner Zucker, and DOH staff, also engaged in a number of discussions and meetings with researchers from academic institutions and government agencies to learn more about planned and ongoing studies and assessments of the public health implications of HVHF.

| Results

Evaluation of Scientific Literature Relevant to the Objectives of the Public Health Review

In order to evaluate the analysis of health impacts in the draft SGEIS in a broader environmental and public health context, DOH reviewed and evaluated relevant emerging scientific literature investigating the environmental health and community health dimensions of HVHF. This was not intended to be a comprehensive review of all the published scientific literature on HVHF. Rather, the emerging literature was surveyed, and studies with direct environmental health relevance were reviewed to better understand the adequacy of the current science to inform questions regarding public health impacts of HVHF.

Two major types of peer-reviewed scientific studies were the focus of the literature review process – studies of impacts to environmental media and studies of health outcomes. As is very often true in environmental health science, both types of studies have limitations that make it difficult to draw firm conclusions about environmental causation of disease from any one study or small group of studies. Strong conclusions about disease causation in environmental health derive from a collective assessment of the weight of evidence from a large body of research that often takes many years to conduct.[4]

Studies of environmental impacts investigate the effects of HVHF activities on environmental media such as air, water and soil. Contamination of environmental media has the potential to contribute to human health impacts if people experience exposures to those contaminants (for example, through breathing contaminated air or drinking contaminated water) that are large enough to cause a biological effect. However, studies of environmental impacts often do not attempt to directly demonstrate whether contamination of environmental media has resulted in significant human exposure or whether a health effect occurs as a result of an exposure. Other studies report on observed human health outcomes potentially associated with HVHF activity (i.e., environmental epidemiology studies). Health outcome studies related to HVHF activity focus on health effects reported among people living near HVHF drilling sites. Most health outcome studies can only suggest a potential statistical relationship between a source of environmental contamination and the observed health outcomes. These studies are limited in their ability to demonstrate that an actual exposure to the source has occurred or that exposure to an environmental source causes a health outcome. Health outcome studies vary in the complexity of their design and how rapidly they can be carried out. Some health outcome study designs that are relatively simple and quick to conduct are often also limited in their ability to account for other unrelated factors (usually referred to as bias and confounding) that might contribute to the observed health effects. Longitudinal prospective cohort studies are among the strongest study designs, but are very expensive and take years to conduct.

HVHF Health Outcome Studies

The public health science surrounding HVHF shale-gas development is currently limited and studies are largely exploratory in nature. Peer-reviewed epidemiologic studies were not found that employ robust study designs addressing possible associations between HVHF activities and adverse health outcomes while providing adequate control for confounding and bias. Scientific studies that contain relevant information investigating human health outcomes potentially associated with HVHF activities are briefly summarized below.

Birth Outcomes

An unpublished 2013 revision to a 2012 working paper by Hill reports results of a study using data on 2,459 natural gas wells completed in Pennsylvania between 2006 and 2010, along with vital records for the years 2003 through 2010. The study compared birth outcomes for infants born to mothers living within selected fixed distances from spudded Marcellus Shale wells (the "existing well" infant group) with outcomes for infants born to mothers living within the same distances from future wells (the “future well” infant group). The outcomes considered were birth weight, gestation, five-minute APGAR (Appearance, Pulse, Grimace, Activity, Respiration) score (a health indicator assessed immediately following birth), small-for-gestational-age (yes/no), premature (yes/no), congenital anomalies (yes/no) and infant death (yes/no). The investigator reported that after specifying a fixed distance of 2.5 km from an existing or future well, and after controlling for multiple risk factors (e.g., maternal age, race, education, WIC status, marital status, insurance status and smoking), the “existing well” infant group had statistically significantly lower averages for birth weight and 5-minute APGAR score, as well as statistically significantly higher prevalence of low birth weight and small-for-gestational age, compared with the “future wells” infant group. No statistically significant differences were observed for prematurity, congenital anomalies or infant death.

Hill’s conclusion that a “causal” relationship between natural gas development and birth outcomes was established may overstate the findings of this single study. The statistical approach used by the investigator, the differences-in-differences method, had in the past been employed primarily by social scientists but is increasingly used in public health studies. In the context of this study, this statistical approach assumed that, in the absence of drilling, average outcomes for the “existing wells” and “future wells” infant groups would have followed parallel paths over time. Because differences may have existed between the two study groups with regard to potential risk factors not incorporated into the statistical analyses (e.g., prenatal care adequacy, maternal lifestyles, pre-existing chronic diseases, perinatal complications) it is possible that this "parallel paths" assumption may not have been appropriate. However, the author was able to demonstrate that, at least with regard to measured characteristics, there were no indications that this key assumption was not met.

A similar study by McKenzie et al. (2014) evaluated potential associations between maternal residence near natural gas wells and birth outcomes in a retrospective cohort study of 124,842 births between 1996 and 2009 in rural Colorado. Specifically, the authors investigated associations between natural gas well density and prevalence of congenital heart defects, neural tube defects, oral clefts, preterm birth, and term low birth weight. The least exposed (reference) group had no natural gas wells within a 10-mile radius. After adjustments for maternal and infant covariates, prevalence of congenital heart defects was significantly positively associated with increased exposure to natural gas development, with an increase of 30% (95% CI: 20% to 50%) for the highest exposure tertile when compared with the reference group. Prevalence of neural tube defects was significantly positively associated with exposure to natural gas development for the highest tertile of exposure, with an increase of 100% (95% CI: 0 to 390%) for the most exposed group when compared with the reference group. Exposure was associated with lower odds of preterm birth and lower odds of low birth weight (i.e., the high exposure groups were less likely to be preterm or low birth weight). No association was found between exposure and oral clefts.

It is notable that these two birth-outcome studies used similar study designs and observed associations between birth-outcome measures and maternal proximity to HVHF well pads. However, there is a lack of coherence between the observed associations in the two studies. Hill reported associations with low birth weight and APGAR score, but no associations with congenital defects. Conversely, McKenzie et al. reported associations between proximity to well pads and some congenital defects, but the highest exposure group had lower odds of preterm birth or low birth weight than the reference group. Taken together, the relationship between maternal proximity to HVHF well pads during pregnancy and birth outcomes, if any, is unclear.

Both birth-outcome studies used proximity to a drilling site as an exposure surrogate, rather than actual environmental contaminant measurements. This was a reasonable approach for an initial exploratory investigation, as it would be difficult and expensive to characterize indoor and outdoor exposures to all potentially relevant environmental agents (e.g., noise, air pollutants, groundwater pollutants, nighttime lighting) at numerous homes and workplaces. However, studies that employ vicinity as a surrogate for exposure cannot identify specific risk factors associated with the observed adverse outcomes or establish how, if at all, these risk factors were related to HVHF. For example, these studies cannot exclude the possibility that another factor unrelated to HVHF also varied by residence proximity to drill pads and contributed to the observed pattern of birth outcomes. The lack of coherent associations between this exposure surrogate and comparable outcomes may reflect weaknesses in the use of this exposure surrogate. The authors noted that greater specificity in exposure estimates would be required to further explore the reported associations.

Case Series and Symptom Reports

Bamberger and Oswald published a study in 2012, which documents case reports of animal and human health effects potentially resulting from nearby natural gas drilling operations. The summary of reported human health effects lacks specificity, but mentions a variety of symptoms such as upper respiratory, burning eyes, headache, gastrointestinal, dermatological, and neurological. The authors acknowledge the lack of complete testing of water, air, soil, and animal tissues that hampered more thorough analysis of the connection between gas drilling and health. They suggest further investigation is needed, ideally with policy changes that could assist in the collection of more complete data sets. Bamberger and Oswald were also guest editors for a 2013 special issue on shale gas development in the same journal (*New Solutions*). The articles in that special issue largely expand on potential health concerns raised in the original Bamberger and Oswald paper, although Bamberger and Oswald (2013) note in their introduction to the special issue that firm conclusions about potential health concerns cannot be established given the lack of relevant data.

Findings from an investigation done by the Earthworks' Oil & Gas Accountability Project were published in a non-peer-reviewed report (Steinzor, 2012). The report summarizes the extent and types of health symptoms experienced by 108 people from 55 households from 14 Pennsylvania counties where HVHF is occurring. It also has results of air sampling near 34 of the households and water sampling from nine of the households. It is difficult to interpret the results of this assessment. Participants report experiencing a number of symptoms, and the results suggest that those living closer than ~½ mile from a gas drilling facility may report symptoms in larger proportions than those living farther than ~½ mile. However, the sample is self-selected, and there was no systematic assessment of baseline health status or comparison with a similar population (the report does mention a five person control group that tended to experience fewer symptoms) unaffected by HVHF. The results also do not adequately account for potential confounders (except smoking).

An unpublished presentation of findings from the Southwest Pennsylvania Environmental Health Project (SWPA-EHP) was made available on the organization's web site. A formal report of these findings was not available; the findings are summarized in a slide presentation.[5] Self-reported symptoms were summarized for patients from one county in southwestern Pennsylvania who sought medical care at the SWPA-EHP clinic. Self-reported symptom categories occurring in 21 – 48 percent of individuals seeking medical care included: skin rash or irritation, nausea or vomiting, abdominal pain, breathing difficulties or cough, and nosebleeds. Other complaints mentioned in the presentation include anxiety/stress, headache, dizziness, eye irritation, and throat irritation. The presentation attributes up to 27 cases[6] of symptom complaints as plausibly associated with a source of exposure in either air or water. However, there is no environmental exposure assessment presented in support of the claimed associations. No air or water monitoring data are presented. The symptoms reported are common in the general population and can have many causes. As with the Earthworks analysis, the sample is self-selected, and there was no systematic assessment of baseline health status or comparison with a similar non-HVHF population. There is no information presented indicating that the analysis attempted to account for potential confounders or other existing exposure sources.

Rabinowitz et al. (2014) conducted a preliminary (hypothesis-generating) study in the same county in southwestern Pennsylvania as the SWPA-EHP report described above. The study found some evidence that residential proximity of natural gas wells may be associated with the prevalence of certain health symptoms, largely acute or self-limiting dermal and upper-respiratory conditions. As the authors noted, follow-up investigations would be required before drawing any conclusions with regard to actual disease incidence or possible causal relationships.

Results from a series of patient evaluations or symptom reports as presented above can only be considered hypothesis generating; that is, they can suggest possible relationships between an environmental exposure and health effects that could be investigated systematically in epidemiology studies designed to control for bias, confounding, temporality and chance findings. These types of clinical reports do not allow conclusions to be drawn about causal associations between HVHF exposures and health risks. However, while many of the reported symptoms are common in the general population, these reports indicate current information is not adequate to exclude the possibility that HVHF is contributing to public health impacts.

Local Community Impacts

There is a broad agreement in the public health community that social factors such as income, education, housing, and access to health care influence health status (i.e., so-called social determinants of health).[7] Many historical examples exist of rapid and concentrated increases in extractive resource development (e.g., energy, precious metals) resulting in local community impacts such as interfering with quality-of-life (e.g., noise, odors), overburdened transportation and health infrastructure, and disproportionate increases in social problems, particularly in small isolated rural communities where local governments and infrastructure tend to be unprepared for rapid changes.[8] These impacts could indirectly result in increased stress, which, in turn, can be associated with increased prevalence of some health problems (for example, WHO, 2009). Similar concerns have been raised in some communities where HVHF activity has increased rapidly (Texas DSHS, 2010).

For example, in some areas of HVHF well pad development nearly all water used for hydraulic fracturing is hauled to the pad by truck. One horizontal well is estimated to require about 1500 to 2000 truck trips over the entire life of the well (NTC Consultants, 2011).

A recent study from Pennsylvania reports that automobile and truck accident rates in 2010 - 2012 from counties with heavy HVHF activity were between 15% and 65% higher than accident rates in counties without HVHF. Rates of traffic fatalities and major injuries were higher in heavy drilling counties in southwestern Pennsylvania compared to non-drilling counties in 2012 (Graham, 2015). Major potential adverse impacts from increased truck traffic include increased traffic congestion and accidents; more damage to roads, bridges and other infrastructure; and spills of hazardous materials during transportation.[9]

Cancer Incidence

Fryzek et al. (2013) conducted a retrospective assessment of the potential for an association between childhood cancer incidence and HVHF in Pennsylvania, and reported no increase in childhood cancers after HVHF commenced. Study limitations included the insensitivity of the methods employed, the rarity of childhood cancers, and the absence of adequate lag time between most HVHF activities and most of the study's childhood cancer diagnoses. These raise some uncertainty about the strength of the study conclusions.

Non-peer-reviewed Information

In addition to investigating information in the peer-reviewed scientific literature, DOH has maintained an ongoing effort to follow news reports and other non-peer-reviewed sources for emerging information related to HVHF and potential public health impacts.[10] Many findings reported through such non-peer-reviewed sources are from informal or anecdotal health evaluations that have significant limitations such as self-selected symptoms reports, non-specific symptoms, lack of exposure data, lack of baseline health information, lack of unexposed comparison groups, and lack of controls for bias and confounding. Reports of this sort cannot be used to draw conclusions about associations between reported health symptoms or complaints and any specific potential environmental exposure source such as HVHF shale-gas development. However, these types of reports suggest hypotheses for associations between health outcomes and shale-gas activities that could be tested with proper environmental epidemiology methods.

HVHF Environmental Studies

Studies investigating HVHF impacts on environmental media such as air or water were included in the review if they provided information about the potential for human exposures from HVHF activity.

Air Quality Impacts

Maintaining good air quality is obviously vital for promoting public health; poor air quality can affect large populations of people, and therefore can contribute to significant morbidity and mortality. DOH programs promote clean outdoor air quality by developing health comparison values for use by DEC and by investigating and helping to correct conditions that contribute to poor indoor air quality. NYS was the first state in the country to establish indoor smoking prohibitions in public spaces under the NYS Clean Indoor Air Act.

The National Institute for Occupational Safety and Health (NIOSH) has assessed potential risks to workers associated with chemical exposure at natural gas drilling sites (NIOSH, 2012). In field studies conducted at 11 sites, respirable crystalline silica and diesel particulates were measured at levels with the potential to pose health hazards. NIOSH has proposed several controls and recommended proper use of personal protective equipment to minimize exposures. NIOSH has also reported that the occupational fatality rate among oil and gas industry workers is seven times higher than the average rate for all US industries (Retzer, 2011). On August 23, 2013, the federal Occupational Safety and Health Administration (OSHA) announced that it intended to propose a revised standard (called a permissible exposure limit) to protect workers from exposure to respirable crystalline silica.[11] OSHA's Notice of Proposed Rulemaking for Occupational Exposure to Respirable Crystalline Silica was published in the Federal Register on September 12, 2013.[12] If enacted, the new regulation would reduce the permissible exposure limit for crystalline silica and would establish certain other requirements related to measuring levels of silica in workplace air, controlling dust, providing respiratory protection, training of workers, and offering medical exams. While the NIOSH assessment focused on worksite air quality, this report is suggestive that uncontrolled silica emissions could affect the air quality of residences or businesses near well pads.

In 2010, the Texas Department of State Health Services collected blood and urine samples from 28 people, living in and near the town of Dish, to determine whether people there had higher levels of volatile organic compounds (VOCs) in their blood than 95% of the general United States (U.S.) population. Community residents had raised concerns that they were experiencing exposure to air contaminants from nearby gas wells and compressor stations. Measuring the presence of chemicals in biological fluids (i.e., biomonitoring) is a technique that can demonstrate that exposure occurred to those chemicals, but does not necessarily identify the source of the exposure, or when exposure occurred. Based on the pattern of VOC values found in the samples, the information obtained from this investigation did not provide evidence that community-wide exposures from gas wells or compressor stations were occurring in the sample population. Other sources of exposure such as cigarette smoking, disinfectant byproducts in drinking water and consumer or occupational/hobby related products could explain many of the findings.

In 2010, the Colorado Department of Public Health and Environment released a public health consultation evaluating the potential public health hazards of ambient air pollution in areas of Garfield County in close proximity to oil and natural gas development activities. This report summarized results from enhanced air quality monitoring implemented following a 2008 public health consultation[13] which found air concentrations near the upper end of EPA's acceptable range for benzene-associated cancer risk at one monitoring site. In this study, air monitoring was used to measure concentrations of chemical contaminants in the air near HVHF activities, and then those measured levels were compared to health-based comparison values for the chemicals. Health comparison values are a risk-assessment tool and are set at levels to be protective of public health. If comparison values are exceeded, it does not imply that adverse health impacts will occur, but it indicates that further investigation of potential exposures is warranted.

In the 2010 report, the investigators concluded that it could not be determined if breathing ambient air in those areas of Garfield County that were monitored could harm people's health. This conclusion was reached because the cancer risks and noncancer hazards for 65 out of 86 contaminants could not be quantitatively estimated due to the unavailability of chronic inhalation toxicity values. Although the evaluation suggests that exposures are not likely to result in significant cancer and noncancer effects (the levels measured are much lower than those known to cause health effects), cumulative health effects from synergistic interactions are unknown. Where quantitative evaluations were possible, increased risks of cancer, long-term (chronic) noncancer hazards and short-term (acute) noncancer hazards (where data were available) were low, although for the latter there is uncertainty because insufficient data are available to evaluate intermittent short-term peak exposures.

A similar risk-assessment study of air-quality monitoring in the Barnett Shale region of Texas was published in 2014 by Bunch et al. (2014). The study summarized air-monitoring data for volatile organic chemicals collected at six fixed monitoring locations in Wise, Denton and Tarrant counties in north-central Texas including areas in and around the city of Fort Worth. The monitoring network is operated by the Texas Commission on Environmental Quality (CEQ) and is described in the report as the most extensive air monitoring network in place in any U.S. shale play. The network includes both real-time monitors and 24-hour average samples analyzed in the laboratory, covers regions of the Barnett shale producing both dry and wet gas, and spans areas of urban and suburban development where the potential for community exposure to any shale-gas air emissions could be significant. The analysis of these data included assessing potential health risks of short-term and long-term exposure to all chemicals measured by the monitoring network using existing health comparison values (for example, Texas CEQ air monitoring comparison values or US EPA reference concentrations). Many of the chemicals measured by the existing network are unrelated to shale-gas development. Therefore, the authors also conducted more refined quantitative risk assessments for a subset of volatile organic chemicals thought to be most likely to be associated with shale gas production.

The Bunch et al. study summarized the results of over 4.6 million data points collected over more than 10 years for up to 105 different volatile organic chemicals per monitor. Only one observed short-term value exceeded an applicable odor-based comparison value.[14] None of the measured short-term (one hour or 24-hour average) air levels for the entire panel of chemicals exceeded an applicable short-term health-based comparison value. Only one chemical (1,2-dibromoethane) had any annual average concentrations that exceeded its applicable long-term health comparison value.[15] The authors noted that the analytical detection limit for 1,2-dibromoethane is substantially higher than its chronic comparison value and about 90% of the 1,2-dibromoethane results that contributed to the exceedances were non-detects. This suggests the true annual average concentrations could have been substantially lower than the reported estimates. The authors also did not consider 1,2-dibromoethane to be a chemical reasonably expected to be associated with shale-gas production. According to the authors, it is used as a lead-scavenger in aviation fuel. The two monitoring locations where the 1,2-dibromoethane 2011 annual averages exceeded applicable comparison values are located near airports. More refined deterministic and probabilistic quantitative risk assessments for annual average concentrations found that estimates of cumulative noncancer and cancer health risks were below levels of concern at all monitoring locations. The authors concluded that their analysis demonstrated that shale gas operations in the monitored region of the Barnett play have not resulted in community-wide exposures to the measured volatile organic chemicals at levels that would pose a health concern.

Macey et al. (2014) analyzed data from grab and passive air samples that were collected in Arkansas, Colorado, Ohio, Pennsylvania and Wyoming by trained volunteers at locations identified through systematic observation of industrial operations and air impacts over the course of residents' daily routines. The investigators reported that concentrations of eight volatile chemicals exceeded risk-based comparison values under several operational circumstances. Benzene, formaldehyde, and hydrogen sulfide were the most common compounds to exceed acute and other risk-based values. However, it was not always clear that the authors employed appropriate risk-based comparison values given the nature of the samples that were collected. For example, the use of comparison values based on lifetime (long-term) cancer risk levels may have substantially overstated cancer risks associated with exposures to short-term levels of air pollutants that were measured. Moreover, retrospective source apportionment efforts are not possible based on study data because the investigators did not collect the necessary control samples, such as upwind air samples, or wind direction data. This complicates evaluation of the study data because, at least in some urban and industrial settings, it is not unusual for atmospheric concentrations of benzene and formaldehyde to exceed some of the comparison values that were employed by the authors (Weisel, 2010).

The Pennsylvania Department of Environmental Protection (PA DEP) conducted short-term, screening-level air quality sampling initiatives in various parts of the Commonwealth where a majority of the Marcellus Shale operations have been undertaken.[16] Sampling windows often captured pollutant concentrations during the early morning hours and late evening hours, to reflect the predominate times when complaints related to Marcellus gas exploration activities are received by the DEP. Following the completion of a comparative analysis, which will consider data from separate surveys conducted in four Pennsylvania regions, the DEP will determine whether additional, longer-term sampling is warranted.

Data from the northeastern and northcentral regions of Pennsylvania are most relevant to New York State, since the Marcellus in those regions produces predominantly natural gas, rather than oil. The PA DEP did not find an immediate health risk to the general public. Certain compounds were detected at levels that produce odors. For example, methyl mercaptan was often detected at levels that generally produce odors. Methyl mercaptan is a naturally occurring compound present in some shale gas formations as well as in crude oil. Methyl mercaptan has a strong unpleasant smell that can be detected by the human nose at very low levels. Olfactory fatigue, or the loss over time of the ability to smell methyl mercaptan, occurs after prolonged exposure. The PA DEP determined that the methyl mercaptan levels detected could cause violations of PA DEP odor emission provisions in 25 Pa. Code Section 123.31 if they persisted off the property and the Department determined that the odors were “malodors” as defined in 25 Pa. Code Section 121. The PA DEP indicated that prolonged or repeated exposures to strong odors may produce odor-related health effects such as headaches and nausea.

Sampling for carbon monoxide, nitrogen dioxide, sulfur dioxide, and ozone in northeastern Pennsylvania did not detect concentrations above National Ambient Air Quality Standards at any of the sampling sites. With regard to benzene, only one two-minute benzene concentration of 400 parts per billion (ppb), reported in northcentral Pennsylvania, produced a hazard quotient[17] close to 1.0 when compared to the most conservative of the three health-based reference concentrations used in by PA DEP. Because of where the monitoring device was located (i.e., next to a parking lot and road), this one benzene reading was considered most likely due to a mobile source. The three canister samples collected during the week, which were sited away from the parking lot, did not detect elevated levels of benzene. Considering that this single high benzene value was measured at the background site, the PA DEP has determined that benzene should not be considered a pollutant of concern near Pennsylvania Marcellus Shale operations.

The PA DEP reported that the use of an infrared camera was an effective tool in showing emissions from drilling operations that may have impacted sampling results. At one well site, the camera documented leaks of what is most likely methane. Although the ambient methane concentrations detected in the air were not considered unacceptable in terms of adverse inhalation health effects, the methane emissions represented a waste of resources and a fractional contribution to greenhouse gas levels. The DEP therefore determined that the camera will continue to be deployed during its future investigative and/or sampling efforts.

Reports from other states using HVHF suggest it is common for trucks to form lines when awaiting access to gas well pads (Gold, 2013). If a line of idling trucks forms near a home, this could potentially increase residents' exposures to diesel exhaust for the duration of operations requiring idling. A recent West Virginia study determined that vehicle traffic and engine exhaust were the likely sources of intermittently high dust and benzene concentrations sometimes observed at distances of 625 feet[18] and farther from the center of well pads (McCawley, 2013).

Shonkoff et al. (2014) reviewed the scientific literature related to air pollution from shale and tight gas development, and noted differences in results obtained by different surveys. For example, McKenzie et al. (2012) reported relatively substantial exposures to certain volatile organic compounds (e.g., trimethylbenzenes, xylenes, and aliphatic hydrocarbons) among residents living ≤ 0.5 mile from oil and gas wells compared with residents living > 0.5 mile from wells. In contrast, Bunch et al. (2014) reported that shale gas production activities in the Barnett Shale Play, Texas, did not result in community-wide exposures to concentrations of volatile organic compounds above federal and state health-based air comparison values. Shonkoff et al. noted that differences between the two studies could have been due to the different sampling methods employed. For example, McKenzie et al., but not Bunch et al., considered data from samples collected at the local (community level) in close proximity to gas development.

Pétron et al. (2012) analyzed data collected at the National Oceanic and Atmospheric Administration Boulder Atmospheric Observatory and reported an alkane and benzene signature when winds blew from the direction of the Denver-Julesburg Basin, an area of considerable oil and gas development. Additional studies have documented substantial greenhouse gas releases and elevated atmospheric ozone concentrations from extensive exploitation of oil and gas deposits by various methods, including HVHF (Kemball-Cook, 2010).

Natural gas can also contain radon, a potential indoor air contaminant. A screening analysis by DOH (see Appendix 2) suggests that radon exposure levels from Marcellus natural gas could contribute a small fraction to the overall indoor radon levels. However, there is substantial uncertainty regarding radon levels in shale gas from various geographic locations and geologic formations because of limited monitoring data, especially from the Appalachian Basin (Rowan and Kramer, 2012), which includes the Marcellus shale.

Water Quality Impacts

Water quantity and quality have obvious importance for public health in terms of having reliable sources of water for public and private drinking-water supplies at all times. Surface waters provide additional indirect public health benefits related to fish resources (both recreation and for food), recreational use (swimming and boating) and flood control in the case of wetland areas. Maintaining adequate surface water quantity and quality helps promote these health benefits. Under the federal Safe Drinking Water Act (SDWA), the US Environmental Protection Agency (US EPA) established the public water system supervision program. In New York State, the DOH has the primary responsibility for implementing and enforcing the drinking water regulations of the SDWA for all public water systems.[19] This also includes oversight and implementation of US EPA's Surface Water Treatment Rule.

With the promulgation of the Surface Water Treatment Rule in the late 1980s, all drinking water taken from surface water sources must be filtered to reduce the risk of waterborne disease. However a waiver, or Filtration Avoidance Determination (FAD), may be granted to a water supplier if it is able to demonstrate ongoing compliance with strict water quality criteria and if it has a plan for the long-term control and management of its watershed.

In New York State, both the City of Syracuse and the City of New York have been issued a FAD. The FAD for the Syracuse public water supply system encompasses Skaneateles Lake and its 59 square mile watershed and for New York City, the FAD encompasses the Catskill and Delaware (Cat/Del) water supplies and its 1600 square mile watershed in the Catskills.

While watershed management is important for any surface water supply, it is critical and required for an unfiltered FAD system. Therefore, both the NYC Cat/Del and Skaneateles Lake watersheds are unique natural and hydrological sources of importance within the State. The importance of these resources is highlighted, in particular, by the 1997 NYC Watershed Memorandum of Agreement (MOA). The MOA is a landmark agreement that recognizes both the importance of preserving high-quality drinking water and the economic health and vitality of communities located within the watershed. It is a legally binding 145 page contract, with 1500 pages of attachments, between NYC, the State, US EPA, nearly 80 local governments in the watershed and environmental groups.

The literature investigating water-related impacts of HVHF activity is relatively extensive compared to literature on other environmental impacts, although most studies do not directly assess the potential for human exposure or public health impacts from water contamination. Osborne et al. (2011) first highlighted the potential for sub-surface methane migration from HVHF activity to affect drinking water wells in Pennsylvania, and subsequent reports from the same group of researchers have continued to investigate this potential source of groundwater contamination. The following summarizes a few of the most recent water-quality investigations of HVHF that could be most germane to understanding the potential for HVHF to contribute to human exposure through drinking water.

Some recent publications have shed light on the potential for and causes of occasional water pollution incidents around oil and gas wells (for example, see: Satterfield, 2011; Sharma, 2014; Warner, 2014; Zhang, 2014). Darrah et al. (2014) identified groundwater contamination clusters that they determined were due to gas leakage from intermediate-depth strata through failures of annulus cement, faulty production casings, and underground gas well failure. Vengosh et al. (2014) identified published data revealing evidence for stray gas contamination, surface water impacts, and the accumulation of radium isotopes in some disposal and spill sites. Some preliminary data suggest inadequate HVHF wastewater treatment could contribute to formation of disinfection byproducts in treated surface waters (e.g., Chang, 2001; Parker, 2014). These and other reports indicate that there remain data gaps and uncertainties regarding the effectiveness of some common mitigation measures related to both well construction and wastewater management, at least as these have been implemented in other states.

An investigation was reported by Kassotis et al. (2014) using in vitro (i.e., cell culture) assays to assess the estrogen- and androgen-receptor activity of HVHF chemical additives and environmental water samples. Twelve chemicals were chosen that were considered to be known or suspected endocrine-disrupting chemicals and were chemical additives used in natural gas operations in Colorado.[20] Groundwater and surface water samples were collected in Garfield County Colorado from areas considered “drilling dense” near locations where natural gas “incidents” had occurred. Reference groundwater and surface samples were collected in areas of Garfield County considered “drilling sparse” and from the nearby Colorado River and a non-drilling reference location in Missouri. Assay results showed the twelve chosen chemicals showed varying degrees of anti-estrogenic and anti-androgenic activity compared to positive control activities (17β -estradiol and testosterone, respectively). Groundwater and surface water samples concentrated 4-times or 40-times from their levels in the environment had varying degrees of estrogenic, anti-estrogenic or anti-androgenic activity in the test assays, generally with higher activities seen from samples collected from the drilling dense sites, although differences from reference samples were not always statistically significant.

Kassotis et al. concluded that, based on *in vitro* assay results of the selected chemicals and water samples from drilling dense vs. reference locations, natural gas drilling operations may result in elevated endocrine disrupting activity in groundwater and surface water. There are a number of study limitations that suggest a strong conclusion attributing the observed assay responses to natural gas drilling is questionable. For instance, there were no chemical analyses presented of the drilling-dense water samples that would allow an evaluation of whether the observed assay results were due to drilling-related chemicals present in the water or to other unrelated chemicals that could have been present from other sources. Similarly, drilling-dense samples and reference samples were not always matched for other potentially influential factors aside from drilling proximity such as the type (drinking water vs. monitoring) and depth of groundwater wells, stream ecology or land use differences adjacent to sampling locations.

Drilling-dense sampling sites were described by Kassotis et al. as being associated with "natural gas incidents" including equipment leaks, spills or natural gas upwelling. However, these incidents took place at varying times from several months to several years prior to sampling and could have involved very different mixtures of materials (such as bulk chemical additives during a spill or formation brine from an equipment leak). The investigators did not provide details concerning the specific nature of any water contamination that might have resulted from these incidents or what environmental remedial activities may have taken place prior to collecting water samples. This information would have been helpful in evaluating the likelihood that water contamination from the incidents had occurred and persisted in the sampled water sources. This information is especially important because the study report provided no analyte concentration data for the study water samples. The proximity of water sample collection locations to drilling activity alone does not conclusively indicate that natural gas drilling operations result in endocrine disrupting activity in the water. Even if further detailed research supported drilling-related contaminants as the source of increased endocrine disrupting activity in the *in vitro* assays used in this study, the relevance of the study methods to actual human exposure and human physiological responses are unknown. Therefore, these results do not allow any assessment of the potential risk to human health posed by such contamination.

A critical review of water resource issues associated with HVHF (Vengosh, 2014) noted that treatment and disposal of HVHF solid waste and wastewater is a significant challenge. Gas wells can bring naturally occurring radioactive materials (NORM) to the surface in the cuttings, flowback water and production brine. NORM consists of uranium and thorium and their decay products. Some of those decay products, namely radium and radon, can be a public health concern if exposure occurs at sufficiently-high levels. Rocks and soil contain NORM at various levels, and certain types of rock tend to have higher concentration of NORM.

NORM in flowback and production brine can plate out and concentrate on internal surfaces of pipes and tanks (scale). NORM in pipe scale contains predominantly radium. This can cause an external radiation exposure risk to workers who work with this equipment.

Induced Earthquakes

Although it has long been known that some forms of underground fluid injection can increase the risk of earthquakes,[21] the long-term impacts of extensive hydraulic fracturing upon the risk of earthquakes in the Northeastern U.S. remains poorly understood. In contrast, some information regarding short-term risks above the Marcellus and Utica shale plays has become available.

Holland (2014) described one of the first observed cases in Oklahoma of earthquakes triggered by the hydraulic fracturing phase (rather than underground wastewater injection). The earthquakes were large enough to be felt by local residents.

In Maxwell's (2013) description of an approach to evaluating HVHF-related seismic events, criteria for confirming events, and existing injection and HVHF seismicity protocols, the author described several seismic events ranging from low to moderate energy. According to the author, during April and May of 2011 hydraulic fracturing near Preese Hall, UK, resulted in an event with magnitude ML=2.3 (local magnitude scale) and later another ML=1.5. The author added that, between 2009 and 2011, 38 earthquakes including a ML=3.8 resulted from hydraulic fracturing in the Horn River Basin shale gas reservoir in north-east British Columbia, Canada.

In 2014, the Ohio Department of Natural Resources (ODNR) announced new, stronger permit conditions for drilling near faults or areas of past seismic activity.[22] The new policies were developed in response to seismic events in Poland Township (Mahoning County) that the ODNR determined were probably connected to hydraulic fracturing near a previously unknown "microfault." Under the new rules, permits issued by ODNR for horizontal drilling within three miles of a known fault or area of seismic activity greater than a 2.0 magnitude require companies to install sensitive seismic monitors. If those monitors detect a seismic event in excess of 1.0 magnitude, activities must pause while the cause is investigated. If the investigation reveals a probable connection to the hydraulic fracturing process, all well completion operations must be suspended. ODNR says that it will develop new criteria and permit conditions for new applications in light of this change in policy. The department will also review previously issued permits for wells that have not been drilled.

Conclusions – Health and Environmental Literature

The science surrounding HVHF shale-gas development and public health risks is only just beginning to emerge. Many of the published reports investigating environmental and health implications of HVHF activities are preliminary or exploratory in nature. As a result, the available science on HVHF currently is limited and largely suggests hypotheses about potential impacts that need further evaluation. Health impacts that have been reported to be potentially associated with exposure to HVHF activities include a variety of acute or self-limiting signs and symptoms such as skin rash or irritation, nausea or vomiting, abdominal pain, breathing difficulties or cough, nosebleeds, anxiety/stress, headache, dizziness, eye irritation, and throat irritation. Other outcomes that have been reported as potentially associated with HVHF exposure include low birth weight and some congenital defects. Studies of environmental impacts have documented sub-surface methane migration from well casings to groundwater and methane leakage to the atmosphere from HVHF infrastructure. Other environmental impacts including noise and dust from well pads and truck traffic, increased traffic accident rates, inadequate wastewater treatment, and induced earthquakes have been observed. The actual degree and extent of these environmental impacts, as well as the extent to which they might contribute to adverse public health impacts are largely unknown. Nevertheless, the existing studies raise substantial questions about whether the public health risks of HVHF activities are sufficiently understood so that they can be adequately managed.

| Results

Information Gathered from Outside Authoritative Organizations, Public Health Experts, and Formal Health Impact Assessments

Other information sources were sought to provide additional background information on public health risk of HVHF for the Public Health Review. Former Commissioner Shah, Acting Commissioner Zucker, and DOH staff held multiple discussions and meetings with public health and environmental authorities in several states to understand their experience with HVHF. Former Commissioner Shah, Acting Commissioner Zucker, and DOH staff also engaged in a number of discussions and meetings with researchers from academic institutions and government agencies to learn more about planned and ongoing studies and assessments of the public health implications of HVHF. Input was sought from three public health expert consultants regarding the potential public health risk posed by HVHF activities. And, health impact assessments conducted by other state, provincial and international governments were reviewed for any additional insights regarding HVHF public health concerns.

Health Impact Assessments

A health impact assessment (HIA) is a decision tool that uses a structured assessment approach to identify impacts of an activity or policy decision and recommend ways to lessen or prevent adverse public health impacts under alternate decision options. The results of these assessments tend to be based on qualitative judgments when decision alternatives being considered involve large-scale, complex issues such as HVHF. HIAs that examined public health risks of HVHF have recently been conducted by governments or academic institutions in Maryland (University of Maryland, 2014), Michigan (University of Michigan, 2013), North Carolina (Research Triangle Environmental Health Collaborative, 2013), Nova Scotia (Wheeler, 2014), the National Institute of Environmental Health Sciences (NIEHS; Penning et al, 2014), the Institute of Medicine (IOM, 2014), and the European Commission (Broomfield, 2012).

The European Commission, which is the executive body of the European Union, published a report (Broomfield, 2012) on the results of a preliminary screening of potential public health and environmental risks related to HVHF in Europe, along with risk management recommendations. For each risk identified by the Commission, the preliminary risk screening approach combined a subjective adverse event probability classification ("rare" to "frequent/long-term definite") with a subjective hazard classification ("slight" to "catastrophic") to develop a risk classification ("low" to "very high"). Using this approach, the Commission determined that HVHF in Europe will entail "high" cumulative risks of groundwater contamination, surface water contamination, depletion of water resources, releases to air, increased noise, and increased traffic.

A 2011 Executive Order Issued by Maryland Governor Martin O'Malley established the Maryland Marcellus Shale Safe Drilling Initiative.[23] The Initiative is jointly administered by the Maryland Department of the Environment and the Maryland Department of Natural Resources. The Executive Order also established a Marcellus Shale Safe Drilling Initiative Advisory Commission composed of a variety of governmental, community, environmental and industry stakeholders. According to the Executive Order, the purpose of the Initiative is to:

"… assist State policymakers and regulators in determining whether and how gas production from the Marcellus shale in Maryland can be accomplished without unacceptable risks of adverse impacts to public health, safety, the environment and natural resources."

As part of the Maryland Initiative, the Maryland Department of Health and Mental Hygiene (MDHMH) announced in September, 2013, two public meetings to receive public input on a study of potential public health impacts associated with possible development of the Marcellus Shale in Western Maryland.[24] MDHMH then oversaw the study, which was performed by the University of Maryland School of Public Health's Maryland Institute for Applied Environmental Health. The final study report, entitled "Potential Public Health Impacts of Natural Gas Development and Production in the Marcellus Shale in Western Maryland," was published in July 2014.[25] The report identifies largely the same types of potential health impacts of HVHF activity as those identified in other HIAs. The report presents a hazard evaluation summary of eight potential adverse impacts, rating four (air quality, healthcare infrastructure, occupational health, and social determinants of health) as having a high likelihood of negative public health impact. Three potential impacts (cumulative exposures/risks, flowback and production water-related, and noise) were rated as moderately high, and one (earthquakes) was rated as low.

In 2013 the University of Michigan's Graham Sustainability Institute released several technical reports on HVHF in the State of Michigan that were intended to provide information for decision makers and stakeholders, as well as to help inform the Institute's "Hydraulic Fracturing in Michigan Integrated Assessment," which will evaluate policy options.[26] Faculty-led and student-staffed teams provided reports on the following topics: Technology, Geology/Hydrogeology, Environment/Ecology, Human Health, Policy/Law, Economics, and Public Perceptions. The Institute noted that its technical reports should not be characterized as final products of the integrated assessment, and that the reports do not provide a scientific risk assessment for aspects of HVHF.

In its Public Health technical report, the Institute preliminarily identified 18 possible public health issues related to HVHF, with "plausibility scores" reflecting qualitative assessments of the evidence suggesting that each issue could be considered a potential public health hazard.[27] Of the 18 issues enumerated, eight were given the highest plausibility score, reflecting the Institute's determination that "scientific evidence exists and is strong (e.g., many studies, good design, causality)." These eight issues were silica exposure, intentional-use chemicals, by-product chemicals, transportation, air quality, water quality, habitat and wildlife (impacts on recreational opportunities, cultural/spiritual practices), and public perceptions (causing, e.g., increased anxiety, family quarrels, depression).

The Institute discussed several "challenges and opportunities" with regard to HVHF in Michigan, beginning with Michigan's lack of a public health tracking system. The Institute also called for complete disclosure of chemicals injected during HVHF, noting that disclosure has thus far been minimal in Michigan, with only a few facilities reporting upon a small number of drilling events out of more than 12,000 wells that have undergone HVHF. The Institute additionally recommended more public health outreach and education in Michigan, particularly in potentially-impacted communities, similar to recommendations in our review. Finally, the Institute indicated that a health economist should be enlisted to help describe risks and benefits of HVHF compared with alternative energy sources.

In response to state legislation allowing the use of horizontal drilling and hydraulic fracturing in North Carolina, a summit meeting was convened in October, 2012, by the Research Triangle Environmental Health Cooperative (EHC). A report presenting recommendations from the summit was released in 2013.[28] According to the report, summit participants represented diverse stakeholder groups including industry, nonprofits, governmental organizations and academia. The report stated that:

> *"The EHC summit aimed to create a neutral space in which to share ideas and experiences to identify gaps in the current knowledge of, and preparations for, the potential impacts of hydraulic fracturing on public health in North Carolina. The summit recommended actions and potential policies to safeguard the health of North Carolinas citizens and environment if hydraulic fracturing occurs in the state."*

Three working groups were formed as part of the summit – exposure pathways, health impacts, and social impacts – and each working group made relevant recommendations for developing new components or strengthening existing components of the state's oil and gas program. While each working group developed extensive specific recommendations, major themes that were common to the working group recommendations included:

- Collect baseline data prior to oil and gas drilling. This includes data on water quality, hydrogeological information, hydrocarbon characterization, air quality, ecosystem information, and population health statistics.
- Develop a comprehensive water and wastewater management plan that addresses how water is allocated among users and how oil and gas drilling wastewater will be managed through treatment, reuse/recycling and disposal.

- Provide adequate and coordinated funding and administrative oversight for oil and gas development programs. Specifically, the state should develop a bonding and remediation program to provide adequate cleanup, remediation, and maintenance funds. Drilling companies should pay into a "premediation" fund financed by a permit fee to drill an oil or gas well. Additional funding is needed to adequately address the potential environmental and social costs of hydraulic fracturing, including collection of comprehensive environmental and health data before, during and after the drilling process. Local, state, and regional agencies should coordinate the administration and oversight of hydraulic fracturing and should avoid duplication of effort.
- Develop and promote a list of best management practices (BMPs) for drilling and hydraulic fracturing. These BMPs should focus on: preventing contaminants from entering the environment; containing contaminants if they do accidentally enter the environment; and monitoring for contaminants to quickly detect releases if they occur, stop them, and begin remediation. Effective regulations require enforcement if violations occur. Regulations must also keep pace with the rapid technological developments in the shale gas industry.

Another assessment was conducted in 2014 by the Nova Scotia Independent Panel on Hydraulic Fracturing, which determined that although HVHF would provide major economic and employment benefits to the province, Nova Scotia does not have the necessary information required to make a final decision on whether to allow HVHF in the province (Wheeler, 2014).[29] Among other things, the review found that: many questions about fracking remain outstanding; municipalities, citizens, Aboriginal governments, and communities should be involved in the risk-assessment and decision-making process; and the report should be used as a basis for informed debate on the issue of HVHF in Nova Scotia. The report recommends that stakeholders "spend whatever time is necessary learning about these issues, keeping an open mind of future developments …" The report also provides 32 recommendations "to safeguard community health, local economies, ecosystem health, and the environment," in the event that the province moves forward with HVHF.

An assessment was published in 2014 by a working group formed by Environmental Health Sciences Core Centers that are funded by the National Institute of Environmental Health Sciences (Penning, 2014). The Inter-Environmental Health Sciences Core Center Working Group on Unconventional Natural Gas Drilling Operations concluded that there are data gaps and uncertainties regarding impacts and the effectiveness of HVHF mitigation measures. The group further concluded that a potential for water and air pollution exists which might endanger public health, and that the social fabric of communities could be impacted by the rapid emergence of drilling operations. The working group recommended research to inform how potential risks could be mitigated. The assessment did not identify novel information or issues, but it lends support to some of the conclusions made in this Public Health Review with regard to data gaps and uncertainties regarding HVHF-related public health impacts.

In 2012, a workshop convened by the Institute of Medicine (IOM) Roundtable on Environmental Health Sciences, Research, and Medicine discussed the human health impact of shale gas extraction through the lens of a health impact assessment. The workshop examined the state of the science regarding shale gas extraction, the direct and indirect environmental health impacts of shale gas extraction, and the use of health impact assessment as a tool that can help decision makers identify the public health consequences of shale gas extraction (IOM, 2014).

The review of HIAs for this Public Health Review focused on identifying any public health risks different from those identified through the scientific literature review. The review found that the public health risks and information gaps identified in the published HIAs were qualitatively similar to those discussed in the literature review section above. In some cases, specific public health risks were emphasized in these assessments:

- The European Commission HIA determined that HVHF in Europe will entail "high" cumulative risks of groundwater contamination, surface water contamination, depletion of water resources, releases to air, increased noise, and increased traffic.
- The University of Michigan assessment identified priority issues including silica exposure, intentional-use chemicals, by-product chemicals, transportation, air quality, water quality, habitat and wildlife (impacts on recreational opportunities, cultural/spiritual practices), and public perceptions (causing, e.g., increased anxiety, family quarrels, depression).
- The North Carolina HIA emphasized planning and monitoring including: collecting baseline data on water quality, air quality and health statistics; developing a comprehensive water and wastewater management plan; adequately support coordinated enforcement; and, develop and promote best practices.
- Both the NIEHS and IOM assessments emphasized the potential for water and air pollution that could adversely affect public health as well as the potential for social disruption that could result from local community impacts caused by rapid development of HVHF activities.

Meetings with Other State Agencies

Commissioner Shah met with officials of the California Department of Public Health (CDPH) and the California Department of Conservation (CDOC) in July, 2013. In

August, 2013, he held separate meetings with officials in Texas (representing the Texas Department of State Health Services (TDSHS), the Texas Railroad Commission (TRC), and the Texas Commission on Environmental Quality (TCEQ)) and officials in Illinois (representing the Illinois Department of Public Health (IDPH) and the Illinois Department of Natural Resources (IDNR)). The purpose of these meetings was to learn directly from the state agencies about each state's experience with oil and gas development and to evaluate how the oil and gas regulatory programs in those states compare to the regulatory program in New York State. The following summarizes the findings of these meetings at the time they occurred in 2013.

California

Like New York, California has a long history of oil and gas development. As is currently the case in New York, essentially all oil and gas wells in California are vertical wells. Most oil wells in California are stimulated using low-volume hydraulic fracturing. The geology in areas currently being developed in California is very different from the Marcellus Shale formation in New York. Most current activity in California produces oil from tight sand formations. These formations also produce a large quantity of formation water (brine), which is re-used for hydraulic fracturing and for enhanced oil recovery. A small fraction of the produced brine is treated and can be used for agricultural irrigation. The formations currently being drilled in California have very little naturally-occurring radioactive material (NORM). The Monterey Shale in California is a shale formation somewhat analogous to the Marcellus Shale, although the Monterey is expected to produce primarily oil. Exploitation of the Monterey Shale would require horizontal drilling and high-volume hydraulic fracturing, but activity in this formation on a commercial scale has so far not taken place because of technical challenges due to the unusual chemical and physical properties of the formation.

Unlike New York, where low-volume hydraulic fracturing has been specifically regulated under the Generic Environmental Impact Statement since 1992, California does not currently have formal regulations specific to hydraulic fracturing. A discussion draft of proposed hydraulic fracturing regulations was released by CDOC for public review and comment in December, 2012. Public feedback was obtained on the discussion draft in a series of public hearings, and a formal proposed rule is expected to be released soon. The discussion draft indicates that all records submitted under the rules would be considered public records for the purposes of the state's public records law. The discussion draft includes provisions that would require well operators to publicly disclose all information about chemical additives and carrier fluids used in hydraulic fracturing fluids for a well. This requirement would be subject to exceptions for information claimed to be trade secrets.

California does not currently conduct public health surveillance monitoring related specifically to oil and gas development. As is the case in New York State, CDPH monitors water quality for public drinking water supplies as a routine part of its drinking water regulatory program. CDPH has reviewed 250 million individual sampling results from its regulatory water monitoring program. Nine drinking water wells were found to have had detections of chemicals used in hydraulic fracturing. Of those, only two wells had an oil or gas well nearby and further investigation suggested the contaminants were most likely related to other sources.

Texas

Texas also has a long history as a major oil and gas producer in the U.S. In 2011, Texas produced the largest quantities of oil and natural gas of any state. Hydraulic fracturing has been used in the state for about 60 years. Starting in 2004, Texas' Barnett Shale formation was one of the first locations in the United States where high-volume hydraulic fracturing and directional drilling were used on a commercial scale to develop an unconventional shale formation. The Barnett Shale is a shale formation underlying areas of north Texas including the City of Fort Worth and surrounding suburban and rural counties that is geologically somewhat similar to the Marcellus Shale. Other areas of significant oil and gas development in unconventional shale formations in the state include the Eagle Ford Shale in south Texas and the Haynesville-Bossier shale in east Texas. The Cline Shale in west Texas is now also attracting commercial attention for potential oil production.

Oil and gas development in Texas is regulated by the TRC. Operators are required to comply with all TRC rules, which cover all aspects of well development, such as well construction, casing and cementing, drilling operations and flaring. Operators are required to document their compliance in well completion forms. Well cementers are licensed in Texas, and well operators are required to employ licensed cementers. Unlike New York regulations, the TRC rules do not include specific separation distances from resources such as surface water. Hydraulic fracturing chemical additive information is required to be submitted to fracfocus.org (a publicly-available online database), with the exception of additive information claimed as trade secrets. The TRC can require operators to provide trade secret information to the agency if needed to respond to emergency situations. There are essentially no oil and gas wastewater discharges in Texas. Most oil and gas wastewater is disposed of in Class II underground injection disposal wells. Some wastewater recycling for use in hydraulic fracturing is now being done. The TCEQ issues permits for air pollutant emissions from oil and gas facilities, and also conducts routine air monitoring and enforcement monitoring. TCEQ has a large network of fixed air monitoring stations for volatile organic chemicals, including monitoring sites located near Barnett Shale wells. TCEQ also uses hand-held and aircraft-mounted infra-red cameras for compliance and enforcement monitoring of oil and gas facilities such as pipelines, tanks, and compressors. The cameras obtain direct evidence of leaks or fugitive emissions of volatile chemicals from equipment and are considered an important enforcement tool by TCEQ staff.

The TDSHS does not have a health surveillance program specific to oil and gas development, but does maintain several general public health surveillance programs similar to those in New York such as infectious-disease reporting, birth defects registry, cancer registry, and trauma registry. TDSHS has noted boomtown problems in some rural parts of the state with rapid increases in oil and gas development. In particular, increased incidence of sexually-transmitted diseases has been observed. Also, acute housing shortages, including shortages of hotel rooms in remote locations, have been observed to result in challenges for regulatory agencies visiting these areas and for social services agencies attempting to place clients in temporary housing. Commonly reported local concerns related to oil and gas development include noise, odors, and impacts from truck traffic.

Illinois

Illinois has a history of oil and gas development similar to New York's. As in New York, conventional vertical wells in Illinois have been stimulated with low-volume hydraulic fracturing for many decades. The New Albany shale formation is an unconventional shale that would require directional drilling and HVHF stimulation for commercial oil and gas development. Illinois convened representatives from statewide environmental organizations and from industry to negotiate legislative language for a program to regulate HVHF activity in the state. The bill was passed into law in 2013 and the IDNR is the agency responsible for implementing the regulatory program.

IDNR staff described several significant elements of the Illinois program that were agreed to in the negotiations. Each well permit application under the Illinois program will be subject to a public hearing process ("contested case" process). Operators in Illinois will be required to conduct water monitoring before and after drilling a well. In Illinois, operators will be subject to a rebuttable presumption of liability, meaning that if water contamination near a HVHF well is discovered, the operator will be assumed to be liable for the contamination unless they can show they did not cause it. A similar law applies to drillers in Pennsylvania, but not in New York. Operators in Illinois will be required to provide complete information on the formula of chemical additives used in each HVHF well to the IDNR. The information will be made available publicly, except for information protected as trade secrets under state law. However, IDNR will be able to share the trade secret information with other state agencies, local emergency responders and physicians when necessary. Operators in Illinois will be required to store HVHF wastewater (including flowback and produced water) in above-ground storage tanks. The draft SGEIS contains the same requirement.

The IDPH does not currently have a health surveillance program specifically targeted at HVHF development. However, the state does maintain similar health surveillance programs to those in New York, including cancer and birth-defect registries and daily chief complaint reporting from emergency departments (i.e., syndromic surveillance). As IDNR works to draft administrative rules to implement the new HVHF law, an inter-agency workgroup in Illinois has been formed that includes relevant state agencies including IDPH. One issue being considered by the workgroup is the roles and responsibilities of each agency in the implementation of the program. Enhanced public health surveillance activities to be conducted by the IDPH is one area being considered by this workgroup. IDPH staff on the call also suggested that health surveillance activities focused on unconventional oil and gas development (which includes HVHF and other technology such as directional drilling) might ideally be coordinated at a national level by the federal Centers for Disease Control and Prevention. However, such a national surveillance program does not currently exist.

As is the case in New York, IDPH works as a consulting agency to address public health issues that are raised by the environmental and natural-resources agencies in the course of monitoring studies or complaint investigations. IDPH is also considering providing relevant training for HVHF-related emergency events to local physicians and emergency responders. IDPH has been made aware of some significant public health concerns in an area of the New Albany shale located in southwestern Ohio where HVHF development is already active. Quality-of-life impacts were mentioned as particularly notable in that region. Examples included rapid increases in housing costs resulting in some renters being priced out of their homes and significant infrastructure damage in some localities due to increased truck traffic.

Public Health Expert Consultation

As part of this Public Health Review, DOH sought additional input on public health aspects of the draft SGEIS by consulting with three external public health experts. The consultants were provided with DEC and DOH documents to review. Meetings were held with the consultants by conference call and the consultants presented their final comments and recommendations in the form of letters to former Commissioner Shah. The public health expert consultants were given three charge questions to help focus their review. Those charge questions were:

- Are there additional potential public health impacts of HVHF gas development that should be considered beyond those already discussed in the SGEIS?

- Are additional mitigation measures beyond those identified in the SGEIS needed to address the potential health impacts of HVHF? If so, what additional prevention or mitigation measures are recommended?
- Are existing and proposed environmental and health monitoring and surveillance systems adequate to establish baseline health indicators and to measure potential health impacts? If not, what additional monitoring is recommended?

The following letters from the public health expert consultants report their findings and recommendations to former Commissioner Shah.

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March 3, 2013

Nirav M. Shah, MD, MPH
Commissioner
New York State Department of Health
Albany, NY
Via Email

Dear Dr. Shah:

Thank you for the opportunity to review your Department's "A Public Health Review of the Department of Environmental Conservation's Supplemental Generic Environmental Impact Statement for Shale---Gas Development" (hereafter, PHR). Your November 20, 2012 letter included the draft report and associated materials on health outcome surveillance, existing and planned interactions between state and local agencies under the proposed shale-gas program, the DEC's SGEIS and the response to comments on the SGEIS.

Your charge to reviewers asked us to "focus on whether additional public---health impacts should be considered in the SGEIS and whether additional mitigation measures are needed to address potential public---health impacts." I provided initial comments on the November 20 draft prior to our conference call on Monday December 3, 2012. After discussion with you, your staff, and my fellow peer reviewers, I wrote the first version of this letter and submitted it to you on December 18, 2012. This new version comments on the updated PHR I received in February 2013. My comments are integrated into the earlier text, with some additional points added as an addendum.

My comments in this letter adopt the convention of using "HVHF" or the phrase "shale gas development" to describe the entire process of natural gas well development and production. I do so because hydraulic fracturing is just one step in the natural gas development process and the potential public health impacts are wide ranging and not limited to fracturing. Lastly, since the final decision ultimately rests with New York decision-makers, these comments are designed to address potential impacts and evaluate proposed mitigations in the event the HVHF ban in New York State is lifted.

My responses to the specific charge questions are below, followed by conclusions and final comments.

Are there additional potential public---health impacts of HVHF gas development that should be considered beyond those already discussed in the SGEIS?

If NY State decides to allow HVHF the DOH has developed a viable approach to addressing the main public health issues associated with shale gas development. The PHR and SGEIS describe a phased start to shale gas development that is coupled with baseline and subsequent monitoring of potential impacts. Although the PHR does not miss any major categories, I have highlighted potential impacts that I believe warrant further attention.

The SGEIS acknowledges that increased traffic accidents are among the expected impacts of HVHF. Given that local government jurisdictions, as opposed to the state, have legal authority to designate and enforce local traffic and road---use laws, it is important that DOH provides communities with tools to address this issue. After our phone call it is my understanding that DOH will recommend that DEC seek ways to strengthen the SGEIS in the area of local road---use agreements, including development of model plans, and will develop approaches for including traffic---related injuries in planned prospective surveillance.

The SGEIS addresses concerns about noise and fugitive dust from pads and traffic, but it is important that DOH clearly define what is included in "visual impairment" and address other nuisance issues that residents may experience. "Light pollution," vibration, and odors can be an issue for residents living near well pads and other production facilities. If gas development occurs in populated areas the impact of odors (as distinct from criteria air pollutants and air toxics) is a likely common complaint. These complaints are often the first signals of air pollution impacts. Details of how DOH plans to work with local health departments to formalize and coordinate systematic data collection on light, vibration, odors, noise, and other nuisance issues should be fleshed out in the PHR and SGEIS. Development of a database for systematic recording of inquiries and citizen complaints can help to identify sentinel events and address community concerns about the potential impacts on health and quality of life.

The SGEIS air analysis looks at both criteria and non---criteria air pollutants and is reasonable to the extent that emission inventories, models, and other key assumptions are reliable. One key uncertainty that should be emphasized in the PHR is the lack of health-based standards for some of the air toxics emitted during well development. Although it is reasonable to use annual and short-term guideline concentrations, EPA provisional risk concentrations, and toxicity values from other authoritative sources, modeling these emissions, as described in the SGEIS, is only the first step in assessing potential air risks. Linking these models to the measurements included in the mitigation plans is important for assessing impacts and evaluating the effectiveness of mitigation.

The term "setback" largely applies to distances to key watersheds in the PHR. I encourage broadening the use of this term in discussions with the public to include distances from air emission sources as well. The PHR summary notes that DEC needs to define more clearly setbacks from NYC watersheds and related infrastructure. The rationale for setbacks for water, air, noise, and other quality of life impacts needs to be clearer throughout the PHR and SGEIS.

The risk from HVHF near plugged or abandoned wells is not directly addressed in the PHR. This potential hazard should also be explored to the extent feasible. Both this hazard and potential well casing failure are scientific uncertainties that may impact on aquifers over time. The SGEIS cites a relatively small probability for well casing failure, but also notes that some parameters that feed into this risk estimate are uncertain. I agree with the DOH's assertion that the value of a highly uncertain probabilistic risk estimate is difficult for decision---makers to evaluate. Nonetheless, the potential for catastrophic failure should be acknowledged given the potential high consequence of a failure.

The overall impact of stress on individual and community health is an important issue that the DOH and DEC need to acknowledge and assess as rigorously as possible. While this concept is implicit in some of the SGEIS text, stress needs to be more fully addressed in the PHR and SGEIS. To help alleviate this concern the DOH and DEC need to encourage active public participation in the permitting process, foster community right---to---know, and make certain monitoring data is publically available. A substantive, ongoing dialogue between State of NY officials and communities will be needed to address this issue long term.

Are additional mitigation measures beyond those identified in the SGEIS needed to address the potential health impacts of HVHF? If so, what additional prevention or mitigation measures are recommended?

As mentioned above, road---use agreements between operators and municipalities are important for reducing potential impacts from truck traffic. While this is appropriate, how this is implemented and enforced at the local level is a key part of mitigation. It is important that DOH work with DEC to develop model agreement language, engage local governments to minimize impacts from trucking operations, and work to ensure this is a "funded" mandate.

The SGEIS includes environmental monitoring as mitigation in cases where the impact of HVHF is uncertain. Continual evaluation of monitoring data is intended to provide assessment of the effectiveness of mitigation requirements and early detection of problems with well construction or operation. It is important that the PHR states the frequency of these evaluations and how this information will be disclosed to the public.

Air monitoring of VOCs for 1 and 24 hrs is mentioned as part of the mitigation strategies outlined in the PHR and SGEIS. It is important to note that even a 1 hr average sample may miss short-term peak pollution levels nearby residents may experience. Though there are no good solutions for real time monitoring for a large number of air toxics, shorter term samples can be collected if done systematically with a strong study design, quality control/assurance, and a clear plan for use of the data. Mitigation approaches should consider using less expensive proxy methods, such as measuring methane plumes, to obtain emission rate estimates. This data may, in turn, be coupled with more rigorous VOC characterization samples to estimate emissions and/or human exposures to air toxics. This VOC characterization is done at the well head in other states. Although the SGEIS states that NY shale is expected to yield mostly "dry" gas, with low petroleum condensate levels, field gas sampling would be informative to help validate existing geochemical data, assess the success of mitigations, and to characterize these potential emission sources. If coupled with radon measurement, this data could be used to address concerns about potential human exposure to radon from this source.

All mitigation assessments sample sizes for baseline air, water, and health indicator measures should be specified to the extent feasible for the proposed "phased" permitting process. While operator groundwater and air monitoring plans proposed in the SGEIS will be reviewed and approved by DEC and DOH, the DEC and DOH should produce guidance on design, implementation and interpretation of monitoring data. This guidance should also define how significant changes from baseline will be determined.

Are existing and proposed environmental and health monitoring and surveillance systems adequate to establish baseline health indicators and to measure potential health impacts? If not, what additional monitoring is recommended?

As a new program there are substantial uncertainties associated with developing the health monitoring and surveillance systems through existing health care systems. Use of "near real time" and longer term tracking and reporting mechanisms is good public health practice, but acceptance of these measures as representative and informative depends on an effective communication platform. I agree that respiratory, asthma, and neurological systems are the place to begin evaluation due to the prevalence of these syndromes and existence of sensitive populations. Where feasible, tracking should focus on expanded data collection in sensitive subpopulations.

It would be useful if DOH would conduct an environmental tracking exercise in as near real time as possible to compare baseline, local regulator, state regulator, and operator collected data. This will require highly specific protocols so that data is collected in ways that provide high quality exposure data that can be explored in tandem with the health outcome data.

Impacts of natural gas development on community character is mentioned in the SGEIS, but formal evaluation metrics are not proposed. While metrics for this issue are likely to be qualitative, it is important that guidance describes how this metric will be measured and/or described prior to the initiation of development. The potential mitigation suggested in the SGEIS, i.e., the DEC policy to abide by local laws or ordinances prohibiting HVHF activity for the first 5 years of the program, may address some community concerns if it is coupled with a substantive communication effort.

Addendum: Additional Comments on the PHR from February 2013 Version Review

Background and Recommendations Section: The lack of substantive research to address many of the main public health concerns is still one of the major limitations facing both public health experts and decision-makers. While this concern is front and center in this draft, the communication plan should be highlighted here as well. This draft also identifies research by the Federal government and others that will address important uncertainties. It is important to highlight some of the data the proposed monitoring and mitigation would collect and how it would address uncertainties that are specific to HVHF in NY.
Given that the final recommendation is about the expert comments, I would also note that it is likely that there will be some unanticipated outcomes – history shows that even the best prepared miss something. The DOH should reserve the option to intervene in cases of unanticipated consequences.

Lastly, the recommendations section should also address more clearly the issue of scale of impacts: if HVHF is allowed in NY State the most public health relevant impacts will be at a local level. The recommendations should be explicit that the mitigations are focused at that level. The section on water, for example, notes that while the total amount of water used at anticipated peak HVHF is small compared to competing demands, there may be "localized or transient impacts that could affect water supplies." The larger issue here is one of scale: both of the industry at peak development, and the local scale where impacts occur. This point is nicely made in the context of water, but this "scale" of impacts point can and should also be made for air, noise, and community quality of life impacts.

Concluding Comments

If shale gas development goes forward in NY the approach outlined in the PHR represents a viable strategy for protecting public health. Prevention of impacts will, however, require a strong partnership between the DOH, DEC, and the local governmental bodies engaged in land use planning, monitoring, and enforcement. It is my belief that mitigation activities will only be perceived as successful if the baseline and follow up monitoring data are high quality, assessment protocols are acceptable to all stakeholders, and the overall process is perceived as unbiased and transparent. This will require an ongoing, substantive dialogue between the public, government, and industry to address stakeholder concerns.

During our conference call you asked the reviewers if a Health Impact Assessment (HIA) should be done for shale gas development in NY and we all said no. As someone who helped develop a HIA in Colorado I know the benefits and shortcomings of HIA for addressing future health impacts from natural gas development. Given the current state of the science I do not think a HIA can project future health effects attributable to shale gas development with reasonable precision. Furthermore, I do not think a state-specific HIA is the best tool for addressing issues that transcend state borders. The impact of methane emissions during well development, for example, is important given the realities of a changing climate. The science assessing the cumulative effects of shale gas development on climate change is, however, still emerging, and the implications of this work for NY-specific regulation unclear. For these reasons I believe New York's proposed prospective monitoring approach that focuses on preventing future exposures, tracking potential health effects, and mitigation is preferable to a HIA at this time.

In closing, thank you for the opportunity to review the DOH's work, and please contact me if you have questions.

Sincerely,

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December 18, 2012

Nirav M. Shah, MD, MPH
Commissioner
New York State Department of Health
Albany, NY
Via Email

Dear Dr. Shah:

Thank you for the opportunity to review your Department's "A Public Health Review of the Department of Environmental Conservation's Supplemental Generic Environmental Impact Statement for Shale-Gas Development" (hereafter, PHR). Your November 20, 2012 letter included the draft report and associated materials on health outcome surveillance, existing and planned interactions between state and local agencies under the proposed shale-gas program, the DEC's SGEIS and the response to comments on the SGEIS.

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My comments in this letter adopt the convention of using "HVHF" or the phrase "shale gas development" to describe the entire process of natural gas well development and production. I do so because hydraulic fracturing is just one step in the natural gas development process. The potential public health impacts can occur either during the relatively intense well development phase or over the much longer production phase.

My responses to the specific charge questions are below, followed by conclusions and final comments.

Are there additional potential public-health impacts of HVHF gas development that should be considered beyond those already discussed in the SGEIS?

The DOH has developed a strong document that is a viable approach to addressing the main public health issues associated with shale gas development. The PHR and SGEIS describe a phased start to shale gas development that is coupled with baseline and subsequent monitoring of potential impacts. Although the PHR does not miss any major categories, I have highlighted potential impacts that I believe warrant further attention.

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The SGEIS air analysis looks at both criteria and non-criteria air pollutants and is reasonable to the extent that emission inventories, models, and other key assumptions are reliable. One key uncertainty that should be emphasized in the PHR is the lack of health-based standards for some of the air toxics emitted during well development. Although it is reasonable to use annual and short-term guideline concentrations, EPA provisional risk concentrations, and toxicity values from other authoritative sources, modeling these emissions, as described in the SGEIS, is only the first step in assessing potential air risks. Linking these models to the measurements included in the mitigation plans is important for assessing impacts and evaluating the effectiveness of mitigation.

The term "setback" largely applies to distances to key watersheds in the PHR. I encourage broadening the use of this term in discussions with the public to include distances from air emission sources as well. The PHR summary notes that DEC needs to define more clearly setbacks from NYC watersheds and related infrastructure. The rationale for setbacks for water, air, and noise impacts needs to be clearer throughout the PHR and SGEIS.

While not formally part of this public health review, potential well casing failure and its impact on aquifers over time is a key scientific uncertainty. The SGEIS cites a relatively small probability, but also notes that some parameters that feed into this risk estimate are inherently uncertain. I agree that for decision-makers the value of a probabilistic risk assessment is problematic when outputs of the analysis are highly uncertain. Nonetheless, the potential for catastrophic failure should be acknowledged given the potential high consequence of some failures.

The overall impact of stress on individual and community health is an important issue that the DOH and DEC need to acknowledge and assess as rigorously as possible. While this concept is implicit in some of the SGEIS text, stress needs to be more fully addressed in the PHR and SGEIS. To help alleviate this concern the DOH and DEC need to encourage active public participation in the permitting process, foster community right-to-know, and make certain monitoring data is publically available. A substantive, ongoing dialogue between State of NY officials and communities will be needed to address this issue long term.

Are additional mitigation measures beyond those identified in the SGEIS needed to address the potential health impacts of HVHF? If so, what additional prevention or mitigation measures are recommended?

As mentioned above, road-use agreements between operators and municipalities are important for reducing potential impacts from truck traffic. While this is appropriate, how this is implemented and enforced at the local level is a key part of mitigation. It is important that DOH work with DEC to develop model agreement language, engage local governments to minimize impacts from trucking operations, and work to ensure this is a "funded" mandate.

The SGEIS includes environmental monitoring as mitigation in cases where the impact of HVHF is uncertain. Continual evaluation of monitoring data is intended to provide assessment of the effectiveness of mitigation requirements and early detection of problems with well construction or operation. It is important that the PHR states the frequency of these evaluations and how this information will be disclosed to the public.

Air monitoring of VOCs for 1 and 24 hrs is mentioned as part of the mitigation strategies outlined in the PHR and SGEIS. It is important to note that even a 1 hr average sample may miss short-term peak pollution levels nearby residents may experience. Though there are no good solutions for real time monitoring for a large number of air toxics, shorter term samples can be collected if done systematically with a strong study design, quality control/assurance, and a clear plan for use of the data. Mitigation approaches should consider using less expensive proxy methods, such as measuring methane plumes, to obtain emission rate estimates. This data may, in turn, be coupled with more rigorous VOC characterization samples to estimate emissions and/or human exposures to air toxics. This VOC characterization is done at the well head in other states. Although the SGEIS states that NY shale is expected to yield mostly "dry" gas, with low petroleum condensate levels, field gas sampling would be informative to help validate existing geochemical data, assess the success of mitigations, and to characterize these potential emission sources.

All mitigation assessments sample sizes for baseline air, water, and health indicator measures should be specified to the extent feasible for the proposed "phased" permitting process. While operator groundwater and air monitoring plans proposed in the SGEIS will be reviewed and approved by DEC and DOH, the DEC and DOH should produce guidance on design, implementation and interpretation of monitoring data. This guidance should also define how significant changes from baseline will be determined.

Are existing and proposed environmental and health monitoring and surveillance systems adequate to establish baseline health indicators and to measure potential health impacts? If not, what additional monitoring is recommended?

As a new program there are substantial uncertainties associated with developing the health monitoring and surveillance systems through existing health care systems. Use of "near real time" and longer term tracking and reporting mechanisms is good public health practice, but acceptance of these measures as representative and informative depends on an effective communication platform. I agree that respiratory, asthma, and neurological systems are the place to begin evaluation due to the prevalence of these syndromes and existence of sensitive populations. Where feasible, tracking should focus on expanded data collection in sensitive subpopulations.

It would be useful if DOH would conduct a environmental tracking exercise in as near real time as possible to compare baseline, local regulator, state regulator, and operator collected data. This will require highly specific protocols so that data is collected in ways that provide high quality exposure data that can be explored in tandem with the health outcome data.

Impacts of natural gas development on community character is mentioned in the SGEIS, but no formal evaluation metrics are proposed. While metrics for this issue are likely to be qualitative, it is important that guidance describes how this metric will be measured and/or described prior to the initiation of development. The potential mitigation suggested in the SGEIS, i.e., the DEC policy to abide by local laws or ordinances prohibiting HVHF activity for the first 5 years of the program, may address some community concerns if it is coupled with a substantive communication effort.

Concluding Comments
If shale gas development goes forward in NY the approach outlined in the PHR represents a reasonable strategy for protecting public health. Prevention of impacts will, however, require a strong partnership between the DOH, DEC, and the local governmental bodies engaged in land use planning, monitoring, and enforcement. It is my belief that mitigation activities will only be perceived as successful if the baseline and follow up monitoring data are high quality, assessment protocols are acceptable to all stakeholders, and the overall process is perceived as unbiased and transparent. This will require an ongoing, substantive dialogue between the public, government, and industry to address stakeholder concerns.

During our conference call you asked the reviewers if a Health Impact Assessment (HIA) should be done for shale gas development in NY and we all said no. As someone who helped develop a HIA in Colorado I know the benefits and shortcomings of HIA for addressing future health impacts from natural gas development. Given the current state of the science I do not think a HIA can project future health effects attributable to shale gas development with reasonable precision. Furthermore, I do not think a state-specific HIA is the best tool for addressing issues that transcend state borders. The impact of methane emissions during well development, for example, is important given the realities of a changing climate. The science assessing the cumulative effects of shale gas development on climate change is, however, still emerging, and the implications of this work for NY-specific regulation unclear. For these reasons I believe New York's proposed prospective monitoring approach that focuses on preventing future exposures, tracking potential health effects, and mitigation is preferable to a HIA at this time.

Thank you for the opportunity to review the DOH's work, and please contact me if you have questions.

Sincerely,

John L. Adgate, PhD, MSPH
Professor and Chair
Department of Environmental and Occupational Health

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March 4,2013

Nirav R. Shah, M.D., M.P.H.
Commissioner, NY State Department of Health
Corning Tower
Empire State Plaza
Albany, NY 12237

Dear Dr. Shah:

I have completed my peer review of the public-health elements of the Department of Environmental Conservation's (DEC) supplemental generic environmental impact statement (SGEIS) for high-volume hydraulic fracturing (HVHF). As requested, this letter summarizes my review of your Department's effort to date.

Overview

The charge was to "focus on whether additional public-health impacts should be considered in the SGEIS and whether additional mitigation measures are needed to address potential public-health impacts. " I also was to "consider whether existing and proposed environmental and health monitoring and surveillance systems are adequate to establish baseline health indicators and to measure potential health impacts." The NY DOH specifically identified several areas of possible concern for public health: contamination of drinking water resources; ambient air pollution; releases of naturally-occurring radioactive materials (NORM); community impacts related to noise and utilization of local services like transportation; healthcare, education, housing and social services; and adequacy of existing and proposed health surveillance and HVHF-related monitoring programs.

Specifically peer reviewers were to address three questions:

1. Are there additional potential public-health impacts of HVHF gas development that should be considered beyond those already discussed in the SGEIS?

2. Are additional mitigation measures beyond those identified in the SGEIS needed to address the potential health impacts of HVHF? If so, what additional prevention or mitigation measures are recommended?

3. Are existing and proposed environmental, health monitoring, and surveillance systems adequate to establish baseline health indicators and to measure potential health impacts? If not, what additional monitoring is recommended?

In addition to the Health Review Scope and Process, you provided a number of documents for review:

1. "NYSDOH Review of NYSDEC’s Supplemental Generic Environmental Impact Statement", dated November 20,2012.

2. "Development of a Health Outcome Surveillance Program for High-Volume Hydraulic Fracturing in New York State" (marked CONFIDENTIAL INTRA-AGENCY DRAFT/FOR DELIBERATION ONLY NOT SUBJECT TO FOIL), dated November 19, 2012.

3. "Description of Anticipated Work and Responsibilities for Center of Environmental Health, Local Health Departments/District Offices, and Department of Environmental Conservation Associated with HVHF Gas Well Drilling" (marked CONFIDENTIAL INTRA-AGENCY DRAFT/FOR DELIBERATION ONLY NOT SUBJECT TO FOIL), dated November 19, 2012.

4. "Advisory Panel on High-Volume Hydraulic Fracturing: State Resource Needs", New York State Department of Health, Center for Environmental Health, dated September 9, 2011.

5. A complete copy of the Interagency Confidential Draft Final SGEIS.

6. A set of health related excerpts from the Draft Final SGEIS prepared by the NY DOH including: (a) a second copy of the Executive Summary from the Draft Final SGEIS; (b) Section 5.4.3.1 of the SGEIS; (c) Section 6.14 of the SGEIS; and (d) a second copy of the Appendix 34, Summary of Health impacts, a document titled "NYSDOH and DEC Summary of Potential Health-Related Impacts and Proposed Mitigation Measures for High-Volume Hydraulic Fracturing".

7. A set of health-related excerpts from the DEC Document: "Response to Comments. Final Supplemental Generic Environmental Impact Statement" including comments excerpted from all areas that might be health related, not just the "Health Impacts" section.

I sent you a first draft of my review on December 2,2012. You held a conference call with John Adgate, Richard Jackson, and I on December 3,2012. On December 7,2012, you emailed me: (1) A revised document titled "A Public Health Review of the Department of Environmental Conservation's Supplemental Generic Environmental Impact Statement for Shale-Gas Development" with changes shown in "track changes", dated December 7, 2012 and (2) a copy of all three of the draft reviewer's comments with annotations (in track changes) from NY DOH staff. On December 17,2012 1 sent you a letter responding to these revised documents. In mid-February you sent me a revised confidential draft: "Public Health Review of the Department of Environmental Conservation's Draft Supplemental Generic Environmental Impact Statement for Shale-Gas Development" and requested review of this draft. Copies of my prior responses to the charge questions with the NY DOH staff comments are attached to this letter as Attachment A. At this time I am responding only to the revised draft public health review.

NY State has done a credible job of thoroughly reviewing potential environmental health impacts of HVHF. It is commendable that such a review has been undertaken prior to issuing permits for such activities. Although this process did not follow the academic model for a Health Impact Assessment I applaud the DOH for having used the DEC SGEIS process to achieve the same end. In some ways this feels like a better process in that it has established the basis for a stronger role for DOH in working with DEC moving forward. As noted previously, I am pleased that NY is committed to reducing methane emissions in the context of HVHF activities. I recommend that New York State continue and expand its efforts to develop cleaner alternative energy sources. New York's renewable energy portfolio standard, Governor Cuomo's NY-Sun initiative and effort to reduce electricity demand 15 percent by 2015, is a good beginning.

As I have noted previously, many of the proposed mitigation measures are a model for other states that are considering or undertaking these operations. I agree with the notion embedded in the latest review that such mitigation measures would need to be monitored over time. Second I agree with the notion of a phased approach to HVHF gas-development that would allow public health problems to be identified earlier, and reduce problems resulting from overly rapid growth ("boom and bust"). Third, I especially concur with the notion of not allowing HVHF gas-development activity within 4000 feet of the New York City and Syracuse drinking-water supply watersheds.

I am pleased that in this latest draft the NY DOH has addressed a number of issues that I had flagged in my prior reports. The revised document more strongly emphases the numerous data gaps and uncertainties with regard to potential public health impacts of HVHF. I agree with the notion that studies that are underway nationally (the US EPA hydraulic fracturing study) and in Pennsylvania will be helpful in this regard. I am less sanguine about ongoing health studies because I think these are unlikely to capture subclinical health effects as well as effects that occur with longer latency or lag times. I agree with the DOH recommendation to expand its Behavioral Risk Factors Surveillance System to collect critical baseline information in the Marcellus region. I also agree with the decision to explore approaches for including worker and traffic-related injuries, psychosocial stress and noise. Perhaps most important is the new recommendation that the DOH will collaborate with the DEC in assessing new data on HVHF health and environmental impacts as well as the effectiveness of mitigation measures. Some of the most important information will be environmental information because of the problems (noted above) with needing to protect the public from effects that are subclinical or have long latencies and are difficult to detect in real-time using epidemiology.

As noted in prior communications, I think that DOH would require resources for public communications engagement, particularly for those most concerned about health, for example, local health agencies, health providers and members of the public.

Thank you very much for again having had the opportunity to review the "Public Health Review of the Department of Environmental Conservation's Draft Supplemental Generic Environmental Impact Statement for Shale-Gas Development". This document as it currently stands is an excellent review of the relevant public health issues, and attendant uncertainties and data gaps.

Very truly yours,

Lynn R. Goldman

Lynn R. Goldman, M.D., M.P.H.
Dean, School of Public Health and Health Services
The George Washington University

Attachment: Attachment A

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December 17,2012

Nirav R. Shah, MD., M.P.H.
Commissioner, NY State Department of Health
Corning Tower
Empire State Plaza,
Albany, NY 12237

Dear Dr. Shah:

I have completed my peer review of the public-health elements of the Department of Environmental Conservation's (DEC) supplemental generic environmental impact statement (SGEIS) for high-volume hydraulic fracturing (HVHF). As requested, this letter summarizes my review of your Department's effort to date.

Overview

As I understand the charge, it was to "focus on whether additional public-health impacts should be considered in the SGEIS and whether additional mitigation measures are needed to address potential public-health impacts. " I also was to "consider whether existing and proposed environmental and health monitoring and surveillance systems are adequate to establish baseline health indicators and to measure potential health impacts." The New York Department of Health (NY DOH) specifically identified several areas of possible concern for public health: contamination of drinking water resources; ambient air pollution; releases of naturally-occurring radioactive materials (NORM); community impacts related to noise and utilization of local services like transportation; healthcare, education, housing and social services; and adequacy of existing and proposed health surveillance and HVHF-related monitoring programs.

You charged peer reviewers to address three questions:

"1. Are there additional potential public-health impacts of HVHF gas development that should be considered beyond those already discussed in the SGEIS?

2. Are additional mitigation measures beyond those identified in the SGEIS needed to address the potential health impacts of HVHF? If so, what additional prevention or mitigation measures are recommended?

3. Are existing and proposed environmental and health monitoring and surveillance systems adequate to establish baseline health indicators and to measure potential health impacts? If not, what additional monitoring is recommended?"

In addition to the Health Review Scope and Process, you provided me with a number of documents for review including:

1. "NYSDOH Review of NYSDEC's Supplemental Generic Environmental Impact Statement", dated November 20, 2012.

2. "Development of a Health Outcome Surveillance Program for High-Volume Hydraulic Fracturing in New York

State" (marked CONFIDENTIAL INTRA-AGENCY DRAFT/FOR DELIBERATION ONLY NOT SUBJECT TO FOIL), dated November 19,2012.

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5.4.3.1 of the SGEIS; (c) Section 6.14 of the SGEIS; and (d) a second copy of the Appendix 34, Summary of Health impacts, a document titled "NYSDOH and DEC Summary of Potential Health-Related Impacts and Proposed Mitigation Measures for High-Volume Hydraulic Fracturing".

7. A set of health-related excerpts from the DEC Document: "Response to Comments. Final Supplemental Generic Environmental Impact Statement" including comments excerpted from all areas that might be health related, not just the "Health Impacts" section.

I sent you a first draft of my review on December 2,2012. You held a conference call with John Adgate, Richard Jackson and I on December 3,2012, during which we discussed potential local-community impacts; health and environmental monitoring and surveillance programs; potential impacts from contamination of air resources; potential impacts from contamination of drinking water resources; potential impacts from naturally-occurring radioactive material (NORM); and other issues that we reviewers had brought forward either in our draft reviews or in our verbal comments and discussion. On December 7,2012, you emailed me: (1) A revised document titled "A Public Health Review of the Department of Environmental Conservation's Supplemental Generic Environmental Impact Statement for Shale-Gas Development" with changes shown in "track changes", dated December 7,2012 and (2) a copy of all three of the draft reviewer's comments with annotations (in track changes) from NY DOH staff. The copy of my draft responses to the charge questions with the NY DOH staff comments is attached to this letter (Attachment A);

General Comments:

From the review of the documents listed above I conclude that NY State has done a credible job of thoroughly reviewing potential environmental health impacts of HVHF. It is commendable that such a review has been undertaken prior to beginning to issue permits for such activities, and that local communities would be involved in the permitting process. The SGEIS report has been provided to the public for review and the extensive numbers of comments that have been received (as per the *Response to Comments* document) are indicative of a participatory public process. It is also clear that involvement of the NY DOH over the last few years has helped to highlight and address a number of potential public health concerns. In particular the draft *"Description of Anticipated Work and Responsibilities for Center of Environmental Health, Local Health*

Departments/District Offices, and Department of Environmental Conservation Associated with H VHF Gas Well Drilling" indicates a thorough and thoughtful approach to assuring that environmental health threats are addressed collaboratively by New York's state and local health and environmental health agencies. In my experience it often is difficult to bring these various branches of government together in order to assure a tight environmental health safety net. This is among the best of such frameworks that I have reviewed. While it is not a formal Health Impact Assessment the review is, nonetheless, very thorough, and I was able to identify only a few areas that require more review.

Generally speaking, if HVHF gas development is permitted in NYS, there are four additional aspects of the approach taken in the SGEIS that are of critical importance for public health. First is that, the proposed mitigation measures should serve as a model for other states that are considering or undertaking these operations. However, no number of mitigation measures can provide one hundred percent assurance of safety and it is therefore important that the New York DOH would have adequate funding for surveillance activities as well as follow up investigations that would allow for identification of ways that mitigation measures need to be improved as well as potential health impacts. Second it is important that, if NY decides to move forward with HVHF gas-development that, as proposed in the SGEIS, there would be a "phased rollout approach". This not only would allow public health problems to be identified earlier, but also reduce problems resulting from overly rapid growth ("boom and bust"). Third, I agree with the SGEIS proposal that would not allow HVHF gas-development activity within 4000 feet of the New York City and Syracuse drinking water supply watersheds. Finally, it is of utmost importance that New York would allow local input into decision-making about permits.

In addition to specific concerns that are described below, there are some general recommendations that I would like to put forward with regard to provision of public information and involvement of the public moving forward:

1. *Continue the Process of Assessing Health Impacts:* Regardless of when and how NY State moves forward with HVHF activities additional health assessment activities are warranted, I recommend that the NY DOH appoint a panel of experts and citizens to constitute a HVHF health assessment committee. Such a committee could support the DOH as well as the DEC and local health and environmental agencies in review of health related data and other issues. Further assessment of health impacts is needed. While the SGEIS accomplishes many of the goals of an HIA there are still additional issues that need to be addressed. If NY State decides to lift the ban on HVHF the committee can guide the NY DOH in its process of adaptive management as well as reviewing any additional data that may come forward. On the other hand, if HVHF is not permitted but continues to be under consideration, NYS should consider conducting a formal HIA an advisory panel could assist with that process. I appreciate that the revised DOH report recommends exploring options for establishing an advisory panel to advise DOH and DEC on health issues. One caveat is that an advisory process would require resources, and that, if NY State moves forward with HVHF resources also should be made available for possible health investigations or even full-scale studies, possibly with guidance from an advisory panel.

2. *Address Right-To-Know:* The CEH DEC and local agencies are planning to develop a tremendous amount of information with regard to HVHF including, potentially: In my draft comments I listed a number of data sets that would be relevant to HVHF-related health concerns and that should be better shared among agencies, industry and the general public. Rightfully there is a focus on information sharing among agencies but public

transparency also is important. The DOH is recommending that DEC upgrade its existing publicly-available web-based oil and gas drilling information to be a clearinghouse that would provide all interested parties with ready access to the breadth of HVHF information collected under the program (e.g., well locations, monitoring data, and health surveillance findings). This is responsive to my concern about this issue. Additionally, I would hope that there would be strong involvement of DOH to assure that health relevant data are captured, including, as noted by DOH, "near-real time monitoring and surveillance results".

3. Engage the Public: It is not clear how the public would be engaged beyond the GEIS process. Local communities have a tremendous amount of information that is useful for agencies, and that understanding their concerns is useful in guiding the development of education and outreach materials. This issue is of great concern both in those communities and statewide and public engagement activities need adequate resources to assure that the State is reaching out and involving the public proactively. In the response to this concern, the DOH has emphasized the efforts that DEC plans to undertake to meet periodically with industry officials and local government staff; to obtain public comment for applications for well pads; to disclose hydraulic fracturing fluid content for each chemical before drilling and after well completion; to post waste tracking forms on a website for view by the public; and to provide local points of contact for disseminating information. These are good efforts. Additionally DOH itself would require resources for public communications engagement, particularly for those most concerned about health, for example, local health agencies, health providers and members of the public.

4. *Address Greenhouse Gases:* The draft SGElS correctly identifies greenhouse gases (GHG) as potentially causing public health impacts, especially methane and carbon dioxide. The SGElS thoroughly assesses the potential for emissions of these gases both in development and production of HVHF wells and in "post production", i.e., transport and use of natural gas, and highlights the requirement to comply with new EPA regulations requiring greenhouse gas mitigation measures and performance standards for new sources in the oil and natural gas industry. However, use of natural gas by utilities and companies to generate electricity in New York will of course emit more GHG's than would result from the development of certain alternative energy sources. Granted, the use of natural gas in New York State will occur regardless of the point of origin of the natural gas. Nonetheless, the draft SGElS points to credible efforts by New York to promote the transition to cleaner sources of electricity, including the renewable energy portfolio standard, Governor Cuomo's NY-Sun initiative, New York's energy efficiency portfolio standard which seeks to reduce electricity demand 15% by 2015. 1 recommend that this approach be strengthened in the context of cheaper natural gas, and (to date) lack of a mechanism to internalize the costs of carbon dioxide and methane emissions to the atmosphere, nationally or in New York.

Specific Comments and Recommendations:

Question 1: Additional potential public-health impacts of HVHF gas development that should be considered beyond those already discussed in the SGElS

Chemicals and Radionuclides: I am pleased that in the December 7 "Public Health Review ..." you noted my concern about the level (and quality) of information about formaldehyde, glycol ethers/ethoxylated alcohols and microbiocides (Attachment A), and have stated your intention to request that DEC "DEC, in collaboration with DOH, must revise the SGElS to reflect additional available" about these chemicals. I also raised a concern with the possibility that flow-back and produced waters could become contaminated by various naturally-occurring metals like arsenic, cadmium, lead, manganese, and mercury, depending on what is present naturally. NY DOH points to language in the SGEIS indicating that a number of required mitigation measures would be used. I would agree that proper measures need to be taken to assure that such waters are properly handled, treated and disposed of. However, I continue to think that such an approach requires information about levels and toxicity of contaminants, including metals.

As to the more general issue of potential public health impacts of HVHF-related chemicals, one of the recommendations in the DOH report is that DEC must continue to engage DOH to evaluate potential health concerns related to any new fracturing additive chemicals that are proposed for use as HVHF development proceeds and to develop protocols that are to be followed for conducting alternatives assessments for HVHF chemical additive products. I strongly agree with this recommendation.

Potential Human Health Impacts:

Drinking Water: *I support DOH plans to evaluate levels of drinking water pollutants and provide a public health interpretation of these data. DOH would require resources for this.*

Air pollution: I reviewed the air pollution models and found them to be quite complex and very dependent on conditions that could be site-specific which as stack heights, placement of engines and presence of H2S or "sour" gas in sites. The model for PM2.5 suggests that additional mitigation measures may be needed to prevent short-range impacts. Similarly the model predicts the need for additional controls of benzene and formaldehyde emissions. The SGEIS also provides preliminary models for ozone formation that suggest the need to address ozone projections over time. Although local communities may not be interested in precise quantification of emissions, permit decisions may at least in part depend on anticipated air releases related to these operations. I appreciate that the DOH would review and interpret air monitoring data including assessing potential health impacts.

Water availability: I appreciate that in response to my draft comments the DOH report has been revised to refer to potential health impacts related to other water-quality issues, including loss of fish resources (recreationally and as a source of healthy food), water recreational opportunities, and flood control. Also in response to my draft comments, DOH has informed me that the DEC has promulgated water withdrawal regulations **(**http://www.dec.nv.nov/regulations/78258.htmI**)** and that the DOH will reference these regulations in their report. Such regulatory requirements are important, as well as carrying out monitoring activities to make sure that the cumulative sum of water withdrawals related to HVHF does not harm downstream aquatic environments.

Socioeconomic impacts: While job creation is expected to occur, new jobs would be distributed unevenly around the state. Some areas could experience short term labor shortages and therefore increased wages, possible negative impacts on existing industries, and in-migration of new specialized workers and their families. Employment in impacted regions is expected to peak in 20 years; income from operations in 30 years. If the additional jobs employ people in these communities who currently are unemployed or underemployed this could increase income to households and reduce service demands on public health. On the other hand, if prices increase rapidly this could have a negative effect on families and increase demands for public health services.

Population impacts: The SGEIS found that while population impacts would be minor statewide there could be more significant impacts in particular areas, perhaps offsetting population declines that are occurring in some of these rural areas. The SGEIS notes that in construction phases there would be many workers who live locally in temporary housing. Local health authorities would experience increased demand for public health services from such temporary residents as well as issues related to safety of food, drinking water and housing. In areas where populations increase quickly there could be impacts on access to medical care and adequacy of emergency medical services.

Traffic: The SGEIS has considered the potential for increased traffic impacts and there likely to would be significant impacts in many areas. In addition to noise and air pollution impacts there are potential impacts due to traffic related injuries. NIOSH has reported that workers in the oil and gas injury have high rates of traffic related injuries and mortality; presumably residential vehicles and pedestrians could be at risk as well.

Healthcare and public health services: *I recommend consideration of potential impact on public health systems and healthcare services from rapid population changes.* I understand, from responses to my draft comments, that DOH thinks that DEC's proposed phased roll out of HVHF permitting would be expected to mitigate the possible effect of rapid population growth and the associated increased demand for services. DOH stated that ongoing interaction with and monitoring of healthcare facilities would keep the agency appraised of impacts on such facilities. Likewise DOH expects that its routine interactions with the local health departments that provide local public health would keep them informed of potential impacts on local public health programs, and resource needs of these programs. While the phased rollout is likely to be helpful on a statewide basis there could be relatively large changes impacting health and public health services in local communities. I would recommend a more proactive approach that would attempt to anticipate potential impacts on healthcare and public health systems before there are any impacts on health in communities. Finally, DOH has noted in response to my draft comments that, "If HVHF permitting is authorized in NYS, additional resources would be made available to local health departments." I would agree with that approach.

Injury control: In response to another one of my recommendations in the earlier draft, the DOH states that it would address additional injury prevention and surveillance activities by exploring mechanisms to include worker and traffic-related injuries/deaths in health surveillance activities, and to enhance injury prevention activities. I would agree with that approach.

Noise: My draft comments noted that noise impacts of HVHF are greater than conventional gas wells during the period of time when horizontal drilling is underway, that HVHF is associated with more noise from diesel truck traffic, and that the SGEIS did not discuss noise impacts on health. *I recommend that if HVHF activities proceed, noise levels near operations should be monitored to determine appropriate mitigation efforts to protect human health.* In its response the DOH states that it "will provide DEC with additional information for the SGEIS on the potential human health effects (i.e., beyond simply annoyance) of noise". As they note, the impact analysis discussion and the mitigation measures are targeted at human receptors. However, I think that an understanding of potential health hazards is relevant to decision making including recommendations for local noise monitoring.

Local emergency planning: The draft SGEIS lays out a set of mitigations that include a requirement for operators of sites to respond in emergency situations (Section 7.13). *I recommend consideration of potential impacts to local first responder systems.* As noted above, the phased rollout would be helpful on a statewide basis there could be relatively large changes in demand for emergency services impacting local communities.

Psychosocial stress: I am pleased that in response to my draft comments the DOH has indicated that their report will specifically identify stress as a public health issue. DOH has indicated that they "will explore approaches/metrics for evaluating stress (e.g., tracking prescription drug use)" and/or via modifications to the BRFSS.

Question 2: Additional mitigation measures beyond those identified in the SGElS needed to address the potential health impacts of HVHF

Generally NY State has proposed a set of mitigation measures that, if successful would do much to address the potential impacts of HVHF. As noted in my general comments (above) I have broad concerns about the engagement and participation of the public in decision making going forward, as well as how the public's rightto-know can be addressed via making information available in real-time. In terms of more specific recommendations, and the DOH response to these recommendations:

1. Permitting decisions need to be informed by information about local impacts especially in areas that are difficult to model in the general case, for example in estimation and control of PM2.5 emissions, which can have serious local impacts.

2. Regional impacts on ozone formation also would need to be addressed over time. DOH indicates that it agrees with this point and that the issue is mentioned in the SGEIS.

3. As noted above, DOH indicates that noise will be recognized as a health hazard, measured, and mitigated to control health risks.

4. DOH has indicted that stress and stress-related health effects also will be identified as potential health hazards.

5. DOH indicates that it will address local traffic impacts as causing potential hazards, specifically, air emissions, increased noise, possibly increased stress and increased risk of unintentional injury.

6. I continue to think that specific communities could see local impacts on local public health and healthcare services as well as emergency medical services and first responders, and that this needs to be addressed proactively.

Question 3: Adequacy of existing and proposed environmental and health monitoring and surveillance systems to establish baseline health indicators and to measure potential health impacts

Generally, NY State has a strong public health surveillance system and the kind of expertise in this area that provides a strong foundation for a special surveillance effort such as the one outlined in the draft document: "Development of a Health Outcome Surveillance Program for High-Volume Hydraulic Fracturing in New York State". The basic elements of the system --near real-time surveillance, longer-term surveillance, and a public reporting mechanism -form a sound framework for such a program.

ESSS: The proposed use of the existing Electronic Syndromic Surveillance System (ESSS) seems appropriate. Covering hospital emergency department visits in most of the state, it would pick up unusual upticks in a number of health conditions and I would agree that the selection of respiratory, asthma and neurological outcomes is a reasonable target for HVHF-related outcomes. I also think that it is reasonable for NY to incorporate new "flags" related to HVHF for detection of unusual numbers of Emergency Room (ER) visits. Additionally the plans for follow-up investigations also are reasonable.

I recommend that NY consider developing and articulating more explicit criteria for when additional actions will be taken in order to fully explicate statements like l'ifunusual patterns or possible links are found". In response to this recommendation DOH indicates that if HVHF permitting is authorized in NYS then they would, *a priori,* more specifically define what is meant by "unusual patterns" or "possible links". In that case I also recommend that NY DOH obtain input both from scientific peer reviewer and stakeholders to increase the credibility and transparency of the effort.

Longer Term Tracking: The proposed longer term tracking effort is appropriate and builds on New York's existing surveillance capacity. I agree that this longer-term effort should be carried out in the absence of findings from the ESSS system since many health issues would not manifest themselves via time-related clusters of ER visits.

I recommended (and NY DOH indicates that they agree) an initial focus on outcomes with short latency periods, which would include birth outcomes (low birth weight, preterm birth, and birth defects) and hospital admissions for myocardial infarction and respiratory diseases. Cancer surveillance also is important but is a longer term effort. I *also recommend monitoring changes in other risk factors for these outcomes, for example, downward trends in air pollution and smoking. As noted above ideally the NY DOH would have resources for follow-up studies.*

Additional Surveillance: In addition to the above there are some additional steps that could be taken to enhance public health surveillance. First, ER surveillance could miss episodes where events are more spread out over time and/or where people either do not seek emergency room care. Second, NY DOH should be able to take advantage of existing routine environmental monitoring, especially of air and water pollutants.

I also recommended (and NY DOH agreed) systematic collection of physician and citizen reports of possible adverse health problems associated with HVHF. They also agreed with my recommendation to link traffic injury and mortality data as well as occupational injury data to GIS data on HVHF activities to spot opportunities to mitigate motor vehicle injury risks in association with HVHF activities. Finally, NY DOH indicates that they have intended that they would conduct analyses of air and drinking water data collected by other state and local agencies and provide surveillance summaries of levels and trends of pollutants associated with HVHF activities.

In closing, I recognize the truly impressive quantity and quality of work that has been performed to date by the NY DOH. I also realize that the above recommendations cannot be accomplished without the application of sufficient resources at multiple levels, from communities through the staff at the NY DOH. Thank you very much for the opportunity to peer review the draft SGEIS and the State DOH plans.

Very truly yours,

Lynn R Goldman

Lynn R. Goldman, M.D., M.P.H.
Dean

Enclosure

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Dr Nirav Shah
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Dear Doctor Shah:

Thank you for your request that I and two other independent health advisors review the materials that were provided to us on High-Volume Hydraulic Fracturing (HVHF) in New York State (NYS).

NYS has taken on a very difficult and important challenge. You and your colleagues have devoted considerable resources and hard work in confronting the health issues related to HVHF. These efforts are truly commendable and for this reason I agreed to perform my review on voluntary non-paid basis for NYS, and my comments are my own and are not those of my employer.

As noted in my Curriculum Vitae, I am a physician, a member of the U.S. Institute of Medicine, and have more than thirty years' experience in environmental public health leadership at the federal and state levels.
Given the importance of energy availability and reduction of petroleum imports, and the pervasiveness of the proponents' advertising campaigns and political power, HVHF is likely to continue in the United States and worldwide. At the same time, HVHF is confounded by serious concerns about environmental degradation and worker and community health impacts. With such important and complex issues regarding HVHF, we are all burdened by inadequate federal health leadership and the paucity of useful federal health research in this area. HVHF is at a scale and impact that the need for a national Health Impact Assessment (HIA) has urgency.

All means of energy production have impacts on health, and these impacts can be substantial at the global, community, and personal levels and include risks to workers, consumers, and residential populations. This is true for the more conventional means of energy production—hydro, coal, petroleum, solar, natural gas. It is also true for HVHP operations.

The public is deeply concerned about HVHF as evidenced by the 80,000 public comments received during the preparation of the NYS SGEIS. The comments enumerated specific health concerns as well as profound worry about the community stress from these operations and impacts to the landscape and beauty of upstate New York. These "quality of life" issues were mentioned but to a lesser extent than quantified toxic exposures in the SGEIS report. Yet such community impacts perdure; they can be multigenerational and small impacts multiplied by centuries become large.

Because of the unknown risks, NYS is appropriately cautious in the decision about HVHF. The following issues are to me the most important health questions about HVHF:

- Have all negative health impacts that can be reasonably anticipated been identified?
- Are public engagement and communication in the decision process adequate?
- Is there a commitment to HVHF process modifications based on experience in and outside NYS?
- Will effects of HVHF be recorded in real time and in ways that are publically accessible?
- Does NYS DoH possess the necessary authority to monitor HVHF?
- Are there qualified individuals and funding for the health accountability and advisory roles for HVHF?
- If NYS makes a decision to proceed with HVHF, will this occur in a careful phased-in rollout with aggressive health oversight?

The following are my observations and recommendations on issues related to health impacts and risk mitigation of HVHF:

Air Contamination: Physical threats to the environment and human health must be appropriately measured and communicated. Placement of real time analyzers at drilling sites is an effective way to monitor airborne threats such as hydrocarbon and greenhouse gas (GHG) emissions and release of pollutants, carcinogens, and neurotoxins into the air and water. At a minimum, testing for contamination of air as well as water must occur with appropriate frequency along with timely and real time notification of DoH and the public.

Water Contamination: On the issue of potential water contamination, the DoH's responsibility for drinking water protection and the prohibition of certain drilling locations are appropriate. It does appear that the DoH will be notified of all permits. This information should be made available in a master information clearinghouse so all impacted parties will be notified as information is being developed.

Noise Impacts: Noise measurement and abatement are also necessary. In the SGEIS it appears that intermittent noise exposures are dismissed because they are transient; yet from a health standpoint noise poses a significant risk. For example, engine-brake noise from large trucks passing a school or health facility will be intermittent but disruptive and potentially harmful. It appears there are provisions to mitigate these exposures during the rollout period, and noise abatement measures must be continued.

Radiation Exposure: On the issue of radiation exposures, it appears that short term risks above background are not particularly evident. I cannot speak to long term risks and defer to Health Physicists. My experience as Director of CDC's National Center for Environmental Health and in California as the State Health Officer is that Health Physicists are in short supply. I suspect that DoH could need additional health physicist staffing although I defer to DoH on this.

Cumulative Risk: It appears that acute health impacts of HVHF are well covered in the documents. The questions about chronic disease threats are more challenging and the answers more incomplete. It seems to me that appropriate worker and other human health protections are necessary and prudent given the uncertainty about long term effects. The active monitoring of health impacts of HVHF appears to be proposed in the documents and is essential. There must be an ongoing and transparent “learn as we go” Health Impact Assessment.

Notification of Risk: The notification process related to environmental monitoring is important. While drilling firms and property owners will be notified of measured levels, some of the documents indicate cases where the DoH and Emergency Authorities “may” be notified or “should” be notified. From a public health perspective, DoH notification should not be optional or permissive. DoH will need to be involved at some point, and the sooner notification occurs the greater the ability to protect health and mitigate impacts. My experience in other settings such as refineries is that “real time” notification is essential. Delays in or failure to notify health authorities and the public should merit aggressive and increasing penalties.

Worker Safety: Workers are the persons most likely to be more exposed. If a site operator contracts or sub-contracts out work, as is often the case for some of the most dangerous work, the operator must still bear the responsibility to protect and train the workers and bear the liability when there are failures. I understand that enforcement authority in New York resides in federal programs; nevertheless worker protection is of great urgency. It is essential that DoH, the National Institute of Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), and other workplace health and safety personnel are able to carry out unannounced inspections and to issue stop-work orders in the presence of imminent hazard. Examples of imminent hazards include violations of the silica respiratory standard, standards for other hydrocarbons, and for noise.

Community Health: Health is more than the absence of disease as DoH staff knows well, and environmental health is more than the absence of toxic exposures. The walkability of communities is a legitimate health priority as is the protection of natural, scenic, and other environmental assets that promote physical activity by community residents. Rates of obesity and diabetes have lethally doubled in the last generation in the United States including New York State, and any development that reduces physical activity or encourages inactivity and unhealthy eating is a health threat. Factors that can discourage walking and biking and other outdoor activity, such as noise, odors, and heavy truck traffic that may be present with HVHF, present a real measurable health threat.

Protection of Sensitive Populations: On the issue of public protection, the DoH’s HIA now contains more explicit discussion of risks to sensitive populations, especially children and the elderly.

Tracking documented illness: In cases of human exposure, there must be prompt and professional medical evaluation and good recordkeeping of workers and others with documented illness. However, registries that track general and undocumented environmental exposures in my own experience are rarely a good investment of limited public health resources. These efforts quickly become financially and administratively untenable.

Health Communication: In earlier documents, there is reflected a misunderstanding of “health communication.” A fundamental tenet of health communication is that it is a two-way process involving listening as well as speaking. Yet in the SGEIS the term communication is misused to mean merely dispersing public information. This misunderstanding is not present in the DoH HIA. In addition, more clarification is needed about how communication will occur and within what timelines. Notification should not be permissive but required. This discussion exemplifies the need for a central clearinghouse for collected data, including planned permits, site locations, drilling dates, discharges, exceedances, and human exposures or illnesses. The public has a “right to know” with appropriate confidentiality of personal protected information.

Health Advisory Committee: The report indicates that an external Health Advisory Committee is to be considered. I urge this most strongly. My experience is that elected officials view Advisory Committees with skepticism, however well-balanced committees of knowledgeable and respected persons of good will and courtesy work well in highly contended situations. Advisory Committees do require clear mission and task statements, as well as appropriate staffing and timelines, bylaws, membership rotation, and sunset dates.

Full Accounting of Impacts: It is important to fully consider potential impacts to local, county and state levels on both the positive and negative sides. “Boomtowns” have inherent social and public health threats, and these negative effects must be mitigated. HVHF needs to create more health benefits than health negatives. This goes back to my original observation that all means of energy production (particularly old coal-fired power plants) are associated with negative health impacts. Ongoing data to better evaluate benefits are needed.

Sufficient Funding: I believe the resource impacts of HVHF on DoH and local health jurisdictions will be substantial. In similar situations of great public concern at CDC we were obliged to assign individuals to regional offices to track concerns. Resources may include health educators, information managers, toxicologists, chemists competent in biomonitoring, industrial hygienists, GIS specialists, occupational health experts, syndromic and sentinel events surveillance, local assignees and clerical staff. My experience is that elected officials often publically promise funding and staffing for roles while the actual funding does not occur or is quietly redirected to other areas.

Phased Rollout with Health Impact Assessment (HIA): The 2011 report on HIA by the National Academy of Sciences Committee that I chaired took a team of experts 18 months to develop. Our Committee asserted that traditional Environmental Impact Assessments (EIAs) are often focused on non-human impacts within an engineering and regulatory framework and too often give little attention to personal or population health. In general, the Committee found that large scale projects and programs with a strong likelihood of human health impacts should be subject to rigorous HIA that is consonant with the National Environmental Policy Act (NEPA). HVHF is precisely the kind of activity to which HIA should be applied. I believe the current DoH HIA (Dec 7, 2012 version) enumerates the issues and concerns well. If the policy decision in NYS is to proceed with HVHF, the need for an HIA is not moot, rather what is needed is an aggressive “learn as you go” HIA during a carefully phased rollout.

In conclusion: With the increasing pressure for HVHF in NYS, if it is approved, it creates a need to assure long term health benefits. The history of extraction industries with their boom and bust cycles can be dealt with wisely if the good of the public overall is the goal and there is strong regulation. These comments are not an endorsement of HVHF; they reflect my belief that the NYS DoH Public Health Review that was updated and sent to me on December 7, 2012, reflects substantial “due diligence.”

Thank you for the chance to review such an important health issue.

Respectfully submitted,

Richard J. Jackson, MD, MPH, FAAP
Professor and Chair of Environmental Health Sciences

Some common themes run through the information obtained from consultation with other state agencies, outside authorities, and the public health expert consultants. Common concerns include air quality impacts, truck traffic impacts, noise, challenges with wastewater management, social disruption associated with rapidly-escalating industrialization in communities, and the cumulative effect of HVHF activities on stress. The public health expert consultants particularly emphasized that data gaps exist regarding the degree and extent to which HVHF contributes indirectly to human health impacts due to stressors including off-site nuisance odors and visual impacts such as nuisance light pollution (i.e., beyond simply annoyance). All of these factors can influence stress and quality of life perceptions that can adversely impact health. Another data gap highlighted by the expert consultants was the need for evaluation of uncertainties regarding the potential indirect public health impacts that could be associated with degradation of surface waters and wetlands through impacts on fish resources (recreationally and as a source of healthy food), other healthy recreational opportunities (e.g., swimming, boating) and flood control.

Most of the recently-published HIAs acknowledge that there are significant gaps in our knowledge of potential public health impacts from HVHF and of the effectiveness to date of some mitigation measures. Other common themes include the need for robust and constantly evolving regulatory framework, for strong enforcement of rules designed to ensure best practices, and for community involvement.

| Overall Conclusions

The DOH Public Health Review finds that information gaps still exist regarding various aspects of HVHF activities. Well-designed, prospective, longitudinal studies are lacking that evaluate the overall effect of HVHF shale-gas development on public health outcomes. The existing science investigating associations between HVHF activities and observable adverse health outcomes is very sparse and the studies that have been published have significant scientific limitations. Nevertheless, studies are suggestive of potential public health risks related to HVHF activity that warrant further careful evaluation. Additional population-based research and surveillance, and more studies involving field investigations in locations with active HVHF shale-gas development, would be valuable.

Systematic investigations studying the effects of HVHF activity on groundwater resources, local-community air quality, radon exposure, noise exposure, wastewater treatment, induced seismicity, traffic, psychosocial stress, and injuries would help reduce scientific uncertainties. While some of the on-going or proposed major study initiatives may help close those existing data gaps, each of these alone would not adequately address the array of complex concerns. For example:

Marcellus Shale Initiative Study.

Geisinger Health System, the lead organization in the collaborative Marcellus Shale Initiative, cares for many patients in areas where shale gas is being developed in Pennsylvania. They began pilot studies in 2013 using well and infrastructure data to estimate exposures to all aspects of Marcellus shale development in Pennsylvania. According to the a National Institutes of Health abstract, Geisinger will use these exposure estimates to evaluate whether asthma control and pregnancy outcomes are affected by Marcellus shale development by studying 30,000 asthma patients and 22,000 pregnancies in the Geisinger Health System from 2006-13. Results from this study are not expected to be available for several years.

University of Colorado at Boulder, Sustainability Research Network.

A five-year cooperative agreement funded by the National Science Foundation (NSF) under NSF's Sustainability Research Network competition, this program involves a multi-disciplinary team of investigators and is intended to address:

> *"the conflict between natural gas extraction and water and air resources protection with the development of a social-ecological system framework with which to assess the conflict and to identify needs for scientific information. Scientific investigations will be conducted to assess and mitigate the problems. Outreach and education efforts will focus on citizen science, public involvement, and awareness of the science and policy issues."*[30]

Published research has been produced from this program investigating associations between HVHF activity and birth outcomes and potential for methane leakage from natural gas infrastructure. The cooperative agreement extends to 2017.

EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources.

Begun in 2011, the purpose of the study is to assess the potential impacts of hydraulic fracturing on drinking water resources, if any, and to identify the driving factors that may affect the severity and frequency of such impacts. The research approach includes:

analyses of existing data, scenario evaluations, laboratory studies, toxicity studies, and case studies. US EPA released a progress report on December 21, 2012 and stated that preliminary results of the study are expected to be released as a draft for public and peer review as soon as the end of 2014, although the full study is not expected to be completed before 2016.

Pennsylvania Department of Environmental Protection (PA DEP) Comprehensive Oil and Gas Development Radiation Study.

Started in early 2013, PA DEP is analyzing the radioactivity levels in produced and flowback waters, wastewater recycling, treatment sludges, and drill cuttings, as well as issues with transportation, storage, and disposal of drilling wastes, the levels of radon in natural gas, and potential exposures to workers and the public. According to a July 2014 update from the PA DEP, publication of a report could occur as soon as the end of 2014.

University of Pennsylvania Study.

A proposed study of HVHF health impacts was announced several months ago. The study is led by researchers from the University of Pennsylvania in collaboration with scientists from Columbia University, Johns Hopkins University, and the University of North Carolina.

These major study initiatives may eventually reduce uncertainties regarding health impacts of HVHF and could contribute to a much more complete knowledge base for managing HVHF risks. However, it will be years before most of these major initiatives are completed.

HVHF is a complex activity that could affect many communities. The number of well pads and associated HVHF activities could be vast and spread out over wide geographic areas where environmental conditions and populations vary. The dispersed nature of the activity magnifies the possibility of process and equipment failures, leading to the potential for cumulative risks for exposures and associated adverse health outcomes. Additionally, the relationships between HVHF environmental impacts and public health are complex and not fully understood. Comprehensive, long-term studies, and in particular longitudinal studies, that could contribute to the understanding of those relationships are either not yet completed or have yet to be initiated. In this instance, however, the overall weight of the evidence from the cumulative body of information contained in this Public Health Review demonstrates that there are significant uncertainties about the kinds of adverse health outcomes that may be associated with HVHF, the likelihood of the occurrence of adverse health outcomes, and the effectiveness of some of the mitigation measures in reducing or preventing environmental impacts which could adversely affect public health.

While a guarantee of absolute safety is not possible, an assessment of the risk to public health must be supported by adequate scientific information to determine with confidence that the overall risk is sufficiently low to justify proceeding with HVHF in New York. The current scientific information is insufficient. Furthermore, it is clear from the existing literature and experience that HVHF activity has resulted in environmental impacts that are potentially adverse to public health. Until the science provides sufficient information to determine the level of risk to public health from HVHF and whether the risks can be adequately managed, HVHF should not proceed in New York State.

| Endnotes

1 The Generic Environmental Impact Statement (1992 GEIS) on the Oil, Gas and Solution Mining Regulatory Program is posted on DEC's website at http://www.dec.ny.gov/energy/45912.html. The 1992 GEIS includes an analysis of impacts from gas drilling and low-volume hydraulic fracturing. Since 1992 the Department has used the 1992 GEIS as the basis of its State Environmental Quality Review Act (SEQRA) review for permit applications for gas drilling in New York State.

2 All internet addresses cited in this report were confirmed to be active as of November 20, 2014.

3 The revision of the SGEIS reviewed by DOH and the DOH expert consultants was a newly revised draft-final SGEIS provided by DEC to DOH on October 22, 2012 that incorporated changes by DEC in response to public comments received on the 2009 draft SGEIS and the 2011 revised draft SGEIS.

4 For example, the broad public health consensus that a causal relationship exists between levels of fine particulate matter in outdoor air and many respiratory and cardiovascular health outcomes, including premature mortality, is based on weight-of-evidence evaluations of several thousand studies published over decades. (See U.S. Environmental Protection Agency, (2009), Integrated Science Assessment for Particulate Matter (Final Report)).

5 As of December, 2014, the slide presentation is no longer available on the SWPA-EHP web site. This report appears to be similar to, and possibly a preliminary version of, the subsequent peer-reviewed study by Rabinowitz et al. (2014)

6 The total number of cases categorized by symptom type sums up to 27, but it is not clear whether some individuals might have been counted in more than one symptom category.

7 For example, see: http://www.cdc.gov/socialdeterminants/.

8 For a recent example, see: http://headwaterseconomics.org/energy/western-counties-fossil-fuel-development.

9 Truck traffic also contributes to airborne emissions of fugitive dust and truck exhaust from the well pad. See Air Quality Impacts discussion above.

10 For example, the Earthworks and Southwest Pennsylvania Environmental Health Project reports described previously.

11 https://www.osha.gov/silica/.

12 The NPRM is available from the Federal Register in print (Document number: 2013-20997) or online at https://federalregister.gov/a/2013-20997.

[13] http://www.atsdr.cdc.gov/HAC/pha/Garfield_County_HC_3-13-08/Garfield_County_HC_3-13-08.pdf.

[14] The maximum 1-hour toluene concentration at one monitoring location in 2007 was 653 micrograms/m^3 vs. a short-term odor comparison value of 640 micrograms/m^3.

[15] Annual average concentrations of 1,2-dibromoethane for 2011 were 0.42 micrograms/m^3 and 0.33 micrograms/m^3 at the Denton Airport South canister and the Fort Worth Northwest canister, respectively vs. the chronic health-based comparison value of 0.0167 micrograms/m^3.

[16] http://www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_related_topics/20349/air/986695.

[17] A hazard quotient is a comparison of an exposure level in the environment to a risk-based comparison value. A hazard quotient at or below 1.0 generally indicates that exposures are unlikely to have significant health risk.

[18] WV's occupied dwelling structure setback is 625 ft from the well-pad center.

[19] US EPA delegated primary SDWA implementation and enforcement authority (known as primacy) to NYS DOH.

[20] Six of the twelve chemicals tested in Kassotis et al. are not listed among the HVHF chemical additives submitted to DEC by drillers and well service companies as potential additives to be used in New York State. These include diethanolamine, diethyl glycol methyl ether, N,N-dimethylformamide, styrene, bisphenol A, and sodium tetraborade (sic) decahydrate. Sodium tetraborate decahydrate is listed in the draft SGEIS as a potential HVHF chemical additive in NYS.

[21] See, for example, U.S. Geological Survey. 2014. Record Number of Oklahoma Tremors Raises Possibility of Damaging Earthquakes. Updated USGS-Oklahoma Geological Survey Joint Statement on Oklahoma Earthquakes http://earthquake.usgs.gov/regional/ceus/products/newsrelease_05022014.php. Also see US EPA's Underground Injection Control web pages: http://yosemite.epa.gov/r10/water.nsf/476d8e2e8829cf19882565d400706530/51bbc02148429af1882568730082f6fa!opendocument.

[22] http://ohiodnr.gov/news/post/ohio-announces-tougher-permit-conditions-for-drilling-activities-near-faults-and-areas-of-seismic-activity.

[23] http://www.governor.maryland.gov/executiveorders/01.01.2011.11.pdf.

[24] http://dhmh.maryland.gov/newsroom1/Pages/Comments-Requested-on-the-Marcellus-Shale-Project.aspx.

[25] http://www.mde.state.md.us/programs/Land/mining/marcellus/Pages/Health_Study.aspx; http://www.marcellushealth.org/final-report.html.

[26] http://graham.umich.edu/knowledge/pubs.

[27] http://graham.umich.edu/media/files/HF-05-Public-Health.pdf.

[28] http://environmentalhealthcollaborative.org/images/2012SummitWorkProduct.pdf.

[29] http://www.novascotia.ca/nse/pollutionprevention/consultation.hydraulic.fracturing.asp (Website includes multiple related publications.)

[30] Routes to Sustainability for Natural Gas Development and Water and Air Resources in the Rocky Mountain Region. National Science Foundation Award Abstract #1240584. http://www.nsf.gov/news/news_summ.jsp?cntn_id=125599; Shonkoff, S.B., et al. (2014). Environmental Public Health Dimensions of shale and Tight Gas Development. *Environmental Health Perspectives*, 122(8):787-95.; http://dx.doi.org/10.1289/ehp.1307866.

[31] For example, a vast literature exists on HVHF engineering, shale-gas geology, geophysics and petrology that is outside of the scope of the Public Health Review and outside of DOH expertise.

| References

Allen, D.T., Torres, V.M., Thomas, J., Sullivan, D.W., Harrison, M., Hendler, A.…, Seinfeld, J.H. (2013). Measurements of Methane Emissions at Natural Gas Production Sites in the United States. *Proceedings of the National Academy of Sciences* (PNAS), 110(44):17768-73.

Bamberger, M., Oswald, R.E. (2013). Introduction: Science and Politics of Shale Gas Extraction. *New Solutions*, Special Issue, 23(1): 7-12.

Bamberger, M, Oswald, R.E. (2012). Impacts of Gas Drilling on Human and Animal Health. *New Solutions*, 22:51-77.

Basu, N. (2013). Public Health Technical Report. Hydraulic Fracturing in the State of Michigan. University of Michigan, School of Public Health. Retrieved from http://graham.umich.edu/media/files/HF-05-Public-Health.pdf.

Broomfield, M. (2012). Support to the Identification of Potential Risks for the Environment and Human Health Arising from Hydrocarbons Operations Involving Hydraulic Fracturing in Europe. European Commission DG Environment publication 07.0307/ENV.C.1/2011/604781/ENV.F1. Retrieved from http://ec.europa.eu/environment/integration/energy/pdf/fracking%20study.pdf.

Bunch, A.G., Perry, C.S., Abraham, L., Wikoff, D.S., Tachivsky, J.A, Hixon, J.G…., Haws, L.C. (2014). Evaluation of Impact of Shale Gas

Operations in the Barnett Shale Region on Volatile Organic Compounds in Air and Potential Human Health Risks. *Science of the Total Environment*, 468-469:832-842.

Centers for Disease Control and Prevention (CDC). (2011). 10 Essential Environmental Public Health Services. Retrieved from http://www.cdc.gov/nceh/ehs/home/healthservice.htm.

Chang, E.E., Lin, Y.P., Chiang, P.C. (2001). Effects of Bromide on the Formation of THMs and HAAs. *Chemosphere*. 43:1029-1034.

Colorado Department of Public Health and Environment. (2010). Health Consultation: Public Health Implications of Ambient Air Exposures as Measured in Rural and Urban Oil & Gas Development Areas – an Analysis of 2008 Air Sampling Data, Garfield County, Colorado. Retrieved from http://www.atsdr.cdc.gov/HAC/pha/GarfieldCountyColorado2010/GarfieldCountyColoradoHC08262010.pdf.

Darrah, T.H., Vengosh, A., Jackson, R.B., Warner, N.R., Poreda, R.J. (2014). Noble Gases Identify the Mechanisms of Fugitive Gas Contamination in Drinking-Water Wells Overlying the Marcellus and Barnett Shales. *Proceedings of the National Academy of Sciences* (PNAS), 111(39):14076-81.

Edwards, P.M., Young, C.J., Aikin, K., deGouw, J.A., Dubé, W.P., Geiger, F., Brown, S.S. (2013). Ozone Photochemistry in an Oil and Natural Gas Extraction Region During Winter: Simulations of a Snow-Free Season in the Uintah Basin, Utah. *Atmospheric Chemistry and Physics*, 13:7503–7552.

Federal Register: The Daily Journal of the United States Government. (September 12, 2013) Occupational Exposure to Respirable Crystalline Silica: A Proposed Rule by the Occupational Safety and Health Administration. Document number: 2013-20997. Retrieved from https://www.federalregister.gov/articles/2013/09/12/2013-20997/occupational-exposure-to-respirable-crystalline-silica.

Field, R.A., Soltis, J., Murphy, S. Air Quality Concerns of Unconventional Oil and Natural Gas Production. (2014) *Environmental Science: Processes & Impacts*, 16(5):954-69.

Finkel, M.L., Hays, J. (2013). The Implications of Unconventional Drilling for Natural Gas: A Global Public Health Concern. *Public Health*, 127(10):889-93.

Fryzek, J., Pastula, S., Jiang, X., Garabrant, D.H. (2013) Childhood Cancer Incidence in Pennsylvania Counties in Relation to Living in Counties with Hydraulic Fracturing Sites. *Journal of Occupational and Environmental Medicine,* 55(7):796-801.

Gold, R., & McGinty, T. (2013, October 25). Energy Boom Puts Wells in America's Backyards. The Wall Street Journal. Retrieved from http://online.wsj.com/articles/SB1000142405270230367240457914943236 5326304.

Graham, J., Irving, J., Tang, X., Sellers, S., Crisp, J., Horwitz, D., & Muehlenbachs, L. (2015). Increased Traffic Accident Rates Associated with Shale Gas Drilling in Pennsylvania. *Accident Analysis and Prevention*, 74:203–209.

Haggerty J., Gude P.H., Delorey M., and Rasker, R. (in press). Long-term effects of income specialization in oil and gas extraction: the U.S. West, 1980 – 2011. *Journal of Energy Economics*.

Headwaters Economics (2013). Oil and Gas Extraction as an Economic Development Strategy. Retrieved from http://headwaterseconomics.org/energy/western-counties-fossil-fuel-development.

Hill, E. (2013). Shale Gas Development and Infant Health: Evidence from Pennsylvania. Working paper. Cornell University, Charles H. Dyson School of Applied Economics and Management. Retrieved from http://dyson.cornell.edu/research/researchpdf/wp/2012/Cornell-Dyson-wp1212.pdf.

Holland, A.A. (2014). Imaging Time Dependent Crustal Deformation Using GPS Geodesy and Induced Seismicity, Stress and Optimal Fault Orientations in the North American Mid-Continent. Graduate Thesis. University of Arizona. Retrieved from http://arizona.openrepository.com/arizona/handle/10150/332903.

Institute of Medicine of the National Academies, Board on Population Health and Public Health Practice, Roundtable on Environmental Health Sciences, Research, and Medicine (IOM). (2014) Health Impact Assessment of Shale Gas Extraction: Workshop Summary. Washington (DC): National Academies Press (US).

Junkins, C. (2013, December 10). Health Dept. Concerned about Benzene Emissions Near Local Gas Drilling Sites. *The Intelligencer, Wheeling News-Register.* Retrieved from http://www.theintelligencer.net/page/content.detail/id/593209/Health-Dept--Concerned-About-Benzene-Emissions-Near-Local-Gas-Drilling.

Kassotis, C.D., Tillit, D.E., Davis, W., Hormann, A.M., Nagel, S.C. (2014). Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region. *Endocrinology,* 155(3):897-907.

Kemball-Cook, S., Bar-Ilan, A., Grant, J., Parker, L., Jung, J., Santamaria, W…. Yarwood, G. (2010). Ozone Impacts of Natural Gas Development in the Haynesville Shale. *Environmental Health Perspectives*, 44(24):9357-9363.

Kohl, C.A., Capo, R.C., Stewart, B.W., Wall, A.J., Schroeder, K.T., Hammack, R.W., Guthrie, G.D. (2014) Strontium Isotopes Test Long-Term Zonal Isolation of Injected and Marcellus Formation Water After Hydraulic Fracturing. *Environmental Science & Technology,* 48(16):9867-73.

Macey, G.P., Breech, R., Chernaik, M., Cox, C., Larson, D., Thomas, D., & Carpenter, D.O. (2014). Air Concentrations of Volatile Compounds Near Oil and Gas Production: A Community-Based Exploratory Study. *Environmental Health,* 13(1), 82.

Maryland Department of the Environment & Maryland Department of Natural Resources (2014). Assessment of Risks from Unconventional Gas Well Development in the Marcellus Shale of Western Maryland. Retrieved from http://www.mde.state.md.us/programs/Land/mining/marcellus/Documents/Complete_RA_for%20posting.pdf.

Maryland, State Government, Executive Department Executive Order 01.01.2011.11. The Marcellus Shale Safe Drilling Initiative. Retrieved from http://www.governor.maryland.gov/executiveorders/01.01.2011.11.pdf.

Maxwell, S. (2013). Unintentional Seismicity Induced by Hydraulic Fracturing. Canadian Society for Exploration Geophysics. CSEG Recorder, 38:08. Retrieved from http://csegrecorder.com/articles/view/unintentional-seismicity-induced-by-hydraulic-fracturing.

McCawley, M. (2013). Air, Noise, and Light Monitoring Results for Assessing Environmental Impacts of Horizontal Gas Well Drilling Operations. West Virginia University School of Public Health, Morgantown, WV. Retrieved from http://wvwri.org/wp-content/uploads/2013/10/A-N-L-Final-Report-FOR-WEB.pdf.

McCawley, M. (2012). Air, Noise, and Light Monitoring Plan for Assessing Environmental Impacts of Horizontal Gas Well Drilling Operations (ETD-10 Project), West Virginia University School of Public Health, Morgantown, WV. Retrieved from http://www.dep.wv.gov/oil-and-gas/Horizontal-Permits/legislativestudies/Documents/WVU%20Final%20Air%20Noise%20Light%20Protocol.pdf.

McKenzie, L.M., Guo, R., Witter, R.Z., Savitz, D.A., Newman, L.S., Adgate, J.L. (2014). Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado. *Environmental Health Perspectives,* 122(4):412-7.

Miller, S.M., Wofsy, S.C., Michalak, A.M., Kort, E.A., Andrews, A.E., Biraud, S.C., Sweeney, C. (2013). Anthropogenic Emissions of Methane in the United States. *Proceedings of the National Academy of Sciences* (PNAS), 110(50):20018-22.

National Institute for Occupational Safety and Health (NIOSH). (2012). Health Hazards in Hydraulic Fracturing. Presented at Institute of Medicine of the National Academies, Roundtable on Environmental Health Sciences, Research, and Medicine. Health Impact Assessment of Shale Gas Extraction workshop. Retrieved from http://www.iom.edu/Activities/Environment/EnvironmentalHealthRT/2012-APR-30.aspx.

National Institute for Occupational Safety and Health (NIOSH). (2010). NIOSH Field Effort to Assess Chemical Exposures in Oil and Gas Workers. NIOSH Fact Sheet. Retrieved from http://www.cdc.gov/niosh/docs/2010-130/pdfs/2010-130.pdf.

New York State Department of Environmental Conservation. (1992). Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program (GEIS). Retrieved from http://www.dec.ny.gov/energy/45912.html.

NTC Consultants. (2011). Impacts on community character of horizontal drilling and high volume hydraulic fracturing in Marcellus shale and other low-permeability gas reservoirs. Final Report. Prepared for the New York State Energy Research and Development Authority. NYSERDA Contract #: 11170 & 1955.

Ohio Department of Natural Resources. (2014, April 4). Ohio Announces Tougher Permit Conditions for Drilling Activities Near Faults and Areas of Seismic Activity. Press Release. Retrieved from http://ohiodnr.gov/news/post/ohio-announces-tougher-permit-conditions-for-drilling-activities-near-faults-and-areas-of-seismic-activity.

Osborn, S.G., Vengosh, A., Warner, N.R., Jackson, R.B. (2011). Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing. Proceedings of the National Academy of Sciences (PNAS), 108: 8172-8176.

Parker, K.M., Zeng, T., Harkness, J., Vengosh, A., Mitch, W.A. (2014). Enhanced Formation of Disinfection Byproducts in Shale Gas Wastewater-Impacted Drinking Water Supplies. *Environmental Science & Technology,* 48(19):11161-9.

Penning, T.M., Breysse, P.N., Gray, K., Howarth, M., Yan, B. (2014). Environmental Health Research Recommendations from the Inter-Environmental Health Sciences Core Center Working Group on Unconventional Natural Gas Drilling Operations. *Environmental Health Perspectives,* 122.11, 1155-1159.

Pennsylvania Department of Environmental Protection. (2012). DEP Conducting Long-Term Marcellus Shale Air Monitoring Study in Southwestern Pennsylvania. Retrieved from http://www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_related_topics/20349/air/986695.

Pétron, G., Frost, G., Miller, B. R., Hirsch, A. I., Montzka, S. A., Karion, A...., & Tans, P. (2012). Hydrocarbon Emissions Characterization in the Colorado Front Range: A Pilot Study. *Journal of Geophysical Research: Atmospheres (1984–2012),* 117(D4).

Rabinowitz, P.M., Slizovskiy, I.B., Lamers, V., Trufan, S.J., Holford, T.R., Dziura, J.D…., Stowe, M.H. (2014) Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania. *Environmental Health Perspectives.* Retrieved from http://ehp.niehs.nih.gov/1307732/.

Research Triangle Environmental Health Collaborative. (2013). Shale Gas Extraction in North Carolina: Public Health Implications. Retrieved from http://environmentalhealthcollaborative.org/images/2012SummitWorkProduct.pdf.

Retzer, K., Hill, R. (2011). Fatal Injuries. WellServicingMagazine.com. Retrieved from http://www.wellservicingmagazine.com/featured-articles/2011/09/fatal-injuries/.

Rowan, E.L., and Kramer, T.F. (2012). Radon-222 Content of Natural Gas Samples from Upper and Middle Devonian Sandstone and Shale Reservoirs in Pennsylvania: Preliminary Data. US Geological Survey. Open-File Report 2012–1159, 6 p., http://pubs.usgs.gov/of/2012/1159. (Available only online.)

Satterfield, P.E., National Environmental Services Center. (2011). Oil and Gas Extraction and Source Water Protection. Tech Brief. Vol. 11, Issue 2. Retrieved from http://www.nesc.wvu.edu/pdf/DW/publications/ontap/tech_brief/TB54_OIlGasExtraction.pdf.

Sharma, S., Mulder, M.L., Sack, A., Schroeder, K., Hammack, R. (2014). Isotope Approach to Assess Hydrologic Connections during Marcellus Shale Drilling. *Groundwater,* 52(3):424-33.

Shonkoff, S.B., Hays, J., Finkel, M.L. (2014). Environmental Public Health Dimensions of Shale and Tight Gas Development. *Environmental Health Perspectives,* 122(8):787-95

Stedman, R.C., Jacquet, J.B., Filteau, M.R., Willits, F.K., Brasier, K.J., McLaughlin, D.K. (2012). Environmental Reviews and Case Studies: Marcellus Shale Gas Development and New Boomtown Research: Views of New York and Pennsylvania Residents. *Environmental Practice,* 14:382-393.

Steinzor, N., Subra, W., Sumi, L. (2012). Gas Patch Roulette: How Shale Gas Development Risks Public Health in Pennsylvania. Earthworks Gas & Oil Accountability Project. Retrieved from http://www.earthworksaction.org/files/publications/Health-Report-Full-FINAL-sm.pdf.

Southwest Pennsylvania Environmental Health Project (SWEHP). Addressing the Effects of Natural Gas Drilling in SWPA. Retrieved from http://www.environmentalhealthproject.org/.

Texas Department of State Health Services (DSHS). (2010). Final Report: DISH, Texas Exposure Investigation, Dish, Denton County, Texas. Retrieved from www.dshs.state.tx.us/epitox/consults/dish_ei_2010.pdf.

United States Department of Energy (US DOE). (2009). Technical support document: energy efficiency program for consumer products and commercial and industrial equipment: residential dishwashers, dehumidifiers, and cooking products, and commercial clothes washers. Office of Energy Efficiency and Renewable Energy, Building Technologies program. EERE-2006-STD-0127.

United States Department of the Interior. U.S. Geological Survey. (2014). General Facts and Concepts about Ground Water. Retrieved from http://pubs.usgs.gov/circ/circ1186/html/gen_facts.html.

United States Department of the Interior. U.S. Geological Survey. (2014). Record Number of Oklahoma Tremors Raises Possibility of Damaging Earthquakes. Updated USGS-Oklahoma Geological Survey Joint Statement on Oklahoma Earthquakes. Retrieved from http://earthquake.usgs.gov/contactus/golden/newsrelease_05022014.php.

United States Environmental Protection Agency (US EPA). (1973). Assessment of Potential Radiological Health Effects from Radon in Natural Gas, by Raymond H. Johnson, Jr., David E. Bernhardt, Neal S. Nelson, DVM, and Harry W. Calley, Jr. EPA 520/1-73-004.

United States Environmental Protection Agency (US EPA). (2009). Integrated Science Assessment for Particulate Matter (Final Report), Washington, DC, EPA/600/R-08/139F. Retrieved from http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_2007_isa.html/.

United States Environmental Protection Agency (US EPA), Pavillion site documents. Retrieved from http://www2.epa.gov/region8/pavillion-site-documents.

United States Environmental Protection Agency (US EPA). (2011). Region 6 administrative records. Retrieved from http://www.epa.gov/region6/6xa/pdf/administrative_record_range_011311.pdf.

United States Environmental Protection Agency (US EPA). Underground Injection Control Program. Retrieved from http://yosemite.epa.gov/r10/water.nsf/476d8e2e8829cf19882565d400706530/51bbc02148429af1882568730082f6fa!opendocument.

United States Department of Labor, Occupational Safety & Health Administration (US DOL OSHA). (2012). Crystalline Silica Rulemaking. Retrieved from https://www.osha.gov/silica/.

United States Department of Labor, Occupational Safety & Health Administration (US DOL OSHA). (2012). Worker Exposure to Silica during Hydraulic Fracturing. Retrieved from https://www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.html.

University of Colorado at Boulder, lead institution. (2012). Routes to Sustainability for Natural Gas Development and Water and Air Resources in the Rocky Mountain Region. National Science Foundation Award Abstract #1240584. Retrieved from http://www.nsf.gov/news/news_summ.jsp?cntn_id=125599.

University of Maryland, Maryland Institute for Applied Environmental Health, School of Public Health (2014). Potential Public Health Impacts of Natural Gas Development and Production in the Marcellus Shale in Western Maryland. Retrieved from http://phpa.dhmh.maryland.gov/OEHFP/EH/Shared%20Documents/Reports/MDMarcellusShalePublicHealthFinalReport08.15.2014.pdf.

University of Michigan, Graham Sustainability Institute. (2013).Hydraulic Fracturing in Michigan Integrated Assessment technical reports. Retrieved from http://graham.umich.edu/knowledge/pubs.

Vengosh, A., Jackson, R.B., Warner, N., Darrah, T.H., Kondash, A. (2014). A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States. *Environmental Science & Technology,* 48(15):8334-48.

Warner, N.R., Christie, C.A., Jackson, R.B., Vengosh, A. (2013). Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania. Environmental Science & Technology, 47(20):11849-57.

Warner, N.R., Darrah, T.H., Jackson, R.B., Millot, R., Kloppmann, W., Vengosh, A. (2014). New Tracers Identify Hydraulic Fracturing Fluids and Accidental Releases from Oil and Gas Operations. Environmental Science & Technology, 48 (21), pp 12552–12560.

Warner, N.R., Jackson, R.B., Darrah, T.H., Osborn, S.G., Down, A., Zhao, K., White, A., & Vengosh, A. (2012). Geochemical Evidence for Possible Natural Migration of Marcellus Formation Brine to Shallow Aquifers in Pennsylvania. *Proceedings of the National Academy of Sciences* (PNAS), 109(30):11961-6.

Weisel, C.P. (2010). Benzene Exposure: An Overview of Monitoring Methods and their Findings. Chemico-Biological Interactions, 184(1-2):58-66.

Werner, A.K., Vink, S., Watt, K., Jagals, P. (2015). Environmental Health Impacts of Unconventional Natural Gas Development: A Review of the Current Strength of Evidence. Science of the Total Environment, 505:1127–1141.

West Virginia Department of Environmental Protection (WVDEP). (2013). Noise, Light, Dust, and Volatile Organic Compounds Generated by the Drilling of Horizontal Wells Related to the Well Location Restriction Regarding Occupied Dwelling Structures. Office of Oil and Gas publication pursuant to WV code §22-6A-12(e). Retrieved from http://www.dep.wv.gov/oil-and-gas/Horizontal-Permits/legislativestudies/Documents/FINAL%20OOG%20Noise%20Light%20Dust%20and%20VOCs%20Report%205-28-2013.pdf.

Wheeler, D., Atherton, F., Bradfield, M., Christmas, K., Dalton, S., Dussealt, M.…, Gagnon, G. (2014). Report of the Nova Scotia Independent Panel on Hydraulic Fracturing. Retrieved from http://energy.novascotia.ca/sites/default/files/Report%20of%20the%20Nova%20Scotia%20Independent%20Panel%20on%20Hydraulic%20Fracturing.pdf.

Witter, R., McKenzie, L., Towle, M., Stinson, K., Scott, K., Newman, L, & Adgate, J. (2010). Health Impact Assessment for Battlement Mesa, Garfield County, Colorado. Colorado School of Public Health, University of Colorado Denver, Colorado School of Public Health. Retrieved from http://www.garfield-county.com/public-health/documents/1%20%20%20Complete%20HIA%20without%20Appendix%20D.pdf.

World Health Organization. (2009). Night Noise Guidelines for Europe. WHO Regional Office for Europe, ISBN 978 92 890 4173 7, Retrieved from http://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf.

Zhang, L., Anderson, N., Dilmore, R., Soeder, D.J., Bromhal, G. (2014). Leakage Detection of Marcellus Shale Natural Gas at an Upper Devonian Gas Monitoring Well: A 3-D Numerical Modeling Approach. *Environmental Science & Technology,* 48(18):10795-803.

| Appendix 1

Supplemental Literature Considered for the Public Health Review

The focused literature review presented above presents and analyzes the peer-reviewed scientific literature judged to be most relevant to assessing the potential for adverse public health risks from HVHF activities. The focused literature review was not intended to encompass the entirety of published literature on HVHF.[31] However, DOH reviewed a broader range of peer-reviewed studies in addition to those discussed in the main report that investigate various aspects of HVHF, but were judged to provide supplemental background information for the Public Health Review. This supplemental peer-reviewed literature provided additional support for the main conclusions of the Public Health Review. An extended bibliographic list of these peer-reviewed studies is presented below, including the study abstracts from each of the peer-reviewed references.

Allen, D.T., Torres, V.M., Thomas, J., Sullivan, D.W., Harrison, M., Hendler, A., Herndon, S.C., Kolb, C.E., Fraser, M.P., Hill, A.D., Lamb, B.K., Miskimins, J., Sawyer, R.F., Seinfeld, J.H. Measurements of Methane Emissions at Natural Gas Production Sites in the United States. Proc Natl Acad Sci U S A. 2013 Oct 29;110(44):17768-73. doi: 10.1073/pnas.1304880110. Epub 2013 Sep 16. Erratum in: Proc Natl Acad Sci U S A. 2013 Oct 29;110(44):18023.

Abstract

Engineering estimates of methane emissions from natural gas production have led to varied projections of national emissions. This work reports direct measurements of methane emissions at 190 onshore natural gas sites in the United States (150 production sites, 27 well completion flowbacks, 9 well unloadings, and 4 workovers). For well completion flowbacks, which clear fractured wells of liquid to allow gas production, methane emissions ranged from 0.01 Mg to 17 Mg (mean = 1.7 Mg; 95% confidence bounds of 0.67-3.3 Mg), compared with an average of 81 Mg per event in the 2011 EPA national emission inventory from April 2013. Emission factors for pneumatic pumps and controllers as well as equipment leaks were both comparable to and higher than estimates in the national inventory. Overall, if emission factors from this work for completion flowbacks, equipment leaks, and pneumatic pumps and controllers are assumed to be representative of national populations and are used to estimate national emissions, total annual emissions from these source categories are calculated to be 957 Gg of methane (with sampling and measurement uncertainties estimated at ± 200 Gg). The estimate for comparable source categories in the EPA national inventory is ~1,200 Gg. Additional measurements of unloadings and workovers are needed to produce national emission estimates for these source categories. The 957 Gg in emissions for completion flowbacks, pneumatics, and equipment leaks, coupled with EPA national inventory estimates for other categories, leads to an estimated 2,300 Gg of methane emissions from natural gas production (0.42% of gross gas production).

Allen, D.T. Atmospheric Emissions and Air Quality Impacts from Natural Gas Production and Use. Annu Rev Chem Biomol Eng. 2014;5:55-75. doi: 10.1146/annurev-chembioeng-060713-035938. Epub 2014 Feb 5. Review.

Abstract

The US Energy Information Administration projects that hydraulic fracturing of shale formations will become a dominant source of domestic natural gas supply over the

next several decades, transforming the energy landscape in the United States. However, the environmental impacts associated with fracking for shale gas have made it controversial. This review examines emissions and impacts of air pollutants associated with shale gas production and use. Emissions and impacts of greenhouse gases, photochemically active air pollutants, and toxic air pollutants are described. In addition to the direct atmospheric impacts of expanded natural gas production, indirect effects are also described. Widespread availability of shale gas can drive down natural gas prices, which, in turn, can impact the use patterns for natural gas. Natural gas production and use in electricity generation are used as a case study for examining these indirect consequences of expanded natural gas availability.

Aukema, K.G., Kasinkas, L., Aksan, A., Wackett, L.P. Use of Silica-Encapsulated Pseudomonas Sp. Strain NCIB 9816-4 in Biodegradation of Novel Hydrocarbon Ring Structures Found in Hydraulic Fracturing Waters. Appl Environ Microbiol. 2014 Aug;80(16):4968-76. doi: 10.1128/AEM.01100-14. Epub 2014 Jun 6.

Abstract

The most problematic hydrocarbons in hydraulic fracturing (fracking) wastewaters consist of fused, isolated, bridged, and spiro ring systems, and ring systems have been poorly studied with respect to biodegradation, prompting the testing here of six major ring structural subclasses using a well-characterized bacterium and a silica encapsulation system previously shown to enhance biodegradation. The direct biological oxygenation of spiro ring compounds was demonstrated here. These and other hydrocarbon ring compounds have previously been shown to be present in flow-back waters and waters produced from hydraulic fracturing operations. Pseudomonas sp. strain NCIB 9816-4, containing naphthalene dioxygenase, was selected for its broad substrate specificity, and it was demonstrated here to oxidize fundamental ring structures that are common in shale-derived waters but not previously investigated with this or related enzymes. Pseudomonas sp. NCIB 9816-4 was tested here in the presence of a silica encasement, a protocol that has previously been shown to protect bacteria against the extremes of salinity present in fracking wastewaters. These studies demonstrate the degradation of highly hydrophobic compounds by a silica-encapsulated model bacterium, demonstrate what it may not degrade, and contribute to knowledge of the full range of hydrocarbon ring compounds that can be oxidized using Pseudomonas sp. NCIB 9816-4.

Bamberger, M., Oswald, R. The Shale Gas Revolution from the Viewpoint of a Former Industry Insider. New Solutions 2014 Jul 29:1-16. [Epub ahead of print].

Abstract

This is an interview conducted with an oil and gas worker who was employed in the industry from 1993 to 2012. He requested that his name not be used. From 2008 to 2012, he drilled wells for a major operator in Bradford County, Pennsylvania. Bradford County is the center of the Marcellus shale gas boom in Northeastern Pennsylvania. In 2012, he formed a consulting business to assist clients who need information on the details of gas and oil drilling operations. In this interview, the worker describes the benefits and difficulties of the hard work involved in drilling unconventional gas wells in Pennsylvania. In particular, he outlines the safety procedures that were in place and how they sometimes failed, leading to workplace injuries. He provides a compelling view of the trade-offs between the economic opportunities of working on a rig and the dangers and stresses of working long hours under hazardous conditions.

Bamberger, M., Oswald, R.E. Unconventional Oil and Gas Extraction and Animal Health. Environ Sci Process Impacts. 2014 Aug;16(8):1860-5.

Abstract

The extraction of hydrocarbons from shale formations using horizontal drilling with high volume hydraulic fracturing (unconventional shale gas and tight oil extraction), while derived from methods that have been used for decades, is a relatively new innovation that was introduced first in the United States and has more recently spread worldwide. Although this has led to the availability of new sources of fossil fuels for domestic consumption and export, important issues have been raised concerning the safety of the process relative to public health, animal health, and our food supply. Because of the multiple toxicants used and generated, and because of the complexity of the drilling, hydraulic fracturing, and completion processes including associated infrastructure such as pipelines, compressor stations and processing plants, impacts on the health of humans and animals are difficult to assess definitively. We discuss here findings concerning the safety of unconventional oil and gas extraction from the perspectives of public health, veterinary medicine, and food safety.

Caulton, D.R., Shepson, P.B., Santoro, R.L., Sparks, J.P., Howarth, R.W., Ingraffea, A.R., Cambaliza, M.O., Sweeney, C., Karion, A., Davis, K.J., Stirm, B.H., Montzka, S.A., Miller, B.R. Toward a Better Understanding and Quantification of Methane Emissions from Shale Gas Development. Proc Natl Acad Sci U S A. 2014 Apr 29;111(17):6237-42. doi: 10.1073/pnas.1316546111. Epub 2014 Apr 14.

Abstract

The identification and quantification of methane emissions from natural gas production has become increasingly important owing to the increase in the natural gas component of the energy sector. An instrumented aircraft platform was used to identify large sources of methane and quantify emission rates in southwestern PA in June 2012. A large regional flux, 2.0-14 g CH4 s(-1) km(-2), was quantified for a ~ 2,800-km(2) area, which did not differ statistically from a bottom-up inventory, 2.3-4.6 g CH4 s(-1) km(-2). Large emissions averaging 34 g CH4/s per well were observed from seven well pads determined to be in the drilling phase, 2 to 3 orders of magnitude greater than US Environmental Protection Agency estimates for this operational phase. The emissions from these well pads, representing ~ 1% of the total number of wells, account for 4-30% of the observed regional flux. More work is needed to determine all of the sources of methane emissions from natural gas production, to ascertain why these emissions occur and to evaluate their climate and atmospheric chemistry impacts.

Chen, J., Al-Wadei, M.H., Kennedy, R.C., Terry, P.D. Hydraulic Fracturing: Paving the Way for a Sustainable Future? J Environ Public Health. 2014;2014:656824. doi: 10.1155/2014/656824. Epub 2014 Mar 25. PubMed PMID: 24790614; PubMed Central PMCID: PMC3984842.

Abstract

With the introduction of hydraulic fracturing technology, the United States has become the largest natural gas producer in the world with a substantial portion of the production coming from shale plays. In this review, we examined current hydraulic fracturing literature including associated wastewater management on quantity and quality of groundwater. We conclude that proper documentation/reporting systems for wastewater discharge and spills need to be enforced at the federal, state, and industrial level. Furthermore, Underground Injection Control (UIC) requirements under SDWA should be extended to hydraulic fracturing operations regardless if diesel fuel is used as a fracturing fluid or not. One of the biggest barriers that hinder the advancement of our knowledge on the hydraulic fracturing process is the lack of transparency of chemicals used in the practice. Federal laws mandating hydraulic companies to disclose fracturing fluid composition and concentration not only to federal and state regulatory agencies but also to health care professionals would encourage this practice. The full disclosure of fracturing chemicals will allow future research to fill knowledge gaps for a better understanding of the impacts of hydraulic fracturing on human health and the environment.

Cluff, M.A., Hartsock, A., MacRae, J.D., Carter, K., Mouser, P.J. Temporal Changes in Microbial Ecology and Geochemistry in Produced Water from Hydraulically Fractured Marcellus Shale Gas Wells. Environ Sci Technol. 2014 Jun 3;48(11):6508-17. doi: 10.1021/es501173p. Epub 2014 May 20.

Abstract

Microorganisms play several important roles in unconventional gas recovery, from biodegradation of hydrocarbons to souring of wells and corrosion of equipment. During and after the hydraulic fracturing process, microorganisms are subjected to harsh physicochemical conditions within the kilometer-deep hydrocarbon-bearing shale, including high pressures, elevated temperatures, exposure to chemical additives and biocides, and brine-level salinities. A portion of the injected fluid returns to the surface and may be reused in other fracturing operations, a process that can enrich for certain taxa. This study tracked microbial community dynamics using pyrotag sequencing of 16S rRNA genes in water samples from three hydraulically fractured Marcellus shale wells in Pennsylvania, USA over a 328-day period. There was a reduction in microbial richness and diversity after fracturing, with the lowest diversity at 49 days. Thirty-one taxa dominated injected, flowback, and produced water communities, which took on distinct signatures as injected carbon and electron acceptors were attenuated within the shale. The majority (>90%) of the community in flowback and produced fluids was related to halotolerant bacteria associated with fermentation, hydrocarbon oxidation, and sulfur-cycling metabolisms, including heterotrophic genera Halolactibacillus, Vibrio, Marinobacter, Halanaerobium, and Halomonas, and autotrophs belonging to Arcobacter. Sequences related to halotolerant methanogenic genera Methanohalophilus and Methanolobus were detected at low abundance (<2%) in produced waters several months after hydraulic fracturing. Five taxa were strong indicators of later produced fluids. These results provide insight into the temporal trajectory of subsurface microbial communities after "fracking" and have important implications for the enrichment of microbes potentially detrimental to well infrastructure and natural gas fouling during this process.

Coram, A., Moss, J., Blashki, G. Harms Unknown: Health Uncertainties Cast Doubt on the Role of Unconventional Gas in Australia's Energy Future. Med J Aust. 2014 Mar 3;200(4):210-3.

Abstract
There is a push to increase production of unconventional gas in Australia, which would intensify the use of the controversial technique of hydraulic fracturing. The uncertainties surrounding the health implications of unconventional gas, when considered together with doubts surrounding its greenhouse gas profile and cost, weigh heavily against proceeding with proposed future developments. The health and environmental impacts of hydraulic fracturing have been the source of widespread public concern. A review of available literature shows a considerable degree of uncertainty, but an emerging consensus about the main risks. Gas is often claimed to be a less climate-damaging alternative to coal; however, this is called into question by the fugitive emissions produced by unconventional gas extraction and the consequences of its export. While the health effects associated with fracturing chemicals have attracted considerable public attention, risks posed by wastewater, community disruption and the interaction between exposures are of also of concern. The health burdens of unconventional gas are likely to fall disproportionately on rural communities, the young and the elderly. While the health and environmental risks and benefits must be compared with other energy choices, coal provides a poor benchmark.

Edwards, P.M., Brown, S.S., Roberts, J.M., Ahmadov, R., Banta, R.M., deGouw, J.A., Dubé, W.P., Field, R.A., Flynn, J.H., Gilman, J.B., Graus, M., Helmig, D., Koss, A., Langford, A.O., Lefer, B.L., Lerner, B.M., Li, R., Li, S.M., McKeen, S.A., Murphy, S.M., Parrish, D.D., Senff, C.J., Soltis, J., Stutz, J., Sweeney, C., Thompson, C.R., Trainer, M.K., Tsai, C., Veres, P.R., Washenfelder, R.A., Warneke, C., Wild, R.J., Young, C.J., Yuan, B., Zamora, R. High Winter Ozone Pollution from Carbonyl Photolysis in an Oil and Gas Basin. Nature. 2014 Oct 16;514(7522):351-4. doi: 10.1038/nature13767. Epub 2014 Oct 1.

Abstract

The United States is now experiencing the most rapid expansion in oil and gas production in four decades, owing in large part to implementation of new extraction technologies such as horizontal drilling combined with hydraulic fracturing. The environmental impacts of this development, from its effect on water quality to the influence of increased methane leakage on climate, have been a matter of intense debate. Air quality impacts are associated with emissions of nitrogen oxides (NOx = NO + NO2) and volatile organic compounds (VOCs), whose photochemistry leads to production of ozone, a secondary pollutant with negative health effects. Recent observations in oil- and gas-producing basins in the western United States have identified ozone mixing ratios well in excess of present air quality standards, but only during winter. Understanding winter ozone production in these regions is scientifically challenging. It occurs during cold periods of snow cover when meteorological inversions concentrate air pollutants from oil and gas activities, but when solar irradiance and absolute humidity, which are both required to initiate conventional photochemistry essential for ozone production, are at a minimum. Here, using data from a remote location in the oil and gas basin of northeastern Utah and a box model, we provide a quantitative assessment of the photochemistry that leads to these extreme winter ozone pollution events, and identify key factors that control ozone production in this unique environment. We find that ozone production occurs at lower NOx and much larger VOC concentrations than does its summertime urban counterpart, leading to carbonyl (oxygenated VOCs with a C = O moiety) photolysis as a dominant oxidant source. Extreme VOC concentrations optimize the ozone production efficiency of NOx. There is considerable potential for global growth in oil and gas extraction from shale. This analysis could help inform strategies to monitor and mitigate air quality impacts and provide broader insight into the response of winter ozone to primary pollutants.

Ellsworth, W.L. Injection-Induced Earthquakes. Science. 2013 Jul 12;341(6142):1225942. doi: 10.1126/science.1225942.

Abstract

Earthquakes in unusual locations have become an important topic of discussion in both North America and Europe, owing to the concern that industrial activity could cause damaging earthquakes. It has long been understood that earthquakes can be induced by impoundment of reservoirs, surface and underground mining, withdrawal of fluids and gas from the subsurface, and injection of fluids into underground formations. Injection-induced earthquakes have, in particular, become a focus of discussion as the application of hydraulic fracturing to tight shale formations is enabling the production of oil and gas from previously unproductive formations. Earthquakes can be induced as part of the process to stimulate the production from tight shale formations, or by disposal of wastewater associated with stimulation and production. Here, I review recent seismic activity that may be associated with industrial activity, with a focus on the disposal of wastewater by injection in deep wells; assess the scientific understanding of induced earthquakes; and discuss the key scientific challenges to be met for assessing this hazard.

Field, R.A., Soltis, J., Murphy, S. Air Quality Concerns of Unconventional Oil and Natural Gas Production. Environ Sci Process Impacts. 2014 May;16(5):954-69. doi: 10.1039/c4em00081a.

Abstract

Increased use of hydraulic fracturing ("fracking") in unconventional oil and natural gas (O & NG) development from coal, sandstone, and shale deposits in the United States (US) has created environmental concerns over water and air quality impacts. In this perspective we focus on how the production of unconventional O & NG affects air quality. We pay particular attention to shale gas as this type of development has transformed natural gas production in the US and is set to become important in the rest of the world. A variety of potential emission sources can be spread over tens of thousands of acres of a production area and this complicates assessment of local and regional air quality impacts. We outline upstream activities including drilling, completion and production. After contrasting the context for development activities in the US and Europe we explore the use of inventories for determining air emissions. Location and scale of analysis is important, as O & NG production emissions in some US basins account for nearly 100% of the pollution burden, whereas in other basins these activities make up less than 10% of total air emissions. While emission inventories are beneficial to quantifying air emissions from a particular source category, they do have limitations when determining air quality impacts from a large area. Air monitoring is essential, not only to validate inventories, but also to measure impacts. We describe the use of measurements, including ground-based mobile monitoring, network stations, airborne, and satellite platforms for measuring air quality impacts. We identify nitrogen oxides, volatile organic compounds (VOC), ozone, hazardous air pollutants (HAP), and methane as pollutants of concern related to O & NG activities. These pollutants can contribute to air quality concerns and they may be regulated in ambient air, due to human health

or climate forcing concerns. Close to well pads, emissions are concentrated and exposure to a wide range of pollutants is possible. Public health protection is improved when emissions are controlled and facilities are located away from where people live. Based on lessons learned in the US we outline an approach for future unconventional O & NG development that includes regulation, assessment and monitoring.

Finkel, M.L., Hays, J. The Implications of Unconventional Drilling for Natural Gas: A Global Public Health Concern. Public Health. 2013 Oct;127(10):889-93. doi: 10.1016/j.puhe.2013.07.005. Epub 2013 Oct 9. Review.

Abstract

Unconventional drilling for natural gas by means of high volume horizontal hydraulic fracturing (fracking) is an important global public health issue. Given that no sound epidemiologic study has been done to assess the extent of exposure-related adverse health effects among populations living in areas where natural gas extraction is going on, it is imperative that research be conducted to quantify the potential risks to the environment and to human health not just in the short-term, but over a longer time period since many diseases (i.e., cancers) appear years after exposure. It should not be concluded that an absence of data implies that no harm is being done.

Flewelling, S.A., Sharma, M. Constraints on Upward Migration of Hydraulic Fracturing Fluid and Brine. Groundwater. 2014 Jan-Feb;52(1):9-19. doi: 10.1111/gwat.12095. Epub 2013 Jul 29.

Abstract

Recent increases in the use of hydraulic fracturing (HF) to aid extraction of oil and gas from black shales have raised concerns regarding potential environmental effects associated with predictions of upward migration of HF fluid and brine. Some recent studies have suggested that such upward migration can be large and that timescales for migration can be as short as a few years. In this article, we discuss the physical constraints on upward fluid migration from black shales (e.g., the Marcellus, Bakken, and Eagle Ford) to shallow aquifers, taking into account the potential changes to the subsurface brought about by HF. Our review of the literature indicates that HF affects a very limited portion of the entire thickness of the overlying bedrock and therefore, is unable to create direct hydraulic communication between black shales and shallow aquifers via induced fractures. As a result, upward migration of HF fluid and brine is controlled by preexisting hydraulic gradients and bedrock permeability. We show that in cases where there is an upward gradient, permeability is low, upward flow rates are low, and mean travel times are long (often $>10^6$ years). Consequently, the recently proposed rapid upward migration of brine and HF fluid, predicted to occur as a result of increased HF activity, does not appear to be physically plausible. Unrealistically high estimates of upward flow are the result of invalid assumptions about HF and the hydrogeology of sedimentary basins.

Goldstein, B.D., Malone, S. Obfuscation does not Provide Comfort: Response to the Article by Fryzek et al on Hydraulic Fracturing and Childhood Cancer. J Occup Environ Med. 2013 Nov;55(11):1376-8.

No summary is available.

Goldstein, B.D., Brooks, B.W., Cohen, S.D., Gates, A.E., Honeycutt, M.E., Morris, J.B., Orme-Zavaleta, J., Penning, T.M., Snawder, J. The Role of Toxicological Science in Meeting the Challenges and Opportunities of Hydraulic Fracturing. Toxicol Sci. 2014 Jun;139(2):271-83. doi: 10.1093/toxsci/kfu061. Epub 2014 Apr 4.

Abstract

We briefly describe how toxicology can inform the discussion and debate of the merits of hydraulic fracturing by providing information on the potential toxicity of the chemical and physical agents associated with this process, individually and in combination. We consider upstream activities related to bringing chemical and physical agents to the site, on-site activities including drilling of wells and containment of agents injected into or produced from the well, and downstream activities including the flow/removal of hydrocarbon products and of produced water from the site. A broad variety of chemical and physical agents are involved. As the industry expands this has raised concern about the potential for toxicological effects on ecosystems, workers, and the general public. Response to these concerns requires a concerted and collaborative toxicological assessment. This assessment should take into account the different geology in areas newly subjected to hydraulic fracturing as well as evolving industrial practices that can alter the chemical and physical agents of toxicological interest. The potential for ecosystem or human exposure to mixtures of these agents presents a particular toxicological and public

health challenge. These data are essential for developing a reliable assessment of the potential risks to the environment and to human health of the rapidly increasing use of hydraulic fracturing and deep underground horizontal drilling techniques for tightly bound shale gas and other fossil fuels. Input from toxicologists will be most effective when employed early in the process, before there are unwanted consequences to the environment and human health, or economic losses due to the need to abandon or rework costly initiatives.

Holland, A.A. Imaging Time Dependent Crustal Deformation Using GPS Geodesy and Induced Seismicity, Stress and Optimal Fault Orientations in the North American Mid-Continent. Graduate Thesis. The University of Arizona. 2014. http://arizona.openrepository.com/arizona/handle/10150/332903.

Abstract

Transient deformation has been observed in a number of different types of tectonic environments. These transient deformation signals are often observed using continuous GPS (CGPS) position time-series observations. Examining transient deformation using CGPS time-series is problematic due to the, often, low signal-to-noise ratios and variability in duration of transient motions observed. A technique to estimate a continuous velocity function from noisy CGPS coordinate time-series of is examined. The resolution of this technique is dependent on the signal-to-noise ratio and the duration or frequency content of the transient signal being modeled. Short period signals require greater signal-to-noise ratios for effective resolution of the actual transient signal. The technique presented here is similar to a low-pass filter but with a number of advantages when working with CGPS data. Data gaps do not adversely impact the technique but limit resolution near the gap epochs, if there is some a priori knowledge of the noise contained within the time-series this

information can be included in the model, and model parameter uncertainties provide information on the uncertainty of instantaneous velocity through time.

A large transient has been observed in the North-American stable continental interior as a significant increase in the number and moment release of earthquakes through time. This increase in the number of earthquakes has been suggested to be largely related changes in oil and gas production activities within the region as triggered or induced seismicity, primarily from fluid injection. One of the first observed cases of triggered earthquakes from hydraulic fracturing where the earthquakes were large enough to be felt by local residents is documented. The multiple strong temporal and spatial correlations between these earthquakes indicate that hydraulic fracturing in a nearby well likely triggered the earthquake sequence. The largest magnitude earthquake in this sequence was a magnitude 2.9 with 16 earthquakes greater than magnitude 2. The earthquakes in this sequence occurred within 2.5 km of the hydraulic fracturing operation and focal depths are similar to the depths of hydraulic fracturing treatment depths. In addition to the documentation of a transient earthquake signal associated with hydraulic fracturing, the observed focal mechanisms throughout Oklahoma are documented. These focal mechanisms were used to examine the maximum horizontal stress orientations and active fault orientations associated with the increased rates of seismicity observed in the region. Generally, active-fault orientations and the stresses are consistent through broad portions of Oklahoma with one exception, the onging Jones earthquake sequence in central Oklahoma that started in 2009. In the Jones earthquake sequence a bi-modal distribution of focal mechanisms are observed. One orientation of active faults observed in the Jones earthquake sequence would not be expected to be active in the observed regional stress field. This unfavorably oriented set of faults appear to be pre-existing structures and activity on these structures may suggest that pore-pressure increases in the sub-surface due to fluid injection in the area make it possible for faults that are not optimally oriented within the regional stress-field to reactivate.

Jackson, R.E., Gorody, A.W., Mayer, B., Roy, J.W., Ryan, M.C., Van Stempvoort, D.R. Groundwater Protection and Unconventional Gas Extraction: The Critical Need for Field-Based Hydrogeological Research. Groundwater. 2013 Jul-Aug;51(4):488-510. doi: 10.1111/gwat.12074. Epub 2013 Jun 7.

Abstract

Unconventional natural gas extraction from tight sandstones, shales, and some coal-beds is typically accomplished by horizontal drilling and hydraulic fracturing that is necessary for economic development of these new hydrocarbon resources. Concerns have been raised regarding the potential for contamination of shallow groundwater by stray gases, formation waters, and fracturing chemicals associated with unconventional gas exploration. A lack of sound scientific hydrogeological field observations and a scarcity of published peer-reviewed articles on the effects of both conventional and unconventional oil and gas activities on shallow groundwater make it difficult to address these issues. Here, we discuss several case studies related to both conventional and unconventional oil and gas activities illustrating how under some circumstances stray or fugitive gas from deep gas-rich formations has migrated from the subsurface into shallow aquifers and how it has affected groundwater quality. Examples include impacts of uncemented well annuli in areas of historic drilling operations, effects related to poor cement bonding in both new and old hydrocarbon wells, and ineffective cementing practices. We also summarize studies describing how structural features influence the role of natural and induced fractures as contaminant fluid migration pathways. On the basis of these studies, we identify two areas where field-focused research is urgently needed to fill current

science gaps related to unconventional gas extraction: (1) baseline geochemical mapping (with time series sampling from a sufficient network of groundwater monitoring wells) and (2) field testing of potential mechanisms and pathways by which hydrocarbon gases, reservoir fluids, and fracturing chemicals might potentially invade and contaminate useable groundwater.

Jackson, R.B., Vengosh, A., Darrah, T.H., Warner, N.R., Down, A., Poreda, R.J., Osborn, S.G., Zhao, K., Karr, J.D. Increased Stray Gas Abundance in a Subset of Drinking Water Wells Near Marcellus Shale Gas Extraction. Proc Natl Acad Sci U S A. 2013 Jul 9;110(28):11250-5. doi: 0.1073/pnas.1221635110. Epub 2013 Jun 24.

Abstract

Horizontal drilling and hydraulic fracturing are transforming energy production, but their potential environmental effects remain controversial. We analyzed 141 drinking water wells across the Appalachian Plateaus physiographic province of northeastern Pennsylvania, examining natural gas concentrations and isotopic signatures with proximity to shale gas wells. Methane was detected in 82% of drinking water samples, with average concentrations six times higher for homes <1 km from natural gas wells ($P = 0.0006$). Ethane was 23 times higher in homes <1 km from gas wells ($P = 0.0013$); propane was detected in 10 water wells, all within approximately 1 km distance ($P = 0.01$). Of three factors previously proposed to influence gas concentrations in shallow groundwater (distances to gas wells, valley bottoms, and the Appalachian Structural Front, a proxy for tectonic deformation), distance to gas wells was highly significant for methane concentrations ($P = 0.007$; multiple regression), whereas distances to valley bottoms and the Appalachian Structural Front were not significant ($P = 0.27$ and $P = 0.11$, respectively). Distance to gas wells was also the most significant factor for Pearson and Spearman correlation analyses ($P < 0.01$). For ethane concentrations, distance to gas wells was the only statistically significant factor ($P < 0.005$). Isotopic signatures (δ(13)C-CH4, δ(13)C-C2H6, and δ(2)H-CH4), hydrocarbon ratios (methane to ethane and propane), and the ratio of the noble gas (4)He to CH4 in groundwater were characteristic of a thermally postmature Marcellus-like source in some cases. Overall, our data suggest that some homeowners living <1 km from gas wells have drinking water contaminated with stray gases.

Jiang, M., Hendrickson, C.T., VanBriesen, J.M. Life Cycle Water Consumption and Wastewater Generation Impacts of a Marcellus Shale Gas Well. Environ Sci Technol. 2014 Feb 4;48(3):1911-20. doi: 10.1021/es4047654. Epub 2014 Jan 10.

Abstract

This study estimates the life cycle water consumption and wastewater generation impacts of a Marcellus shale gas well from its construction to end of life. Direct water consumption at the well site was assessed by analysis of data from approximately 500 individual well completion reports collected in 2010 by the Pennsylvania Department of Conservation and Natural Resources. Indirect water consumption for supply chain production at each life cycle stage of the well was estimated using the economic input-output life cycle assessment (EIO-LCA) method. Life cycle direct and indirect water quality pollution impacts were assessed and compared using the tool for the reduction and assessment of chemical and other environmental impacts (TRACI). Wastewater treatment cost was proposed as an additional indicator for water quality pollution impacts from shale gas well wastewater. Four water management scenarios for Marcellus shale well wastewater were assessed: current conditions in Pennsylvania; complete discharge; direct reuse and desalination; and complete desalination. The results show that under the current conditions, an average Marcellus shale gas well consumes 20,000 m(3) (with a range from 6700 to 33,000 m(3)) of freshwater per well over its life cycle excluding final gas utilization, with 65% direct water consumption at the well site and 35% indirect water consumption across the supply chain production. If all flowback and produced water is released into the environment without treatment, direct wastewater from a Marcellus shale gas well is estimated to have 300-3000 kg N-eq eutrophication potential, 900-23,000 kg 2,4D-eq freshwater ecotoxicity potential, 0-370 kg benzene-eq carcinogenic potential, and 2800-71,000 MT toluene-eq noncarcinogenic potential. The potential toxicity of the chemicals in the wastewater from the well site exceeds those associated with supply chain production, except for carcinogenic effects. If all the Marcellus shale well wastewater is treated to surface discharge standards by desalination, $59,000-270,000 per well would be required. The life cycle study results indicate that when gas end use is not considered hydraulic fracturing is the largest contributor to the life cycle water impacts of a Marcellus shale gas well.

Kohl, C.A., Capo, R.C., Stewart, B.W., Wall, A.J., Schroeder, K.T., Hammack, R.W., Guthrie, G.D. Strontium Isotopes Test Long-Term Zonal Isolation of Injected and Marcellus Formation Water After Hydraulic Fracturing. Environ Sci Technol. 2014 Aug 19;48(16):9867-73. doi: 10.1021/es501099k. Epub 2014 Jul 28.

Abstract

One concern regarding unconventional hydrocarbon production from organic-rich shale is that hydraulic fracture stimulation could create pathways that allow injected fluids and deep brines from the target formation or adjacent units to migrate upward into shallow drinking water aquifers. This study presents Sr isotope and geochemical data from a well-constrained site in Greene County, Pennsylvania, in which samples were collected before and after hydraulic fracturing of the Middle Devonian

Marcellus Shale. Results spanning a 15-month period indicated no significant migration of Marcellus-derived fluids into Upper Devonian/Lower Mississippian units located 900-1200 m above the lateral Marcellus boreholes or into groundwater sampled at a spring near the site. Monitoring the Sr isotope ratio of water from legacy oil and gas wells or drinking water wells can provide a sensitive early warning of upward brine migration for many years after well stimulation.

Kondash, A.J., Warner, N.R., Lahav, O., Vengosh, A. Radium and Barium Removal through Blending Hydraulic Fracturing Fluids with Acid Mine Drainage. Environ Sci Technol. 2014 Jan 21;48(2):1334-42. doi: 10.1021/es403852h. Epub 2013 Dec 24.

Abstract

Wastewaters generated during hydraulic fracturing of the Marcellus Shale typically contain high concentrations of salts, naturally occurring radioactive material (NORM), and metals, such as barium, that pose environmental and public health risks upon inadequate treatment and disposal. In addition, fresh water scarcity in dry regions or during periods of drought could limit shale gas development. This paper explores the possibility of using alternative water sources and their impact on NORM levels through blending acid mine drainage (AMD) effluent with recycled hydraulic fracturing flowback fluids (HFFFs). We conducted a series of laboratory experiments in which the chemistry and NORM of different mix proportions of AMD and HFFF were examined after reacting for 48 h. The experimental data combined with geochemical modeling and X-ray diffraction analysis suggest that several ions, including sulfate, iron, barium, strontium, and a large portion of radium (60-100%), precipitated into newly formed solids composed mainly of Sr barite within the first ~ 10 h of mixing. The results imply that blending AMD and HFFF could be an effective management practice for both remediation of the high NORM in the Marcellus HFFF wastewater and beneficial utilization of AMD that is currently contaminating waterways in northeastern U.S.A.

Lautz, L.K., Hoke, G.D., Lu, Z., Siegel, D.I., Christian, K., Kessler, J.D., Teale, N.G. Using Discriminant Analysis to Determine Sources of Salinity in Shallow Groundwater Prior to Hydraulic Fracturing. Environ Sci Technol. 2014 Aug 19;48(16):9061-9. doi: 10.1021/es502244v. Epub 2014 Aug 1.

Abstract

High-volume hydraulic fracturing (HVHF) gas-drilling operations in the Marcellus Play have raised environmental concerns, including the risk of groundwater contamination. Fingerprinting water impacted by gas-drilling operations is not trivial given other potential sources of contamination. We present a multivariate statistical modeling framework for developing a quantitative, geochemical fingerprinting tool to distinguish sources of high salinity in shallow groundwater. The model was developed using new geochemical data for 204 wells in New York State (NYS), which has a HVHF moratorium and published data for additional wells in NYS and several salinity sources (Appalachian Basin brines, road salt, septic effluent, and animal waste). The model incorporates a stochastic simulation to predict the geochemistry of high salinity (>20 mg/L Cl) groundwater impacted by different salinity sources and then employs linear discriminant analysis to classify samples from different populations. Model results indicate Appalachian Basin brines are the primary source of salinity in 35% of sampled NYS groundwater wells with >20 mg/L Cl. The model provides an effective means for differentiating groundwater impacted by basin brines versus other contaminants. Using this framework, similar discriminatory tools can be derived for other regions from background water quality data.

Mackie, P., Johnman, C., Sim, F. Hydraulic Fracturing: A New Public Health Problem 138 Years in the Making? Public Health. 2013 Oct;127(10):887-8. doi:10.1016/j.puhe.2013.09.009. Epub 2013 Oct 19. PubMed PMID: 24148802.

Summary

It is clear that hydraulic fracturing IS a public health issue, just as fuel poverty and carbon reduction are public health issues. It is also clear that it is a complex issue: there will never be all the necessary information to make risk free choices, so governments will, as usual, have to seek to balance the known – and suspected – risks to health on the basis of what evidence there is, until such time as the evidence is stronger. To do that, it is imperative to ensure a public health approach is included when planning and decision making on this issue takes place: that cannot be too soon.

Maguire-Boyle, S.J., Garner, D.J., Heimann, J.E., Gao, L., Orbaek, A.W., Barron, A.R. Automated Method for Determining the Flow of Surface Functionalized Nanoparticles through a Hydraulically Fractured Mineral Formation Using Plasmonic Silver Nanoparticles. Environ Sci Process Impacts. 2014 Feb;16(2):220-31. doi: 10.1039/c3em00718a.

Abstract

Quantifying nanoparticle (NP) transport within porous geological media is imperative in the design of tracers and sensors to monitor the environmental impact of hydraulic fracturing that has seen increasing concern over recent years, in particular the potential pollution and contamination of aquifers. The surface chemistry of a NP defining many of its solubility and transport properties means that there is a wide range of functionality that it is desirable to screen for optimum transport. Most prior transport methods are limited in determining if significant adsorption occurs of a NP over a limited column distance, however, translating this to effects over large

distances is difficult. Herein we report an automated method that allows for the simulation of adsorption effects of a dilute nanoparticle solution over large distances under a range of solution parameters. Using plasmonic silver NPs and UV-visible spectroscopic detection allows for low concentrations to be used while offering greater consistency in peak absorbance leading to a higher degree of data reliability and statistics. As an example, breakthrough curves were determined for mercaptosuccinic acid (MSA) and cysteamine (CYS) functionalized Ag NPs passing through Ottawa sand (typical proppant material) immobile phase (C) or bypassing the immobile phase (C0). Automation allows for multiple sequences such that the absorption plateau after each breakthrough and the rate of breakthrough can be compared for multiple runs to provide statistical analysis. The mobility of the NPs as a function of pH is readily determined. The stickiness (α) of the NP to the immobile phase calculated from the C/C0 ratio shows that MSA-Ag NPs show good mobility, with a slight decrease around neutral pH, while CYS-Ag NPs shows an almost sinusoidal variation. The automated process described herein allows for rapid screening of NP functionality, as a function of immobile phase (proppant versus reservoir material), hydraulic fracturing fluid additives (guar, surfactant) and conditions (pH, temperature).

Maguire-Boyle, S.J., Barron, A.R. Organic Compounds in Produced Waters from Shale Gas Wells. Environ Sci Process Impacts. 2014 Sep 24;16(10):2237-48. doi: 10.1039/c4em00376d.

Abstract

A detailed analysis is reported of the organic composition of produced water samples from typical shale gas wells in the Marcellus (PA), Eagle Ford (TX), and Barnett (NM) formations. The quality of shale gas produced (and frac flowback) waters is a current environmental concern and disposal problem for producers. Re-use of produced water for hydraulic fracturing is being encouraged; however, knowledge of the organic impurities is important in determining the method of treatment. The metal content was determined by inductively coupled plasma optical emission spectrometry (ICP-OES). Mineral elements are expected depending on the reservoir geology and salts used in hydraulic fracturing; however, significant levels of other transition metals and heavier main group elements are observed. The presence of scaling elements (Ca and Ba) is related to the pH of the water rather than total dissolved solids (TDS). Using gas chromatography mass spectrometry (GC/MS) analysis of the chloroform extracts of the produced water samples, a plethora of organic compounds were identified. In each water sample, the majority of organics are saturated (aliphatic), and only a small fraction comes under aromatic, resin, and asphaltene categories. Unlike coalbed methane produced water it appears that shale oil/gas produced water does not contain significant quantities of polyaromatic hydrocarbons reducing the potential health hazard. Marcellus and Barnett produced waters contain predominantly C6-C16 hydrocarbons, while the Eagle Ford produced water shows the highest concentration in the C17-C30 range. The structures of the saturated hydrocarbons identified generally follows the trend of linear > branched > cyclic. Heterocyclic compounds are identified with the largest fraction being fatty alcohols, esters, and ethers. However, the presence of various fatty acid phthalate esters in the Barnett and Marcellus produced waters can be related to their use in drilling fluids and breaker additives rather than their presence in connate fluids. Halogen containing compounds are found in each of the water samples, and although the fluorocarbon compounds identified are used as tracers, the presence of chlorocarbons and organobromides formed as a consequence of using chlorine containing oxidants (to remove bacteria from source water), suggests that industry should concentrate on non-chemical treatments of frac and produced waters.

Manda, A.K., Heath, J.L., Klein, W.A., Griffin, M.T., Montz, B.E. Evolution of Multi-Well Pad Development and Influence of Well Pads on Environmental Violations and Wastewater Volumes in the Marcellus Shale (USA). J Environ Manage. 2014 Sep 1;142:36-45. doi: 0.1016/j.jenvman.2014.04.011. Epub 2014 May 8.

Abstract

A majority of well pads for unconventional gas wells that are drilled into the Marcellus shale (northeastern USA) consist of multiple wells (in some cases as many as 12 wells per pad), yet the influence of the evolution of well pad development on the extent of environmental violations and wastewater production is unknown. Although the development of multi-well pads (MWP) at the expense of single well pads (SWP) has been mostly driven by economic factors, the concentrated nature of drilling activities from hydraulic fracturing and horizontal drilling operations on MWP suggests that MWP may create less surface disturbance, produce more volumes of wastewater, and generate more environmental violations than SWP. To explore these hypotheses, we use geospatial techniques and statistical analyses (i.e., regression and Mann-Whitney tests) to assess development of unconventional shale gas wells, and quantify environmental violations and wastewater volumes on SWP and MWP in Pennsylvania. The analyses include assessments of the influence of different types of well pads on potential, minor and major environmental events. Results reveal that (a) in recent years, a majority of pads on which new wells for unconventional gas were drilled are MWP, (b) on average, MWP have about five wells located on each pad and thus, had the transition to MWP not occurred, between two and four times as much land surface

disturbance would have occurred per year if drilling was relegated to SWP, (c) there were more environmental violations on MWP than SWP, but when the number of wells were taken into account, fewer environmental violations per well were observed on MWP than on SWP, (d) there were more wastewater and recycled wastewater volumes per pad and per well produced on MWP than on SWP, and (e) the proportion of wastewater that was recycled was higher on MWP than SWP. This study sheds light on how the evolution from SWP to MWP has influenced environmental violations and wastewater production in a field that has undergone rapid development in recent years.

Mash, R., Minnaar, J., Mash, B. Health and Fracking: Should the Medical Profession be Concerned? S Afr Med J. 2014 Feb 26;104(5):332-5. doi: 10.7196/samj.7860.

Abstract

The use of natural gas that is obtained from high-volume hydraulic fracturing (fracking) may reduce carbon emissions relative to the use of coal and have substantial economic benefits for South Africa. However, concerns have been raised regarding the health and environmental impacts. The drilling and fracking processes use hundreds of chemicals as well as silica sand. Additional elements are either released from or formed in the shale during drilling. These substances can enter the environment in various ways: through failures in the well casing; via alternative underground pathways; as wastewater, spills and leaks on the wellpad; through transportation accidents; and as air pollution. Although many of these chemicals and elements have known adverse health effects, there is little evidence available on the health impacts of fracking. These health concerns have not yet been fully addressed in policy making, and the authors recommend that the voice of health professionals should be part of the public debate on fracking and that a full health impact assessment be required before companies are given the go-ahead to drill.

Mazur, A. How did the Fracking Controversy Emerge in the Period 2010-2012? Public Underst Sci. 2014 Aug 8. pii: 0963662514545311. [Epub ahead of print]

Abstract

In 2010-2012, the controversy over fracking grew rapidly, first in the United States, and then internationally. An important step was the anti-fracking documentary film Gasland. With help from celebrity sources, the film was produced and won a prize at the Sundance Film Festival by early 2010 and had an Oscar nomination by early 2011, in the meantime popularizing potent images of hazard including tainted aquifers and ignitable water running from kitchen faucets. During this period, major US news organizations paid little attention to the issue. The offshore Deepwater Horizon disaster of April 2010 spurred The New York Times to prolific reporting on potential risks of the new onshore technique for extracting shale gas. With flagship news coverage, the controversy had by 2012 gained wide media attention that evoked public concern and opposition, spreading from the United States to other nations.

McJeon, H., Edmonds, J., Bauer, N., Clarke, L., Fisher, B., Flannery, B.P., Hilaire, J., Krey, V., Marangoni, G., Mi, R., Riahi, K., Rogner, H., Tavoni, M. Limited Impact on Decadal-Scale Climate Change from Increased Use of Natural Gas. Nature. 2014 Oct 23;514(7523):482-5. doi: 10.1038/nature13837. Epub 2014 Oct 15.

Abstract

The most important energy development of the past decade has been the wide deployment of hydraulic fracturing technologies that enable the production of previously uneconomic shale gas resources in North America. If these advanced gas production technologies were to be deployed globally, the energy market could see a large influx of economically competitive unconventional gas resources. The climate implications of such abundant natural gas have been hotly debated. Some researchers have observed that abundant natural gas substituting for coal could reduce carbon dioxide (CO2) emissions. Others have reported that the non-CO2 greenhouse gas emissions associated with shale gas production make its lifecycle emissions higher than those of coal. Assessment of the full impact of abundant gas on climate change requires an integrated approach to the global energy-economy-climate systems, but the literature has been limited in either its geographic scope or its coverage of greenhouse gases. Here we show that market-driven increases in global supplies of unconventional natural gas do not discernibly reduce the trajectory of greenhouse gas emissions or climate forcing. Our results, based on simulations from five state-of-the-art integrated assessment models of energy-economy-climate systems independently forced by an abundant gas scenario, project large additional natural gas consumption of up to +170 per cent by 2050. The impact on CO2 emissions, however, is found to be much smaller (from -2 per cent to +11 per cent), and a majority of the models reported a small increase in climate forcing (from -0.3 per cent to +7 per cent) associated with the increased use of abundant gas. Our results show that although market penetration of globally abundant gas may

substantially change the future energy system, it is not necessarily an effective substitute for climate change mitigation policy.

Mohan, A.M., Bibby, K.J., Lipus, D., Hammack, R.W., Gregory, K.B. The Functional Potential of Microbial Communities in Hydraulic Fracturing Source Water and Produced Water from Natural Gas Extraction Characterized By Metagenomic Sequencing. PLoS One. 2014 Oct 22;9(10):e107682. doi: 10.1371/journal.pone.0107682. eCollection 2014.

Abstract

Microbial activity in produced water from hydraulic fracturing operations can lead to undesired environmental impacts and increase gas production costs. However, the metabolic profile of these microbial communities is not well understood. Here, for the first time, we present results from a shotgun metagenome of microbial communities in both hydraulic fracturing source water and wastewater produced by hydraulic fracturing. Taxonomic analyses showed an increase in anaerobic/facultative anaerobic classes related to Clostridia, Gammaproteobacteria, Bacteroidia and Epsilonproteobacteria in produced water as compared to predominantly aerobic Alphaproteobacteria in the fracturing source water. The metabolic profile revealed a relative increase in genes responsible for carbohydrate metabolism, respiration, sporulation and dormancy, iron acquisition and metabolism, stress response and sulfur metabolism in the produced water samples. These results suggest that microbial communities in produced water have an increased genetic ability to handle stress, which has significant implications for produced water management, such as disinfection.

Murali Mohan, A., Hartsock, A., Hammack, R.W., Vidic, R.D., Gregory, K.B. Microbial Communities In Flowback Water Impoundments from Hydraulic Fracturing for Recovery of Shale Gas. FEMS Microbiol Ecol. 2013 Dec;86(3):567-80. doi: 10.1111/1574-6941.12183. Epub 2013 Aug 13.

Abstract

Hydraulic fracturing for natural gas extraction from shale produces waste brine known as flowback that is impounded at the surface prior to reuse and/or disposal. During impoundment, microbial activity can alter the fate of metals including radionuclides, give rise to odorous compounds, and result in biocorrosion that complicates water and waste management and increases production costs. Here, we describe the microbial ecology at multiple depths of three flowback impoundments from the Marcellus shale that were managed differently. 16S rRNA gene clone libraries revealed that bacterial communities in the untreated and biocide-amended impoundments were depth dependent, diverse, and most similar to species within the taxa γ-proteobacteria, α-proteobacteria, δ-proteobacteria, Clostridia, Synergistetes, Thermotogae, Spirochetes, and Bacteroidetes. The bacterial community in the pretreated and aerated impoundment was uniform with depth, less diverse, and most similar to known iodide-oxidizing bacteria in the α-proteobacteria. Archaea were identified only in the untreated and biocide-amended impoundments and were affiliated to the Methanomicrobia class. This is the first study of microbial communities in flowback water impoundments from hydraulic fracturing. The findings expand our knowledge of microbial diversity of an emergent and unexplored environment and may guide the management of flowback impoundments.

Murali Mohan, A., Hartsock, A., Bibby, K.J., Hammack, R.W., Vidic, R.D., Gregory, K.B. Microbial Community Changes in Hydraulic Fracturing Fluids and Produced Water from Shale Gas Extraction. Environ Sci Technol. 2013 Nov 19;47(22):13141-50. doi: 10.1021/es402928b. Epub 2013 Oct 31.

Abstract

Microbial communities associated with produced water from hydraulic fracturing are not well understood, and their deleterious activity can lead to significant increases in production costs and adverse environmental impacts. In this study, we compared the microbial ecology in prefracturing fluids (fracturing source water and fracturing fluid) and produced water at multiple time points from a natural gas well in southwestern Pennsylvania using 16S rRNA gene-based clone libraries, pyrosequencing, and quantitative PCR. The majority of the bacterial community in prefracturing fluids constituted aerobic species affiliated with the class Alphaproteobacteria. However, their relative abundance decreased in produced water with an increase in halotolerant, anaerobic/facultative anaerobic species affiliated with the classes Clostridia, Bacilli, Gammaproteobacteria, Epsilonproteobacteria, Bacteroidia, and Fusobacteria. Produced water collected at the last time point (day 187) consisted almost entirely of sequences similar to Clostridia and showed a decrease in bacterial abundance by 3 orders of magnitude compared to the prefracturing fluids and produced water samplesfrom earlier time points. Geochemical analysis showed that produced water contained higher concentrations of salts and total radioactivity compared to prefracturing fluids. This study provides evidence of long-term subsurface selection of the microbial community introduced through hydraulic fracturing, which may include significant implications for disinfection as well as reuse of produced water in future fracturing operations.

Rafferty, M.A., Limonik, E. Is Shale Gas Drilling an Energy Solution or Public Health Crisis? Public Health Nurs. 2013 Sep-Oct;30(5):454-62. doi: 10.1111/phn.12036. Epub 2013 Apr 22.

Abstract
High-volume horizontal hydraulic fracturing, a controversial new mining technique used to drill for shale gas, is being implemented worldwide. Chemicals used in the process are known neurotoxins, carcinogens, and endocrine disruptors. People who live near shale gas drilling sites report symptoms that they attribute to contaminated air and water. When they seek help from clinicians, a diagnosis is often elusive because the chemicals to which the patients have been exposed are a closely guarded trade secret. Many nurses have voiced grave concern about shale gas drilling safety. Full disclosure of the chemicals used in the process is necessary in order for nurses and other health professionals to effectively care for patients. The economic exuberance surrounding natural gas has resulted in insufficient scrutiny into the health implications. Nursing research aimed at determining what effect unconventional drilling has on human health could help fill that gap. Public health nurses using the precautionary principle should advocate for a more concerted transition from fossil fuels to sustainable energy. Any initiation or further expansion of unconventional gas drilling must be preceded by a comprehensive Health Impact Assessment (HIA).

Ren, L., Zhao, J., Hu, Y. Hydraulic Fracture Extending into Network in Shale: Reviewing Influence Factors and their Mechanism. ScientificWorldJournal. 2014;2014:847107. doi: 0.1155/2014/847107. Epub 2014 Jun 15.

Abstract
Hydraulic fracture in shale reservoir presents complex network propagation, which has essential difference with traditional plane biwing fracture at forming mechanism.

Based on the research results of experiments, field fracturing practice, theory analysis, and numerical simulation, the influence factors and their mechanism of hydraulic fracture extending into network in shale have been systematically analyzed and discussed. Research results show that the fracture propagation in shale reservoir is influenced by the geological and the engineering factors, which includes rock mineral composition, rock mechanical properties, horizontal stress field, natural fractures, treating net pressure, fracturing fluid viscosity, and fracturing scale. This study has important theoretical value and practical significance to understand fracture network propagation mechanism in shale reservoir and contributes to improving the science and efficiency of shale reservoir fracturing design.

Rich, A.L., Crosby, E.C. Analysis of Reserve Pit Sludge from Unconventional Natural Gas Hydraulic Fracturing and Drilling Operations for the Presence of Technologically Enhanced Naturally Occurring Radioactive Material (TENORM). New Solut. 2013;23(1):117-35.

Abstract

Soil and water (sludge) obtained from reserve pits used in unconventional natural gas mining was analyzed for the presence of technologically enhanced naturally occurring radioactive material (TENORM). Samples were analyzed for total gamma, alpha, and beta radiation, and specific radionuclides: beryllium, potassium, scandium, cobalt, cesium, thallium, lead-210 and -214, bismuth-212 and -214, radium-226 and -228, thorium, uranium, and strontium-89 and -90. Laboratory analysis confirmed elevated beta readings recorded at 1329 ± 311 pCi/g. Specific radionuclides present in an active reserve pit and the soil of a leveled, vacated reserve pit included 232Thorium decay series (228Ra, 228Th, 208Tl), and 226Radium decay series (214Pb, 214Bi, 210Pb) radionuclides. The potential for

impact of TENORM to the environment, occupational workers, and the general public is presented with potential health effects of individual radionuclides. Current oversight, exemption of TENORM in federal and state regulations, and complexity in reporting are discussed.

Roundtable on Environmental Health Sciences, Research, and Medicine, Board on Population Health and Public Health Practice, Institute of Medicine. Health Impact Assessment of Shale Gas Extraction: Workshop Summary. Washington (DC): National Academies Press (US); 2014 Dec 30.

Excerpt

Natural gas extraction from shale formations, which includes hydraulic fracturing, is increasingly in the news as the use of extraction technologies has expanded, rural communities have been transformed seemingly overnight, public awareness has increased, and regulations have been developed. The governmental public health system, which retains primary responsibility for health, was not an early participant in discussions about shale gas extraction; thus public health is lacking critical information about environmental health impacts of these technologies and is limited in its ability to address concerns raised by regulators at the federal and state levels, communities, and workers employed in the shale gas extraction industry. Health Impact Assessment of Shale Gas Extraction is the summary of a workshop convened in 2012 by the Institute of Medicine (IOM) Roundtable on Environmental Health Sciences, Research, and Medicine to discuss the human health impact of shale gas extraction through the lens of a health impact assessment. Eminent scientists, physicians, public health experts, and representatives from government agencies at federal and state levels, from nongovernment organizations, from the business sector, and from interest groups representing the interests of the citizens met to exchange ideas and to inform on hydraulic fracturing as a means of extraction of natural gas. This report examines the state of the science regarding shale gas extraction, the direct and indirect environmental health impacts of shale gas extraction, and the use of health impact assessment as a tool that can help decision makers identify the public health consequences of shale gas extraction.

Roy, A.A., Adams, P.J., Robinson, A.L. Air Pollutant Emissions from the Development, Production, and Processing of Marcellus Shale Natural Gas. J Air Waste Manag Assoc. 2014 Jan;64(1):19-37. PubMed PMID: 24620400.

Abstract

The Marcellus Shale is one of the largest natural gas reserves in the United States; it has recently been the focus of intense drilling and leasing activity. This paper describes an air emissions inventory for the development, production, and processing of natural gas in the Marcellus Shale region for 2009 and 2020. It includes estimates of the emissions of oxides of nitrogen (NOx), volatile organic compounds (VOCs), and primary fine particulate matter (< or = 2.5 microm aerodynamic diameter; PM2.5) from major activities such as drilling, hydraulic fracturing, compressor stations, and completion venting. The inventory is constructed using a process-level approach; a Monte Carlo analysis is used to explicitly account for the uncertainty. Emissions were estimated for 2009 and projected to 2020, accounting for the effects of existing and potential additional regulations. In 2020, Marcellus activities are predicted to contribute 6-18% (95% confidence interval) of the NOx emissions in the Marcellus region, with an average contribution of 12% (129 tons/day). In 2020, the predicted contribution of Marcellus activities to the regional anthropogenic VOC emissions ranged between 7% and 28% (95% confidence interval), with an average contribution of 12% (100 tons/day).

These estimates account for the implementation of recently promulgated regulations such as the Tier 4 off-road diesel engine regulation and the US. Environmental Protection Agency's (EPA) Oil and Gas Rule. These regulations significantly reduce the Marcellus VOC and NOx emissions, but there are significant opportunities for further reduction in these emissions using existing technologies.

Implications

The Marcellus Shale is one of the largest natural gas reserves in United States. The development and production of this gas may emit substantial amounts of oxides of nitrogen and volatile organic compounds. These emissions may have special significance because Marcellus development is occurring close to areas that have been designated nonattainment for the ozone standard. Control technologies exist to substantially reduce these impacts. PM2.5 emissions are predicted to be negligible in a regional context, but elemental carbon emissions from diesel powered equipment may be important.

Rozell, D.J. "Constraints on Upward Migration of Hydraulic Fracturing Fluid and Brine" by S.A. Flewelling and M. Sharma. Groundwater. 2014 Jul-Aug;52(4):491-2. doi: 10.1111/gwat.12229. Epub 2014 Jun 27.

No summary is available.

Sang, W., Stoof, C.R., Zhang,W., Morales, V.L., Gao, B., Kay, R.W., Liu, L., Zhang, Y., Steenhuis, T.S. Effect of Hydrofracking Fluid on Colloid Transport in the Unsaturated Zone. Environ Sci Technol. 2014 Jul 15;48(14):8266-74. doi: 10.1021/es501441e. Epub 2014 Jun 25.

Abstract

Hydraulic fracturing is expanding rapidly in the US to meet increasing energy demand and requires high volumes of hydrofracking fluid to displace natural gas from shale. Accidental spills and deliberate land application of hydrofracking fluids, which return to the surface during hydrofracking, are common causes of environmental contamination. Since the chemistry of hydrofracking fluids favors transport of colloids and mineral particles through rock cracks, it may also facilitate transport of in situ colloids and associated pollutants in unsaturated soils. We investigated this by subsequently injecting deionized water and flowback fluid at increasing flow rates into unsaturated sand columns containing colloids. Colloid retention and mobilization was measured in the column effluent and visualized in situ with bright field microscopy. While <5% of initial colloids were released by flushing with deionized water, 32-36% were released by flushing with flowback fluid in two distinct breakthrough peaks. These peaks resulted from 1) surface tension reduction and steric repulsion and 2) slow kinetic disaggregation of colloid flocs. Increasing the flow rate of the flowback fluid mobilized an additional 36% of colloids, due to the expansion of water filled pore space. This study suggests that hydrofracking fluid may also indirectly contaminate groundwater by remobilizing existing colloidal pollutants.

Sommariva, R., Blake, R.S., Cuss, R.J., Cordell, R.L., Harrington, J.F., White, I.R., Monks, P.S. Observations of the Release of Non-Methane Hydrocarbons from

Fractured Shale. Environ Sci Technol. 2014 Aug 5;48(15):8891-6. doi: 10.1021/es502508w. Epub 2014 Jul 14.

Abstract
The organic content of shale has become of commercial interest as a source of hydrocarbons, owing to the development of hydraulic fracturing ("fracking"). While the main focus is on the extraction of methane, shale also contains significant amounts of non-methane hydrocarbons (NMHCs). We describe the first real-time observations of the release of NMHCs from a fractured shale. Samples from the Bowland-Hodder formation (England) were analyzed under different conditions using mass spectrometry, with the objective of understanding the dynamic process of gas release upon fracturing of the shale. A wide range of NMHCs (alkanes, cycloalkanes, aromatics, and bicyclic hydrocarbons) are released at parts per million or parts per billion level with temperature- and humidity-dependent release rates, which can be rationalized in terms of the physicochemical characteristics of different hydrocarbon classes. Our results indicate that higher energy inputs (i.e., temperatures) significantly increase the amount of NMHCs released from shale, while humidity tends to suppress it; additionally, a large fraction of the gas is released within the first hour after the shale has been fractured. These findings suggest that other hydrocarbons of commercial interest may be extracted from shale and open the possibility to optimize the "fracking" process, improving gas yields and reducing environmental impacts.

Stephens, D.B. Analysis of the Groundwater Monitoring Controversy at the Pavillion, Wyoming Natural Gas Field. Groundwater. 2014 Sep 17. doi: 10.1111/gwat.12272. [Epub ahead of print].

Abstract
The U.S. Environmental Protection Agency (EPA) was contacted by citizens of Pavillion, Wyoming 6 years ago regarding taste and odor in their water wells in an area where hydraulic fracturing operations were occurring. EPA conducted a field investigation, including drilling two deep monitor wells, and concluded in a draft report that constituents associated with hydraulic fracturing had impacted the drinking water aquifer. Following extensive media coverage, pressure from state and other federal agencies, and extensive technical criticism from industry, EPA stated the draft report would not undergo peer review, that it would not rely on the conclusions, and that it had relinquished its lead role in the investigation to the State of Wyoming for further investigation without resolving the source of the taste and odor problem. Review of the events leading up to EPA's decision suggests that much of the criticism could have been avoided through improved preproject planning with clear objectives. Such planning would have identified the high national significance and potential implications of the proposed work. Expanded stakeholder involvement and technical input could have eliminated some of the difficulties that plagued the investigation. However, collecting baseline groundwater quality data prior to initiating hydraulic fracturing likely would have been an effective way to evaluate potential impacts. The Pavillion groundwater investigation provides an excellent opportunity for improving field methods, report transparency, clarity of communication, and the peer review process in future investigations of the impacts of hydraulic fracturing on groundwater.

Stringfellow, W.T., Domen, J.K., Camarillo, M.K., Sandelin, W.L., Borglin, S. Physical, Chemical, and Biological Characteristics of Compounds Used in Hydraulic Fracturing. J Hazard Mater. 2014 Jun 30;275:37-54. doi: 10.1016/j.jhazmat.2014.04.040. Epub 2014 Apr 25.

Abstract

Hydraulic fracturing (HF), a method to enhance oil and gas production, has become increasingly common throughout the U.S. As such, it is important to characterize the chemicals found in HF fluids to evaluate potential environmental fate, including fate in treatment systems, and human health impacts. Eighty-one common HF chemical additives were identified and categorized according to their functions. Physical and chemical characteristics of these additives were determined using publicly available chemical information databases. Fifty-five of the compounds are organic and twenty-seven of these are considered readily or inherently biodegradable. Seventeen chemicals have high theoretical chemical oxygen demand and are used in concentrations that present potential treatment challenges. Most of the HF chemicals evaluated are non-toxic or of low toxicity and only three are classified as Category 2 oral toxins according to standards in the Globally Harmonized System of Classification and Labeling of Chemicals; however, toxicity information was not located for thirty of the HF chemicals evaluated. Volatilization is not expected to be a significant exposure pathway for most HF chemicals. Gaps in toxicity and other chemical properties suggest deficiencies in the current state of knowledge, highlighting the need for further assessment to understand potential issues associated with HF chemicals in the environment.

Sun, M., Lowry, G.V., Gregory, K.B. Selective Oxidation of Bromide in Wastewater Brines from Hydraulic Fracturing. Water Res. 2013 Jul 1;47(11):3723-31. doi:10.1016/j.watres.2013.04.041. Epub 2013 Apr 30.

Abstract

Brines generated from oil and natural gas production, including flowback water and produced water from hydraulic fracturing of shale gas, may contain elevated concentrations of bromide (~1 g/L). Bromide is a broad concern due to the potential for forming brominated disinfection byproducts (DBPs) during drinking water treatment. Conventional treatment processes for bromide removal is costly and not specific. Selective bromide removal is technically challenging due to the presence of other ions in the brine, especially chloride as high as 30-200 g/L. This study evaluates the ability of solid graphite electrodes to selectively oxidize bromide to bromine in flowback water and produced water from a shale gas operation in Southwestern PA. The bromine can then be outgassed from the solution and recovered, as a process well understood in the bromine industry. This study revealed that bromide may be selectively and rapidly removed from oil and gas brines (~10 h(-1) m(-2) for produced water and ~60 h(-1) m(-2) for flowback water). The electrolysis occurs with a current efficiency between 60 and 90%, and the estimated energy cost is ~6 kJ/g Br. These data are similar to those for the chlor-alkali process that is commonly used for chlorine gas and sodium hydroxide production. The results demonstrate that bromide may be selectively removed from oil and gas brines to create an opportunity for environmental protection and resource recovery.

Thurman, E.M., Ferrer, I., Blotevogel, J., Borch, T. Analysis of Hydraulic Fracturing Flowback and Produced Waters Using Accurate Mass: Identification of Ethoxylated Surfactants. Anal Chem. 2014 Oct 7;86(19):9653-61. doi: 10.1021/ac502163k. Epub 2014 Sep 16.

Abstract

Two series of ethylene oxide (EO) surfactants, polyethylene glycols (PEGs from EO3 to EO33) and linear alkyl ethoxylates (LAEs C-9 to C-15 with EO3-EO28), were identified in hydraulic fracturing flowback and produced water using a new application of the Kendrick mass defect and liquid chromatography/quadrupole-time-of-flight mass spectrometry. The Kendrick mass defect differentiates the proton, ammonium, and sodium adducts in both singly and doubly charged forms. A structural model of adduct formation is presented, and binding constants are calculated, which is based on a spherical cagelike conformation, where the central cation ($NH_4^{(+)}$ or $Na^{(+)}$) is coordinated with ether oxygens. A major purpose of the study was the identification of the ethylene oxide (EO) surfactants and the construction of a database with accurate masses and retention times in order to unravel the mass spectral complexity of surfactant mixtures used in hydraulic fracturing fluids. For example, over 500 accurate mass assignments are made in a few seconds of computer time, which then is used as a fingerprint chromatogram of the water samples. This technique is applied to a series of flowback and produced water samples to illustrate the usefulness of ethoxylate "fingerprinting", in a first application to monitor water quality that results from fluids used in hydraulic fracturing.

Vikram, A., Lipus, D., Bibby, K. Produced Water Exposure Alters Bacterial Response to Biocides. Environ Sci Technol. 2014 Oct 22. [Epub ahead of print].

Abstract

Microbial activity during the holding and reuse of wastewater from hydraulic fracturing operations, termed produced water, may lead to issues with corrosion, sulfide release, and fouling. Biocides are applied to control biological activity, often with limited efficacy, which is typically attributed to chemical interactions with the produced water. However, it is unknown whether there is a biologically driven mechanism to biocide tolerance in produced water. Here, we demonstrate that produced water exposure results in an enhanced tolerance against the typically used biocide glutaraldehyde and increased susceptibility to the oxidative biocide hypochlorite in a native and a model bacteria and that this altered resistance is due to the salinity of the produced water. In addition, we elucidate the genetic response of the model organism Pseudomonas fluorescens to produced water exposure to provide a mechanistic interpretation of the altered biocide resistance. The RNA-seq data demonstrated the induction of genes involved in osmotic stress, energy production and conversion, membrane integrity, and protein transport following produced water exposure, which facilitates bacterial survival and alters biocide tolerance. Efforts to fundamentally understand biocide resistance mechanisms, which enable the optimization of biocide application, hold significant implications for greening of the fracturing process through encouraging produced water recycling. Specifically, these results suggest the necessity of optimizing biocide application at the level of individual shale plays, rather than historical experience, based upon produced water characteristics and salinity.

Webb, E., Bushkin-Bedient, S., et al. 2014. Developmental and Reproductive Effects of Chemicals Associated with Unconventional Oil and Natural Gas Operations. Rev. Environ. Health. 29: 307-318.

Abstract

Abstract Unconventional oil and gas (UOG) operations have the potential to increase air and water pollution in communities located near UOG operations. Every stage of UOG operation from well construction to extraction, operations, transportation, and distribution can lead to air and water contamination. Hundreds of chemicals are associated with the process of unconventional oil and natural gas production. In this work, we review the scientific literature providing evidence that adult and early life exposure to chemicals associated with UOG operations can result in adverse reproductive health and developmental effects in humans. Volatile organic compounds (VOCs) [including benzene, toluene, ethyl benzene, and xylene (BTEX) and formaldehyde] and heavy metals (including arsenic, cadmium and lead) are just a few of the known contributors to reduced air and water quality that pose a threat to human developmental and reproductive health. The developing fetus is particularly sensitive to environmental factors, which include air and water pollution. Research shows that there are critical windows of vulnerability during prenatal and early postnatal development, during which chemical exposures can cause potentially permanent damage to the growing embryo and fetus. Many of the air and water pollutants found near UOG operation sites are recognized as being developmental and reproductive toxicants; therefore there is a compelling need to increase our knowledge of the potential health consequences for adults, infants, and children from these chemicals through rapid and thorough health research investigation.

Weber, B.A., Geigle, J., Barkdull, C. 2014. Rural North Dakota's Oil Boom and its Impact on Social Services. Soc Work. Jan; 59(1):62-72.

Abstract

Over the last five years, North Dakota has experienced an oil boom based on high oil prices and hydraulic fracturing technologies. This has brought economic expansion and population growth to rural communities that had previously experienced decades of depopulation and economic struggle. Although the state has enjoyed many benefits--especially in juxtaposition to a sluggish national economy--the boom has also meant the arrival of economic refugees and dramatic impacts on largely rural social service systems. In the midst of a rapidly changing situation, available information tends to swing between euphoria over economic success and hysteria about rising crime and shifting cultures. In response, the authors used a primary focus group with county social service directors from across the state and a followup focus group with social workers operating on the edge of oil activity. Grounded in resilience theory, qualitative analysis of the primary focus group, and triangulation of data from other sources, this study provides a more objective report of the housing and social challenges, the benefits of the boom, and the challenges to solutions.

Zhang, T., Gregory, K., Hammack, R.W., Vidic, R.D. Co-precipitation of Radium with Barium and Strontium Sulfate and its Impact on the Fate of Radium During Treatment of Produced Water from Unconventional Gas Extraction. Environ Sci Technol. 2014 Apr 15;48(8):4596-603. doi: 10.1021/es405168b. Epub 2014 Apr 7.

Abstract

Radium occurs in flowback and produced waters from hydraulic fracturing for unconventional gas extraction along with high concentrations of barium and strontium and elevated salinity. Radium is often removed from this wastewater by co-precipitation with barium or other alkaline earth metals. The distribution equation for Ra in the precipitate is derived from the equilibrium of the lattice replacement reaction (inclusion) between the Ra(2+) ion and the carrier ions (e.g., Ba(2+) and Sr(2+)) in aqueous and solid phases and is often applied to describe the fate of radium in these systems. Although the theoretical distribution coefficient for Ra-SrSO4 (Kd = 237) is much larger than that for Ra-BaSO4 (Kd = 1.54), previous studies have focused on Ra-BaSO4 equilibrium. This study evaluates the equilibria and kinetics of co-precipitation reactions in Ra-Ba-SO4 and Ra-Sr-SO4 binary systems and the Ra-Ba-Sr-SO4 ternary system under varying ionic strength (IS) conditions that are representative of brines generated during unconventional gas extraction. Results show that radium removal generally follows the theoretical distribution law in binary systems and is enhanced in the Ra-Ba-SO4 system and restrained in the Ra-Sr-SO4 system by high IS. However, the experimental distribution coefficient (Kd') varies widely and cannot be accurately described by the distribution equation, which depends on IS, kinetics of carrier precipitation and does not account for radium removal by adsorption. Radium removal in the ternary system is controlled by the co-precipitation of Ra-Ba-SO4, which is attributed to the rapid BaSO4 nucleation rate and closer ionic radii of Ra(2+) with Ba(2+) than with Sr(2+). Carrier (i.e., barite) recycling during water treatment was shown to be effective in

enhancing radium removal even after co-precipitation was completed. Calculations based on experimental results show that Ra levels in the precipitate generated in centralized waste treatment facilities far exceed regulatory limits for disposal in municipal sanitary landfills and require careful monitoring of allowed source term loading (ASTL) for technically enhanced naturally occurring materials (TENORM) in these landfills. Several alternatives for sustainable management of TENORM are discussed.

Zvala-Araiza, D., Sullivan, D.W., Allen, D.T. 2014. Atmospheric Hydrocarbon Emissions and Concentrations in the Barnett Shale Natural Gas Production Region. EnvSciTech. 48:5314−5321.

Abstract

Hourly ambient hydrocarbon concentration data were collected, in the Barnett Shale Natural Gas Production Region, using automated gas chromatography (auto-GC), for the period from April 2010 to December 2011. Data for three sites were compared: a site in the geographical center of the natural gas production region (Eagle Mountain Lake (EML)); a rural/suburban site at the periphery of the production region (Flower Mound Shiloh), and an urban site (Hinton). The dominant hydrocarbon species observed in the Barnett Shale region were light alkanes. Analyses of daily, monthly, and hourly patterns showed little variation in relative composition. Observed concentrations were compared to concentrations predicted using a dispersion model (AERMOD) and a spatially resolved inventory of volatile organic compounds (VOC) emissions from natural gas production (Barnett Shale Special Emissions Inventory) prepared by the Texas Commission on Environmental Quality (TCEQ), and other emissions information. The predicted concentrations of VOC due to natural gas production were 0-40% lower than background corrected

measurements, after accounting for potential under-estimation of certain emission categories. Hourly and daily variations in observed, background corrected concentrations were primarily explained by variability in meteorology, suggesting that episodic emission events had little impact on hourly averaged concentrations. Total emissions for VOC from natural gas production sources are estimated to be approximately 25,300 tons/yr, when accounting for potential under-estimation of certain emission categories. This region produced, in 2011, approximately 5 bcf/d of natural gas (100 Gg/d) for a VOC to natural gas production ratio (mass basis) of 0.0006.

In addition to studies published in the peer-reviewed scientific literature, there are many documents produced by governmental organizations on all aspects of HVHF activities. The following reports also provided additional background information for the Public Health Review.

Colorado's Air Quality Control Commission. REGULATION NUMBER 3, STATIONARY SOURCE PERMITTING AND AIR POLLUTANT EMISSION NOTICE, REQUIREMENTS 5 CCR 1001-5 http://perma.cc/TEP5-T7TM

Rulemaking Summary
On February 23, 2014, Colorado's Air Quality Control Commission ("Commission") fully adopted EPA's

Standards of Performance for Crude Oil and Natural Gas Production, Transmission, and Distribution found in 40 C.F.R. Part 60, Subpart OOOO ("NSPS OOOO") into Regulation Number 6, Part A; adopted corresponding revisions to its emissions reporting and permitting framework in Regulation Number 3, Parts A, B, and C; and adopted complementary oil and gas control measures in Regulation Number 7. This rulemaking was the culmination of the Commission's October 2012, directive to consider full adoption of EPA's NSPS OOOO. These oil and gas control measures revisions focus on identifying and repairing leaks in the oil and gas sector, but also contain some recordkeeping and reporting requirements. This rulemaking received support from environmental groups and some companies within the oil and gas industry. In addition to extensive VOC reductions, the Regulation Number 7 revisions also regulate methane emissions from the oil and gas industry.

These oil and gas control measures are estimated to reduce VOC emissions by approximately 93,500 tons per year and methane/ethane emissions by approximately 65,000 tons per year, at a cost of approximately $42.5 million per year.

US EPA. 2014. Advance notice of proposed rulemaking under 40 CFR Chapter I [EPA–HQ–OPPT–2011–1019; FRL–9909–13] Hydraulic Fracturing Chemicals and Mixtures.

Summary

In its response to a citizen petition submitted under section 21 of the Toxic Substances Control Act (TSCA), EPA indicated that as a first step, it would convene a stakeholder process to develop an approach to obtain information on chemical substances and mixtures used in hydraulic fracturing. To gather information to inform EPA's proposal, the Agency is issuing this advance notice of proposed rulemaking (ANPR) and initiating a public participation process to seek comment on the information that should be reported or disclosed for hydraulic fracturing chemical substances and mixtures and the mechanism for obtaining this information. This mechanism could be regulatory (under TSCA section 8(a) and/or section 8(d)), voluntary, or a combination of both and could include best management practices, third-party certification and collection, and incentives for disclosure of this information. In addition, the Agency is seeking comment on ways of minimizing reporting burdens and costs and of avoiding the duplication of state and other federal agency information collections, while at the same time maximizing data available for EPA risk characterization, external transparency, and public understanding. Also, EPA is soliciting comments on incentives and recognition programs that could be used to support the development and use of safer chemicals in hydraulic fracturing.

Dusseault, M. & Jackson, R. Seepage Pathway Assessment for Natural Gas to Shallow Groundwater During Well Stimulation, Production and After Abandonment. GeoMontréal 2013 [66th Canadian Geotechnical Conference and the 11th Joint CGS/IAH-CNC Groundwater Conference].

Abstract

Hydraulic fracture stimulation (HFS) of unconventional oil and gas reservoirs has become the focus of public concern with respect to fugitive gas emissions, fracture height growth, induced seismicity and groundwater pollution. We evaluate the potential pathways of fugitive gas seepage during stimulation and production and conclude that the quality of surface casing and deeper casing installations is a major concern with respect to future gas migration. The pathway outside the casing is of greatest concern, and likely leads to many wells leaking natural gas upwards from intermediate, non-depleted thin gas zones, rather than from the deeper target reservoirs which are depleted during production. We substantiate this argument with isotopic data from the Western Canada Sedimentary Basin. These paths must be understood and the probability of leakage addressed by mitigating methods such as casing perforation and squeeze, expanding packers of long life and controlled leak-off into saline aquifers. With a few exceptions, hydraulic fracture stimulation itself appears not to be a significant risk. These exceptions include situations involving fluids during the high pressure stage of HFS when (1) old well casings are intersected by fracturing fluids and (2) when these fluids pressurize nearby offset wells that have not been shut in, and particularly offset wells in the same formation that are surrounded by a region of pressure depletion where the horizontal stresses have also been diminished.

Ellsworth, W.l., Hickman, S,H., Lleons, A.l., Mcgarr, A., Michael, A.J., Rubinstein, J.l. 2012. Are Seismicity Rate Changes in the Midcontinent Natural Or Manmade? SSA 2012 Abstract # 12-137.

Summary

A remarkable increase in the rate of M 3 and greater earthquakes is currently in progress in the US midcontinent. The average number of M >= 3 earthquakes/year increased starting in 2001, culminating in a six-fold increase over 20th century levels in 2011. Is this increase natural or manmade? To address this question, we take a regional approach to explore changes in the rate of earthquake occurrence in the midcontinent (defined here as 85° to 108° West, 25° to 50° North) using the USGS Preliminary Determination of Epicenters and National Seismic Hazard Map catalogs. These catalogs appear to be complete for M >= 3 since 1970. From 1970 through 2000, the rate of M >= 3 events averaged 21 +- 7.6/year in the entire region. This rate increased to 29 +- 3.5 from 2001 through 2008. In 2009, 2010 and 2011, 50, 87 and 134 events occurred, respectively. The modest increase that began in 2001 is due to increased seismicity in the coal bed methane field of the Raton Basin along the Colorado-New Mexico border west of Trinidad, CO. The acceleration in activity that began in 2009 appears to involve a combination of source regions of oil and gas production, including the Guy, Arkansas region, and in central and southern

Oklahoma. Horton, et al. (2012) provided strong evidence linking the Guy, AR activity to deep waste water injection wells. In Oklahoma, the rate of M >= 3 events abruptly increased in 2009 from 1.2/year in the previous half-century to over 25/year. This rate increase is exclusive of the November 2011 M 5.6 earthquake and its aftershocks. A naturally-occurring rate change of this magnitude is unprecedented outside of volcanic settings or in the absence of a main shock, of which there were neither in this region. While the seismicity rate changes described here are almost certainly manmade, it remains to be determined how they are related to either changes in extraction methodologies or the rate of oil and gas production.

Hammack, R., Harbert, W., Sharma, S., Stewart, B., Capo, R., Wall, A., Wells, A., Diehl, R., Blaushild, D., Sams, J., Veloski, G. 2014. An Evaluation of Fracture Growth and Gas/Fluid Migration as Horizontal Marcellus Shale Gas Wells are Hydraulically Fractured in Greene County, Pennsylvania; NETL-TRS-3-2014; EPAct Technical Report Series; U.S. Department of Energy, National Energy Technology Laboratory: Pittsburgh, PA.

Executive Summary
This field study monitored the induced fracturing of six horizontal Marcellus Shale gas wells in Greene County, Pennsylvania. The study had two research objectives: 1) to determine the maximum height of fractures created by hydraulic fracturing at this location; and 2) to determine if natural gas or fluids from the hydraulically fractured Marcellus Shale had migrated 3,800 ft upward to an overlying Upper Devonian/Lower Mississippian gas field during or after hydraulic fracturing.

The Tully Limestone occurs about 280 ft above the Marcellus Shale at this location and is considered to be a barrier to upward fracture growth when intact.

Microseismic monitoring using vertical geophone arrays located 10,288 microseismic events during hydraulic fracturing; about 40% of the events were above the Tully Limestone, but all events were at least 2,000 ft below producing zones in the overlying Upper Devonian/Lower Mississippian gas field, and more than 5,000 ft below drinking water aquifers.

Monitoring for evidence of fluid and gas migration was performed during and after the hydraulic fracturing of six horizontal Marcellus Shale gas wells. This monitoring program included: 1) gas pressure and production histories of three Upper Devonian/Lower Mississippian wells; 2) chemical and isotopic analysis of the gas produced from seven Upper Devonian/Lower Mississippian wells; 3) chemical and isotopic analysis of water produced from five Upper Devonian/Lower Mississippian wells; and 4) monitoring for perfluorocarbon tracers in gas produced from two Upper Devonian/Lower Mississippian wells.

Gas production and pressure histories from three Upper Devonian/Lower Mississippian gas wells that directly overlie stimulated, horizontal Marcellus Shale gas wells recorded no production or pressure increase in the 12-month period after hydraulic fracturing. An increase would imply communication with the over-pressured Marcellus Formation below. Sampling to detect possible migration of fluid and gas from the underlying hydraulically fractured Marcellus Shale gas wells commenced 2 months prior to hydraulic fracturing to establish background conditions. Analyses have been completed for gas samples collected up to 8 months after hydraulic fracturing and for produced water samples collected up to 5 months after hydraulic fracturing. Samples of gas and produced water continue to be collected monthly (produced water) and bimonthly (gas) from seven Upper Devonian/Lower Mississippian gas wells.

Current findings are: 1) no evidence of gas migration from the Marcellus Shale; and 2) no evidence of brine migration from the Marcellus Shale. Four perfluorocarbon tracers were injected with hydraulic fracturing fluids into 10 stages of a 14-stage, horizontal Marcellus Shale gas well during stimulation. Gas samples collected from two Upper Devonian/Lower Mississippian wells that directly overlie the tracer injection well were analyzed for presence of the tracer. No tracer was found in 17 gas samples taken from each of the two wells during the 2-month period after completion of the hydraulic fracturing.

Pennsylvania DEP. Regional Determination Letters. http://files.dep.state.pa.us/OilGas/BOGM/BOGMPortalFiles/OilGasReports/Determination_Letters/Regional_Determination_Letters.pdf.

Summary

The following list identifies cases where DEP determined that a private water supply was impacted by oil and gas activities. The oil and gas activities referenced in the list below include operations associated with both conventional and unconventional drilling activities that either resulted in a water diminution event or an increase in constituents above background conditions. This list is intended to identify historic water supply impacts and does not necessarily represent ongoing impacts. Many of the water supply complaints listed below have either returned to background conditions, have been mitigated through the installation of water treatment controls or have been addressed through the replacement of the original water supply. This list is dynamic in nature and will be updated to reflect new water supply impacts as they are reported to DEP and a determination is made; however, the list will retain cases of water supply impacts even after the impact has been resolved.

Public Health Association Australia (2014) Submission to Northern Territory Legislative Assembly Inquiry into Hydraulic Fracturing. PHAA NT Branch, ACT, Australia.

No summary is available.

Schumacher B, Griggs J, Askren D, Litman B, Shannon B, Mehrhoff M, Nelson A, Schultz MK. 2014. Development of Rapid Radiochemical Method for Gross Alpha and Gross Beta Activity Concentration in Flowback and Produced Waters from Hydraulic Fracturing Operations (EPA Report).

Summary and Conclusions

Three parts of The Gross Alpha and Gross Beta Method in FPWHFO were tested using a matrix based on the composition of a FPWHFO sample received from the EPA to determine whether they would satisfy method development guidelines outlined in the Method Validation Guide for Qualifying Methods Used by Radiological Laboratories Participating in Incident Response Activities (EPA, 2009). Two of the three parts comprise measurements of alpha emitters in the sample while the third is designed to measure beta emitters.

The MQOs for each of the three parts differed based on the matrix complexity, the instruments used for analyses, and the nuclear constants associated with the principal radionuclides used for the development process, and variation associated with preparation of the test samples. The as-tested MQOs and measured results are presented in Table 3. The final method with flow diagram used in this method development study is presented in Attachment III.

Each of the three parts of the method validated met all of the acceptance criteria for method uncertainty as shown in Tables 6A, 6B, and 6C. A summary of the observed levels of uncertainty at each of three activity levels is summarized in Tables 7A, 7B, and 7C. Detectable levels of bias were observed across the activity levels for each of the three measurements as summarized in Table 10. The levels of bias, however, were so large that they compromised the determinatoin of method uncertainty. The detection capability for each of the three parts was successfully verified as summarized in 9A, 9B, and 9C.

Although all testing criteria were met as described in this report, the complexity of the matrix prevented development of a single-measurement method for gross alpha and beta in FPWHFO samples that will be simple, economical, and sufficiently rugged in matrices beyond the one used for the testing. Performing this analysis required a level of effort that was much different from previous analytical methods in other water matrices for alpha or beta emitters. Several unique approaches were attempted in order to identify an analytical approach that would accommodate this particularly challenging matrix. Section 11 provides a brief synopsis of development activities and Attachment 1 provides additional detail supporting the method development activities preliminary to final testing.

The final approach for gross alpha requires two measurements. The first measurement involves gross alpha by liquid scintillation counting following chemical separation to isolate thorium, uranium and polonium from the matrix. Method testing in the surrogate matrix indicates that a measureable bias is associated with the technique. Average recovery were 74±11% (k=1) of the known concentration of 230Th. Recoveries ranged from 57–104%. Although all of the testing criteria were met, the observed low bias raises possible questions about the ruggedness of the technique, especially with regard to use of the method for analyzing of FPWHFO of different compositions, from different regions or different times in the hydraulic fracturing life cycle. Possible future work should be done to improve the ruggedness of the method and to develop estimates of uncertainty and decision criteria that would protect against decision errors using this screening technique.17 See Section 11 for recommendations for possible future work in this area.

The second measurement for alpha activity associated with 226Ra is performed by gamma spectrometry. The gamma spectrometry measurement is used to simultaneously determine the activity of longer-lived members of the thorium and uranium decay chains for calculation of gross beta activity. Although the development process detected bias in the gamma spectrometry measurements at some levels, the magnitude of the bias is lower than that observed for the alpha and there is no need for concern about the ruggedness of the non-destructive measurement technique since there are no variables such chemical separations that will introduce variable levels of bias into the method. Section 11 suggests the possibility of future work to improve the sensitivity of the gamma spectrometry measurement.

Due to the physics of the measurement technologies, radionuclide determinations performed by gamma spectrometry are generally less sensitive and have higher uncertainty that those performed by the liquid scintillation counting. This complicates the reporting process, the determination of uncertainty, and prevents calculation of a single meaningful value for gross alpha detection capability. Section 11 recommends that measurements of gross alpha by LSC and of 226Ra be reported and interpreted separately and suggests the possibility of future work that would improve the sensitivity of the gamma spectrometry measurement thereby minimize the disparity in the sensitivity of the two techniques.

Finally, as mentioned in the introduction in Section 1, all gross alpha and beta measurements are limited by the complexities of radioactive decay and ingrowth in the uranium and thorium decay chains which causes the alpha and beta activity physically present in the sample to change over time. Thus gross alpha and beta measurements are often not (inter-) comparable from measurement to measurement or laboratory to laboratory. This significantly complicated the interpretation of gross alpha and beta results. Section 11 recommends that future work explore the impact of timing on the performance of the method and the interpretation of results, a project that would benefit gross alpha and beta measurements of natural products in all water matrices.

Stinson, R.J., Townsend, I., Donley, T.L., Chirenje, T., Patrick, D. 2014. Heavy Metal Distribution in Surficial Water: A Possible Link to Hydrocarbon Exploration and Extraction, Middle Susquehanna River Sub-Basin, Pennsylvania. Northeastern Section – Geological Society of America, Northeastern Section, 49th Annual Meeting (23–25 March, 2014), Lancaster, Pennsylvania.

Summary

Several environmental and human health concerns have emerged in the past few years due to the recent boom of hydrocarbon exploration and the new hydraulic fracturing methods involved. Although many different concerns exist, groundwater contamination has continually been the focal point of water issues relating to hydraulic fracturing. Surficial water has a fast residence time in the hydrologic cycle and does not directly impact humans as much as groundwater; therefore, it tends to be overlooked. For a chance to better understand the interaction between surface water and hydraulic fracturing, this project helps to determine if hydraulic fracturing is influencing the local watershed. Water samples were collected from tributaries leading into the Susquehanna River, from Bradford and Wyoming Counties, PA, to measure the concentrations of potential pollutants. Concentrations of heavy metals, such as arsenic, strontium, selenium, barium, nickel, cadmium, lead, copper, and zinc, were measured by means of atomic absorption spectrophotometry. On-site measurements, comprising of temperature, pH, dissolved oxygen, conductivity, and turbidity, were also measured. A statistical analysis of the collected data was interpreted and graphical representations were produced to portray the results. Results of the analyzed data showing a trend in increased concentration levels of pollutants with distinct distribution patterns could be considered a link to hydraulic fracturing. Effluence in surficial water can be acquired via runoff, which can originate from different phases of the hydraulic fracturing process; specifically, the handling and disposal of all fluids. This project holds the groundwork for additional research to understand the relationship between surficial water and hydraulic fracturing. Further investigation and modeling can be attempted to recognize the following: how the pollutants are deposited and transported, watershed quality and impacts (negative or positive), if the pollutants found are at levels that can endanger human health, and, most importantly, whether hydraulic fracturing can be labeled as a point-source or not.

US EPA. 2014. Advance notice of proposed rulemaking under 40 CFR Chapter I [EPA–HQ–OPPT–2011–1019; FRL–9909–13] Hydraulic Fracturing Chemicals and Mixtures.

Summary

In its response to a citizen petition submitted under section 21 of the Toxic Substances Control Act (TSCA), EPA indicated that as a first step, it would convene a stakeholder process to develop an approach to obtain information on chemical substances and mixtures used in hydraulic fracturing. To gather information to inform EPA’s proposal, the Agency is issuing this advance notice of proposed rulemaking (ANPR) and initiating a public participation process to seek comment on the information that should be reported or disclosed for hydraulic fracturing chemical substances and mixtures and the mechanism for obtaining this information. This mechanism could be regulatory (under TSCA section 8(a) and/or section 8(d)), voluntary, or a combination of both and could include best management practices, third-party certification and collection, and incentives for disclosure of this information. In addition, the Agency is seeking comment on ways of minimizing reporting burdens and costs and of avoiding the duplication of state and other federal agency information collections, while at the same time maximizing data available for EPA risk characterization, external transparency, and public understanding. Also, EPA is soliciting comments on incentives and recognition programs that could be used to support the development and use of safer chemicals in hydraulic fracturing.

USGS. 2014. Record Number of Oklahoma Tremors Raises Possibility of Damaging Earthquakes. Updated USGS-Oklahoma Geological Survey Joint Statement on Oklahoma Earthquakes. Originally Released: 10/22/2013 1:07:59 PM; Updated May 2, 2014. http://earthquake.usgs.gov/regional/ceus/products/newsrelease_05022014.php.

Summary

The rate of earthquakes in Oklahoma has increased by about 50 percent since October 2013, significantly increasing the chance for a damaging quake in central Oklahoma. In a new joint statement by the U.S. Geological Survey and Oklahoma Geological Survey, the agencies reported that 183 earthquakes of magnitude 3.0 or greater occurred in Oklahoma from October 2013 through April 14, 2014. This compares with a long-term average from 1978 to 2008 of only two magnitude 3.0 or larger earthquakes per year. As a result of the increased number of small and moderate shocks, the likelihood of future, damaging earthquakes has increased for central and north-central Oklahoma.

“We hope that this new advisory of increased hazard will become a crucial consideration in earthquake preparedness for residents, schools and businesses in the central Oklahoma area,” said Dr. Bill Leith, USGS Senior Science Advisor for Earthquakes and Geologic Hazards. “Building owners and government officials should have a special concern for older, unreinforced brick structures, which are vulnerable to serious damage during sufficient shaking.”

The joint statement indicates that a likely contributing factor to the increase in earthquakes is wastewater disposal by injection into deep geologic formations. The water injection can increase underground pressures, lubricate faults and cause earthquakes – a process known as injection-induced seismicity. Much of this wastewater is a byproduct of oil and gas production and is routinely disposed of by injection into wells specifically designed and approved for this purpose. The recent earthquake rate changes are not due to typical, random fluctuations in natural seismicity rates.

Oklahoma’s heightened earthquake activity since 2009 includes 20 magnitude 4.0 to 4.8 quakes, plus one of the two largest recorded earthquakes in Oklahoma’s history – a magnitude 5.6 earthquake that occurred near Prague on Nov. 5, 2011, which damaged a number of homes and the historic Benedictine Hall at St. Gregory's University in Shawnee.

As a result of the increased seismicity, the Oklahoma Geological Survey has increased the number of monitoring stations and now operates a seismograph network of 15 permanent stations and 17 temporary stations. Both agencies are actively involved in research to determine the cause of the increased earthquake rate and to quantify the increased hazard in central Oklahoma.

| Appendix 2

Radon Screening Analysis

Radon is a naturally occurring, radioactive gas found in soil and rock. It seeps into homes through cracks in the foundation, walls, and joints. Radon comes from the natural (radioactive) breakdown of uranium in soil, rock and water and gets into the air. The amount of uranium in soil, rock and water varies across New York State. Radon from soil is the primary source of elevated levels in homes. Radon is a potential public health concern because elevated radon levels in the home can increase the risk of lung cancer for residents. This risk is greatly increased among smokers living in homes with elevated radon levels.

The New York State Department of Health has been collecting radon data since 1987. The data come from New York residents who choose to test their homes through the DOH radon program (Figures A and B).The information contained in the database is posted on the DOH website (http://www.health.ny.gov/environmental/radiological/radon/radon.htm) and contains basement radon results for about 70,000 homes. The information is listed by county and town and is updated semi-annually. DOH has a radon outreach and education program that promotes testing and mitigation in high risk radon areas and encourages testing by providing low-cost radon test kits to residents across the state.

Radon from Natural Gas

Natural gas contains radon from the decay of naturally occurring radium. The amount of radon will vary depending on the source of natural gas. Radon undergoes radioactive decay with a 3.8 day half-life. This means that the amount of radon in the natural gas decreases by 50% every 3.8 days. Transport of the natural gas through gathering and distribution lines provides time for radon gas to decay resulting in a lower concentration of radon when delivered to the customer.

Published estimates of indoor radon concentrations due to the use of natural gas in homes (US EPA, 1973) suggest that radon from natural gas use is typically a very small contributor to the total indoor radon levels in the home, compared to radon levels in the soil gas. Most gas appliances are vented, therefore only unvented appliances (mostly gas ranges) are assumed to contribute radon to indoor air.

A 1973 US EPA study found an average radon level in US natural gas wells of 37 picocuries per liter (pCi/L) (range: 0.2 to 1,450 pCi/L). The highest radon concentrations are from natural gas that originates in Texas, Oklahoma and Kansas. Similar estimates have been reported for natural gas from other parts of the world. A more recent study of radon in Pennsylvania natural gas wells conducted by the US Geological Survey (Rowan and Kramer, 2012) showed a radon concentration range of 1-79 pCi/L.

To determine whether radon in natural gas contributes to the overall indoor radon levels in the home, EPA made the following assumptions: home size (8000 ft3), gas usage (27 ft3/day) and number of air exchanges (1 per hour). Based on the above assumptions and an average radon concentration of 20 pCi/L (in gas at the burner) in an unvented kitchen range, the contribution from radon in natural gas results in an indoor radon concentration of about of 0.0028 pCi/L. Using the highest reported US radon concentration (1450 pCi/L) in an unvented kitchen range shows an increase of about 0.2 pCi/L. For comparison, the average outdoor radon concentration in the US is 0.4 pCi/L, and according to the NYSDOH radon database, the average indoor radon concentration in New York State in homes that have been tested, mostly located in high radon areas, is 6.2 pCi/L. The nationwide average indoor radon concentration is 1.3 pCi/L.

The assumptions used to estimate indoor radon contribution from burning natural gas were established in 1973 and may not represent present kitchen stove usage. Current data on gas use states that a typical home uses from 4.5-12.5 ft^3/day (rather than the 27 ft^3/day used above) depending on whether or not the gas range has a pilot light (US DOE, 2009). Using these revised gas consumption values, a radon concentration of 20 pCi/L and keeping all the other parameter values the same, the contribution from an unvented gas appliance falls to 0.00046 to 0.0011pCi/L. If instead of the average radon concentration of 20 pCi/L we use the maximum measured concentration of 1450 pCi/L, the contribution to the indoor radon level from natural gas will range from 0.03 – 0.08 pCi/L. Assuming a smaller dwelling of 4,000 ft^3 the radon concentration could increase to 0.16 pCi/l from natural gas.

In summary, it is generally accepted that sources other than soil such as groundwater, consumer products (e.g., granite counter tops) and natural gas are not considered significant contributors to indoor radon concentrations. The above calculation demonstrate that natural gas has the potential to contribute a small amount of radon to the indoor air of homes from the use of unvented gas ranges. Based on the EPA methodologies, this contribution could be as high 0.16 pCi/L using the most recent data on gas consumption in a small dwelling. This contribution should be considered in the context of what we know about radon concentrations in the environment which is that the average outdoor radon concentration in the US is 0.4 pCi/L, the nationwide average indoor is 1.3 pCi/L and according to the NYSDOH radon database, the average indoor radon concentration in New York State is 6.2 pCi/L.

Figure A New York State short-term indoor radon levels by county.

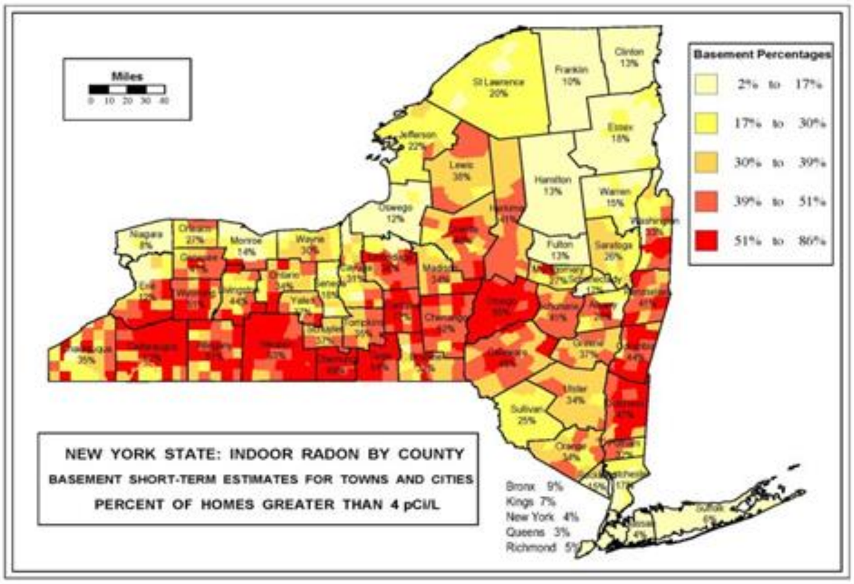
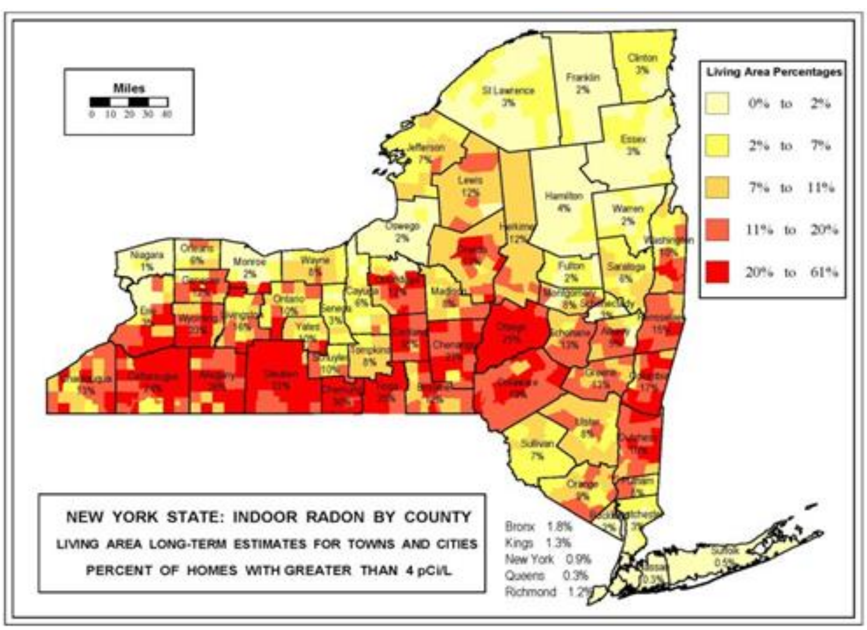


Figure B New York State long-term indoor radon levels by county.



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Appendix B

Modeling of Ozone Impacts from Well Pad Activities and Associated Truck Traffic and Compressor Stations for Future Peak Well Development Conditions in the Marcellus Shale Area of New York State

Final

Supplemental Generic Environmental Impact Statement

Response to Comments

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Modeling of Ozone Impacts from Well Pad Activities and Associated Truck Traffic and Compressor Stations for Future Peak Well Development Conditions in the Marcellus Shale Area of New York State

1.0 Introduction

Section 6.5.3 of the SGEIS presents projected regional emissions of ozone precursors (NO_X and VOCs) which are associated with well pad activities and related truck traffic during the time when the peak number of wells per year is expected to be drilled in the future. These estimates are based on industry's projections of these activities as described in the ALL/IOGA-NY report, referenced in the SGEIS.[1] The emissions estimates reflect worst case future operations wherein 2216 horizontal and 246 vertical wells could be drilled in a year and under a set of conservative assumptions listed in Section 6.5.3 of the SGEIS. These emissions calculations account for operational restrictions on certain of the equipment, such as time periods for the drilling and fracturing engines, but not on others such as dehydrators and line heaters which are presumed to be operated full year around. In addition to these regional well pad emissions, an estimate of ozone precursor emissions from truck traffic expected during the peak well drilling conditions were made in Section 6.5.3 of the SGEIS. For this purpose, industry provided an average Vehicle Miles Traveled (VMT) of about 20-25 miles for light and heavy duty trucks.[2] The Department used the average VMT to generate the necessary emissions of NO_X and VOC over the Marcellus Shale counties using EPA's MOVES model, as further described below.

As noted in Section 6.5.3 of the 2011 revised draft SGEIS, a screening level modeling assessment was to be undertaken prior to the Final SGEIS to determine the need for potential further mitigation measures and to guide the future needs of the Ozone modeling by the Department in its commitments to EPA for the ozone State Implementation Plan (SIP) process. The analysis carried out in this document serves as that first level screening assessment and serves to guide the future development of the ozone SIP modeling for New York. To project a more complete picture of the influence of gas development in New York, a rough estimate has also been made of the potential number of "typical" compressor station engines which might be required for the long term average amount of gas to be extracted for the peak number of wells to be developed. The emissions from these compressor station engines are calculated and the resultant incremental ozone levels are determined in conjunction with well drilling activity results to determine the maximum projected levels in the future years.

For the ozone modeling, the well pad emissions were distributed over the Marcellus Shale area in proportion to the expected number of wells to be drilled on a county-wide basis according to the Socio-Economic Impact Analysis Report prepared for the SGEIS.[3] Furthermore, for the modeling analysis, these emissions were assigned to specific "model cells" which, to the extent possible, avoided allocation of emissions in modeling cells in areas in which drilling would be prohibited. On the other hand, the truck emissions were distributed evenly over the Marcellus Shale area since no restrictions nor details were available on their movement over the region.

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1 ALL/IOGA-NY Industry Information Report, dated September 16, 2010.
2 ALL Consulting letter of March 16, 2011 from Daniel Arthur to Brad Gill of IOGA-NY.
3 Socio-economic Impact Analysis, Prepared by Ecology and Environment for the 2011 rdSGEIS. http://www.dec.ny.gov/docs/materials_minerals_pdf/rdsgeisecon0811.pdf

The details of the emission processing are provided in the next section. The compressor station engine emissions were distributed in the same manner as the well pad operations as described further below.

The estimated model ready emissions were then input to the EPA's Community Multiscale Air Quality (CMAQ) model for regional ozone modeling with all the other necessary information. The simulation requires meteorological data in the region which was generated mainly from a meteorological simulation model. The ozone projections were then made at a set of receptor locations on an appropriate modeling grid overlaid on the area of interest, including all of New York and neighboring states. The modeling methodologies are described in Section 3.

The CMAQ model projected daily maximum 8-hour Ozone levels associated with additional precursor emissions due to the peak well development were then superimposed over the region to depict the incremental impacts associated with the increased emissions from well drilling activities. The analysis was performed for a "baseline year" (2007) for projections relative to "current" conditions and a future year (2020) scenario which is more in line with the projected time frame for achieving the peak number of wells in the Socio-economic Impact Analysis report. The 2020 inventory was readily available as one of the inventories being currently tested for modeling assessments related to potential future ozone work for the SIP process. Since the industry projected emissions are based on worst case assumptions on some of the equipment which might not represent their actual use in the future, another CMAQ analysis was performed for a more likely emissions scenario associated with the future long term well development projections. This limited emissions scenario also incorporated certain emission reductions anticipated from the improvements in the drilling and fracturing engines emissions in future years as a result of recommended mitigation measures to be incorporated in the Final SGEIS and as a result of anticipated fleet turnover. The resultant impacts are presented in Section 4 for the two sets of increased emissions associated with the peak number of wells to be developed and the two sets of regional inventories. The compressor station emission calculation methods and the resultant ozone impacts are presented in Section 5.

The ozone impacts presented in this report are preliminary screening level impacts and cannot be used to project any compliance determinations for the current or potential future ozone standards, for the reasons discussed in Section 3. That assessment will be made in the ozone SIP process in cooperation with EPA region 2 following EPA defined procedures for such analysis. These EPA procedures account for the conservative nature of the model as well as of the "raw" projected concentrations over the modeling domain by adjusting the consequent total ozone levels at monitoring site concentrations. This leads to more realistic projection of potential future ozone levels at these sites. In addition, the screening modeling assessment is based on the estimated peak number of well to be developed in a ten year period after horizontal drilling is allowed, while the Socio-economic Impact Analysis report also presents an average and low development scenarios which could also be viable. The purpose of this particular analysis is to indicate the relative influence and significance of the gas development emissions on the future work to be undertaken by the Department during the long term timeframe projected to be necessary to reach the expected peak number of wells development in New York.

2.0 Emissions Processing Methods

In order to determine the impact of additional emissions associated with the proposed gas drilling in the Marcellus Shale area on local and regional ozone air quality, an emission inventory of drilling activities was developed and processed to create air quality model-ready emission files. Emission inventories for use in air quality modeling are typically developed for criteria pollutants at the county level and annual time resolution. It is then necessary to: 1) spatially allocate the county level emissions to the model grid cell level, 2) temporally allocate the annual emissions to the hour time resolution in order to predict hourly concentrations, and 3) chemically speciate the criteria pollutants to allow the use of chemical transformations built into the model for the species related to ozone formation. These steps were accomplished using EPA's Sparse Matrix Operator Kernel Emissions (SMOKE) model as described below. In the modeling analysis, emissions for well pad activities and truck traffic around the well pads and in the Marcellus Shale area were considered. The emissions from motor vehicles were calculated using EPA's Motor Vehicle Emission Simulator (MOVES) model using county level specific data developed from the most recent DOT/DMV data for New York instead of using "default" values in MOVES. Furthermore, emissions of ozone precursors from projected compressor station engines necessary to process the average total gas developed over a ten year period were made and modeled, as described in Section 5.0.

2.1 Total Shale Area Emissions and County Distribution

Total regional emissions of all activities except truck traffic from projected peak of 2462 wells per year were preferentially distributed among the counties where the shale is noted to have optimal thickness (see Figure 4-9 of the SGEIS). Using this criterion, Section 4 of the Socio-economic Impact Analysis report allocates the well development to four areas in the state, as follows:

- **Region A**: 50% of all new well construction would occur in Region A (Broome, Chemung, and Tioga counties);

- **Region B:** 23% of all new well construction would occur in Region B (Delaware, Otsego, and Sullivan counties);

- **Region C**: 5% of all new well construction would occur in Region C (Cattaraugus and Chautauqua counties); and

- **Remainder of the State:** 22% of new well construction would occur in other locations throughout the area covered by the Marcellus Shale and other low-permeability formations in New York State.

For the 22% of the wells in the "remainder of the state" category, the following distribution of wells was made in adjacent counties to those in Regions A to C based on the expected likelihood that the chosen areas will contribute to downwind Ozone formation in concert with the emissions from Regions A to C: rounded percentages of 3% each in Allegany and Steuben counties and 5% each in Tomkins, Chenango and Schuyler counties,.

The emissions associated with truck traffic used for the various activities necessary for the gas drilling and corresponding to the peak number of well drilling were equally assigned to each of the counties in the Marcellus Shale area. Since no information is available on the specific areas or routes on which this traffic would preferentially occur, this simple distribution was deemed adequate. Furthermore, as discussed in the SGEIS, the emissions of truck traffic are deemed small relative to both the emissions from all other well development activities, as well as relative to the existing mobile source emissions in the Marcellus Shale area.

Annual well pad emissions of NO_X and VOC for all other activities were estimated for the following activities: drilling, fracturing, flaring, venting, and production. The emissions were differentiated by these activities in order to assign SMOKE processing properly. Two emissions scenarios were considered in the modeling. The first scenario was based on the estimated NO_X and VOC emissions in the ALL-IOGA-NY 3/16/10 information report for the various well pad sources. These emissions accounted for the temporal operational restrictions on certain of the equipment, while other emissions were assumed to operate full year round. However, there are certain restrictions on the use of equipment such as the line heater and other likely modifications and restrictions to the engine use in the future years, when the peak emissions are to be realized, which also need to be considered. Thus, another scenario was developed to test the response of the modeled Ozone levels in an attempt to provide a range of potential impacts associated with future well development.

This second scenario started with the assumptions and emissions provided by industry and made the following modifications to the NO_X emissions:

1. The line heaters were assumed to only operate during the colder months and the emissions were prorated accordingly over the "ozone season" months;

2. It was assumed that not all wells would require a wellhead compressor as noted by industry. Thus, these emissions were reduced by 25% to allow for this likelihood in the production stage emissions;

3. The drilling and fracturing engine emissions were reduced to account for two possible conditions during the timeframes when the peak number of well would be drilled (as explained below). First, industry noted in the 3/16/10 information report that there will be limits on the number of engines available for drilling and fracturing due to the ongoing gas drilling in other shale plays. In addition, industry expects certain turnover of the older engines during this time span. In this analysis we are assuming that such a turnover would also be necessary in order for industry to demonstrate compliance with the 1-hour NO_2 ambient standard. Thus, the NO_X emissions are reduced from both drilling and fracturing engines by 25% as representing a likely minimum reduction scenario. It should be noted that in these latter calculations, it is assumed that Tier 4 engines would replace the tier 2 engines, the latter engines being assumed in industry's calculations of NO_X and VOC emissions in the 3/16/10 information report. Since for the fracturing engines the Tier 4 emission limit is only reduced by 40% from the Tier 2 limit, this factor was also incorporated in the NO_X emissions calculations. That is, account is taken of the fact that NO_X emissions from fracturing engines will still be contributing a significant portion to the non-road engines total emissions; and

4. No change is made to the flaring emissions since it is assumed that the flaring within the operational limitations described in the SGEIS may still be necessary to test the gas wells.

VOC emissions are essentially dominated by the glycol dehydrator emissions, with small contributions from the engines and very limited duration venting emissions pursuant to the permit restrictions discussed in the SGEIS. Since these latter emissions are relatively small and there is no information on whether fewer dehydrators would be used, no change was made to the VOC emissions for this scenario. It is also expected that any such emissions changes would not significantly alter the ozone impact results due to the lower overall VOC emissions and their contribution to ozone formation. Finally, no changes were made to the truck traffic emissions calculated from the weighted average VMT provided by industry.

Total estimated emissions for the shale area are shown in Table 1 for these two scenarios. For the VOC emissions, the drilling, fracturing and venting emissions were combined to simplify internal modeling assignments since these represent small fractions each of the total VOC emissions.

Table 1. Total Well Pad and Truck Traffic Emissions for Peak Number of Wells in the Shale Area.

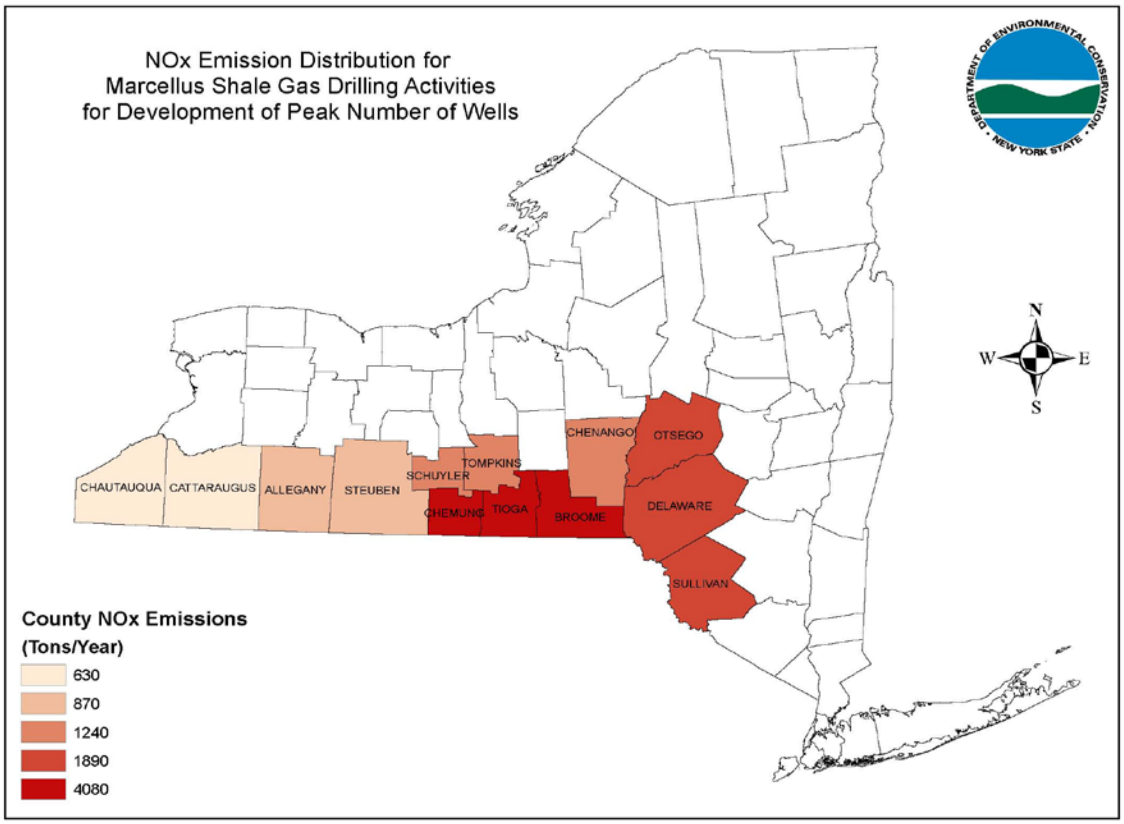
Activity	Total NO_X Emissions (tpy)		Total VOC Emissions (tpy)
	Peak Emissions Case	Limited Emissions Case	
Drilling	8785	6589	1296
Fracturing-NO_X/Venting-VOC	3235	2750	
Flaring	3013	3013	
Production	9274	5877	5974
Motor Vehicle Traffic	687	687	70

Using the percentages defined above from the Socio-economic Impact Analysis, the fractions of the total emissions were then allocated to each county as indicated in Table 2. The distribution of NO_X emissions is depicted in Figure 1 for the well pad activities. A similar distribution holds for VOC emissions. The higher emissions appear along the south central region where shale thickness is the largest.

Table 2. Fraction of Total Emissions of Well Pad Activities Assigned to Each County.

County	Fraction
Broome	0.1667
Chemung	0.1667
Tioga	0.1667
Delaware	0.0767
Otsego	0.0767
Sullivan	0.0767
Cattaraugus	0.0250
Chautauqua	0.0250
Allegany	0.0350
Steuben	0.0350
Tompkins	0.0500
Chenango	0.0500
Schuyler	0.0500

Figure 1. County Level Distribution of NO_X Emissions for Peak Emission Scenario for Well Pad Activities.



2.2 SMOKE Processing

Spatial and temporal allocation, as well as chemical speciation of emissions in SMOKE is largely accomplished using source classification codes (SCC). In order to process the emissions associated with gas drilling, SCC codes were assigned to more accurately represent drilling activities. This was possible since the source types for well drilling activities and the type of fuel these will use are known. For example, it is known that drilling and fracturing engines are internal combustion engines and will essentially use diesel fuel. This makes it possible to assign a higher level of association in the SCC assignment than at the "default" categories which would be otherwise used in SMOKE. In addition, much of the well pad emissions occur due to the use of internal combustion engines burning diesel fuel or natural gas. Thus, the following SCC codes were assigned to the well pad activities.

Table 3. Source Classification Code (SCC) Assignments for Gas Drilling Activities. (Updated 2012)

Activity	Device	Fuel	SCC
Drilling	Drilling Engine	Diesel	2102004000
Fracturing	Fracturing Engine	Diesel	2102004000
Flaring	Flare	Natural Gas	2310021500
Production	Line Heater/Gas Compressor Engine	Natural Gas	2102006002
On-road Truck Emissions	Primarily Diesel with some Gasoline Trucks	Diesel/Gasoline	2230070000

Applying the fractions from Table 2 to the total shale emission estimates in Table 1, county total emissions by SCC code were calculated as shown in Table 4. The VOC emissions in the "Drilling and Fracturing" column include the venting emissions from Table 1. These emissions represent the peak well drilling emissions scenario calculated from the ALL-IOGA-NY information report. The corresponding allocations for the alternative limited emissions scenario representative of likely conditions in the future case are not presented in the table, but were proportionately assigned the same way as for the peak emission scenario using the fractions in Table 2.

Table 4. County Total SCC Level Emission Estimates for Peak Well Pad Activity under **Peak Emissions Scenario.**

	Drilling & Fracturing SCC-2102004000		**Flaring** SCC-2310021500	**Production** SCC- 2102006002	
	NO_X	VOC	NO_X	NO_X	VOC
Broome	2003.7	216.0	502.3	1546.0	995.9
Chemung	2003.7	216.0	502.3	1546.0	995.9
Tioga	2003.7	216.0	502.3	1546.0	995.9
Delaware	921.9	99.4	231.1	711.3	458.2
Otsego	921.9	99.4	231.1	711.3	458.2
Sullivan	921.9	99.4	231.1	711.3	458.2
Cattaraugus	300.5	32.4	75.3	231.9	149.4
Chautauqua	300.5	32.4	75.3	231.9	149.4
Allegany	420.7	45.4	105.5	324.6	209.1
Steuben	420.7	45.4	105.5	324.6	209.1
Tompkins	601.0	64.8	150.7	463.7	298.7
Chenango	601.0	64.8	150.7	463.7	298.7
Schuyler	601.0	64.8	150.7	463.7	298.7

As part of New York's SIP development process, MOVES-based motor vehicle emissions were available for each county in the Marcellus Shale area. These emissions were generated by executing annual county-level MOVES runs using the most recently developed input data for 2007. A second set of runs were then performed using the same inputs, but increasing the emissions by the additional truck traffic VMT uniformly over the Marcellus Shale counties based on the industry provided traffic information. The difference in county-level NO_X and VOC emissions is attributed to increased truck traffic associated with drilling activities. The overall increase in emissions is indicated in the SGEIS to be 687 tons per year for NO_X and 70 tons per year for VOC. This is an average of 20 to 25 tpy NO_X and about 2.5 tpy VOC for each county in the drilling area.

2.3 Model Spatial Allocation of Well Pad Emissions

When emission inventories are processed through SMOKE, these are spatially allocated to individual grid cells for modeling purposes based on their assigned SCC code. The SCC codes are, in turn, linked to gridding surrogates, which represent the fraction of emissions for a particular activity in an individual grid cell. For example, the gridding surrogate of roadway miles would be used to locate emissions from motor vehicles, as it is assumed that driving activity would only occur on roadways and the emissions assigned to the grid cell would be proportional to the relative amount of roadway miles in that grid cell.

The surrogate code to SCC cross reference file used by SMOKE is developed by EPA at the national level. Since the SGEIS has identified areas in the Marcellus Shale where gas drilling would be prohibited (state parks, Primary Aquifers and surface water drinking supply watersheds), this cross reference file was overridden to avoid the possibility of placing emissions in these sensitive areas. Therefore, customized spatial allocation was used to place these emissions in model grid cells that did not contain any of these features or where these were minimally present. Although there are further distance restrictions from certain water bodies as identified in the SGEIS, this level of refinement was not made to the specific grids chosen for the modeling since such effects would be inconsequential to the projected ozone levels. Thus, this simplification is appropriate for the current purposes. Mobile source emissions were allocated using the typical gridding surrogate of roadways in SMOKE.

Figure 2 shows areas of the state where gas drilling would be prohibited and Figure 3 shows the selected grid cells where emissions were placed in order to avoid these general areas. These restrictions were applied to the well pad activities summarized in Table 4, except for the traffic emissions. As noted previously, the truck traffic emissions were allocated to each of the grid cells in the Marcellus Shale in accordance with the gridding surrogates in the SMOKE emissions processor.

Figure 2. Prohibited Gas Drilling Areas in the Marcellus Shale.

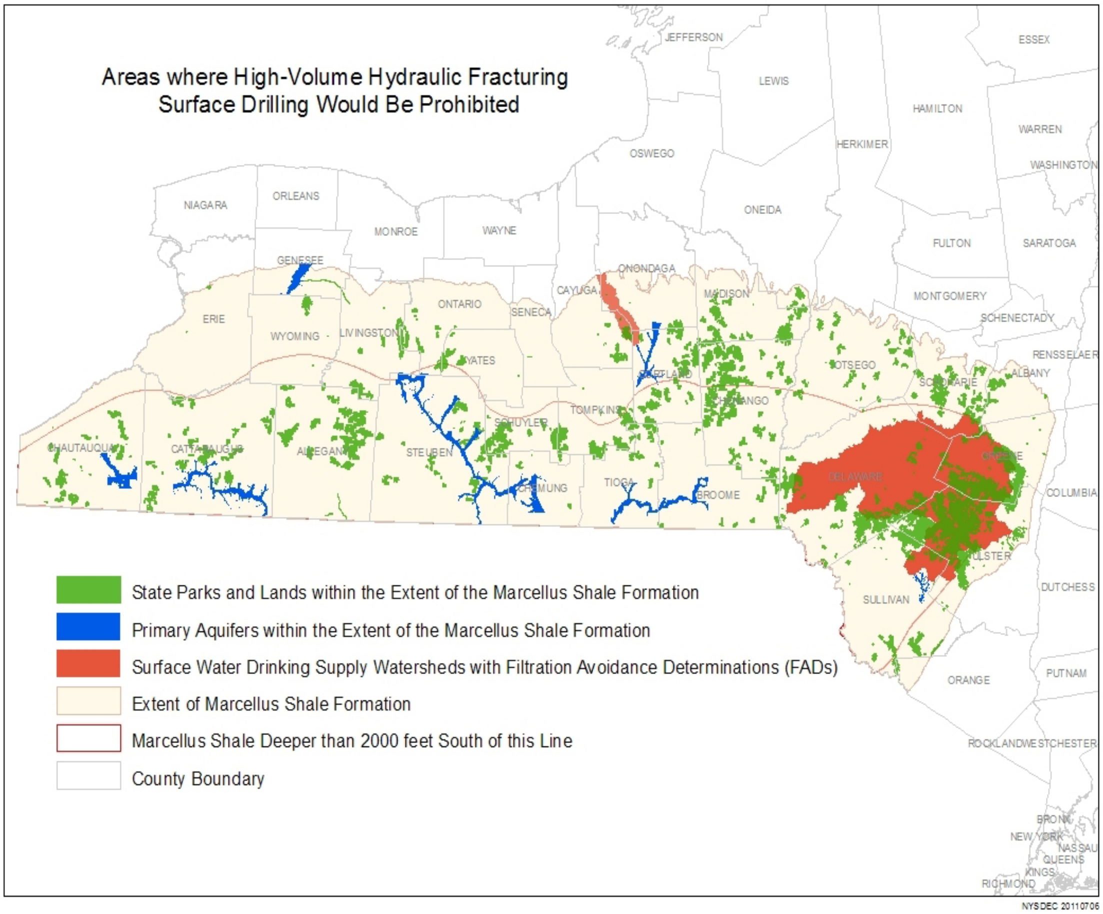
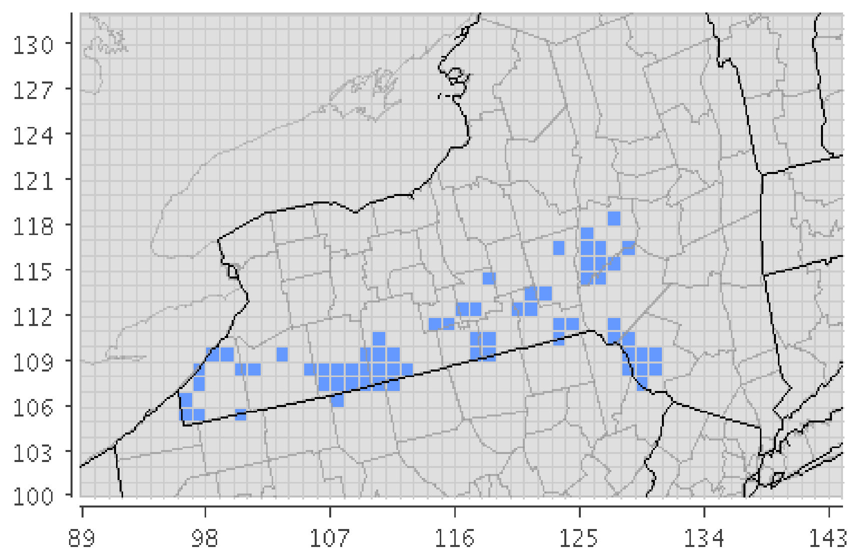


Figure 3. Modeling Grid Cells Selected to Locate Gas Drilling Emissions for the Well Pad Activities



2.4 Temporal Allocation

As with spatial allocation, SMOKE temporally allocates annual emissions to hourly values based on temporal profiles related to SCC codes. For this modeling exercise, it was assumed that drilling activities would occur during all months of the year, on weekdays and weekends, as well as all hours of the day. There is no indication from industry of any temporal restrictions on gas drilling. Therefore, monthly, weekly and hourly temporal allocation profiles were selected such that emissions from gas drilling would be evenly spread out over all hours of the year.

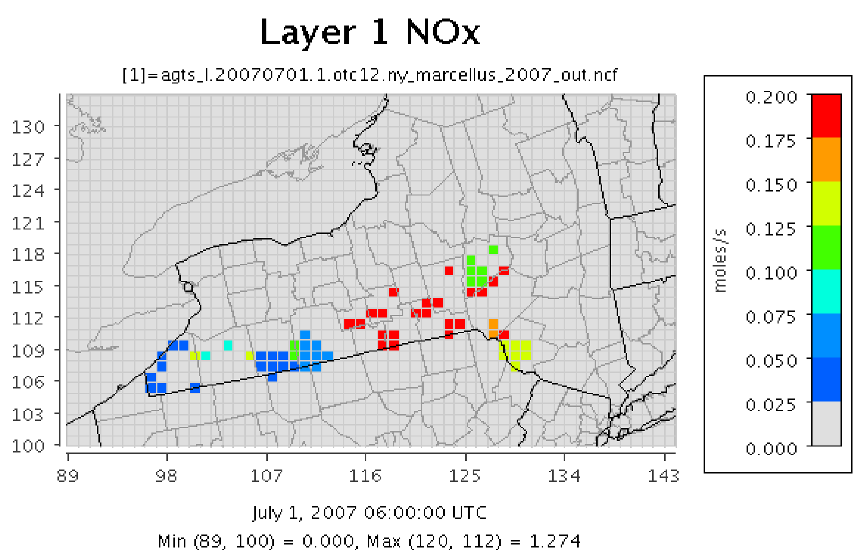
2.5 Chemical Speciation

Emission inventories are typically prepared for criteria pollutants which then must be chemically speciated to air quality model-ready species (i.e., $NO_X \rightarrow NO + NO2$; VOC → CB5 Species). This is again accomplished by applying speciation profiles to criteria pollutants based on source characteristics. Most of the well pad emissions come from natural gas or diesel powered internal combustion engines and, thus, the latest SMOKE default speciation profiles available for these SCC codes were utilized.

2.6 Results of Emission Processing

SMOKE was run for the entire year to generate daily files of hourly, gridded and chemically speciated model-ready inputs for the CMAQ air quality model. Figure 4 shows an example of the hourly NO_X emission values for July 1, 2007. As can be seen from this figure and Figure 1, NO_X emissions are highest where the shale thickness is greatest, but also are influenced by the number of grid cells in the available drilling areas.

Figure 4. Example Hourly NO_X Emissions Allocated in SMOKE for 7/1/07 Meteorological Data



3.0 Ozone Modeling Methodologies

Ozone concentrations were predicted using the state of-the-science EPA Community Multiscale Air Quality (CMAQ) model. Since ozone is formed from its precursors, NO_X and VOC, with chemical reactions under conducive meteorological condition days (i.e. high solar radiation), the simulation was limited to the "ozone season" which runs from April 15 through October 30. The model estimated the 8-hour ozone air quality impacts in accord with the averaging time of the national ambient air quality standard (NAAQS). Three modeling cases were performed to determine the incremental impacts of the estimated emission from the Marcellus Shale gas drill activities described in Section 2.0: i) impacts of the industry projected maximum additional emissions under peak well drilling activities relative to the baseline Ozone Transport Commission (OTC) 2007 emissions inventory platform used in modeling assessments in support of New York's Ozone SIP work, ii) the same Marcellus Shale emissions, except impacts relative to a projected 2020 emissions inventory scenario generated by OTC, and iii) a limited emissions scenario described in Section 2.0 relative to the 2020 emissions inventory scenario. The existing and future inventories are described further below.

The total ozone modeling system includes three major components: regional emission inventory modeling, meteorology modeling, and the ozone air quality modeling. The emission modeling prepares the emission data inputs, the meteorology modeling creates the meteorological data necessary for determining transport and dispersion, which are then input to CMAQ to calculate ozone impacts. The following subsections provide a brief description of each of these three components.

3.1 Baseline and Future Emissions Inventories

The inventory of the additional emissions associated with the peak number of wells to be drilled per year in the Marcellus Shale area were described in Section 2.0. In order to determine the consequence of these emissions on ozone levels, it is necessary to consider these emissions in concert with an inventory of either existing or future projected overall emissions of the precursors from all potential significant sources on a regional level. This is necessary because ozone, unlike most other criteria pollutants, is secondarily formed in the atmosphere as a result of a series of complex chemical reactions involving both anthropogenic and biogenic emissions under the influence of conducive meteorological conditions such as high solar radiation.

Thus, for the "baseline" situation, use is made of the detailed OTC 2007 Level 2 modeling emission inventory and platform which forms the basis of New York's current SIP modeling work. The base case 2007 Level 2 emissions include the following source types in the modeling region electric generating unit (EGU) point, Non-EGU point, on road mobile, non-road, area and biogenic emissions developed by The Mid-Atlantic Regional Air Management Association (MARAMA) for the year 2007 within the Mid-Atlantic/Northeast Visibility Union (MANE-VU) states. For the other Regional Planning Organizations (RPOs) in the modeling domain, the EPA NEI2008 inventories were used. A full description of the 2007 Level 2 emission inventory can be found at MARAMA's webpage.[4]

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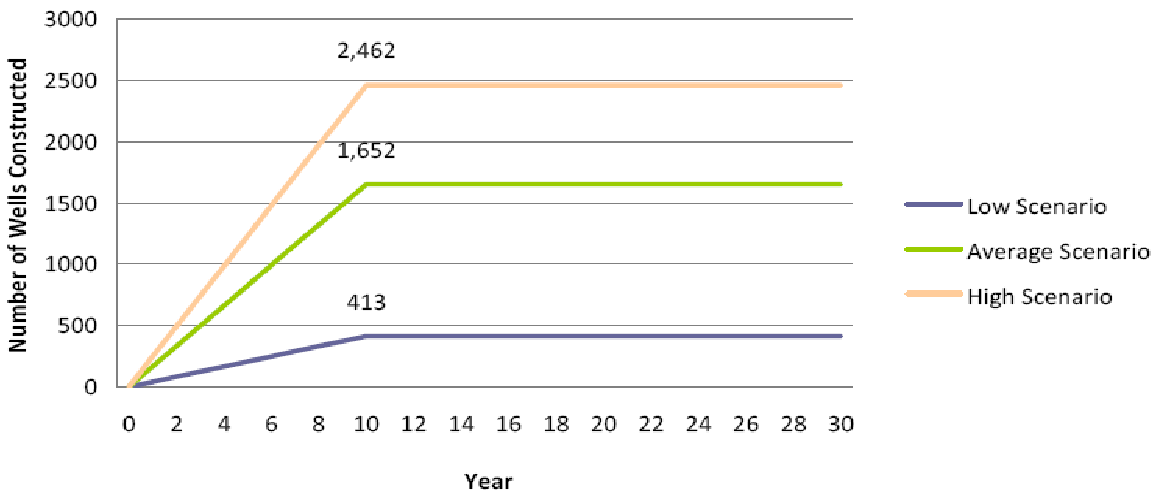
[4] See: http://www.marama.org/technical-center/emissions-inventory/2007-emissions-and-projections/2007-emissions-inventory

In addition to this base case, an additional future inventory scenario has been used to determine the impacts of gas drilling activities during the peak well development timeframe. According to Section 4 of the Socio-economic Impact Analysis, it is expected that gas development will proceed at a steady pace after drilling starts and will achieve the peak level of wells drilled per year in about ten years (see "Figure 4-1" repeated below from the study).

Annual Number of Wells Completed in New York State Under Each Development Scenario



Therefore, in order to determine the ozone impacts during this expected peak well development timeframe, a future emissions inventory was also modeled. As part of the OTC air quality modeling efforts by northeast state for future SIP planning activities, a 2020 "scenario 4" inventory was readily available and was used in this assessment. The 2020 projected inventory includes the following modifications by OTC to the 2007 inventory:

1) a domain-wide NO_X reduction of 65% from EGUs due to mainly the Cross State Air Pollution Rule (CSAPR);

2) a domain-wide NO_X reduction of 49% from non-road engines;

3) a domain-wide NO_X reduction of 70% from on-road mobile source turnover;

4) a domain-wide VOC reduction of 30% from EGUs and on-road mobile sources; and

5) an extra 5% NO_X reduction in the Ozone Transport Region emissions.

In this analysis, the additional Marcellus Shale drilling activity emissions were added to the OTC base 2007 Level 2 emission case and the 2020 "scenario 4" case and CMAQ was then applied to perform the simulation for the ozone season using the "baseline year" 2007 meteorological data. The incremental impacts due to the gas development activities alone were then determined relative to these two regional emissions scenarios as the difference in impacts in these inventories with and without the additional Marcellus Shale emissions. These incremental impacts are then use to determine the relative influence of the additional emissions.

3.2 Meteorological Processor

In order to simulate the transport and dispersion of ozone precursor emissions from the multitude of sources over the whole modeling domain, a set of meteorological parameters which affect these processes have to be developed from observations and simulation of atmospheric dynamics. This was accomplished for the base year of 2007 using the Weather Research Forecast (WRF) version 3.1 (Skamarock et al. 2008) model developed by the National Center of Atmospheric Research (NCAR). WRF is a state-of-the-art mesoscale numerical weather prediction system designed to serve both operational weather forecasting and atmospheric research needs. It has become widely used in the air quality modeling community to create meteorological fields used to drive air quality models. The WRF modeling was performed on two "nested" grids with 36 km covering the whole US continent and 12 km grids covering the eastern half of the US. Throughout the model simulations, WRF was "nudged" towards reanalysis of the meteorological fields (such as temperature, humidity, and wind) developed by the National Center for Environmental Prediction (NCEP) using four-dimensional data assimilation in order to reduce the potential bias caused by numerical simulations. The details of the 2007 WRF simulations and assessment of the simulations are available in the following two documents (Baker et al, 2010 and Sistla et al, 2010).

3.3 CMAQ Ozone Model

Ozone air quality impact simulations were performed with the CMAQ model, version 4.71 (Byun and Schere, 2006) developed by EPA. The model is applied with the carbon-bond 5 (CB-05) gas phase chemistry mechanism which accounts for 156 reactions involving 56 species (Yarwood, et.al. 2005). CMAQ is an Eulerian grid model that contains a set of dynamic equations to represent the transport, diffusion, deposition, and chemical reaction of the pollutants in the atmosphere. To solve the dynamic equations, both initial and boundary conditions are required which served as the initial time condition and influx of the pollutants into the modeling domain, respectively. CMAQ was run with a 12 km grid domain covering the Eastern half of US using climatological time invariant boundary conditions. CMAQ predicts hourly ozone concentrations at each of the modeled grid cells used in the simulation and then determines the corresponding 8-hour running averages at the grid cells. These are then used in order to calculate the overall maxima during the ozone season. In this analysis, the incremental ozone impacts due to the additional precursor emissions from the gas drilling activities were calculated to determine their potential consequence on the local and regional air quality.

4.0 Results of the Modeling Simulations

Ozone modeling for the two gas development scenarios was conducted in conjunction with a "current" baseline inventory and a future regional emission inventory cases using the input data and assumptions described in the previous sections. The main purpose of this modeling exercise was to determine whether the future peak level of well development in New York could pose a potential concern with Ozone levels such that future mitigation measures would need to be considered in New York's SIP planning work in association with EPA Region 2. To that end, the results are cast in terms of a range of potential incremental ozone impacts from emissions associated with future gas development in New York. These results are also contingent on the realization of the projected emissions and its future timeframes, as well as on the projected future emissions scenario which assumes expected reductions from certain source sectors in the 2020 timeframe. Thus, it is important that the results presented be viewed in their totality and are not misrepresented with respect to the Department's overall approach to use of the modeling exercise.

The results of CMAQ ozone predictions are presented first for the worst case emissions developed using industry's projections of the peak number of wells per year (2462). These results are presented relative to the "baseline" 2007 and future 2020 emission scenario cases to determine the range of the expected impacts. Guided by these results, the limited emissions scenario case, wherein reductions in well pad emissions due to more likely conditions associated with the future timeframes of peak well development conditions, are presented next relative to the future 2020 scenario. The additional modeling which accounts for estimated emissions due to compressor engines necessary to process the amount of gas during the peak well development timeframe are presented in Section 5.0.

4.1 Ozone Impacts under the Peak Emissions Scenario.

It is not certain that the projected emissions associated with the peak number of future well development depicted in Figure 4-1 of the Socio-Economic Impact Analysis would take about ten years to be achieved from the startup of well drilling. Thus, the increased emissions associated with these activities were modeled relative to both a 'baseline" 2007 case as representative of "current' conditions, as well as relative to the future 2020 scenario 4 emissions inventory reflecting conditions more likely to be used for the future New York ozone SIP work.

The increased emissions due to the gas development in the New York's portion of Marcellus Shale were added to the "baseline 2007" emissions and the CMAQ model used to predict daily maximum 8-hour impacts over the full grid cell and for the ozone season meteorological conditions. The model was also used to perform the same analysis for the "baseline" 2007 inventory only and then the difference in these projections was calculated to be the incremental impacts associated with the gas development emissions during peak well drilling conditions. The same process was followed with the future 2020 scenario. The results were then reviewed and presented both spatially and temporally to describe the consequent impacts.

To begin with, the incremental impacts of the daily maximum 8-hour ozone were found to increase and decrease when gas development emissions were added, with the latter occurring during periods of low ozone formation and due to the "scavenging" or titration effects of NO_X. That is, NO_X emissions have a tendency to initially reduce ozone concentrations at the local level. Examples of these effects are depicted in Figure 5 for a day (8/2/07) in which high ozone formation occurred and in figure 6 for another day (8/21/07) when the meteorological conditions were not conducive for photochemical reaction to form ozone. The results are presented for both the "baseline" 2007 scenario (A) and the 2020 future scenario (B). It is seen that the incremental ozone levels are confined on both modeled days to the general area of projected well drilling activity emissions depicted in Figure 1, with little impacts in the higher ozone regions along the coastal areas and, in particular, the New York City metropolitan area. The increased impacts are up to 9ppb while the reduced impacts (note the negative scale in figure 6) are up to 5 ppb on the respective days. One reason for the relatively "localized' maxima is the fact that the sources modeled have relatively low stacks and are "assigned" to the lowest layer of the CMAQ model (from the surface to 40m) in which these are transported and dispersed.

The overall daily maximum 8-hour impacts during the whole ozone season for the two emission inventories are depicted in Figure 7. Although the areal extent of the incremental increased impacts in ozone level has magnified relative to the single day depicted in figure 5, the higher ozone increases are still confined mainly to the areas where the drilling well activities are expected to occur. It is also seen that the maximum incremental impacts for the 2020 emissions scenario are slightly higher than for the 2007 inventory. This is mainly due to the fact that these impacts are calculated by taking a differences between the inventories with and without the Marcellus Shale activities, coupled with the fact that the future 2020 inventory and consequent total impacts are projected to be significantly lower than those for the 2007 inventory. The maximum projected impacts over the area are about 6 to10 ppb, with the higher impacts covering a larger area in the case of the 2020 future inventory.

In order to get an understanding of the level of increased impacts over the total area of the projected increases indicated in figure 7, the average ozone impacts over the areas depicted in Figure 7 were also calculated. Figure 8 is a "time series" of the average daily maximum 8-hour incremental ozone levels for the total areas impacted by the Marcellus Shale emissions, plotted for each of the ozone season days. The averages are presented for both the baseline 2007 and future 2020 regional inventories. In terms of the average ozone levels projected for the total affected area, the impacts are much lower than the "localized" maxima, with a maximum of about 1.2ppb. This is expected given the relatively small areas over which the higher impacts are projected to occur. These calculated averages, however, are not to be used to draw conclusions on the effects of the Marcellus Shale emissions with respect to future ozone assessments to be performed for SIP purposes which will rely on the form of the standard at the upper percentile of the 8-hour impacts.

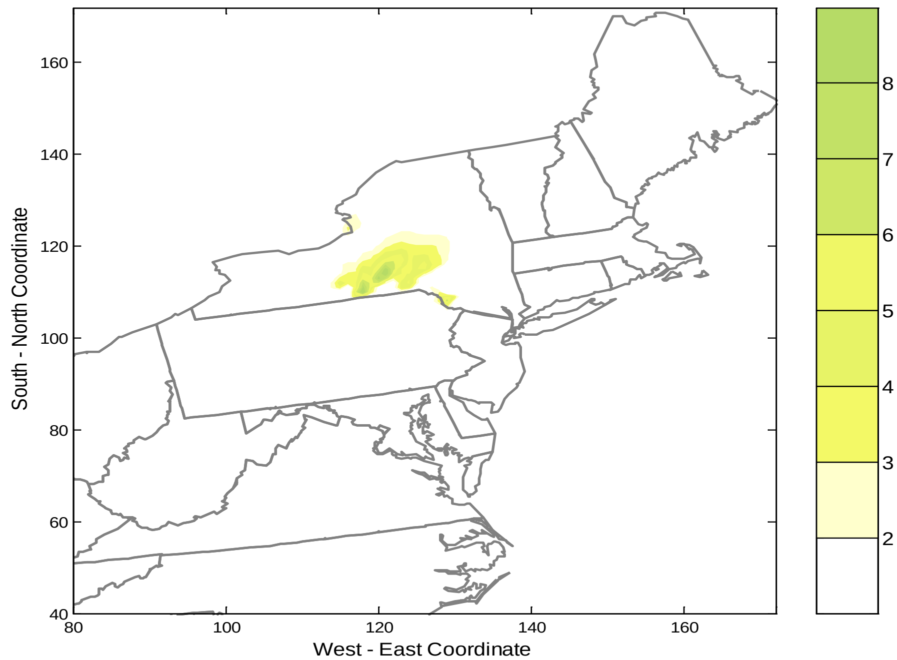
The projected incremental daily maximum 8-hour ozone impacts shown in figure 7 during peak well development timeframes are at levels which could have a potential to be significant. However, these predicted impacts alone do not form the basis of determinations of standards compliance for ozone. These projections have to be viewed within the context of how these are to be used in SIP demonstrations of future ozone standards compliance. Unlike the "permitting" modeling analyses where projections are added to background levels, such as those performed in Section 6.5.2 of the SGEIS, regional ozone modeling and standards compliance must follow established EPA guidance.[5] These established procedures to perform projected compliance calculations use the existing "design" concentrations at monitors and a relative response factor (RRF) approach to account for the conservative nature of the modeled projections. These procedures rely heavily on ozone predictions at the monitor locations. To that end, the incremental maximum 8-hour ozone levels during the whole season and for the "baseline" 2007 and 2020 future inventories are plotted in figure 9 at the existing ozone monitor within the Ozone Transport Region (OTR). It is seen that there are a limited number of monitors at which the

[5] See http://www.epa.gov/scram001/guidance_sip.htm

incremental impacts are relatively high, with only the Camp Georgetown monitor showing maximum impacts from 6 to 9ppb. Impacts at essentially all other monitors are less than 4 ppb.

Figure 5. Maximum Incremental 8-Hour Ozone Concentration for August 2, 2007 Meteorology (**high Ozone day**) due to Increased Emissions including Marcellus Shale Activities Minus (A) Impacts with 2007 Baseline Emissions and (B) 2020 Future Year Project Emissions.

(A)



(B)

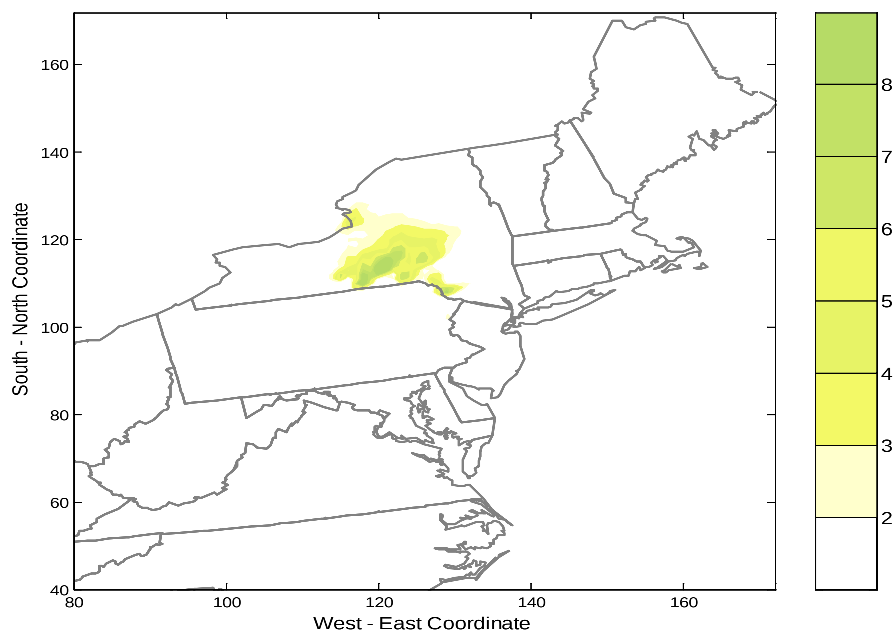
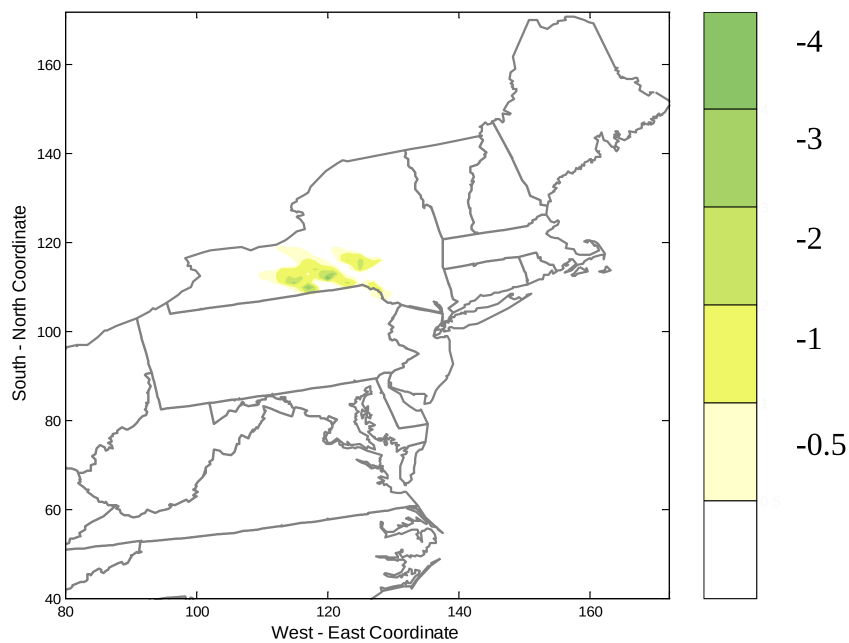


Figure 6. Maximum Incremental 8-Hour Ozone Concentration for August 21, 2007 Meteorology (**low Ozone day**) due to Increased Emissions Including Marcellus Shale Activities Minus (A) Impacts with 2007 Baseline Emission and (B) 2020 Future Year Project Emission.

(A)



(B)

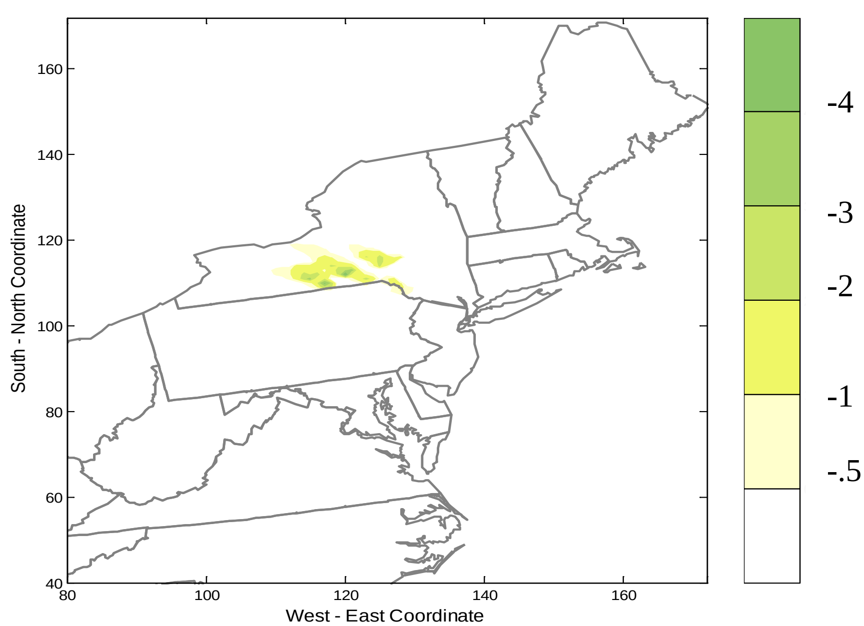
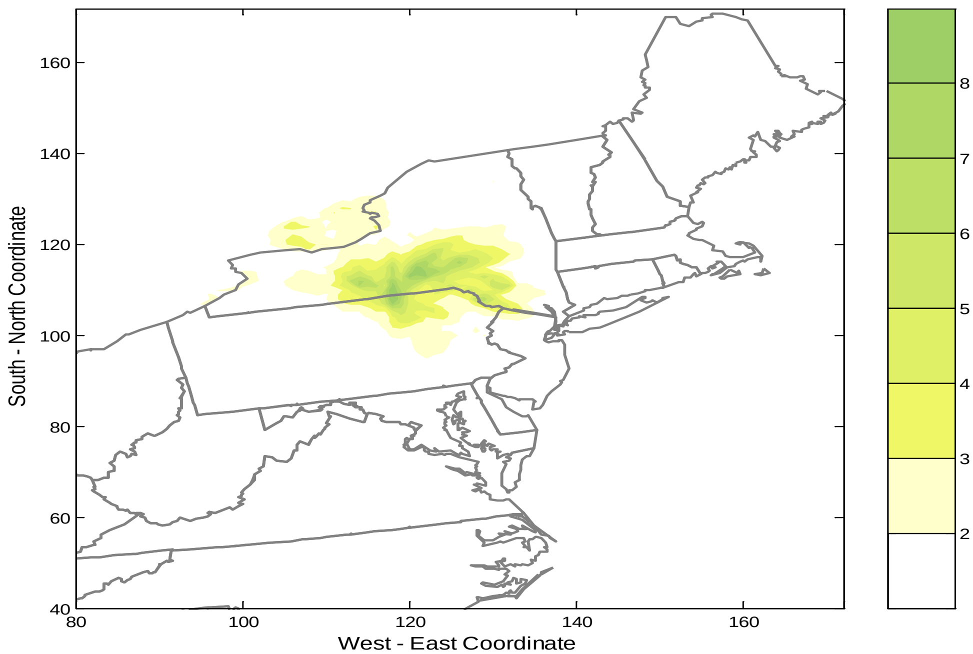


Figure 7. Incremental Daily Maximum 8-Hour Ozone Concentration for the Complete Ozone Season for the Additional Marcellus Shale Activities Under **Peak Emissions Scenario** and (A) Impacts with 2007 Baseline Emission and (B) 2020 Future Year Project Emission.

(A)



(B)

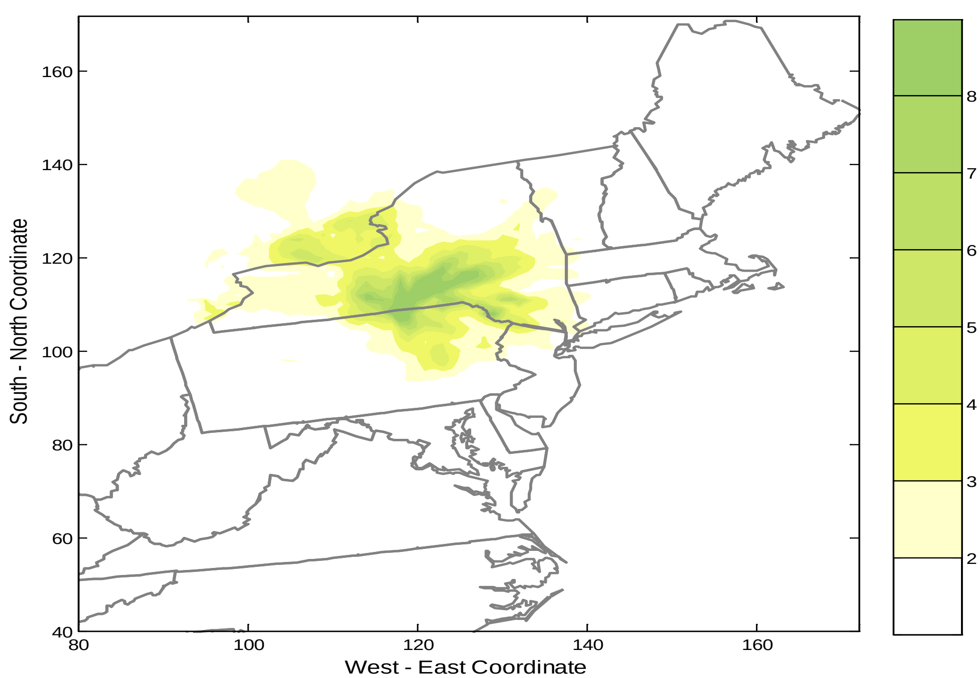
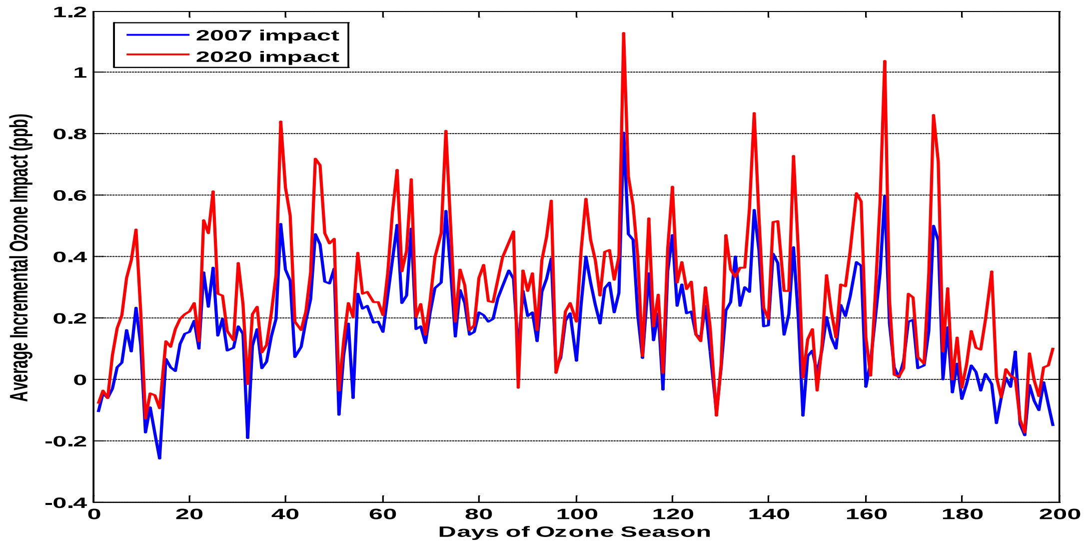


Figure 8. Time Series of the **Average** Modeling Maximum Daily 8-Hour Incremental Ozone in the Area Impacted by Marcellus Shale Drilling Activities for the Two Regional Inventory Cases (day 1 is April 15 while day 198 is October 30).

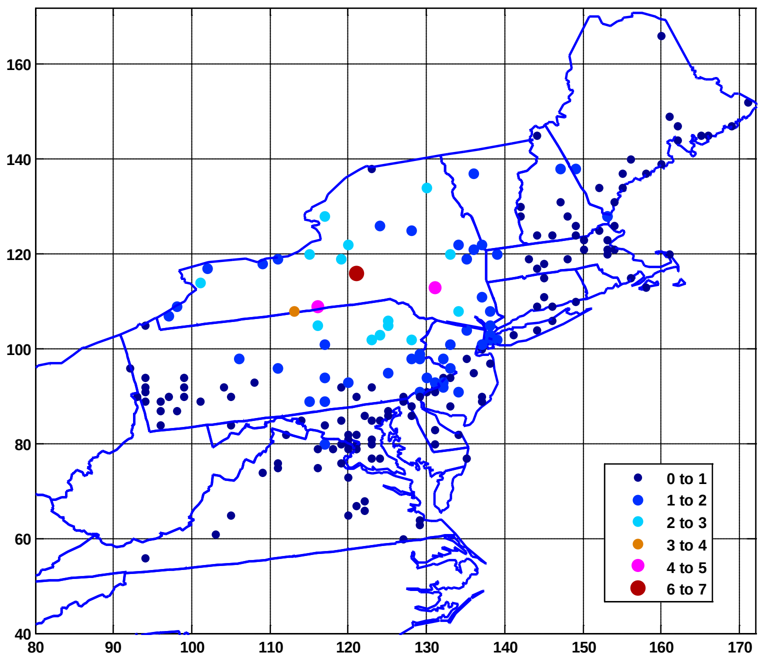


Coupled with the projected levels at the monitor locations, it is also very important to consider whether the higher incremental impacts due to well drilling activities are associated with times and locations of higher total predicted ozone levels. To that end, all the projected incremental daily maximum 8-hour ozone levels were plotted against the corresponding predicted ozone levels at the OTR monitors. The results are presented in Figure 10 for the two regional inventories. In these plots the incremental impacts are coupled with the total modeled impacts at the particular OTR monitor sites. The CMAQ modeling results indicate that the higher incremental impacts and total ozone levels essentially occur on the same days which are conducive to ozone formation. Thus, Figure 10 indicates that the higher incremental impacts have a tendency to occur at times and locations when the overall predicted concentrations are relatively lower for both inventory scenarios (in the range of 30 to 50ppb).

This is because the higher predictions due to the Marcellus Shale emissions occur in areas of New York with relatively lower predicted and observed ozone levels. On the other hand, some of the incremental daily maximum 8-hour ozone impacts due to the drilling activities are predicted to occur at locations where the total ozone levels are predicted to be at or around the current standard of 75 ppb. These occur mainly in the New York metropolitan area and along the eastern coastline. The incremental impacts in these areas are in the range of 1 to 3ppb. Although these impacts might seem relatively low, these must be cast within the EPA compliance demonstration procedures to determine whether these would affect the standard compliance in the areas where the current standard is currently approached or exceeded or is projected to be exceeded.

Figure 9. Incremental Daily Maximum 8-Hour Ozone Impacts at Ozone Monitors within OTR for the Entire Ozone Season and for the 2007 Inventory **(A)** and the 2020 Inventory **(B)**.

(A)



(B)

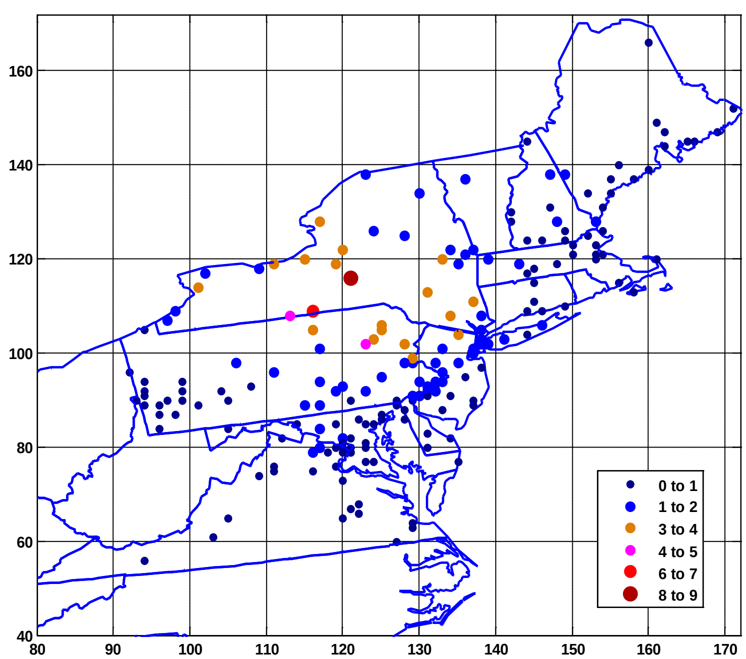
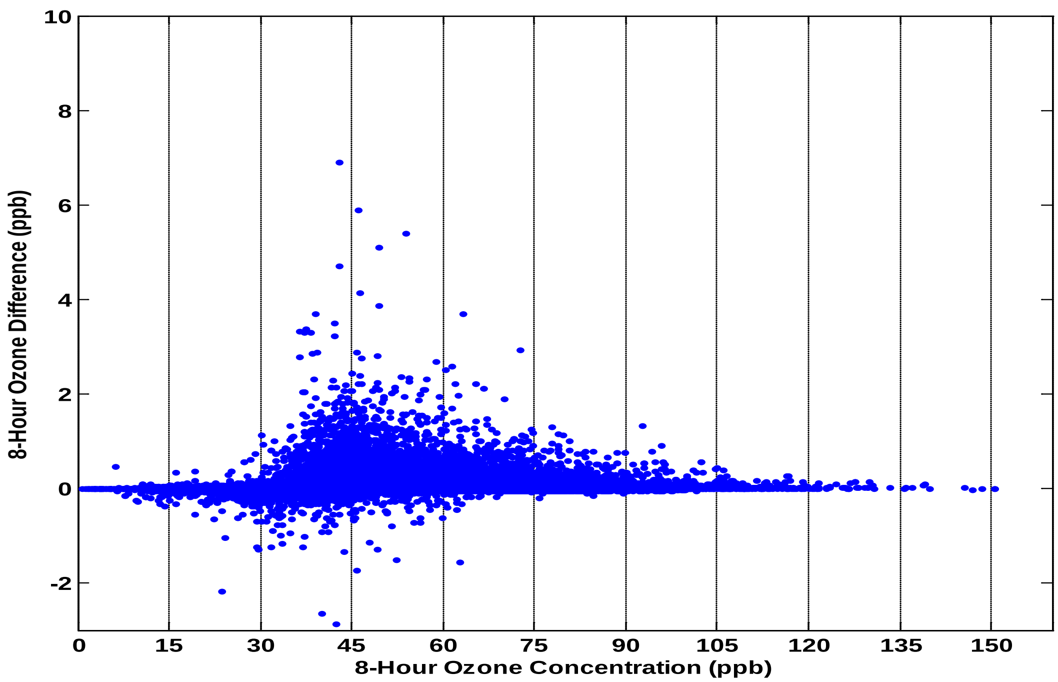
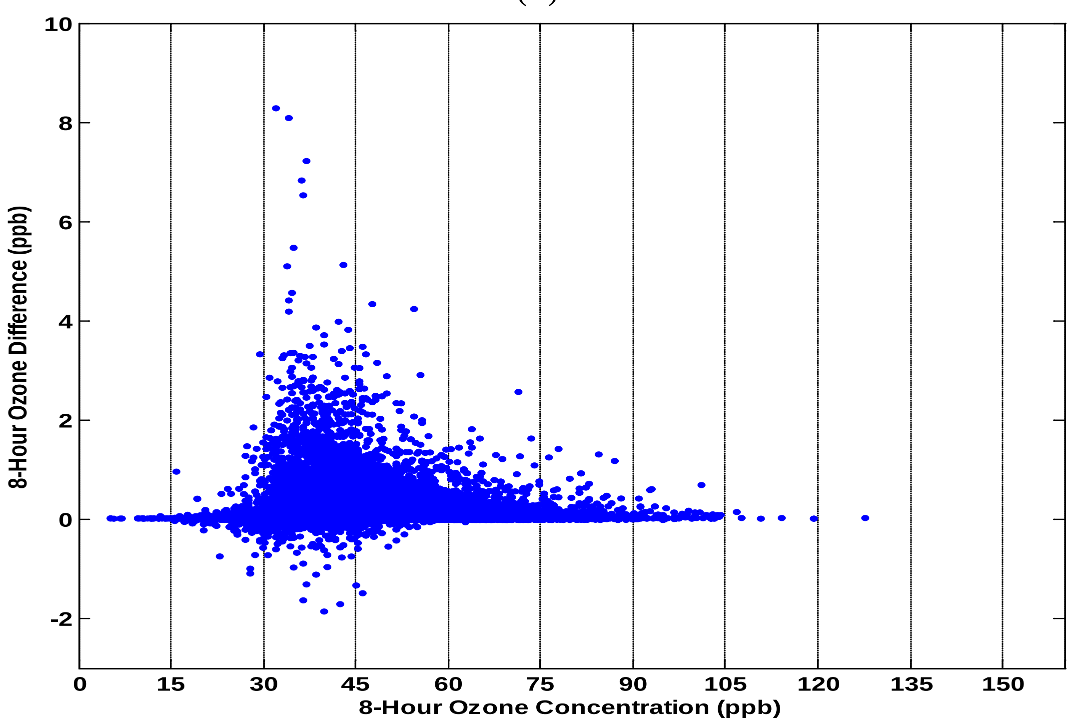


Figure 10. Incremental 8-Hour Ozone Impacts Versus Total Modeled 8-Hour Ozone at all Monitors within OTR with: **(A)** 2007 Baseline Emission Case, **(B)** Future 2020 Projected Emission Case.

(A)



(B)



Thus, it is critical to note that the incremental impacts and the projected total ozone levels cannot be used at this time to reach any conclusions on issues related to whether these incremental impacts will or will not result in standards compliance, for a number of reasons. First, there are specific EPA established calculation methodologies for ozone compliance demonstrations for future projections which must be performed to make such determinations for SIP purposes. However, it is premature to make such calculations at this time without a full understanding of: 1) how well the timeframes and levels of projected emissions from New York's portion of the well drilling activities as incorporated in this study will be actualized, 2) the potential future emissions expected from the full regional emissions associated with gas development, including those from neighboring states such as Pennsylvania and West Virginia, which have to be included in a final regional inventory to be relied upon by OTC states and EPA to make determinations. This inventory could differ from the 2020 inventory used in this analysis, and 3) the likely possibility that during the projected timeframes for gas development in New York and the SIP inventory development, EPA could act to revise the ozone standard.

The significant issue for item 1 which needs to be more fully explored is the level of emissions which are more likely to be representative of future gas development in the timeframes defined in the Socio-economic Impact Analysis. As discussed in Section 2.0, the peak emission projections for peak well development per year are likely an over prediction of future conditions due to the factors associated with the operational restrictions at the well pad and the non-road engine turnover which could occur in future years. To address this situation, the next section presents results of the alternative limited emissions scenario.

4.2 Ozone Impacts for the Limited Emissions Scenario.

The maximum projected emissions of NO_X assumed for the gas development during peak well development of 2462 wells per year were modified for this scenario to account for the expected limits on some of the production equipment (wellhead compressors and line heaters) and the future turnover of the older drilling and fracturing engines. Since limited amount of flaring will be allowed per well pad, no reduction was made to these emissions, although as gas lines are put in place, reduced emissions completions (i.e. green completion) could reduce the need for flaring. No reductions in VOC emissions were made in this scenario since these were mainly associated with glycol dehydrators, but for which no projected limitations were identified by industry. This limited emissions scenario should be viewed as the lower end emissions reductions relative to the worst case emissions and the likely conditions in the future if the well development was not to peak until ten years after it is initiated in New York.

Thus, the regional inventory which was used in conjunction with this scenario was limited to the future 2020 Scenario 4 from OTC as described the Section 2.0. This was deemed appropriate since the projected emissions assumptions used with future well development in New York under this limited emissions case would be realized only closer to the end of the approximate ten year timeframe to reach peak number of wells per year. In addition, the previous results for the peak emissions scenario indicated that the incremental impacts due to gas development are higher relative to this future scenario.

For the limited emissions scenario, not all of the results depicted in the peak emissions scenario need to be repeated. Figure 11 presents the incremental daily maximum 8-hour ozone impacts for the entire ozone season over the modeling grid. In comparison to the corresponding results in Figure 7(B), it is observed that the areal extent of the overall impacts, as well as the areas of the higher impacts, are significantly reduced. This is as expected since there is a significant reduction of approximately 25percent in NO_X emissions in this scenario versus the peak emission case. The corresponding incremental impacts at the OTR monitors are presented in Figure 12. Again, the areal extent and the larger impacts are reduced relative to the results for the peak emissions case in Figure 9(B). In particular, the maximum 8-hour ozone impacts in Figure 12 of 7ppb is about 77 percent of the 9ppb maximum in Figure 9(B), consistent with the reduced NO_X emissions. Furthermore, as in the case of the peak emissions scenario, the maxima for the limited emissions scenario occur at times and monitors where the total projected ozone levels for the 2020 emissions inventory are lower, as depicted in Figure 13. These impacts are now about 6ppb versus the 8ppb maximum for the peak emission case in figure 10(B). The incremental impacts associated with projected total ozone levels in the higher total ozone range of 60 to 75ppm are about 2ppb, reduced from the 3ppb maxima under the peak emissions case.

Figure 11. Incremental Daily Maximum 8-hour Ozone Concentration under the **Limited Emissions Scenario** for the Complete Ozone Season for the Additional Marcellus Shale Activities under the 2020 Future Year Project Emissions.

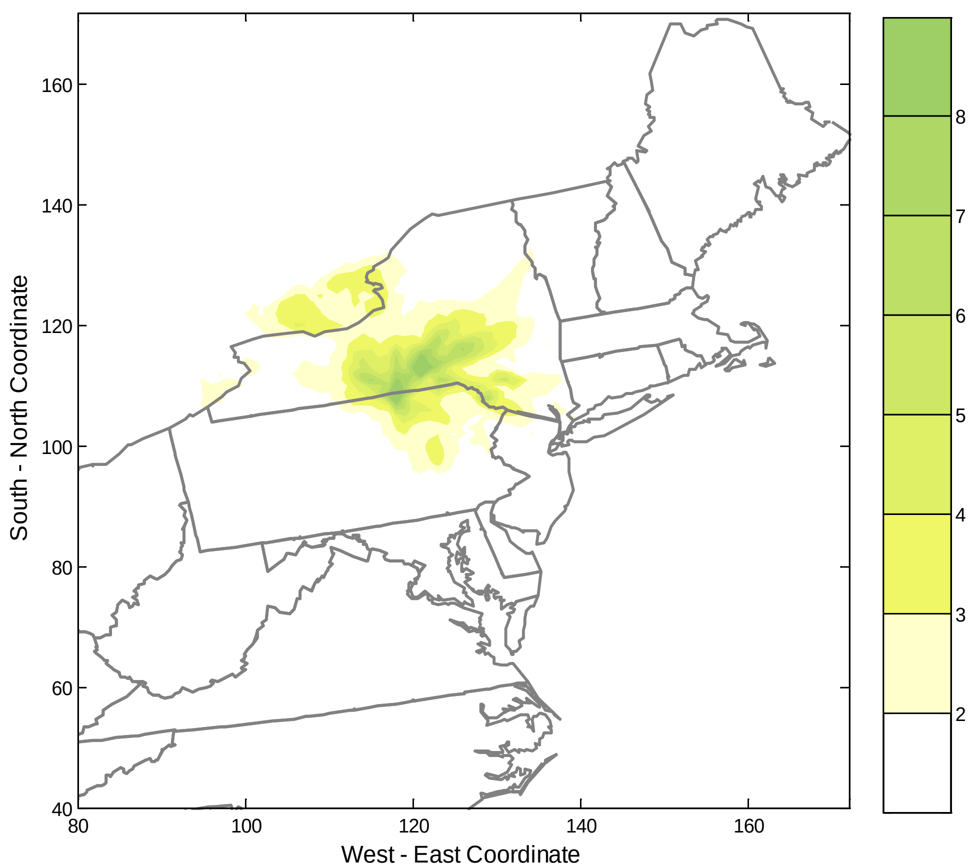


Figure 12. The Incremental Daily Maximum 8-Hour Impacts at Ozone Monitors within OTR for the **Limited Emissions Scenario** for the Ozone Season and for the 2020 Regional Inventory.

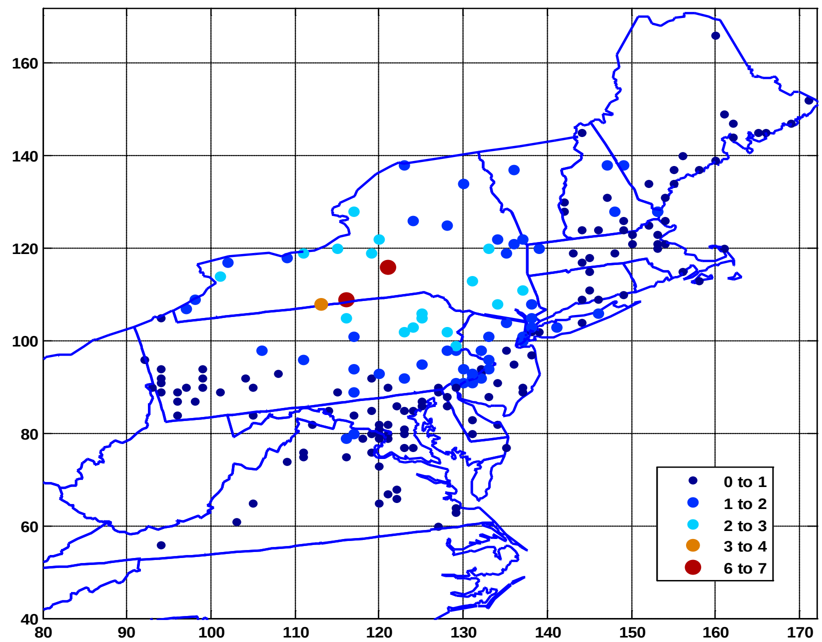
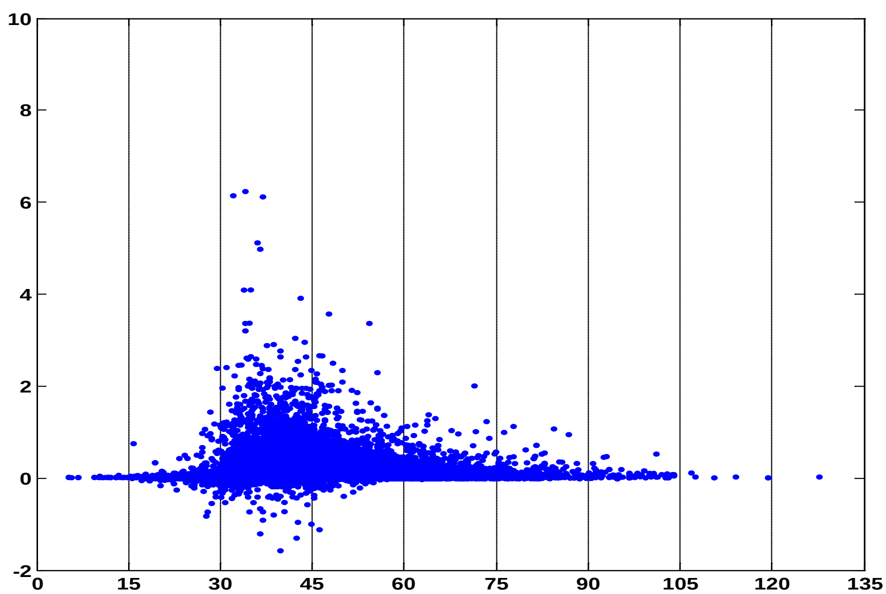


Figure 13. Incremental 8-Hour ozone impacts versus total modeled 8-Hour ozone at all monitors within OTR under the **limited emissions scenario** and with the future 2020 emission inventory.



5.0 <u>Impacts of Additional Compressor Station Emissions and the Marcellus Shale Limited Emissions Scenario.</u>

There are no projections of the number of compressor stations or processing plants which would be necessary to process the gas produced during the peak well development period described previously. It is possible that some of the existing stations could be used to a limited extent for this purpose, but it will be necessary to modify existing or to build new facilities in order to handle the projected amount of gas which is planned to be produced. The Department has already permitted some compressor stations and received applications for others along the border with Pennsylvania to process gas developed in the Marcellus Shale area of that state. Based on information in these permits and the Socio-economic Impact Analysis, it is possible to make a rough estimate of the number of compressor engines and associated emissions during the future peak well development time period. This information can then be used to determine the consequence of the additional increased ozone precursors due to the compressor facilities on projected incremental Ozone impacts previously discussed.

The next section presents the steps taken to estimate the potential NO_X and VOC emissions associated with the additional compressor stations using information from the Socio-Economic Impact Analysis and emission factors and rates from the ALL/IOGA responses to the Department's information request.[6] These factors and emission rates are also checked against similar information from a recently permitted compressor station or for which applications have been received in New York. Section 5.2 then presents the combined modeled incremental ozone impacts of the compressor stations and the limited emissions scenario relative to the 2020 future regional inventory. In addition, a preliminary assessment of total ozone levels for the 2020 future inventory case, with and without the Marcellus Shale emissions, are presented in Section 5.3 to allow a simple comparison of the regional effects of the additional emissions anticipated in future timeframes.

5.1 Emission Estimates for Compressor Engines.

To calculate the NO_X and VOC emissions from the potential number of engines which might be necessary to process the gas from the Marcellus Shale area during peak well development timeframes described in Section 2.0, the projected average amount of gas to be produced in the same timeframe was calculated. The gas production estimates for "high" and "low" conditions are provided in Section 4.1.3 of the Socio-economic Impact Analysis and in Section 5.16 of the Final SGEIS. For the current purposes, the gas estimates for the first ten years of production are used to calculate the weighted average gas production per well. The use of the ten year estimate also provides for a more appropriate value due to the considerable decrease in gas production after the ten years which could underestimate the average gas production value and the corresponding number of engines required. The projected "high" and "low" gas production rates are repeated below from the SGEIS Section 5.16:

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[6] ALL/IOGA Responses to DEC Information Request, dated October 14, 2009 which contains the report : *Horizontally Drilled/High-Volume Hydraulically Fractured Wells Air Emissions Data*, dated 8/26/09.

High Estimate:
Year 1: initial production rate of 8.72 million cubic feet per day (Mmcf/d), declining to 3.49Mmcf/d.
Years 2 to 4: initial production rate of 3.49Mmcf/d, declining to 1.25 Mmcf/d.
Years 5 to 10: initial production rate of 1.25 Mmcf/d, declining to 0.55 Mmcf/d.

Low Estimate:
Year 1: initial production rate of 3.26 Mmcf/d, declining to 1.14 Mmcf/d.
Years 2 to 4: initial production rate of 1.14 Mmcf/d, declining to 0.49 Mmcf/d.
Years 5 to 10: initial production rate of 0.49 Mmcf/d, declining to 0.29 Mmcf/d.

Using these values a weighted average (by years) gas production rate of 1.28 Mmcf/day is calculated per well produced over the first ten year of gas development. The total expected gas production is then simply the product of this rate and the estimated peak number of wells from the ALL/IOGA report of 2462 wells per year, or 3153 Mmcf/day. The "generic" compressor station engine modeled in Section 6.5.2 of the SGEIS is rated at 1775hp and is assumed to be able to process up to 40 Mmcf/day of gas (at 4 wells per year and maximum gas production of 10Mmcf/day from the ALL/IOGA August 26, 2009 report). To check on the appropriateness of this assumption, information from a recently permitted compressor station in New York was used. The Dunbar station will process an average of 235 Mmcf/day of gas using a number of engines with a total rating of about 10,060hp. Using this ratio of the Dunbar engine horsepower to the gas production, a level of gas production which corresponds to a 1775 hp engine was determined to be 41Mmcf/day. This matches the above value very well. Thus, the number of "generic" engines which would be necessary to process all of the average gas production in the ten year timeframe is calculated to be approximately 77 (3153 Mmcf/day divided by 41).

The next step in determining total NO_X and VOC emissions due to the estimated number of 77 "generic" engines was to use the emission rates from the ALL/IOGA emission report for the "generic" engines. It was noted in the report that the emission rates provided related to the emission factors of 0.7 and 0.27 gr/hp-hr for NO_X and VOC, respectively. The VOC factor corresponds to the use of an oxidation catalyst which will be required for essentially all these new engines per 40 CFR Part 63, Subpart ZZZZ (see Appendix 17). On the other hand, the NO_X emission factor is below the NSPS Subpart JJJJ factor of 2.0 g/hp-hr, but was noted by ALL/IOGA to be supported by the manufacturer's data. To check on these factors, the emissions from Dunbar and another compressor station for which a permit application has been received in New York were checked. In both these cases, the manufacturer's guarantee for NO_X is at 0.5 g/hp-hr, which confirms the factor used for the "generic" engine. For VOC, the factor for the "generic" source is essentially identical to the value used for these sources as well.

The corresponding emission rates of NO_X and VOC for the "generic" engines are 34 and 5 tons/year, respectively, from the ALL/IOGA report, as used in the modeling in Section 6.5.2 of the SGEIS. These rates are almost identical to the Dunbar facility values when adjusted for the horsepower differences. Thus, for the seventy seven "generic" sources, the total NO_X and VOC emissions are determined to be 2618 tons/year and 385 tons/year, respectively. These total emissions are 14 percent and 5 percent of the total NO_X and VOC emissions under the limited emissions scenario presented previously. These emissions were added to the limited emission scenario and the resultant incremental ozone impacts determined for the 2020 future regional inventory case which is the more likely scenario of future peak well development.

5.2 Ozone Impacts for the Marcellus Shale Development including the Compressor "Station" Engine Emissions.

The emissions from seventy seven "generic" 1775 hp engines estimated to process the gas under the peak well development scenario were calculated. Since the location of the compressor stations is unknown at this time, the emissions were spatially distributed as in the peak and limited emissions scenarios as described in Section 2.0. Furthermore, since these engines are associated with relatively low stacks with low plume rises due to likely downwash effects, the total emissions were "assigned" to the lowest layer of the CMAQ model which is from the surface to 40m and were assumed to be spread over the cells to which these were preferentially assigned as in Section 2.3 and Figure 3.

The calculated incremental daily maximum 8-hour ozone concentrations are depicted in Figure 14 for the Marcellus Shale limited emissions scenario plus the compressor station engines relative to the 2020 future regional emissions inventory. Figure 15 presents these incremental daily maxima at the OTR monitors, while Figure 16 presents each of the incremental 8-hour ozone impacts at these monitors against the total predicted ozone levels at the monitors. These results are consistent with previous depictions for the peak and limited emissions scenarios. To get an estimate of the contributions of the compressor engine emissions relative to the incremental impacts from other Marcellus Shale activities, a comparison of figures 14 to 16 can be made to the corresponding figures 11 to13 for the limited emissions scenario with the 2020 future inventory. This comparison indicates that the compressor engines are projected to result in a small addition to the overall incremental impacts of the order of 1ppb. This result is in line with the relatively small NO_X emissions associated with these compressor engines which were estimated at 14percent of the limited emissions scenario NO_X emissions. This, in turn, relates to the low NO_X emission factor expected from these new compressor stations which will service the Marcellus Shale gas development.

5.3 Preliminary Results for Total Daily Maximum 8-Hour Ozone Impacts

As discussed in Section 4.0, it is not possible, nor appropriate at this time, to project whether the emissions associated with gas development in the Marcellus Shale could affect the ozone standard compliance status in New York for a number of important reasons. These reasons were discussed in Section 4.1. However, it is possible to depict the incremental impacts associated with the additional NO_X and VOC emissions due to the gas development relative to the projected total impacts from the full 2020 inventory such that the relative influence on the concentration patterns can be ascertained. Similar information is already available to an extent from figures 13 and 16 where the incremental impacts are associated with the corresponding total impacts where the relative magnitudes of the incremental impacts versus the total ozone levels can be determined. Another way to depict this relationship is to show the ozone levels with and without the additional emissions from gas development. Since the incremental impacts were found to be larger for the 2020 future inventory and since this regional inventory is the more likely scenario than the 2007 inventory as far as the future timeframes for peak well development, the comparison is made of the 2020 future regional inventory ozone levels with and without the gas development emissions.

Figure 17 presents the predicted total daily maximum 8-hour ozone levels with the 2020 inventory with and without the additional Marcellus Shale emissions, including the compressor station engine emissions. The difference between these figures indicates the relative influence of the incremental impacts due to gas development with respect to the projected total ozone impacts expected in the future years. It is seen that the additional incremental impacts due to the Marcellus Shale associated emissions are not expected to change the total concentration patterns to a significant degree. However, the potential influence of these emissions at specific locations cannot be simply ascertained or dismissed, especially at monitor locations which are used for standard compliance demonstration, at some of which the observed levels are already high. The proper assessment must await the detailed analysis to be performed for the ozone SIP.

6.0 Conclusions

A screening level modeling analysis of regional ozone impacts due to estimated emissions from various well pad activities, associated truck traffic and compressor station engines was performed for assumed conditions under projected future peak well development. Some of the projections were based on the Socio-Economic Impact Analysis in support of the SGEIS, while other emissions and assumptions were made by the Department based on supplemental available information. Two well development emission scenarios were modeled using EPA's recommended CMAQ regional model which were coupled with two readily available regional emission inventories. The two Marcellus Shale emission scenarios represent the peak emissions and a limited NO_X emission scenarios, both associated with projected peak well development, but with the limited emission scenario, account for the likely future actual operations of some of the sources modeled. The regional inventories represented a "current" (2007) condition scenario and another future (2020) inventory scenario, both developed by the OTC, with the latter representing the anticipated timeframes when the peak well production is to occur.

The results of the modeling indicate that the incremental daily maximum 8-hour ozone impacts are maximized within the general region where the drilling activities are most likely to be the highest, with impacts reducing considerably with distance away from this limited area. The overall maximum incremental impacts are in the range of 6 to 10 ppb, but occur in areas where the predictions and observations of ozone are relatively low compared to the current standard. On the other hand, in areas with higher predicted and observed total ozone levels, the incremental ozone impacts from the gas development are low; in the range of 1 to 3ppb. While the overall maxima can be qualified as significant within the context of how that term is used in modeling relative to the corresponding standard (i.e. a few percent of the standard), this qualification cannot be used to translate to adverse effects within the context of this SGEIS. This is because the projected impacts must be further analyzed using EPA established procedures for compliance demonstrations within the SIP process.

That assessment, however, is premature at this time and must await the development of a more rigorous emission inventory for not only New York, but also for neighboring states which could impact New York's compliance determinations. Furthermore, it is essential that the proper future inventory (such as for 2020) which will be relied upon by EPA and the northeast states be finalized before such an analysis can be undertaken. Given that the peak well development is projected not to occur in New York for about ten years after horizontal drilling starts, the best approach to address the ozone projections and their consequences is to rely on the ozone SIP process which the Department must undertake in concert with EPA Region II to assure future compliance with the standard. This process will better quantify the resultant impacts and serve best to define any necessary control measures during the future timeframes when peak emissions might be reached. In addition, this process can better address the likelihood that EPA will revisit the ozone standard in this future timeframe.

The assumptions made in the modeling are based on viable options that if implemented by industry and the Department will assure that the above projected impacts have been properly quantified from the Marcellus Shale gas development activities. Specifically, two main aspects of the assumptions which should be assured to be implemented by industry and the Department will be mentioned. The modeling uses industry's projected regional emissions for drilling and fracturing engines which assumes an average emission factor from EPA Tier 2 engines. Thus, the above results are valid to the extent that the regional emissions projected are not significantly increased by the use of lower tier engines which could result in an inordinate increasing effect on the emissions. This is true even if the percentages of the lower tier engines are not large (see Table 6-20 of the Final SGEIS for the engine emission factors and percentages in use) since the lower tier engines have a significantly larger emission factor which can offset their lower percentages in the fleet of engines to be used for drilling and fracturing. In addition, the limited emissions scenario assumes that at least 25% of these engines will be replaced by the time peak well drilling conditions are realized over a ten year period. This assumption is consistent with the assumed non-road mobile source turnover in the OTC 2020 future inventory. This "turnover" emission reduction can be achieved in reality by the use of the newer Tier 4 engines which the manufacturers are in line to achieve starting in the 2014-5 timeframe, well before the peak emission conditions are projected to occur. In addition, cleaner fuel engines, such as natural gas and electric driven engines, might be more practically viable during this future time period. The other assumption which the Department will assure during the site specific permitting for the compressor stations is that the NO_X and VOC emission factors and rates used in this assessment would be imposed on compressor stations and would be representative of the proposed new facilities. Since these factors can be readily achieved and are in fact currently met by proposed facilities in New York through manufacturer's guarantees, the emissions imposed on new compressor stations will reflect the emission factors used in the modeling assessment.

Figure 14. Incremental Daily Maximum 8-Hour Ozone Levels for the **Compressor Station Engines Plus the Limited Emissions Scenario** for the Complete Ozone Season and the 2020 Future Inventory.

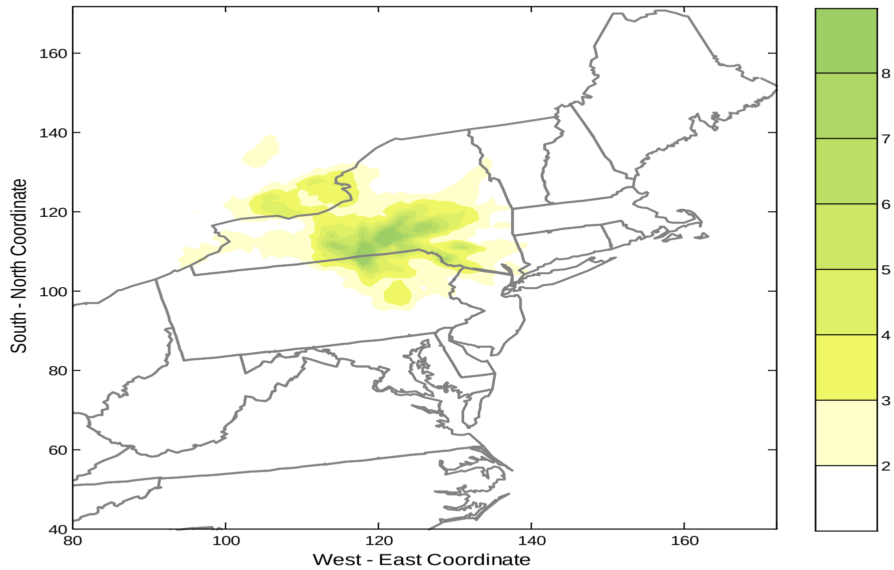


Figure 15. Incremental Daily Maximum 8-Hour Impacts at Ozone Monitors within OTR for the **Compressor Station Emissions Plus the Limited Emissions Scenario** for the Ozone Season and for the 2020 Regional Inventory.

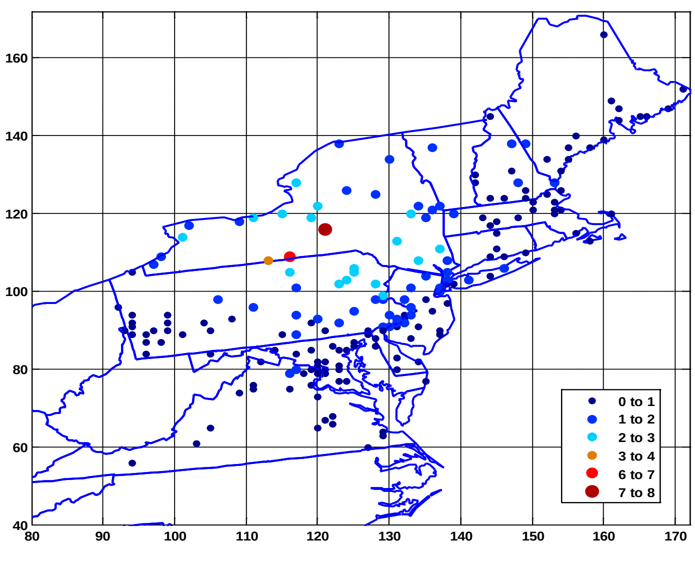


Figure 16. Incremental 8-Hour Ozone Impacts Versus Total Modeled 8-Hour Ozone at all Monitors within OTR for the **Compressor Stations Plus the Limited Emissions Scenario** and with the Future 2020 Emission Inventory.

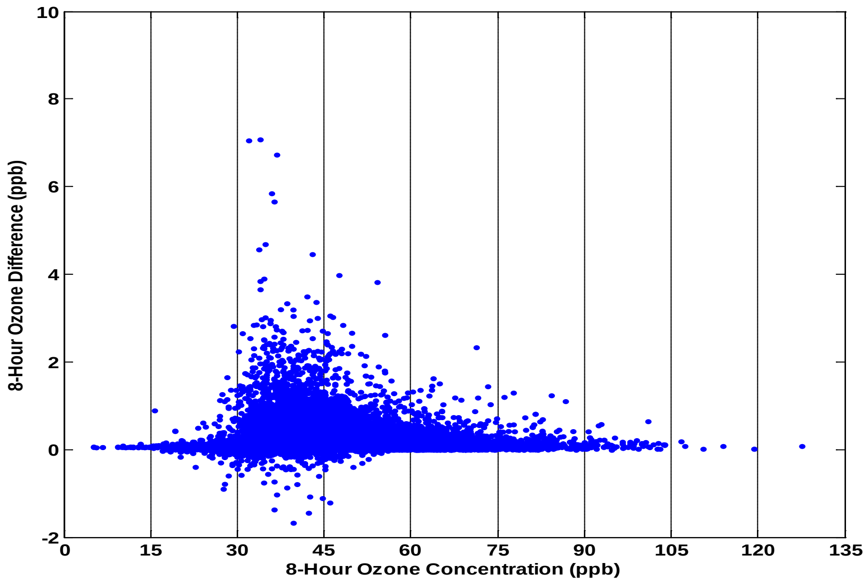
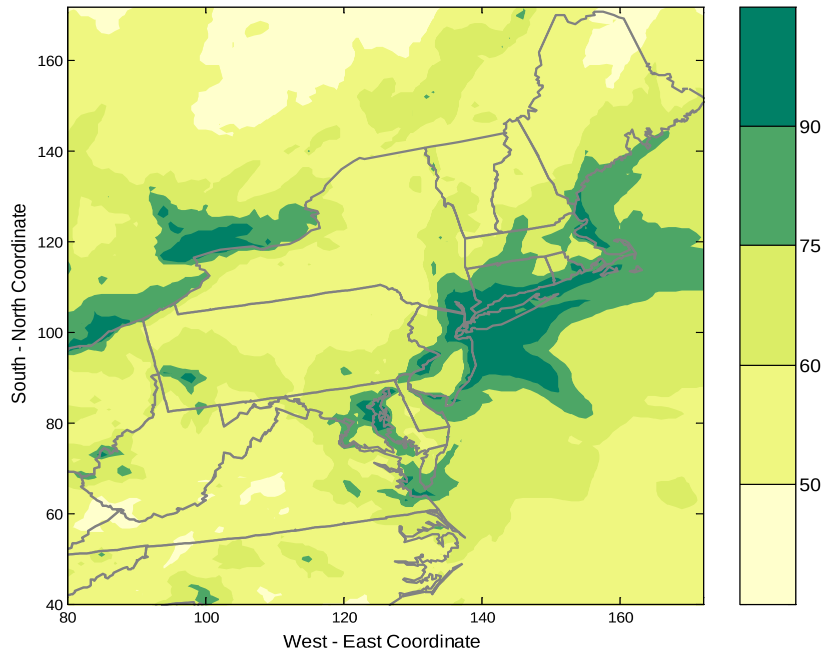
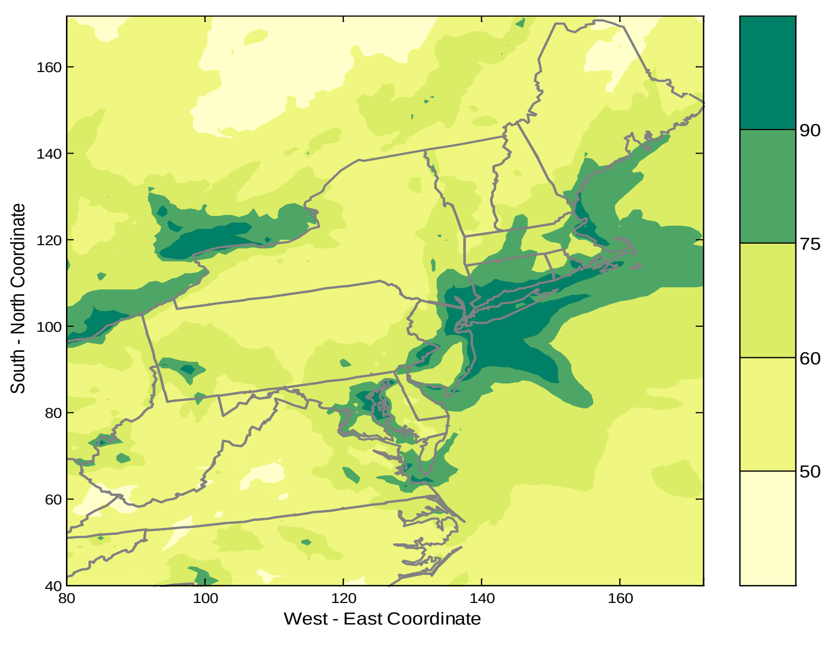


Figure 17. Total Daily Maximum 8-Hour Ozone Impacts for Future 2020 Inventory *without* (A) and *with* (B) Marcellus Shale Well Development Activities under the Limited Emissions Scenario Plus Compressor Station Engine Emissions.

(A)



(B)



References:

Baker, D. et al, 2010: Protocol for WRF Meteorological Modeling in Support of Regional SIP Air Quality Modeling in the OTR. Available at www.otc.org/

Byun, D.W. and K.L. Shere, 2006: Review of the governing equations, computational algorithms, and other components of the Model-3 Community Multiscale Air Quality (CMAQ) modeling system. Appl. Mech. Rev., 59, 51-77.

Sistla, G. et al, 2010: Assessment of 2007 WRF Meteorological Modeling in support of Regional Air Quality Modeling in the Ozone Transport Region (OTR) for 2007. Available at www.otc.org/

Skamarock, W., J. Klemp, J. Dudhia, D. Gill, D. Barker, M. Duda, X.-Y. Huang, W. Wang, and J. Powers, 2008: *A description of the Advanced Research WRF Version* 3, NCAR Tech. Note, NCAR TN-475+STR, 113 pp.

Yarwood, G., S. Rao, M. Yocke, and G. Whitten, 2005, Updates to the Carbon Bond Chemical Mechanism: CB05. Final Report to the US EPA, RT-0400675. Available at: http://www.camx.com/publ/pdfs/CB05_Final_Report_120805.pdf.

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Appendix C

Dispersion Modeling Input and Output Data, Sensitivity Analysis and Explanation of NAAQS and Toxics Threshold Establishment Process

Final

Supplemental Generic Environmental Impact Statement

Response to Comments

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This appendix contains two sections. Section I provides sample modeling input data and model sensitivity analysis to address issues raised about the building downwash dimensions used in the modeling analysis. In addition, sample concentration contours of PM2.5 and NO_2 impacts are presented to depict areas around the well pad where there is a potential for exceeding the 24 hour and 1 hour standards, respectively, for these pollutants. Section II presents a brief background on the procedures used by EPA to develop ambient air quality standards for criteria pollutants and those used by the Department to establish air guideline concentration thresholds.

I. <u>Model Input Data and Sensitivity Analysis</u>

This section provides the AERMOD model emission inputs data, the receptor grid plot and the revised source location on the well pad, wind roses, and sample contour plots for PM2.5 and NO2 impacts from the final set of model runs. In addition, the results of sensitivity analysis to address issues raised during the public comments on specific source input data have been included in the appendix. The emissions data used in the AERMOD modeling were taken for the most part from the ALL Consultant's document: *"Horizontally Drilled/HVHF Wells Air Emissions Data"*, dated 8/26/09. That report was contained in the ALL/IOGA October 14, 2009 responses to the Department's Information Request. The latter report also provided the findings of the independent Department staff review of the emission factors and rates some of which were subsequently modified for use in the modeling.

The appendix does not repeat all of the data from the 8/26/09 ALL report. Instead, only the PM and NO_2 modeling stack and emission rate data are detailed since these pollutants were found to exceed the short term NAAQS in the 2011 revised draft SGEIS modeling for which further refinements were made for the final SGEIS. The emissions for other pollutants and under average conditions used for the annual modeling can be found in the ALL Consulting report. The emissions input data used for PM were different from the NO_2 to the extent that the multiple drilling and compressor engines were represented as multiple point sources for the NO_2 modeling since the results of the modeling indicated potential exceedances of standards for the latter even with the Tier 2 engines. This is discussed in the Final SGEIS, Section 6.5.2.6. In addition, the engine tier level used in the PM versus NO_2 assessments were different, as detailed below, for the same reason.

PM Modeling Input Data

For the PM10 and PM2.5 standards compliance modeling, "Worst Case Drilling Emissions"-Table 8, "Worst Case Completion Emissions"-Table 15, "worst case emissions for the line heater"-Table 18, and the "maximum off-site compressor station emission"-Table24 from the ALL 8/26/09 report were used. The emissions of PM2.5 and PM10 were calculated by multiplying the total PM (given in the above tables) by EPA emission factors 0.69 and 0.89, respectively. In addition, per the ALL report, tier 1 emission rates were used for the drilling engines and tier 2 emissions for the compressor engines and the fracturing engines.

The specific source inputs in the AERMOD model are provided in Table 1 with: 15 fracturing engines (FRAC1 to FRAC15), 1 compressor engine (COMP), 1 drilling rig engine (RIGENG), 1 heater (HEATER), 1 flare (FLARE), and 1 off-site compressor (OFFCOMP). Each source was associated with its own "building" structure, except for the fracturing engine stacks which were divided between 2 "buildings" in separate 7 and 8 engines per set configuration. The structure heights were: 6ft for compressor engine and heater, 10 ft for the fracturing engines, 9 ft for the rig engine and 14 ft for the offsite compressor. Approximate lengths and widths for each structure were input to the BPIP model which in turn calculated the model projected structure width and length of each source for each 36 wind flow sector. The structure dimensions were approximate estimates from photographs. In addition, the flare “stack height” represents the minimum plume height estimated with the EPA SCREEN3 model using the heat release rate as explained in the SGEIS since AERMOD does not directly calculated the plume height for this source type.

Table 1. Stack/emission input parameters used in PM modeling scenarios.

Source	Stack height (m)	Stack Temp (K)	Stack Velocity (m/s)	Stack Diameter (m)	PM emission (lb/hr)	PM10 emission (lb/hr)	PM2.5 emission (lb/hr)
FRAC1	3.9624	616.48	57.912	0.3536	0.4400	0.3916	0.3036
FRAC2	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC3	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC4	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC5	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC6	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC7	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC8	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC9	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC10	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC11	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC12	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC13	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC14	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
FRAC15	3.9624	616.48	57.912	0.3554	0.4400	0.3916	0.3036
COMP	3.048	616.48	100.584	0.1524	1.0000	0.8900	0.6900
RIGENG	3.048	616.48	100.584	0.1524	2.4000	2.1360	1.6560
HEATER	3.048	533.15	10.668	0.1015	0.0400	0.0356	0.0276
FLARE	150	293	0.01	0.1015	10.0000	8.9000	6.9
OFFCOMP	4.572	672.04	57.912	0.3557	0.1200	0.1068	0.0828

A 150x150m well pad was set up encompassing all the sources, except the off-site compressor was placed adjacent to the pad. The receptor grid was set up outside the fence out to 600m at 30m increments. Part of the receptor grid and the final source configuration of the fracturing engines are depicted in figure 1. There were no receptors inside the fence.

Modeling was done separately for drilling and fracturing scenarios since these operations will not occur simultaneously at a well pad. For the drilling scenarios all fracturing engine sources were removed from the model and for the fracturing scenarios, the drilling rig and compressor sources were removed from the model.

Model calculations were made for the maximum 24 hour concentration for PM10 and the 8th highest 24 hour concentration for PM2.5. The results were compared to their respective NAAQS, minus the respective background levels as described in Section 6.5.2 of the SGEIS.

NO_2 modeling Input Data

Emission and stack data for modeling of NO_2 were taken from the same reports and Tables noted above for PM. For the drilling rig engines, the emission rate was adjusted in these runs to be the tier 2 engine emission factor (tier1 times 0.695). Both the drilling and compressor engines were modeled as individual sets of 5 point sources for the NO_2 impacts as a refinement to the single source representation used for PM. Sources modeled for NO_2 are presented in Table 2. The stack parameters were the same as in Table 1, except as noted for the individual drilling and compressor engines representation. Also, structure dimensions were the same as for PM modeling, except the compressor structure height was adjusted to 10ft based on review of the photographs, while the offsite compressor building height was set to the 25ft which was determined to be the height necessary to eliminate the exceedances of the formaldehyde AGC.

Table 2. Stack/emission input parameters used in NO_2 modeling

Source	Stack Height (m)	Stack Temp. (K)	Stack Velocity (m/s)	Stack Diameter (m)	NO_2 Emission (lb/hr)
FRAC1	3.9624	616.48	57.912	0.3536	1.4
FRAC2	3.9624	616.48	57.912	0.3554	1.4
FRAC3	3.9624	616.48	57.912	0.3554	1.4
FRAC4	3.9624	616.48	57.912	0.3554	1.4
FRAC5	3.9624	616.48	57.912	0.3554	1.4
FRAC6	3.9624	616.48	57.912	0.3554	1.4
FRAC7	3.9624	616.48	57.912	0.3554	1.4
FRAC8	3.9624	616.48	57.912	0.3554	1.4
FRAC9	3.9624	616.48	57.912	0.3554	1.4
FRAC10	3.9624	616.48	57.912	0.3554	1.4
FRAC11	3.9624	616.48	57.912	0.3554	1.4
FRAC12	3.9624	616.48	57.912	0.3554	1.4
FRAC13	3.9624	616.48	57.912	0.3554	1.4
FRAC14	3.9624	616.48	57.912	0.3554	1.4
FRAC15	3.9624	616.48	57.912	0.3554	1.4
COMP1	3.048	616.48	100.584	0.1524	6.4
COMP2	3.048	616.48	100.584	0.1524	6.4
COMP3	3.048	616.48	100.584	0.1524	6.4
COMP4	3.048	616.48	100.584	0.1524	6.4
COMP5	3.048	616.48	100.584	0.1524	6.4
RIGENG1	3.048	616.48	100.584	0.1524	5.699
RIGENG2	3.048	616.48	100.584	0.1524	5.699
RIGENG3	3.048	616.48	100.584	0.1524	5.699
RIGENG4	3.048	616.48	100.584	0.1524	5.699

Source	Stack Height (m)	Stack Temp. (K)	Stack Velocity (m/s)	Stack Diameter (m)	NO_2 Emission (lb/hr)
RIGENG5	3.048	616.48	100.584	0.1524	5.699
HEATER	3.048	533.15	10.668	0.1015	0.2
FLARE	150	293	0.01	0.1015	34
OFFCOMP	7.6	672.04	57.912	0.3557	7.8

The same well pad and receptor configuration as in PM modeling was used. Based on a sensitivity analysis and the limited model evaluation results from EPA, the Ozone Limiting Method (OLM) with OLMGROUP ALL option in AERMOD was used in the final analysis of impacts. For the hourly background Ozone values, measurements from Elmira, NY was used.

The 1 hour NO_2 impacts were calculated for following source groups:

"Fracturing": 15 fracturing engines, heater, flare and off-site compressor
"Drilling": 5 compressor engines, 5 drilling rig engines, heater, flare and off-site compressor
"Compressor": 5 on-site compressors engines
"RigEngine": 5 drilling rig engines

The source groups allowed the determination of respective impacts from various operations and combination of sources. The resultant impacts were compared to the 1 hour NAAQS, minus the background values.

Meteorological data

The modeling performed for the SGEIS used meteorological data from 6 sites, as discussed in Section 6.5.2. These sites were: Albany, Syracuse, Binghamton, Jamestown, Buffalo and Montgomery County Airport. The wind roses for the two years of data used from each site are presented in Figure 2. The wind rose depicts the average annual percentages of wind direction (as direction from) in wind speed categories such that the annual "dominant" directions and the associated average wind speeds can be discerned for a given site.

Model Sensitivity Analysis for Building/Structure Heights

A concern raised during the public comment period related to the effects of choosing the building dimensions from photographs instead of actual data. A related concern was the potential effects of the building structures of a source on an adjacent source's impacts. The significance of these concerns was tested by performing sensitivity calculations by AERMOD to determine their consequences. Specifically, the placement of the off-site compressor station next to the well pad could have a significant contribution to maximum impacts of drilling and fracturing source groups. This is due to the fact that some of the building dimensions from BPIP for these latter sources were assigned the higher building height of the compressor building for a limited set of wind flows. However, these flows would result in impacts over the well pad, which were not considered in the standards compliance determinations.

To explicitly demonstrate this conclusion, the AERMOD model was rerun with the off-site compressor completely removed from the BPIP building dimension calculations and the resultant inputs parameters and Albany meteorological data used in the analysis. The maximum impacts for all pollutants, source groups and both years modeled were identical to those presented in previous Table 6.19 of the 2011 revised draft SGEIS (revised Table 6-20 of the Final SGEIS). This leads us to conclude that the off-site compressor did not impact our modeling results, nor the conclusions reached.

The other concern raised with the influence of the downwash effects by the structure dimensions was the use of approximate values from photographs. One of the concerns related to the new AERMOD model's approach to downwash calculations, as noted in a reference submitted with comments. However, the "new" AERMOD approach to downwash calculations only related to higher impacts noted for sources which have Good Engineering Practice (GEP) stack heights. Since none of the sources modeled for the SGEIS have GEP heights, the issue was not germane.

The use of approximate building dimensions in the modeling was due to lack of such actual data from the industry in the ALL Consulting emission reports. Furthermore, no such actual data was submitted during the public comments, nor was forthcoming from industry. Thus, a sensitivity analysis was performed with the fracturing engines to determine how the equipment dimensions influence modeled impacts. In the SGEIS modeling, the fracturing engine height ("building height") was set to 10ft. For the sensitivity study, the value was changed to 9ft and then to 11ft and BPIP was rerun. Then AERMOD was run with two years of Albany meteorological data and the results compared to the 10ft building height impacts.

For these sensitivity impacts, the fracturing engines were located in the middle of the well pad (as explained in Section 6.5.2 of the Final SGEIS) and AERMOD run with the three building heights. The results showed that the sensitivity of the impacts to a building height changes is within expectation and not as dramatic as was the basis of the concern raised. A 10% increase (decrease) in fracturing building height lead to a 6-11% increase (decrease) in maximum 24 hour impacts for PM2.5, while PM10 impacts changed 5-9%. In addition, the distances to where the concentrations fell below the critical value (NAAQS-background concentration) were similar for all three building heights; i.e. about 70m for PM2.5. For NO2, the same exercise was performed. In this instance, a 10% increase (decrease) in building height lead to 3-5% increase (decrease) in maximum 1-hour impacts. In this case also, the distances to where the concentrations fell below the critical value were the same as for the 10ft building height case. These results are the expected results of changing the stack height to envelop the likely heights expected for these sources.

Thus, it is concluded that the building dimensions used in the original analysis are adequate for the projections of standard compliance and other determinations for all of the engines. The additional modeling performed for the Final SGEIS removed the compressor engines from the AERMOD runs and also located the set of fracturing and drilling engines near the center of the well pad.

Concentration Contour Maps of PM2.5 and NO_2 Impacts

The additional modeling analysis performed in response to public comments on the 2011 revised draft SGEIS considered the placement of the drilling and completion engines near the center of the well pad and the cyclical nature of the completion engine operations. In order to determine the downwind distances where the maximum concentrations fall below the corresponding NAAQS- minus-background levels discussed in Section 6.5.2, concentration pattern maps were generated from the AERMOD results. For PM2.5, the impacts to below the standard were found to occur approximately right at or just beyond the well pad boundary. The concentration contour maps of the PM2.5 24 hour 8th highest impacts for the Buffalo 2007 meteorological data year for the completion engines, with and without accounting for the cycle operations, are presented in Figure 3. For the 1 hour NO_2 impacts, it was found that certain OLM contour plots did not provide a realistic drop-off of impacts in certain directions versus PVMRM maps. An example for the 8th highest daily maximum 1 hour concentration plots for the completion engines are presents in Figure 4 for the case of Albany, 2007 data with the OLM and PVMRM methods. A similar plot for the drilling engines and the Albany 2007 data with the PVMRM method is presented in Figure 5 and appears to be in line with expected patterns.

Figure 1. Well pad source layout for the set of final supplemental modeling runs and the surrounding near field receptor grid.

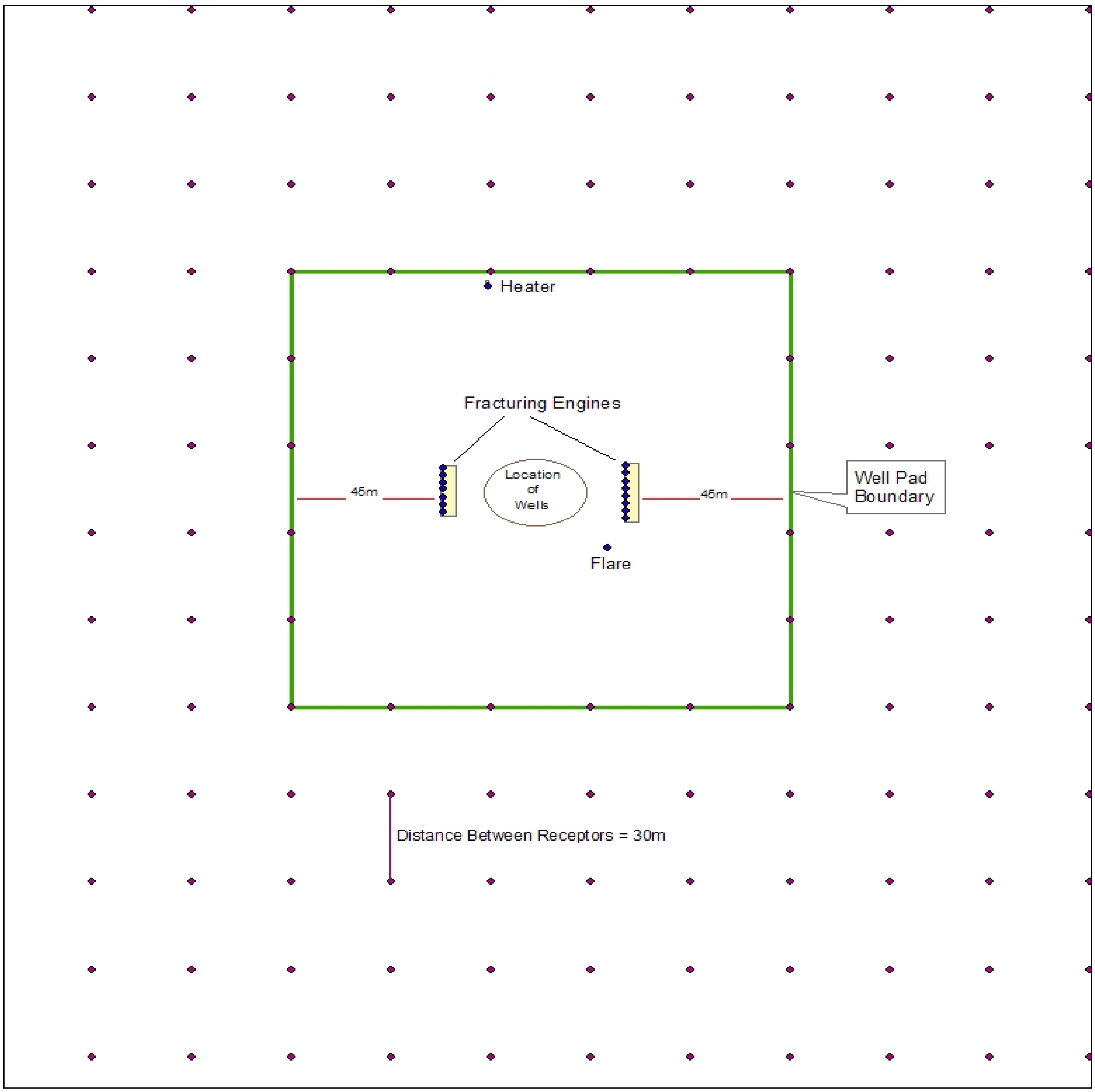
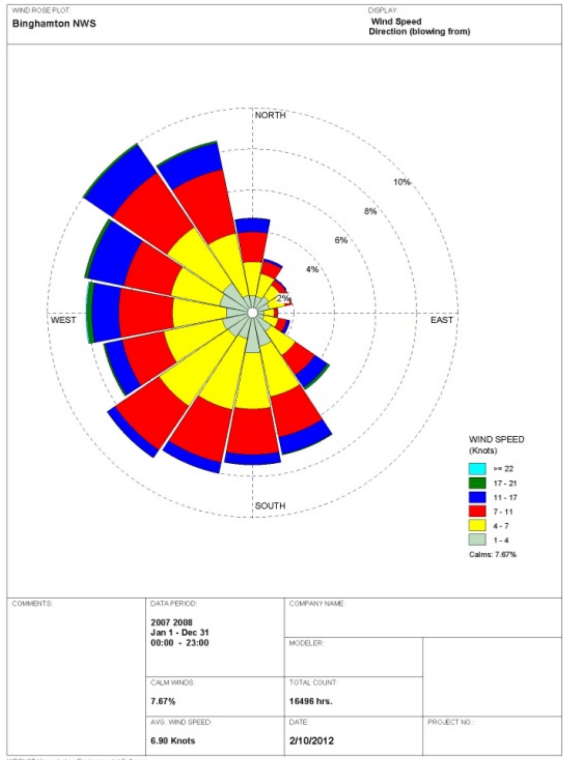
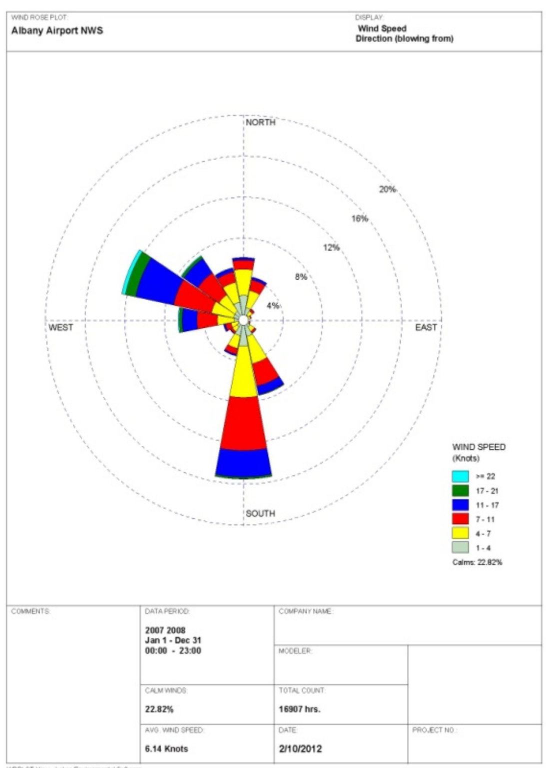
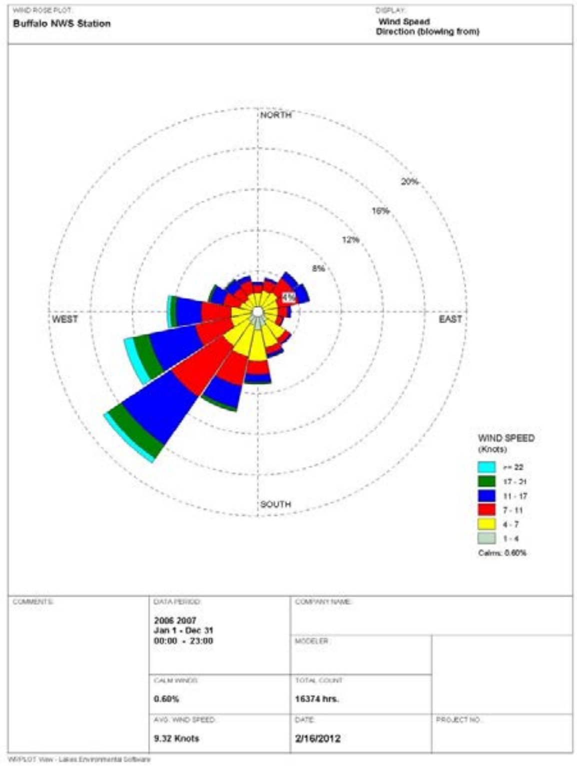


Figure 2. Wind Roses from Meteorological Data Sites






WIND ROSE PLOT:
Buffalo NWS Station
DISPLAY:
Wind Speed
Direction (blowing from)
NORTH
SOUTH
WEST
EAST
20%
16%
12%
8%
4%
WIND SPEED
(Knots)
>= 22
17 - 21
11 - 17
7 - 11
4 - 7
1 - 4
Calms: 0.60%
COMMENTS:
DATA PERIOD:
2006 2007
Jan 1 - Dec 31
00:00 - 23:00
COMPANY NAME:
MODELER:
CALM WINDS:
0.60%
TOTAL COUNT:
16374 hrs.
AVG. WIND SPEED:
9.32 Knots
DATE:
2/16/2012
PROJECT NO.:
WRPLOT View - Lakes Environmental Software

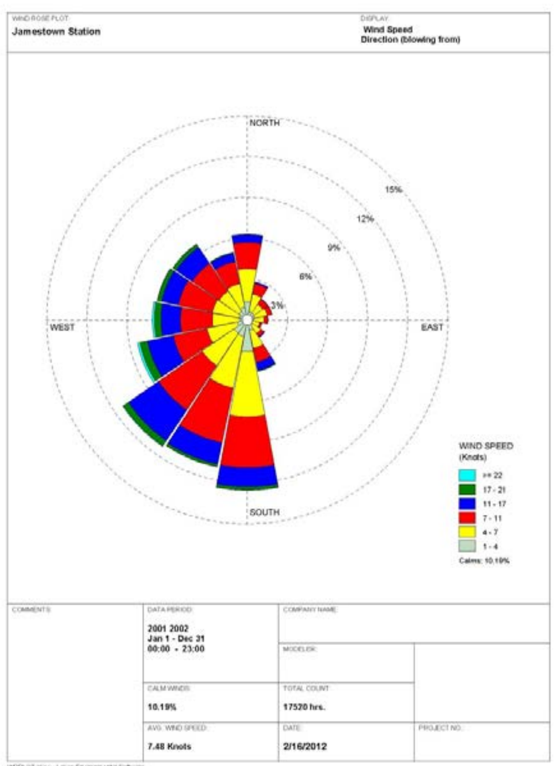
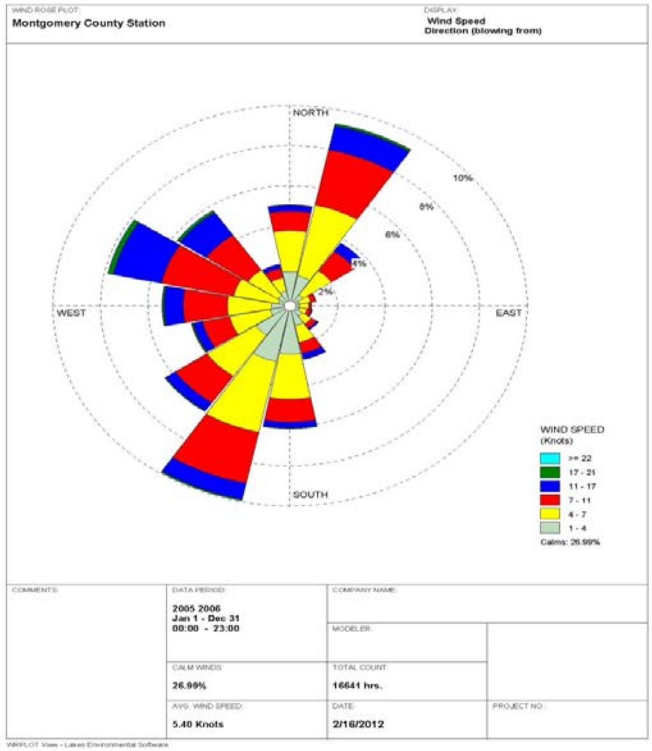

WIND ROSE PLOT:
Jamestown Station
DISPLAY:
Wind Speed
Direction (blowing from)
NORTH
SOUTH
WEST
EAST
15%
12%
9%
6%
3%
WIND SPEED
(Knots)
>= 22
17 - 21
11 - 17
7 - 11
4 - 7
1 - 4
Calms: 10.19%
COMMENTS:
DATA PERIOD:
2001 2002
Jan 1 - Dec 31
00:00 - 23:00
COMPANY NAME:
MODELER:
CALM WINDS:
10.19%
TOTAL COUNT:
17520 hrs.
AVG. WIND SPEED:
7.48 Knots
DATE:
2/16/2012
PROJECT NO.:
WRPLOT View - Lakes Environmental Software

Figure 2 (continued). Wind Roses from Meteorological Data Sites



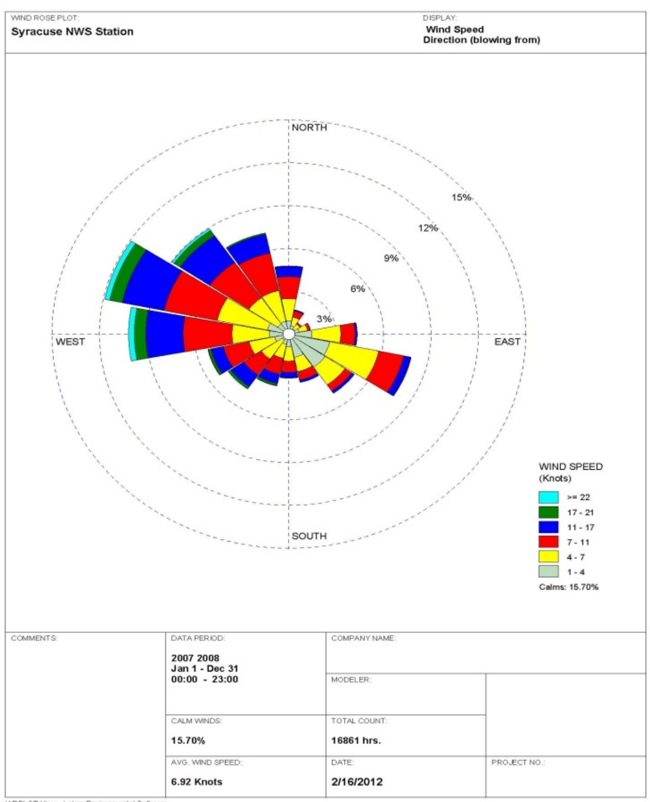
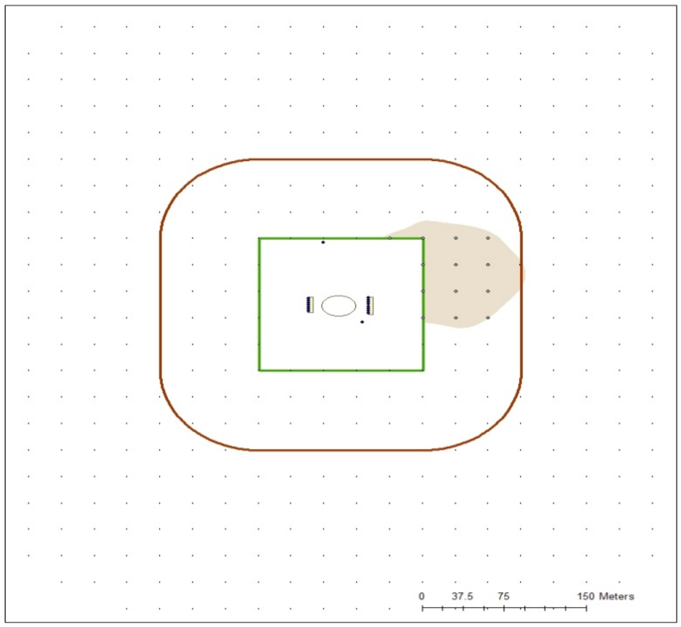


Figure 3. PM2.5 8th Highest 24 hour Impact Contours for the Completion Engines, Placed at the Well Pad Center and without (A) and with (B) the Cyclical Emissions for Albany 2007 Data.

(A)



(B)

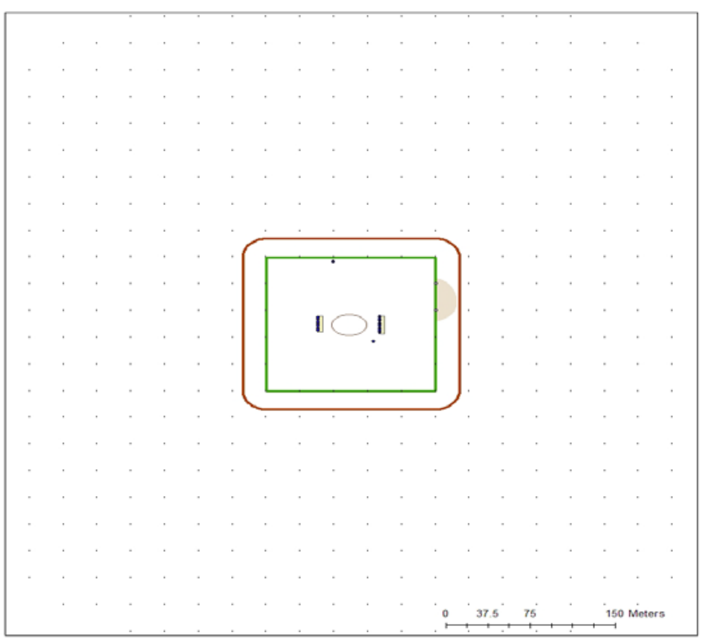
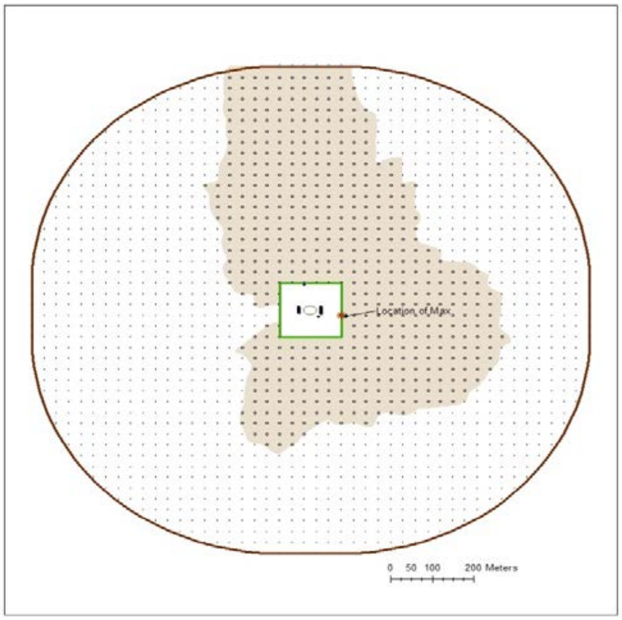
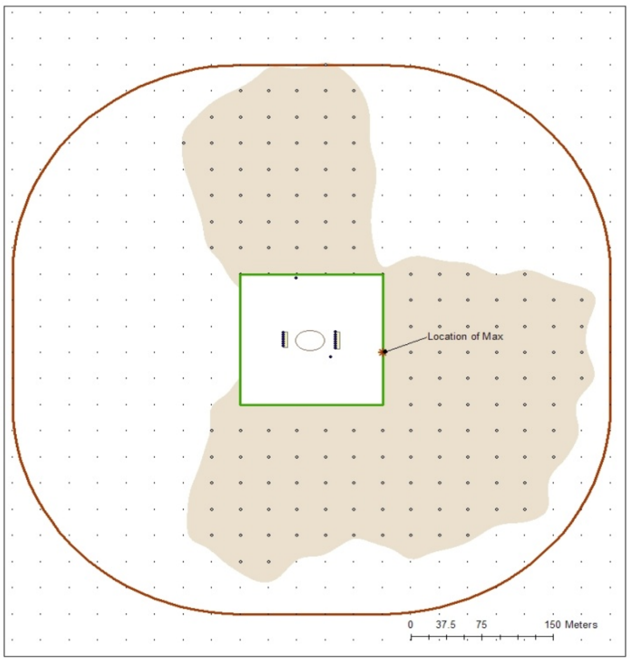


Figure 4. NO_2 8th Highest Daily Maximum 1-Hour Impacts for the Completion Engines with (A) OLM and (B) PVMRM using Albany 2007 Data.

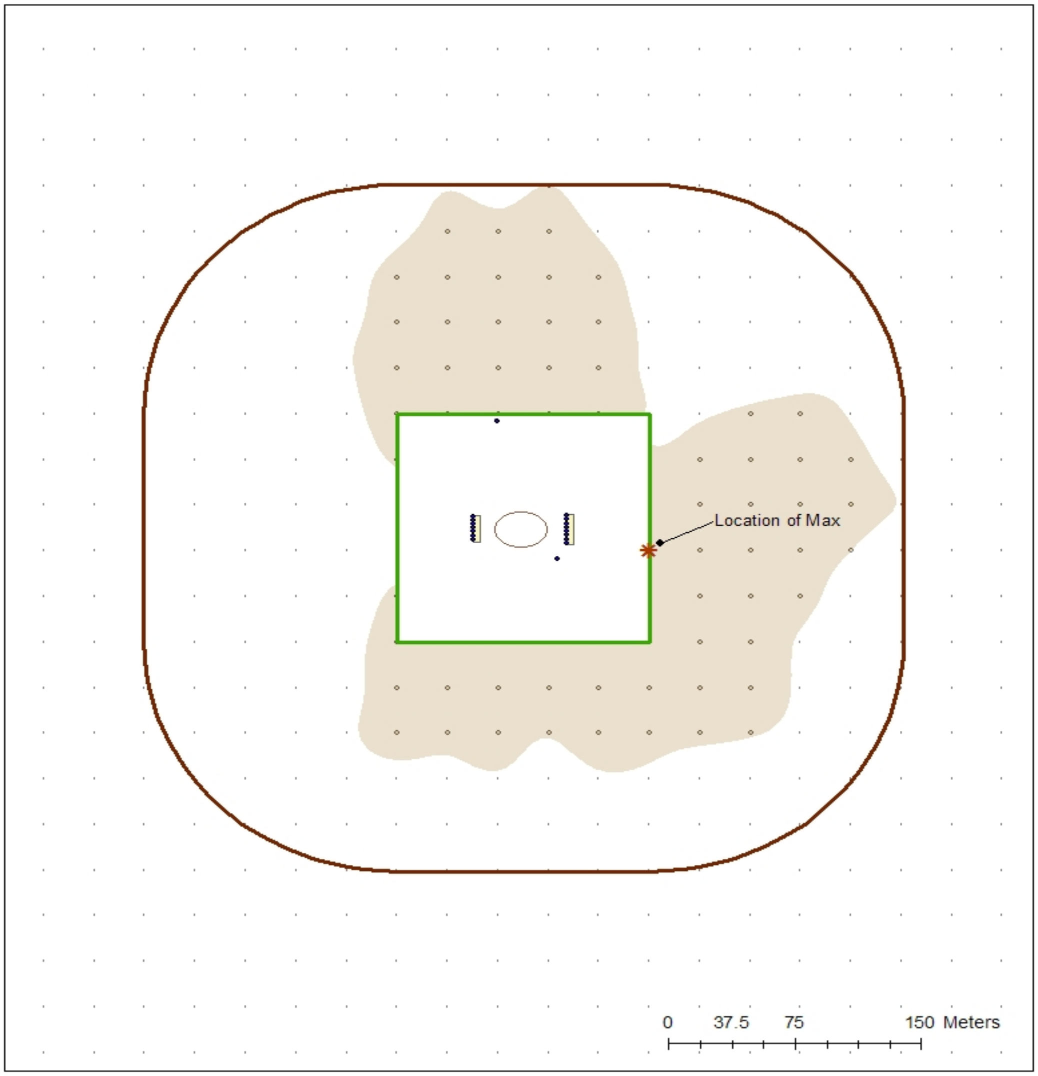
(A)





(B)

Figure 5. NO_2 8th Highest Daily Maximum 1-Hour Impacts for the Drilling Engines with PVMRM and Albany 2007 Data.



II. Summary of Procedures used by EPA to Establish National Ambient Air Quality Standards (NAAQS) for criteria pollutants and by the Department to establish Air Guideline Concentrations for Toxic Contaminants.

An area voiced by the public as a potential public health concern is air quality and whether the ambient standards and toxic thresholds used by the Department to determine the potential for adverse effects are adequately protective. The Department, along with other state and federal agencies, uses the national ambient air quality standards (NAAQS) to determine whether the public is exposed to acceptable ambient concentrations for the six criteria pollutants for which EPA has established NAAQS. Furthermore, the Department's Division of Air Resources (DAR) has established ambient air guideline concentrations (or thresholds) for non-criteria (or toxic) pollutants to determine the potential for adverse effects on public health (NYSDEC Air Guide- 1, DEC Program Policy DAR -1: *Guidelines for the Control of Toxic Ambient Air Contaminants*). These NAAQS and the toxic thresholds are routinely used for comparison to source impacts in order to determine the public's exposure by using actual observed monitoring data and/or model predicted concentrations.

For obvious reasons, a proposed source can only conduct a modeling analysis to determine the potential for adverse impacts under various future operational conditions. For the SGEIS, the Department undertook a comprehensive and detailed modeling analysis of all potential sources associated with gas drilling, completion and production activities related to well pad operations. All anticipated criteria and toxic pollutants from these sources were modeled under a set of conservative assumptions to predict worst case impacts. Details of the modeling approach and the results are presented in Section 6.5.2 of the Final SGEIS. The methodologies used in the modeling rely on EPA and Department recommended technical approaches and are, by their nature, formulated to predict impacts which are at or above the expected levels which could be observed in actuality. Thus, there is a level of conservatism in these predictions which further assures compliance with the NAAQS and toxic thresholds.

Using the NAAQS and toxic thresholds, the Final SGEIS recommends a set of mitigation measures to assure that predicted impacts which could exceed these levels are alleviated. These measures are discussed in Section 6.5.2 and summarized in Section 7.5 of the SGEIS in order to reduce air quality impacts below NAAQS and thresholds, including operational limits and equipment emission controls. The modeling analysis also incorporated existing conditions as determined by observed data for criteria pollutants at the Department's air quality monitoring network in the Marcellus Shale area. The current observations from all these monitors indicate attainment of all promulgated NAAQS currently in effect. As EPA promulgates new standards or revises existing ones, the Department will be required to assure compliance with these changes through its State Implementation Plan (SIP) and permitting process. For example, EPA finalized the 1 hour SO_2 and NO_2 standards after the release of the 2009 dSGEIS. These standards were then addressed in the 2011 rdSGEIS and necessary mitigation measures were recommended.

The issue which has arisen is whether the NAAQS and toxic guideline concentrations used by the Department to minimize public health effects due to air pollution from gas well activities are protective of public health. These levels have been established by the EPA and Department with a large margin of safety in order to protect even the most sensitive in the population. The steps taken to assure this level of protection are described below for the NAAQS established by EPA and for the toxic thresholds established by the Department.

NAAQS Development and Promulgation Process[1]

The Clean Air Act (CAA) governs the establishment and revision of National Ambient Air Quality Standards (NAAQS). The EPA has established NAAQS for six common air pollutants (lead, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter and ozone). The NAAQS are intended to accurately reflect the latest scientific knowledge about all the public health and environmental (welfare) effects associated with exposure to the specific air pollutant. Primary NAAQS are defined as the ambient air concentration that protects public health with an adequate margin of safety from adverse health effects of exposure. Secondary NAAQS are defined as the ambient air concentration that protects the public welfare from any known or anticipated adverse effects associated with the presence of the pollutant in ambient air.

The requirement that primary standards provide an adequate margin of safety was intended to address uncertainties associated with inconclusive scientific and technical information available at the time of standard setting. It was also intended to provide a reasonable degree of protection against hazards that research has not yet identified. When making a determination about an adequate margin of safety, the EPA is seeking not only to prevent pollution levels that have been demonstrated to be harmful but also to prevent lower pollutant levels that may pose an unacceptable risk of harm, even if the risk is not precisely identified as to nature or degree.

The CAA does not require the Administrator to establish a primary NAAQS at a zero-risk level or at “background” concentration levels, but rather at a level that reduces risk sufficiently so as to protect public health with an adequate margin of safety.

The Clean Air Act requires a comprehensive review of the latest scientific information on a five year basis to identify if the NAAQS should be revised. There are four phases of the NAAQS review process that guide the five year review process; 1) the preparation of plan for the review, 2) the preparation of an Integrated Science Assessment, 3) the preparation of a Risk/Exposure Assessment and 4) the preparation of a Policy Assessment.

During the planning phase, the EPA will convene science policy workshops to gather input from the scientific community and the general public to identify policy relevant issues associated with the specific NAAQS. Based on these workshops, EPA will prepare an integrated review plan that includes a schedule for the entire review process and identifies all the policy relevant issues that will be considered during the review process.

The next step involves preparation of an Integrated Science Assessment (ISA) document by EPA which is a comprehensive review, synthesis and evaluation of all the policy relevant science for

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[1] For further detailed information see: Process of Reviewing the National Ambient Air Quality Standards, http://www.epa.gov/ttn/naaqs/review.html

the air pollutant. This document includes key scientific judgments that are important to inform the risk and exposure assessments.

The preparation of the Risk/Exposure Assessment (REA) document builds off the ISA to develop quantitative characterization of exposures and associated risk to human health and the environment that is associated with recent air quality, as well as, air quality that is estimated to just meet the current or alternative standard(s) under consideration. The uncertainty associated with these estimates is also characterized.

The final step is the preparation of a Policy Assessment document that includes the EPA staff's analysis of the scientific basis for alternative policy options for consideration by the EPA senior management prior to rulemaking. This document bridges the gap between the scientific assessments in the ISA and REA and the judgments required of the EPA Administrator in determining whether it is appropriate to retain or revise the NAAQS. This step facilitates the Clean Air Science Advisory Council (CASAC) advice to the Agency and recommendations to the Administrator on the adequacy of the existing standards or revisions that may be appropriate to consider. The Policy Assessment focuses on the information that is most pertinent to evaluating the basic elements of the NAAQS: indicator, averaging time, form and level.

The scientific review during the development of all these documents is thorough and extensive. The Clean Air Science Advisory Committee (CASAC) was established by the Clean Air Act and provides independent advice to the Administrator on the technical basis of all of EPA's NAAQS. CASAC critically reviews all of the above documents developed by the EPA and provides key recommendations about retaining or revising the standards. Drafts of all of these documents are also available to CASAC and the general public for review and comment before they are finalized by EPA.

After this entire process is complete, the EPA will take into consideration all of the final scientific information developed, the final policy assessment, and the advice of CASAC to develop and publish a notice of proposed rulemaking that communicates the Administrators proposed decision regarding the review of the NAAQS. A public comment period, which includes public hearings, follows the publication of the notice of proposed rulemaking. The EPA will issue a final rule after taking into account all of the comments received on the proposed rule.

Air Guide-1 Guideline Concentrations for the Assessment of Toxic Pollutant Impacts.

The Division of Air Resources relies upon the Department's Air Guide-1 (DEC Program Policy DAR -1) to assess the potential for adverse public health impacts from non-criteria pollutants. These are pollutants for which EPA has not established national ambient air quality standards (NAAQS), but have been, nonetheless, identified to pose potential public health concerns. Air Guide-1 analysis is a conservative public health risk screening tool created and used by the Department for the assessment of the risk posed from the inhalation of ambient air toxics. The Air Guide 1 process involves, among other steps, the identification and determination of the emission rates of air toxics from sources under review, the dispersion modeling of these air toxic emissions to predict long term (annual) and short-term (one hour) impacts, and the comparison of these predicted impacts to numerical guideline levels developed to be protective of public health.

The annual ambient guideline concentrations (AGCs) and Short-term Guideline Concentrations (SGCs) contained in Air Guide-1 were developed to be protective of public health and are based upon the most recent toxicological information available. These values were last updated after a comprehensive review by the Department and the New York State Department of Health (NYSDOH) in October 2010. The SGCs were developed to protect the general population from one hour exposures that can result in adverse acute health effects. The AGCs were developed to protect the general population from annual exposures which can result in adverse chronic health effects that include cancer and non-cancer endpoints. These guideline levels are conservative in that these are intended to protect the general public, including sensitive subpopulations, from adverse health effects that may be induced by exposure to ambient air contaminants by using degrees of safety factors. These factors depend on the toxicity of the specific pollutant and whether the effects are expected from short term or long term exposure, including potential for cancer causing effect. The procedures which are used by the Department to derive these guidelines are contained in Appendix C of the DEC Air Guide-1.

The AGCs are based on the most conservative cancer or non-cancer annual exposure limits. AGCs used to assess the risk for non-cancer effects are based on reference concentrations. USEPA has defined a reference concentration as an estimate of continuous inhalation exposure to the human population, including sensitive subgroups such as children, that is likely to be without an appreciable risk of deleterious effects during a lifetime of exposure. Certain of these reference concentrations have large uncertainties due to the nature and paucity of available data. On the other hand, the Air Guide-1 AGCs derived from cancer studies are defined as a chemical concentration in air that is associated with an estimated excess lifetime human cancer risk of one per one-million people (1×10^{-6}). A risk level of 1 in a million implies a likelihood that one person, out of one million equally exposed people, would contract cancer if exposed continuously (24 hours per day) to that specific concentration over 70 years (an assumed lifetime). This risk would be an excess cancer risk that is in addition to any cancer risk borne by a person not exposed to these air toxics.

As a comparison, the acceptable cancer risk used by the USEPA to make regulatory decisions about the need for further air pollution reductions for sources regulated under the 1990 Clean Air Act is 100-in-a-million (1×10^{-4}). The acceptable cancer risk used by the Department’s Division of Air Resources to make regulatory permitting decisions about the need to consider further air pollution controls ranges from 1 to 10-in-a-million. Thus, the Department is using cancer risk values which are more protective than EPA. These decisions, however, are based on case specific information to assess the acceptability of proposed source’s emissions during the permitting or SEQRA process, and are not just a bright line between air levels that cause health effects and those that do not.

Similarly, levels of “safety factors” are used by DAR’s Air Guide 1 to derive 1 hour short term guideline concentrations (SGCs). For many of these SGCs, a minimum factor of about ten is used to drive the thresholds deemed acceptable in the general populations from the levels which have been determined acceptable to workers at facilities. This level of conservatism is used by the Department to also protect the sensitive in the population.