Natural Gas Development: Extracting Externalities – Towards Precaution-Based Decision-Making

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In recent years, natural gas has become an increasingly important energy resource throughout North America. As demand for natural gas continues to rise, the continent has experienced an unprecedented expansion in the resource's extraction and development. This increase in development activities has given rise to the potential for greater adverse environmental and human health impacts. Only recently have comprehensive studies evaluating the potential environmental and health effects of extraction techniques, including hydraulic fracturing, begun to be published; there is now compelling evidence that natural gas development poses significant threats to the environment and to human health. Despite these emerging studies, there continues to be considerable informational gaps regarding increases in air pollution, contamination of water resources from the complex mixture of chemicals used in natural gas development, and the subsequent adverse effects on ecosystems and the health of humans and other species. These gaps in information make effective regulation of development activities difficult to achieve. Faced with growing public concern regarding the environmental contamination associated with natural gas development, many states, provinces, and municipalities across the United States and Canada have begun to implement precautionary-based moratoriums and other preventative legislative and regulatory measures to protect communities against probable adverse effects. Preventative approaches have varied greatly, from modification of municipal zoning laws to state- and provincial-level moratoriums on hydraulic fracturing, or in the case of the Province of Quebec, an anticipated halt to all future shale gas development activities. While there may be no one-size-fits-all solution appropriate for all jurisdictions, we argue that successful and effective regulation of the industry may prove impossible without greater understanding of the interaction between development, exploration, the environment, and human health. Currently, we are far from comprehending the full extent to which unprecedented natural gas development is affecting the environment. Hence, we maintain that moratoriums on natural gas development are necessary until such time it can be determined that the activity will not present significant risks to human health, ecosystems, and the surrounding environment.

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Ces dernières années, le gaz naturel est devenu une importante ressource énergétique en Amérique du Nord. Tandis que la demande est en pleine expansion, le continent a aussi vu accroître l'extraction et le développement de cette ressource. L'essor du gaz naturel a engendré la possibilité impacts négatifs majeurs sur l'environnement et sur notre santé. Ce n'est que récemment qu'ont commencé à être publiées des études exhaustives évaluant les effets potentiels des techniques d'extractions, incluant la fracturation hydraulique, sur l'environnement et sur la santé. Malgré ces nouvelles études, nous avons encore trop peu d'informations sur les effets que cela pourrait avoir sur la pollution de l'air, sur la contamination des sources d'eau par les mélanges chimiques complexes utilisés pour l'extraction des gaz naturels, et subséquemment, sur l'impact négatif que cela aurait sur les écosystèmes et la santé des êtres humains et d'autres espèces vivantes. Ce manque d'information rend difficile la mise en place de régulations efficaces dans le développement de ces activités. Face à l'inquiétude grandissante du public quant à la contamination de l'environnement associée à l'exploitation des gaz naturels, de nombreux états, provinces et municipalités aux États-Unis et au Canada, se basant sur le principe de précaution, ont commencé à mettre en place des moratoires, des mesures législatives et d'autres réglementations préventives afin de protéger les communautés d'effets dommageables probables. Cette approche préventive varie de la modification des règles municipales de zonage aux moratoires provinciaux sur la fracturation hydraulique, ou, dans le cas du Québec, l'interdiction prévue du développement de toute activité future liée aux gaz de schiste. Bien qu'il n'y ait probablement pas de solution unique pour toutes ces juridictions, nous considérons qu'une réglementation efficace et réussie de cette industrie serait impossible sans une meilleure compréhension de l'interaction entre le développement, la recherche, l'environnement et notre santé. Nous n'avons pour le moment que trop peu d'informations sur l'effet total qu'aurait sur l'environnement cette exploitation sans précédent des gaz naturels. Dès lors, nous soutenons qu'il est nécessaire de créer des moratoires sur l'exploitation de ces gaz naturels jusqu'à ce qu'il puisse être déterminé que cela ne présentera pas de risque significatif pour la santé des êtres humains, les écosystèmes et l'environnement.

In 2001, during a commencement speech to graduating students from the Fletcher School of Law and Diplomacy at Tufts University, Kofi Annan, former Secretary General of the United Nations ("UN"), stated: "[c]ontrary to popular belief, we do not face a choice between economy and ecology. It is often said that protecting the environment would constrain or even undermine economic growth. In fact, the opposite is true: unless we protect resources and the Earth's natural capital, we shall not be able to sustain economic growth."[1] The statement by Mr. Annan highlights an impervious paradigm in the North American psyche: that protection of the environment equates to constrained economic development and decreased overall wealth. Economic growth and environmental protection, it is often surmised, cannot be reconciled. The argument suggests that if development activities are too heavily regulated, then nation-states and their citizens may lose out on jobs, higher standards of living, and general prosperity. However, as Mr. Annan so eloquently affirms, sustaining a modicum of economic activity can only be possible if we also maintain the integrity of those most valuable resources, "the Earth's natural capital,"[2] for instance water, viable soil, and clean, breathable air. Such resources allow for the very continuance of life and nurture humanity so that civilizations may flourish. Akin to those "physiological needs" found within Maslow's hierarchy,[3] the planet naturally provides those basic sources of sustenance (e.g., air, water, food) that then allow for life's greater pursuits, including economic development.

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1 Kofi Annan, "Containing Climate Change: A Global Challenge", (Commencement Address, delivered at the Fletcher School of Law and Diplomacy, Tufts University, 20 May 2001), (2001) 25:2 The Fletcher F World Aff 5 at 7.

2 *Ibid*.

3 AH Maslow, "A Theory of Human Motivation" (1943) 50:4 Psychological Review 370 at 373-74.

In our world today, the natural resources of oil and gas could arguably be said to play a pivotal, if not crucial role in our lives, meeting what we now consider basic needs. Natural gas, the subject of this article, provides electricity, heating, cooking fuel, transportation, lighting, and more throughout the North American continent.[4] Yet, even with the energy benefits of natural gas and its reputation for being "the cleanest of all the fossil fuels,"[5] extraction of the resource is associated with a number of significant environmental and health risks.[6] Despite these risks, a regulatory disconnect in both the United States ("US") and Canada has occurred between the development of natural gas and the protection of essential natural resources (e.g., water), human health, and the environment. Even with newly-emerging legislation to regulate natural gas development, the environmental and health effects of drilling in sensitive areas, such as being close to human populations, agriculture, or essential ecosystems, are still poorly understood. Specifically, there has been insufficient research conducted to analyze the immediate and cumulative environmental and health effects of the process of hydraulic fracturing, also called hydrofracking or fracking, within natural gas wells. Ever-emerging reports now indicate that hydraulic fracturing indeed poses considerable risks to potable water supplies and human health, and may even be a significant contributor to global warming.[7]

Knowing intuitively, as we do, that the preservation of life on Earth requires a clean and healthy environment, it is clearly impossible to support the notion that energy, above all else, is so valuable that it is worth risking the fundamental resources that sustain us. In this scenario, there is no room for a cost-benefit analysis between industry, environment, and human health. Nor is it appropriate to balance (in monetary terms) human life, ecosystems, and the natural world against energy consumption and economic growth. Yet in North America, we consistently see that extractive sector development is favored over precaution and the protection of human health and the environment: a cart before the horse scenario. In our steadfast quest for energy acquisition, we have continually neglected the principles of precaution and responsible development. We have opted instead to pursue rapid and widespread resource extraction, mitigating environmental and health hazards as they arise.

In this article, we contend that additional comprehensive, peer reviewed studies are required in order to effectively regulate, mitigate, and ultimately prevent adverse environmental and health effects of natural gas development. In light of the highly suggestive data[8] to indicate that there are significant environmental and health problems associated with natural gas development, and even though there are informational shortcomings, we argue that moratoriums on all hydraulic fracturing activities, as well as any further drilling and exploration are

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4 Natural Gas Supply Association, *Uses of Natural Gas*, online: NaturalGas.org <http://www.naturalgas.org>.

5 Natural Gas Supply Association, *Natural Gas and the Environment*, online: NaturalGas.org <http://www.naturalgas.org>.

6 EPA Clean Energy, *Natural Gas*, online: US Environmental Protection Agency <http://www.epa.gov>.

7 See e.g. "Documents: Natural Gas's Toxic Waste", *The New York Times* (26 February 2011), online: The New York Times <http://www.nytimes.com> [Documents]; Robert W Howarth, Renee Santoro & Anthony Ingraffea, "Methane and the Greenhouse-Gas Footprint of Natural Gas from Shale Formations" (2011) 106 Climatic Change 679 [Howarth, Santoro & Ingraffea 2011]; Theo Colborn et al, "Natural Gas Operations from a Public Health Perspective" (2011) 17:5 Human and Ecological Risk Assessment 1039.

8 See Section 3 at 164.

needed.[9] While we recognize the importance of natural gas as an energy resource, we argue that successful and effective regulation of the industry may prove impossible without greater understanding of the interaction between development, exploration, and the environment. We abstain from using a cost-benefit analysis (i.e., monetizing all costs and benefits in comparing alternative technologies and policies) to determine whether precaution, via the implementation of moratoriums on development, must be exercised. We instead contend that moratoriums are the only way to prevent costly externalities that include extensive contamination and overuse of valuable potable water resources, land contamination, increased seismic activity, and other effects.

We base our proposal for natural gas development moratoriums on the well-established and widely accepted precautionary principle.[10] Recognized to varying degrees in both Canada and the US,[11] the principle demands precautionary measures "even if some cause and effect relationships are not fully established scientifically."[12] Although multiple variations of the precautionary principle exist, we advocate use of the 2001 *Lowell Statement on Science and the Precautionary Principle* ("*Lowell Statement*"),[13] with consideration also to the 1998 *Wingspread Consensus Statement on the Precautionary Principle*[14] and the concepts found within the 1997 *Declaration on the Responsibilities of the Present Generations Towards Future Generations*.[15] These documents, including the principles found within them, provide the substantial foundation for our assertion that because natural gas development poses considerable risks to human health and the environment, many of which remain unknown or as yet proven definitively, a moratorium on extraction and development activities must occur. If we choose to merely claim adherence to precautionary ideals within our domestic and international laws without manifestly conforming to the principles, we leave ourselves vulnerable to a future of unknown, and possibly severe, environmental contamination with health effects that may linger for decades.

This article is divided into four sections. Section 2 provides the underlying theoretical framework for our argument, situating the *Lowell Statement* as our central point of reference when considering the primary justifications for development moratoriums. Section 3 presents an overview of the human health and environmental hazards that are present in natural gas development activities, with additional consideration to the practice of hydraulic fracturing. In

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9 Although we advocate for greater, comprehensive research of natural gas development and the implementation of precautionary moratoriums in the interim, we also acknowledge that the use of hydraulic fracturing and other resource extraction techniques may still be necessary on a small, controlled scale for the purposes of study.

10 Further discussion of the precautionary principle and its acceptance within international environmental law will be found at 8, below.

11 Further discussion of the precautionary principle's use within Canadian and American law will be found at 164-67, below.

12 Precautionary Principle, *The Wingspread Consensus Statement on the Precautionary Principle* (26 January 1998), online: Science and Environmental Health Network <http://www.sehn.org> [*Wingspread*].

13 International Summit on Science and the Precautionary Principle, *Lowell Statement on Science and the Precautionary Principle* (17 December 2001), online: Lowell Center for Sustainable Production <http://www.sustainableproduction.org> [*Lowell Statement*].

14 *Wingspread*, *supra* note 12.

15 *Declaration on the Responsibilities of the Present Generations Towards Future Generations*, 29 C/Res 31, UNESCOR, 29th Sess, Supp No 44, (1997) 69 [*Declaration*].

this section, we examine the epidemiology and toxicology related to exposures from complex chemical mixtures arising from hydraulic fracturing, taking into account existing informational gaps. Section 4 offers an overarching analysis of hydraulic fracturing and natural gas development moratorium efforts. This section considers the role of precaution in guiding municipalities, states, and provinces in their attempts to implement moratoriums or other preventative measures on development activities.

2. THE PRECAUTIONARY PRINCIPLE: A PRIMER

2.1 Precautionary Principle Defined

The role of the precautionary principle in the context of natural gas development is an essential consideration to the legal rationales behind implementing moratoriums on hydraulic fracturing and natural gas development, generally. Principle 15 of the 1992 *Rio Declaration on Environment and Development* ("*Rio Declaration*") expresses one of the most widely-accepted definitions[16] of the precautionary principle in environmental matters, stating: "[i]n order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. *Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation*."[17] Although the *Rio Declaration*'s characterization of the precautionary principle is not legally binding upon signatory nation-states,[18] the Principle establishes a uniform "consensus" that precaution need be exercised in matters of development and potential environmental harm.[19]

Alternative versions of the precautionary principle exist and the *Lowell Statement* is arguably better suited to the environmental and health concerns surrounding natural gas development. Issued in December of 2001, the *Lowell Statement* calls "for the recognition of the precautionary principle as a key component of environmental and health policy decision-making, particularly when complex and uncertain threats must be addressed."[20] The *Statement* advocates precautionary "action on early warnings … even if the exact nature and magnitude of the harm are not fully understood," as well as "application of transparent and inclusive decision-making processes that increase the participation of all stakeholders and communities,

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16 Claudia Saladin, "Precautionary Principle in International Law" (2000) 6:4 International Journal of Occupational and Environmental Health 270 at 273; Joakim Zander, *The Application of the Precautionary Principle in Practice: Comparative Dimensions* (Cambridge: Cambridge University Press, 2010) at 36-37; John S Applegate, "The Precautionary Preference: An American Perspective on the Precautionary Principle" (2000) 6:3 Human and Ecological Risk Assessment 413 at 414-15.

17 UNCED, *Rio Declaration on Environment and Development*, UN Doc A/CONF.151/5/Rev.1 (1992), 31 ILM 874 (1992), Principle 15 [*Rio Declaration*] (emphasis added); David Hunter, James Salzman & Durwood Zaelke, *International Environmental Law and Policy*, 3rd ed (Foundation Press, 2007) ("[t]he *Rio Declaration* may be understood as a bargain between the affluent North concerned with global environmental problems and the poor South concerned primarily with development questions" at 189). Hunter, Salzman, and Zaelke's characterization, though perhaps overly simplistic, highlights the fact that the *Rio Declaration* was highly qualified and extremely politicized.

18 Hunter, Salzman & Zaelke, *supra* note 17 at 189.

19 *Ibid* at 190.

20 *Lowell Statement*, *supra* note 13.

particularly those potentially affected by a policy choice."[21] The *Lowell Statement* acknowledges existing scientific limitations and the uncertainties surrounding environmental and human health effects of development activities; however, the *Statement* asserts "that waiting for incontrovertible scientific evidence of harm before preventive action is taken can increase the risk of costly mistakes that can cause serious and irreversible harm not only to ecosystem and human health and well-being, but also to the economy."[22] For these reasons, the *Lowell Statement* is a compelling version of the precautionary principle for the purposes of assessing concerns surrounding natural gas development.

The 1998 *Wingspread Consensus Statement on the Precautionary Principle* ("*Wingspread Statement*"), much like the *Lowell Statement*, advocates an open, inclusive, and democratic approach to implementation of the precautionary principle: "[t]he process of applying the Precautionary Principle must be open, informed and democratic and must include potentially affected parties."[23] Such an approach implies increased public access to information,[24] open and public forums prior to decision- and rule-making, and greater overall transparency in administrative, legislative, and regulatory processes.[25] Included in the *Lowell Statement* is the understanding that protective regulatory decisions regarding development activities must often be made despite existing informational gaps and imperfect scientific certainty.[26] The *Lowell Statement* asserts that "[d]ecision-makers frequently look for high levels of proof of causal links between a technology and a risk before acting, so that their decisions will be protected from accusations of being arbitrary."[27] As is characteristic of many high risk development activities, however, science is far from understanding the comprehensive, far-reaching effects of natural gas development upon human health and the environment. Nor may science provide an understanding of these effects in the immediate future, but the *Lowell Statement* astutely reaffirms the logical notion that "not knowing whether an action is harmful *is not the same thing* as knowing that it is safe."[28]

A final, important component of the *Lowell Statement* places the onus of precautionary responsibility upon the "originators of potentially dangerous activities."[29] Thus, the developer, not the public, is tasked with proving an activity (in this case, resource extraction) has been

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21 *Ibid*.

22 *Ibid*.

23 *Wingspread*, *supra* note 12.

24 Access to information is one of the major obstacles to comprehensive, peer reviewed studies of the environmental and health effects of natural gas development. Further discussion of existing informational gaps is found at pages 171-72, below.

25 Transparency is an issue that often plagues the natural gas industry. See e.g. Lynne Peeples, "Fracking's Toxic Secrets: Lack of Transparency Over Natural Gas Drilling Endangers Public Health, Advocates Say", *The Huffington Post* (21 November 2012), online: The Huffington Post <http://www.huffintonpost.com>; Federal Energy Regulatory Commission, News Release, RM13-1-000/RM12-3-000, "FERC Launches Inquiry to Improve Natural Gas Market Price Transparency" (15 November 2012), online: FERC <http://www.ferc.gov>.

26 *Lowell Statement*, *supra* note 13.

27 *Ibid*.

28 *Ibid* (emphasis added).

29 *Lowell Statement*, *supra* note 13.

adequately and impartially studied, does not present serious threats to human health and the environment, and is being performed with the highest safeguards in place.[30] This component does not negate the responsibility of government and regulators to ensure the public's safety and wellbeing nor does it suggest that the public should not continue to employ due diligence in its monitoring of development activities. Yet, shifting the "burden of proof"[31] would presumably require the extractive sector to demonstrate, through an assortment of objective, transparent, and peer-reviewed studies, that a particular development activity did not pose significant threats to the environment and human health and could be conducted in a way that minimizes risk.

In contemplating application of the precautionary principle to development activities, the preferred method recognizes the concept that "[p]recaution is a principle of justice, that no one should have to live with fear of harm to their health and environment."[32] Though the ideals of justice are not the subject of this article, it should be noted that concepts of justice may often be informed by society and may also be a reflection of a culture's values and moral code.[33] As a result, the argument could be made that within certain societies, justice is better served by the protection of economic interests over human health and environment or vice versa. However, the more customary approach, largely recognized throughout international law, establishes that "environment and human rights are intrinsically linked, and … environmental degradation leads to poverty and human indignity."[34] This approach highlights the social and economic inequities that may result when otherwise healthy, livable environments are allowed to become contaminated and uninhabitable. If we accept the existence of this innate, correlative relationship between human life and the environment, then the role of precaution in development activities demands contemplation without conducting (and basing conclusions upon) a dubious cost-benefit analysis of economic factors against the immeasurable human life and natural world.

We thus do not seek, or attempt here, to undertake a cost-benefit analysis in order to assess which regulatory responses are appropriate for natural gas development. Such an endeavor would entail considering the uses of natural gas as a feedstock and energy source mainly for producing electricity and thus would require a comparison of all of the alternatives for these uses, including estimating damages for all externalities. This endeavor would also require assuming that hydraulic fracturing should not be undertaken if the costs outweigh the benefits. This approach presumes that one can not only create a complete inventory of items that may be affected through time, but that one can also assign monetary values to all of the damages, including non-market goods like human health. Weighing economic considerations against

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30 *Ibid*.

31 *Wingspread*, *supra* note 12.

32 Joel Tickner, Carolyn Raffensperger & Nancy Myers, *The Precautionary Principle in Action: A Handbook*, 1st ed (1999) at 15, online: Lowell Center for Sustainable Production <http://www.sustainableproduction.org>.

33 Matthew Alan Cahn & Rory O'Brien, *Thinking About the Environment: Readings on Politics, Property, and the Physical World* (Armonk, NY: M.E. Sharpe, 1996) at 57.

34 Jona Razzaque, "Right to a Healthy Environment in Human Rights Law" in Mashood A Baderin & Manisuli Ssenyonjo, eds, *International Human Rights Law: Six Decades After the UDHR and Beyond* (Surrey: Ashgate Publishing Group, 2010) at 115.

human life and the environment, with the assumption that each represents a good or service from which a quantifiable value may be ascertained is, in our view, an undesirable approach to determining the need to exercise precaution.[35]

Clearly, implementation of the precautionary principle presents several challenges. In application and theory, the principle contains a number of flaws. The principle lacks a congruent environmental ethic, meaning those values that are attached to the relationship between the environment, humanity, health, economics, and other aspects of the natural and artificial world.[36] As indicated above, if we apply an environmental ethic that places energy needs above all other considerations, the precautionary principle may be utilized to invoke a cost-benefit analysis. Potential adverse environmental and health effects will be balanced against the perceived greater need for energy development and consumption. Conversely, if the ethic is to place environmental considerations as supreme, the precautionary principle may presuppose a complete halt to all development activities lest environmental damage occur. Thus, the precautionary principle will be construed and applied differently throughout the world by industry, governments, communities, and individuals, as according to each set of unique needs and value systems.

In relation to natural gas development and precaution, the *Lowell Statement* is comprised of essential components that convey an arguably more balanced environmental ethic: "[t]he goal of precaution is to prevent harm, not to prevent progress. We believe that applying precautionary policies can foster innovation in better materials, safer products, and alternative production processes." Simply, the *Statement* allows room for both progress and precautionary prevention. The *Statement* contains other desirable objectives as well, including "upholding the basic right of each individual (and future generations) to a healthy, life-sustaining environment" and advocating for "action on early warnings, when there is credible evidence that harm is occurring or likely to occur." Collectively, these elements are significant to the *Lowell Statement's* attractiveness as a robust and meaningful construction of the precautionary principle as applied to natural gas development.

The right of future generations to a clean and healthy environment bears mentioning here. As written, the *Lowell Statement* intrinsically recognizes the importance of environmental stewardship in a temporal sense, extending duties of precaution to protect those individuals of the unborn generations. Great debate exists over whether unborn persons actually possess

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35 The concept of payment for ecosystem services is not discussed in this article. For further discussion and critique of the cost-benefit analysis approach see Nicholas A Ashford, "The Legacy of the Precautionary Principle in US Law: The Rise of Cost-Benefit Analysis and Risk Assessment as Undermining Factors in Health, Safety and Environmental Protection" in Nicolas de Sadeleer, ed, *Implementing the Precautionary Principle: Approaches from the Nordic Countries, EU and USA* (London: Earthscan, 2007) 352 at 366; Michael S Baram, "Cost-Benefit Analysis: An Inadequate Basis for Health, Safety, and Environmental Regulatory Decisionmaking (1979-1980) 8 Ecology LQ 473.

36 Andrew Brennan & Yeuk-Sze Lo, "Environmental Ethics" in Edward N Zalta, ed, *The Stanford Encyclopedia of Philosophy* (Fall 2011), online: Stanford Encyclopedia of Philosophy <http://plato.stanford.edu>.

legal rights; however, this topic is outside the scope of our present discussion.[37] Placing existing disagreements aside, the notion that human society would be concerned about the condition of the planet for our progeny is not a new one. In 1997, the General Conference of the United Nations Educational, Scientific and Cultural Organization recognized the rights of future generations by adopting the *Declaration on the Responsibilities of the Present Generations Towards Future Generations*.[38] The *Declaration* covers a montage of topics, from peace to biodiversity to freedom of choice.[39] In the context of development activities, articles 4 and 5, entitled "Preservation of life on Earth" and "Protection of the environment" respectively, place responsibilities on "present generations" toward "future generations" with regard to conservation and sustainable development.[40] In its first line, article 4 states "[t]he present generations have the responsibility to bequeath to future generations an Earth which will not one day be irreversibly damaged by human activity."[41] Article 5 asserts that "present generations should take into account possible consequences for future generations of major projects before these are carried out."[42]

The UN is not the only organization to affirm the right of future generations to a healthy and sustainable Earth. *The Bemidji Statement on Seventh Generation Guardianship*, issued by the Indigenous Environmental Network, confirms "[w]e have the sacred right and obligation to protect the common wealth of our lands and the common health of our people and all our relations for this generation and seven generations to come."[43] Indeed, even selected federal environmental statutes in the US and Canada look directly to the impending needs of future generations as an important policy consideration. For example, according to the *National Environmental Policy Act* ("*NEPA*"), "it is the continuing policy of the Federal Government, in cooperation with State and local governments … to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."[44] In describing its role in "promot[ing] environmental stewardship,"[45] Environment Canada states that "[c]ontinually striving to be world-class is at the core of [the Department's] approach to protecting our envi-

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37 For discussion of the rights of future generations, see e.g. Burns H Weston, "Climate Change and Intergenerational Justice: Foundational Reflections" (2008) 9:3 Vt J Envtl L 375; Ori J Herstein, "The Identity and (Legal) Rights of Future Generations" (2009) 77 Geo Wash L Rev 1173; Axel Gosseries, "On Future Generations' Future Rights" (2008) 16:4 J Polit Philos 446; Science and Environmental Health Network and the International Human Rights Clinic at Harvard Law School, *Models for Protecting the Environment for Future Generations* (October 2008), online: Science and Environmental Health Network <http://www.sehn/org>.

38 *Declaration*, *supra* note 15.

39 *Ibid* at arts 2, 6, 9.

40 *Ibid* at arts 4, 5.

41 *Ibid* at art 4.

42 *Ibid* at art 5(4).

43 Indigenous Environmental Network, *The Bemidji Statement on Seventh Generation Guardianship* (6 July 2006), online: Science and Environmental Health Network <http://www.sehn.org>.

44 US, *The National Environmental Policy Act of 1969*, 42 USC § 4331(a) (2000) [*NEPA*].

45 Environment Canada, *Acts, Regulations and Agreements*, online: Environment Canada <http://www.ec.gc.ca>.

ronment today and for future generations."[46] Similar language referencing the rights of future generations can also be found within various state constitutions and environmental statutes throughout the US.[47]

2.2 Precaution in Practice

In practice, several applications of the precautionary principle currently exist, from full or partial moratoriums on development activities to non-binding legislative and policy guidelines.[48] The full extent to which the principle is applied within American and Canadian regulation and development will not be discussed here. It is important to note, however, that the principle has been incorporated within numerous federal acts in Canada, including the *Federal Sustainable Development Act*[49] and the *Canadian Environmental Protection Act*,[50] among others.[51] According to Environment Canada, "Canada's [federal] environmental policy is guided by the precautionary principle," and the UN Conference on Environment and Development's 1992 *Rio Declaration* has been used as a guiding standard.[52] Unlike Canada, the US has not expressly incorporated the precautionary principle into the language of federal legislation.[53] In the past, decision-making regarding adverse environmental and health effects has often been carried out as a reactionary response[54] or following the completion of cost-benefit analyses.[55] Nevertheless,

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46 *Ibid*.

47 See e.g. Cal Pub Res Code § 21001 (c), (e) (2011); Mont Code Ann § 75-1-103 (2011); IL Const art XI, § 1; Hawaii Const art XI, § 1.

48 Catherine Tinker, "Responsibility for Biological Diversity Conservation Under International Law" (1995) 28 Vand J Transnat'l L 777 at 794, 804.

49 *Federal Sustainable Development Act*, SC 2008, c 33, s 9(1) ("[T]he Minister shall develop … a Federal Sustainable Development Strategy based on the Precautionary Principle").

50 *Canadian Environmental Protection Act*, 1999, SC 1999, c 33, Preamble, ss 2(1)(a), 6(1.1), 76.1.

51 See e.g. *Oceans Act*, SC 1996, c 31, Preamble ("[whereas] Canada promotes the wide application of the precautionary approach to the conservation, management and exploitation of marine resources"), s 30(c) ("[t]he national strategy will be based on the principles of … the precautionary approach, that is, erring on the side of caution"); Bob Boulden et al, *Regional Environmental Effects Framework* (2000) at 11, online: Canadian Environmental Assessment Agency <http://www.publications.gc.ca>.

52 Environment Canada Sustainable Development, *Planning for a Sustainable Future: A Federal Sustainable Development Strategy for Canada* (October 2010) at 7, online: Environment Canada <http://www.ec.gc.ca>.

53 Zander, *supra* note 16 at 268-69.

54 Robert V Percival, "Who's Afraid of the Precautionary Principle?" (2006) 23 Pace Envtl L Rev 21 at 22.

55 See Baram, *supra* note 35 at 479-81 (cost-benefit analyses may continue to be used by federal environmental regulators throughout the US. In 2009, the US Supreme Court held that the EPA was justified in using a cost-benefit analysis when promulgating regulations under § 316(b) of the *Clean Water Act*. *Entergy Corp v Riverkeeper, Inc*, 556 US 208 (2009)).

elements of the principle are found within various US federal environmental statutes, such as the *NEPA*[56] and the *Endangered Species Act*.[57]

Both Canada and the US also employ the use of environmental assessments and/or environmental impact statements prior to commencing many development projects.[58] Environmental assessments and impact statements are precautionary in nature and, as stated, are ideally prepared before a development activity has begun. Canada and the US each have different standards to trigger the use of assessments and impact statements, which can occur simultaneously on federal, and state or provincial levels. According to the US Environmental Protection Agency ("the EPA," also referred to as "the agency"), environmental impact statements are "prepared for projects that the proposing agency views as having significant prospective environmental impacts."[59] The impact statement "should provide a discussion of significant environmental impacts and reasonable alternatives … which would avoid or minimize adverse impacts or enhance the quality of the human environment."[60] The *Canadian Environmental Assessment Act* ("*CEAA*") includes as one of its primary purposes the goal "to ensure that designated projects … are considered in a careful and precautionary manner to avoid significant adverse environmental effects."[61]

Given the prevalence of precautionary-based federal environmental statutes within both Canada and the US, it is unsurprising that Canadian provinces and US states have begun to apply the precautionary principle to development activities on a provincial, state, and most

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56 *NEPA*, *supra* note 44 at § 4331 (a) ("[t]he Congress, recognizing the profound impact of man"s activity on the interrelations of all components of the natural environment … and recognizing further the critical importance of restoring and maintaining environmental quality to the overall welfare and development of man, declares that it is the continuing policy of the Federal Government … to use all practicable means and measures … to foster and promote the general welfare, to create … conditions under which man and nature can exist in productive harmony"); *ibid* at § 4331 (c) ("[t]he Congress recognizes that each person should enjoy a healthful environment and that each person has a responsibility to contribute to the preservation and enhancement of the environment").

57 *Endangered Species Act of 1973*, 16 USC § 1531(a)(5) (2002) ("[t]he Congress finds and declares that … encouraging the States and other interested parties … to develop and maintain conservation programs which meet national and international standards is a key to … better safeguarding, for the benefit of all citizens, the Nation's heritage of fish, wildlife, and plants").

58 See e.g. *Canadian Environmental Assessment Act, 2012*, SC 2012, c 19 s 52 [*CEAA*]; *NEPA Regulations*, 40 CFR § 1501.2-1501.4 (1978).

59 EPA Mid-Atlantic Region, *Environmental Assessments & Environmental Impact Statements*, online: US Environmental Protection Agency <http://www.epa.gov>.

60 *Ibid*.

61 *CEAA*, *supra* note 58 at s 4(1)(b).

notably at the municipal level.[62] In 2003, the City of San Francisco, California amended its environment code by adding the *Precautionary Principle Policy Statement* ("*Policy Statement*"), a five-part codification of the precautionary principle, which applies to all of the municipality's future development decision-making.[63] The *Policy Statement* affirms "an equal right to a healthy and safe environment"[64] and utilizes "the Precautionary Principle … as a policy framework to develop and implement laws for a healthier and more just San Francisco."[65] In the Province of Quebec, the precautionary principle has been directly incorporated into provincial legislation, including the *Sustainable Development Act*[66] and the *Environment Quality Act*.[67] The principle is also implied, though not explicitly stated, in Quebec's *An Act to Affirm the Collective Nature of Water Resources and Provide for Increased Water Resource Protection*.[68]

The Supreme Court of Canada has also endorsed the use of the precautionary principle within municipal legislation, as was seen in the 2001 case *114957 Canada Ltée (Spraytech, Société d'arrosage) v Hudson (Town of)*.[69] The case involved two landscaping and lawn care companies (Spraytech and Chemlawn, the "companies") and the Town of Hudson, a municipality located just west of Montreal, Quebec.[70] The Town, having adopted a bylaw restricting the use of cosmetic pesticides, issued a summons to the companies, citing a violation of the

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62 As a general rule, Canadian provinces have exclusive, constitutionally protected jurisdiction over the "exploration," "development, conservation and management" of non-renewable natural resources (*Constitution Act, 1867* (UK), 30 & 31 Vict, c 3, s 92A, reprinted in RSC 1985, App II, No 5 at s 92(A)). There have been exceptions to this rule as illustrated by the controversial 1980 National Energy Program which provided, among other provisions, the federal government "a 25% interest in all existing and future petroleum rights on Canada Lands." (Thomas J Courchene, "Energy Prices, Equalization and Canadian Federalism: Comparing Canada's Energy Price Shocks" (2006) 31 Queen's LJ 644 at 660). By 1984, the National Energy Program was essentially dismantled (*ibid* at 661). In the US, oil and natural gas regulation is accomplished through a combination of state and federal regulations. See e.g. EPA, *Oil and Gas Extractive Sector (NAICS 211)*, online: US Environmental Protection Agency <http://www.epa.gov>; FERC, Natural Gas, online: Federal Energy Regulatory Commission <http:// www.ferc.gov>; COGCC, Amended Rules, online: Colorado Oil and Gas Commission <http://www.cogcc.state.co.us>; *Oklahoma Corporation Commission*, online: Oklahoma Corporation Commission <http://www/occ.state.ok.uk>; *Alabama Oil and Gas Board*, online: Geological Survey of Alabama <http://www.gsa.state.al.us>.

63 US, San Francisco, *Environment Code*, c 1 § 100-104 (2003), online: American Legal Publishing Corporation <http://www.amlegal.com/library/ca/sfrancisco.shtml>.

64 *Ibid* at § 100(a).

65 *Ibid* at § 100(d).

66 *Sustainable Development Act*, RSQ 2006, c D-8.1.1 s 6(j) ("[w]hen there are threats of serious or irreversible damage, lack of full scientific certainty must not be used as a reason for postponing the adoption of effective measures to prevent environmental degradation").

67 *Environment Quality Act*, RSQ 2009, c Q-2 s 31.102 ("[t]he Minister must conduct an assessment of the cumulative impacts of water withdrawals and consumptive uses. The assessment must evaluate the application of the prevention principle and the precautionary principle").

68 *An Act to Affirm the Collective Nature of Water Resources and Provide for Increased Water Resource Protection*, RSQ 2009, c C-6.2, Preamble ("[as] water is indispensable to life and is a vulnerable and exhaustible resource … it is important to preserve water and improve water management to meet the needs of present and future generations").

69 2001 SCC 40, [2001] 2 SCR 241 [*Spraytech*].

70 *Ibid* at paras 5-6.

newly adopted ordinance.[71] In considering the Town of Hudson's authority to regulate the use of pesticides within its perimeters and to "improve the health of the Town's inhabitants,"[72] the court noted that "to permit the Town to regulate pesticide use is consistent with principles of international law and policy."[73] The bylaw, the court determined, "respect[ed] international law's 'precautionary principle'" and "[i]n the context of the precautionary principle's tenets, the Town's concerns about pesticides fit well under their rubric of preventive action."[74] Though the court's focus in *Spraytech* was upon the use and regulation of pesticides, the majority's comments in obiter dicta are encouraging for proponents of the precautionary principle's use in Canadian natural gas development activities. The court, in citing several scholarly articles regarding the precautionary principle's widespread incorporation within statutes and treaties worldwide, supported the notion that "there may be 'currently sufficient state practice to allow a good argument that the precautionary principle is a principle of customary international law.'"[75] Hypothetically, inclusion of the precautionary principle into that group of laws that comprise customary norms would create a more definitive obligation upon nation-states to include the principles of precaution in all future planning and development—an inspiring, though seemingly unrealistic notion at present. The court's discussion in *Spraytech*, however, may be one step in the right direction.

3. EXTRACTING EXTERNALITIES: IGNORANCE IS NOT BLISS

Widespread controversy surrounds the use of hydraulic fracturing in natural gas extraction. Natural gas drilling occurs near, and oftentimes through, subterranean water aquifers.[76] Many coal bed methane basins in the US are located within or adjacent to an underground source of drinking water,[77] creating a high risk for water contamination. In addition to the risks to potable water resources, natural gas development may cause significant air and land contamination issues. Through migration of contaminants and emissions released during well construction and operation, natural gas development poses considerable risks to human health and the environment. The following sections provide a synopsis of the existing and potential health and environmental concerns associated with increased natural gas development. These concerns—notwithstanding informational gaps—make evident the rationale for precaution behind the call for natural gas development moratoriums.

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71 *Ibid* at paras 6-7.

72 *Ibid* at para 29.

73 *Ibid* at para 30.

74 *Ibid* at paras 31-32.

75 *Ibid* at para 32.

76 EPA Water: Hydraulic Fracturing, *Evaluation of Impacts to Underground Sources of Drinking Water by Hydraulic Fracturing of Coalbed Methane Reservoirs Study* (2004), 1-1, 5-2, 5-14, online: US Environmental Protection Agency <http://www.epa.gov> [*Impacts to USDW*].

77 *Ibid* at 5-14, ES-7.

3.1 Environmental Effects: An Overview

Hydraulic fracturing is an extraction process used to increase the flow and production of natural gas wells.[78] The process involves pumping, under high pressure, "fracturing fluid" deep into gas wells, thereby creating fractures within rock beds.[79] The underground fractures create channels which allow trapped gas to escape up to a well's surface.[80] Used commercially since the late 1940s, hydrofracking has been traditionally employed to stimulate well production.[81] Today, with the advent of new technologies and attempts to increase production, hydraulic fracturing is used in nearly all natural gas operations in Canada and the US.[82] In 2009, in the US alone, there were over 493,000 producing natural gas wells.[83] As of 2010, the US was estimated to be the largest producer of natural gas on the planet.[84] According to these estimates, Canada was the fourth largest producer, behind Russia and the European Union.[85]

The fracking process employs a multitude of toxic and carcinogenic substances, many of which may seep into underground aquifers or into nearby water systems. There are several pathways through which water contamination may occur: substandard waste disposal practices in which toxins seep into water supplies,[86] faulty well construction or improperly sealed wells,[87] and through transport of contaminants via fractured subsurface formations (e.g., shale rock).[88] Methane, which is explosive and an asphyxiant, is one of the primary components of natural gas and it may also enter groundwater supplies during drilling and extraction.[89] In

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78 Independent Petroleum Association of America, *Hydraulic Fracturing: Effects on Energy Supply, the Economy, and the Environment* (April 2008), online: Energy in Depth <http://www.energyindepth.org>.

79 *Ibid*.

80 *Ibid*.

81 American Oil & Gas Historical Society, Shooters – *A "Fracking" History*, online: American Oil & Gas Historical Society <http://www.aoghs.org>.

82 CSUG, *Understanding Hydraulic Fracturing*, online: Canadian Society for Unconventional Gas <http://www.csug.ca>.

83 EIA, *Number of Producing Gas Wells*, online: US Energy Information Administration <http://www.eia.gov>.

84 CIA, *Country Comparison: Natural Gas – Production*, online: Central Intelligence Agency <http://www.cia.gov> [CIA].

85 *Ibid*.

86 Ian Urbina, "Regulation Lax as Gas Wells' Tainted Water Hits Rivers", *The New York Times* (26 February 2011), online: The New York Times <http://www.nytimes.com>.

87 Russell Gold, "Faulty Wells, Not Fracking, Blamed for Water Pollution", *The Wall Street Journal* (25 March 2012), online: The Wall Street Journal <http://www.wsj.com>.

88 Tom Myers, "Potential Contaminant Pathways from Hydraulically Fractured Shale to Aquifers" (2012) 50:6 Groundwater 872 at 880; Intermountain Oil and Gas BMP Project, *Coalbed Methane*, online: Getches Wilkinson Center for Natural Resources, Energy, and the Environment <http://www.oilandgasbmps.org>. The Myers study was funded by the Catskill Mountainkeeper and the Park Foundation, both "outspoken opponents of hydraulic fracturing operations," and has been criticised by some as being impartial (Taylor Kuykendall, "Study Opposes Assumption Frack Fluid Can't Migrate to Surface", *The State Journal* (3 May 2012), online: The State Journal <http://www.statejournal.com>).

89 Stephen G Osborn et al, "Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing" (2011) 108:20 Proceedings of the National Academy of Sciences 8172 at 8173, online: Proceedings of the National Academy of Sciences <http://www.pnas.org>.

addition to concerns over water contamination, natural gas development is accompanied by significant externalities pertaining to use and shortages of water, air pollution, accidents caused by extreme weather conditions, and the consequent adverse effects on the health of humans, other species, and ecosystems.

In February 2011, the *New York Times* published over 1,000 pages of state and federal documents detailing existing and potential environmental impacts of natural gas development in the US.[90] The publications included field surveys, documents from various state and federal agencies, EPA briefings, as well as leaked reports describing the EPA's growing concern over contamination of underground sources of drinking water.[91] We address only those documents most illustrative of the increasing environmental and health concerns associated with natural gas development. These concerns have been documented by both state and federal agencies, the severity of which has been recognized by the EPA, as discussed in the paragraphs below.

In a 2010 leaked document concerning the EPA's national compliance and enforcement strategy, the EPA stated, "[e]nvironmental impacts caused by energy extraction activities are significant. As oil and gas development encroach on suburban and urban areas, human health and environmental impacts are expected to escalate."[92] The report made clear that the risks of contamination are present in all areas of natural gas development, including contamination of "surface water, groundwater, air, and surface media."[93] Environmental pollution during natural gas operations may occur for a multitude of reasons. Emissions released to the ambient air and contamination of aquifers and soil during the construction and operation of wells is often unavoidable. Other forms of surface and subsurface contamination may result from faulty equipment, improper waste disposal and management, or negligence.[94]

Natural gas development has also been linked to increased seismic activity and the EPA's report noted that such activity is of growing concern.[95] The recent release of a National Research Council report entitled *Induced Seismicity Potential in Energy Technologies*[96] substantiated that "[h]ydraulic fracturing to date has been confirmed as the cause for small, felt seismic events at one location in the world."[97] The report also stated that "water injection for disposal

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90 Documents, *supra* note 7.

91 *Ibid*.

92 *Ibid* at 1.

93 *Ibid* at 3.

94 *Ibid*.

95 Ibid at 3. See also Henry Fountain, "Add Quakes to Rumblings over Gas Rush", *The New York Times* (12 December 2011), online: The New York Times <http://www.nytimes.com>; Sarah Eddington, "Arkansas Earthquakes Decline After 'Fracking' Injection Well Closures", *The Huffington Post* (14 March 2011), online: The Huffington Post <http://www.huffingtonpost.com>; Alec Liu & Jeremy A Kaplan, "Earthquakes in Arkansas May Be Man-Made, Experts Warn", *Fox News* (1 March 2011), online: Fox News <http://www.foxnews.com>; Shawn McCarthy, "Shale Gas 'Fracking' Halted After Possible Quake Link", *The Globe and Mail* (1 June 2011), online: The Globe and Mail <http://www.theglobeandmail.com>.

96 National Academy of Sciences, *Induced Seismicity Potential in Energy Technologies (Report in Brief)* (2012), online: Division on Life and Earth Sciences of the National Academies <http://www.dels.nas.edu> [National Academy of Sciences].

97 *Ibid* at 3.

[of well wastewater] has been suspected or determined a likely cause for induced seismicity at approximately eight sites in the past several decades."[98] Injection wells are often used to dispose of wastewater produced during natural gas extraction activities.[99] Despite the report's conclusions regarding resource development and extraction activities, the Research Council indicated that there currently exist "no standard methods to implement risk assessments for induced seismicity."[100] An assessment would be used to determine "how induced earthquakes might cause damage to structures and human injuries or deaths"[101] and the report recommends such an undertaking for all "individual energy projects."[102]

In addition to the concerns discussed above, the EPA documents also addressed the adverse effects caused specifically by the widespread use of hydraulic fracturing within extraction activities. In a January 2010 briefing report for Robert Sussman, EPA Senior Policy Counsel to the EPA Administrator, the agency characterized "incidences of drinking water contamination resulting from [hydraulic fracturing] activities" as "anecdotal," while also recognizing that hydrofracking has the potential to cause adverse environmental and health effects.[103] The briefing presented a candid overview of the regulatory and informational gaps that surround hydraulic fracturing, stating: "EPA recognizes potential indirect impacts from [hydraulic fracturing] may exist beyond the scope of the [*Safe Drinking Water Act*] and the 2004 study such as surface discharge of waste waters, depletion of drinking water supplies, and methane migration."[104] The study to which the briefing referred was conducted by the EPA in 2004 and asserted to have found no link between hydraulic fracturing of coal bed methane wells and contamination of underground sources of drinking water.[105] The conclusions of the 2004 study were highly controversial. Critics condemned the EPA's conclusion that further investigation of hydrofracking in coal bed methane reservoirs was unnecessary despite an admitted "lack of field water quality data regarding the fate of the substances in the hydraulic fracturing fluids within these sources of drinking water."[106]

The condemnation of the findings in the 2004 report is exemplary of criticisms typically directed at studies conducted on natural gas development.[107] Scrutiny originates from

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98 *Ibid*.

99 *Ibid*.

100 National Academy of Sciences, *supra* note 96 at 3.

101 *Ibid*.

102 *Ibid* at 4.

103 Documents, *supra* note 7 at 7-8.

104 *Ibid* at 8.

105 *Impacts to USDW*, *supra* note 76 at 7-4.

106 Weston Wilson, *Whistle Blower Memo to Colorado Senators Regarding 2004 EPA Hydraulic Fracturing Report* (8 October 2004), online: LA Times <http://www.latimes.com>.

107 See e.g. Public Accountability Initiative, Contaminated Inquiry: *How a University of Texas Fracking Study Led by a Gas Industry Insider Spun the Facts and Misled the Public* (July 2012), online: Public Accountability Initiative <http://www.public-accountability.org/research/reports> [Public Accountability]; *Controversy Mounts over EPA's Release of Draft Report on Fracking* (15 May 2012), online: OMB Watch <http://www.ombwatch.org>; University at Buffalo, The State University of New York, News Release, "University at Buffalo Statement Regarding Shale Resources and Society Institute" (28 June 2012), online: University at Buffalo <http://www.buffalo.edu/news>.

all sectors: industry; government; and the public. At times, such criticism has been warranted as investigators were revealed to harbor financial interests[108] or conclusions were drawn using incomplete or unreliable data.[109] However, the general trend of disagreement points to a much more disquieting dilemma. There exists too little information to unambiguously identify the short- and long-term effects of natural gas development. The fact that development activities may potentially cause adverse environmental damage is perhaps commonsensical; however, the rate at which natural gas is currently being developed throughout the United States, for example, is unprecedented.[110] Consequently, it may be difficult (if not impossible) to ascertain, at this time, what environmental and human health effects will come to pass, as we shall discuss below.

3.2 Chemical Components of Hydraulic Fracturing Fluid

In the abovementioned EPA briefing for Robert Sussman, reference was made to a 2010 report compiled by the Environmental Working Group ("Working Group") which found that the EPA was failing in its duties to regulate hydraulic fracturing fluid.[111] The Working Group report presented a somber picture of poorly functioning federal and state regulatory frameworks and described several environmental and health risks linked to the process of hydraulic fracturing.[112] The report emphasized the hazards associated with the use of petroleum distillates and diesel fuel as components of fracturing fluid, with particular emphasis placed upon the presence of the related group of compounds benzene, toluene, ethylbenzene, and xylene ("BTEX"), often found in high levels in diesel fuel.[113] Benzene is an accepted human carcinogen (International Agency for Research on Cancer ("IARC") group 1), while ethylbenzene is possibly carcinogenic to humans (IARC group 2B), and toluene and xylene are not classifiable as to their carcinogenicity (IARC group 3).[114]

The use of diesel fuel in fracking fluid, although regulated in the US under the *Safe Drinking Water Act*, raises significant environmental and health concerns given that "BTEX chemicals … can pollute water in very small amounts and are known to cause cancer and other serious health problems."[115] Exposure to any of these four chemicals can produce neurological

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108 *Public Accountability*, *supra* note 107.

109 Wilson, *supra* note 106 at 4-5, 11-14.

110 See US EIA, *Annual Energy Outlook 2013 Early Release Overview* at 10, online: US Energy Information Administration <http://www.eia.gov/forecasts/aeo> [US EIA].

111 Documents, *supra* note 7 at 7.

112 Dusty Horwitt, *Drilling Around the Law*, Environmental Working Group at 2, online: Environmental Working Group <http://www.ewg.org>.

113 *Ibid*.

114 IARC, "Chemical Agents and Related Occupations" (2012) 100F IARC Monographs on the Evaluation of Carcinogenic Risks to Humans at 285, online: International Agency for Research on Cancer <http://www.iarc.fr>; IARC, "Some Industrial Chemicals" (2000) 77 IARC Monographs on the Evaluation of Carcinogenic Risks to Humans at 257, online: International Agency for Research on Cancer <http://www.iarc.fr>; IARC, "Re-evaluation of Some Organic Chemicals, Hydrazine and Hydrogen Peroxide" (1999) 71 IARC Monographs on the Evaluation of Carcinogenic Risks to Humans at 855, 1204, online: International Agency for Research on Cancer <http://www.iarc.fr>.

115 Horwitt, *supra* note 112 at 7.

symptoms and impairment.[116] Benzene, in particular, is "readily absorbed" in both animals and humans, where it may act as a neurotoxin or affect reproduction and development.[117] According to the EPA risk assessment on benzene:

> As is the case with many other organic solvents, benzene has been shown to produce neurotoxic effects in experimental animals and humans after short-term exposures to relatively high concentrations of the compound. Benzene produces generalized symptoms such as dizziness, headache, and vertigo, leading to drowsiness, tremor, delirium, and loss of consciousness.[118]

Benzene can also cause hematological effects, which may ultimately lead to aplastic anemia and acute myelogenous leukemia.[119]

The EPA's toxicological review of toluene reveals similar, significant acute health effects to those of benzene. The report states that upon inhalation:

> The most sensitive effects [of toluene] observed in humans following inhalation exposure are neurologic effects, including altered color vision, dizziness, fatigue, headache, and decreased performance in neurobehavioral tests. Exposure to higher levels in humans and animals have resulted in respiratory tract irritation. Animal studies of toluene inhalation have revealed delayed neurodevelopment and decreased offspring weight at levels that also resulted in maternal toxicity.[120]

Xylenes, comprising the isomers of o-,p-, and m-xylene, may cause the following:

> Reversible symptoms of neurological impairment and irritation of the eyes and throat are well-known health hazards from acute inhalation exposure to xylenes and other aromatic solvents in humans. In general, these acute effects are most pronounced at high exposure levels, in excess of 1000 ppm; at lower concentrations, more subtle effects may occur. Animal studies more clearly identify neurological effects as sensitive effects of repeated inhalation exposure to xylenes.[121]

According to the Agency for Toxic Substances and Disease Registry ("ATSDR"):

> Exposure to high levels of ethylbenzene in the air for short periods can cause eye and throat irritation. Exposure to higher levels can result in vertigo and dizziness. Exposure to relatively low concentrations of ethylbenzene for several days to weeks

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116 See ATSDR, *Interaction Profile for: Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX)* (May 2004) at ix, online: Agency for Toxic Substances & Disease Registry <http://www.atsdr.cdc.gov> (we note that adverse effects depend on dose, duration, and frequency of exposure; as well, exposure to complex mixtures may lead to toxicological effects that are not a simple function of the individual ones) [ATSDR].

117 EPA Integrated Risk Information System, *Toxicological Review of Benzene* (October 2002) at xiii and 3, online: US Environmental Protection Agency <http://www.epa.gov>. See also Office of Environmental Health Hazard Assessment, *Prioritization of Toxic Air Contaminants – Children's Environmental Health Protection Act – Final Report* (October 2001) at benzene – 1, online: OEHHA <http://www.oehha.ca.gov>.

118 *Ibid* at 143.

119 *Ibid* at 28.

120 EPA Integrated Risk Information System, *Toxicological Review of Toluene* (September 2005) at 88, online: US Environmental Protection Agency <http://www.epa.gov>.

121 EPA Integrated Risk Information System, *Toxicological Review of Xylenes* (January 2003) at 52, online: US Environmental Protection Agency <http://www.epa.gov>.

> resulted in potentially irreversible damage to the inner ear and hearing of animals. Exposures to relatively low concentrations of ethylbenzene for several months to years caused kidney damage in animals.[122]

There does not appear to be any studies on the long-term, non-cancerous effects of ethylbenzene in humans,[123] and the EPA offers no formal risk assessment of the substance.[124]

Although the four BTEX compounds often appear together, there is limited data as to their joint effects on health.[125] The findings from toxicological reviews of the chemicals indicate that multiple symptoms may be caused from exposure. As we discuss further in the epidemiological section below, the physiological response depends on various factors, including the components of the mixture, the concentrations of the individual components, and the duration and frequency of exposure. However, prediction of specific effects from a specific mixture is impossible.

Alongside BTEX chemicals, the Working Group considered the dangers associated with various petroleum distillates used within hydraulic fracturing fluid. The Working Group found that distillates may be equally as damaging as the BTEX chemicals found within diesel fuel.[126] In addition to containing diesel fuel and benzene,[127] distillates may comprise inter alia asphalt, paraffin wax, gasoline, fuel oil, and paint thinners.[128] However, the Working Group acknowledged that significant informational gaps still exist when attempting to identify precisely which petroleum distillates are being used by companies within the natural gas extractive sector.[129] Despite these information gaps, a 2011 investigation by the US House of Representatives Committee on Energy and Commerce Minority Staff found:

> The BTEX compounds appeared in 60 hydraulic fracturing products used between 2005 and 2009 and were used in 11.4 million gallons of hydraulic fracturing fluids. In addition, the hydraulic fracturing companies injected more than 30 million gallons of diesel fuel or hydraulic fracturing fluids containing diesel fuel in wells in 19 states.[130]

The Energy and Commerce Committee's report, entitled "Chemicals Used in Hydraulic Fracturing," confirmed that of those "hydraulic fracturing products" studied, the Committee found a total of "750 chemicals and other components."[131]

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122 ATSDR, *Toxicological Profile for Ethylbenzene* (November 2010) at 4, online: Agency for Toxic Substances & Disease Registry <http://www.atsdr.cdc.gov>.

123 *Ibid*.

124 See EPA Integrated Risk Information System, *Ethylbenzene* at II.B-II.C, online: US Environmental Protection Agency <http://www.epa.gov>.

125 ATSDR, *supra* note 116 at ix.

126 Horwitt, *supra* note 112 at 9.

127 *Ibid* at 9-10.

128 *Ibid* at 9.

129 *Ibid* at 12.

130 US, Minority Staff of United States House of Representatives Committee on Energy and Commerce, 112th Cong, *Chemicals Used in Hydraulic Fracturing* (April 2011) at 10 [US Minority Staff Report].

131 *Ibid* at 5.

One of the largest obstacles to research and identification of the potential environmental and human health effects associated with hydraulic fracturing fluid is public access to information. In the US, natural gas developers have consistently guarded the complex chemical makeup of hydraulic fracturing fluid as proprietary information.[132] Neither state nor federal laws have generally required public disclosure of fracking fluid's chemical components, though some exceptions do exist for emergency situations, healthcare professionals, and environmental agencies.[133] Barriers surrounding access to information have limited the ability to conduct comprehensive studies, including studies relating to human health and water and air pollution.

Despite these existing informational gaps, The Endocrine Disruption Exchange ("TEDX") began research on the relationship between natural gas development and human health in 2004, following a request from the Oil and Gas Accountability Project of the US based non-profit organization Earthworks.[134] TEDX, located in Paonia, Colorado, "is a non-profit organization dedicated to compiling and disseminating the scientific evidence on the health and environmental problems caused by low-dose exposure to chemicals that interfere with development and function, called endocrine disruptors."[135] TEDX's research showed that land, air, and water pollution, which are present at all stages of natural gas development, pose a variety of serious short- and long-term risks to human health.[136]

A significant portion of TEDX's research focused upon analyses of the chemicals used within natural gas extraction activities, such as hydraulic fracturing. Chemical data were drawn from a variety of sources, including Material Safety Data Sheets,[137] federally mandated state Tier II reports,[138] private studies,[139] and information gathered following a nearby "accidental blow-out of the Crosby Well in Wyoming."[140] Despite the organization's ability to collect a substantial quantity of data regarding the chemicals used in natural gas extraction, TEDX

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132 Hannah Wiseman, "Trade Secrets, Disclosure, and Dissent in a Fracturing Energy Revolution" (2011) 111:1 Colum L Rev Sidebar 1 at 5-6.

133 *Ibid*.

134 Colborn et al, *supra* note 7 at 1042.

135 TEDX, online: The Endocrine Disruption Exchange <http://www.endocrinedisruption.com>.

136 Colborn et al, *supra* note 7 at 1042, 1046, 1048.

137 EPA Emergency Management, Emergency Planning and Community Right- to-Know Act (EPCRA) Hazardous Chemical Storage Reporting Requirements, online: US Environmental Protection Agency <http://www.epa.gov/osweroe1/content/epcra/> ("[Material Safety Data Sheets] are detailed information sheets that provide data on health hazards and physical hazards of chemicals along with associated protective measures. Over 500,000 products have [Material Safety Data Sheets] which are normally obtained from the chemical manufacturer").

138 *Ibid* ("Tier II forms require basic facility identification information, employee contact information for both emergencies and non-emergencies, and information about chemicals stored or used at the facility").

139 Colborn et al, *supra* note 7 at 1043 (TEDX was "provided data from a 2007 … study, sponsored by 19 oil and gas companies and conducted by a third party consultant and analytical laboratory").

140 *Ibid* ("[w]hen the blow-out occurred, methane and other gases, petroleum condensates, and drilling fluids (muds) were released from fissures in the ground adjacent to the well. During the 58 hours the eruption took place, 25,000 square feet of soil surface in the area were contaminated. The driller released copies of the [Material Safety Data Sheets] for the products used during the blow-out and later [TEDX] found the names of several more products from remedial action work plans to clean up the site").

researchers, like those of the Working Group, were unable to fill all existing informational gaps because of an inability to access information from industry:

> It should be clear that our list of products is not complete, but represents only products and chemicals that we were able to identify, through a variety of sources, as being used by industry during natural gas operations. For most products, we cannot definitively say whether they were used during drilling or during fracking … [Material Safety Data Sheets] and Tier II reports are fraught with gaps in information about the formulation of the products. The percent of the total composition of the product is rarely reported on these forms. The most critical limiting factor in our research was that Chemical Abstract Service (CAS) numbers[141] were often not provided on [Material Safety Data Sheets].[142]

Recognizing the limitations of the data in TEDX's research, the organization's results nevertheless present a disquieting view of the potential for adverse human health effects associated with natural gas development. The potential health effects from air, water, and land contamination can be serious and may occur acutely (e.g., neurological problems) or over long periods of time (e.g., cancer). TEDX's study identified Chemical Abstract Service numbers for 353 substances used within natural gas extraction, the majority of which have the potential to affect human health upon immediate exposure.[143] Nearly half of the chemical substances used could harm the major system functions of the human body, including the nervous and immune systems.[144] Many of the chemicals are also known to have significant adverse effects on wildlife and habitat.[145]

3.3 Air Pollution

The research conducted by TEDX also found that chemical compounds used within natural gas production and delivery, combined with nitrogen oxides from equipment exhaust, often create rural ground-level ozone air pollution similar to that seen in urban areas.[146] Ground-level ozone, a common secondary air pollutant from the emissions of volatile organic compounds and nitrogen oxides, causes serious, acute effects on human health. The EPA states:

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141 *Ibid* at 1044 ("[t]he American Chemical Society has established the CAS number system to identify unique chemical substances. CAS numbers identify substances that may be a single chemical, an isomer of a chemical, a mixture of isomers, polymers, biological sequences, or a mixture of related chemicals. For purposes of accuracy, [TEDX's] research into the health effects of chemicals used in natural gas operations was restricted to only chemicals for which a CAS number was available").

142 *Ibid* at 1043-44.

143 Ibid at 1045. See TEDX, *Multistate Summary* (27 January 2011), online: The Endocrine Disruption Exchange <http://www.endocrinedisruption.com> (list of most commonly used substances at 6); TEDX, *Multistate Spreadsheet* (29 March 2011), online: The Endocrine Disruption Exchange <http://www.endocrinedisruption.com> (detailed list (not comprehensive) of substances used in natural gas operations); Frac Focus, *What Chemicals Are Used*, online: Frac Focus <http://fracfocus.org> (list of chemicals used within hydraulic fracturing activities); US Minority Staff Report, *supra* note 130 at 13-30 (additional list of chemicals used within hydraulic fracturing activities).

144 Colborn et al, *supra* note 7 at 1046. See generally EPA Pollution Prevention and Toxics, *Chemicals in the Environment: OPPT Chemical Fact Sheets*, online: US Environmental Protection Agency <http://www.epa.gov/chemfact> (additional chemical fact sheets).

145 Colborn et al, *supra* note 7 at 1046.

146 *Ibid* at 1042.

> Breathing ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, emphysema, and asthma. Ground-level ozone also can reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue.[147]

The US Centers for Disease Control and Prevention reports that even "[s]hort-term exposures to ozone have been associated with an increase in mortality as well as cardiovascular- and respiratory-related hospitalizations."[148] This was echoed in a review from the World Health Organization:

> Based on a meta-analysis of studies published during the period between 1996 and 2001 on short-term effects of [ozone] on all non-accidental causes of death in all ages (or older than 65 years), significant increase of the risk of dying (between 0.2 % and 0.6 % per each increase in 10 $\mu g/m^3$ or 5 [parts per billion]) was shown.[149]

This statement means that when ozone increases by a specific amount (5 parts per billion) on a particular day, the percent increase in the number of deaths in the exposed population will also increase on that day. The actual increase will depend on how much the concentration of ozone has increased: if the increase is 5 parts per billion, then the expected increase in mortality is between 0.2 and 0.6 percent; if the increase is 10 parts per billion, then the expected increase in mortality would be between 0.4 and 1.2 percent.[150]

Many rural regions have experienced increased air pollution where natural gas development activities are present. Such pollution has the potential to spread several hundred miles beyond a single production site.[151] The State of Wyoming, one of the most rural and sparsely populated states in the US,[152] has seen concentrations of ozone that far exceed those found in larger, polluted urban centers, such as Los Angeles, California.[153] Wyoming residents have complained of nose bleeds, shortness of breath, and eye irritation, with at-risk persons (i.e., children, the elderly, and those with respiratory illness) being advised to stay indoors and avoid outdoor activity and exercise.[154] In March, 2011 levels of ozone in Wyoming were reported to

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147 EPA Ground-Level Ozone, *Health Effects*, online: US Environmental Protection Agency <http://www.epa.gov>.

148 Fuyuen Y Yip et al, "Unhealthy Air Quality – United States (2006-09)" 60 Morbidity and Mortality Weekly 28 at 28, online: Centers for Disease Control and Prevention <http://www.cdc.gov>.

149 World Health Organization, *Health Aspects of Air Pollution with Particulate Matter, Ozone and Nitrogen Dioxide* (WHO Regional Office for Europe, 2003) at 31, online: World Health Organization <http://www.euro.who.int/document/e79097.pdf>.

150 *Ibid*.

151 Colborn et al, *supra* note 7 at 1042.

152 *Welcome to the State of Wyoming*, online: State of Wyoming <http://www.wyoming.gov>.

153 Mead Gruver, "Wyoming Plagued By Big-City Problem: Smog", *The Washington Post* (8 March 2011), online: The Washington Post <http://www.washingtonpost.com/wp -dyn/content/article/2011/03/08/AR2011030802905.html>; Wendy Koch, "Wyoming's Smog Exceeds Los Angeles' Due to Gas Drilling", *USA Today* (9 March 2011), online: USA Today <http://content.usatoday.com/communities/greenhouse/post/2011/03/wyomings-smog-exceeds-los-angeles-due-to-gas-drilling/1#.UVED4lfah24>.

154 Gruver, *supra* note 153.

have reached up to 124 parts per billion, significantly higher than the EPA's national ambient air quality standards for ozone of 75 parts per billion (or 0.075 parts per million).[155]

3.4 Migration of Contaminants[156]

Natural gas development and waste disposal techniques have also negatively impacted agricultural and livestock farms. In New York State, a March 2011 gathering of "farmers, landowners, attorneys," and other concerned citizens drew a crowd of more than 400 people, and heard first-hand testimony regarding the industry's effects on farmland and livestock.[157] Testimonies described livestock deaths, birth defects, reproduction issues, and contamination of organic agricultural crops as a result of extraction and production activities.[158] The practice of ground surface disposal of natural gas wastes, called "landfarming," has also caused concern among landowners and farmers.[159] Landfarming, as described by the EPA, "involves spreading excavated contaminated soils in a thin layer on the ground surface and stimulating aerobic microbial activity within soils through aeration and/or the addition of minerals, nutrients, and moisture."[160] In the rural region of Hill County, Texas, neighboring residents to landfarms complained of burning skin and eyes, contamination of livestock feed, and land contaminant migration.[161] Two agricultural farmers voiced concerns regarding the diminished value of their land, as contaminated farmlands no longer yield viable crops.[162]

The aforementioned documents, reports, and testimonies present startling, but predictable revelations. According to the 2010 EPA report concerning national enforcement and compliance strategy, the EPA has already received and investigated several complaints related to coal bed methane operations throughout Region 8, a geographical area encompassing six states in the western US.[163] The complaints described various instances of chemical migration into underground sources of drinking water and improper treatment and disposal of produced waters.[164] The report attributed increased air pollution in Region 8 to the rapid development of natural gas throughout the area, stating "Colorado, Wyoming, and Utah have seen ozone levels that exceed nation[al] ambient air quality standards with levels increasing at several sites."[165]

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155 *Ibid*; Koch, *supra* note 153; EPA Air and Radiation, *National Ambient Air Quality Standards (NAAQS)*, online: US Environmental Protection Agency <www.epa.gov> [EPA Air and Radiation].

156 See also discussion regarding extreme weather events and land and water contamination at 186-87.

157 John Christensen, "Hydrofracking Woes Aired in Penn Yen", *The Chronicle Express* (17 March 2011), online: The Chronicle Express <http://www.chronicle-express.com>.

158 *Ibid*.

159 EPA Underground Storage Tanks, *Landfarming*, online: US Environmental Protection Agency <http://www.epa.gov>.

160 *Ibid*.

161 Spike Johnson & Peggy Heinkel-Wolfe, "Practice Lays Waste to Land", *Denton Record-Chronicle* (31 March 2011), online: Denton Record-Chronicle <http://www.dentonrc.com>.

162 *Ibid*.

163 Documents, *supra* note 7 at 3-4; EPA, *EPA Region 8 (Mountains and Plains)*, online: US Environmental Protection Agency <http://www.epa.gov>.

164 Documents, *supra* note 7 at 4.

165 *Ibid*.

3.5 Climate Change

Of notable significance, the EPA report makes mention of the correlation between natural gas production and increased emissions of organic compounds, such as methane, "a potent greenhouse gas" and significant contributor to climate change.[166] The association between natural gas and climate change has only recently begun to surface in mainstream media, although development of the resource has long been associated with significant emissions of methane.[167] Largely considered a clean energy source, the burning of natural gas emits far fewer harmful emissions than other conventional fuel sources;[168] thus, in terms of global warming, natural gas has often been viewed as a superior resource. However, the same may not be true of natural gas development activities, from hydraulic fracturing of shale gas in particular.

A recent study conducted by Cornell University Professor Robert Howarth and his collaborators ("Howarth study") concluded that methane emissions from certain aspects of shale gas production resulted in a larger greenhouse gas footprint than that of other fossil fuels, such as oil and coal.[169] The Howarth study considered emission factors from various points of natural gas use and development, including fugitive emissions, losses during well completion, venting and equipment leaks, losses in processing, and emissions in transport, storage, and distribution,[170] but did not consider the amount of energy required in fracking versus conventional operations. The authors estimated that 3.6 to 7.9 percent of total methane produced from shale operations was released to the atmosphere as compared to 1.7 to 6.0 percent for conventional operations.[171] The researchers also determined that over a 20-year time horizon, "the [greenhouse gas] footprint for shale gas is 22 % to 43 % greater than that for conventional gas."[172] They further concluded that even when methane emissions are focused over the more widely accepted 100-year time horizon, the greenhouse gas footprint is still substantial.[173]

Since its publication in April 2011, the Howarth study has received a great amount of public attention, including heavy criticism by many in the energy sector. Energy In Depth, a website run by various oil and gas producers in the US, published a scathing critique of Howarth's work, stating that the researchers had "manipulate[d] the study parameters."[174] The article criticized the study for its admitted lack of data, as well as the researchers' use of the 20-year time horizon within which to assess methane emissions.[175] Debate still surrounds the appropriate time period within which to measure global warming potential, with each green-

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166 *Ibid*.

167 EPA Climate Change, *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2009* (15 April 2011) at ES-9, online: US Environmental Protection Agency <http://epa.gov>.

168 *Overview of Natural Gas, Background*, online: NaturalGas.org <http://www.naturalgas.org>.

169 Howarth, Santoro & Ingraffea 2011, *supra* note 7 at 687.

170 *Ibid* at 680.

171 *Ibid* at 683.

172 *Ibid* at 685.

173 *Ibid*.

174 Energy in Depth, *Five Things to Know About the Cornell Shale Study* (2011) at 1, online: Energy in Depth <http://energyindepth.org/wp-content/uploads/2011/10/Five-Things-to-Know-Factsheet-FINAL.pdf>.

175 *Ibid*.

house gas having different warming impacts over varied time spans.[176] The Intergovernmental Panel on Climate Change traditionally uses time horizons of 20, 100, or 500 years to measure the global warming potential of individual greenhouse gases.[177] Indeed, one molecule of methane has a warming potential equivalent to 56 (over 20 years), 21 (over 100 years), and 6.5 molecules (over 500 years) of carbon dioxide.[178] Other researchers at Cornell have also disagreed with the Howarth study's assumptions, particularly with the upper estimate of 7.9 percent of total methane production that will be lost during production.[179] These researchers argued that possible technical improvements could reduce the amount of fugitive emissions, and they disagreed with Howarth's assessment of unconventional natural gas development's contribution to greenhouse gas emissions.[180] Howarth, in a rebuttal paper, disputed these contentions.[181] It is beyond the scope of the present paper to attempt to reconcile these differences. Rather, we believe that one should be able to estimate the total impact of shale gas drilling, including the energy and greenhouse gas emissions used in the entire process, and we hope that improved data will be forthcoming.

Undeniably, substandard and insufficient access to information is one of the largest obstacles facing researchers when attempting to assess the impacts of natural gas development on human health and the environment. Howarth himself acknowledged insufficiencies in the data of the Cornell study, stating: "the uncertainty in the magnitude of fugitive emissions is large. Given the importance of methane in global warming, these emissions deserve far greater study than has occurred in the past. We urge both more direct measurements and refined accounting to better quantify lost and unaccounted for gas."[182] Insufficient data and reporting, and outdated measurements of emissions of greenhouse gases are industry-wide issues. In a document concerning the petroleum and natural gas industries' emissions of greenhouse gases, the EPA recognized such informational deficiencies, with particular emphasis upon the impact and measurement of methane emissions.[183] The EPA conceded that the agency had "significantly underestimated" emissions of greenhouse gases from certain aspects of resource

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176 Dan Lashof, "Natural Gas Needs Tighter Production Practices to Reduce Global Warming Pollution", (12 April 2011), online: Switchboard, National Resources Defense Council Staff Blog <http://switchboard.nrdc.org>.

177 Piers Forster et al, "Changes in Atmospheric Constituents and in Radiative Forcing" in S Solomon et al, eds, *Climate Change 2007*: *The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge: Cambridge University Press, 2007) 131 at 212.

178 United Nations Framework Convention on Climate Change, *Global Warming Potentials*, online: UNFCCC <http://www.unfccc.int>.

179 Lawrence M Cathles et al, "A Commentary on "The Greenhouse-Gas Footprint of Natural Gas in Shale Formations" by R W Howarth, R Santoro, and Anthony Ingraffea" (2012) 113:2 Climatic Change 525 at 526.

180 *Ibid* at 527-28.

181 Robert W Howarth, Renee Santoro & Anthony Ingraffea, "Venting and Leaking of Methane from Shale Gas Development: Response to Cathles et al." (2012) 113:2 Climatic Change 537 [Howarth, Santoro & Ingraffea 2012].

182 Howarth, Santoro & Ingraffea 2011, *supra* note 7 at 688.

183 EPA Climate Change, *Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry* at 8, online: US Environmental Protection <http://www.epa.gov>.

extraction activities (oil and gas), specifically those from the following sources: "well venting for liquids unloading; gas well venting during well completions; gas well venting during well workovers; crude oil and condensate storage tanks; centrifugal compressor wet seal degassing venting; scrubber dump valves; onshore combustion; and flaring."[184]

3.6 Contamination of Water Resources

Public access to information and lack of reliable, scientific data to accurately determine the environmental and health effects of development activities, including hydraulic fracturing, continue to be a key obstacle to effective regulation of the natural gas industry. These sentiments were echoed in one of the few existing peer reviewed studies regarding the relationship between hydrofracking and methane contamination of underground sources of drinking water in two counties of Pennsylvania, made public in May 2011.[185] The study showed higher concentrations of methane in drinking wells (36-190 meters in depth) in active areas of natural gas extraction as compared to non-active areas.[186] The study also showed that methane in the active areas was derived from deep shale formations (about 1500 meters in depth). A number of mechanisms were proposed by which methane could migrate into the shallow drinking water wells and the authors suggested two likely avenues: from leaky gas-well casings or from gas following new fractures or enlarged ones in the rock formed during the fracturing process.[187] The researchers did not measure components of hydraulic fracturing fluid contamination within the shallow groundwater resources, but stated "[o]ur results show evidence for methane contamination of shallow drinking-water systems … and suggest important environmental risks accompanying shale-gas exploration worldwide."[188]

Although the May 2011 study did not find evidence of hydrofracking fluid within shallow groundwater resources, recent EPA sampling test results of drinking water and deep monitoring wells in Pavillion, Wyoming ("Pavillion investigation") indicate that hydraulic fracturing fluid contaminants may indeed be polluting aquifers.[189] At a public meeting held on November 9, 2011 in Pavillion, the EPA presented test results, which included findings of petroleum-related compounds, 2-butoxyethanol phenols, phenols, and naphthalene in the sampled stock and private drinking water wells.[190] Residents were told that the "ATSDR recommended that residents use alternate water for cooking and drinking [a]nd ventilation of bathrooms for those wells with high methane [levels]."[191] Sampling of the Pavillion area's deep monitoring wells revealed potassium and chloride levels "significantly elevated," up to 18-times above normal concentrations.[192] Samples found "synthetic organic compounds" and "methane at near satu-

184 *Ibid*.

185 Osborn et al, *supra* note 89.

186 *Ibid* at 8172-73.

187 *Ibid* at 8175.

188 *Ibid* at 8172.

189 Abraham Lustgarten, "EPA Finds Compound Used in Fracking in Wyoming Aquifer", *ProPublica* (10 November 2011), online: ProPublica <http://www.propublica.org>.

190 EPA Region 8, *EPA Pavillion Groundwater Investigation: 2010-2011 Sampling Summary of Results and Next Steps* at 4, online: US Environmental Protection Agency <http://www.epa.gov>.

191 *Ibid*.

192 *Ibid* at 6.

ration levels [with a] similar isotopic signature to production gas."[193] The samples also revealed "other petroleum-related detections," including the presence of BTEX chemicals, with benzene at 50-times the maximum contaminant level.[194] In a December 2011 press release regarding the draft findings of the Pavillion investigation, the EPA stated that "analysis of samples taken from the [a]gency's deep monitoring wells … indicate[d] detection of synthetic chemicals, like glycols and alcohols consistent with gas production and hydraulic fracturing fluids, benzene concentrations well above [*Safe Drinking Water Act*] standards and high methane levels."[195] The EPA's findings confirmed that the chemicals found in tested public and private drinking water wells were "consistent with migration from areas of gas production," although at the time of testing, levels were "generally below established health and safety standards."[196]

The research methodology and subsequent findings of the Pavillion investigation were compiled for public comment in a draft document released on December 8, 2011.[197] As has been the case in almost every major study regarding hydraulic fracturing and natural gas development, the EPA's initial findings were met with fervent criticism. Controversy focused upon the EPA's methodology in collecting water samples as well as the EPA's interpretation, and subsequent release, of the study's initial findings.[198] In a December 12, 2011 press release, Encana, a North American energy producer, emphasized that the company "strongly disagre[ed] with the [EPA's] preliminary conclusions in its draft report related to the groundwater study in the Pavillion natural gas field of Wyoming."[199] Among other criticisms, Encana stated that "[t]he EPA's data from existing domestic water wells align[ed] with all previous testing done by Encana in the area and show[ed] no impacts from oil and gas development."[200] In relation to the agency's preliminary conclusions regarding contaminants found in deep monitoring wells, Encana asserted that "the EPA's findings … [were] conjecture, not factual and only serve[d] to trigger undue alarm."[201]

Amidst a growing controversy and given the importance of transparency, the EPA agreed to postpone the Pavillion investigation's peer review process to allow for "further sampling of the deep monitoring wells drilled."[202] In a March 2012 press release regarding the delay, the EPA stated: "[t]he EPA, the State of Wyoming, and the [Northern Arapahoe and Eastern

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193 *Ibid*.

194 *Ibid*.

195 US Environmental Protection Agency, News Release, "EPA Releases Draft Findings of Pavillion, Wyoming Ground Water Investigation for Public Comment and Independent Scientific Review" (8 December 2011), online: US Environmental Protection Agency <http://www.epa.gov>.

196 *Ibid*.

197 EPA Region 8, *Pavillion Groundwater Investigation*, online: US Environmental Protection Agency <http://www.epa.gov> [EPA Region 8].

198 Laura Zuckerman, "USGS Aquifer Tests Near Pavillion, Wyoming Reveal Petroleum-Based Pollutants in Samples", *The Huffington Post* (28 September 2012), online: Huffington Post <http://www.huffingtonpost.com>.

199 Encana, News Release, "Why Encana Refutes U.S. EPA Pavillion Groundwater Report" (12 December 2011), online: Encana <http://www.encana.com>.

200 *Ibid*.

201 *Ibid*.

202 EPA Region 8, *supra* note 197.

Shoshone] Tribes recognize that further sampling of the deep monitoring wells drilled for the [a]gency's groundwater study is important to clarify questions about the initial monitoring results."[203] In addition to the abovementioned parties, the US Geological Survey ("USGS") was tasked to conduct well sampling in Pavillion, "at the request of the State of Wyoming and in coordination with [the] EPA."[204] The USGS sampling results were released on September 26, 2012, and public comments regarding the EPA's draft report will now be accepted through September 2013.[205]

The USGS sampling data has triggered another round of (expected) debate. Initial reactions to the data have been polarizing, with various conflicting media reports as to what the results say in relation to previously released EPA findings.[206] The EPA reported that the USGS sampling results were "generally consistent" with the EPA's own study results,[207] while Energy in Depth issued a news release purporting "[e]normous [d]ifferences between USGS and EPA on Pavillion."[208] The USGS itself added little to the differing interpretations of data as it was agreed that the agency would not conduct its own analysis of the information collected.[209] The State of Wyoming has taken an equally cautious approach to premature interpretation of results, as the State's Department of Environmental Quality will be conducting its own examination of all well samples.[210]

After the conclusion of extensive peer review, the EPA's results could prove extremely significant to definitively establishing a connection between groundwater contamination and natural gas development activities; or conversely, to create further divisions. At present, the EPA makes clear that the "draft research report is not final as described in [the] EPA's Information Quality Guidelines, and does not represent and should not be construed to represent [a]gency policy or views."[211] Despite the still essential need for peer review and interpretation of newly collected well sampling data, it is important to note the assertions made within the EPA's initial draft report. With regard to the EPA's study of Pavillion's shallow groundwater sources, "[d]etection of high concentrations of benzene, xylenes, gasoline range organics, and total purgeable hydrocarbons in groundwater samples from shallow monitoring wells near pits

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203 US Environmental Protection Agency, News Release, "Statement on Pavillion, Wyoming Groundwater Investigation" (8 March 2012), online: US Environmental Protection Agency <http://www.epa.gov>.

204 EPA Region 8, *supra* note 197.

205 *Ibid*.

206 See e.g. Paula Dittrick, "API: USGS Did Better Job Testing Pavillion Water than EPA", *Oil and Gas Journal* (18 October 2012), online: Oil and Gas Journal <http://www.ogj.com>; Zuckerman, *supra* note 198.

207 Tennille Tracy, "New EPA Findings Test Fracking Site", *The Wall Street Journal* (10 October 2012), online: Wall Street Journal <http://www.online.wsj.com>.

208 Energy in Depth,"*UPDATE* Enormous Differences Between USGS and EPA on Pavillion" (16 October 2012), online: Energy in Depth Blog <http://www.energyindepth.org>.

209 Mike Soraghan, "EPA, Driller Differ on New Pavillion Water Test Results", *E&E Publishing LLC* (27 September 2012), online: E&E Publishing LLC <http://www.eenews.net>.

210 Adam Voge, "Wyoming Gov. Mead: Wait for Analysis of Pavillion Data", *Casper Star Tribune* (2 October 2012), online: Casper-Star Tribune<http://www.trib.com>.

211 *Notice of Extension of Public Comment Period*, 77 Fed Reg 3770 (2012).

indicate[d] that pits are a source of shallow groundwater contamination."[212] As to the study's findings for deep wells, the draft report stated: "[a]lternative explanations were carefully considered to explain individual sets of data. However, when considered together with other lines of evidence, the data indicate likely impact to groundwater that can be explained by hydraulic fracturing."[213]

A final, important consideration to natural gas development and issues of water resource degradation involves the route of contamination via extreme weather events and mismanagement of wastes. In addition to underground injection, wastewater from natural gas development activities is most commonly stored in aboveground, open pits.[214] The liquid volume held by pits may vary by operation, but on average open pits will store approximately "750,000 gallons" of wastewater product.[215] In the US, not all states require the use of pit liners when storing natural gas wastewater[216] and the migration of contaminant chemicals may thus occur via seepage through the soil. Water resources have also been contaminated due to negligent wastewater pit management.[217] In late 2009, Atlas Resources LLC was fined $97,350 USD for "allowing used hydraulic fracturing fluids to overfill a wastewater pit and contaminate a high-quality watershed in Hopewell Township, Washington County," Pennsylvania.[218] There have been other such events of water contamination due to operator neglect in Pennsylvania;[219] however, open storage pits are also vulnerable to extreme weather patterns, in particular flooding.[220] The occurrence of extreme weather events (e.g., hurricanes and other severe storm activity) has risen steadily over the last several years and is expected to continue with changes in the Earth's climate.[221] Flooding is of primary concern for areas with extractive sector development close to rivers and other large bodies of water, where floodwaters could potentially mix with wastewater storage, contaminating otherwise pristine water supplies.[222]

3.7 Epidemiology: Investigating Health Effects in Humans from Complex Mixtures of Hydraulic Fracturing Fluid

As indicated above, hydraulic fracturing fluids are comprised of many compounds, with over 750 chemicals identified by the US House of Representatives Committee on Energy and

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212 EPA Region 8, *Draft Report: Investigation of Ground Water Contamination Near Pavillion, Wyoming* (December 2011) at xi, online: US Environmental Protection Agency <http://www.epa.gov>.

213 *Ibid* at xiii.

214 Nathan Atkinson & Katie King, "Flooding and Fracking: A Review of Extreme Weather Impacts on Drilling Activities" (2012) 27:2 Nat Resources & Env't 28 at 29.

215 *Ibid*.

216 *Ibid*.

217 *Ibid* at 30.

218 Pennsylvania Department of Environmental Protection, News Release, "DEP Fines Atlas Resources for Drilling Wastewater Spill in Washington County" (17 August 2010), online: Pennsylvania Department of Environmental Protection <http://www.portal.state.pa.us>; Atkinson & King, *supra* note 214 at 30.

219 Atkinson & King, *supra* note 214 at 30.

220 *Ibid*.

221 Erin Overby, "Sandy and the Rise of Extreme Weather", *The New Yorker* (1 November 2012), online: The New Yorker <http://www.newyorker.com>.

222 Atkinson & King, *supra* note 214 at 29-30.

Commerce.[223] Some of these components have known toxicities, but toxicological and epidemiological information on the health effects is lacking for most others. Although we specifically discussed BTEX above, other compounds and mixtures of compounds may produce health effects that are not predictable by their known toxicities. Different combinations at various levels of exposure may lead to differing effects in humans and in other species. Although it is common in epidemiological studies of environmental and occupational hazards that exposures are from complex mixtures, the varying formulations, the route (ingestion, inhalation, or both), and the actual extent duration, and frequency of exposure, precludes predicting effects using standard risk assessment techniques and complicates the interpretation of any health studies conducted in affected human populations. Establishing that the observed health effects are causally-related to environmental exposures requires replication of findings, and this would be difficult to achieve because of the variability in the formulations of fracking fluids, actual exposures to individuals, and variability in physiological responses of people.

There is indeed a paucity of information on the effects of mixtures. For example, even for BTEX, there were not enough data for ATSDR to make specific statements, but rather the agency had to rely on a model in which effects are added across the four compounds.[224] For some compounds, mixtures in which individual components are above their threshold doses (i.e., doses below which no effects are observed) for non-cancer outcomes may lead to synergies, meaning that the effects may be greater than the sum of the effects across the individual compounds.[225] For cancer, there appears to be some data suggesting that the effects on cancer in rodents of mixtures at low concentrations may also be synergistic independent of the dose.[226]

As suggested above, one of the main issues associated with investigating the health effects of complex mixtures, either those present in air, water, or other routes of exposures to humans and other species, is that often the effects may be subtle. For example, as part of the US National Toxicology Program investigating common groundwater contaminants, Germolec and colleagues showed in 1989 that mice exposed to 25 contaminants in water led to suppression of the immune system, even though frank toxicological effects were not found.[227] The implications for human exposure from toxicological studies are difficult to assess, especially since extrapolating from the effects of mice to people may not be accurate. However, one possible implication is that immunological effects caused by mixtures could lead to various non-specific health problems in humans; again, the actual effects will depend on the specific components, concentrations, frequency, and duration of exposure, and there may be extensive variability in how people respond to these toxic compounds.

From an epidemiological perspective, there are serious issues in determining whether exposure to a complex mixture is associated with specific health problems. Consider first the problem of determining acute health effects (i.e., effects that occur just after exposure) from

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223 US Minority Staff Report, *supra* note 130 at 1.

224 ATSDR, *supra* note 116.

225 Emily Monosson, "Chemical Mixtures: Considering the Evolution of Toxicology and Chemical Assessment" (2005) 113:4 Environmental Health Perspectives 383.

226 *Ibid*.

227 Dori R Germolec et al, "Toxicology Studies of a Chemical Mixture of 25 Groundwater Contaminants: II. Immunosuppression in B6C3F Mice" (1989) 13 Fundamental and Applied Toxicology 377 at 377.

well water, for example, that may be contaminated by fracking fluids and other chemicals not native to the region. First, specific contaminants and concentrations will likely vary between the wells because of different routes of migration, so that exposures to individuals will vary. Second, responses of individuals will likely vary, not just because of the differing mixtures, but also because people may react differently to the same mixture of compounds. We have discussed above that exposure to BTEX can lead to various symptoms and individuals may respond differently to the same exposures. These varying reactions are due to differences in how people metabolize compounds, as well as the different reactions that people will have when exposed to other agents, such as environmental tobacco smoke or to complex mixtures in the workplace. Thus, it is unclear that any one health outcome will dominate, such as stomach problems or headache. The inability to uniquely identify one or more health outcomes complicates the interpretation of health studies, and this may be magnified by the complexity of the fracking fluids and the specific composition of the mixture after migration. Third, most hydraulic fracturing activities occur in rural areas, where populations are not large. This means that even if exposure to these complex mixtures did actually cause specific health effects in the population, it may not be detectable statistically because of the size of the study.[228] The upshot of these design problems is that it is unlikely that any study of acute effects would find any health problems, even though these problems may exist. In other words, these studies may not be able to validate complaints of persons exposed nor could they show that exposure to contaminated well water is hazardous.

Consider now that there may also be long-term (i.e., chronic) effects caused by exposure to these complex mixtures. Given that there are a number of carcinogens in fracking fluid, one could postulate that given enough exposure, excess cancers may be caused. There are again myriad issues with attempting to investigate this particular problem. In addition to the problems mentioned above in terms of heterogeneity of exposure and that individual responses may vary (i.e., different types of cancer may result in different people), cancer is actually a 'rare disease' (i.e., the proportion of people with cancer is much smaller than, say, the proportion with a headache). Thus, even larger populations than in the studies of acute health effects are required. Moreover, most cancers take a considerable time to develop (referred to as the "induction period"), and for adults this can be anywhere from 10-30 years before solid tumors develop.[229] Thus, any study would require at least 10-20 years of follow-up to detect any possible excesses. This means that one would need to follow populations forward in time: such studies are complicated, as there are difficulties associated with measuring well water, keeping track of people who move or who die, as well as determining whether participants have been

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[228] This aspect of study design is referred to as "statistical power," which is defined as the probability of detecting a health effect in a population assuming that one is actually present. Statistical power depends mainly on the size of the population and the strength of the true effect.

[229] For children with cancer, such as leukemia, the latency period is far shorter. One of the very first papers on estimating latency periods in cancer was carried out in 1974 by Armenian and Lilienfield (HK Armenian and A Lilienfeld, "The Distribution of Incubation Periods of Neoplastic Diseases" (1974) 99:2 American Journal of Epidemiology 92). They estimated incubation (or latency) periods for a number of cancer sites and exposures. Briefly, they found long latencies (>10 years) for most solid tumours and found shorter latencies for the leukemias and lymphomas (non-solid tumours). A good reference for estimating latency periods for more typical exposures to ionizing radiation is SC Darby, S.C., et al, "Mortality in a Cohort of Women Given X-Ray Therapy for Metropathia Haemorrhagica" (1994) 56 International Journal of Cancer 793.

diagnosed with a cancer. The relevancy of these chronic studies to the problem at hand obviously diminishes, as results would not be available for decades.[230]

In summary, epidemiology will likely not be helpful in identifying adverse health effects in communities affected by natural gas development. The corollary is that one could not place much faith in studies that did not find any such effects. Risk assessment, using toxicological data on individual compounds and estimating the joint effects, could possibly play a role in estimating effects, but these types of studies could be severely limited by insufficient toxicological data on the individual compounds, lack of data on the effects of mixtures, uncertainties in the statistical methods used to estimate the joint effects, and the difficulties associated with extrapolating effects from rodents to humans. Given that there are toxic compounds and that there is evidence that fracking fluids can contaminate underground aquifers and subsequently well water, the protection of the public's health must rely on limiting these activities until such time that non-toxic formulations of fracking fluid are found or contamination can be constrained. This is the essence of the precautionary principle and it underscores the need for studies on exposure to fracking compounds in groundwater and in the air.

3.8 Measuring Externalities

Many of the externalities associated with natural gas development manifest as costs to individuals (e.g., acute and chronic health effects), as well as to species and ecosystems. Many of these effects are reflected in public costs, such as costs to healthcare systems, increases in air pollution and consequent damages, water shortages due to use in extraction and due to contaminated aquifers, and if measured, environmental contamination. However, the majority of financial earnings from development endeavors are private in nature. This dichotomy is not new to environmental problems and the costs can be dramatic.

According to Chesapeake Energy, one of the largest natural gas producers in the US, drilling a new well may use up to 600,000 gallons of water, while fracturing a horizontal well "requires an average of 4.5 million gallons of water per well."[231] These are enormous amounts of water and for regions that experience frequent water shortages;[232] and ultimately, the significant depletion of freshwater resources, combined with the potential for groundwater contamination, may outweigh the public economic benefits (e.g., job creation) of increased natural gas development. Such a challenge currently faces the residents of Texas, where severe drought, coupled with already existing water shortages, could cost Texans as much as "$115.7 billion a year by 2060."[233] Already, towns in hard-hit areas of west Texas have initiated plans to use recycled wastewater for consumption.[234] Potable water supplies used within hydraulic fracturing activities will inevitably be excluded from these plans as the supplies are not recyclable and

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230 There are "retrospective" designs that can be used to look back in time rather than looking forward, but these are limited because specific exposures that occurred in the past cannot be measured easily.

231 Chesapeake Energy, *Water Use in Deep Shale Exploration* (May 2012) at 1, online: Chesapeake Energy <http://www.chk.com/>.

232 See e.g. Joe Carroll, "Worst Drought in More than a Century Strikes Texas Oil Boom", Bloomberg (13 June 2011), online: Bloomberg <http://www.bloomberg.com>.

233 "Water in Texas: The Thirsty Road Ahead", *The Economist* (12 November 2011), online: The Economist <www.economist.com>.

234 *Ibid*.

not suitable for human use.[235] As a result, oil and gas producers may be facing more stringent regulations on water use as state legislators struggle to manage the region's steadily declining sources of drinking water.[236]

Externalities caused by increased levels of ground-level ozone also take a significant toll on agriculture, human health, and ecosystems. In the US, the EPA estimates that ground-level ozone is responsible for approximately "$500 million [USD] in reduced crop production each year."[237] Environment Canada has stated that "air pollution costs Canadians and the Canadian economy billions of dollars per year."[238] These costs are not limited to economic and healthcare costs, but also include the "loss in social welfare due to pain, suffering, and death."[239] According to Environment Canada, reducing ground-level ozone "would have significant health benefits, including reducing the number of premature deaths by hundreds, reducing hospital admissions and emergency room visits by thousands, and reducing restricted activity days by millions. These health improvements would result in several hundred million dollars in savings for Canada's medical system."[240]

Despite the high risks of inducing costly externalities, including unanticipated land contamination and subterranean or surface migration of chemicals into drinking and agricultural water resources, natural gas development, extraction, and production are at an all-time high.[241] In a May 2011 speech on energy policy, US President Barack Obama declared, "the potential for natural gas is enormous."[242] The President's speech endorsed passage of the now defunct *NAT GAS Act*,[243] a bipartisan bill reintroduced to Congress in April 2011, which would have encouraged the use and purchase of natural gas vehicles via a series of amendments to the *Internal Revenue Code*.[244] The US President's support of natural gas development has become,

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235 *Ibid*.

236 *Ibid*.

237 EPA Air Quality Planning and Standards, *Ozone: Good Up High, Bad Nearby* (June 2003), online: US Environmental Protection Agency <http://www.epa.gov>.

238 Environment Canada Air, *Human Health Costs*, online: Environment Canada <http://www.ec.gc.ca>.

239 *Ibid*.

240 *Ibid*; Federal-Provincial Working Group on Air Quality Objectives and Guidelines, *National Ambient Air Quality Objectives for Ground-Level Ozone, Summary Science Assessment Document* (July 1999) at S-9, online: Health Canada <http://www.hc-sc.gc.ca> (In Canada and the US, ground-level ozone readings vary seasonally, by region, and by urban or rural settings. Within Canada, the highest concentrations of ground-level ozone have been found between the months of May to September, "with most sites recording maximum hourly ozone values over 100 [parts per billion]"); CCME, *Our Work: Smog*, online: Canadian Council of Ministers of the Environment <http://www.ccme.ca> (the Canada-wide standard for ground-level ozone is currently set at an average of 65 parts per billion over an eight-hour time span); EPA Air and Radiation, *supra* note 155 (in the US, the EPA has set the eight-hour ground-level ozone concentration objective at 75 parts per billion).

241 US EIA, *supra* note 110.

242 US President Barack Obama, "Remarks by the President on America's Energy Security" (delivered at Georgetown University, 30 March 2011), online: The White House <http://www.whitehouse.gov>.

243 Ed Dolan, "What Stands in the Way of Natural Gas Replacing Gasoline in the US?", *OilPrice* (8 January 2013), online: OilPrice <http://www.oilprice.com>.

244 *Ibid*; US, Bill HR1380, *New Alternative Transportation to Give Americans Solutions Act of 2011*, 112th Cong, 2011.

in many regards, the mainstream position among many North American political leaders. To illustrate, in the 2010 Speech from the Throne, Canada's Conservative government boasted of the nation's place as the "third largest natural gas producer"[245] in the world, stating that such resource development helped to "secure [Canada's] place as a clean energy superpower."[246]

Politicians are not alone in their views on natural gas. *New York Times* op-ed columnist, Joe Nocera, described the northeast US Marcellus Shale natural gas reserves as "an incredible gift."[247] Also in the *New York Times*, in a letter to the editor, Robert Catell, Chair of the Advanced Energy Research and Technology Center, urged the US to "not forgo the opportunity presented by natural gas from shale."[248] Citing natural gas as "the cleanest of the fossil fuels," Catell emphasized the resource's importance "[i]n this time of energy uncertainty."[249] Although Catell's article lauded natural gas' potential as a principal energy resource, he readily acknowledged that the industry faced many hurdles with regard to "performance standards, transparency and communication."[250] The hurdles to which Catell referred highlight a fundamental controversy surrounding natural gas development and hydraulic fracturing activities. As we discussed above, many of the identified adverse effects may be impossible to ascertain with scientific certainty or accuracy, and there have been significant issues associated with monitoring and safety assessments of development activities.[251]

The precautionary principle establishes that concrete evidence need not be required when assessing a development activity that may cause a plethora of health and environmental hazards. To date, however, precaution and public participation have been set aside in favor of increased, opaque extraction and production activities. This approach is in direct conflict with the foundations of precautionary-based, responsible development and decision-making which, when utilized effectively, would undoubtedly support a moratorium on any activity that presented the potential for severe, widespread, and long-lasting negative effects. True, "[a]lmost all human/industrial activities will have some impact on ecosystems," but "[t]he virtue of the precautionary principle is to continuously try to reduce our impacts rather than trying to identify a level of impact that is safe or acceptable."[252] Still, reducing the adverse impacts of a natural gas development may be impossible without comprehensive, transparent studies of extraction and production activities themselves. Until that time, precautionary measures in the shape of development moratoriums are greatly needed in order to safeguard human health and the environment.

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245 Other sources indicate that, as of 2010, Canada is actually the fourth largest producer in the world: see CIA, *supra* note 84.

246 Governor General Michaëlle Jean, "A Stronger Canada. A Stronger Economy. Now and for the Future. Speech from the Throne to the Open Third Session of the Fortieth Parliament of Canada" (Ottawa 3 March 2010) at 9, online: Speech from the Throne <http://www.speech.gc.ca>.

247 Joe Nocera, "About My Support for Natural Gas", *The New York Times* (15 April 2011) A21.

248 Robert B Catell, "The Promise and Risks of Natural Gas", Letter to the Editor, *The New York Times* (31 March 2011) A26.

249 *Ibid*.

250 *Ibid*.

251 See e.g. Earthworks, *Inadequate Enforcement Means Current Colorado Oil and Gas Development Is Irresponsible* (March 2012) at 2, online: Earthworks <http://www.earthworksaction.org>.

252 Tickner, Raffensperger & Myers, *supra* note 32 at 16.

4. NATURAL GAS DEVELOPMENT AND HYDRAULIC FRACTURING MORATORIUM EFFORTS: LEGAL AND SOCIOPOLITICAL IMPLICATIONS

As illustrated in the sections above, natural gas development and the practice of hydraulic fracturing are associated with environmental and health risks. Many of the risks, especially the risks to human health, are unknown or, as previously discussed (e.g., migration of fracking compounds and methane into groundwater) are only beginning to be recognized through scientific study and research. In areas with expanding natural gas development and exploration, concerns regarding health, environmental degradation, contaminated water resources, and other forms of pollution have given rise to complete or partial moratoriums on hydraulic fracturing in development activities.[253] Such actions, largely congruent with precautionary principle rationales, have also come in the form of resolutions expressing political support for regulation, additional research, and review of the adverse effects associated with natural gas development.[254] Local government responses have been particularly widespread in the US.[255] However, the path to moratoriums is not without resistance, both political and legal.[256] Arguments against hydrofracking moratoriums are primarily economic in nature—the practice significantly increases natural gas production as well as the total quantity of recoverable gas reserves.[257] Such is the argument of shale gas proponents in the Province of Quebec, where development of the resource promised to offset the Province's increasing debt. As of March 2012, the Province retained the highest debt in Canada,[258] with a gross debt[259] of approximately 54.2 percent of gross domestic product.[260] Given the economic benefits associated with

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253 See e.g. Food & Water Watch, *Local Actions Against Fracking*, online: Food & Water Watch <http://www.foodandwaterwatch.org> [Food & Water Watch] for a list of state and municipal actions that seek to further regulate natural gas development in the US; Sierra Club Atlantic, *Hydraulic Fracturing in Atlantic Canada: The Risk to Our Water, Our Air, and Our Economies* (August 2011) at 6, online: Sierra Club <http://www.sierraclub.ca> [Sierra Club Atlantic].

254 See Food & Water Watch, *supra* note 253.

255 *Ibid*.

256 See e.g. *Anschutz Exploration Corp v Dryden (Town of)*, 940 NYS (2d) 458 (NY Sup Ct, Tompkins County 2012) [*Anschutz*] (upholding municipal ordinance banning all oil and natural gas development activities, including hydraulic fracturing); Rob Juteau, "Little Falls Split on Hydraulic Fracturing Moratorium", *Utica Observer-Dispatch* (22 February 2012), online: Utica Observer-Dispatch <http://www.uticaod.com>; Nicolas Van Praet, "Quebec on Pace to Become Canada's Poorest Province", *National Post* (8 February 2012), online: National Post <http://news.nationalpost.com>.

257 Jessica Rivero Gilbert, "Assessing the Risks and Benefits of Hydraulic Fracturing" (2011) 18:2 Mo Envtl L & Pol'y Rev 169 at 174.

258 Ministère des Finances et de l'Économie, *Comparisons with Other Governments in Canada*, online: Finances Québec <http://www.finances.gouv.qc.ca>.

259 Ministère des Finances et de l'Économie du Québec, *Debt Concepts*, online: Finances Québec <http://www.finances.gouv.qc.ca> (Finances Québec measures gross debt as the following: "[d]ebt contracted on financial markets [plus] [t]he government's commitments to state employee retirement plans and futur[e] employee benefits [minus] [t]he balance of the Generations Fund"); Ministère des Finances et de l'Économie du Québec, *Actions Taken to Reduce The Debt*, online: Finances Québec <http://www.finances.gouv.qc.ca> (the Generations Fund was created to reduce debt in Québec and utilizes "water-power royalties" as its main source of funding).

260 Ministère des Finances et de L'Économie du Québec, *Québec's Debt*, online: Finances Québec <http://www.finances.gouv.qc.ca>.

natural gas extraction, it appears clear that without greater political support for development and hydrofracking regulation on state, provincial, and federal levels, and without widespread incorporation of the precautionary principle into resource administration, local moratorium efforts may ultimately be doomed to fail.

4.1 Canada

In North America, the Province of Quebec has demonstrated the greatest penchant for the exercise of precaution when assessing the potential for, and dangers of, natural gas development within its borders. The Province is home to a portion of the Utica Shale gas formation which extends from the city of Montreal to the Province's capital, Quebec City.[261] If developed, the Utica Shale has been estimated to be worth between $38.3 and $178.5 billion CAD.[262] However, to date, very few wells have been drilled in the Utica Shale[263] as a result of a temporary moratorium instituted in March 2011 by the Government of Quebec.[264]

The Quebec moratorium was established following the release of a report regarding shale gas development by the Province's Bureau d'audiences publiques sur l'environnement ("BAPE"), translated as the Office of Public Hearings on the Environment.[265] The report, entitled *Sustainable Development of the Shale Gas Industry in Quebec*, proposed the implementation of a strategic environmental assessment to fill existing informational gaps surrounding the practice of hydraulic fracturing.[266] The report also recommended a temporary moratorium on hydraulic fracturing except for those operations "related directly to the [environmental] assessment."[267] The BAPE recommendations were largely accepted by Pierre Arcand, Quebec's then Minister of Sustainable Development, Environment, and Parks. In March 2011, the Minister announced plans to commence a concurrent assessment of and temporary moratorium on hydraulic fracturing, except for those fracturing activities to be studied as part of the

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261 National Energy Board, *Energy Briefing Note: A Primer for Understanding Canadian Shale Gas* (November 2009) at 19, online: National Energy Board <http://www.neb-one.gc.ca> [National Energy Board]; CAPP, Shale Gas, online: Canadian Association of Petroleum Producers <http://www.capp.ca> (Shale, a form of natural gas, "is found in very fine-grained sedimentary rock tightly locked in very small spaces and requires advanced technologies to drill and extract," such as hydraulic fracturing).

262 Ministère des Finances et de l'Économie du Québec, *A Fair and Competitive Royalty System for Responsible Shale Gas Production* (March 2011) at 7, online: Finances Québec <http://www.finances.gouv.qc.ca>.

263 National Energy Board, *supra* note 261.

264 Rhéal Séguin, "Quebec halts shale gas exploration", *The Globe and Mail* (8 March 2011), online: The Globe and Mail <http://www.theglobeandmail.com>.

265 Stephan Trudeau, "Quebec Shale Gas Development Update: BAPE Report Released by Minister Arcand", (8 March 2011), online: Davis LLP <http://www.davis.ca>.

266 Bureau d'audiences publiques sur l'environnement, *Sustainable Development of the Shale Gas Industry in Québec, Inquiry and Public Hearing Report, Excerpts from Report 273* (Québec: Bureau d'audiences publiques sur l'environnement, 2011) at 223, 245 [BAPE] (The BAPE defines strategic environmental assessments in the following manner: "an impact analysis process applied to government policies, plans and programs, and to any other initiative situated upstream of projects. Its purpose is to provide an overview of the potential impacts that several similar projects would have, and it is carried out early in the process of planning new activities or the reconsidering future of existing activities, in order to address environmental, health-related, social and economic considerations").

267 *Ibid* at 226.

recommended strategic environmental assessment.[268] Approximately one year later, Minister Arcand declared the Province would enact an absolute, comprehensive ban on all hydraulic fracturing activities, including those previously utilized as part of the ongoing environmental assessment.[269]

Despite Quebec's already precautionary approach towards natural gas development decision-making, in September 2012, following the Province's election of the Parti Québécois,[270] newly appointed Minister of Natural Resources Martine Ouellet announced the government's outright opposition to all shale gas development, including the government's plans for "a sweeping moratorium, both on exploration and on extraction."[271] In a statement to the media, the Minister declared "I cannot see the day when the extraction of natural gas by the fracking method can be done in a safe way."[272] The Minister also criticized the Province's current strategic environmental assessment committee, asserting that certain committee "members [were] in direct conflict of interest."[273] As a result, the government has indicated its plans to initiate a new study of natural gas development under the BAPE.[274] Industry reaction across the Province has been mixed. Given the previously existing moratorium on development activities, in theory, very little has changed.[275] However, many in the natural gas industry have expressed disappointment in the newly elected government's "hard line" against shale gas development and question the provincial government's short- and long-term fiscal strategy.[276]

The Province of Quebec faces more than mere verbal opposition from industry in regard to its resource development policies, past and present. In November 2012, Lone Pine Resources Inc. filed a Notice of Intent to Submit a Claim against the Government of Canada,[277] citing violations of the *North American Free Trade Agreement* ("*NAFTA*"), Chapter 11.[278] Chapter 11 is intended to "[protect] investors against arbitrary expropriation and expropriation without

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268 Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs, Press Release, "Operations of This Industry Will Be Subject to the Development of Scientific Knowledge" (8 March 2011), online: Ministère du Développement durable, de l'Environnement, de la faune et des Parcs <http://www.mddep.gouv.qc.ca>.

269 Pierre Bertrand, "Quebec Installs Outright Moratorium on Hydraulic Fracturing", *International Business Times* (4 April 2012), online: International Business Times <http://wwwibtimes.com>.

270 Alexander Panetta, "Parti Quebecois wins Quebec election 2012", *National Post* (4 September 2012), online: National Post <http://www.news.nationalpost.com>.

271 Sophie Cousineau, Bertrand Marotte & Rhéal Séguin, "Quebec gas in peril as PQ signals ban", *The Globe and Mail* (20 September 2012), online: The Globe and Mail <http://www.theglobeandmail.com>.

272 *Ibid*.

273 "PQ Says No To Shale Gas", *CTV News* (20 September 2012), online: CTV News <http://www.montreal.ctvnews.ca>.

274 Cousineau, Marotte & Séguin, *supra* note 271.

275 Amanda Stephenson, "Oil Firms Take Issue with PQ Minister", *Calgary Herald* (21 September 2012), online: Calgary Herald <http://www.calgaryherald.com>.

276 Cousineau, Marotte & Séguin , *supra* note 271.

277 Lone Pine Resources Inc, Press Release, "Lone Pine Resources Submits *NAFTA* Notice of Intent to Response to Expropriation of Rights in Quebec" (15 November 2012), online: Yahoo Finance <http://www.finance.yahoo.com>.

278 Michael J Styczen, *NAFTA Claim For Compensation Arising Out of Quebec Shale Gas Ban* (20 November 2012), online: Davis LLP <http://www.davis.ca>.

compensation by the *NAFTA* member states."[279] Lone Pine's complaint comes following the 2011 passage of Quebec's Bill 18, *An Act to limit oil and gas activities*,[280] which led to the revocation of the company's exploration permits, totaling 33,460 acres.[281] The company maintains the Province now owes $250 million in compensation.[282] The *Act*, which seeks to limit resource extraction in certain geographic areas of Quebec, invalidates "[a]ny mining right" in the restricted zone,[283] including those held by Lone Pine. In considering the viability of Lone Pine's claim under *NAFTA*, Attorney Michael Styczen, Associate at Davis LLP, Calgary stated:

> *NAFTA* [Chapter] 11 claims resulting out of regulatory change do not often result in any recovery for the complaining party (the right of each state to pass regulations to protect the environment not being considered an expropriation) [though] a claim such as this (with existing licenses explicitly cancelled without compensation) may well [have] a better chance of success, and may result in claims by other producers whose rights were cancelled without compensation as a result of Bill 18.[284]

The controversy surrounding hydraulic fracturing and natural gas development is not limited to the Province of Quebec in Canada. A recent poll by Environics Research found that approximately 62 percent of all Canadians were in favor of a nationwide moratorium on the practice of hydrofracking,[285] while only 28 percent opposed such precautionary measures.[286] Though only Quebec has instituted a complete moratorium on hydrofracking, other Canadian provinces have begun to take alternative precautionary steps to assess the practice's adverse environmental impacts and confront growing social discontent.[287] In June 2011, the Province of Nova Scotia began a review of the environmental effects associated with "hydraulic fracturing in onshore petroleum exploration."[288] Results of the review are expected for 2014, following an April 2012 extension, during which time the Province hopes to "consider technical reviews underway in Canada and the [US]."[289] The review has elicited numerous public comments that illustrate deep-seated concern over hydraulic fracturing,[290] prompting the Province

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279 *Ibid*.

280 Bill 18, *An Act to limit oil and gas activities*, 2nd Sess, 39th Leg, Quebec, 2011 (assented to 13 June 2011), SQ 2011, c 13 [*Bill 18*].

281 Styczen, *supra* note 278.

282 *Ibid*.

283 *Bill 18*, *supra* note 280 at s 2.

284 Styczen, *supra* note 278.

285 Council of Canadians, Press Release, "Don't Frack with Our Water, Say Majority of Canadians in New Poll" (6 February 2012), online: Council of Canadians <http://www.canadians.org>.

286 "Majority of Canadians Support a Moratorium on Fracking", *National Post* (6 February 2012), online: Canada.com <http://www.canada.com>.

287 Sierra Club Atlantic, *supra* note 253 at 13-20.

288 Government of Nova Scotia, *Hydraulic Fracturing Review*, online: Government of Nova Scotia <http://www.gov.ns.ca>.

289 Government of Nova Scotia, News Release, "Province Extends Hydraulic Fracturing Review" (16 April 2012), online: Nova Scotia <http://www.novascotia.ca> [Government of Nova Scotia 2012].

290 Government of Nova Scotia, *Consultation on Hydraulic Fracturing, Public Comments and Review*, online: Government of Nova Scotia <http://www.gov.ns.ca>.

to place a temporary moratorium on the practice, though "traditional oil and gas operations will continue."[291]

In New Brunswick, where approximately one-seventh of the province is leased to oil and gas developers,[292] citizens, environmental groups, and lobbyists have become increasingly mobilized.[293] In August 2011, more than 1,000 protesters assembled before the Province's capital of Fredericton to protest hydraulic fracturing and its use within New Brunswick shale gas development.[294] The Canadian federal government has also responded to the rising political and social pressures surrounding hydraulic fracturing. In late 2011, the government announced its intent to conduct two separate environmental assessments of the practice's environmental effects.[295] The study was conducted by Environment Canada and scientists from the Council of Canadian Academies[296] and was being prepared for peer review when this article was written.[297]

4.2 The United States

In the US, moratorium efforts on hydraulic fracturing are quickly becoming commonplace. Municipal governments across the country have been particularly active in this regard, with well over 100 local ordinances passed that either support legislative action against hydraulic fracturing or effectively ban the activity altogether.[298] For many American legislators, the precautionary principle serves as an underlying, guiding tenet at the foundation of moratorium efforts. Such was the case for the Vermont State Legislature which in May 2012 passed *An Act Relating to Hydraulic Fracturing Wells for Natural Gas and Oil Production* ("*House Bill 464*").[299] The *Act* established a total ban on all hydraulic fracturing activities within the State until such time as the process "[could] be conducted without risk of contamination to the groundwater of Vermont."[300] In its explanation for instituting the moratorium, the Vermont legislature noted that it was acting "to ensure the state's underground sources of drinking water remain free of contamination."[301]

As public concern mounts over ever-increasing natural gas development, state municipalities have also begun to utilize a variety of legal instruments in attempts to safeguard against

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291 Government of Nova Scotia 2012, *supra* note 289.

292 Sierra Club Atlantic, *supra* note 253 at 13.

293 See e.g. Daniel McHardie, "Environmental Groups Mobilize Against Shale Gas", *CBC News* (1 December 2011), online: CBC News <http://www.cbc.ca>; "More than 1,000 protest hydro-fracking", *CBC News* (1 August 2011), online: CBC News <http://www.cbc.ca> ["1,000 Protest"].

294 "1,000 Protest", *supra* note 293.

295 "Natural Gas Fracking Reviews Launched", *CBC News* (23 September 2011), online: CBC News <http://www.cbc.ca/news>.

296 *Ibid*.

297 Council of Canadian Academies, *Harnessing Science and Technology to Understand the Environmental Impacts of Shale Gas Extraction*, online: Council of Canadian Academies <http://www.scienceadvice.ca>.

298 Food & Water Watch, *supra* note 253.

299 US, HB464, *An Act Relating to Hydraulic Fracturing Wells for Natural Gas and Oil Production*, 2011-12, Reg Sess, Vt, 2012, (enacted) [*House Bill 464*].

300 *Ibid* at § 1(4).

301 *Ibid* at § 1(3).

potential adverse environmental and health effects. Among these instruments include land use and zoning ordinances,[302] and even municipal police powers.[303] The use of zoning ordinances has been uniquely successful for municipalities seeking to ban hydraulic fracturing within town or city limits. In the State of New York, at least two municipal zoning ordinances have now been tested within the trial court system and both were found to withstand judicial scrutiny.[304]

The first case, *Anschutz v Town of Dryden*, sought to determine "whether a local municipality may use its power to regulate land use to prohibit exploration for, and production of, oil and natural gas."[305] In August 2011, the defendant Town of Dryden amended the local zoning ordinance to effectively ban all natural gas and oil development within the town's geographical limits.[306] The town, located within the Marcellus Shale region,[307] had previously leased roughly 22,200 acres to plaintiff Anschutz Exploration Corporation for the development of natural gas.[308] As a result of the zoning ordinance and its prospective impact on future natural gas development, Anschutz sought to invalidate the ordinance, arguing, inter alia, that the amendment was "preempted by the Oil, Gas, and Solution Mining Law" of New York State.[309]

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302 See e.g. US, Town of Middlefield, *A Local Law Repealing the Town of Middlefield Zoning Ordinance and Adopting the Town of Middlefield Zoning Law* (14 June 2011), online: <http://www.middlefieldny.com/uploads/1/2/6/8/12682437/zoning_law_061411_2011_final.pdf>; US, Town of Dryden, *Town of Dryden Notice of Adoption of Amendments to Zoning Ordinance* (24 July 2011), online: Food & Water Watch <http://documents.foodandwaterwatch.org/doc/Frack_Actions_DrydenNY.pdf>.

303 See e.g. US, Home Rule Charter of the City of Pittsburgh, Pennsylvania at §§ 618.01, 618.05, online: <http://earthlawcenter.org/static/uploads/documents/Marcellus_Shale_Ord_Pittsburgh_1.pdf> (codification of ordinance 37-2010, Marcellus Shale Natural Gas Drilling [City of Pittsburgh]; US, Town of Mountain Lake, Natural Gas Extraction Ordinance, ordinance 2011-01 at arts 2(3), 6(1), online: Community Environmental Legal Defense Fund <http://celdf.live2.radicaldesigns.org/downloads/Ordinance-Mt.pdf > [Town of Mountain Lake].

304 *Anschutz*, *supra* note 256; *Cooperstown Holstein Corp v Middlefield (Town of)*, 943 NYS (2d) 722 (NY Sup Ct, Otsego County 2012) (affirmed *Cooperstown Holstein Corp v Middlefield (Town of)*, 2013 NY Slip Op 3148 (NY Sup Ct, App Div, Third Dept 2013) [*Cooperstown*].

305 *Anschutz*, *supra* note 256 at 461.

306 *Ibid*.

307 New York State Department of Environmental Conservation, *Marcellus Shale*, online: New York State Department of Environmental Conservation <http://www.dec.ny.gov> [Department of Environmental Conservation] ("[t]he Marcellus Shale is a black shale formation extending deep underground from Ohio and West Virginia northeast into Pennsylvania and southern New York … [g]eologists estimate that the entire Marcellus Shale formation may contain up to 489 trillion cubic feet of natural gas throughout its entire extent").

308 *Anschutz*, *supra* note 256 at 461 (the trial court did not address the legal issues pertaining to the development leases or the large financial expenses incurred by Anschutz Exploration Corp as a result of relying on those leases).

309 *Anschutz*, *supra* note 256 at 461; US, New York, *Environmental Conservation Law*, art 23 (codification of *Oil, Gas, and Solution Mining Law*, see online: <http://www.dec.ny.gov/energy/26498.html>.

In determining the validity of the plaintiff's claim, the trial court focused its decision upon the principle of stare decisis,[310] comparing the plaintiff's argument to a similarly-situated case involving the State's *Mined Land Reclamation Law*.[311] Decided by the Court of Appeals of New York in 1987, the case considered whether New York's *Mined Land Reclamation Law*, through the use of a supersede provision, effectively preempted all local zoning ordinances "relating to the extractive mining industry."[312] The appeals court considered the legislative intent behind the law and determined that only those local ordinances "dealing with the actual operation and process of mining would frustrate the statutory purpose."[313] Thus, zoning ordinances that prohibited extraction activities altogether would not be in violation of the statute's regulatory intent.[314] Because the New York Legislature had not specifically restricted municipalities from regulating "permissible uses of land," the Town's "total ban on extraction of natural resources [was] permissible."[315]

The second New York case to recently consider the validity of a municipal ordinance banning oil and gas development was *Cooperstown v Town of Middlefield.*[316] Plaintiff Cooperstown Holstein Corporation owned property within the Town of Middlefield upon which it had "previously executed [two] oil and gas leases" in February and March of 2007.[317] The leases, claimed Cooperstown, were now "frustrated" by the enforcement of a June 2011 zoning ordinance which banned all oil and gas development within the Town of Middlefield.[318] *Cooperstown*, like *Anschutz*, was heard before New York's Supreme Court, a trial level court, in February 2012, and considered a similar question of law: was Middlefield's municipal ordinance superseded by section 23-0303(2) of New York's *Environmental Conservation Law*, also referred to as the *Oil, Gas and Solution Mining Law*?[319]

Section 23-0303(2) states: "[t]he provisions of this article shall supersede all local laws or ordinances relating to the regulation of the oil, gas and solution mining industries."[320] The *Cooperstown* trial court took a similar approach to *Anschutz* and first looked to the State legislature's intent when enacting the *Oil, Gas and Solution Mining Law*.[321] Through an extensive

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310 James A Ballentine & William S Anderson, Ballentine's Law Dictionary, 3rd ed, (Rochester, NY: Lawyers Cooperative Publishing Co., 1969) *sub verbo* "stare decisis" ("[t]he doctrine or principle that decisions should stand as precedents for guidance in cases arising in the future. A strong judicial policy that the determination of a point of law by a court will generally be followed by a court of the same or lower rank in a subsequent case which presents the same legal problem, although different parties are involved in the subsequent case").

311 *Anschutz*, *supra* note 256 at 466.

312 *Ibid* (citing *In the Matter of Frew Run Gravel Products, Inc v Carroll (Town of)*, 71 NY (2d) 126 at 129 (NY Ct App 1987) [*In the Matter of Frew Run*]).

313 *In the Matter of Frew Run*, *ibid* at 133.

314 *Ibid*.

315 *Anschutz*, *supra* note 256 at 473.

316 *Cooperstown*, *supra* note 304.

317 *Ibid* at 723.

318 *Ibid*.

319 *Ibid* at 723-24.

320 *Environmental Conservation Law*, NY CLS ECL art 23 tit 3 §§ 23-0303(2) (2012).

321 *Cooperstown*, *supra* note 304 at 724.

review of the legislative history leading up to enactment of section 23-0303(2), the court found the following: "[n]either the plain reading of the statutory language nor the history of [*Environmental Conservation Law*] §23-[0303(2)] would lead this court to conclude that the phrase was intended by the Legislature to abrogate the constitutional or statutory authority vested in local municipalities to enact legislation affecting land use."[322] The court found that because Middlefield's land use ordinance did not regulate the "how," but rather the "where" of oil and gas development, the ordinance was thus in compliance with state law.[323]

Despite the favorable rulings obtained by New York municipalities with regard to resource development moratoriums, the State's courts have made clear that zoning ordinances are only valid "in the absence of a clear expression of legislative intent to preempt local control over land use."[324] In the 1987 case *Turnpike Woods v Town of Stony Point*, the Court of Appeals of New York stated: "[w]hile towns may impose certain restrictions and conditions on the use and development of land pursuant to the appropriate legislative grant of authority … they may not exercise this grant of power in a manner inconsistent with State law—unless the power to amend or supersede State law has been expressly conferred."[325] This condition leaves municipal moratoriums highly vulnerable to changes in the State's oil and gas regulatory framework. Such was the case in Pennsylvania, where a newly passed bill sought to significantly limit the ability of local municipalities to pass ordinances relating to oil and gas development activities.[326]

The bill, Pennsylvania *House Bill 1950*, more commonly referred to as *Act 13*, sought to supersede all local ordinances passed in relation to oil and gas development.[327] Section 3304 of the bill, entitled "Uniformity of Local Ordinances," created the impossibility of locally-instituted moratoriums, as the section stated that "all local ordinances regulating oil and gas operations shall allow for the reasonable development of oil and gas resources."[328] "Reasonable development" was defined to include a multitude of construction, production, and extraction activities related to oil and natural gas development. The term created a non-discriminatory structure of sorts, where a municipality was barred from imposing land use ordinances relating to oil and natural gas development that would not also be applicable to "other industrial uses or other land development within the particular zoning district where the oil and gas operations [were] situated."[329] The bill further defined the applicable parameters of local zoning ordinances by explicitly authorizing natural gas development activities in "agricultural and

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322 *Ibid* at 728.

323 *Ibid* at 729.

324 *Anschutz*, *supra* note 256 at 466 (citing *In the Matter of Gernatt Asphalt Products, Inc v Sardinia (Town of)*, 87 NY2d 668 (NY Ct App 1996)) at 682. Other US state courts have considered the validity of local zoning ordinances to ban oil and natural gas development activities (see e.g. *Greeley (City of) v Lundvall Brothers, Inc*, 830 P (2d) 1061 (Colo Sup Ct 1992)).

325 *Turnpike Woods, Inc v Stony Point (Town of)*, 70 NY (2d) 735 at 737 (NY Ct App 1987) (overturning a local ordinance that significantly delayed plaintiff developer Turnpike Woods' construction of a subdivision, in violation of New York Town Law § 276(4)).

326 US, HB1950, *An Act Amending Title 58 (Oil and Gas) of the Pennsylvania Consolidated Statutes*, 2012, Pa, 2012 [*Act 13*].

327 *Ibid* at § 3302.

328 *Ibid* at § 3304(a).

329 *Ibid* at § 3304(b)(3).

industrial zoning districts," provided certain requirements were met.[330] Once signed into law, the Pennsylvania bill effectively disempowered municipalities from regulating zoning in the area of oil and gas development. The bill established legal standing for any party claiming to be "aggrieved" by the enactment of an adverse municipal ordinance and granted a right to attorney fees and costs to the affected party.[331] Additionally, the new bill revoked the ability of an offending local government "to receive funds [collected] under Chapter 23 [(relating to unconventional gas well fees)][332] … until the local government amend[ed] or repeal[ed] its ordinance."[333]

In response to *Act 13*'s overriding land use measures, which effectively stripped municipalities of their right to govern the placement of oil and gas development activities, Robinson Township, the non-profit Delaware Riverkeeper Network, and several other Pennsylvanian municipalities ("Petitioners")[334] brought suit against the Commonwealth of Pennsylvania, asserting that *Act 13* violated several provisions of both the state and federal constitutions.[335] The Petitioners alleged twelve violations in all, stating that *Act 13* "prevent[ed] them from fulfilling their constitutional and statutory obligations to protect the health, safety and welfare of their citizens, as well as public natural resources from the industrial activity of oil and gas drilling."[336] In a 4-3 decision, the Commonwealth Court of Pennsylvania described the *Act*'s various provisions, stating that "Act 13 preempt[ed] local regulation, including environmental laws and zoning code provisions except in limited instances" and also gave "the power of eminent domain to a corporation that is empowered to transport, sell or store natural gas … and require[d] uniformity of local ordinances."[337]

Of particular importance to our discussion here was the court's ruling concerning the *Act*'s "requirement that municipal ordinances be amended to include oil and gas operations in all zoning districts."[338] Petitioners argued that forcing municipalities to enact zoning ordinances of this nature was a violation of article 1, section 1 of the Pennsylvania Constitution as well as an infringement of section 1 of the Fourteenth Amendment of the US Constitution.[339] Article 1, section 1 states: "[a]ll men are born equally free and independent, and have certain inherent and indefeasible rights, among which are those of enjoying and defending life and liberty, of acquiring, possessing and protecting property and reputation, and of pursuing their own

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330 *Ibid* at § 3304(b)(7).

331 *Ibid* at §§ 3306(1), 3307.

332 An unconventional gas well, as defined by *Act 13* is "[a] bore hole drilled or being drilled for the purpose of or to be used for the production of natural gas from an unconventional formation" (*Act 13*, *supra* note 326 § 3203). Section 2302 allowed local and municipal governments to "impose a fee on unconventional gas wells that have been spud in the county" (*ibid* at § 2302(a)).

333 *Ibid* at § 3308.

334 The issue of standing is outside the scope of our discussion here; however, the Commonwealth Court of Pennsylvania did discuss this component in great detail. See *Robinson (Township of) v Pennsylvania*, 52 A (3d) 463 at 471-78 (Commw Ct Pa 2012) [*Robinson v Pennsylvania*].

335 *Ibid* at 469-70.

336 *Ibid* at 469.

337 *Ibid* at 468-69.

338 *Ibid* at 480.

339 *Ibid*.

happiness."[340] Section 1 of the Fourteenth Amendment to the *US Constitution* maintains that "[n]o State shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States; nor shall any State deprive any person of life, liberty, or property, without due process of law; nor deny to any person within its jurisdiction the equal protection of the laws."[341]

In making its determination, the court analyzed the alleged constitutional violations from a substantive due process standpoint, taking "into consideration the rights of all property owners subject to the zoning and the public interests sought to be protected."[342] Citing the Pennsylvania Supreme Court, the court explained that a "substantive due process inquiry … must accord substantial deference to the preservation of rights of property owners … [though a] property owner is obliged to utilize his property in a manner that will not harm others … and zoning ordinances may validly protect the interests of neighboring property owners from harm."[343] Thus, for the State's compulsory zoning ordinance modifications to be constitutional, they "must be directed toward the community as a whole, concerned with the public interest generally, and justified by a *balancing* of community costs and benefits."[344] Here, the court determined that *Act 13*'s mandatory zoning requirements did "not protect the interests of neighboring property owners from harm" and created "irrational [zoning] classifications," allowing oil and gas development to be permitted in all sectors of the municipalities, including neighborhoods and other residential areas. Therefore, the court found the provision to be an unconstitutional violation of substantive due process.[345] The court discussed each of the complaints in turn, ruling in favor of Petitioners on four of the twelve counts brought by the township, all of which will not be discussed here.[346] In October 2012, the case was heard before the Supreme Court of Pennsylvania on appeal;[347] however, as of the end of December 2012, a decision has not yet been released.

As an alternative to local zoning ordinances, other US municipalities have attempted (or successfully enacted) hydraulic fracturing moratoriums on the basis that development activities threaten the residents and the environment of the town, constitute a legal nuisance, or even violate civil and political rights.[348] In December 2010, the City of Pittsburgh, Pennsylvania

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340 PA Const art I, § 1.

341 US Const amend XIV, § 1.

342 *Robinson v Pennsylvania*, *supra* note 334 at 482.

343 *Ibid* (quoting *In re Realen Valley Forges Greenes Assocs*, 838 A (2d) 718 at 728 (Sup Ct Pa 2003), quoting *Hopewell Twp Board of Supervisors v Golla*, 452 A (2d) 1337 at 1341-42 (Sup Ct Pa 1982)).

344 *Ibid* at 482 (emphasis added by Commw Ct Pa 2012).

345 *Ibid* at 484.

346 *Ibid* at 470-71.

347 Kevin Begos, "Pennsylvania Zoning Laws For Gas Drilling, Known As Act 13, Debated in State Supreme Court", *The Huffington Post* (18 October 2012), online: The Huffington Post <http://www.huffingtonpost.com>.

348 See e.g. City of Pittsburgh, *supra* note 303; Town of Mountain Lake, *supra* note 303; *Northeast Natural Energy LLC v Morgantown (City of)*, Civil Action No 11-C-411 (W Va Cir Ct, Monongalia County 2011) [*Morgantown*].

passed a municipal ordinance[349] which banned natural gas extraction and created a "Bill of Rights for the residents and communities of the City."[350] Among other privileges, the ordinance asserted certain environmental and human rights held by the Pittsburgh community, including the right to "sustainably access, use, consume, and preserve water."[351] Perhaps most divisive, in light of the *Act 13* discussion above, is section 618.04(c) which states the following: "[c]orporations engaged in the extraction of natural gas shall not possess the authority or power to enforce state or federal preemptive law against the people of the City of Pittsburgh, or to challenge or overturn municipal ordinances adopted by the City Council of Pittsburgh."[352] Whether the City of Pittsburgh will alter its local ordinance, either voluntarily or by force, remains to be seen. Many important decisions for the State's future oil and gas development regulations rest with the decision of Pennsylvania's Supreme Court in *Robinson v Pennsylvania*.[353]

The final approach used by municipalities to institute moratoriums on natural gas development activities to be here addressed was instituted by the City of Morgantown, West Virginia in June 2011.[354] The Town successfully passed a local ordinance which characterized hydraulic fracturing as a public nuisance and banned the activity within municipal limits as well as one mile outside of the city's borders.[355] In addition to the potential adverse environmental and health effects caused by hydraulic fracturing, the ordinance maintained that the activity "interfere[d] with the rights of citizens in the enjoyment of their property" and thus constituted a public nuisance.[356] Similar to other municipalities described herein, the City of Morgantown asserted the authority to protect the citizenry from "injury or annoyance," abate those activities that would constitute a hazard or public nuisance, and "promote the public morals, safety, health, and good order" of the city via enactment of the ordinance.[357]

Within days of its enactment, the Morgantown ordinance was legally challenged[358] on the basis that it was preempted (or superseded) by West Virginia State laws which govern the regulation of oil and gas development activities.[359] The case was decided before the Circuit Court of Monongalia County in August 2011. In its decision, the circuit court looked to legislative intent to determine the precise role of the State's Department of Environmental Protection in

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349 City of Pittsburgh, *supra* note 303. See City Clerk's Office, *Legislative Information Center*, online: City of Pittsburgh <http://www. http://pittsburghpa.gov>.

350 City of Pittsburgh, *supra* note 303 at § 618.01.

351 *Ibid* at §§ 618.03, 618.03(a).

352 *Ibid* at § 618.04(c).

353 At the time this article was authored, the Supreme Court of Pennsylvania had not yet released a decision in *Robinson v Pennsylvania*.

354 "Morgantown Bans Fracking", *Metro News* (22 June 2011), online: Metro News <http://www.wvmetronews.com>.

355 US, City of Morgantown, *Well Drilling*, c 1 art 721 (ord 11-24) at §§ 721.01(a)-(b) (2011).

356 *Ibid*.

357 *Ibid*.

358 Ben Adduchio, "Company Sues Morgantown over Drilling Ban", *West Virginia Public Broadcasting* (27 June 2011), online: West Virginia Public Broadcasting <http://www.wvpubcast.org>.

359 *Morgantown*, *supra* note 348 at 1.

the area of oil and gas development.[360] The court noted that Chapter 22 of the *West Virginia Code* outlined specific regulatory parameters "related to the exploration, development, production, storage and recovery of [West Virginia's] oil and gas."[361] Unlike New York, the West Virginia court did not distinguish Morgantown's zoning ordinance from other forms of oil and gas regulation authorized specifically to the State. The court reasoned that because the local ordinance was within "the same field" as the applicable state law, the "doctrine of preemption" applied, meaning the town was preempted from passing ordinances that arguably overlapped state regulation.[362] Further, the state law contained no specific exemptions which would allow for municipal governance over any aspect of oil and gas development.[363] The circuit court's analysis extended to the general role of municipalities within the State and made clear that the authorities granted Morgantown by the legislature were not unconditional.[364] Citing West Virginia's Supreme Court, the court reiterated that in the balancing of municipal and state law, "it is generally held that if there are inconsistencies, the municipal ordinance must yield."[365]

In its decision, the West Virginia circuit court highlighted one of the principal controversies surrounding natural gas regulation: "[t]his Court is mindful that the environmental issues regarding the fracking process are foremost in the public's concern."[366] The court acknowledged the desire of Morgantown's citizens to exercise precaution in oil and gas development activities, but noted its belief that the State's government was taking appropriate measures to alleviate citizen concerns, referring to a related executive order signed by the State's Governor.[367] The order, issued in July 2011, iterated the importance of natural gas development to West Virginia's economy while simultaneously acknowledging the need "to further the immediate preservation of public health, safety and welfare and to prevent substantial harm to the public interest that could result from the occurrence of any one particular Potential Environmental Incident."[368] The order seems an encouraging, though modest, response to public concern surrounding hydraulic fracturing. Issued to provide interim, strengthened regulation "while the Legislature … works to formulate and advance its [regulatory reform] proposal," the order required new rules be instituted to augment precautionary and safety measures.[369]

West Virginia is not the only American state to take what appear to be subtle, proactive measures in response to increased public concerns regarding hydraulic fracturing and natural

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360 *Ibid* at 6.

361 *Ibid*.

362 *Ibid* at 6-7.

363 *Ibid* at 9.

364 *Morgantown*, *supra* note 348 at 7.

365 *Ibid* at 7-8.

366 *Ibid* at 9.

367 *Ibid* at 9.

368 US, State of West Virginia Executive Department, *Executive Order No 4-11* (2011), online: Office of Governor Earl Ray Tomblin <http://www.governor.wv.gov>. Here we see a pertinent example of the conflicting environmental ethics associated with application of the precautionary principle (see discussion page 164). The executive order highlights a cost-benefit analysis that has occurred between development of resources and protection of environment and health. This analysis is presumably the result of an environmental ethic which favors development of resources above other considerations.

369 *Ibid*.

gas development. A small number of states have now instituted or are in the process of approving temporary moratoriums on hydrofracking activities. In January 2012, the New Jersey State Legislature passed into law a bill imposing a one-year moratorium on all hydraulic fracturing.[370] The moratorium was instituted "in order to conduct an investigation into whether hydraulic fracturing could have or is likely to have an adverse impact on air and water quality in [the] State."[371] The bill was introduced in the New Jersey Senate in December 2010 and originally called for the permanent prohibition of all hydrofracking within the State.[372]

Although the original bill passed through both New Jersey's Senate and General Assembly, the *Act* was conditionally vetoed by the State's Governor in August 2011.[373] The Governor reasoned that while the environmental and health concerns surrounding hydraulic fracturing were warranted, he did "not believe that the case [had] been made to justify a complete, permanent, statutory prohibition on fracking."[374] The bill was returned to the legislature with a new proposal: "a one-year moratorium on fracking in New Jersey while the issue [was] studied by the [US Department of Energy], [US Environmental Protection Agency], and [New Jersey Department of Environmental Protection]."[375] The changes were accepted by a nearly unanimous New Jersey legislature.[376] Despite implementing a successful temporary moratorium, the legislature's compromise was viewed by many New Jersey citizens and environmental groups as a poor response to the growing concerns and distrust surrounding oil and gas development.[377] However, new legislation in the form of *Assembly Bill 3644*[378] was recently introduced by Republican State Assemblyman Declan O'Scanlon which seeks to extend New Jersey's temporary moratorium.[379] The extension would ban hydrofracking until such time as the EPA completed its study of the Pavillion, Wyoming gas fields, allowing the State's Department of

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370 US, SB2576, *An Act concerning certain drilling techniques and supplementing P.L. 1985, c. 432*, 2010-11, Reg Sess, NJ, 2012 (enacted).

371 *Ibid* at s 1 (at the time of its passing, the New Jersey legislature acknowledged that hydraulic fracturing activities were not yet occurring in the state).

372 US, SB2576, *An Act concerning certain drilling techniques and supplementing P.L. 1985, c. 432*, 2010-11, Reg Sess, NJ, 2010.

373 See Bills 2010-2011, S2576, online: New Jersey State Legislature <http://www.njleg.state.nj.us> [NJ Bills 2010-11].

374 Governor Chris Christie, *Senate Bill No 2576*, online: New Jersey State Legislature <http://www.njleg.state.nj.us>.

375 *Ibid*.

376 See NJ Bills 2010-11, *supra* note 373.

377 Sierra Club New Jersey Chapter, Press Release, "Legislature Fails to Protect our Water from Fracking" (10 January 2012), online: Sierra Club <http://www.sierraclub.org>; Alexis Levinson, "Christie Proposes One-Year Moratorium on Fracking", *The Daily Caller* (25 August 2011), online: The Daily Caller <http://dailycaller.com>; Sierra Club Scrapbook, *Big New Jersey Rally Demands Fracking Ban in Delaware River Basin* (11 January 2012), online: Sierra Club <http://www.sierraclub.org>.

378 US, AB3644, *Establishes moratorium on hydraulic fracturing for purposes of natural gas exploration or production until certain conditions are met*, 2012-13, Reg Sess, NJ, 2013.

379 Mark J Bonamo, "State Assemblyman Introduces Fracking Ban Extension Bill", *NJ.com* (27 December 2012), online: NJ.com <http://www.nj.com>.

Environmental Protection time to review the EPA's conclusions and make determinations of its own.[380]

Unlike its neighboring New Jersey, New York State has yet to pass significant legislation regarding hydraulic fracturing.[381] In 2010, both the New York Senate and Assembly passed a bill providing for a temporary moratorium on hydraulic fracturing; however, the bill was vetoed by then Governor David Paterson.[382] The Governor instead issued an executive order which curtailed permitting and directed that further environmental review of the process be initiated.[383] Despite this legislative setback, there currently exist several bills working their way through the New York Legislature which address both regulation of natural gas development and the use of hydrofracking.[384] For example, *Assembly Bill 7218A*, initiated in April 2011, would completely "[prohibit] the use of hydraulic fracturing and the disposal and/or processing of any fluid which was used in a hydraulic fracturing process."[385] *Assembly Bill 7400A*, though introduced shortly after *Assembly Bill 7218A*, moved remarkably quicker through the legislature.[386] The bill sought to temporarily suspend hydraulic fracturing activities to allow "the state and its residents the opportunity to continue the review and analysis of the effects of hydraulic fracturing on water and air quality, environmental safety and public health."[387] In January 2012, the bill died in the State Senate, only to return to the Assembly for further amendment.[388]

As of October 2012, New York State enjoys an administrative moratorium of sorts as the State's Department of Environmental Conservation evaluates the environmental effects associated with horizontal drilling and hydraulic fracturing within the Marcellus Shale.[389] In accordance with the abovementioned executive order,[390] the department must also prepare a

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380 *Ibid*.

381 Information from this article is current through December 2012.

382 Tom Zeller Jr, "New York Governor Vetoes Fracking Bill", *The New York Times* (11 December 2010), online: The New York Times <http://www.nytimes.com>.

383 US, State of New York Executive Chamber, Executive Order No 41: *Requiring Further Environmental Review* (2010), online: Governor Andrew M Cuomo <http://www.governor.ny.gov> [Executive Order].

384 See e.g. US, SB1230, *Establishes a moratorium on the issuance of permits for the drilling of wells and prohibits drilling within two miles of the New York city water supply infrastructure*, 2011-12, Reg Sess, NY, 2011; US, SB1234, *Relates to the regulation of the drilling of natural gas resources*, 2011-12, Reg Sess, NY, 2011; US, SB2697A, *Relates to natural gas development using hydraulic fracturing*, 2011-12, Reg Sess, NY, 2011; US, SB5592, *Suspends hydraulic fracturing for the extraction of natural gas or oil*, 2011-12, Reg Sess, NY, 2011; US, AB7218A, *Prohibits the use of hydraulic fracturing in the extraction of oil and gas*, 2011-12, Reg Sess, NY, 2011 [Assembly Bill 7218A]; US, AB7400A, *Suspends hydraulic fracturing for the extraction of natural gas or oil*, 2011-12, Reg Sess, NY, 2011 [*Assembly Bill 7400A*].

385 *Assembly Bill 7218A*, *supra* note 385.

386 *Assembly Bill 7400A*, *supra* note 385.

387 *Ibid* at s 1.

388 See New York State Assembly, *A07400 Summary*, online: NY State Assembly <http://www.assembly.state.ny.us>.

389 Cailin Lechner, "New York's Moratorium on Hydraulic Fracturing Likely to Continue", (23 October 2012), online: RegBlog <http://www.law.upenn.edu>; Department of Environmental Conservation, *supra* note 307.

390 Executive Order, *supra* note 383.

"Supplemental Generic Environmental Impact Statement,"[391] which also includes an assessment of public health effects.[392] Thus far, the impact statement has undergone two public comment periods, with the second ending in January 2012.[393] While preparation of the impact statement remains ongoing, the executive order indicates that no new permits for horizontal drilling and hydraulic fracturing will be issued.[394] The State's Department of Environmental Conservation also indicated that "no permits [for high-volume fracturing] will be issued until [the department] has the proper enforcement capacity to monitor all fracturing activities."[395]

State level efforts to curb hydrofracking, though often unsuccessful, continue to occur. In 2011, the State of Maryland's General Assembly House of Delegates successfully passed *The Marcellus Shale Safe Drilling Act of 2011*.[396] The bill called for the creation of a special advisory committee for the purpose of studying the potential adverse environmental and health effects caused by shale gas extraction, including hydraulic fracturing.[397] Upon completion of the study, the advisory committee would provide "findings, conclusions, and recommendations, if any, for statutory or regulatory changes" to Maryland's oil and gas laws.[398] The House of Delegates passed the bill by a vote of 98 to 40.[399] Nonetheless, the bill failed to move through the stages of Maryland's Senate approval, eventually expiring upon its first reading.[400]

4.3 Implications for Natural Gas Development

The previous discussion serves to highlight the growing trend towards incorporation of the precautionary principle into natural gas regulatory frameworks at the state, provincial, and municipal levels in both Canada and the US. The means by which local, state, and provincial governments have attempted to incorporate the principle are varied, but have carried one common, underlying objective: protect human health and the environment against adverse effects caused by increased development activities. Each effort is illustrative of a legislative approach that emphasizes precaution when potential risks have been documented, even though probabilities of each outcome have not been identified with precision and not all possible outcomes have

391 SGEIS on the Oil, Gas and Solution Mining Regulatory Program, Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, online: New York State Department of Environmental Conservation <http://www.dec.ny.gov> [SGEIS].

392 Lechner, *supra* note 389.

393 SGEIS, *supra* note 391.

394 Executive Order, *supra* note 383.

395 Department of Environmental Conservation, Press Release, "New Recommendations Issued in Hydraulic Fracturing Review" (30 June 2011), online: New York State Department of Environmental Conservation <http://www.dec.ny.gov>.

396 US, HB852, *The Marcellus Shale Safe Drilling Act of 2011*, 2011, Reg Sess, Md, 2011.

397 *Ibid* at s 14107.1.

398 *Ibid* at s 14107.1(F).

399 See Maryland General Assembly, *House Bill 852*, online: Maryland Legislature <http://www.mgaleg.maryland.gov>.

400 US, SB634, *The Marcellus Shale Drilling Act of 2011*, 2011, Reg Sess, Md, 2011; Tom Pelton "Drilling Down to the Deadline: At Midnight, Clock Will Run Out For Hydraulic Fracturing Bill in Maryland", *Bay Daily* (11 April 2011), online: Chesapeake Bay Foundation <http://cbf.typepad.com>.

been identified. Although not all municipal and state moratorium efforts have been successful, each attempt effectively advocates, in a public setting, the need for precautionary-based decision-making that provides for "sound, rational processes for preventing negative impacts of human activities on human and ecosystem health."[401] This "sound, rational"[402] approach to natural resource regulation supports our primary argument: in the face of potentially significant adverse environmental and health effects, a complete moratorium on hydraulic fracturing and natural gas development is required until further, comprehensive research may be conducted. The precautionary measures advocated by the Province of Quebec and the recent passage of *House Bill 464* in Vermont are promising developments in the growing trend towards responsible development decision-making and precautionary moratoriums.[403] As demonstrated, many municipalities, states, and provinces have already attempted to pass or succeeded in passing a variety of moratorium-type ordinances and legislation. These efforts are exemplary of a public will that supports the exercise of precaution in the face of increased uncertainty and life-threatening risk.

5. CONCLUSIONS

The sections above illustrate that natural gas development activities are, by nature, associated with risks of significant contamination and subsequent adverse effects on the health of ecosystems and individuals, even though many of the consequences of contamination are not fully understood. We argue that precautionary measures via the use of safety guidelines and increased regulation are essential, and that a cost-benefit analysis is inappropriate. Without immediate precautionary actions, costly (not just in monetary terms), irreversible externalities to human health and the environment will occur. Natural gas development requires comprehensive safeguards to protect valuable resources and prevent against irreparable damage. Yet, such safeguards are impossible to implement if there exists a significant lack of information and scientific data regarding the effects of development upon human life and the natural environment. In particular, there are sizeable informational shortcomings surrounding the use of hydraulic fracturing within extraction activities. Our arguments indicate clearly that a precautionary moratorium on all natural gas development is required until the short- and long-term effects of extraction activities can be accurately ascertained.

In the US and Canada, many municipal, state, and provincial governments have already begun to take steps towards complete moratoriums on hydrofracking and other resource development activities. Some, like the State of Vermont, have been highly successful in this regard, while others have experienced powerful opposition from fellow legislators and industry. Despite the opposition and perceived failures of many local and state governments to pass binding moratoriums, each effort represents the emerging trend towards public support of precautionary-based regulation and decision-making. The precaution that citizens have sought to exercise through moratorium efforts is based, in part, on legitimate, fundamental concerns for the health of exposed populations in ingesting materials that are established toxicants. Although we cannot predict with certainty what the specific health effects of exposure to these toxicants will be, as these will vary between individuals, it is clear that exposure to fracking

401 *Lowell Statement*, *supra* note 13.

402 *Ibid*.

403 See *House Bill 464*, *supra* note 299; see also discussion of the Province of Quebec, pages 45-47.

fluid's complex mixtures will cause adverse health effects across exposed populations, not to mention adverse effects on natural, non-renewable resources and ecosystems. As well, it is clear that fracking causes air pollution that has known adverse health effects and may increase the emission of greenhouse gases. Many US government health officials share the concerns of citizens and have publicly acknowledged issues in access to information regarding the toxicology of hydraulic fracturing chemical additives.[404]

In addition to existing informational gaps, recent reports indicate that US state oil and gas administrative agencies are failing to fulfill their regulatory duties.[405] Without proper enforcement, even the most minimal health and environmental safeguards become meaningless. Exercise of the precautionary principle requires, at a fundamental level, acceptance of "the basic right of each individual (and future generations) to a healthy, life-sustaining environment."[406] The *Lowell Statement* calls not for the complete halt to human development and progress, but for the adoption of "the precautionary principle in environmental and health decision-making."[407] A moratorium on natural gas development is in accordance with this underlying principle and places human health and environmental considerations at the foundation of any responsible natural gas regulatory and development decision-making framework.

Indeed, moratoriums on hydraulic fracturing and natural gas development activities offer the most reasonable solution to alleviate the public's growing unease and trepidation surrounding natural gas development. Moratoriums allow for increased scientific research of hydraulic fracturing and the associated risks while simultaneously preventing future harms. Research is needed to determine the extent of migration of fracking fluids into underground aquifers and into the environment, including subsequent human exposure. Further, new technologies are needed to reduce the toxic nature of fracking fluids and the effects on air and water. Should governments and industry choose to dismiss mounting evidence of the associated risks, and access to information remains a primary obstacle to comprehensive environmental and health assessments, public tensions will undoubtedly continue to rise. The industry may ultimately face a serious public relations crisis as well as an increase in lawsuits for damages. More importantly, society will remain vulnerable to short- and long-term adverse effects, and the costs, in terms of reduced quality of life, increased acute and chronic illnesses, and loss of productivity, could be substantial. Such widespread endangerment should itself be considered an unacceptable risk.

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404 Alex Wayne, "Fracking Moratorium Urged by U.S. Doctors until Health Studies Conducted", Bloomberg (9 January 2012), online: Bloomberg <http://www.bloomberg.com>.

405 See Earthworks, "Breaking All the Rules: The Crisis in Oil and Gas Regulatory Enforcement" (September 2012), online: Earthworks <http://www.earthworksaction.org>; see also Horwitt, *supra* note 112 at 2, 12.

406 *Lowell Statement*, *supra* note 13.

407 *Ibid*.