FOLLOW THE MAPS: WATER AND FAULTS EVERYWHERE
FRACKING CONTAMINANTS CAN'T BE CONTAINED

Hydrogeologists[1] say that long term water contamination (especially in valleys where most farms and homes are) is assured if High Volume Slickwater Horizontal Hydrofracking is permitted), but short term contamination of our flowing underground aquifers is also at risk with fracking. And the Supplemental Generic Environmental Impact Statement (SGEIS) of our Dept. of Environmental Conservation (DEC) has not referenced ***maps that would tell of endless pathways for drinking water contamination.***

Aquifer maps (Bugliosi, 1988; series of five USGS maps)[2] depict West-of-the-Hudson Upstate as replete with a bountiful, inter-connected system of large freshwater aquifers that feed our lakes, reservoirs, rivers. NYS has a wealth of groundwater, aquifers like branches of a huge tree, with smaller leaf-like aquifer pools (marked L and G) seemingly everywhere else on the maps. Groundwater moves and flows , so fracking contaminants can't be contained in such a web of water. **MISSING FROM THE SGEIS[3]**

The SGEIS admits that fracking operations within "Aquifers pose the risk of causing significant adverse impacts to water resources." And "standard mitigation measures may only partially mitigate impacts. Such partial mitigation would be unacceptable due to the potential consequences posed by such impacts." (6.1.3.4) Yet the SGEIS still calls for fracking into and within 500 ft of hundreds of NYS aquifers.

Earthquake Fault maps (Jacobi, 2002), also not included, indicate that many long and intersecting fault lines, some "high risk," occur throughout NYS and in proximity to the NYC Watershed. He concludes there is "a web of basement faults that crisscross NYS…. and it appears that not only are there more faults than previously suspected in NYS, but also, many of these faults are seismically active." And "most of the basement faults that extend to the surface rocks are seismically capable, even those that do not have historical seismicity ascribed to them." And "the high number of faults means that most cultural facilities (e.g., waste disposal sites, bridges, pipelines) are not far from a potentially seismically active fault." Lastly, "it is vitally important to assess the maximum credible seismic event that can be expected along these faults." (*Basement Faults and Seismicity…* 2002, p. 95,105-6) **MISSING FROM THE SGEIS**

By failing to reference all known fractures and faults, the SGEIS is risking "ground and surface water contamination through seismic activity stemming from natural causes or from lubrication and pressurization [by fracking] along dormant faults" (EPA testimony of hydrogeologist Rubin, 2010. p.3).

Faults, many unmapped, extend to the surface rocks and "provide pathways for contaminants and gas migration through geologic zones believed to be physically isolated, based on incomplete data" (Rubin, Ibid., p.1). There is a history of fracking-induced earthquakes (Nikiforuk, Energy Bulletin, 2011). The gas industry admits its "models fail to predict fracture behavior precisely, and in many cases, models fail completely" (Bennett, Oilfield Review, Winter 2005-6, p 44).

Karst maps (Veni, 2001, *Living With Karst*, AGI) show a band of fragile cavernous limestone (as Howe Cavern area with caves, sinkholes, shafts, sinking streams, springs) running E-W across central NYS and N-S along the west side of the Hudson. Surface and underground toxic spills and releases penetrate into and flow quickly within karst aquifers. **MISSING FROM THE SGEIS**

Flood Plain maps updated to indicate actual 500 year "Irene" flood plains would make relevant the SGEIS call for a possible ban on fracking in 100 year flood plains. And worth mentioning is predicted future flooding that will be more extreme and more frequent, one impact of our changing climate. Floodwaters, of course, transport contaminants everywhere, quickly. **MISSING FROM THE SGEIS**

Abandoned Oil and Gas Well maps

The population of 44,000 to 57,000 abandoned oil and gas wells, *(NYS Mineral Resources, Annual Report 2009, p. 22)* and of thousands of old, unplugged water wells, mostly unmapped, serve as potential conduits for fracking contaminants into drinking water. **MISSING FROM THE SGEIS**

[1]Arthur Palmer, Paul Rubin, http://hydroquest.com/Schoharie/

[2] www.schoharievalleywatch.org ; also, see www.dec.ny.gov/lands/36119.html

[3]Except SGEIS 2011, Appendix 5, drilling application addendum, which suggests USGS as source for aquifer water withdrawal.

Research by: Louise Maher-Johnson, maherjohnson@gmail.com and Clark Rhoades, cjrsailor@gmail.com

MISSING IN SGEIS: EARTHQUAKE RISK ASSESSMENT

"Earthquakes and seismic activity, whether naturally occurring, or induced from hydrofracking or fluid injection episodes, may shear casings and WILL crack cement sheaths used to isolate and protect freshwater aquifers from drilling contamination. Similarly, seismic activity may also degrade other vulnerable items, including dams, pipelines, bridges, reservoirs, and nuclear power plants." -Hydro-geologist Paul Rubin, Delaware River Basin Commission Expert Fact Sheet

Earthquake Probability and Fracking

The unexplored question by the NYS Dept. of Environmental Conservation (DEC) Supplemental Generic Environmental Impact Statement (SGEIS) about the relatively new combined technique of High Volume Slickwater Horizontal Hydrofracking is **how can seismicity or earthquake probability be determined other than by past earthquakes**?

NY Has More Seismically Active Faults Than Expected

Robert F. Jacobi, distinguished SUNY structural geologist, studied the question of seismicity in his detailed research out of the University of Buffalo, accepted in 2002, entitled, *Basement Faults and Seismicity in the Appalachian Basin of New York State)*. He concludes there is "a web of basement faults that crisscross NYS…. and it appears that not only are there more faults than previously suspected in NYS, but also**, many of these faults are seismically active**." (Jacobi, 2002, p. 75)[1]

Earthquake Epicenters Near NYC Watershed

As for the three counties bordering the NYC Watershed, he concludes that the epicenters of three seismic events in easternmost Otsego County at the border of Schoharie County could be interconnected with the nearby major fault (Sprakers Fault) in Schoharie County which, in turn**,** could be related to two seismic events in Delaware County (Jacobi, 2002, p.105 and figure 1).[1] All this known seismic activity is just to the north, west and southwest of the NYC Watershed.

Yet the DEC SGEIS, in 2011, neglects to mention any of the extensive earthquake fault research by Dr. Jacobi, even though he had led a 2000-2007 study for our state Department of Energy, NYSERDA, on finding natural gas reserves by locating faults (Jacobi, 2007)[3].

Comprehensive Earthquake Fault Maps Not in SGEIS

Nor does the SGEIS include any of Jacobi's well known 2002 fault maps. Instead the DEC relies on a 1977 Isachsen/McKendree map of "fault features" (Figure 4.13) which Jacobi described as a "preliminary brittle structure map." (Jacobi, 2002, p.101)[1] The 1977 map shows a very minimal number of faults.

Most Faults Seismically Capable

Jacobi further explains that "most of the basement faults that extend to the surface rocks [in NYS] are seismically capable, even those that do not have historical seismicity ascribed to them." And "the high number of faults means that most cultural facilities (e.g., waste disposal sites, bridges, pipelines) are not far from a potentially seismically active fault." One example he cites: "…in the Mohawk Valley region, the south end of the Hinckley Reservoir dam is adjacent to the Prospect Fault. Thus, it is vitally important to assess the maximum credible seismic event that can be expected along these faults." (Jacobi, 2002, p. 105-6)[1]

Inaccurate Historical Earthquake Data Near the NYC Watershed

Further study is needed into the seismic potential of the NYC Watershed and its surrounding counties and other NY counties in the Marcellus-Utica shale gas area. Enough historical quakes exist to sound an alarm, though. For instance, according to the USGS earthquake database,[4] there have been **91 earthquakes up to 5.3 in magnitude between 1973 and 2011** in the Richmondville/East Worcester area bordering Schoharie and Otsego Counties, just two towns removed from the NYC watershed reservoirs. But the SGEIS *Table 4.2* on earthquakes lists none in Otsego County and only 7 in Schoharie County for the period 1970 to 2009, while its earthquake map (*Figure 4.15*) shows only one in the area bordering the two counties.

High Risk Earthquake Area Near NYC Watershed

This border area to the northwest of the NYC watershed, is one of the red-starred, high risk areas noted by Jacobi in his 2002 major and minor fault maps**.** Two parallel major faults run through this border area. Heightening the risk even more, another pair of parallel and major fault lines run north-south just east of this border. Since they intersect the first pair, slippage of one fault could reasonably cause a domino effect, increasing the magnitude or area of the earthquake. *(Jacobi. 2002, figure 5)*[1]

Earthquakes since 1970 in Greene, Delaware and Schoharie Counties, all part of NYC Watershed, also demonstrate that this upstate area is seismically active. SGEIS, Figure 4.15 indicates numerous earthquakes in Sullivan Rockland and Westchester counties in the same time period, 1970 to 2009. Even the minimal 1977 fault map in the SGEIS (Figure 4.13) indicates a plethora of faults north of Westchester County, close to the water tunnels entering the metropolitan area.

Potential Seismic Problems: Gilboa Dam and Indian Point Nuclear Plant

Fractures enlarged and faults lubricated by repeated fracking in the counties surrounding the NYC Watershed could conceivably risk earthquakes near the Gilboa Dam and Indian Point Nuclear Power Plant. A rupture of the Gilboa Dam, near the Sprakers fault and the NYC watershed system, could lead to great mortality and the flooding of several surrounding counties. Considering that the pressure released by a single earthquake fault can activate several other nearby faults and increase the destruction caused by the initial quake (a**s** exemplified recently in Japan), the existence of a fault line near NY's Indian Point nuclear power plant poses a huge risk.

DEC Conclusion Based on Inaccurate Earthquake Map and Table

Based on the outdated, incomplete fault map (*SGEIS Figure 4.13*) and the table and map of known quakes (*Table 4.2 and Figure 4.15*), the DEC concludes that "independent pre-drilling seismic survey probably is unnecessary in most cases because of the relatively low level of seismic risk in the fairways of the Marcellus and Utica shales."(*6.14.2*) This conclusion is in sharp contrast to that of Jacobi: "Thus, it is vitally important to assess the maximum credible seismic event that can be expected along these faults." (Jacobi, 2002, p.106)[1]

Failed Seismic Modeling and Japan's Recent Quake
Five fault segments failed simultaneously in Japan's recent quake (which caused a tsunami and nuclear meltdown), producing a quake much larger than the model had predicted. The Japanese earthquake models predicted that only one or two faults would rupture at once and their models are based on a 400 year historical record, taking a long view, whereas US models (as evident in the DEC and other USGS tables), are based on the past three decades. Seismologist Mark Peterson, who leads the USGS project mapping seismic risk in the United States, says that his agency is now updating its model of major faults in the Western United States, based on the events in Japan. (Barone, 2011)[5] New York needs to do the same before allowing fracking.

Earthquakes in the Northeast, Understudied But With Broader Impact
Since most earthquake study in the US is on faults west of the Rockies, the DEC should be wary and await further science. Also true of the Northeast is that quakes travel greater distances, e.g., the earthquake in VA in August, 2011 was felt "as far south as Atlanta, Georgia as far north as Quebec City, Quebec; as far west as Illinois and as far east as Fredericton, New Brunswick.… East of the Rocky Mountains, an earthquake can be felt over an area as much as ten times larger than a similar magnitude earthquake on the west coast…. The relatively shallow depth of this quake also contributed to its widespread effects." (Wikipedia)[6]

Since records have been kept, New York State has experienced more than 300 earthquakes large enough to be felt by humans. In the central and eastern United States the bedrock is older and more rigid than in the west. As a result, seismic waves travel greater distances with less attenuation (lessening of intensity) than in the western United States. When similar earthquakes are compared, the region of maximum ground motion in the East may be up to 10 times larger than in the West. (Tarbuck et al, p. 19)[7]

Attica, Wyoming County, NY, has a long history of earthquakes- 1737, 1929, 1966, 2009. In August, 1929, besides dishes and wall pictures falling, "an increased flow at the Attica reservoir was noted for several days after the earthquake; a number of wells near the reservoir went dry….The earthquake was felt throughout most of New York and the New England states, northeastern Ohio, northern Pennsylvania, and southern Ontario, Canada. Strong aftershocks were felt at Attica on Dec 2 and 3." (Rubin, 2010; USGS Earthquake Hazards Program)[8]

"In September 1944. an earthquake near Massena, New York, damaged masonry, plumbing, and house foundations…Press reports indicated a number of wells in St. Lawrence County went dry… This earthquake was felt over approximately 450,000 kilometers, including all the New England States, Delaware, Maryland, New Jersey, Pennsylvania, and portions of Michigan and Ohio. A few points in Illinois, Indiana, Virginia, and Wisconsin also reported feeling the tremor." [8]

Earthquakes need further independent science, as does the cumulative seismic impact of fracking over 100,000 wells in PA and NY.[9]

Fifty Year History of Injection-Induced Earthquakes

In 1962, the military at the Rocky Mountain Arsenal, CO, pumped chemical waste into a disposal well drilled two miles underground. The injection of fluids then triggered 1,500 earthquakes between 1962 and 1967. After the military stopped injecting waste, three earthquakes greater than 5 on the Richter scale rocked the Denver area, resulting in more than $8-million worth of property damage. Scientists later found the earthquakes resulted from fluid injection that unbalanced an existing fault or fracture. (Nififoruk, 2011)[10]

Many of these scientists, quoted in Cypser's study, *Colorado Law & Induced Seismicity*,[11] share the conclusion of Scott Ausbrooks, a geohazard specialist for the Arkansas Geological Survey: "It is confirmed and established that injection wells can induce seismicity." (Nikiforuk, 2011)[10]

But even with a fifty year history of pressurized injection-induced earthquakes in TX, OK, AK, CO, Alberta, UK, British Columbia (Nikiforuk, 2011)[10], the DEC SGEIS mentions only two minor seismic events, at Dale and Avoca, NY, and, while admitting that the pressurized fluid injection caused the quakes at these sites by lubricating faults, it assesses no risk with future injections because the injection of fluids for extended periods of time at high pressure is significantly different from hydraulic fracturing process (*SGEIS 6.13.1.2*).

Instead of requiring further study and taking the precaution of banning fracking in a broad area around the NYC Watershed and its aging infrastructure, and all watersheds and aquifers, the SGEIS calls for minimal setbacks. And states: "No significant adverse impacts from induced seismicity are expected to result from HVHF [High Volume Hydrofracking] operations" (*2011 SGEIS, 6.13*). Note that the eleven quakes in Ohio in 2011 seem also to have been induced by wastewater injection (Fountain, NYT, 2012*).*[12]

A similar concern was addressed by the EPA in 1990, i.e., "the potential for induced earthquakes to breach the confining layers of waste-disposal reservoirs, which would then permit the possible upward migration of contaminated fluids" (Nicholson and Wesson, 1951, p. 12).[13]

Major Fault in Four Western NY Counties

Jacobi also delineated the length of the major western NYS fault, the CLF, from Canada through Lake Ontario and through the western NYS counties of Orleans, Monroe, Genessee, Wyoming and Allegheny. His study concludes that "the CLF is presently potentially seismically active" (Jacobi & Fountain, 1993, p18).[14]

Initial Research in 1977 on the Minimum Pressure To Induce Seismic Activity

In this research Jacobi sites the 1977 CLF study of Fletcher & Sykes[15] which focused on "the sharp increase in seismicity at our site near Dale [Wyoming County, NY] following the initiation of fluid injection under high pressure (120 bars tophole) at a hydraulic mining operation nearby. This facility, which mines salt from the Vernon Formation of Silurian age, is centered near the Clarendon-Linden Fault, a major north-south trending system of high-angle thrust faults that extends for over 100 km from Lake Ontario to Allegheny County, New York. Although the seismic events were small (none were recorded at our station 30 km to the northwest), as many as 80 occurred per day, and many were felt locally. The marked increase in seismic activity after attaining high pressures, the closeness of these events to the bottom of the injection well, and the near cessation of activity within 48 hours of the shutdown of injection strongly suggest that this activity was caused by the triggering of tectonic strain on or near the Clarendon-Linden Fault by the high fluid pressures of the mining operation. The minimum pressure (41-48 bars) at which seismic activity occurred is consistent with predictions made by applying the Hubbert and Rubey theory of effective stress to hydrofracturing stress measurements from Alma, New York."[14] Indeed, this decades old study implies that **a specific well injection volume, pressure and depth can be ascertained in order to avoid induced earthquakes.**

The contrast between the minimum pressure to induce seismic activity of 48 bars (less than 700 pounds per square inch or psi) with the average of 10,000 psi used in High Volume Slickwater HydroFracking currently is huge, and the DEC should address this discrepancy. This is essential information; science needs to be done before fracking begins.

Yet the DEC dismisses this 1977 study by saying that these induced earthquakes in Dale were lower in magnitude than a naturally occurring one in the area. And adds that "Similar solution mining well operations in later years located further from the fault system…did not create an increase in seismic activity" (p. 4-33). This is, again, a missed opportunity by the DEC to explore future quake avoidance by understanding the pressure, volume and depth ratios of drilling, with respect to the type of injection fluid (salt water vs slickwater). This 1977 study is actually making the case for not fracking in proximity to a fault, and should oblige the DEC to utilize Jacobi's more comprehensive fault maps and continue to map other faults in NYS.

Cumulative Impact of Fluid Injection Pressure on NYC Water Tunnels

"Repeated microseismic events over the course of years could have a detrimental effect on the concrete tunnel liners [of the NYC Watershed tunnel infrastructure]," according to Paul Rush, DEP Deputy Commissioner. "Hydrofracking operations are anticipated to involve pressures in the range of 5,000-10,000 psi [pounds per square inch]. The structural analysis using tunnel specifications indicated that differential pressures as low as 20 psi could have a detrimental impact on the unreinforced concrete liners of the Delaware tunnels…. **The risk from elevated pressures increases as more wells are drilled and hydraulically fractured (fracked).**" (Rush, 2011)[16]

Seismic Risk to Well Casings and Sealants Is Great

Naturally occurring earthquakes will almost certainly disrupt and degrade the cement sheath materials used in gas wells to protect freshwater aquifers (Rubin, 2011).[17] This would be true of fracking-induced earthquakes also.

"Ground motions from even one significant earthquake, among many that occur over time, may catastrophically shear numerous gas well casings. Or, at the very least, may result in fracturing and loss of integrity of well casing cement designed to isolate freshwater aquifers from deep saline waters. As such, earthquakes may instantly destroy the integrity of geologic formations that formerly protected freshwater aquifers. Restoration of contaminated freshwater aquifers is probably not possible, thus well failures from any single or combinations of mechanisms is likely an irrevocable commitment of natural resources." (Rubin, 2010)[18]

Cumulative Impacts of Fracking on a Well Pad
Also missing from the SGEIS is research to measure cumulative impacts of fracking and re-fracking several wells on a single well pad. A single one-mile-long lateral arm from one well needs to be fracked every 500 ft., which means ten separate explosive frackings. Then several other drilled wells **(**the SGEIS expects there to be ten wells per pad) on that same well pad, just 20 ft apart, will each require perhaps ten frackings. Then re-frackings later on. This means extensive repeated pressure on the integrity of each well and many opportunities to open up existing fractures and faults.

Independent research is needed to locate faults and to understand fracking pressures re casings and sealants, fractures, faults, induced earthquakes, cumulative impacts of repeated frackings. All wells leak anyway, according to Cornell's Ingraffea,[19] and will eventually stop producing and be abandoned and corrode -and probably contribute to polluting our drinking water over time. But short term thinking dominates the industry, the SGEIS, and proposed state regulations.

Gas Industry Admits Their Models Have Failed
This need for further research before pursuing hydrofracking amongst this web of faults, is recognized by the gas industry: "fractures and faults…. make predicting hydraulic fracture behavior difficult" and "models fail to predict fracture behavior precisely, and in many cases, models fail completely…" (Bennett et al, 2005-2006, p. 44).[20]

EPA Concerns Need to Be Addressed in NY
The many recommendations in the EPA response to the DEC SGEIS of 2009 should have been incorporated into 2011 revised draft.

And the SGEIS should have addressed the concern expressed in the EPA's 2004 study re pathway of contaminants: "…EPA found that the volume of the space within the fracture area may not hold the volume of fluid pumped into the ground during a typical fracturing event. Therefore, EPA assumes that a greater volume of fracturing fluid must 'leak off' to intersecting smaller fractures…or that fluid may move beyond the idealized, hypothetical 'edge of the fracture zone'. …**that fracture fluids often take a stair-step transport path through the natural fracture system**" (Environmental Protection Agency, 2004, p. 12).[21]

When Jacobi says: "most of the basement faults that extend to the surface rocks are seismically capable, even those that do not have historical seismicity ascribed to them,"[1] he is not only addressing quake potential. He is also informing that deep faults have pathways to the surface; in fact, one method geologists use to ascertain where best to drill is soil tests that indicate gas far beneath by its presence in the soil. Fracture pathways already exist for contaminants to "stair-step" to our aquifers and soils, streams and reservoirs.

MISSING IN SGEIS : AQUIFERS EVERYWHERE, AND THEIR DEGRADATION

"The productive life of gas wells is < 20 years compared to aquifer life of about one million years." -Hydro-geologist Paul Rubin, DRBC Expert Fact Sheet

"Shale wells will last about 8 years and only about 20% of the gas is recoverable, The rock formations shattered by fracking will be 'thousands of times more permeable,' allowing the remaining 80 per cent of shale gas and underground water, 10 times more salty than sea water, to continue circulating, bubbling to the surface through the disused gas wells. Over time, methane could leak into the groundwater and gas leaks could gush, uncontrolled, into the air. 'Because this happens deep below, it is not visible on the surface'" (Shale-gas extraction after-affects will threaten drinking water, could jeopardize agriculture, Hydro-geologist Durand quoted by Dougherty, 2011).[22]

*Retired DEC environmental engineering technician, Paul Hetzler: "*I managed scores of groundwater remediation projects in the 1990s. I've reviewed countless hydrogeologic reports and seen thousands of lab results from contaminated wells…. Hydraulic fracturing will contaminate New York's aquifers**.** If you were looking for a way to poison the drinking water supply here in the Northeast, you couldn't find a more chillingly effective and thorough method of doing so than with hydraulic fracturing." **(**Hetzler, 2011)[23]

"The dangers to our waters are, in fact, extreme. The damage may not show up for years, the ruination of our water may at first be invisible and in the end irreparable. (Rubin quoting Cyla Allison, 2011)[24]

Fracking Toxins Left Deep in the Earth "Move" to Nearby Aquifers, Then to Down-Gradient Aquifers

Residual fracking fluids left deep in the earth "supposedly remain in place, deep beneath the surface. Not true- they move. Any groundwater hydrologist knows that groundwater flow is not limited to shallow depths. The patterns and physics of flow have been quantified since the early 20th century and have been verified many thousands of times in the field. Even if there are no problems in and around drilling sites, the contaminants will move slowly but inevitably down-gradient to the major river valleys. In the Appalachians, that happens to be were most of the population centers and highest-yielding aquifers are located…. This is not raising a false alarm, but as close to a scientific fact as it is possible to get in the field of subsurface geology." (Palmer, 2011, p. 2-3)[25]

"It's possible that the contaminants will become so diluted that they will remain below drinking-water standards. But why should we impose this kind of low-level contamination on a large percentage of our population? This kind of contamination has a vile history. There are many examples where the toxic effects of contaminants were not realized until far too late- remember DDT, PCB's, thalidomide, etc? Remember Times Beach, Missouri? Love Canal, New York? The CDC lists hundreds of low-level contaminants in human bodies just from casual exposure. Just what we need is additional contaminants injected into the ground, where it will be literally impossible (both physically and economically) to remove them. If fracking becomes like a gold rush, with landowners grabbing for royalties to keep ahead of their neighbors, there will be widespread plumes of chemicals at depth." (Palmer, 2011, p.3)[25]

And, Palmer concludes, “there is real potential for contamination in surrounding river valleys well within our own lifetimes.” (p.5) And “there is no hope of remediating the situation.” (p.8)

Migration Pathways for Contaminants into Aquifers

The DEC has not studied in depth the many underground and surface pathways for methane and other contaminants to reach our drinking water wells and aquifers. Migration pathways include both frack-induced and natural rock fractures, minor and major earthquake faults, cement casing and sealant failures, wastewater spills, wastewater ejection by treatment facilities into streams, leaks from tens of thousands of old and open abandoned wells (many unknown), channels between the wellbore and the earth, and seismic episodes. The short term view of the DEC also disregards the eventual failure of all wells with time and the eventual migration or “stair-stepping” up of contaminants toward aquifers, wells and surface water.

“Fracking contaminants, once mobilized vertically along fault planes and fractures, especially under pressurized conditions, can reach freshwater aquifers. Even if all fracking fluids were comprised of non-toxic chemicals, the risk of interconnecting deep saline-bearing formations (i.e., connate water) and/or radioactive fluids with freshwater aquifers is not warranted.” (Rubin, 2010, EPA Testimony, p.4-5). [2]

Aquifer Sealant Materials Not Durable

Research conducted by the gas industry and others indicates that the cement sheaths and casing materials used to isolate freshwater aquifers will fail in less than 80 to 100 years, and in many cases far sooner. Aquifer sealant materials are not durable in the long-term and will fail due to a variety mechanisms (e.g., cement shrinking, debonding, cracking, corrosion) resulting from both natural and seismically-induced factors *(*Rubin, 2011*).*[26]

Deep Shale Methane Migration into Drinking Water

The SGEIS has dismissed the recent peer-reviewed Duke University study “Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing,”[27] which its authors, Osborn et al, claimed was “the first peer-reviewed study to suggest that deep, thermogenic methane is migrating into drinking water near shale-gas wells.” The DEC concluded the methane contamination was naturally occurring at the wells tested, and didn’t address the scientists’ claim that the isotope or fingerprint of the methane found in the water wells was proof of a deep shale source. The research by Jacobi, i.e., his mapping of fractures using soil gas analyses, is conclusive evidence that pre-existing fractures provide pathways for gas to travel near and to the surface.

Jacobi and Fountain, in 1993 1996, and in 2002, successfully identified and measured methane seepage from fractures that most likely extend downward to gas-producing shales, which indicates that open vertical pathways already exist, confirming the risk that opening and expanding these fractures during fracking will provide even greater gas and contaminant migration pathways. They found that “the background methane gas content in soil is on the order of 4 ppm [parts per million], but over open fractures in NYS, the soil gas content increases to 40-1000+ ppm” (Jacobi, 2002, p.79).[1]

“Numerous joints [joints and faults are collectively termed fractures] in the Appalachian Basin [of NYS], even in the absence of gas well installations, provide open, functioning, avenues for upward migration of methane. Gas-rich joints encountered by exploration well boreholes may interconnect and enhance preexisting joint pathways for methane, deep-seated saline water, radioactivity and, following development of horizontal gas wells, for contaminated LNAPL (Light NonAqueous Phase Liquids; e.g., chemicals with a density less than freshwater, such as benzene) fracture fluids to migrate to aquifers, reservoirs, lakes, rivers, streams, wells, and even homes.” (Rubin, 2010, p.4)[18]

Misleading and Incomplete Aquifer Maps on the DEC Site and in 1992 GEIS
The DEC posted one aquifer map on the introduction page to Marcellus natural gas, a page which is not part of the 2011 SGEIS. This map shows 12 isolated and small primary aquifers in the Marcellus area (primary is defined as providing drinking water for 10,000 or more people), but excludes the hundreds of other aquifers that supply well water to over two million statewide. Seventeen counties in the Marcellus shale gas area appear to be without drinking water on this DEC map, as they have no primary aquifers. This DEC website map also excludes the Utica shale area, which is broader, extending north to Saratoga.

It should be noted that all drinking water, directly or indirectly, comes from groundwater aquifers, even municipal water in reservoirs.

Digging back into the 1992 GEIS of the DEC, there is another incomplete aquifer map that includes the 19 statewide primary aquifers and a handful of principal aquifers (or non-primary, in that each aquifer fails to serve a population of 10,000). But in 1992 the DEC had available its own DEC/USGS very comprehensive set of five oversized aquifer maps of west-of-the-Hudson upstate, depicting hundreds of principal aquifers.

Digging further yet into the website, there is a greatly reduced and therefore difficult to interpret statewide map of both primary and principal aquifers, again, not part of any of the three Generic Environmental Impact Statements (GEIS).

DEC’s Own Comprehensive Aquifer Mapping Not Part of SGEIS
The DEC has not referred to or included its own comprehensive 1988 DEC/USGS aquifer maps in either of its three environmental impact statements (1992, 2009, 2011), except indirectly in an addendum to Appendix 5 of SGEIS 2011 re drilling companies in need of locating aquifers as a source of water for fracking. This series of five maps shows hundreds of unconsolidated aquifers, shallow or surficial (close to the surface) aquifers that are supported by sand and gravel, and therefore permeable and at risk for contaminants to penetrate them, but very productive. Even these maps give an incomplete picture of the abundance of NY groundwater as they do not include the many admittedly unknown unconsolidated aquifers or any of the many bedrock aquifers- those on firm, less shallow, less permeable bedrock. (Bugilosi, Trudell & Casey, 1988).

Bountiful and Interconnected Aquifers: Pollution Control Not Possible
These DEC/USGS aquifer maps depict aquifers everywhere, often huge and resembling underground lakes and wide, elongated rivers of groundwater, and these aquifers feed into and under and flow out of our surface lakes and reservoirs. Water is everywhere, and

most of it connected. If these aquifers feed our lakes and reservoirs, they can pollute them, and visa versa.

Surface Water Connected to Aquifers Connected to Surface Water
A diagram in the DEC 1992 GEIS shows the surface water-to-aquifer connection, i.e., rivers and marshes draining into freshwater aquifers. In this web of freshwater, surface water can contaminate aquifers which, in turn, can transfer these contaminants to surface water- lakes, reservoirs, streams. And "gas well contaminants that enter freshwater aquifers slowly migrate down gradient until reaching moderate and high-yielding unconsolidated aquifers used by larger population centers. Low level chronic exposure to unknown and untested toxic and carcinogenic fracking chemicals is likely to needlessly place the population at risk." (Rubin, 2011)[26]

Upstate Aquifers Surround the NYC Watershed Reservoirs
Two of the five detailed DEC/USGS aquifer maps, the Lower Hudson and Hudson Mohawk maps, depict aquifers surrounding and connecting to the NYC drinking water "protected" reservoirs**.** Aquifers contaminated by fracking, flooding, etc., can pollute surface reservoirs**.** And "aquifers can be vulnerable to gas field related contaminants from below and above**."** (Rubin, 2011**)**[26]

Plentiful Drinking and Irrigation Water As a Valuable Resource
Our states' prodigious amount of water is in deep contrast to the US Southwest, Texas and California where fast depleting aquifers, reservoirs, lakes and rivers are creating a water problem that is expected to soon become an emergency. The DEC should consider that NY's blue gold, a priceless asset, could also be an economic boon.

Ambiguous and Misleading Language About Fracking Aquifers
The DEC uses ambiguous and misleading language about fracking on locations above our aquifers**.** In the SGEIS Executive Summary it holds that only locations above primary aquifers (twelve in the shale gas area) will be exempted from fracking, with minimum setbacks at their boundaries. And that the hundreds of other aquifers or principal aquifers (all non-primary aquifers, so designated because they are not sourced for larger populations) and their small setback of 500 feet from their boundaries, will be subject to temporary specific site determinations.

But in SGEIS 6.1.3.4 the language changes to- "the Department concludes that HVHF operations within Primary and Principal Aquifers pose the risk of causing significant adverse impacts to water resources. And that…standard mitigation measures may only partially mitigate such impacts. Such partial mitigation would be unacceptable due to the potential consequence posed by such threats." This is contradictory and confusing wording. Should fracking through and near all aquifers be exempt, or not? What does "'significant' adverse impacts" mean? Is cost benefit analysis to be applied, that is, how many people will be poisoned?

EPA Study Demonstrates Wyoming Aquifer Contaminated by Fracking Chemicals
Will the DEC outright ban drilling into all aquifers now that the EPA has released its three year study of aquifer contamination by fracking chemicals in Pavilion, Wyoming,[28] where drilling through aquifers was permitted? (A glance at the comprehensive aquifer

map by USGS and DEC will indicate that NY doesn't have much surface area to frack without drilling into an aquifer.)

Aquifer Buffer of 500 Feet, When Lateral Will Extend 5000+ Feet

The DEC is proposing a 500 ft buffer from boundaries of an aquifer, even though fracking horizontal arms extend for a mile or more underground, thus fracking beneath the aquifer if not through it. And even these small buffers or setbacks are up for site specific review and possible buffer removal after 2 years.

MISSING FROM SGEIS: RISKS FROM KARST AND EXTREME FLOODING

"The carbonate [limestone or calcium carbonate] aquifers should be afforded even greater protection than that contemplated for the bordering New York City watersheds, where alternate reservoirs and groundwater resources could be tapped in the event of likely extensive groundwater and surface water contamination from failed gas plays."

-Hydro-geologist Paul Rubin, Hydroquest [26]

Karst in Neither Mentioned nor Mapped by the DEC in its SGEIS. Another risky omission. Karst is the fragile underground limestone or carbonate formation which contains networks of sinkholes, caverns, and caves, all acting as conduits allowing storm and floodwater to rush into aquifers. The Cobleskill Plateau of east central NYS, for example, is known for its Howe Cavern and many other deep caves. "Gas well development in this area is sure to degrade NY's longest and best-developed karst aquifers and the ecotourism industry that revolves around it" (Rubin, 2011).[26]

Further Endangering Endangered Bat Species

Bats are a keystone or essential ecosystem species at risk from white nose syndrome and would be at greater risk from fracking due to the potential migration of methane and other gas field contaminants into caves. NYS is home to many endangered bat species due to our karst. (Rubin, 2010).[29]

Contamination Is Rapid and Unmitigated in Karst

"Because groundwater moves rapidly through caves, much like that in surface streams, almost no natural cleansing of contaminants occurs. For this reason, conduit portions of **karst aquifers are THE most hydrologically vulnerable aquifers anywhere**. Contaminated karst streams resurge as springs where their adverse impact to streams, lakes, reservoirs, ecosystems, and wetland species and water quality may be rapid." (Rubin, 2011)[26]

Karst is Present in Many Parts of NYS

These cavernous formations extend in a band from Albany to Buffalo and south along the Hudson River's west bank, through Kingston, etc. And elsewhere. (Veni et. al., 2001)

Karst Aquifer Contamination Can Spread Downstream Quickly

Karst aquifers are large and unconsolidated, the latter meaning they are formed by sand, gravel, and some stone (in the case of karst, limestone or calcium carbonate). They are close to the surface and permeable from above and below, as well as open to direct entrance of surface water (streams, floods) though sinkholes and caves. Also, the water tends to move rapidly and contaminants are not then cleansed.

Gas drilling in and under fragile karst should be permanently banned. Drinking water downstream would be at risk with no backup aquifer available. Yet gas leases have proliferated in karst areas, and no hint of risk has been mentioned by the DEC, even though there has been national press coverage over a ban on fracking based on karst risk in Monroe County, West Virginia.

Floods and Earthquakes in Areas of Fragile Karst
Record floods upstate in karst areas have carried pollutants from barns, cellars, bathrooms , etc., directly into karst aquifers. Earthquakes pose a risk to fragile karst aquifers (Howe Cave area and nearby areas have a history of earthquakes) and warrant mention and study in a DEC statement of environmental impact.

Flood Plain Maps Are Inaccurate
The DEC suggests that fracking won't take place on 100 year floodplains, but maps should be updated to reflect the reality of 100 year floodplains and even the recent storm Irene dramatic 200+ year floodplains. (Analysis of historic peak water year by HydroQuest determined that flooding associated with Hurricane Irene was a 500-year[30] event in one upstate county (see: http://hydroquset.com/Schoharie). The DEC should recognize the science of more extreme flooding events occurring more often, as predicted by government and international meteorologists and scientific computer modeling re global warming and climate crisis. There is no point to banning fracking on floodplains if you don't realistically identify them.

Fracturing the Future
Industry claims of safely confining the byproducts of fracking (radon, heavy metals, toxic chemicals, etc.) within deep rock formations defies common sense and any sense of precaution. That this recent Halliburton and Big Oil technology is exempt from federal regulation (Energy Act 2005) is unreasonable and unsafe.

Every one of the perhaps 70,000 wells planned for NYS will be an eventual channel for contaminants to move to our aquifers, soils, streams. Every one creates a channel between its wellbore and the earth, for transporting contaminants. Every one will, over time, corrode and leak.

The economic consequences of chronically sickening New Yorkers with fracking byproducts migrating to our water and soils, our meats and milk, will be large. Law suits, emigration, collapse of real estate and farming (our two largest statewide industries), and entire ecosystems.

The plan to frack farms and aquifers is jeopardizing the future. Farmland and water are our state's richest natural resources, and ones that will become more valuable in time. The future is about water and food and renewable energy. And the future should begin now.

Much needed is long term thinking about the combined and cumulative risks of fracking farmlands and woodlands and wetlands, and thereby threatening wildlife and farm animals, and our aquifers, streaming everywhere underground. We all live downstream. And down-aquifer. And above fractures and faults. Upstate and downstate.

Researched and written by
Louise Maher-Johnson, maherjohnson@gmail.com
Clark Rhoades, cjrsailor@gmail.com

Comprehensive earthquake fault maps and aquifers maps for NYS are online at www.schoharievalleywatch.org and elsewhere.

Citations

MAPS:
Bugliosi et al. *Potential yields of wells in unconsolidated aquifers in upstate New York*. (1988). Produced by USGS for NYS DEC. http://www.dec.ny.gov/lands/36119.html and www.schoharievalleywatch.org
Jacobi, R. D. (2002). *Basement faults and seismicity in the Appalachian basin of New York state*. Tectonophysics, *353*(1-4), 75-113. http://freepages.genealogy.rootsweb.ancestry.com/~springport/pictures350/NYS - JacobiTectonics.pdf (figures 2 and 5)
Veni et al, American Geological Institite, Living With Karst (2001). http://hydroquest.com/Schoharie/

PEER-REVIEWED SCIENTCE:
Physicians, Scientist and Engineers for Healthy Energy, www.psehealthyenergy.org

CITATIONS FOR PAGES 2-13
[1]Jacobi, R. D. (2002). *Basement faults and seismicity in the Appalachian basin of New York state*. Tectonophysics, *353*(1-4), 75-113. http://freepages.genealogy.rootsweb.ancestry.com/~springport/pictures350/NYS - JacobiTectonics.pdf
[2]Rubin P.A. (2010).Testimony to the EPA, Sept.2010, www.hydroquest.com ????
[3]Jacobi, R. D. (2007). *Innovative methodology for detection of fractured controlled sweet spots in the northern Appalachian*. http://www.netl.doe.gov/KMD/cds/disk41/C- Basin Analysis/NT40698 Final Topical-1.pdf
[4]US Geological Service. Earthquake Data Base. NEIC: Earthquake Search Result for Latitude 42.674N- Longitude 74.496W Radius 200. km
[5]Barone, J. (2011, December 20). *Lessons from the great Japanese quake*. *Discover Magazine*, http://discovermagazine.com/2012/jan-feb/15
[6]Wikipedia. Earthquake-VA-August 2011.
[7]Tarbuck et al. digitalGeology.net *Earthquakes East of the Rockies* p 19. http://www.digitalgeology.net/page19.html
[8]Rubin, P.A. (2010). *New York Earthquake History*. http://hydroquest.com/Riverkeeper/
[9]Ingraffea, A. *Information for an Informed Citizenry*. http://nyrad.org/video.html
[10]Nikiforuk, A. (2011). Energy bulletin. *Fracking and quaking, they're linked*. http://energybulletin.net/stories/2011-11-18/fracking-and-quaking-theyre-linked
[11]Cypser, D.A., *Colorado Law & Induced Seismicity* . http://www.darlenecypser.com/induceq/ColoradoLawandInducedSeismicity.html

[12]Fountain, H. (2012, January 1). *Disposal halted at well after new quake in Ohio*. New York Times. http://www.nytimes.com/2012/01/02/science/earth/youngstown-injection-well-stays-shut-after-earthquake.html
[13]Nicholson, C., & Wesson, R. L. Environmental Protection Agency, (1951). *Earthquake hazard associated with deep well injection- a report to the U.S. environmental protection agency*. http://foodfreedom.files.wordpress.com/2011/11/earthquake-hazard-associated-with-deep-well-injection-report-to-epa-nicholson-wesson-1990.pdf
[14]Jacobi, R.D., & Fountain, J.C., (1993). *The southern extension and reactivations of the Clarendon -Linden Fault System.* P.18. Geographie physique et Quaternaire, vol.47.
[15]Fletcher, Jon B., Sykes, Lynn R. (1977). *Earthquakes related to hydraulic mining and natural seismic activity in western New York State*. Journal of Geophysical Research, Volume 82, Issue B26, p. 3767-3780
[16]Rush, P. (2011, September 22). *Oversight - the revised environmental impact statement on hydraulic fracturing and the New York City drinking water infrastructure*. http://www.nyc.gov/html/dep/html/testimony/hydrofracking_revised_eis_09222011.shtml
[17]Rubin, P. A. (2011). *Cement Failure Mechanisms (and Testimony at NYS Assembly, Oct. 6,2011*). www.hydroquest.com/Hydrofracking/
[18]Rubin, P.A., (2010, Nov. 15). *Report for the Delaware River Basin Commission Consolidated Administrative Hearing on Grandfathered Exploration Wells*. www.hydroquest.com/Riverkeeper/
[19]Ingraffea, A. *The Marcellus Shale Gas Play*…. http://nyrad.org/video.html
[20]Bennet, L. et.al. (2005-2006). *The source for hydraulic fracture characterization*. *OilfieldReview*, p. 44. http://www.slb.com/~/media/Files/resources/oilfield_review/ors05/win05/04_the_source_for_hydraulic.ashx
[21]Environmental Protection Agency. (2004). *Evaluation of impacts to underground sources of drinking water by hydraulic fracturing of coalbed methane reservoirs study*. http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_coalbedmethanestudy.cfm
[22]Dougherty, K. (2011, March 07). *Fracking will cause 'irreversible harm'*. *Montreal Gazette*, http://wellwatch.wordpress.com/2011/03/07/montreal-gazette-fracking-will-cause-irreversible-harm/
[23]Hetzler, P. (2011, December 13). *Hydrofracking sure to contaminate water*. *Watertown Daily Times*. http://www.watertowndailytimes.com/article/20111213/OPINION02/712139975
[24]Rubin, P. (2011, December 06). *Technical justification in support of requiring cabot to immediately resume water deliveries to adversely impacted residents of dimock, pa*. http://hydroquest.com/Hydrofracking/ Dimock Press Statement 12-06-11.pdf
[25]Palmer, A. (2012). *Some Concerns About Hydrofracturing in Shale-Gas Production*. http://hydroquest.com/Schoharie/
[26]Rubin, P.A. (2012). *Aquifer & Karst Protection Considerations in Schoharie and Other New York State Counties (Comments on the NYS High-Volume Hydraulic Fracturing 2011 revised draft SGEIS).* http://.hydroquest.com/Schoharie/ also see,
Heavenrich, S. (2011). *Cornell professor wants EPA to take closer look at fracking technology*. Broader View Weekly, March 3, 2011. http://www.tiogagaslease.org/images/BVW_03_03_11.pdf
[27]Jackson, R, et al. *Responses to Frequently Asked Questions and Comments about the Shale Gas* Paper by Osborn et al., Duke University. http://www.nicholas.duke.edu/hydrofracking/responses-about-gas-shale
[28]EPA *Groundwater Investigation Pavillion*, Dec.2011 http://www.epa.gov/region8/superfund/wy/pavillion/
[29]Rubin, P.A. Maps: *Endangered Bat Species*; *White Nose Syndrome the Eastern US*. http://hydroquest.com/Riverkeeper/
[30]Rubin, P. A. *Schoharie Ck Flood Return Report*. http://hydroquest.com/Schoharie/