Finger Lakes LPG Storage, LLC

MEMORANDUM

FROM: Leonard Dionisio
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DATE: January 19, 2012

RE: Response to Public Comments regarding geology and underground storage caverns

As the geologists principally responsible for the review of the geology in and around the underground salt caverns proposed for LPG storage on the US Salt property and for the oversight of the geomechanical and other evaluations conducted of those caverns, this memorandum is to respond to certain public comments made regarding geology, geologic faults, seismic concerns, and the ability of the salt caverns to retain the LPG. In support of the underground storage applications submitted to the Department, we have worked on the Reservoir Suitability Report and we have reviewed all of the underlying test results, as well as other information developed over the years for solution mining and natural gas storage activities that have occurred on this site for over 100 years.

Based on our review of the comments and our knowledge of the site, it is our professional opinion based on our decades of experience that the public comments do not in any way raise any concern regarding the suitability of the underground salt caverns to store LPG in a safe, reliable and environmentally sensitive manner. Our specific responses to the comments follow:

Leaching of Cavern Contents into the Lake

Dr. John Halfman submitted a comment letter (letter B32) where he again reiterates that he is worried about migration of brine into the Lake bottom. In April, at the public information session held by Finger Lakes, we spoke with Dr. Halfman and pointed out to him that the underground salt caverns proposed for storage here could not possibly do so since this location is downdip and any brine that might possibly leak out of US Salt caverns (as discussed below, this is not possible) that are not pressurized would stay downdip due to the specific gravity. In addition, less use of road salt has helped to reduce the sodium and chlorides in the lakes.

Most importantly, from a hydraulics point of view, it makes no difference whether there is propane, butane or brine in the proposed storage caverns since all provide hydraulic support to the cavern walls, and the required mechanical integrity test being performed before the cavern is placed into storage, will confirm that the fluids are not leaching into the Lake bottom. In the caverns, no matter what the fluids are, pressures on the roof and cavern walls remains well within the ability of the salt to safely store the hydrocarbons.

The Fate of a Spill into Seneca Lake

A spill from the brine pond into the lake will likely flow to the deepest part of the lake due to the specific gravity of the brine. The existing saline layer in the deep part of the lake does not increase unless there is additional circulation placed in contact with the Salina beds. Further, if there is a spill, the high density brine would sink to the bottom of the lake, but this would minimize the potential damage caused to the upper layer of fresh water that is used for public consumption.

In addition, Wing, et al (1995) and Halfman, et al (2006) pointed out that a large volume of salt reaching the Lakes occurs from road deicing, "mine waste" and other groundwater sources. It should be noted that the mine waste referenced is not referencing anything directly from the salt caverns. Wing further hypothesized that the bottom of Seneca Lake intersects the Salina section and that this contact has increased the amount of sodium and chlorine in the lake. If this hypothesis is correct, then this is a naturally occurring event unrelated to our proposed project. Finally, something not mentioned in these articles are the other chemicals and fertilizers used for agricultural purposes that can add significantly to the run off factor.

Dr. Halfman quotes Jolly, USGS, Reston, Va., who graphed the lake concentration of chloride in ppm for the entire 20^{th} Century, showing that the concentration peaked between 1970 and 1980, declining ever since. Possibly that coincided with the ending of the Morton injection wells. His concern that the additional pressure of LPG on the Finger Lakes caverns would induce seepage into the lake is unfounded since the pressure of the stored hydrocarbon is the same as the brine head in the cavern and since the mechanical testing has shown that the caverns do not leak, there can be no influx of brine into the lake.

Dr. Halfman indicates that his data and graph show that the salinity in the lake has been decreasing and he concludes that this data mimics the declining salt production on the lake. This assumption is in error as the production of salt has been increasing. Salt by its nature is impermeable and will not allow the migration of LPG or brine. The pressure in the caverns will remain the same whether it is filled with brine or LPG.

Faulting and Seismicity

Comment letter A224 (written by an attorney) raised a number of concerns related to faulting and seismicity. However, the alleged inadequacy of the DSEIS to address, analyze and research seismicity are moot since the only thing Finger Lakes can analyze is the historical information, and to understand geologically where the faults may be. Finger Lakes knows where the faults are located from our geological studies, and we are aware of what might or might not happen over time. However, based on company experience, site data and public data, no cavern has ever failed due to geological movements within the salt.

None of the reports Finger Lakes has reviewed show faults in the deeply glacial gouged Seneca or any of the other lakes. One significant point related to faulting is referenced in the Stone and Webster (S&W) report submitted with public comments as fault 20, the strike-slip fault purported to run north to south on the west side of Seneca Lake. First of all, the fault trace on the S&W map, is not continuous and cannot be traced the entire length.

More specifically, the Structural Map of South-Central New York (figure 2.3-1 in the S&W report) shows a questionable north-south lateral fault on the west side of Seneca Lake and another one just west of Ithaca, New York. The question marks indicate that the faults are interrupted and not known from direct physical evidence. Indeed, in section 2.4 of the report, Structure and Tectonics, page 2.4-1, S&W writes "Another fault, in the Seneca Lake area, shows right lateral offset of hundreds of feet, cuts salt beds, and surface emanations of brine. However there is **no** seismicity associated with the Seneca Lake fault. Information on its association with basement structure is lacking. The Central Stable Region as a whole has been subject to gentle uplift since Paleozoic time. No major tectonic structures of regional extent are considered active or potentially active."

More significantly, if the fault were active, some or all of the water courses/streams that run down the slopes from west to east perpendicular to the fault trace 20 into the lake would be displaced or offset by the fault. There is no displacement of any stream shown on any map all along the west side of the lake. Moreover to raise an issue with regard to fracking wells and seismic events is clearly an attempt to connect that issue with what is proposed and it should be well known by now that this project is not related in any way to that activity.

As has been the case in recent earthquakes in the northeast, no underground pipes, sewers or water lines were affected. Once again, Emergency Shut Down Valves will prevent release of LPG if there is surface damage to the facility as a result of an earthquake. It is worthwhile to note that there has never been a recorded seismic event over 3 on the Richter scale in Schuyler County. See Draft DEC SGEIS, 2011, p. 4-30.

The Jacobi earthquake studies show that few basement faults reach the surface and even those that are inferred have plenty of question marks on the maps and cross-sections where there is no indication of the fault locations. To say that the basement faults have "been repeatedly reactivated" is without evidentiary support since none have been "recent" in geological time.

The Finger Lakes design copiously defines the methods that will be used to reduce or limit the possibility of failure in the brine pond, expulsion of LPG into the atmosphere, or damage to rail and pipeline facilities.

Comment letter A224 (referenced above) references a dissertation prepared by Courtney Lugert. We have obtained a copy of this dissertation and reviewed it. It does not in any way support the notion that there are faults that could have any adverse effect on the caverns that have been in existence for decades on the US Salt property and used for hydrocarbon storage starting in 1964.

The dissertation concentrates on the East side of Seneca Lake between Watkins Glen and Ovid to the North. The thesis refers to the northwest, far updip toward the formation's outcrop, Trenton-Black River fields in the towns of Prattsburgh and Pulteney, and southwest of Watkins Glen where much of the good thermally developed oil and gas production is located. None of that production or formation characteristics are similar to the subject Salina salt beds discussed by Finger Lakes in its underground storage permit application. In addition, in the same southwest area at Avoca, drilling of several brine disposal wells were attempted, some as deep as 12,500 feet finding no faults, but formations that were similar to quartzite with no porosity or permeability.

Dr. John Fountain, one of the Thesis Committee members for Lugert's dissertation, did a surface soil gas study in the area of Bath/Savona in the late 1990s ago and found no propane or butane anywhere around the Bath Petroleum (now Inergy Midstream) salt cavern storage site, thus concluding there were no fracture pathways or faults which existed in the salt. In 1997, Dr. Robert Jacobi also examined well logs, driller's logs, seismic reflection profiles, and performed reconnaissance in the area surrounding the Bath/Savona site and found no structures that could be construed as faulting. See **Exhibit 1** attached to this memorandum.

Lugert notes that "[d]uring the Alleghanian Orogeny lateral compression caused the layers [of rock] overlying the Silurian salt to slip to the northwest along a decollement that formed within the salt, while the layers below remained fixed." (Lugert, 2005, p. 5). As noted in Finger Lakes' underground storage permit application, because the literature avers that the faulting below is not affecting the geologic framework of the Watkins Glen site, comments will be limited to the salt section and overlying formations. At the Finger Lakes site, Lugert shows in Figure 4.9 on page 112, from seismic, that the S1, S2, S3, and S4 faults are not affected below from basement faulting, or above the salt – simply along the decollement as is the case at Watkins Glen. Based on well drilling, detailed well logging and cross-sectional construction from sonar surveys, the faults are well known and even so, the brine field has been developed with several caverns being acceptable for safe, secure storage of natural gas and LPG over many years previously. DEC has insisted that numerous adjacent old wells be reentered and new casing inspection and cement bond logs be performed. The result is that the site is secure based on logging inspection and proper plugging and abandonment of older nearby wells.

Part of the dissertation comments on Fracture Intensification Domains or FID's and ENE striking lineaments (surface lines similar to a pipeline right of way) affecting the Trenton-Black River formation – none of those are near the Finger Lakes site. Lugert referenced FIDs as being defined by Jacobi and Fountain (1996) and are inferred to indicate areas with an increased likelihood of faulting. However, the dissertation refers to the Tully limestone west of Ithaca, out of the area for Finger Lakes permitting.

There is no question that there are surface lineations in abundance all over the world, and specifically in New York and the area of Watkins Glen and Seneca Lake. However, those that can be traced consistently for miles, or those that are absolute reflections of prevalent basement faulting that extend to the earth's surface, are few. Due to the fact that no fracturing of the rocks in the area will be performed, this limits the validity of the public concern in comments on the DSEIS.

The rocks that are exposed in the study area are limited to Middle Devonian Tully to Upper Devonian Canadaway Group, not including those from the Onondaga through Salina Formation.   Folding and topographic structures such as anticlines are prevalent in the area and run from southwest in Pennsylvania both north and south as well as northeast thru the Watkins Glen area. Some topographic features can be traced continuously for miles while others are not exposed. There are multiple fractures in both exposed and buried rocks throughout the area. There are three northeastward trending normal faults with small throws of between 8 and 30 meters, none of which affect the salt properties.

Lugert further notes that "[a]long the western shore of Seneca Lake is the Seneca Lake fault. Murphy (1981) described the Seneca Lake fault as a 355° trending, right lateral strike-slip fault, extending south from Himrod, New York to the Elmira Dome. Its location is outside the study area, but its significant length (>100km) and horizontal offset (approximately 390m) make it an important feature". (Lugert, 2005, pp. 18-19). However, based on our review, the trace on the surface is not continuous and it has had no effect on the US Salt operations of the brine field within the Salina Formation salt. There is no indication fault movement has occurred later than during Devonian basin development.

Researchers disagree as to whether fracture spacing increases or decreases near faults, improving or limiting fluid movements in those areas, respectively. Other researchers have emphasized occurrences of lineaments with faults, fractures and different formation contacts and formation thickness without concluding there is a direct relationship with future movement.

Lugert notes that there are primarily two groups of fractures in the study area: ENE-E trending strike parallel group and a NNW-N trending cross strike group. ENE striking fracture set is the second most common within the study group. The E striking set is the least common. The third most common is the N striking fracture set. The NNW trending fracture set is the most common at 120 sites – 58%. However, all are surface features and outcrops that are related to release of stress with the beds being close to the surface.

In discussing rock type controls on fracture spacing, Lugert states that "……several authors suggest a linear relationship exists between bed thickness and fracture spacing (although others dispute their claim)." (Lugert, 2005, p. 82). In this discussion, the author presents "the results of the analysis designed to determine if the change in fracture spacing observed between the southern and northern portion of the study area in the ENE- and E-striking fracture sets can be attributed to lithologic changes." The dissertation talks about the frequency of fracture sets and their location and concludes that "the distribution of frequencies (fracture) within each lithology is consistent across the different lithologies." However, it notes that the primary frequency of fracturing was in the northern portion of the study area. Most importantly, for the proposed project, none of this can be related to Watkins Glen since the formations studied were all surface outcrops above the Onondaga and Marcellus Shale.

As part of the author's evaluation of fracture potential, soil gas methodologies were reviewed. As noted above, this is the avenue of analysis that one of Lugert's thesis committee members, Dr. Fountain, performed in 1997 for the Bath/Savona area. See **Exhibit 2** attached to this memorandum. As Lugert explains (pp. 105-109), soil gas methodology is based on the concept that thermogenic gas will accumulate in soil above open bedrock fractures (Budney, 2002). In this scenario fractures in the bedrock provide a high permeability pathway which gas can exploit as it migrates from gas-bearing units below. Using the ratio of ethane to methane, researchers are able to distinguish whether the gas extracted from the soil is of thermogenic origin (Budney, 2002). Using soil gas composition to determine gas origin is based on the principle that the amount of ethane in biogenic gas (shallow sourced) is undetectable, therefore if ethane is detected in significant amounts the gas is considered thermogenic gas, which has a deep source (e.g. Jacobi and Fountain, 1993, 1996 and 2000; Budney).

The typical pattern of gas concentration along the traverse is valued near background, punctuated by clusters of higher values. Budney (2002) found that the number of samples containing ethane was elevated between the towns of Ovid and Valois and decreased south of Valois (in the direction of Watkins Glen). This pattern is similar to that of the elevated fracture frequencies for the ENE- and E- striking fracture sets in the same region and pattern was also observed in the same sets in the lineament data. Frequency graphics in the dissertation show the fewest lineaments and lowest soil gas responses in the area east, across the lake from the US Salt plant and the Finger Lakes Project.

Within the Lugert study area a seismic line parallel to the Lake on the east side of Seneca Lake was examined by Jacobi and Lowenstein. There is a significant amount of faulting in the deep sections (from just above the Trenton, to well within the basement), but only a small number of faults (3, 6 and 7) were identified above the Trenton Group by Jacobi and Lowenstein (2003). Several of the deeper faults terminate once they enter the Paleozoic section and are not recognized farther up into the section. Based on the age of the sections they intersect, three faults near Valois may have been active during Ordovician time, but not recently.

Faults S1-S5 shown in the Lugert study are in the Silurian Salt near Hector. They are the result of movement along the decollement and strictly within the salt section. Finger Lakes' studies show that the faults are sealing since the caverns that encountered the faults do not leak. In addition, field operational experience shows that breaks in the fault reseal, by salt recrystallization, and the salt becomes stronger in compressive strength. Ancient basement faulting has no affect on the brine and storage field decollement faults at Watkins Glen even though there is an indication that surface lineaments might be loosely related to the basement faulting.

In summary, this paper was written to explain the reasons for the prolific Trenton-Black River limestone hydrocarbon production and has nothing to do with the salt production and planned storage area near Watkins Glen, except for the fault sequence S1-S5, discussed above. However, its focus is the area east of Seneca Lake. The Thesis only briefly refers to the salt section and we have used industry earthquake data and predictions, and empirical local data to assist in supporting permitting for the site.