Executive Statement

In our opinion, various unquantified aspects of geological, geophysical and hydrological conditions in the vicinity of the current Cayuga Salt Mine make it premature for the New York State Department of Environmental Conservation (NYSDEC) to grant permission for the expansion of the current Cayuga Mine workings northward, beyond the existing mining licenses. Nor should the construction of Shaft #4 at the Cayuga Mine site be approved without further study of geological and hydrological conditions in the area between the proposed position of Shaft #4 and the current Cargill-Cayuga mine workings.

As previously recommended, there needs to be a full independent re-evaluation of the geological risk of mining in the northern area using all the data available, including company data presently restricted from the public domain due to "company secret" clauses. If there is an environmental disaster caused by the company knowingly mining in an unstable geological zone, then they should be held responsible both financially and legally for their actions.

The following paragraphs summarise the reasons for our concerns. For complete quantification of the various geological, geophysical and hydrological observations and arguments, all the relevant documents are appended as referenced pdfs.

What causes salt mine failures?

Worldwide, what drives significant instability at times of salt mine expansion is an unexpected intersection with aquifer zones holding substantial halite-undersaturated pore water volumes, generally located in or immediately out-of-salt (Warren, 2017). This is especially so when such unexpected freshened water volumes are connected via open fracture networks to the mine workings. This type of connection, in combination with unexpected structural complexity, leads to water inflow problems, which can precede loss of a salt mine via a combination of flooding and mine roof collapse. Worse yet, is the hydrological connection scenario where intersected aquifers are connected to large cavities and solution-channels filled with halite-undersaturated waters. Subsurface salt cavities form where a salt bed is in contact with under-saturated pore water. Proximity to water-filled fractures and cavities was the subsurface situation immediately prior to the catastrophic collapse of the Retsof Mine Roof (Warren, 2016a). Salt ore degradation due to long-term proximity to low-permeability undersaturated waters also explains why the Himrod mine on the shore of Seneca Lake was never an economic success (see Warren 2016a and the various international case histories of salt loss discussed in Warren, 2017 and Chapter 13 in Warren 2016b).

Geophysics indicates erosional thinning of carbonate layers in mine roof

Geophysical mapping of the thicknesses of suprasalt strata, especially to the north of the current mine workings, are increasingly likely to intersect problematic conditions (see Ferguson and Warren 2017). The Frontenac Point Anomaly is a geologically unstable zone identified in Ferguson and

Warren 2017 geophysical report as a sediment-filled glacially-eroded valley located below the current Cayuga Lake thalweg. It is a region where the Silurian Onondaga Formation is eroded and subcrops against the deeper parts of the Pleistocene sediment-filled Cayuga Lake valley floor. As such, any map showing this Anomaly should extend along the eroded subcrop area of the Onondaga Limestone, as shown in Figure 1 as the mapped area enclosed within the blue outline.

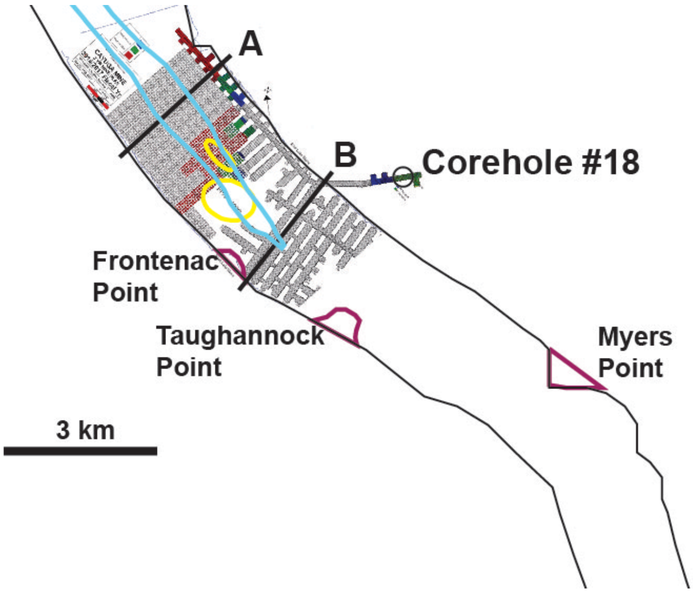

Figure 1. Comparison of presently mapped Frontenac Point Anomaly (yellow) to geologically unstable zones tied to glacially induced erosional thinning (enclosed with the blue line), as reported in Ferguson and Warren 2017. Background map is Cayuga Mine 3-year plan. The A and B lines refer to geological cross sections based on seismic profiles (Ferguson and Warren, 2017). The yellow ellipses show the position the Frontenac Point anomaly as published in Cargill's 3-year mine plan

The present mapped location of the Frontenac Point Anomaly is outlined in yellow in Figure 1 based on the Cargill Cayuga Mine 3-year mine plan, dated Feb 2017. The present maps of the areal extent of the Frontenac Point Anomaly, as published by Cargill, have caused confusion and misinterpretation by not publically defining what the Anomaly is. This has led to the incorrect assumption that it is a localized feature that can be avoided by a 1000 ft exclusion zone around an oval-shaped anomaly and that mining to the north can avoid this zone. This is an incorrect assumption as seismic profiles show the actual anomaly is the geologically unstable zone created by glacially-induced erosional downcutting into the carbonate beam (Silurian Onondaga limestones) and filling of the downcut channel with unconsolidated water-saturated Pleistocene sediments. The glacial sediment filled channel overlies the proposed mineable salt section, as indicated by the region within the blue line in Figure 1. An unthinned carbonate beam is the theoretical stable geological section above the planned level of expanded mining operations. A stable carbonate layer (beam) above a salt level prevents a mine roof from collapsing, with associated fresh water entry into the salt mine. Seismic analysis shows this theoretical assumption of unthinned roof beam above the proposed mine area to the north of the current mine workings is wrong.

Any attempt to mine in the area outlined in blue in Figure 1 has a high probability of encountering geologically unstable zones, with a high probability of direct connection with freshwater zones in the overlying glacial aquifers through fractures in the thinned overlying rock, as explained in the Ferguson and Warren 2017 report. This same carbonate that constitutes the roof beam must be better quantified before upward-reaming Shaft 4 is approved (see next section).

The present proposed mining activity in shafts U-74 and U-72 are expected to encounter this unstable geological zone. The proposed change in the beam sizes for the mining methods will not prevent a direct connection of lake water with the mining cavity as it will not stabilize the existing fracture system induced in the thinned overlying rock zones by glacial downcutting (Ferguson and Warren, 2017).

Hydrological unknowns related to the proposed excavation of Shaft 4

Current geological and hydrological conditions likely to be encountered in the excavation of Shaft 4 have not been adequately assessed by the present level of geological study of the wireline and core collected in the drilling of corehole 18 (Warren, 2016c). Corehole 18 is the designated guide well for the geology and hydrology that will be encountered during the upward reaming of Shaft 4. Our concerns with the existing public-domain data relate to Shaft 4 are:

1. Inadequate quantification of the permeability and porosity (measures of likely water inflows) at the known potential aquifer level (Bertie-Oriskany units). This aquifer will be encountered during planned upward reaming of Shaft #4. The upward-reaming method of shaft construction makes it difficult to control high levels of water inflow, if encountered at the aquifer level, so there is the potential for flooding of the mine. If a mine shaft is dug from the surface down then there is less of a problem as any unexpected water outflow is not connected to the mine level.

In the drilling of the borehole 18, the Bertie -Oriskany interval was sampled via cuttings, not cored. The pump test to test aquifer properties was done during the drilling of what is a vertical borehole. With only cuttings as the aquifer sample, and no image logs, it is not known if the encountered aquifer is homogenous or inhomogenous. The latter is typical of a fractured carbonate aquifer reservoir. If the encountered aquifer was homogenous and undisturbed, then the pump test already done to quantify water entry rates can be extrapolated reasonably to predict flow conditions in a 14-foot wide reamed shaft. If the aquifer is a fractured carbonate, with a high density of vertical fractures, then flow rates and aquifer interconnectedness have not been reliably quantified by the current pump test, which was conducted in a narrow vertical borehole and so is unlikely to have tested the presence of adjacent open vertical fractures.

2. The current description of salt textures in the RESPEC core report of Corehole #18 does not define or adequately document the nature of geological and hydrological processes likely preserved in the core. Current understandings in the field of salt sedimentology allows one to differentiate between tectonic, diagenetic and salt dissolution textures and breccias in salt cores. This approach was not undertaken in the Corehole 18 core descriptions done by RESPEC. And yet, work on the publically-available core from stratigraphic cored well drilled in the 1960s during the planning stages of the nearby Himrod Mine shows all these textures are present in the various salt layers of the Syracuse Fm where they are distinct and capable of being classified (Warren, 2016c). Such a sedimentological study of the salt core in Corehole #18 would better refine the hydrological situation in the vicinity of Corehole #18 and Shaft #4 and if there is a possible hydrological connection already in existence between the top of salt and the overlying potential aquifers located in and above the Bertie Formation.

References

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