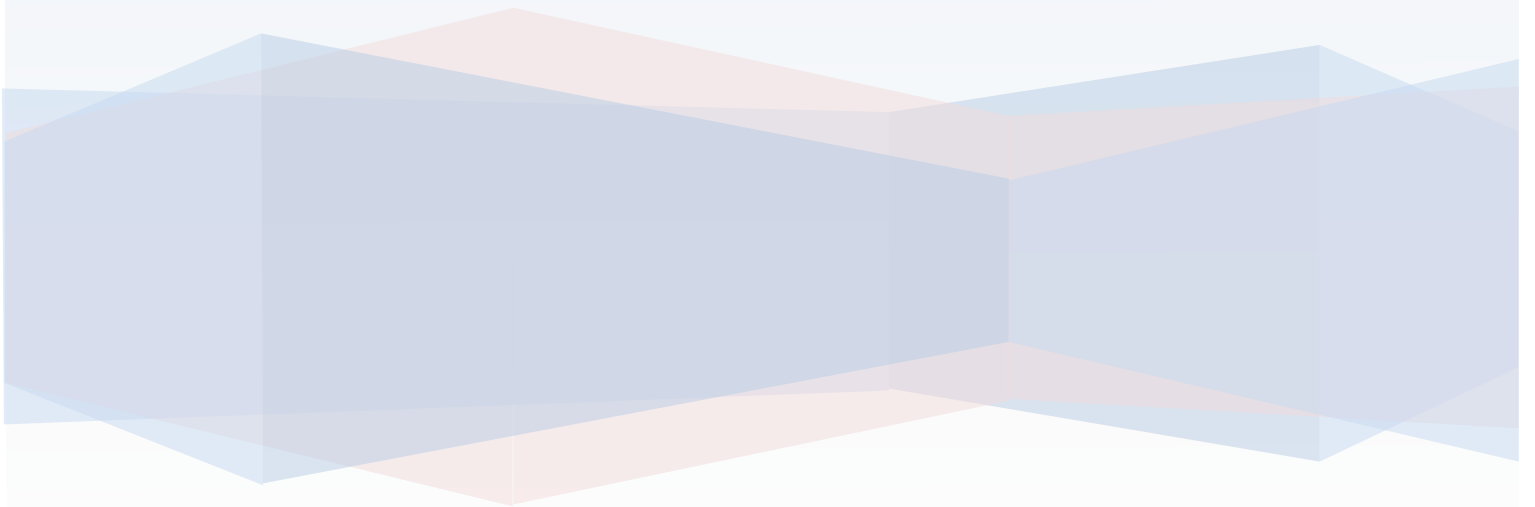


An Environmental Perspective of Liquid Petroleum Storage in Salt Mines Off of Seneca Lake

SIE: Professor Halfman

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Seneca Lake is one of the most indispensable resources in upstate New York. It is the largest of the Finger Lakes, which was formed by glacial activity thousands of years ago. Present day, Seneca Lake supplies quality drinking water to approximately 100,000 people and about nine million gallons of water is withdrawn daily to supply the residences and the local businesses of the area.¹ One of the most unique features of Seneca Lake is its immense depth at 186 meters or 610 feet, which makes it the sixteenth deepest lake in the United States.^{2 3} Another unique feature to Seneca Lake is the salt content that is present. The lake is currently two to ten times saltier than any of the other Finger Lakes.⁴ This has not always been the case though.

Recently, the streams that act as inputs to the lake are being tainted with large amounts of nutrients. Reeder Creek, for example, has concentrated animal feeding operations (CAFO) upstream, which, due to animal excrement and waste management issues, nitrate and phosphate levels are very high. Reeder Creek has the highest contribution of phosphate and nitrates to the lake. As another example, Castle Creek runs directly through Geneva, and much of the urban waste is improperly disposed of through the creek into Seneca Lake. Due to the industrial nature of Geneva, Castle Creek supplies a large portion to the salinity of the lake.

¹ John Halfman, "Water Quality of Seneca Lake, New York: A 2011 Update," *Department of Geosciences & Environmental Studies* (December 27, 2011): 1.

² Halfman, 1.

³ "Lake & Reservoir Search Results." Web. 12 Apr. 2012.

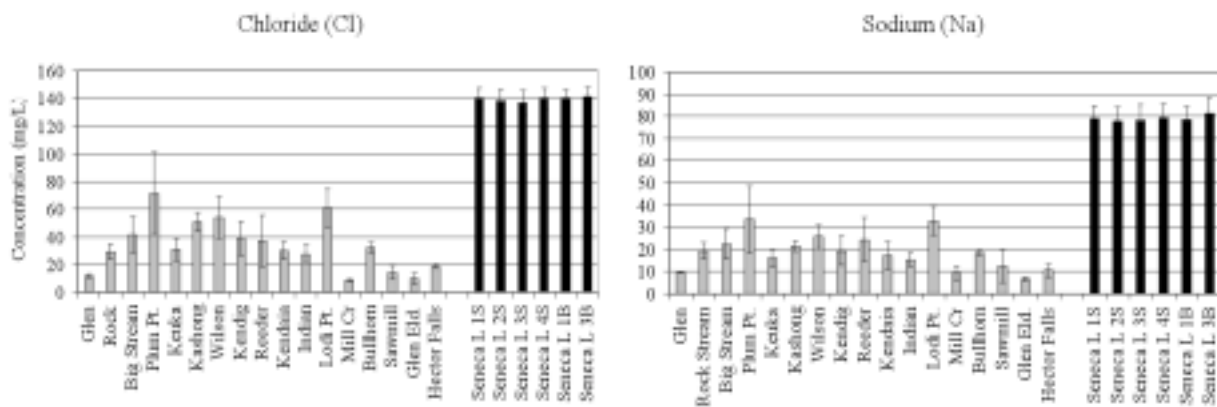
<<http://www.lakelubbers.com/usa-deepest-lakes-in-usa-L1-C3/>>.

⁴ Wing, Michael R., Amy Preston, Nadine Acquisto, and William F. Ahrnsbrak. "Intrusion of Saline Groundwater into Seneca and Cayuga Lakes, New York." *Limnology and Oceanography* 40.4 (1995): 791-801. *JSTOR*. Web. 9 Apr. 2012.

<<http://www.jstor.org/stable/pdfplus/2838313.pdf?acceptTC=true>>.

Along both the eastern and western boundaries of the lake, there are a large number of vineyards. Tourism, specifically of the wine industry, contributes to a large portion of the revenue in the area. The wineries along both the eastern and western edges of the lake have their fair share of other types of contributions to the lake as well. Runoff into the lake from vineyards contributes and escalates the phosphate and nitrate fluctuations of the lake. As of right now, the total input of phosphates into the lake is greater than the total outputs, so the net phosphate level in the lake is increasing, thus increasing the productivity in the lake.⁵ A more productive lake leads to higher algae levels, which affects dissolved oxygen levels, and can threaten the fish that thrive in the lake.

Looking specifically at sodium and chloride content in Seneca Lake, there is a very noticeable anomaly. Sodium chloride content in most bodies of water can usually be calculated by adding up all the input values and subtracting the output values, but Seneca Lake is unique in that all the inputs do not necessarily equal the expected amount of

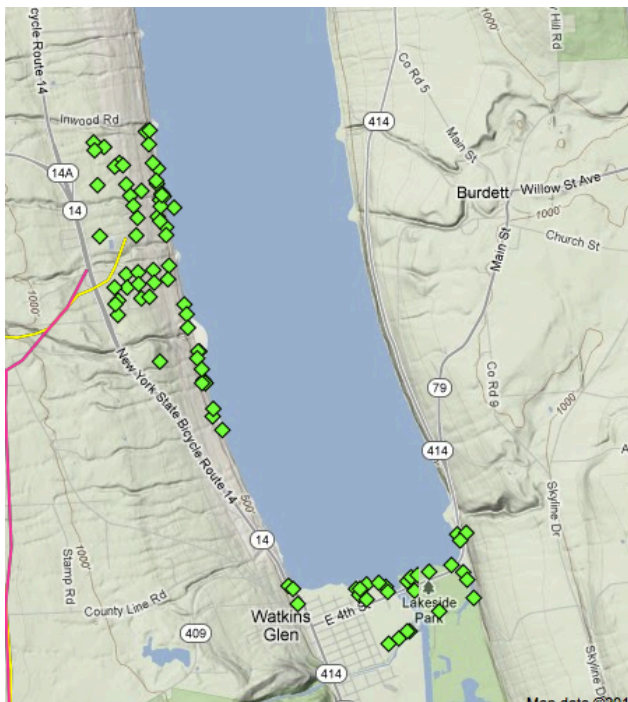


sodium and chloride in the lake, as the

⁵ Halfman, 26.

previous two graphs (courtesy of Halfman) show. There are seventeen stream inputs and each stream's composition is well documented at entering the lake at about 20-60 mg/L.⁶ The main influence on the lake had not been fully identified until just recently. The most common accepted answer is that the deepest parts of the lake intersect a salt layer that runs between 450 and 600 meters below the surface.⁷ The lake being so close to this salt layer provides the opportunity for some ground water to leach up, and intrude into the lake. However, this intrusion does not account for the fluctuations that are present in the lake.

From what is known about the history of the salinity of Seneca Lake, chloride concentrations were at about 40 mg/L in 1900 and rose to 170 mg/L in 1960, and have



been decreasing since 1970. A very similar trend is seen in the chloride concentrations as sodium.⁸ This follows the same trend of salt productions in mines in Watkins Glen. Production of salt increased until the 1970's and then decreased quickly thereafter.⁹ Forty years after the salt mines in Watkins Glen have been put to rest, the chloride levels are down to 120 mg/L.¹⁰ A location map of the salt mines in Watkins Glen and

⁶ Wing, et al. 792.

⁷ Wing, et al. 791.

⁸ Halfman, 28.

⁹ John Halfman, February 6th, 2012

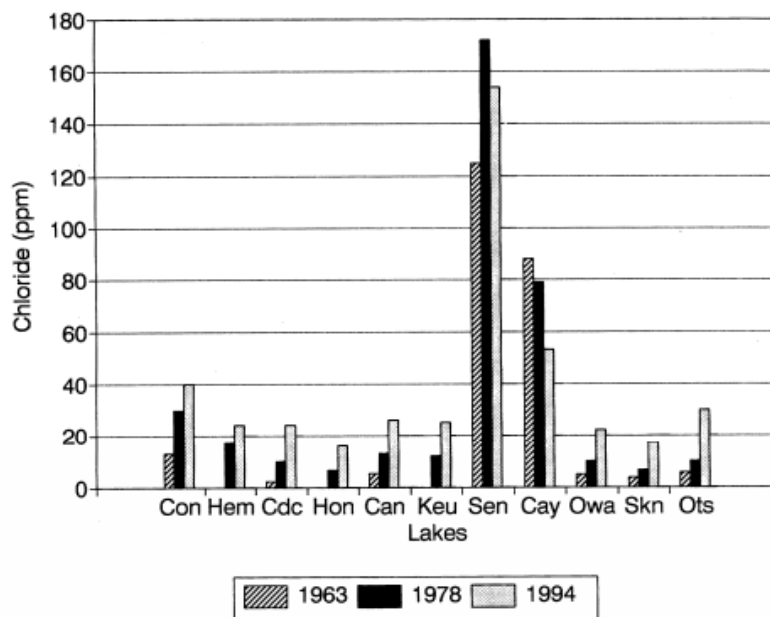
¹⁰ Halfman, 28.

on the southwestern edge of the lake can be seen in this map (courtesy of FracTracker).

The reason that this is not lower given the nearly half a century since the dramatic decrease is the large residence time of the lake. Due to the large volume of the lake and the input and outputs, the residence time of the lake is about 18.6 years.¹¹ This long of a residence time means that any chemical changes within the lake take longer periods of time to notice, but at the same time, it takes longer for the lake to recover.

The possible correlation between sodium chloride levels in the lake and salt mine activity can be attributed to the ways the salt was harvested. Hot water was injected at a very high pressure into the salt water a couple hundred meters below the earth. It was then brought back up as brine, or very salty water. The brine was then heat processed to evaporate all the water, and all that was left was commercial-grade table salt.¹² The high

pressure may have caused more salt to be introduced into the ground water, and thus be introduced into the water column. This introduction of salt may be the source of the missing 100 mg/L or so of sodium chloride in Seneca



¹¹ Halfman, 1.

¹² "Salt Mining & Manufacturing." *Watkins Glen*. Web. 6 Apr. 2012. <<http://www.watkinsglenchamber.com/Home/Visitors/Things-to-do/Arts-and-Culture/History-%281%29/Salt-Mining---Manufacturing.aspx>>.

Lake. All this being taken into consideration, it can be seen that the salt mining that occurred in Watkins Glen in the 1970's had a direct impact on the salinity of the water that is still seen today. As it can be seen in the chart above, the other Finger Lakes are not as salty as Seneca and also, there was a peak in the 1970's, which has been decreasing since (graph courtesy of Wing, et al.).

Since the 1970's, not much salt mining has been going on, however now there are new plans for these abandoned mines. Kansas City-based Inergy, which focuses primarily on the storage and transportation of propane has plans to use these mines to store liquid petroleum gas (LPG). The LPG would be stored under high pressure (approximately 1000 psi) and up to 2.1 million barrels (65.1 million gallons) of LPG would be stored in the mines.¹³ During the storage practices, large pools of extremely salinated water, also known as brine, will be used to manage the movement and storage of the LPG. The brine will be stored and secured in a thirteen-acre pond that will include many layers of protection to avoid leaks or other catastrophes. Not only does Inergy plan on storing LPG in the mine, but also plans on expanding them through a process called solution mining.

Solution mining (also known as in-situ leach mining) is similar to hydrofracking. The system is set into place when a fracturing liquid is injected into the earth and circulated through the rock and brought back up through another pipe. The rapid and high-pressure flow of the brine in the solution mining breaks up the rock layer, and releases gas that is trapped in these rocks. Currently, hydrofracking is not allowed in New

¹³ Mantius, Peter. "New York State to Require Environmental Impact Statement for Large Scale LPG Storage in NY Watershed." *DC Bureau*. Web. 6 Apr. 2012. <<http://www.dcbureau.org/20110207166/natural-resources-news-service/new-york-state-to-require-environmental-impact-statement-for-large-scale-lpg-storage-in-ny-watershed.html>>.

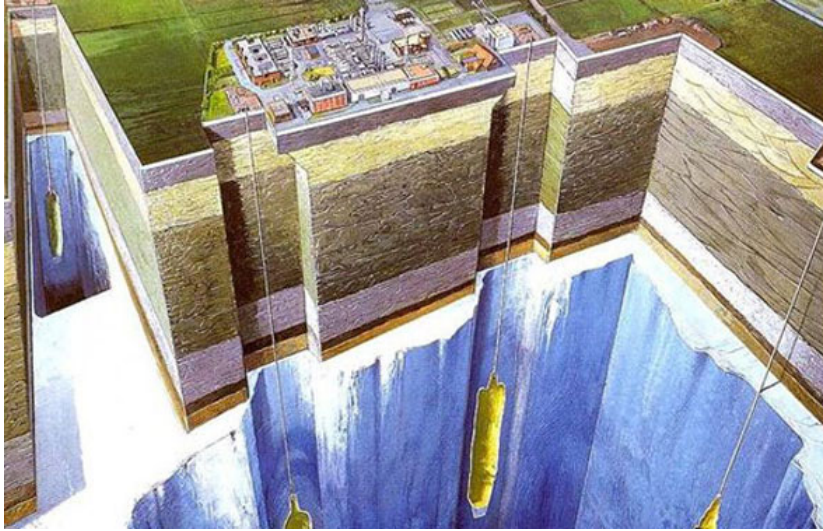
York State, but there have recently been many movements to overturn that decision. The main argument against hydrofracking is the liquid chemicals that are used in breaking up the shale that holds the gas. Inergy, however has not commented on what sort of fluid they will be using to solution mine, but one assumption is that brine could be used.

In the neighboring state of Pennsylvania, hydrofracking has been used for obtaining natural gas. Although the chemicals may be different in the actual fracturing fluid, the principle is very similar. There are numerous accounts of water supplies being ruined by fracturing chemicals and natural gas. Some of these accounts include situations where water becomes flammable and leaded with chemicals that can severely harm or even kill someone who drinks the water.¹⁴ This problem is highly applicable and possibly foreboding to what might happen at Seneca Lake.

Typically, the most damaging aspect about hydrofracking is the fracturing liquid itself, and if this liquid is leaked above ground it can seep into the ground water and have devastating results. For Seneca Lakes, the stakes are increased. As aforementioned, there has been evidence that the caves may not be completely structurally sound. The high pressures of the water during salt extraction during the 1970's had put a fair bit of sodium and chloride into the water table. There is no difference between what will happen when Inergy starts the process of solution mining. The worst-case scenario is that the solution mining uses a chemical heavy fracturing liquid, which will eventually make its way into the water table, and into the lake within a short period of time. This chemical would then proceed to devastate the lake and if left untreated or ignored, could make the lake undrinkable or even not able to swim in. The best-case scenario would be that Inergy uses

¹⁴ "Letters From PA." *Skaneateles Lake Watershed and Hydrofracking*. Web. 13 Apr. 2012. <<http://fivetownwatershed.wordpress.com/letters-from-pa/>>.

the salty brine to break apart the shale, but then the brine is inevitable going to make its way into the lake as well, thus adding vast amount of salt into the lake, and bringing the lake back up to where it was in the 1970's. Inergy will also be using this method to expand the mine so that it will be able to handle 5 million barrels (155 million gallons) of LPG.¹⁵



Another implication of storing LPG in the mines will be the increased truck and train traffic to and from the sites. A drawing of the proposed site is on the left (courtesy of dcbureau.com).

The plant has the potential to operate around the clock, every day of the year. Running at full efficiency, the plant can fill twelve rail cars every twelve hours, and four trucks every hour. The rail line that will be used runs almost parallel to route 14 along the lake and the trucks will use the common roads. There are two concerns that can be brought up: safety and aesthetic. Although not an everyday occurrence, it is not unheard of for trucks or trains explode. Two months ago in Wisconsin a truck was transferring 3,400 gallons of propane from storage to the truck and the hose became loose, and eventually caught fire and exploded.¹⁶ Fortunately, no one was hurt, but the threat remains that situations like this can happen and will. In 2009,

¹⁵ "Plan For Gas Storage Facility Worries Some Residents." *Coalition to Protect New York*. Web. 14 Apr. 2012. <<http://www.coalitiontoprotectnewyork.org/plan-for-gas-storage-facility-worries-some-residents/>>.

¹⁶ "Worker Escapes Injury in Propane Explosion." *GazetteXtra*. Web. 15 Apr. 2012. <<http://gazetteextra.com/news/2012/feb/04/worker-escapes-injury-propane-explosion/>>.

there was a tragic accident in Italy when a train with fourteen cars of LPG broke and axel and over turned. One of the cars leaked and the single car ignited. The explosion was large enough to destroy five nearby buildings. Seventeen people died in the explosion and 34 other individuals were injured (12 of which were in severe condition) with burns.¹⁷ The plant in Watkins Glen will have high rates of transportation, so the risk of something happening is a distinct possibility.

Aesthetes of the area will also be strongly affected. Given that most of the gas storage operation will be preformed underground, the high rates of traffic has the possibility to ruin the tranquility of the wineries and vineyards along the lake. If the natural beauty of Seneca Lake is compromised, then some of the tourism that we receive may decline, affecting the revenue of local businesses. On top of the heightened traffic, there is also the thirteen-acre brine pool. Although there have been questions about the security of the brine pool because the location itself will be on an incline near the shore of the Seneca. When this facility was in the planning stages in 2009, Inergy was asked to present a specialized dam permit, but within the next couple days attorneys of Inergy claimed that one would not be necessary.

Similar to how trucks and train transportation carry their own risks, storage of 65.1 million gallons of extremely salty water can pose a severe risk. If something was to happen and a wall of the reservoir was to fail, millions of gallons of this solution would make its way into Seneca Lake. This introduction of such a saline solution to the lake could cause catastrophic issues to the local ecosystems and to the quality of the drinking water. If the

¹⁷ "Routine Train Malfunction Causes Deadly Liquefied Petroleum Gas (LPG) Explosion In Italy." *Atomic Insights*. Web. 15 Apr. 2012. <<http://atomicinsights.com/2009/07/routine-train-malfunction-causes-deadly-liquified-petroleum-gas-lpg-explosion-in-italy.html>>.

water became too salty for consumption, a desalination process would need to be established. Currently it is a very expensive and energy intensive process. In 2008, the rate was a little over \$3 per 1,000 gallons. This would equate to an extra spending of \$27,000 daily (almost \$10 million yearly) to desalinate the water.¹⁸ These pools have also broken in recent history: Kentucky in 2000 and Tennessee in 2008. The accident in Kentucky was called the Marin County Sludge Spill, where a pool of coal slurry broke and leaked into an abandoned mine, and continued to eventually make it into Wolf Creek. All in all, 306 million gallons of sludge made it out and turned a normally three meter wide creek into a ninety one meter wide slurry of ooze.¹⁹ In more recent news, the Kingston Fossil Plant had an accident in 2008 that released 1.1 billion gallons of coal fly into the nearby river. When the spill made it to the river, it killed all the fish and blanketed the surrounding area, causing severe destruction to the ecosystem. It cost the government almost a billion dollars to clean up the mess.²⁰ Although brine is not the same as coal ash, the risk is still there. If those pools failed, there is very little that can be done to stop the impending ecological and financial disaster.

In these present tough economic times, two of the benefits of the new LPG storage facility are a new job market and also revenue to the state through taxes. Inergy states that "benefits include 8-10 full time jobs and 50 construction jobs along with additional tax

¹⁸ "Desalination." *Wikipedia*. Wikimedia Foundation, 15 Apr. 2012. Web. 15 Apr. 2012. <<http://en.wikipedia.org/wiki/Desalination>>.

¹⁹ "Martin County Sludge Spill." *Wikipedia*. Wikimedia Foundation, 21 Mar. 2012. Web. 15 Apr. 2012. <http://en.wikipedia.org/wiki/Martin_County_sludge_spill>.

²⁰ "Kingston Fossil Plant Coal Fly Ash Slurry Spill." *Wikipedia*. Wikimedia Foundation, 04 July 2012. Web. 15 Apr. 2012. <http://en.wikipedia.org/wiki/Kingston_Fossil_Plant_coal_fly_ash_slurry_spill>.

revenues to the town, county, and local school districts.”²¹ This is a large benefit because it will bring revenue to Watkins Glen and will support the local government and school systems. Unfortunately, in another report it was stated the Inergy reported to the Schuyler County Industrial Development Authority for reductions in both sale and property tax, which has the potential to undercut some of the few benefits of this whole program.²² This basically negates one of the only positive aspects of the whole Inergy operation.

Many of the local citizens in Watkins Glen and the surrounding areas do not want to allow Inergy to continue with the plans. One of the largest opponents to Inergy is the organization GAS FREE SENECA. They were founded specifically to front the threat posed by Inergy. Originally, it was established by just a few citizens, but has recently grown into a much more powerful group with both local businesses and national environmental groups support.²³ As of now, there is around 100 private businesses that support the movement of GAS FREE SENECA. In January of this year, GAS FREE SENECA had received over 5,000 signatures in a petition against Inergy, and has been raising money to hire an environmental lawyer.²⁴ This group has grown so dramatically since its inception, which is a strong indicator that the residents do not want Inergy to store LPG in the mines of Watkins Glen.

²¹ <http://www.coalitiontoprotectnewyork.org/plan-for-gas-storage-facility-worries-some-residents/>

²² <http://www.dcbureau.org/20110207166/natural-resources-news-service/new-york-state-to-require-environmental-impact-statement-for-large-scale-lpg-storage-in-ny-watershed.html>

²³ "GAS FREE SENECA." *GAS FREE SENECA*. Web. 15 Apr. 2012. <<http://gasfreeseneca.com/>>.

²⁴ "YNN." *Gas Free Seneca Preparing for Possible Litigation Against Inergy*. Web. 15 Apr. 2012. <http://fingerlakes.ynn.com/content/top_stories/570558/gas-free-seneca-preparing-for-possible-litigation-against-inergy/>.

Given all the risks associated, there are little to no benefits to allowing Inergy to use the mines in Watkins Glen for the storage for LPG. The risk of the solution mining liquid to permeate into the lake, the increased truck and train traffic poses significant threats to people and the aesthetics of the lake, and also the threat that the brine poses to the lake if something were to go wrong. Although this has not happened in the recent past, if the mine was at full capacity of 65.1 million gallons of LPG, and it were to ignite, it would produce an explosion with the energy comparable to a 1.5 megaton nuclear weapon, which is about 300 times more powerful than the bomb dropped on Hiroshima. Considering that the Finger Lakes region is one of the few areas left virtually unscathed by modern industrialization, it is necessary to keep it that way. The lake has been struggling to maintain its purity in recent years and allowing Inergy to store LPG in the mines that have been known to have permeable properties in the past will send the lake into a tailspin. It is our duty to protect this lake and not allow it to become tainted through industrialization. Any way the project is looked at, the negative far outweighs the positives.