Group SIE - 2012

Seneca Lake Watershed Management Project Et al:

The Effects of Mining Operations Within the Watershed

Taylor Robert Michael Weber

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This report explains in detail the hazardous environmental effects that mining has on both Seneca Lake and its entire watershed. The report focuses on both sedimentation and erosion rates within the lake and its sub-watersheds. This report was constructed in accordance with the Group SIE class at the Hobart and William Smith Colleges in Geneva, NY and should be used to educate the surrounding community of the potential environmental hazards that mining operations have on Seneca Lake.

"Water is fluid, soft, and yielding. But water will wear away rock, which is rigid and cannot yield. As a rule, whatever is fluid, soft, and yielding will overcome whatever is rigid and hard. This is another paradox: what is soft is strong"

- *Lao-Tzu*

Seneca Lake is home to approximately 60,000 people who live within the watershed boundaries and provides them with grade AA drinking water throughout the year. Though there is quite an abundance of fresh drinking water for the watershed's population, it seems that over the years that the quality of the drinking water has slightly diminished. The lake has shifted towards a mesotrophic state since the 1970s and is now moving towards a eutrophic state due to the increase of sediment and turbidity in the water column. Some put the blame on farmers and their spreading of pesticides, others question the waste water treatment plants and their processes for cleaning soiled water. The purpose of this specific study is to determine whether or not mining activity poses a threat to Seneca Lake and its watershed. This report will focus heavily on the specifics of mining waste, how that waste is transported down slope, what happens to that waste once it reaches Seneca Lake, and what actions can be taken in order to keep the lake in a healthy state for years to come.

Mining within the Seneca Lake watershed poses environmental threats to both the lake's water quality and the wellbeing of the flora and fauna that thrive in and around Seneca Lake. Open pit mining not only increases turbidity levels within the lake, but introduces heavy metals and toxic mining waste directly into the lake. With approximately forty open mines within the Seneca Lake watershed, it is not hard to believe that mining activity is a major contribution to the lakes degradation of water quality. With the NYSDEC only permitting mining operations for the past two decades, there are mines in the Seneca Lake watershed that are “grandfathered” in and the laws set in place for the reclamation of those mines do not apply to the reclamation laws prior to 1975. With no one to implement best management practices for these abandoned mines, it is possible that these mines are causing more of a threat to Seneca Lake than originally posed. Other than these abandoned mines, there are still active mines running within the watershed and causing the lake to experience high levels of turbidity and an increase in sedimentation rates. The following paragraphs have been formulated in accordance with the Seneca Lake Watershed Management Plan and give insight on the environmental threats that mines have on the watershed and Seneca Lake.

Open pit mining is a division of mining that specifies in obtaining loose strata from the surface of the crust. Its methods include the digging of earth in a step-latter formation in order to reach deeper depths. These mines often develop into large holes that scar the face of the land it resided on. This report specifically focuses on sand and gravel pit mines within the Seneca Lake watershed and the possible damages that these mines have on Seneca Lake and its watershed. (Figure 1) marks off all the mines that are within the watershed by a code number which allows for easy identification of the type of commodity, municipality, status, bond amounts, and owners of the mines. This numerical code can be easily interpreted by using (Table 1). (Table 2) shows a list of mines within Seneca, Yates, and Schuyler County that were given permits by the NYSDEC for land reclamation once mining activity seizes. Schuyler County has the highest reclamation permits with a total count of 21 permits. These permits mimic the number of active mines within the Seneca Lake watershed, specifically in the Catherine Creek and Bullhorn Creek sub-watersheds.

(Table 1) displays the amount of money bonded to a mine for the reclamation of the mine once mining activity seizes. According to this table, all mines that are listed as “sand and gravel” pit mines under the commodity column, have a total bond amount of $174,600.00. Of the seven inactive mines within the watershed that predate the 1975 Mining Reclamation Act, all seven have a bond total of $0.00 and will not get funding for reclaiming the mine since its laws do not apply to the act. These mines may be the source of the pollution in Seneca Lake due to the fact that these sand and gravel pit mines do not have best management practices or any funds to restore the mine back to its original state. Please refer to (Table 1) to see these statistics under the “bonded amount” column.

Land erosion has been always been a problem within the Seneca Lake watershed and has lead to the increase of sedimentation and turbidity in the lake. The reason for these changes simply has to do with the characteristics of the watershed. There are four factors that contribute to the erosion of any watershed and those include: the type of climate we live in, the topography of the landscape, the soil characteristics, and the amount of vegetation within the Seneca Lake watershed. Seneca Lake resides in a climate where in an average year it accumulate approximately 35 inches of rain and its watershed has a steep topography since glaciers carved out the finger lakes during the last ice age, 14,000 years ago. One of the only factors that save Seneca Lake from becoming an even more turbid body of water is the amount of vegetation within the watershed. If you examine (Table 3) and (Figure 2), you will see that most of the land use within the Seneca Lake watershed is forested land accounting for approximately 42%, while agricultural land use is a mere 40%. Having 82% of the land use within the Seneca Lake watershed be rooted land is good for controlling the amount of sediment that runs down slope. Climate is one factor that strongly affects lakes productivity since rain is the major source of transportation of sediment into Seneca Lake. Accumulating an average of 35 inches of rain a year, the Seneca Lake watershed has the ability to capture approximately 457 square miles of surface water not including Seneca Lake itself which captures approximately 66 square miles of surface water during a rain event. Since the size of the watershed is very large, it can take up to an entire day for water to move from the watershed boundaries all the way down to the lake. During this lag period, water is transporting sediment from higher topography and is accumulating in the lower regions of the watershed where stream velocities can sometimes peak at 2 meters/second. This increase of velocities is what destroys and erodes the banks of the stream and tributaries that lead into Seneca Lake. Mining waste is a direct point source pollutant for Seneca Lake because of where it is placed once it is retrieved from the mine. Mines that are close to the lake's edges experience the fastest runoff and stream velocities since this is where all of the rain water accumulates after a strong rain event.

A vast majority of the forested land is located at the southern half of the watershed where 90% of the 30 sand and gravel pit mines are located. (Figure 3) shows that of the 30 sand and gravel pit mines, 28 of them are within the southern half of the lake where the vast majority of land is rooted land. This rooted land just may be the only factor that has saved Seneca Lake from going fully eutrophic. Roots and vegetation act as sediment and water buffers for all runoff that enters the lake. The roots of trees, bushes, and plants absorb water which decreases the velocity of surface run off. As the velocity of surface runoff decreases so does erosion rates due to the fact that sediment needs faster water velocities to move more sediment. This process is explained even further along with best management practices later in this report.

The Seneca Lake watershed has quite a range in topography ranging anywhere on average from a 4° slope to a 42° slope in the lower regions of the watershed. Slope greatly effects erosion rates within the watershed and can lead to slumps, creeps, and minor landslides which in fact can release even more sediment into Seneca Lake. The steeper a slope is, the faster water can transport sediment downhill since there is more potential energy at higher elevations. As shown in (Figure 4), the steeper slopes are in the bottom half of the Seneca Lake watershed which average approximately 30% gradient. Most of the sand and gravel pit mines are located within these huge gradient slopes, 85% of which are in Schuyler County. These highly graded slopes are a good indicator of the amount of erosion that takes place within the watershed. By erosional processes, steeper slopes have the ability to erode faster than slopes with low percent grades. Therefore, mines that are within the 30% gradient in Schuyler County are more likely to experience heavier erosion whereas mines in the northern territory of the Seneca Lake watershed experience low, but steady periods of erosion. Slope angles play quite a significant role in the transportation of sediment downhill because slopes with a larger degree, have more potential energy to erode more sediment.

The transportation of sediment down a slope is an important factor to take in to consideration when determining erosion and sedimentation rates in a watershed. Starting with the source of the sediment, miners expose coarse and fine grained sediment to the surface of the sand and gravel pit mine which allows for natural erosional processes to occur. Usually, mines have different piles of rock on its property. Miners usually have a few piles for extracted gravel and one pile for mining waste such as top soil and clay. These waste piles are usually rich with nutrients such as phosphates, nitrates, and sulfates. These big waste piles are not covered by erosion-controlling tarps and rain water is quick to make flat of these waste piles. Rain water is a powerful source of erosion and is responsible for the breakdown of sediment and the eventual transportation into Seneca Lake. Shortly after rain events occur, the sediment reaches either streams or tributaries by the destructive force of the rain water. The sediment is then transported downstream where it is eroded even further by smashing into other rocks along the river bed. During the sediments trip down the stream, oxidation occurs and reacts with iron rich sediment and other metals from the mine and produces acids that increase the lakes pH and form more acid rain. By the time the sediment reaches the lake, it has undergone heavy erosion and is broken down to fractions that actually keep it in suspension. Once the sediment and acids reach Seneca Lake, they are dispersed throughout the lake and stay in suspension due to their grain diameter. The coarse material sinks to the bottom where it accumulates according to grain size potentially killing off aquatic plant life. Steam discharge and stream velocities can give a very good estimate of how much sediment influx there is into Seneca Lake.

When taking into consideration the streams and tributaries that provide Seneca Lake with its water, understand that besides surface runoff directly into the lake, streams and tributaries are the only means of transport of sediment into the lake. (Figure 5) shows a sample of the many streams and creeks that flow into Seneca Lake. Notice that Gleen Creek and its tributaries, Catherine Creek and its tributaries are the main means of transport for sediment into the lake since most of the sand and gravel pit mines fall into these sub-watersheds as well.

Turbidity is the main concern for this report and the Seneca Lake Watershed Project and studies performed by the Seneca County Soil and Water Conservation District (SCSWCD) has revealed helpful information on Seneca Lake turbidity from 1991 – 2006. There data was recorded as follows; "Minimum mean yearly turbidity was observed in 2002 at 0.53 ± 0.06 NTU. Maximum mean yearly turbidity occurred one year later in 2003 at 3.87 ± .39 NTU. Mean annual turbidity for the study period was 0.98 NTU which is below the 1 NTU standard required for nonfiltration of drinking water in New York State" (Makarewicz, Pg.9). Mining activity can be the main cause for this increase of turbidity levels from one year to the next. Secchi disk depth measurements were taken from 1991-2006 and the SCSWCD revealed the following data using (Figure 6). "Turbidity, which is a measure of organic and inorganic particles in the water, accounted for 10% of the variability in the secchi disk readings. Neither regression is strong but the decrease in secchi disk readings appears to be related to an increase in inorganic particles in the water" (Makarewicz, Pg.10). Could this be the introduction of mining waste into Seneca Lake such as sediment and inorganic particles?

Other than sediment being transported into Seneca Lake, there are other pollutants that come from mines which find their ways into the lake. Once a mine creates a big enough hole in the ground, it can fill up with rain water and become a pit lake which may be responsible for nutrient loading into Seneca Lake. Mines other than sand and gravel pit mines are the biggest threat to Seneca Lake due to the miners bringing corrosive minerals to the surface. These mines include: iron ore, dolomite, limestone, and salt mines. These four types of mines have different effects on the Seneca Lake in that each mineral weathers differently. The iron oxidizes in a pit lake and creates iron oxide, commonly known as rust. The dolomite and limestones weather down to clay particles which feed the lake with more sediment creating more turbid water. The salt simply dissolves in the pit lake leading to high salinity concentrations. Then when a heavy rain event occurs, the pit lakes can overflow leading to a surge of waste water directly into Seneca Lake.

Though mining operations are an environmental hazard for Seneca Lake's water quality, there are many way in which miners and their supervisors can decrease and maybe even eliminate these hazards entirely. Best management practices or (BMPs) have been used for decades by miners to decrease the erosional rates within a watershed and the sedimentation rates in lakes or rivers. BMPs have also been used to aid in restoring or reclaiming the mine back to its original state once mining activity seizes. From sediment barriers to diversion ditches and everything in-between, there are dozens of ways to keep turbidity levels down in Seneca Lake. One method that stands out from the rest is a process called silt fencing. It is a relatively cheap and successful method for capturing the small fraction sized sediment that flows out of a sand and gravel mine. A silt fence is exactly what it sounds like. It is a long strip of fabric meshed together usually with nylon or another strong material that keeps clay and silt sized particles from percolating through the fabric. Rather, it falls through a pre-dug ditch which is loosely filled with porous rock fragments to capture the silt and clay sized sediment. Instead of flowing directly into Seneca Lake, the sediment is captured in the pore spaces of the rock fragments and stays trapped allowing only the water to pass through where it is then transported by ground water back into Seneca Lake as a relatively clean drinking source. The silt and clay sized fractions pose the biggest threats for Seneca Lake because these sediment sizes stay in suspension once they reach the lake whereas larger sized sediment like pebbles and sand fall to the bottom of the lake which does not affect the turbidity of the lake.

Another type of erosion controlling method used by miners are vegetation buffers. These methods are both affordable and easy to implement. A vegetation buffer is simply a row or section of plants, grass, and trees that act to slow down the velocity of runoff after a strong rain event. The main goal in controlling erosion rates on a landscape is either eliminating the amount of water on the surface of the watershed or redirecting the water to a different part of the watershed with in fact will slow down the times it takes water and sediment to reach Seneca Lake. Roots are a fabulous water absorber and act to slow down surface runoff. By planting rows beyond rows of vegetation buffers, rain water will have been fully absorbed by the time it reaches the banks of the lake. These buffer strips can be placed in and around the mining property and around areas in the mines that have bare land. The effectiveness of these buffer strips depends entirely on the placement of the strips and the amount of vegetation planted in and around the mine.

BMPs can be both long term and short term methods used to control erosion and sedimentation. “Long-term erosion-control methods are more cost-effective if properly planned and coordinated with mining activities. At many sites, short-term erosion control will be needed until long-term controls are established” (Norman, Pg. 30). Both long term and short term BMP methods should be used when reclaiming a mine because usually one single method is unsuccessful. So, by using both vegetation buffers, a short-term method, and silt nets, a long-term method, the likelihood that the reclamation project will be a success will be far greater than just one of these methods alone. With the addition of short and long term methods, it is more likely that the combination will yield successful results.

With quite a large residence time, Seneca Lake can be polluted with mining waste just as easily as it can be cleaned after mining activities seize. Preventing erosion rates and sedimentation rates in the lake is the most important act of stewardship one community can have on the productivity and cleanliness of Seneca Lake and its fragile watershed. Keeping the community aware of potential environmental hazards that the lake may encounter during mining operations is a very useful and significant way of keeping the lake clean. Lastly, by applying certain BMPs to the current situations, miners that work within the Seneca Lake watershed might be able to keep the lake in a healthy and low turbid state for generations to come.