The Mystery of North Shore's Disappearing Pond

L2R GLOBE Project 2012-2013

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Project Background:

North Shore Hebrew Academy High School was constructed six years ago on the top of Community Drive hill which slopes down to Long Island Sound some 4 miles to the north. One feature that figured into the design was a pond at the front and topographic bottom of the school to serve a number of purposes:

1. catch basin for 15 acres of sloping school property, much of which is paved

2. aesthetic natural landscape asset

3. natural lab for environmental science and ecology classes

Since its inception the pond has served its purposes well. The pond has retaining sidewalls and storm drains that channel water into the ocean in the event of flooding. To give you an idea of the steep topography, one day shortly after the first perennials were planted, it rained heavily and a mudslide pushed the entire landscape into the pond (an expensive lesson: check the weather).

2006-A Bad Day at North Shore [Google Earth]

Initial Observation:

On a routine GLOBE monitoring day our Environmental Science students noticed that the shoreline of the pond had receded significantly from fall of 2011 to spring 0f 2012. Their alarm was communicated to the department chair (myself) who noted that the pond in fact had been receding for the past 4 years. The Pond is essentially a catch basin for large volumes of run-off with little recourse.

Overarching Question: **Why is the pond receding?**

2007 Aerial Photo [Google Earth]

2011 Scale-Comparable Aerial Photo [Google Earth]

Blue Line = 2007 Shoreline from Previous Picture

Research Team:

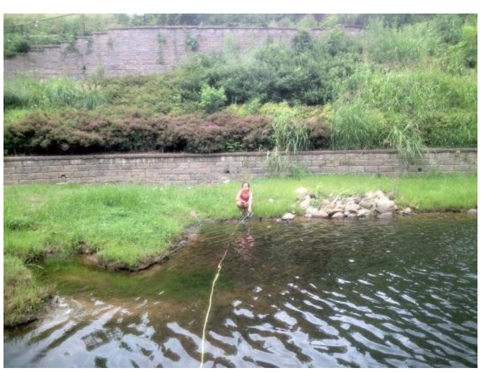
Our project is somewhat unique in that our research team is comprised of volunteers from the Environmental Science Class at the school. The GLOBE program is the field monitoring component of our very full Environmental Science Class, one of our most popular junior electives. The student volunteers were brought together and the problem was presented and explored in depth. Following the collaborative rubric issued by GLOBE, the project was divided into study areas, each with two to four students working on their study of choice, but with opportunities to share information, thoughts or new directions in the larger group.

Areas of Study:

1. Volume/Dimension Study:

To determine how much volume was lost was essentially asking how bad the problem was. We needed some method of estimating the present dimensions of the pond and comparing these to past estimates. By extrapolation we should be able to determine the life of the pond at present rates of depletion.

Calculating surface area seemed straight-forward. We would use the GLOBE tape measure tool and make several measurements across the pond at various points.

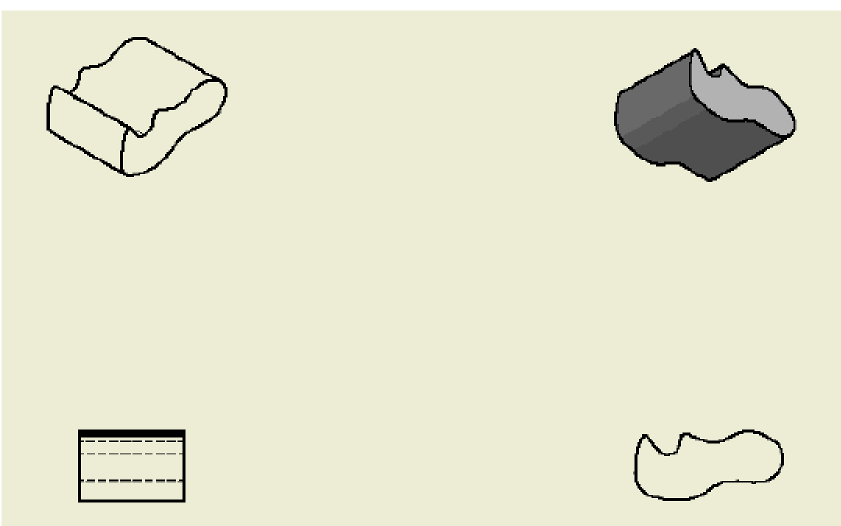


Then borrowing a method we use for leaf surface area we would superimpose the aerial view of the pond onto a grid and count the number of squares and partial squares covered. Initially we used transparencies and graph paper but it was

discovered that we could superimpose and resize both the pond image and the grid on computer.

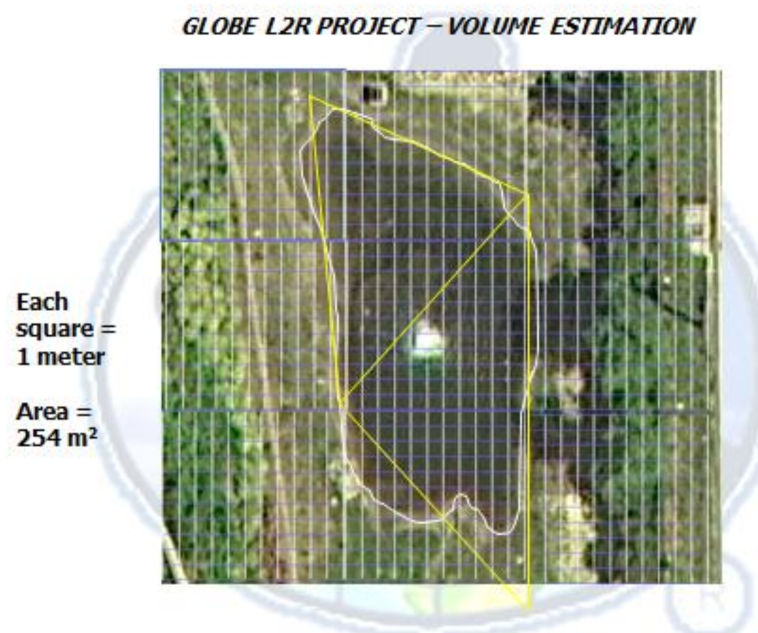
The next challenge was to calculate the volume. Research showed that depth surveys of bodies of water were typically done with sonar and plotting software. Because our pond was not very deep we decided actual measurements were better. Besides we could use our boat! We used a weight on a string but this proved inaccurate due to drifting. We settled on a bamboo pole and our handy GLOBE tape measure tool. We divided the pond into four quarters and tried to record the deepest points in each quarter. Our work (and one accident) showed that the pond had a very muddy bottom of detritus and sediments, but was roughly one meter deep at the deepest points in the four quarters. We were able to make a one meter contour line using our measurements. The detritus and sediments would inform another study we wanted to do on turbidity.

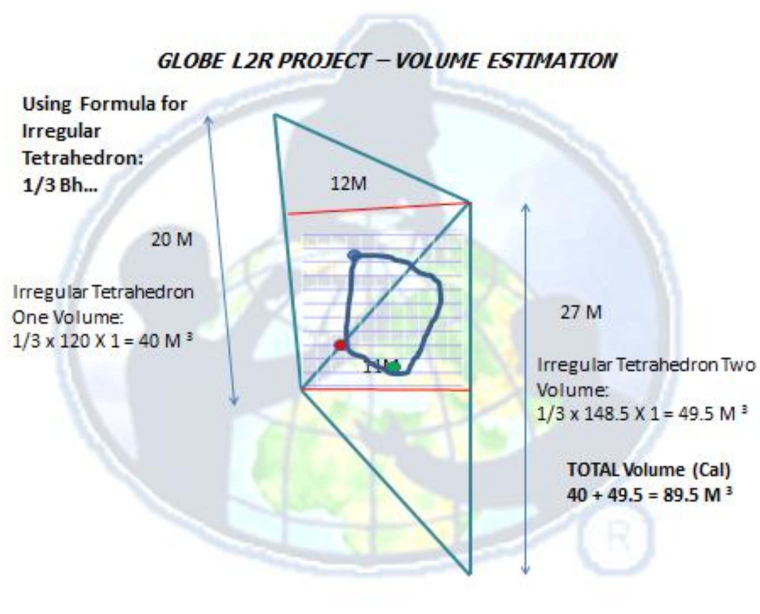
The challenge came in using the data to obtain volume. We thought about dividing the pond into one meter slices and using the equation for a parabola in each with the vertex as the depth. Using calculus the sum of the slices would give us an approximate volume but we would have to take another set of depth measurements every meter over the length of the pond. Another idea was to use a computer rendering program to map out the surface and 'pull out' the volume. This idea was first discussed with Gary at GLOBE L2R but we didn't really have the software to go with this method.



Practice rendering of the pond

Mr. Lou Prevet, one of our math teachers suggested we use tetrahedron math: If we could superimpose one or two triangles that had the same surface area as the pond we could use the pond depth of one meter as the height of tetrahedrons. Using the formula 1/3 (Area) x Height we could get the volume of irregular tetrahedrons that would approximate the pond volume. This was much easier. Furthermore, by enlarging the triangles over past aerial pictures and adding 25 cm to the depth (the estimated depth in 2007 was 1.25 m) we could estimate the volume before the pond began shrinking. This allows us to estimate the life of the pond.





Our data summary is as follows:

- **Current volume estimate = 89.5 m^3**
- **Past volume estimate = 120 m^3**
- **At a rate of 30 m^3 of water loss per year the pond will dry out in 14-15 years**

2. Drainage and Runoff Study:

Our pond is a catch basin for surface and ground water runoff. Our school property is 15 acres which slopes steeply from south to north towards Long Island Sound. The southwest quarter of the property is parking lots for cars and bus pick-up (3 acres). The parking lot is impermeable and therefore has storm drains at its lowest points.

If runoff is directed to the pond either through groundwater or surface water one would assume the pond would be getting larger, not smaller. This prompted the Drainage and Runoff Study.

We wanted to see if drainage water was getting down to the pond. First we measured the area of the parking lot with our measuring wheel and the elevation with a home-made inclinometer. We decided to tip colored-marked water into the drains and see if the marked water entered the pond. The 'tipping team' emptied 30 gallons of marked water three times into three storm drains. The 'observing team' noted that no marked water entered the pond. Instead they noted obstructions in the drainage pipes at the pond site. It was concluded that runoff through storm drains was not refilling the pond leaving surface water runoff through swales during heavy rain and ground water movement as the sources of recharge. This opened the doors to two more studies; one measuring annual rainfall and snowmelt and another examining the porosity and permeability of the soils.

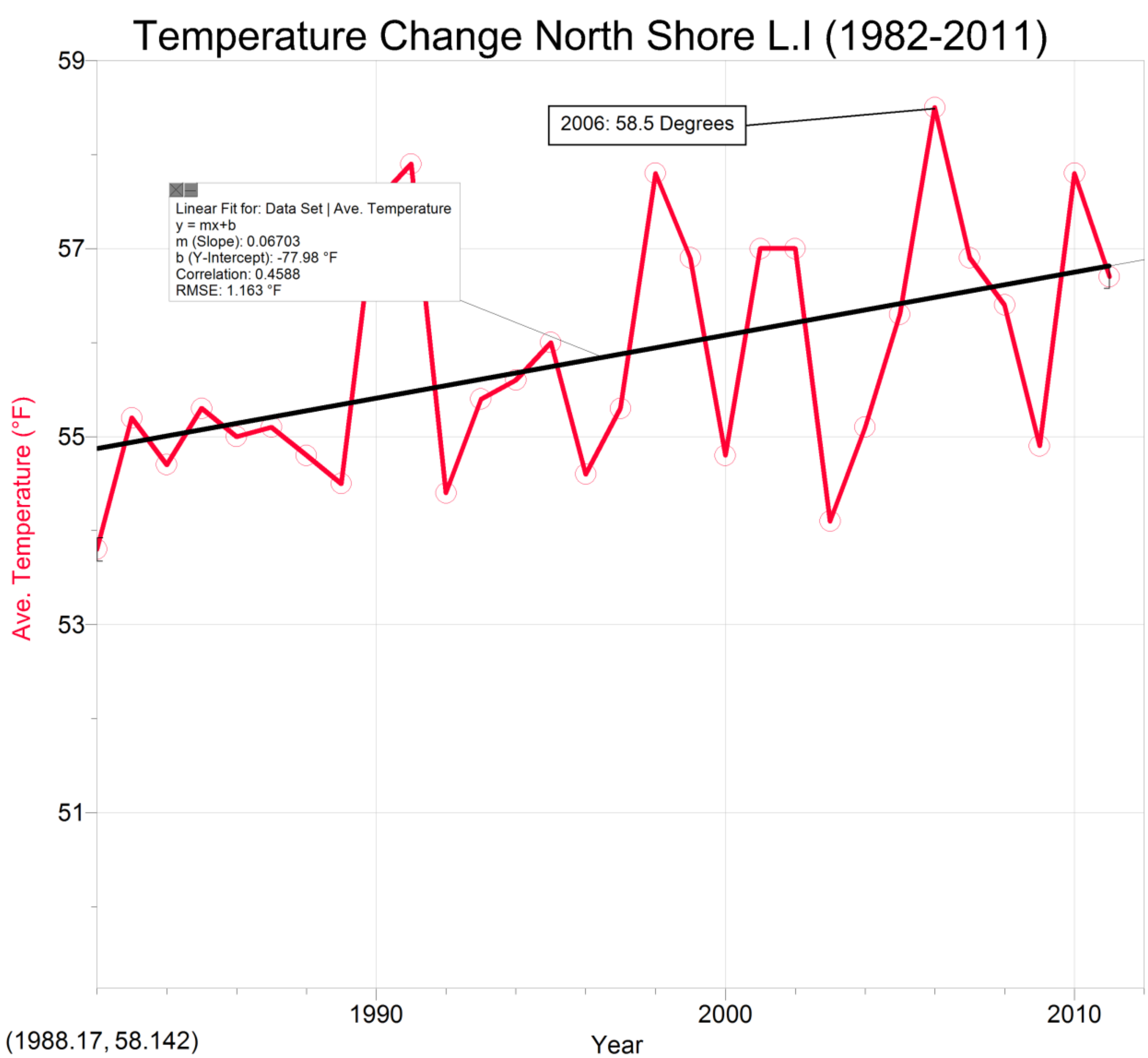
3. Climate Study:

The climate study began by making a distinction between climate and weather. How much time does it take to establish a trend in environmental conditions? How much until you can establish a change in these trends? These are not always easy questions. Our first impulse was to correlate daily temperature measurements from our GLOBE weather station with changes in pond volume but right away we encountered many problems. Rates of evaporation were dependent on water temperature, not necessarily air temperature. Water temperature, in turn depended on volume, which we said was changing. Humidity was also an important factor in rate of evaporation. So was wind.

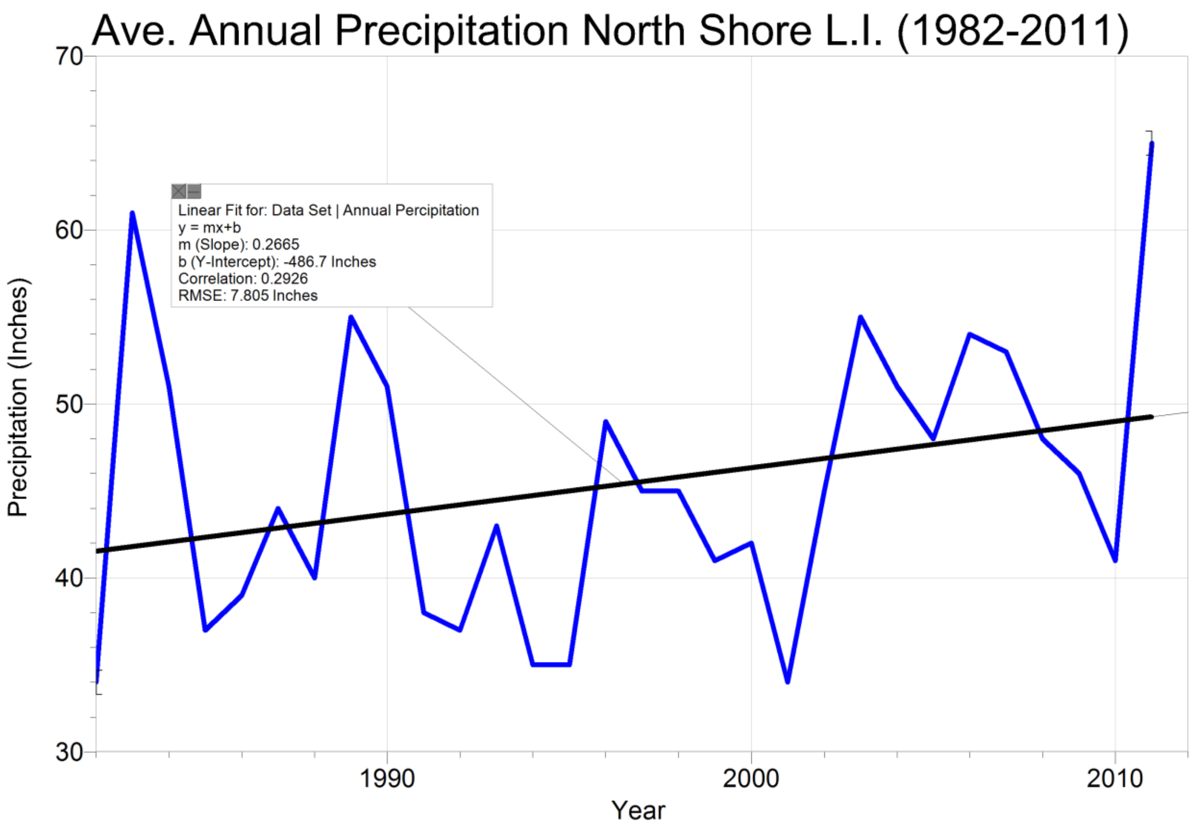
Alongside temperature measurements from the air we began using our IR thermometer to take pond temperature, surface temperature and relative humidity

measurements at 9 am and 3 pm daily. These measurements were part of our IOP (Intensive Observation Period) data that we were sharing with Mr. Peter Dorofy who was using the data for climate modeling. One thing that we observed while taking these recordings is the dramatic effect of cloud cover on surface temperatures. Insolation, or the amount of solar radiation absorbed and reflected by the pond probably would have the greatest effect on pond volume.

It was back to the drawing board. We decided to work with what we had. In terms of climate data our GLOBE efforts go back only five years. Our nearest reliable weather station is La Guardia Airport nine miles southeast of the school. We could access La Guardia's data through the National Climate Data Center (NCDC) which had temperature and precipitation data going back to at least 1961. We plotted the data for the last 30 years using LoggerPro and before our eyes was the warming trend. A best line fit showed an increase of 0.067 Farenheit degrees over the period.



Could rising temperatures be the reason for loss of pond volume? As stated, there are plenty of other variables one of which is precipitation. Increasing temperatures should intensify the water cycle and the result should be higher rainfall. Would the data support this assumption? It did!



The line of best fit in this case shows an increase of about a quarter of an inch per year over the last 30 years. One variable it would seem offsets the other and we know there are plenty of other variables at work in climate alone. We would have to say that our findings were inconclusive. The door is open for more work to be done in finding a climate-related reason for the shrinking pond.

-Calculate present surface area of the pond using on-site measurements. Correlate with remote sensing calculations from Peter's group. Compare with historical surface area provided by on-site estimation and estimation using historical mapping

-Use geometric modeling to estimate volume of water remaining, volume of water lost and estimate rate of water loss. Extrapolate against existing volume estimate to determine the expected life of the pond

4. Liner Study:

This study was interesting because it was generated not by brainstorming, but by observation. On our initial exploratory trip to the pond to 'check out the problem' we noticed an exposed sheet of rubber material at one shoreline of the pond and this prompted the question of whether or not the sheet extended underneath the pond. On closer inspection we noticed tears and holes in the rubber sheet. Depending on its size a pond 'liner' would serve to prevent water loss by infiltration downwards. The only way water could leave is by evaporation. It would also interfere with groundwater recharge.

Our group's hypothesis was that the pond liner was leaking. Maybe it had chemically decomposed or it had been punctured. This might explain why the pond was shrinking. We thought about different methods for testing the liner that was exposed. One suggestion was to get a sheet of liner, stretch it across a drum and apply weight until it failed. Another was to somehow examine the decomposition rate under various conditions. Then someone came up with the brilliant idea of asking experts whether this in fact was pond liner and, if it was, for how long would it remain waterproof. This became our first course of action.

We were rudely turned away by the school architect who directed us to our school's head custodian who surprisingly could answer all our questions. This is what we discovered:

> **(i) The pond was lined. 45 mil EPDM**
>
> **(ii) The rubber we found on site was the liner for the swale; a rough channel filled with large rocks that directed surface water to the pond, not pond liner. This was a factor that the Drainage Team should investigate.**
>
> **(iii) The pond liner was 'permanent' and there was no way pond water could leak out. Our man was there when the liner seams were completed.**

We double checked on-line to confirm: the standard for permanent liners was 45 mil EPDM (Ethylene Propylene Diene Monomer) which the Firestone Company claims to be 'winterproof and waterproof' for the life of the pond. The only way water could leave the pond was upwards, not downwards. Our part in this project was over.

5. Hydrology Study:

This study began with the question: What factors influence the rate of evaporation of water? Temperature was the obvious direct one, but what about the indirect factors? Our brainstorming came up with these variables:

a. Surface Area: The higher the surface area the faster the rate of evaporation

b. Volume: The lower the volume the faster the rate of evaporation because the water would heat up faster

c. Wind: Wind would increase the rate of evaporation

d. Humidity: High humidity would decrease the rate of evaporation

e. The Reflectivity or Aldebo of the Pond: Darker surfaces absorb more energy than light ones and thus they heat up more or faster

f. The Turbidity of the Pond: Cloudiness of pond water due to suspended particles would cause the pond to warm up

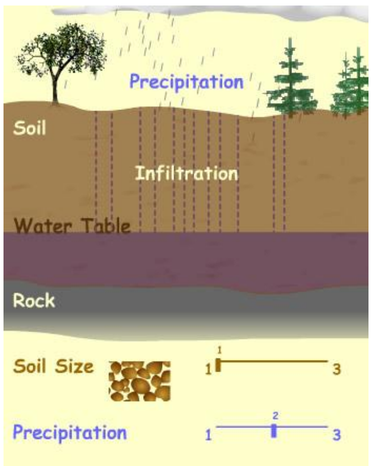
While some of these factors were being studied by other teams (Climate and Dimensions) we decided to look at the factors that were more related to the pond itself: Reflectivity and Turbidity. Turbidity and water temperature are part of our weekly pond hydrology measurements so we even had data to work with.

A baseline experiment proved our hypotheses that cloudiness and dark surfaces increase temperature of water. A one liter beaker of pure water was placed on the window sill as a control. Beside it we placed one liter of orange juice (a continuous suspension) and a liter of dirty water that we stirred gently every hour on the hour (a discontinuous suspension). On the other side we placed a beaker of pure water on a white sheet of paper and on another we placed a beaker of pure water on a dark sheet of paper. Under 60 watt lights, the orange juice and dark paper trials warmed up faster than the discontinuous suspension and light paper trials. Furthermore these stayed warmer longer when the lights were turned off (See Appendix for data)

Our pond is certainly dark on the bottom suggesting high absorption of energy and low reflectivity, leaving us to consider turbidity. Particles suspended in the water would increase energy absorption. Wind drives the movement of pond water constantly re-suspending particles and because the pond is next to a fast-moving highway, there is always some artificial wind. Furthermore, particle accumulation over time would make the pond shallower which in turn would speed up evaporation. Our group would measure the turbidity and temperature of the pond as well as air temperature and wind speed and look for relationships.

Our findings were not terribly conclusive. As expected our 'solar noon' recording of water temperature was less than air temperature depending on Tempmin or the low temperature recorded by our GLOBE weather station the night before. But some days when turbidity was high the temperature spread between air and water was greater than on days when turbidity was lower, the opposite of what we expected. One observation made was that cloud cover played a more significant role in the temperature differences between air and water. It became clear that this was not a simple one-variable study and that some modeling was probably in order.

6. Soil Infiltration Study:

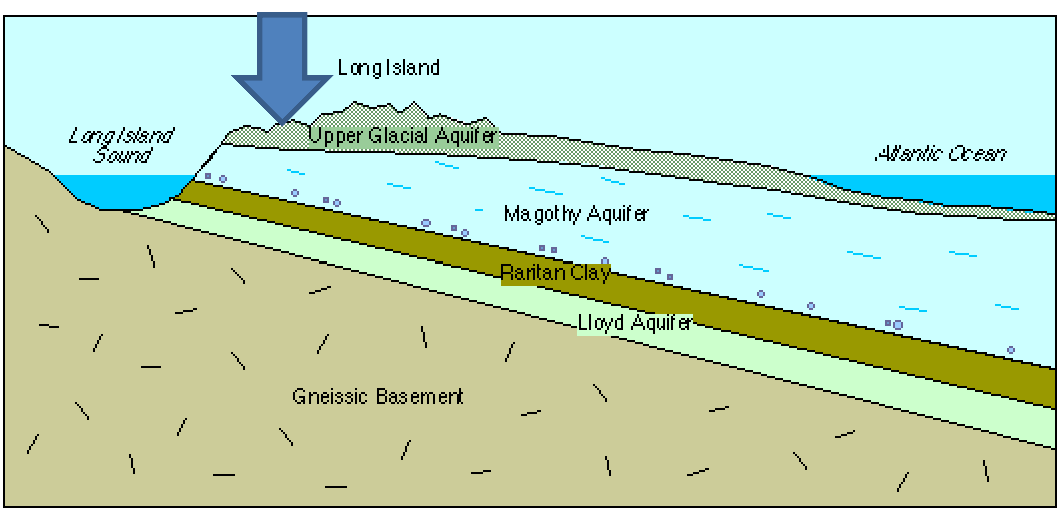


This study would examine the rate at which water made its way downward through the ground. There were a number of ideas we were considering:

1. If the pond was not lined then a high rate of infiltration might account for the loss of water from the pond. Note: The Liner Team found that this was not the case and no infiltration could be taking place in the actual pond.

2. If the rate of infiltration was high on the school property then the rate of recharge of the pond might be low or slow.

The background ideas for this study came from our Soil and Water unit in the En. Sci. Course. We learned that the Magothy Aquifer supplies most of Long Island with fresh water.



The Magothy Aquifer is unconfined, meaning to obtain water, wells have to be drilled and the water has to be pumped out. This supply, we were told, would likely be sufficient for the population except that Long Islanders are heavy users of fresh water. Much of our water goes towards irrigation which means that most of it will go into the atmosphere by evaporation or transpiration. The wells of the North Shore of Long Island often form dry 'cones' in the aquifer and these often fill with saltwater from Long Island Sound. This is called intrusion. Salt water intrusion has led to many well closings in the area north of our school.

Our idea was to measure the infiltration rate of the soil around the pond at various sites on our school property that would be part of the 'catchment area' of our pond and compare these rates to standards. The plan was to use ducting tubes of fixed diameter and hammer them into the ground to a fixed depth at each site and pour water into each. By timing the rate at which the volume of the cans emptied we could determine how fast water moved into the ground.

Our data was as follows:

Site 1: Highest elevation (crest of hill): Rate=12 cm^3 / sec

Site 2: Middle elevation (next to parking lot): Rate=14 cm^3 / sec

Site 3: Lowest elevation (the pond) Rate=17 cm^3 / sec

See appendix for complete data collection

We couldn't find much in the way of standards to which we could compare our data. It occurred to us that measurements taken elsewhere would have to be taken using the same size ducting driven to the same depth. The rates of infiltration seemed high but that could have been more due to the recent excavation that took place in the construction of the school than due to topographic factors of Long Island. Our group was left guessing that high infiltration through loose and dry soil was the variable that was preventing runoff water from recharging the pond.

In Conclusion:

In one of our last meetings, after exchanges of results, someone asked whether other ponds in the area were also losing water. Google Earth showed two ponds within half a mile from the school. One was at Deepdale Golf Club to the east and the other at Fresh Meadows Country Club to our north. We were able to get in touch with a Mr. Simms of FMCC who informed us that all his ponds had to be dredged, 'groomed' and refilled every five years as part of maintenance and to his knowledge the neighboring club had to do the same.

The consensus of the 'Pond Squad' was that this was a phenomenal project. The studies were educational and worthwhile. The teams learned much about the processes of environmental research and how to work cooperatively. But the most rewarding part was the making of the video. We felt afterwards that we had achieved something amazing: we had made environmental science really cool! Kids and adults alike could watch our work, learn a bit about climate, hydrology and soil science and at the same time enjoy an entertaining video. The Disappearing Pond may still be a mystery, but in these other terms the Pond Squad was a huge success.

Thank You, Julie Malmberg and everyone at L2R for all your support.

-Gerard Wykes-

Science Dept. Chair
NSHAHS