Research Projects as a Teaching Tool for Earth Science Classes

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Introduction

The primary mission of the educational programs offered by the Center for High Pressure Research (CHiPR), which has its headquarters at the State University of New York at Stony Brook, is to facilitate the integration of the process of "doing science" into our culture. In order to address this mission, CHiPR educational staff have designed a variety of educational programs appropriate for a wide range of audiences, including pre-schoolers, elementary school children, secondary school students, undergraduates, and practicing teachers. However, the bulk of CHiPR's educational programs are aimed at the secondary schools, where in New York State, Regents Earth Science is taught.

In order to administer these educational programs, CHiPR has established the Earth Science Educational Resource Center (ESERC). ESERC offers teacher workshops, programs that bring undergraduate and pre-college students to CHiPR laboratories to perform experiments, World Wide Web-based teaching materials, research equipment for teachers and their students to use, and summer internships for educators. In addition, CHiPR educators serve as mentors for secondary school students who are performing research projects. An example of a program that includes this type of research component is the Sayville Honors Earth Science program, which represents a collaboration between ESERC and Sayville High School on Long Island.

The goal of the Sayville Honors Earth Science program is to exercise the analytical thinking skills of highly motivated students who are studying Earth Science in secondary school, and to introduce them to the process of doing research as a means of testing hypotheses and answering questions. The program presents students with an opportunity to study Earth Science at a level that is consistent with an undergraduate college level introductory Earth Science course. In addition, this program provides us the opportunity to pilot various research activities, by interacting with the target-age students, that can then be offered to teachers in our annual "Research Projects for Earth Science Classes" summer workshop and through other programs during the academic year.

In 1993, the New York State Earth Science Program Modifications, often referred to as the "Modified Syllabus", was offered to school districts as an optional alternative to the 1970 Earth Science syllabus. Districts that elect to adopt the Modified Syllabus are expected to develop a "local component" for the Regents Earth Science course that provides for the students to conduct a research project. While the Sayville Honors Earth Science course goes well beyond the Regents course in the depth of the material that it presents, the research projects conducted by the students in the Sayville program can serve as pilots for similar projects that other schools can use to satisfy the local component.

For this program, CHiPR and the Department of Geosciences have arranged for students enrolled in Brian Vorwald's Honors Earth Science class at Sayville High School to receive University credit (GEO 122) for successfully completing the course, and for completing a research project under the direction of Geosciences faculty, Janet Niebling, and Glenn Richard. Mr. Vorwald, who also teaches introductory Earth Science at Suffolk Community College, has designed the lecture and laboratory components of the Honors course to present the material at a college level and selects students for the course based on stringent eligibility criteria. In general, the participants fall within the top 10% of their graduating class.

The Sayville Honors Earth Science course is scheduled over a two-year cycle. During the first year, in ninth grade, students enroll in the lecture and laboratory component of the course. When they reach tenth grade, they conduct a major research project. Most of these have focused upon some aspect of Long Island's geology.

Twenty four students who began the course in 1995 received credit as they completed their research projects in 1996. These projects examined Long Island's geology as well as processes that take place in the Earth's interior.

During the current 1997 to 1998 school year, eighteen students who enrolled in the lecture and laboratory components in 1996 are conducting their research projects. Presently, student projects are examining geological processes that have created and are now shaping the Peconic River watershed and estuary, and are collectively entitled the "Peconic Estuary Watershed Project". Projects include the chemistry of ground and surface water, stream flow, erosion and deposition of sediment on the shores of Peconic Bay, and climatological variations within the watershed. As these projects progress, the third cohort of students is enrolled in the lecture and laboratory portion of the course.

For the research component of the Sayville Honors Earth Science program, students work in groups to conduct experiments that address particular questions or hypotheses. They are given guidance by CHiPR personnel and Mr. Vorwald throughout the process of designing and conducting the experiment and while they are considering the results. The Earth Science Educational Resource Center makes equipment and materials, as well as CHiPR facilities available for the students to use for their projects.

The student projects for the first two years of the research component are described below. Additional information about these projects and the Sayville Honors Earth Science program in general has been posted on the World Wide Web at:

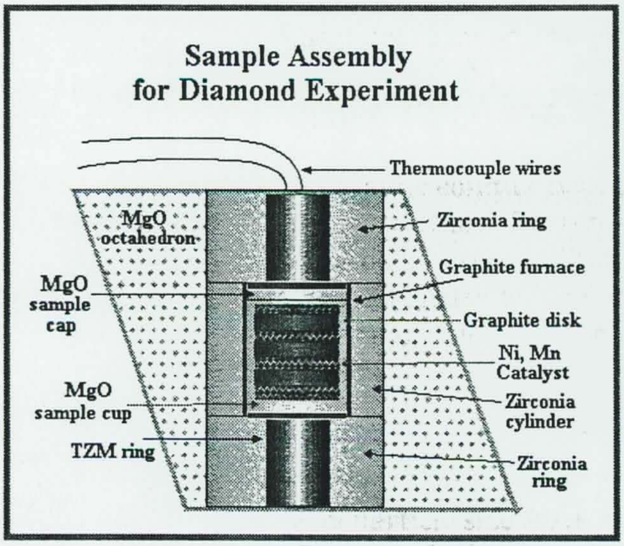
http://www.journey.sunysb.edu/Sayville

Sayville High School Honors Earth Science Class 1996 Student Projects

Creating synthetic diamonds

Students: Blair, Robert; Johnston Brian; Marasia, Joseph; Sweeney, Richard

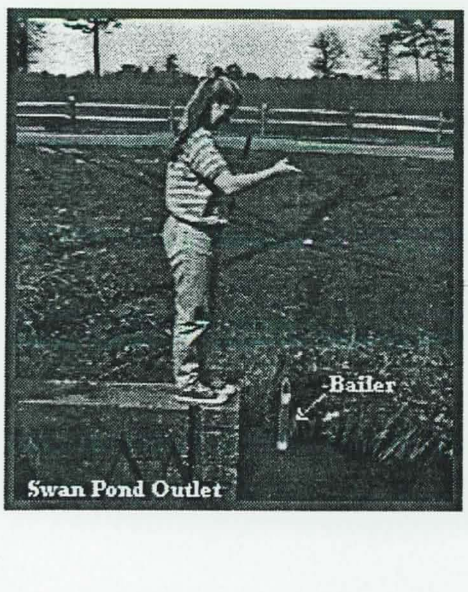
What are the best conditions, in terms of time, pressure and temperature, for creating diamonds? What physical processes occur when graphite is subjected to Mantle-like conditions? What methods are used to test for diamond?

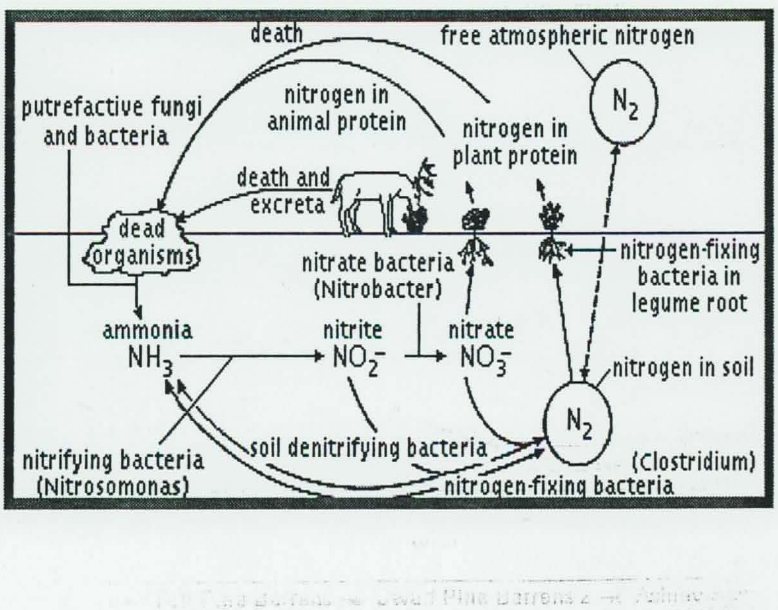


Chemical analysis of water in pond and river systems on Long Island

Students: Kamensky, Kira; Purdy, Lisa

What chemicals do we find? What chemicals do we see as a result of human activities? Where do we see these chemicals? Identify the sources of the chemicals, such as storm sewers, a golf course, a manufacturing plant, etc. How do these chemicals vary independently with one another?





Seasonal beach profile

Students: Cruz, Courtney; Dunleavy, Heather; Glenn, Meryl; MacDonell, Kate; McGrath, Jennifer; Morrissey, Taryn

How do the change in seasons and storms affect the sand budget of a beach?

Choose a location, and conduct a beach profile during different seasons, and before and after storms that will create larger than normal waves, to see the effect of waves on the beach. Where is sediment added or lost? Where in the tidal cycle does this occur? Compare profiles and determine the cross-sectional areas of sediment. Compare and contrast these cross-sections. How would you calculate the amount (volume) of sand added or lost at the beach? Is it reasonable to average the cross-sectional area of the sediment lost or gained, and multiply it by the length of the beach? How many profiles would be a reasonable number to use?

Hydraulic conductivity models

Students: Cruse, Theresa; Kavanagh, Robert

How do porosity, infiltration rates and permeability vary in various Long Island soils?

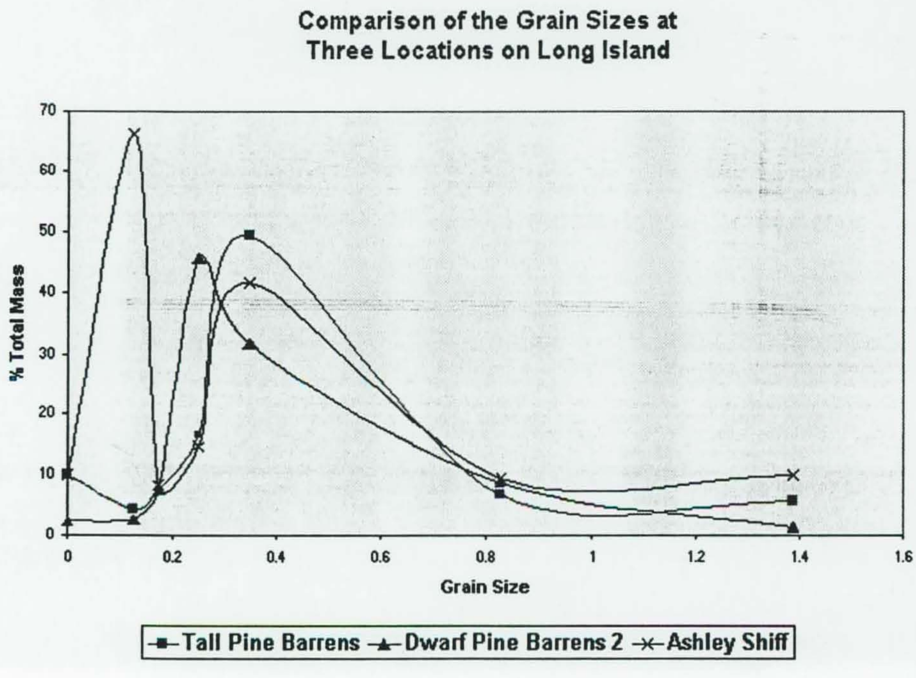
Create a model, using a cylinder and sand and/or gravel, to explain the permeability, porosity and infiltration rates of Long Island soils.

Soil particle size analysis and vegetation

Students: Collumbell, Brian; Daniello, Nicholas; Della Rosa, Peter; Hanlon, Sean; Nintzel, Eric; Style, Steven

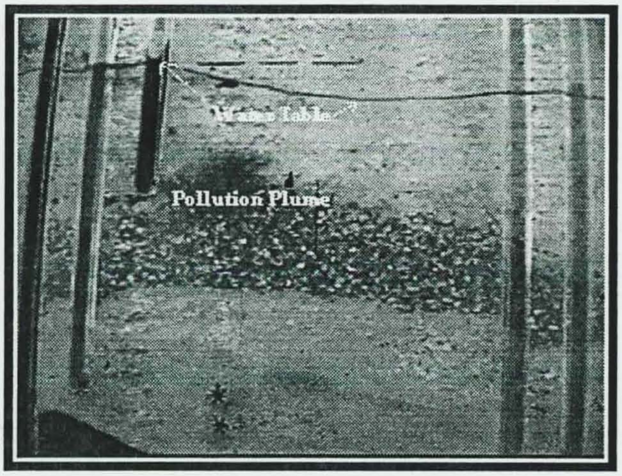
How does soil particle size affect the type of vegetation that grows?

Choose several sites, including the Pine Barrens and an oak-hickory forest, and take soil samples. Use sieves to analyze the samples, and graph the results. Relate the soil size to the existing vegetation at the various sites. Create a model, using a formula, and/or your data and descriptions, to help you predict the type of vegetation that might grow in a particular soil size.



Daily and geographic temperature variation models
Students: Bandura, Kevin; Beach, Kevin; Kremburg, Tyler
How does location affect temperature?
Measure temperature changes that occur over a 24-hour period at three different locations on Long Island. Use this data to create a model that describes the relationship between the temperature patterns at the three sites. Given a one-day temperature pattern at one site, can you use the model to predict the patterns at the two other sites? Temperature readings over 24 hours need to be conducted several times. How many times before you can come up with a fairly accurate model? What explains the differences between the sites? What role does wind play in the picture? What parameters are you going to keep constant in order to come up with a reasonably simple model?

Hydraulic conductivity, Darcy's Law and physical groundwater flow models
Student: Olson, Sarah
How can a physical groundwater flow model be used to prove Darcy's Law?
Use a physical groundwater flow model to collect data to prove or disprove Darcy's law. Use the data in conjunction with Darcy's law, and calculate the hydraulic conductivity for different sections in the groundwater flow model: unconfined aquifer-coarse sand, unconfined aquifer-fine/medium sand, and confined aquifer- coarse sand. Compare the calculated hydraulic conductivities of the different types of aquifers. Compare the experimental hydraulic conductivity data for different sediment sizes with accepted data. How does hydraulic conductivity affect the area of contamination by pollution in the groundwater?



Sayville High School Honors Earth Science Class 1997 Student Projects

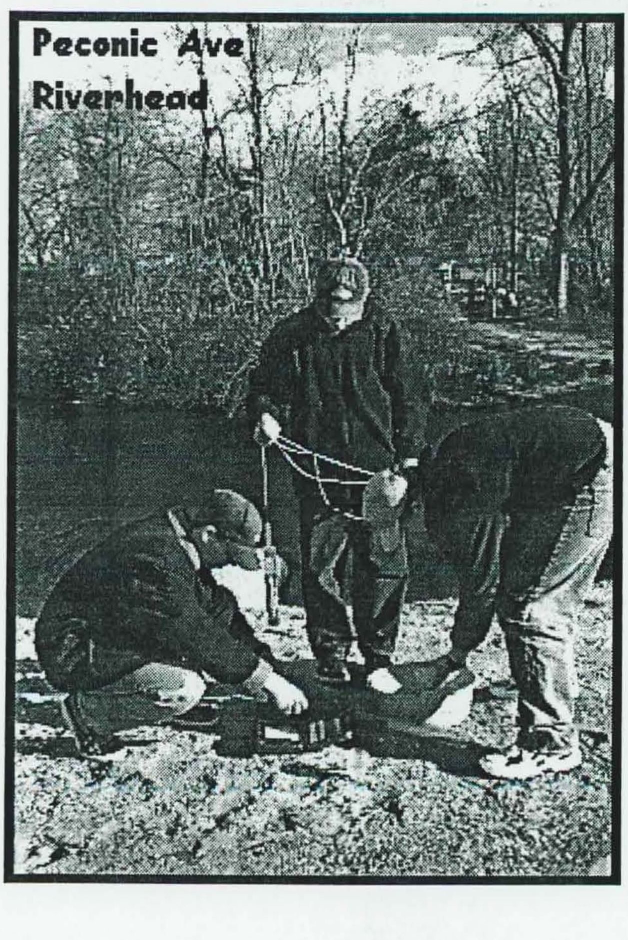
Peconic Estuary Watershed Project

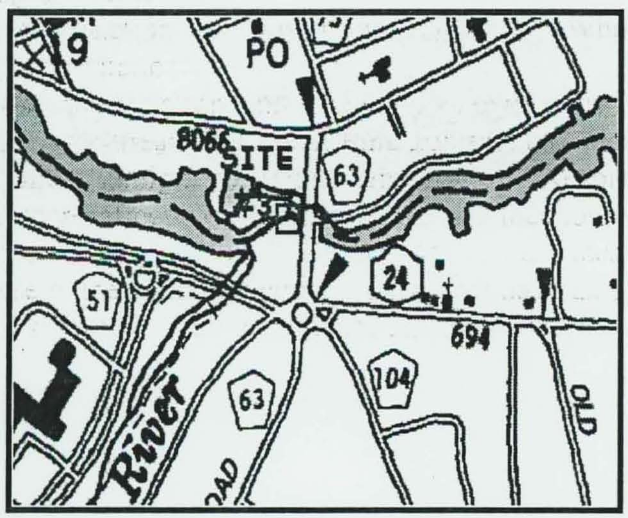
Water chemistry along the non-tidal portion of the river, seasonal and before and after storms.

Students: Dittmar, Jan; Seluga, Michael; Sinacore, Steve;

How do the seasons and the local environment of the river affect its water chemistry?

Pick three localities along the river. Measure water temperature, air temperature, nitrate level, dissolved oxygen, total dissolved solids, and pH. Compare the water chemistry between the localities. What is different about the local environment upstream vs. downstream? Compare the water chemistry in different seasons. What may cause these changes? What else changes seasonally besides the temperature? Listen to weather forecasts. Do storms affect the water chemistry? Are their effects immediate or is there lag time? Do you observe this at each locality? What variable changed the most? Use a topographic and soil map to investigate the drainage areas for your three localities i.e. volume, soil types, flora, land use, etc.





Water chemistry along the tidal portion of the river, seasonal and during high and low tides.

Students: Angelastro, Michael; Elenteny, Terrence; Garbarino, William

How do the seasons and the daily tides affect the water chemistry?

Pick three localities along the river. Measure water temperature, air temperature, nitrate level, dissolved oxygen, total dissolved solids, pH. Compare the water chemistry between the localities. How does the water chemistry vary with respect to distance from the mouth of the Peconic River? From the shoreline? How does the local environment differ at each locality? Compare the water chemistry in different seasons. What may cause these changes? What else changes seasonally besides the temperature? Do tides affect the water chemistry? Are their effects the same at each locality? What variable changed the most?

Climatological variations within the watershed, both temperature and precipitation.

Students: Larado, Kate; Maggio, Marielena

How does temperature and precipitation vary within the watershed? What effect does location have on the temperature and precipitation?

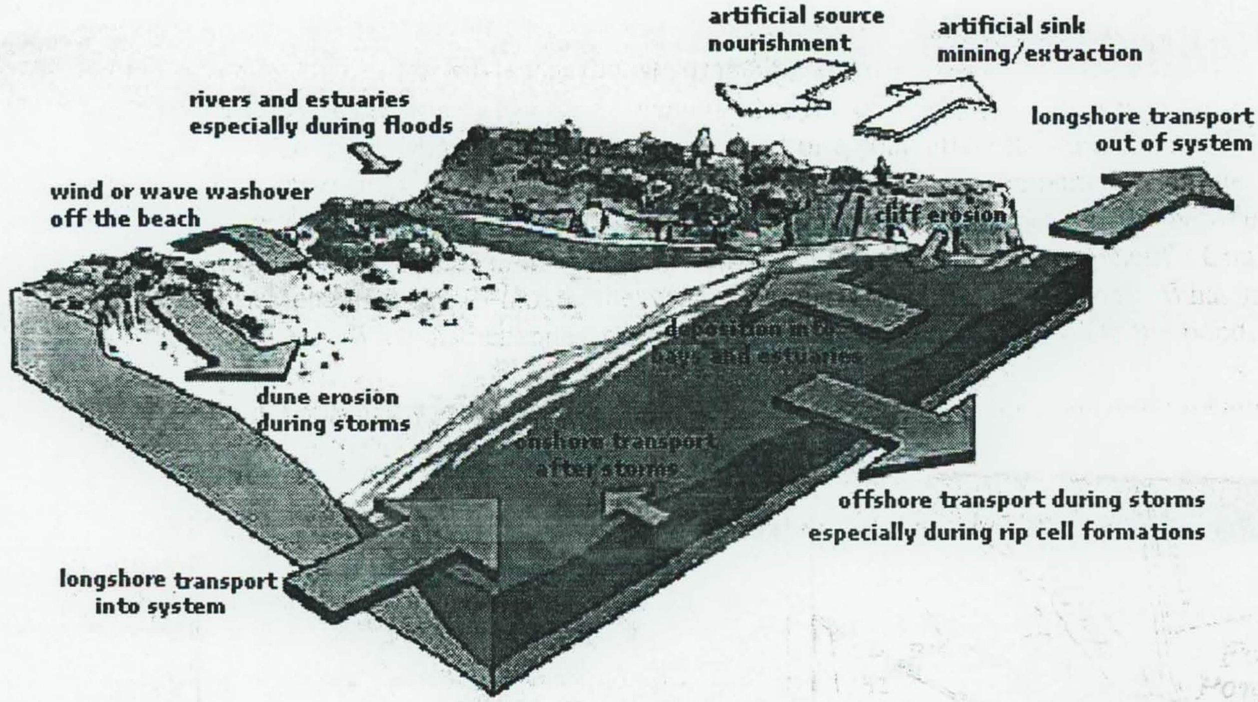
Set up stations for collecting precipitation and measuring temperature. Stations should be selected upriver, midway and downstream (i.e. river, Pine Barrens, bay mouth). Select a time of day and a spot away from direct sunlight for taking temperature. Record weather conditions. Does the proximity to the shore affect your data? Do all the locations experience the same difference in temperature (overall high and low)? Do the coastal areas receive more or less rain? What is the extent of land use in the general vicinity? Does this have an effect on temperature? Keep track of wind patterns, since they may or may not affect your temperatures and amount or duration of precipitation.

Flow rates in non-tidal portion of the river, seasonal and before and after storms.

Students: Munkenbeck, Kate; Nayi, Amy

Are a storm's effects measurable immediately or is there lag time?

Flow rates are affected by factors other than tides. Determine the volumetric flow past a point, a cross section is necessary. Compare the flow rates between localities. Listen to weather forecasts. Plan a trip before and after a storm. Are a storm's effects measurable immediately? Is the lag time always the same throughout the river? Throughout the seasons? What factors may influence lag time? Investigate the effect a storm has on a river system.



Geomorphology of a bay.

Students: Mastroianni, Jillian; Stoeber, Kristin

Do littoral drift direction and direction of spit growth coincide?

Use a map to find spits forming in the Peconic Bay area. Visit the spits and determine from which direction the sand was transported. Observe the direction of wave refraction, and determine the direction of littoral drift. Do the littoral drift (determined by wave refraction) and sediment transport (determined by spit geomorphology) directions coincide? Determine a possible source of sand for the spit. Does the source have to be up-drift or down-drift? Observe the topography of the neighboring shoreline (500 yards or so). What shoreline features might indicate a source of sand for the spit? Does the observed data support published data?

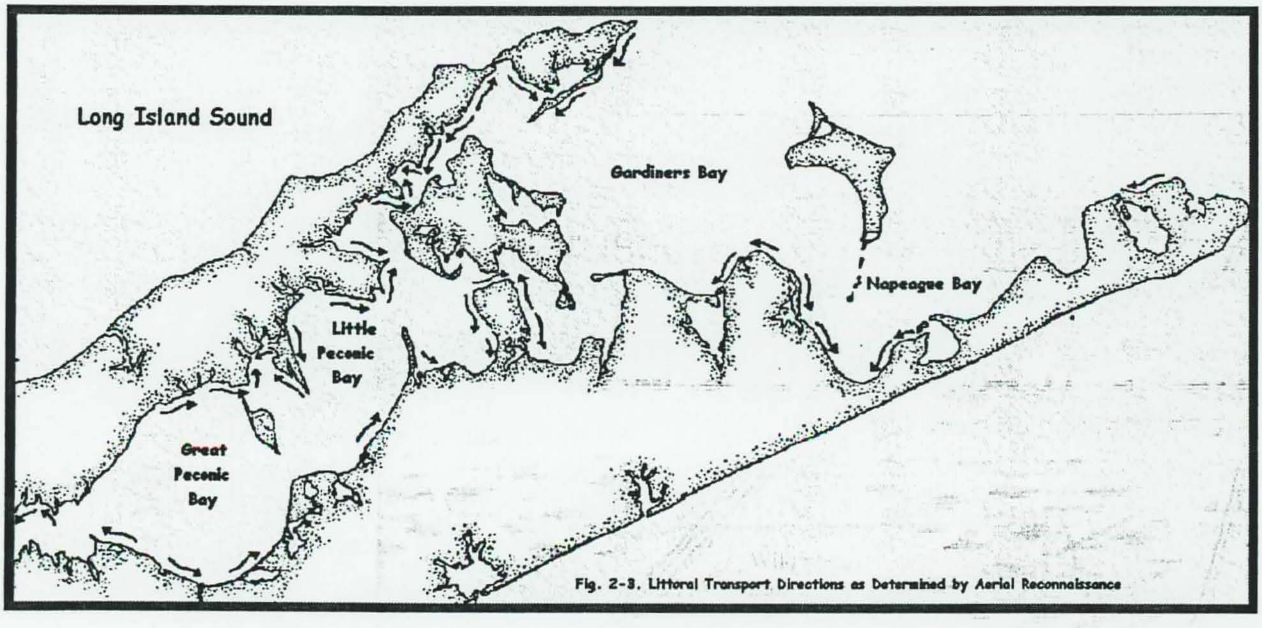


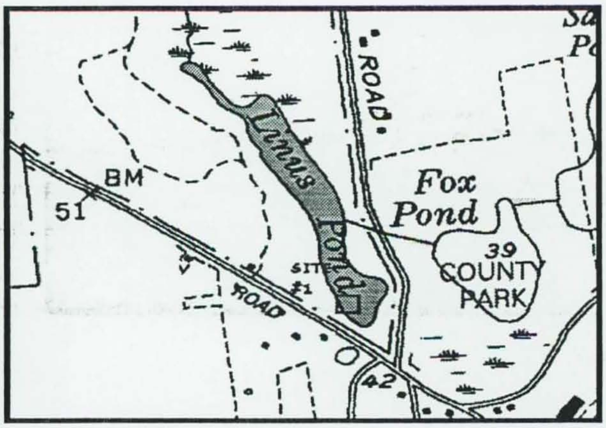
Fig. 2-3. Littoral Transport Directions as Determined by Aerial Reconnaissance

Comparative chemistry of the tributary ponds.

Students: Ganshaw, Adrian; Scordamaglia, Drew

How do the seasons or the local environment of a pond affect its water chemistry?

Pick three areas (ponds). Measure water temperature, air temperature, nitrate level, dissolved oxygen, total dissolved solids, and pH. Compare the water chemistry between the localities. Are there differences in the ponds' geomorphology and local environment? Could this affect the water chemistry? Compare the water chemistry in different seasons. What may cause these changes? What else changes seasonally besides the temperature? Do the ponds have an inflow and outflow stream? Describe what type of land use the inflow stream passes through. Use a topographic and soil map to investigate the drainage areas for your three localities i.e. volume, soil types, flora, land use, etc.

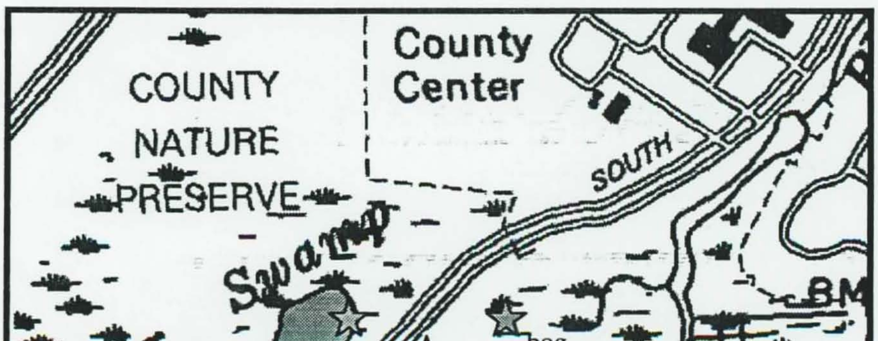


Comparative chemistry of different environments within a localized area

Student: Patel, Garvin

What effect do different vegetation types have on water chemistry?

Locate an area (0.25 sq. mi. - 0.50 sq. mi.) that has varying environments within it (ie. lake, pond, swamp, bog, marsh). Describe each environment accurately (ie. elevation above sea level, direction of groundwater flow, soil type, identify the major flora, and degree of water movement). Measure the dissolved oxygen, nitrogen and pH in each environment. Sample water directly from the flora where possible. Locate a nearby groundwater well for comparison.



Erosion Control at Montauk Point

Students: Brooks, Erica; Furshpan, Laura; Zink, Jessica

What is being done to control erosion at Montauk Point and is there still evidence for continued erosion? What indications do you see of past erosion?

Visit Montauk Point during low tide. Walk around the vicinity (including beach), observe any construction or anthropogenic structures, and describe their function. Is there any beach in these areas? Why or why not? Locate areas along the bluff that have been left undisturbed and describe the shape of the coastline here. Find a large boulder in the inter-tidal zone and note the level or height of the sand surrounding the rock. Use this as your reference point by which to gauge an increase or decrease in sand throughout your study (use more than one boulder). Do a correlation study to identify strata that were once continuous layers. Why do they no longer appear to be continuous? Is it because erosion removed portions of some layers or is it that parts of them have been covered up by slumping? Is there any evidence of folding or faulting?