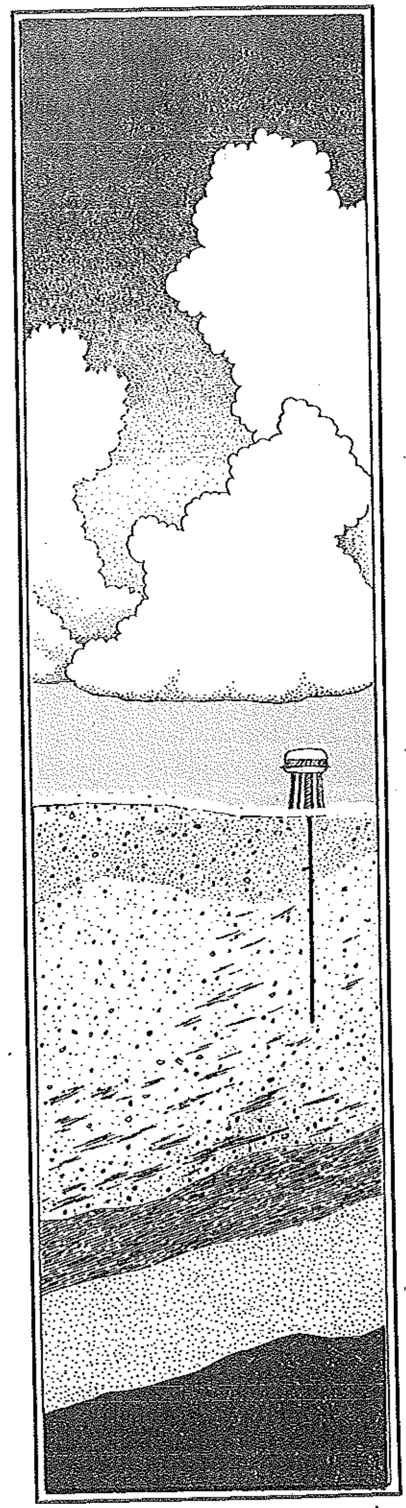
LONG ISLAND WATER RESOURCES

A Curriculum Activities Guide



Grades 7–12

Museum of Long Island Natural Sciences
Earth and Space Sciences Department

StonyBrook

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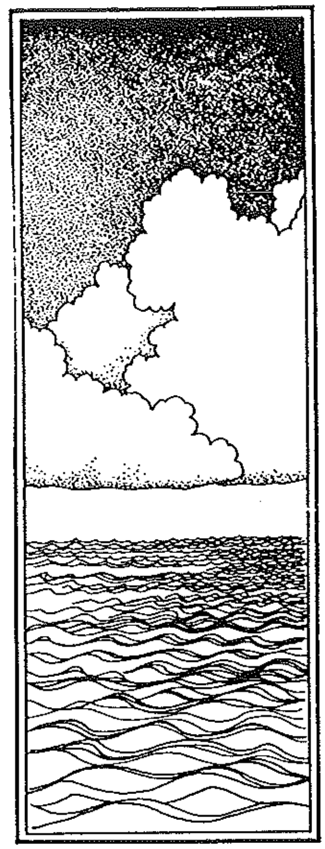

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Project Sponsored by
New York State Legislative Commission on Water Resource Needs of Long Island

Foreword

Any effort to protect a significant natural resource must include public education strategies. Whether the natural asset is California redwoods, bald eagles, great whales, tropical rainforests or Pine Barrens overlying Long Island's purest reserves of groundwater there is no chance that proper conservation practices will emerge in the absence of widely accepted citizen expectations. There is a qualitative difference, however, between information transfer that simply raises concerns and that which truly informs.

As reports of major gasoline leaks and other significant contamination events crowd our newspapers with increasing frequency, Long Islanders have become aware that many local public drinking sources and supplies are at risk. Our population has learned from news sources to be concerned about how poor land use planning and the contamination potential of our chemical intensive society now threaten our well being. Their growing concern has, in turn, stimulated Legislative initiatives designed to protect and preserve potable supplies of groundwater.

It is unfortunate that this education process has been mostly reactive rather than anticipatory for we are now in a race against time to take corrective actions before our drinking water source areas are lost forever. Clearly, as the next generation moves through our schools we must reverse these modalities of learning. It is the present generation that will assume responsibility for managing the water resources that shall, in turn, sustain the health and safety of all future generations. Neither our children or our grandchildren should be handicapped by ignorance. Unlike all too many adults of this generation, they need not have to learn how vital Long Island's groundwater supply is by casual inference or as the result of crisis. It is within this context that we are grateful that the New York State Legislative Commission on Water Resource Needs of Long Island has wisely sponsored the creation of this curriculum.

This curriculum strives to accelerate the ultimate protection of Long Island's water resources by providing a structured, interdisciplinary approach to learning about this vital subject within our public schools. It endeavors to provide basic information about our water system, the problems it faces and solutions to those problems. It presumes that all Long Islanders need to be informed about their responsibilities to the groundwater resources of the island that they live upon. It recognizes that as Long Island's resource management options lapse any wise public policies that we or any future generation may adopt will take on even greater significance as time goes on. Its goal is to assure that proper long term care of the ground and surface waters of Long Island will be sustained in perpetuity through the broad consensus of an informed citizenry.

Steven Englebright
Project Director

Author's Note

Long Island's water resources are a timely issue indeed. A Long Islander would be hard pressed to pick up a Newsday or a local paper without finding an article on the condition of our water supply. Water problems are not new to Long Island, though. There have been plenty of examples in Long Island's past that have been so tragically played out from west to east: Brooklyn, Queens, Nassau. In our search for water there is no place left to go beyond Suffolk; except to the sea.

It is our fortune to live in a society that allows the opportunity to change our destiny. A democracy such as ours requires citizens with multi-faceted backgrounds who are able to address and complete difficult decision-making processes. As Long Island's time elapses, decisions that insure the sustainability of our water resources need to be made.

This curriculum strives to assist this decision-making process through providing an interdisciplinary approach to learning about our water system, the problems it faces and possible solutions to those problems. The decisions that need to be made can and should only be made by the informed.

Maria T. Weisenberg
Curriculum Designer

The creation of a curriculum should be the smallest portion of its lifespan. It is unfortunate that so many curricula so often are let go by the wayside. It is with the hope that this book be long-lived, that your comments, corrections and additions are requested. All are welcome and can be sent to the following address:

Museum of Long Island Natural Sciences
Earth and Space Sciences Building
SUNY at Stony Brook
Stony Brook, New York 11794-2151

Rationale

The purpose of this guide is to provide a resource book that enables both teacher and student to learn about Long Island's water through understanding and appreciating this enormous, fragile resource and how we affect it. The activities found in this curriculum are designed to encourage a way of thinking that leads to the discovery of methods and tools that can allow Long Islanders to preserve their water while maintaining an acceptable quality of life.

HOW TO USE THIS GUIDE

The activities in this curriculum guide are arranged in two parts:

1) Teacher Information Pages
2) Student Activity Pages

Teacher Information Pages

The Teacher Information Pages are located at the beginning of each activity.

This section contains the following parts:

a. Objectives
b. Suggested Grade Level and Discipline
c. Elementary Syllabus References
d. Behavioral Objectives
e. Materials
f. Background Information
g. Procedure
h. References
i. Question Answers

Student Activity Pages

The Student Activity Pages are the pages located at the end of each activity. Depending on the topic and arrangement, each activity contains some or all of the following parts:

a. Vocabulary List
b. Student Procedures
c. Information Sheets
d. Observation or Data Sheets
e. Read Sheets
f. Work Sheets
g. Analysis Sheets
h. Question Sheets

Table of Contents

Activities

Resources

Overview of Objectives

1. THE HYDROGEOLOGY OF SUFFOLK COUNTY, N.Y.: Understanding What's Underground.

   OBJECTIVE: Using contour maps representing the altitudes of the aquifer and aquifer-related formations below Suffolk County, students will plot a hydrogeologic cross section of Long Island.

2. LONG ISLAND'S WATER BUDGET: Graphing The Hydrologic Cycle.

   OBJECTIVE: A water budget for Long Island, N.Y. will be calculated based on data of precipitation and evaporation. A graph will be plotted from this data allowing for identification of climate type, months of water usage, months of recharge, months of flood potential and months when irrigation is needed.

3. HYDROGRAPHING MASSAPEQUA CREEK: Analyzing A Long Island Stream.

   OBJECTIVE: A hydrograph of Massapequa Creek in Massapequa, N.Y. will be constructed using USGS stream discharge data.

4. LONG ISLAND'S STREAMS: Surface Expressions of Groundwater.

   OBJECTIVE: Using a Long Island stream map, hydrologic data and question sheets, Long Island's streams are introduced in conjunction with their geographic and hydrologic characteristics.

5. THE PINE BARRENS: Long Island's Watershed.

   OBJECTIVE: Long Island's Pine Barrens and the Hempstead Plains are fire climax ecosystems. A mapping activity introduces these ecosystems and the gradation between the various fire climax communities.

6. HAZARDOUS HOUSEHOLD PRODUCTS SURVEY: Hazardous Wastes In the House.

   OBJECTIVE: Students inventory hazardous substances in their homes and rate the toxicity of these substances. An adult in the household assists in going through the inventoried substances, recording which ones were around when he/she was the student's age. Hazardous household products are discussed from the perspective of their potential to contaminate groundwater supplies.

7. ASSESSING HEALTH RISKS: Who Pays the Price?

OBJECTIVE: Mathematical models are used by government agencies such as the U.S. Environmental Protection Agency (EPA) to estimate the satistical risk to an individual from lifetime consumption of water containing small concentrations of chemicals. Students will use one such model to compute and assess health risks of lifetime consumption of one or more contaminants.

8. SOILS AND GROUNDWATER QUALITY: A Tool for Regional Land Use Planning.

OBJECTIVE: Using the characteristics and properties of 6 soil associations representative of Long Island soils, knowledge of groundwater dynamics and a land use planning chart, students will identify and select the land uses most congruous with the limitations of Long Island soils and the continued viability of groundwater resources.

9. ENVIRONMENTAL DECISION-MAKING IN THE PINE BARRENS: Economic Growth or Groundwater Quality.

OBJECTIVE: A mock public hearing debating a proposal to limit development in the Pine Barrens introduces students to the socio-economic issues, costs and conflicts involved in decision-making that concerns economic growth vs. natural resource conservation.

10. AGRICULTURE IN EASTERN SUFFOLK: Groundwater and Agricultural Chemicals.

OBJECTIVE: Using maps depicting land uses, nitrate levels in recharge water and groundwater contamination from the pesticide Aldicarb, students will associate groundwater contamination with sources of pollution such as pesticides, fertilizers and sewage. The dynamics of groundwater movement is introduced as a land use planning tool.

11. GROUNDWATER IN NASSAU COUNTY: Quantity and Quality Problems.

OBJECTIVE: Using maps depicting groundwater mining, sewer districts, synthetic organic chemical pollution and land uses, students will associate groundwater contamination and depletion with land use patterns and population density. Important Nassau County watershed areas will be identified by inference from maps.

WATER
The Most Important Substance On Earth

WATER AND LIFE GO BACK A LONG WAY

Imagine life on earth without water. An uncommon originality would certainly be in order. Water has been a well-spring for life from the very beginning and has had a major role in the evolution of life ever since. The characteristics and distribution of life has, by and large, been determined by water.

WATER, ITS CHEMISTRY AND PROPERTIES

Water is the most important, abundant and unique substance on earth. Its chemical structure is responsible for many characteristics that make water basic to life. A water molecule is composed of two hydrogen atoms covalently bonded to an oxygen atom, as shown in figure 1. The nature and arrangement of this bond causes a polarity to exist between the ends of the molecule. The two hydrogen atoms exhibit a local positive charge while the oxygen atom exhibits a local negative charge. Water molecules have mutual attraction because of their polarity. This attraction is known as a hydrogen bond. It occurs when the negative oxygen end of the molecule has an attraction for the positive hydrogen atoms of another molecule. Hydrogen bonding produces many of water's qualities that are essential to life and the environmental mechanics that support it. Clouds, for example, would not form if not for hydrogen bonding. The mutual attraction of water molecules keeps the cloud mass together.

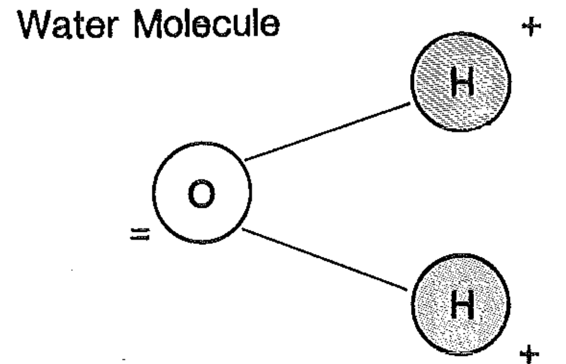


figure 1

SURFACE TENSION

Surface tension, also called cohesive tension, is another property resulting from hydrogen bonding. Molecules of water are attracted to one another and give the liquid's surface an encasing film. This occurs because the molecules of the surface can only attract those water molecules adjacent and beneath them. This molecular cohesion is the force that holds water drops together as they coalesce in clouds and later fall to earth. When they land on your raincoat, surface tension makes the droplets bead up. Many aquatic insects, such as the water strider, skim along this surface film that is their habitat.

ADHESION, COHESION AND CAPILLARY ACTION

Water molecules also are attracted to the solids they come in contact with. This attraction is called adhesion. The adhesive force of attraction causes water to be retained in soil, making it accessible for use by plants. Water is able to defy gravity by the forces of cohesion and adhesion working in unison. This behavior is called capillary action and occurs in small tubes, such as those found in tree trunks, or in small spaces such as those found between soil particles. Capillary action works by the combined attraction of water molecules for themselves and for other substances.

WATER'S PHYSICAL CHARACTERISTICS

Pure water is odorless, tasteless, colorless and transparent. It has a neutral pH and is non-toxic. Water is an excellent solvent and is rarely found in a pure state. Most substances are soluble, to some degree, in water because of its polar nature. These soluble materials include all the inorganic substances required by living things. Water's solvency makes it a superior source of trace minerals and salts needed by living things. The composition of dissolved substances in water depends on the characteristics of the localities where it is found.

Living things are best able to use water when it is liquid. Water occurs in the liquid state over a wide temperature range ($0^{o}C$-$100^{o}C$ or $32^{o}F$-$212^{o}F$). It vaporizes above $100^{o}C$ and freezes below $0^{o}C$. Water is the only substance that is found, naturally, in all three states (solid, liquid and gas).

WATER AND TEMPERATURE CHANGES

Water undergoes very distinct changes as its temperature changes. As water cools it becomes more dense. The density of water continues to increase until it reaches $4^{o}C$. Cool, dense water sinks to the bottom of the water body it is contained in. As the temperature drops below $4^{o}C$, water density decreases. Molecules of freezing water form a crystalline arrangement making the water less dense. The lighter water rises towards the surface and "floats" above the more dense water. Ice forms and floats evidencing its low density.

This property of water is important to living things. If it did not occur, lakes and ponds would freeze from the bottom up. The insulating and life-protecting ice surface would not form. Aquatic plants and animals in temperate and northern climates would be unable to survive the winter season.

THE WORLDWIDE DISTRIBUTION OF WATER

Oceans cover most of the earth. Over 70% of our planet's surface is water. Most of the world's water (97%) is saltwater and is unuseable. Over 3/4 of the free water is locked up in glaciers and ice caps. All totalled, less than 1% of the earth's water is fresh and useable.

The World's Supply of Water

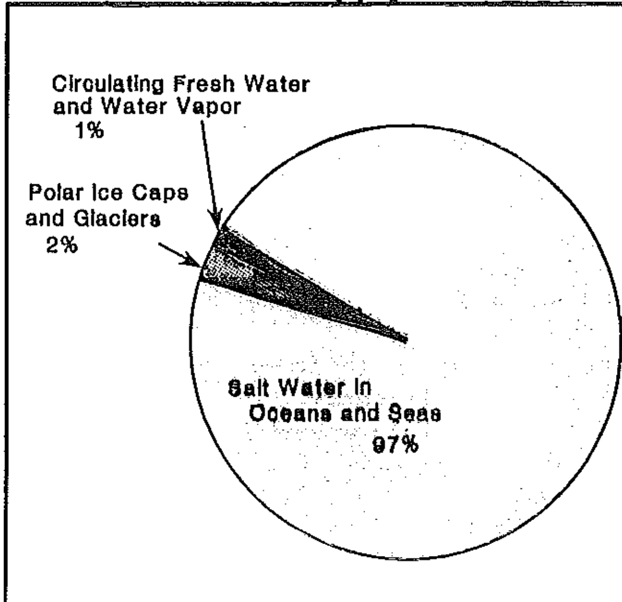


figure 2

Water resources are found throughout the world in many forms and places. These include groundwater, rivers, streams, lakes, reserviors, springs, precipitation and atmospheric water.

WATER IS ESSENTIAL TO HUMAN ACTIVITIES

Water is an essential part cf almost all human activities. Water is indispensible to our agriculture and is used in the manufacture of virtually everything we use. Activities within our homes would come to a standstill without an adequate supply of water.

The Water Cycle

The water cycle is a continuous exchange of water between land, ocean and atmosphere. Since the amount of water is constant, the water cycle can be considered a closed system. The ocean's saltwater makes up 97% of earth's water. The remaining 3% is freshwater. Nearly 2% of the freshwater is frozen in glaciers and ice sheets. The remaining 1% is made up of atmospheric water vapor, groundwater and all the freshwater lakes, ponds, streams and rivers.

Though all water on earth is included in the cycle, not all forms and locations cycle at the same rate. For example, glaciers and groundwater restrict and restrain water movement for extended periods, sometimes spanning thousands of years.

EVAPORATED WATER RISES, CONDENSES AND FORMS CLOUDS

The ocean is the water cycle's largest storage area. The sun provides energy for the evaporation of great quantities of ocean water. This water vapor rises, meets colder air and condenses on particles of ocean salt, dust and pollutants. During condensation, water changes from a gas to a liquid. The newly formed water droplets would fall to earth if not for the continually rising warm air currents keeping them aloft. As water droplets collide, they form larger drops. The surface tension of water makes this possible. Larger and heavier water drops fall when air currents can no longer negate their downward movement. Precipitation falls.

WATER FALLS FROM CLOUDS AND RETURNS TO EARTH

As water falling from clouds reaches the earth, it may continue in one of three possible directions. It can:

a. evaporate before or after it reaches earth's surface,

b. enter the ground and be taken up by plants to be used and then transpired, or

c. enter the soil bound for the groundwater.

LONG ISLAND'S WATER CYCLE

Long Island's average annual precipitation is 44 inches. About half of our precipitation returns to the atmosphere by evapotranspiration (evaporation and plant transpiration). Most evapotranspiration occurs during the warm months when days are longer, plants are in full leaf and the earth absorbs most of the sun's heat.

GROUNDWATER IS LONG ISLAND'S SOLE SOURCE OF FRESHWATER

Groundwater is Long Island's sole source of freshwater. Precipitation is the only source of groundwater and its replenishment. Under natural conditions, about 50% of our annual rainfall enters the groundwater.

Gravity causes rainwater to move downward through the soil layers to the aquifer. Aquifers are porous rock deposits that hold water. Groundwater occupies the spaces between the loose rock particles that form the aquifer. Groundwater is in slow, though constant, motion. It may travel only 2 or 3 feet per year.

The top of the water-saturated aquifer is called the water table. Groundwater wells must be deep enough to tap the water below the water table. Most lakes, streams and ponds found on Long Island are groundwater-fed and their water levels are determined by the water table level.

Under natural conditions, water recharging the aquifers roughly equals the water exiting the groundwater. A system in just such balance is said to be in equilibrium. Precipitation enters the groundwater by way of the land's surface and leaves by one of several routes which include:

a. stream or river outflow

b. spring outflow

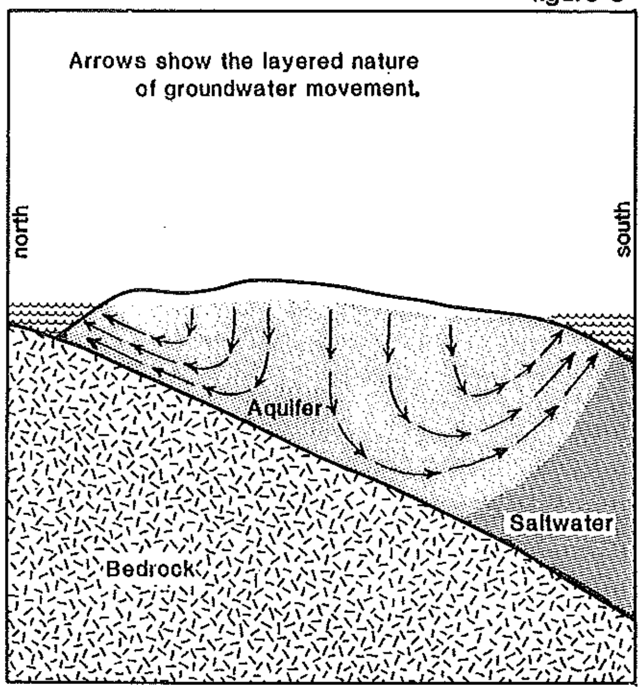
c. outflows that occur, in varying depths, under the surface of Long Island as shown in Figure 3.

As groundwater returns to the ocean via one of these passages, Long Island's ater cycle completes its revolution to begin another round of exchanges between land, sea and sky.

PEOPLE HAVE CHANGED LONG ISLAND'S HYDROLOGIC SYSTEM IN MANY WAYS

Long Island's natural hydrologic system has been changed by human development. Before the arrival of Europeans, Native Americans made use of Long Island's water resources. They were a part of the natural system because they used water on its own terms. Their lifestyles were sculpted by water. Camps were made near water. They hunted by, fished in and drew water from lakes and streams. After the arrival of Europeans, the ways of using the water supply changed profoundly. Surface water supplies and the areas around them no longer dictated settlement patterns. Shallow wells could be dug throughout the Island and the supply appeared boundless.

figure 3



Arrows show the layered nature of groundwater movement.

The problems of water quality and quantity faced today are rooted in the past. Though the problems don't stretch back as far as colonial days, our attitude towards natural resource use does.

Development of Long Island's water supply came in stages as the population grew and unfurled from west to east. Modifications in the systems that tap the water supply and disposed of its wastes were forced as a growing population gave rise to pollution problems.

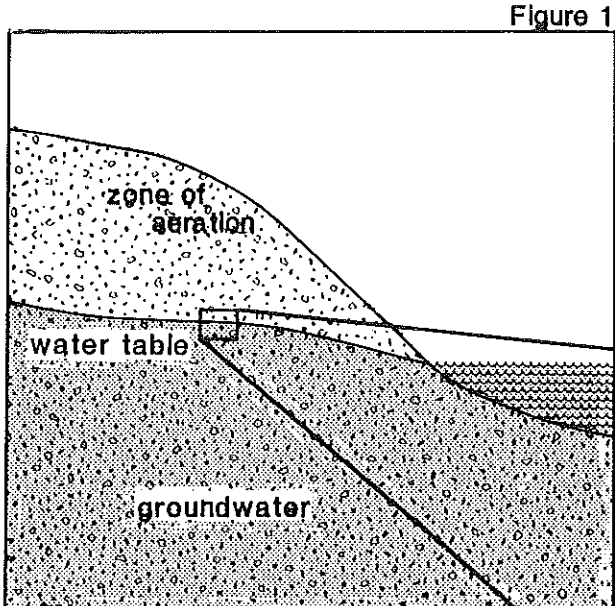
Private wells and cesspools gradually but steadily lead to public water wells that supply water and extensive sewer systems that dispose of waste waters out to sea. Even today, as population grows and expands across Long Island, we kindle the quality and quantity problems that originated long ago but continue to leave us with an ever-shrinking water supply.

LONG ISLAND'S GROUNDWATER
Underground and Misunderstood

GROUNDWATER IS LONG ISLAND'S SOLE SOURCE OF DRINKING WATER

Groundwater is the most hidden portion of Long Island's Water Cycle. Its invisibility leads to misconceptions about its distinct and fragile characteristics. Though vastly misunderstood, groundwater is indispensible because it is Long Island's only source of fresh drinking water.

Figure 1

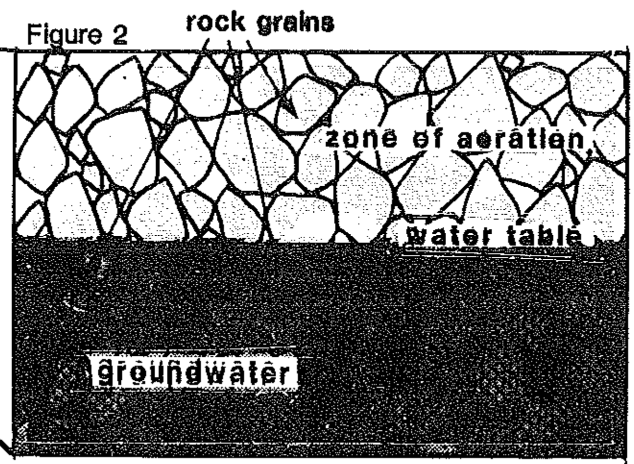


Zones of Underground Water

RAINFALL IS LONG ISLAND'S SOLE SOURCE OF GROUNDWATER

All the water contained in Long Island's groundwater initially arrived by cloud. The groundwater now below us and all the water that will eventually become groundwater fell and will fall as rain or snow. Precipitation bound for the groundwater must traverse the soil between the land's surface and the surface of the groundwater or water table as shown in Figure 1. Water that reaches the land and filters through the soil does not always descend to the groundwater reservior. It may remain in the Zone of Aeration until it is absorbed by a plant or returns to the air by evaporation. The soil in the Zone of Aeration is unsaturated because the spaces or pores between the soil particles are not filled with water as they are in the groundwater or Saturated Zone as shown in Figure 2. In unsaturated soil, air fills the spaces between the soil grains. Water is held in this area by capillary attraction or adhesion. Water on its way to the groundwater percolates, by gravity, through layers of soil until it reaches the water table. Below the water table, the pore spaces between sand, gravel and clay are completely filled or saturated with water.

Figure 2



Enlargement of Water Table Area in Figure 1

The water table is the topmost level of the groundwater. This level varies throughout Long Island and water table elevations roughly conform to the contours of the land's surface elevation. The water table also fluctuates seasonally and is influenced by variations in rainfall.

The depth of the water ranges between one and one hundred feet below the surface of Long Island. Many of our lakes and ponds are exposed sections of groundwater. The level of these surface water bodies is the same as that of the water table.

Some elevations of this variable water table rise as high as 90 ft. above sea level. The aquifer system then extends down from this height to a depth that, in some places, approaches 2,000 ft. below sea level.

AQUIFERS AND CONFINING LAYERS

A rock formation or group of formations that holds water and allows water to move through it is called an aquifer. Long Island's groundwater system contains three major aquifers. These aquifer formations are as follows:

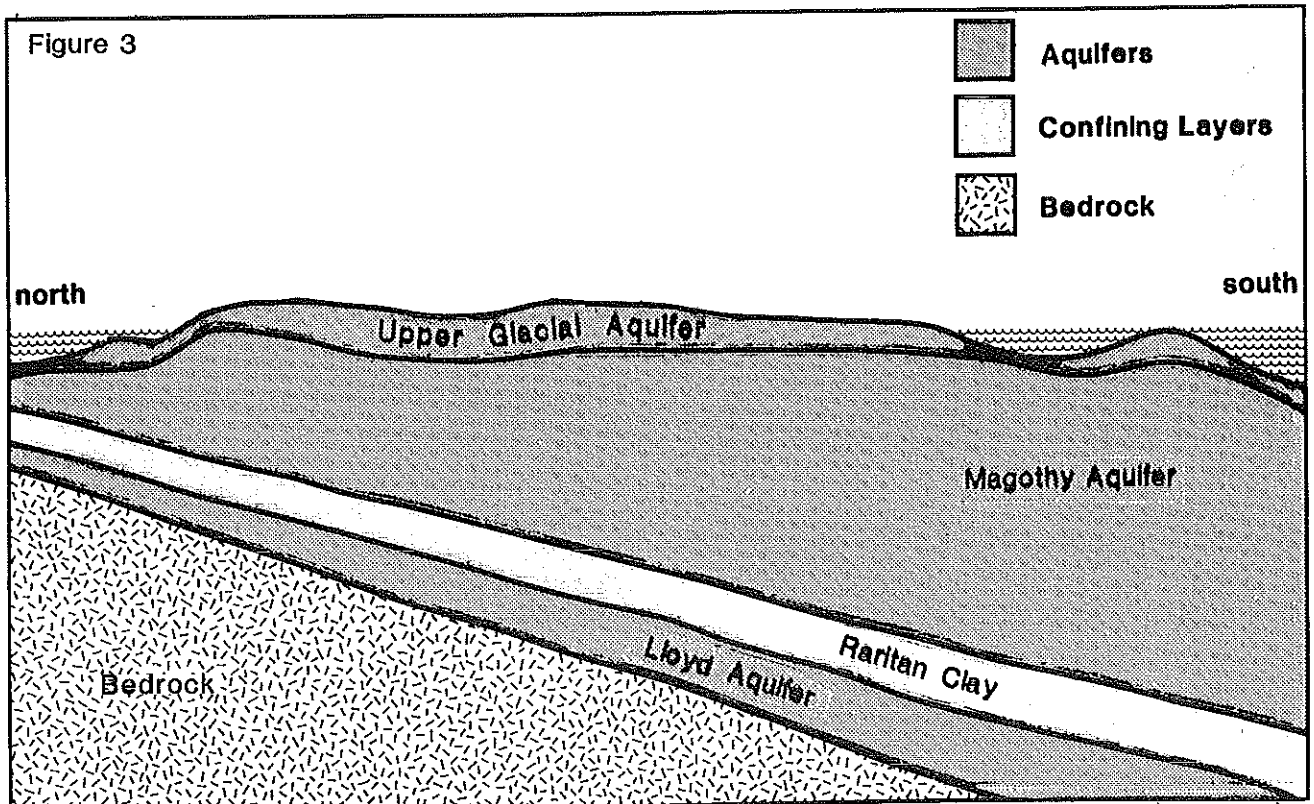
1. The Upper Glacial Aquifer,
2. The Magothy Aquifer and
3. The Lloyd Aquifer

Confining layers are another type of formation found in Long Island's hydrologic system. The Raritan Clay, located above the Lloyd Aquifer and below the Magothy Aquifer, is one such formation. A confining layer is characteristically impermeable throughout most of its formation due to its rock composition. Water moves slowly through confining layers and little water is stored in them. A cross section of Long Island's 3 major aquifers and 1 major confining layer is found in Figure 3.

ALL LONG ISLAND'S AQUIFERS ARE INTERCONNECTED

The sediment deposits beneath Long Island are divided into several aquifer and confining layers because they are of different geologic origin and rock composition. They are, however, integral parts of one large system

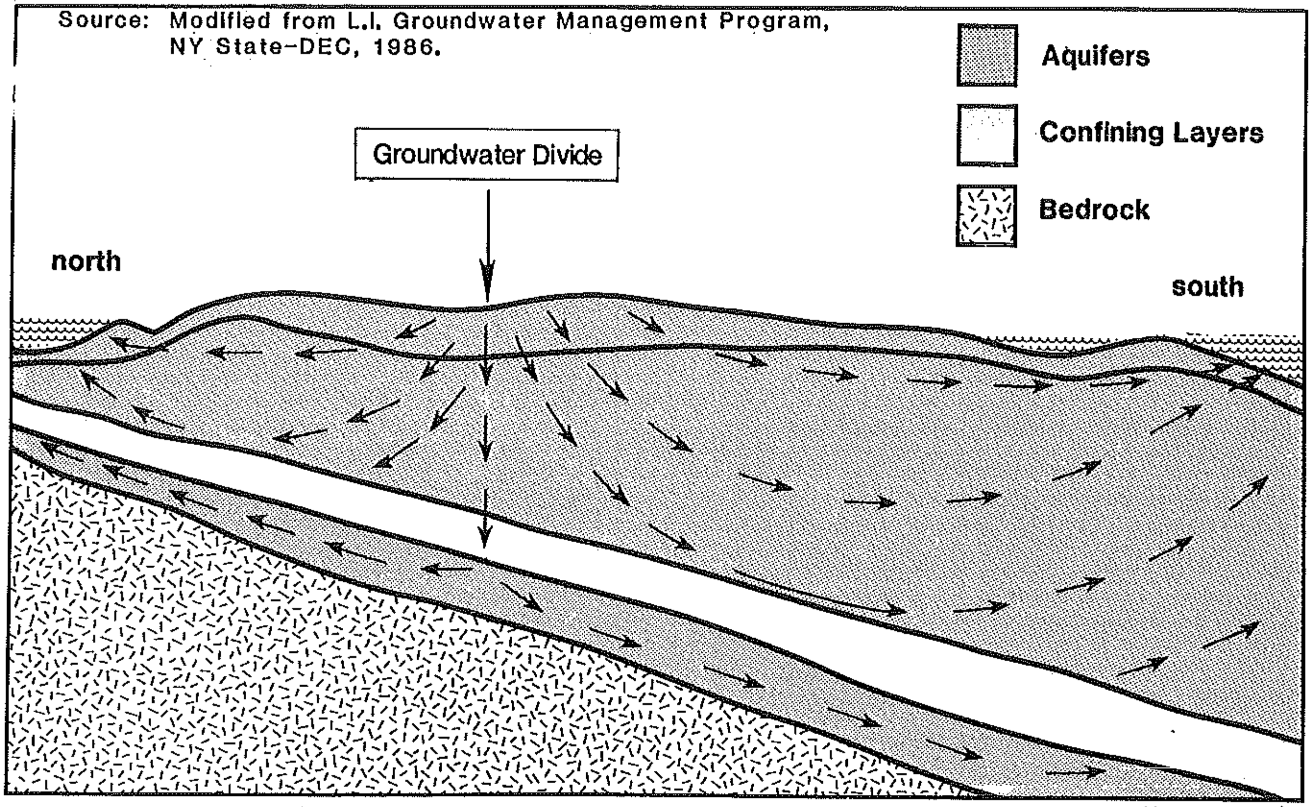
Figure 3



Cross Section of Long Island's Hydrologic Formations

Not to scale.

Figure 4



Generalized Groundwater Movement Patterns

that is interconnected by the groundwater that moves through and between them. Diagrams of this groundwater system often convey an impression of each aquifer as separate and isolated. Readers should caution themselves against this interpretation as problems associated with the water in one aquifer will most likely, in time, travel through the rest of the system.

RAINWATER REPLENISHES OUR AQUIFERS

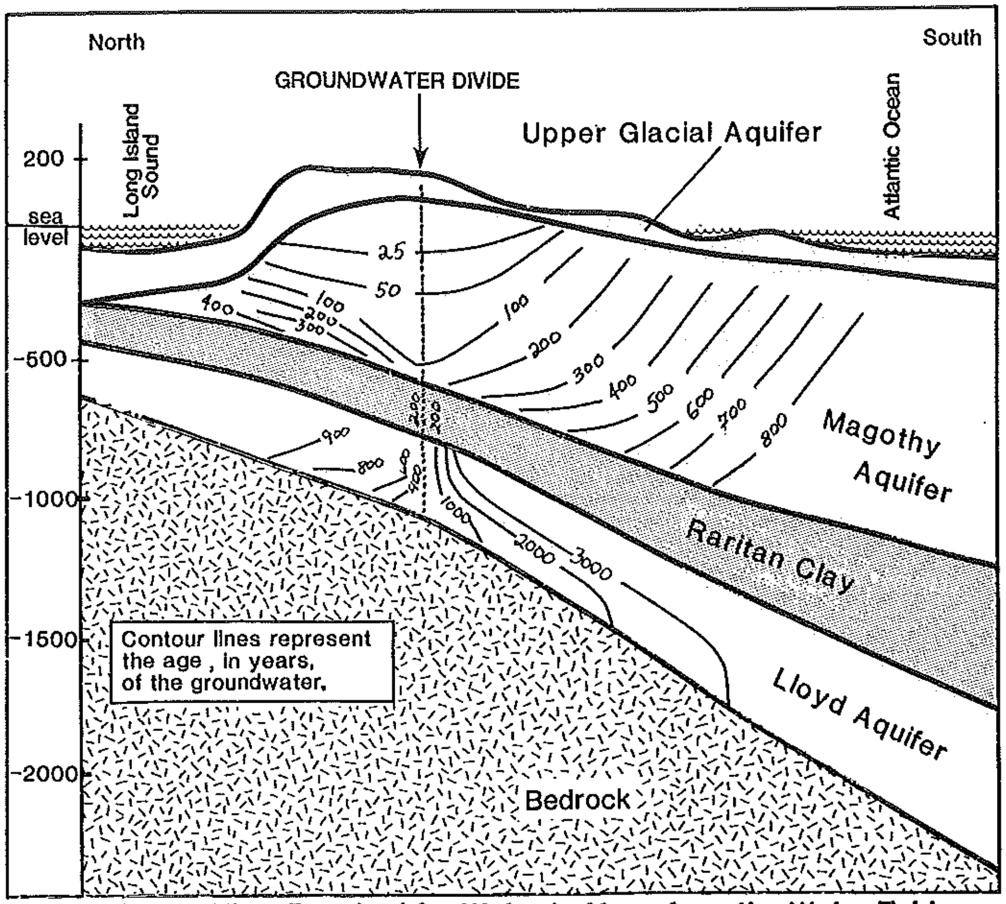
Rainwater that travels through the soil and reaches the groundwater is called recharge. Water is constantly leaving the groundwater system by natural outflow or by human use. Recharging water replenishes the water that leaves the system. In developed areas on Long Island, recharge basins or "sumps" are excavated to facilitate natural groundwater replenishment. These artificial recharge areas are necessary because paving and building construction has disturbed natural rainwater infiltration patterns and increased surface runoff.

GROUNDWATER MOVES THROUGH THE AQUIFER SYSTEM

Water that enters Long Island's aquifers is in constant motion. Water movement or flow patterns in this system are dynamic and vary according to location. Groundwater movement patterns are illustrated in Figure 4. Along the central east-west corridor of our island, groundwater moves vertically downward towards the underlying bedrock and arcs back upwards towards both of the coasts. The groundwater divide is the area where groundwater moving

Water can remain in Long Island's aquifer system for thousands of years.

Figure 5



Approximate Time Required for Water to Move from the Water Table to Points Within Long Island's Groundwater System

SOURCE: Modified from Franke and Cohen, 1972.

vertically eventually separates into north or south flows as illustrated in Figure 4. Moving north and south away from the Ronkonkoma Moraine and towards the coasts, groundwater in the system moves primarily horizontally and shallow towards coastal waters. As a result of this shallow horizontal movement, water recharging in areas near the coast has a shorter residence time in the aquifer system.

GROUNDWATER MOVES SLOWLY

Groundwater movement occurs very slowly. Its rate of movement can be measured in feet per year. Figure 5 shows approximations of the time required for groundwater to travel from the water table to various locations in Long Island's regional groundwater system. Groundwater movement time varies considerably depending on its location. For example, water entering a shallow flow region near the coast may take 25 years to reach coastal waters while water at the groundwater divide's water table may require 3,000 years to reach the base of the Lloyd Aquifer.

LONG ISLAND'S GROUNDWATER IS PLENTIFUL AND FRAGILE

The water-holding capacity of the aquifers below Nassau and Suffolk Counties is quite extensive. Trillions of gallons of freshwater are contained within this system. These water-bearing geologic formations are the only source of potable water for all of Long Island's present and future needs.

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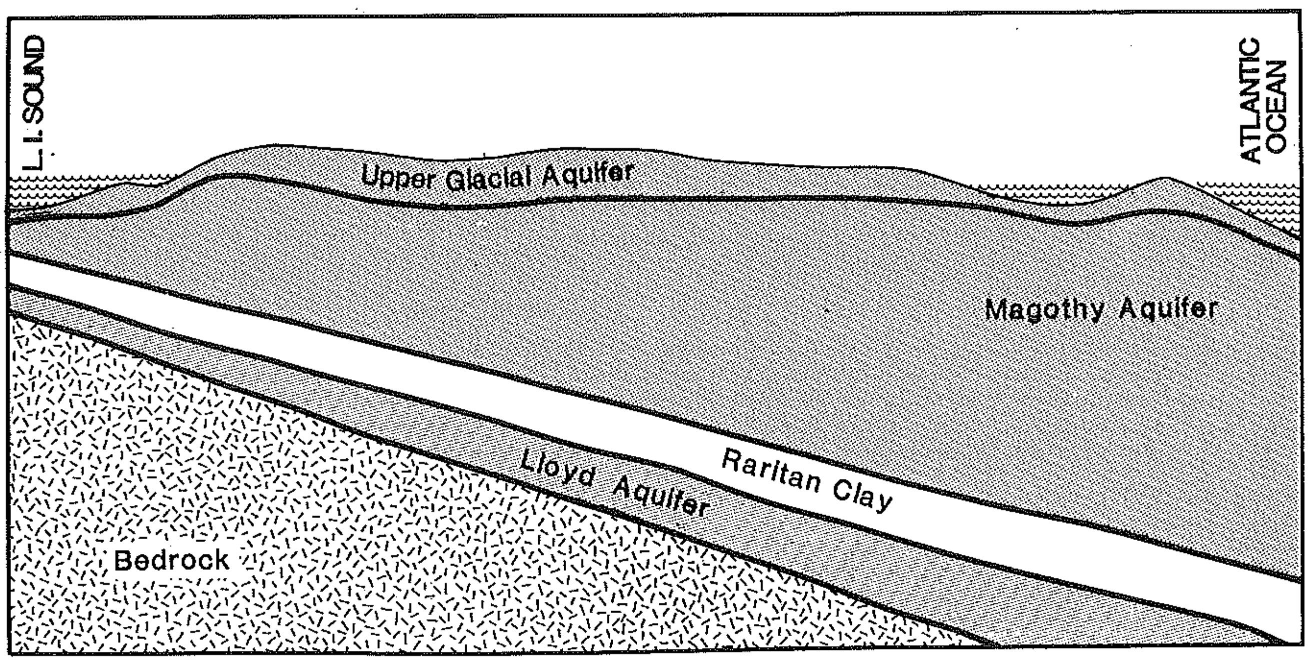
Understanding What's Underground



THE HYDROGEOLOGY OF SUFFOLK COUNTY, N.Y.

Understanding What's Underground

OBJECTIVES

Using contour maps representing the altitudes of the aquifer and aquifer - related formations below Suffolk County, students will plot a hydrogeologic cross section of Long Island.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 7-12
Earth Science
Environmental Science

1. Middle School Syllabus:

   II A-2a, 2c

2. Regents Earth Science Syllabus:

   Topic XIII A-1, A-2, A-3
   Topic IX B-1, B-2.3

BEHAVIORAL OBJECTIVES

Upon completion of this activity, students should be able to:

a. obtain and record data at intervals along a predetermined cross section of Long Island on each of 5 maps representing specific hydrogeologic formations.

b. manipulate these data to produce a cross section of Long Island's Aquifer System.

MAJOR UNDERSTANDINGS

Long Island is composed of unconsolidated rock material that is categorized into hydrogeologic units (aquifers and confining layers) that share similar hydrogeologic characteristics.

Long Island has 3 major aquifers: the Upper Glacial, the Magothy and the Lloyd Sands, and 1 major confining layer: the Raritan Clay. Other minor aquifers and confining layers occur.

Deep borings and well logs provide evidence of the physical and hydraulic characteristics which distinguish aquifers and aquifer-related formations.

Data collected in this manner can be visually presented using contour maps and hydrogeologic cross section graphs.

All aquifers below Long Island are interconnected.

Depending on proximity to a confining layer, groundwater is stored in either artesian or water table conditions.

Artesian and water table aquifers differ in their response to pumping.

Artesian aquifers are more sensitive to pumping than are water table aquifers.

MATERIALS

Vocabulary Sheet
Student Procedures
Maps A-E
Hydrogeology Data Sheet
Hydrogeologic Cross Section of Long Island
Colored Pencils

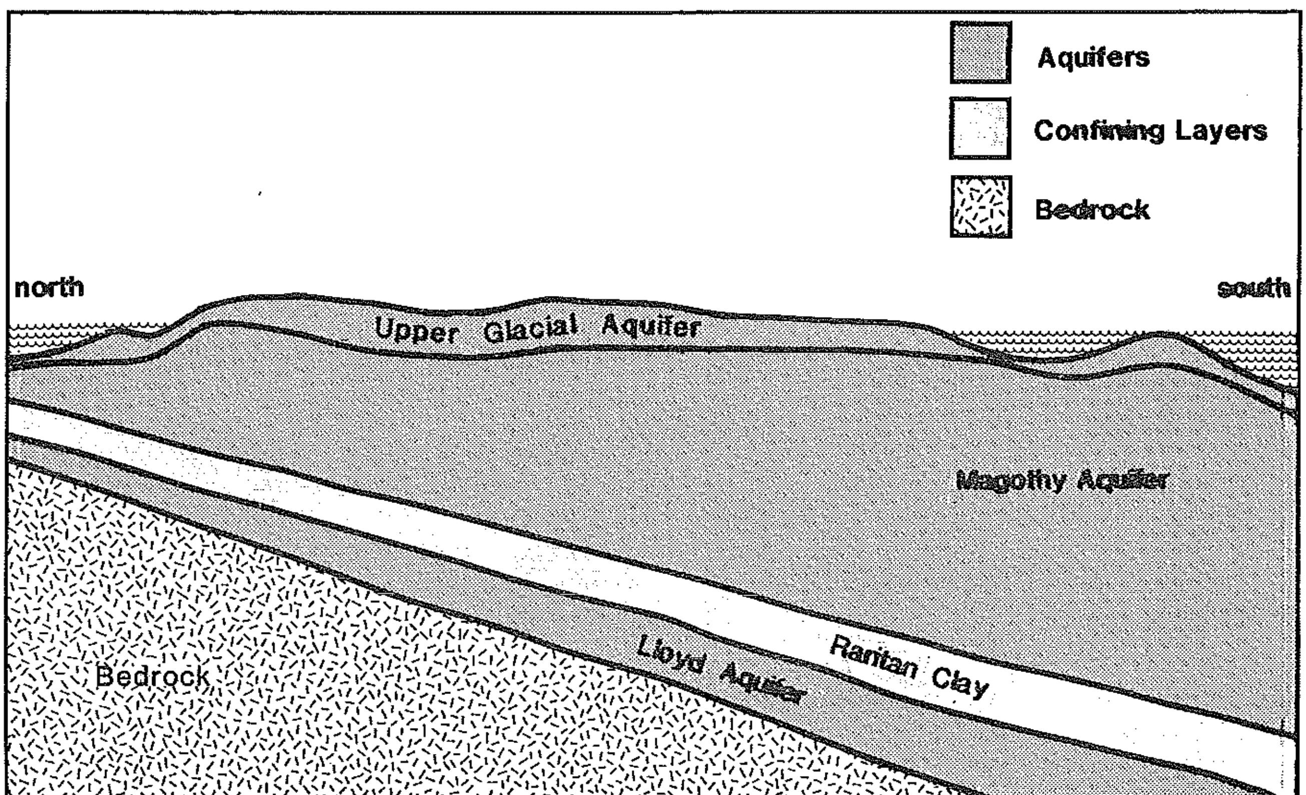
BACKGROUND INFORMATION

Long Island's Aquifer Formations

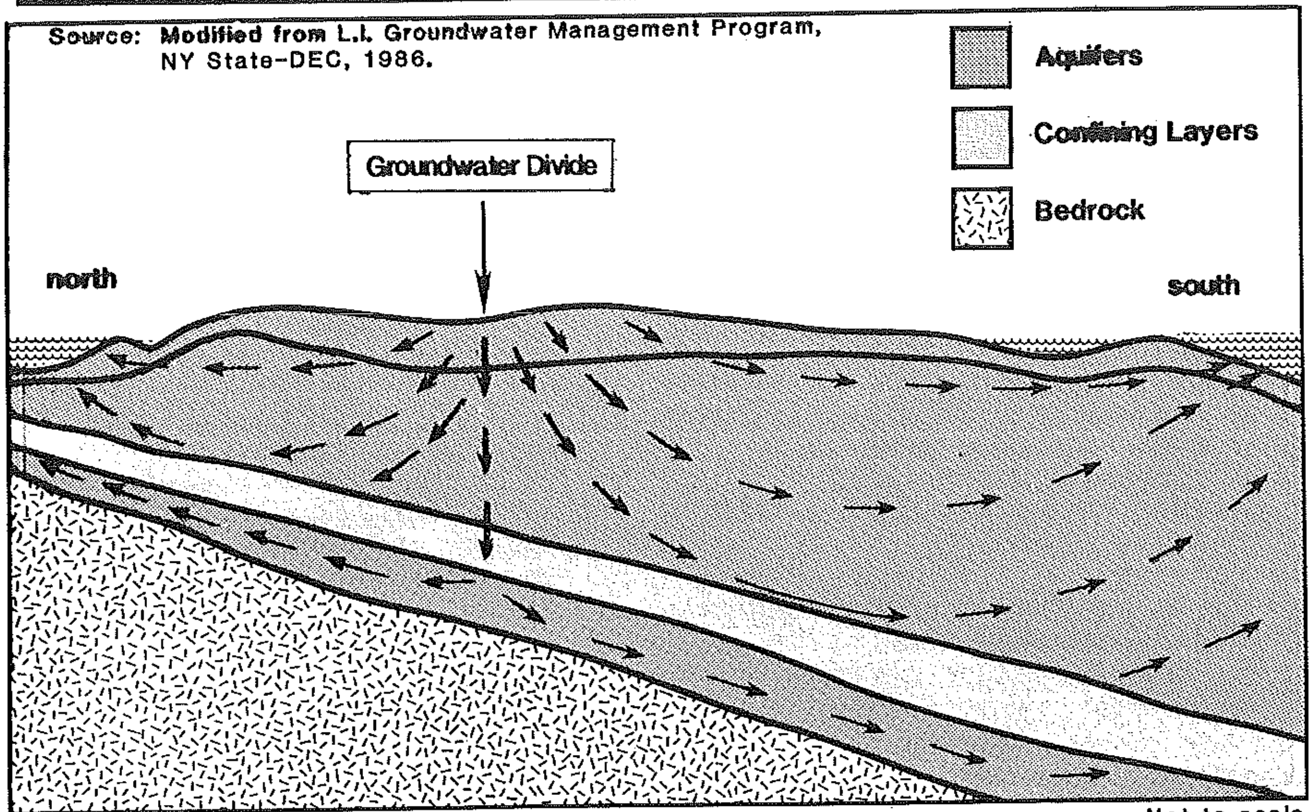
The groundwater reservoir system of Long Island is composed of unconsolidated rock material that includes lenses and layers of clay, sand, gravel, clayey and silty sand and silt. This material, depositional in origin, is categorized into hydrogeologic units, each consisting of a geologic unit or group of geologic units which share similar hydraulic characteristics. For example, the Upper Glacial aquifer contains a good deal of sand and gravel. The aquifer's rock constituents enable it to hold a large amount of water which is readily extracted by pumping. The Raritan clay deposit, in contrast, consists primarily of clay, although beds of more permeable materials are common within it. Generally, this layer holds and transmits little water and serves as a confining layer to the underlying Lloyd aquifer. Long Island's hydrogeologic formations differ in their rock constituents and the amounts of groundwater they can hold and transmit.

The hydrogeologic units on Long Island include aquifers and confining layers of low permeability, which separate the aquifers. Long Island's major aquifers or water-bearing hydrogeologic units, from the land's surface down, are: the Upper Glacial, the Magothy and the Lloyd. The major confining hydrogeologic unit is the Raritan clay. Smaller aquifers and confining layers occur throughout the Island. For the purposes of the following activity, the focus will be on the major units shown in Figure 1. The whole groundwater system is underlain by crystalline bedrock. This impervious rock effectively contains the water above it.

figure 1



Cross Section of Long Island's Hydrologic Formations



Generalized Groundwater Movement Patterns

figure 2

How Do We Know What's Down There ?

How do we know what's down there anyway? We recognize the various hydrogeologic formations found below Long Island by using information gathered from deep borings and well logs. Deep borings bring up samples of rock material and well logs provide data on how underground deposits respond to pumping. Together these sources furnish physical evidence and hydraulic characteristics that can be correlated to form pictures of the water bearing and other related formations that can be visually presented as cross-sectional and contour maps. The maps used and created in the activity will be of the bedrock, the major aquifers and confining layer formations and the water table.

L.I. Aquifers Are Interconnected

A generalized description of Long Island's water reservoir can mislead if it is used to predict groundwater movement both through and between the aquifers. Large scale maps often convey the impression of complete separation of formations. For example, on a generalized map the Lloyd sands seem totally cut off and, therefore, protected by the thick Raritan clay layer. In reality, there is circulation throughout the whole system. All the aquifers below Long Island are interconnected.

Groundwater Movement

Groundwater movement in Long Island's aquifers is more rapid horizontally than vertically. The near-horizontal clay and silt lenses and beds occurring throughout and between the aquifers are partly responsible for this horizontal movement. These horizontal clay lenses and larger clay formations that occur within and between the aquifers confine and limit movement but do not prevent the vertical movement of groundwater through them.

Of all the aquifers below Long Island's surface, the Upper Glacial has, on the average, greater rates of vertical groundwater flow. This is due to its composition of outwash deposits, such as fine to coarse sand and gravel. The high porosity of these glacial deposits readily permits water movement throughout. In the Magothy, vertical movement of water is impeded by horizontal lenses of clay and silt. Locally, vertical groundwater movement is facilitated by the discontinuity of these horizontal lenses of impermeable sediments. Actual movement through clay and silt beds occurs very slowly.

The Raritan Clay Does Not Restrict Groundwater Movement

The Lloyd aquifer is recharged by water moving downward through the Upper Glacial, the Magothy and the Raritan clay. This deepest aquifer's main watershed is in the Ronkonkoma Moraine area. The Raritan clay that lies above the Lloyd sands confines the aquifer but does not completely restrict groundwater flow from one aquifer to another. Sections of the Raritan are more permeable than others. Beds of sand are common and thin beds of gravel occur locally. In addition, Raritan clay layers are not continuous throughout the formation due, most probably, to sporadic deposition and erosion after their formation.

Groundwater Storage Conditions

Considerable information can be gathered about an aquifer by the manner and speed with which groundwater is extracted from it. Characteristics that can be obtained in this manner include the aquifer's general geologic composition and the conditions under which the water is stored. Depending on its location, the groundwater in Long Island's aquifers is stored under two distinct conditions: water table and artesian. Water table conditions occur when an aquifer is unconfined, as is the Upper Glacial and, to a small extent, the Magothy. The water table, or topmost level of the aquifer, is free to rise and fall depending on withdrawal and recharge conditions. Artesian conditions occur in confined aquifers, such as the Lloyd and most of the Magothy. Artesian conditions are found where water completely fills an aquifer that is capped by a layer of low permeability. The aquifer, being contained by a generally non-porous layer above and below, is under pressure.

Groundwater Pumping Under Different Storage Conditions

Artesian and water table aquifers differ in their response to pumping. In an aquifer under water table conditions, the height of the water in a well could be at the same level as the water table outside the well. As water is pumped, the level of water in a well drops. The level of the water table in the vicinity of the well would also be lowered. This lowering takes on a conical shape and is appropriately termed the cone of depression. As the water table is lowered in the area of the well, a steep gradient may be produced in the water table. This gradient between the cone's base and the height of the original water table is the drawdown. The groundwater flow, from areas of high pressure to that of low pressure, is increased and subsequently increases the amount of water the well will yield. Beyond a limited amount of drawdown, the well's yield fails to increase. The amount of water released from storage in a water table aquifer, per unit decline in pressure, is commonly hundreds of times greater than the amount released from an artesian aquifer.

In an artesian aquifer, the height of the water in a well could be at a level higher than the level of the aquifer. Artesian aquifers are more sensitive to withdrawals than water table aquifers. In Long Island's groundwater system, the Lloyd aquifer, experiencing only five percent of the system's total water moving through it, is considerably more sensitive to pumping than is the Magothy. This is due to the aquifer's smaller total volume and its reduced flow. In artesian aquifers such as the Lloyd, pumping effects are usually greater in the horizontal direction, as contrasted with the vertical effects of water table pumping. A decline in groundwater levels caused by pumping may be hundreds or thousands of times greater laterally from the well than vertically above or below the zone tapped by the well. Saltwater intrusion has become a problem in the Lloyd aquifer because of this horizontal retreat of freshwater.

Groundwater Is Best Managed When Its Mechanics Are Understood

The groundwater system beneath Long Island is a tremendous natural resource. Though large, it is interconnected and complex. The aquifers are continuous below all of Long Island. The system's elements demonstrate considerable diversity in both physical make up and response to utilization. Because we are so dependent upon our water supply and have such potential to affect its quality, quantity and movement patterns, it is imperative that it be understood and managed as a regional system.

PROCEDURE

1. Present material on Long Island's Aquifer System.

2. Instruct students to use the Student Procedure Sheet to complete the Hydrogeologic Cross Section of Long Island graph.

3. Assist students in the use of the Aquifer Formation Contour maps and the Hydrogeologic Cross Section Worksheet.

REFERENCES

ELEMENTS OF PHYSICAL GEOGRAPHY, by Arthur N. Strahler and Alan H. Strahler, John Wiley and Sons, 1976.

HYDROGEOLOGY OF SUFFOLK COUNTY, LONG ISLAND, NEW YORK, by H. M. Jensen and Julian Soren, U.S. Geological Survey, 1974.

LONG ISLAND GROUNDWATER MANAGEMENT PROGRAM - DRAFT, New York State Department of Environmental Conservation, Albany, 1983.

UNDERGROUND WATER RESOURCES OF LONG ISLAND, NEW YORK, A. C. Veatch et al., Professional Paper No. 44, United States Geological Survey, 1906.

MAPPING OF GEOLOGIC FORMATIONS AND AQUIFERS OF LONG ISLAND, NEW YORK by Russen Suter, Wallace DeLaguna and Nathaniel M. Perlmutter, Water Power and Control Commission, NY State, 1949.

1985 PROGRESS REPORT, NYS Legislative Commission on Water Resource Needs of Long Island.

THE CONSERVATIONIST: SPECIAL ISSUE - NEW YORK'S WATERS, NY State Department of Environmental Conservation, May - June, 1986.

Vocabulary

GROUNDWATER: The supply of freshwater occurring in aquifers below the earth's surface.

AQUIFER: An underground geologic formation that stores significant quantities of groundwater and allows that water to move through it.

CONFINING LAYER: A rock layer of low permeability, such as clay, which overlays and confines an aquifer.

HYDROGEOLOGIC UNITS: Geologic units classified according to their hydraulic characteristics. Aquifers and confining layers are hydrogeologic units.

BEDROCK: The continuous solid impermeable rock of the continental crust. Bedrock is found beneath Long Island's groundwater system.

WATER TABLE: The surface of the groundwater.

WATER TABLE AQUIFER: An unconfined aquifer where the water table is free to rise or fall depending on recharge or groundwater pumping conditions.

ARTESIAN AQUIFER: An aquifer which is overlain by impermeable strata or a confining layer. The water in such an aquifer is under pressure.

ARTESIAN WELL: A well that taps a confined aquifer.

CONE OF DEPRESSION: The cone-shaped lowering of the water table that takes place near a well.

CROSS SECTION: A section formed by a plant cutting through an object that is useful in representing the interior of that object.

SALTWATER INTRUSION: The flow of saltwater from the sea into a groundwater system that results from the overpumping of a groundwater system that is in hydraulic connection with the sea.

Student Procedures

Some Background On Maps A - E

1. All of the maps show formations that are under Long Island.

2. All of the maps show the level of the top of the formations below Long Island.

3. The lines on the maps are contour lines showing different depths below ground or heights above ground.

4. On some maps a heavy double line shows where that formation is believed to end.

5. The vertical line A-A' and the points along that line are the same on each map.

6. The formations shown on Maps A-E are also under western Long Island. They are, however, not included in this map series.

7. The top of the water table is also the top of the Upper Glacial Aquifer.

Part 1

You will need the following to complete Part 1:

MAPS A-E
HYDROGEOLOGY DATA SHEET

Use Maps A-E and the following procedure to complete your DATA SHEET. Use the same procedure for each map.

1. Locate line A-A'.

2. a) Use the HYDROGEOLOGY DATA SHEET to record the level of the top of each formation at points 0-4 along Line A-A'.

   b) If a point falls between two contour lines, estimate its depth or height using contour lines between which it is located.

Part 2

You will need the following to complete Part 2:

HYDROGEOLOGY DATA SHEET
HYDROGEOLOGIC CROSS SECTION OF L.I. WORKSHEET

1. a) Turn to your data sheet. Each of the boxes with numbers 0-4 matches one of the L.I. Maps (A through E).

   b) Now turn to the Worksheet "Hydrogeologic Cross-Section of Long Island".

      (i) It shows a north-south cross-section through Long Island looking towards the West.

      (ii) On the vertical axis, the numbers going down are depths below sea level in feet.

      (iii) Height above sea level is also shown.

      (iv) Along the horizontal axis on the bottom, the numbers 0-4 match up to the numbers along line A-A' on each of the L.I. Maps A-E.

   c) Plot the depths to bedrock from Map A on the Worksheet with the cross-section.

      (i) Use the information for Map A from your Data Sheet.

      (ii) On the cross-section, plot an X at the correct depth above each boxed number.

      (iii) Connect the X's with a solid pencil line.

      (iv) You now have a picture as to how deep it is to bedrock along this N-S line across Long Island.

   d) Repeat this procedure for the depth to the Lloyd Aquifer (Map B).

   e) Repeat the procedure for the depth to the Raritan Clay (Map C).

   f) Repeat the procedure for the depth to the Magothy Aquifer (Map D).

   g) Repeat the procedure for the depth to the water table (Map E).

2. Label the formations on your completed cross-section.

3. Color the formations for better interpretation. Use the following key:

Bedrock	:	blue
Lloyd Aquifer	:	yellow
Raritan Clay	:	green
Magothy Aquifer	:	white
Water Table	:	red

Hydrogeology Data Sheet

1. Use this sheet to record the depth of each formation at points 0-4 found along line A-A' on each map.

2. If a point falls between two contour lines, estimate its height or depth using the contour lines that it falls between.

3. If the level of a formation is below sea level record the depth with a negative sign.

MAP A

Bedrock Depths	
0	
1	
2	
3	
4	

MAP B

Lloyd Aquifer Depths	
0	
1	
2	
3	
4	

MAP C

Raritan Clay Depths	
0	
1	
2	
3	
4	

MAP D

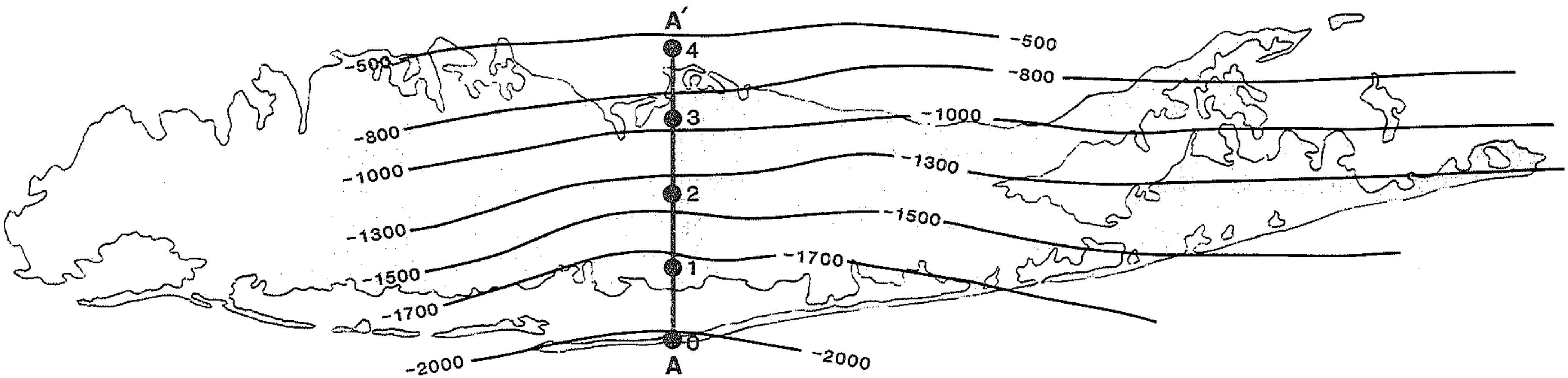
Magothy Aquifer Depths	
0	
1	
2	
3	
4	

MAP E

Water Table Levels	
0	
1	
2	
3	
4	

Map A

TOP OF THE BEDROCK FORMATION
Beneath Suffolk County, Long Island

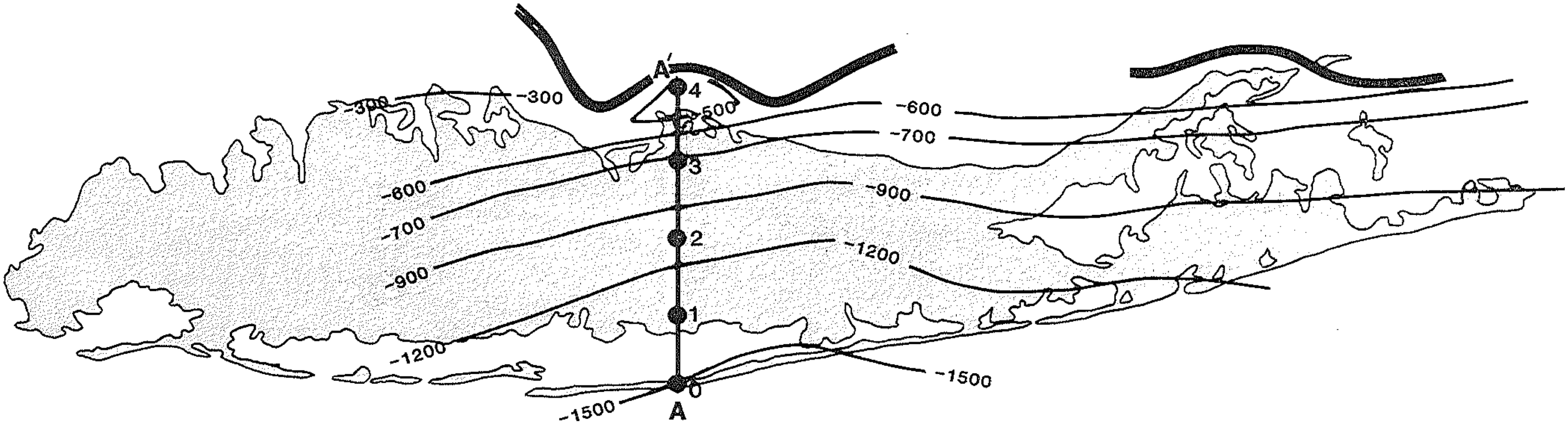


Contour lines are in feet above or below sea level.

Source: Modified from Jensen and Soren, 1974.

Map B

TOP OF THE LLOYD SANDS FORMATION
Beneath Suffolk County, Long Island



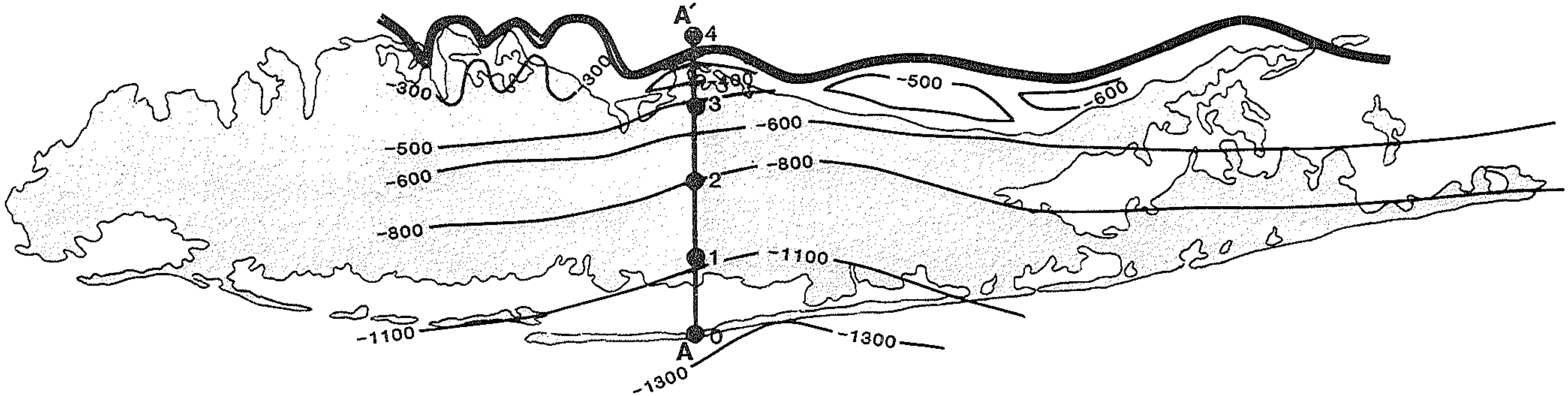
The heavy double line marks the limit of the Lloyd Sands aquifer. This formation does not exist north of this line.

Contour lines are in feet above or below sea level.

Source: Modified from Jensen and Soren, 1974.

Map C

TOP OF THE RARITAN CLAY FORMATION
Beneath Suffolk County, Long Island



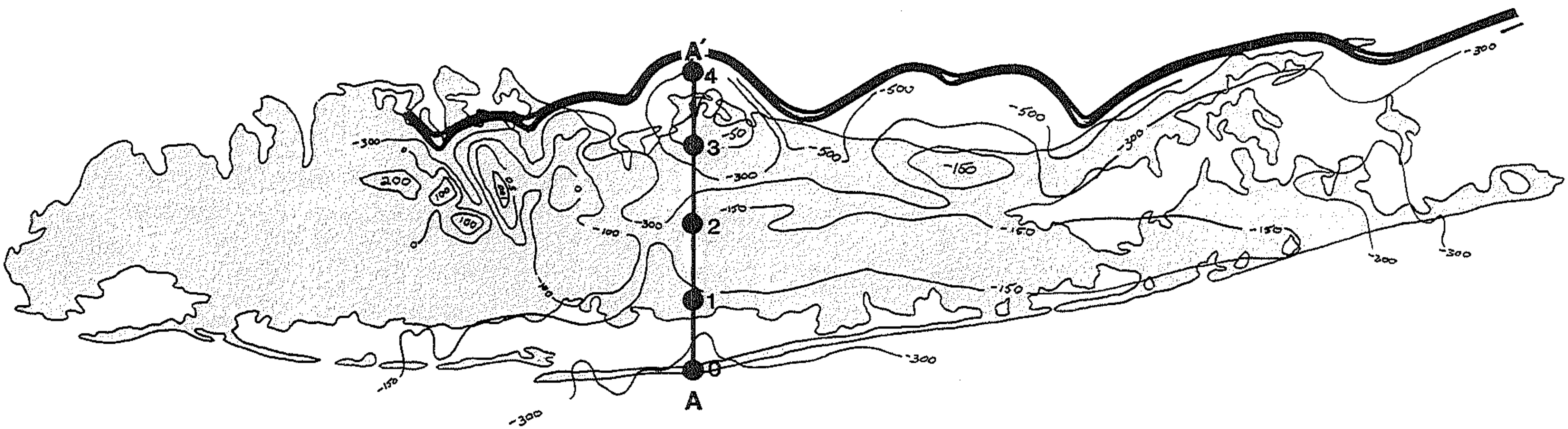
The heavy double line marks the limit of the Raritan Clay. This formation does not exist north of this line.

Contour lines are in feet above or below sea level.

Source: Modified from ensen and Soren, 1974.

Map D

TOP OF THE MAGOTHY AQUIFER FORMATION
Beneath Suffolk County, Long Island



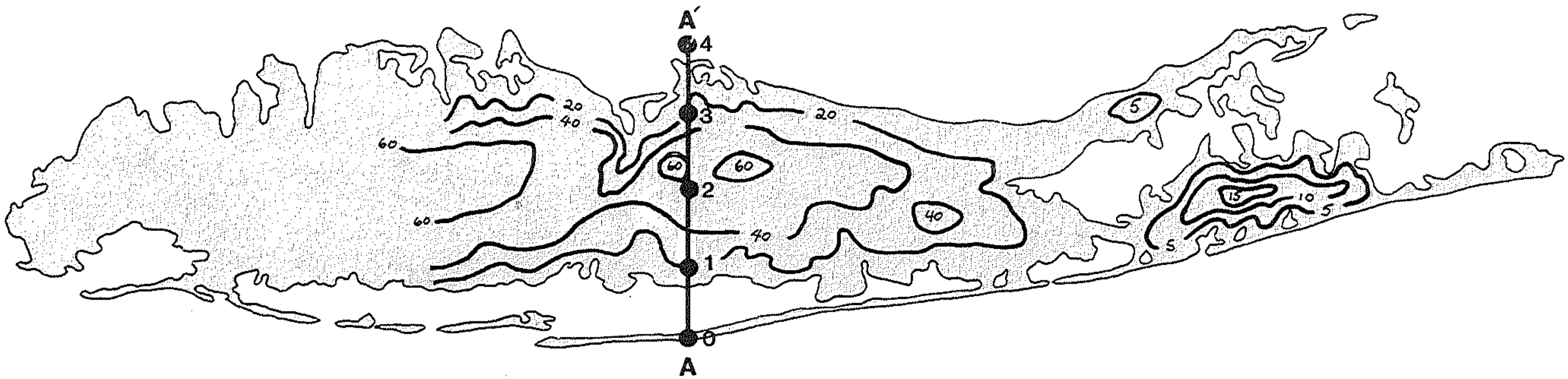
The heavy double line marks the limit of the Magothy aquifer. This formation does not exist north of this line.

Contour lines are in feet above or below sea level.

Source: Modified from Jensen and Soren, 1974.

TOP OF THE WATER TABLE
Beneath Suffolk County, Long Island

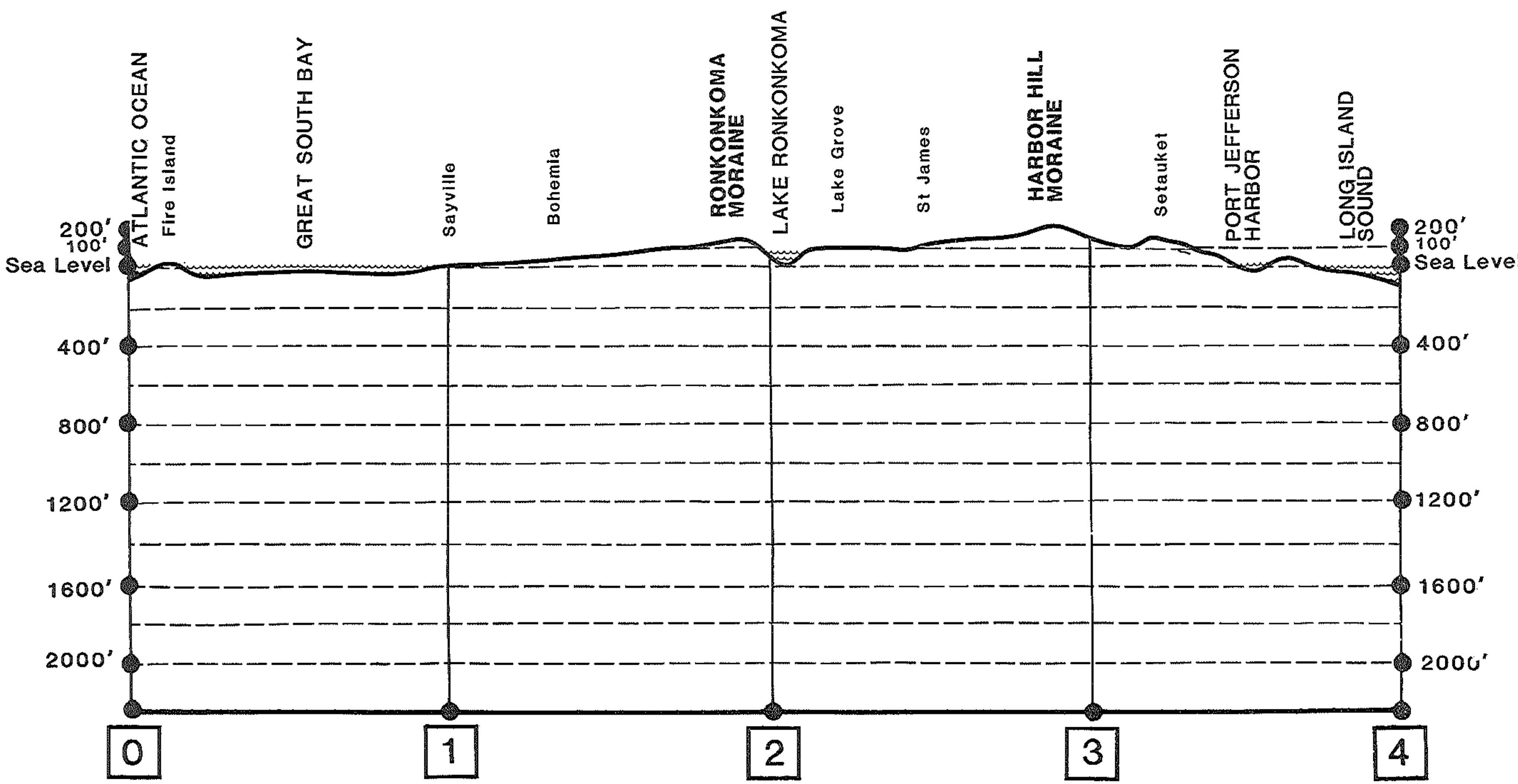
Map E



Contour lines are in feet above or below sea level.

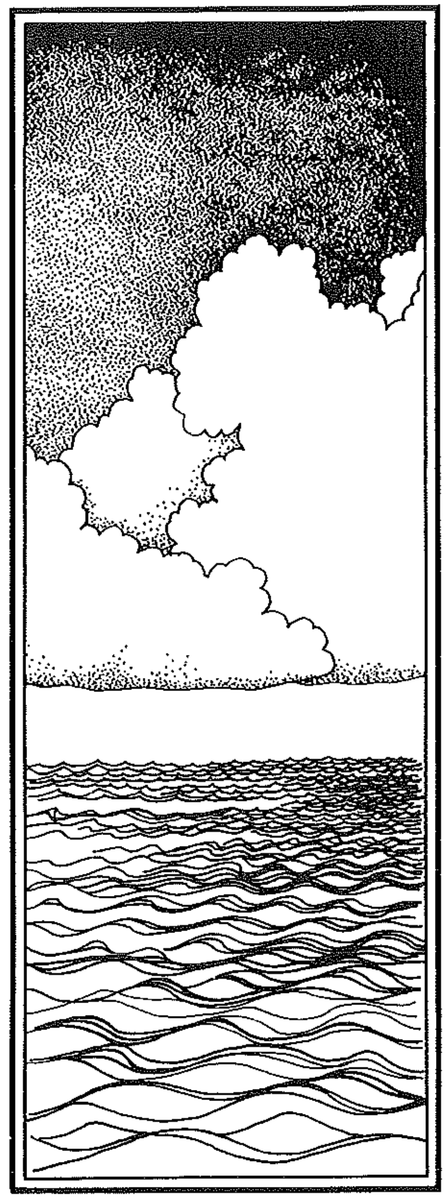
Source: Modified from Jensen and Soren, 1974.

Hydrogeologic Cross Section of Long Island



LONG ISLAND'S WATER BUDGET

Graphing The Hydrologic Cycle



LONG ISLAND'S WATER BUDGET
Graphing The Hydrologic Cycle

OBJECTIVES

A water budget for Long Island, N.Y. will be calculated based on data of precipitation and evaporation. A graph will be plotted from this data allowing for identification of climate type, months of water usage, months of recharge, months of flood potential and months when irrigation is needed.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 9-12
Earth Science

Earth Science Syllabus

Topic VIII-B-1

BEHAVIORAL OBJECTIVES

Upon completion of this activity students should be able to:

a. calculate a water budget for Long Island given data on precipitation and evapotranspiration.

b. plot a graph from these data.

c. identify the following information about Long Island:

   1. climate type
   2. months of water usage
   3. months of recharge
   4. months of flood potential
   5. months when irrigation may be needed.

MATERIALS

Vocabulary - Student Procedure Sheet
Water Budget Table and Graph
Question Sheet

MAJOR UNDERSTANDINGS

The water budget is a model which can be used to analyze the fluctuations of a regional water cycle over a year's duration.

A water budget analyzes the natural water cycle of a region.

BACKGROUND INFORMATION

A budget is a statement of anticipated income and expenditures, or outgo. A water budget is a mathematical model of the hydrologic cycle for a geographic region on a month to month basis, up to twelve months. In a water budget, the income is precipitation (converted to liquid equivalents) and the outgo is moisture lost due to evaporation and transpiration. Evaporation and transpiration are combined as one value and are referred to as evapotranspiration.

Through comparison of monthly precipitation and evapotranspiration, conclusions can be drawn with respect to infiltration, groundwater storage, temperature and other climate factors. The maximum amount of water that could evapotranspire if the water were available (potential evapotranspiration, Ep) can be determined for each month. This value is directly related to temperature and amount of vegetation.

However, if not enough water is available the amount of water actually given off during a month (actual evapotranspiration, Ea) will be less than the potential evapotranspiration. It must be noted that Ea will equal Ep whenever possible.

The amount of water stored in the ground within pore spaces when precipitation exceeds evapotranspiration is referred to as Storage. Most areas are estimated to have a maximum storage of 100 mm. Water budget computations consider only the "capillary water" stored above the water table and within the rooting zone of plants. After the soil attains a storage of 100 mm, water will pass through this zone and on to the zone of saturation. This water is then considered to be Surplus water.

When precipitation is less than Ep and there is water in Storage, water will be lost from soil storage (if available) to meet the demand. This negative change in storage (- St) is referred to as Usage.

If precipitation is less than Ep and there is no available water in Storage, Ea will be less than Ep and a Deficit situation is said to exist.

When storage is less than 100 mm and precipitation is greater than Ep, the excess water will become Storage and be referred to as Recharge.

Volume of water per unit area is expressed in millimeters.

PROCEDURE

1. Conduct a class discussion during which the concepts and terminology of a water budget will be developed. This is the natural follow-up to the water budget lab within the scope of the Regents Syllabus.

Regents Approach

a) First complete Water Budgets from the "supplement".)
b) Have students complete the table and plot the graphs.
c) Conduct a discussion which interprets the Long Island climate and hydrologic cycle.
d) Follow-up with analysis of stream hydrograph.

Non-Regents Approach

a) conduct a class discussion which introduces:
   (i) the Hydrologic Cycle,
   (ii) factors which determine whether infiltration or runoff will occur,
   (iii) generalized water budget concepts.

b) Present the COMPLETED data table and duscuss its interpretation.
c) Graph the data as outlined in the Student Activity.
d) Discuss how climate characteristics can be inferred from water budget analysis.
e) Follow-up with analysis of stream hydrograph.

REFERENCES

AN ATLAS OF LONG ISLAND WATER RESOURCES, Philip Cohen et.al., New York Water Resources Commission Bulletin 62, 1968.

BROOKHAVEN NATIONAL LABORATORY ANALYSIS CLIMATIC DATA 1949-64, C. Nagel.

LONG ISLAND'S WATER BUDGET
Graphing The Hydrologic Cycle

Vocabulary

Precipitation (P) is the moisture source for the water budget. All forms of precipitation have been converted to liquid equivalents.

Potential Evapotranspiration (Eq) is the maximum amount of water that could evapotranspire if the water were available.

Actual Evapotranspiration (Ea) is the amount of water actually given off during a month. It can not exceed Ep and will equal Ep whenever possible.

Storage (St) is the amount of water stored in pores and on the surface of the soil particles. Most areas are estimated to have a maximum of 100 mm. Storage occurs when P is greater than Ep.

Pores are the spaces between rocks or rock material where water can move and be stored.

Change in Storage (St)

a. Usage: Moisture is lost from storage because Ep is greater than P. This is negative St.
b. Deficit: Ep is greater than the combined storage and precipitation. A deficit can only occur when St = 0.
c. Recharge (positive St): Groundwater storage is building up when P is greater than Ep and St is less than zero.

Surplus (S) occurs when soil storage is 100 mm and precipitation is greater than Ep. Surplus water eventually becomes runoff.

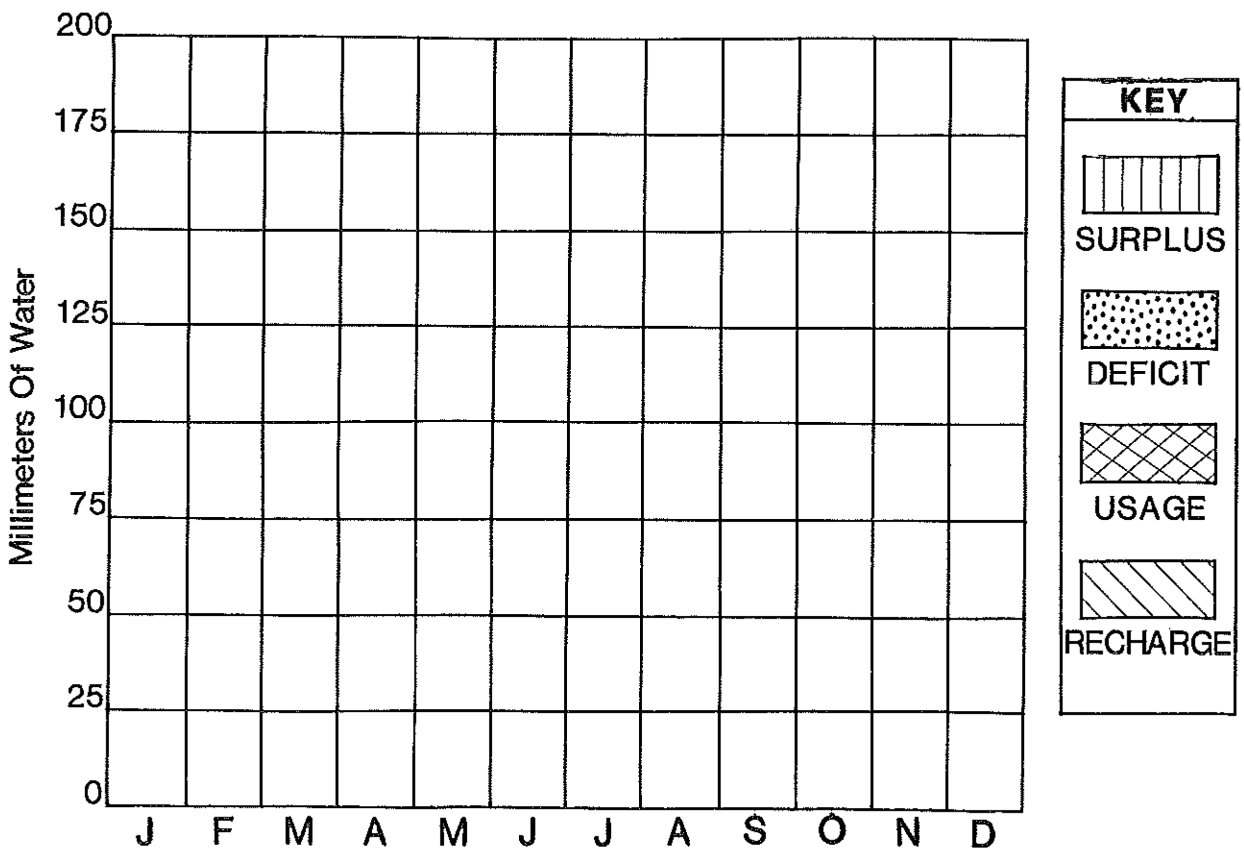
Student Procedures

1. Compute the water budget for Long Island on the accompaning chart.
2. After you have completed the water budget, draw a graph on the graph grid provided.
   a. Plot only P, Ep and Ea.
   b. Use a line of different color for each factor.
   c. The areas between the plotted lines show surplusses, deficits, usage and recharge. Shade these areas using the key provided. The size of the area between the lines is a measure of the amount of surplus, deficit, usage or recharge.

Water Budget Table And Graph

Long Island, New York

	J	F	M	A	M	J	J	A	S	O	N	D
P	105	107	125	109	86	63	86	122	94	93	112	117
Ep	1	3	17	41	74	112	137	114	79	51	3	1
P–Ep												
St												
St												
Ea												
D												
S												



LONG ISLAND'S WATER BUDGET
Question Sheet

Answer the following questions.

1. What is the only source of water for a local water budget?

   a. floods
   b. precipitation
   c. rivers
   d. groundwater

2. What factor causes the potential evaporation (Ep) to change from month to month?

   a. precipitation
   b. average temperature
   c. soil type

3. When there is more precipitation than potential evapotranspiration, soil moisture storage ______________.

   a. increases
   b. decreases
   c. stays the same

4. When there is more evapotranspiration than precipitation, soil moisture storage _________.

   a. increases
   b. decreases
   c. stays the same

5. According to your completed water budget and graph, during which months does a surplus of water exist on Long Island?

   ____

   ____

6. According to your data and graph, during which months does a water deficit occur on Long Island?

   ____

   ____

7. During which months does a USAGE situation exist?

   ____

   ____

8. During which months is RECHARGE of the groundwater occurring?

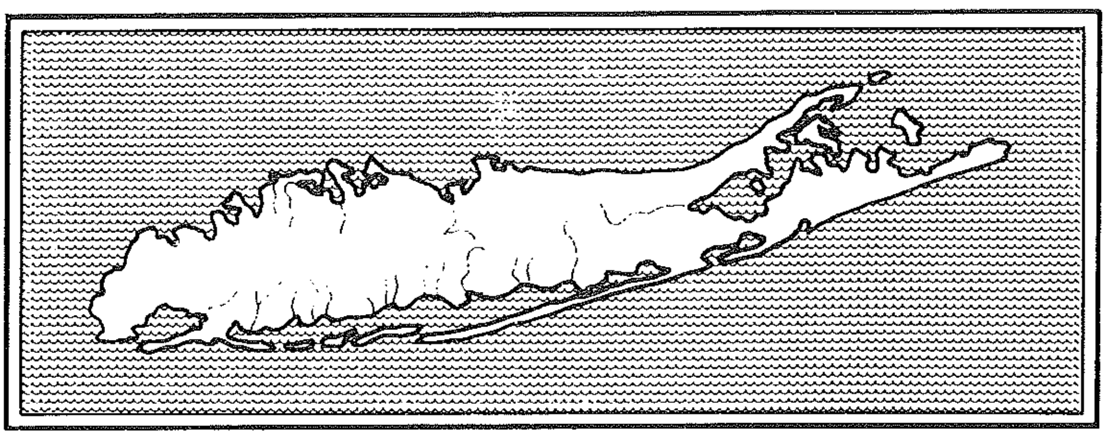
   ____

   ____

Activity #3

HYDROGRAPHING MASSAPEQUA CREEK

Analyzing A Long Island Stream



HYDROGRAPHING MASSAPEQUA CREEK

Analyzing A Long Island Stream

OBJECTIVES

A hydrograph of Massapequa Creek in Massapequa, NY will be constructed using USGS stream discharge data.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 9-12
Earth Science

Earth Science Syllabus

Topic VIII-B-2

BEHAVIORAL OBJECTIVES

Upon completion of this activity, students should be able to:

a. calculate the mean daily discharge for Massapequa Creek for 1 year.

b. make a hydrograph of this information.

c. analyze and compare these data with the Long Island Water Budget.

MATERIALS

Long Island Stream's Vocabulary Sheet
Massapequa Creek Data Sheet
Question Sheet

MAJOR UNDERSTANDINGS

The discharge of a stream is the volume of water which passes a given point within a given time.

The U. S. Geological Survey measures stream discharge using automatic instruments which make a continuous record of discharge.

These data are published yearly by the USGS Water Resources Division.

This includes data on the following:

a) streams: stage, discharge and water quality,
b) lakes: stage, content and water quality,
c) groundwater: levels and quality.

BACKGROUND INFORMATION

The streamflow or discharge of a local stream is the volume of water which passes a given point within a given time. This measures the rate of flow of the stream in terms of volume of flow rather than rate of flow. The U.S. Geological Survey gauges the discharge of streams using automatic instruments which make a continuous record of discharge. This information can then be compared to the water budget of a region.

Streamflow Is Variable

Stream discharge usually varies from day to day depending on recent precipitation. It also varies seasonally. It is on this basis that it can be compared to the water budget. Generally, discharge is greatest during periods of surplus, when there is much runoff. In the northeast there is usually a lag time before you see a surplus due to the melting of accumulated snow and ice in the spring.

Discharge is usually reduced during periods of usage and deficit. On Long Island, discharge is often high in early to mid-summer even though warm and dry subsurface water conditions exist. This is due to increased precipitation from late afternoon and evening showers and thunderstorms.

U.S. Geological Survey Keeps Records On New York's Water Resources

Water resources data for each water year in New York (October through September of the following year) are published yearly by the Water Resources Division of the United States Geological Survey. These data consist of records of stage, discharge and water quality of streams; stage, contents and water quality of lakes and reservoirs; and water levels and water quality of groundwater wells.

PROCEDURE

1. Conduct a classroom discussion during which the concepts and terminology of streams and hydrographs will be developed. Review the water budget concepts.

2. Instruct your students in the procedure for graphing stream discharge. The data for Massapequa Creek is located on the Student Procedures Sheet.

3. Have students compare their stream hydrograph with the Long Island water budget. Follow-up with the question sheet provided at the end of this section.

IN ADDITION

Use Section 4 (Long Island's Streams) for additional activities and information on L.I. streams and their close connection with groundwater.

REFERENCES

ELEMENTS OF PHYSICAL GEOGRAPHY, by Arthur N. Strahler and Alan H. Strahler, John Wiley and Sons, 1976.

WATER RESOURCES DATA FOR NEW YORK, Long Island, Water Year 1984, U.S. Geological Survey Water-Data Report

1. Refer to the discharge data below for Massapequa Creek. Note that the data are presented for October 1983 through September 1984.

2. Graph the data provided in the manner explained by your teacher.

3. Compare your graph with the water budget for Long Island.

Discharge, In Cubic Feet Per Second, Water Year October 1983 To 1984
Mean Values

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	8.9	4.9	9.0	12	9.0	16	23	18	38	43	20	10
2	19	4.9	8.6	12	8.6	14	21	17	78	24	20	9.5
3	5.8	5.4	11	12	8.6	14	20	18	41	27	19	14
4	5.4	9.0	32	12	16	13	21	31	35	22	20	28
5	4.9	5.4	14	11	13	20	58	19	32	20	26	13
6	4.9	5.4	15	11	11	19	27	18	30	24	20	11
7.	4.4	4.9	14	11	10	14	24	17	29	42	29	11
8	4.0	4.9	11	11	9.5	13	22	21	28	24	22	10
9	4.0	4.9	10	10	9.0	13	21	23	26	21	18	10
10	4.0	32	9.5	11	9.0	12	21	18	24	20	17	9.5
11	4.0	17	9.0	12	9.5	12	20	17	23	23	17	9.5
12	28	8.6	12	10	9.0	12	20	18	21	21	16	9.0
13	9.5	7.7	45	9.5	8.6	31	19	17	26	18	16	8.6
14	6.3	6.7	27	9.5	8.6	62	33	19	27	17	16	11
15	5.8	9.7	15	9.5	10	23	37	16	22	16	15	20
16	5.4	27	13	9.5	9.0	20	70	16	20	21	14	11
17	4.9	9.5	12	9.0	8.6	20	32	15	20	16	14	9.5
18	4.9	8.1	12	9.0	8.6	18	28	14	20	25	14	9.0
19	8.7	7.7	11	9.0	8.1	17	26	14	30	18	13	9.0
20	5.4	7.7	11	8.6	8.1	16	24	15	20	16	13	9.0
21	4.9	11	11	8.6	8.1	25	23	21	18	63	12	8.6
22	4.9	7.7	46	8.6	8.1	19	22	15	17	28	12	8.1
23	8.2	7.2	17	8.6	8.6	16	30	31	16	23	12	8.1
24	37	11	15	13	28	15	26	21	20	21	12	8.1
25	8.6	34	13	14	12	15	22	16	48	20	11	8.1
26	7.7	12	12	11	10	14	20	16	21	18	11	8.1
27	6.7	11	11	11	9.5	14	20	15	19	68	11	7.7
28	6.3	12	27	10	69	16	19	16	20	30	11	9.5
29	5.8	19	17	9.5	20	48	19	17	20	25	11	8.6
30	5.4	9.5	13	9.5	---	31	19	76	36	23	11	8.1
31	5.4	---	13	10	---	25	---	80	---	21	12	---
TOTAL	249.1	325.8	496.1	322.4	365.1	617	787	685	825	798	485	314.6

Drainage Area. -- 38 sq. mi.

Remarks. -- Records good.

HYDROGRAPHING MASSAPEQUA CREEK
Question Sheet

Answer the following questions.

1. During which month is stream discharge the lowest?

   a. January c. October
   b. June d. April

2. According to the Long Island Water Budget, this lowered stream discharge occurs just after what water budget condition?

   a. deficit c. surplus
   b. recharge d. usage

3. Why does stream discharge decrease from June though October?

   ____

   ____

4. Why does stream discharge generally increase from January through June?

   ____

   ____

5. Which of the following could explain the relatively high stream discharge in June and July, even though the water budget indicates very dry conditions?

   a. decreased precipitation c. increased precipitation
   b. heavy cloud cover d. high temperatures

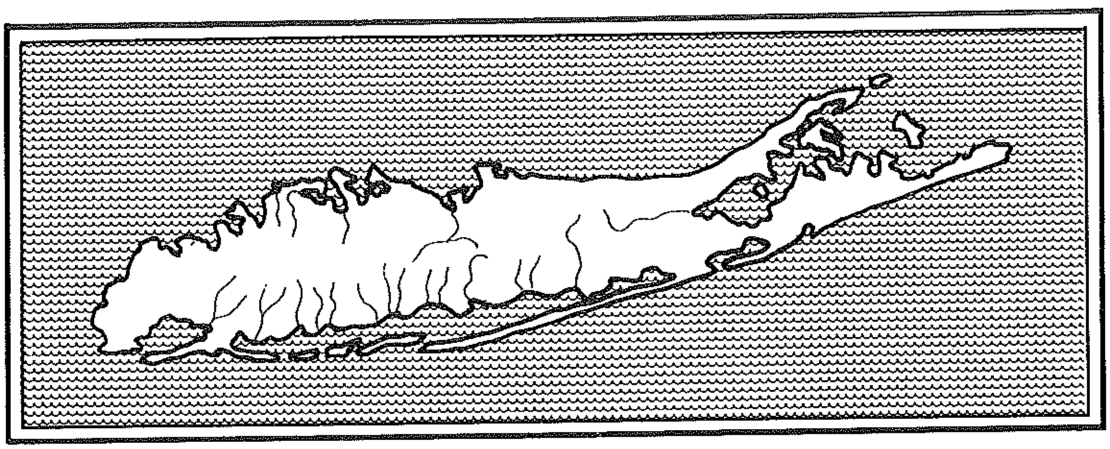
6. During the months of increasing stream discharge, what conditions exist with respect to the Long Island Water Budget?

   a. deficit c. surplus
   b. recharge d. usage

Activity #4

LONG ISLAND'S STREAMS

Surface Expressions Of Groundwater



LONG ISLAND'S STREAMS
Surface Expressions Of Groundwater

OBJECTIVES

Using a Long Island stream map, hydrologic data and question sheets, Long Island's streams are introduced in conjunction with their geographic and hydrologic characteristics.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 8-12
Earth Science

Earth Science Syllabus

Topic VIII-B-2

BEHAVIORAL OBJECTIVES

Upon completion of this activity, students should be able to:

a. locate on a map a nearby stream and record its name, surface drainage area and average flow.

b. identify hydrogeographic information on Long Island's streams using a map and hydrologic data.

c. identify groundwater mining or the over pumping of groundwater as the most serious threat to the continued existence of Long Island's streams.

MATERIALS

Vocabulary Sheet
Long Island's Streams Information Sheet
Question Sheet

MAJOR UNDERSTANDINGS

Under natural conditions, Long Island streams are primarily groundwater fed. (95% of their flows are from groundwater outflow.)

Stream flow on Long Island varies from month to month and from year to year.

Stream flow also varies from stream to stream because of artificial control conditions and differences in the areas that contribute groundwater to the stream systems.

The quality of Long Island's streams is related to the quality of the groundwater and runoff that feeds them.

Long Island's streams are integral parts of both the natural and human ecosystems.

Groundwater-fed streams will completely disappear if groundwater levels fall below the level of the stream bed. They may reappear during rainfall events that produce runoff.

The most serious threat to Long Island's streams is groundwater mining primarily brought about by sewering.

BACKGROUND INFORMATION

Long Island Streams

Long Island's little known freshwater streams are different from those found on the mainland and in textbooks describing stream characteristics.

Mainland streams generally have large tributary systems that primarily drain overland flow or runoff resulting from rainfall and melting snow. Precipitation is their main source of flow. They often run dry in times of drought due to their dependency on precipitation.

Groundwater Is The Source Of Long Island Streams

Most Long Island streams, under natural conditions, receive only 5% of their total flow from runoff. The remaining 95% comes from groundwater outflow. Their stream beds are below the water table. The water that enters a stream from groundwater is called the base flow of the stream. A drought will effect a Long Island stream only to the degree it effects the water table. A stream will only run dry when the water table is lowered beneath the stream bed.

Streamflow Is Variable

Streamflow on Long Island varies from month to month and from year to year. For all Long Island streams, maximum flow occurs in March or April. The greatest monthly precipitation occurs during these months. Little precipitation is lost to evapotranspiration due to low air temperature and vegetation dormancy. In addition, snow that may have accumulated throughout the winter months melts in these early spring months.

Minimum streamflow occurs in September. During the summer months, evapotranspiration has been at its highest due to high temperatures and transpiration from vegetation.

A comparison of the monthly outflows of Long Island streams during the months of least outflow indicates that the total outflow averages about 1.5 times the total during the month of minimum outflow. This value is an average of all Long Island streams. In actuality, this relationship varies considerably from stream to stream. For example, an examination of the months of maximum and minimum outflows for the Nissequogue River shows the total maximum monthly outflow is 1.2 times the total minimum monthly outflow. In contrast, when comparing outflows during the same months, the Peconic River's total maximum outflow is almost 2 times the total during the month of minimum outflow.

These island-wide variations are related to differences in artificial control of the flows of streams as well as differences in the areas that contribute groundwater and runoff to the stream systems.

Stream Quality

The quality of water in Long Island's streams is related to the close interconnection of groundwater, runoff and streamflow. A stream's quality is only as good as the groundwater and runoff that feeds into it.

Problems Facing Long Island Streams

The leading threat to the continued vigor of many of Long Island's streams is the overpumping of groundwater. This groundwater depletion is primarily due to the extensive sewering found throughout Nassau County and in south-western Suffolk County. Sewer systems in these regions have replaced cesspools and septic tanks. On-site waste disposal systems return water directly back to the aquifer. In populated areas, however, they present groundwater contamination problems. Sewers remove treated wastewater to coastal waters, alleviating pollution providing there is no leakage.

As water levels are reduced by groundwater mining the water levels of Long Island's lakes and streams, fed almost entirely by groundwater, are lowered and can completely disappear if groundwater levels fall below the stream bed.

Streams Are Important

Although diminutive in size, Long Island's streams are exceedingly important to both human ecology and the ecology of natural systems that exist on Long Island. The streams and related wetlands are vital to the region's ecological health. Wetlands provide habitats for plants and animals adapted to aquatic environments and support animals in surrounding areas with a necessary part of their habitat: water. As stopovers along the Atlantic Flyway, these wetlands are integral coastal migration resting and feeding areas. The outflow of freshwater streams reduces the salinity of Long Island's bays and lagoons, particularly those restricted by the barrier beach. Freshwater has molded these saltwater environs and created conditions for the formation of premier shellfish habitat. By holding down salinity levels in areas such as the Great South Bay, the streams protect hard shell clams from starfish and drills.

Freshwater streams are vital to Long Island's human ecological health, too. They contribute to the Island's economic, aesthetic and recreational value. As natural places, they combine needed open space with the exhilaration that only a riparian environment can bring.

PROCEDURE

1. Introduce background material on Long Island streams.
2. Hand out the following:
   a) Vocabulary-Student Procedure Sheet
   b) Long Island Streams Reference Sheet
   c) Long Island Streams Question Sheets
3. Review Question Sheets upon completion.

REFERENCES

AN ATLAS OF LONG ISLAND WATER RESOURCES, Philip Cohen et.al., New York Water Resources Commission Bulletin 62, 1968.

ELEMENTS OF PHYSICAL GEOGRAPHY, by Arthur N. Strahler and Alan H. Strahler, John Wiley and Sons, 1976.

Vocabulary

STREAM: A long, narrow body of flowing water that occupies a channel and moves to lower levels under the force of gravity.

RUNOFF: Water flowing over the land's surface

GROUNDWATER: The supply of freshwater occurring in aquifers below the earth's surface.

BASE FLOW: Water that enters a stream from groundwater.

WATER TABLE: The surface of the groundwater.

STREAM DISCHARGE: The volume of water that passes a given point within a given time.

STAGE: The height of the water surface in a stream or a lake.

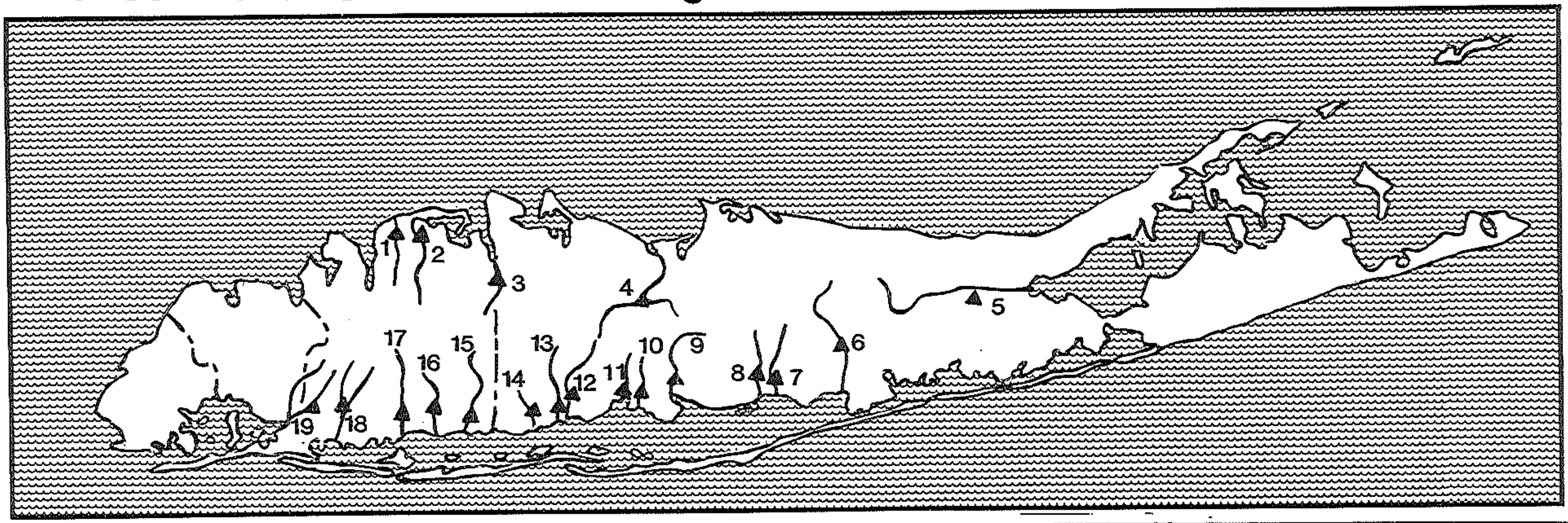
GAUGING STATION: A particular site on a stream, canal, lake or reservoir where systematic observations of hydrologic data are obtained.

DRAINAGE BASIN: That part of the earth's surface that is occupied by a drainage system which consists of a surface stream together with its tributary streams and bodies of impounded water such as lakes and reservoirs. A drainage basin is the watershed for runoff.

HYDROGRAPH: A graph that shows the relationship between stream discharge and precipitation.

GROUNDWATER MINING: A condition occurring when more groundwater is removed from an aquifer than is replaced.

Freshwater Streams On Long Island



INFORMATION SHEET

Adapted from, An Atlas of Long Island Water Resources, Philip Cohen et. al., New York Water Resources Commission Bulletin 62, 1968.

Stream Name	Surface Drainage Area (square miles)	Average Flow (cubic feet per second)
1 Glen Cove Creek	11	7.2
2 Mill Neck Creek	12	9.5
3 Cold Spring Brook	7	4.6
4 Nissequogue River	27	42.2
5 Peconic River	75	35.5
6 Carmans River	71	24.2
7 Swan River	9	13.0
8 Patchogue River	14	21.2
9 Connetquot River	24	39.4
10 Champlin Creek	7	7.5
11 Penataquit Creek	5	6.2
12 Sampawams Creek	23	9.8
13 Carlls River	35	27.7
14 Santapogue Creek	7	4.6
15 Massapequa Creek	38	11.9
16 Bellmore Creek	17	11.2
17 East Meadow Brook	31	17.5
18 Pines Brook Outlet	10	5.1
19 Valley Stream	4	4.8

LONG ISLAND'S STREAMS
Question Sheet

Answer the following questions.

1. Locate the stream that is nearest to your school and record the following information:

   a. stream's name: ____________________

   b. its surface drainage: ____________ square miles

   c. its average flow (cfs'): ____________ cubic feet per second

2. Locate the streams with the largest and second largest surface drainage area.

   a. largest surface drainage area ____________________

   b. 2nd largest surface drainage area ____________________

3. Locate the streams with the largest and second largest average flow.

   a. largest average flow ____________________

   b. 2nd largest average flow ____________________

4. Which part of Long Island has the greatest number of streams flowing into it? (circle one.)

   a. north shore   b. south shore

5. On the map, two streams appear to begin near the same area. One stream flows north, the other south. Locate these streams and record these names below.

   a. north flowing: ____________________

   b. south flowing: ____________________

6. The source of most of the water flowing in Long Island's streams is from ____________.

   a. precipitation   c. the Atlantic Ocean
   b. groundwater   d. Connecticut

7. Which body of water would you predict has the smallest percentage of salt?

   a. Long Island Sound
   b. Great South Bay
   c. Atlantic Ocean

8. What is the most serious threat to the continued existence of Long Island Streams?

   a. detergents
   b. groundwater mining caused by sewering
   c. pesticides
   d. domestic ducks

9. If the water table is lowered below the bottom of a stream bed what will happen to the stream?

   a. the stream will flood
   b. the stream will disappear
   c. the stream will stay the same
   d. the stream will become polluted

sole source of drinking water for the residents of Nassau and Suffolk Counties. Most of our soils allow precipitation to drain swiftly through them. Land uses upon these soils can affect both the quality and quantity of water entering the groundwater.

In this activity the focus will be on land uses and soil properties as they affect and are affected by the groundwater resources beneath Long Island.

PROCEDURE

Part 1: SOIL TYPES

1. Present material on soil associations and land use planning.

2. Instruct students to complete Worksheet #1 using Data Sheets A and B. Clarify certain terms such as housing density, native vegetation and open space. This worksheet will assist the student in assimilating the considerable information needed to complete this activity.

Part 2: SOIL PERMEABILITY AND LAND USE PLANNING

1. Instruct students to design a simple land use plan based on one variable: soil permeability.

2. Briefly discuss the soil symbols found on Worksheet #2. Many students will feel uneasy, artistically, about working with these symbols. Convey to them that their map should exhibit good land use planning but doesn't have to be a work of art.

REFERENCE

HUNTINGTON ENVIRONMENTAL PLANNING PROGRAM, J. Thomas Atkine et al., Regional Planning Master's Thesis, Dept. of Regional Planning and Landscape Architecture, University of Pennsylvania, 1972.

SITE EVALUATION AND LAND USE PLANNING USING NATURAL RESOURCE INFORMATION Cooperative Extension of Suffolk County, edited from Developer's Handbook, Allen Carroll.

SOIL SURVEY OF SUFFOLK COUNTY, NEW YORK USDA - Soil Conservation Service, April 1975.

SOILS: An introduction to soils and plant growth, Roy L. Donahue et al. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1977.

UNDERSTANDING OUR GROUNDWATER: Cooperative Extension of Suffolk County, 246 Griffing Ave., Riverhead, N.Y. 11901

SOILS AND GROUNDWATER QUALITY

A Tool For Regional Land Use Planning

OBJECTIVES

Using the characteristics and properties of 6 soil associations representative of Long Island soils, knowledge of groundwater dynamics and a land use planning chart, students will identify and select the land use most congruous with limitations of Long Island soils and the continued viability of groundwater resources.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 7-12
Earth Science
Land Use Planning
Environmental Studies

Middle School Syllabus
Block D, II A1-A2-A3

Regents Syllabus
Topic II
Topic XIII A-1,A-2,A-3
Topic IX A-1.3,A-1.4

BEHAVIORAL OBJECTIVES

Upon completion of this activity students should be able to:

a. Identify soil types that are most compatible with certain land use practices.

b. Using their knowledge of soil characteristics and land use needs and effects, design a community whose development does not threaten its water supply.

MATERIALS

Vocabulary Sheet
Data Sheets A and B
Soil Types Worksheet
Land Use Planning Instruction Sheet
Land Use Planning Worksheet
Question Sheet
pencil and ball point pen

MAJOR UNDERSTANDINGS

The characteristics of soils throughout Long Island vary.

Soil characteristics influence land uses.

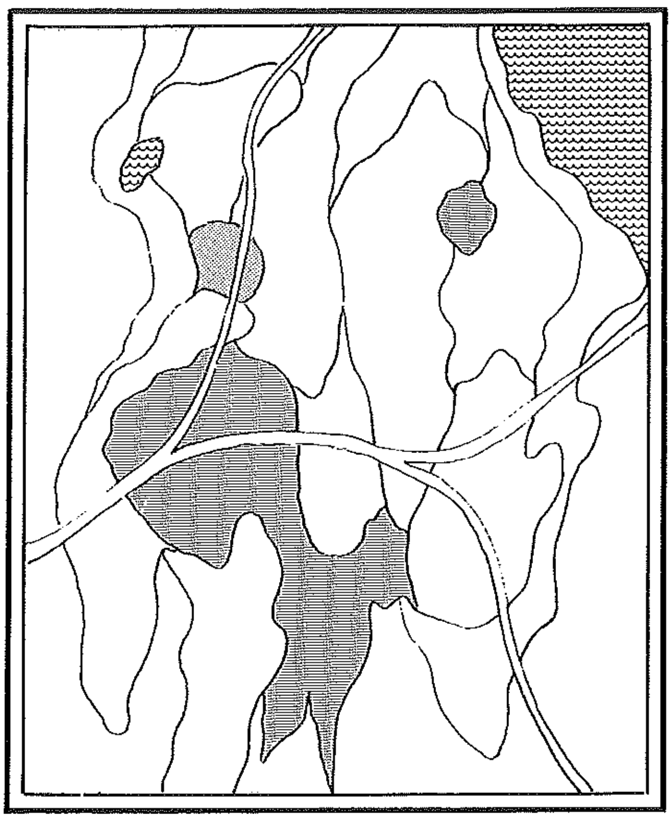
Land use practices can affect Long Island's water resources.

Prudent land use decisions made with the knowledge of soil and groundwater dynamics can protect Long Island's drinking water supply.

BACKGROUND INFORMATION

There are many kinds of soils. Soils possess a wide range of characteristics and properties that will either restrict their use or make them suitable for specific land uses. Most soils lie somewhere between these extremes. A single property does not affect all uses of a soil equally. For example, a soil that is suitable for a homesite may not be suitable for a lawn or cesspool. On Long Island, the land's soils and our uses of them can have considerable effect on our groundwater resources. The permeable soils found on Long Island are an important part of the aquifer system that is the

SOILS AND GROUNDWATER QUALITY



A Tool For Regional Land Use Planning

Assessing Health Risks Worksheet

1. a. Chemical found in Groundwater: ____________________

   b. Concentration of Chemical: ____________________

   c. Estimated cancer risk for lifetime consumption of water containing 1 ppb of contaminant. LOOK UP in TABLE A.: ____________________

2. a. Chemical found in Groundwater: ____________________

   b. Concentration of Chemical: ____________________

   c. Estimated cancer risk for lifetime consumption of water containing 1 ppb of contaminant. LOOK UP in TABLE A.: ____________________

Directions

1. Fill in the blanks in the box to the right. The answers can be located on Information Sheet B.

2. Use the equation outline below to assess the health risks of a contaminated well. Complete STEPS 1 and 2 for each chemical. Complete STEP 3 to compute the additive effect of the 2 contaminants.

STEP 1

(1) Chemical name: ____________________

$\frac{\boxed{A}\ \_\_\_\_\_\_}{1 \times 10^{6}} = \boxed{B}\ \_\_\_\_\_\_$

STEP 2

$\boxed{C}\ \_\_\_\_\_\_ \times \boxed{B}\ \_\_\_\_\_\_ = \boxed{D}\ \_\_\_\_\_\_$

(2) Chemical name: ____________________

$\frac{\boxed{A}\ \_\_\_\_\_\_}{1 \times 10^{6}} = \boxed{B}\ \_\_\_\_\_\_$

$\boxed{C}\ \_\_\_\_\_\_ \times \boxed{B}\ \_\_\_\_\_\_ = \boxed{D}\ \_\_\_\_\_\_$

STEP 3

$\boxed{D}\ \_\_\_\_\_\_ + \boxed{D}\ \_\_\_\_\_\_ = \boxed{E}\ \_\_\_\_\_\_$

☞ If an individual drinks water form this contaminated well over a lifetime, his/her chances of developing cancer are ____________________.

Information Sheet B

Problem Card

Contaminants in Well Water

A shallow private drinking water well near an industrial area is found to be contaminated with BENZENE and VINYL CHLORIDE. These two synthetic organic chemicals are known human carcinogens. Laboratory tests find concentrations as high as 202 ppb for BENZENE and 300 ppb for VINYL CHLORIDE.

Estimate the health risk (or the chances of acquiring cancer) to an individual who drinks water of this quality throughout his/her lifetime.

Table A

ESTIMATED CANCER RISKS
from Lifetime Consumption of Water Containing 1 ppb of a Given Chemical

Chemical	Estimated Risk per $1X10^6$ population / 1 ppb
Benzene	4.4
Alpha-BHC	3.5
Gamma-BHC (Lindane)	13
Carbon tetrachloride	1.9
Chloroform	4.1
Dibromochloropropane (DBCP)	200
1,1-Dichloroethane	150
1,2-Dichloroethane	1
Dioxane	0.39
Ethylene dibromide (EDB)	480
Parathion	29.0
Tetrachloroethylene	0.93
1,1,2-Trichloroethane	1.6
Trichloroethylene	0.3
Vinyl chloride	4.1

Source: Adapted from Council on Environmental Quality, *Contamination of Groundwater by Toxic Organic Chemicals.* Washington, D.C.: U.S. Government Printing Office, 1981. Table 14. Based on information from Crump, K.S., Guess, H.A., *Drinking Water and Cancer: Review of Recent Findings and Assessment of Risks.* Springfield, Virginia: National Technical Information Services, 1980; Vinyl Chloride data from International Agency for Research on Cancer: *IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans.* Supplement 4. Lyons, France: IARC, 1982.

Information Sheet A

A = ESTIMATED CANCER RISK FOR LIFETIME CONSUMPTION OF WATER CONTAINING 1 ppb OF A CONTAMINANT

How To Find :

Find A by referring to Table 1. Find the synthetic organic chemical contaminant on the list. Locate its corresponding risk value in the column under the heading Estimated Risk per $1X10^6$ population. This number should be entered in #2 on the Risk Assessment Worksheet.

B = ESTIMATED CANCER RISK PER INDIVIDUAL FOR LIFETIME CONSUMPTION OF WATER CONTAINING 1 ppb OF A CONTAMINANT

How To Find:

B is computed by dividing A by $1X10^6$ (or 1,000,000). Compute this value for each chemical GIVEN. ENTER this value in #3 on the Risk Assessment Worksheet.

C = THE CONCENTRATION OF CONTAMINANTS FOUND IN GROUNDWATER IN ppb.

How To Find:

C is a value that is given to you by your teacher. Enter this value in #4 on the Risk Assessment Worksheet.

D = UPPER LIMIT ON LIFETIME CANCER RISK

How To Find :

D is a value found by multiplying the concentration of contaminants C in the well by the estimated cancer risk per individual B. This number estimates the chances of an individual contracting cancer if he/she drank contaminated well water throughout their lifetime. An example of how this value is expressed is as follows: If a person's upper limit on lifetime cancer risk is $3.0X10^{-2}$, he/she will have a 3/100 or a 3 in 100 chance of developing cancer. Enter these values in #5 on the Risk Assessment Worksheet.

E = ADDITIVE EFFECT OF TWO OR MORE "UPPER LIMIT ON CANCER RISK"

How To Find :

E is a value found by adding the UPPER LIMIT ON LIFETIME CANCER RISK of both chemicals found in groundwater.

Student Procedures

1. Read the "Contaminants in Well Water" Problem Card.

2. Using the Problem Card and the Information Sheet, record the necessary information in the spaces provided on Worksheet #1.

3. Use the following 2 step outline to assess the health risks for each chemical mentioned on the Problem Card. Enter the chemical's name, and the other information you have located, in the equation outline provided on Worksheet #1.

4. Complete the health assessment equation for each chemical.

Procedure For Each Contaminant

Use the outline below to assess health risk to an individual from lifetime consumption of water containing one or more contaminants.

STEP 1

Derive the health risk to an individual using the following equation:

$$\frac{\text{Estimated cancer risk for lifetime consumption of water containing 1 ppb of a contaminant } \boxed{A}}{1X10^{6}} = \text{Estimated cancer risk per individual for lifetime consumption of water containing 1 ppb of a contaminant. } \boxed{B}$$

STEP 2

Calculate the risk from each contaminant using the following equation:

$$\text{Concentration of contaminants found in ground-water in parts per billion (ppb). } \boxed{C} \times \text{Estimated risk per individual from lifetime consumption of water containing 1 ppb of a contaminant. } \boxed{B} = \text{Upper limits on lifetime cancer risk. } \boxed{D}$$

NOTE: Repeat this procedure for additional chemicals.

5. Add the two "Upper Limit on Lifetime Cancer Risk" figures D that you have found using your equations.

Vocabulary

EPIDEMIOLOGY: The study of the occurrence of human diseases and the situations that accompany high rates of disease.

SYNERGISM: The combined, simultaneous action of two or more substances such that the total effect is greater than the sum of the effects if each substance is used individually.

ANTAGONISM: The combined, simultaneous action of two or more substances such that the total effect is less than the sum of the effects if each substance is used individually.

Vocabulary

GROUNDWATER: The supply of freshwater occurring in aquifers below the earth's surface.

AQUIFER: An underground geologic formation that stores significant quantities of groundwater and allows that water to move through it.

CONTAMINANT: An introduced gas, liquid or solid that makes a resource, such as groundwater, unfit for a specific purpose.

TOXIC SUBSTANCE: A hazardous substance that is poisonous or harmful to certain types of plant and animal life.

CARCINOGEN: A substance that causes cancer.

TERATOGEN: A substance that causes birth defects.

MUTAGEN: A substance that causes genetic damage.

TOXICITY: The degree to which a substance is poisonous or harmful to plant or animal life.

ACUTE EXPOSURE: An exposure to a substance occurring within a short time. An acute exposure to a substance rapidly abosrbed by the body can produce immediate toxic effects.

CHRONIC EXPOSURE: An exposure to a substance occurring over a long period of time.

SYNTHETIC ORGANIC CHEMICAL: Manmade chemical compounds containing carbon and made from either inorganic substances, like carbonates or cyanides, or from other organic compounds.

PART PER BILLION (ppb): A very small quantity representing the relationship between two substances. For example, if a chemical is present in a concentration of 5 ppb it means that for every 5 parts of a chemical there are 1 billion parts water. Many synthetic organic chemicals are believed to be harmful at these low levels, especially if consumed over a long period of time.

DRINKING WATER GUIDELINES: Guidelines formulated by federal and state agencies that regulate the quality of our water supply. Guidelines place limits on the amount of contaminants in our water supply.

ONE IN A MILLION RISK FACTOR: A risk factor used by federal agencies to regulate contaminants in water supplies. Known and reviewed carcinogens are not allowed in the water supply in concentrations higher than that which would cause cancer in more than 1 person in a population of 1 million over a lifetime.

A shallow private drinking water well in an industrial area is found to be contaminated with Benzene and Vinyl Chloride. These two synthetic organics are known human carcinogens. Laboratory tests find concentrations as high as 202 ppb for Benzene and 300 ppb for Vinyl Chloride.

Estimation of the risk to an individual, who drinks water of the quality throughout his/her life, of acquiring cancer would be worked out as follows:

CHEMICAL : Benzene
CONCENTRATION : 202 ppb

STEP 1

$$\frac{4.4 \text{ (Estimated risk per } 1\times10^{6} \text{ population per 1 ppb of contaminant)}}{1\times10^{6}} = 4.4\times10^{-5} \text{ (estimated cancer risk per individual)}$$

STEP 2

$$202 \text{ ppb(concentration)} \times 4.4\times10^{-5} \text{(estimated cancer risk per individual)} = 8.8\times10^{-3} \text{(upper limits on cancer risk)}$$

****

CHEMICAL : Vinyl Chloride
CONCENTRATION : 300 ppb

STEP 1

$$\frac{4.1 \text{ (Estimated risk per } 1\times10^{6} \text{ population per 1 ppb of Contaminant)}}{1\times10^{6}} = 4.1\times10^{-5} \text{ (estimated cancer risk per individual)}$$

STEP 2

$$300 \text{ ppb(concentration)} \times 4.1\times10^{-5} \text{(estimated cancer risk per individual)} = 1.2\times10^{-2} \text{(upper limits on cancer risk)}$$

****

Assuming the effect of these two chemicals is additive, and not synergistic (the effect of two or more chemicals being greater than the sum of their parts) or antagonistic (the effect of two or more chemicals being less than the sum of their parts), the addition of the two separate cancer risks (D) would give us a rough estimate of the chances an individual who regularly drank the water would have of developing cancer.

STEP 3

$$(8.8\times10^{-3}) + (1.2\times10^{-2}) = 2.0\times10^{-2} \text{ or } \frac{2}{100}$$

(upper limit on cancer risk) (additive effect of two chemicals)

This estimate indicates that an individual would have a 2 in 100 chance of developing cancer.

REFERENCES

A CITIZEN'S HANDBOOK ON GROUNDWATER PROTECTION, Wendy Gordon, Natural Resource Defense Council, Inc., 122 East 42nd Street, New York, NY 10168, 1984.

PROGRESS REPORT, NYS Legislative Commission on Water Resource Needs of Long Island, 1984, 1985.

THE LONG ISLAND COMPREHENSIVE WASTE TREATMENT MANAGEMENT PLAN (208 Program). Lee E. Koppelman, Project Director, Nassau-Suffolk Regional Planning Board, 1978.

Proposed Revisions

During 1984, the EPA published Recommended Maximum Contaminant Levels (RMCL) for 9 synthetic organic chemicals:

The Recommended Maximum Contaminant Levels For 9 Synthetic Organic Chemicals

Compounds	Proposed RMCL
trichloroethylene	0
tetrachloroethylene	0
carbon tetrachloride	0
vinyl chloride	0
1,2 dichloroethane	0
benzene	0
1,1 dichloroethylene	0
1,1,1 trichloroethane	.2 mg/l (200 ppb)
p, dichlorobenzene	.75 mg/l (750 ppb)

These proposed maximum limits are recommended guidelines and are not enforceable as standards. Reactions to these revised limits on only 9 synthetic organic chemicals are alarming. The Suffolk County Department of Health Services estimates that 108 public wells or over 1/4 of their total public supply wells would be taken out of service.

As continued research substantiates the true health risks of synthetic organic chemicals it seems likely that the present interim guidelines will become more stringent. Caution should be taken not to be lulled into a false sense of security by these interim guidelines. At first glance the guidelines convey an impression of being rooted in safety. Most of them are not.

Uncertainties In Health Risk Estimates

With so little known about synthetic organic chemicals and their interactions with one another, risk assessment becomes linear because it assumes that cancer risks are additive (i.e. that increments in the concentration of chemicals in groundwater will result in proportional increases in cancer.) Other uncertainties in risk assessment include: the validity of the model; the method of extrapolation from animals to humans; synergistic effects among carcinogens (total risk is greater than the sum of the parts) and the effect of undetected chemicals in water.

PROCEDURE

1. Present material on Health Risk Assessment.
2. Introduce or review scientific notation.
3. Hand out materials. Go over the contamination problem presented on the Problem Card.
4. Assist students in completing the equations on Worksheet #1.

FOR DISCUSSION

Is risk assessment and the establishment of normal risk levels ethical?

The majority of synthetic organic chemicals that have been assigned guidelines based on health risk data have lower maximum contamination levels than those that are not based on health risk.

a. Are the guidelines not based on health risks set too high?

b. Is our society setting itself up for some future water quality crisis and major health problems?

c. Are present guidelines a false blanket of security that impedes our efforts to protect and preserve our water resources?

presents complex problems for valid epidemiological studies. The monitoring of subjects and control of variables is virtually impossible. In addition, water is rarely contaminated by only one chemical. Synthetic organic chemicals can react with one another or with naturally occurring compounds to produce other dangerous compounds. Animal testing is generally used as a basis for health risk assessment.

Assessing Risks

Federal and state government agencies are responsible for establishing guidelines that regulate the quality of our water supply. These agencies, such as the Environmental Protection Agency (EPA), use mathematical models to estimate the statistical risks to individuals exposed to small concentrations of given chemicals over time. Federal agencies regulate guidelines on the basis of $1x10^6$ or one in a million risk. In other words, if a population of 1 million were to consume water regulated by these guidelines for their lifetime, one person would be expected to contract cancer over that lifetime.

Present Guidelines

Since 1977, guidelines issued by the New York State Department of Health (NYSDOH) have informally regulated synthetic organic chemicals in public water supplies. Most of these guidelines are not related to the threat to public health. As shown in Table 2, these recommended guidelines permit up to 50 parts per billion (ppb) for any one compound and 100 ppb for any combination of compounds. Note that only 5 of the compounds listed have levels set below 50 ppb.

Table 2

NY STATE DRINKING WATER GUIDELINE LEVELS (In Parts Per Billion)

1,1,1 Trichloroethane	50
1,1,2 Trichloroethane	50
1,1,2 Trichloroethylene	50
Tetrachloroethylene	50
Trichlorotrifluorethane	50
Carbon tetrachloride	50
Methylene Chloride	50
Toluene	50
Xylenes	50
Ethylbenzene	50
1,1 Dichloroethane	50
1,3,5 Trimethylbenzene	50
1,2,4 Trimethylbenzene	50
1,1 Dichloroethane	50
Dioctyl Phthalate	50
dichlorobenzene	50
1,2, Dichloropropane	50
Dibrom	50
Paraquat	50
cis 1,2, dichloroethylene	50
1,2 dichloroethane	50
1,1 dichloroethene	50
Bromobenzene	50*
Chlorotoluene	50*
Chlorobenzene	50*
Oxamyl	50
Dinoseb	50
Carbofuran	15
Aldicarb	7
Benzene	5
Vinyl Chloride	5
1,3 Dichloropropene	2
Dacthal	50

* Total should not exceed 50 ppb for combined chemicals.

Note: Other synthetic organic or pesticide chemicals not listed will have a maximum level of 50 ppb for any one compound or 100 ppb for any combination until a specific evaluation is conducted.

Unless otherwise noted, the combination of compounds should not exceed 100 ppb.

Source: Suffolk County Department of Health Services; Report on Water Supply Priorities, April 1984, page 9.

synthetic organic chemicals. The route through which these chemicals enter the groundwater is dependent on how they are used. Any chemical released or spilt on the land's surface or discharged into a cess-pool or well has the potential to contaminate water supplies. Industry and agriculture are the principal sources of synthetic organic pollutants. A smaller, though significant, source of contamination are household chemicals that contain many of the same synthetic organics that are ending up in our aquifers. (See Hazardous Household Waste Survey for more on this subject.)

Health Risks?

There is increasing concern about the effects of synthetic organics on human health. Many are believed to be toxic, carcinogenic, teratogenic or mutagenic. The chemicals listed in Table 1 are those commonly found in drinking water. All these chemicals are known to produce toxic effects after acute exposure. Some symptoms include liver and kidney damage, depression of the central nervous system causing dizziness, nausea, fatigue, poor coordination and mental dullness.

The most pernicious health problems brought about by synthetic organic chemicals, however, result from long-term low-level exposure. Exposure at these chronic levels is most perturbing to accurate health risk assessment. At present there are no drinking water standards or guidelines that estimate true risk to public health for most of the synthetic organics found in groundwater.

This delay in formation of standards is, in part, due to problems associated with assessing the health impact of long-term, low-level exposure to known or suspected carcinogens. Little is known about the health effects of chronic low-level exposure. The long latency period for cancer which can range from 10 to 40 years,

TABLE 1
Synthetic Organic Compounds Commonly Found In Drinking Water

Chemical	Highest Groundwater Concentration Reported (ppb)
1,1,1-Trichloroethane	401,300
Trichloroethylene (TCE)	35,000
2,3,4,6-Tetrachlorophenol (TCP)*	34,000
Pentachlorophenol (PCP)*	24,000
Toluene	6,400
Ethylene dibromide*	4,500
Acetone	3,000
Methylene chloride*	3,000
Tetrachlorethylene	3,000
Dioxane	2,100
Ethylbenzene	2,000
Tetrachloroethane	1,500
Dibromochloropropane (DBCP)*	1,240
Cyclohexane	540
Aldicarb*	515
Chloroform	490
Di-n-butyl-phthalate	470
Carbon tetrachloride	400
1,2-Dichloroethane	400
Vinyl chloride	380
Benzene	330
1,2-Dichloroethylene	323
Xylene	300
Isopropyl benzene	290
1,1-Dichloroethylene	280
Bis(2-ethylhexyl)phthalate	170
Trifluorotrichloroethane	135
2,4-Dichlorophenoxy-acetic Acid (2,4-D)*	100
Dibromochloromethane	55
Lindane (gamma-BHC)*	46
Chloromethane	44
Butyl benzyl phthalate	38
1,1,2-Trichloroethane	20
Bromoform	20
1,1-Dichloroethane	7
alpha-BHC	6
Parathion*	4.6
delta-BHC	3.8

* = Pesticide.

Sources. Based on Council on Environmental Quality. *Contamination of Groundwater by Toxic Organic Chemicals* Washington, D C., U S Govt. Printing Office. Jan 1981. Tables 8 and 13; U S. Environmental Protection Agency. National Revised Primary Drinking Water Regulations. Volatile Synthetic Organic Chemicals in Drinking Water. Advanced Notice of Proposed Rulemaking 47 Fed Reg 9350 (March 4, 1982) Table 1: Ramlit Associates, Inc., *Groundwater Contamination by Pesticides A California Assessment* Submitted to State Water Resources Control Board. Sacramento. California Publication No 83-4SP. June, 1983; Joseph Baier, Dennis Moran. "Status Report on Aldicarb Contamination of Groundwater as of September 1981." Hauppage. New York: Suffolk County Department of Health Services, 1981

ASSESSING HEALTH RISKS
Who Pays The Price?

OBJECTIVES

Mathematical models are used by government agencies such as the U.S. Environmental Protection Agency (EPA) to estimate the statistical risk to an individual from lifetime consumption of water containing small concentrations of chemicals. Students will use one such model to compute and assess health risks of lifetime consumption of one or more contaminants.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 10-12
Biology
Chemistry
Environmental Science

BEHAVIORAL OBJECTIVES

Upon completion of this activity, students should be able to:

a. manipulate scientific notation.

b. calculate the risk of one or more synthetic organic chemicals to human health when consumed in drinking water over a lifetime.

MATERIALS

Vocabulary Sheet
Student Procedure Sheet
Information Sheets A and B
Assessing Health Risks Worksheet

MAJOR UNDERSTANDINGS

Regulation of contaminants in drinking water is formulated based on a defined acceptable risk to public health.

The most serious threat to Long Island's water supply is contamination by synthetic organic chemicals.

Synthetic organic chemicals most threaten public health when exposure to them is low-level and long-term.

The present guidelines available for most synthetic organic chemicals are <u>not</u> based upon the threat to public health.

So little is known about the health risks of most synthetic organic chemicals and the effects of combining them that regulations based on health risks to the public have not been established.

As additional data are gathered to better evaluate drinking water standards it is likely that existing non-health related standards will become more stringent.

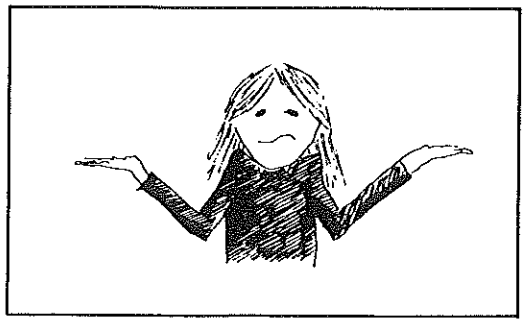
Changing water quality criteria by instituting more stringent standards will create a situation in which guidelines that are acceptable today are considered harmful to human health.

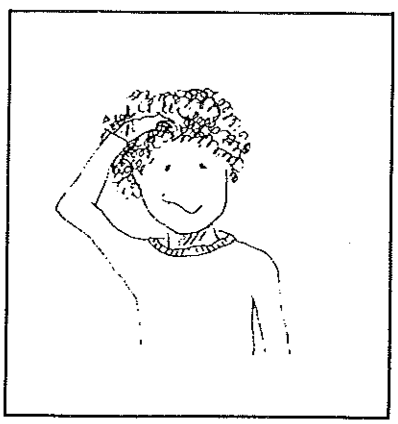
BACKGROUND INFORMATION

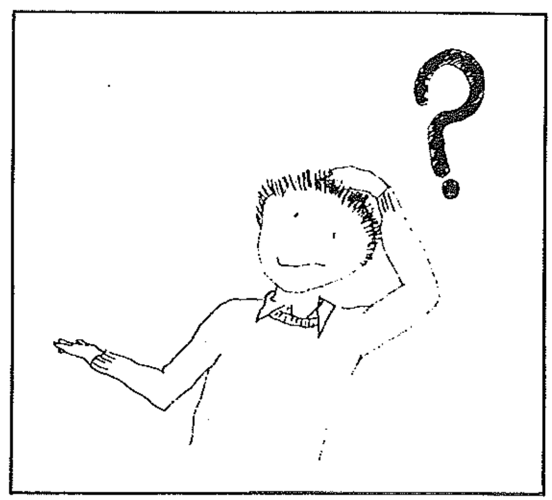
Long Island is one of a handful of areas in the United States dependent solely on aquifers for its drinking water supply. The most serious threat to this supply is contamination by

ASSESSING HEALTH RISKS

Who Pays The Price?







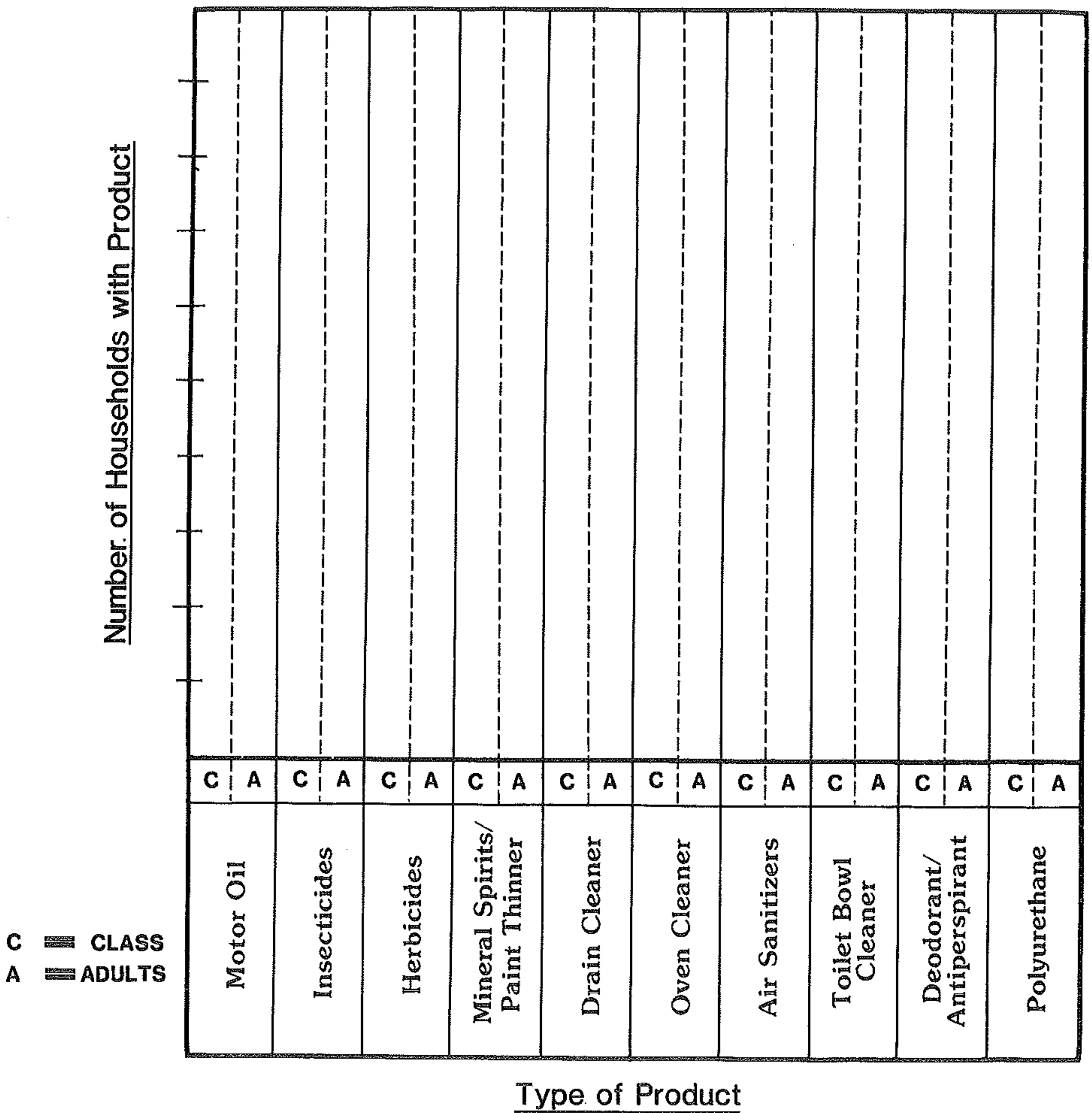
Survey Results Graph

DIRECTIONS

1. Using the data provided by the classes' surveys, complete the graph below:

   a. Above each of the ten household hazardous substances shown below on the graph, indicate the number of these substances found by class members and the number recorded by adults.

   b. Draw bars to graph these numbers.



Hazardous Household Products SURVEY

DIRECTIONS

1. Rate each item's toxicity using the scale found on the TOXICITY REFERENCE SHEET. Fill in Column 1 with this number.
2. Place a check in Column 2 next to each item you find in your home.
3. Have an adult in your home place a check in Column 3 if an item was found in his/her house when he/she was your age.

TAKE NOTE

a. Columns should be filled in only when item is present in your home.

b. Aside from cleaners such as soap, DO NOT TOUCH ANY CONTAINERS!

1	Item	2	3
	Motor Oil		
	Gasoline		
	Anti-freeze		
	Engine Motor Cleaner		
	Car Polish		
	Insecticides		
	Herbicides or Weed Killers		
	Chlordane		
	Pet Flea Collars		
	Flea Shampoo		
	Rodent Poison		
	Fertilizers		
	Paint		
	Shellac		
	Polyurethane		
	Turpentine		
	Mineral Spirits/Paint Thinner		
	Wood Stains		
	Wood Preservatives/Cresote		
	Paint Removers		
	subtotal		

1	Item	2	3
	Lubricating Oil		
	Kerosene		
	Drain Cleaner		
	Oven Cleaner		
	Disinfectants		
	Furniture Polish		
	Spot/Stain Remover		
	Glass Cleaner		
	Cesspool Cleaner		
	Floor Polish/Cleaner		
	Nail Polish Remover		
	Toilet Bowl Cleaner		
	Air Sanitizer		
	Soap		
	Deodorant/Antiperspirant		
	Clothes Detergent		
	Metal Cleaner		
	Other ____________		
	____________		
	____________		
	total		

Year Adult Was Your Age ____________

Toxicity Reference Sheet

TOXICITY RATING	LETHAL DOSE FOR 150 lb. HUMAN	HOUSEHOLD PRODUCTS
1 Slightly Toxic	1 Pint to 1 Quart	Dry cell batteries, glass cleaner, deodorants/anti-perspirants, hand soap
2 Moderately Toxic	1 Ounce to 1 Pint	Motor oil, gasoline, anti-freeze, car polish, most paints, polyurethane, wood stains, lubricating oil (3 in 1), kerosene, most oven cleaners, many disinfectants, furniture polish, spot/stain remover, floor polish, most floor cleaners, nail polish remover, many detergents, metal cleaners
3 Very Toxic	1 Teaspoon to 1 Ounce	Engine motor cleaners, shellac, turpentine, mineral spirits/paint thinner, wood preservative/creosote, paint remover, chlordane, malathion, pet flea collars, flea shampoo, most toilet bowl cleaners, air sanitizers
4 Extremely Toxic	7 Drops to 1 Teaspoon	Fertilizers, many insecticides, herbicides (weed killers), rodent poison
5 Super Toxic	A taste (less than 7 drops)	A few pesticides like: parathion, isobenzan, paroxon

HAZARDOUS HOUSEHOLD PRODUCTS SURVEY

Vocabulary

GROUNDWATER: The supply of freshwater occurring in aquifers below the earth's surface.

HAZARDOUS WASTES: Waste that requires special handling to avoid illness or injury to people or damage to property.

TOXIC WASTE: A hazardous waste that is poisonous to certain types of living things.

TOXICITY: The degree to which a substance is poisonous or harmful to plant or animal life.

HAZARDOUS HOUSEHOLD WASTES: Hazardous products used in the home that are thrown away.

LANDFILL: A place where waste material is deposited, compacted with heavy machinery and covered with soil.

LEACHING: The process by which soluble materials in soil such as nutrients, pesticide chemicals and contaminants are dissolved and washed into lower layers of the soil and, possibly, the groundwater.

LEACHATE: The liquid material produced by leaching.

POLLUTANT: An introduced gas, liquid or solid that makes a resource unfit for a specific purpose.

SURVEY: To study or examine a subject in a comprehensive way.

Student Procedures

1. Using the rating system found on the Toxicity Reference Sheet, rate the toxicities of the hazardous substances found in or around your home. Enter this rating in Column 1.

2. Take the Hazardous Household Products Survey home. Ask your parent or another adult to help you survey your home - they can help you locate some of the substances. Place an X in Column 2 for each substance you find in your home. Aside from some of the cleaners such as soap, DO NOT TOUCH ANY CONTAINERS. If you can't find an item, leave Column 2 blank.

SUGGESTED TIME FOR COMPLETION

One class period to present background information and to give assignment on survey.

One class period to tabulate class frequencies and construct bar graph.

One class period to discuss results.

TAKE NOTE

Because of the nature of this activity it may be advisable to send home with the student a permission slip to be signed by the parent as well as a statement concerning the activity's purpose.

FOR DISCUSSION

Which substances are listed most frequently by both students and adults? Which ones are listed the least frequently?

Are people disregarding the hazardous potential of chemicals found in their homes?

Should we have regulations on Long Island which ban certain types of hazardous substances?

Discuss ways in which the amounts of hazardous substances can be reduced by substituting less toxic alternatives.

Discuss alternatives to throwing away hazardous substances.

REFERENCES

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both in the household and in industry/agriculture.

First, we begin by understanding that the waste we discard can contain significant amounts of hazardous substances and that these wastes represent a potential threat to our groundwater supplies. Only with the realization that many common household items, in waste form, are hazardous can we make informed decisions concerning whether to purchase them, how to dispose of them or whether to consider using a less toxic alternative.

We can even make a difference in the area of hazardous wastes produced by industry and agriculture. We can refrain from purchasing products that contain hazardous chemicals or those that create hazardous wastes as by-products of production. We can buy agricultural products locally and in season, and demand produce be cultivated using farming practices that don't use hazardous chemicals or use them sparingly, only when needed.

Hazardous wastes are a reality in our society - one that isn't going to go away. As individuals, we have the most control and influence in the realm of our households. When we throw something away perhaps the best question to ask is, "do I want this in my drinking water?"

PROCEDURE

1. Begin this activity with a brief discussion on what makes a substance toxic or hazardous. Point out the varying degree of toxicity.

2. Ask students to write down the following types of toxic or hazardous substances that can be found in or around their home.

   a. 2 non-food substances they would describe as non-toxic.

   b. 2 non-food substances they would describe as slightly toxic.

   c. 2 non-food substances they would describe as toxic.

   d. 2 non-food substances they would describe as extremely toxic.

3. Hand out survey material. Go over procedure.

4. When students have their surveys complete, use a count of hands to determine how many students and assisting adults recorded the following representative hazardous items.

   a. Motor Oil
   b. Insecticide
   c. Herbicides
   d. Mineral Spirits/Paint Thinner
   e. Drain Cleaner
   f. Oven Cleaner
   g. Air Sanitizers
   h. Toilet Bowl Cleaner
   i. Deodorant/Antiperspirant
   j. Polyurethane

   Record these items on the chalkboard. Instruct students to copy these data to be used to complete the graphing exercise.

5. If necessary, give students instructions about how to construct bar graphs.

6. Discuss the results of this activity and the implications of hazardous and toxic substances in our environment. Discuss ways to control this problem.

Private Well Contamination By Household Synthetic Organic Chemicals

A study done by the Center for Environmental Research at Cornell University analyzed the results of well water testing done by the Suffolk County Department of Health Services. Samples from 1,000 private wells in 4 communities were tested for 15 organic chemicals. Ten of the chemicals were detected in one or more water samples. 24% of the wells sampled contained detectable amounts of at least one organic chemical and 3.7% contained one or more chemicals at concentrations higher than those allowable under State Department of Health guidelines. The chemical found most often was 1,1,1 trichloroethane, a major ingredient in cesspool cleaners and drain openers that have since been banned. (This chemical is still present in other products such as engine metal cleaner and household cleaning fluid. About 40,000 pounds of 1,1,1 trichloroethane is found in consumer products that are sold annually in Nassau and Suffolk Counties.) This study was done on residential communities that rely on private wells. Since little or no industry is found in these communities, shallow groundwater contamination is due to residential or commercial activities. Results indicate that the percentage of wells affected in a community is directly proportional to its housing density. This further implies that household on-site waste disposal can contribute to groundwater contamination by synthetic organic chemicals.

Hazardous Household Wastes In Landfills

Long Islanders dispose of most of their household wastes in landfills. A landfill seems like a more appropriate and safe place for hazardous household wastes than the direct infusion of those wastes into a cesspool system. However, for the toxic ingredients in the wastes, it may not be the final resting place.

Once the wastes are buried at the landfill, rain or melting snow may permeate the soil and become contaminated as it comes into contact with household toxic wastes. Wastes become a water problem at this juncture. If a landfill is improperly placed, constructed or maintained, contaminated rainwater may continue to travel through the soil and could eventually reach and contaminate groundwater. In addition, hazardous household waste is almost always disposed of as household waste and is dumped in areas that are not equipped to handle and monitor toxic wastes. No one really knows exactly what is in these landfills.

Leaky landfills are especially threatening on Long Island because groundwater is our sole source of drinking water. Once contaminated, groundwater may remain so for hundreds or perhaps thousands of years. Lack of sunlight, oxygen and decomposing organisms can increase the amount of time it can take for the normal degradation of toxic wastes. This could leave groundwater unsafe as a drinking water resource for generations.

Can We Make A Difference?

What can we do to affect the problem of hazardous waste disposal? Although most hazardous wastes are byproducts of agricultural practices and industrial processes, there are ways we can affect hazardous waste disposal

Many products in our households contain hazardous chemicals that we may not be aware of.

A lack of awareness concerning the potential dangers of hazardous chemicals may lead to improper handling and disposal of them.

Hazardous household products become hazardous wastes when they are no longer needed.

Hazardous household products have varying degrees of toxicity.

Hazardous household products are exempt from regulations that control hazardous waste disposal.

Hazardous household products that are disposed of improperly have the potential to end up in our drinking water.

Synthetic organic chemicals and other hazardous substances are the most serious threats to the drinking water of Long Island.

BACKGROUND INFORMATION

Waste is an inevitable product of our society. If it breaks, is not needed anymore, or we grow tired of it, we throw it away.

Our society produces a lot of garbage. U.S. Environmental Protection Agency (EPA) estimates reveal that combined residential and industrial wastes are thrown out at a rate of 3½ pounds per person per day or 1,300 pounds per year. This waste will most likely, end up on our landfills. But all this garbage is not the same....

All Garbage Is Not Equal

Most of us tend to think of industry as responsible for the hazardous wastes that we frequently hear threaten our communities. We're right if we are referring to MOST of the hazardous wastes. If we look inside our own yards, though, we'd be surprised to learn that hidden amidst the TV dinner trays, plastic milk jugs and tunafish cans, more than one full pound of toxic wastes is disposed of by every American family each year. Unwanted bottles of insecticides, waste motor oil, and almost empty cans of wood preservative: these are examples of household wastes that are much more than ordinary garbage. They are hazardous wastes.

Each American family throws away more than 1 pound of toxic wastes each year.

Once these substances becomes wastes the likelihood of their ending up in our groundwater supplies increases. Some are carelessly disposed of by pouring down a kitchen sink or a storm drain or by flushing down a toilet before they ever reach a landfill. These "on-site" methods are extremely debilitating to groundwater supplies in areas where cesspools are the rule, as is true in most of Suffolk County. Cesspools work very well as recharge conduits in Long Island's permeable soils. They function the same way whether their recharge is contaminated or not.

HAZARDOUS HOUSEHOLD PRODUCTS SURVEY

Hazardous Wastes In The Home

OBJECTIVES

Students inventory hazardous substances in their homes and rate their toxicities. An adult in the household assists in going through the inventoried substances, recording which ones were around when he/she was the student's age. Hazardous household products are discussed from the perspective of their potential to contaminate groundwater supplies.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 7-12
Chemistry
Environmental Studies
Social Studies
Home Economics
Health

BEHAVIORAL OBJECTIVES

SURVEY

Upon completion of this activity students should be able to:

1. Identify hazardous substances found in the home today and one generation ago.

2. Rate and record the toxicity of each hazardous substance using a Toxicity Data Sheet.

3. Explain why the number of hazardous household substances used today differs from the number used when adults were children.

SURVEY RESULTS

Upon completion of this activity students should be able to:

1. Construct a Bar Graph to demonstrate the changes in hazardous household product usage over the last generation.

2. Pick 3 hazardous substances, found during their survey, and name one alternative that could be used to replace each substance.

3. List hazardous substances, found during the survey, that could be eliminated from the home to reduce the potential for groundwater contamination.

4. Describe how household hazardous products can harm our groundwater supplies.

MATERIALS

Vocabulary Sheet
Hazardous Household Products Survey
Survey Results Graph

MAJOR UNDERSTANDINGS

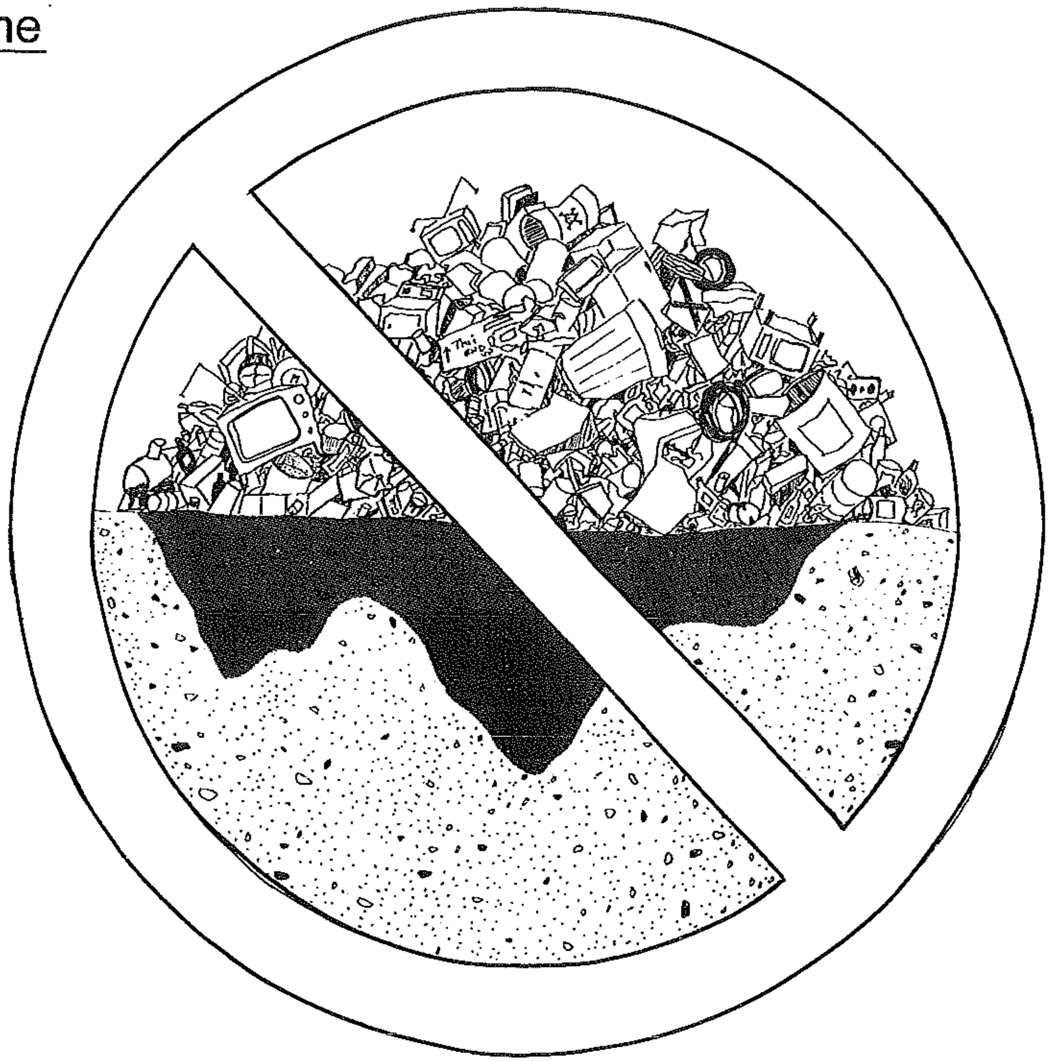
Households today use many more hazardous products than their counterparts of a generation ago.

The kinds of hazardous products used today are different than those used a generation ago.

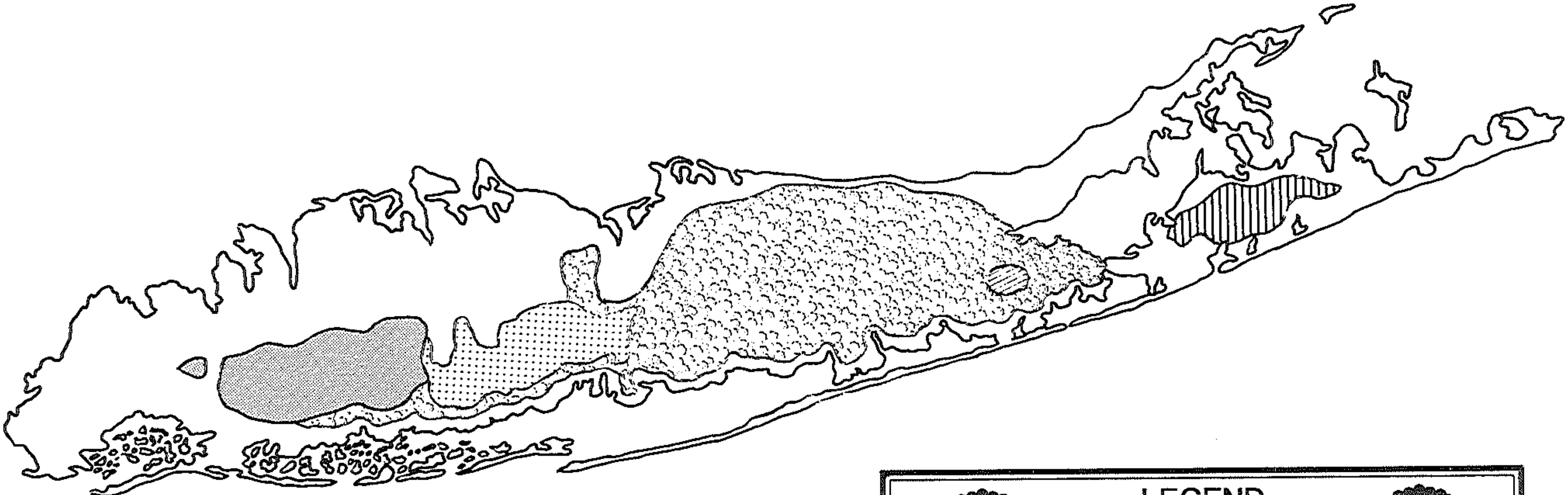
Activity #6

HAZARDOUS HOUSEHOLD PRODUCTS SURVEY

Hazardous Wastes In The Home



THE PINE BARRENS
Long Island's Watershed



LEGEND

- HEMPSTEAD PLAINS ....red
- OAK BRUSH PLAINS ....yellow
- CENTRAL SUFFOLK PINE BARRENS......orange
- DWARF PINE PLAINS ....blue
- SOUTH FORK PINE BARRENS ....green

DIRECTIONS

1. Color the patterned sections of this map.
   Use the map legend to select the proper color.
2. Use this map to complete Question Sheets A and B.

Source: Modified from Cryan, 1977.

Vocabulary

Oak Brush Plains: This woodland is Long Island's most western formation of the Pine Barrens. This area is characterized by dense thickets of scrub oak with occasional pitch pines spaced widely apart. Originally covered about 50,000 acres; today 2,000 remain.

Central Pine Barrens: This woodland is found east of the Oak Brush Plains. Pitch pines become increasingly dominant. Almost all of central Suffolk is covered with Pine Barrens. The Pine Barrens also covers much of Long Island's South Fork. It is absent from the North Fork.

Dwarf Pine Plains: Found in Westhampton, Long Island, the dwarf pitch pine forest is one of three such forests in the world. Pines and scrub oak in this area average 4 to 6 feet in height when full grown.

Groundwater: Water which exists underground in the spaces between sand or rocks called "pores". Groundwater is rainwater that falls on earth and sinks through the soil.

Aquifer: A layer of rock material (such as sand) which holds water and allows water to move through it.

Recharge: Water that travels down through the ground to replenish the groundwater supply.

Groundwater Recharge Area: An area of special importance to the groundwater because its location and quality of its soil allows for large amounts of water to return to the aquifer reservoirs.

Vocabulary

Wisconsin Glacial Stage: The last of 4 principal North American glacial stages. This stage is believed to have lasted 60,000 years. The last ice disappeared from the north-central United States about 10,000 to 15,000 years ago.

Outwash Plain: A plain formed by water melting from a glacier. The meltwater carried rock material away from a moraine and deposited it over a large area. The rocks were sorted by the water. Heavier rock material was deposited closer to the moraine while lighter material such as sand and silt was carried further by the water.

Moraine: Unsorted rocks or fragments of rocks carried down and dumped by the glacier. These rocks are angular in shape and often scratched because they are dragged and not rolled along by the glacier.

Till: Unsorted glacial rock deposits usually found in moraines.

Ronkonkoma Moraine: The moraine left by the first glacial advance of the Wisconsin Stage occurring about 60,000 years ago.

Harbor Hill Moraine: The moraine left by the final advance of the Wisconsin Glacial stage occurring about 23,000 years ago.

Terryville Outwash Plain: The outwash plain located between the Harbor Hill Moraine to the north and the Ronkonkoma Moraine to the south.

Hempstead Outwash Plain: The outwash plain found south of the Ronkonkoma Moraine.

Fire Climax Ecosystem: An ecological system that maintains its dominance by encouraging and adapting to fire.

Pine Barrens: A type of plant and animal community that has adaptations allowing them to survive in a system maintained by fire.

Pitch Pine: A tree found in the Pine Barrens. Considered the most fire adapted tree in the northeast U.S.

Scrub Oak: A low thicket-forming shrub found in the Pine Barrens. A large root system allows this oak to quickly sprout new growth after a fire.

Hempstead Plains: Found in Nassau County, these plains were America's eastern-most true prairie. They once covered 60,000 acres; today only about 19 acres remain.

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found. Pines in this area average 4 to 6 feet in height. Harsh conditions of nutrient-poor soil and frequent wildfires have molded the pigmy forest, producing a rare ecosystem adapted to extreme fire stress.

The Pine Barrens And Long Island's Groundwater

The porous soils in the outwash plain formations on Long Island make these landforms superb natural recharge areas. Because the Pine Barrens grow on this permeable substrate, they have become associated with Long Island's aquifer system. The Pine Barrens are an important part of our groundwater system, their continued existence insures a clean abundant supply of drinking water.

PROCEDURE

1. Present material on the Pine Barrens according to your particular discipline and purpose.

2. Instruct your students to complete the mapping exercise. Stress that this map portrays Long Island before there was development of the Pine Barrens. For example, you might point out that the Hempstead Plains are, in effect, an extirpated ecosystem. So little of the plains remains that its integrity as a system has permanently been disrupted.

MODIFICATIONS

1. This mapping exercise could be further enriched through the viewing of the Museum of Long Island Natural Sciences' film, "LONG ISLAND WILDERNESS... THE PINE BARRENS".

2. This mapping exercise has been developed primarily to help students learn more about Long Island's water resources. However, Long Island's geology and past vegetation history has application in many disciplines throughout the sciences and social sciences.

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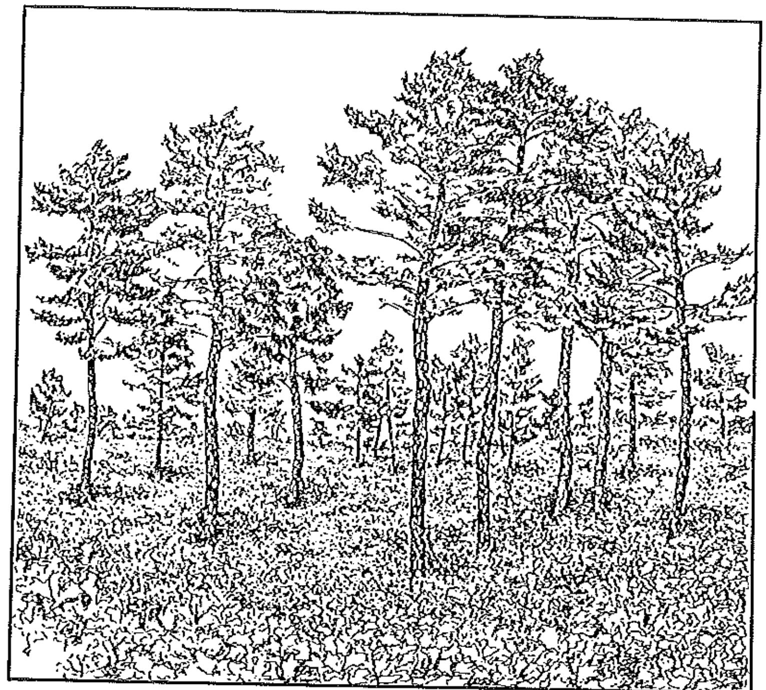
Moraines

Morainal soils on Long Island are generally made up of till or unsorted sediments. They contain enough silt, clay and organic matter to enrich the soil and allow it to retain moisture. Deciduous hardwood forests are found on most of Long Island's morainal hills. Chestnut-oak forests once covered the morainal areas. Earlier in this century blight eliminated most of the large chestnut trees. Oaks now dominate the hills, while the chestnuts barely reach shrub height before dying back. The blight girdles the young shoots. Portions of the Ronkonkoma Moraine such as the Manorville and Riverhead Hills are sandy and gravelly and are more like outwash deposits.



OAK BRUSH PLAINS LANDSCAPE

Outwash Plains

Outwash soils are generally composed of sorted rock material such as sand and gravel. The excessively-drained soils found here support a series of four fire climax ecosystems. These fire dependent plant communities form west-east gradations as they occur along Long Island's central corridor. From west to east, these communities are:

a. Hempstead Plains: These plains were America's easternmost true prairie. This grassland originally encompassed 60,000 acres. Today only 19 remain.

b. Oak Brush Plains: This woodland is the most western formation of the Long Island Pine Barrens. Widely spaced Pitch pines (Pinus rigida) rise like islands surrounded by dense thickets of Scrub Oak (Quercus ilicifolia) and Dwarf Chestnut Oak (Quercus prinoides). The Oak Bush Plains originally encompassed 50,000 acres. Today 2,000 remain intact. The Heath Hen, an eastern subspecies of the Greater Prairie Chicken, was a common resident of the Oak Brush Plains. Because of habitat destruction and excessive market hunting, the Heath Hen had been extirpated from Long Island by the 1930's. The species became extinct by 1932.

c. Central Pine Barrens: The Central Pine Barrens are found east of the Oak Brush Plains. They are characterized by the increasing dominance of the Pitch pine (Pinus rigida). This region has 3 major streams that traverse the Pine Barrens: The Connetquot, Carmens and Peconic Rivers. Unique Pine Barrens flora and fauna are found in these wet-lands. Further east, the Pine Barrens cover sections of the Ronkonkoma Moraine that are sandy and gravelly.

d. Dwarf Pine Plains: South of Riverhead near the Suffolk County Airport in Westhampton a globally rare dwarf pitch pine forest is

BACKGROUND INFORMATION

Glaciers Shaped Long Island's Surface

Long Island's surface topography originated from the deposits left by the last two advances of glacial ice occurring during the Wisconsin Glacial Stage. As these glaciers retreated northward, the rock material left behind and the manner in which it was deposited and sorted left regional differences in Long Island's soils, topography and microclimates. These factors, in addition to vegetational history determine the vegetation of Long Island's present and past.

Glacial Landforms

As the glacier receded, meltwater sorted the glacial till and formed the broad, flat outwash plains. The Terryville Outwash Plain occurs between the Harbor Hill and the Ronkonkoma Moraines while the Hempstead Outwash Plain is found south of the Ronkonkoma Moraine. These outwash plains cover large expanses of Long Island and their soils are predominately sandy.

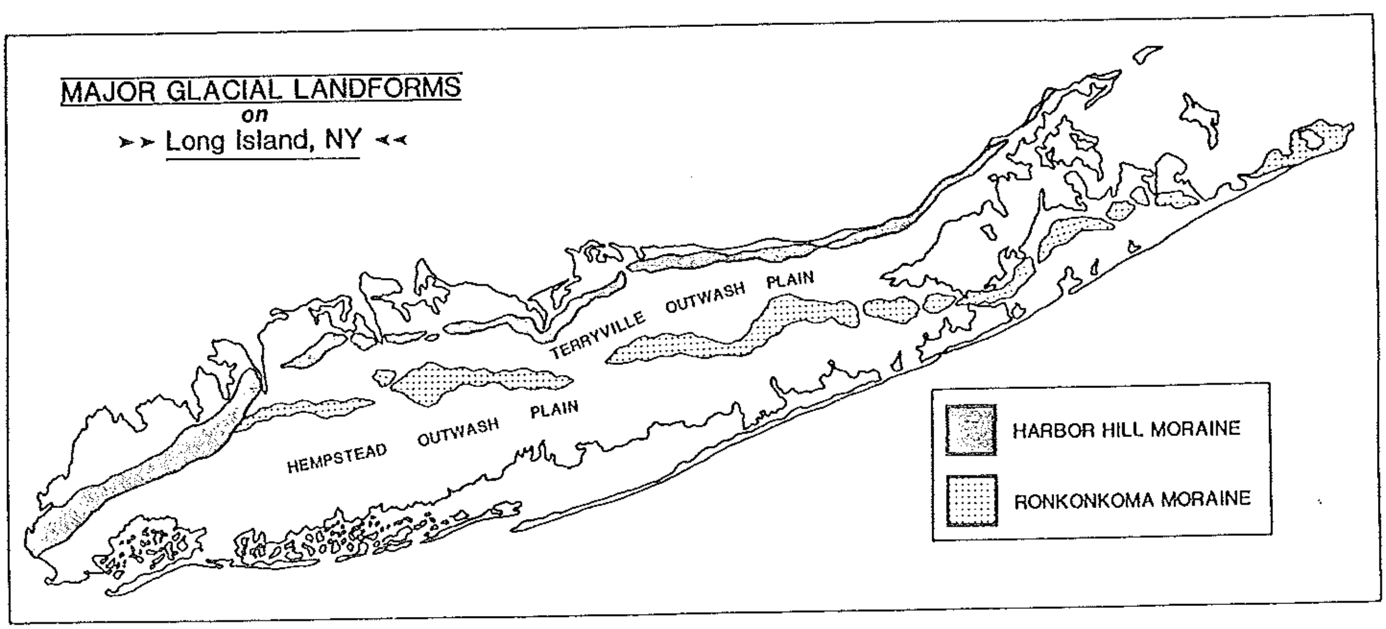
The Pine Barrens

About 5,000 to 8,000 years ago, the Pine Barrens and other fire climax ecosystems began to appear on these outwash plains. Today we continue to find them on the remaining natural portions of the outwash plains.

The last substantial stand of Pine Barrens endures in central and eastern Brookhaven and encompasses the Terryville Outwash Plain, the Hempstead Outwash Plain and portions of the Ronkonkoma Moraine (such as the Manorville and Riverhead Hills) that are sandy and gravelly as are the outwash deposits.

Soils, Landforms And Vegetation Patterns

Soils play a feature role in both the ecology and water resources of a region. Long Island's soils can be broadly classified according to their glacial origins. Soils found on moraines and outwash plains will generally differ because outwash plain deposits have been sorted by water. Since soils influence the types of plants in an area, vegetation trends can be correlated with soil types. Therefore, on Long Island, vegetation patterns can be associated with glacial landforms. The following descriptions demonstrate how the soil composition of glacial landforms influences vegetation.



THE PINE BARRENS
Long Island's Watershed

OBJECTIVES

Long Island's Pine Barrens and the Hempstead Plains are fire climax ecosystems. A mapping activity introduces these ecosystems and the gradations between the various fire climax communities.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 7-12
Earth Science
Biology
Environmental Studies
Long Island History

Earth Science Regents Syllabus

Topic II C-1
Topic IX B-2

BEHAVIORAL OBJECTIVES

Upon completion of this activity, students should be able to:

a. identify Long Island's various fire climax ecosystems (most specifically Pine Barrens communities).

b. describe a connection between Long Island's Pine Barrens and groundwater resources.

MATERIALS

Vocabulary Sheet
Pine Barrens Map
Color markers or pencils

MAJOR UNDERSTANDINGS

Long Island's Pine Barrens are fire climax ecosystems that are dependent upon fire to maintain their existence.

Long Island's Pine Barrens once encompassed over 250,000 acres. Today less than 100,000 remain.

Long Island's Pine Barrens are predomiantly found on the sandy outwash plain formations.

Long Island's Pine Barrens support many plant and animal species that are absent or rarely found in most eastern deciduous forests.

Long Island's Pine Barrens consist of several formations that contain various arrangements of plant and animal species that are endemic to the Pine Barrens but occur in different distributions and abundance.

Long Island's most recent glaciation has determined the character and placement of soils.

Soils influence the vegetation that grows upon them.

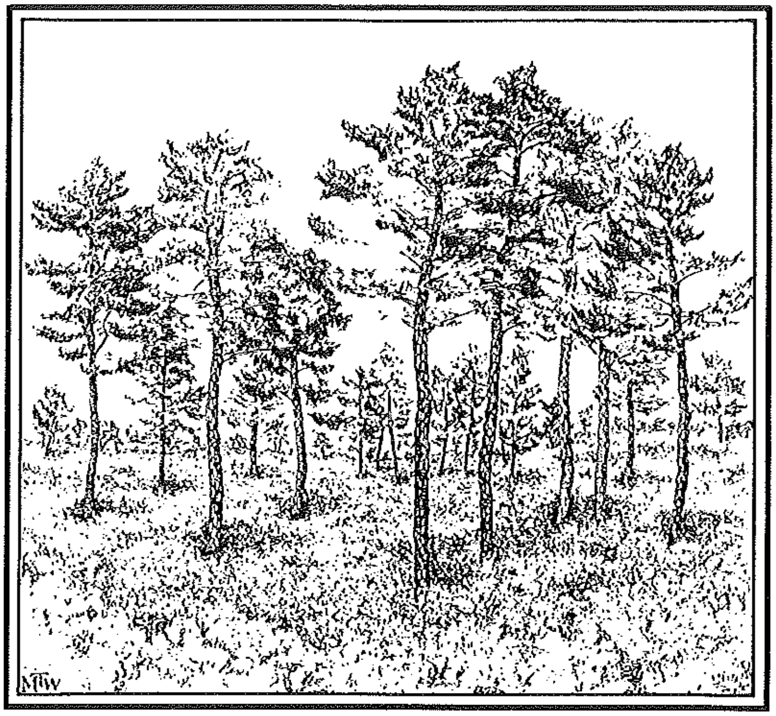
The vegetation patterns we find on Long Island today have their origins in the glacial deposits of the past.

The porous soils of Long Island's outwash plains make them superb natural recharge areas.

The Pine Barrens occur on these same outwash plains and are, therefore, associated with Long Island's groundwater resources.

THE PINE BARRENS

Long Island's Watershed



SOILS AND GROUNDWATER QUALITY

Vocabulary

SOIL ASSOCIATIONS: A grouping of soils of similar characteristics.

SOIL PROFILE: A side view of a vertical section of soil showing all horizontal layers.

SOIL HORIZON: An individual layer in a soil profile. Each horizon has its own characteristic properties.

PERMEABILITY: The quality of soil that enables water to move through it.

AVAILABLE MOISTURE CAPACITY OR SOIL STORAGE (ST): The amount of water in soil that is available to plants.

SAND: A name that refers to the size of a rock particle. Sand is finer than gravel but coarser than clay and silt. Sand can contain particles of any mineral, however, it often is mostly quartz. Sand does not hold water well and water moves quickly through it.

SILT: A name that refers to the size of a rock particle. Silt particles are finer than sand but coarser than clay.

CLAY: A name that refers to the size of a rock particle. Clay particles are extremely fine. Clay holds water very well and tends to stick together when wet. Because of this characteristic, it can be shaped and molded to make pottery.

SOIL TEXTURE: The relative proportions of sand, silt and clay particles in a mass of soil. Soil texture largely determines the ability of soil to hold water and have water move through it.

LOAM: Soil that contains substantial proportions of sand, silt and clay.

COARSE-TEXTURED SOIL: Sand and loamy sand.

MODERATELY COARSE-TEXTURED SOIL: Sandy loam and fine sandy loam.

MEDIUM-TEXTURED SOIL: Very fine sandy loam, loam, silt loam, silt loam and silt.

WATER TABLE: The upper surface of groundwater; that level below which the soil is saturated with water.

SEASONAL HIGH WATER TABLE: The highest level the water table will rise to during the year (usually during spring).

Vocabulary

Soil Drainage Terms

EXCESSIVELY DRAINED: These soils are very porous and rapidly permeable with a low water-holding capacity.

WELL-DRAINED: These soils are moderately permeable in surface and subsoil layers and rapid or very rapid beneath these layers.

MODERATELY WELL-DRAINED: These soils commonly have a slowly permeable layer in or immediately beneath the upper part of the soil profile.

POORLY DRAINED: These soils are wet for long periods of time.

Soil Types Worksheet

SOILS	SOIL SYMBOLS
1. Carver and Plymouth Sands:	Cp
2. Haven Loam:	Ha
3. Montauk Fine Sandy Loam:	Mf
4. Plymouth Loamy Sand:	Pl
5. Riverhead Sandy Loam:	Rd
6. Scio Silt Loam:	Sc

DIRECTIONS

Using Data Sheets A and B, select the soils that are most suitable for the land uses listed below. Record the soil symbol(s) on the line next to each land use.

1. Agricultural fields: ____________________
2. Open space: ____________________
3. Homesites: ____________________
4. Homesites with cesspools: ____________________
5. Homesites with restrictions on housing density: ____________________
6. Homesites with lawns: ____________________
7. Homesites with native vegetation: ____________________
8. Athletic fields, golf fairways: ____________________
9. Sanitary landfills: ____________________

Data Sheet A

Land Uses

HOMESITES

Homes or other buildings of 3 stories or less.

Soil Characteristics Considered:
1. Depth to seasonal high water table.

Concerns: water table may cause problems with basements and foundations.

CESSPOOLS

Homesite Sewage Disposal Systems

Soil Characteristics Considered:
1. Soil permeability.
2. Depth to seasonal high water table.

Concerns: housing density; dense concentrations of cesspools can pollute groundwater with nitrates and synthetic organic chemicals.

LAWNS, GOLFCOURSES, ATHLETIC AND AGRICULTURAL FIELDS

Areas where native vegetation has been replaced.

Soil Characteristics Considered:
1. Soil Surface texture.
2. Depth to seasonal high water table.

Concerns:
1. Groundwater pollution may occur from leaching of fertilizers and pesticides.
2. Suitability of soil for growing grass and agricultural products.

SANITARY LANDFILLS

Landfills are places where garbage is disposed of by burial.

Soil Characteristics Considered:
1. Soil permeability.
2. Depth of seasonal high water table.

Concerns: rainwater contaminated by toxic materials in landfills may leach through soil and pollute groundwater.

Soil Characteristics

PLYMOUTH LOAMY SAND — Pi

Texture: coarse
Drainage: excessive
Soil Storage: low to very low
Permeability: rapid throughout
Native Vegetation: Pine Barrens
Location: moraines and outwash plains

CARVER AND PLYMOUTH SANDS — Cp

Texture: coarse
Drainage: excessive
Soil Storage: low
Permeability: rapid throughout
Native Vegetation: Pine Barrens
Location: outwash plain

RIVERHEAD SANDY LOAM — Rd

Texture: moderately coarse
Drainage: well drained
Soil Storage: moderate to high
Permeability: surface layer - moderately rapid
substratum - very rapid
Native Vegetation: oak-hardwood forest
Location: moraines and outwash plains

HAVEN LOAM — Ha

Texture: medium
Drainage: well-drained
Soil Storage: moderate to high
Permeability: surface layer-moderate
Substratum - rapid to very rapid
Native Vegetation: Pine Barrens
Location: outwash plain between terminal moraines

SCIO SILT LOAM — Sc

Texture: medium
Drainage: moderately well-drained
Soil Storage: moderate to high
Permeability: surface layer - moderate
substratum - moderately slow
Native Vegetation:
Location: moraines but mostly on outwash
Water Table: found at depth of 1½ to 2 ft. in wet periods below 30" during dry periods

MONTAUK FINE SAND LOAM — Mf

Texture: moderately coarse
Drainage: well-drained to moderately well-drained
Soil Storage: moderate to high
Permeability: surface layer - moderate to moderately rapid
substratum - moderately slow
Native Vegetation: oak-hardwood forest
Location: terminal moraines

Data Sheet B

Land Use Planning Chart

SLIGHT indicates:

(1) that the soil has few or no limitations for a particular use,
(2) that any limitation can be overcome at little cost,
(3) or that the use will have little impact on ground water.

MODERATE indicates;

(1) that the limitation is harder to correct,
(2) that there is a danger of groundwater contamination,
(3) or that it is not possible in some areas to correct entirely.

SEVERE indicates:

(1) the use of the soil is severely limited by some soil characteristic,
(2) that the danger of groundwater pollution is extreme,
(3) that the costs of overcoming the limitations are excessive.

For use in determining the suitability of certain land uses for particular soil types.

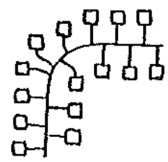
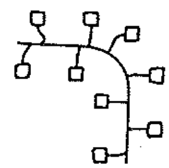
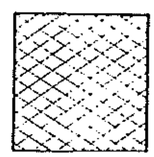
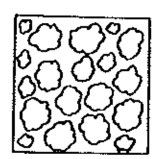
SOIL TYPES / LAND USES	CESSPOOLS or SEWAGE DISPOSAL FIELDS	HOMESITES	LAWNS, GOLF COURSES, ATHLETIC FIELDS, AGRICULTURAL FIELDS	SANITARY LANDFILLS
1. Carver and Plymouth Sands **Cp**	SLIGHT: but dependent on housing density.	SLIGHT	SEVERE: sandy surface layer, rapid permeability, hazard of water pollution by leaching of fertilizers and pesticides.	SEVERE: rapid permeability; hazard of water pollution.
2. Haven Loam **Ha**	SLIGHT: but dependent on housing density.	SLIGHT	SLIGHT: but dependent on amount and type of pesticides and fertilizers used.	SEVERE: rapid permeability; hazard of water pollution.
3. Montauk Fine Sandy Loam **Mf**	SEVERE: moderately slow permeability.	SLIGHT	SLIGHT: but dependent on amount and type of pesticides and fertilizers used.	MODERATE: but dependent on importance of recharge area.
4. Plymouth Loamy Sand **Pl**	SLIGHT: but dependent on housing density.	SLIGHT	SEVERE: sandy surface layer, rapid permeability, hazard of water pollution by leaching of fertilizers and pesticides.	SEVERE: rapid permeability; hazard of water pollution.
5. Riverhead Sandy Loam **Rd**	SLIGHT: but dependent on housing density.	SLIGHT	SLIGHT: but dependent on amount and type of pesticides and fertilizers used.	SEVERE: rapid permeability; hazard of water pollution.
6. Scio Silt Loam **Sc**	SEVERE: moderately slow permeability in substratum.	MODERATE: seasonal high water table at a depth of 1½ to 2 ft.	SLIGHT: but dependent on amount and type of pesticides and fertilizers used.	SEVERE: seasonal high water table level at depth of 1½ to 2 feet.

Land Use Planning Map

Plan the development of a Long Island community that does not threaten its own groundwater supply. Use the information you learned in Part 1 to help you with your Land Use Planning Map. Don't feel that you must use the land use patterns that you may be familiar with such as those found in your neighborhood.

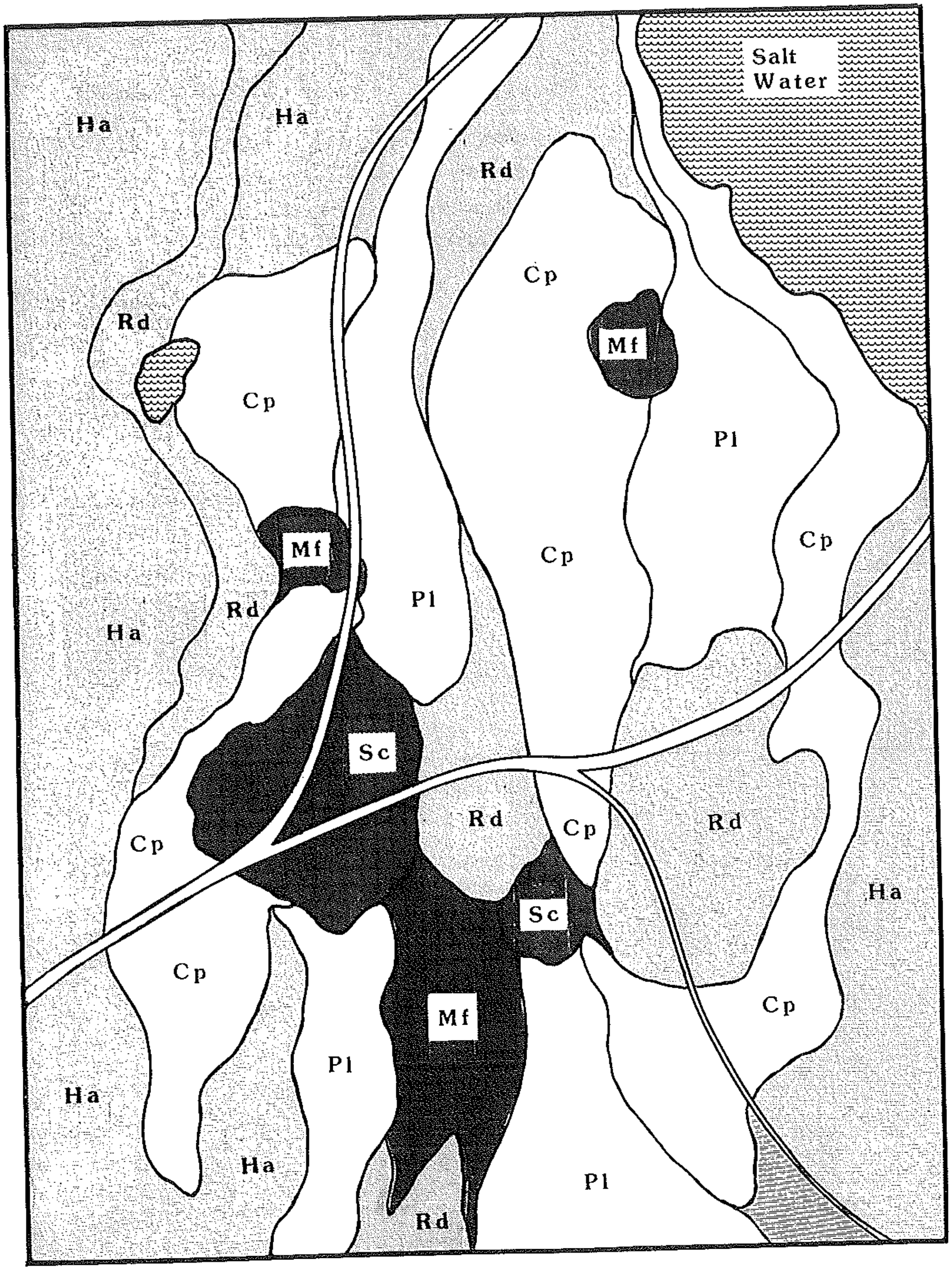
1. Use the map on the Land Use Planning Worksheet to plan your land development. Sketch lightly with a pencil. Use the land use symbols found on this page. Use the best land uses for each soil type.

2. When your outline is finished use a ballpoint pen to darken in your sketch. Keep in mind that your goal is land use that preserves groundwater. If a land use doesn't you can leave it out.

Land Uses Symbols	
	HOMESITES
	LOW DENSITY HOMESITES
	ATHLETIC FIELDS
	FARMLAND
	SANITARY LANDFILL
	OPEN SPACE

Soil Permeability
Very Rapid
Moderately Rapid
Moderate to Slow

Land Use Planning Worksheet



SOILS AND GROUNDWATER QUALITY
Question Sheet

Answer the following questions.

1. What factor makes soil unsuitable for homesites?

   a. Sandy surface layer.

   b. Water table close to the land's surface.

   c. Rapid permeability.

   d. Coarse texture.

2. Why does slow permeability create a severe rating condition for cesspools on the LAND USE PLANNING CHART?

   a. It interferes with the cesspool installation.

   b. It allows for pollution of the groundwater.

   c. Cesspools need water to drain from them to function properly.

   d. Water will drain through the cesspool too rapidly causing them to work improperly.

3. If cesspools are used in very permeable soil what might happen to the groundwater beneath them?

   a. The groundwater will move faster beneath the cesspool.

   b. The groundwater may become polluted.

   c. The cesspools will prevent the groundwater from receiving recharge water.

   d. The groundwater levels will be reduced.

4. How can landfills affect the quality of water beneath them?

   ____

   ____

5. Two lawns are planted using the same variety of grass. One is planted on Plymouth and Carver Sands, the other on Haven Loam. Because of the different characteristics of these soils one of these lawns will need additional care if both lawns are to maintain the same quality. Circle the soil type that will need additional lawn care.

   a. Plymouth and Carver Sands b. Haven Loam

6. Lawns grown on sandy, excessively drained soils are likely to require additional fertilizer, pesticides and water. List 2 effects that this additional lawn care may have on the groundwater.

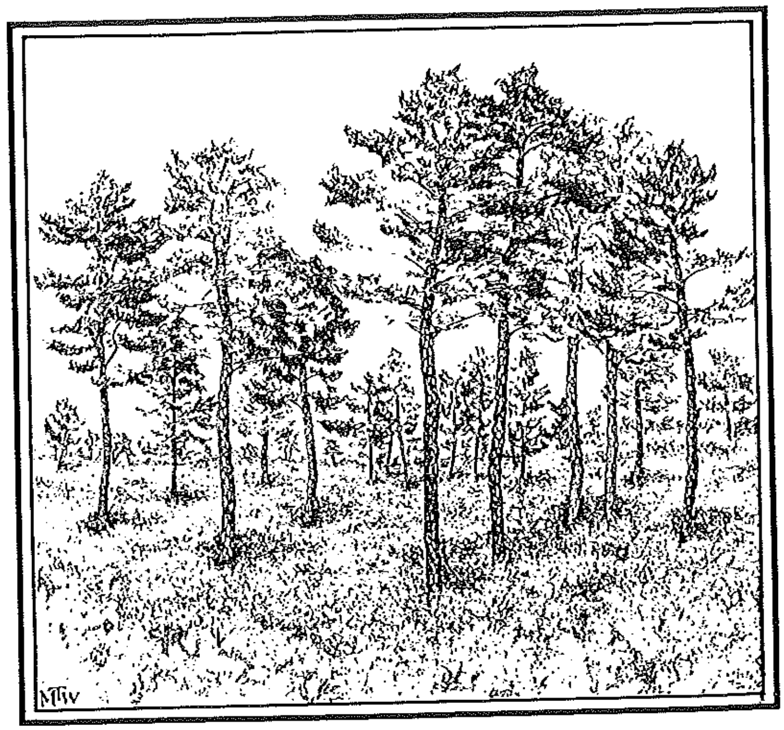
   a. ____

   b. ____

Activity #9

ENVIRONMENTAL DECISION-MAKING IN THE PINE BARRENS

Economic Growth
or
Groundwater Quality



ENVIRONMENTAL DECISION-MAKING IN THE PINE BARRENS

Economic Growth or Groundwater Quality

OBJECTIVES

A mock public hearing discussing a proposal to limit development in the Pine Barrens introduces students to the socio-economic issues, costs and conflicts involved in decision-making that concerns economic growth vs. natural resource conservation.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 7-12
Social Studies
Environmental Studies
Language Arts

BEHAVIORAL OBJECTIVES

Upon completion of this activity, students should be able to, depending on their role in the public hearing:

a. assist in the preparation of an effective presentation of an assigned viewpoint.

b. effectively present an assigned viewpoint at the mock public hearing.

c. using arguments prepared and presented by both sides of the issue, make a decision about a proposal to limit development in a critical groundwater recharge zone.

d. discuss the PROS and CONS of controlled building and be able to list 3 PROS and 3 CONS on this issue.

e. make a decision on whether to have controlled development and give 2 reasons to support their decision.

MATERIALS

Position Cards
Pros and Cons Worksheet

MAJOR UNDERSTANDINGS

Land is an important facet of human ecology because it provides the basic materials for survival.

Human societies have unlimited wants and needs which must be reconciled with the finite resources that they use.

There is a link between land use and environmental quality.

Certain land uses can irreversibly limit our use options. These include:

a. land uses which disrupt sensitive ecological systems such as the Pine Barrens to a degree which precludes re-establishment of that system.

b. land uses which alter natural resources such as groundwater and renders them useless to society for large spans of time.

Proper land use planning is accomplished through familiarity with local environmental conditions, identification of potential problems and decisive action to achieve land uses that are most appropriate to the local geography and ecology.

Unlimited property rights are not an absolute but vary depending on the society in which we live.

Adjustments in property rights must be carefully examined so that they reflect rational thought and concern for our present and future well-being.

BACKGROUND INFORMATION

The Pine Barrens

The Pine Barrens once covered about 250,000 acres on Long Island. Today less than half these acres remain; nearly all are found in Suffolk County. The most conspicuous feature of the Pine Barrens is the dominant pitch pine found in association with scrub oak, low-bush blueberry, black huckleberry, sheep laurel, bracken fern, wintergreen and bearberry.

The economic reality of Long Island in the mid-1980's forecasts extensive changes in these remaining tracts of the Pine Barrens. Though substantially reduced from its original range, the 100,000 remaining acres still face unrelenting developmental pressure. Until recently, though, the Pine Barrens remained sparsely developed and underutilized. This deliberate avoidance was a backlash arising from the Pine Barrens' inability to support Long Island's past agrarian economic system. The same sandy, dry soils that gave advantage to the pitch pine failed to sustain our agricultural designs. Other factors, such as its propensity and actual need to burn to reduce competition from non-pine barrens species, also contributed to the stigmatizing of the Pine Barrens. As our economic structure shifted towards industrial, commercial and extensive residential development, the Pine Barrens offered a commodity that coincided, at last, with our needs - land.

But, just when we thought the Pine Barrens had little to offer but wide open space for development, we discover that beneath its sandy soil there lies the most pristine portions of the underground aquifers that are the sole source of drinking water for millions of Long Islanders.

Land Use, The Pine Barrens And Groundwater Quality

On 20th century Long Island, any development that alters the natural vegetation will affect the quality of the groundwater. Recharging water enters the groundwater at the land's surface. Concentrations of of contaminants in groundwater, therefore, are directly related to their discharge at the land's surface. Affronts to our aquifers include the leaching of materials such as agricultural chemicals, nitrates from cesspools, hazardous wastes from industry and fuel spills.

The groundwater beneath Suffolk's Pine Barrens is pure because it has largely been inaccessible to the wide range of human activity. Water percolating down through Pine Barrens soil will continue to recharge high quality potable water only if the Pine Barrens continue.

Inevitably, land use decisions will have to be made to insure the continuation of the quality of Long Island life both in terms of economics and natural resource protection. Our last wilderness areas and also our last substantial, unpolluted aquifer reservoir are one and the same. Without proper planning, the undoing of one will likewise undo the other.

Long Island's Hydrogeologic Zones

The strategic importance of the Pine Barrens to Long Island's groundwater reserves can best be perceived through the understanding of the hydrogeologic zone concept. The hydrogeologic zone concept was developed in 1978 as a part of THE LONG ISLAND COMPREHENSIVE WASTE TREATMENT MANAGEMENT PLAN (208 STUDY) prepared by The Nassau-Suffolk Regional Planning Board. Originally conceived to guide wastewater management decisions, the zonation concept's effectiveness in other land use planning areas soon became apparent. For example, the hydrogeologic zones were used in the 1983 Long Island Landfill law as a way of determining future sanitary landfill sites on Long Island. This law requires the phasing out of all landfills in important groundwater recharge areas.

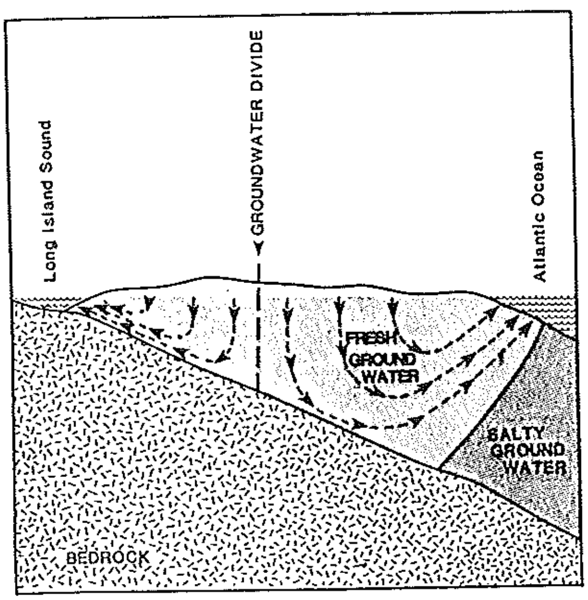


Figure 1 GROUNDWATER MOVEMENT IS LAYERED

A hydrogeologic zone is determined by the flow dynamics and groundwater quality of an area. Groundwater tends to move in a layered pattern with little mixing, as shown by the arrows in Figure 1. Water that has entered the groundwater is in motion towards the sea.

Because of the differences in groundwater flow dynamics, hydrogeologic zones are separated into two categories:

1) deep flow recharge zones and
2) shallow flow recharge zones.

Deep Flow Recharge Zones

Deep flow recharge zones are characterized by a vertical component to the groundwater flow of the water recharging in these zones. Gradually, the groundwater moving vertically levels off to move horizontally before arching upwards toward the coast. The boundary between the deep and the shallow flow recharge zones occurs when groundwater flow loses its vertical component and becomes completely horizontal. The boundary is defined as the most shoreward point of this horizontal flow. Water entering the deep flow area must travel quite a distance through the aquifer system before discharging into coastal waters.

Shallow Flow Recharge Zones

In the shallow flow recharge areas, recharging water enters only a shallow portion of the aquifer. Its residence time in the aquifer is short when compared to the hundreds or thousands of years water may remain in the deeper aquifers. The groundwater occurring in the deeper aquifers beneath the shallow recharge zone was originally recharged in the deep flow recharge zone.

Most Water Used On Long Island Is Recharged In The Deep Flow Zone

Because of the nature of the groundwater flow in the deep flow recharge area, the aquifer area influenced is considerably larger than might be expected from the size of the land area that recharges it, as shown in Figure 2. Precipitation recharging this area replenishes the Magothy and Lloyd Aquifers which provide drinking water to most Long Island residents.

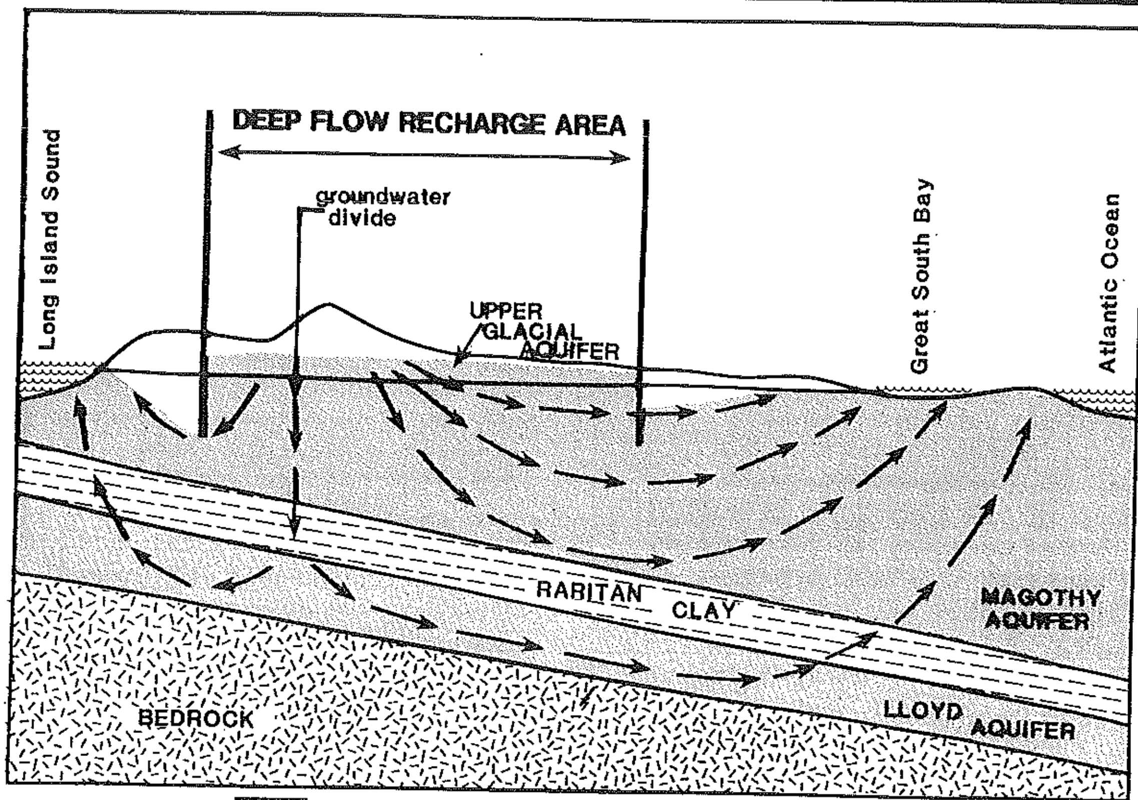


Figure 2

Aquifers Containing Fresh Groundwater

Extent Of The Shallow Flow Recharge Area

Source: Modified from L. I. Groundwater Management Program, NY State-DEC, 1986.

Most of the remaining Pine Barrens acreage occurs in the deep flow recharge zones found in central Suffolk County and on the south fork. The groundwater below the Pine Barrens is of exceptional quality because the land above is in its natural condition. The water is plentiful because the land's natural recharge patterns remain intact.

Protecting Natural Areas Protects Groundwater

In order to protect groundwater quality and quantity, it is imperative that land use decisions are made while land is still in its natural state. The Pine Barrens stands found on Long Island are indicators of fresh, clean and abundant groundwater.

When the natural landscape is changed by humans, the condition of their groundwater supply is changed.

PROCEDURE

1. Present material on the Pine Barrens and arrange for a viewing of the film, "Long Island Wilderness...The Pine Barrens."

2. Three students should either volunteer or be assigned the role of County Legislator. Divide the remaining class members into six groups. Appoint a moderator for the Public Hearing.

3. Each group member should receive a copy of his/her group's position.

4. Group members should become familiarized with their assigned points of view. Each group should prepare a presentation to give at the Public Hearing. A discussion of the difference between fact and opinion at this juncture would help students with their presentations.

5. The County Legislators should spend this time becoming familiarized with the various groups' positions. Provide them with viewpoint sheets of the other groups. Stress that their job is one of responsibility to protect and improve the quality of life of their constituents both for the present and future.

6. At the Public Hearing, each group's spokesperson should present the group's viewpoint. After each presentation the floor can be opened for questions. (During question time, students not involved in the presenting group can act as members of the public).

7. After the Public Hearing, the Legislators should cast their votes for or against the proposal to limit development in the Pine Barrens. The Legislators should provide reasons for their position.

8. Student should complete the PROS and CONS Worksheet.

ADVANCED PLANNING

Make arrangements for the film, "Long Island Wilderness...The Pine Barrens".

MODIFICATIONS

If class numbers require fewer groups, coalitions can be formed between groups who share similar positions.

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THE LONG ISLAND PINE BARRENS...OUR FRAGILE WILDERNESS, Glenn A. Richard, Museum of Long Island Natural Sciences, Occasional Publication No. 3, SUNY at Stony Brook, 1979.

THE PINE BARRENS, John McPhee, Ballantine Books, NY, 1967.

Vocabulary

GROUNDWATER: The supply of freshwater occurring in aquifers below the earth's surface.

AQUIFER: An underground geologic formation that stores significant quantities of groundwater and allows that water to move through it.

RECHARGE: Water that travels down through the ground to replenish the groundwater supply.

GROUNDWATER RECHARGE AREA: An area that is especially important to the groundwater because its location, geology and quality of soil allow for large amounts of water to return to the groundwater reservoirs.

ECOLOGICAL COMMUNITY: A group of plants and animals in an area that are dependent on each other for food and other needs.

LAND USE: The way humans use the land. Some land use examples are building houses and factories, farming, landfilling garbage and recreational activities such as hunting, camping and hiking.

LEGISLATURE: A group of elected officials who have the authority to make laws.

LEGISLATION: Laws made by a legislature.

PUBLIC HEARING: A meeting where public officials and private citizens can express their positions on specific issues.

COALITION: A union or combinations of persons or groups into one group.

CONTROLLED BUILDING PROPOSAL: A proposal to limit development in an area. In our activity, this proposal would control development in the Pine Barrens; an important groundwater recharge area.

name ____________________

ENVIRONMENTAL DECISION-MAKING
In The Pine Barrens

Legislator

Position Card

Responsibilities

Responsible for the protection and improvement of the quality of life for constituents.

Position

Undecided about a proposal to limit building in the Pine Barrens.

The Problem

The population, represented by the legislator, would benefit from the increased opportunities fo jobs that building would bring. New industry would increase the tax base of the community, providing money for the improvement and maintanence of community structures and service.

On the other hand, uncontrolled building on the Pine Barrens may harm the pure groundwater that exists beneath it. If contaminated, the groundwater system could remain so for a long time. This groundwater is Long Island's only source of drinking water.

Legislative Powers

Each Legislator has the power to introduce or influence legislation that may become law. They are influenced by many groups both for and against this proposal.

Decision

The Legislator's decision on the proposal should be based on what is in the best interest of the community as a whole both present and future.

notes

name ____________________

ENVIRONMENTAL DECISION-MAKING
In The Pine Barrens

County Department Of Public Health

Position Card

Responsibilities

Responsible for the maintenance of public health standards.

Position

Favors the proposal to limit building in the Pine Barrens.

Argument

1. Factories, industrial parks, stores and houses increase the likelihood of groundwater contamination because of the potential for intentional or unintentional toxic spills. This can include deliberate spills or ones caused by decaying storage containers or leaks in sewer systems.

2. The potential for harm to the only source of drinking water we have outweighs the benefits we would receive from an increase in industry.

notes

name ______________________

ENVIRONMENTAL DECISION-MAKING
In The Pine Barrens

Town Planning Board

Position Card

This board is responsible for planning the development of a township located in the county where the proposal to limit development is being considered. This town has extensive stands of Pine Barrens within it. If the proposal passes, development of this town would be particularly affected.

Position

Opposed to the proposal to limit building in the Pine Barrens.

Argument

1. Companies that own factories pay taxes. New taxes will provide new monies to increase and improve services to the community.

2. New factories create new jobs and reduce unemployment.

3. New factories attract new workers to the community. New workers in an area require new housing and services such as stores, restaurants and movie theatres. In this way a community grows.

4. The construction of new houses would relieve the housing shortage.

notes

name ______________________________

ENVIRONMENTAL DECISION-MAKING
In The Pine Barrens

Pine Barrens Preservation Society

Position Card

This group is made up of private citizens concerned about the ever increasing destruction of the rare and unique Pine Barrens ecosystem. As concerned citizens, they are exercising their right to make their views known to their elected representatives.

Position

Favors the proposal to limit building in the Pine Barrens.

Argument

The Pine Barrens should be protected because of the following reasons:

1. The Pine Barrens is a rare, unusual and very complex ecosystem.
2. Many endangered and threatened plants and animals exist in the Pine Barrens. Over-development could result in their elimination from Long Island.
3. The Pine Barren is a fire-dependent forest community. Large tracts of land are required to allow burns to occur. Without fire the Pine Barrens cannot maintain itself.

notes

name ____________________

ENVIRONMENTAL DECISION-MAKING
In The Pine Barrens

Citizens For The Preservation Of Long Island's Water Resources

Position Card

This group is made up of private citizens concerned over the ever increasing contamination of groundwater supplies on Long Island. They are exercising their rights as citizens to make their views known to their elected representatives.

Position
Favors the proposal to limit building in the Pine Barrens.

Argument
Construction of homes and factories in the Pine Barrens has the potential to affect groundwater quality in the following ways:

1. The construction of buildings, roads and parking lots may disrupt the rainwater drainage patterns in these important groundwater recharge areas.

2. Hazardous materials may be intentionally or unintentionally spilled and enter the groundwater system.

notes

name ______________________

ENVIRONMENTAL DECISION-MAKING
In The Pine Barrens

Metro Plastics Company

Position Card

The Metro Plastics Company is a mid-sized plastics manufacturing company. They are interested in moving their operation to Long Island. They produce toxic wastes as by-products of their manufacturing process. They are concerned about groundwater pollution and plan to install safety equipment to monitor the production, storage and transport of hazardous wastes.

Position

Opposed to the proposal to control building in the Pine Barrens.

Argument

1. If their factory is built, they would offer 500 new jobs with excellent benefits to local people.

2. Once established, their company will pay taxes. Taxes will contribute to the well-being of the community through an increased ability to provide services.

3. Undeveloped construction sites, in the Pine Barrens, are excellent locations because they are close to New York City and because they are low-priced when compared with other real estate on Long Island.

notes

name ______________________

ENVIRONMENTAL DECISION-MAKING
In The Pine Barrens

Long Island Development Company

Position Card

The Long Island Development Company is a large, private construction company that develops land. They build houses, stores, shopping malls, restaurants, public buildings, factories, industrial parks, roadways and bridges. They are a profit-making company and employ many Long Islanders.

Position

Opposed to the proposal to control building in the Pine Barrens.

Argument

1. Increased industry brings more people into the county which means more housing will be needed. More people and more housing mean more services needed for these people. New roadways, stores, etc. will be needed.

2. These construction booms create many new construction jobs.

3. Limiting construction in the county's largest undeveloped area would slow economic growth in the county.

4. A controlled building law would force the L.I. Development Co. to move off the Island because it would not be profitable to stay. This would cause the unemployment of many Long Islanders.

5. Without new tax monies (which new factories and homes would provide) the county will be unable to start new public service projects and may be unable to maintain existing ones.

notes

Pros and Cons Worksheet

You've seen the film, attended the hearing and observed the results of the County Legislators' voting - now come to your own conclusion about the proposal to limit development in the Pine Barrens.

DIRECTIONS

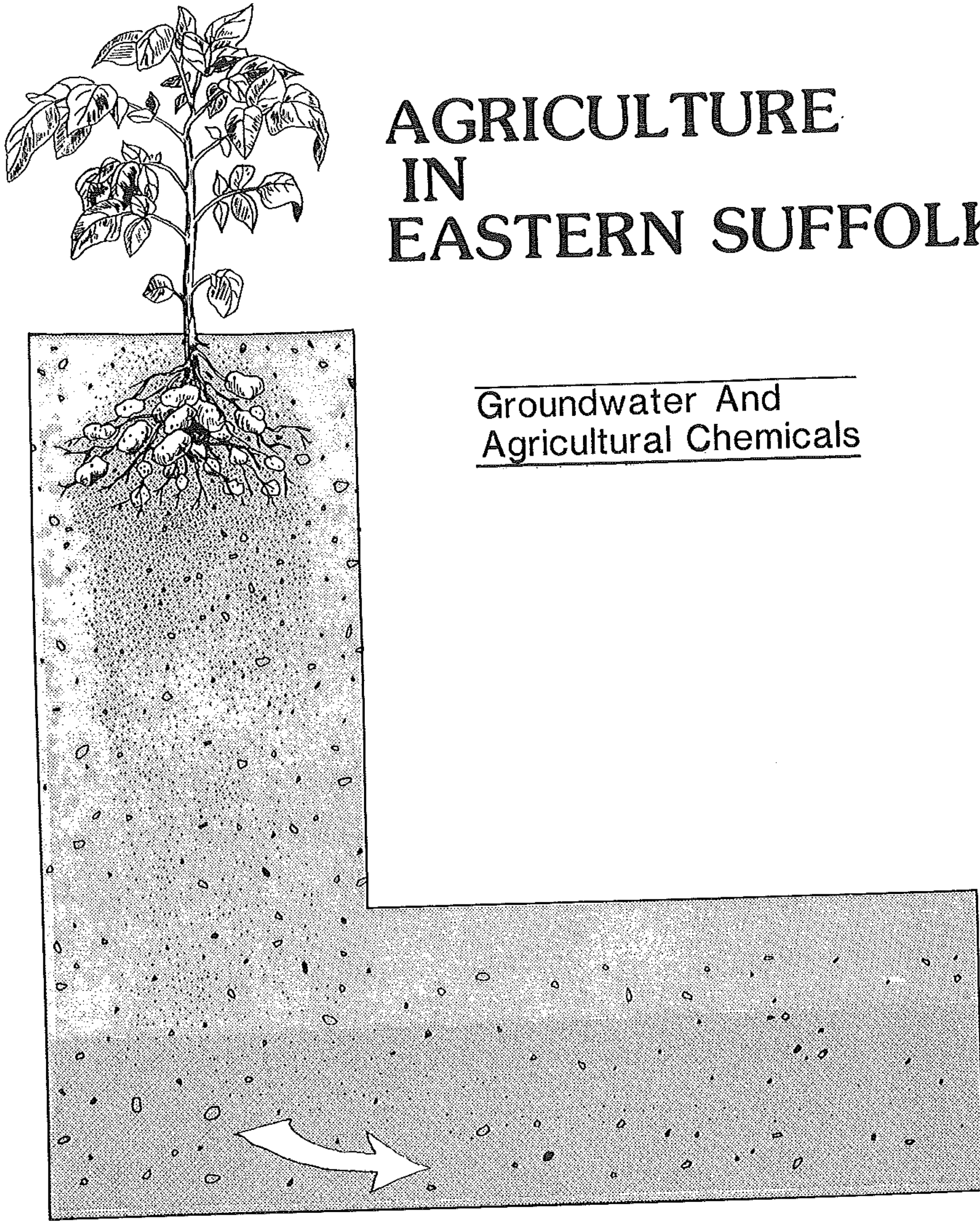
Add more PROS and CONS to the list and come to your own conclusion about the proposal for controlled development in the Pine Barrens.

PROS	CONS
1. ground water recharge area drainage would be unaffected	1. will cause unemployment among construction workers
2. ____	2. ____
3. ____	3. ____
4. ____	4. ____
5. ____	5. ____

If I was a legislator I'd vote ____________(for or against) the controlled building proposal for the following reasons:

1. ____________________

2. ____________________



AGRICULTURE IN EASTERN SUFFOLK

Groundwater And Agricultural Chemicals

AGRICULTURE IN EASTERN SUFFOLK

Groundwater and Agricultural Chemicals

OBJECTIVES

Using maps depicting land uses, nitrate levels in recharge water and groundwater contamination from Aldicarb, students will associate groundwater contamination with pollution sources such as pesticides, fertilizers and sewage. The dynamics of groundwater movement is introduced as a land use planning tool.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 9-12
Earth Science
Social Studies

Earth Science Regents Syllabus

Topic II C-1
Topic VIII A-3

BEHAVIORAL OBJECTIVES

NITRATES IN GROUNDWATER

Upon completion of this activity students should be able to:

a. list sources of nitrates in groundwater.

b. identify problems caused by nitrates in groundwater.

c. prepare a map transparency that associates land uses with the levels of nitrogen-nitrates in water that recharges the groundwater.

PESTICIDES AND GROUNDWATER MOVEMENT

Upon completion of this activity students should be able to:

a. describe how pesticides can enter the groundwater.

b. identify the direction of groundwater movement using information given on Map Worksheet #3.

c. examine the issue of who is responsible when groundwater becomes contaminated.

d. extrapolate the direction of movement that nitrate-contaminated recharge (Map worksheets #1 and #2) would take using information obtained on Map worksheet #3: Pesticides in Groundwater.

MATERIALS

Vocabulary Sheet
Maps A-C
Student Procedures
Question Sheets
Colored markers or pencils in the following colors:

- green
- red
- yellow
- blue
- orange

1 9"x7" acetate sheet

MAJOR UNDERSTANDINGS

Low population density in a region does not guarantee that groundwater will remain pure.

Modern agricultural practices can result in contamination of groundwater from pesticides and fertilizers.

The Pine Barrens of Suffolk County is the largest expanse of open space that remains on Long Island.

The Pine Barrens is a critical Long Island watershed because of its excessively well-drained soils and its location.

Groundwater quality is most effectively preserved by conservation of open space.

BACKGROUND MATERIAL

Suffolk Is A Diverse County

Suffolk, Long Island's eastern-most county, is multi-faceted and distinctive in many respects. Its western portion is similar to Nassau--a heavily populated urban-surburban community that enjoys economic growth, stability and a high standard of living. Moving east, surburbia subtly shifts towards rural farmland and open space. Suffolk's soils and climate enable the county to produce more agricultural products than any other county in New York. Suffolk also has other distinctions. Two, in particular, are intricately connected and important to the continuance of the high quality of life Long Islanders have grown to expect.

Groundwater And The Pine Barrens

One of these distinctions is a natural abundance of pristine groundwater stored primarily in a three tier aquifer system that, in places, attains depths of over 2,000 ft. below sea level. The second distinction is the Pine Barrens. This pitch pine-dominated wilderness inconspicuously flourishes on the same soils that allow ready passage and storage of recharge water. The Pine Barrens and the groundwater system comprise a considerable portion of Long Island's natural heritage and are coupled in a manner that makes it unlikely to preserve one resource without protecting the other.

Nassau And Suffolk Overlay The Same Water Resource

Suffolk County's groundwater resources are contiguous with the aquifers that underlie Nassau County. Though geologically the same beneath the ground, the two counties face different problems above the ground.

Suffolk Still Has Time

Because of a lower population density and a time lag in development pressures, Suffolk does not face the immediate dilemma that irks Nassau's water supply system. However, as development pressures in Suffolk continue to mount, harbingers of future quandaries - contaminated wells - begin to appear. Suffolk, however, still has time to make essential land use decisions.

Nassau no longer has so extensive a choice. With some amount of fortune, Suffolk, being the most eastern county on Long Island, can learn from the imprudent mistakes made by its neighboring sequence of counties stretching west towards NYC.

Rural Long Island Faces Groundwater Problems

A problem that Suffolk has recently had to face, with no true Nassau County counterpart to learn from, is groundwater contamination by agricultural pesticides. This problem first surfaced in 1980 when Aldicarb was detected in private wells in eastern Long Island. As more wells were found to be contaminated, it became apparent that low population density and a land's rural character do not guarantee pure groundwater below.

Since then, a number of other pesticides have been found in Suffolk County groundwater.

Pesticides And Fertilizers Can Leach Into Groundwater

Pesticide contamination is not the only groundwater problem induced by modern farming practices. Nitrates leach from applications of artifical fertilizer and find their way into the groundwater. Nitrates also enter aquifers by way of turf fertilizers and cesspools.

Land Uses Above Ground Determine Groundwater Quality Below Ground

Human activities above the ground determine the quality of water below. The concentration of contaminants in groundwater is related to the amount of pollutants released at the land's surface where groundwater recharge begins.

Recharging water in agricultural areas can contain nitrates and pesticides. Residential locations may recharge water that contains nitrates from sewage and turf fertilizer and organic chemicals that may be used on-site.

Groundwater Preservation

Groundwater is most effectively protected by comprehensive knowledge of the integral aspects of the aquifer system and proper planning and use of the land's surface. In critical watershed areas, the preservation of open space or the most limited use of the land are the only unequivocal methods of protecting groundwater. In Suffolk County, critical watershed areas are synonymous with the Pine Barrens. Figure 1 shows the portion of Suffolk covered with this ecosystem.

The Pine Barrens Is An Important Aquifer Watershed

Two important characteristics of the Pine Barrens promote its decisive significance as a critical watershed area. One of these characteristics is its soils. Generally sandy and excessively well-drained, these soils quite readily allow water to penetrate them. The surface of the soil is almost always dry. These soils are perhaps the major factor responsible for the evolution of the Pine Barrens and their endurance today. Until recently, soils determined the patterns of land development. Development pressures in Suffolk have historically been agrarian. Consequently, the Pine Barrens, unsuited for agriculture, has been left untouched prior to the

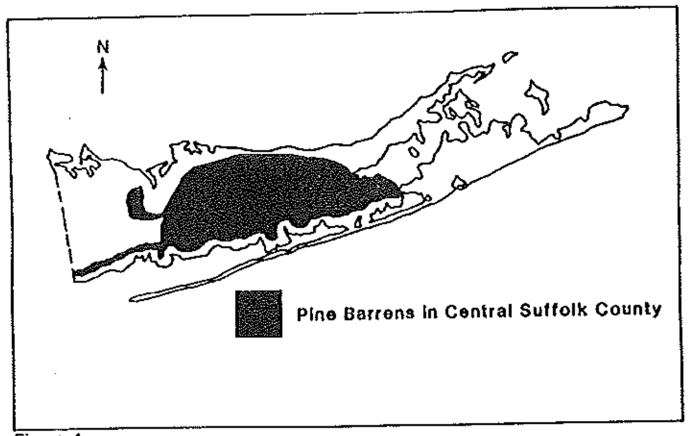


Figure 1

recent residential, commercial and industrial development boom. As adequate drinking water becomes scarce and pressure for development in the Pine Barrens increases, arduous decisions will have to be made that determine what types of land use in the Pine Barrens will be congruous with preserving groundwater quality.

PROCEDURE

1. Present material on groundwater and its contamination by agricultural chemicals.

2. Hand out materials.

3. Instruct students to use the Student Procedure Sheet to complete the mapping activities.

4. Have students answer the question sheets.

REFERENCES

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LONG ISLAND GROUNDWATER MANAGEMENT PLAN - DRAFT, New York State Department of Environmental Conservation, Albany, 1983.

A CITIZEN'S HANDBOOK ON GROUNDWATER PROTECTION, Wendy Gordon, Natural Resources Defense Council, Inc., 122 East 42nd Street, New York, NY 10168.

SOUTHOLD DEMONSTRATION SITE - New York State Fertilizer and Pesticide Demonstration Project, Keith Porter et al., Center for Environmental Research. Cornell University, Ithaca, New York, 1983.

WATERSHED DISTRICT STUDY for the Town of East Hampton, Rochris & Associates, Inc. et al., Sept. 1982.

Vocabulary

NITRATE (NO_3): A compound of nitrogen and oxygen. Nitrates are considered health hazards and are linked with the disease infant methomoglobinemia and also with stomach cancer. Methemoglobinema affects babies by depriving their cells of oxygen. Sources of nitrates in groundwater include cesspools, artifical fertilizers, sewer line leaks and farm animal wastes.

RESIDENTIAL AREAS: Places where houses are located. Nitrate problems result from high cesspool densities and artifical fertilizers used on lawns.

RECHARGE: Precipitation water that replenishes the groundwater aquifers.

PESTICIDES: Substances used to kill or control animal, insect and plant populations.

ALDICARB: A pesticide that was used on potato fields in Suffolk County from 1976-1979. It entered groundwater and is responsible for contaminating thousands of private wells. The manufacturer of the pesticide has provided filters for these wells. The pesticide was banned from use on Long Island in 1980.

PLUME: The path followed by particles, liquids and gases discharged into the air, surface water and groundwater. In the case of groundwater, a contaminant will flow from its source, in the direction of groundwater movement.

GRADIENT: The rate of change between two points; the quantity of change per unit of distance.

The following activity uses a study area located in the town of Southampton. The study area is the small triangle on the map below.

1. MAP A: LAND USES

   Color the different land uses according to the colors listed on the Land Use Key found to the left of the map.

2. MAP B: NITROGEN IN RECHARGE WATER

   Place an acetate sheet over Map B. Use a ball point pen to trace the triangular outline of the study site. Be sure the boundary lines continue to line up as you complete the activity.

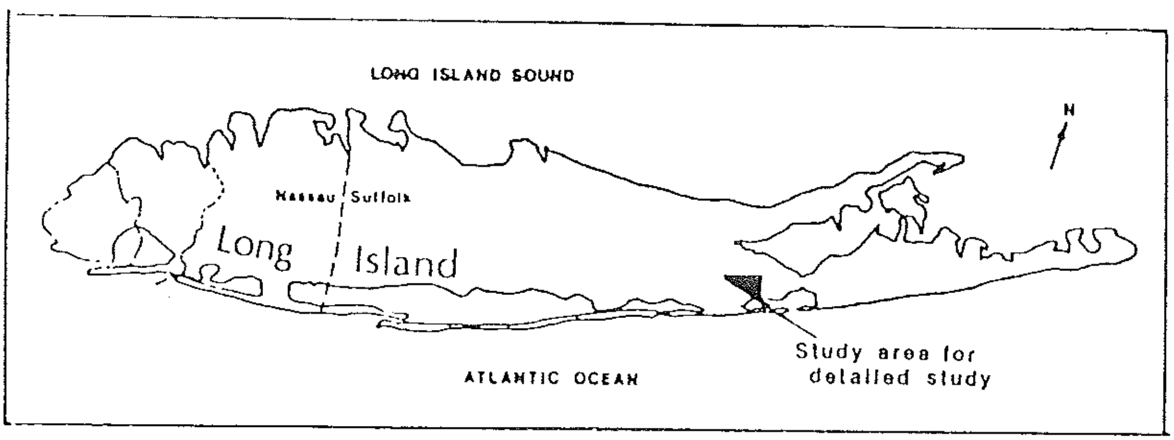
3. Use a ball point pen to trace over the pattern, on Map B.

4. When step 3 is completed, place the acetate sheet over Map A. Line both maps up.

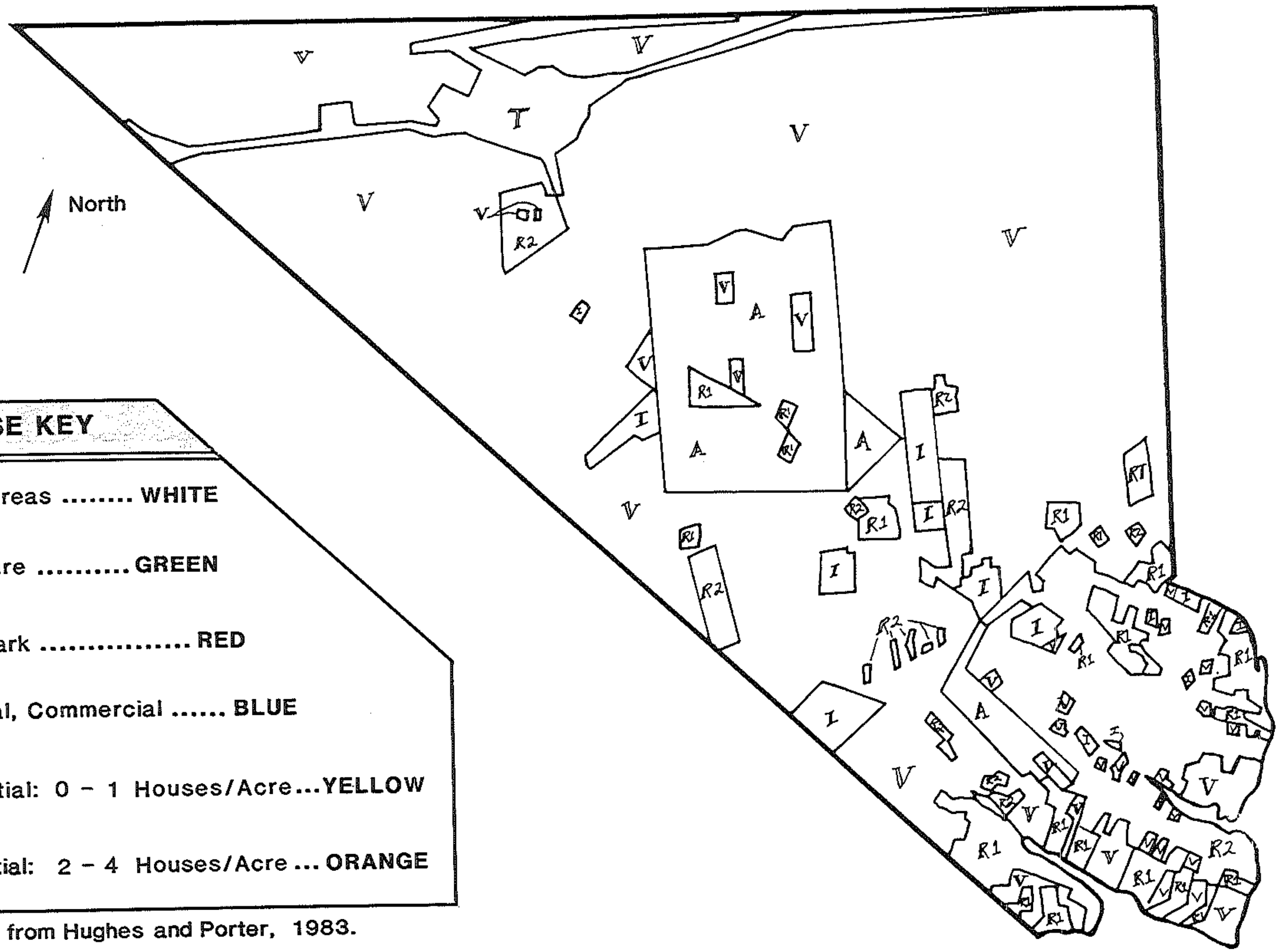
5. Use these two maps and your knowledge of groundwater to answer the NITRATES AND GROUNDWATER Question Sheet.

6. MAP C: EXISTING AND POTENTIAL ALDICARB CONTAMINATION

   Use Map C to answer the PESTICIDES AND GROUNDWATER Question Sheet.



Map A



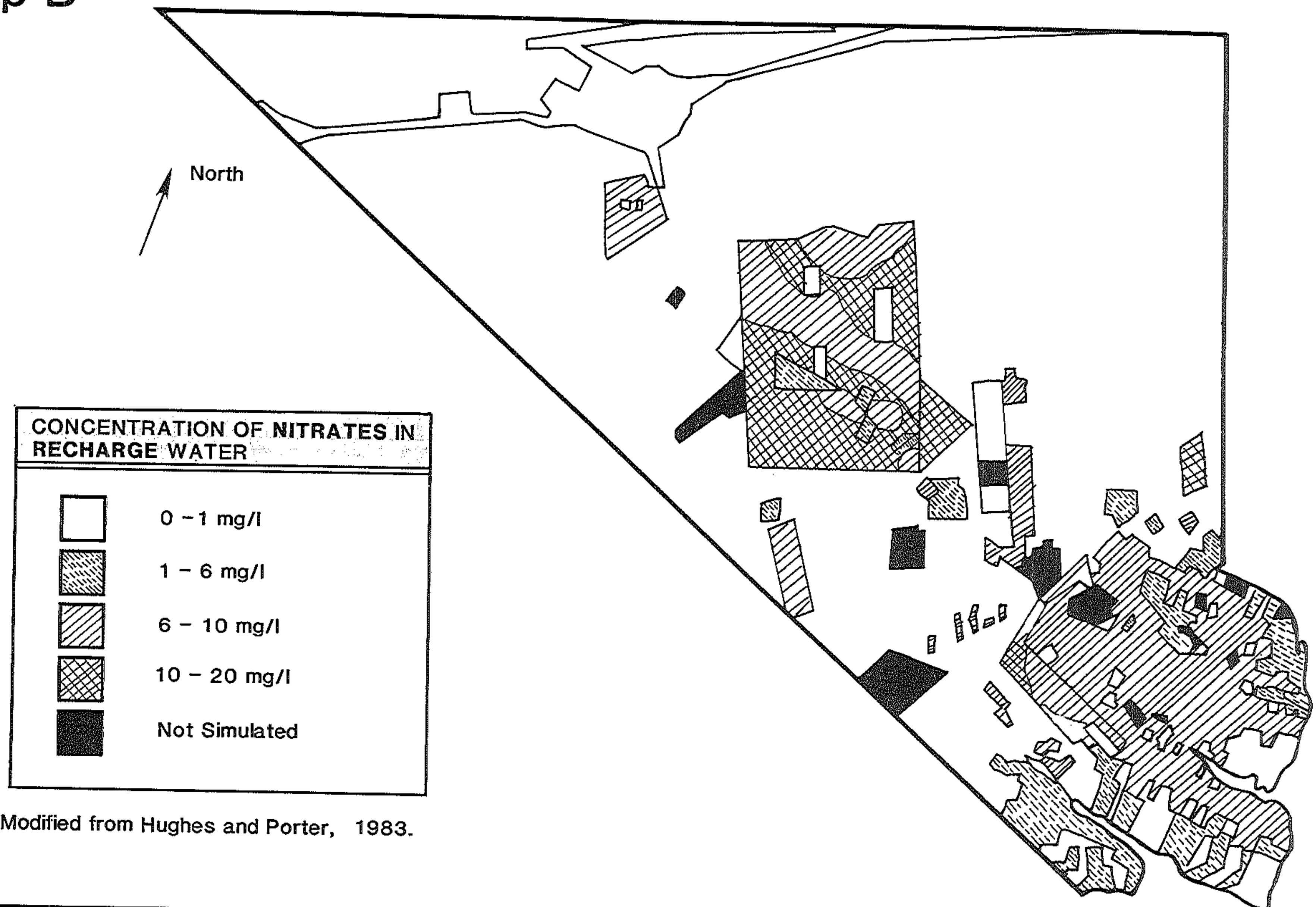
LAND USE KEY

V	Vacant Areas .... WHITE
A	Agriculture .... GREEN
RT	Trailer Park .... RED
I	Industrial, Commercial ...... BLUE
R1	Residential: 0 – 1 Houses/Acre...YELLOW
R2	Residential: 2 – 4 Houses/Acre ... ORANGE

Source: Modified from Hughes and Porter, 1983.

Map B

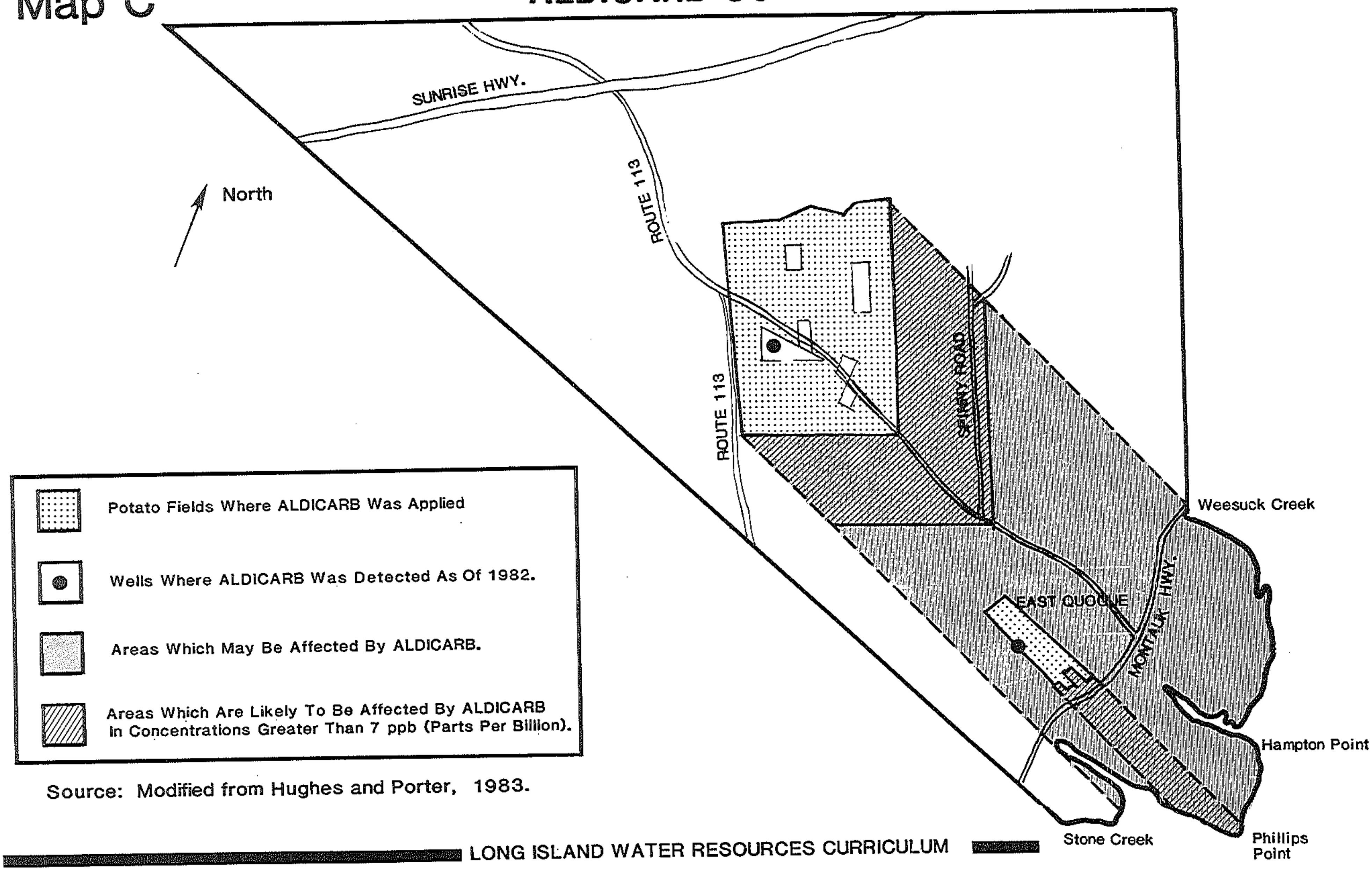
NITROGEN IN RECHARGE



Source: Modified from Hughes and Porter, 1983.

EXISTING AND POTENTIAL ALDICARB CONTAMINATION

Map C



Source: Modified from Hughes and Porter, 1983.

NITRATES AND GROUNDWATER
Question Sheet For Maps A and B

Answer the following questions.

1. How do residential areas contribute to the nitrate contamination of groundwater?

   a. Through pesticide use.

   b. By leaving trees and other native plants on the land.

   c. Through cesspools and artificial lawn fertilizers.

   d. By paving over large portions of the yard.

2. Look at the two categories for residential land use (R1 and R2). Why do these two areas have different concentrations of nitrates in their recharge water?

   ____

3. How do agricultural areas contribute to the nitrate contamination of groundwater?

   a. Through pesticide use.

   b. By applications of artificial fertilizers.

   c. By concentrating farm animals, such as ducks in one large area.

   d. By plowing fields too early in the spring.

4. Which 2 land uses have the highest concentration of nitrogen in their recharge?

   a. Industrial/Commercial and Trailer Parks.

   b. Trailer Parks and Agriculture.

   c. Residential (R1) and Agriculture.

   d. Vacant Areas and Residential (R2).

5. What category has the lowest concentration of nitrates in its recharge water?

   a. Trailer Park.

   b. Agriculture.

   c. Vacant Area.

   d. Residential (R1).

6. Why would this category have low concentrations of nitrogen in its recharge water?

   ____

   ____

Question Sheet For Maps A and B

7. Observe the agricultural area (A) that occupies a big rectangle near the center of the map. What might cause the bands of different nitrate concentrations that run from the top left to the bottom right portion of the rectangle? Hint: What factor most affects the rate at which recharge water moves through the soil?

PESTICIDES AND GROUNDWATER
Question Sheet For Map C

Answer the following questions.

1. What is Aldicarb?

   a. An artifical fertilizer. c. A pesticide.
   b. A variety of Potatoe. d. An industrial cleaner.

2. In which direction is the Aldicarb plume predicted to move?

   a. northeast c. north
   b. southeast d. west

3. Compare Map C and Map B. Map B shows the nitrate levels in water recharging under different land uses. Using information found on Map C, predict the direction in which the nitrate-contaminated groundwater will move.

   a. northeast c. north
   b. southeast d. west

4. List 1 reason why the area furthest down gradient from the potatoe field may or may not be contaminated while the area closest to the field is likely to have high concentrations of Aldicarb.

   ____

   ____

5. Find Spinny Road on the map. If you lived on this street and got your drinking water from a private well it is quite possible that it would be contaminated with Aldicarb above the safe limit. Answer the following questions:

   a. Who do you think should be held responsible for this contamination: the potatoe farmer or the pesticide manufacturer?

   ____

   b. Why? ____________________________________

   ____

   ____

PESTICIDES AND GROUNDWATER
Question Sheet For Map C

Now that you know about groundwater movement in Southampton, Long Island, answer the following questions:

6. Which land areas on Map C would be important to protect if you were responsible for land use planning decisions that would protect groundwater quality in East Quogue?

   a. Land south of East Quogue.

   b. Land northwest of East Quogue.

   c. Land northeast of East Quogue.

   d. Land west of East Quogue.

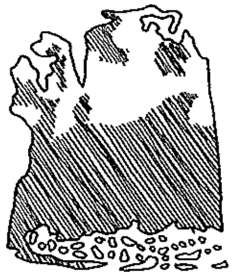
7. Why are these areas most important to groundwater protection?

   ____

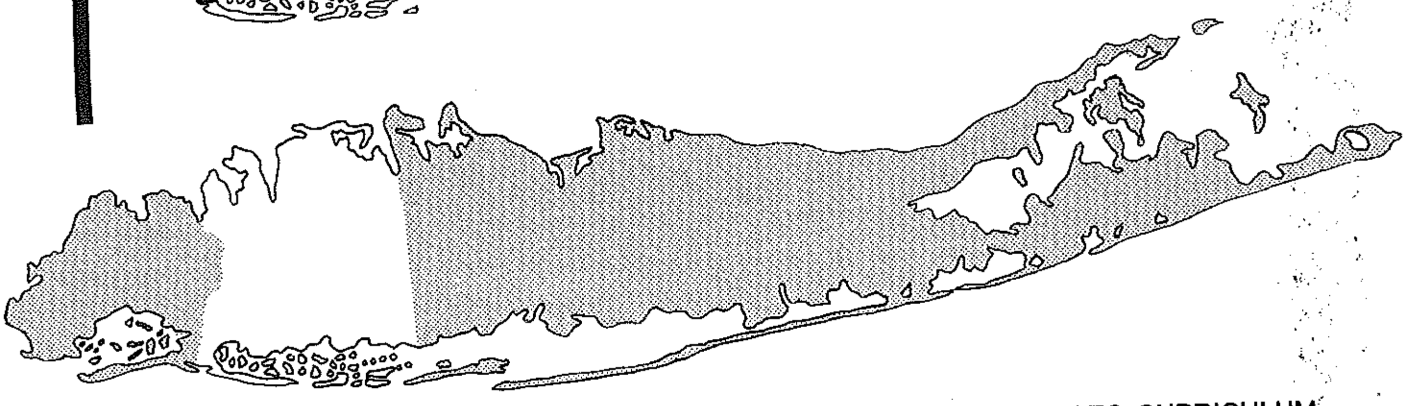
   ____

Activity #11

GROUNDWATER IN NASSAU COUNTY



Quantity And Quality Problems



LONG ISLAND WATER RESOURCES CURRICULUM

GROUNDWATER IN NASSAU COUNTY

Quantity and Quality Problems

OBJECTIVES

Using maps depicting groundwater mining, sewer districts, synthetic organic chemical pollution and land uses, students will associate groundwater contamination and depletion with land use patterns and population density. Critical Nassau County watershed areas will be identified by inference from maps.

SUGGESTED GRADE LEVEL AND DISCIPLINE

Grades 9-12
Earth Science
Soil Studies
Environmental Science
Land Use Planning

Earth Science Syllabus

Topic VIII-A-3

BEHAVIORAL OBJECTIVES

Upon completion of this activity students should be able to:

a. correlate areas in Nassau County that show evidence of groundwater contamination with land use patterns above the aquifer.

b. correlate areas in Nassau County that are experiencing groundwater quantity problems with population density.

c. identify areas in Nassau County that would be most suitable for protection status as critical watershed areas.

d. make 3 recommendations that would help insure the protection of critical watershed areas.

MATERIALS

Maps A-D
Vocabulary Sheet
2 8½"x5½" acetate sheets
#2 pencil
ball point pen
Question Sheets

MAJOR UNDERSTANDINGS

Land use patterns can affect groundwater quality.

Densely populated areas can affect the quantity of groundwater beneath them.

Densely populated sections in Nassau County have become sewered to protect the groundwater from domestic waste-water pollution.

Sewers reduce groundwater recharge by diverting wastewater into coastal waters.

The level of groundwater in certain areas in Nassau County is declining because sewer systems divert recharge water and dense populations place a great demand on the water supply.

A condition known as groundwater mining occurs when more water is taken out of an aquifer than is replaced.

Once contaminated, Long Island's groundwater can remain so for hundreds or even thousands of years.

Two parcels of land in North Nassau, representing 14% of the county's land area, have been designated as Special Groundwater Protection Areas and are the last remaining Nassau County Watersheds that harbor clean and plentiful groundwater.

BACKGROUND INFORMATION

Nassau County, sandwiched between the metropolitan boroughs of Queens and Brooklyn on the west and Suffolk County on the east, is a community evolving from a surburban to an urban community in its own right. As the county's development has expanded and its ensuing population grown, the pressure placed upon its water supply has posed serious questions that concern the ability of the land to support future water use needs.

Nassau County's Water Resources

Nassau is, like Suffolk to the east, wholly dependent on its underlying groundwater for all water needs. As the county's development continues, an increased demand will be levied upon its water resources. Increasing water usage, extensive sewering, less land available for precipitation recharge and an expanding economic infrastructure will continue to hold the potential for affronts to the integrity of the aquifers below Nassau County.

The capacity of land to support human populations is not infinite. At some point, the land's ability to provide for needs and to be renewed will reach a standoff. Once this level is exceeded, natural resources, such as water, become effectively non-renewable. In the view of the New York State Commission on Long Island Water Resources, "the manageable carrying capacity of Nassau County is at its limit now."

The given capacity of land to adequately support the population's water resource needs can be further reduced by human activities that affect groundwater quality and quantity.

Groundwater Quantity

Groundwater quantity in Nassau County is altered by human activities. Sewering, overpumping and diminution of open space all contribute to the depression of groundwater levels.

Nassau Is Extensively Sewered

Most of Nassau County is sewered. Sewer systems were installed to prevent the domestic wastewater in high density communities from entering the underlying aquifer system. All of Nassau's 14 municipal sewer systems discharge their wastewater into coastal waters. Unfortunately, by discharging this water into the ocean or Long Island Sound, sewers also prevent the replenishment of water into the groundwater system. Reduction of groundwater recharge affects water, both above and below the land's surface, in the following ways:

a. The water table is lowered.

b. Stream and lake water levels are reduced.

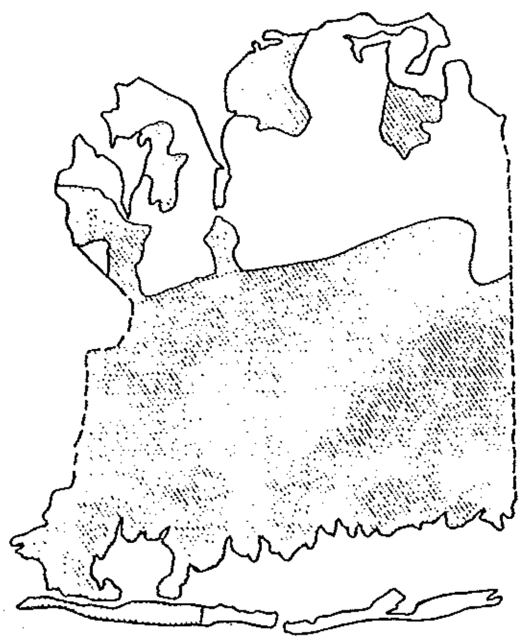
c. Salt water intrusion occurs in coastal regions.

d. The amount of freshwater flowing into the bays decreases. This increases the salinity of the bays, which has implications for the viability of the shellfish industry which requires a reduced bay salinity.

Developing Land Disrupts Groundwater Recharge

Groundwater usage is associated with population density. More people use more water. In addition, highly populated areas, being more developed, disrupt groundwater recharge patterns.

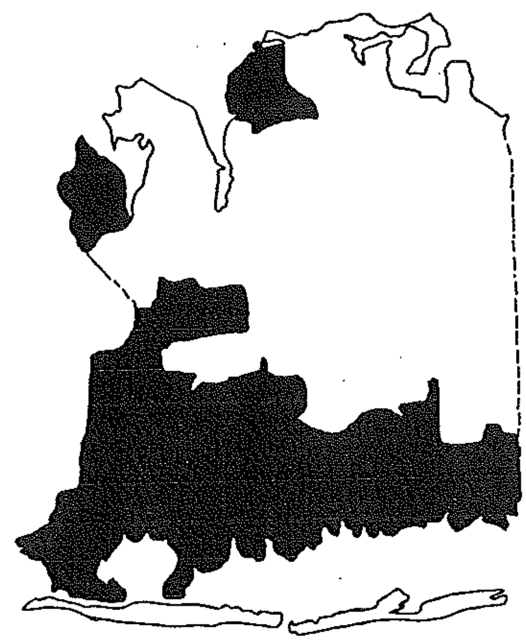
SEWERS IN NASSAU COUNTY



Areas where sewers are located.

Figure 1

GROUNDWATER MINING



Areas where groundwater mining is occurring.

Figure 2

Once channeled into the sea, the wastewater is lost to the groundwater system.

Groundwater Mining

The groundwater quantity problem is exacerbated by the rate of groundwater pumping in the more populated areas of the county. In some places, more water is taken out of the ground than is replaced. This condition is called groundwater mining.

Since the water used in a community is usually pumped in that area, high density sewered sections suffer both overpumping and diminished groundwater recharge.

Groundwater Quality

The other means by which the county's water supply is reduced is by contamination. Pollution removes large portions of water from the useable supply.

Contaminants found in Nassau County groundwater are of the following categories:

- bacteria
- chlorides (salt)
- nitrogen/nitrate
- synthetic organics such as
  - solvents and degreasers
  - gasoline and other petroleum-based products
  - pesticides

Synthetic Organic Chemicals

Synthetic organics are the most serious threat to the groundwater supply of Nassau County. These chemicals are problematic for two reasons.

1. Many synthetic organics are associated with a variety of health problems. The most serious threats to health include organic damage, genetic disorders and cancer. The precise danger that most of these chemicals pose remains unknown or uncertain. Little is known about their long-term health effects or the synergism between two or more of them.

2. It takes only a small amount of these chemicals to contaminate large amounts of groundwater.

Sources of Synthetic Organic Chemical Pollution

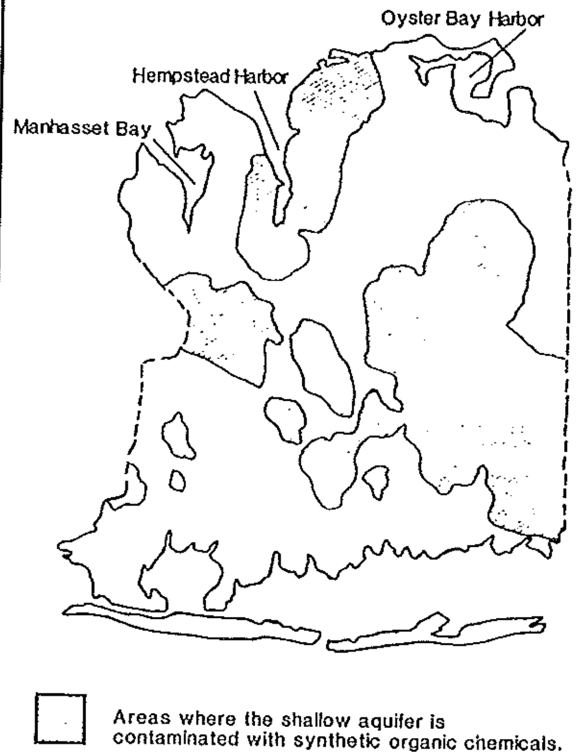
Sources of synthetic organic pollution include household products, sewer leaks, chemical spills and leaks (especially petroleum products), solid waste disposal sites, hazardous waste disposal sites, and turf and agricultural chemicals, such as pesticides.

Synthetic Organics in the Water Supply

A 1980 study of 368 public wells in Nassau County suggests the extent of synthetic organic chemical pollution in the water supply. Findings reveal

Figure 3

AREAS WHERE AQUIFER IS POLLUTED WITH SYNTHETIC ORGANICS



varying degrees of contamination in 37% of the wells tested. Study samples were taken from all 3 major aquifers. By far the most contaminated aquifer was the Upper Glacial, with 62% of the wells showing evidence of synthetic organics. The degradation of this topmost aquifer harbingers worsening problems for the water supply system as a whole.

The aquifer system that supplies our water is in constant, though very slow motion. Figure 4 depicts the groundwater flow through the three tiers of Long Island's aquifer system. Because of the dynamic nature of this system's flow patterns, the threat that surface contamination presents will persevere as it continues on its migration through the aquifers. Wells that are the deepest and furthest away will, in general, be the last to be affected by migrating front.

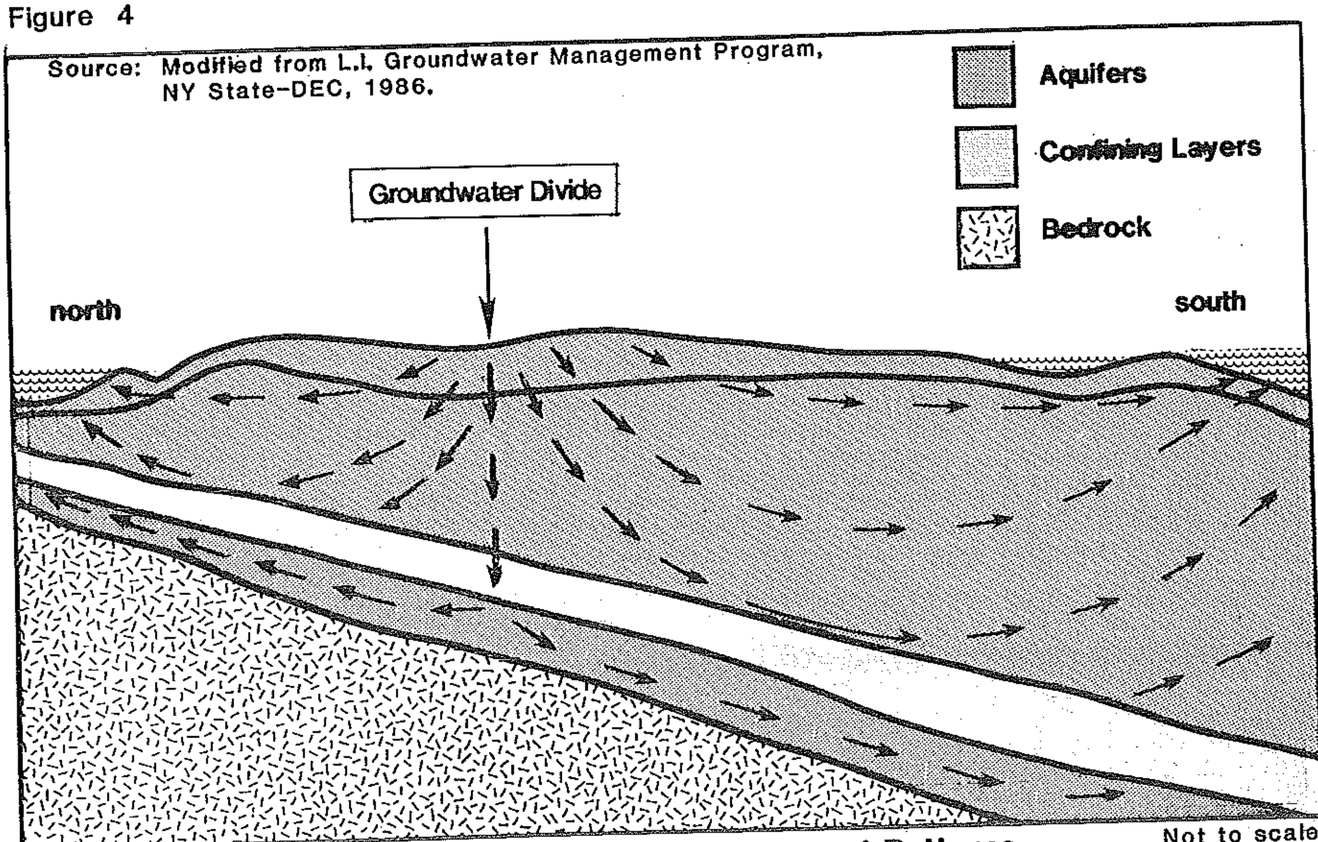
Depending on location, aquifer pollution is a long-term problem. For example, contamination entering the aquifer in the deep flow recharge zone, running east--west across Long Island's main section could reach the deep Magothy in 50 years or less. The projection for reaching the base of the Lloyd Aquifer is 3,000 years. Contaminants entering particular parts of the system can persist for thousands of years.

As further information is amassed regarding the health consequences of synthetic organic compounds, drinking water standards will have to be revised. In June of 1984, the Environmental Protection Agency published Recommended Maximum Contaminant Levels for nine synthetic organic compounds. In response to these recommendations, the Nassau County Department of Health estimated that 108 public supply wells out of 419 could be removed from service should the recommendations become standards. The extent of Nassau's possible water supply reduction is startling considering that the recommendations involving nine compounds out of thousands used every day by industry and the general public.

Nassau's Watersheds

Clearly, Nassau County faces serious present and future problems regarding synthetic organic chemical pollution. Areas in Nassau that are relatively free of these pollutants are the same areas where we find stabilized water quantity. One area is in the northern section of the Town of Oyster Bay; the other is a smaller portion of the Town of North Hempstead. Because of patterns of development, these areas are generally clear of industrial development, landfills and other sources of toxic chemical pollution. In addition low population density limits sources of domestic wastes. Because this area is largely unsewered, most groundwater pumped

Figure 4



Generalized Groundwater Movement Patterns

NASSAU COUNTY'S SPECIAL GROUNDWATER PROTECTION AREAS

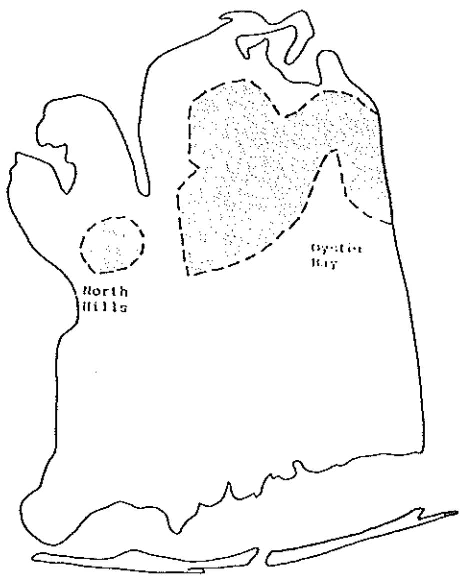


Figure 5

from the water supply here is recharged into the aquifer system.

These two watershed areas have been designated as Special Groundwater Protection Areas by Nassau County. Though recognized as critical watershed areas, land use planning decisions that have the potential to affect the integrity of the groundwater beneath these lands rests with the village municipalities that comprise the Special Groundwater Protection Area. Because of the large number of individual villages, uniform planning and protection are difficult to attain. At present, no consistent regional approach has been possible in land use planning because of the power of traditional rule.

PROCEDURE

1. Present material on Long Island's groundwater and the quality and quantity problems faced in Nassau County today.

2. Hand out materials.

3. Instruct students to use the Student Procedure Sheet to complete the mapping activities. The activities in Part 1 (Groundwater Quality Problems) and Part 2 (Groundwater Quality Problems) can be used independently of each other. Part 3 (Nassau County Watershed Areas) uses the mapping activities of Parts 1 and 2 to discuss watersheds and watershed protection.

4. Have students answer the question sheets.

REFERENCES

AN ATLAS OF LONG ISLAND WATER RESOURCES, Philip Cohen et.al., New York Water Resources Commission Bulletin 62, 1968.

1984 PROGRESS REPORT, NYS Legislative Commission on Water Resource Needs of Long Island.

LONG ISLAND GROUNDWATER MANAGEMENT PROGRAM, NY State Department of Environmental Conservation, June 1986.

HARD CHOICES: An Action Plan for the Protection, Correction and Conservation of Nassau County's Water Supply, edited by James T. B. Tripp and Sarah J. Meyland, The Coalition for the Protection of Long Island's Groundwater, 1987.

ASSESSMENT OF GROUNDWATER CONTAMINATION BY NITROGEN AND SYNTHETIC ORGANICS IN TWO WATER DISTRICTS IN NASSAU COUNTY, NY, Henry B. F. Hughes, James Pike and Keith S. Porter, Center for Environmental Research, Cornell University, Ithaca, NY, 1985.

A CITIZEN'S HANDBOOK ON GROUNDWATER PROTECTION, Wendy Gordan, Natural Resource Defense Council, Inc., 1984.

Vocabulary

GROUNDWATER: The supply of freshwater occurring in aquifers below the earth's surface.

AQUIFER: An underground geologic formation that stores significant quantities of groundwater and allows that water to move through it.

RECHARGE: Water from precipitation that travels down through the ground to replenish the groundwater supply.

WASTEWATER: Water that has been contaminated in some manner and is unfit for drinking.

SEWER SYSTEM: A pipeline which transports wastewater to a treatment plant and, on Long Island, eventually discharges the treated water into coastal waters.

SALTWATER INTRUSION: The flow of saltwater from the sea into a groundwater system. Saltwater intrusion results from the overpumping of a groundwater system that is in hydraulic connection with the sea.

GROUNDWATER MINING: A condition that occurs when more water is removed from the groundwater than is replaced.

LAND USE: The way humans use the land. Some examples of land use are building houses and factories, farming, landfilling garbage and recreational activities such as hunting, camping and hiking.

CONTAMINANTS: An introduced gas, liquid or solid that makes a resource unfit for a specific purpose.

SYNTHETIC ORGANIC CHEMICALS: Manmade chemical compounds containing carbon and made from either inorganic substances, like carbonates or cyanides or from other organic compounds. Many of these chemicals are associated with a variety of health problems. Very small amounts of these chemicals can contaminate large amounts of water.

LANDFILL: A place where waste material is deposited, compacted with heavy machinery and covered with soil.

HAZARDOUS WASTES: Waste that requires special handling to avoid illness or injury to people or damage to property.

OPEN SPACE: Land that is left in its natural condition.

WATERSHED: In a groundwater system, a watershed is an area where precipitation is recharged into the groundwater.

SPECIAL GROUNDWATER PROTECTION AREAS: Certain areas in Nassau County, Long Island that recharge high quantities of quality water because the land is relatively undeveloped.

Student Procedures

Maps A and B

1. Place an acetate sheet over Map A. Trace the boundary lines of Nassau County on the sheet using a thick pencil line. Map A shows the areas in Nassau County that have had organic chemicals detected in the Upper Glacial aquifer. Use a #2 pencil to shade in the portions of the map that show contamination.

2. Place the same acetate sheet over Map B. Be certain that county boundary lines line up. Use a ball point pen to copy the symbols representing hazardous waste sites and landfills. Indicate industrial/commercial development by copying the pattern representing this type of development on the map.

3. Answer the questions on the Question Sheet for Maps A and B.

Maps C and D

1. Place an acetate sheet over Map C. Trace the boundary lines of Nassau County on the sheet using a thick pencil line. Map C shows the areas in Nassau that are sewered. Use a #2 pencil to shade in the portions of the map which represent sewered areas.

2. Place the same acetate sheet over Map D. Be certain that county boundary lines line up. Map D shows the areas in Nassau that are experiencing groundwater mining. Using a ball point pen, indicate areas experiencing groundwater mining by copying the pattern representing this condition.

3. Answer the questions on the Question sheet for Maps C and D.

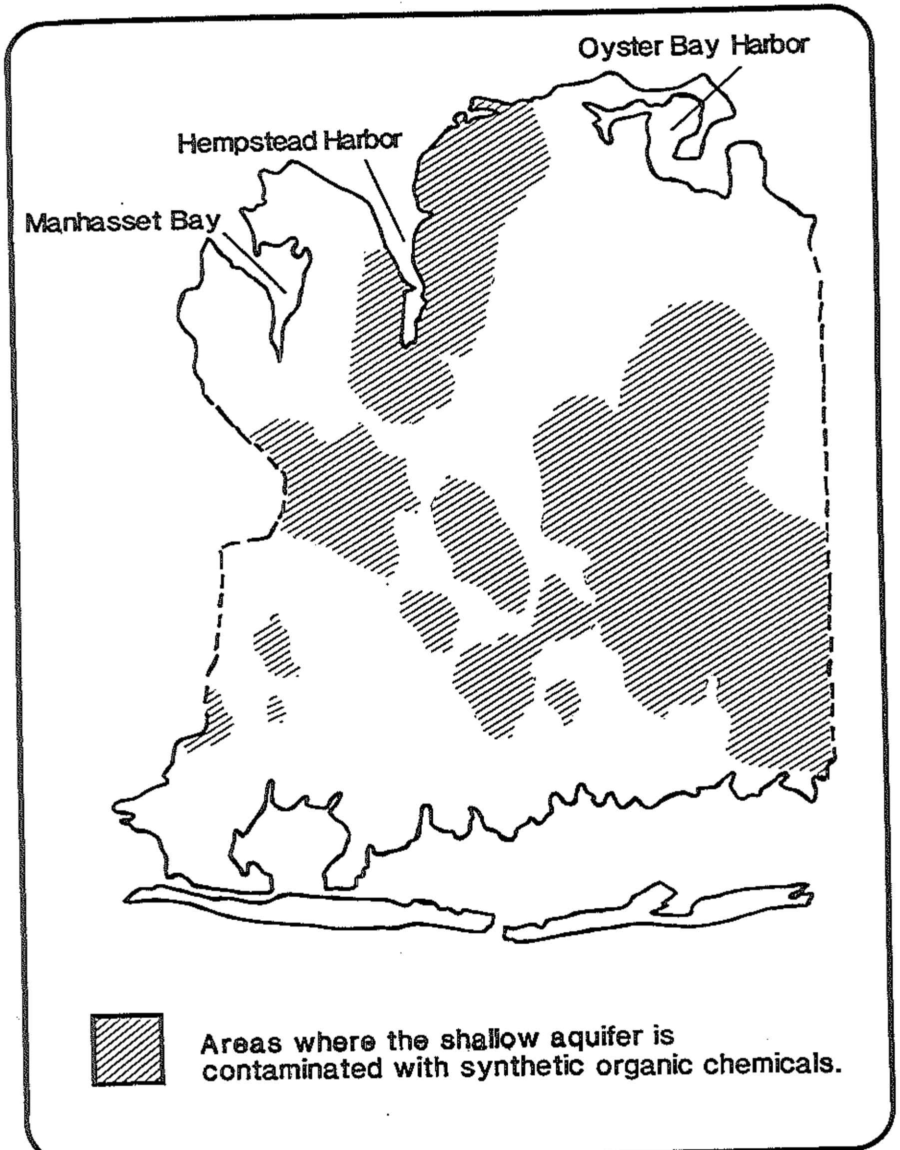
Maps A, B, C, and D

1. Place the 2 acetate sheets made from Maps A, B, C and D together. Line up the county boundary lines.

2. Answer the questions on the Question Sheet for Maps A, B, C and D.

Map A

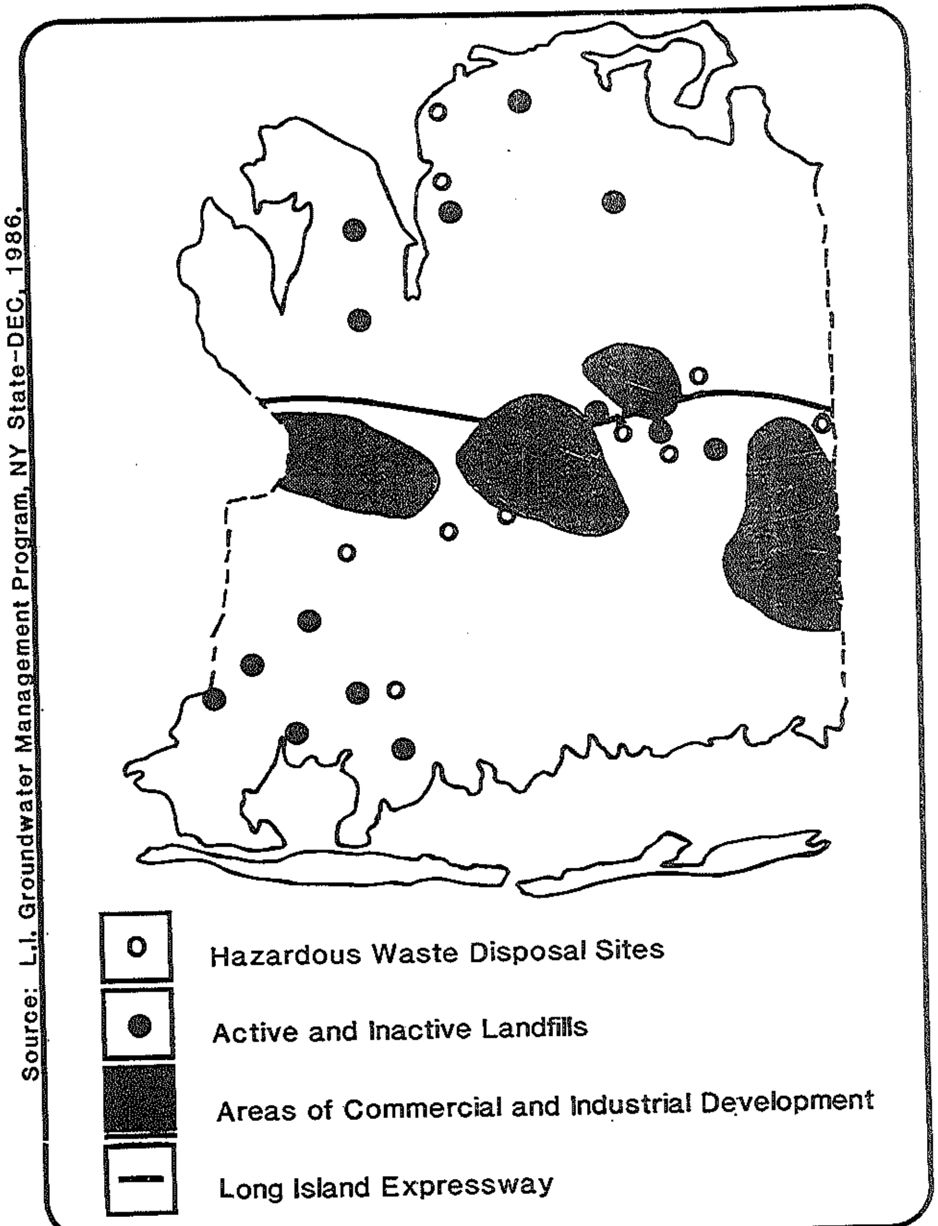
Synthetic Organic Chemicals in the Shallow Aquifer, Nassau County, L. I.



Source: Draft Nassau County Master Water Plan, 1980.

Map B

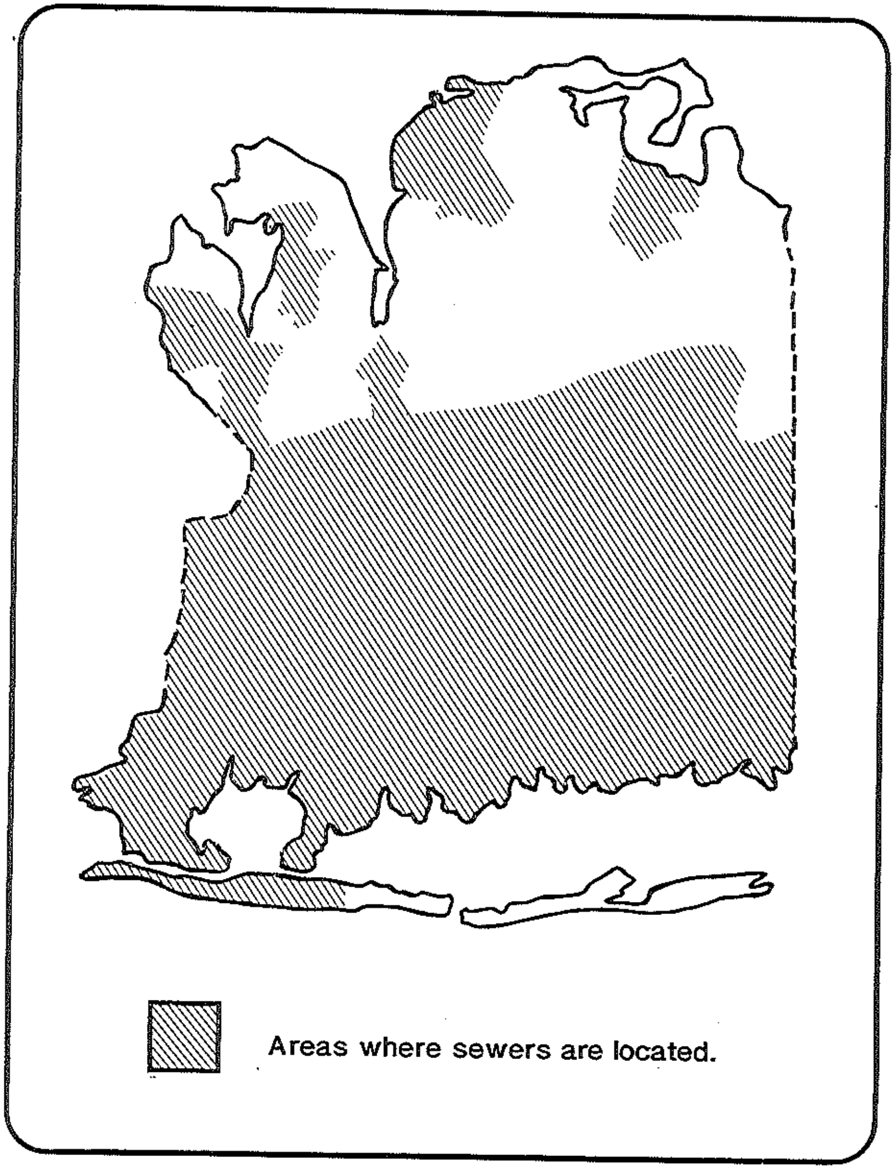
Landfills, Hazardous Waste Sites and Commercial/Industrial Areas



Source: L.I. Groundwater Management Program, NY State-DEC, 1986.

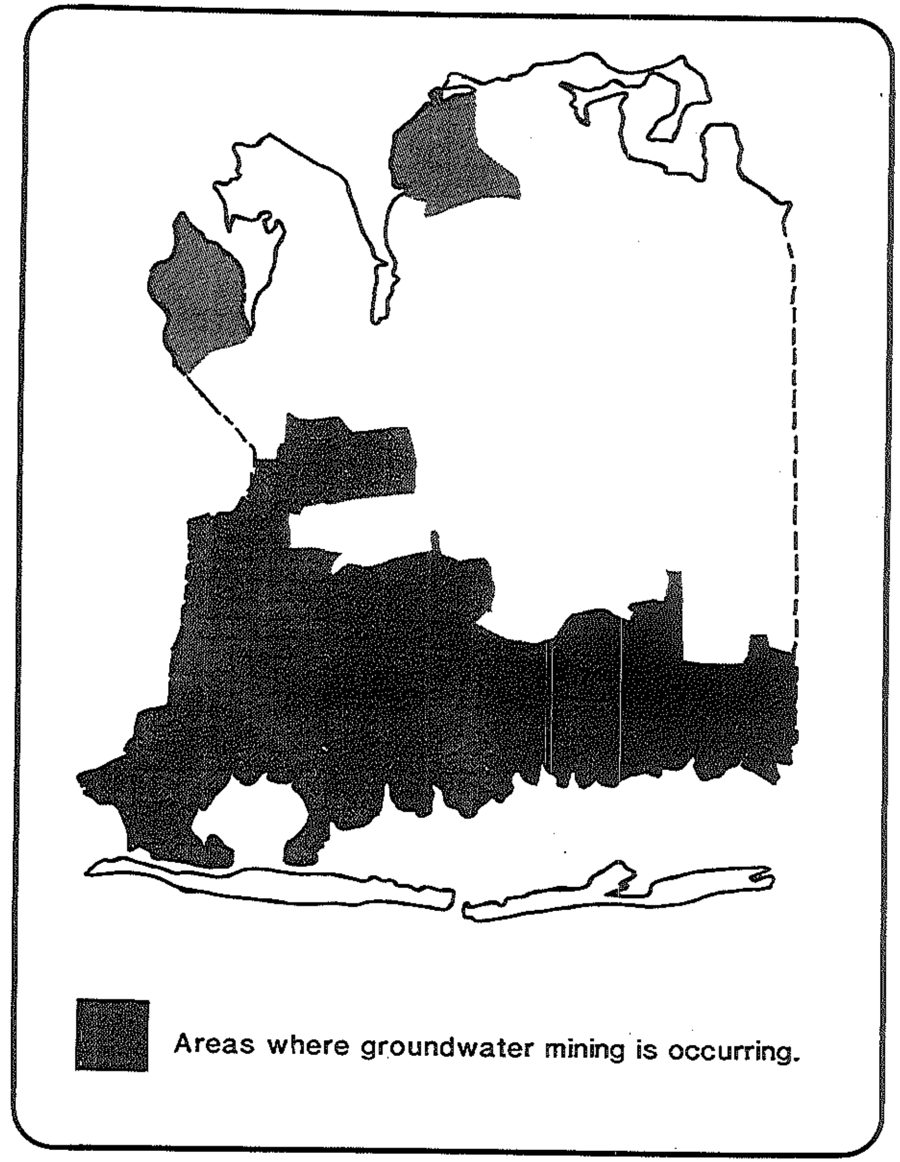
Map C

Sewer Systems in Nassau County, L. I.



Map D

Groundwater Mining in Nassau County



Source: 1984 Progress Report, NYS Commission.

GROUNDWATER QUALITY PROBLEMS
Question Sheet For Maps A and B

Answer the following questions.

1. Which portion of Nassau County is most severly polluted with synthetic organic chemicals?

   a. Southwest Nassau
   b. Northeast Nassau
   c. Eastern Nassau
   d. Northwest Nassau

2. Where are areas of commercial/indistrial development generally located in Nassau County?

   a. Southern Nassau
   b. Northern Nassau
   c. Central Nassau, near the L.I. Expressway
   d. Northeastern Nassau

3. In terms of where they are found, which of the following best describes how areas of commercial/industrial development, hazardous waste sites and landfills (Map B) are connected to the areas where the Upper Glacial aquifer is polluted with synthetic organic chemicals (Map A)?

   a. Many of the areas in Map B occur over areas where the Upper Glacial aquifer is contaminated.
   b. There is little connection between the two areas.

4. Which of the following bays or harbors is most likely to be affected by contaminated groundwater?

   a. Manhasset Bay
   b. Hempstead Harbor
   c. Oyster Bay Harbor
   d. Cold Spring Harbor

GROUNDWATER QUANTITY PROBLEMS
Question Sheet For Maps C and D

Answer the following questions.

1. Sewer systems are used in areas that are heavily populated to prevent groundwater pollution. Using this information, what portion of Nassau County is most heavily populated.

   a. Southern Nassau b. Northern Nassau

2. Groundwater mining is a condition occurring when more groundwater is removed from the ground than is replaced. Using this information and Map D, what portion of Nassau County is experiencing groundwater mining?

   a. Southern Nassau b. Northern Nassau

3. Sewer systems in Nassau County treat wastewater and then pump it into coastal waters. What effect might sewers have on groundwater levels?

   a. Sewers raise groundwater levels. c. Sewers lower groundwater levels.

   b. Sewers have no effect on groundwater levels.

4. In terms of where they are found, which of the following best describes how areas that use sewer systems are connected with areas that experience groundwater mining?

   a. Many of the groundwater mining areas in Map D occur in areas where sewer systems are located. b. There is little connection between the two areas.

5. List 2 reasons why certain areas in northern Nassau county <u>do not</u> experience groundwater mining.

   a. ______________________________

   b. ______________________________

GROUNDWATER PROTECTION
Question Sheet For Maps A, B, C and D

Answer the following questions.

1. Which statements best describe the map that results when all 4 map overlays are placed together? More than 1 statement can be chosen.

   a. Most groundwater quantity problems occur in areas that are separate from the areas that experience groundwater quality problems.

   b. Very little of Nassau County's total area is free of ground water quality and quantity problems.

   c. Many areas experience both groundwater quality and quantity problems.

   d. Nassau County still has a large amount of area where the groundwater is free of quality and quantity problems.

2. Using your map overlays, circle the areas below that remain free of groundwater quality and quantity problems.

   a. Southeast Nassau

   b. North central Nassau

   c. Portions of northwest and northeast Nassau

   d. Southwest Nassau

3. List 2 reasons why these areas remain problem-free.

   a. ____

   b. ____

4. If you were to give special protection to areas in Nassau County to protect the groundwater, which land areas would you select? Draw a line around these areas on your map overlay.

5. List 2 recommendations you would suggest to insure the protection of these watershed areas.

   a. ____

   b. ____

Other Curriculum Resources

A CURRICULUM ACTIVITIES GUIDE TO WATER POLLUTION AND ENVIRONMENTAL STUDIES - Volume one and two, John Hershey et al, 1972.

Volume 1: contains activities covering the hydrologic cycle, human activities, ecological perspectives and social and political factors.

Volume 2: is an appendix to Volume 1 and is a technical reference guide organized into 4 parts: chemistry, bacteriology, aquatic biology and engineering and physics.

A CURRICULUM ACTIVITIES GUIDE TO WATERSHED INVESTIGATION AND ENVIRONMENTAL STUDIES, Peter A. Gail, et al., 1974.

Primarily addresses surface watershed studies in an interdisciplinary manner.

(Institute for Environmental Education, 32000 Chagrin Boulevard, Cleveland, Ohio 44124, contact for prices.)

A GUIDE FOR TEACHING REGIONAL ENVIRONMENTAL PLANNING, Martin T. Hetherington et al.

(Science and Mathematics Teaching Center, E-37 McDonel Hall, Michigan State University, East Lansing, Michigan 49924, free.)

GROUNDWATER: A VITAL RESOURCE - Student Activities, compiled by Cedar Creek Learning Center in cooperation with Tennessee Valley Authority, 1986.

(Tennessee Valley Authority, Office of Natural Resources and Economic Development, Environmental Energy Education Program, Knoxville, Tennessee 37902, free.)

INVESTIGATING YOUR ENVIRONMENT - Teaching Materials for Environmental Education, U.S.D.A. Forest Service, Washington, D.C., 1980.

UNDERSTANDING THE GAME OF THE ENVIRONMENT - An Illustrated Guide to Understanding Ecological Principles, David R. Houston, Agricultural Information Bulletin No. 426, U.S.D.A. Forest Service, Washington, D.C., 1979.

(U.S.D.A. Forest Service, P. O. Box 2417, Room 3233, Washington, D.C. 20013, available free.)

PROJECT WILD: an interdisciplinary, supplementary environmental and conservation curriculum.

(Mike Cavanagh, New York State Dept. of Environmental Conservation, 50 Wolf Road, Room 507, Albany, NY 12233, phone # (518) 457-0849, contact for more information.)

THE RAIN BOOK (Grades 2-7). 1980

THE LAKE BOOK (10-12). 1981

THE POND BOOK (4-7). 1977

THE ESTUARY BOOK (7-12). 1981

THE CREEK BOOK (3-7). 1978

THE BEACH BOOK (2-7). 1978

THE SNOW BOOK (2-7). 1978

These are creative environmental activity and idea books.

(Western Education Development Group, The University of British Columbia, Vancouver, British Columbia, Canada V6T 1W5, write for a book list and order form.)

BIOLOGICAL ENVIRONMENTAL PICTORAL INVESTIGATIONS, Paul W. Richard, Laboratory School at the University of Northern Colorado, 1978.

A student activity guide for exploring environmental topics through the use of pictures. Classroom use. Grades 7-8. (Stonecrop, P.O. Box 685, Greeley, Co. 80632, $4.75 plus 15% postage and handling.)

CARE OF A SMALL PLANET:
1) THE HUMANITIES, Margaret Cottom-Winslow, 1980.
2) THE SCIENCES, Paul F. Brandwein, 1980.
3) THE SOCIAL SCIENCES, Rudolph Schwartz, 1980.

Three separate, overlapping text that explore environmental concepts through science, social science and humanities. Classroom and lab use. Grades 7-8. (Harcourt Brace Jovanovich, Inc., 757 Third Ave., New York, NY 10017, Student Resource Books, $4.50 each, Teacher guide, $1.20.)

ENCOUNTER WITH THE NORTHWEST ENVIRONMENT: NATURAL AND URBAN, Environmental Planning and Management Associates, 1980.

Provides a framework for exploring a regional environment and setting up a system of environmental learning sites. Both natural and urban sites are considered. Grades 9-12. (ERIC, Clearinghouse for Science, Mathematics and Environmental Education, 1200 Chambers Road, Columbus, OH 43212, contact for price.)

ENVIRONMENTAL EDUCATION ACTIVITIES MANUAL, William B. Stapp and Dorothy A. Cox, 1979.

Contains materials that integrate an environmental education model into the learning activities of students K-12. (William B. Stapp/Dorothy A. Cox, 32493 Shady Ridge Drive, Farmington Hills, MI 48108, contact for price.)

ENVIRONMENTAL ENCOUNTER: Experiences in Decision-making for the Built and Natural Environment, Joanne Henderson Pratt et al., 1979.

(Reverchon Press, P. O. Box 19647, Dallas, TX 75219, $14.95/softbound.)

INVESTIGATING YOUR ENVIRONMENT: Biological Sciences Curriculum Study, Regents of the University of Colorado, 1975.

An instructional module supporting specific environmental explorations. Grades 9-12. Science, social studies. (Addison-Wesley Publishing Company, 2725 Sand Hill Road, Menlo Park, CA 94025, teacher handbook $6.00, student hardbook $6.60.)

WE CAN HELP: Environmental Education Teaching Resources, Minnesota Environmental Science Foundation, 1975.

Environmental education teaching resource packet with multiple outdoor investigations designed to enhance information gathering. Grades K-12. (Jenny Publishing Company, 57 Queen Avenue, South Minneapolis, MN 55405. Contact for prices.)

TUNING THE GREEN MACHINE, An Integrated View of Environmental Systems, Institute for Environmental Education, Oceana, Dobbs Ferry, NY, 1978.

Other Curriculum Resources continued

THE STORY OF DRINKING WATER - Teacher's Guide, Advanced Level, Grades 7,8,9, Rosalie Bock, 1984.
(American Water Works Association, Public Information Dept., 6666 W. Quincey Avenue., Denver, CO 80235, write for curriculum samples, price list and order form.)

THE SEARCH FOR SOLUTIONS TEACHING NOTES
This is a compendium of science classroom activities often including water and water - resources - related topic. Published 3 times a year. (THE SEARCH FOR SOLUTIONS TEACHING NOTES, Playback Associates, 708 3rd Avenue, New York, New York 10017, contact to be placed on mailing list, free.)

Groundwater and Surfacewater Information

A GUIDE TO THE STUDY OF FRESHWATER ECOLOGY, William A. Andrews, Contours Series: Prentice Hall, Englewood Cliffs, NJ 1977. Also by same author:

A GUIDE TO THE STUDY OF ENVIRONMENTAL POLLUTION

A GUIDE TO THE STUDY OF SOIL ECOLOGY

A GUIDE TO THE STUDY OF TERRESTRIAL ECOLOGY

THE FRESHWATER SOCIETY
Innovative public education material. (Ginny Lee, Freshwater Society, 2500 Shadywood, Box 90, Navarre, MN 55392, phone # (612) 471-7467, contact for more information, a publication list and an order form.)

UNDERSTANDING OUR GROUNDWATER, Cooperative Extension of Suffolk County.
This is a series of 9 bulletins and 56 fact sheets. Topics include groundwater resources, conservation pollution, land use, groundwater management. (David Newton, Cooperative Extension of Suffolk, 246 Griffing Ave., Riverhead, NY 11901, contact for publication list/order form.)

A CITIZEN'S HANDBOOK ON GROUNDWATER PROTECTION, Wendy Gordon, Natural Resources Defense Council, 1984.
(Natural Resources Defense Council, 122 East 42nd Street, New York, NY 10168, $10.00 /paper.)

GROUNDWATER MANAGEMENT, A Handbook for the South Fork, Group for the South Fork, 1982.
Though this booklet deals with Long Island's South Fork much of the information is applicable to other regions of Long Island.

GUIDE TO DRINKING WATER QUALITY TESTS AND WATER TREATMENT SYSTEMS, Group for the South Fork, 1986.
This guide contains information that will aid in understanding laboratory test results for drinking water and the options available for treatment. (Group for the South Fork, Inc., Box 569, Bridgehampton, NY 11932, $3.00, each booklet.)

The Pine Barrens and Other Long Island Environments

THE PINE BARRENS OF RONKONKOMA - A Guide for the Hiker to the Long Island Pine Barrens, Lawrence G. Paul, New York - New Jersey Trail Conference, 1986.

A GUIDE TO LONG ISLAND PRESERVES - The Nature Conservancy.
(The Nature Conservancy, Long Island Chapter, P. O. Box 72, Cold Spring Harbor, NY 11724, phone # (516) 367-3225, contact for prices and ordering information.)

GUIDEBOOK TO FIELD EXCURSIONS, New York State Geological Association Guidebook, 1975. Copies can be purchased from:
(Dr. Daniel Merriam, Dept. of Geology, Syracuse University, Syracuse, NY 13210, or: Dr. Manfred P. Wolff, Dept. of Geology, Hofstra University, Hempstead, NY 11550, contact for price.)

A GUIDE TO THE PLANT COMMUNITIES OF THE NAPEAGUE DUNES, Ann F. Johnson, Southampton, NY, 1985.
(Ann F. Johnson, 37 South Main Street, Southampton, NY 11968, $6.00/paper.)

NATIVE AND NEAR NATIVE - An Introduction to Long Island Plants, Albert Hostek, 1976.
(The Environmental Centers of Setauket-Smithtown, Inc., Box 257, Smithtown, NY 11787, $6.70/paper.)

FILM: "LONG ISLAND WILDERNESS...THE PINE BARRENS".
22 minutes. Produced by the Museum of Long Island Natural Sciences, SUNY at Stony Brook. Informative overview of Long Island's Pine Barrens formations. Available to public school districts through BOCES.

BOCES I: Westhampton Beach, 288-6400
BOCES II: Central Suffolk, 277-7405
BOCES III: Western Suffolk, 543-0855
BOCES IV: Nassau, 877-1910, x 200

Available to community and adult groups through the Suffolk County Cooperative Library System, 286-1600.

Land Use Planning Information

COOPERATIVE EXTENSION OF SUFFOLK COUNTY publishes several bulletins, fact sheets and a directory on LANDUSE.
(David Newton, Cooperative Extension of Suffolk County, 246 Griffing Avenue., Riverhead, NY 11901, contact to obtain a LANDUSE PLANNING AND MANAGEMENT publications list and order form.)

DESIGN WITH NATURE, Ian L. McHarg, Natural History Press, New York, 1969.

REAL WORLD EXPERIENCE WITH TDRs Transferable development rights) An Update, Stanley D. Schiff.
(Piedmont Environmental Council, 28-C Main Street, Box 460, Warrenton, Virginia 22186.)

Organizations Involved in Groundwater Issues

Many organizations both public and private are involved in the management and protection of Long Island's groundwater and surface water resources. The major ones are listed below and on the following page. Following each organization's name and address is a brief description of their activities and involvements. This list should by no means be considered complete. Local town environmental agencies, educational institutions and private environmental organizations are also good sources of information and assistance.

Cooperative Extension of Suffolk County
246 Griffing Avenue
Riverhead, NY 11901
phone (516) 727-7850

Cooperative Extension of Nassau County
1425 Old Country Road., Bldg. J.
Plainview, NY 11803
phone (516) 454-0900
Responsibilities include information dissemination and education.

Long Island Regional Planning Board
H. Lee Dennison Building
12th Floor
Veteran's Highway
Hauppauge, NY 11788
phone (516) 360-5200
Responsibilities include studies, planning, education.

New York State Commission on the Water Resource Needs of Long Island
State Office Building
Veteran's Highway
Hauppauge, NY 11788
phone (516) 360-6206
or
43 S. Middle Neck Road
Great Neck, NY 11021
phone (516) 482-7722
Responsibilities include studies, legislation, education.

New York State Department of Environmental Conservation
Building 40
SUNY at Stony Brook
Stony Brook, NY 11794
phone (516) 751-7900
Responsibilities include regulations, management, monitoring, law enforcement, permit issuance, planning and education.

Suffolk County Department of Health Services
225 Rabro Dr., E.
Hauppauge, NY 11788
phone (516) 348-2917
or
Suffolk County Center
Riverhead, NY 11901
phone (516) 548-3888

Suffolk County Planning Department
County Center
Hauppauge, NY 11788
phone (516) 979-2922
Can provide information on land use, zoning, mapping, population distribution and growth and other planning data.

Suffolk County Water Authority
Sunrise Highway at Pond Road
Oakdale, NY 11769
phone (516) 589-5200
Responsibilities: distribution of water, monitoring, planning, education.

U.S. Soil Conservation Service
127 East Main Street
Riverhead, NY 11901
phone (516) 727-2315

Can provide information and advice on soils, land use, erosion control and water management. Soil maps.

U.S. Geological Survey
5 Aerial Way
Syossett, NY 11790
phone (516) 938-8830

Responsibilities include studies, maps, monitoring, education.

Water Resources Program
Center for Environmental Research
Hollister Hall
Cornell University
Ithaca, NY 14853

This center is involved in many groundwater and land use studies on Long Island.

ACTION for the Preservation and Conservation of the North Shore of Long Island, Inc.
328 Main Street
Huntington, NY 11743

Mailing address:
P. O. Box 492
Huntington, NY 11743
phone (516) 271-3029

Information collecting and disseminating organization. Contact for speakers. Newsletter 8/year - $10.00.

The Coalition for the Protection of Long Island's Groundwater
c/o Long Island Citizens Campaign
518 Broadway, Massapequa, NY 11758
phone (516) 798-6556

A coalition of Long Island civic and environmental groups involved in issues related to L.I.'s groundwater.

Group for the South Fork, Inc.
Box 569
Bridgehampton, NY 11932
phone (516) 537-1400

Information collecting and disseminating organization. Contact for speakers. Publications, newsletter.

The Long Island Pine Barrens Society
P. O. Box 9
Smithtown, NY 11787

A private, non-profit environmental organization committed to the preservation and understanding of Long Island's Pitch Pine - Scrub Oak woodlands. Education, information dissemination and field trips.

The Nature Conservancy - Long Island Chapter
P. O. Box 72
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A national, private, non-profit conservation organization committed to preserving natural diversity by protecting ecologically unique lands. Preserves are open to the public. Prior permission must be obtained.