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A Resource Inventory and Impact Analysis of Great Bog and the Horse Point Delta/Esker System

Problems in Environmental Science course (Biology 493), Colby College

Biologists Organized For Ecosystem Assessment, Colby College

A Resource Inventory and Impact Analysis of Great Bog and the Horse Point Delta/Esker System

Biology 493
Colby College
Waterville, Maine 04901

MEMO

DATE: May 28, 1991

TO: Report recipients

FROM: Professors David Firmage, Russell Cole and Herbert Wilson

RE: Class report on the Horse Point Esker and Great Bog

This report is the work of students in the Problems in Environmental Science course (Biology 493) taught at Colby College during the fall semester of 1990. The course is taken by seniors who are majoring in Biology with a concentration in Environmental Science. The students are treated as though they were an environmental consulting firm. The object of the course is to teach the students how to approach a problem, how to outline a workplan and what is necessary to carry the plan out successfully. As part of this learning process the students use methods and tools they have learned about in other courses and are introduced to new methodology as needed. Standard methods of analysis are used as well as up-to-date instrumentation for any of the original analysis done. However, there are time constraints involved in the study as all requirements for the course must be completed within the fall semester. These constraints mean that new data can only be gathered during the months of September through early November and typically that extensive analysis can not be done. Also, in order to teach various techniques and to have the students consider a problem from a number of angles, the project is expanded to more areas than a group might normally take on for a short term project. This means that in some areas we sacrifice some depth for more breadth.

We make this report available in the hope that the work contained herein may be of interest or help to others interested in the problem addressed. We realize that each area of the study could and perhaps should be expanded. We feel confident of the quality of the work done and only wish the time had been available so that the students could fulfill their desire to conduct a more comprehensive study.

A Resource Inventory and Impact Analysis of Great Bog and the Horse Point Delta/Esker System

Submitted by BOFEA
(Biologists Organized For Ecosystem Assessment)
March 10, 1991

Biology 493
Colby College
Waterville, Maine 04901

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INTRODUCTION

In May of 1990, Tilcon-Maine, Inc. submitted an application to mine gravel on the east side of Horse Point Road on Horse Point in the Town of Belgrade. The project site covers 46 acres and the proposed excavation covers 16 acres. An estimated 740,000 cubic yards of material will be removed over a period of six or seven years (Pfister, pers. comm.). According to Tilcon (Timson *et al.*, 1990) the maximum depth of the pit will be 78 feet and the bottom of the pit will be a minimum of 6 feet above the water table. At the present time the application is on hold until Tilcon redesignates the buffer zones adjacent to Horse Point Road and makes other necessary changes. Tilcon can then resubmit their application for approval.[1]

Our purpose was to complete a background study of the Horse Point area and an overview of the drainage basin in order that several significant biological and geological issues could be considered. The most important of these concerns are the following:

- Possible effects on the water quality
  - -of Great Bog
  - -of the Horse Point aquifer
  - -of Great Pond
- Possible degradation of a regionally significant esker complex
- Possible effects on a significant wetland
- Possible effects on rare species
- Possible effects of increased road use by gravel trucks on Horse Point and local communities
- Possible non-compliance of proposed mining with existing federal, state, and local regulations

Although many of these concerns are not presently supported with definitive evidence, some have delayed the acceptance of Tilcon's application. This has allowed time for our studies and investigations. It

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[1] At the time this manuscript was written, Tilcon-Maine, Inc. was in the process of revising their first application. Since then, the second application has been submitted, and necessary changes (given the time available) within this text have been made accordingly.

is hoped that these studies will help to determine if the previously mentioned concerns are in fact valid. We also hope that the information gathered and presented in this report will provide the background necessary to help others reach decisions on the issues. Finally, based on the evidence we have gathered in this report, we will make some recommendations about the proposed mining project and the area of Great Bog.

BACKGROUND

Geologic History of Maine Overview

Most of Maine bedrock is composed of rock that has been repeatedly metamorphosed throughout the history of the region (Guidotti, 1988). Much of the present bedrock can be traced back to the Siluro-Devonian metamorphosis which affected most of Maine. The north and east parts of the state are formed of a low grade metamorphic rock while the south is mainly composed of high grade metamorphic rock.

The bedrock of the Norridgewock quadrangle, which contains Great Pond and Great Bog, consists of Devonian and Silurian lightly metamorphosed sedimentary rock (Anon., 1978) but the bedrock underlying Great Pond is a granitic igneous intrusion, the Rome Pluton. It was formed in the Devonian period, 403 million years ago (Caldwell *et al.*, 1988).

The more recent events that drastically changed the surface geology of Maine were the periods of glaciation during the Late Pleistocene. Glaciation has had a significant effect on the surficial geology and topography on this area. Weathering and erosion by glaciers has contributed to the formation of most of Maine's lakes, such as Great Pond, which was formed by glacial scouring of the Rome Pluton (Caldwell *et al.*, 1988).

There have been several periods of glaciation and deglaciation. In Maine, the only remaining evidence of glaciation is that of the last period of glaciation in the Late Wisconsin of the Pleistocene. The Laurentide Ice Sheet moved in a south-southeasterly direction across Maine and stopped its forward movement approximately 20,000 years ago (Caldwell, 1982). At its greatest extent, the ice sheet reached across all of Maine and out onto the continental shelf. The thickness of the sheet is estimated to have been at least one kilometer. The weight of this ice sheet depressed the crust 40 meters or more (Bloom, 1960) and since much of the earth's water was tied up in the glacier, sea level was lowered by at least 100 meters. Sea level rebounded with the melting of the ice sheet between 13,300 and 12,700 years ago (Caldwell, 1982).

Tills

As the glacier moved over the land it picked up soil and rock and carried it within the ice. As the ice sheet retreated, it left behind the eroded material that it had carried in the form of till of two varieties. Both types of till have common characteristics of being poorly sorted clay to boulder sized sediments which blanket large areas. *Basal till* is formed beneath the ice, especially in stagnant conditions. It is a compact layer of fine grained, clay-sized sediments mixed with cobbles and boulders. Consequently, the porosity, which is a measure of the interstitial space between grains is extremely low. Permeability, the resistance to flow in the interstitial spaces between grains, is also extremely low. This is especially true in comparison to that of gravel deposits. *Ablation till* on the other hand is less compact. Though its sediments are of the same origin and degree of sorting, ablation till is deposited as the ice melts. Sediments in the ice are simply left behind as the ice thaws. This kind of till is not compacted under a kilometer or more of ice as it is deposited, so the permeability and porosity are generally higher than basal till.

Stratified Drift

Other remnants of glaciation include stratified drift deposits which are eskers, deltas, and kames. Such formations are often deposited as an ice sheet stops moving, stagnates, and melts. The sediment-laden melt waters deposit their sediments in a characteristic manner. Grain size in deposits is a function of the energy in the depositing fluid medium. That is, in slower moving conditions, the grain sizes deposited are smaller than in faster, higher energy environments. A discussion of each stratified drift deposit follows.

Eskers are deposits of well-rounded gravel which are associated with stagnant ice sheets. Eskers are sinuous, stratified drift deposits, often known locally as horsebacks or whalebacks (Fig. 1). Such sand and gravel deposits tend to be long, though they can be discontinuous for hundreds of kilometers; and narrow, rarely wider than 400-700 meters (Embleton and King, 1968). They have steep slopes, approximately 30° (Kehoe, 1982) and rarely exceed 40 - 50 meters in height (Embleton and King, 1968).

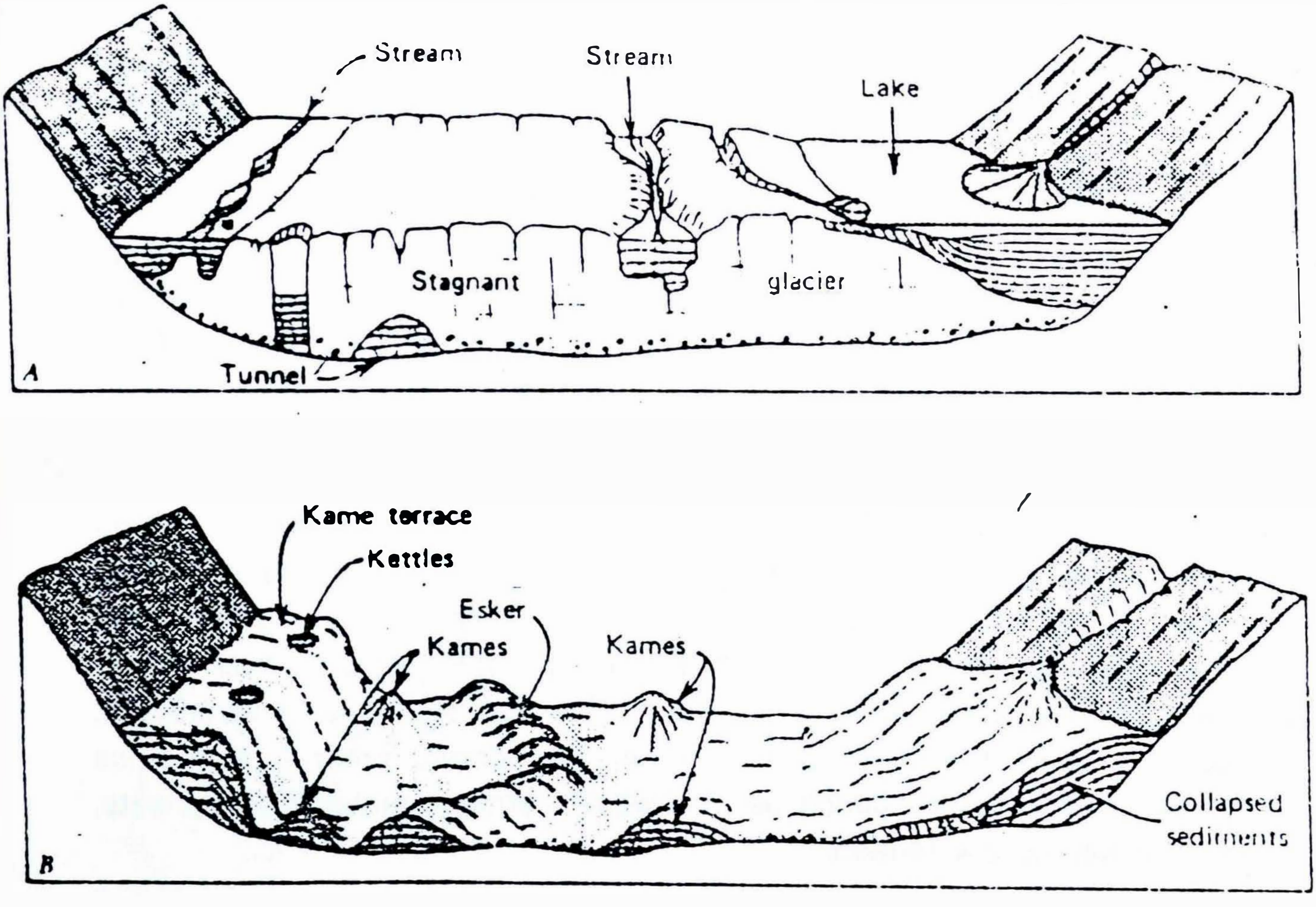


Figure 1. The origin of glacial deposits. A. During glaciation B. After glaciation (From Flint, 1971).

Eskers originate via sedimentary deposition from subglacial meltwater streams. As an ice sheet stagnates and begins melting, much sediment rich runoff is produced. Some of this ends up flowing under the glacier within ice tunnels. Sediments in these tunnels accumulate and have characteristics in their bedding of any stream channel deposit. The tunnel migrates over time upward in the ice; this is the reason for the ridge-like deposit rather than the infilling of a valley stream channel in normal terrestrial systems. Eskers generally follow the direction of ice movement even though they are deposited under stagnant ice conditions. The porosity of esker deposits is generally high, approximately 20% (Caswell, 1979), but is a bit variable due to the degree of sorting. Permeability is exceedingly high, ranging from 200-5,000 gallons per day per square foot (Thompson, 1978). This high permeability is due to the large, well-rounded nature of the grains combined with the generally moderately sorted nature of the deposits.

During this deglaciation process, a rise in sea level caused by the release of water tied up in the ice sheet also influenced the local geology. As it rose it deposited a marine clay named the Presumpscot Formation over much of southern Maine. The formation is characterized as a sheet of gray, silty clay containing marine fossils (Bloom, 1960). There is evidence of this formation extending north to Bingham (Fig. 2). As the sea level advanced, it kept pace with the retreating glacier as evidenced by the existence of glacio-marine deltas. Fast-moving meltwater streams flowing off the glacier entered the slow-moving sea water and deposited materials in the form of deltas. Where streams, such as those which form eskers, exit the ice sheet, a number of different deposits may result. Glacial outwash forms when the stream enters a terrestrial environment. Outwash is characteristically poorly sorted and sloped away from the ice sheet terminus. Where subglacial meltwaters enter aquatic environments, deltas and kames are formed.

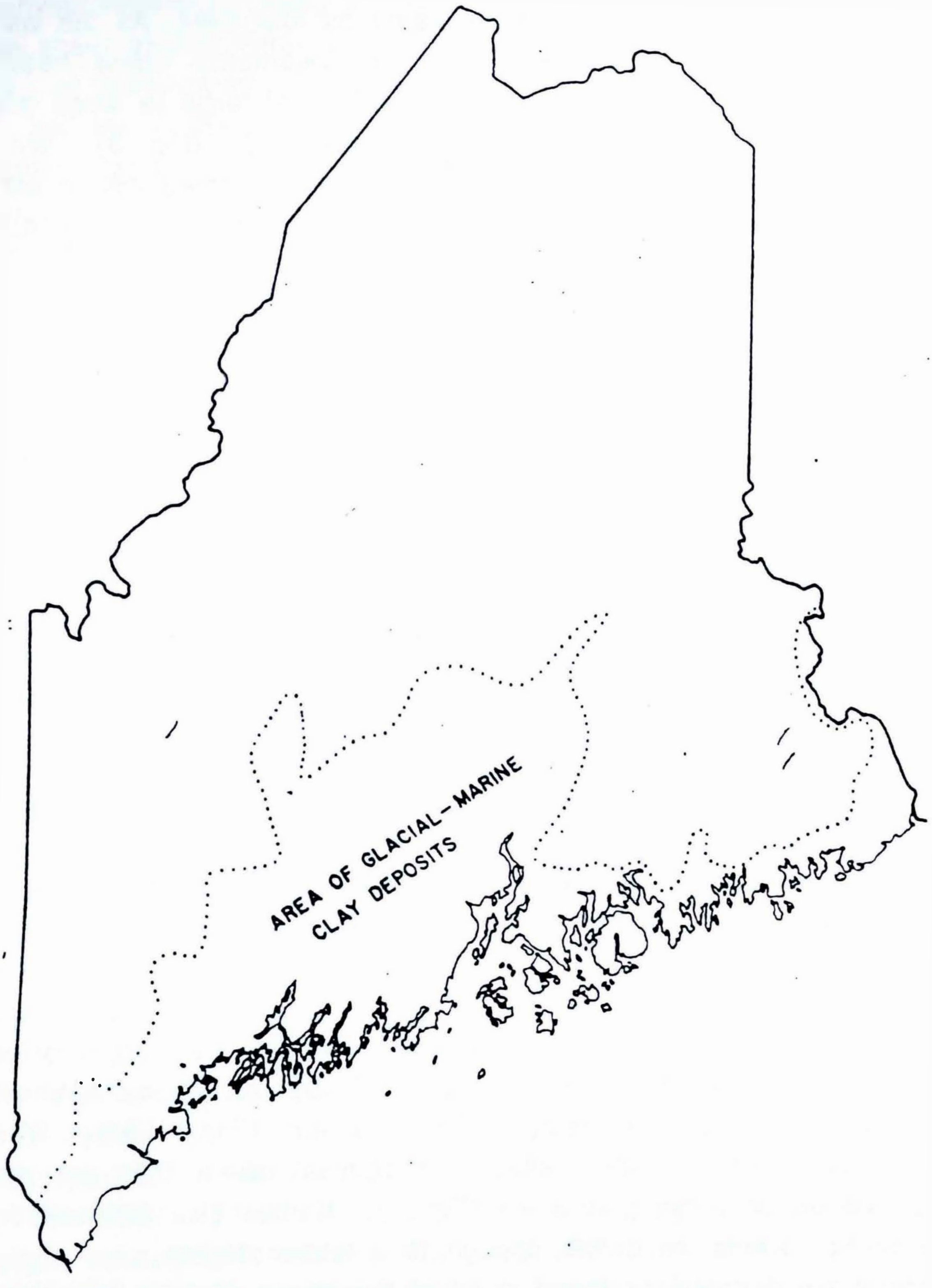


Figure 2. Extent of glacio-marine deposits (Presumpscot Formation) (From Timpson, 1989).

Glacial esker deltas are much the same as any delta. As the water slows down, it is left with finer and finer sediments since heavier particles settle out. There is a linear transgression of large to small grain size from the topset to the foreset and bottomset beds. (Fig. 3). Within each bed, the sediment is well-sorted. Porosity and permeability in esker deltas are similar to that of eskers. Both are fairly high, but quite variable.

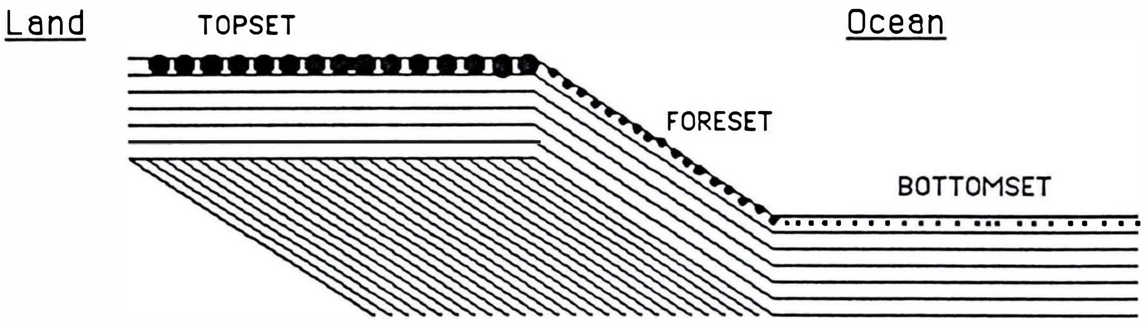


Figure 3 . A schematic representation of a delta with water flowing from left to right. Note the fining of sediment toward the ocean in the Topset-Foreset-Bottomset bedding sequence. (lines represent bedding planes and dots relative sediment sizes.)

Kames are a bit more complex than deltas in that their origin is less straightforward. In general, kames are rather amorphous deposits running perpendicular to an ice sheet margin (Embleton and King, 1968). While they are often formed as mini-deltas in proglacial lakes, they are also often formed on or within glacial ice (Fig. 1). Kames also show sorting and stratification similar to deltas, though to a lesser degree.

Kettles are depressions found in all of the above deposits associated with stagnant ice sheets. Kettles range in size from one to tens of meters deep and up to 13 kilometers in diameter. Most kettles have no surface drainage, and as a result, many have standing water in their bases. Others may have bogs where the base has been infilled with sediments or hydrophylic vegetation. Stagnant ice serves as the origin of kettles. As the ice sheet begins melting, some large pieces of ice are broken off and covered or surrounded by glacial deposits. These surrounding deposits serve as insulation which further retards the melting of the ice, facilitating greater surrounding deposition. As the covered ice does melt, the support for the overlying sediments is lost and collapse follows into the ice void.

The end of the effects of glaciation occurred about 8,000 years ago when the ice sheet had completely retreated from Maine. A thin veneer of the Presumpscot formation was left as a result of the increased sea level at this time. The subsequent re-emergence of the crust caused the sea level to retreat to it's present level (Bloom, 1960).

The Horse Point Esker/Delta System

The Belgrade esker/delta complex is a portion of a large esker complex that extends from Bingham in the north to Augusta in the south, a distance of approximately 100 kilometers. This complex is comprised predominantly of a large esker and associated delta and kame deposits (Kehoe, 1982). Much of the complex may be underlain by basal till or overlain by ablation till. Most segments have some coverage by the marine clay of the Presumpscot Formation. This is an exceptional example of an esker delta complex for it contains glacio-marine deltas which are found in no other state in the United States (Timson and Pickart, 1989). In areas further south the sea level was well below the terminus as the ice sheet melted and no deltas were formed. The corresponding formations south of Maine are glacial outwash deposits. In Maine, however, the sea level had risen to such an extent that the terminus of the ice sheet was often within the ocean, a necessary condition for the formation of glacio-marine deltas. These deltas are demarcations of periods where glacial ablation paused for some amount of time.

The Horse Point esker/delta system is only a small part of this Belgrade esker/delta complex. The Horse Point esker/delta system covers approximately 3,645 hectares, and has deposits which are characteristic of the process of deglaciation (Fig. 4). Horse Point is comprised of an esker system running north-south along the axis of the point. It is approximately 600 meters wide and 42 meters high. A delta is present in the central portion of the point, and immediately south there is kame deposit. On the hill just north of the delta deposit there is a section overlain by ablation till. This till is also exposed along the esker south of the kame deposits. Seven kettle holes are scattered throughout the deposits, located on the west and east sides of the delta and kame deposits. The area surrounding the esker to the east is covered by the Presumpscot Formation. To the west, the existence of the Presumpscot Formation is less evident. The Horse Point area then represents not just one, but at least six different features caused by the Laurentide Ice Sheet. The Horse Point section of the Belgrade Esker complex is significant due to the large numbers of well-formed deltas along the eastern central portions of the point (Anon, 1978).

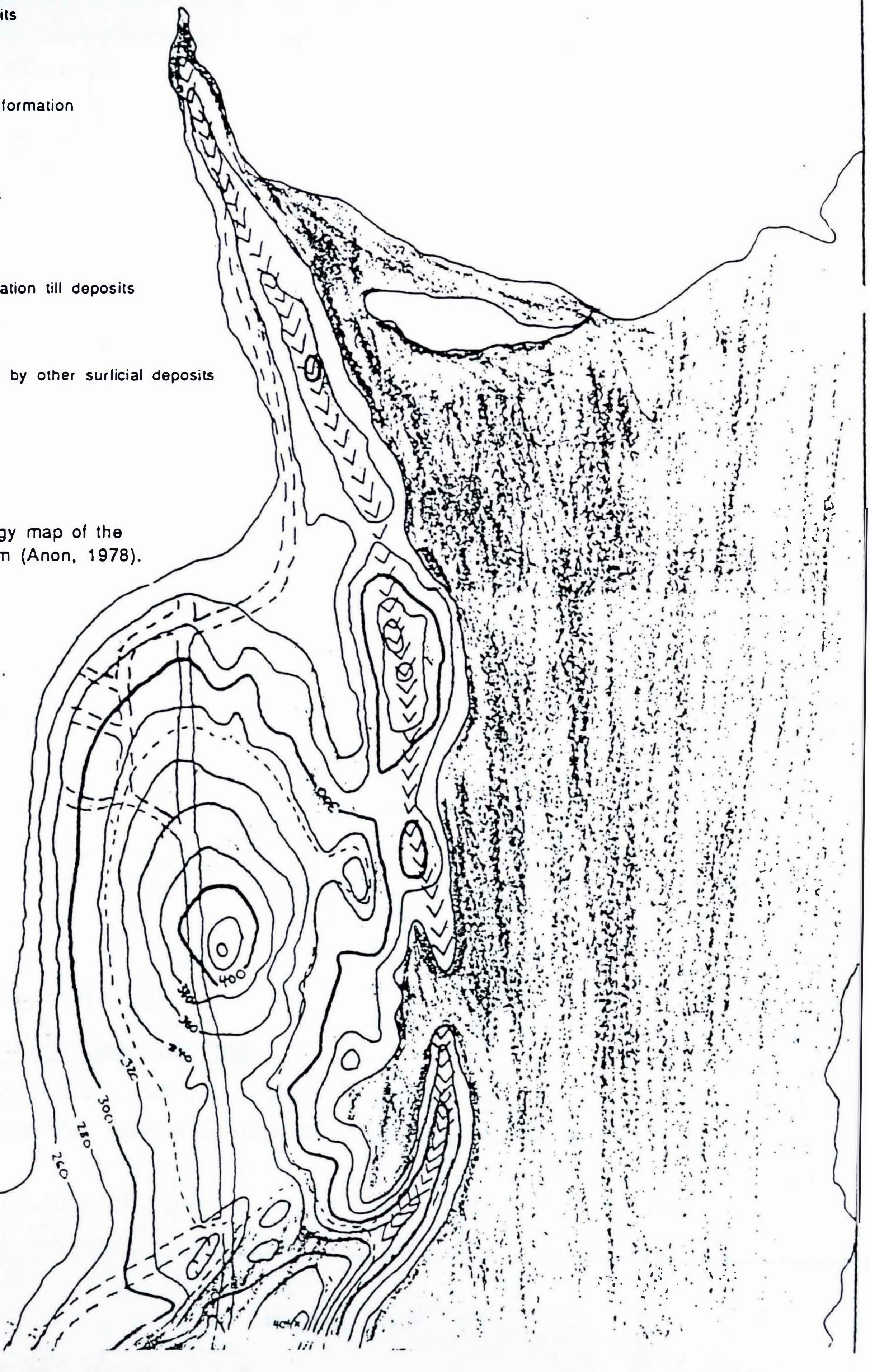
The Horse Point esker delta system contains an excellent example of an esker, so much so that Kehoe (1982), after an inventory of the eskers of Maine, recommended it to the state to be considered as a critical area. The reasons for this recommendation include the well-defined morphology of the esker and the unique complex of deltas, kames, and kettles. This esker system provides a particularly lucid record of the deglaciation process and is an extremely valuable educational and research site.

The seven kettles on Horse Point have been recommended to the Critical Areas Program for classification as critical areas (Timson and Pickart, 1989). Several of these kettles possess a peat bog covering the base, while others are dry. The seven taken together represent a significantly diverse spectrum of dry to wetland covered kettle bottoms without areas of open water (Timson and Pickart, 1989). Kettles are not unique to this system though the ones in the Horse Point esker delta system are some of the best known in Maine (Timson and Pickart, 1989). The Horse Point section of the Belgrade Esker Complex is especially significant because of its great variety of glacial geologic deposits.

MAP LEGEND

Green	Swamp deposits
Blue	Presumpscot formation
. Green	Delta deposits
Brown	Kame and ablation till deposits
(esker symbol)	Esker covered by other surficial deposits
(gravel pit symbol)	Gravel pits

igure 4. Surficial geology map of the
orse Point esker system (Anon, 1978).



Horse Point Complex

Aquifer Hydrology

An aquifer is defined as an underground water source significant to human consumption and can be found in sand, gravel deposits, or bedrock formations (Caswell, 1987). There are geological formations that hold large amounts of water, but do not yield the water to wells; these are not considered to be aquifers. Gravel aquifers are usually common wherever there has been extensive glacial activity. Unconsolidated material, such as gravel and sand, is highly permeable (Kazmann, 1988). Water flows through easily, although in general, coarse gravel is more productive than fine gravel and sands (Kazmann, 1988). Within Maine, eskers (unsorted gravel deposits) are typically the highest yielding gravel aquifers, and are the sites of many home and commercial wells (Caswell, 1987).

Consolidated material aquifers, such as those in bedrock and bedrock fractures, are found throughout the United States. Aquifers that form in sand and limestone bedrock are highly productive. Non-metamorphosed bedrock is permeable enough to allow the water to be retrieved, and limestone bedrock often consists of water filled cavities formed by the dissolving action of water on the limestone. Most other bedrock, such as granite, shale, schist and quartz, is highly impermeable. The only way an aquifer can form in these is by water collecting in the fractures (Kazmann, 1988).

Several items must be considered when looking at aquifer dynamics. To begin with, water moves through aquifers naturally and is also removed by humans. For an aquifer to remain a source of water, it must be replenished; this restoration is known as recharge. There are usually several recharge avenues for an aquifer, one of which is direct precipitation. Rain or snow falling directly onto the area above an aquifer can infiltrate the many layers of material and trickle down into it (Fig. 5). Precipitation will run through a highly permeable topsoil, but in the case of somewhat impermeable topsoil (such as clay), the water will run through at a much slower rate. The rate of infiltration not only depends on the permeability of the topsoil, but also on the layer of material between the topsoil and the aquifer. The grain size of the gravel in this layer controls the rate and amount of flow into the aquifer (Kazmann, 1988).

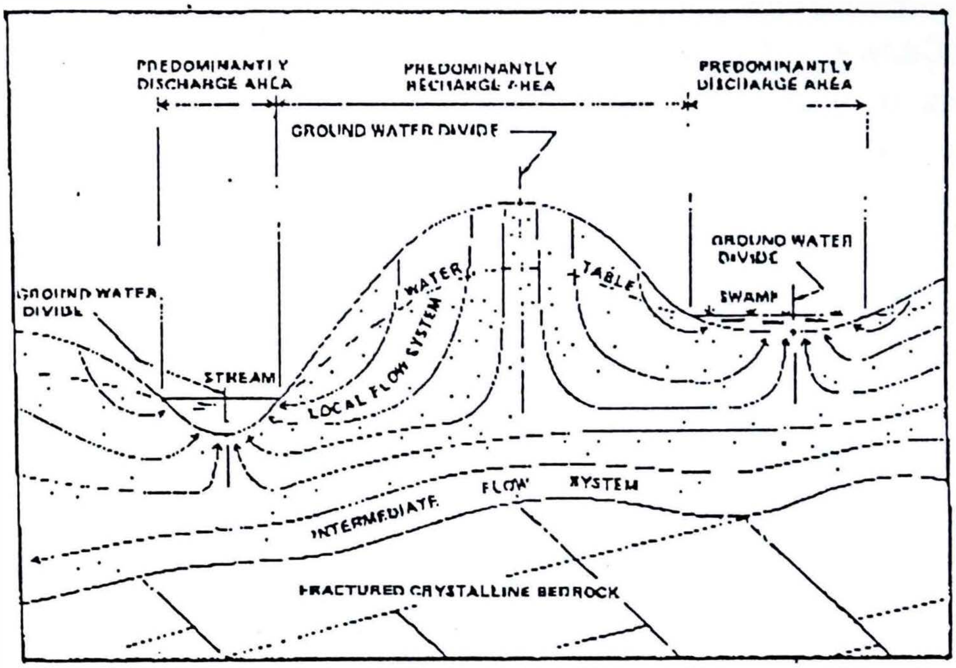


Figure 5. Groundwater Dynamics In a Gravel System (Caswell, 1987).

The other recharge avenue of an aquifer is surface water. Lakes or streams near an aquifer often contribute to the water level if they are at a higher elevation than the aquifer. If the body of water is immediately adjacent to the aquifer, then the level of the water table will be at or above the level of the lake.

Regardless of human withdrawal of groundwater, the recharge entering an aquifer will also move out, a process known as discharge (Caswell, 1987). This may occur in the form of streams that are downslope from the aquifer and run out on the surface, or in the form of underground seepage into a body of water that has a lower elevation than the aquifer (Fig. 5) (Caswell, 1987).

Withdrawel of water by humans has an important effect on aquifers. As long as the rate at which water is being removed is not faster than the rate of recharge, then the overall water level will remain the same with the addition of slight depressions around any wells. However, if water is being removed too quickly, then the level of the aquifer will drop. One consideration is also the fact that most wells are only used during daylight hours, and have time to recharge at night (Caswell, 1987).

It is important to note that gravel or sand overlying aquifers often acts as a natural filtration system that removes many water impurities. Suspended particles and silt are removed from the water as it travels through the sand and gravel above and within an aquifer. The potential overall result may be that the water supplied by aquifers is fairly clean, and needs little or no filtering once removed from the ground. In looking at the dollar cost of water use, the amount of filtering needed is important to paying consumers. Filtration systems can be very expensive, depending on the type of filtration to be used and the amount necessary. The less filtration is involved, the less the consumer must pay for a clean water supply.

When looking at the economic aspect as well as the natural resource aspect of aquifers, it is important to understand the uniqueness of this resource. Water, as long as it is carefully managed, is a renewable resource. This is especially evident in aquifers; the water removed for consumption is being constantly recharged. In general, then, aquifers function in three ways: as filtering systems, as pipelines that move water from one place to another, and as underground reservoirs (Kazmann, 1988). In the aquifer in question (Fig. 5), the function is primarily as a filtration device and as a reservoir for the drinking water of the people who live on Horse Point, as well as a filter for some of the water that moves into Great Pond and Great Bog.

The Effects of Sedimentation and Erosion on Aquatic Ecosystems

Sand and gravel mining is a significant contributor to sedimentation and erosion (Department of Environmental Protection, 1975). This is especially true in Maine, where the most numerous and significant mining type is that of gravel and sand (Department of Environmental Protection, 1975). There are over three thousand gravel and sand pits in Maine. These pits are the most significant cause of water quality degradation among all mining types in Maine (Department of Environmental Protection, 1975). Mining sand and gravel completely removes vegetation from an area and creates a steep slope and increased potential for nutrient leaching and erosion.

Runoff

Rainfall Intensity and Soil Characteristics

Surface runoff is generated when either rainfall intensity exceeds the rate at which the soil absorbs water, or when soil is water-saturated. In an undisturbed area, water can leave the soil through subsurface movement, evaporation, or transpiration. Once the trees are cut, however, transpiration declines, and a major link in the hydrologic cycle disappears. When this link is removed, soil infiltration decreases (due to a decrease in root uptake) and soil saturation is more likely. The result is an increase in overland flow, which contributes to an increase in the rate of erosion (Statham, 1977).

Vegetational cover is probably the most important factor governing runoff, and sheet or laminar erosion. The volume of overland flow is increased, as explained above. The soil's ability to resist erosion also declines due to the loss of roots which hold the soil particles together. In a natural forest, trees and dead leaf litter both serve as a physical barrier which shields soil from direct rainfall. Without this shield, rainsplash loosens sediment particles from the substrate, while sheet water flow entrains these particles. The sediment load in water flow is, in turn, increased by turbulence caused by rainsplash. The combination of all of these factors generally leads to more flow, a higher sediment load in runoff, higher flow velocity, and, therefore, increased erosion (Statham, 1977).

Nutrient and Sediment Composition of Runoff

The composition of the sediment load of runoff, which generally includes nitrogen, phosphorus, hydronium ions, metallic ions, and other ions leached from the soil, is affected by removing vegetation. Plant nutrient uptake decreases, leaving higher nutrient concentrations in soil. These nutrients are then leached out by runoff. It has been shown that the amount of material that can be removed from the soil is related directly to the vegetation of the area (Fig. 6) (Henderson-Sellers and Markland, 1987).

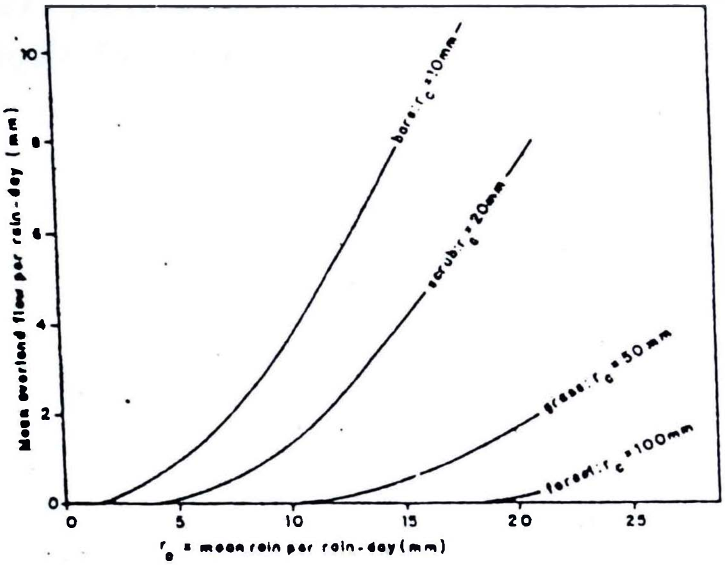


Figure 6. The relationship between estimated overland flow as an indirect indicator of erosion, rainfall intensity given by r_o = mean rain per day; (ii) vegitation cover, indicated by r_c stotage capacity for each day's rainfall (Henderson-Sellers and Markland, 1987).

Nitrogen, which is sometimes a limiting nutrient of aquatic plant growth, is leached out of the soil in significant amounts (Brewer, 1988). Without the shade of trees, soil temperature increases and therefore the activity of nitrifying bacteria increases. A reduction of competition with tree roots for ammonium contributes to a rise in nitrification by bacteria. Nitrate ions which would normally be taken up in plant biomass or remain bound to the substrate become readily available to be leached from the soil (Henderson-Sellers and Markland, 1987).

The leaching of nitrate and hydrogen ions may also result in the release of many cations from the soil. Cations which are normally bound to soil particles also bind to nitrate ions. Therefore, as nitrate ions leave the soil, they tend to carry many cations with them. The result is a net increase of the ions leaving the ecosystem (Likens *et al.,* 1970).

Phosphorus, the nutrient which limits plant and algal growth in most lake systems, is leached from soils through runoff and erosion (Hynes, 1963). Although phosphorus tends to form insoluble complexes with cations in the soil, it can still leave the ecosystem either in its inorganic soluble form, or bound to soil load of surface runoff. Over long periods of time, phosphorus loss can be significant (Stevenson, 1986). The phosphorus load of surface runoff is related to degree of slope, soil type, runoff velocity and intensity of rainfall (Stevenson, 1986).

The principles explained above have been examined in an extensive study conducted at Hubbard Brook Forest (Likens *et al.,* 1970). After forest harvesting, a net loss of all ions in the soil was found, with the exception of ammonium, sulfate, and bicarbonate. The gross ion outputs of streams in the study site increased dramatically only one year after cutting. The total gross export of sediment changed from 13.9 metric tons/km^2 before cutting to 75 metric tons/km^2 after cutting. The water became acidic, (pH 4.3), enriched in metallic ions and silica, and the nitrate concentration was double the recommended drinking water levels (Likens *et al.,* 1970).

The sediments, nutrients, and ions carried by surface runoff are ultimately drained into aquatic ecosystems where they can cause significant damage. Lakes and reservoirs are generally the most susceptible ecosystems (Novotny and Chesters, 1989). This is probably because pollution dispersal is limited in lake systems and because lakes have lower turnover rates than streams and rivers.

The Effects of Increased Nutrient and Sediment Loads in Runoff on Aquatic Ecosystems

In general, the effects of increased nutrient levels in a lake lead to accelerated eutrophication. The process begins when limiting nutrients, such as phosphorous and nitrogen, enter the system. Plant and algal growth are no longer kept in check and primary production flourishes. Initially, the amount of dissolved oxygen is increased because photosynthesis exceeds respiration. However, as plant and algal biomass accumulates, the pool of dead plant and algal matter also accumulates. Bacterial decomposition of this organic matter increases, creating an oxygen sink in the hypolimnion. As dead organic matter accumulates and begins to fill in the lake basin, the hypolimnion becomes more shallow and increasingly anoxic. Faunal life there is limited to species which are tolerant of low levels of oxygen. Because algal blooms also decrease the penetration of light to deeper parts of the lake, submergent vegetation is also damaged (Brewer, 1988).

The Impact of Suspended Solids

Inert suspended solids are also deposited in aquatic ecosystems through surface runoff (Hynes, 1963). Their effects on aquatic ecosystems can be divided into categories based on particle size. Small, light particles, such as clay mine slurries, remain suspended in the water column for long periods of time, affecting flora and fauna throughout the water column. Larger, heavier particles tend to settle on the lake or stream bed, changing it from a non-silted to a silted environment, thereby affecting bottom fauna and flora.

The suspension of small, light particles in the water column causes the water to become opaque. This opacity has both immediate and long term effects on the aquatic system. Plant and algal growth declines, due to the decreased availability of light for photosynthesis. This decrease in plant and algal material, in turn, damages the next link in the food chain - fish which depend on primary production as a food source. Because the plant community requires time to recover, lack of food continues to affect fish populations beyond the time sedimentation ceases. Fish populations that depend on visual cues for food capture are directly affected by reduced visibility due to suspended particles because the probability of seeing and successfully capturing prey are diminished (Hynes, 1963).

Large and heavy particles, such as silt and sand, settle on the bottom of the water body, especially if there is a lack of current. Deposited sediment smothers algal growth, kills rooted plants and mosses, and alters the substratum. For example, mine grit decreases the number of weed beds (Hynes, 1963). Silt-like materials, even in small amounts, can destroy vegetation. An alteration in the makeup of the floral community results, changing from a community of plants adapted to a non-silted environment to one adapted to silt (Hynes, 1963).

The faunal community is also altered by sediment settling on a lake or stream bottom. Sediment fills up cracks and crevices in the stream or lake bed, thereby destroying places of hiding for cryptic animals. The hold-fast mechanisms of limpets, caddisfly larvae, snails and other stone fauna are rendered ineffective if sediment covers the stone bed. Thus, the fauna of a pristine natural community are gradually replaced by burrowing and tube-building organisms, which are better adapted to silted conditions (Hynes, 1963).

Several fish species, such as minnows, white perch, yellow perch, chain pickerel, rainbow trout, lake trout, and salmon spawn near lake shorelines and can suffer severe damage through the effects of sedimentation on spawning grounds (Bourque, pers. comm.). Silt is most likely to become deposited in the same types of areas as chosen for spawning sites. Therefore, only a small amount of silt is necessary to have an adverse effect on fish reproduction. Silt from mine run-off is a common source of this problem (Hynes, 1963).

In conclusion, gravel and sand mining can be expected to result in increased overland flow and increased nutrient and inert solid load in runoff. Characteristics of the active mining pit would include complete removal of vegetation and creation of an almost vertical slope. In the pit, overland flow and nutrient and sediment load in runoff can be expected to increase because plant uptake of nutrients and water no longer occurs, roots no longer serve to hold sediment particles together, and the physical rain-shield of leaf litter and trees is absent. The artificially steep slope also contributes to increased overland flow. Pit runoff should drain into the center of the pit, and percolate through several feet of sand and gravel before reaching groundwater. While runoff percolation through sand and gravel may filter out some suspended solids and insoluble phosphorus, dissolved compounds can be expected to enter the groundwater. The effects of these compounds on the aquatic system into which groundwater flows may lead to eutrophication and damage to lake flora and fauna.

The Effect of Adjacent Wetlands on Lake Water Quality

Degradation of lake water quality can be deterred when a wetland borders its shore. The runoff water which enters the wetland first before reaching the lake is slowed, allowing some sediments to fall out and be deposited before reaching the lake (Zorach, 1979). The wetland is also able to absorb nutrients which would normally be deposited directly into the lake if the wetland buffer was not present. Several of these nutrients, especially nitrogen and phosphorus, are important limiting factors to both systems. These may lead to lake eutrophication if added in excess. The soil, especially wetland peat, as well as the root systems of plants in the wetland, are important in the uptake of water and nutrients. The only situation in which the wetland may not be able to absorb nutrients is when there is excessive runoff, causing a sudden influx of nutrients which cannot be taken up at a rapid enough rate. Usually the net overland export of water is less than the net input because the biota is adapted for a large range of water and nutrient levels, and also a large amount of the water is lost through evapotranspiration. Wetlands have been used for waste treatment and it has been successful in the short-term (Zorach, 1979). However, when nutrient levels are excessive, the bacteria which are essential for plant nutrient uptake are not able to process effectively, and adjacent water bodies are degraded. Proper use of buffer strips or protection zones around a wetland are important for wetland protection (Zorach, 1979).

Much of the nutrients which enter the wetland are "transformed through sorption, coprecipitation, active uptake, nitrification and denitrification" (Zorach, 1979), and therefore become an integral part of the plant life and substrate within the system, limiting the amount which eventually reaches the open water. Nitrogen and phosphorus, which are important limiting factors for plant growth, are usually taken up by the substrate and biota of the wetland. Other nutrients which are important to water quality will be discussed later in the text where tests are discussed in detail. Usually these nutrients, when not in excess, promote diversity and productivity of plant species. Nitrogen is taken up more readily than phosphorus and is easily fixed in the wetland community, but when either is in excess or water flow rates are increased, which happens when there is a large amount of runoff, plant and soil sorption is reduced (Richardson and Marshal, 1986). This allows more nutrients to reach the lake.

Nitrogen is quickly lost through denitrification at a faster rate than the uptake of nitrogen (Reddy *et al.*, 1989), therefore adding more nitrogen to the atmosphere and leaving less for the biota. Because nitrogen is an essential element in plant growth the wetland becomes a nitrogen sink, taking up as much nitrogen as it can handle. The uptake of nitrogen is dependent on the oxygen supply from the atmosphere and the NH_4^+ supply from nitrogen mineralization or external inputs of nitrogen. Therefore, there must be a good supply of oxygen available to the roots and stems of the plants within the wetland system so that nitrogen will be taken out of the surrounding water.

Phosphorus removal is variable from wetland to wetland, and from season to season. Most phosphorus is taken out of the available water during the growing seasons, but phosphorus sorption is lowest during periods of high water or flooding (Richardson and Marshal, 1986). Once it is incorporated into the ecosystem the storage of the phosphorus is dependent on decomposition and mineralization rates of dead organics and the incorporation of organic phosphorus into the soil and the removal from water by soil adsorption. When there is increased dead organic matter more phosphorus returns to the water, although the soil compartment is the main phosphorus sink. Richardson and Marshal (1986) showed that nearly 35% of the annual above ground phosphorus uptake was returned to the soil of the Michigan fen ecosystem through standing dead organics and litterfall. In the soil, the phosphorus is more prone to loss from the ecosystem through leaching. Not only does much of the phosphorus which is added to a system return to the soil, but microorganisms in the litterfall are only able to take up low additions of phosphorus, and the amount which they can hold decreases over time (Richardson and Marshal, 1986).

Land Use Patterns

Land use for cropland, pasture, forest, roadways, and commercial development is of great concern. All may cause erosion, unfavorable soil conditions, and are sources of phosphorous and sediment deposition. Phosphorous runoff is carried into lakes over the ground's surface following rainfall or snowmelt. This runoff and deposition, which finds its way into nearby water systems, encourages lake eutrophication. The amount of phosphorous which is carried from a particular piece of land by surface runoff is largely dependent on how the land is being used.

Forested land accounts for relatively little phosphorous runoff when compared to other land uses. The volume of water which runs off forested land is less than that of most other land uses. The leaf canopy of the trees intercepts some of the precipitation and stores it until it evaporates, and much of the phosphorous is taken up into the forest biomass via the extensive root systems present. Finally, natural irregularities of the forest floor provide many small depressions which can temporarily store water which would otherwise run off.

The amount of land used for agriculture and pasture has continued to decrease in the state of Maine since 1964, although there is still a significant amount of phosphorous runoff coming from agricultural areas. The runoff is attributed to inadequate and poorly managed plowing techniques as well as nutrient build-up from fertilizers. Fertilizer should not be applied during wet periods when it will runoff almost immediately, and the amount of fertilizer applied should be limited. Inadequate manure storage also contributes to the phosphorous loading.

Residential development (i.e. when forest land is converted to residential use), results in both the volume and quality of the surface runoff to change. Surface storage area is flattened for lawns and gardens, while houses are placed over previously permeable soil. These changes combine to increase the amount of water leaving the site in the surface runoff, sometimes by as much as 50%. The increased load of phosphorous may be in the form of dry atmosphere fall out (dust), soil particles, detergents, fertilizers, faulty septic system runoff, or decaying grass clippings. Shoreline residences are of particular interest as they may have a direct impact on the water system. Non-shoreline residences have the same inputs although there is not always a direct route to the water system.

Mining activity allows for erosion and subsequent phosphorous runoff. The uncovered landscape creates passageways for great quantities of sediment. Lakes and rivers experience increased turbidity -- often rendering them inhabitable.

Land designated for road use is significant, as the presence of roads facilitates surface runoff. Roads allow for the water to be directed into ditches, while natural drainage ways are diverted or eliminated. The surface runoff from paved roads consists mainly of residential runoff and serves as a passageway for sediments and nutrients bound for rivers and lakes.

Wetland Types and Ecological Significance

Wetland Types and Vegetation

A wetland is defined as land where the water table is at, near or above the surface long enough to promote the formation of hydric soils or to promote the growth of hydrophytes. There are a variety of freshwater wetlands present in Maine. These ecosystems are essential natural habitats for wildlife, and possess educational and recreational value for human beings. They may also perform important flood protection and pollution control functions. An increasing number of disturbances, such as development and mining, adjacent to wetlands has intensified awareness that more research needs to be conducted concerning the importance of these ecosystems. Prior to discussing their ecological significance, it is important to become familiar with types of wetlands and wetland vegetation. Four general types of freshwater wetlands can be recognized, each with a characteristic vegetation diversity (Table 1).

Bogs: Ombrotrophic peatlands with the water table at or near the surface. In ombrotrophic peatlands, the bog surface, which may be raised or level, is unaffected by groundwater from the surrounding terrain and depends entirely upon precipitation and dry atmospheric fallout for their nutrient input. Therefore, it is generally acidic and low in nutrients. Bogs are dominated by sphagnum mosses, ericaceous shrubs, and may be treed or treeless.

Fens: Minerotrophic peatlands with the water table at or above the surface. Minerotrophic peatlands receive nutrient input from both surrounding groundwater and precipitation. The moving waters result in a more nutrient-rich area, possessing a more diverse flora than bogs. The peat is often well-decomposed and the dominant vegetation includes sedges, grasses, reeds, and sphagnum mosses.

Marshes: Wetlands that have well-decomposed peat and are periodically inundated by standing or slowly moving, mineral-enriched water. The vegetation consists predominantly of emergent sedges, grasses, rushes, and reeds which border grass and sedge meadows with surrounding bands of shrubs and trees. Where open water occurs, submergent and floating vegetation thrive.

Swamps: Wetlands characterized by trees and shrubs, usually without abundant peat. The vegetation types include deciduous shrubs, evergreens, and a variety of soft and hardwood trees.

Table 1. Ecosystem types found within the four general categories of freshwater wetlands. Each ecosystem contains a diversity of vegetation communities.*

Bog	Fen
Raised bog	Rich fen
Lakeside bog	Patterned rich fen
Kettle-hole bog	Unpatterned rich fen
Maritime bog	Poor fen
Subalpine/alpine bog	Patterned poor fen
Marsh	**Swamp**
Shallow emergent	Coniferous seepage forest
Deep emergent	Outwash seepage forest
Sedge meadow	Hardwood flood plain forest
Beaver flowage and meadow	Shrub swamp
Tidal fresh marsh and flats	Tupelo swamp

*Maine Ecosytem Classification, June 28, 1990. Maine Critical Areas Program.

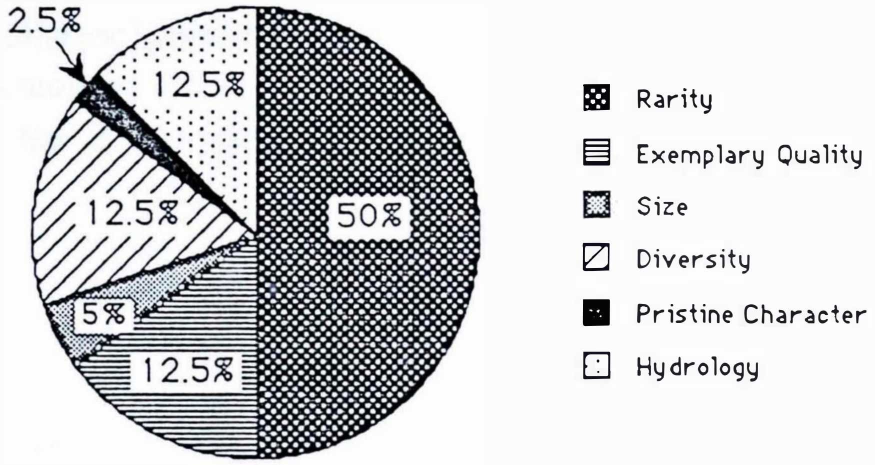
Evaluation of Wetlands as a Natural Area

Evaluation of the ecological significance of wetlands is an area open for study. Presently, there is no comprehensive system for determining the importance of such ecosystems. However, there has been a study by Maine's Critical Areas Program (CAP) which attempted to evaluate peatlands with regard to its significance as a natural area. The CAP developed a means of comparison among wetlands. They did this in a quantitative way by constructing an index. The parameters used in the index were outlined in terms of rarity of natural features; outstanding representative quality of natural features; and cultural significance (Fig. 7). Once the index value of a wetland is established, it can then be compared to other wetlands. The higher the index value, the greater the importance as a natural area. The total scores for each peatland where grouped into five protection priority classes, ranging from exceptionally significant (class 1) to unexceptional (class 5). The criteria emphasized natural (80%) over cultural values (20%). Among the natural factors, rarity received the greatest importance followed by quality of type and diversity. Cultural values including recreation, education, and aesthetic beauty were also given significant weight. The purpose of studying these parameters was to determine whether the natural features of a peatland were of such high scientific and cultural value that consideration should be given to protect the area from mining or development.

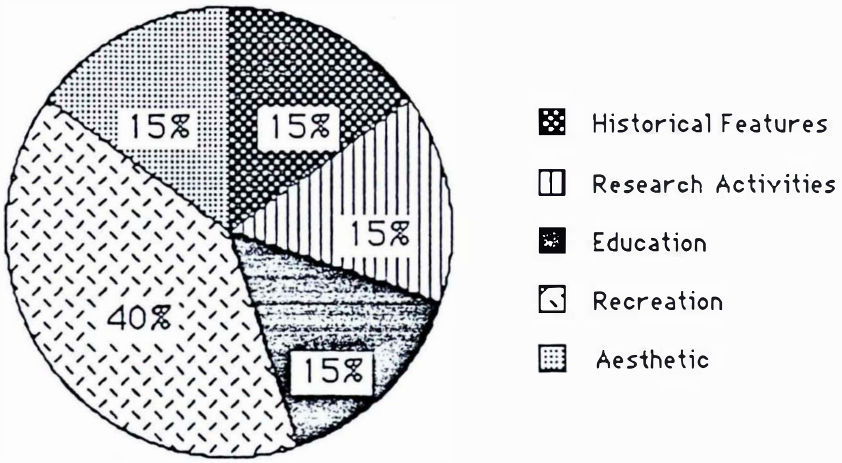
Stockwell and Hunter (1985) have completed a three year study on the distribution and abundance of birds, reptiles, amphibians and small mammals in peatlands of central Maine and have used many of the criteria found in Maine's Critical Areas evaluation scheme. They emphasized the parameters found under natural values, such as geomorphological types (diversity), size, vegetation types, and wildlife types (rarity of components). When asked what parameters they would use to set up a system for evaluating peatlands, their suggestions followed those in the Critical Areas evaluation (Stockwell, pers. comm.). Golet and Larson have also listed criteria by which a wetland can be evaluated as an area for preservation (Zorach, 1979). They included rarity as a primary criteria, followed by proximity of wetland types, breeding habitat for ducks, migration areas for birds and waterfowl, presence of uncommon geomorphological features in, or associated with, a wetland such as eskers, and wetlands linked with waterways. The Critical Areas system has identified the major aspects of a wetland's inventory. This type of inventory is necessary to determine relative importance of different wetlands and to justify the protection of appropriate ecosystems.

Significance of Wetlands

Freshwater wetlands have a variety of significance extending from natural to cultural values.



Part A. Natural values



Part B. Cultural values

Fig. 7. Shows the parameters used in establishing an index in order to create a means of comparison among wetlands. This criteria emphasizes natural over cultural values 80% to 20% respectively.

Because wetlands are associated with water, people are drawn to them for recreational uses. Human uses may include camping, watersports and nature walks. Wetlands are also important natural buffers. Commercially, the peat characterized by peatlands is utilized for fuel and agricultural fertilizer (Stockwell and Hunter, 1985). Furthermore, wetlands, particularly peatlands, are proving to be valuable habitats for wildlife (Stockwell and Hunter, 1985). The diversity of wildlife and vegetation types not only provides educational value, but produces a unique, natural area comprised of abundant life.

Wetlands may provide important sources of food, shelter, and protection from predators for wildlife. Factors affecting suitability of freshwater wetlands as wildlife habitats are shown in Table 2. Structural complexity of wetlands is a major determinant of wildlife diversity. Wetland size, type, heterogeneity, and diversity of adjacent upland and surrounding habitats, enhances the value of the wetland environment for many wildlife species (Zorach, 1979).

Table 2. Criteria for the evaluation of wetlands as a wildlife habitat*

Factors	Importance
Class richness	Two or more wetlands enhance the number of plant and animal species within a system.
Size	Small wetlands are important for individual breeding pairs while larger wetlands are important for statewide populations and flocks.
Diversity of wetland types	Valuable to diversity of species.
Adjacent habitat	Mixed habitat types (fields, woodlands, ponds) promote body, greater diversity, and, productivity.
Vegetation cover type	Increases diversity for wildlife.

*Zorach, 1979. Maine Critical Areas Program.

Wetland vegetation is important and offers food sources for waterfowl and migratory birds. Great Bog was rated moderate for waterfowl habitat in the late 1960's and 1970's by the Maine Department of Inland Fisheries and Wildlife (Ritchie, 1990). During the 1960's evaluation, several wetland types including a shallow fresh marsh, a deep fresh marsh, and a wooded swamp were found within the wetland complex which included Great Bog. This diversity of wetland types which further accentuates vegetation diversity, enhances the importance of the area as nesting, breeding, and migration habitat for waterfowl. Species expected to frequent the Great Bog area include: the American Black Duck, Mallard, Wood-Duck, Green-winged and Blue-winged Teal, Ring-necked Duck, Hooded Merganser and the Common Loon (Belgrade Comprehensive Land Use Plan, 1987). Loons can be found throughout Maine and records show that between 1983 and 1990, twenty to forty-seven adults were counted during the annual loon count on Great Pond (Maine Audubon Society, 1990). Also, between one and four nests were discovered each year during the last four years of the count.

Furthermore, a variety of game species may inhabit wetlands although they are not restricted to them. Deer may use wetlands as travel corridors to reach food sources or for shelter during extreme weather conditions. However, according to records of the Maine Department of Inland Fisheries and Wildlife, there have been no indications of the presence of any deer wintering areas at Great Bog (Ritchie, 1990). Moose may also visit wetland ponds to feed on aquatic plants. Other wildlife known to use wetlands are beavers, muskrats, otters, and minks (Belgrade Comprehensive Land Use Plan, 1987). Extensive tracks and bedding sites seen during our field work have confirmed the presence of large mammals such as moose and deer at the Great Bog, and we feel that this evidence warrants further study.

There is a profound lack of information on the wildlife of peatlands. In one of the few wildlife studies, Stockwell and Hunter (1985) showed that species found in nine peatlands were not necessarily unique or unusual, but the fact that such a wide variety of species was found in a small area is significant. That is, each peatland studied revealed a much higher species richness, especially of birds, than any other habitat in Maine. From our on site surveys, we have found Great Bog to be a unique ecosystem with the potential to have high species richness as well as providing a habitat for rare and endangered species. It is recommended that the Department of Inland Fisheries and Wildlife construct an in depth study of the flora and fauna in this area.

If wetlands are misused for any reason, these "last and largest relatively undisturbed ecosystems" (Stockwell, 1985) can be disrupted. Wildlife species may be forced to relocate, and the assemblage of those species may never be found within the same ecosystem again. Some disturbances may include; recreational use of wetlands by snow machines and all-terrain vehicles thereby disrupting the behavioral patterns of the inhabitants; illegal hunting and trapping creating unnatural stresses on the fauna; illegal collection of rare species of wildflowers, especially orchids, leading to localized species extinction; visitation of wetlands by classes, scientists, and tourists; and the construction of roadways and railways and mining across or adjacent to wetlands greatly disrupting their water movement and natural balance. Freshwater wetlands are vital ecosystems for wildlife, particularly waterfowl (Zorach, 1979), to allow them to diminish. To maintain their diversity and enhance their use as a wildlife habitat, as well as preserving their beauty for the human society, past management practices must be reconsidered.

According to Weller (Zorach, 1979), management decisions should complement the natural functions of a wetland, allowing natural processes to occur. Factors which tend to disturb the structure or function of a wetland should be kept to a minimum. The only method of efficiently determining how to manage wetlands is by using an effective evaluation like the one outlined by the Maine Critical Areas Program. This criteria, however, only recognizes wetlands for their ecological importance and disregards their economic importance. Economics such as peat resources and forest products are a factor in management and should be considered. Once a wetland can be evaluated, the decision whether to keep the area off limits to excess disturbances can be made.

Wetland Classification

Of all wetland types in existence, the two that are most important to the scope of this study are bogs and fens. Each will be discussed in turn.

Bogs

There are generally three major bog types: kettle-hole bogs, raised bogs, and lakeside bogs. The geological and hydrological activity that takes place during the formation of the peat determines the type of bog that is formed.

Kettle-hole bogs

Kettle-hole bogs were initially formed when large portions of the receding glaciers were broken off and deposited in depressions carved in the rock. This stagnant ice was then surrounded or covered by glacial deposits that further hindered the melting of the ice. As the covered ice finally melted, steep, water filled basins resulted. These basins then went through a process called quaking bog succession, the end result being a kettle hole bog.

Quaking bog succession occurs when sediment begins to fill in the sides of a lake, pond or water filled depression usually due to the effects of eutrophication. As it does, marsh and bog plants grow in this sediment and extend beyond it, out toward the center of the lake. This forms a floating mat of plants, typically mosses. As the mat grows, the mosses and bog plants die, and form peat. This results in a more acidic environment which in turn promotes the growth of more bog plants. This process continues until the entire bog has been filled in.

Bogs formed in this manner typically have severely restricted water flow and are termed ombrotrophic peatlands. These are peatlands that receive all water inputs from precipitation and runoff. Bogs of this type typically have open water in their centers and a surrounding fringe of vegetation that makes up the mat. These differ from raised bogs in this respect and more often refer to the kettle-hole bogs. Quaking bog succession almost always results in the formation of ombrotrophic peatlands and kettle-hole bogs (Johnson, 1985).

Raised Bogs

Raised bogs also begin as small lakes, ponds or water filled depressions but the process which creates them is slightly different and results in a slightly different type of bog. Raised bogs occur where there was previously a continuous flow of water through a lake or pond basin.

The process which results in this bog formation is termed flow-through succession.

Flow-through succession often occurs in a lake basin that has a continuous inflow and outflow of water. The flow of water deposits sediment in the middle of the lake causing a build up of material. Marsh and bog plants colonize this new "land", stabilize it, and as a result add to its accumulation by trapping more sediment from the flowing water. Overtime, the plants die, sink to bottom and increase the organic nutrient supply. As this organic deposit grows, it begins to divert the flow of water around it. This gradual accumulation of peat results in a raised bog. Eventually, the raised bog will accumulate enough sediment to bring the bog into contact with a firmer land mass and thus remove all water flow from around it (Johnson, 1985).

Raised bogs are classed as minerotrophic peatlands. These peatlands receive water that has first passed through soil before seeping into the bog or from direct precipitation. Because of this, minerotrophic peatlands usually have a high ground water level and occupy a low geographic point, thus a raised bog appears as a dome rising over the substrate and the only water is around the fringes (Johnson, 1985).

Lakeside Bogs

Lakeside bogs begin not with a depression that fills in but with a lake that overflows. This process is called paludification. Paludification results when the boundaries of a lake or bog are flooded due to climate or geologic change. The water causes the soil or peat to compress and become impermeable to flow. Thus, the water receives very little mixing or replenishing, resulting in wet, acidic conditions. Mosses and bog plants grow in this environment and the wetland is formed. Lakeside bogs typically extend out from the shore of the lake and transform from more solid, stable, dry land to spongy, wet land closer to the lake (Johnson, 1985).

Lakeside bogs are termed transitional peatlands because they are a transition zone between the dry land ecosystem and the lake. Transitional peatlands are often intermediates between the two other classes of bogs described previously as well. They receive water and nutrients from several sources including precipitation, and some flow from the surrounding area. Once a transitional peatland is formed, it can receive nutrients from the soil but is not considered minerotrophic because it also receives organic inputs from the other area it borders, such as a lake or another bog (Johnson, 1985).

Fens

Fens differ from bogs in that along with precipitation, its major sources of nutrient input are from groundwater movement and overland water flow. In bogs, groundwater movement is minimal at best and overland flow input only occurs during storm events. Fens are still composed of peat but the peat and the water held by the peat is not as acidic.

Because of the water flow in fens, pH and nutrient levels are typically higher. The continuous flow removes the waste products that accumulate in a true bog and lead to the acidic environment while replenishing the nutrient supply (Johnson, 1985).

Fens are formed by many of the same processes that form other bogs and in some cases, were once bogs. The differences arise because fens usually form over a substrate that is impermeable to water (bedrock or clay), fens are also situated on slopes and thus are often much more shallow. This results in the continuous flow of water characteristic of fens.

Ecological Functioning of Bogs and Fens

Bogs and fens serve several equally important environmental functions. First, bogs and fens are separate and distinct ecosystems which provide habitat for a variety of flora and fauna, some of which can be found in no other place but a bog or fen. Bogs and fens also act as buffer systems to lakes from the surrounding land. Chemicals and compounds that are added to the soil accumulate in the runoff of water from storms and flow down slopes toward the lake. If untouched, this water flows directly into the lake and as in the case of phosphorous, leads to algal blooms and an increased rate of eutrophication. If a bog is present, this water flows into it and the bog acts as a sponge and filter, holding the nutrients and decreasing the net flow into the lake.

As well as being critical habitats for flora and fauna and acting as a buffer for lakes to nutrients, bogs are also primary sources of peat. Peat has a commercial value for fuel and the harvesting of peat from bogs has some economic value (Stockwell and Hunter, 1985).

It is clear that bogs serve several environmentally important functions. It is clearer still that bogs are very sensitive ecosystems and only by understanding all aspects of the bogs interaction with the environment can bogs be managed correctly and efficiently.

Rare and Endangered Species

Maine peatlands provide a habitat for several threatened and endangered species. These species, by definition, are classified as rare. Rarity results from any of three characteristics: narrow habitat requirements, low population size, and narrow geographic range; each of these characteristics is independent of the others (Rabinowitz, 1986). The rarest species demonstrate all three characteristics.

Rare species are especially susceptible to extinction. Recent distribution data (Fig. 8) support habitat alteration as the most significant effect (Enger, et al., 1990). The rate of species extinction has increased over the last 100 years in proportion to the rate of habitat alteration. With the growing human population, habitat alteration is rising at a tremendous rate. This, in turn, is driving the extinction rate to levels higher than at any other time in history. Therefore, the effect of habitat alteration should be a major consideration when plans for mining or development involve an area that rare species may inhabit.

The conservation and protection of rare and endangered species is encouraged at both the state and federal level. Federally, the Endangered Species Act of 1973 was written to protect rare and endangered species. Amendments have been made through 1988. Those made in 1988 were added because of several Congressional findings. One of these was as follows: "The Congress finds and declares that various species of fish, wildlife, and plants in the U.S. have been rendered extinct as a consequence of economic growth and economic development untempered by adequate concern and conservation." Unfortunately, the standards of the Act do not protect species that have not already been officially classified as endangered or threatened. Consequently, areas where such species survive may be destroyed or altered before their significance is known. The conservation of plants and animals also depends on help at the state level. The State Planning Office of Maine, through the Critical Areas Program, encourages this conservation. The program was established to identify areas "which contain natural features of state significance" (Tyler, pers. comm.). This program identifies and registers areas that are considered to have unique natural habitats. These habitats may contain rare plant or animal species, distinct geologic formations, or extraordinary scenic landscapes. Although the Critical Areas Program can recognize these regions and attempt to gain the cooperation of landowners, it has no legislative power to protect these areas.

For regulatory purposes, rare species are classified as threatened or endangered. Threatened species "are likely to move into the endangered category in the near future if the causal factors keep operating" (Thornback and Jenkins, 1982), while endangered species are "in danger of extinction and whose survival is unlikely if the causal factors continue operating" (Thornback and Jenkins, 1982). Maine's Endangered and Threatened Plants List was compiled by the Critical Areas Program to encourage the protection of Maine's rare species. This list includes two species that prefer peatlands as their habitat that are not only listed at the state level, but at the federal level as well. The U.S. Fish and Wildlife Service has classified the Prairie White-fringed Orchid (*Platanthera leucophaea*) as threatened (endangered at the state level) and the Small Whorled Pogonia (*Isotria medeoloides*) as endangered (also at the state level). The threatened Prairie White-fringed Orchid has not been seen since 1985. It is threatened by collectors and by habitat destruction (Crow, 1982). Although this species has not been seen for almost six years, species are not considered extinct unless they are "not definitely located in the wild during the past fifty years" (Thornback and Jenkins, 1982). The endangered Small Whorled Pogonia is one of the rarest orchids in the country. There are 49 populations of this orchid known to exist and although it is distributed throughout the Northeast, over 80% of its total population is located in Maine and New Hampshire. The primary threat to this plant is also habitat destruction (Campbell and Rooney, pers. comm.).

Habitat alteration is the most significant contributor to the rising levels of species rarity, and even extinction (Fig. 8). Therefore, the most effective way to ensure the survival of declining species is not necessarily to protect the individual, but to protect the habitat.

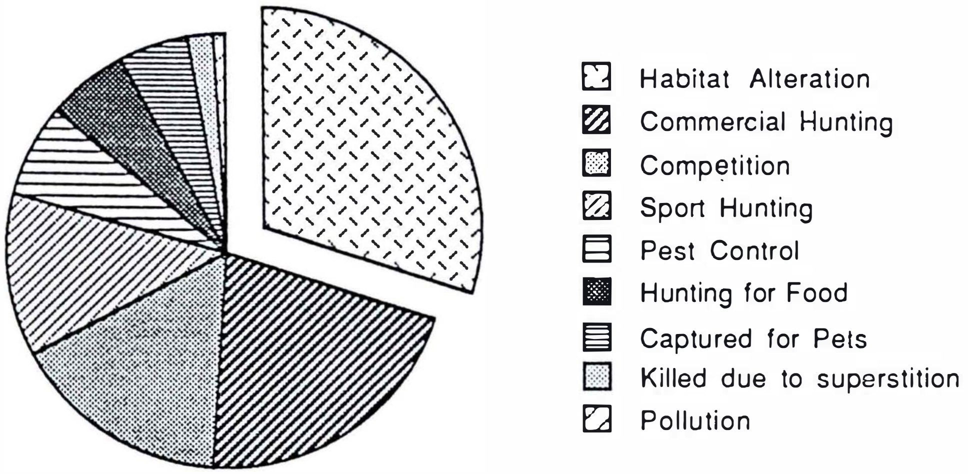


Fig.8 Major Factors Contributing to Species Extinction (modified from Enger et al., 1990)

APPLICABLE REGULATIONS

Regulatory Levels

Federal and state laws are consulted when applications for development near wetlands and Great Pond are submitted to the state. The application is reviewed by the state and must be approved before any excavation begins. Both state and local permits are needed before any construction can begin. The federal, state, and local laws also outline enforcement policies once the development commences. Tilcon, when submitting their application must work within the limits of the laws relating to gravel mining and environmental protection.

Government institutions have set up a hierarchy of laws to allow the smaller agencies to pass laws more specific to their setting. Federal laws are the most general, establishing nationwide standards. It is then up to the states and local governments to form stricter versions of the federal regulations. The states must adopt the federal laws, but often impose stricter regulations to suit the needs of the individual state. To do this, each state must consider its unique characteristics: its industries, geography, topography and ecosystems. Townships and municipalities may pass regulations and ordinances that conform to the specific needs of the people within their localities. The citizens of the townships and municipalities that adopt these regulations often can impose stricter rules than state laws. The state laws will take effect if no local laws or ordinance exists.

Federal

The following is a description of potentially relevant federal laws. The majority of the wetland regulations are concerned with the preservation of the ecosystem and the protection of the wildlife which use these ecosystems.

The *Water Bank Program for Wetlands Preservation Act* states that the wetlands of the nation are being reduced and those that remain are a natural resource that should be maintained. The word 'resource' refers to the idea that this area is of some value in its natural state. It declares "to preserve, restore, and improve wetlands of the nation... to reduce runoff and soil and wind erosion" It gives the Secretary of Agriculture the responsibility to design and carry out a program to prevent serious loss of wetlands and to preserve, restore and improve these areas.

The *Migratory Bird Treaty Act* is an agreement among U.S. Mexican, Japanese and British governments, declaring that the harassing or harming -- in any way -- of migratory birds listed in this act, unlawful. The Act requires the protection of the wetlands used by these birds for the purpose of breeding, nesting, or migration (ELR Stat. OUT 129).

The *North American Wetlands Conservation Act* protects, enhances, restores and manages the diversity of wetland ecosystems and other habitats for migratory birds and wildlife in North America. The underlining purpose of this Act is to assure that nongame migratory birds do not reach the point at which measures of the *Endangered Species Act* are necessary (U.S. Code Ch16 § 4401).

The *Endangered Species Act* declares that harming any endangered species wildlife is unlawful. It is unlawful to damage any other area "in knowing violation of state law any endangered plant species." Programs designed for the conservation of these species and that the federal government will cooperate with state and local agencies to conserve these endangered species. Finally, it avows the financial means whereby the ecosystems on which endangered species and threatened species are dependent may be conserved. (ELR Stat. ESA 011)

Note that these regulations will not be applicable unless an endangered or threatened species or a listed migratory bird is found to be dependent on Great Bog. Even then it must be proven that the excavation has a negative impact on the primary wetland.

State of Maine

In order to gain approval to mine on the Belgrade esker, Tilcon must comply with state of Maine and local laws, as well as federal laws. The proposed site of Tilcon's gravel pit is close to a peatland. Thus, a large majority of the laws reviewed will pertain to surface mining and water quality.

The application procedure for obtaining a permit to mine, and the regulations that deem a permit necessary to mine, will be discussed in great detail. Usually two state laws are consulted by the state when reviewing an application like Tilcon's: the *Natural Resource Protection Act*

(NRPA), and the *Site Location and Development Act.* In addition, Tilcon has to comply with one local ordinance, *The Shoreland Zoning Ordinance* from the Town of Belgrade, Maine. This law, which includes strict wetlands regulations, could have the largest impact on the decision as to whether Tilcon is permitted to mine a gravel pit of the proposed size on the Horse Point esker.

Pertinent Regulations Regarding Mining Proposals

Federal

Mining as a land use

The *Watershed Protection and Flood Prevention Act* is the only federal law about mining, applicable to the Tilcon situation. For the most part, the Act says that any erosion or sediment damages in a watershed "resulting in the loss of life and damage to property constitute a menace to the national welfare." The federal government will cooperate with the state and local agencies in conserving and utilizing the land to preserve, protect and improve the nation's land and water resources (U.S. Code Title 16 Ch.18 §1001).

Water Quality

The Federal Water Pollution Control Act, is better known as the 'Clean Water Act'. It gives national quality standards for all sources of water. However, in one section it specifically discloses how the Environmental Protection Agency oversees programs with other government agencies to regulate mining procedures. It mandates that all mining operations must be able to control water pollution that will effect water quality in any part of a watershed, including siltation from the mine surface.

State of Maine

The Site Location and Development Act is used to insure that developments within the State will have a minimal adverse impact on the environment, within and adjacent to the location to be developed, as well as protecting the general health of the people in the surrounding area

(Maine State Code, Title 38 § 481). This Act also describes which permits are needed to operate a site. Since Tilcon will be excavating and transporting gravel, only the pertinent parts of the Act will be explained.

Tilcon, the party submitting the application, must prove that they are financially capable of running the site with minimal side effects. In all cases this means producing an accurate and complete list of estimated costs and a letter from an investing financial institution to prove financial backing. Proof of their capability to meet the pollution control standards is required (Title 38 Ch. 373§1(A)). Much of the machinery that controls the amount of pollution released is usually installed towards the end of development. If the company is coming to the final stretch of construction and it does not have sufficient funds to install and operate the machinery, it may forestall this phase altogether (Title 38 Ch. 373 §1(B)). To keep track of how compliant the various developers are, the Board asks each developer to submit a record of his/her prior operations (Title 38 Ch. 373§ 2 (A&B)).

Chapter 375 of the *Site Location and Development Act* is termed the No Adverse Environmental Effect Standards.

> "To determine whether the developer has made adequate provision for fitting the development harmoniously into the existing natural environment and that the development will not adversely affect existing uses."
> (Title 38 Ch. 375)

The following segments describe the standards that must be met by a developer.

No Unreasonable Adverse Effect On Air Quality.

"The Board recognizes non-point source emissions derived from industry can effect the air" (Ch. 375 §1(A)). The increased traffic generated should not dramatically affect the ambient air quality (§1(C)).

Erosion and Sedimentation Control.

During and after development erosion and sedimentation, especially of top soil, should be controlled. It is important to do this in order to protect water quality and wildlife habitats (§ 5 (A)). The Board requires evidence to show: 1) Any sediment from erosion will be removed from the runoff water before it leaves the site (§ 5 (A. 2)). 2) A permanent erosion control system will be installed on the slopes within fifteen days after the final grading has been completed. If this is not possible then "temporary measures will be implemented" (§ 5 (A.3)). If vegetation is used as control measure, mulch and the appropriate plant species will be used (§ 5 (A.5. a & b)).

<u>No Unreasonable Adverse Effect on Surface Water Quality</u>.

Ground water is frequently used by Maine's citizens as a source of drinking and bathing water, therefore the quality of the ground water should be maintained. This section states that it is unlawful to decrease the physical, biological and chemical levels below the level specified by the State Drinking Water regulations (§ 7 (A & B.1)). The diesel fuel stored on the site cannot be allowed to seep into the ground water (§7 (C)). A proposed "plan of action, and alternatives, [are] to be followed in the event the proposed development results in ground water contamination." (§ 7 (D.5)).

<u>Buffer Strips</u>.

Natural buffer strips protect the quality of water and wildlife habitat. Buffer strips can serve as visual screens, hiding undesirable land uses (§ 9 (A)). A natural buffer strip between the development and a water body will be left, to protect the water body from sedimentation and storm water runoff (§ 9 (B.1)). The width of the buffer strip will be large enough to allow for the movement of wildlife (§ 9 (B.2)). Excavation sites will retain a minimum buffer strip of 150 feet from all property lines, to shield it from public view. If written permission is obtained from a neighbor, a minimum 25 foot wide buffer strip is allowed (§ 9 (3.a)).

<u>Control of Noise</u>.

Minimum sound level limits are declared within this section. At the property line of the development the noise level may not exceed 75 dBA (decibel ampheres) at any time of the day. When a proposed development is to be located within a residential area, "where the pre-development ambient hourly sound level is equal or below 45 dBA and/or the night time ambient hourly sound level is equal to below 35 dBA", the sound level will not exceed 55 dBA between 7am and 7pm (§ 10 (C.I.v.)).

The Natural Resources Protection Act (NRPA) states the areas within Maine that are of economic or aesthetic value to the State and its people should be protected. As the name implies, the Act considers natural areas, especially unique areas to be of extreme value. To make sure developers recognize this, NRPA requires the developer to apply for another permit.

This Act prohibits any activity to be performed or cause to be performed if the activity is on land adjacent to a freshwater wetland greater than 10 acres in size. Specifically, the Ticon operation may not cause the erosion of soil or material into the secondary wetland, if after further study it is found to be continous with Great Bog. To operate, a permit must first be obtaining from the Board of Environmental Protection (Title 38 M.R.S.A. § 480-C). The excavation of gravel qualifies as one these activities. The Board will then grant the permit if, and only if, it feels the application is complete. Terms and conditions may be added if the Board deems them necessary to prevent any unsuitable harm. In order for the application to be complete it must meet the following standards:

1) The activity will not unreasonably interfere with existing scenic or aesthetic uses.
2) No unreasonable erosion of soil or sediment, from the terrestrial to the freshwater environment, will be caused.
3) No unreasonable harm will come to any significant wildlife habitat, freshwater wetland plant habitat, aquatic habitat, travel corridor, freshwater or other aquatic life. The Board considers proposed actions taken to avoid, reduce, or eliminate any potential adverse effect, to determine whether or not there is any unreasonable harm to significant wildlife habitat.
4) No unreasonable interference with the natural flow of water, either surface or subsurface.
5) The quality of the water will not fall below the standard given by the state water quality law (§ 480-D).

The Wetland Protection Rules of the NRPA states if a proposed mineral excavation is located in a wetland, the applicants must submit an alternative location to excavate. If no other practical location is available then the application may be considered only if the applicant can demonstrate there will be no meaningful loss of the wetland (Title 38 Ch 310 § E).

Reclamation of the site by vegetation is aided by the developer. The procedure for reclamation falls under chapter 365 of Title 38, Standards for Establishing Vegetation on Lands Adjacent to Ponds Under Great Ponds Alteration Statue. This regulation prevents exposed mineral soil from being eroded by surface runoff. Any disturbed land must be mulched immediately with hay, straw or some other suitable material at a rate of 1 bale/500 sq. ft. This will be done as soon as weather permits -- after May 1. The area will be limed, 1 lb/10 sq. ft, and fertilized with 10-20-10 fertilizer or the equivalent at the rate of no more than 10 lbs/425 sq. ft. Seed used will be the standard mixture or the equivalent given in the Maine Environmental Quality Handbook, spread at the rate of 1 lb/1000 sq. ft. After seeding hay or straw will be applied, 1 bale/500 sq.ft. When the grass has grown it may not be cut any smaller than 2.5 inches high (Title 38 M.R.S.A. Ch. 365).

Local

The state of Maine has a guideline for municipal *Shoreland Zoning Ordinances* under 06-096 Department of Environmental Protection Chapter 1000. The municipalities must follow the guidelines when establishing stricter setbacks and districts within their own "shoreland zone". The Mandatory Shoreland Zoning Act, title 38 M.S.R.A. sections 435-449, requires all municipalities to adopt, administer, and enforce ordinances which regulate land use activities and which apply to all land areas within 250 feet, horizontal distance, of the normal high water mark of any great pond; within 250 feet, horizontal distance, of the upland edge of a freshwater wetland; and within 75 feet, horizontal distance, of the normal high-water line of a stream.

Mineral Exploration and Extraction.

Under the guidelines, any extraction site must abide by the following rules:

1) A reclamation plan shall be filed with and approved by the Planning Board before a permit is granted. Such plan shall describe in detail procedures to be undertaken to fulfill the requirements of paragraph 4 below.

2) Unless authorized persuant to the Natural Resources Protection Act, Title 38, M.R.S.A., section 480-C no part of any extraction operation, including drainage and runoff control features shall be permitted within 100 feet of the normal high water line of a great pond classified GPA or a river flowing to a great pond classified GPA and within 75 feet of the normal high-water line of any other water body, tributary stream, or the upland edge of a wetland. Extraction operations shall not be permitted within 75 feet of any property line without written permission of the owner of such adjacent property.

3) Developers of new gravel pits along significant river segments shall demonstrate that no reasonable mining site outside the shoreland zone exists. When gravel pits must be located within the zone, they shall be set back as far as practicable from the normal high-water line and no less than 75 feet and screened from the river by existing vegetation.

4) Within 12 months following the completion of extraction operations at any extraction site, which operations shall be deemed complete when less than 100 cubic yards of materials are removed in any consecutive 12 month period, ground levels and grades shall be established in accordance with the following:

a. All debris, stumps, and similar material shall be removed for disposal in an approved location, or shall be buried on site. Only materials generated on-site may be buried or covered on-site.

The Shoreland Zoning Ordinance for the Town of Belgrade.

The current version of the Town of Belgrade's *Shoreland Zoning Ordinance*, adopted March 3, 1989, applies to all land areas within 250 feet, horizontal distance, of the normal high water mark of any pond, river, stream, lake or freshwater wetlands. Wetlands are defined as areas enclosed by the normal high water mark of inland waters and areas otherwise identified on the basis of soils, vegetation, or other criteria as inland wetland including but not limited to swamps, marshes or bogs (Paragraph G § 13).

Section 1. Purposes

The purposes of these ordinances are to further the maintenance of safe and healthful conditions; prevent and control water pollution; protect spawning grounds, fish, aquatic life, bird and other wildlife habitat; control building sites, placement as well as actual points of access to inland waters and natural beauty.

Section 10. Land Uses

25. Commercial Gravel Extraction and processing
  a. Prohibited in Resource Protection Districts
  b. Prohibited in limited Residential/Recreational areas
  c. Prohibited in General Development areas

The Town of Belgrade must either adopt the new amendment in the state ordinance which continues "and within 75 feet, horizontal distance, of the normal high-water line of a stream" to be their own, or adopt stricter rules, by December 31, 1991. The Town of Belgrade Planning Board minutes from November 1, 1990, indicate the town will discuss the 1989 state amendments to the Shoreland Zoning Ordinance at the Town Meeting in March of 1991.

Relevant issues

Tilcon states in the original application that the buffer strip adjacent to the road will be 25 feet. Tilcon was given permission to have this width by the Town of Belgrade, however, DEP over ruled this decision. Their reason for over ruling Belgrade is the Horse Point road falls under the definition of a road specified by the Site Location and Development Act. For this reason, DEP mandates the width of the buffer strip, adjacent to the road should be 150 feet. According to the application, along the eastern edge, between the pit edge and the bog a 170 foot buffer strip of undisturbed land will be maintained.[1] To the south is Blue Rock Industries (Appendix III). These two gravel companies have agreed to allow each other to mine to the 25 foot mark from their common property line. On this edge no buffer strip is planned. These buffer strips, along with the placement of hay bales, should eliminate all possible erosion and

[1] This buffer zone has since been reduced to 100 feet in Tilcon-Maine's second application.

sedimentation problems (Tilcon application, Exhibit #18). It is up to Belgrade to enforce these buffer strip widths, if they don't then the State is responsible for enforcement.

The State states that each town has the legal authority to regulate the mining operations within their respective town lines. According to the State, all of the towns must have their Shoreland Overlay Districts zoned by December 31, 1991. This will protect all areas within 250 feet, horizontal measurement, of a Resource Protection District (RPD). A RPD is an inland wetland that may adversely be effected by development. Belgrade has yet to zone out the protected districts. When Belgrade does finish zoning the Great Bog area, there are two possible results. One, Tilcon has received the permit before Belgrade has finished zoning, forcing the Town of Belgrade to let Tilcon fall under a grandfather clause. Or second, Belgrade finishes zoning during the application review period, Tilcon may find itself forced to reduce the size of the gravel pit, depending on how long their permit has been under review (Wright, pers. comm.).

Traffic levels will fluctuate depending on the amount of gravel needed by Tilcon throughout the year. Tilcon plans to operate ten hours a day, five days a week during customary demand schedules (Wright, pers. comm.). Nevertheless, Tilcon has reserved the option to work a 12 hour day, six days a week schedule (Phister, pers. comm.). For this reason, traffic levels will usually be lower than the traffic level stated in the proposal. The road was inspected by the Department of Transportation (DOT) and found it to be in adequate condition and safe enough to handle the increased traffic (see Tilcon application). DOT suggested that Tilcon move the entrance way 200 feet north, to increase the visibility time. Tilcon agreed and moved the entrance to the suggested location (Phister, pers. comm.).

To prevent contamination of the groundwater from the stored diesel fuel, Tilcon will build a reinforced concrete dike. The fuel tank will hold 10,000 gallons, but will be designed to hold 11,000 gallons. The hoses leading to the pump will go over the dike wall instead of through it, thereby leaving the wall unbroken (Phister, pers. comm.). The machinery will be refueled on paved surface to prevent any spilled fuel from seeping into the ground. Spills of 20 gallons or less will be cleaned using sorbent pads. Any larger spills and spills outside the containment structure will be immediately reported to the proper authorities. These preventive measures are in compliance with the Site Location and Development Act, specifically the No Unreasonable Adverse Effect on Groundwater Quality section (Tilcon application, Exhibit #17).

Air quality will be controlled with methods in agreement with the Site Location and Development Act. Air emissions for the rock crusher have already been licensed by DEP "to permit emissions that are characterized by less than 5% opacity (Tilcon application, Exhibit #9)." Dust created by the excavation will be knocked down by a continuous spray of mist, that will be sprayed from nozzles placed on the front of the crusher. To reduce the amount of dust and dirt on the public roads the entrance way will be paved, with the expectation being that the dirt and dust will fall off the trucks before they reach the main road. Loaded trucks will use tarps to reduce gravel and sand from spilling on to the road. Dust on the roads will be knocked down by periodic sprayings of water (Phister, pers. comm.). These sprayings will ensure the visible emissions do not exceed 5% opacity (Tilcon application, Exhibit #9).

Noise levels will be negligible from the road (Phister, pers. comm.). The Site Location and Development Act states the noise level will not go above 55 decibel amperes (dBA) from 7am to 7pm. Potential sources of noise includes two front end loaders, transportation trucks, rock crusher, and a rock screening plant. The loudest sources are the screening plant and the rock crusher, each having a "noise baffle type housing" to reduce the amount of noise produced by the diesel engines. Together they produce a noise level of 84.6 dBA at a distance of 50 feet. The noise produced is louder than the standards allowed by law. Tilcon feels the depth of the pit and the natural buffer strips will reduce the decibel level sufficiently to come within legal standards at the nearest property line (Tilcon application, Exhibit #19). Reclamation of the gravel pit will be done in phases, following the sequence of excavation. "The phased approach to reclamation is used so that the area of disturbed ground exposed to precipitation at any one time is minimized (Tilcon application, Exhibit #13)." The law says that reclamation shall be done as soon as possible (Standards for Establishing Vegetation). According to the application, the reclamation process will take six years. As the excavation proceeds the top soil will be stockpiled in another section of the proposed site. When Tilcon decides to reclaim a portion of the pit, it will reuse the topsoil it has stockpiled to cover the pit. The pit will be seeded, fertilized, limed and mulched to prevent erosion, after it has been graded. The rates for seed and mulch are both above the levels stated in chapter 365 of Title 38, but this will not have any impact whatsoever on the water chemistry. Upon completion of the site all final slopes will have a slope of at the most 3:1 (horizontal:vertical) (Tilcon application, Exhibit #13). Tilcon is considering plowing over the ridge on the eastern side of the site to create this slope (Phister, pers. comm.). If this were to be done there will be the loss of part of a unique geological feature, the esker. This will in turn have a dramatic effect on the water flow within the microwatershed.

ANALYTICAL PROCEDURES AND FINDINGS

Great Pond Drainage Basin

Rationale

To understand localized problems within a given area of a drainage system, a general overview of the entire system must be completed. In this case, the Great Pond drainage basin was studied to quantify land use patterns within the area. Agriculture, mining, residential, road, wetland and forest areas were each determined. Data obtained indicate relative effects of land use on the water quality of Great Pond particularly in regard to phosphorus loading. Ultimately, this analysis will provide a context for interpreting the importance of the Horse Point wetlands and esker complex, as well as possible effects of Tilcon's proposed mining on Horse Point.

Methods

The drainage basin around Great Pond, established by DEP, was traced onto 7 1/2 minute topographical maps (Readfield, Belgrade, Belgrade Lakes, Rome, and Mercer). A large composite map was then constructed. The drainage basin was broken down into four sections, based on drainage patterns established by elevation and natural boundaries. These quadrants were considered sub-drainage basins, and are therefore not uniform in area. By tracing and photoreducing, the boundary of the watershed and quadrants were transferred on to a 8 1/2 X 11 inch mylar overhead sheet.

A set of the most recent USDA aerial photographs taken on September 9, 1980 were obtained from the Agricultural Stabilization and Conservation Service. These photos were mounted onto a second large board, and covered by a single sheet of mylar. The drainage basin boundry from the mylar overhead sheet was then projected and copied onto the set of photos. After the lines had been drawn, these lines were manually corrected for increased accuracy. Boundaries were set to follow ridge lines based on visual cues, such as roads.

Land use types within the Great Pond drainage basin were then examined. Wetlands, open water, islands, agriculture, and mining areas within each quadrant were isolated by tracing. The category of wetlands included all types of aquatic land except for the Great Pond itself. Agriculture was also a general grouping, encompassing pastures, hay fields, cornfields, and other cultivated farmlands. The other three categories were specific in nature. If there was a question as to the land use type, a dissecting microscope was used to identify characteristic features of the land use type. The total area of the quadrants within the drainage basin, as well as the above categories were then quantified using Zidas digitizer, in hectares. Residential area was determined in each quadrant by counting the number of homes from the topographic map, also 1980. These numbers were then multiplied by the DEP average of O.2 hectares per residence. Also, the number of shoreline homes was counted in each quadrant, and the shoreline was measured using a "map wheel," to establish their relative abundance. Total road area was established by tracing both state/municipal and private roads on the topographic maps within each quadrant using a "map wheel." The area was then scaled, and multiplied by 15.24 meters for state/municipal roads and 7.62 meters for private roads (DEP). This figure was then converted into hectares. The data for each type of land use was then totalled, and subtracted from the total land area to obtain forest area. Unfortunately, logging area was undeterminable within the forestland, as a result of difficulty to see patterns from the air, and the inability to ground truth the 1980 data. In addition to the quantification of land types, inlets and outlets to Great Pond were determined based on the topographic maps.

As a check on the accuracy of digitizing, the areas of the islands were subtracted from the area of the pond basin, and this area was compared to the established area of the lake.

It should also be noted that 1990 Soil Conservation Service (SCS) photographs were examined to acertain any potential changes in land use since the 1980 USDA photographs were taken. As a result of these comparisons, it was concluded that very few changes in land use patterns have occcured in the past ten years.

Data

The 7 1/2 minute base map shows the determined quadrants. Quadrant I is located in the northwest corner of the map; quadrant II in the northeast; quadrant III in the southeast; and quadrant IV in the southwest. The sizes of the quadrants were far from being uniform. Quadrant I was determined to be 2833.4 ha, quadrant II was 2549.5 hectares, quadrant III was 855.9 hectares, and quadrant IV was 2124.9 hectares. The total land area within the drainage basin was 8363.6 hectares (Table 3). The area of Great Pond was calculated to be 3282.6 hectares. When our calculated area of Great Pond was compared with the established area by the Department of Environmental Protection's figure of 3313.0 hectares, there was only 0.9% difference. Therefore, this digitizing data can be considered to be accurate. By adding the areas of land and water, the total area of the Great Pond drainage basin was determined to be 11646.3 hectares.

Table 3: Land area (ha) by quadrat of the Great Pond drainage basin.

QUADRAT	AREA (HA)
I	2833.4
II	2549.5
III	855.9
IV	2124.9
Total	8363.7

Table 4: Land use patterns in Great Pond drainage basin, by area and percentage.

LAND PATTERN TYPE	AREA (HA)	PERCENT OF TOTAL
Forest	6885.2	82.3
Wetlands	519.7	6.2
Agriculture	519.2	6.2
Residential	243.4	2.9
Roads	164.9	2.0
Mining	31.4	0.4

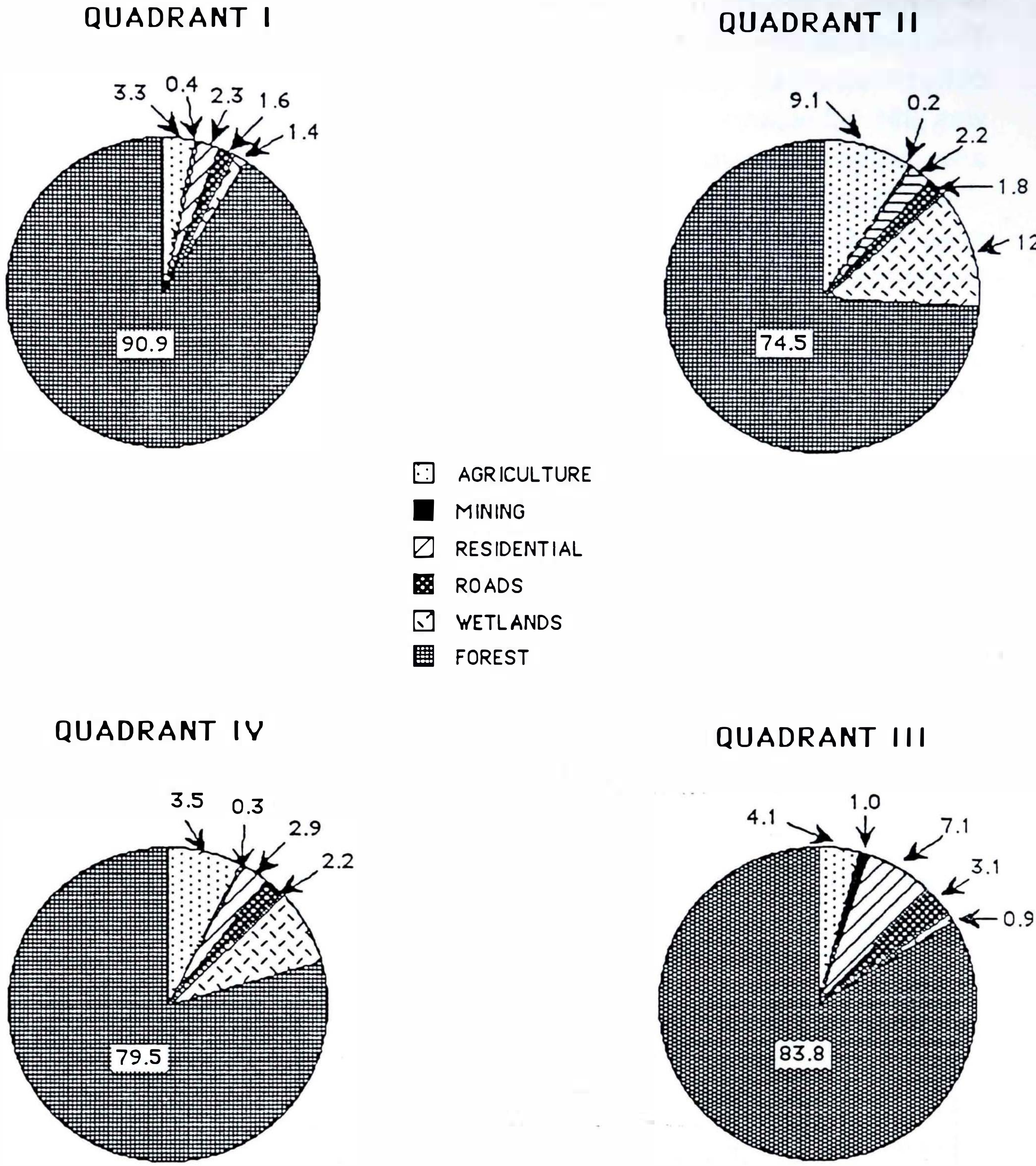


Figure 9. Land type patterns by quadrant in Great Bog drainage basin

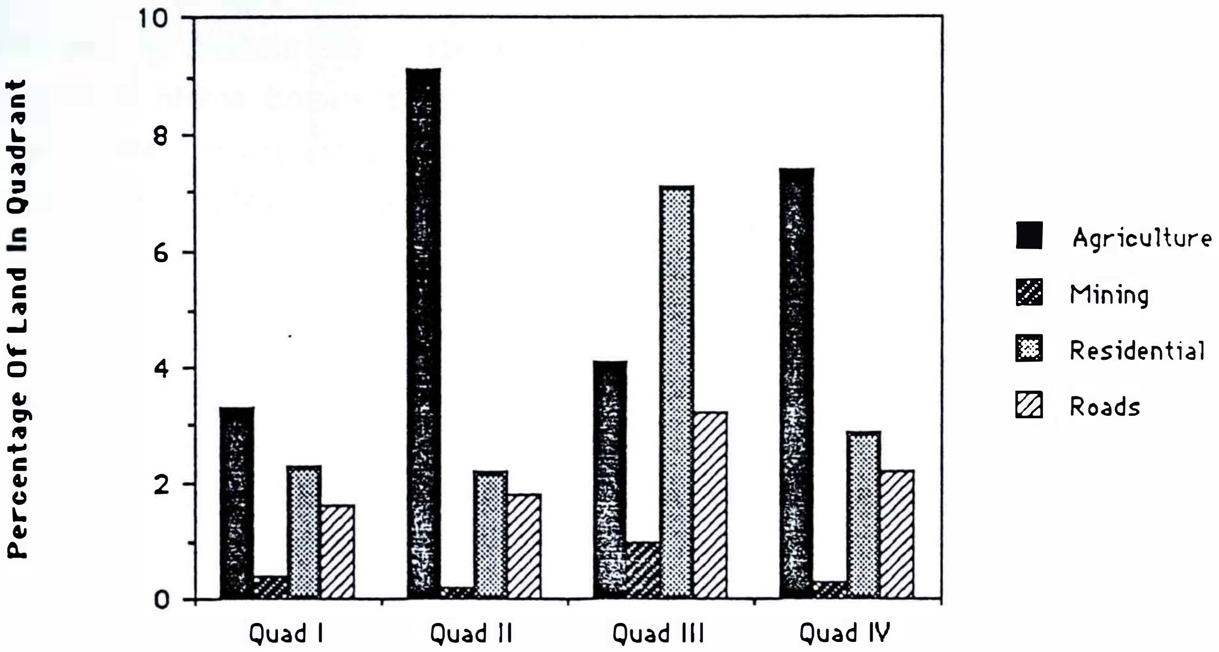


Figure 10. Land use patterns in Great Pond drainage basin within each quadrant.

The largest of all the land patterns within the watershed was clearly that of forested area, with 82.3% (6885.2 ha). In quadrant I, forested land made up 90.1% of the total land area. Quadrant III had 83.8%, quadrant IV had 79.5%, and quadrant II had 74.5% forested land. (Table 3, Fig. 9). Unfortunately, as stated before, logging areas within the drainage basin were unquantifiable, though this activity did indeed exist. From the 1980 photographs, some signs of commercial logging could be seen in quadrants I and II. The rest of this land must be assumed to be undisturbed forest land.

Wetlands were another major land pattern within the drainage basin, holding 6.2% (519.7 ha) of the land (Table 4). Quadrant II had the largest land area percent of the four quadrants, with 12.1%. It is also important to note that the largest wetland within the drainage basin was located in this quadrant, in the North Bay region of the pond, splitting it in half.

Quadrant IV had the second largest wetland percentage with 7.6%, followed by quadrant I, 1.4%, and quadrant III, 0.9% (Fig. 9).

Agriculture was the third most common land pattern in the drainage basin, encompassing 519.2 hectares (6.2%) of the land within the basin. Of the different managed land use patterns, agriculture was the most common type (Fig. 10). Agriculture was most prevalent in quadrant II, with 9.1% of the land being used for this purpose. This was followed by quadrant IV with 7.4%, quadrant III with 4.1%, and quadrant I with 3.3% (Fig. 9).

Behind agriculture, residential land use made up 2.9% (243.4 ha) of the total land patterns (Table 4). Quadrant III had the highest percentage, with 7.1% of the land being used by residences. This was followed by 2.9% in quadrant IV, 2.3% in I, and 2.2% in II (Fig 9. and Fig. 10).

The total shoreline distance around Great Pond was approximately 33.5 miles. The density of houses along the shoreline was highest in quadrant III at 25.6 houses/mile of shoreline. This was followed by quadrant I at 17.3 houses/mile, quadrant II at 14.6 houses/mile, and quadrant IV at 13.7 houses/mile (Fig. 11). Eliminating wetlands shoreline "space", the data showed quadrant III at 25.6 houses/mile, quadrant II at 18.9 houses/mile, quadrant I at 18.8 houses/mile and quadrant IV at 17.9 houses/mile (Fig. 12).

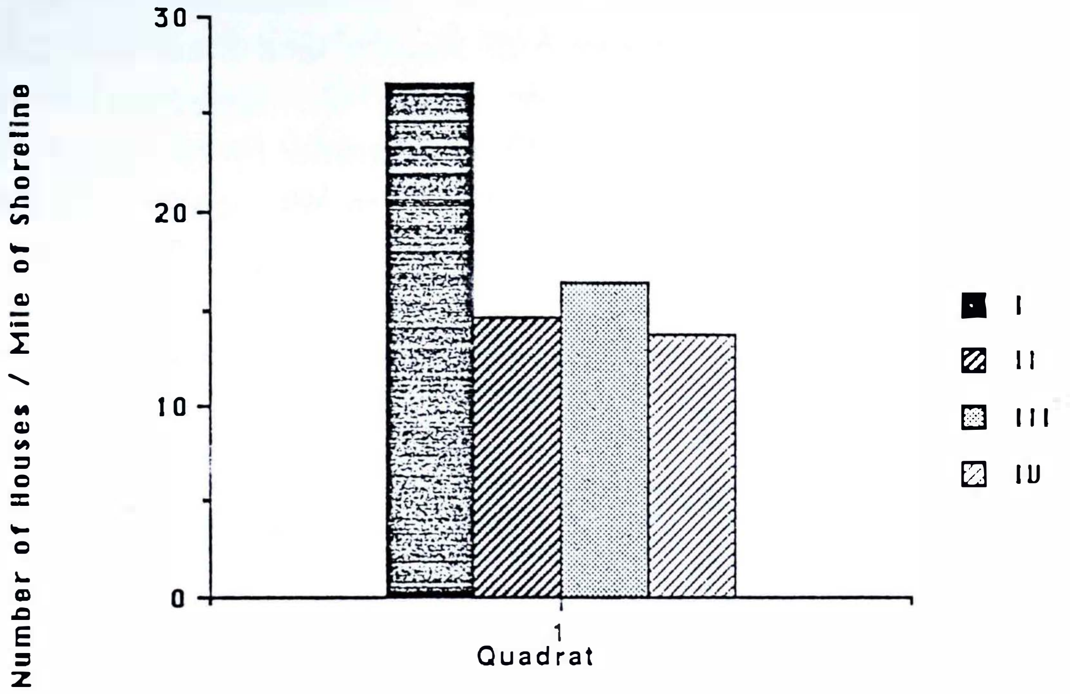


Figure 11. Density of houses along Great Pond shoreline

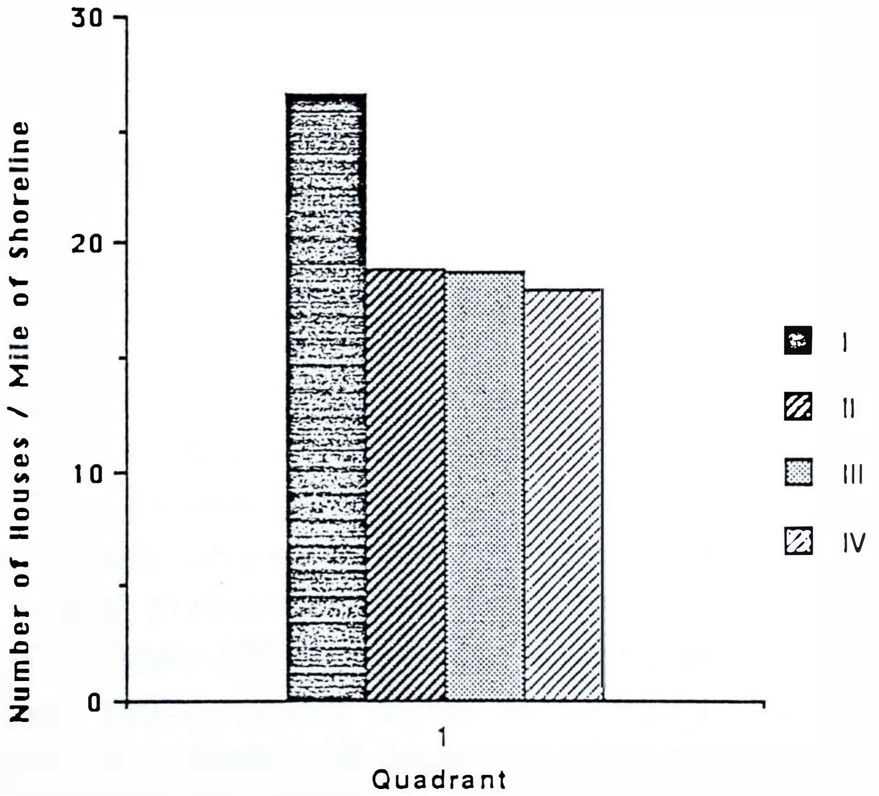


Figure 12. Density of houses along Great Pond shoreline discounting wetland shoreline.

Roads had the next highest proportion of area to land area, with 2.0% (164.9 ha) private and state/municipal roads (Table 5). Quadrant III had the largest percentage of road area, with 3.2%, followed by IV with 2.2%, II with 1.8%, and I with 1.6% (Fig. 9 and Fig. 10). The breakdown of private and state/Municipal roads varied as well (Table 5).

Table 5: Total road area (ha) in the Great Pond drainage basin, by quadrant and road type.

Quadrant	State & Municipal	Private	Total
I	30.5	14.5	44.9
II	39.4	7.4	46.8
III	14.2	12.5	26.7
IV	37.1	9.5	46.5

Mining had the lowest relative area of all land use patterns studied, making up only .4% (31.4 ha) of the land area (Table 5). Quadrant III had 1% of its land devoted to mining, quadrant I had 0.4%, quadrant IV had 0.3%, and quadrant II had 0.2% (Fig. 9 and Fig. 10). All of the registered mines in 1980 have been circled in black on the 7 1/2 minute overlay. Other mines were quantified by digitizing, but have not been labelled.

General Trends And Analysis

From the data, several trends emerge. Quadrant I seems to be the most harmless of all the quadrants. The percentages of all the land use types are quite small, and therefore impact to Great Pond is minimal. However, two streams -- Rome Trout Brook and Robbins Mill Stream -- do provide inlets for nutrients to reach the pond. Intensifying this effect is the bisection of Route 225 with the two streams approximately one half mile from the shore of Great Pond. This allows sediments and nutrients off of the roads to have a more direct route into Great Pond.

Quadrants II and IV are very similar in terms of relative land use percentages (Fig. 9 and Fig. 10). These two areas have high proportions of wetlands. Phosphorus loading may not be as high in these areas as expected, because of the ability of the wetlands to serve as a natural buffer. These wetlands will use and trap the phosphorus before it becomes a problem, therefore phosphorus loading by agriculture, residences, roads and mining may be smaller than expected. Quadrant II's large wetland, as it extends through the middle of the quadrant, will buffer most activity to the west. The water must drain through the wetland before it can reach the pond. However, at North Bay, where the Great Meadow Stream drains into Great Pond, a large amount of phosphorus loading and sedimentation can be expected. In addition, Great Meadow Stream actually originates in North Pond. Though there is no evidence of water quality problems in this North Pond, there still may be a nutrient flow. Both Route 225 and a lesser road crosses the Great Meadow Stream. Thus, an outside factor exists in the drainage basin, increasing the magnitude of nutrient and sediment inflow to North Bay. There are two farms close to the shore which will pose an additional threat to Great Pond. Several farms are located both at Jamaica Point and Richards Point, providing easy access for nutrient loading.

Another "hot spot" for problems is found in quadrant IV, where Bog Brook drains into Great Pond through the center of Austin Bog. Route 27 passes over Bog Brook, giving it another source for nutrients. Higher levels of nutrients and sediments might be found at this point. In addition, there is some agriculture near the lake and Austin Bog.

In quadrant III, a special problem can be seen. There is an abnormally high amount of residences and roads. Residences provide a source for nutrient loading, and the high amounts of roads provide an inlet for these nutrients to reach the pond. Phosphorus loading may be significantly higher in this area.

There is also another external source for pollution problems, an inlet from Salmon Lake. Salmon Lake has been extremely polluted for some time, and has been plagued with algal blooms (Belgrade, 1987). Water drains from Salmon Lake through North Belgrade, where quadrants II and III meet. Large amounts of nutrients and other pollutants may be expected at this point. This inlet is likely to be the most significant contributor of phosphorus to the entire drainage basin. The nutrient loading may be boosted further by Route 8 which passes directly over the inlet.

There is also an output source on Great Pond, located between quadrants IV and I. A dam allows for an export of water from Great Pond to Long Pond. This allows for the turnover of the lake water over time, a rate of 2.5 years (Belgrade, 1987), lessening long term impacts on nutrient loading in Great Pond.

From the combination of the inputs from Salmon Lake and North Pond, and the output to Long Pond, it becomes apparent that to fully analyze the Great Pond drainage basin, one must increase the scope of the study. One way of doing this would be to analyze the subwatershed, which includes the whole Belgrade Lake system.

Sources Of Error

It is important to realize that this watershed analysis is based upon 1980 photographs. According to sources, agriculture has decreased slightly in the area since the photographs were taken. Residential land has expanded in the past decade. The acting town manager for Belgrade believes that there has been a steady increase in the number of houses within the total watershed of Great Pond because of the economic boom in the mid-eighties (Bates, pers. comm.). He stated that plumbing permits have gone up from 150 to 180 between 1989 and 1990. This indicates that there has been either new building or renovations of existing cottages. It can therefore be speculated that camp roads have increased as well. Forest area has stayed the same over the time. Due to legislation protecting development, the area of wetlands is not likely to have changed over the period. Looking at 1990 Soil Conservation Department photographs, it can be seen that very few changes of land use patterns have occurred over the past decade.

It is important, too, to mention sources of error in the process. During the photoreduction stage of the watershed mapping, land was indeed "lost" due to cutting and pasting. In setting the scale, the road by which the scale was established was not perfectly straight, leading to a possible slight overestimation of land area. These two sources of error, appear to have cancelled themselves out, as the lake basin was determined to be accurate within 1%.

Summary

In summary, based on 1980 data, agriculture plays a significant role in the phosphorus loading within the Great Pond drainage basin. Roads and residential land play a lesser role, yet still a significant one with regard to both phosphorus loading and sedimentation. Mining seems to have a minimal role in the watershed, its largest impact being possible sedimentation. In addition, perhaps the most significant issue in the drainage basin lies outside the basin -- Salmon Lake.

Geological Cross-Section of the Horse Point Esker

To understand potential effects of gravel mining in the Horse Point region, it is necessary to examine the local geomorphology. For this, a composite cross-sectional diagram was developed.

Methods

The diagram is a compilation from several sources. The baseline surface contours were taken from a photocopied enlargement of a 7.5

minute U.S. Geological Survey topographical map (Rome Quadrangle, 1980). The underlying sediments were inferred from the maps Hydrological Data for Significant Sand and Gravel Aquifers (map 31, 1984) and the Surficial Geology of the Norridgewock Quadrangle, Maine Geological Survey (1987). The proposed mining site was located on the cross-section from data taken from the Tilcon application. Tilcon questionnaires sent to residents provided well depths. Additional information was obtained from ground truthing.

Data

The compilation of all the available data resulted in a three dimensional cross-sectional view of the Horse Point esker (Fig. 13). In general; the data points for subsurface formations were scattered along the esker. The north-south and east-west lines were chosen to incorporate the maximum number of data points and for the inclusion of the proposed mining site.

The test pits and drilled wells provided the best insight into the composition of the esker. However, much of the diagram was composed from general inferences made from the maps, and through the relatively arbitrary linkage of the known data points. An unavoidable result of this method was several contradictions in the stratification layers. For example, there is a test pit data point about three hundred feet east along the east-west line which suggests that the water table is actually lower than the lake water level. If in fact this is the case, it is a very unusual occurrence. For this reason the point was not included in the diagram.

The final result, when the limitations are realized, is an effective representation of the geology and hydrology of the Horse Point esker. Looking at the west-east face of the cross-section, the lake water level dominates the water table level. Towards the center of the esker (east) the dynamics of the aquifer can been seen by in the elevated water table. The sixty-five foot depth corresponds to the height of the water table above bedrock. The 140 foot mark denotes the total depth to bedrock from the surface. At the corner of the west-east, north-south cross section, the mine pit depth is thirty-six feet from the surface, while the water table is eight feet below this, at forty-four feet below the surface. Moving on to the north-south axis, the twenty-three foot mark denotes the level of the water table below the surface. This also marks the high point of the aquifer along the cross-sectional axes. Also along this angle, note that the bog water level is approximately two to three feet higher than the lake water level.

Summary

This view of the mining site is particularly helpful in visualizing the extent of the mine, and the proposed level of excavation. The amount of gravel to be removed is evident. The diagram is also useful in understanding the dynamics of the aquifer, and the effects that mining might have on the water levels. The diminished buffering capabilities, as a result of the removal of the gravel, can be visualized. Other features of interest include the exposed bedrock at the north end, as well as the lake and bog water levels in comparison to the aquifer water level.

Fig. 13

Horse Point Aquifer

Rationale

Any mining of the esker on Horse Point has the potential to affect the aquifer located beneath the esker. Because this esker is the source of water for the local community, it is important to investigate the potential qualitative and quantitative effects on the aquifer. To determine these effects, the extent and flow dynamics of the aquifer was determined.

Methods

Data were obtained from maps, well data from the Maine Geological Survey (MGS) and the initial Tilcon application (Timson, et al., 1990), and the Groundwater Handbook for the State of Maine (Caswell, 1987). The map used was the Sand and Gravel Aquifer map of the Rome quadrangle (Map 31, 1987), which illustrates the location of all known aquifers and their potential yield. Mark Loiselle from the Maine Geological Survey helped to clarify our interpretations (Loisell, pers. comm.). Soil data were obtained from the USDA Soil Survey of the area (NCSS, 1978). In addition, a walk across the esker and soil samples were taken to compare to the soil survey data.

Data and Interpretation

The Sand and Gravel Aquifer Map used depicted the entire extent of the Horse Point Aquifer. As shown in Appendix 3, the aquifer underlies most of Horse Point, with the exception of the northwestern portion of the peninsula. Loiselle (pers. comm.) suggested that bedrock may be close to the land surface in this area preventing the aquifer from permeating the hill. Without any detailed geologic survey through seismic reflection, it remains conjecture. The well data collected from MGS and that obtained by Timson, et al., (1990) for the Tilcon application are of two types: wells drilled into the bedrock below the aquifer and wells drilled into the gravel of the aquifer. The majority of the wells are bedrock wells and do not give any indication of the level of the aquifer. Tilcon drilled several wells into the gravel to find the water table underneath the proposed mining area, and found the water table to be at 255.2 feet (above sea level) and 254.6 feet. At the time of the testing, the level of Great Pond was estimated to be 248.0 feet above sea level. The block view of the proposed mining area (figure 14) shows the relationships among the different water levels. It is important to recognize that water levels fluctuate seasonally, so these data are not necessarily true for the entire year. The lack of any other highly specific drilling and geological data (Loiselle, pers. comm.) precludes the determination of the water table levels for the remainder of the aquifer.

The research conducted allowed the determination of the horizontal but not the vertical extent of the aquifer. The drilling points from the Tilcon application indicate a rough estimate for the water table level of 273 ft. below the area of the proposed pit, keeping in mind that the level probably varies across the esker and may vary seasonally. More conclusive was the information obtained about aquifer dynamics. The main recharge is believed to be precipitation, which falls on a topsoil composed of sand with some clay. The topsoil on Horse Point has been classified by the U.S.D.A. as a Hinckely-Windsor-Deerfield (HWD) association (NCSS, 1978). HWD soils are primarily sandy deposits with some gravel and are the result of glacial outwash (NCSS, 1978). This is a permeable mixture, allowing rain and snow to infiltrate the gravel beneath. It is very likely that in heavy rains and spring melts, there is runoff down the surface of the esker into the bordering bog and lake. However, most of the time the precipitation flows down through the gravel of the esker into the aquifer. Since the level of the aquifer is estimated to be higher than the bog and lake levels, then water is also expected to be flowing into these via discharge areas on the slopes of the esker or underground directly from the aquifer into the bodies of surface water.

Summary

The removal of gravel and the formation of a pit could have several effects. First, a pollution buffer zone above a portion of the aquifer would be removed, increasing the risk of water contamination. Tilcon will also be adding a slight risk factor, in the form of a petroleum storage tank and a gas pump, although the application outlines the precautions they will be undertaking regarding this factor (see Relevant Issues, p. 54). Second, the slope of the pit sides causes the runoff to be more concentrated at the pit bottom (Figure 15 shows the slope of the pit). This may have the effect of increasing the level of the water table directly beneath the pit. Third, more water added directly to the aquifer may mean more water flowing into the lake and bog. This could affect the bog by raising its water level and thus changing the local environment. The bog may also be affected by the potential pollution mentioned above.

Great Bog Genesis

There were many difficulties in classifying Great Bog due to the fact that it has characteristics of several wetland ecosystem types. These ecosystems include those of a raised bog, a lakeside shore bog, and a poor fen. Great Bog also has a large expanse of open mat which is dominated by low ericaceous shrubs. To ascertain the reason for the existence of these wetland ecosystem types, it was necessary to examine the pattern of formation of Great Bog. To do this, two important aspects of the Horse Point area had to be examined. One was to determine the shape of the Great Bog basin, and the second was to look at the history of human disturbance around Great Pond.

One of the keys to explaining some of the features of Great Bog is that Great Pond is a dammed lake whose water level is over five to seven feet higher than its original level. This means that when Great Bog was forming, the water level in North Bay was probably so low that the two ecosystems had no physical contact. It was not until the dam was built approximately 100 years ago that the two ecosystems were joined.

Estimating the shape of the basin was done by taking peat cores in several locations on the bog. The peat depth on the bog varied tremendously depending on the location. Approximately 100 meters behind the ponds, the peat depth was less than one meter. Clay was found beneath which was at least 6 meters thick. The peat depth near the center of the bog, however, was more than 6 meters. This, coupled with the presence of a *lagg* (moat), indicates Great Bog formed in a basin bounded by the presence of the esker to the West, the bedrock ridges to the South and East, and a ridge of marine clay to the North. As a result of these observational data, it became possible to formulate a mechanism of the formation of Great Bog that explained the existence of the ecosystem types found in the area.

When Great Bog first began to form, it is likely that material ran down the ridges from the East, West and South and was deposited in the center of the basin. The peatland grew from this center point in an upward and outward direction (Fig. 15). This, over time, formed a domed peatland that filled the entire basin. The peat depth in the center of the dome was much thicker than the peat along the edges. This led to the formation of the lagg around the perimeter (Fig. 16). Eventually, as the peatland continued to grow, the edge of the peatland spilled over the clay ridge to the North and began to approach North Bay. Some time after the peatland spilled over the clay ridge, the water level of Great Pond was raised, thereby flooding Great Bog to a certain extent. This flooding may have led to the erosion of Great Bog, we believe it is through this erosion that the ponds on the mat formed. This is supported by the fact that the peat depth behind the ponds is only one meter, indicating the location of the clay ridge is at this point and probably extends approximately 100 meters toward the upland. The raised water level also resulted in the eastern portion of the lagg being flooded and opening it up to Great Pond, thus forming a site for potential exchange.

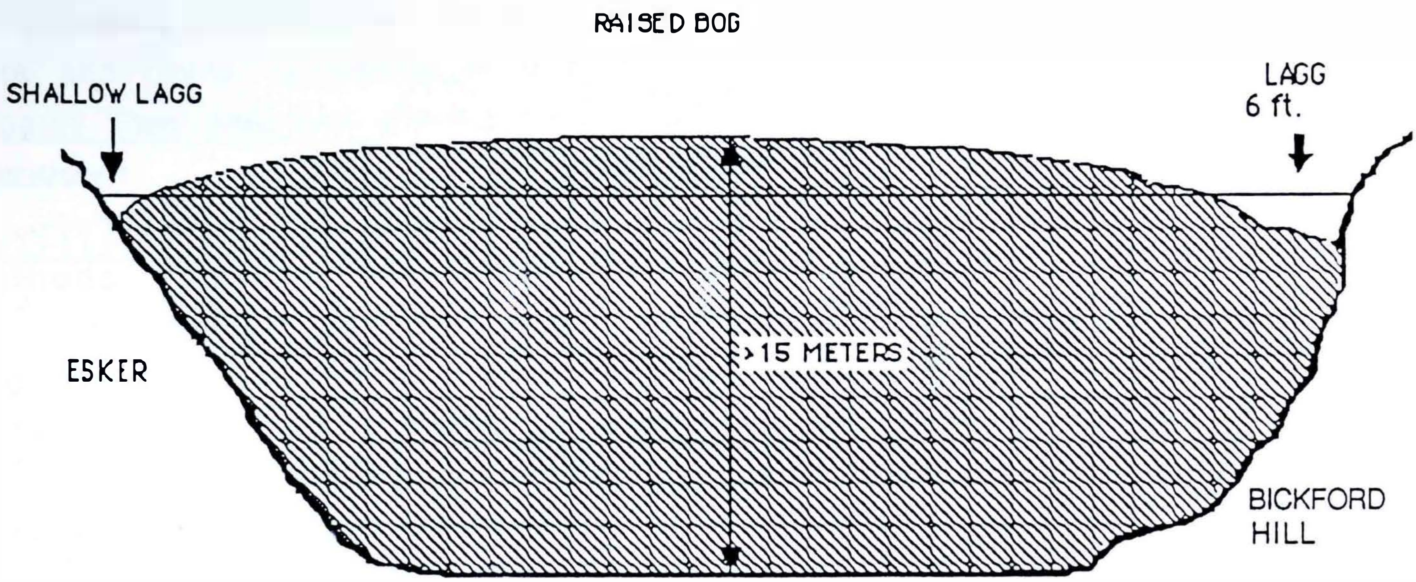


Figure 16. East-West cross section of Great Bog.

Botanical Characterization of Great Bog

Great Bog is found in the valley between Horse Point Esker and Bickford Hill. It is surrounded on three sides by land and only the small northern boundary of the bog is open to Great Pond's North Bay. Great Bog encompasses nearly 135 hectares and is approximately 1.5 miles long (north to south) by .5 miles wide (east to west). Other than precipitation, the bog does not appear to receive any water input except as runoff from the surrounding ridge or the occasional flooding of Great Pond. The formation of Great Bog is perhaps a bit more complicated than many raised bogs since its development was disrupted, *circa* 1867, by the construction of a dam on the southern end of Great Pond which raised the water level between five and seven feet.

Great Bog is now a diverse ecosystem with several different types of habitats which may be affected by mining. To conduct a meaningful resource inventory and impact analysis, an understanding of the components of the ecosystem being studied is necessary. For this project,

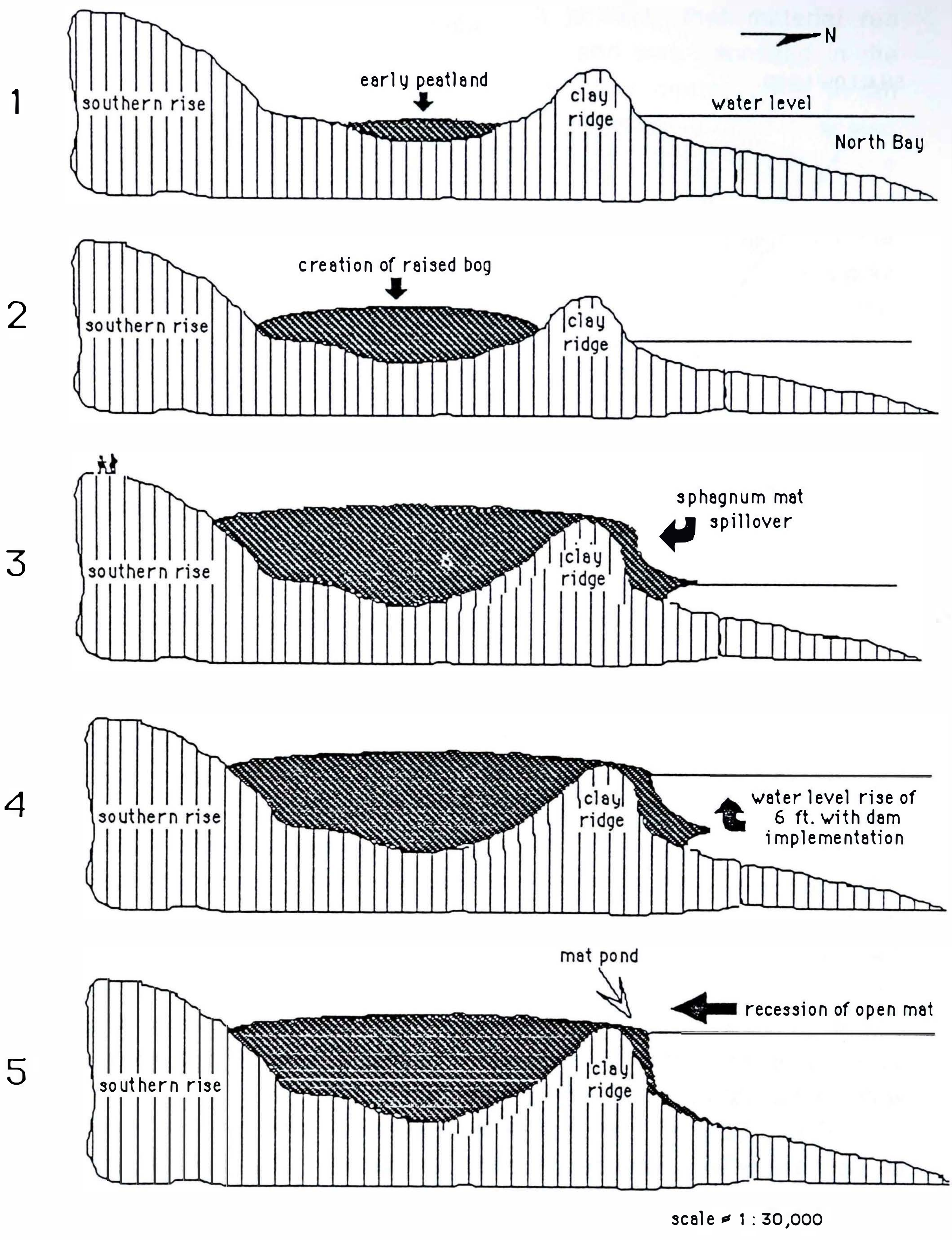


Figure 15. Great Bog genesis and succession.

an accurate classification of Great Bog in terms of its geomorphology, flora and fauna, is pivotal in enabling BOFEA to assess the potential impacts that a gravel mining operation could have on the Great Bog ecosystem.

Methods

Two methods of plant community analysis were used to study Great Bog. The first was the line-intercept method which is a plotless sampling technique especially useful in the analysis of both plant and animal communities in which dominant organisms are relatively large. The data taken were based upon individuals found along a sampling line and were analyzed with respect to their density (number of individuals/area sampled), dominance (area of coverage/area sampled), and frequency (number of intervals in which species occurs/total number of intervals). Once these values were computed, the importance value (sum of the relative density, relative dominance, and relative frequency) was calculated for each species. Because the transect line is laid down randomly, counts numbers of individuals, and measures crown area, the samples taken should be quite accurate and representative of the study community (Cox, 1990).

Within Great Bog, five transects were laid out to determine the vegetative cover. Three 50 meter long transects were in the forested areas while the two 10 meter long transects were on the open mat. They were specifically placed in areas of the bog that appeared to have different vegetative types although the actual site within each type was randomly chosen. Each plant within the vegetative types was categorized in one of three zones: the ground cover, the tall shrub zone, or the upper canopy. The distance that a plant covered along the line as well as the greatest width of the plant perpendicular to the transect was recorded.

The quadrat method is a plot analysis technique used quite frequently to collect quantitative information about the composition and structure of populations and communities (Cox, 1990). Quadrat sampling on Great Bog was done with 1/2 m x 1 m quadrats since the ground cover being sampled was relatively small. Quadrats were laid down randomly in areas of different vegetative cover. Once the frame was down, the percentage of cover for each plant species within the quadrat was recorded using the Daubenmire method of estimation (Daubenmire, 1968). The percentage of cover for each species in the quadrats was converted to the average midpoint of the range and then placed in a cover class to facilitate calculations.

Results

The map of Great Bog (Fig. 17) shows the locations of the sample sites. The transects are represented as numbers while the areas of quadrat sampling are labeled with letters. The data collected from the line-intercept study was used to calculate the importance values for each species within each transect. Transect section #1 (forested upland) was dominated by black spruce (*Picea mariana*) in the upper canopy, mountain holly (*Nemopanthus mucronatus*) in the tall shrub zone, and maple seedlings in the ground cover (Fig. 18). However, transect section #2 (open bog mat) revealed a high abundance of leatherleaf (*Chameadaphne calyculata*) and no arboreal vegetation (Fig. 18). The results for quadrats in section A (Fig. 17) show a high percentage of *Sphagnum* and club moss and no leatherleaf while quadrats in section B and section C reveal a high percentage of *Sphagnum* moss but also a high abundance of leatherleaf (Fig. 19). *Sphagnum* moss is an important constituent of peatlands and was found in all three sampling locations although its abundance varied. Finally, a fourth vegetational zone was found in the lagg along the bog's western edge and extending into the secondary wetland. Although no vegetational analysis was conducted in this area, observational data indicates a high percentage of red maple and other deciduous species.

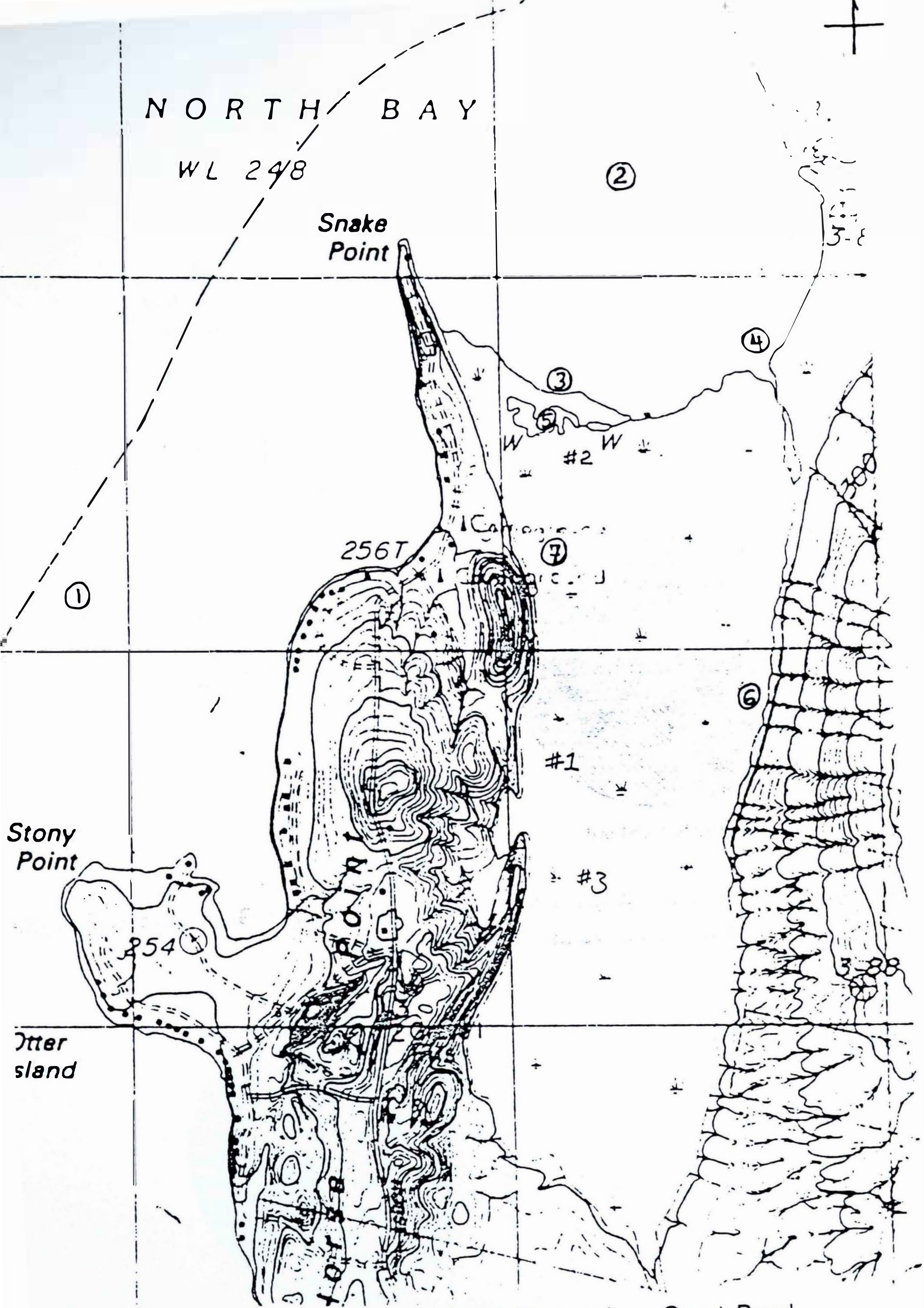


Figure 17. Water sample sites on Great Bog and on Great Pond.

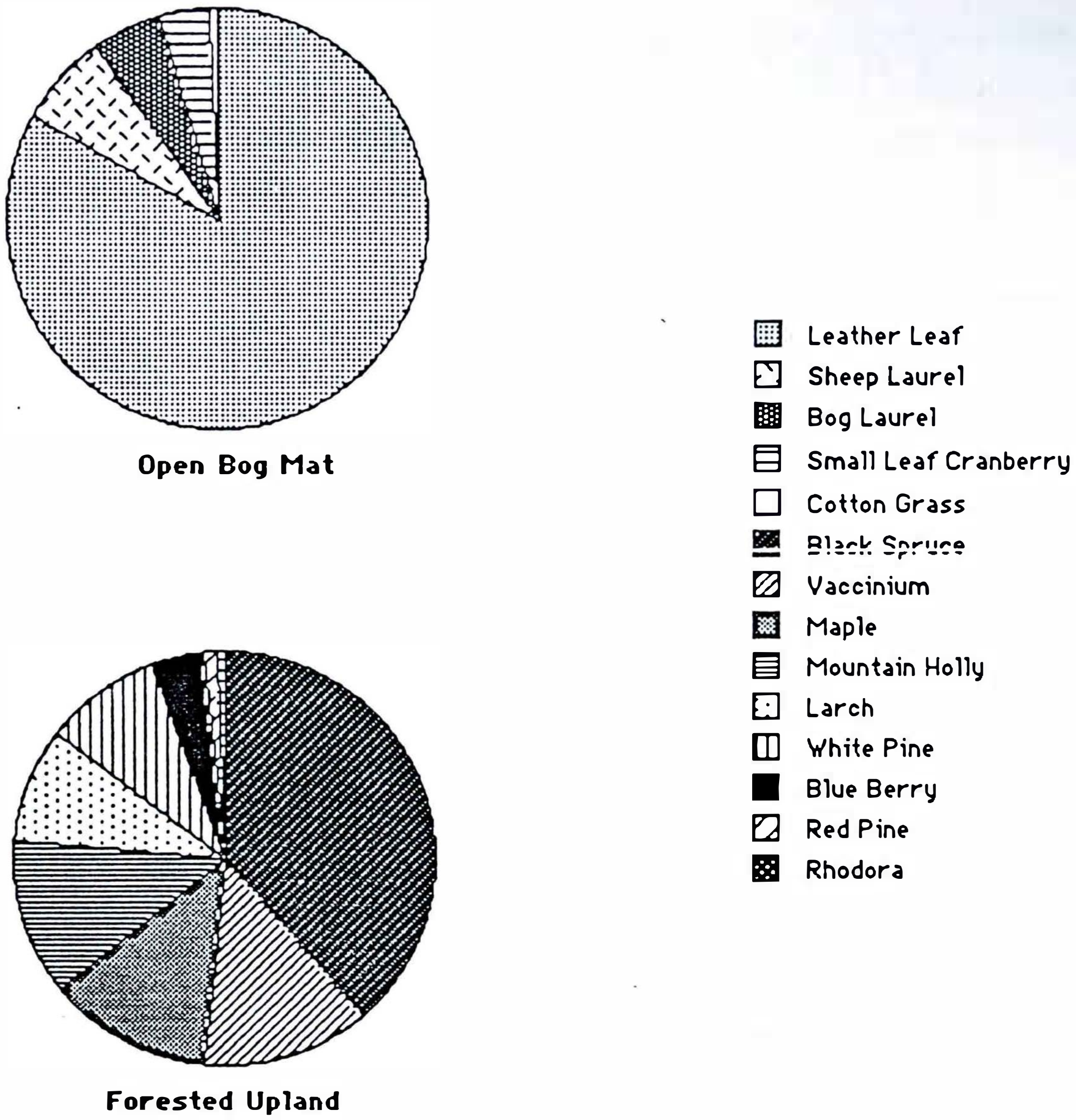


Figure 18. Transect Results From Two Areas Within Great Bog Using The Importance Value For Each Species.

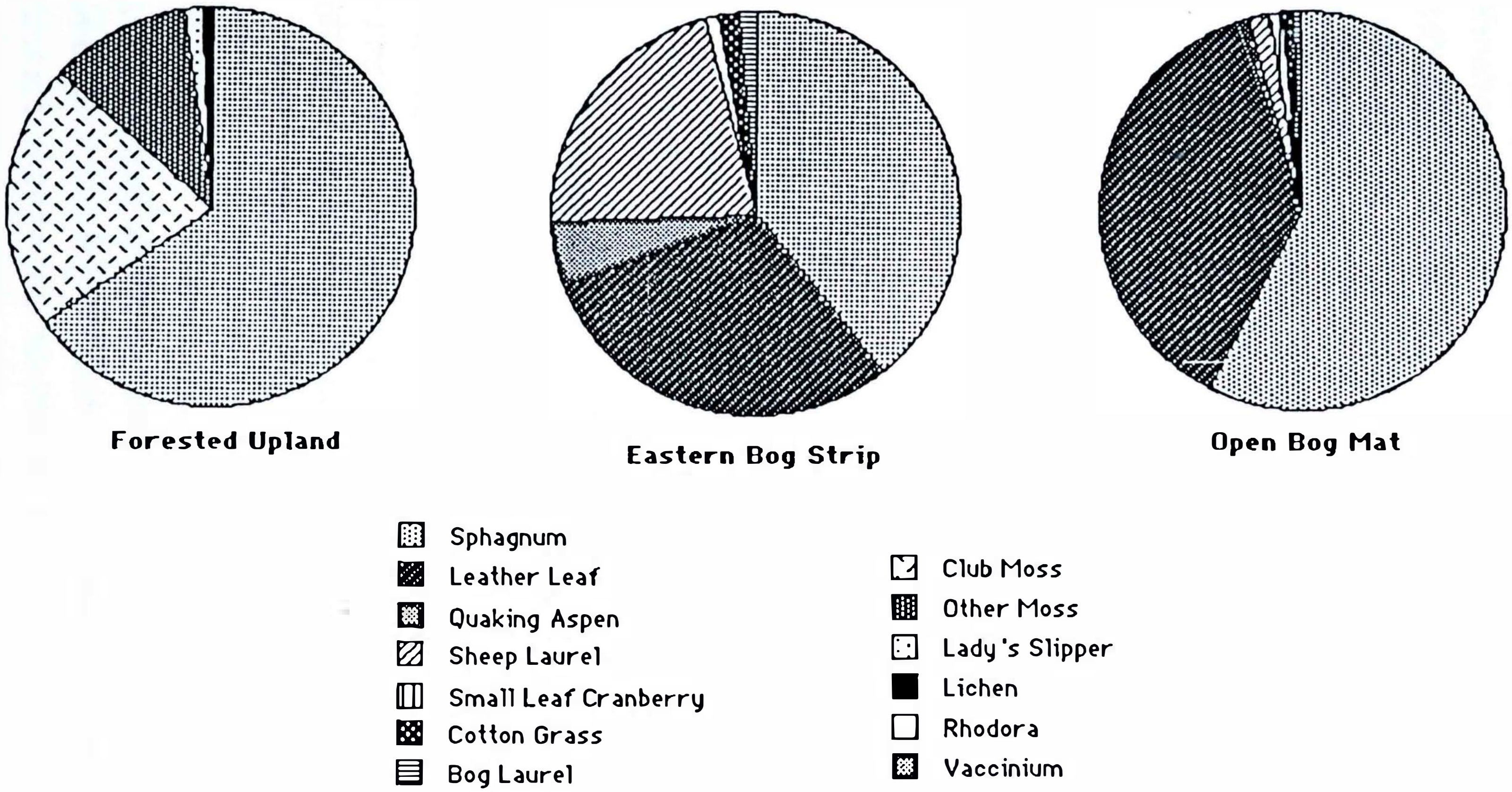


Figure 19. Quadrat Results From Three Areas Within Great Bog Using Average Midpoint of Range For Species Coverage

Classification of Great Bog

To classify Great Bog, the classification scheme adopted by the Maine Critical Areas Program (CAP) was used (Worley and Sullivan, 1980). This classification scheme groups ecologically similar peatlands on the basis of physiognomy and composition and other biotic features. Great Bog was classified through the use of aerial infrared photographs from the Soil Conservation Service (SCS), black and white aerial photographs from the United States Department of Agriculture (USDA), and line intercept and quadrat analyses conducted by the members of BOFEA.

LANDSCAPE UNIT -- Wetland

A wetland is defined as land where the water table is at, near or above the land surface long enough to promote the formation of hydric soils or to promote the growth of hydrophytes.

LANDSCAPE SUBUNIT -- Peatland

A peatland is defined as any 3-dimensional portion of the landscape that is wetland and has organic soil (i.e. peat). Peat is generally defined as soil that consists mostly of organic residues accumulated as the result of incomplete decomposition of dead plant material.

FORMATION -- Bog

This level of classification was difficult to ascertain due to some of the unusual characteristics present in Great Bog. Areas of Great Bog have many characteristics typical of a fen and it would be easy to classify it as such, especially if one interprets the CAP classification verbatim. However, after investigating the area and making some assumptions based on peatland genesis, it was decided that the Formation of Great Bog should be termed a bog. (See Great Bog Genesis for further discussion)

LANDFORM -- Plateau

It was decided that Great Bog as a whole is a raised bog with a plateau landform because of the lagg located on the bogs eastern, western and southern sides in which there is almost permanent standing water. The lagg is so deep on the southeastern edge that it does not conform to the usual characteristics but forms a channel of often visibly flowing water. The presence of a lagg is an indicator of a raised bog; and the plateau landform is due to the fact that the elevated surface is more or less level. (See Great Bog Genesis for further discussion)

LANDFORM PATTERN -- Reticuloid, with ponds

This level of the classification categorizes peatlands through the pattern and distribution of surface features such as pools, ridges, depressions, and tree/shrub islands. Reticuloid refers to the existence of a distinct pattern of features which is present on the bog. It should be noted that the ponds only exist on one small section of the bog that differs floristically from the rest of the peatland. (See Great Bog Genesis for further discussion)

SYSTEM -- Palustrine

Great Bog is a freshwater system (less than 0.5% salinity) that is dominated by trees, shrubs, and nonaquatic mosses.

CLASS /SUBCLASS -- These levels describe the general appearance of the area in terms of "either plant life form or physiography and composition of the substrate" (Worley and Sullivan,1980; p. 31). Great Bog has three class and corresponding subclass types.

DOMINANCE TYPE/DOMINANCE SUBTYPE -- Dominance types are defined on the basis of the dominant species in the uppermost stratum of continuous (at least 30%) plant cover within each class. Dominance subtypes are defined on the basis of the dominant species occurring in the next, continuous or nearly continuous, stratum beneath the stratum used to provide the dominance types.

1) *CLASS: Low Shrub* -- represents the open mat
   SUBCLASS -- Deciduous Angiosperm
   DOMINANCE TYPE -- Leatherleaf (*Chameadaphne calyculata*)
   DOMINANCE SUBTYPE -- Sphagnum moss (*Sphagnum sp.*)

2) *CLASS: Forest* -- represents almost the entire upland area

SUBCLASS -- Evergreen Conifer

DOMINANCE TYPE -- Black Spruce (*Picea mariana*)

DOMINANCE SUBTYPE -- Mt. Holly (*Nemopanthus mucronatus*)

3) *CLASS: Tall Shrub* -- represents the eastern edge of the bog where the channel is located

SUBCLASS -- Deciduous Angiosperm

DOMINANCE TYPE -- Mt. Holly (*Nemopanthus mucronatus*)

DOMINANCE SUBTYPE -- Cinnamon Fern (*Osmunda cinnamomea)*

Great Bog Ecology

Great Bog was divided into four zones, each with a particular flora. The open mat, for example, was dominated by sphagnum and leatherleaf (Fig.18) whereas the raised section of the bog had abundant numbers of trees and shrubs. The existence of these different vegetative zones contributes to the high species diversity found in this ecosystem.

With the diversity of flora and the habitats they form, come animal species specific to their characteristics. Arboreal vegetation, for instance, may be home to tree-nesting birds while open vegetation may house ground-nesting birds that need the thick leatherleaf cover for protection. Stockwell and Hunter (1985) found that faunal composition in peatland ecosystems was most dissimilar between arboreal vegetation and open vegetation. Thus, the richness of the vegetative habitats was correlated with the richness of animal species. Further studies showed that the factor of peatland area had no correlation to the richness of species diversity (Stockwell and Hunter, 1985). Even though Great Bog encompasses quite a large area, this may not be as important to animal species diversity as the diversity of the peatland vegetation it provides. The exception to this may be the occurrence of deer and moose which are probably attracted to both the vegetative diversity and the large area of Great Bog.

Having four distinct vegetative types also creates an important habitat: the boundary strip or ecotone. The boundary strip or ecotone is the habitat formed between two dissimilar types of vegetation. These zones are important biologically because they are often home to quite a variety of animal species (Reader, 1988). In Great Bog the ecotones are often quite broad whereas in other places the divisions between vegetational zones are quite distinct. It is important to realize that because Great Bog has several vegetative areas associated with it, there will also exist different types of ecotones. The ecotone formed between the upland and the open mat will be significantly different than the one formed between forested upland and the tall shrub zone. These different ecotone types play a major role in contributing to the total species diversity of the Great Bog ecosystem

It should be noted there is evidence that succession is proceeding in the forested upland where their exists an extensive stand of sugar maple seedlings. It can be concluded from this observation that one of two processes is occuring. Either the sugar maple is in the midst of out-competing the black spruce and the entire stand will eventually be replaced, or the maple seedlings are only germinating but not growing successfully, resulting in the persistence of the black spruce stand. The latter is the more likely process occuring in this stand, the reason being that Sugar Maple generally does not grow well under the conditions found at that site and the fact that no sugar maple saplings were seen.

Because Great Bog has significant peatland vegetative diversity, and has characteristics of several wetland ecosystem types, it is a very unusual ecosystem. The value of this biological diversity should be seriously considered and carefully weighed when reviewing Tilcon's proposal to mine the adjacent esker. The ramifications that such a mining operation could have on this delicate ecosystem can be far reaching and irreversible.

Water Quality Analysis

Great Pond is a healthy and relatively clean lake in the Belgrade chain. The land bordering the lake is relatively forested with no single prominent point source of pollution exists. One of the small point sources include the largely seasonal cottages, the diffuse non-point sources include the surrounding agricultural lands, and the atmospheric inputs of acid rain and heavy metals.

With the undertaking of Tilcon's proposed mining of the Horse Point Esker will come changes in the surrounding area. Road construction, building construction, forest clearing, soil disturbance, and sewage disposal -- all effects of the proposed mining -- will cause special problems to the area not the least of which is increased erosion and nutrification of the watershed runoff.

High concentrations of nutrients present in the aquifer and the lake proper, especially nitrogen and phosphorus, are of special concern as large amounts of these nutrients can be rapidly taken up by aquatic algae and trigger rapid eutrophication of the lake. Typically, algal blooms take place in the summer and these are the most opportune times to measure primary production.

BOFEA has undertaken certain testing procedures to predict the effects of Tilcon's proposed mining. The resultant data interpretations from our testing is highly speculative and any conclusions we may reach by no means represent definitely the course the Great Pond and bog system will take. These data represent the results of testing from only one point in time; in order to get a more refined view of the situation further sampling over succeeding times is necessary. Below is a listing and brief description of the tests which were considered; the rationale for each test is also given.

Dissolved Oxygen (DO) - The amount of oxygen that is dissolved in the water strongly indicates the quality of the water in the bog and bordering lake. DO concentration will indicate the degree of eutrophication from silt, sedimentation and organic runoff. DO levels fluctuate with photosynthetic and respiratory processes; thus we expect DO levels through the winter to be relatively uniform, while in the summer -- with algal blooms and higher temperatures -- lower levels of DO are expected. The resultant respiration of high levels of nutrients such as nitrogen and phosphorous, as well as increased organics present in the summer, serve to drive DO down.

pH - This measurement can reflect the general lithology of the system. Any change in the acid-base balance of a system can severely test the physiology of organisms and can lead to reduced reproduction and even death. Changes in pH occur by three main means: respiration, photosynthesis, and acidic precipitation (Davis et al., 1978). Thus we would expect lower levels of pH taken from bottom samples where there is an increased rate of respiratory metabolism as opposed to surface samples (Davis et al., 1978). In special cases one may find surface pH readings more than one hundred times greater than bottom samples; this is mostly attributable to high photosynthetic activity during large algal blooms. A direct correlation may be made between pH and the levels of free carbon dioxide in the system (R.S. Irving and Associates, Inc., 1982). It will be interesting to compare the values of the lake proper to those of the bog and its lakeside border. The pH mean for Maine lakes is 6.85, with a range of 5.4-7.8. From previous studies we know that the northwest and southeast corners of Great Pond have pH values of 6.8 (6.0-7.1) and 6.9 (6.1-7.1) respectively (Davis et al., 1978).

Temperature - This relatively simple measurement will tell us the approximate range in which organisms present in the system (at the particular time of sampling) thrive. Temperature has a direct relationship to primary production in the aquatic system, it also has an inverse relationship to the various gases dissolved in the water (R.S. Irving and Associates Inc, 1982). Since aquatic production is so sensitive to the processes of eutrophication and sedimentation, we may then, through comparitive analysis of previously gathered data from other similar experiments, determine whether or not it is likely that the effects of Tilcon's mining operation will have an impact on water temperature in the bog and pond.

Total Suspended Solids (TSS) - Filterable residues - This test is a measure of the total suspended matter in the lake by silt and other sediment. The vast majority of these solids enter the system through the processes of erosion, typically with values greatest after rain storms, then typically lessening as the particles settle on the bottom. Large levels of suspended solids can decrease light penetration and result in reduced plant growth. It may also harm filter-feeders and suffocate benthic organisms (Davis et al., 1978 and R.S. Irving and Associates Inc., 1982).

Total Dissolved Solids (TDS) - Non-Filterable residues - We expect these solids to have a similar but lessened effect on light penetration as those termed 'suspended' solids. However, unlike those solids, these typically contain organic as well as inorganic compounds in solution and do not harm filter-feeders and other benthic organisms.

Conductivity - With this test we can discover the amounts of ions and anions suspended in the water column. This test will provide an estimate of the resistance to electrical flow and the relative amount of dissolved solids in the system. It measures the specific conductance as it correlates (positively) to dissolved solids as they in turn suggest rates of nutrification and/or eutrophication. The mean conductance for Maine Lakes is 40.6 μmhos/cm with a range of 21-77 μmhos/cm. From previous studies we know that the northwest corner of Great Pond has a specific conductance of 27 μmhos/cm, while the southeast corner has a specific conductance of 29 μmhos/cm (R.S. Irving and Associates Inc., 1982).

Ammonia - Ammonia is one of the major sources for nitrogen in aquatic systems and (along with phosphorus) is a limiting nutrient towards plant growth. Ammonia results from the aerobic reduction of nitrogenous material, that is it is generally a metabolic by-product of heterotrophic bacteria and is usually viewed as an indicator of untreated sewage (R.S. Irving and Associates Inc., 1982). Large concentrations of ammonia can cause nutrient overload and speed up the process of eutrophication. Highest levels of ammonia are typically found in the late spring and early summer.

Nitrate - Nitrate is the end product of aerobic oxidation, it is formed through nitrification from ammonium. Nitrate is important to assess in water quality because, unlike ammonium, it is biologically available to phytoplankton (primarily blue-green algae) and macrophytes for growth. Nitrate may be reduced to ammonia. It too serves as an indicator for untreated sewage. High concentrations of fixed inorganic nitrogen may be found in deep waters during periods of stratification (Davis et al., 1978, and McKee and Wolf, 1963).

Total Phosphorous - Phosphorus is of major importance to biological systems and (along with nitrogen) is a limiting nutrient towards plant growth. It is a major constituent of fertilizers and detergents and is easily leached into water. Phosphorus generally comes in three forms: dissolved organic, particulate organic, and inorganic. Concentrations above 0.1 mg/l are considered to be characteristic of the conditions of a eutrophic lake and therefore are highest is the summer corresponding to the algal blooms (Davis et al., 1978, and McKee and Wolf, 1963).

Orthophosphate - Orthophosphate is the most significant form of inorganic phosphorus and is very important to measure because it is the most biologically accessible one, especially for phytoplankton and higher plants, and is therefore closely linked to eutrophication. The highest values then, are not surprisingly found in the summer corresponding with the seasonal algal blooms (Davis et al., 1978). Also we may expect that orthophosphate values will increase with depth in the water column.

Lead - Lead is a common heavy metal that can be accumulated in living tissues and is toxic at relatively low levels. Safe level for lead in water was defined in 1962 as .05 ppm (Davis et al., 1978). Lead samples were analyzed by North East Laboratories, Winslow ME.

Hardness (Calcium content) - Calcium ions in solution act as a buffer against acidic inputs like acid rain and may be a significant counterbalance in offsetting the acidic conditions put forth from the Great Bog's sphagnum moss system on Great Pond. A minor contribution of calcium ions can come from calcium chloride, used in de-icing roads. Also there is the possibility of Tilcon using a calcium compound to keep dust down on unpaved access roads. A major input of calcium may come from the dissolution of $CaCO_3$ from limestone and other calcareous sedimentary rocks. This measurement is a function of the lithology of the system, and since there is not a great amount of calcium present in the sediments of the system the underlying geology is not believed to be a major source in the Great Pond area.

Tannins and Lignins - An analysis of tannins and lignins will be used as an indicator for measuring exchange rates between the bog and the pond. Tannic acid, the principle product and a strong indicator for the presence of tannins and lignins, is given off in the process of decay of organic material. With this measurement we can designate flow rates between the bog, the area of highest decomposition, and the lake proper.

Sample Sites

For the Great Pond/Great Bog area, seven sample sites with a total of thirteen water samples were selected (Fig. 17). Three sites (#'s 5, 6 & 7) were located on the northern portion of the bog itself (including open water within the bog system). Two sites (#'s 3 & 4) were located on the edge of the mat in North Bay, one (#2) in the center of North Bay and one (#1) on Great Pond proper. Three samples -- surface, mid-depth, and bottom -- were taken at site 1 and site 2 due to deeper water at these locations. The water depth at site 1 was approximately thirty feet, and the depth at site 2 was approximately nine feet. Samples were taken at mid-depth at the remaining five sites (total depth at these sites was less than six feet). In addition, two repeat samples were taken at sites 3 and 6 in order to detect sampling and/or analysis variability.

Samples were not taken from the central, wooded area of the bog due to the fact that there is no permanent standing water associated with that area. An exception to this is that standing and flowing water did form in the upland area after it rained, and this standing water often persisted for a few days depending on the quantity of rain that fell. All of the permanent standing or flowing water on the bog is found in the open ponds on the mat, in the channel that runs along the bogs eastern and southeastern edge, and in the lagg that is found on the western edge. It is important to note that even those areas of the bog that did not have permanent standing or flowing water were nonetheless near saturation, and relatively little rain was required for standing water to form. The three times that BOFEA surveyed the bog the water level, especially near the channel, was several centimeters above the bog surface.

Site 1 was chosen because it was representative of the water quality throughout the lake and it would serve as a baseline to which the other sites could be compared in terms of water chemistry. Site numbers 2, 3 and 4 were all chosen because by comparing the water quality from the bog itself to these sites, it will be possible to estimate how much diffusion and/or exchange is occuring between the bog and Great Pond

(North Bay). Tannins and lignins, for instance, are only produced within the bog system; through analysis, the amount of tannins and lignins in the bog water (#'s 5, 6 & 7) can be compared to the amount in North Bay. If relatively heavy amounts are found in North Bay, then it can be concluded that some water exchange does occur between the pond and the bog. Finally, sites 5, 6 and 7 were chosen because they were representative of the different areas of the bog. Site 5 out on the open mat, site 6 in the channel that receives a high amount of runoff from the adjacent ridge, and site 7 in the lagg that receives runoff from the esker and is near a populated area.

Sampling Preparation

Bottles for each of the tests to be performed were prepared for each sample site. Because of similar preservation techniques, turbidity and suspended solids tests were placed in the same bottle as were ammonia and total phosphorus. All bottles were washed with ammonium molybdate (except for those prepared for nitrate analysis) and then rinsed three times with deionized, or micropure water. The bottles prepared for nitrate were washed in a similar manner to those above except excluded the addition of ammonium molybdate.

Each bottle was labeled with the test name, the type of preservation needed, and the code for the sample site. The code used identified the area, the sample site, the depth for the sample, and whether it was a replicate. When the samples were taken, date and time of sampling were recorded on the label.

On site, 5.25 N sulfuric acid was added to the ammonia and total phosphorus bottles until the pH of the samples was at most 2. This was confirmed by litmus paper analysis. Orthophosphate was filtered twice, first with general laboratory filter paper and then through a membrane filter, before being placed in sample bottles. All of the bottles were placed on ice at the sampling site and kept at 4°C when returned to the lab.

Sampling Preparation for Storm

Separate bottles were prepared for nitrate, total phosphorus, and total suspended solids as described above for each storm sampling site. The samples were also preserved as described above.

Analysis of Samples

Table 7: Tests and methods used for on-site analysis of samples.

Test	Method
Dissolved Oxygen	YSI D.O. meter
pH	Beckman pH/temp. meter
Conductivity	YSI Model 33 S-C-T. meter
Temperature	Beckman ph/temp. meter

Table 8: Tests and methods used for in-lab analysis of samples.

Test	Method
Tannin and lignin	Hach tannin and lignin test kit, DR/3 portable spectrophotometer
Turbidity	Hach DR/3000 spectrophotometer, turbidity test, range: 0-600 FTU.
Total suspended solids	Hach DR/3000 spectrophotometer, residue, nonfilterable, range: 0-1000 mg/L
Ammonia	Wescan Model 360 Ammonia Analyzer
Nitrate	Hach DR/3000 spectrophotometer, Cadmium Reduction Method, range: 0-5.0 mg/L
Total Phosphorous	Hach DR/3000 spectrophotometer, Persulfate/UV Oxidation Method, range: 0-20.00mg/L
Orthophosphate	Hach DR/3000 spectrophotometer, Molybdovanadate Method, range: 0-20.00mg/L
Lead	Samples sent to N.E. Lab
Zinc	Samples sent to N.E. Lab

Data and Interpretation

Temperature -- The temperature varied from 8.0-12.2^{o}C but showed no significant trend. This was probably due to the occurrence of the fall overturn. Storm runoff temperature was approximately equivalent to ambient temperature- 4.5 to 5.0^{o}C.

pH -- In the lake, pH was only very slightly acidic (6.69-6.86), while in the bog it was significantly lower (3.35-3.45). No significant difference due to depth was found within the lake, probably because of the fall overturn. The lake pH compares well with the mean pH for Maine lakes

(6.85). Because free carbon dioxide reacts with hydrogen to form carbonic acid, pH is an indicator of carbon dioxide levels. Therefore a low pH may represent that respiration is exceeding photosynthesis. This is a typical quality of eutrophic lakes. However, due to the fact pH levels appear to be relatively normal in Great Pond, the Pond does not seem to be eutrophic.

During the storm sampling, pH levels in the runoff from the pit were found to be 5.26-5.71. Runoff pH was lower than lake pH, probably because storm water tends to be acidic. Phosphorus solubility in water is highest in pH of 5-7 (Stevenson, 1986). This means that the storm water runoff is in a pH range that allows it to become saturated with phosphorous. Therefore, if this water is typical of runoff from around gravel pits, it will be carrying a maximum load of phosphorous from the gravel pit and surrounding land to the lake.

Dissolved Oxygen -- Dissolved oxygen throughout the lake remained relatively constant. Because samples were taken during the fall overturn, dissolved oxygen levels would not be expected to vary over depth or site location. A gradual decrease in dissolved oxygen was noted from the lake fringe of the bog (10.6 ppm) to the inner mat (5.1 ppm). This is an indicator of the anoxic conditions typical of bog environments. Dissolved oxygen at site 7 (Fig. 17) was extremely low (5.1 ppm), lower than anywhere else on the bog, and suggests eutrophic conditions.

Total Suspended Solids -- Total suspended solids in the bog and lake varied from 2-7 mg/l but showed no identifiable trend. During storm event sampling, total suspended solids levels were found to be much higher than in the lake and bog water (125 - 246 mg/l). High levels can be attributed to a lack of sufficient vegetation and an artificially steep slope which increases overland flow and sediment loading.

Conductivity -- Conductivity in the lake varied between 30 and 40 µMHOS with no obvious gradient corresponding to depth in water column. At site 3 (the lake fringe of the bog), conductivity is similar to that of the lake. However, in the bog, levels were higher, especially at site 7 (near a non-point pollution source: Fig. 17). This may be indicative of the increase in dissolved solids in the water.

Conductivity during the storm sampling was low (10-15 μMHOS) but this may not be an accurate representation of the total solids in the runoff. Conductivity is a measure of dissolved solids only, not suspended solids. Most of the material in the runoff water is suspended, not dissolved.

Tannins and Lignins -- Tannin and lignin levels, which for us can serve as an index of flow rates, followed an expected trend of increasing from the low levels in the open pond (0.1 mg/l) to the high levels found in the standing water on the mat (9.6 mg/l). Levels were low in the open water of the lake (0.1-0.4 mg/l), slightly higher in the lake near the bog (0.5 mg/l), and very high on mat (5.9-9.6 mg/l). This indicates that while there is some flow of water between the bog and the lake, it is insufficient for substantial mixing to occur. The comparison of levels of tannins and lignins on the mat near the inner lagg (sample site 6) and the lake near the channel outlet (sample site 4) indicates either that flow from the channel in the eastern lagg to the lake is insignificant or that tannins and lignins are absorbed by the bog as they travel through the channel.

Nitrates -- There was a sharp increase in nitrate levels from the lake edge (0.4 mg/l) to the inner mat (2.2 mg/l). This trend was expected because the bog acts as a nutrient filter and therefore activly absorbs nitrates.

Nitrate levels during the storm sample fell in the range of the lake and bog samples. Therefore, storm runoff should not cause significant increases in nitrate loading in the lake.

Total Phosphorous/Orthophosphate -- Both total phosphorous and orthophosphate showed similar trends of increasing concentrations from the lake edge towards the inner mat (orthophosphates: 13.08-22.61 ppb, total phosphorous: 4.61-15.78 ppb), once again showing that the bog acts as a nutrient filter. At three sample sites, total phosphorus levels were found to be lower than orthophosphate levels. The reason for this is unclear. In the lake, orthophosphates showed little variance but total phosphorous increased with depth (by approximately 10 ppb from surface to bottom). Fall overturn is probably responsible for the relatively even distribution of orthophosphates, or dissolved phosphorous. Total phosphorus includes phosphorus bound to sediment particles and in organic matter which are more likely to settle to the bottom.

The storm sampling indicated that very large amounts of total phosphorous (711-2536 ppb) are leached out of the soil and travel in the runoff. The runoff percolates through the gravel and sand at the bottom of the pit into the ground water. While phosphorus bound to sediment particles may be filtered out, dissolved phosphorus will enter the ground water and may eventually flow into the lake or bog.

The bog and lake ecosystem have only a limited capacity to absorb phosphorous and an excess increases the rate of eutrophication. While phosphorous test results were not indicative of eutrophic conditions in the Pond, a local resident has informed us that algal blooms did occur in the summer of 1990. Because phosphorus is generally the limiting nutrient for algae, an algal bloom indicates excess phosphorus is present in the lake, and eutrophication may be accelerated.

Ammonia -- Levels of ammonia in the lake and bog approached zero (0.04-0.11 ppm). Care should be taken if quoting these "near zero" numbers due to the fact that these ammonia levels represent the absolute low end of our instruments sensitivity. Numbers this low represent, to an appreciable extent, background "noise" instead of actual ammonia concentrations.

Lead and Zinc -- Spot sampling was conducted for lead and zinc in the lake. Both lead and zinc readings were low (0.002 ppm and < 0.02 ppm respectively) and were not above recommended levels.

Conclusion

In conclusion, our results showed that water quality varied throughout the sampling sites due to several factors. First, at site 7 (Fig. 17), test results indicated eutrophic characteristics. Site 7 is near a boy scout camp, and probably receives runoff from the camp. Runoff from the camp to the bog apparently contains high nitrate and phosphorus concentrations, which would account for the high nutrient concentrations found at the site. Other tests, such as dissolved oxygen and conductivity, were also characteristic of eutrophic conditions.

Sampling data also supported the fact that the bog acts as a nutrient filter. This was shown by orthophosphate, total phosphorus, nitrate, and turbidity, which all tended to decrease from the inner mat to the lake. Another factor contributing to variation in water chemical analyses is the flow rate of water from the bog environment to the lake. While flow was observed in the eastern lagg at the time of the sampling, tannin and lignin concentrations did not show significant mixing between the inner lagg and lake. This can be explained either by a low flow rate in the lagg, or by the absorption of tannins and lignins by the bog as water travels through the lagg. Turbidity, suspended solids, orthophosphate, and total phosphorus show similar trends, supporting the tannin and lignin data.

Storm sampling showed that overland flow was much higher on the gravel pit than on the natural forest floor. Over the course of one and half hours, runoff from the pit was ample for collection of samples. However, no runoff was found on the forest floor. Overland flow can be expected to increase greatly in an area characteristic of a gravel pit.

Land Use Patterns in the Study Area

This portion of the report will present an objective analysis of various land use patterns within the Horse Point study area. Residential and commercial development, as well as road management will be presented in terms of facts, impacts, mitigations, and possible solutions. The importance of aesthetics and educational value within the study area will also be discussed.

The property owners of the land contained within the Horse Point study area, have been identified through the use of property tax maps and associated owner listings. Tax maps #14, #15, #16 and #17, in combination with their lot listings, distinguish residentially or commercially-owned lots within the Town of Belgrade, Kennebec County, Maine (see Appendix IV).

Residential Analysis

Shoreline

Residential land use along the shoreline of North Bay has been considered because of the potential runoff from the summer cottages and year-round homes. The density of houses and the rate at which they are increasing suggests how vulnerable the lake is to residential phosphorous loading and sedimentation. Using a 7 1/2 minute topographical map from 1980, 26 houses were counted from Stony Point to Snake Point along North Bay. The current number of houses was calculated to be 50. (videotape, 1990).

Impacts and Mitigations

The data indicates that there has been significant growth along the North Bay shoreline. The acting town manager of Belgrade (Bates, pers. comm.) has confirmed these findings stating that the residential growth has not slowed down since 1988 as it has in the rest of the state of Maine (Khuns, pers. comm.). The number of plumbing permits has gone up in Belgrade from 150 to 190 in the years 1989-1990, which indicates significant growth or renovation of existing cottages (Bates, pers. comm.). The cottages along the shoreline may account for the small point sources of pollution entering the lake. Pipes entering the lake, faulty sewer systems and sediment runoff from camp roads are a few of the contributors to lake water pollution. The shoreline along North Bay, not including the wetland areas, is a rocky forested buffer zone. From the data available from DEP it can be concluded that although there has been growth along the Belgrade shoreline near North Bay, significant contributions by Belgrade changing the levels of phosphorous in the lake have not been found. North Bay is apparently free of the impacts of development, namely high phosphorous, for the time being.

Non-Shoreline

The town of Belgrade has been experiencing significant development pressure due to recent population increases, according to The Belgrade Comprehensive Land Use Proposal (BCLUP) of 1987. The proposal states that most of the development has been residential; however, as is usually the case, commercial development has followed. Although the majority of the land within this study area is residentially-owned (refer to Quadrant II of large overlay), there is a small percentage of commercially-owned land that is indicated by crosshatch marks on the property tax maps (see Appendix IV). The commercially-owned land is clustered in only a few areas. This aggregation of commercially-utilized land may perhaps magnify possible problems pertaining to the residential areas around these commercial sites.

The recent population increase has resulted in escalated levels of residential development within the study area. Based on analysis of aerial photos and property tax maps of the area, development occurs all over the study area, mainly concentrated in these areas: Snake Point, Stony Point, and along both Horse Point Road and Route 8. Most of the concentrated areas are associated with Great Bog and proposed gravel mining site boundaries (see Appendix IV). Problems that result from the increased amount of development include erosion due to construction, leaking tanks within septic systems, and an increased number of access road utilization that may provide storm runoff an avenue for transporting toxic chemicals and nutrients to the edge of the pond or bog.

Results of the 1987 Belgrade Planning Board Survey show that the majority of Belgrade residents believe that the town should have the ability to control where future development takes place. In addition, residents feel the need to adopt a land-use ordinance to separate residential area from industrial and commercial development. Lack of action taken from the survey's results has directly lead to problems involving the Tilcon Mining Corporation located in the heart of a Belgrade residential area. An analysis of the impacts relating to gravel mining indicates numerous problems -- noise pollution, air emissions, a need for proposed buffer strips and road management and safety, changes in property values, and any ecological disturbances that may surface.

Impacts and Mitigations

In response to noise pollution, the Tilcon Corporation application proposes to limit the hours of project operation from 7AM to 7PM. Also proposed is the containment of the most significant source of noise, the rock crushing and sorting plant, in a "noise baffle type housing" (Proposed Tilcon Application, Exhibit #19).

Tilcon's projected noise level does in fact exceed the Maine DEP regulation of 55dBA by 7.3 dB; however the corporation application plans to correct this with topographic and earthen barriers as well as vegetative covering. The Site Location of Development Law, Title 38, Section 482-A states that the board shall adopt amended rules for the control of noise generated by commercial or industrial developments.

These rules must:

> A. Reflect consideration of local zoning with regard to both the zone in which the development is located and the proximity of the development to residential areas;
>
> B. Employ a consistent methodology to assess background and intrusive noise effects of developments of a similar nature;
>
> C. Provide that the board may limit the hours of operation of the development to minimize the impact on surrounding users;
>
> D. Contain an appropriate list of activities that, although connected with a development, are wholly or partially exempt from review by the development.

Possible solutions to enhance the proposal and resident approval might include further limiting the hours of operation, limiting the amount of trucks and other noise-producing vehicles, and proceed with actual noise measurements once the project is established. In addition, Belgrade should require Tilcon's compliance with all other applicable federal, state, and local laws, pertaining particularly to excessive decibel levels.

The Tilcon corporation as mentioned above, proposes the use of a portable rock crusher licensed by DEP. This type of machinery would contribute point source air emissions that cause concern for gravel dust control. When established, the project proposes to employ water spray nozzles in conjunction with the crushing operation to comply with the 5% opacity standard. The usage of these spray nozzles will be weather dependent and based on the need for dust control.

In conjunction with the mining activity, a 10,000 gallon diesel-fueled electric generator will be located on site. The fuel tank for the generator will be used to operate the rock crusher as well as the front end loaders, both of which are on site. The fuel tank will be contained in a 25X20X3 foot reinforced concrete dike which is equipped with on site emergency response measures to leakage problems and fuel spills. This emergency equipment will include: sorbent pads, a container for sorbent pads, and a two-way radio on the Tilcon Maine, Inc., frequency.

In addition to meeting emission standards, the use of buffer strips by the Tilcon Corporation has tremendous ecological significance. Preventing soil erosion and the addition of high levels of nutrients to the surrounding water body should be of main priority. Within the Proposed Tilcon Application, the corporation states that 30 remaining acres of the 133 total will be devoted to buffer zones for adjacent property or wetlands. Portions of these buffer zones are heavily vegetated and will provide complete visual screening of the proposed project from the road, according to Exhibit #18 of the Proposed Tilcon Application.

In areas of needed vegetation on the buffer zone, Tilcon has proposed to enhance the existing vegetation by planting six-foot tall White Pine trees. According to the application, plantings on the Horse Point buffer strip will be observed on a monthly basis and replaced as necessary. "Additional protection of the bog will be afforded by conducting the excavation in such a manner so as to assure that surface runoff over disturbed ground is always toward the interior of the site" (Proposed Tilcon Application, Exhibit #18). Also, due to the proposed buffer strip widths, there will be no private wells within 250 ft. of the mining; in addition, no public water supply wells occur within 2500 ft. of the proposed gravel pit and no on site water supply wells are proposed by the project. Therefore, the risk of groundwater contamination is greatly reduced by the inclusion of these buffer strips and safety precautions taken for fuel tank related problems.

Tilcon has also proposed a mutual excavation agreement with its abutting neighbor, Blue Rock Industries, to eliminate the necessity of a buffer zone between both pieces of property. Although this notion contains many potential ecological drawbacks, the Maine DEP permits an abutting landowner to waive the requirement of a buffer zone with official written consent from both sides.

The 1987 Belgrade Comprehensive Land Use Plan indicates that natural buffer strips should be required along all intermittent and perennial streams adequate to serve as filter strips and wildlife corridors. In addition, the Site Location of Development Law, Chapter 21 defines natural buffer strips as an area or belt of land which:

> 1) Is covered with trees or other vegetation:
>
> 2) Runs along the border between a development site and an adjacent piece of land, body of water, or other specified area:
>
> 3) Serves to protect the piece of land or body of water from adverse effects of the development or preserves some existing quantity or use in the area of the development.

Possible solutions might include reconsidering the addition of buffer strips, observing them on a monthly basis, and maintaining them indefinitely. These initiatives will further hold back decibel levels, dust drift and contaminated water runoff from entering the surrounding ecosystem.

Commercial development, present and proposed, could significantly alter shoreline property values within the Horse Point area. Information regarding shorefront property values was obtained from phone conversations. Changes in value due to local commercial land use patterns was the focus of the conversations.

Robert Bates, the temporary acting town manager of Belgrade, expressed a positive attitude towards present and potential mining areas. From an assessor standpoint, Mr. Bates believes that waterfront areas will continue to be in demand, as larger more recent sales have already occurred in the Horse Point area. Mr. Bates also suggested that full scale mining operations will have little or no effect on property values. He claims, "the houses there [in the Horse Point area] were built long after the pit was there", concluding, "that open pit mining does not affect property values, even if it runs against our common sense." He believes there is little concern and that gravel mining does not affect property value.

On the contrary, a local real estate agency primarily dealing with shorefront property and values has very different thoughts pertaining to the Horse Point area. When interviewed about what kinds of impacts local mining may have on property values, Mr. Kirk of ERA Day's Real Estate Agency suggested a pessimistic outcome. Mr. Kirk believes the property value will be affected quite dramatically, particularly the lakeshore properties and along Horse Point road. He clearly states, "that the mining will by no means enhance business [Real estate] in the area." Mr. Kirk claims to have seen the negative effect on the shoreline areas already stating, "People want to buy the land, but read the newspaper and reject it." He concluded the conversation stating, "As of right now, there is no drop in price, but it will eventually happen [to further continue business]. We have seen the 'not buying' aspect, therefore it is definitely becoming a value problem."

Approval of the proposed Tilcon application may change existing property values and taxes within the study area. Currently, Tilcon pays between $700 and $800 in property taxes to the Town of Belgrade. Should their permit to mine be approved, the value of Tilcon's property would greatly increase, and Tilcon would be able to sell the land and permit to an eligible buyer if it became economically feasible. It would be in the best interest of the Town of Belgrade to prompt a reassessment of properties to take advantage of this untapped source of revenue.

Commercial Development

Within the Horse Point study area, commercial land use is defined best by three industries -- mining, logging, and agriculture. Each type of industry has a strong potential to effect its surroundings negatively, particularly adjacent wetland areas, such as Great Pond and Great Bog. These negative effects may come in various forms such as increased sediment nutrient loading and ground water contamination.

A commercial industry that has caused recent concern among the residential owners of the bog and esker complex is gravel mining. According to the property tax maps, three corporations: Tilcon of Maine, Blue Rock Industries and Ebb Tide Properties, Inc., own a significant portion of the bog and esker complex. Seven of the approximate eleven bog-type lots are owned by these gravel corporations comprising a total of 2.2% of gravel corporation owned land within Quadrant II of the large watershed overlay.

In addition to this corporate property, there are four major residential owners of the bog that are concerned about the corporations' land use and the potential negative effects. Although there are only four lots within the bog that are residentially-owned, virtually all of the land surrounding these corporations is residentially-owned, which establishes more concern within the area.

The mining proposed according to the Tilcon Application states that as much as 740,000 cubic yards of material is expected to be excavated from the project site. Phased gravel extraction and reclamation have been proposed to occur on approximately 14^{+} acres of the 133 acre project site. The phasing method of the project will allow the excavation of smaller mining cells within the overall proposed 14^{+} acres.

According to owner listings of property tax map #17, a large portion of land appears to be directed towards logging. Timberland, Inc., lot #30 of this map, is primarily concerned with tree growth in terms of "cut and let Mother Nature supply," according to long-time Belgrade resident, Roger Bickford (pers. comm.). There are also other possible logging areas within this map's boundaries, e.g. lot #29, owned by the Bessey Development. Tukey Bros., located on property map #15, lot 10E, utilizes a saw mill only. Timber is brought in from external sources with no logging activity on site.

Of the three commercial industries mentioned in this report, agriculture seems to be the least prominent land use pattern within the Horse Point area. According to the acting town manager of Belgrade, (Bates, pers. comm.), mining and logging have been constant industries past and present, whereas agriculture has been slowly declining, especially over the past ten years. Mr. Bates claimed there is only one working farm within our study area. He further explained that there is no official watershed district in Belgrade, therefore obtaining information concerning specific land use patterns within the study can prove to be difficult.

Impacts and Mitigations

The present rates of erosion have been accelerated by human activities, such as mining, logging, and agriculture. Sediment pollution of nearby water systems from these commercial industries is a potential soil erosion problem that may decrease water quality and harm wildlife. This problem promotes great concern for the surrounding water systems, Great Bog and Great Pond.

Mining contributes to erosion by removal of all surface vegetation, leaving only bare soil that is vulnerable to strong erosive impacts by wind and rain. Also, erosion is further enhanced by an increased steepness of slope resulting in higher levels of runoff. Strategies that may be used for reducing mining-related erosion include: reclamation, regrading the area to provide a more gently sloping land surface; re-vegetating the land, and where necessary, fertilizing and/or watering the area to help establish vegetation; and clearing the topsoil in stages as needed, to minimize the length of time the soil is exposed.

Problems that may occur within the logging industry are also related to erosion. Contributing factors deal primarily with the removal of vegetation, skidder trails near streams and lakeshores, and the absence of buffer strips. Minimizing impacts can occur from re-vegetation, proper utilization of machinery, and the inclusion of buffer strips.

Although agriculture is not the most prominent industry in the Horse Point study area, it can have several negative effects on the surrounding ecosystems. Problems from agricultural land use patterns include erosion as a major contributing factor. Unfortunately, soil erosion from cropland leads to reduced crop quality and agricultural income. It is therefore necessary, ecologically as well as economically, to minimize impacts as much as possible. "Techniques that involve soil conservation methods include contour plowing, terracing, and cover-crop planting. These methods can slow surface runoff, increase filtration, and enhance soil conservation, thus reducing erosion rates" (Montgomery, 1989).

Agriculture can effect the wetland ecosystems in several ways. Open manure storage, grazing livestock near water systems, and the over-application of fertilizers are representative problems. These problems can be minimized by the utilization of manure containment facilities, careful location and management of livestock and fertilizer application.

Road Assessment

If Tilcon were allowed to proceed with the mining of gravel on Horse Point Road, there would be an increase in the amount and type of traffic. Tilcon proposes that 14 yard trucks carrying eighteen tons per trip, will make 44 round trips per day, from 7:00 am to 7:00 pm., with the option of operating an additional eight trips per day if needed. These numbers represent the maximum number of trips and hours of operation. The truck traffic will occur in surges with no trucks on the road some days and up to sixteen on others (Pfister, pers. comm.). An assessment of the road quality and type was necessary to evaluate its ability to safely accommodate the traffic increase.

Methods

Based on minimum standards established by the state, and the town of Belgrade for local roads, a set of criteria were devised to evaluate Horse Point Road (Table 8). Road quality was based on a 4 point scale from very good (newly paved) to poor (many cracks, and crumbled edges). Other factors studied include road and shoulder widths, shoulder type, road crown, presence of road side obstructions, and any potential safety hazards such as curves and steep rises. The presence of houses visible from the road, and the concentration of houses along the road were also noted.

Table 8: Minimum Maine State and Belgrade Standards for Local Roads in Comparison to the Tilcon Application for Gravel Mining on Horse Point, Belgrade, Maine

Characteristic	State[1]	Belgrade[2]	Tilcon[3]
Road width	18'	20'	20'
Shoulder width (each side)	3'	3'	3'

[1]As outlined in Maine state Site Location of Development Law
[2]From Town of Belgrade Shoreland Zoning Ordinance
[3]Tilcon Application Submitted to Maine Department of Environmental Protection, May 1990

The road evaluation began at the intersection of Route 8 and Horse Point Road and finished where the Camp Bomazeen access road begins. Every tenth of a mile for 3.1 miles the road and shoulder widths were measured with a 50m tape measure, and shoulder type and other observations were recorded. The road width was measured from one edge of the pavement to the opposite pavement edge. The shoulders were measured from the road edge to either the end of level road side areas or to the start of road side vegetation.

Data and Interpretation

Horse Point Road is a local road, used primarily for access to adjacent residential properties as defined by the Department of Environmental Protection Site Location of Development Law. It has no posted speed limit, allowing vehicles to travel up to 45 mph. Horse Point Road is approximately three miles long and has an average road width of 20.6 feet. This average width exceeds the minimum standard of 18.0 ft. set by the state of Maine, and is just wider than Belgrade's minimum of 20.0 ft. In the early fall, when BOFEA members observed the condition of Horse Point Road, the road appeared to be in reasonably good condition with few cracks and a crown in some extended areas. The shoulders are composed of a packed sand and gravel mixture with occasional vegetation cover, and little deterioration. The ability of the shoulder to remain in a firm, packed condition during the spring melt was not evaluated, however, and it is reasonable to speculate that the shoulder conditions would deteriorate to some extent. The shoulder width varies from 0.0 ft. to 11.8 ft and averages 2.7 ft. -- just slightly lower than the state and local minimum of 3.0 feet. There appear to be some areas for car pull-offs, although some shoulder obstructions were observed as well as several areas of the road where a steep rise is accompanied by curves. These areas would represent potential safety hazards to vehicles under poor weather conditions, or upon the meeting of heavy trucks and other private vehicles. Finally, it should be noted that the substrate on which Horse Point Road is built is not homogenous. A section of the road runs directly over a portion of the wetland and therfore occupies a low point within the region. This wetland section of the road would have some potential problems associated with it that portions located at higher geographical points -- such as over the esker -- may not have. These problems would all be associated with the softer substrate and the increased drainage within the wetland region.

Most of the houses along Horse Point Road are visible from the road and are separated from the road by lawns of at least 50 feet. The year-round homes on Horse Point Road are concentrated in the area between the camp roads H8 and H9, and then again beyond H12 see appendix tax map. The potential presence of children and pets in these areas of road side house concentration creates a significant hazard along Horse Point Road. In addition to the houses along the road, there are many accessory camp roads that lead to lakefront homes. The entries of these roads onto Horse Point Road may also signal possible traffic hazards.

Tilcon proposes to build an access road from Horse Point Road to the proposed mining site. This road would be sprayed with water mist and calcium to keep the dust down and would be paved the last 200 ft. before intersecting with Horse Point Road to prevent the trucks from carrying mud onto the road. The Department of Transportation requires that at an intersection there must be a sight distance in each direction of 10 ft. for every mph of the speed limit on that road. Tilcon had originally proposed to build the entrance in a location which DOT found to have insufficient sight distances and asked Tilcon to relocate the road. Tilcon then moved the location of the proposed access road 200 ft. further down Horse Point Road. DOT has determined that this newly proposed location of Tilcon's entrance complies with the standard having at least a 450 ft. sight distance in each direction (Wright, pers. comm.).

The results from this study indicate that in general, Horse Point Road is of the quality and construction able to accommodate the traffic that would be generated by Tilcon's proposed gravel excavation. Although the road and shoulder are of adequate width, there are other factors that should be studied to obtain a more complete analysis. These factors include potential safety hazards such as winter road conditions, summertime traffic increases, and use of the road by pedestrians and cyclists. Summertime increases are due to use of the road by seasonal residents and visitors of Camp Bomazeen. In addition, the effects of the traffic increase on other municipal roads through North Belgrade, Waterville, Oakland, and Fairfield should be considered as Tilcon has proposed to use many routes outside of Belgrade for gravel transportation.

It should be stressed, however, that the road assessment conducted by members of BOFEA should not replace a formal road safety and traffic study by qualified engineers. BOFEA members did not take core borings of the road, nor did we evaluate the road through different seasons in order to asses possible seasonal differences in road safety.

Summary

Provisions should be made for the maintenance and repair of Horse Point Road and the shoulder should be expanded to a constant minimum width of 3.0 feet to allow room for car pull-off. In addition, a reduced speed limit should be determined, posted, and enforced to prevent speed related accidents, especially in areas of residential home concentration.

Aesthetics and Recreation

The area of concern is not only comprised of residential lands, but also pristine wetlands and shorelands property. The Belgrade Lake watershed, of which the Horse Point study area is a part, is "interconnected among seven principle lakes and comprises an area of 83 square miles" (The Belgrade Great Bog Protection Association). This watershed contains the wildlife sanctuary known as The Great Bog, which presumably provides living, breeding, and wintering grounds for numerous types of animals.

"Horse Point itself is an esker, a glacial deposit of gravel sitting on top of a great aquifer or pure water supply" (The Belgrade Great Bog Protection Association). This natural water supply provides recreational opportunities and ecological significance for the entire Belgrade community. This area holds property owned by the National Boy Scout Pine Tree Council Jamboree Camp, numerous summer residences and potential archaeological artifacts.

An archaeological survey has been conducted prior to excavation to determine the potential archaeological significance within the area. The results of these findings proved to be negative. Therefore, prehistoric Indian development is highly unlikely in this area. Had there been a discovery of significant archaeological resources, it would have been excavated with a proper scientific method, or protected through various legal and physical means, according to the proposed Tilcon application.

If the established Horse Point community is disrupted by proposed commercial activity, there is potential for social, ecological, and economic upset for the Town of Belgrade. Further ecological analysis within the proposed mining area by the Department of Inland Fisheries and Wildlife may better assess the area's future. However, the information necessary to rate the wetlands for all wildlife species is limited at this time.

In conclusion, a broader recommendation based on the 1987 BCLUP involves the development and enactment of a town-wide zoning ordinance. This ordinance would deal primarily with "separating non-compatible land uses, protecting property values, minimizing environmental degradation and nuisances, directing more intensive residential and commercial development to village areas and away from agricultural and rural areas, and reflective of the characteristic of the soils found in Belgrade" (1987 BCLUP). This ordinance, if enacted to its fullest potential, could ameliorate present conditions existing between residential and commercial communities within the Belgrade area.

CONCLUSIONS

The purpose of this study was to provide background information and recommendations regarding the Great Pond drainage basin and specifically the Horse Point area. Existing land use in the basin was examined to understand nutrient loading potentials to the pond as well as the relative significance of natural areas in the basin. In the Horse Point region, a biological inventory of Great Bog was undertaken to provide baseline data for assessing changes and understanding the significance of this bog. Water quality of both the bog and the pond were recorded as baseline data to assess future changes and as an aid in understanding exchange relationships between the bog and Great Pond.

In this study, BOFEA has addressed several issues concerning Tilcon's proposed mining of the Horse Point esker. Although it is possible that the aquifer will be adversely affected by the mining, BOFEA does not feel that it has sufficient data to state definitively what the results of such a mining operation would be. However, the ramifications of the possible impacts are of such significance that they warrant careful consideration. The sides of the gravel pit will concentrate nutrient-rich runoff into the bottom of the pit. Phosphorus, nitrates and dissolved solids are typically in high concentration in surface runoff on gravel surfaces. As the runoff passes through the gravel, many of the nutrients may be filtered out, but there is potential for some nutrient loading of surface waters. These compounds may also gain entrance to domestic water systems. The long term result of nutrient loading is the increased potential for algal blooms and eutrophication of the pond.

Water draining through the pit may also raise the water level directly beneath the pit. This is likely to affect groundwater flow patterns which may also induce a slight change in bog water level. Such changes in water level may have a significant impact on the biota of the bog.

Gravel mining comprises a small percentage of land use in the Great Pond Drainage Basin. This indicates that the cumulative effects of mining on the drainage basin are limited. Other land use issues include road usage. Certain aspects of the road such as the speed limit and shoulder width should be considered. However, in general, Horse Point Road appears to be adequate to handle the expected increase in road traffic. Buffer strips around the mining area are also important land use issues. They play an integral part in reducing noise, concealing the unattractive pit, and decreasing dust drift by reducing wind action.

It appears that Tilcon has complied with existing laws concerning wetlands and development. However, the originally proposed buffer strips adjacent to the road must be increased to at least 150 feet. In addition, the suggestion of Inland Fish and Wildlife to comply with the new state guidelines protecting areas withing 250 feet of wetlands rated as moderate value for waterfowl should be followed, even though this regulation will not be adopted by the town of Belgrade until this coming year. Federal regulations on wetlands do not apply for this mining operation because Tilcon is not mining directly on the wetland. However, indirect effects on the biota may be felt.

From a biological perspective, wetlands have unparalleled wildlife diversity. Wildlife, especially on wetlands, is affected most by human disturbances. Great Bog itself seems to be an excellent natural wetland resource because of its diversity of at least four vegetational zones. Diversity is amplified by ecotones between these zones and by neighboring wetlands such as Great Meadow. This high biotic diversity indicates Great Bog's uniqueness especially in this watershed. As of yet, rare or endangered species, which add significance to a wetland, have not been documented. A more extensive wildlife inventory needs to be conducted in different seasons to determine whether or not rare species are present.

In summary, BOFEA feels that the bog's relatively large size, high species diversity, and its association with the Horse Point Esker, Great Pond, and Great Meadow creates an environment that deserves special attention. Although currently not on the list with the Critical Areas Program, its present and future value as an educational resource, as well as a biologically and geologically diverse area, deserves Critical Area status as well as protection from any deleterious human activity.

SUMMARY OF RECOMMENDATIONS

From our study of the Horse Point gravel mining proposal, BOFEA believes that mining in this unique area is not the most suitable use of the land area. The area is unique both biologically and geologically. We offer the following recommendations for further study.

GENERAL CONCERNS:

- The Great Pond drainage basin is a subset of a larger watershed which needs to be investigated for environmental impacts of nutrient and pollutant inflow.

- Storm event sampling should be replicated as a measure of the nutrient content of the surface runoff. In particular, the effects of this water draining directly into the groundwater through the pit should be determined. This should provide a further indication of the impact of the land use on water quality.

- More nutrient information should be gathered for Great Bog, especially for phosphorus, to determine the biological effect of increased nutrient loading.

- Maps of wetlands resource protection areas should be clarified by the DEP. In such maps, Great Bog needs to be accurately delineated for increased precision in posting buffer strips.

- Maine CAP (Critical Areas Program) should conduct an intense resource inventory of Great Bog to better assess the ecological and geological diversity that is present. Consideration of the preservation of habitats associated with rare and endangered species should also be incorporated into such a study. The area should be reconsidered for CAP listing.

- Maine IFW (Inland Fisheries and Wildlife) should undertake a wildlife inventory of Great Bog. Special attention should be paid to the claims of its high biodiversity and possible importance as a deer wintering area.

- Camp Bomazeen should look into its sewage disposal strategies. Such sewage should not be allowed to overwinter in septic vaults. There is evidence that such practices have led to excessive nutrient leaching and may contribute to the local seasonal eutrophication of Great Pond.

Generally, BOFEA would like to have the area protected from mining. However, if mining does take place, we offer the following recommendations to ameliorate the negative impacts. These immediate concerns should be addressed before mining begins to take place.

IMMEDIATE CONCERNS

- The unposted forty-five mph speed limit should be re-evaluated. A possible speed reduction for trucks on Horse Point Road may significantly increase road safety.
- A minimum shoulder width of three feet should be established in order to maintain safety by increasing road visibility.
- A buffer strip of a minimum of 250 horizontal feet in width should be maintained between soil exposed by mining and the normal high water mark in order to comply with new state and local legislation and reduce the impact on the bog.
- The smaller elevated wetland north of the mining site should be considered continuous with Great Bog. Buffer zones should be delineated with appropriate distances from this area.
- Pit construction must focus surface runoff to areas within the pit in order to reduce the potential effects of runoff on the bog biota.
- The effects of storm water draining directly into the groundwater through the pit should be determined.
- Aquifer water quality and level of the water table should be monitored as the mining progresses as a way of detecting below ground water quality and quantity changes.
- To avoid further damage to the esker, pit slope stabilizing during reclamation should be achieved by the addition of imported clean fills which will not be subject to excessive nutrient leaching. Materials from within the buffer zone should not be used for this

purpose. Reduction or removal of the esker ridge will alter overland flow into the bog.

- Some guarantee of pit restoration occurring in a reasonable amount of time after completion of mining needs to be achieved. As mining in cells is completed, immediate replanting should occur.

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APPENDIX II: THE TOPOGRAPHIC MAP

The large overlay over the 7 1/2 minute topographic map delineates the Great Pond Drainage Basin as well as the quadrants used in this study. In addition, it shows the breakdown of several land types, including wetlands, roads, rivers, gravel mines, rivers, and Great Pond.

APPENDIX III: PROPERTY TAX MAP AND OVERLAY

Appendix III consists of an enlarged topographic map with an overlay representing property tax maps #14, #15, #16 and #17 of Belgrade. The topographic and tax map overlay combination enables tha identification of the property owners and the land contained within the Horse Point study area. The map is located in Arey 202, Colby College, Waterville, Maine.

Appendix IV: Water Quality Data

site	suspended solids (mg/l)	turbidity (FTU)	nitrates (mg/l)	total P (ppb)	conductivity (uMHOS)	temperature (C)	pH	dissolved oxygen (ppm)	tannins and lignins (mg/l)	orthophosphates (ppb)	ammonia (ppm)	lead (ppm)	zinc (ppm)
One (s)	2	2	0.4	11.31	40	12.2	6.78	8.5	0.1	55.99	0.04		
One (m)	3	2	0.5	22.48	30	8.0	6.83	11.5	0.4	14.03	0.05		
One (b)	2	4	0.6		35	9.9	6.86	11	0.2	13.08	0.05		
Two (s)	2	5	0.3	13.55	30	10.5	6.70	12	0.5	14.98	0.05		
Two (m)	5	6	0.3	20.25	30	10.0	6.65	11.6	0.5	9.26	0.07	0	<0.02
Two (b)	5	6	0.8	22.48	30	11.0	6.69	11.8	0.5	14.03	0.09		
Three	2	5	0.4		30	11.5	6.40	10.6	0.7	13.08	0.09		
Three (r)	3	6	0.5	4.61					0.7	13.08	0.09		
Four	3	4	0.5	69.40	30	10.0	6.72	11.8	0.5	10.22	0.11		
Five	3	41	2.2	9.08	45	10.2	3.45	8.7	9.6	15.94	0.11		
Six	5	34	1.8	15.78		14.5	3.11		6.1	22.61	0.11		
Six (r)	7	33	1.4						5.9	17.85	0.11		
Seven	4	50	2.0	53.76	60	9.6	3.25	5.1	9.0	510.82	0.10		

STORM SAMPLING

sample number time	rain gauge (mm)	nitrates (mg/l)	total P (ppb)	conductivity (uMHOS)	temperature (C)	pH	dissolved oxygen (ppm)
one	15:55	2	2536	15	5	5.71	8.5
two	16:25	2.5	1667	10	4.5	5.54	11.5
three	16:55	3	711	10	4.5	5.26	11

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