4. Environmental Inventory and Analysis

Any understanding of why Mashpee's natural resources require and deserve protection must be based on an understanding of what they are and why they are important. In the following sections we will, therefore, take a tour through Mashpee's natural world from the bottom up.

The chapter begins with the bedrock on which Cape Cod is built. It addresses the fascinating processes that caused more than 400 feet of sand, gravel and stones to be deposited upon that bedrock and how the upper level of those deposits has been modified by wind, water, plants, bacteria, worms and other natural forces to become what we call soil. Next is an analysis of the values and limitations of our various soil types.

The following section briefly describes those aspects of our landscape which give Mashpee its special character, including distinctive landforms, scenic areas and unique environments. We will look at the impact that development has had, and may have in the future, on the town's scenic character and on recreational use of various areas.

Interacting with soils and the plants and animals that rely on them, including man, and flowing over and under and surrounding all, water and the variety of environments it creates is studied next. We will look at groundwater as a resource for man and at its effect on surface environments such as bogs, marshes, rivers and ponds. We will study those surface water bodies as their waters flow to, and meet, the sea, looking at our estuaries, salt marshes, salt ponds and bays.

Mashpee's vegetation is reviewed next, with an emphasis on three basic plant communities: upland forests and fields, freshwater wetlands and pond and stream edges.

A review of Mashpee's fisheries and wildlife looks at finfish, shellfish, mammals, birds, and insects and then discusses wildlife corridors and Mashpee's rare, threatened and endangered species.

Finally, environmental problems that could influence our open space and recreation planning efforts are briefly reviewed.

A. The Ground Beneath Us - Geology, Soils and Topography

In describing his discovery of the principle of the lever, Archimedes is reported to have said "Give me a place to stand, and I will move the world". Alas, Archimedes had no such place to stand, only the earth itself, and despite our brief incursions into space, neither have we. Though we do not often think of it, the earth below our feet is basic to our existence. We must walk on it, build our homes, factories and schools on it, mine our raw materials from it, grow our food in its soil and, on Cape Cod, draw our water from it.

1. Bedrock Geology

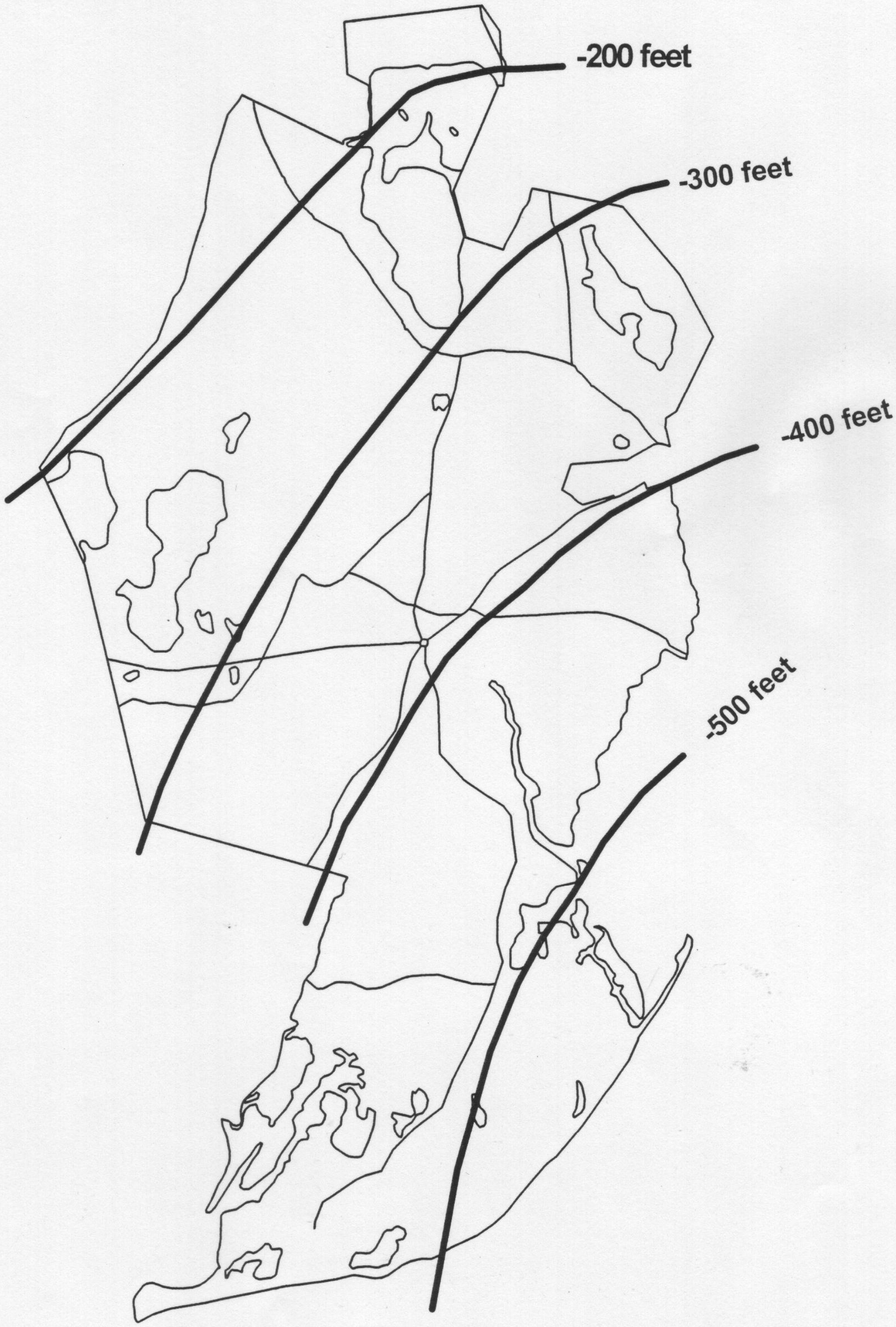
It is appropriate, therefore, that we begin our exploration of Mashpee's open spaces and natural places with an investigation of its foundations. Deep below our feet, 200 to 500 feet down depending on where you stand (see Map 4-1), lies the solid rock crust of the earth's mantle. (Things get less solid and very hot if you head further towards the center of the planet, but we will limit ourselves here to the cooler upper crust only!) Along with the rest of Cape Cod and Plymouth County, Mashpee is underlain by plutonic and metamorphic rocks of probable Proterozoic Z age (Upper Proterozoic - 600,000,000 to 2 billion years old) with occasional inclusions of plutonic and volcanic rocks of Paleozoic or younger age. These include granite, gneiss and schist, with feldspathic gneiss and amphibolite predominating. In other words, there is a very old and hard bed of rock down there. It is also a rather solid bed, with no known fault lines and infrequent local seismic activity (few earthquakes of any significance).

In the two billion years or so since our local bedrock was formed, much has happened to it. Cape Cod itself is only a relatively new surficial feature. As far as those rocks down there are concerned, it's just a temporary drift of sand. The rocks themselves are part of a giant piece of the earth's crust, called a tectonic plate, upon which much of America and the western North Atlantic Ocean lie. That plate, which floats on the molten inner core of the planet, has been drifting from place to place on the surface of the earth for billions of years, becoming part of one, then another, land mass (or continent). In other words, a map of the world done a few billion years ago would look nothing like it does now, and our local bedrock would be unrecognizable to us.

Meanwhile, much has been happening to the bedrock and above it. There has been some volcanic activity, some raising and lowering, folding and bending of the rock due to the incredible forces and stresses caused by those moving tectonic plates. At the same time, there has also been weathering by the forces of wind and water, which has gradually worn down the surface of the bedrock and broken it into grains of sand. That sand may have become part of other more recent types of rock (sedimentary rocks like sandstone) in other places. Ice, in the form of the great mile-thick sheets of the ice ages, has also worn down our rocks and in its wake left the remains of other rocks from Maine and northern New England in the form of the 200-500 foot thick pile of sand, silt and stones which is now known as Cape Cod.

Depth to Bedrock

Map 4-1



2. Surficial Geology - Glacial Impacts

What we know as Cape Cod is essentially a surficial geologic feature. It is a pile of "overburden": sand and gravel, boulders, stones and some clays laid down by massive glacial action during what is referred to by geologists as the Wisconsin stage of the Upper Pleistocene epoch, about 15-25,000 years ago. This overburden of glacial debris, or "drift", makes up the geologic features that we can actually see as we look around our town, including the hills, "kettle hole" ponds and the generally southward-sloping topography.

All of the major surface features of the land we know as Mashpee, except our coastal dunes and sand spits, were created by the action of the 10,000-foot thick ice sheet which covered New England up to 15,000 years ago. This ice sheet acted as a form of giant conveyor belt, bringing from the north particles of clay, silt, sand, gravel, boulders and even large blocks of bedrock torn from their place of origin by the crushing power of the glacier.

The conveyor belt, of course, is only an analogy. In reality the movement of the ice might be better understood as if the ice caps were a giant pile of soft ice cream placed at the north pole. As climatic changes involving the whole planet caused more and more ice to build up over the poles (more ice cream to be added to the pile) the weight of the ice at the center caused the edges to be pushed out further and further. That weight of ice was so tremendous that the surface of the earth itself bent beneath it and is, to this day, still springing back gradually to its original elevation. As the outer portion of glacier moved, it crushed and scraped and gouged away at the mountains and valleys and ancient soils of northern New England and bits and pieces of Maine, New Hampshire and Massachusetts became imbedded in its ice and moved to what is now Cape Cod.

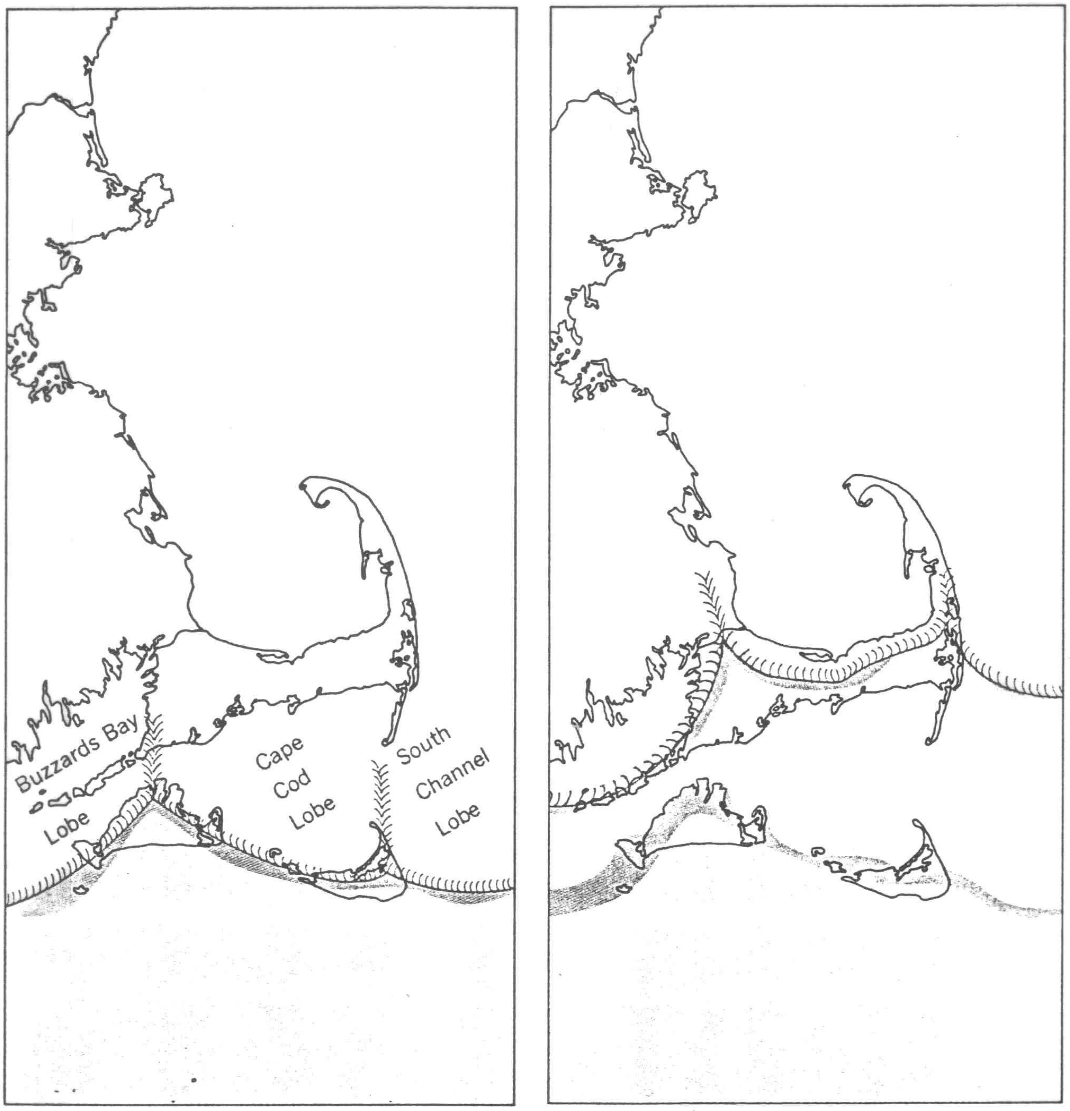
The edge of the glacier did not move everywhere at the same speed or in a straight line. Due to basins in the underlying bedrock encountered by parts of the glacier, some moved more quickly than others and formed rounded "lobes" which overlapped each other where movement was slower. Cape Cod's basic shape was created by the location of three such lobes, referred to as the Buzzards Bay, Cape Cod Bay and South Channel Lobes (see Map 4-2). Martha's Vineyard and Nantucket also owe their existence to these three lobes as they made their farthest advance to the south in the face of warmer air masses.

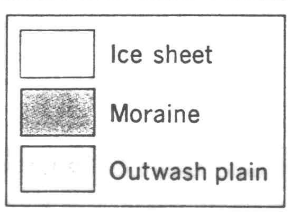
As our theoretical pile of ice cream would melt first at the edges, so too did the Wisconsin glacier. Fluctuations in the world's climate caused it to melt back and advance again a number of times as the rate of melting and evaporation became more, or less, rapid than could be equaled by new ice spreading south. As the ice melted, the bits and pieces of sand and stone were released to settle out on the spot or flow with meltwaters toward the sea. The larger boulders and chunks of bedrock generally settled out quickly at the edge of the melting glacier. As a result, where the edge of the glacier was at the same location over hundreds of years during periods of climatic stability, large piles of rock were left, creating ridges called "moraines". Martha's Vineyard and Nantucket are the remains of such a moraine at the farthest southward edge of the glacier.

After retreating rapidly during a period of warmer climate, a final stable period left the edge of the glacier over Cape Cod, resulting in the creation of moraines known as the Buzzards Bay Moraine (along the west side of Falmouth and Bourne), the Sandwich Moraine (extending from the Cape Cod Canal to Orleans and now marked by the Mid-Cape Highway) and the Elizabeth

Cape Cod Glacial Lobes

Map 4-2





Moraines and outwash plains on Martha's Vineyard, Nantucket, and Cape Cod mark positions of the ice front during retreat. The relationships between the deposits and the lobes can be seen in this figure.

Source: "Geologic History of Cape Cod, Massachusetts" by Robert N. Oldale

Islands. It is estimated that the ice began to melt back very rapidly from these moraines about 15,500 years ago, with the edge of the glacier retreating to a point north of Boston within 1,000 years. The final retreat began in the west with the Buzzards Bay lobe, followed by the other two in sequence. As a result, the glacial deposits in the western portion of the Cape are older than those to the east.

Another type of deposit of boulders and larger stones, along with sand and gravel, exists in South Mashpee in the New Seabury and Popponesset Beach area. It is called a "kame" and consists of hills of debris that originally filled holes in the irregular surface of the unevenly melting ice sheet. At such points, debris from rapidly melting upper levels of a glacier often covered slower melting lower portions, leaving a very uneven land surface as the lower ice melted away.

The reverse of that process resulted in the creation of hundreds of "kettle holes" in Mashpee and throughout the Cape. Where a large block of ice melted less quickly and became separated from the main glacial lobe, it was quickly surrounded and sometimes buried by sands and gravels being washed down by meltwaters from the retreating wall of ice (see figure 4A). In Mashpee, such kettle holes are scattered throughout the "Mashpee Pitted Outwash Plain" and are the primary reason for the existence of all of our ponds and most cedar swamps and other isolated freshwater wetlands. Such ponds exist where the elevation of groundwater exceeds that of the bottom of a kettle hole.

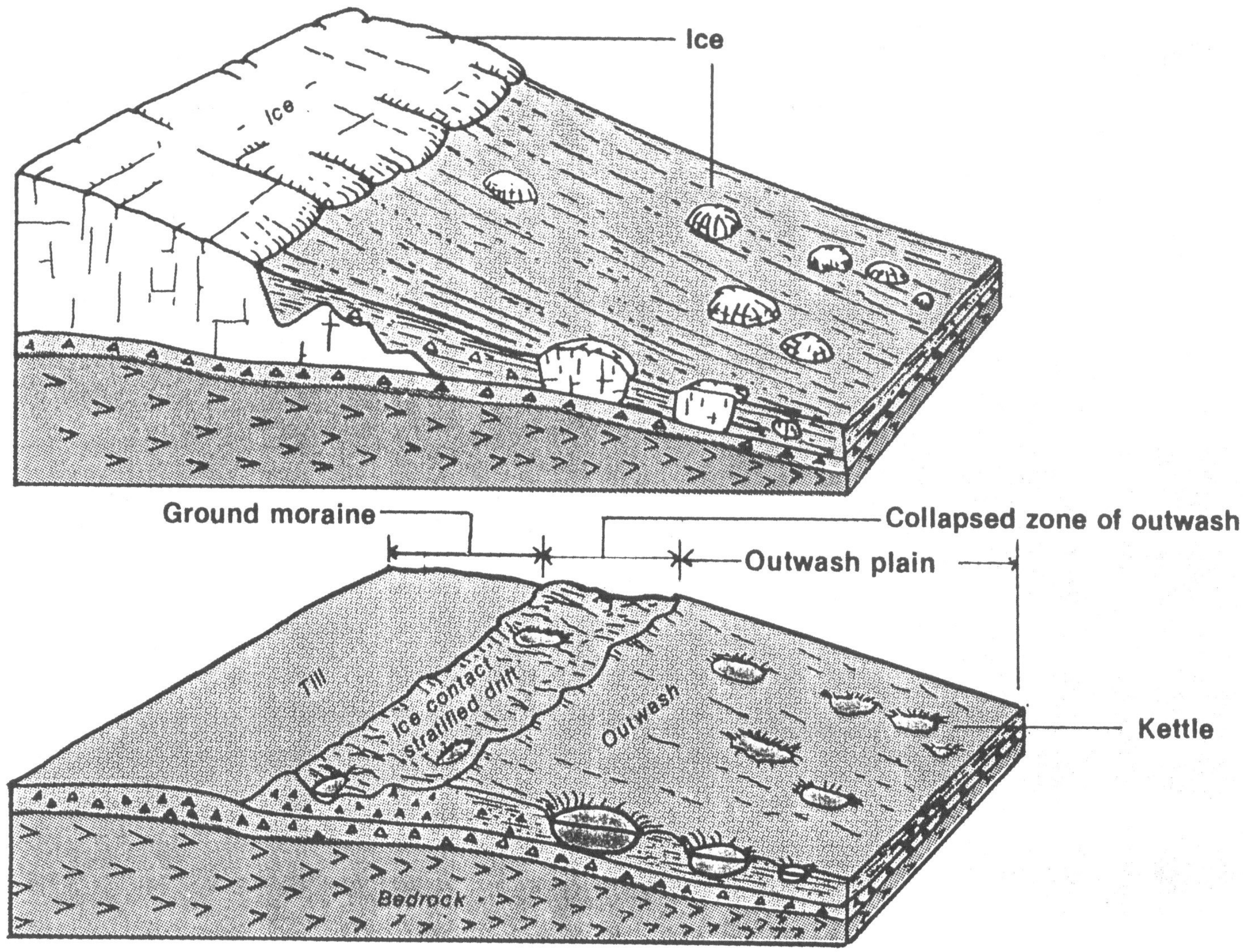
The vast majority of Mashpee is covered by gravelly sand and pebble to cobble-sized gravel typical of the outwash plain. It is so named because it forms a relatively level (except for the kettle holes) and gently southward sloping plain created when water rushing down from the edge of the glacier (as it paused at the Sandwich Moraine) carried with it the smaller pieces and particles of rock from the north that had been imbedded in the glacial ice. The fact that the margin of the ice sheet remained at the moraine for a significant period of time indicates that melting and evaporation roughly equaled the enormous amount of ice that was pushing south from Canada, meaning that vast quantities of water rushed south from the moraine carrying their load of sediments.

Since the debris over which it flowed was not a perfectly even surface, because sediment loads were high and because water volume varied with the rate of melting, the waters from the glacier did not flow evenly over the plain nor were their sediments deposited evenly. As with meltwater from today's smaller mountain glaciers and with many rivers and river deltas in level terrain, the glacial meltwater flowed in numerous wandering streams making up a braided pattern over the landscape. As with most streams, sediments settled out at the inside of bends and were scoured at the outside due to the differential in speed of the water flowing on either side.

(The ability of a stream to carry sediments is largely related to the volume and speed of the water flow. Since there is a certain amount of friction and cohesion between water molecules, a mass of water will attempt to flow down a slope together. At a bend, the molecules at the inside can be imagined to slow down to wait for the others while those at the outside move faster to catch up. So where the water slows down, it loses its ability to carry sediments and drops them and vice versa. This is also why, when canoeing the Mashpee River, one will normally find a deeper channel and quicker water at the outside of a bend.)

Creation of Kettle Holes

Figure 4-A



Source: "Geologic Hisory of Cape Cod, Massachusetts" - Robert N. Oldale

The variation in the rate of melting led to a similar variation in the volume and speed of flow of the outwash streams and their ability to carry various sizes of stones and sediments. (The larger a stream is, the faster it tends to flow, given the same slope, because a proportionally smaller amount of its water molecules come in contact with the sides and bottom of its channel, resulting in less loss of speed to friction and turbulence.) The combination of all of these factors caused meltwater streams to snake all over the outwash plain, with channels bending outward and whole streams moving their course as sediments and stones were dropped off in the old channels. At the same time these factors left pockets of different-sized materials in different places in a very complicated system of layer upon layer of outwash materials throughout the plain. The finest clay and silt was largely washed from the Cape entirely and now lies on the ocean floor. Most of what is left behind on the plain consists of varying sizes of sand and gravel.

As a result, the outwash plain is generally very easily developed both for earthmoving and construction at the surface and for drilling of water supply wells. However, the size of the sand and gravel particles and the arrangement of layers of various sized materials have a great effect on the rate at which water will be produced by a well or at which groundwater will move towards the sea. Finer materials such as silt or clay contain smaller spaces between particles in which water can be stored. Larger materials such as gravel contain larger spaces and thus much larger quantities of water between them. Water will also flow much more quickly through those larger spaces to a well.

These variations had a clear effect on the Town's test well program to establish public water supply wells in the mid-1980s. In one case, a test well was drilled just north of Santuit Pond which found very fine and tightly packed materials and thus very little promise for a large volume of groundwater. However, a second well drilled only 200 feet north yielded much larger particle sizes and a potential yield of over one million gallons of water per day. Specific testing must be done at any site which is proposed for public water supply. Not all sites are as suitable as others. Once a good producing site has been found it should be valued highly and protected from development or contamination.

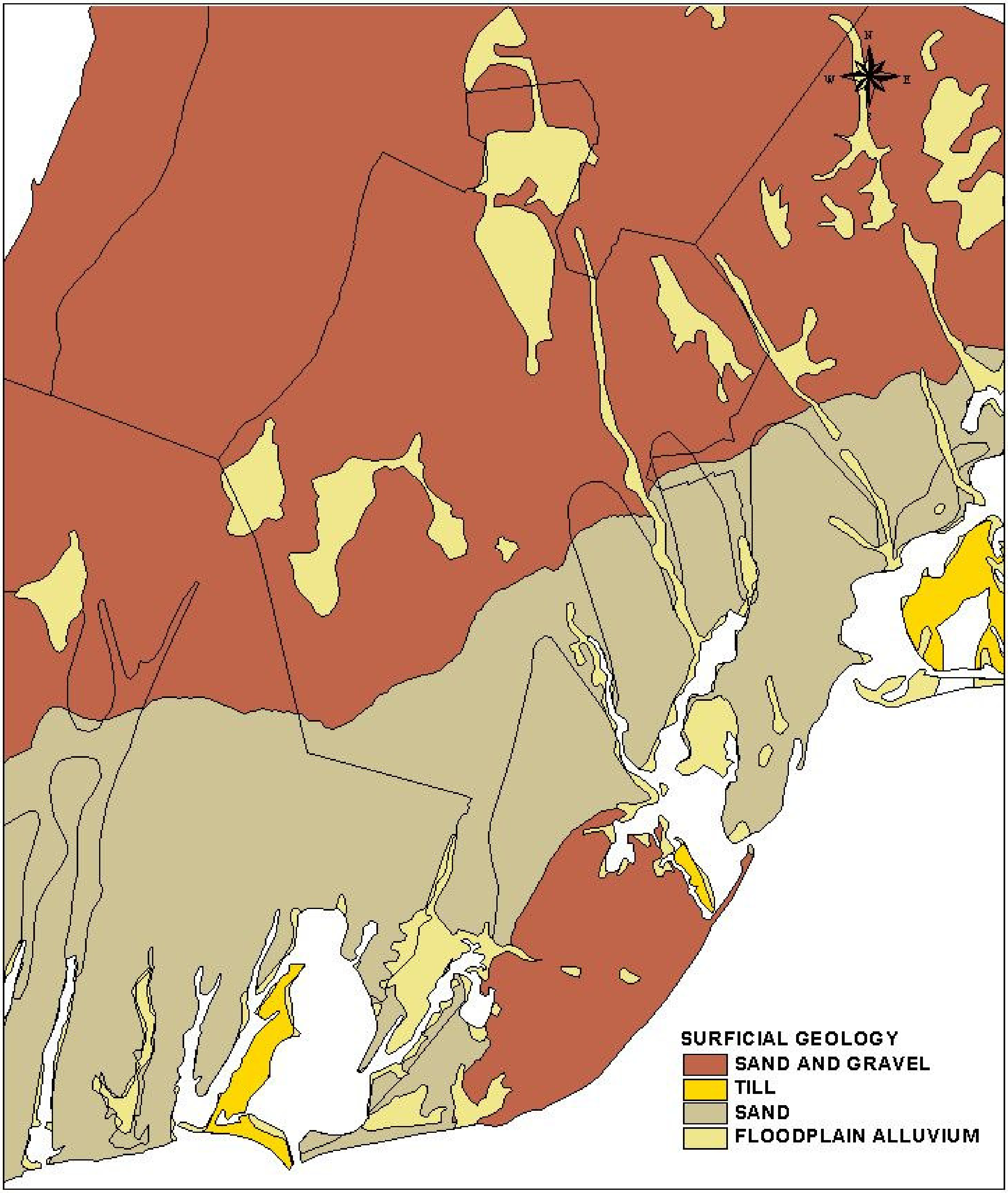
The size of the particles left behind by streams has shown one other important effect on the developability of land in Mashpee along a seemingly unimportant and apparently dry stream valley called Quaker (or Quaker's) Run. Unlike the Mashpee, Quashnet, Santuit and Childs Rivers, which have an obvious stream channel, a source in one of our ponds and sediments along their channels which are very similar to the rest of the outwash plain, Quaker Run is visible only as a series of cranberry bog ditches until it is within only a few hundred yards of its end in Shoestring Bay. It has no apparent source and has a channel which consists of materials which are quite different than those of the surrounding plain. Its channel is made up of mostly undifferentiated sands and gravels, with some silt and clay.

Quaker Run is, in effect, a buried river valley which extends from Wakeby Pond, along South Sandwich and Noisy Hole Roads, through a series of active and abandoned cranberry bogs to Shoestring Bay. (It is likely that it was created by meltwaters from a large block of ice which left behind the kettle hole now known as Wakeby Pond.) Although it is visible as a surface channel only at its southern end, its existence became painfully clear to homeowners, road builders and developers in a new subdivision along its course who were flooded by its high waters during an abnormally wet spring. A geologic feature such as this underground river should be considered a

Mashpee Surficial Geology

Source: USGS via MassGIS

Map 4-3



critical element both in locating and designing development and in defining what areas are best left aside as open space.

There are a number of other old stream valleys in Mashpee which are now dry or seem much too large to have been created by rainwater falling on our porous soils. Many were created after the outwash plain was formed but before all the buried ice blocks had melted. At that time the still very cold climate kept the upper part of the ground frozen, as with today's tundras in northern Canada and Alaska. Rainwater and meltwater, as well as the thawing of the soil itself, beginning at the lower end of these valleys, eroded this frozen surface much more readily than it can in today's unfrozen porous soils, and since water was not as readily absorbed into the ground, there was, of course, a larger volume available to flow in streams and cause erosion. One clear example of such a valley is known as Gould’s Spring and roughly divides the part of the Mashpee River Woodlands conservation area which lies east of the Mashpee River.

The glaciers had one last impact on Mashpee's land surface as they melted away. The combination of cold ice and warmer atmosphere produced a great deal of wind. Before any plant life had returned, the outwash sediments were very susceptible to extensive erosion by both water and wind. While rains and the last of the glacial meltwaters carved stream valleys like that of the Mashpee River and Gould's Spring, the winds picked up finer sediment particles and then deposited them in what is called an "aeolian mantle" over the coarser sediments of the outwash plain. Where this mantle is fairly deep, we now have our best agricultural soils.

3. Surficial Geology - Non-Glacial Factors

Although the vast majority of Mashpee's land area and topography was created by glacial processes, non-glacial (or post-glacial) factors are responsible for a few significant features, primarily along the coast and inland waterways.

After the glaciers retreated and the numerous ice blocks that were left behind melted, the resulting kettle holes began to change in character. Steep slopes began to collapse around their edges to form a more-gentle grade. Plants and trees repopulated the landscape and their falling leaves and other detritus began to cover the glacial sediments and settle into the bottoms of kettle holes. At that time, it is likely that all of the kettle holes, except those still containing recently melted ice, were dry. All of the present Cape Cod was, in fact, well inland from the sea, which had dropped 400 feet during the ice age due to the large volume of water bound up in the ice caps. As the ice gradually melted, sea level rose until, about 3,500 years ago, it reached a level similar to today's.

That rise in sea level had two effects on Mashpee and the Cape. Since fresh water is lighter than salt water, it floats above it when the two meet. As the sea level rose, fresh water which reached the ground as precipitation and percolated down into the porous outwash sediments to become "groundwater" eventually met the salt water which had also entered the permeable sediments along the edges of the rising sea. The fresh water floated above the salt water in a slightly curved "lense", thickest at the center of the Cape (North side of Mashpee) and thinnest along the edges (South Mashpee). As the sea rose, so did the lens of fresh water, which soon became high enough so that its upper surface was higher than that of the bottoms of many kettle holes. The results were our typical kettle hole ponds (all of Mashpee's fresh water ponds are in kettle holes).

Where the groundwater level is at or near the same elevation as the bottom of a kettle, an isolated wetland results rather than a pond.

The second major impact of the rising sea was the inundation of coastal areas, including kettle holes and river valleys that had been created during the ice age and subsequent melting, and the action of sea waves and storms on the new coastline. Sea level rise continues at a relatively slow rate (now accelerating due to global warming) but it is the action of wind and waves that has a more immediate and visible impact on our shores. When the sea rose close to its current levels 6,000 years ago, Mashpee's coastline extended far south (up to two miles) of its current location. Continuing gradual sea level rises combined with wave action, particularly during storms, have eroded away that ancient coast and created such features of our landscape as the 40 foot high sea cliffs at Succonesset Point and along Nantucket Sound, where the coast continues to be eroded, and sand spits such as Popponesset Spit and Dead Neck (South Cape Beach). Similar processes are underway at a smaller scale within Popponesset and Waquoit Bays.

Other factors have played a smaller role in modifying the landscape left by the glaciers. Our rivers carry both sediment and detritus (dead leaves and other organic materials) which settles out in slow-moving waters as was previously described. Over the years, the deposition of these materials creates a flat valley bottom composed largely of organic materials and fine particles of sediment. Where these are dryer, excellent soils result. Where closer to the groundwater surface, wet meadows, wooded swamps and other wetlands result. In the early days of Mashpee, extensive cedar swamps existed along some of our rivers, most notably along the Quashnet. Cedar is highly weather resistant, so those swamps were heavily cut for shakes, shingles and fence posts. During the late 1800's, many of the wet meadows and cedar swamps were cleared, drained and diked to become cranberry bogs. It is said that the Quashnet River valley became the world's longest cranberry bog. Numerous other bogs were operated along the Mashpee, Childs and Santuit Rivers.

Isolated kettle hole wetlands and small ponds also became filled over the years with leaf litter and other organic materials. These have become marshes, meadows, swamps and bogs. In some cases, organic materials have built up to such a depth that the water table is no longer close enough to the surface to sustain a wetland environment. A number of these isolated wetlands were also converted to cranberry production using ditches and various pumping mechanisms to supply water from adjacent ponds and streams.

The existence of these kettle hole ponds and wetlands, filled-in kettles and coastal features give Mashpee and adjacent areas of the outwash plain a unique character and environment. They are the primary habitat for many of our unique and endangered plant and animal species. Unfortunately, the ponds and coast are our most attractive features both for recreation and development. They are, as a result, fairly heavily developed, high-priced and most in need of protection through regulation and conservation land purchases. Along with the Town's rivers and the large blocks of undeveloped woodlands included in the Mashpee National Wildlife Refuge, they largely define the location of planned open space corridors and conservation areas. Understanding their history, characteristics and natural resource value is critical to an understanding of our open space needs.