C. The Waters Around Us - Water Resources

"Water, water everywhere" - that old line is so true of Cape Cod and of Mashpee. Not only is the Cape surrounded by the sea, effectively made an island by the Cape Cod Canal, and liberally sprinkled with lakes, ponds, marshes and streams, but we're also surrounded by hundreds of feet of groundwater below and thousands of feet of moist atmosphere above. You may know that our bodies are largely composed of water, that our primeval ancestors came from the sea and that you could survive for weeks without food but would soon die without water. But do you ever stop to think about how important clean water is to all of us? During the 1980s, the subject of water supply and water quality became the prime topic of conversation and concern in Mashpee. In response, the Mashpee Water District was created in 1987 and the Mashpee Sewer Commission in 1988. During the 1990s the emphasis shifted to major nitrogen overloading of our estuarine waters, caused by the septic systems that accompanied our massive growth in the 1970s and 80s. The Water District now services the majority of properties in the town, using six wells, with additional wells projected. The Sewer Commission is just completing a plan for wastewater facilities and nitrogen management in our watersheds. We have no outside source of drinking water like Boston has the Quabbin Reservoir. We must drink the stuff that's beneath our feet in our groundwater aquifer and we're still learning how to keep our feet clean and our drinking water pure. Trying to clean up the nitrogen mess that's already happened in our bays is an even more daunting task.

1. Groundwater

As noted previously, Mashpee is underlain at a depth of up to 500 feet by solid bedrock which has been buried by the Ice Age glaciers under sand, gravel, silt, clay and stones. Those sediments are not solid. Their particles rest against each other at certain points, but there are billions of spaces of various sizes between the particles. Where large particles such as gravel and stones are present, those spaces are correspondingly large. On the other hand, where the particles are small, or where there is a thorough mix of large and small particles, the spaces are small.

Those spaces under Mashpee are largely filled by water. It originated as rainfall and snowmelt which trickled down, or "percolated", through the spaces between the particles above, until it reached the bedrock, or a layer of very tightly packed sediment, or water. The millions of gallons of fresh water which have thus settled into our sediments are known as "groundwater". The top of that sea of groundwater is known as the "groundwater table". The sediments between which those water molecules sit are said to be "saturated". The whole body of groundwater under Cape Cod is known as an "aquifer".

One might expect that because of the force of gravity, the groundwater table might be perfectly flat under Cape Cod. However, a number of factors combine to ensure that such is not the case. When the level of the sea rose after the last Ice Age, its salt water percolated into the sediments of the Cape from the sides (that is, along the shoreline). Since salt water is heavier than the fresh water which also percolates into the ground from rain and snow above, it crept under the fresh groundwater. At the same time, the lighter fresh water actually floats above the salt water (imagine a drop of oil floating on water).

When rainwater and snowmelt enter the ground, they do not immediately sink to the groundwater table. It takes time for water molecules to penetrate the sediments, or "percolate". The rate of percolation depends on the number and size of the spaces between sediment particles. Water will move more quickly through the large spaces in stone or gravel layers and more slowly through the smaller spaces in sand and silt layers. Sometime it cannot move through a wet clay layer at all. On the average, however, groundwater under Mashpee moves downward at a rate of 6 to 20 inches per hour, or 12 to 40 feet per day. Since the land surface of the Cape is not perfectly level, it takes water longer to move from the surface to sea level at high points and a shorter time at low elevations near the sea. As a result, the groundwater level under higher points is almost always higher than that under lower points, unless the grain sizes of the sediments under a high point are much larger than those under a nearby low point.

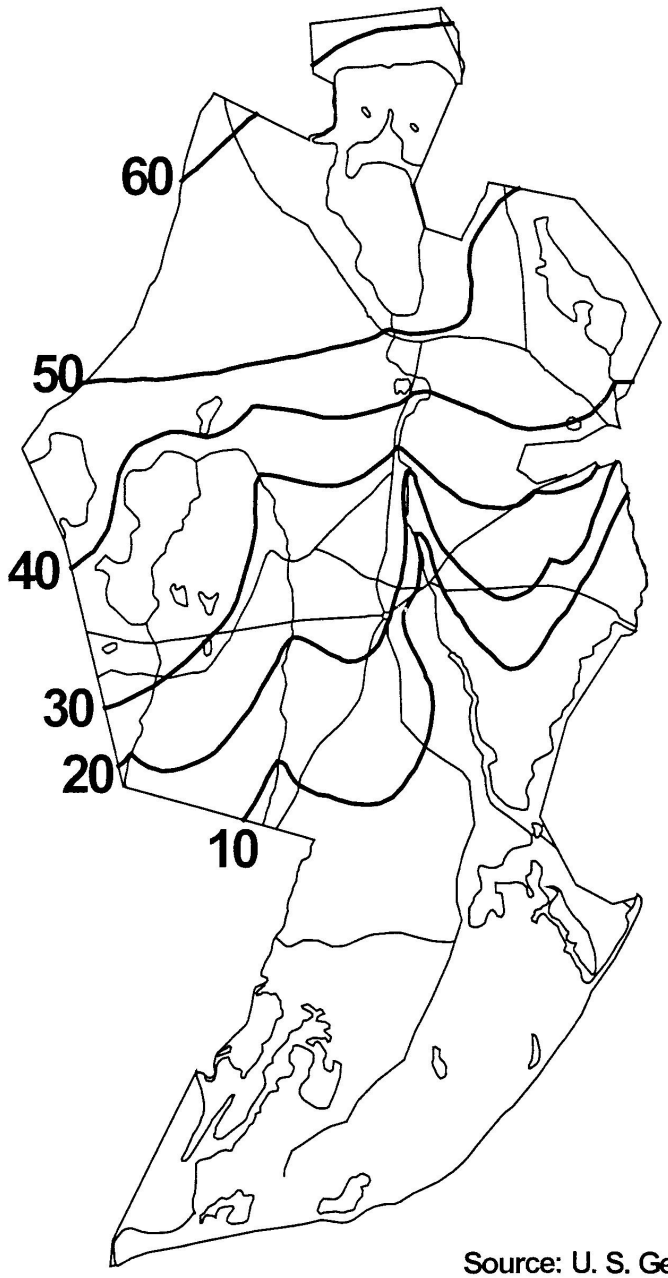
The combined effect of the differences in land elevation, the fairly slow movement of water through the sediments and the tendency of fresh water to float over salt water is that the groundwater under Cape Cod is formed into six roughly rounded or lense-shaped mounds called "lenses" or "groundwater flow cells". Mashpee, along with Barnstable, Falmouth, Sandwich and parts of Bourne and Yarmouth, lies on top of the highest and largest of these cells, known as the "Sagamore Lens". The Sagamore Lens stretches 24 miles from west to east and 16 miles from north to south and has an elevation of more than 60 feet above sea level at its highest point under the Camp Edwards Military Reservation. The shape of this lens means that in Mashpee the highest points in the groundwater table are in the north, with the water table gradually lowering to zero at the south coast. The bottom of the lens is also curved, and to a much greater degree than its top.

Because of the relative densities of salt and fresh water, the fresh water table extends down below sea level about 40 times deeper than it extends above sea level. Thus, where the groundwater elevation is 40 feet above sea level, it would theoretically extend 1600 feet below sea level. Where groundwater elevation is 1 foot above sea level, the bottom of the lens should be 40 feet deep. Since Mashpee is underlain by bedrock 200 to 500 feet deep, but has a water table elevation greater than 10 feet above sea level, there is bedrock, rather than salt water, beneath our fresh water aquifer in most of the Town. However, near the sea in areas like Monomoscoy and Seconsett Islands where the water table is 2 feet or less, salt water is present less than 80 feet down. This means that wells drilled on those islands must be shallow or they will draw salt water rather than fresh.

Where the land meets the sea, and the edge of the fresh water lens meets the salt water, the lighter fresh groundwater tends to bubble up in fresh water springs in our bays and along the coast, mixing with the salt water and leaving our water table. This effect acts as a giant drain on the aquifer and, assisted by the slope of the groundwater table, causes fresh water to move from the highest points of the aquifer towards the sea. This lateral movement is much slower than the vertical percolation to the groundwater table mentioned earlier, averaging about one foot per day in Mashpee's outwash plain sediments. As a result, not only is our groundwater table higher in north Mashpee than in the south, but the groundwater is actually moving generally south to the sea. Map 4-15 illustrates elevation of the top of Mashpee’s groundwater table.

A number of other factors affect the elevation and movement of groundwater in portions of the aquifer. Where a kettle hole has resulted in a pond, the surface of the groundwater table is

Groundwater Elevations | Map 4-15



Source: U. S. Geological Survey

exposed and is drawn by gravity to become a level spot in the otherwise sloping aquifer. As a result, at the northern end of our ponds, the elevation of the pond is lower than would be expected in the surrounding aquifer. Conversely, at the southern end it is higher. This difference in elevation means that along those edges of the pond the groundwater table will slope at a steeper angle than in the surrounding area and that it will flow more quickly either into the pond at the north end or away from the pond at the south end.

A second factor which can affect groundwater elevation is the existence of impermeable (hard or impossible to penetrate) layers in the sediment lying above the water table. Water from rain or snowmelt cannot percolate through these materials, which may be clay layers or organic sediments accumulated in kettle holes, and remains on top of them resulting in what is known as a "perched" water table. Another factor which may cause a high spot or "mound" in the water table is the percolation of an artifically high amount of water into the ground at a concentrated point such as a leaching pit or pond for road runoff or sewage disposal. Finally, artificially low spots are created wherever a well pumps groundwater out of the aquifer. Every well creates a roughly circular or oval "cone of depression" in the water table. For small household wells this depression may be barely noticeable. For large public water supply wells it can be many feet deep and affect the water level in nearby ponds, wetlands and streams, as well as other wells in the area.

The long-term overall elevation of the groundwater in the Sagamore Lens depends for the most part on the rate at which it is recharged by rainfall and snowmelt, i.e. on the weather. In dry years it goes down and in wet years it is higher. Since records have been kept, it has varied as much as nine feet between the wettest month (July, 1973) and the driest (February, 1967).

Water supply wells withdraw a great deal of water from the aquifer and cause local depressions in the water table and a slight drop in its overall average height. Public water supply wells on the Cape withdraw about 50 million gallons of water per day during the summer and 25 million in the off season, or over 10 billion gallons per year. Private wells may pump an additional 1.5 to 2 billion gallons per year.

The vast majority of this water is returned to the groundwater via septic systems, sewage treatment plants, cesspools and irrigation, though some is lost to evaporation and transpiration by irrigated plants. However, the water that is returned is often highly polluted. Even though septic systems appear to work well in Mashpee's porous outwash soils, they often “work” too well, allowing polluted water to move rapidly to the groundwater, and the neighbor's well, as well as to our ponds and estuaries, without the filtering and chemical reactions that tend to purify wastewater in tighter soils with a higher organic content.

Some pollutants are not treated by septic systems at all. Nitrogen, for example, leaves most septic systems at a concentration of 35 milligrams per liter of wastewater (35 mg/l), with about 26 mg/l of that reaching the water table, whereas the state drinking water standard is 10 mg/l and the drinking water target recommended by the Cape Cod Commission is 5 mg/l. Target water column levels in our estuaries are much lower than that, with a concentration of 0.38, for example, required to maintain the ecological health of Popponesset Bay. For such pollutants, the only means of reducing them to safe levels is dilution with clean water from somewhere else in the aquifer, “natural attenuation” by algae in ponds and streams or advanced ("tertiary")

wastewater treatment. This has led Mashpee, along with other Cape Cod towns, to adopt zoning regulations which require lot sizes (one to two acres) which will allow for enough groundwater to sufficiently dilute the nitrogen from septic systems to meet the 5 or 10 mg/l drinking water standard, although they are inadequate to meet the levels needed to protect the bays.

Some contaminants, however, are so toxic that no amount of dilution is able to make the affected groundwater absolutely safe. A large portion of Falmouth and significant areas in the Briarwood, Tri-Town Circle and Summerwood areas of Mashpee were polluted by such toxic chemicals originating as haphazardly used fuels or cleaning compounds at the Massachusetts Military Reservation or other municipal or private locations, resulting in the abandonment of a public water supply well and millions of dollars in public expense to pipe in clean water from other areas. (How long will there be such clean "other areas" available on the Cape?) Most gasoline stations are water pollution time bombs ticking away over the aquifer, although new standards for double walled tanks and monitoring systems have reduced the threat somewhat. One gallon of gasoline can make a million gallons of fresh groundwater undrinkable. Other industrial operations, even seemingly safe operations such as electrical and computer manufacturing plants, use hazardous materials in their day-to-day operations.

Most insidious and frightening of all, each of us uses a variety of dangerous chemicals, from paint thinner, to antifreeze, to pesticides and insecticides in our own homes and casually spills them in our yard or down the drain to our septic systems. As thousands of additional homes are built and additional thousands of people move into Mashpee, the effects of our careless use of such materials will become more and more apparent and dangerous.

The Town's landfill, now closed and capped, caused a massive amount of hazardous and cancer-causing chemicals to enter our groundwater. It may have been partly responsible for the pollution of wells in the Ashers Path and Summerwood areas, resulting in almost two million dollars of costs to Mashpee taxpayers for providing clean drinking water to those areas. The pollution from the landfill is flowing to the Mashpee River, adding to the problems in that river and in Popponesset Bay. Although the landfill issue has now been dealt with, we must still reduce use of hazardous materials when possible and have to be much more careful, as individuals and as a Town, in disposing of such things properly if we insist on using them.

2. Groundwater Resources

The contamination of private wells by the sewage treatment plant and fuel and de-icer spills at Otis Air National Guard Base, by hazardous materials possibly originating at the Town Landfill, by neighboring septic systems on small lots and by over-pumping in coastal areas where salt water intrusion occurs, led the Town to initiate the development of a public water supply system, which was taken over by the independent Mashpee Water District established in 1987.

A great deal of money was spent in the late 1980s to design and construct water mains to service the contaminated Tri-Town Circle, Briarwood, Ashers Path and Summerwood areas of the Town. After acquiring the private High Wood Water Company, which served New Seabury and Mashpee Commons, in 1990, the District expanded to serve 60 percent of the town, and further

system expansion has brought that to about 90 percent. Additional millions have been spent to identify, acquire and protect possible public well sites.

Unlike many other areas of the state, such as the Boston area, Cape Cod does not rely on surface water ponds or reservoirs for its drinking water. Although the Cape has over 350 ponds, only one, Long Pond in Falmouth, is used and protected as a drinking water supply. The rest are too easily polluted and/or already surrounded by excessive development and are thus not practical alternatives for a safe water supply. Instead, all public water supplies, including a portion of Falmouth's, come from more than 140 wells drilled into our groundwater aquifer. In Mashpee, the Water District currently operates six wells with a total pumping capacity of 5,080,000 gallons per day.

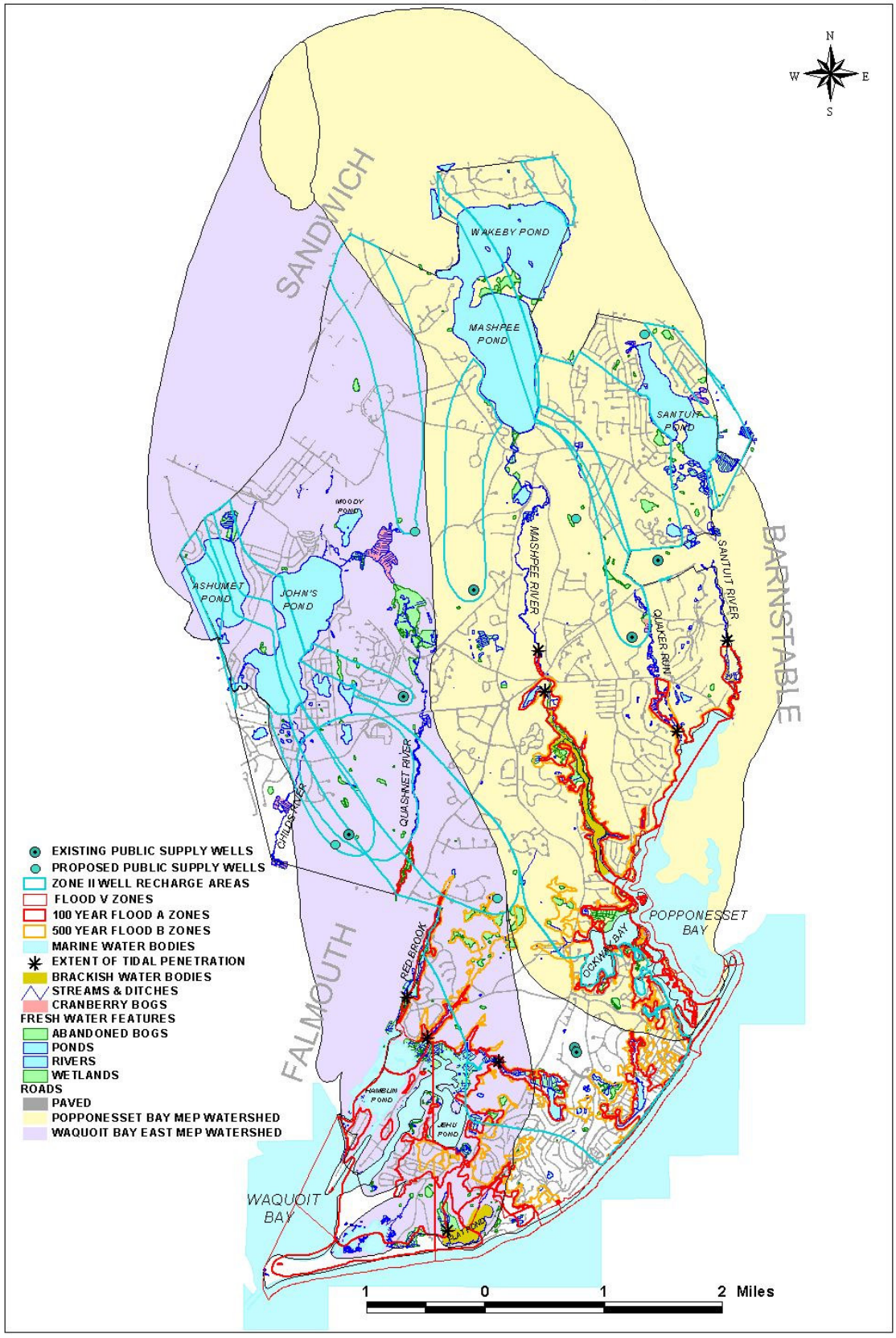
The Town's well development efforts began in 1983 with a test well drilled in South Mashpee by a consultant working for the Board of Health. Although the well produced large volumes of water, it was unusable without expensive treatment due to high levels of naturally occurring iron and manganese. That problem illustrates one of the major constraints to successful development of public water supplies for the Town. Many areas, particularly near old cedar swamps and bogs, produce water which is unsuitable without treatment. Areas near the coast where sodium occurs in groundwater are also unsuitable for public wells. Those areas generally south of identified pollutant sources such as Otis Air National Guard Base, the current and former Town landfills, gasoline stations, large septic systems at condominium projects and commercial developments, and some industrial sites must all be eliminated from consideration as well sites. Areas south (downhill in the groundwater table) from large areas of small lot subdivision are also not promising as public well sites. Finally, state regulations require that there be at least a 400 foot radius of land around any public community water supply well which is controlled by the water supplier and protected from development with buildings, septic systems, road drains, etc. Land within 400 feet of existing residences, therefore, had to be eliminated in the Town's search for water supplies.

As a result of these factors, a number of sites were chosen in 1986 by the Town's Water Quality Review Committee for test wells to determine the quantity and quality of water available. Fifteen 2 1/2 inch wells were drilled on nine parcels of land, four of which are owned by the Town. Three did not produce a large enough volume of water for a public supply. Three others showed excessive levels of iron and manganese. One other well produced large quantities of good water except for excessive silt. Of the remaining eight wells which produced excellent results, three are on Town land, one has already been surrounded by single-family homes and septic systems and another is threatened with the same fate.

Since its creation, the Water District explored and developed some of these and other well sites and has purchased 155.5 acres for well development and protection. Those well sites are our community's most precious and valuable resource. They must be protected from development and contamination at all costs or there will be no clean drinking water in Mashpee's future. In addition, because our zoning allows for increasing our current population by another 50 percent, more clean well sites must be found.

Mashpee Water Resources

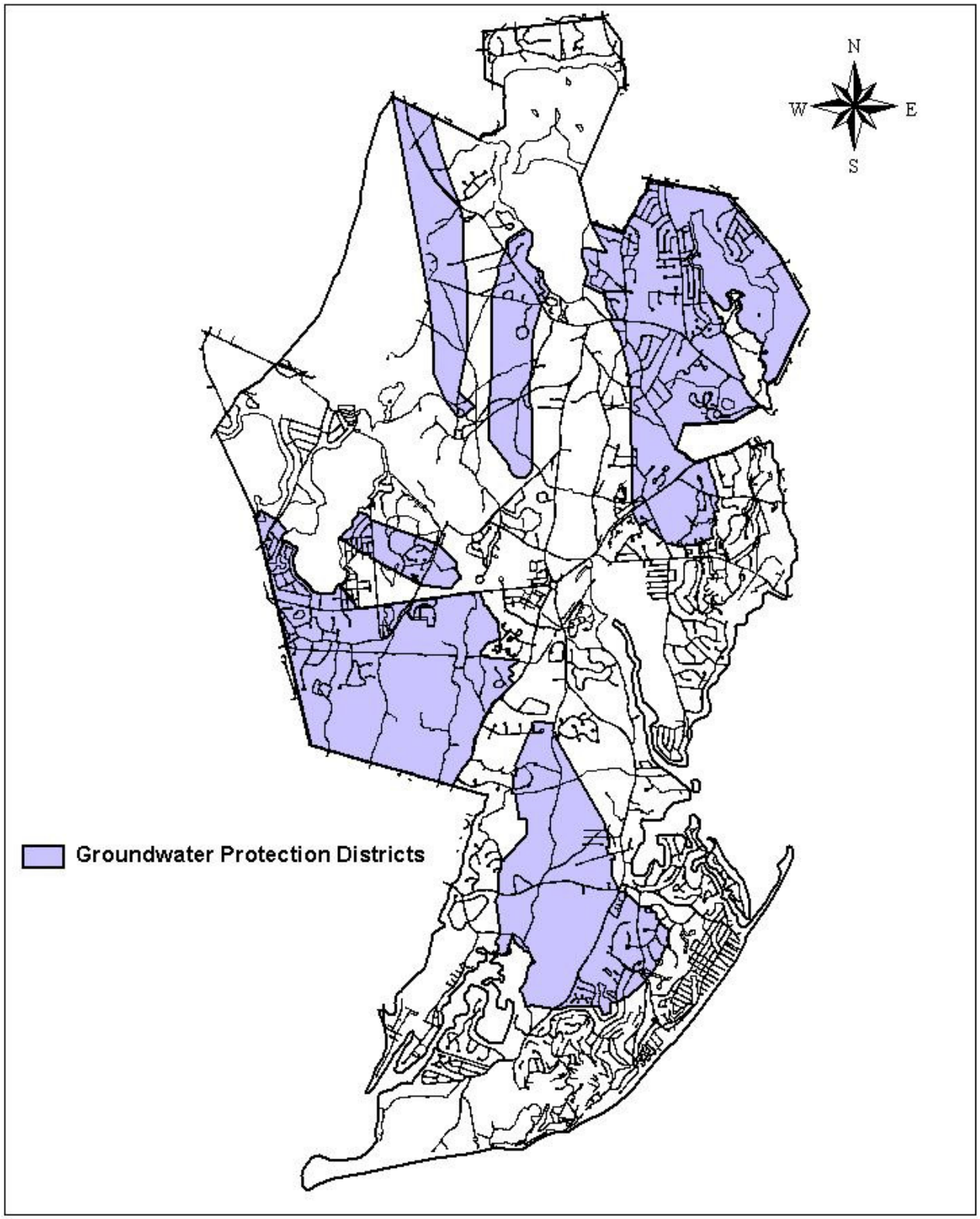
Map 4-16



Back of 11x17 Water Resources map

Groundwater Protection Districts

Map 4-17



A number of approaches can be, and have been, taken by the Town to meet its future water supply needs. One method is large lot zoning, which reduces both the potential demand and the likelihood that private wells will become contaminated. Most of the northern half of the town is zoned for 80,000 square foot lots.

A second approach has been the adoption of zoning regulations which create groundwater protection districts, based on estimated recharge zones ("Zone IIs") of existing and proposed wells, in which certain uses of land and of hazardous materials are restricted. Map 4-16 shows Mashpee water resources, including the currently-approved Zone IIs of Mashpee's wells and those of wells in Cotuit and Falmouth which extend into Mashpee. Map 4-17 depicts Groundwater Protection Districts designated and protected under the zoning bylaw. On a case-by-case basis, large condominium projects have constructed and maintain sophisticated wastewater treatment plants to minimize groundwater pollution to meet the Town's zoning requirements and conditions imposed by the Planning Board and by the Cape Cod Commission on Developments of Regional Impact, including the Commission's former "no net nitrogen" standard (recently changed to allow new nitrogen loads based on a per acre "fair share" of target nitrogen loads for each receiving water body). The Massachusetts Department of Environmental Protection has also recently begun requiring "no net nitrogen" for new or expanded wastewater treatment plants under their jurisdiction in watersheds with excessive nitrogen loading. The Town's Open Space Incentive Development zoning by-law also provides for a transfer of development rights from sensitive areas, including proposed well areas, to areas where development will have fewer negative impacts.

Finally, and most effectively, the Town and the Water District have purchased or otherwise obtained title to large tracts of land to protect well sites and their groundwater recharge areas. Additional acquisitions of open space lands continue to be an important means to protect water resources and must be a key element of the Town's open space plan.

3. Freshwater Wetlands

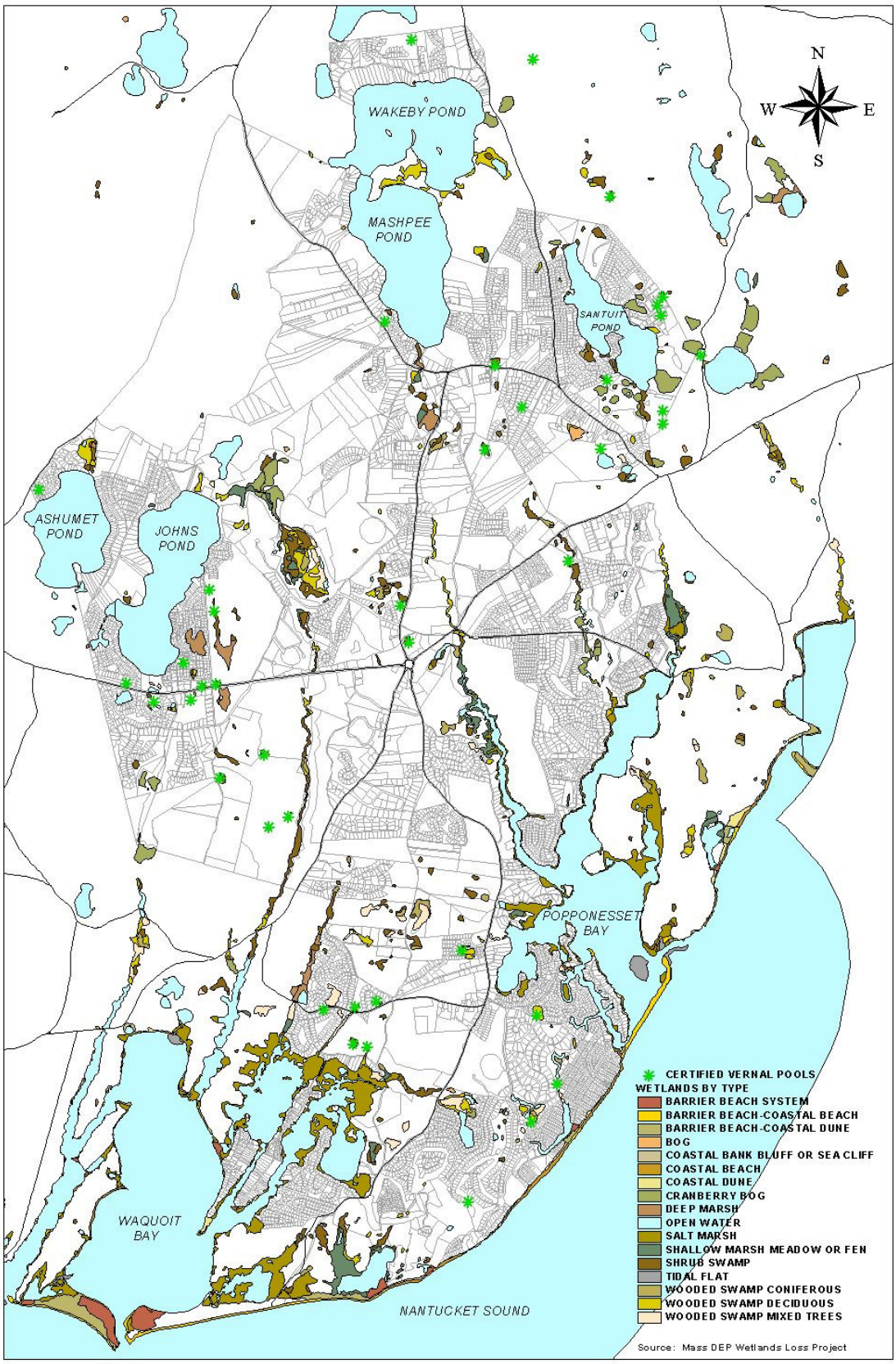
"Wetlands" - the term has been a rallying point for environmental concerns. The value of wetlands for water quality protection, groundwater recharge, flood control, fisheries, wildlife habitat, recreation, education, aesthetics and the pure enjoyment of their "wildness" in increasingly developed areas has now been recognized. But what are these places we call "wetlands"?

Simply put, they are areas in which water is the dominant fact of life for plants and animals. They are areas where water covers the land either permanently or intermittently or where groundwater levels are so high that plant roots must live in water for most of their lives. Technically speaking, there are three key attributes, of which an area must have at least one, that define a wetland:

1) The presence of wetland plants, known as "hydrophytes" (defined as any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water),

Mashpee Wetlands

Map 4-18



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2) the presence of wet soils, known as "hydric" soils (in Mashpee these include the soils referred to by the county soil survey maps as Berryland mucky loamy coarse sand, Freetown mucky peat, Freetown and Swansea mucks, Freetown coarse sand, Ipswich, Pawcatuck and Matunuck peats and some areas of Pipestone loamy coarse sand where the water table is high, as well as beaches - see Map 4-5) or

3) soil saturation or flooding at some time during the growing season of each year.

There are a number of types of salt and freshwater wetlands, and a number of systems for identifying them. In Massachusetts, the state's Wetlands Protection Act and regulations promulgated by the Department of Environmental Protection describe wetlands primarily on the basis of plant species. However, the most scientifically organized approach to naming wetland types is the "Classification of Wetlands and Deepwater Habitats of the United States" which was published by the U.S. Fish and Wildlife Service in 1979. Based on those classifications, the Service developed a series of National Wetlands Inventory Maps, using aerial photo interpretation techniques, which include coverage of Mashpee. Map 4-18 identifies Mashpee wetlands, including state-certified vernal pools.

The FWS Classification and Inventory Maps are based on five basic wetland systems, which are further broken down in a hierarchy of subsystems, classes, subclasses and dominance types. The five basic systems are the palustrine (freshwater vegetated wetlands), lacustrine (larger ponds and lakes), riverine (rivers, streams and their channels), estuarine (estuaries, salt marshes, salt ponds and beaches) and marine (the sea). We will be reviewing each type of wetland system in that order in the next few sections of this chapter, and we begin here with the freshwater vegetated wetlands.

Palustrine wetlands include those vegetated wetlands we have traditionally called freshwater marshes, bogs, wet meadows, shrub swamps or wooded swamps, as well as small ponds under 20 acres. Although many are well hidden and not often visited, the Town of Mashpee is liberally sprinkled with such places. As with the rest of our landscape, the majority of these inland wetlands owe their existence to the Ice Age glaciers. Although the largest and deepest of the hundreds of kettle holes they left behind became our lakes and ponds, many are just deep enough so that their bottoms touch the groundwater table. Some were formerly small ponds which have filled with leaf litter, dead plants and other organic and mineral sediments so that open water is no longer present. In others, small areas of open water exist for all or part of the year. Many have become overgrown with shrubs and even large trees.

Some samples of the small pond type of palustrine wetland in Mashpee include Martha's Pond, Amos Pond and Deborah Bottles (Flashy) Pond. These have either an unconsolidated bottom of silt, sand or gravel or an aquatic bed of plants that grow principally on or below the surface of the water for most of the growing season in most years. Along their edges they will either have an unvegetated beach or bank, known in the FWS Classification as an "unconsolidated shore", or will merge into another more highly vegetated wetland type such as a freshwater marsh or "emergent wetland". These attractive meeting places of land and water can be found adjacent to ponds such as Martha's or Amos, in old flooded cranberry bogs such as those along Coombs Road in the Noisy Hole Conservation Area or in the John's Pond Park Conservation Area,

adjacent to rivers like the Mashpee south of Route 28, or on their own in isolated kettle holes. They are prime waterfowl and muskrat habitat.

In many cases, a marsh will be joined on its landward edge by a scrub-shrub wetland dominated by shrubs, young trees, or trees and shrubs which have been stunted by environmental conditions such as lack of nutrients in the soil. Under the FWS Classification no more than 30% of the trees in such areas will exceed 20 feet in height, and at least 30% of the area must be covered by shrubs rather than smaller non-woody vegetation. A beautiful little shrub swamp, locally known as "Noisy Hole", lies between Meetinghouse and Noisy Hole Roads just south of Hollow Road. Others exist along the upper reaches of Quaker Run north of Route 28 in the Noisy Hole Conservation Area and throughout the Town independently or along the edges of ponds and marshes.

One prime example of a swamp made up of stunted older trees is a small Atlantic White Cedar swamp tucked away on land owned by the state's Division of Fisheries and Wildlife south of Holland Mill Road. In an area known as the South Mashpee Pine Barrens, it is part of an amazing landscape of contrasts where dry tangled expanses of scrub oak and occasional pitch pine are offset by cool kettle holes full of cedars, orchids, mosses and sundews.

Home to endangered species of plants and moths, the Pine Barrens' most attractive features also include examples of the two other classes in the FWS palustrine system, the moss-lichen wetland and the forested wetland. Whereas mosses and lichens usually form a ground cover under a dominant layer of trees or shrubs in many of our wetlands, in a few small spots on the edges of cedar swamps in the Pine Barrens they have maintained a place in the sun, forming small areas of moss-lichen wetland. (Another such wetland exists among scrub oak adjacent to the Water District's proposed "P-1" well on state DCR land west of the Quashnet River.)

These spots, which are intermittently flooded by high groundwater levels, are home to the curious insect-eating sundew and are often bordered by colorful stands of sheep laurel. Their adjacent companions, the cedar swamps, offer a stark contrast of dark and towering vegetation, the mystery of tangled roots, more mosses, tricky footing, waters hidden from the sun...and the allure of orchids. Large white cedar swamps once existed throughout Mashpee. Most have been cut and replaced by something less stately. Those that remain, in the Pine Barrens and in South Mashpee between Great Hay and Great Oak Roads, within the Jehu Pond Conservation Area (although the largest is still privately owned), are treasures that must be guarded and preserved.

"Vernal" or "spring" pools are wetlands or other depressions which are normally filled with open water only for a few months of the year, usually in the late spring and summer. They are normally filled either directly by snowmelt or runoff from spring rains, or by the higher water table levels that they cause. The classic vernal pool will fill in late March or early April and be dried out by September. It is also isolated from other permanent wetlands or water bodies, a critical factor for certain rare species such as wood frogs, spotted salamanders and fairy shrimp, whose eggs or young would be quickly devoured by fish or other creatures which populate more permanent water bodies.

Until recently the importance of vernal pools was not widely recognized and there was little information available on vernal pool locations in Mashpee. However, in the last 20 years, regulatory protection has been extended to such pools under federal, state and Town laws and a program of mapping and certification has been established by the Massachusetts Natural Heritage and Endangered Species Program. In response, the Mashpee Conservation Commission and volunteers have had most of our vernal pools located and certified.

One type of wetland, which is simply described as a farmed palustrine wetland in the FWS Classification, makes up a large portion of Mashpee's wetland acreage. It is what we've come to refer to as bogs, or more specifically, cranberry bogs. These are not really bogs in the classic sense of the quaking bogs of northern New England. They are, instead, radically altered former wetlands of other sorts such as cedar swamps, shrub swamps or riparian wetlands. These wetlands were cleared of their natural vegetation, drained by ditches, sometimes re-graded, diked, dammed and covered with sand taken from nearby banks. They were planted in a monoculture of cranberries, dosed with fertilizers and pesticides and flooded artificially using dams on our ponds or pumps from rivers or man-made ponds.

Where at one time the Quashnet River boasted one of the finest sea-run brook trout fisheries in existence, the combination of a mill dam and then extensive clearing and reshaping of its wetlands destroyed its trout fishery and turned it into what is reputed to have been the world's longest cranberry bog. Quaker Run suffered a similar fate, though as a much smaller stream its trout fishery was not as prominent. To a lesser degree, all of our other streams, including the Mashpee, Santuit and Childs Rivers, Red and Abigail's Brooks and Dutchman's Creek were similarly altered in what seems to have been a 19th century frenzy of cranberry bog development. Many of our other isolated inland wetlands of any size, except a few cedar swamps which were too small or to difficult to flood, were also converted to cranberry production.

Hurricanes in the 1930's and 1950's, a cancer scare in the late 50's and low prices for cranberries put most of the smaller bogs out of business. The Quashnet Valley Country Club turned part of a cranberry bog (that had originally been our largest cedar swamp) into a golf course (much of the undeveloped portion of the bog is now re-growing as a shrub/cedar swamp. Today almost all of Mashpee's cranberry bogs have been abandoned or are out of production. The current exceptions are the Chop Chaque and Baker bogs adjacent to Santuit Pond and the Conservation Commission's Garner Bog on the Childs River. The Conservation Commission's bogs in Johns Pond Park are still maintained, but are out of production until contamination caused by a fuel spill at Otis Air National Guard Base has been cleaned up.

Over 300 acres of old bogs lie abandoned and are reverting to various states of "naturalness" depending on their location and the height of the local water table. Some, such as portions of the Town bog in John's Pond Park, are becoming freshwater marshes. "Washburn's Pond", an old bog on the Mashpee River owned by the Division of Fisheries and Wildlife, is normally flooded and can be called, most aptly, a pond (and home to large bass and other fish). Some old bogs in drier areas that were formerly irrigated by pumping, such as those at the head of Canaway's (Muddy) Cove, now part of the Mashpee River Woodlands Conservation Area, had taken on the appearance of an open meadow but are now becoming forested. Where bogs were developed

adjacent to salt water, as on Red and Abigail's Brooks and Dutchman's Creek, the sea has moved in and created a salt or brackish tidal marsh.

The remainder of our old cranberry bogs have become scrub-shrub swamps or wooded swamps. Along the Quashnet River, pitch pines, birches and poplars have grown to heights of 30 to 40 feet on old bogs abandoned in the 1950's and purchased by the Division of Fisheries and Wildlife. Tucked away and almost invisible in the northern section of the Mashpee River Woodlands is a good-sized bog now grown up in red maples. Nature has begun to restore the destruction wrought by man.

That destruction of wetlands was not limited to cranberry bog development, the nineteenth century or to Cape Cod. Throughout our history wetlands have been misunderstood as scary places, wastelands, breeders of disease or impediments to the march of progress. They have been drained, filled, plowed over and paved under in the name of mosquito control, land development, agriculture and highway construction. Massachusetts has the unfortunate distinction of having undertaken America's first filling for real estate development, that of Town Cove in Boston in 1641. The filling and destruction of wetlands continues to this day, not only in Massachusetts but throughout the country, mostly for agricultural purposes. In the mid 70's the U.S. Fish and Wildlife Service estimated that 46% of the nation's original wetlands had been lost, and that the destruction continued at a rate of 550,000 acres per year. At that time there were approximately 99 million acres of wetlands left in the country, or approximately 5% of total land area, with 93.7 million acres in inland areas and 5.2 million acres in coastal areas.

Fortunately, there has been a gradual turnaround in our thinking about wetlands. Beginning in the 1950's when the Fish and Wildlife Service demonstrated the critical value of Midwestern wetlands to waterfowl populations and publicized their first estimates of wetland losses, and accelerating during the environmental movement of the 1960's and 70's, both the public and government have begun to recognize the value, and in some cases the critical importance, of wetlands. In Massachusetts, major floods in the 1950's and increased consciousness of the value of coastal wetlands to marine fisheries and shellfisheries led to the adoption in 1963 of the nation's first wetland protection law, requiring a state permit to alter a tidal wetland. This was followed in 1965 by a similar law which protected inland wetlands. In 1965 and 1967 respectively, laws were passed which allowed for permanent restriction of alteration of coastal and freshwater wetlands.

These laws recognize a number of the benefits derived from wetlands, such as flood damage prevention and nurturing of marine fish species. At both the state and federal levels studies and reports have documented the value of wetlands. "A Guide to Important Characteristics and Values of Freshwater Wetlands in the Northeast," by the Water Resources Research Center of the University of Massachusetts at Amherst, indicates that wetlands are a valuable potential source of groundwater, that they have a high aesthetic value due to their visual diversity and contrast, that they are valuable for recreation and education, that they retain floodwaters and reduce the impacts of flooding on developed areas, that they are critical to the survival of waterfowl and many furbearing mammals and that they are important to marsh birds, songbirds, deer, rabbits, pheasants and grouse.

The Congressional Office of Technology Assessment (OTA), in its 1984 report entitled "Wetlands, Their Use and Regulation," went into even greater detail in explaining the value of wetlands. Although they saw less value in wetlands for groundwater supply, flood peak reduction and shoreline stabilization along coasts and rivers were found to be of significant value. Wildlife food and habitat was again emphasized. For example, the report pointed out that coastal marshes and certain types of inland freshwater wetlands achieve some of the highest rates of plant productivity of any natural ecosystem and that in saltwater marshes up to 70 percent of that plant material is eventually broken down into small particles and flushed into adjacent waters, where it becomes a potential food source for fish and shellfish.

The OTA report pointed out additional scientific and cultural values of wetlands. It noted that by temporarily or permanently retaining pollutants, such as suspended solids, excess nutrients, toxic chemicals and disease-causing micro-organisms, wetlands can improve the quality of water that flows through them. Wetlands have even been used successfully for secondary and tertiary treatment of sewage effluents. One of the primary mechanisms for water quality improvement in wetlands is the fact that their dense plant life and broad, shallow nature reduce the velocity of water flow and cause organic and inorganic suspended materials to settle out, along with associated pollutants such as nutrients, pathogens, heavy metals and chlorinated and petroleum hydrocarbons. Some of the pollutants may be converted by biochemical processes to less harmful forms, some may remain buried, and others may be taken up by wetland plants and either recycled or transported from it.

Nutrients such as nitrogen and phosphorous readily adsorb to sediment and thereby tend to become trapped in the anaerobic sediments of wetlands where they are rapidly assimilated by rooted wetland plants. At the end of the growing season, however, much of the assimilated nutrients may be leached from the plants, exported by water flow as detritus, or rapidly colonized by bacterial decomposers which convert nitrogen, for example, to ammonia. Viruses and bacteria from sewage effluent or road runoff are also adsorbed onto suspended particulates which may be trapped in wetlands. They can remain for many months in wetland soils, where they may be exposed to ultraviolet radiation or attacked by chemicals and other organisms, or they may otherwise die off naturally.

The OTA report also noted that wetlands play a role in climatic and atmospheric functions. Since water warms and cools slowly in comparison with land areas, wetlands tend to have a moderating influence on nearby atmospheric temperatures, warming the air in the winter and cooling it in the summer. They are also a source of water to the atmosphere through evaporation and the release of water vapor from plants (evapotranspiration). In addition, through processes of microbial decomposition, wetlands may either store or emit gaseous byproducts important to global atmospheric stability.

Finally, OTA noted that for many personal reasons, whether ethical, religious, esthetic or recreational in nature, people value wetlands for their intrinsic, intangible values as natural areas essentially untouched by man's presence. In many areas wetlands are the last to be developed and thus the last link to our origins in nature. Their aesthetic value is high due to the interface and interplay of land and water. They can be bright and open or haunting and mysterious, and they can be quietly, peacefully, enjoyed. People need a break once in a while, and wetlands can

soothe the soul. Protecting our diverse wetlands is therefore a key element of Mashpee's OSCAR plan.

4. Lakes and Ponds

Mashpee is blessed with an abundance of freshwater lakes and ponds. They range from the 729 acre Mashpee-Wakeby Pond (a "lake" by anyone's definition) to 0.1 acre Fresh Pond (largely filled by development of the New Seabury golf course and barely rating the term "pond"). Depending on what definitions you use, there are approximately 23 fresh water ponds in the Town covering 1455 acres. Under the U.S. Fish and Wildlife Service Classifications, the larger lakes are "lacustrine" wetlands, while the smaller ponds fall into the "palustrine" category. Mashpee-Wakeby Pond, John's Pond (317 acres), Santuit Pond (172 acres), Ashumet Pond (203 acres, of which 152 acres are in Mashpee), Great Flat Pond (37 acres, tidal slightly brackish water) and Moody Pond (18 acres) are the only water bodies listed as lacustrine. The first four are our major recreational freshwater ponds. Because Flat Pond is a former salt pond which is still influenced by tidal flow, it will be covered later in our discussion of Estuarine Systems.

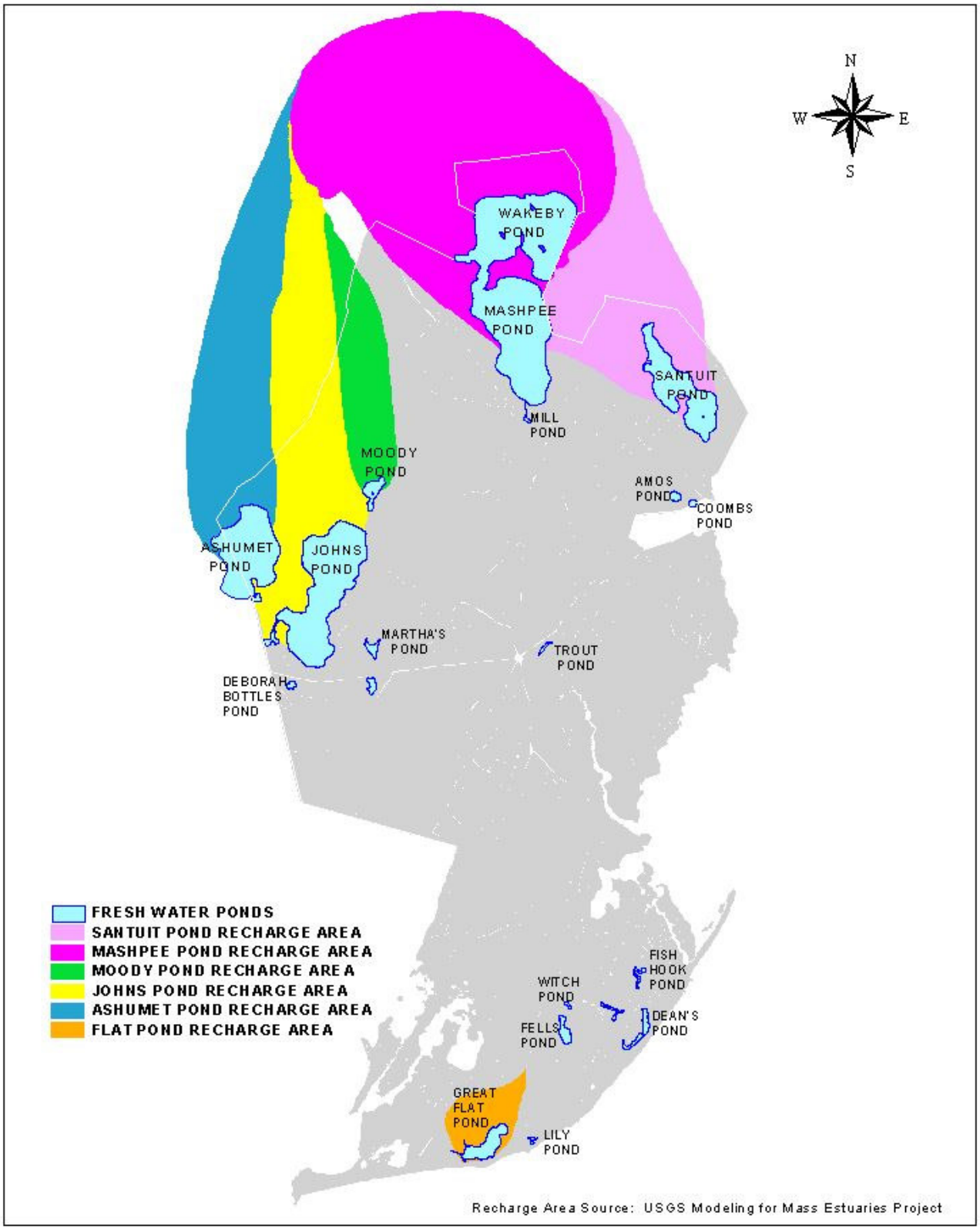
All of our large inland ponds, as well as the smaller ponds classified as palustrine, lie in the kettle hole depressions that were left to us by the glaciers of the Ice Age. Giant blocks of ice were buried in outwash sediments and later melted, leaving large kettle holes. In the case of Mashpee-Wakeby and John's Ponds, there were apparently at least two such ice blocks, which left kettles now connected by shallower areas. The kettle hole nature of the ponds becomes clearer upon review of bathymetric maps (depth charts) of the ponds. Mashpee-Wakeby, John's and Ashumet Ponds show rather deep bottoms, with maximum depths of 87, 62 and 65 feet respectively. Santuit Pond, on the other hand, is extremely shallow, with a maximum depth of only 9 feet and a mean depth of 4.2 feet. Moody Pond has a maximum depth of 14 feet and averages approximately 8 feet in depth.

During the last 50 years, the shorelines of the four major freshwater ponds have become heavily developed, first with summer camps, and more recently with year-round homes. This development has been drawn by the lake's recreational opportunities, including fishing, boating and swimming, and their natural beauty. However, the development thus attracted to their shores has begun to destroy our lakes. Shorelines and their unique plant communities have been severely disrupted by man-made beaches and docks and the footsteps of many visitors. The noise of motorboats has drowned out the sounds of waterfowl. Fishermen and swimmers are disturbed by high-powered boats, water skiers and "jet skis." The aesthetic beauty of the lake experience has been reduced by hundreds of residences located close to the shore. Most insidious of all, however, and most critical to the health and attractiveness of our ponds, has been a rapid decline in the quality of their waters.

Scientists classify the relative health and water quality characteristics of ponds by their "trophic state," referring to the metabolism of a pond and the available supplies of the nutrients nitrogen and phosphorous. Those nutrient supplies are critical to the pond's food chain. However, in excessive amounts they accelerate the process of "eutrophication," or over-nutrification of a pond and lead to excessive plant growth, lack of oxygen as plants die off and take it up, loss of fish stocks due to insufficient oxygen, algal blooms and associated foul odors, loss of water clarity

Fresh Water Ponds

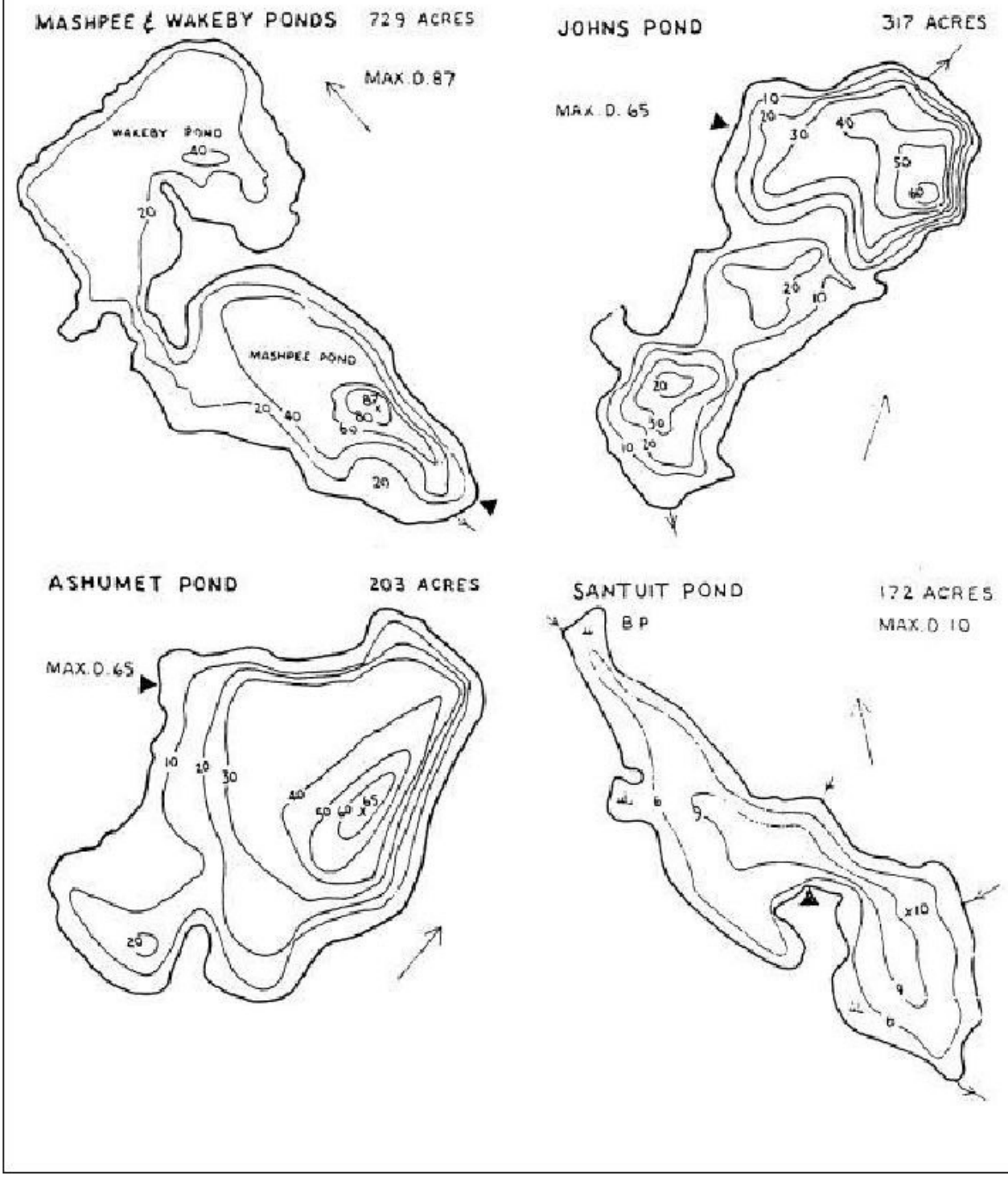
Map 4-19



Major Ponds

Bathymetry Source: Mass DFW

Map 4-20



and suitability for recreational purposes and eventual filling of the pond with organic matter, creating a palustrine wetland.

Due to relatively small surface watersheds, low erosion rates, poorly developed soils and low concentrations of nitrogen and phosphorous in the outwash plain soils, most Cape Cod ponds were originally poorly fed with nutrients, or "oligotrophic". As such, there was little algae or other phytoplankton growth and very little suspended matter, resulting in extremely clear waters. Such ponds support a high diversity of fish species (but in small numbers), are excellent for swimming and boating and are highly scenic. Many of the Cape's ponds retain that status. However, none in Mashpee have survived in that state.

Mashpee-Wakeby, John's and Ashumet Ponds have received increased levels of nitrogen and phosphorous due to heavy development along their shorelines. Septic systems, road drains and fertilized lawns and gardens all leach nitrogen and phosphorous into the groundwater feeding our ponds, or into the ponds directly as runoff during storms. This additional nutrient load has led to a fairly rapid change in their water quality. Phytoplankton has increased, although it is highly variable, with occasional phytoplankton blooms, including blue-green algae. Suspended matter is increased, though also variable. Food supplies and habitat are abundant, resulting in relatively high and diverse populations of both bottom fauna and fish.

For our purposes, both boating and swimming are appropriate, while recreational fishing is highly productive. All three ponds contain deep bottoms which remain cold throughout the year below 40 feet, making a fine trout fishery possible. Each develops thermal stratification during the spring and summer, with a warmer upper stratum or "epilimnion", having uniform warmer temperature and wind-mixed circulation, a middle stratum or "metalimnion" showing a large temperature gradient, rapidly going from warm to cold with increased depth, and the cold bottom stratum or "hypolimnion", which remains undisturbed throughout the summer, having little circulation. These strata are highly resistant to mixing.

Although trout and similar salmonids prefer cold waters, they also require adequate oxygen. Since the waters of the hypolimnion contain little dissolved oxygen due to their source in groundwater (which contains little oxygen at lower depths) their lack of mixing with the oxygenated waters of the epilimnion, and as a result of respiration by sediment microbes and benthic fauna, along with the metabolism of organisms attached to suspended organic material, there is a delicate balance during the summer months for salmonids. They must find waters which are deep enough to have the proper cool temperature, but not so deep that oxygen is inadequate.

In our ponds, those qualifications are met only in a thin 4-6 foot layer of water just below the metalimnion. Anything which would tend to decrease available oxygen in the water could narrow or eliminate this critical layer. When a lake becomes over-nutrified and algal blooms result, as has happened with increasing frequency in Ashumet Pond, oxygen production is at first increased. But when the algal blooms die off, their decomposition and partial mineralization cause rapidly reduced oxygen levels, leading to fish kills.

During the fall, reductions in air temperature result in a corresponding decrease in the temperature of waters in the epilimnion. As the epilimnetic and hypolymnetic waters approach the same temperature, the thermal resistance to mixing decreases greatly. The pond begins to circulate to the bottom and continues to mix throughout the winter. This helps to restore oxygen to the pond through aeration at the upper level by wind and wave action. However, when ice covers our ponds, which usually occurs in January and February, wind-driven mixing is eliminated and oxygen depletion occurs in the bottom waters.

Santuit and Moody Ponds present a quite different environment than that of the three larger ponds. Both are very shallow. As a result, their waters are warm and thoroughly mixed by wind and wave action in the summer. Salmonids cannot be supported, and warm water species such as bass, pickerel and perch predominate. However, Moody Pond is a small pond (18 acres) with a totally undeveloped shoreline. Although it has suffered from algal blooms, it is a fairly healthy pond. It can probably be classed as mesotrophic.

Santuit Pond, on the other hand, is clearly eutrophic. It is surrounded on the west and northeast by dense residential development on small lots averaging 1/4 acre. No public or community wastewater collection or treatment is in place, and all residences use septic systems or cesspools. Because of the shallow nature of the pond and low flushing rate caused partly by fairly impervious organic bottom sediments, it has become over-nutrified, with dense aquatic vegetation, frequent algal blooms, foul odors and poor quality for swimming and boating. There is a high frequency of flatleaf pondweed (*Potamogeton robbinsii*), which is an indicator of high phosphorous content in bottom sediments. Floating plankton species are dominated by *Microcystis sp*., a colonial blue green algae capable of creating obnoxious blooms if it windrows.

Indeed, of 35 Cape Cod ponds surveyed by the state Department of Environmental Quality Engineering in 1980, Santuit Pond had the highest trophic state score, indicating the worst eutrophication, and total phosphorous of 0.53 mg/l compared to 0.20 in Mashpee-Wakeby, 0.01 in Ashumet and 0.07 in John's Ponds. Water quality has only become worse in recent years, with pea soup green waters being the norm in summer and fall. Major steps, including land acquisition, elimination of road runoff and sewering of adjacent developments, must be taken if Santuit Pond is to be restored as a natural asset.

One of the first steps toward protection of water quality in our large ponds was taken in 1985 when the Mashpee Planning Department engaged K-V Associates of Falmouth to determine and map the groundwater recharge areas, or “zones of contribution”, of Santuit, Mashpee-Wakeby, John's, Moody and Ashumet Ponds as well as the saltwater Jehu and Hamblins Ponds and Ockway Bay. Zones of contribution are the surface land areas which, through precipitation and recharge of the groundwater aquifer “uphill” from a pond, provide most of its water. Additional water is provided by direct surface runoff from the surrounding surface watershed (or all land which slopes toward the pond) and precipitation onto the surface of the pond itself.

Using “flow meters” along the edge of the pond, groundwater monitoring wells upgradient in the acquifer, knowledge of local precipitation, groundwater recharge and evaporation rates and of the hydraulic conductivity of the underlying sediments (how fast water can move through the ground), K-V Associates determined the size, shape and location of each pond's zone of

contribution and mapped the results on 1"=400' scale maps. These maps were a useful tool in determining appropriate zoning and land use regulations, in reviewing proposed land developments and in prioritizing conservation land acquisitions aimed at protecting the quality of water in our ponds.

More recently, the U. S. Geological Survey (USGS) has developed their "Upper Cape" groundwater model. The model has been used for numerous projects related to contaminant plumes at the Massachusetts Military Reservation and, more recently, as a key part of the Massachusetts Estuaries Program (MEP). Under the MEP, which was developed to model nitrogen impacts on coastal water bodies and set "Total Maximum Daily Load" targets for each bay, groundwater watersheds and sub-watersheds were mapped by USGS. These new watershed delineations have now been incorporated into Mashpee zoning requirements for water quality protection and are being used in development of wastewater facilities plans by the Mashpee Sewer Commission.

Further study needs to be done to accurately determine the sources of nutrients and other pollutants into each of our ponds (particularly Santuit Pond), the fate of those materials in the pond environment, and the possible solutions, in addition to sewering, for any problems that become apparent. Our lakes are one of our most visible and valuable assets and they need to be treated with care.

5. Rivers and Streams

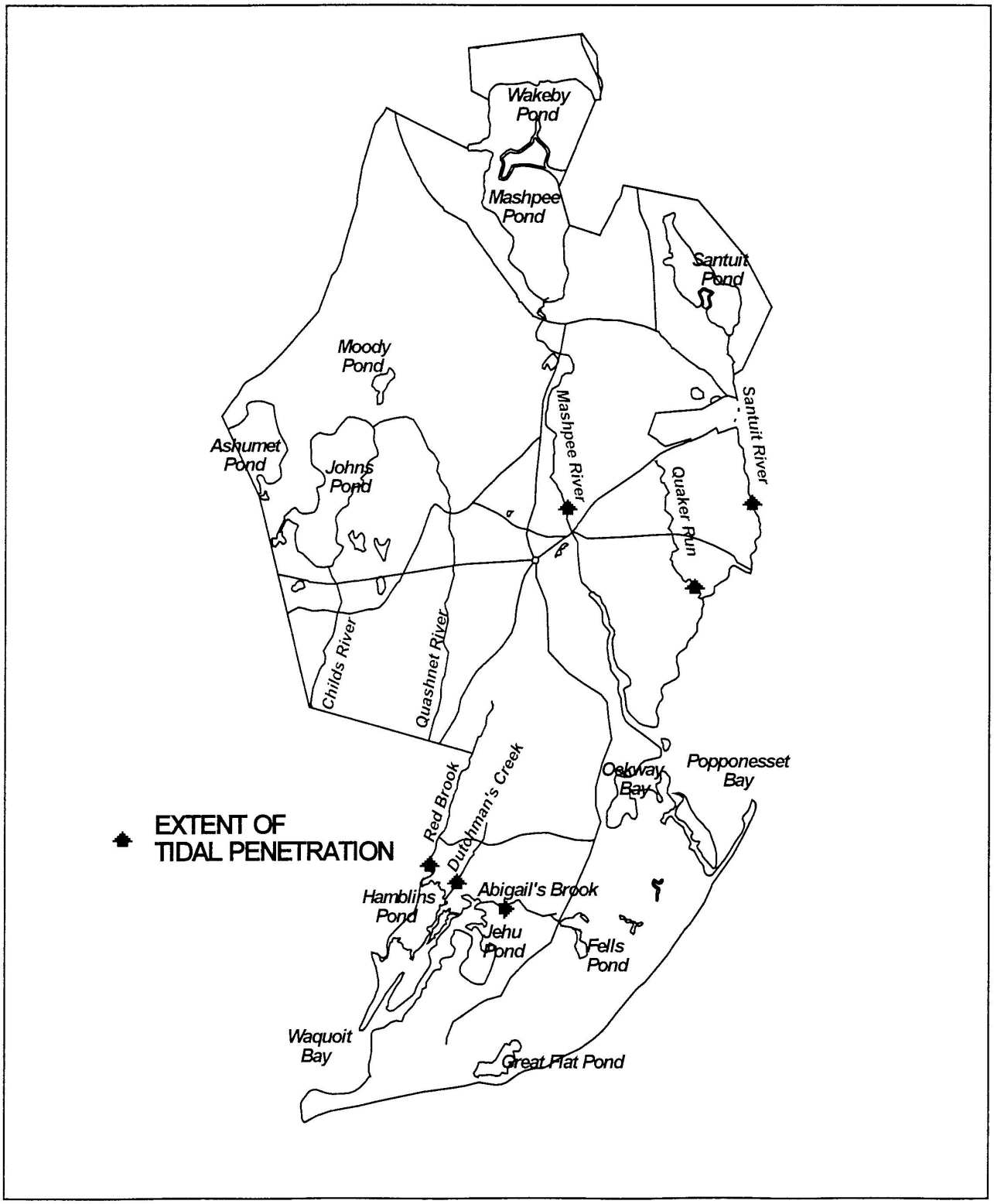
The traditional heart and soul of Mashpee are its rivers. The Mashpee River - bearer of our Town's name and central to it in both location and history. The Quashnet - famous trout stream, the "world's longest cranberry bog", focus of a nationally-honored restoration effort. The Santuit - quiet and unnoticed on our border with Barnstable, site of towering beeches, dainty ladies slippers and archaeological treasures. The Childs - herring river, reduced by man, hidden away. Quaker Run - larger than it looks, an ancient valley, an underground river not easily tamed. The smaller streams - Red Brook, Abigail's Brook, Dutchman's Creek - peacefully flowing to the sea. All of our streams have a character of their own and a unique value in the scheme of things.

The **Mashpee River** ("Mashpee" meaning "A great river coming from a pond bearing many fish" in Massachuset Algonkian dialect) has long been the focus of human interest in the area. As did its' smaller sisters, the Mashpee bore many fish for both the Native American and his white visitors. Among the first acts of the fledgling government of the "District of Marshpee", before we were a town, were the establishment of "catchers" and a "catching place" to take advantage of the annual bounty of herring produced by the stream and to distribute them equally to all families. The herring came to the Wampanoag for thousands of years, captured in weirs and gill nets, and still come in the spring to delight their beholders at the Mill Pond fish ladder on Main Street adjacent to the Mashpee Indian Museum.

When the District needed funds, it also turned to the Mashpee, leasing out the rights to the river's prized sea-run trout to rich fishermen from Boston. When Mashpee became a Town and its lands could be sold to outsiders, the same fishermen and their friends bought up the lands along the river to protect their prized sport. The Mashpee River Trout Club, and eventually one man

Rivers and Streams

Map 4-21



named John W. Farley, controlled almost all of the river and guarded it from the development which destroyed so many of our other natural treasures. Through his gifts to The Trustees of Reservations and wise purchases from his successors by the townspeople of Mashpee and by the state's Division of Fisheries and Wildlife, our main artery will forever be preserved for our enjoyment, and that of the trout and herring.

In another way, the trout has saved the **Quashnet River**, lesser sister to the Mashpee but no less important to mother nature. In its original form, it ran through a deep valley filled with huge oaks, cedars, hemlocks, beeches and white pines up to twelve feet in diameter as a cool spring-fed stream. As such, it was an ideal home for the sea-run brook trout, or "salter". The salter spawned in the fresh waters of the stream, but went to sea and the rich waters of Waquoit Bay to feed, growing to twice the size of its freshwater cousins. Such prize fish drew some of the most famous sportsmen of the day, including Daniel Webster, to the banks of the Quashnet.

Herring, too, trafficked the river, though not in numbers as great as those on the Mashpee. In an effort to improve the river's herring fishery, the District of Marshpee voted in the 1850s to connect the river's headwaters in large cedar swamps east of John's Pond (now replaced by the Town's cranberry bogs and the Quashnet Valley Country Club) to the pond via a man-made channel. All went for nothing, as a gristmill and dam had been built downstream in Falmouth, cutting off both trout and herring from their spawning grounds.

In 1895, the cranberry industry moved in, building dikes and dams, channeling the river, filling and leveling the valley with sand. The advent of chemical pesticides such as rotenone and DDT brought the final insult. Mother nature and time, however, seem to have a way of making amends. In the 1950s, flooding caused by hurricanes, and low cranberry prices which made it uneconomical to repair the resulting damage, led to the abandonment of the bogs on the lower half of the river. With the mill dam gone and the cold water springs still flowing, trout were again a possibility. The state's Division of Fisheries and Game stocked the stream with brook trout and brown trout. The results were impressive, with the browns adopting the salters' sea-run habits and weighing in on fishermen's lines at up to twelve pounds. In order to protect this fishery, the Division bought a narrow strip of land along the lower reaches of the river in 1965, including 22 acres in Mashpee.

Soon, however, shrubs which had taken over the bogs began to choke the river as well, causing it to overflow and undercut its banks. Waters became shallower and too warm for the trout. Something had to be done. Acting on a strong belief that the Quashnet still had the makings of the prize trout stream it once was, a fisheries biologist from the renamed Division of Fisheries and Wildlife, Joe Bergin, sought help. He found it in the members of the Southeastern Massachusetts Chapter of Trout Unlimited, an organization dedicated to protecting and improving the nation's sport fisheries.

Under the tireless leadership of Francis Smith, a Falmouth plumber and avid fisherman, the group began in 1976 an impressive and continuing project of clearing, building and planting which has restored more than a mile of the stream as a prime trout spawning area. However, as it seems to have been for the last 150 years, the trout was again threatened by man's activities. Real estate development in both Falmouth and Mashpee threatened the stream, this time with

pollution from wastewater effluents and degradation of its banks by too many neighbors' footsteps.

As part of an effort to ensure that the trout do not again become just a memory, a working group of six local organizations was established in 1986. Called the Quashnet Coalition and made up of the Citizens for the Protection of Waquoit Bay, Trout Unlimited (Cape Cod chapter and Massachusetts/Rhode Island Council), the Association for the Preservation of Cape Cod, the Falmouth 300 Committee, the Falmouth Rod and Gun Club and the Mashpee Wampanoag Indian Tribal Council, Inc., the group proposed and lobbied extensively for state legislation funding the purchase of 340 acres along the river in Mashpee south of Route 151 on which 400 condominium units had been approved. The effort was successful and the purchase was completed in 1988 by the state's Department of Environmental Management (now the Department of Conservation & Recreation) and Division of Fisheries and Wildlife. Additional state purchases were made along the river in Falmouth.

In 1995, the town of Mashpee purchased 135 acres south of Route 151 on the west side of the river as the site of its' new high school. 54 acres along the river and adjacent to the state's land were set aside as open space under a conservation easement granted to the U.S. Fish and Wildlife Service. In 2001, with the assistance of the Orenda Wildlife Land Trust, the Town purchased the 14.1 acre Dawson property surrounding the river on the south side of Route 151, subject to a Conservation Restriction held by the Division of Fisheries and Wildlife. Orenda purchased and held another 4.6 acres on the north side of Route 151. Directly north of the Orenda land is a landlocked tax-taking property held by the Town, and open space and golf course portions of the Quashnet Valley Country Club. The only other land along the river in Mashpee was recently approved for a Chapter 40B housing project by the owners of Mashpee Commons, with the land directly adjacent to the river set aside as open space, completing efforts to protect the banks of the entire river. With careful management of the open space along the river and reduction of nutrients reaching the river from wastewater and stormwater, the Quashnet will be well on its way to full recovery as a permanent natural asset for the enjoyment of future generations.

There are a few trout still, and native "brookies" at that, in the **Santuit River**, along with "salters" and an active herring run. Being a smaller stream than either the Mashpee or Quashnet, and divided by the Mashpee/Barnstable town line, it was largely ignored until recently. It, too, had its mill (Sampson's Mill, where Old Mill Road crosses the river) and its upper reaches were diked and channeled and dammed to grow cranberries. In spite of that "management", however, parts of its course seem to have retained a unique natural identity. Below Route 28, the Santuit flows quiet and cool through a deep valley dominated by massive, towering beeches. Above its banks, lovely ladies' slippers carpet the forest floor.

During the 1980s, a golf course and condominiums were built above its banks. Excavation for those projects had a sad effect on one of the Santuit's other treasures, its past. Workers tearing up the forest to build the golf course also tore up a priceless archaeologic site. For though the Santuit is a forgotten place today, our Native American predecessors knew its' banks well, hunting and fishing and establishing camps dated to at least 5000 years ago. They left a valuable record of their times along the Santuit in a number of sites which have been identified by the State Archaeologist. Nothing can replace the site which has been destroyed, but the developers

of the golf course agreed to protect the rest through legal deed restrictions and careful development practices.

Just before it ends its short course at Shoestring Bay, an arm of Popponesset Bay, the Santuit meanders through a broad marsh, slowed and backed up by the tides. Here it is transformed by tides and salty water into what the U.S. Fish and Wildlife Service's classification system would call an estuarine, rather than a riverine environment. The marsh is thronged by waterfowl and wading birds. Grasses and sedges proliferate. Unfortunately, so do condominiums. In this case, the Cotuit Bay Condominiums were not only built much too close to the marsh, but their septic system wastes appear to have polluted both the River and Shoestring Bay, which has been seasonally closed to shellfishing due to high levels of coliform bacteria. In 2002, however, the developers of the Willowbend Country Club, as a condition of Cape Cod Commission approval of a 9 hole expansion, agreed to connect the Cotuit Bay Condos to their state-of-the-art wastewater treatment plant, a first step, it is hoped, in cleaning up the River and Shoestring Bay.

In addition, between 1999 and 2005, the Town, through purchases funded by its Land Bank and directly by the Conservation Commission, as well as a land trade with the Willowbend Country Club, acquired 46 lots in a "paper" subdivision just north of the Cotuit Bay Condominiums which, along with a single landlocked parcel just south of Route 28, now make up the 37.15 acre Santuit River Conservation Area. The Town owns an additional 47 tax-taking lots encompassing 6.48 acres in the same paper subdivision which could be added to the Conservation Area. There are a final 17 privately-owned lots intermixed with these Town lands, which will need to be acquired to ensure its protection.

In 2002, the Towns of Mashpee and Barnstable jointly purchased the 293 acre Santuit Pond Preserve, which includes 173.36 acres in Mashpee on Santuit Pond and the upper portion of the Santuit River, subject to a Conservation Restriction purchased by the Mass. Division of Fisheries & Wildlife. The land was purchased in reaction to proposals for another golf course which would have clear cut much of the land while maintaining operations of the extensive cranberry bogs on the property. The state's Conservation Restriction calls for organic management of the cranberry bogs and abandonment of the bogs within 300 feet of the River, intended to result in their restoration to a natural state to protect fisheries and wildlife resources. Because of difficulties finding a contractor to operate the bogs organically, they have not been harvested since the Towns' purchase and may never be restored to operation, leaving the potential for their restoration as natural wetlands.

The Santuit River's waters, from the eutrophic Santuit Pond surrounded by cranberry bogs, undersized single-family lots and septic systems, to its middle reaches impacted by uncontrolled road runoff, to its estuary suffering from both over-nutrification and high bacterial counts, are currently in sad shape. But the banks of the Santuit have retained much of their charm, and the recent land purchases and ongoing planning efforts for stormwater management and development of a municipal sewer system offer hope that it may someday be restored to something more like its condition when those native camps were set up thousands of years ago.

The same Willowbend Country Club which borders the Santuit River also dominates much of the course of its neighbor, the elusive **Quaker Run**. Unlike our other streams, the waters of Quaker (or Quaker's) Run flow mostly underground through porous unconsolidated sands and gravels

left in a glacial outwash channel. Its valley actually begins in Peters Pond in Sandwich, crossing over to Wakeby Pond in the area of John Ewer Road, and then paralleling South Sandwich Road, Noisy Hole Road and Simons Road before surface flow becomes a steady stream in the Country Club's cranberry bogs south of Old Mill Road.

Being unconsolidated and of generally larger materials than the surrounding layers of sandy and silty outwash sediments, the valley of Quaker Run relates differently to groundwater levels than surrounding lands. When it rains, or the snow melts, water which percolates into the ground in the valley flows more quickly to the sea. When combined with runoff from adjacent land, and especially from the increasing number of streets in the valley, the result is relatively rapid fluctuation in groundwater levels. Draining more slowly than surface rivers, but more quickly than groundwater in the rest of the town, flood or spring snow melt waters in Quaker Run act like a slow-moving "wave" of groundwater which has inundated subdivision streets and house lots foolishly located atop what is, in effect, a river bed.

More development in the valley would increase roadway and other impervious surface area, resulting in more runoff into the giant drain which is Quaker Run, potentially resulting in higher annual flood levels. Such increasing groundwater elevation could also affect the wetlands which dominate the valley's natural environment. From overgrown cranberry bogs near Wakeby Pond in Sandwich's Ryder Conservation Area, to abandoned bogs in the Besse Bog and Als Conservation Areas north and south of Main Street (Route 130) connected by a system of drainage ditches, to shrub swamps along Noisy Hole Road and the large active and abandoned bogs south of Route 28, the valley of Quaker Run is a series of natural and unnatural wetlands. With increased levels of flooding, these wetlands could be under deeper water for longer periods of the year. The plant species which were established as a result of natural sequences of flooded and dry conditions could someday be replaced by species more tolerant of permanently wet conditions. Partly in order to avoid such impacts and to protect wetland species directly, the Town has made a number of land purchases and transferred tax taking lands to the Conservation Commission to create the Noisy Hole Conservation Area. Additional cluster subdivision lands have been set aside and added to the Conservation Area as well, significantly reducing privately held vacant lands along the valley, and the threats of increased flooding.

The **Childs River** in Mashpee may be misnamed. Although it is certainly a child among our rivers, it can be said to barely rate riverine status, being at best a stream or brook and, in much of its course, a mere hand-dug ditch. Indeed, it was once better known under the name "Waquoit Herring Company's Ditch". As the latter name implies, the Childs River conveyed, and still does, thousands of herring between the sea and its source in John's Pond. However, its size and flow have been much reduced by man's machinations. When our predecessors dug their ditch between John's Pond and the Quashnet River to improve the latter's herring fishery, they did their work so well that today much more water flows from the pond to the Quashnet than to its natural outlet in the Childs River.

Though there is still enough water for the herring, other damage done in the name of cranberry bog operations has seriously impeded their access to the pond. In addition to the usual dams and dikes and ditches associated with the river's cranberry bogs (which in Mashpee are now owned by the Conservation Commission) the A. D. Makepeace Co. in the 1960's enclosed the pond's outlet within a large culvert for its first few hundred feet, using the structure to control water

flow to its bogs downstream. When the level of water in the pond is high, the force its waters exert within the culvert is so great that few herring can struggle through the pipe and into the pond. Despite the efforts of Town employees and others to net the herring at the culvert's outlet and carry them in buckets to the pond, most do not make it. Man seems to have goofed again in his efforts to manipulate nature.

Fortunately, this may be one error that can be corrected. When it bought the old Makepeace bogs in the early 1980s, the Town Conservation Commission also acquired the rights to the river and the unfortunate culvert. With most of its course in Mashpee now surrounded by permanently protected Town conservation land, it may be that removal of the culvert by the Town, and its replacement by a fish ladder, may some day restore the Childs to a happier state, for both fish and people.

Down by the sea flow a few quiet streams. Meandering mostly through quiet woods, wetlands and abandoned cranberry bogs, **Red Brook, Abigail's Brook** and **Dutchman's Creek** all send their waters eventually to Waquoit Bay--Red Brook and Dutchman's Creek by way of Hamblin's Pond and Little River, Abigail's Brook by way of Great River. Red Brook, which for most of its course forms the town line with Falmouth, arises as a man-made drainage ditch in shrub swamps among the South Mashpee Pine Barrens. Much of its lower end was converted by a dike from a tidal estuary to a cranberry bog operation near the turn of the century. The dike kept out salt water. The same was done to most of Dutchman's Creek (which flows from a shrub swamp just north of Red Brook Road) and Abigail's Brook (flowing from both tiny Witch Pond and a larger pond known successively as Wells, then Jim's, and now Fells Pond in New Seabury).

With tidal salt water excluded and replaced by fresh ground water and stream flow, the usual ditching, diking and sanding was done to convert tidal marshes into cranberry bogs as along our other rivers and ponds. As with the Quashnet, however, nature had its revenge. Hurricanes came, the works of man were destroyed and abandoned, and an estuarine environment is being restored. Red Brook's bogs are now flooded ponds. One, known locally as Shadow Pond, now graces the north side of Red Brook Road at the town line. The land on its west bank was recently donated to the U.S Fish and Wildlife Service as part of the Mashpee National Wildlife Refuge. Dutchman's Creek now runs through a wet meadow. The long series of bogs along Abigail's Brook, known formerly as Abigail's Swamp, are returning to nature as meadows, shrub swamp, fresh water and salt water marshes (although invasive *Phragmites* reeds are becoming a major problem). Nature takes her course.

Like the other water features noted so far, our rivers and streams reflect the glacial geology of Cape Cod and the groundwater aquifer which underlies it. Many lie in former outwash channels left by the main glacier or by the melting ice blocks which formed our larger kettle hole ponds. Although most appear to have their source in those ponds and, indeed, large volumes of water flow to our four larger rivers from the ponds, much of their water comes directly from the groundwater aquifer. In addition to defining the water level in the ponds, it appears in hundreds of springs and seeps along our river banks and in the beds of the rivers. Indeed, Red Brook and Dutchman's Creek have no apparent source, rising solely from groundwater springs and resulting wetlands. As we noted for the Quashnet River, these cold groundwater springs provide ideal

water temperatures for trout, keeping the rivers cool in the summer and relatively warmer and clear of ice in the winter-- as long as man doesn't interfere.

Our rivers and streams fall into the Fish and Wildlife Service's "riverine" wetlands category. They usually have a central channel with a sand or gravel bottom which is clear of aquatic vegetation. Where the sea's tides or other factors slow the flow of water, finer sediments, leaf litter and other detritus settle out and cover the bottom with an organic muck. In shallow areas aquatic plants such as the floating "duckweed" occupy much of the stream surface, providing a source of food relished by waterfowl. Along the streams edge, especially as the flow of water slows and valleys broaden near the sea, persistent emergent vegetation such as cattails and rushes indicate a palustrine wetland edge, or marsh.

Despite appearances, however, one of the key elements in the food chain of the river is not the duckweed, or cattail or live vegetation, or even the algae which play a key role in ponds and bays, but rather the fallen leaves and other remains of the trees and shrubs which overhang the banks of the upper reaches of each of our rivers. Over ninety percent of the plant-derived energy in a stream may come from fallen leaves and other dead plant material which is rapidly decomposed in the water, becoming the detritus which is the basic source of food for aquatic life. This natural detritus is a key element in the nutrient balance which is critical to the health of the stream and its inhabitants.

Man's activities, however, have in many cases disturbed the original balance of nutrients, oxygen, water temperature and streambed characteristics which defined our riverine ecosystems. As we have seen, cranberry bog and mill development drastically changed both streambed and water flow. Waters slowed by dams and dikes become warmer. Warmer water contains less oxygen than colder, fast-flowing water. Trout need high levels of oxygen to survive. Nutrients added to the river both as cranberry bog fertilizer and as detritus from rapidly growing and dying bog vegetation, as well as from septic systems in its watershed and road drains along the stream, cause excessive aquatic vegetation growth, further slowing and warming the stream, depleting oxygen, attracting unnatural numbers of waterfowl which themselves add more nutrients to the stream in a continuing cycle of stream habitat degradation.

We are finding that even long-abandoned cranberry bogs along our rivers have continued to have a negative impact, not only leaching fertilizers bound up in their soils, but also adding a tremendous volume of leaf litter through their systems of man-made drainage ditches. Even more ominous items such as heavy metals and volatile organic compounds are being added to our river waters from road runoff, leaking fuel storage tanks, hazardous household wastes dumped carelessly into septic systems, and similar hazardous wastes from both domestic and commercial sources leaching from existing and former landfills (dumps) into the groundwater which feeds our streams. In the streams' estuarine reaches, nitrogen is overloading our rivers and ruining their habitat quality. Primarily from wastewater effluent leached into the ground by septic systems and wastewater treatment plants, nitrogen is also dumped into the river via surface runoff or groundwater from lawn, garden and golf course fertilizers, from acid rain generated both locally and at Midwestern power plants, from animal wastes and by dry deposition in automobile exhausts, all exacerbated by the stripping of our forests and their filtering soils and replacement with impervious surfaces and more wastewater-generating development.

Clearly, one of our primary conservation goals has to be the improvement and protection of water quality in our rivers and streams. Once this is guaranteed, the restoration of our trout and other fisheries to their former glory can be possible. In addition, the linear nature, wildlife value and attractiveness of our streams defines the basis for a system of open space corridors throughout the Town. Such corridors can be a prime recreational asset for us, providing hiking trails, canoeing and fishing and can be vital for the migration and survival of our cherished animal friends. With foresight and a willingness to take, and pay for, the necessary steps, our rivers can once again become our main arteries - the heart and soul of Mashpee.

6. Estuarine Systems

They are our pride and joy. Mashpee's bays, tidal creeks, marshes, salt ponds, dunes and beaches have long been our playground, our source of income and our special places.

Under the Fish and Wildlife classification, all are grouped into the category of estuarine wetlands, although the term otherwise applies to those river mouths and bays where fresh water meets the salty water of the sea. The rain and snow that fell years ago in Sandwich, at Otis Air National Guard Base and throughout Mashpee has percolated into the groundwater table and made its slow but steady way down to the coast, or has appeared in springs in Mashpee Pond or along the Quashnet River where, joined with the rains that fell last week on the ponds or this morning on the impermeable surface of Route 28, it flows into Popponesset Bay, or Hamblin Pond, or Waquoit Bay.

We noted earlier in describing Cape Cod's freshwater "lenses" that fresh water is less dense than sea water and thus "floats" above it where they meet. This same effect is a key to understanding the estuary as well, for it both defines its environment and makes it one of the most significant in amount and variety of biological production. Where a rapidly flowing river meets the sea, it pushes the lighter fresh water over the heavier salt water to create a distinct "wedge" where the boundary between the two is fairly clear. As the tides change, this wedge will move up or downstream, and with it will go the fish and biota that require one or the other type of water. Since Mashpee's rivers are rather flat and slow-moving, this effect is only indistinctly seen. Our estuaries are dominated instead by the force of the tides, which cause turbulence at the salt/fresh interface and produce a partial mixing of the waters and a more gradual change from fresh to salty water.

In the Mashpee River estuary, for example, salinity at Gooseberry Island is approximately 17 parts-per-thousand (ppt). Upstream at Whitcomb's Landing salinity averages only 9 ppt. Just north of Canaway's Cove, 1.5 miles upstream, salinity has fallen to almost zero. The difference in density between salt and fresh water, combined with the rotation of the earth, has another interesting effect on the distribution and mixing of the two in broad estuaries such as our bays. Called the "coriolis effect", the rotation of the earth causes a counter-clockwise circular motion of water in the bays, which means that salty water on an incoming tide will tend to concentrate on the east side of the bay, leaving the west side less salty. The ebb and flow of the tides causes this pattern to shift constantly throughout the day. In a longer cycle, weather also affects the salinity levels in an estuary. In dry weather, when river flow is low, sea water, finding less

resistance to its tidal force, will intrude farther up the estuary. Conversely, in wet weather or during snowmelt and the spring thaw, fresh water will push farther into the bays.

All of these variations in salinity and tidal action result in a unique environment for fish and shellfish and a wide variety of indigenous species. One group of fish, the "anadramous" fish (including herring, shad, striped bass and our famous "salters" or sea-run trout), are able to thrive in both salt and fresh water and are thus commonly found in estuaries. Others move in and out with the flow of salt water.

The action of tides and of river flows also have an effect on the speed of water movement and its ability to carry both mineral and organic sediments and detritus. Where the tides meet the river, the flow and movement of water is slowed and sediments are dropped to the bottom or concentrated in the water. Materials which settle out form the basis of future salt marshes and tidal flats and the high concentration of detritus and mineral nutrients results in rich feeding grounds for molluscs, crustaceans, worms and small fish which are, in turn, eaten by larger fish. The flats and marshes are, of course, home to our quahogs, soft shell clams and crabs. Once they produced vast numbers of oysters as well, the shucking of which provided employment for many of Mashpee's youth. Naturally occurring oysters are largely a memory for now, but oysters recently seeded in trays by the Shellfish Constable have been very successful and offer great promise for the future.

Another species of shellfish which has suffered a steep decline is the sweet bay scallop. The causes of its disappearance are not certain, and its numbers seem to have always been cyclical, but one of the most solid theories relates to the dependence of its young, or "spat" on the eel grass to which they attach themselves at a critical point in their lives. The eel grass beds of Waquoit and Popponesset Bays have been virtually eliminated in the last thirty years, due to over-nutrification of our bay waters with nitrogen contributed by septic systems, other wastewater sources, fertilizers, and stormwater runoff of acid rain (nitrogen dioxide is one of the acids). The nitrogen causes the growth of excessive amounts of algae, which both reduce light penetration through the water column while alive (eelgrass needs sunlight to survive), then die off and cover the bottom of the bay. The scallops, which prefer a clean sandy bottom, are not happy.

The eel grass beds, along with marshes and floating plankton, were the primary food source for "forage" fish species such as Atlantic silversides, sticklebacks, pipefish, mummichogs and killifish. These, in turn, are eaten by larger species such as the bluefish, cod, mackerel and sea bass which enter bays and estuaries to feed. Their loss has degraded those food sources and may have contributed to the decline of sport and commercial fisheries.

Aside from the transition between fresh and salt water conditions, the meeting of the rivers and the sea also results in a range of acidity in estuarine waters. Our rivers are rather acidic, with a pH of 5.0 to 6.0, whereas normal seawater has a pH of approximately 8.0 (rather alkaline) due to buffering with carbonate and bicarbonates. As with salt content, pH can affect the species of fish to be found at any point in the estuarine system. Mixing and gradual transition from acidic to alkaline conditions is similar to that for salinity. In addition to its effect on aquatic life, the change in acidity also has an effect on water chemistry and the composition of bottom sediments.

Particularly noticeable on the Mashpee River is the effect on dissolved iron. Iron dissolves at higher concentrations in acidic fresh water and is carried along as $Fe(OH)_2$ with the river's flow. However, less acidic sea water cannot hold as much iron in solution. As a result, as pH becomes higher in the estuarine interface zone, iron is "precipitated" out as Fe_2O_3 (rust) and falls to the bottom, giving bottom sediments in certain areas a distinct rusty red color. On the Mashpee River, this occurs in the areas just upstream from Amos Landing. Similar chemical changes, along with the slow water flows at the river/tidal interface, can result in the deposition of other elements, including heavy metals and other hazardous materials, in estuarine sediments.

If you were to take a canoe trip down the Mashpee River from Route 28 to Popponesset Bay, you would probably not notice the change in salinity or even the red bottom sediments caused by iron precipitation. However, you would certainly notice the changing water levels caused by the tides, which have a range of approximately 2.5 feet in our bays and estuaries. You will also notice a change in the riverside marshes and wetlands that is quite dramatic in that two mile stretch. Near Route 28 and upstream, most of the wetlands associated with the river are palustrine wooded and shrub swamps, some of which were once ditched and cleared as cranberry bogs. Just south of the highway, however, the river becomes gradually wider, the effect of tides begins to be felt, and the streamside takes on the character of a freshwater marsh, with plant species such as the cattail, bulrushes, wild rice, buttonbush, arrow-arum, pickerelweed and similar marsh species predominant.

Whereas most riverine wetlands appear in narrow bands along the shore, here the effect of the tides broadens the wetlands as we go further downstream and produces a unique tidal freshwater marsh environment. These marshes, unlike inland freshwater marshes, are subject to the constantly changing water levels brought by twice-daily tides. In addition, this is fresh water, not the tidal brackish or salty water found in salt marshes. When the salt water tides of the bay meet the river's flow, they have an effect much farther upstream than their actual penetration. They push against the waters upstream, temporarily backing them up in an effect called "tidal bore". Thus, although we've noted that salt is present in the river's water up to Canaway's (Muddy) Cove 1.5 miles upstream from Popponesset Bay, tidal bore causes water level fluctuations a half mile farther upstream at Route 28. It is within that half mile that the unique tidal freshwater marsh dominates the shoreline with a much greater variety of plant species than are found in either inland or coastal marshes. Because of this variety and the very limited areas of the Town where the proper conditions are present, our tidal freshwater marshes deserve special care and protection.

As we continue our journey downriver to Canaway's (Muddy) Cove, the gradual change to brackish and saltwater marsh types becomes apparent. The river broadens out and the marshes become extensive. The source of the name “Canaway” is unknown to the author, but the local residents’ name “Muddy Cove” is quite apt, for it is indeed very shallow and quite muddy, having filled in over the years with the mucky organic remains of generations of marsh plants. From here on down the river and along the shores of all our bays and inlets the salt marsh becomes predominant, covering approximately 250 acres of waterfront.

The extent of our salt marshes was once greater along the west side of Popponesset Bay, in Ockway Bay and Popponesset Creek. However, large areas were dredged and filled during the development of Popponesset and New Seabury. Such filling is not new, and has been one of the major tragedies of our relationship with nature. For although we have in the past seen salt marshes merely as breeding places for mosquitoes, impassable flat muddy places and prime candidates for filling as expensive waterfront real estate, they are instead one of the most productive environments on earth. Except for cultivated sugar cane, no crop exceeds the production of organic nutrients by their dense grasses. These grasses, primarily cordgrass (*spartina alterniflora*) whose stiff 4-6 foot stalks dominate the wet edge of the marsh in the upper half of the intertidal zone, and salt hay (*spartina patens*) whose shorter, finer grasses form extensive flat meadows inland to where cyclical spring tides occasionally inundate their roots, form the basis for a food chain that stretches far out to sea, eventually providing us with our favorite seafood dinners.

Salt marsh grasses grow extremely rapidly. Where sand bars are present in salt waters protected from the ocean's waves, they are often quickly populated by the water tolerant cordgrass. As they continue through annual cycles of growth and death (their visible portions die back in the fall, but their root systems and "rhyzomes" survive to produce a new crop in the spring) the fallen stalks of each years' grasses build up layer upon layer on the original mineral soils of the sand bar. In addition, their roots and stalks slow the flow of water, trapping additional sediments which help raise the marsh to higher and higher levels. Although the level of the sea is also gradually rising, the growth of marsh grasses outpaces it easily, in some cases adding up to one foot of "land" elevation per year. In a mature salt marsh, after hundreds of years of such deposition, the resulting layers of peat can easily reach 20-30 feet in thickness.

As the elevation of the resulting marsh above daily water levels becomes greater and greater, the cordgrass remains exposed for most of each tidal cycle. Such exposure is less than ideal for the cordgrass, and it is eventually replaced by salt hay, which continues the annual cycle of growth and death, further building up the marsh surface. Also present in such areas is *Distichlis spicata*, known as spike grass.

The annual die-back of our salt marsh grasses does more than add to the marshes' elevation. Bacteria in the mud of the marsh and out in the bay break down the fragments of dead grasses that reach them, releasing chemical compounds needed by marine plants and, particularly, by the rich blanket of plankton that floats on our inshore waters. The partially decomposed plant materials known as detritus are washed by the tides out into the salt creeks and bays where they become food for quahogs, clams, scallops and small fish. In addition, living upon the uppermost layer of marsh mud, where oxygen is available, are photosynthetic algae consisting of single cells, filaments and thin mats of tiny shelled diatoms. These algae are active year round and serve as food for such creatures as the rough periwinkle (*Littorina saxatilis*), the mud snail (*Nassa obsoleta*) and three species of fiddler crabs (*Uca pugilator, Uca minax and Uca pugnax*).

Many species feed directly on the marsh grasses themselves. Canada geese feed on spartina rootstocks and stems. Black ducks eat rootstocks and grass seeds. Myriad insect species such as grasshoppers, crickets, ants, stink bugs and caterpillars join in the feast. These insects are, in turn, eaten by beetles, flies, dragonflies, wasps and spiders. All of the insects are food for the

thousands of birds which congregate at the marsh in late summer when insect populations are high. The swallows, in particular, are common at South Cape Beach where they swoop down in swarms to catch greenhead flies in mid flight. They are often joined by kingbirds, robins, redwings and yellow throats.

Aside from feeding directly on the saltmarsh grass roots and seeds, the black duck and other waterfowl, as well as other birds like the sparrows and clapper rails, feed on creatures that also eat the grasses. A favorite dish is the salt marsh snail (*Melampus bidentatus*), which makes for easy pickings as it climbs the grass stems when the tide is high. Fiddler crabs are eaten by ducks, herons and other wading and shore birds. At the top of this food chain, sparrows may be eaten by hawks or owls, and the ducks may end up on our plates.

A good deal of the nutrients produced by the salt marsh may be removed through the air by the birds we've mentioned. More is taken by the blue crabs and diamond-backed terrapins that eat the fiddler crabs. Many of the smaller fish, such as the mummichog (*Fundulus heteroclitus*) and pipefish (*Syngnathus fuscus*) that feed on detritus are in turn eaten by the larger striped bass and bluefish. However, despite all these herbivores and carnivores, the vast majority of the detritus and nutrients produced by the marsh is transported by the tides out to the bays and the open sea where bacteria continues its decomposition and fish and crustaceans use it as a prime source of food. This export of nutrients makes the ocean waters along our coast ten times as productive as the waters of the open ocean. It has been shown that more than two thirds of the fish and shellfish harvested along our coast are directly or indirectly dependent on the salt marsh food chain.

So why do we continue to destroy our marshes? Most of us like seafood, so why are we foolishly eliminating its source? Shortsighted land speculation, a belief that "my little dock won't do any harm", and a sad lack of knowledge of our natural world and its processes all seem to be at fault. Our ancestors on the Cape realized the value and abundance of the salt marsh. Although they may not have known that the fish and shellfish they caught were dependent on it, its rich crops of salt hay were coveted. In Mashpee, numbered lots of salt marsh were auctioned off each year for harvesting by the highest bidder. Over the years, however, as the hay became less important we lost sight of the marshes' value. Just since World War II more than 20,000 acres of salt marsh have been filled in Massachusetts alone, quite a few of them here in Mashpee. It's time we changed our ways.

7. Dunes and Beaches

Protecting our bays and marshes from the waves and the fury of open ocean storms are two vital barrier beaches; Popponesset Spit, protecting Popponesset Bay and its tributaries, and Dead Neck, which, along with nearby Washburn Island in Falmouth, shields Waquoit Bay and its environs. Here is the world of sand dunes. Not large or numerous in Mashpee, they are a pretty place for a stroll or to watch the terns and swallows as they swoop and dive.

Here, another type of grass is critical to the very existence of the barrier beach system. Where the salt marsh grasses thrived in an extremely wet environment, these grasses and other dune plants must survive in extremely dry soil conditions and in the face of constant abuse by wind,

salt spray and blowing sand. Chief among them is American beachgrass (*Ammophila brevigulata*). Spreading rapidly via horizontal runners, or "rhizomes", each blade of this grass traps wind-borne sand around it. As more sand is trapped, it forms higher and higher hills, which become dunes.

Amazingly, where most plants would be killed if buried in sand, the same conditions stimulate beachgrass to grow more rapidly so that a cycle of growth and sand deposition and more growth results in the rapid creation of large dunes. Such dunes have grown to heights of 400 feet or more in areas such as the coastal barrier islands of North Carolina and the tip of Cape Cod at Provincetown. Those areas are directly exposed to the fierce winds of ocean storms, and so dune-building processes are extreme. Our dunes are much smaller by comparison and have been significantly disturbed by man's activities.

Both Popponesset Spit and Dead Neck are basically sand spits which have been built up from sandy materials washed from Succonesset Point and nearby eroding sand cliffs by storm waves, and carried to the spits by the action of waves in a process known as “littoral drift”, which we will discuss later. Once the sand reaches the spits, it is either blown inland by coastal breezes, which in the summer generally come from the southwest in Mashpee, or it is washed over and onto the spit and dunes by storm waves, a process called, logically enough, “washover”. While washover can move large volumes of sand very quickly, it is fairly infrequent.

The action of the wind, however, is constant. Grains of sand are continually blown up from the beach to the dunes and around the dune system. Where beachgrass and other plants are present the sand is trapped and helps to build dunes. Where no grass is present, the sand moves on until it is stopped by vegetation or blows into the waters of our coastal bays and salt ponds. The lack of grasses can quickly lead to severe wind erosion of the barrier beach dunes, creating “blowouts” and destroying the barrier beach’s ability to protect inland areas from storm waves.

A blowout can lead to a washover and, occasionally, in large storms, wave erosion of the barrier beach so extensive that the sea cuts right through, eliminating the barrier beach’s protective shield against flooding and erosion in the bays and estuaries. The washover and cut of North Beach in Chatham in the late 1980s is one demonstration of the consequences which accompany the loss of a barrier beach. Washovers which occur on Popponesset Spit directly opposite Popponesset Island are a warning of similar possibilities in Mashpee.

Knowing the value of our barrier beach dunes, then, we must take steps to protect them. In the past our spits have been leveled and seriously altered to accommodate beachgoers and parking for their cars. The vital beachgrass has been trampled in too many places and occasionally run over by four wheel drive vehicles, not only killing the grass but destroying the vital network of roots and rhizomes that holds our dunes in place. Management efforts in South Cape Beach State Park have helped to protect and restore the dunes, but the Park also brings the crowds of people that could destroy them. Popponesset Spit is in private hands and is de-facto protected by limited access, but the imminent threat to millions of dollars in real estate illustrated by washovers during coastal storms is an incentive to those responsible to protect what little is left of its grasses and dunes and thus avoid the costs of carelessness.

Now that we have reviewed the values of our estuarine wetlands and dunes, we come to the fun part. The journey of the drop of water that fell in Sandwich, percolated into the groundwater table, found its way to a spring in Mashpee Pond and then down the river past abandoned cranberry bogs, wooded swamps, the cattails of the tidal freshwater marsh, the spartina grasses of the salt marsh and into Popponesset Bay, has ended in the open breezy waters of Nantucket Sound. Here is where the land meets the sea on our bright and splendid coastal beaches. From Popponesset Spit, to Popponesset Beach, Rock Landing, Succonesset Point and South Cape Beach to Dead Neck they form a golden ribbon of sand five miles long that is a joy to sunbathers and fishermen, swimmers and shore birds, admirers of the long view to Martha's Vineyard and the tiny treasures of sea shells. The beach is a prime mover of both our economy and of our souls. It is a place to contemplate, to relax and have fun.

It is not a permanent place, but constantly changing, ever new. The tides and waves, storms and calm, fog and baking sun are daily variables that cannot escape our attention. However, on both larger and smaller scales, other changes are taking place that are not so easily noticed. The beach itself is moving, sand grain by sand grain. When the wind blows, we can see it move. It gets into our picnic baskets and covers our beach blankets. As we noted before, this blowing sand often moves inland to become part of sand dunes. But how did it get to the beach in the first place?

As with so much of the basic structure of Mashpee, its origins have to do with the great glaciers of the Ice Age. The outwash sediments that they produced make up all of Mashpee. At the same time, the melting of the glaciers resulted in higher and higher sea levels. When the glaciers were at their peak, what is now Mashpee was miles from the ocean, part of an area of plains and low hills which stretched 200 miles east on what has come to be called "George's Cape". As the sea level rose, part of George's Cape became cut off to become "George's Island". Finally the rise of the sea and the action of sea waves eroded and drowned the island now known to us as "George's Bank", the great fishing ground of New England, while the remainder of George's Cape became today's Cape Cod.

At the same time, the rising sea was moving ever closer to Mashpee's current shoreline. As it did, and as wave action eroded the land, the outwash sediments became suspended in the turbulent sea waters and moved with ocean currents. Over the centuries the pattern of those currents has certainly changed, and sand at the sea bottom and along our beaches could have come from anywhere nearby, even from old George's Island, stirred up from bottom sediments and washed ashore by storm waves.

However, much of our beach sand comes from a more local source. Continuing the process of coastal erosion that began as the sea started its post-glacial rise, storm waves eat away at the sea cliffs of Succonesset Point and Rock Landing. With each winter the sea slowly pushes closer to the heart of Mashpee. The erosion at Succonesset is not as spectacular as that along the bluffs of the outer Cape at the National Seashore where the sea's annual landward progress can be measured in feet. Succonesset is exposed to the less violent waters of Nantucket and Vineyard Sounds (it is actually on the dividing line between the two) where average annual erosion is measurable in inches. But as the level of the sea continues to rise, Succonesset Point and the bluffs along our coast will continue to disappear.

When storm waves come, they undercut the bluffs and cause landslides that deposit glacial silts, sands and stones on the beach in front of them. Movement does not end with the storm, however. As each wave hits the beach, it stirs up the sand grains and, as with rivers and streams that carry sediment, is able, based on its speed and force, to carry away particles of various sizes. The wavelength, or distance between wave crests, also plays a role in how much sediment the waves move by determining how deep into the water their influence is felt. Generally, waves are able to stir up bottom sediments to a depth that is one half their wavelength. Thus, large waves with longer wavelengths move not only the sands that lie on the beach but also sediments yards away under the water. Storm waves can move boulders, but even the small wavelets of a calm day can move a bit of silt and sand.

If our coastline was perfectly straight and each wave approached it at a right angle, the sand grains that were stirred up by waves would simply move back and forth on the same stretch of beach and the shape of our coastline would remain the same. But the coast is not straight and waves approach from a variety of angles based on wind and weather patterns far out to sea. As a result, a grain of sand that is picked up by a wave as it strikes the beach will not be returned to the same spot as the wave breaks and retreats back to the sea as backwash. Instead, it will be moved down the beach a ways in the direction that the wave hit the beach. As one wave after another picks up the sand grain, it is moved up, then down the beach and along the beach as well in a zig zag pattern. This process of movement is known as “littoral drift”.

In slightly deeper water out a ways from the beach, a second sand moving process is at work as well. Sediments stirred up as the waves approach the beach are moved along the coast by ocean currents. Along Mashpee’s coast, those currents strike Succonesset Point head on at a right angle and then split in half, heading east along the shore towards Popponesset Spit and west towards Dead Neck. Those east and west currents become “longshore currents” and they carry suspended bottom sediments, as well as the sands washed from Succonesset Point, along with them. As wave lengths and wave activity are increased or reduced under the influence of the weather, the shape of the coastline or depth of the bottom, sediment is picked up or dropped off along the coast. Where it is dropped off, it piles up, resulting in shallower and shallower water depths and a “sand bar.”

Further deposits of sand, particularly during storms, can result in a sand bar whose top lies above the normal surface of the water. Once that happens, the wind begins the process of dune formation, the seeds of beachgrass arrive and soon a sandy bit of land has built up where once there was only water. Where this land is separate from the mainland, it often forms what is known as a “barrier island” across a bay mouth, protecting the waters of the bay from storm waves and allowing the development of salt marshes. In Mashpee we have no barrier islands, but have instead “barrier spits” which are in all respects the same but are connected at one end to the mainland. Popponesset Spit and Dead Neck are our barrier spits, protecting Popponesset and Waquoit Bays from ocean waves and allowing the development of salt marshes and of sheltered waterfront real estate.

Where a spit grows completely across the mouth of a bay, blocking off the flow of salt water, it is called a ‘barrier spit” or “baymouth barrier”. In Mashpee we have two such barriers, one of which was completed only within the last 150 years. Separating Great Flat Pond from the sea, the final blockage of its’ outlet caused great concern among the inhabitants of the Marshpee

District who were used to fishing its waters for ocean species and herring or potting or spearing eels. In 1878 they voted to create a ditch between Great Flat and Sedge Lot Ponds, behind South Cape Beach, in an effort to maintain the valuable tidal fishery. That ditch still flows, as do the tides in and out of Great Flat Pond, but its plant life and environment are more and more that of a fresh water tidal marsh since its main source of water is now groundwater springs rather than the sea. The other bay now cut off from the sea by a barrier beach is little Dean's Pond in Popponesset, now entirely a fresh water pond.

As we walk on our beach, we become aware that the beach is more than just sand and water. It is also home, although a very uncomfortable and challenging home, for a variety of creatures. In an ecologist's terms, beaches are the most physically stressed, and least productive, ecosystems among the estuarine wetlands. They are made up of constantly shifting materials fully exposed to wave and tidal energy. No plants can find a safe anchorage, except the unicellular algae which are the beach's only primary food producers. The beach is subject both to inundation by cool ocean water and rapid drying (its sandy materials percolate very rapidly) with accompanying oven-like summer temperatures. Moving sands borne by wind or water in turn bury, then expose, beach organisms. Washing by waves cleans the sand of a large amount of organic materials which could have served as food sources.

However, food does exist within the sands of the beach. Along with bacteria and diatoms, microscopic green algae live on the surface of the sand grains, feeding on organic molecules in sea water which is washed up by wave action, then drains down between the sand particles, often becoming attached to their surfaces. These tiny organisms are, in turn, eaten by single celled animals called protozoans. Largely made up of a diverse group of ciliates, these protozoans, although invisible to us, can add up to a huge mass of food for larger animals.

Those "larger" animals, most ranging from 1/12 to 1/15 inch in size, are collectively referred to as the "meiofauna" (middle-sized animals). This group of creatures is dominated by the nematodes, or roundworms. One of the most numerous and successful animals on earth, inhabiting just about every kind of habitat there is, our nematodes range from an average 1/16 inch in length to almost an inch. All are able to wiggle their way through the sand grains, eating the algae and other microorganisms, as well as other nematodes.

Gastrotrichs are flattened, elongated creatures somewhat like nematodes that wander among the sand grains sucking up microorganisms. Tiny crustaceans also are abundant in our sands. Related to lobsters and crabs, they include copepods, which crawl around the sand grains on tiny legs, and ostracods, which look a bit like miniature clams. Also walking around on four pairs of stubby legs is the tardigrade, or "water bear", which punctures the diatoms and blue green algae cells and sucks out their contents. Finally, the turbellarions, or flatworms, are carnivores which eat protozoans, copepods, ostracods and just about anything else smaller than them. For short periods of time, other creatures join the meiofauna between the sand grains. Until they grow too large, the larval and juvenile stages of snails, bivalves, crustaceans and polychaete worms feed on the protozoans and meiofauna.

Because there is so little plant life on the beach, what animal life there is must subsist on the microfauna and meiofauna, or on detritus which originates in more productive areas such as the salt marsh or shallow areas of the sea bottom. Most such animals are filter or deposit feeders like

the surf clam, mole crab and various burrowing amphipods that live below the surface of the sand. When the tide comes in, they extend their siphons and tentacle plumes to feed on water-borne detritus, phytoplankton or zooplankton. Crabs and snails live in burrows under the surface as well, emerging with the incoming tide to search for food. Along with fleas, flies and beetles, they feed among the drifted detritus left at the high tide line.

On our beaches, there will usually be two or more rows of such drifted materials, the highest row indicating the height of the most recent spring tide (twice a month highest tide), the lowest indicating the height of the most recent high tide. These rows are usually composed of seaweeds, which are algae such as Irish moss (*Chondrus crispus*), a red algae sometimes called "dulse", palmated ("fingered") kelp and perforated kelp (*Laminaria*), which are brown algae and among our largest varieties of seaweed, common rockweed (*fucus*), a brown algae with air bubbles along its midrib which cause it to float, and sea lettuce, the largest green algae, which comes in a flat oval form (*Ulva lactuca*) and a thin ribbon-like form (*Ulva lanceolata*), both of which have ruffled edges and a brilliant green color. Also present at the drift line are the remains of eel grass, which is not an algae like the seaweeds, but rather a unique marine seed plant.

All manner of other dead animals, plants and man-made materials may also be found among the drifted line of seaweeds. Jellyfish and an occasional poisonous Portuguese Man-of-War may be seen shining among the weeds, their globs of jelly and colorfully ribbed air sac providing a smooth contrast to the tangled mass of weeds. Unfortunately, globs of another sort, gooey crude oil from the occasional tanker spill or wreck, can sometimes be found, much to the displeasure of an unwitting walker.

Curious plant-like animals also find their way to the drift line. "Sea Pork" (*Amaronicum*) is an orange to pale yellow colony of primitive "sea squirts" shaped like a rubbery warped hot dog. And then there is the eerily-named "Deadman's Fingers" (*Haliclona occulata*), a yellow to orange sponge resembling a cluster of fingers which is often washed up onto the beach during storms. Storms have also provided, at least during the days of wooden sailing ships, some of the more interesting man-made items which have washed up from the sea. Today, unfortunately, the flotsam washed from the sea is more likely to include plastic or styrofoam trash which poses a significant threat to marine mammals and waterfowl, as well as to the beauty of our beaches.

Although insects are uncommon at the beach, two types become readily apparent if one disturbs the detritus at the drift lines. Flies, including the vicious biting greenhead fly, are often present, feasting on the rotting organic debris. Underneath the piles of seaweed, temporarily visible if one moves aside the weeds, are numerous tiny crustaceans called sand fleas or "beach hoppers" which eat the seaweed and burrow in the sand.

Although such curiosities as sea pork and deadman's fingers are interesting, sea lettuce, kelp and Irish moss may be edible, and an occasional interesting piece of driftwood or other man-made object may wash ashore, the real prize and attraction to the beachcomber are our beautiful and varied seashells. Constituting the earthly remains of echinoderms (spiny skinned animals like the sand dollar, sea urchin, sea cucumber and starfish), gastropods (snails, periwinkles, and the large channeled and knobbed whelks) and mollusks (clams, scallops, oysters, mussels, cockles, jingles and slippers), they provide an endlessly renewed treasure trove for delighted visitor and native

alike. Many a morning has been spent combing the beaches of Mashpee for that "perfect" specimen.

Our glacial past provides other colorful and unique jewels, washed down from northern hills and polished by the sea. Colorful stones sprinkled along the edge of the water are washed to shore by the incoming swash of waves, but unlike the smaller grains of sand which continue on their zig-zag course in the process of littoral drift, these stones are left behind by the weaker energy of backwash returning to the sea. Thus stranded, they provide an endless variety of semi-precious pebbles of quartz, feldspar, granite, gneiss, sandstone, phyllites, graphite, argillites, coal, brick, and the colorful fragments of old glass rounded and frosted by the surf.

Our beaches also provide for more active pursuits. Swimming, of course, is the classic beach activity at both the state park and South Cape Town Beach, as well as the private beaches of Popponesset and New Seabury. Sunning and picnicking occupy the swimmers when they finally retreat from the water. At Rock Landing and Popponesset Beach, windsurfing and sailing are enjoyed. Surfing is not a viable pastime, however, on the tiny waves of Nantucket Sound.

The jetties on Dead Neck at the mouth of Waquoit Bay are the year-round home of both fish and fishermen, and when the swimmers have gone and the weather turns colder, the surf fisherman reigns supreme, lined up in rows along South Cape Beach. Even before the beach blanket and the bikini, the fishermen were there. When our ancestors in the Great and General Court decided to turn over the ownership of the waterfront and beaches to private individuals, they kept for the public two rights upon the beach, fowling and fishing. In a Commonwealth whose symbol is the cod and whose heart and business have so long been tied to the sea, it could be no other way.

8. The Sea

"Men that go down to the sea" have long been a staple of the legend and lore of Massachusetts, and especially of Cape Cod. The first white men to see the Cape were either the Viking seamen of Leif Ericsson or French and Portuguese fishermen harvesting the rich bounty of George's Bank. Even before the Pilgrims came across the sea, those fishermen had landed on the Cape and made contact with the local Indians. The Wampanoags themselves were no strangers to the sea, not only enjoying its fruits of fish and shellfish, but also traveling along the coast and out to Martha's Vineyard and Nantucket in the sea-going canoes they carved from the giant trees that covered Cape Cod.

As soon as the Pilgrims settled in, seaborne commerce began not only with the Indians, but also with outlying settlements that were quickly established along the edge of Cape Cod Bay and the Boston area as well as with the Dutch in New York and Connecticut. Fishing quickly became established as a prime source of sustenance for the Pilgrims and those who followed, and almost every coastal town had its harbor and boatyard. By the 19th century, fishing was a major enterprise, with swift schooners cruising the Grand Banks off Newfoundland as well as the waters closer to home. Farther off at sea merchantmen, and eventually the famed clippers, extended New England's trade routes to all parts of the world and brought great wealth to their owners. Fantastic fortunes were made in whaling as well. Concentrating at first on Nantucket

when local stocks of whales were plentiful, the whaling industry soon came to dominate other local ports, with its greatest home in New Bedford.

Most Cape Cod towns other than Mashpee have dozens of classic mansions and homes built with the riches of ship owners and sea captains. Mashpee has no such mansions, but nonetheless played a role in the fishing and whaling industries. Mashpee Wampanoags often went to sea and were famed for their prowess with the harpoon. Although most did not become rich men in the dangerous and low paying jobs they were allowed, at least one did quite well for himself. Solomon Attaquin saw the world as a seaman, going to sea as a 12 year old cook on a fishing schooner, becoming a whaler at fourteen, and visiting Europe and the West Indies on merchant ships. Retiring from the sea at age 24, he returned to Mashpee where, in 1840, he opened the famous Attaquin Hotel and began a 22 year career in various District and Town offices, becoming one of the Town's first selectmen.

Mashpee has never had a deepwater port or the fleets of fishing vessels and merchantmen that made some of our neighbors rich. But what was not had in the way of monetary wealth was kept in the beautiful, clean and productive shellfish beds and bays we inherited. New Bedford got the riches of the whaling business, but got a polluted and dead harbor in the bargain.

Mashpee does not have the industrial waste discharges and sewage outfalls of New Bedford and other harbors, but we have had a major impact on the quality of our sea waters. The sheer number of people and homes has resulted in groundwater pollution from septic systems, road drains, fuel storage, fertilizers, pesticides and careless dumping of hazardous materials on the ground, and direct pollution of our bays by salt, petroleum products, fertilizers and animal droppings washed off roadways and parking lots by rainfall and snowmelt (itself contaminated by nitrogen oxide, mercury and other contaminants blown in from the Midwest and mid-Atlantic states). Discharges from large boats moored in our waters can add to the contamination, although they have now been banned and pump-out facilities have been made available in our bays. However, high-powered boats still damage the bays by discharging exhaust oil slicks and stirring up bottom sediments with their prop wash. Along with algae in the water column resulting from over-nutrification from septic systems, cranberry bogs and lawn fertilizers, the latter results in an almost muddy bay, cutting off sunlight to phytoplankton and bottom vegetation and burying vegetation and shellfish alike in layers of sediment and dead algae which settle out when things are quieter. Marsh vegetation, a primary nutrient source for juvenile fish which also helps reduce nitrogen impacts on our bays, is also being damaged by boating activity and docks.

Through over-nutrification, we have destroyed virtually all of our eel grass beds, eliminating the "childhood home" of the scallops which were once abundant in our bays. Over-nutrification has led to excessive levels of aquatic vegetation in some areas which, along with feeding by humans, results in artificially high numbers of waterfowl. The ducks, geese and swans bring their own bacterial and other pollutants into the estuarine environment and have been at least partly responsible for the contamination and closure of shellfish beds.

Although we might not have thought about it, materials are also blown by winds from the land's surface into the sea. Along with river flows and groundwater springs, the winds deliver sands and silts, organic particles and pesticides, automobile exhaust and acid rain to the sea. Although

this land-to-sea movement contributes basic materials for the building of coastal forms and is a source of salts and chemical nutrients necessary to the health of coastal and oceanic systems, it also brings waste products which are often harmful, either because they are over-concentrations of otherwise useful and needed materials, or because they are directly toxic to living things.

Man's refuse does not come only from his landward activities. Out at sea we continue an even more direct abuse of its waters, dumping garbage, sewage, bilge water, fuels, radioactive wastes and other signs of our passage. Sinkings and other marine accidents result in major oil spills. The sea is a very large place, but even it can only take so much abuse.

In one way, the sea may get some measure of revenge for our mistreatment of its waters. As noted previously, the level of the sea continues to rise as the polar ice cap continues the shrinkage that began when the Wisconsin Ice Age glaciers retreated from our area. At the same time, the land under us is sinking. When Mashpee was covered by glaciers, the weight of the ice caused the earth's crust below it to sink. As the ice melted and this weight was removed, the land first rebounded, springing a bit higher than its original elevation. At that time, the rise in land elevation outpaced the rising sea. Now, however, that rebound has ended and the land is once again subsiding, while the sea continues to rise. Data from the last 100 years indicates that two thirds of the apparent (or relative) rise in sea level actually results from the sinking of the land. Over the last 40 years, this relative sea level rise has ranged between 2 and 3 millimeters per year.

However, mounting scientific evidence indicates that our release of carbon into the atmosphere, through the burning of hydrocarbon fuels, is causing a global climatic warming. Carbon dioxide in the atmosphere traps solar radiation which might otherwise be reflected back out into space. The result is a gradual warming of the atmosphere known as the "greenhouse effect". The warmer atmosphere causes increased melting of the ice caps and thus increased sea levels. Some scientists believe that this effect and the resulting melting is accelerating rapidly. Whereas relative sea level in our area has increased by 0.5 ft. in the last 60 years, they predict that it could rise by an additional 1.8 to 11.3 feet by the year 2100.

If that is the case, significant portions of our coastline will be submerged within the next 100 years. In addition, even apparently high locations like the bluffs at New Seabury will be severely affected, since higher sea levels will result in the submergence of coastal jetties and other protective devices and storm waves having a much greater erosive force on coastal banks will bring them down. All of the beach nourishment and sea walls we can pay for may become pointless. While waterfront real estate may have been a profitable investment until now, building on the fragile edge of the sea might not have been such a bright idea after all.

9. Water Quality Classification

While Mashpee's bays, ponds and rivers have suffered much in recent years due to over-nutrification and, in a few cases, suspected contamination from hazardous waste sources, under the state Division of Water Pollution Control's classification system they are generally considered to be in good condition. That classification system, which was adopted under the provisions of the Massachusetts Clean Waters Act, M.G.L. c. 21, ss. 26-53 (which itself was adopted in response to the Federal Water Pollution Control Act), designates the uses for which

the various waters of the Commonwealth shall be enhanced, maintained and protected. For each class of waters, water quality criteria are prescribed which are required to sustain certain designated uses, along with regulations necessary to achieve the designated uses and maintain existing water quality, including, where appropriate, the prohibition of discharges. The classifications and regulations are specified in 314 CMR 4.00.

A number of Mashpee water bodies have been designated as "Outstanding Resource Waters" under 314 CMR, Section 4.04. These include Great Flat Pond, Fells Pond, Lilly Pond (also known as Little Flat Pond), Sedge Lot Pond, Witch Pond, Red Brook, Hamblin's Pond, Jehu Pond and the portions of Waquoit bay which lie within the Waquoit Bay Area of Critical Environmental Concern (ACEC). All vernal pools certified by the state's Natural Heritage & Endangered Species Program are also automatically designated as Outstanding Resource Waters. Under the state's regulations, new or increased discharges of pollutants into these waters are prohibited.

All inland waters in Mashpee have been designated Class B. Waters assigned to this class are designated for protection and propagation of fish, other aquatic life and wildlife, and for "primary and secondary contact recreation". Primary contact recreation is "any recreation or water use, such as swimming and water skiing, in which there is prolonged and intimate contact with the water sufficient to constitute a health hazard". Secondary contact recreation is defined as "any recreation or water use in which contact with the water is either incidental or accidental, such as fishing, boating and limited contact incident to shoreline activities". For Class B inland waters, the following minimum criteria are applicable:

WATER QUALITY CRITERIA FOR INLAND WATERS - CLASS B

PARAMETER	CRITERIA
Dissolved Oxygen	Minimum of 5.0 mg/l in warm water fisheries and a minimum 6.0 mg/l in cold water fisheries. A cold water fishery is defined as waters whose quality is capable of sustaining a year-round population of cold water trout (salmonidae).
Temperature	Shall not exceed 83 deg. F (28.3 deg. c) in warm water fisheries or 68 deg. F (20 deg. c) in cold water fisheries, nor shall the rise `resulting from artificial origin exceed 4.0 deg. F (2.2 deg. c).
pH	Shall be in the range of 6.6 -8.0 standard units and not more than 0.2 units outside of the naturally occurring range.
Fecal Coliform Bacteria	Shall not exceed a log mean for a set of samples of 200 per 100 ml, nor shall more than 10% of the total samples exceed 400 per 100 ml during any monthly sampling period, except as provided in 314 CMR 4.02(1).

Mashpee's coastal and marine waters, i.e. those subject to the rise and fall of the tide, have been designated Class SA. Waters assigned to this class are designated for the uses of protection and propagation of fish, other aquatic life and wildlife, for primary and secondary contact recreation

and for shellfish harvesting without depuration in approved areas. Minimum water quality criteria are as follows:

WATER QUALITY CRITERIA FOR COASTAL AND MARINE WATERS - CLASS SA

PARAMETER	CRITERIA
Dissolved Oxygen	Shall be a minimum of 85% of saturation at water temperatures above 77 deg. F (25 deg.c) and shall be a minimum of 6.0 mg/l at water temperatures of 77 deg. F 925 deg. C) and below.
Temperature Increase	None except where increase will not exceed the recommended limits on the most sensitive water use.
pH	Shall be in the range of 6.5-8.5 standard units and not more than 0.2 units outside the naturally occurring range.
Total Coliform Bacteria	Shall not exceed a median value of 70 MPN per 100 ml and not more than 10% of the samples shall exceed 230 MPN per 100 ml in any monthly sampling period.

10. Recreational Uses

Mashpee's water bodies provide the vast majority of its outdoor recreational opportunities. Our Cape Cod location means beaches and bays, swimming and sailing, shellfish and dune walks to locals, summer residents and thousands of visitors from around the world. Like all of our neighbors on the Cape, both our economy and our way of life revolve around the pleasures to be found in and around water.

Located on Nantucket and Vineyard Sounds, Mashpee has 5.27 miles of ocean beaches. Until 1983, almost none was publicly owned, the only exception being the 0.38 mile Town Beach acquired in the early 1960's and a tiny (0.09 mile) stretch in Popponesset owned by the state's Division of Fisheries and Wildlife and used as a fisherman's access to Nantucket Sound.

The acquisition by the Massachusetts Department of Environmental Management (now Division of Conservation & Recreation) of 432 acres of beaches, dunes, salt ponds, marshes and coastal woodlands in 1983, most of which had been permitted for intense residential and commercial development by the New Seabury Corporation, greatly changed the situation and created one of Mashpee's crown jewels. **South Cape Beach State Park** put another 1.33 miles of our beaches, extensive Waquoit Bay frontage, two coastal ponds and extensive salt and freshwater wetlands into permanent public ownership. An additional 63 acres was added to the park in1995.

In 1995, the state also opened a new 200 car parking area and beach facility to replace temporary facilities used since the park's opening. Originally intended to replace the Town's current facility, the new beach is likely to remain in state ownership due to Mashpee Town Meeting's rejection of a proposed swap of lands with the state. Unless such a swap occurs, it is likely that the state's original plans for an additional 400 car parking area, visitor center and new beach

facility to replace the current Town Beach will remain on hold indefinitely. However, the Town has now acquired from the state a 10 acre site at the mouth of Great River which would have been part of the proposed trade. No specific plans have been made for the use of that site.

The existing **South Cape Town Beach** has seen recent storms eat away at its once-200+ car parking area. By 1996 parking capacity was reduced to 166 spaces. In early 1996, volunteers led by the Harbormaster created a 100-foot section of experimental "sacrificial dune" seaward of a portion of the parking lot, which sits directly on the beach, a federally-designated coastal barrier beach on which new "hard" construction is prohibited, in an attempt to save what is left of the parking lot from further storm damage. The experiment has only been partially successful, with major damage occurring to the parking area in recent storms. By 2007, capacity was further reduced to 138 spaces, of which 7 were designated for handicapped parking

Mashpee residents and visitors alike crowd both the Town and state beaches during the summer months, with the parking lots filling early on peak weekends. In an attempt to provide alternative access, the Town and Cape Cod Regional Transit Authority instituted a "Mashpee Trolley" bus service to the beach from many Mashpee neighborhoods in the summer of 1995. The service was repeated in 1996, but did not prove cost effective and was abandoned.

Both beaches provide lifeguard protection during the summer months, allowing safe swimming in the clam waters of Vineyard Sound. Aside from other traditional beach activities such as sunbathing and picnicking, South Cape Beach is also a beautiful place for a walk. Dead Neck, with a mile of small sand dunes which form a barrier beach for Waquoit Bay, offers walking along both the Vineyard Sound beach and the shores of Waquoit Bay and Sedge Lot Pond, as well as along an old road which runs through its center to the stone jetties at the entrance to the Bay. The jetties themselves are a popular fishing area. Surf fishing also occurs along the beach, primarily in the "off" season, and shellfish harvesting is popular along the Waquoit Bay shore.

Inland, the state park offers hiking trails and old sand roads for exploring the wonders of coastal forests, cool bogs, marshes and pristine Great Flat Pond, a former arm of the sea now cut off and become a mostly fresh water pond and marsh. Both the state and the Mashpee Conservation Commission offer guided nature tours through the varied habitats of the park, which hosts nesting ospreys, piping plovers, terns and other fascinating wildlife. For more sedentary nature lovers, watching the swans on Sedge Lot Pond, particularly in combination with a beautiful sunset, is one of the park's most treasured memories.

Mashpee also has two fine fresh water beaches. The town beach at **Johns Pond Park** Conservation Area, previously leased from private owners by the Coast Guard for the use of military families from the Massachusetts Military Reservation, was acquired by the Town in 1983 with the assistance of a state Self-Help Program grant. It offers lifeguard-protected swimming in addition to playground facilities, a picnic area and four miles of sand roads and walking trails, while 17-acre Moody Pond is favored for fishing and canoeing. Because the park was acquired with state funding assistance, its facilities are open to all residents of the Commonwealth.

Johns Pond Park also includes thirty acres of cranberry bogs that once provided a fascinating look at that part of the Cape's history and economy. However, while the bogs are still maintained to a certain extent by a contractor, they have not been harvested commercially in recent years due to contamination by EDB originating in a fuel spill area at Otis Air National Guard Base. The Ocean Spray cranberry cooperative will not accept berries from the bog until it has been cleaned up and stayed clean for a number of years. A treatment plant to treat water extracted by a series of wells from this "FS-1" plume was built by the military adjacent to the northeast portion of the bogs in 1999 and is scheduled to continue in operation for up to twenty more years. The treated water is discharged back into a portion of the bogs via bubblers. Recent testing had shown clean waters in all but a small portion of the bogs, but they have not been restored to commercial production.

Our other fresh pond beach, open only to Mashpee residents, is the beautiful **Attaquin Park** beach on 729 acre Mashpee/Wakeby Pond. Located at the head of the Mashpee River in the heart of the traditional Wampanoag village of Mashpee, the beach has long been a favorite summer cooling-off spot. It offers lifeguard-protected swimming, playground facilities and a picnic area as well as 8.4 acres of ancient forest. It once also boasted a well-used baseball diamond, now replaced by the facilities of Heritage Memorial Park and totally overgrown. For a brief time in the 1970s it also hosted a re-creation of a Wampanoag encampment.

Also located on Mashpee/Wakeby Pond is The Trustees of Reservations' **Lowell Holly Reservation**. Occupying a peninsula called Conaumet Neck, which divides Mashpee Pond into "Mashpee Pond" and "Wakeby Pond", it offers public access (for a fee during peak summer months) to over two miles of shoreline and beautiful stands of American Beech, holly, white pines and rhododendrons. Facilities include 1.5 miles of walking trails, picnic tables and a small swimming beach on Wakeby Pond (no lifeguard).

There are no public beaches on Santuit Pond or Ashumet Pond, Mashpee's other large freshwater ponds, although there is a Town Landing, with an unpaved boat access suitable only for small boats and canoes, on Santuit Pond. Much of the southern shore of the pond, as well as the northern tip, however, are publicly owned. On the other hand, there is no public land at all on the Mashpee portion of Ashumet Pond or on any of the town's other small freshwater ponds (other then Moody Pond, mentioned above in Johns Pond Park).

Public ownership and access along Mashpee's rivers is another story. Major efforts have been made over the years to acquire public lands along the Mashpee, Quashnet, Childs Rivers and Santuit Rivers which have resulted in extensive opportunities for river-related recreation.

Almost the entire length of the **Mashpee River** is protected as open space by the Town, The Trustees of Reservations and the Mass. Division of Fisheries and Wildlife (DFW).

The Mashpee Conservation Commission owns 433.33 acres along the river. At the head of the river is the 1.8 acre Mashpee Pond Conservation Area, adjacent to 8.4 acre Attaquin Park with its public swimming beach. The 431.53 acre Mashpee River Woodlands Conservation Area consists of the 15.22 acre Lopez property and the 11.2 acre Fitch property on Meetinghouse Road adjacent to The Trustees of Reservations Mashpee River Reservation, both with limited walking

trails and parking areas, the original 391.41 Mashpee River Woodlands property south of Route 28, most of which was purchased with the assistance of state Self-Help and federal Land & Water Conservation Fund grants, and the 13.7 acre Harry Desrosiers memorial property, which was donated in a property tax deal by the Stenberg family. The original Woodlands property offers more than eight miles of maintained trails and sand roads through cool pine forests with spectacular views of the river, salt and fresh water marshes and abandoned cranberry bogs. The area is popular for fishing, canoeing and bird watching and is the site of many of the Conservation Commission's guided nature tours throughout the year. Parking areas and trailheads are located on Mashpee Neck Road, Quinaquisset Avenue, River Road and at the Desrosiers property on Great Neck Road South.

More recently, the Town, using Cape Cod Land Bank funds, has acquired additional properties in the Mashpee River corridor, including the 9.3 acre Attaquin Hotel property on Route 130 adjacent to Attaquin Park and the Town's 2.7 acre Veterans Memorial Park (a.k.a. Collins Lot) and the 16.46 acre Rothschild Trust property (which had been proposed as the Mashpee Place shopping center) immediately west of the River on Route 28, both of which are under the control of the Board of Selectmen. No public access facilities have been developed to date at these Land Bank properties.

The Commonwealth of Massachusetts Division of Fisheries & Wildlife owns the 33.2 acre Fishermen's Landing boat ramp property just east of the head of the river adjacent to Attaquin Park. It also owns a series of parcels totaling 56.78 acres along the river between Route 130 and Meetinghouse Road, including a number of abandoned cranberry bogs and a permanently flooded bog called Washburn Pond. Limited fishing access is available at Washburn Pond.

The Trustees of Reservations' 230.96 acre Mashpee River Reservation stretches downriver from the Mass. DFW lands mentioned above, abutting the Lopez, Fitch and Rothschild Trust properties between there and Route 28, to Canaway's Cove south of Route 28 adjacent to the main Mashpee River Woodlands property. It includes well-developed trails and a canoe access point known as Farley's Camp south of Route 28 (although vehicle access has been eliminated at Farley's Camp due to trash dumping problems). However, there has been very little development of public access to the majority of their land, which lies north of Route 28, except in conjunction with Mashpee Conservation Commission access points at the Lopez and Fitch properties.

The Orenda Wildlife land Trust has also acquired their 0.76 acre Mashpee River Sanctuary just west of the river, bringing total contiguous public and land trust open space in the Mashpee River Corridor to 791.89 acres.

The **Quashnet River**, like the Mashpee, was once famous as a sea-run trout fishery. More recently, it has become famous for the efforts of dedicated volunteers from Trout Unlimited to restore the glory of that fishery, which had been ruined by a mill dam and extensive development of cranberry bogs along the river. Beginning in 1975, they have restored more than a mile of the river as prime trout habitat. In order to protect the river and their work, they also played a big role in convincing the state to make major land purchases along the river in the late 1980s. Mass. DFW and DCR now jointly own 336.15 acres along the river south of Route 151 which is managed through the Waquoit Bay National Estuarine Research Reserve. DFW owns another

22.1 acres directly on the river in the area of Trout Unlimited's restoration project, and DCR recently acquired 30.55 acres west of the river adjacent to the jointly-owned property. While this area has not been formally developed for public access, except for an informal parking area at the south end of the state lands on Martin Road in Falmouth, its sand roads are popular for hiking and off-road vehicles (although ATVs and dirt bikes have become a significant problem) while the river itself now provides excellent catch and release trout fishing. Vehicle access to the river via Whitings Road and other dirt roads through the property has been closed with gates due to trash dumping prolems.

As noted previously, except for one small area which is proposed to be set aside as open space as part of the Mashpee Commons development (Jobs-Whiting Trust 40B project approved) the Town owns the remainder of the river frontage south of Route 151. 54 acres of the Mashpee High School property on the west side of the river and adjacent to the state's land is under a conservation easement in favor of the U.S. Fish & Wildlife Service as part of the Mashpee National Wildlife Refuge. As part of its 58.78 acre Quashnet River Conservation Area, the Conservation Commission manages the 14.5 acre Dawson property directly on the south side of Route 151, subject to a conservation restriction held by Mass. DFW. Although there are rough dirt roads onto the property from Route 151, there is no developed public access.

At the upper end of the Quashnet River, Johns Pond Park Conservation Area protects 308.02 acres for public enjoyment, as noted previously. While most of the river's length through the Park is occupied by cranberry bogs, the fish ladder at its outlet from Johns Pond, adjacent to the town beach and parking area, is a popular spot when the herring are running. The property is laced with miles of walking trails and sand roads (although here again ATV and dirt bike use, as well as trash dumping, has become a major problem), although a number of roads are now gated in conjunction with the cranberry bog operation and the military's FS-1 contaminant plume treatment plant. The Conservation Commission also owns the 1.64 acre Bates Road portion of the Quashnet River Conservation Area just north of Route 151, adjacent to Orenda Wildlife Land Trust's 3.53 acre property directly on the river, which was purchased in conjunction with the Town's Dawson property. There is no formal public access facility, although a Town bike path follows Route 151 adjacent to the property.

Aside from one small landlocked "owners unknown" property, the remainder of the Quashnet River's frontage in Mashpee is private open space and golf course within the Quashnet Valley Country Club condominium, ensuring that there will never be residential or other development along the entire length of the Quashnet River in Mashpee.

The tiny **Childs River**, once also known as the "Waquoit Herring Company's Ditch", has not been forgotten in the Town's conservation efforts. With the assistance of Self-Help funds, its entire length in Mashpee south of Old Barnstable Road was purchased from the D.L Makepeace cranberry company along with one active cranberry bog and a portion of another shared with the Town of Falmouth. This small stream through the woods provides an ideal location for "family river scoops" and other nature tours provided by the Conservation Commission, which manages the land as its Childs River Conservation Area. Access is via a dirt road through the property known as Milford (or Brown's) Road, along which vehicles may park. The Conservation Area is surrounded by additional protected open space owned by the Falmouth Rod & Gun Club (63.94

acres subject to a recorded conservation restriction), the Town's 32.7 acre Andrade Conservation Area and cluster subdivision open space owned by the Childs River East and Childs River West homeowners associations, although public walking trails are limited to Milford Road and the cranberry bog access roads.

North of Old Barnstable Road, the Conservation Commission owns a one rod wide strip of land associated with the former Makepeace bog operation. A 3.6 acre parcel of subdivision open space taken by the Town for taxes abuts the west side of the strip between Old Barnstable Road and Route 151, although there is no developed access to the parcel.

The **Santuit River**, shared with the Town of Barnstable, boasts beautiful marshes alive with waterfowl in its tidal reaches as well as a rare surviving sea-run brook trout fishery. With excellent potential for passive recreation opportunities, it has been the most recent target of open space protection efforts.

The Conservation Commission has managed a landlocked 0.86 acre parcel on its west bank just south of Route 28 since the late 1980s. At that time, the Willowbend Country Club development acquired the remainder of the west bank between Route 28 and Sampson's Mill Road. An undisturbed buffer of 150 feet in width was left between the river and the new golf course, with a larger 9.27 acre parcel adjacent to Sampson's Mill Road set aside as a well site and left basically undeveloped. Though there is no public access to this property, an easement was established in favor of the Mass. Division of Fisheries & Wildlife to access the river for stream management.

At the south side of Sampson's Mill Road, the Mashpee side of the river is bounded by a 30 acre parcel which includes an equestrian center operated by the Mashpee Wampanoag Indian Tribal Council. At the mouth of the river, at Quinaquisset Avenue, are a single family residence and a row of condominium buildings included in the Cotuit Bay Condominium. Neither portion of the river's bank is open to the public. However, the intervening quarter mile of frontage, including more than fifteen acres of marshes and the adjacent uplands, has now been protected as the 37.15 acre Santuit River Conservation Area, acquired since 1999 through a land trade with the Willowbend Country Club owners and a series of purchases and donations from the Peck family and others. Many of the Peck parcels are interspersed with another 6.48 acres of Town tax-taking land. Parking is possible at the end of the paved portion of Popponesset Avenue, while that road continues as a dirt trail through the property, looping to the Cotuit Bay Condos and connecting to another trail onto the tribal property. Most of the Barnstable side of the river is developed, except for the Barnstable Conservation Commission's 25 acre Santuit River Conservation Area at the mouth of the river.

There is no public ownership or access to the river in the vicinity of Routes 28 and 130, but at the head of the river The Towns of Mashpee and Barnstable own the previously-mentioned Santuit Pond Preserve, with roughly 1500 feet of frontage along the river.

Of Mashpee's four smaller streams, Red Brook, Abigail's Brook, Quaker Run and Dutchman's Creek, all are bordered by some amount of publicly-owned conservation lands, although there is little in the way of developed access facilities. However, each has the potential to provide opportunities for enjoyable walks in idyllic settings.

All of the Mashpee shore of **Red Brook** north of Old Ockway Road is managed by the Conservation Commission, while south of that road it is all included in cluster subdivision open space owned by the Seabrook Village and Seabrook Shores homeowners associations. The stream is accessible to the public only at Old Ockway Road, a dirt road that connects to Holland Mill Road through the South Mashpee Pine Barrens Conservation Area and forms part of the proposed "Cross-Cape Trail" the first designated segment of Barnstable County's "Cape Cod Pathways" trail network.

Abigail's Brook, is paralleled by abandoned cranberry bog access roads. All of its length west of Great Oak Road is owned by the U. S. Fish & Wildlife Service or the Mashpee Conservation Commission as part of the "Bufflehead Bay" portion of the Mashpee National Wildlife Refuge. Two parking areas provide trailheads to that area. The eastern end of the stream, to its sources in Fells Pond and Witch Pond, runs through abandoned cranberry bogs privately owned by New Seabury Properties, LLC.

The headwaters of **Quaker Run** are in a series of wetlands north of Route 28 owned by the Town as part of the Noisy Hole Conservation Area, which has no developed public access facilities, although it is traversed by a number of open dirt roads. All of the stream south of Route 28 is surrounded by private lands, primarily the Willowbend Country Club's golf course, cranberry bogs and associated protected open space.

The entire course of **Dutchman's Creek**, except for an area of salt marsh on the east of the creek at Monomoscoy Road, is owned by the Town either as part of the South Mashpee Pine Barrens and Dutchman's Creek Conservation Areas or as tax-taking property. However, there is no formal parking area or trail access.

Any discussion of water-based recreation on Cape Cod can hardly ignore boating and related activities. They constitute one of our principal outdoor enjoyments. All four of our large freshwater ponds are extensively used by boaters and fishermen and have public boat ramps. Mashpee, Johns and Ashumet Ponds have state-owned boat ramps and are used yearly by thousands of power boats, jet skis and water skiers. Mashpee Pond is annually the site of more than thirty fishing tournaments of various sorts attracting contestants from all over New England. Santuit Pond has only an unpaved Town landing and is too shallow and muddy for high-powered boats and water skiing, but it is an excellent warm-water fishery and boasts a number of state record fish.

On salt water, there are three principal public landings, all Town-owned. The **Great River** landing is located on the east side of Great River off Great Oak Road. The **Ockway Bay** landing is located on the west side of the bay off Great Neck Road South. The **Pirates Cove** landing (formerly known as the Cherry Tree landing) is located at the head of Popponesset Bay at the end of Mashpee Neck Road. All three were totally reconstructed with paved ramps and parking areas in 1986 using funds provided by the state's Coastal Zone Management Office. Because of that state funding, they were open to use by anyone for 20 years but are now limited to use by Town residents. A fourth small undeveloped landing, owned by the Conservation Commission, is located at the end of **Punkhorn Point Road** opposite Gooseberry Island and is used primarily by

local shellfishermen and canoeists. Other public access points available on Seconsett and Monomoscoy Islands and on Whipporwill Circle are not suitable for boat launching and are mainly available for shellfishing access.

As a recreational resource, our harbors and bays are caught between the proverbial "rock and a hard place". Because Mashpee has been one of the fastest growing towns in New England during the last four decades, and because much of its development is related to summer recreational opportunities, the demand for boating, swimming, fishing, water skiing, sailing, sail boarding and other activities, and their related facilities, has grown tremendously at the same time that the natural resource impacts of overall land development, as well as of those marine activities, have become increasingly apparent.

The Town's year-round population has increased from 3700 in 1980 (U.S. Census) to 15,000 in 2007 (Planning Department estimate). The number of dwellings has increased from 3582 in 1980 to 9965 in 2007. Meanwhile, estimated summer population, reflecting the seasonal recreation-oriented nature of the town, has increased from 13,481 in 1980 (CCPEDC estimate) to 30,684 in 2007 (Planning Department estimate). One-third of the Town's dwelling units are only occupied during the warmer months, with many of those used only for a few weeks in July and August or as weekend getaways.

This growth in population has brought with it a rapid increase in demand for water-related recreational activities. Four sources, of varying accuracy and length of record keeping, illustrate the growth in that demand.

In 1960, there were 206 resident shellfish permits issued, along with 58 non-resident and 15 commercial permits. By 1970, the numbers had grown to 472, 115 and 28 respectively. In 1980, 683 permits were issued to residents and 91 to non-resident families, along with 33 commercial and 14 commercial scallop permits. 1989 saw the issuance of 716 resident permits (including families and seniors), 12 non-resident family permits and 15 commercial permits. For 1995, 597 resident (family and senior), 26 non-resident and 20 commercial permits were issued. In 2006, 723 resident (family and senior), 24 non-resident and 13 commercial permits were issued. In this case, permits increased steadily between 1960 and 1980 but leveled off and have not significantly increased, while population has quadrupled.

This may indicate either a change in the interests of new residents of the Town or, more ominously, a limited or reduced shellfish resource. The latter issue may be more appropriately judged by the numbers of commercial licenses issued, which might be expected to vary at a rate more closely reflecting the resource base than would family and senior permits, which are more recreation-oriented. From 15 commercial permits in 1960, the number increased to 28 in 1970, dropped to 3 in 1972, boomed to 51 (with 42 additional scallop permits) in 1979, dropped off to 7 (plus 4 scallop) in 1983 and gradually built up to 15 in 1989 (no scallop permits) and 20 in 1995. It has since dropped back to 13 in 2006, less than in 1960. Scallops have virtually disappeared from Mashpee waters, compared to the pre-1990 situation, and no commercial scallop permits issued. Oysters had disappeared from Mashpee waters even before the 1980s, but have now been brought back by the Shellfish Department through seeding on artificial reefs in the lower Mashpee River, helping to spark new interest in recreational shellfishing. The seeding

program began in 2004, resulting in a harvest of approximately 100,000 oysters from January to March 2006, increasing to an estimated 160,000 during the same months of 2007.

Records on beachgoers in Mashpee are less accurate and harder to come by. It was only in 1970 that the town first employed lifeguards and parking attendants at South Cape Beach and began to charge for parking. Receipts that year were $1878. In 1974, a system of resident beach stickers was first established, but no records of numbers sold are available, except that $2387 was collected for them. The first year for which numbers are available is 1979, when 1139 two-year resident beach stickers were sold and $5010 was collected. By 1986, 2392 one-year resident stickers were sold and it was estimated that 250 persons used the South Cape Town Beach on a weekday and 500 on weekends, with a peak day of 625 persons on the July 4th holiday. In 1987, peak day use was 826. For the summer of 1990, 2289 resident beach stickers were sold, with revenues of $37,215. 1996 saw the sale of 2100 resident beach stickers, 180 guest passes and 112 timeshare condo passes at $49,370. By 2007 total resident beach stickers numbered over 4500, for total revenue of $103,965.

Boating has also grown significantly since the 1970s, based on two measures of activity. The Annual Report of the Harbormaster listed the number of registered moorings beginning in 1976, although permits were first required in 1972. 102 were listed for 1976, then approximately 200 for the next nine years, followed by a sudden boom (trailing our 1980s real estate development boom by about a year) to 360 in 1986, 406 in 1987, 720 in 1988, 650 in 1989 and.630 in 1995. By 2007, total registered moorings had increased to 890, but all feasible mooring fields have now been filled to capacity. With continuing growth in the town, demand for moorings has continued to increase, resulting in lengthy waiting lists for mooring permits in all areas.

A second source of data also underlines the tremendous growth in boating. Under the provisions of Chapter 60B of Massachusetts General Laws, any boat valued over $1500 ($1000 until recently) is assessed for excise taxes. Based on the records kept by the Mashpee Assessors' staff, there were 167 of such boats in Mashpee for fiscal year 1980. That number had increased to 333 in 1985, 660 in 1989, and stood at 891 in 1995, an increase of 434% over the 1980 figure, showing a growth rate much higher than that of the Town's population. By fiscal year 2007, when the value had increased to $1500, 1173 of such boats were assessed. While smaller or older boats are not covered by these figures, and the replacement of old boats with newer, larger and more expensive boats may account for an overstatement of the actual growth in total numbers of boats in the Town, the trend is, again, quite clear.

With regard to an estimate of total boats in the Town, the motor boat registration list produced by the Division of Marine and Recreational Vehicles for 1989 showed 1346 boats of all sizes registered or "moored" (which does not necessarily indicate an actual mooring) in the Town, of which 1267 were "moored" in Mashpee. The total listed by the state has increased to 2217 as of 2006. Beyond this number, there are various canoes, small sailboats and other un-powered boats. No information has been gathered on jet skis, sailboards, surfers, divers or other forms of marine recreation. Clearly, however, the general trend is to a significant increase in marine recreational activities, generally related to population growth. With the potential for almost 23,000 year--round and over 36,000 summer residents under approved permits and current zoning, there will very likely continue to be similar growth in recreational boating.

Water-Based Recreation

Map 4-22