THE WAQUOIT BAY WATERSHED AND ITS STREAMS

The Waquoit Bay watershed formed during a glacial advance and retreat 21,000 to 17,000 years ago (Oldale 1991).* As glaciers move, they scrape and pluck rocks and soil, which they later deposit in beds called moraines. As the glacier melted, torrents of water washed sand and gravel from these beds and redeposited it; the resulting cover of loose sand and gravel is called an *outwash plain*. Huge blocks of ice left behind by the glacier created depressions in the outwash plain and left gaps in the sediments when they melted. Many of these depressions have since filled with water and form a common feature on Cape Cod. The deepest of these holes are called kettle ponds; well known examples include Fresh Pond, John's Pond and Ashumet Pond. The scattered kettle holes give the area a pitted look, and regions of this kind are therefore called *pitted outwash plains*. The Waquoit Bay watershed lies entirely in one such area called the *Mashpee Pitted Outwash Plain*.

Water flows easily through the spaces between the large sand grains, and this accounts for many of the basic processes and problems that we find in the Waquoit Bay watershed and other watersheds that lie in pitted outwash plains on Cape Cod. Therefore, understanding how water flows through a pitted outwash plain allows us to understand much of what we see in the estuary.

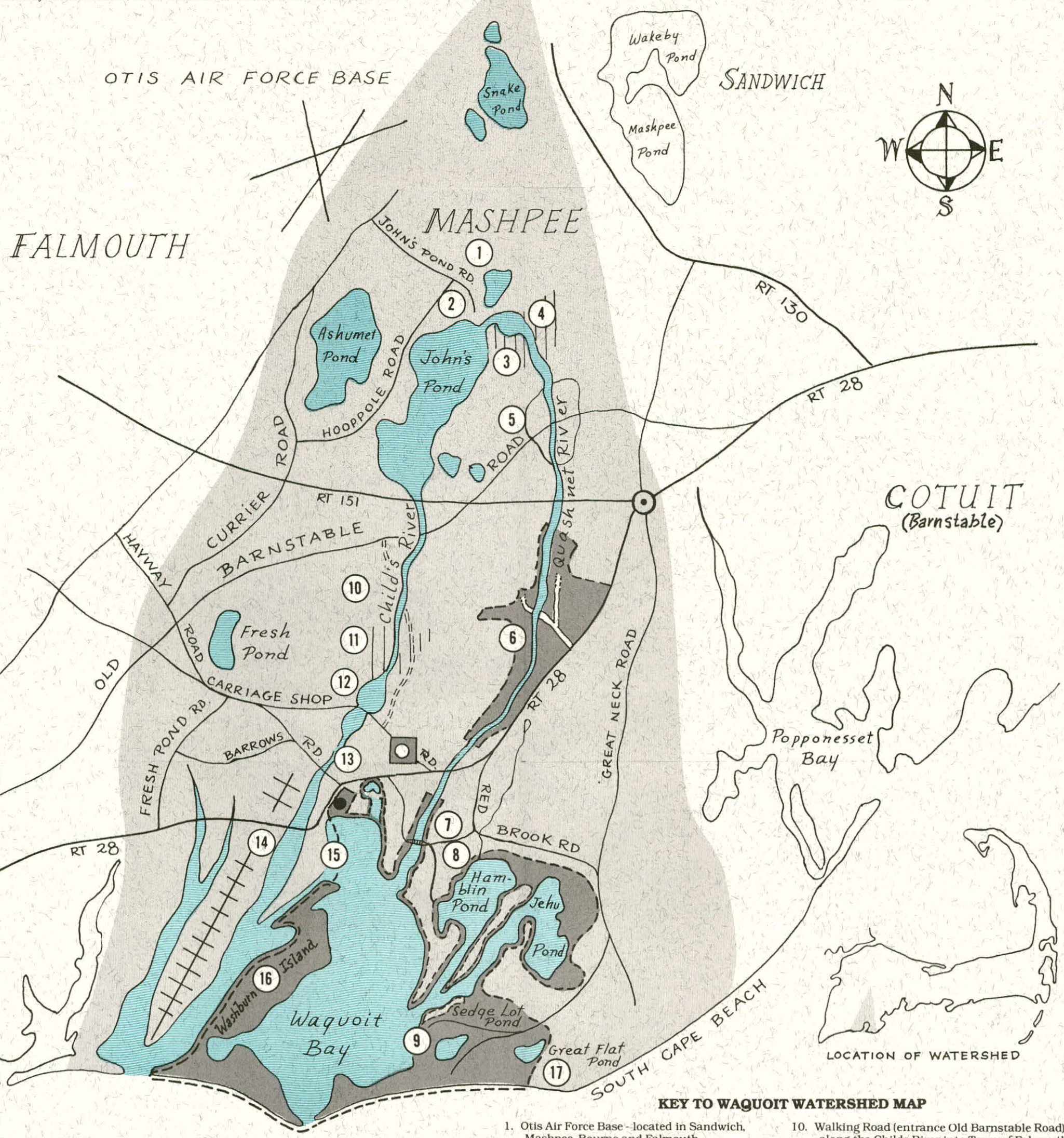
In an average watershed, 50% of the water falling on it flows over the surface, and the other 50% seeps, or percolates, into the ground. However, in most Cape Cod watersheds, which lie on pitted outwash plains, there is little surface runoff. Up to 90% of the annual rain and snowfall (42-44 inches) percolates into the ground, and 10% flows over the surface into streams and ponds. Water that seeps into the ground continues to percolate downwards until it reaches impermeable rock or the top of an *aquifer* (an aquifer is a region in which all the pores between the sediment grains are filled with water). At that point, it begins to flow laterally.

Hundreds of springs trickling from the banks of Red Brook, the Child's River and the Quashnet River illustrate the widespread movement of underground water in the Waquoit Bay watershed. These streams, like most on Cape Cod, are fed not by direct rainfall but by groundwater that emerges where the elevation of the land drops below the level of the aquifer. Water travelling through the ground moves relatively slowly because it follows a circuitous path through the small spaces between sand and soil particles. When it emerges, it speeds up because it can travel more freely. Streams which are fed by groundwater, seeping out from below, are called *gaining streams*.

Because water moves freely in the coarse sediments of pitted outwash plains, septic waste that enters the ground from peoples' homes flows to other parts of the watershed. Thus, a particular pond or stream receives septic waste not only from houses bordering it, but from all the houses in the watershed. In fact, a critical environmental problem occurring in Waquoit Bay and similar coastal areas results from the daily combined septic waste from all homes in the watershed.

*The term *watershed* typically refers to a region from which rainfall and snowmelt flows over the land surface into a body of water. Because much of the water moving through the Waquoit Bay region flows underground rather than over the surface, geologists characterize the system as *flow divides*. We have opted to use the more commonly understood term, watershed. Dates from Dr. Robert Oldale, USGS, 1991.

These materials were developed by the Department of Environmental Management's Waquoit Bay National Estuarine Research Reserve, jointly with Cooperative Extension U/MASS Barnstable County Office, under a grant from the National Oceanic and Atmospheric Administration.



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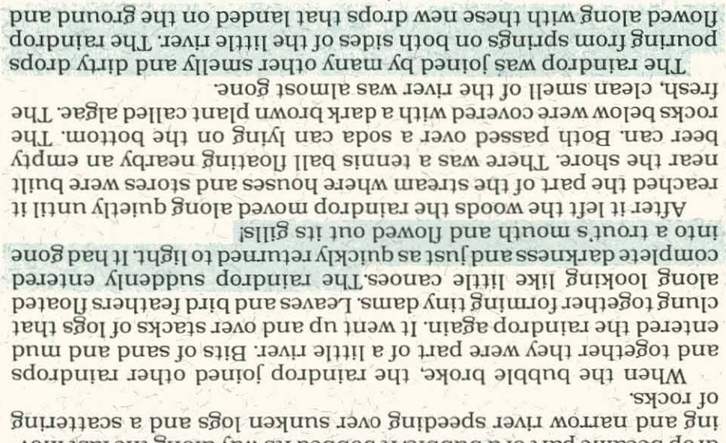
- ⊙ Mashpee Rotary and Commons Shopping Mall
- ▣ Waquoit village
- ● Waquoit Bay National Estuarine Research Reserve Headquarters - former Swift Estate
- Waquoit Watershed Boundaries
- Major Rivers and Ponds in the Waquoit Watershed
- Waquoit Reserve and Other Major Conservation Lands

KEY TO WAQUOIT WATERSHED MAP

1. Otis Air Force Base - located in Sandwich, Mashpee, Bourne and Falmouth
2. John's Pond - source of Childs River
3. Freshwater Marsh - former cranberry bog - source of the Quashnet River
4. Cranberry Bog - Town of Mashpee
5. Quashnet Golf Course - former cranberry bog
6. Dam on Quashnet River - formerly DEM now part of the Waquoit Estuarine Reserve
7. Moonakis River (lower part of Quashnet) Bridge - brackish and marsh wetlands
8. Red Brook River
9. Hall House property - Waquoit Reverse
10. Walking Road (entrance Old Barnstable Road) along the Childs River into Town of Falmouth Cranberry Bog - Falmouth Rod and Gun Club conservation lands
11. Town of Falmouth Cranberry Bog
12. Lily Pond Wetlands
13. Child's River - saltwater wedge
14. Edwards Boat Yard on the Child's River
15. D.E.K. Seafarms on the Seapit River
16. Washburn Island - a barrier island - Waquoit Reserve
17. South Cape Beach - a barrier beach - Waquoit Reserve

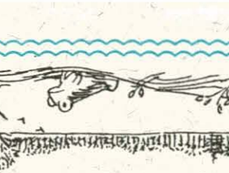
THE RAINDROP JOURNEY

TEXT: John F. Waters
ILLUSTRATIONS: Louise Russell



A One early fall day an area of clouds and rain formed off the coast of North Carolina. Within hours it grew into a sizeable autumn storm and headed north along the coast toward New England and Cape Cod. During the night on Cape Cod it began to rain, a hard rain, and soon the raindrops soaked all the land. Streams filled, little ponds overflowed, and the rivers ran faster and faster. One of the billions of tiny raindrops had an interesting journey and its story follows.

B The raindrop landed right in the middle of a kettle pond in an outwash plain on Cape Cod. It was joined by millions of other raindrops. The wind blew hard out of the northeast tossing the raindrop up and down as it began to drift toward shore. As it drifted the raindrop headed for a narrow opening in the pond.



B The raindrop, clean and pure, flew along in a fast current until it landed in the middle of a small stream. The rushing water carried mud and all kinds of debris. And soon the raindrop became cloudy. The cloudy little raindrop moved steadily, and soon it was out of sight of the pond. The river entered a woodland swamp.

Along the banks were tall green trees and thick bushes. Some were so laden with big leaves their branches hung out over the river almost touching the cool water. The raindrop moved along through the dark woods until it emerged on the other side.

C Here the wind was not blowing as it was stopped by the trees in the woods. The sun lighted up a beautiful freshwater marsh where cat o'nine tails stood tall like a green army of slender sentries. When the wind blew the sentries nodded in unison. Along a low area, clumps of red cranberries grew right along the stream where the raindrop passed. There were tiny frogs swimming in the water. Big, green bullfrogs sent out loud and low croaking noises. Water striders used the water to skim along the surface as though they were skating on ice. The water striders skirted in and around the light green pools of floating duckweed.

D As the stream flowed into a flooded cranberry bog, the raindrop slid over and around thousands of bobbing red berries. A cranberry

kept pushing against each other. The raindrop, as part of the freshwater on top, continued to flow out toward the bay.

The raindrop traveled over the saltwater passing through a salt marsh lush with Spartina, a marsh grass. Then it flowed out into the wide bay. Wind blown waves and tidal currents mixed it with the saltwater below. Then it and all the other raindrops became part of the big bay. The bay was an estuary, a place where saltwater from the ocean meets freshwater moving down through the hills

I and rivers of the land. It was also where mud, oil, chemicals, bacteria and viruses, brought down into the watershed by the billions of raindrops, became part of the estuary, too.

J What happened next? How would you finish the story of *The Raindrop Journey*?

Lettered, blue-shaded sections of the story represent key science ideas relating to how a coastal watershed works. For more information refer to the Educators' Guidebook *Watershed To Bay*, available from Waquoit Bay Reserve, Box 92W, Waquoit, MA 02536; and Barnstable County Cooperative Extension, Railroad Ave., Barnstable, MA 02630.

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3 harvest was underway. The dam gates holding the water in the bog

D were closed, but the raindrop and a few cranberries slipped over the top and splashed into the stream below.

After the raindrop passed through the cranberry bogs and fresh water marshes, it entered a wider river. The river was filling with water from the surrounding area. Water came from underground springs, or flowed from the roads and parking lots. As the raindrop passed next to a large airport something happened! Airports have airplanes, and airplanes need oil and gasoline to run their engines.

E When it rained the night before, some gasoline and oil washed off the runways and into the river. The raindrop, holding tiny specks of mud, picked up some oil. The once pure and clear raindrop had an oily sheen as it journeyed along under the sun.

The dirty raindrop was joined by other raindrops with oil and chemicals as it drifted through the middle of a golf course and into more woods. Here the little river widened and slowed down. The water was barely moving and that meant the raindrop was also barely moving. All around were vast islands of duckweed which made the surface water a light green. And long stemmed plants, looking like dark green strings, waved back and forth near the bottom. Along the river banks were all kinds of green bushes, tall grasses, and leafy ferns.

4 Something amazing happened to the raindrop. As it passed through the wetland it entered the roots of a lily pad. Later, when

E the raindrop came out of the leaf of the lily pad, it was changed. The lily pad had taken the chemicals out of the raindrop and made it clean again.

When the raindrop reached a dam it moved very fast over the top. It was like a tiny waterfall. There was froth and foam and the raindrop became part of a bubble. It bobbed its way along the fast moving and narrow river speeding over sunken logs and a scattering of rocks.

When the bubble broke, the raindrop joined other raindrops and together they were part of a little river. Bits of sand and mud entered the raindrop again. It went up and over stacks of logs that clung together forming tiny dams. Leaves and bird feathers floated along looking like little canoes.The raindrop suddenly entered

F complete darkness and just as quickly returned to light. It had gone into a trout's mouth and flowed out its gills!

After it left the woods the raindrop moved along quietly until it reached the part of the stream where houses and stores were built near the shore. There was a tennis ball floating nearby an empty beer can. Both passed over a soda can lying on the bottom. The rocks below were covered with a dark brown plant called algae. The fresh, clean smell of the river was almost gone.

G The raindrop was joined by many other smelly and dirty drops pouring from springs on both sides of the little river. The raindrop flowed along with these new drops that landed on the ground and

5 traveled down between particles of soil, moving slowly through the ground toward the river. Along the way they had passed under roads, houses and stores. People above the ground driving on the roads, visiting the stores, and living in the houses were making

G waste and getting rid of it. They put it in the sink, down the toilet and dumped it on the ground. Many of the chemicals ended up in the septic systems attached to the houses. The chemicals, along with tiny living bacteria and viruses from human waste, were picked up and carried by the raindrops coming into the river. They all headed to the sea.

When the raindrop neared a shallow saltwater bay, plants along the banks of the little river began to change. Gone were the many different green bushes, ferns and flowers. There were stiff grasses such as sedges, reeds and rushes. Cattails hovered over all of them.

The ocean tide was coming. A surge of saltwater entered a passage and flowed along the bay and into the river. Saltwater rushed up the river, reaching the place where the raindrop was drifting. The raindrop sped over the top of the saltwater. The mighty tide of saltwater kept pouring in. The advancing saltwater pushed the freshwater back up stream much as a snowplow pushes back

H snow after a winter northeaster. It acted like a moving dam.

The saltwater, being denser and heavier, flowed beneath the freshwater. The saltwater was filled with dirt and mud specks making it darker in color than the freshwater. The two kinds of water