Chapter 1

Shaping the Harbor

> Long Island is a gift from ocean's waves or from Neptune's hands.
>
> —Ebenezer Emmons (Thompson, 1849)

Geological History

Long Island "was formed gradually and was reclaimed from the sea," according to Dr. Benjamin Franklin Thompson in his 1849 edition of *The History of Long Island from Its Discovery and Settlement to the Present Time*. This was the conventional wisdom of the day as expressed by an eminent scholar and by circumstance a Setauket resident, whose home, the Thompson House, is preserved as a historic landmark. Thompson quotes Dr. Ebenezer Emmons: "Long Island is a gift from ocean's waves or from Neptune's hands, sands washed from the deep by waves from the broad sea breaking on the skirts of land and by casting up debris of a wasted continent."

What a different view from what we now know about the geology of Long Island. But Dr. Emmons was certainly correct in his assertion that the Island is composed of material from a wasted continent, for Long Island is indeed the residue of the pressure and grinding of glaciers many hundreds of feet thick that moved across the face of New England, finally retreating some twenty thousand years ago (Sirkin, 1995). Robert Cushman Murphy, in his wonderful vignette of Long Island entitled *Fish-Shaped Paumanok* (1964), points out that we can find the remnants of the Adirondack, Laurentian, Green, and White Mountains here on the Island.

Long Island is considered a youthful or primary coast—the consequence of the sea coming in contact with a land feature that was formed by terrestrial processes (Shepard, 1963). In this case, the terrestrial processes are due to glaciations during the last ice age.

The Island, as we see it, is essentially the residue of two intersecting terminal moraines. The older of the two moraines, the Ronkonkoma, represents the most southern advance of the Wisconsin glacial period (according to Sirkin [1995], sediments date to about forty thousand years ago). The glacier apparently retreated and then readvanced to create the terminal moraine that forms Long Island's north fork and intersects the older Ronkonkoma moraine somewhat to the west of Lake Success (Yasso and Hartman, 1976).

The southern advance of the Harbor Hill Moraine was just to the south of Stony Brook Harbor and the soils of this feature consist of crudely stratified sand and gravel with some boulders and till (Lubke, 1964). Till is unsorted debris deposited directly by the ice, with particle sizes varying from silt to boulders. Elevations along this moraine in the vicinity of the harbor are in the range of 150 ft (46 m) above sea level.

In a January 1849 letter to his friend Benjamin Thompson, William Sidney Mount commented on the till that gives shape to much of the perimeter of the harbor. The letter describes how Mount and his brother, Alonzo Shepard Mount, searched "the high banks bordering the sound" for pigments to be used in their paintings:

> As we strolled along the bank we picked of brown, yellow, and red—we thought the rich "placer" must be somewhere near. Shepard struck his hoe a few feet up the bank and we were astonished to see a lot of bright red running down the bank and mingling with the sand. It was a rich day for us—we worked with the spirit of gold diggers, and were well paid. The red found in balls, was in tint like India red, and Venetian red—some of those sandstone balls contained purple, some yellow, and some red, like orange vermillion . . . The browns had the nature of Vandyke brown, Cologne earth and Cappah brown. We also discovered pure black. What interested us very much was the finding of several brimstone balls of a sea green color. (Frankenstein, 1974)

The exact manner by which the harbor was formed is still debated. Some believe it was formed by glacial tectonic processes; the prevailing view seems to be that the harbor was formed by erosional processes. However, a recent interpretation suggested by Professor Gilbert Hanson of Stony Brook University is that a subglacial stream shaped the Stony Brook Harbor valley (November 2004; personal communication). Today, the visible remnants of that process are a series of tunnel valleys weaving their way through the uplands surrounding the harbor.

Some characteristics of tunnel valleys include:

- elongated, steep-sided depressions,
- intersecting, sinuous networks,
- termination at an outwash fan,
- movement up and down hill (O Cofaigh, 1996).

Many of these features can be seen on the relief map (Fig. 1.1). For example, see the s-shaped, steep-sided valley leading from the south end of Stony Brook Harbor across the edge of the moraine onto the outwash fan. Also, note the valley

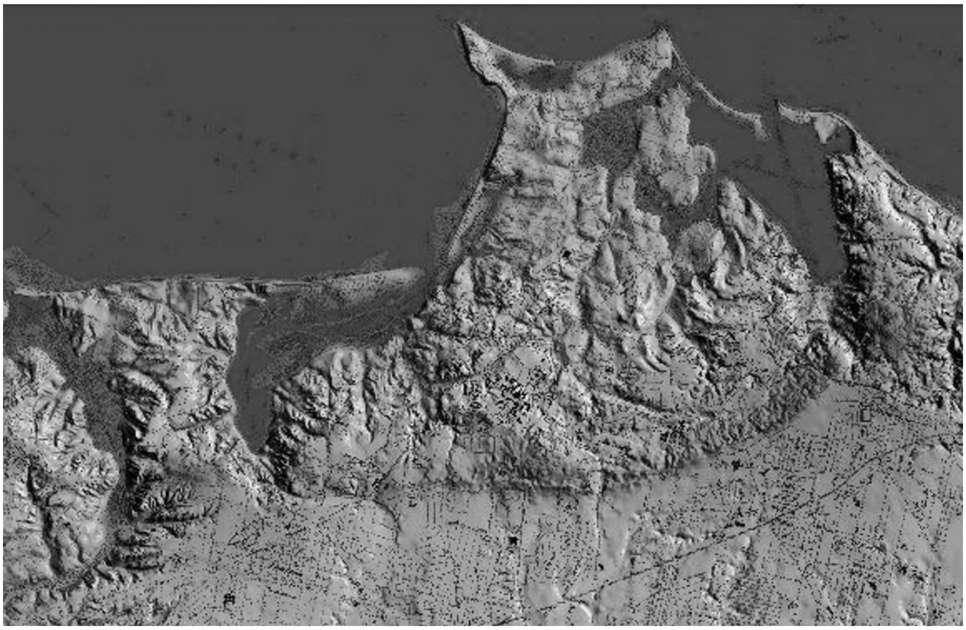

Figure 1.1. Relief map of Stony Brook Harbor surroundings showing tunnel valleys. Gilbert Hanson, Department of Geosciences, Stony Brook University.

leading up from the northeast side of the harbor. In this case, the valley leads past the Long Island Museum, uphill to the Stony Brook Railroad Station, then downhill toward Setauket (Hanson, November 2004, personal communication).

A subglacial stream channel at the interface of the glacier and the underlying terrestrial surface may have led out of the harbor. This channel would have carried meltwater and sediment under considerable pressure due to the height of the water table in the overlying ice. The hydraulic pressure could have been sufficient to push water up-gradient through numerous smaller channels near the front of the glacier, eroding steep-sided tunnel valleys.

Today, in many cases, these valleys serve as local roadways (i.e., Harbor Hill Road in Head-of-the-Harbor, Route 25A past the Stony Brook Railroad Station; and Stony Brook Road on the east side of the Gyrodyne property—now partly Stony Brook University property).

According to Hanson, the Stony Brook Harbor valley may be a lobe of a much larger system spreading generally east-west some 4–5 nautical miles (7.4–9.3 km) north of the harbor. Evidence of this system, based on seismic studies, is shown on the topographic map of the Pre-Tertiary surface beneath Long Island Sound (Grim et al., 1970).

Perhaps a more conventional view is that the hilly terrain immediately surrounding the harbor, including the steep bluffs of Nissequogue and Crane Neck, were left as the glacier retreated. Known as a ground moraine, the soil is comprised of till and some stratified sand and gravel (Lubke, 1964).

All of this glacial material, no matter how deposited, is perched on top of sediments eroded from the ancient Appalachian Mountains some 135 million years ago (Yasso and Hartman, 1976). About seventy million years ago, during the Tertiary period, these coastal plain sediments were tilted to the southeast as a consequence of the uplift of the Appalachians. Approximately 800 ft (244 m) below Stony Brook Harbor these tilted sediments rest on igneous and metamorphic rock that date back several hundred million years.

Underlying the 100–200 ft (30–61 m) of Wisconsin glacial deposits are, from the top to bedrock, the Magothy formation and two layers of the Raritan formation, first a clay layer and then the Lloyd sand member. Locally, the thicknesses of these layers are roughly 200–400 ft (61–122 m), 180 ft (55 m), and 200 ft (61 m), respectively (Lubke, 1964). It is in the three sandy formations (the upper aquifer, the Magothy, and the Lloyd sand) that Long Island derives its invaluable groundwater resources.

Some fifteen thousand years ago, the sea began to creep shoreward across the continental shelf (Emery and Uchupi, 1972). It is the sea that has given Long Island its distinctive "fish-shaped" appearance that Walt Whitman so beautifully describes in *Leaves of Grass*. And, it is the sea that will continue to shape Long Island, because the unconsolidated glacial materials are particularly prone to adjustment by the wind, waves, currents, and, for now, the rising sea level.

The central basin of the Sound, including the area of Stony Brook Harbor, was isolated from the sea by the Mattituck Sill, a topographic high traversing the Sound approximately 30 nautical miles (56 km) east of the harbor. Today the sill is about 70 ft (21 m) below mean low water (MLW), but it rises abruptly above the adjacent sea floor just to the east where the depths are about 120 ft (37 m).

Apparently the central basin of the Sound was a freshwater lake until roughly eight thousand years ago, when the level of the sea rose sufficiently to breach the Mattituck Sill. However, the double connection with the ocean, at both ends of the Sound, was not complete until about six thousand years ago, when sea level topped the sill at Hell Gate in the East River (Koppelman et al., 1976). The harbor and Island as we think of them today are probably only about three thousand years old (Koppelman et al., 1976).

However, even before the Sound was filled with ocean water, the erosional forces of wind and waves began to reshape the glacial debris left behind as the glaciers receded. Waves erode shorelines due to impact and hydraulic pressure, and to corrasion (the grinding and scraping of particles) and solution. The bluffs of Nissequogue and Crane Neck are particularly prone to being undercut by waves and alongshore currents associated with storm surges. The undercut steep slopes destabilize the unconsolidated glacial material, causing the crest of the bluffs to slump. To the west, in the vicinity of Oak Neck Point near Oyster Bay, bluffs similar to those adjacent to Stony Brook Harbor were estimated to have eroded 500 ft (152 m) in 250 years, based on data from surveys by the Coast and Geodetic Survey (Shepard and Wanless, 1971).

The northwest-facing Nissequogue and west-facing Crane Neck bluffs are particularly oriented to erosional forces of the prevailing northwesterly winds of winter. It is then that the resultant winds are the strongest and most persistent during the year (Ullman et al., 1996).

Tidal currents and littoral currents flowing parallel to the bluff faces of Nissequogue and Crane Neck have formed two overlapping baymouth bars—Long Beach and West Meadow Beach (Fig. 1.2). These beach deposits consist of

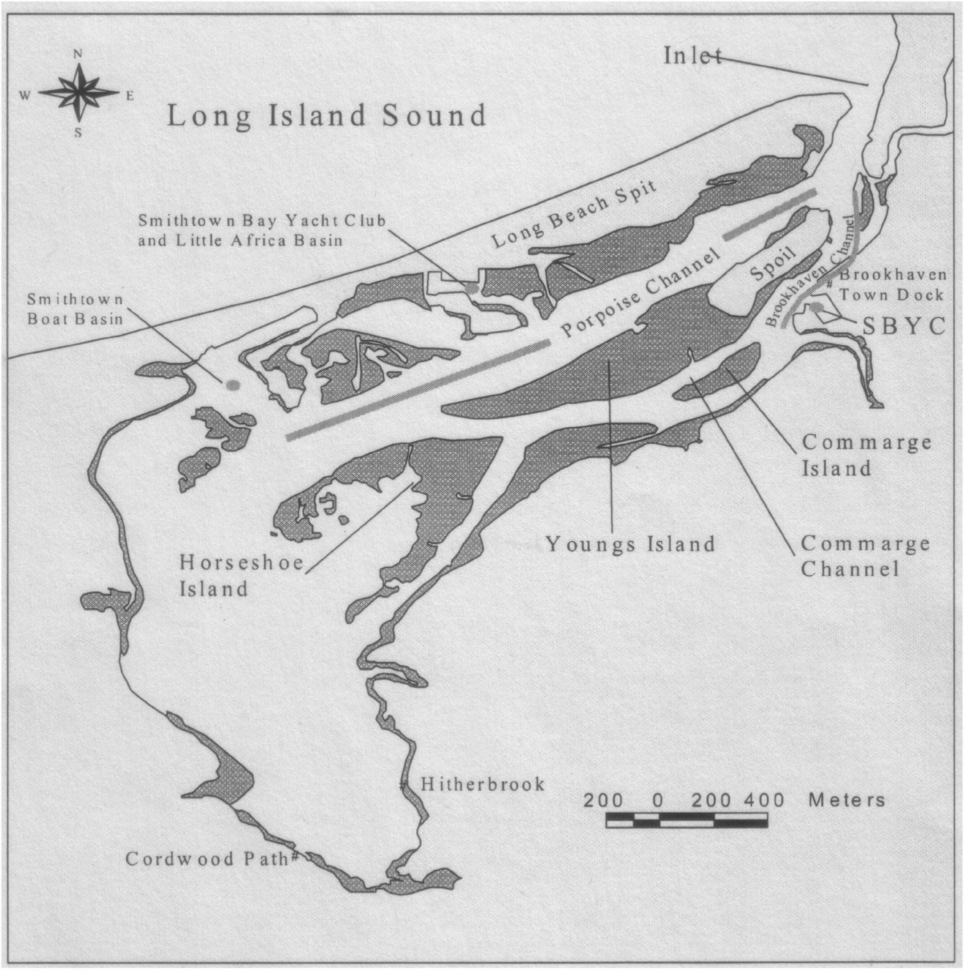

FIGURE 1.2. Location map of Stony Brook Harbor (40° 55' N; 73° 10' W).

sand, gravel, and some boulders (Lubke, 1964), but they are constantly moving and being fed by new source material from the adjacent bluffs. The relatively recent (last century or so) movement and growth of these two bars are illustrated in Figure 1.3. Long Beach grew to the northeast some 230 yd (210 m) between 1886, when the Coast and Geodetic Survey undertook the first detailed hydrographic surveys of the area, and 1967. The formation of Long Beach was again located in 1999 using the Global Positioning System (GPS) (Swanson and Wilson, 2005). The spit extended to the northeast about 60 yd (55 m) between

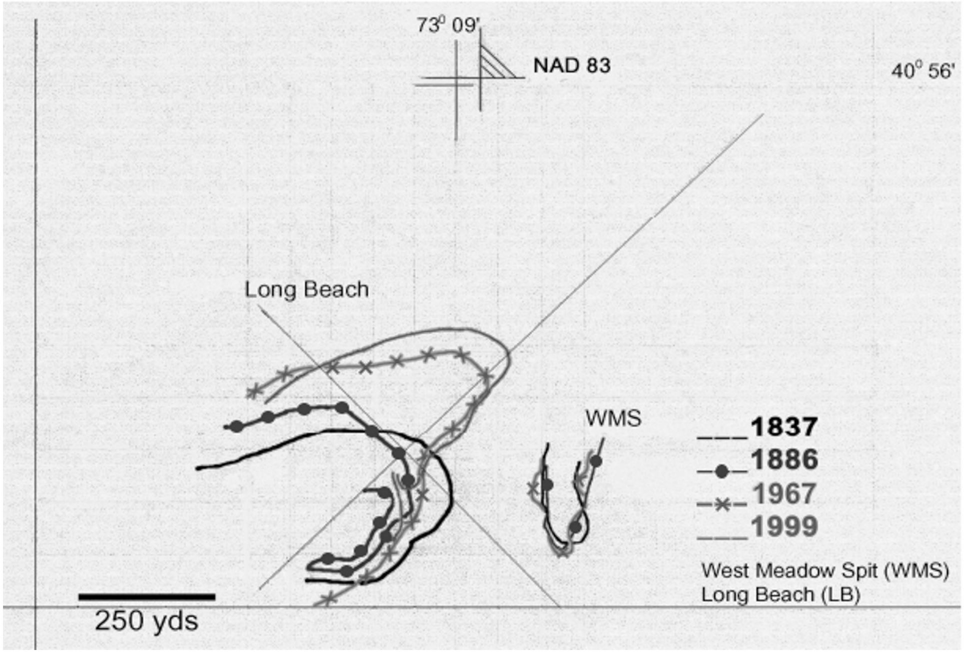

FIGURE 1.3. Growth of Long Beach Spit 1837–1999.

1967 and 1999. The growth rate between 1886 and 1967 and between 1967 and 1999 was about 2.8 and 1.9 yd per year (2.6 and 1.7 m per year), respectively.

West Meadow Beach advanced only slightly to the south during the same period. The entrance to Stony Brook Harbor between the two spits has shifted about 25° to the west from south-by-east to south over the century.

The continued growth of Long Beach has resulted in the accumulation of at least 45,000 yd^3 (34,400 m^3) of material at its northeast terminus since 1967. This is roughly the equivalent of a 15 yd^3 (11.5 m^3) truck dumping a load of sand and gravel every four days. A comparison of the change in contours of the shoal on the west side of the entrance to Stony Brook Harbor suggests that another 23,000 yd^3 (17,580 m^3) of material have been deposited there. The Long Beach spit and shoal may be gradually expanding out into the Sound.

If Long Beach continues to impinge upon the harbor entrance channel and the volume of water between mean high and mean low tides (tidal prism) entering and exiting the harbor remains unchanged, it is inevitable that erosion of West Meadow Beach will occur. In fact, this appears to be the case. Inspection of aerial photographs suggests that a bight in West Meadow Beach seems to be developing but has been kept in check through beach nourishment in 1980, 1997, and 2005. Alternatively, the Long Beach spit and shoal may expand further into the Sound—possibly spilling over into the offshore extension of the harbor entrance channel.

Based on marsh core dating (Cademartori, 2001) and the very recent rate of spit development on Long Beach, it may be that only fifteen hundred to two thousand years ago the harbor was an open embayment of Smithtown Bay contained between the bluffs at Nissequogue and Crane Neck. Some of the youngest natural geologic features of the harbor are the marsh deposits that formed in the harbor's quiescent waters as the growing baymouth bars isolated it from the main body of the Sound. Marsh sediments consist primarily of clay, silt, sand, and organic matter (Lubke, 1964).

Sediments of the Harbor

We have made the point that Stony Brook Harbor is relatively undisturbed by human-related activities compared to other bays and harbors on the north shore of Long Island. However, the surficial sediments of the harbor have in fact been disturbed considerably in certain portions of the harbor—particularly in the dredged channels and basins, and at disposal sites. Surficial sediments have also been altered along the fringes of the harbor where stormwater runoff is discharged.

Depending upon the area drained, the introduced sediments can vary considerably. Fine sediments and sand from eroding hillsides as well as from sanding roads in winter are introduced into the harbor in significant quantities. The highways and parking lots that harden the surface of the land around the harbor prevent stormwater infiltration and thus provide efficient means for transporting sediments and other materials into the waterway.

Sand has also been placed at several locations throughout the harbor for the purpose of creating public and private beaches. The Town of Smithtown maintained a public beach at the foot of Cordwood Path at the south end of the harbor for much of the 20th century. That sand has washed into the harbor, forming a sand bar just to the south.

Several private-property owners along the east side of West Meadow Creek between the former Wells's Shipyard and the north end of Erland Road imported significant quantities of sand to create beaches during the 1970s. This sand has washed into the creek and has probably been distributed up and down the creek bed. It could be contributing to the formation of sandbars near the entrance to Aunt Amy's Creek because of the greater strength of flood current relative to ebb.

The actual sediment distribution in the harbor is primarily a function of the tidal energy that ebbs and flows through it. Where current velocities are strong, the sediments are coarse, and where the waters are quiescent, the sediments are fine. Thus, there is a general reduction in sediment size from the harbor entrance to the head of the harbor. Storms are also important in distributing sediments within the harbor. A seven-foot storm surge, for example, will increase the volume of water entering the harbor over a tidal cycle by about 166 percent.

However, the cross-sectional area through which this volume of water must enter the harbor varies as a function of time. The maximum cross-sectional area is 220 percent greater than the cross-sectional area at a spring tide, maximum flood velocity. A maximum current during a significant storm surge may not differ greatly from normal current maxima. However, because of the higher stands of water, sediments not normally wetted are destabilized and washed into the waterway by current and gravitational forces. The general sediment distribution found in the harbor has been documented from a survey completed by Thore Omholt (1973) with additions and modifications found from several class projects undertaken at the School of Marine and Atmospheric Sciences (formerly the Marine Sciences Research Center [MSRC]) at Stony Brook University.

The southern end of the harbor (south of $40^0 54'45''$) has shoaled over the past century, even considering the relative rise in sea level and the fact that the channels are now maintained by dredging. It appears that the current rate of shoaling in the southern harbor is about 50 percent of that for the period 1886–1967. It should be noted that the sounding data from the early surveys used in these calculations were sparse compared to modern surveys.

That the rate of shoaling has decreased in the southern harbor is intriguing, and it may be due to changes in land-use practices and entrapment of sediment in dredged channels. Swanson and Wilson (2005) observed:

> From 1886–1967, the harbor drainage basin was largely undeveloped or in agriculture. Runoff from agricultural lands probably was not contained. The initial dredging of the harbor channels took place only in 1953. Since 1967, agriculture has essentially ceased, the land has been developed—much of the northeast part of the harbor drainage

basin being relatively high density residential and the southern and western harbor drainage basin being old field or low density residential housing (two acre or greater). Second growth forest has also replaced agricultural usage in some cases.

By the 1990s, dredging of the harbor channels had become routine, and so sediment is removed by engineering techniques.

Anthropogenic sources of sediment to the harbor are from storm drains, urban runoff, and sand imported for beach nourishment. Most sediment is transported through the harbor entrance due to the imbalance in ebb and flood tidal currents. Sediments are also accreting on the harbor bottom due to erosion of inappropriately placed fill from dredging operations and alterations of the natural morphology of the harbor to create navigational channels. The latter can cause creation of erosional or depositional surfaces that previously had been more or less stable.

Beach nourishment at Cordwood Path Beach and in West Meadow Creek over the last thirty to forty years has resulted in sand washing into adjacent waterways. Several surficial sediment samples obtained in the head of the harbor indicate sand mixed with silt and clays—very likely the consequence of the operation of the former public beach at Cordwood Path.

Anecdotal evidence suggests that there is shoaling and a general change in the character of the sediments in the tidal portion of Stony Brook (we use the proper name of the mill creek in Stony Brook, which is Stony Brook, not Stony Brook Creek). The likely sources of sediments creating this change are modification of storm drains along Main Street in the hamlet of Stony Brook in the mid-1980s, changes in channel morphology as a consequence of dredging, and erosion of filled land at the site of the Stony Brook Boat Works.

The latter facility and the adjacent parking lot are located on fill covering a former marsh at the mouth of Stony Brook. Relatively strong tidal currents (0.6 knots, 0.31 m/s) now flow around this artificial feature, whereas the original broad, meandering, marshy mouth of the brook probably dissipated the energy of the tidal currents, maintaining the marsh as a more or less stable feature. Sediment that once would have accumulated in the adjacent marshes is now confined to the channel.

In the 19th century, small commercial vessels carrying 50 to 200 tons (45 to 182 tonnes) traversed the brook, bringing grain to be ground at the gristmill (Lapham, 1942). These vessels typically had retractable centerboards and moved on high waters. The entrance to the brook, according to the 1886 Coast Survey hydrographic survey, was 1–3 ft (0.3–0.9 m) above MLW. The creek depths were not even charted. Lapham states that the creek at one time was broad. Marsh grass apparently did not proliferate. He speculates that the 1856 and 1891 breaches in the milldam washed sediment into the brook, which caused shoaling and creation of marsh conditions. While the entrance to the creek is now considerably different than it was a century ago, it still remains, for all practical purposes, dry at low water.

Of course, the fill on the northeast end of Young's Island changed the characteristics of the harbor entrance, reducing the cross-sectional area of the channel through which the currents are restrained to flow and providing new surfaces that waves and currents can erode.

The surface sediments at the southern end of the harbor are roughly 60–80 percent fine material as determined by a relatively recent MSRC research class. Based on ^{210}Pb dating of sediment cores, these fine sediments could have been accumulating at the rate of 0.12 in/year (0.3 cm/year) over the last half-century. While these fine organic-rich sediments may not be the most ideal from the perspective of the recreational user, they serve an important ecological function in that they inhibit the intrusion of salt water into the local groundwater table (Lubke, 1964).