1992

Restoration, Nourishment and Stabilization at Browning Beach, South Kingstown, Rhode Island

Robert Lee Gass
University of Rhode Island

RESTORATION, NOURISHMENT AND STABILIZATION

AT

BROWNING BEACH, SOUTH KINGSTOWN, RHODE ISLAND

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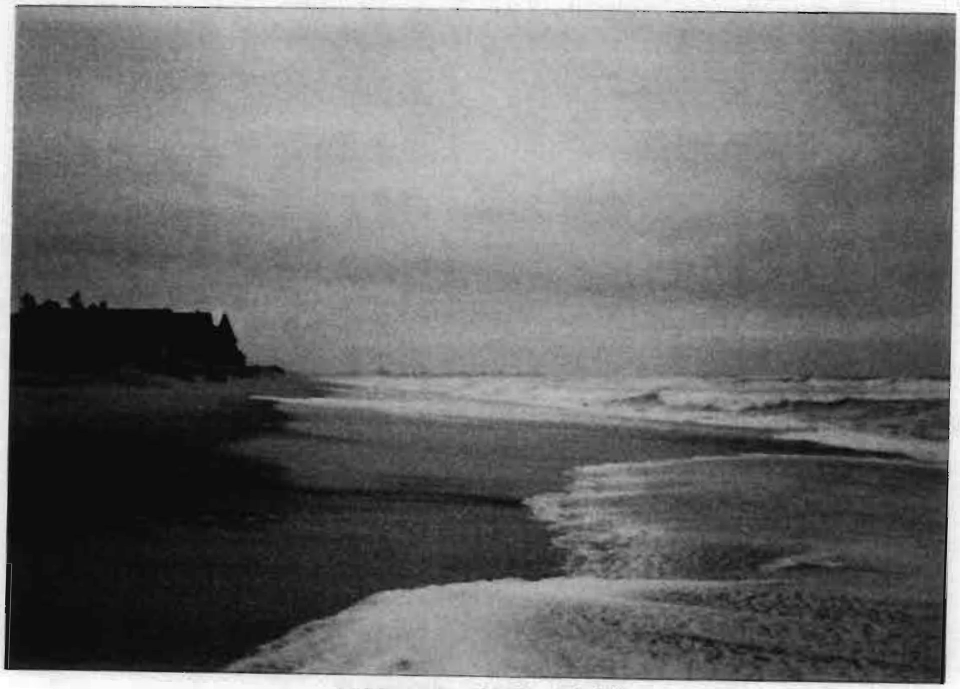

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1992

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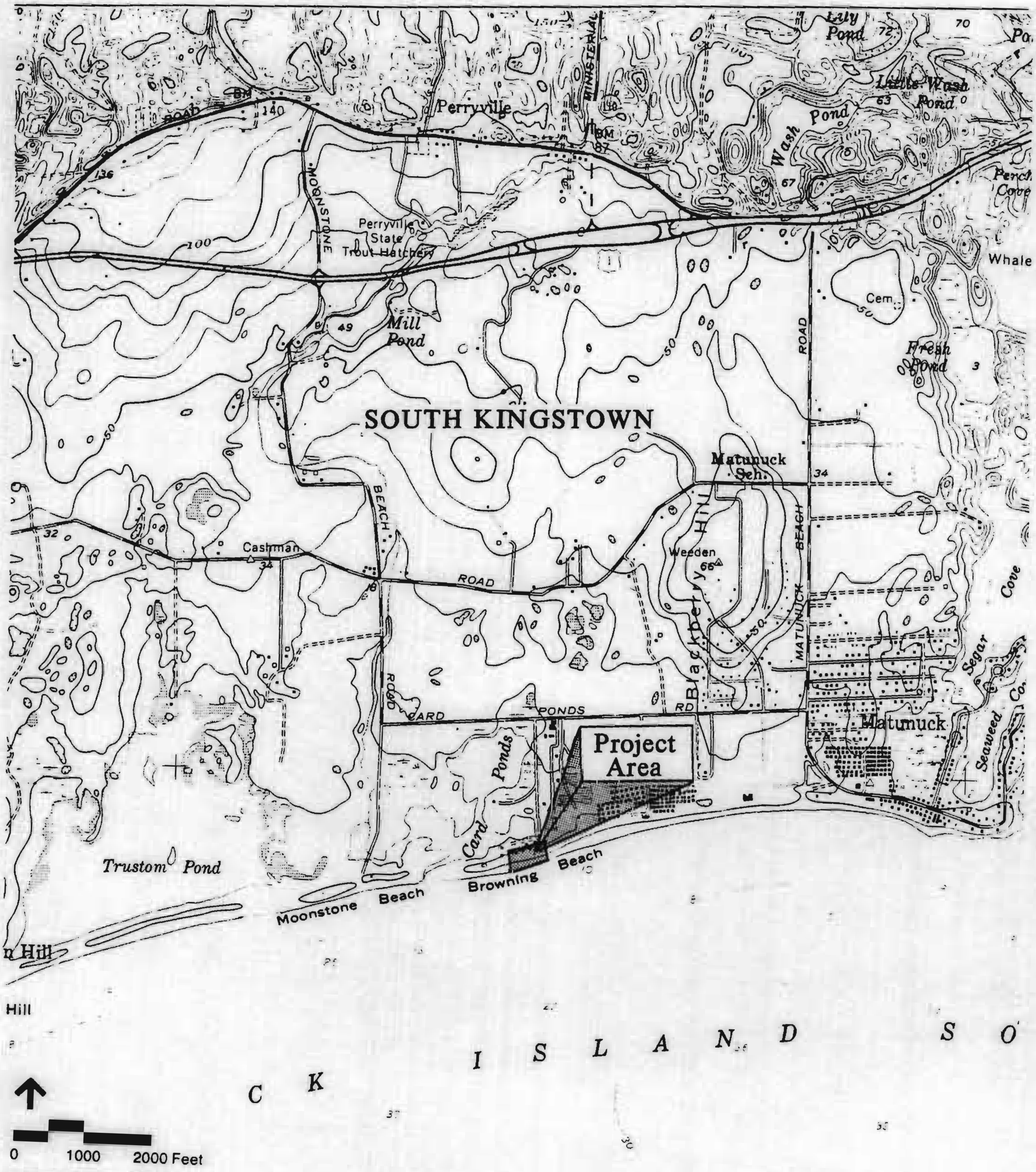
CONTENTS

PART I Introduction

Browning Beach is situated on the south shore of Rhode Island just to the west of Matunick. Midway along the barrier beach connecting Green Hill Point and Matunick Point is a narrow strand separating Card's Pond from Block Island Sound (see figure 1). Five homes were built along this section of the barrier beach in the early 1930's. At that time, the homes were situated near the back property lines. Aerial photographs indicate the primary dune system was well established and densely vegetated.

After sixty years of shoreline retreat, most of which has taken place in the last seventeen years, the primary dune system has eroded to a position very close to the homes. In an effort to re-establish and strengthen the dune, the homeowners applied for and received authorization to install a series of sand fences and plant dune vegetation. While wind-blown sand did accumulate behind the sand fences during the summer of 1991, it was ineffective in maintaining the feature during coastal storms.

With the failure of the sand fence programs proposed by Coastal Concervancy Services (CCS), an alternative method applied in North Carolina and Florida for artificially re-establishing the natural dune systems, has been evaluated by Vanasse, Hangen, and Brustlin (VHB), the Coastal Resources Management Council (CRMC), and myself.



Vanasse Hangen Brustlin, Inc.

Vicinity Map

Figure 1

A. Statement of the Problem

Continuing erosion of the dune at Browning Beach is removing the natural line of defense against flooding and wave damage resulting from coastal storm events. The erosional escarpment has been cut back past the former dune crest and is now being cut into the back of the dune feature. Consequently, the crest elevation is being progressively lowered as the dune retreats. Further erosion will result in the total loss of this frontal dune, and threatens the existing residences with future storm damage.

The occurrence of Hurricane Bob in August 1991 resulted in major beach erosion along the Rhode Island coast. The sand fencing configuration installed at the project site in the summer of 1991 was completely destroyed. Comparison of photographs taken before and after the storm indicates that the dune crest was cut back by twenty to thirty feet, to within several feet of the Bontecou, Harris, and Duval residences (see figures 2-9).

Approximately two months later, upon threat of a second major coastal storm, the property owners installed emergency structures to prevent significant property damage. These temporary structures consist of two levels of three foot by nine foot concrete blocks stacked in a convex configuration. While effective in preventing further storm damage to the frontal dune, these temporary erosion control structures are not acceptable for permanent use along this reach of Rhode Island shoreline. Located on an "undeveloped barrier", structural shoreline

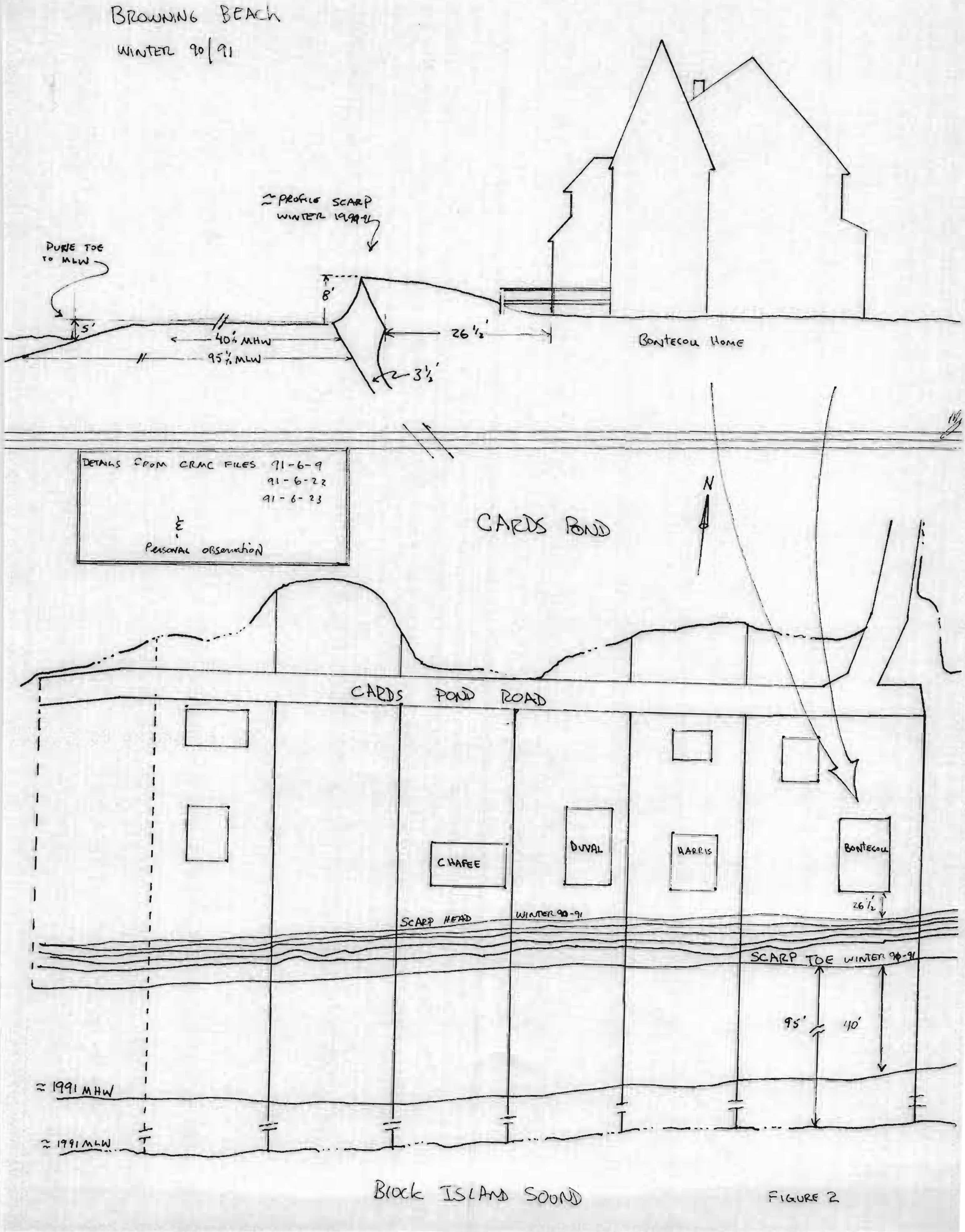

BROWNING BEACH
WINTER 90/91
≈ PROFILE SCARP
WINTER 1990-91
DUNE TOE TO MLW
5'
8'
40' MHW
95' MLW
26 1/2'
3 1/2'
BONTECOU HOME
DETAILS FROM CRMC FILES 91-6-9
91-6-22
91-6-23
&
PERSONAL OBSERVATION
N
CARDS POND
CARDS POND ROAD
CHAFEE
DUVAL
HARRIS
BONTECOU
26 1/2'
SCARP HEAD WINTER 90-91
SCARP TOE WINTER 90-91
95'
40'
≈ 1991 MHW
≈ 1991 MLW
BLOCK ISLAND SOUND

FIGURE 2

RIGHT TO LEFT
BONTECOU AND HARRIS
COTTAGES
MARCH 1991

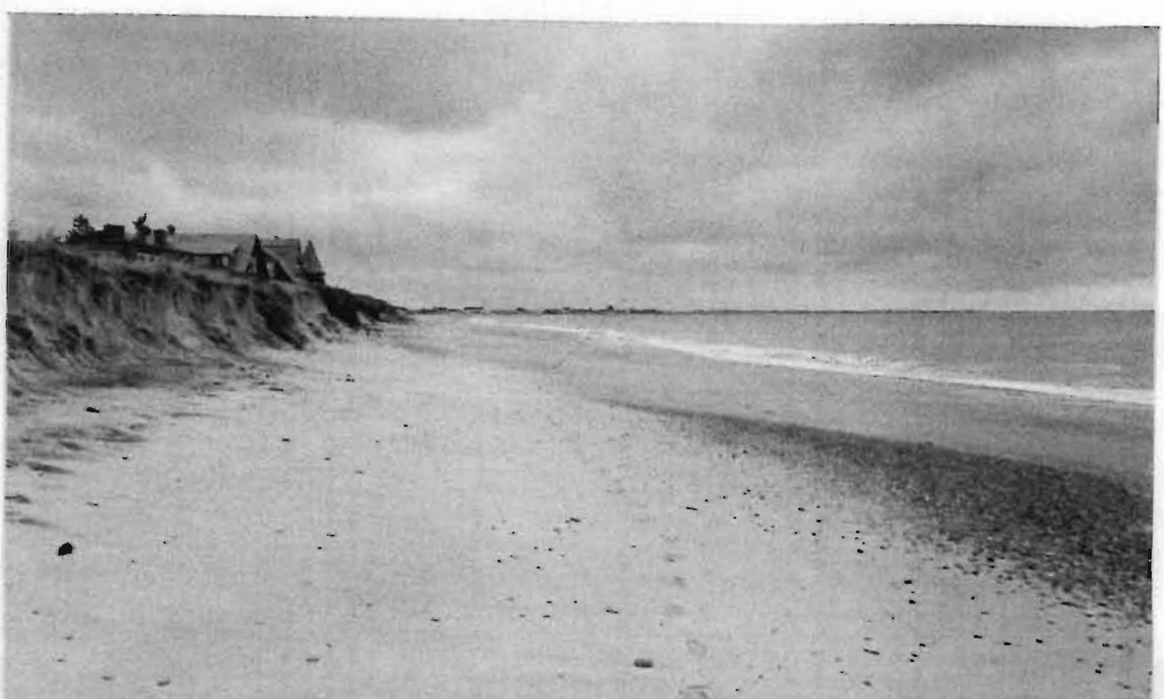
RIGHT TO LEFT
HARRIS AND DUVAL
COTTAGES
MARCH 1991

RIGHT TO LEFT
DUVAL AND CHAFFEE
COTTAGES
MARCH 1991

FIGURE 3

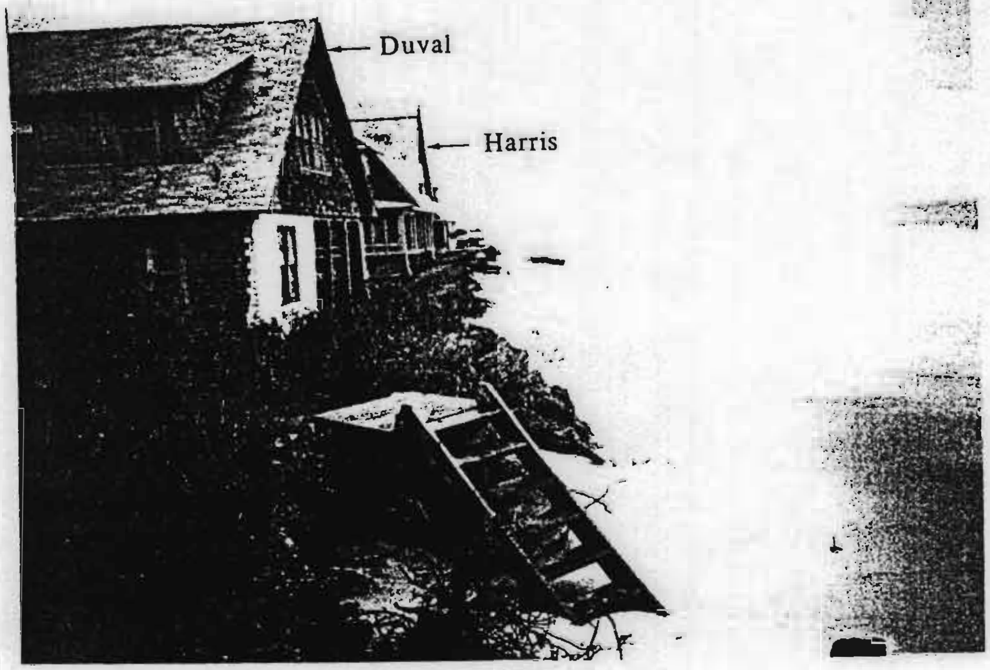
RIGHT TO LEFT
DUVAL, CHAFFEE
AND WESTERN MOST
COTTAGE; MARCH 1991

WESTERN MOST
COTTAGE
MARCH 1991

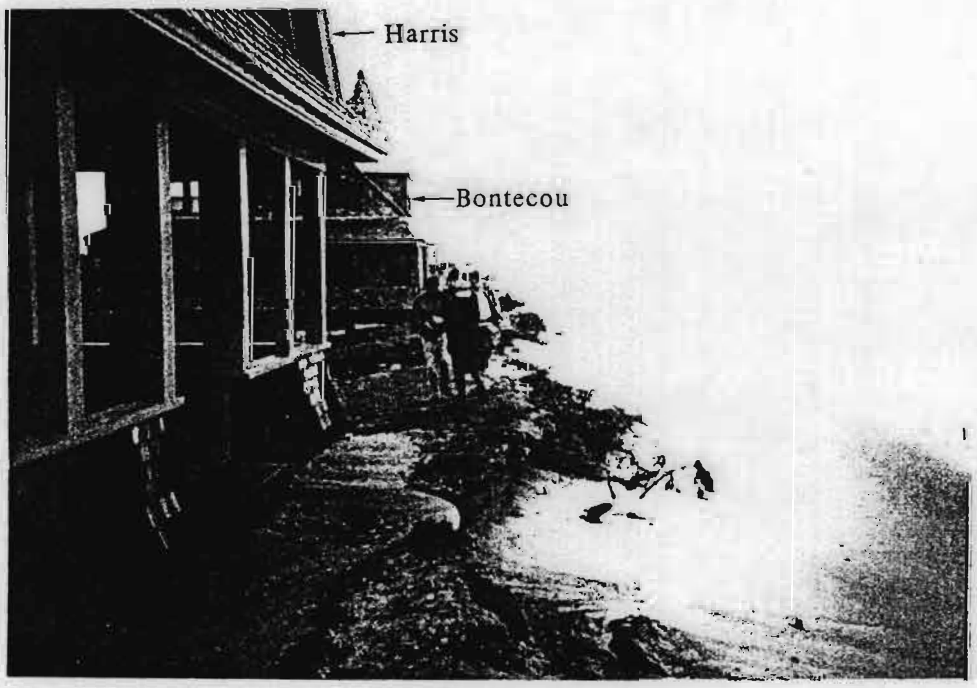


VIEW TO THE EAST
BROWNING BEACH
MARCH 1991

FIGURE 4



View to East



View to East

Vanasse Hangen Brustlin, Inc.

Project Site During Halloween Storm
October 30, 1991

FIGURE 5

LEFT TO RIGHT:
DUVAL, HARRIS,
BONTECOU
NOVEMBER 1991

ON THE DUNE LINE
FACING WEST
NOVEMBER 1991

LEFT TO RIGHT:
HARRIS, BONTECOU
NOVEMBER 1991

NOTE THE
INSTILLATION OF
"PROTECTIVE"
CONCRETE BLOCKS

FIGURE 6

Bontecou Home

Harris Home

Vanasse Hangen Brustlin, Inc.

Project Site After Halloween Storm

FIGURE 7

LAST PROPERTY
TO THE WEST
NOVEMBER 1991

CHAFFEE HOME
VIEW TO NORTH
NOVEMBER 1991

CHAFFEE, DUVAL, HARRIS
AND BONTECOU COTTAGES
AS SEEN FACING EAST
NOVEMBER 1991

FIGURE 8

DUVAL HOME
VIEW TO WEST
ON THE DUNE CREST
NOVEMBER 1991

DUVAL HOME
VIEW TO NORTH
NOVEMBER 1991

HARRIS, DUVAL, CHAFFEE
AND WESTERN MOST COTTAGE
VIEW TO WEST
NOVEMBER 1991

FIGURE 9

protection methods are prohibited. Therefore, these temporary structures must eventually be removed.

While structural shoreline stabilization methods on undeveloped barriers are prohibited, Rhode Island coastal policy does allow nonstructural methods for controlling shoreline retreat such as beach nourishment, sand fencing and vegetation stabilization.[1] Due to the relatively narrow beach, it is apparent that a sand fencing and dune grass program alone will not be sufficient to re-establish and maintain the integrity of the dune system. Beach nourishment for this size project would be cost prohibitive. Since the homes were originally constructed at the rear of the lots, moving the homes is not an option.

In accordance with Rhode Island coastal management policy for this section of shoreline, the natural dune system is the only available protection for the residences. The desire of the property owners is to enhance the natural dune system and provide a means for its stability during high frequency coastal storms. In states with similar coastal management strategies, this objective has been achieved through the use of "sand-filled geotextile units" or simply put: sand bags. This paper will evaluate the feasibility of artificially stabilizing a barrier beach in general, and specifically the use of geotextile units coupled with dune nourishment and vegetation stabilization at Browning Beach. Regulatory considerations were examined and compared with those of Florida and North Carolina. Regional

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[1]Rhode Island Coastal Resource Management Plan, (1990).

coastal processes at the project site have been reviewed and some observations and opinions are offered concerning how the regulatory process has progressed thus far. A cursory evaluation will be made concerning the interesting turn of events surrounding this project. It was, and still is hoped by the owners that the proposed design may serve as a demonstration project, providing short and long-term information on beach response and project effectiveness for future coastal management decisions. It is the desire of the author that this project at Browning Beach does not send an inappropriate signal to the owners of other similar properties in the area.

PART II Coast Erosion

At present there is a worldwide tendency towards shoreline erosion (Tanner and Stapor[2]; Bird[3], and many others) usually apparent in the progressive retreat of backshore cliffs and dunes, and the concurrent landward displacement of the shoreline. Such erosion may be attributed to a variety of natural mechanisms, including sea-level rise, tectonic instability and subsidence, climatic change (particularly increasing storminess and shifting storm tracks), plus numerous man-made causes. Man-made causes are mainly associated with changes in the sediment budget, for example through dredging, aggregate extraction, infilling or impedance of supply (both on the coast and along sediment-contributing streams).

Bird [4] has presented a global summary of coastal changes based on IGU-CCE correspondents reports and a more detailed account was published in Bird and Schwartz.[5] The overall impact

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[2]Tanner, W. F. and Stapor, F. W. Jr (1972). International Geography, Montreal 2, 1020 - 1021.

[3]Bird, E. C. F. (1976). "Shoreline Changes During the Past Century.", IGU, Melbourne.

Bird, E. C. F. (1981) Geography Physics Quarterly 35, p. 241 - 244.

Bird, E. C. F. (1985). "Coastline Changes." Wiley-Interscience, Chichester.

[4]Bird, E. C. F. (1985). "Coastline Changes." Wiley-Interscience, Chichester.

[5]Bird, E. C. F. and Schwartz, M. L.(eds.)(1985). "The World's Coastlines." Van Nostrand Rheinhold, New York.

of this compilation is impressive, indicating the widespread prevalence of erosion. While coastal accretion does occur in a few places, it tends to be related either (i) to the natural redistribution of sediment within generally eroding sediment cells, (ii) to exogenic sediment sources (mainly rivers), (iii) in areas of continuing isostatic uplift, or (iv) due to human activities (mining, spoil tipping, capture of longshore drift, estuarine reclamation etc.).

It is clear from Bird's book that there have been few systematic attempts to record shoreline change accurately over long periods. One exception is on the Dutch coast where regular beach profiling is undertaken as part of the national storm warning service and records stretch back over 100 years.[6] Fortunately, another exception is on the south shore of Rhode Island, where Boothroyd, Graves and Scott have compiled significant data[7]. It is important to recognize that the process of coast erosion is part of a natural tendency towards equilibrium. All shorelines attempt to redistribute sediment so as to minimize variations in response to the spectrum of incident-wave processes. Thus, actions aimed at slowing or halting erosion are, paradoxically, courting instability.

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[6]Edleman, T. (1966). Proceedings 10th Conference on Coast Engineering. ASCE, 489-501.

[7]Boothroyd, Jon C., Graves, Scott M., and Galagan, C. W. (1988). "Advance and retreat of the southern Rhode Island Shoreline, 1939-1985; Including berm volume." Technical Report No. 7-SRG. Prepared for Sea Grant College Program, University of Rhode Island. Kingston, RI.

PART III Regulatory Considerations

With the failure of the sand fencing program, it was apparent that an alternative method of erosion control would be necessary to restore and maintain the protective dune feature at the project site. In Florida and North Carolina, where structural erosion control methods are also prohibited in certain areas, homeowners have used sand-filled geotextile units to temporarily stabilize shoreline areas and create a base or core for dune restoration. While these methods have not been applied in Rhode Island as yet, VHB's study evaluated "soft" technology for possible use at Browning Beach as a demonstration project or case study.

A. Soft Structure Coastal Policy

The acceptance of soft shoreline stabilization methods would be, in essence, a legislative compromise that allows owners of nonconforming structures threatened by storm attack some course of action to protect their property. Because of the short durability of these methods, they are considered temporary. The objective being to allow time for property owners to move threatened structures, or more effectively manage the ultimate loss of the property. The owners have argued this is a viable compromise in cases such as Browning Beach, where the cottages were built in a responsible manner during the 1930's, long before the passage of restrictive legislation. (Of note is the appearance that the owners of the properties have done little to protect their diminishing dune system. But then, what could they have done to protect the system other than keep the system as natural as possible? Even so, the system will still tend to migrate inland.)

B. Soft Structure Coastal Policy in North Carolina

In North Carolina regulations prohibit the use of traditional shoreline structures such as wooden bulkheads or stone revetments. However, temporary erosion structures, defined as "bulkheads or revetments constructed of sandbags", may be used to protect "immanently threatened" structures. A structure is considered to be immanently threatened when the foundation is less than twenty feet from the erosional escarpment.[8] General conditions applying to the use of these structures include: 1) the structure must not interfere with public access and use of the beach; and, 2) the structure cannot remain continuously exposed for more than six months. Further, adjacent property owner consent is required in certain situations, and the structure cannot be constructed seaward of the mean high water line. The permittee is responsible for the removal of remnants of the structure in the event of destruction by storm events.

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[8]North Carolina Administrative Code, Section .0308 Specific Use Standards, 1991.

C. Soft Structure Coastal Policy in Florida

Florida regulations allow shoreline protection if a habitable structure is vulnerable to erosion from a five-year storm event. Geotextile structures have been allowed in Florida. However, policy revisions presently under consideration allow their use to deter dune erosion during high frequency storm events where dune or bluff erosion is the dominant mechanism of shoreline retreat. Further, geotextile units may be used to prevent flooding where no significant dune exists. Special conditions require nourishment of the dune to cover the structure. Nourishment is required only once per year if the structure becomes exposed for a long period of time. In addition, the structure must be removed by the applicant if it is determined to have an adverse impact on the beach-dune system. Florida regulations also require a monitoring program for coastal protection installations.[9]

D. Soft Structure Coastal Policy in Rhode Island

The dynamic, fragile nature of the coastal zone has been recognized by the legislators in Florida, North Carolina and Rhode Island, leading to the adoption of similar coastal protection policies. The owners argue conditions at Browning Beach are consistent with the criteria applied in Florida and

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[9]Harris, Lee E., "Developments in sand-filled container systems for coastal erosion control in Florida." ASCE Proceedings, Coastal Zone pp. 2225-2232. (1989).

North Carolina to determine whether use of sand bags is appropriate at a given site. The residences are within ten feet of the erosional escarpment, and the dune feature is the only source of protection against flooding and wave action.

The use of geotextile structures has been accepted in Florida and North Carolina due to their relative temporary nature.[10] Essentially comprised of fabric and sand, the structures have a limited design life when compared to wood, stone or concrete. As a result, they are not viewed as permanent, long-term feature of the shore line. Geotextile units are vulnerable to deterioration with time and can be dismantled in the event that associated impacts are determined to be unacceptable. Once destroyed, the materials are easily assimilated into the coastal system by natural coastal processes.

To determine the feasibility of a dune restoration plan incorporating a geotextile core, early in the planning process two meetings were held with the engineers of VHB, a representative of Hospital Trust, the property owners and staff members of the Rhode Island Coastal Resource Management Council. Based on these meetings, it was determined that the use of geotextile structures may be considered by the council, possibly on an experimental basis. The proprietors hoped such a design would restore and enhance the functional qualities of the natural dune system at the site, thereby benefiting the property owners,

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[10]Vanasse Hangen Brustlin, Inc., "Browning Beach Dune Restoration Plan, Matunuck, Rhode Island." Prepared for Hospital Trust, (1992).

while controlling long-term effects on the natural coastal system.

PART IV The Evolution of Rhode Island's Barriers

In consideration of the proposed changes to the barrier beach system it is helpful to examine how the barrier beaches came to be and the processes affecting their present condition. New England is part of one of the oldest continuously surviving land masses on Earth. Five hundred million years ago, the predecessors of the Berkshires and the Green Mountains formed as a chain of Islands. Since then, the land has not been static. The earth has been forced up and worn away many times. Over geologic time sea level has constantly changed at a variable rate. One of the more spectacular drops in sea level occurred nearly two million years ago when changes in Earth's climate caused the polar icecaps to expand and the sea level to fall. The ice migrated to about 40 miles south of Rhode Islands present shore. Fifteen thousand years ago the ice sheet commenced its retreat and passed to the north of Charlstown Pond roughly three thousand years later.[11] As the glacier retreated it deposited large quantities of sediment, known as glacial till. When it paused long enough the till piled up into steep irregular hills called moraines.

As the icecaps melted large volumes of water were released into ocean basins and the sea level to rise. Studies of the

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[11]Dillon, W. P. 1970. Submergence Effects on a Rhode Island Barrier and Lagoon and Inferences on Migration of Barriers. Journal of Geology, 78.

bedrock beneath Block Island Sound[12] disclosed what is now sea floor was at several times crossed by a number of rivers. As sea level rose a series of coastlines similar to those on Rhode Island's shores were formed then submerged. Barrier beaches similar to those seen today along the south shore are preserved in much of their original detail on the sea floor of Block Island Sound. The present coastline is comparably modern. Dillon estimates that as little as three thousand five hundred years ago sea level along the Rhode Island Shore was approximately fifteen feet below its present level and the barriers and salt ponds were considerably further seaward than they are now.[13]

The glaciers left their mark on the landscape. Valleys were filled with till and high points were eroded. Glacial till was blanketed in areas with a layer of out wash sediments deposited by the streams that carried the water released by the melting ice. The new shoreline was irregular and changed rapidly. A developing shoreline is usually in a greater state of disequilibrium than an old shoreline. In attempting to achieve harmony with the elements, the new shoreline will tend to straighten its irregularities. The erosive force of waves is concentrated on the jagged headlands and sediments accumulate in protected waters in bays and between headlands. Given sufficient time and sand, long wide barriers like those seen along southern

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[12]Coastal Waters Cover Pre-glacial River Valleys. Maritimes, 16 (4), (1972).

[13]Dillon.

Long Island and the Carolinas will form along shallow embayments. And so, this is how a series of small barriers have developed along Rhode Island's relatively young shoreline.

Rhode Island's coastline is still far from static. These barriers are slowly migrating inland. As the sea level rises, waves erode the barriers on their ocean side and during storms, wash sand into the ponds. Slowly the barriers move shoreward and the ponds, as their relative level increases, flood the low lying mainland. In Rhode Island this migratory process is sustained by rising sea level and a small supply of sand.

Measurements made in Newport since 1930 indicate that the relative sea level is slowly rising in this region at an average rate of .0096 feet per year, just under one eighth of an inch per year. That translates to about one foot of sea level rise every century.[14] A vertical rise of one foot per century or one eighth of an inch per year may not at first glance appear to be any cause for concern. However, since the slope of Rhode Island's south shore beaches to twelve feet above mean sea level has been calculated as a one foot rise for every thirty feet of run (1:30), the surrender of land to the sea due to sea level rise on Rhode Island's South shore is approximately thirty to fifty feet per century.[15] This is about one third to one half a foot per

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[14]Hicks, S. D. 1970. Changes in Sea Level on Rhode Island's Coast. Maritimes, 16 (4).

[15]Olsen, Stephen B. and Grant, Malcolm J. A report on a Management Problem and an Evaluation of Options, in Rhode Island's Barrier beaches: Volume I, p 7.

year in many places! An advance of this magnitude cannot be ignored when planning the management in these areas.

Rhode Island's barrier beaches are formed and governed by marine processes. Changes in sea level, wave action, near shore currents and sediment supply all combine to control the evolution of barriers and their present natural processes. Furthermore, the barriers are the dikes upon which the existence of the salt pond depends. They are also the mainland's principal protection from the forces of the open ocean.

A. The Geomorphology of Browning Beach

The southern shoreline of Rhode Island is a glacial out wash plain characterized by a series of headlands linked by narrow, wave built barrier spits. Headland features are comprised of glacial till or till covered bedrock, with the barrier spits separating brackish lagoons. Browning Beach, in this case, is the headland that separates Cards Pond, a brackish lagoon, from the waters of Block Island Sound. The geomorphic features of the southern Rhode Island shoreline are attributed to gradually rising sea level and an insufficient sand supply. As a result, vertical accretion of the barriers was limited and long term near shore processes have produced a net inland migration of the barrier spits.[16] This landward migration or "roll over" occurs as inlet processes and wave driven wash over events produce a net landward transfer of sediment and, ultimately, inland migration

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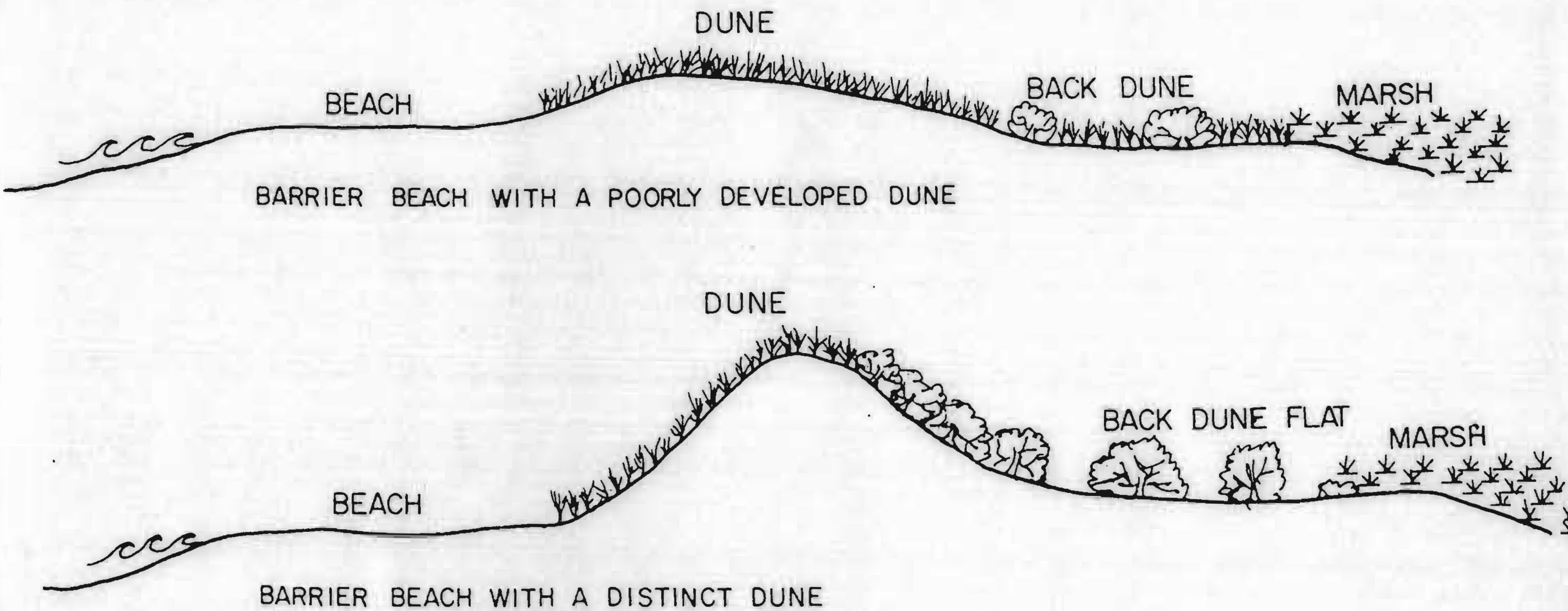
[16]Dillon.

of the barrier feature. As a result of this process, back barrier lagoonal deposits have become exposed on the shore face of the barrier beaches. This phenomenon is characteristic of a sediment starved littoral system.

B. Seasonal Processes Affecting a Barrier Beach

A cross section of a beach and a barrier illustrates a number of discrete characteristics (see figure 10). If there are no high frequency storms, the dunes may be relatively stable for several years. The beaches, however, are in a state of continual flux. During the summer small waves transport sand up onto the beach and build a wide flat embankment. In the winter, larger waves cut back the beach, carry the sand offshore, and deposit it on one or more bars parallel to the beach. The beach is therefore narrower and steeper in the winter. Rocks that are covered with sand during the summer may be exposed in the winter months (see figure 11).

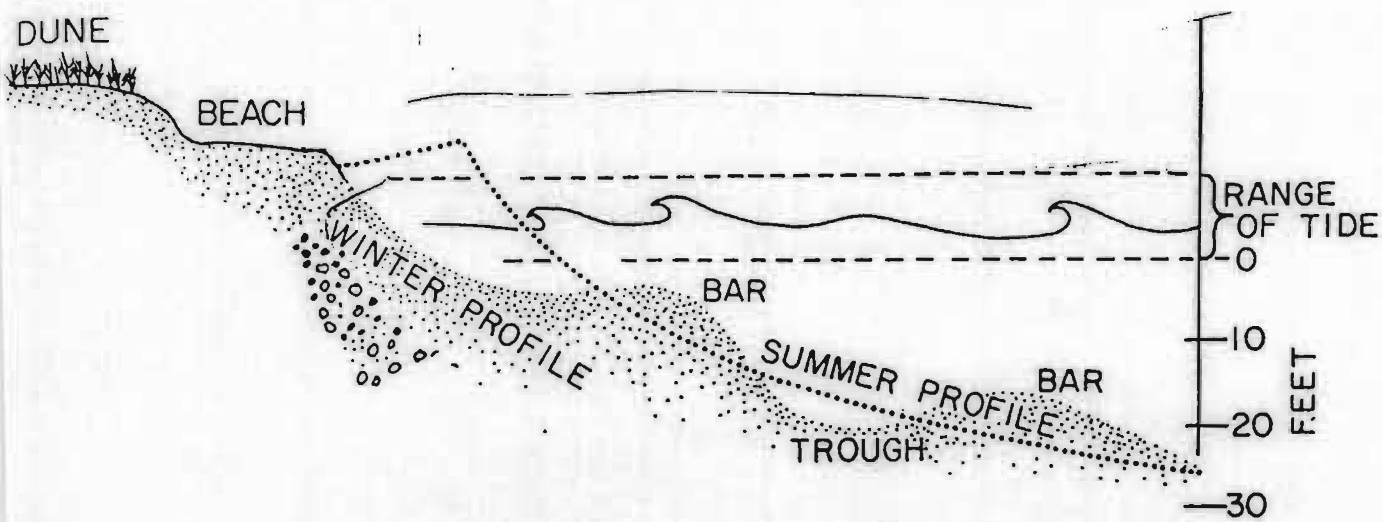
The movement of the beach, however, is not limited to a seasonal on shore and offshore migration. Long shore currents are set up by waves striking the beach at an angle. Each breaking wave produces a slight long shore impulse, and these combine to form a current (see figure 12). Sand placed into suspension by breaking waves is transported parallel along the shore by the current. This movement is called long shore drift. Over a long period of time, waves dominate from a given direction and a net current up or down the beach is produced. McMaster



Cross sections of typical Rhode Island barriers showing the beach, undeveloped and developed dunes, the back dune and the marsh. Developed dunes are usually densely vegetated by shrubs and small trees on the pond side. Only barriers with a developed dune have a distinct back dune zone. The primary dune vegetation is American beachgrass.

FROM: A REPORT ON A MANAGEMENT PROBLEM AND AN EVALUATION OF OPTIONS, IN RHODE ISLANDS BARRIER BEACHES

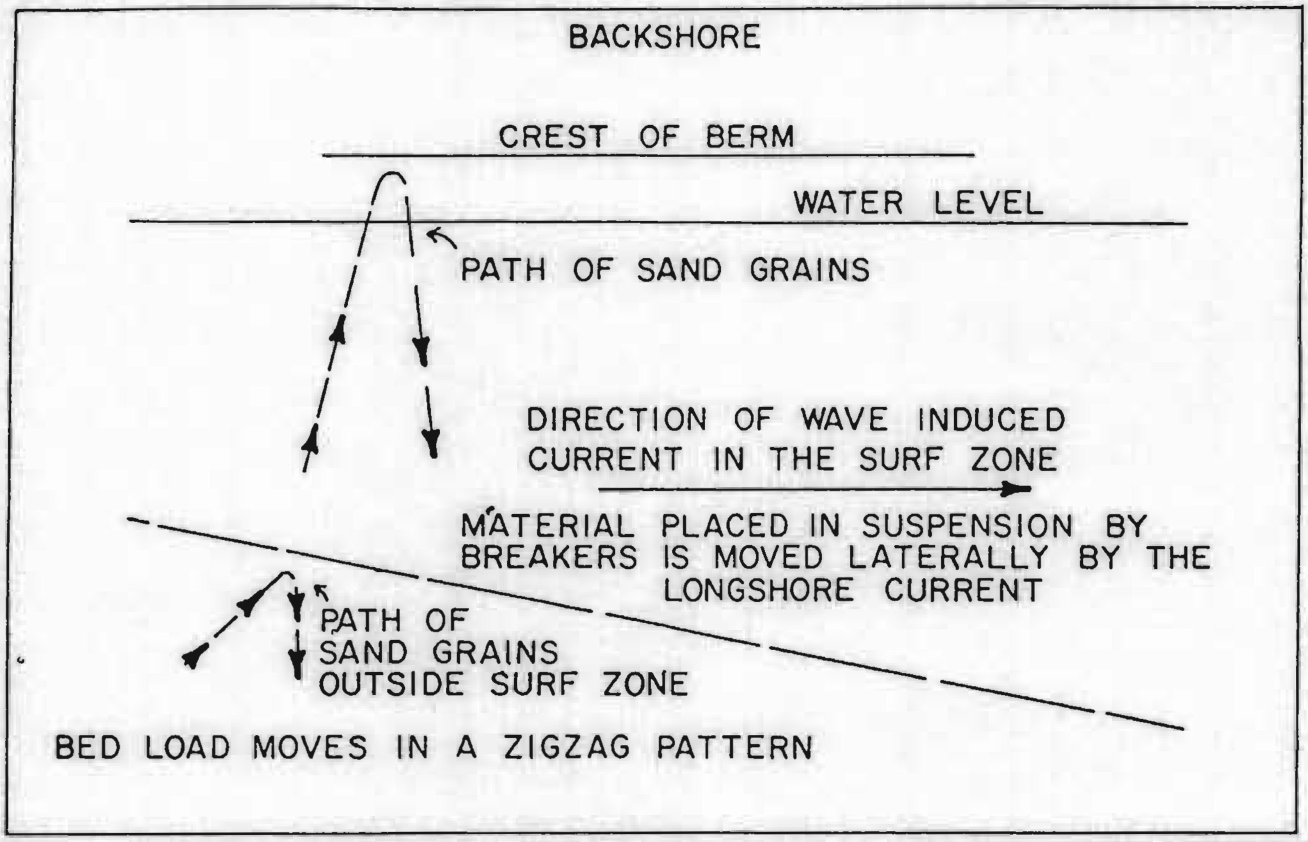
FIGURE 10



Winter and summer beach profiles.

FROM: A REPORT ON A MANAGEMENT PROBLEM AND AN EVALUATION OF OPTIONS, IN RHODE ISLANDS BARRIER BEACHES

FIGURE 11



The longshore drift of sand. Reprinted from Bascom, Willard. "Beaches", August 1967, *Oceanography: Readings from Scientific American*. San Francisco: W. H. Freeman & Co., 1971.

FROM: A REPORT ON A MANAGEMENT PROBLEM AND AN EVALUATION OF OPTIONS, IN RHODE ISLANDS BARRIER BEACHES

FIGURE 12

found that the long shore drift patterns along Rhode Island's shore from Point Judith to Watch Hill appear to converge toward the center of this section of shoreline.[17]

C. Natural Barrier Dune Formation, Stabilization and Erosion

Dunes may develop on a barrier beach when sand is blown off the beach and accumulates behind it. Wind born sand accumulates rapidly around semipermeable objects. The most common and natural semipermeable object on the beach is beach grass, a very effective element in the natural building and stabilization of dunes. The blades and stems of the grass reduce the wind velocity so that blowing sand drops down and is trapped. Other semipermeable barriers such as snow fences and dead christmas trees accumulate sand in a similar manner. Where enough sand is available and conditions are relatively stable, a parallel dune may form seaward of the first dune and the older dune may become permanently stabilized with secondary vegetation, mostly shrubs and some low trees. Most of Rhode Island's barriers support only one low dune line which, in its natural state, is well vegetated with beach grass and a few shrubs.

If the stabilizing cover of beach grass is destroyed, the sand particles are no longer protected from the wind. When the grass is destroyed on the fore dune and the dune crest, the wind will erode a cut into the dune. This is known as a blowout and

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[17]McMaster, R. L. 1960. Mineralogy as an Indicator of Beach Sand Movement Along the Rhode Island Shore. Journal of Sedimentary Petrology, 30 (3).

looks like a footpath stretching from the dune crest to the beach. If beach grass does not recolonize the exposed sand, erosion will continue and the cut will deepen and widen at the sides. Under natural conditions blowouts are usually recolonized. On heavily used beaches though, blowouts are often used as footpaths. Beach grass is an extraordinarily hardy and well adapted plant but it will not tolerate trampling. Unless a blowout is protected from vehicular and human traffic, recolonization may be delayed or prevented and erosion may be severe.

D. Winds on Rhode Island's South Shore

As previously alluded, winds are extremely important in barrier dune formation and erosion. Along the south shore of Rhode Island winds are of an east-northeast orientation. As such, the Rhode Island shoreline is exposed to wind and wave events from the east and southeasterly directions. Prevailing winds in the area are from the southwest, west, and northwest.[18] Southwest winds, although relatively infrequent, tend to be strongest and can generate waves that cause significant erosion of the beaches and frontal dunes along the south shore.[19] The

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[18]U.S. Army Corps of Engineers, South Shore, state of Rhode Island, beach erosion control study. Letter from the secretary of the Army. 81st Congress, 2nd session, House document No. 490. U.S. Government Printing Office, Washington D. C., (1950).

[19]U.S. Army Corps of Engineers, 1950; McMaster and Freidrich, 1986; Boothroyd, 1987; and others.

south shore beaches are generally sheltered from northeast storm events.

E. Waves on a Barrier Beach

Sand dunes are especially vulnerable to wave erosion because they are made of an unconsolidated and light material. Wave erosion of dunes is usually more spectacular than wind erosion. During storms, waves may wash over the barrier and erode what is known as a washover. These are similar to blowouts but are different in that they are formed by waves rather than wind, and are most often wider and deeper than blowouts. Waves frequently erode the dune to the height of the beach in a washover and transport sand into the pond where it forms a delta-shaped deposit. The dune is repaired by the recolonization of beachgrass.[20] Hence, the barrier beach rolls over itself in a tank tread fashion as it migrates shoreward. The natural process of dune growth may be assisted if snow fences are placed across the breach to accelerate the accumulation of sand. A washover may develop into a permanent or seasonal breechway.

F. Waves on Rhode Island's South Shore

Sources of wave data for the Rhode Island coast appear to be limited to two studies. In 1950, the U.S. Army Corps of Engineers conducted a Beach Erosion Control Study, compiling wind, storm swell and other meteorologic data relative to south

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[20] Olsen.

shore coastal processes. For the period of 1932 to 1942, studies indicate medium swells (6 - 12 feet) and high swells (over 12 feet) occur less than two percent of the time from the east and southeast, the direction of principle exposure. High swell conditions originated solely from the southern quadrant.[21]

The Raytheon Corporation under contract to the New England Power Company, recorded wave data for a one-year period between April 1974 and April 1975 with a pressure sensor located in twenty five feet of water off the Charlstown beaches. For the period of record, significant wave heights were less than 1.5 feet sixty-eight percent of the time and less than three feet ninety-two percent of the time. Significant wave heights of over five feet occurred 2.2% of the time (eight days out of the year).[22] As expected, there was a distinct seasonal pattern to the local wave regime, with more intense wave action occurring during the winter months.

G. Hurricanes

During hurricanes, barriers may be breached along their entire length and dunes may be completely destroyed. This

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[21]U.S. Army corps of Engineers, 1950

[22]Raytheon Co. n.d. Charlestown Hydrographic Study October 1974 - April 1975. Final Report. Prepared by Raytheon Co., Portsmouth, RI. Submitted to Yankee Atomic Electric Co., Westborough, MA. 113pp.

Raytheon Co. n.d. Charlestown Hydrographic Study April 1974 - April 1975. Final report. Prepared by Raytheon Co., Portsmouth, Ri. Submitted to Yankee Atomic Electric Co., Westborough, MA. 113 pp.

happened on many south shore barriers during the hurricanes of 1938 and 1954. Before the 1938 hurricane the dunes on the southshore barriers were considerably higher than they are today. In their natural state, barriers respond to severe wave erosion in a unique and efficient manner. In a major storm, waves quickly erode the foredune and carry the sand seaward thus extending shallow water further out from the dunes. (It is interesting to recall that most of Rhode Island's barriers support only one low dune line which, in its natural state, is well vegetated with beachgrass and a few shrubs.) Waves, therefore, break and loose much of their energy, progressively further away from the barrier. If however, the barrier has been developed and artificially stabilized by a seawall, the self-sacrificing process cannot take place and the force of the waves will remain concentrated upon the barrier. As a result, erosion during a severe storm may be worse. In North Carolina the extensive dune fields around Cape Hatteras were artificially stabilized and extended by sand bagging and massive plantings of beachgrass. There is some controversy over whether or not this has caused over-stabilization that is aggravating wave erosion rather than preventing it.[23] The subject of hurricane frequency and severity has received little attention until the passage of hurricane Bob in 1991, and Andrew in 1992. Rhode Island is known to have been threatened by seventy-one hurricanes since 1635, of

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[23]Dolan, R. 1972. Barrier Beach Stabilization Along the Outer Banks of North Carolina: A Reappraisal. Science 176 (4032).

which thirteen caused severe tidal flooding, twenty-five caused moderate flooding and thirty three caused little or no flooding.[24] From 1936 to the present there have been thirty tropical cyclones to hit Rhode Island. Eleven of them were tropical depressions and nineteen of them were full-fledged hurricanes. The decade on record with the most cyclonic activity was the 1950's. During this period there were eight tropical cyclones and six hurricanes. The 1960's follow closely with seven tropical depressions and six hurricanes. Between the years of 1958 and 1963 there was one tropical cyclone to affect the state each year. The longest respite between tropical cyclones was eight years: from 1977 to 1984. During the years of 1944, 1950, 1954, 1960, 1962, 1971, 1972, and 1985 two tropical cyclones hit the state. If you think those statistics are amazing, consider the fact that Rhode Island is the smallest state in the Union. Think for a moment about the statistical possibility of tropical cyclones making land fall on the south shores of Rhode Island coast twice in the same year! In 1954, two tropical cyclones made land fall on the southern New England coast.[25]

For a quarter of a century, the United States has experienced major hurricanes far less frequently than

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[24]Department of the Army, Corps of Engineers. 1960. Hurricane Survey Interim Report, Narragansett Pier Rhode Island. U. S. Government Printing Office, Washington, D. C.

[25]Valley, David. 1992. of the National Weather Service at T. F. Green Airport. Personal communication.

meteorologists have expected. William M. Gray of Colorado State University, has linked the frequency of severe hurricanes in the United States to the amount of rain in the Western Sahel region of Africa, just below the Sahara. He believes an extended drought is likely to end there within the next few years, concluding the lull in major hurricane activity here. Between 1947 and 1969, a rainy period in the Sahel, thirteen hurricanes with winds more than 110 miles per hour struck the East Coast. From 1970 through 1987, a dry period, only one such storm hit.[26] Barrier beaches, as previously noted, are particularly vulnerable to hurricane damage. They are the first line of defense against the sea and they are presently low in profile. By 1938, extensive development had taken place on the south shore beaches. With a few isolated exceptions (namely Browning Beach), the hurricane swept all structures off of all the barrier beaches in the state. Many of these areas were again built up, when, in 1954, another hurricane swept them clean for a second time. In 1938, two hundred sixty-two lives were lost and the statewide property damage was about one-hundred million dollars. In 1954, nineteen lives were lost and property damage was in excess of two-hundred million dollars. The destruction of buildings on barriers greatly increased the damage to properties on the mainland side of the ponds. Large quantities of debris,

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[26]Gray, William M. 1992. In "Storm Cycles and Coastal Growth Could Make Disaster a Way of Life, New York Times, this Week in Review, section 4 August 30, 1992. (as quoted by Peter Applebome)

including whole houses, were swept across the ponds. This debris battered, and in some cases, destroyed houses on the mainland shore. After the storm, its removal was a major problem and great expense.[27]

During such severe hurricanes as these, it is the storm surge which causes such extensive damage. Low atmospheric pressure and the piling up of waves along the coast causes sea level to rise dramatically. During the 1938 hurricane, sea level rose between ten and fourteen feet along the state's ocean shoreline. The amount of increase depends upon the shape of the coast and, therefore, varies significantly within a relatively small area. A long narrow indentation such as Narragansett Bay tends to funnel the waves and concentrate them upon a small area. The storm surge height in Providence is, therefore, greater than it is along the south shore. The majority of Rhode Island's barriers are presently so low that the dune crest is below the still water height of the 1938 and the 1954 hurricanes. The Corps of Engineers designs coastal protection features in reference to a Standard Project Hurricane (SPH). This is defined as a storm that may be expected from the most severe combinations of meteorological conditions that are considered reasonably characteristic of the region involved, excluding rare conditions. Neither the 1938 nor the 1954 hurricanes reached the SPH level. The levels of still water for the 1938 and the 1954 hurricanes

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[27]Olsen.

1954 hurricanes during the storm surge at various South Shore Rhode Island barriers are shown in figure 13.[28]

H. Tides/Storm Surge in the Project Area

The elevation of the water surface during storm events is critical to any type of coastal project planning. The northeast office of the Federal Emergency Management Agency was contacted by VHB to determine the recurrence intervals of extreme tide elevations in the project vicinity. The frequency curve for Newport, Rhode Island is shown in figure 14. Based on this curve, the table shown in figure 15 lists the still water elevations associated with various storm events with respect to the National Geodetic Vertical Datum.[29]

Of particular interest to the present study are the observed water elevations during the two recent severe storms: Hurricane Bob and the Halloween Storm. According to the National Ocean Service in Rockville, Maryland, for the Newport, Rhode Island tide station, the maximum observed water level during Hurricane Bob was +7.16 feet relative to the National Geodetic Vertical Datum (NGVD). The Halloween Storm produced maximum water levels of +6.09 feet NGVD, with superelevated tides occurring for approximately two days (see figure 14). Comparing this water level data to the frequency curve shown in figure 16, Hurricane

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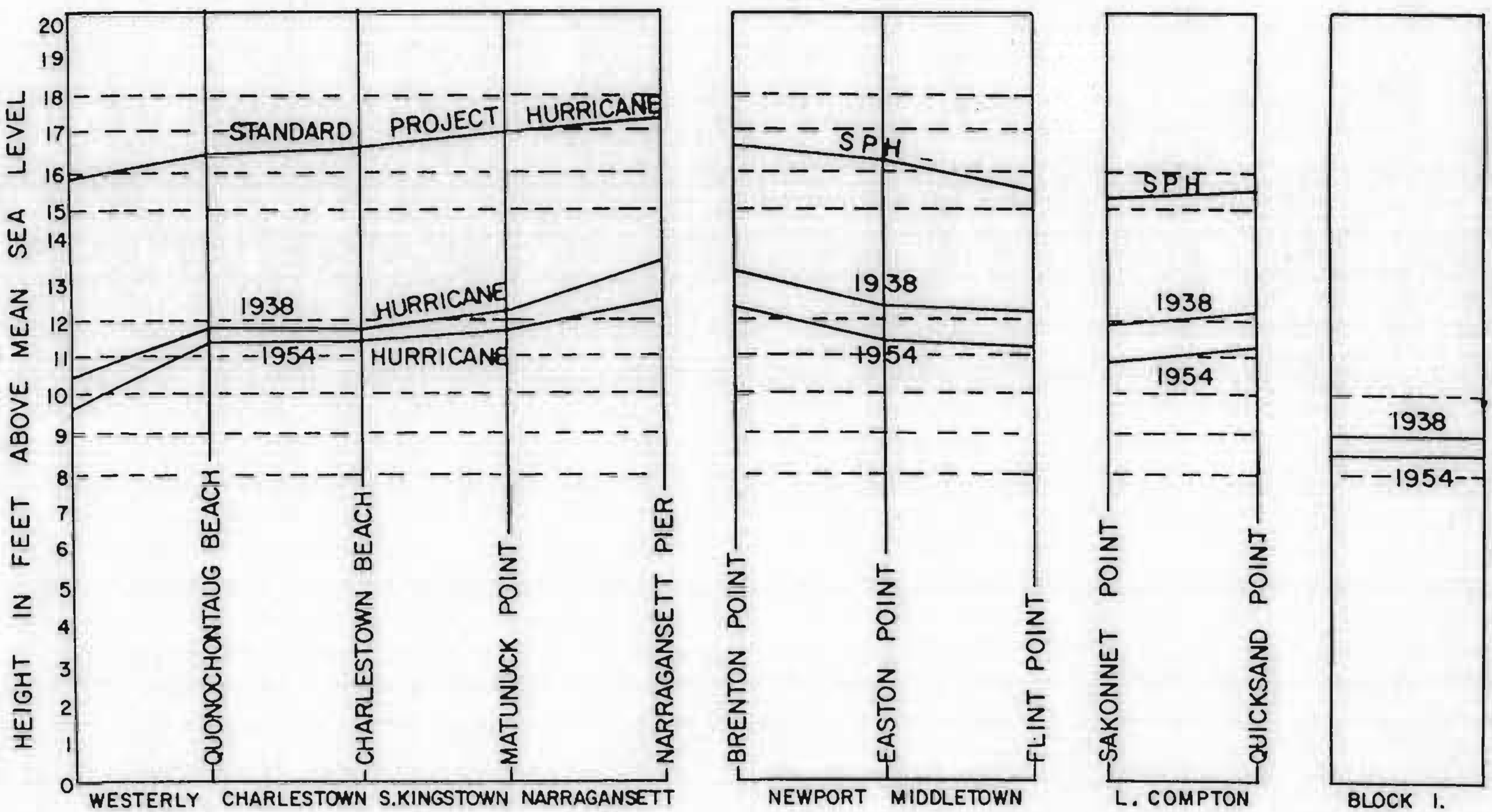
[28]Olsen.

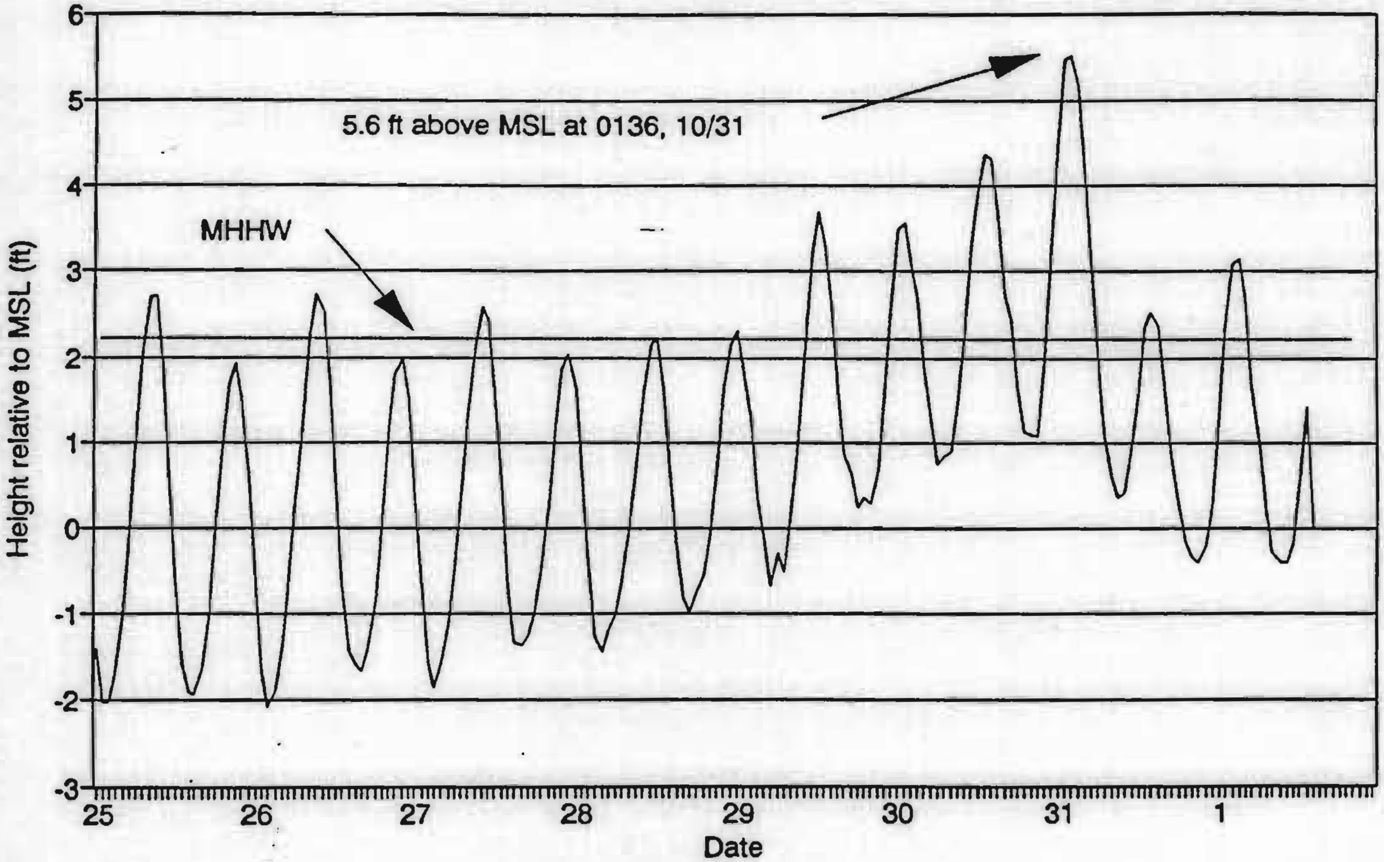
[29]FEMA, 1992. Communication between VHB and Mr Keven Merley, Federal Emergency Management Agency, Northeast Office.

HURRICANE STILLWATER FLOOD LEVELS



FROM: A REPORT ON A MANAGEMENT PROBLEM AND AN EVALUATION OF OPTIONS, IN RHODE ISLANDS BARRIER BEACHES

FIGURE 13



Source: ASA 1992

Vanasse Hangen Brustlin, Inc.

Tide Height at Newport, R.I.
October 25 - November 1, 1991

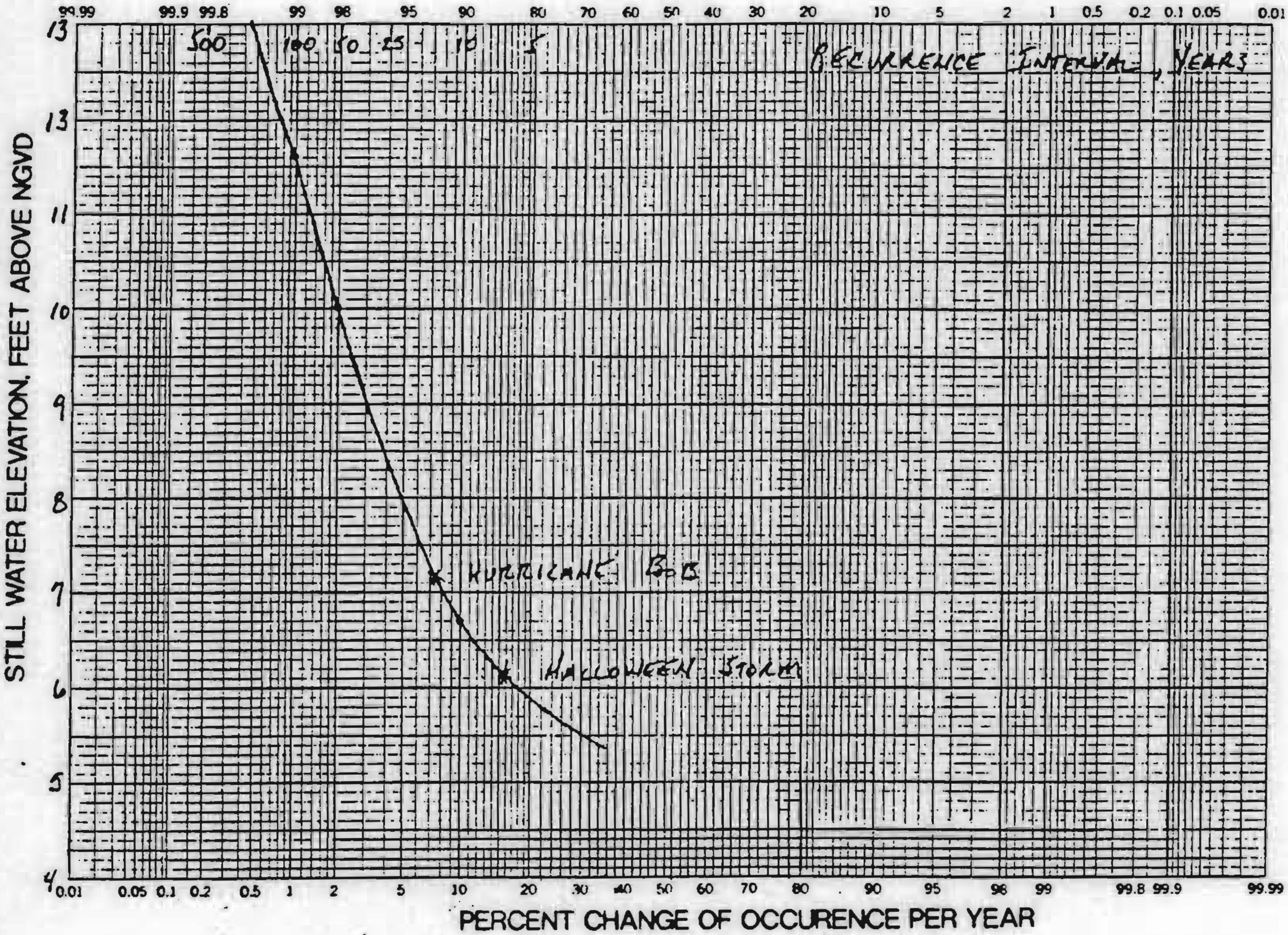
FIGURE 14

TABLE 1: RECURRENCE INTERVALS FOR STORM EVENTS NEWPORT, RHODE ISLAND

Event (Yr)	Water Elevation (NGVD)
10	+ 6.7'
50	+ 10.0'
100	+ 11.6'
500	+ 15.4'

AS DERIVED FROM FIGURE 16

FIGURE 15



Vanasse Hangen Brustlin, Inc.

Water Frequency Curve

FIGURE 16

Bob was a thirteen year event which has an eight percent chance of occurring in any one year.[30] (an interesting statistic since the National Weather Service determined the longest period Rhode Island has gone without a tropical cyclone is eight years!) The Halloween Storm was a seven year event with respect to water levels, with a sixteen percent chance of occurring in any one year.

I. Sand Budgets

Along a coast line where sand is predominant, it is useful to think of sand movements in terms of a budget. Sources and losses can be identified and even quantified over time. Little detailed information is presently available for the Rhode Island shoreline but some general observations can be made.

The supply of sand along the Rhode Island shore is small. Offshore, however, large deposits exist. Surveys made by the Corps of Engineers' "Sand Inventory Program" have shown that an estimated 141 million cubic yards of sand lie in a belt one to four miles off Rhode Island's south shore.[31] Rarely, however, does the turbulence of storm waves move significant amounts of this sand onshore.

Sand is never lost from the overall budget, however it can be moved from system to system within the budget through a number

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[30]VHB. 1992.

[31]Duane, B. 1969. Sand Inventory Program. Shore and Beach, 37(2).

of processes. Dry sand, unprotected by vegetation, is blown off the beaches and dunes out to sea or inland. More dramatic losses occur when waves wash over the barriers and transport large volumes of sand into the ponds. Over geologic time, and so long as the barriers are migrating shoreward, this sand is only temporarily lost to the system. In terms of our lifetimes however, sand washed into the ponds is lost from the beaches and the active sand budget.

J. Sediment Budget in the Project Area

Sediment supplies to the south shore of Rhode Island are provided by erosion of the headlands, the primary dune system, beach and shoreface areas. There are no fluvial sources of sediment in the area. Sediment is lost from the immediate littoral system, either temporarily or permanently, through overwash processes, deposition in flood tidal deltas, or transport offshore to the inner shelf.

PART V Arguments For and Against the Project

There are numerous arguments as to why a project such as this one should not be undertaken. Literature from conservationists, biologists, geologists and economists suggests that the long range expectation of survival of such a barrier beach is an "exercise in futility". Engineers as a whole are still trying to find a way to beat the system. Then there are also arguments as to why property owners should be allowed to achieve the full and best use of their properties.

A. Illustrated Problems With Engineered Shorelines

The most aspiring motion for halting the shoreline retreat on the entire Atlantic seaboard and re-establishing a status quo on the U.S. coastline was the suggestion of an engineer from Singapore, Siew-Koon Ho. In 1971, Singapore was confronted with having to reclaim land from the sea. The reclaimed stretch, five miles long and up to two-thousand-two-hundred feet wide, was armored with a seawall. Soon thereafter, waves began to undermine the seawall. Siew-Koon Ho proposed a more natural protection - artificial headlands. Ho reasoned, if the rocky headlands of a natural coast drew wave energy and protected quiet pocket beaches between them, engineers could create similar structures. Today Singapore's headlands of rubble stretch out into the longshore current and trap sand. The result, at least temporarily, is a scalloped shoreline, a series of low, triangular headlands 800 feet apart with quiet bays between. In 1974, Ho and Australian colleague, Richard Silvester, described the project for halting erosion, stabilizing and even causing accretion on the Atlantic Coast in Civil Engineering. Silvester said that here, finally, was a way to beat the Atlantic Ocean on North Carolina's Outer Banks.

Silvester and Ho proposed growing the headlands at the Outer Banks behind floating breakwaters. A breakwater is simply a wall parallel to the shore. Behind the breakwater a wave shadow forms and sand drops out of the weakened longshore current. Silvester and Ho proposed a clever movable breakwater built as a platform of submerged steel tubes. As sand accumulates behind the breakwater, the platform is moved seaward until the headland reaches the desired size. The headland is stabilized with a rock-armored tip and flanks.

Ho and Silvester point out that a singular advantage of the protective headlands is that the dunes along the beach can be bulldozed and the sand used to fill behind the headlands. The newly leveled dune area is planted with trees and lawn grasses which would then thrive with their roots finding the water table not far below ground. Both the old dune field and the new beach could become prime development and recreation areas and broaden the local tax base as the shore line becomes stable.

Ho and Silvester continue the defense of their plan stating the headland system also offers beach users the advantage of many types of beach within a short distance. Near the headland itself wave energy would be strong and the waves right for surfers. In the cup of the bay waves would be smaller: an ideal area for weaker swimmers and a calm place where people could launch boats. A beach with a series of bays would allow fishermen, swimmers, and boaters to enjoy special reserves. Everybody would be a winner!

Silvester and Ho prided themselves in pointing out that all these benefits are the result of engineering that imitates nature. Their system grew out of observations of beaches adjacent to natural headlands. Their vision of engineering which imitated and improves on nature became wide spread among their colleagues. Orville T. Magoon, when he was the Chief engineer of the South Pacific Division of the U.S. Army Corps of Engineers, called artificial headlands "one of the most promising means of stabilizing a shoreline and also developing a recreational beach." There was no reason, he believed, why engineers could not build structures that would "duplicate the success of nature in stabilizing sedimentary coastlines." However, ten years later Magoon called artificial headlands "one of the enigmas of coastal planning and coastal engineers." This was because a number of breakwaters have suffered serious and costly damage despite extensive theoretical and experimental testing.[32]

Engineers have often tried and failed to protect development by stabilizing the beach. History tells us that betting on beach

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[32]Magoon, O. T., Calvarese, V., and Clark, D. (1984). In "breakwaters, Design and Construction", pp 167-172. Thomas Telford, London, p 466, coastal environments.

stabilization is a high-risk wager. Kaufman and Pickley compare a wager on beach stabilization to "pulling the handle on a one-armed bandit, it's hard to quit betting, especially if big losses are proceeded by small wins."[33] Pickley and Kaufman continue: "Coastal Engineers of the past twenty years, many of whom are still teaching and practicing, have the highest failure rate of any group of engineers in the world. If bridges were failing as frequently as seawalls, a drive on any major highway would require considerable disregard for life and limb."[34]

Most shoreline engineers would dispute these odds and name a number of places where they have tamed the shoreline. But a shoreline engineer considers a jetty or seawall a success if it endures fifteen, twenty, or thirty years, its predicted design life. Also, to an engineer, a seawall that lasts fifteen years and protects the property behind it is a success whether or not it destroys the beach in front of it. Cape May's jetties successfully protect the harbor inlet, although the town spent itself into poverty trying futilely to hold its beaches and tourists, and to defend its property tax base against the ocean. In the case of Browning Beach, the present owners would be happy with just another five to ten years. In that light, perhaps the owners feel that the sand bag revetment has a very good chance of being successful.

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[33]Kaufman, W. and Pickley, O. H. Jr., "The Beaches are Moving: The drowning of America's Shoreline". Anchor Press, Doubleday, New York, (1983).

[34]Kaufman.

Developers and engineers regularly discuss environmental "trade-offs", giving up some natural quality to gain another benefit. The trade-offs required by many coastal projects, however, are seldom factored into engineers' cost analysis or even predicted. Engineers trying to protect development volunteer what is usually a no-win situation. The beach changes in shape and position because it is part of a dynamic equilibrium. This is an undeniable fact of life and geology on a barrier beach -- and any other coastal environment for that matter!

The ensuing excerpts from Kaufman and Pickley's book, The Beaches are Moving, are appropriate to the Browning Beach dune restoration plan and coastal engineering in general:

"The following principles have made engineers indignant and angry, but they are proven by careful observation of coastal engineering and its consequences:

1. No erosion problem exists until people lay out property lines and build. Beach changes only trouble people who have strong attachments to immovable objects and fixed lines. Shoreline engineers are rarely, if ever, called in to stabilize a wild beach.

2. Anything built on or near the beach usually increases the rate of erosion. Seawalls, bulkheads, groins, and house foundations reduce the flexibility of the system to respond to changes in the dynamic equilibrium. If energy patterns

and sea level change and the beach does not, residents will lose more than under the natural system.

3. Once you start protecting a beach you can't stop. By destroying the beach, most protective measures eventually create peril for themselves and increased danger to the development they protect. When protective seawalls or artificial dune walls or jetties begin to give way, a healthy natural system does not exist as a backdrop. Also, residents seeing a seawall crumble often feel more freighted of the ocean than those watching natural erosion. The sequence of beach protection is also a sequence of increasing expenses.

4. In order to "save" the beach we destroy it. When we stop erosion it is not to save the beach, but the development behind the beach. The beach that has become inflexible disappears rapidly, as it did at Miami Beach.

5. The cost of saving property is greater than the value of the property saved. This is particularly true when the long-range costs are accounted for and we recognize that storms occasionally wipe out whatever defenses have been erected."

Shoreline engineering is brought into the natural system by those responsible for creating the problems. The engineering solutions usually cost taxpayers more money than the property behind the shoreline is worth, especially since the beach is often destroyed by its fortification. Even if the fortification is funded by private citizens, longshore access, a public trust right, will eventually be denied. Civil involvement, which will invariably become a cost the public, will soon follow.

Over the past three thousand years, shoreline engineers and property owners have worked toward the same goal - stabilization. With many variations in design and theory, they have tried to realize their goal in one of three ways: building structures perpendicular to the shoreline (groins and jetties) to trap the sand in the longshore currents; building structures parallel to the shoreline (breakwaters) or to absorb the impact of breaking wave (seawalls, bulkheads, and revetments); replenishing or "nourishing" the beaches by pumping new sand onto the beach or into the longshore currents. Few projects have been able to stabilize the shore without some detrimental compromise.

B. Perspective on Replenishment and Dune Building

"If nature can build a beach out of sand, why can't man?" This is a question asked over and over again. It looks simple enough. "Why not simply shape sand into beaches and dunes the way nature shapes a beach?... All that is required to build a beach is to simply dump sand at the water's edge." And so this is the way so many property owners and local governments, and even the federal government, have approached the problem. In some cases they continue to do so today. All over the Atlantic seaboard, from Maine to Florida, homeowners and local governments have constructed sand fences and planted beach grasses. They have laid down barriers of scrap lumber and old Christmas trees to trap sand and rebuild the dunes degraded or completely eroded as a result of development, or worse yet, natural processes. The fact remains, unfortunately, that beaches and dunes constructed or altered by man, like nature's, will move to preserve themselves, and that is the very problem engineers and property owners would like to solve. When property owners pay to build or enhance a beach they want it to stay the shape and size they had it made. Even though a fixed shape and a healthy beach are contradictions, it was not too long ago most believed beaches could be "naturally" fixed in place.

In the 1930's the federal government began the most massive dune-building project known... the reclamation of North Carolina's Outer Banks. Geologists, engineers, and politicians collaborated on the project to rebuild the Outer Banks ravaged by the sea and the economy ravaged by the Great Depression by using the Civilian Conservation Corps (CCC). No one had any idea at that time that shoreline erosion would later threaten to destroy the Outer Banks that they had so aggressively set out to "fix". Many scientists and historians believed that the instability of the Outer Banks had only begun when colonists stripped the islands of timber and turned their goats and cattle loose on the stabilizing dune grasses.[35] The notion of correcting the

[35]Brown, R. H. 1948. Historical Geography of the United States. New York: Harcourt, Brace and Co.

mistakes of the past and hundreds of workers saving a spectacular landscape had great psychological and economic appeal during the Depression. Along more than thirty miles of beach the CCC planted some two million five hundred thousand trees and shrubs and enough beach grass to protect three-thousand-two-hundred fifty-four acres of dune. They staked over six-hundred-twenty-five miles of slatted sand fence.[36] The goal was to trap sand and build a high wall of fore dunes. It was not long before scientists and government officials looked in awe at the fifteen to twenty foot high dunes and felt they had saved the doomed islands. Thirty years later it was suggested that the beautiful dunes are not in the likeness of the pre-colonial natural system. These colossal artificially stabilized dunes are actually destroying the very islands they were designed to protect. Dr. Robert Dolan of the University of Virginia who has studied cross sections of the islands and numerous maps and charts of the area, is convinced the dunes have acted much like a seawall. The ocean's energy has been concentrated on the beaches, most of which form Cape Hatteras National Seashore because the dunes are too high to permit overtopping and too continuous to allow inlets and breakthroughs, except under extreme conditions, The beaches have narrowed and the offshore profile is growing steeper, thereby creating stronger waves. The dunes themselves are so successfully planted that their back and front sides are very

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[36]Dolan, R., Godfrey, P., Odum, W., "Man's impact on the Barrier Islands of North Carolina." in American Scientist, Volume 61, March-April, (1973).

steep. Waves strike this face with greater impact than a gentle slope, and erosion is fast and impressive. The protection the dunes first offered has lasted just long enough to attract significant development behind them. It has been said that this development is ripe for a major disaster.

Homes, motels, shopping areas, and even a U.S. Navy Base have been built up behind the dunes. Dr. Jack Pierce, a geologist with the Smithsonian Institution, says the dune wall, while undamaged, acts like a dike damming up flood waters rising in Pamlico Sound behind Hatteras Island during a major storm. He postulates that a strong dune line may leave the towns behind it as the only weak points. This may be principally true since the high dune wall catches sand which would normally blow inland over lower, less completely vegetated dunes to form secondary dunes and a higher midsection for the island. Paul Godfrey, of the National Park service, illuminated yet another threat posed by the dune wall: "Because the wall stops all over wash, the marshes on the back side of the islands, starved for new sand, gradually erode, making the islands narrower and more likely to be breached in a large storm."[37] Winter storms of 1973 suggest how close the Outer Banks might be to witnessing the reality of Godfrey and Pierce's appraisals. High waves topped some dunes and carved through the steep narrow walls of others. Roads behind the dunes were flooded from the ocean, and not the sound.

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[37]Godfrey, P. J. 1970. Oceanic Overwash and its Ecological Implications on the Outer Banks of North Carolina. National Park Service Report. Washington, D. C.

In several places inlets threatened to slice through the island, especially the resort town of Buxton, North Carolina where several motels and houses collapsed. Only highway department heavy equipment pushing sand back onto the dunes around the clock saved Buxton from being the first town destroyed by a protective dune wall.[38]

When man-made dunes began to capitulate, the Corp's response was to pump new sand onto the beaches. In order to protect the dune, an expensive artificial beach was deemed necessary. Where erosion threatened Cape Hatteras Lighthouse, the artificial beach was held in place with groins. The beach and the dunes just south of the light house began to erode as the groins cut off the longshore current.

Simple sand replenishment seems like the most natural of all engineering solutions. However, when the plan is transferred from the drawing board to the field, the idea has proven itself simpler than the fact. Another significant problem is where to find the sand. The conventional solution is to pump the sand out of the bay across the island onto the open beaches. With our relatively new awareness for the productivity of marshes and estuaries, we have become increasingly hesitant to lessen their value by stirring up large quantities of sediment. Additionally, a large depression in the floor of a lagoon will change wave patterns and energy, perhaps causing erosion on the back side of

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[38]Kaufman.

the island where none previously existed. Finally, the lagoon accumulates its sand under conditions much calmer than that of the ocean. The sand is finer than beach sand and often disappears rapidly when exposed to ocean surf.

Dredgers have been forced out of the bays and lagoons into the continental shelf, where dredging is more costly. Dredging offshore also leaves a hole that may either increase wave energy or change wave refraction patterns or both. The U.S. Army Corps of Engineers has looked into a compromise between lagoons and shelf by using the sand dredged during routine maintenance of inlets and channels. However, the difficulty with using inlet and channel sand is that near major harbors industrial wastes of all kinds are present in these "dredge spoils". The beaches are not a preferred disposal site for these hazardous industrial wastes.

Finally, replenishment has a much more fatal flaw than size of the project, the source of the sand, or pollution. For all intents and purposes it is nothing more than cosmetics. The beach is somewhat like an iceberg. Only a very small part is visible at the surface. The true beach is more than a narrow strip of bathing sand. It is a wedge of sediment three of four miles wide stretching underwater to depths of thirty to forty feet. Replenishment only drops sand on the thin visible strip of upper beach. Anyone who suggests building up the entire shoreface down to thirty feet below the surface of the sea would not be taken seriously!

The overall effect of replenishing only the upper beach is to steepen the beach profile. The wind and seas will always work to return the beach to its natural, more uniform shape. The steeper profile of replenished beaches is the reason they erode more rapidly relative to the natural beach. To maintain its shape a replenished beach has to be re-replenished on a continuous basis. As nearby sand supplies become scarce, sand has to be imported at a far greater cost.

The community is so thrilled and amazed to see a wide new replenished beach that the temporary nature of the solution is rarely recognized. A re-replenished beach disappeared at North Carolina's Wrightsville Beach in 1978, leaving only a line of steep mane-made dunes facing the sea. To make a more useful beach, city fathers bulldozed the front part of the dunes and spread the sand out as a new beach. The offshore slope had already become unnaturally steep, and 1978 storms wiped out the new beach, leaving a five to six foot scarp between the beach and the first dunes.[39]

C. Evolving Approaches to an Age Old Problem

Richard Silvester and Siew-koon Ho's proposal to save the National Seashore with a frontage of artificial headlands has much in common with the plan to save the Outer Banks shores with a great dune wall. Since the consonant endorsement in the 1930's

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[39]Kaufman.

of the dune wall, coastal engineers and shoreline geologists have progressed along different lines of thought.

Engineers have refined their calculations of stress and strain in the natural system and in the structures they build to defend the beach. They calculate and predict wave and wind forces, weather probabilities, and the required strength of building materials. With new technology and theories new defenses are designed. This new sophistication has yielded a plethora (or perhaps a pandora's box!) of new designs, many of which imitate nature in some way. Experts estimate hundreds of designs for "low cost" protection have been published. Professor Billy Edge of Clemson University, a member of the National Shoreline Erosion Demonstration Program, feels only ten percent of the low cost solutions show any promise. Among these, he lists artificial seaweed developed in Germany, concrete blocks preglued to a filtercloth mat, cement bags, a reef of buoyant frisbees, and several kinds of sea bags. The geotextile revetment proposal for Browning Beach is one such relatively new low cost solution that is of Dutch origin. A judgement one can make concerning these new designs is that however novel, all have the same intent - substituting a status quo amid natural changes. Edge holds up the simplest solution with the least restraint. He points to a very effective dune preservation measure proposed by the Nassau-Suffolk Regional Planning Commission: plant dunes with poison ivy. (a rather sinister solution!)

Conceivably because engineers have had very little success in subduing the sea, they are quick to repeat that which seems to have worked before. Thus, Silvester and Ho propose for the U. S. eastern seaboard that which appears to have worked in Singapore.

Geologists, on the other hand, whose job more often is to describe than to build walls or solve problems, have become increasingly aware of beaches as whole and uniquely different systems. Wave conditions, abundance and quality of materials, rate of sea-level rise, and shoreline shape are quite different in Singapore and North Carolina. Even beaches on adjacent islands of the Outer Banks differ significantly. It is safe to say no two beaches are exactly alike.

D. Analysis

Engineers are hired to treat specific and local symptoms. As such, their solutions seldom include the full scope of beach movement. If they did nobody could afford to carry out the solution. Who wants to hire an engineer that will propose a solution to a problem that cannot be paid for? Hence, engineers are driven by economics to come up with designs that the client is likely to be able to afford.

It is clear by now that most beaches are larger than the problems treated by engineers. The shoreface extends up to four miles offshore into water thirty feet deep. On barrier islands and beaches all visible land and development are part of the dynamic equilibrium. While whole systems do not experience the rapid changes seen on their beaches, their evolution is not nearly as slow as the evolution of an animal species. Within a human lifetime one can see the extensive migration of the entire barrier beach. What makes the barrier beach evolution predictable and gradual is the amazing flexibility of the beach itself. When engineering changes the character of the beach and tries to stabilize it, unpredictable change accelerates on the whole system. Wave attack may become stronger and storms more destructive. Dunefields may begin to disappear and the marshes on the lagoon side may shrink. Fish and shellfish grounds may disappear, wildlife populations drop. Polluted water running off the mainland or seeping out of septic fields is no longer purified by the natural filter system.

The difference between the holistic viewpoint of the geologist and the problem oriented prospective of the engineer and the property owner, like all conceptual differences, manifests itself in their description of the problem. To property owners and to engineers employed by them, when a shore line moves into the boundaries of any piece of property, land is eroding. The word carries with it a sense of irreparable loss of vital land. "Within the world of private property, moving shorelines are trespassers to be subdued and evicted."[40] Geologists, looking at the larger picture in time and space, see no permanent loss but a migration, islands and barriers rolling

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[40]Kaufman.

over themselves in a tank tread fashion. Migration is the process of travel for the sake of survival of the system.

Since both disciplines denote measurable changes, which best describes the beaches? The most acceptable definition is highly dependent on the audience. To the owner property it is indeed lost as beaches move. However, to the unbiased observer not burdened with the financial responsibility of the impending loss of valuable property, the entire system comes into focus. Sand is taken away here and added there just as inland erosion moves soil from one ecosystem to another, from field to river or swamp, or from swamp to ocean. The moving sand of the beaches stays in the beach system or is replaced by sand arriving from fresh sources. The beach ecosystem, under natural conditions, does not loose any vital material. The beach merely moves, changes shape and survives. Migration, while not acceptable to most property owners, appears to best describe the natural beach. Actual loss or erosion of sand and whole beaches, and even whole islands, does occur, mainly as a result of human intervention. Groins, jetties, breakwaters, dams, seawalls, bulkheads, and even artificial dunes, prohibit the beach from using its natural defenses. Serious and rapid true erosion is most often caused by man, not defeated by him.

Whatever one wants to call it: erosion or migration, it does cause a problem for property owners. It burdens the coast with problems whose weight is in proportion to coastal development. So why not defend valuable development against migration? The properties at Browning Beach are said to value over five million dollars. The answer: migration is itself a survival mechanism, a response to a great force. To replace migration with engineering one must ask if their efforts meet the natural adversary as economically and durably as migration itself. Geologists have said the adversary is nothing less than melting polar icecaps and rising sea level. As previously noted, rising sea level is a significant effect with which to be reckoned.

As sea level rises, islands and beaches do not stand still and allow water to pass over them. The dynamic barrier system retreats through a series of complex maneuvers. These include inlet formation during storms, inlet tidal deltas, inlet migration, overwash, and dune formation. Engineers well versed in geology estimate that for every foot rise in sea level the beach retreats anywhere from a hundred to a thousand feet. Some islands in South Carolina are rolling over themselves in retreat so fast that salt-marsh grasses are still anchored in the mud that reappears on the ocean side. In New England sea level appears to be rising at the rapid rate of three feet a century. Where the land is sinking, sea level rises even faster.

E. An Owner's Perspective

Equally compelling but much shorter arguments can be made for moving on with these type of projects especially if significant short term profits are promising. In conversations with Michelle Christensen, executor of the properties on Browning Beach, it became apparent the owners and executor of the properties are intimately aware of the risks and probable outcome of such a project. They are willing to take that risk and live with the consequences as long as they can get five to ten years of use out of that property. (By that time, the owners will have recouped their investment and/or will have sold the property, or in the event of loss, collected the insurance money.)

PART VI The Management of Coastal Lands and Sediments

The distribution and management of coastal land resources is an intricate issue. Managers are faced with the delicate problem of how to make everybody happy and do what is right for the coast, obviously a contradiction of terms. Not only are these lands subjected to a range of naturally interacting processes, but they have been dominated by personal desires. There is a great demand for shorefront property. Where the desire for private ownership of shorefront property was not prevalent, realtors have created the demand. While proximity to the sea has advantages, it does require temperate management. Awareness and realistic perception of natural hazards is crucial if risks are to be minimized. Many examples have been cited in which inadequate understanding has exacerbated rather than solved coastal land management problems. Accelerated erosion, disappearing beaches, increased frequency of flooding, progressive siltation, degraded ecosystems are symptoms of Man's inability to provide competent coastal land management. However, to add to these difficulties, many of these problems may also occur naturally.

In recent years there has been a revolution in coastal land management. Solutions proposed by engineers are no longer eagerly accepted. The explicit inability of massive and expansive concrete structures to protect coastlands, without further environmental damage, has led to a major reassessment of management policies, designs and techniques. A more realistic approach is being adopted, drawing on objective scientific observations, a variety of engineering skills, biophysical and biochemical techniques and socio-economic assessments. Together these offer the prospect of far more effective management of the world's shorelines.

Coastal environments are dynamic. They comprise a continual transformation of mass, energy and information. Coastal management should implement policies within management structures that accommodate this dynamism and coastal property owners should be prepared to accept this dynamism as an integral part of ownership. Frequently, however, management objectives on the public and private front, focus on static solutions, such as securing the shoreline against erosion, maintaining constant channel depth or cultivation of a continuous dune stabilized with beach grasses. It has become obvious that such static solutions place an undesirable stress on many coastal environments, and may in some cases, promote a catastrophic reaction or system failure. The first rule of coastal management should always be "to work with, rather than against, the natural system".[41]

Transfer of mass along the coast conjures a scenario of losses and gains. Man has made a considerable number of attempts to control and modify these budgets by stopping losses, interrupting flows, and even redistributing sands. During

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[41]Carter, W. B. G., Coastal Environments: An Introduction to the Physical Processes., p. 432, (1988).

attempts to take land back from the sea, sediment may be removed from the coastal system, creating a critical scarcity elsewhere. Artificial manipulation of the sediment budget invariably leads to an interruption in the natural coastal processes resulting in unnatural zones of sediment deposition and erosion, surpluses and deficits of nutrients and forced changes in coastal ecosystems themselves.

Additionally, increasing concentrations of people levy an ever-increasing stress on coastlands. This may result in gradual deterioration of the environment. Deterioration of coastal areas may manifest itself, either through direct physical or chemical change, or through indirect impacts on the survival of plant and animal life and the performance of coastal ecosystem as a whole. Human pressures on coastlands are highly variable. Accessibility and activities frequently restrict land-use potential to the degree that exploitation of resource potential is uneven. It is known, for example, that a parking lot near a beach has a profound effect on the increasing the level of beach use. Some activities serve to minimize coastal uses. For instance, the use of coastlands for low level military training often unintentionally provides protection for vulnerable areas.

The demand for shorefront property continues to rise. Much of the barrier coast has been developed by speculators, initially creating rather than satisfying a demand. Shorefront properties are sold for exorbitant prices despite their vulnerability to storm damage. (Recall that the Browning Beach properties consisting of five lots are said to have a market value of one million dollars apiece, totaling five million dollars.) Coastal development is often promoted by prior provision of basic services such as roads, electricity, water and sewerage to attract purchasers. Government regulations in the past, for example have also provided initiatives for development.

The National Flood Insurance Program (NIFP) was one such program. Set up in 1968, its purpose was to subsidize insurance coverage for communities at risk from flood hazards. It is interesting to note that commercial insurance companies are reluctant to write erosion or coastal storm damage coverage, because on those occasions when they were prepared to, premiums were high and customers few.[42] The NIFP is administered by the Federal Emergency Management Agency (FEMA), and legally obligates the Federal Government to Compensate flood victims, provided certain specified planning and constructural guidelines have been met. Inadvertently, this subsidy promoted development in vulnerable coastal areas, to which commercial insurance would not normally be extended. Thus expensive beach front houses are protected by the generosity of the Federal Government, and can rebuild from public funds if they are damaged or destroyed. A measure of how far the NFIP has been diverted from its original

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[42]Mitchell, J. K. (1974). "The Community Response to Coast Erosion". University of Chicago, Res. Pap., Geography, No. 156. p. 106.

altruism is proffered by Monday[43], who shows that although only ten percent of the flood-prone communities are coastal, they account for sixty-seven percent of NFIP indemnities, and that four areas (Tampa, Miami, Galveston and New Orleans) accounted for thirty-eight percent. Between 1970 and 1982, $665 million had been paid out on claims for coastal damage. In 1983, the Reagan Administration revoked, for financial reasons rather than environmental principles, the provision enabling the NIFP cover to be extended to new barrier Island developments. This revocation was achieved under the Coastal Barrier Resources Act passed by Congress in 1982. In addition to eliminating the role of the NIFP, the Act forbids all Federal expenditure on development infrastructure (roads, bridges, sewerage, etc.), as a disincentive to private development on listed barrier islands. Browning Beach in South Kingstown is covered under the CBRA directive. Godschalk[44] provides a description and commentary on this piece of legislation. There remains the fear that some barrier islands will be surreptitiously removed from the list, so restoring subsidies to avaricious developers.

Property development in Florida would not be viable without such preliminary treatment. The dirty details of the often crafty plots and actions to further coastal development have

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[43]Monday, J. (ed.)(1983). "Preventing Coastal Flood Disasters." Association of Flood Plain Managers/Natural Hazards Research Center, Boulder, Col.

[44]Godschalk, D. R. (1984). "Impacts of the Coastal Barrier Resources Act: A Pilot Study". Dep. City. Regional Plan., University of North Carolina, Chapel Hill, NC.

received extensive and often anecdotal coverage in books by Kaufman and Pilkey[45] and Schoenbaum[46] on North Carolina, and Blake[47] on Florida.

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[45]Kaufman.

[46]Schoenbaum, T. J. (1982). "Islands, Capes and Sounds". J. F. Blair, Winston-Salem, North Carolina.

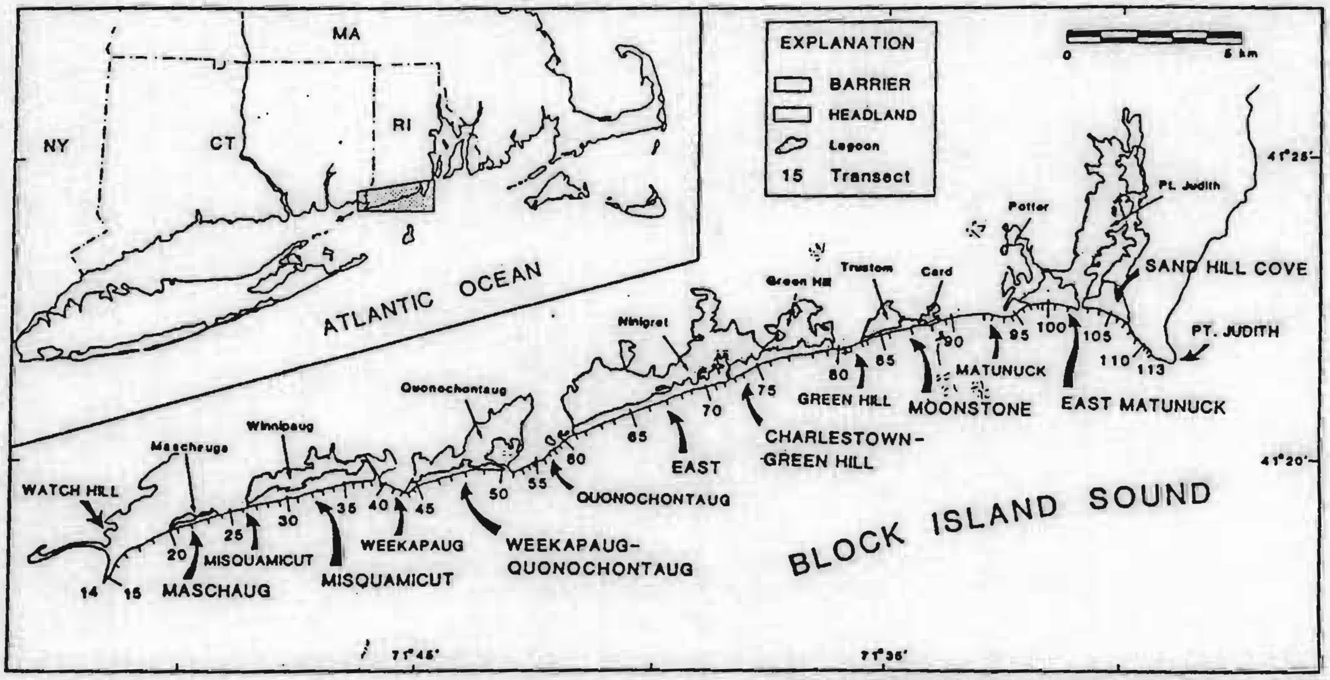
[47]Blake, D. (1981). "Land into Water - Water into Land." Florida State University Press, Tallahassee.

PART VII Managing Browning Beach: A Case Study

The site is on a undeveloped barrier beach that has undergone erosion at an irregular rate since the construction some sixty years ago. Undeveloped barrier beaches, as defined by CRMC, are essentially free of commercial/industrial buildings (excluding public utility lines), houses, surfaced roads, and structural shoreline protection facilities. The shoreline of concern for this project lies on and between numbers 88-90 (see figure 17). The studies by Boothroyd, Galagan, and Graves indicate that erosion rates have gone from 0.00 FT/YR between 1939-1975, to as much as 7.62 FT/YR between 1981-1985 (see figures 18, 19 and 20).[48] In the past year (May 90 to May 92), I personally witnessed nearly thirty feet of erosion in these areas, the most dramatic of which was a result of Hurricane Bob and the Halloween Storm of late summer and fall of 1991. Even without these significant weather patterns, the erosion in this area has been significant for the past ten years. This indicates that there is a state of significant disequilibrium existing in this area.

Literature on the subject of barrier beaches and erosion tends to suggest that further interference by man in this area will only postpone the inevitable at best, and will exacerbate the problem at worst. From this literature and my classes in Marine Affairs I have learned barrier beaches are narrow strips

[48]Boothroyd.



Source: Boothroyd, Galagan, & Graves, 1988

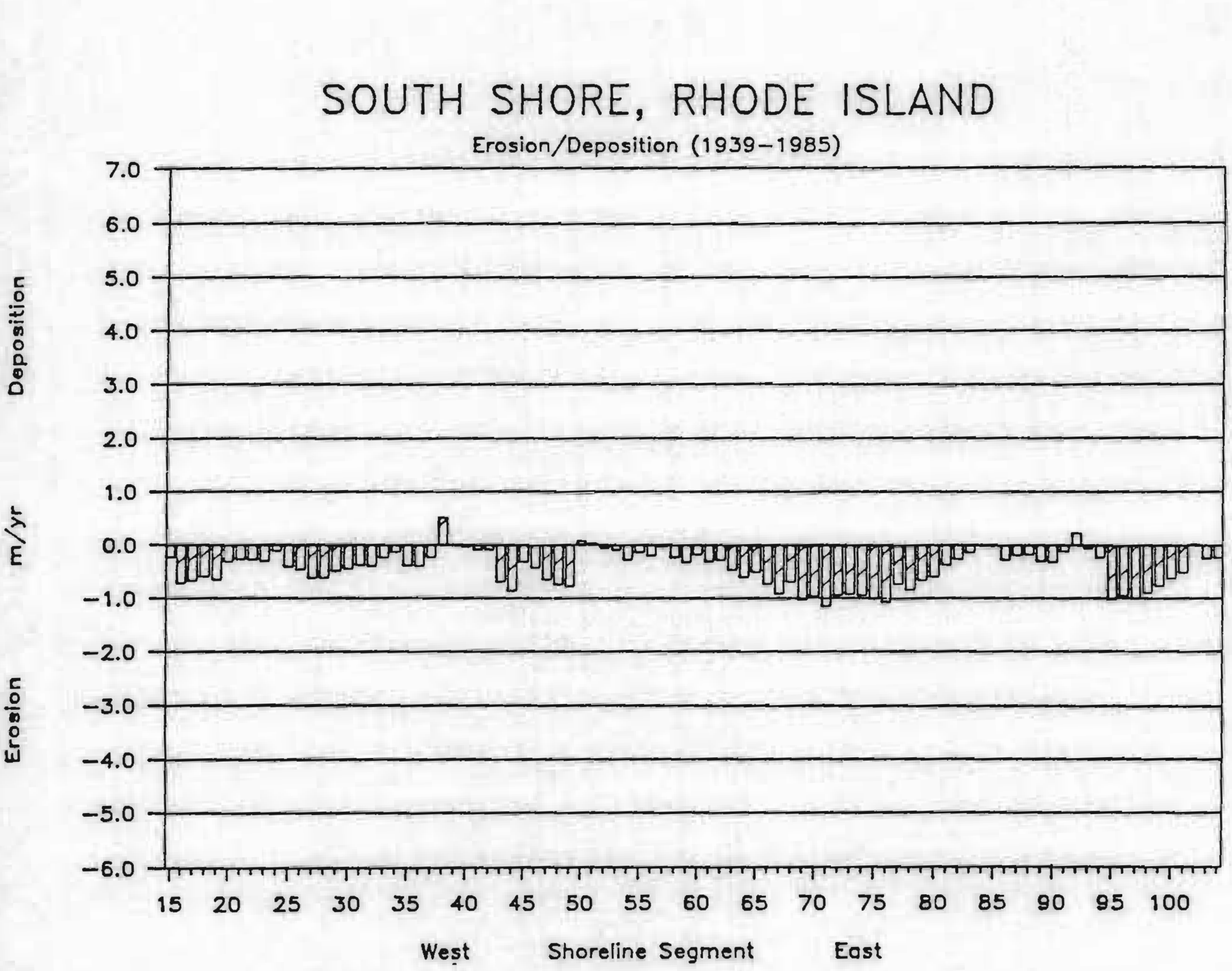
FIGURE 17

TABLE 2a: SHORELINE RETREAT (FT) BROWNING BEACH, RHODE ISLAND (Boothroyd, Galagan, Graves, 1988a)

Shoreline Segment	1939-1975	1939-1985	1975-1985	1975-1981	1981-1985
88-89	0.00	-26.1	-26.1	-4.16	-21.91
89-90	-11.22	-45.31	-34.1	-4.19	-29.90

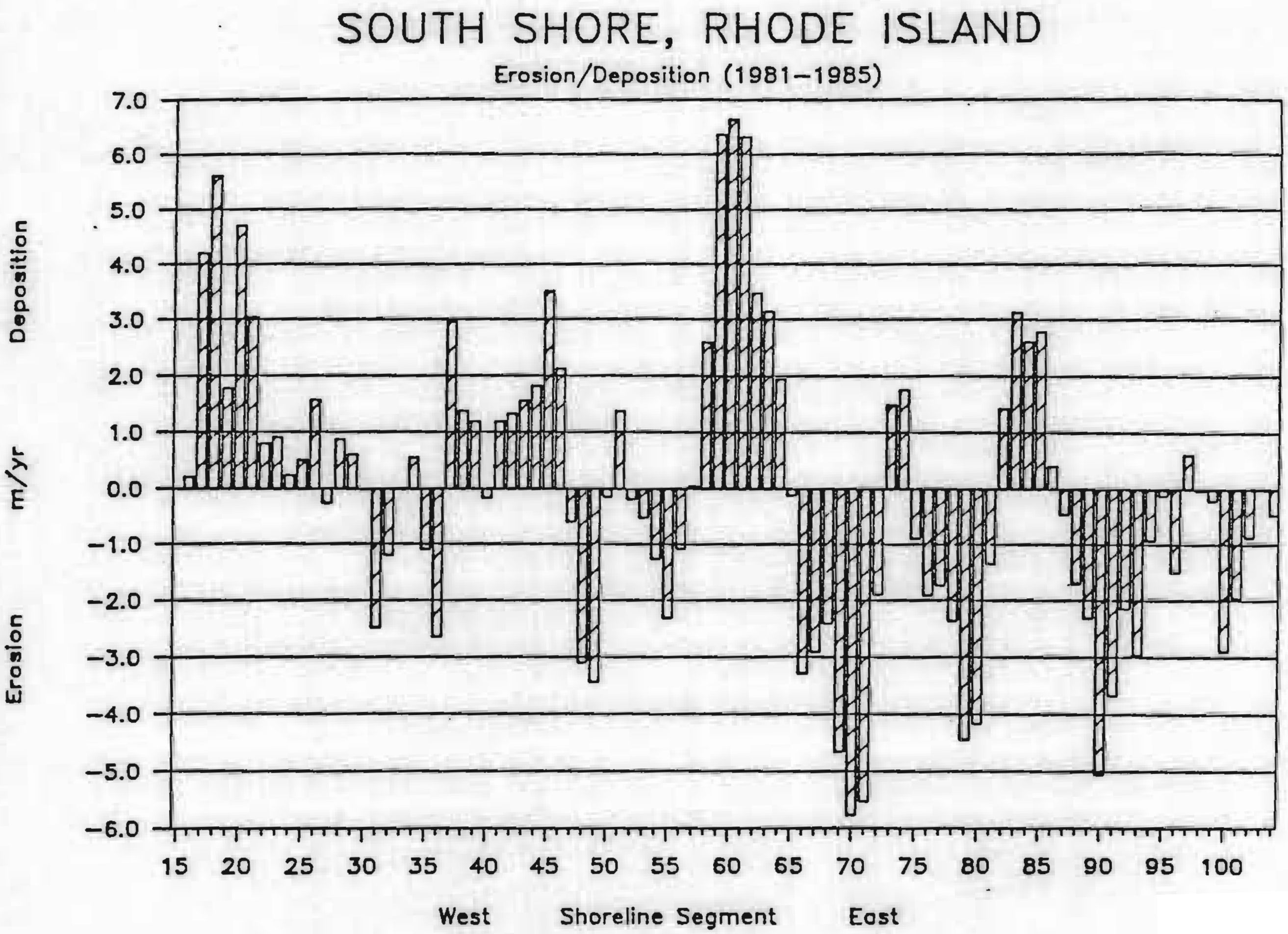
TABLE 2b: SHORELINE RETREAT RATES (FT/YR) BROWNING BEACH, RHODE ISLAND (Boothroyd, Galagan, Graves, 1988a)

Shoreline Segment	1939-1975	1939-1985	1975-1985	1975-1981	1981-1985
88-89	0.00	-0.56	-2.6	-0.7	-5.57
89-90	-0.29	-0.99	-3.4	-0.7	-7.62



Source: Boothroyd, Galagan, & Graves, 1988
Shoreline Change Histogram
1939-1985

FIGURE 19



Source: Boothroyd, Galagan, & Graves, 1988
Shoreline Change Histogram
1981-1985

FIGURE 20

of land made of unconsolidated material, usually extending parallel to the coast and separated from the mainland by a coastal pond, tidal water body, or coastal wetland. In most cases, barrier beaches contain dunes or dune fields. The lateral limits of barrier beaches are defined by the area where unconsolidated sands or cobble abut rock glacial till, or other sediments unrelated to deposits made by the forces of the wind and waves. This definition of a barrier beach system is commonly associated with many geomaphic descriptors. These descriptors include, but are not limited to, barrier islands, bay barriers, and spits. Spits are further described as toombolo, shingle, suspate, and flying spits. The terms "bar" and "ridge" were once used to describe a barrier system, but have since been replaced with the term "barrier".

The owners of the homes on Browning Beach have put forth a Dune restoration plan that proposes to enhance the natural dune and provide a means for its stability during high frequency coastal storms. While structural shoreline stabilization methods on undeveloped barriers are prohibited, Rhode Island coastal policy does allow nonstructural methods for controlling shoreline retreat such as beach nourishment, sand fencing and vegetation stabilization. Due to the relatively narrow beach, it is apparent that a sand fencing and dune grass program alone was not sufficient to re-establish and maintain the integrity of the dune system. Beach nourishment for this size project is cost prohibitive. Since the homes were originally constructed at the rear of the lots, moving the homes on their present lots is not an option.

In accordance with Rhode Island coastal management policy for this section of the shoreline, the natural dune system is, therefore, the only available protection for the residences.

In states with similar coastal management strategies, this objective has been achieved through the use of soft shoreline stabilization methods: sand-filled geotextile units or sand bags. Hence, we are discussing creating a natural looking artificial dune in the midst of a dynamic natural system. The nature of these geotextile units is to rebuild a core for the dune which has since eroded. It is my opinion that these geotextile units are designed to hold or stabilize the net flow of sand. Through direct interpretation of Rhode Island's Coastal Resources Plan this is not in accordance with stabilization as specified by the aforementioned. Vegetation stabilization is the only type of stabilization mentioned.

In VHB's own words the acceptance of soft shoreline stabilization methods is essentially a legislative compromise that allows owners of nonconforming structures that are threatened by storm attack some course of action to protect their property. Because of the durability of these methods, they are considered to be temporary, allowing time for property owners to move threatened structures, or more effectively manage the ultimate loss of the property. But just how temporary are these polypropelene carbonized bags? From my conversations with the representative at the factory they will last indefinitely if not exposed to sunlight. They are composed of carbonized polyproplene so that they are highly resistant to ultraviolet light. In other words, they do not readily decompose when exposed to the environment or as part of the ecosystem. The company provided test results that indicate these geotextile units retained up to one-hundred percent of their strength after five years of continuous natural exposure and up to eighty-seven percent of their original strength after five years of accelerated exposure. The company admits that no tests have been conducted to determine how long it would take for such plastics to completely decompose under these conditions.

VHB argues this is a reasonable compromise in cases such as Browning Beach, where the cottages were built in a responsible manner, long before the passage of restrictive legislation. The term responsible manner is a debatable one. Yes, there were no restrictions of such construction back in the 1930's (However, I think the Chaffee house is less than 30 years old.). There was little or no understanding of the value as a natural resource, nor the dynamic nature of barrier beach systems. Today there is. Unfortunately, just because something seemed, or was, responsible yesterday does not mean that it is today!

VHB has gone to great pains to establish the fact that shoreline erosion is extensive in this area, and that the erosion has only recently become extensive, and that the vast majority of the erosion has taken place in the last two years. I believe that they have failed to address the system as a whole and I furthermore believe that they are attempting to appease their clients while proposing a project that may be palatable to CRMC through a legislative compromise.

A. Retrospect

Has the Coastal Resources Management Council been fair to the property owners in their bid to receive a permit for the Browning Beach Dune Restoration Plan? This was the question raised by the Tax Assessor of South Kingstown, George Lovesky and the executor of the properties, Machille Christensen, of Hospital Trust. I would have to agree with the tax assessor and executor that CRMC has not been fair in the process. First, the owners and CRMC had a meeting to determine the feasibility of such a project at the onset. It was during this meeting that CRMC said that the project could and probably would (according to Hospital Trust and VHB officials) receive favorable consideration. CRMC's senior civil engineer, Nick Pasani, even suggested that the owners consider the polyproplyene sandbags instead of the standard jute sandbags. The major concern of CRMC at the early meetings was longshore accessibility of public trust lands (that area between high and low tide). So, prior to applying for the permit under the guidelines of CRMC regulations, the owners sought a plan from a professional engineering firm (VHB) at a significant expense. When the plan was formalized and taken to CRMC for its final preliminary look, the previous senior civil engineer was employed elsewhere and the parties involved were then told by the new senior civil engineer and the director of CRMC that the plan would not receive favorable consideration from the Council and they were discouraged from submitting the plan.

Yet, another similar scenario came to light concerning the dune fencing program of the previous year. A plan was submitted by CCS in behalf of the property owners to install sand fencing and plant dune grasses. The plan was approved by the Council with the knowledge that the fences were planned and placed in what was later determined an ineffective manner. The owners rightfully feel that the professionals at CRMC, including biologists and civil engineers and an office full of coastal experts knew of this error yet they let them progress with the project.

Surely an office with this kind of power should have their ducks in a row when it comes to these kind of "power decisions" that end up costing property owners hundreds of thousands of dollars in professional and legal fees while they are spinning their wheels. While every body has a right to request a permit, they aught to also have a feel for the "grass roots" party line before they do so. While I personally feel that such projects involving unnatural stabilization are a mistake in terms of the life of the barrier beach and ecosystem, I also feel that the property owners have the right to a fair deal. They, after all, procured the property prior to the recent legislation on the coastal zone. If we have regulated them out of being able to achieve the best and highest use of their properties then they should be justly compensated. By denying the owners the privilege of protecting their properties, we as a society, have devalued these properties in the eyes of the owners. We, as a society, have decided what we think is best for our shoreline and what is best for the public interest. If we really mean what we say in all that literature then properties such as these should be condemned by the state and fair market value at today's prices should be just compensation.

Still another weird twist in the dune restoration plan showed itself. It seems that the director of CRMC has acquiesced and is allowing the placement of yet another set of massive concrete blocks seaward of those already in place.

In the final preparations for this paper I talked with Machelle Christensen of Hospital Trust Bank, the executor of the properties involved and she relayed that they had been very recently granted a temporary permit to construct an additional convex structure of large cement blocks seaward of the ones already in place and fill in the space with sand. I am having great difficulty in understanding this decision by Grover Fugate, the director of CRMC. Instead of using geotextile units to re-establish the core of the dune, which CRMC already rejected, they are going to enhance the dune with exactly what the coastal management plan of Rhode Island forbids.

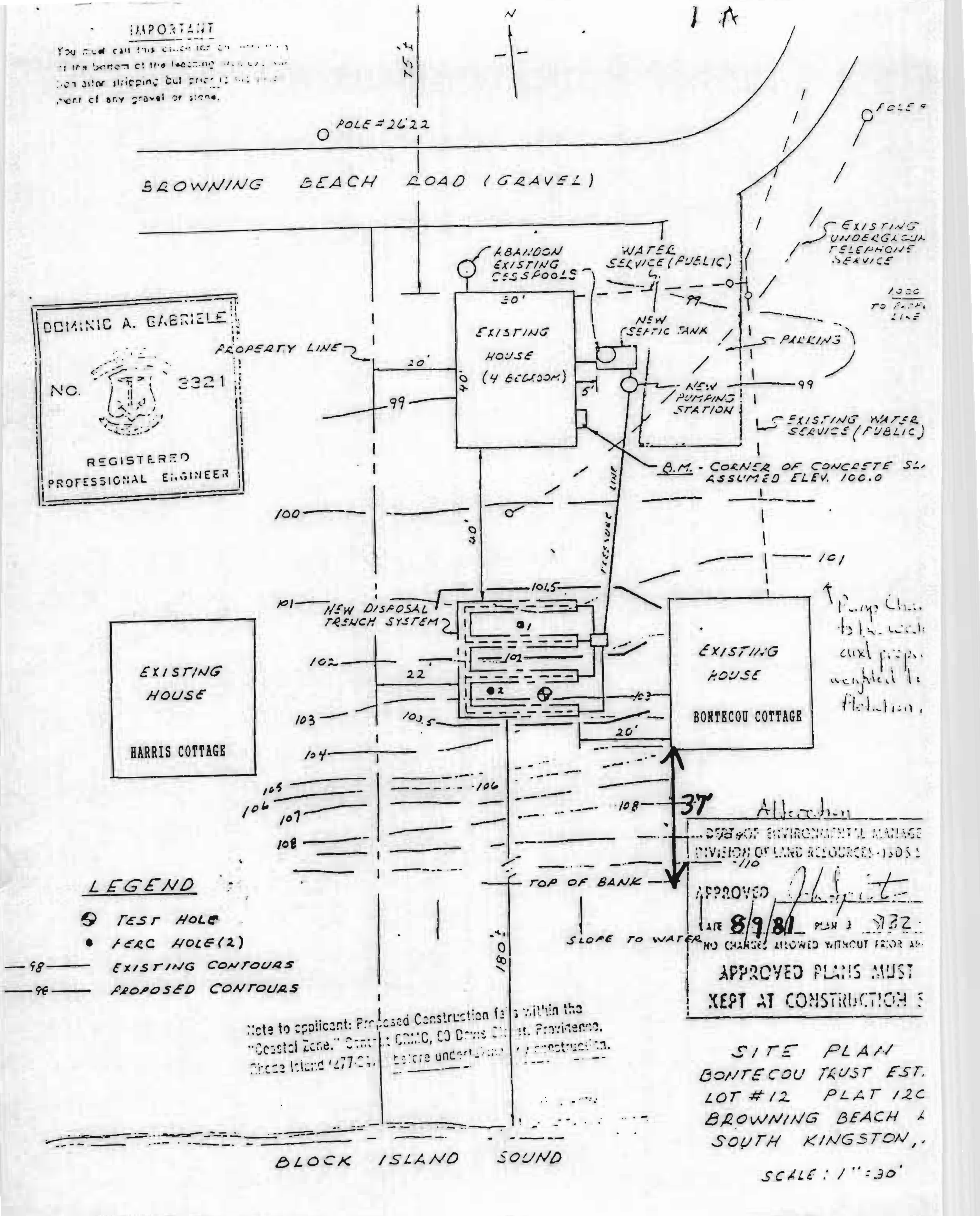
As a prospective coastal manager there are several things with which to be apprehensive:

1. The problem will be made worse for those who live on the barrier beach who do not, or can not afford to, participate. The immediate result will be accelerated erosion on either side of the structure.
2. As the beach profile is steepened longshore access, a public trust right, will become nonexistent.
3. As the beach profile in front of the structure steepens and this area becomes a prominent headland the wave energy will be focused on that structure and the home behind it. Constant maintenance will be required.
4. Additionally, others will see the president that has been set here and expect the same privilege... thus making an already fragile system even more vulnerable.

Dealing with knowledgeable people on shoreline management issues who are willing and eager to continue to exploit these areas, even with the full knowledge of the consequences presents a significant challenge. The owners of these properties are determined to hang on to these properties to squeeze every possible ounce of personal pleasure and rental income out of them before the barrier is gone, even if their presence in the area accelerates the degradation of the system. If there were ever a time when the State should condemn property and donate it to the national park service this is it. This State is acting in a irresponsible manner by doing otherwise. The property should be procured at market value by the State and the homes should be removed, and the site should be returned to its natural state so that it can migrate to survive.

B. Epilogue

The "Nor-easter" of the eleventh and twelfth of December, 1992, tossed the temporary concrete blocks in front of the cottages at Browning Beach as if they were a child's set of building blocks. Virtually all of the fortifications placed by the owners during the year since the Halloween Storm and Hurricane Bob have been displaced or washed out to sea. The very foundations of these homes are exposed today as if they were never covered. The condition of the beach today is strong evidence that these cottages ought not be there. In spite of the evidence, the property owners are clamoring to their attorneys to stop CRMC from condemning their real estate as the final draft of this paper is being prepared.



THE RELATIVE POSITION OF THE BONTECOU AND HARRIS COTTAGES IN 1981

(EPILOGUE)

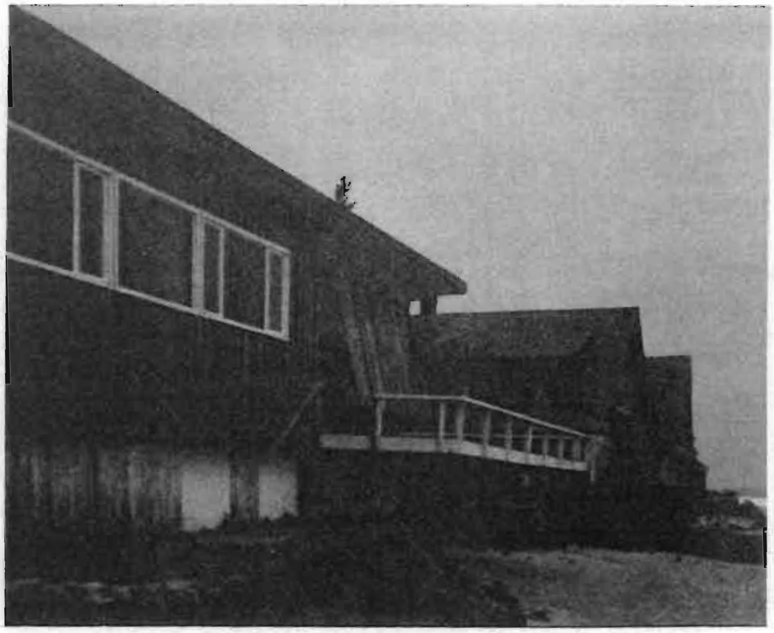
BONTECOU COTTAGE
DECEMBER 92
FACING WEST

FOUNDATION OF
HARRIS COTTAGE
DECEMBER 92

DUVAL COTTAGE
DECEMBER 92

NOR-EASTER
OF DECEMBER 92
EFFECT ON "PROTECTIVE"
CONCRETE BLOCKS

(EPILOGUE)



CHAFFEE'S COTTAGE
DECEMBER 1992

LEFT TO RIGHT
HARRIS AND BONTECOU
COTTAGES; DECEMBER 1992

RIGHT TO LEFT
HARRIS, DUVAL AND CHAFFEE
COTTAGES; DECEMBER 1992

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