Evaluating a Prefabricated Submerged Breakwater and Double-T Sill for Beach Erosion Prevention, Cape May Point, NJ

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ABSTRACT

As part of the US Army Corps of Engineers National Shoreline Erosion Control Development and Demonstration Program, a demonstration project has been installed at Cape May Point, NJ to evaluate prototype-scale "innovative" or "non-traditional" methods of shoreline erosion control. The project consists of placing a linear prefabricated concrete submerged breakwater called the Beachsaver Reef™ and a linear prefabricated concrete sill called the Double-T across the seaward end of two adjacent groin compartments, in order to assess the effectiveness of these structures in retaining sand within the groin compartments and to reduce shoreline erosion. The beach site, at the mouth of Delaware Bay on the extreme southern tip of New Jersey, is subject to both wave and tidal current interactions and has experienced historic erosion and shoreline retreat. Nine existing stone groins have created eight groin cells around a curved shoreline from the Atlantic Ocean into Delaware Bay. The Beachsaver Reef™ in cell 5 is the second such structure at this site and new improvements include shallow placement with a crest elevation of 0 MLW and a geotextile fabric base to minimize settlement and scour. Placement was in August and September 2002, by barge-mounted crane and divers, in –2.7 m of water. Some excavation and fill of the bed was required to maintain the desired depth of placement. The Double-T sill in cell 6 is the first installation of such a device for erosion control. These units were placed at the same –2.7 m depth in four days in October 2002 with the same barge-mounted crane and divers. No bed cut/fill was required and no filter cloth was used. Stone was placed between the side of the groins and both structures to fully enclose each cell as a perched beach compartment. Monitoring of the project includes 29 beach profiles in all 8 cells to document shoreline change and beach volume retention, scour and settlement measurements for structural stability, sediment samples to assess grains size changes, wave and current monitoring to measure wave/current modifications and aerial photography to document shoreline and duneline movements and regional sediment changes. This project will evaluate the use of two prefabricated concrete structures as coastal erosion control devices and if they retain sand within the compartments, as well as retain new beach fill sand to be placed in 2004.

INTRODUCTION

The U.S. Army Corps of Engineers Research and Development Center is authorized under Section 227 of the Water Resources and Development Act of 1996, to

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administer the National Shoreline Erosion Control Development and Demonstration Program, (hereafter called the Section 227 Project) which demonstrates prototype-scale "innovative" or "non-traditional" methods of shoreline erosion control and evaluates the effectiveness of these devices or methods. This research and development effort has three primary objectives, 1) to assess and advance the state of the art of beach erosion control technology, 2) to encourage and achieve the development of innovative solutions to beach erosion control and 3) to communicate the findings to the public and to further the use of well-engineered alternative approaches to beach erosion control.

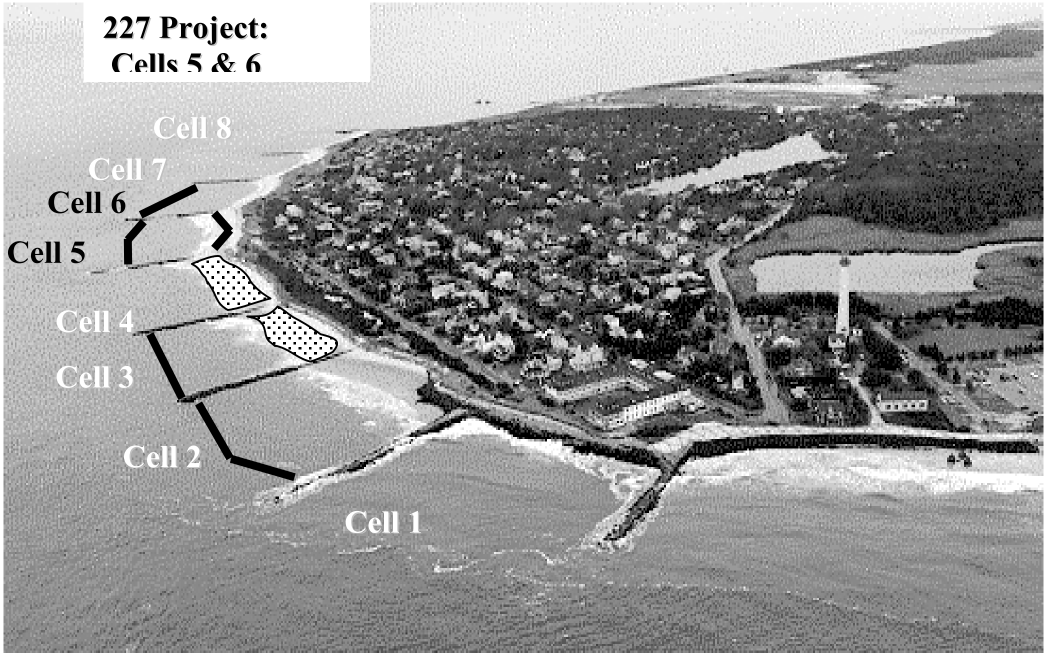
Under this R&D initiative, several projects are underway on all four coasts of the US. The first of these demonstration projects is located at Cape May Point, NJ, the southern-most beach along the New Jersey shore. The Engineering Research and Development Center's (ERDC) Coastal and Hydraulics Laboratory (CHL) and the Philadelphia District (NAP) have planned, designed, and constructed a Demonstration Project to assess the use of prefabricated concrete structures for erosion control. The proposed plan for the Demonstration Project was developed through coordination with U.S. Army Corps of Engineers, Headquarters (HQ), the Coastal Engineering Research Board (CERB), the State of New Jersey Department of Environmental Protection (NJDEP) and local interests at Cape May Point. NJDEP has agreed to participate as the non-Federal sponsor for the Demonstration Project.

The beach at Cape May Point covers a 1.8 km length of shore along the north side of the entrance to Delaware Bay and thus the beaches have both characteristics of an open Atlantic Ocean beach as well as an estuary beach setting. The Borough of Cape May Point is bordered on the east by a freshwater wetland called Cape May Meadows and the City of Cape May (Figure 1). Cape May Inlet is located on the northeast border of Cape May City. The beachfront at Cape May Point has experienced erosion that is threatening the 4.5 m high primary dune and upland structures located behind the dunes. Waves break on the beach from the east to south from waves originating in the Atlantic Ocean and from the south to west from waves originating across the 26 km fetch of the mouth of Delaware Bay. Wave heights average 0.6 m in the summer and 1.2 m in the winter, with higher waves common during storms. The mean semidiurnal tide range is 1.46 m. In addition to wave activity, a north marginal flood channel parallels the shore and is just 182 m offshore of the beachfront. Flood tidal currents in this channel, at maximum, are estimated to be on the order of 0.77 m/s. The net sediment transport is approximately 153,000 m^3 per year to the west into the Bay and is a function of angle of wave approach as well as predominantly bayward tidal flow along this marginal flood channel just off the beach (USACE, 1997). The ebb flow out of Delaware Bay is mainly confined to an ebb channel located further offshore.

Beach and dune erosion has been a problem at Cape May Point for some time due to this interaction between waves and tidal currents. Over a period from 1879 to 1943, the shoreline generally eroded. Between 1924 and 1929, after construction of jetties at Cape May Inlet to the east, the City of Cape May built 24 groins to slow an erosional trend progressing along the coast from east to west. In 1930, a steel sheet pile bulkhead was placed between the existing timber cribs along the beachfront of Cape May City.

Figure 1. Location Map of Cape May Point, NJ

Between 1930 and 1942, the Borough of Cape May Point, further to the west, also constructed a series of steel groins along the boroughs shoreline to slow erosion of its shoreline. Erosion rates were measured around 6.1 m/yr just to the west of Cape May Inlet and between 5.2 to 6.1 m/yr in the vicinity of Cape May Meadows from 1927 to 1943 (U.S. Congress, 1953). A timber/steel bulkhead was constructed at the eastern end of Cape May Point in 1934 to protect upland property. Erosion continued downdrift of Cape May Inlet between 1939 and 1941, and eight additional groins were constructed in front of Cape May City. At Cape May Point, a series of nine timber and stone groins, with a length of around 152 m, were completed in 1945 around the point to help stabilize the eroding shoreline and replace the earlier steel groins. They were placed at ~ 150 to 300 m spacing creating eight groin cells (Figure 2). Between 1946 and 1952, Cape May City replaced their smaller groin field from east to west with 5 large stone groins and a continuous stone seawall. Two new groins were constructed on the west end of Cape May City between 1952 and 1954. After the Ash Wednesday Northeaster of 1962, the City rehabilitated the existing groins and constructed two additional groins for a total of nine groins that covered the entire length of the city's beachfront. This shore protection stabilized the Cape May City's shoreline, but west of the last groin at Third Avenue, a crenulated-shaped shoreline formed in front of the unprotected Cape May Meadows. By



Groin Cell
1- Existing shoreline rock revetment
2 - Existing Beachsaver Reef - 1994
3 – Existing Beachsaver Reef - 1994; Beach Fill - 2000
4 – Control cell; Beach Fill - 2000
5 – Beachsaver Reef (Section 227 Project); Dune base gabions
6 – Double-T Sill (Section 227 Project)
7 – Control cell
8 – Control Cell

Figure 2. Site plan with groin cell configurations

the mid 1980's little sand was on the City of Cape May beach and a beach fill project was placed between 1988 and 1991. Additional fill material was placed in 1993, 1995 and 1997, but stopped at the Third Avenue groin, leaving the Cape May Meadows shoreline some 396 m landward of the Cape May City seawall (USACE, 1997).

To the west of Cape May Meadows, the stone groins at Cape May Point have been moderately successful, and over a period from 1971 to 1994 the pocket beaches within the groin cells have experienced variable erosion and dune scarping. Cells 1 to 5 (closest to the ocean) experienced variable erosion and accretion and cells 6 to 8 (closest to the bay) were generally accretive. The general trend since 1994 was for erosion in all cells. This erosion now threatens upland infrastructure. The stone revetment in cell 1 at the dune base has protected the dune and a large shorefront building but there is no dry beach in that cell. Erosion east of the first groin required placement of stone filled polymer baskets along the dune face to protect the dune in front of the Cape May Lighthouse and park. In May 1994, a 305m-long Beachsaver Reef™ was installed in cells 2 and 3 as part of the State of New Jersey Pilot Reef Project. These reefs were placed across the entire length of the cells at the seaward end of the groins, effectively making an enclosed compartment. A 2-year monitoring (Herrington *et al*, 1997) concluded that the Beachsaver Reefs™ stabilized the inshore beach by reducing sand losses from the beach profile landward of the reef structure. Cell 2 retained almost all of its sand and cell 3 lost a smaller amount of sand compared with cell 4 that acted as a control with no structure. Due to limits in the monitoring data, results are somewhat inconclusive in demonstrating the effectiveness of the structures in retaining sand within the groin compartments. The Reef units did settle reducing the wave attenuating abilities of the structure and a scour trough formed on the landward side of the reef units, but the structure did act as a perched beach retaining sand in the intertidal area of the closed compartments. Due to continued dune scarping over time, a seawall of rock rubble and gabions were constructed just seaward of the dune base in cell 5 in 1999 to 2000 to prevent loss of the dune. A small truck haul beach fill was also placed in cell 3 behind the Beachsaver Reef™ and in control cell 4 in 2000 to protect the dune in these two cells from scarping.

SECTION 227 PROJECT

Beachsaver Reef™ Installation

As part of the Section 227 project, in the summer of 2002 a new Beachsaver Reef™ was constructed at the seaward end of cell 5. The triangular shape Beachsaver Reef™ is a narrow-crested prefabricated concrete breakwater structure that is 3.05 m-long, 4.57 m-wide and 1.83 m-high, weighing 19.1 metric tons (Figure 3). The units have a narrow crest width of 0.31 m. Individual units were locked together by a built-in hook and eye configuration to make a long submerged continuous reef structure at the seaward end of the groins. Rock was placed between the end reef unit and the groin on each end of the line, enclosing the entire cell as a perched beach, similar to the configuration of the original deployment in cells 2 and 3. The original objective of these types of structures is to cause the waves to break as they pass over the crest, but past experience indicates that they are poor wave attenuators (Stauble and Tabar, in press). The Section 227 project is to test how well the units retain sand that is trapped within the compartment by the reef acting as a sill.

Monitoring of the first deployment had showed that the reefs were somewhat effective in trapping sand within the compartments (primarily in the intertidal area of the beach profile), but scour at the landward base of the reef caused it to settle and loose much of its wave attenuation. Wave attenuation was determined to be around 10%. While most of the sand was retained in cell 2, cell 3 experienced erosion over time (Herrington *et al*, 1997). To mitigate for the scour and settlement that was measured in the first placement, the new Section 227 construction in cell 5 placed units on a geotextile scour blanket (Figure 4). This linear submerged breakwater structure was tied into the groins on either end with the placement of rocks to make a completely enclosed perched beach in that cell, as was done in the first project. The units were placed at a water depth of –2.7 m so that its crest was even with the water surface at MLW. This placement is shallower than the original deployments in cells 2 and 3, and the addition of the new geotextile scour blanket were improvements to this new construction.

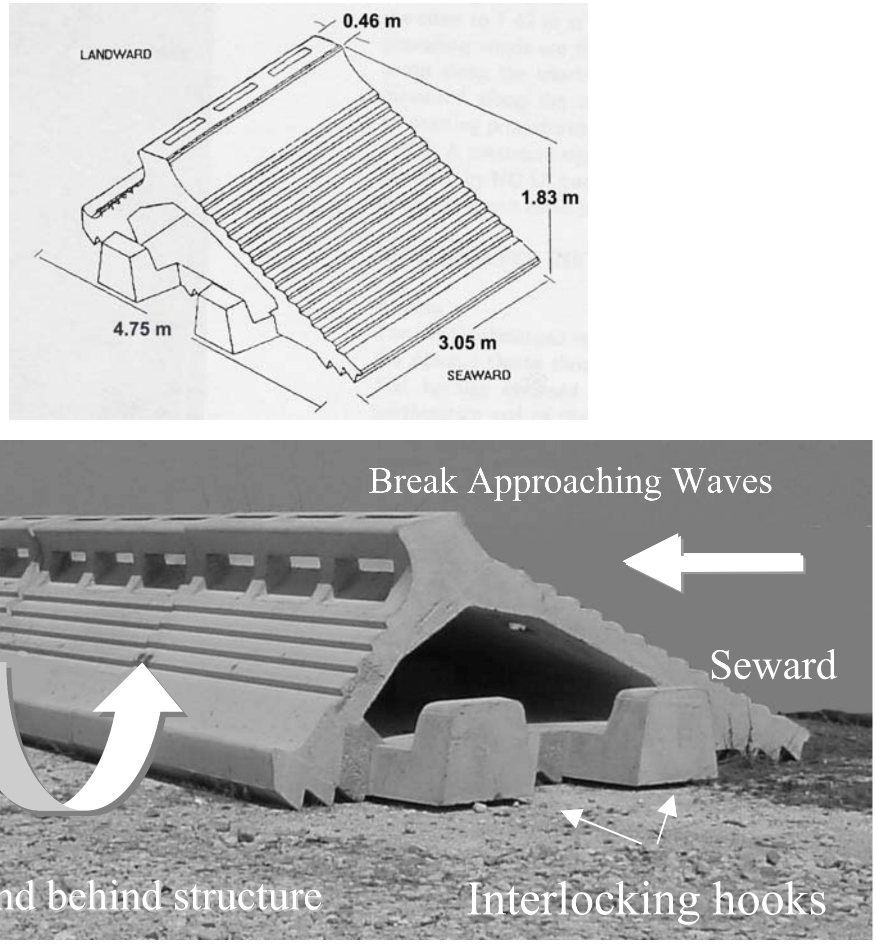


Figure 3. Beachsaver Reef™ dimensions and configuration

Figure 4. Geotextile fabric mat base for Beachsaver Reef™

The approximate 18 sq m geotextile mat had a pillow structure filled with concrete on the landward edge to anchor the mat to the bed. The rolled up geotextile mat was deployed by a barge-mounted crane. Once on the bottom, the mat was extended seaward. Three interlocking Beachsaver Reef™ units were then placed on the seaward side of each geotextile mat with the use of the crane. Divers were used to align the individual units and insure that the interlocking was accomplished.

An initial survey in March 2002 indicated that the –2.7 m contour was nearly parallel with the shoreline and the end of the groins. Just before placement a new survey in June 2002 indicated that the –2.7 m contour had moved seaward on the eastern one-third of the groin cell and landward on the western end. In order to maintain the desired depth of placement, excavation with a barge-mounted backhoe was required along the eastern portion of the line due to deposition of sand in the spring of 2002. The orientation of the line of Beachsaver Reef™ units was angled slightly seaward to parallel the –2.7 m contour. As the reef line reached the center of the cell, sand fill was placed on the bed before the filter cloth was placed to bring the bed elevation up to the required depth, due to scour of the bottom as the units were being placed. The barge-mounted backhoe excavated the sand from the nearshore on the landward side of the placement line. This cut and fill requirement increased the installation time. A new alignment was selected in the middle of the cell to bring the line more landward to alleviate the requirement for fill. The final alignment of the placement of the 72 3-m-long units had a seaward bow in the line due to the change in bed elevation at the time of placement from the pre-installation survey five months before. This change in bed elevation is indicative of the strong flood currents just seaward of the groins that have caused the nearshore to change elevations frequently over time. Placement was originally scheduled for mid-June but was delayed to mid-August due to environmental concerns during the mating season of horseshoe crabs (*Limulus polyphemus*) in Delaware Bay. The Beachsaver Reef™ installation was completed over a five-week period from 16 August to 25 September 2002, with a total of 25 working days.

Double-T Sill Installation

In cell 6, a prefabricated concrete Double-T structure was placed and is expected to act as a sill across the seaward end of that cell to create a perched beach. The name comes from the shape of the precast concrete units with two vertical legs on a flat base when viewed on its end looks like two TT's. This Double-T design is typically used for parking garage supports. The units for this particular application for coastal erosion prevention are made of marine grade concrete and reinforced with coated rebar. The 9.14 m-long and 3.66 m-wide units are placed end to end in an inverted position with the flat surface on the sand bed at –2.7 m depth (Figure 5). The vertical legs extend 0.8 m in the water column and a single unit has a weight of 17.3 metric tons. For this application, an extension of the legs on one end of each unit allowed an interlocking effect between the units, designed to maintaining a linear orientation of the sill. The sill was located near the seaward end of the groins and was attached to the groins at both ends by rock, creating a closed structure.

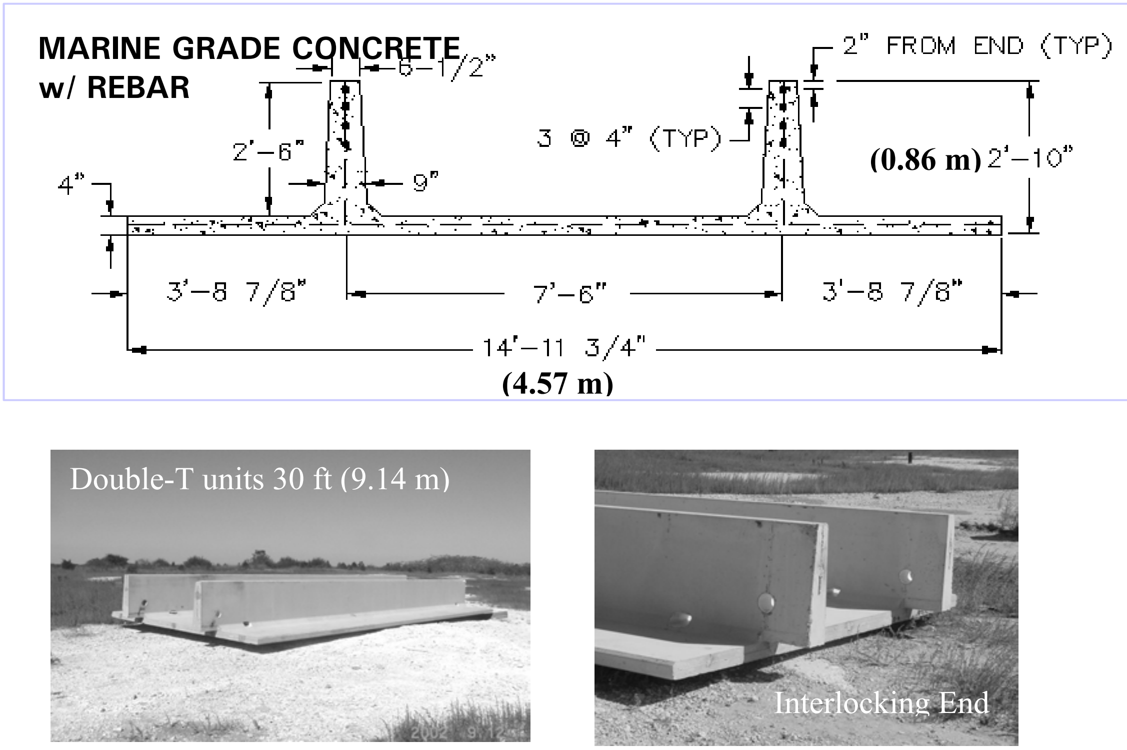


Figure 5. Double-T sill dimensions and placement configuration

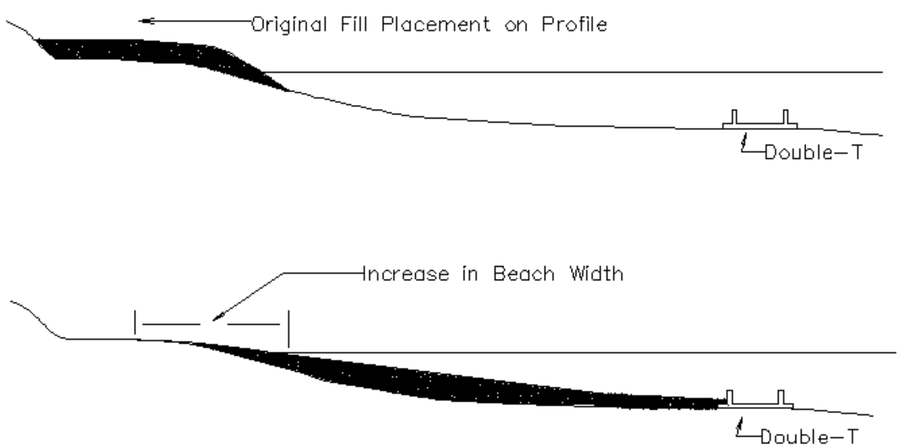


Figure 6. Idealized response of sill to trap sand

The idea is to trap sand within the groin compartment as shown in Figure 6. This type of structure has never been used for erosion prevention and fits the non-traditional or innovative criteria under the Section 227 program. Units were trucked to the staging site in there usual position with the legs facing downward. The units were flipped upside down when placed on the barge. A crane was attached to the inverted legs and the unit was lifted off the barge and placed on the bottom. Divers assisted in the alignment and interlocking as the units were placed on the seabed. Surveys of cell 6 in March and June 2002 indicated that the –2.7 m NAVD contour straight and parallel to the shoreline near the seaward end of the groins and did not change over time. No excavation or fill was needed to place these units and no filter cloth was used as a base. With a length about three times that of the Beachsaver Reef™ units, only 22 units were needed to span the 200 m of the cell. It only took four working days to complete this installation between 26 September and 2 October 2002.

OBJECTIVES

This location at Cape May Point is somewhat unique in that strong flood tidal currents just seaward of the existing groins play an important role in the movement of sand along this beach. Waves, approaching the beach from a range of 180 degrees from east to west, also have an influence on sand transport, with the larger waves approaching from the east to south quadrant of the open Atlantic Ocean. The combination of the waves and flood tidal currents produce a net longshore current from east to west and has resulted in erosion of sand from the groin compartments. The primary objectives of this Demonstration Project are therefore 1) to evaluate effectiveness of the various nearshore submerged structures in retaining sand on the beach, as compared with unprotected groin compartments, 2) compare the effectiveness of the more costly Beachsaver Reef™ with the less expensive Double-T submerged sill and 3) as a long-term objective to evaluate if theses various structures lengthen the time between periodic renourishments for the proposed Cape May Meadows to Cape May Point beach fill project scheduled for construction in 2004.

Initial monitoring of the project over the first year will focus on comparing retention of native sand behind the new Beachsaver Reef™ (cell 5) with that behind the Double-T sill (cell 6). Monitoring will also examine the behavior of the remaining advanced fill placed in cells 3 and 4 in December 2000 to evaluate the effectiveness of the initial 1994 Beachsaver Reef™ installation in cell 3 in reducing loss of sand from the beach relative to the open groin compartment (cell 4). The other cells (cell 1, 2, 7 and 8) will be also be monitored to evaluate relative beach change in the absence of sand fill for the various structure and control configurations. The Lower Cape May Meadows to Cape May Point Federal Project is expected to go to construction (subject to funding) following the first year of monitoring. The Federal project includes beachfill in all cells within the Cape May Point Demonstration Project area. After construction of the Federal project, monitoring of the Demonstration Project will focus on effectiveness of the Beachsaver Reefs™ and the submerged Double-T sill in retaining beachfill and reducing renourishment requirements for the Federal project.

Monitoring Plan

The goal of this study is to monitor the project performance for three years and assess the sand trapping capabilities of each type of structure. The Beachsaver Reef™ is designed to reduce wave transmission and trap sand on the landward side. The Double-T sill is designed to be a cost effective alternative to retrain sand on its landward side within the groin cell. Five components are to be included in the monitoring plan, including beach profile surveys, settlement and scour measurements, sediment composition changes, wave and current assessment and aerial photography

Profiles

The groin cells are indicated in Figure 2, and are numbered “1” through “8” from southeast to northwest. Groin cells 1, 2, and 3 are 152 to 168 m in width, as measured between the seaward ends of the structures. The remaining groin cells (4 through 8) are between 213 and 244 m wide. Three cross-sections were established and surveyed in groin cells 1, 2, and 3, with four cross-sections established and surveyed in cells 4 through 8. A total of 29 cross-sections were surveyed in the eight groin cells. In each cell, profiles were measured at a distance of 30.5 m feet from the groins that define each cell. In groin cells 1, 2, and 3, one additional profile line was surveyed midway between the two “outer” lines. In groin cells 4 through 8, two additional cross-sections were surveyed at approximately equal intervals between the outer lines, normal to the shoreline alignment at the survey control point.

Profiles were established at a project-specific set of semi-permanent benchmarks (concrete post or metal pipe with survey disc). The surveys were collected relative to NJ State Plane Grid Coordinates (NAD83) with a vertical datum of NAVD88. Each cross-section extended from behind the dune line seaward from the survey monument for a distance of 152 m (short line surveys for pre-construction data) or 1250 m (long line surveys for area wide coverage) beyond the seaward ends of the groin cells. In cells with a sill or submerged breakwater (cells 2, 3, 5, and 6), elevations at the landward toe, crest, and seaward toe of the sill or breakwater unit was measured where the profile line crossed the structure. The profiles over the dune were measured with a GPS survey system and the beach and foreshore out to wading depth were measured with either the GPS system or survey/rod method. A boat/fathometer survey continued the line seaward to the survey limit to measure the nearshore inside the cells as well as the marginal flood channel and shoals found in the nearshore.

The initial detailed bathymetric survey of cells 5 and 6 were collected in January 2002 and the 29-line survey of the entire Cape May Point beach area was collected in March of 2002 to characterize the pre-construction bathymetry. An additional detailed survey was collected in June 2002 in cells 5 and 6 prior to construction of the new structures to determine placement options and locations. Earlier profiles were collected in July 2000 and January 2001 of selected sites within the study area. The bathymetry shows that a flood channel is located just off the groins and a dynamic and changeable shoal is located seaward of that (Figure 7).

The monitoring of the beach profile evolution will measure shoreline change and bathymetric grids constructed in the Geographic Information System (GIS) will measure sediment volume change, which is an indicator of how much sediment is retained behind

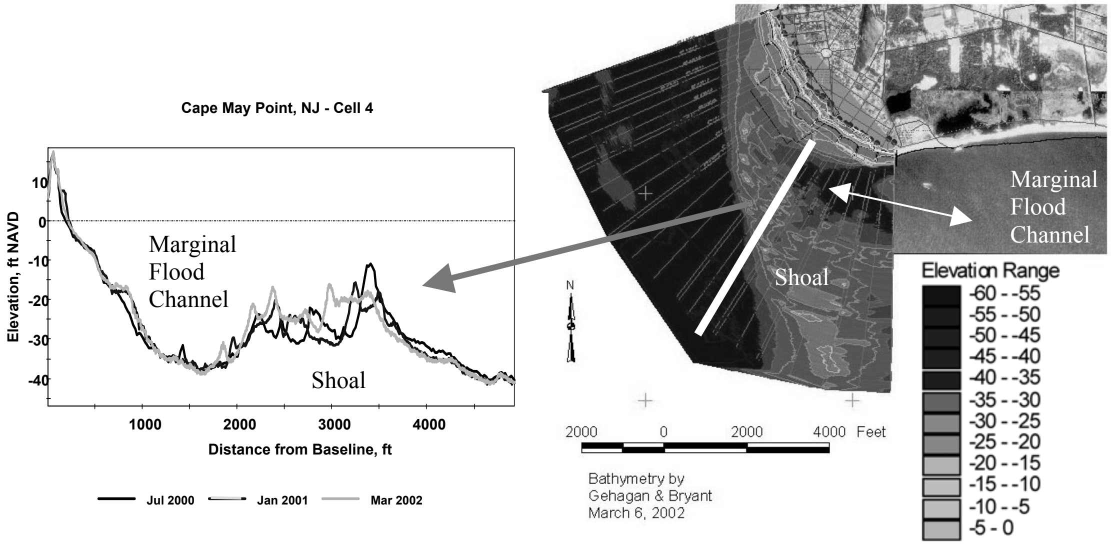


Figure 7. Local bathymetry of shoal and marginal flood channel, with example of one of 29 profile lines

the test structures relative to the control cells. Three-dimensional bathymetric change analysis in a GIS will provide patterns of sediment change and evaluate both profile sand volume retained and shoreline evolution. The shoreline is defined as the mean high water (MHW) datum, which is 0.54 m above NAVD88 relative to the closest tide gage at Cape May Canal, 3.8 km north of the study site.

Settlement and Scour

In order to determine the settlement of the sill or breakwater crest, elevation measurements are taken along the crest of each sill/breakwater structure. These measurements are taken concurrent with the beach profile surveys. The top of the Beachsaver Reef™ was measured at the crest of the unit and the top of the Double-T sill was measured on top of the seaward vertical leg (Figure 8). Settlement and reorientation of both structures will be evaluated. Settlement occurred quickly (within the first three months after installation) in monitoring other prefabricated reef projects (Stauble and Tabar in press). Scour at the base of the units will also be monitored with careful surveying at the seaward and landward base of the units to monitor any scour trough formation or realignment of either type of structure.

As each Beachsaver Reef™ unit was placed, detailed measurements were made of the tops of the units and its orientation as placed. The Beachsaver Reef™ units were placed between 16 August and 25 September 2002. A post-construction survey was obtained of both the Beachsaver Reef™ and Double-T sill unit crests after final placement of the last Double-T unit on 7 October 2002. Since the Double-T sill only required four days to be completely installed (between 26 September and 2 October 2002), only a single survey of the tops of these units was done on 7 October 2002. Figure 8 shows the

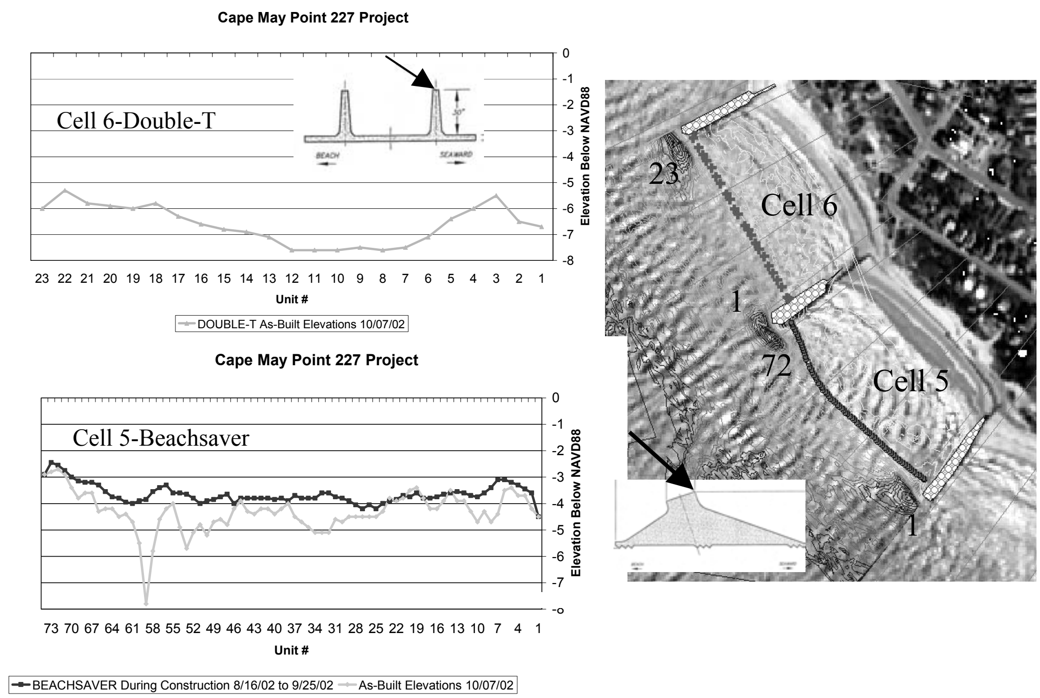


Figure 8. Settlement measurements and placement layout of Beachsaver Reef™ and Double-T Sill. Measurements made at top of each unit (at arrow).

change in elevation of the top of the Beachsaver Reef™ units from when each unit was placed (dark line on plot) and on 7 October (light line on plot), some twelve days after final installation. The average settlement was 0.2 m and the average crest elevation was within the planned range of 0.9 to 1.2 m. Three of the units have settled into a suspected scour hole with a loss of 1.2 m of elevation. Most of the Double-T sill unit crests were placed between 1.8 and 2.1 m depth as planned (Figure 8).

Subsequent surveys will be obtained at four survey intervals (March, June, September and December) for a period of two years for both beach profiles and settlement. In the event of a storm with significant shoreline impacts, an expedited survey will also be obtained. Scour, settlement and reorientation need to be documented to evaluate projects structural stability. Excessive changes in the positions of both types of units may affect their ability to retain sand. The new geotextile fabric layer will be evaluated as to its effectiveness in preventing scour and settlement.

Sediments

Sediment samples were collected from the mid-tide area in cells 5 and 6 in April 2002 to characterize the winter grain size distributions. An additional sample series was collected along selected profile lines in August 2002 to characterize the pre-project grain size distribution within all of the groin compartments. Preliminary analysis of these sediment samples indicates that the beach in this area contains a coarse fraction, most likely due to the high wave/current interactions at this location. Both spatial and temporal variations in the distribution of sediments are found at this site, with coarser sand on the beach and finer sands in the nearshore. Sand also gets slightly coarser from the ocean side to the bay side cells. A seasonal component is also present where coarser sands are present in the winter and finer sands are found in the summer months. A distinctive yellow color and coarse pea size gravel size distribution was also introduced when the upland fill material was placed in cells 3 and 4 in the summer of 2000. Some of this material is still found on the backshore of the two cells. Heavy minerals and mica flakes are also more concentrated in the high water line area in cells 5, 6 and 7.

Additional sediment samples will be collected 1 year after construction to determine if any change in grain size distribution occurs following placement of the structures. Samples will be collected at the dune base, berm crest/highwater line, mid-tide, swash/low-tide line and at the –0.91 m and –1.83 m location inshore of the structures and seaward of the structures at –2.74 m and –3.66 m NAVD88 along selected profile lines covering all of the cells. Sediment monitoring will provide a measure of how these structures retain sand in the perched beach concept and if the grain size distribution will change from the pre-construction time frame. Both cross-shore and between-cell grain distributions will be monitored for change.

Waves and Currents

Since both waves and tidal currents are suspected to transport sediment in this area, wave transmission across these two types of breakwaters will be measured. Initial planning calls for a short period of deployment of four wave gages (one set each on the landward and ocean side of the Double-T sill and Beachsaver Reef™ units) to measure the transmission of the waves. A deployment of an Acoustic Doppler Current Profiler (ADCP) is also planned to identify circulation patterns within the cells with structures and in the control cell 4 and just outside the groin compartments to determine changes in scour and/or depositional patterns related to the units. Visual observations of the pre-installation indicate a seaward rip current common along the sides of the groins. Visual observations of ice chunks flowing around the Cape on a flood tide in March 2003 after installation of the structures indicated that ice was trapped in cell 5 behind the Beachsaver Reef™ and the circulation in both cells 5 and 6 were more circular in the center of the groin compartments. Both the Beachsaver Reef™ and Double-T sill elevations were lower in the center of their respective lines and may be influencing circulation in their groin compartments. The rock tying in the structures to the ends of the groins may be inhibiting formation of the near-groin rip currents observed before installation.

Aerial Photography

Detailed aerial photography that shows the wet/dry line on the beach photographed at low tide can be helpful in assessing the change in shoreline position, beach width and duneline position, as well as intertidal sediment deposition patterns. Photos are available for the past several years and will be flown on an annual basis for this project. The newer photo sets are digital and rectified and are easily incorporated into the GIS. The wet/dry shoreline, duneline and groins are drawn from the aerial photography for each year and the change in position of the shore and dune line will be compared over time to assess the movement of the shoreline and dune line in each cell, as well as the width of the intertidal beach. The datum-based shoreline will also be drawn based on the mean high water (MHW) local elevation from the local NOAA tide gage using elevations from the beach profiles. These two lines for shoreline identification will be compared over the monitoring period to assess shoreline stability.

Conclusions

The project was constructed between August and October 2002 with placement of 72 Beachsaver Reef™ units in cell 5 and 22 Double-T sill units in cell 6. A monitoring program will evaluate the performance of these two structures. The primary purpose is to evaluate how these structures retain sand within their respective groin compartments. Based on this evaluation, a projection will be made to determine how each structure will affect the maintenance and life cycle cost of a beach nourishment project scheduled for construction in 2004.

Three types of performance measures are proposed to evaluate the projects effectiveness: functional performance (sand retention), economic performance (reduction of renourishment quantities/lengthening of renourishment cycles), and structural performance (structure stability). Relative performance of the Beachsaver Reef™ vs. the submerged Double-T sill will also be assessed. Parameters used to measure performance will be determined from monitoring data. For each category, measurement parameters were defined, and performance criteria suggested.

Performance Criteria

Functional Performance (Sand Retention): focuses on the degree to which the offshore structures retain sand and reduce sand loss from groin cells. Sand loss may occur due to cross-shore processes (post-construction equilibration, seasonal beach profile change, and storm-induced beach erosion) and due to longshore processes (natural gradients in longshore sand transport, and interruption of sand transport by structures). Functional performance measures will be evaluated from beach profile surveys starting from initial construction and continuing throughout the monitoring program. Measurements in beach volume and dry beach width will be used to evaluate performance. Differences will be compared between structured and non-structured cells and between the Beachsaver Reef™ and Double-T configuration. If 30% more sand volume is retained within the structured cells relative to the control (and relative to the other type of structure) it will be successful. Success will also be achieved if the dry beach width is 30% wider in the structured cells relative to the control cell (and relative to the dry beach width in the cell with the other type of structure).

Economic Performance (Reduction of Renourishment Quantities/Lengthening of Renourishment Cycle): focuses on project cost savings realized for the Federal beachfill project as a result of reduced renourishment quantities and/or a longer renourishment cycle. Economic performance will be evaluated at the time of the first renourishment following initial construction of the Federal project. The design renourishment cycle for the Federal project is 4 years. Measurement of difference in costs to renourish structured and non-structured groin cells (based on different volume requirements) and between Beachsaver Reef™ and Double-T sill configurations will be evaluated along with the length of time between construction and condition when the beach profile is less than the design template (and associated renourishment cycle costs). The structure will be successful if average annual renourishment cost savings is greater than average annual structure cost.

Structural Performance (Measure of Structure Stability): focuses on stability of the reef and sill structures. Structural performance will be evaluated throughout the duration of the monitoring program by measuring the scour, settlement and alignment. Any decrease in elevation of structure crest due to settlement, rotation, or translation will be determined from elevation surveys along crest of structure. Change in alongshore structure integrity, such as formation of gaps in the structure due to separation of interlocking units or other structure failure resulting in sand loss due to higher permeability will also be determined from elevation surveys. Scour depth of the seabed adjacent to structure (seaward and landward sides) will be compared to initial elevation at time of structure placement. Any excessive scour may result in failure of structure or change sand transport patterns. The structures will be successful if the average lowering of crest elevation is < 0.31 m, if no gaps form that result in localized sand loss through structures and if the average scour at the base of each type of structure is < 0.61 m.

This first site in the National Shoreline Erosion Control Development and Demonstration Program will conduct research and demonstrate prototype-scale "innovative" or "non-traditional" methods of using prefabricated concrete structures for shoreline erosion control and evaluate the effectiveness of these devices. This R&D effort will aid in the assessment and advancement of the state of the art of this type of beach erosion control technology and help in the development of these innovative solutions to beach erosion control. The knowledge gained on this project will further the use of well-engineered alternative approaches to beach erosion control.

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