potential environmental impacts. The next section presents details on the proposed scope of services and associated cost estimates.

7. Phase II Scope of Services

Prior to considering any modification and/or enhancement to the Grove Beach Point region, it is important to understand the coastal processes that drive the dynamic nature of the beach, interact with man-made structures, and ultimately shape the coastline. As such the existing environmental conditions and coastal processes must be well understood. The existing environmental conditions within the region will be evaluated in preparation for evaluating and selecting potential alternatives for mitigating the erosion at Grove Beach Point. The existing conditions assessment will use the results of Tasks 1, 2, and 3 (presented below) to develop a complete picture of the ongoing processes that shape the entire Grove Beach Point region, not just the local area. Therefore, the existing conditions assessment, as well as the potential alternative evaluation (Task 4), will be founded on a system wide approach. This system wide approach is a key component of providing GBPA with the most appropriate and cost effective solution for managing the beach.

Woods Hole Group's recent completion of the evaluation and engineering alternative assessment of Hammonasset Beach will provide invaluable data for assessment of the Grove Beach Point shoreline. Woods Hole Group can utilize this information to provide additional detail and a significant cost reduction by eliminating required tasks. For example, wave data has already been collected for the regional area, and can be used to provide wave information for wave transformation modeling of the Grove Beach Point region. In addition, WHG has already completed estimates of water surface elevations resulting from 5-, 10-, 50-, and 100-yr storms. Storm surge data from the U.S. Army Corps of Engineers and modeling results from previous Woods Hole Group work in Long Island Sound was extended and used to determine the storm surge caused by the severe storms in the Hammonasset Beach region. These storms will be incorporated into the analysis to evaluate the impact of storm events on the range of alternatives.

Task 1 – Historical Shoreline Change

In a physical system like that of Grove Beach Point, the geologic and historical perspective is an important piece of understanding the past history of the region, as well as insight into the future. Regional geomorphic change is the evolution of depositional environments for coastal stretches over extended periods of time. Aerial photographs and topographic and hydrographic surveys of coastal and nearshore morphology provide data for quantifying regional geomorphology and change. Coastal shoreline change and digital bathymetric data for the same region, but different time periods, produce a method for calculating potential sediment movement within a region. Utilizing the historical maps, data, and information, a shoreline change analysis will be performed for the Grove Beach and Clinton Beach region. This information can then be used for estimating magnitude and direction of sediment transport, provide a historical perspective, examine the geomorphic variations in the coastal zone, and ground-truthing of the numerical sediment transport model (Task 3).

This approach has been used by WHG in numerous beach erosion assessments and previous large-scale coastal studies to provide invaluable information related to historic and contemporary changes along beaches. The information also helps in guiding the alternative selection and assessment. Figure 23 shows an example of historic shoreline change analysis performed for Hammonasset Beach, CT.

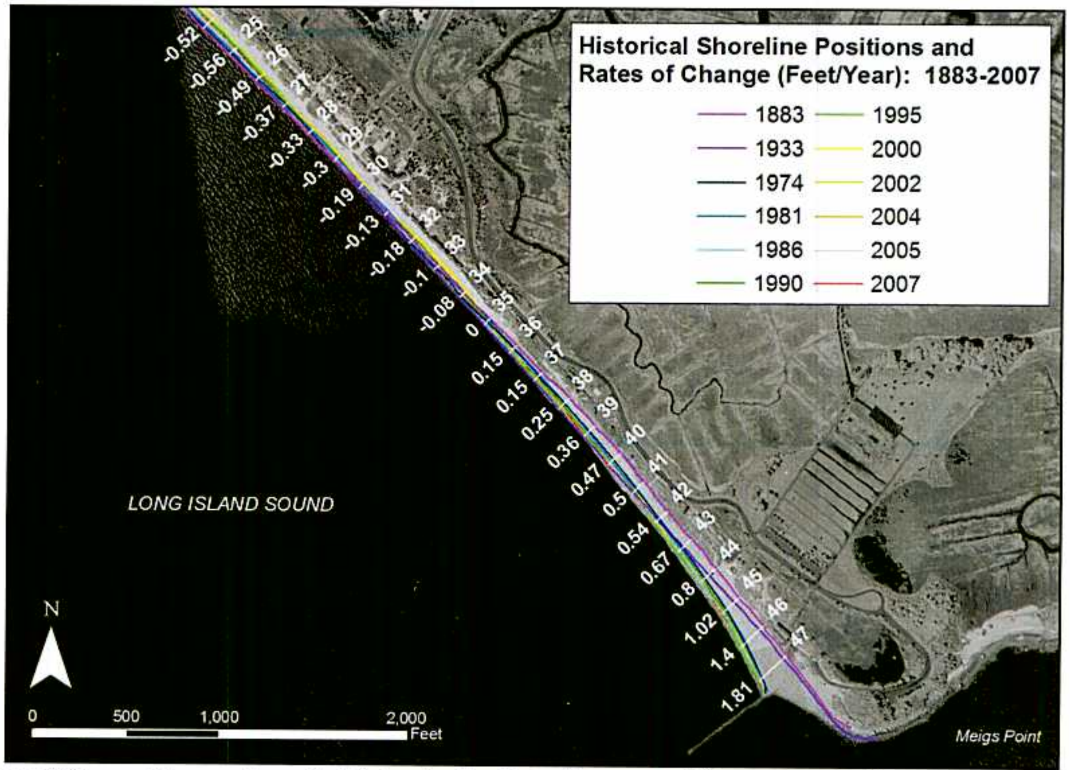

Figure 23. Example of historical shoreline positions and linear regression shoreline change rate: 1883–2007 for Hammonasset Beach.

Task 2 – Wave Climatology and Transformation

The impact of waves in the nearshore environment, specifically on shorelines that are highly populated or serve significant recreational and/or economic benefits, is one of the key reasons to understand wave propagation, transformations, and predictions for site-specific areas. The impact of waves on nearshore processes and shoreline change is highly dependent on the offshore wave climate and the transformation of waves propagating to the shoreline. Subsequently, as the waves interact with the coastline, the wave-induced currents are a major component of sediment transport and shoreline change. Therefore, a key component of understanding the areas of erosion and accretion along Grove Beach Point is determining the nature of the wave field both offshore and in the nearshore region.

In addition, in order to evaluate local sediment transport pathways, assess impacts of, and identify potential alternatives to mitigate the erosion at Grove Beach Point, an understanding of the regional wave climate is required. The Grove Beach Point region represents a complex coastal setting. The offshore bathymetry, offshore bars and islands, tidal shoals, coastal structures, and orientation of the beach influence wave heights and directions in vicinity of Grove Beach Point. Therefore, before an effective solution can be determined, wave modeling is required to simulate refraction, diffraction, shoaling and breaking of waves. These wave transformations have a significant impact on the effects waves will have on the shoreline. For example, wave refraction and diffraction produce an uneven distribution of wave energy along the coast and affect sediment transport in the region. Wave energy may end up being distributed unevenly along the coast; therefore resulting in areas of increased erosion ("hot spots") or creating variations in sediment transport pathways along the length of the coast. Wave modeling allows for quantitative predictions of these processes.

A regional, spectral wave model will be utilized to propagate water waves over the irregular bathymetry offshore of Grove Beach Point and provide "state-of-the-art" in nearshore wave prediction. The spectral approach makes it possible to model more accurately the actual sea surface, which is composed of a large variety of waves moving in different directions and with different frequencies, phases, and heights. By simulating the wave components that propagate towards the shoreline, accurate nearshore statistical parameters can be calculated and used as input for localized sediment transport, and alternatives analysis modeling (including design wave parameters for structural design).

Results from the regional wave modeling will provide information on how the waves propagate to the shoreline and Grove Beach Point, reveal areas of increased erosion (the location of "hot spots"), and provide the basis for more detailed local analysis (e.g., impacts of coastal structures, lifetime of beach nourishment, etc.). In addition, one of the primary advantages of wave modeling is the ability to simulate multiple scenarios. Once the model domain has been developed, it can be modified to determine the effect that various changes (e.g., evaluation of structural configurations, initial evaluation of varying beach nourishment templates, offshore borrow site dredging, etc.) have on the wave climate. The wave input can also be modified to simulate a wide range of wave conditions (e.g., storm events, seasonal variations, etc.) and therefore determine the changing impacts on the shoreline. Numerical wave modeling is a key component of understanding changes in wave height, wave direction, areas of increased energy concentration, structural design, sediment transport, and ultimately proper shoreline management.

Woods Hole Group has regularly implemented wave modeling to evaluated coastal areas and assess alternatives to mitigate coastal erosion. Figure 24 shows example wave modeling results for projects Woods Hole Group has successfully completed related to beach restoration and alternative assessment.

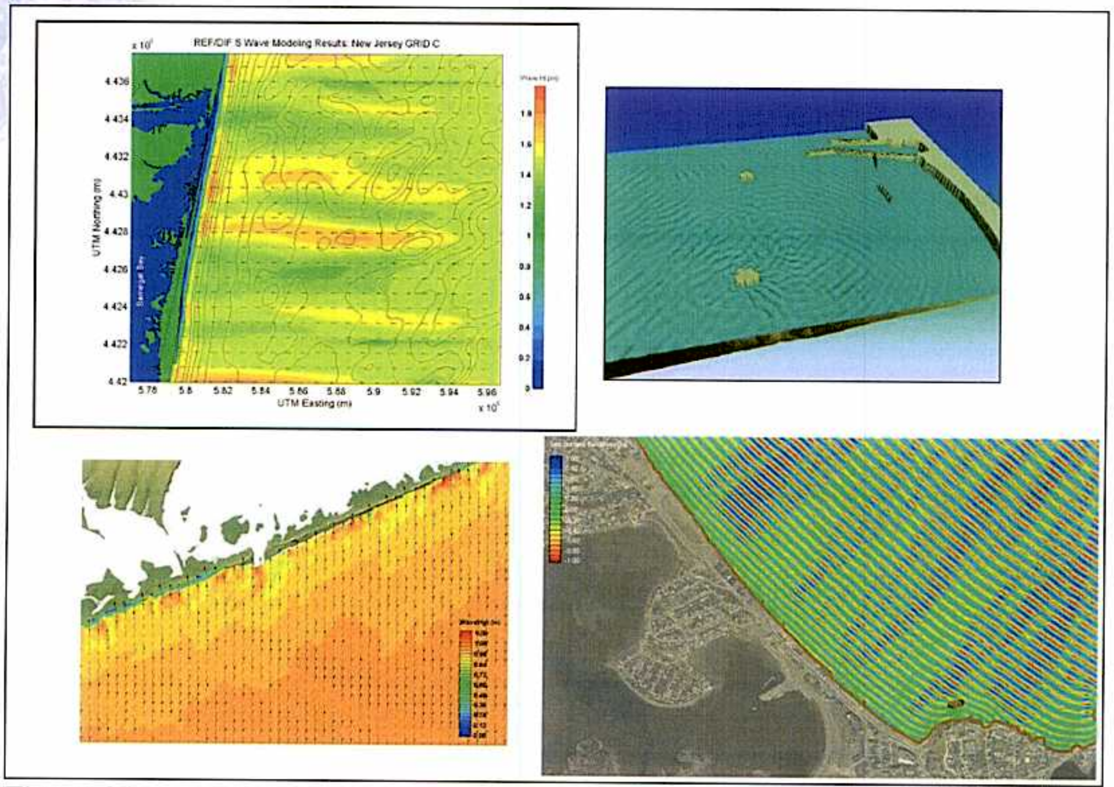

Figure 24. **Examples of wave modeling results used to assess a variety of coastal settings in the completion of successful beach erosion and alternative analysis studies.**

Task 3 - Sediment Transport Modeling

Understanding the wave transformations is a critical step in determination of shoreline processes and changes, and this wave information is required in order to provide an estimate on how sediment moves in the nearshore region. In order to evaluate and assess any alternative that may be considered in the coastal region along Grove Beach Point, the sediment transport dynamics for the current conditions must be understood. A complete understanding of the nearshore system requires modeling of both sediment transport direction and volumes of cross- (onshore/offshore) and longshore (along the beach face) transport.

Wave action constantly moves sand in the longshore direction due to wave-induced currents created by breaking waves. These wave-induced currents are ultimately what moves sand around on the beach. As such, the wave modeling results are the key input into the sediment transport modeling. From the wave modeling results, wave-induced currents, and subsequently, sediment transport fluxes (rates and directions of sand movement) will be developed. These fluxes indicate the net sediment transport potential along the shoreline of Grove Beach Point. In addition, areas of convergence and divergence (the patterns of erosion and accretion) will be determined to identify potential spatial variations in the sand movement.

The goal of the sediment transport model is to provide a physically-based representation of alongshore currents and sediment transport driven by breaking waves in the surf zone.

The specific objective is to obtain physically-based estimates of the alongshore sediment flux integrated across the surf zone. As such, the existing movement of sediment will be identified, and subsequently the influence of various alternatives on the sand movement can be determined. For example, the lifetime of beach nourishment or the influence of groins along the shoreline can be determined.

While the longshore sediment transport is mostly due to the long-term average wave conditions, the cross-shore sediment transport is most often a result of infrequent storm events. During a storm, natural wave forces will shape the cross-shore profile based on a number of parameters including wave height, wave steepness, and the median grain size of the beach. Since the profile shape is sensitive to water level, periods of significant storm surge conditions generally govern the overall cross-shore transport.

Through this combination of the longshore and cross-shore sediment transport modeling results, the potential nourishment design can be developed with confidence. Although qualitative methods are available to predict shoreline change and beach nourishment performance, only numerical modeling of the wave, storm surge, and sediment transport conditions can provide the quantitative data needed for proper design of beach nourishment projects and/or assess the influence of structural alternatives.

Task 4 – Alternatives Analysis and Conceptual Design

An alternatives analysis is the basis for determining the optimal solution and assessing potential impacts (both physical and environmental). A variety of factors are considered when evaluating the various alternatives (e.g., cost, feasibility, performance, environmental impacts, constructability, etc.), with the overall objective focused on selecting the optimal solution. As such, the goal of the assessment is to evaluate reasonable, practicable, and feasible alternatives that will achieve the goals and objectives of the project, while minimizing the short and long-term adverse effects (if any).

The ultimate goal of the modeling and existing conditions analysis is to be able to apply the system to evaluate of a wide range of alternatives. By simulating the changes to the system that each alternative produces, it will be feasible to accurately predict the short- and long-term performance of each alternative, as well as provide conceptual design guidance in order to optimize each alternative. The alternatives analysis is intended to achieve an appropriate balance between engineering, economic, and environmental interests, and to develop consensus on recommended alternative(s) that are suitable for the range of involved stakeholders. The alternatives will be geared towards mitigating the ongoing erosion occurring at Grove Beach Point, while creating a sustainable system that does not have significant environmental impacts. The final alternatives will be determined jointly between Woods Hole Group and the GBPA. A maximum of 3 alternatives will be selected for final evaluation. Woods Hole Group has used this approach to successfully select, design, and construct significant shoreline protection projects. Potential alternatives could include both non-structural and structural options, including, but not limited to:

- Vegetation
- Beach replenishment
- Nearshore bar replenishment
- Dune Reconstruction
- Manual sand relocation and/or bypassing
- Groins
- Revetments
- Seawalls
- Existing Structural modification

The alternatives analysis will be geared towards finding the most cost-effective, environmentally acceptable alternative that is able to provide a sustained beach at Grove Beach Point. From a technical standpoint the alternative analysis will focus on the performance of the beach or proposed beach nourishment. The lifetime, and expected renourishment schedule, will be a key to determining the feasibility of each alternative. The alternatives analysis performed as part of the feasibility evaluation can also be directly used for the environmental impact evaluation document.

The alternatives analysis will also consist of an evaluation of the condition of existing shore protection structures (e.g., groins, seawalls, and jetties). This inspection will focus on the structural integrity of existing shore protection measures and highlight potential areas of improvement. The potential impact of existing structures will be evaluated quantitatively to determine their relative importance for future nourishment activities. In addition, an assessment of the beach stability in general will be conducted.

Following the completion of the alternatives analysis, a conceptual design for the preferred alternative will be developed. For example, assuming that beach nourishment will be a at least a component of the preferred alternative, the conceptual design will include factors such as the placement of the fill, the equilibrium profile type of the beach, the location and effect of existing shoreline structures, beach planform response, effects of tapered edges on the fill, effects of combined spreading and background erosion, and effect on the sediment transport in the region.

The wave and sediment transport modeling developed in previous tasks will be utilized to evaluate "hot spots" in the nourishment segments. To ensure proper distribution of nourishment sand along Grove Beach Point, the anticipated impacts of "hot-spots" on coastal erosion rates needs to be determined. As such, enhancement of beach fill design life in regions of increased erosion rates may require overfill in certain locations and/or structural enhancements.

Task 5 - Reporting

An engineering evaluation report will be provided, which will include, but not be limited to, results of analyses, a summary of existing conditions, the alternative selection process and selected alternatives, the alternative analysis, preferred alternative selection, and conceptual design. The alternative analysis presented in the report will describe each alternative, summarize advantages and disadvantages, evaluate costs, assess overall performance, evaluate potential maintenance requirements, and elements of a successful management approach. Five copies of the report will be provided to GBPA.

Task 6 - Bathymetric Survey (optional)

Bathymetric measurements of the Grove Point Beach region would more accurately characterize the nearshore zone lending improved evaluation of the nearshore coastal processes and improved design of beach nourishment and/or structural components. The hydrographic survey would be performed by a two-person field crew, which will include a certified hydrographer. The crew will be equipped with a survey vessel, a Leica survey grade Differential Global Positioning System (DGPS) and an Innerspace Model "448" digital depth sounder. Vessel positioning will be accomplished using a Leica Model "MX9400N" DGPS navigator and a Leica Model "MX9400R" DGPS reference unit. The DGPS reference unit will be set on a known horizontal control point and will transmit real time GPS corrections to the survey vessel via radio link. The vessel-based navigator unit will receive the corrections via radio link and automatically apply the corrections to the position data.

Precise water depths will be obtained using an Innerspace Model 448 high resolution depth sounder with a 200kHz transducer. Water depths with an accuracy of ±0.1 foot will be recorded continuously on strip chart and also stored digitally by the vessel-based computer. At preset increments along each survey transect, the computer will mark the strip chart to enable correlation with the digital data during post-processing. The Model 448 depth sounder incorporates transducer draft corrections, calibration for speed of sound through water and gain control. Calibration will be accomplished by performing "bar checks" at the beginning and end of the survey day. Water level will be continuously monitored during survey operations and during post-processing soundings will be corrected to a NAVD 88 datum based on the tidal measurements.

A survey line spacing of approximately 200 feet will be used and integrated to create a bathymetric surface of the nearshore Grove Beach Point region. Depending on boat speed during the survey (estimated at 3-5 knots), position measurements will be made approximately every 10-15 feet along each survey line. Depth values are recorded continuously (approximately every 0.5 seconds, or every 3 feet along the survey line).

Task 7 - Native (Beach) Grain Size Analysis (optional)

In order to determine the sediment characteristics of the native (beach) material, approximately five (5) grab samples of the beach material will be obtained near the mean tide level of the proposed nourishment sites and analyzed for grain size and chemical contamination, if necessary. This data can be utilized for the sediment transport modeling to determine the anticipated erosion rates and equilibrium beach profile shape. After performing a grain size analysis, the beach sediment data can also be used to determine if the upland borrow source is compatible for the beach nourishment. A differential GPS will be used to estimate the position of each sample.

Task 8 – Draft Letter to USACE (optional)

Woods Hole Group would be willing to draft a letter to the USACE New England District expressing the interest of the GBPA in acquiring beach-compatible sediment from future federal dredging projects in the region. This letter would be addressed directly to the Colonel of the New England USACE District.

Phase II Costs

A summary of the proposed budgets by task is provided below. The costs presented are fixed fee, and would not be exceeded without prior consent of the GBPA.

Task 1 – Historical Shoreline Change	$8,500
Task 2 – Wave Climatology and Transformation	$11,800
Task 3 – Sediment Transport Modeling	$9,900
Task 4 – Alternative Analysis and Conceptual Design	$9,750
Task 5 – Reporting	$7,600
TOTAL	**$47,550**
Task 6 (optional) – Bathymetric Survey	$12,500
Task 7 (optional) – Grain Size Analysis	$1,300
Task 8 (optional) – Letter to USACE	$600

References

Doane-Collins Engineering Associates, LLC. 2004. Grove Beach Point Association Certificate of Permission Application.

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State of Connecticut, 1979. Coastal Area Management Program. Department of Environmental Protection. Planning Report No. 29: Shoreline Erosion Analysis and Recommended Planning Process. Hartford, CT, 1979.