FINAL

An Investigation of Factors Governing Sediment Transport Affecting the Shoreline Contours of Chapman Beach, Westbrook, Connecticut

Prepared For

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Executive Summary

Historically, the sediments forming the sandy beachfront of Chapman Beach have been derived from a number of glacial till deposits found principally along the bordering inshore landmass. Progressive erosion of these deposits over the past 15,000 years, since the termination of the last glacial advance, has supplied abundant sands to the area favoring beach formation and the development of a number of prominent headlands and offshore shoals. Increasing human habitation in the area and the associated construction of seawalls to protect backshore properties have effectively isolated this source area from the offshore. This, in combination with the steady increase in mean sea level elevations , has upset the balance between sediment supply and transport energy needed to maintain a beach. As a result Chapman Beach has experienced continuing erosion sufficient to reduce both the recreational utility of the beachfront and its ability to absorb storm wave energies and to protect the adjoining upland. In an effort to reduce this erosion a number of shore perpendicular structures have been placed along the beach. Reviews of historical data and visual surveys conducted during 2001-2002 as part of this investigation indicate that these structures have been reasonably effective and served to trap materials transported as part of the longshore transport system in the area and/or placed on the beach. The effectiveness of these structures has been graphically illustrated by the acceleration in local beach erosion following the removal of the pile and timber groin fronting Hogan Drive. This together with examinations of the adjoining beach segments indicates that the future integrity of Chapman Beach can only be realized by the continuing presence of groins and some effort to maintain or increase the amount of sediment supplied to the beach. This variety of observations result in the following recommendations:

1. *Conduct an engineering study of the structural integrity of each of the existing groins along Chapman Beach as soon as possible.*

2. *Replace and/or reconstruct the historical groins in the area between Segment 7 and Hogan Drive (see Report Figs.).*

3. *Investigate the history of renourishment with particular emphasis on Segment 1.*

4. *Plan to renourish Segment 2 and the western end of Segment 3.*

5. *Initiate, as soon as possible, a detailed topographic survey of the beach face.*

Introduction

In common with many shoreline areas in Connecticut, Chapman Beach in Westbrook (Fig.1) has been subject to continuing effort in order to maintain recreational utility and a margin sufficient to reduce the energies of storm driven waves impacting the bordering backshore. This effort has lead to the construction of a series of shore perpendicular structures or groins and the placement of sands along several segments of the beach. Despite this work however, the area of the beach above mean high water remains limited along much of Chapman Beach and accelerated erosion has been reported in several areas. These conditions appear to be the result of a variety of factors both natural and man-associated. The resulting interactions produce a sediment transport regime characterized by significant spatial and temporal variability. This variability complicates beachfront management and requires care in the specification and placement of shore protection structures and/or renourishment sands if long term stability is to be realized. Optimal designs require a clear understanding of the sources of sediment to the beach in combination with the energies affecting sand transport. In the fall of 2001 an investigation of these factors based on a combination of existing historical data and selected field observations was initiated. The following report provides a summary of the results of this investigation.

Study Area.

The Chapman Beach study area extends for a distance of approximately 0.35 nm from the entrance to Cold Spring Brook along a southwest tending line to Old Kelsey Point (Fig.1). With the exception of a short segment of barrier beach fronting the tidal marsh along Cold Spring Brook the backshore of the beach is densely populated with residential housing and associated roadways. Reviews of State of Connecticut aerial photographs indicate that these conditions have prevailed for more fifty years. This human intervention has been placed along the edge of a glacial deposit of sediment associated with an end moraine (Flint, 1975) . This deposit contains a variety of glacial debris ranging in texture from sands to gravels and boulders with the potential to provide both a supply of materials to the beachface and a effective armor for the backshore. At several locations erosion has exposed underlying bedrock and an abundance of boulder sized erratics.

The transport of sediments to and along the Chapman Beach study area represents the resultant of interactions between the astronomical tide, tidal currents, winds, wind waves, and long term sea level stand. The astronomical tide in the area is dominated by the semi-diurnal lunar component (M2) resulting in a tidal period of approximately 12.4hr. Tidal range varies from a minimum of approximately 3.0ft during neaps to a maximum of 5.7ft during springs. The associated tidal currents typically display low speeds except in the area immediately adjacent to the entrance to Cold Spring Brook. Current direction generally parallels water depth contours.

The wind field affecting the study area is dominated by south westerlies for much of the year interspersed with northwesterlies during the winter. Storms rich in easterly winds can occur at any time of the the year but are most common during the spring and fall seasonal transitions. The prominence of the backshore and Old Kelsey Point in combination with the orientation of the beach effectively shelters the majority of the beachface from direct wind effects. Only along the barrier beach adjoining the entrance to Cold Spring Brook is there a significant wind driven transport of sand. Historically this component has contributed to the maintenance of a prominent dune line bordering the tidal marsh.

The offshore wind field often results in the generation of an energetic surface wave field. These waves propagate shoreward along trajectories controlled by wind direction and local water depth contours. The relatively shallow water depths and shore parallel contours characterizing the areas immediately offshore of Chapman Beach (Fig.1) favor near normal angles of approach with the wave fronts parallel to the beachface. This together with the dominance of southwesterly winds, shoreline orientation, and sheltering provided by Old Kelsey Point and the associated shoal, favors limited wave driven longshore transport except during moderately energetic storm events. During these events transport may proceed to the east or west for short periods of time. Historical data suggest that the net result of these aperiodic events is a west to east drift of sands across the mouth of Cold Spring Brook towards Chalker Beach (Fig.1).

Since the termination of last glacial period, more than 15,000 years ago, mean sea level elevations have been progressively rising. Over the past 64 years this has resulted in an increase in average sea level stand of approximately 0.083in/yr at New London, Connecticut (Gornitz and

Crouch,2000) or slightly more than 4in in 50 years. Although a relatively small number, this rise favors a shoreward migration of the mean high water line narrowing the recreational beach and repositioning the line of wave breaking. The latter may alter transport dynamics and facilitate an increase in erosion. There are no data to suggest that this trend will change in the near future. In the limit, increasing sea levels may drown the beach for some or all of each tidal cycle.

Existing Beach Characteristics

Proceeding east to west, the shoreline along Chapman Beach can be divided into three (3) distinct areas, a barrier beach adjoining the entrance to Cold Spring Brook, a region of rocky intertidal with pocket beaches, and a linear fringing beach at the foot of the upland. The barrier beach extends for a distance of approximately 500ft west from the entrance to Cold Spring Brook to the beginnings of the upland at Chapman Drive (Fig.2). Beach width at mean high tide (late summer,2002) is approximately 15-18ft from the waterline to the edge of the wetland. The upper beach surface is nearly horizontal and there is no evidence of a backshore dune. Sands appear to be well sorted and medium fine in texture.

To the west of the barrier beach lies a region of rock dominated shoreline. Sandy beachfront in this area occurs in a series of discrete pockets bordered by natural or constructed shore perpendicular boundaries (see Figs. 3,4, and 5). The backshore in the area is naturally armored in some areas and has been artificially armored by the placement of rip-rap in others. Direct wave attack along the backshore is a regular occurrence along this portion of the shoreline.

Continuing west around a prominent rock outcrop (Fig.5) leads to the beginning of a linear beach segment which lies at the foot of the upland and extends to Old Kelsey Point. Approximately 1500ft in length, this portion of the shoreline has been divided into a series of seven (7) segments by the construction of low profile, shore perpendicular groins. The majority of these segments are bounded along their inshore edge by prominent masonry seawalls serving as a retaining structure for residential lawns. The width of the recreational beach within each of these segments varies substantially.

Numbering the segments sequentially 1 to 7 with Segment 1 adjoining Old Kelsey Point and No.7 at the eastern limit (see Fig.6), an east to west traverse along this reach shows the planview to be nearly crescentic with relatively minor interruptions in form due to the presence of the groins. The associated decrease in average beach width with distance west appears representative of a system dominated by a west to east longshore drift of sediment. This general areawide trend can be observed within many of the individual segments. On Segment 7, for example, the horizontal distance between the mean high water line and the backshore near the mid-point of the beach is approximately 45ft decreasing to approximately 34ft along the eastern face of the west bounding groin (August,2002 survey). Sediments throughout this segment appear well sorted with surface distributions dominated by medium to fine sands (Fig.7). This segment represents one of the most used and accessible areas of Chapman Beach and one that is not bordered by a seawall along its inshore limits (Fig.8).

Proceeding to the west, beach width decreases in each of the next two segments equaling approximately 23ft near the mid-point of Segment 6 and 10ft in Segment 5. Each of these segments is bordered by seawalls (Fig. 9). In Segment 4 however, the trend is reversed and the mid-point width increases to nearly 18ft with minimal east to west variation along the Segment. This reversal is short-lived with entry into Segment 3 accompanied by a rapid decrease in the width of the beach above the high water line. This Segment appears to be the longest individual Segment and is bordered by a complex seawall with reinforcing gussets extending onto the beach face (Fig.10). Beach width near the mid-point is approximately 9ft to the face of the main wall. Distance to the offshore edge of the gussets is substantially less. Grain size analysis shows the surficial sediments along this segment to be essentially identical to those found along Segment 7 (Fig.11). Sediments are very well sorted with a mean grain size of approximately 0.5mm and minimal to no concentrations of fines or the coarser grained sands and gravels.

Moving next to Segment 2 reveals one of the shorter Segments along Chapman Beach and overall the narrowest (Fig.12). Beach width ranges from 8-10ft on the eastern and western ends of the Segment, along the bordering groins, to nearly zero at the mid-point. The spring high tide line intersects the seawall along most of the Segment. The characteristics along this segment stand in sharp contrast to those prevailing along Segment 1 where an evident platform of sand provides a relatively wide recreational beach having a mid-point width of approximately 30ft. The sandy beachface in this last segment grades smoothly into a vegetated backshore slope and there is no bordering seawall (Fig.13) . Sieving of a sample of sand obtained along the high water line near the mid-point of the beach shows sediments to be less well sorted and somewhat coarser than those found along Segments 3 and 7 (Fig.14). This marked change in contours and sediment grain size characteristics suggests that at least some portion of the sands found along Segment 1 has been artificially placed .

Historical Trends

The aerial photographic record maintained by the State of Connecticut for the period 1970 to 2000 provides graphic illustration of the spatial variation in sediment transport and shoreline erosion affecting the Chapman Beach Study area (see Figs.15-19). For the fringing portion of the beach in the area between Old Kelsey Point and Segment 7 (see Fig.6), the prevalence of accretion along the western side of each groin provides clear evidence of the dominance of west to east longshore transport throughout this period. Similar patterns to the east of the entrance to Cold Spring Brook suggest that this transport continues beyond the eastern limits of Chapman Beach and is little affected by discharge from the Brook. Overall the net change in beach contours along this section appears to be relatively minor with the observed variations consistent with those expected due to rising sea level and/or short term effects associated with high energy storm events.

Continuing east beyond the limits of Segment 7, the aerial photographic record shows relatively substantive change over the thirty year period. In 1980 the area of the shoreline leading to the western end of the barrier beach was fronted by an evident sand fillet bounded to the east by a shore perpendicular structure extending offshore in the vicinity of Hogan Drive (Fig.6 and Fig.16). By 1990 the eastern boundary of this fillet is less distinct and the feature appears to be progressively eroding (Fig.17). By 1995 an evident intertidal region appears in the area previously sanded (Fig.18) extending east to the barrier beach. Observations in 2002, as part of this investigation, find sands in the vicinity of Hogan Drive confined to small pocket deposits with limited width during high water conditions.

The erosion affecting the areas immediately east of Segment 7 has also affected the contours of the barrier beach. Comparisons of the aerial planviews shows significant retreat of the high water line over the period 1970 to present and the emergence of evident intertidal strands (see Figs.15-19). Conversations with longtime residents indicate that this planview retreat was accompanied by a significant reduction in beach elevation resulting in the elimination of the backshore dune along the barrier. The photos provide no indication of increasing downstream accretion associated with this erosion suggesting that the majority of the displaced sands moved offshore beyond the limits of the beach. The consistency of the overwash patterns in each photograph indicates that a relatively minor fraction of the mobile sands was moved inshore over the adjoining tidal wetland.

Discussion

The sandy shoreline of Chapman Beach and much of the sediment found along the adjoining offshore is the result of the historical erosion of moraine and outwash deposits and subsequent transport under the combined effects of winds, wind waves, tidal currents and long-term sea level stand. As sea level rises the intertidal margin would tend to move inshore resulting in progressive erosion of the upland and a continuing supply of sediment to the alongshore transport system. In common with many coastal areas, this cycle has been interrupted on Chapman Beach by the construction of backshore bordering seawalls. The presence of these structures serves both to impede upland erosion, choking off the supply of new sediment to the beach, and to modify wave energies affecting the beach due to reflection and the associated increase in backwash velocities. This combination of factors would in time lead to an elimination of the sandy beachfront in the absence of some means to trap sediments moving as part of the offshore transport system. This fact was recognized many years ago by residents along the coast of Connecticut and resulted in the construction of numerous shore perpendicular structures or groins similar to those found along Chapman Beach and much of the adjoining shoreline to Cornfield Point (Fig.1).

The groins placed along Chapman Beach appear to have maintained relatively stable contours in the area between Old Kelsey Point and Segment 7 over the period 1970 to present. The well sorted and nearly uni-modal nature of the sediments both onshore and off through much of the area appears indicative of active and continuing recycling between the beach and the adjoining offshore. The near shore-normal approach of incoming waves favors a dominance of onshore-offshore relative to longshore displacement. The latter however does occur due to the combined influence of tidal currents and second order wave effects. As a result the ability of the transport cycle to maintain stable beach contours is uniquely dependent on sediment supplies and transport energies. With few exceptions these appear to have been in reasonable balance over the past thirty years resulting in relatively stable beach contours along much of Chapman Beach.

Along the fringing portion of the beach between Old Kelsey Point and Segment 7 the natural sediment supplies have not been sufficient to maintain reasonable beach width in Segment 2 and portions of Segment 3. Both areas experience periods of total inundation during spring high water conditions. This narrowing is consistent with a west to east longshore transport system and should be particularly evident in Segment 1. The fact that it is not suggests that this area was artificially nourished most probably within the past ten years. Alternatively, it may be that Segment 1 is a relatively low energy area due to sheltering provided by Old Kelsey Point and that this in combination with one of the largest groin structures on Chapman Beach favors more efficient trapping and longterm retention of materials entrained in the Segment from the longshore drift. Although accurate determination of the cause of this accretion requires more detailed information than is currently available the presence and reasonable longevity of the large sand mass in Segment 1 holds out the promise that a similar deposit could be created in

Segment 2 using a combination of sand placement and groin extension and/or repair.

To the east of Segment 7, in the area leading to the barrier beach, present conditions result in minimal sediment trapping. As noted above, the extent of sandy beachface above mean high water is confined in this area to a few discrete pockets. Historically, this area has seen the construction of a number of groins. The remnants of several remain in evidence today. The most prominent of these was a pile and timber structure extending offshore in the vicinity of Hogan Drive. This was removed in the early 1990's. The remaining remnants are extremely low profile and porous resulting in low trap efficiency. This combination of groin removal and deterioration has evidently contributed to the observed erosion of beachface sediments over the past ten years significantly reducing the recreational utility of the area and increasing the exposure of the adjoining backshore to high energy storm waves. The functionality of the groins along the fringing portion of the beach between Segments 1 and 7 indicates that restoration of the beachface along the more eastern sections of Chapman Beach will only be realized if the historical structures are replaced and existing structures repaired.

In addition to facilitating accretion and beach formation, the replacement of the historical groins in the area between Hogan Drive and Segment 7 may also serve to reduce transport energies affecting the western limits of the barrier beach. Although such conditions are unlikely to be sufficient to result in the return of the historical dune they will contribute to the long term stability of the barrier and potentially facilitate an increase in beach width. These characteristics, in turn, will directly benefit the bordering tidal marsh.

Recommendations

1. *Conduct an engineering study of the structural integrity of each of the existing groins along Chapman Beach as soon as possible*. Factors such as foundation characteristics, materials, groin height, length and the amount of rock per unit length or “density” as it affects porosity or the structure’s ability to block longshore movement of sands should be considered. Given the characteristics of the sediment transport regime in this area, the presence of impermeable groins

is essential to the maintenance of the recreational beach.

2. *Replace and/or reconstruct the historical groins in the area between Segment 7 and Hogan Drive.* The development of structures sufficient to trap sands in this area must be considered essential to the creation and retention of sandy beachfront for recreational use and to reduce storm wave energies along the bordering backshore.

3. *Investigate the history of renourishment with particular emphasis on Segment 1.* The existence of previous permits for renourishment would greatly facilitate future renourishment efforts.

4. *Plan to renourish Segment 2 and the western end of Segment 3.* Sands selected for this purpose must display a mean grain size slightly coarser and be less well sorted than the materials presently residing in these segments. Sieve analysis of offshore samples obtained at points inshore of the 5ft isobath (water depth contour) show sediments to be significantly finer and more well sorted than existing beachfront materials indicating that this nearshore area will not provide sands suitable for renourishment (Fig. 20). It should be recognized that in the absence of falling sea level all segments will, at some time in the future, require some amount of renourishment.

5. *Initiate, as soon as possible, a detailed topographic survey of the beach face.* This survey by providing accurate measurements of both the existing plan and elevation contours of the beach will provide a basis for future quantitative evaluations of erosion and accretion. This survey should be repeated periodically and/or as conditions evidently change, such as after a major storm event. These data are essential to the effective management of the beachfront resource.

References

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