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SEDIMENT MANAGEMENT PLAN

GOLDSMITH INLET
SAND ACCRETION AND WATER QUALITY STUDY

Prepared For:

Town of Southold
Planning Department
54375 Main Road
P.O. Box 1179
Southold, NY 11971

This document was prepared for the New York State Department of State with funds provided under NYS DOS EPF Contract C007079 – Goldsmith Inlet and for the County of Suffolk under the Agreement for Improvements to Goldsmith Inlet (CP8207)

Prepared By:

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August 1, 2013

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Town of Southold
Planning Department
53093 Route Main Road
P.O. Box 1179
Southold, NY 11971

Attn: Mark Terry, Principal Planner, LWRP Coordinator

Re: Goldsmith Inlet
Sediment Management Plan

Dear Mr. Terry,

Presented herein is the second submission from eDesign Dynamics satisfying the analysis component of our agreement with the Town of Southold for the above referenced project. This Report is intended as an analysis and discussion of data reported in the "Bathymetric Study and Sediment Monitoring Report" submitted June 1, 2013. Our next submission will be a Draft Recommendation and Action Plan based on the analysis within this Report. If you have any questions or require further assistance, please feel free to contact us.

Sincerely,

Eric Rothstein
Managing Partner
eDesign Dynamics

Background

EDD was contracted by the Town of Southold, NY, to perform several sets of measurements within Goldsmith Inlet in coordination with the performance of water quality and detailed water level measurements by the Cornell Cooperative Extension. While the final results of these measurements are not yet assembled, this Sediment Management Report is intended as a companion to the Bathymetric Study and Sediment Monitoring Report, providing analysis and insight into the data already reported and presented in there.

Goldsmith Inlet and Tidal Flushing

The geometries of the Channel connecting Goldsmith Pond and the Long Island Sound are perpetually changing and, in the process, influencing the flowrates between the two water bodies. For the purpose of clarity, we will use the term Inlet to refer to the entire system, Pond to refer to the deep water body to the south, and Channel to refer to the connection between the Pond and the Sound. The field research performed by eDesign Dynamics (EDD) has been design to document and quantify those changes, and to correlate them with the tidal prism study carried out by Cornell Cooperative Extension along with climate data collected reported the study period. The concern behind this effort is the appearance of diminished water quality conditions within the Pond over time, and the persistent concern that, without intervention, the Channel will become overburdened with marine sediment, thus reducing flushing with the Sound and further diminishing water quality. It is also a concern that this process could lead to Channel closure, either the consequence of gradual sediment buildup over time, or the result of a large volume of sediment washed into the Channel during a high energy storm event. For some years it has been the Town's practice to perform a dredging operation annually at the mouth of the Channel, removing the sand that has accumulated in the spit and relocating it on the beaches to the east. The Town is interested in verifying the efficacy of this practice and identifying alternatives that could be employed at a lower-cost and with greater longevity / sustainability.

The Channel connects the inland Pond with the Long Island Sound, and is driven by the relative elevations of each water body, which is regulated by the tides. As the tide rises, water flows into the Pond at a sufficient rate to cause the elevation in the Pond to nearly match the elevation in the Sound. In a typical cycle, the level in the Pond will reach approximately 0.5 feet lower than the peak in the Sound, with a delay of 20-30 minutes. During this flooding period, there is no significant obstruction limiting the flow of water into the Pond, and the Pond elevations behave as if they are entirely regulated by the tide. As the tide recedes in the Sound, the Channel flow reverses and the flowrate out of the Pond remains sufficient to keep the Pond level equal with the Sound for a period of two to three hours. At this point, the level in the Pond has dropped to the point where the physical properties of the connecting Channel begin to limit the rate of flow, and the Sound begins to drop more quickly than the Pond. Minimum levels in the Pond never fall as low as low tide, since the ebb flow trails behind the tide due to being

restricted by the geometry of the Channel. Approximately nine hours after high tide, and three hours after low tide, the flow in the Channel reverses direction, and the Sound again begins to flood the Pond. This typical cycle is illustrated in Figure 1.

Each cycle, a volume of water flushes out of the Pond and a similar volume flushes back in. This twice daily exchange helps to sustain the quality of water in the Pond, along with a number of upland sources. It is presumed that some of these sources, which include overflow from Autumn Pond, direct precipitation, runoff from adjacent areas, and groundwater contributions, carry some concentration of pollutants that have a net adverse impact on water quality. If water quality in the Pond is not to diminish over time, then the combination of tidal flushing along with the Pond's ecosystem must flush, decompose or sequester contaminants at a rate at least equal to the contributing load. Each of these processes, and others, have considerable influence in the regulation of ecological conditions within Goldsmith and the Inlet's long-term health. Consideration of upland contributions to the Pond was not part of this scope of work.

This Sediment Management Plan is intended as an analysis of EDD's bathymetric study of the Channel and measurements taken from October 8, 2012, and March 20, 2013. These data were first reported to the Town on June 1, 2013, in our Bathymetric Study and Sediment Monitoring Report. In this document we described the methodology behind the transect surveys and the thalweg surveys and provide a number of images to assist with visualization of the results. In this document, we provide correlation between the water level record generated by Cornell, climate data collected from the National Weather Service, and the physical results of the bathymetric surveys, and offer some interpretation of how these processes are related.

Discussion of Channel Bathymetry

EDD's detailed transect study performed October 8 and November 9, 2012, and March 20, 2013, produced three snapshots of the Channel floor. The figures provided in the Sediment Monitoring Report are not reproduced in this document. We also provided a summary of the net deposition and erosion that occurred over each time interval. Figure 2 demonstrates this same summary graphically, using colors to signify the net extents of both deposition and scouring within each portion of the Channel over the period of time specified.

Figure 2A shows changes to the Channel bathymetry between October 8 and November 9, 2012. During this period, several major events occurred which were expected to alter conditions at the Inlet. On October 24th, the Town performed a dredge of the material that had accumulated at the east of the jetty, a sizeable spit of sand protruding eastward and causing the Channel to also move to the east. The dredge was performed in advance of Hurricane Sandy due to concerns that the high energy storm could wash the material inland toward the Pond. On October 29th, Sandy struck the area causing considerable storm surge and also altering the Channel topography. On November 7th and 8th, another storm, a Nor'easter, dropped an inch of rain under high winds, further altering Channel conditions. The changes shown in Figure 2A are the result of all three events as well as smaller daily changes. Net deposition during this period, measured between Transects 6 and 11 (523 ft), was 11,200 ft^3.

Figure 2B demonstrates changes in Channel bathymetry between the survey dates of November 9, 2012, and March 20, 2013. Several high-energy climatic events occurred in this period, too, but with different effects. Net deposition during this period measured between Transects 6 and 11 was 2,800 ft3. Figure 2C describes changes during the entire interval from October 8, 2012, and March 20, 2013, illustrating a total net deposition of 14,000 ft^3. These values translate to net daily deposition rates per foot of Channel given in Table 1. The daily value for the second monitoring period is more than an order of magnitude lower than the period containing Sandy and the Nor'easter. This suggests that those events played a very large role in the net movement of sediment to the Inlet interior. As measurements were not taken with sufficient frequency to identify the physical effects of each major storm, it is impossible to describe rates of deposition and scour associated with individual climatic events using these data alone.

Thalweg, Sill, and Regulating Flow

In addition to the transect measurements, EDD twice surveyed the Channel in a manner designed to map the bathymetry of the Channel's thalweg. The thalweg describes the deepest part of a channel or valley, and generally defines the portion of the channel that possesses the highest velocities and volume flowrates. The thalweg became included in the bathymetric study due to an interest in locating the point in the Channel that regulates the ebb tides from the Inlet system. The ebb of the inlet is principally driven by the Pond elevation relative to the "sill" within the Channel. The sill behaves like an underwater dam or weir, and slows the water upstream. Once the water spills over the sill, it ceases to be regulated by it, and the velocity increases. Generally, the sill in a system such as Goldsmith Inlet will define the rate of ebb flow, especially toward the end of the cycle. By taking measurements of the thalweg along the portion of the Channel which is most likely to constrict the flow, we were able to locate the zone where dredging might be most effective. If subsequent dredging operations are able to lower the sill by excavating the Channel floor in this zone, the rate and period of discharge from the Pond can be increased.

Cornell Cooperative Extension is in the process of refining several large sets of data collected between May 16, 2012, and May 23, 2013. These include the water levels logged at three locations within the Pond and one in the Sound. The data are of sufficiently high resolution to allow us to understand the cycling flows into and out of the Pond (see Figure 1 and discussion above) and to provide us a record of climatic events as they influence the relationship between water levels in the Pond and the Sound.

Similar data, though of lesser detail, were collected by Morgan & Kraus in the execution of their "Physical Processes Study of Goldsmith Inlet, New York," 2007[1]. In this paper, Morgan & Kraus assert that the Channel is "flood dominant," with higher velocities and higher sediment loading found entering the Pond than when draining the Pond. This imbalance leads to a net sediment loading that is most visible in the accumulation of the flood shoals at the southern end of the Channel, since higher velocity water is capable of greater sediment carrying capacity. Morgan & Kraus also assert that at least two sills regulate ebb flow from the Pond, one near the flood shoals which plays the larger role in regulating ebb flow, and one nearer the Sound, which plays a lesser role. EDD's thalweg measurements located a sill in the area between Transects 6 and 8. Thalweg measurements further south into the flood shoal were not

[1] Morgan, M.J. and Kraus, N.C, (2007). "Physical Processes Study of Goldsmith Inlet, New York." Proceedings Coastal Sediments '07 Conference, ASCE Press, Reston, VA 2331-2344.

feasible because of the very subtle changes in bathymetry there where the Channel floor is nearly flat over large sections.

Morgan & Kraus also discuss the morphology at the beaches, jetty, and mouth of the Channel. They summarize that after jetty construction in 1964, as the fillet to the west of the jetty gradually formed, that sand transport and bypassing patterns from west to east were altered until a new steady-state was reached. During this time, lasting until approximately 1978, beach erosion to the east may have accelerated as the littoral drift was interrupted by the new jetty. After this time, and with the formation of the spit at the east side of the jetty (aka attachment fillet), sand bypassing resumed and beach conditions became more stable. Morgan & Kraus warn that removal of the spit may reintroduce instabilities that could again alter the littoral conditions to the east by interfering with the shoreline geometry and reducing bypassing, though they acknowledge that removing the spit may be necessary, on an emergency basis, to maintain an open Channel. EDD agrees with Morgan & Kraus' assessment with respect to sand bypassing and beach stability. A corollary concern not directly addressed by Morgan & Kraus, however, is the potential role of the spit (and the eastward movement of the Channel mouth) in reducing the rate of sediment transport from the Sound to the Channel. At the same time, we are also concerned that the accumulation at the mouth of the Channel could become a sediment source during high-energy storms, thus increasing the volume of sand moving up the Channel and into the Pond. A more detailed discussion of these issues will be contained in EDD's subsequent report..

Discussion of Water Level Logger Data

Examination of the water level data shows the presence of two daily tide cycles (semidiurnal), one with greater amplitude than the other, depending on the relative positions of the sun and moon. The wave forms are sometimes distorted due to the influence of climate, particularly wind speed and direction. Most notably, water levels measured in the Sound will shift up or down depending on the wind, thus influencing the water level response in the Inlet and the degree of flushing experienced in the cycle.

As described above, the flood period sees a close relationship between Sound levels and Pond levels, and flow into the Pond does not appear limited by the geometry of the Channel. Water levels during the ebb period, however, are not similar, as the flow out of the Pond is restricted by Channel conditions, and the Pond reaches a minimum elevation well above the Sound. Study of these Pond minima as they vary over time provides insight into how the degree of tidal flushing is influenced by climatic conditions. If the Pond drops to a level that is higher than average, then it can be presumed that flushing is limited during this cycle. If these minimum levels are found to be increasing over time, then it is likely that the Channel geometry is changing, either through sediment movement or deposition, and reducing the volume flushed. Similarly, if an abrupt and sustained change in the typical minimum Pond level is seen, it can be presumed that a high-energy climatic event has occurred, and flow conditions in the Channel have been altered.

Figure3A tracks the minimum elevation in the Pond for the entire monitoring period at Logger #3. Spikes in the graph indicate either extreme weather events or anomalies in the data based on instrument error. Since we are interested in tracking the changing minima, we have generated Figure 3B, which ignores the

extreme events and calls out periods during which the changes in the minimum elevations can be interpreted as being in one direction only and at similar rates. Ten periods were isolated and fitted with linear trend lines that approximate the rate of change. The slopes of the trend lines, which vary between positive or negative minimum elevations, are reported in Table 2 for each period. Where the slopes are positive, the flushing volume is decreasing and, while slopes are negative, flushing is increasing. Period One, which lasts for 108 days, shows no net increase or decrease in Pond minima and demonstrates relative stability. Periods Two and Ten, which last for 58 and 43 days respectively, show dramatic and prolonged changes in the flushing volume which would be associated with consistent daily changes in the Channel bathymetry due not to extreme climate events but to more subtle conditions that are regulating deposition and scour. Although not conclusive, the general trend of the entire study period shows that net conditions over the long term are slowly leading toward net sediment deposition.

This conclusion is consistent with the depositional rates calculated from the Channel transects, with suggest an average depositional rate (expressed as cubic feet of sediment deposited over one foot of Channel per day) of 0.67 ft3/ft/day for the period between 10/8 and 11/9/12, and 0.041 for the period between 11/9/12 and 3/20/13. The water level data also suggest that if an additional transect survey had been performed at the end of May 2013, the final period would have shown net scouring. Because the transect measurements were performed only several times, and because the water level minima only describe trends in flushing volumes from day to day, it is not possible to verify or quantify these conclusions with certainty. However, the data does make it clear that: a) There exist alternating periods of net deposition, net scouring, and relative stability, and b) These periods are generally separated by high-energy climatic events.

Water Levels and Climatic Events

In order to elaborate this second conclusion, EDD procured detailed climate data from the National Weather Service collected at Mattituck Inlet, the nearest climate station available. These data, reported in five minute intervals, provide record of wind speed and direction, the climatic factors that most influence tidal flushing in the Inlet. Unfortunately, a flaw in the operation of the climate station, or an error in reporting, has caused some of the data provided to be incomplete. During each early morning, for a period of approximately three to four hours, no data are reported. This appears to be true until April 26, 2013, when the daily records are complete. Additionally, the precipitation record appears to be inconsistent with that observed at Southold and with other (less detailed) data sets procured by EDD. To compensate for this, we have used the precipitation record from daily climate data reported by Wunderground.com. The gap in morning wind data could not be compensated for in this analysis.

As seen in Figure 3, it is reasonable to presume that the various periods of rise or fall are distinguishable by large climatic events or other physical changes to the Channel, such as dredging or other construction work. Figure 4 shows a snapshot of the wind speed, direction, and precipitation depth for the days separating each period. These “wind roses” graphically demonstrate the direction of origin and shows an accounting of the average wind speed measured in five minute intervals. Calm days appear as blue and green. Windy days typically lean in one primary direction, and appear red and orange, denoting higher velocities. Comparison of Figures 3A and 3B demonstrates that most but not all periods are separated by large events. Additionally, scrutiny of the climate data demonstrates that not all high-energy climate events provoke changes in Channel conditions. Figure 5 shows wind roses for a selection of high-energy

events that do not appear to have influenced Channel conditions. As yet, separating out wind speed and direction for correlation with Channel behavior has not contributed to the analysis. While wind speed and direction are incontrovertible components affecting sediment loading, we have identified no obvious consistency between these specific events.

Precipitation does not play a direct role in influencing Channel bathymetry or tidal flushing, but does play a role in the measurements of water levels in the Pond. The total catchment area for Goldsmith Inlet is approximately 640 acres. Under most conditions, the vast majority of rainfall reaching this area is infiltrated by the sandy soils of the region. However, during very large events, or events that occur while the soils are previously saturated, significant volumes of runoff are expected to reach the Pond and raise water levels there. Additionally, groundwater in the area likely discharges to the Pond at a relatively fixed rate, but this rate will increase when the groundwater table is high. In these ways, precipitation does play a role in the Pond water levels, though quantifying that role is beyond this scope of work. Other measureable factors, like Pond salinity, may provide some basis for estimating upland contributions to flushing as well as better understanding water quality concerns.

Observations from Aerial Images

Use of aerial images to assess slight changes in land forms is problematic for several reasons. Variations in resolution, lighting conditions, and camera angles can each contribute to apparent inconsistencies on the ground that do not genuinely exist. Furthermore, the water level at the time of the photograph will have a large influence on the appearance or cover of the intertidal zones, making it difficult to measure beach erosion, channel widths, etc.

Google Earth provides the opportunity to view historical aerial images in rapid sequence. At Goldsmith Inlet, the record goes back to 1994 and shows 12 separate images of the site, each aligned identically to allow for close inspection of landmarks and their surroundings. Although these observations are not conclusive, an inspection of these images provides some record of visible changes over the past 20 years.

The flood shoal present at the Pond's connection with the Channel has been evident for some time. An aerial photo taken in 1938 shows clearly a portion of the developing shoal, thought it appears to have a much lesser extent than in recent years. Again, the photograph does not inform us of the tide elevation (influencing visibility), and lighting conditions may interfere with the ability to distinguish the shoal, but the photo does provide us with evidence that the flood shoal has grown toward the Pond interior in the past 75 years. Aerial photos taken in 1962, 1972 and 1978 also appear to confirm this observation. The Google Earth image from 1994 appears to have been taken at high tide and the shoal is not visible. The subsequent images, ranging from 2001 to 2012, do not appear to suggest that the shoal has been growing to any significant degree.

As discussed above, the Channel is a dynamic body that is expected to alter course over time and in response to extreme events. This is primarily evident at the north end of the Channel where its course altered by the accreting spit (or attachment fillet) and by its periodic removal by dredging. As the spit grows, it appears to force the Channel to exit further to the east. Based on Google Earth images, the spit

is shown increasing from 1994 to 2004, with a dramatic reduction sometime between 4/1/04 and 10/30/06. The spit again increases until 9/5/09, and is shown reduced on 9/19/10. It is reduced a third time before the image dated 3/6/12. The Channel is also shown scouring very close to Mill Road in 2004, but that appears to be corrected by 2008. What is clear from the 1938 aerial is that the Channel has generally migrated toward the west, eliminating some structures built east of Mill Road.

Assessing beach conditions from these aerial photos is especially difficult because of the variations in the tides, but it does appear that, in images taken after the spit has been removed, the beach to the east is also diminished. This would be consistent with Morgan & Kraus' assertion that the fully developed spit aids in sand bypassing from west to east, and its removal could interrupt beach accretion until some steady state is reached. Morgan & Kraus also assert that for 14 years after construction of the jetty, sand that would have been deposited to the east of the Channel was instead accreting west of the jetty to form the fillet. Once the western fillet and the eastern (attachment) fillet reach their maturity, the sand bypassing process and deposition on the easterly beaches are restored. In general, it appears clear that the width of the beach to the east has diminished since the earliest aerial taken in 1938.

Careful inspection of the dunes over the beach, particularly at the point immediately east of the Channel, shows that there has been little or no retreat of the dunes since the 2001 image. When comparing the 1994 with the 2001 image, however, it appears that the dunes retreated on the order of 20 feet, which is significant. Because of image quality and camera angle, it is difficult to compare with the aerials taken before 1994.

After construction of the jetty in 1964, the accretion fillet to its west quickly developed, extending the beach adjacent to the jetty by a total of approximately 300 feet. An aerial image from 1967 shows the fillet extending already half the way up the jetty, though with no signs of the attachment fillet to the east. By 1972, the accretion fillet is clearly fully developed, and the attachment fillet has begun to form, and by 1978, conditions resemble those found today with the Channel bending far to the east before connecting with the Sound.

Conclusions/Next Steps

At the time of submission of this Report, EDD is continuing to prepare a flow model based on physical conditions within the Channel. The model, constructed in DYNLET (DYNamic Behavior of Tidal flow at InLETs), which is a package first developed by the US Army Corps of Engineers. The modeling will allow us to correlate the water level data with flow in the Channel, and can be configured to confirm the role played by presence of the sill and predict changes in behavior that result from dredge the Channel bed to remove or relocate the sill. DYNLET looks at the Channel geometry, materials (to assess friction) and the forces driving flow namely, tides, waves and wind. The results of this analysis will be included in the Recommendations and Action Plans that will be submitted as part of EDD's Task 8.

In this current analysis, EDD has observed that changes in Channel behavior, namely periods of incremental increase or decrease in flushing volumes, are typically separated by high-energy climatic events, though not exclusively. We have also observed that not all such events influence Channel

behavior. Looking at principally at wind speed and direction, EDD has not been able to identify a correlation between climate and periods of net deposition or net scouring, though there appear to be scour-dominant events and deposition-dominated events. As Cornell Cooperative Extension elaborates the results of their studies, these will be included in the analysis.

In the forthcoming Recommendations and Action Plans, EDD will describe our recommendations for sustaining the connection between the Pond and the Sound, and will submit a protocol for the Town's use in assessing the appropriate course of action when maintenance becomes due. If the DYNLET modeling confirms the role of the sill in regulating flushing, our protocol will include instructions for performing a thalweg survey, and corresponding recommendations for dredging. EDD has not yet determined if it is advantageous to dredge the spit (or attachment fillet) on an annual basis, given the role it is presumed to play in supporting bypassing of sand from west to east.

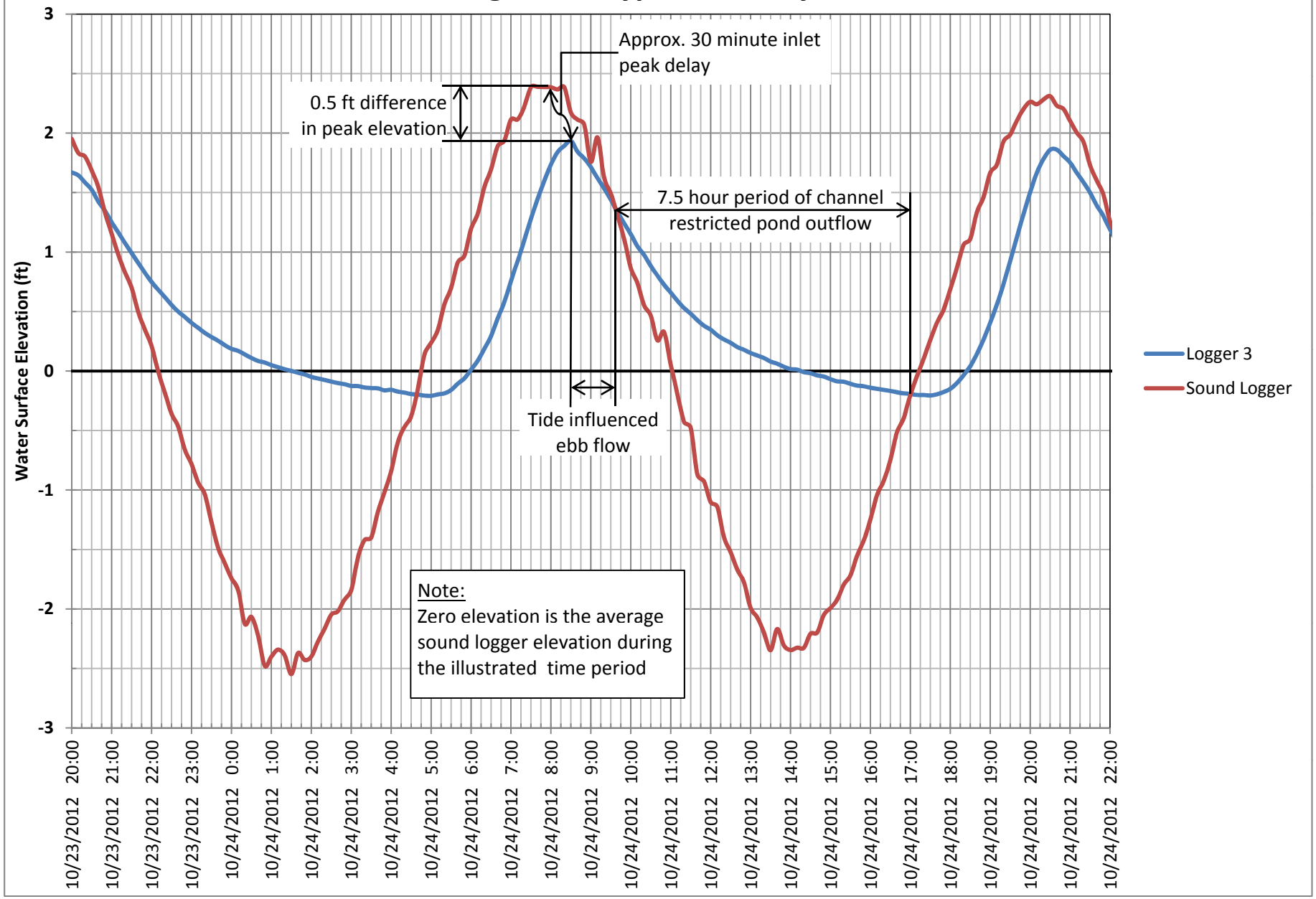
Table 1 - Net Deposition Rates

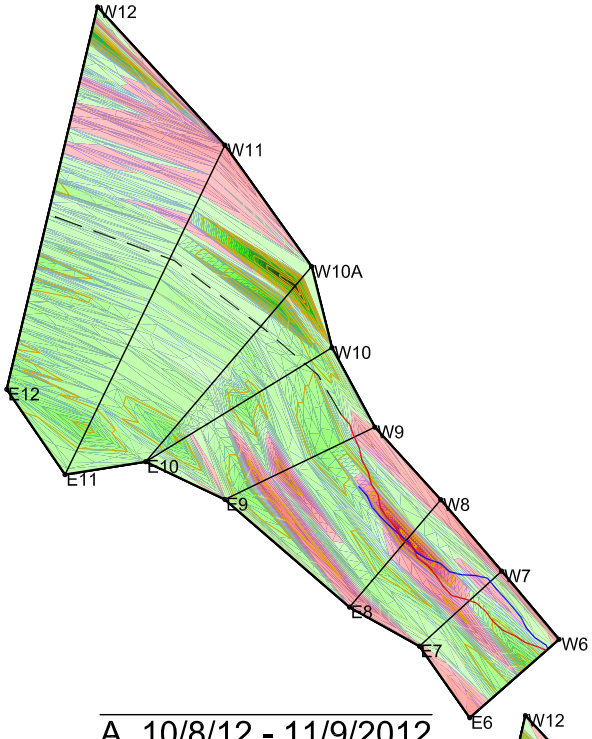
Period	Total Net Deposition between Transects 6 and 11 (ft3)	Total Distance between Transects 6 and 11 (ft)	Days Between Measurements	Daily Rate of Net Deposition (ft3/ft/day)
10/8/12-11/9/12	11240	523	32	0.672
11/9/12-3/20/13	2806	523	131	0.041
10/8/12-3/20/13	14046	523	163	0.165

Table 2 - Trends in Pond Minimum Elevations

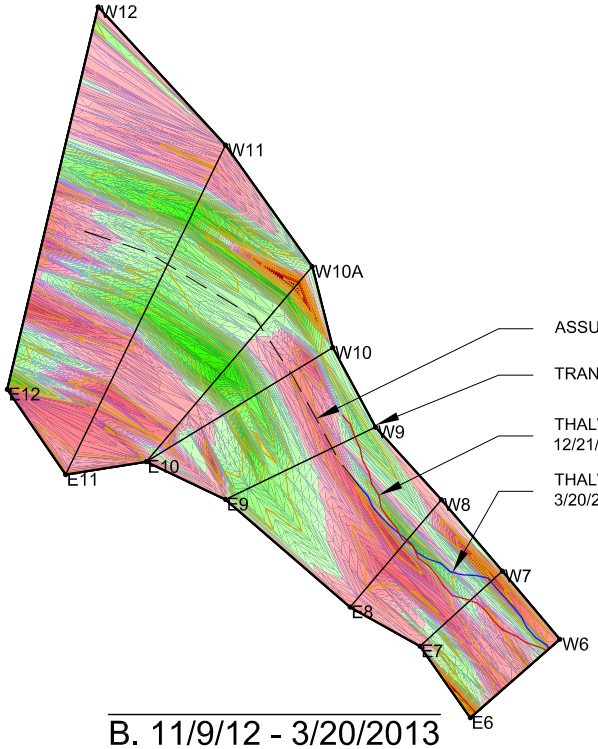
Period	Dates	No. of Days	Total Change in Minimum Elevation (ft)	Change in Minimum Elevation (ft/day)
one	5/16/12-8/31/12	108	0	0
two	9/1/12-10/28/12	58	0.2726	0.0047
three	10/30/12-11/6/12	8	-0.1688	-0.0211
four	11/10/12-12/20/12	41	-0.0492	-0.0012
five	12/22/12-1/5/13	15	-0.2595	-0.0173
six	1/6/13-1/17/13	12	0.3936	0.0328
seven	1/18/13-2/7/13	21	-0.0756	-0.0036
eight	2/11/13-2/17/13	7	0.0504	0.0072
nine	2/19/13-4/5/13	46	0.0736	0.0016
ten	4/8/13-5/20/13	43	-0.3612	-0.0084

Figure 1 - Typical Tide Cycle

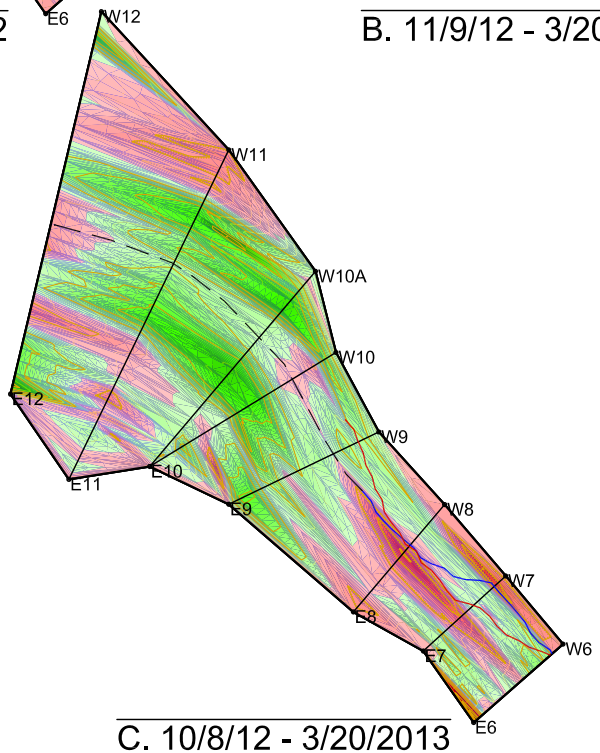




A. 10/8/12 - 11/9/2012



B. 11/9/12 - 3/20/2013



C. 10/8/12 - 3/20/2013

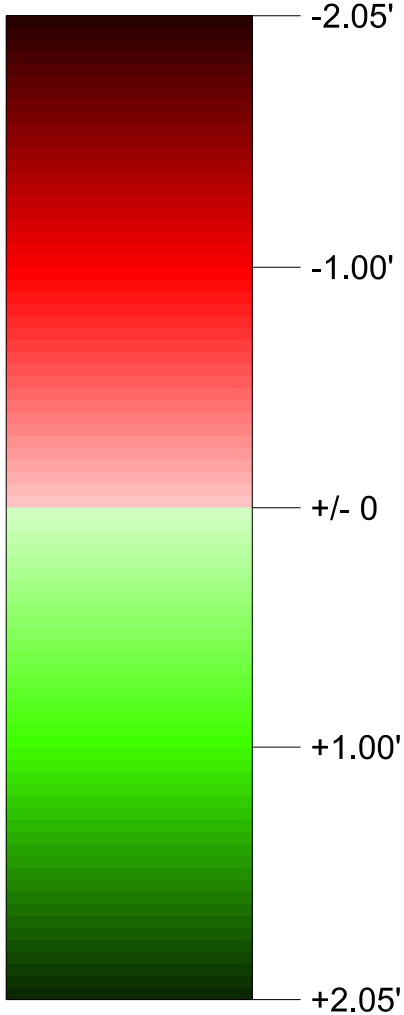
ASSUMED THALWEG (TYP.)

TRANSECT STATION (TYP.)

THALWEG SURVEYED 12/21/2013 (TYP.)

THALWEG SURVEYED 3/20/2013 (TYP.)

CHANGE IN INLET SURFACE ELEVATION OVER THE PERIOD DESCRIBED



TRANSECT SURVEY DATES:

10/8/2012
11/9/2012
3/20/2013

THALWEG SURVEY DATES:

12/21/2012
3/20/2013

FIGURE 2 - SCOUR AND DEPOSITION

Figure 3A - Pond Minimum Elevations

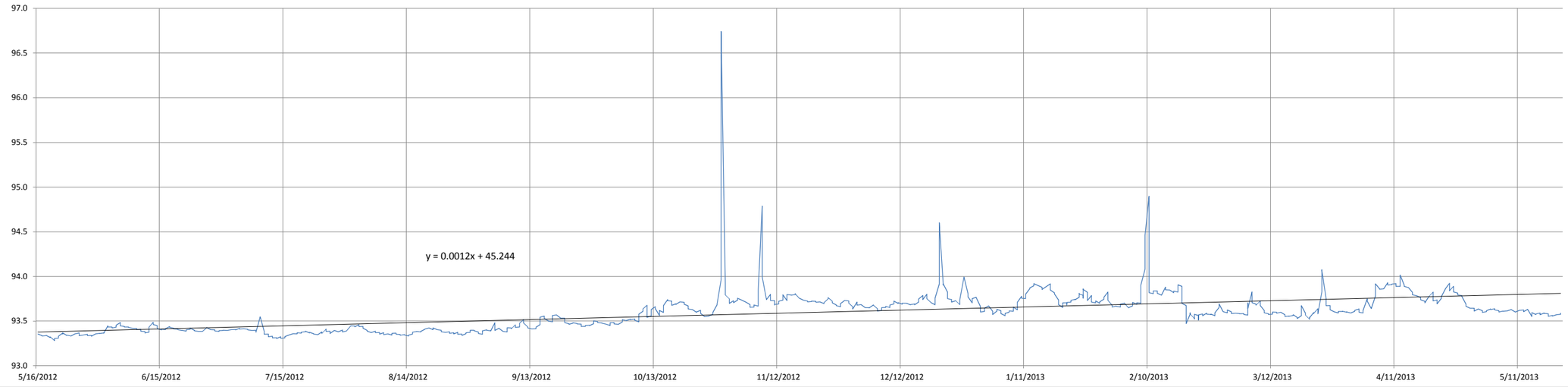
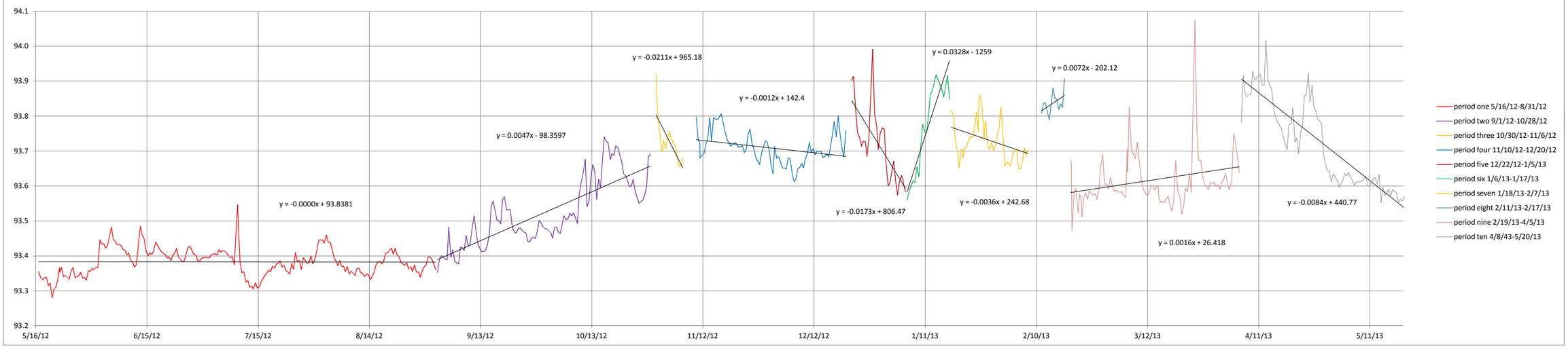


Figure 3B - Trends in Pond Minimum Elevations



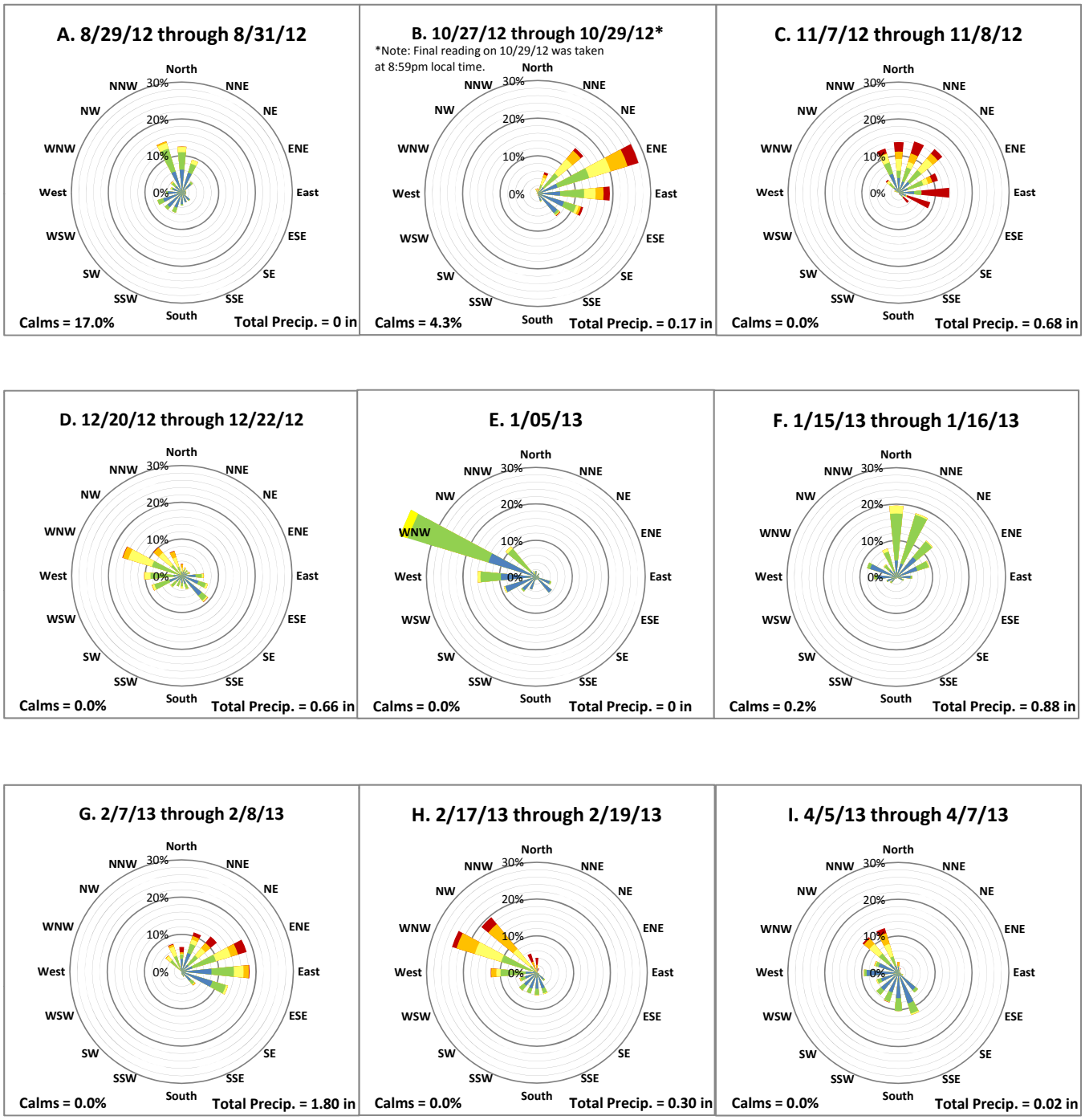


Figure 4 - Wind velocity distributions following each period of increasing or decreasing minimum pond elevations.

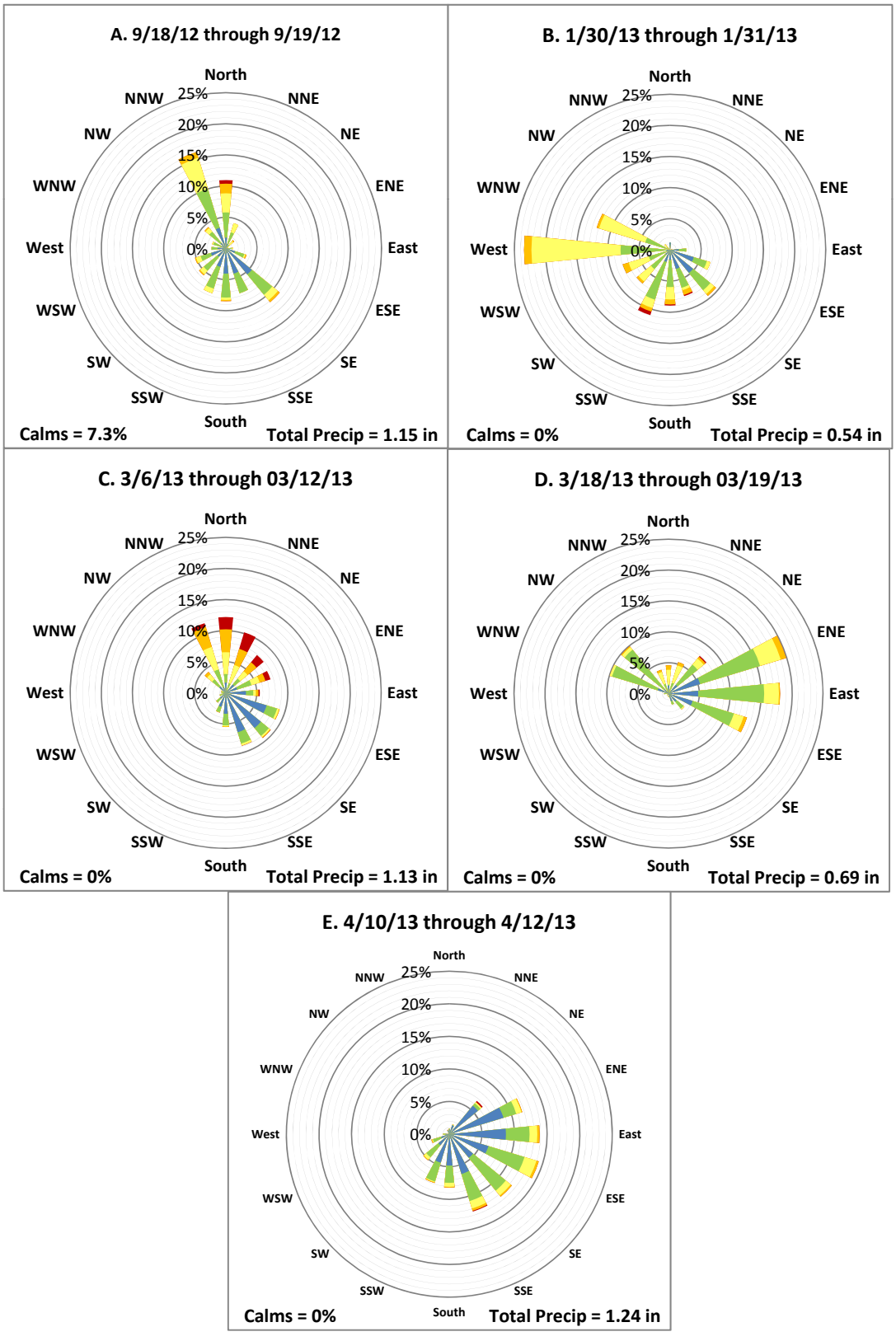


Figure 5 - Wind velocity distributions for other high energy events.

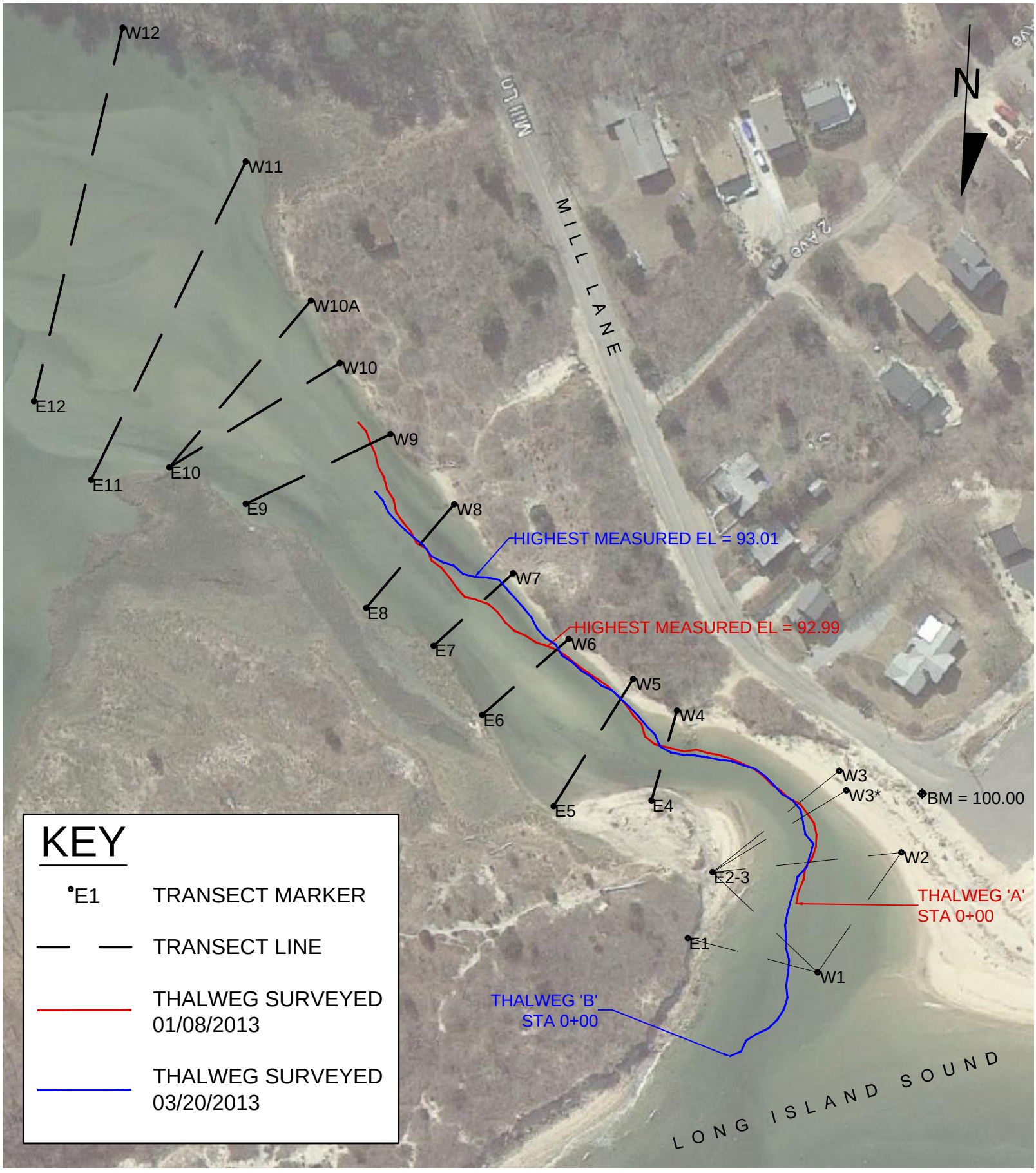



Figure 6 - Transect and Thalweg Location Plan