Appendix C

Excerpt from the Report of the Wells Scientific Review Panel (2007)

Wells Harbor Monitoring Program

Final Report
of the
Wells Scientific Review Panel

Report submitted to the Town of Wells

Prepared on behalf of the
Wells Scientific Review Panel
by the
Maine Geological Survey

February 2007

Executive Summary

The Wells Scientific Review Panel (WSRP) was established in 1998 to review the data generated by a program to monitor the consequences of dredging at Wells Harbor on the neighboring saltwater marsh. Seven scientists with expertise in marine science comprise the panel. A compromise agreement in 1998 among the parties on all sides of the dredging issue allowed a reduced dredge to proceed in 2000, and required the Town of Wells to monitor the adjacent salt marsh to assess impacts that may be caused by the dredging activity. The outcome of the monitoring program is intended as essential input to discussions of future dredging.

The Town of Wells hired a consultant, Woodlot Alternatives, to collect monitoring information from 39 sites along channels in the saltwater marsh adjacent to Wells Harbor. Staff from Woodlot Alternatives surveyed marsh features at the survey sites twice annually – once in the spring and again in the fall. Surveys were conducted for two years prior to the dredge, and for 5 years after the dredge.

Datasets were submitted to the WSRP annually for their consideration. The WSRP met on five occasions to review the monitoring information collected up to the time of each meeting and to summarize findings. The first meeting was used to set definitions for important terms to be used throughout the review process. During the second through fourth meetings, the WSRP conducted a qualitative review of the monitoring data, inspecting maps of each survey location and noting where features showed progradation, erosion, or remained stable during the time period considered. For the final review, the WSRP used a quantitative analysis using digital datasets of each survey for three two-year time periods – one before and two following the dredge. The quantitative analysis established numerical unit changes over time at each site, thereby allowing statistical analysis that might reveal trends in the data. The details of this quantitative analysis may be found in the body of this report.

The WSRP’s review of the pre-dredge monitoring data revealed that 19 sites were eroding, 9 sites were stable or prograding, and 11 sites that showed some erosion and some progradation (mixed). In 2002, the WSRP reviewed post-dredge data to that date and found that the status of 25 of the sites was generally unchanged. Five sites showed changes toward increasing stability or progradation, while eight sites showed changes toward increasing instability or erosion. In 2004, the WSRP reviewed all the monitoring data collected to date, and similarly concluded that the status of most sites remained unchanged.

Furthermore, the more rigorous quantitative analysis of change in 2006 does not indicate a systematic change of any surveyed feature related to any measured parameters. The pre-dredge data suggest a very limited inverse correlation of the magnitude of erosion and distance from the harbor, which is reflected in the post-dredge data. No clear dredge-related signal rises above the natural background variation in the datasets.

After careful review of the monitoring information generated through the entire program, the WSRP at this time finds no convincing evidence of any impacts on the marsh directly related to dredging that took place in November-December of 2000.

Introduction

The Wells Scientific Review Panel (WSRP) was established in 1998 to review the data generated by a program to monitor the consequences of dredging at Wells Harbor on the neighboring saltwater marsh. Seven scientists with expertise in marine science comprise the panel.

Background. Wells Harbor was constructed in the Webhannet River estuary beginning in the 1960s. At the location of the harbor, the estuary is a sand-dominated system, with a flood-tidal delta on the landward side of the narrow inlet, an ebb-tidal delta on the seaward side, and significant sand beaches bounding the inlet. Prior to harbor dredging and jetty construction, sand was exchanged freely among the tidal deltas and neighboring beaches. The harbor area is bordered on the west side by Webhannet Marsh, most of which is within the Rachel Carson National Wildlife Refuge. The marsh consists of thousands of acres of high and low salt marsh, abundant salt pans, and is dissected by numerous tidal channels that converge at the harbor area.

Dredging by the U.S. Army Corps of Engineers (Corps) at Wells Harbor was first begun in 1962 but proceeded slowly due to equipment problems, storms, and a high rate of shoaling. Over the course of several years, additional attempts were made to reach the full design capacity of the harbor. Along with continued dredging, the Corps also built jetties on both sides of the inlet to the harbor area to stabilize the channel. These jetties were modified numerous times through the early course of the dredging effort. The final dredging and jetty configuration were completed in 1974.

Following the 1974 dredge, shoaling at a rate higher than anticipated by the Corps continued to fill in the harbor. Several protracted cycles of debate followed in the 1980s among town officials, state agencies, federal agencies and interest groups, but without any agreement on additional dredging. The most recent debates began in 1995 and led to a compromise agreement in 1998 among the parties to allow a reduced dredge, protect a portion of the flood-tidal delta with a conservation easement, and require monitoring of the adjacent salt marsh to assess impacts that may be caused by the dredging activity. The outcome of the monitoring program would become essential input to discussions concerning future efforts to dredge the harbor.

Charge to the Panel. The 1998 agreement to dredge Wells Harbor established the Wells Scientific Review Panel, consisting of six scientists with marine expertise and the Maine State Geologist. This panel was charged with the following tasks:

- Develop definitions for terms that might be used during review processes, most notably "natural variation."
- Review data related to natural variation in the marsh, channels, sandbars, and sand bodies.
- Review any proposed interim dredges with the goal of avoiding or addressing effects of the proposal on monitoring results.
- Identify, quantify, and track variations occurring post-dredge in the areas surveyed through hydrographic surveys, and in the marsh, marsh channels, sandbars, and sand bodies monitored by the town.
- Prepare and submit interim reports to the Stakeholder Committee.

- Interpret and evaluate variations in areas surveyed by hydrographic surveys, marsh, marsh channels, sand bars and sand bodies attributable to dredging activity.
- Prepare a final report summarizing and interpreting the monitoring data with respect to effects of the dredge.

Panel members.

Michele Dionne, Wells National Estuarine Research Reserve
Duncan FitzGerald, Boston University
Joseph Kelley, University of Maine
Robert Marvinney, Maine Geological Survey
Marcel Moreau, Moreau Associates
Peter Rosen, Northeastern University
Larry Ward, University of New Hampshire

Panel Process. Since 1998, the Town of Wells has retained a consultant, Woodlot Alternatives, to conduct the majority of the marsh monitoring work. Each spring and fall from 1998 through the spring of 2005, staff from Woodlot carried out monitoring tasks at predetermined locations, and generated a report with maps and photographs for each monitoring locality, which were provided to the Panel for review. There were two years of pre-dredge monitoring followed by five years of post-dredge monitoring.

Each year, digital datasets of monitoring information were provided to the State Geologist, the Chairman of the WSRP. He subsequently manipulated these datasets using the Maine Geological Survey's geographic information system to generate maps comparing positions of mapped features (e.g. base of bank, edge of vegetation) over successive years of monitoring. The WSRP met as a body on five occasions: July 29, 1999 to develop definitions for terms, reported previously; January 26, 2001 to review monitoring data collected prior to the dredge; August 1, 2002 to review monitoring data collected to date; May 5, 2004 to review the data collected during 2003; and on February 2, 2007 for a final review of data and final report.

At each meeting, datasets, photographs, and other information provided by Woodlot were reviewed and discussed. For each monitoring site, the WSRP characterized the conditions of the site as eroding, stable, or accreting, and comparisons were made in subsequent years. Each of the interim reports of the WSRP is included in Appendix D.

In the decision-making process, the WSRP strove for consensus, which we have achieved fairly well in the WSRP's earlier conclusions. However, the scientific process is not aimed at building consensus, but at acquiring new knowledge through the testing of hypotheses. While this monitoring program was carefully designed to measure features in locations that the WSRP felt might be sensitive to the impacts of dredging, all factors that may affect the outcome of such experimentation in a natural setting may not have been taken into consideration. Such unknown factors may contribute to the uncertainty of the results and, subsequently, differences of opinion among scientists reviewing the results of this experimentation. Therefore, it is entirely possible that the WSRP will not be in consensus on the conclusions of this report.

2000 Dredge

Dredging at Wells Harbor was carried out by contractors to the Corps during October-December 2000. Approximately 145,000 cubic yards of material were dredged from the federal navigation channel and anchorage, and an additional 35,000 cubic yards were dredged from the municipal portion of the project (Figure 1).

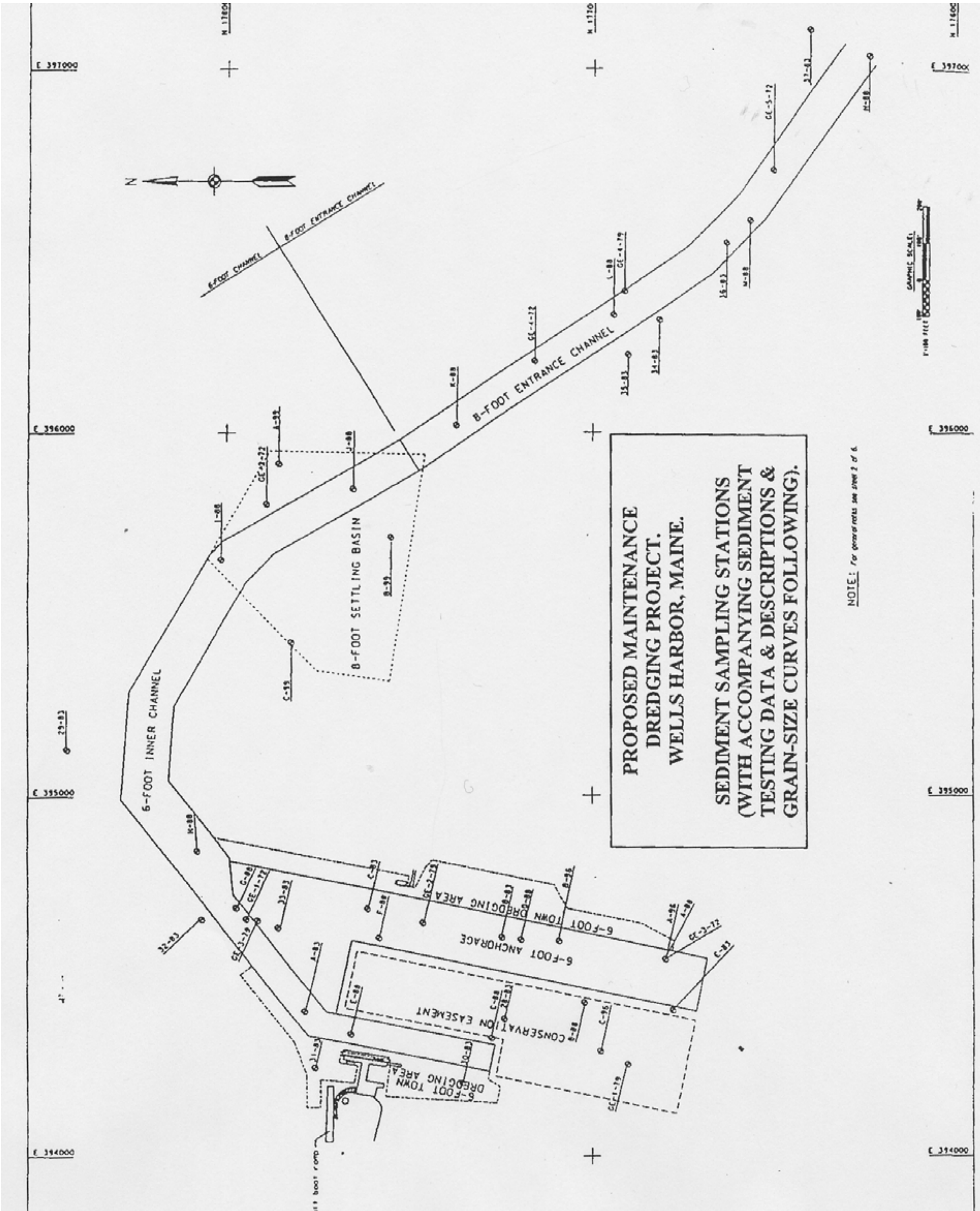

Figure 1. Outline map of Wells Harbor showing federal channel, federal anchorage, town dredging areas, and conservation easement.

The dredging contractor used a GPS-guided cutting head and hydraulic dredge system to carry out this work. Through the use of hydraulic pumps, pipes, and heavy machinery, about 60,000 cubic yards of dredge spoils were placed on Wells Beach and about 120,000 cubic yards were placed on Drakes Island beach. The Corps of Engineers surveyed the harbor, navigation channel, and the lower Webhannet River before the dredge to establish pre-dredge conditions. The Corps also surveyed the same areas following the dredge to verify that the contractor met the obligations of their contract. See Figure 2.

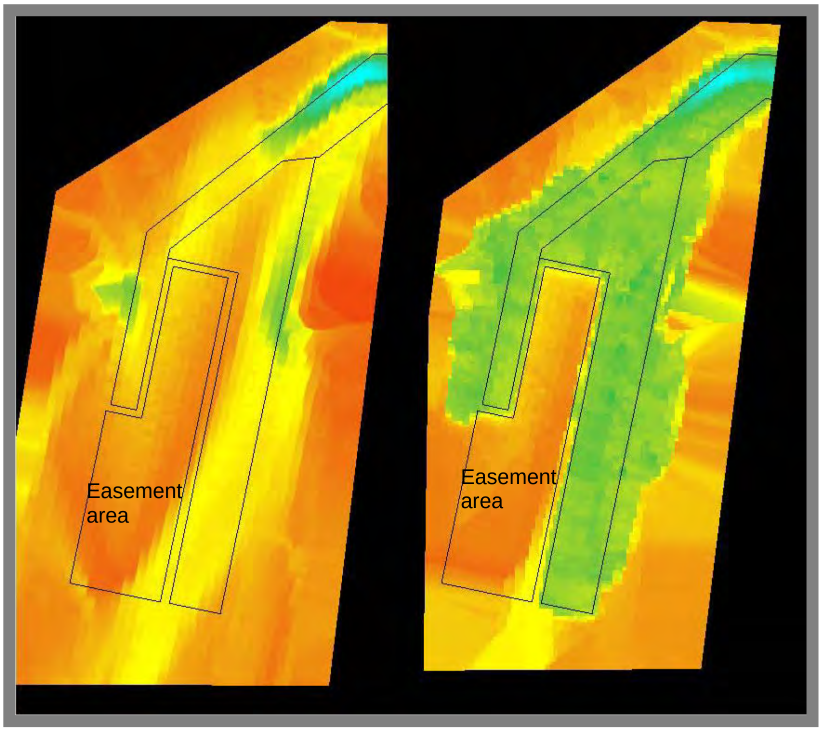

Figure 2. Wells Harbor bathymetry before (left) and after (right) dredge. Oranges and yellows are shallow areas, greens and blues are deep areas. The easement area on the flood tidal sandbar is shown, as are the outlines of the federal navigation project.

Marsh monitoring program

Monitoring sites. Through a series of meetings prior to the dredge, a broad stakeholder community including the State Geologist reviewed maps of the Webhannet Marsh and eventually selected 39 sites for monitoring work (Figure 3). These sites are broadly distributed around the northern part of Webhannet marsh and include areas immediately adjacent to the harbor, areas remotely located in upstream portions of tidal channels, and locations between these two extremes. Sites were also selected to represent what the stakeholders felt were eroding, accreting, and stable sites. The monitoring sites are all marginal to tidal channels, where most scientists feel the greatest response of the marsh and tidal channels to dredging might occur.

Process. The Town's contractor, Woodlot Alternatives conducted all the in-field measurements at the monitoring site. Woodlot first established the monitoring sites with a rebar marker and located them via GPS. For the site locations and subsequent mapping of features, Woodlot used a combination of surveyor-grade GPS receivers and integrated laser rangefinders. These integrated components provide an accuracy of +/- 5 cm in x,y,z parameters. At each monitoring site, Woodlot staff mapped the following features (descriptions abbreviated from annual reports by Woodlot):

- Edge of vegetation: this represents the limit of low marsh vegetation, where bare mud or a cut bank replaces smooth cordgrass (*Spartina alterniflora*).
- Edge of high marsh: this represents the boundary between areas dominated by low marsh vegetation and areas dominated by high marsh vegetation, typically consisting of saltmeadow cordgrass (*Spartina patens*) and other species.
- Bottom of bank: this represents the unvegetated, vertical cuts in marsh sediment and tidal channel banks. Bottom of bank lines in the datasets and on the maps may represent vertical banks that range in height from a few centimeters to more than 3 meters. Some sites include multiple cut banks.
- Tidal channel transects: at four monitoring sites, Woodlot mapped channel transects. At each site, three roughly parallel transects were surveyed across the tidal channel adjacent to the monitoring site.

Each site was occupied twice annually, once in the late spring and again in the fall, for the purposes of mapping these features. A total of 15 surveys were conducted over the course of the project.

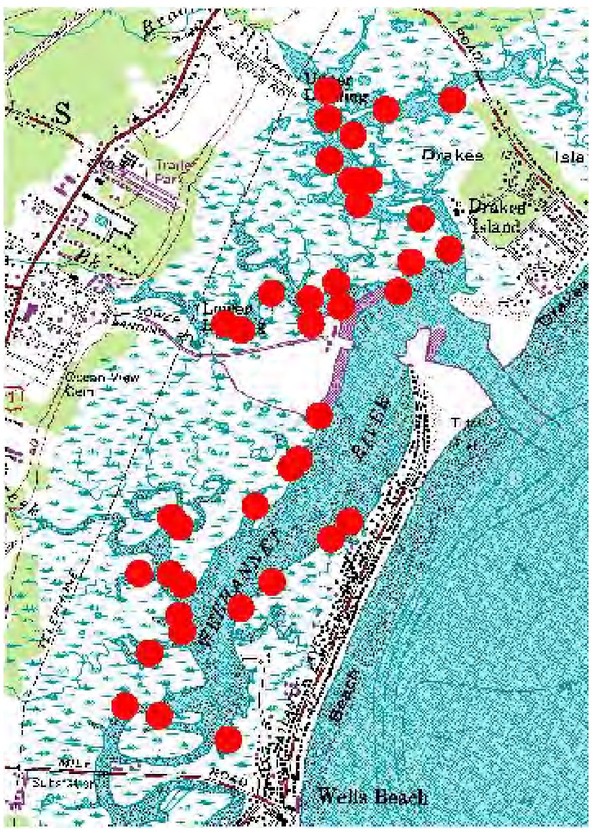

Figure 3. Location of 39 monitoring sites on Webhannet marsh at Wells, Maine. Sites are located along the margins of tidal channels in the marsh and include a variety of channel sizes and settings within the marsh.

Revisions to monitoring. At our 2002 meeting, members of the WSRP expressed concerns about the quality of mapping the edge of vegetation (both low marsh and high marsh) during the spring monitoring event. Salt marsh vegetation is generally dormant in much of April and often into May, making the task of mapping the edge of vegetation highly subjective. The WSRP recognized this subjectivity in the radical changes in the edge of vegetation (both low and high marsh) from year to year. The best time to map this feature is in late August or early

September when vegetation is at its height of the growth season. The WSRP subsequently recommended to the Town that springtime mapping of the edge of vegetation be discontinued and that the edge of vegetation should be mapped in August or September. Springtime mapping of the base of the cut banks continued.

At several locations, staff from Woodlot Alternatives needed to reset marker rebar farther back from the margin of the channel because slumping of the bank removed the rebar. In some cases the rebar may have been lost due to dislodgement by ice. In each of these situations, the rebar was resurveyed so that the older data could be used with the new data. In one case, the site had to be reestablished at a different location on the marsh to discourage frequent vandalism facilitated by the presence of a nearby road.

Climate summary during monitoring years

The following summary highlights significant statewide or coastal storms that occurred during the period of active monitoring. This summary is drawn from web-based resources provided by the National Weather Service and the Northeast Regional Climate Center.

<u>Pre-dredge years</u>

- 1998: The most significant weather event was the multi-day January ice storm that caused significant, protracted power outages over much of the state, but was of little consequence along the coast. There were no significant coastal storms during the remainder of the year.
- 1999: A significant snowstorm occurred in southern Maine in March, but this was mostly a precipitation event with little wind. Hurricane Floyd dumped several inches on most of Maine in September, but again, this was without damaging winds.
- 2000: This was a quiet year, particularly in the fall, which facilitated harbor dredging ahead of schedule.

<u>Post-dredge years</u>

- 2001: A series of winter storms affected the coast, first in February, but with the most significant storm in March. This storm included persistent northeast winds that resulted in some beach erosion. This year was also the driest on record, as recorded in Portland.
- 2002: The remnants of Hurricanes Isadore and Hanna passed by Maine in September accompanied by significant rain, but little significant wind.
- 2003: The remnants of Hurricane Isabel passed by Maine in September with some rain and little wind. October was a particularly wet month. December saw two major snowstorms, but these were primarily precipitation events.
- 2004: An April coastal storm was mostly rain. The remnants of Hurricane Charley dumped record precipitation in northern Maine, but were not of particular consequence on the coast.
- 2005: A winter storm with significant snow and wind out of the north affected the coast in January. Another storm occurred in mid-March, but with winds primarily from the northwest. April had heavy rains, and also marked the end of the marsh monitoring program. This year went on to become Portland’s wettest year on record.

In summary, during the three years of monitoring prior to the dredge, no significant winter storms or extra tropical storms affected the Wells area. Immediately following the dredge, in March 2001 a significant winter storm affected coastal Maine causing some coastal erosion. This storm significantly redistributed the dredge spoils on both Wells and Drakes Island beaches. The lack of storms in the pre-dredge period, and the occurrence of storms immediately following the dredge complicates analysis of natural vs. man-made effects, but does not preclude such analysis.

Analysis

Prior to each meeting of the WSRP, Marvinney imported into the Maine Geological Survey's geographic information system the monitoring datasets from Woodlot Alternatives. Marvinney then created a series of maps for each site showing the positions of marsh features at the time of each monitoring event.

For several select sites Woodlot Alternatives collected multiple profiles across channels to document changes to these channels during the period of study. Marvinney imported the profile information into MGS's GIS and generated 3-dimensional models of the channels. While the modeling capability of MGS's software is not robust, it is sufficient to determine the polarity (erosion, accretion) and relative magnitude of changes in the channels.

Along with the photographs and descriptions provided by Woodlot Alternatives, these maps of marsh features and 3D channel models form the basis for classifying changes at each monitoring site.

Early reviews by the WSRP

For the January 2001 meeting, the WSRP used simple categories to describe each of the sites: eroding, stable, and prograding, with some modifiers for each term. For the August 2002 meeting, the WSRP developed more detailed categories:

- **Active erosion**: Measurable recession of mapped feature(s).
- **Erosional features developing:** Erosional features appear or increase in size, but little or no recession of mapped feature(s).
- **Mixed:** Some mapped features prograding, but some erosional features develop or increase in size.
- **Stable:** No measurable change in any mapped feature.
- **Prograding:** Some prograding of a mapped feature evident.

These categories were used along with some modifiers and additional comments to classify each surveyed site. For some sites, we further refined the description by applying the categories to individual environments of the site, i.e. banks, low marsh, high marsh, etc.

<u>2002 review summary:</u> The review of the monitoring data collected prior to dredging found 19 sites that were eroding, 9 sites that were stable or prograding, and 11 sites that showed some erosion and some progradation (mixed). Comparing the pre- and post-dredge monitoring data, the WSRP found that the status of 25 sites was generally unchanged. That is, those that were eroding before the dredge continued to erode and those that were stable or prograding before the dredge continued to do so as well. Five sites showed changes toward increasing

stability or progradation, while eight sites showed changes toward increasing instability or erosion.

Comparison of the 3D models for each transect at different times presented some interesting insights into the dynamics of the tidal channels in the marsh. One site showed constant loss of sediment in the channel throughout the period of study. The other sites showed inconsistent patterns of gains and losses throughout the period.

At the time of this review the WSRP found no convincing evidence that any of the changes were related to the dredge in 2000.

2003 review summary: While generally the same as the 2002 review with 25 of the sites unchanged, the WSRP found four sites that showed changes toward increasing stability or progradation, and 10 sites that showed changes toward increasing instability or erosion. A consistent and noteworthy change was the increase in number and extension of cut banks in the northernmost section of the marsh (W102 – W107). For the most part, the new cut bank features were first mapped in April 2001, but for W106 they were first noted in the fall of 2000. Most of these sites are along the major channel that continues to the north of Drakes Island Road. Some of the changes might be related to migration of the channel, although the WSRP could not rule out some relationship to the dredge.

Note, however, that Woodlot Alternatives addresses some of the WSRP's concerns with cut banks in their September 2004 monitoring report. In that report, Woodlot notes:

> While the extent of cut banks may be increasing at some monitoring points, it is apparent that in some cases where the SRP interpreted plotted survey results as representing increasing extents of cut banks may, in fact, be the result of increased data collection by the Woodlot monitoring team…. While a potential solution to this issue is to crop the survey data at the extents of the pre-dredge survey work, Woodlot believes that the presentation of all collected data best reflects the unbiased approach to the collection and presentation of information obtained as part of the field survey work.

The WSRP was encouraged during the 2003 review by the bathymetric maps provided by the Corps of Engineers, which demonstrated that the primary elements of the harbor were remaining fairly stable. The western navigation channel in particular has been persistent, while some material has filled in the southern portion of the eastern anchorage area. Some of the sand in the conservation easement area has been redistributed to other areas. Volume estimates supplied by the Army Corps of Engineers indicate that about 6000 yards of sediment have been removed from the conservation easement area through this redistribution. The settling basin or 'arrowhead' area at the entrance to the anchorage area has also experienced a redistribution of sediment.

2007 Review

In preparation for the final review of the monitoring data, Marvinney conducted extensive analyses of the datasets over the course of several months during the winter of 2006. One of the shortcomings noted by the WSRP in earlier reviews was that most of the analysis by the WSRP was qualitative in nature. WSRP members looked at plots of datasets and visually determined the nature and magnitude of changes. For the final analysis, WSRP members preferred a more quantitative approach to change analysis.

GIS analysis of datasets. Each year of the monitoring program, Woodlot Alternatives provided Marvinney with digital datasets representing both the spring and fall monitoring surveys. These datasets were relatively easily imported into the Maine Geological Survey's geographic information system for subsequent analysis. For each monitoring site during each survey, the dataset consisted of lines representing surveyed locations for the base of bank (BOB), the edge of vegetation (EOV), and the edge of high marsh (EOHM). For some sites, the BOB dataset contained multiple lines representing multiple tiers of bank failures. The total data ensemble includes more than 1700 individual datasets.

For the qualitative review sessions, Marvinney generated a series of simple plots for each site at a common scale, showing the most current location of surveyed features relative to the earliest pre-dredge data, and the most current relative to the first post-dredge data. A more rigorous process was necessary to approach a more quantitative analysis.

Change analysis. For the quantitative analysis, Marvinney compared two-year time slices of datasets. This was done for three reasons. First and most importantly, the pre-dredge datasets covered a two-year period, so no lengthier time slice could be used consistently throughout the series of datasets. Second, reviewing two-year time slices would tend to even out irregularities in the measurements and natural variation in the processes. Third, using two-year time slices reduced the workload to a manageable level.

Table 1. Datasets used in the quantitative analyses are shown in bold in this listing of all available data.

Survey Date	Feature datasets
July 1998	BOB, EOV, EOHM
October 1998	**BOB, EOV, EOHM**
May 1999	BOB, EOV, EOHM
September 1999	BOB, EOV, EOHM
May 2000	BOB, EOV, EOHM
August 2000	**BOB, EOV, EOHM**
April 2001	BOB, EOV, EOHM
October 2001	BOB, EOV, EOHM
April 2002	BOB, EOV, EOHM
September 2002	**BOB, EOV, EOHM**
April 2003	BOB
September 2003	BOB, EOV, EOHM
April 2004	BOB
October 2004	**BOB, EOV, EOHM**
April 2005	BOB

Although it may appear that the WSRP has used only a small subset of available data for the quantitative analysis, two points should be considered:

1) The WSRP visually reviewed all datasets available at the time of each panel meeting. The WSRP noted no radical changes in progradation/erosion rates nor dramatic reversals in trends from one year to the next, giving the panel some confidence that conducting the quantitative analysis on two-year time slices would not miss important single-year events and compromise the conclusions.

2) Since erosion/progradation are on-going processes, and the locations of features are not reset to a starting point each year, the two-year time slices incorporate the changes that occurred during the intervening year. This information is not discarded in the same sense that data would be discarded by selecting only a subset of monitoring sites for analysis.

The quantitative analysis is based on areal change from one time period to the next. For each site, the BOB, EOV, and EOHM changes were analyzed separately, resulting in more than 450 datasets representing the two-year time slice analyses for each feature type at each site. (Note: not every site has cut banks and not every site has high marsh vegetation.) In order to be able to work the datasets from all sites together, several steps were taken:

- To be consistent in the lengths of features examined, the boundaries were set for each feature type based on the maximum length of that feature shared by all datasets. Arbitrary lines representing these boundaries were entered into the GIS (see Figure 4).
- Negative changes in area between features represented erosion and positive changes in the area between features represented accretion. Note that at some sites, it is fairly unlikely for accretion to occur in high banks. In the example (Figure 4), the areas shown as accreting are very small compared to the total area of change, and are inconsequential in the overall analysis. Some interpretation was required for large positive changes in banks, which in most instances were noted in Woodlot's reports as loose blocks that have extended toward the channel. There are few instances of this issue in the datasets, and where they occurred, those segments were not used in the analysis.
- At sites where the banks included several tiers, the different tiers were treated separately. The lengths of the features and the areal change between them were separately measured, and the total length of all features and their areal changes were summed for subsequent analysis. At some sites where the secondary tiers were small, they were not included in the analysis.
- To compare rates of erosion/accretion among survey stations, the areal changes were standardized to change per unit length of the feature. The feature lengths were determined directly by the GIS software and represent the summed length from node to node along each feature in the dataset. This is the length of the feature, not the straight-line distance between end points.
- For each time slice analyzed, the feature length used to determine unit change was the average of the two lines being compared. This is because in almost all cases, the two lines were not parallel. In the worst instances, the two lines used for averaging varied by 3%.
- Results were compiled in a spreadsheet and used in comparative statistics.

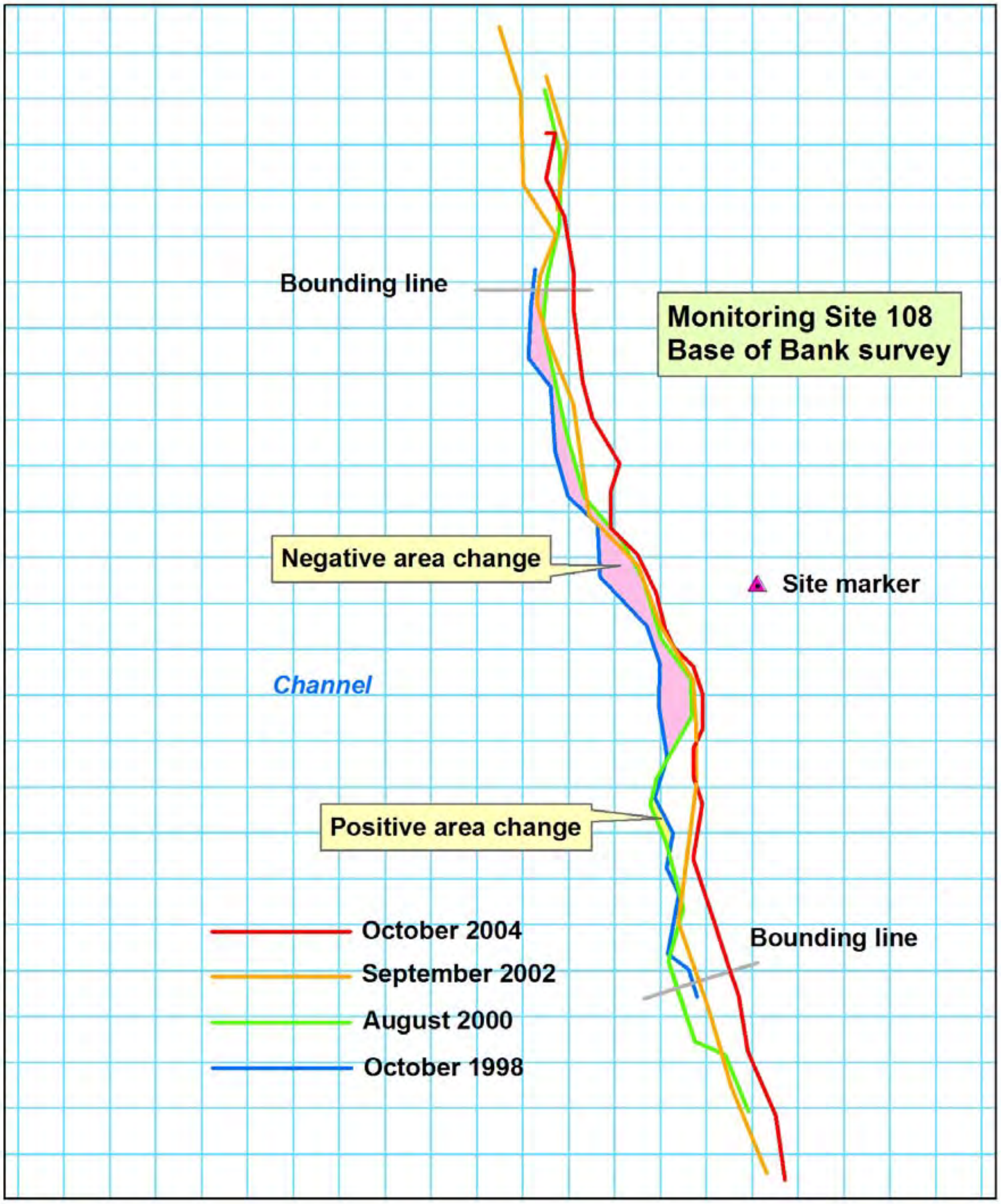

Figure 4. Example of change analysis on datasets representing the base of bank for site 108. Lines representing the position of the base of bank during the time of each survey are shown in different colors. A negative change is where the line retreats from the channel, and a positive change is where the line advances toward the channel since the previous survey. The blue grid has 5-foot cells.

In addition to the analysis of areal change over time, Marvinney reviewed the changes relative to other characteristics of the monitoring site. Using ArcMap tools and one-foot resolution digital orthophotographic imagery from the Maine Office of Geographic Information Systems, Marvinney collected a number of parameters for this analysis. This excellent color imagery was collected at low tide in the Spring of 2003 (Figure 5).

- Channel distance to harbor. Using measuring tools in ArcMap, the distance along the channel from the monitoring point to a point near the entrance to the harbor was measured.
- Channel width. This was measured at each site for high tide and low tide.
- Distance to channel center. This was measured from the monitoring site to the visually interpreted center of the thalweg in the channel.
- Fetch length. Both the perpendicular cross-channel fetch and the maximum fetch were measured from the imagery.
- Fetch direction. Both the perpendicular and maximum fetch directions were determined.

Figure 5. Example for Site 120 of measurements made at each site using Spring 2003 one-foot resolution digital imagery and ArcMap software. Distances were measured in meters using the ArcMap measuring tools. Fetch azimuths were determined directly from the image. North is at the top.

Results. The results of the GIS analysis are compiled in a spreadsheet, presented in Tables 2-4, with each feature type presented in its own sheet.

Description of table columns

- The first six columns in each table are the measured areal changes for each two-year period, in both square feet and square meters. Since the datasets were collected in state plane coordinates, the square-feet measurement comes directly from the digital datasets. The conversion to square meters was done in the spreadsheet.
- Reference length, both in feet and meters, is the length of feature used to standardize to change per unit length. The reference length is the average length of the two lines bounding the change area for each time slice.
- Total change in square feet and square meters, is the sum of all changes measured in the two-year time slices.
- Unit change for each two-year time slice is the areal change for that period, divided by the reference length.
- Total unit change is the sum of unit changes for each time slice.
- The remaining table columns represent the measurements of distances, widths, fetch lengths, and fetch directions as described above.

For each of the datasets, the Excel spreadsheet statistical functions were used to determine statistical correlations of feature change with other parameters. Correlations diagrams were produced for each and presented here.

Base of Bank

The relationship between changes in the bank position and channel distance to the harbor shows a limited correlation in all datasets, ranging from a low correlation coefficient of 0.08 in the 2000-2002 dataset, to a high of 0.269 for the 1998-2000 dataset. (See Appendix A for graphical presentations of correlations.) The correlation coefficient for the entire period is 0.259. The comparison of pre-dredge and post-dredge unit change datasets suggest that the 1998-2000, the 2000-2002, and the 2002-2004 datasets are all taken from the same population, i.e. the mean values for unit change for each dataset are not statistically different from each other. (See Appendix B for discussion of the statistical comparison of datasets.) There is little statistically meaningful correlation of the changes to the banks and any other parameter measured as part of this analysis. The unit change in the base of bank was also plotted on a rose diagram relative to fetch direction, both for maximum and perpendicular fetch (Appendix C). There is no clear correlation of magnitude of change and fetch direction in either dataset.

Edge of Vegetation

The relationship between changes in the edge of vegetation and channel distance to the harbor shows very limited correlation in all datasets, ranging from a low correlation coefficient of 0.0019 in the 1998-2000 and 2000-2002 datasets, to a high of 0.1275 for the 2002-2004 dataset. The correlation coefficient for the entire period is essentially 0. The comparison of pre-dredge and post-dredge datasets suggest that the 2000-2002 and 2002-2004 datasets are taken from the same population, i.e. there is no statistical difference in the means from the first period to the last period. However, the 1998-2000 dataset of unit change is statistically different from the other two datasets. Notably, the mean change during the pre-dredge period is negative, while the means of both post-dredge periods are positive. There is little statistically meaningful correlation of the changes to the edge of vegetation and any other parameter measured as part of this analysis.

Edge of High Marsh

The relationship between changes in the edge of high marsh and channel distance to the harbor shows very limited correlation in all datasets, ranging from a low correlation coefficient of 0.0115 in the 2000-2002 dataset, to a high of 0.0915 for the 2002-2004 dataset. The correlation coefficient for the entire period is essentially 0.0018. The comparison of pre-dredge and post-dredge datasets suggest that the 1998-2000 and 2000-2002 datasets are taken from the same population, i.e. there is no statistical difference in the mean unit change in these two datasets. However, the 2002-2004 dataset of unit change is statistically different from the other two datasets. There is little statistically meaningful correlation of the changes to the edge of high marsh and any other parameter measured as part of this analysis.

These analyses of single variables relative to another demonstrate very little correlation over all parameters measured. It may be that more of a relationship might be discerned through multi-variate statistical analysis, but this exercise was not undertaken. It may be that the observed changes relate to other parameters that were not measured as a part of this program.

Conclusions

The Wells Scientific Review Panel reviewed all of the marsh-monitoring information generated as a requirement of the agreement to dredge Wells Harbor in 2000. There were 15 surveys of the marsh during this period that generated datasets for each of the 39 monitoring sites. During the winter of 2001, the WSRP reviewed the pre-dredge data. The review of the monitoring data collected to that date found 19 sites that were eroding, 9 sites that were stable or prograding, and 11 sites that showed some erosion and some progradation (mixed). In 2002, the WSRP reviewed post-dredge data to that date and found that the status of some 25 of the sites was generally unchanged. That is, those that were eroding before the dredge continued to erode and those that were stable or prograding before the dredge continued to do so as well. Five sites showed changes toward increasing stability or progradation, while eight sites showed changes toward increasing instability or erosion.

In 2004, the WSRP reviewed all the monitoring data collected to date. After careful review, the WSRP has some concerns about some areas of the marsh. Most notable are the changes in sites W102-W107 along the major channel to the north wherein the cut banks seemed to be extending. However, later discussions with staff from Woodlot Alternatives suggests that the apparent extension of some cut banks may have been more a product of survey variability than actual physical changes.

Furthermore, the more rigorous analysis by Marvinney involving calculated areas of change do not indicate a systematic change related to any measured parameters. Logically, if measurable changes in erosion and accretion of the monitoring sites occurred in response to the 2000 dredge, then effects would be greatest at sites nearest the harbor and diminish with distance from the harbor. The pre-dredge data suggest a very limited inverse correlation of the magnitude of erosion and distance from the harbor, which is reflected in the post-dredge data. No clear dredge-related signal rises above the natural background variation in the datasets.

After careful review of the monitoring information generated through the entire program, the WSRP at this time finds no convincing evidence of any effects directly related to dredging that took place in November-December of 2000. Similarly, a NOAA CICETT-funded monitoring study of the tidal flats and tidal channels immediately landward of the jettied entrance channel showed that this area responded little to the dredging activity (Rits, 2003).

References

Rits, M., 2003, Wave-current interaction, sediment transport, and the response of a jettied channel to dredging, Wells inlet, Maine: Boston University, Master of Arts thesis, 314 p.