foot) of beach in the shore parallel direction. Between 2 and 10 of the profiles at each OCRM benchmark surrounding Singleton Swash had to be excluded from the analysis because their landward-most point was too far seaward when compared to the majority of the remaining annual profiles.

The unit volumes were compiled for each OCRM benchmark location and plotted as time series data. In addition, differences between the unit volumes of successive annual beach profiles were determined and the differences were normalized to a yearly rate. Normalization to a yearly rate allows for volume comparisons without having to be concerned with the time period between the beach profile surveys, as the interval between surveys is not standard. In some instances there was more than one survey during one calendar year and other times several years passed between beach profile surveys that could be used in this analysis. The normalized annual unit volume change rates were also plotted as time series data.

Figures 8-1 through 8-15, in Appendix C, provide examples of the beach profiles and plots of the calculated time series of unit volume changes and unit volume change rates at the benchmarks north of Singleton Swash, while Figures 8-16 through 8-25 depict the same information south of the swash. Figures 8-26 through 8-35, in Appendix C, provide examples of the beach profiles and plots of the calculated time series of unit volume changes and unit volume change rates at the benchmarks north of White Point Swash, while Figures 8-36 through 8-44 depict the same information south of the swash.

Singleton Swash Profile Analysis

As can be seen in Figure 1-2 above, the OCRM benchmark monunments used in this analysis from north to south are 5515, 5513, 5510, 5505, and 5500, with 5510 immediately north of the swash and 5505 immediately south. Figure 2-1 shows the time series of changes in beach profile unit volume for the benchmarks north of Singleton Swash. The timeline in Figure 1-4 above shows that the Arcadian Shores beach nourishment project was completed in June of 1999. The change in the unit volumes between 1999 and the end of 2000 clearly shows the addition of sand via beach nourishment. The shape of the line representing OCRM 5515 (blue) is slightly different from the other two because there was a gap in the useable beach profile data at OCRM 5515 from January 1999 to September 2000. OCRM 5513 (green) and 5510 (red) had useable beach profile data in January 2000.

Figure 2-1: Unit Volume Change (cu.yd/ft) over time at OCRM Benchmarks North of Singleton Swash.

Figure 2-1 also shows the reduction in beach profile unit volume at all three locations subsequent to the beach nourishment project. However, the relative change in volume at 5510 is noticeably less than the other two locations, both of which are north of 5510. This could indicate that the beach at 5510 is capable of retaining more of the nourishment sand that was placed there or that it is capable of retaining more of the sand in the littoral drift (north to south) than the other two locations.

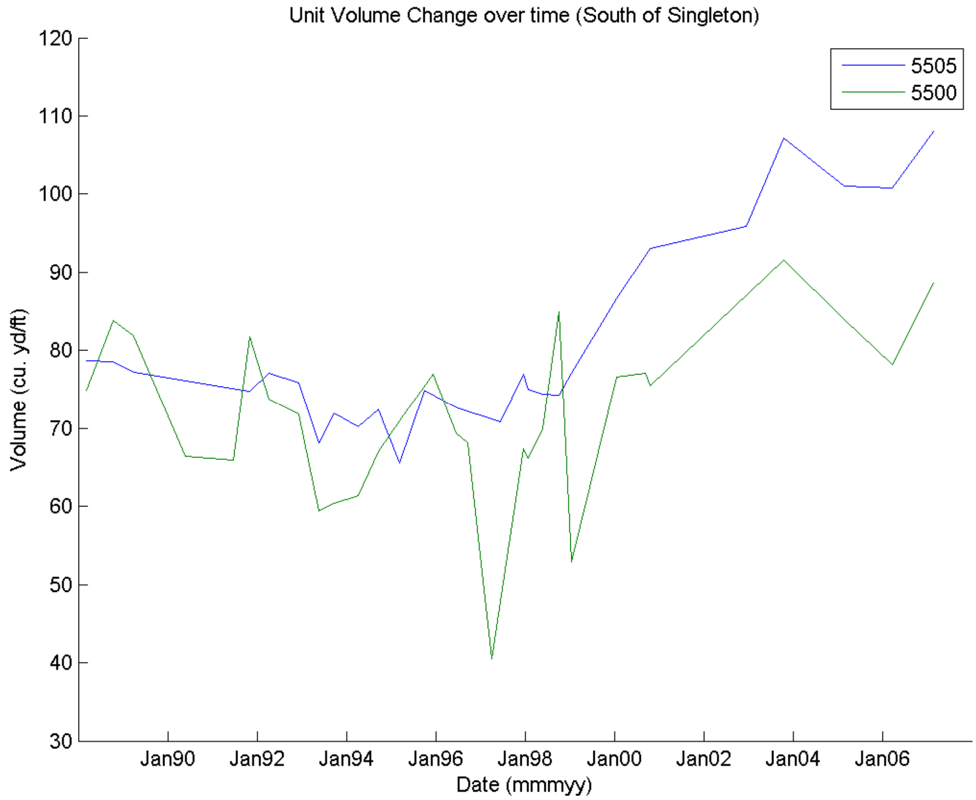

Figure 2-2: Unit Volume Change (cu.yd/ft) over time at OCRM Monuments South of Singleton Swash.

Figure 2-2 shows the time series of changes in beach profile unit volume for the benchmarks south of Singleton Swash. Benchmark 5505 is the closest downdrift (south) of Singleton Swash, while benchmark 5500 is farther south. Unlike 5500, whose unit volume fluctuates considerably from 1988 until 2000, the unit volume of 5505 is relatively stable, between 65 and 77 cubic yards per linear foot, throughout the 1990s. Between January 1999 and January 2000, benchmark 5505 begins a clear trend of increasing unit volumes relative to historic levels. There is little doubt that this increase is due to the beach nourishment project at Arcadian Shores that was completed in June 1999. Benchmark 5505 added more than 30 cubic yards per linear foot since the beach nourishment project. It is unclear whether the increase in unit volume at 5500 between January 1999 and January 2000 is continued periodicity or a response that can be directly attributed to the beach nourishment. If the influence of the beach nourishment project at 5500 began immediately afterwards, then 5500 has also added more than 30 cubic yards per linear foot, otherwise, the contribution of the beach nourishment project to the volumetric gains at 5500 are approximately 15 cubic yards per linear foot.

White Point Swash Profile Analysis

As can be seen in Figure 1-3 above, the OCRM benchmarks used in this analysis from north to south are 5700, 5650, 5590, and 5580, with 5650 immediately north of the swash and 5590 immediately south. Figure 2-3 shows the time series of changes in beach profile unit volume for the benchmarks north of White Point Swash. The beach nourishment project for North Myrtle Beach (Reach 1 of the Myrtle Beach Shore Protection Project) was completed in May of 1997. The change in the unit volumes between September 1996 and mid-1997 clearly shows the addition of sand via beach nourishment.

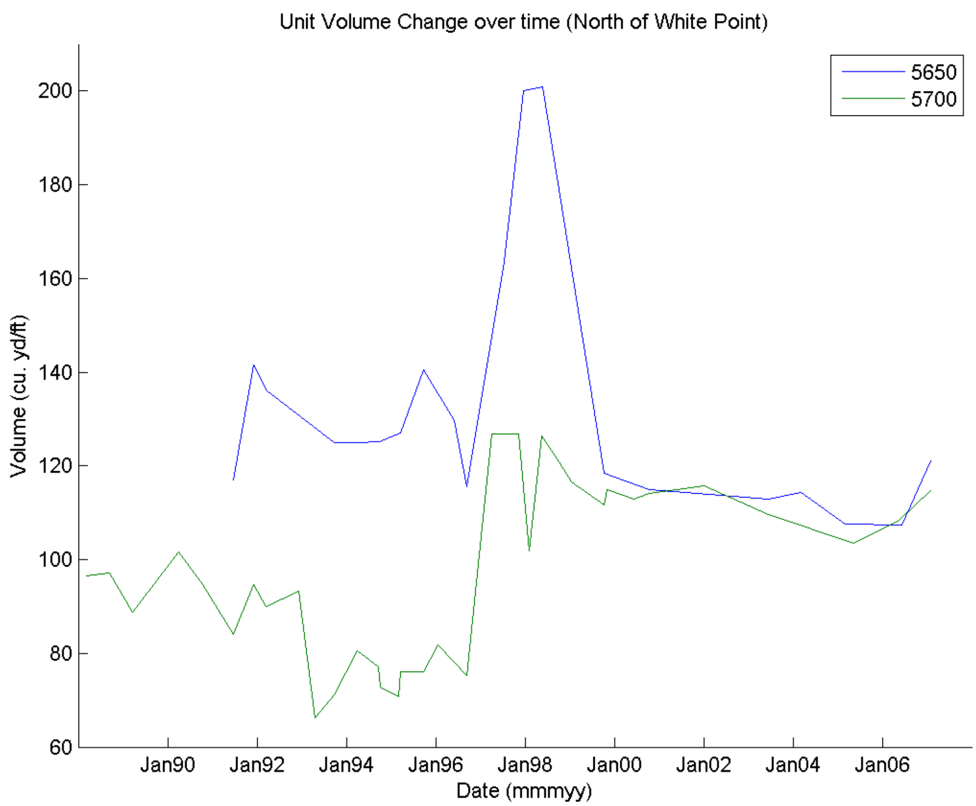

Figure 2-3: Unit Volume Change (cu.yd/ft) over time at OCRM Monuments North of White Point Swash.

Benchmark 5700 is located within the area nourished by the Federal project, while 5650 is located just outside of the tapered end of the beach nourishment. The green line in Figure 2-3 indicates that the unit volume at 5700 experienced a large increase due to the nourishment, immediately followed by a period of relatively constant unit volume, and then settling into a trend of slight loss of volume (erosion). This analysis cannot explain the loss and recovery in 1998 with absolute certainty, it could be a seasonal, cross-shore movement of sand as a result of a winter storm, or it could be an unknown vertical datum difference between datasets.

The large decrease in unit volume at benchmark 5650 from May 1998 to October 1999 does not represent an actual unit volume change due to coastal processes. Unfortunately, the beach profiles from 1989 until May 1998 seem to have been collected at a different landward starting point than the profiles from October 1999 until February 2007. Because a uniform horizontal alignment adjustment could not be found for all of the historic profiles at 5650, the unit volumes were computed over the two distinct time periods. The large decrease is the result of this fragmented approach. It is clear from the blue line in Figure 2-3 that there is a trend of slight volume loss (erosion) from October 1999 until June 2006.

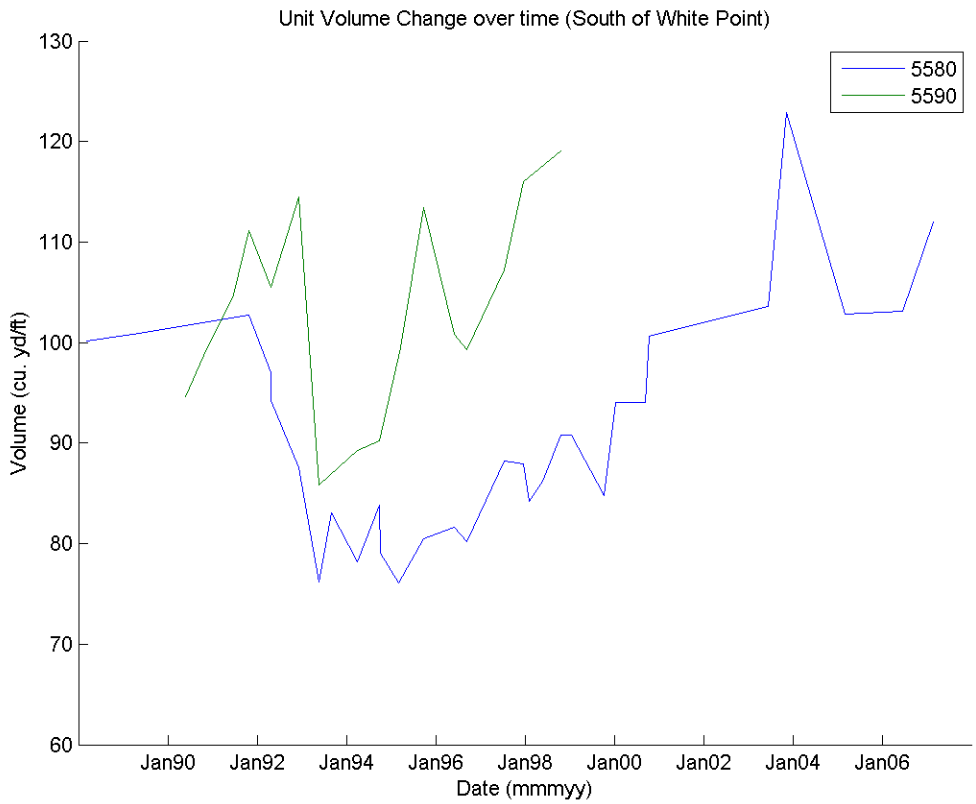

Figure 2-4: Unit Volume Change (cu.yd/ft) over time at OCRM Monuments South of White Point Swash.

Figure 2-4 shows the time series of changes in beach profile unit volume for the benchmarks south of White Point Swash. Benchmark 5590 is the closest downdrift (south) of White Point Swash, while benchmark 5580 is farther south. Regrettably, beach profile data was only available at benchmark 5590 until October 1998. Therefore, there were only three beach profiles taken at 5590 after the North Myrtle Beach nourishment project, July 1997, December 1997, and October 1998. During this time period, there is a clear trend of increasing beach profile unit volumes. It is likely that this trend can be attributed to the nourishment project, but due to the short period of record and the variability in the unit volumes prior to the nourishment, there is larger uncertainty in this conclusion than for the other profiles in this analysis.

Prior to the 1997 nourishment project at North Myrtle Beach, benchmark 5580 experienced steady erosion from 1991 until 1993 and fluctuations in unit volume that resulted in an average unit volume of approximately 80 cubic yards per linear foot until October 1996. Since the nourishment project, the beach at 5580 has experienced relatively steady volume gains (accretion). The exceptions are the winter of 1997, summer of 1999 (Hurricanes Dennis, Floyd, and Irene), and between 2003 and 2005 (Hurricanes Isabel, Alex, Charlie, and Gaston). Since benchmark 5580 is outside the limits of both the North Myrtle Beach and Arcadian Shores nourishment projects, and the long-term trend in this area is one of mild erosion, it is reasonable to conclude that fill material (sand) from the North Myrtle Beach nourishment project is being transported around White Point Swash to the south and is responsible for adding at least 20 cubic yards per linear foot to the profile volume.

Beach Profile Analysis Summary

The beach profile data and the unit volume changes calculated from the profile data clearly show the influence of the 1999 Arcadian Shores beach nourishment on the beaches both north and south of Singleton Swash. The sand added to the littoral system north of the Swash is being transported south, through and around the Swash. Singleton Swash is not acting as a barrier to longshore sediment transport. Similarly, the unit volume changes both north and south of White Point Swash also demonstrate the influence of the 1997 North Myrtle Beach nourishment project. With an analysis of this type, it is difficult to quantify the amount of sand added by the nourishments to the beaches downdrift of the swashes with absolute certainty. However, this analysis has shown that there are definite similarities in how the adjacent nourishment projects have affected the beaches on either side of both swashes. For comparison purposes and assuming no coastal processes other than longshore transport directed from the nourishment areas to the south, the magnitude of sediment volume added to the profiles immediately north and south of both swashes was very similar.

More specifically, OCRM 5510 (immediately north of Singleton) had gained and maintained approximately 45 cu.yd/ft in the two years following the Arcadian Shores nourishment, while OCRM 5650 (immediately north of White Point) had gained and appeared to be maintaining approximately 37 cu.yd/ft in the two years following the nourishment of Reach 1 of Myrtle Beach. In addition, OCRM 5505 (immediately south of Singleton) had gained approximately 16 cu.yd/ft in the two years following the Arcadian Shores nourishment, while OCRM 5590 had gained approximately 20 cu.yd/ft in the two years following the nourishment of Reach 1 of Myrtle Beach. OCRM 5505 continued to add volume almost 5 years subsequent to the completion of the Arcadian Shores nourishment. Unfortunately, the data record for OCRM 5590 ended in late 1998.

Despite the fact that Singleton Swash is 490 feet south of the Arcadian Shores full nourishment template and White Point Swash is 1740 feet south of the Reach 1 full nourishment template, the time scale and magnitude of sediment transport to, through, and around the swashes suggest that the influence of the 1990s beach nourishment projects on the swashes are relatively equal.

3. LIDAR Contour Analysis

This analysis makes use of multiple sets of Airborne Topographic Mapper LIDAR data, collected in partnership with the National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center, the NASA Wallops Flight Facility, the U. S.

Geological Survey (USGS) Center for Coastal and Regional Marine Geology, and the NOAA Aircraft Operations Center.

The LIDAR datasets from this source were provided in the Universal Transverse Mercator (UTM) horizontal coordinate system, horizontal datum of North American Datum of 1983 (NAD83), and vertical datum of North American Vertical Datum of 1988 (NAVD88).

The LIDAR available for and used in this analysis were collected on:

- October 15-16, 1996;
- September 20 - October 2, 1997;
- September 2-6, 1998;
- September 18 - October 10, 1999;
- August 5-7, 2000; and
- December 11, 2005 – January 13, 2006.

The availability of multiple LIDAR datasets allows for both a qualitative and quantitative analysis of changes to both swash channels, their surrounding banks, and the surrounding shorelines. The LIDAR analysis for White Point and Singleton swashes was accomplished entirely within the Geographic Information System (GIS) software package by ESRI, named ArcMAP.

Singleton Swash LIDAR Analysis

The LIDAR datasets listed above were available as XYZ point data on a grid layout having 5-meter grid spacing. Figure 3-1 shows the 2005-2006 LIDAR XYZ data plotted on top of a 2006 aerial photograph of Singleton Swash.

Figure 3-1: Data points from 2005-2006 LIDAR at Singleton Swash.

While data in this format is useful and informative, it becomes much more valuable for comparisons and analyses once it has been added to a GIS and used to generate a 3-dimensional (3D) surface. Not only does the 3D surface aid in visualization of the XYZ data, but it provides multiple opportunities for analyzing the topographic and bathymetric data.

Figure 3-2 provides an example of what the XYZ point data looks like once it has been imported into a GIS and transformed into a 3D surface. All of the LIDAR data in this study was transformed into a Triangulated Irregular Network (TIN). TINs represent a surface through a set of nodes (XY coordinates) that store elevation data (Z), connected by edges to from contiguous, non-overlapping triangular facets. TINs are typically used for high-precision modeling of specific areas, such as engineering applications, where they are useful because they allow calculations of area and volume.

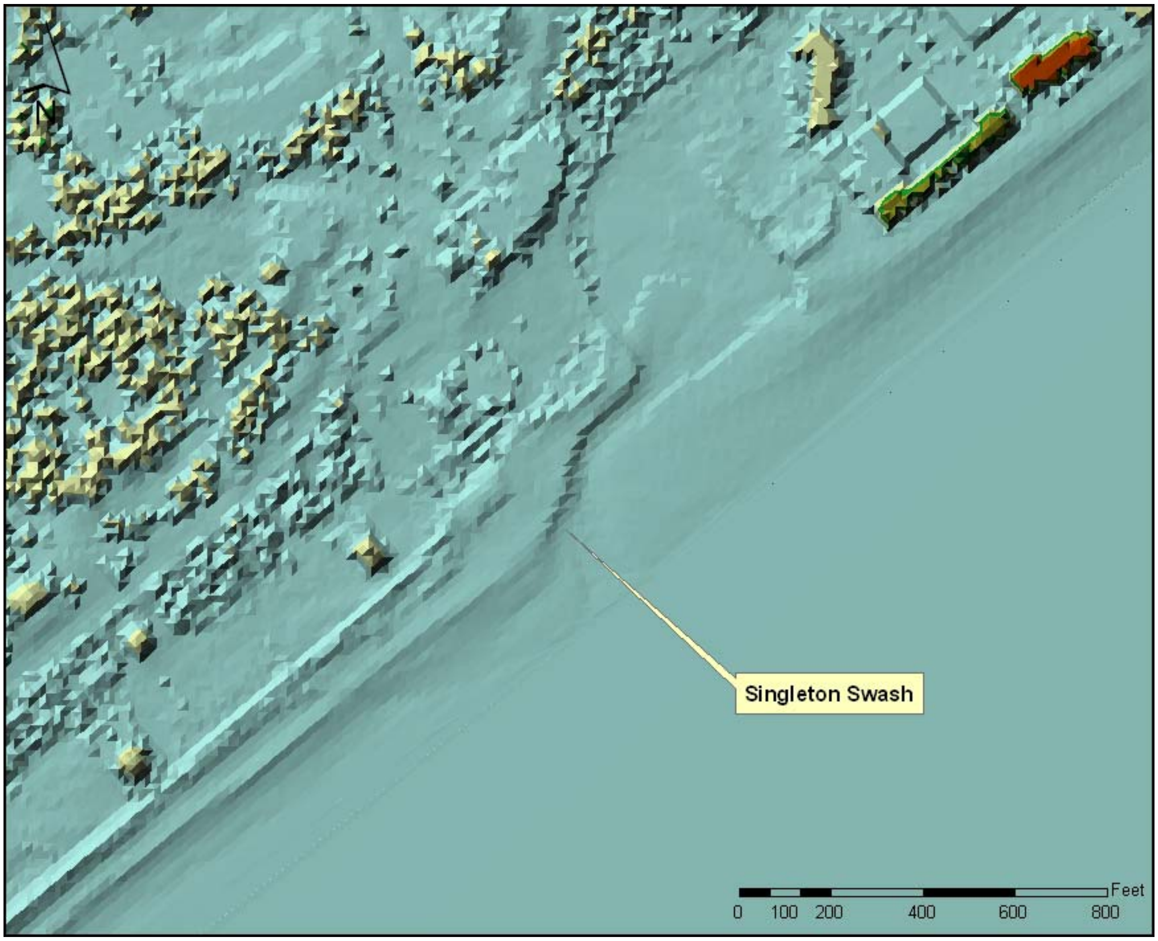

Figure 3-2: Triangulated Irregular Network (TIN) of 2005-2006 LIDAR data at Singleton Swash.

This analysis used TINs as an intermediate step in order to generate elevation contour data for Singleton and White Point swashes and their surrounding shorelines. The GIS was also used to generate the contour data from the TIN surface. Because of the flexibility and computational power of the GIS, contours were generated at elevation intervals deemed most useful for this analysis. In this case, elevation contours were generated by the GIS every 0.125 meters.

The benchmark information for Springmaid Pier in Figure 8-45 confirms that a constant elevation contour interval of 0.125 meters provides the best approximation of the mean high water (MHW) contour and reasonable approximations of the mean tide level (MTL) and mean higher high water (MHHW) contours. Figure 3-3 shows the elevation contours generated from the TIN for the area surrounding Singleton Swash. This analysis focuses on the +0.625 meter and -0.125 meter contours because they approximate the MHW and MTL tidal datums respectively. The -0.125 meter elevation contour is also the lowest elevation contour common to most of the LIDAR datasets.

After the contours were generated, it was necessary to devise a means of comparing the contours from different LIDAR datasets. Since this study focuses on the swash channel, four (4) points were visually established along the approximate centerline of the

Singleton Swash channel as it existed in the 1999 aerial photos, which were taken in mid-February of 1999. According to the timeline in Figure 1-4, this was prior to the completion of the beach nourishment project, Hurricanes Dennis, Floyd and Irene, and the October 1999 relocation of the swash channel. Therefore, the centerline of the channel in the 1999 aerial should represent a relatively "natural" channel condition and serve as a good benchmark for measuring changes in the channel configurations as presented by the LIDAR contours.

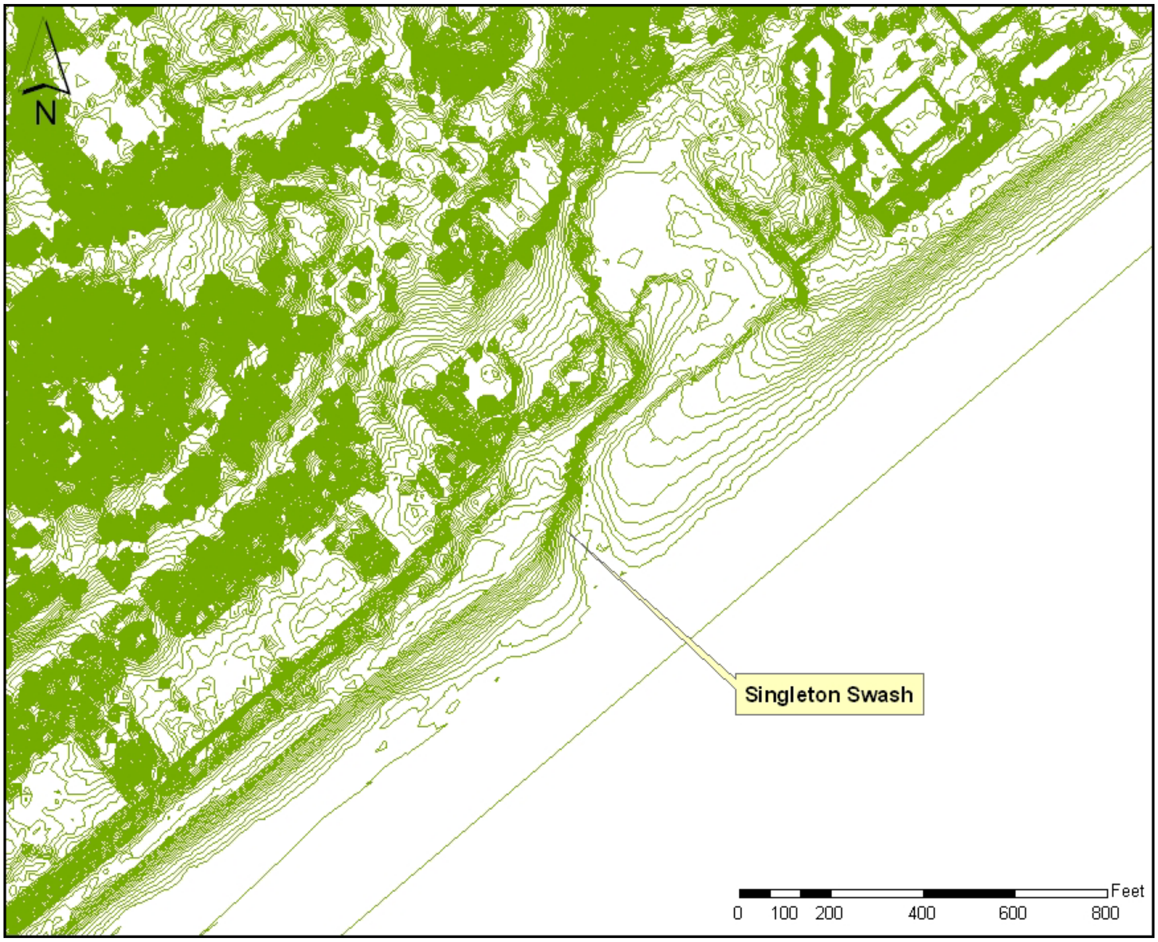

Figure 3-3: Contour map constructed from 2005-2006 LIDAR TIN at Singleton Swash.

In addition to the four (4) centerline points, which are labeled A through D in Figure 3-4, four (4) channel-perpendicular section lines were established with their midpoint located at the centerline points. The section lines are labeled A-A through D-D.

Positions of the swash channel relative to the 1999 centerline were recorded by measuring the distances from the centerline points to the MHW and MTL contours on either side. All measurements began at the centerline point and terminated at the intersection of the section line with the LIDAR contours representing MHW and MTL. The measurements were recorded as distances to the right and left banks, with right and left being defined from the perspective of someone standing in the Atlantic Ocean looking towards land. All distances to the left of the centerline point were recorded as a positive value and all distances to the right of the centerline point were recorded as a negative value. Therefore, if the distance to right bank is listed as positive, it is immediately known that the right bank of the swash channel has moved to the left of the original centerline from the 1999 aerial photo. Figure 3-4 provides an example of the comparison of the +0.625 meter contours between the LIDAR datasets from the years 2000 and 2005 for Singleton Swash. The LIDAR contours, centerline points, and sections are displayed on top of the 2006 aerial photograph.

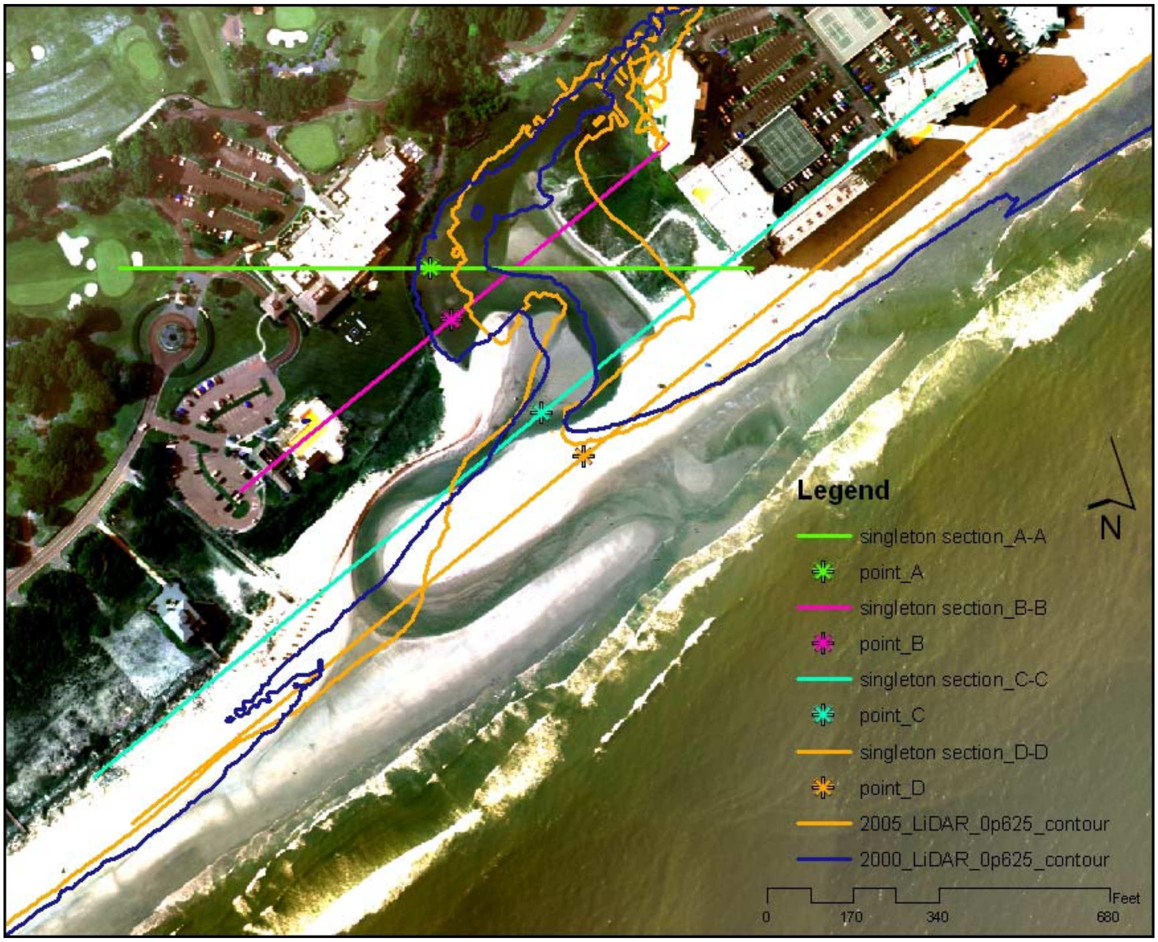

Figure 3-4: +0.625 meter LIDAR elevation contour comparison for 2000 and 2005 at Singleton Swash.

In Figure 3-4 above, the right bank of the +0.625 meter contour for the 2000 LIDAR dataset is 33.9 meters (111.2 feet) to the right of centerline point D and the 2005 LIDAR dataset is 18.6 meters (61.0 feet) to the right. This means the right bank of the swash channel along Section D-D has moved 15.3 meters (50.2 feet) to the left, with left being the direction of net longshore sediment transport.

Figures 6-1 through 6-5, in Appendix A, provide visual comparisons for the +0.625 meter (MHW) LIDAR contour for 1996 through 2005, while Figures 6-6 through 6-9 provide the visual comparisons for the -0.125 meter (MTL) LIDAR contour for 1997 through 2005.

Numerical comparisons for the changes to the +0.625 meter (MHW) and -0.125 meter (MTL) LIDAR elevation contours are provided by Tables 3-1 and 3-2 respectively. Tables 3-1 and 3-2 provide summaries of all the measurements of the left and right swash channel banks from the centerline points (A through D). The top half of the tables list the distances to the banks from the centerline points according to the year of the LIDAR dataset. The bottom half of the tables show cumulative differences in the positions of the swash channel banks from the centerline points according to the year of the LIDAR dataset. Unfortunately, the lack of +0.625 meter contours at Sections A-A and B-B in the 1996 and 1999 datasets and lack of -0.125 meter contours at Sections A-A through C-C in the 1996, 1999, 2000, and 2005 datasets resulted in no measurements and therefore no differences and an inability to determine accurate cumulative differences. The lack of contour data is a legacy of the lack of XYZ point data from the LIDAR datasets and could be attributed to the turbidity of the water or the quality and sophistication of the LIDAR instrumentation.

With the exception of Section D-D in 1997, Sections C-C and D-D, located in the swash channel mouth, had complete +0.625 meter contour coverage. Likewise, Section D-D only lacked coverage of the -0.125 meter contour in 1996.

From 1996-1997, both the banks defined by the +0.625 meter contour along Section C-C moved farther away from the centerline point, with the right bank moving 50.2 meters (164.7 feet) and the left bank moving 15.6 meters (51.2 feet). According to the timeline in Figure 1-4, there were two (2) hurricanes (Bertha and Fran) and two (2) tropical storms to impact the study area between the collection of the 1996 and 1997 LIDAR datasets. It is reasonable to attribute this widening of the swash channel mouth to the elevated water surface elevations, waves, etc that accompanied the four (4) storms in 1996.

Except for the 1999 conditions, when the right bank moved slightly left of centerline point C, the general trend for the right bank along Section C-C has been for movement to the right, as evidenced by the cumulative movement of 127.9 meters (419.6 feet) to the right as of the 2005 LIDAR dataset. Meanwhile, the left bank along Section C-C has experienced a general shift to the left, but with large magnitude shifts to the left and right during the time period from 1996 to 2005. From 1998 to 1999, the left bank moved 167.5 meters (549.5 feet) to the left, while from 1999 to 2000, the left bank moved 162.3 meters (532.5 feet) back to the right. It is likely that the movement to the left from 1998 to 1999 is a direct result of the Arcadian Shore beach nourishment project, which was completed in June 1999, and the movement back to the right from 1999 to 2000 is a direct result of the mechanical relocation of the channel in October 1999.

While the cumulative movement of both banks along Section D-D was to the right, the intermediate changes to the positions of the banks were characterized by relatively large magnitude movements to the right and left. For example, the right bank along Section D-D moved 149.0 meters (488.8 feet) to the right between 1996 and 1997 and 159.6 meters (523.6 feet) to the right between 1999 and 2000. These movements are likely due to the storms in 1996 and the mechanical channel relocation in October 1999.

Like the right bank, the left bank along Section D-D moved 331.6 meters (1087.9 feet) to the right between 1999 and 2000 and was certainly due to the mechanical channel relocation in October 1999. The left bank also moved to the right by 80.1 meters (262.8 feet) between 2000 and 2005. The movement of the left bank to the right during this time period is most likely a result of the seven (7) mechanical channel relocations during the period from 2000 to 2005, with the last one in May of 2005.

As can be seen from Figures 6-6 through 6-9 in Appendix A and in Table 3-2 above, there is little available data with which to analyze the movements of the -0.125 meter (MTL) LIDAR elevation contour through time. The swash channel banks along Section D-D are the only ones with more than two sets of measurements. After very slight movements between 1997 and 1998, both the right and left banks move large distances to the left, 197.8 meters (648.9 feet) and 207.8 meters (681.8 feet) respectively, between 1998 and 1999. The time period between the 1998 and 1999 LIDAR datasets includes the completion of the Arcadian Shores nourishment project in June and Hurricanes Dennis and Floyd in September of 1999.

Between 1999 and 2000, both banks along Section D-D moved back to the right. The right bank moved 137.6 meters (451.4 feet) and the left bank moved 136.0 meters (446.2 feet). This movement back to the right is due to the mechanical channel relocation in July 2000. Between 2000 and 2005, both banks defined by the -0.125 meter (MTL) LIDAR elevation contour remain somewhat constant in their position. This is most likely a result of the seven (7) mechanical channel relocations during the period from 2000 to 2005. Figure 3-4 provides visual evidence of the relatively small movements between 2000 and 2005.

Table 3-1: Summary of measured changes to +0.625 meter LIDAR elevation contour at Singleton Swash.

0.625 meter contour	Section A-A		Section B-B		Section C-C		Section D-D	
LIDAR Date	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)
1996	n/a	n/a	n/a	n/a	14.4	28.4	-5.8	158.0
1997	-4.7	9.0	2.1	16.4	-35.8	44.0	-154.8	n/a
1998	-11.0	9.5	-1.2	16.4	-2.3	35.0	-109.4	251.4
1999	n/a	n/a	n/a	n/a	1.6	202.5	125.7	536.6
2000	-34.1	8.7	-44.3	16.1	-41.9	40.2	-33.9	205.0
2005	-141.1	-15.5	-114.5	-11.9	-113.5	69.5	-18.6	124.9

	Section A-A		Section B-B		Section C-C		Section D-D	
LIDAR Date	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Left bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Left bank (m)
1996								
1997					-50.2	15.6	-149	
1998	-6.3	0.5	-3.3	0.0	-16.7	6.6	-103.6	
1999					-12.8	174.1	131.5	285.2
2000					-56.3	11.8	-28.1	-46.4
2005					-127.9	41.1	-12.8	-126.5

n/a = no data available

Table 3-2: Summary of measured changes to -0.125 meter LIDAR elevation contour at Singleton Swash.

-0.125 meter contour	Section A-A		Section B-B		Section C-C		Section D-D	
LIDAR Date	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)
1996	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1997	2.9	7.8	5.3	13.9	4.0	19.2	3.9	32.7
1998	5.9	8.2	5.6	13.4	6.7	21.5	6.5	28.6
1999	n/a	n/a	n/a	n/a	n/a	n/a	204.3	236.4
2000	n/a	n/a	n/a	n/a	n/a	n/a	66.7	100.4
2005	n/a	n/a	n/a	n/a	n/a	n/a	84.8	105.2

	Section A-A		Section B-B		Section C-C		Section D-D	
LIDAR Date	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Left bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Left bank (m)
1996								
1997								
1998	3.0	0.4	0.3	-0.5	2.7	2.3	2.6	-4.1
1999							200.4	203.7
2000							62.8	67.7
2005							80.9	72.5

n/a = no data available

White Point Swash LIDAR Analysis

The beach nourishment project at North Myrtle Beach was completed by May 1997. This means that the 1996 LIDAR dataset represents a pre-nourishment condition for White Point Swash and the 1997-2005 LIDAR datasets represent a post-nourishment condition.

The LIDAR contour analysis for White Point Swash followed the same procedure and data analysis as Singleton Swash. Available LIDAR XYZ point data from the same time periods as the Singleton analysis were transformed into a 3D surface (TIN) and then used to generate elevation contour data. The difference between the two analyses was that only two (2) centerline points were established within the White Point Swash channel. The reduction in the number of centerline points was appropriate because the northern bank of the interior swash channel is stabilized by a wooden bulkhead.

Figure 3-5 provides an example of the comparison of the +0.625 meter contours between the LIDAR datasets from the years 2000 and 2005 for White Point Swash. The LIDAR contours, centerline points, and sections are displayed on top of the 2006 aerial photograph. Figures 6-10 through 6-14, in Appendix A, provide visual comparisons for the +0.625 meter (MHW) LIDAR contour for 1996 through 2005, while Figures 6-15 through 6-18 provide the visual comparisons for the -0.125 meter (MTL) LIDAR contour for 1997 through 2005.

Numerical comparisons for the changes to the +0.625 meter (MHW) and -0.125 meter (MTL) LIDAR elevation contours are provided by Tables 3-3 and 3-4 respectively. Tables 3-3 and 3-4 provide summaries of all the measurements of the left and right swash channel banks from the centerline points (A and B). The measurements were recorded as distances to the right and left banks, with right and left being defined from the perspective of someone looking towards land. The top half of the tables list the distances to the banks from the centerline points according to the year of the LIDAR dataset. The bottom half of the tables show cumulative differences in the positions of the swash channel banks from the centerline points according to the year of the LIDAR dataset. Unfortunately, the lack of +0.625 (MHW) meter contours at Section A-A in the 1996 dataset and lack of -0.125 (MTL) meter contours at Section A-A in the 1996, 1999, and 2005 datasets resulted in no measurements and therefore no differences and an inability to determine accurate cumulative differences.

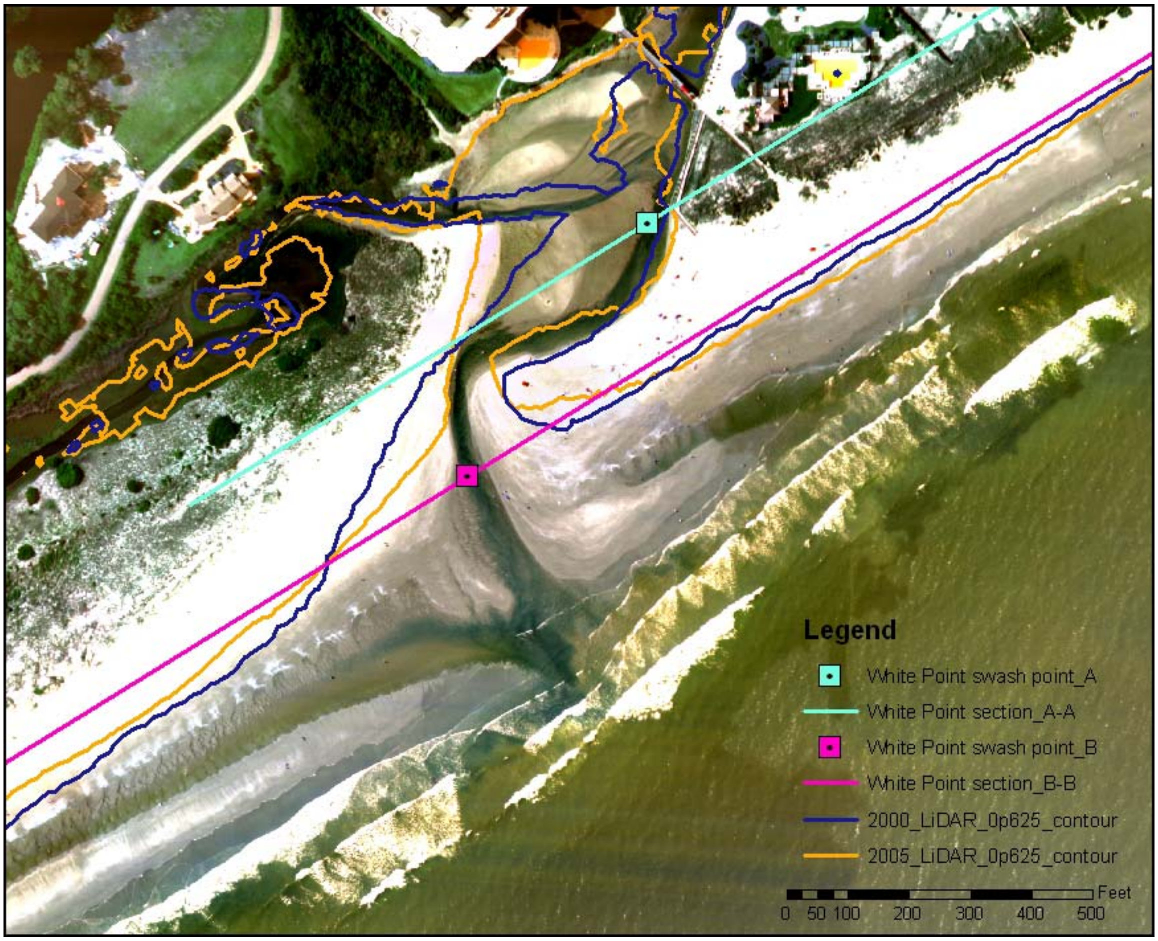

Figure 3-5: +0.625 meter LIDAR elevation contour comparison for 2000 and 2005 at White Point Swash.

With the exception of the period from 1996 to 1997, the position of the right bank of the +0.625 meter (MHW) contour along Section B-B is relatively stable. From 1996 to 1997, the right bank moved 198.6 meters (651.6 feet) to the left, but after that it oscillated to the right and left by only approximately 20 meters (65 feet). The large move to the left is most likely due to the jagged nature of the +0.625 meter contour in the 1996 data (see Figure 6-10) and not due to a physical or environmental stimulus.

The left bank of the +0.625 meter contour along Section B-B has experienced slightly more variability. The left bank made moves to the left of 98.7 meters (323.8 feet), 94.0 meters (308.4 feet), and 3.1 meters (10.2 feet) during 1996-1997, 1998-1999, and 2000-2005 respectively. Conversely, the left bank moved to the right by 54.3 meters (178.1 feet) and 81.5 meters (267.4 feet) during 1997-1998 and 1999-2000 respectively.

Table 3-3: Summary of measured changes to +0.625 meter LIDAR elevation contour at White Point Swash.

0.625 meter contour	Section A-A		Section B-B	
LIDAR Date	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)
1996	n/a	n/a	-253.8	26.1
1997	-1.7	110.9	-55.2	124.8
1998	-7.5	90.7	-34.3	70.5
1999	-10.5	110.6	-61.6	164.5
2000	-10.8	105.0	-47.3	83.0
2005	-12.8	114.2	-78.0	86.1

	Section A-A		Section B-B	
LIDAR Date	Cumulative Difference in Right bank (m)	Cumulative Difference in Left bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Left bank (m)
1996				
1997			198.6	98.7
1998	-5.8	-20.2	219.5	44.4
1999	-8.8	-0.3	192.2	138.4
2000	-9.1	-5.9	206.5	56.9
2005	-11.1	3.3	175.8	60

n/a = no data available

Table 3-4: Summary of measured changes to -0.125 meter LIDAR elevation contour at White Point Swash.

-0.125 meter contour	Section A-A		Section B-B	
LIDAR Date	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)
1996	n/a	n/a	n/a	n/a
1997	11.5	106.8	0	16.0
1998	0	36.7	4.0	18.2
1999	n/a	n/a	-1.2	19.8
2000	-2.1	17.9	-12.1	17.4
2005	n/a	n/a	7.5	13.8

	Section A-A		Section B-B	
LIDAR Date	Cumulative Difference in Right bank (m)	Cumulative Difference in Left bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Left bank (m)
1996				
1997				
1998	-11.5	-70.1	4	2.2
1999			-1.2	3.8
2000			-12.1	1.4
2005			7.5	-2.2

n/a = no data available

The right bank of Section A-A is largely stabilized by the wooden bulkhead just to the northeast of centerline point A. However, the left bank of Section B-B is free to migrate and though not seen in the 2005 cumulative difference in Table 3-3, it does move left and right approximately four (4) times more than the right bank.

Limited information is available for the -0.125 meter (MTL) contour along Section A-A at White Point Swash. The only useful comparison of the position of the banks along Section A-A is between the 1997 and 1998 LIDAR contours. Both channel banks defined by the -0.125 meter contour moved to the right, with the right bank moving 11.5 meters (37.7 feet) and the left bank moving 70.1 meters (230.0 feet) to the right.

Interestingly, there was more movement in the right bank of the -0.125 meter contour along Section B-B than there was in the left bank, which is not near a stabilization structure. The left bank along Section B-B moved a total of 9.8 meters (32.2 feet) and resulted in a net movement to the right of 2.2 meters (7.2 feet). Meanwhile, the right bank along section B-B moved a total of 39.7 meters (130.2 feet) and resulted in a net movement to the left of 7.5 meters (24.6 feet).

LIDAR Analysis Summary

The number of available LIDAR datasets and their temporal distribution was adequate for the analysis being performed. However, having additional datasets between the years 2000 and 2005 would have resulted in a more complete time series of comparisons of the swash channel configurations. In addition, the LIDAR technology is limited in its ability to capture bathymetry in this area of the country due to the amount of suspended sediment in the water. Because of this, several datasets were missing meaningful representations of the mean tide level (MTL) contour. Despite these limitations, this analysis was able to assemble information on how the swashes have changed due to their response to coastal processes and engineering activities over time.

The trend of the outer ocean portion of the Singleton Swash channel appears to suggest a widening of the channel in response to large coastal storms (hurricanes and tropical storms) and a meandering nature under “normal” conditions. It is difficult to discern a signal due to the many mechanical swash relocations. However, it seems clear that the swash channel will trend to the right along Section C-C and to the left along Section D-D, creating a meandering channel with some degree of oxbow formation as seen in the 2006 aerial photograph. Right and left are defined from the perspective of someone looking towards land.

The right bank of the White Point Swash channel is remarkably stable at both Section A-A and Section B-B. The stability at Section A-A is influenced by the bulkhead to the northeast, but Section B-B is within the active surfzone and its stability is somewhat surprising considering the movement of the portion of the Singleton Swash channel within the surfzone. The position of the left bank of the channel at Section B-B is extremely stable for the -0.125 meter contour (MTL), but does experience some variability for the +0.625 meter contour (MHW). Movements of the left bank to the left between 1996-1997 and 1998-1999 could be attributed to the storms between these periods and the movements of the left bank to the right between 1997-1998 and 1999-2000 could be attributed to the lack of storms between these periods.

While Singleton and White Point are similar in many ways, the LIDAR analysis reinforces that the two swashes are dissimilar in their responses to the forces acting upon them. These responses are most striking within the portion of the channel closest to the ocean. The Singleton Swash channel meanders to the degree that it must be mechanically relocated in order to avoid adverse impacts to the environment and structures surrounding it, while the White Point Swash channel experiences limited short-term variability but appears to maintain long-term relative stability.

4. Aerial Photography Analysis

Historical aerial photographs of Horry County, specifically the areas surrounding Singleton and White Point Swash, were available and have been used in this analysis to augment the LIDAR analysis presented in the previous section. Even though the aerial photographs cannot be utilized with the same level of precision as the LIDAR data contours, they are valuable resources for gaining a better qualitative understanding of the movement of the two swash channels being studied.

Five sets of aerial photographs that were spatially referenced or could be spatially referenced were available for this analysis and the aerial flights occurred on:

- March 29, 1983
- February 11, 1989
- January 23, 1994
- February 16, 1999
- June 9, 2006

Future references to the aerial photography collected on these dates will only include the year of the flight.

The analysis of the aerial photographs took place within the same Geographic Information System (GIS) project file as the previous LIDAR analysis. Several of the photographs had to be georeferenced prior to their use. Georeferencing refers to the process of defining how raster (photographic) data is situated in map coordinates, allowing it to be viewed and analyzed with other geographic data.
Once all of the aerial photographs were defined by the correct map coordinates, the investigation began the analysis of defining a common, yet spatially and temporally varying method of comparison between the sets of aerial photos. This is commonly accomplished by identifying and storing the mean high water (MHW) or mean higher high water (MHHW) line on each set of aerial photographs. This common approach was taken with this analysis as well and the resulting line will hereafter be referred to as the MHW line. The process of identifying and storing the MHW line involved a large amount of personal judgment on the part of the investigator in order to determine changes in color that denote the boundary between portions of the beach that get wet with average

tidal fluctuations and those portions of the beach that do not. For this reason, the results of this analysis are purely qualitative and were not intended to supply actual measured changes in swash channel configurations from one time period to the next.

Appendix B contains figures providing the site-specific portions of all the aerial photos overlaid with the identified MHW line for each photo. Figures 7-1 through 7-5, in Appendix B, provide the photos from 1983 through 2006 for Singleton Swash and Figure 4-1 below (and Figure 7-6 in Appendix B) shows all of the MHW lines for Singleton Swash overlaid on the 2006 aerial photo. Figures 7-7 through 7-10, in Appendix B, provide the photos from 1989 through 2006 for White Point Swash and Figure 4-2 below (and Figure 7-11 in Appendix B) shows all of the MHW lines for White Point Swash overlaid on the 2006 aerial photo.

Singleton Swash Aerial Photo Analysis

The MHW lines from 1983 through 1999 in Figure 4-1 below are all prior to the June 1999 nourishment of Arcadian Shores. There are relatively small scale changes in the Singleton Swash channel from 1983 to 1999 and none of the MHW lines indicate any meandering of the channel like is present in the 2006 MHW line. This photographic evidence suggests that prior to the nourishment project at Arcadian Shores, the swash channel was hydraulically efficient and maintaining its position with only minor variations of its position to the north or south. There is no record of any maintenance of the open coast portion of the Singleton Swash channel prior to October 1999, so there is nothing to suggest that the pre-nourishment stability is man-made.

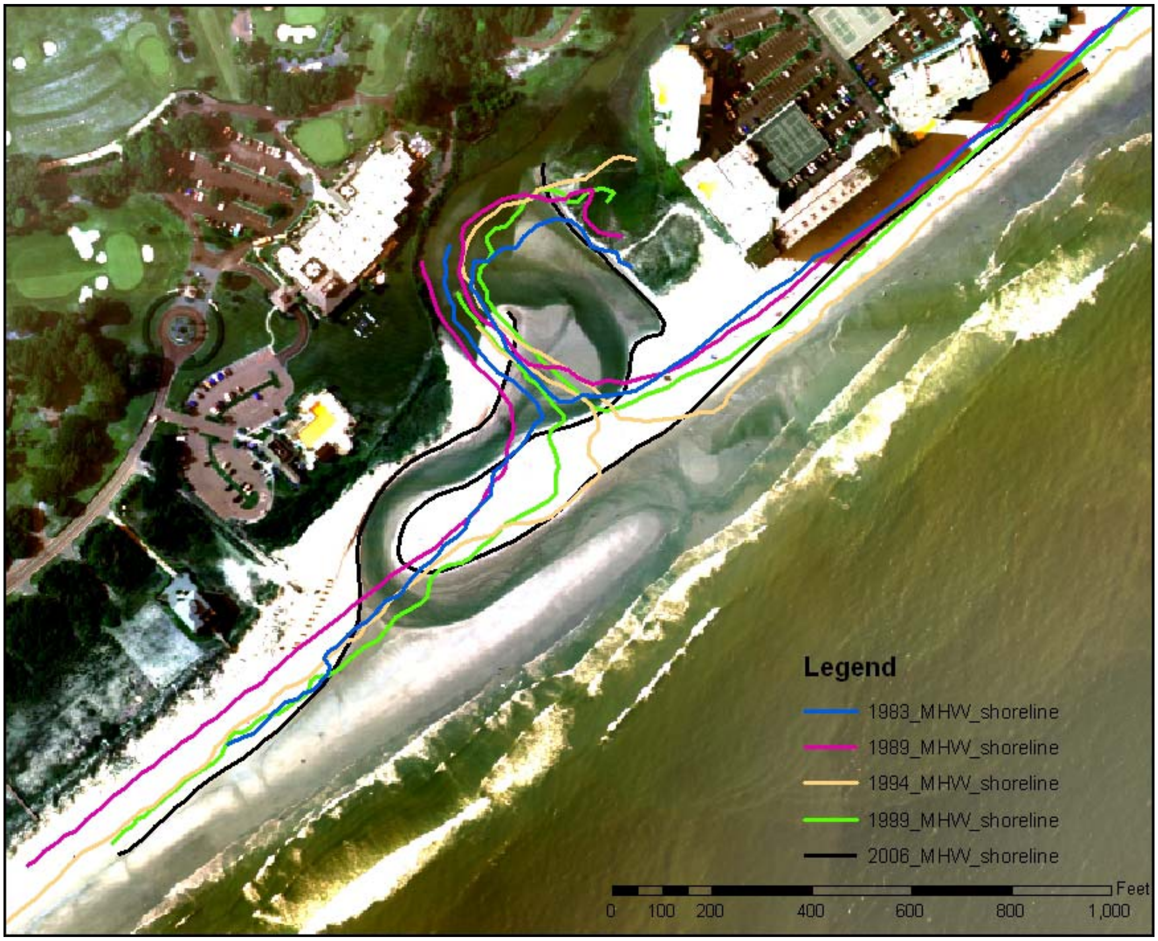

Figure 4-1: Summary of Aerial Photo MHW contours at Singleton Swash (on 2006 aerial).

White Point Swash Aerial Photo Analysis

The 1989 and 1994 MHW lines in Figure 4-2 below are prior to the nourishment project at North Myrtle Beach. From the MHW lines, it appears that the swash channel mouth was slightly wider in 1989 than in 1994 and that the spit on the North Myrtle Beach side grew toward the south and west between 1989 and 1994. Construction of the beach nourishment project for North Myrtle Beach was completed by May 1997, so the 1999 and 2006 MHW lines represent a post-nourishment condition of White Point Swash.

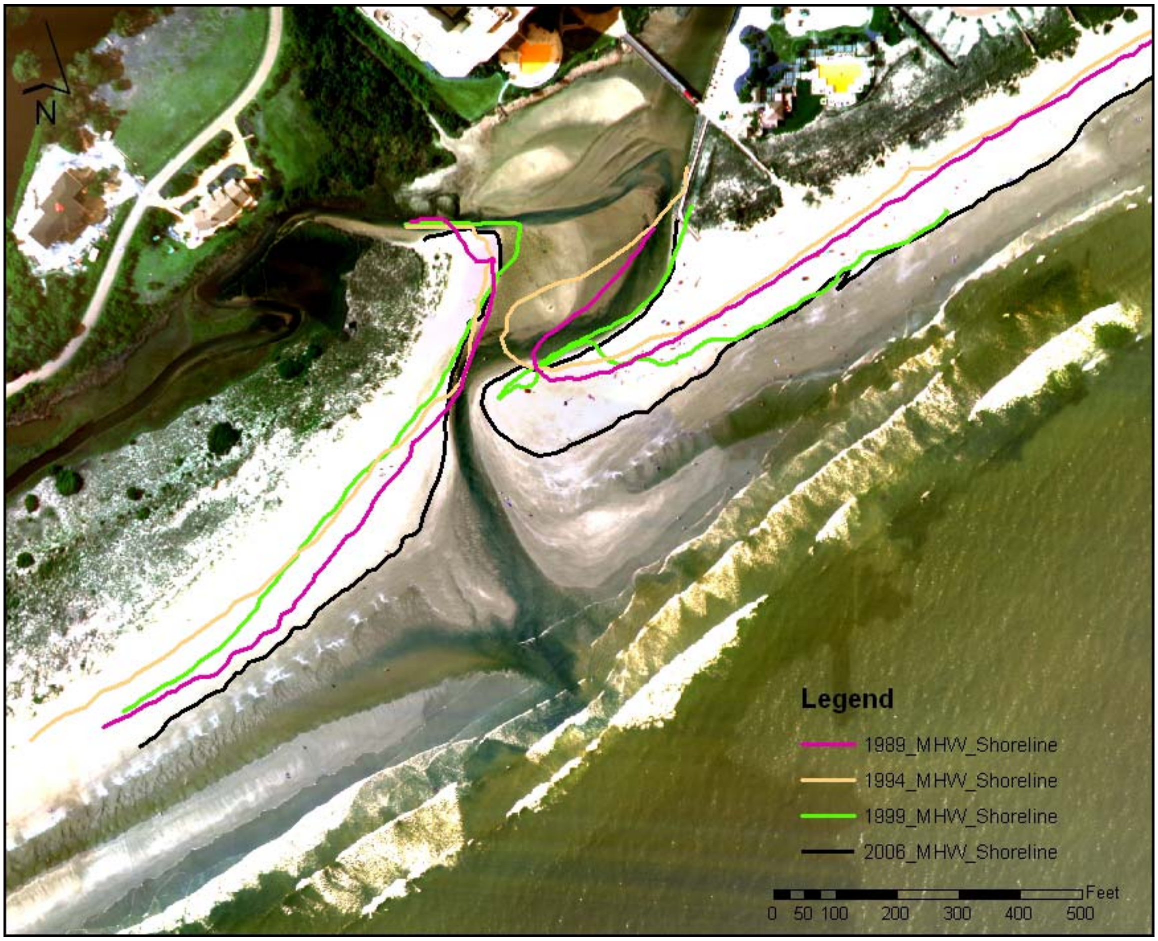

Figure 4-2: Summary of Aerial Photo MHW contours at White Point Swash (on 2006 aerial).

Aerial Photo Analysis Summary

Qualitative evidence from the aerial photographs of Singleton and White Point Swashes supports the assertion that both swash channels were more or less stable prior to each of the beach nourishment projects. The Singleton Swash MHW channel does exhibit minor changes to the channel width and position between 1983 and 1999, but shows none of the tendencies toward major realignment seen in the post-nourishment LIDAR results. The MHW contours at White Point Swash reinforce the findings of the LIDAR analysis by demonstrating relatively minor changes from one period to the next and doing so in a manner that is not consistent enough to have significant cumulative impacts.

5. Conclusions

Singleton and White Point are similar in their size, position, location, and the meteorological forces and coastal processes directed at and around them. The beach profile analysis showed that they are also similar with respect to the volume of sand transported through and around them as a result of beach nourishment projects to their north. Conversely, the aerial photography and LIDAR analyses, showed that the two swashes are dissimilar in their responses to the forces acting upon them. The portion of the Singleton Swash channel closest to the ocean drifts so far to the south and with such regularity that it often requires mechanical relocation in order to avoid adverse impacts to the environment and structures surrounding it. The same portion of the White Point Swash channel experiences limited short-term variability but appears to maintain long-term relative stability. One of the glaring differences between the two swashes is the existence two structures within the interior channel of White Point Swash, a wooden bulkhead along a portion of the northern bank and a small rock structure of indeterminate size and length on the southern bank closer to the ocean. It is probable that White Point Swash owes its stability largely to the wooden bulkhead and a lesser degree to the rock structure. Evidence suggests that the meandering of Singleton Swash will continue to require mechanical relocation unless a structural solution can be found. Given the apparent success of the structures at White Point Swash and the proven similarities of the two swashes, perhaps a similar structural approach would provide stability to Singleton Swash. Additional study of the probable benefits, costs, and impacts will be necessary if a structural solution to the migration of Singleton Swash is going to be strongly considered.

6. APPENDIX A: LIDAR Figures

Singleton Swash LIDAR Contour Comparison Figures

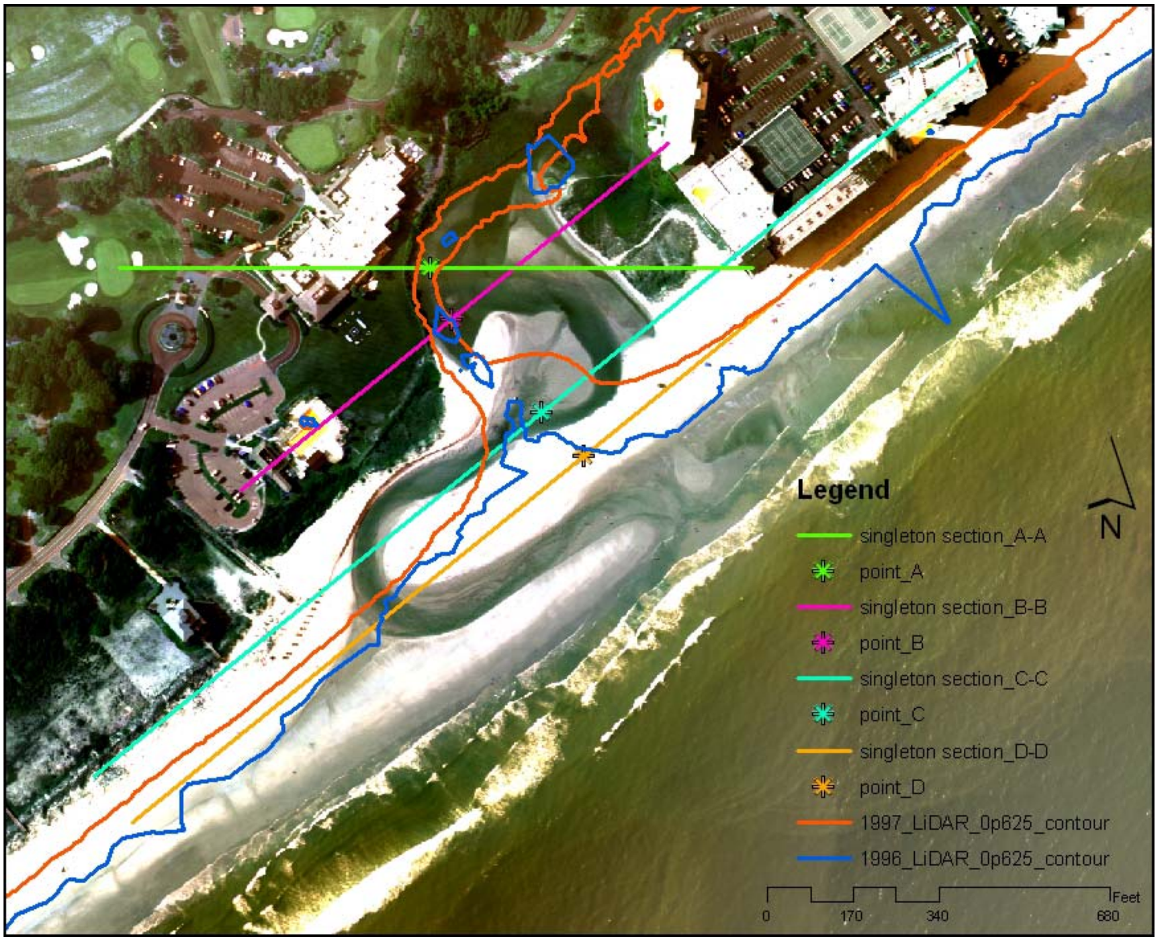

Figure 6-1: +0.625 meter LIDAR elevation contour comparison for 1996 and 1997 at Singleton Swash.

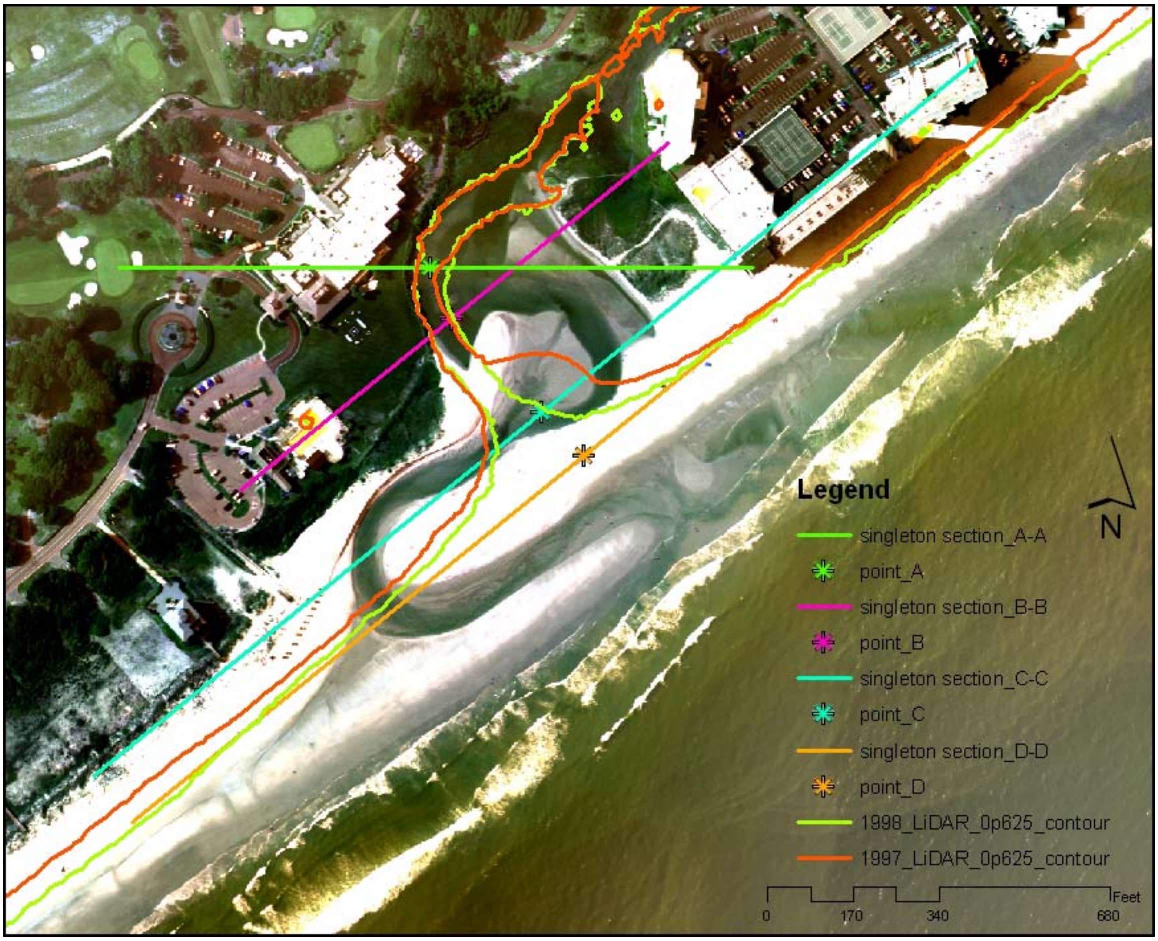

Figure 6-2: +0.625 meter LIDAR elevation contour comparison for 1997 and 1998 at Singleton Swash.

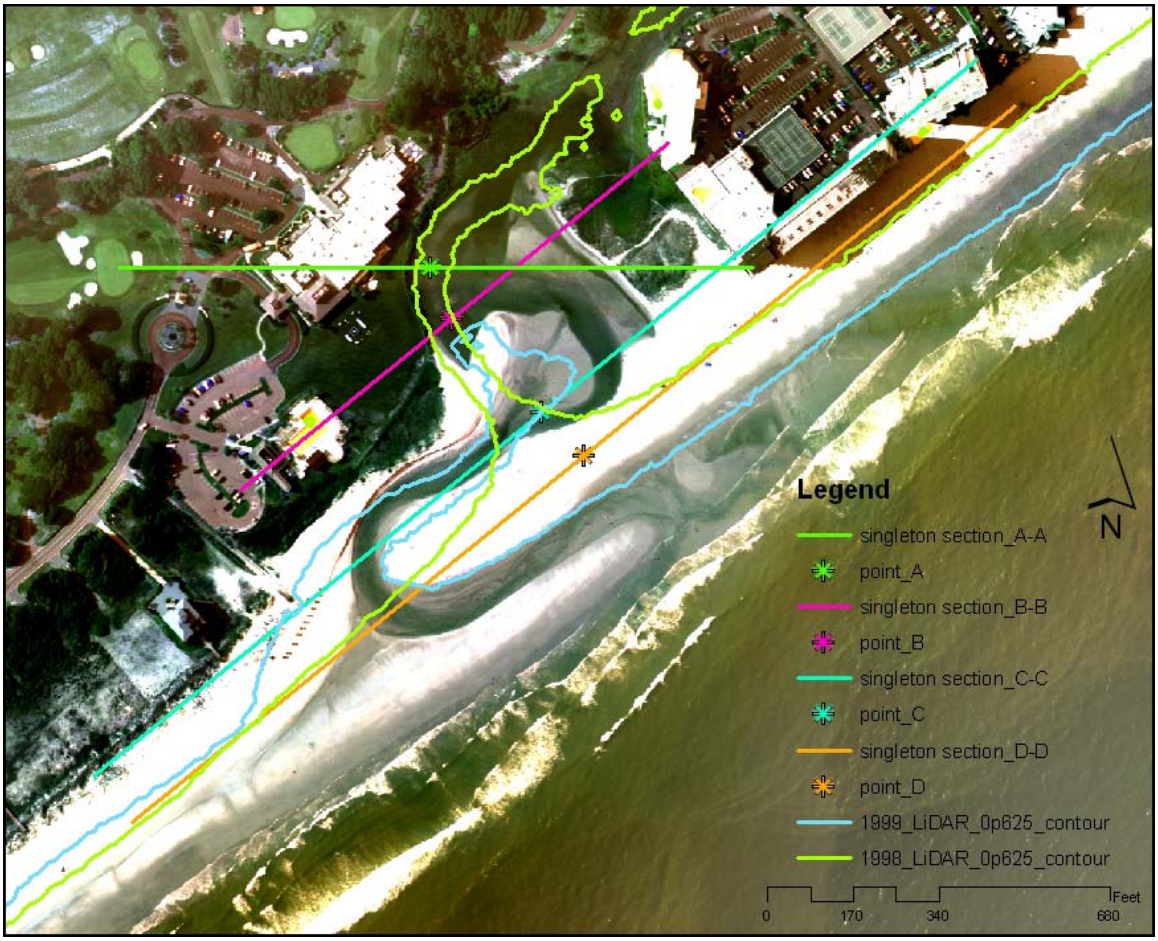

Figure 6-3: +0.625 meter LIDAR elevation contour comparison for 1998 and 1999 at Singleton Swash.

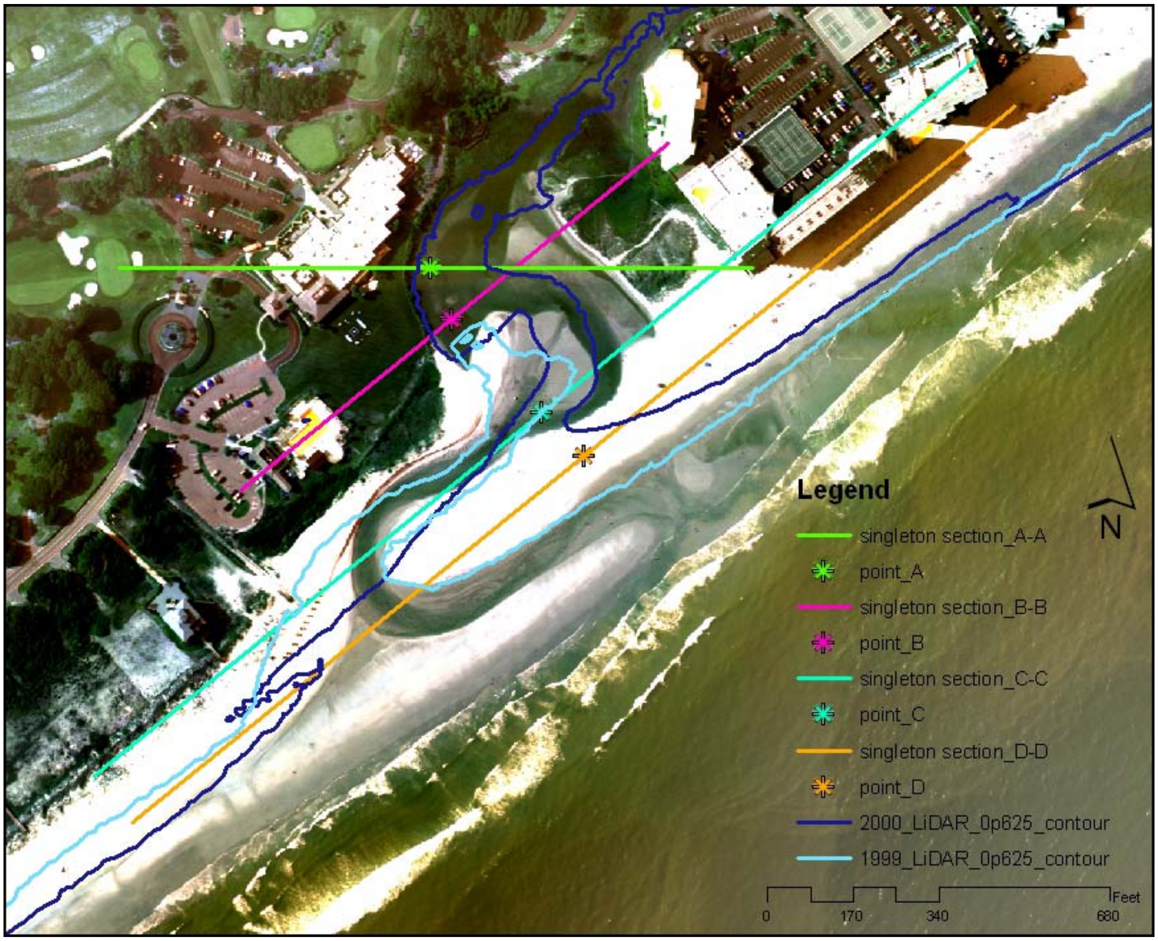

Figure 6-4: +0.625 meter LIDAR elevation contour comparison for 1999 and 2000 at Singleton Swash.

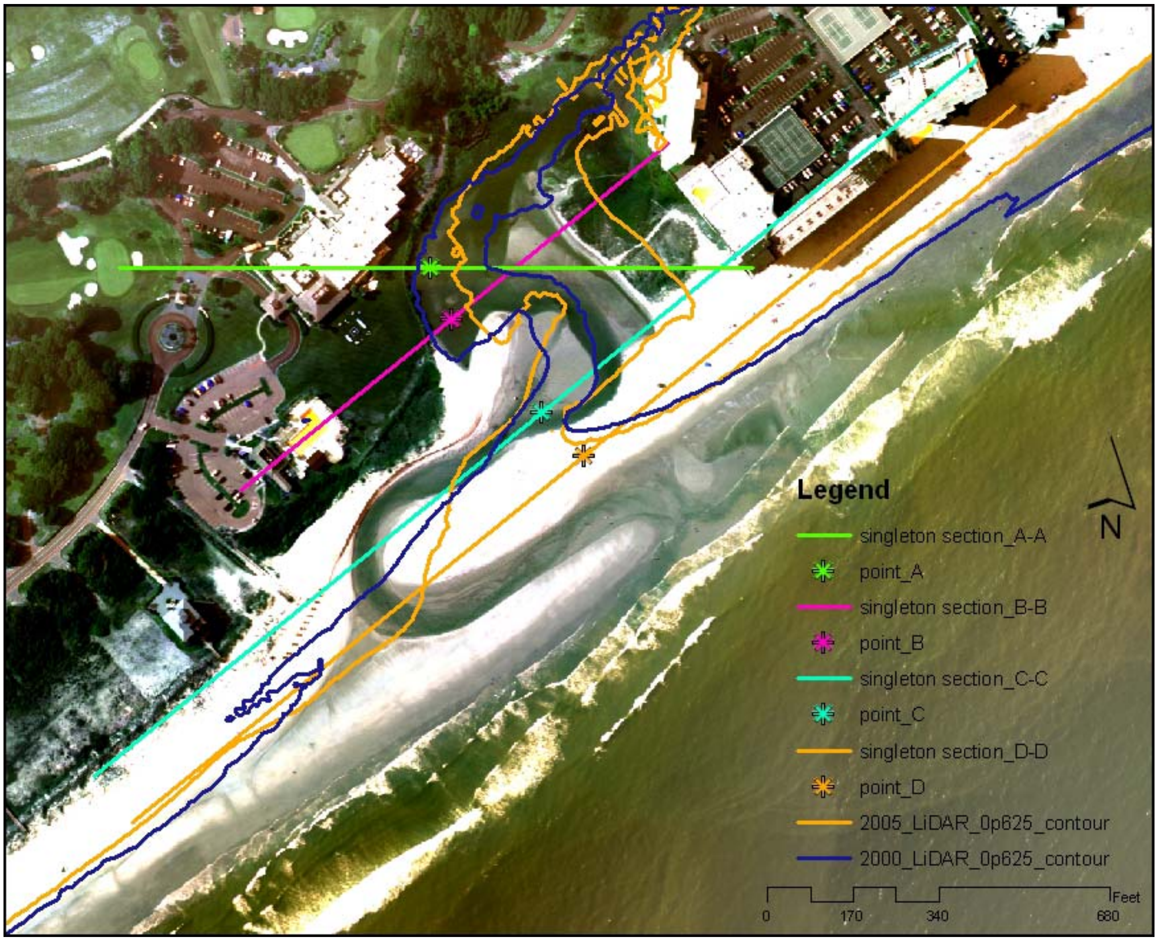

Figure 6-5: +0.625 meter LIDAR elevation contour comparison for 2000 and 2005 at Singleton Swash.

Table 6-1: Summary of measured changes to +0.625 meter LIDAR elevation contour at Singleton Swash.

0.625 meter contour	Section A-A		Section B-B		Section C-C		Section D-D	
LIDAR Date	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)
1996	n/a	n/a	n/a	n/a	14.4	28.4	-5.8	158.0
1997	-4.7	9.0	2.1	16.4	-35.8	44.0	-154.8	n/a
1998	-11.0	9.5	-1.2	16.4	-2.3	35.0	-109.4	251.4
1999	n/a	n/a	n/a	n/a	1.6	202.5	125.7	536.6
2000	-34.1	8.7	-44.3	16.1	-41.9	40.2	-33.9	205.0
2005	-141.1	-15.5	-114.5	-11.9	-113.5	69.5	-18.6	124.9

0.625 meter contour	Section A-A		Section B-B		Section C-C		Section D-D	
LIDAR Date	Difference in Right bank (meters)	Difference in Left Bank (meters)	Difference in Right bank (meters)	Difference in Left Bank (meters)	Difference in Right bank (meters)	Difference in Left Bank (meters)	Difference in Right bank (meters)	Difference in Left Bank (meters)
1996								
1997					-50.2	15.6	-149	
1998	-6.3	0.5	-3.3	0.0	33.5	-9.0	45.4	
1999					3.9	167.5	235.1	285.2
2000					-43.5	-162.3	-159.6	-331.6
2005	-107.0	-24.2	-70.2	-28.0	-71.6	29.3	15.3	-80.1

0.625 meter contour	Section A-A		Section B-B		Section C-C		Section D-D	
LIDAR Date	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)
1996								
1997					-50.2	15.6	-149	
1998	-6.3	0.5	-3.3	0.0	-16.7	6.6	-103.6	
1999					-12.8	174.1	131.5	285.2
2000					-56.3	11.8	-28.1	-46.4
2005					-127.9	41.1	-12.8	-126.5

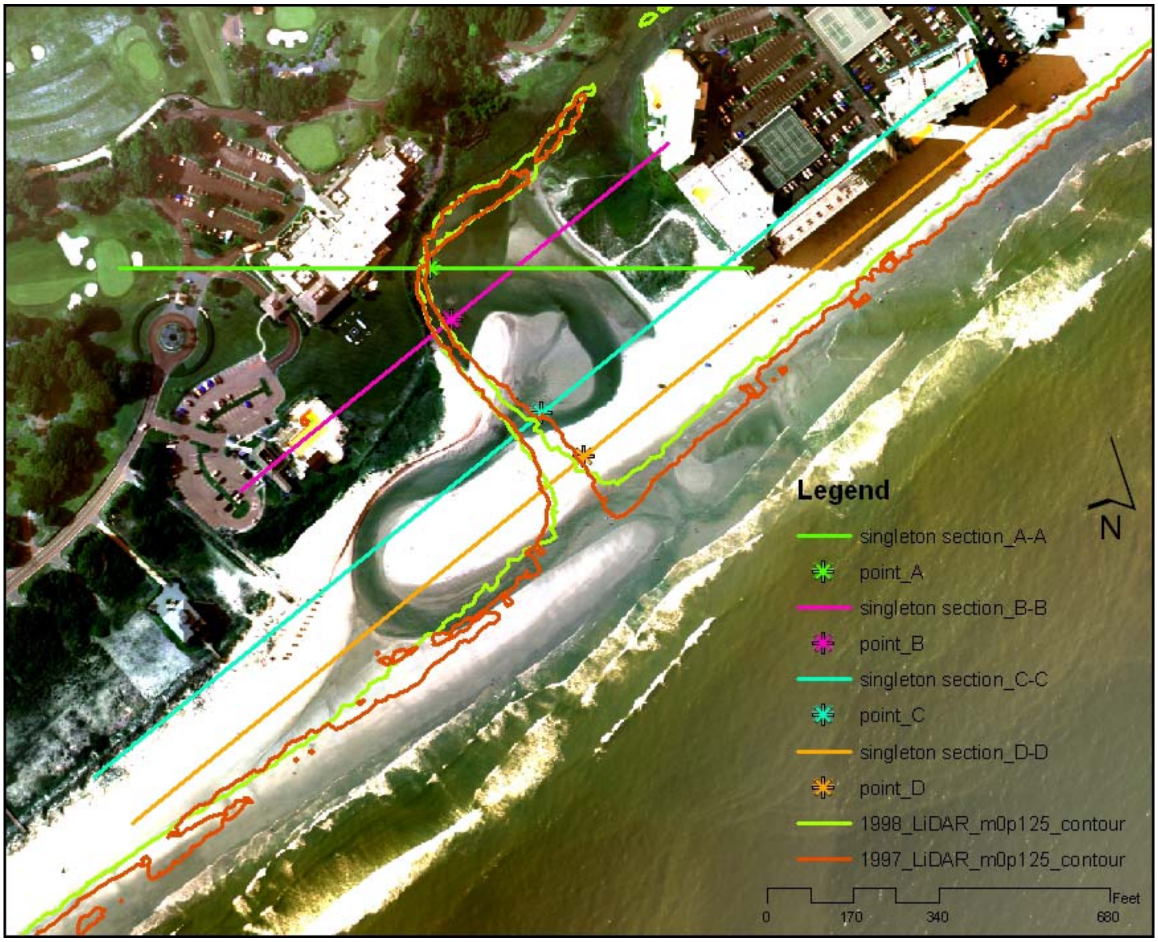

Figure 6-6: -0.125 meter LIDAR elevation contour comparison for 1997 and 1998 at Singleton Swash.

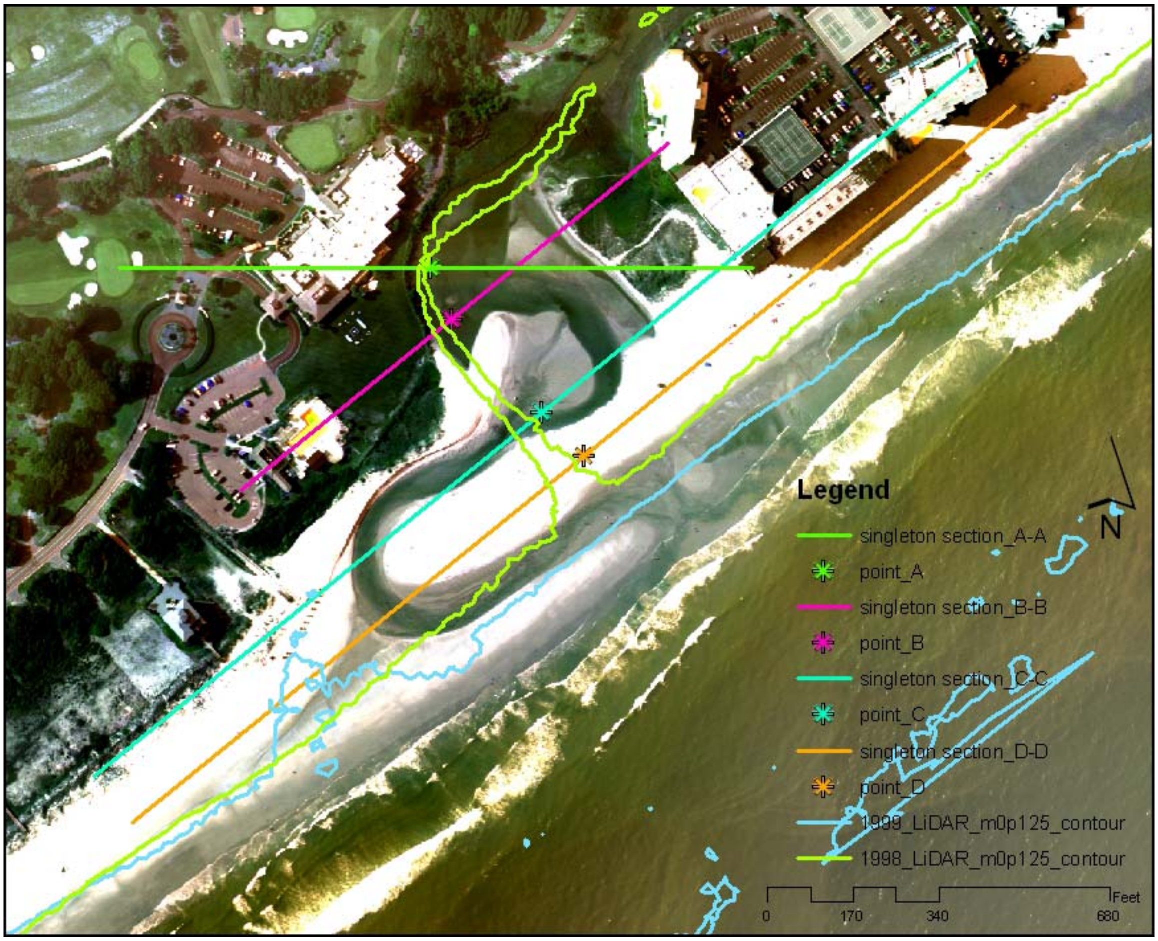

Figure 6-7: -0.125 meter LIDAR elevation contour comparison for 1998 and 1999 at Singleton Swash.

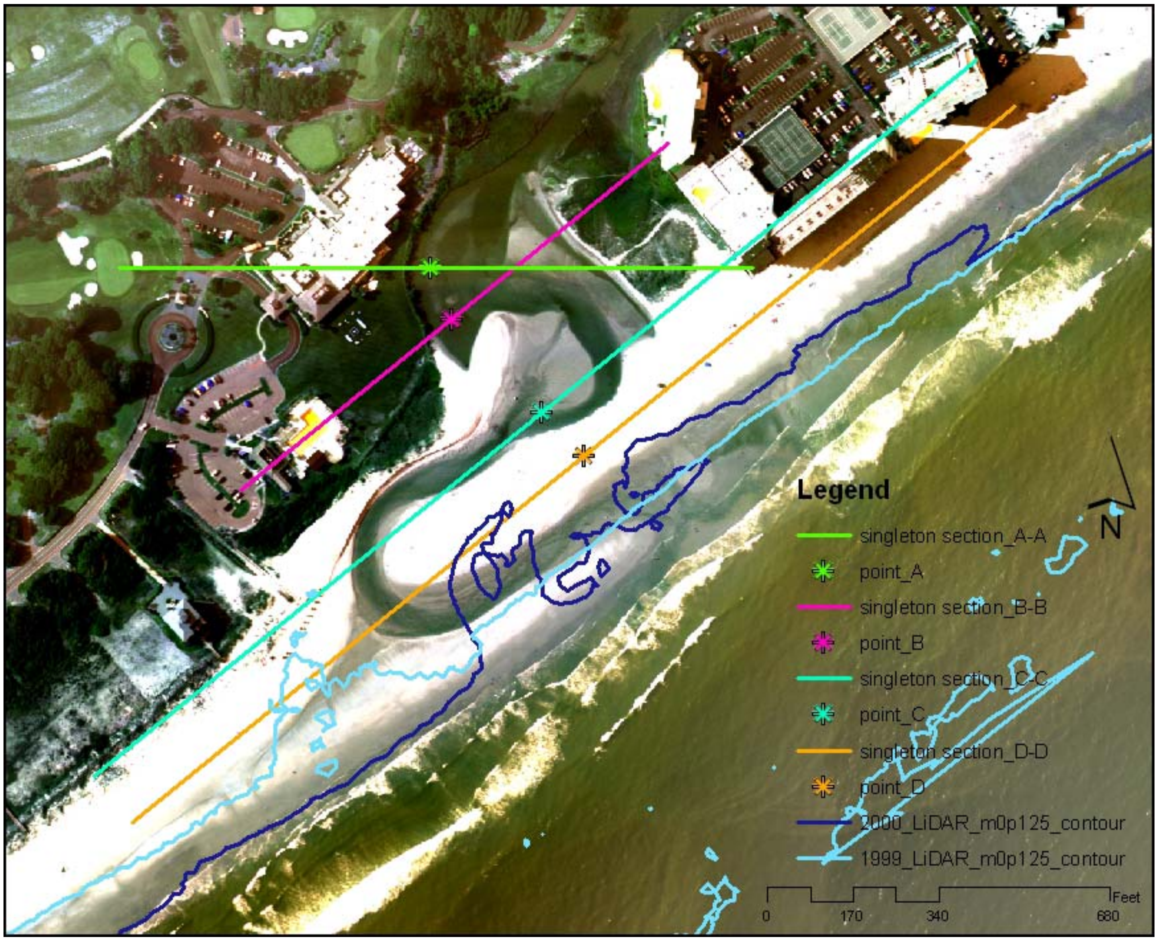

Figure 6-8: -0.125 meter LIDAR elevation contour comparison for 1999 and 2000 at Singleton Swash.

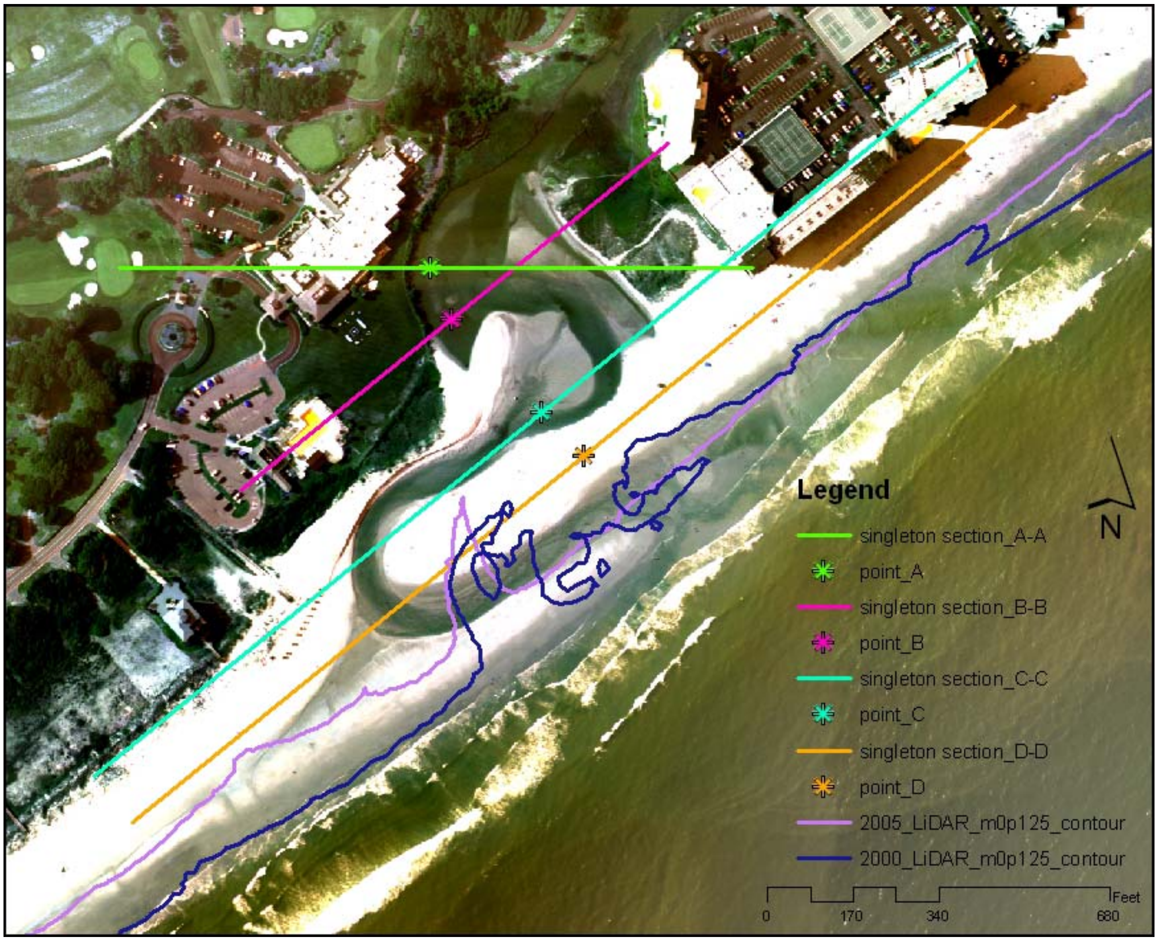

Figure 6-9: -0.125 meter LIDAR elevation contour comparison for 2000 and 2005 at Singleton Swash.

Table 6-2: Summary of measured changes to -0.125 meter LIDAR contour at Singleton Swash.

-0.125 meter contour	Section A-A		Section B-B		Section C-C		Section D-D	
LiDAR Date	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)	Distance to Right bank (meters)	Distance to Left Bank (meters)
1996	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1997	2.9	7.8	5.3	13.9	4.0	19.2	3.9	32.7
1998	5.9	8.2	5.6	13.4	6.7	21.5	6.5	28.6
1999	n/a	n/a	n/a	n/a	n/a	n/a	204.3	236.4
2000	n/a	n/a	n/a	n/a	n/a	n/a	66.7	100.4
2005	n/a	n/a	n/a	n/a	n/a	n/a	84.8	105.2

-0.125 meter contour	Section A-A		Section B-B		Section C-C		Section D-D	
LiDAR Date	Difference in Right bank (meters)	Difference in Left Bank (meters)	Difference in Right bank (meters)	Difference in Left Bank (meters)	Difference in Right bank (meters)	Difference in Left Bank (meters)	Difference in Right bank (meters)	Difference in Left Bank (meters)
1996								
1997								
1998	3.0	0.4	0.3	-0.5	2.7	2.3	2.6	-4.1
1999							197.8	207.8
2000							-137.6	-136.0
2005							18.1	4.8

-0.125 meter contour	Section A-A		Section B-B		Section C-C		Section D-D	
LiDAR Date	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)	Cumulative Difference in Right bank (m)
1996								
1997								
1998	3.0	0.4	0.3	-0.5	2.7	2.3	2.6	-4.1
1999							200.4	203.7
2000							62.8	67.7
2005							80.9	72.5

White Point Swash LIDAR Contour Comparison Figures

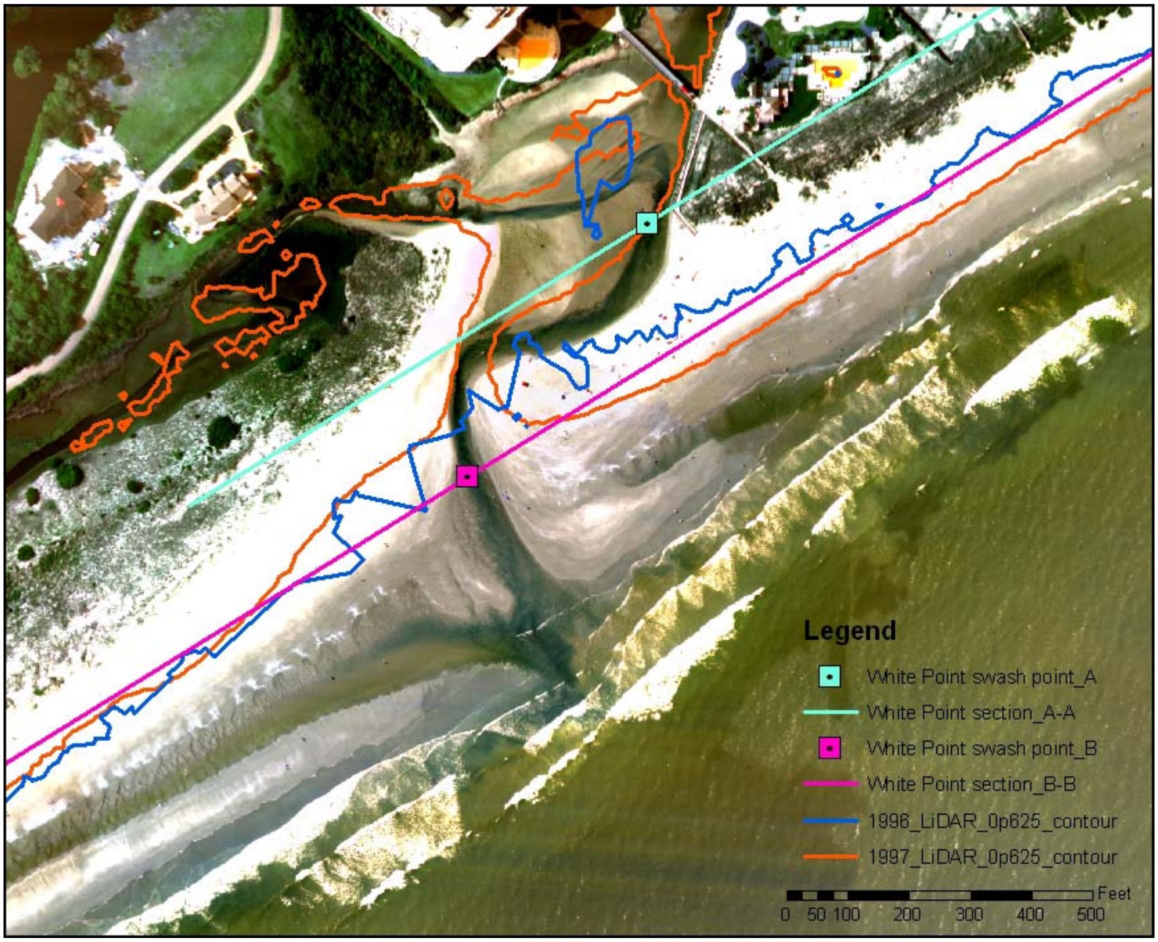

Figure 6-10: +0.625 meter LIDAR elevation contour comparison for 1996 and 1997 at White Point Swash.