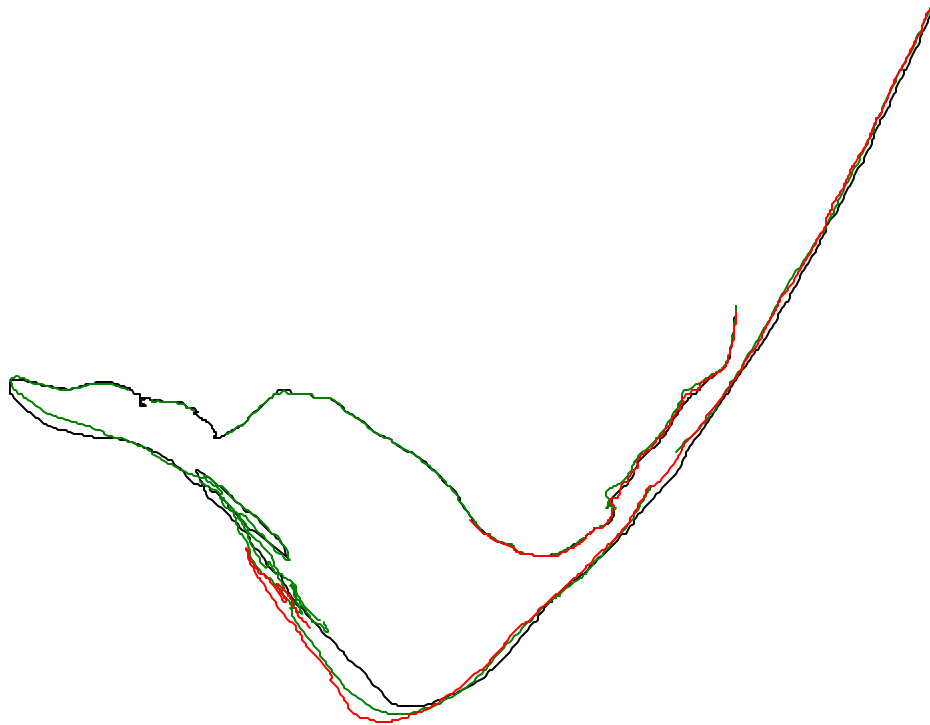


Assateague Island National Seashore

Geomorphologic Monitoring Program

2004 Report



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Abstract

The Geomorphologic Monitoring Program initiated in 1995 was continued at Assateague Island National Seashore in 2004. In addition to documenting baseline conditions and assisting in change monitoring, the data will be used to examine the ongoing North End Restoration project, including the effects of nearshore dredging.

This year, collected data included topographic profiles, shoreline positions, lidar, and aerial photography. Topographic profiles were collected along 22 transects in spring 2004 and along 23 transects in fall 2004. The shoreline positions were mapped in February, March, July, and November of 2004. All survey data were processed, compiled, and archived in the Electronic Library. Additional data collection this year included NASA lidar data, collected on August 27 and available in 2005, and georeferenced aerial photographs of Assateague Island, taken on October 25, 2003 and delivered to the Park in 2004. The shorelines of Assateague Island and the smaller bay islands were digitized using these photographs and added to the Electronic Library.

Introduction

The dynamic nature of coastal barriers such as Assateague Island influences nearly every aspect of their ecology. Barrier islands are disturbance-driven ecosystems, and their morphology and ecology are shaped by physical forces on an accelerated time scale in comparison to mainland systems. Because of the rapid pace and scope of change, long term monitoring is crucial to the understanding of natural barrier island conditions as well as anthropogenic influences.

The geomorphology of Assateague Island is influenced by many factors including waves, storm energy, alongshore sediment transport, island overwash, wind, nearshore bathymetry, and engineering projects. Assateague Island is wave-dominated (average 1 m) and microtidal (0-2 m, 4 m spring tide). Wave heights are highest in the fall and winter, when they approach the shoreline from the northeast and east; the smaller summer waves approach the coast from the east and southeast. Winter northeasters occur more frequently and for a longer duration than summer tropical storms and hurricanes. These waves, along with overwash and wind, move sediment onto the island. Longshore transport of sediment is meteorologically driven and has a net southerly littoral drift between 114750 m³ and 214200 m³ (Underwood 1995). The southward transport is evident in the seaward offset of shoreline position north of the Ocean City Inlet jetty, which traps sand as it moves alongshore towards the south.

The National Park Service (NPS) contracted with the U.S. Army Corps of Engineers (USACE) in 1991 to develop recommendations for a coastal change monitoring program at Assateague Island. These recommendations were reported in *A Physical Monitoring Plan for Northern Assateague Island, Maryland* (Stauble 1994). In 1995, ASIS initiated a long-term program to begin monitoring key aspects of island geomorphology. At present, the program includes three primary elements:

1. Documentation of the shoreline position on a quarterly basis in order to describe and evaluate trends in shoreline stability, rates of shoreline change, and storm-driven change.

2. Documentation of cross-island topographic profile elevations on a biannual basis in order to describe and evaluate trends in island topographic relief and storm-driven change.
3. Use of lidar (light detection and ranging) data, an airborne laser technology that provides detailed topographic data on bare earth areas of the island. This technology has a horizontal resolution of 1 meter and vertical accuracy within 15 cm. The lidar data are processed into a three-dimensional GIS layer for analysis. This project, a cooperative effort between NASA, USGS, and NPS, consists of irregularly scheduled aerial surveys. ASIS involvement consists of topographic profiling and shoreline mapping for ground-truthing during aerial surveys. The project has recently moved beyond the research stage and is now a part of the park's Geomorphologic Monitoring Program. Methodologies involving data management and distribution are still under development.

Information resulting from the Monitoring Program is intended to provide a general description of island conditions and to provide a basis for evaluating long-term management strategies. Data generated by the program will also support coastal processes research, habitat characterization studies, and evaluation of beach and berm restoration projects.

This report summarizes the methods used by ASIS staff to collect, process, analyze, and archive topographic profile and shoreline change data collected during 2004 as part of the long-term Geomorphologic Monitoring Program.

North End Restoration Project

The North End restoration project is intended to address the effects of the Ocean City jetties, which have caused sediment starvation of the north end of Assateague Island. This project is expected to affect the geomorphology of Assateague Island in several ways. Sand bypassing will increase the sediment supply to the north end of the island, thereby altering shoreline change rates and sediment transport rates. This bypassing, along with dredging of the ebb tidal delta, may also lead to changes in nearshore and surf zone bathymetry.

The first, short-term phase of the North End restoration project began in September 2002 with the placement of 1.4 million m³ of sand along the beach between 2.5 and 12 km south of the Ocean City inlet. The U.S. Army Corps of Engineers completed the construction in January 2003. The long-term restoration plan calls for biannual sand bypassing of 145,000 m³/yr for the next 25 years. The first round of bypassing occurred from January 31 to February 13, 2004, and was followed by a second cycle between October 2 and November 26, 2004.

In preparation for dredging, bathymetric surveys of Ocean City inlet and the ebb tidal delta were performed in January and April of 2003, and in January and November of 2004; survey areas varied. This sand was placed in the nearshore and surf zone area, approximately 3 to 3.5 km south of the Ocean City inlet's south jetty.

Topographic Profile Surveys

The profile network baseline, established by Taylor, Wisemann and Taylor in 1993, and expanded by NPS personnel in 1995, provides horizontal and vertical controls for all data collection. Individual baseline monuments are numbered consecutively from north to south and are labeled with the prefix “NPS” or “GPS” to denote whether the baseline monument was established by NPS or by Taylor, Wisemann, and Taylor, respectively (Table 1). These monuments were re-occupied in 2004 using new survey equipment in order to verify their documented geographic coordinates and to compare the new survey equipment to the equipment used in previous years (Table 2).

Spacing between GPS monuments is 2.0 km, with NPS monuments located approximately midway between GPS monuments along the northern 10 km of Assateague Island (Figure 1). This results in 22 profile lines spaced at 1 km intervals on the North End and at 2 km intervals for the remainder of the Maryland coast. In fall 2004, an additional (23rd) profile line was added near the north end of the island to enhance the North End restoration project monitoring. The line is located between two established profile lines and is called NPS 3.75. There are no profile transects in the Virginia section of Assateague Island.

Topographic profiles were collected April 15-May 7 and September 27-November 11, 2004. Profile surveys were conducted from each primary monument along the baseline and are aligned roughly perpendicularly to the ocean shoreline at a 291/111 degree azimuth from true north. This year, both the survey equipment and the survey datum changed. Elevations were collected using a Trimble 5700 GPS total station and referenced to the NAVD88 datum. Surface elevation points were collected along each transect line at approximately 10 meter intervals and at significant changes in topography. Each profile line extends from wading depth oceanside to wading depth bayside (with 0.0 meters above sea level as a goal endpoint on either side) or up to the point where heavy vegetation obstructs the line of sight to the target. All transects are surveyed relative to a control monument or witness point along the baseline. Surveyed transects are identified in Table 3 according to seasonal survey periods for 1995-2004.

All files are stored as digital NYXZ values (Point Number, Northing, Easting, Elevation). Coordinates are in UTM, meters, referenced to NAD-83. The vertical datum used is NAVD-88, meters. Metadata is created for each shapefile, and contains information on collection, processing, and, beginning in 2004, any significant weather events. All data is saved in the ASIS Electronic Library and on an external hard drive backup.

Data Quality

The quality of the topographic profiles (collected 1995-2004) was reviewed. Overall, the dataset was found to have been collected in a rigorous manner and to contain reliable points, but suspected errors and unexplainable offsets were documented in a summary report available at G:\Electronic_Library\10_Geomorphology\07_Geomorphological_Monitoring\Documentation\DocumentationMetadata.

Transect Locations

Transect lines surveyed in 2004 included GPS-1 through GPS-17 and NPS-1.5 through NPS-5.5. Of the areas profiled, the northernmost 8 kilometers of Assateague Island have experienced the

most significant changes in topography during the past 60 years due to the influence of the adjacent Ocean City inlet and its northern jetty. The North End is characterized by relatively low topographic relief with surface elevations ranging from 0.0 m or less at the shoreline to approximately 3.0 m (NGVD). Lines GPS1 – NPS4.5 represent true cross-island profiles in that their extent includes complete surface elevations from the ocean to the bay shoreline.

The “developed zone” is the area of Assateague Island that extends 0.4 km to the north and 6 km to the south of the Verrazano Bridge. It is dominated by an artificial dune line and steeply sloping beach. Changes in bulldozed dune locations can be seen in profiles NPS 5.5 through GPS 8.

The remaining 19 km of the Maryland portion of Assateague Island, represented by survey lines GPS9-GPS17, is characterized by smaller dune features (generally 4.0-6.0 m NGVD) separated by low overwash gaps of varying widths and extents. According to the USACE analysis, the effects of the inlet jetties are minimized along this entire section of the park, which is open to 4-wheel drive vehicles and is referred to as the off-road vehicle (ORV) zone.

In general, it is difficult to interpret large-scale directional movement with the limited nature of linear transects. Interpretation must consider meteorological conditions, ebb shoal protection, and subjectivity introduced into the profile collection process by various technicians’ assessment of a representative profile.

Observations

Elevations along profile lines in 2004 were compared to elevations measured in 2002 and 2003 (Figures A1-A21). There were no particularly surprising changes between 2003 and 2004, but the profiles do exhibit some differences, which are described below.

On the north end of the island, the spring 2004 profile lines along GPS 1 through GPS 3 were very similar to those of the previous two years. Profiles GPS 3.0, NPS 3.5, and GPS 4.0 traversed the constructed berm on the north end of the island. At GPS 3, the profile was slightly lower (0.2 m) in elevation than previous profiles on the bay side. At NPS 3.5, the profile was at a lower elevation than in previous years (0.2m generally, but 0.6 m at the seaward base of the constructed berm). At GPS 4.0 the constructed berm expanded 20 m farther seaward.

South of the constructed berm, At NPS 4.5, the beach face accreted seaward but the dune crest lowered in elevation. At GPS 5, the shoreface was not as steep as the previous two years, and the overall profile was slightly lower in elevation.

Profile lines NPS 5.5 through GPS 7 traverse Assateague State Park. At NPS 5.5, the bay side of the dune lowered in elevation (0.4 m) and the seaward base of the dune accreted. GPS 6 and GPS 7 had very similar profiles as in past years. The dune at GPS 8, which is in the developed area of the National Seashore, was much lower, and the base accreted. These changes may be due to intentional reconstruction of the artificial dune line.

South of the state park, changes in profile lines varied. At GPS 9 and 10, the beach volume increased. At GPS 11, the bay side of the dune changed in shape, with the side of the dune losing volume and the base of the dune increasing in volume. The shoreface at GPS 12 and GPS 13 is slightly steeper than during the previous two spring surveys, while GPS 14 and GPS 15 had fairly similar profiles in comparison to previous years. GPS 16 had a smoother beach, and at GPS 17, the beach extended seaward by about 30 m compared to its spring 2003 position.

This comparison demonstrated that the measured heights are within an expected range. The observations are not exhaustive but may provide an introduction to the changes seen in figures A1-A21.

GPS Shoreline Surveys

Mapping the horizontal shoreline position with GPS can be useful in understanding the dynamics of a barrier system such as Assateague Island. Although patterns of shoreline change are difficult to assess when examining a limited data set, general trends of accretion, erosion, and migration are identifiable. Analysis of shoreline position must consider the subjectivity of the technician's recognition of the high tide line; the role that variable tide levels *within* the average tide window play in shoreline appearance, particularly on the low-lying bay side; and the influence of meteorological events and conditions on shorelines.

Methods

The shoreline position is surveyed four times each year. In 2004, it was surveyed in February, March, July, and November. In winter and summer, only the position of the Maryland ocean shoreline is surveyed. In spring and fall, surveys include the Maryland and Virginia ocean shorelines, the northern 8 kilometers of the Maryland bay shoreline, and the bayside extent of the southern tip of the island, also known as Toms Cove Hook. Optimally, shoreline mapping is completed at the end of each season. For example, the spring shoreline is surveyed at the end of winter to show pre-season conditions and the effects of the predominating meteorological and tidal conditions of the previous season.

All surveys are executed during near-average tidal ranges when the predicted high tides run close to the Mean High Water, and allowing several days before and after lunar water level extremes. Prior to surveys, tide levels are checked at various local stations (including Ocean City Fishing Pier, Isle of Wight Bay, and Wallops Island) through the NOAA website www.tidesonline.nos.noaa.gov. In addition, a QuickPlan is utilized in the PathFinder Office software to generate a list of observation times that would optimize the accuracy of the desired GPS configuration.

The ocean shoreline is surveyed by driving a four wheel ATV at a relatively constant speed (between 5 and 10 mph) along the high tide line. For the purposes of this monitoring program, "ocean shoreline" is defined as the average position of the most recent high tide as evidenced by the obvious wet/dry sand line or deposited wrack. The GPS receiver is configured to record positions at a very short interval (typically one position every 2 seconds) for the best representation of the shoreline position. The North End bay shoreline is surveyed by walking the

actual water line within two hours of the most recent high tide, while the GPS receiver records positions every 3 seconds. In areas along the bayside that lack dry uplands, the shoreline is identified as the open water/vegetation margin. This allows for tidal creeks and other shoreline irregularities to be included within the surveyed line.

Standard kinematic differential GPS survey methods are employed for all shoreline surveys of Assateague Island. The GPS survey equipment is the Trimble Pathfinder ProXR system, which integrates an updated GPS receiver with MSK beacon real-time differential capability. This system eliminates the need for establishing a local base station while maintaining the sub-meter accuracy standards for field mapping. Within each shoreline survey session, the location of a known surveyed point is occupied and recorded within the data file to serve as an accuracy check for each survey session. The GPS is configured to record points even if radio-link is lost. A detailed Standard Operating Protocol can be found in the ASIS Electronic Library, Resource Identification Number (RIN) 10.07, Geomorphologic Monitoring, SOP's, SOP_Profile_Collection and SOP_Profile_Processing.

These data were collected in ArcPad 6.0.1 on a Trimble Recon with Trimble GPSCorrect. All data were real-time differentially corrected using beacon signals from Annapolis, MD or Driver, VA. GPS data files are downloaded to the PC using the PathFinder Office utility software, and all files are differentially corrected through post-processing using data from the VIMS CORS station. Post-processing accounts for the points that are not real-time corrected, results in generally more accurate position data for all points, and introduces a basic level of consistency to surveys. Base station files were downloaded from the New Jersey Department of Environmental Protection's website, <http://www.state.nj.us/dep/gis/>. Shoreline files were checked for accuracy by comparing the collected known-point positions to actual positions. They were then exported as a GIS shapefile for analysis and mapping.

Individual files for each shoreline segment are labeled according to the survey date and the specific area surveyed, "MD" for Maryland or "VA" for Virginia, followed by an "O" for ocean or "B" for bay. For example, the file labeled "MDO399" contains the data collected along the Maryland ocean shoreline during March 1999. All data files are stored on the hard drive of the PC in the shoreline project of the PathFinder Office software. Shoreline maps are finally combined within their respective seasons as one Arcview GIS shapefile labeled by month and year (e.g., 'Shoreline 0499' for the shoreline position collected in April 1999). New procedures implemented in summer 2002 require checking shoreline shapefiles for errors by scrolling one frame at a time through the entire map at a 1:2,000 view scale. Gaps of less than 5 meters can be joined if they are clearly unintentional or erroneous. If additional vertices are needed, natural line-flow must be mimicked. Clusters of off-line points, such as those recorded while standing still, should be removed carefully. Metadata is created for each file, and contains information on collection, processing, and, beginning in 2004, any significant weather events. Shorelines and metadata are stored on an external hard drive backup and in the Electronic Library under RIN 10.05, Geomorphology, Shoreline Processes, GIS_Shoreline_Data.

Data Quality

A quality review was done of the shoreline positions collected 1994-2004. Overall, the dataset was found to have been collected in a rigorous manner and to contain reliable points, but suspected errors and unexplainable offsets were documented in a summary report available at G:\Electronic_Library\10_Geomorphology\05_Shoreline_Processes\Documentation\DocumentationMetadata.

Observations

The 2004 bay shorelines of the North End were in approximately the same locations as in 2003. The November 2004 bay shoreline was almost consistently landward of the March 2004 bay shoreline. In some areas, the 2004 shoreline was up to 8 m landward of its 2003 position; in others, it was up to 34 m seaward of its position. At Toms Cove Hook, the tip of the Hook elongated and thinned in 2004, and the inlet shoreline moved seaward of its 2003 position. Ocean shoreline positions in 2004 were within the range of shoreline positions mapped in 2003.

Future Data Collection

Shoreline position surveys will continue along Assateague Island as part of the long-term Geomorphologic Monitoring program in order to build the necessary database for future analysis. They will be used to assess the new North End restoration project and will also be valuable as ground-truthing data, along with topographic profiles, for future lidar surveys. In the near future, lidar data may be used to extract a datum-based shoreline. Aerial photographs may also be used to delineate shorelines. Ground-based shoreline survey efforts may be enhanced in support of USACE datum-based shoreline extraction methods.

Additional Data Collection

Lidar data were collected by NASA on August 27, 2004 and will be processed by USGS and delivered to the Park in 2005. Aerial photographs taken on October 25, 2003 were orthorectified and delivered to the Park in 2004. They capture all of Assateague Island, with the exception of the edge of Toms Cove, and are available in the Electronic Library at G:\Electronic_Library\23_GIS\04_Aerial_Photography\2003. Shorelines of Assateague Island and the smaller bay islands were delineated using heads-up digitizing techniques. These shapefiles are available in the Electronic Library at G:\Electronic_Library\10_Geomorphology\05_Shoreline_Processes\Historic_Shorelines.

Recommendations

Several initiatives would enhance the current Geomorphologic Monitoring Program.

1. Methodology for mapping 3-dimensional shoreline position and/or beach topography should be developed. This would allow more comprehensive analyses of shoreline change, such as changes in slope and volume.

2. Methodology for comparing existing shoreline position data to lidar datasets, or to extrapolate datum-based lidar shorelines to wet-dry shoreline position, should be explored. This would allow integration of existing datasets with new lidar data.
3. Existing data should be used to calculate shoreline, topographic, areal, and volumetric changes on the island, particularly on the North End with respect to the long-term sediment bypassing that began in fall 2003 as part of the USACE restoration plan. Analyses should also identify short-term and long-term morphologic trends and changes. They may also incorporate meteorological data into the analyses.

Literature Cited

- O'Connell, M., 2002. Assateague Island National Seashore Geomorphological Monitoring Program 2001 Report. Berlin, MD.
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- Taylor, Wiseman and Taylor, 1993. *GPS Survey Report*. Taylor, Wiseman and Taylor Engineering Company, Mount Laurel, NJ.
- Underwood, S.G., 1995. *Historical Development of Ocean City Inlet Ebb Shoal and Its Effect on Northern Assateague Island*. U.S. Army Engineer Waterways Experiment Station, Coastal Engineering Research Center, Vicksburg, MS.



Figure 1. Locations of baseline monuments used in topographic profile surveys.

STATION ID	Northing (m)	Easting (m)	Elevation (m)	Distance (m)
NPS-0.5	0.17	0.13	0.75	0.21
GPS-1	0.01	0.02	0.02	0.02
Witness 1	1.78	1.26	0.24	2.18
NPS-1.25	0.19	0.21	0.03	0.28
NPS-1.5	0.40	0.29	0.06	0.50
NPS-1.75	0.19	0.44	0.04	0.48
GPS-2 RESET	0.02	0.03	0.05	0.04
NPS-2.25	0.17	0.18	0.04	0.25
NPS-2.5	0.34	0.02	0.06	0.34
NPS-2.75	0.16	0.32	0.05	0.36
GPS-3		not resurveyed		
NPS-3.25	0.13	0.26	0.07	0.29
NPS-3.5 reset to COE2	0.01	0.04	0.10	0.05
NPS-3.75 RESET	0.08	0.37	0.02	0.38
GPS-4 RESET	0.02	0.04	0.06	0.04
NPS-4.25 reset	0.07	0.16	0.14	0.17
NPS-4.5 RESET	0.20	0.08	0.11	0.21
NPS-4.75		not resurveyed		
GPS-5		not resurveyed		
NPS-5.25	0.11	0.38	0.03	0.39
NPS-5.5	0.05	0.20	0.04	0.20
Witness5.5	0.37	0.40	0.07	0.55
NPS-5.75	0.06	0.45	0.27	0.45
GPS-6	0.00	0.01	0.05	0.01
Witness6		not resurveyed		
GPS-7		not resurveyed		
Witness7	0.64	0.04	0.03	0.65
GPS-8	0.03	0.03	0.03	0.04
Witness8	1.10	0.42	1.31	1.18
GPS-9	0.01	0.01	0.01	0.01
Witness9	0.10	0.02	0.03	0.10
GPS-10		not resurveyed		
Witness10	0.18	0.09	0.02	0.20
GPS-11	0.02	0.02	0.02	0.03
Witness11	0.13	0.55	0.00	0.57
GPS-12	0.03	0.02	0.03	0.04
Witness12	0.48	0.28	1.31	0.56
GPS-13	0.03	0.03	0.02	0.04
Witness13	0.01	0.11	0.06	0.11
GPS-14	0.02	0.03	0.02	0.04
Witness14	0.34	0.10	0.05	0.36
GPS-15		not resurveyed		
Witness15	0.10	0.21	0.03	0.24
GPS-16	0.03	0.04	0.05	0.05
Witness16	0.51	0.18	0.05	0.54
GPS-17	0.04	0.03	0.04	0.05
Minimum offset	0.00	0.01	0.00	0.01
Maximum offset	1.78	1.26	1.31	2.18
Mean offset	0.21	0.19	0.14	0.31
Standard Deviation	0.32	0.23	0.30	0.39

Table 2. Offsets between documented baseline monument positions and the positions recorded during 2004 re-surveys. Coordinates are UTM, Zone 18 North, meters, NAD 83; elevations are referenced to NGVD 1929, meters

STATION ID	Northing (m)	Easting (m)	Elevation (m)
NPS-0.5	4241280.60	491398.08	2.046
GPS-1	4240962.44	491103.63	1.312
Witness 1	4240926.16	491192.29	3.819
NPS-1.25	4240477.83	490915.40	1.524
NPS-1.5	4240044.61	490747.31	2.753
NPS-1.75	4239581.61	490534.11	1.859
GPS-2 RESET	4239099.93	490368.49	1.715
NPS-2.25	4238633.71	490189.66	1.267
NPS-2.5	4238117.01	490028.78	1.484
NPS-2.75	4237645.04	489931.39	1.440
NPS-3.25	4236632.93	489583.51	0.868
NPS-3.5 reset to COE2	4236172.38	489464.32	1.681
NPS-3.75 RESET	4235624.32	489179.57	1.125
GPS-4 RESET	4235180.93	489046.39	0.995
NPS-4.25 reset	4234568.43	488913.47	3.888
NPS-4.5 RESET	4234255.56	488775.35	1.818
NPS-5.25	4232796.43	488296.56	2.737
NPS-5.5	4232371.70	488031.59	1.907
Witness5.5	4232447.06	488079.52	2.210
NPS-5.75	4231840.49	487929.66	5.031
GPS-6	4231472.12	487613.01	1.282
Witness7	4229607.66	486856.68	1.507
GPS-8	4227683.19	486221.18	1.312
Witness8	4227591.11	486464.35	5.809
GPS-9	4225844.72	485716.11	1.012
Witness9	4225896.28	485662.68	1.884
Witness10	4224252.24	485267.44	1.800
GPS-11	4222115.89	484685.29	0.806
Witness11	4221879.10	484624.75	2.827
GPS-12	4220079.01	484127.34	1.379
Witness12	4220312.80	484167.62	1.580
GPS-13	4218245.76	483460.90	0.524
pvc13	4218257.47	483472.82	0.887
Witness13	4218486.02	483634.49	2.308
GPS-14	4216307.26	482635.13	1.258
Witness14	4216121.92	482556.87	1.874
Witness15	4214864.38	481947.67	1.913
GPS-16	4212759.12	480783.81	1.200
Witness16	4212418.68	480590.59	1.638
GPS-17	4211025.32	479733.48	0.988
Witness17	4211236.63	479878.24	1.670
b141	4211248.39	479870.08	1.560

Table 1. Positions and elevations of baseline monuments, collected during resurveys in 2004, and used in topographic profile surveys. Coordinates are UTM, Zone 18 North, meters, NAD 83; elevations are referenced to NGVD 1929, meters.

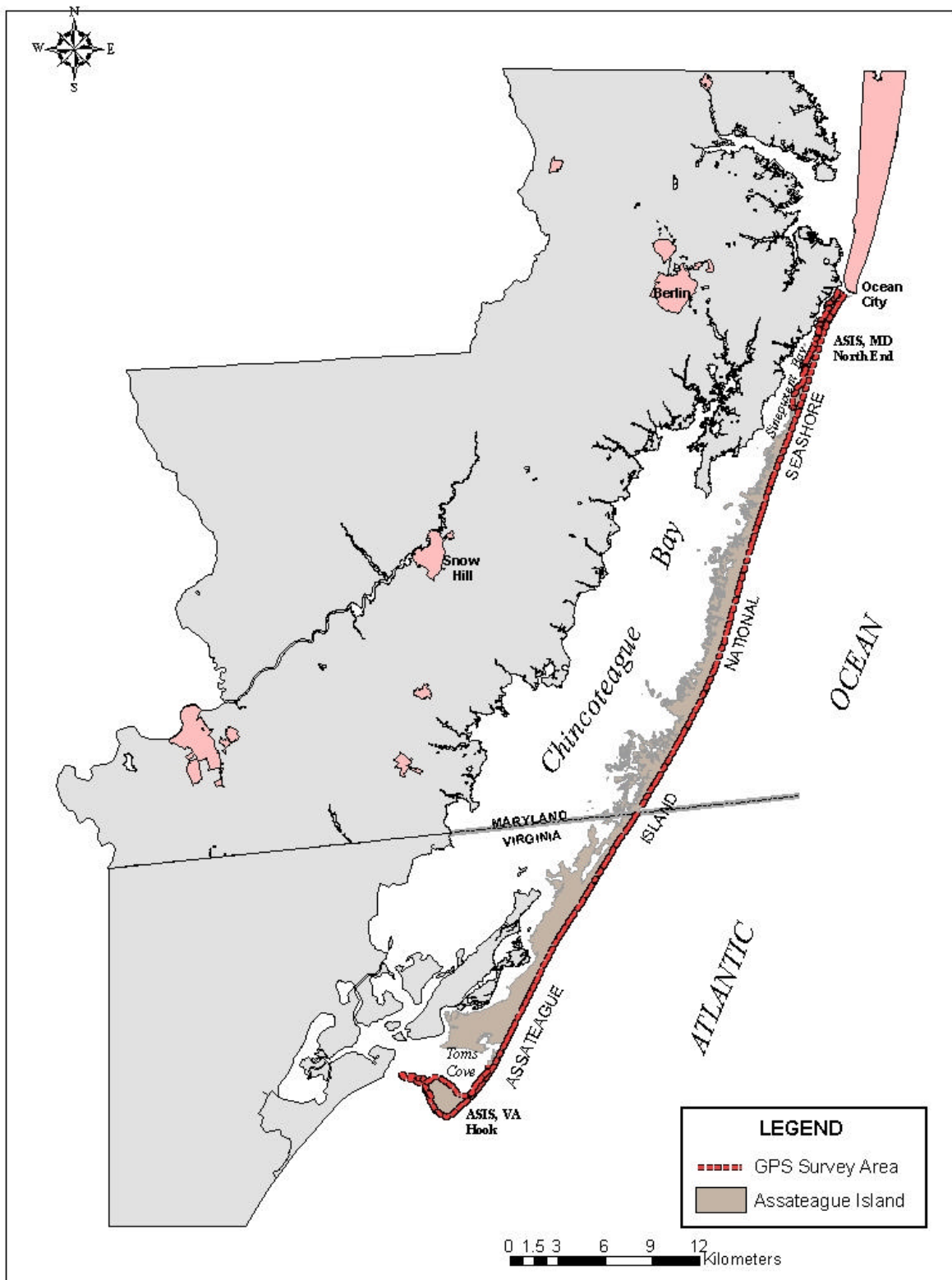


Figure 2. The Extent of GPS shoreline surveys on Assateague Island, 2001.

Survey Line	March 1995	Sept 1995	March 1996	May 1996	Sept 1996	April 1997	Sept 1997	Feb 1998	April 1998	June 1998	Oct 1998	April 1999	Oct 1999	May 2000	Aug 2000	Oct 2000	April 2001	June 2001	Sept 2001	April 2002	July 2002	Sept 2002	April 2003	April 2004	October 2004
GPS-1	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*
NPS-1.5	*	*	*		*	*	*		*		*	*	*	*	*	*	*		*	*		*	*	*	*
GPS-2	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*		*	*		*	*	*	*
NPS2.5	*	*	*		*	*	*	*	*		*	*	*	*	*	*	*		*	*		*	*	*	*
GPS-3	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*
NPS-3.5	*	*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-4	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*
NPS-4.5	*	*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-5	*	*	*	*	*	*	*	*	*		*	*	*	*		*	*	*	*	*		*	*	*	*
NPS5.5		*	*		*	*	*	*	*		*	*	*	*		*	*	*	*	*	*	*	*	*	*
GPS-6		*	*		*	*	*	*	*		*	*	*	*		*	*	*	*	*	*	*	*	*	*
GPS-7		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-8		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-9		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-10		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-11		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-12		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-13		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-14		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-15		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-16		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*
GPS-17		*	*		*	*	*		*		*	*	*	*		*	*	*	*	*		*	*	*	*

Table 3. Topographic profile surveys by transect, 1995-2003.

Appendix A
Topographic Profile Surveys

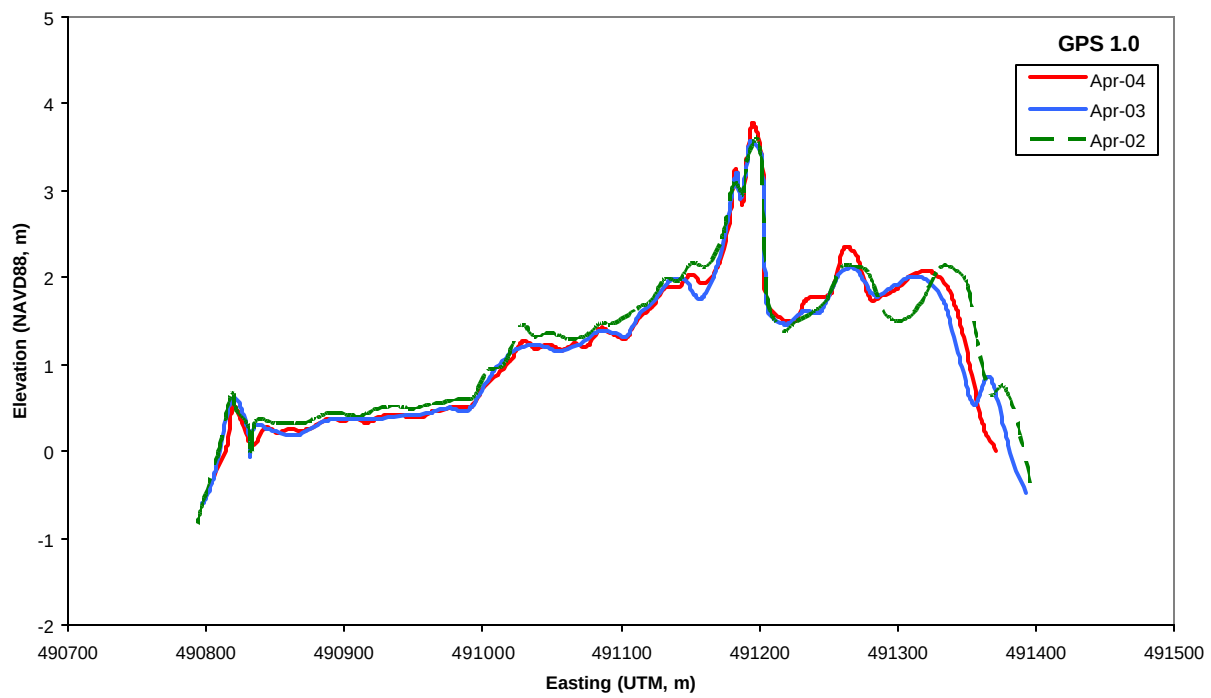


Figure A-1. Survey line GPS 1.0.

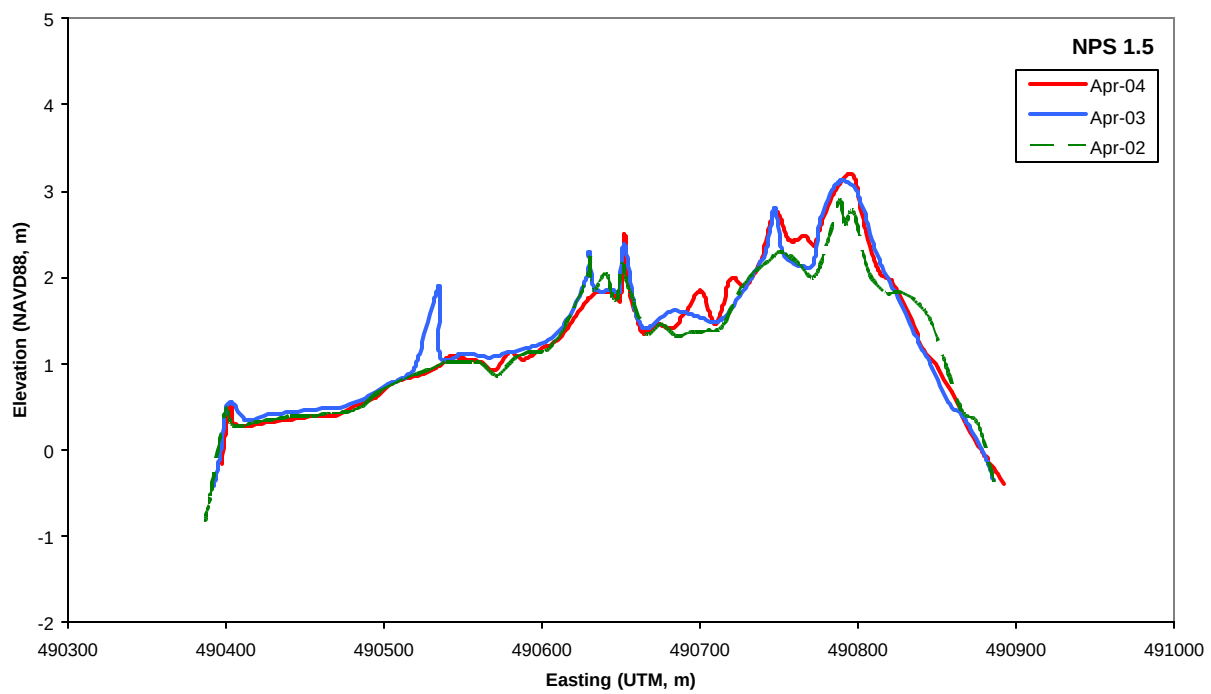


Figure A-2. Survey line NPS 1.5.

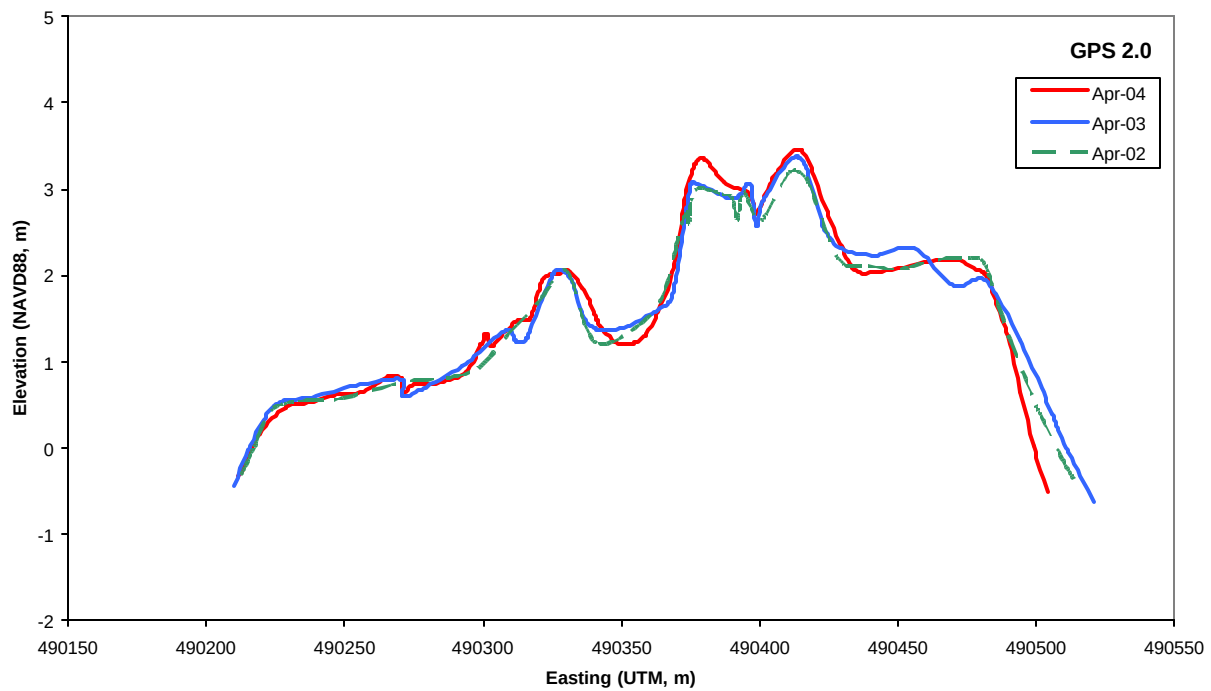


Figure A-3. Survey line GPS 2.0.

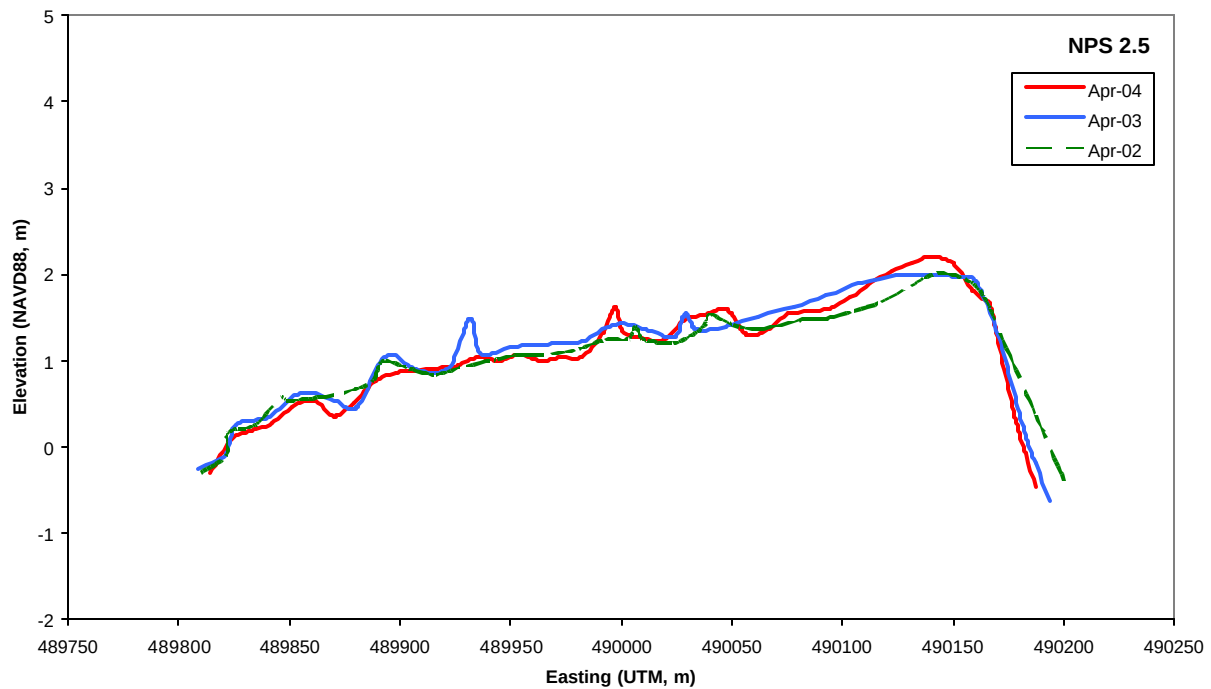


Figure A-4. Survey line NPS 2.5.

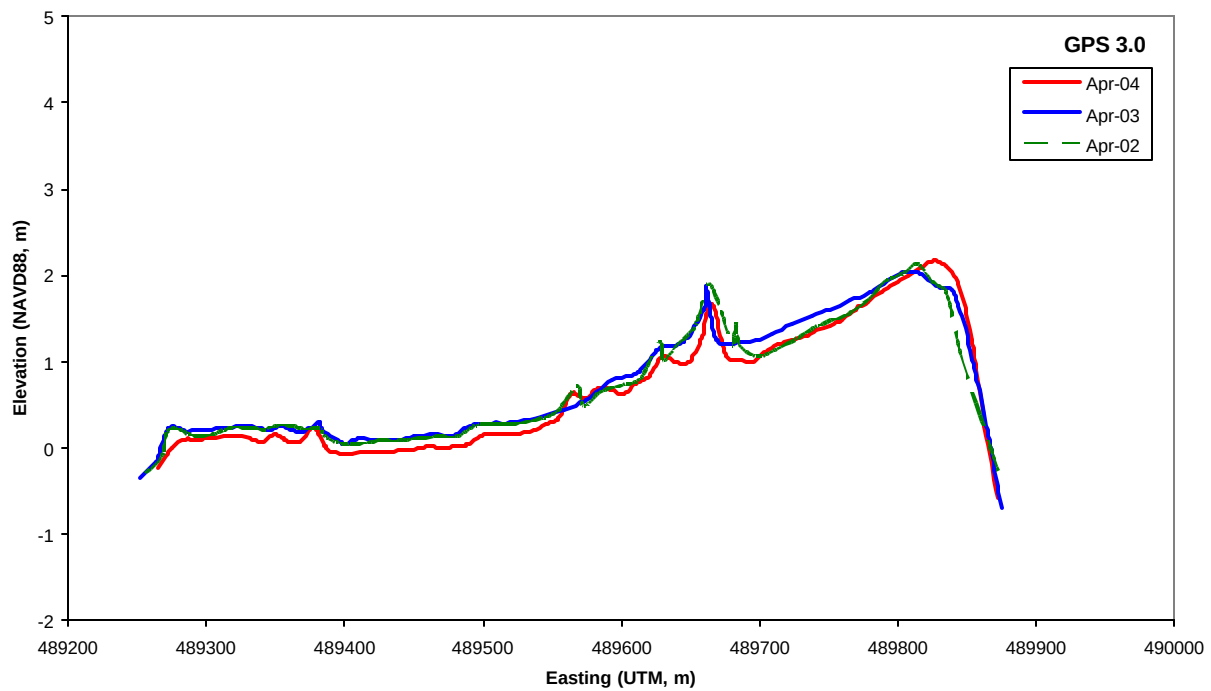


Figure A-5. Survey line GPS 3.0.

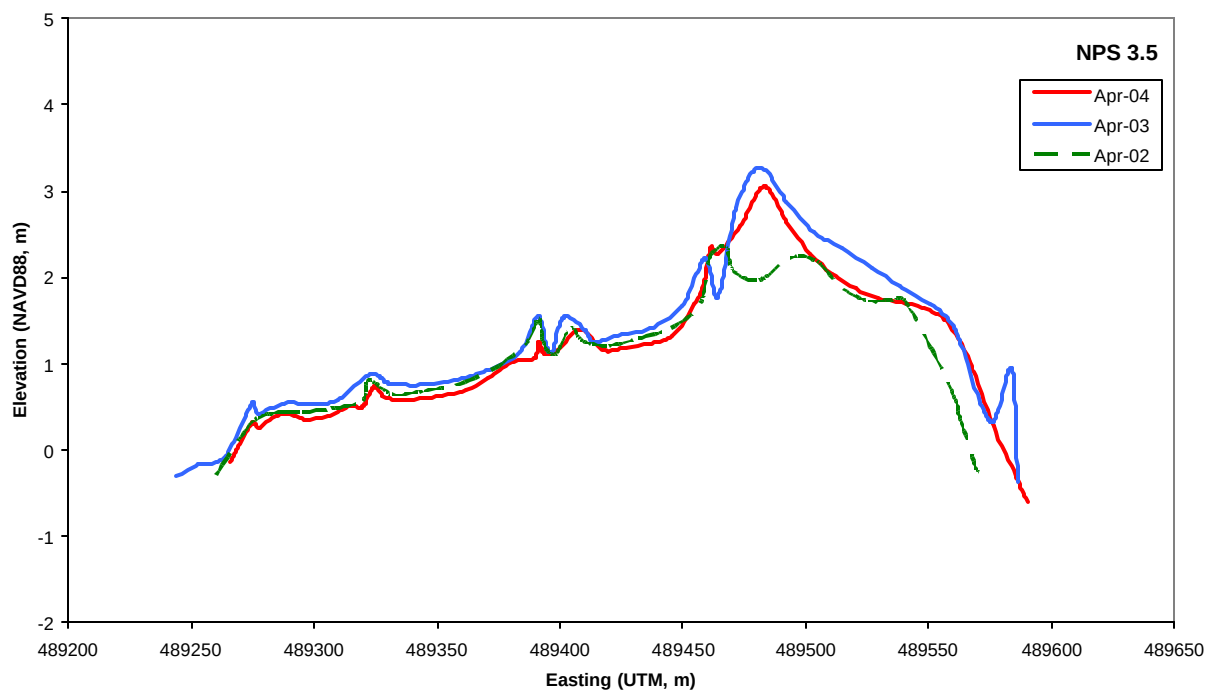


Figure A-6. Survey line NPS 3.5.

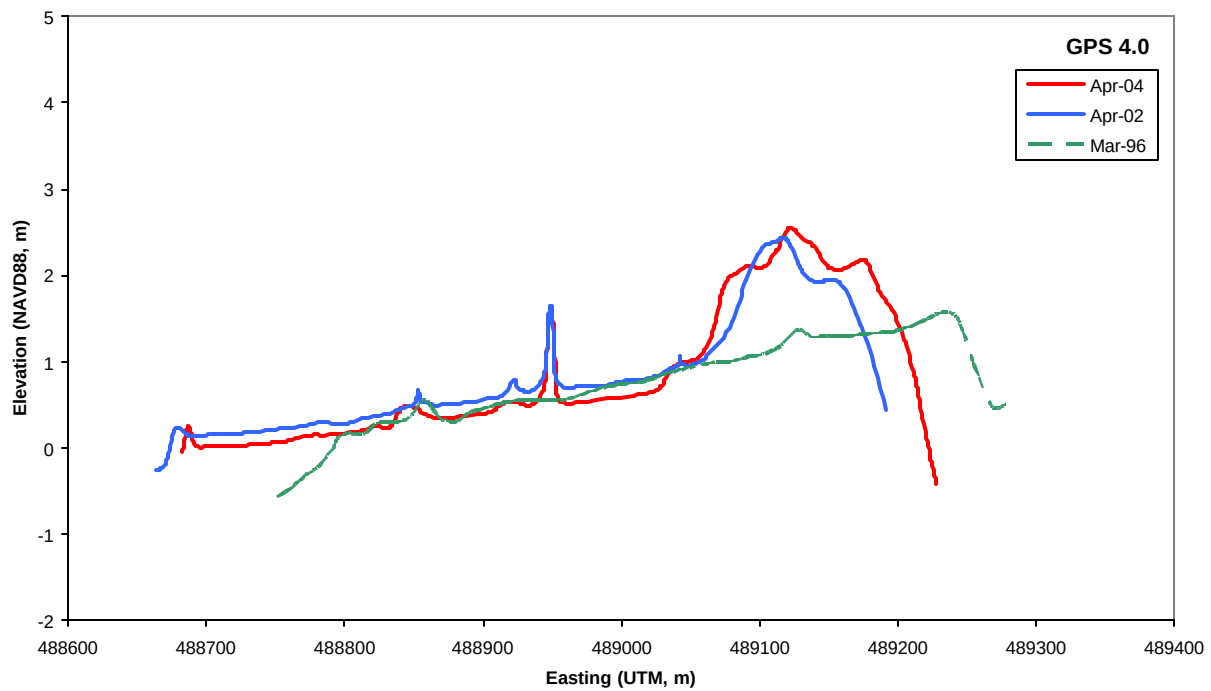


Figure A-7. Survey line GPS 4.0.

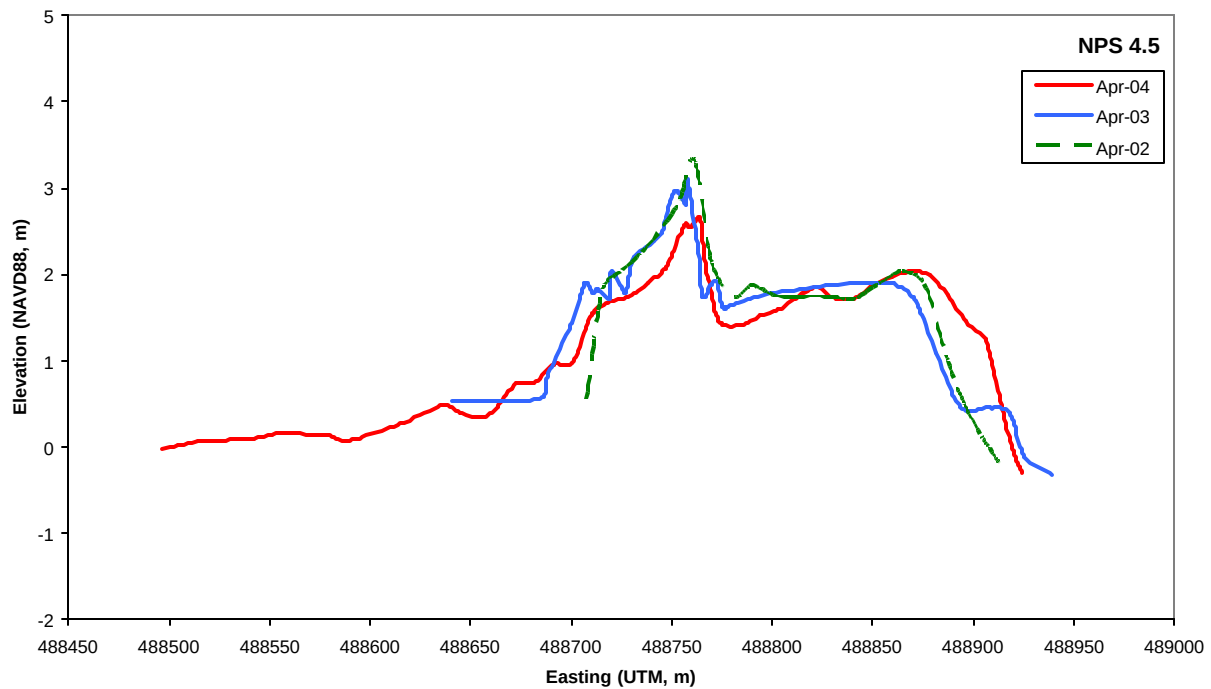


Figure A-8. Survey line NPS 4.5.

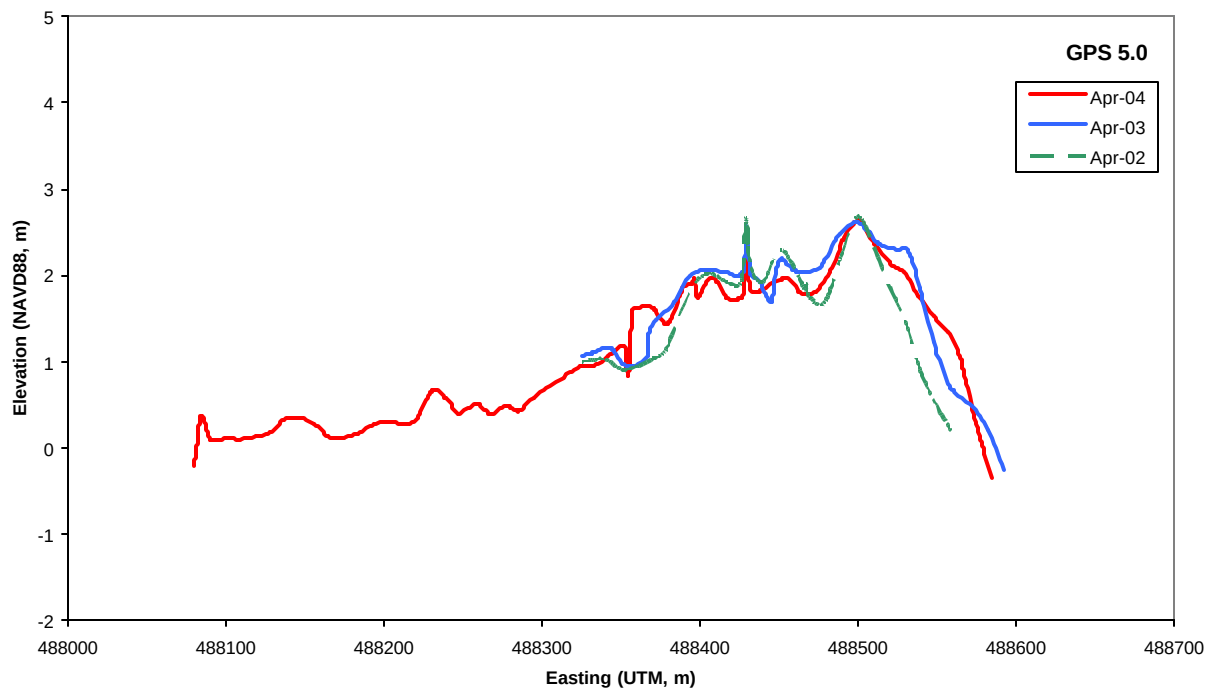


Figure A-9. Survey line GPS 5.0.

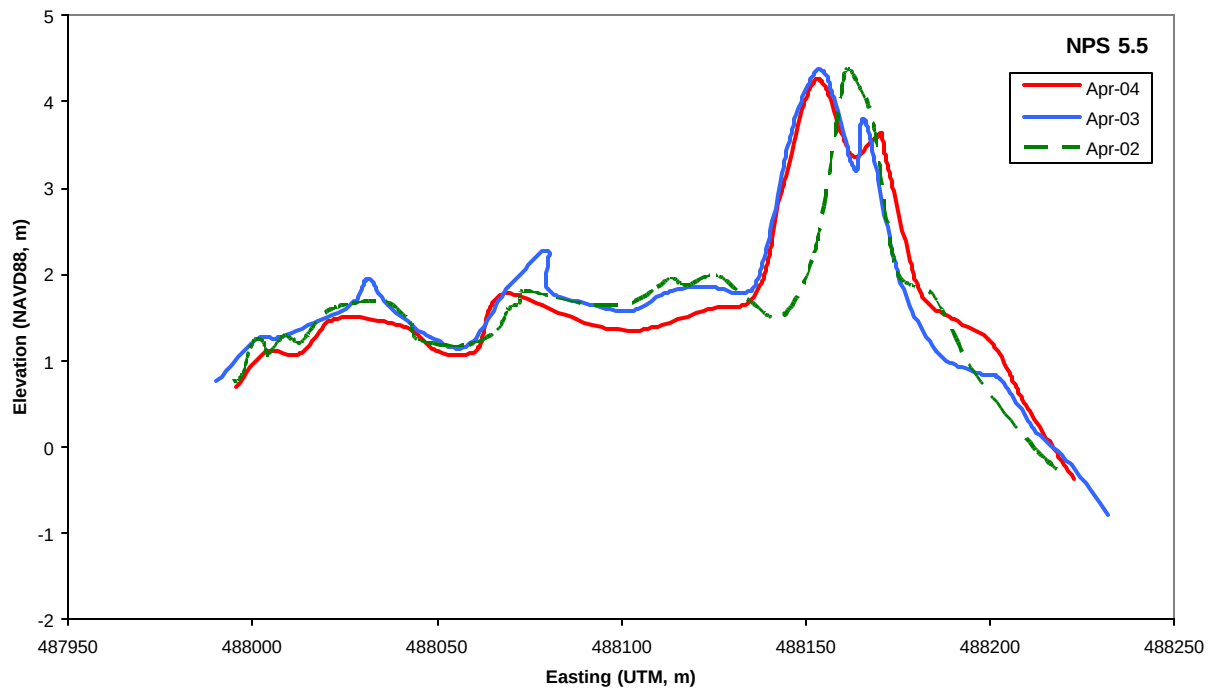


Figure A-10. Survey line NPS 5.5.

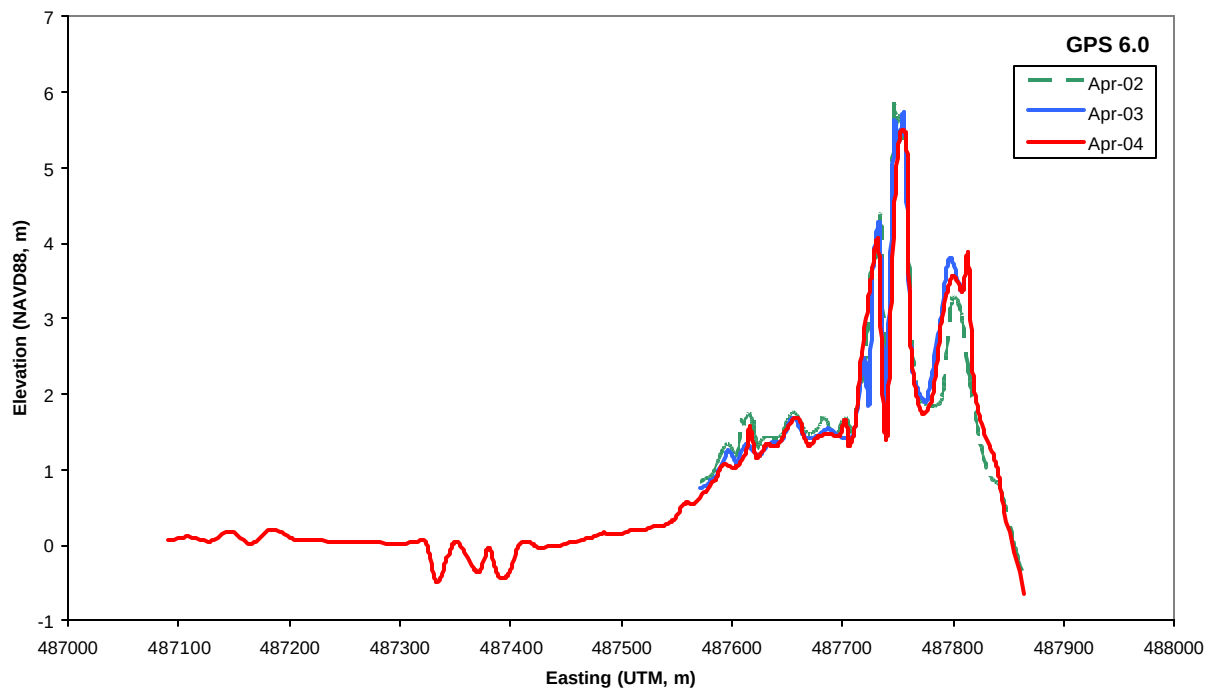


Figure A-11. Survey line GPS 6.0.

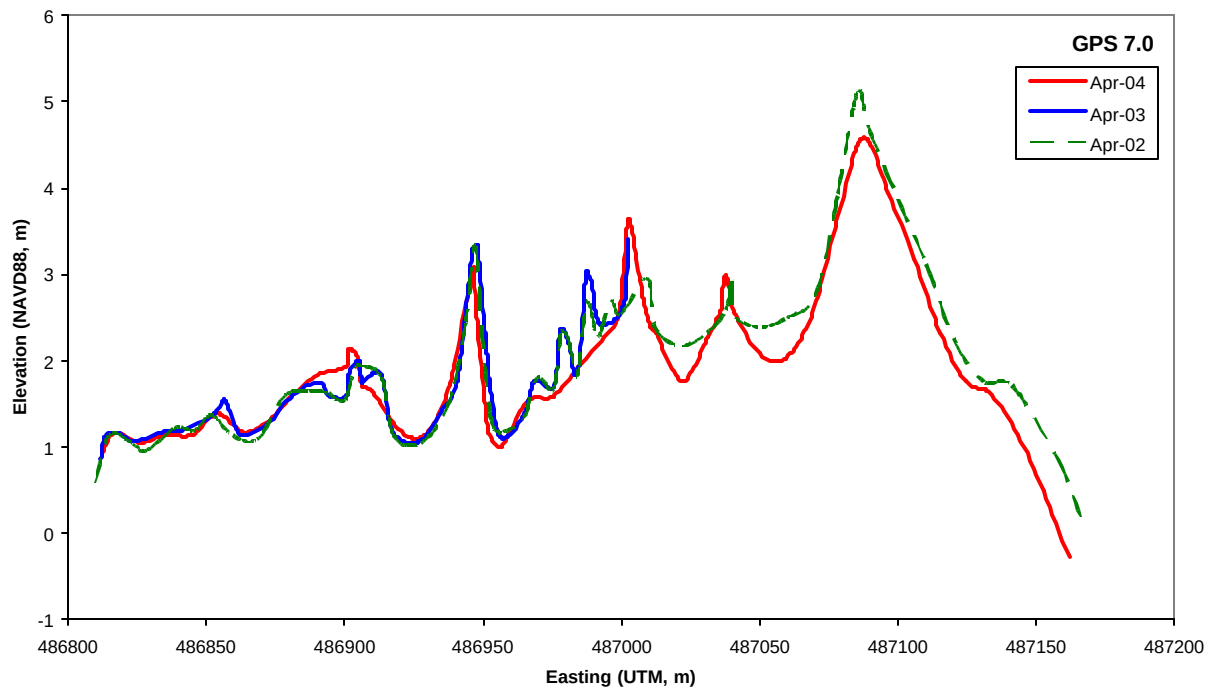


Figure A-12. Survey line GPS 7.0.

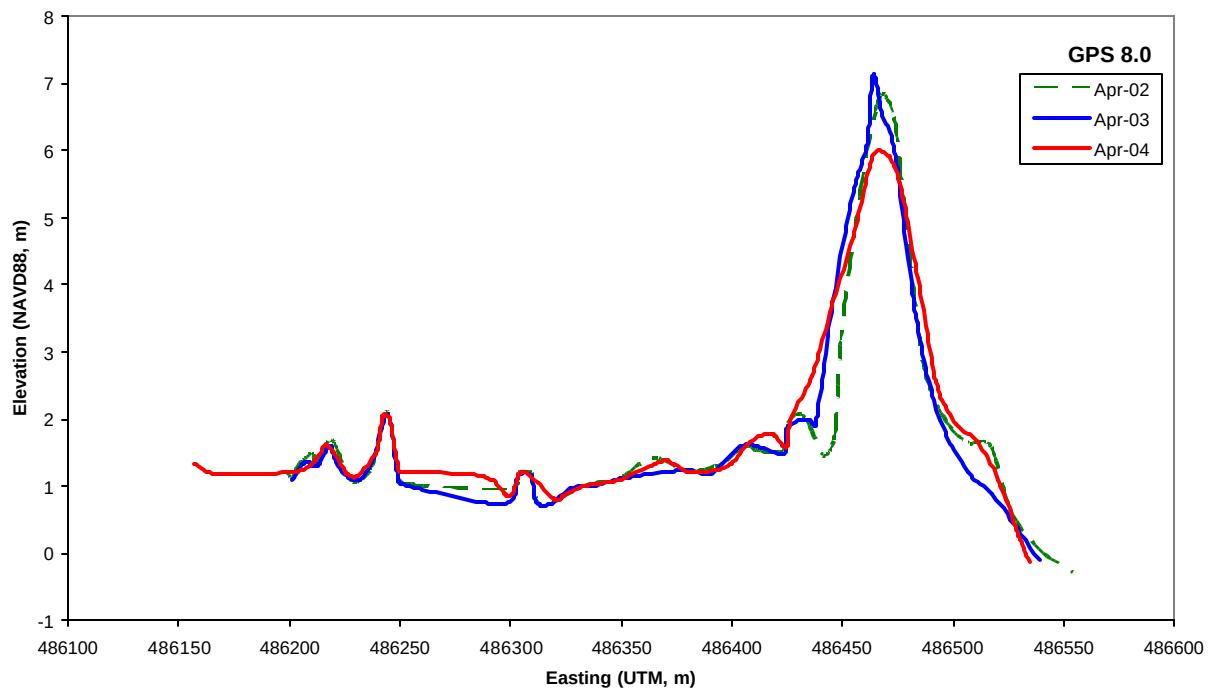


Figure A-13. Survey line GPS 8.0.

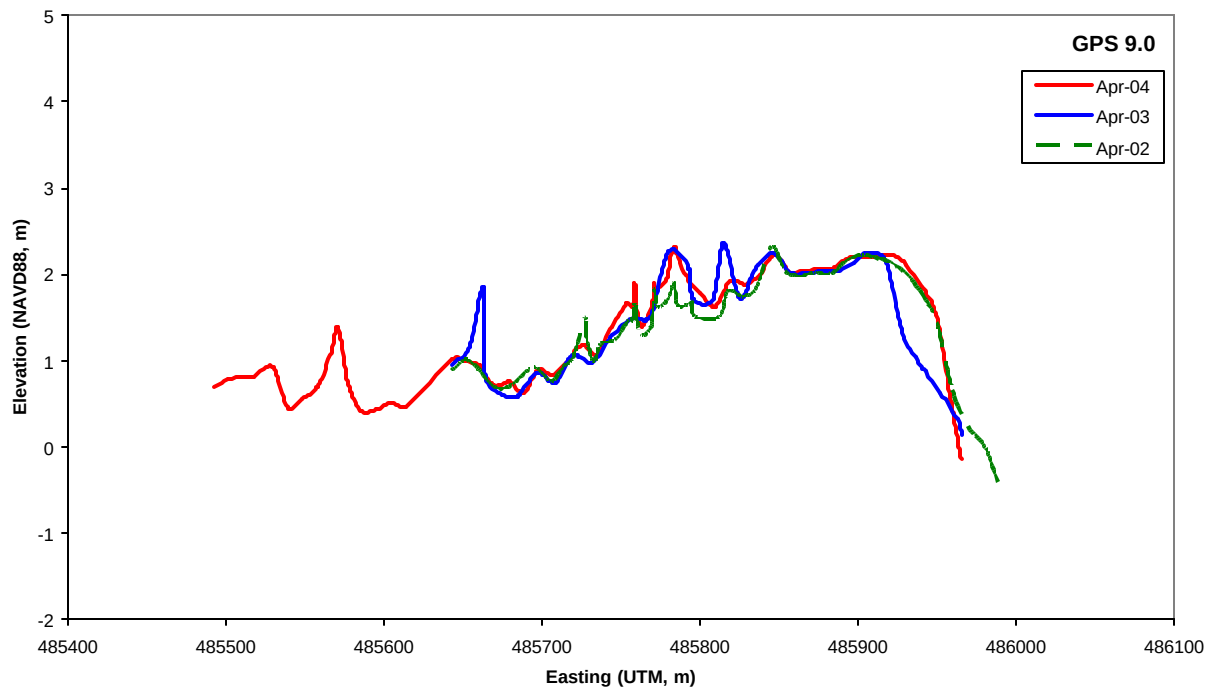


Figure A-14. Survey line GPS 9.0.

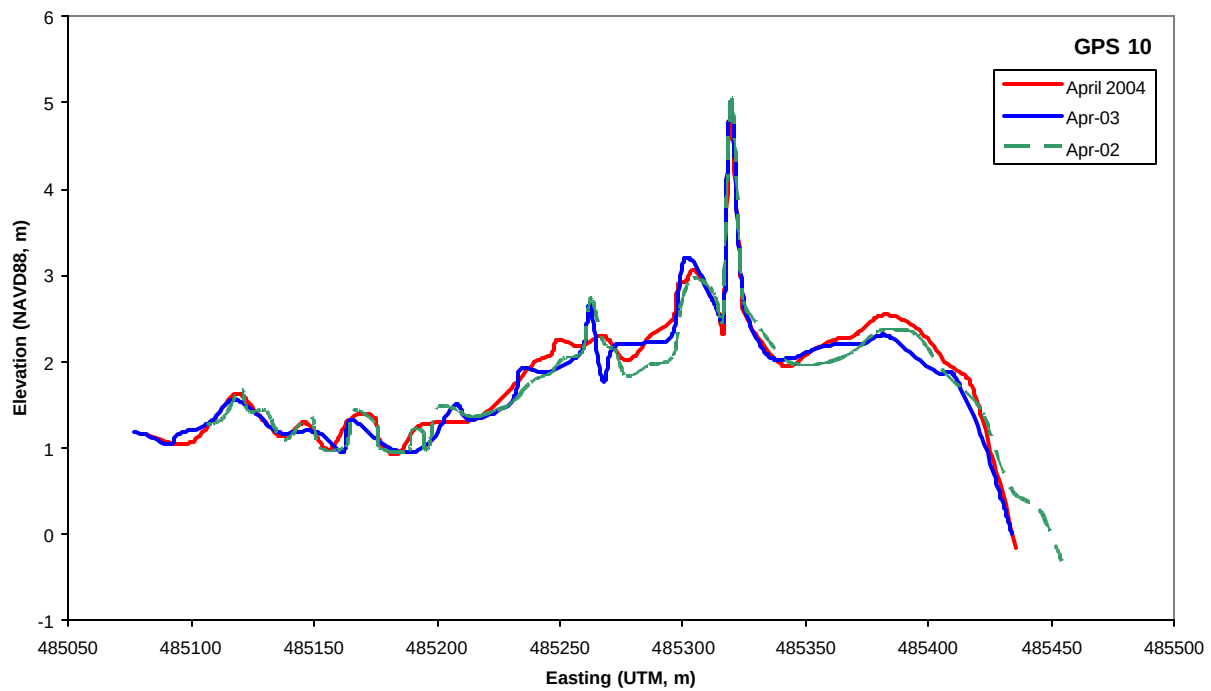


Figure A-15. Survey line GPS 10.0.

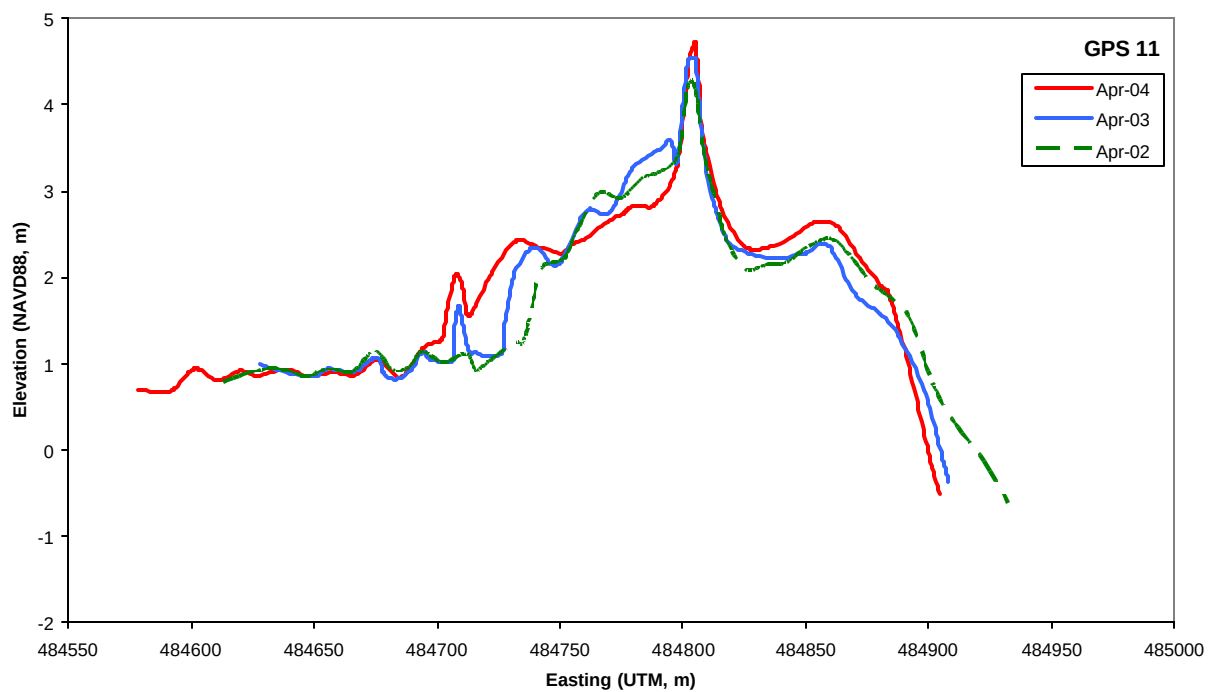


Figure A-16. Survey line GPS 11.0.

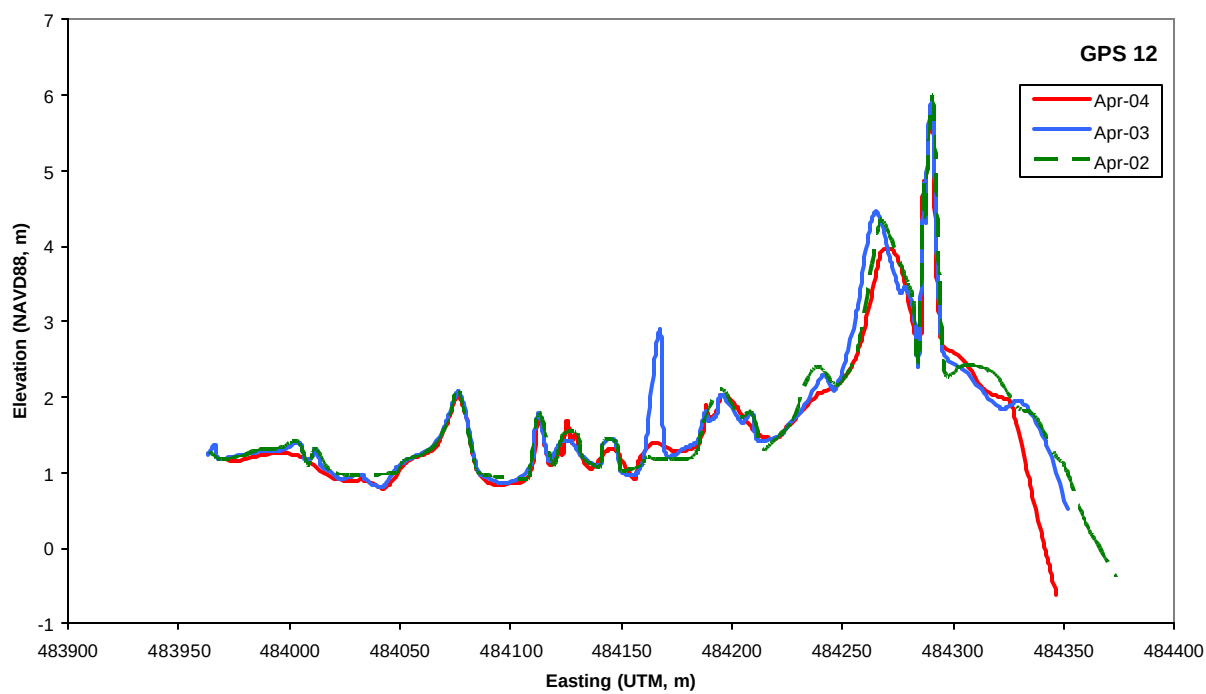


Figure A-17. Survey line GPS 12.0.

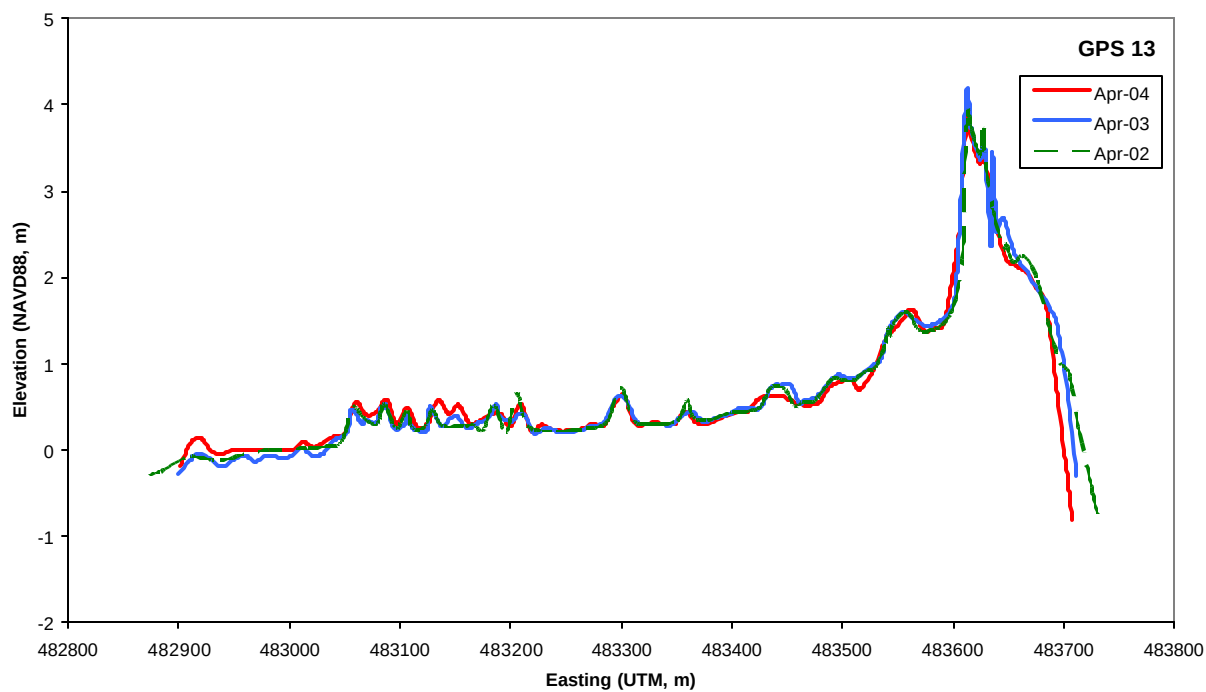


Figure A-18. Survey line GPS 13.0.

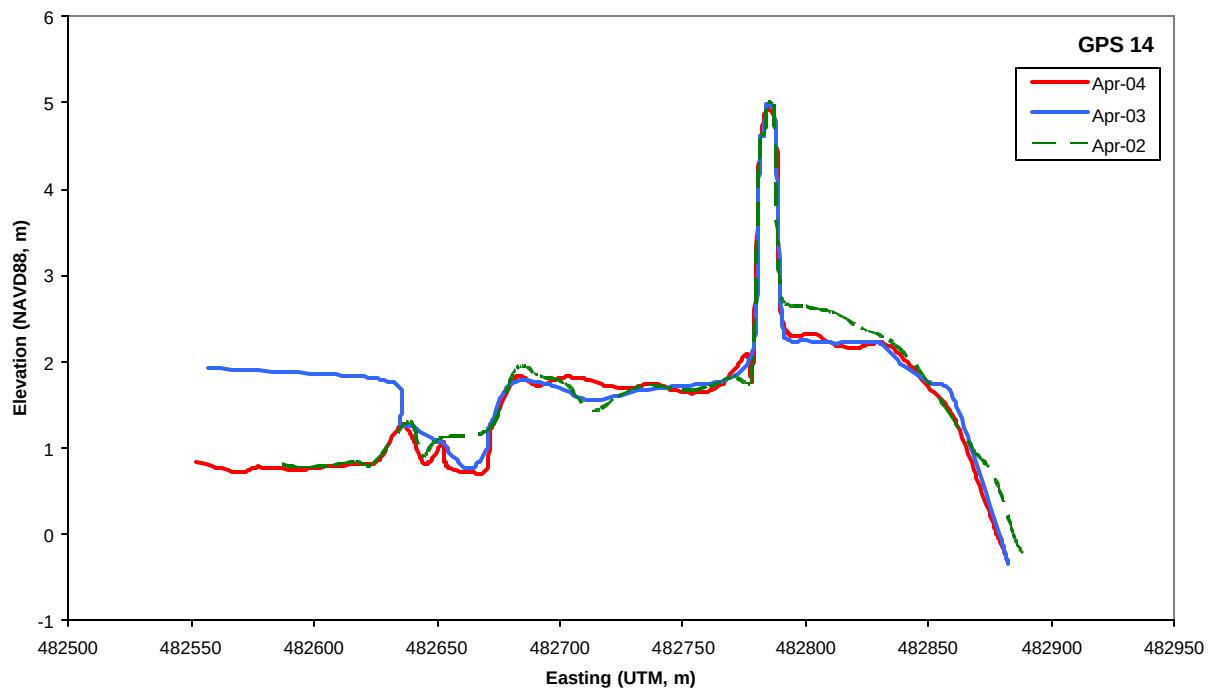


Figure A-19. Survey line GPS 14.0.

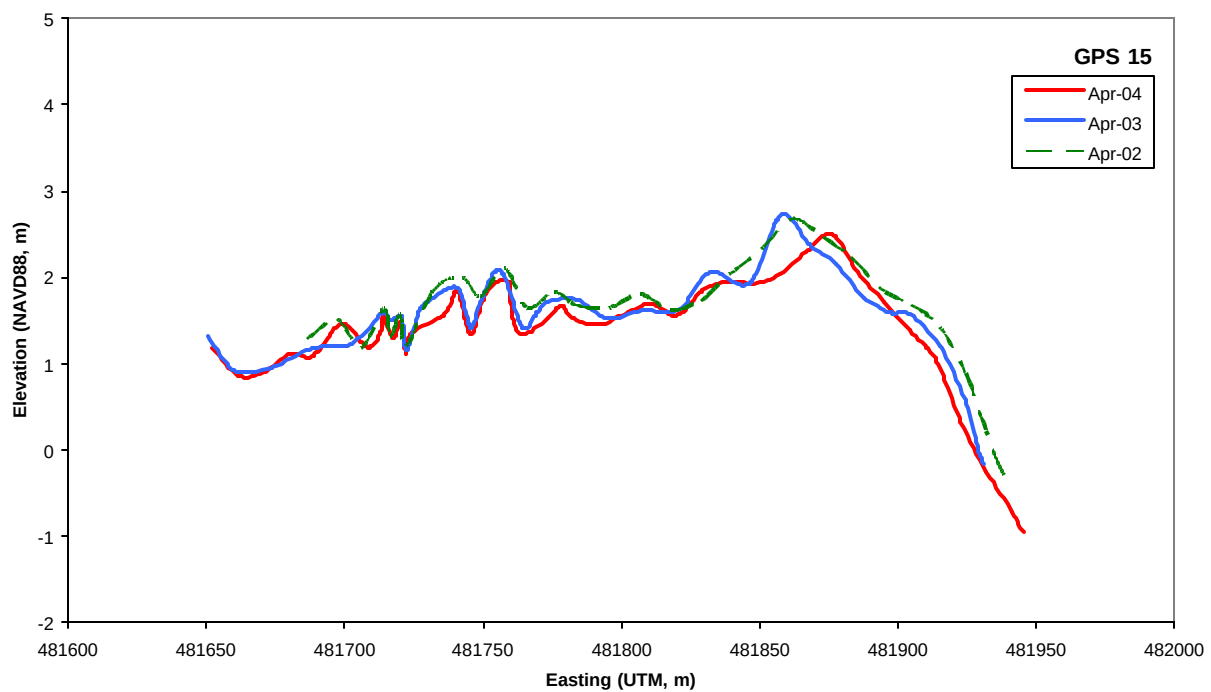


Figure A-20. Survey line GPS 15.0.

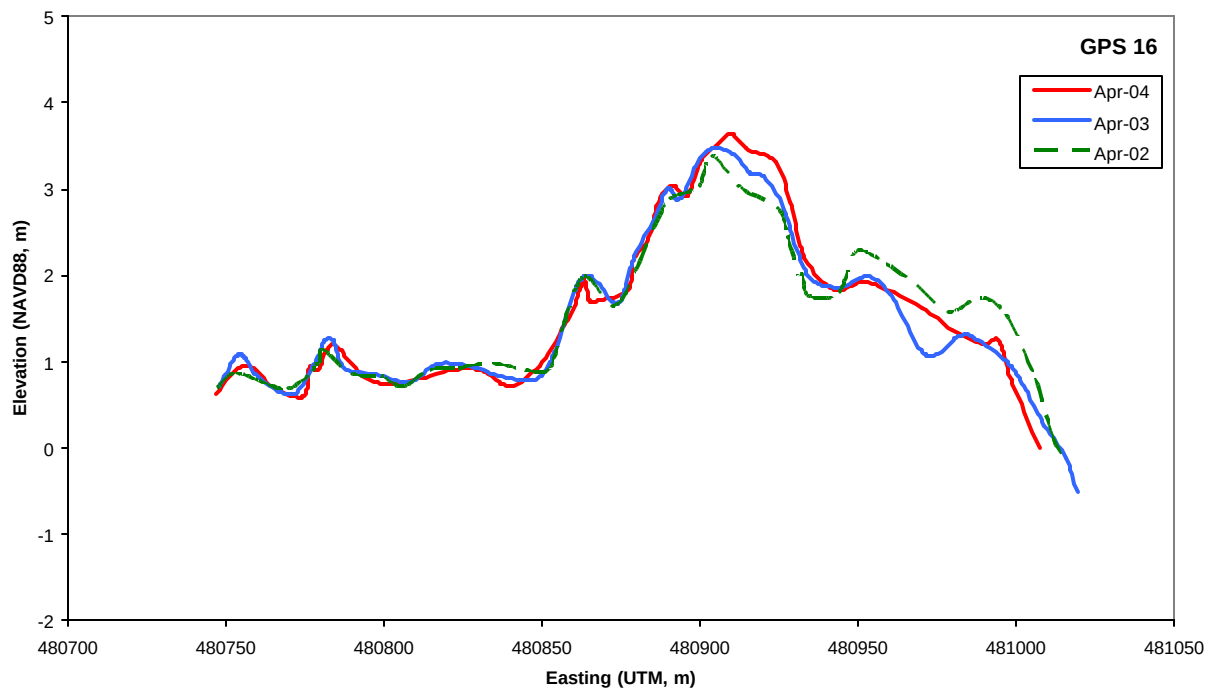


Figure A-20. Survey line GPS 16.0.

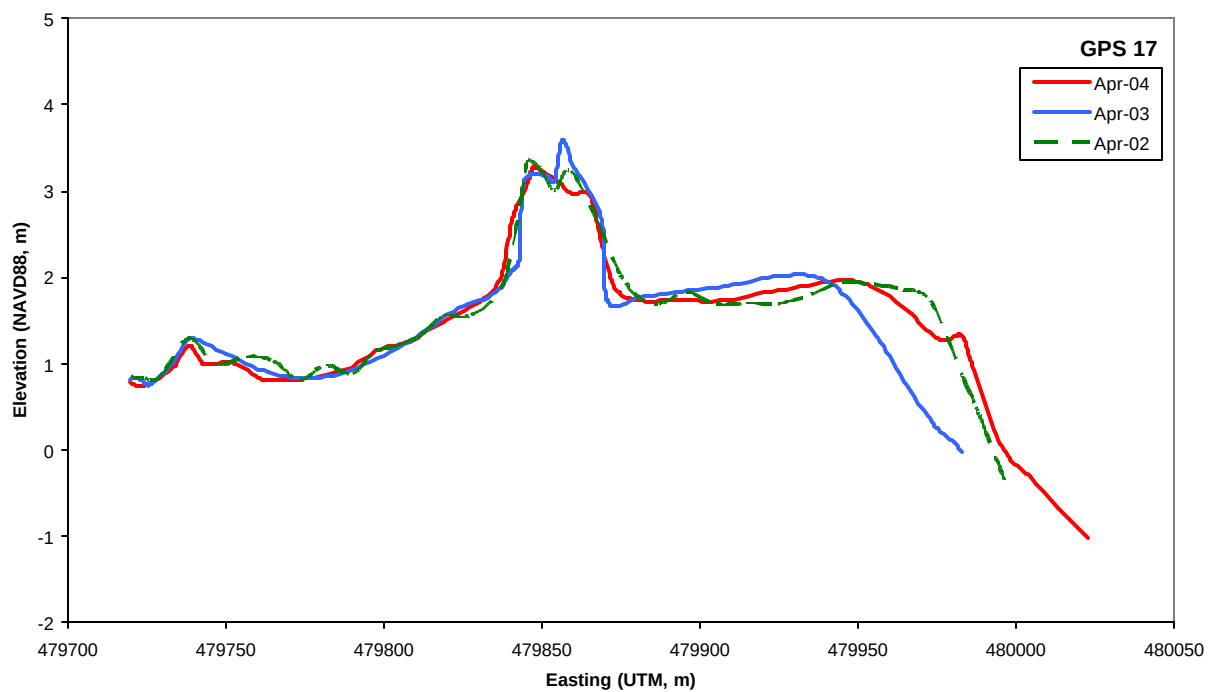


Figure A-21. Survey line GPS 17.0.