2008 BEACH RESTORATION PROJECT
ISLE OF PALMS SOUTH CAROLINA

Monitoring Report No 6
April 2015

Prepared for:

City of Isle of Palms

CSE
COASTAL SCIENCE & ENGINEERING

2008 Isle of Palms Beach Restoration Project

YEAR 6 (2014) MONITORING REPORT

Prepared for:

City of Isle of Palms

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[2386YR3]

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COVER PHOTO: Aerial view of Isle of Palms in October 2014 [Photo by SB Traynum]

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EXECUTIVE SUMMARY

This report presents results of Year 6 beach and inlet monitoring following the 2008 beach restoration project at the Isle of Palms, which was accomplished in May–June 2008 under permit P/N 2007-02631-2IG. Annual surveys are being conducted to track the performance of the project, measure sand volumes remaining, and provide a condition survey of the beach, inlets, and shoals from Dewees Inlet to Breach Inlet.

Year 6 monitoring involved a condition survey in September 2014. These data are compared with pre-project and post-project conditions in the project area (north of 53rd Avenue). Data for remaining areas of the Isle of Palms and Breach Inlet are compared with earlier surveys by CSE and SCDHEC–Office of Ocean & Coastal Resource Management (OCRM). The report includes:

- Shoreline history and summary of the 2008 beach restoration project.
- Important dates of events (Table A).
- Description of the data collection and analysis methods.
- Monitoring results by section of shoreline using seven (7) reaches along the island.
- Nourishment volume remaining within the project limits.
- Identification of local erosion "hot spots."
- Discussion of findings.

The 2008 beach restoration project placed 933,895 cubic yards (cy) of sand from offshore in three reaches between 53rd Avenue and Dewees Inlet. As of September 2014 (~6 years after project completion):

- Reach A (53rd Avenue to Beach Club Villas) has severely eroded along the eastern half of the reach, while the western half has shown more typical erosion. Presently, stations 254–274 contain less sand than the pre-nourishment condition, while stations 224–252 show an average of 44.7 cubic yards per foot (cy/ft) more sand than the pre-nourishment condition. Overall, Reach A shows a net loss of 142 percent of the nourishment volume, although ~85 percent of the fill placed from station 224 to station 258 remains within those fill limits. Reach A lost ~53,000 cy from July 2013 to September 2014.

- Reach B (Mariners Walk Villas to the 18th fairway of Wild Dunes Links Course) retains ~57 percent of the nourishment volume with a loss of ~48,000 cy over the past year. Erosion has been concentrated along the eastern third of the reach (Ocean Club – 18th Hole)

- Reach C (a 1,000-ft length of Dewees Inlet shoreline adjacent to the 17th hole and 18th tee of the Wild Dunes Links Course) retains ~235 percent of the nourishment volume (Fig A), gaining ~16,800 cy over the past year.

Collectively, ~31.8 percent of the nourishment fill remained within the fill limits as of September 2014. Overall, the island gained 30,200 cy (0.8 cy/ft) of sand between July 2013 and September 2014 (Fig B) which is the largest gain observed since the March–September 2010 interval. The beach west of 53rd Avenue gained ~47,500 cy, while the beach east of 53rd Avenue lost ~17,300 cy. Erosion was prevalent near Seascape, Ocean Club, Beachwood East, Dune Crest Lane, 6rd Avenue, and 27th Avenue.

TABLE A. Important dates of events related to the 2008 beach nourishment project and subsequent monitoring.

Milestone	Date	Comment
Beach Condition Survey	Jul 2007	
Pre-Construction Survey	Mar 2008	
Project Construction	May–Jun 2008	934,000 cy placed along 10,200 feet (ft) of shoreline
Monitoring Survey	Mar 2009	93 percent of nourishment volume remained within the fill placement area
Monitoring Survey	Sep 2009	81 percent of nourishment volume remained within the fill placement area
Year 1 Monitoring Report	Dec 2009	
Monitoring Survey	Mar 2010	73 percent of nourishment volume remained within the fill placement area
Monitoring Survey	Sep 2010	72 percent of nourishment volume remained within the fill placement area
Permit Application Submitted	Oct 2010	
Year 2 Monitoring Report	Mar 2011	
Monitoring Survey	Jun 2011	66 percent of nourishment volume remained within the fill placement area
Year 3 Monitoring Report	Nov 2011	
Shoal Management Project	Mar–Apr 2012	Redistribution of 87,700 cy at the northeastern end of the island
Monitoring Survey	July 2012	57 percent of nourishment volume remained within the fill placement area
Year 4 Monitoring Report	Nov 2012	
Monitoring Survey	July 2013	40 percent of nourishment volume remained within the fill placement area
Year 5 Monitoring Report	Dec 2013	
Monitoring Survey	Sep 2014	32 percent of nourishment volume remained within the fill placement area
Shoal Management Project	Nov 14 – Feb 15	Redistribution of 240,000 cy at the northeastern end of the island
Year 6 Monitoring Report	Apr 2015	

A shoal management project was completed as planned in the winter of 2014–2015, transferring ~240,000 cy of sand from harvest areas between 53rd and 56th Avenues, Beach Club Villas II to Shipwatch, and the offshore shoal. Details of that project are not included herein, but will be provided in an independent report. CSE anticipates that some type of remedial measures will be required by the next permit window beginning in November 2015 due to the oncoming shoal still being in Stage 2 of the bypass cycle (not yet fully attached and merging with the shore).

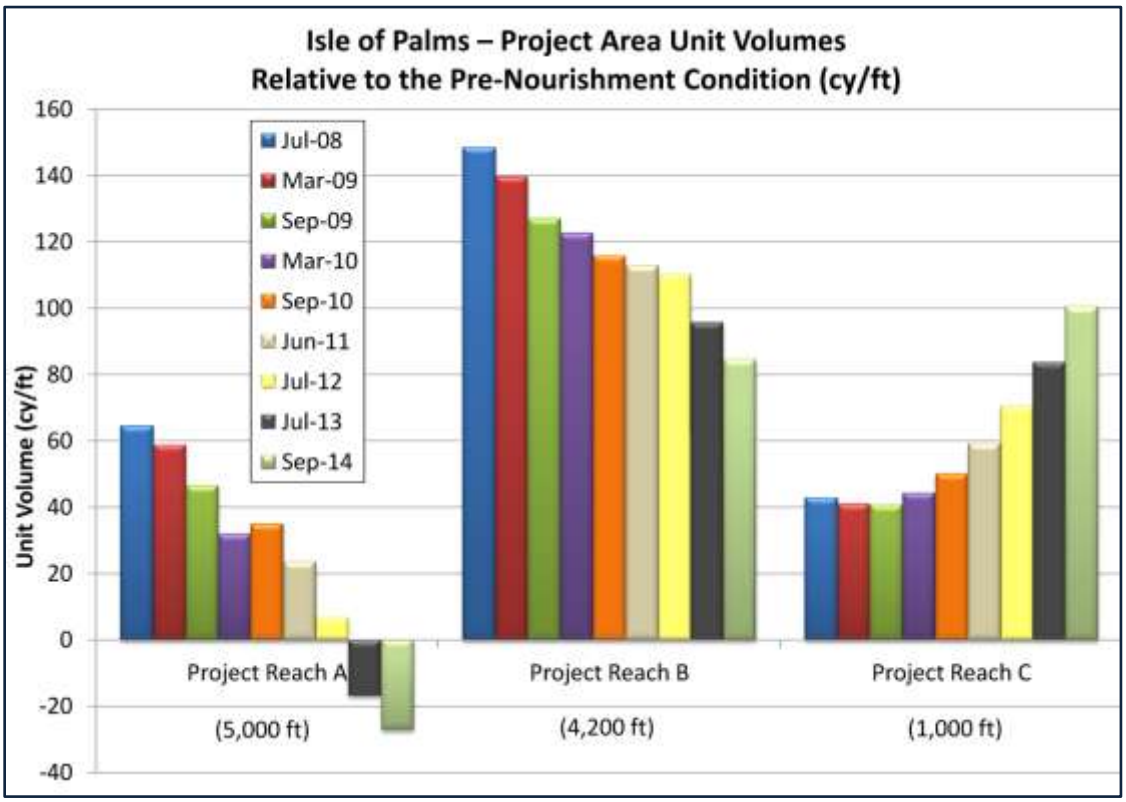

FIGURE A. Percent of nourishment volume remaining in project areas as of September 2014.

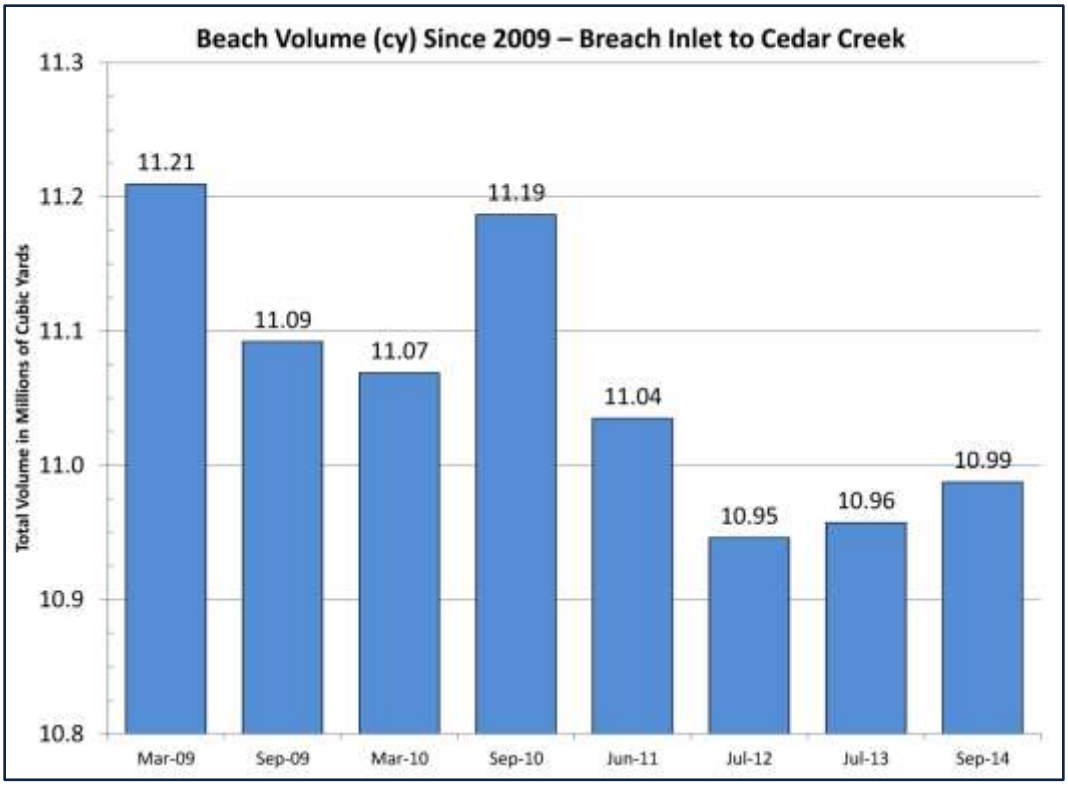

FIGURE B. Total beach volume at Isle of Palms from March 2009 to September 2014. Volume is measured to local closure depth (between −10 ft and −18 ft NAVD).

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1.0 INTRODUCTION

This monitoring report is provided to the City of Isle of Palms by Coastal Science & Engineering (CSE) as part of a three-year agreement for beach monitoring following the 2008 Isle of Palms beach restoration project (P/N 2007-02631-2IG) (CSE 2008). This report details the eighth island-wide data collection after nourishment. It follows submission of the Years 1–4 monitoring reports (CSE 2009, 2010, 2011a,b, 2012, 2013a). Discussions presented herein are based on comparisons of pre-project and post-project data with surveys performed through September 2014.

The analyses presented in this report provide an updated condition of the beach ~6 years after the completion of the 2008 restoration project. This report provides beach profile volumes along the length of the Isle of Palms, including detailed volume changes in the project areas. Ground and aerial photography are included to identify features such as dunes, escarpments, sand texture and color, as well as to give a visual representation of the beach width for comparison with previous and future surveys.

1.1 Setting

Isle of Palms is an ~7-mile-long, southeast-facing, barrier island located ~8 miles east of Charleston, South Carolina. It is bounded by Dewees Inlet and Dewees Island to the northeast and Breach Inlet and Sullivan's Island to the southwest. A feature typical of the central South Carolina barrier islands is the "drumstick" shape (Hayes 1979) produced by the interaction of waves and tides, and formation of prominent ebb-tidal deltas at the inlets. Seaward shoals of each delta produce wave refraction and variable longshore transport rates, which leads to a wider upcoast (northern) end and a relatively narrow downcoast end (Breach Inlet end, Fig 1.1).

The wider end of the island is influenced by shoal bypassing, a process whereby sand is periodically released from the inlet delta and moved onshore through wave action (Fig 1.2). This process occurs at somewhat regular intervals (average interval between events from 1941 to 1997 is 6.6 years, Gaudiano 1998) and contributes to the overall health of the island. However, it also can cause focused erosion in areas adjacent to the shoal attachment zone (Kana et al 1985).

FIGURE 1.1. Isle of Palms is a typical "drumstick" barrier island (after Hayes 1979), where the upcoast end is wider due to sediment accumulation through shoal-bypass events, and the downcoast end usually forms a growing recurve spit. Other examples of drumstick barrier islands along South Carolina are Bull Island, Kiawah Island, and Fripp Island. Zones of sediment transport reversal generally occur in the lee of delta shoals which are situated offshore. Upon shoal attachment to the beach, transport directions in the vicinity of the shoal switch, spreading sand away from the attachment point (see for example – Fig 1.2).

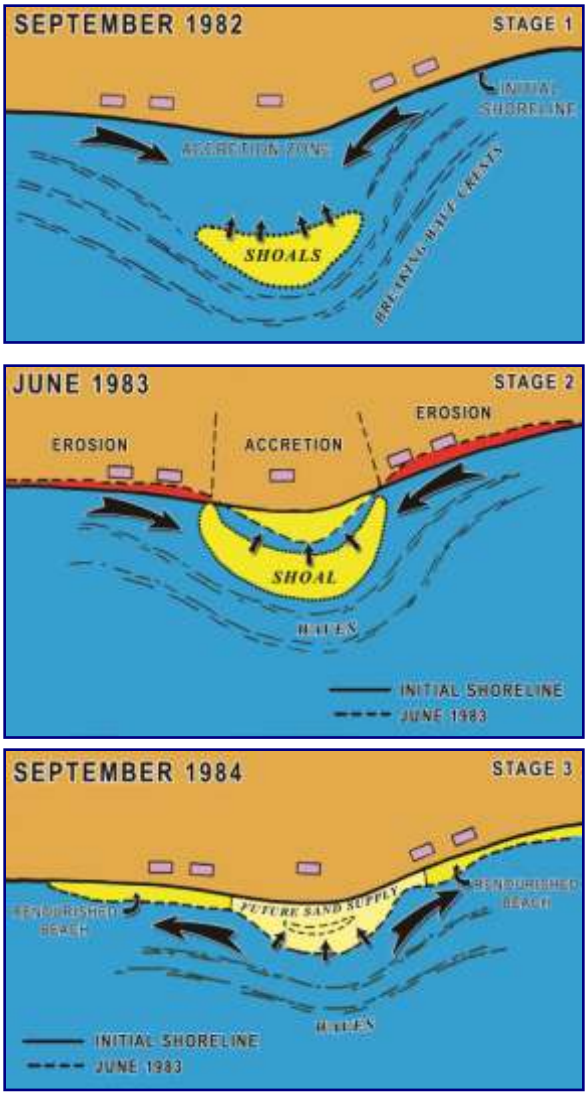

FIGURE 1.2.

[LEFT]
Schematic of the shoal-bypass cycle originally modeled from a bypass event at IOP. During Stages 1 and 2 of the cycle, accretion in the lee of the shoal is accompanied by erosion on either side of the attachment site. (After Kana et al 1985)

[RIGHT]
Shoal-bypass event at the northeastern end of IOP. The upper photo shows a shoal in Stage 1 of the bypass cycle in March 1996. The middle image, taken in 1997, shows that the shoal is beginning to attach to the beach and is in Stage 2 of the bypass cycle. The lower image (from December 1998) shows the shoal completely attached (Stage 3), and sand has spread to previously eroded areas.

The long-term accretion trend at Isle of Palms is a direct result of shoal bypassing at Dewees Inlet. Numerous episodic events have deposited sand on the northeastern end of the island (Gaudiano 1998). The annual average sand gain from shoal-bypass events is ~100,000 cubic yards/yr (cy/yr); however, ~120,000–130,000 cy/yr are typically lost to downcoast areas each year, leaving a net sand deficit of ~20,000–30,000 cy/yr at the northeastern end (CSE 2007). A more detailed explanation of the coastal processes and erosion history of Isle of Palms is provided in CSE (2007, 2008, 2009).

The shoal-bypassing event which led to the 2008 project appears to have begun around 2003. By 2004, some areas (eg – Port O'Call) experienced 150 ft of beach recession in one year (ATM 2006). In February 2007, exposed bars extended nearly one-half mile offshore around Beach Club Villas and the Wild Dunes Property Owners beach house (Fig 1.3). The southern part of the attaching shoal was already in Stage 3 with some sand moving south to nourish other parts of Isle of Palms; the northern side remained in Stage 2. As Figure 1.3 shows, all properties north of Beach Club Villas had lost their dry-sand beach by then. To protect buildings, property owners placed ~5-gallon-sized sand bags along the scarped dune. These bags were quickly destroyed or washed away, and property owners replaced them with large (1 cy) sand bags in front of buildings for protection. Erosion continued into 2008, eventually claiming half of the signature 18th hole of the Wild Dunes Links Course and leaving no beach (even at low tide) in front of several properties.

FIGURE 1.3.

[UPPER]

February 2007 oblique aerial image of the northeastern end of IOP showing the approaching shoal in Stage 2 of the bypass cycle.

Note loss of dry beach and various shore-protection measures from Mariners Walk Villas to the 18th fairway (red-outlined arrows – focused erosion).

[LOWER]

Small, 5-gallon-sized sand bags (left) and large 1 cy-sized sandbags (right) installed by property owners to temporarily offer protection to buildings.

Prior to the 2008 project, little to no beach was present at low tide near the Ocean Club condominiums.

Left image courtesy of Coastal Carolina University Beach Erosion Research and Monitoring Program.

1.2 The 2008 Isle of Palms Beach Restoration Project

The 2008 beach restoration project was designed to add ~850,000 cy of sand to ~10,200 linear feet of beach (Fig 1.4). The fill was to be placed in three reaches. Reaches A and B were located along the oceanfront spanning from ~53rd Avenue to the 18th fairway of the Wild Dunes Links Course, separated by an accretion zone associated with the shoal-bypassing event. Reach C represented a portion of the Dewees Inlet shoreline. Roughly 2,600 linear feet of Reach A bordered publically accessible areas of the City. The remaining fill bordered the Wild Dunes community. Design fill volumes for full sections (excluding tapers) were 75 cy/ft in Reach A, 140 cy/ft to 180 cy/ft for Reach B, and 27 cy/ft in Reach C.

The City of Isle of Palms entered into a contract with Weeks Marine of Covington (LA) for placement of 780,000 cy of sand along 9,200 linear feet of beach. Two change orders increased the total volume to 847,400 cy over 10,200 ft of beach and added a fill section to the Dewees Inlet shoreline. The original bid was for $7,914,100, and the total cost after the change orders was $8,402,090.

The final volume added to the beach calculated from Weeks Marine's surveys was 933,895 cy, which was ~10 percent greater than the design volume of 847,400 cy. The overage of 86,495 cy was not a pay quantity as stated in the contract; therefore, the City was only required to pay for the contract volume of 847,400.

FIGURE 1.4. Project map of the 2008 IOP restoration project. The project was designed to nourish sections of the beach and provide sufficient sand to offset losses associated with long-term erosion as well as an ongoing shoal-bypass event. Borrow areas were located 2-3 miles offshore. Area D was not dredged.

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2.0 METHODS

Monitoring efforts for the present report were performed in September 2014. Changes in the volume of sand in the active beach zone were evaluated by obtaining topographic and bathymetric data along shore-perpendicular transects at established locations along the beach (herein referred to as the baseline) (Fig 2.1). The present baseline spans from the center of the Breach Inlet Bridge (station 0+00) and continues to Cedar Creek spit at the northeastern end of the island (station 376+00). The monitoring baseline overlaps the baseline used in the project beginning at 53rd Avenue which was the location of project station 0+00 (that station is now station 222+00). Stationing relates to the distance along the shore with the number before the "+" symbol representing 100 feet (ft). Therefore, station 36+00 is 3,600 ft from station 0+00. The baseline is generally set landward of the present active beach to allow for future erosion/accretion.

Topographic data were collected via RTK-GPS (Trimble™ R8 GNSS), which provides position and elevation measurements at centimeter accuracy. Beach profiles were obtained by collecting data at low tide along the dunes, berm, and active beach to low-tide wading depth. Overwater work was then performed at high tide to overlap the land-based work (Fig 2.2) and was collected with RTK-GPS coupled with an Odom CV100™ precision echo sounder mounted on CSE's survey vessel, the *RV Southern Echo*. Profiles were collected from the most landward accessible point in the dune system to a minimum of 1,500 ft from the baseline. Profiles in the project area extended up to 6,000 ft offshore to encompass the shoals associated with Dewees Inlet. Alongshore spacing of the profiles ranged from 200 ft to 1,000 ft with the more closely spaced profiles in the project area and along Breach Inlet. Comparative profiles from CSE's monitoring efforts are shown in Appendix A. The complexity of areas impacted by inlets requires more detailed analysis (closer profile spacing) to fully incorporate volume changes associated with shoal-bypassing events and inlet migration.

To better understand regional sand volume changes, seven reaches were defined along Isle of Palms. By combining several profiles into a reach, it is easier to identify overall sediment gains and losses over large portions of the beach. In the project area, the reaches differ from reaches used during construction so as to encompass areas where no work was performed. [Some sections of this report may refer to volume changes within constructed project reaches and will be clearly indicated.]

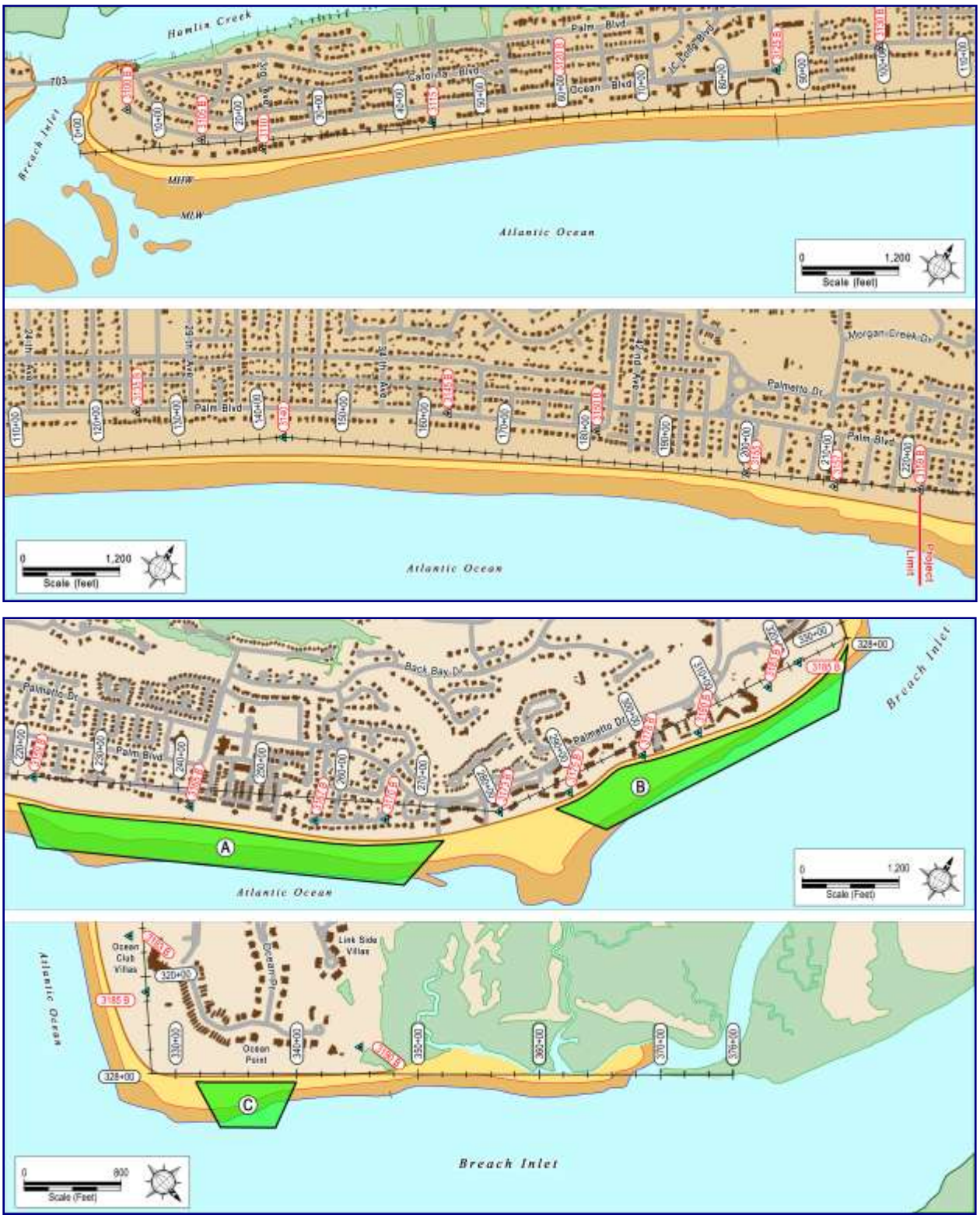


FIGURE 2.1 CSE established a monitoring baseline to encompass the length of IOP. The baseline between stations 222+00 and 376+00 corresponds to the baseline used in the 2008 project (project stations 0+00 through 174+00). Red labels indicate locations of OCRM survey monuments. Green areas show limits of the 2008 nourishment project. CSE profile sections are oriented perpendicular to the baseline while OCRM profiles are perpendicular to the local beach azimuth. [CSE and OCRM azimuths are only significantly different at Breach Inlet.]

FIGURE 2.2. CSE beach monitoring methods include land-based data collection using Trimble™ RTK GPS from the backshore to low-tide wading depth and over-water work using RTK GPS linked to a precision echosounder aboard CSE's survey boat (RV *Southern Echo).*

The reaches used for monitoring purposes are shown in Figure 2.3 and are defined as follows:

Reach 1	0+00 to OCRM 3115	Breach Inlet to 6th Avenue
Reach 2	OCRM 3115 to OCRM 3125	6th Avenue to Sea Cabins Pier
Reach 3	OCRM 3125 to OCRM 3140	Sea Cabins Pier to 31st Avenue
Reach 4	OCRM 3140 to 222+00	31st Avenue to 53rd Avenue
Reach 5	222+00 to 280+00	53rd Avenue to Wild Dunes Property Owners Beach House
Reach 6	280+00 to 328+00	Wild Dunes Property Owners Beach House to Dewees Inlet
Reach 7	330+00 to 370+00	Dewees Inlet Shoreline

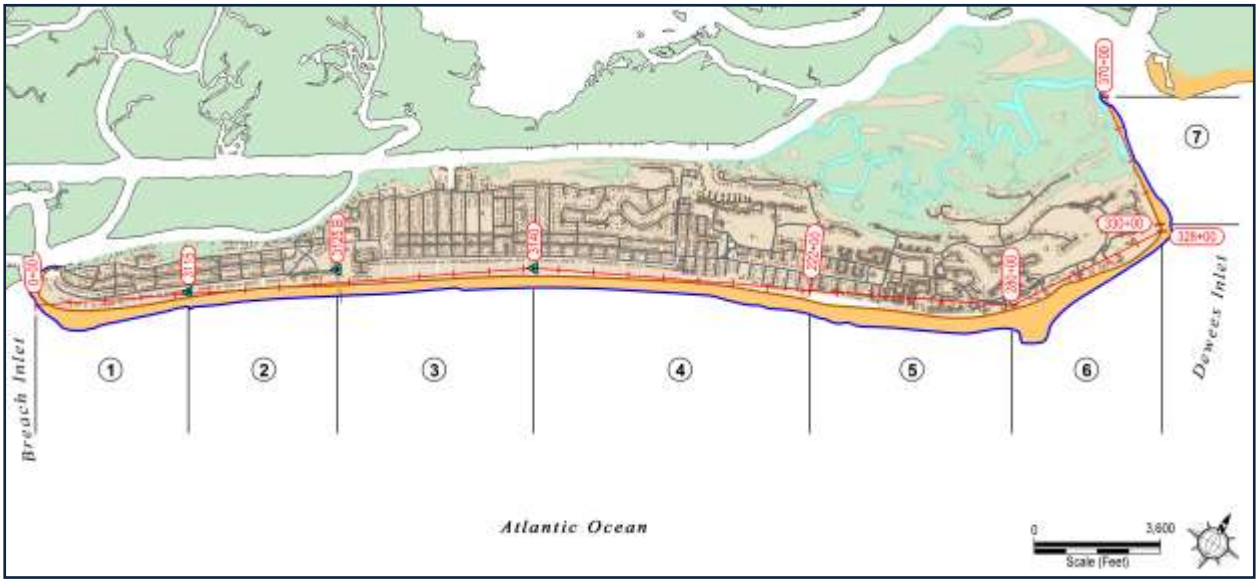


FIGURE 2.3. Location map of the reaches used in post-project monitoring at Isle of Palms. The 2008 beach restoration project occurred in subareas within Reaches 5, 6, and 7.

To determine changes in beach volume along Isle of Palms, beach profile data were entered into CSE's in-house custom software, Beach Profile Analysis System (BPAS), which converts 2D profile data in x–y (distance–elevation) format to 3D volumes. The software provides a quantitative and objective way of determining ideal minimum beach profiles and how the sand volume per unit length of shoreline compares with the desired condition. It also provides an accurate method of comparing historical profiles—as the volume method measures sand volumes in the active beach zone rather than extrapolating volumes based on single-contour shoreline position (ie – from aerial photography). Unit-volume calculations can distinguish the quantity of sediment in the dunes, on the dry beach, in the intertidal zone to wading depth, and in the remaining area offshore to the approximate limit of profile change (closure depth).

Figure 2.4 depicts the profile volume concept. The reference boundaries are site-specific, but ideally encompass the entire zone over which sand moves each year.

Sand volume was calculated between the primary dune and between −10 ft and −18 ft NAVD. The lower calculation limit was site-specific, as profiles in the center of the island and along Dewees Inlet generally have deeper closure depths than areas in the unstable inlet/shoal zones. Comparative volumes and volume changes were computed using standard procedures (average-end-area method, in which the average of the area under the profiles computed at the ends of each cell is multiplied by the length of the cell to determine the cell's sand volume). Certain adjustments were made to account for changes in the baseline direction and for volumes at the turn in the baseline at Dewees Inlet.

Sand volumes for offshore areas were calculated from digital terrain models (DTMs) produced from MATLAB and AutoCAD® Civil 3D®. DTMs are digital 3D representations of the topography and bathymetry of an area and are useful for calculating changes in contour positions and calculating sediment volumes. Position data were entered into software as x–y–z coordinates and were processed to provide cross-section profiles and volumes. DTMs from the 2014 data collections were compared with earlier collections (pre-project and post-project) to determine changes in shoal positions and volumes. Color contour maps were also produced from the DTMs.

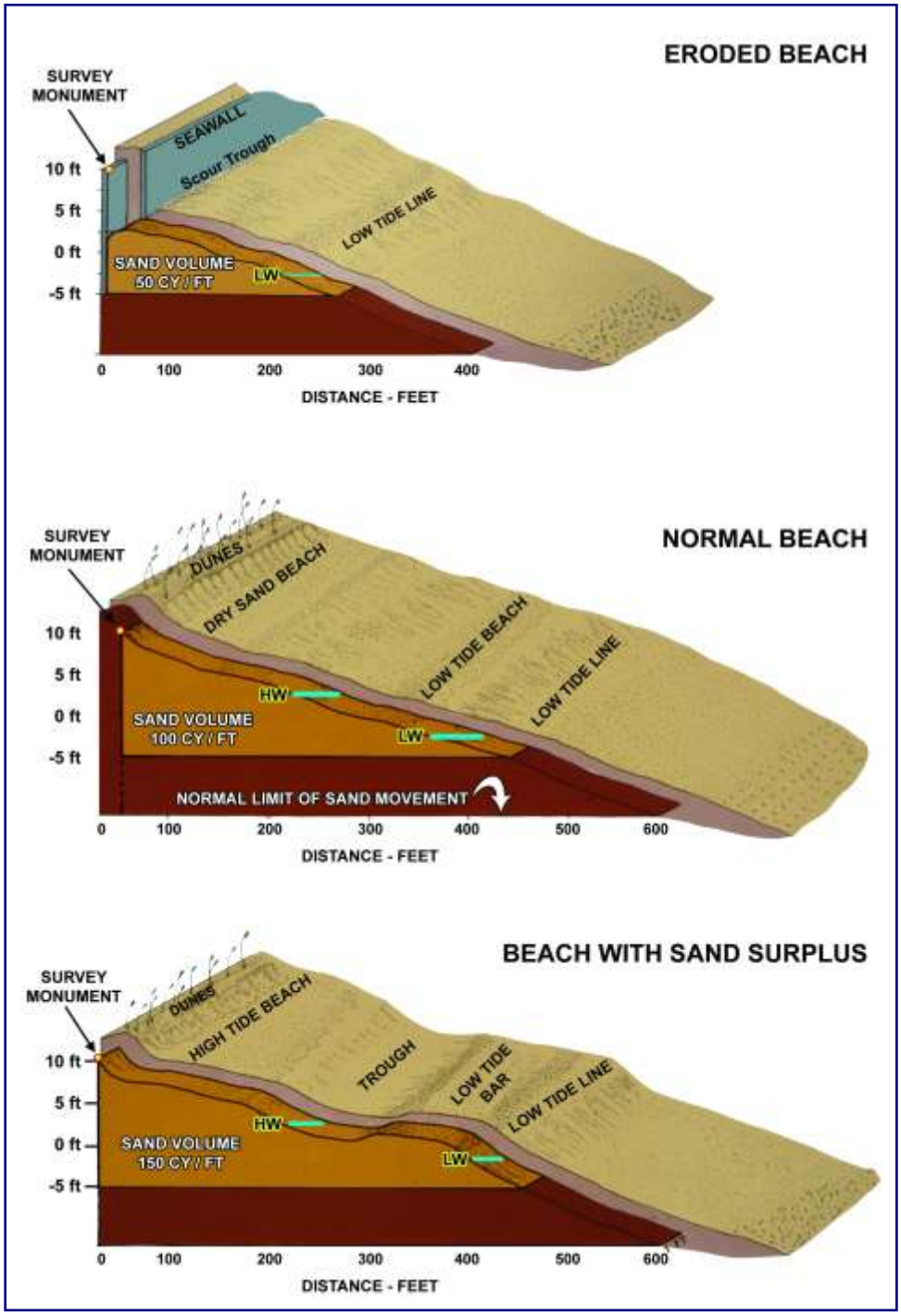


FIGURE 2.4. Calculation of unit-width profile volumes is a means of comparing the condition of one section of beach with another. Profile volumes are the amount of sand contained in a one-foot length of beach between specified elevations. [After Kana 1990]

3.0 RESULTS

3.1 Beach Condition in Monitoring Reaches

The results of the 2014 monitoring survey show that the island gained ~30,200 cy (0.8 cy/ft) of sand from July 2013 to September 2014. Reaches 2, 5, and 6 were erosional; however, Reaches 5 and 6 lost less sand than the previous year (continuing the trend from 2012–2013). Reach 1 (near Breach Inlet) gained nearly all of the sand lost during the prior year (~55,000 cy) while portions of Reach 2 (near 6th Avenue) eroded significantly. Reaches 3 and 4 were fairly stable, gaining ~3,000 and 13,500 cy (respectively), although localized erosion was observed near 29th–30th Avenues and 47th–48th Avenues. Reaches 5 and 6 showed the least amount of volume losses since 2009; however, localized areas were highly erosional. Reach 7 continued its accretional trend observed since 2008. Volume change data for each monitoring station and reach are given in Figure 3.1, and Table 3.1a,b and Table 3.2.

Previous studies have demonstrated that sand tends to move away from shoal-attachment zones in both directions (Kana et al 1985, Kana & Gaudiano 2001). This is apparent from the results illustrated in Figure 3.1. Note the diminishing volume of sand in Reach 5 and Reach 6, and the gain of sand in Reaches 2, 3, 4, and 7 since project completion. Reach 5 has fed sand to the south(west), nourishing most of the island, while losses in Reach 6 have fed sand to the Dewees Inlet shoreline (Reach 7). Sand transport along Isle of Palms is not uniformly from “north to south” but rather occurs in complex patterns which are linked to the stage of “shoal bypassing” and the proximity to inlet channels. Temporary erosion observed in 2011–2013 in Reach 1 appears to be related to changes occurring in the delta of Breach Inlet.

The following sections describe detailed volume changes within each reach and discuss changes to the inlet deltas.

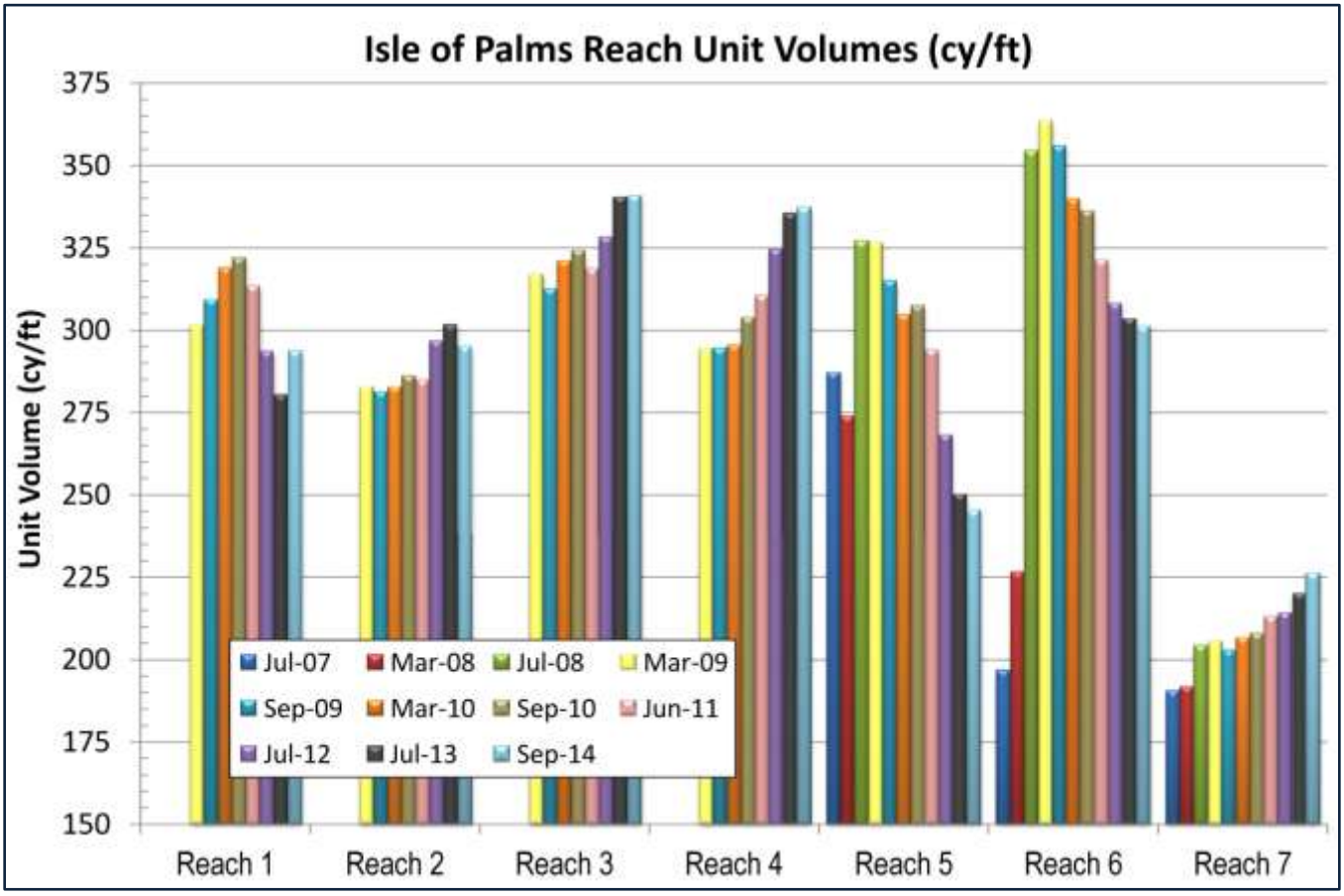


FIGURE 3.1. Average unit-width volumes for each monitoring reach at Isle of Palms. See Figure 2.3 for reach boundaries. Unit volumes were calculated from the primary dune to a profile-specific depth, generally between −9 ft and −13 ft NAVD for the beachfront. Nourishment occurred prior to the July 2008 data collection in Reaches 5, 6, and 7. Design-fill unit volumes for full sections were ~75 cy/ft in Reach 5, ~140-180 cy/ft in Reach 6, and ~27 cy/ft in Reach 7. See Figure 2.1 for beach nourishment locations.

TABLE 3.1a.

Profile unit-width volumes for each monitoring station at Isle of Palms. Nourishment occurred between stations 224 to 274 and stations 286 to 340 prior to the July 2008 data collection.

Volumes are calculated between the approximate crest of the primary dune and the indicated "elevation lens" depth. Nourishment areas are highlighted in blue (project reach A), green, (project reach B), and yellow (project reach C).

As additional surveys are completed, calculation limits may change to better encompass volume changes. This results in small differences in reported volumes between the present and earlier reports.

Reach	Line	Elevation Lens (ft NAVD)	Distance to Next (ft)	Unit Volume (cy/ft)								
				Mar-08	Jul-08	Mar-09	Sep-09	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14
Reach 1	3100	-13	0			371.4	371.4	390.6	-	333.4	386.2	378.1
	3105	-11	0			541.3	541.3	548.6	515.3	448.0	492.4	511.9
	0	-10	400			211.7	141.0	212.3	227.1	224.2	147.5	168.2
	4	-10	400			340.5	309.3	343.4	314.9	296.7	259.0	277.6
	8	-10	400			326.5	344.8	333.1	340.3	306.9	283.9	320.3
	12	-10	400			396.0	432.5	430.4	396.7	358.7	380.7	399.1
	16	-10	400			350.0	389.4	382.6	357.8	300.9	331.6	357.2
	20	-10	270			271.7	317.3	317.4	303.1	265.7	244.6	283.8
	3110	-11	730			295.4	311.6	323.5	316.3	292.4	270.7	286.1
	30	-12	1000			275.9	276.9	300.9	301.8	290.9	276.9	280.2
	40	-12	390			261.2	261.3	272.4	270.2	276.1	265.6	252.4
Reach 2	3115	-12	610			294.4	288.1	293.0	293.0	308.0	297.3	279.5
	50	-12	1000			293.2	296.7	305.3	298.7	307.0	302.4	283.6
	60	-12	1000			265.6	269.5	274.7	274.7	286.2	287.9	279.5
	70	-12	1000			284.1	282.7	280.1	284.9	297.0	307.9	302.5
	80	-12	670			276.3	265.7	274.9	270.5	283.2	298.5	300.5
Reach 3	3125	-12	330			312.4	308.1	314.0	312.1	326.3	333.9	347.9
	90	-13	1000			300.9	292.5	302.0	303.1	316.4	322.3	336.5
	100	-13	1000			311.1	304.4	324.0	315.0	320.8	329.9	342.9
	110	-13	1000			307.2	306.8	316.5	309.6	321.6	331.5	332.3
	120	-13	500			330.4	323.6	336.6	330.6	349.0	355.1	349.9
	3135	-12	500			315.4	314.3	318.6	313.1	322.1	341.3	325.4
	130	-13	1000			298.9	294.1	300.9	297.5	299.7	324.3	306.9
	140	-13	290			371.1	367.3	383.5	376.6	382.5	397.6	399.7
Reach 4	3140	-12	710			296.0	292.4	305.4	299.0	298.0	312.1	319.2
	150	-13	1000			311.5	299.5	309.7	311.3	313.0	330.1	337.9
	160	-13	290			297.8	284.6	283.1	291.6	305.0	316.3	328.2
	3145	-12	710			268.2	263.7	249.2	263.8	284.6	289.3	307.9
	170	-13	1000			292.5	291.8	293.4	289.8	317.0	335.4	339.3
	180	-12	150			277.7	275.7	293.6	295.4	312.0	331.2	332.8
	3150	-12	850			289.6	295.3	315.0	325.0	343.3	349.5	356.4
	190	-12	1000			280.6	275.9	293.7	310.8	327.7	331.5	324.0
	200	-12	200			316.5	307.9	326.9	337.7	349.7	356.6	355.5
	202	-12	200		280.5	317.7	325.0	337.3	341.1	351.3	360.3	356.9
	204	-12	200		286.8	315.9	333.0	343.5	344.8	352.8	360.5	357.7
	206	-12	200		288.7	314.3	336.4	344.8	346.4	353.4	363.7	361.7
	208	-11	200		255.9	281.6	294.1	308.8	311.9	327.0	343.2	332.7
	210	-11	200		287.8	306.7	328.2	341.7	346.6	354.9	367.7	373.4
	212	-11	200		258.0	274.0	298.1	310.7	316.0	335.2	335.8	335.8
	214	-11	200		251.7	281.8	305.3	306.3	321.3	334.9	340.3	315.7
	216	-11	200		253.4	286.8	302.3	303.1	317.0	332.4	344.0	320.3
	218	-11	200		274.5	309.6	312.9	318.8	332.6	342.8	352.5	344.5
	220	-11	200		269.5	305.9	309.1	315.1	327.8	343.5	357.0	358.7
Reach 5	222	-10	200	252.0	261.0	292.6	295.7	305.9	322.4	337.3	339.2	346.5
	224	-10	200	221.5	233.5	269.0	273.0	271.3	288.3	309.0	306.5	310.4
	226	-10	200	217.6	225.3	274.0	286.8	276.8	281.8	300.8	294.0	304.0
	228	-10	200	222.6	252.1	292.2	299.8	288.4	285.6	296.4	287.7	296.3
	230	-10	200	233.0	284.4	306.3	307.4	304.6	296.5	293.8	293.6	287.1
	232	-10	200	273.9	316.6	336.9	336.8	333.6	327.2	318.1	307.8	300.0
	234	-10	200	245.9	320.5	335.1	327.9	319.7	317.6	301.7	298.1	282.1
	236	-10	200	214.2	295.1	317.1	300.6	297.7	294.7	284.6	267.4	252.3
	238	-10	200	204.8	294.6	318.1	299.6	297.9	296.4	279.9	269.7	249.4
	240	-10	200	184.4	277.6	307.6	285.8	283.3	285.9	269.5	250.1	232.1
	242	-10	200	182.6	273.6	304.3	283.8	282.3	280.0	260.6	241.0	223.2
	244	-10	200	189.8	283.1	313.0	297.7	290.0	281.0	267.9	250.0	233.9
	246	-10	200	181.8	271.0	286.4	271.4	264.5	262.6	239.8	214.6	211.7
	248	-10	200	188.7	272.2	280.5	267.2	258.1	255.9	230.1	218.3	217.5
	250	-10	200	186.5	282.2	278.3	261.2	254.2	248.6	220.9	223.7	217.8
	252	-10	200	197.9	291.9	275.9	265.5	253.2	245.8	225.0	245.9	199.5

TABLE 3.1b.

Profile unit-width volumes for each monitoring station at Isle of Palms. Nourishment occurred between stations 224 to 274 and stations 286 to 340 prior to the July 2008 data collection.

Volumes are calculated between the approximate crest of the primary dune and the indicated "elevation lens" depth. Nourishment areas are highlighted in blue (project reach A), green, (project reach B), and yellow (project reach C).

As additional surveys are completed, calculation limits may change to better encompass volume changes. This results in small differences in reported volumes between the present and earlier reports.

Reach	Line	Elevation Lens (ft NAVD)	Distance to Next (ft)	Unit Volume (cy/ft)								
				Mar-08	Jul-08	Mar-09	Sep-09	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14
Reach 5 (continued)	254	-10	200	197.5	298.1	270.3	267.1	242.3	236.0	222.0	242.8	172.7
	256	-10	200	212.3	313.2	276.2	273.8	240.7	233.6	234.1	230.9	164.1
	258	-10	200	201.7	297.6	256.8	252.6	214.6	216.7	218.2	185.2	155.1
	260	-10	200	229.1	305.9	270.5	256.9	216.8	216.5	223.7	170.5	139.2
	262	-10	200	283.5	346.2	340.9	297.5	276.0	251.1	242.2	206.3	121.7
	264	-10	200	332.0	392.1	383.9	343.7	310.1	239.8	241.9	193.3	149.3
	266	-10	200	366.5	437.5	392.2	365.7	328.0	290.3	266.8	218.5	200.9
	268	-10	200	363.3	408.5	342.5	335.4	320.3	302.1	280.9	170.8	210.5
	270	-10	200	393.0	422.7	343.0	340.3	337.1	295.1	240.5	212.9	248.8
	272	-10	200	407.3	420.9	371.0	352.7	354.2	322.9	267.1	191.5	266.9
	274	-10	200	341.5	344.6	300.7	289.8	307.6	293.4	227.6	160.5	215.9
	276	-10	200	461.8	459.1	427.9	399.1	433.3	417.3	331.7	320.3	367.1
	278	-10	400	463.2	415.2	384.9	371.7	436.7	426.2	297.4	296.8	345.9
Reach 6	280	-10	200	461.0	436.6	602.3	603.9	557.5	458.7	336.9	423.2	439.0
	282	-10	200	501.0	440.4	616.0	634.9	549.6	411.5	338.5	400.3	449.7
	284	-10	200	515.3	522.2	627.9	679.5	583.0	497.7	403.1	466.1	541.2
	286	-10	200	445.3	471.8	553.2	587.5	506.8	452.7	374.6	438.0	543.9
	288	-10	200	333.0	423.8	433.6	453.8	445.8	442.6	382.5	389.5	453.6
	290	-10	200	255.4	357.3	387.9	390.9	391.1	412.7	372.3	385.9	429.5
	292	-10	200	246.8	355.6	382.7	389.3	377.8	423.4	404.6	418.7	453.9
	294	-10	200	235.7	363.0	378.1	380.7	370.7	395.9	405.5	416.5	426.3
	296	-10	200	213.5	354.7	359.8	353.7	352.3	375.0	385.0	374.6	389.4
	298	-10	200	191.1	354.1	349.5	339.4	337.2	356.5	366.0	343.0	318.6
	300	-10	200	173.6	347.5	336.8	323.6	320.5	339.7	349.9	316.1	289.4
	302	-10	200	149.8	339.3	329.5	306.7	305.8	317.6	328.1	306.1	271.6
	304	-10	200	141.5	333.2	307.5	289.8	283.0	292.3	310.2	273.6	236.4
	306	-10	200	171.7	372.6	359.8	312.2	305.7	310.8	338.8	299.0	275.4
	308	-10	200	155.4	341.0	301.7	287.0	260.9	260.9	289.4	230.0	200.7
	310	-10	200	152.6	312.9	284.6	241.6	233.9	245.9	239.0	188.3	149.5
	312	-10	200	111.2	281.0	234.7	215.2	194.3	192.6	197.5	169.9	115.2
	314	-10	200	86.9	246.1	198.9	169.0	170.6	156.0	171.2	110.7	100.2
	316	-10	200	136.4	309.3	268.6	252.7	254.3	235.4	223.0	210.9	173.8
	318	-10	200	128.2	312.0	272.7	256.8	251.8	229.4	238.9	182.4	162.4
	320	-10	200	140.9	324.5	284.3	271.8	264.8	238.8	251.9	212.2	186.4
	322	-10	200	205.4	368.5	336.5	318.2	295.5	267.3	249.9	247.9	225.7
	324	-10	200	212.3	361.7	342.8	331.6	304.0	270.8	255.0	265.2	252.2
	326	-10	200	174.1	291.2	314.4	309.9	290.1	258.3	243.0	253.8	251.1
	328	-10	100	241.0	285.3	341.4	321.5	307.5	259.6	263.1	324.7	284.4
Reach 7	330	-18	200	228.2	262.4	281.7	297.0	348.6	374.3	374.5	372.3	352.8
	332	-18	200	286.9	333.6	340.5	344.8	383.5	389.5	396.8	409.6	424.5
	334	-18	200	252.6	295.8	324.2	328.5	349.0	357.5	372.1	391.7	406.4
	336	-18	200	232.8	284.0	281.2	291.3	300.7	319.1	330.0	343.4	362.8
	338	-18	200	214.7	261.2	247.8	240.3	245.2	252.3	266.0	280.9	304.9
	340	-18	200	204.6	244.6	223.2	216.1	212.5	218.4	224.8	233.3	246.4
	342	-18	200	227.6	246.4	239.2	232.7	226.1	232.4	246.7	253.5	264.2
	344	-18	200	201.1	209.5	208.3	205.0	196.4	198.6	209.7	215.3	222.2
	346	-18	200	196.4	198.1	201.8	197.7	189.3	193.5	194.9	199.7	203.8
	348	-15	200	150.9	147.2	150.7	149.0	136.2	147.2	144.0	146.2	150.7
	350	-15	200	170.1	169.7	170.7	167.5	165.5	165.1	168.0	173.8	181.4
	352	-15	200	159.8	160.4	155.2	153.3	157.3	158.9	160.2	169.6	174.2
	354	-15	200	170.1	171.1	168.1	165.0	171.8	174.2	176.5	184.0	185.4
	356	-15	200	186.5	185.6	183.1	177.9	185.1	189.1	188.6	195.4	190.9
	358	-15	200	175.3	171.9	173.1	163.8	174.5	180.0	178.4	175.2	164.8
	360	-15	200	177.2	172.0	174.4	164.2	175.7	181.8	177.5	170.8	155.4
	362	-15	200	173.3	167.4	173.1	164.5	174.9	174.4	167.6	154.9	143.6
	364	-15	200	146.2	141.2	137.5	139.7	145.2	136.3	129.3	117.6	108.4
	366	-13	200	137.4	131.6	146.1	138.9	131.2	136.8	135.6	132.9	138.6
	368	-13	200	168.9	174.2	183.7	178.5	177.0	174.2	180.1	188.4	209.1
	370	-13	0				176.0	178.8	193.5	-	-	-

TABLE 3.2. Isle of Palms reach volume analysis from March 2008 through September 2014. Nourishment occurred May–June 2008, prior to the July 2008 data collection. Volumes are calculated for each profile to a profile-specific depth, and then extrapolated to the next profile using the average-end-area method. The March 2008 data collection represents the pre-nourishment condition. As additional surveys are completed, calculation limits may change to better encompass volume changes. This results in small differences in reported volumes between the present and earlier reports.

			Total Volume (cy)										Average unit Volume (cy/ft)									
Reach	Limits	Length (ft)	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14
Reach 1	0-3115	4,390	-	-	1,323,935	1,357,979	1,400,189	1,413,097	1,376,054	1,288,983	1,230,930	1,285,718	-	-	301.6	309.3	318.9	321.9	313.5	293.6	280.4	292.9
Reach 2	3115-3125	4,280	-	-	1,210,927	1,204,056	1,210,097	1,224,707	1,219,874	1,270,043	1,290,942	1,263,051	-	-	282.9	281.3	282.7	286.1	285.0	296.7	301.6	295.1
Reach 3	3125-3140	5,620	-	-	1,781,858	1,756,250	1,803,023	1,822,223	1,791,564	1,844,155	1,912,700	1,915,699	-	-	317.1	312.5	320.8	324.2	318.8	328.1	340.3	340.9
Reach 4	3140-222	7,910	-	-	2,329,739	2,329,333	2,337,148	2,403,086	2,455,964	2,566,721	2,653,128	2,666,687	-	-	294.5	294.5	295.5	303.8	310.5	324.5	335.4	337.1
Reach 5	222-280	6,000	1,643,654	1,961,934	1,959,318	1,889,689	1,827,412	1,844,446	1,764,364	1,609,354	1,501,967	1,472,128	273.9	327.0	326.6	314.9	304.6	307.4	294.1	268.2	250.3	245.4
Reach 6	280-328	4,900	1,109,721	1,737,374	1,780,813	1,743,807	1,664,778	1,647,178	1,574,542	1,509,881	1,487,043	1,476,023	226.5	354.6	363.4	355.9	339.8	336.2	321.3	308.1	303.5	301.2
Reach 7	330-370	4,000	766,568	816,758	822,893	810,992	826,350	832,184	852,642	857,028	880,678	904,210	191.6	204.2	205.7	202.7	206.6	208.0	213.2	214.3	220.2	226.1

			Net Change Since Previous										Unit Change Since Previous (cy/ft)									
Reach	Limits	Length (ft)	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14
Reach 1	0-3115	4,390	-	-	-	34,044	42,210	12,908	-37,043	-87,071	-58,053	54,788	-	-	-	7.8	9.6	2.9	-8.4	-19.8	-13.2	12.5
Reach 2	3115-3125	4,280	-	-	-	-6,870	6,041	14,610	-4,833	50,169	20,898	-27,891	-	-	-	-1.6	1.4	3.4	-1.1	11.7	4.9	-6.5
Reach 3	3125-3140	5,620	-	-	-	-25,608	46,773	19,201	-30,659	52,591	68,545	2,998	-	-	-	-4.6	8.3	3.4	-5.5	9.4	12.2	0.5
Reach 4	3140-222	7,910	-	-	-	-407	7,815	65,939	52,878	110,757	86,407	13,559	-	-	-	-0.1	1.0	8.3	6.7	14.0	10.9	1.7
Reach 5	222-280	6,000	-76,815	318,280	-2,616	-69,630	-62,276	17,033	-80,082	-155,010	-107,387	-29,840	-13.1	53.0	-0.4	-11.6	-10.4	2.8	-13.3	-25.8	-17.9	-5.0
Reach 6	280-328	4,900	146,076	627,653	43,439	-37,006	-79,029	-17,599	-72,636	-64,661	-22,838	-11,020	29.8	128.1	8.9	-7.6	-16.1	-3.6	-14.8	-13.2	-4.7	-2.2
Reach 7	330-370	4,000	4,393	50,190	6,135	-11,901	15,358	5,834	20,459	4,385	23,650	23,532	1.1	12.5	1.5	-3.0	3.8	1.5	5.1	1.1	5.9	5.9
Total Change Since Previous			71,655	996,123	46,958	-117,379	-23,108	117,925	-151,916	-88,840	11,222	26,126	1.9	26.8	1.3	-3.2	-0.6	3.2	-4.1	-2.4	0.3	0.7

			Net Change Since Prenourishment (cy)										Unit Change Since Prenourishment (cy/ft)									
Reach	Limits	Length (ft)	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14	Mar-08	Jul-08	Mar-09	Sep-09	Mar-10	Sep-10	Jun-11	Jul-12	Jul-13	Sep-14
Reach 5	222-280	6,000	-	318,280	315,664	246,034	183,758	200,792	120,710	-34,300	-141,687	-171,527	-	53.0	52.6	41.0	30.6	33.5	20.1	-5.7	-23.6	-28.5
Reach 6	280-328	4,900	-	627,653	671,092	634,086	555,057	537,458	464,822	400,161	377,322	366,302	-	128.1	137.0	129.4	113.3	109.7	94.9	81.7	77.0	74.8
Reach 7	330-370	4,000	-	50,190	56,325	44,424	59,782	65,615	86,074	90,459	114,109	137,641	-	12.5	14.1	11.1	14.9	16.4	21.5	22.6	28.5	34.4
5-7 Total Change Since Prenourishment			-	996,123	1,043,081	924,544	798,597	803,865	671,606	456,320	349,745	332,417	-	66.9	70.0	62.0	53.6	54.0	45.1	30.6	23.5	22.3

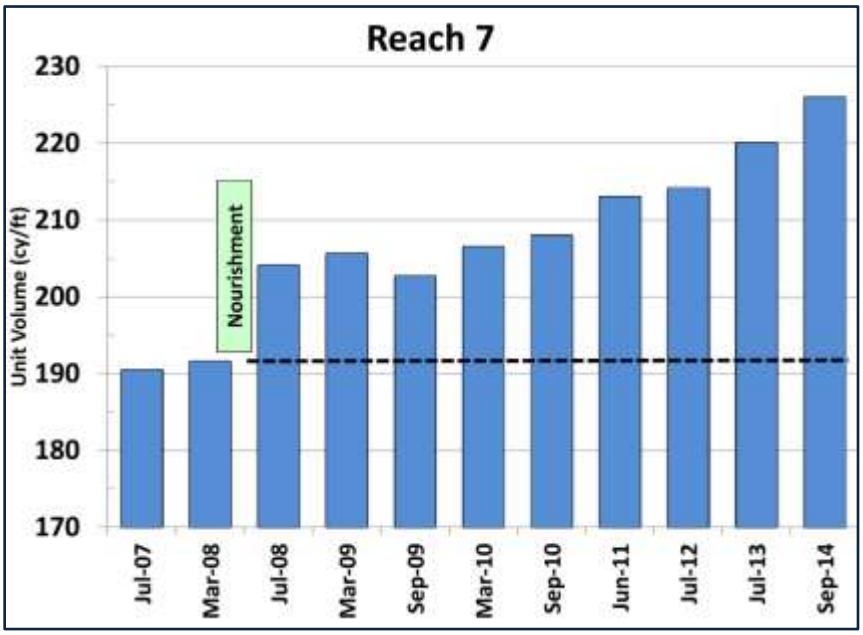
Reach 7 — Dewees Inlet (Volume Changes)

FIGURE 3.2. Reach 7. **[UPPER LEFT]** December 2007. **[UPPER RIGHT]** June 2008 following nourishment. **[LOWER]** October 2014. [Upper images by TW Kana] [Lower image by S Traynum]

Dewees Inlet (Fig 3.2, previous page) generally receives less wave energy than the rest of the Isle of Palms due to the sheltering effects of the ebb-tidal delta associated with the inlet. Shorelines along stable inlets usually show less dynamic volume changes than ocean-facing beaches; however, over time, they can experience severe erosion due to several factors. One factor thought to contribute to localized erosion along the Dewees Inlet shoreline is wave focusing through breaks in the inlet delta (Kana and Dinnel 1980). Breaks between the outer shoals on the Dewees Island side of the channel allow larger waves or destabilizing diffracted waves to reach the Isle of Palms shoreline and cause localized erosion. A low profile groin was built in 1981 near the 17th tee of the Wild Dunes Links Course to trap sand moving into Dewees Inlet and slow erosion (Kana et al 1985) (see Fig 3.2). The monitoring reach (Fig 3.3) extends from the turn in the shoreline near the 18th tee to the end of Cedar Creek spit.

Reach 7 has consistently gained sand since 2007 (Fig 3.4, upper), with most of the accretion being focused near the seaward end of the reach (17th green and 18th tee area). The area seaward of the groin (station 348+00 near the 17th tee) has gained ~81,800 cy of sand since nourishment in 2008 (most of which was gained between stations 330+00 and 338+00). Of note is that erosion which occurred rapidly following the project at stations 338+00 – 342+00 has recovered and the beach is healthier than the post-nourishment condition at all of these stations. The beach inland of the groin has been relatively stable, showing a net gain of ~5,600 cy since nourishment.

FIGURE 3.3. Station map of the Dewees Inlet area (Reach 7). Reach 7 spans from station 330+00 near the 18th tee to station 368+00 near Cedar Creek spit. The approximate limits of Reach C nourishment are identified by the orange-highlighted bar. The 1981 low profile groin is positioned near station 348+00. [July 2011 aerial image by Independent Mapping Consultants Inc]



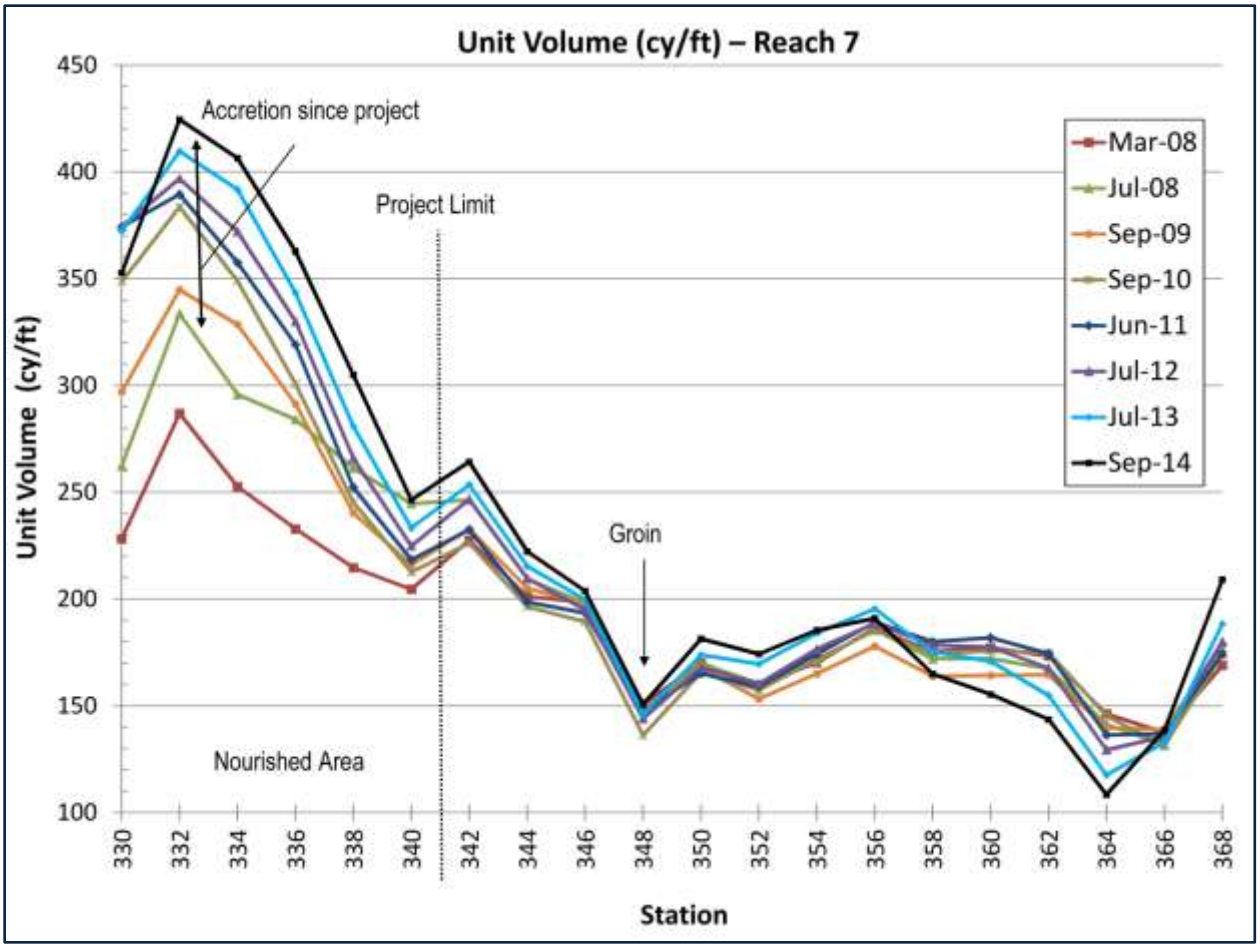


FIGURE 3.4. **[UPPER]** Cumulative unit volumes for Reach 7 from 2007 to 2014. **[LOWER]** Unit volumes for stations in Dewees Inlet. Profiles in the southwestern portion of the reach (17th green – 18th tee) have accreted following the project, while the remaining stations have been stable or have eroded. The difference between 2014 (black line) and post-nourishment (green line) shows the volume change since nourishment.

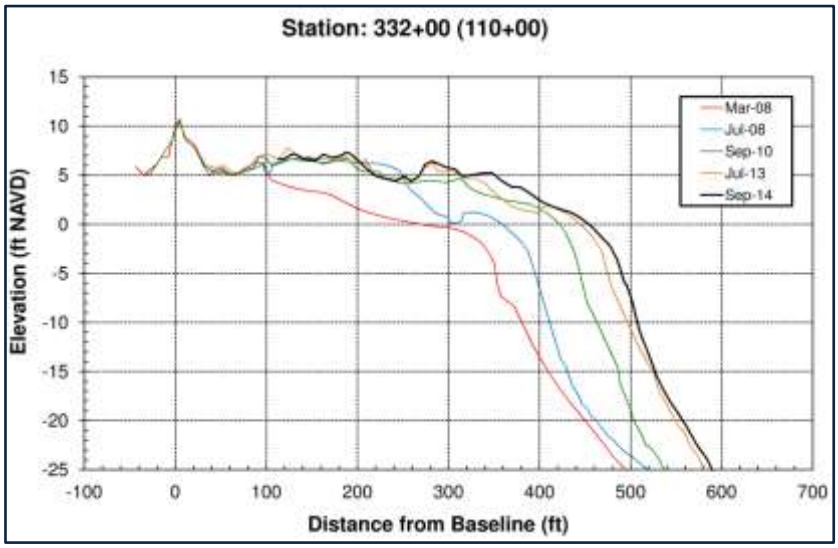
Overall, the reach gained 23,500 cy (5.9 cy/ft) of sand over the past year, essentially the same volume as the previous year. As of September 2014, the reach contained 137,600 cy (34.4 cy/ft) more sand than the pre-nourishment condition. Wave action directed toward and into the inlet moved sand from the front beach to the inlet shoreline, leading to the observed accretion. Once the sand reaches Cedar Creek Spit, or is moved below the influence of wave action, tidal currents in Dewees Inlet carry it offshore, building the delta system. Over the last few years, a significant sandbar (termed a trailing ebb spit) formed just offshore of the point (see Section 3.2). Sand lost from the front beach, some of which may be cycled through Reach 7, is likely the source of sand for this growing feature.

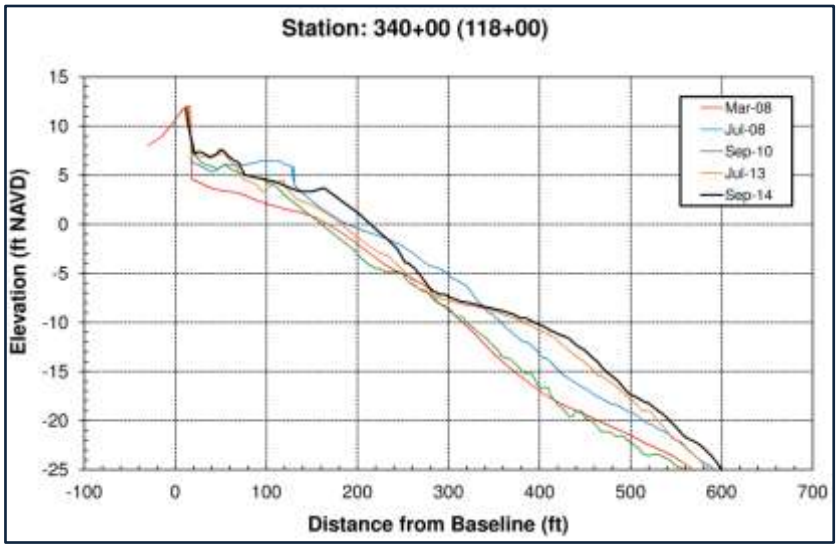
Profiles from select stations in Reach 7 are shown in Figure 3.5. Station 332+00 is just seaward of the beach access at the 17th green. The 0 ft NAVD contour (approximate mean sea level) has accreted ~100 ft seaward since the 2008 nourishment project. The station has accreted between every monitoring survey since 2008. Station 340+00 is located along the central portion of the 17th fairway of the Links Course. This area eroded rapidly following the project; however, since 2009, the position of the berm crest has been fairly stable. Over the past few years, the lower profile (below −7 ft NAVD) has gained a significant amount of sand, which is essentially forcing this portion of Dewees Inlet away from Isle of Palms. The wider underwater base is likely contributing to the ~50 ft growth of the berm since 2010.

Station 354+00 is located near the Seagrass Lane boardwalk and has been fairly stable since 2007 with only minor fluctuations in the position of the berm crest. Significant dune growth since 2008 is evident and is characteristic for an area showing long-term stability. Much like station 340+00, gains were observed in the lower profile (−7 ft to −17 ft NAVD). Profiles and aerial imagery show the spit (stations 356+00 to 368+00) has transitioned from bare sand flats to a vegetated dune area with a dry beach. Since May 2008, the profiles show over ~4 ft of vertical dune growth, though a loss of ~70 ft of beach width at the 0 ft NAVD contour.

Ground photos of Reach 7 show that vegetation has spread and matured along the 2008 fill area (Fig 3.6). The escarpment which ran along the 17th green prior to nourishment has healed and is now well set back from the water. A substantial amount of wrack (dead marsh grass) has accumulated along the shoreline in this reach. The wrack facilitates dune growth and is a benefit to beach organisms. USFWS generally discourages removal of wrack from the beach.

[Note: These results are based on profile volumes between the foredune and −13 ft to −18 ft NAVD. They do not include changes along the Dewees Inlet channel margin between −18 ft and −38 ft, the approximate inlet depth along the reach.]





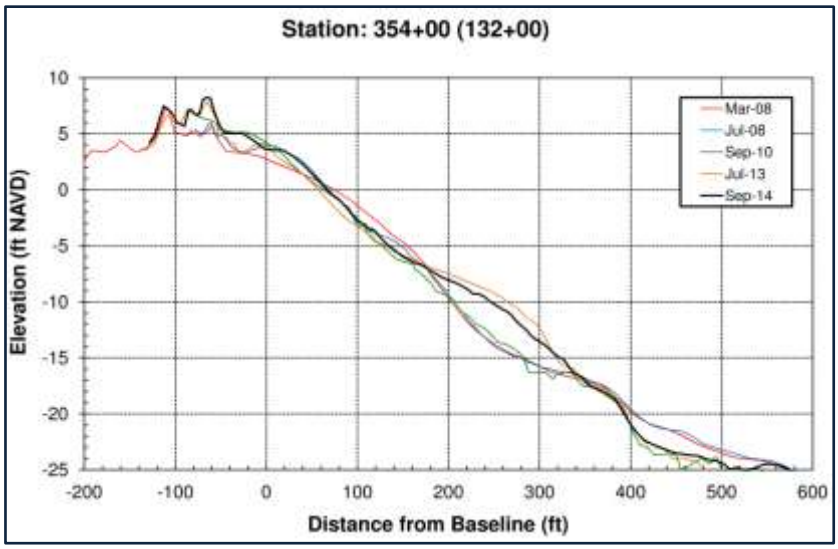


FIGURE 3.5.

Profiles for selected stations in Reach 7.

The seaward end of the reach has accreted (station 332+00) since nourishment, while the central and inland portions of the reach have remained fairly stable.

FIGURE 3.6.

[UPPER] Station 348+00 looking inland.

[MIDDLE] Looking seaward along the 17th hole.

[LOWER] Looking landward from near the 18th tee.

[Photos by D Giles in September 2014]

Reach 6 — Wild Dunes Property Owners Beach House to Dewees Inlet

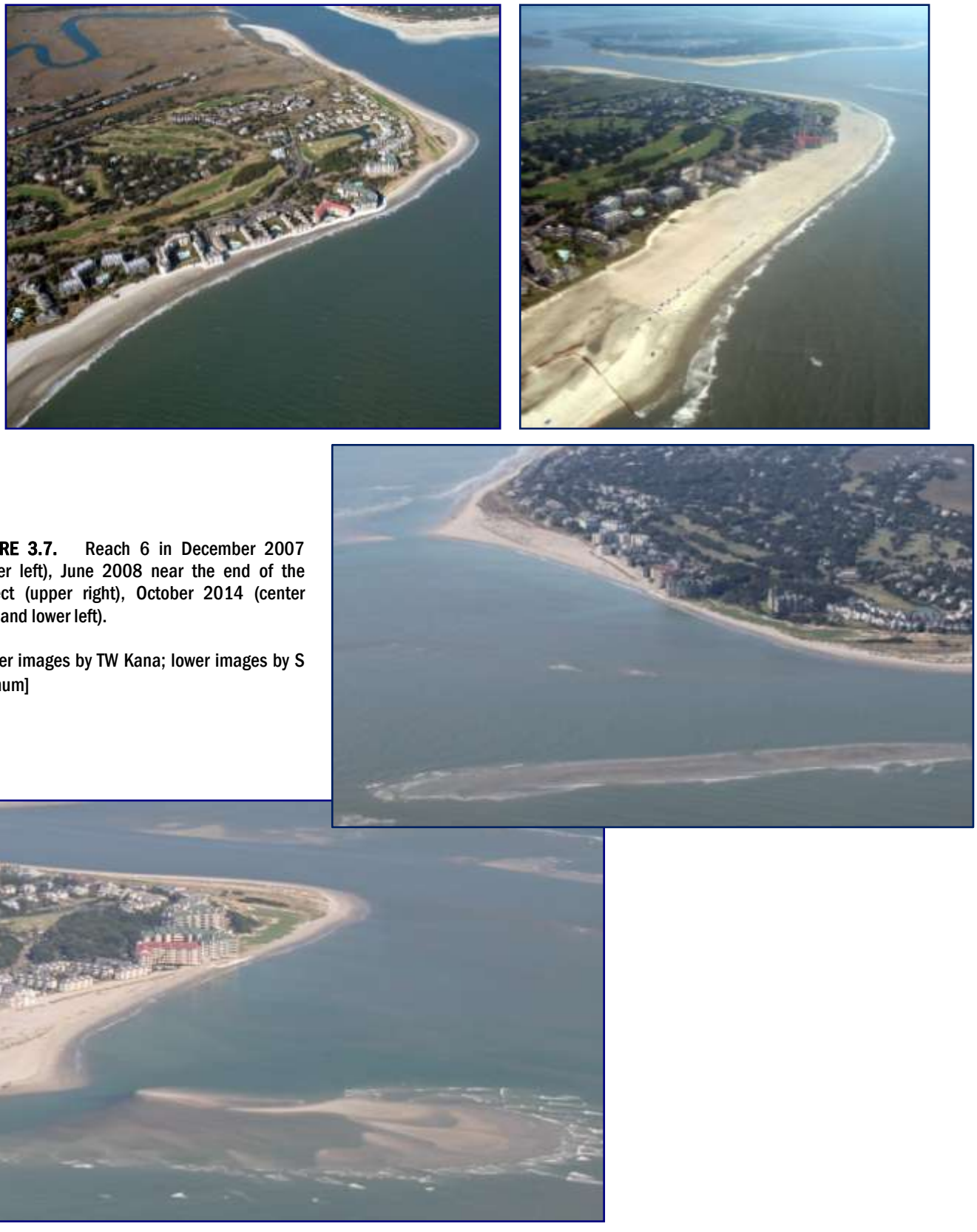


FIGURE 3.7. Reach 6 in December 2007 (upper left), June 2008 near the end of the project (upper right), October 2014 (center right and lower left).

[Upper images by TW Kana; lower images by S Traynum]

Reach 6 (Fig 3.7, previous page) extends from the Wild Dunes Property Owners Beach House ~4,900 ft northeast to the 18th fairway, where the beach turns into Dewees Inlet (station 280+00 to station 328+00, Fig 3.8). Shoal-bypassing events have highly impacted this area since the island's formation. Depending on the location and timing of the bypass events, the shoreline can change hundreds of feet over a period of several months (Kana et al 1985, Gaudiano 1998). As was the case in 2007–2008, the shoreline may encroach on development in this reach when shoal-bypass events are prolonged.

FIGURE 3.8. Reach 6 spans from the Wild Dunes Property Owners Beach House (station 280+00) to the 18th fairway of the Wild Dunes Links Course (station 328+00). The approximate limits of nourishment Reach B are identified by the orange-highlighted bar. [July 2011 aerial image by Independent Mapping Consultants Inc]

Previous studies have suggested that the background, long-term erosion for the northeastern end of Isle of Palms is between 15,000 cy/yr and 30,000 cy/yr even though the estimated average volume of sand added by each shoal-bypass event is ~500,000 cy (CSE 2007). This means that, while large fluctuations in the shoreline and severe local erosion may occur, the long-term erosion rate for the area is relatively low. Sand simply migrates from one area of the beach to another and is either transported back to Dewees Inlet or downcoast to Isle of Palms, eventually being replaced by offshore sand through another shoal-bypassing event.

Prior to nourishment in June 2008, most of Reach 6 was severely eroded with profile volumes seaward of development well below an ideal condition. Property owners had piled sand bags against buildings for protection, and little or no dry beach was present (see Fig 1.3). The condition was beginning to improve just before the nourishment as the shoal attaching at the western end of the reach was in Stage 3 of the bypass cycle. Sand was moving from the shoal toward Dewees Inlet, but not quickly enough to restore the beach along most properties north of the Wild Dunes Property Owners Beach House (WDPOBH).

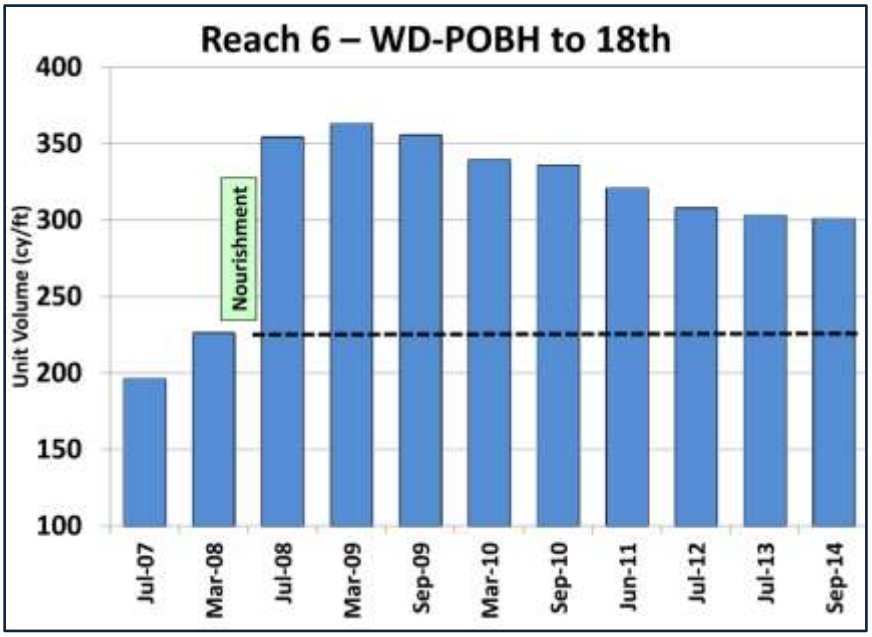
Additional sand was needed to supplement the natural sand transport condition. Between March and July 2008, ~628,000 cy of sand were added to the reach through nourishment and natural spreading of sand from the shoal (the design volume for this reach was 550,000 cy). Average profile unit volumes increased from 226 cy/ft to 355 cy/ft (calculated to −10 ft NAVD) (Fig 3.9, upper).

Following the 2008 project, Reach 6 has responded to shoal-bypass events. The western end of the reach has gained sand via small shoals in 2009, 2010, and 2014. The eastern end has eroded as sand has diverged from the area near Ocean Club, moving toward Dewees Inlet or west to the beach behind the approaching shoal. A series of vertical aerial images are shown in Figure 3.10 highlighting the dynamic shoreline evolution since 2007.

The area near the Wild Dunes Property Owners Beach House (WDPOBH) has maintained an excess sand supply in the dry beach (Fig 3.11), while the area from Mariners Walk to Summer-house has been fairly stable since nourishment. The shoreline between Seascape and the 18th hole has been an erosional hotspot since nourishment. With narrower setbacks and hotspot erosion, this area has required mitigation efforts to attempt to maintain a beach and protect structures, including an ~87,000 cy shoal-management project in 2012, emergency sandbags and experimental temporary erosion-control structures (wave-dissipation device–Fig 3.12, center right), and another shoal-management project in winter of 2014–2015.

Over the past year, the reach accreted between stations 280+00 and 294+00 (WDPOBH to Summer House) and eroded east of Summer House. Accretion along the western end of the reach was due to the buildup of the shoreline salient (bulge) in the lee of the attaching shoal. This accretion was at the expense of the eastern end the reach and portions of Reach 5. Accretion averaged ~50 cy/ft along stations 280+00 to 294+00, which equates to a net gain of ~77,600 cy along these stations. Average erosion from stations 296+00 to 328+00 was 26.2 cy/ft, with a maximum loss of 54.7 cy/ft at station 312+00 (between Seascape and Ocean Club). Losses along these stations totaled 88,600 cy from 2013 to 2014.

Severe erosion has eliminated most of the dry beach near Seascape, Ocean Club, and the 18th hole, resulting in property owners implementing emergency measures which included installation of one-ton sandbags and an experimental wave-dissipation device (Fig 3.12). As of September 2014, most of the sandbag revetment along the golf course had settled or been displaced to the point of it being non-functional. There were also many damaged bags adjacent to Ocean Club; however, newer bags had been placed to reinforce the temporary revetment and provide protection to the structure.



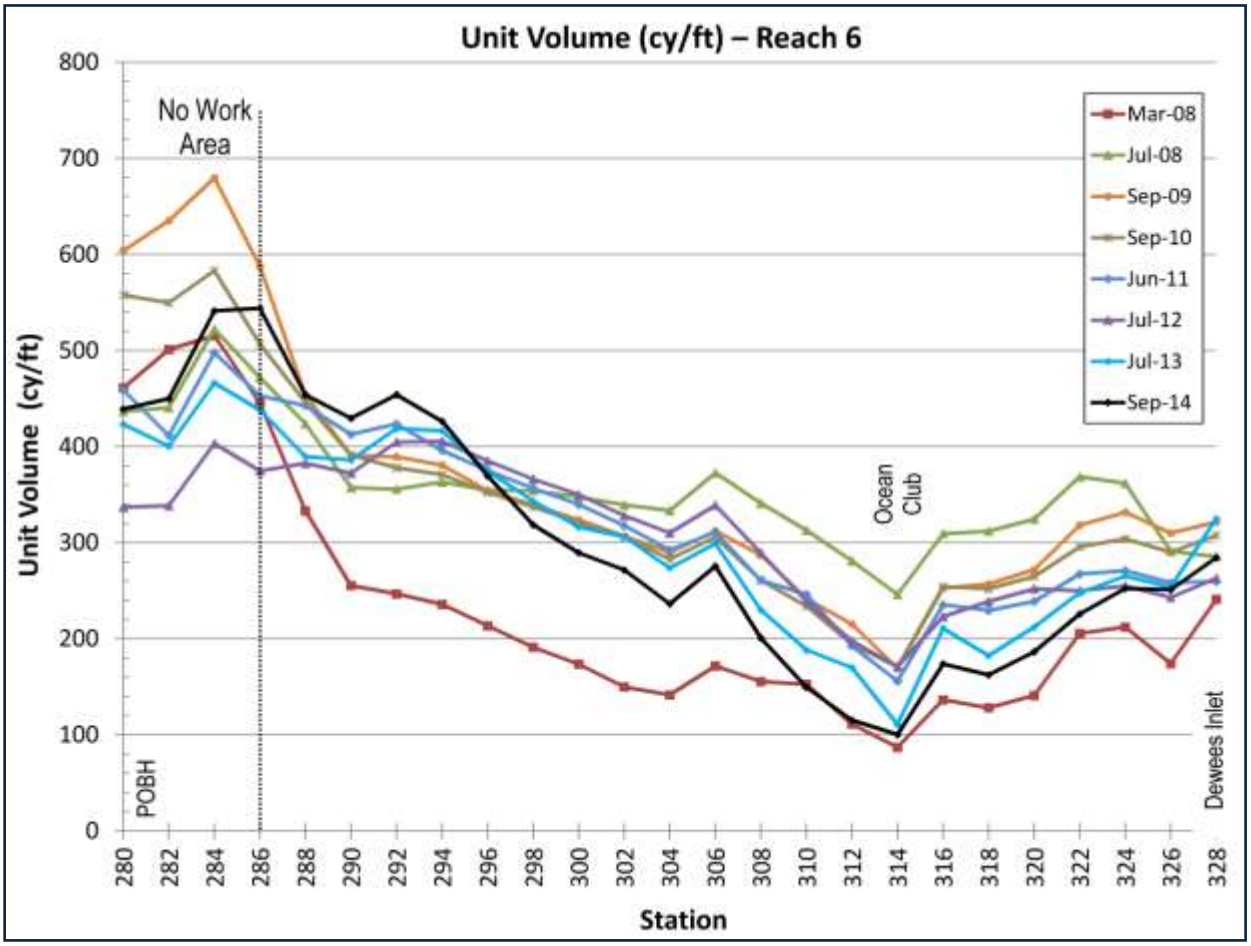


FIGURE 3.9. **[UPPER]** Bar graph showing beach unit volumes calculated to −10 ft NAVD in Reach 6. Overall, this reach has over 100 cy/ft more sand in July 2012 than in July 2007 (prior to shoal attachment and nourishment. **[LOWER]** Profile unit-width volumes for stations in Reach 6. Erosion has dominated the ends of the reach. The beach was much more stable from 2009 to 2012; however, erosion increased along the eastern portion of the reach over the past year.

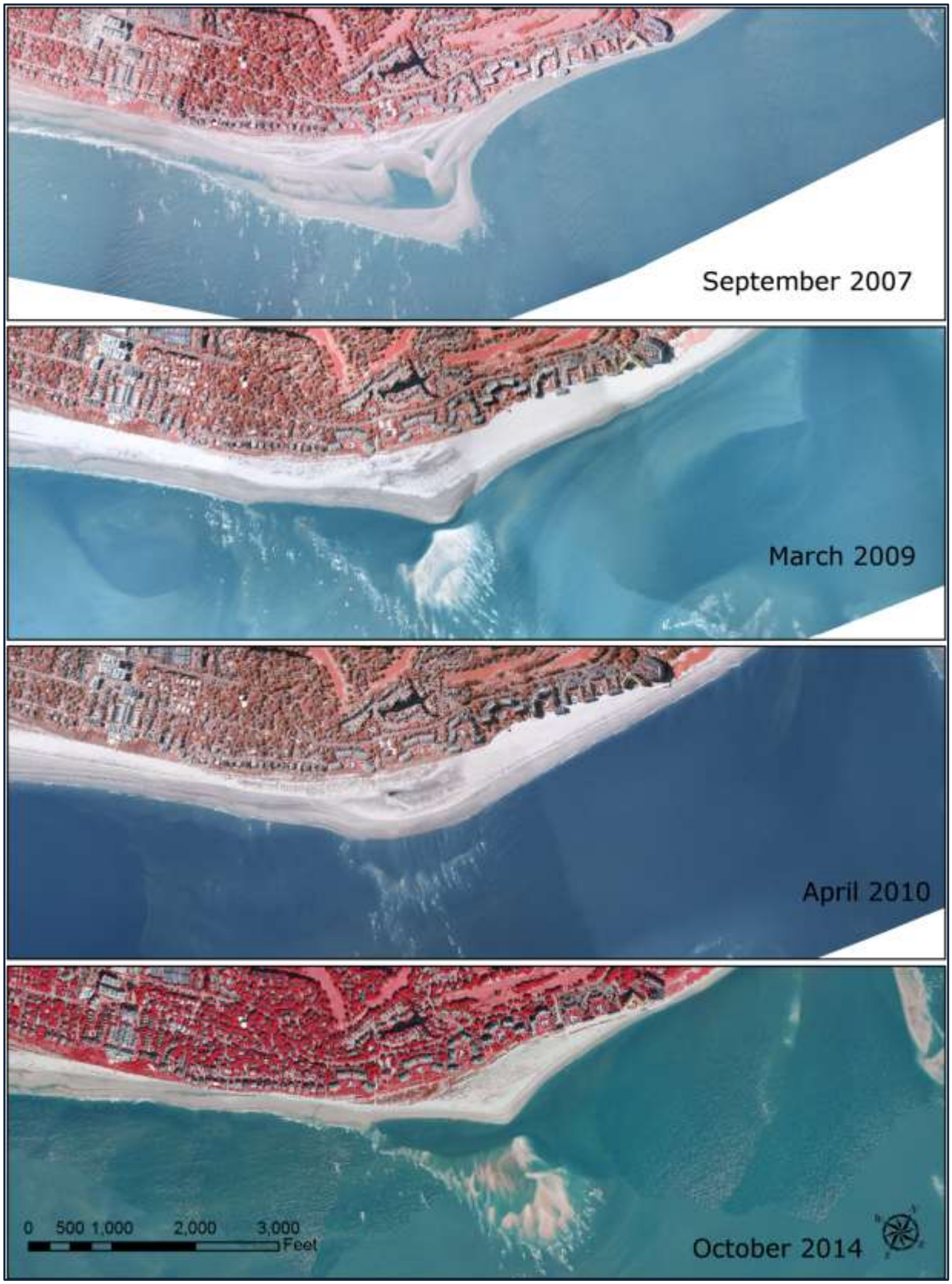


FIGURE 3.10. Sequence of aerial photographs showing four distinct shoal-bypass events occurring between 2007 and 2014. The 2009 and 2010 events were of much smaller scale than the 2007 event or the present event. Images were obtained by Independent Mapping Consultants (IMC, Charlotte NC).

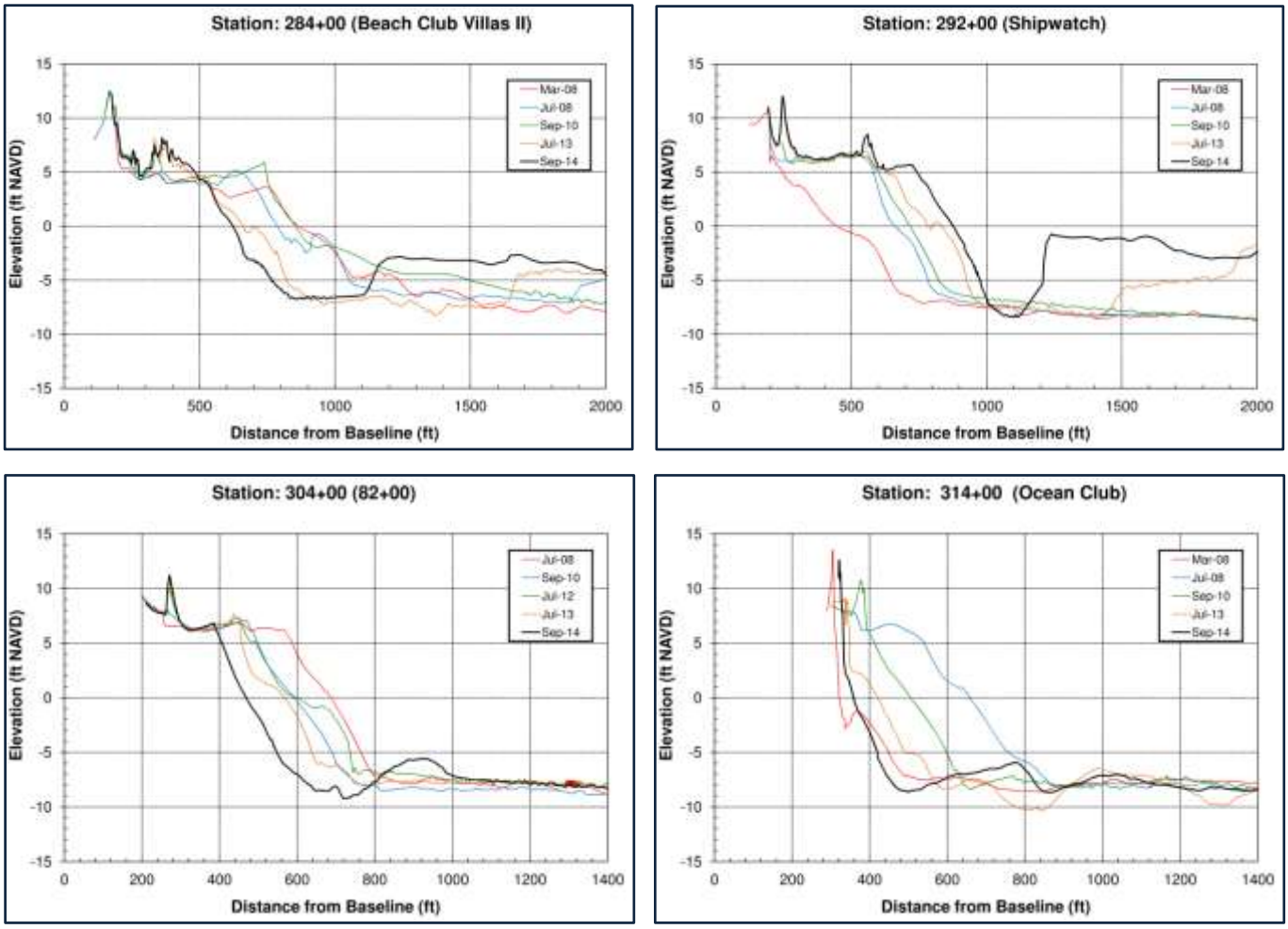


FIGURE 3.11. Profiles for selected stations in Reach 6. Station 284+00 rapidly eroded from 2009 to 2012; however, the berm was stable over the past two years as the shoal moved closer to the beach. Station 292+00 (Shipwatch) has accreted since nourishment. It is directly in the lee of the approaching shoal, which was ~300 ft from the beach in September 2014. Station 314+00 eroded rapidly the first year after the 2008 project and continues to be an erosion hotspot.

FIGURE 3.12.

[UPPER LEFT] View west from station 324+00..

[CENTER LEFT] View west from station 318+00.

[CENTER RIGHT] The experimental "wave dissipation system" installed in front of Seascape.

[LOWER LEFT] Dunes and dry berm present in front of Port O'Call.

[LOWER RIGHT] View west from station 292+00 showing the accretional salient (bulge) leeward of the approaching shoal.

[Photos by S Traynum]

Overall, Reach 6 lost ~11,000 cy (2.2 cy/ft) of sand from July 2013 to September 2014. It presently holds 366,000 cy (74.8 cy/ft) more sand than the pre-nourishment (March 2008) condition. Stations 280, 282, and 310 presently hold less sand than the pre-nourishment condition, while the remainder of the reach holds up to 207 cy/ft more sand than was present in March 2008. Apart from the erosional hotspot encompassing Seascape, Ocean Club and the 18th hole, the majority of the reach maintains a wide dry beach and growing dunes. Dune growth has continued since nourishment, with some areas having dunes 5 ft high with a base over 40 ft wide (at Port O'Call).

Reach 5 — 53rd Avenue to Wild Dunes Property Owners Beach House

FIGURE 3.13.

[UPPER LEFT]
Reach 5 in December 2007.
[Photo by TW Kana]

[LOWER LEFT]
Reach 5 on 21 October 2014.
[Photos by S Traynum]

[LOWER RIGHT]
Reach 5 on 21 October 2014.
[Photos by S Traynum]

Reach 5 (Fig 3.13, previous page) spans ~6,000 ft between 53rd Avenue and the Wild Dunes Property Owners Beach House and encompasses project Reach A (Fig 3.14, stations 222+00 thru 280+00). Like Reach 6, this area is greatly influenced by shoal-bypass events, especially at the northern end of the reach where the majority of shoals attach to the beach.

Prior to the 2008 nourishment, an erosional arc had formed in the area of the Wild Dunes Grand Pavilion (station ~248+00) (see Fig 3.10). Erosional arcs are typical in areas adjacent to shoal attachment sites because of wave refraction and sediment transport reversals, which drive sand from these areas into the lee of the shoal during Stages 1 and 2 of the shoal-bypass cycle. Immediately prior to nourishment, the "2007" shoal had completely attached (Stage 3) at the northern end of the reach, and sand was beginning to spread into the eroded areas.

Reach 5 gained ~318,000 cy (128.1 cy/ft) of sand between March and July 2008; this included nourishment and natural accretion from the shoal attachment (Fig 3.15, upper). The design volume was 270,000 cy, and CSE estimates ~340,000 cy of sand were added to the project area between March and July 2008. [Note the project reach limits differ from the monitoring reach, producing the difference in accretion numbers.] Design fill unit volumes were ~75 cy/ft throughout area A, decreasing in the taper sections. Dry beach width increased up to ~225 ft in this reach. The northern portion of Reach 5 was highly erosional prior to the nourishment project, losing up to 45 cy/ft between July 2007 and March 2008 (Fig 3.15, lower). The rest of the reach was more stable, gaining sand at most stations.

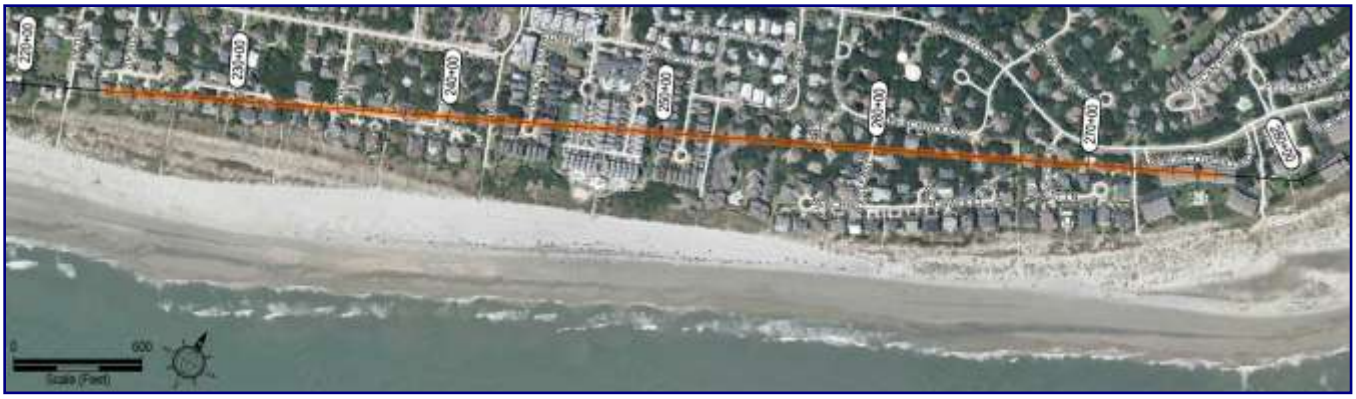
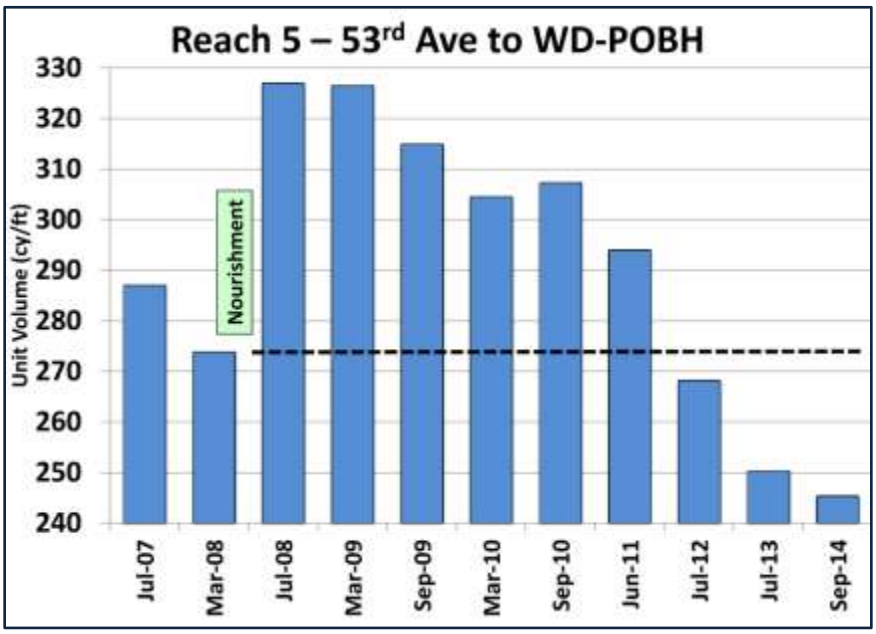


FIGURE 3.14. Reach 5 spans from 53rd Avenue (station 222+00) to the Wild Dunes POBH (station 280+00). The approximate limits of nourishment Reach A are identified by the orange-highlighted bar. [March 2009 aerial image by Independent Mapping Consultants Inc]



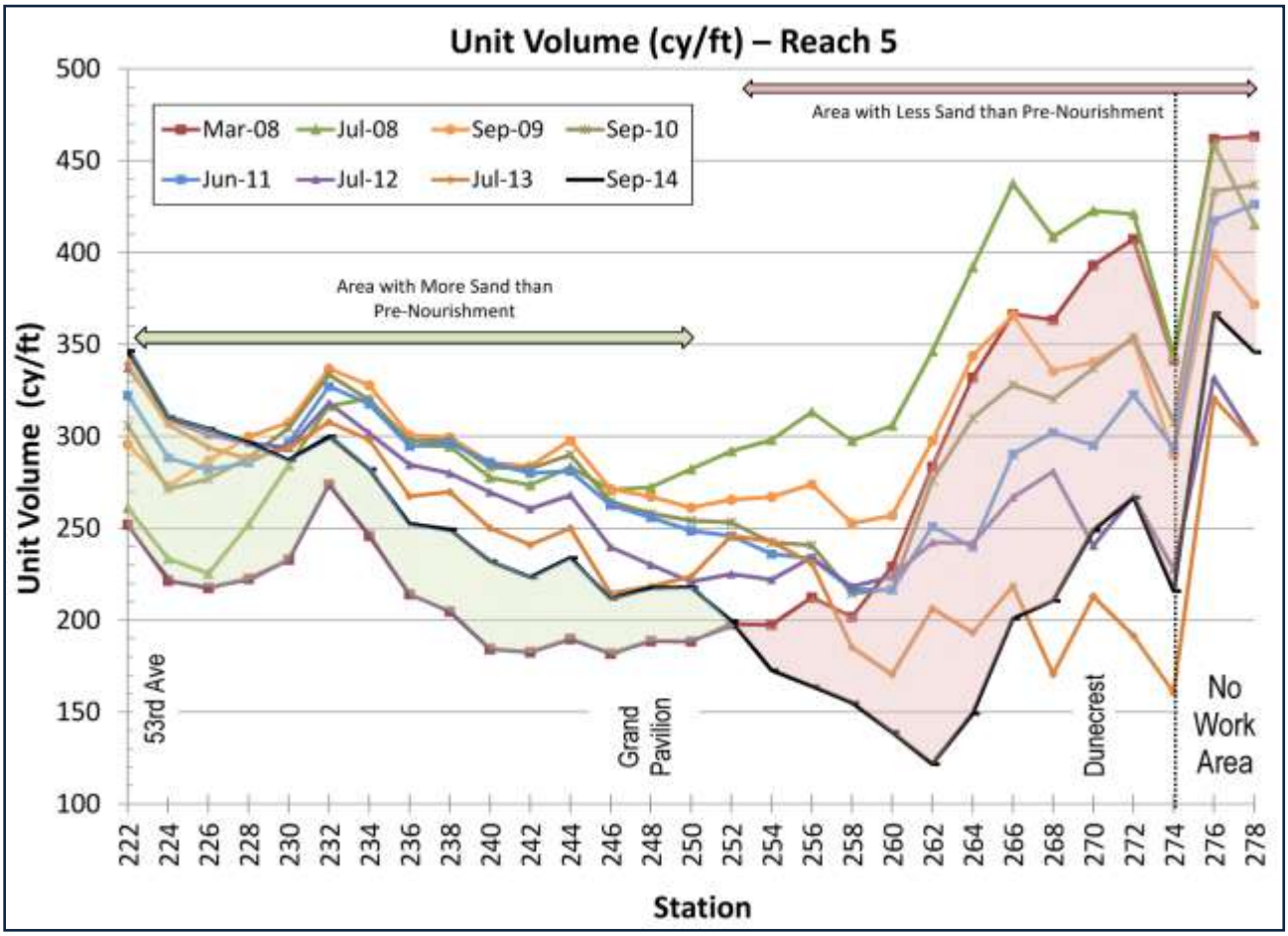


FIGURE 3.15. **[UPPER]** Bar graph showing beach unit volumes calculated to −10 ft NAVD in Reach 5. While the 2014 average sand volume is less than the pre-nourishment condition, stations 222–252 (3,000 ft of a total of 6,000 ft of Reach 5) still hold ~168,000 cy (56.1 cy/ft) more sand than the pre-nourishment condition. **[LOWER]** Profile unit-width volumes for stations in Reach 5. Erosion has dominated the northern part of the reach (stations 250–278) and is associated with excess sand spreading from shoal attachment events in 2006, 2009, and 2010 and shoal-induced erosion from the present event.

The western half of Reach 5 was fairly stable between 2008 and 2011 while the eastern half eroded significantly due to spreading of excess sand accumulated during shoal bypass events from 2007–2010. Beginning in 2011, the central portion of the reach showed increased erosion, accretion slowed along the western end of the reach (53rd–56th Avenues) and erosion accelerated along the eastern end of the reach near Beachwood East and Dunecrest Lane.

As of July 2012, less sand was present in Reach 5 than was present prior to nourishment in 2008. This net loss was the result of spreading of the excess sand present following the 2007 shoal event at the eastern half of the reach. At that point, the eastern ~1,800 ft of the beach was below the pre-nourishment condition and had lost a total of ~245,000 cy (Stations 260+00 – 280+00) since March 2008 (Fig 3.15). This includes the nourishment quantity of ~45,000 cy added to this area. Over the same time, the western ~3,800 ft of beach showed a net increase of 210,000 cy (including ~270,000 cy of nourishment). Since 2012, the area showing net loss compared to the pre-nourishment condition has continued to expand to the west, and now encompasses the eastern ~3,000 ft of the reach (Fig 3.16).

Reach 5 lost 29,800 cy (5.0 cy/ft) of sand between July 2013 and September 2014, which is the lowest annual erosion value observed since nourishment. Erosion was most severe between stations 252+00 (Seagrove) and 264+00 (Beachwood East), which lost an average of 53.3 cy/ft (Fig 3.17). Erosion was also pronounced between stations 234+00 (56th Avenue) through 244+00 (Pavilion Boulevard), averaging 17.2 cy/ft. The losses were accompanied by moderate accretion along the western end of the reach (53rd–55th Avenues) and significant gains at the east end, averaging 50 cy/ft between stations 268+00 and 278+00 (Dunecrest Lane and Beach Club Villas).

The reach contains ~171,500 cy (28.6 cy/ft) less sand than the pre-nourishment condition; however, as previously mentioned, net erosion compared to the pre-nourishment condition is confined to the eastern half of the reach. The western half of the reach is still much healthier than the pre-nourishment condition. Erosion diminishes toward the eastern end of the reach, though berm recession is still evident (Figs 3.18 and 3.19). The offshore underwater area has gained volume as the western edge of the shoal-bypass event approaches the beach and is within the volume calculation limits.

FIGURE 3.16. October 2014 aerial image of Reach 5 showing the approaching shoal at the northern end of the reach and the remaining fill from the 2008 nourishment (bright sparsely vegetated sand in the lower half of the image).

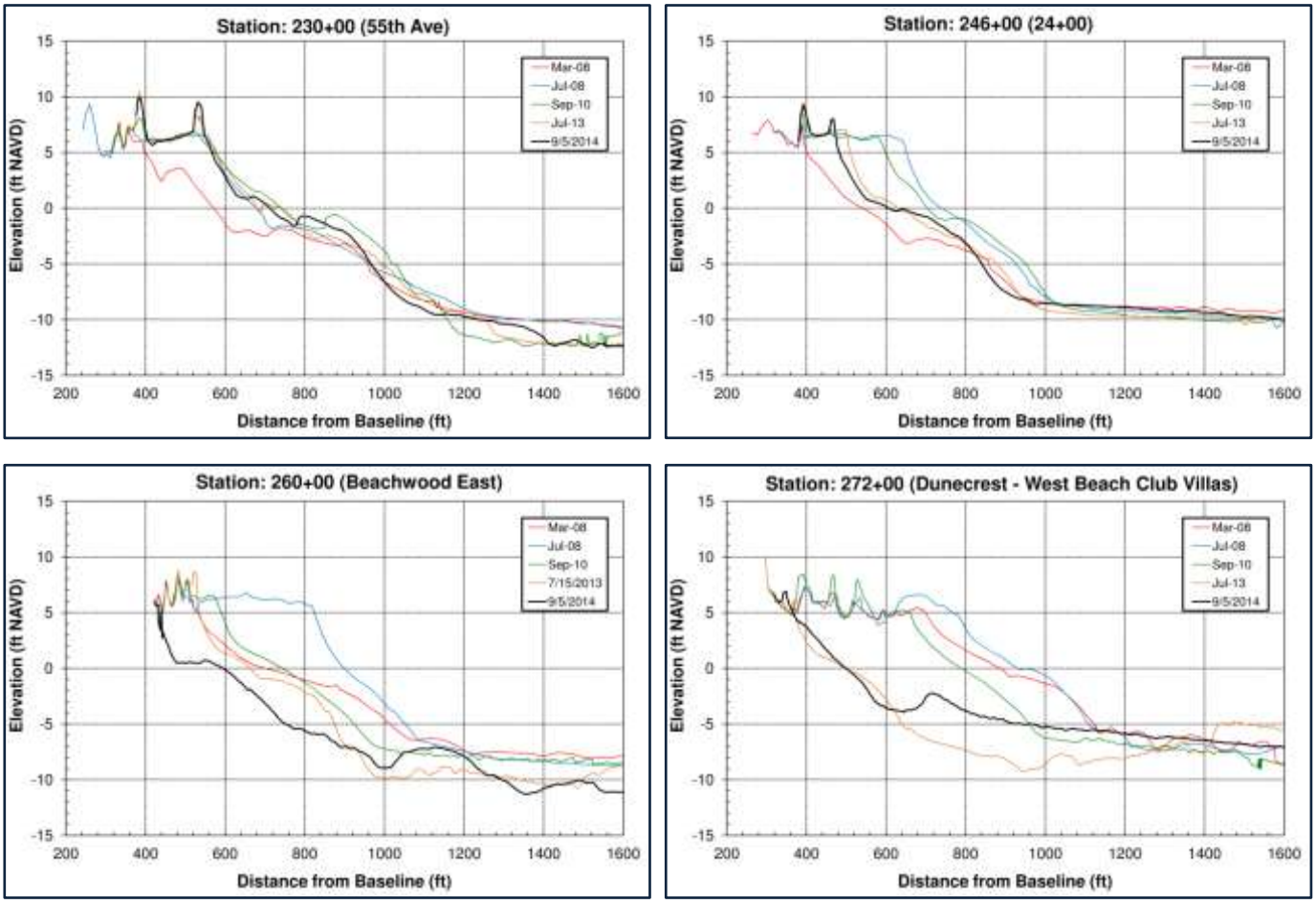


FIGURE 3.17. Profiles for selected stations in Reach 5. Sand is attaching to the beach at various locations along the eastern half of the reach, causing an erosional arc (see text) and isolated sand bars. The western edge of the bypassing shoal is attaching to the low-tide beach at station 272+00.

FIGURE 3.18.

Ground photos along various areas of Reach 5 in September 2014.

[UPPER RIGHT] View east from station 272+00.

[CENTER] View west from station 272+00.

[LOWER RIGHT] Sand bags placed as emergency erosion protection Beachwood East.

FIGURE 3.19.

Ground photos along various areas of Reach 5 in September 2014.

[1st RIGHT] Sand bags extend along the portion of Reach 5 east of the Grand Pavilion.

[2nd RIGHT] Exposed revetment at Seagrove.

[3rd RIGHT] Station 248+00 at Grand Pavilion.

[4th RIGHT] Looking west across the dunes at station 236+00.

Summary of Volume Changes in Reaches 5–7 (53rd Avenue to Cedar Creek)

The various erosion/accretion observations along the eastern end of the Isle of Palms (Reaches 5–7) were detailed in the previous sections. The influence of Dewees Inlet leads to rapid shoreline fluctuations that are difficult to predict; however, the City's monitoring efforts have generated a reliable and comprehensive dataset which allows for advance planning and better projections of future changes.

Over the past year, the beach along Reaches 5–7 experienced localized dynamic changes, including areas of significant accretion and rapid erosion. The severity of localized change was the result of the large shoal bypass event, which is currently in the most impactful position relative to the shore (Stage 2 of the bypass cycle). The shoal was close to shore and had increased in elevation to produce the maximum breakwater effect. Significant observations occurring in Reaches 5–7 between 2013 and 2014 included:

1) Landward migration and increased elevations of the offshore shoal.
2) Continued erosion in broad arcs on either side of the shoal, leading to severe erosion along the center of the arcs (Beachwood East and Ocean Club/18th hole).
3) Accretion in the lee of the shoal forming a salient (bulge) in the shoreline near Mariners Walk.
4) Continued growth of the "trailing ebb spit."

Overall, Reaches 5–7 lost only 17,330 cy (1.2 cy/ft) of sand over the past year, although this number may be deceiving as there were isolated areas that significantly eroded. Losses in the erosional areas were compensated by gains in other areas and from the shoal as it nears shore and some underwater sand is included in volume calculations. The reaches hold 332,000 cy (22.3 cy/ft) more sand in September 2014 than the pre-nourishment condition, which is ~33 percent of the nourishment volume (Fig 3.20). The loss of 663,000 cy over the ~6 years since nourishment equates to an average annual erosion rate of 7.2 cy/ft/yr. Annual erosion rates in Reaches 5, 6 and 7 are −13.2 cy/ft/yr, −8.6 cy/ft/yr, and +3.5 cy/ft/yr (respectively).

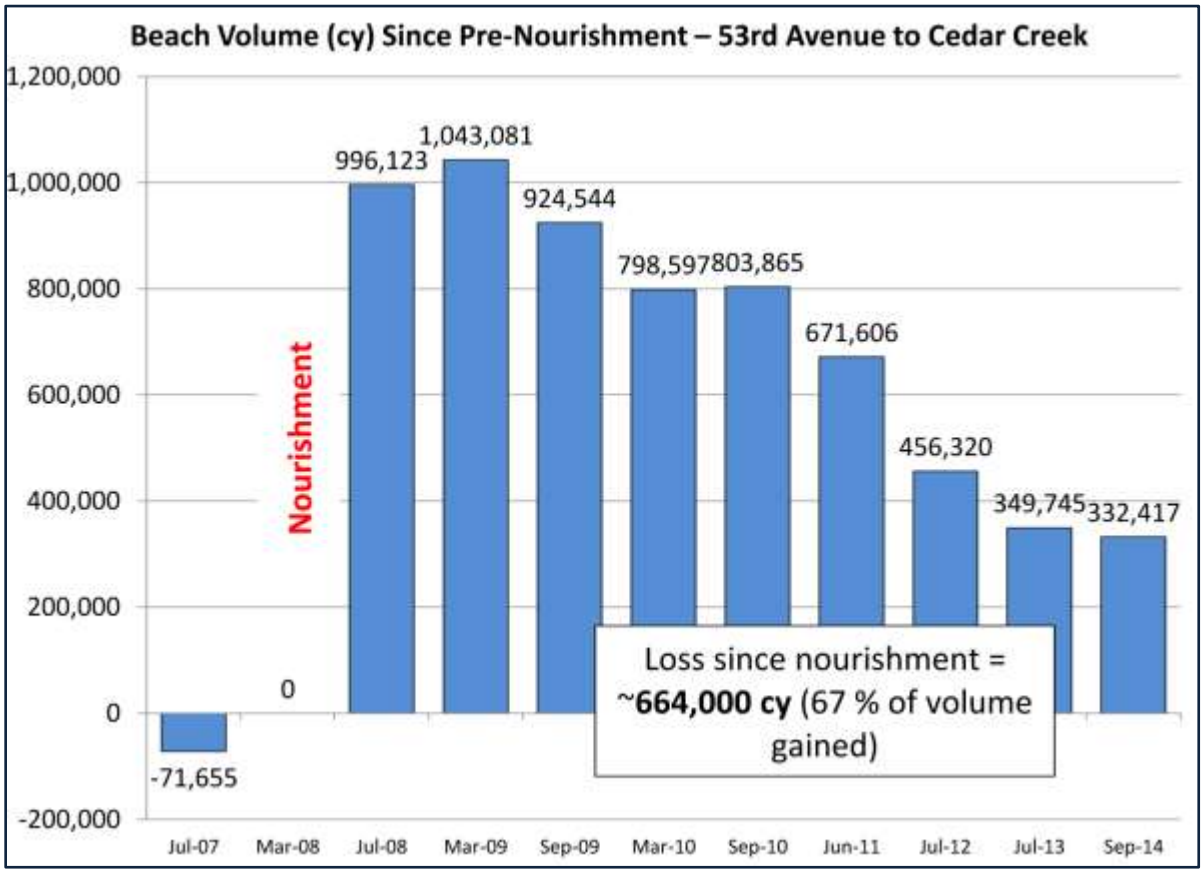


FIGURE 3.20. Beach volume relative to March 2008 (pre-nourishment). The values shown include all areas (both nourished and non-nourished) and do not account for sand accumulated at the turn in the baseline at the northeastern point, which is estimated to have gained over 50,000 cy since March 2008.

Central Reaches 2–4 (6th Avenue to 53rd Avenue)

Reaches 2–4 represent the central portion of the island and have historically been stable to accretional over the past century. The reaches are considered to be outside of the direct influence of Dewees and Breach Inlets and are classified as "S" for standard erosion zones by SCDHEC–OCRM. Erosion/accretion signatures along "S" zones tend to be predictable over the long term. Short-term changes in sand volume are generally smaller in magnitude than in areas close to inlets (SCSGC 2001).

Reaches 2–4 represent 17,810 ft of shoreline between 6th and 53rd Avenues (Fig 3.21). CSE established profile stations at 1,000-ft spacing and reoccupied monuments established by SCDHEC–OCRM, which have been surveyed generally every year since the early 1990s. CSE has obtained 8 sets of profiles spanning March 2009 to September 2014. Unit volume changes for Reaches 1–4 are shown in Figure 3.22.

Reaches 2–4 have generally been accretional since 2009, with isolated periods of erosion occurring during some intervals (ie, March–September 2009). Overall, the three reaches lost ~11,000 cy (0.6 cy/ft); however, all losses were accounted for in Reach 2 (which lost ~28,000 cy). Reaches 3–4 gained ~16,500 cy. Since 2009, the central reaches have gained 522,900 cy (29.4 cy/ft), which is an average annual accretion rate of 5.3 cy/ft/yr.

Details for each reach are given in the following sections.

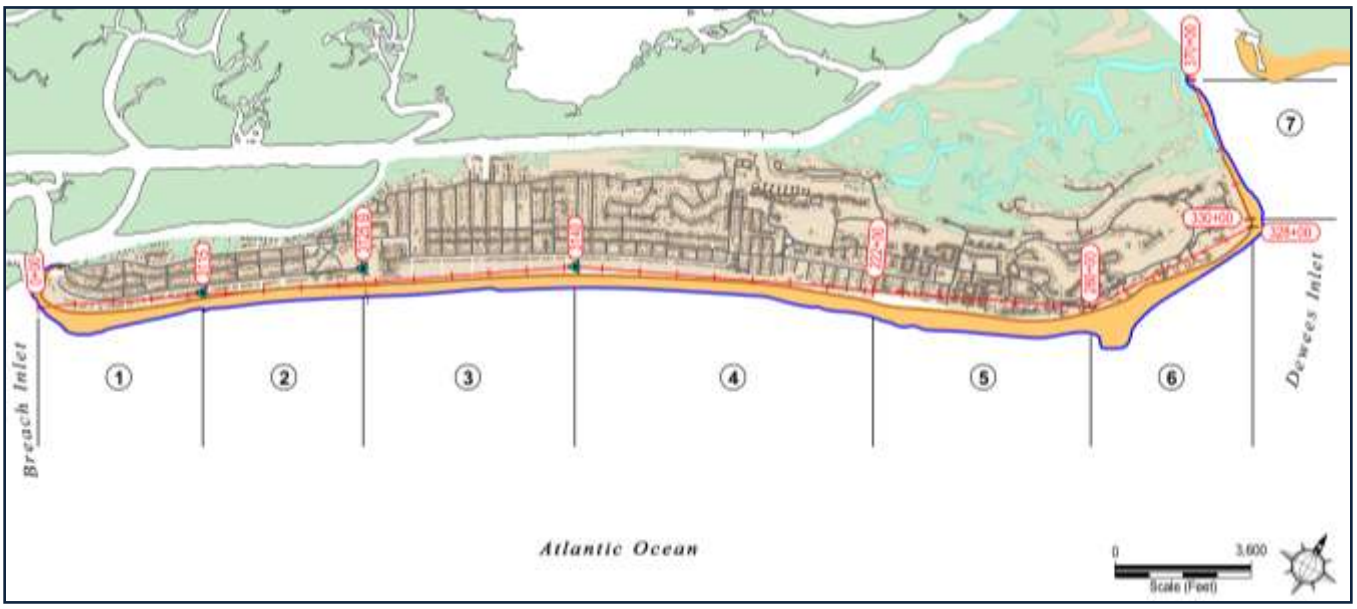


FIGURE 3.21. Monitoring reach boundaries.

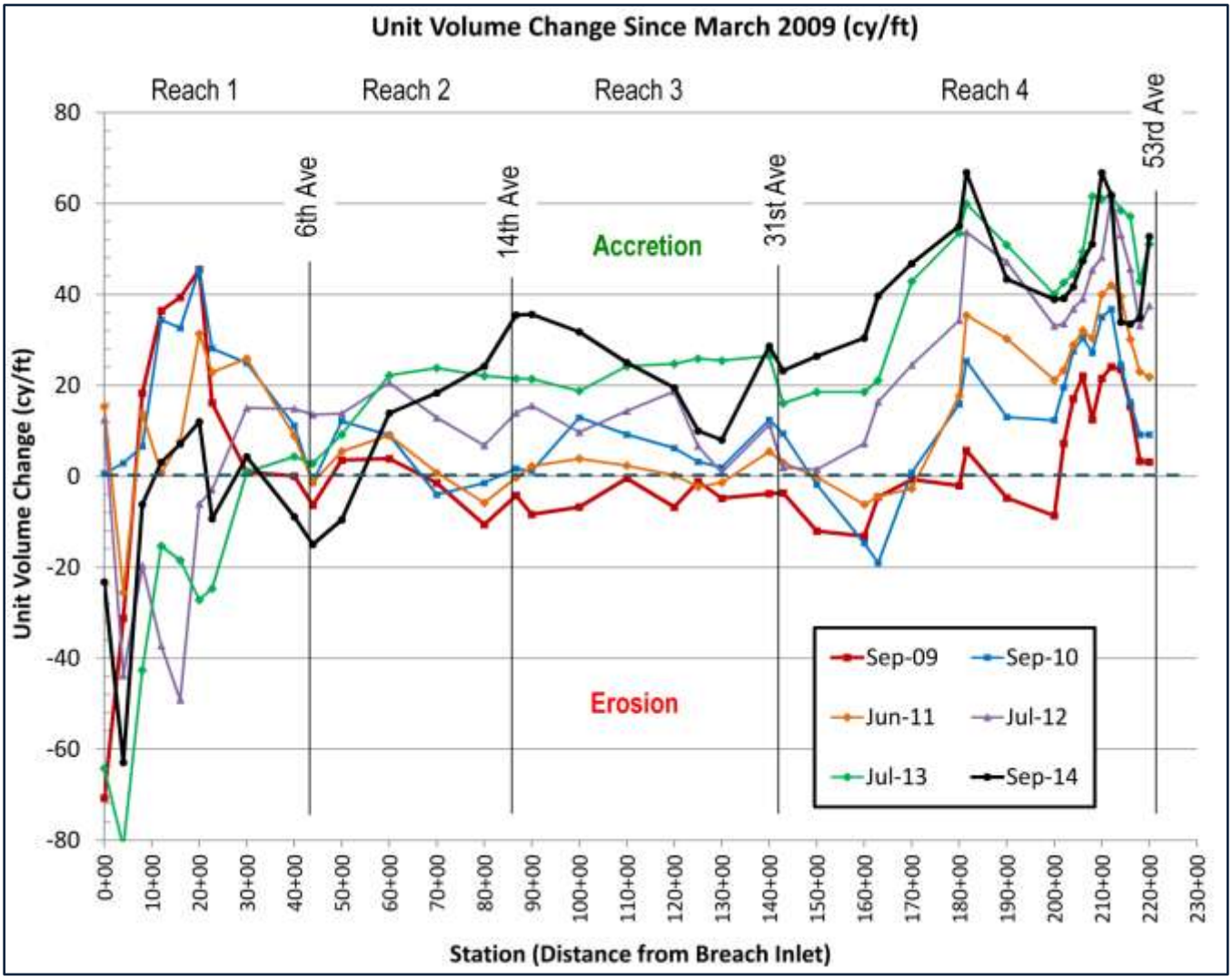


FIGURE 3.22. Profile unit-width volume change (cy/ft) between March 2009 and later dates for Reaches 1–4. CSE established and surveyed profiles spaced 1,000 ft apart within the Isle of Palms reaches and reoccupied monuments surveyed annually by SCDHEC-OCRM. Historically, these reaches have been accretional; however, between March and September 2009, most stations outside of the influence of the inlet or project were erosional. Since September 2009, most stations have shown accretion and are currently healthier than the March 2009 condition (ie – where the black line is greater than zero). The higher rates and westward sequence of accretion along Reach 4 illustrate the downcoast spread of nourishment sand from Reach 5. [Volumes are relative to the March 2009 condition.]

Reach 4 — 31st Avenue to 53rd Avenue

Reach 4 spans 7,910 ft between 31st Avenue and 53rd Avenue (stations OCRM 3140 to CSE 222+00) (Fig 3.23). Being immediately downdrift of the 2008 nourishment project, it should, therefore, benefit from losses of nourishment sand from the project area. Reach 4 was stable from March to September 2009 and has accreted between each monitoring event since then (see Table 3.2).

FIGURE 3.23. Reach 4 – stations OCRM 3140 (31st Avenue) to CSE 222+00 (53rd Avenue) – noted by the orange-highlighted bar.

Over the past year (2013–2014), the western half of Reach 4 (31st–42nd Avenues) accreted while the eastern half (42nd–53rd Avenues) was generally erosional. Volume change averaged +8.3 cy/ft from 31st to 42nd Avenues and −6.4 cy/ft east of 42nd Avenue. The erosion observed between 42nd and 53rd Avenues is the first significant erosional trend observed over any portion of Reach 4 since 2009. Stations 216+00 and 218+00 (near 51st Avenue) experienced some recession of the dry beach; however, each profile is still ~100 ft wider than the 2009 condition. Remaining profiles within the reach were generally stable or accretional in the upper profile (dry beach area); any losses were in the wet beach or underwater portion of the profile (Fig 3.24).

Overall, **Reach 4 gained ~13,500 cy (1.7 cy/ft) of sand between July 2013 and September 2014.** Since March 2009, the reach has gained ~337,000 cy (42.6 cy/ft), which is an average annual accretion rate of 7.7 cy/ft/yr. Erosion observed in the eastern portion of the reach is likely a result of a reduced supply of sand from Reach 5. Sediment transport from Reach 5 is being impacted by the ongoing shoal-bypass event as more sand is moving to the east (in the lee of the shoal) than typical, resulting in reduced transport to the west (into Reach 4). Once the shoal attaches, normal sediment transport may resume and the accretional trend of Reach 4 should re-establish.

Historical accretion along this reach (combined with sufficient setbacks for development) has led to a substantial dune system between most structures and the beach (Fig 3.25). As long as there is slow steady accretion, the foredune will continue to build wider and higher, offering more storm protection to property behind the dunes (Fig 3.26).

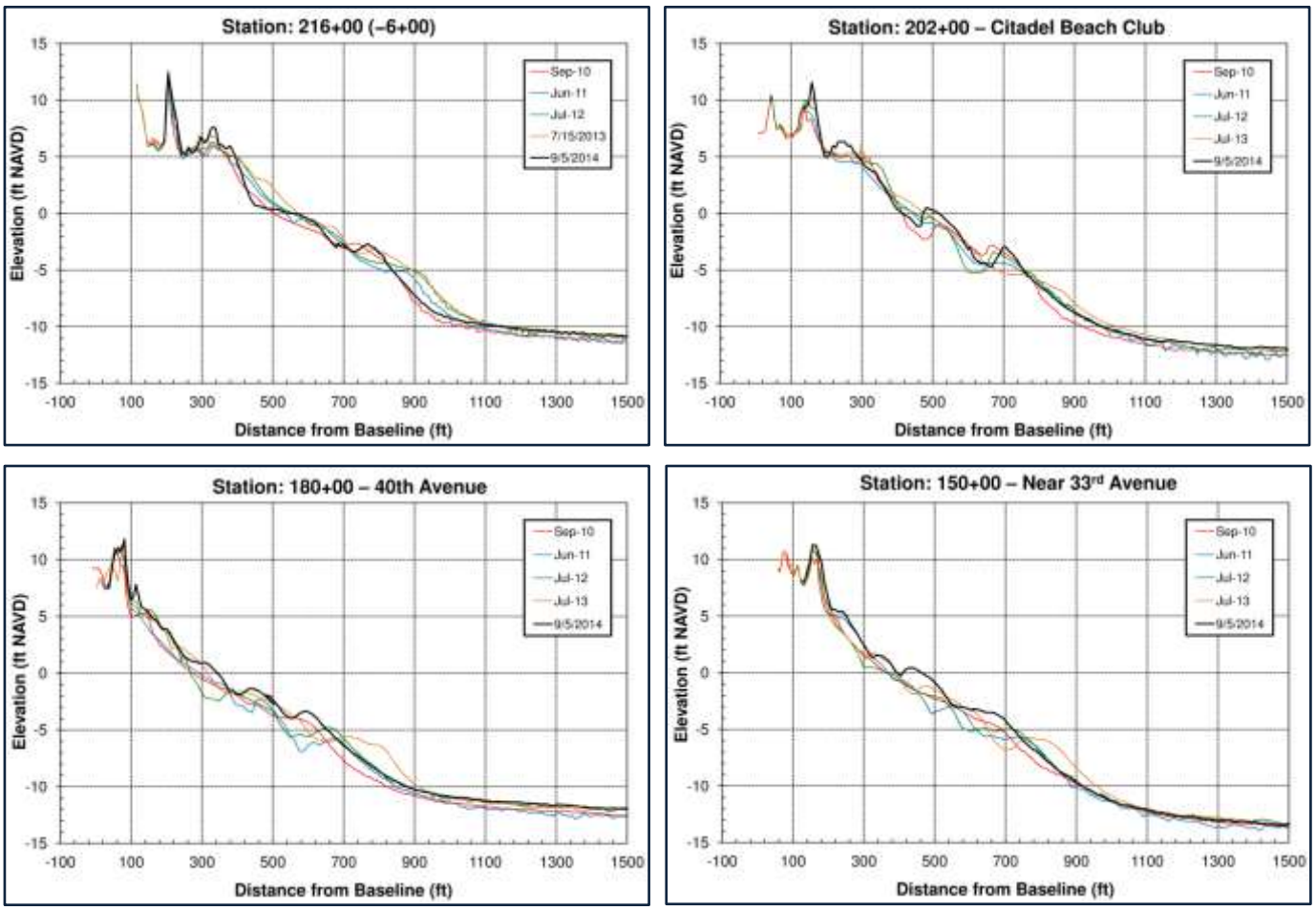


FIGURE 3.24. Profiles from Reach 4 stations 216+00 (51st Avenue), 202+00 (47th Avenue), 180+00 (40th Avenue), and 150+00 (33rd Avenue

FIGURE 3.25. September 2014 photos from Reach 4. **[TOP]** 53rd Avenue looking west into small erosion arc. **[CENTER]** View west from 44th Avenue. **[BOTTOM]** View west from 36th Avenue showing expanding dune vegetation across a growing berm. [Photos by D Giles]

FIGURE 3.26. October 2014 aerial image of the central portion of Isle of Palms. The seawall (arrow) protecting the Citadel Beach Club (exposed in the 1980s) is now buried behind nearly 100 ft dunes. [Photo by SB Traynum]

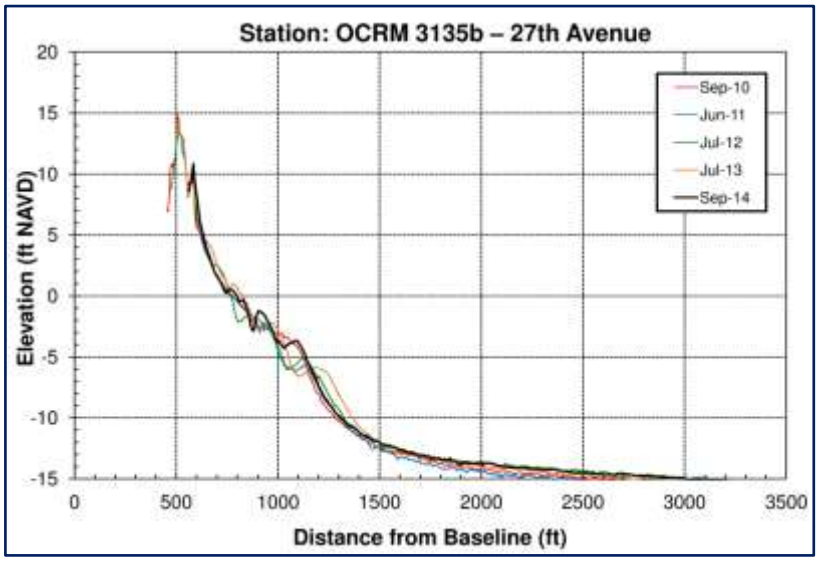
Reach 3 — The Sea Cabins Pier to 31st Avenue

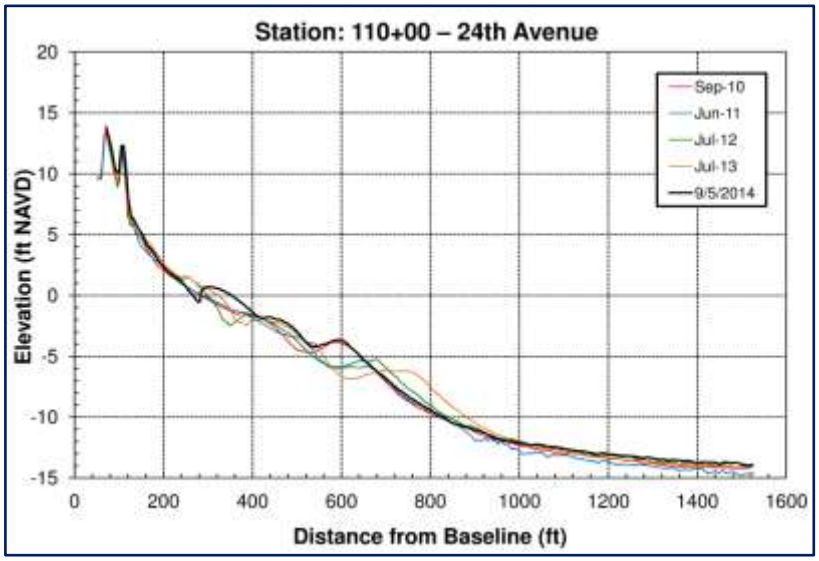
Reach 3 spans the oceanfront from the Sea Cabins Pier to 31st Avenue (OCRM monuments 3125 to 3140, Fig 3.27). Like Reach 4, the long-term trend in this area is stable to accretional. Profiles from OCRM station 3135 (near 27th Avenue) show the beach has gained ~40 ft in width at the +5-ft NAVD contour (Fig 3.28) over the past ten years. A similar trend is evident at OCRM station 3125 (14th Avenue) with dune growth and beach widening over the past ten years.

FIGURE 3.27. Reach 3 spans from station OCRM 3125 (pier) to station OCRM 3140 (31st Avenue) — noted by the orange-highlighted bar.

Reach 3 has shown various periods of erosion and accretion since CSE began island-wide monitoring in 2009. This is typical for stable to moderately accretional beaches as variations in wave conditions from year to year and temporary changes in sediment supply lead to minor fluctuations in yearly volume change. Over the long term, the trend is accretion.

Since March 2009, erosion rates in Reach 3 have ranged from −8.2 cy/ft/yr to +17.4 cy/ft/yr. Between July 2013 and September 2014, Reach 3 gained ~3,000 cy (0.5 cy/ft) of sand. Within the reach, stations 120+00–130+00 (26th–28th Avenues) eroded and all other stations gained sand. Dunes continue to grow throughout the reach, and coupled with the large setbacks of structures, provide significant storm protection for moderate storms. The reach has gained ~133,000 cy since March 2009, an average accretion rate of 4.3 cy/ft/yr. Photos are shown in Figure 3.29.





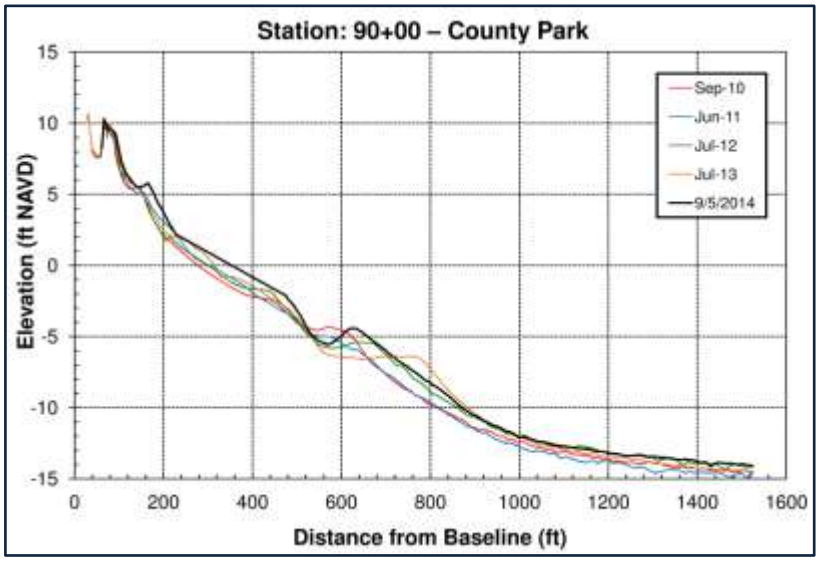


FIGURE 3.28.

Profiles from OCRM station 3135 (27th Avenue) (upper), station 110+00 (24th Avenue) (middle), and station 90+00 (County Park) (lower).

FIGURE 3.29. **[UPPER LEFT]** View east from 21st Avenue. **[UPPER RIGHT]** View west from 30th Avenue. **[LOWER]** October 2014 aerial view of Reach 3. [Upper photos by D Giles in September 2014. Lower photo by S Traynum.]

Reach 2 — 6th Avenue to the Sea Cabins Pier

Reach 2 spans 4,280 ft between 6th Avenue and the Sea Cabins Pier (OCRM monuments 3115–3125) (Fig 3.30). Reach 2 shows an erosion/accretion pattern similar to Reach 3 with intermittent periods of accretion and erosion resulting in a long term trend of accretion.

FIGURE 3.30. Reach 2 spans from OCRM 3115 (6th Avenue) to OCRM 3125 (Sea Cabins Pier) – noted by the orange-highlighted bar.

Since 2009, the annual volume change between monitoring events ranged from −5.6 cy/ft/yr to +11.1 cy/ft/yr. Erosion was most severe over this past year, with the **beach losing 27,900 cy (6.5 cy/ft) between July 2013 and September 2014**. Station 80+00 was the only profile measuring accretion (+2.1 cy/ft) (Fig 3.31). The remaining stations between 6th Avenue and 10th Avenue lost an average of 12.6 cy/ft. Erosion was most severe near 6th and 7th Avenues as an erosional arc was impacting the dunes and producing large escarpments (Fig 3.32). There were signs of recovery in September 2014 (accumulations of wind-blown sand at the bottom of the escarpment with vegetation "runners" growing), which indicate the scarping occurred earlier in the year. This erosion is a continuation of erosion observed in 2013, at which point the scarp was active and no dry beach was present seaward of the scarp.

Overall, the reach has gained 52,100 cy since March 2009, an average annual accretion rate of 2.2 cy/ft/yr. OCRM station 3115 and station 50+00 presently have less sand than the March 2009 condition.

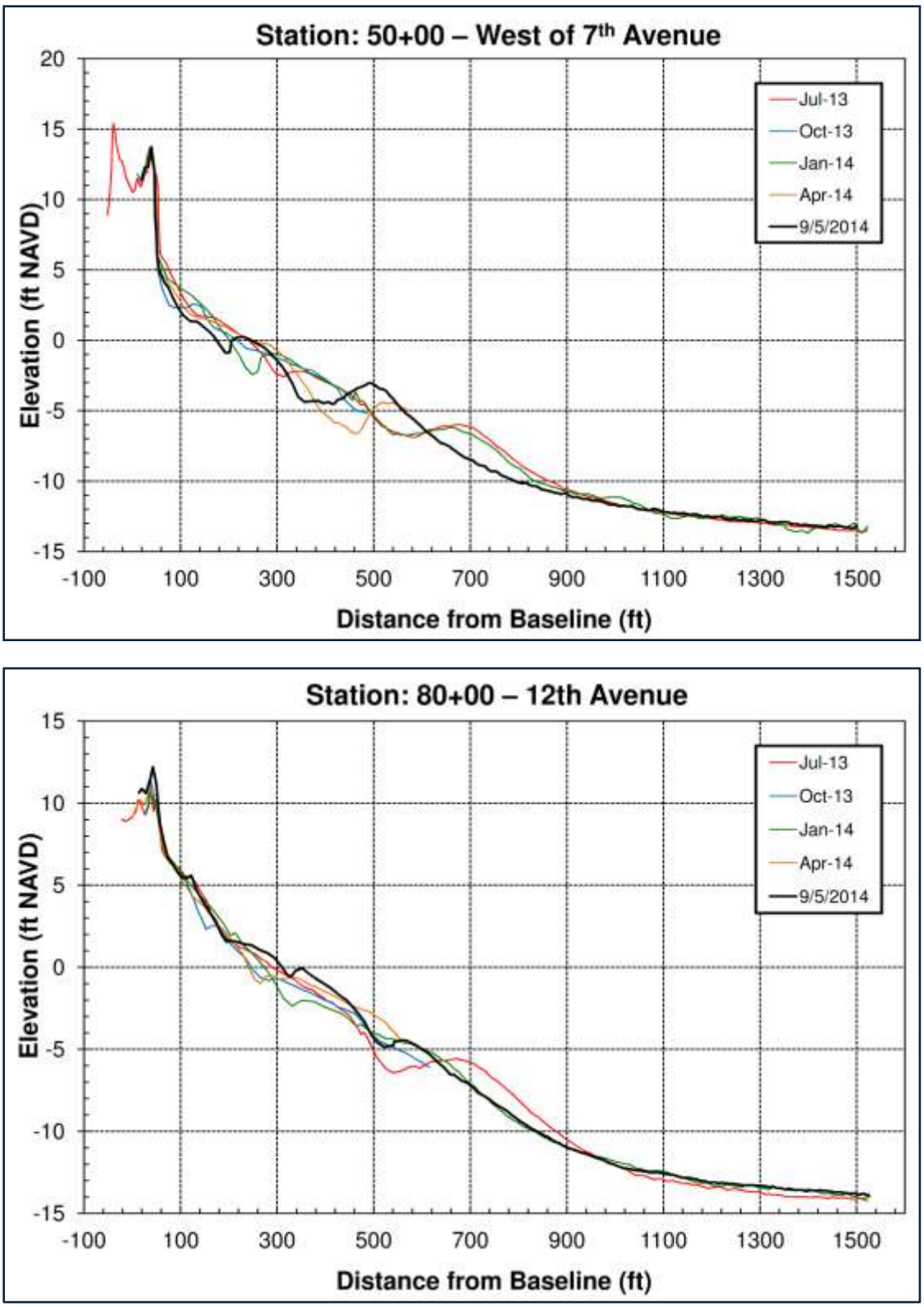


FIGURE 3.31. Profiles from station 50+00 (7th Avenue, upper) and station 80+00 (12th Avenue, lower).

FIGURE 3.32. **[UPPER]** 6th Avenue looking east. **[MIDDLE]** Station 60+00 near 8th Avenue. **[LOWER]** Station 70+00 looking east near front beach. [Photos by S Traynum]

Reach 1 — Breach Inlet

Reach 1, between Breach Inlet and 6th Avenue (Fig 3.33), is classified as an unstabilized inlet erosion zone due to the dynamic nature of the shoals associated with the inlet delta. While labeled as unstable, the long-term trend for this reach is accretion with an estimated growth of ~8.9 ft/yr (linear beach width). The historical accretion trend in this reach is due to a plentiful sand supply from upcoast and sand trapping by the Breach Inlet ebb-tidal delta.

Sand supply originates from shoal-bypass events at Dewees Inlet and longshore sand transport from north to south over the length of Isle of Palms. Excess sand is deposited along the southern spit of the island (Reach 1) and in the Breach Inlet ebb-tidal delta. Shoals of Breach Inlet form a protuberance in the shoreline, which backs sand up along the oceanfront much like a terminal groin traps sand. Changes in this area are related to bars from the inlet delta migrating onto the beach or marginal flood channels moving landward or seaward. Such natural processes lead to rapid changes in the beach volume compared to the central Isle of Palms reaches.

Reach 1 lost ~182,000 cy of sand from September 2010 to July 2013, which led to loss of dunes, damaged walkovers, and generally the most eroded beach condition in that area in recent memory. Some areas lost over 100 ft of dune and dry beach width from 2011 to 2013. The erosion was atypical for the reach, which has historically accreted, and generated concerns from property owners. CSE predicted the erosional trend would reverse based on the amount of sand moving in from upcoast reaches; however, additional monitoring was conducted to more closely track the conditions.

FIGURE 3.33. Reach 1 spans between Breach Inlet and 6th Avenue – noted by the orange-highlighted bar.

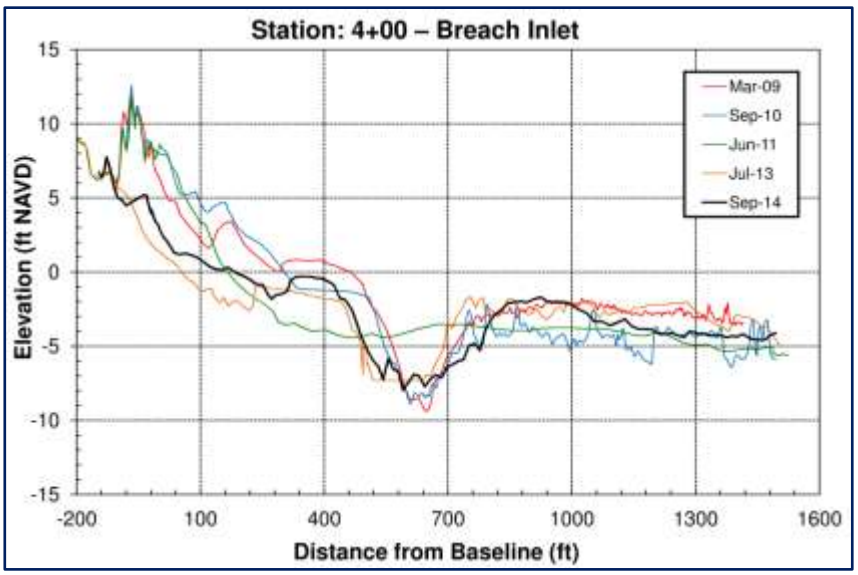
Between 2013 and 2014, Reach 1 accreted, resulting in a growing dry beach and evidence of dune recovery (Fig 3.34). Overall, the reach gained 58,850 cy (13.4 cy/ft), which is a similar magnitude to the volume lost the prior year. Station 40+00 (near 6th Avenue) was the only station to lose sand. Accretional areas gained up to 41 cy/ft and over 50 ft of dry beach. The reach shows a net loss of 34,000 cy since March 2009, which is an average annual erosion rate of 1.4 cy/ft/yr.

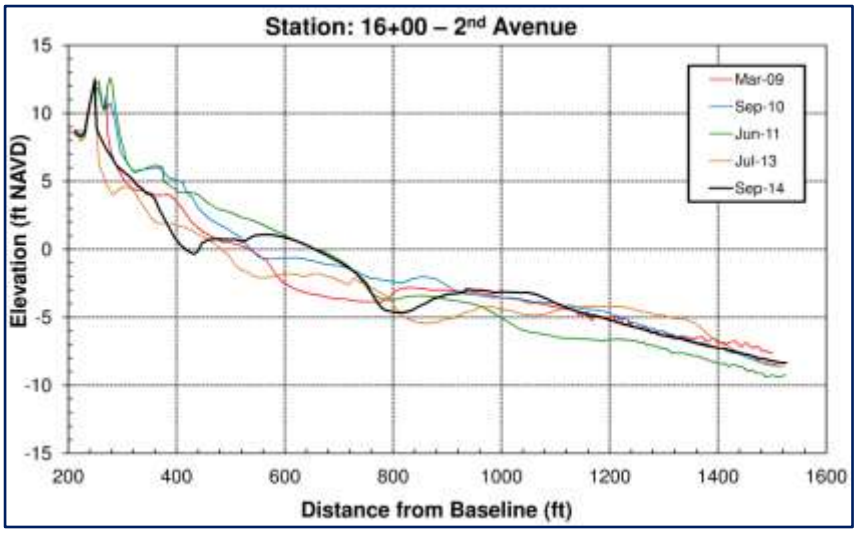
The beach condition near Breach Inlet is heavily influenced by currents and shoals. Net sediment transport to the west causes the main channel to migrate west, over-extending along the eastern portion of Sullivan's Island. Much like Dewees Inlet at the eastern end of Isle of Palms, periodic breaks in the delta shoals allow the main channel to relocate further east, starting the migration process over again (Fig 3.35).

A realignment event occurred between 2009 and 2011. Between 2013 and 2014, the seaward end of the inlet migrated away from Isle of Palms which caused the delta shoals to shift southwest, likely drawing off sand from the beach near Breach Inlet. Between 2013 and 2014, the Isle of Palms side of the Breach Inlet delta was fairly stable (Fig 3.36). The area seaward of the marginal flood channel increased in elevation slightly (~1 ft), but the bulk of the shoal did not move significantly west. The buildup may be beneficial to the beach, as it may act as a terminal groin and help keep sand from moving into the inlet as quickly. The marginal flood channel was also relatively stable, which is favorable for stability of the beach.

The changes observed near Breach Inlet (Fig 3.37) highlight the dynamic nature of barrier-island shorelines adjacent to inlets. Often, beach condition is driven by short-term events associated with inlet changes rather than long-term erosional patterns. As evidenced by recent changes, decades' worth of accretion can be lost rapidly due to inlet effects. Similarly, a shoal-bypass event may restore a beach which has suffered long-term erosion (eg – Fripp Island, CSE 2013b). While local beach changes due to inlet effects are difficult to predict several years in advance, regular monitoring provides the best method to plan for potential issues and project near-future changes.

While the accretion observed over the past year is welcomed, erosion occurring in Reach 2 may limit the amount of incoming sand over the next year. Erosion during the upcoming year would not be surprising; however, as mentioned, the beach condition is largely controlled by the delta, and yearly volume changes are difficult to predict. CSE continues to believe the long-term accretional pattern will allow the beach to maintain sufficient sand to protect structures barring storm events or inlet-induced erosional hotspots.





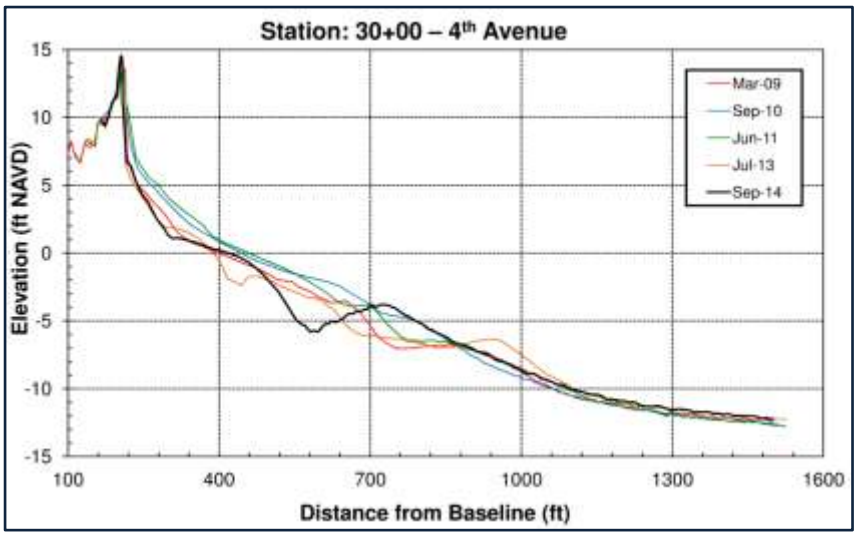


FIGURE 3.34.

Profiles from stations 4+00 and 16+00 near Breach Inlet and station 30+00 near 2nd Avenue.

Located about 500–700 ft from the baseline, a marginal flood channel reformed at station 4+00 between 2012 and 2013. Profiles show it migrated landward from July to October 2013 and has remained stable of the past year.

FIGURE 3.35.
October 2014 aerial images of Breach Inlet area.

[UPPER] The marginal flood channel separates the delta shoal from the low-tide beach.

[MIDDLE] The dry-sand beach on the spit has recovered over the past year.

[LOWER] The delta extends over a large portion of Sullivan's Island.

[Photos by SB Traynum]

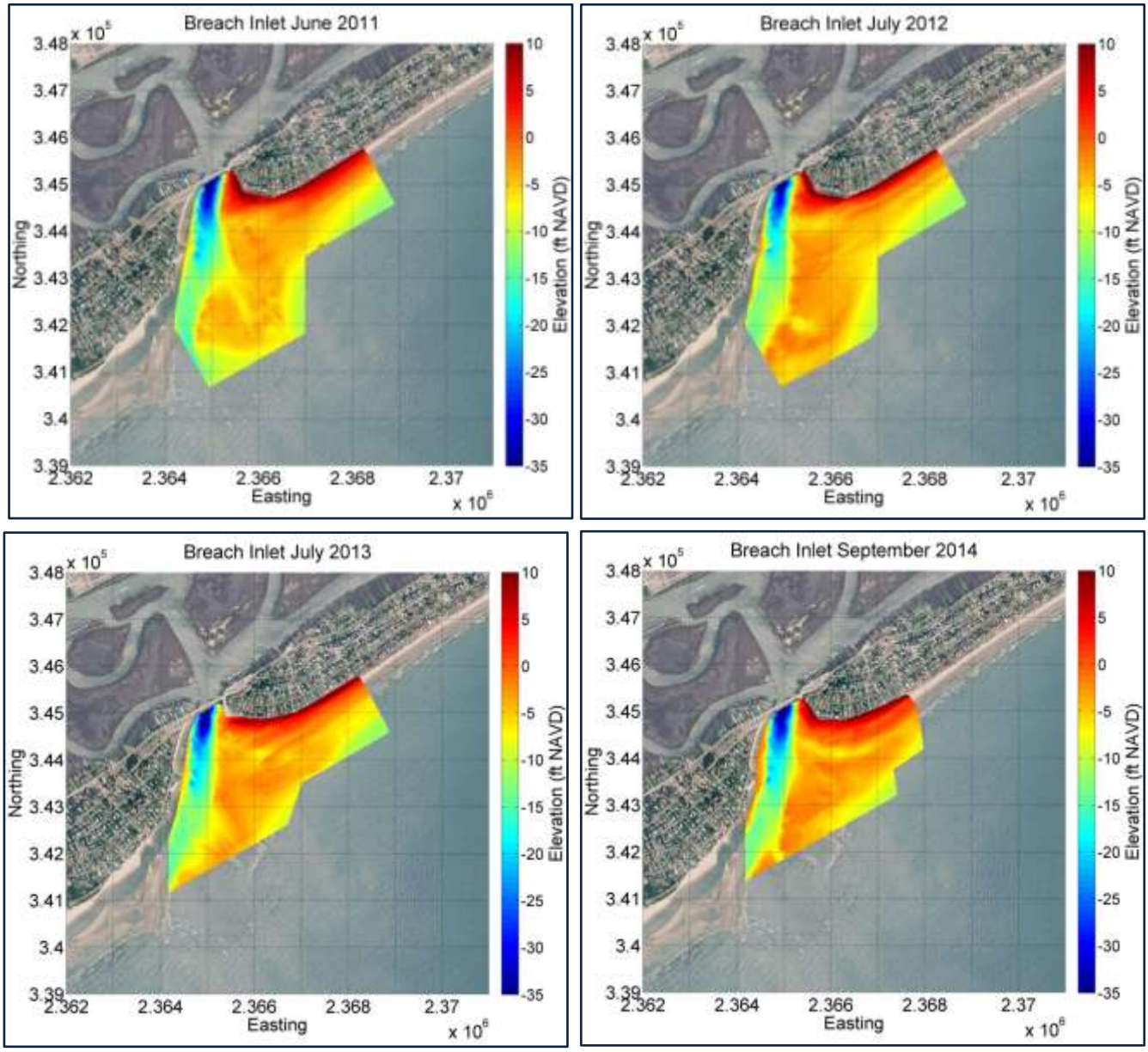


FIGURE 3.36. Color DTMs of Breach Inlet and neighboring IOP shoreline in June 2011, July 2012, July 2013, and September 2014.

FIGURE 3.37.

[UPPER LEFT] View west from beach access 2 (10 July 2012).

[2nd LEFT] Beach access 2 (29 October 2012) – Hurricane *Sandy* caused over 50 ft of dune erosion and damaged walkovers in this area. [Photo by D Kynoski]

[3rd LEFT] Beach access 2 (October 2013) – Note recovery of the berm and healthy dunes.

[BOTTOM] Beach access 2 (September 2014).

3.2 Dewees Inlet and Delta

CSE has monitored the morphology of Dewees Inlet since 2007. During the past seven years, a major channel avulsion event shifted the main channel east. Details of the morphological changes occurring from 2007 to 2012 are given in earlier reports to the City (CSE 2010, 2011a,b). The present report focuses on current conditions of the ebb-tidal delta and the impact it is having on the beach. Morphologic changes are highlighted in digital terrain models (DTMs) (Fig 3.38). Section profiles from selected stations are shown in Figure 3.39.

The most significant change in the delta from 2013 to 2014 was the continued onshore migration of the attaching shoal. The shoal attachment area encompasses the shoreline between Dunecrest Lane and Shipwatch (stations 268+00 to 294+00). The leading edge of the shoal migrated ~500 ft along the eastern body of the shoal (at Mariners Walk), while the western end attached to the beach along the shallow, underwater portion of the profile. While the "western arm" of the shoal has attached to the beach, it remains low in the profile and has not yet fully merged with the beach.

Some accretion was observed near Dunecrest Lane, likely due to the attachment, but not to the extent typical of these events. This is likely a result of additional sand buildup seaward of this area, which is essentially building another emergent shoal offshore of the present one. This is clear in later aerial images, which show a line of breaking waves seaward of the emergent arm (with an area of calm water between them, indicating deeper water). This seaward shoal is preventing full merging of the landward shoal and extending the "Stage 2" status of the shoal-bypass event.

A cross-section of the shoal (at station 292+00 – Shipwatch) over the last five years is shown in Figure 3.39. The landward migration of the shoal is evident in the successive profiles, culminating in the shoal reaching within 300 ft of the shoreline in September 2014. Of note is that in 2013, the shoal (orange line) had two leading fronts, one at approximately −5 ft NAVD (1,500 ft form the baseline) and the other at −2 ft NAVD (2,000 ft from the baseline).

The lower front has been slowing its migration since 2012, from ~700 ft/yr (2011–2012) to ~600 ft (2012–2013) and only ~300 ft from 2013 to 2014. Over the past year, the higher front migrated at a faster rate than the lower front, merging with the lower front and forming a typical slip-face placed ~300 ft from the beach. The slowing of the lower front is due to the reduced wave action reaching the landward portion of the shoal as the elevation increased and more shoal becomes emergent. The slowing of the migration is extending Stage 2 and delaying full attachment.

While not fully evident in the available survey data, another process potentially delaying attachment and recovery of the beach is northern spreading of the sand on the seaward (eastern) portion of the shoal. When shoals first become emergent, they typically have a circular shape. As waves work the seaward side of the shoal, sand begins to spread laterally (north and south), forming a horseshoe-shaped feature (see Fig 1.2). The “arms” of the horseshoe are typically the part that needs to fully attach before beach recovery is possible.

While the present shoal has a leading edge that was nearing attachment in late 2014, an excess of sand essentially led to another emergent shoal forming seaward of the leading front. [While all the sand is currently part of one large bypass event, localized accumulations can act as individual events and can evolve independently of other features.] Observations following the September 2014 survey suggest that this seaward sand mass is spreading to the north and may evolve into an “arm” which must extend northward and landward until it attaches to the beach (Fig 3.40).

Another significant process continuing in the delta is the buildup of the trailing ebb spit at the northeastern corner of the island. This feature has grown substantially over the past three years, gaining an estimated 350,000 cy since 2011. The elevations have increased and sand has extended to the south over 1,200 ft. To provide a spatial measure of the extent of the shoal growth, the area above −6 ft NAVD (area with breakers at low-tide with moderate waves) has increased from no acreage in 2011 to 11.9 acres in 2014. As this feature continues to grow, it will shelter the beach at the northern end (golf course area) from waves and may act as a terminal groin to trap some sand moving from the front beach into the inlet.

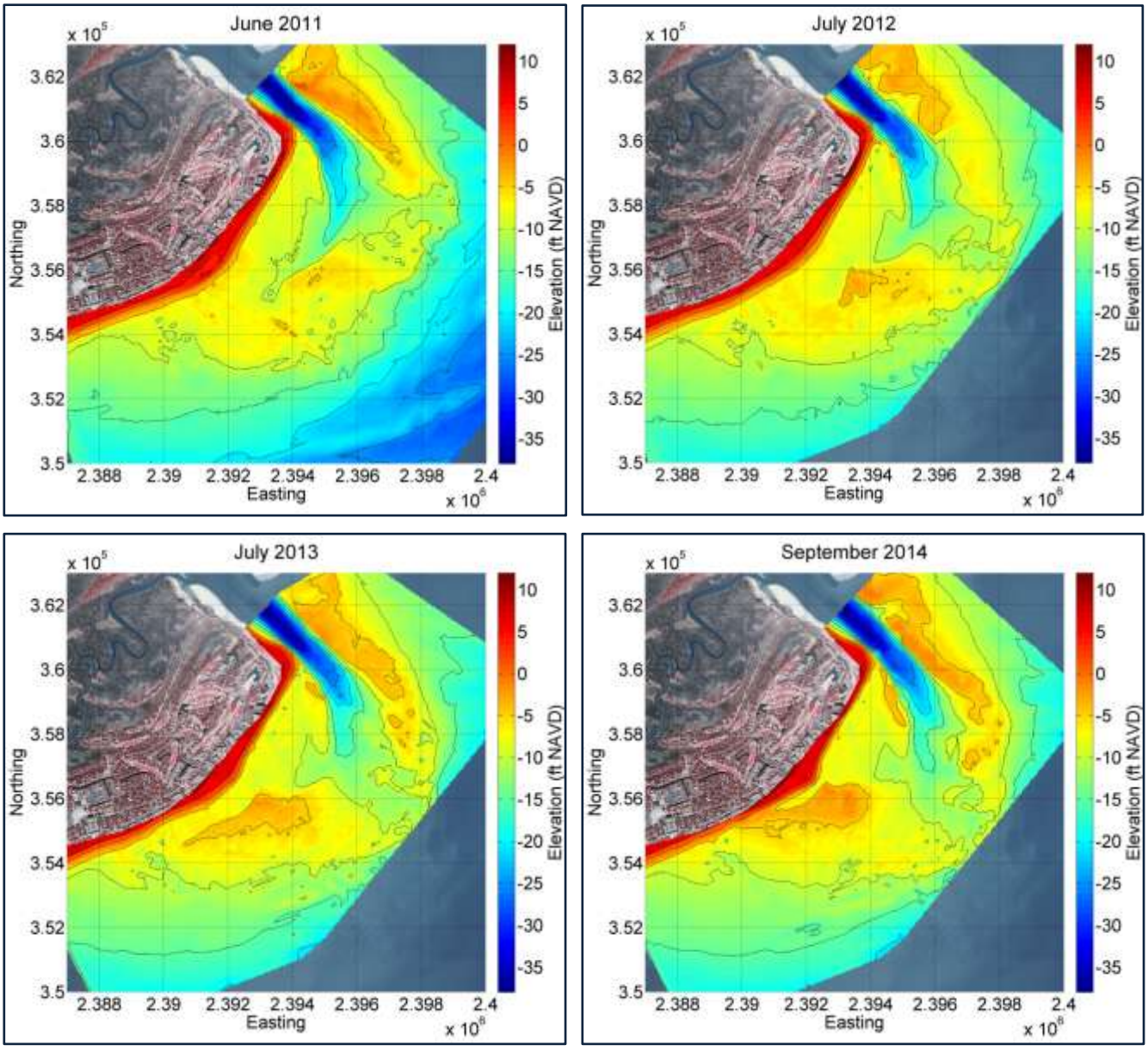
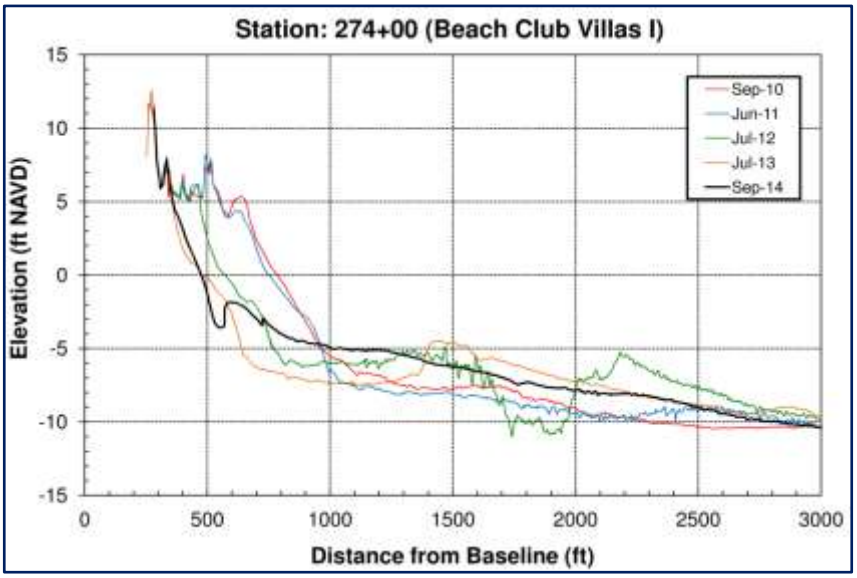
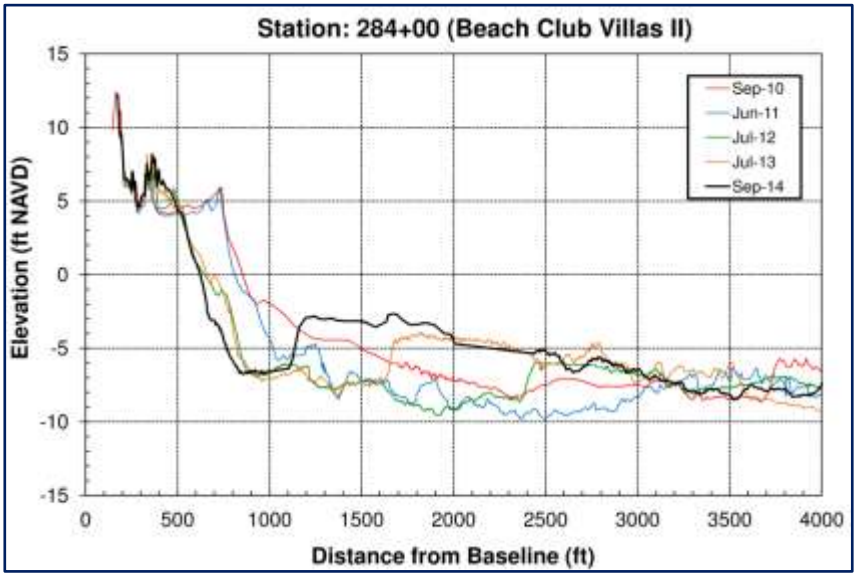


FIGURE 3.38. Color DTMs from the June 2011, July 2012, July 2013, and September 2014 surveys of the Dewees Inlet ebb-tidal delta.





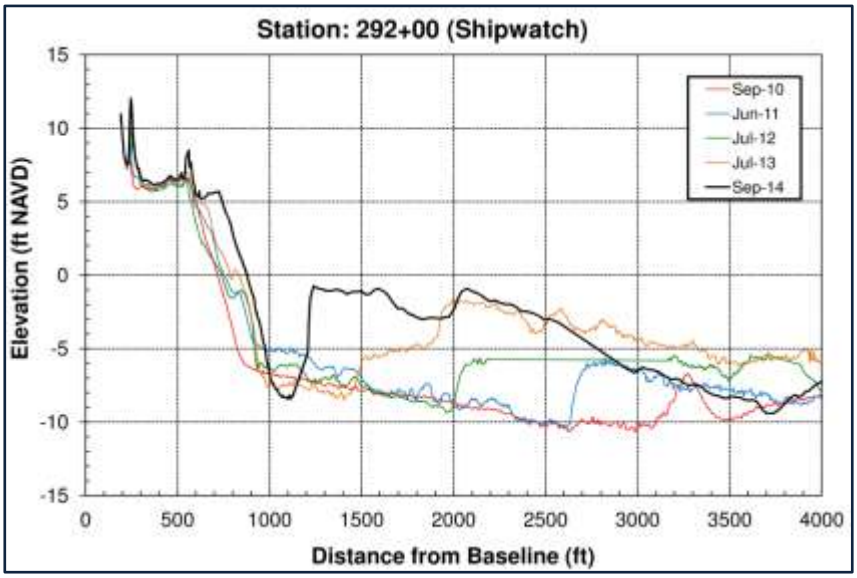


FIGURE 3.39.

Profiles from station 274+00 (Beach Club Villas I), station 284+00 (Beach Club Villas II), and station 292+00 (Shipwatch) showing the position of the shoal migrating toward the beach.

The western area (station 274+00) attached along the shallow underwater portion of the profile (approximately −3 ft NAVD).

FIGURE 3.40. October 2014 aerial images of the shoal off the northeastern end of Isle of Palms.

To more simply show the migration of shoals in the Dewees Inlet delta, CSE extracted the −6 ft NAVD contour to use as a proxy for shoal boundaries. Areas were produced from those contours, colored, and placed into GIS software to develop schematics of the delta over two time periods (Fig 3.41). The first spans 2007–2010 and shows how the existing sand platform (Area A – which generated the large 2007 event requiring the 2008 project) merged with the shoreline over the four-year period. At the same time, the channel avulsion event was occurring, noted by the southwest migration of the offshore shoal (Area B).

The second map spans 2011–2014 and shows the onshore immigration of the current shoal-bypass event (Area A). Of note is the merging of two independent shoals in 2011 and 2012. In 2011, two distinct shoal features are present near Area A. The northern shoal was from the offshore shoal (originally seaward of the 2007 channel), and the southern shoal was from remnants of the 2007 delta terminal lobe (west of the 2007 channel). By 2012 (white areas in lower map), the two shoals were nearly connected and had fully merged by 2013, with the terminal lobe sand forming the western “arm” of the merged shoal complex.

The second series also shows growth of the trailing ebb spit (Area B) and southern deflection of the channel marginal linear bar (Area C) on the northern side of the main channel.

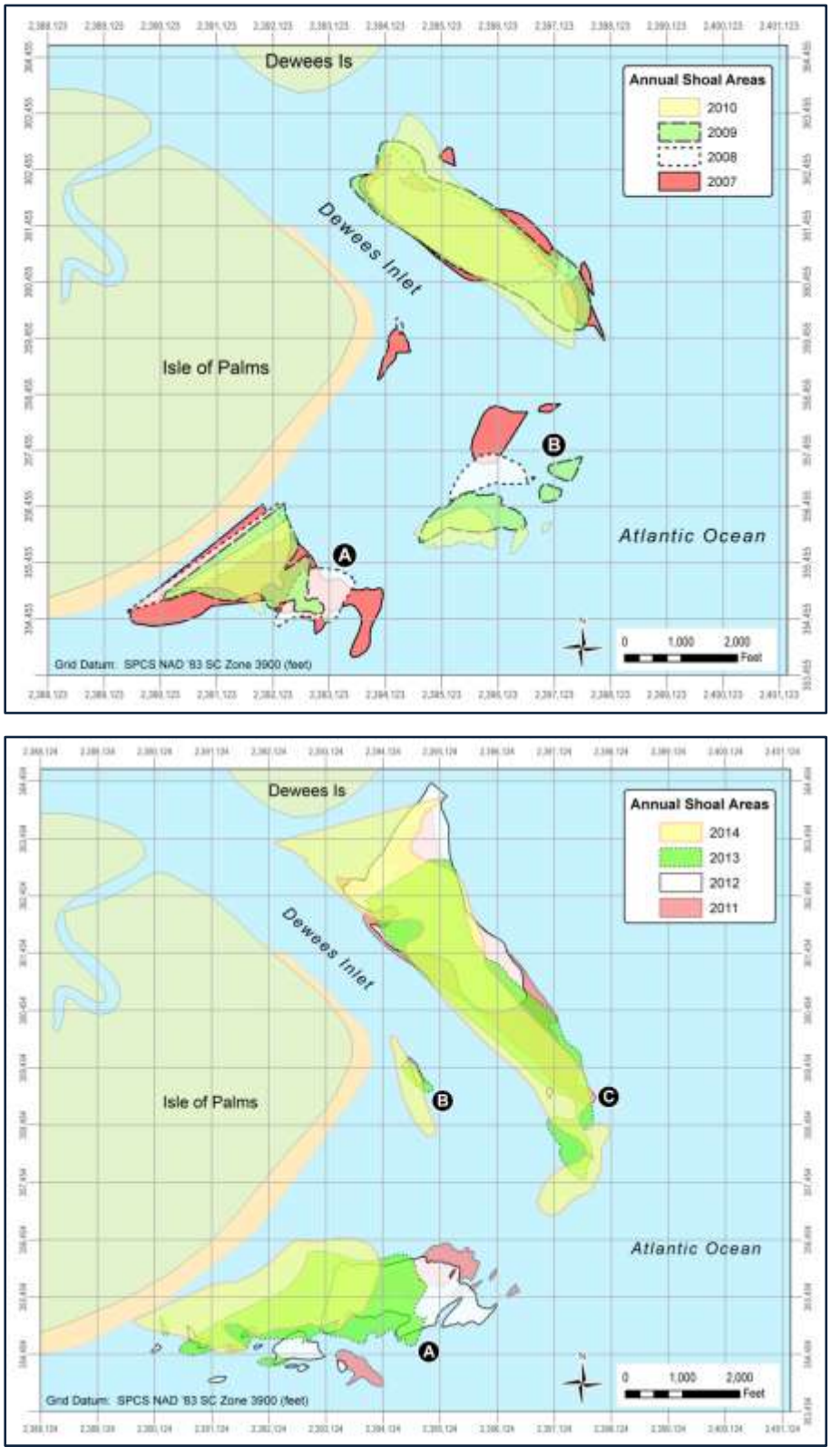


FIGURE 3.41. Schematic of the shoal extents from 2007 to 2010 (upper) and from 2011 to 2014 (lower). Boundaries show the general location of the −6 ft contour. Labels are described in the text.

3.3 Project Area Volume Changes

The following section provides volume change results within the limits of the 2008 nourishment project boundaries. It provides a measure of how much sand is left within the initial alongshore fill limits. While these results are useful for measuring project performance, it should be noted that sand gained or lost from these areas may be accounted for in adjacent areas as noted in Section 3.1.

Within the fill limits of the *Dewees Inlet* project area (nourishment Reach C, Fig 3.42), the beach continued to gain sand. **Overall, the project reach has gained ~16,800 cy (16.8 cy/ft) since July 2013, leaving it with 235 percent of the nourishment volume remaining** (Fig 3.43). As of September 2014, Reach C contained ~100,600 cy more sand than the pre-nourishment condition. Accretion between stations 330+00 and 338+00 (area of the 18th tee and fairway) is likely due to losses in Reach 6. The volume change trends along the 18th fairway of the Wild Dunes Links Course (which wraps around the northeastern point of the island) provide an indicator of net sand transport from the oceanfront to the inlet shoreline in this area, consistent with the findings of Kana and Dinnel (1980).

The length of beach within the project boundary Reach B (between Shipwatch and the 18th fairway) presently retains 84.6 cy/ft more sand than the pre-nourishment condition (compared to 148.4 cy/ft immediately following nourishment). **As of September 2014, 57.0 percent of the nourishment volume remains in project Reach B.** Overall project Reach B lost ~48,000 cy (11.2 cy/ft) of sand since July 2013.

Project Reach A lost 53,500 (10.3 cy/ft) between 2013 and 2014. The project area presently retains an average of 27.1 cy/ft less sand than the pre-nourishment condition compared to 64.6 cy/ft more sand immediately post-nourishment. **As a whole, the reach shows less sand than the pre-nourishment condition; however, the western half of the reach still retains more sand than the pre-nourishment condition.** Extensive erosion of the eastern end of the reach skews the overall totals. See details in Section 3.1.

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FIGURE 3.42. Reaches for the 2008 nourishment project. The graphic shows the project baseline with 0+00 located at 53rd Avenue (monitoring station 222+00).

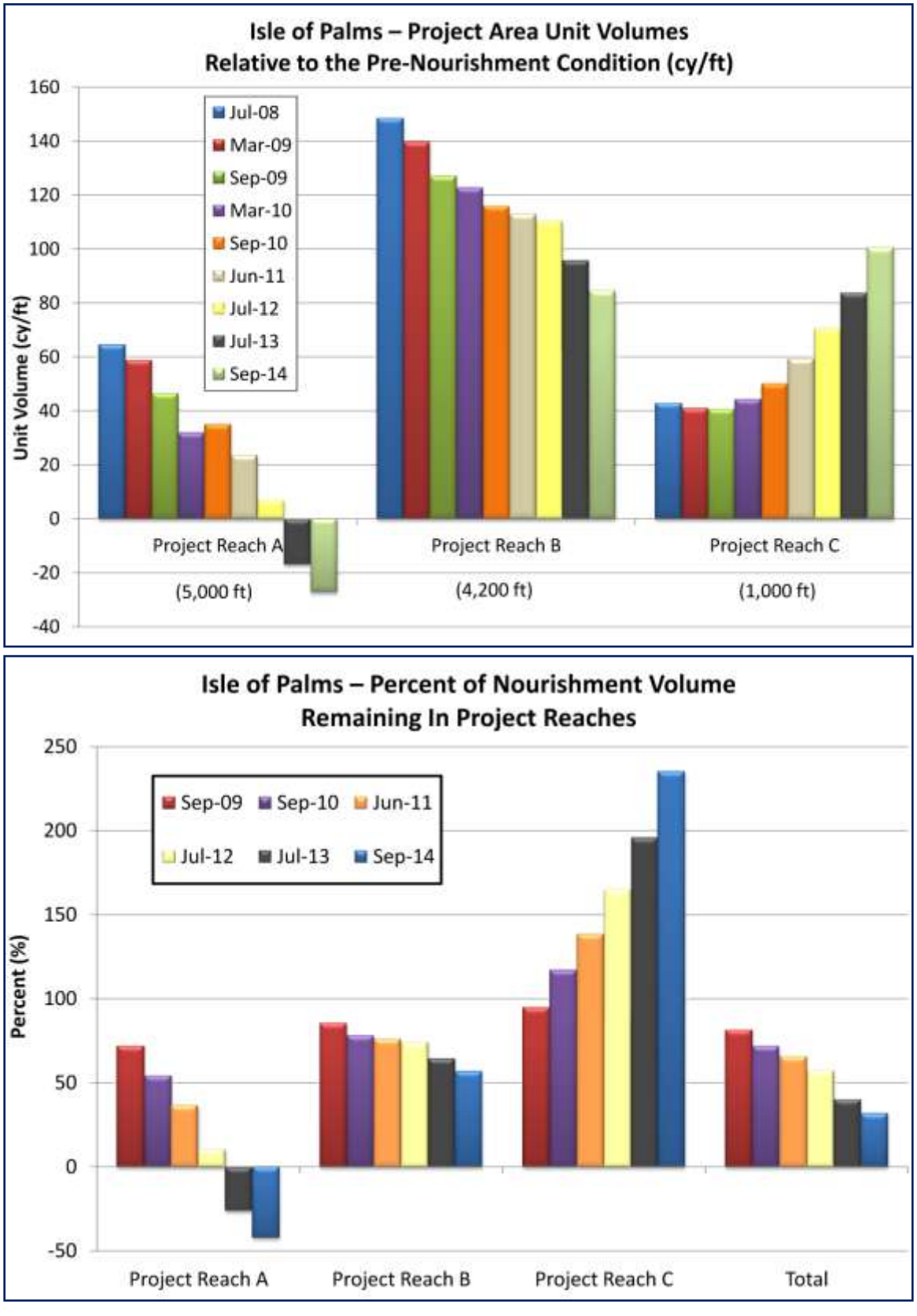

FIGURE 3.43. **[UPPER]** Project area unit volumes relative to the pre-nourishment (March 2008) condition, which is zero on these graphs. [Note that the project area limits differ from monitoring reach limits.] **[LOWER]** Percent of nourishment volume remaining in each project area.

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4.0 DISCUSSION AND RECOMMENDATIONS

CSE has collected detailed morphological data at Isle of Palms over the past seven years (2007–2014). During that time, significant changes have occurred in Dewees Inlet which have impacted the shoreline and will continue to control beach volume changes at the northeastern end for several years. Specifically, a channel avulsion event (shift of the channel to a more northerly position) has been occurring, which has released over one million cubic yards of sand from the inlet delta. As of September 2014, this sand was nearing attachment to the beach and erosional arcs associated with the shoal had eroded the dry-sand beach enough to warrant emergency action by property owners.

A shoal management project was completed between November 2014 and February 2015, which transferred ~240,000 cy of sand from accreted beach areas and the shoal to the eroded areas. Details of that project will be provided in an independent report. This report, similar to previous monitoring reports, focuses on the condition as of September 2014 to provide a stand-alone account of the beach condition.

Significant findings of the present monitoring effort are:

- Onshore migration of the offshore shoal, which is beginning to attach at the western end and is ~300 ft from the beach on the eastern end.
- Erosional arcs on either side of the shoal have resulted in loss of the dry beach and emergency measures, including placement of sandbags and installation of an experimental wave-dissipation system.
- Net erosion along the east end was relatively low; however, localized hotspots eroded significantly, including near Beachwood East, 57th Avenue–Grand Pavilion, and near Ocean Club and the 18th hole.
- Isolated pockets of erosion were also observed along the central part of the island, most significantly near 6th Avenue and 27th Avenue.
- Overall, the east end lost ~17,300 cy of sand from July 2013 to September 2014. Losses in erosional areas were compensated by gains in the shoal attachment site and in Reach 7.
- Downcoast areas gained 47,500 cy over the past year with the majority of gain in Reach 1 (Breach Inlet). Reach 2 was erosional, losing ~28,000 cy.
- Areas near Breach Inlet, which had eroded in recent years, are recovering. A dry-sand beach has developed along some of the previous most severely eroded areas (stations 4+00–8+00).

Overall, the island gained ~30,000 cy (0.8 cy/ft) of sand between July 2013 and September 2014.

CSE anticipates another shoal management project will be needed in the winter of 2015–2016 permit window. As detailed herein, while the shoal is beginning to attach, the process is not moving rapidly enough to naturally restore eroded areas. It is likely that at least some of the areas restored in the 2014–2015 shoal project will need attention next fall or sooner.

The results of this report provide the City with an updated condition of the beach and offer guidance for beach maintenance activities. The City's commitment to regular, detailed monitoring of the beach is a model for other coastal communities looking to protect their most valuable physical asset. The September 2014 monitoring effort is the last effort included in the present agreement between the City and CSE. CSE will provide the City with a proposal, upon request, to continue monitoring efforts such as those detailed herein.

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ACKNOWLEDGMENTS

This report is prepared under an agreement between the City of Isle of Palms and CSE. It is the sixth in a series of annual reports following the 2008 beach restoration project at the northeastern end of the island.

CSE thanks the Isle of Palms City Council (Mayor Dick Cronin), Linda Lovvorn Tucker (city administrator), and Emily Dziuban (assistant to the administrator) for their continued support and coordination of this project.

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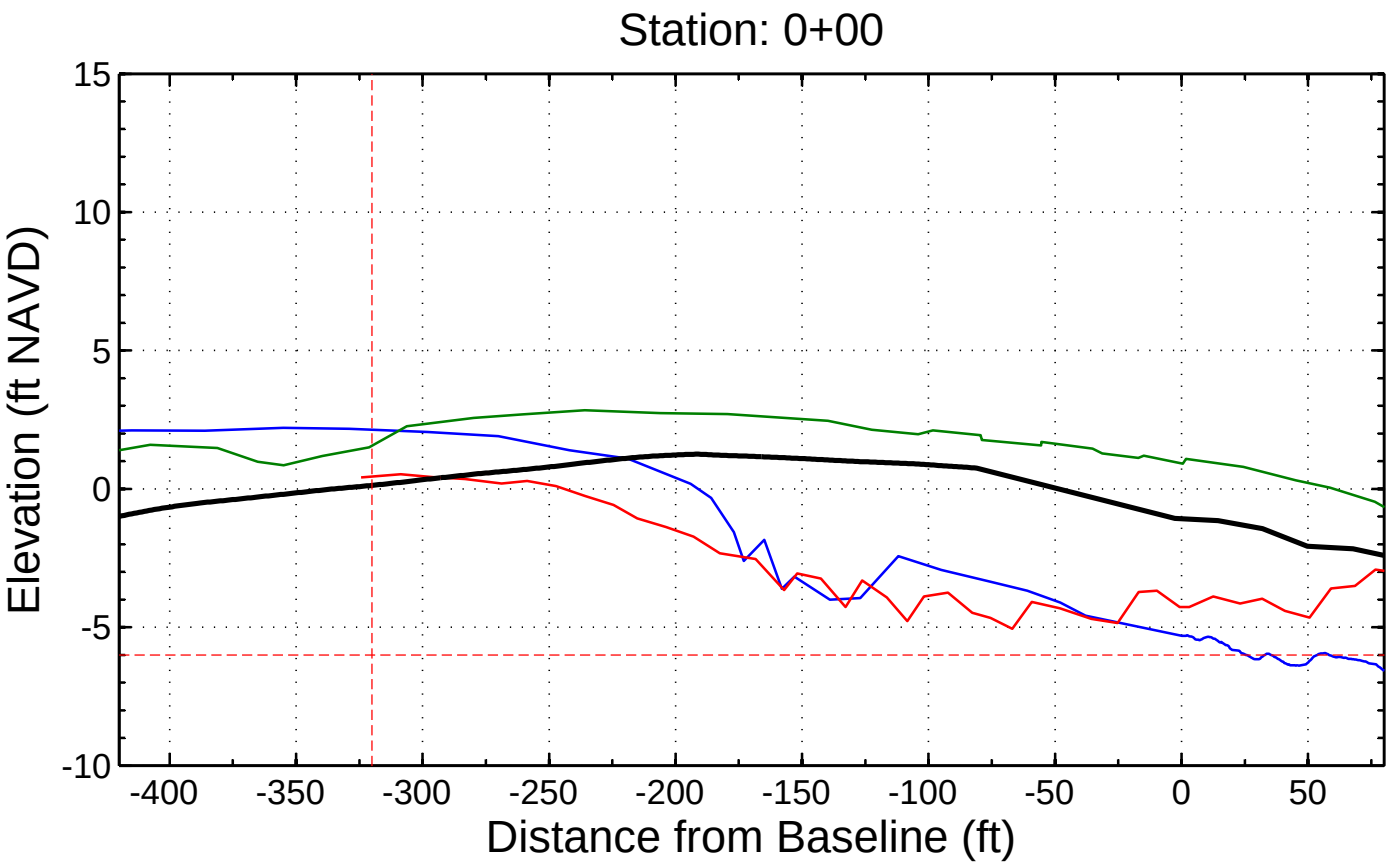
CSE's data collection and analyses were directed by Steven Traynum with assistance by Drew Giles, Luke Fleniken, Trey Hair, and Tim Kana. Graphics were prepared by Trey Hair and Steven Traynum using AutoCAD®'s Civil 3D®, MATLAB®, and Global Mapper® for digital terrain models. The report was written by Steven Traynum and Dr. Timothy Kana (SC PG 564) with production assistance by Diana Sangster and Trey Hair.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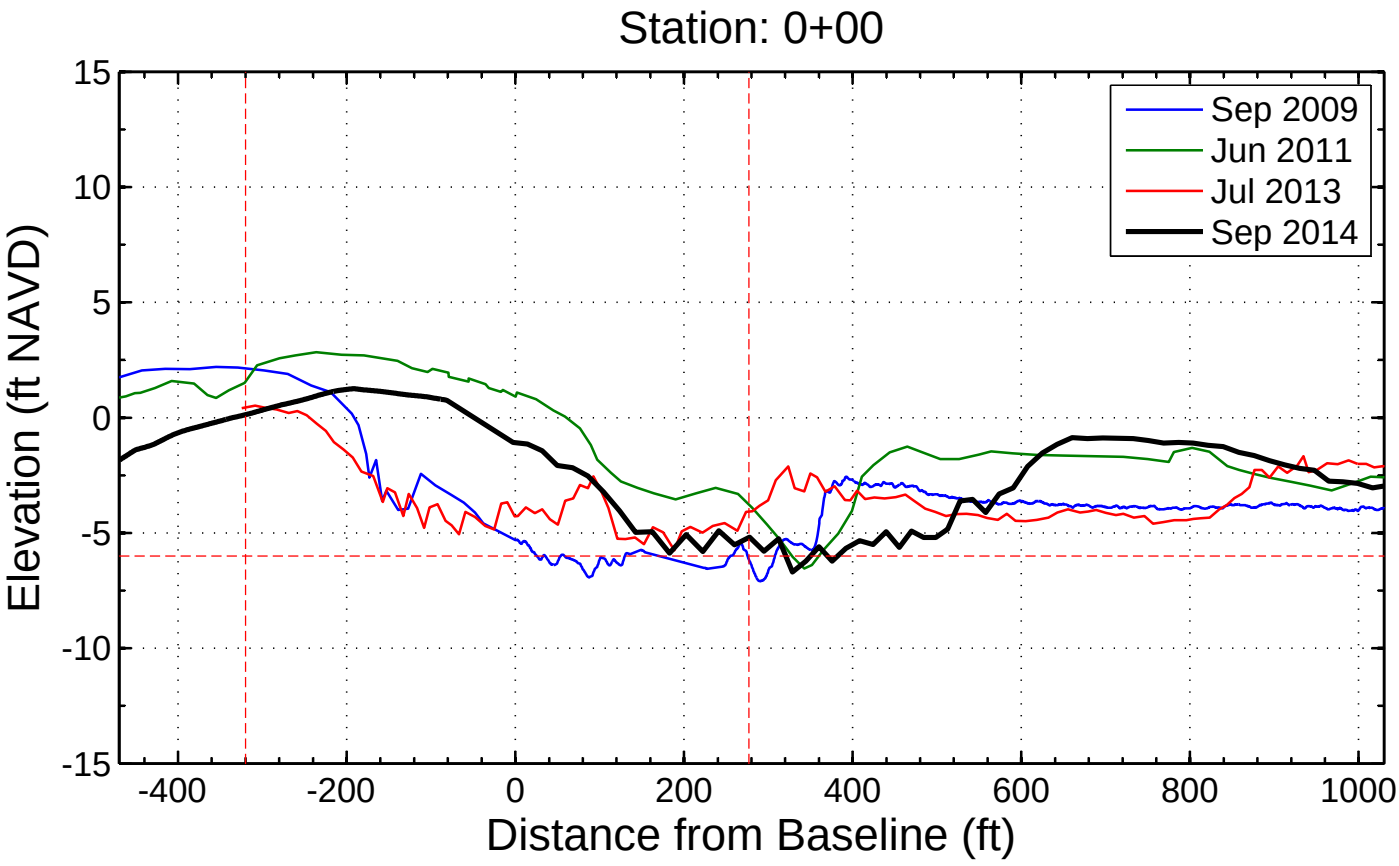
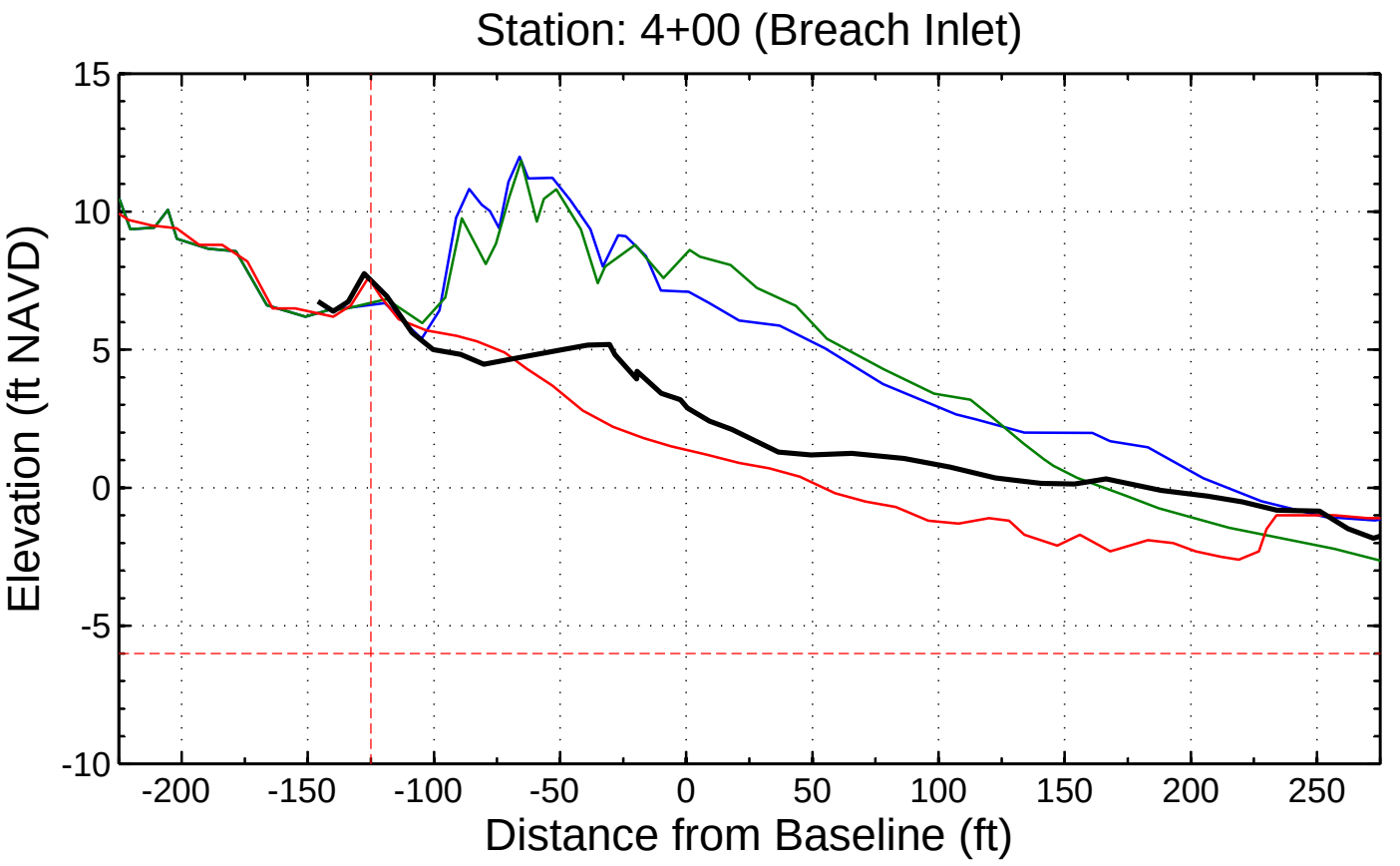
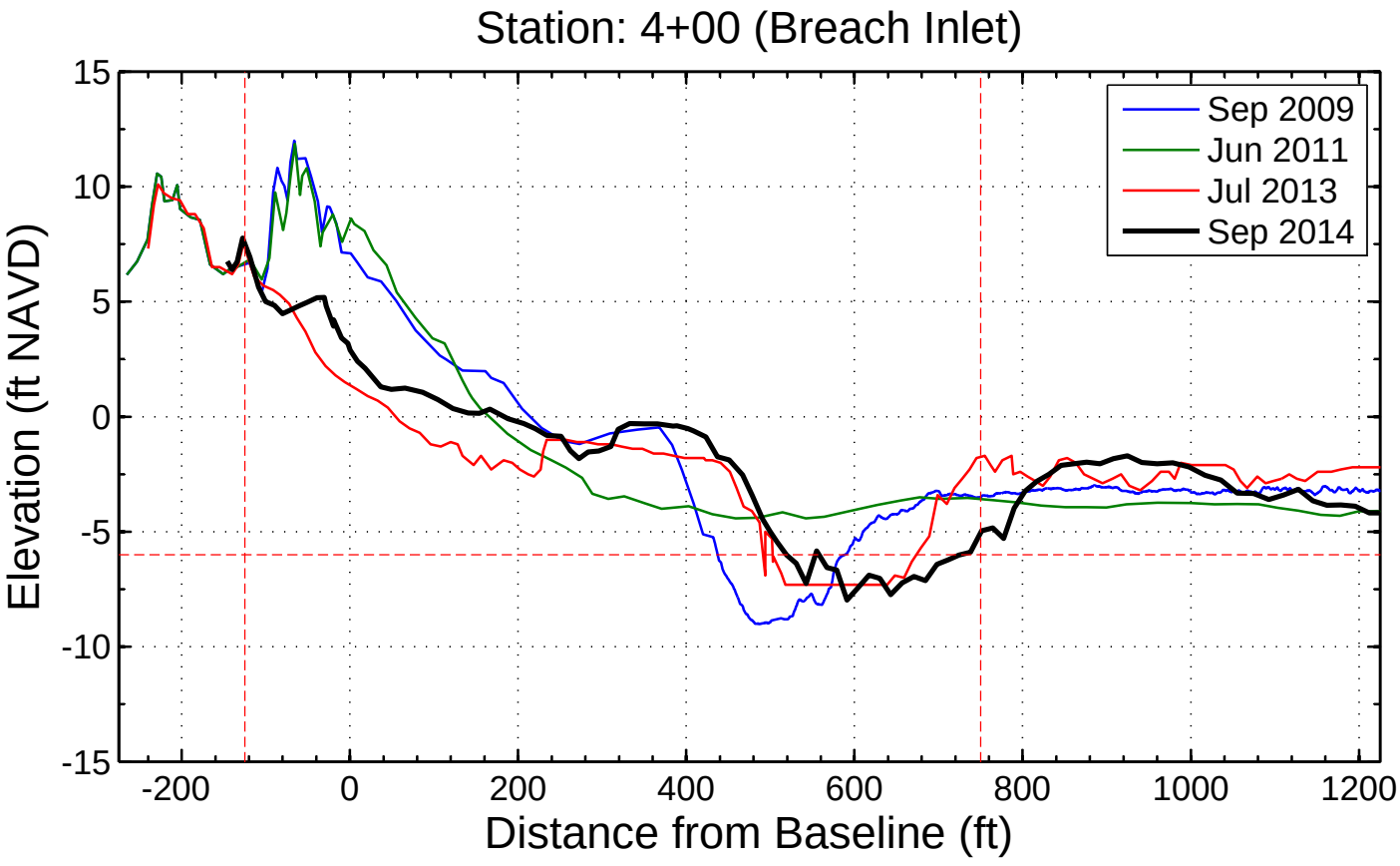
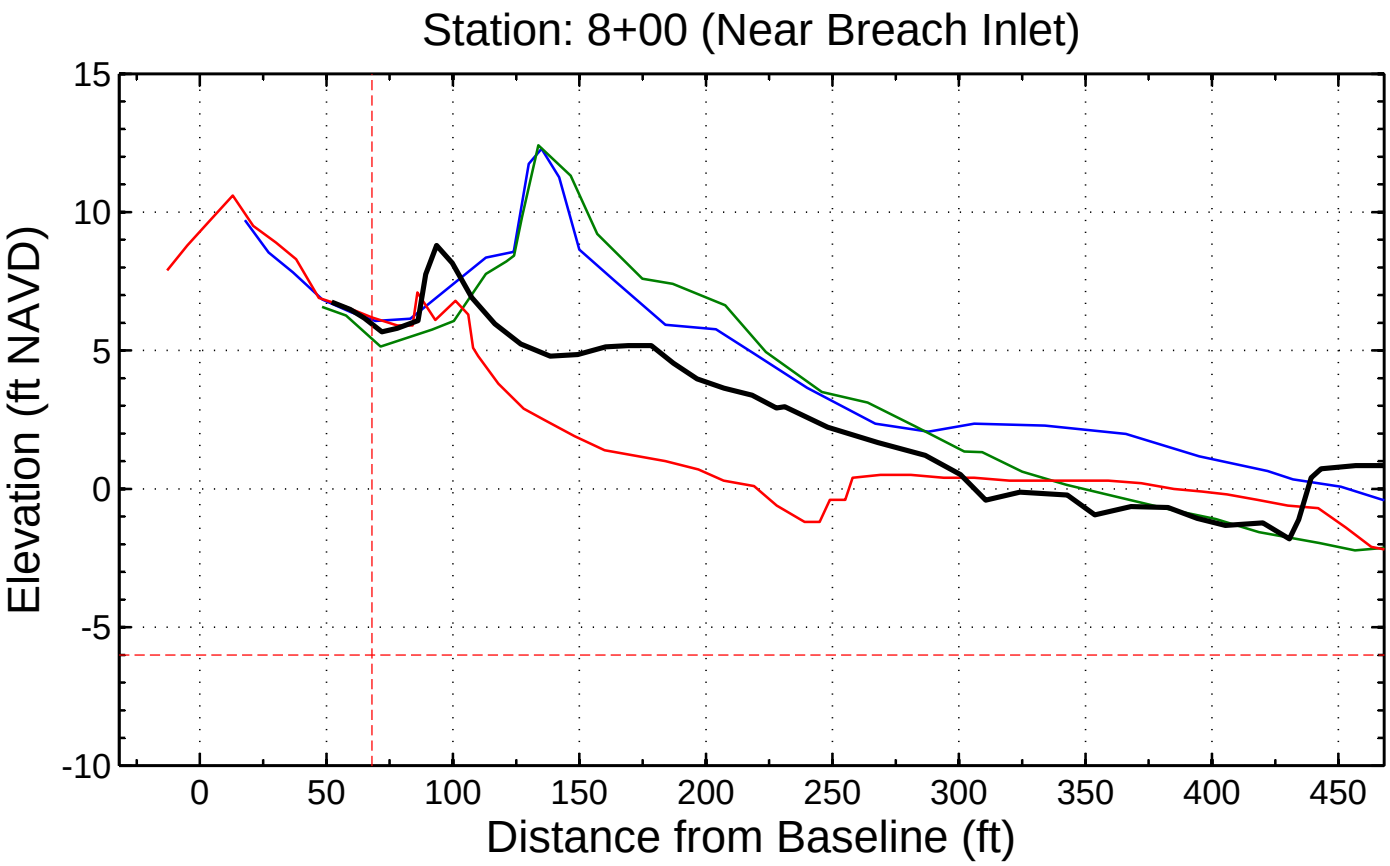
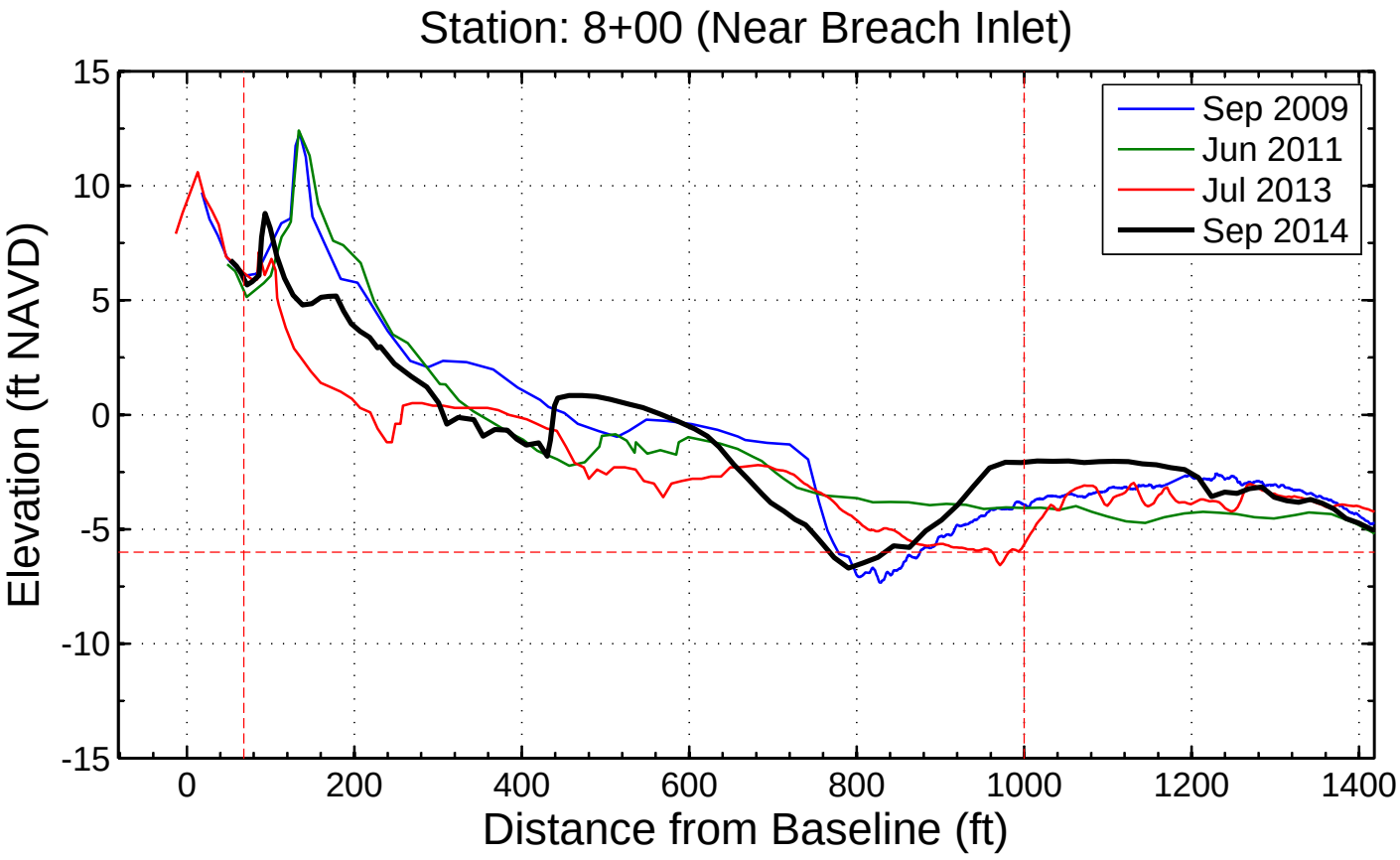
Elevation (ft NAVD)
15
10
5
0
-5
-10
-400
-350
-300
-250
-200
-150
-100
-50
0
50
Distance from Baseline (ft)

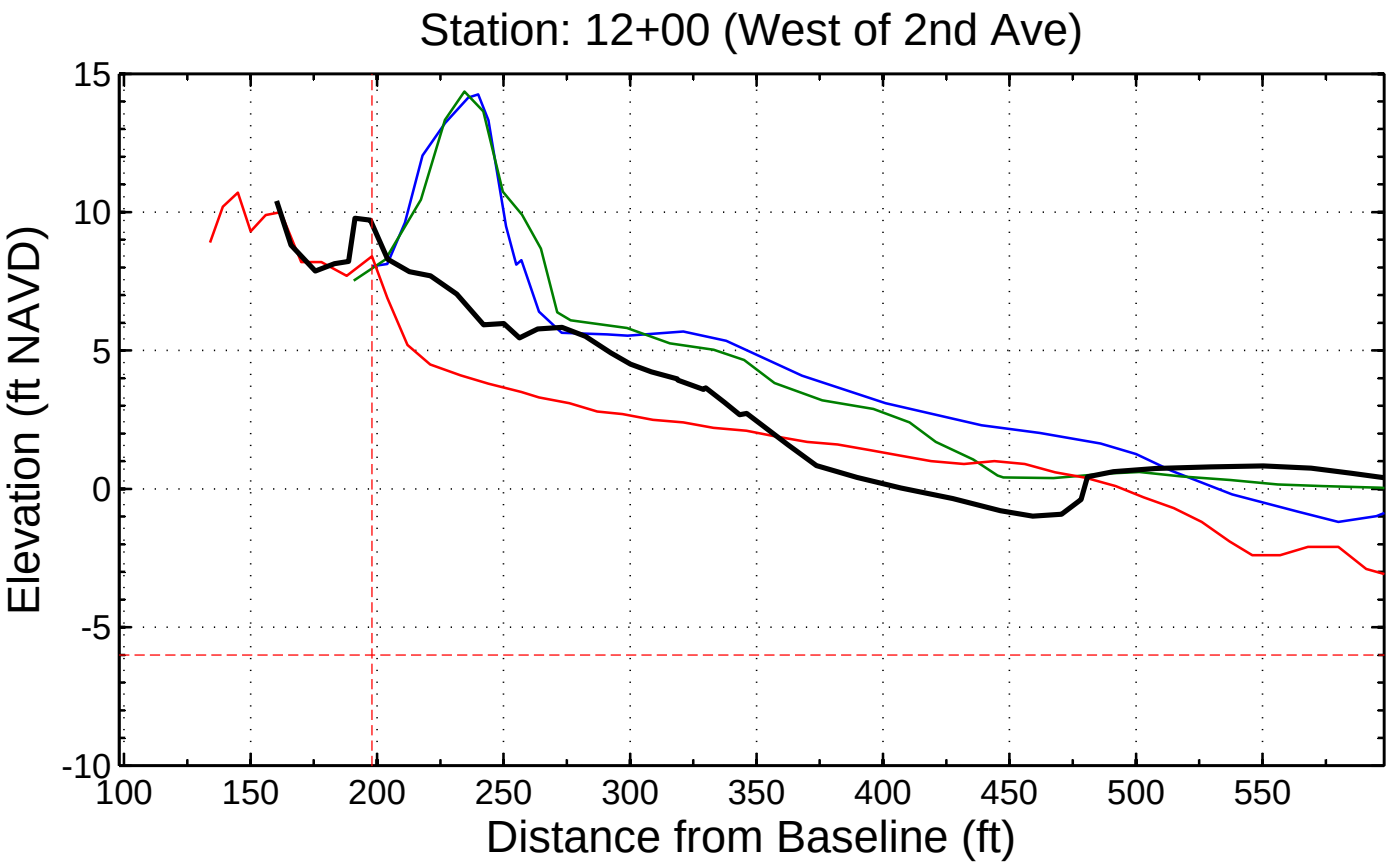

Station: 0+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-400
-200
0
200
400
600
800
1000
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014

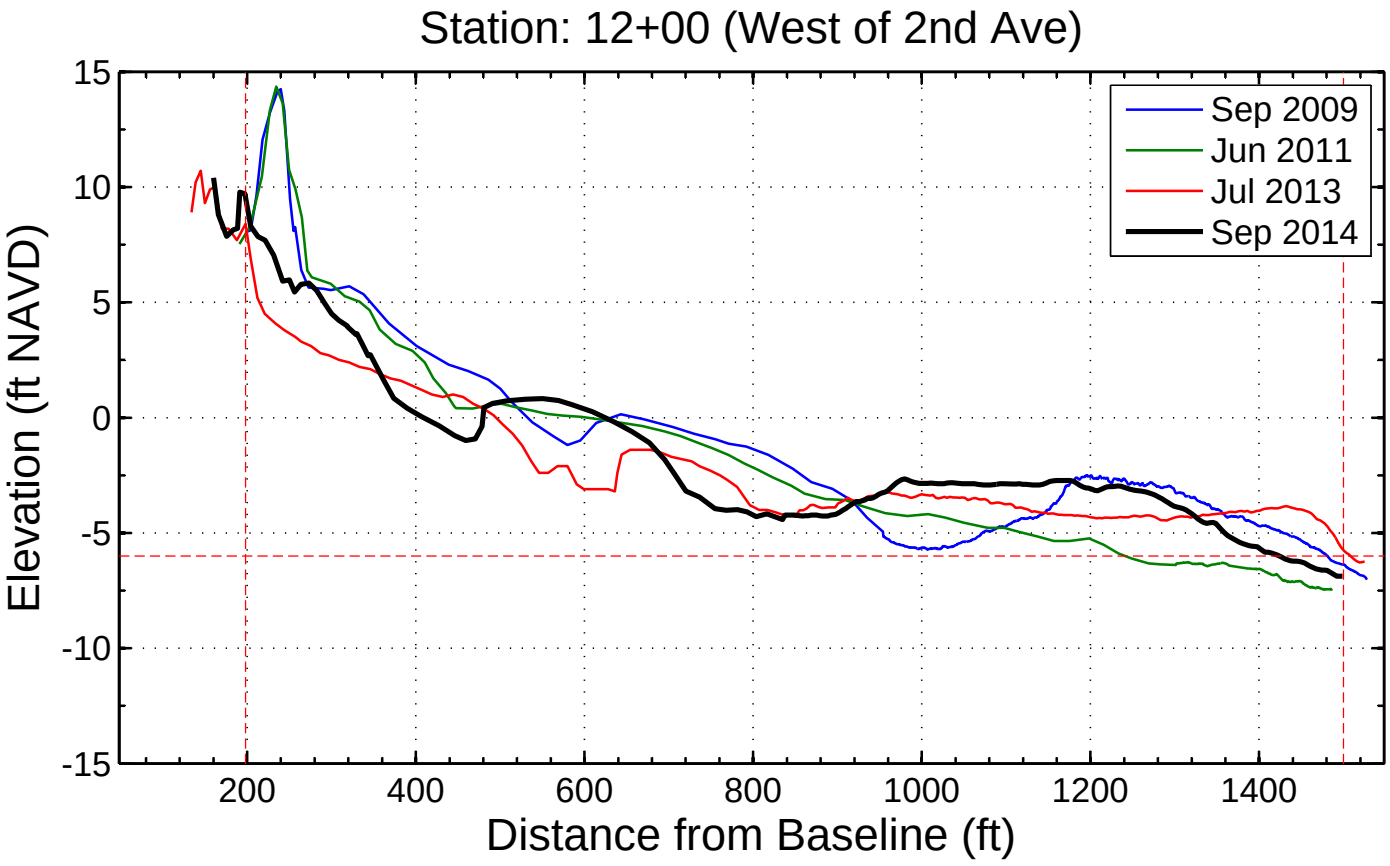

Station: 4+00 (Breach Inlet)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-200
-150
-100
-50
0
50
100
150
200
250
Distance from Baseline (ft)

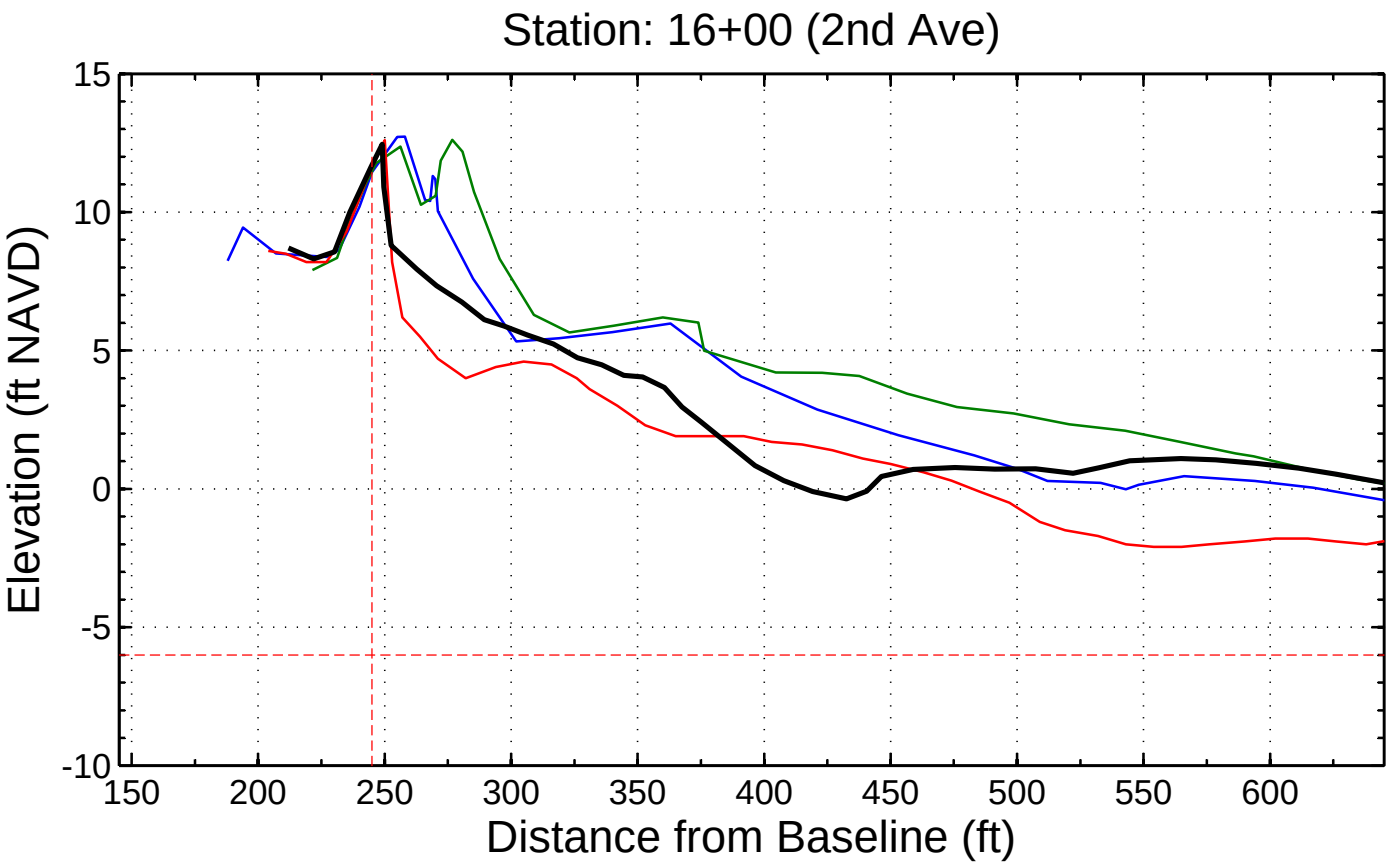

Station: 4+00 (Breach Inlet)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-200
0
200
400
600
800
1000
1200
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 8+00 (Near Breach Inlet)
Elevation (ft NAVD)
15
10
5
0
-5
-10
0
50
100
150
200
250
300
350
400
450
Distance from Baseline (ft)


Station: 8+00 (Near Breach Inlet)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 12+00 (West of 2nd Ave)
Elevation (ft NAVD)
15
10
5
0
-5
-10
100
150
200
250
300
350
400
450
500
550
Distance from Baseline (ft)


Station: 12+00 (West of 2nd Ave)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 16+00 (2nd Ave)
Elevation (ft NAVD)
15
10
5
0
-5
-10
150
200
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300
350
400
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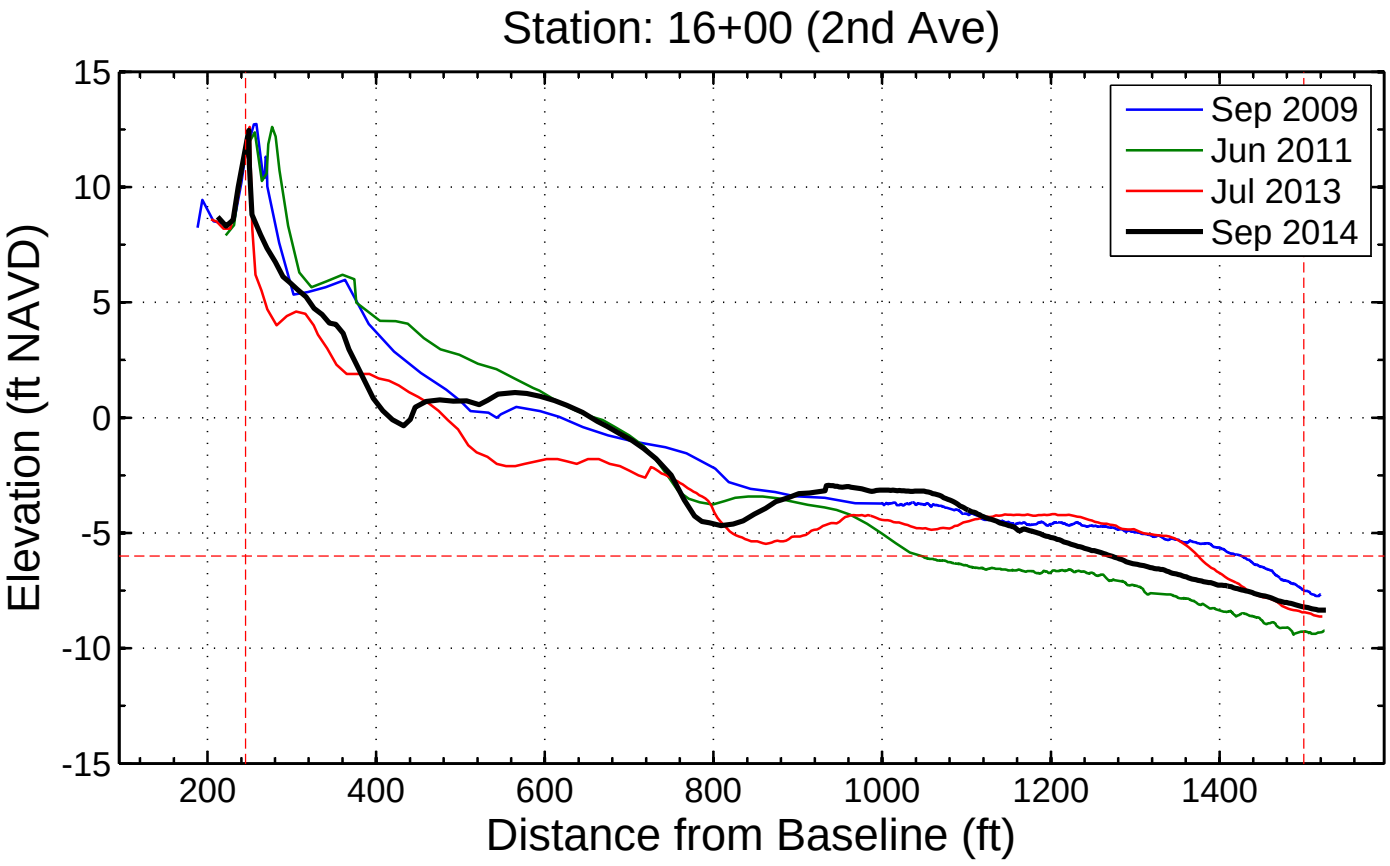
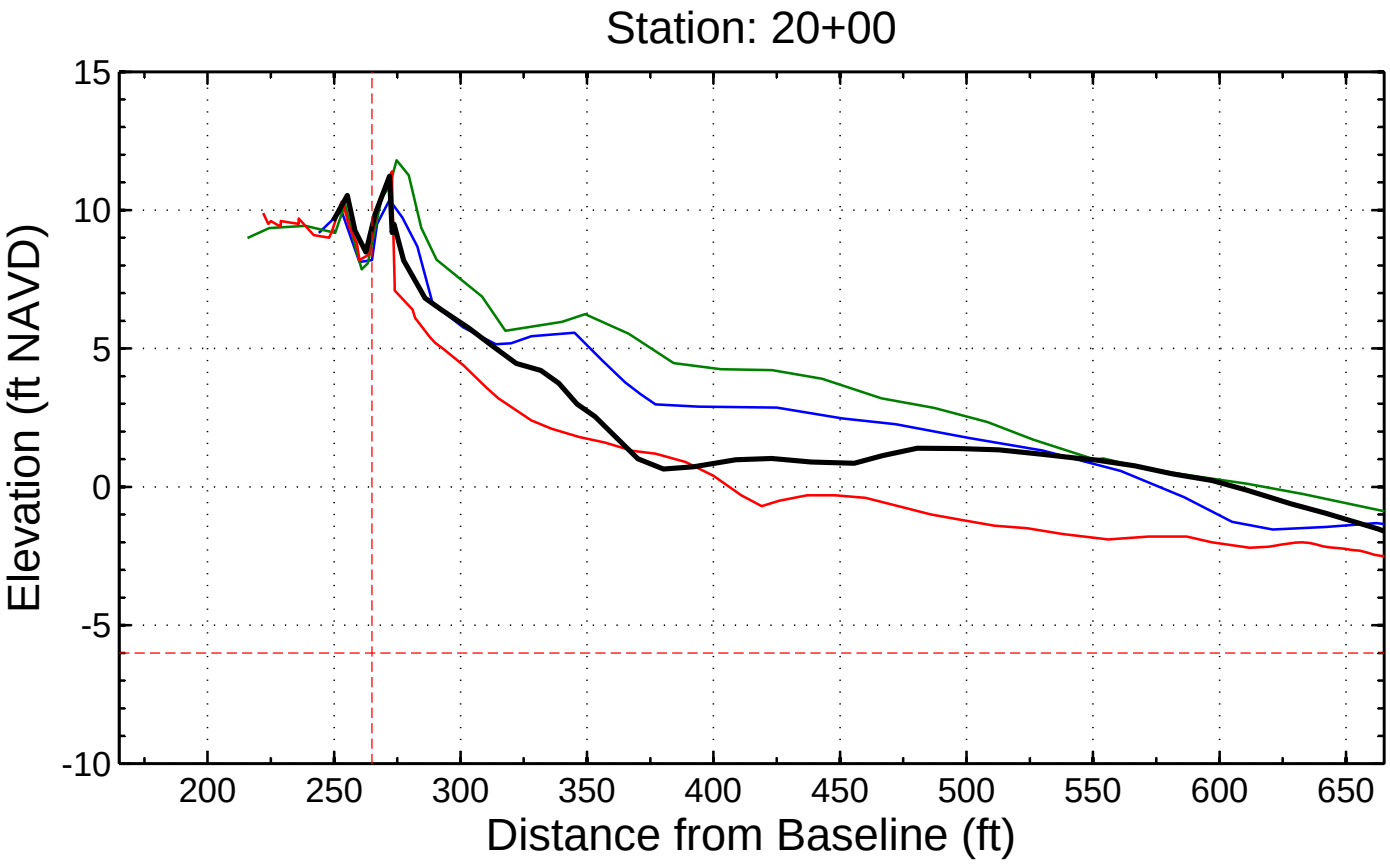
500
550
600
Distance from Baseline (ft)


Station: 16+00 (2nd Ave)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 20+00
Elevation (ft NAVD)
15
10
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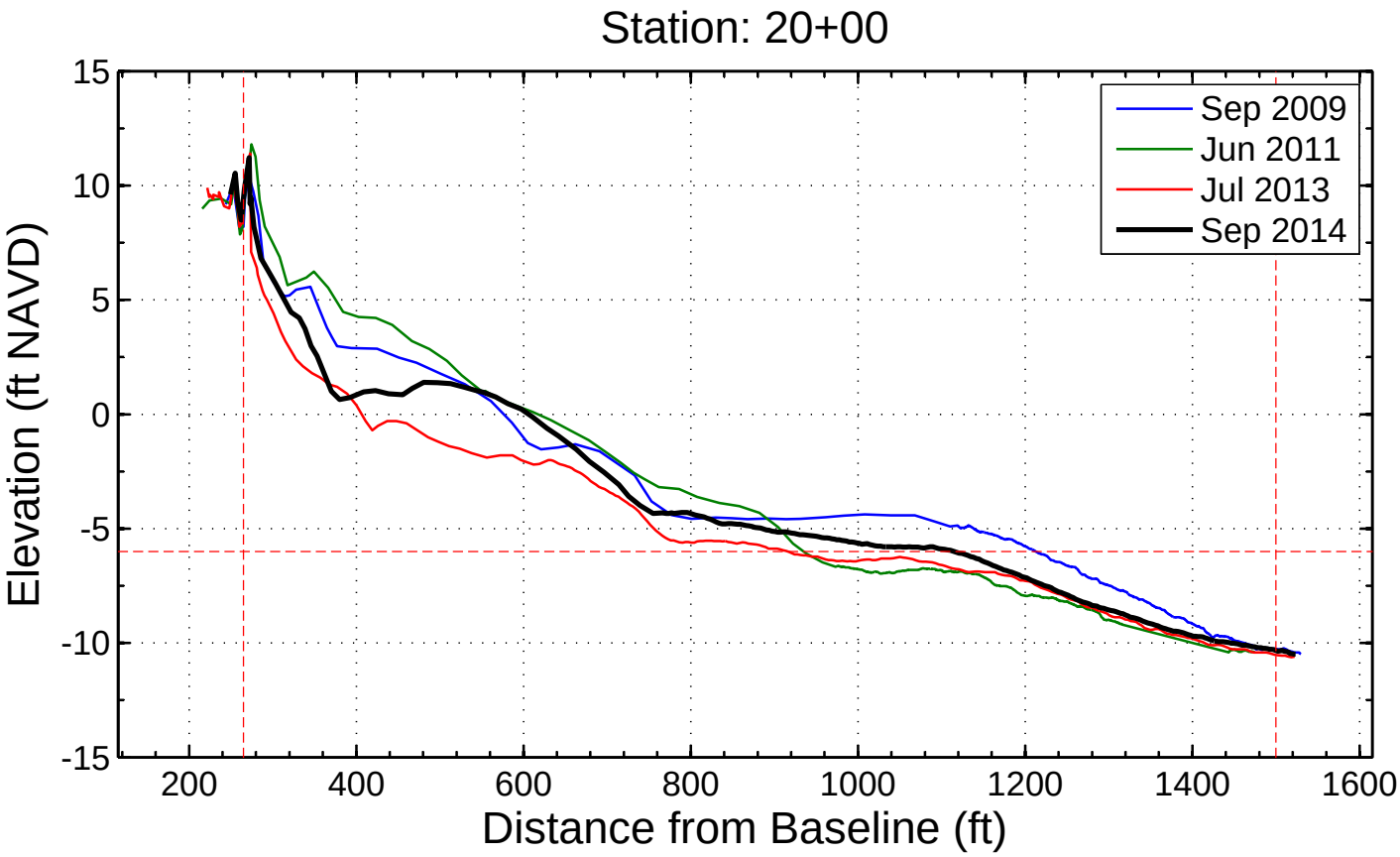
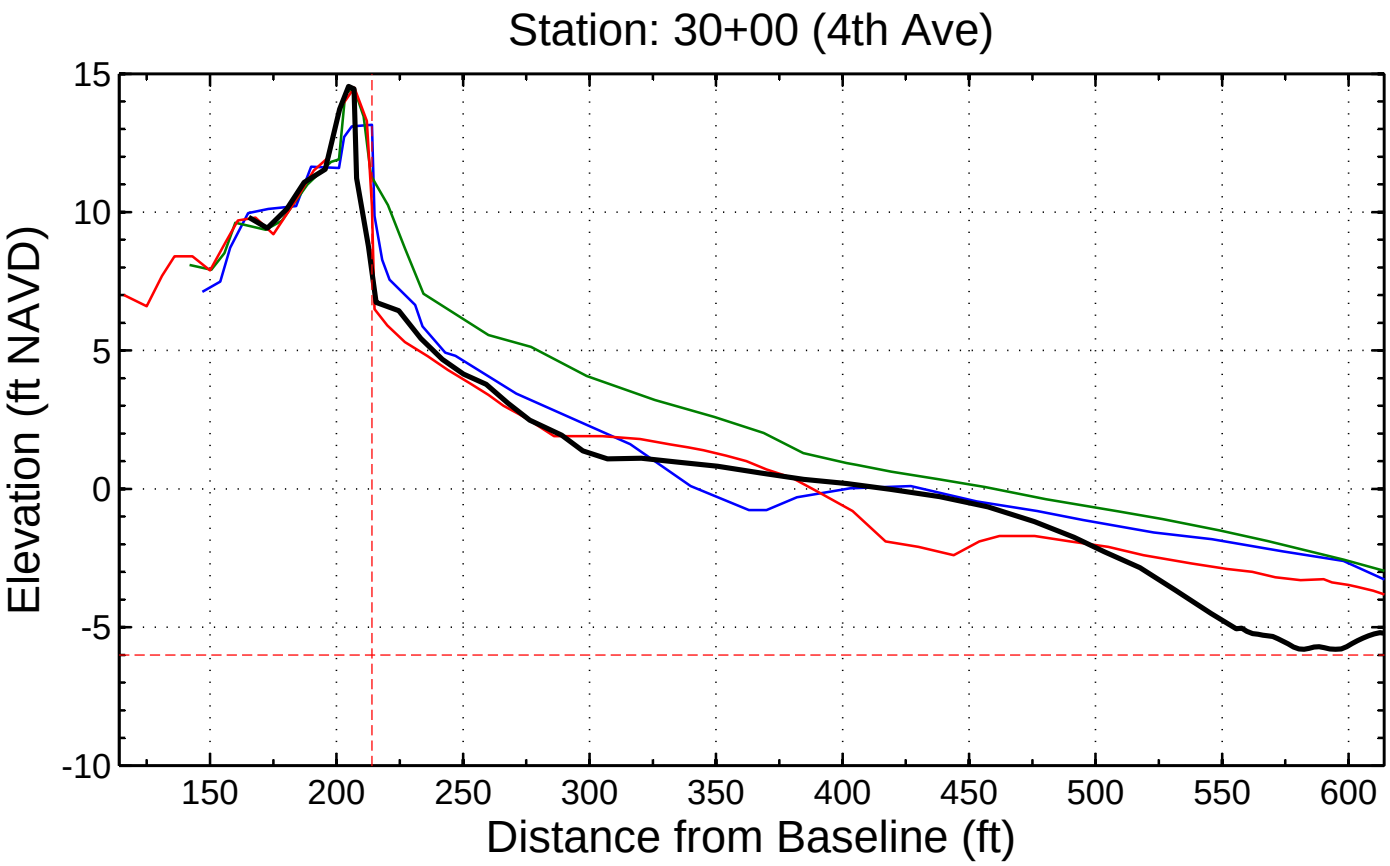
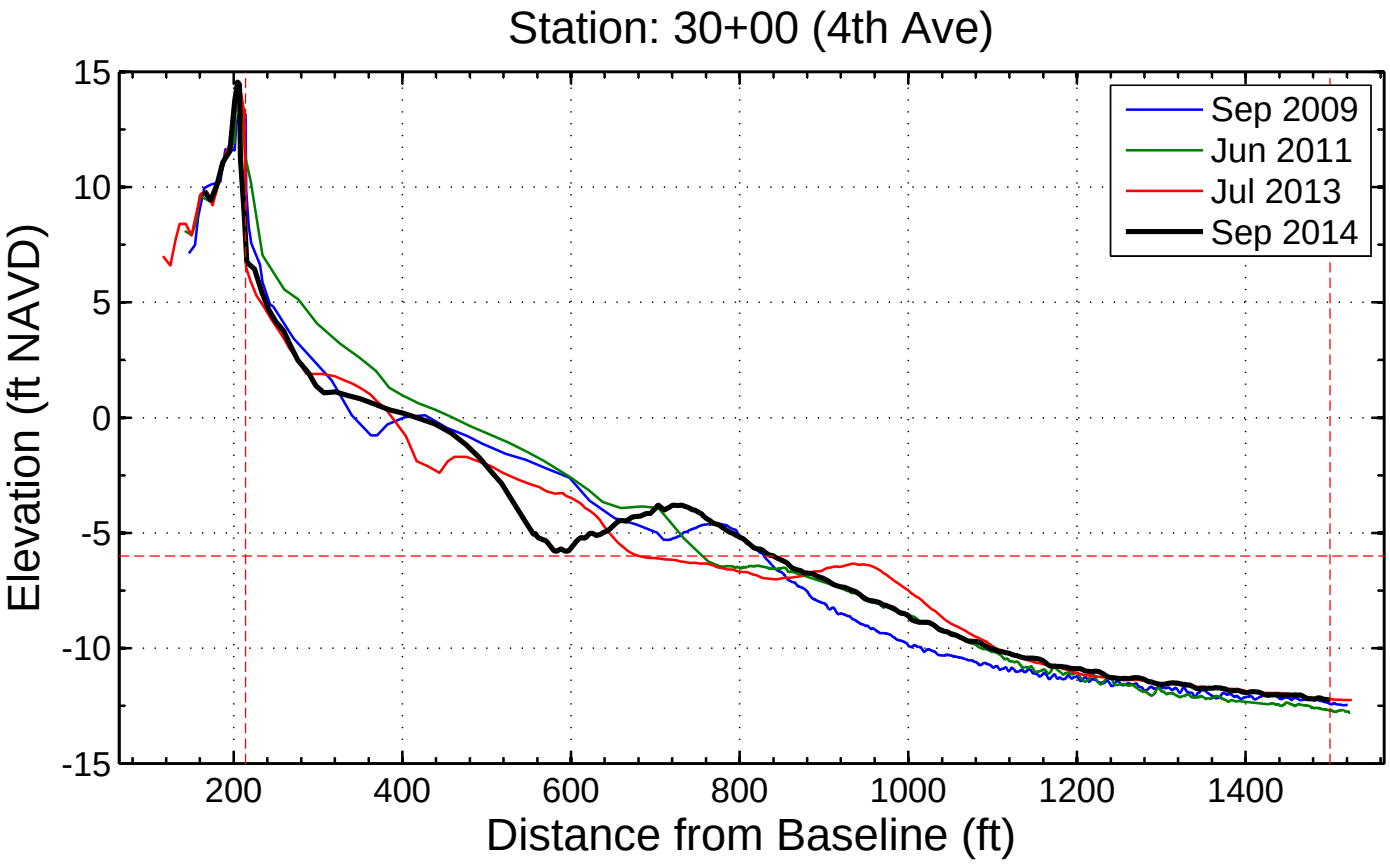
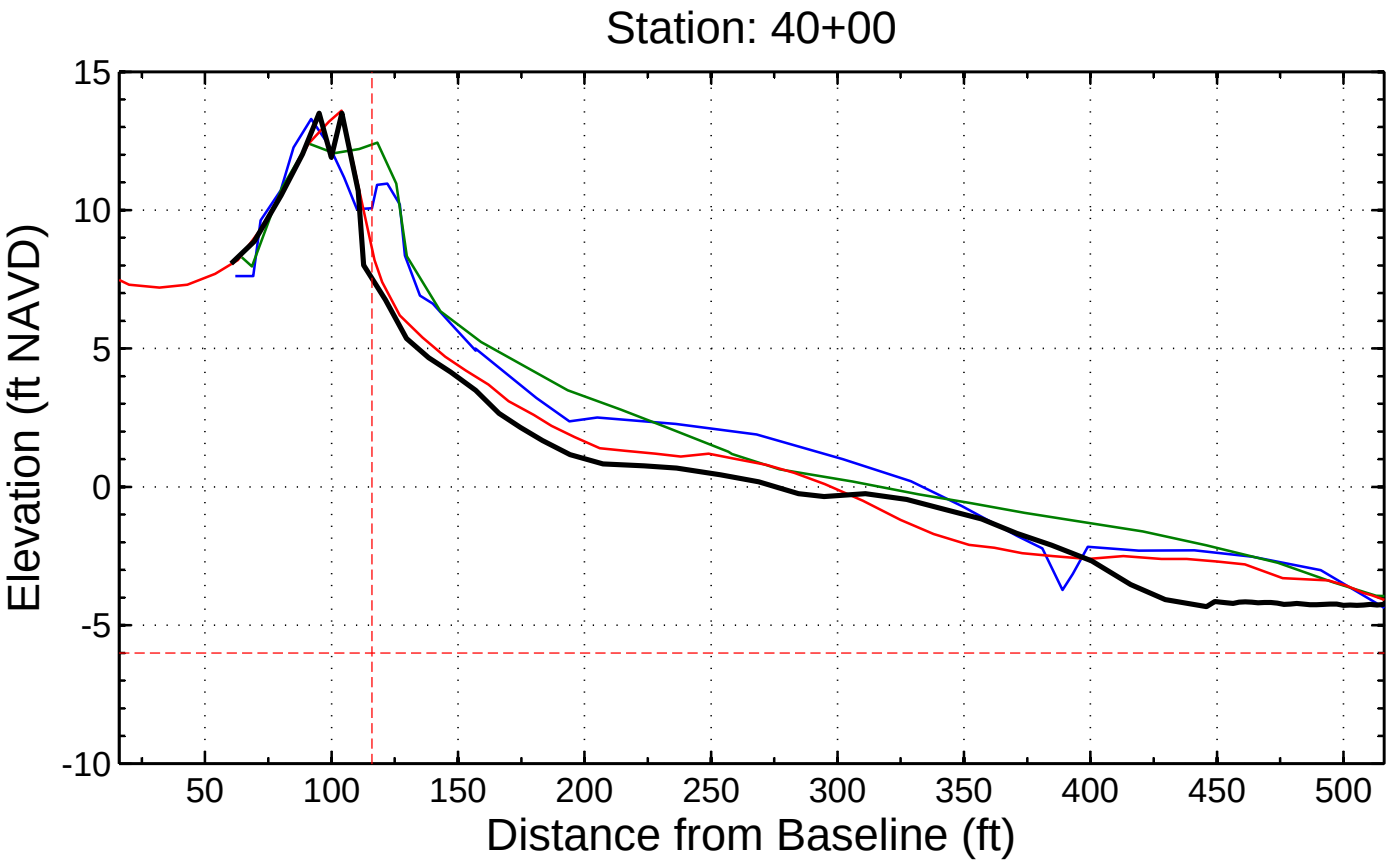
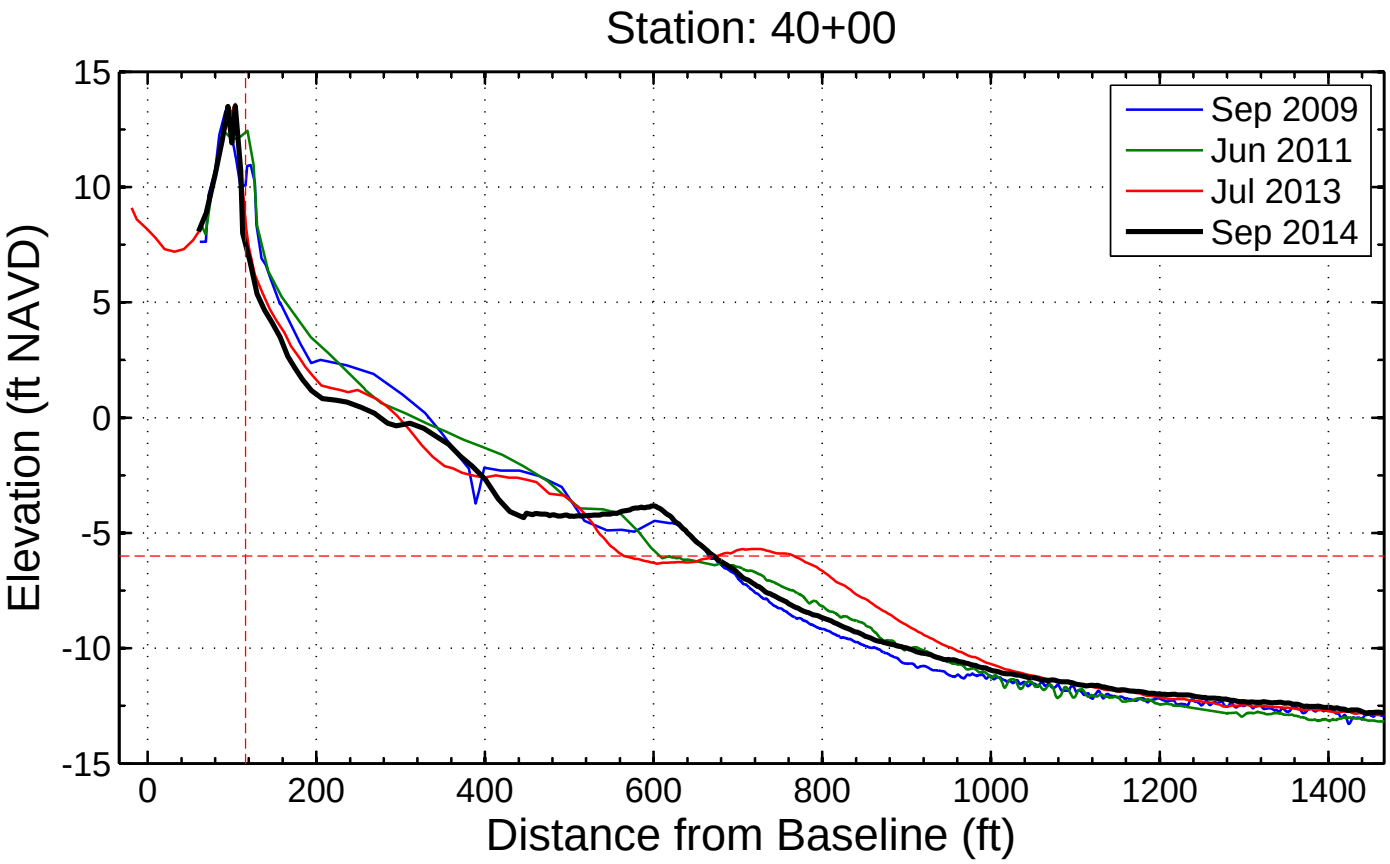
0
-5
-10
200
250
300
350
400
450
500
550
600
650
Distance from Baseline (ft)

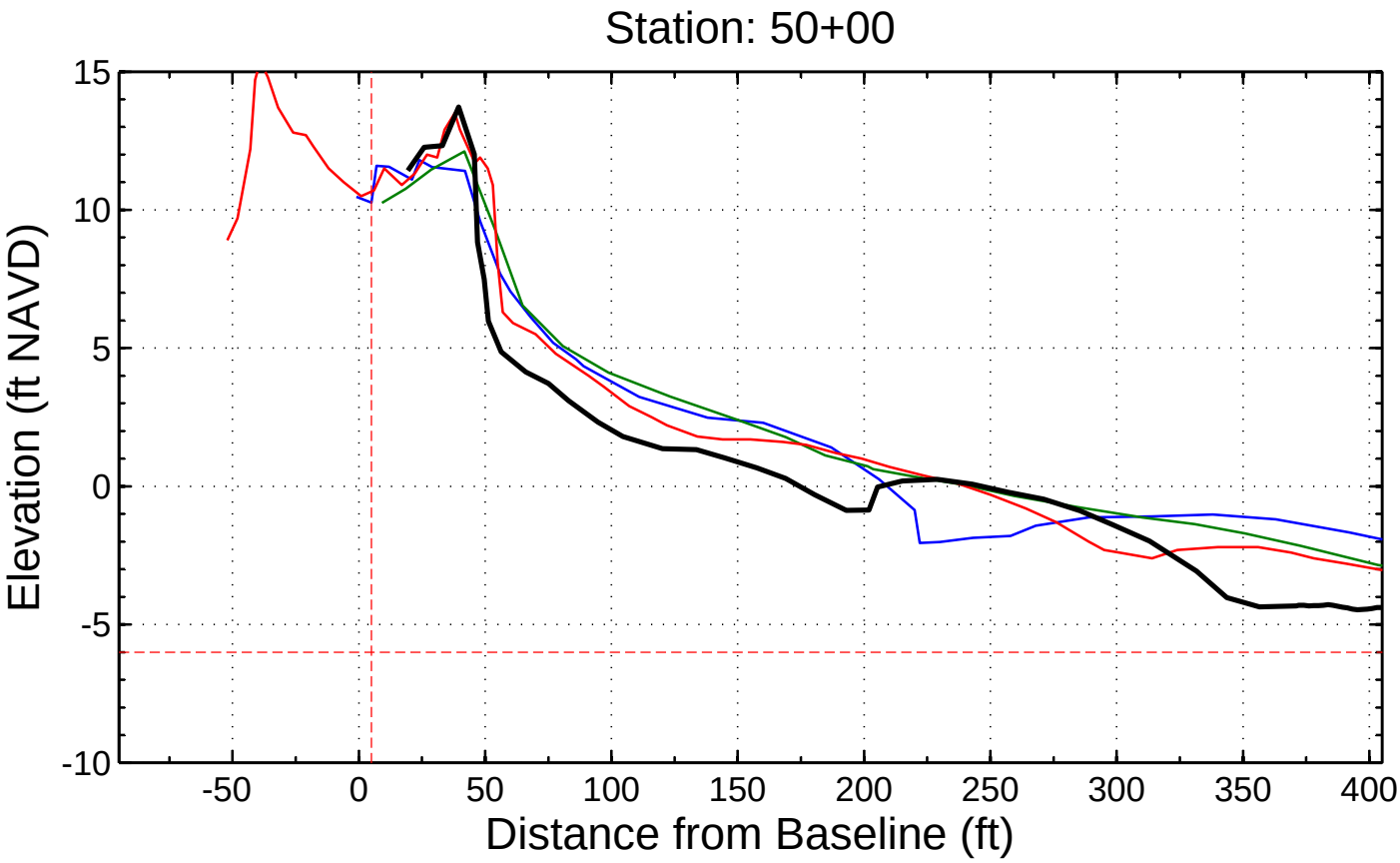

Station: 20+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 30+00 (4th Ave)
Elevation (ft NAVD)
15
10
5
0
-5
-10
150
200
250
300
350
400
450
500
550
600
Distance from Baseline (ft)


Station: 30+00 (4th Ave)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 40+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
50
100
150
200
250
300
350
400
450
500
Distance from Baseline (ft)


Station: 40+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 50+00
Elevation (ft NAVD)
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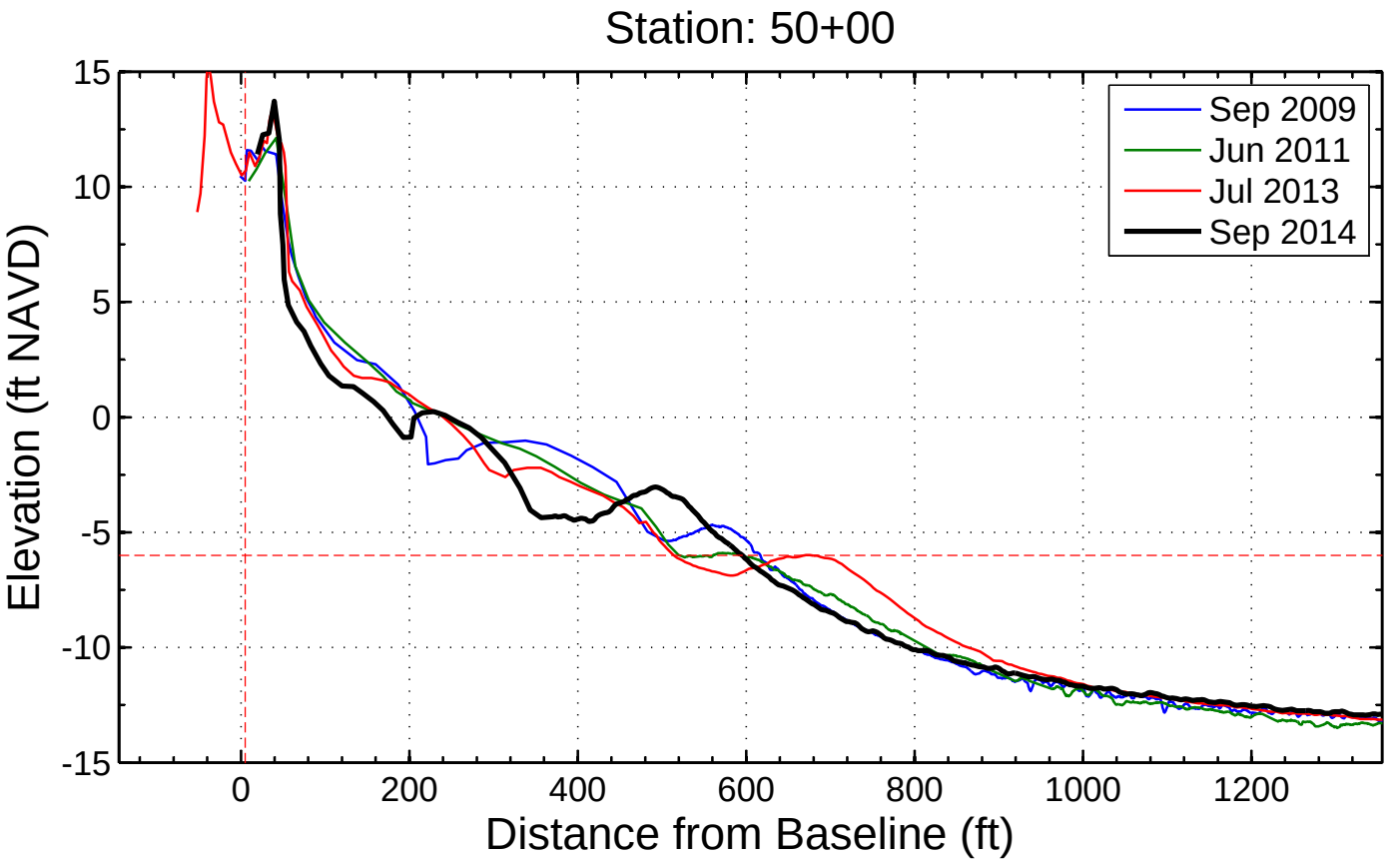
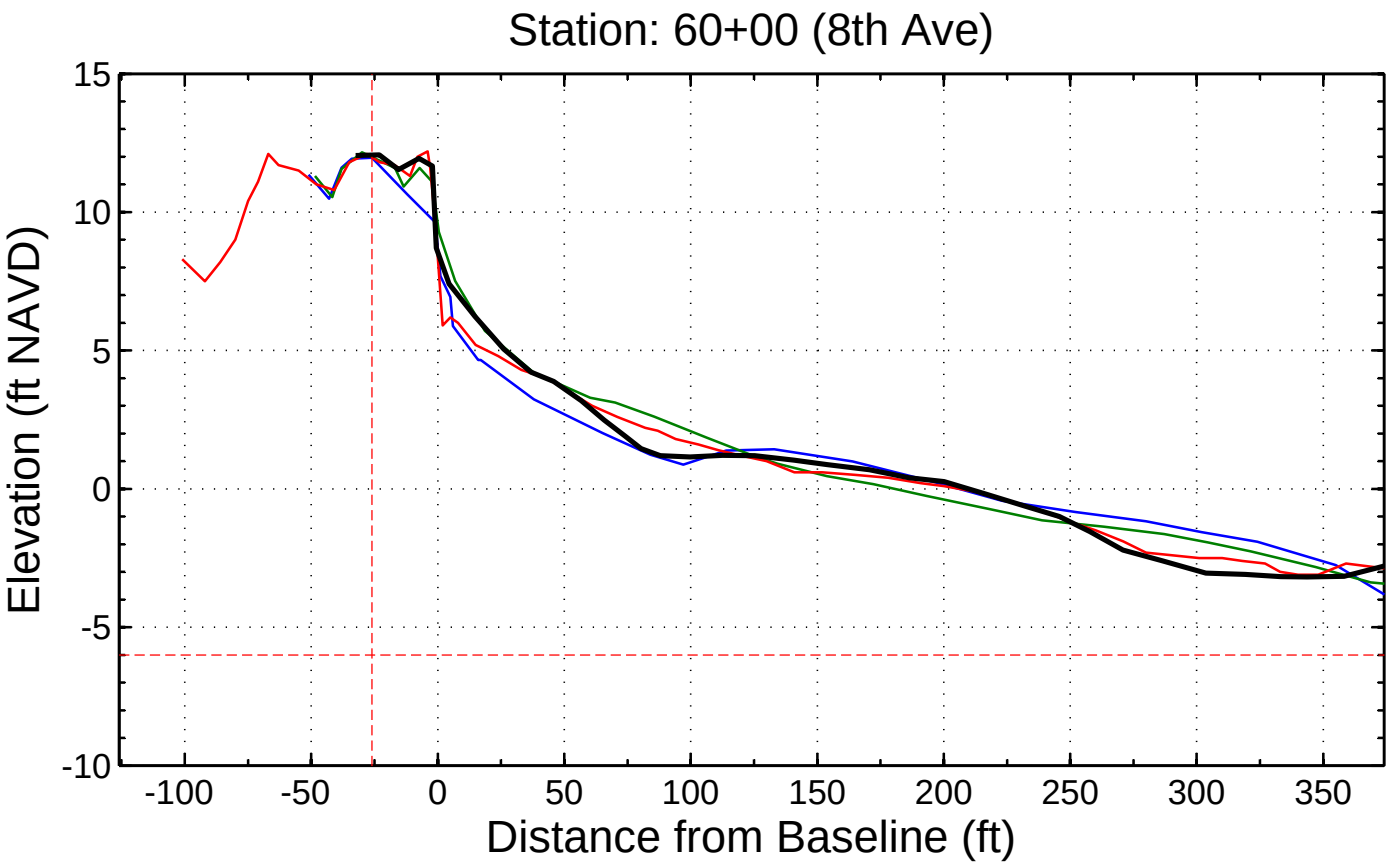
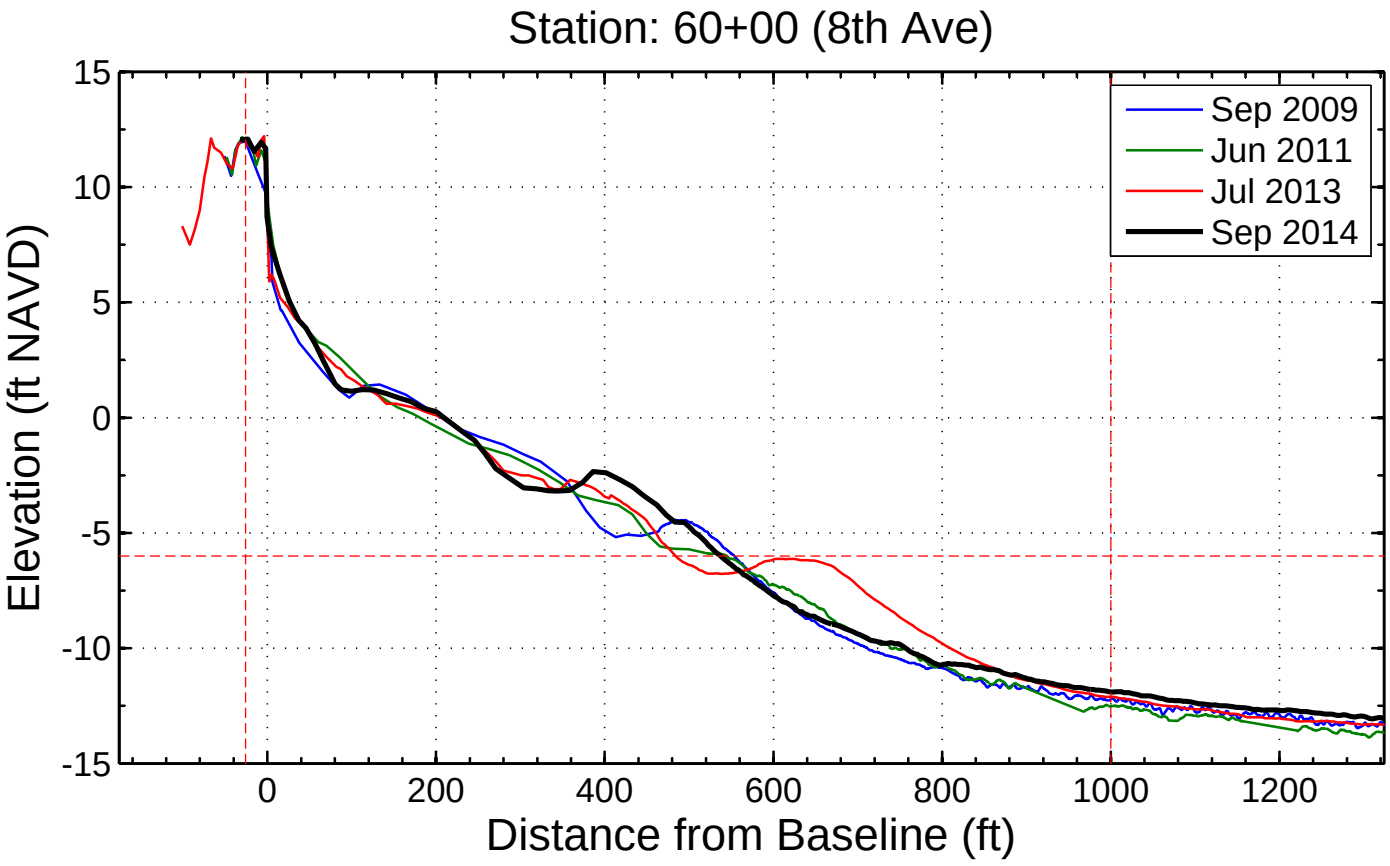
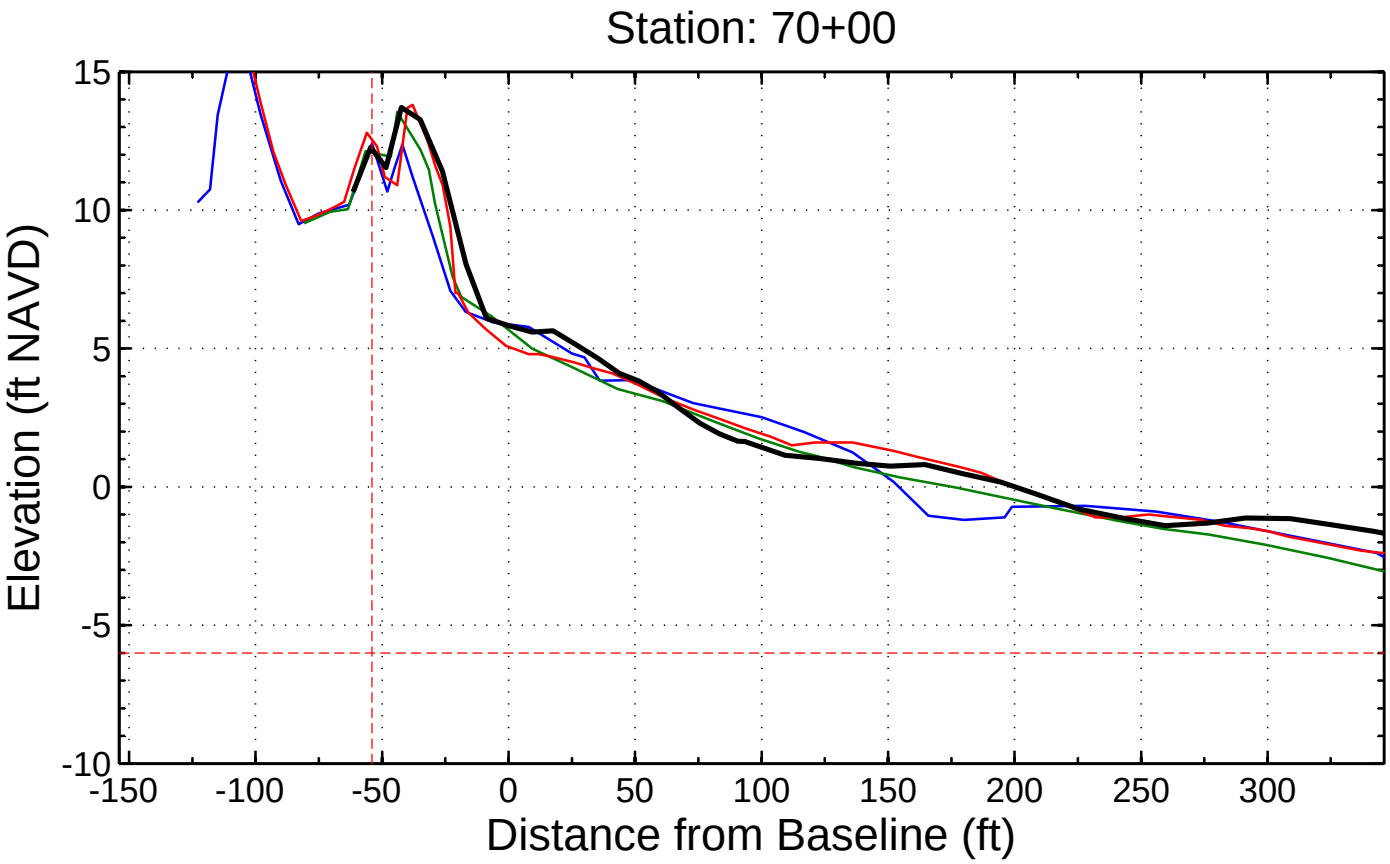
-5
-10
-50
0
50
100
150
200
250
300
350
400
Distance from Baseline (ft)


Station: 50+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 60+00 (8th Ave)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-100
-50
0
50
100
150
200
250
300
350
Distance from Baseline (ft)


Station: 60+00 (8th Ave)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 70+00
Elevation (ft NAVD)
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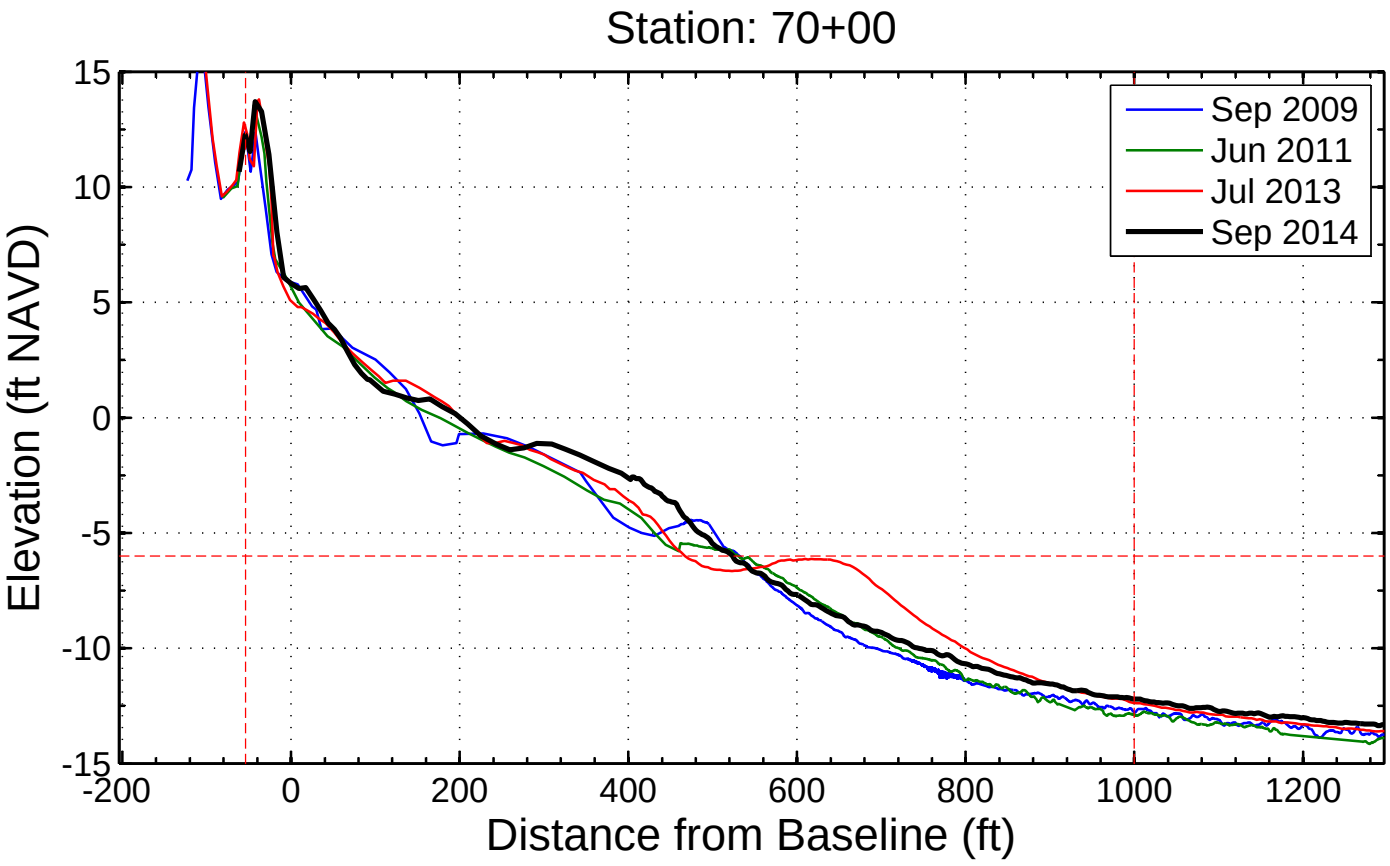
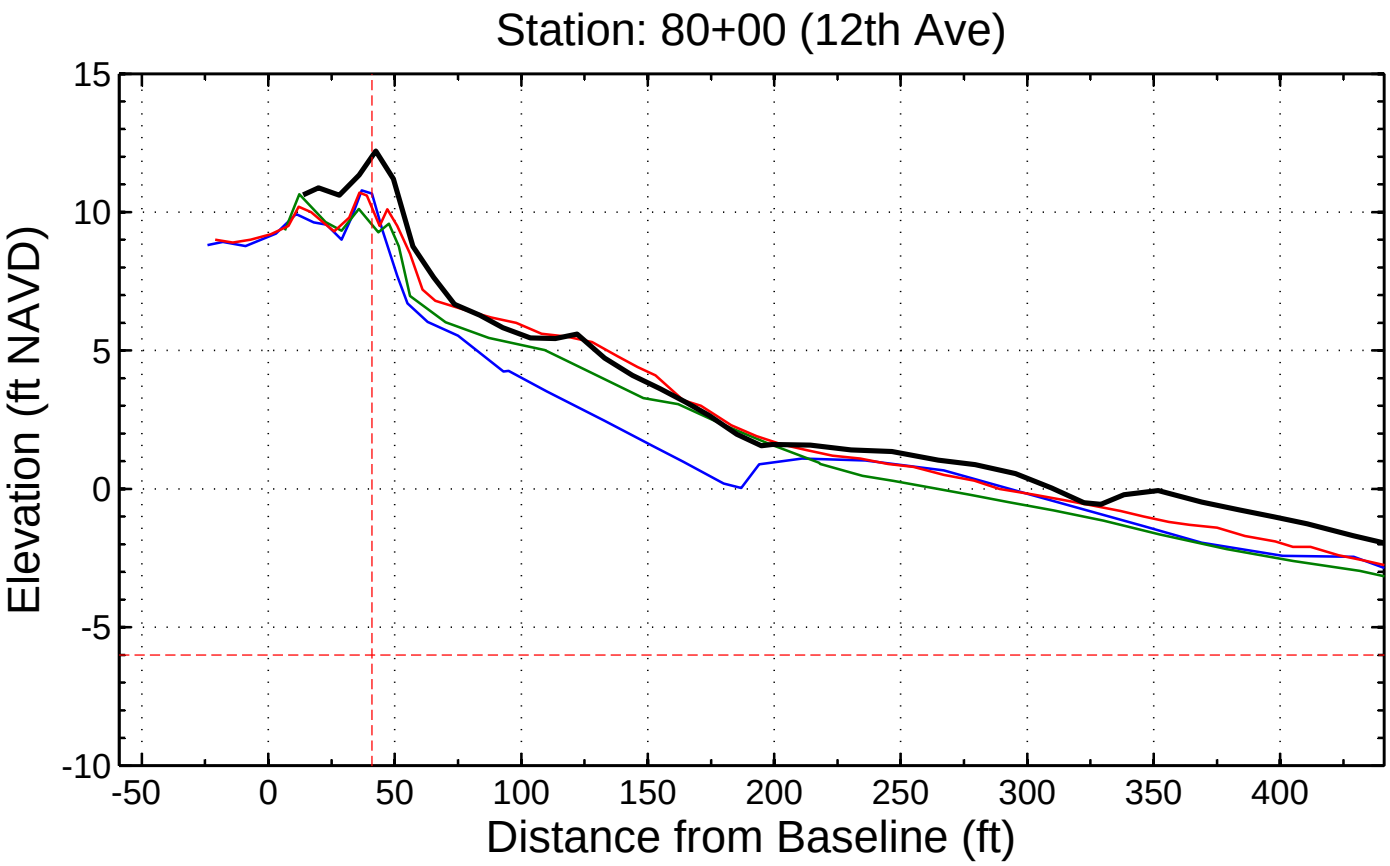
5
0
-5
-10
-150
-100
-50
0
50
100
150
200
250
300
Distance from Baseline (ft)


Station: 70+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
-200
0
200
400
600
800
1000
1200
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 80+00 (12th Ave)
Elevation (ft NAVD)
15
10
5
0
-5
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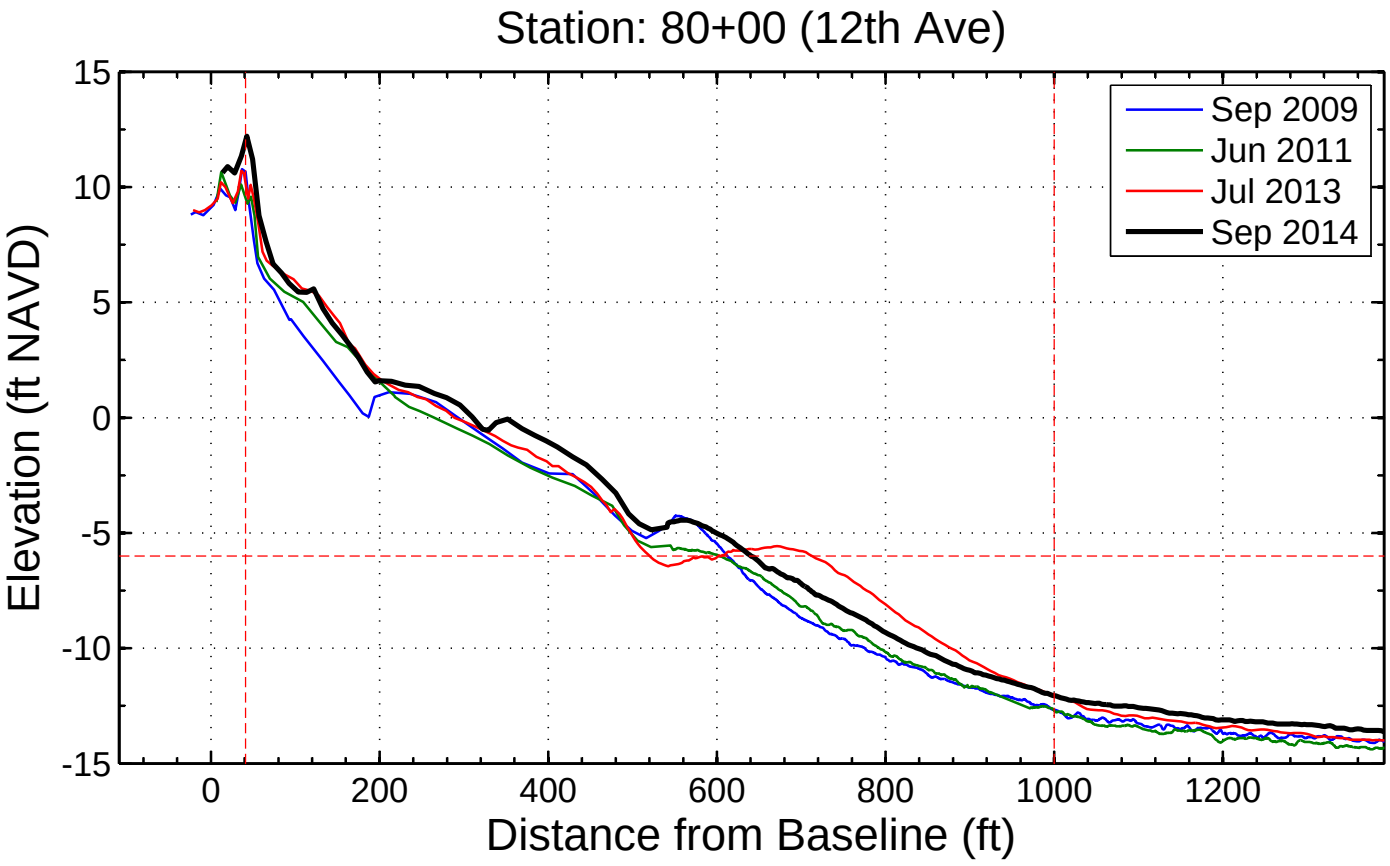
-50
0
50
100
150
200
250
300
350
400
Distance from Baseline (ft)


Station: 80+00 (12th Ave)
Elevation (ft NAVD)
15
10
5
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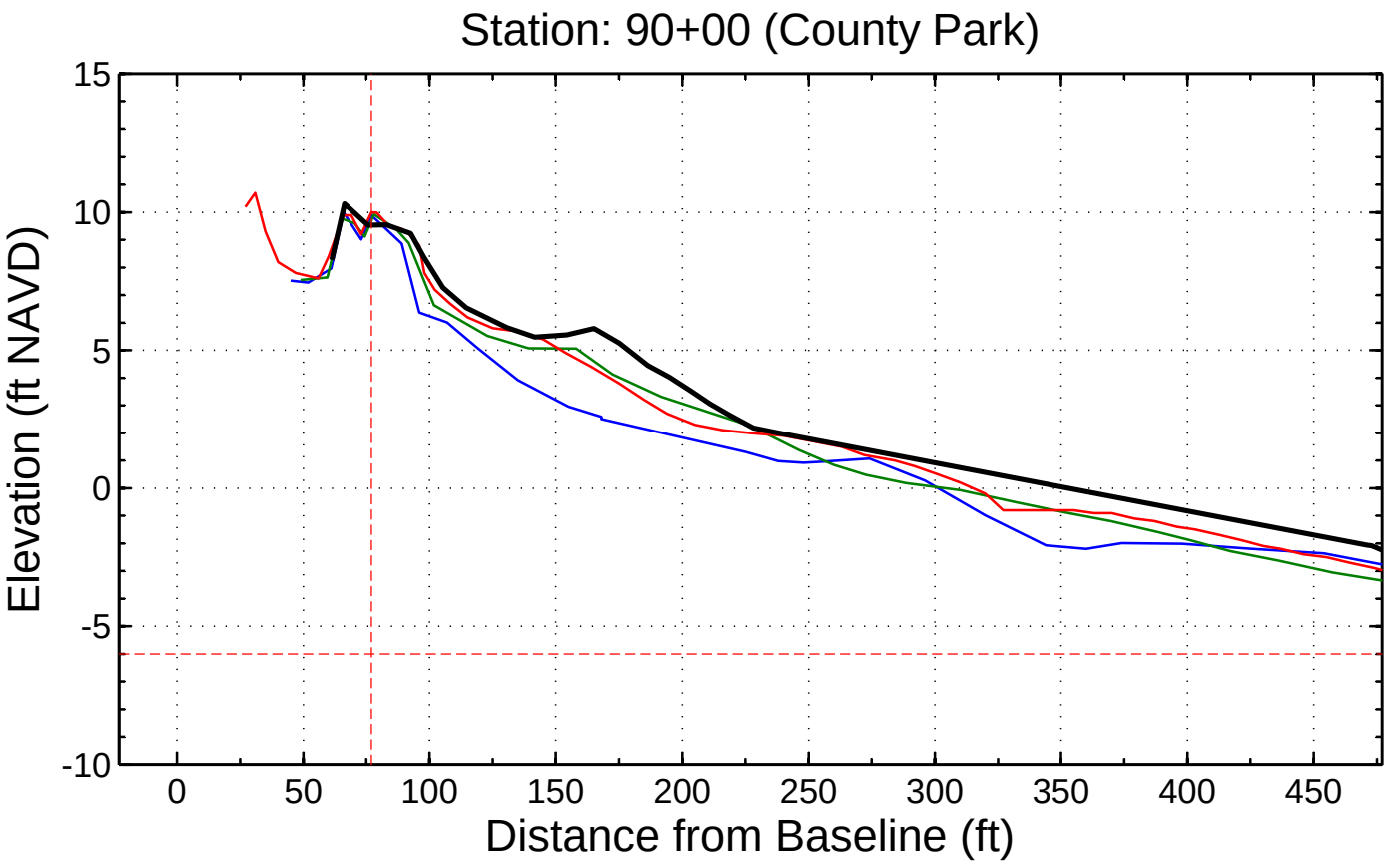
-5
-10
-15
0
200
400
600
800
1000
1200
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 90+00 (County Park)
Elevation (ft NAVD)
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10
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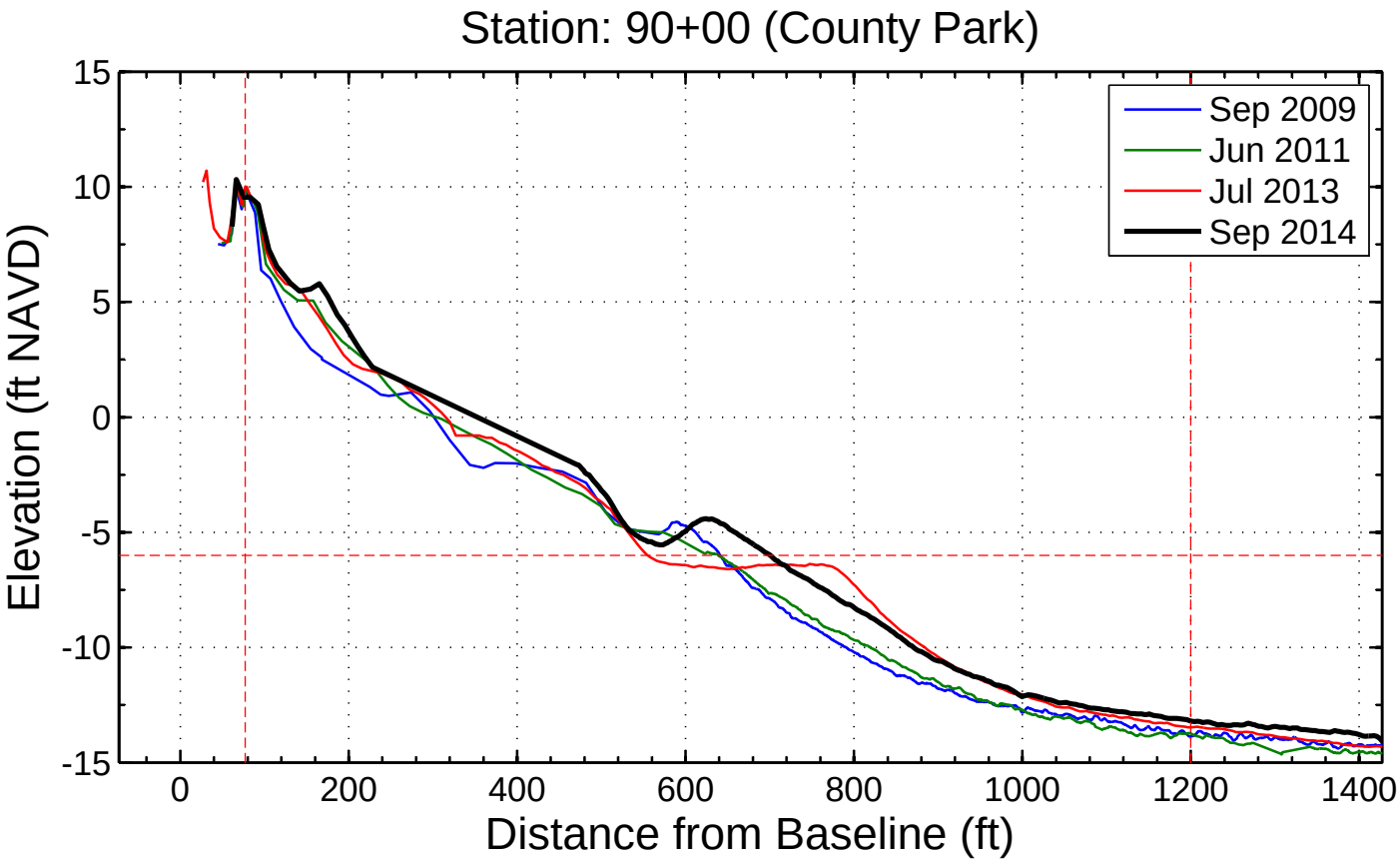
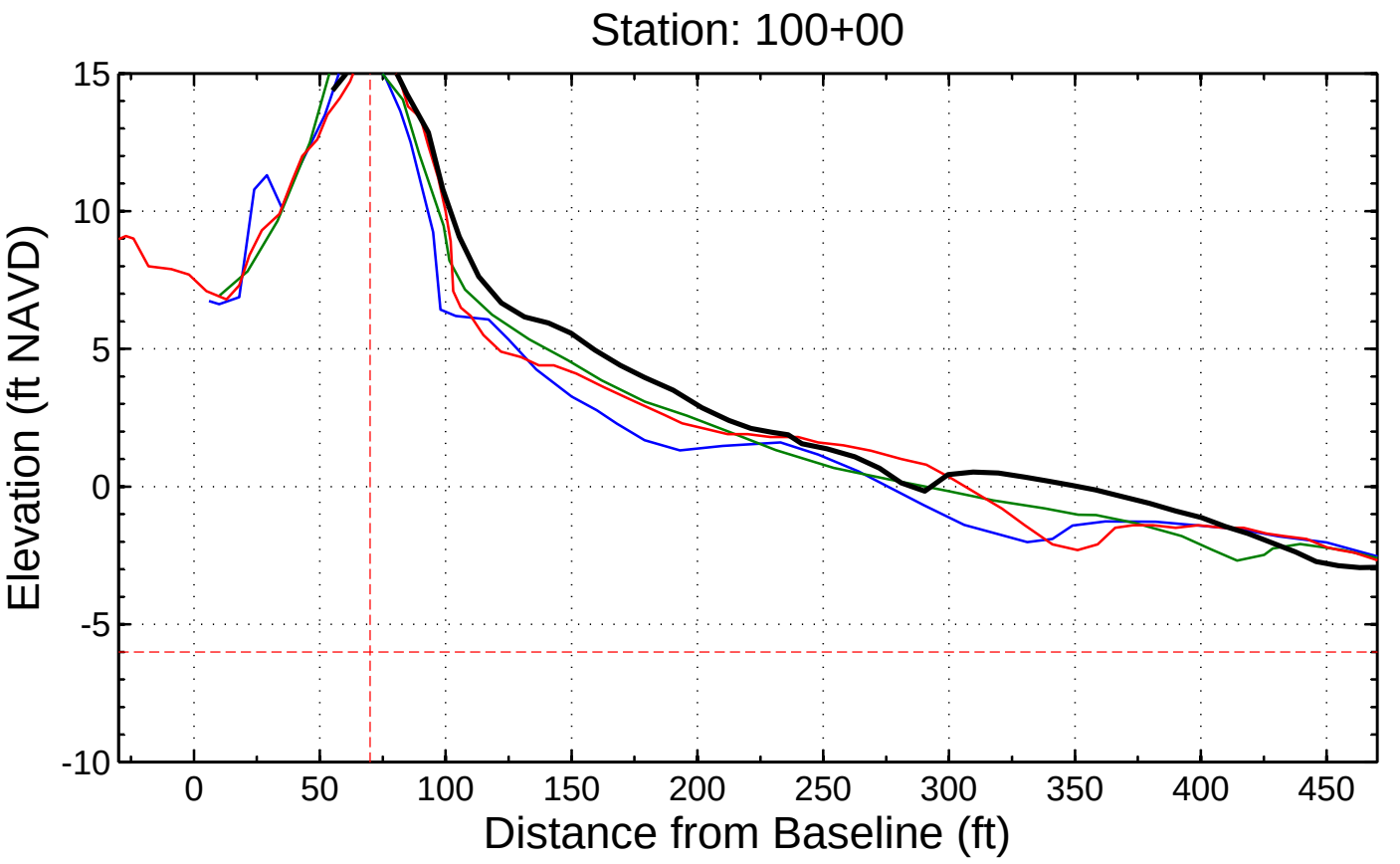
0
-5
-10
0
50
100
150
200
250
300
350
400
450
Distance from Baseline (ft)


Station: 90+00 (County Park)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 100+00
Elevation (ft NAVD)
15
10
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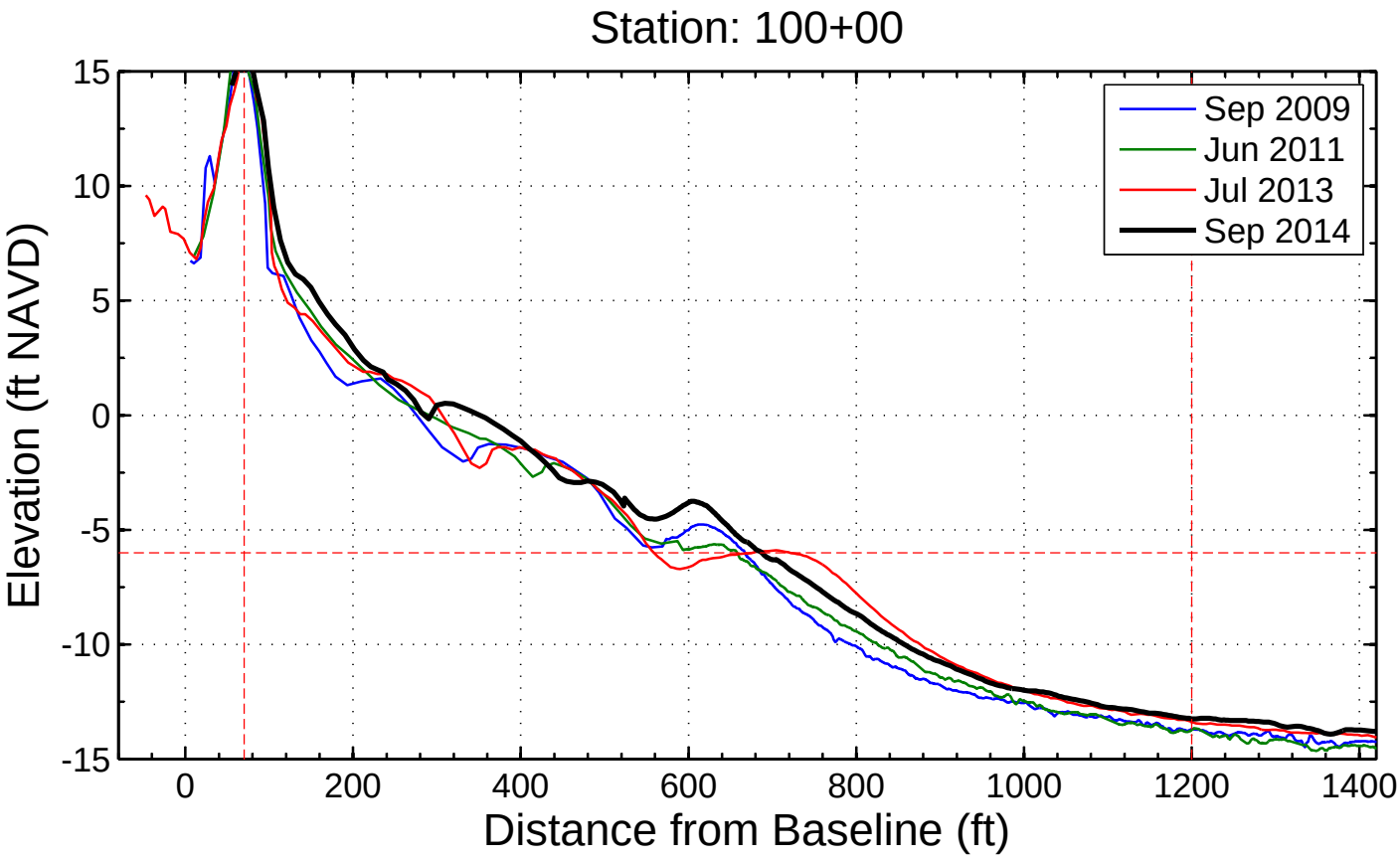
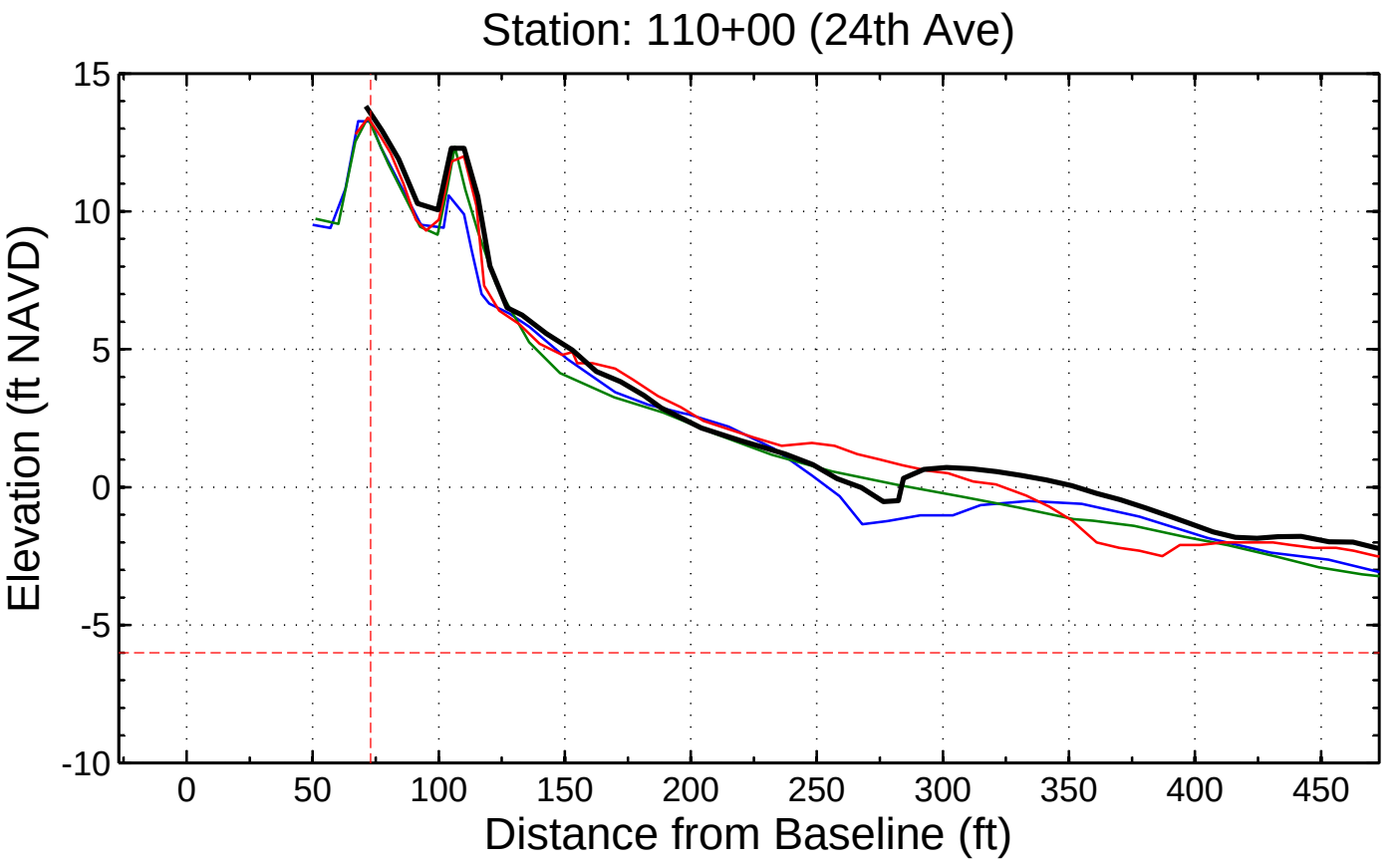
0
-5
-10
0
50
100
150
200
250
300
350
400
450
Distance from Baseline (ft)


Station: 100+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 110+00 (24th Ave)
Elevation (ft NAVD)
15
10
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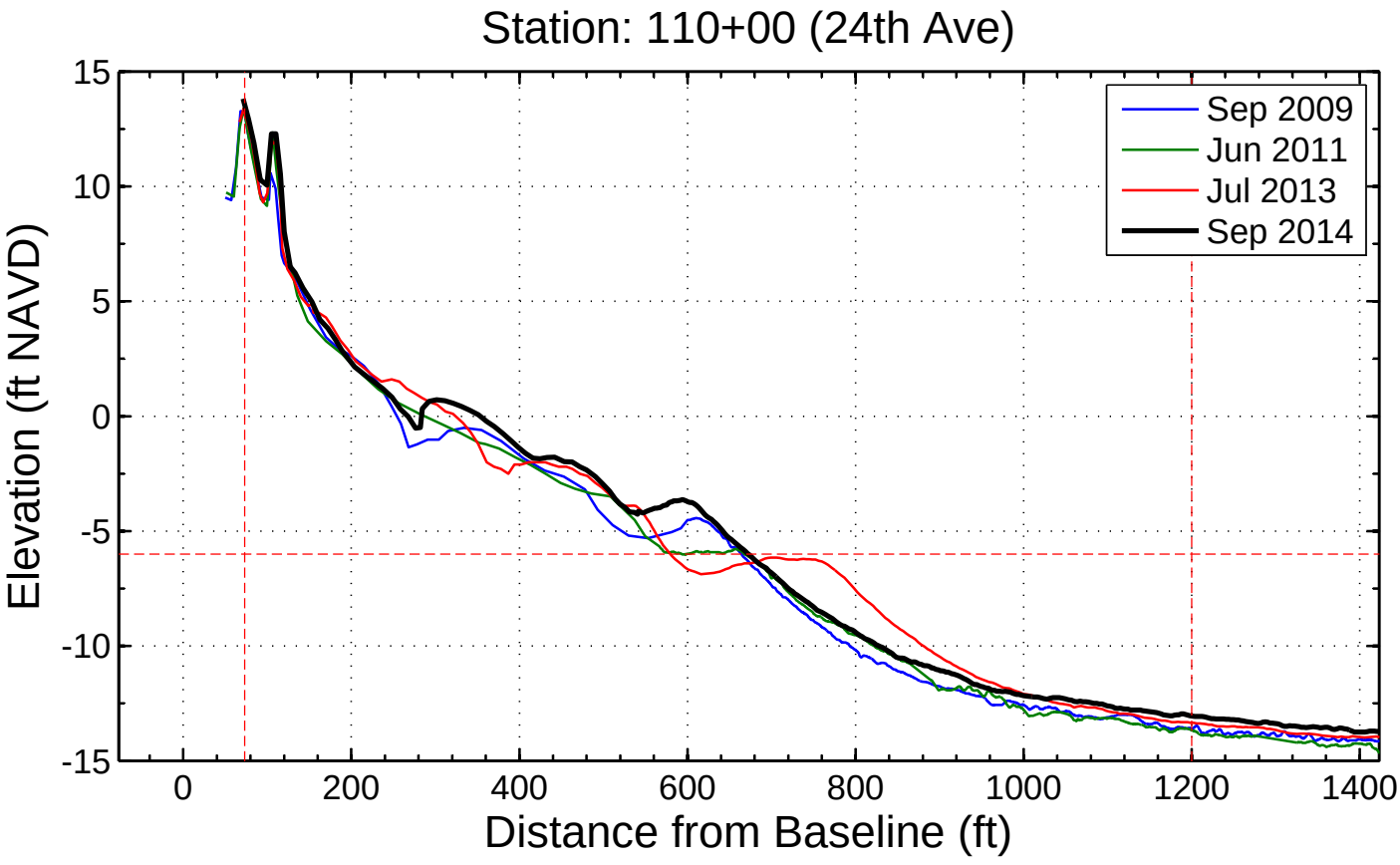
0
-5
-10
0
50
100
150
200
250
300
350
400
450
Distance from Baseline (ft)


Station: 110+00 (24th Ave)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
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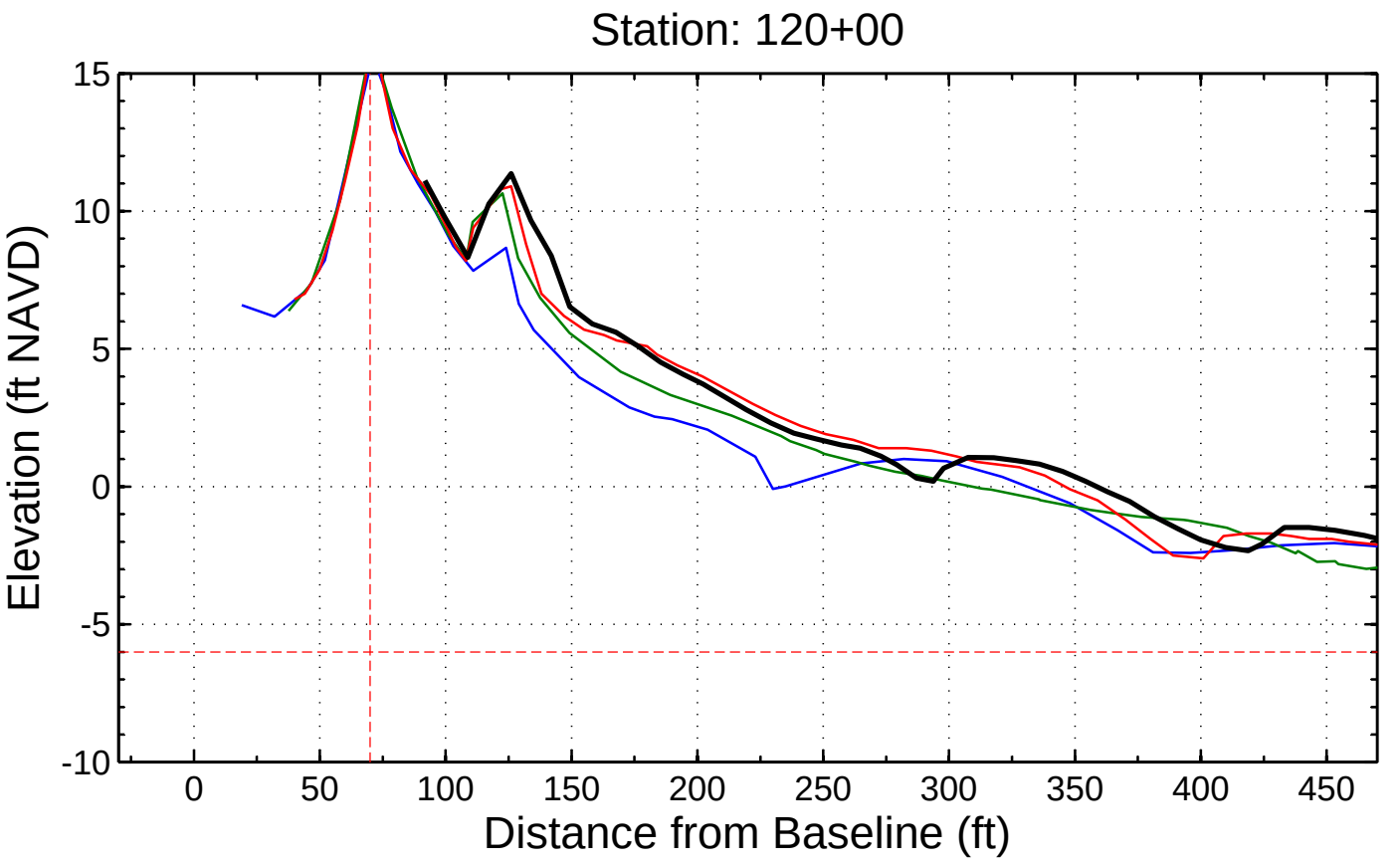
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 120+00
Elevation (ft NAVD)
15
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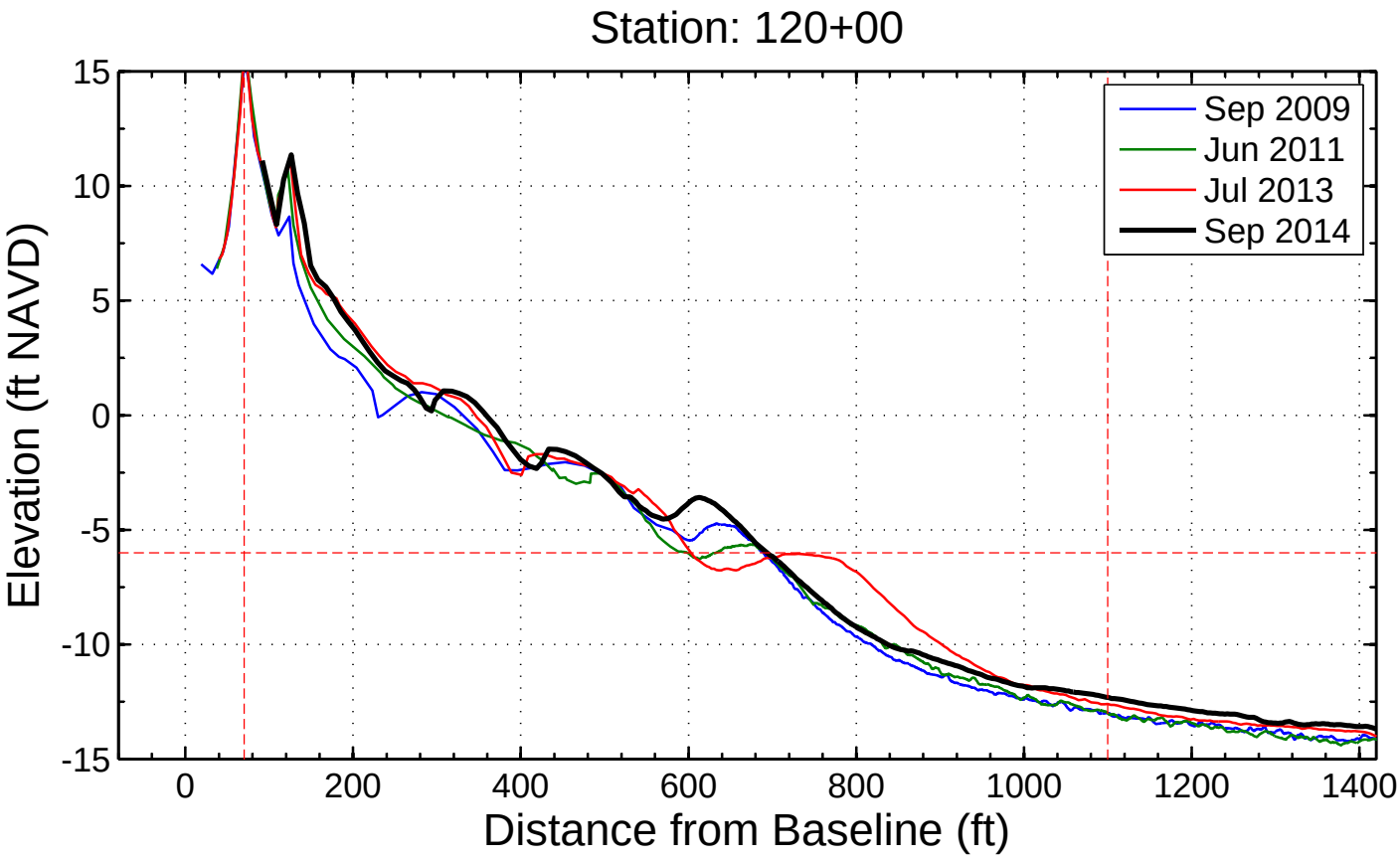
0
-5
-10
0
50
100
150
200
250
300
350
400
450
Distance from Baseline (ft)


Station: 120+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
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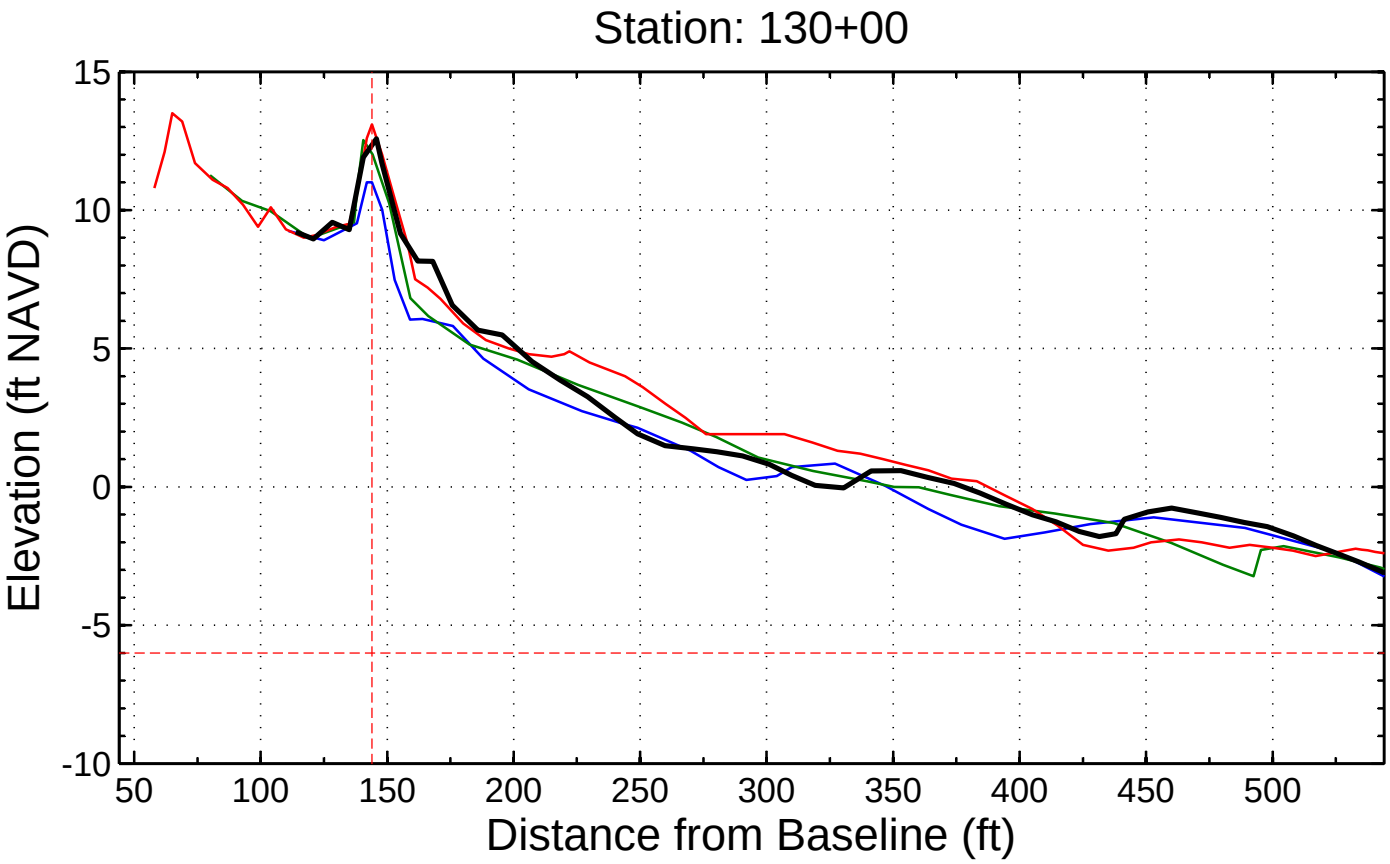
0
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 130+00
Elevation (ft NAVD)
15
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0
-5
-10
50
100
150
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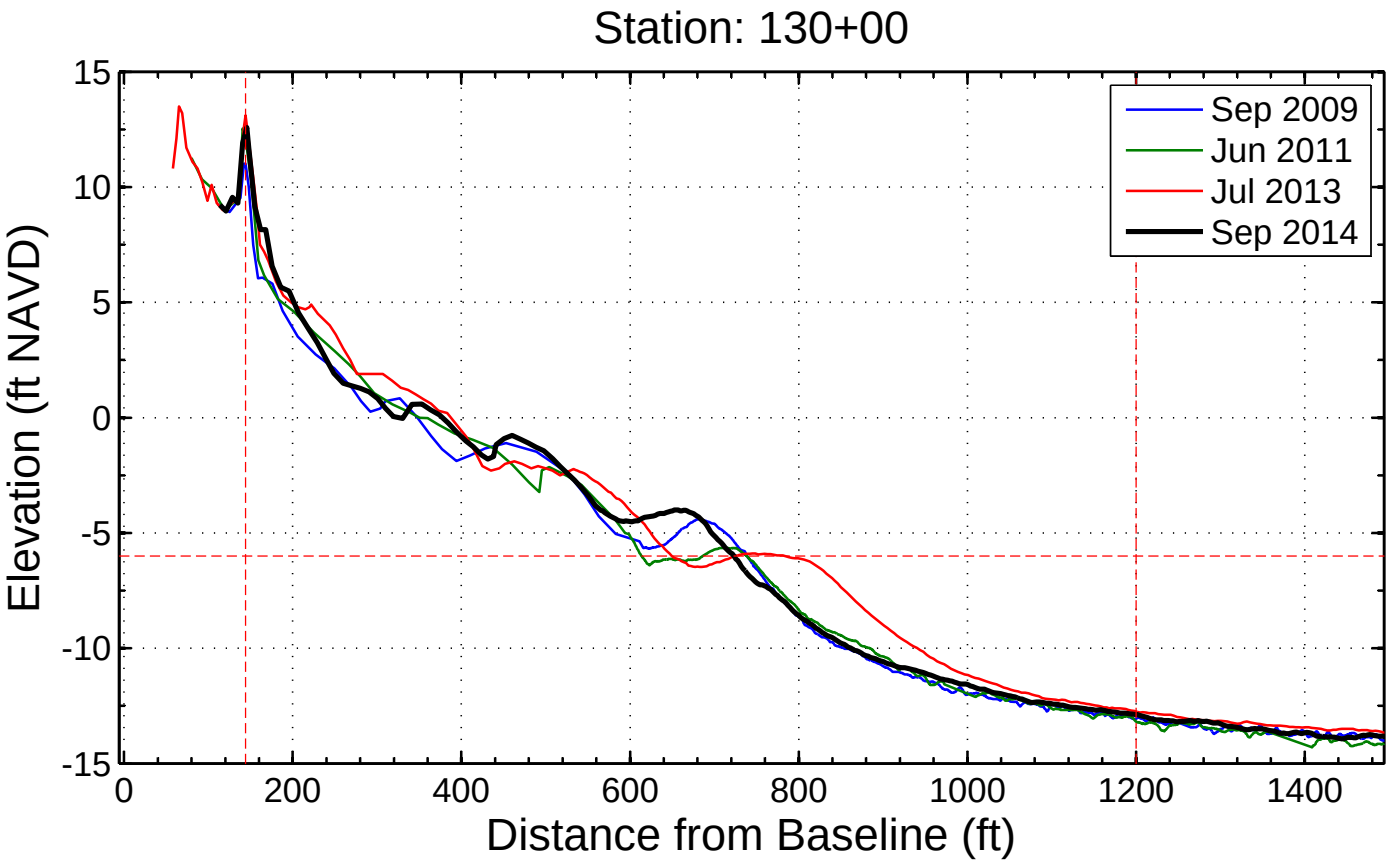
300
350
400
450
500
Distance from Baseline (ft)


Station: 130+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
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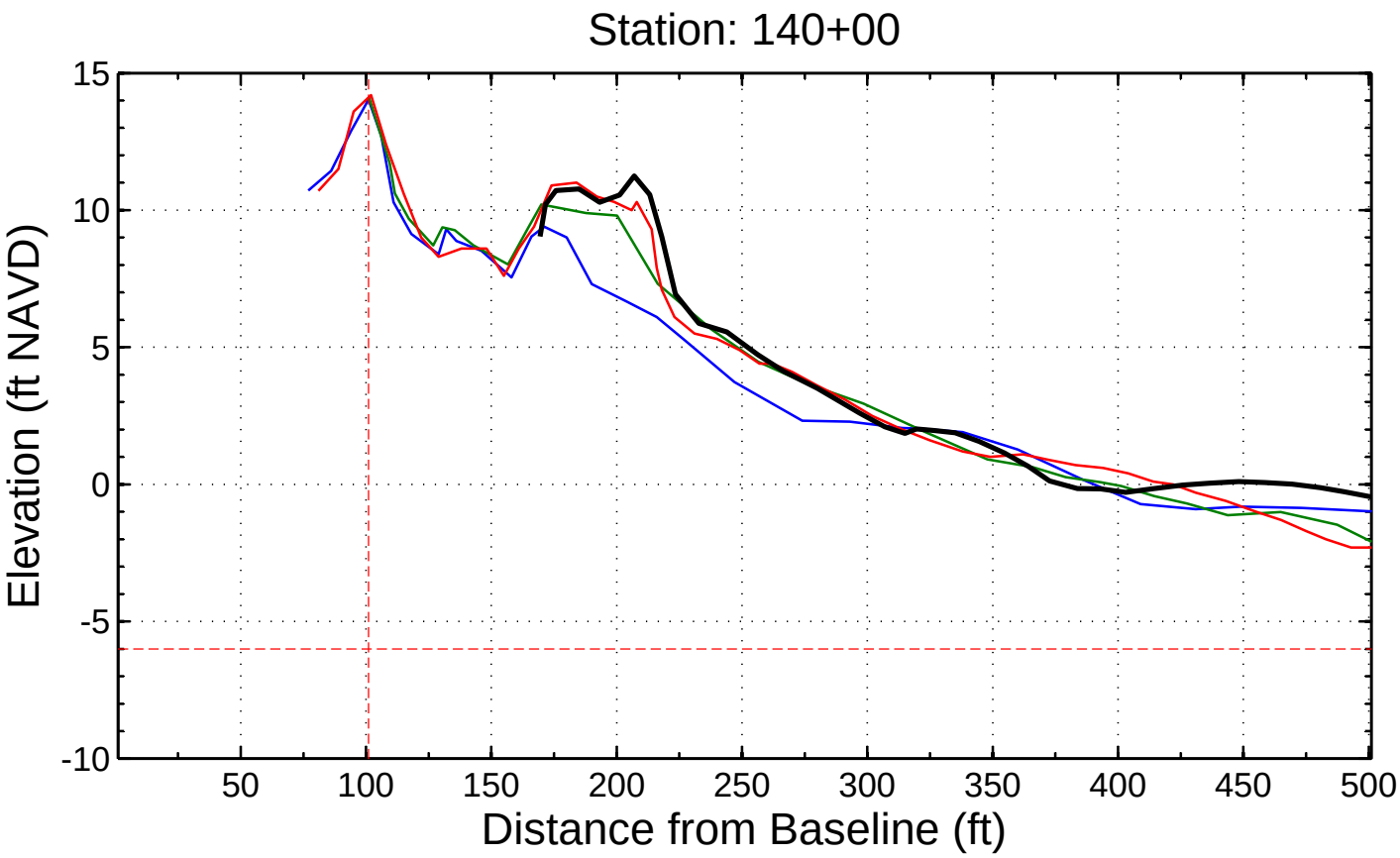
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 140+00
Elevation (ft NAVD)
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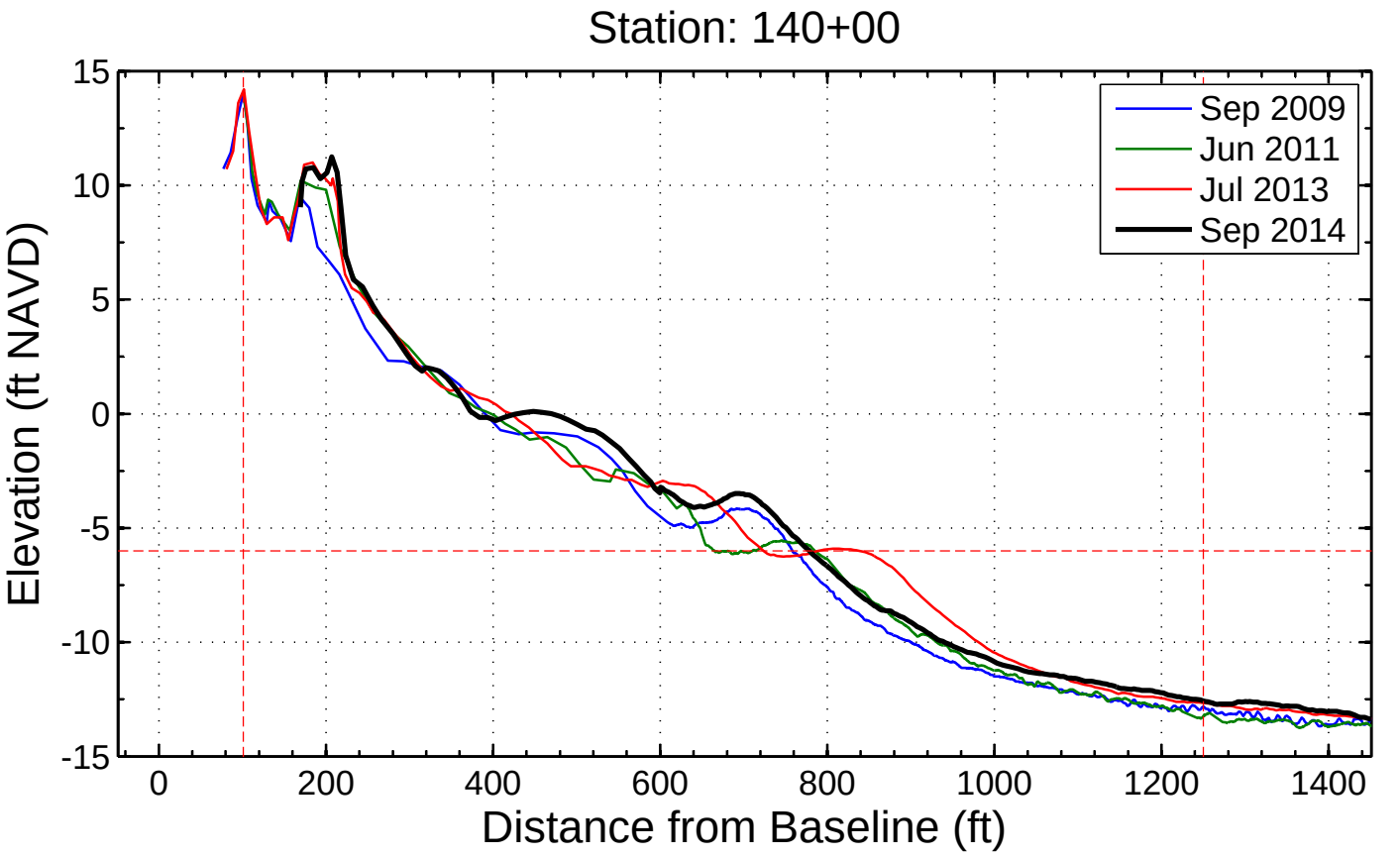
0
-5
-10
50
100
150
200
250
300
350
400
450
500
Distance from Baseline (ft)


Station: 140+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
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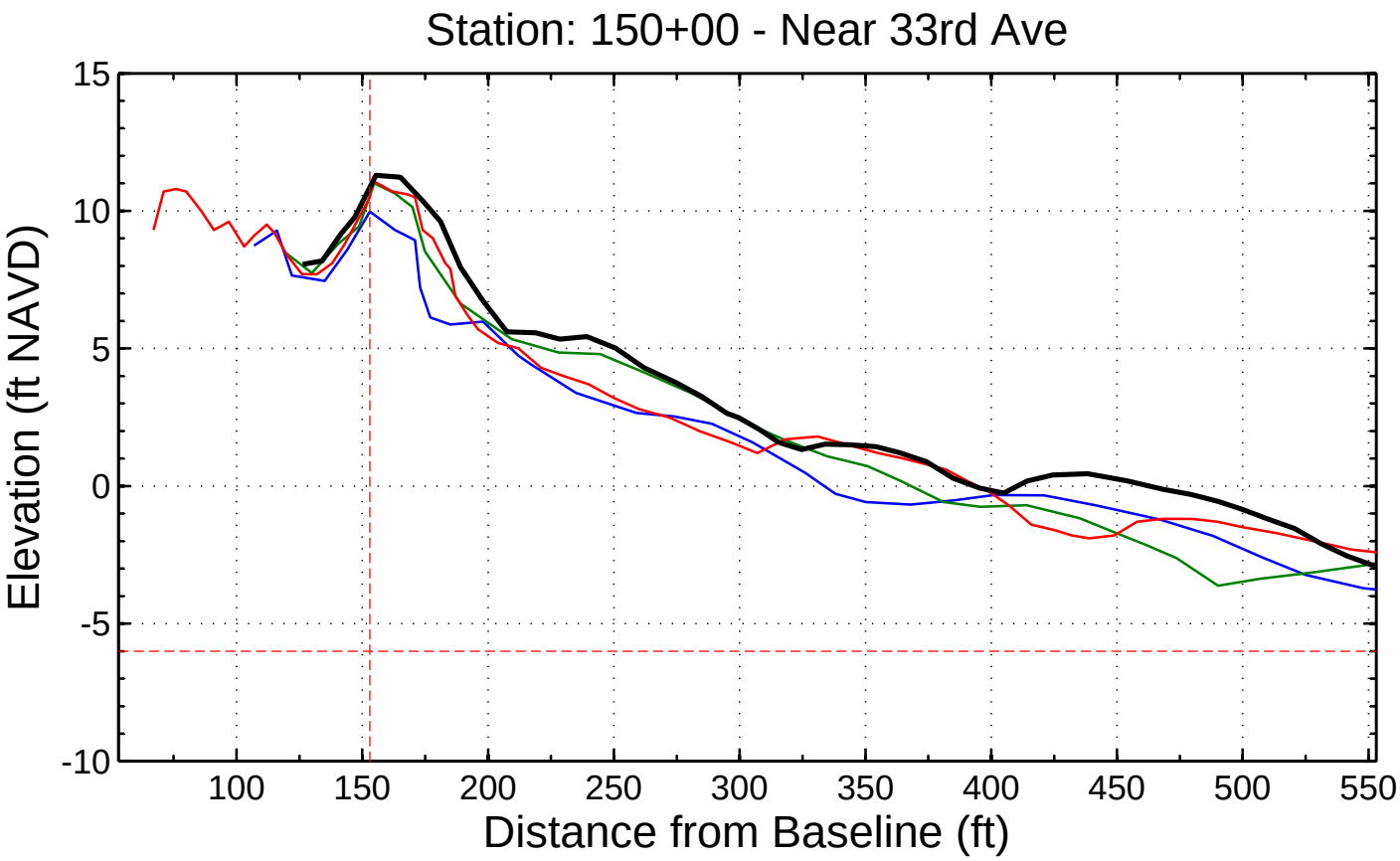
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 150+00 - Near 33rd Ave
Elevation (ft NAVD)
15
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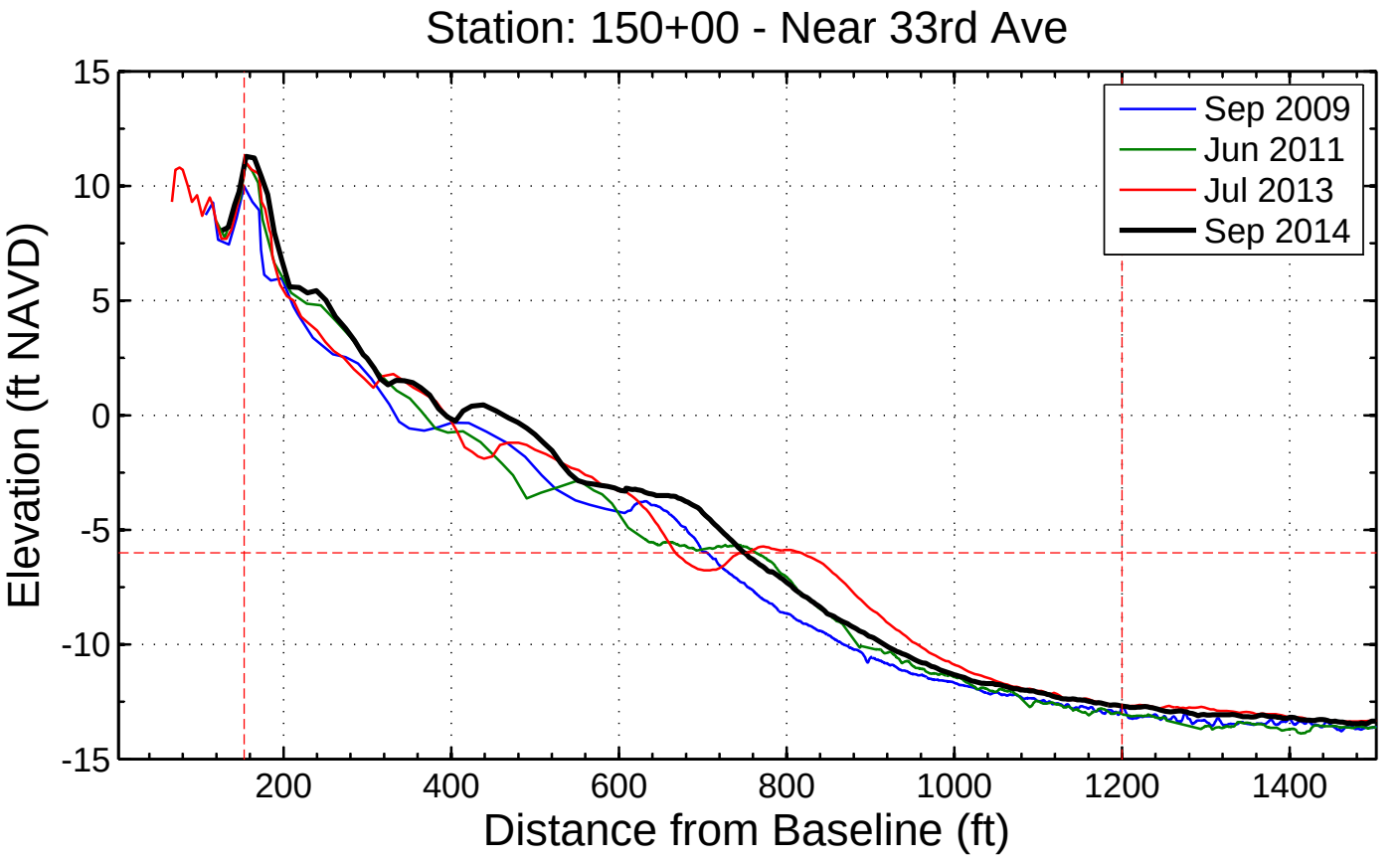
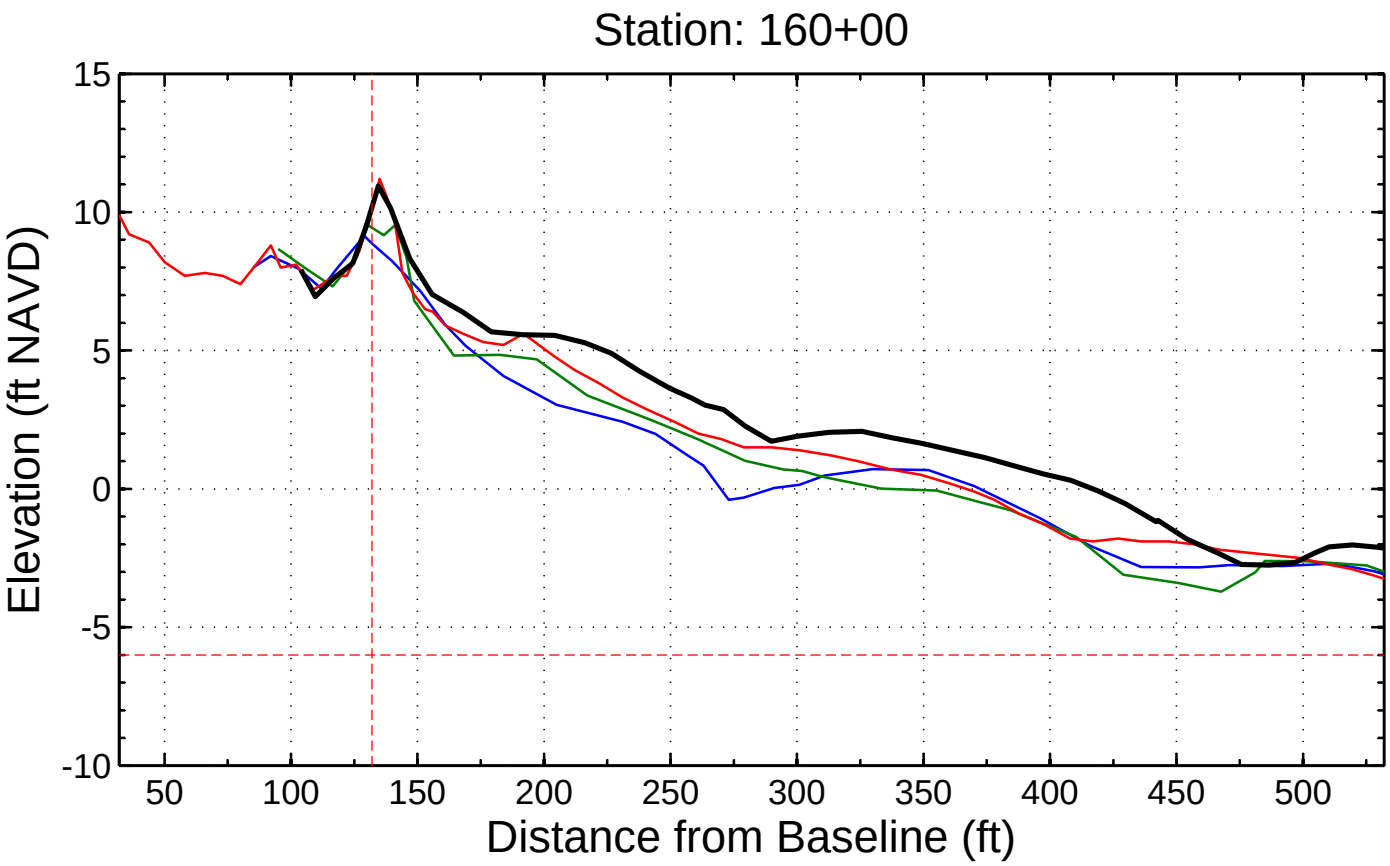
0
-5
-10
100
150
200
250
300
350
400
450
500
550
Distance from Baseline (ft)


Station: 150+00 - Near 33rd Ave
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 160+00
Elevation (ft NAVD)
15
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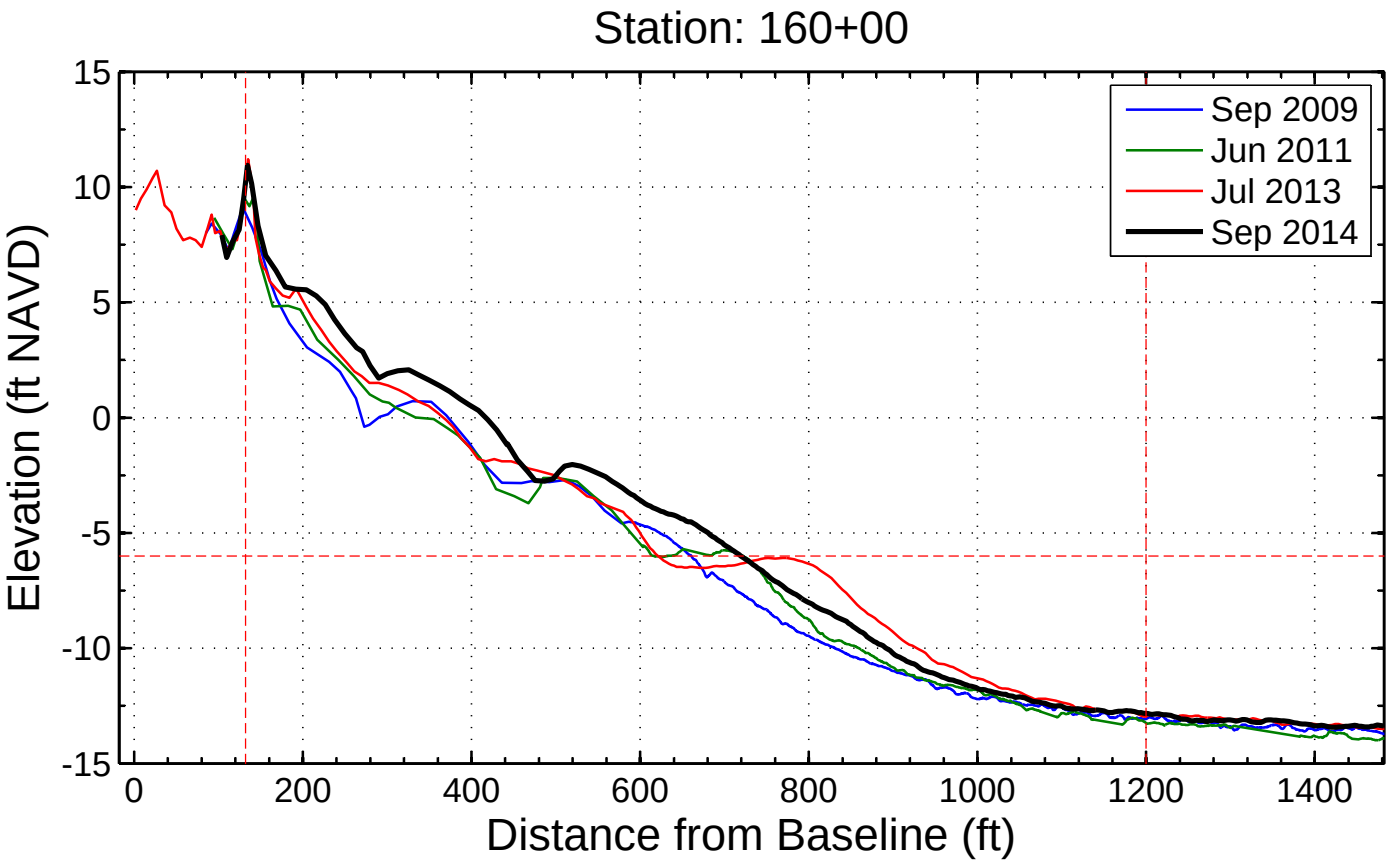
0
-5
-10
50
100
150
200
250
300
350
400
450
500
Distance from Baseline (ft)


Station: 160+00
Elevation (ft NAVD)
15
10
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0
-5
-10
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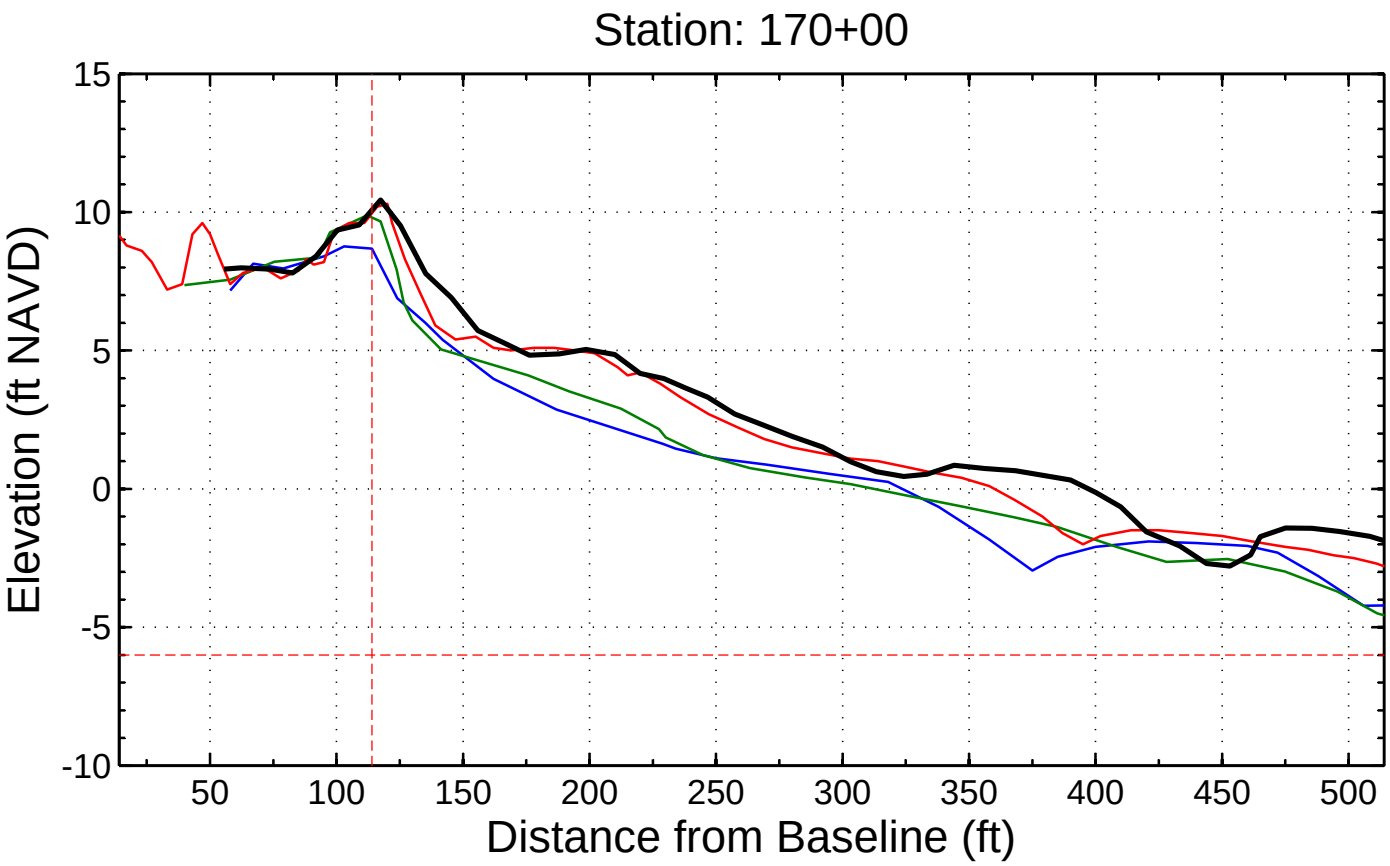
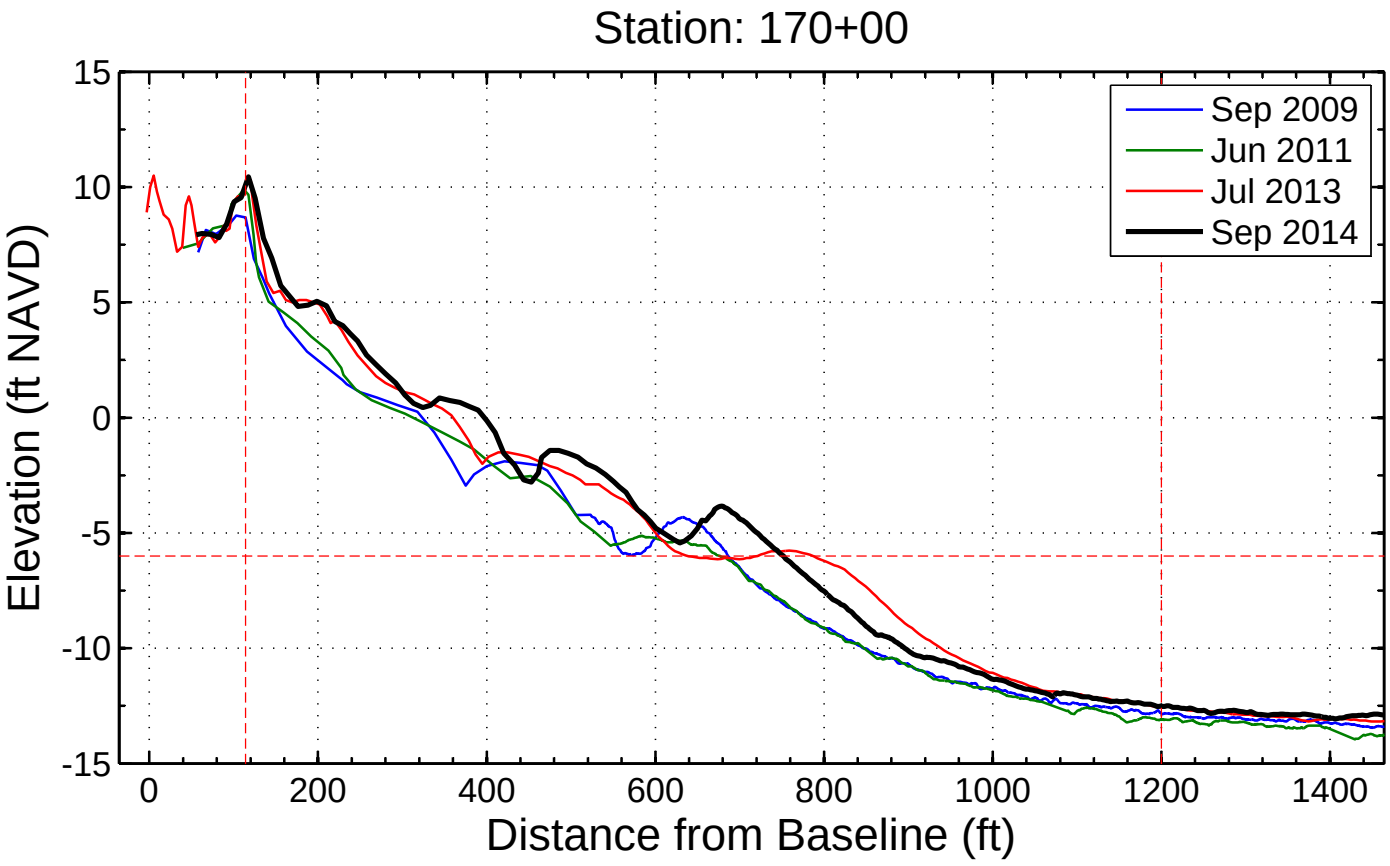
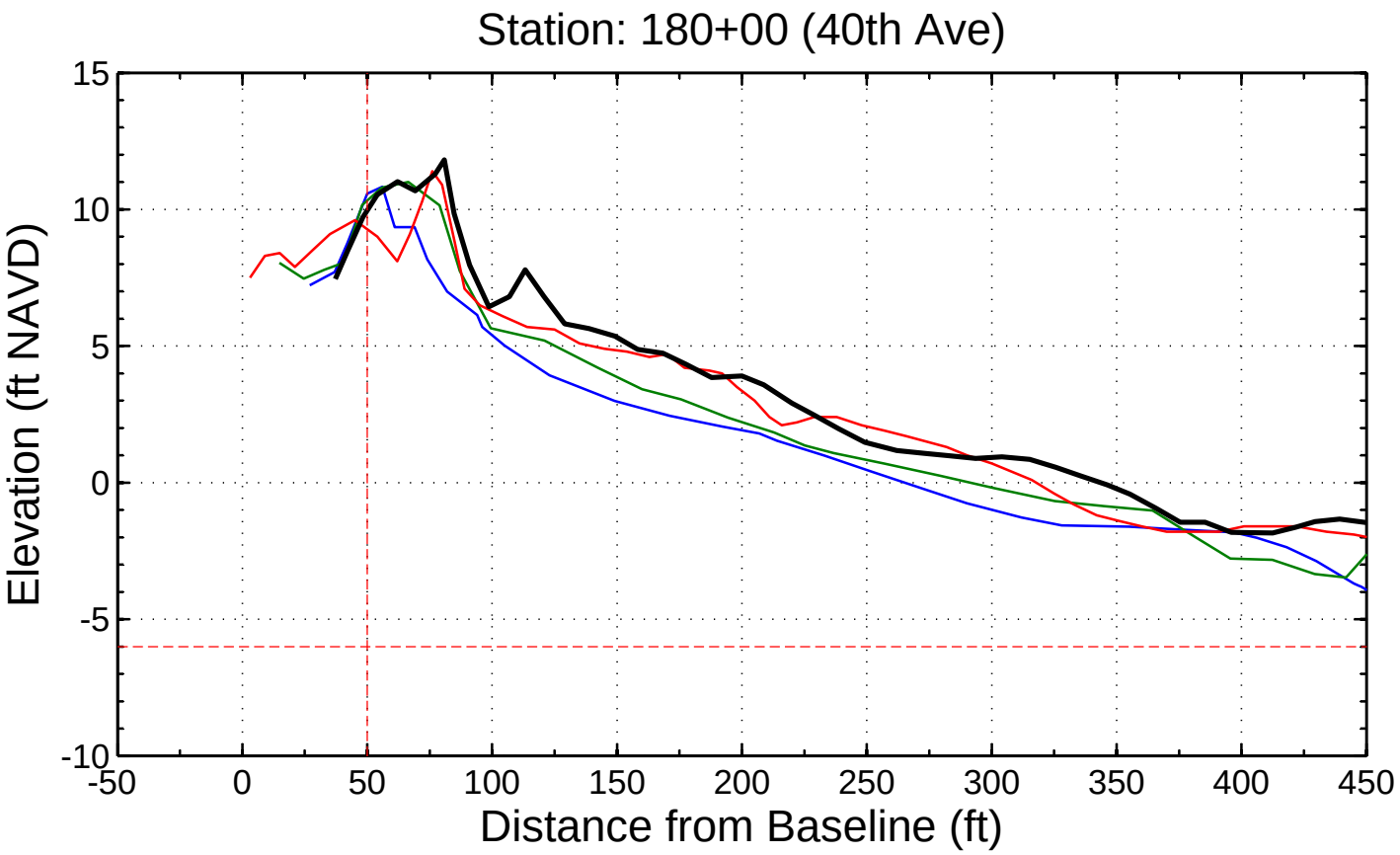
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 170+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
50
100
150
200
250
300
350
400
450
500
Distance from Baseline (ft)


Station: 170+00
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 180+00 (40th Ave)
Elevation (ft NAVD)
15
10
5
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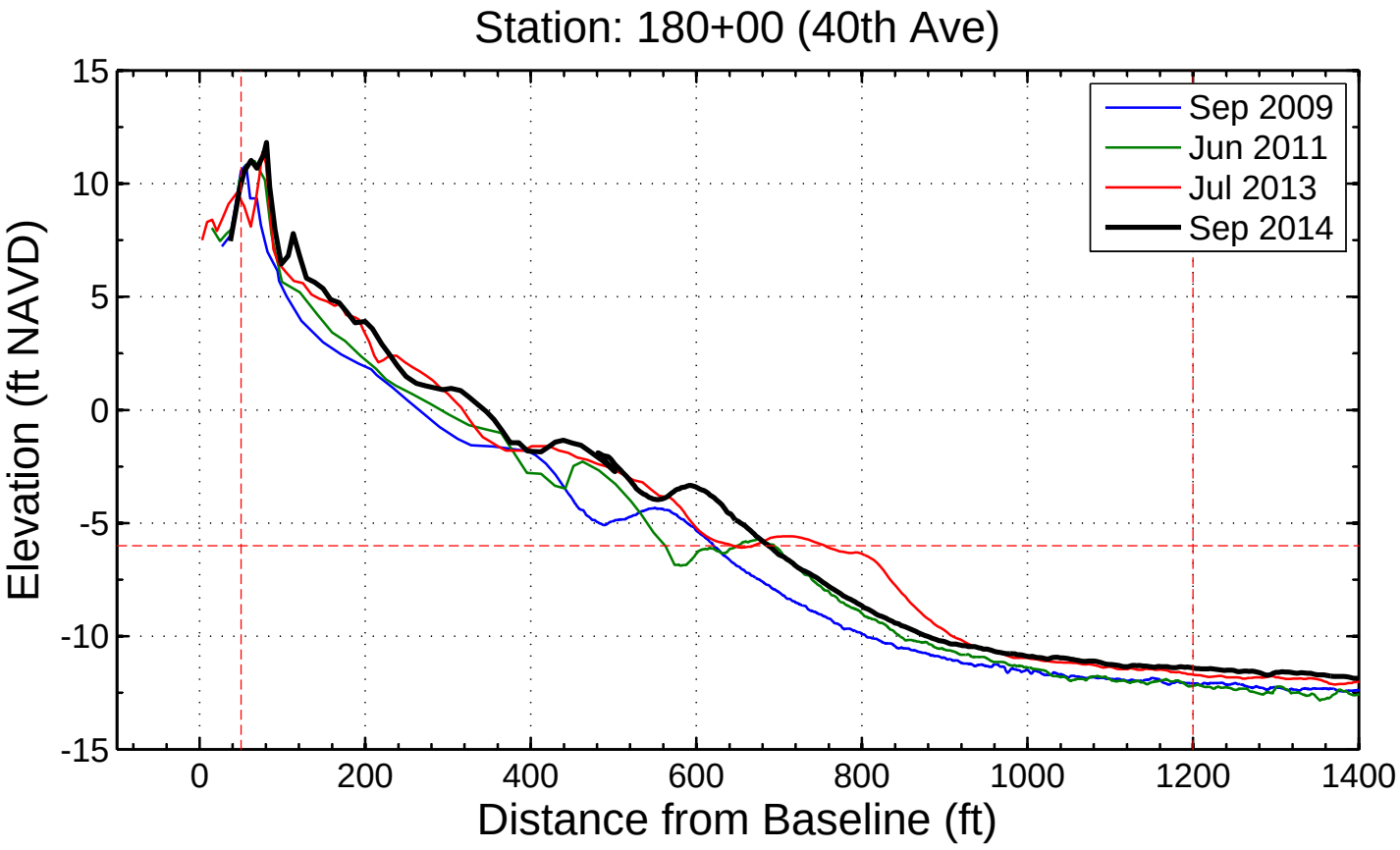
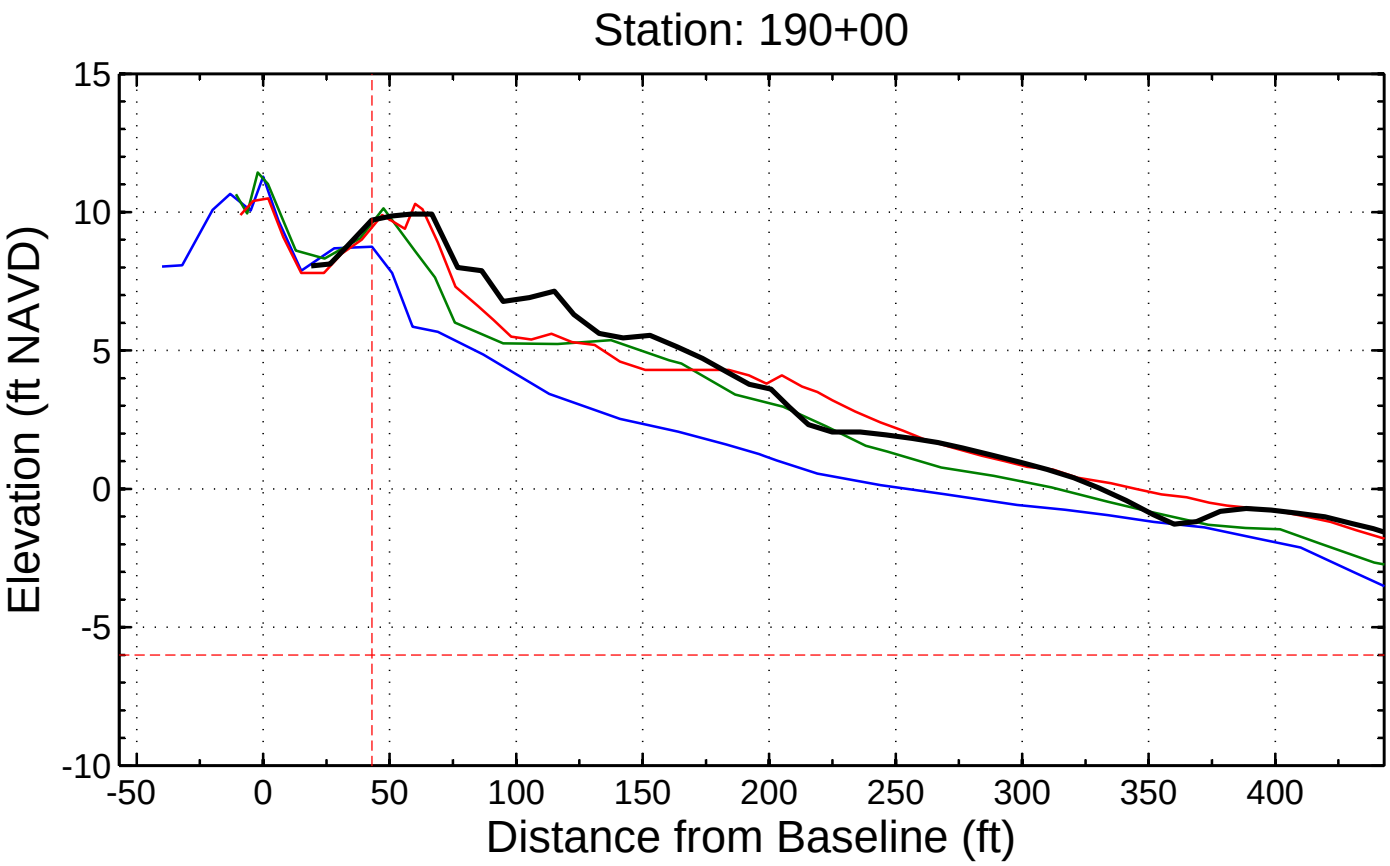
-5
-10
-50
0
50
100
150
200
250
300
350
400
450
Distance from Baseline (ft)


Station: 180+00 (40th Ave)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 190+00
Elevation (ft NAVD)
15
10
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0
-5
-10
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200
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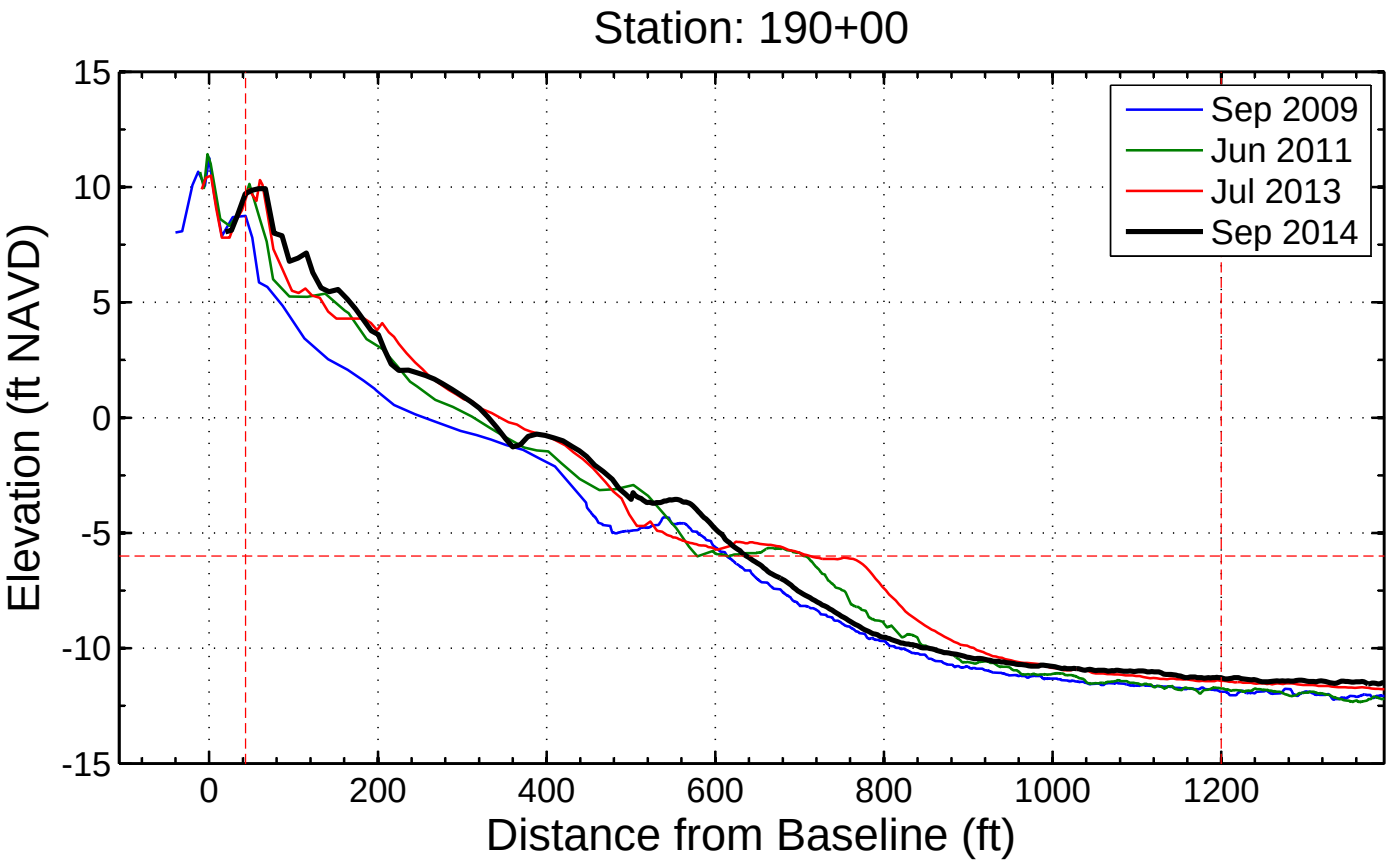
350
400
Distance from Baseline (ft)


Station: 190+00
Elevation (ft NAVD)
15
10
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-5
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-15
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600
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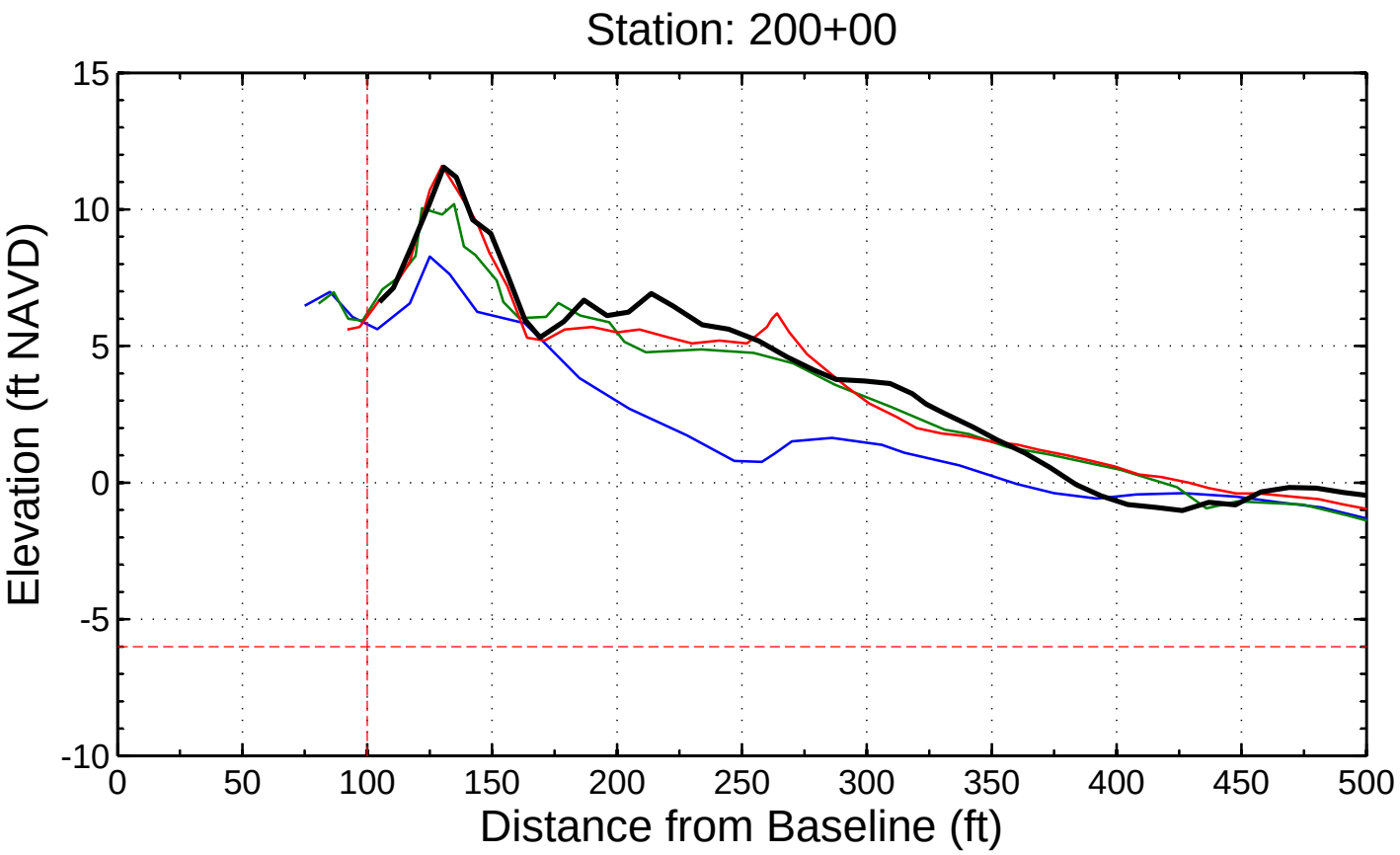
1000
1200
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 200+00
Elevation (ft NAVD)
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-5
-10
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50
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150
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300
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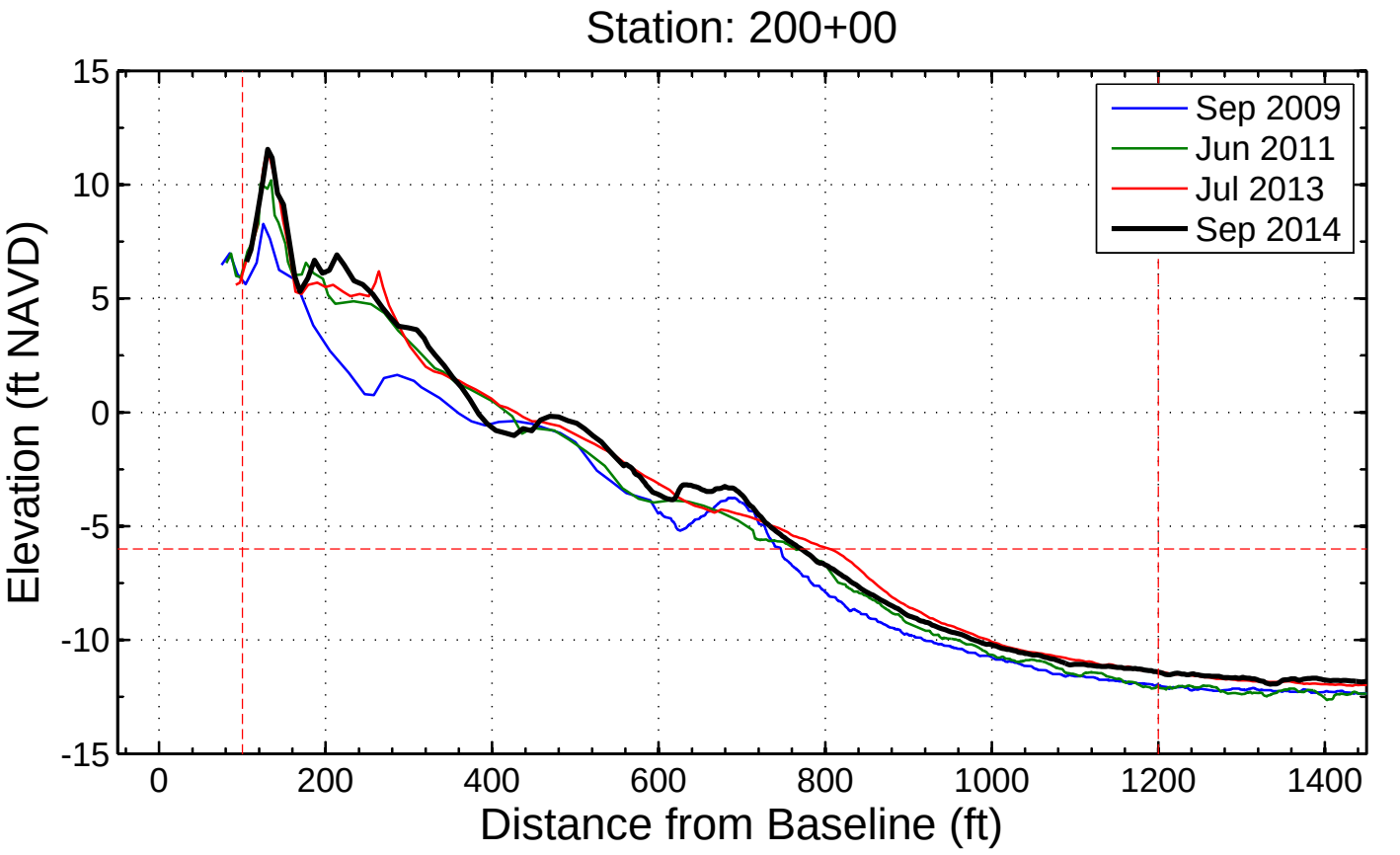
450
500
Distance from Baseline (ft)


Station: 200+00
Elevation (ft NAVD)
15
10
5
0
-5
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200
400
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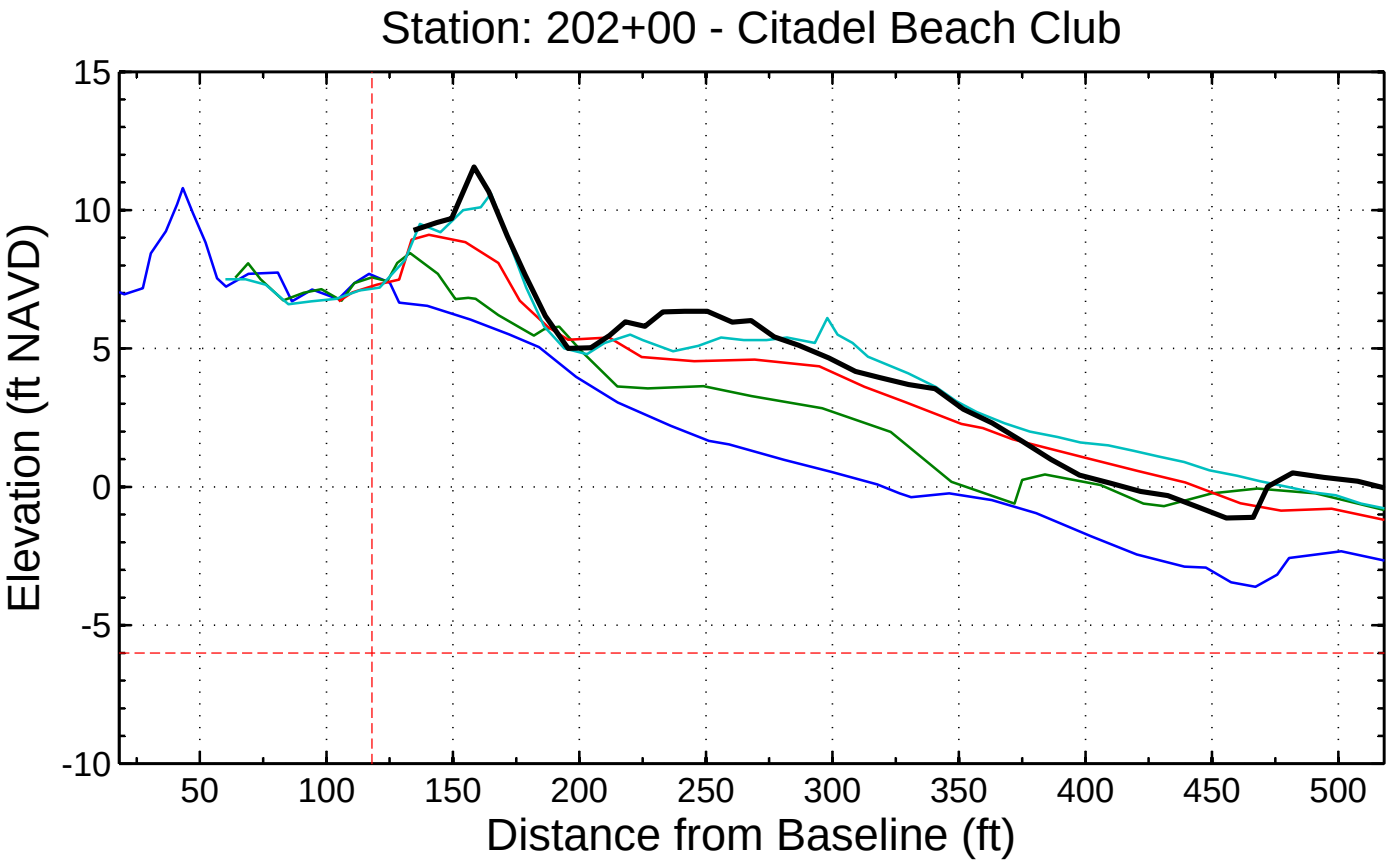
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 202+00 - Citadel Beach Club
Elevation (ft NAVD)
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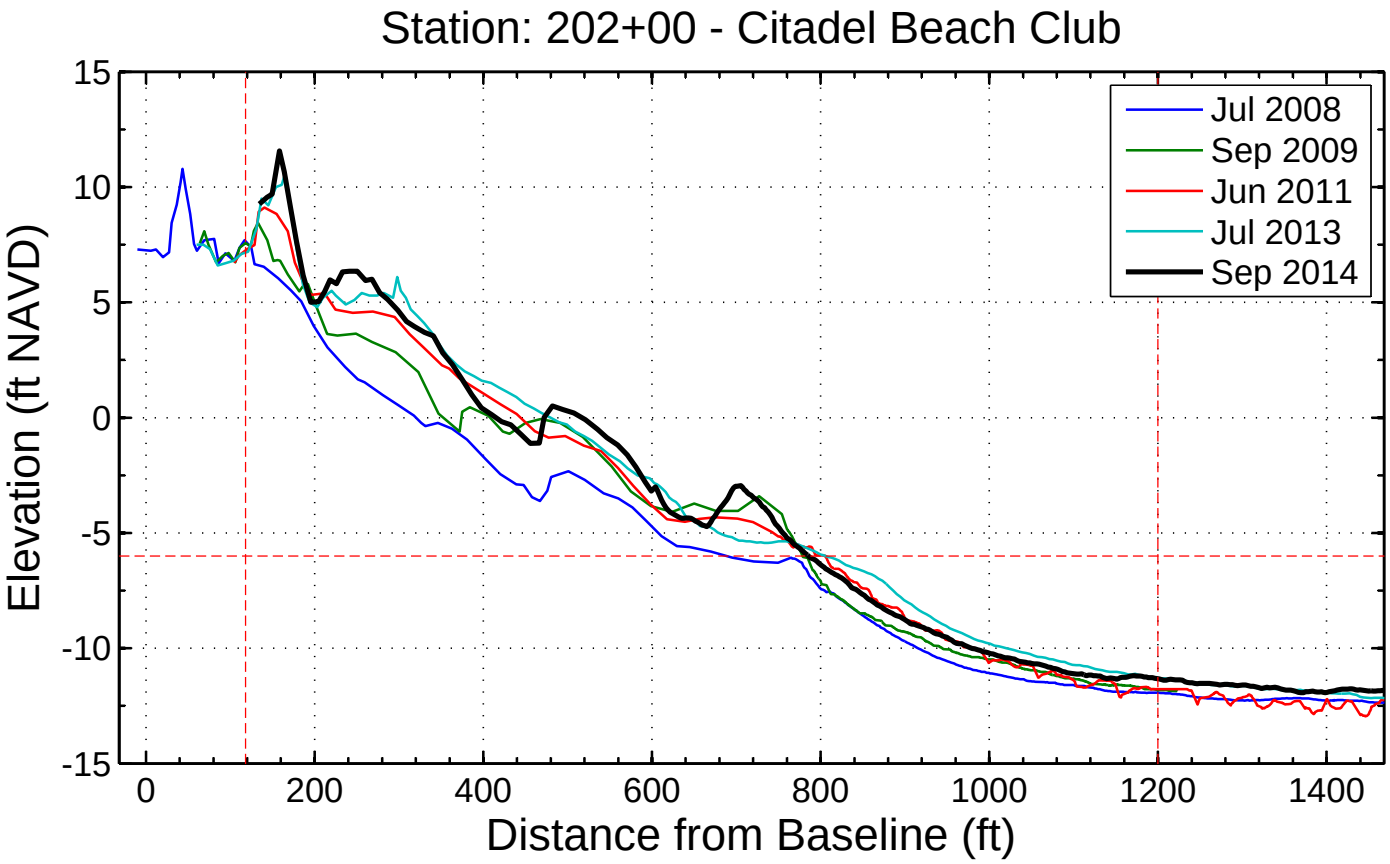
0
-5
-10
50
100
150
200
250
300
350
400
450
500
Distance from Baseline (ft)


Station: 202+00 - Citadel Beach Club
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
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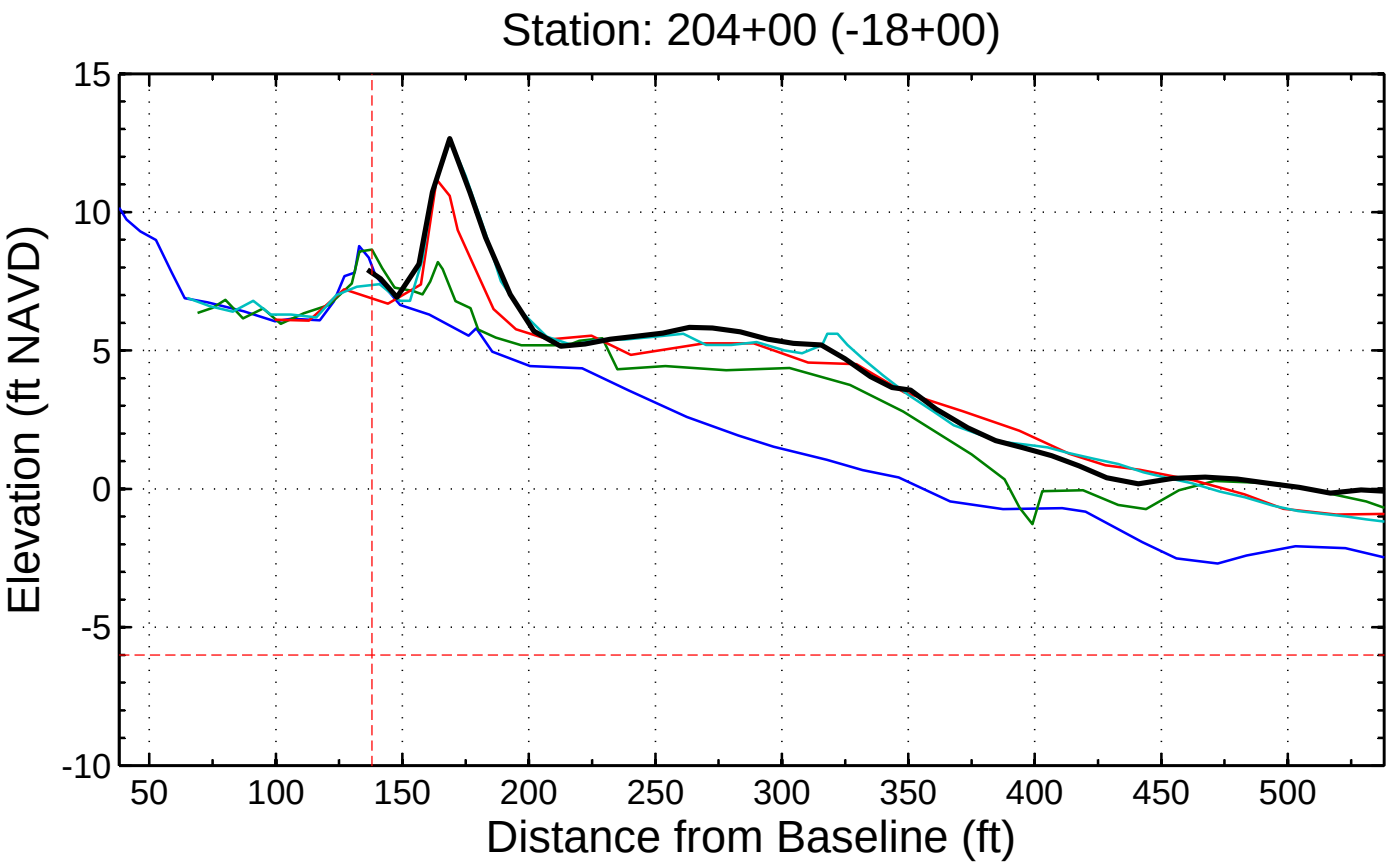
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 204+00 (-18+00)
Elevation (ft NAVD)
15
10
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0
-5
-10
50
100
150
200
250
300
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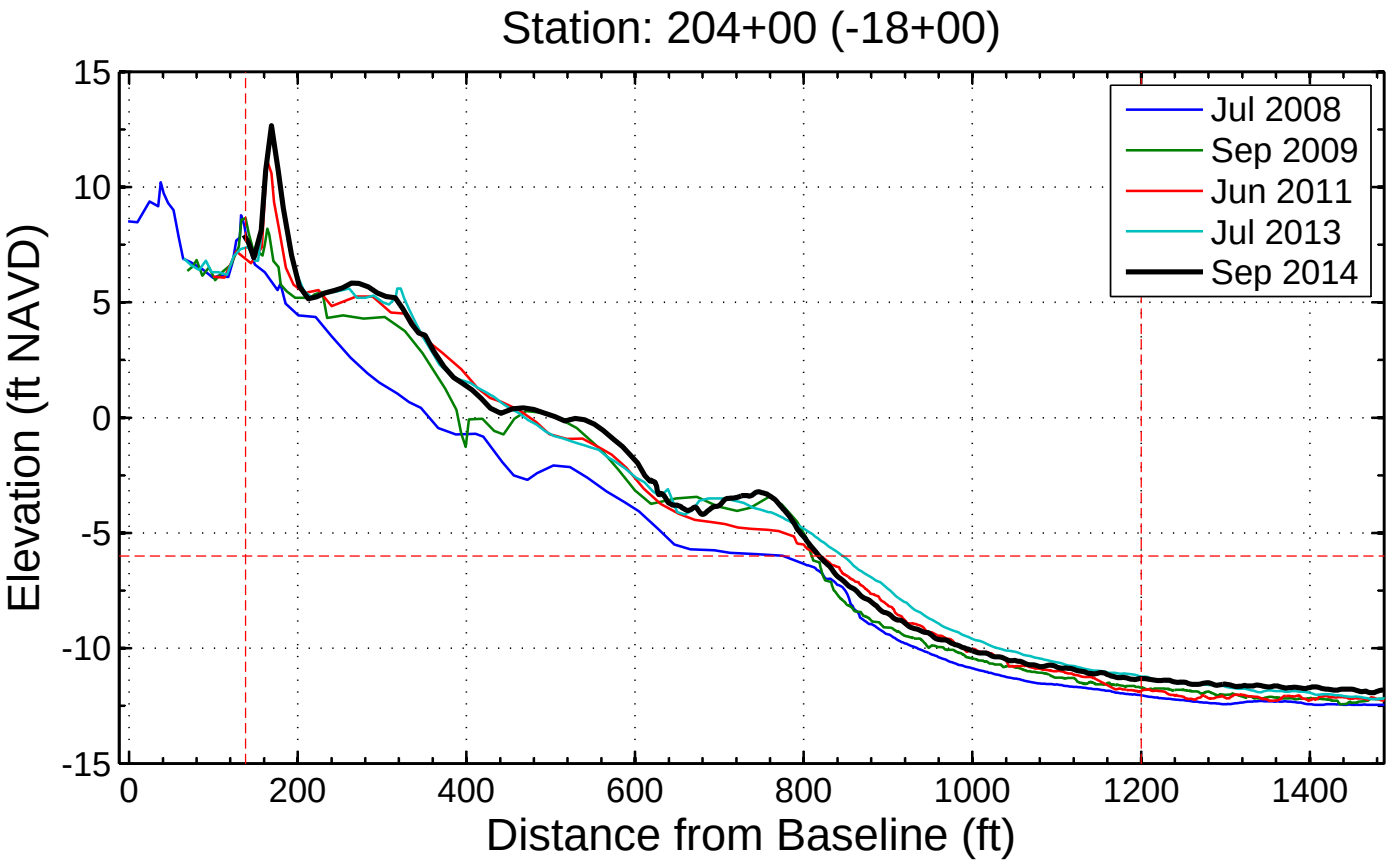
400
450
500
Distance from Baseline (ft)


Station: 204+00 (-18+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
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200
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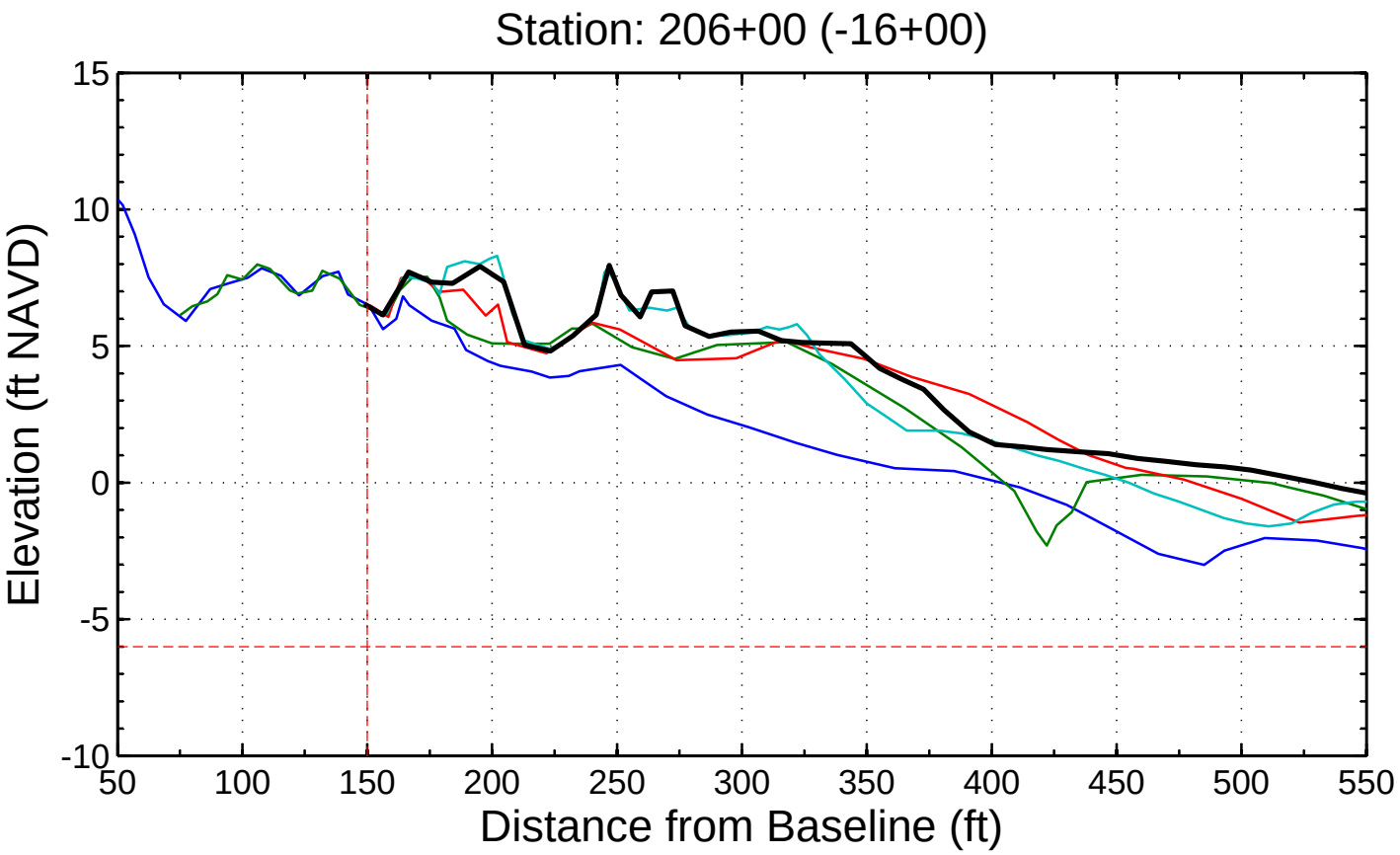
1000
1200
1400
Distance from Baseline (ft)
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 206+00 (-16+00)
Elevation (ft NAVD)
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-5
-10
50
100
150
200
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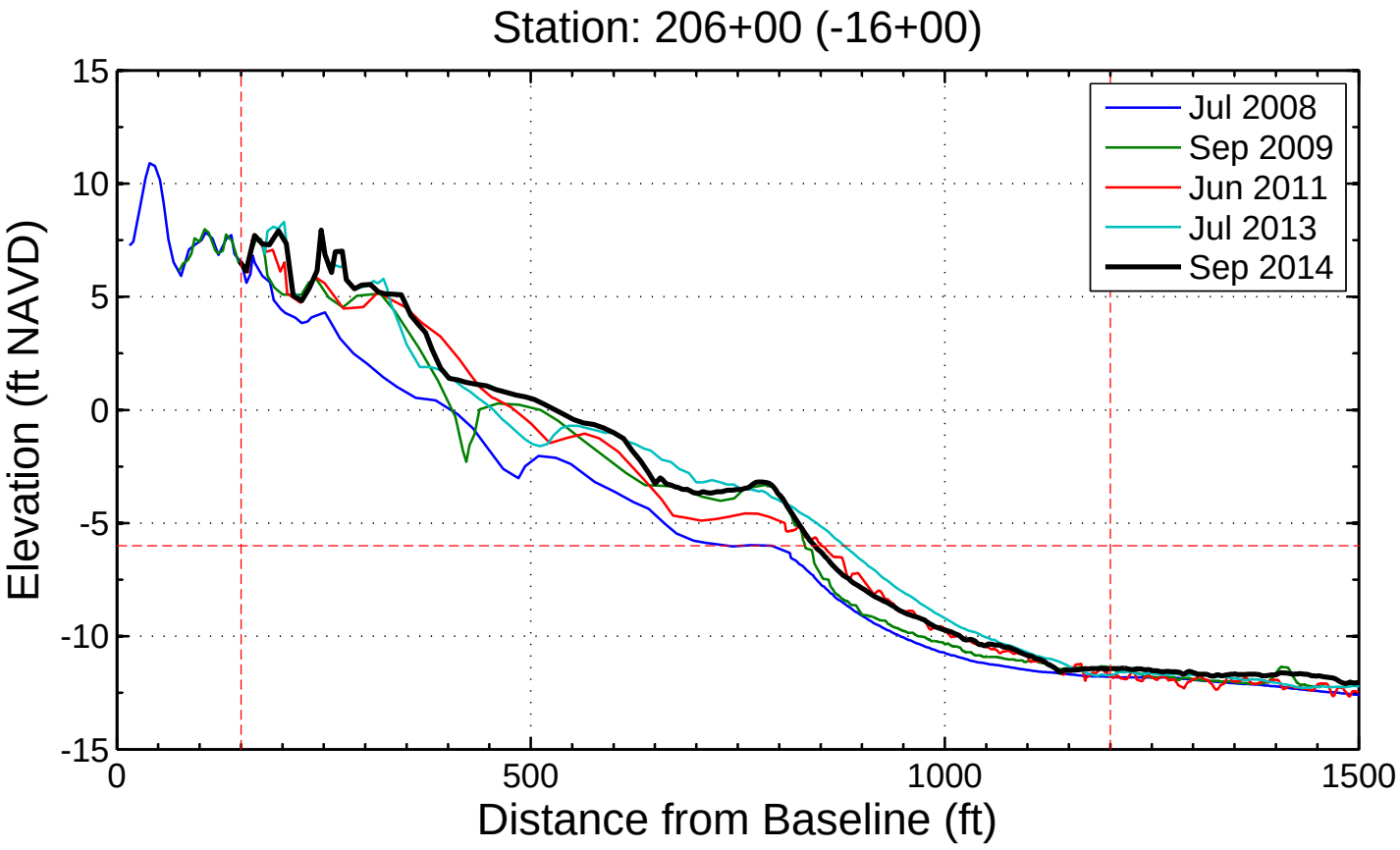
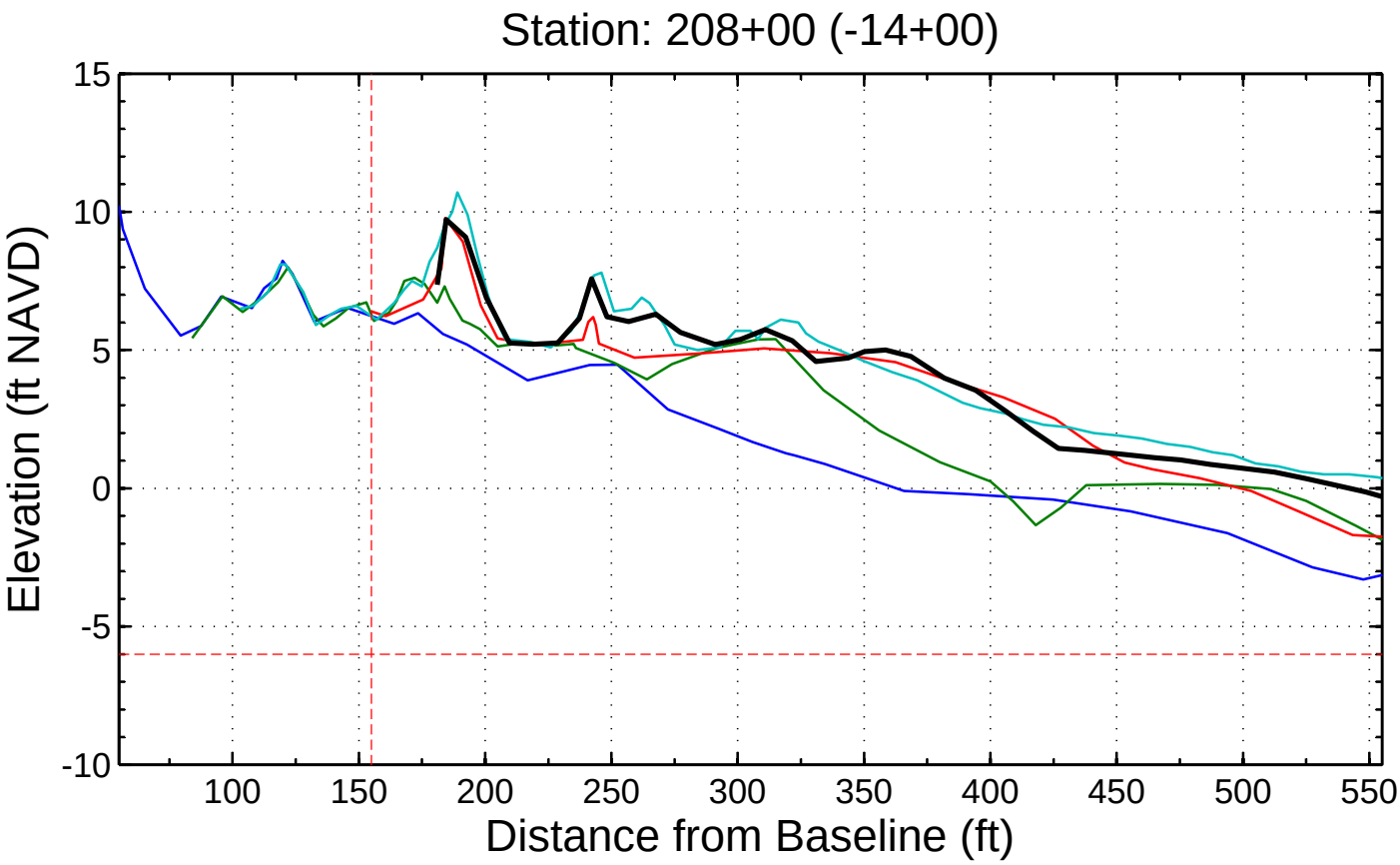
350
400
450
500
550
Distance from Baseline (ft)


Station: 206+00 (-16+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
500
1000
1500
Distance from Baseline (ft)
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 208+00 (-14+00)
Elevation (ft NAVD)
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-5
-10
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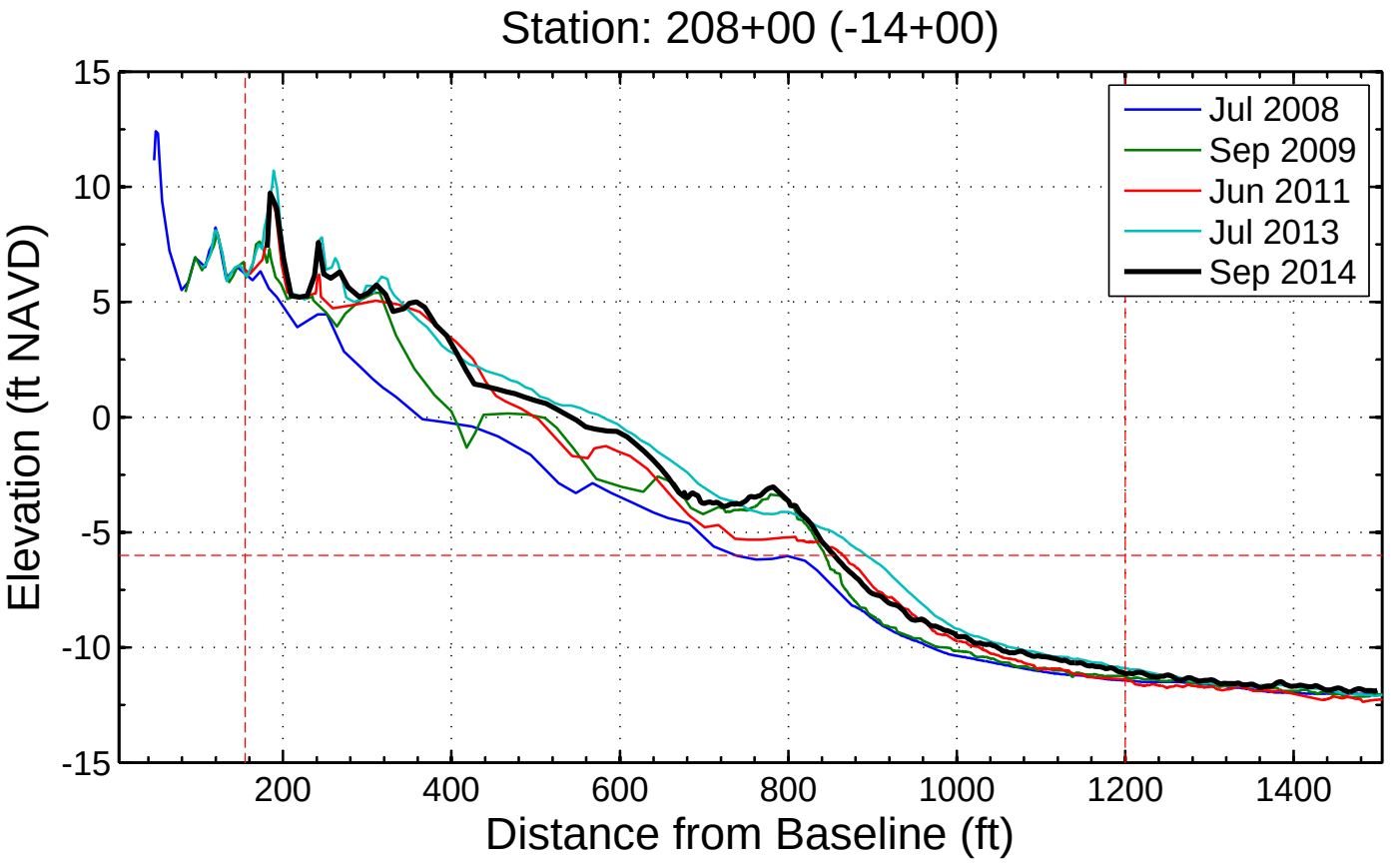
550
Distance from Baseline (ft)


Station: 208+00 (-14+00)
Elevation (ft NAVD)
15
10
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0
-5
-10
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200
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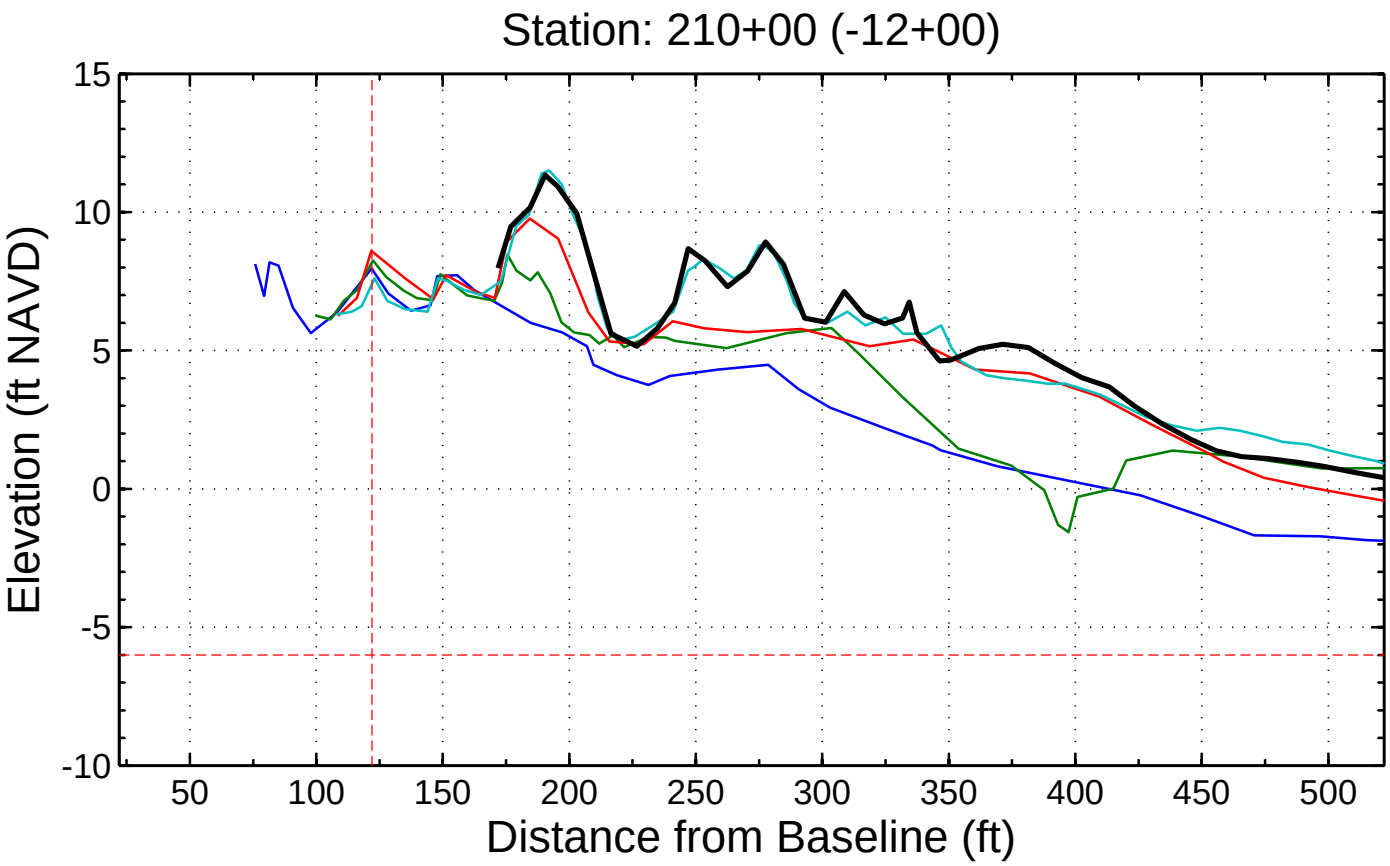
1000
1200
1400
Distance from Baseline (ft)
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 210+00 (-12+00)
Elevation (ft NAVD)
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-5
-10
50
100
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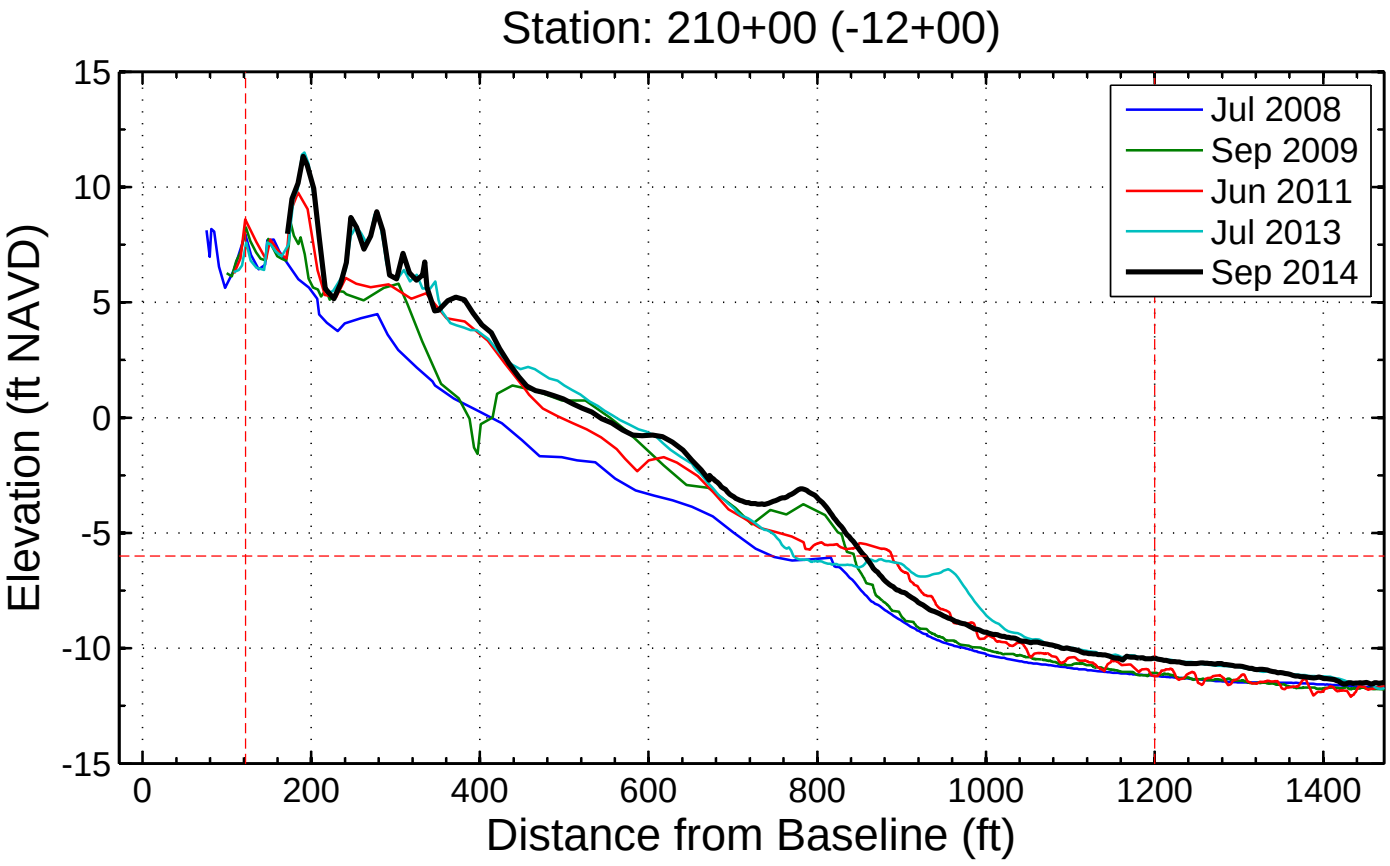
350
400
450
500
Distance from Baseline (ft)


Station: 210+00 (-12+00)
Elevation (ft NAVD)
15
10
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0
-5
-10
-15
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200
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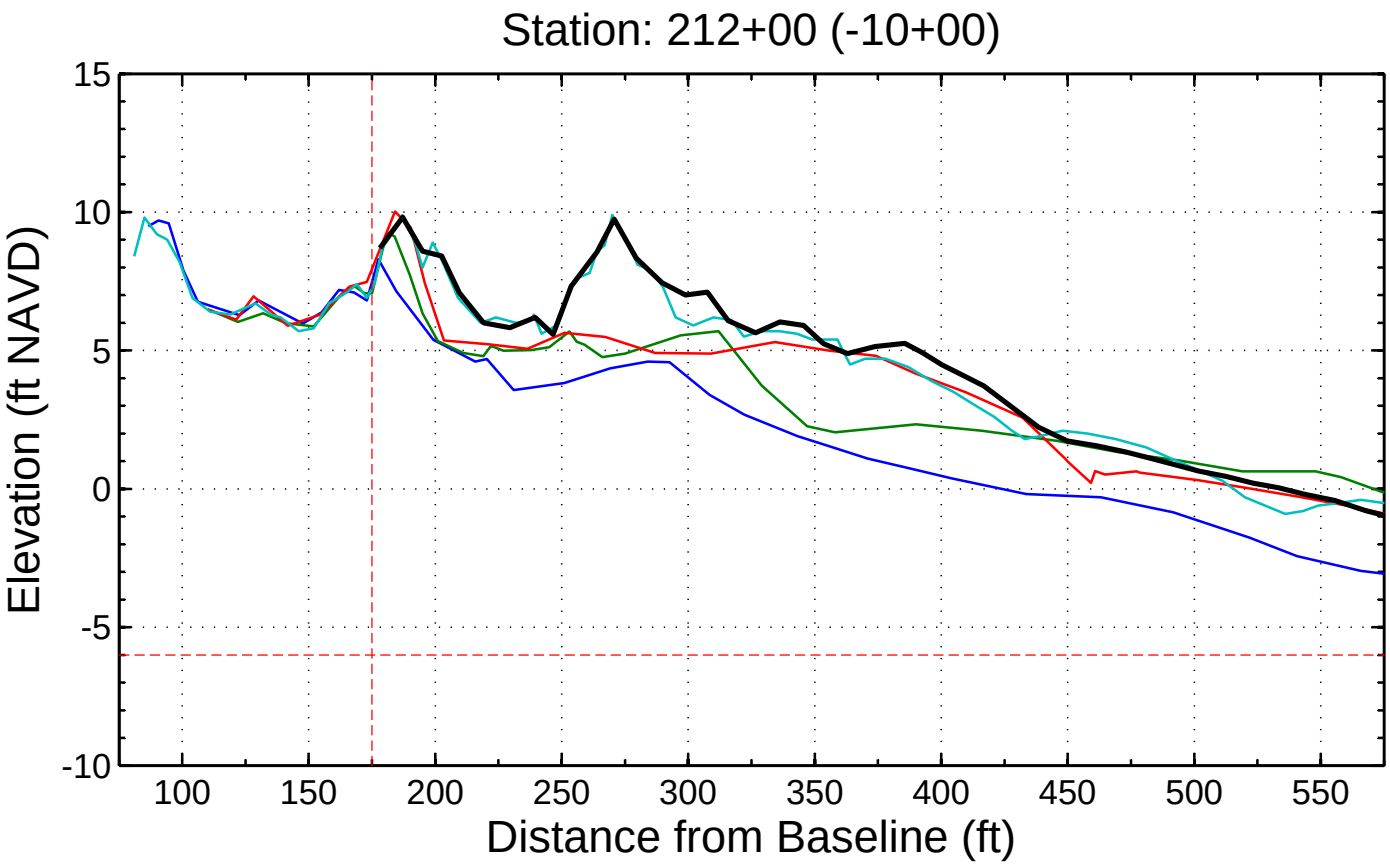
800
1000
1200
1400
Distance from Baseline (ft)
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 212+00 (-10+00)
Elevation (ft NAVD)
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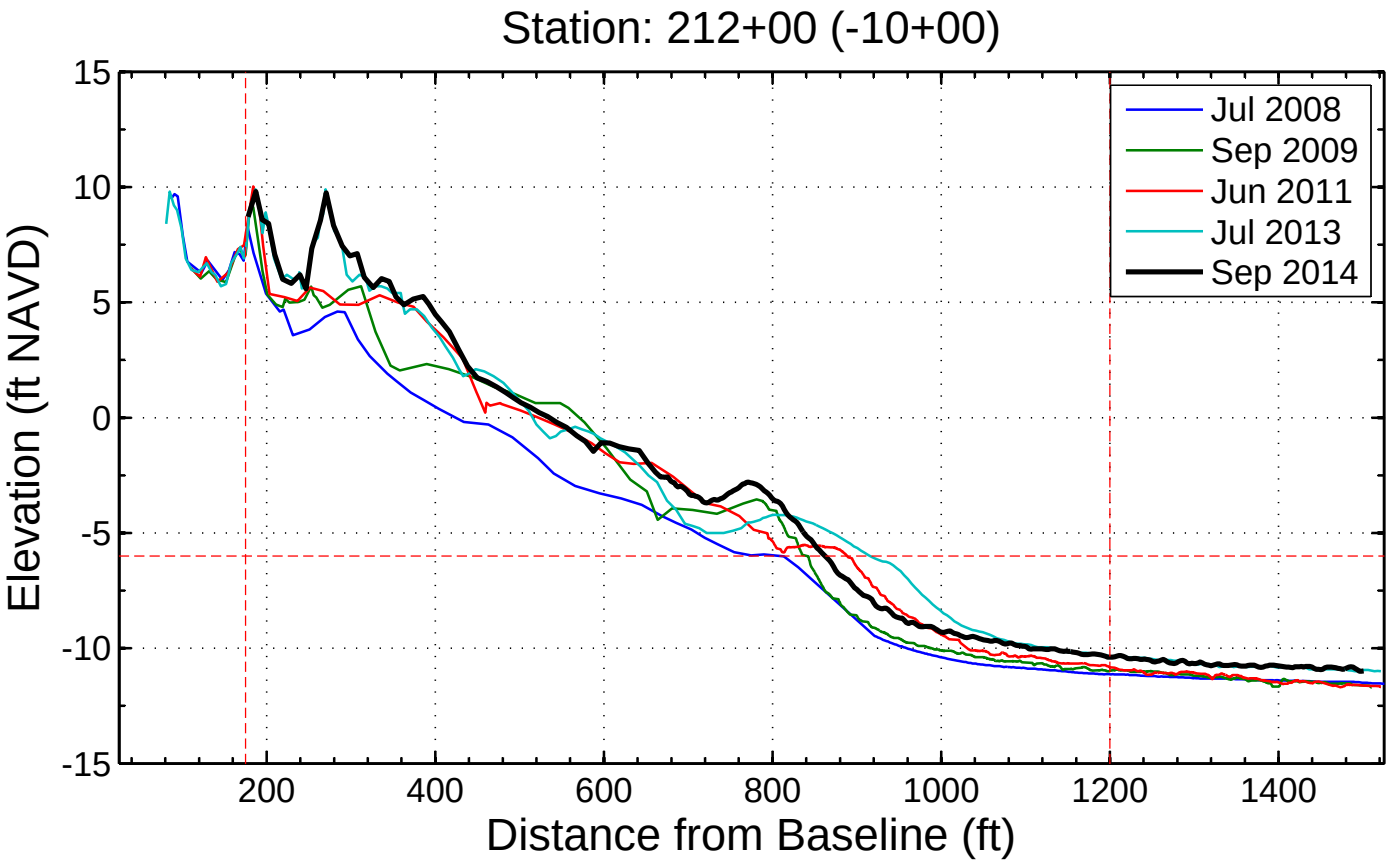
0
-5
-10
100
150
200
250
300
350
400
450
500
550
Distance from Baseline (ft)


Station: 212+00 (-10+00)
Elevation (ft NAVD)
15
10
5
0
-5
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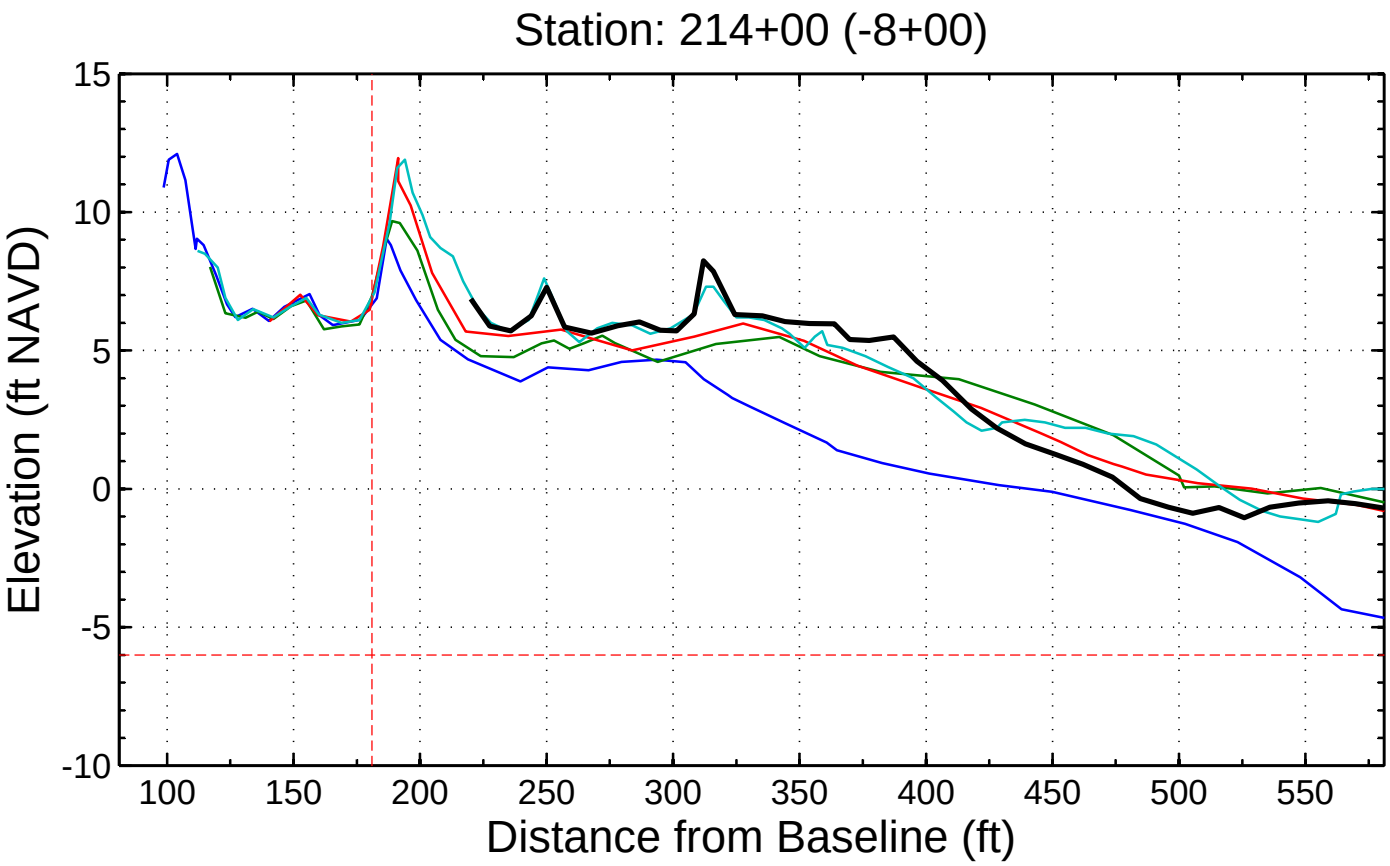
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 214+00 (-8+00)
Elevation (ft NAVD)
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100
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200
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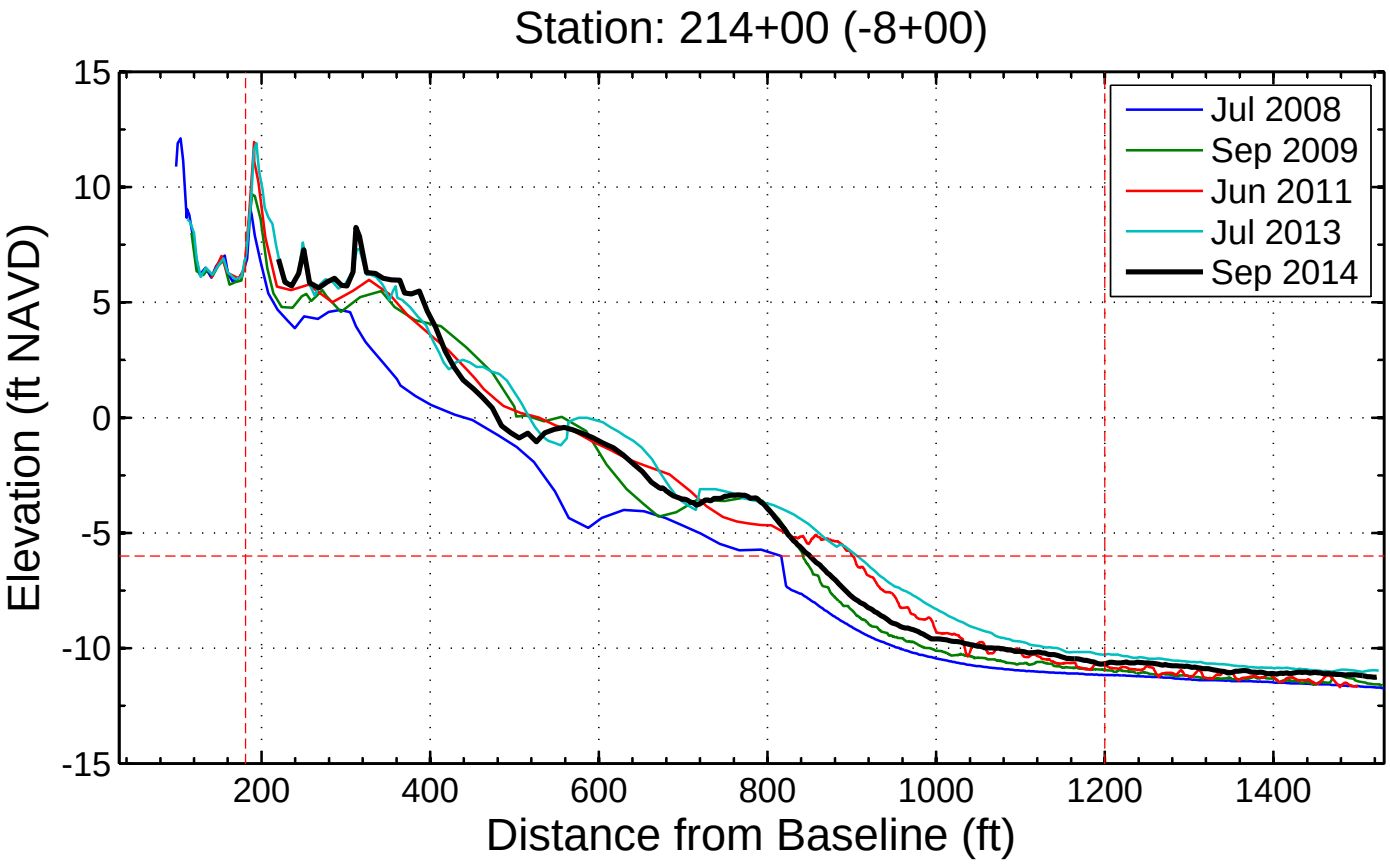
400
450
500
550
Distance from Baseline (ft)


Station: 214+00 (-8+00)
Elevation (ft NAVD)
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10
5
0
-5
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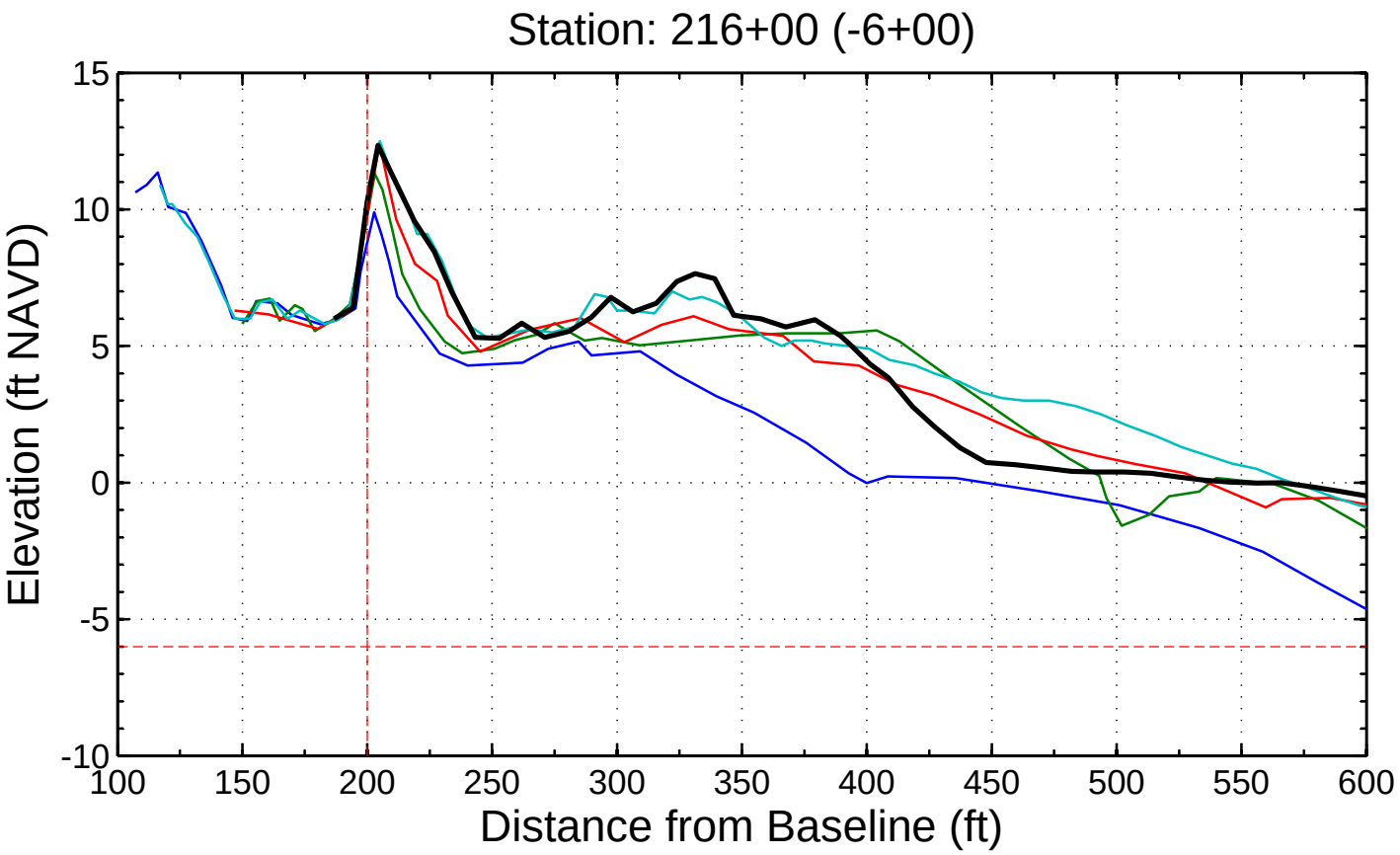
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 216+00 (-6+00)
Elevation (ft NAVD)
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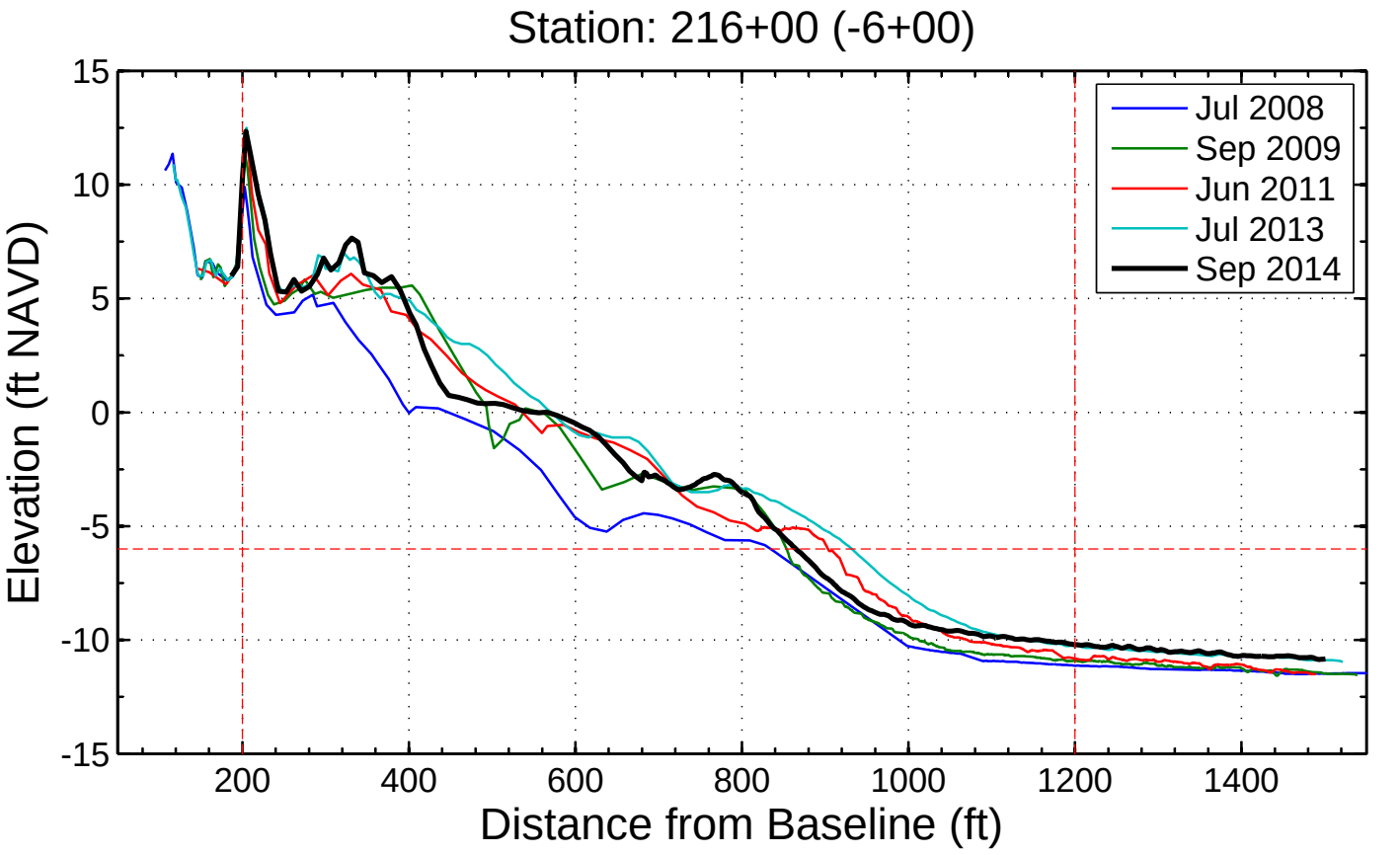
-5
-10
100
150
200
250
300
350
400
450
500
550
600
Distance from Baseline (ft)


Station: 216+00 (-6+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
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200
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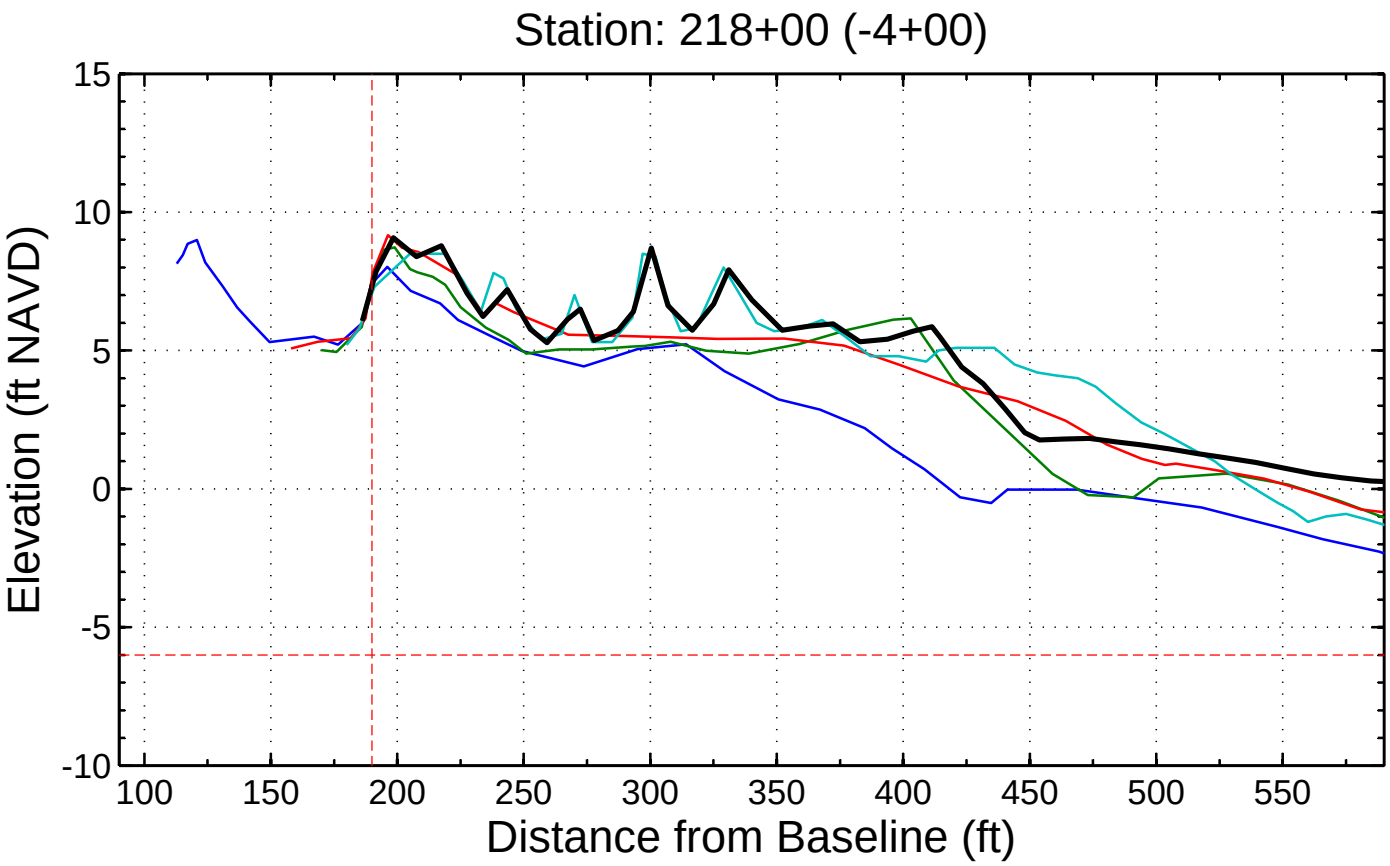
600
800
1000
1200
1400
Distance from Baseline (ft)
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 218+00 (-4+00)
Elevation (ft NAVD)
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-5
-10
100
150
200
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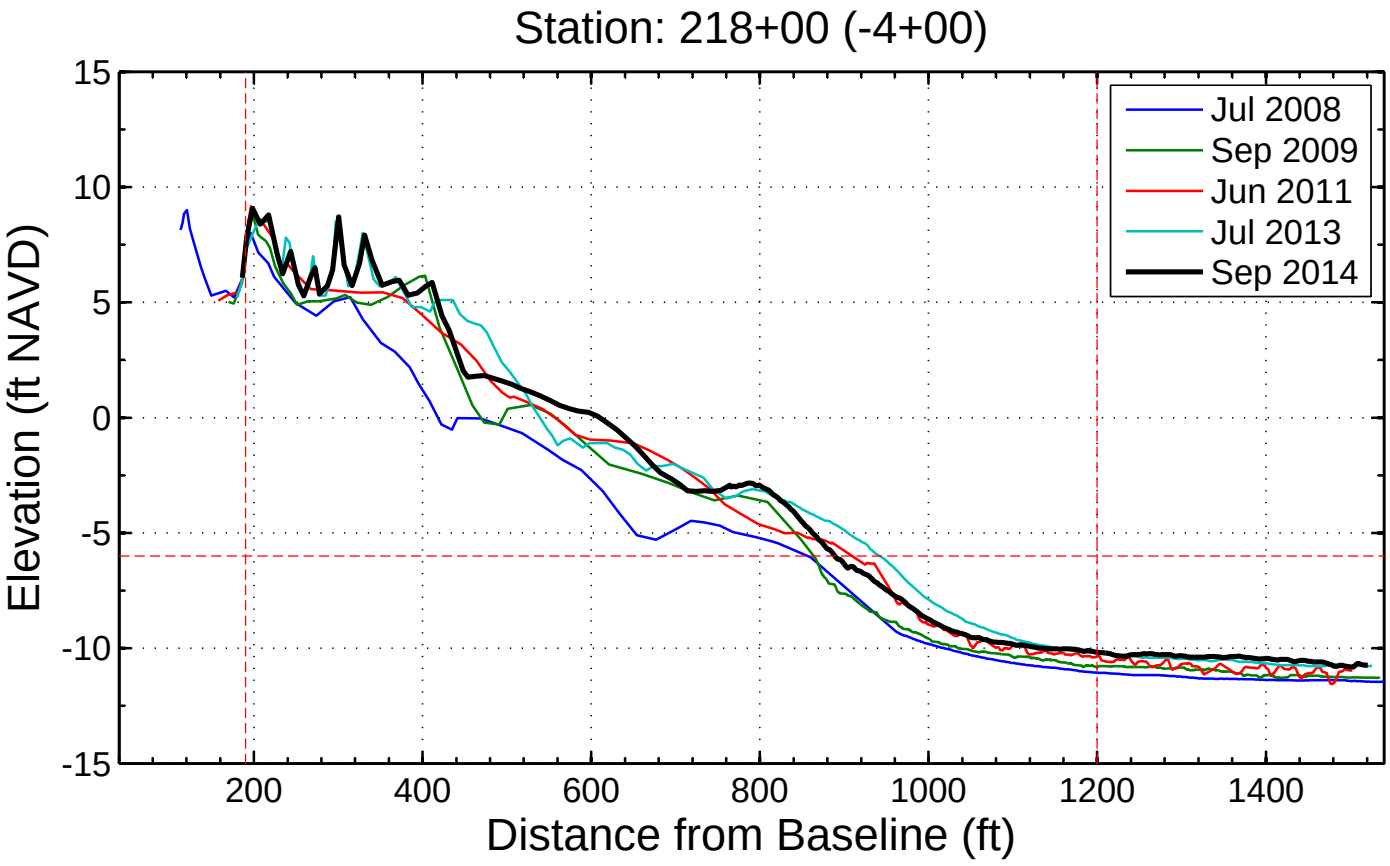
300
350
400
450
500
550
Distance from Baseline (ft)


Station: 218+00 (-4+00)
Elevation (ft NAVD)
15
10
5
0
-5
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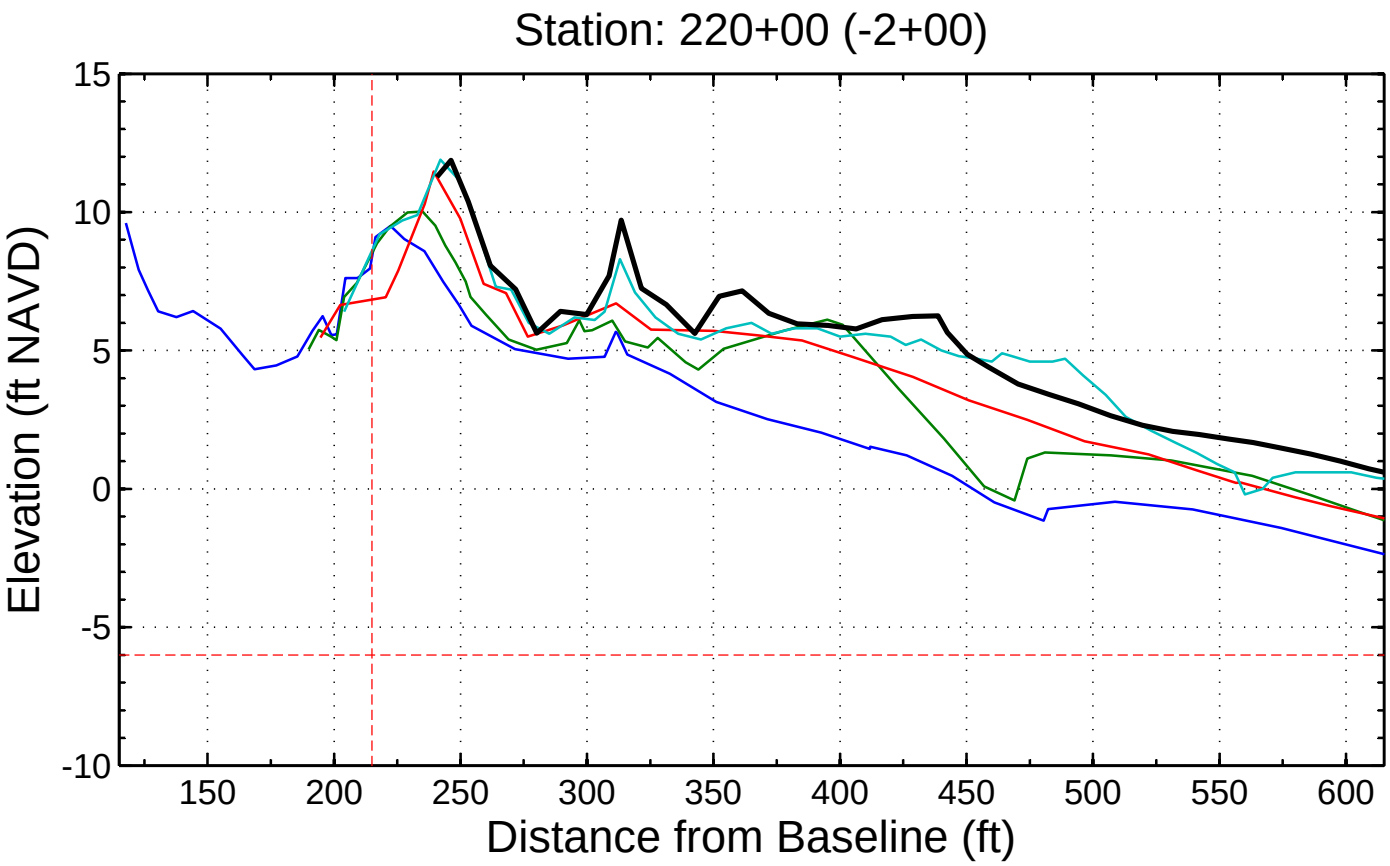
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 220+00 (-2+00)
Elevation (ft NAVD)
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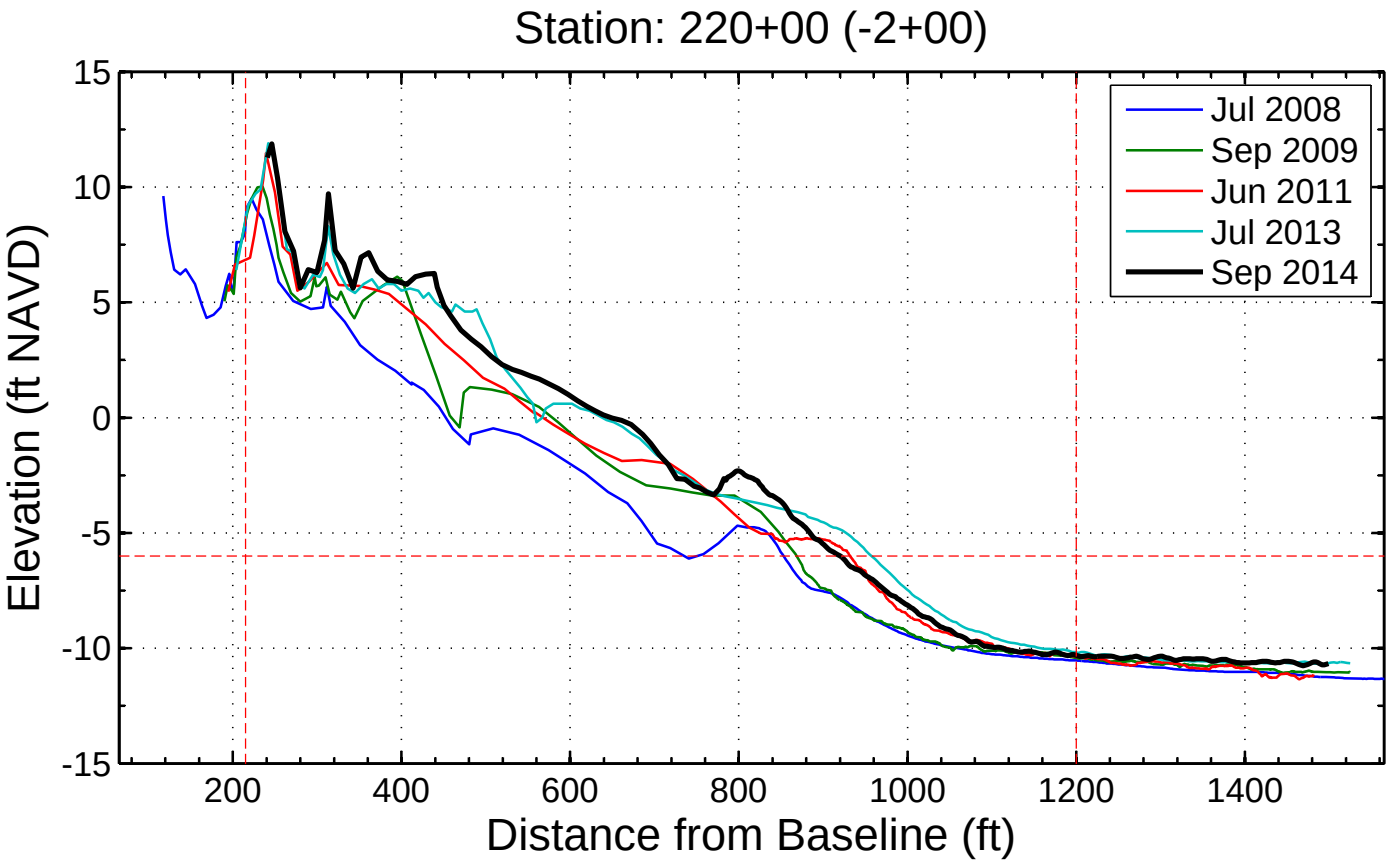
0
-5
-10
150
200
250
300
350
400
450
500
550
600
Distance from Baseline (ft)


Station: 220+00 (-2+00)
Elevation (ft NAVD)
15
10
5
0
-5
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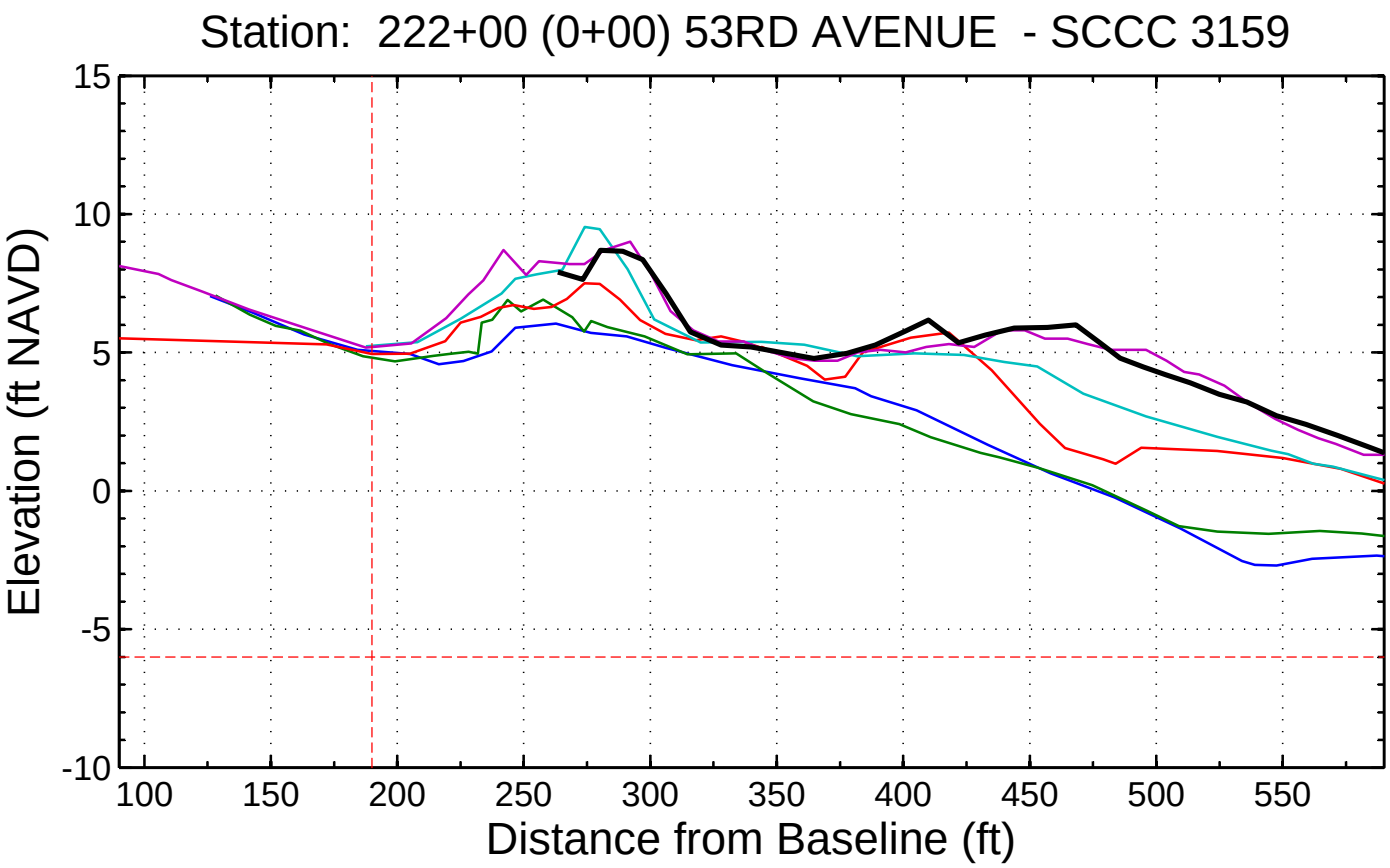
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 222+00 (0+00) 53RD AVENUE - SCCC 3159
Elevation (ft NAVD)
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0
-5
-10
100
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200
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300
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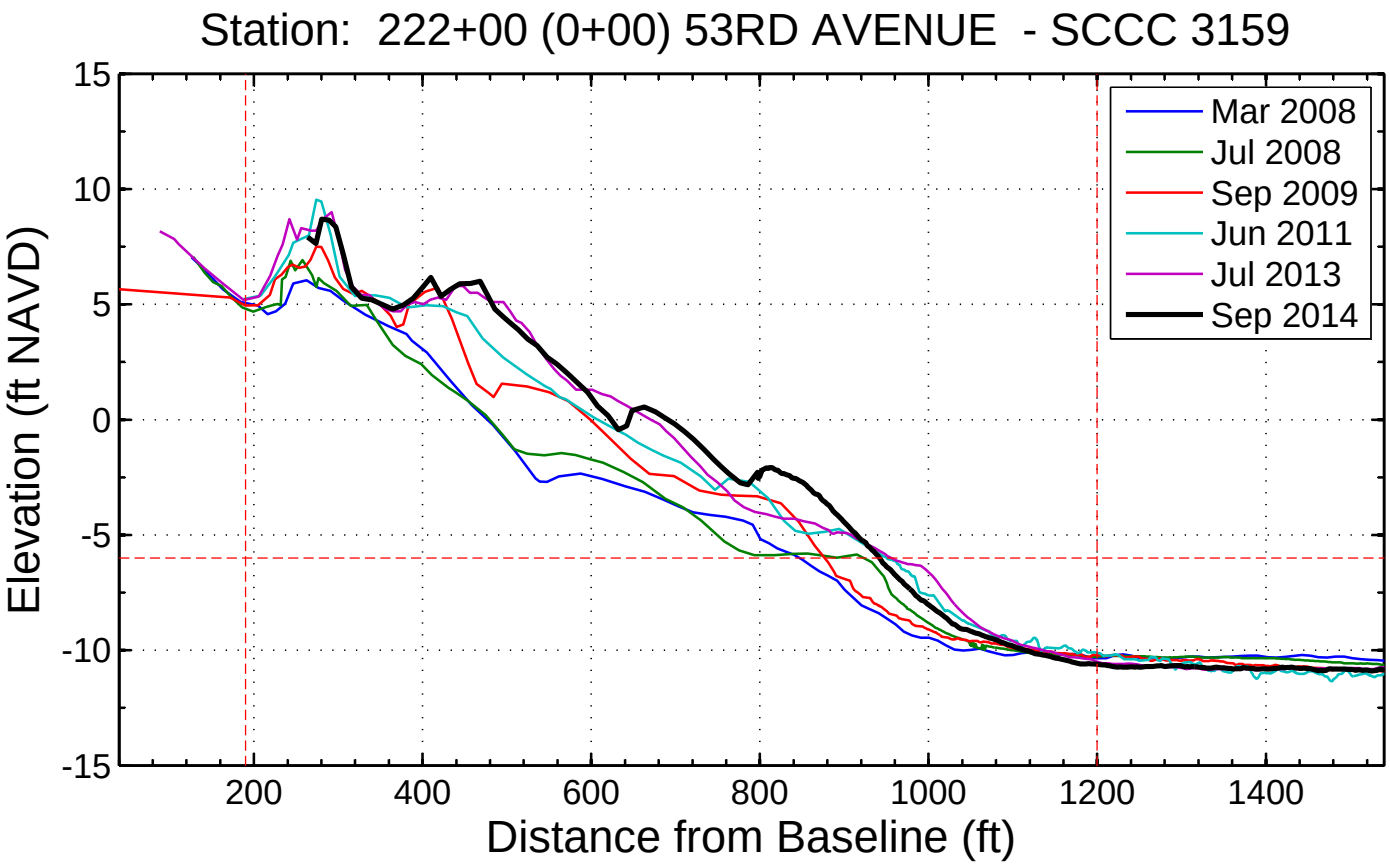
400
450
500
550
Distance from Baseline (ft)


Station: 222+00 (0+00) 53RD AVENUE - SCCC 3159
Elevation (ft NAVD)
15
10
5
0
-5
-10
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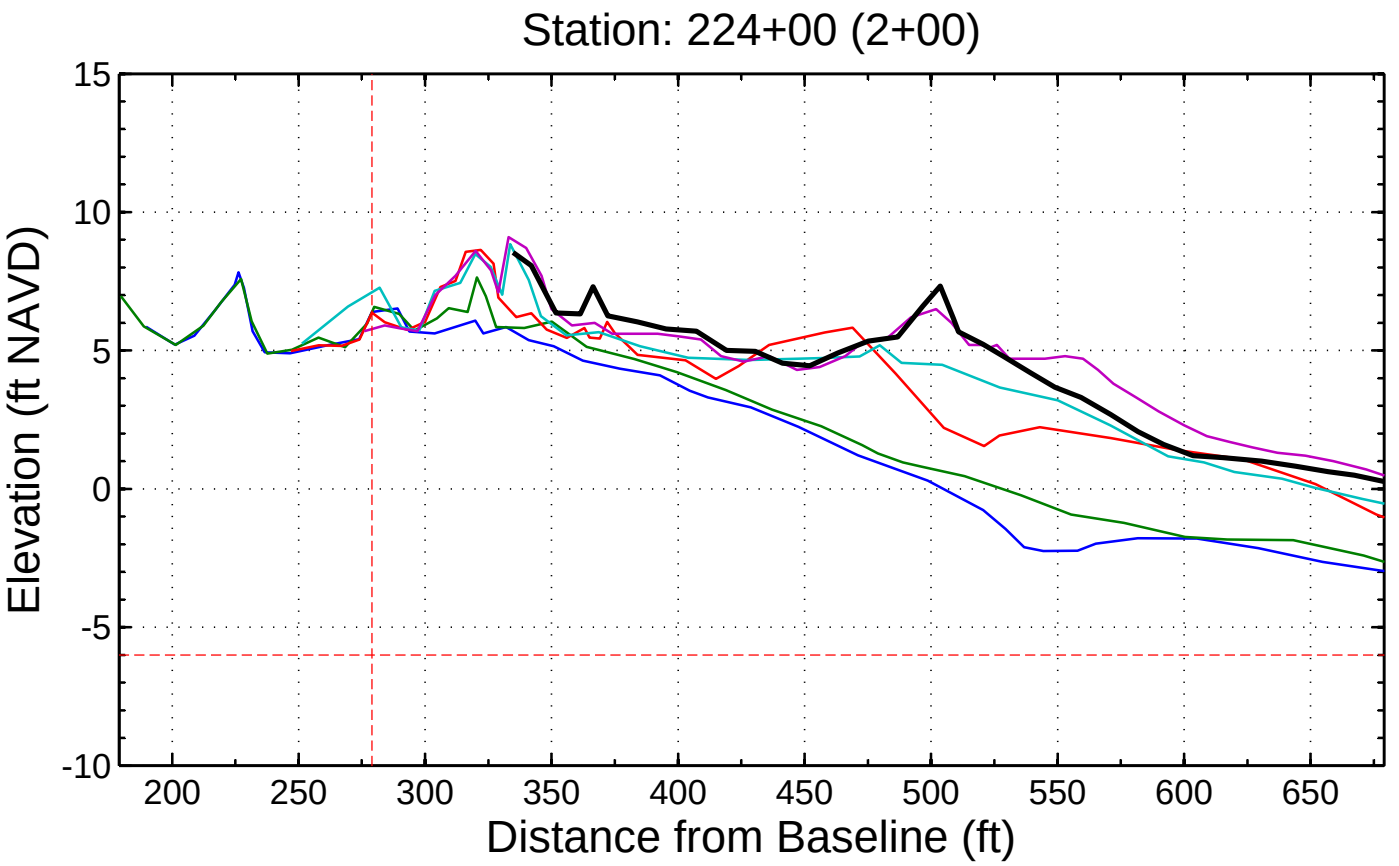
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 224+00 (2+00)
Elevation (ft NAVD)
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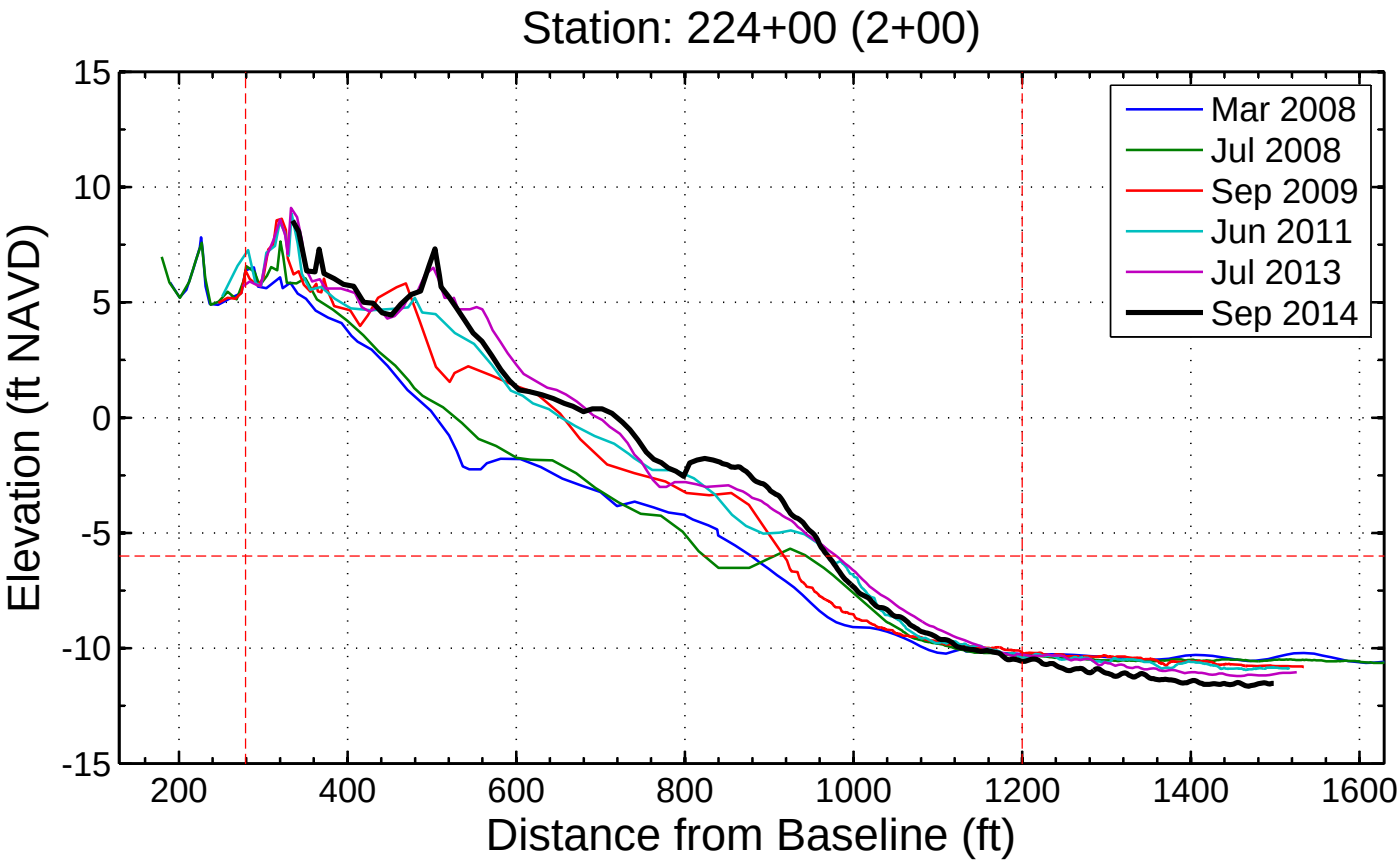
0
-5
-10
200
250
300
350
400
450
500
550
600
650
Distance from Baseline (ft)


Station: 224+00 (2+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
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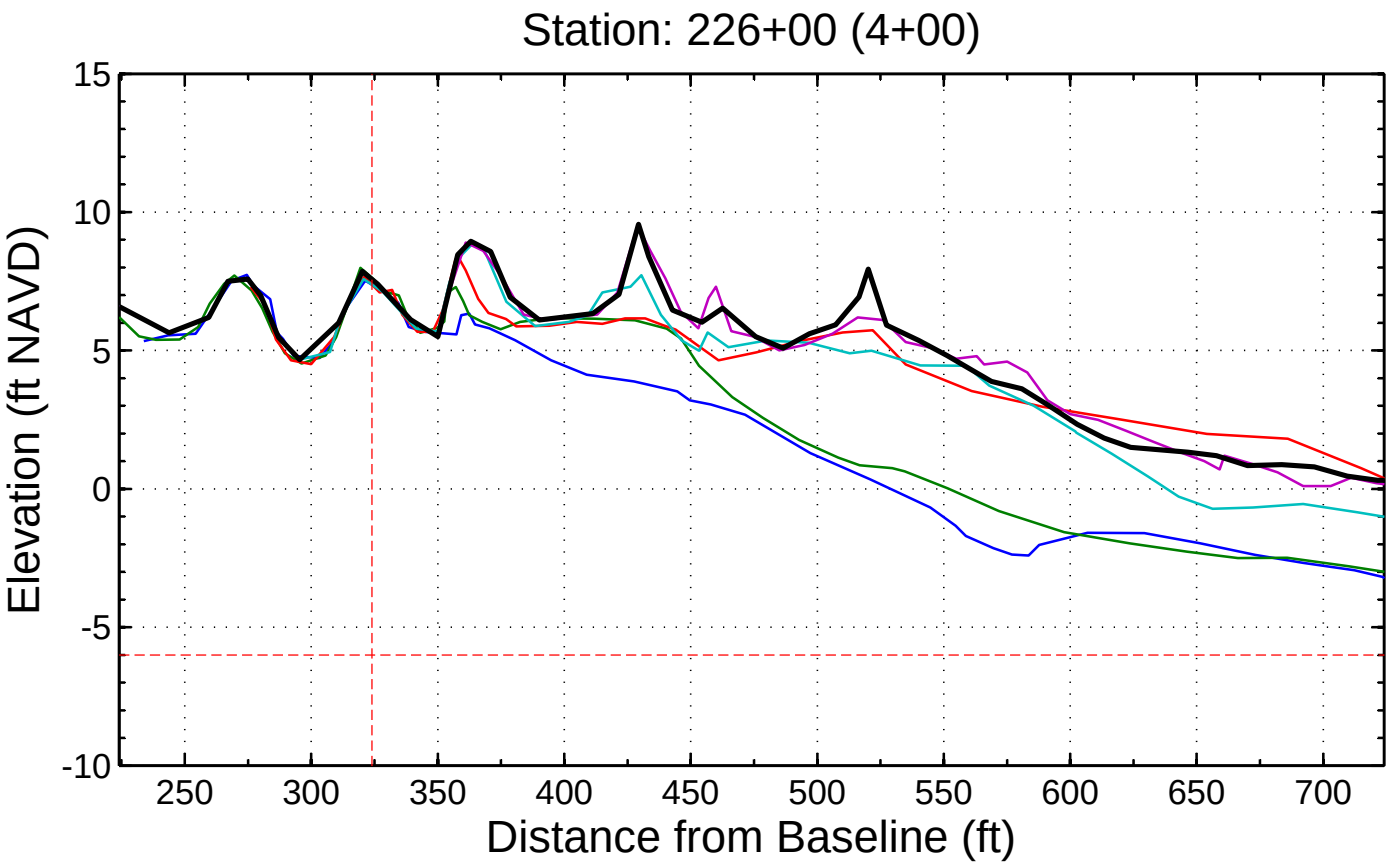
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 226+00 (4+00)
Elevation (ft NAVD)
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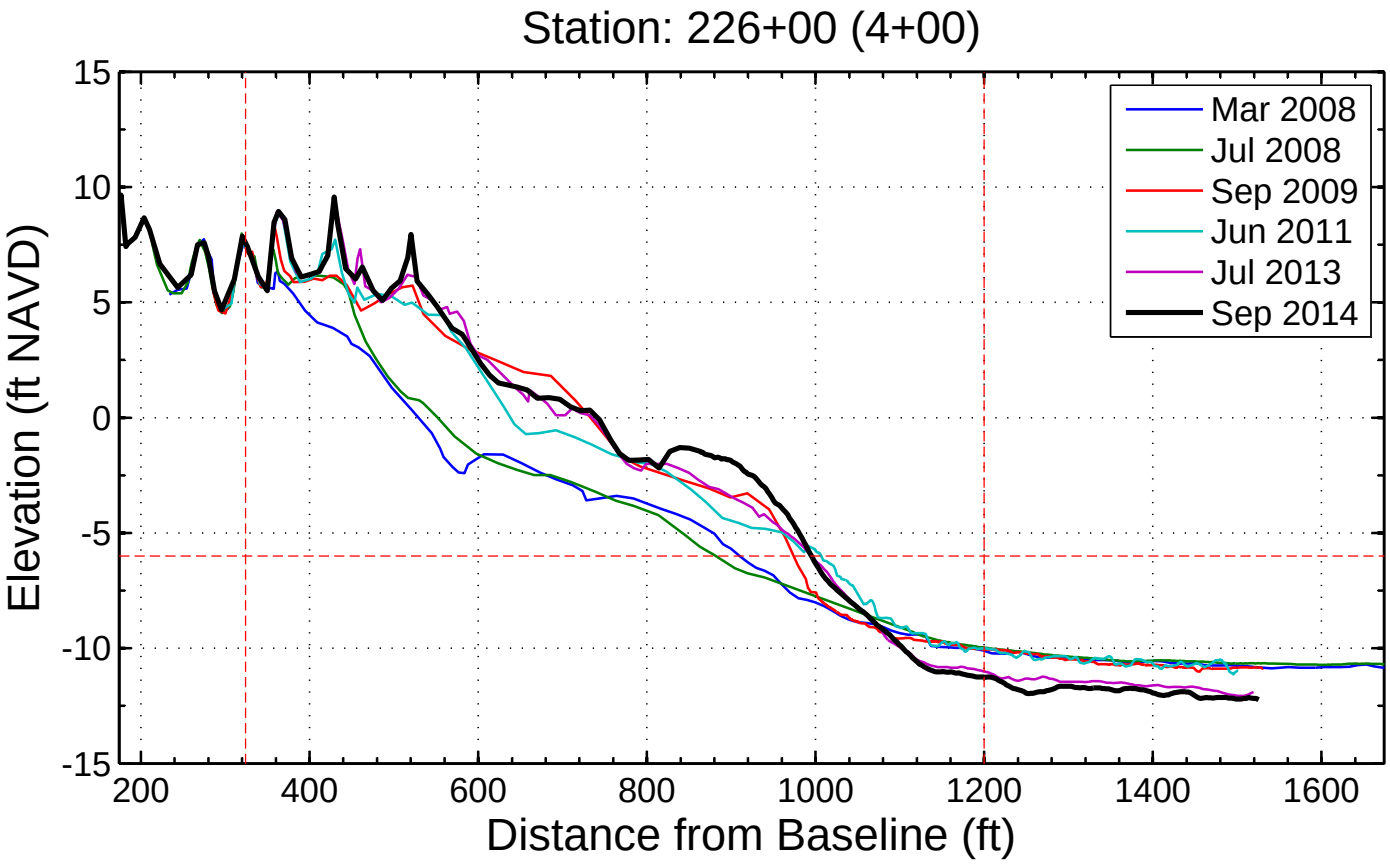
0
-5
-10
250
300
350
400
450
500
550
600
650
700
Distance from Baseline (ft)


Station: 226+00 (4+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
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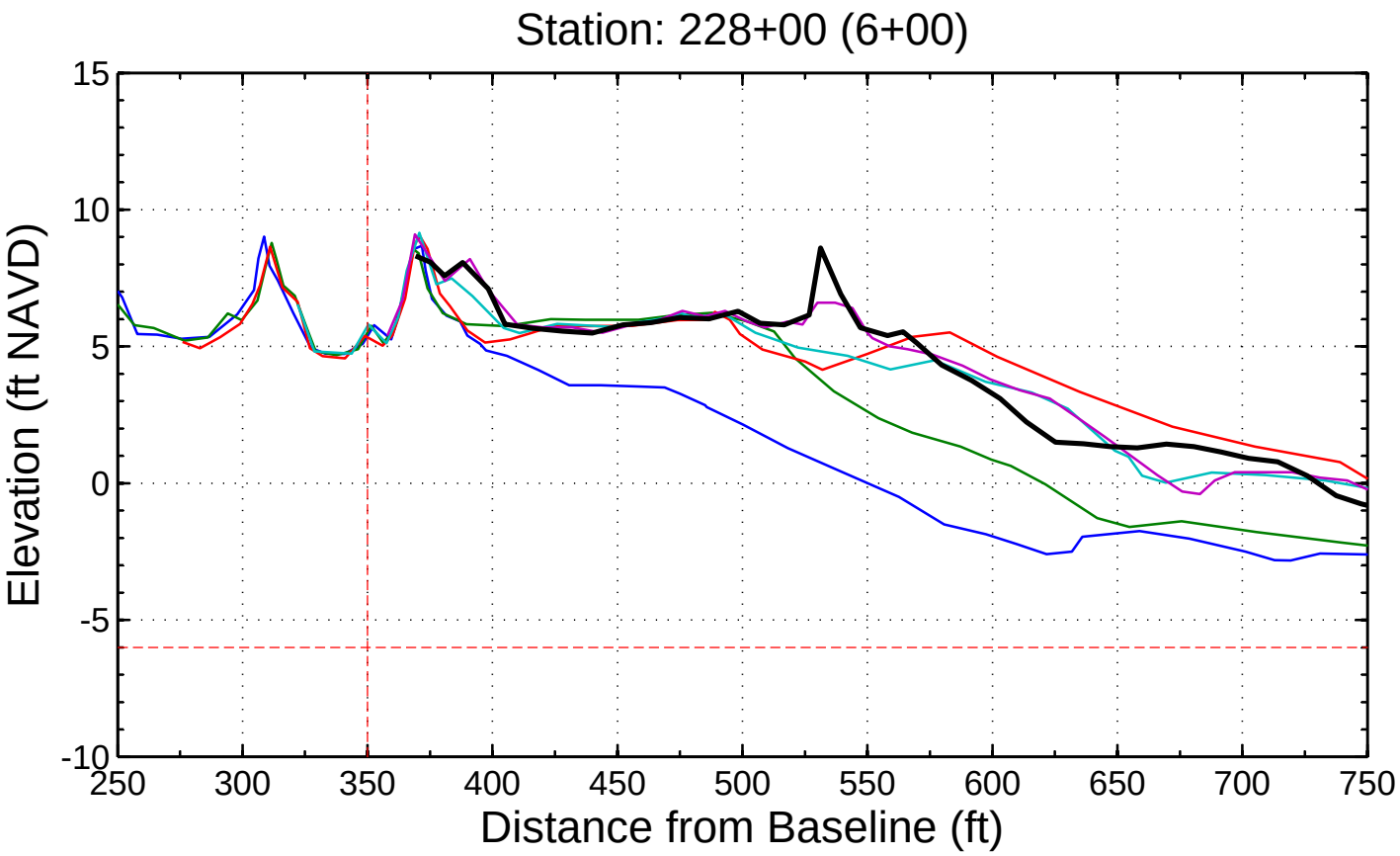
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 228+00 (6+00)
Elevation (ft NAVD)
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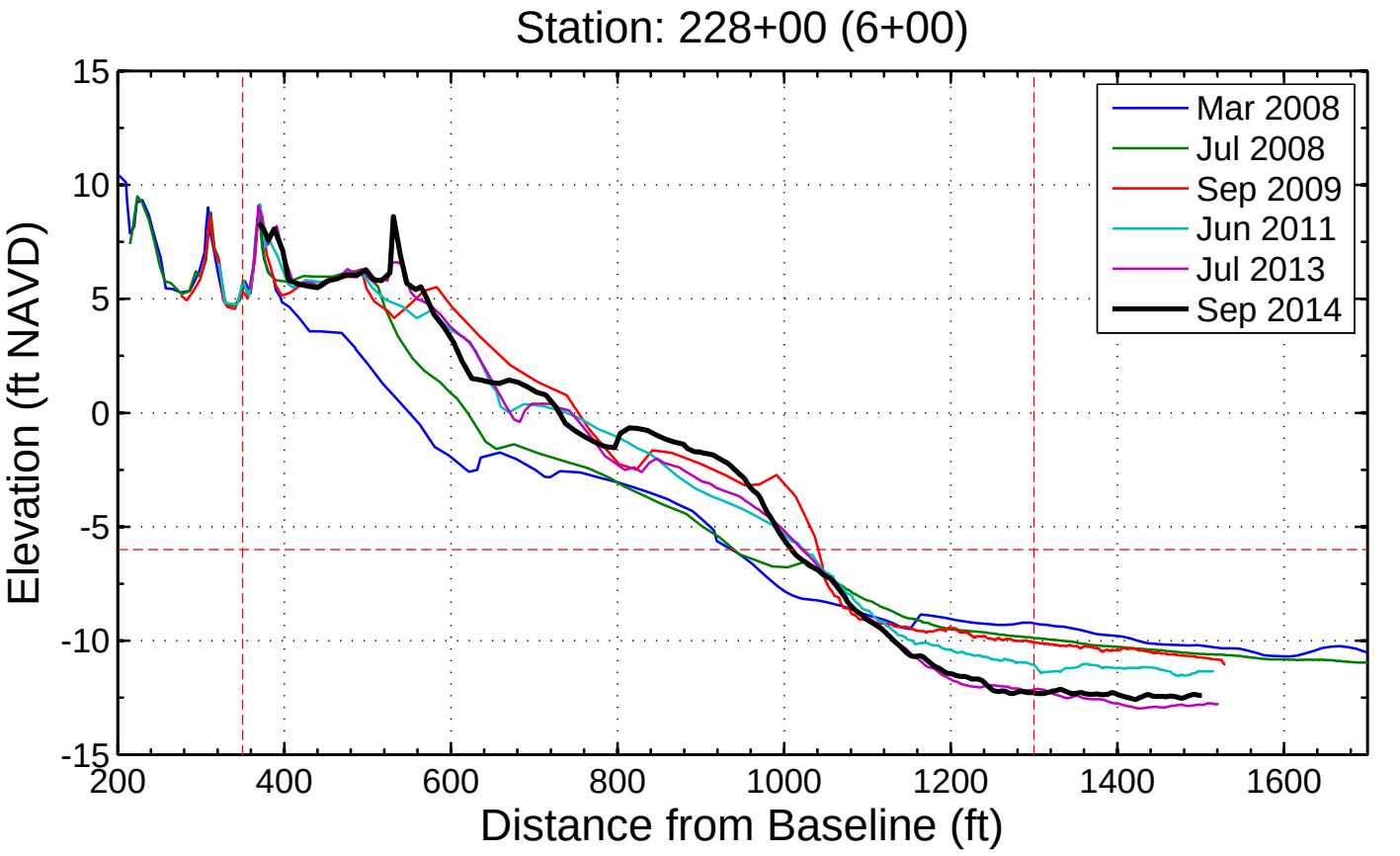
-5
-10
250
300
350
400
450
500
550
600
650
700
750
Distance from Baseline (ft)


Station: 228+00 (6+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
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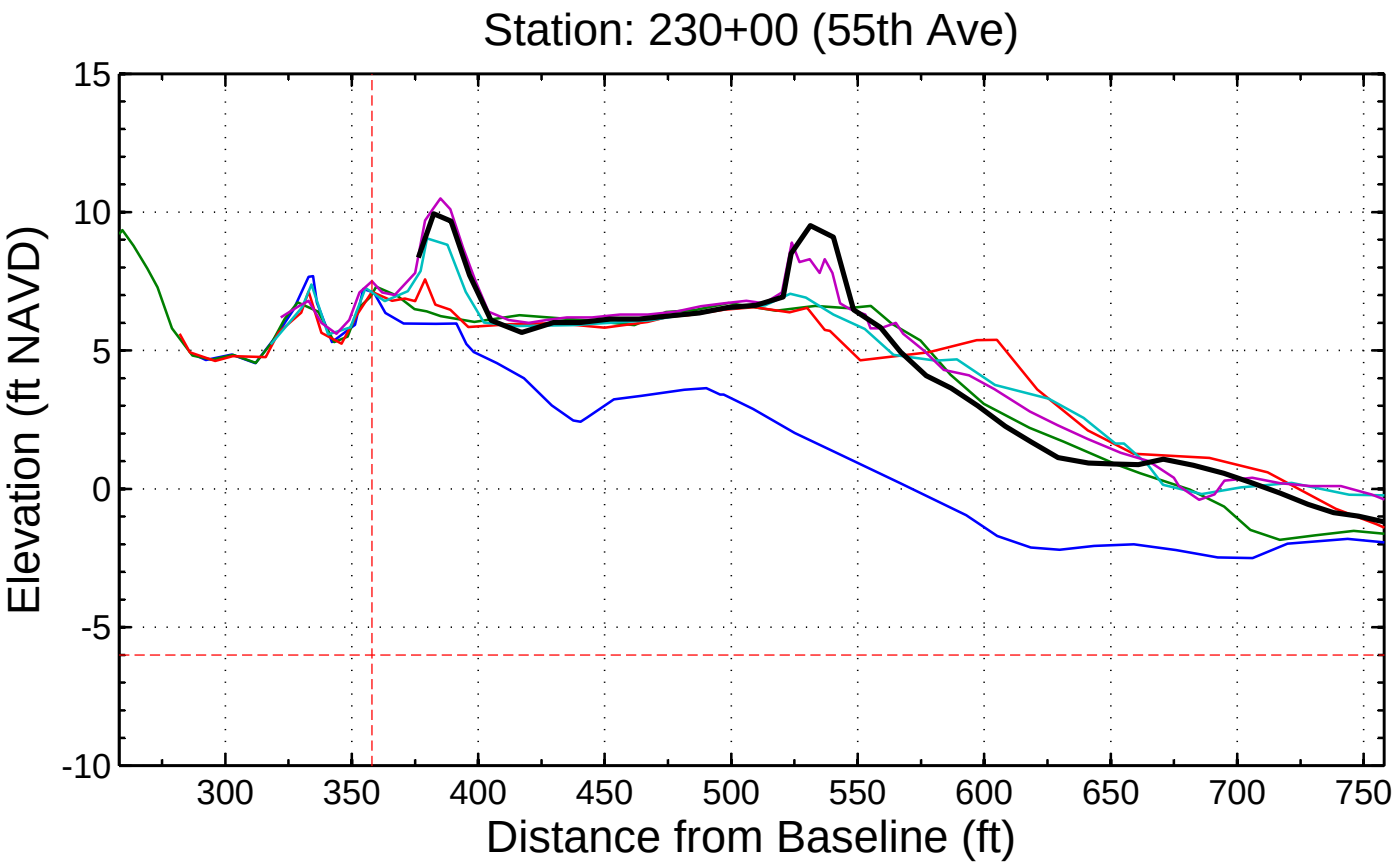
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 230+00 (55th Ave)
Elevation (ft NAVD)
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-5
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300
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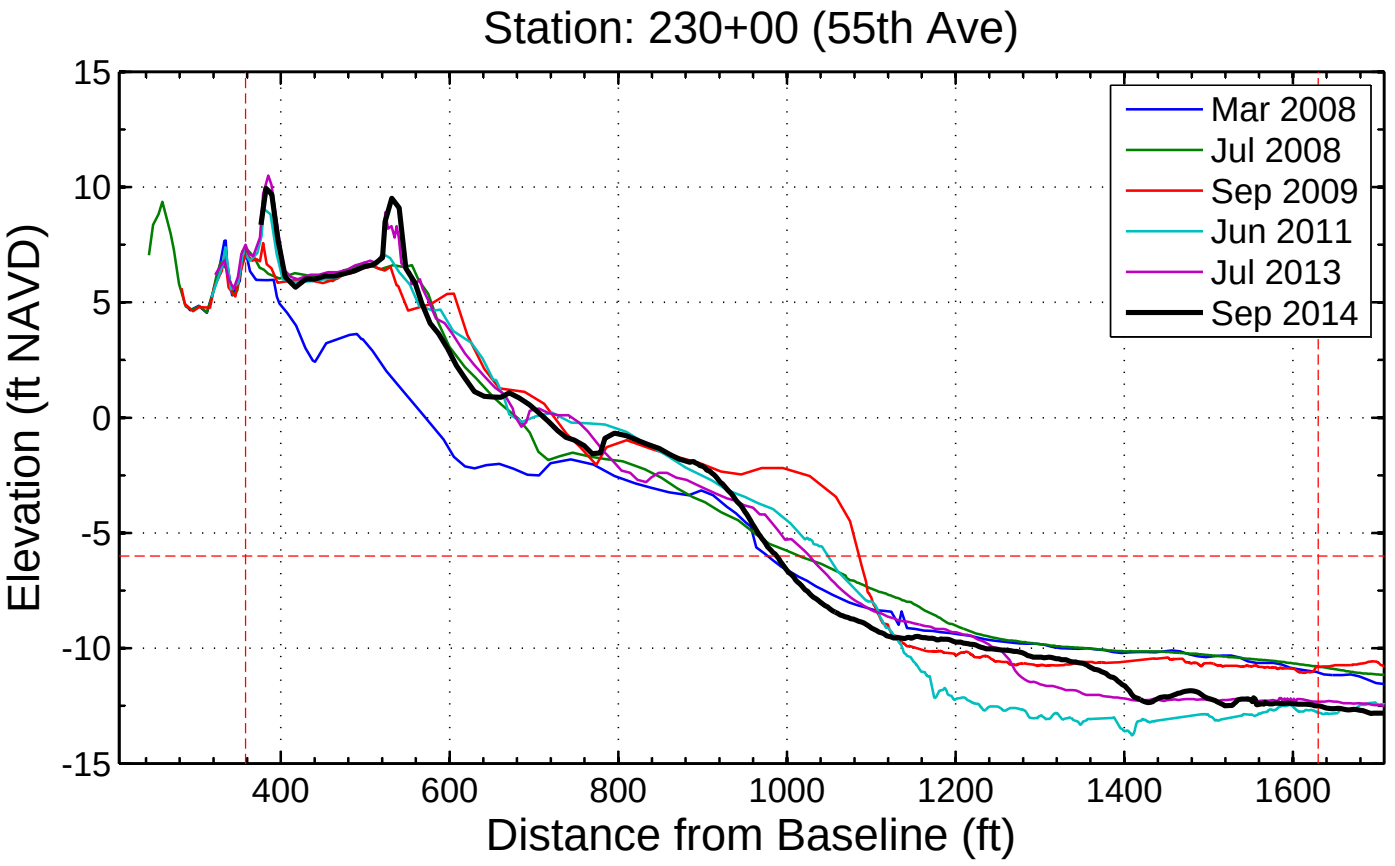
600
650
700
750
Distance from Baseline (ft)


Station: 230+00 (55th Ave)
Elevation (ft NAVD)
15
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5
0
-5
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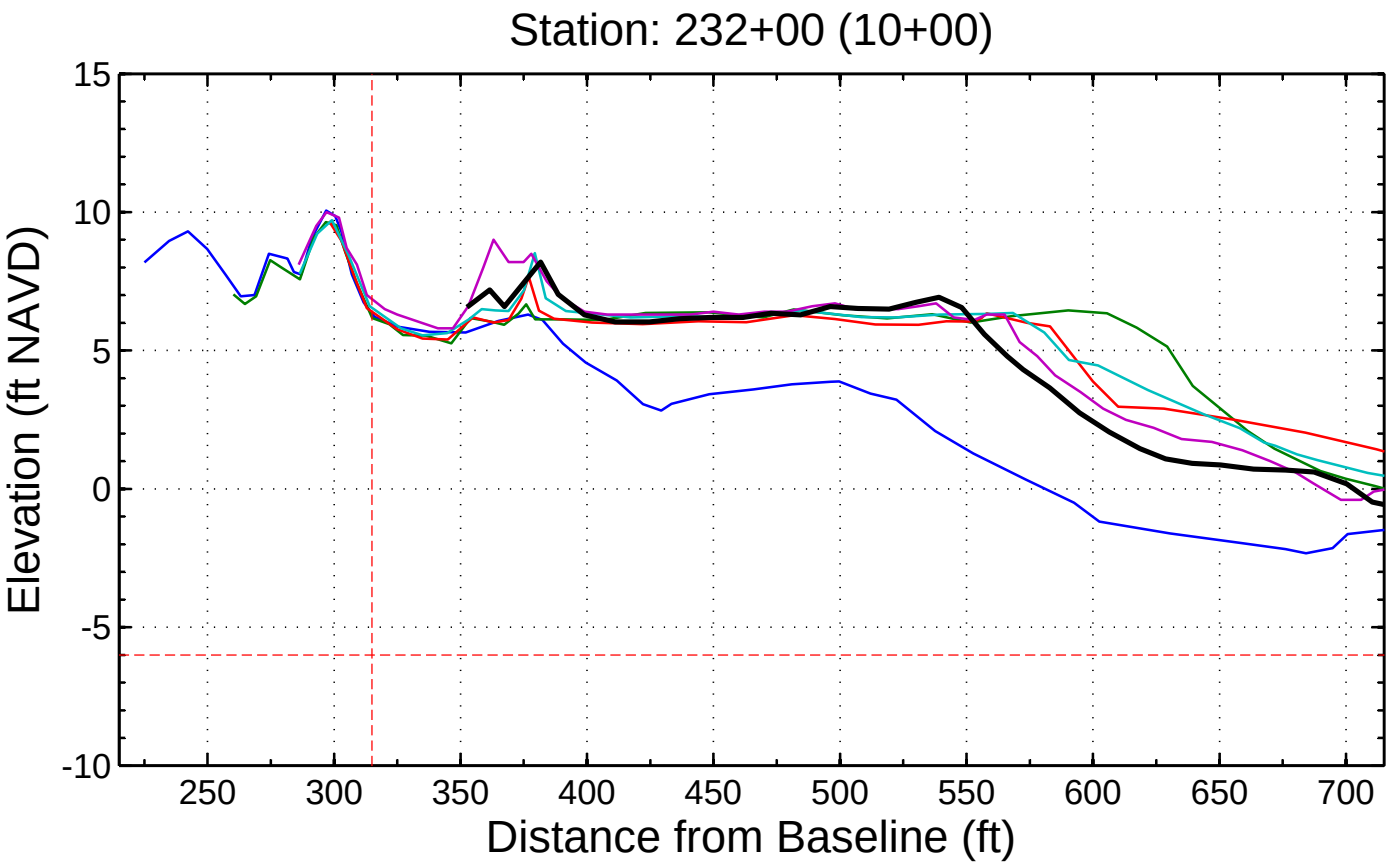
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 232+00 (10+00)
Elevation (ft NAVD)
15
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0
-5
-10
250
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350
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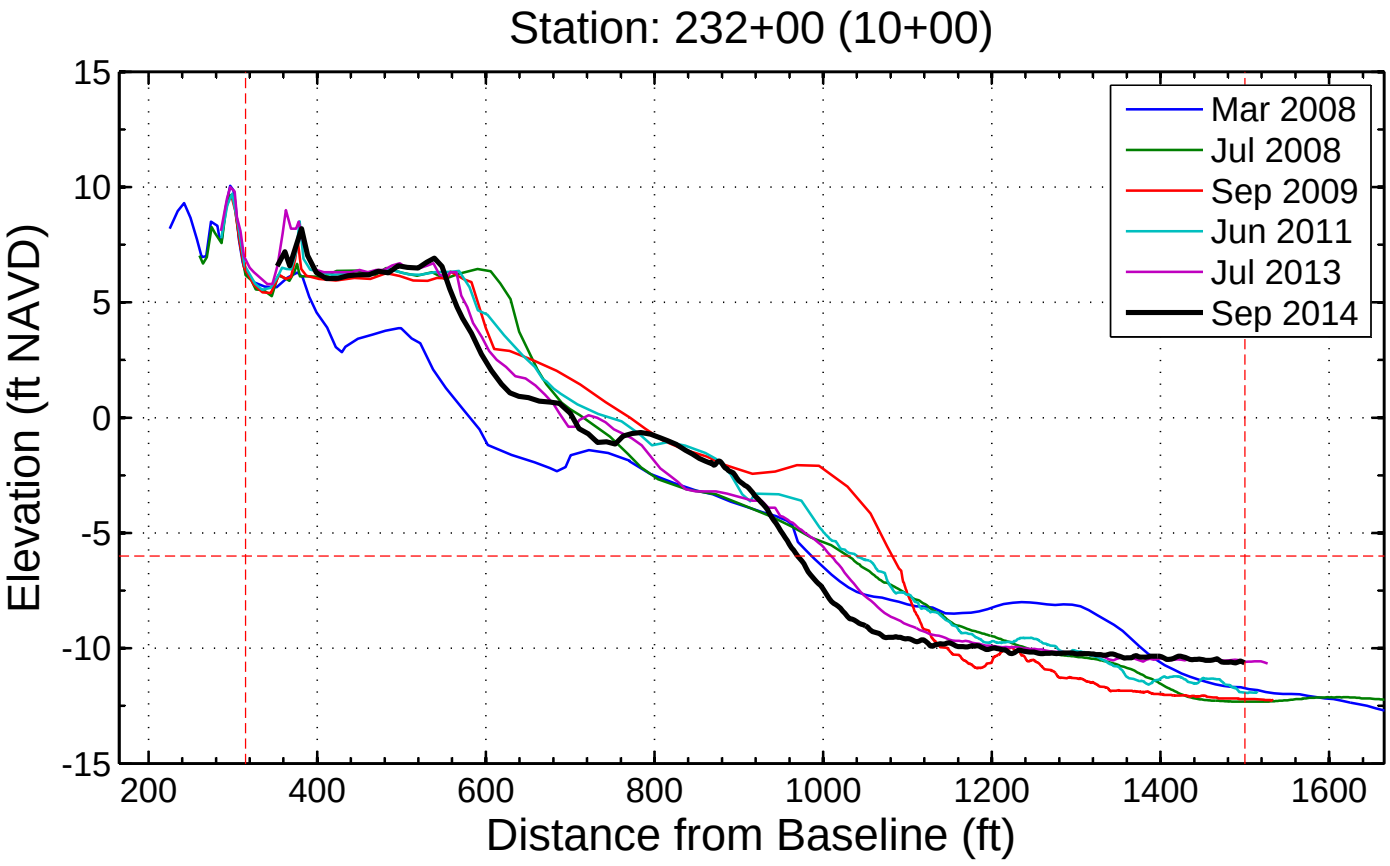
450
500
550
600
650
700
Distance from Baseline (ft)


Station: 232+00 (10+00)
Elevation (ft NAVD)
15
10
5
0
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-10
-15
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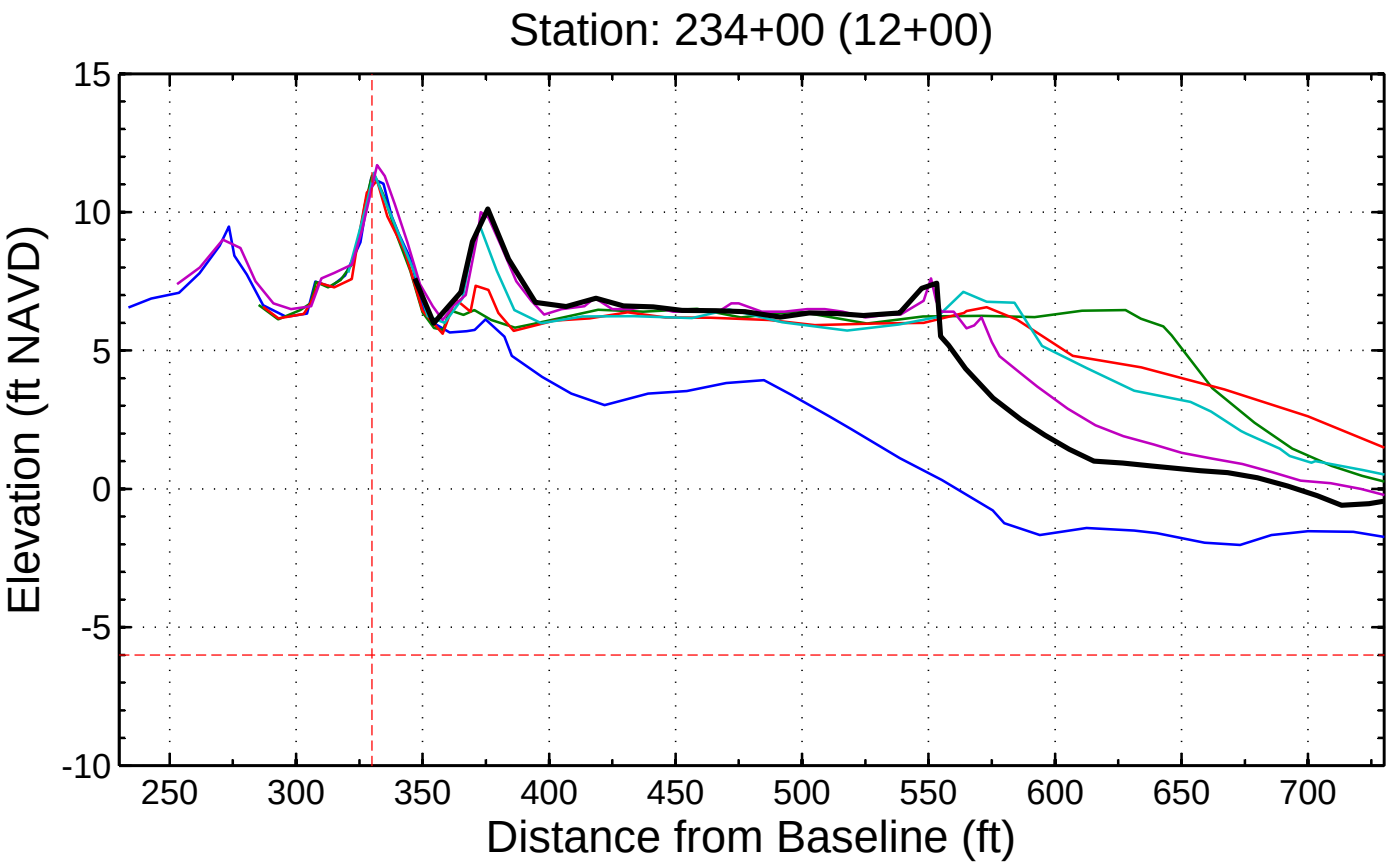
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 234+00 (12+00)
Elevation (ft NAVD)
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10
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0
-5
-10
250
300
350
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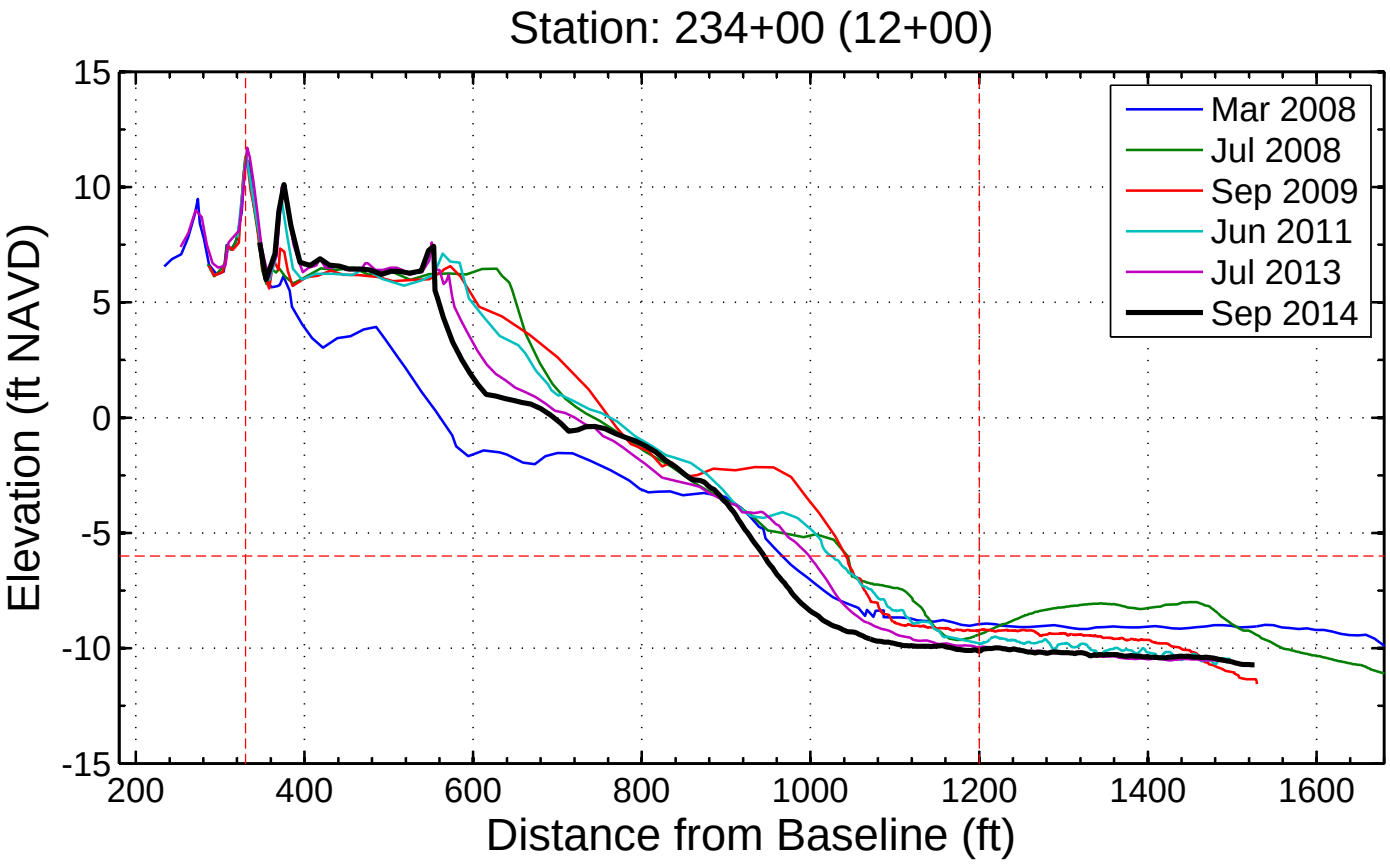
650
700
Distance from Baseline (ft)


Station: 234+00 (12+00)
Elevation (ft NAVD)
15
10
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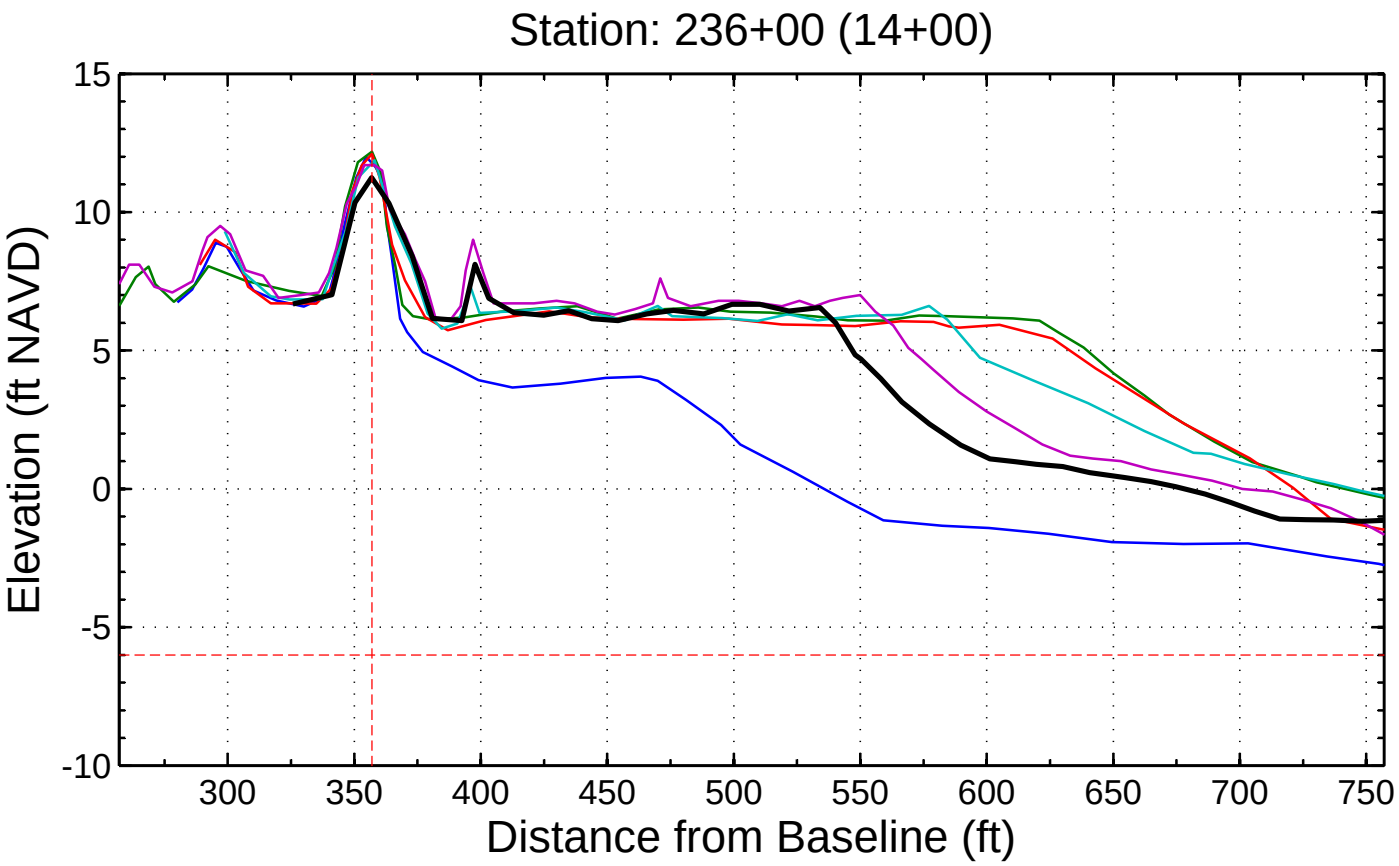
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 236+00 (14+00)
Elevation (ft NAVD)
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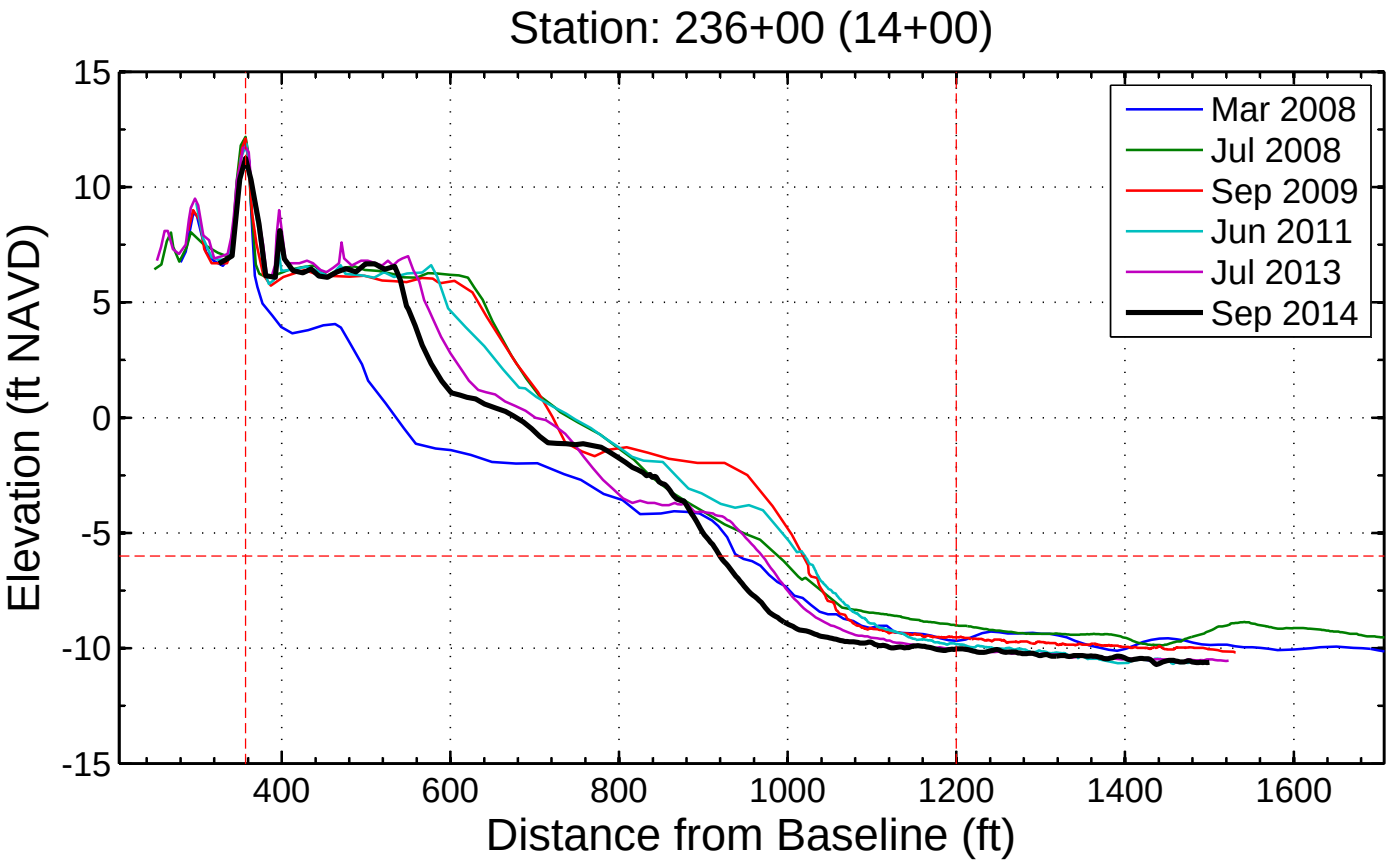
Distance from Baseline (ft)


Station: 236+00 (14+00)
Elevation (ft NAVD)
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10
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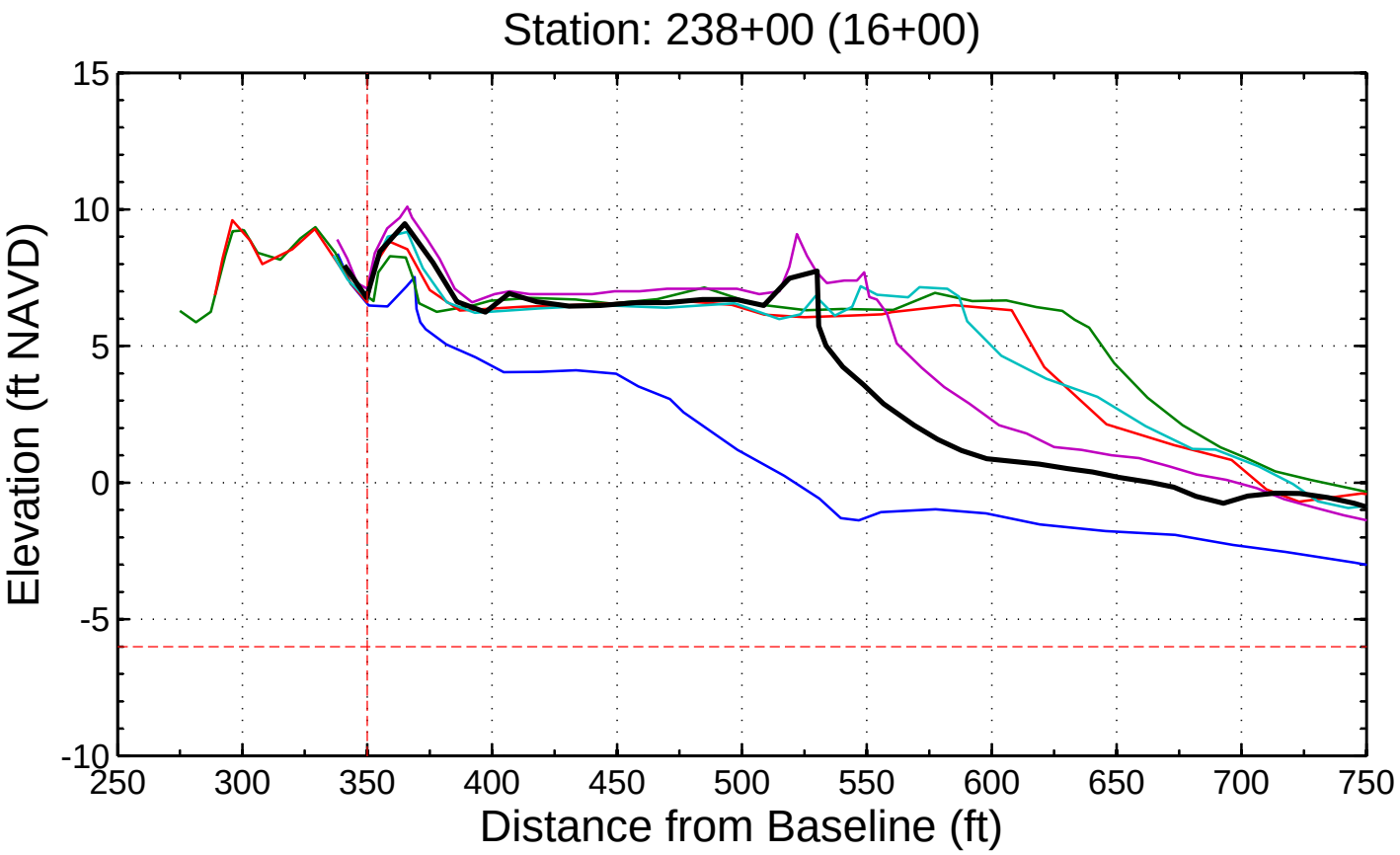
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 238+00 (16+00)
Elevation (ft NAVD)
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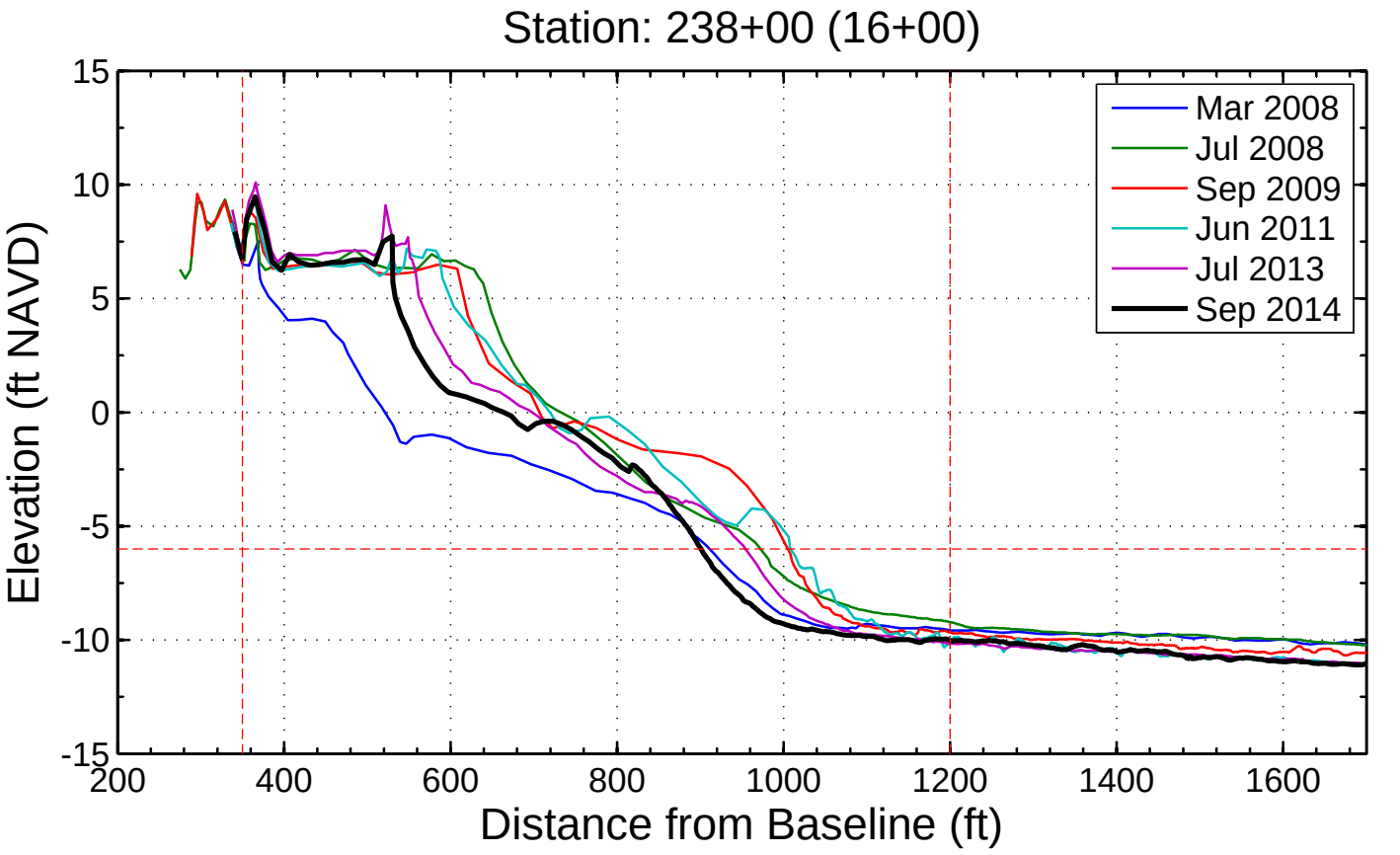
Distance from Baseline (ft)


Station: 238+00 (16+00)
Elevation (ft NAVD)
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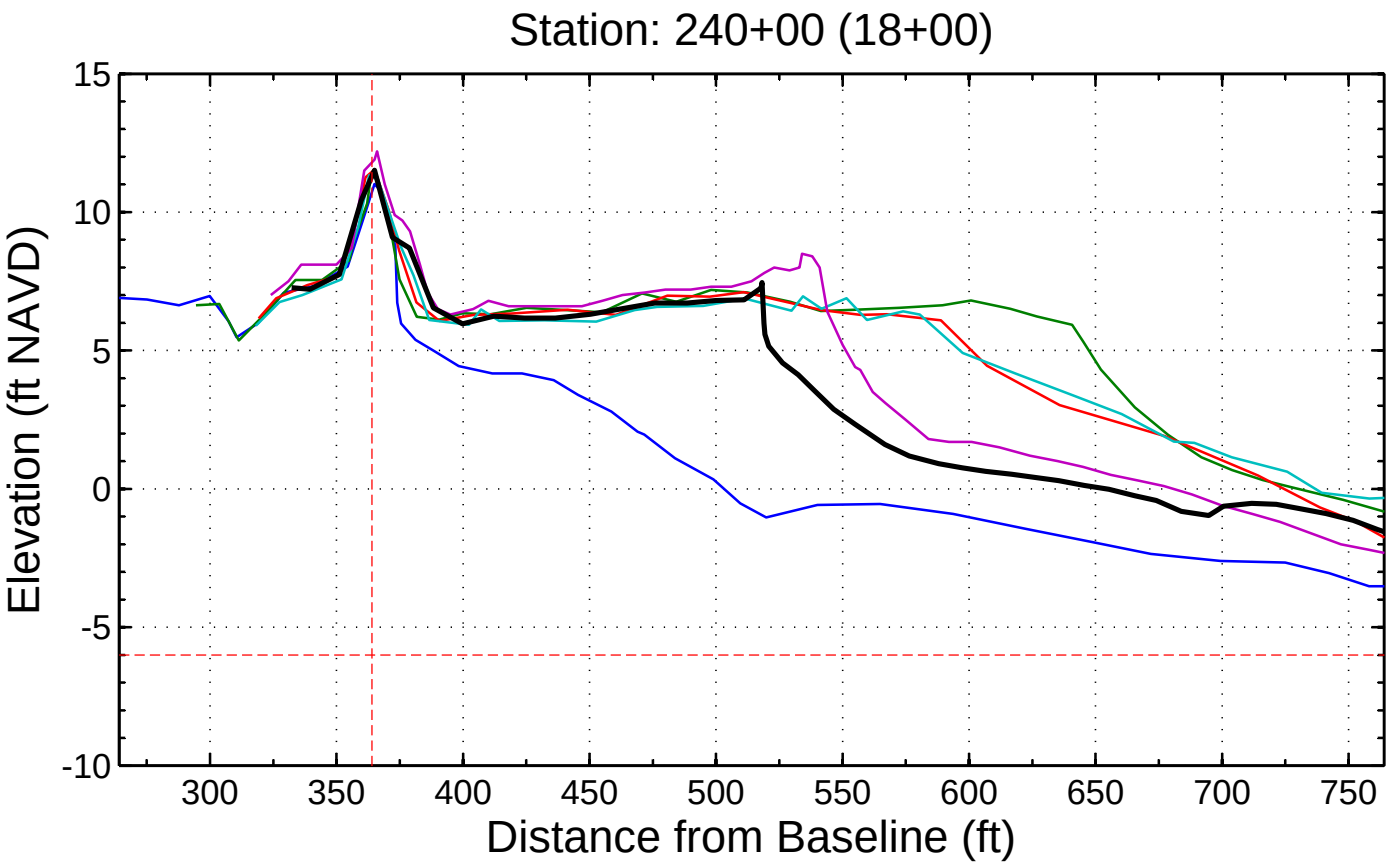
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 240+00 (18+00)
Elevation (ft NAVD)
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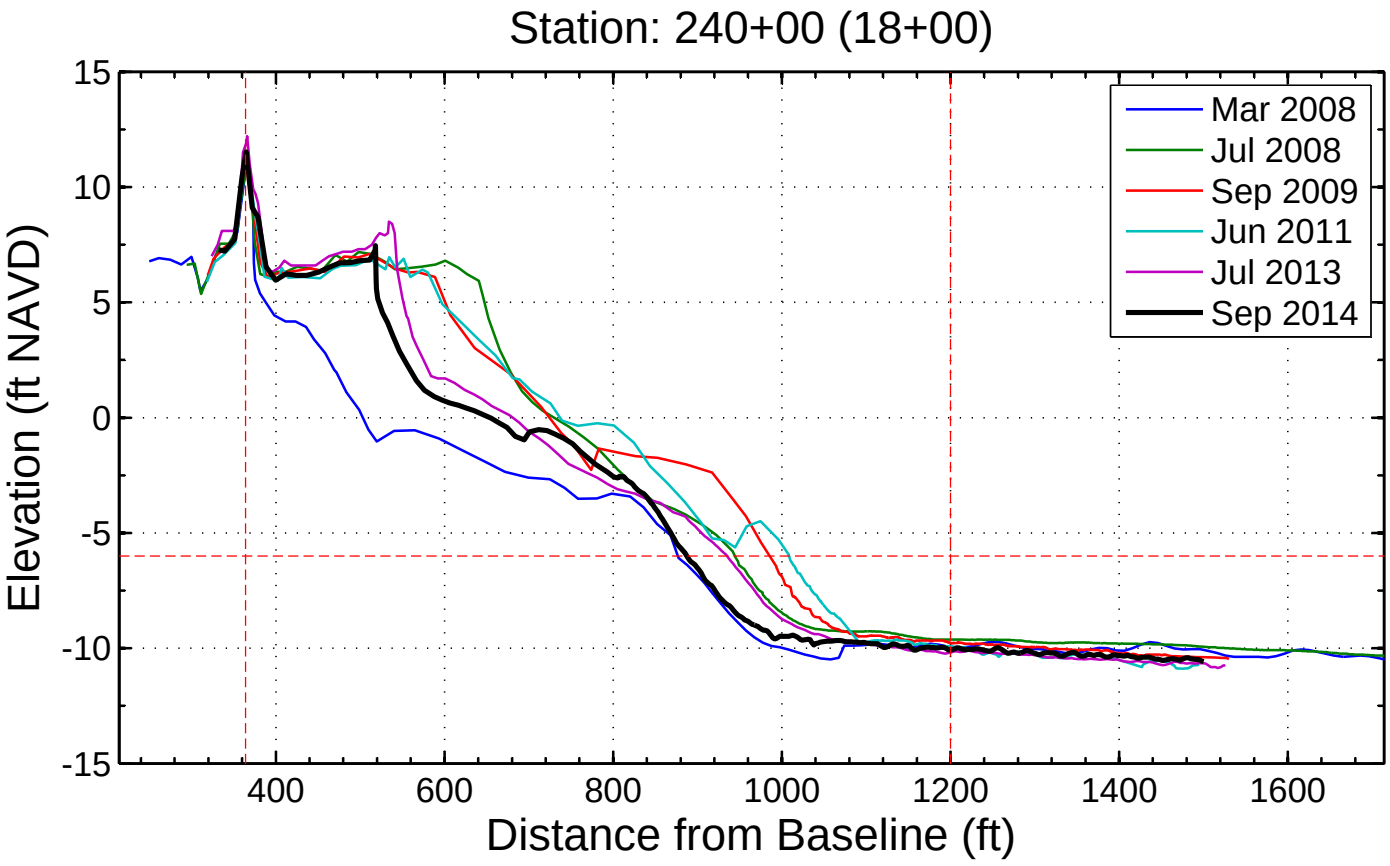
750
Distance from Baseline (ft)


Station: 240+00 (18+00)
Elevation (ft NAVD)
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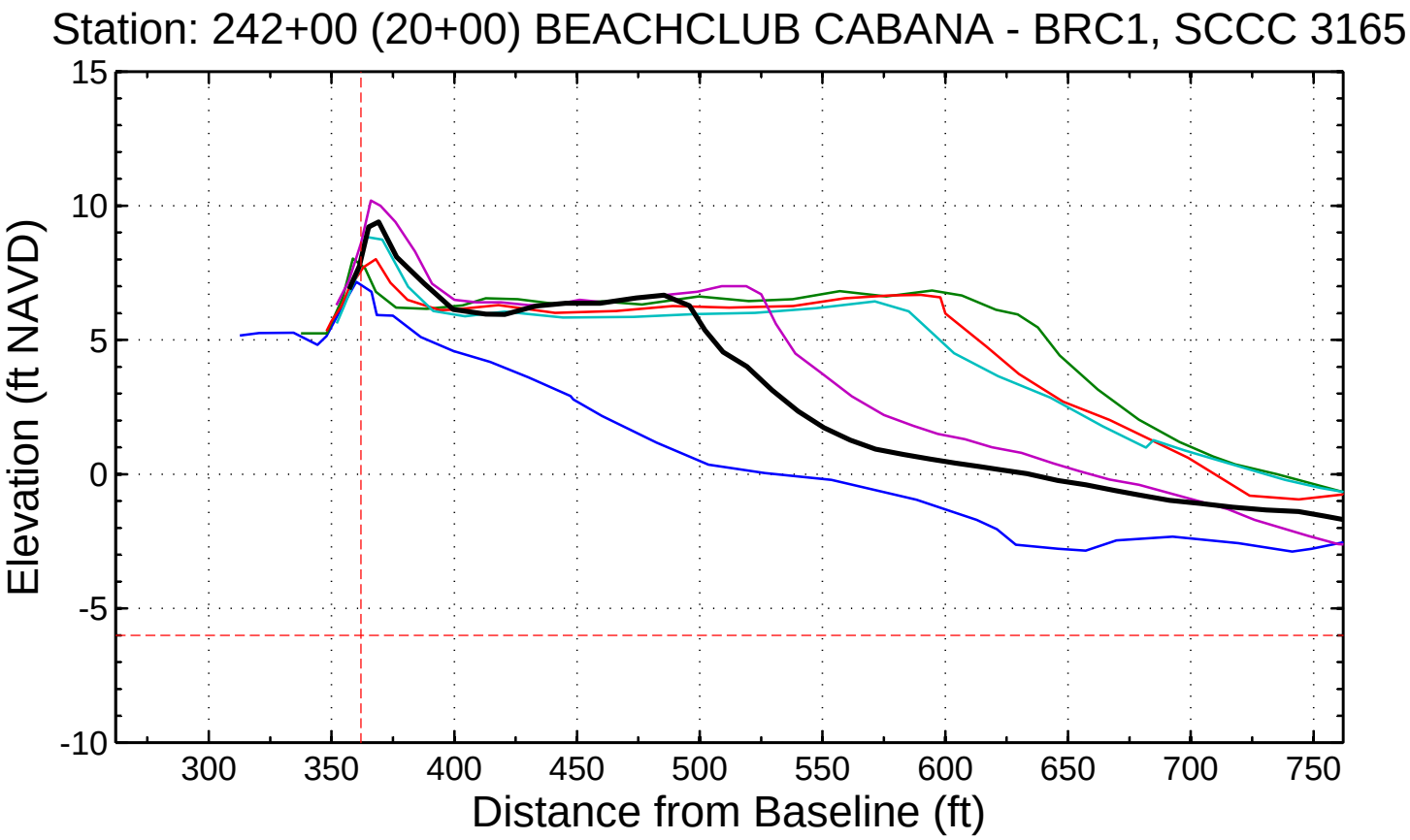
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 242+00 (20+00) BEACHCLUB CABANA - BRC1, SCCC 3165
Elevation (ft NAVD)
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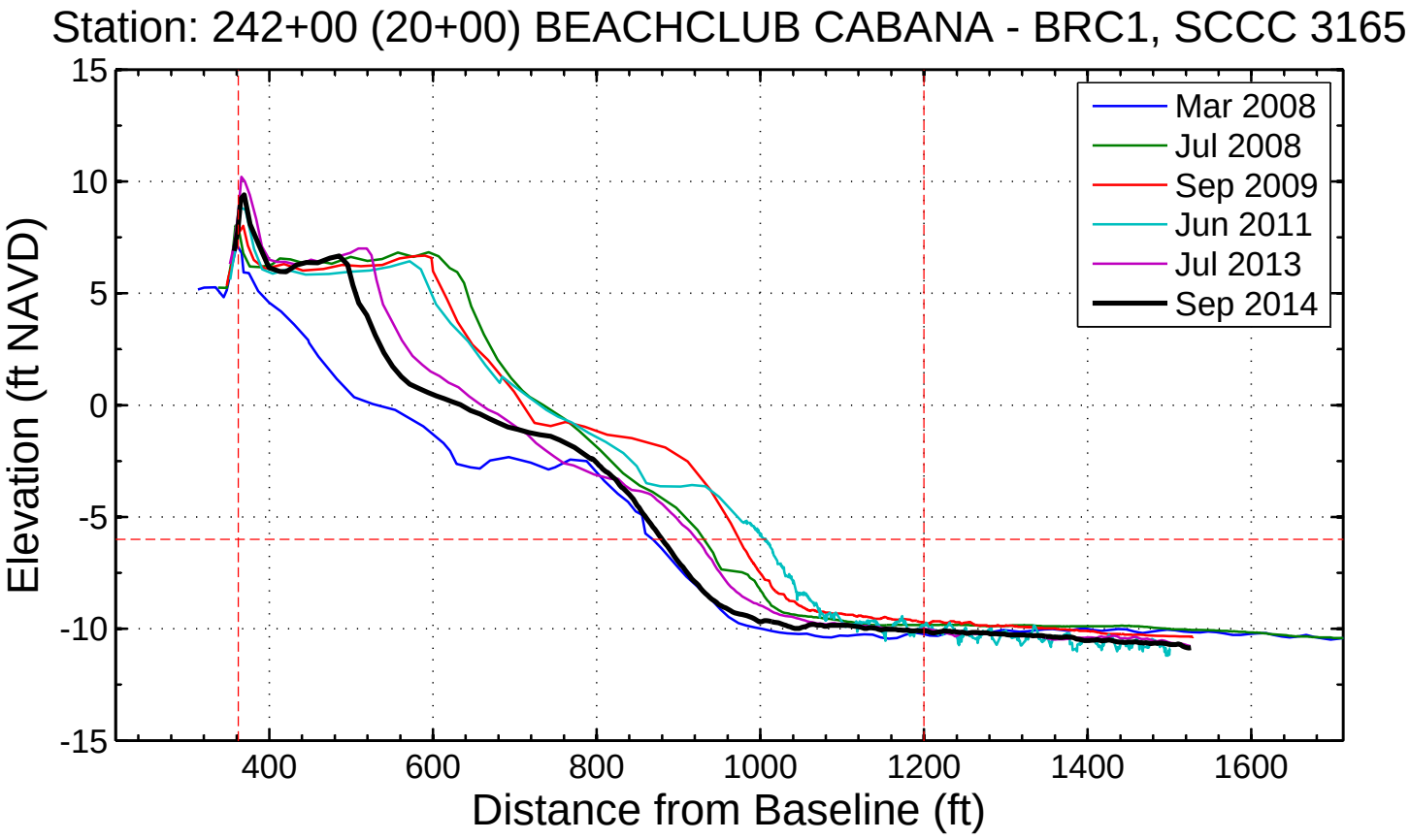
Distance from Baseline (ft)


Station: 242+00 (20+00) BEACHCLUB CABANA - BRC1, SCCC 3165
Elevation (ft NAVD)
15
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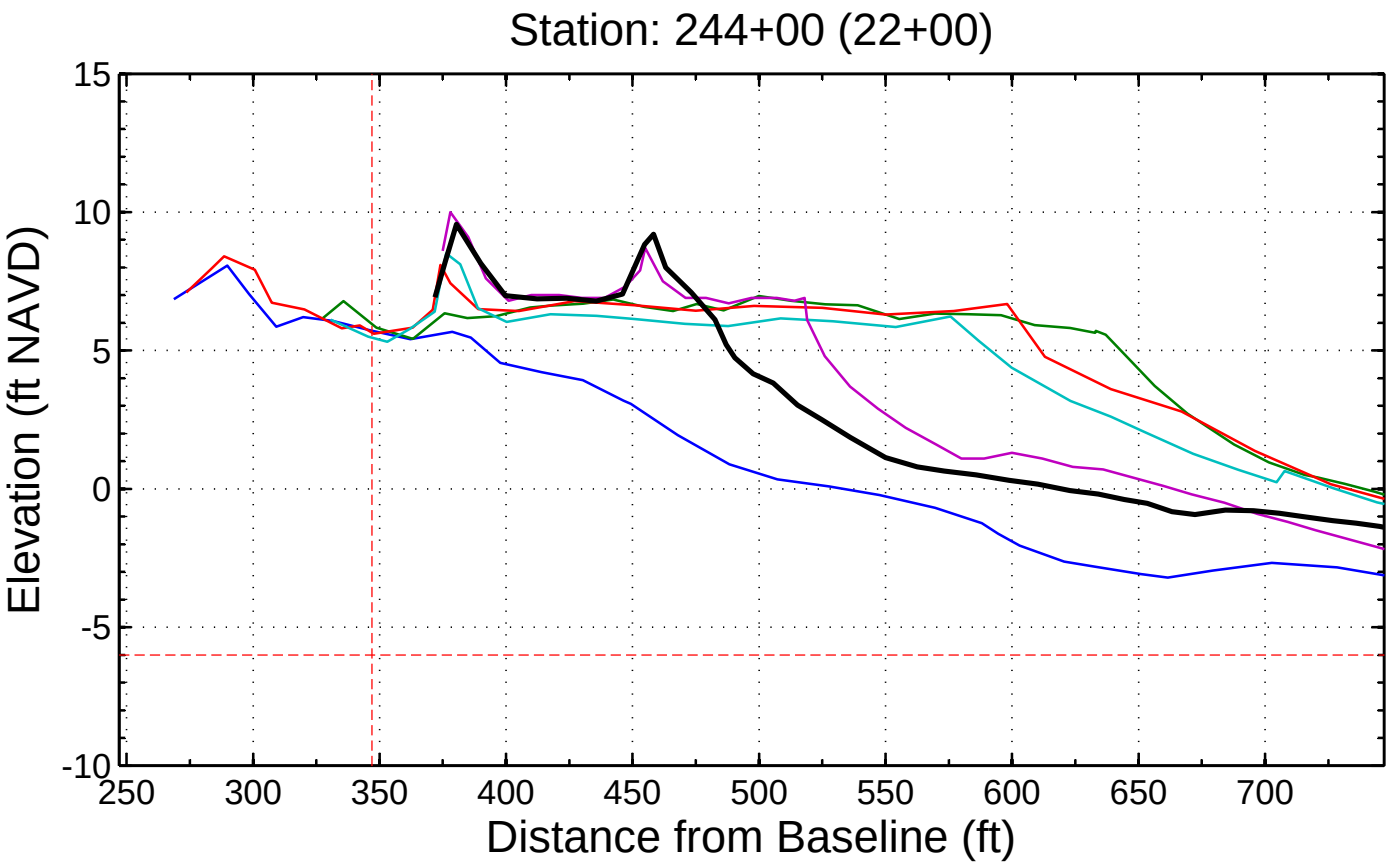
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 244+00 (22+00)
Elevation (ft NAVD)
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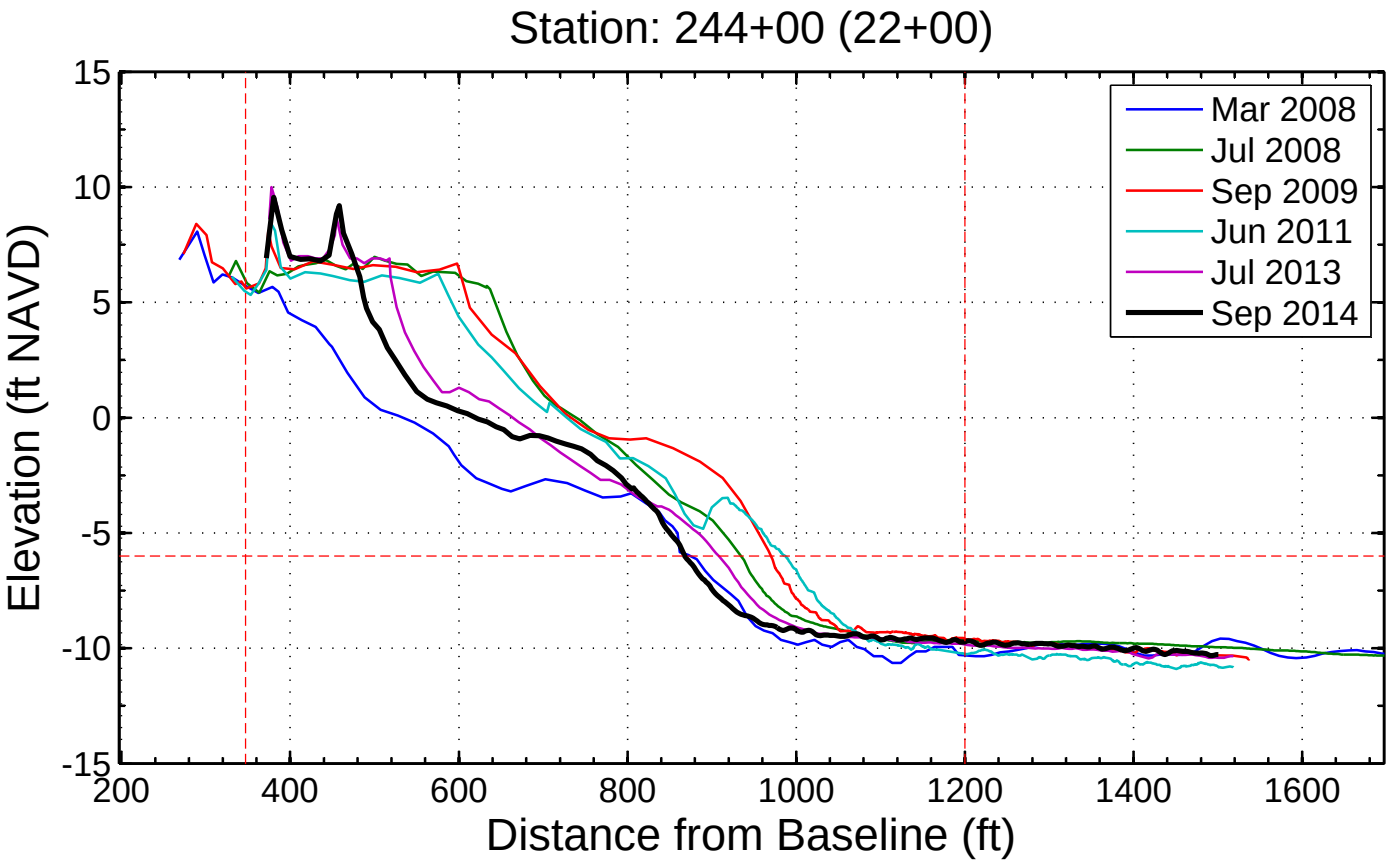
700
Distance from Baseline (ft)


Station: 244+00 (22+00)
Elevation (ft NAVD)
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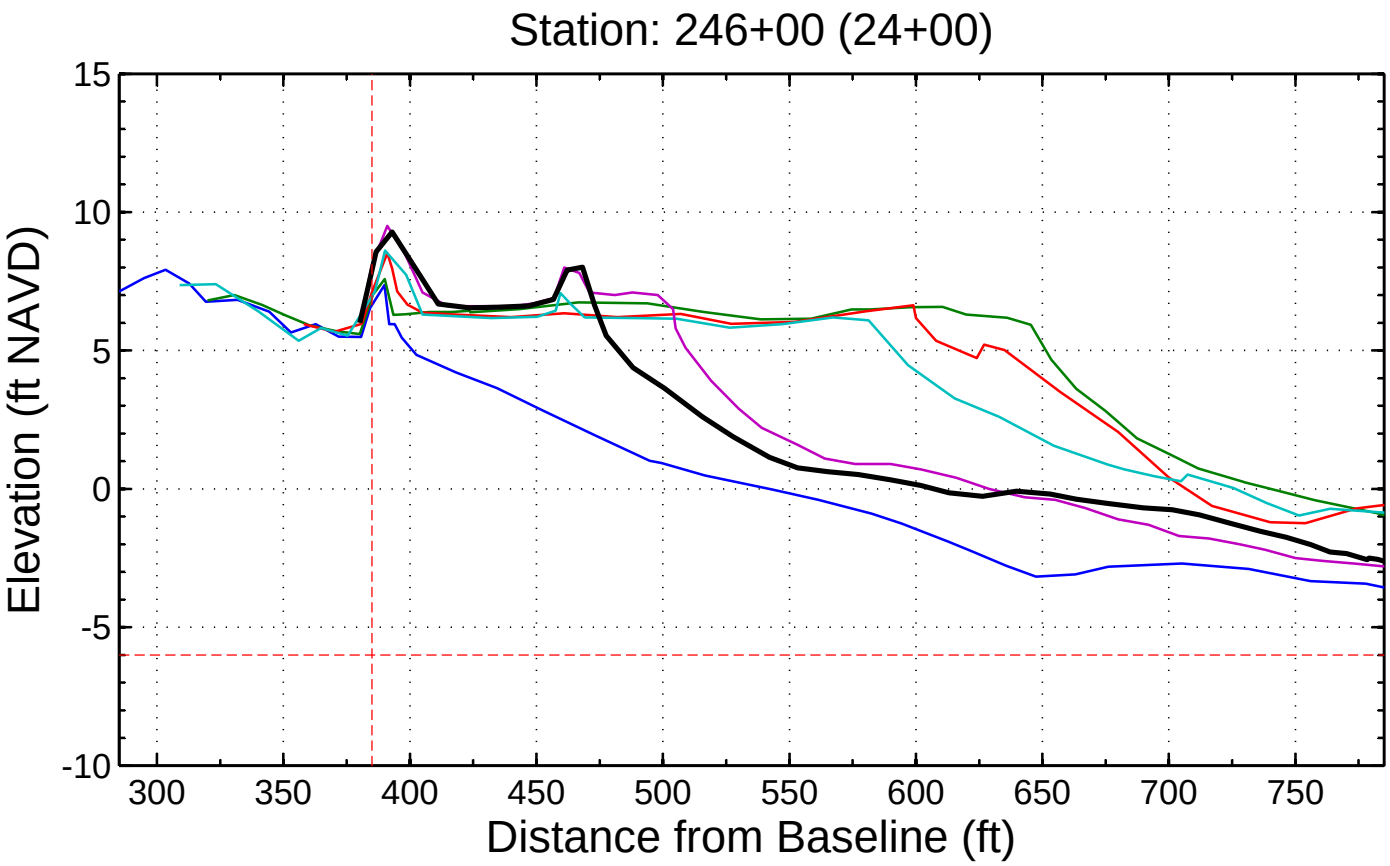
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 246+00 (24+00)
Elevation (ft NAVD)
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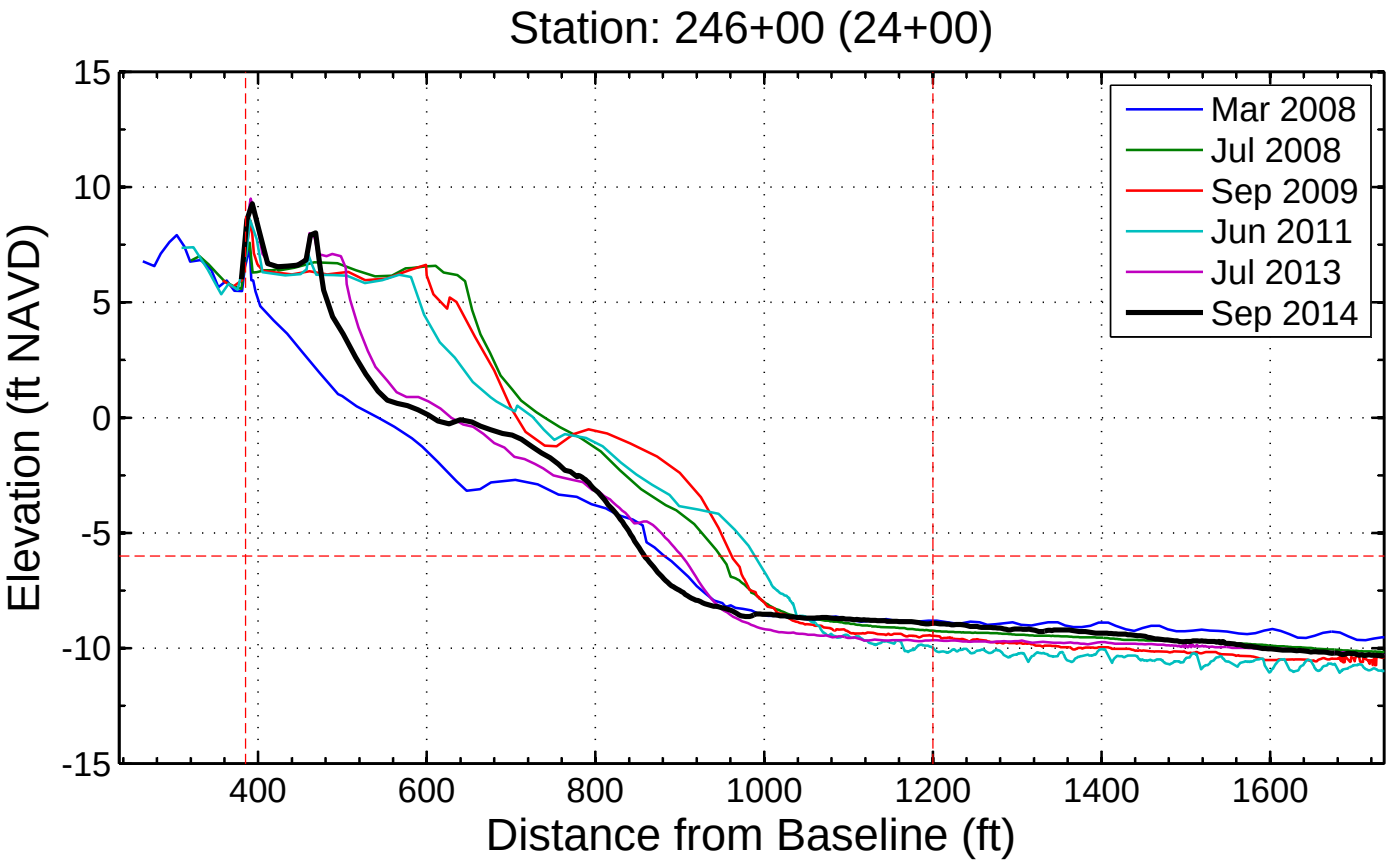
750
Distance from Baseline (ft)


Station: 246+00 (24+00)
Elevation (ft NAVD)
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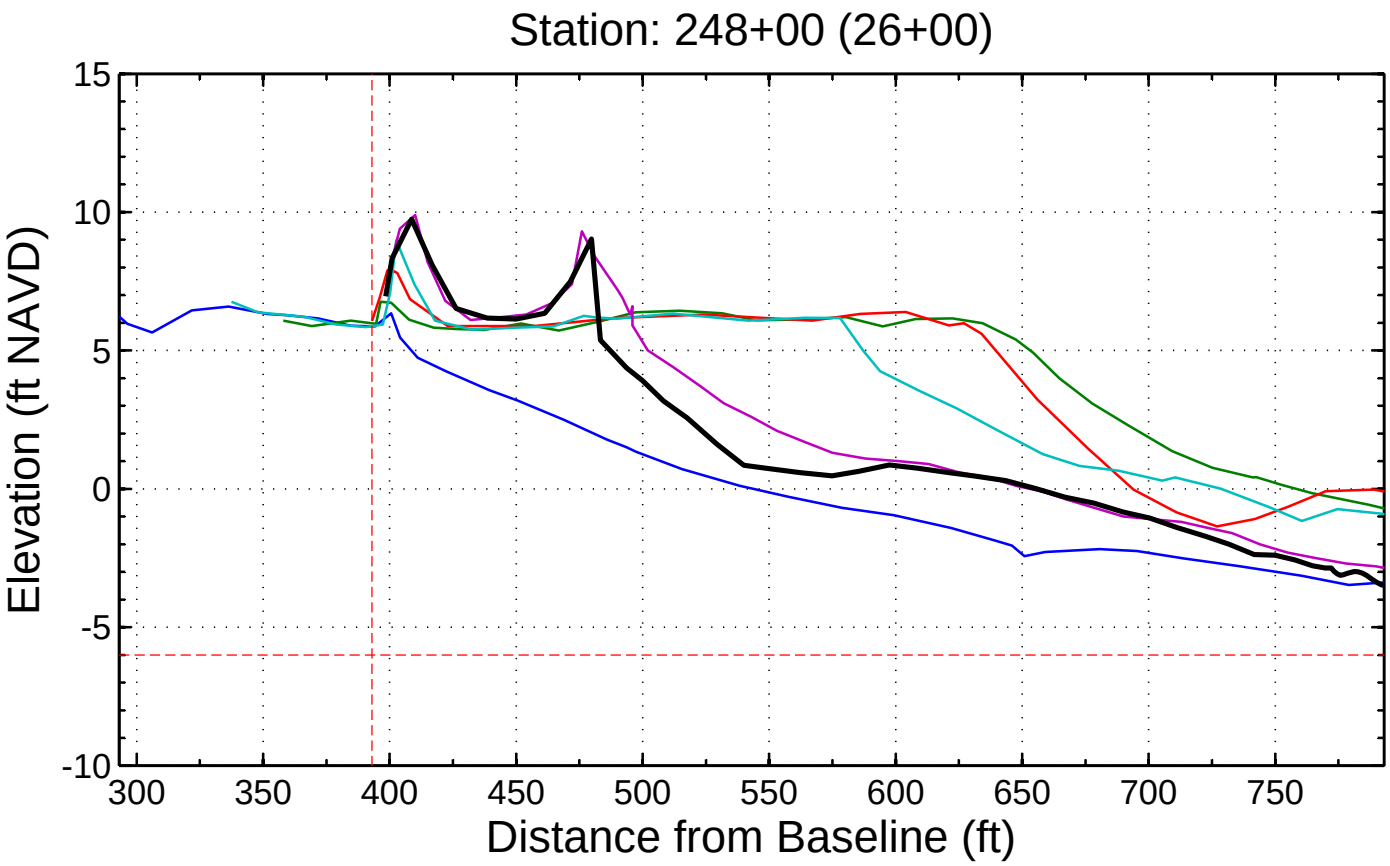
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 248+00 (26+00)
Elevation (ft NAVD)
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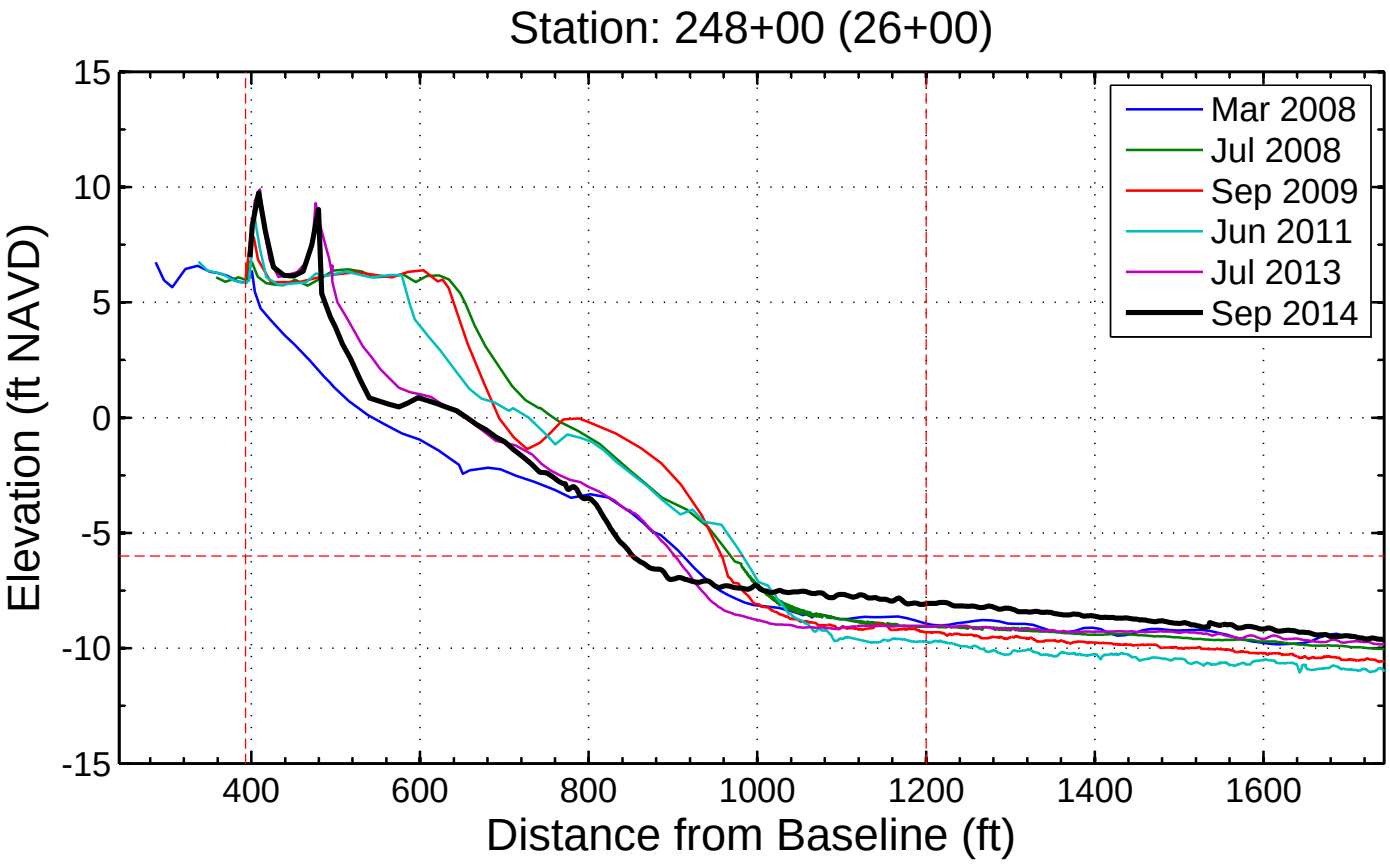
750
Distance from Baseline (ft)


Station: 248+00 (26+00)
Elevation (ft NAVD)
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10
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-5
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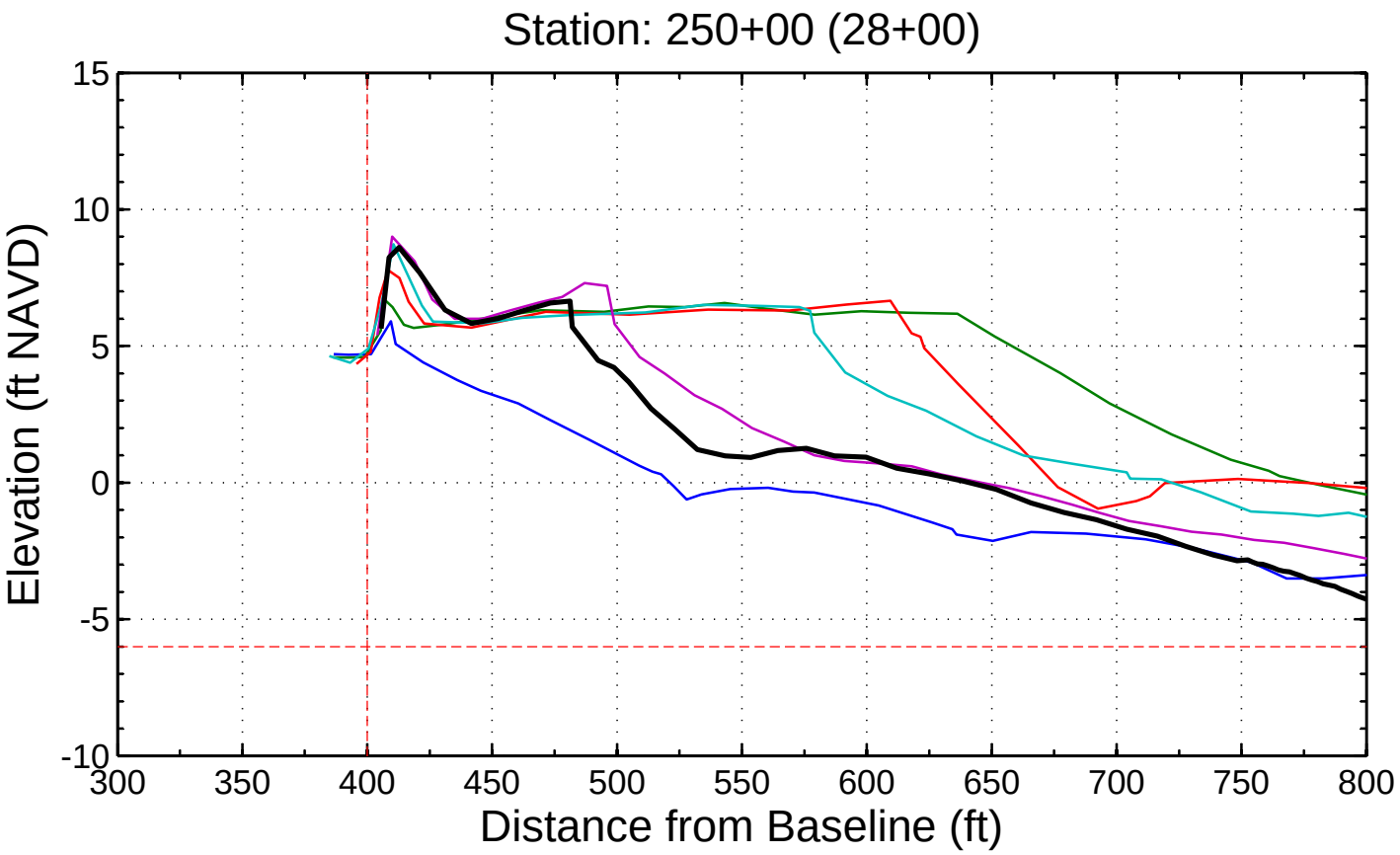
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 250+00 (28+00)
Elevation (ft NAVD)
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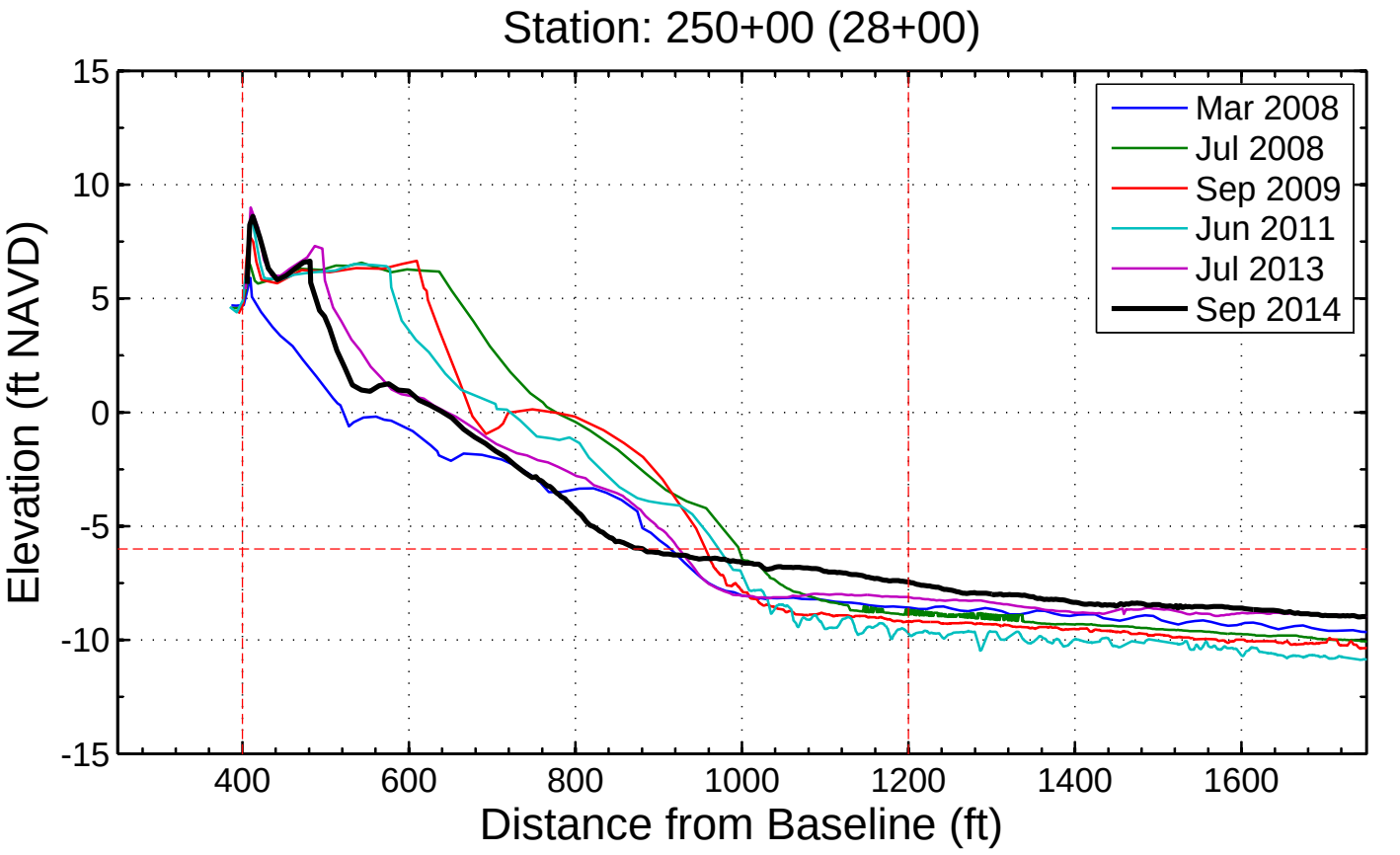
800
Distance from Baseline (ft)


Station: 250+00 (28+00)
Elevation (ft NAVD)
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10
5
0
-5
-10
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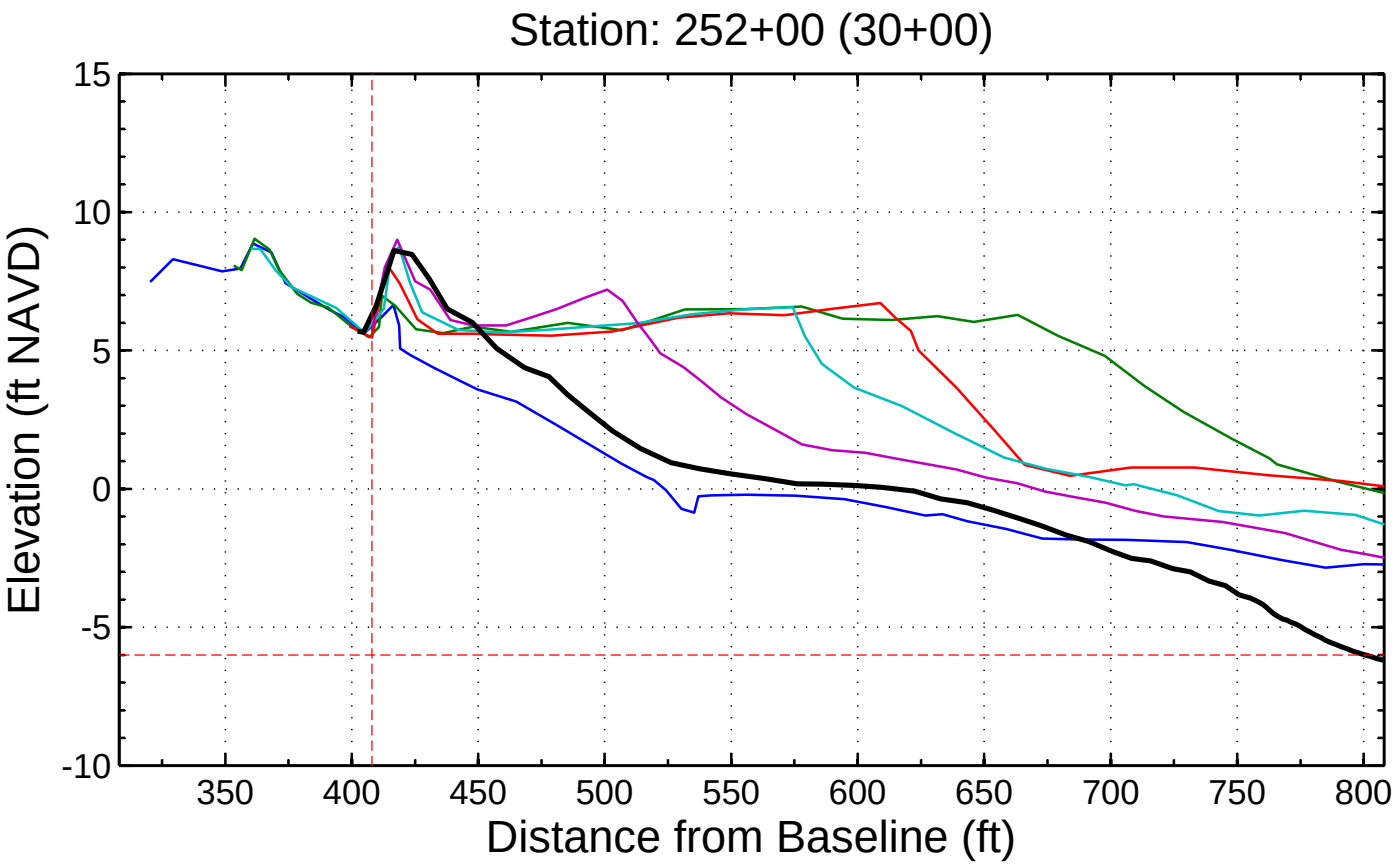
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 252+00 (30+00)
Elevation (ft NAVD)
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-5
-10
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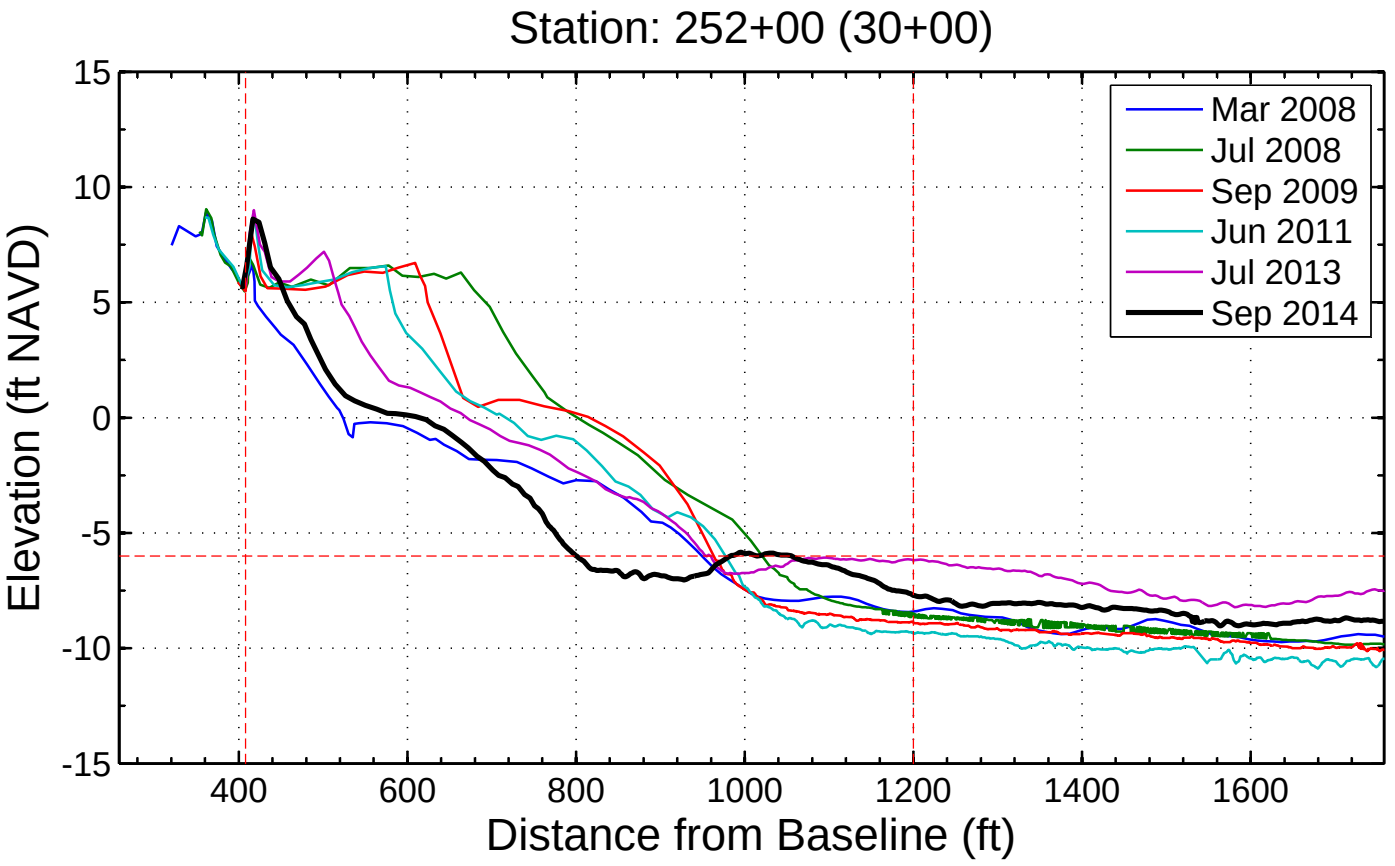
500
550
600
650
700
750
800
Distance from Baseline (ft)


Station: 252+00 (30+00)
Elevation (ft NAVD)
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10
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0
-5
-10
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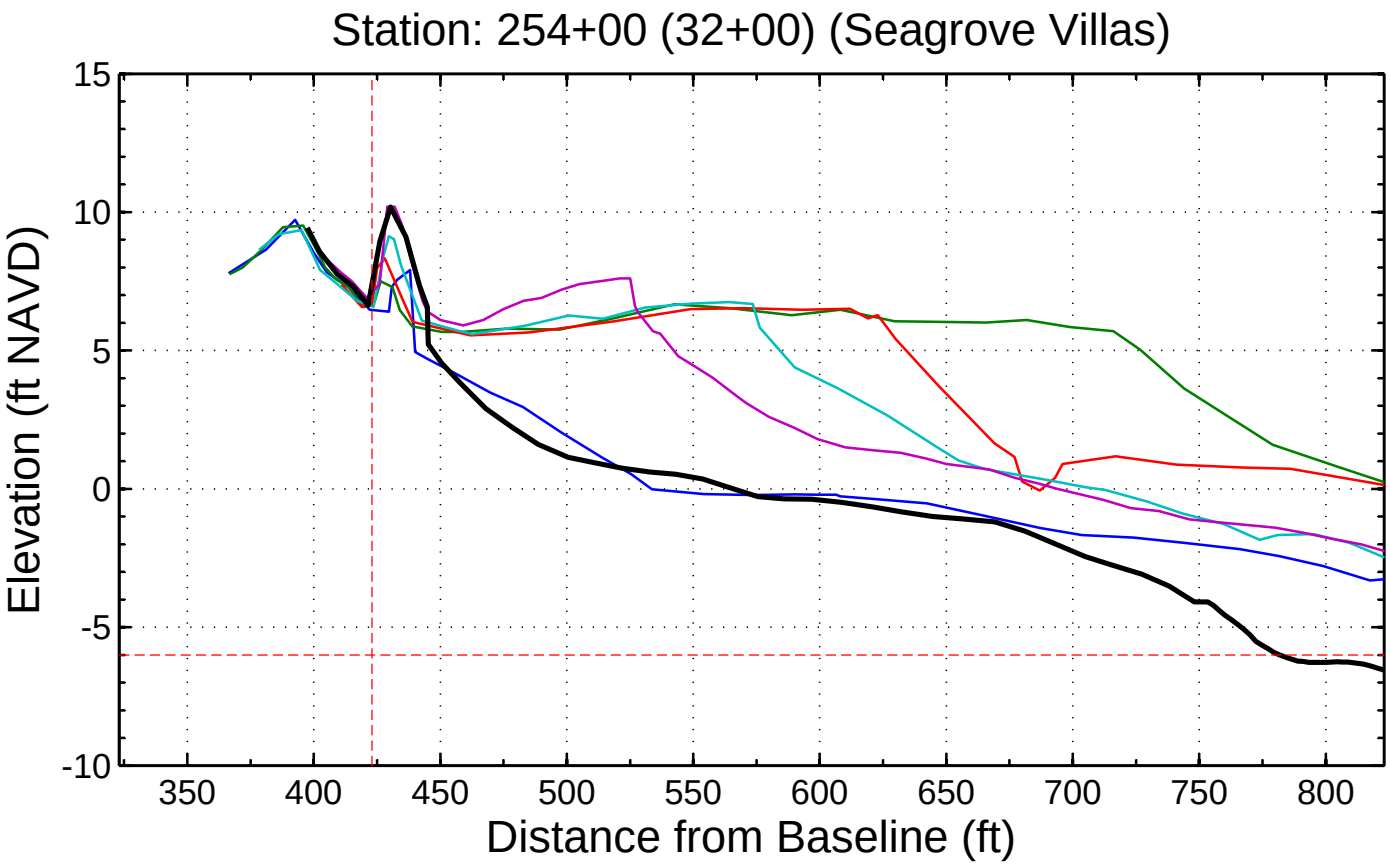
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 254+00 (32+00) (Seagrove Villas)
Elevation (ft NAVD)
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-5
-10
350
400
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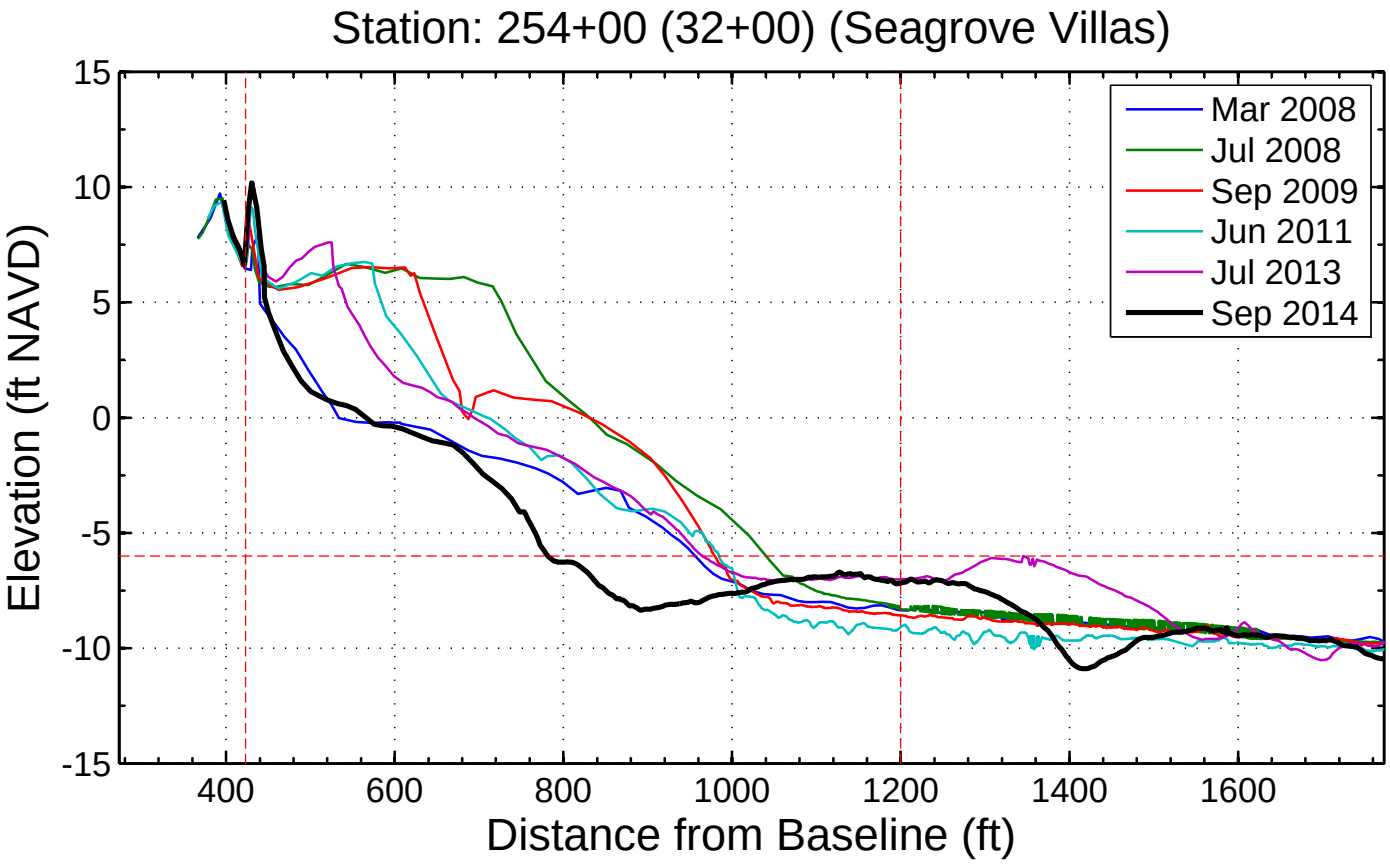
550
600
650
700
750
800
Distance from Baseline (ft)


Station: 254+00 (32+00) (Seagrove Villas)
Elevation (ft NAVD)
15
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-5
-10
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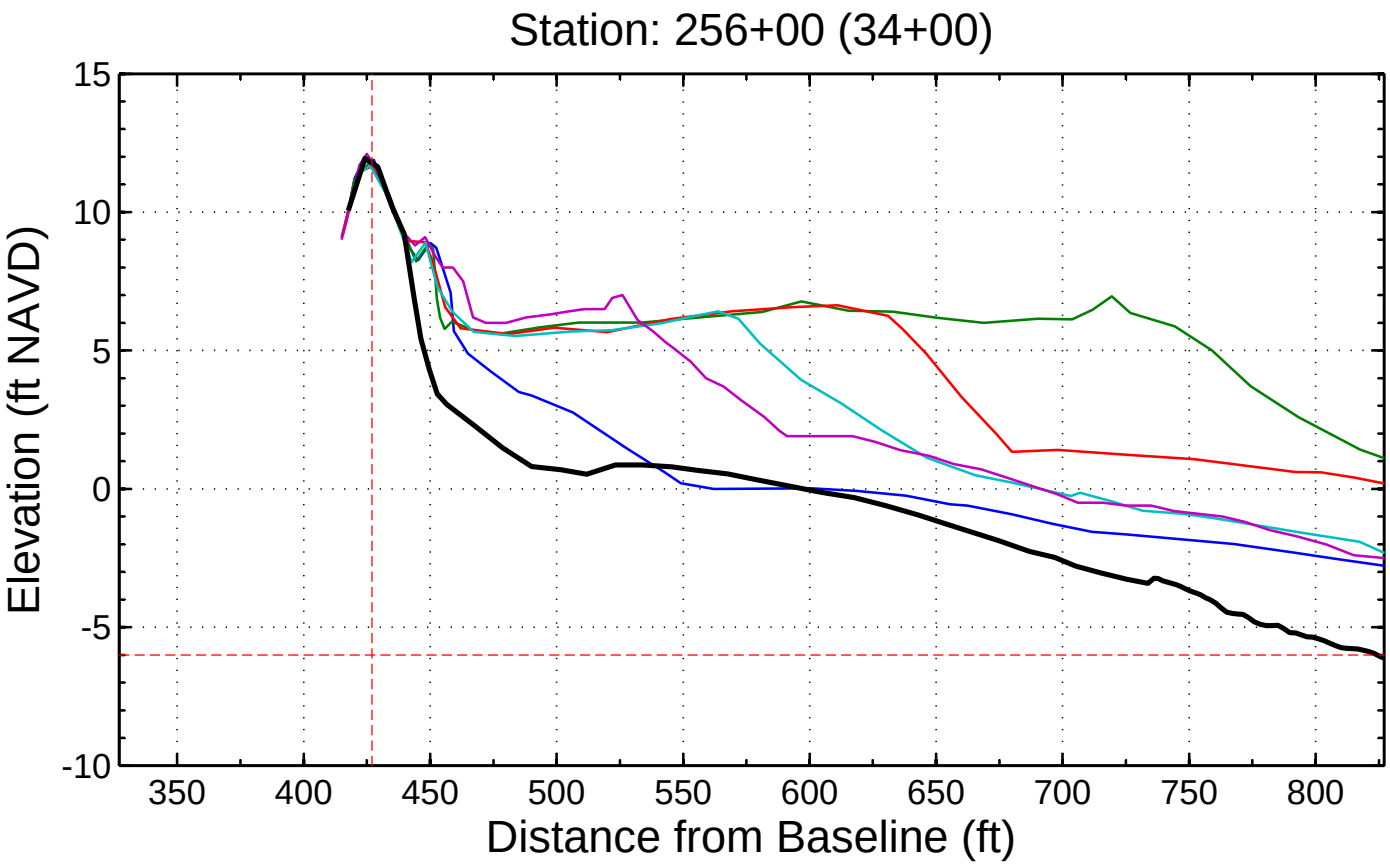
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 256+00 (34+00)
Elevation (ft NAVD)
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600
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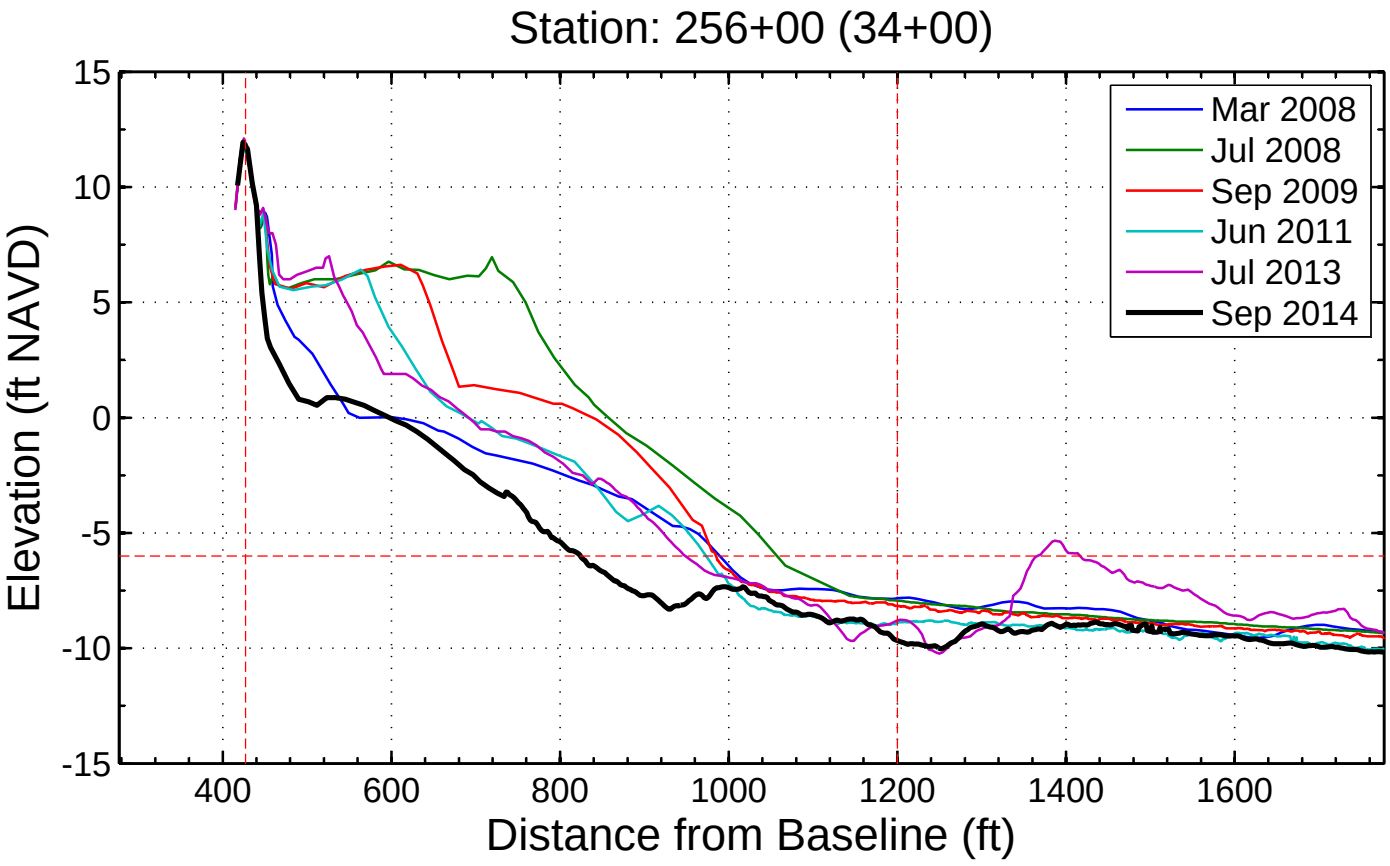
800
Distance from Baseline (ft)


Station: 256+00 (34+00)
Elevation (ft NAVD)
15
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-5
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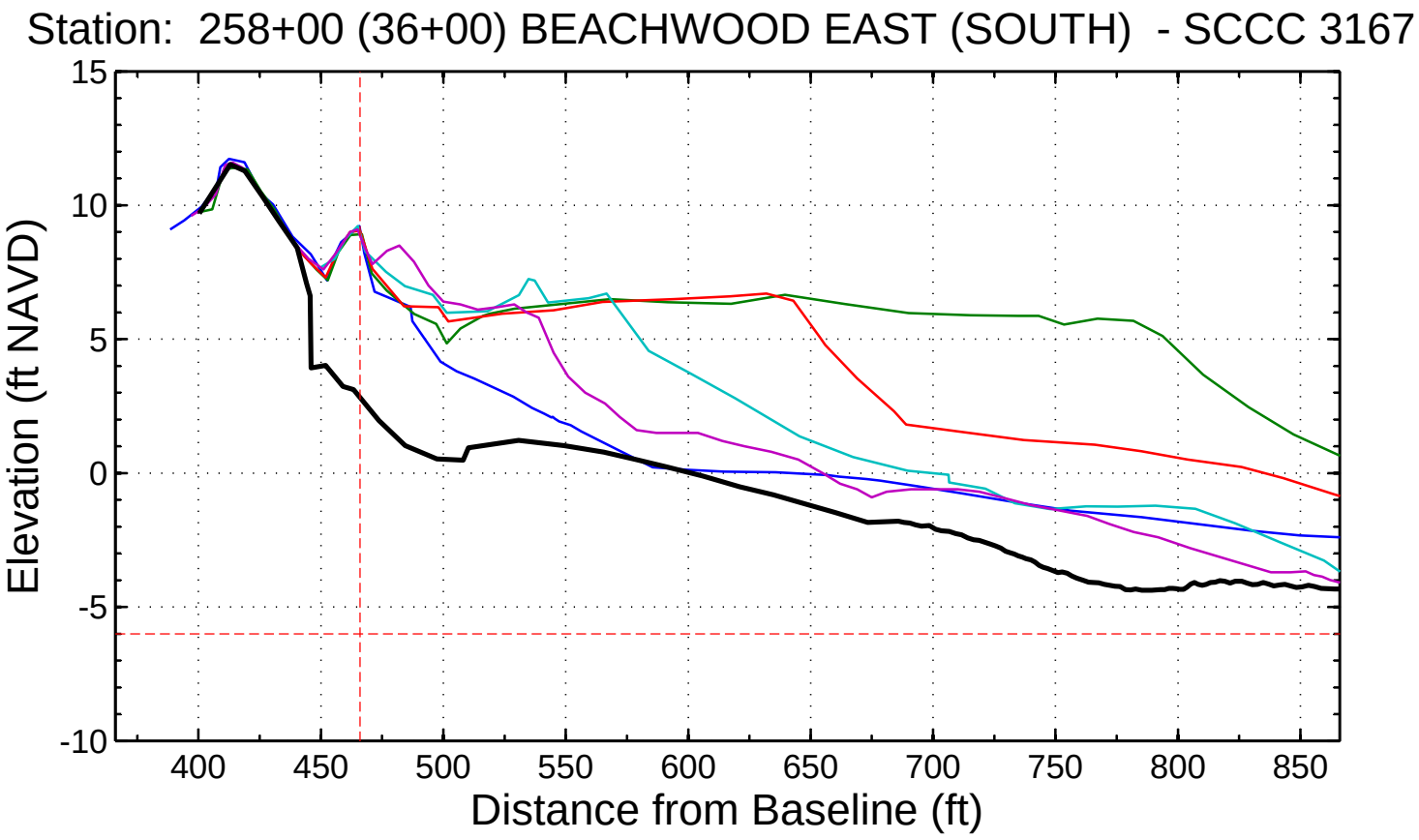
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 258+00 (36+00) BEACHWOOD EAST (SOUTH) - SCCC 3167
Elevation (ft NAVD)
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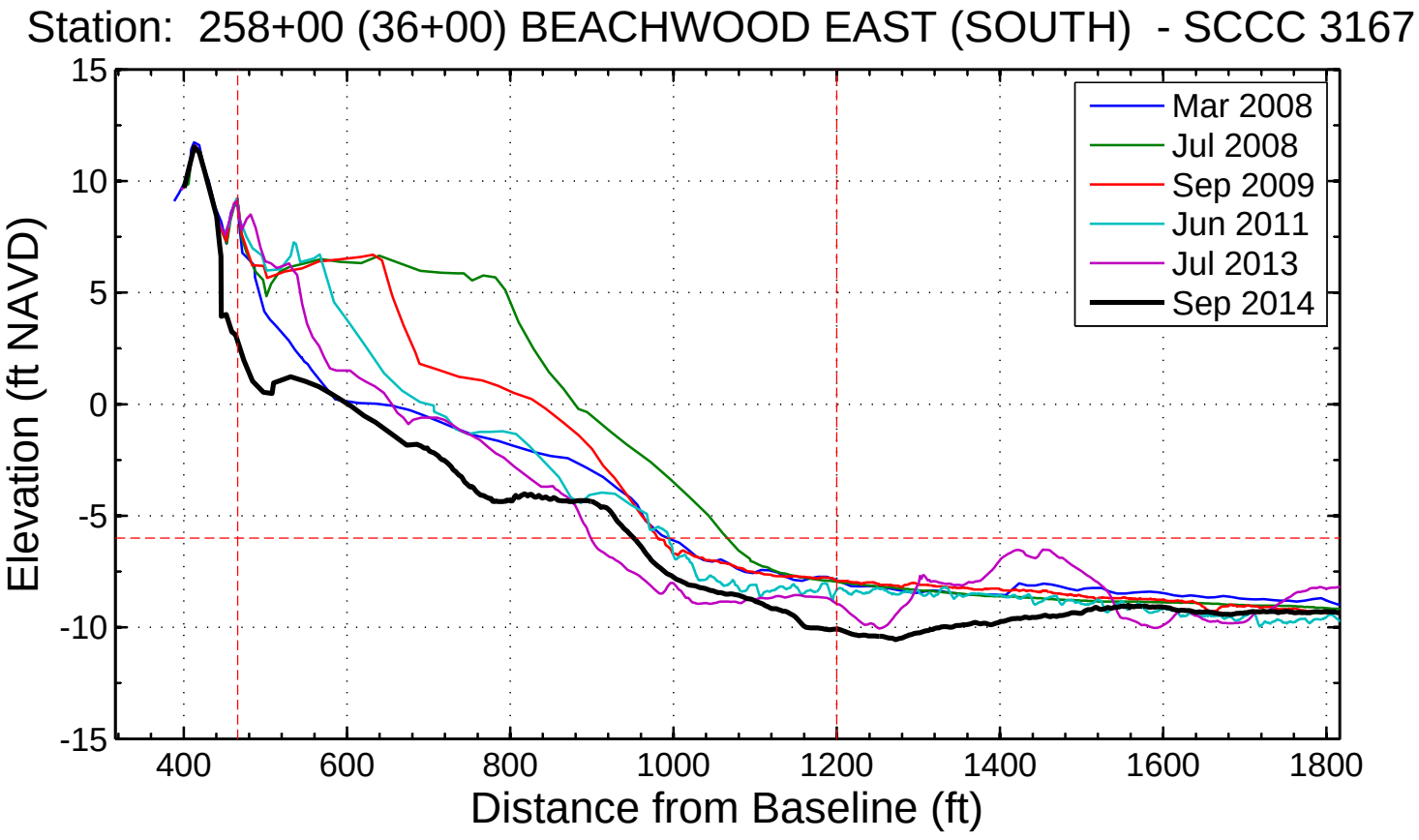
600
650
700
750
800
850
Distance from Baseline (ft)


Station: 258+00 (36+00) BEACHWOOD EAST (SOUTH) - SCCC 3167
Elevation (ft NAVD)
15
10
5
0
-5
-10
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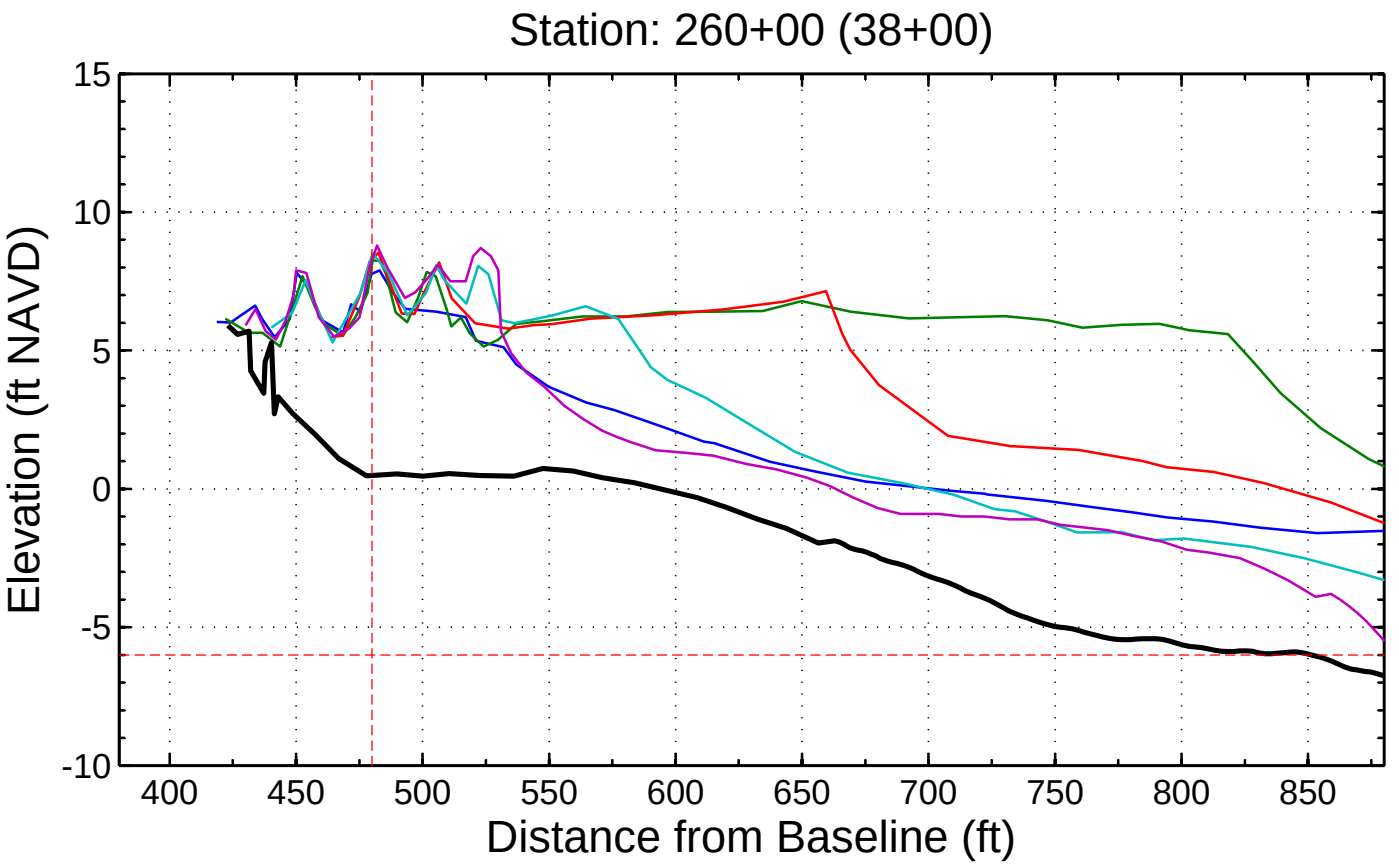
1400
1600
1800
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 260+00 (38+00)
Elevation (ft NAVD)
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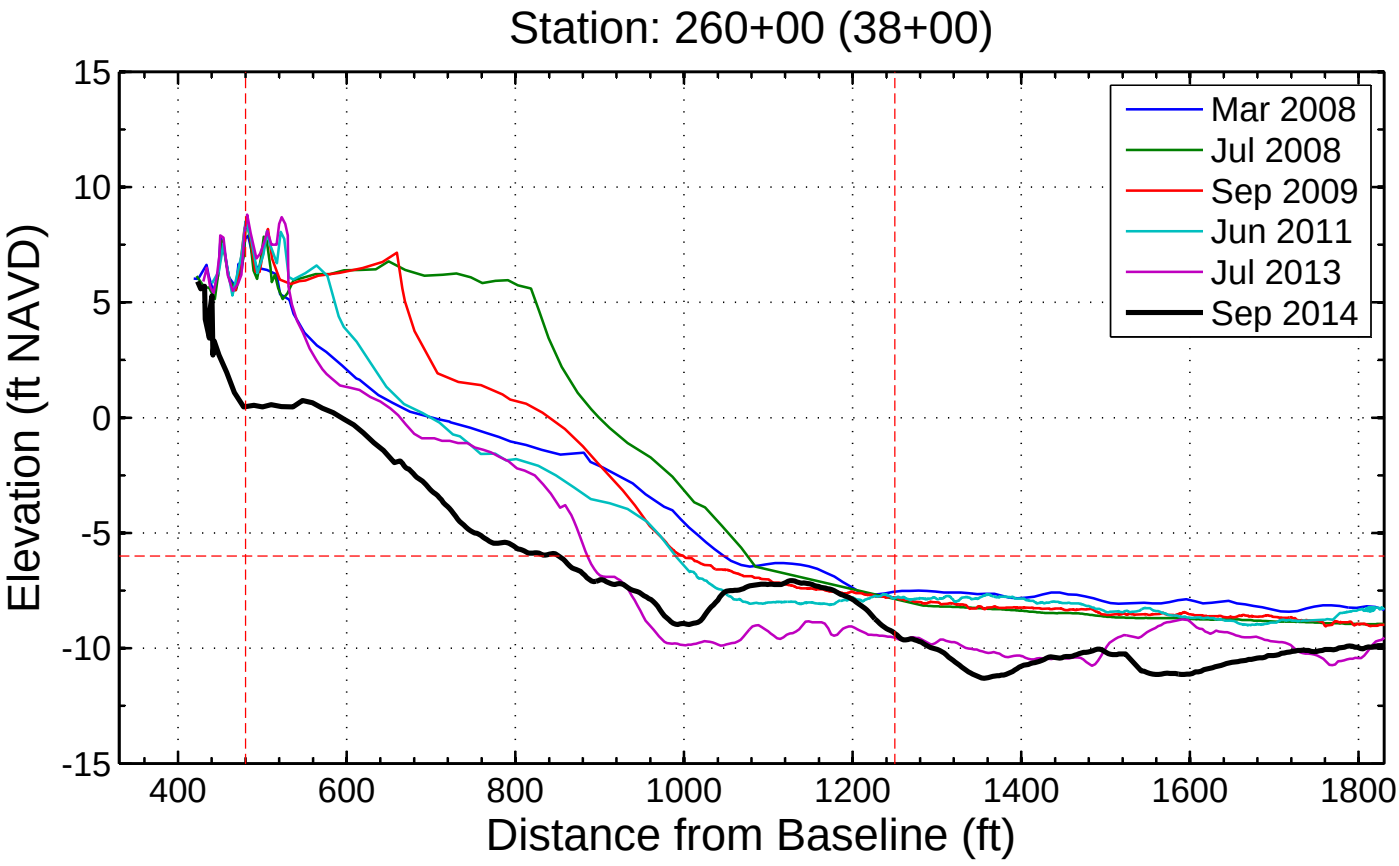
850
Distance from Baseline (ft)


Station: 260+00 (38+00)
Elevation (ft NAVD)
15
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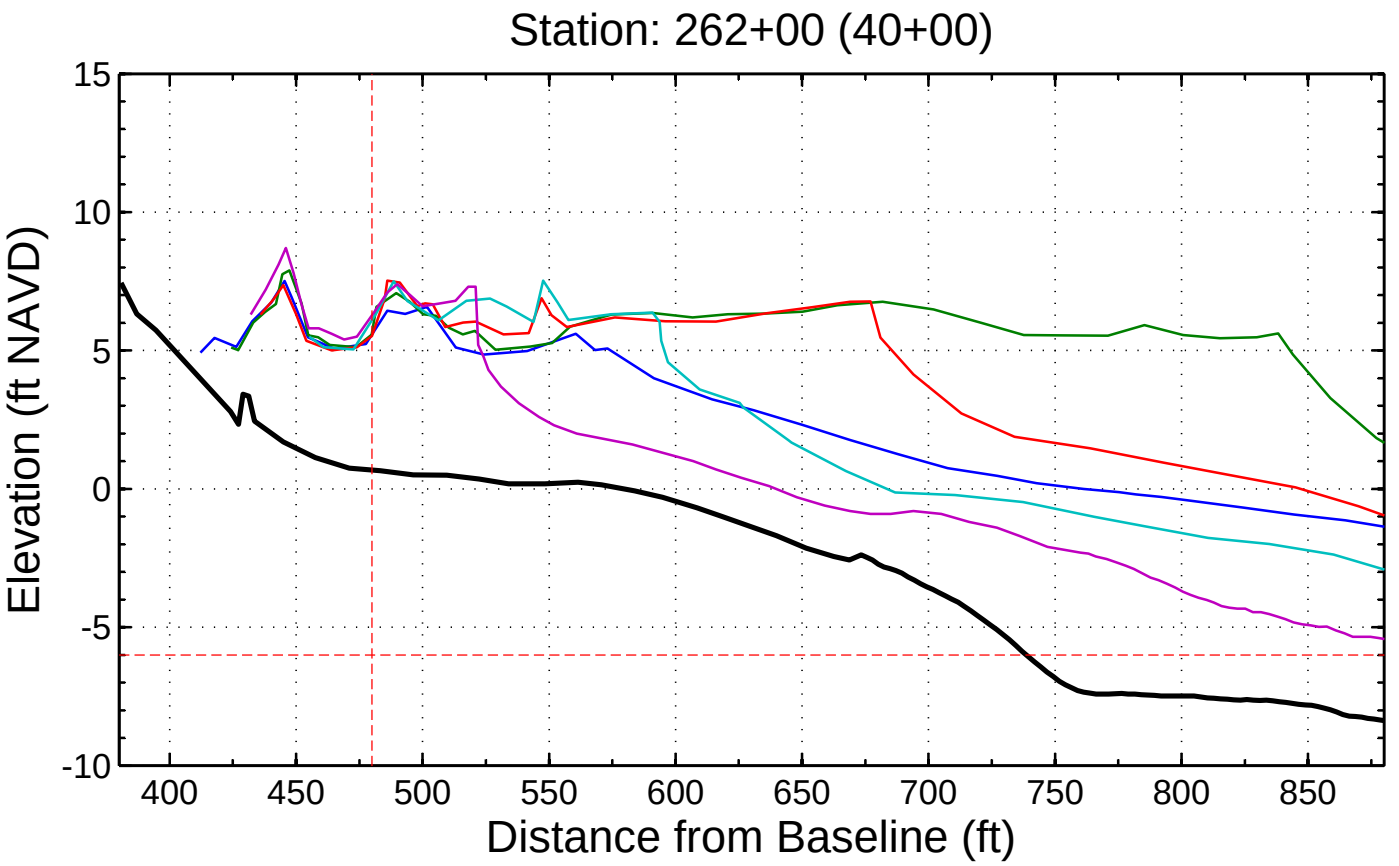
1400
1600
1800
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 262+00 (40+00)
Elevation (ft NAVD)
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750
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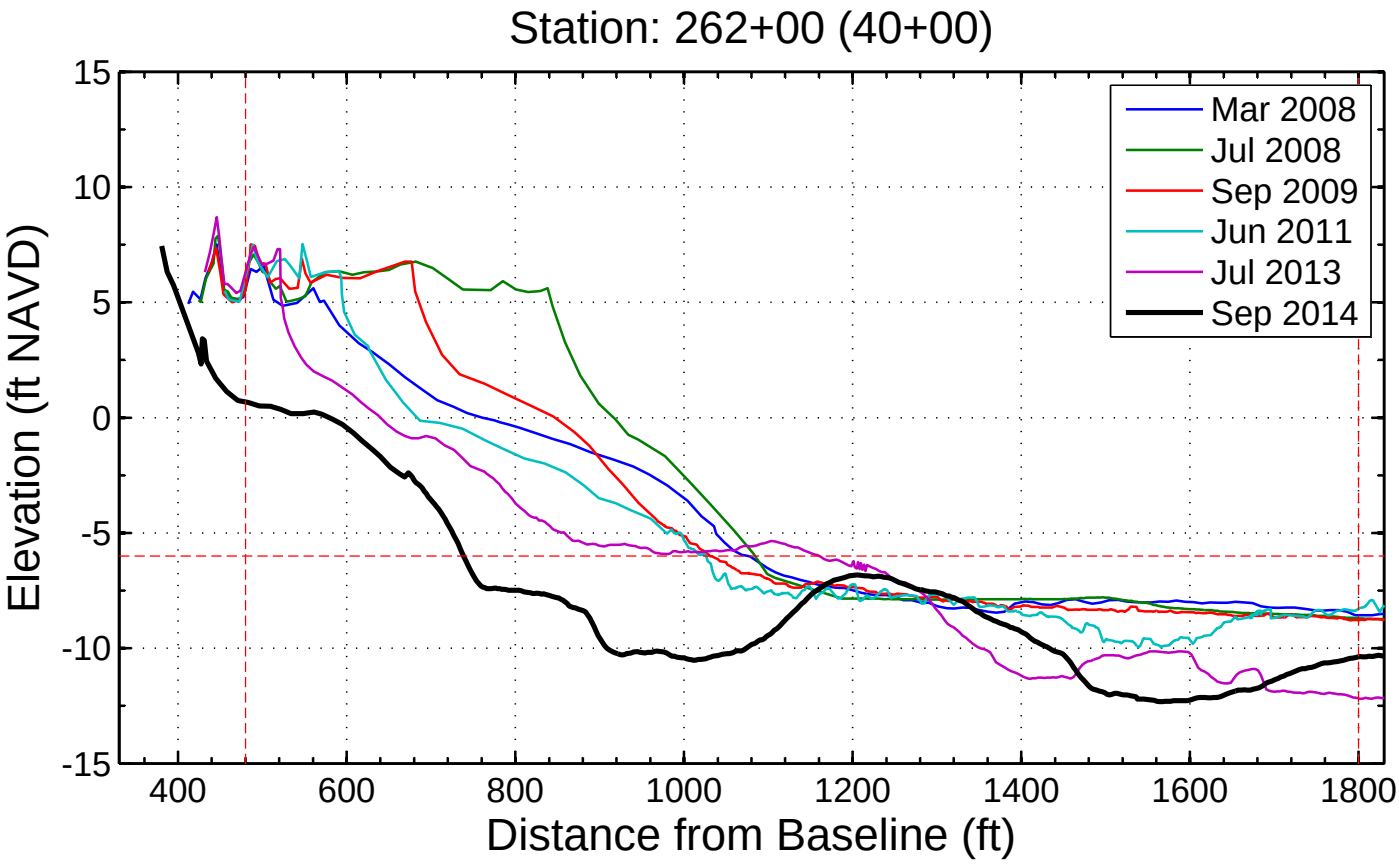
850
Distance from Baseline (ft)


Station: 262+00 (40+00)
Elevation (ft NAVD)
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10
5
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-5
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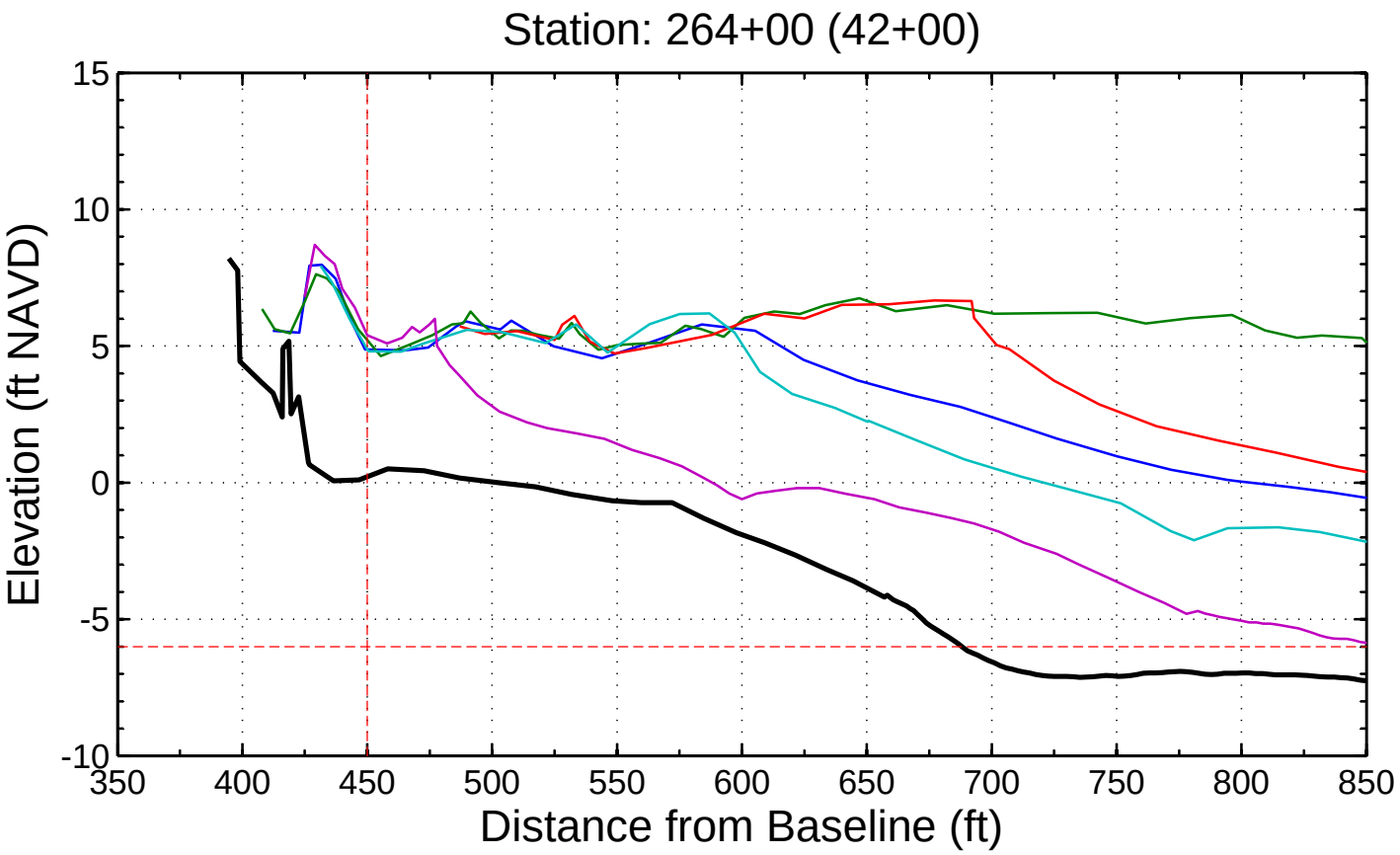
1200
1400
1600
1800
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 264+00 (42+00)
Elevation (ft NAVD)
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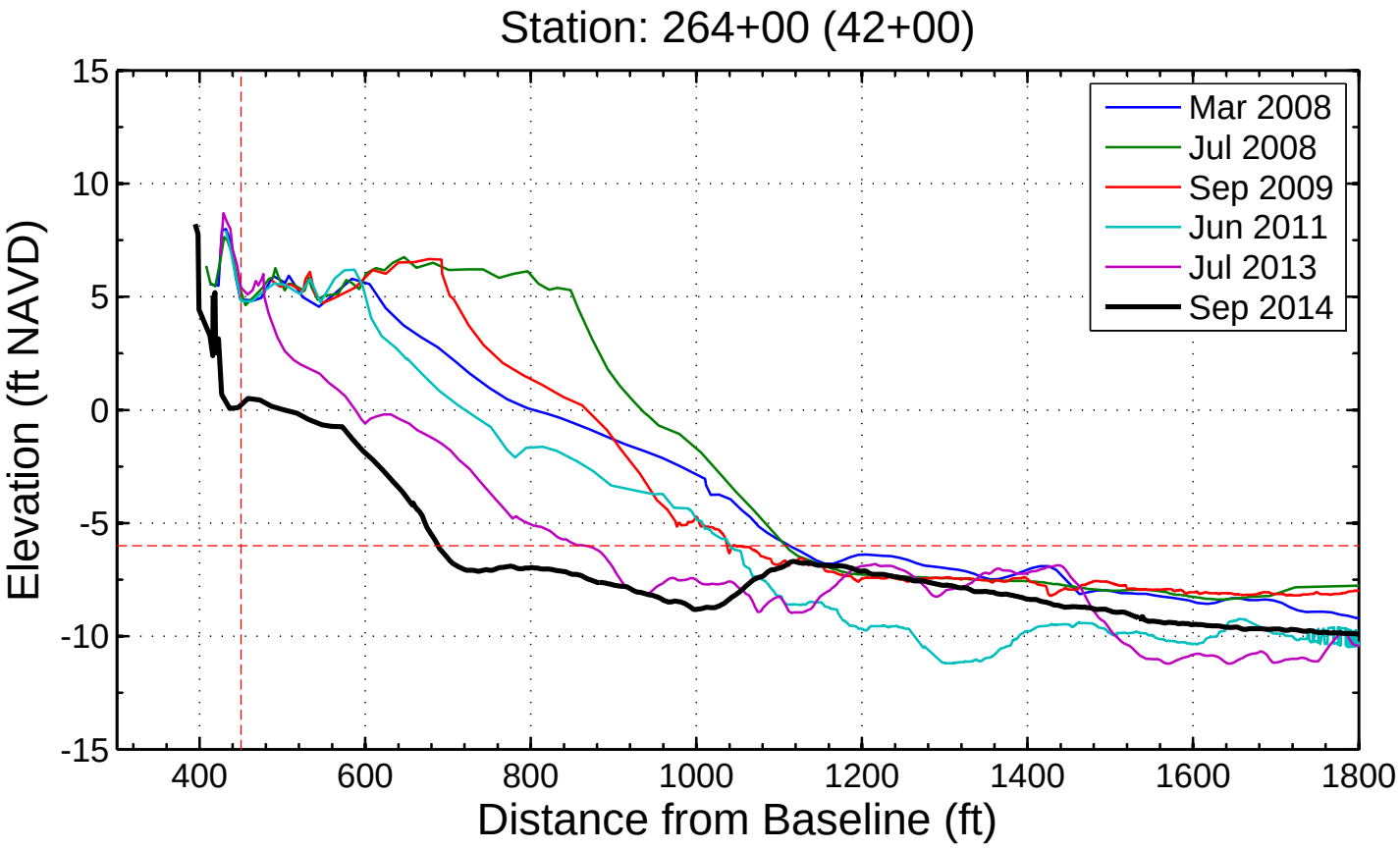
850
Distance from Baseline (ft)


Station: 264+00 (42+00)
Elevation (ft NAVD)
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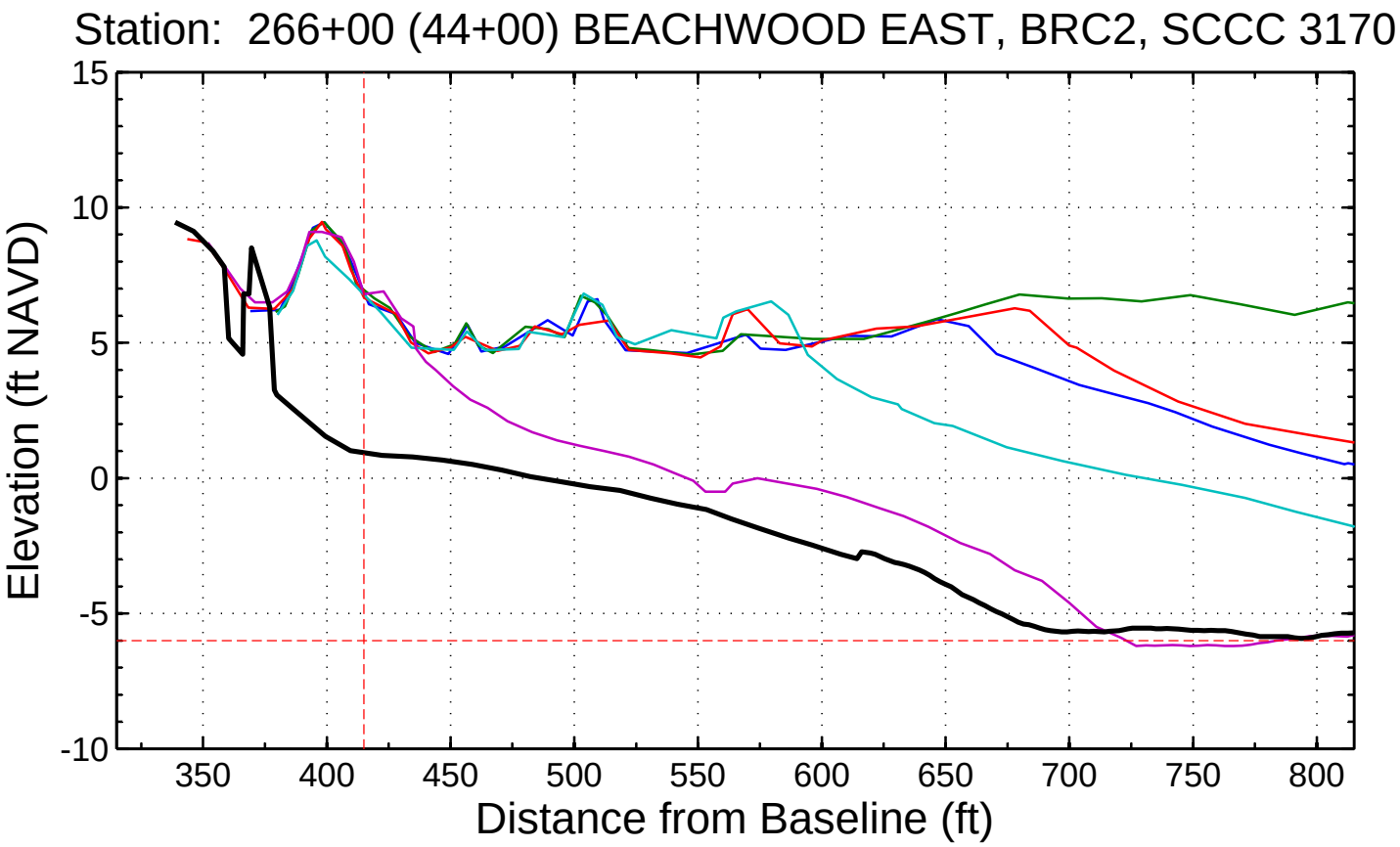
1600
1800
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 266+00 (44+00) BEACHWOOD EAST, BRC2, SCCC 3170
Elevation (ft NAVD)
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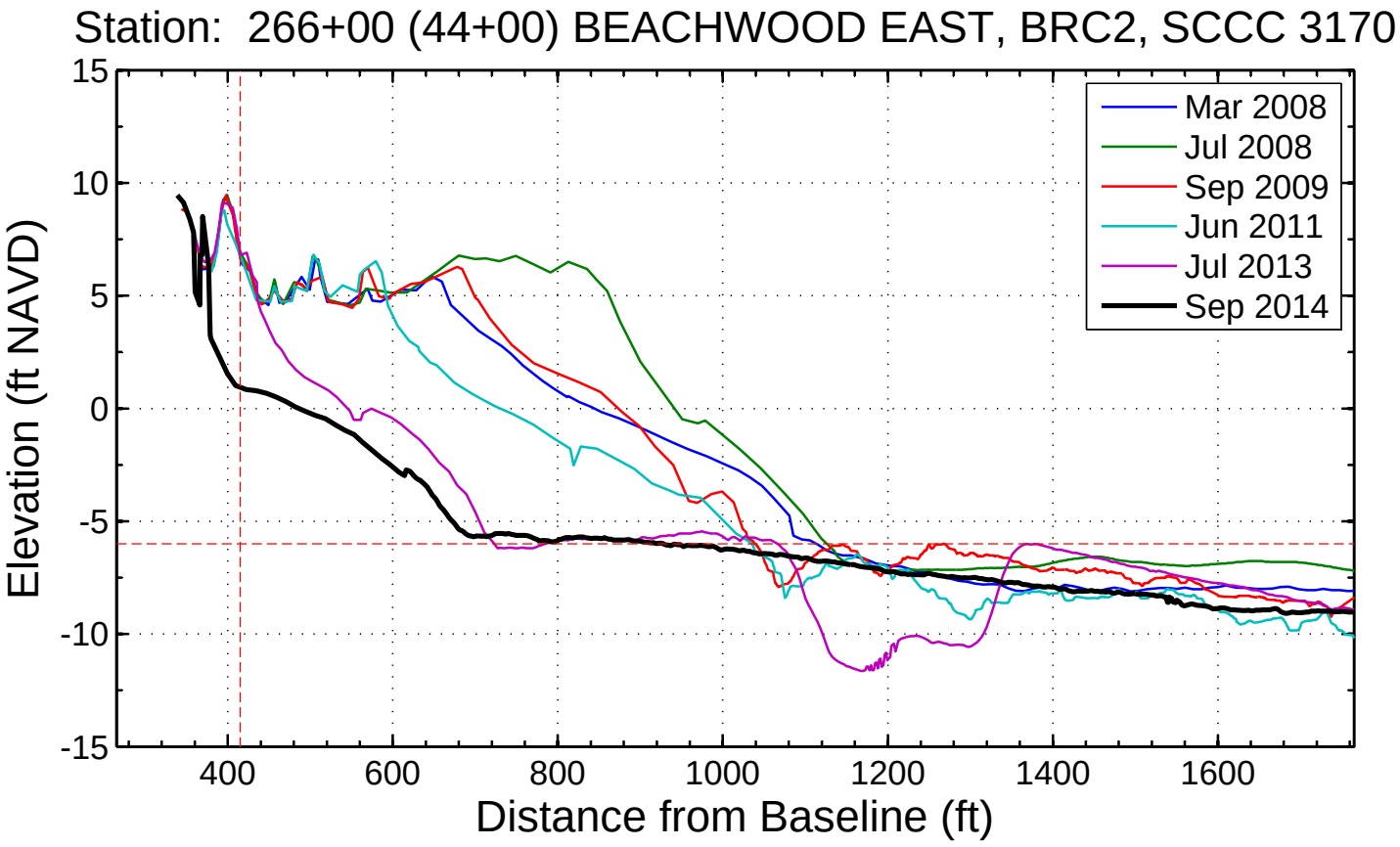
Distance from Baseline (ft)


Station: 266+00 (44+00) BEACHWOOD EAST, BRC2, SCCC 3170
Elevation (ft NAVD)
15
10
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-10
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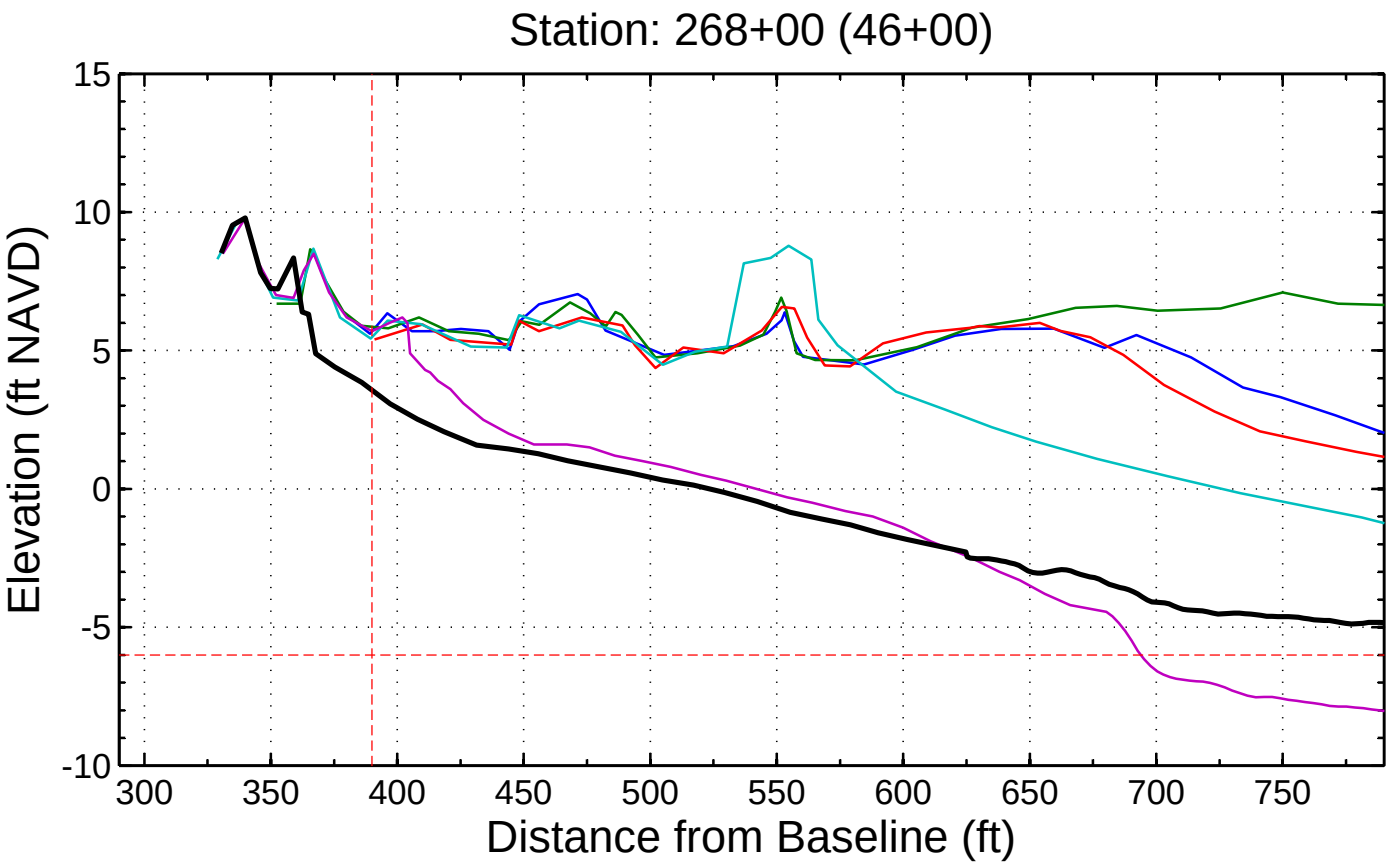
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 268+00 (46+00)
Elevation (ft NAVD)
15
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-5
-10
300
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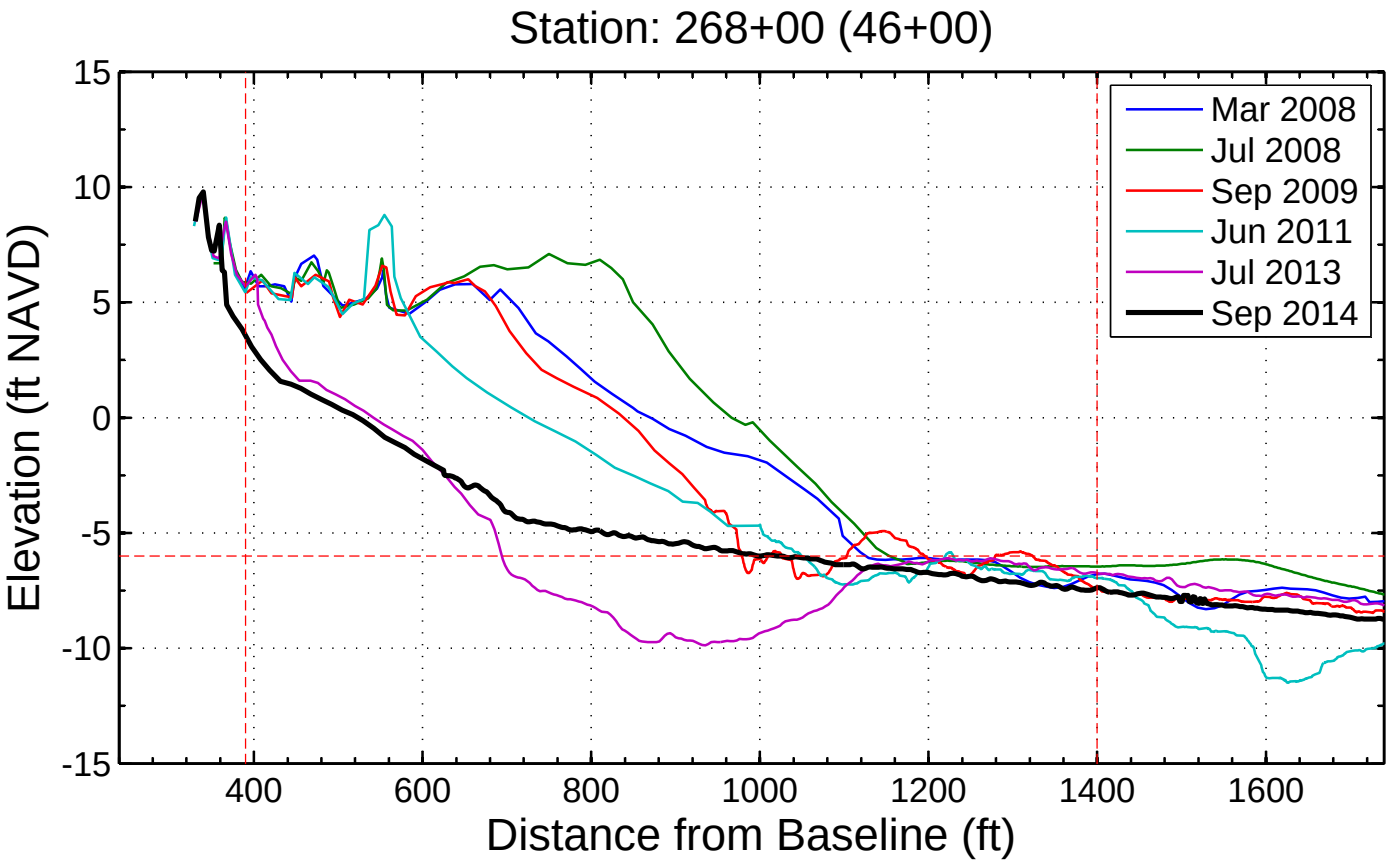
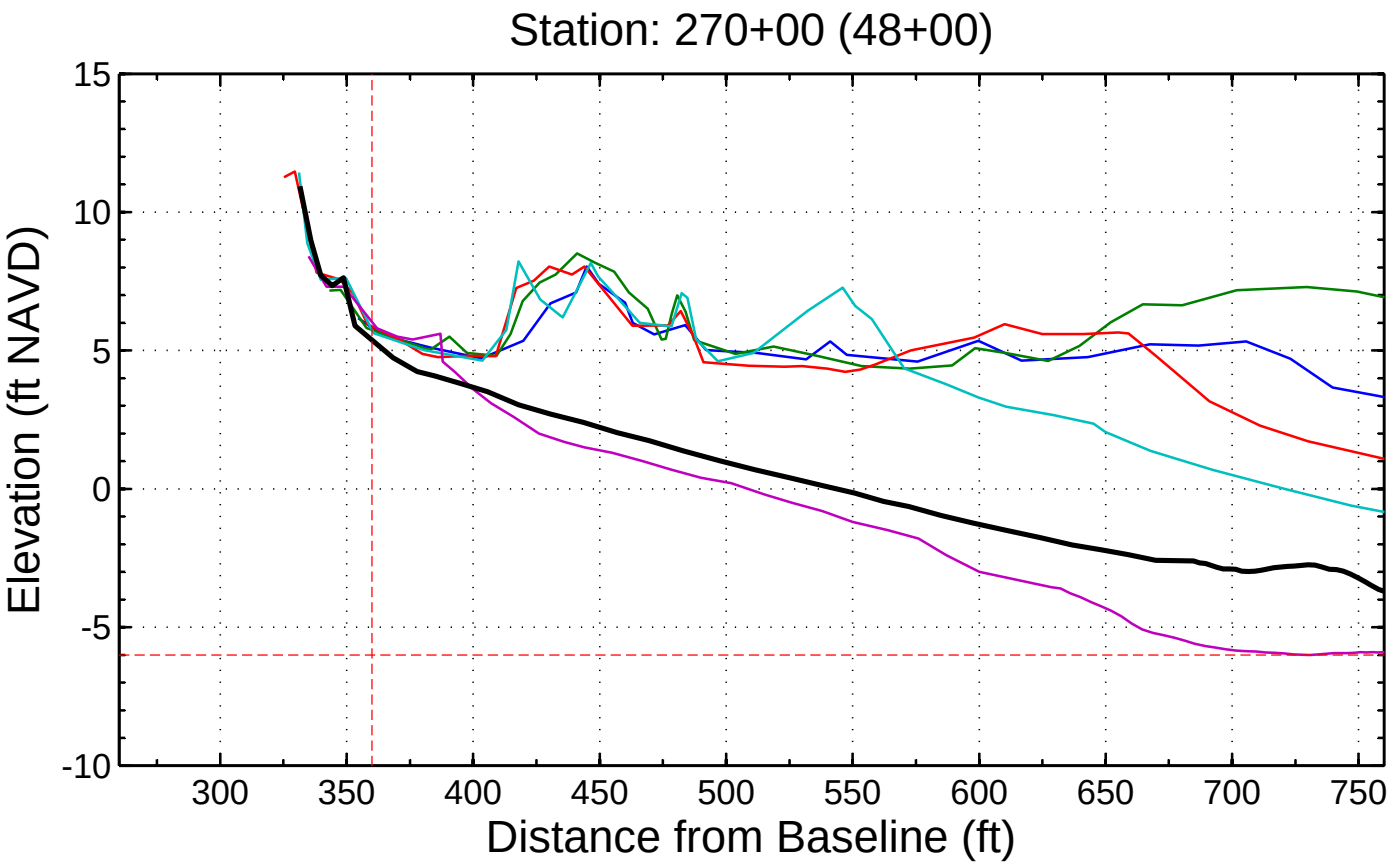
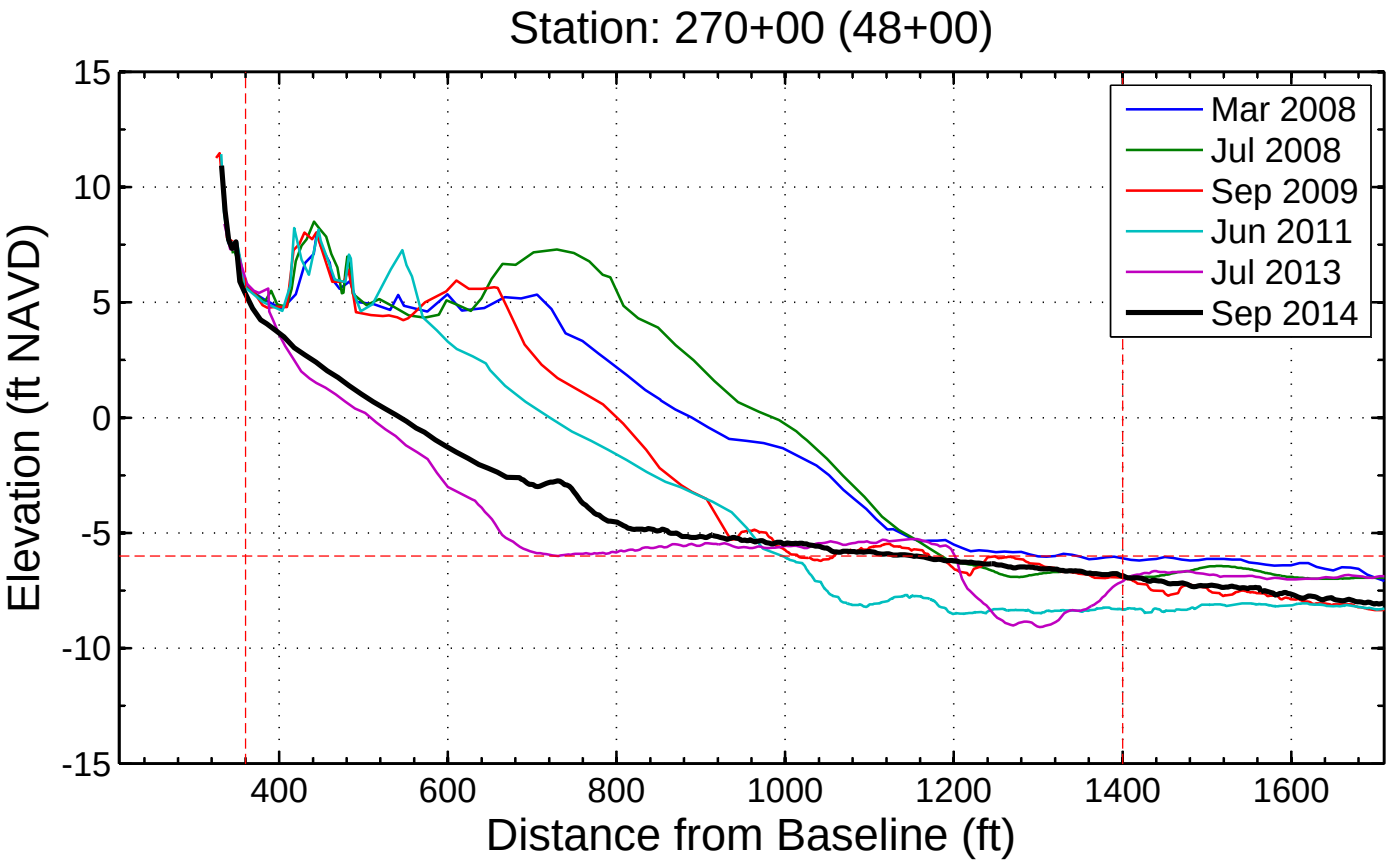
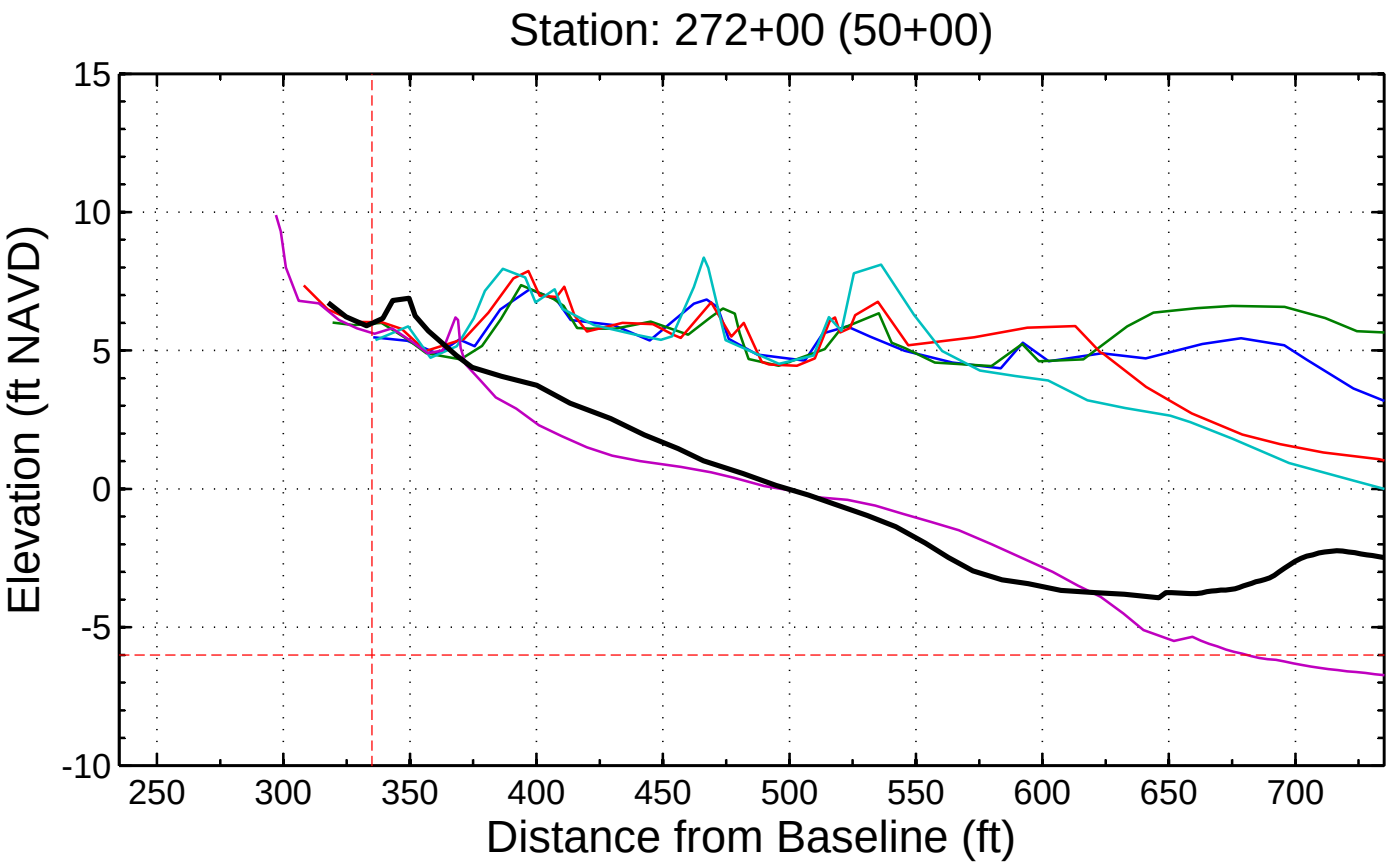
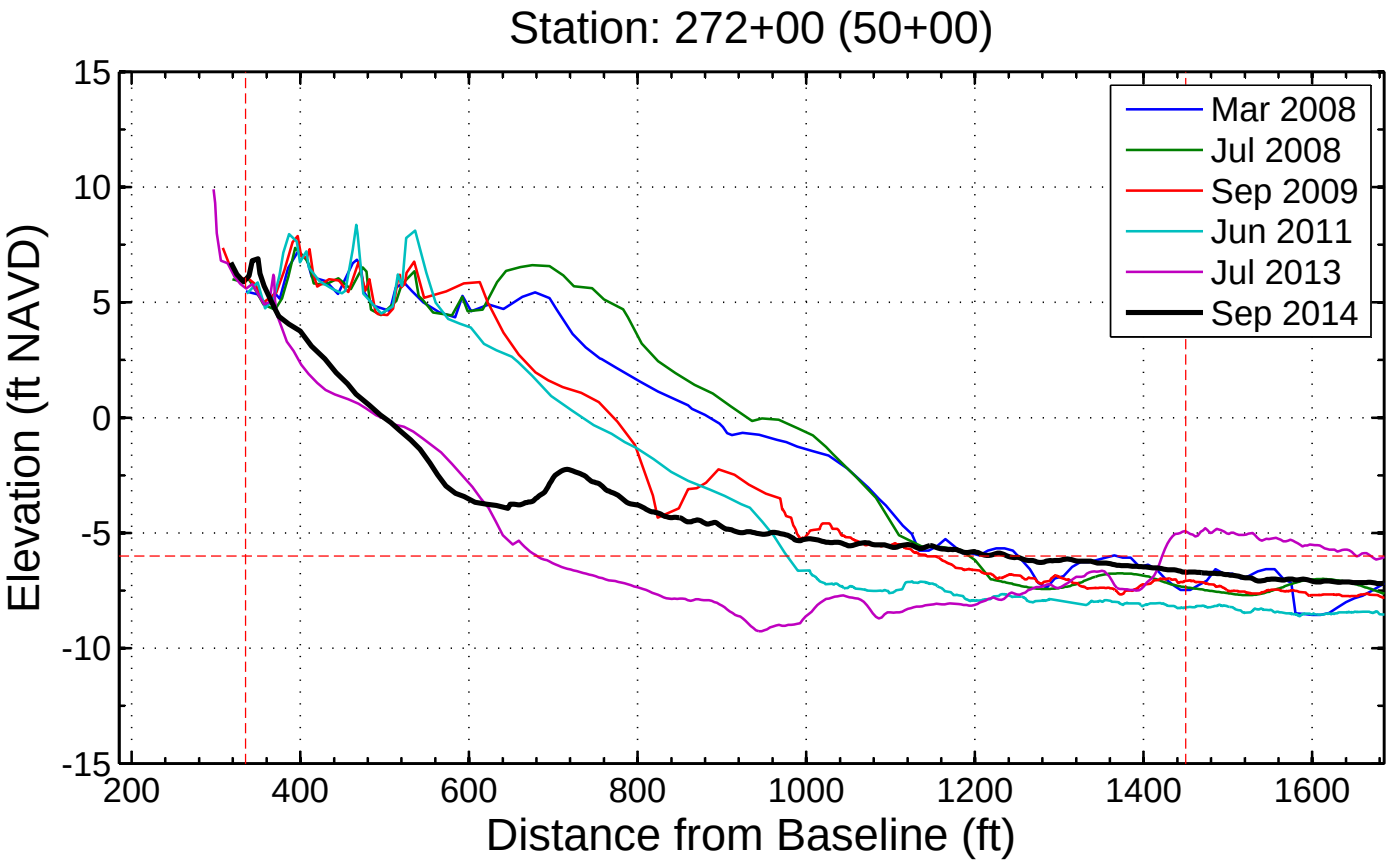
550
600
650
700
750
Distance from Baseline (ft)

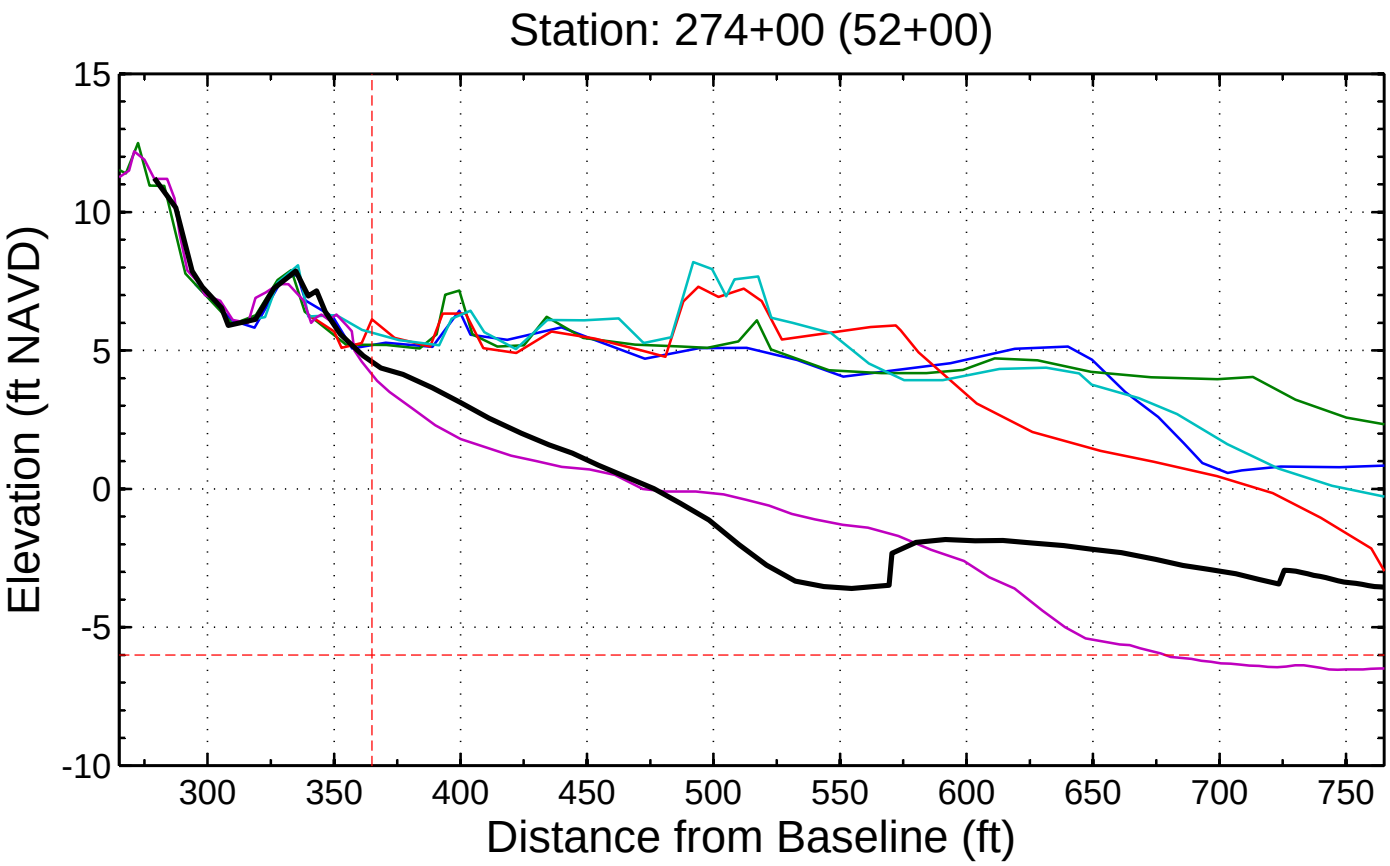

Station: 268+00 (46+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 270+00 (48+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
300
350
400
450
500
550
600
650
700
750
Distance from Baseline (ft)


Station: 270+00 (48+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 272+00 (50+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
250
300
350
400
450
500
550
600
650
700
Distance from Baseline (ft)


Station: 272+00 (50+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 274+00 (52+00)
Elevation (ft NAVD)
15
10
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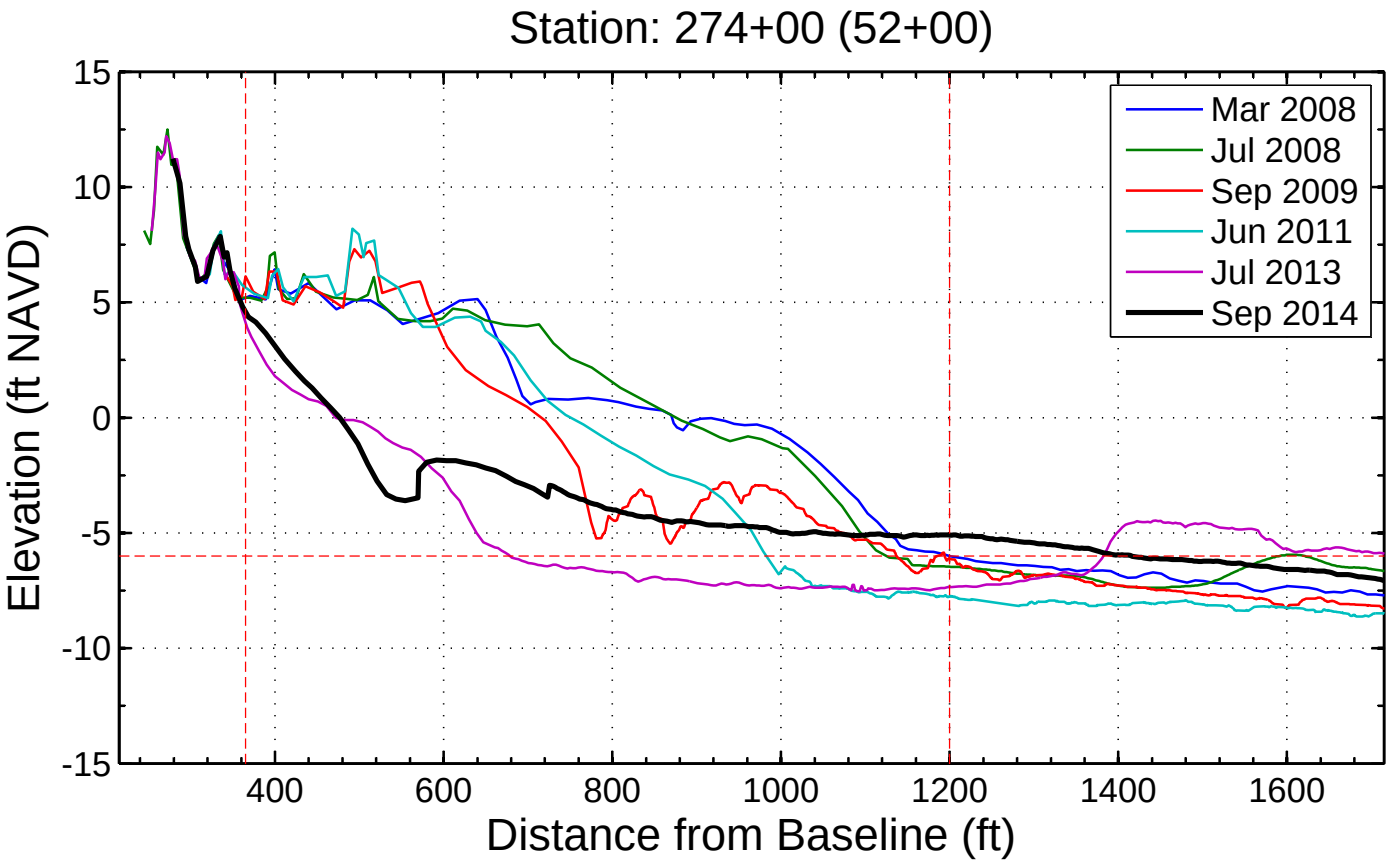
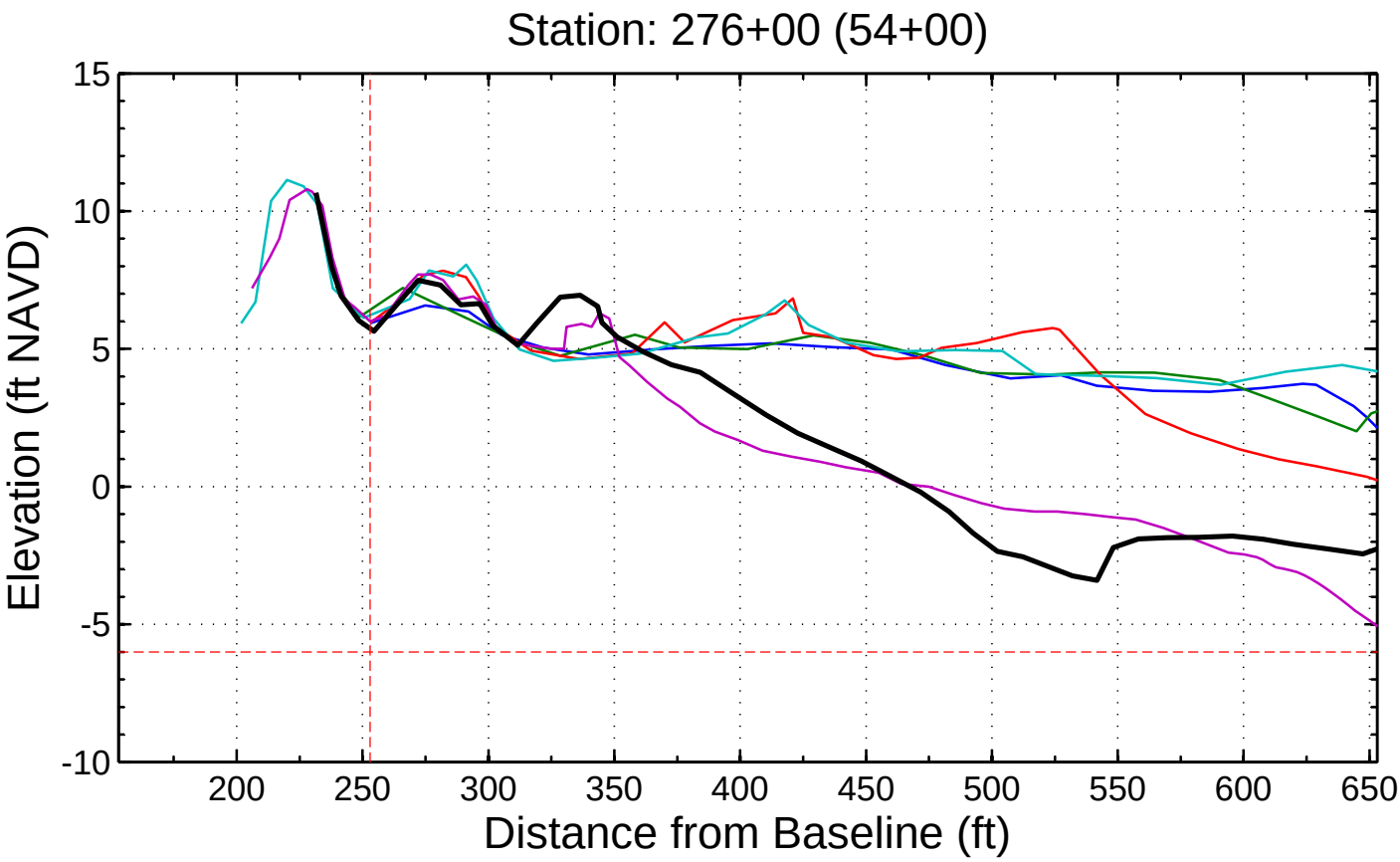
0
-5
-10
300
350
400
450
500
550
600
650
700
750
Distance from Baseline (ft)


Station: 274+00 (52+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 276+00 (54+00)
Elevation (ft NAVD)
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10
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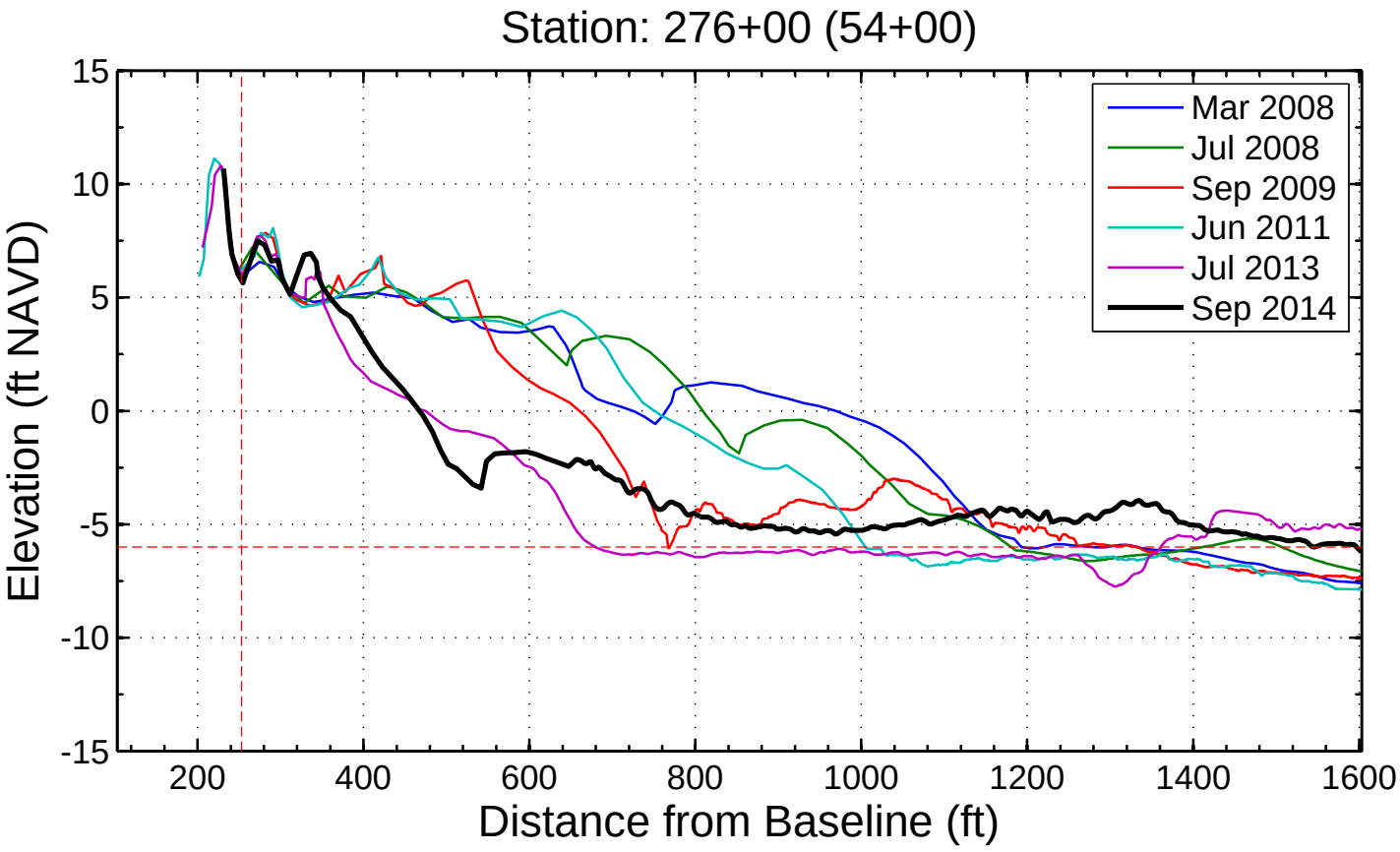
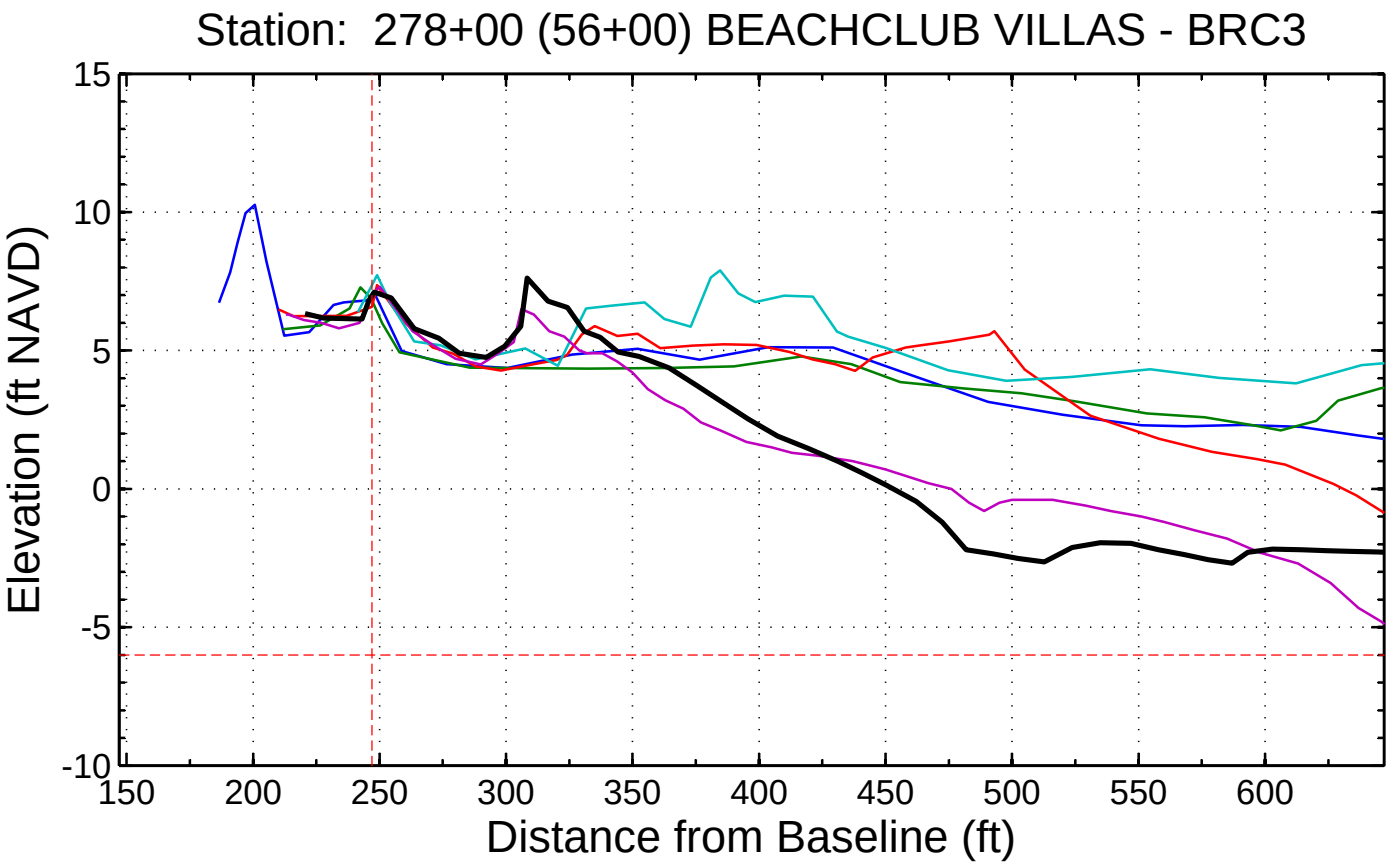
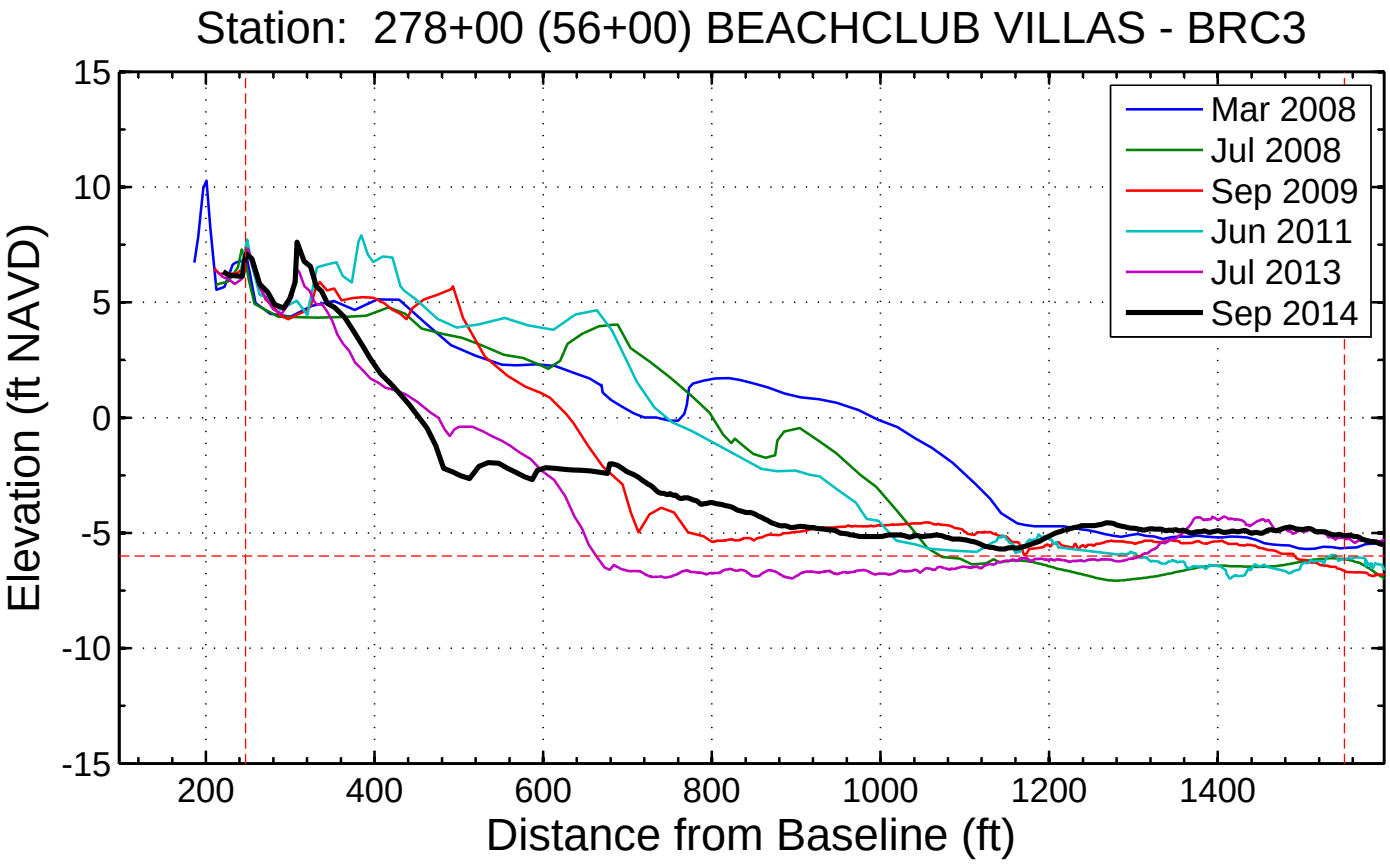
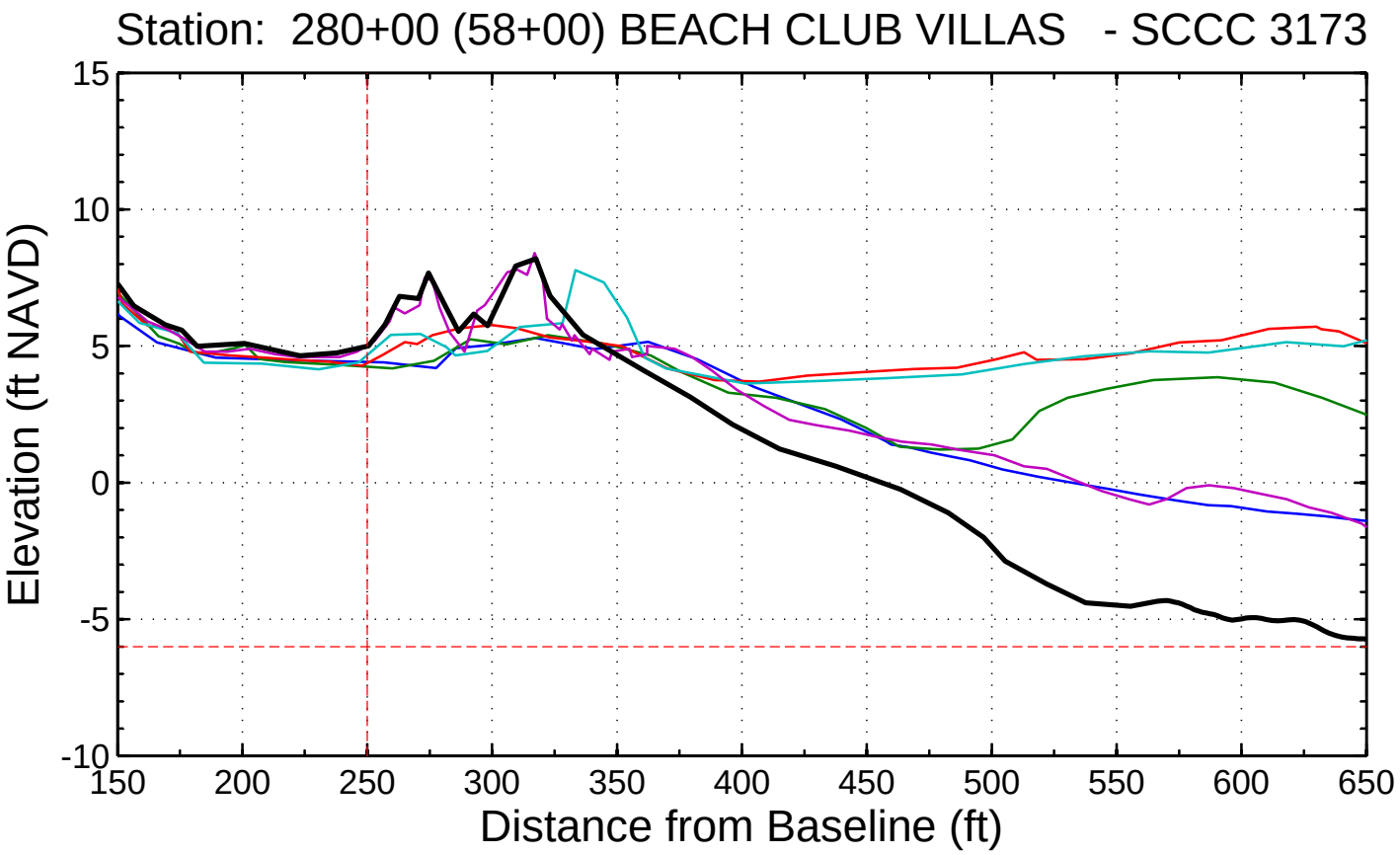
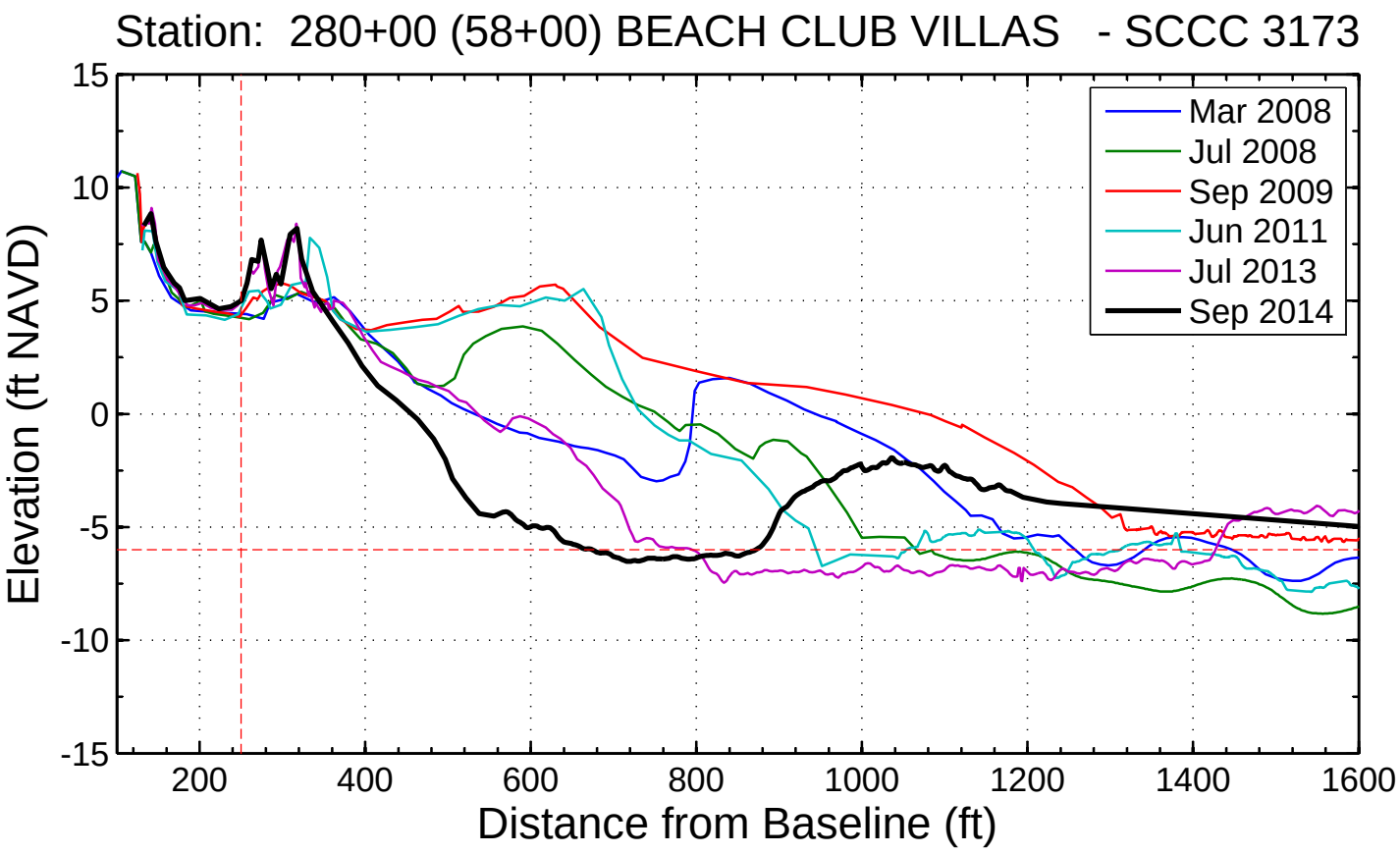
0
-5
-10
200
250
300
350
400
450
500
550
600
650
Distance from Baseline (ft)

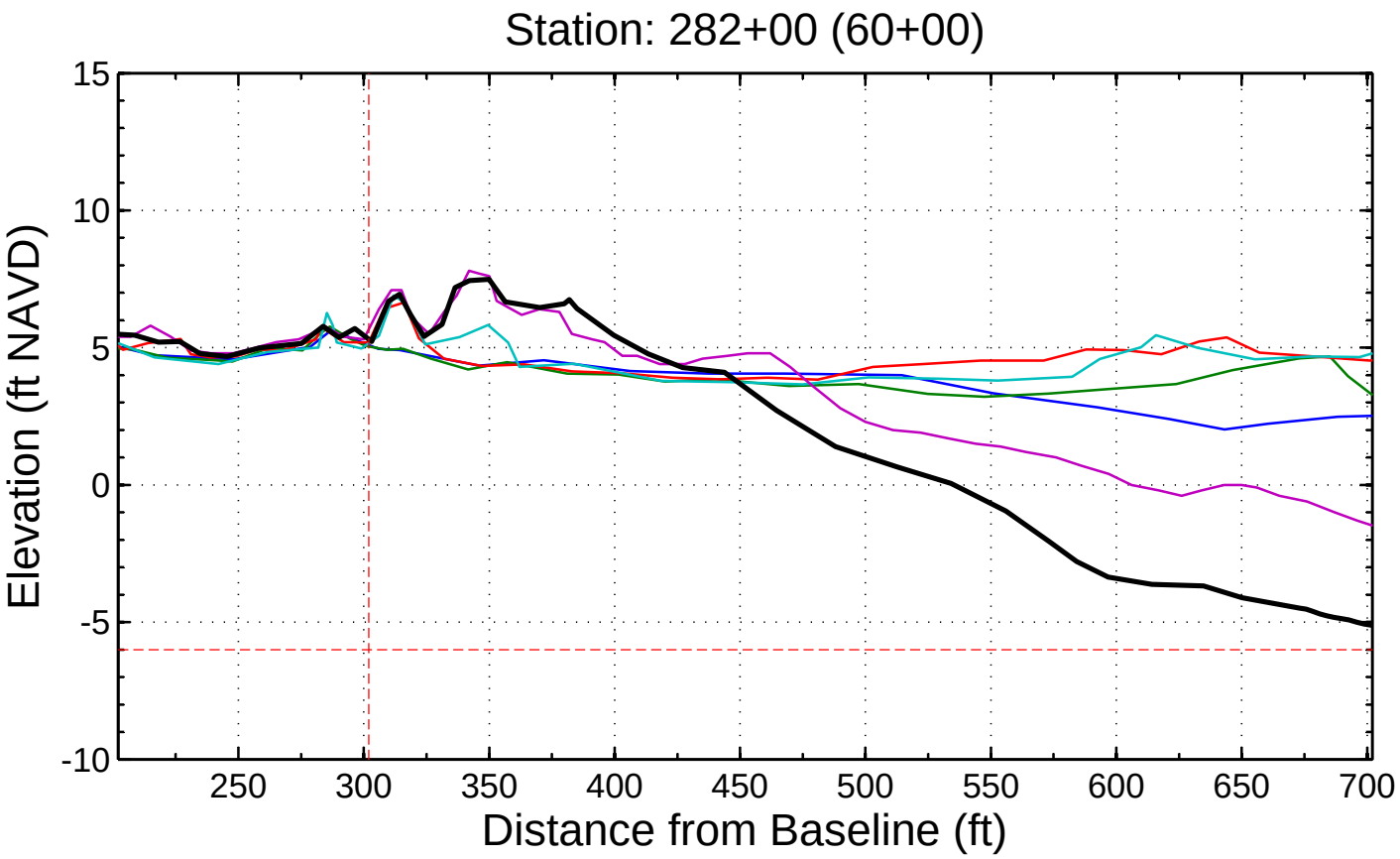

Station: 276+00 (54+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014

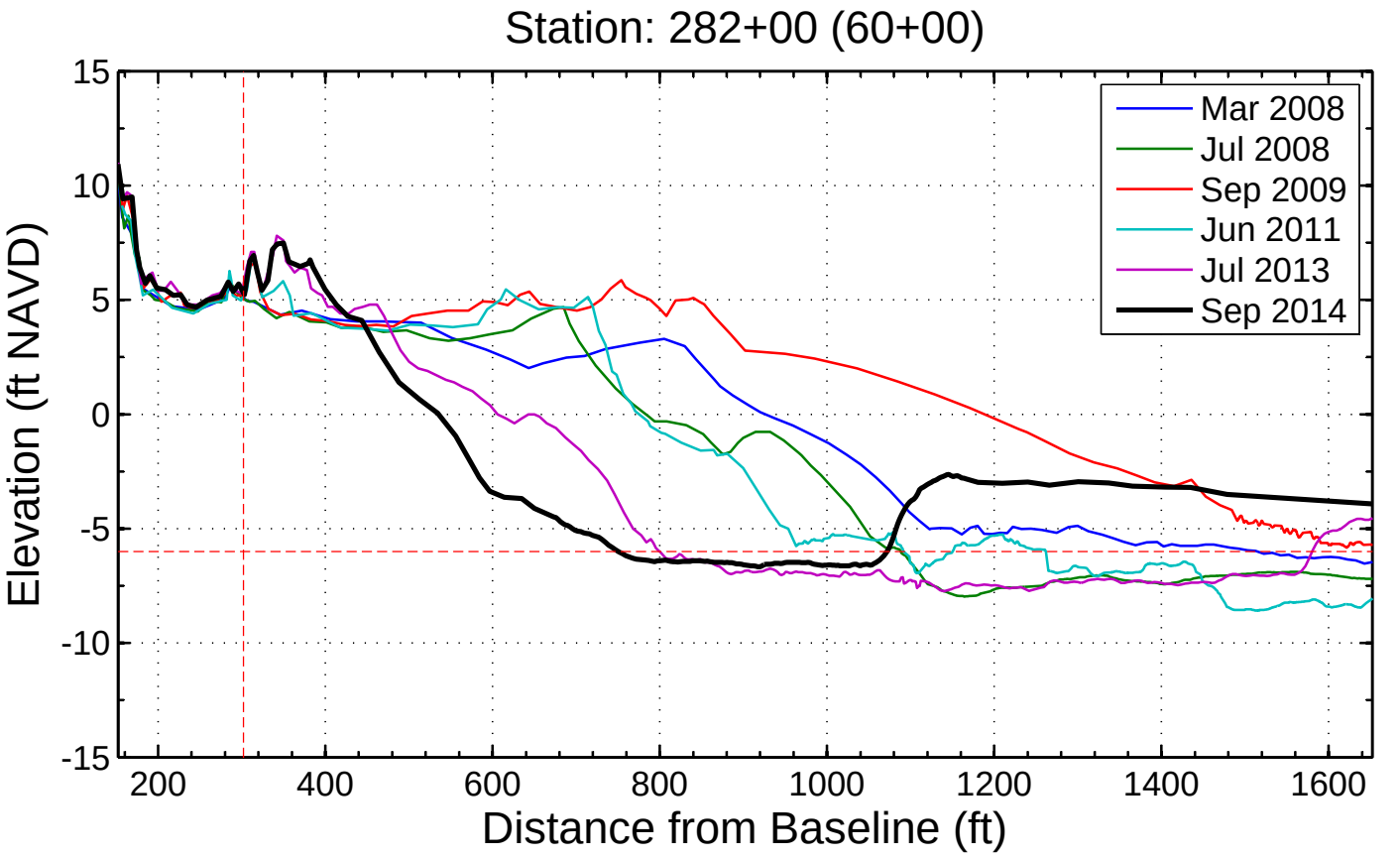

Station: 278+00 (56+00) BEACHCLUB VILLAS - BRC3
Elevation (ft NAVD)
15
10
5
0
-5
-10
150
200
250
300
350
400
450
500
550
600
Distance from Baseline (ft)

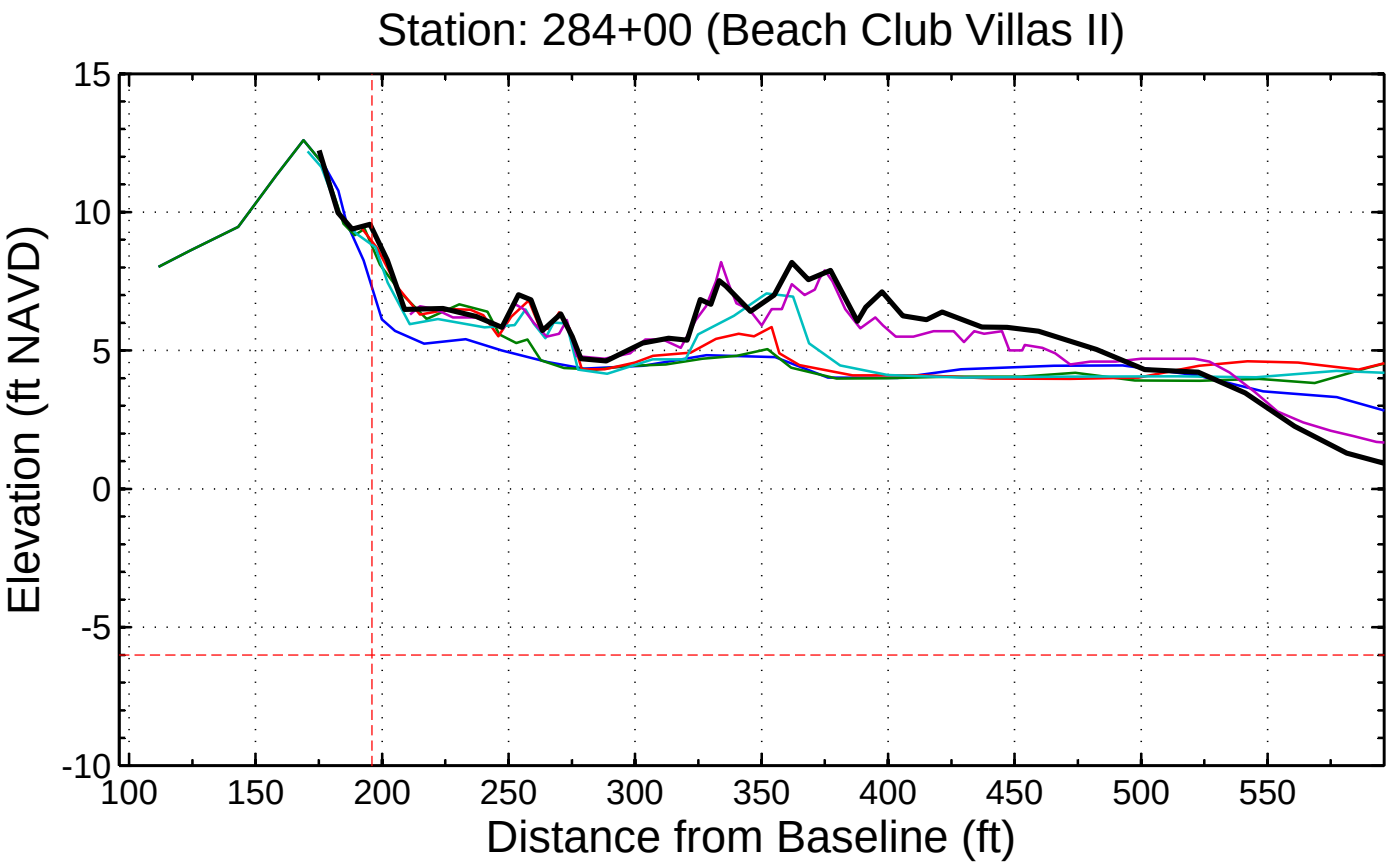

Station: 278+00 (56+00) BEACHCLUB VILLAS - BRC3
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 280+00 (58+00) BEACH CLUB VILLAS - SCCC 3173
Elevation (ft NAVD)
15
10
5
0
-5
-10
150
200
250
300
350
400
450
500
550
600
650
Distance from Baseline (ft)


Station: 280+00 (58+00) BEACH CLUB VILLAS - SCCC 3173
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 282+00 (60+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
250
300
350
400
450
500
550
600
650
700
Distance from Baseline (ft)


Station: 282+00 (60+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 284+00 (Beach Club Villas II)
Elevation (ft NAVD)
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10
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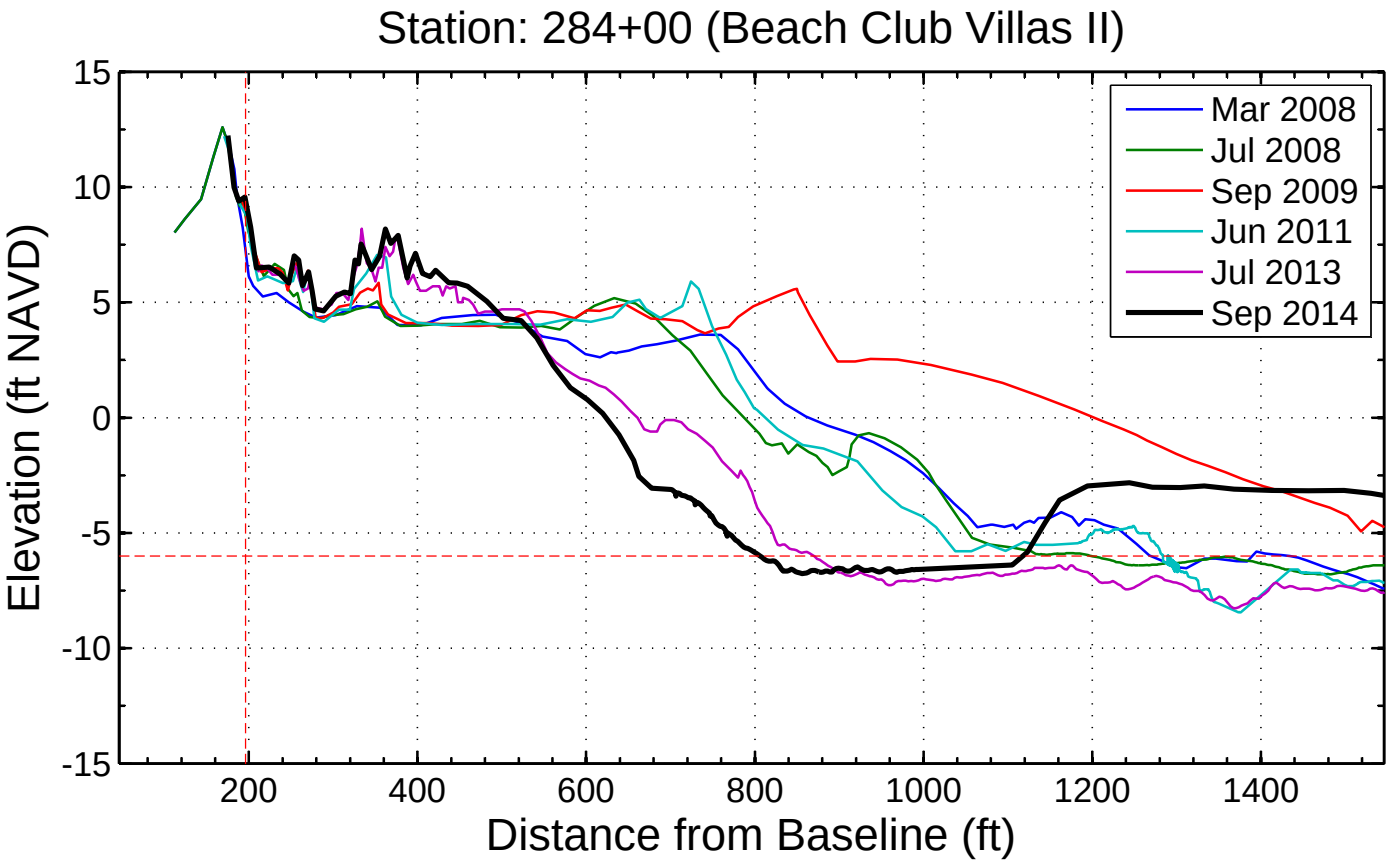
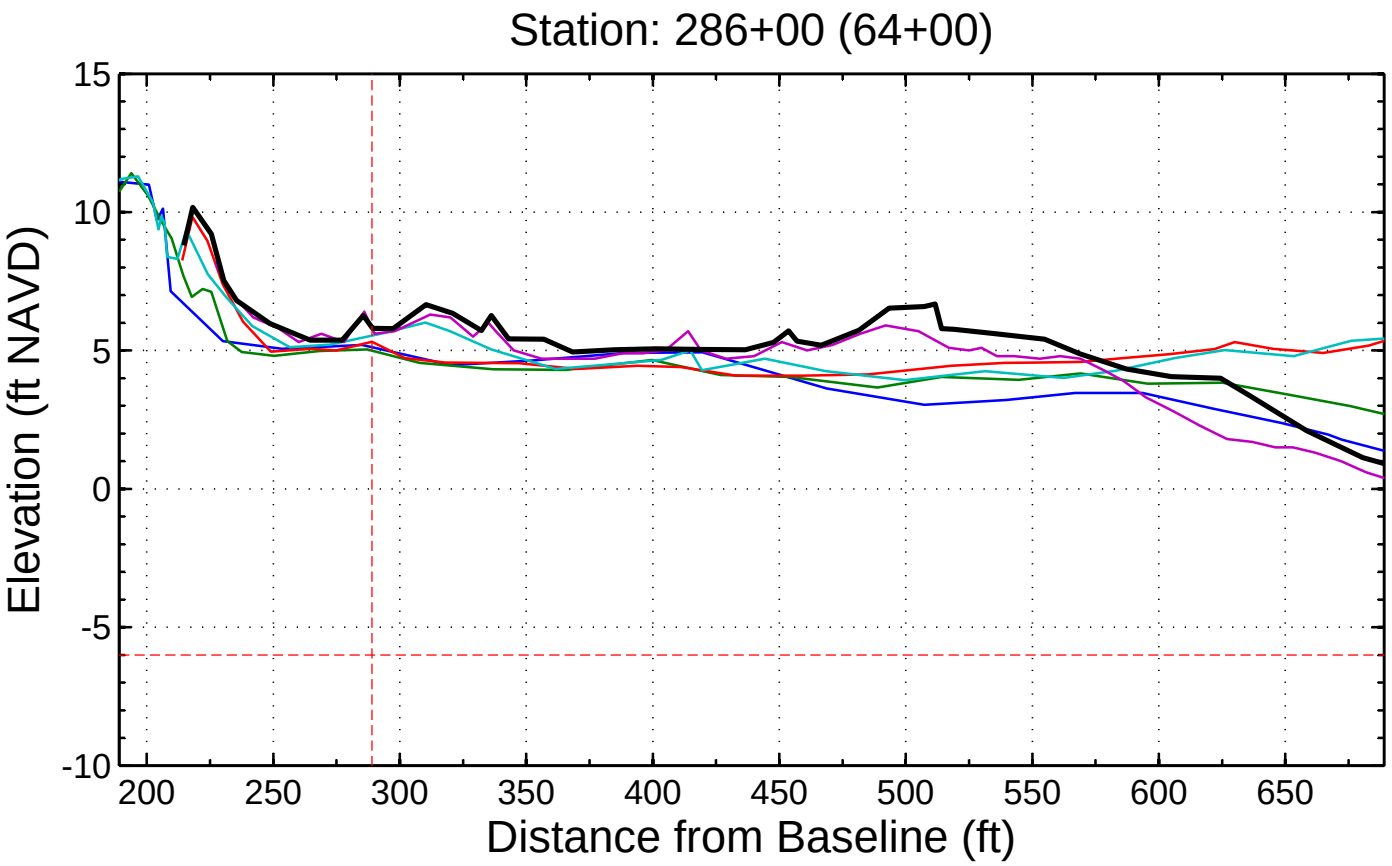
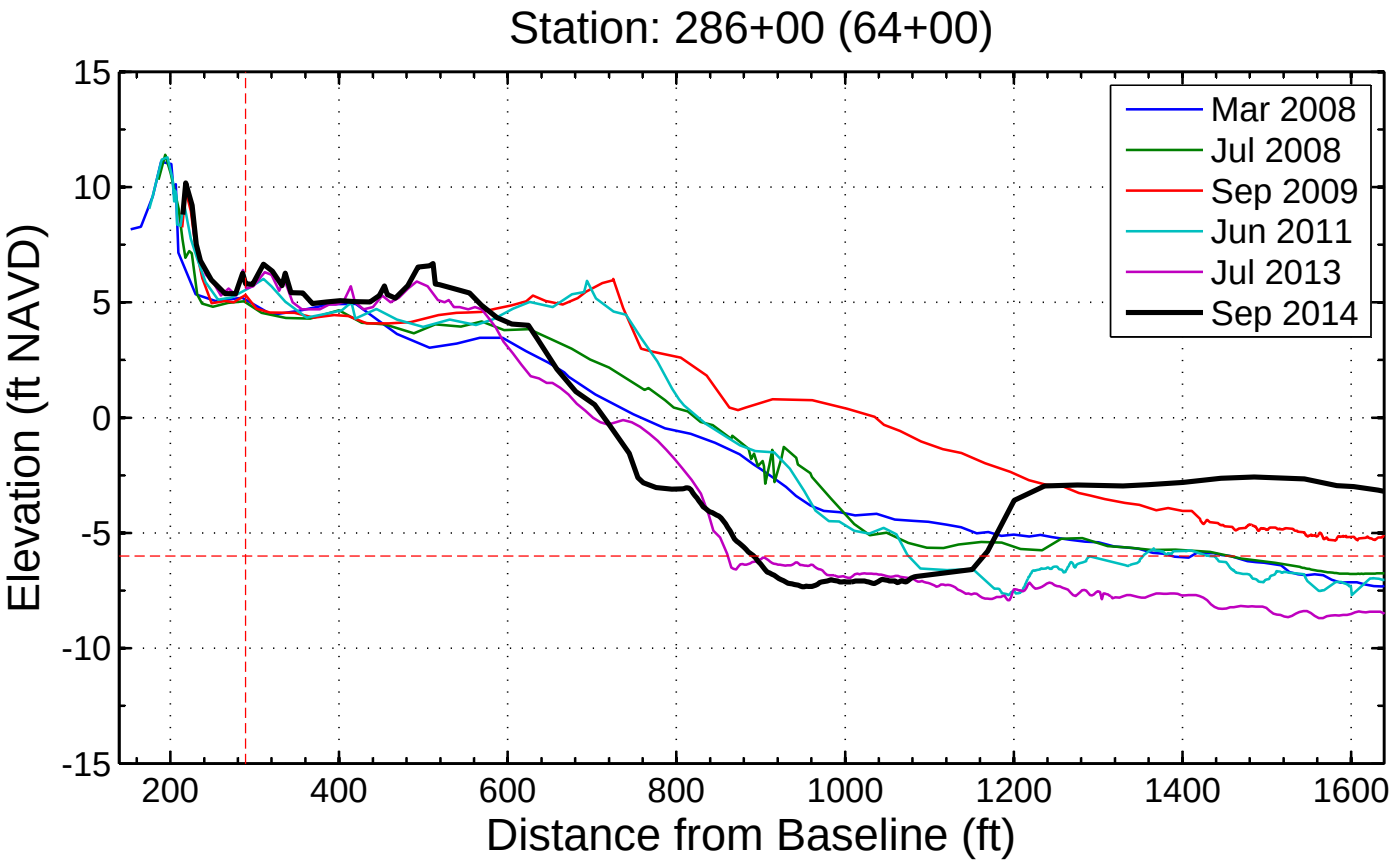
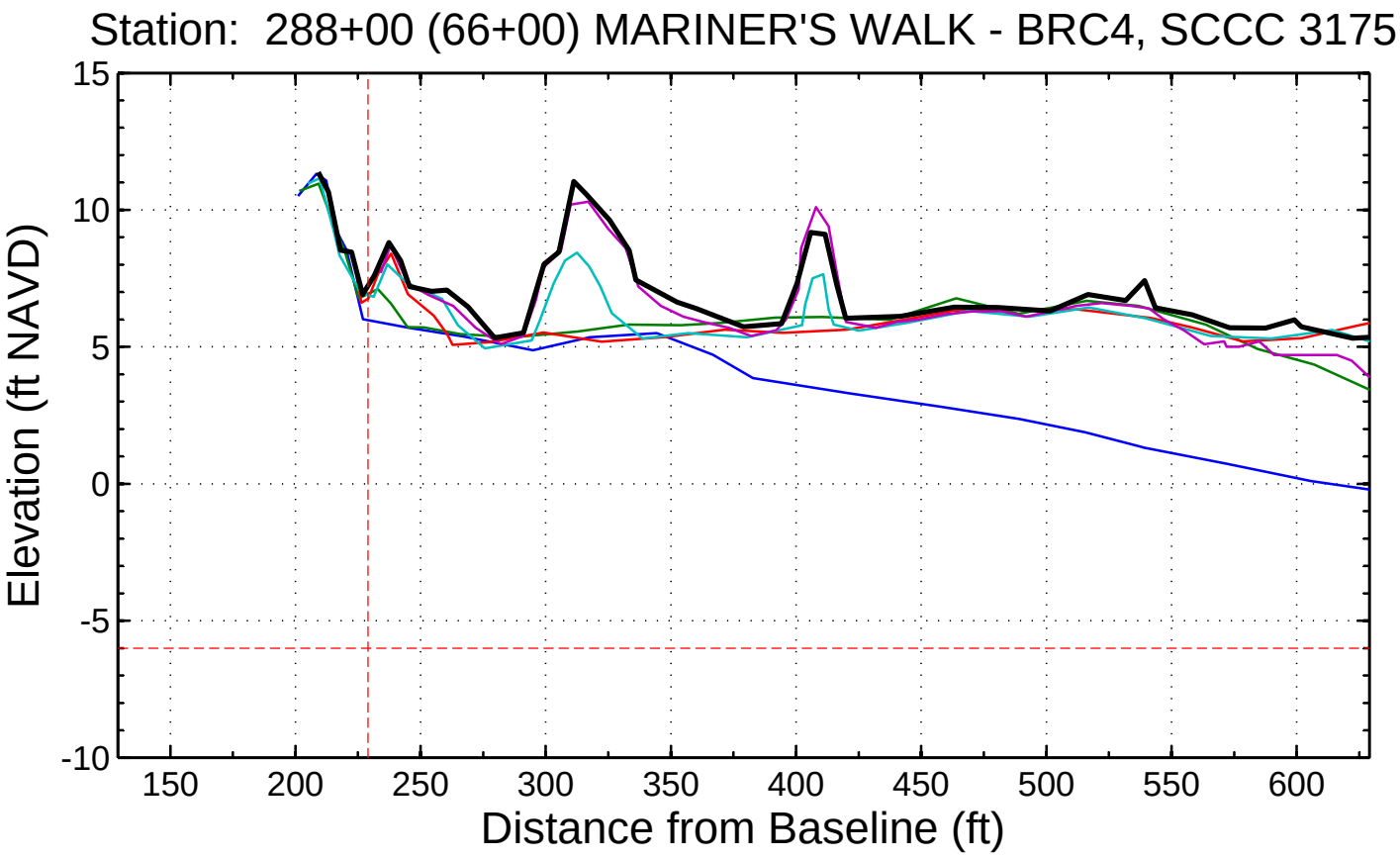
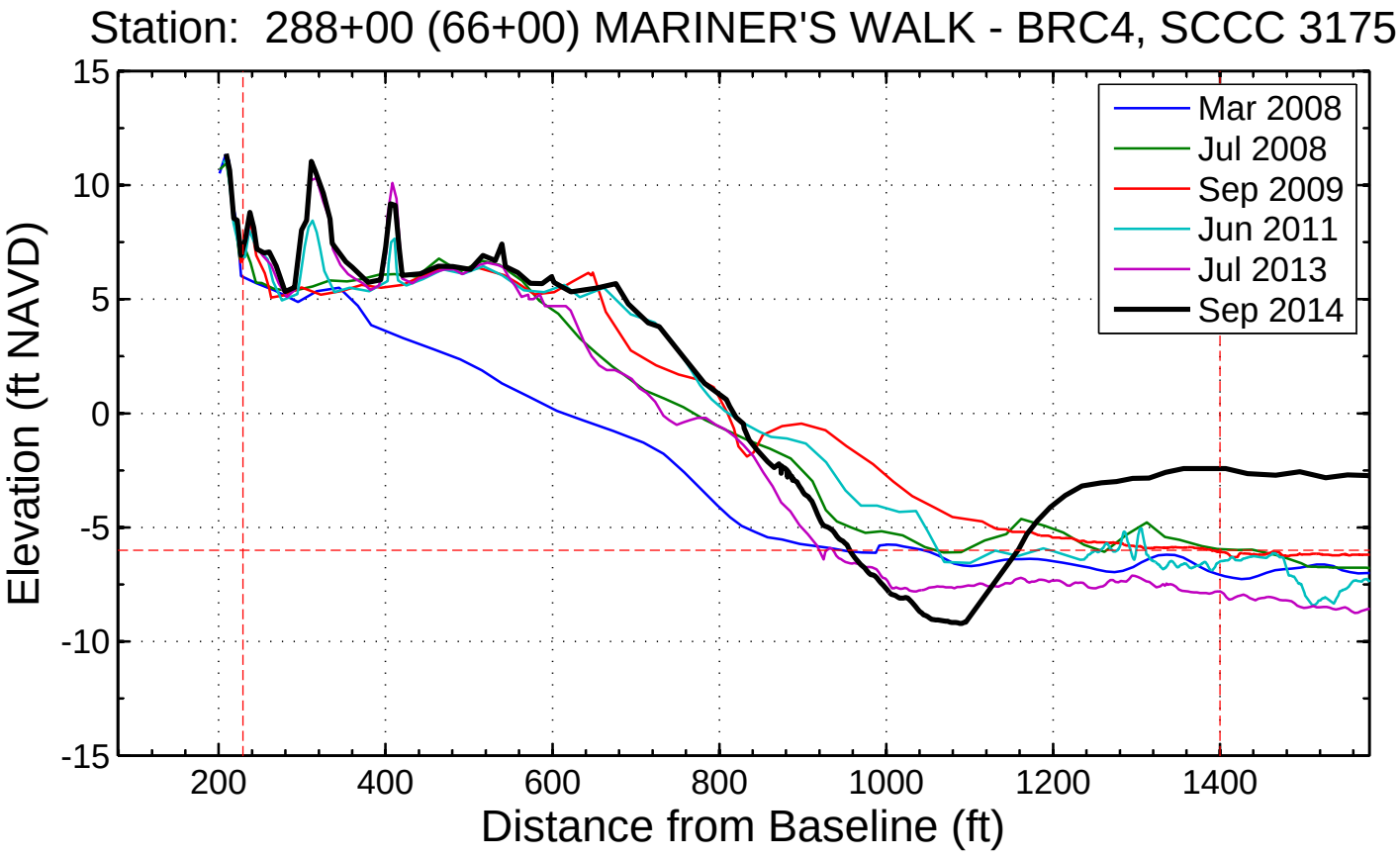
0
-5
-10
100
150
200
250
300
350
400
450
500
550
Distance from Baseline (ft)

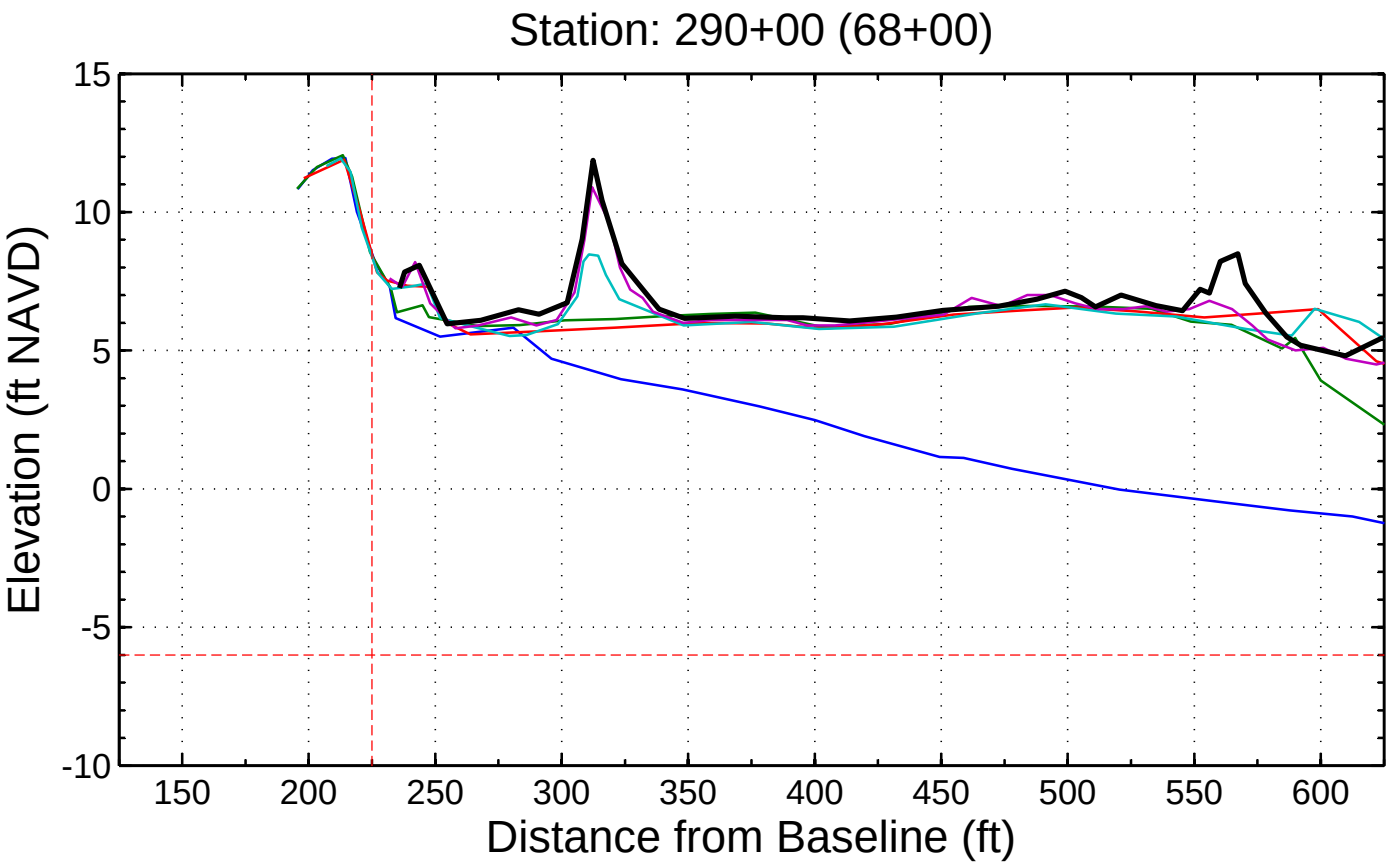

Station: 284+00 (Beach Club Villas II)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 286+00 (64+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
200
250
300
350
400
450
500
550
600
650
Distance from Baseline (ft)


Station: 286+00 (64+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 288+00 (66+00) MARINER'S WALK - BRC4, SCCC 3175
Elevation (ft NAVD)
15
10
5
0
-5
-10
150
200
250
300
350
400
450
500
550
600
Distance from Baseline (ft)


Station: 288+00 (66+00) MARINER'S WALK - BRC4, SCCC 3175
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 290+00 (68+00)
Elevation (ft NAVD)
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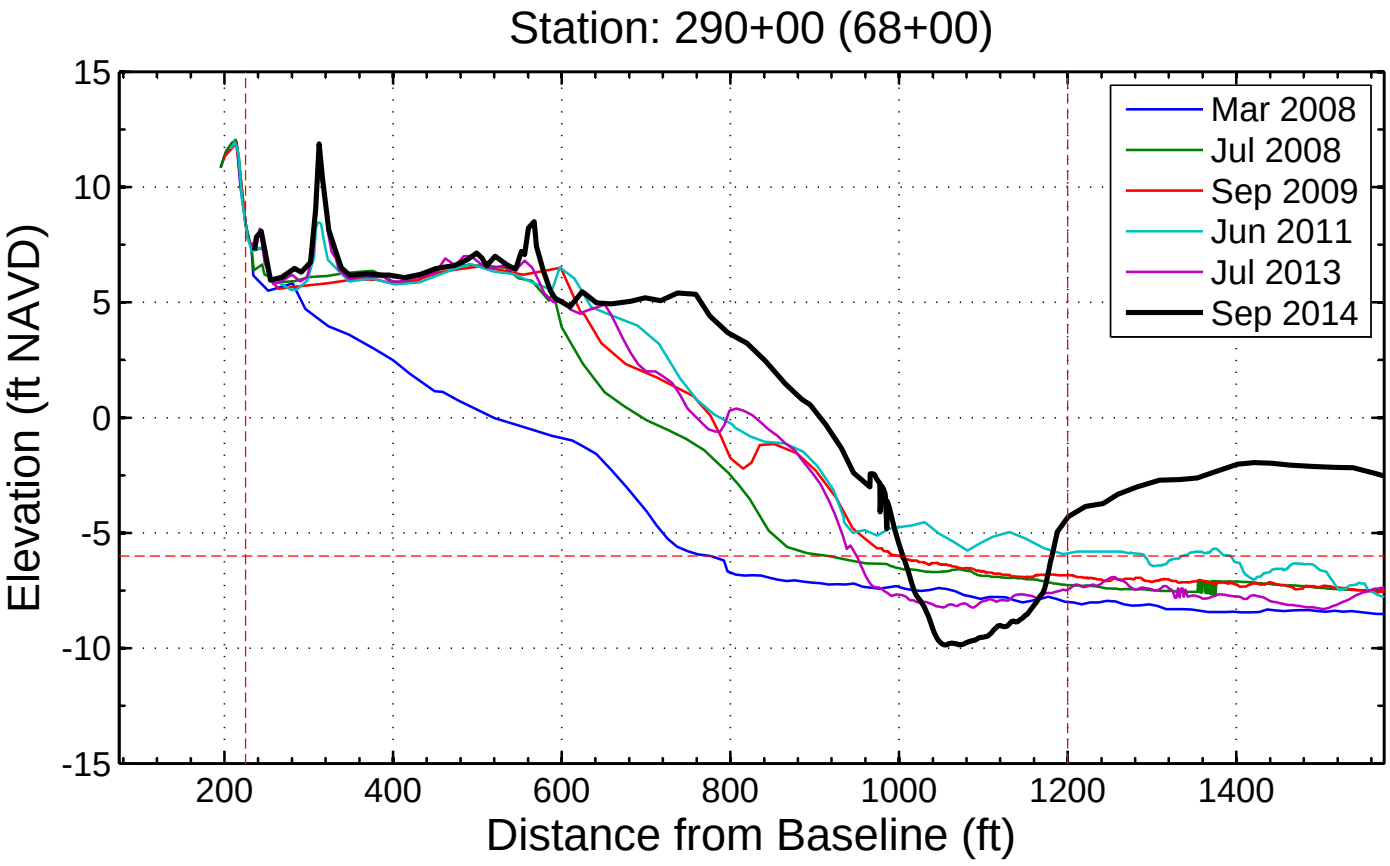
0
-5
-10
150
200
250
300
350
400
450
500
550
600
Distance from Baseline (ft)


Station: 290+00 (68+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
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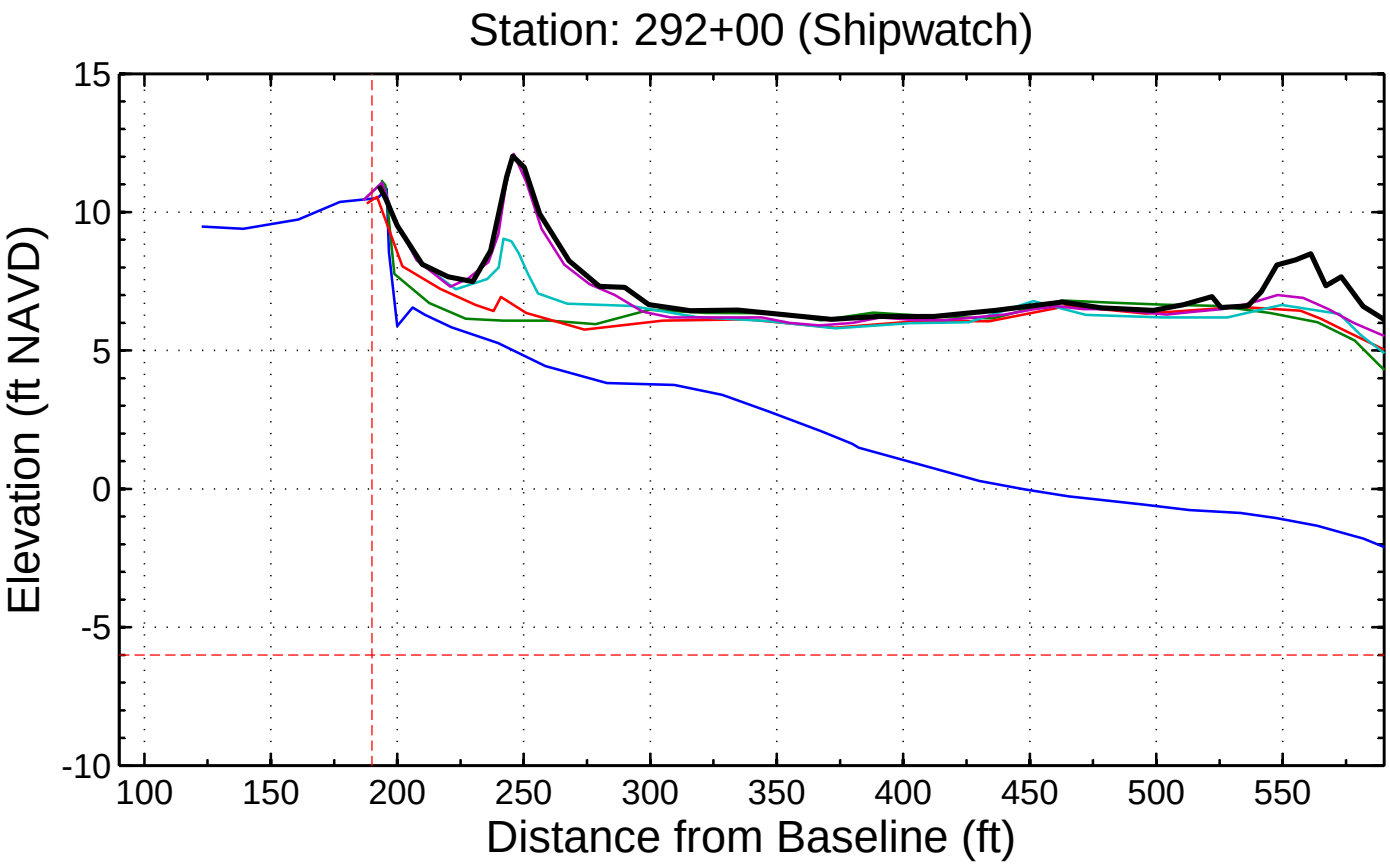
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 292+00 (Shipwatch)
Elevation (ft NAVD)
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10
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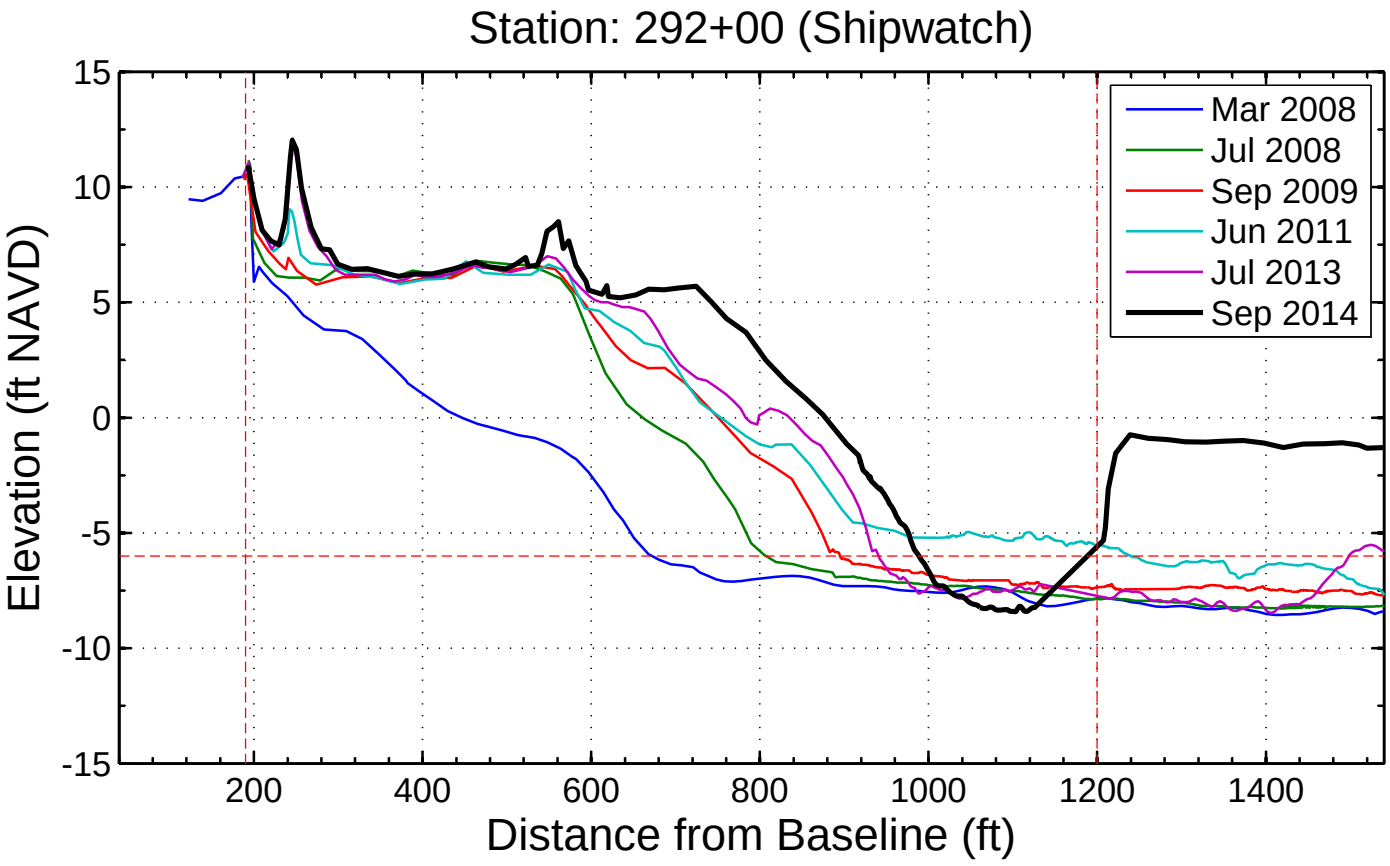
0
-5
-10
100
150
200
250
300
350
400
450
500
550
Distance from Baseline (ft)


Station: 292+00 (Shipwatch)
Elevation (ft NAVD)
15
10
5
0
-5
-10
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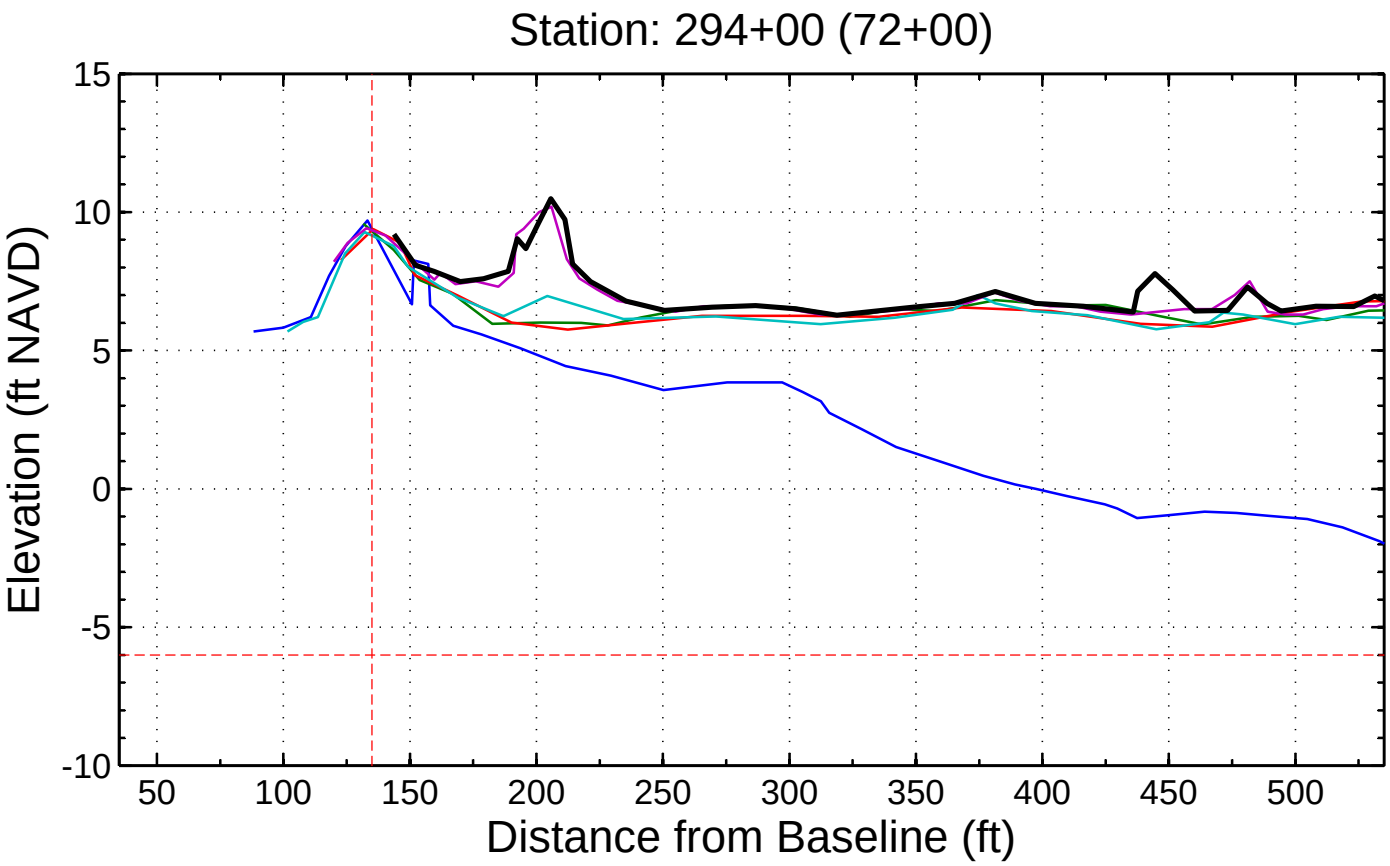
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 294+00 (72+00)
Elevation (ft NAVD)
15
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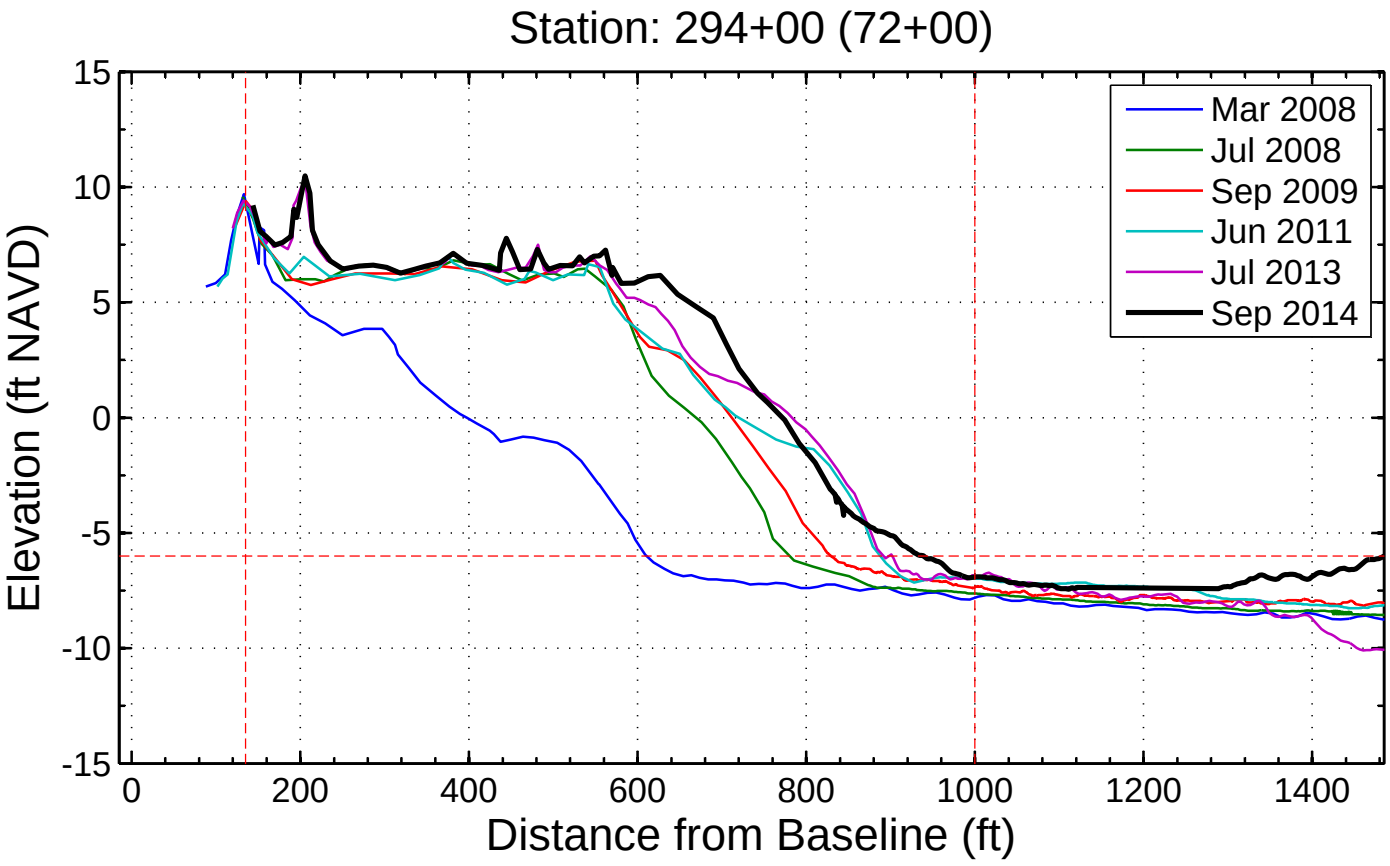
0
-5
-10
50
100
150
200
250
300
350
400
450
500
Distance from Baseline (ft)


Station: 294+00 (72+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
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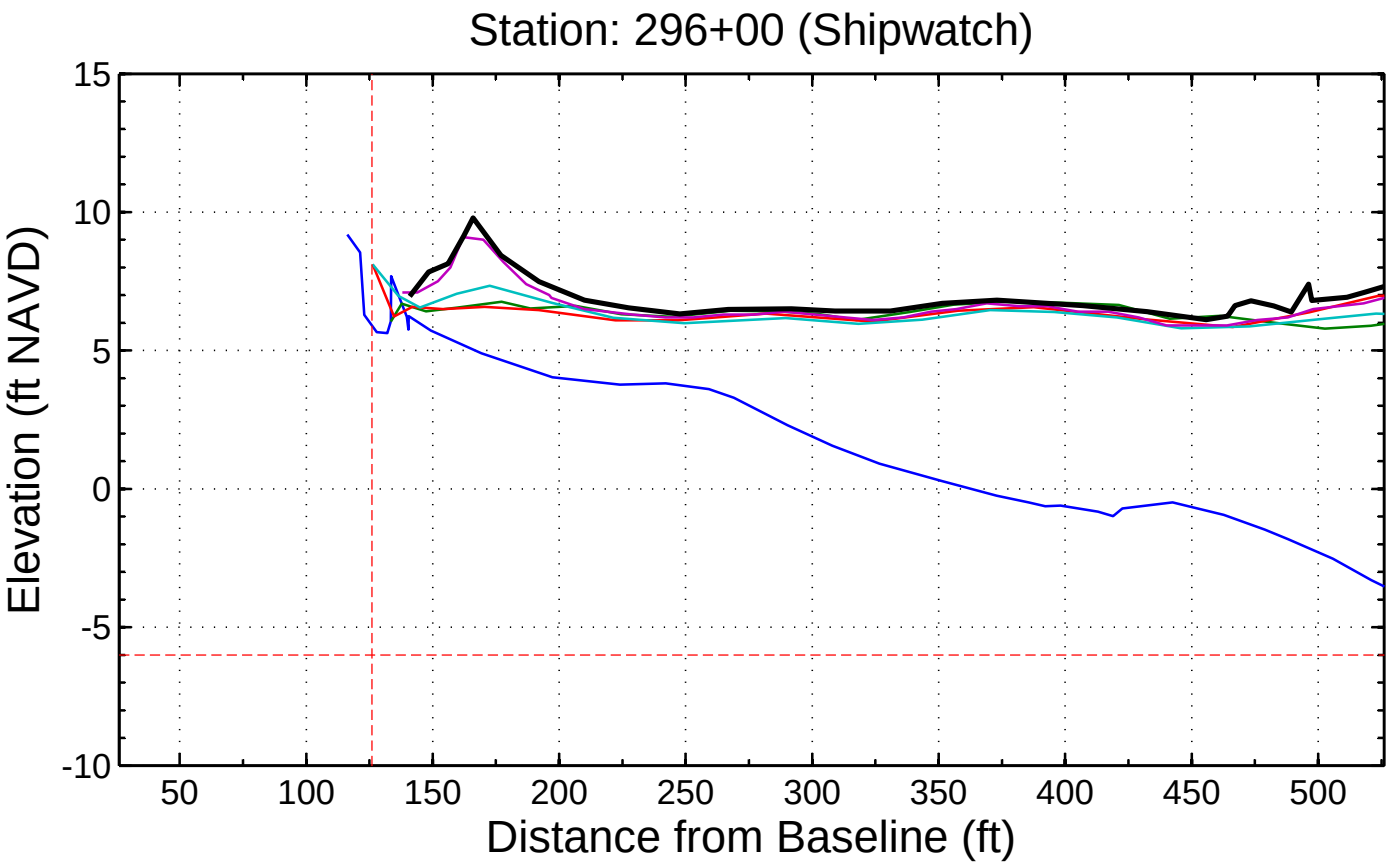
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 296+00 (Shipwatch)
Elevation (ft NAVD)
15
10
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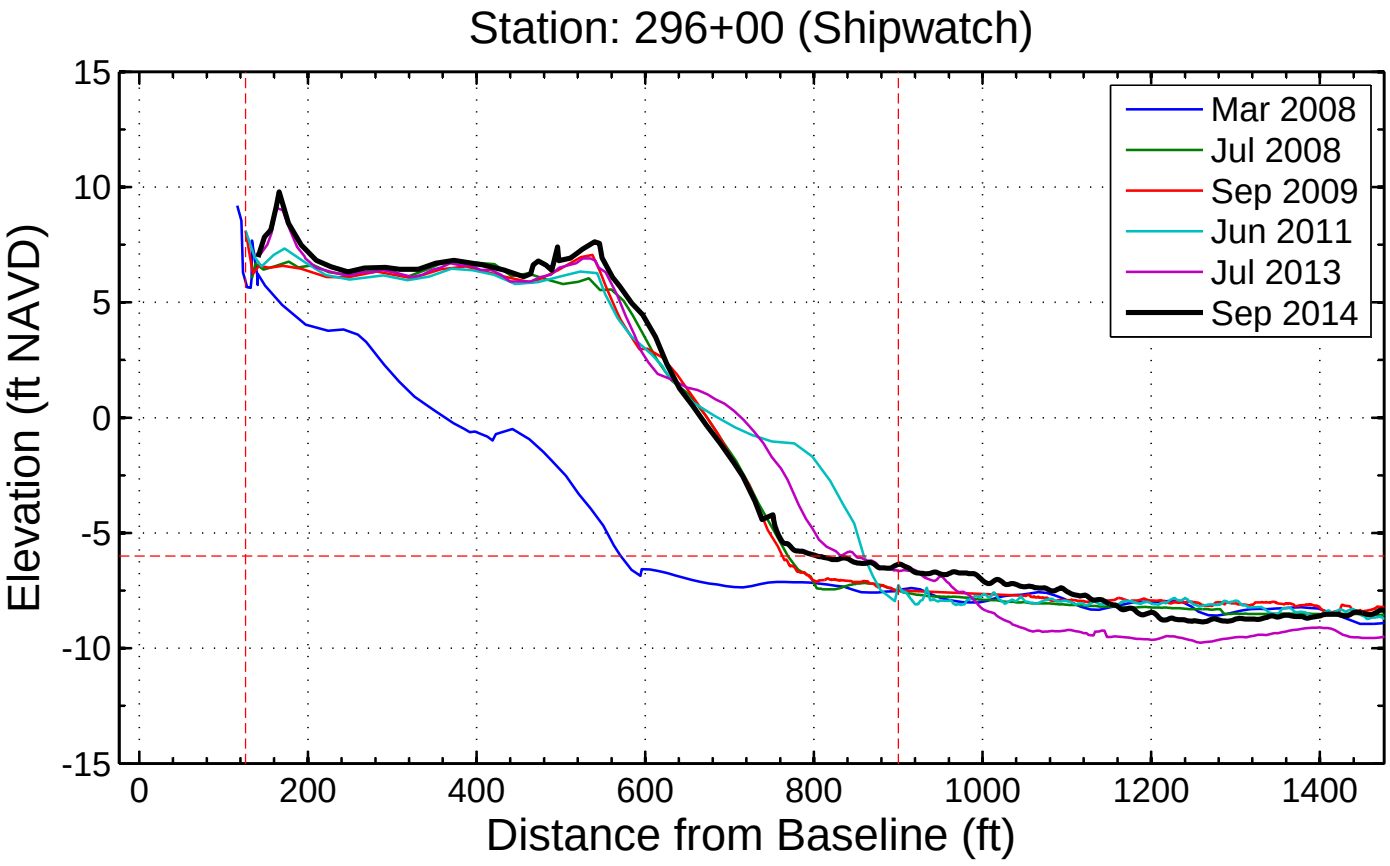
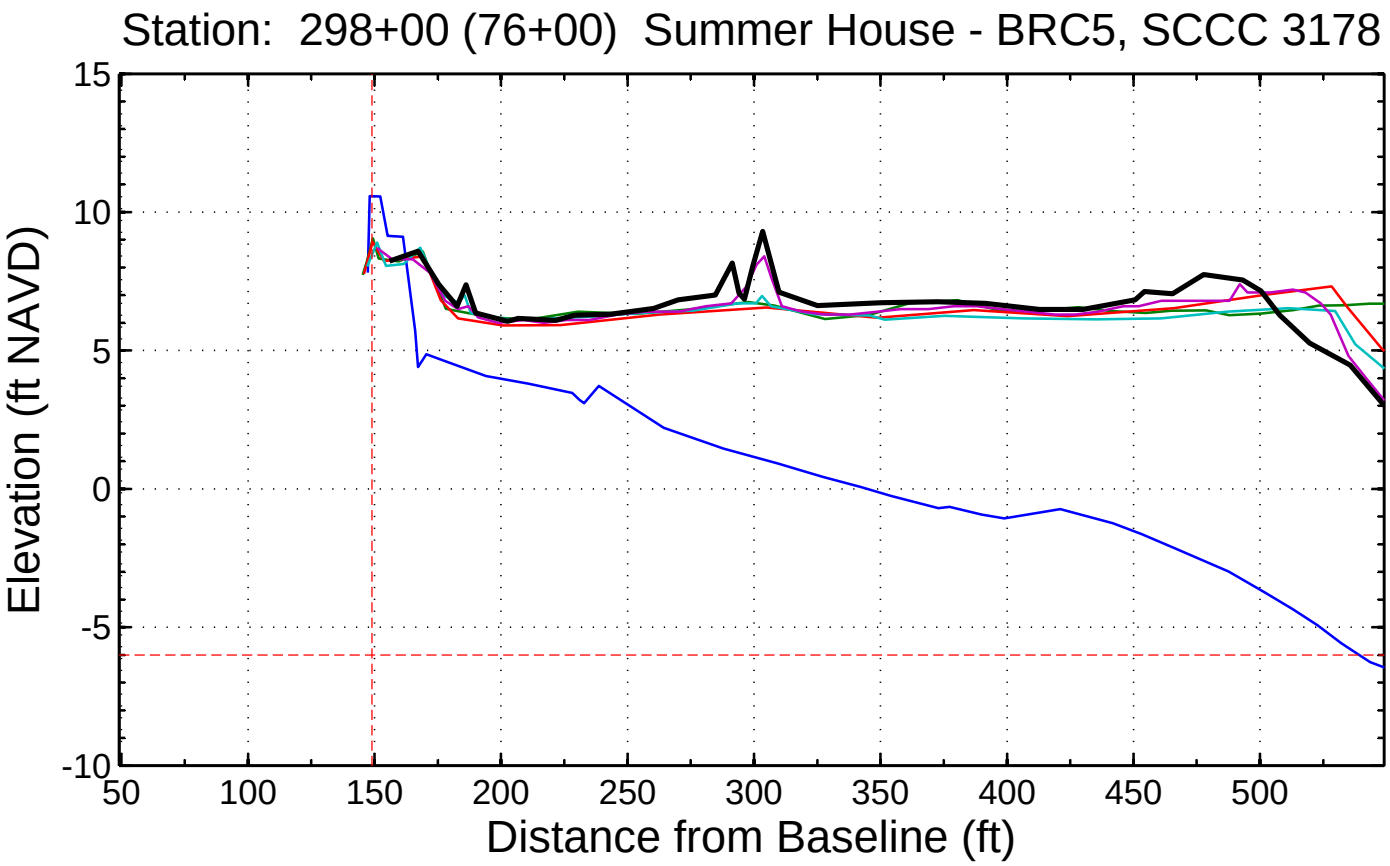
0
-5
-10
50
100
150
200
250
300
350
400
450
500
Distance from Baseline (ft)


Station: 296+00 (Shipwatch)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 298+00 (76+00) Summer House - BRC5, SCCC 3178
Elevation (ft NAVD)
15
10
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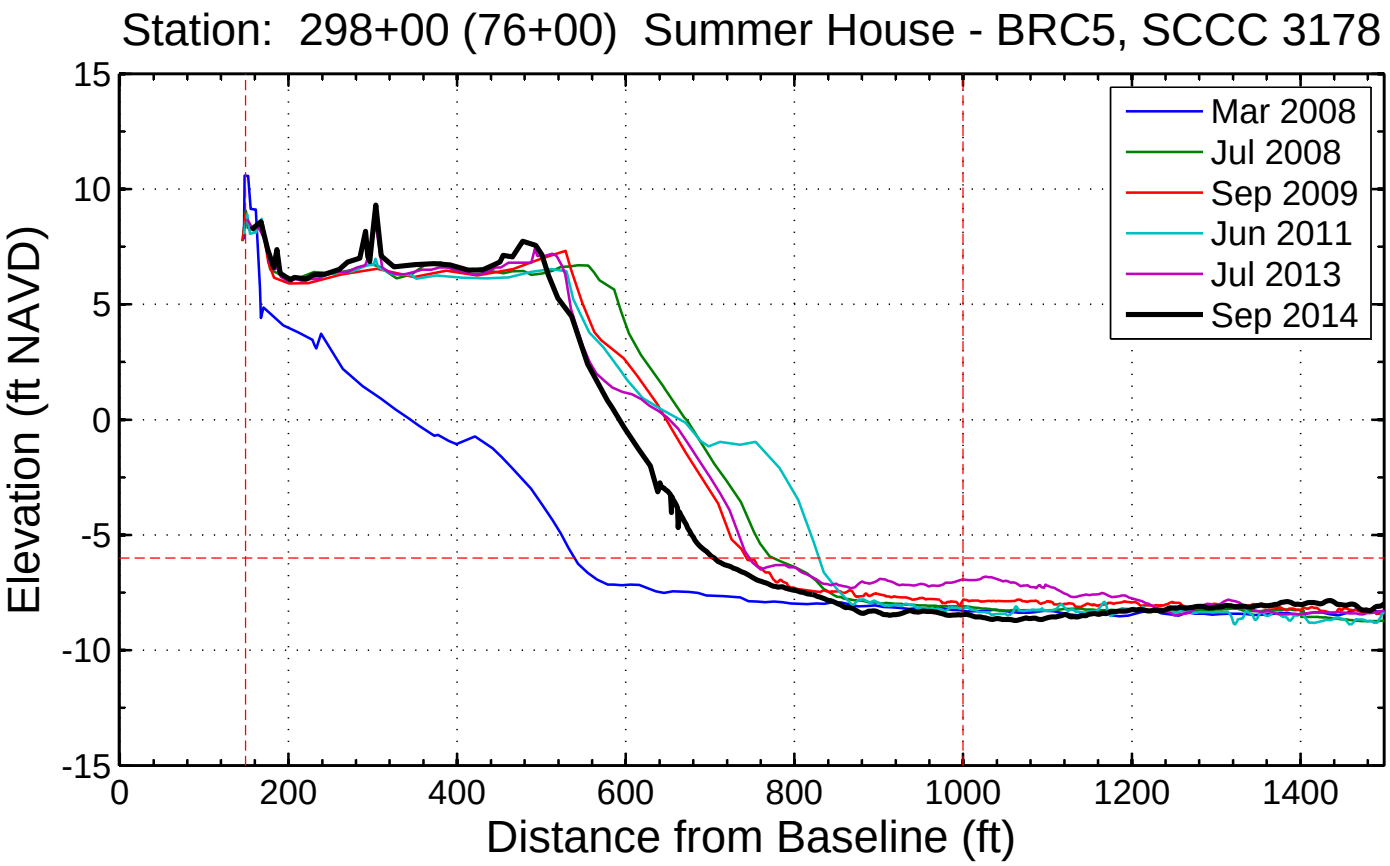
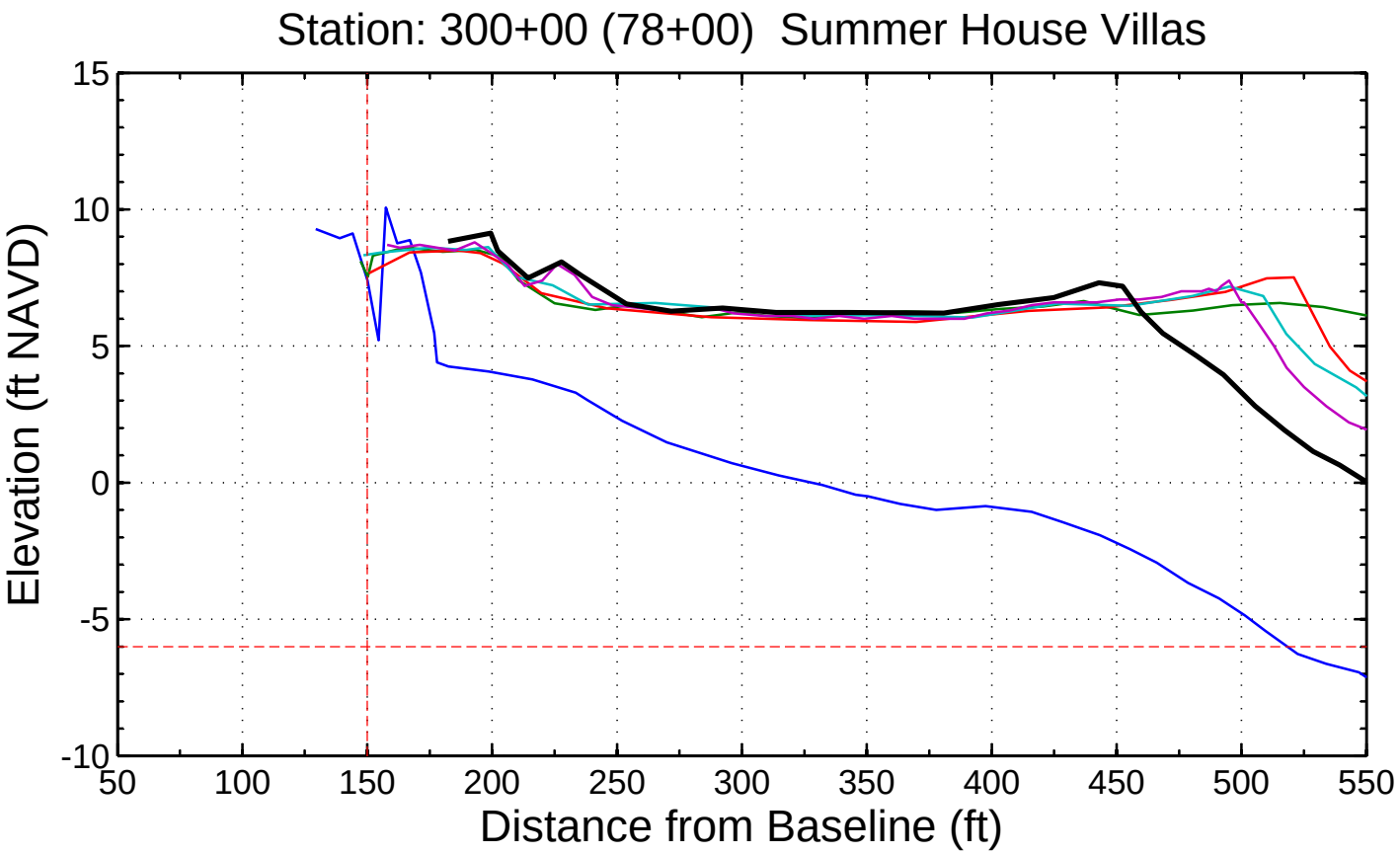
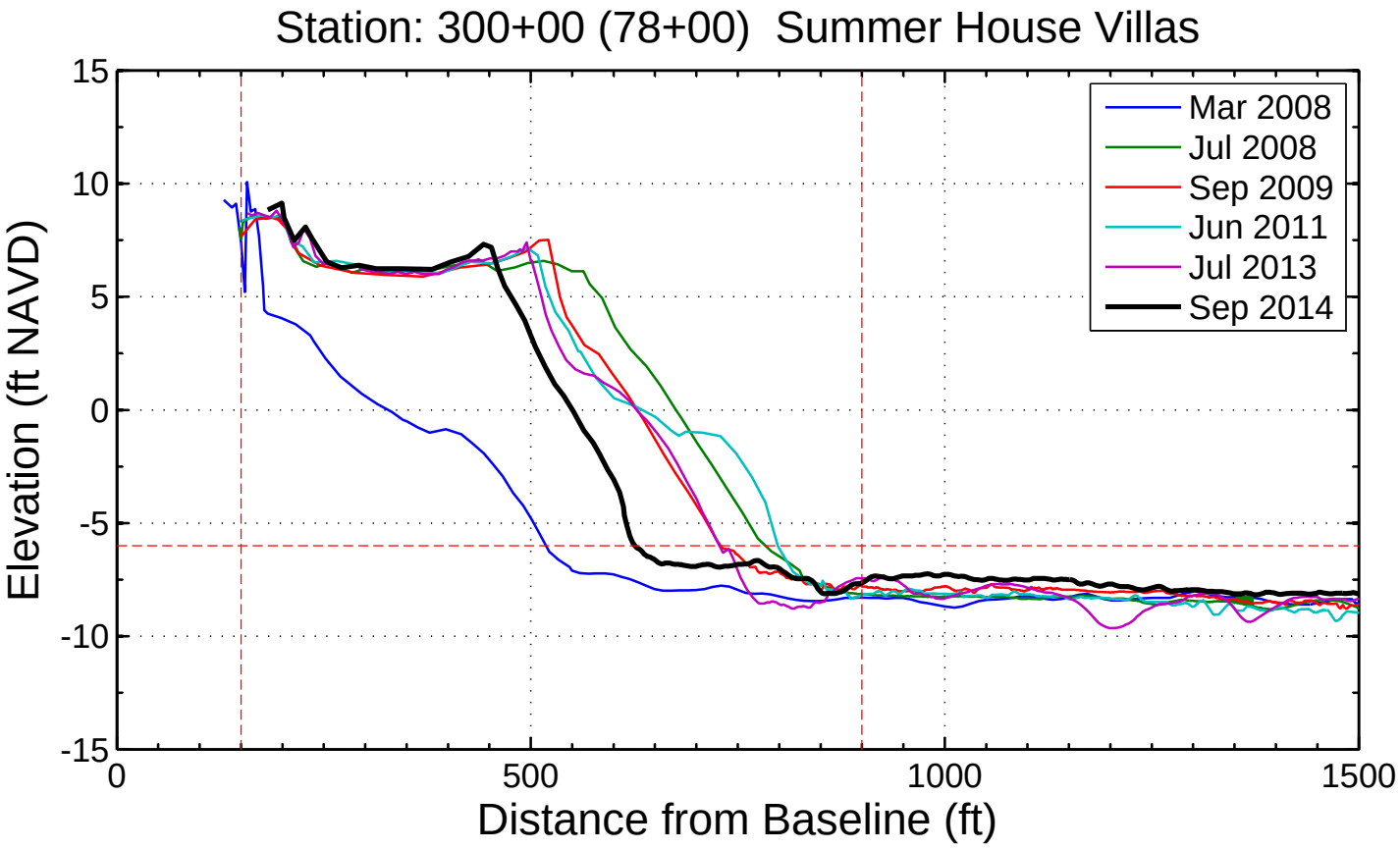
0
-5
-10
50
100
150
200
250
300
350
400
450
500
Distance from Baseline (ft)


Station: 298+00 (76+00) Summer House - BRC5, SCCC 3178
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
0
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 300+00 (78+00) Summer House Villas
Elevation (ft NAVD)
Distance from Baseline (ft)
15
10
5
0
-5
-10
50
100
150
200
250
300
350
400
450
500
550


Station: 300+00 (78+00) Summer House Villas
Elevation (ft NAVD)
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014
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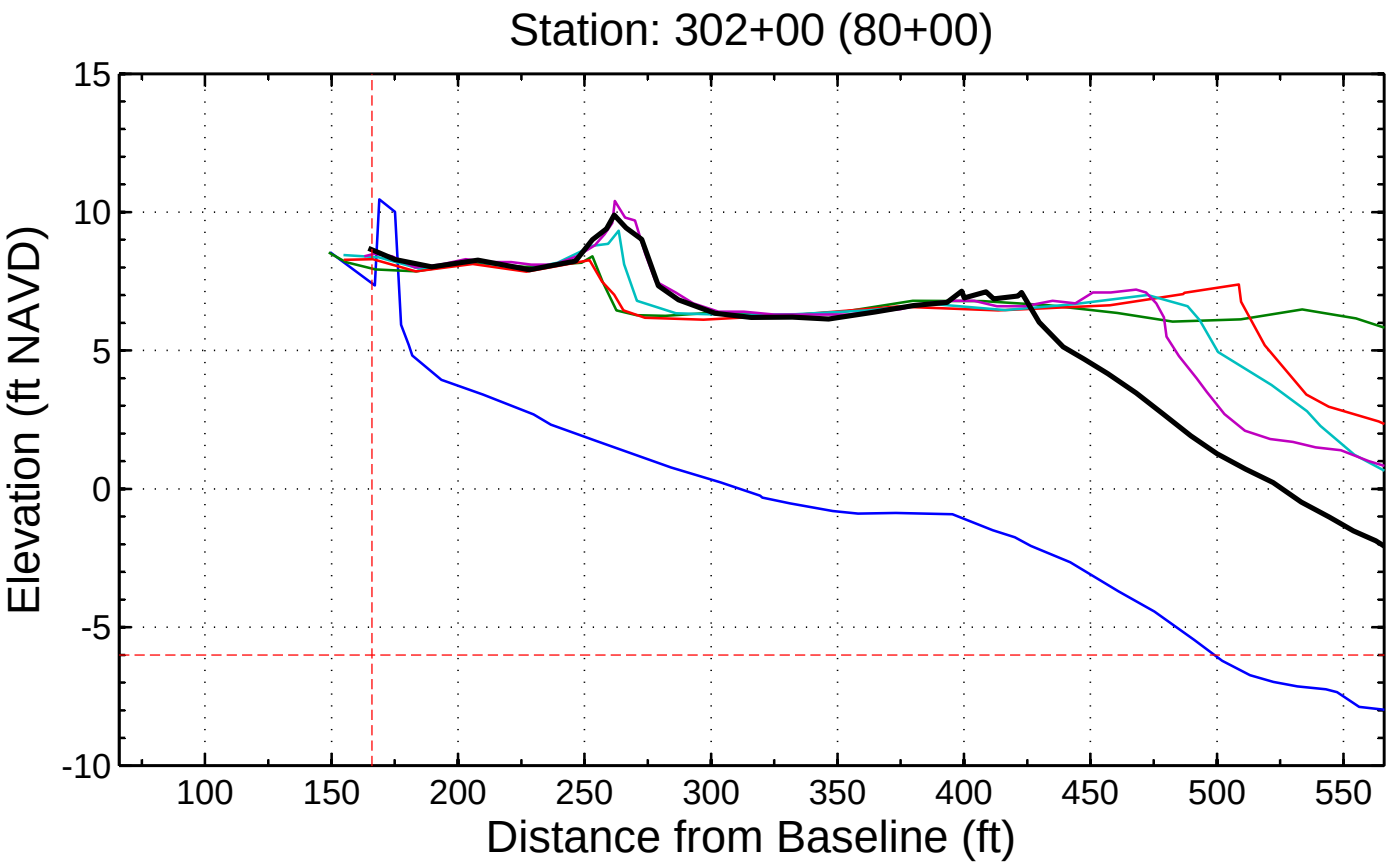
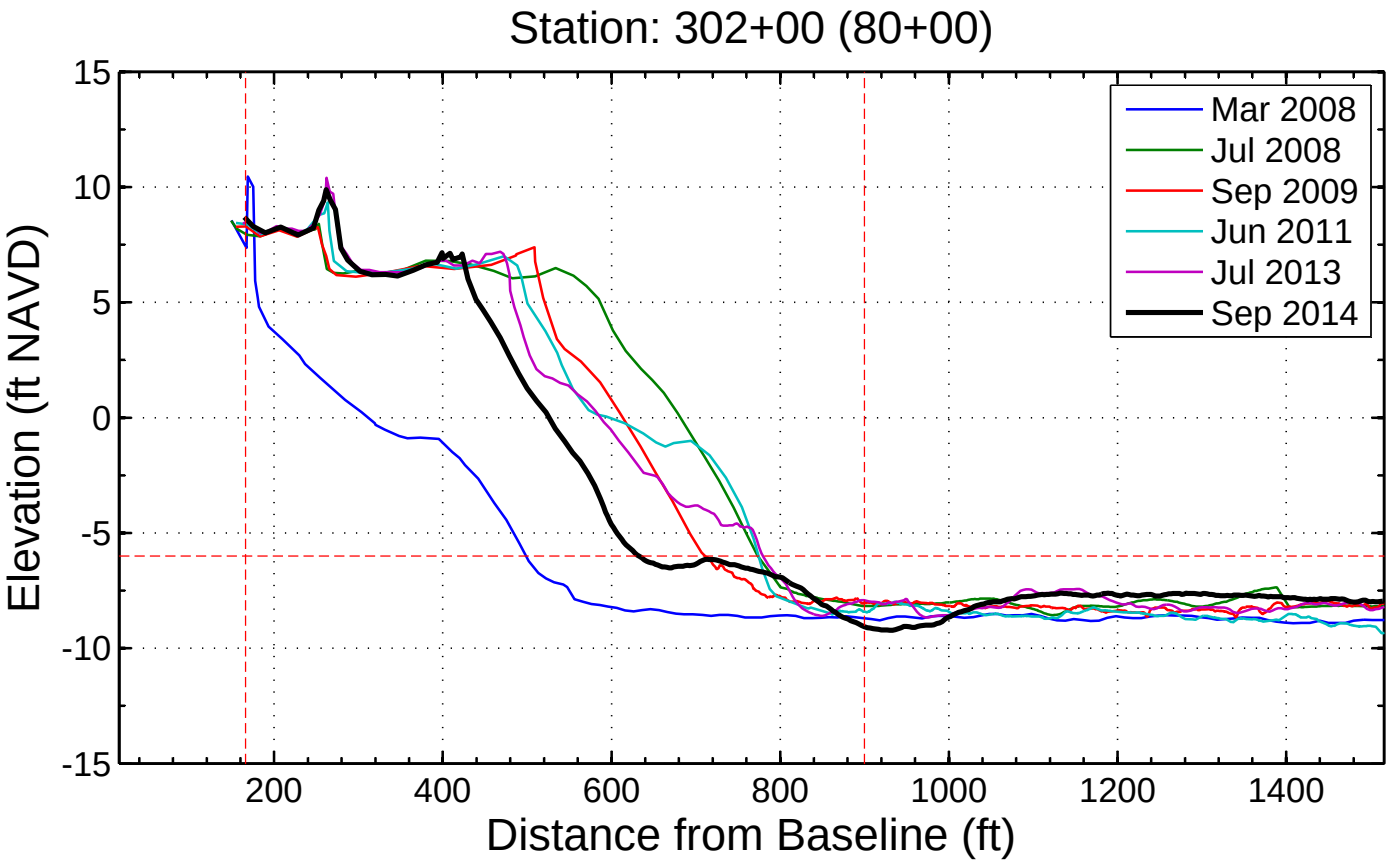
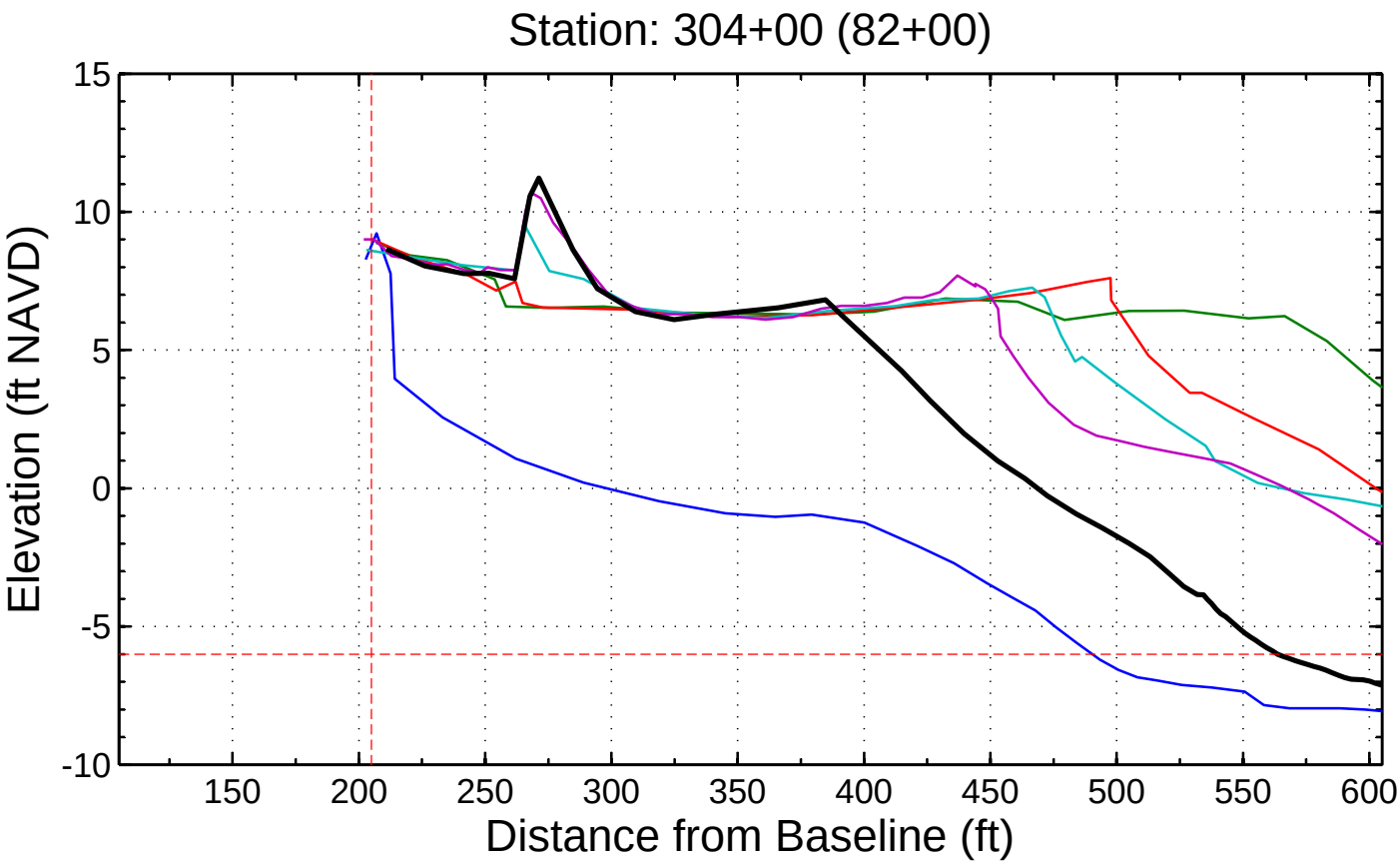
5
0
-5
-10
-15
0
500
1000
1500


Station: 302+00 (80+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
100
150
200
250
300
350
400
450
500
550
Distance from Baseline (ft)


Station: 302+00 (80+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 304+00 (82+00)
Elevation (ft NAVD)
15
10
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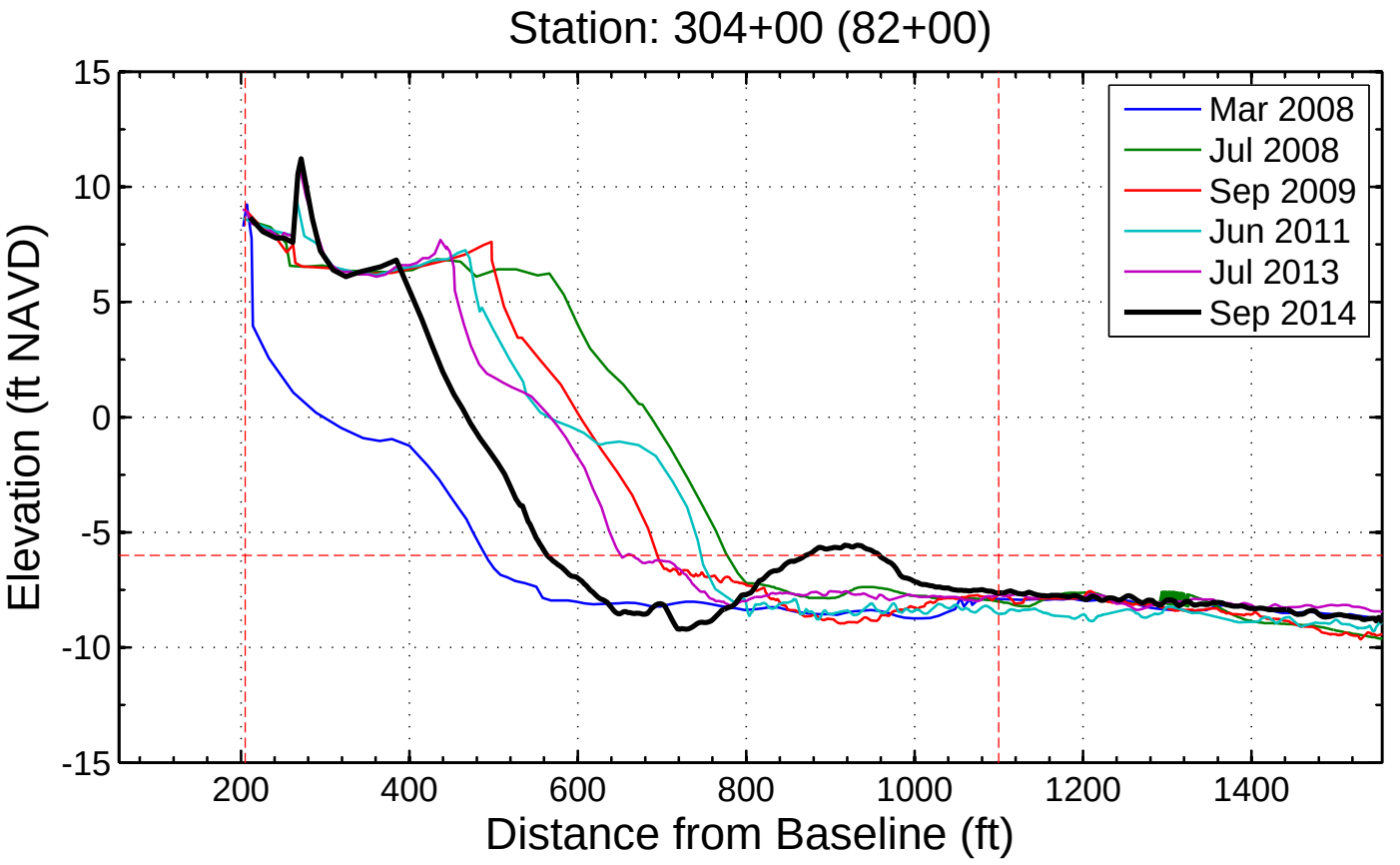
0
-5
-10
150
200
250
300
350
400
450
500
550
600
Distance from Baseline (ft)


Station: 304+00 (82+00)
Elevation (ft NAVD)
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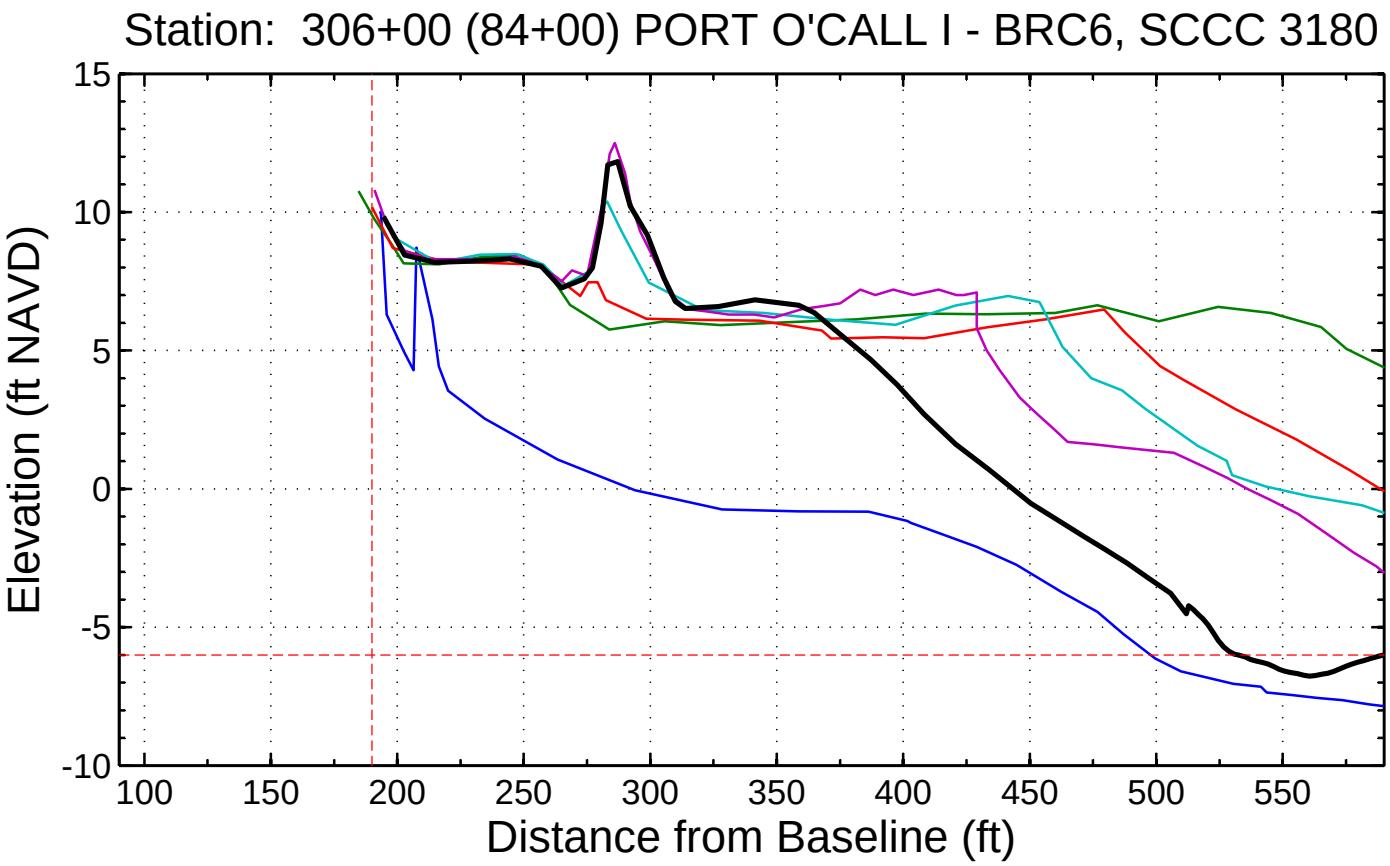
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 306+00 (84+00) PORT O'CALL I - BRC6, SCCC 3180
Elevation (ft NAVD)
15
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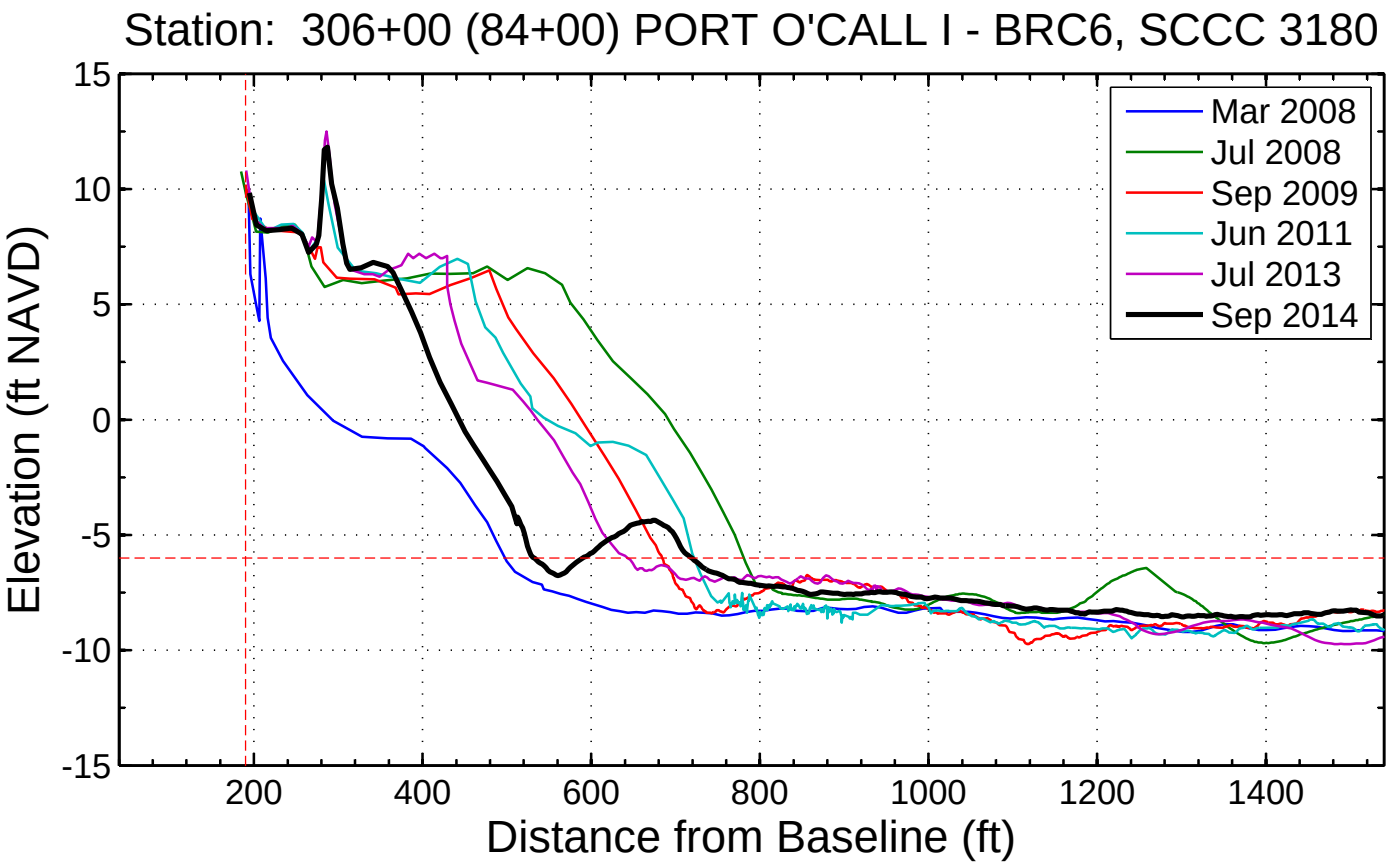
0
-5
-10
100
150
200
250
300
350
400
450
500
550
Distance from Baseline (ft)


Station: 306+00 (84+00) PORT O'CALL I - BRC6, SCCC 3180
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
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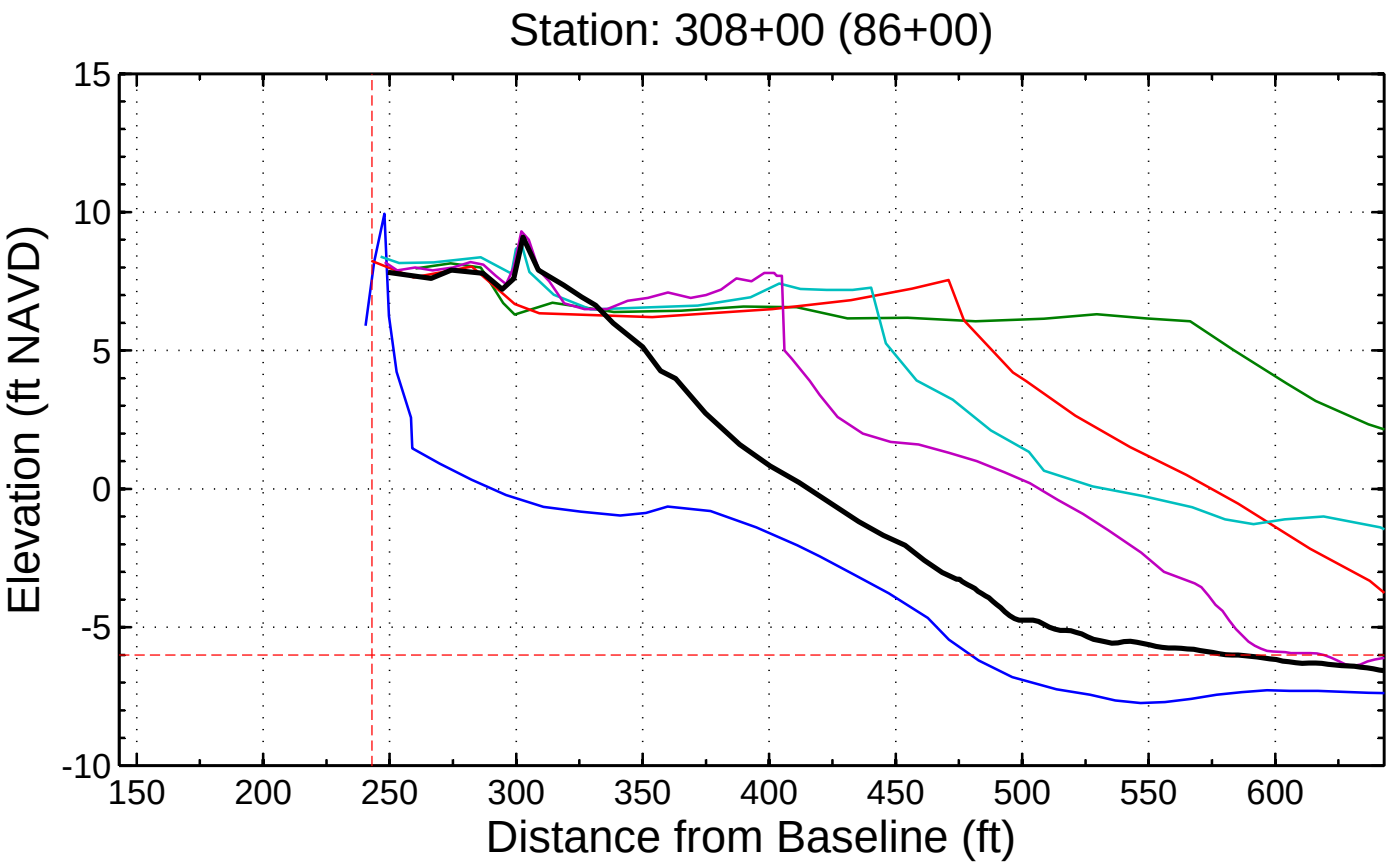
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 308+00 (86+00)
Elevation (ft NAVD)
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-5
-10
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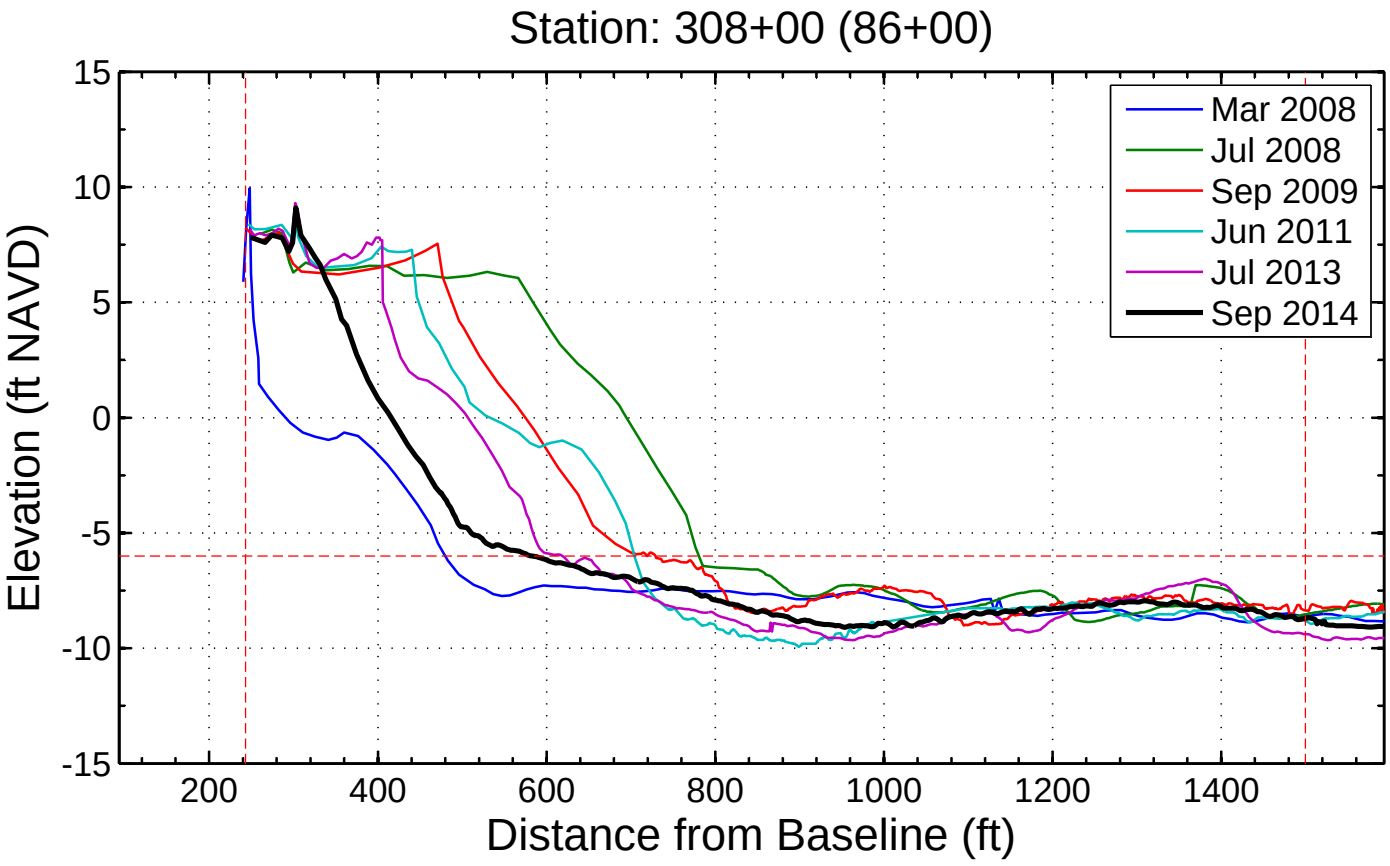
500
550
600
Distance from Baseline (ft)


Station: 308+00 (86+00)
Elevation (ft NAVD)
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10
5
0
-5
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1000
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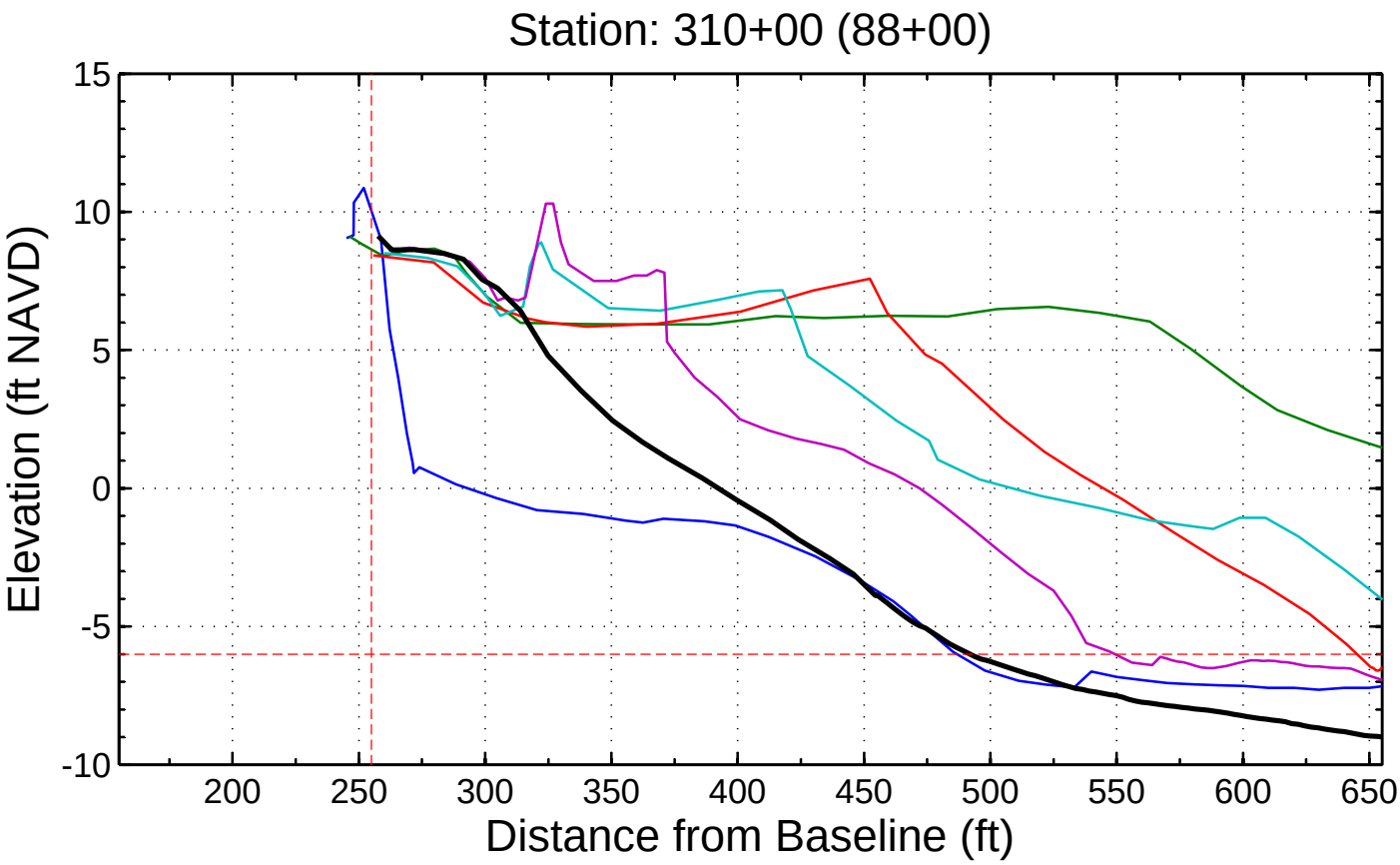
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 310+00 (88+00)
Elevation (ft NAVD)
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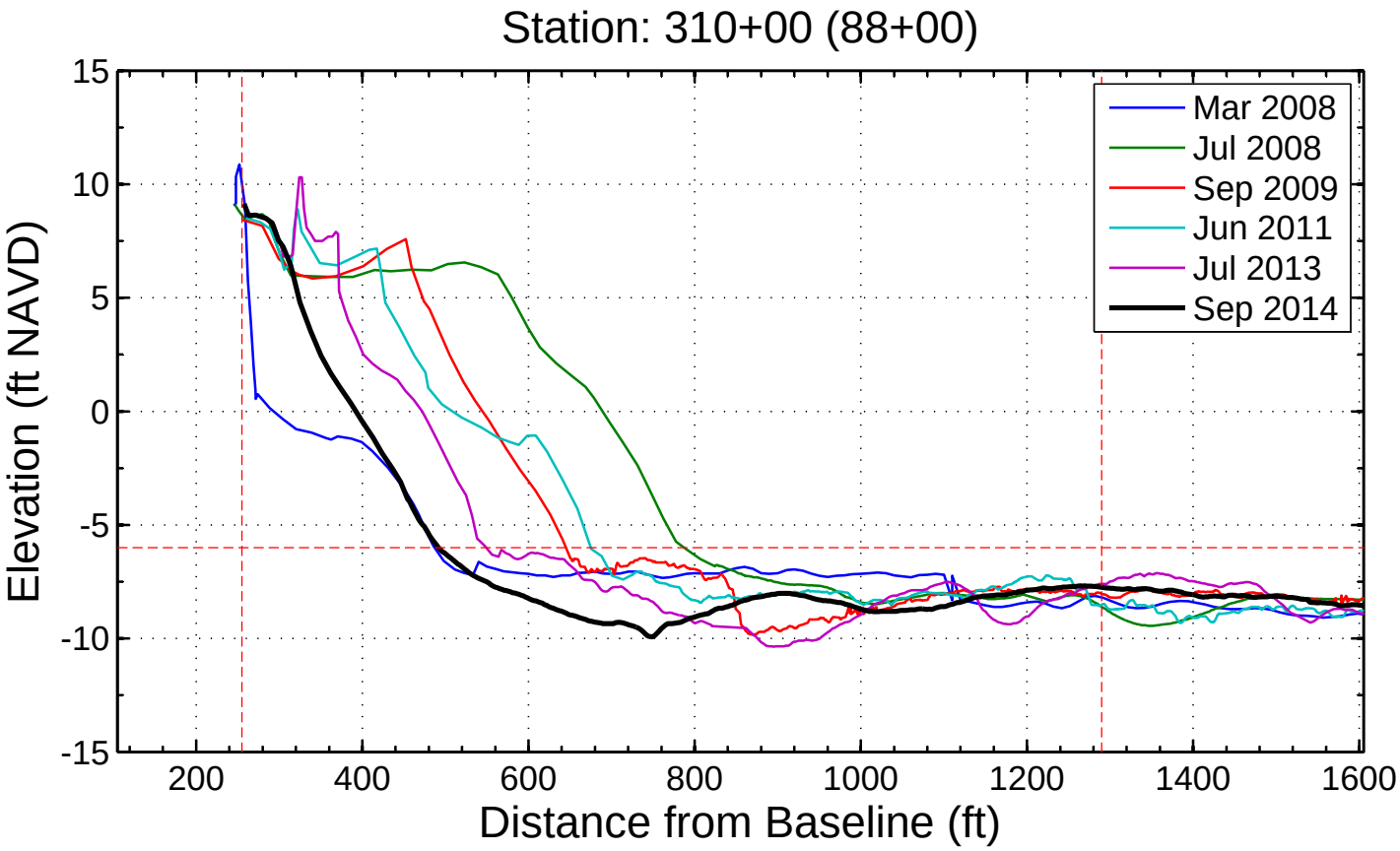
550
600
650
Distance from Baseline (ft)


Station: 310+00 (88+00)
Elevation (ft NAVD)
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10
5
0
-5
-10
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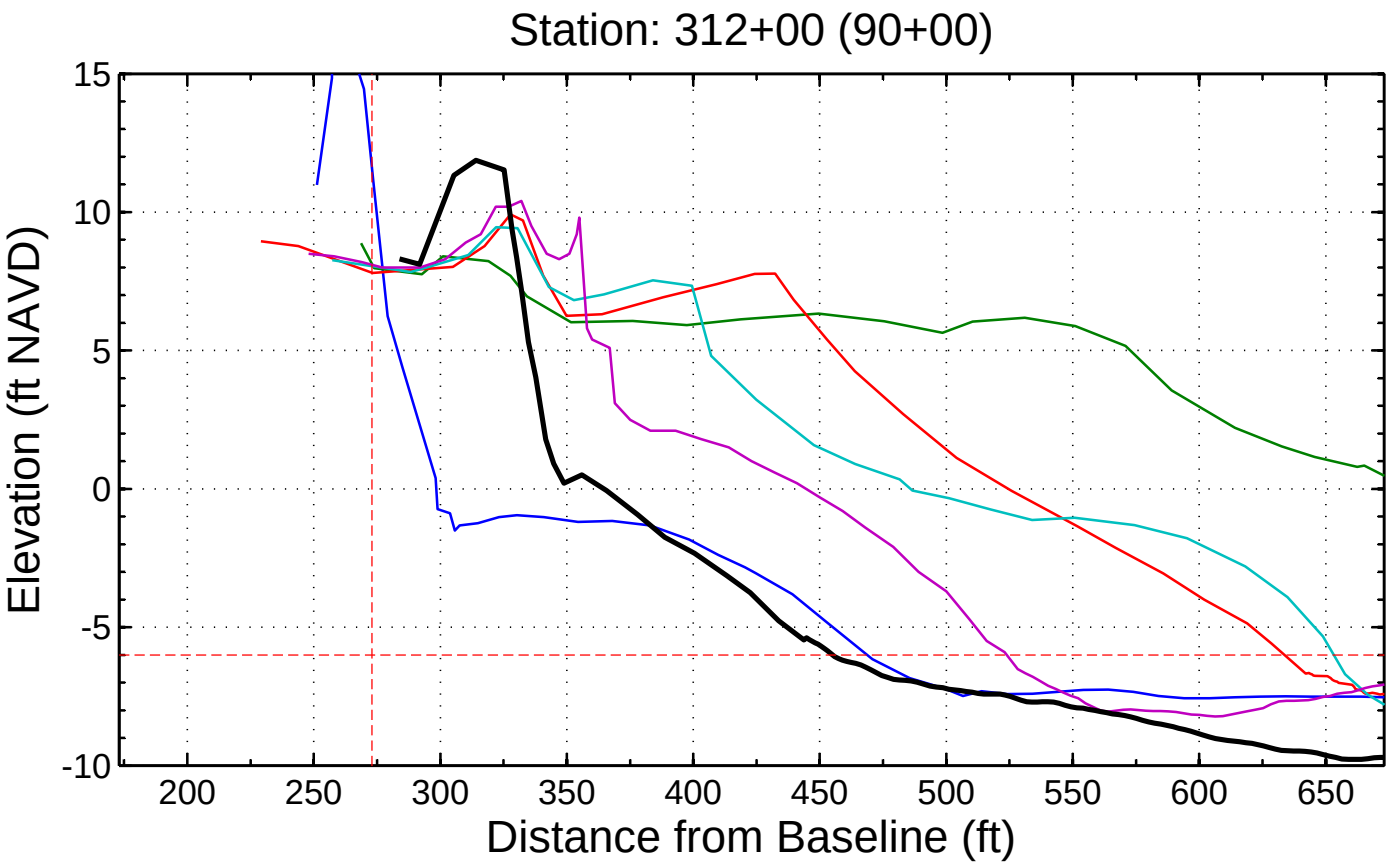
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 312+00 (90+00)
Elevation (ft NAVD)
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10
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0
-5
-10
200
250
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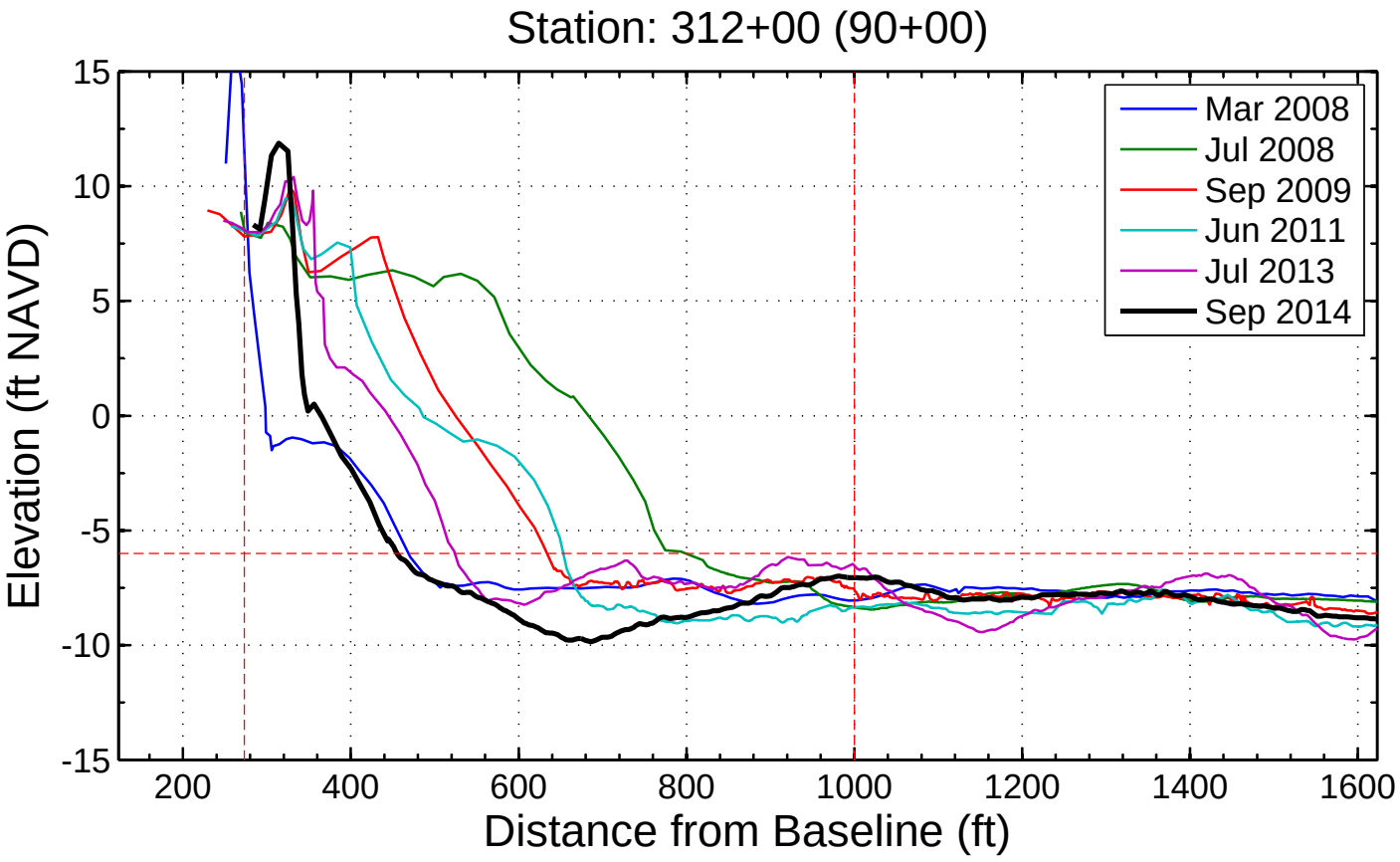
350
400
450
500
550
600
650
Distance from Baseline (ft)


Station: 312+00 (90+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
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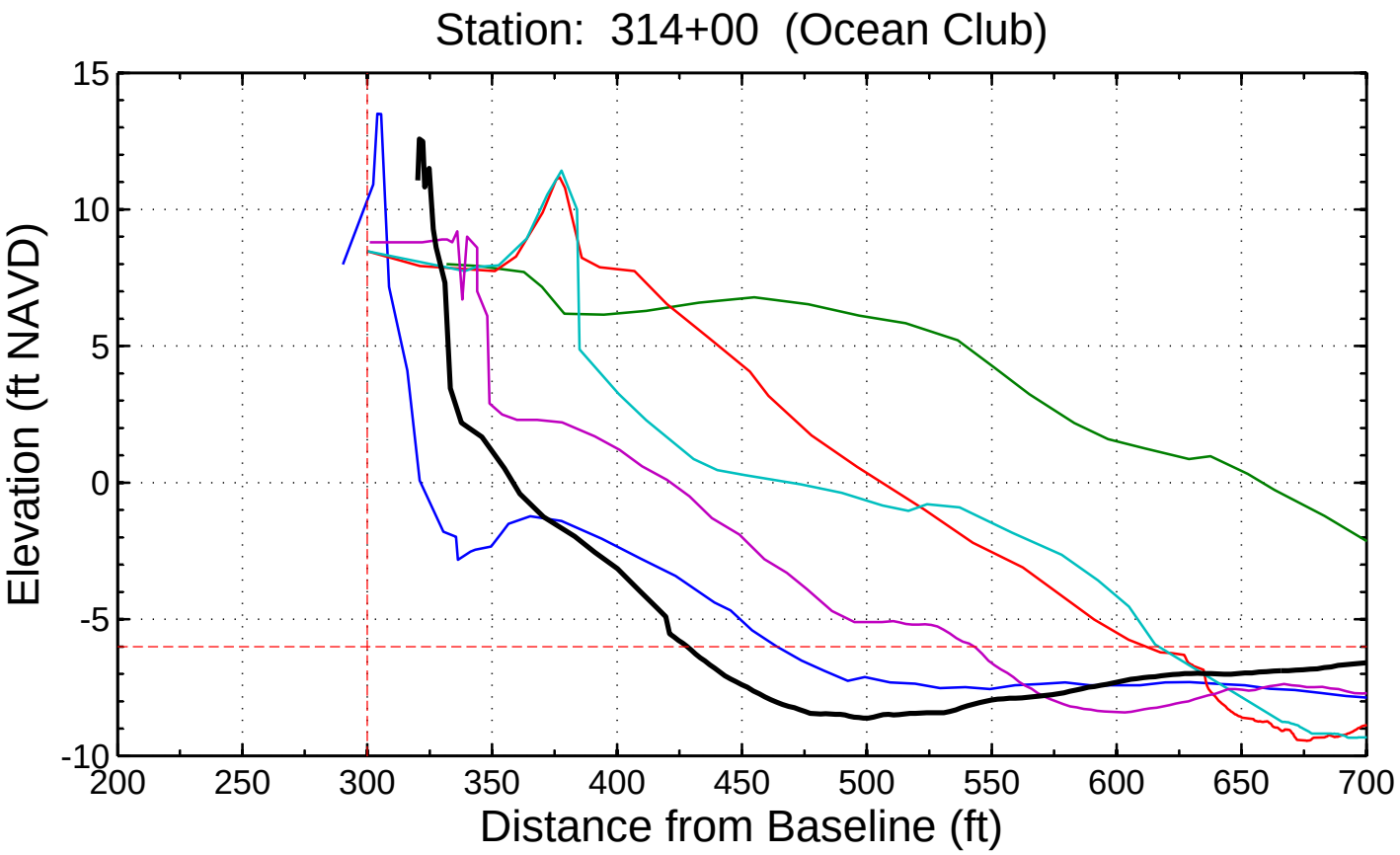
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 314+00 (Ocean Club)
Elevation (ft NAVD)
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10
5
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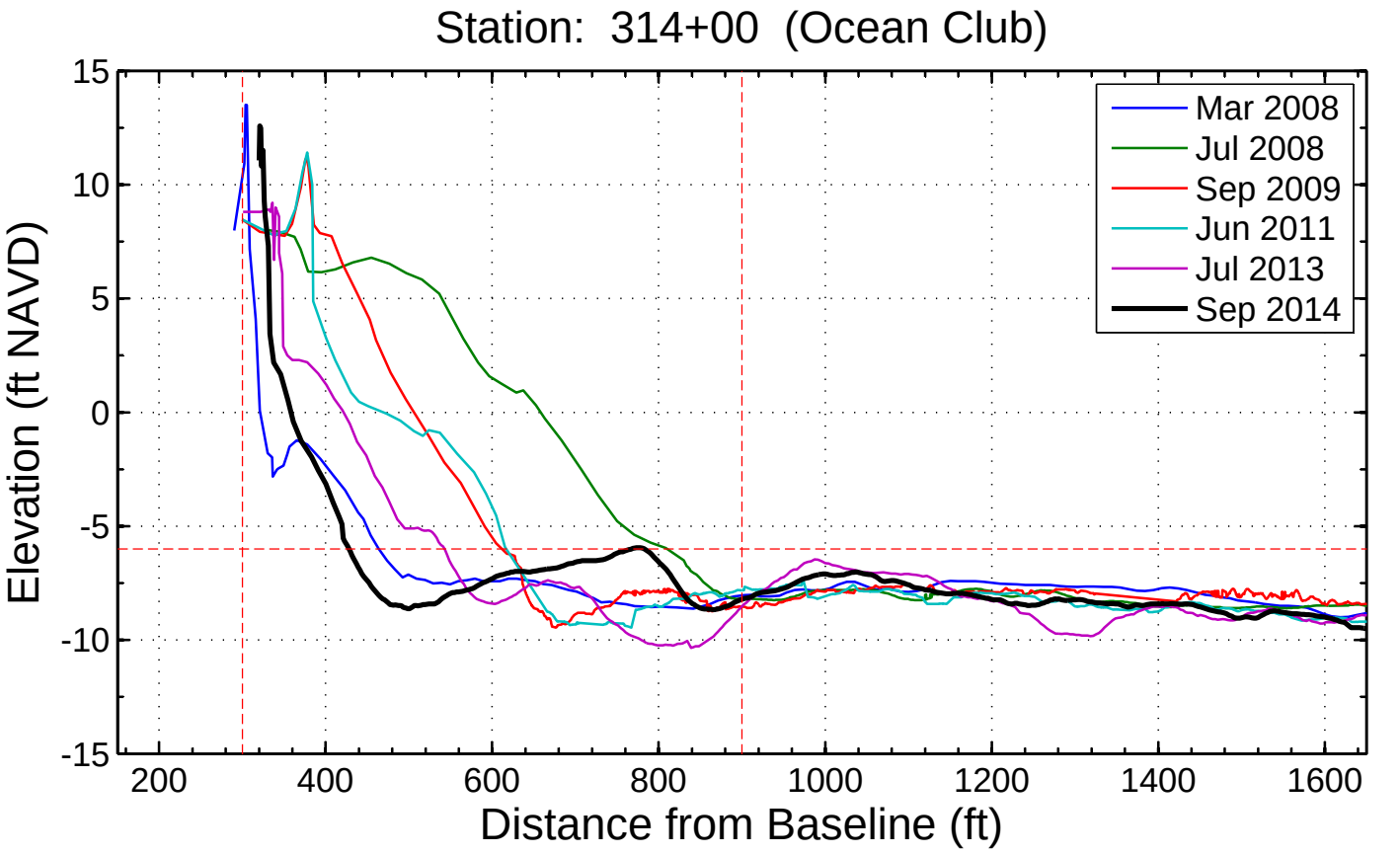
-5
-10
200
250
300
350
400
450
500
550
600
650
700
Distance from Baseline (ft)


Station: 314+00 (Ocean Club)
Elevation (ft NAVD)
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10
5
0
-5
-10
-15
200
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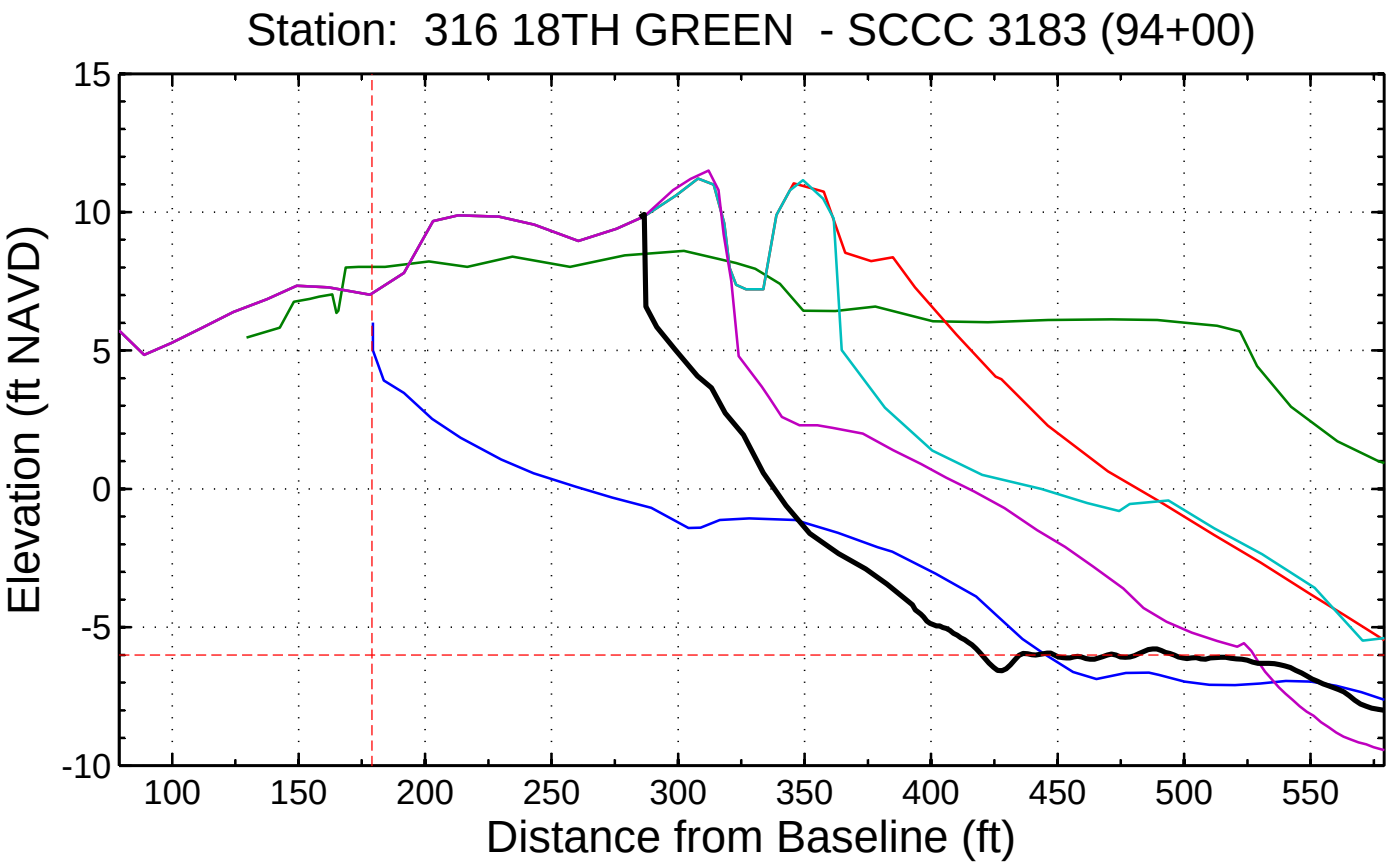
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 316 18TH GREEN - SCCC 3183 (94+00)
Elevation (ft NAVD)
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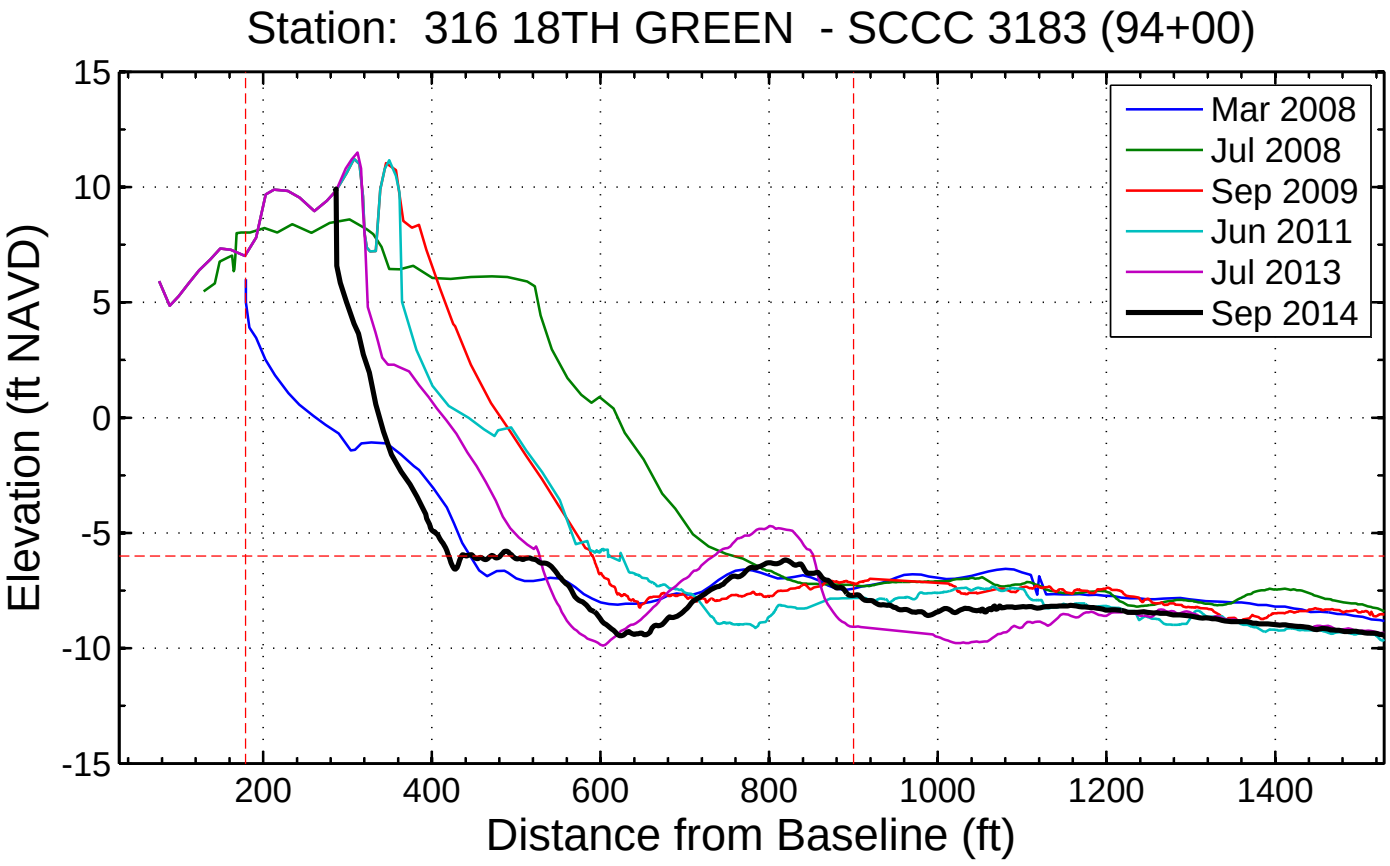
-5
-10
100
150
200
250
300
350
400
450
500
550
Distance from Baseline (ft)


Station: 316 18TH GREEN - SCCC 3183 (94+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
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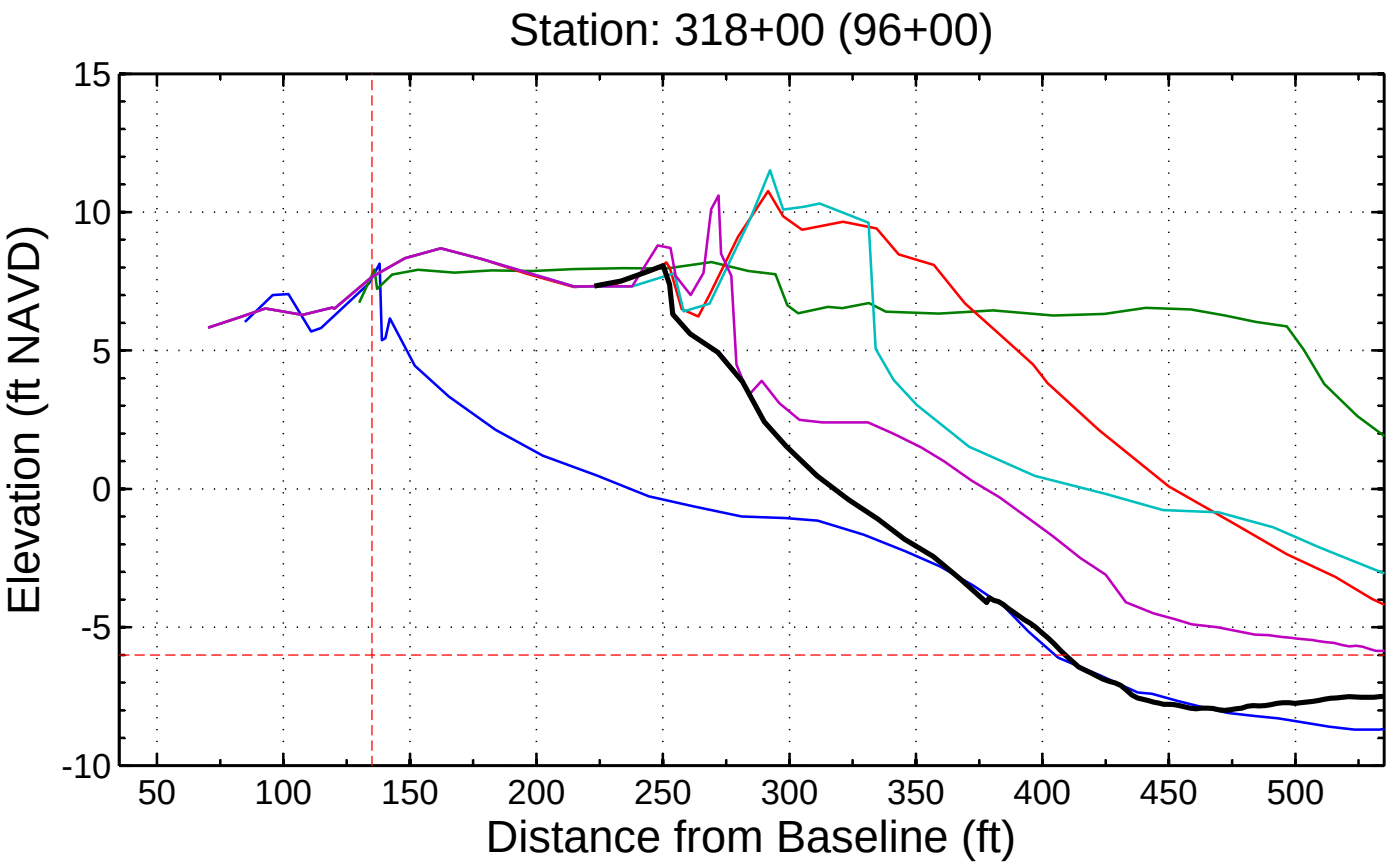
800
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 318+00 (96+00)
Elevation (ft NAVD)
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-10
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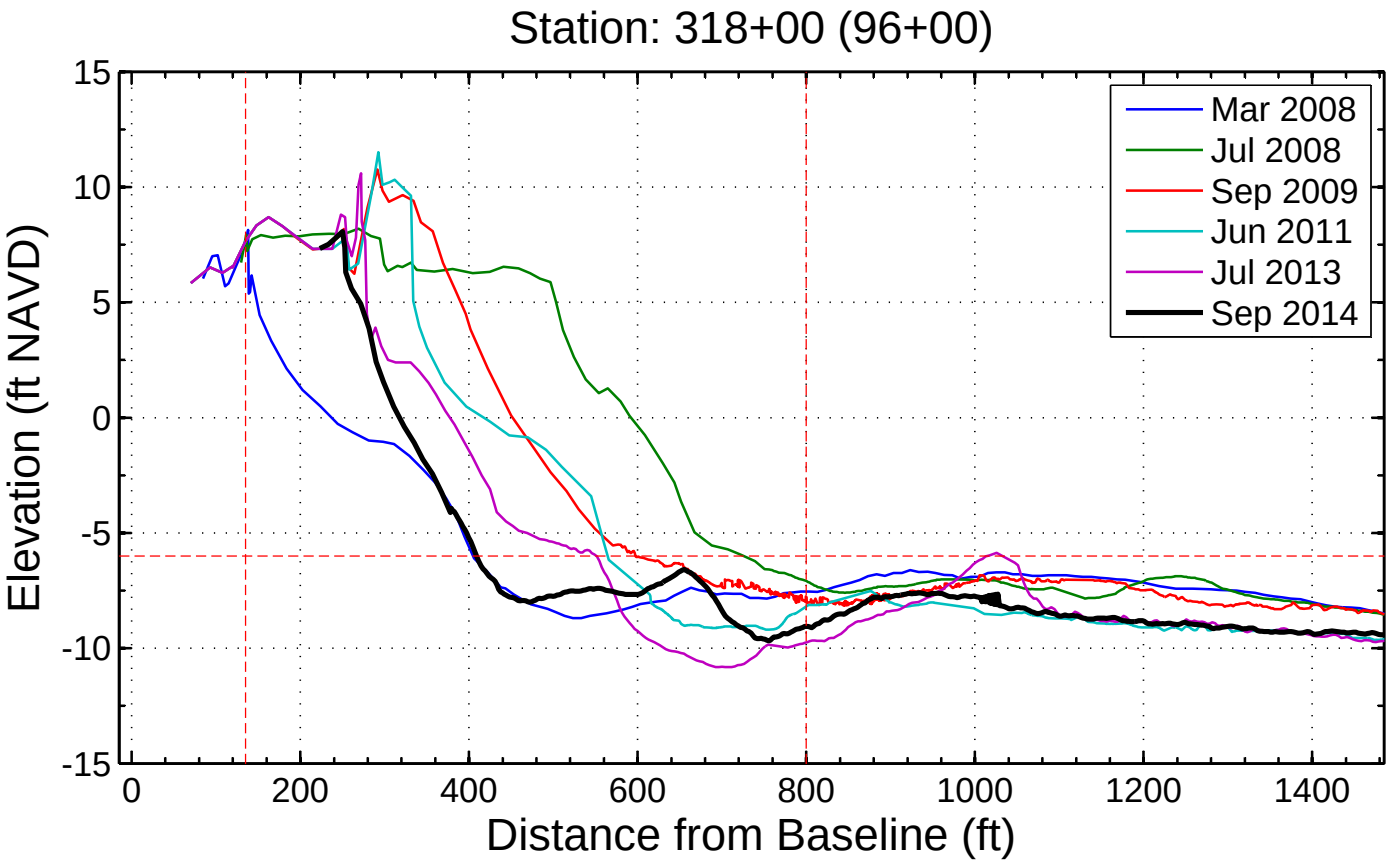
500
Distance from Baseline (ft)


Station: 318+00 (96+00)
Elevation (ft NAVD)
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-10
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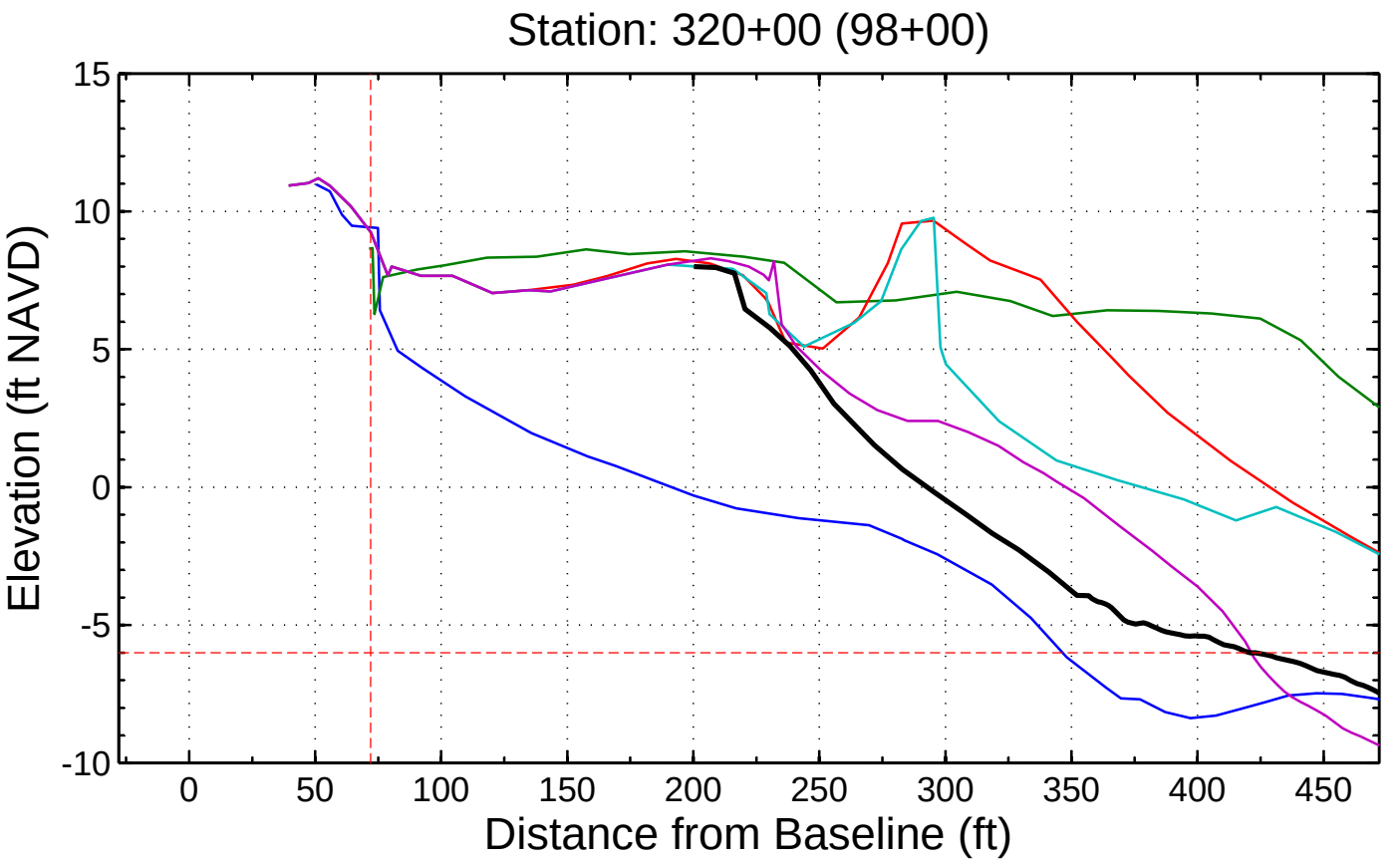
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 320+00 (98+00)
Elevation (ft NAVD)
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-5
-10
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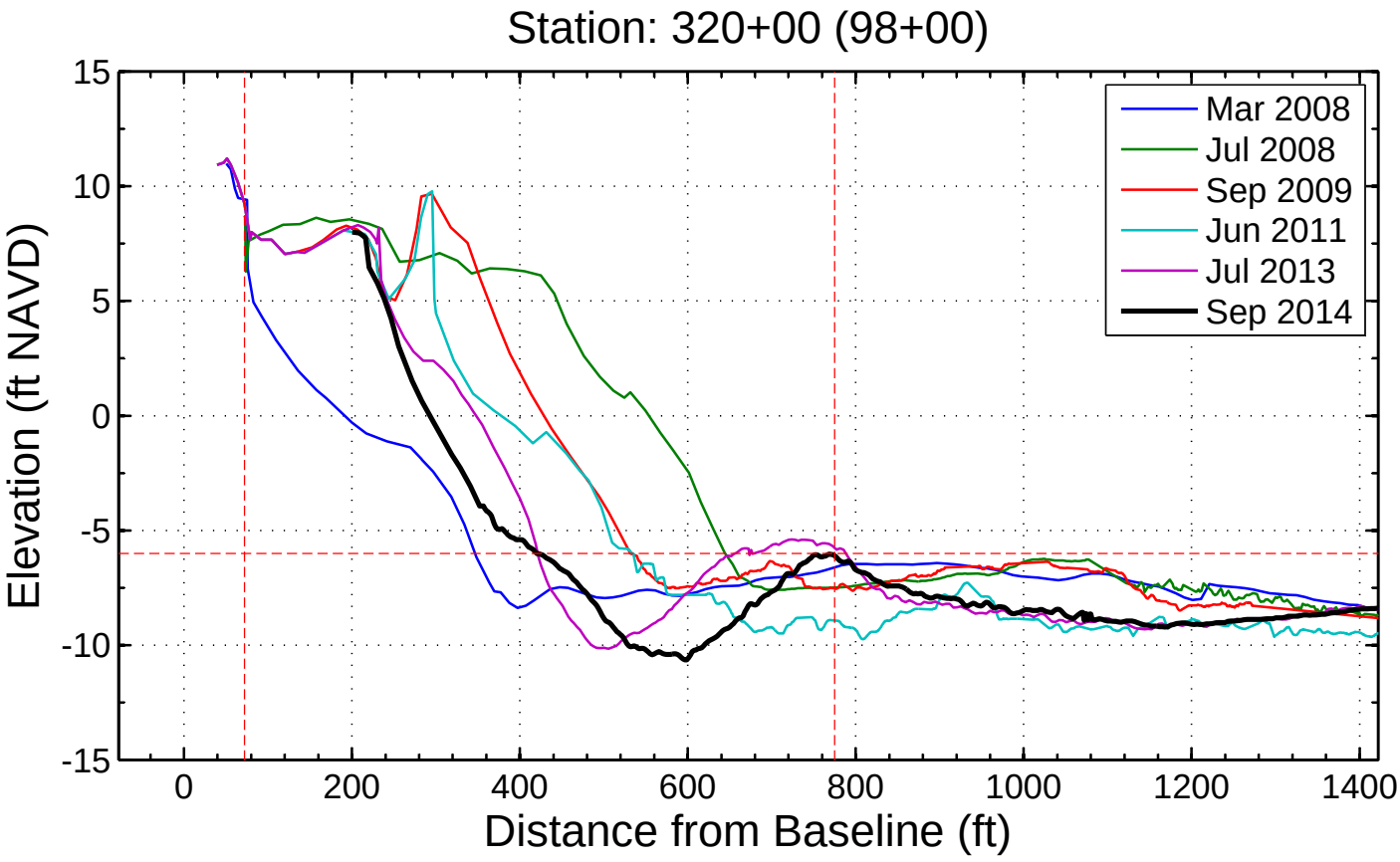
400
450
Distance from Baseline (ft)


Station: 320+00 (98+00)
Elevation (ft NAVD)
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-15
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600
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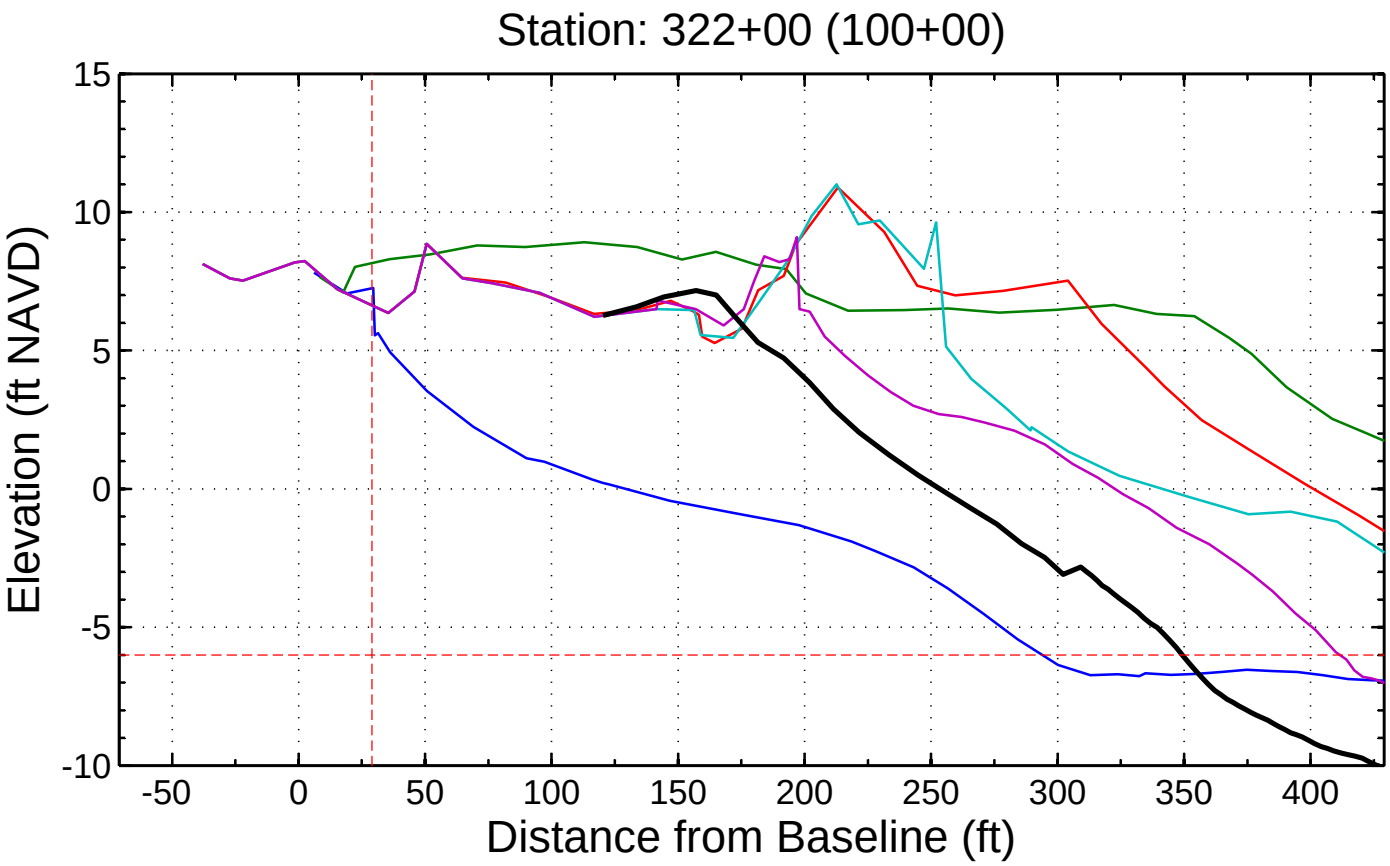
1000
1200
1400
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 322+00 (100+00)
Elevation (ft NAVD)
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-10
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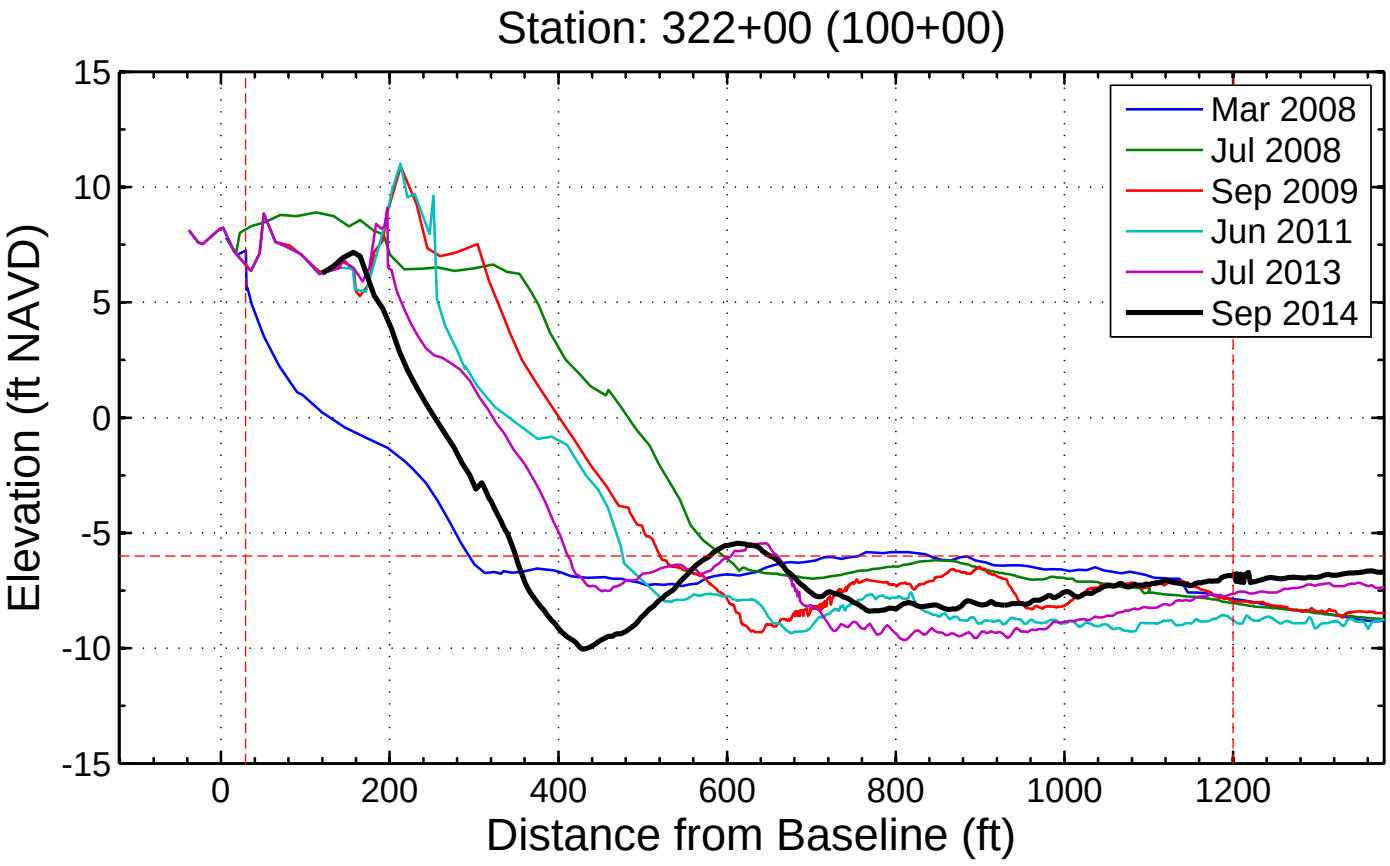
350
400
Distance from Baseline (ft)


Station: 322+00 (100+00)
Elevation (ft NAVD)
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10
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-10
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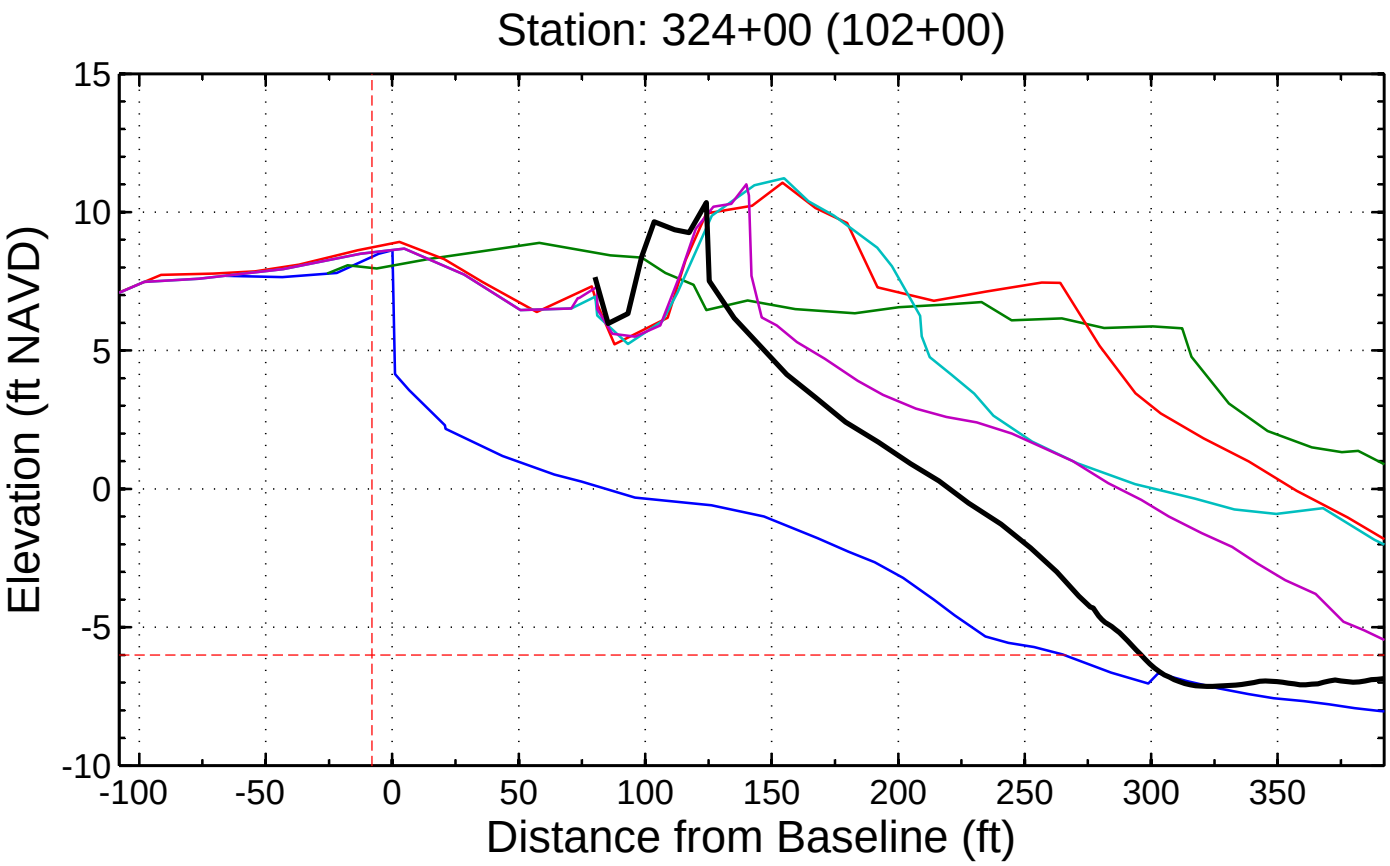
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 324+00 (102+00)
Elevation (ft NAVD)
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-10
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0
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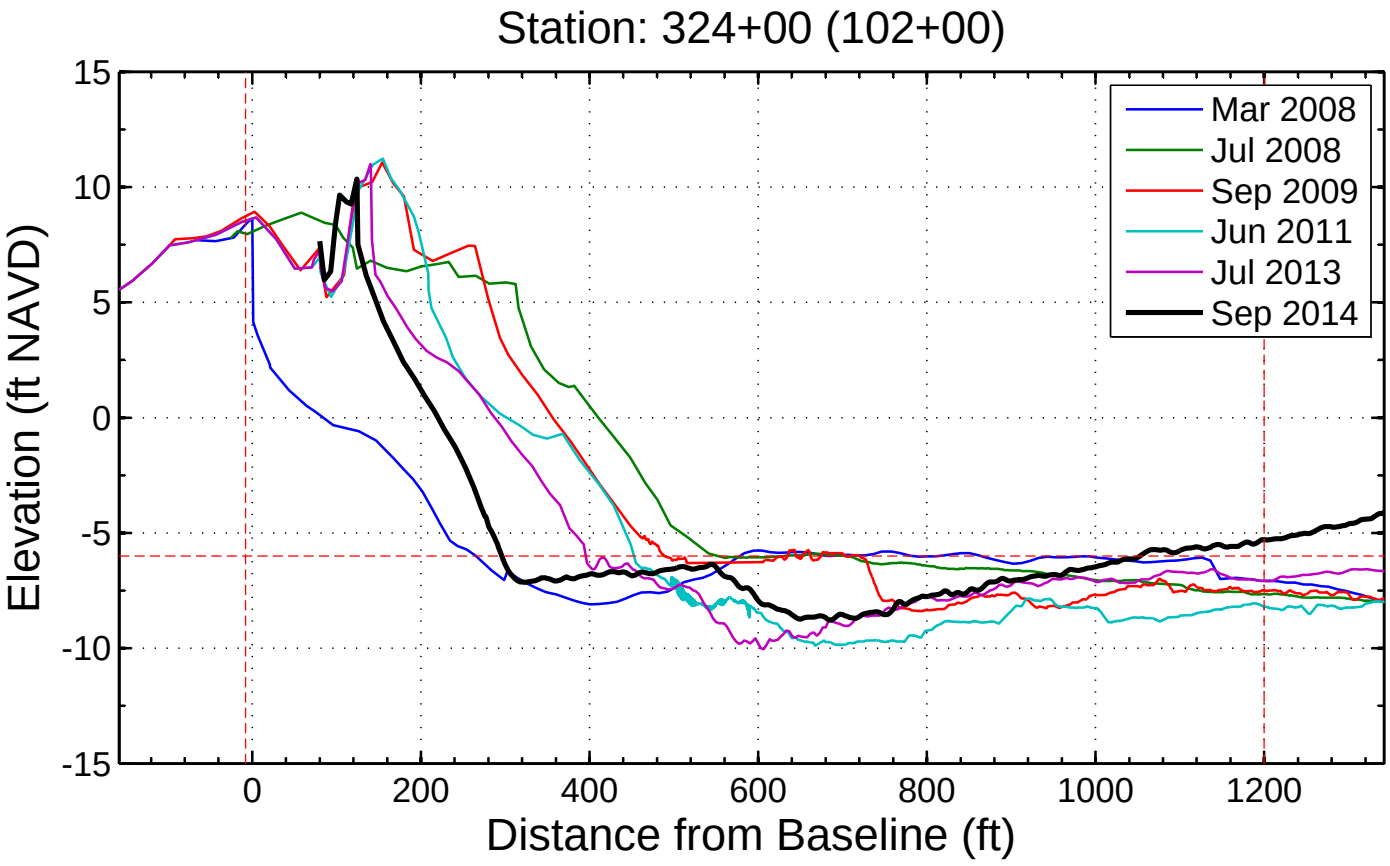
100
150
200
250
300
350
Distance from Baseline (ft)


Station: 324+00 (102+00)
Elevation (ft NAVD)
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5
0
-5
-10
-15
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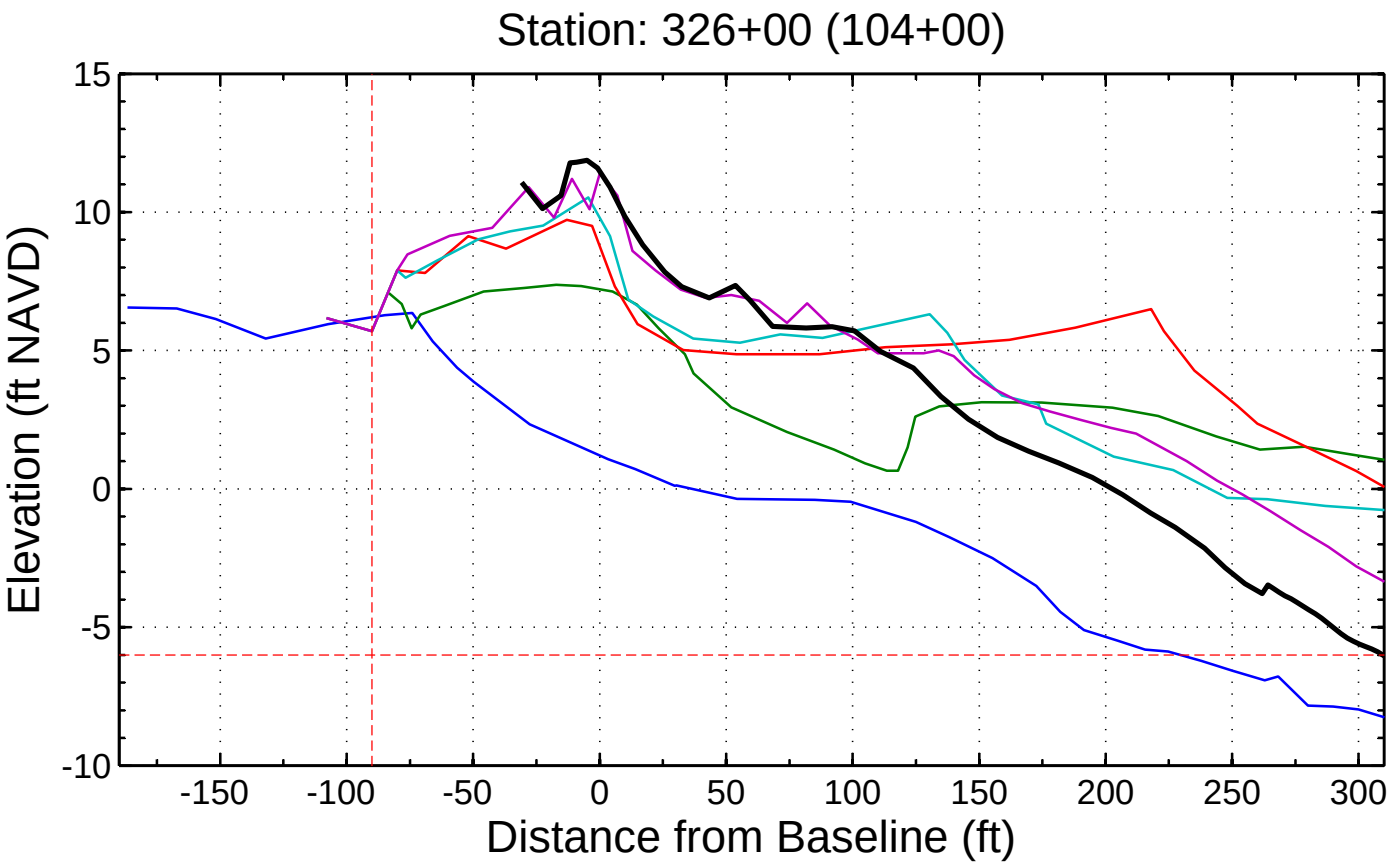
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 326+00 (104+00)
Elevation (ft NAVD)
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-100
-50
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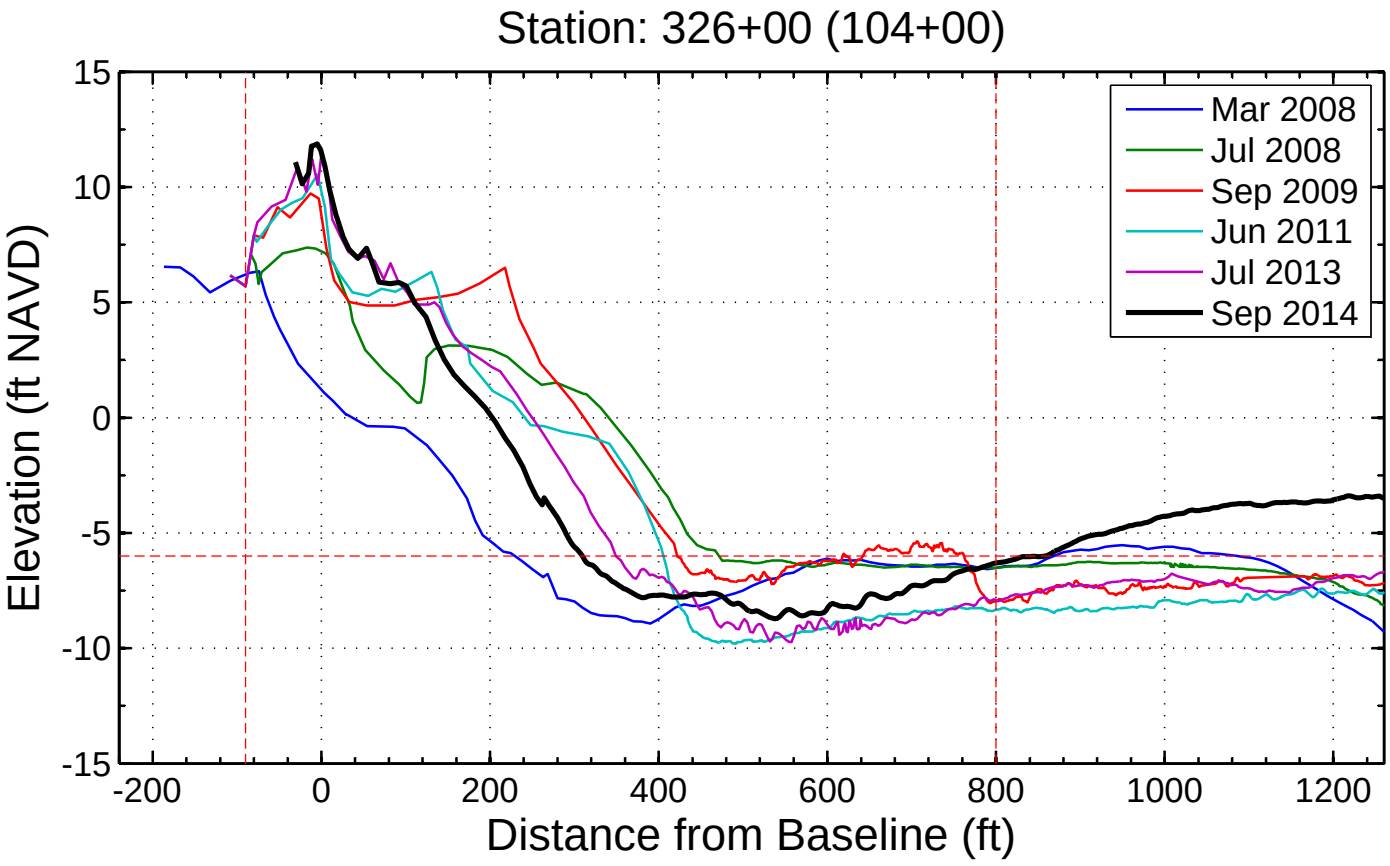
100
150
200
250
300
Distance from Baseline (ft)


Station: 326+00 (104+00)
Elevation (ft NAVD)
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10
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0
-5
-10
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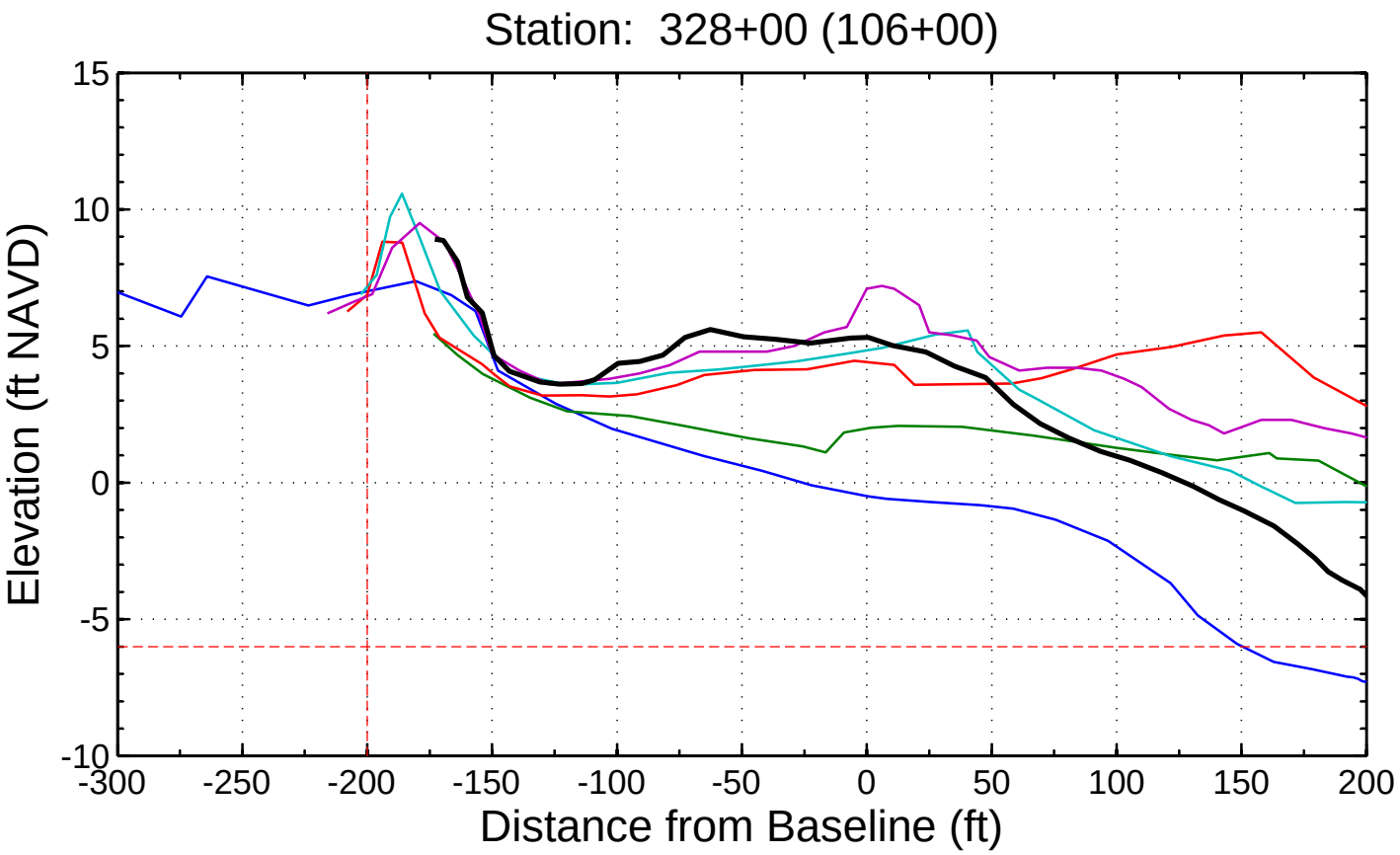
600
800
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 328+00 (106+00)
Elevation (ft NAVD)
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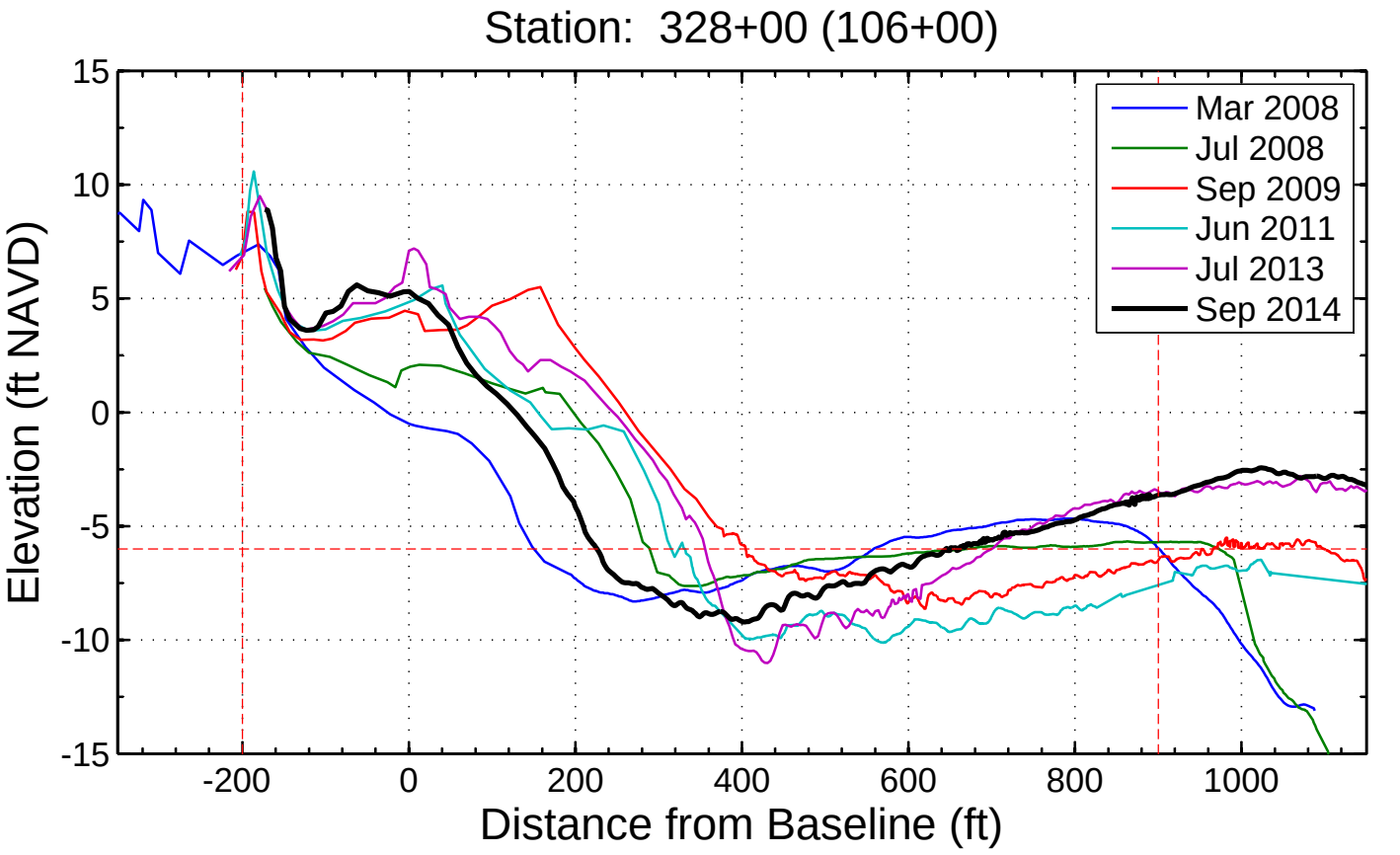
100
150
200
Distance from Baleline (ft)


Station: 328+00 (106+00)
Elevation (ft NAVD)
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-5
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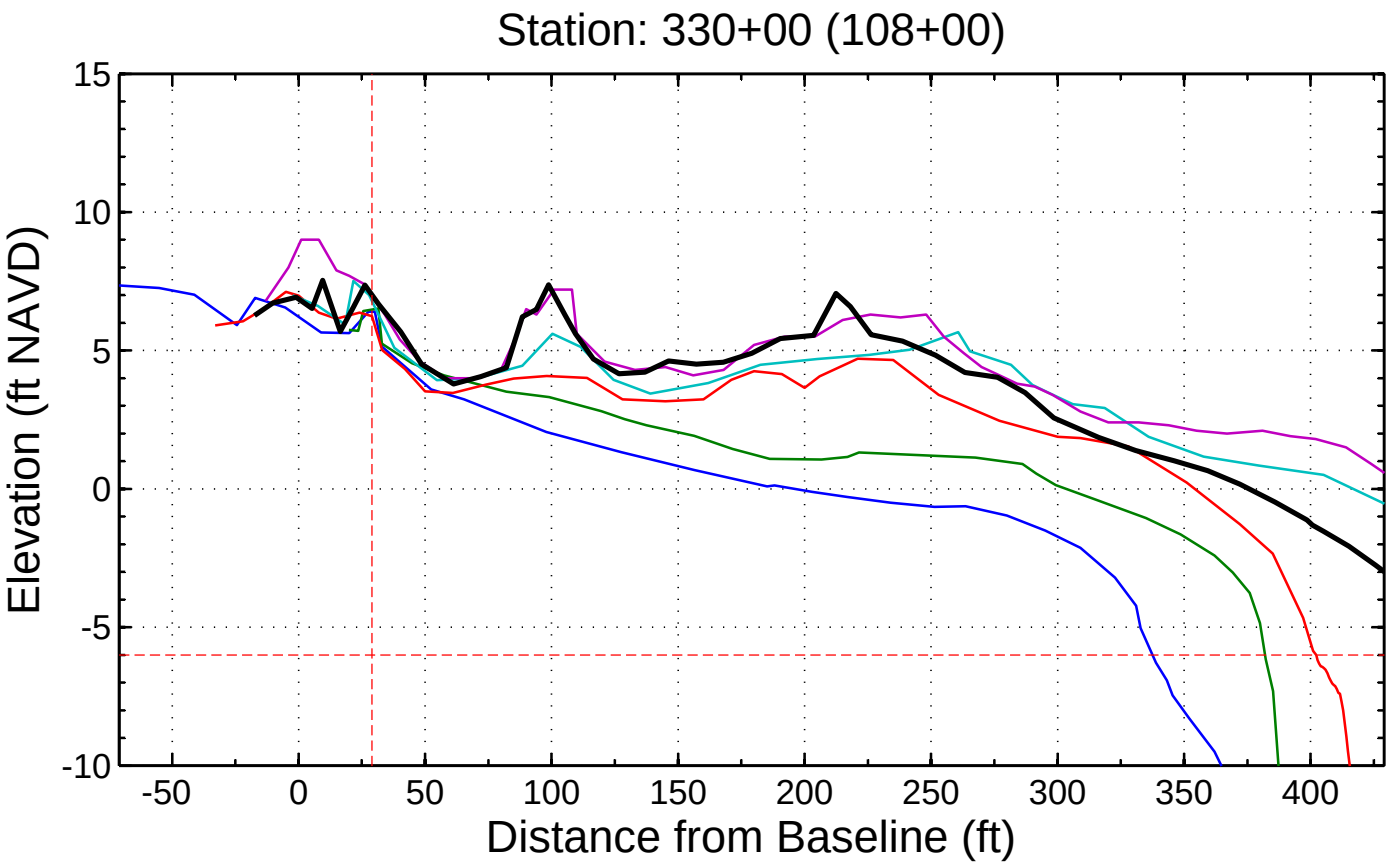
800
1000
Distance from Baleline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 330+00 (108+00)
Elevation (ft NAVD)
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50
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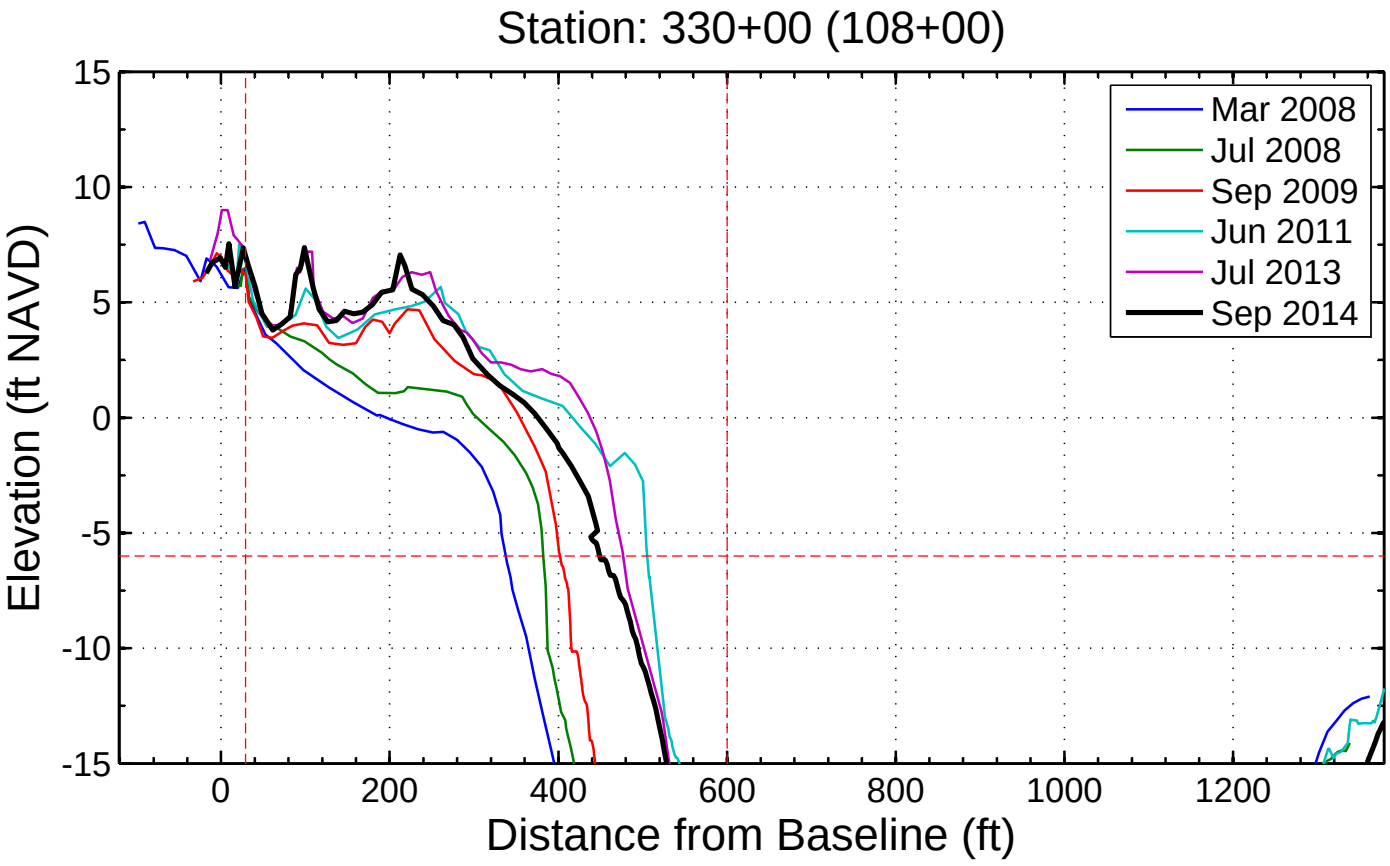
350
400
Distance from Baseline (ft)


Station: 330+00 (108+00)
Elevation (ft NAVD)
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-5
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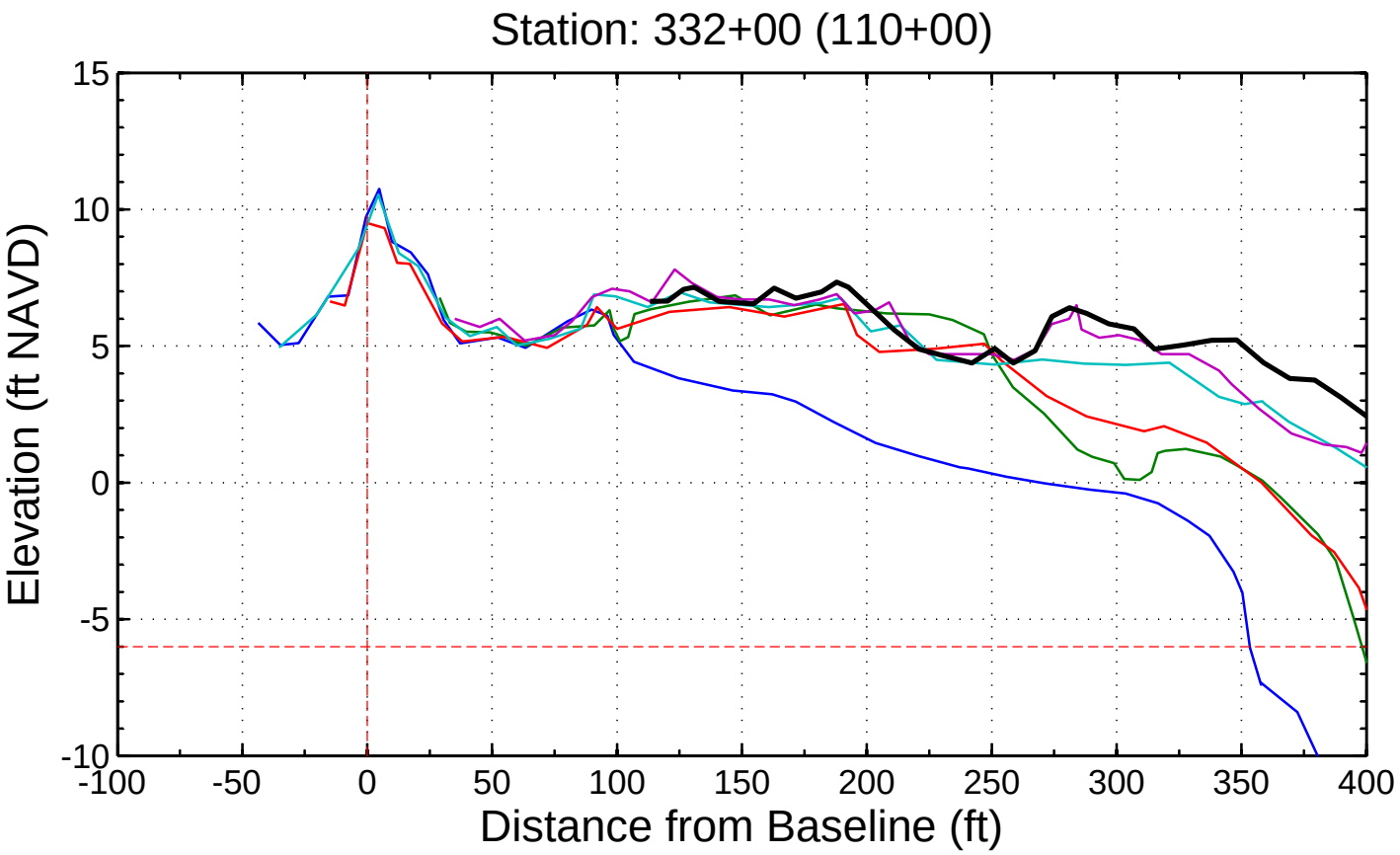
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 332+00 (110+00)
Elevation (ft NAVD)
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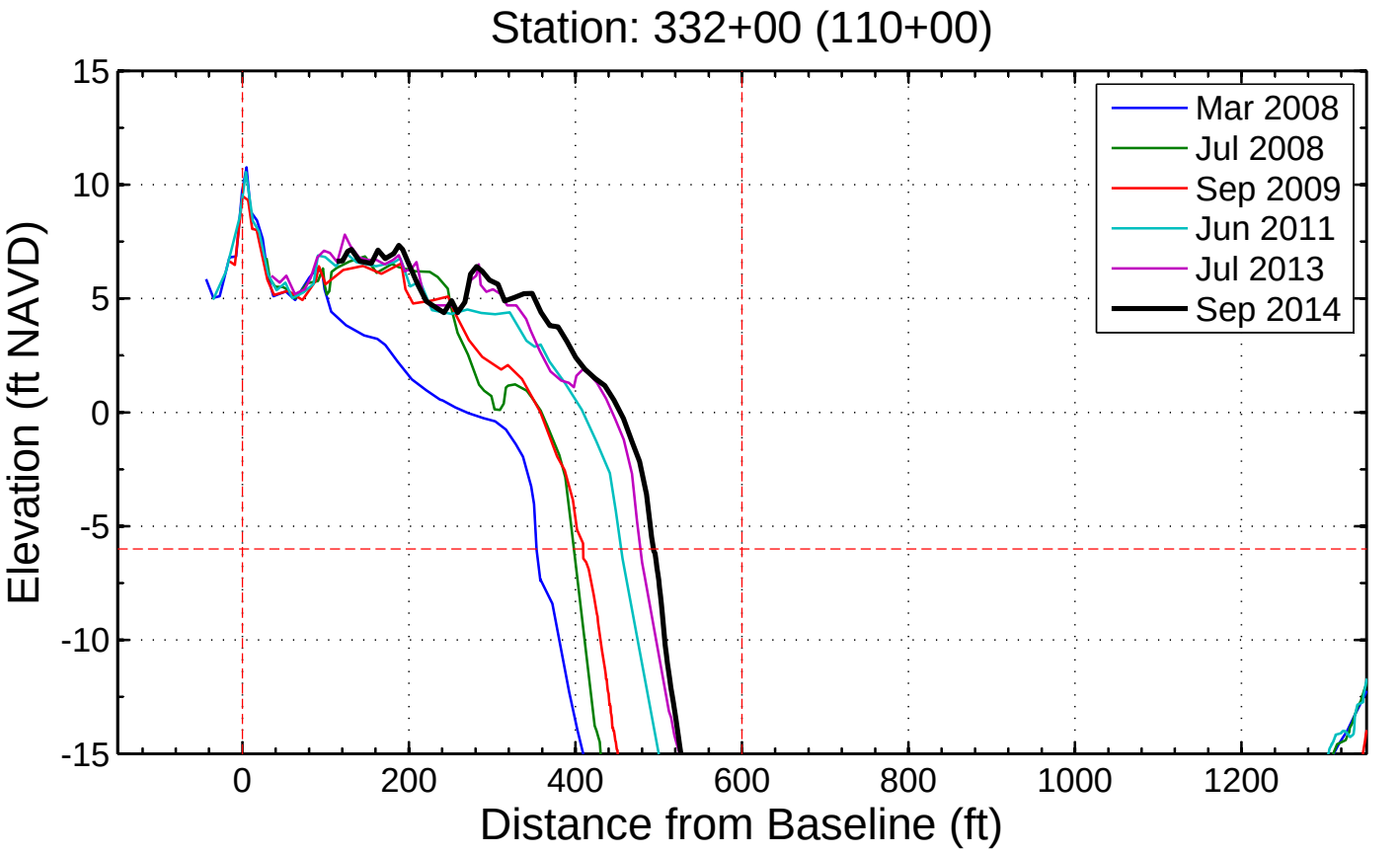
200
250
300
350
400
Distance from Baseline (ft)


Station: 332+00 (110+00)
Elevation (ft NAVD)
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0
-5
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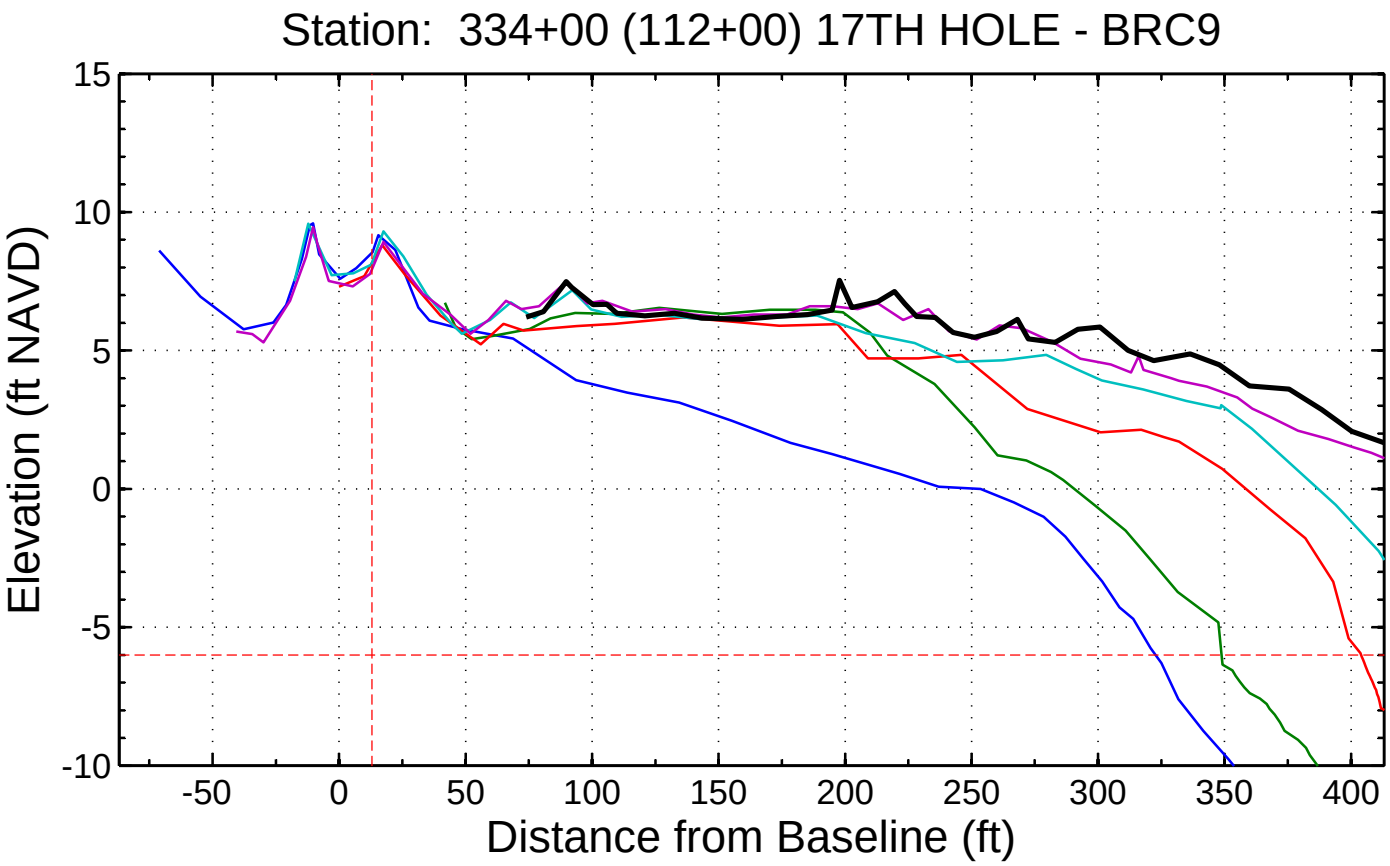
800
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 334+00 (112+00) 17TH HOLE - BRC9
Elevation (ft NAVD)
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-5
-10
-50
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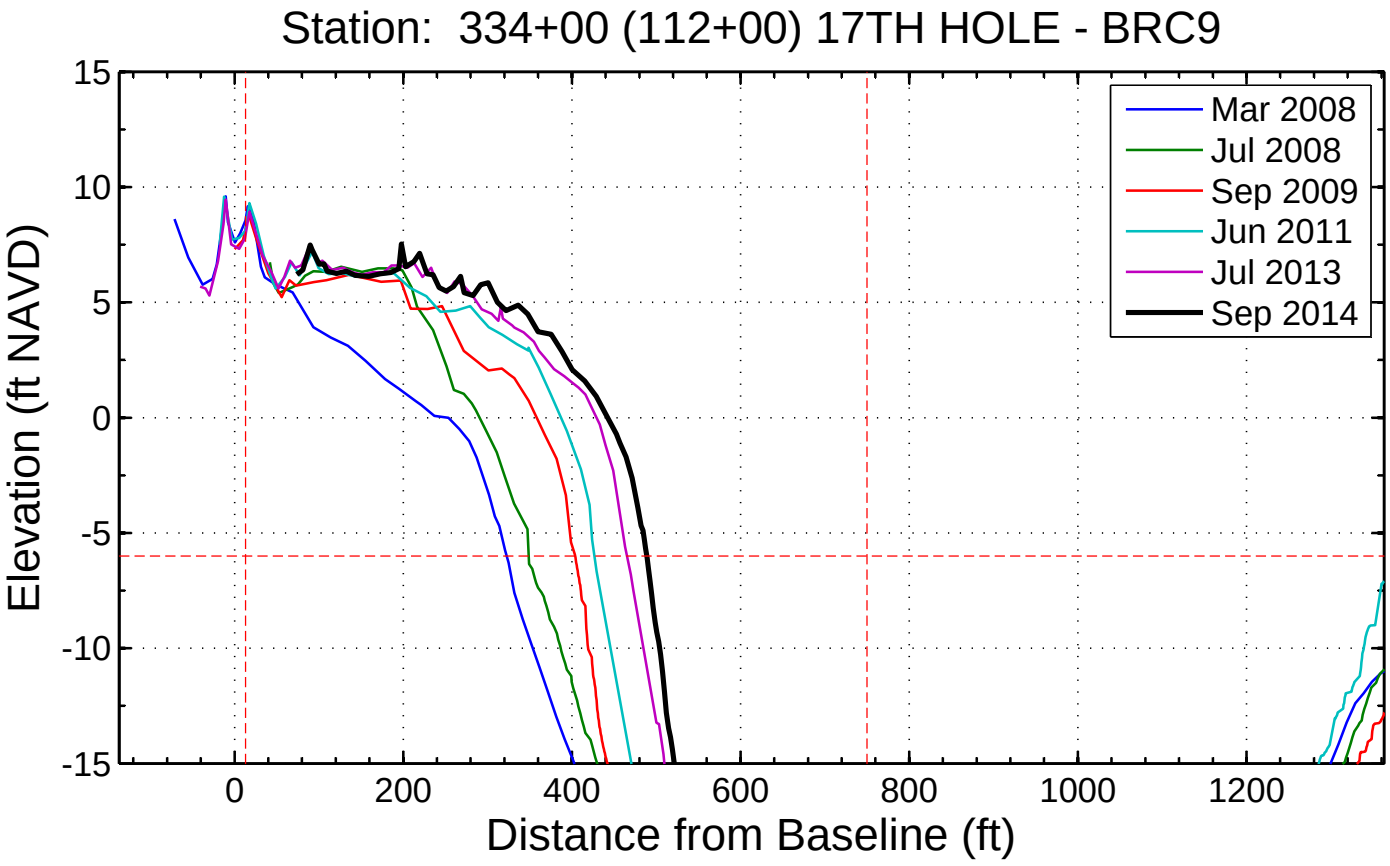
100
150
200
250
300
350
400
Distance from Baseline (ft)


Station: 334+00 (112+00) 17TH HOLE - BRC9
Elevation (ft NAVD)
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0
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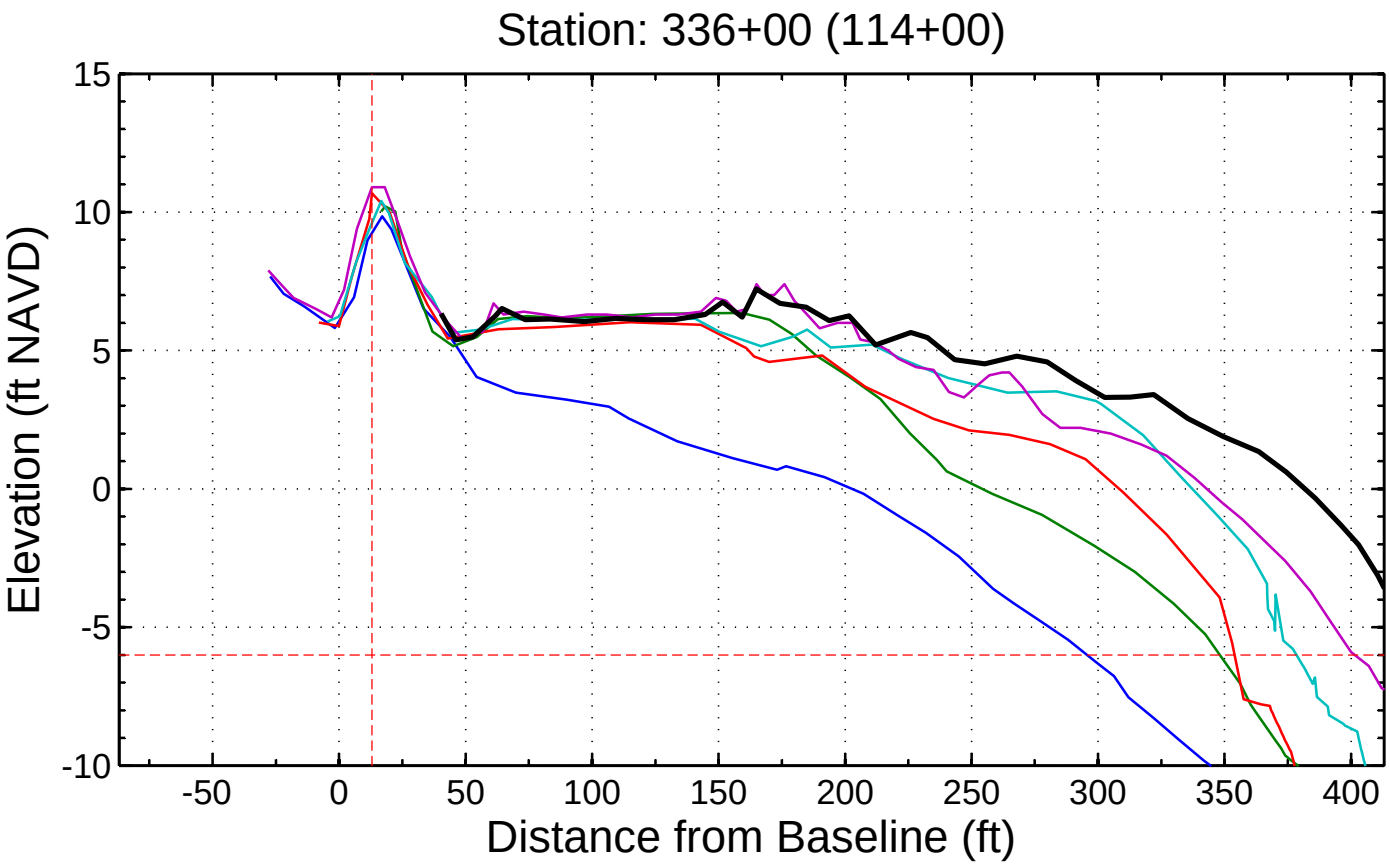
400
600
800
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 336+00 (114+00)
Elevation (ft NAVD)
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-5
-10
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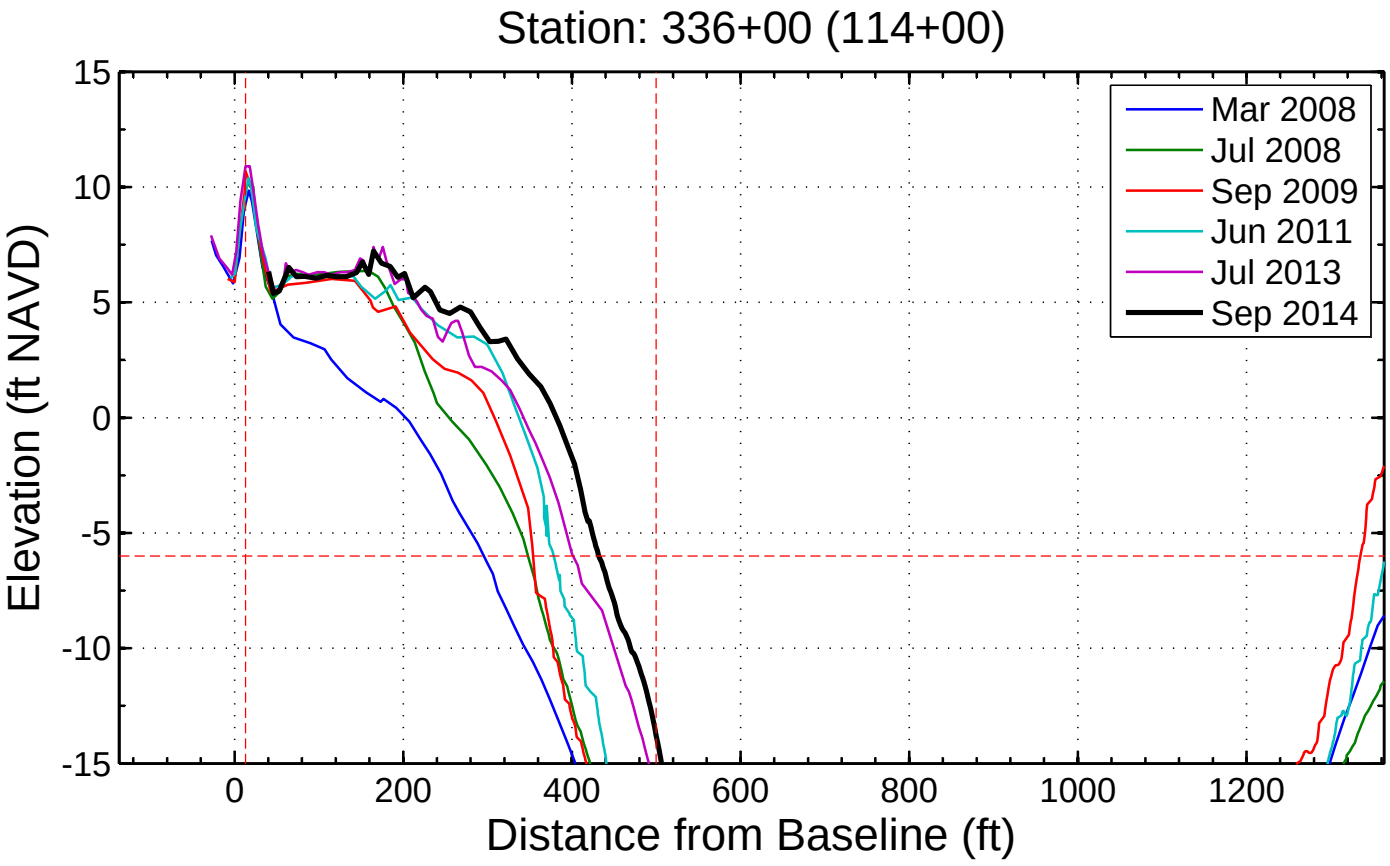
0
50
100
150
200
250
300
350
400
Distance from Baseline (ft)


Station: 336+00 (114+00)
Elevation (ft NAVD)
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5
0
-5
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200
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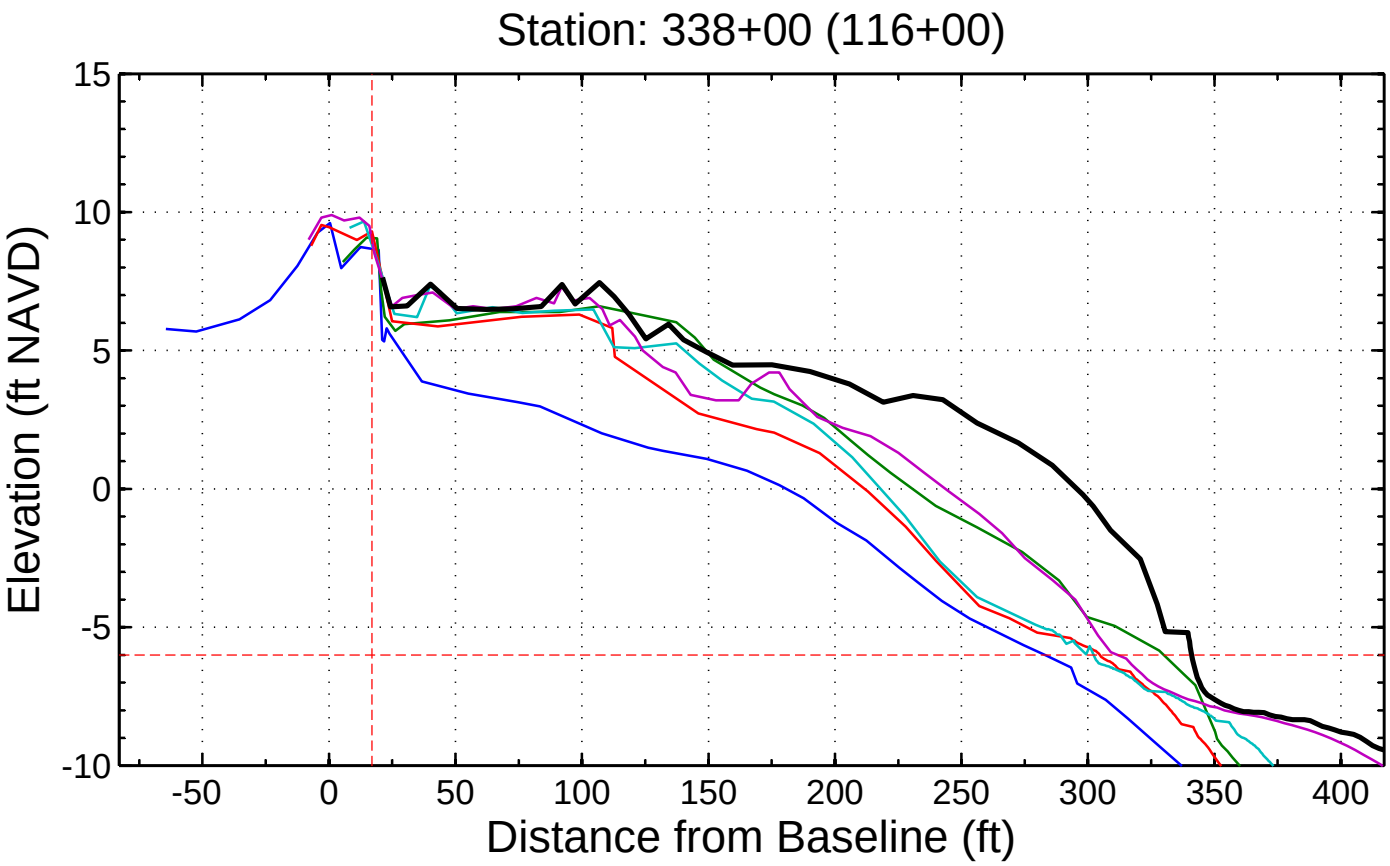
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 338+00 (116+00)
Elevation (ft NAVD)
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-5
-10
-50
0
50
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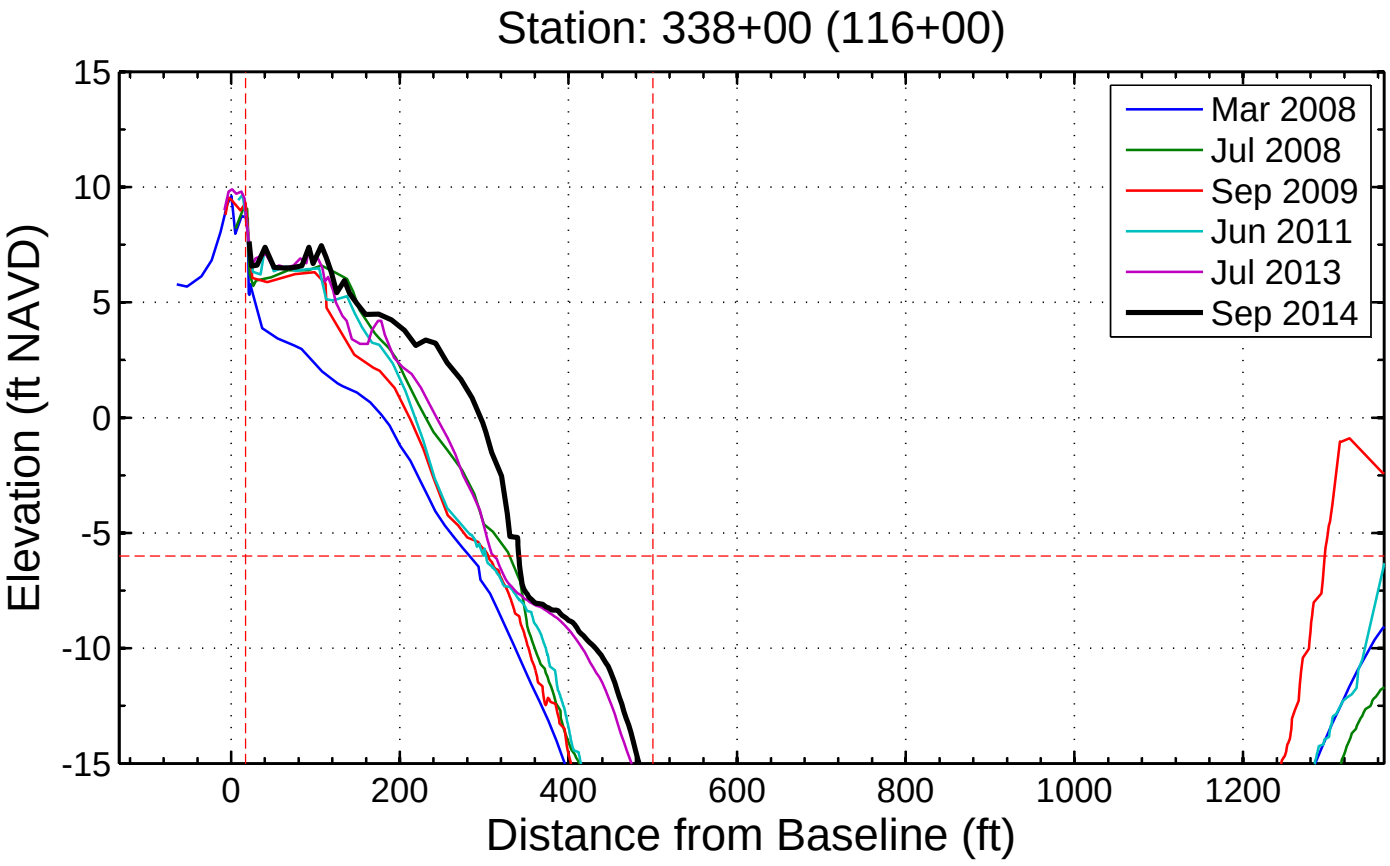
200
250
300
350
400
Distance from Baseline (ft)


Station: 338+00 (116+00)
Elevation (ft NAVD)
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10
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0
-5
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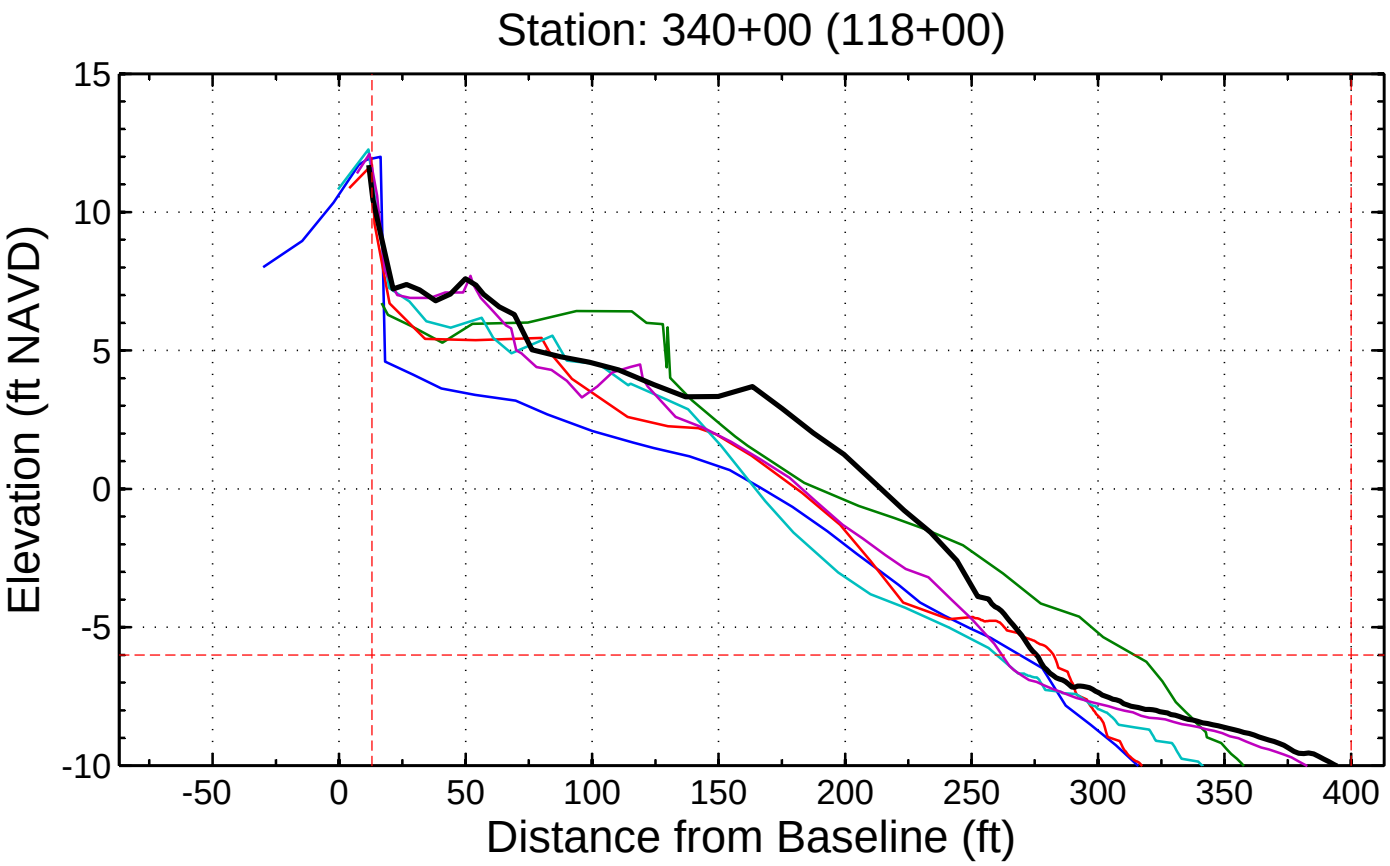
600
800
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 340+00 (118+00)
Elevation (ft NAVD)
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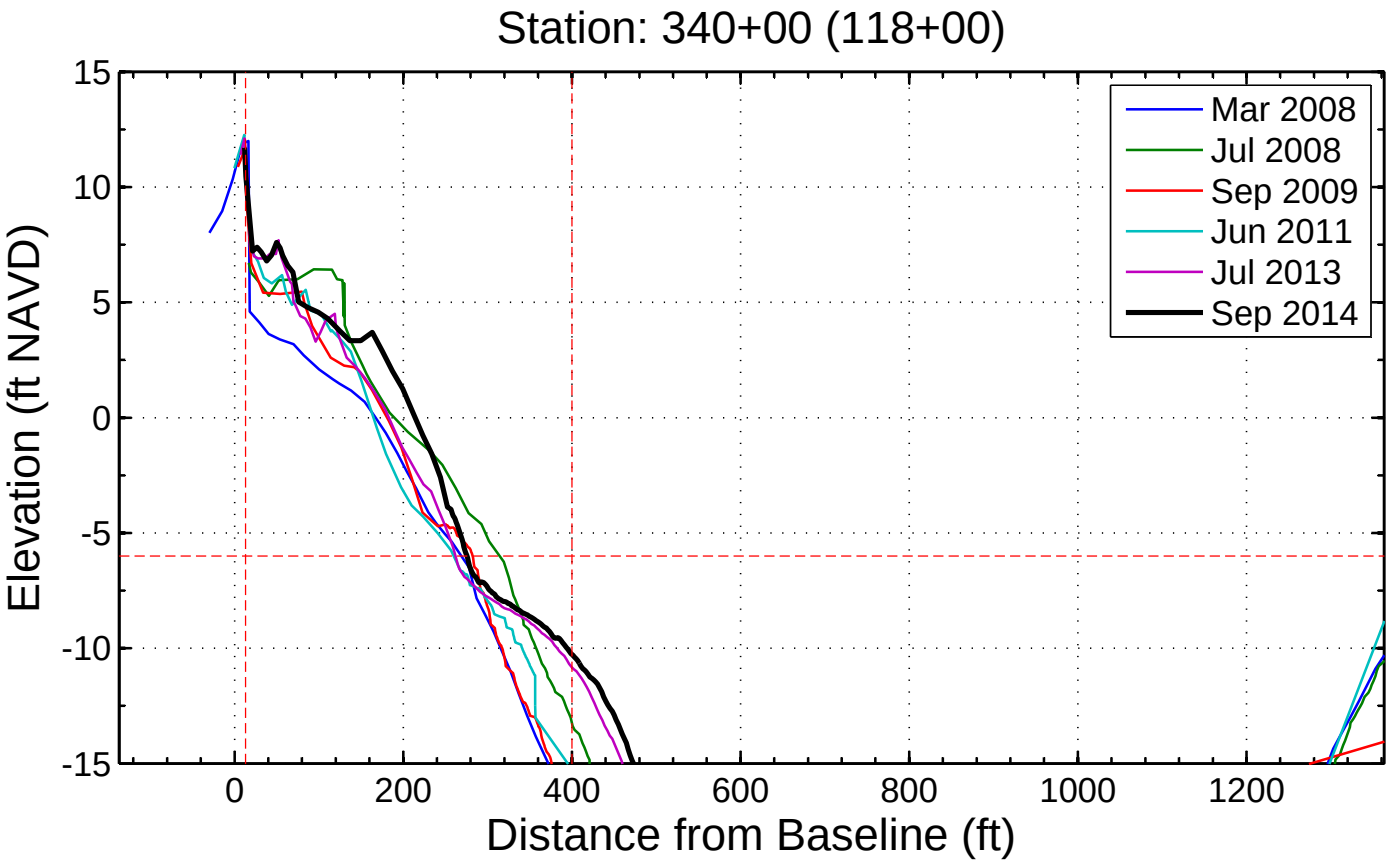
-5
-10
-50
0
50
100
150
200
250
300
350
400
Distance from Baseline (ft)


Station: 340+00 (118+00)
Elevation (ft NAVD)
15
10
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0
-5
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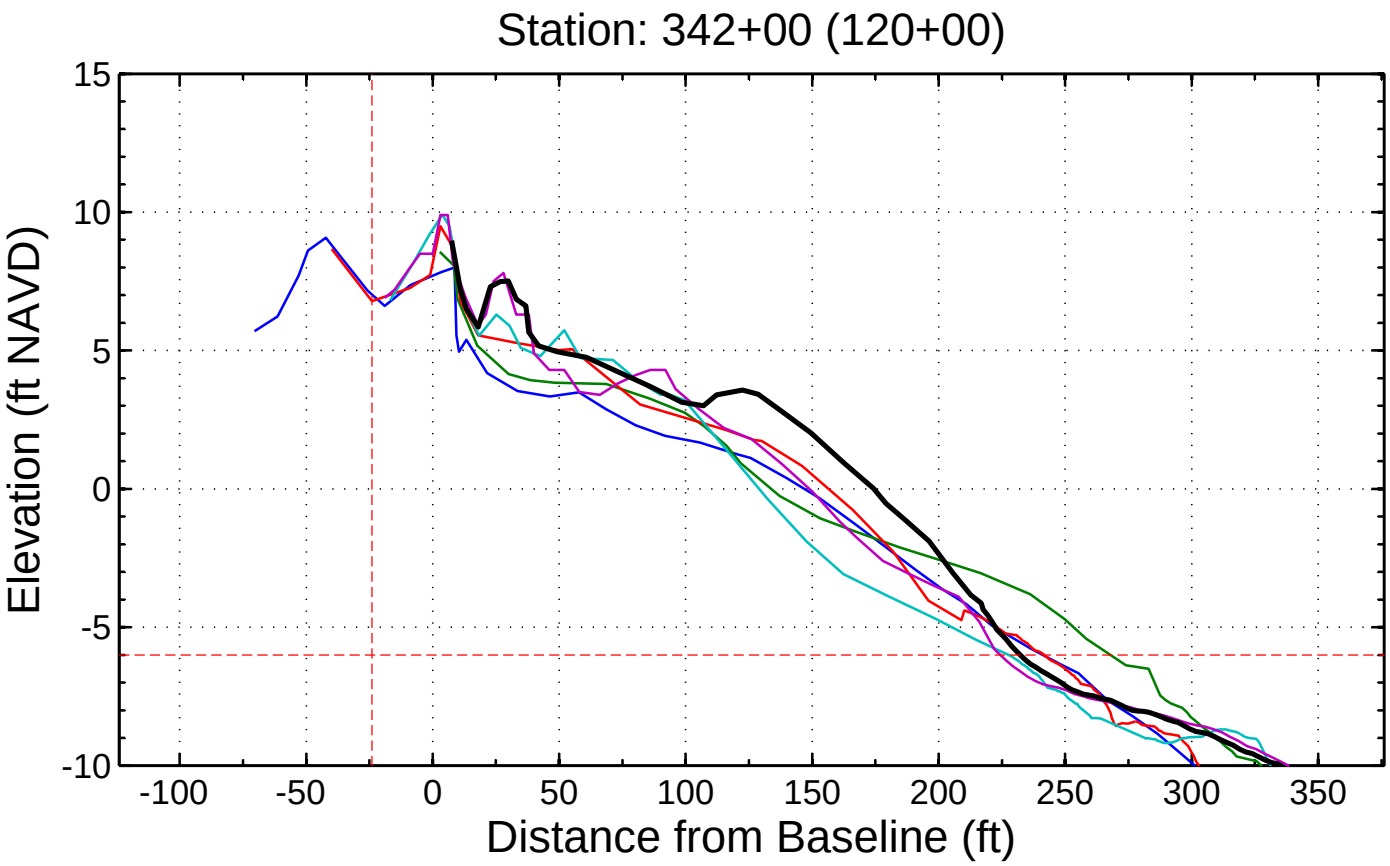
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 342+00 (120+00)
Elevation (ft NAVD)
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-5
-10
-100
-50
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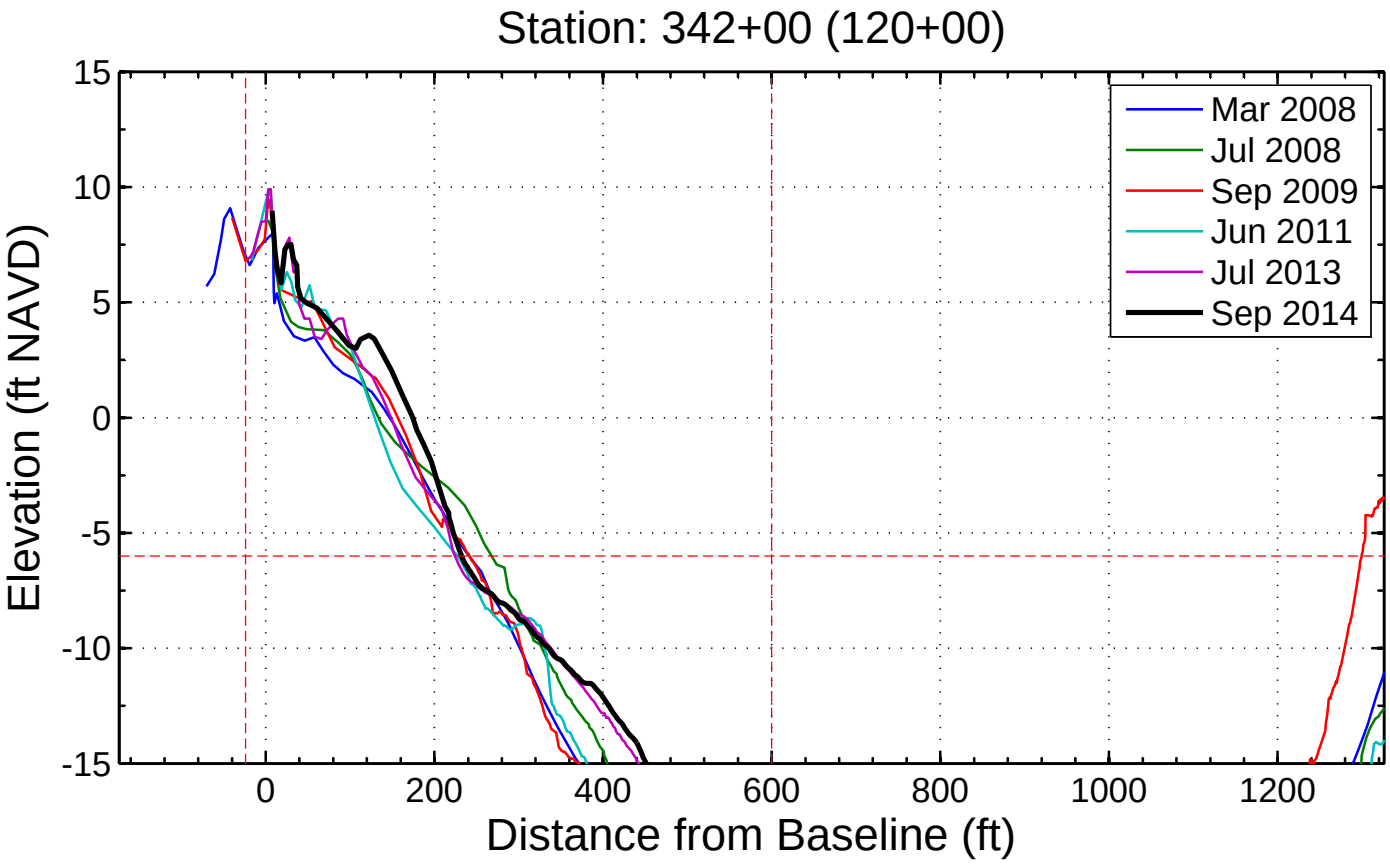
100
150
200
250
300
350
Distance from Baseline (ft)


Station: 342+00 (120+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
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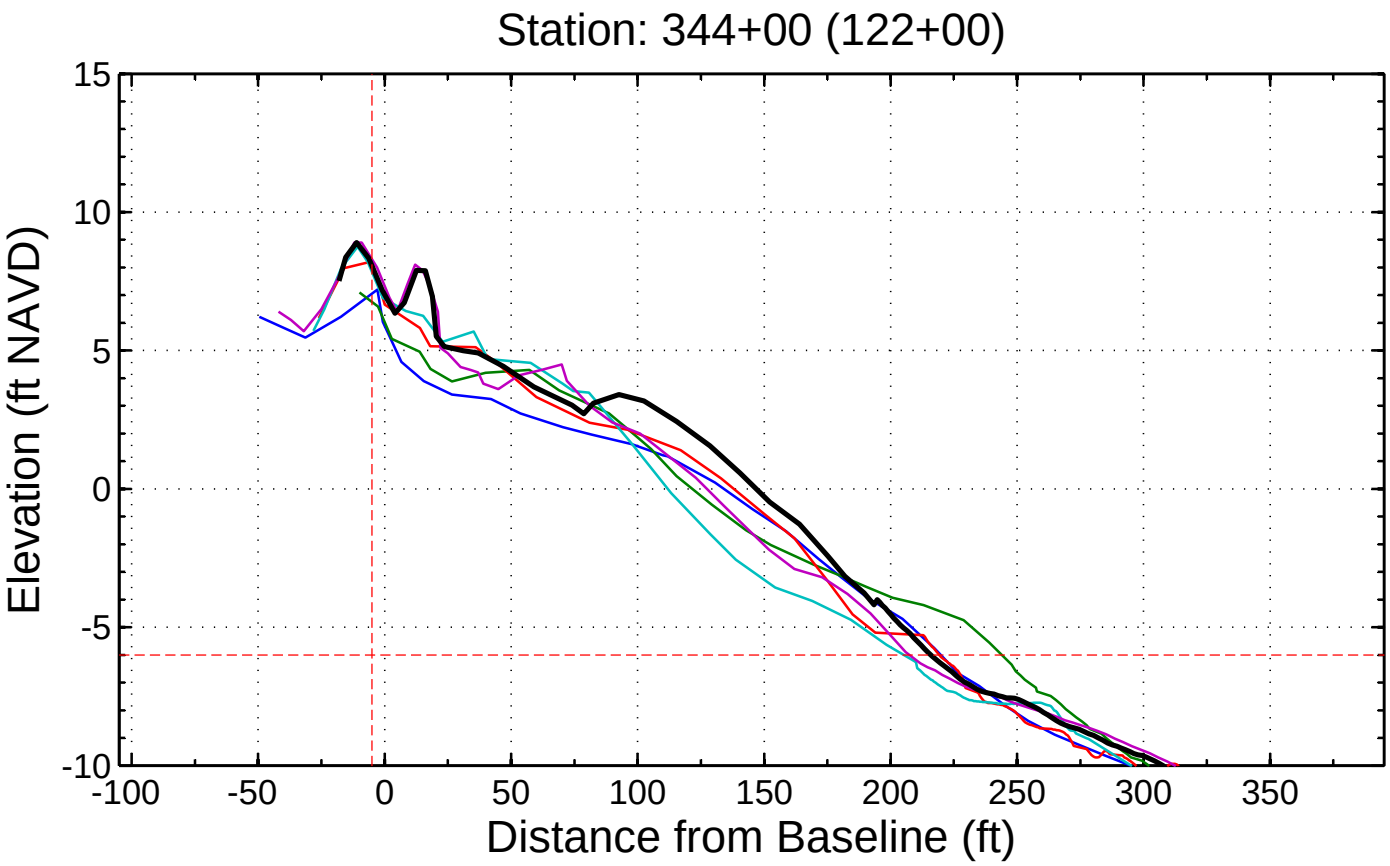
200
400
600
800
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 344+00 (122+00)
Elevation (ft NAVD)
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-5
-10
-100
-50
0
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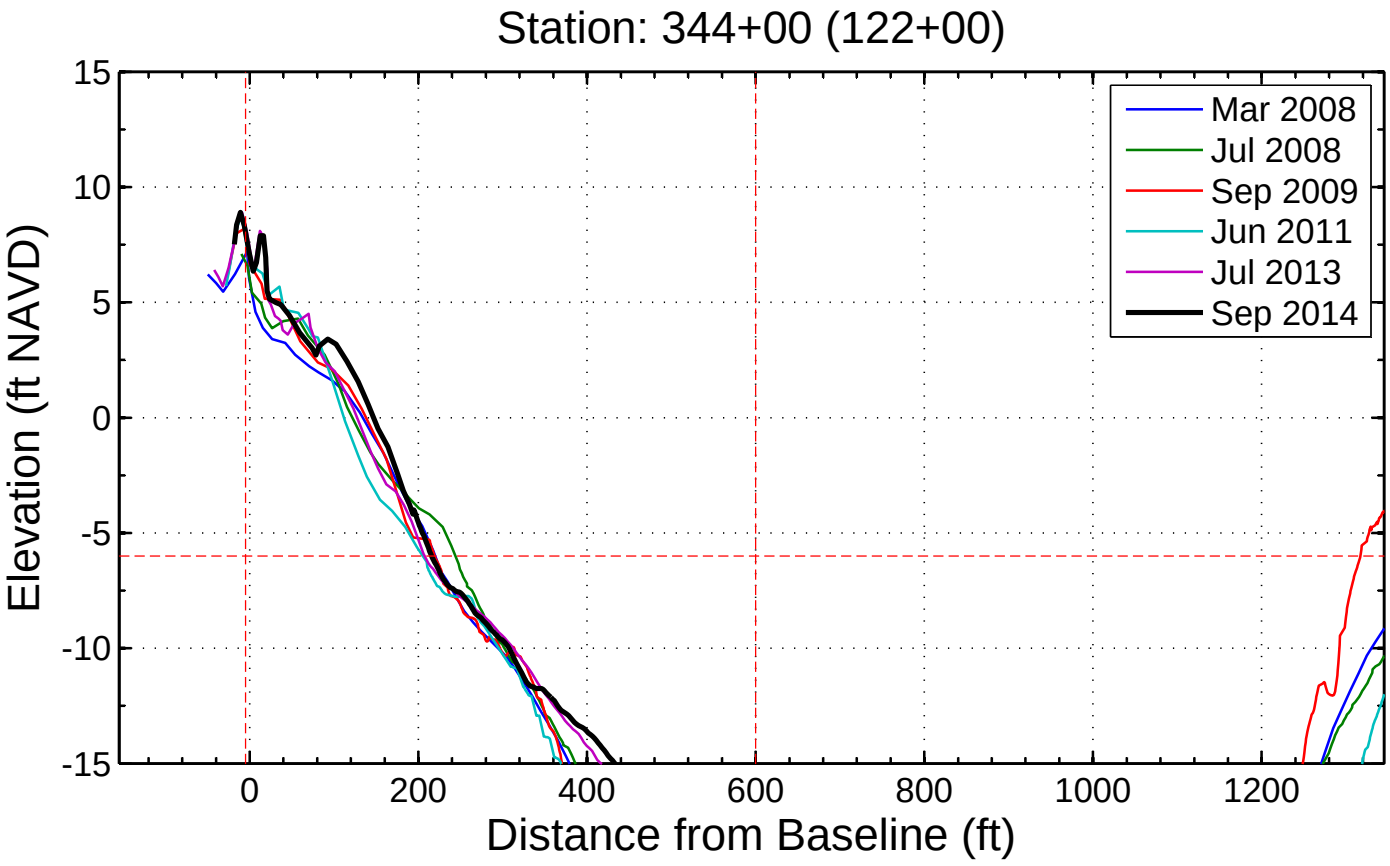
100
150
200
250
300
350
Distance from Baseline (ft)


Station: 344+00 (122+00)
Elevation (ft NAVD)
15
10
5
0
-5
-10
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600
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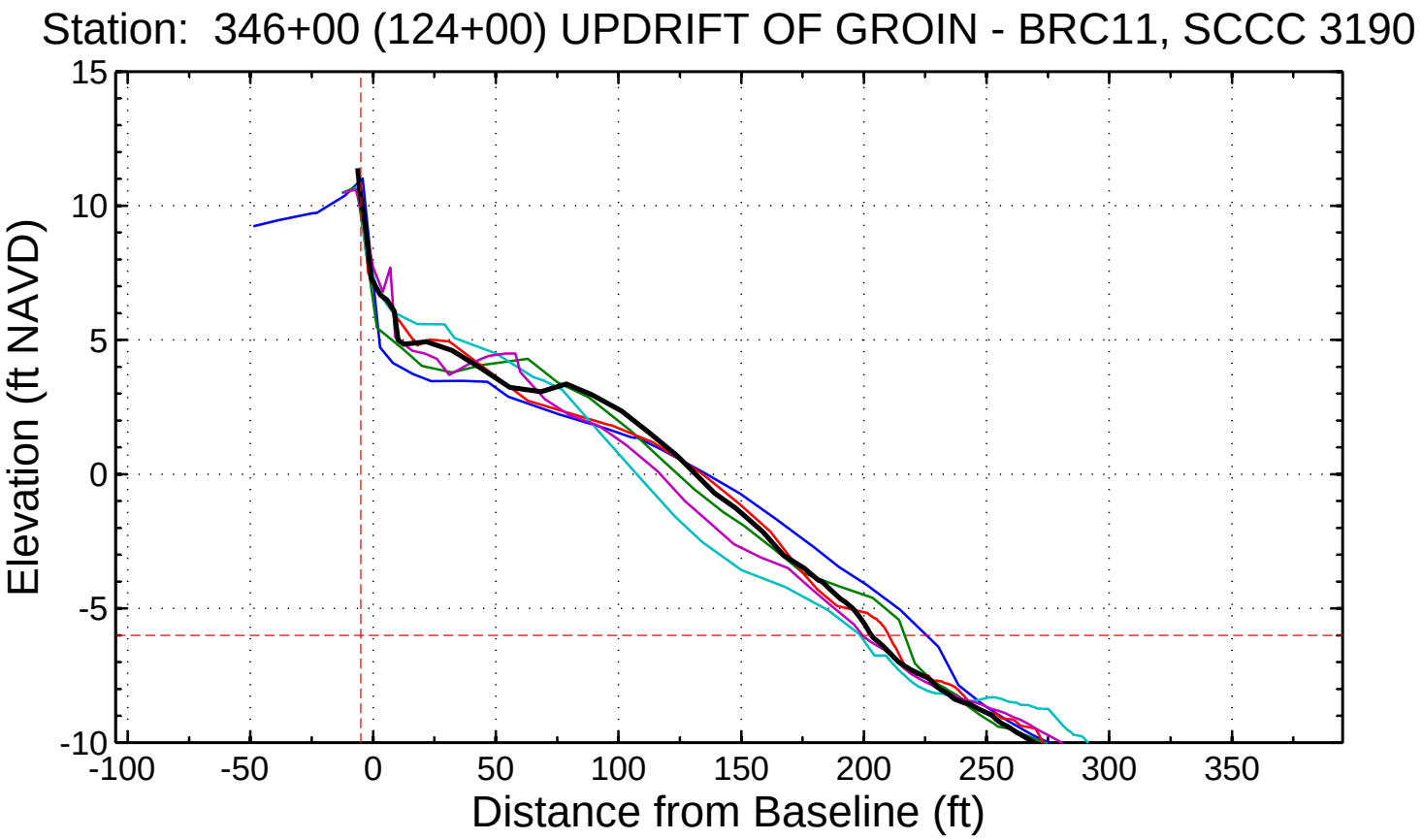
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 346+00 (124+00) UPDRIFT OF GROIN - BRC11, SCCC 3190
Elevation (ft NAVD)
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10
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-5
-10
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-50
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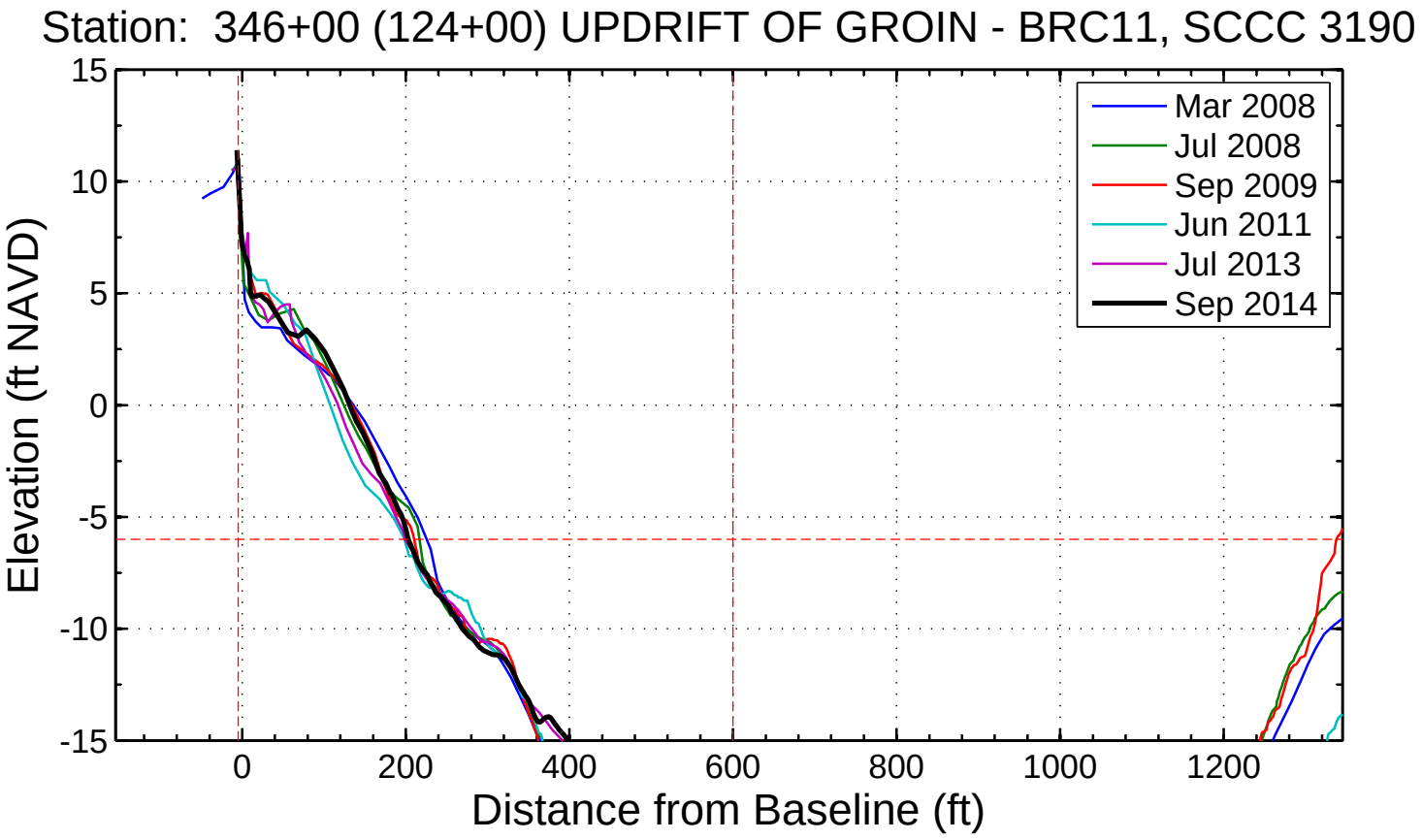
100
150
200
250
300
350
Distance from Baseline (ft)


Station: 346+00 (124+00) UPDRIFT OF GROIN - BRC11, SCCC 3190
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
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200
400
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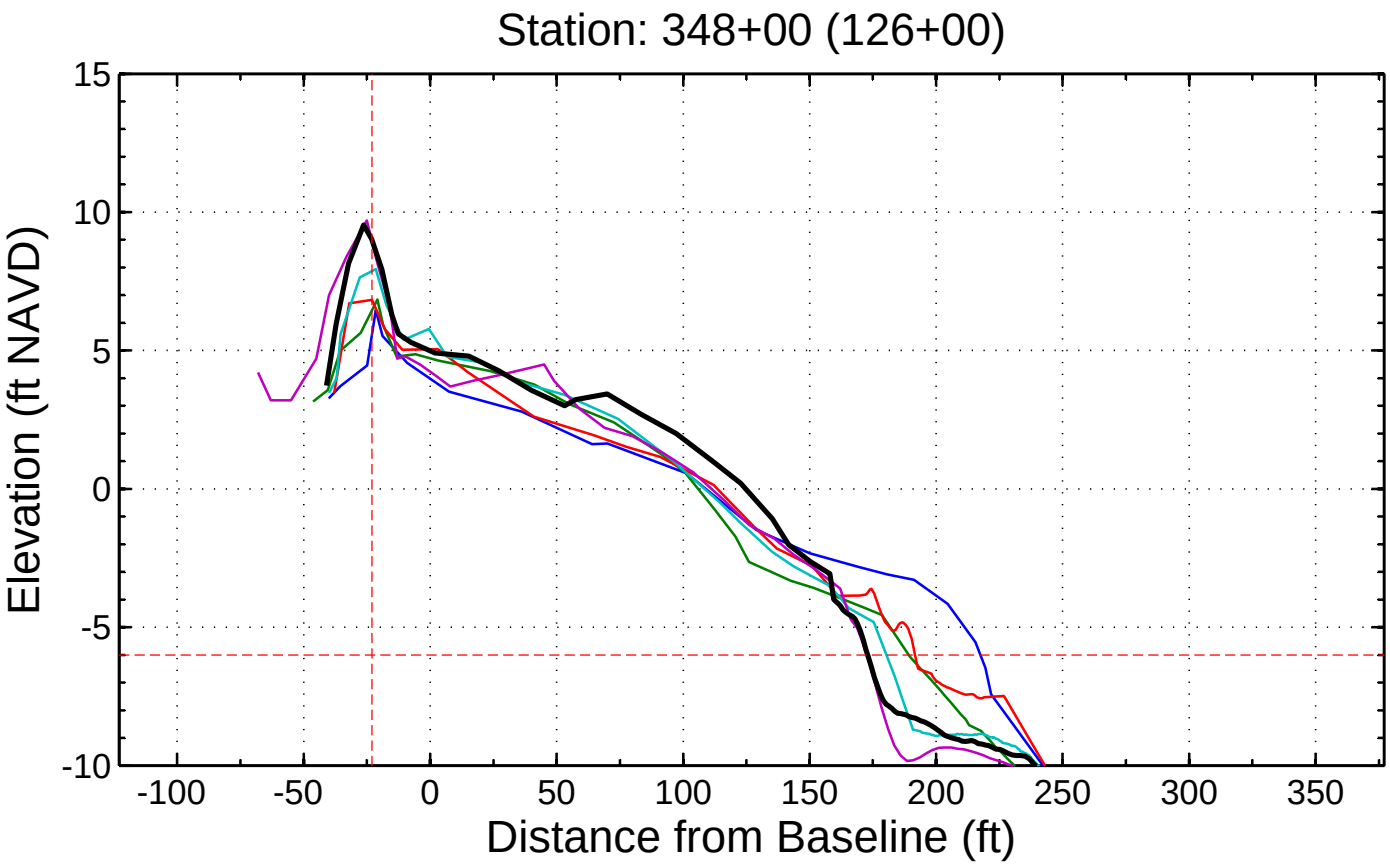
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 348+00 (126+00)
Elevation (ft NAVD)
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-5
-10
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-50
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150
200
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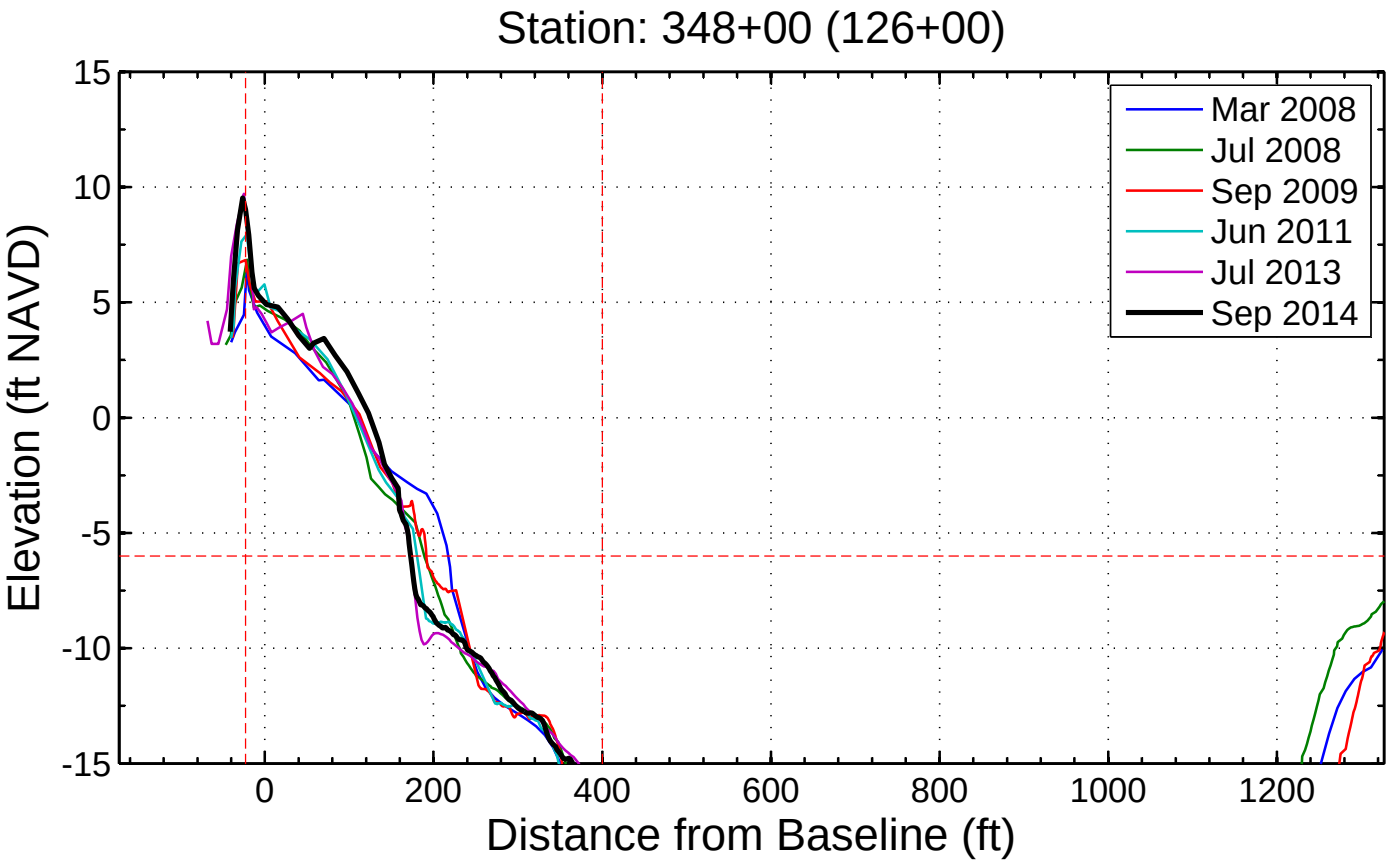
350
Distance from Baseline (ft)


Station: 348+00 (126+00)
Elevation (ft NAVD)
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10
5
0
-5
-10
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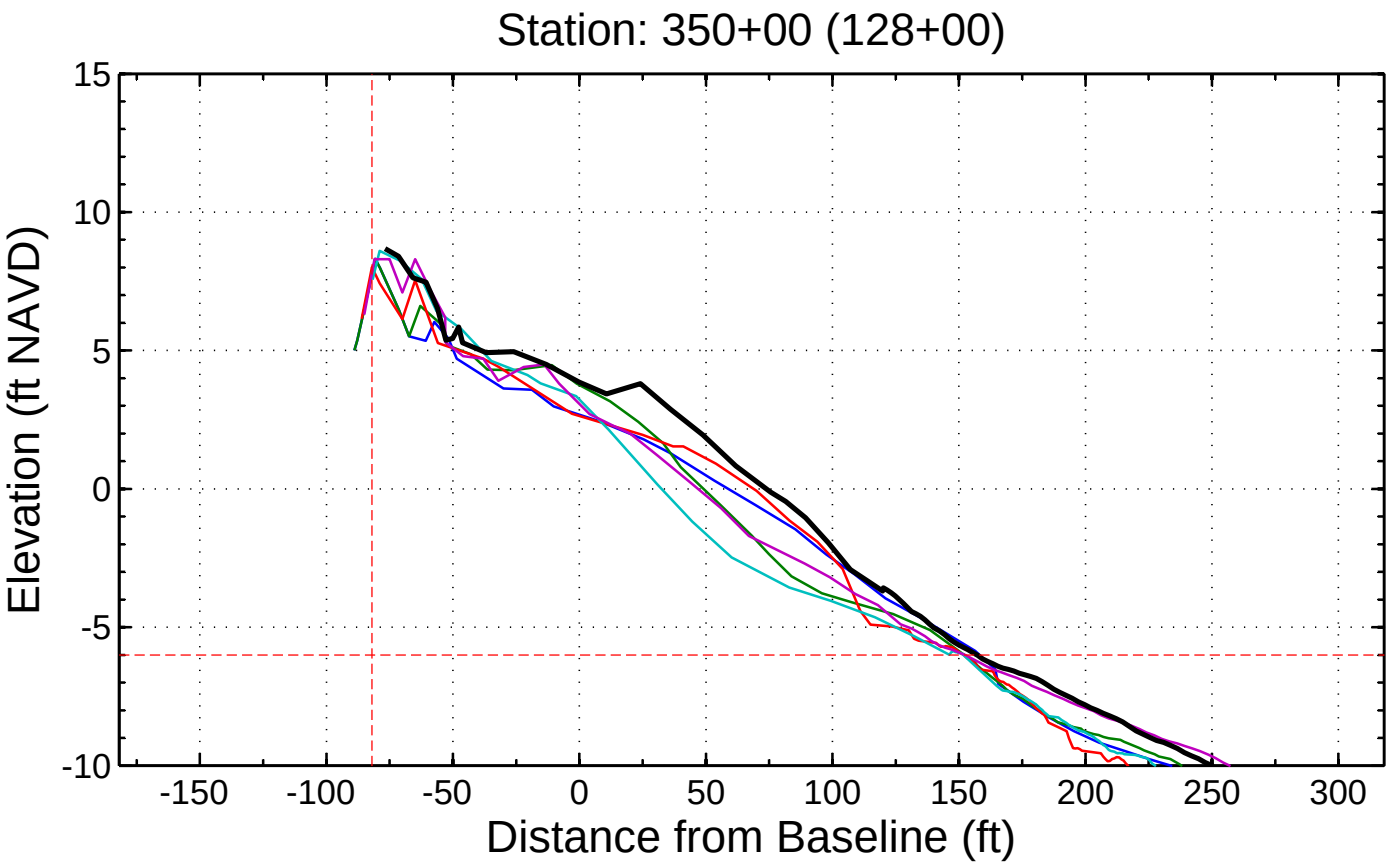
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 350+00 (128+00)
Elevation (ft NAVD)
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-5
-10
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-100
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100
150
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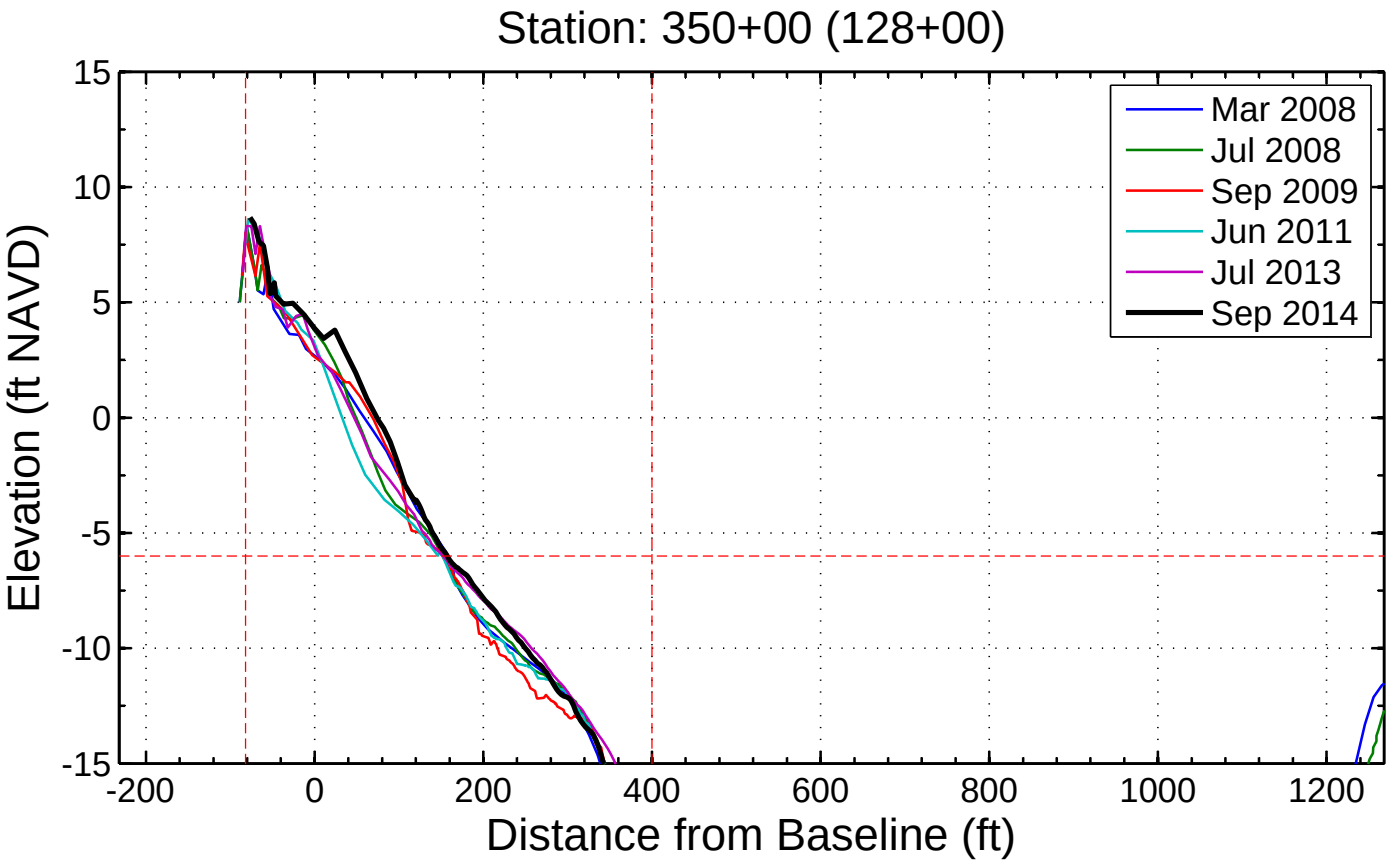
250
300
Distance from Baseline (ft)


Station: 350+00 (128+00)
Elevation (ft NAVD)
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10
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0
-5
-10
-15
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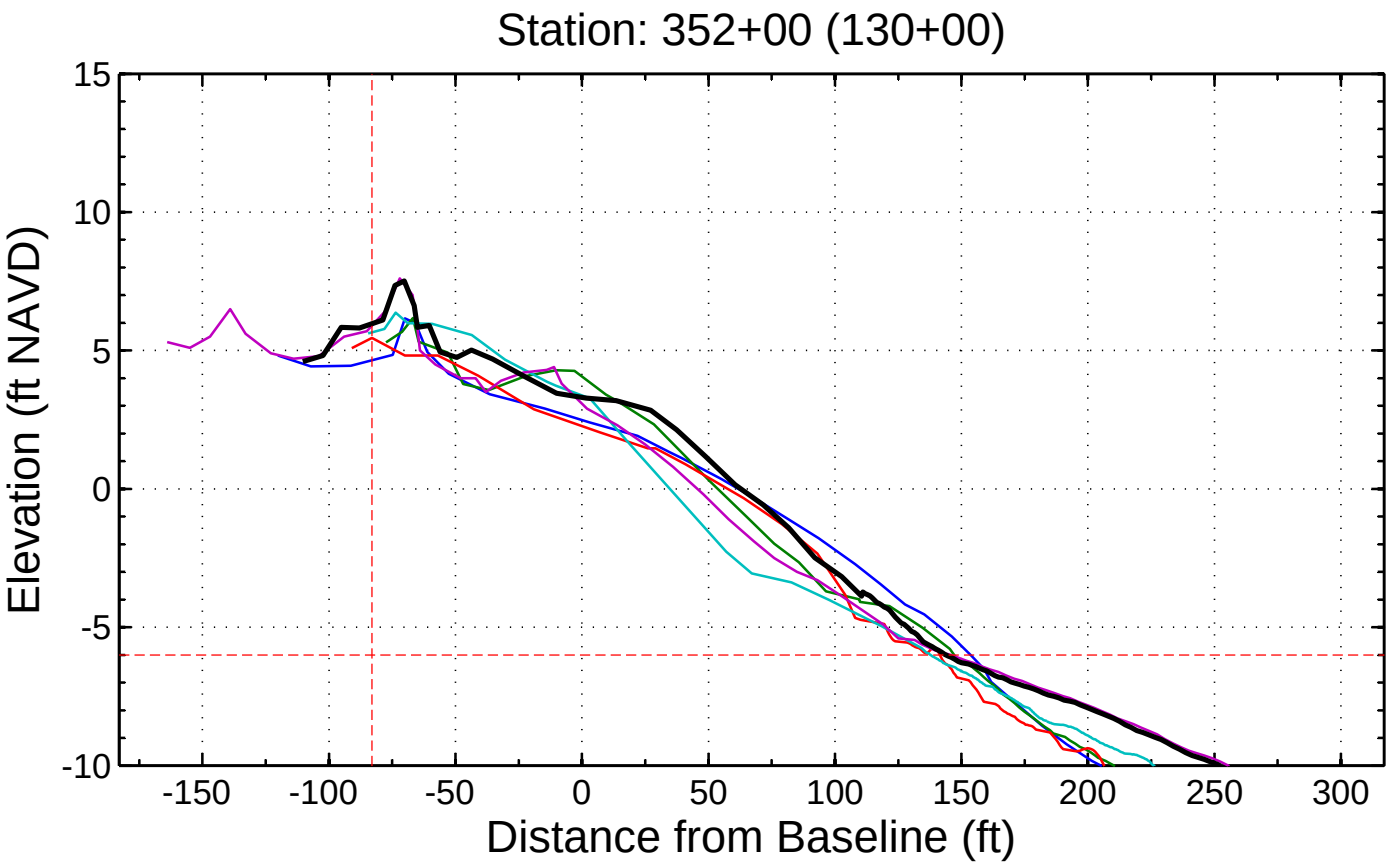
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 352+00 (130+00)
Elevation (ft NAVD)
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-10
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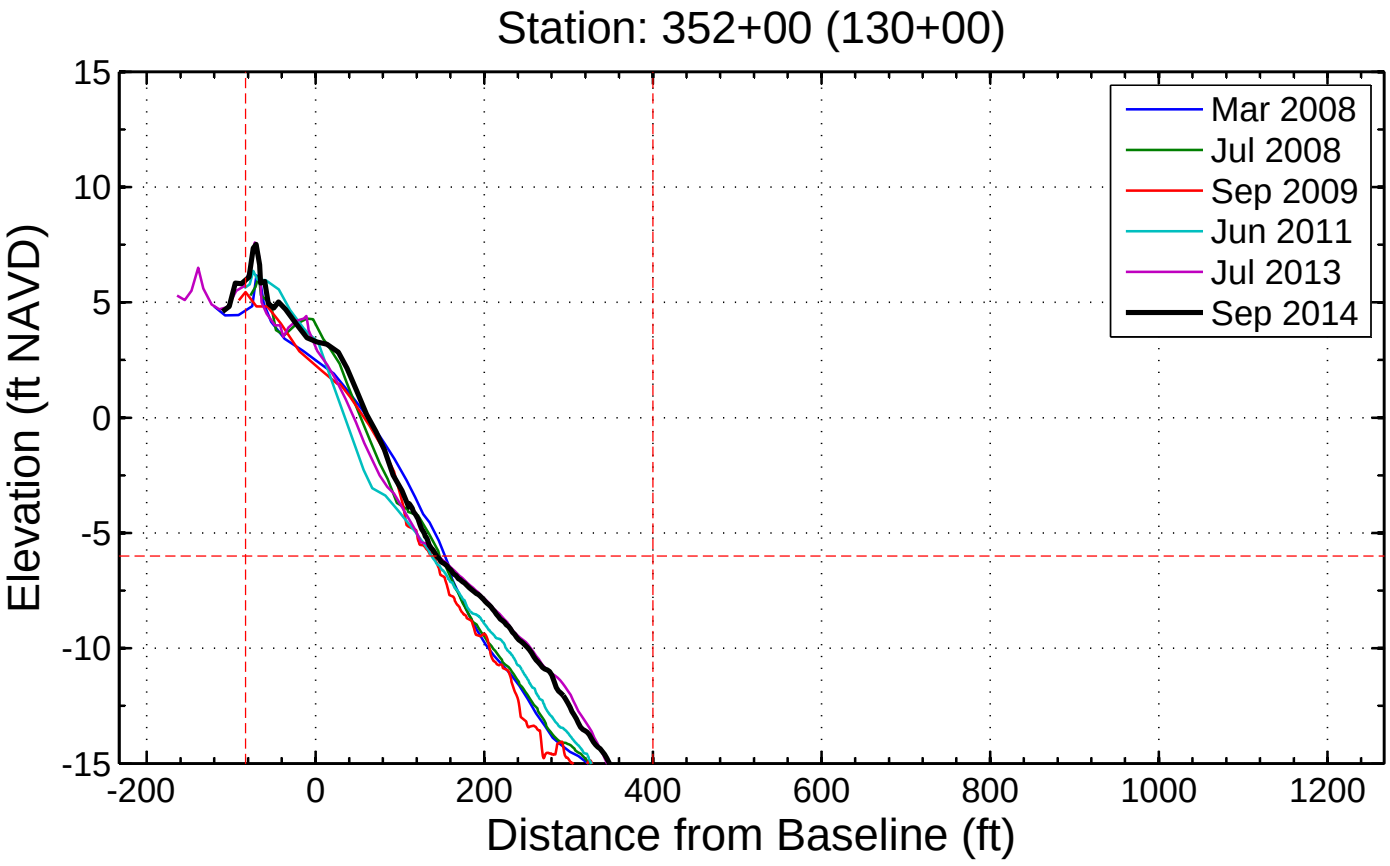
Distance from Baseline (ft)


Station: 352+00 (130+00)
Elevation (ft NAVD)
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10
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0
-5
-10
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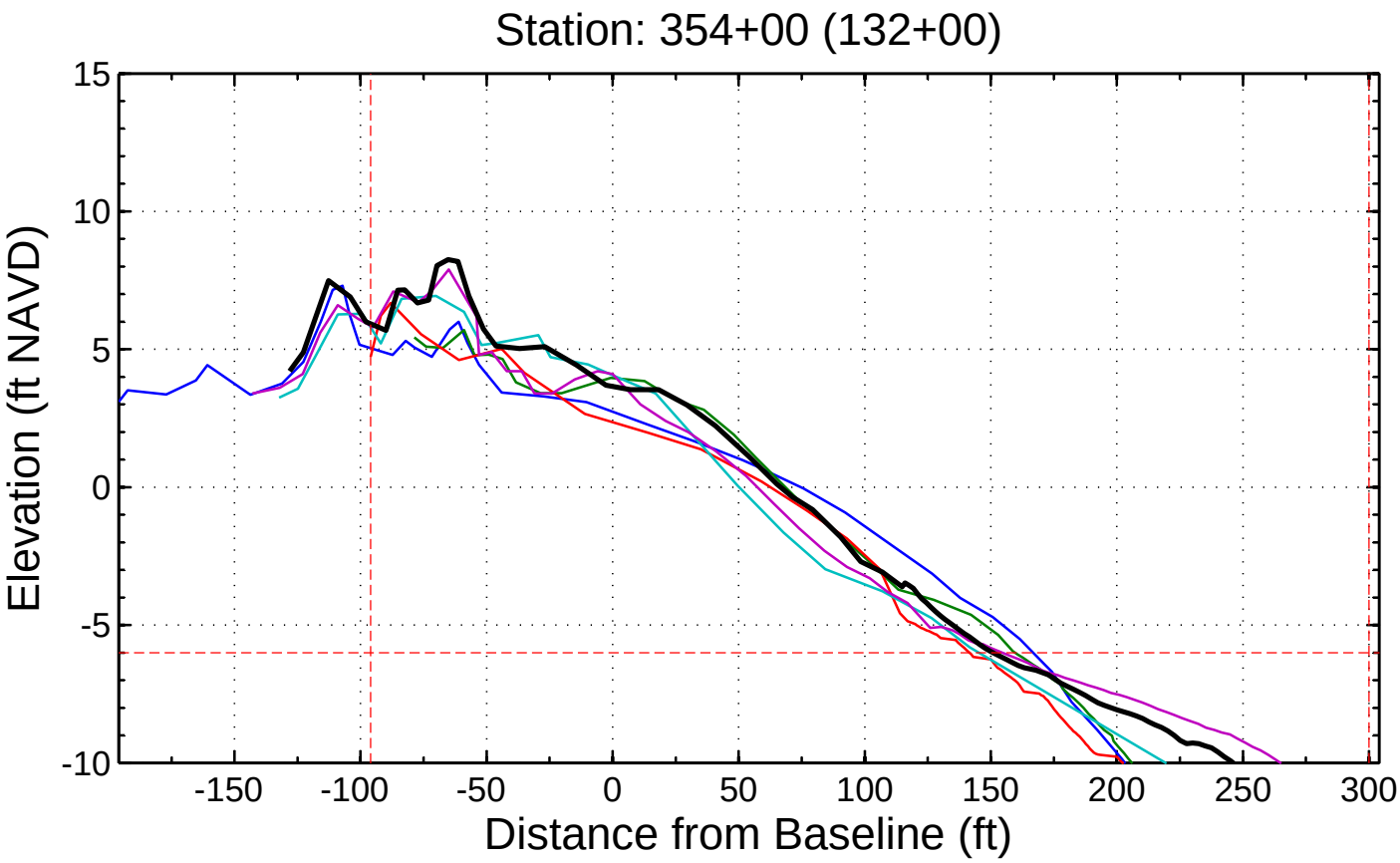
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 354+00 (132+00)
Elevation (ft NAVD)
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-100
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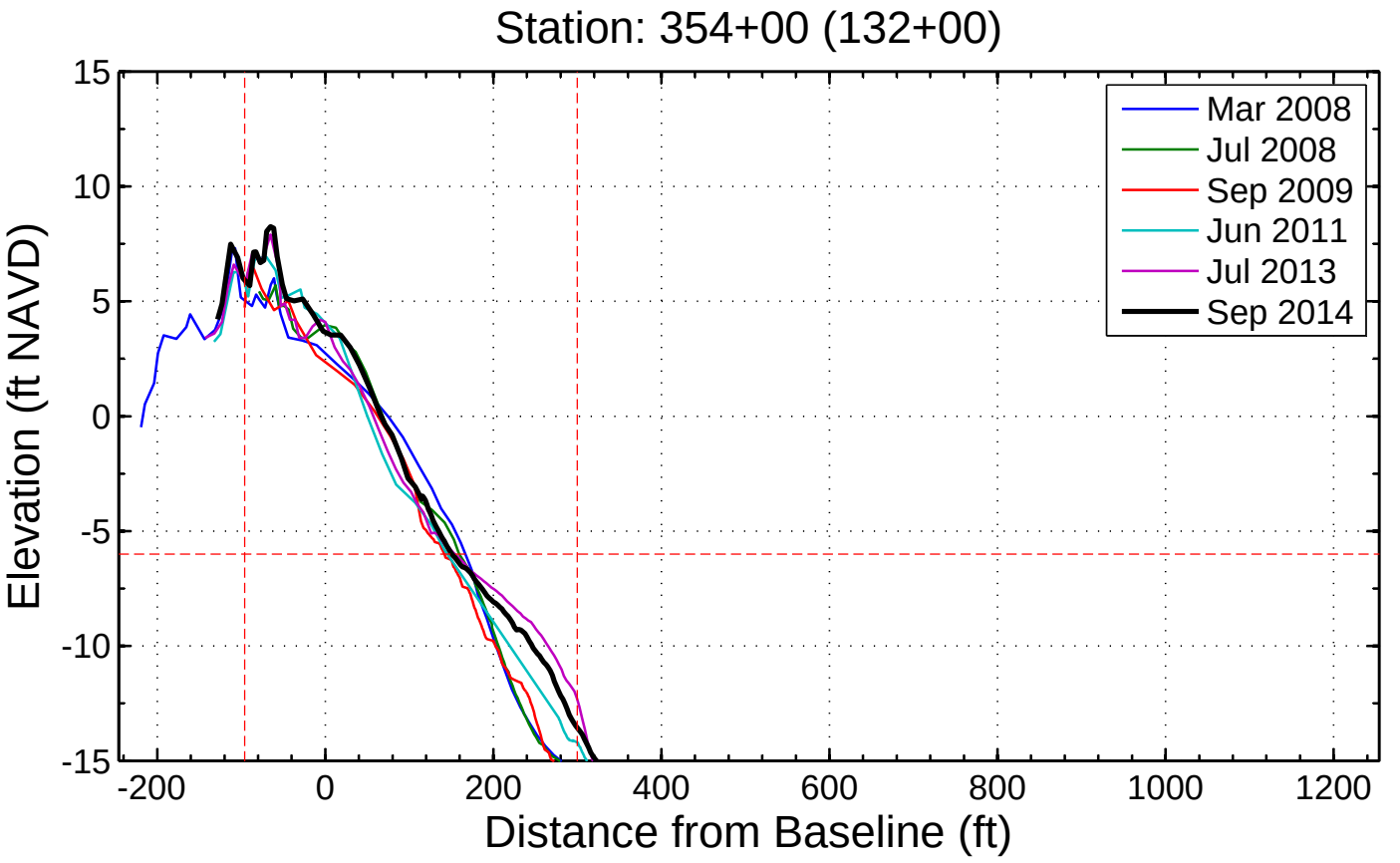
Distance from Baseline (ft)


Station: 354+00 (132+00)
Elevation (ft NAVD)
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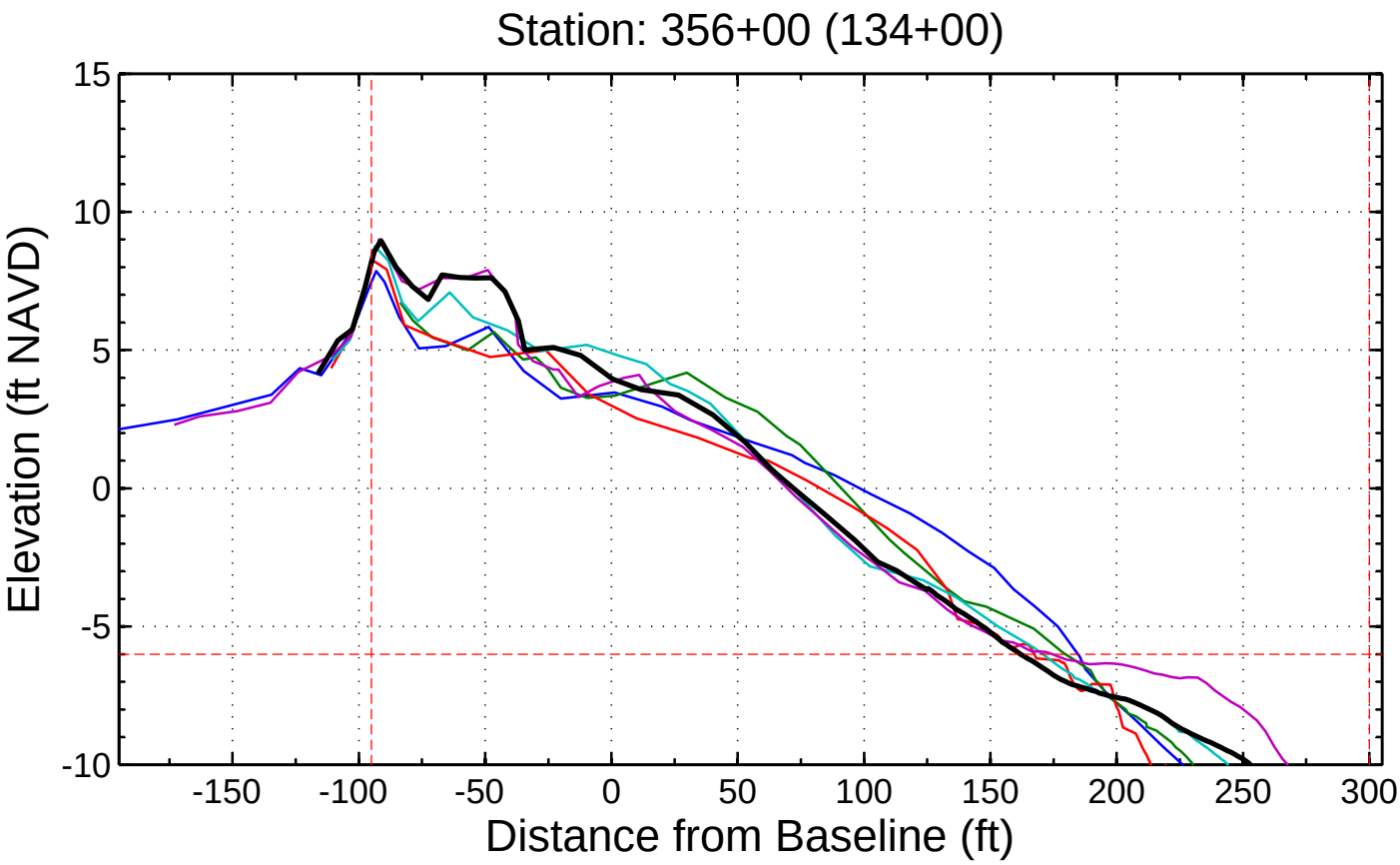
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 356+00 (134+00)
Elevation (ft NAVD)
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-10
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-100
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150
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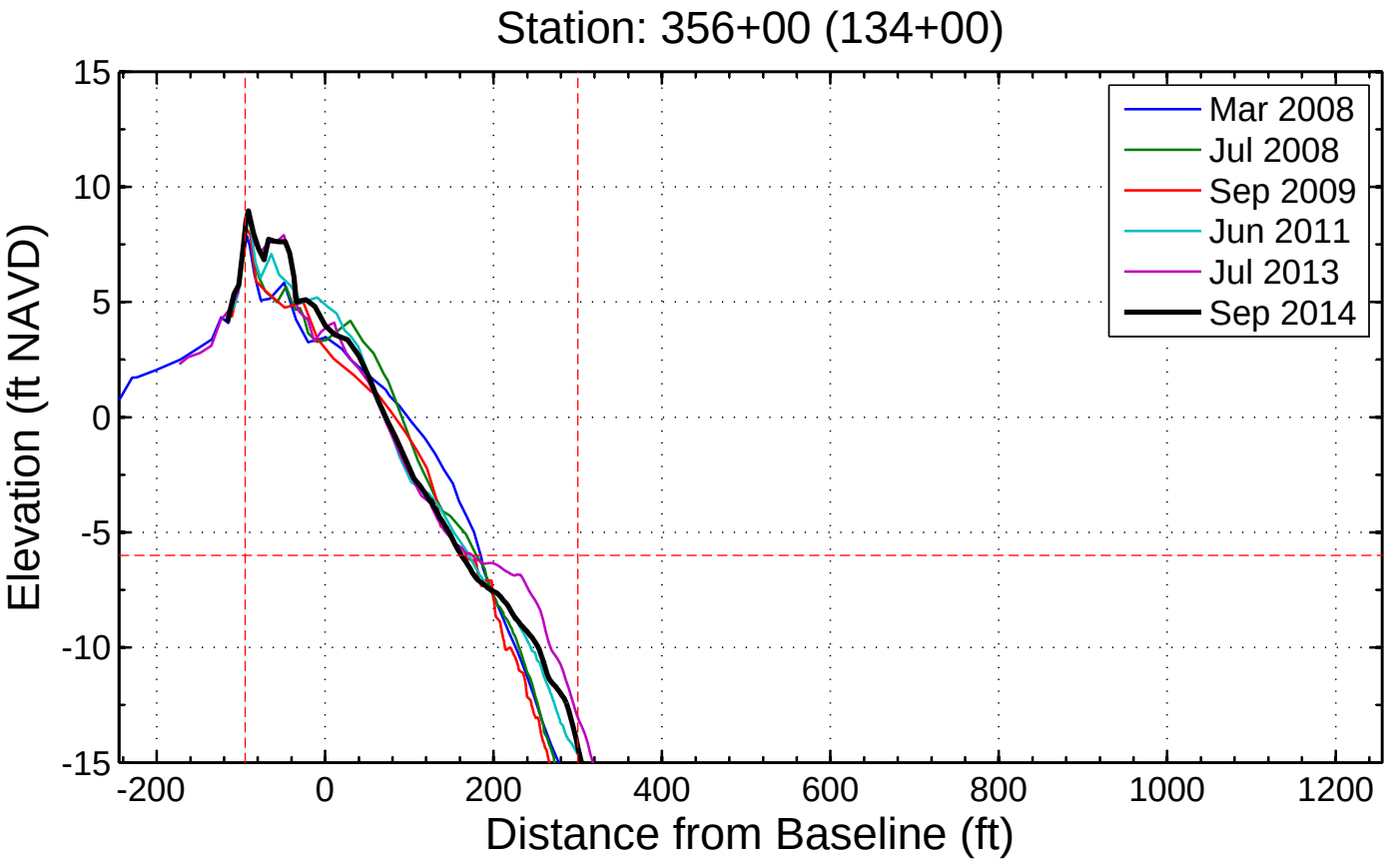
300
Distance from Baseline (ft)


Station: 356+00 (134+00)
Elevation (ft NAVD)
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10
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-5
-10
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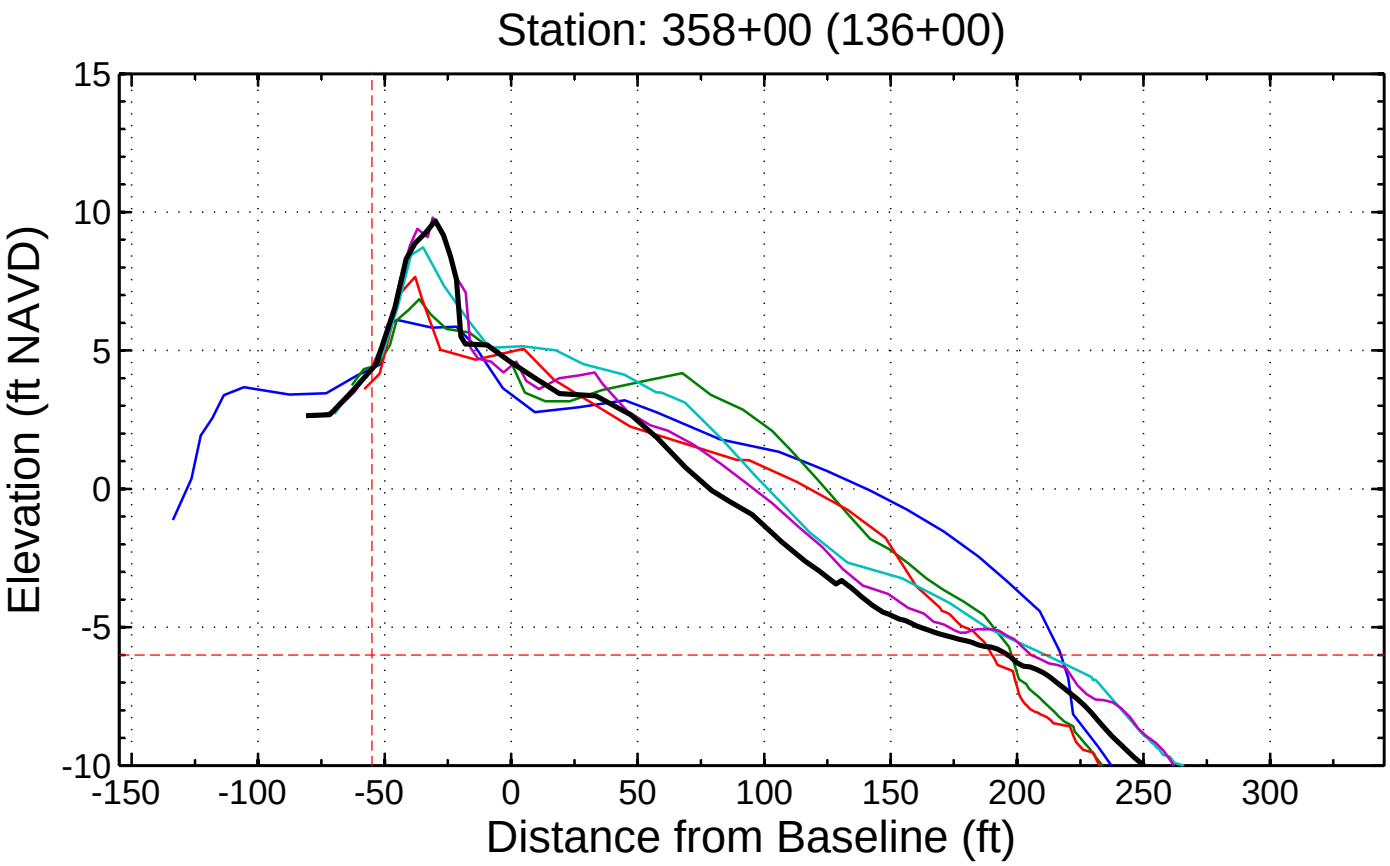
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 358+00 (136+00)
Elevation (ft NAVD)
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-5
-10
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-100
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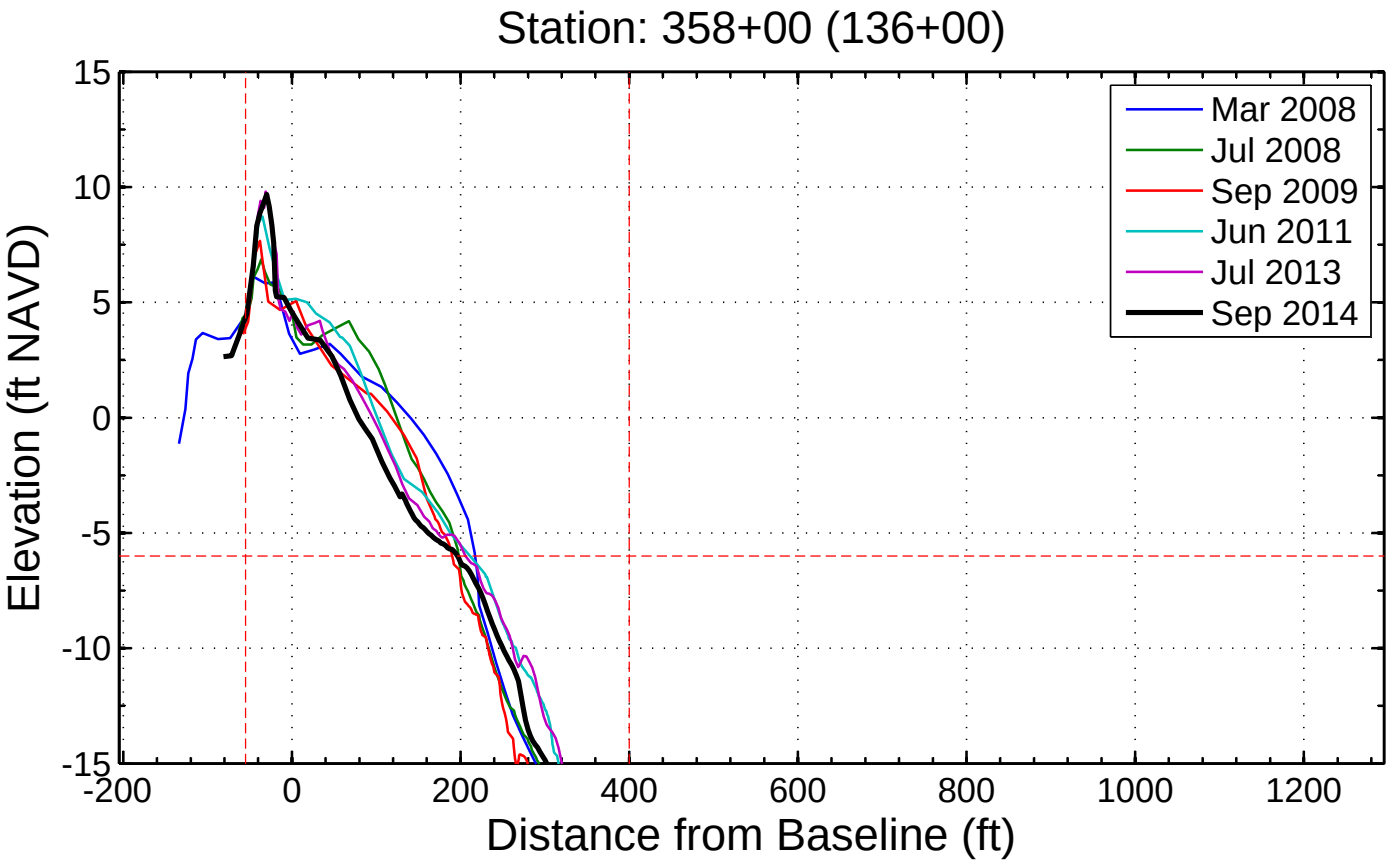
100
150
200
250
300
Distance from Baseline (ft)


Station: 358+00 (136+00)
Elevation (ft NAVD)
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10
5
0
-5
-10
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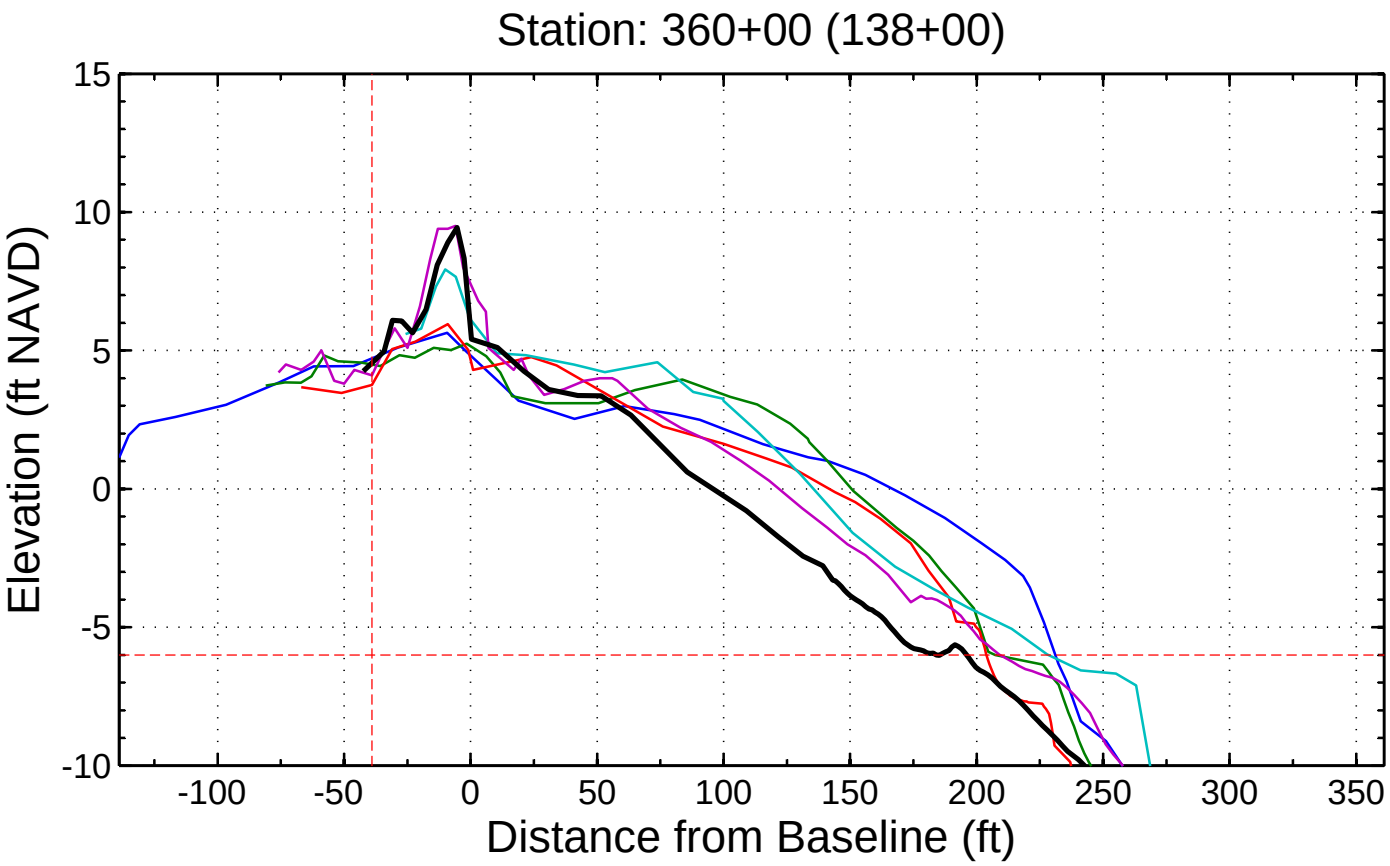
400
600
800
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 360+00 (138+00)
Elevation (ft NAVD)
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-5
-10
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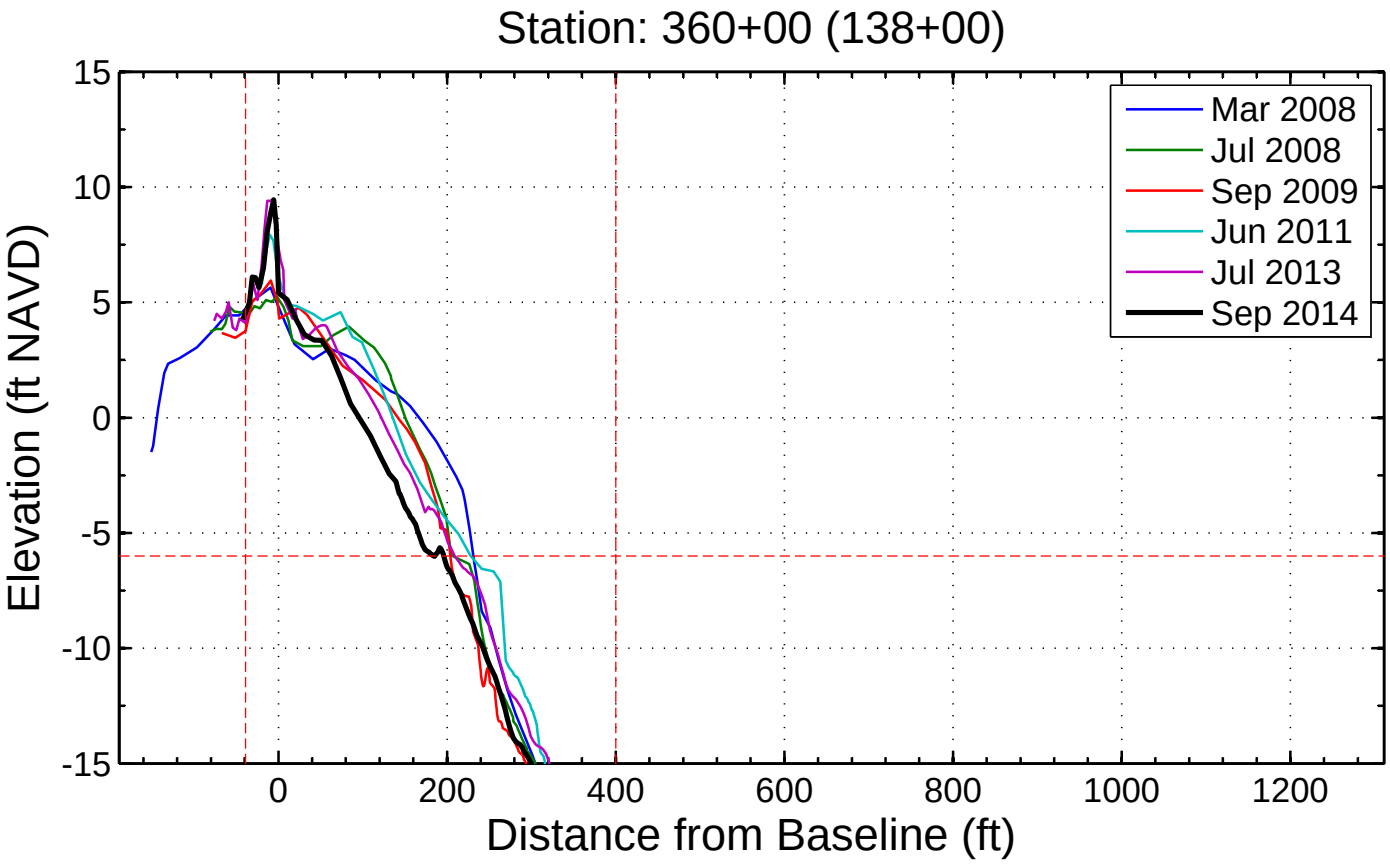
150
200
250
300
350
Distance from Baseline (ft)


Station: 360+00 (138+00)
Elevation (ft NAVD)
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10
5
0
-5
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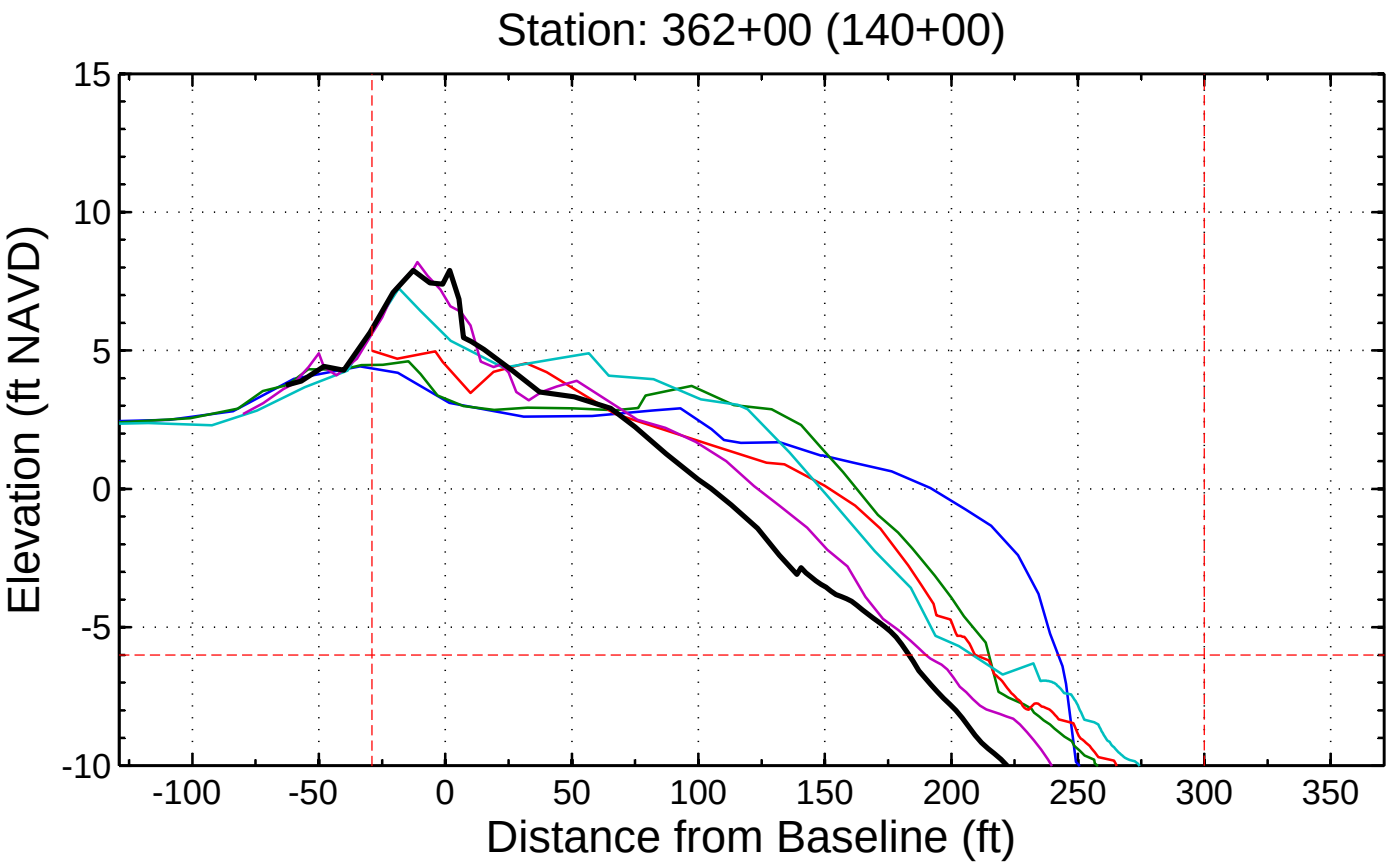
400
600
800
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 362+00 (140+00)
Elevation (ft NAVD)
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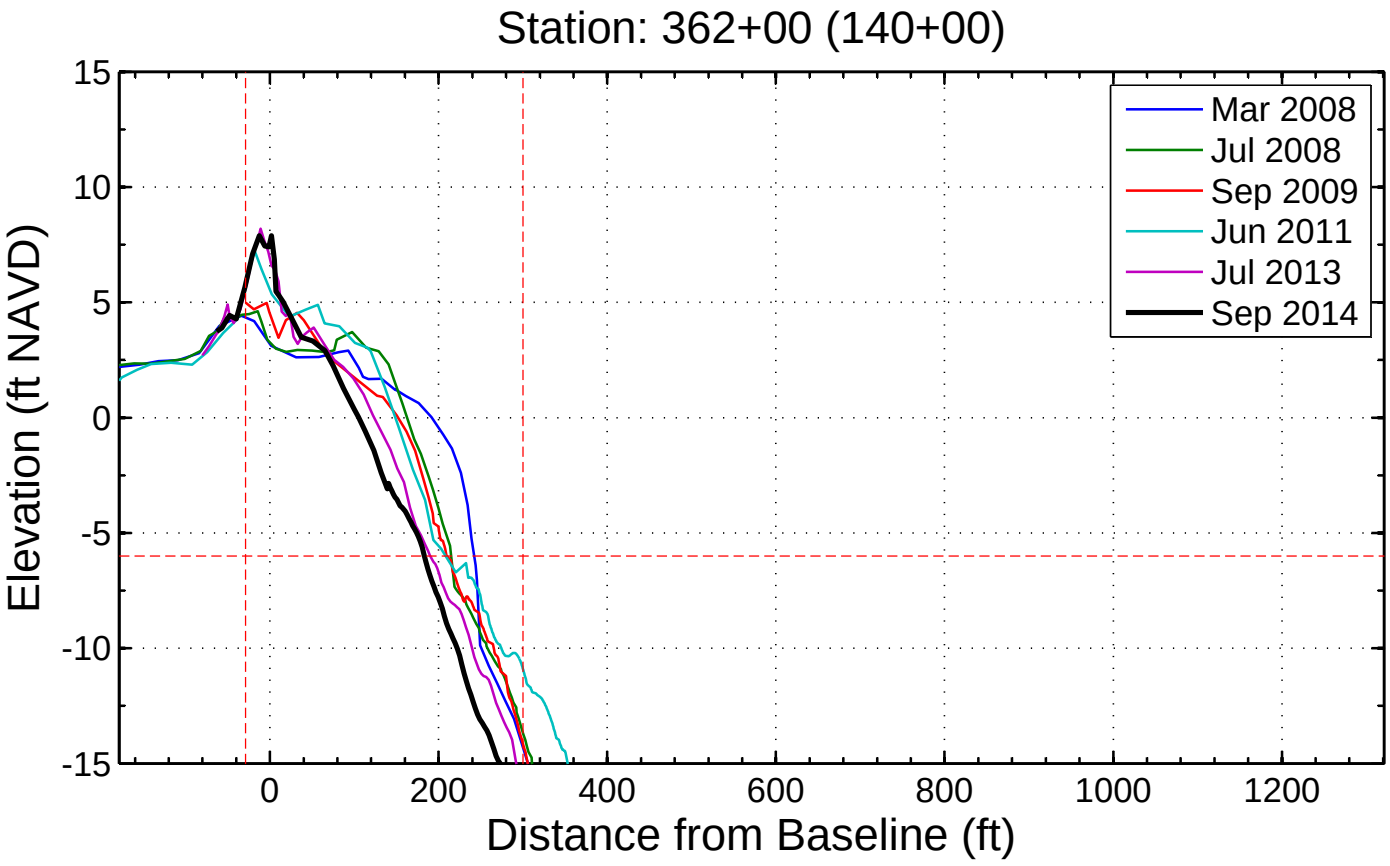
100
150
200
250
300
350
Distance from Baseline (ft)


Station: 362+00 (140+00)
Elevation (ft NAVD)
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10
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0
-5
-10
-15
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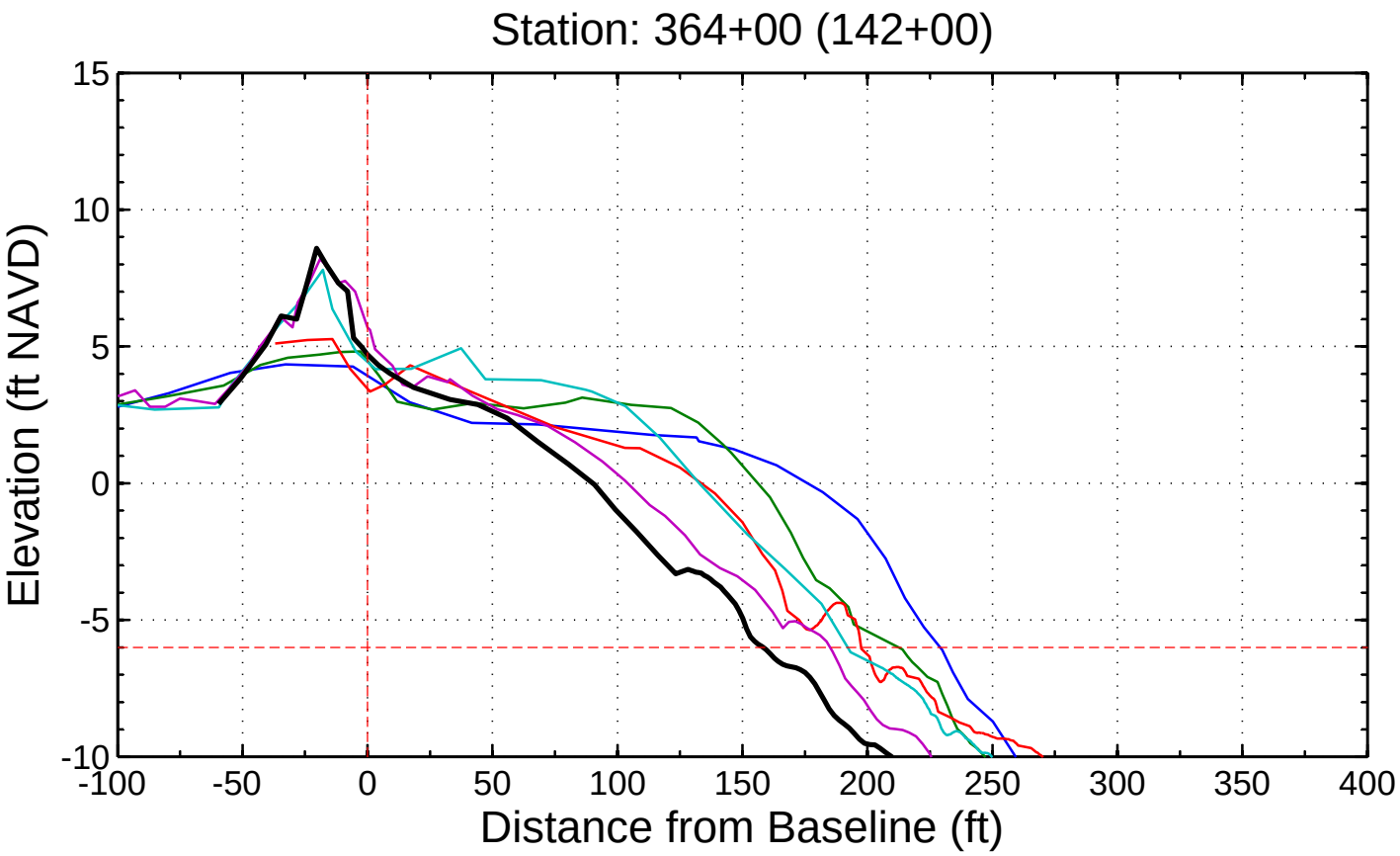
200
400
600
800
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 364+00 (142+00)
Elevation (ft NAVD)
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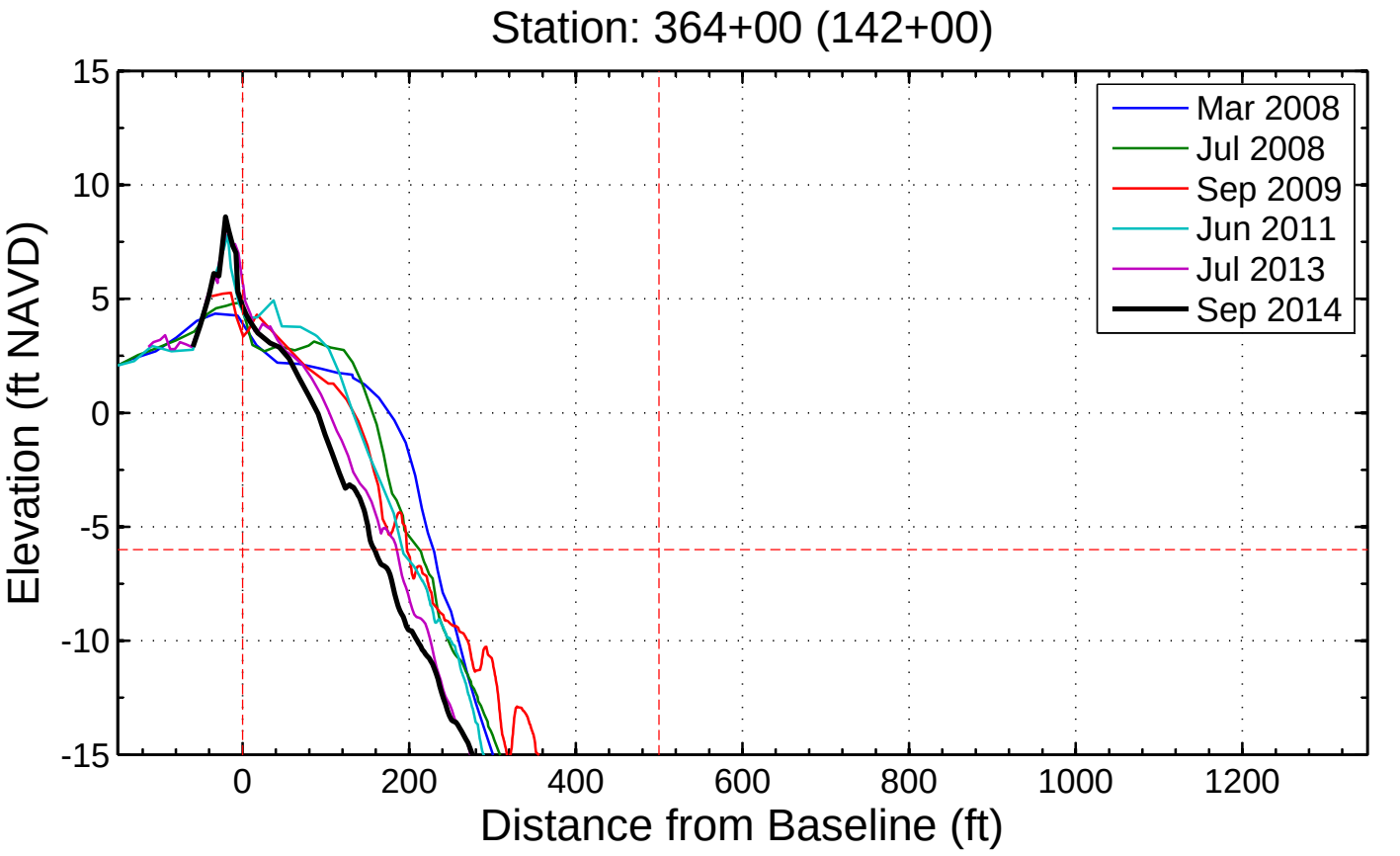
-10
-100
-50
0
50
100
150
200
250
300
350
400
Distance from Baseline (ft)


Station: 364+00 (142+00)
Elevation (ft NAVD)
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10
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0
-5
-10
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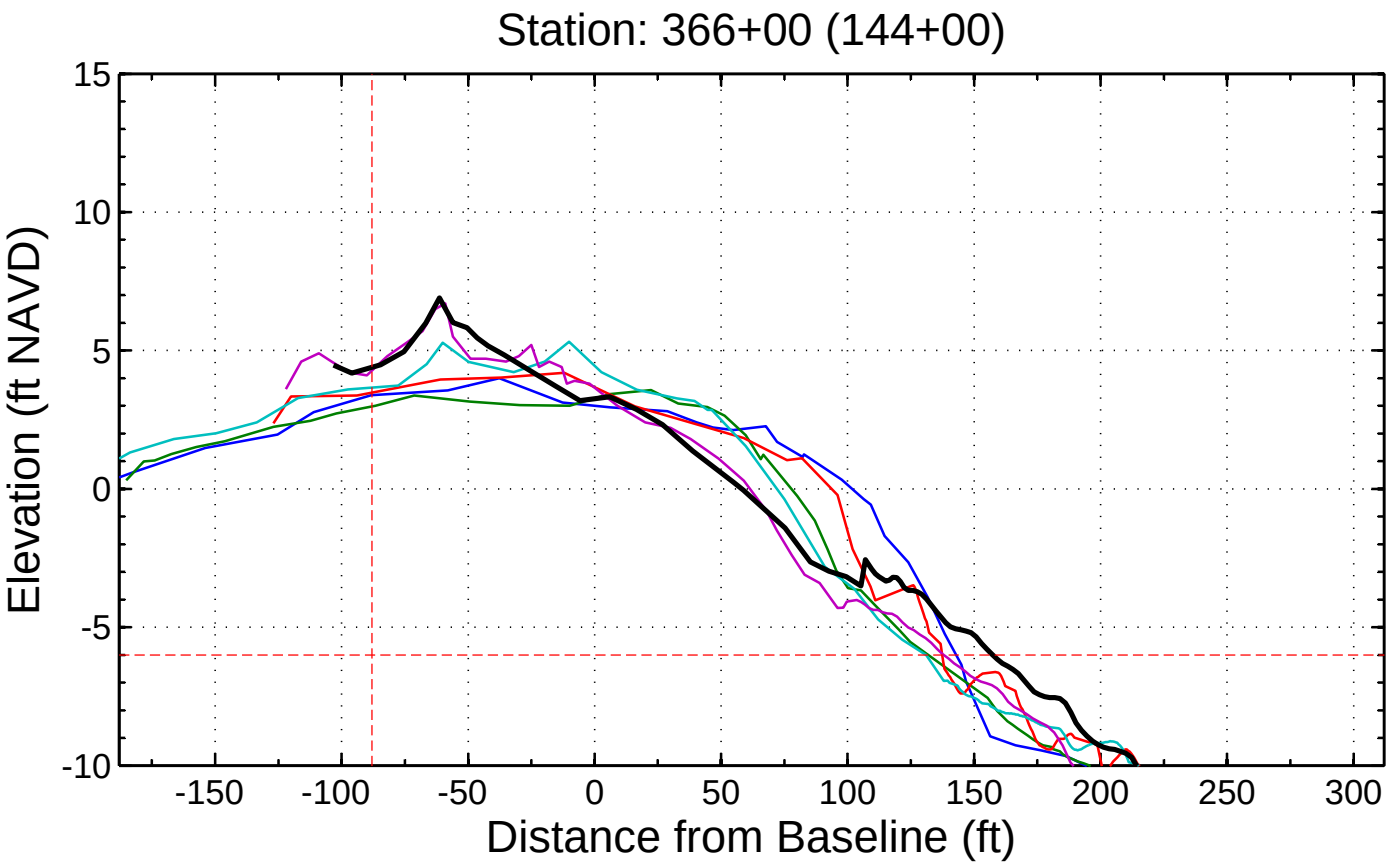
200
400
600
800
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014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Elevation (ft NAVD)
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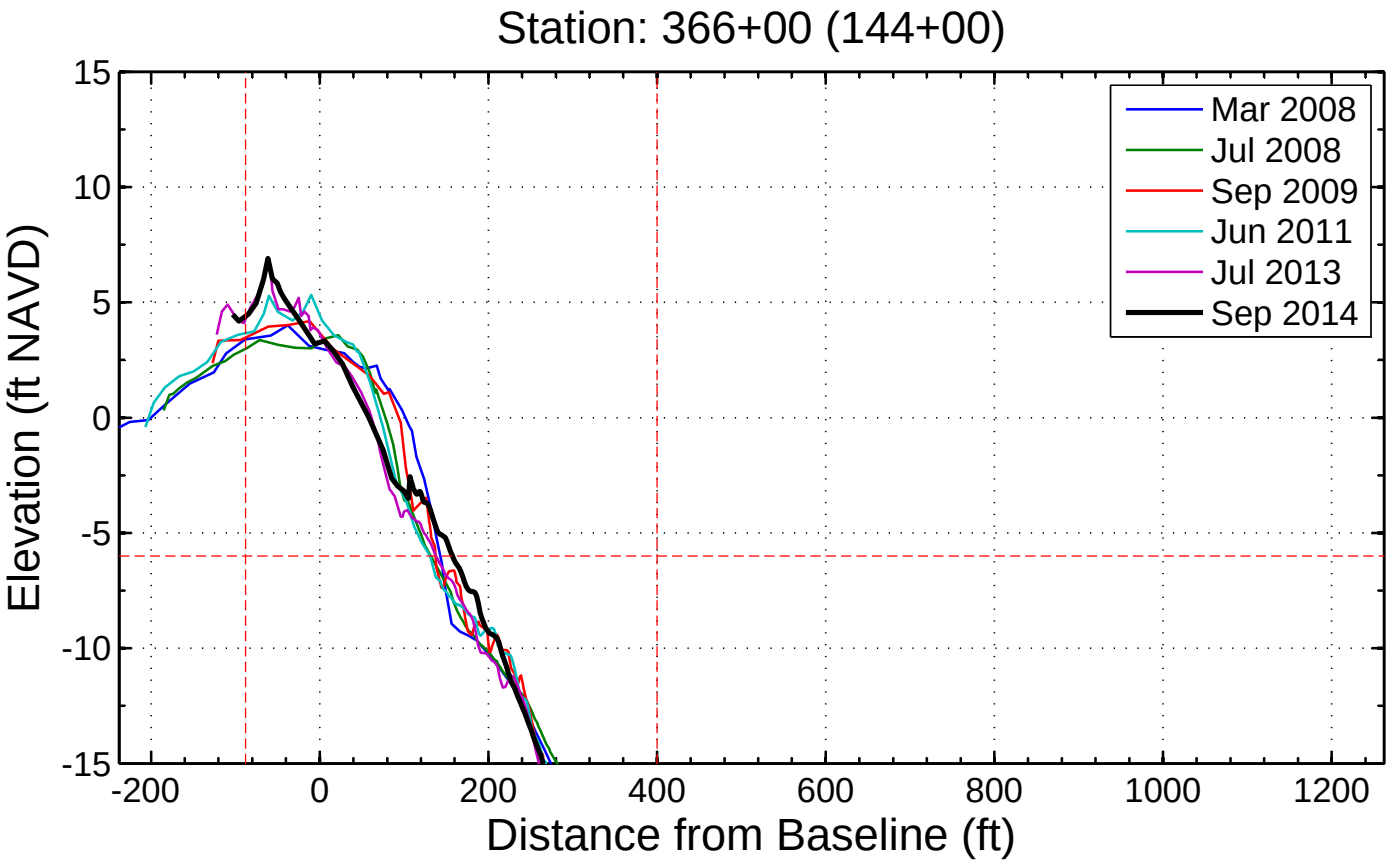
100
150
200
250
300
Distance from Baseline (ft)


Station: 366+00 (144+00)
Elevation (ft NAVD)
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0
-5
-10
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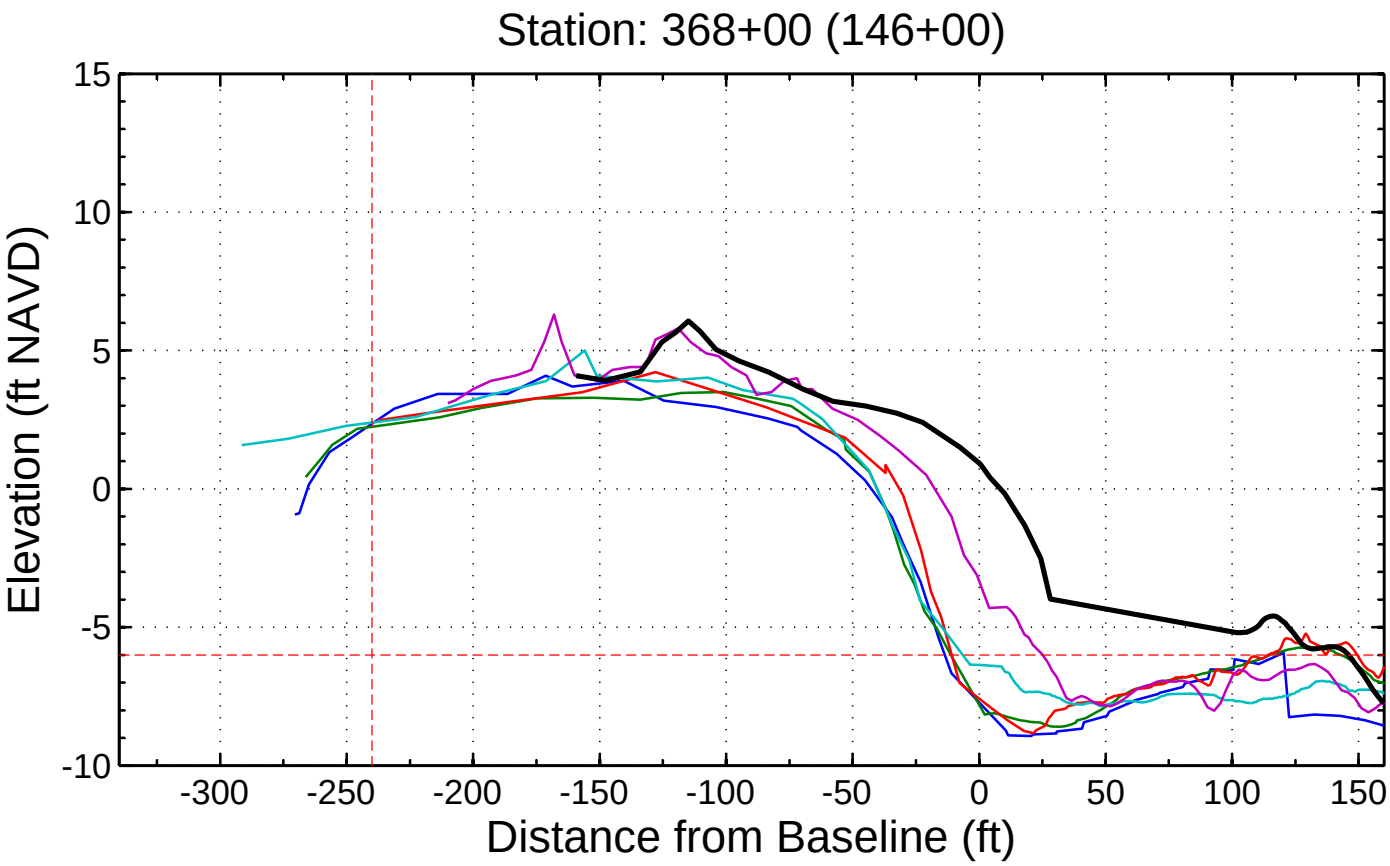
600
800
1000
1200
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 368+00 (146+00)
Elevation (ft NAVD)
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-300
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-200
-150
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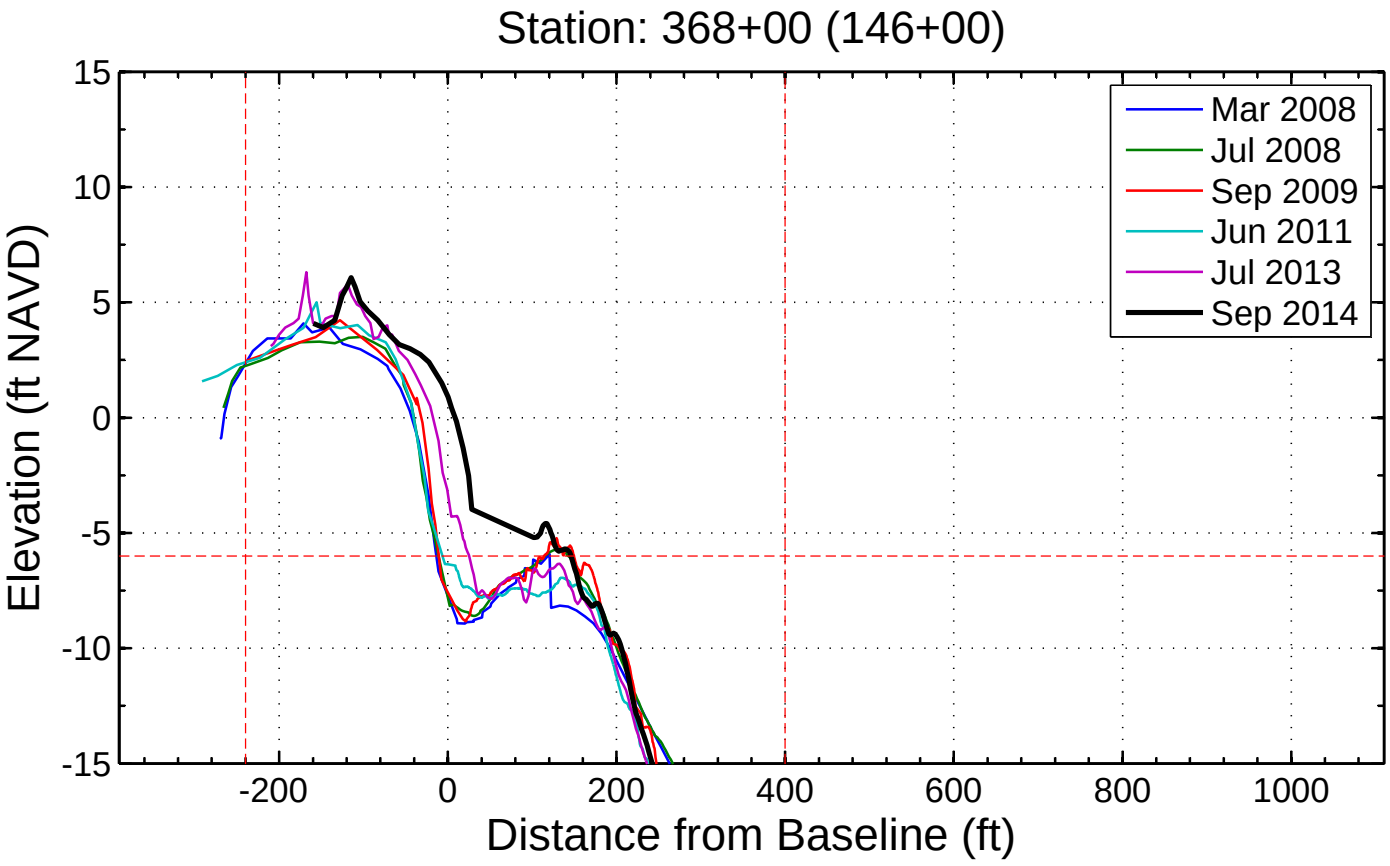
-50
0
50
100
150
Distance from Baseline (ft)


Station: 368+00 (146+00)
Elevation (ft NAVD)
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0
-5
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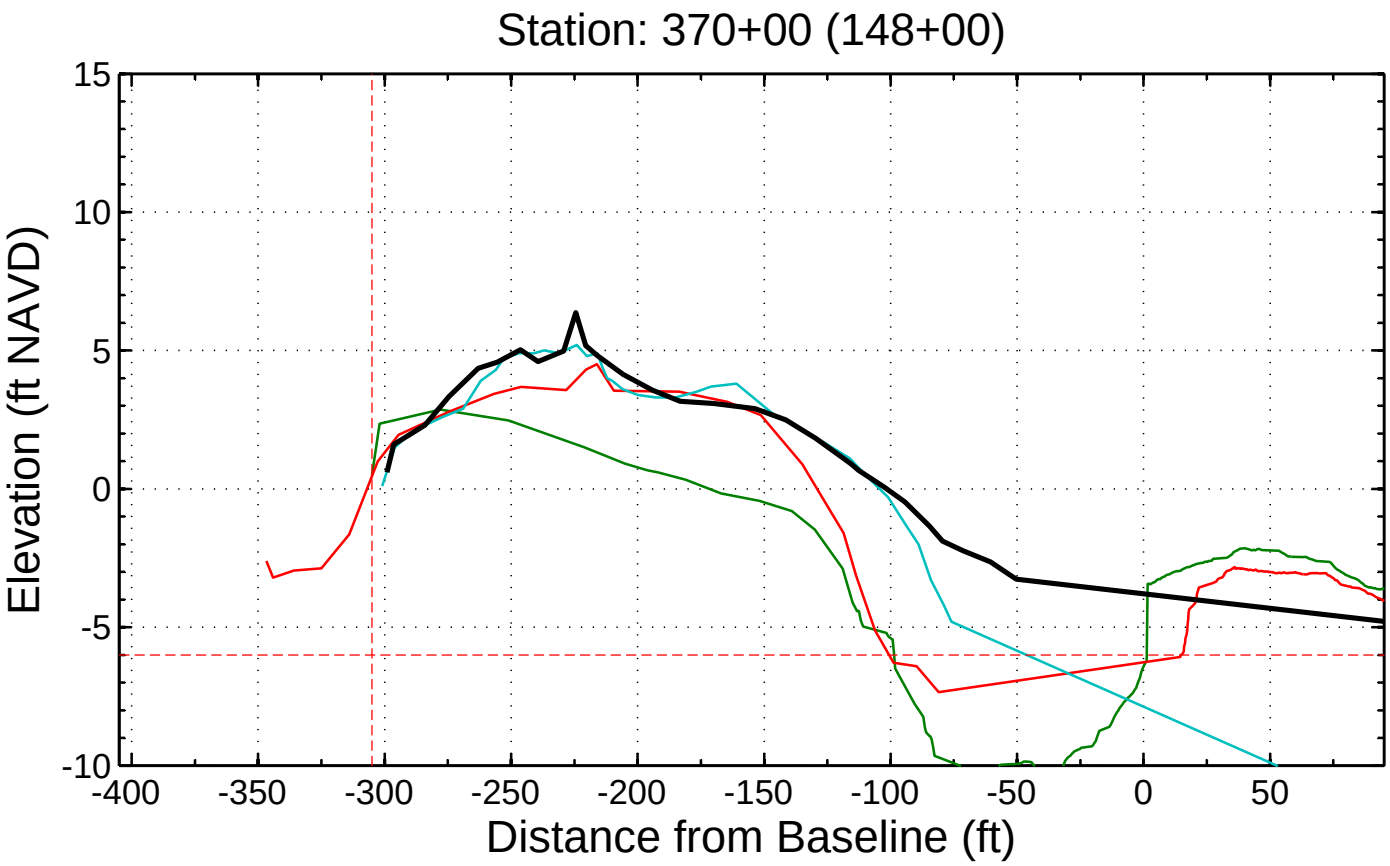
400
600
800
1000
Distance from Baseline (ft)
Mar 2008
Jul 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: 370+00 (148+00)
Elevation (ft NAVD)
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-200
-150
-100
-50
0
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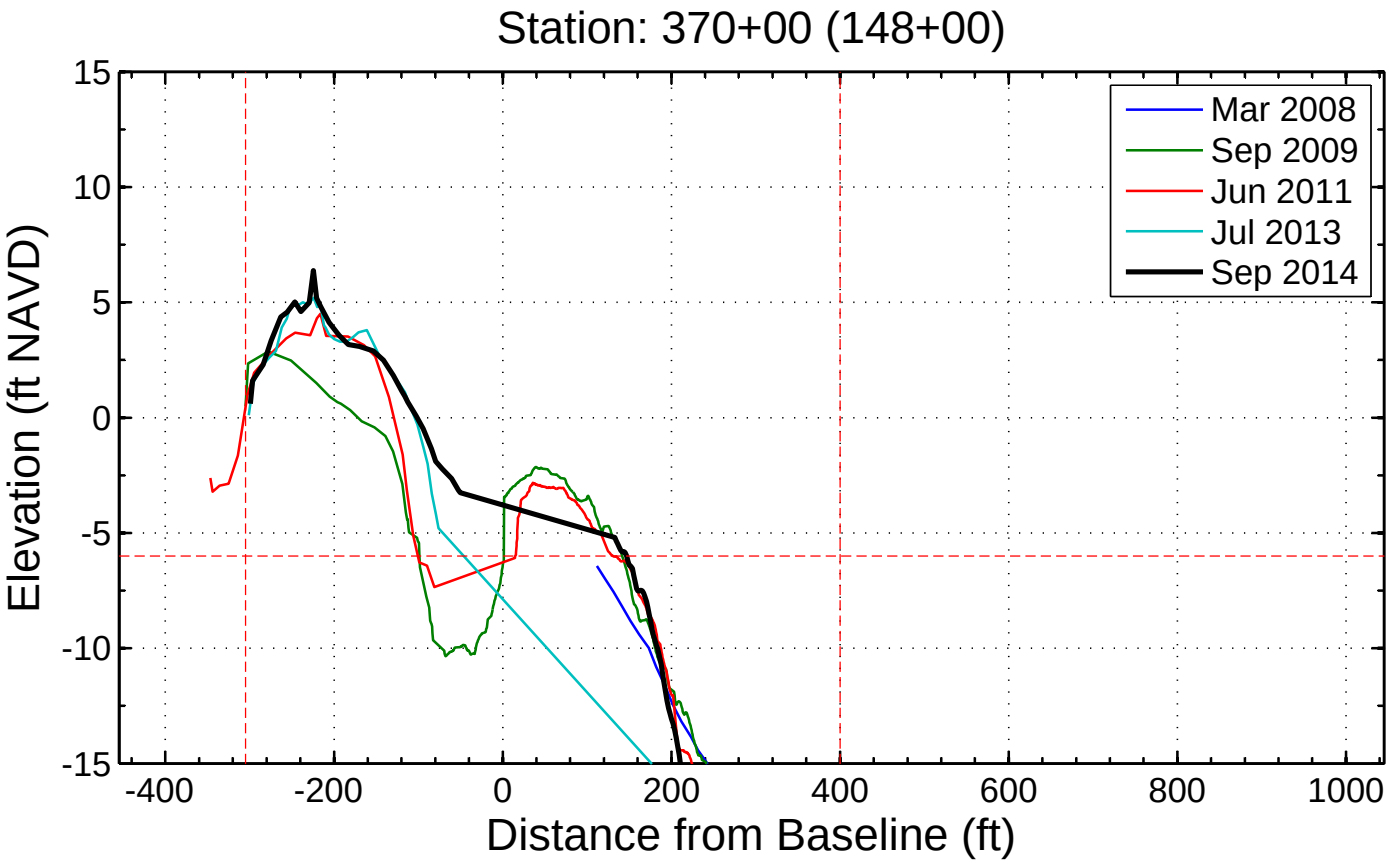
Distance from Baseline (ft)


Station: 370+00 (148+00)
Elevation (ft NAVD)
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10
5
0
-5
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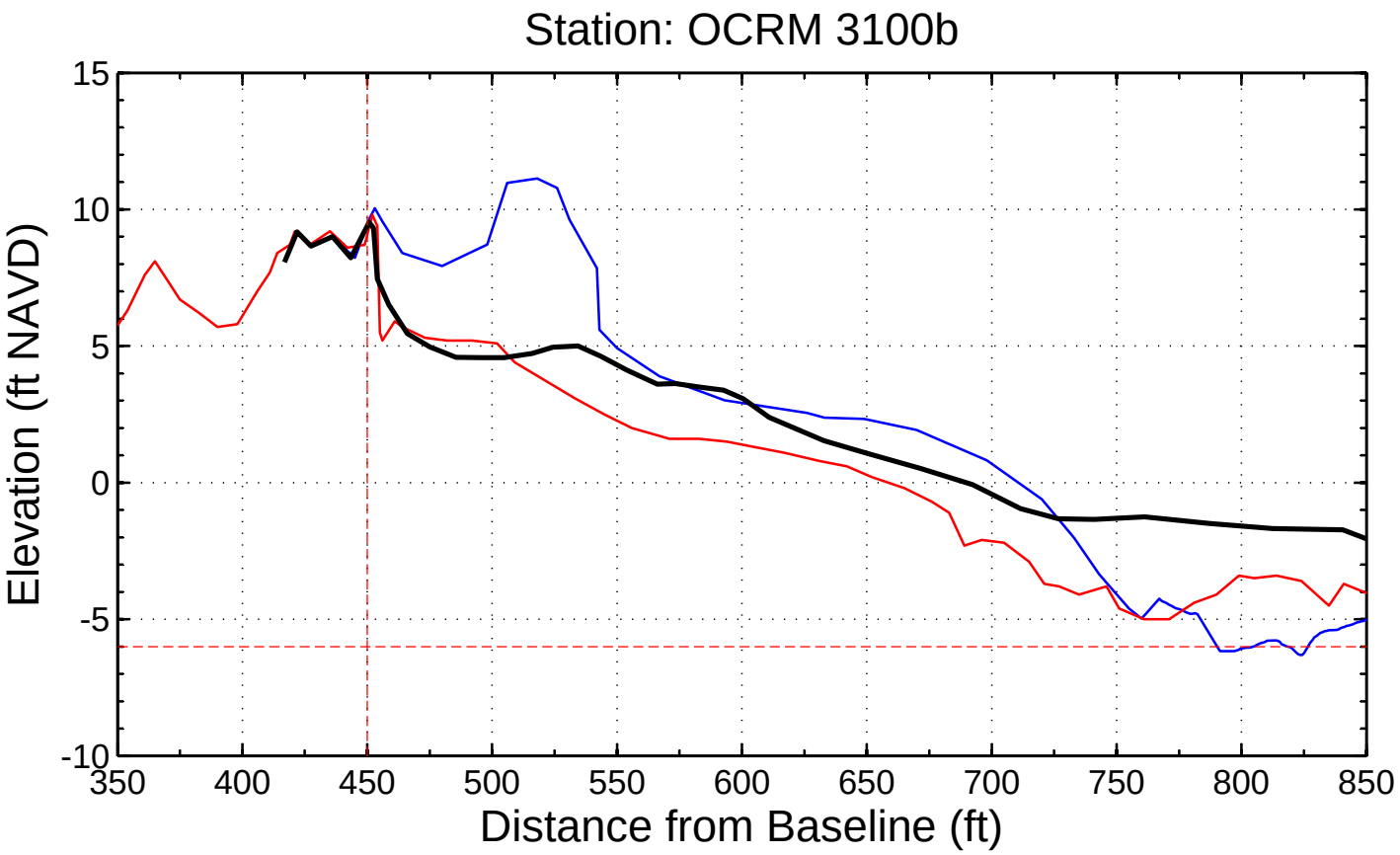
400
600
800
1000
Distance from Baseline (ft)
Mar 2008
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: OCRM 3100b
Elevation (ft NAVD)
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-10
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400
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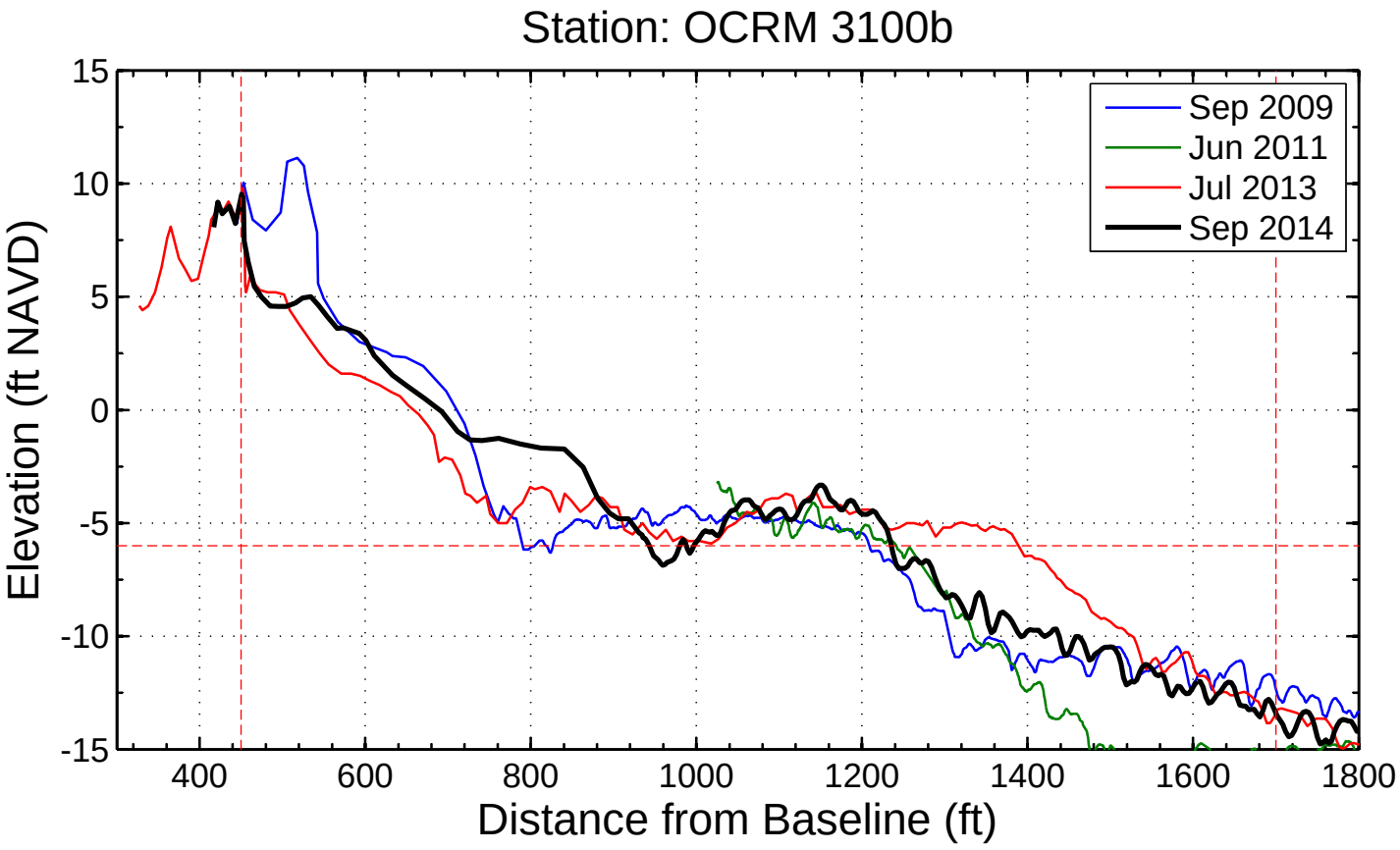
500
550
600
650
700
750
800
850
Distance from Baseline (ft)


Station: OCRM 3100b
Elevation (ft NAVD)
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10
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0
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800
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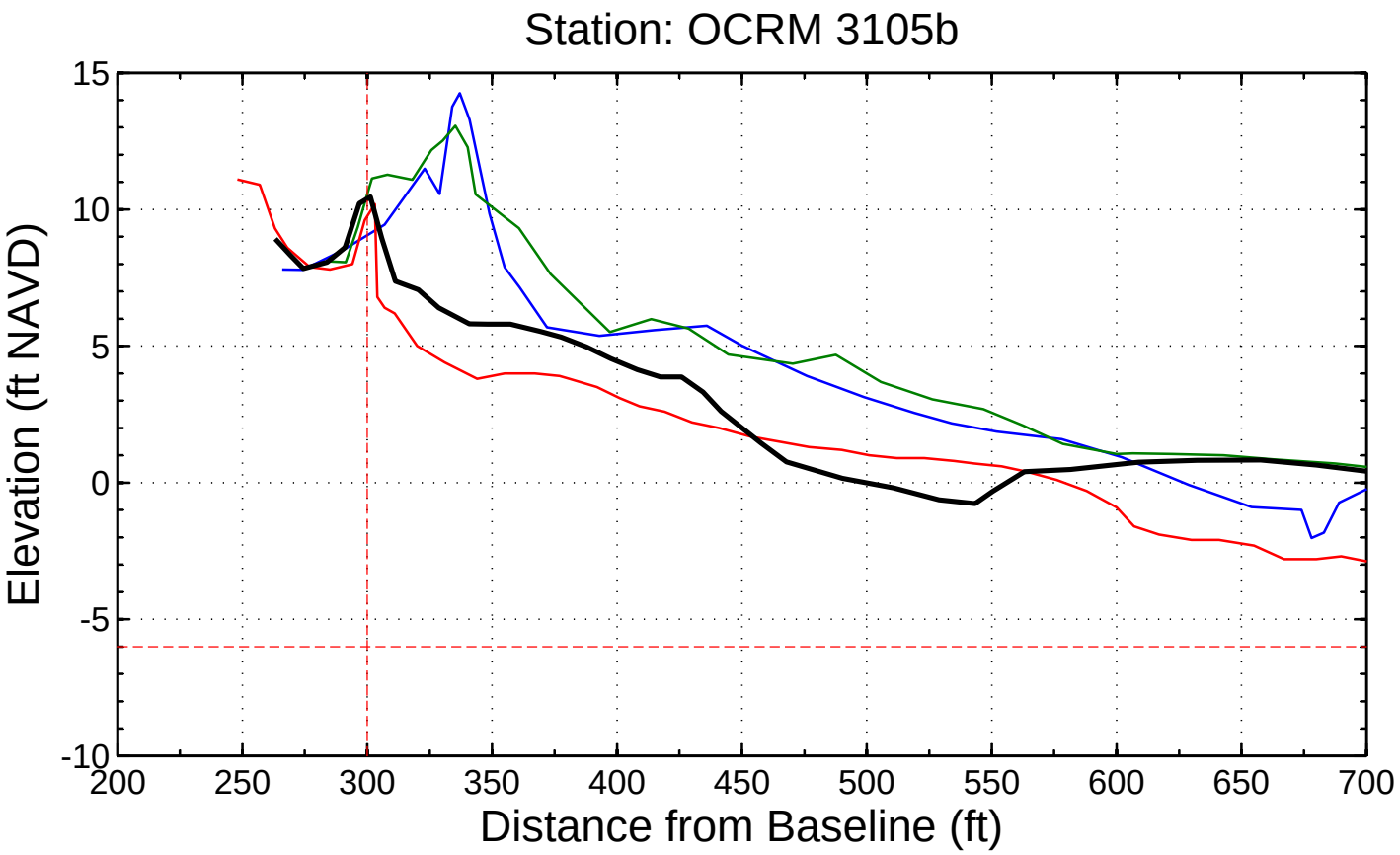
1200
1400
1600
1800
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: OCRM 3105b
Elevation (ft NAVD)
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-5
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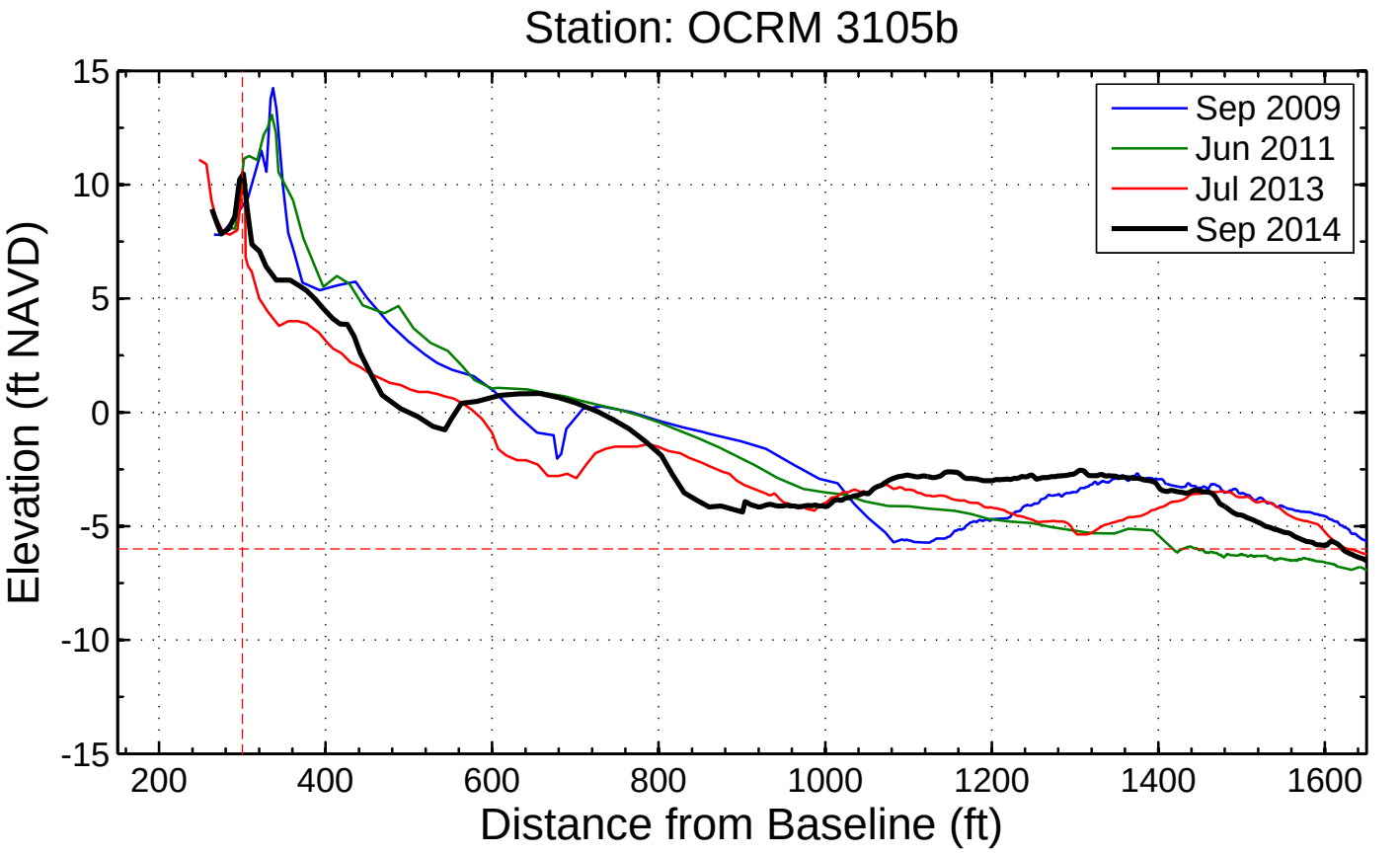
200
250
300
350
400
450
500
550
600
650
700
Distance from Baseline (ft)


Station: OCRM 3105b
Elevation (ft NAVD)
15
10
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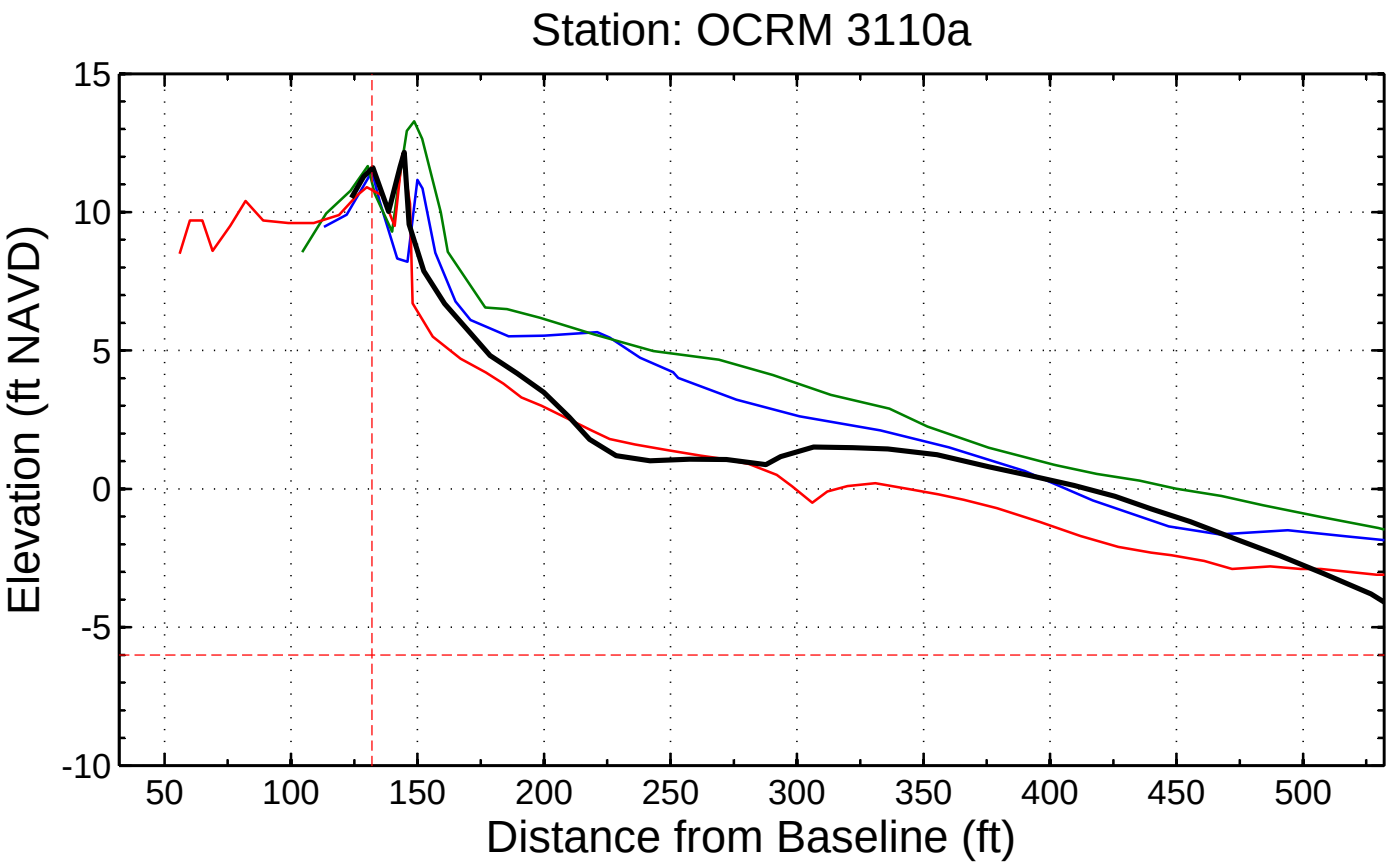
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: OCRM 3110a
Elevation (ft NAVD)
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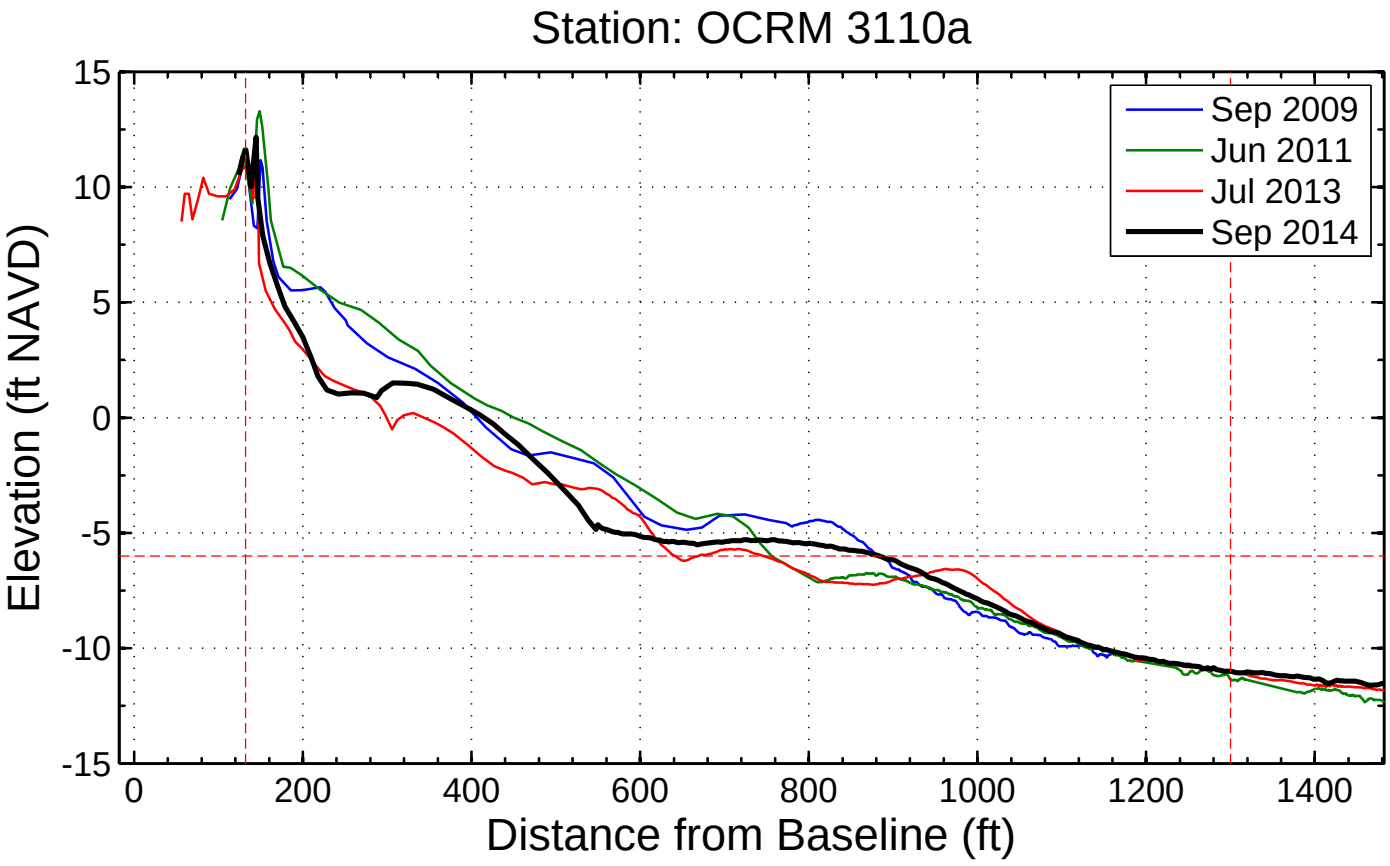
400
450
500
Distance from Baseline (ft)


Station: OCRM 3110a
Elevation (ft NAVD)
15
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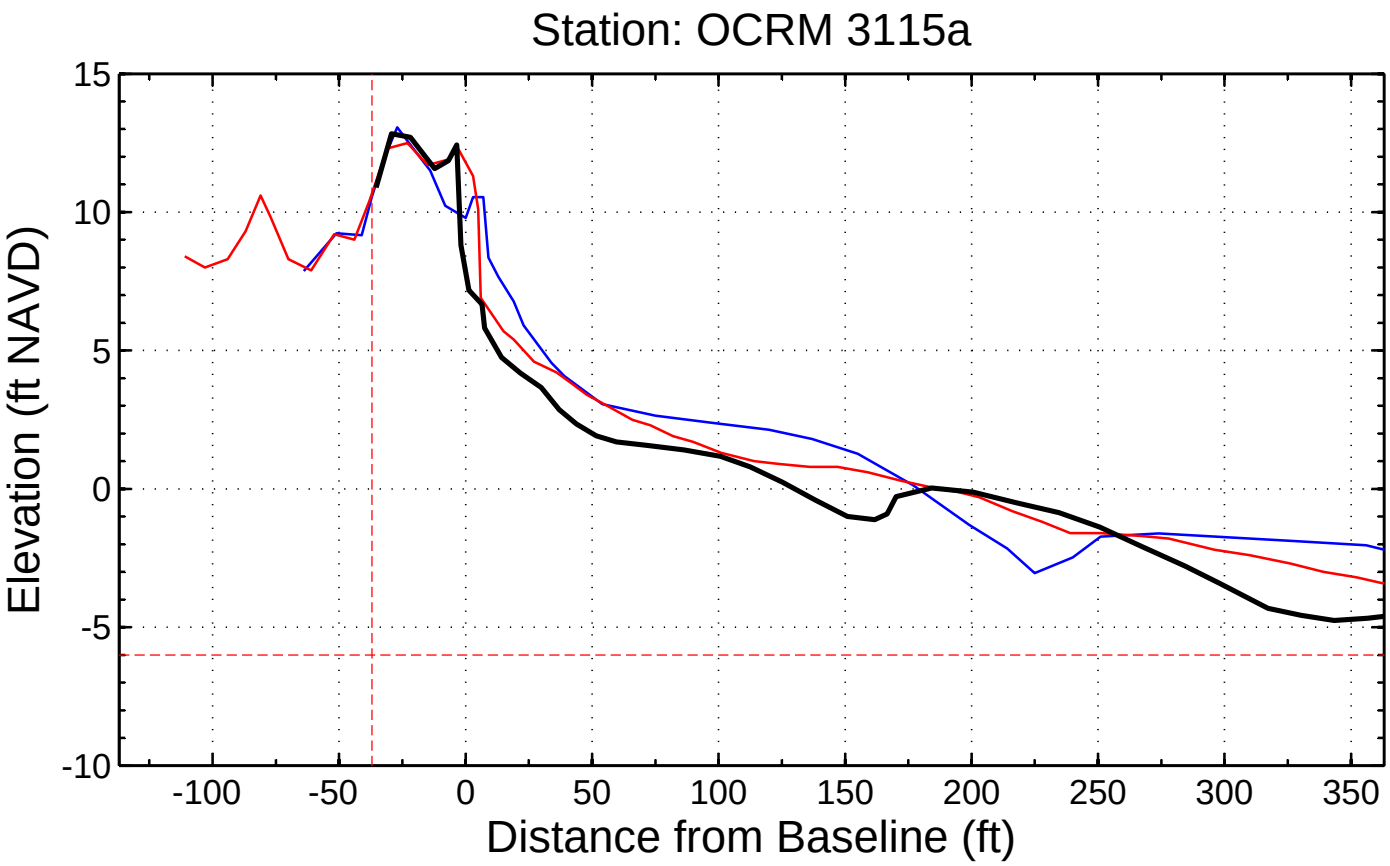
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: OCRM 3115a
Elevation (ft NAVD)
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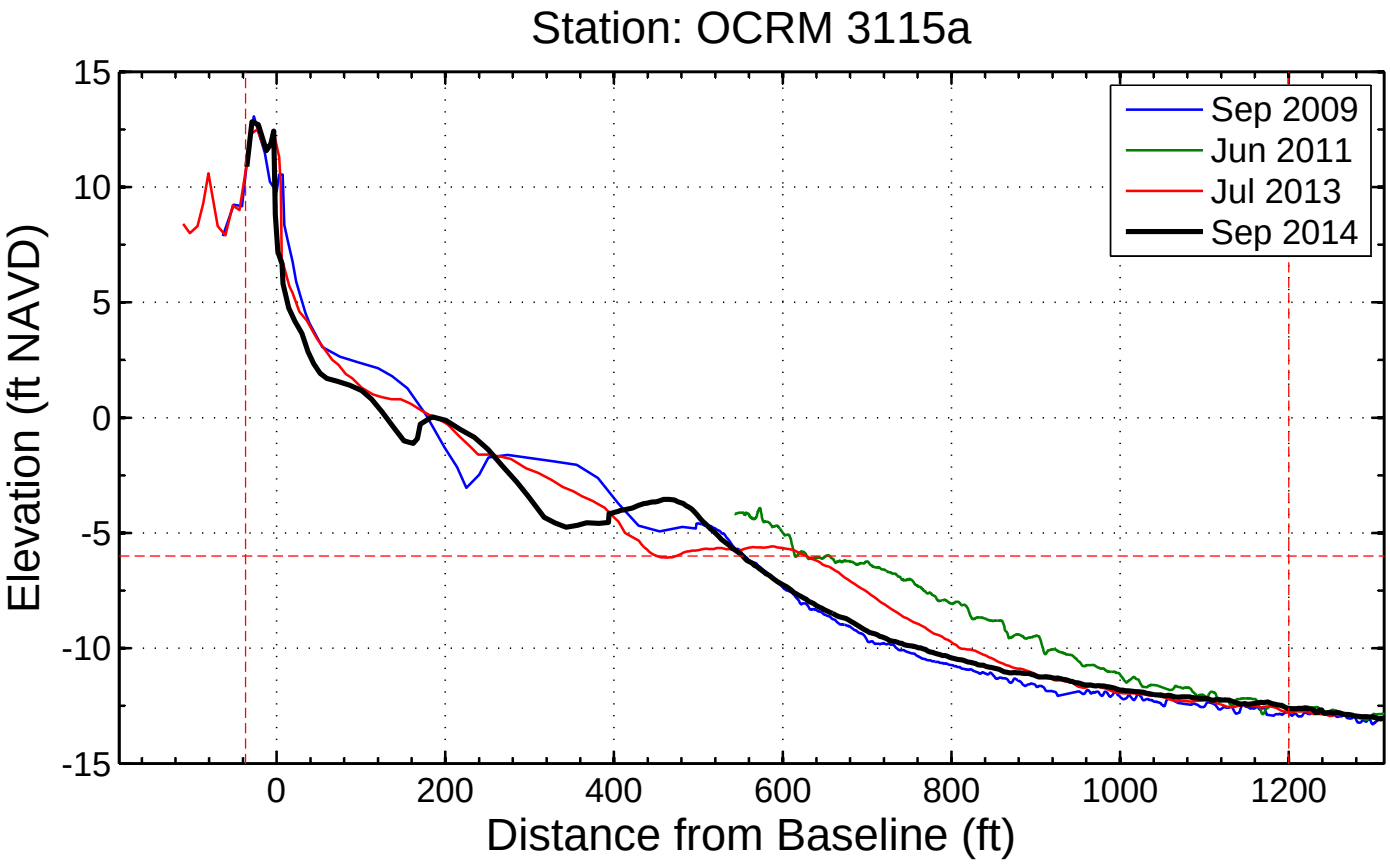
Distance from Baseline (ft)


Station: OCRM 3115a
Elevation (ft NAVD)
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0
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-10
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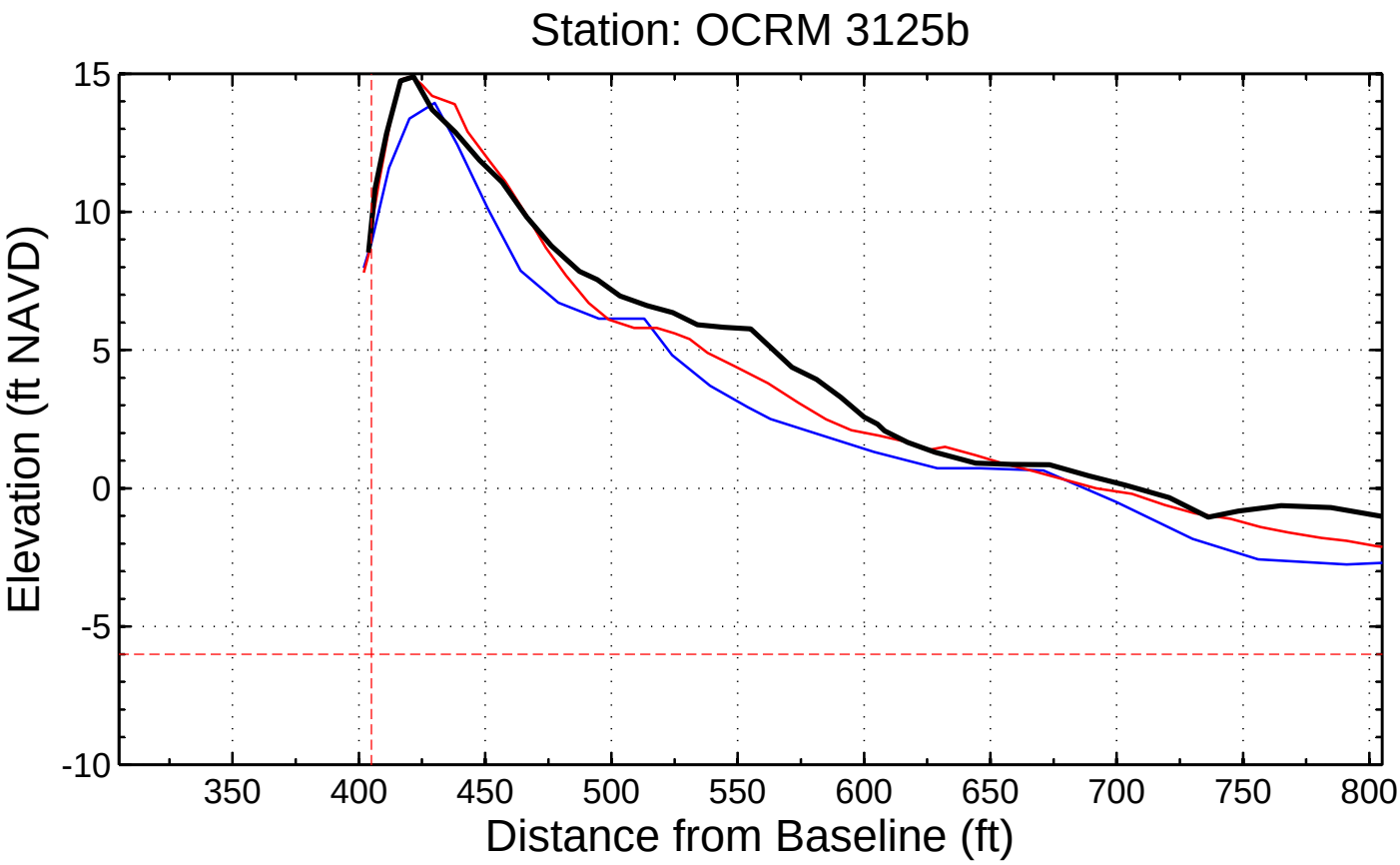
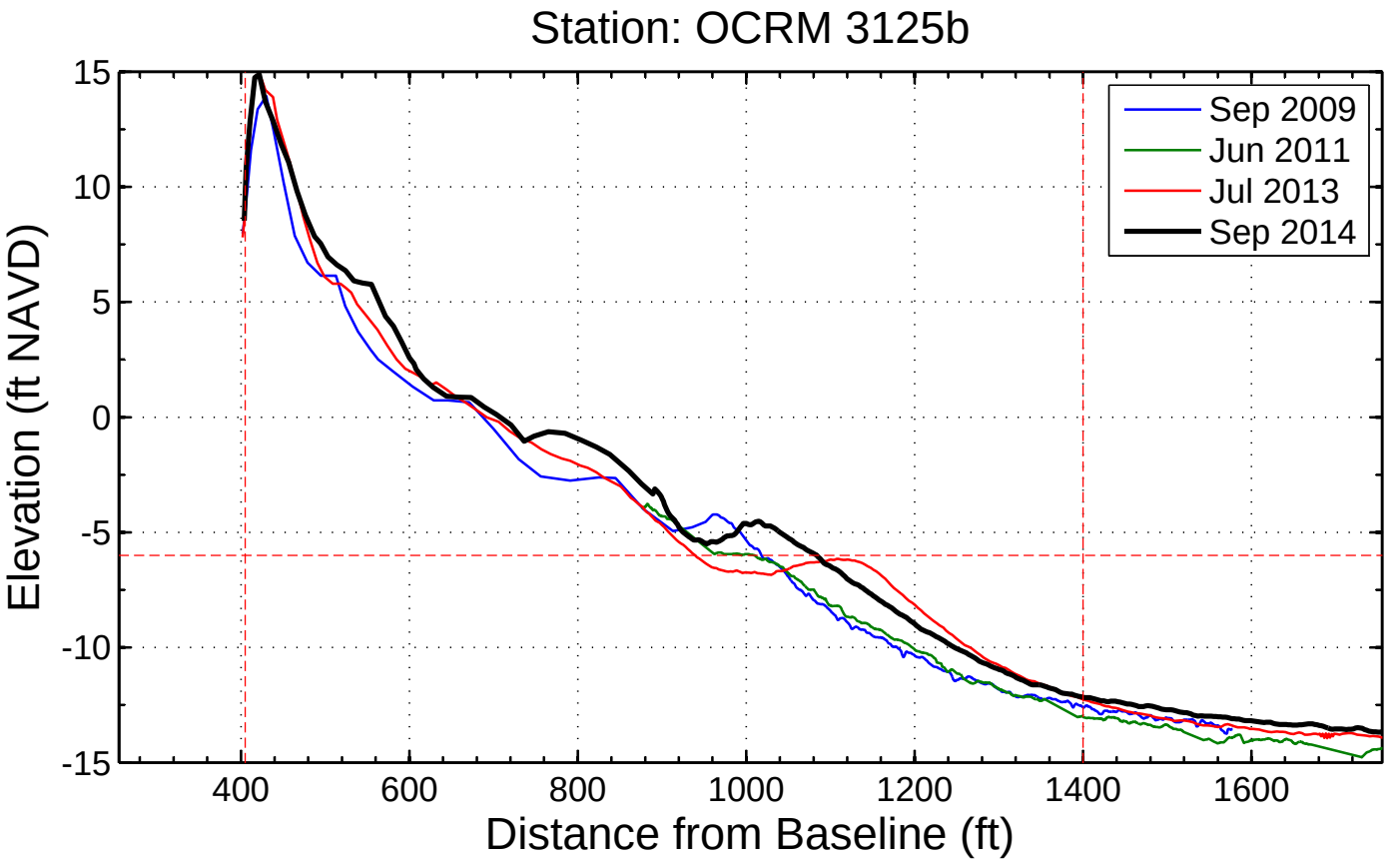
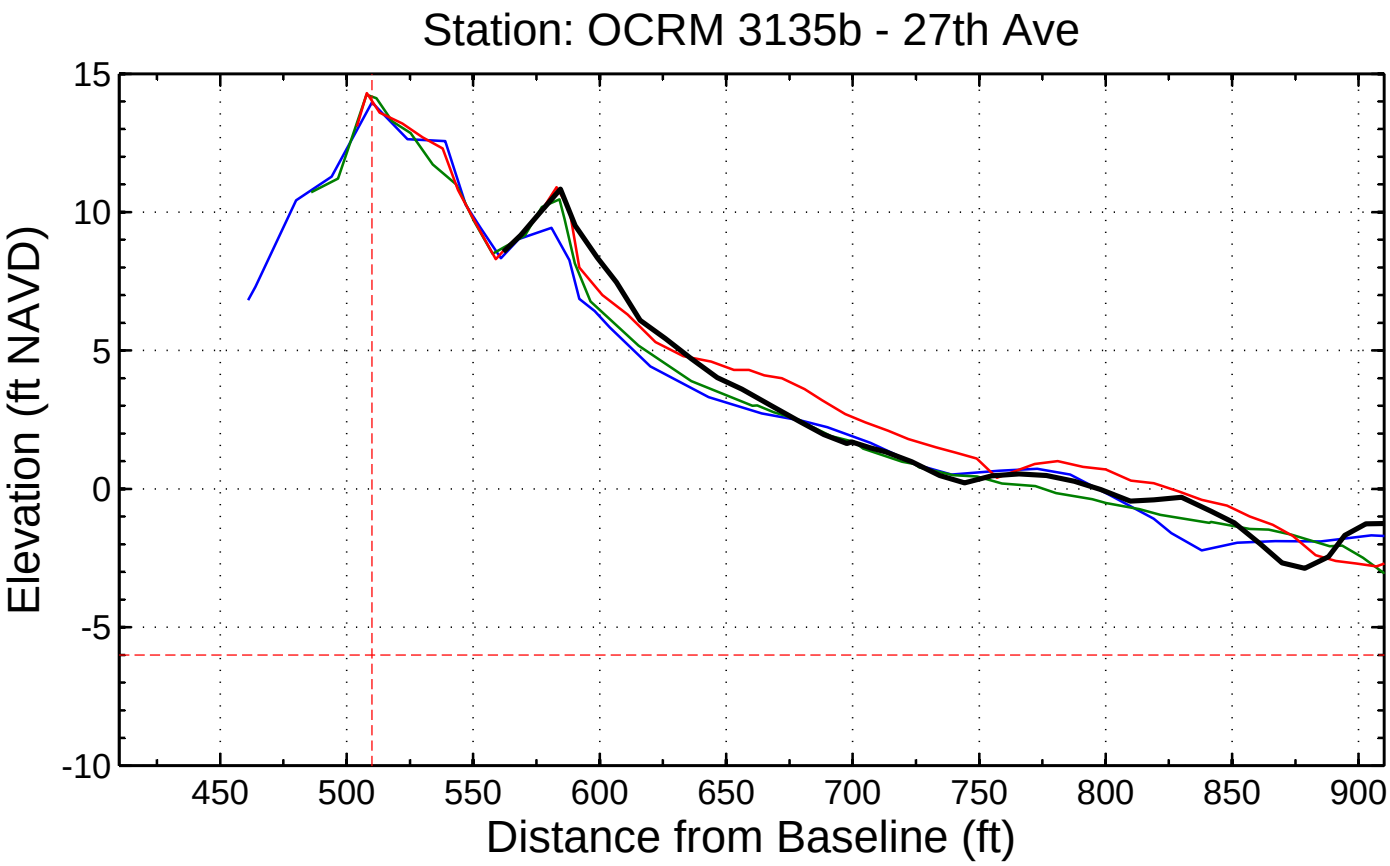
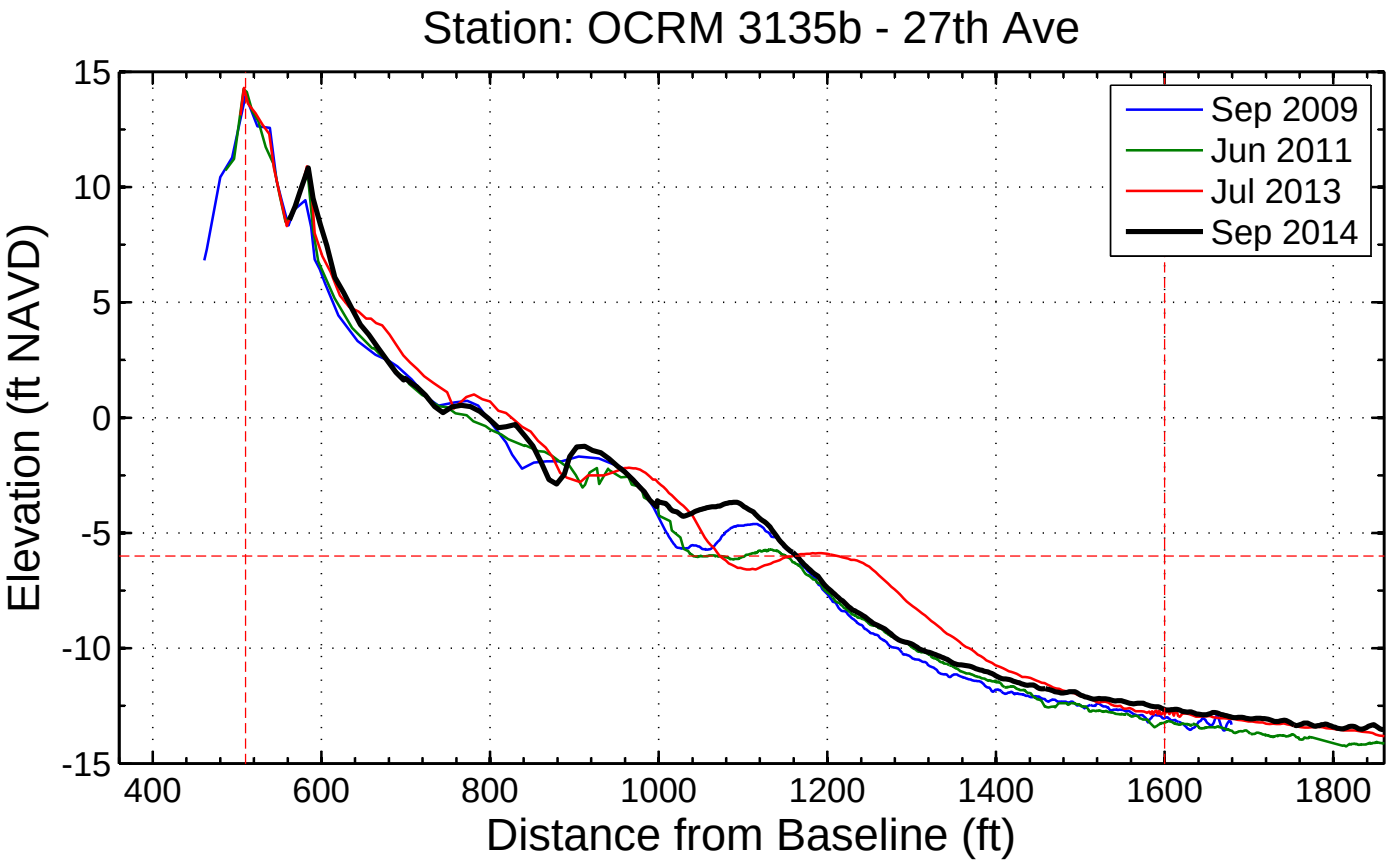
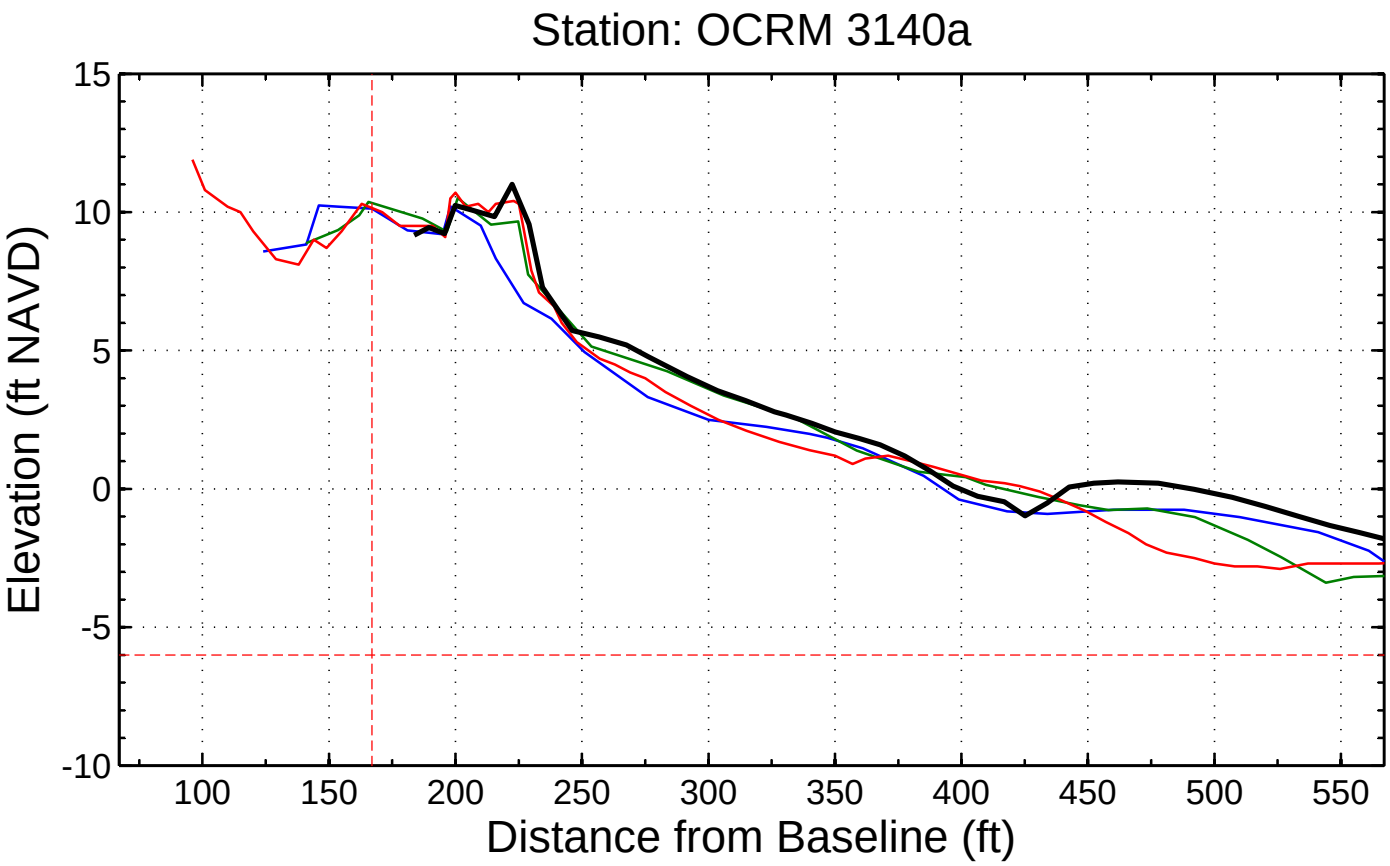
800
1000
1200
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014

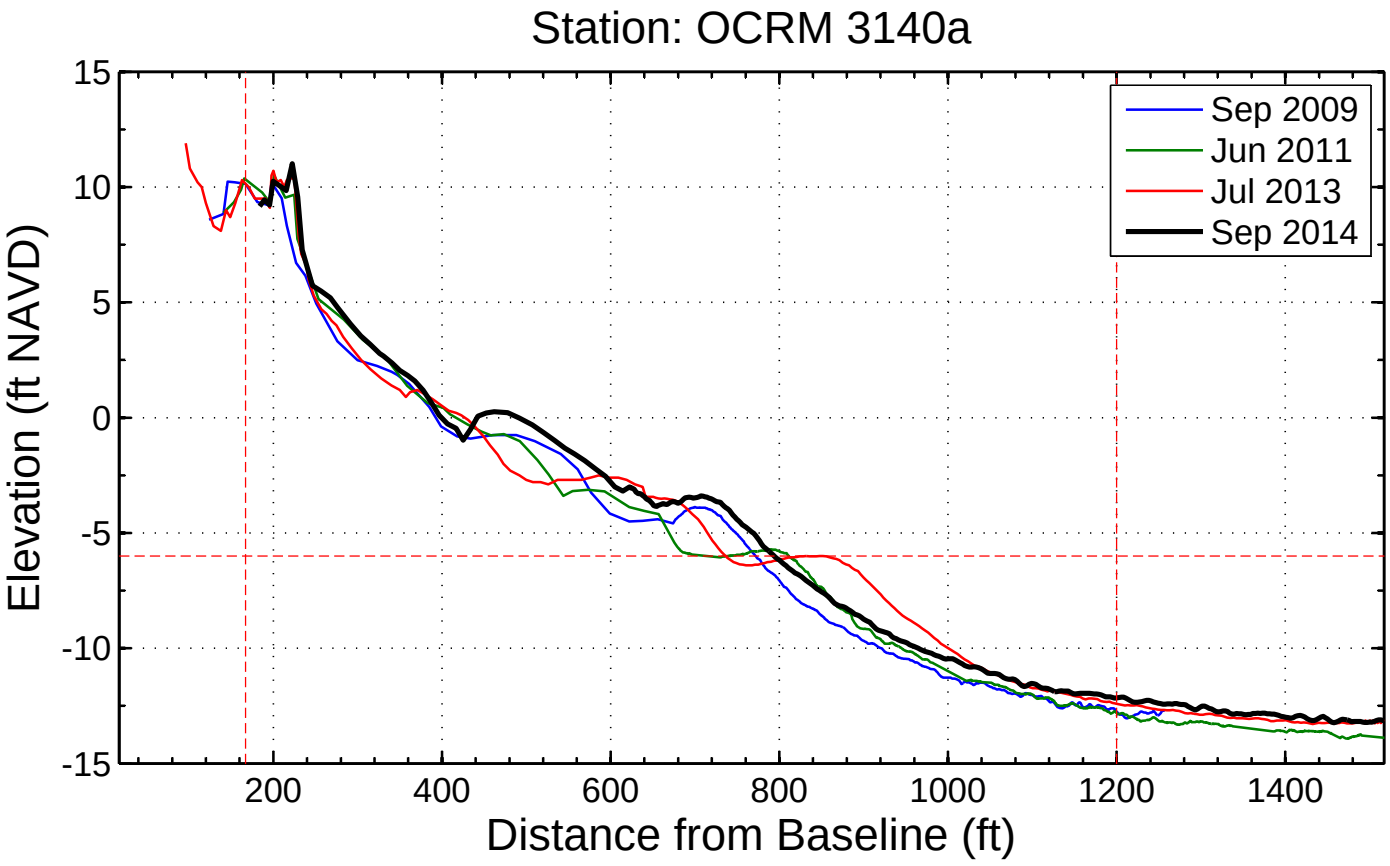

Station: OCRM 3125b
Elevation (ft NAVD)
15
10
5
0
-5
-10
350
400
450
500
550
600
650
700
750
800
Distance from Baseline (ft)

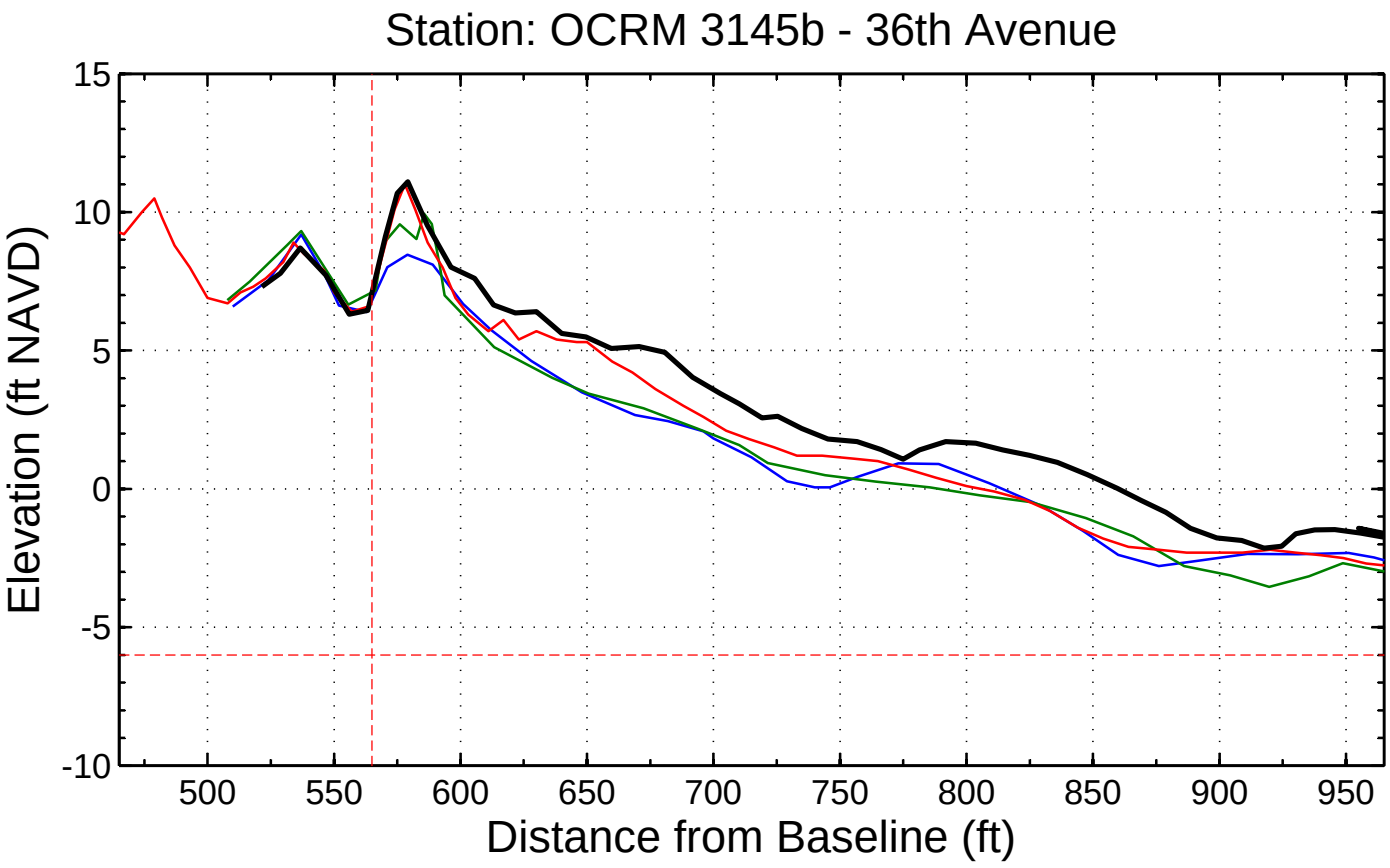

Station: OCRM 3125b
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014

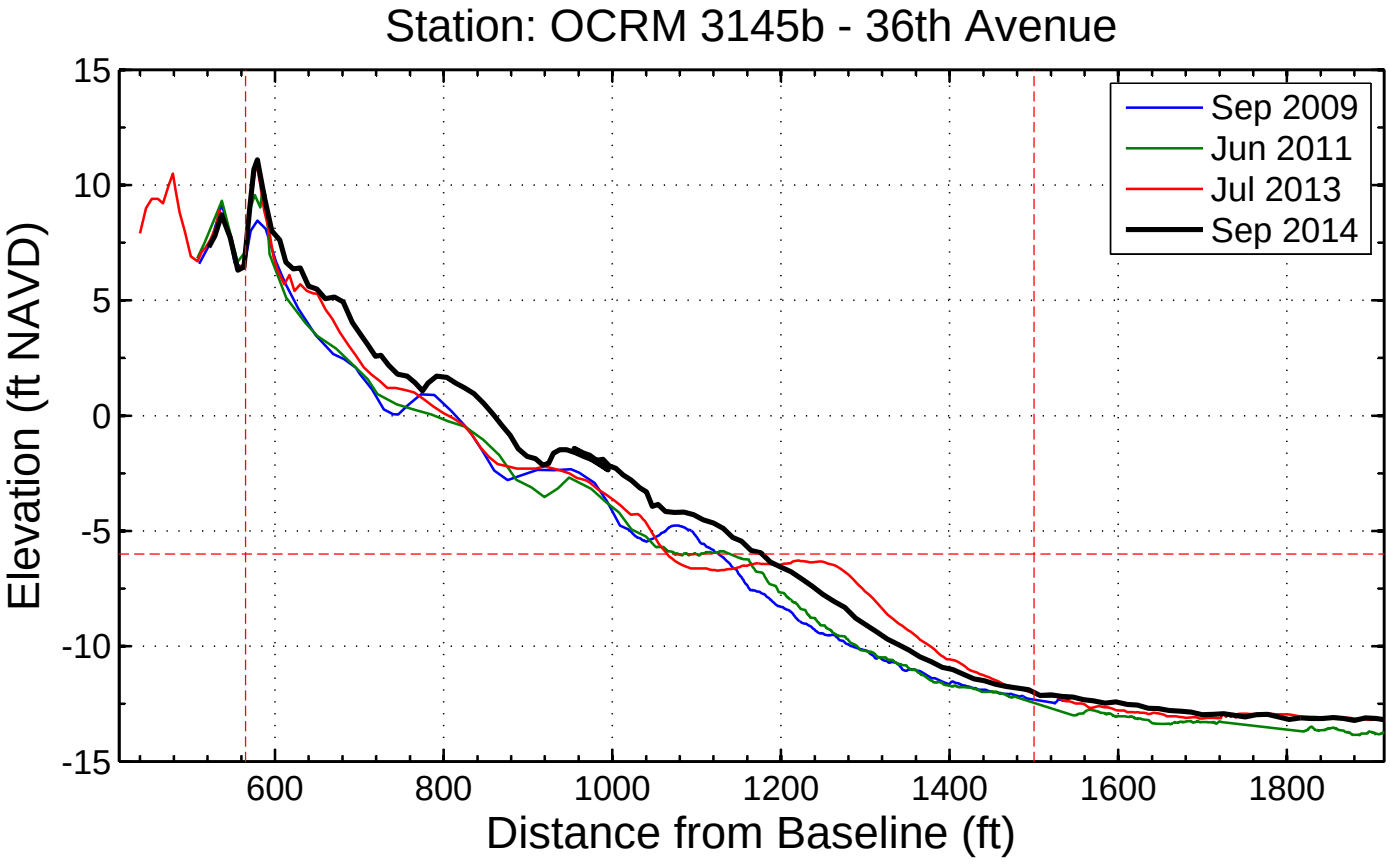

Station: OCRM 3135b - 27th Ave
Elevation (ft NAVD)
15
10
5
0
-5
-10
450
500
550
600
650
700
750
800
850
900
Distance from Baseline (ft)

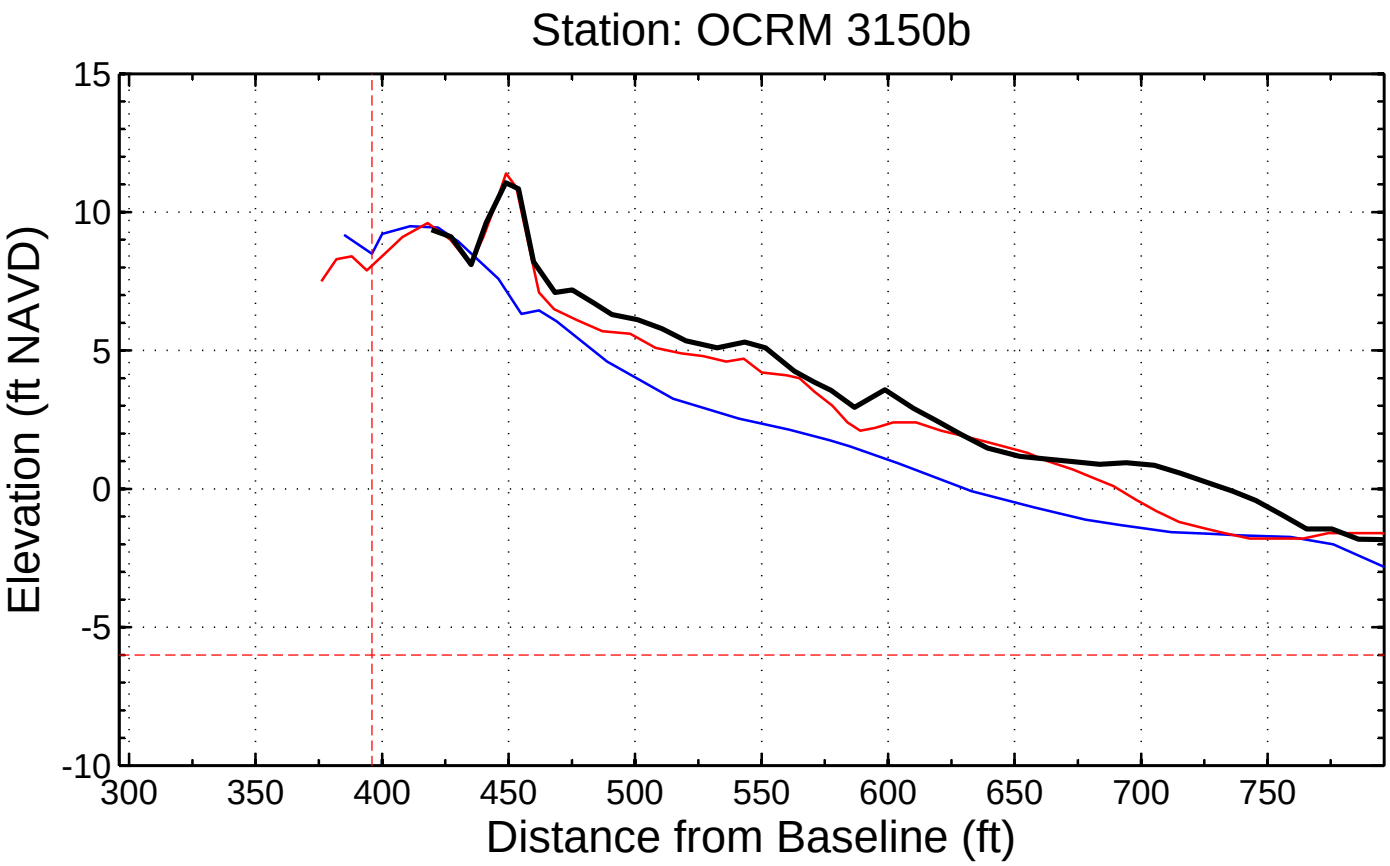

Station: OCRM 3135b - 27th Ave
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
400
600
800
1000
1200
1400
1600
1800
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014

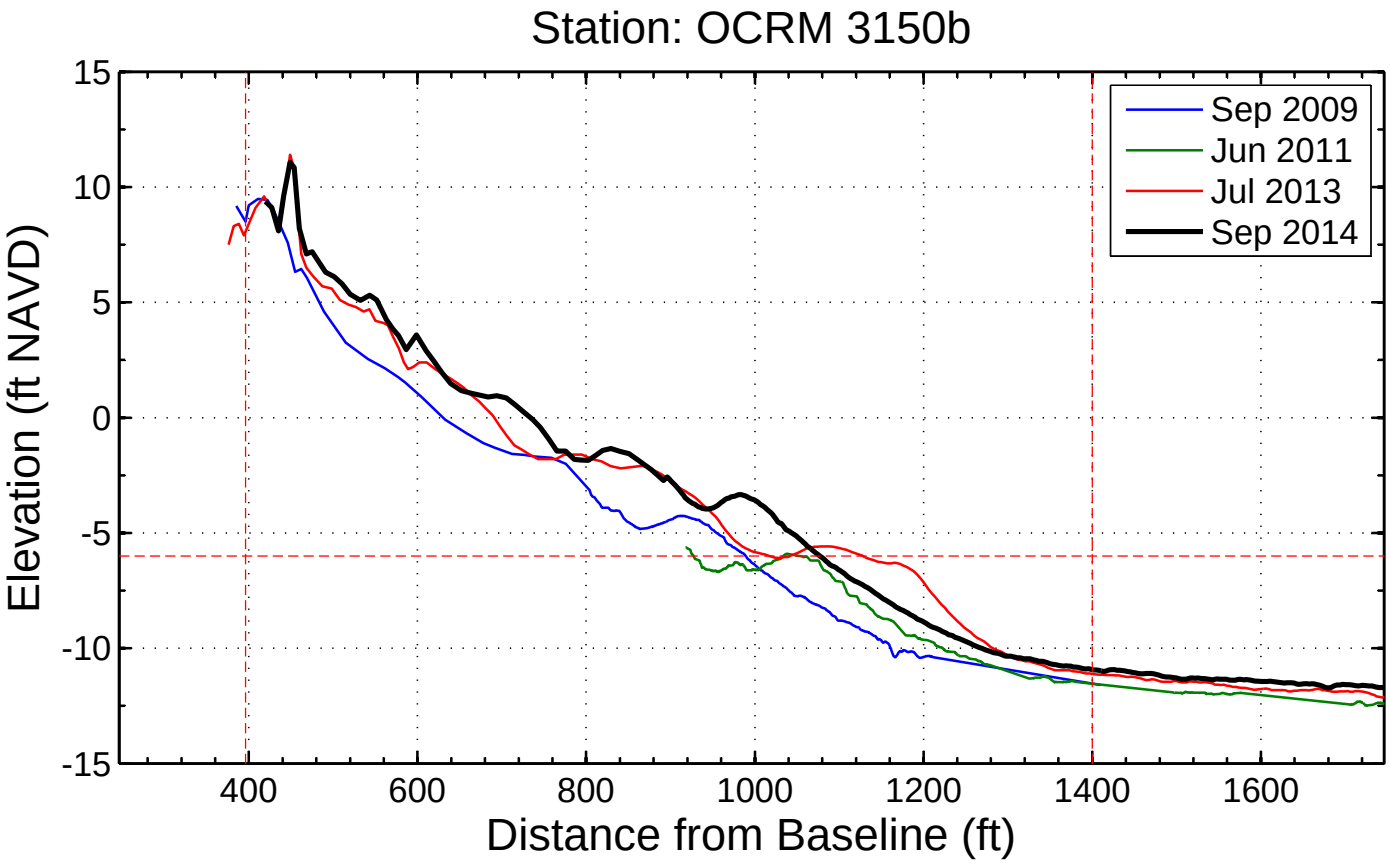

Station: OCRM 3140a
Elevation (ft NAVD)
15
10
5
0
-5
-10
100
150
200
250
300
350
400
450
500
550
Distance from Baseline (ft)


Station: OCRM 3140a
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
200
400
600
800
1000
1200
1400
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: OCRM 3145b - 36th Avenue
Elevation (ft NAVD)
15
10
5
0
-5
-10
500
550
600
650
700
750
800
850
900
950
Distance from Baseline (ft)


Station: OCRM 3145b - 36th Avenue
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
600
800
1000
1200
1400
1600
1800
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014


Station: OCRM 3150b
Elevation (ft NAVD)
15
10
5
0
-5
-10
300
350
400
450
500
550
600
650
700
750
Distance from Baseline (ft)


Station: OCRM 3150b
Elevation (ft NAVD)
15
10
5
0
-5
-10
-15
400
600
800
1000
1200
1400
1600
Distance from Baseline (ft)
Sep 2009
Jun 2011
Jul 2013
Sep 2014