

**State of California  
The California Natural Resources Agency  
Department of Water Resources**

**Division of Integrated Regional Water Management  
North Central Regional Office**

# **Bed Sediment Monitoring in the South Delta Fall 2010 – Spring 2012**

**March 2013**



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**Memorandum Report  
March 2013**

# Memorandum

Date: March 25, 2013

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Bay Delta Office

From: Eric Hong, Chief  
North Central Regional Office  
Division of Integrated Regional Water Management  
Department of Water Resources

Subject: Memorandum Report - Bed Sediment Monitoring in the South Delta Fall 2010 - Spring 2012

Attached for your information and use is the Memorandum Report - Bed Sediment Monitoring in the South Delta Fall 2010 - Spring 2012, January 2013. This report presents sediment monitoring results at 17 sites in the south Delta between the Fall 2010 and Spring 2012.

If you have any questions, please contact me at (916) 376-9655 or the North Central Region Office's technical lead for this project, Dean Crippen at (916) 376-9662.

Attachment

Appendices

RS  
3/25/13

DC  
3/26/13

Jan 4/8/13

EA 4-11-13

# Executive Summary

The Department of Water Resources North Central Regional Office has been studying sediment levels and characteristics in the south Delta since 1998. A study of 17 sites is being conducted for the Bay-Delta Office in response to public comments regarding the potential effects of proposed permanent barriers on sediment accumulation.

This report covers semi-annual surveys conducted between the fall of 2010 and the spring of 2012. In addition, monthly surveys have been conducted at select sites since March 2012.

Semi-annual surveys for the reporting period show stable or decreasing sediment levels with the exception at OR-1, OR-6 and OR-8 where sediment levels appear to be increasing.

During the monthly survey study period the temporary barriers were installed between April and May. Grant Line Canal experienced lower flows during May through July. Sediment levels began to increase in June, but in August, as the flow in Grant Line Canal increased sediment levels began to decrease. Only GLC-3 had a net increase in sediment volume as of August.

Recommendations include:

- Modifying the study plan to further understand the trends in sediment transport, by making study sites larger, reducing the number of study sites, and possibly conducting flow studies in select locations.
- Continue monthly monitoring at select sites.

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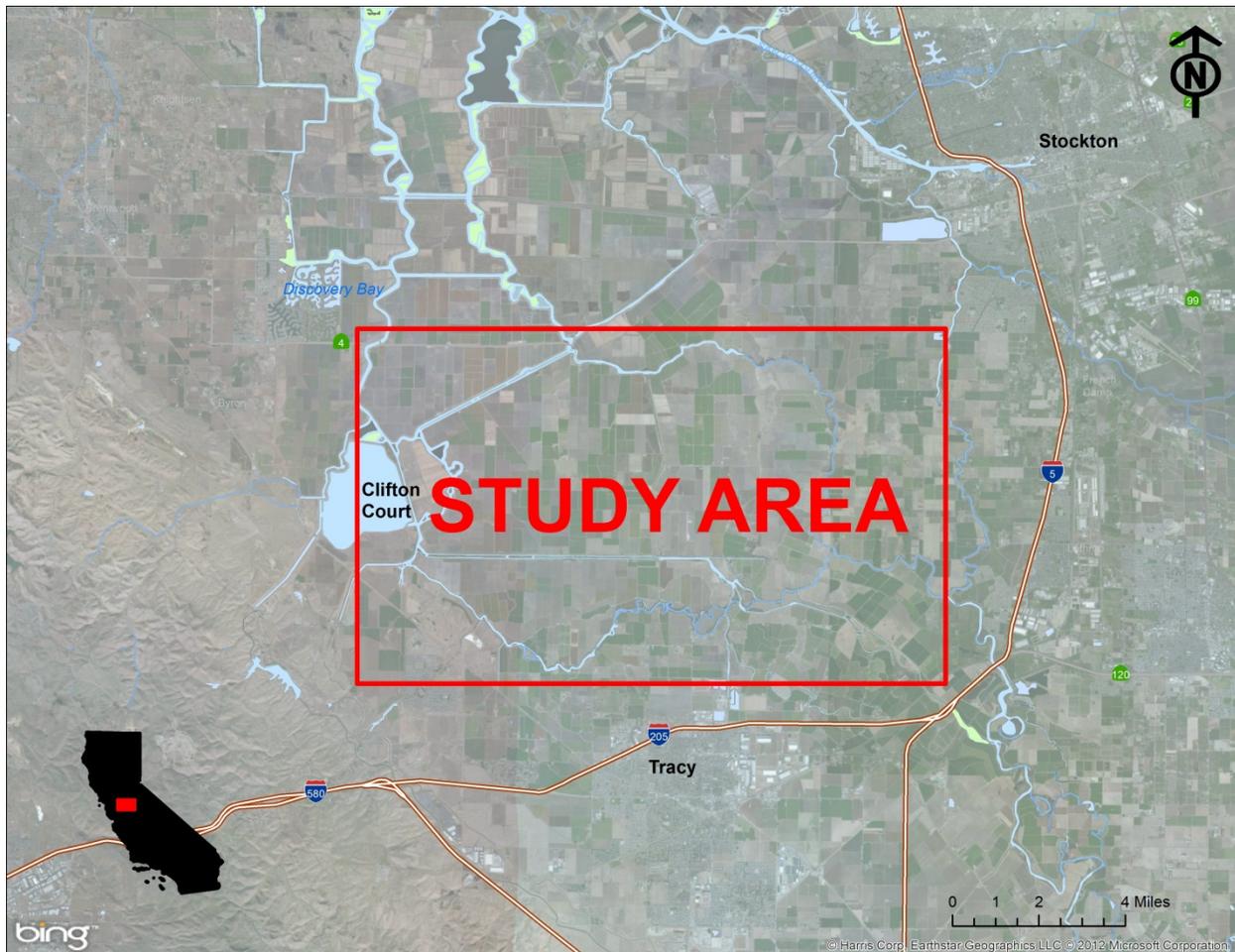
# Acronyms and Abbreviations

<b>BDCP</b>	Bay Delta Conservation Plan
<b>BDO</b>	Bay-Delta Office
<b>BM</b>	Benchmark
<b>BTS</b>	Bathymetry and Technical Support Section
<b>CDEC</b>	California Data Exchange Center
<b>DC</b>	Doughty Cut
<b>DWR</b>	Department of Water Resources
<b>GIS</b>	Geographic Information System
<b>GLC</b>	Grant Line Canal
<b>GPS</b>	Global Positioning System
<b>GWSA&amp;SS</b>	Ground Water Supply Assessment and Special Studies Section
<b>MR</b>	Middle River
<b>NCRO</b>	North Central Region Office
<b>OR</b>	Old River
<b>RTK</b>	Real Time Kinematic
<b>TBP</b>	Temporary Barriers Project



# 1.0 Introduction

The Department of Water Resources (DWR) North Central Region Office (NCRO) is actively studying sedimentation levels in the south Delta (Figure 1-1) in an effort to understand the potential effects of proposed permanent barriers on sediment accumulation in the south Delta. These effects are being studied by the collection of bathymetric data before and after the annual installation and removal of the temporary barriers of the Temporary Barrier Project (TBP). This report presents the bathymetric data collected between the fall of 2010 to the spring of 2012.



**Figure 1-1: Vicinity Map**

Seventeen sites are monitored on Old River, Grant Line Canal/ Fabian Bell Canal, Middle River, and Doughty Cut. The locations of the 17 sites and the temporary barriers can be found on the Site Map, Figure 1-2. Benchmark coordinates and elevation can be found in Table 1-1.



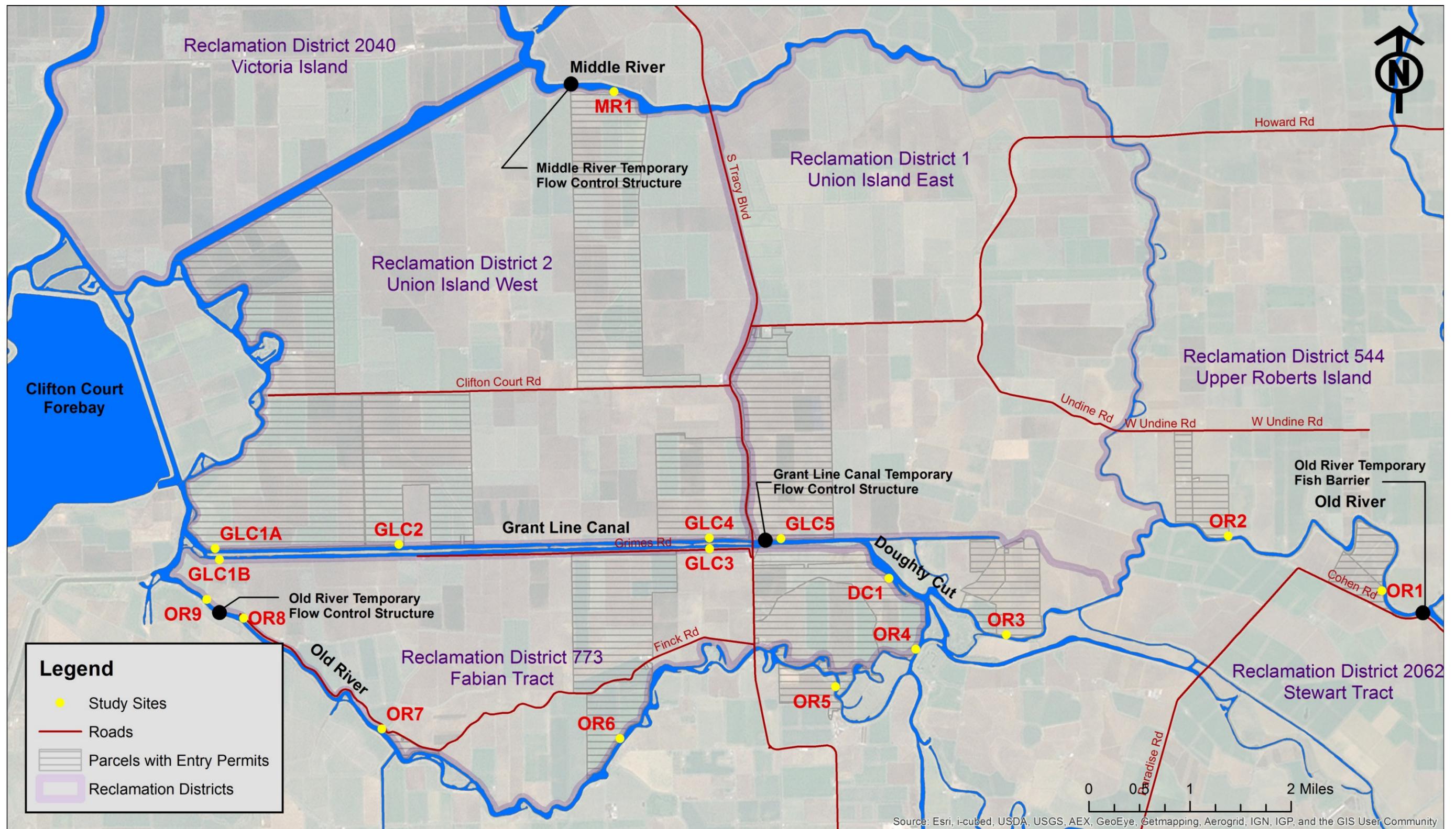


Figure 1-2: Site Map



**Table 1-1: Benchmark Elevations and Locations**

<b>Benchmark</b>	<b>Elevation (feet)</b>	<b>Latitude (Decimal Degrees)</b>	<b>Longitude (Decimal Degrees)</b>	<b>State Plane X-ft</b>	<b>State Plane Y-ft</b>
DC-1	20.72	37.81435	-121.42506	6294449.74	2120307.01
GLC-1A	17.62	37.82020	-121.54681	6259303.29	2122805.45
GLC-1B	18.05	37.81859	-121.54608	6259305.56	2122224.37
GLC-2	17.59	37.82034	-121.51359	6268899.49	2122754.53
GLC-3	20.67	37.81901	-121.45743	6285124.49	2122091.09
GLC-4	17.69	37.82056	-121.45743	6285130.19	2122660.83
GLC-5	20.27	37.82027	-121.44449	6288868.42	2122519.24
MR-1	16.33	37.88461	-121.47338	6280761.78	2146028.81
OR-1	27.80	37.81134	-121.33600	6320164.47	2118967.76
OR-2	23.55	37.81956	-121.36362	6312215.45	2122031.84
OR-3	18.60	37.80599	-121.40402	6300499.15	2117202.48
OR-4	24.83	37.80417	-121.42046	6295745.57	2116592.15
OR-5	18.08	37.79898	-121.43508	6291497.35	2114734.54
OR-6	21.80	37.79209	-121.47417	6280181.76	2112344.82
OR-7	14.05	37.79401	-121.51722	6267751.40	2113175.01
OR-8	18.05	37.81015	-121.54188	6260692.40	2119124.36
OR-9	17.61	37.81293	-121.54849	6258794.32	2120162.37

*Surveyed in June 2006, Reference Datum: NAVD88.  
Latitude and Longitude converted from Northing and Easting.*

## 1.1 PREVIOUS REPORTS

Two previous reports have been submitted to the Bay-Delta Office (BDO): *Bed Sediment Monitoring in the South Delta Memorandum Report (DWR 2004)*; and *Bed Sediment Monitoring in the South Delta Spring 2003 – Fall 2010 (DWR 2011)*.

The DWR 2004 report covered surveys from fall 2000 through fall 2002. Bathymetric and sediment sample data was collected during the reporting period on a semi-annual basis. The report concluded that erosion occurred between the fall and spring and sediment deposition occurred between the spring and fall with a net erosion occurring at sites directly below the barriers. It was recommended that monitoring be continued.

The DWR 2011 report covered surveys from spring 2003 through fall 2010. Bathymetric and sediment sample data was collected during the reporting period on a semi-annual basis. The report concluded volumetric analysis results were



inconclusive and unreliable, and cross-sections should only be used for a qualitative analysis. Many sites showed little change in sediment levels between 2000 and 2010, but there did appear to be a trend of increases in sediment levels up stream of the barriers. Sediment analysis showed no significant long-term changes and it was recommended that sediment sampling be stopped.

## 1.2 REPORT COMPONENTS

Data sets for the DWR 2004 and DWR 2011 reports came from semi-annual bathymetric surveys and sediment sampling. This report will cover semi-annual surveys performed between the fall of 2010 to the spring of 2012. In addition to semi-annual surveys, monthly surveys at select sites were conducted.

### 1.2.1 Semi-Annual Bathymetric Surveys

Semi-annual surveys continue to be conducted at the 17 sites, with a modification to GLC-2. Beginning with the spring 2012 survey, as recommended in the DWR 2011 report, GLC-2 was split into two sites: GLC-2A and GLC-2B (Figure 1-3). All sites, with the exception of MR-1, were surveyed using a multi-beam depth sounder, providing significantly better coverage than the single-beam depth sounder used for the surveys in the previous reports.

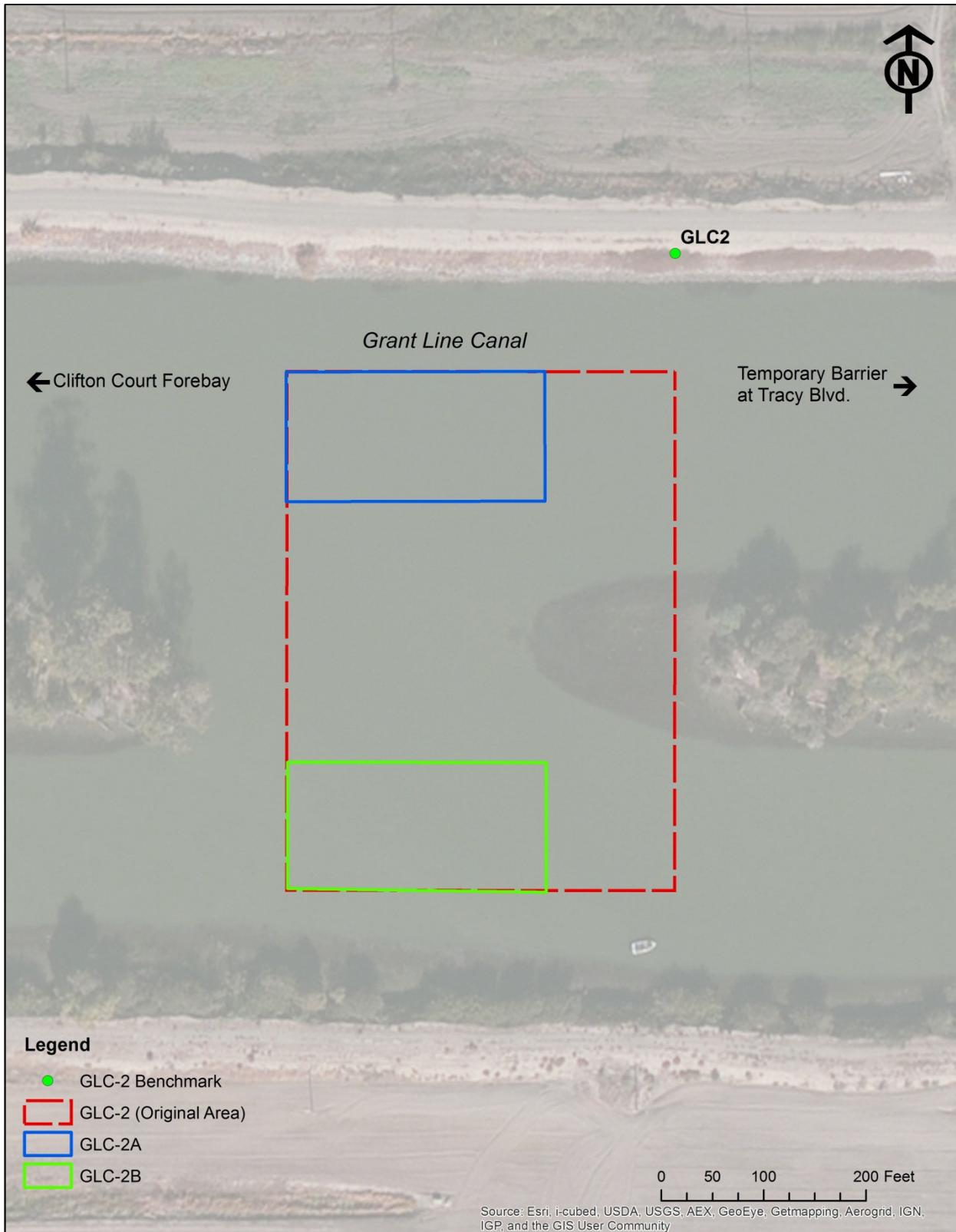
Boat access to MR-1 is limited by the barrier, shallow water and aquatic growth, resulting in less frequent surveys. In July 2012, MR-1 was surveyed using a single-beam depth sounder mounted to a kayak. The kayak mounted depth sounder is still in the evaluation stage, but may allow for MR-1 to be more routinely surveyed.

### 1.2.2 Monthly Bathymetric Surveys

Changes in flows, tidal influences and aquatic plant growth can have a significant impact on the channel bed and sediment levels. Semi-annual bathymetric surveys of small areas can be difficult to put into context because of the potential for significant changes to the channel bed over a six month period.

As recommended in the DWR 2011 report, GLC-4, GLC-5 and DC-1 are being monitored monthly for a 12 month period. GLC-4, GLC-5 and DC-1 were chosen because their depth minimizes aquatic growth, are above and below a barrier, and are three consecutive sites. GLC-3 was later added to the monthly surveys because of its close proximity to the GLC-4, and minimal additional time required to survey the site.





**Figure 1-3: Conversion of GLC-2 to GLC-2A and GLC-2B**



## 2.0 Study Methodology

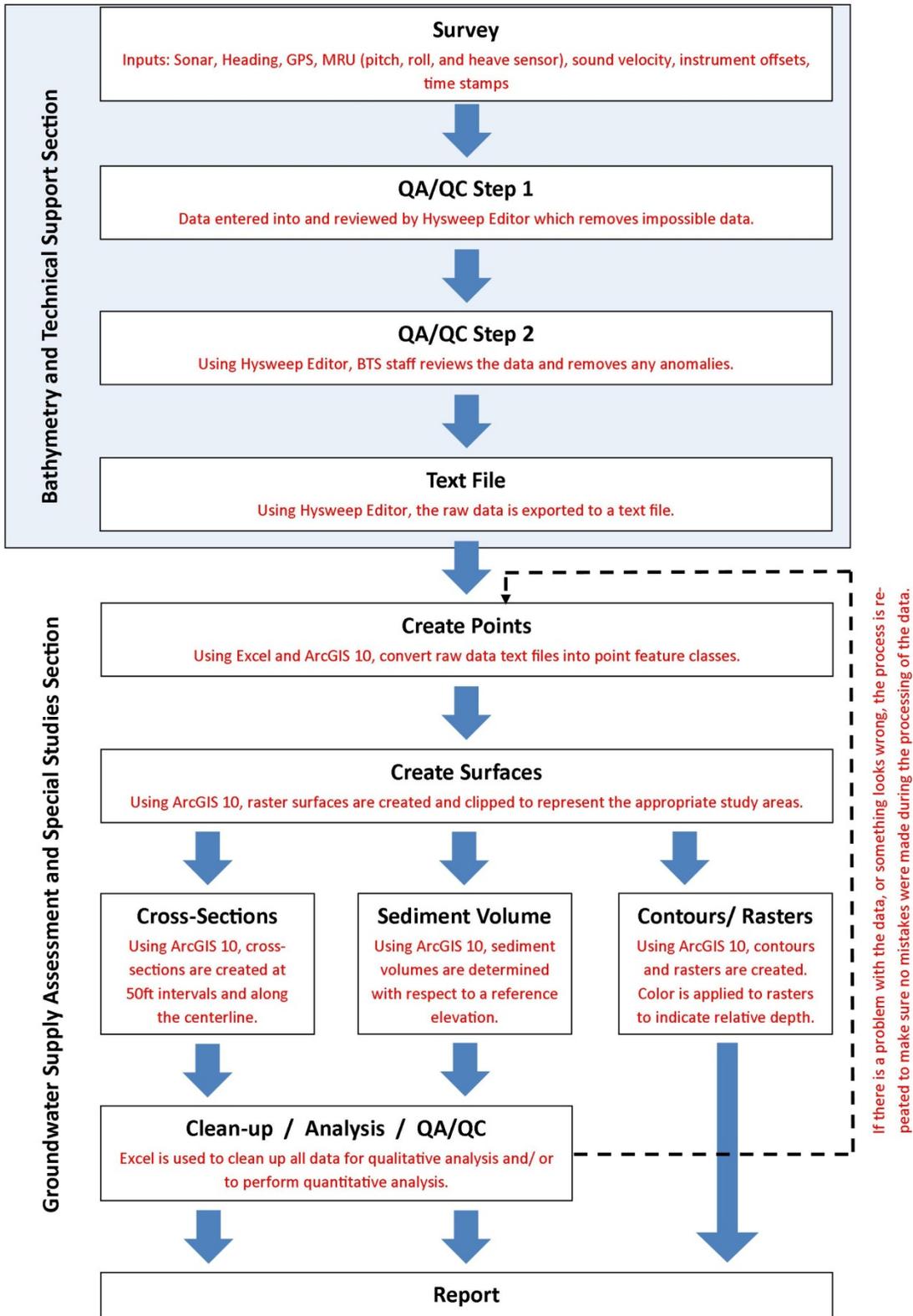
The data collection process and analysis is a complex and multi-step process. Figure 2-1 shows a simplified flow chart of the process from collecting data to the writing of the report. The entire process is a collaborative effort between NCRO's *Groundwater Supply Assessment and Special Studies Section (GWSA&SS)* and the *Bathymetry and Technical Support Section (BTS)*. The GWSA&SS is responsible for the method, timing, analysis and report writing. The BTS collects data and provides input about technical limitations, field conditions, and constraints.

### 2.1 DATA COLLECTION

The data contained within this report was collected using a multi-beam depth sounder and Real Time Kinematic Global Positioning System (RTK GPS), with the exception of some data collected at MR-1. The multi-beam depth sounder provides near 100% site coverage and, with the RTK GPS, surveying the benchmark (BM) and water surface elevations are no longer required. While the BM and water surface elevation no longer need to be surveyed when the RTK GPS is used, a base station is required and a person is needed to secure and monitor the base station.

Entry permits have proven to be a challenge for this project. Obtaining, and renewing permits has been costly and time consuming. Some permits require yearly updating and/or have conditions tied to the permit such as submission of survey data and/ or notice prior to entry. Advances in technology have minimized the need for staff to access sites by vehicle, allowing for some flexibility in keeping permits current. The Site Map, Figure 1-2, shows parcels where a permit either currently exists or existed. The GWSA&SS has contacted DWR's Real Estate Branch in an effort to make all permits current.





**Figure 2-1: The Sediment Monitoring Process**



## 2.2 DATA ANALYSIS

ArcGIS 10 and Microsoft Excel were the predominate software programs used to analyze the bathymetric data. Excel was used to store the raw data, which was imported into ArcGIS. ArcGIS was used to create points and surfaces that were used to create cross-sections, profiles, and volumes. The first step of the volumetric analysis, comparing study area surfaces to a reference elevation of -100ft NAVD88, was performed in ArcGIS. Excel was used to do the volumetric analysis and to create all of the plots of the data that were exported from ArcGIS.

### 2.2.1 Cross-Sections

Cross-section plots show data from the reporting period (fall 2010 – spring 2012) in color and all previous data (historic data) was included in the plots in light gray to provide a historic reference. All cross-section plots have the same vertical reference scale for easy comparison between sites.

For each site, a subjective visual inspection of the cross-sections and centerline profiles were conducted for the reporting period. The visual inspection was done by one person on the same day to minimize differences in interpretation. Two questions were evaluated in the visual inspection:

- 1.) Is there an increasing/ decreasing trend in sediment levels within the reporting period?
- 2.) How does the reporting period data fit with the historical data?

There were six possible responses for each of the above questions. Table 2-1 describes the possible responses and their meaning.



**Table 2-1: Visual Inspection Criterion**

**Sediment Levels During Reporting Period**

Increasing	Consistent increase from survey to survey AND/ OR season to season.
Possible Increase	Appears to be a possible increasing trend.
Stable	Tight grouping of data, difficult to determine any significant pattern.
Possible Decrease	Appears to be a possible decreasing trend.
Decreasing	Consistent decrease from survey to survey AND/ OR season to season.
Unknown	Data not tightly grouped and has no discernible pattern.

**Reporting Period Compared to Historical Data**

Above Historical	Most of the data is above the upper limits of the historical data.
High Side of Historical	Most of the data is in the upper half of the historical data range.
Consistent w/ Historical	Most of the data is near the middle of the historical data range.
Low Side of Historical	Most of the data is in the lower half of the historical data range.
Below Historical	Most of the data is below the lower limits of the historical data.
Above & Below Historical	Data is both above and below historical limits.

**2.2.2 Volumetric Analysis**

A month to month volumetric analysis was conducted for four sites: GLC-3, GLC-4, GLC-5 and DC-1. All surveys were initially compared to a reference elevation of -100ft NAVD88; this was done so that future surveys could be easily compared and not be based off one, possibly bad, data set. Volumetric data was taken from ArcGIS and put into Excel for further process, and results are reported in both graphical and tabular formats. Table 2-2, provides a list and description of the column heading along with any pertinent equations.

In addition to the volumetric analysis, contour plots were made for each monthly survey. The background of the contour plots is a raster image where relative depth is indicated by color, where **RED** is shallower and **GREEN** is deeper.



**Table 2-2: Monthly Volumetric Calculations Headings**

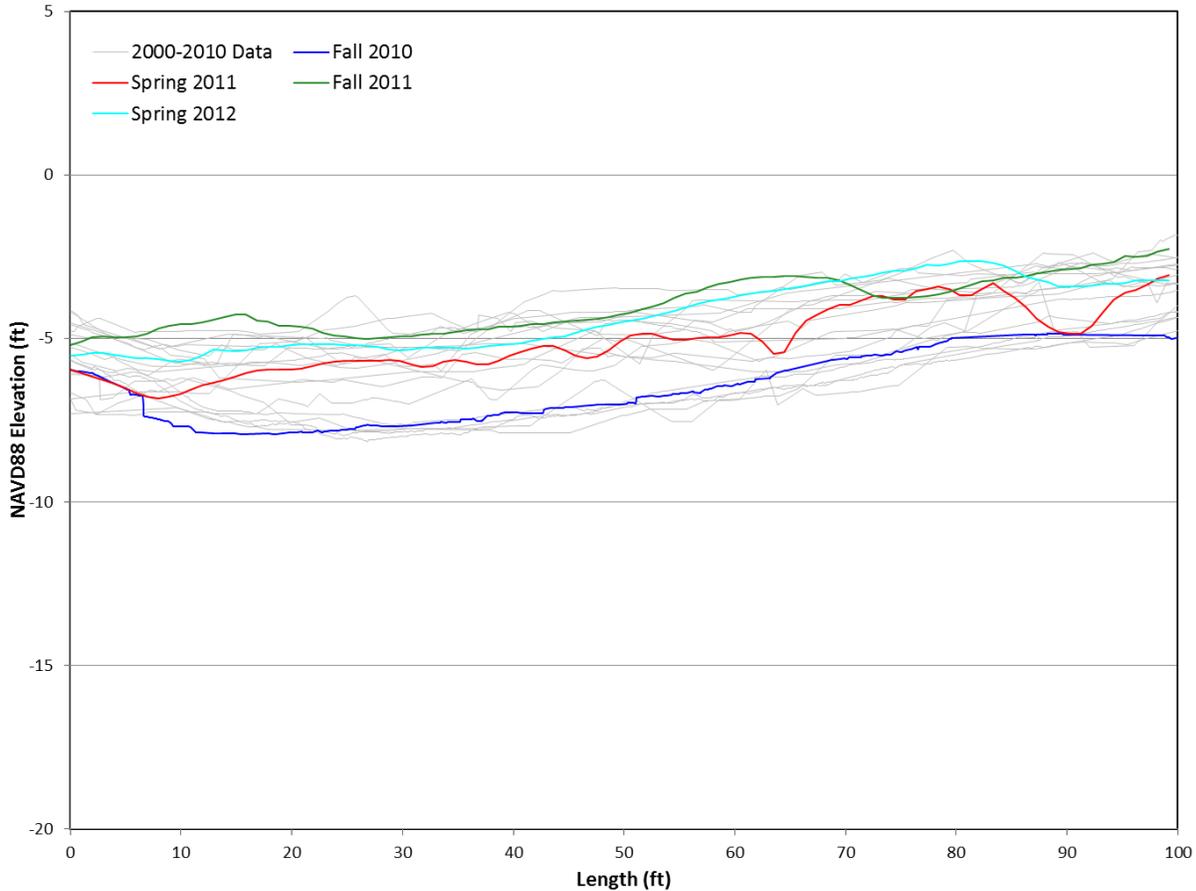
<b>Site</b>	The site being monitored.
<b>Area</b>	The area of the study area based on the dimensions.
<b>Month</b>	The month the survey was done.
<b>Year</b>	The year the survey was done.
<b>Survey Date</b> <i>[mmdyy]</i>	The date of the survey in the <i>mmdyy</i> format.
<b>Volume [ft<sup>3</sup>]</b> <i>(ArcGIS)</i>	The volume in cubic feet, based on the area of the raster surface and a reference elevation of -100ft NAVD88.
<b>Area [ft<sup>2</sup>]</b> <i>(ArcGIS)</i>	The area of the surface from the survey. If a large portion of the area is not included, compared to other surveys, it has a significant impact on the volumetric analysis.
<b>Mean Calculated Elevation [ft]</b>	The mean calculated elevation [=100ft - (volume/area)] is a quick reference value to compare to past average elevations and make sure the data is reasonable. The volume and area used were the ArcGIS surface values.
<b>Normalized Volume [ft<sup>3</sup>]</b>	The normalized volume [=Volume <sub>GIS</sub> + (Area <sub>real</sub> - Area <sub>GIS</sub> ) x (Ref Elev - Mean Calculated Elev)] normalizes all data to the real area of the study area and uses the mean calculated elevation to fill in voids.
<b>Volume [ft<sup>3</sup>]</b> <i>(Normalized to first month, Normalized Area)</i>	The volume (using the normalized volume) is normalized to the first monthly survey data set to compare changes in sediment volume.
<b>Volume [yds<sup>3</sup>]</b> <i>(Normalized Area)</i>	Convert volume from cubic feet to cubic yards.
<b>Month to Month Vol. Change [yds<sup>3</sup>]</b>	The month to month volume change [=V <sub>i</sub> - V <sub>i-1</sub> ]
<b>Average Change in Volume [yds<sup>3</sup>]</b>	The average change in sediment volume since the first month data began being collected.



# 3.0 Results and Discussion

## 3.1 SEMI-ANNUAL SURVEY DATA

Cross-sections for the semi-annual surveys can be found in Appendices A through Q. Figure 3-1 is an example plot for a cross-section at OR-1. Data from spring 2000 through spring 2010 are in gray, providing historic context, while the four most current surveys (fall 2010, spring 2011, fall 2011 and spring 2012), all using the multi-beam depth sounder, are color coded.



**Figure 3-1: Cross-Section Sample (OR-1)**

The results of the visual inspection of the cross-sections for the 17 sites are summarized in Table 3-1. As seen in Table 3-1, OR-1 shows a value of “Increasing” under *Sediment Levels* and “Above & Below Historical” under *Compared to Historical Data*. In Figure 3-1, the fall 2010 cross-section is the lowest of the four reporting period cross-sections, followed by spring 2011, spring 2012, and fall 2011. While Figure 3-1 is only one of the six plots evaluated before determining the value shown in Table 3-1, it appears over the last four surveys, there has been an increasing trend in sediment levels.



The fall 2010 line is near the bottom of the historical range while fall 2011 and spring 2012 are near the top, and spring 2011 is about in the middle. It is possible that the *Compared to Historical Data* result could have been either “Consistent w/ Historical” or possibly “Above & Below Historical”. In the five other plots in Appendix A, there are sufficient cross-sections above and below the historical range to justify the result of “Above & Below Historical”.

**Table 3-1: Semi-Annual Cross-Section Visual Inspection Results**

Site	Sediment Levels	Compared to Historic Data
OR-1	<b>Increasing</b>	<b>Above &amp; Below Historical</b>
OR-2	Unknown	Low Side of Historical
OR-3	Unknown	Consistent w/ Historical
OR-4	Possible Decrease	Low Side of Historical
OR-5	Stable	Consistent w/ Historical
OR-6	<b>Possible Increase</b>	Consistent w/ Historical
OR-7	Stable	Consistent w/ Historical
OR-8	<b>Possible Increase</b>	Consistent w/ Historical
OR-9	Stable	Low Side of Historical
GLC-1A	Stable	Low Side of Historical
GLC-1B	Stable	Consistent w/ Historical
GLC-2	Decreasing	<b>Above &amp; Below Historical</b>
GLC-3	Stable	<b>High Side of Historical</b>
GLC-4	Stable	Low Side of Historical
GLC-5	Stable	Consistent w/ Historical
DC-1	Possible Decrease	<b>High Side of Historical</b>
MR-1	Stable	Consistent w/ Historical

A result of “Above & Below Historical” could be the result of 1.) aquatic growth and survey timing, 2.) extreme fluctuations in sediment, or 3.) both. The short-term inconsistency is worth further consideration to develop an understanding of why there are such large fluctuations in sediment levels.



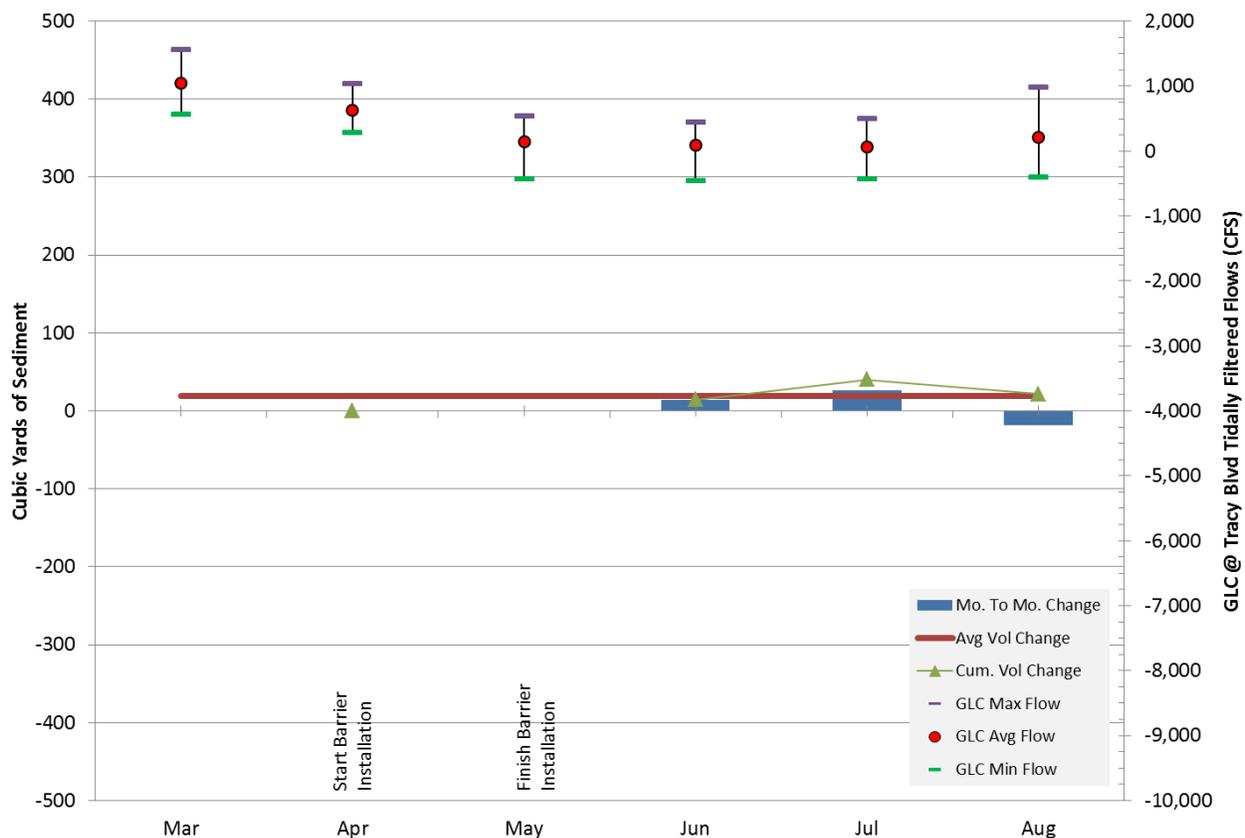
## 3.2 MONTHLY DATA

### 3.2.1 GLC-3

Monthly surveys for GLC-3 did not officially begin until June 2012, but the semi-annual data from April was included (Figure 3-2, Table 3-2). Because there were no data collected for March and May, it is not possible to see if the installation of the barrier might have had an impact on sediment levels. Given the current data, the average change in elevation of GLC-3 is 0.31 inches.

In 2012, Grant Line Canal experienced lower flows during May through July (Figure 3-2), with all three months having similar minimum, maximum and average flows. Beginning in June, sediment volumes began to increase, but in August, when the maximum flow through Grant Line Canal increased, the sediment levels begin to decrease.

The contours and raster images in Figure 3-3 show little change between April and August. There is some obvious areas where sediment built up, indicated by the growing areas of red, in July and August.



**Figure 3-2: GLC-3 2012 Monthly Changes in Sediment Volume**



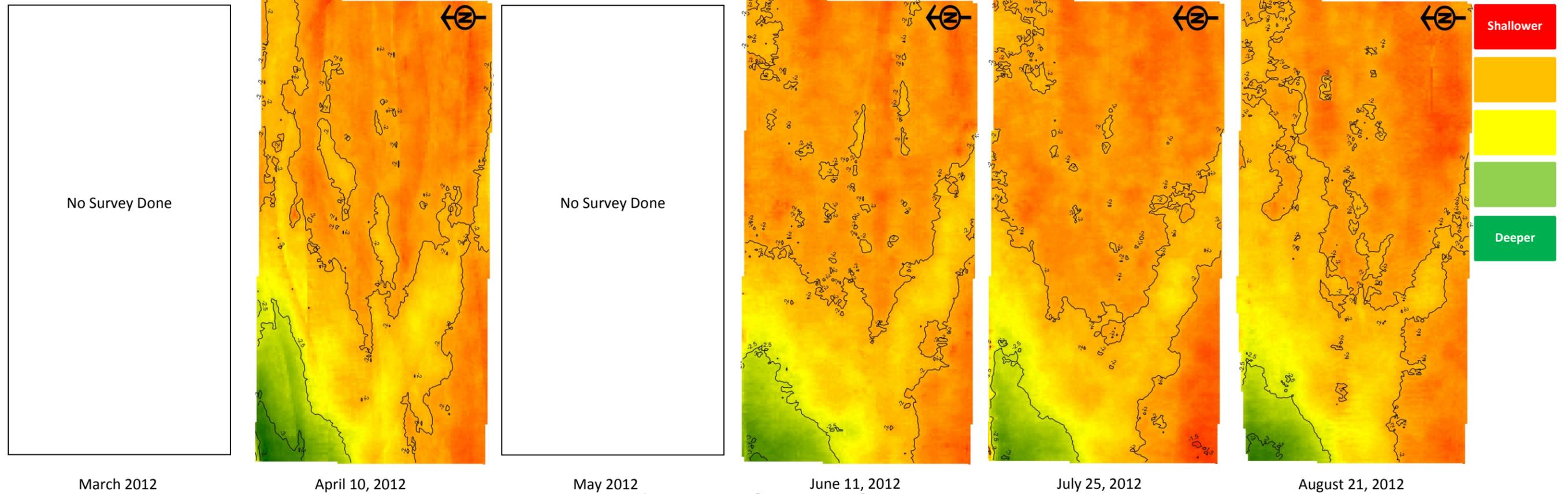


Figure 3-3: GLC-3 Monthly Contours

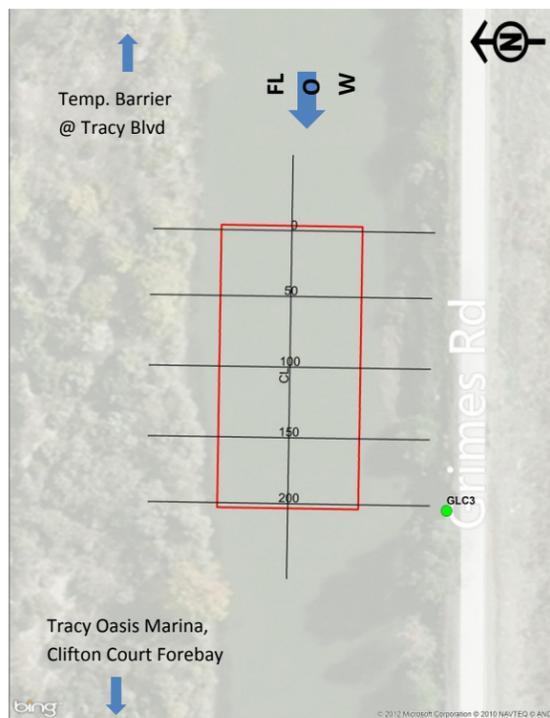


Table 3-2: GLC-3 Monthly Volumetric Calculations

Site: GLC3  
 Area: 20,000 ft<sup>2</sup>

Month	Year	Survey Date [mmdyy]	Volume [ft <sup>3</sup> ] (ArcGIS)	Area [ft <sup>2</sup> ] (ArcGIS)	Mean Calc'd Elevation [ft]	Normalized Volume [ft <sup>3</sup> ]	Volume [ft <sup>3</sup> ] (Normalized Area)	Volume [yds <sup>3</sup> ] (Normalized Area)	Month to Month Vol. Change [yds <sup>3</sup> ]	Average Change in Volume [yds <sup>3</sup> ]
Mar	2012								0	19
Apr	2012	041012	-1,946,019	19,867	-2.05	-1,959,047	0	0	0	19
May	2012									19
Jun	2012	061112	-1,944,540	19,848	-2.03	-1,959,431	385	14	14	19
Jul	2012	072512	-1,947,002	19,866	-1.99	-1,960,135	1,088	40	26	19
Aug	2012	082112	-1,929,454	19,692	-2.02	-1,959,632	585	22	-19	19

### 3.2.2. GLC-4

GLC-4 is the first downstream site of the barrier on Grant Line Canal. As can be seen in Figure 3-4, in 2012 there was a depletion of sediment in April and May; but beginning in June, sediment levels began to increase. However, because of the large depletion of sediment in April, the average change in volume between March and August was 217 cubic yards (Table 3-3), an average reduction of sediment of 3.5 inches for the site.

Contour and raster images in Figure 3-5 show the study area being shallower in March with darker red on the right side of the study area and light green on the left side. As the months progressed the green on the left darkened and the red area lightened, until July / August when the red area began to darken, which is consistent with Figure 3-4.

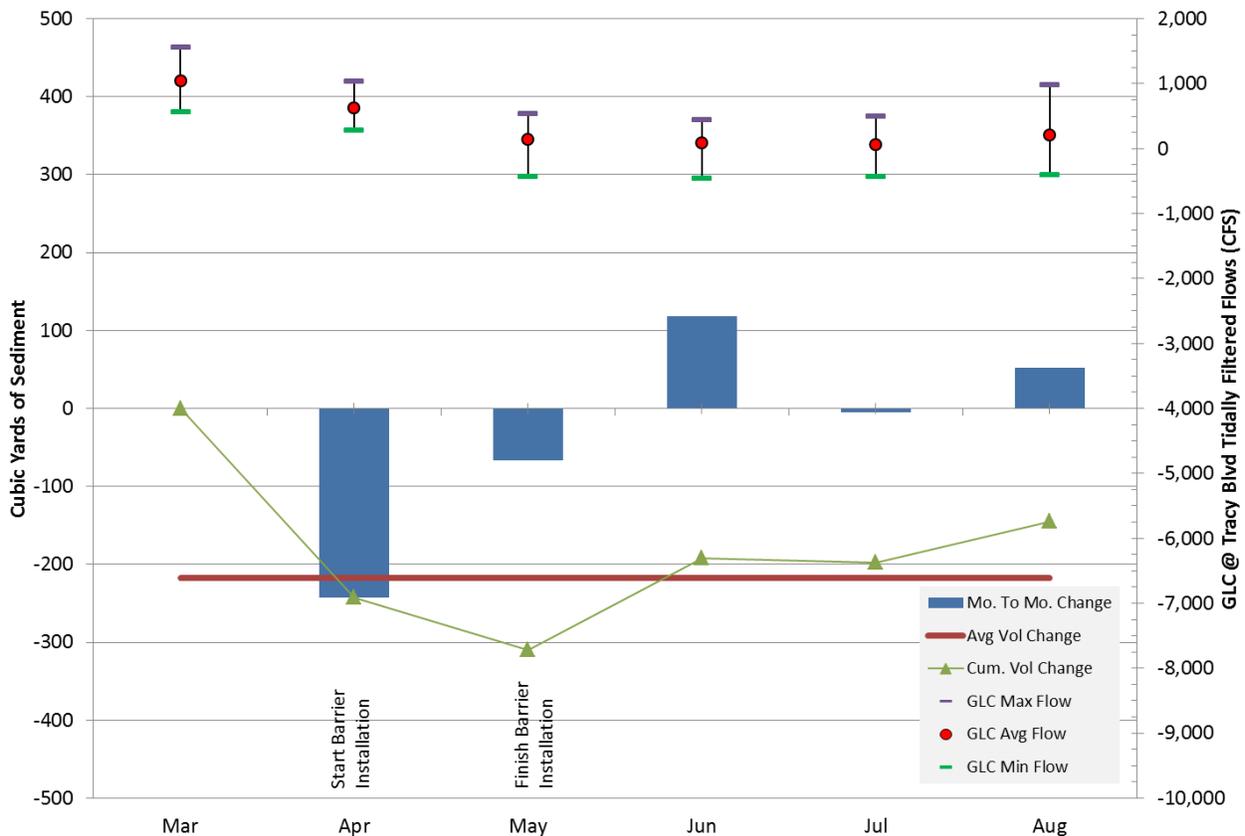


Figure 3-4: GLC-4 2012 Monthly Changes in Sediment Volume



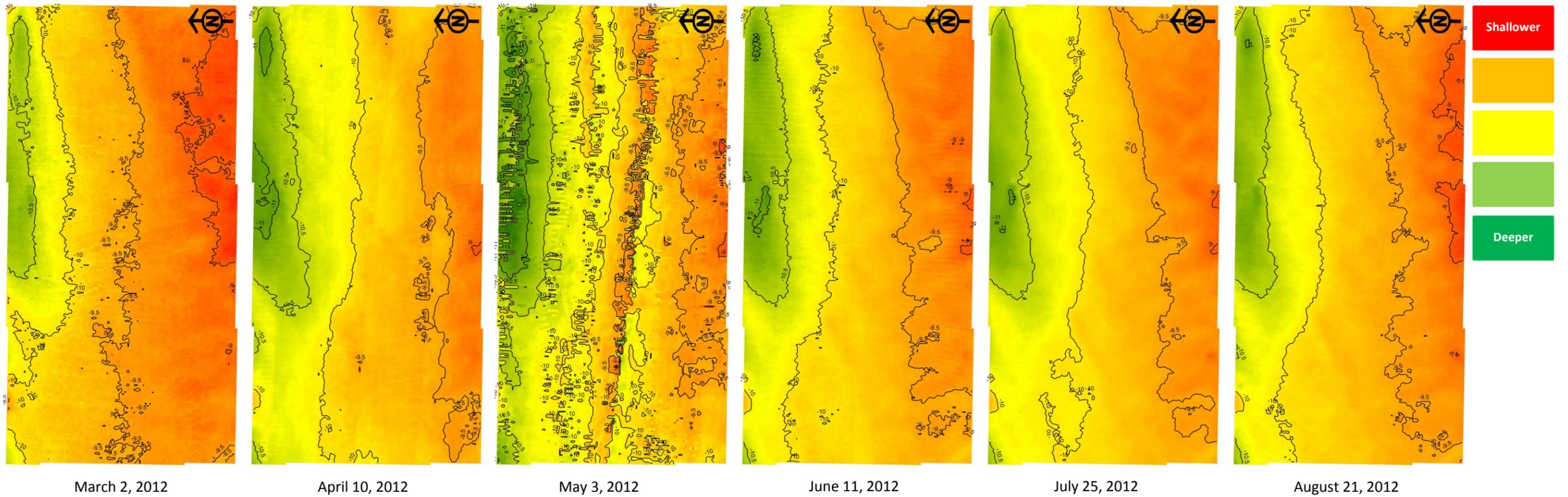


Figure 3-5: GLC-4 Monthly Contours

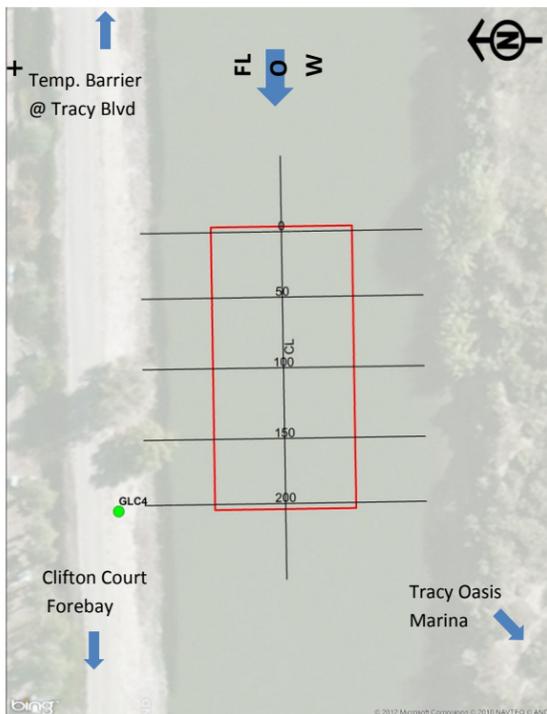


Table 3-3: GLC-4 Monthly Volumetric Calculations

Site: GLC4  
Area: 20000 ft<sup>2</sup>

Month	Year	Survey Date [mmddyy]	Volume [ft <sup>3</sup> ] (ArcGIS)	Area [ft <sup>2</sup> ] (ArcGIS)	Mean Calc'd Elevation [ft]	Normalized Volume [ft <sup>3</sup> ]	Volume [ft <sup>3</sup> ] (Normalized Area)	Volume [yds <sup>3</sup> ] (Normalized Area)	Month to Month Vol. Change [yds <sup>3</sup> ]	Average Change in Volume [yds <sup>3</sup> ]
Mar	2012	030212	-1,797,662	19,883	-9.59	-1,808,240	0	0		-217
Apr	2012	041012	-1,791,241	19,884	-9.92	-1,801,690	-6,550	-243	-243	-217
May	2012	050312	-1,789,348	19,883	-10.01	-1,799,878	-8,363	-310	-67	-217
Jun	2012	061112	-1,792,599	19,884	-9.85	-1,803,056	-5,184	-192	118	-217
Jul	2012	072512	-1,792,362	19,883	-9.85	-1,802,909	-5,332	-197	-5	-217
Aug	2012	082112	-1,793,768	19,883	-9.78	-1,804,323	-3,918	-145	52	-217



### 3.2.3 GLC-5

GLC-5 is the first study area upstream of the barrier on Grant Line Canal. In 2012, sediment levels decreased during April and May. Beginning in June, sediment accretion occurred in the study area. The barrier raises the water level upstream, decreasing the flow velocity, possibly enough to allow suspended particles to settle out. The rise in sediment levels in June (Figure 3-6, Table 3-4) may indicate that the barrier impacts upstream sediment levels. However, after the June peak, sediment accumulation decreased until August, when some scouring occurred. In August there was a net monthly depletion of 90 cubic yards.

The contour and raster images in Figure 3-7 agree with the trend seen in Figure 3-6, with April and May showing more green, but the following months areas of red and orange begin to increase.

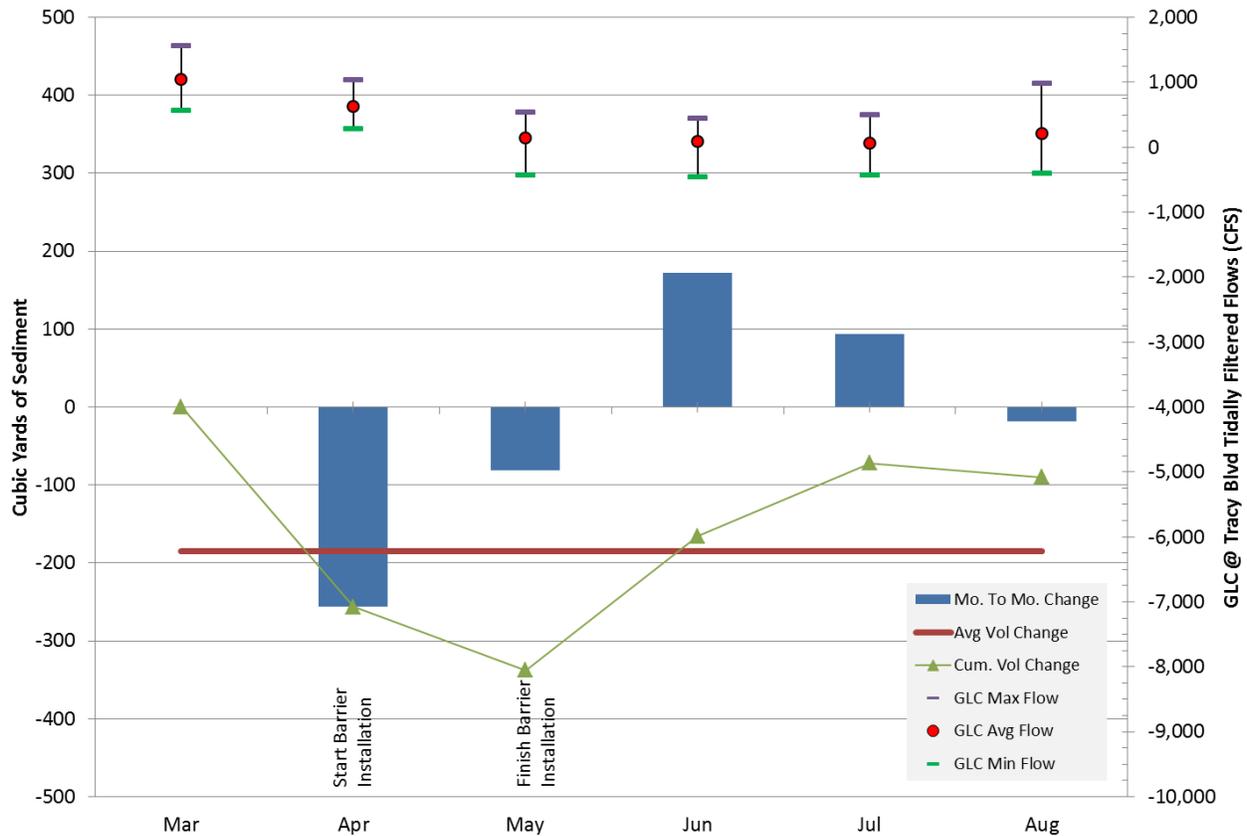


Figure 3-6: GLC-5 2012 Monthly Changes in Sediment Volume



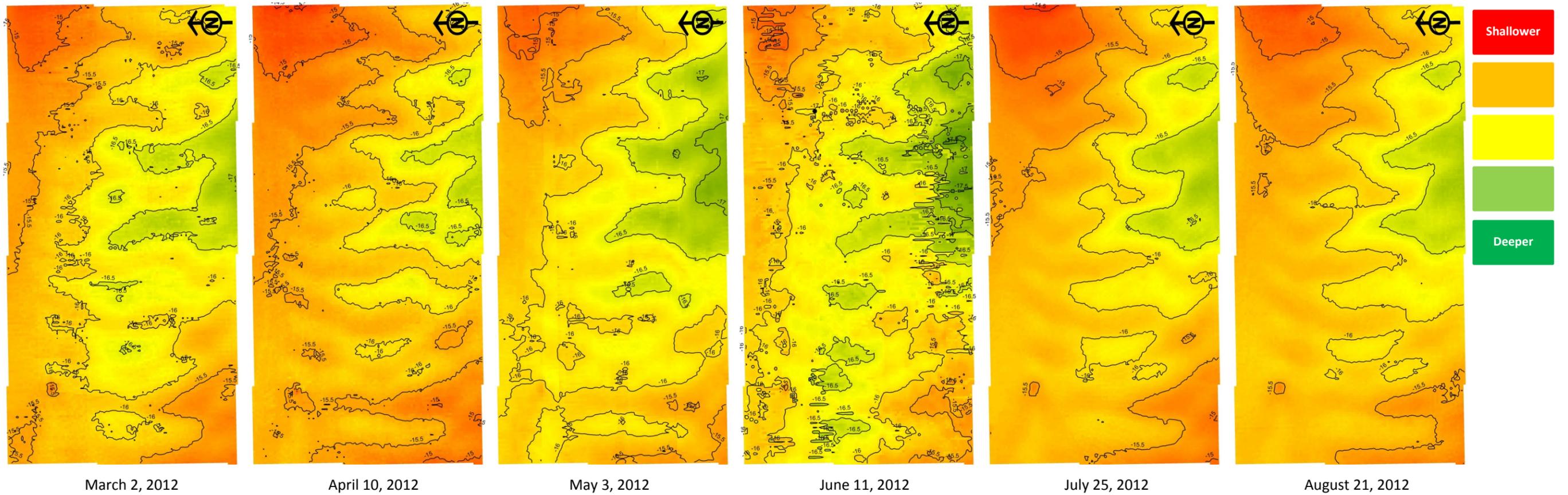


Figure 3-7: GLC-5 Monthly Contours



Table 3-4: GLC-5 Monthly Volumetric Calculations

Site: GLC5  
Area: 20000 ft<sup>2</sup>

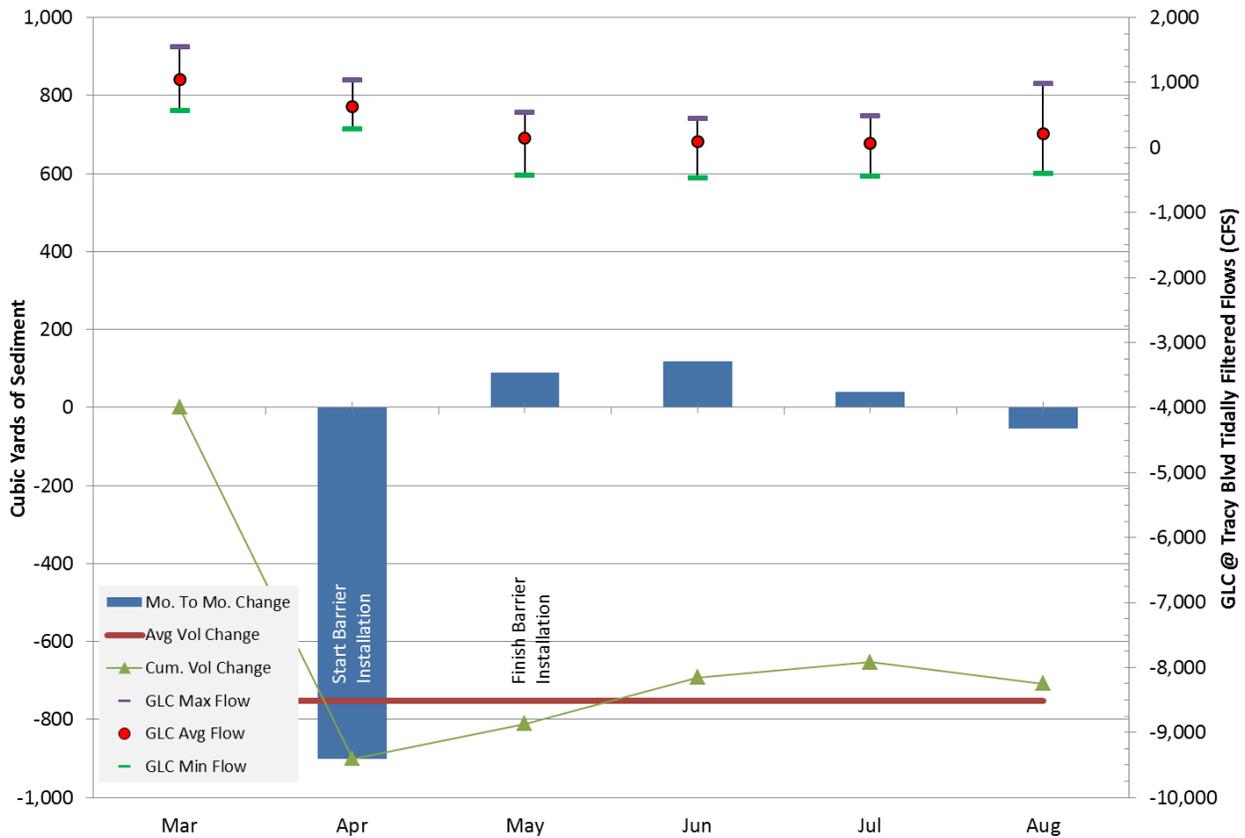
Month	Year	Survey Date [mmdyy]	Volume [ft <sup>3</sup> ] (ArcGIS)	Area [ft <sup>2</sup> ] (ArcGIS)	Mean Calc'd Elevation [ft]	Normalized Volume [ft <sup>3</sup> ]	Volume [ft <sup>3</sup> ] (Normalized Area)	Volume [yds <sup>3</sup> ] (Normalized Area)	Month to Month Vol. Change [yds <sup>3</sup> ]	Average Change in Volume [yds <sup>3</sup> ]
Mar	2012	030212	-1,676,614	19,885	-15.68	-1,686,311	0	0		-185
Apr	2012	041012	-1,669,721	19,885	-16.03	-1,679,377	-6,933	-257	-257	-185
May	2012	050312	-1,667,545	19,885	-16.14	-1,677,189	-9,121	-338	-81	-185
Jun	2012	061112	-1,672,161	19,885	-15.91	-1,681,831	-4,479	-166	172	-185
Jul	2012	072412	-1,674,687	19,885	-15.78	-1,684,372	-1,939	-72	94	-185
Aug	2012	082112	-1,674,190	19,885	-15.81	-1,683,873	-2,438	-90	-18	-185



### 3.2.4 DC-1

DC-1 is the second site upstream of the barrier on Grant Line Canal (Figure 1-2) and is a wider study area, 275ft, compared to the normal 100ft wide study area. Figure 3-8 (and Table 3-5) shows a large decrease in sediment volume in April, 2012. This could possibly be attributed to not being able to survey a portion of the study area. Looking at the contour and raster images in Figure 3-9, the bottom right corner is missing for every month. It appears more of that bank is missing in April, which could account for some of the large drop in sediment volumes, since that bank is steep and contains more volume than the “normalized volume” (Table 2-2) equation would have accounted for.

A similar pattern to the three other sites appears in Figure 3-8, with depletion in April and accretion in June and July followed by depletion of sediment in August.



**Figure 3-8: DC-1 2012 Monthly Changes in Sediment Volume**



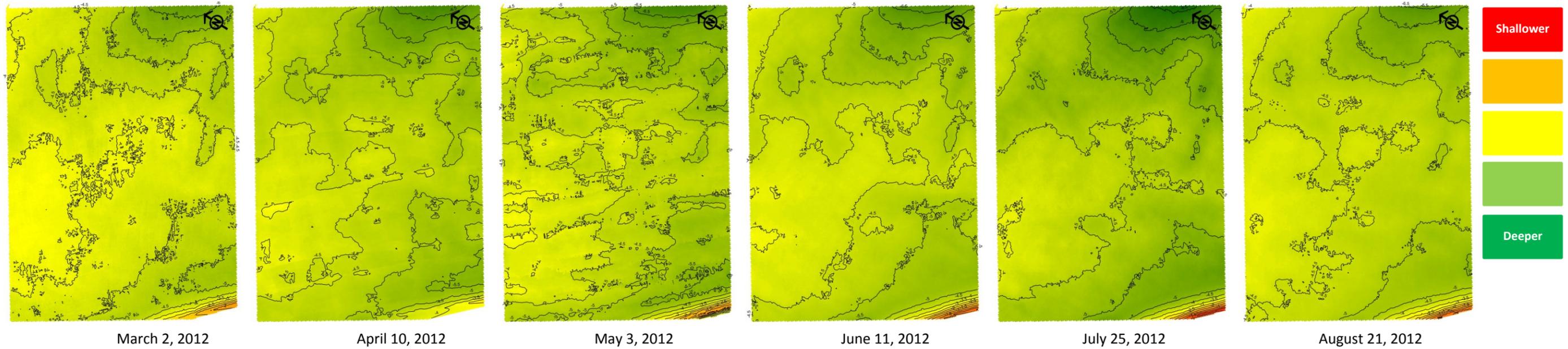


Figure 3-9: DC-1 Monthly Contours

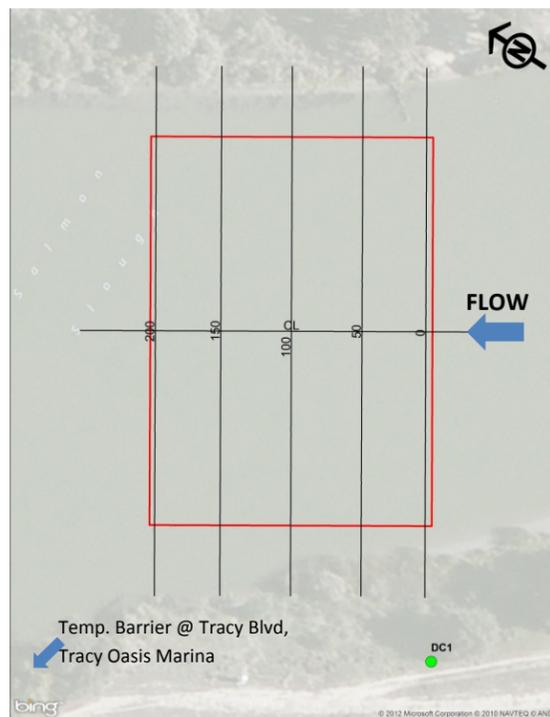


Table 3-5: DC-1 Monthly Volumetric Calculations

Site: DC1  
 Area: 55000 ft<sup>2</sup>

Month	Year	Survey Date [mmddyy]	Volume [ft <sup>3</sup> ] (ArcGIS)	Area [ft <sup>2</sup> ] (ArcGIS)	Mean Calc'd Elevation [ft]	Normalized Volume [ft <sup>3</sup> ]	Volume [ft <sup>3</sup> ] (Normalized Area)	Volume [yds <sup>3</sup> ] (Normalized Area)	Month to Month Vol. Change [yds <sup>3</sup> ]	Average Change in Volume [yds <sup>3</sup> ]
Mar	2012	030212	-5,236,717	54,781	-4.41	-5,257,652	0	0		-753
Apr	2012	041012	-5,199,178	54,641	-4.85	-5,233,337	-24,315	-901	-901	-753
May	2012	050312	-5,220,133	54,836	-4.80	-5,235,745	-21,907	-811	89	-753
Jun	2012	061112	-5,219,717	54,798	-4.75	-5,238,958	-18,694	-692	119	-753
Jul	2012	072412	-5,221,556	54,806	-4.73	-5,240,039	-17,613	-652	40	-753
Aug	2012	082112	-5,217,984	54,784	-4.75	-5,238,557	-19,095	-707	-55	-753

## 4.0 Conclusions

Semi-annual cross-sections, for the most part, appear to be stable over the reporting period. OR-1 is the only site that showed an increasing trend in sediment levels and was not consistent with historic data. OR-6 and OR-8 appear to have a possible increasing trend, but data from the reporting period are consistent with historical data.

Monthly surveys at the four sites all appear to have a similar trend of decreasing sediment levels in March through May and increasing trends June and July, and in August trend reverses. The barrier on Grant Line Canal is generally installed between April and May. The average flow in Grant Line Canal also began to decrease around the same period. Between March and August, three of the sites (GLC-4, GLC-5 and DC-1) have a net decrease in sediment volume. The monthly survey data collection will continue until March 2013; any conclusions prior to then are strictly preliminary.

## 5.0 Recommendations

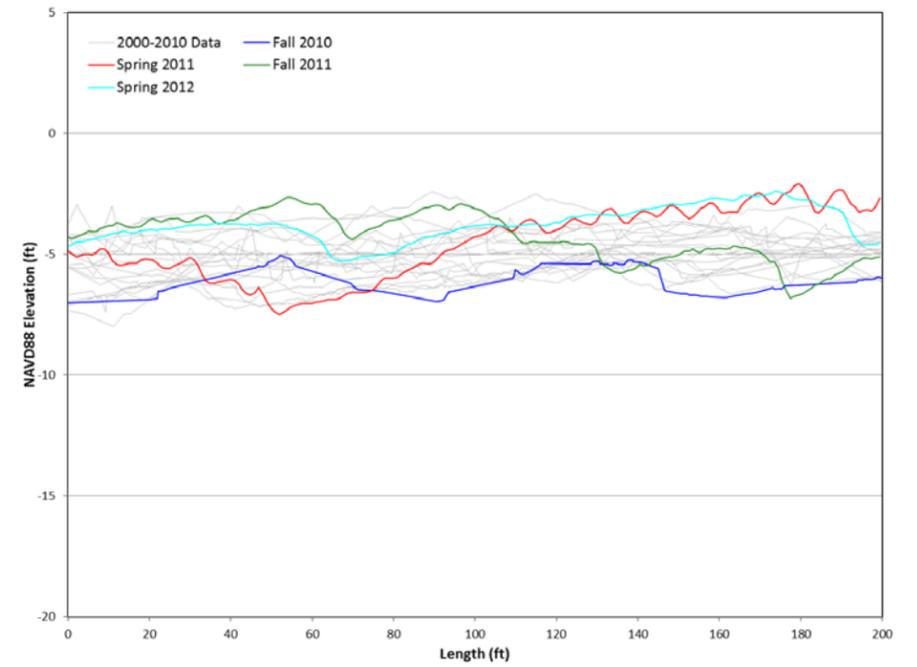
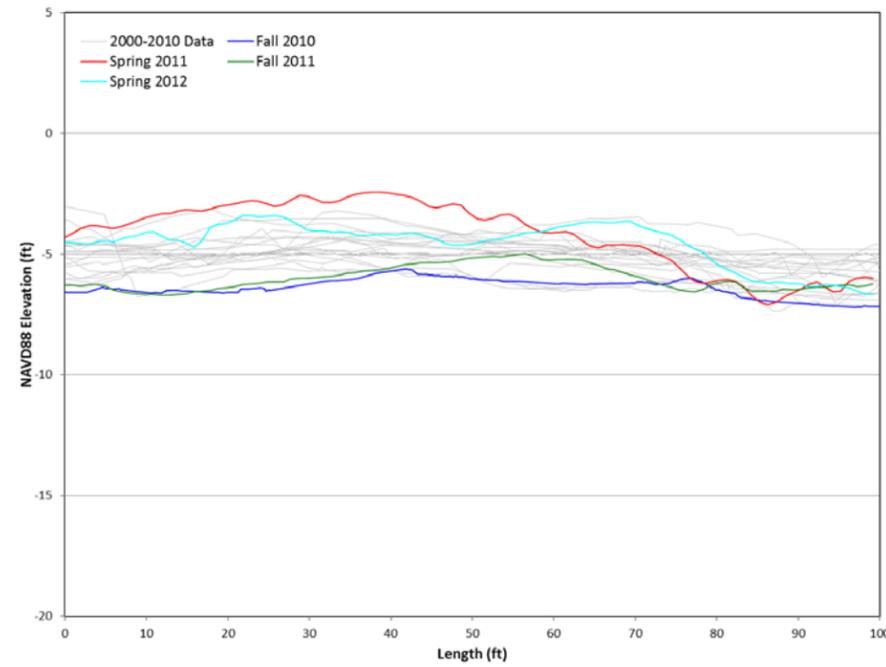
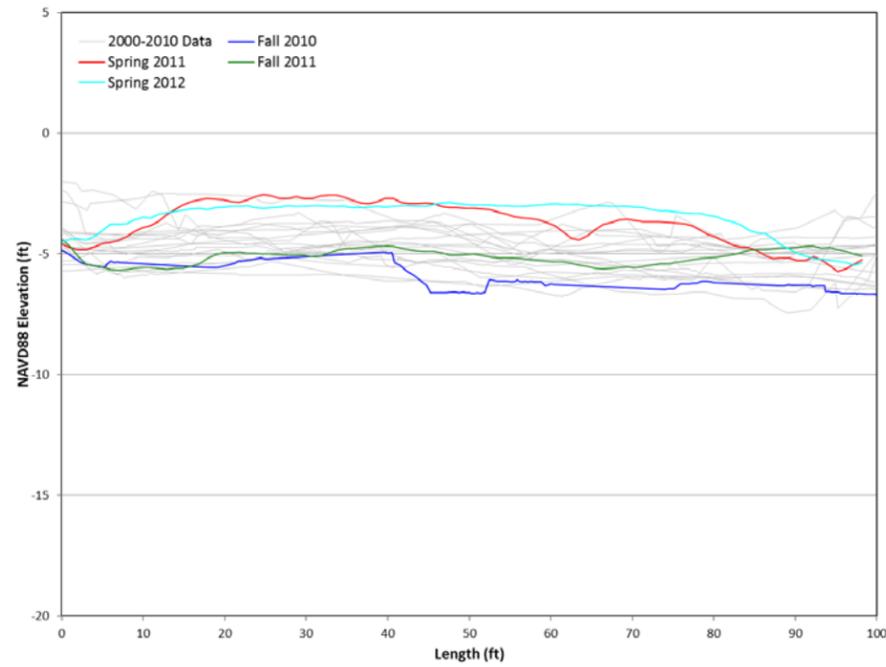
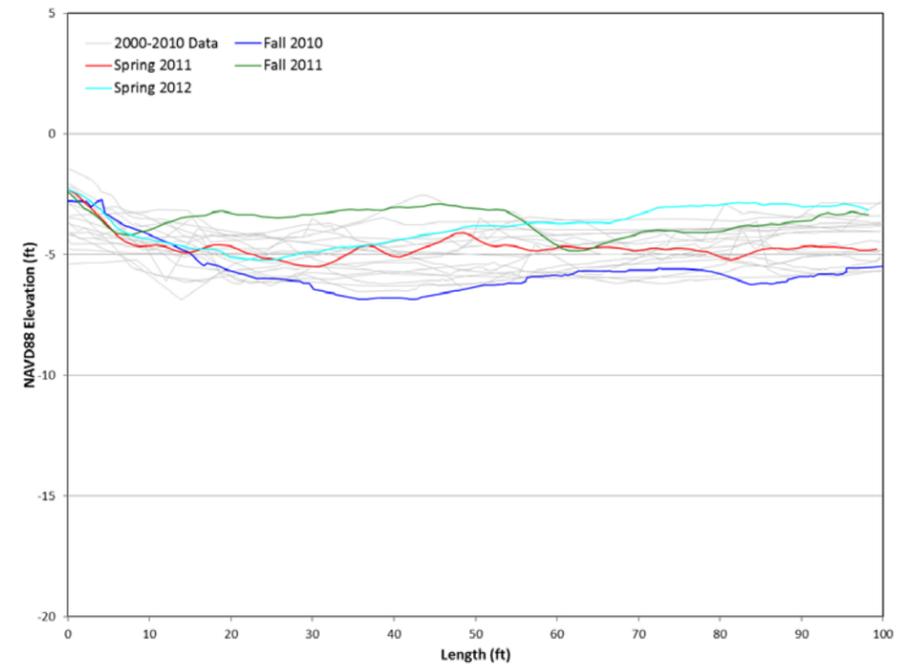
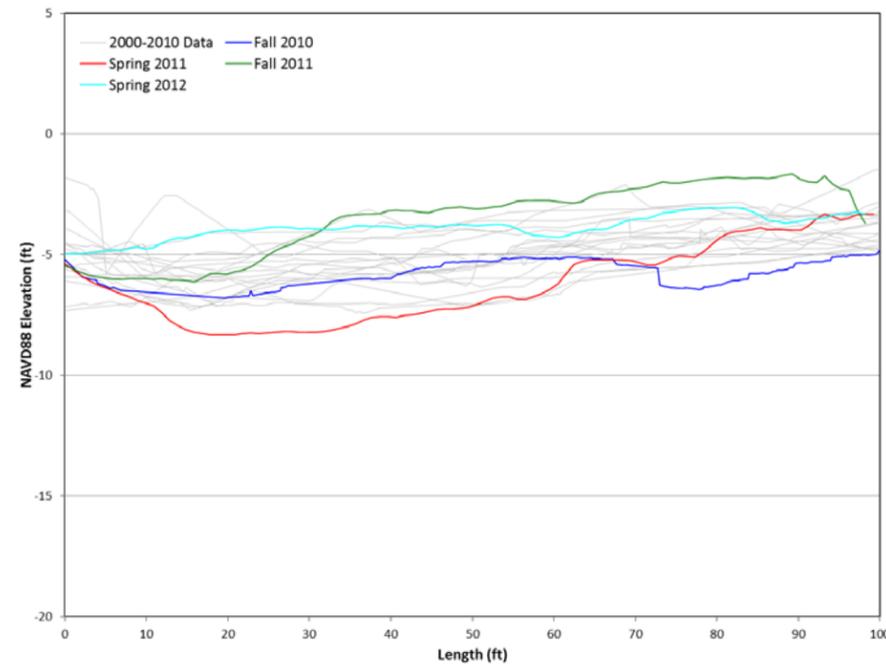
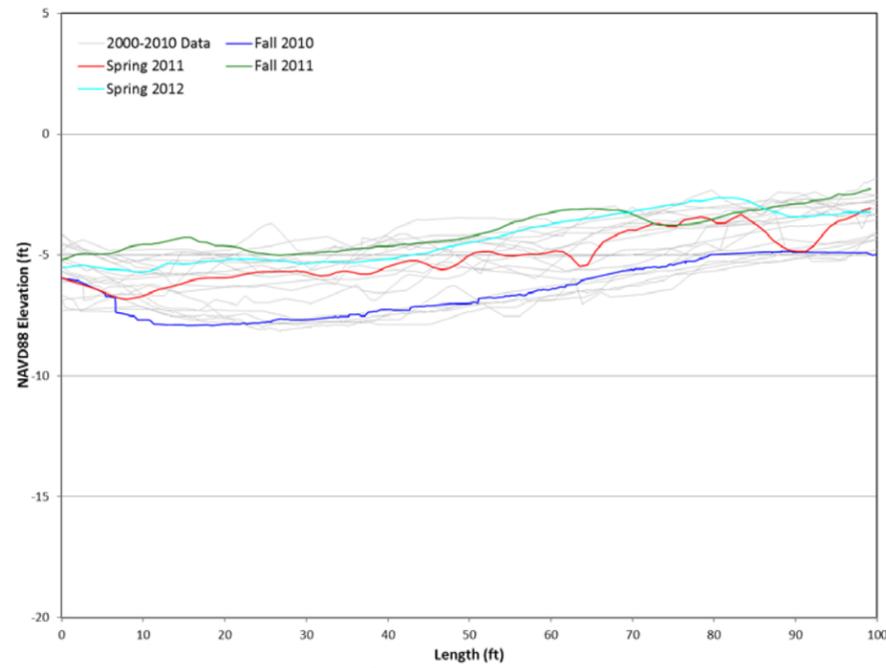
The semi-annual surveys and the cross-sections that result, provide insight into how south Delta channels are changing due to sediment loads and aquatic growth. The cross-sections, however, are not sufficient to determine the impact the barriers have on sediment levels. The monthly surveys have provided new information, and interesting insights into trends that deserve further exploration.

The following recommendations are being made to improve the effectiveness of the study.

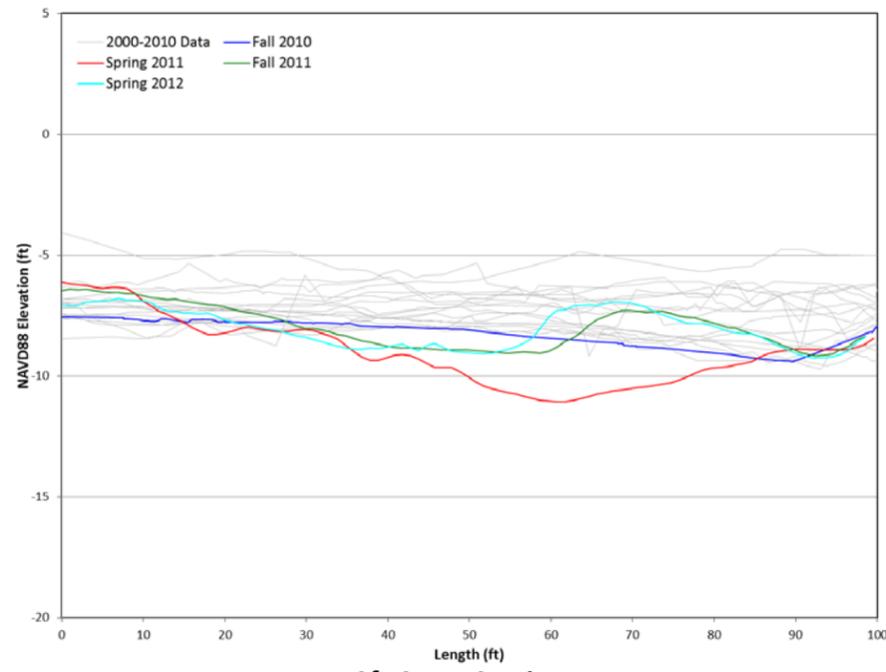
1. Redesign the study to further the understanding of trends in sediment transport. Things to consider in a revised study plan include reducing the number of study areas, expanding the survey area of each study site.
2. Continue monthly monitoring at select sites to see if there is a correlation between changes in flow and / or the barrier installation and removal schedule and changes in sediment levels.



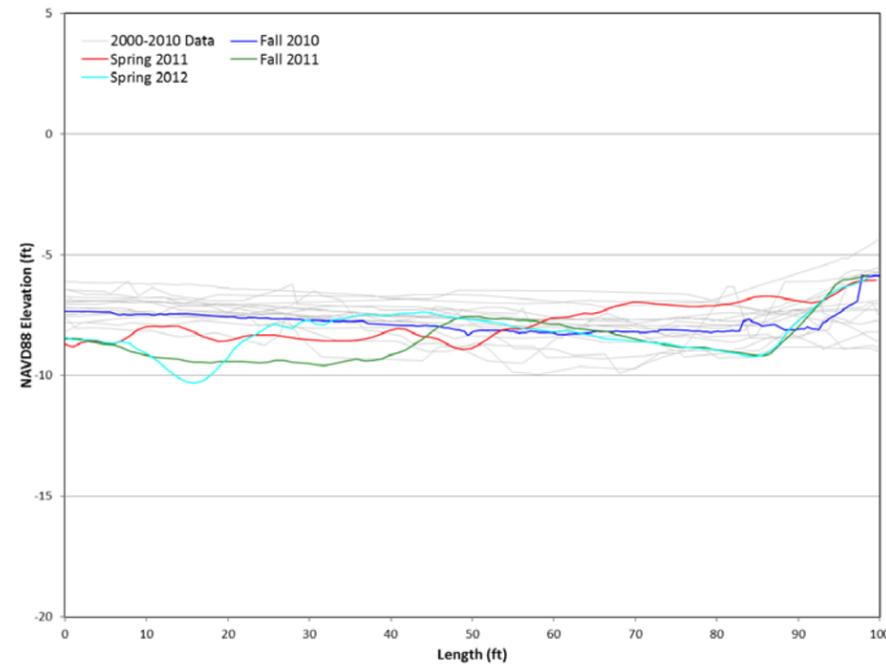
# Appendix A: OR-1 Semi-Annual Cross-Sections



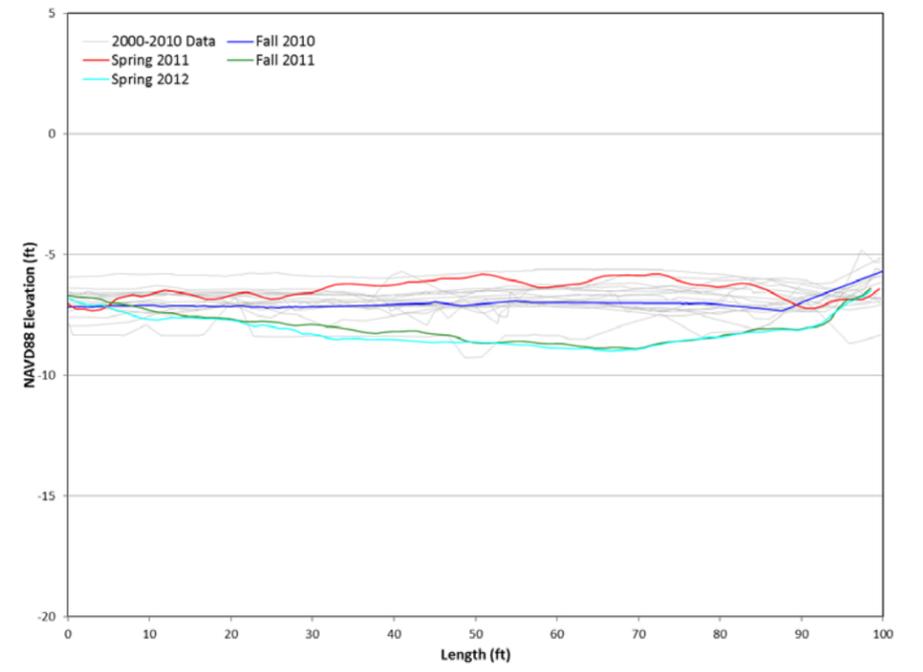
# Appendix B: OR-2 Semi-Annual Cross-Sections



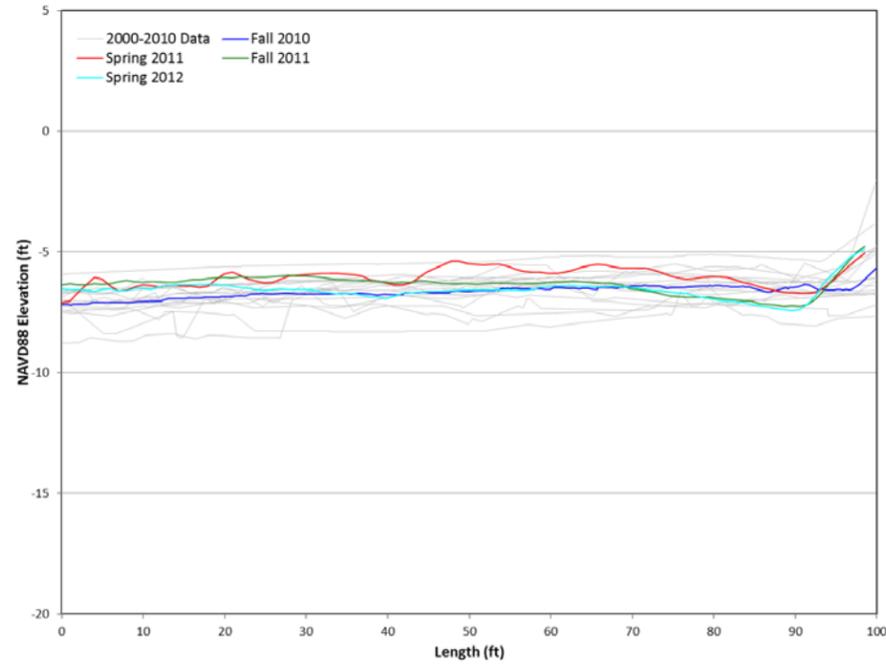
0ft Cross-Section



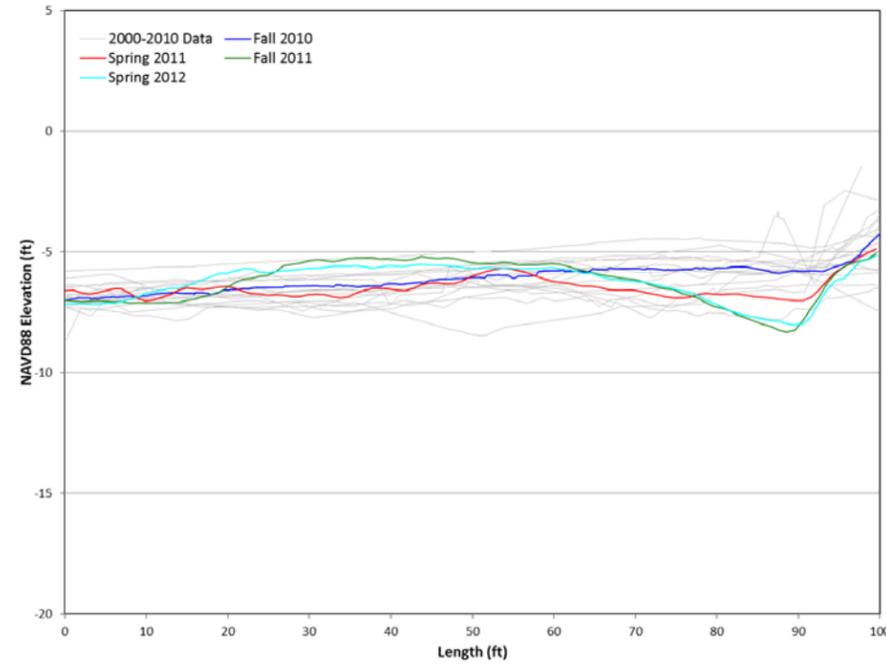
50ft Cross-Section



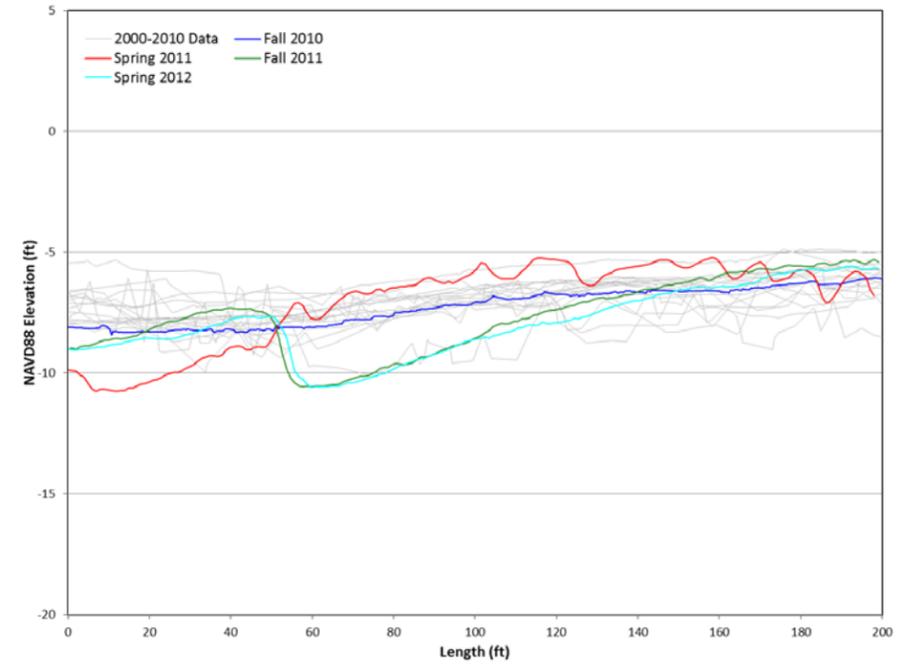
100ft Cross-Section



150ft Cross-Section



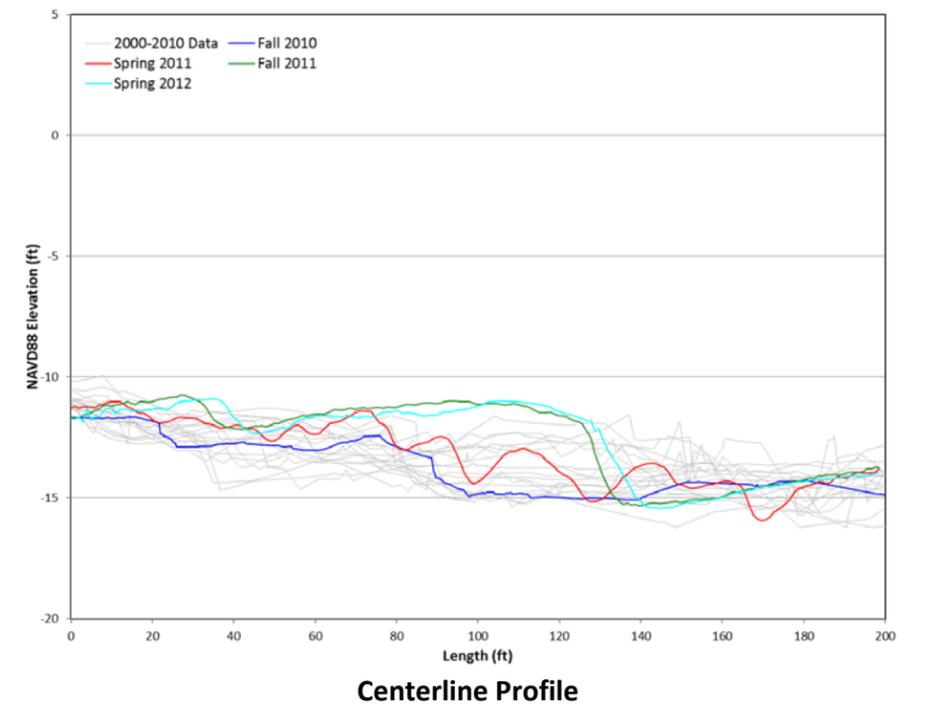
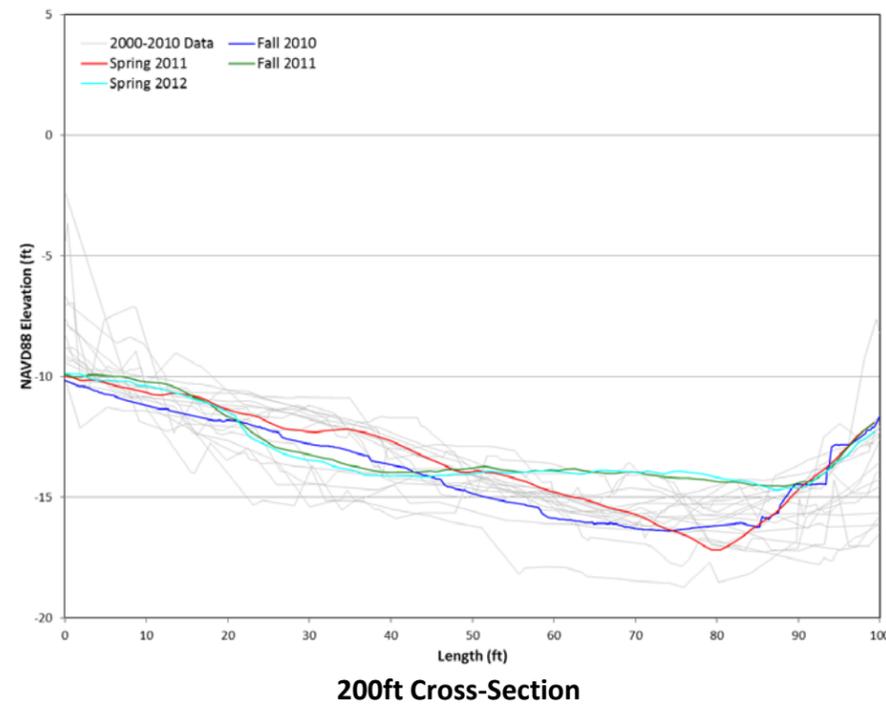
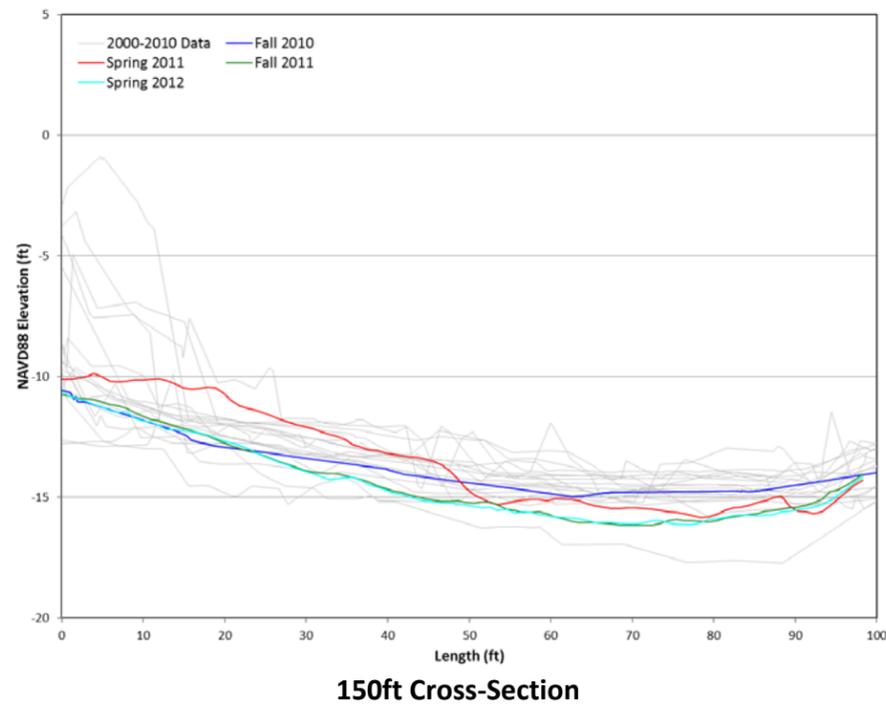
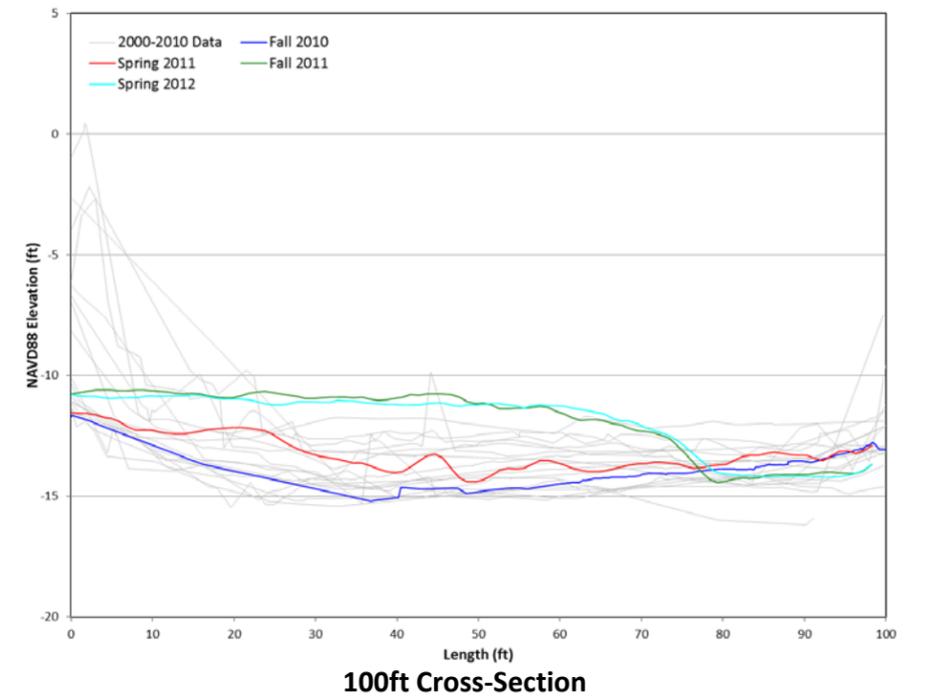
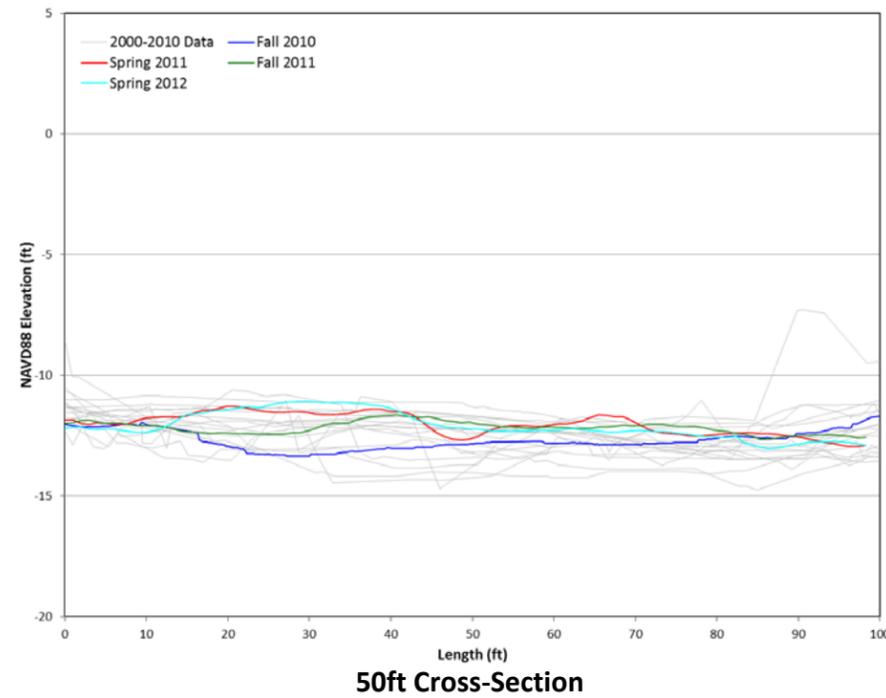
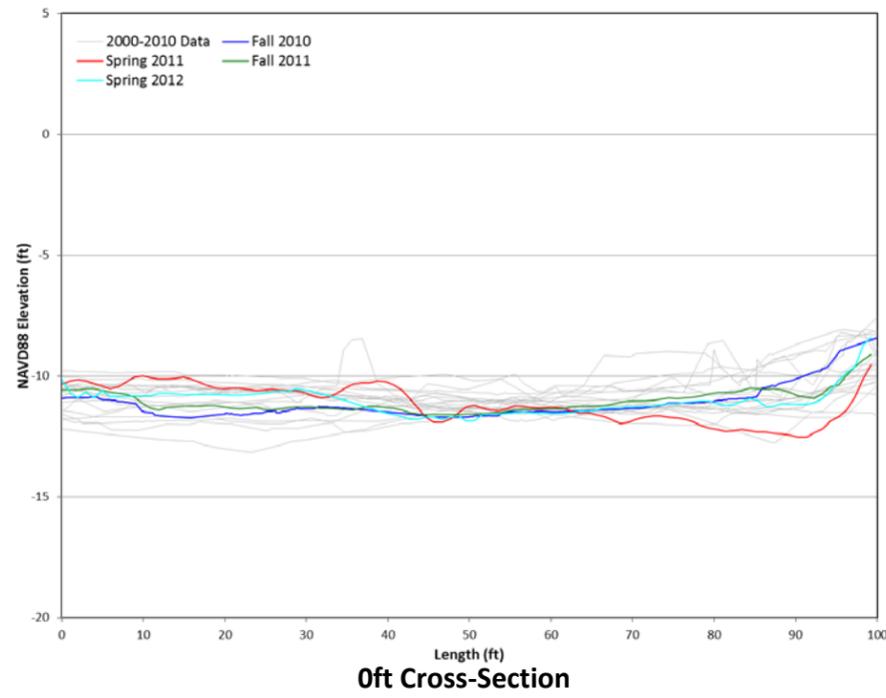
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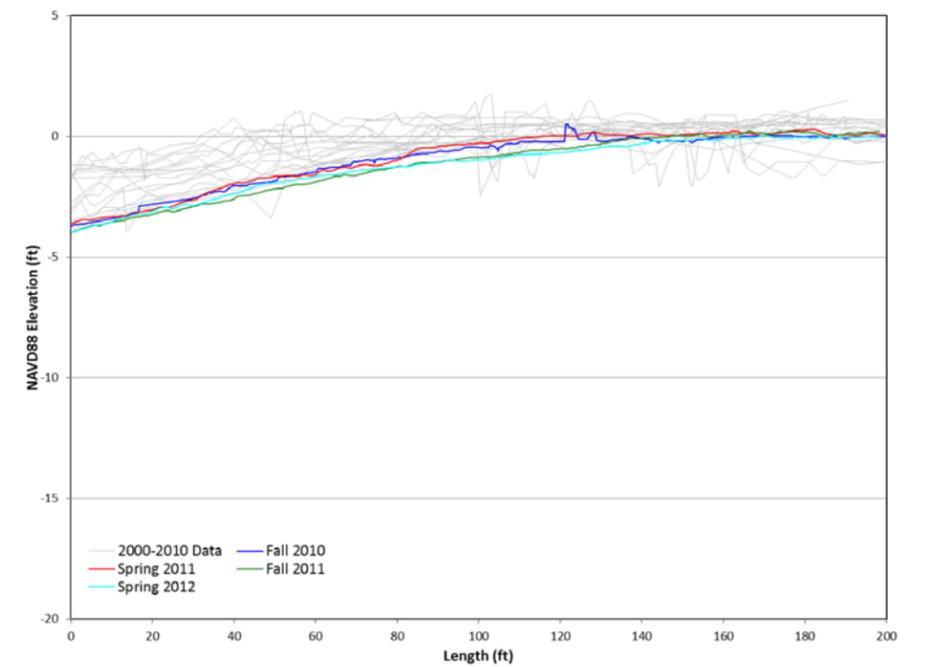
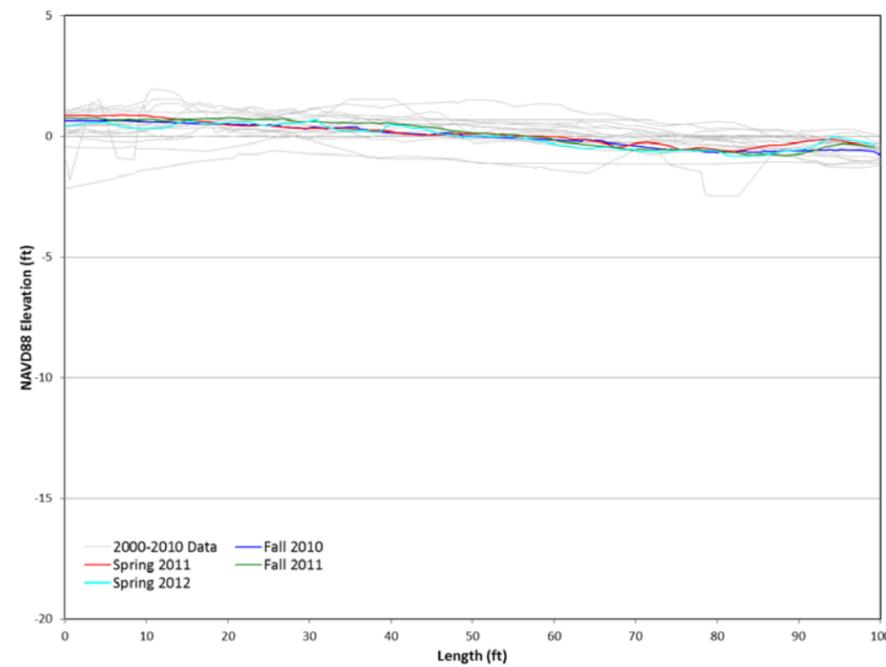
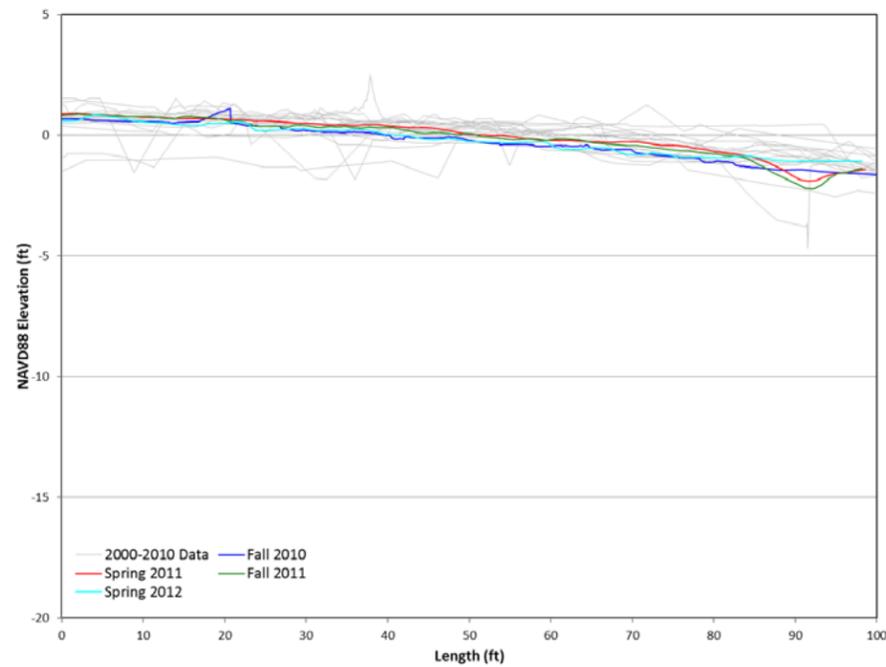
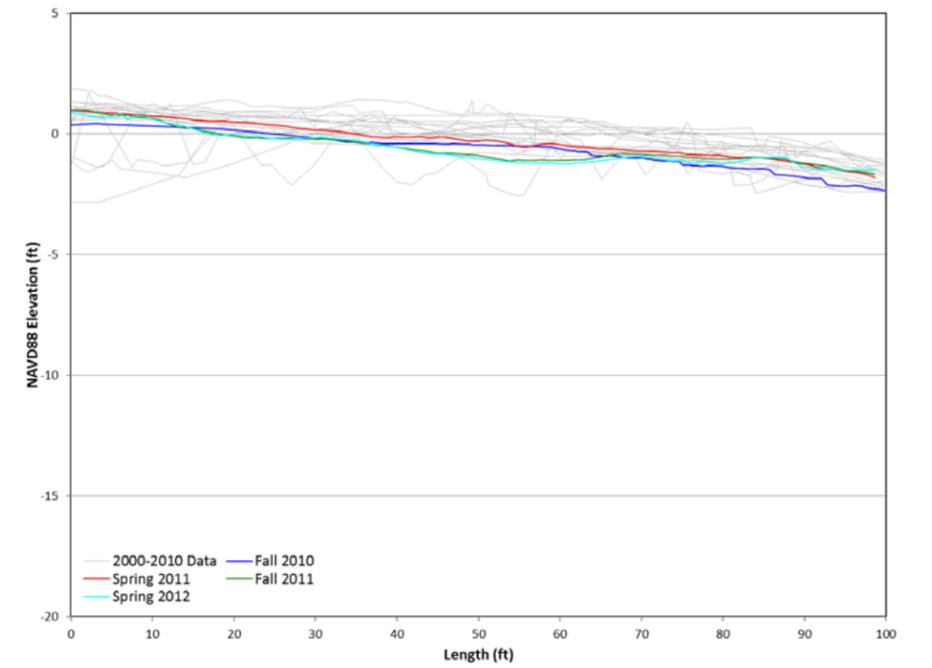
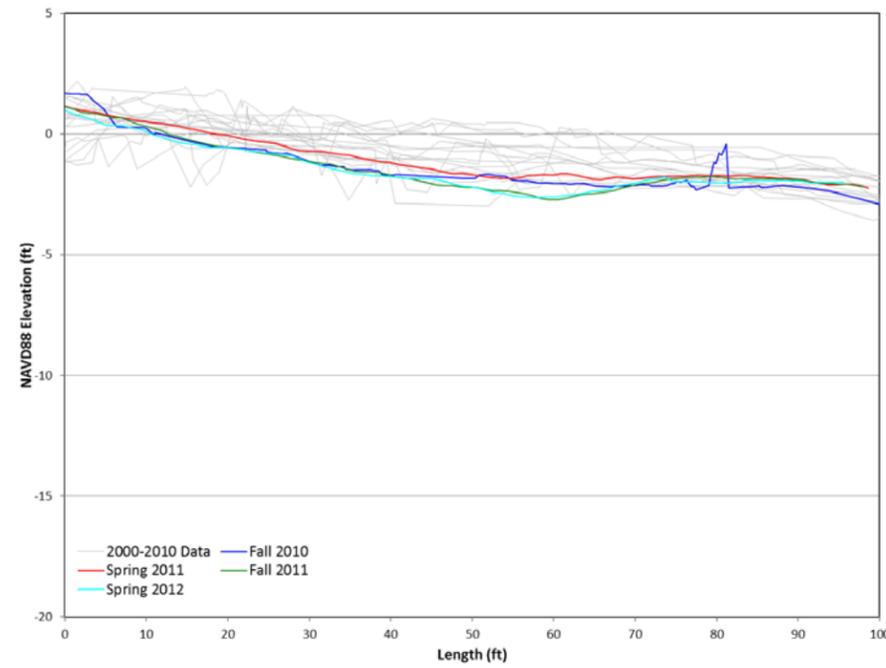
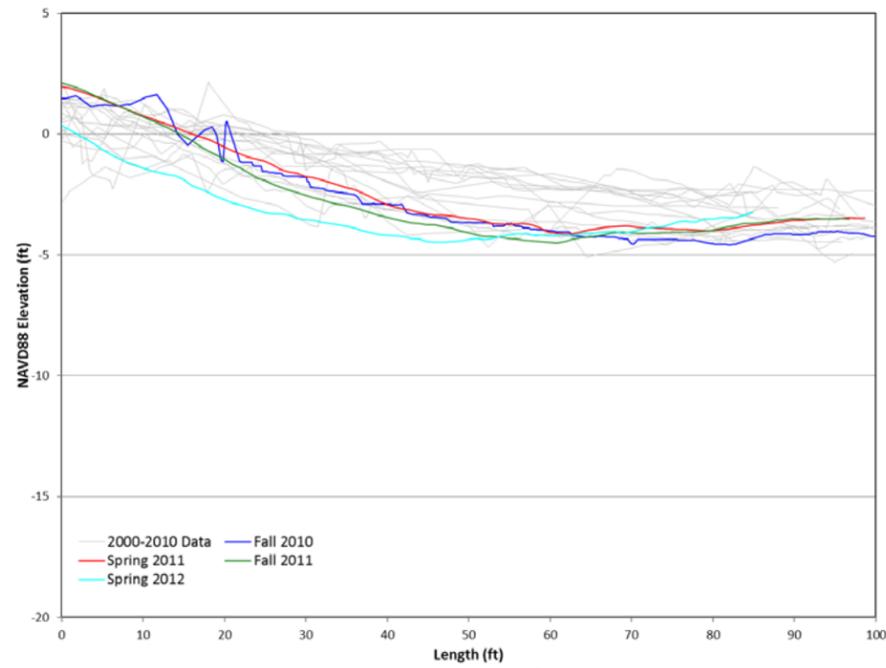
Centerline Profile



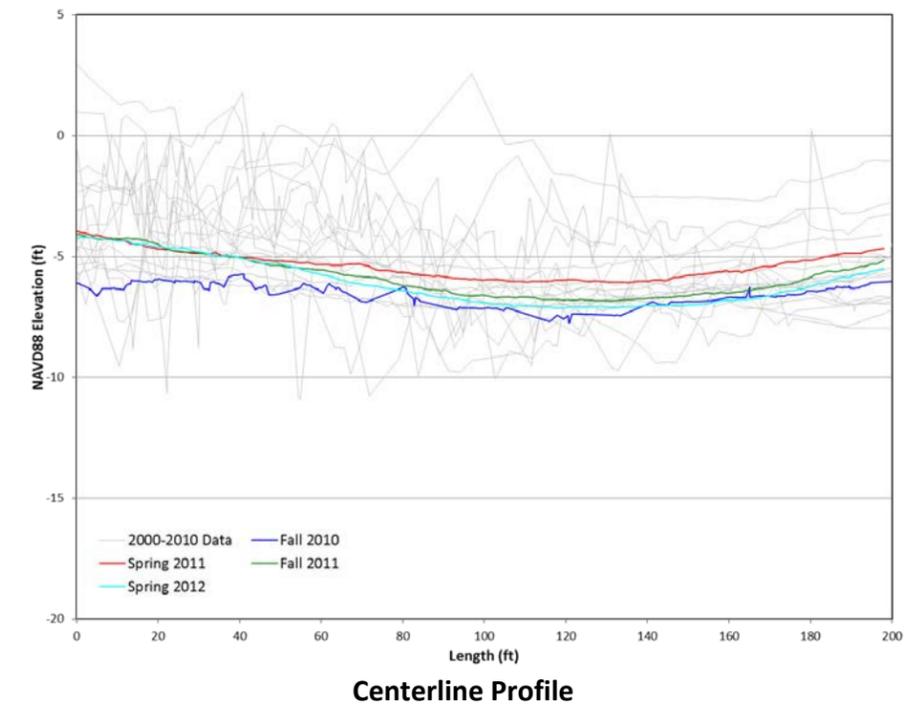
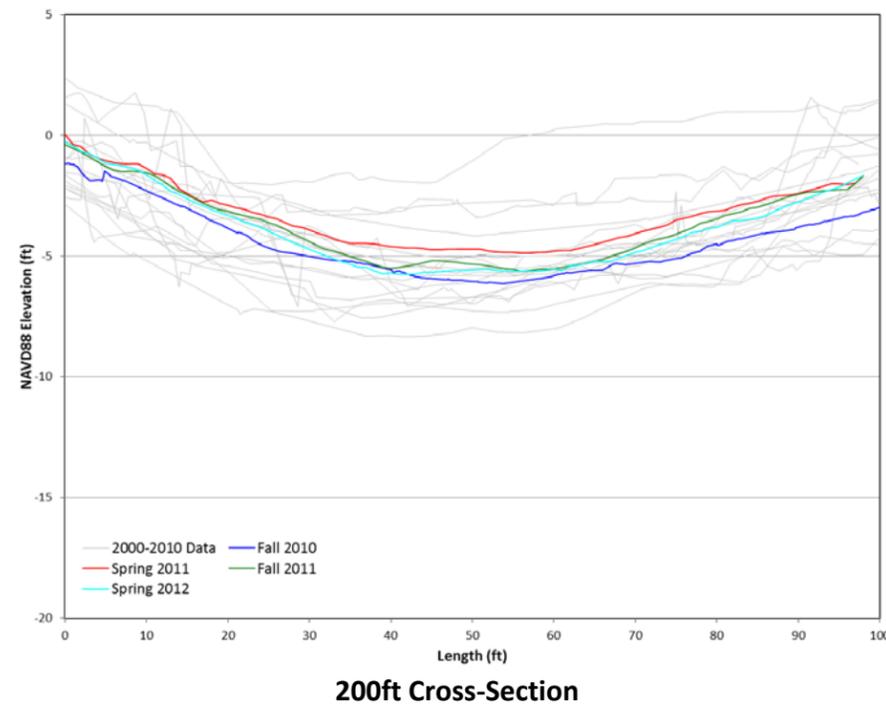
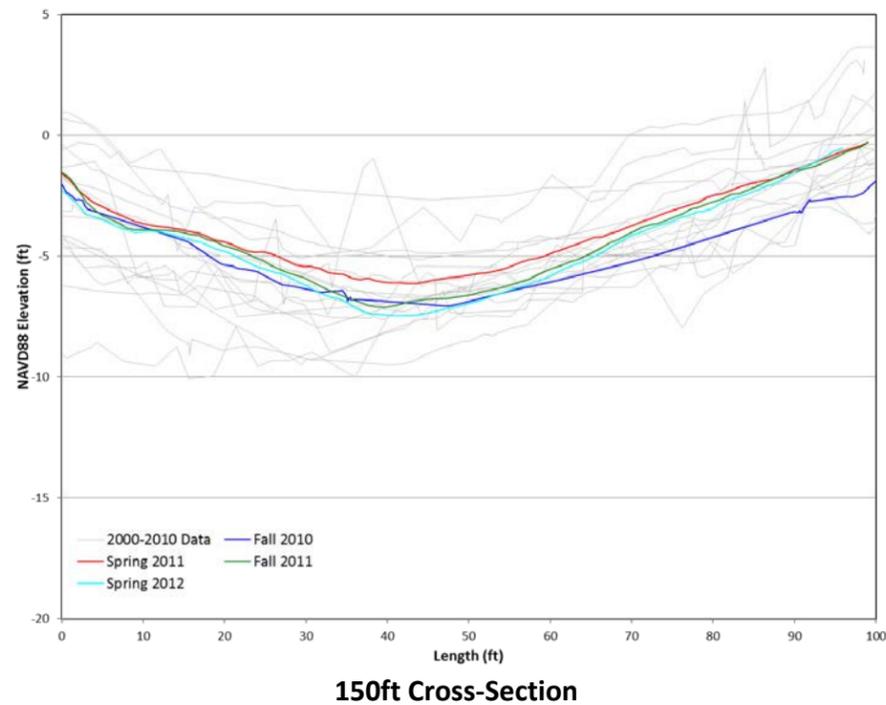
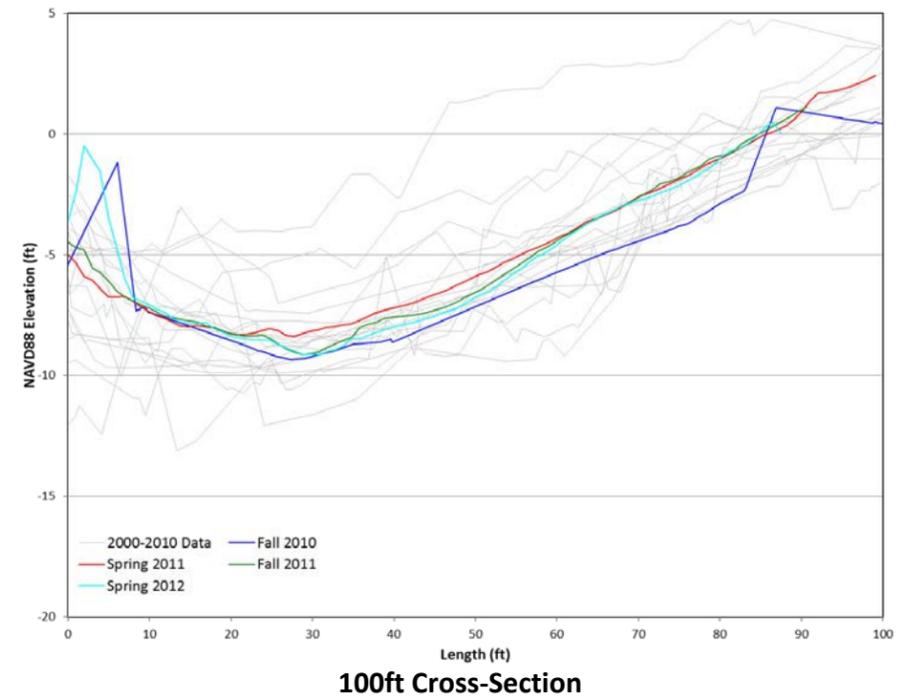
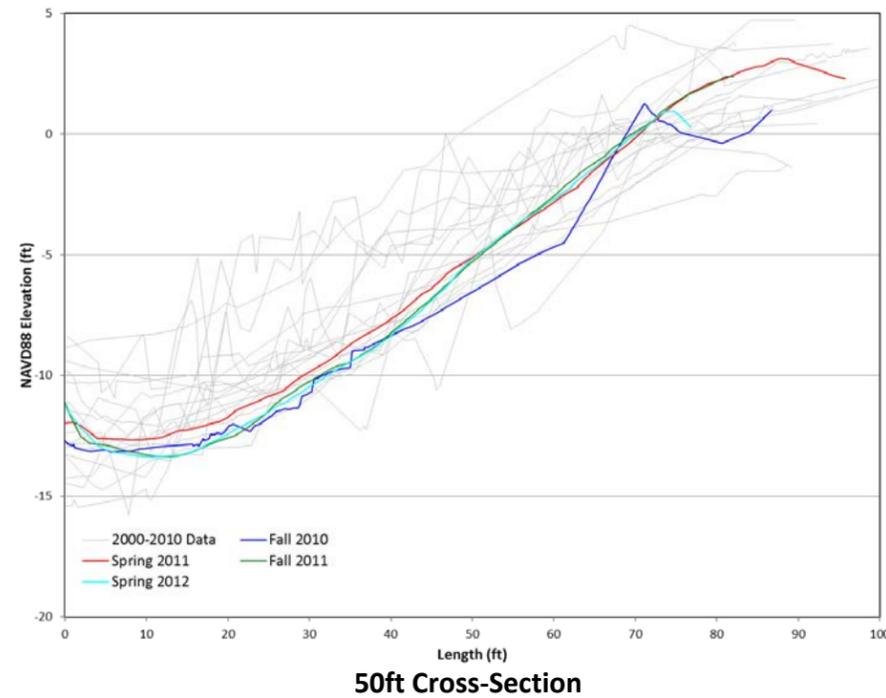
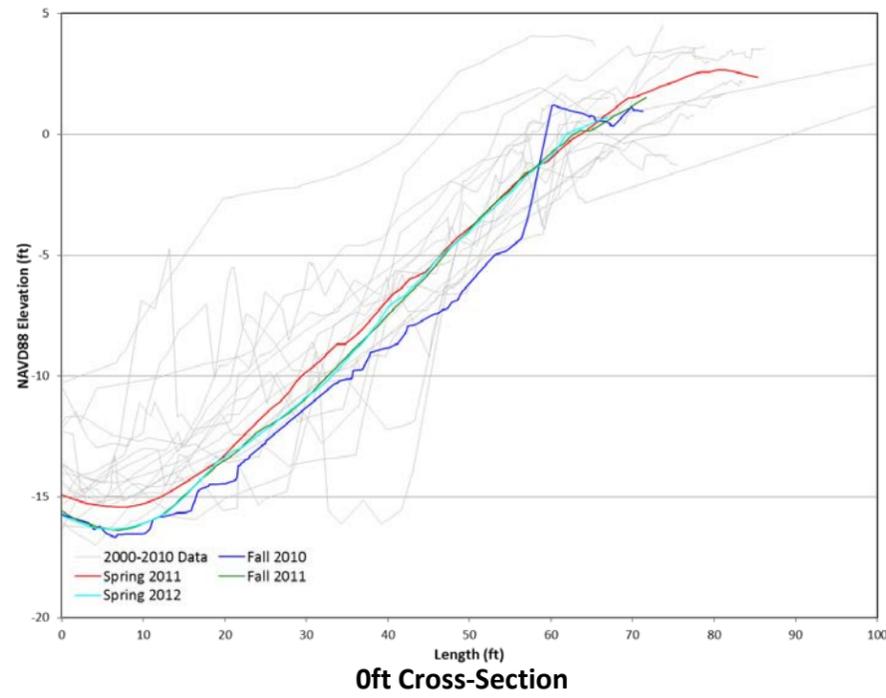
# Appendix C: OR-3 Semi-Annual Cross-Sections



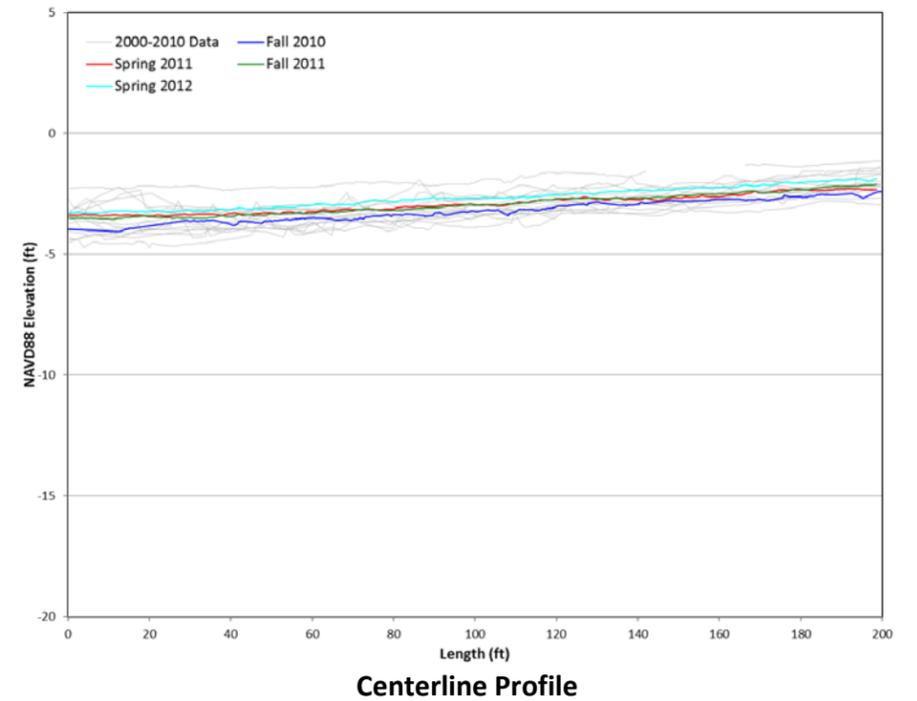
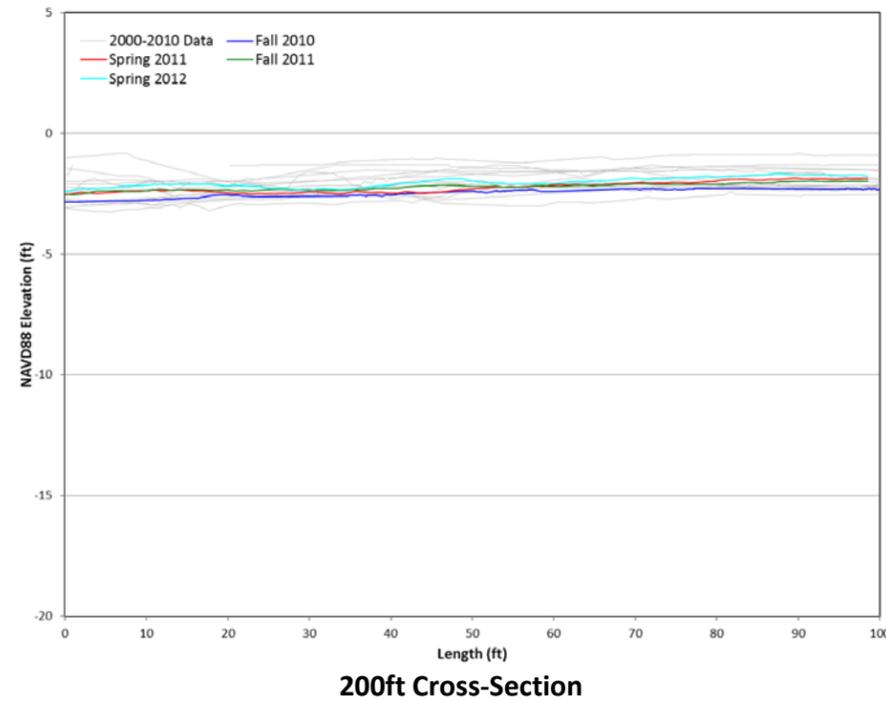
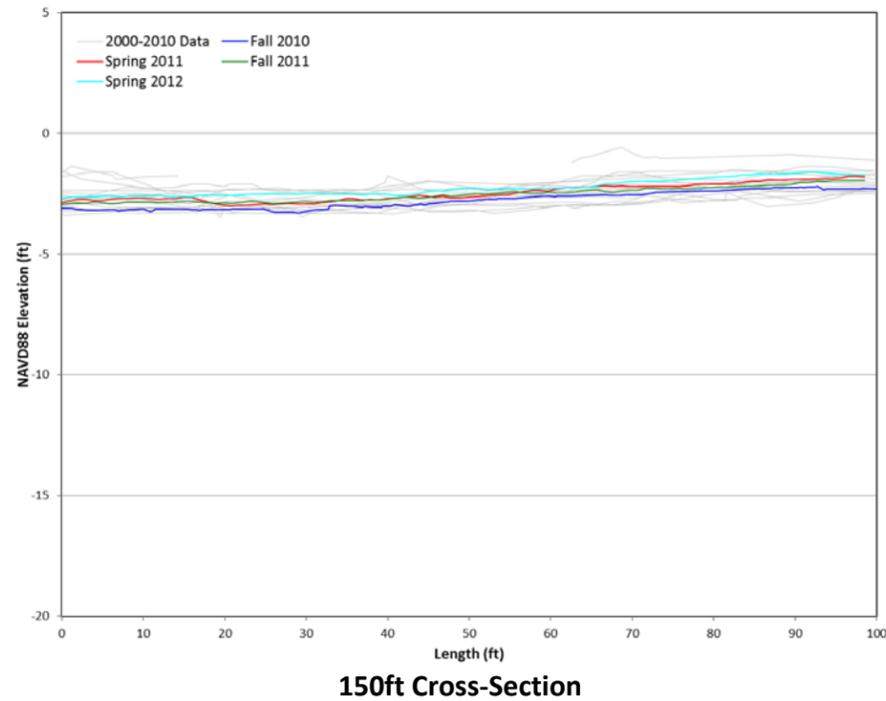
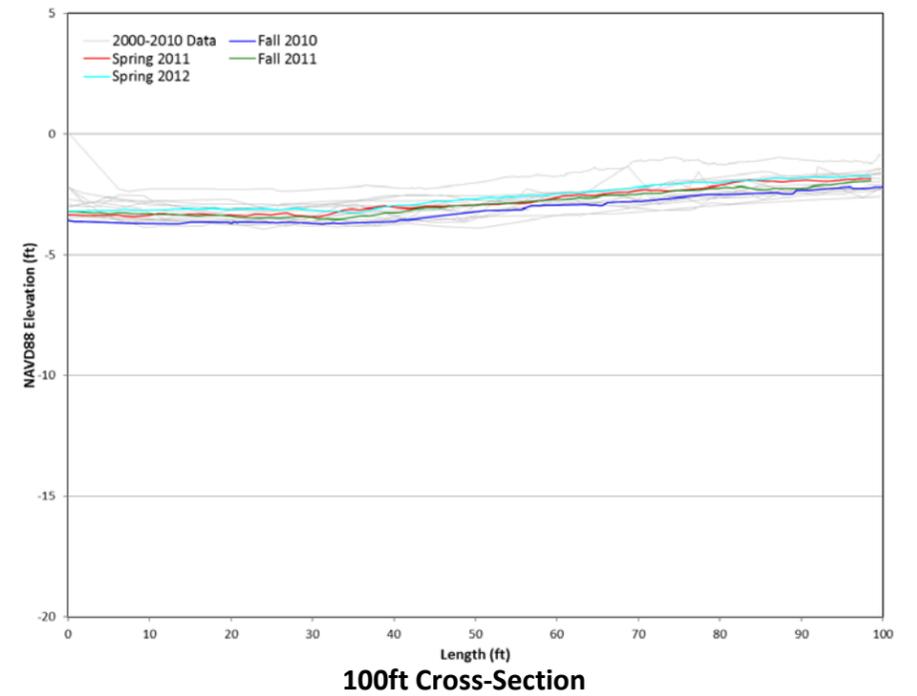
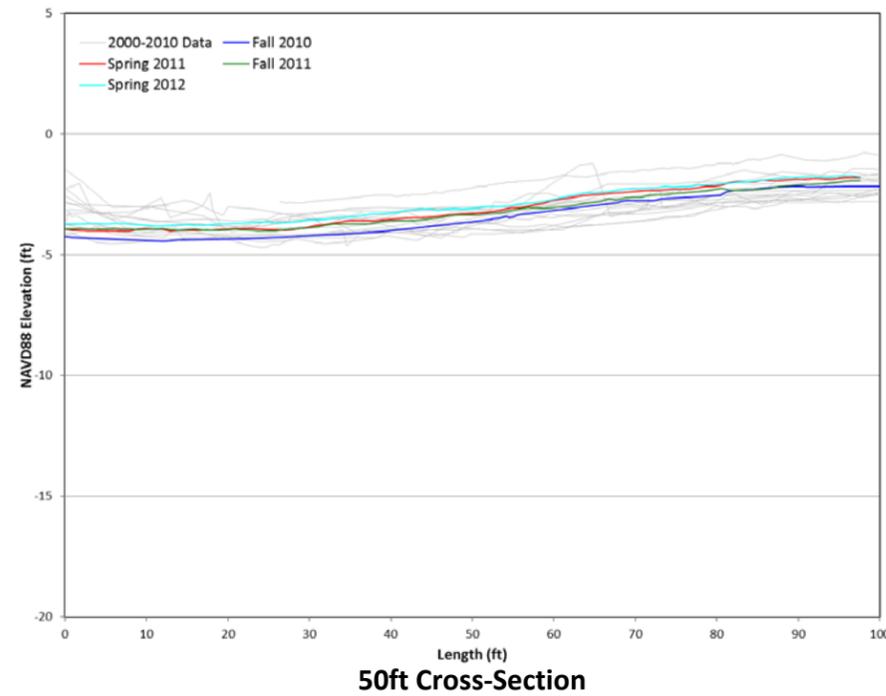
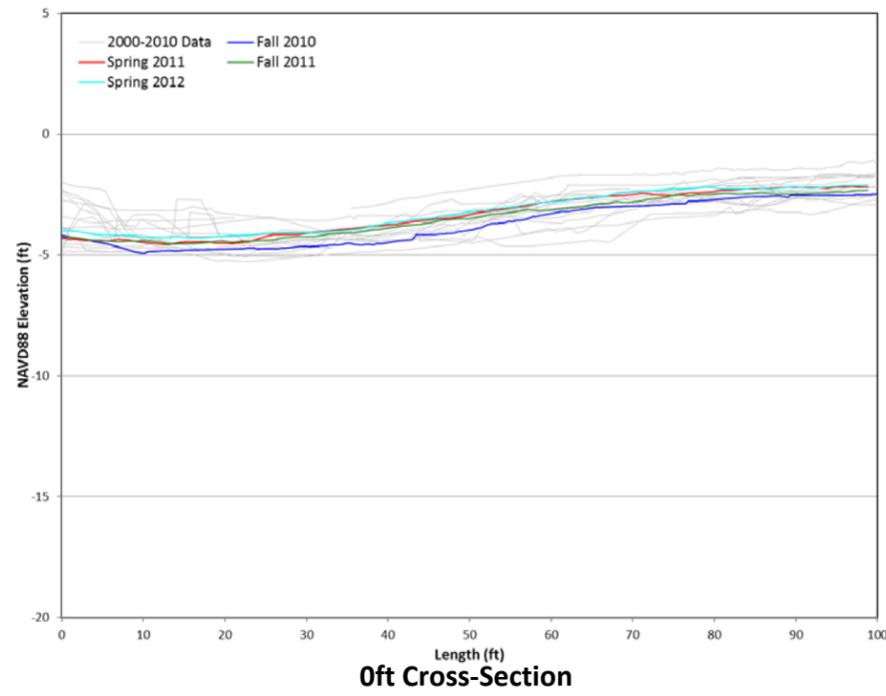
# Appendix D: OR-4 Semi-Annual Cross-Sections



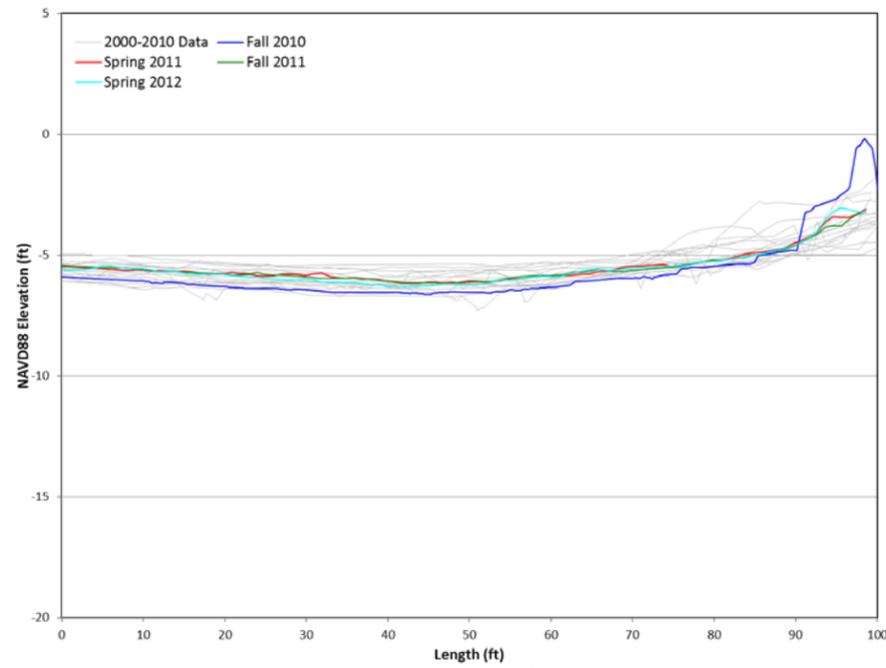
# Appendix E: OR-5 Semi-Annual Cross-Sections



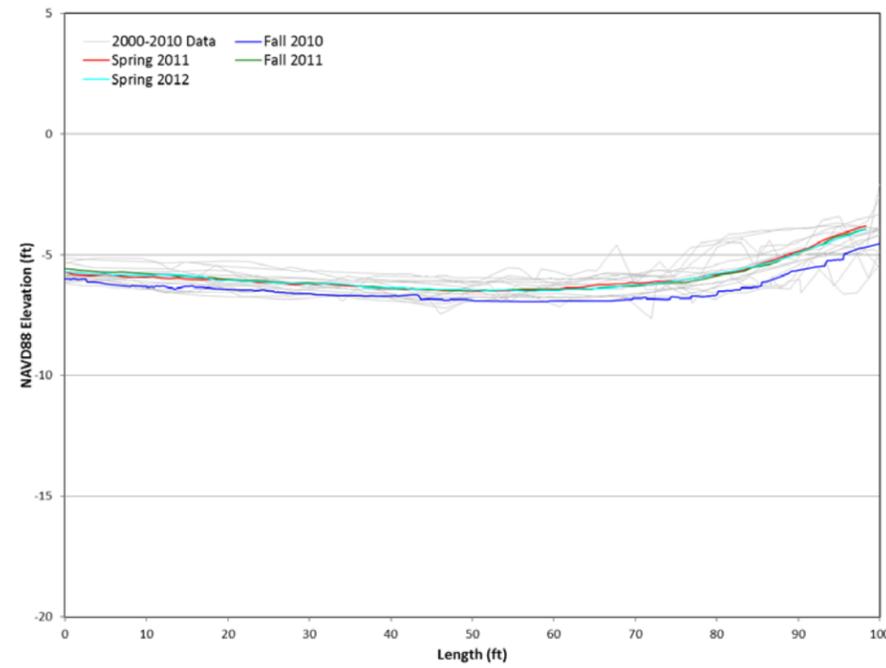
# Appendix F: OR-6 Semi-Annual Cross-Sections



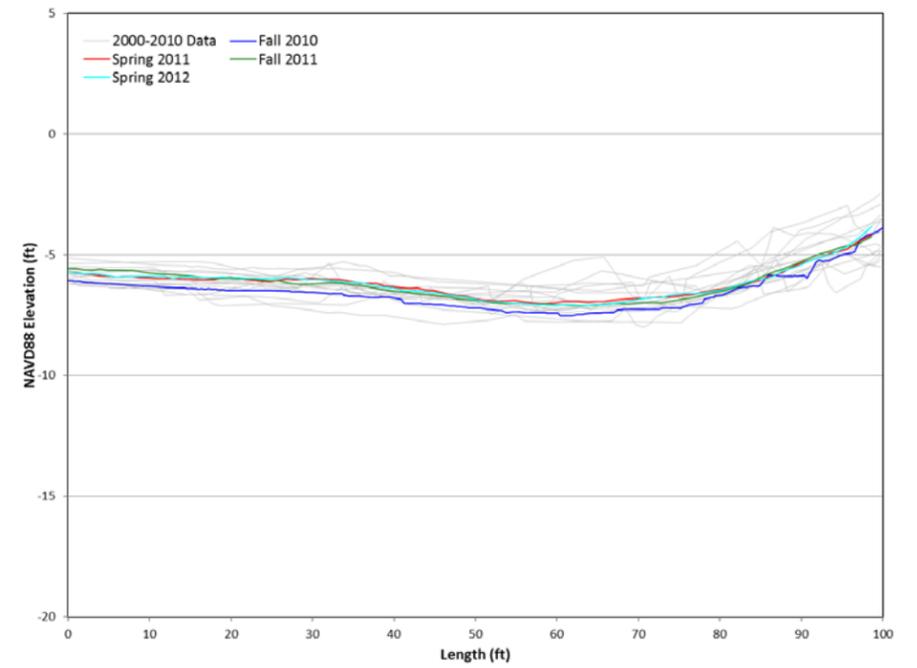
# Appendix G: OR-7 Semi-Annual Cross-Sections



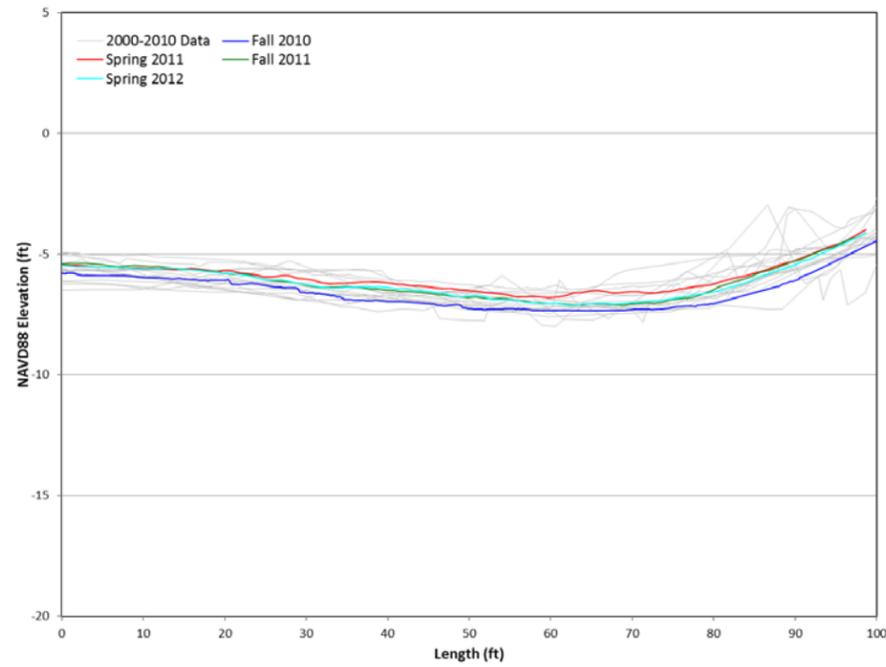
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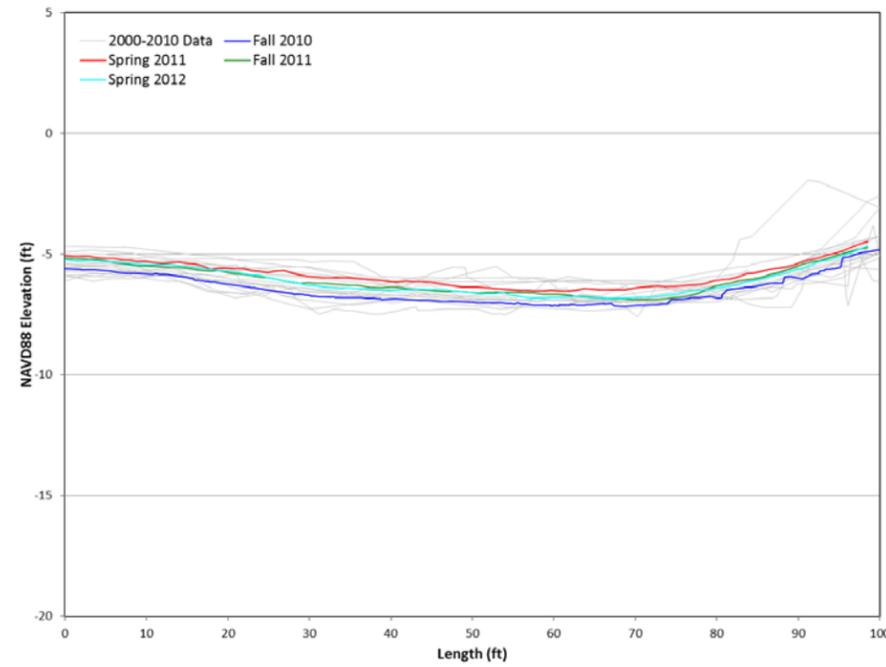
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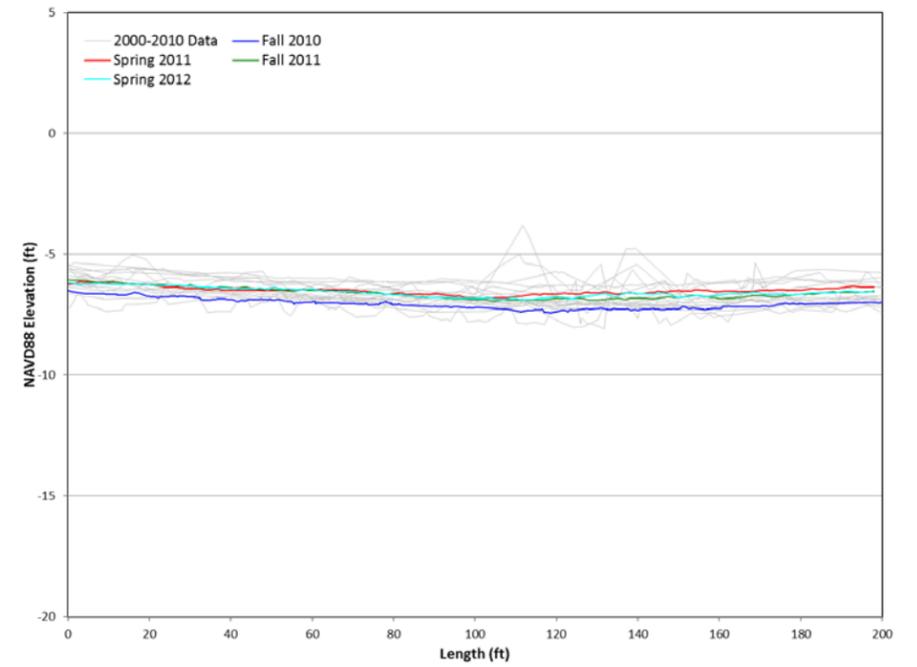
**100ft Cross-Section**



**150ft Cross-Section**



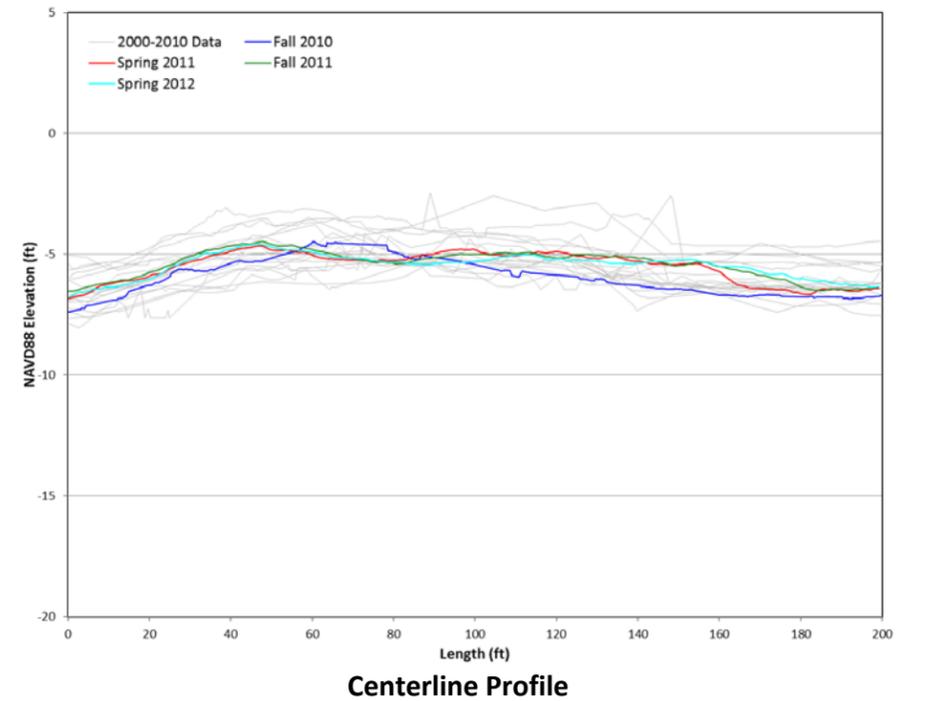
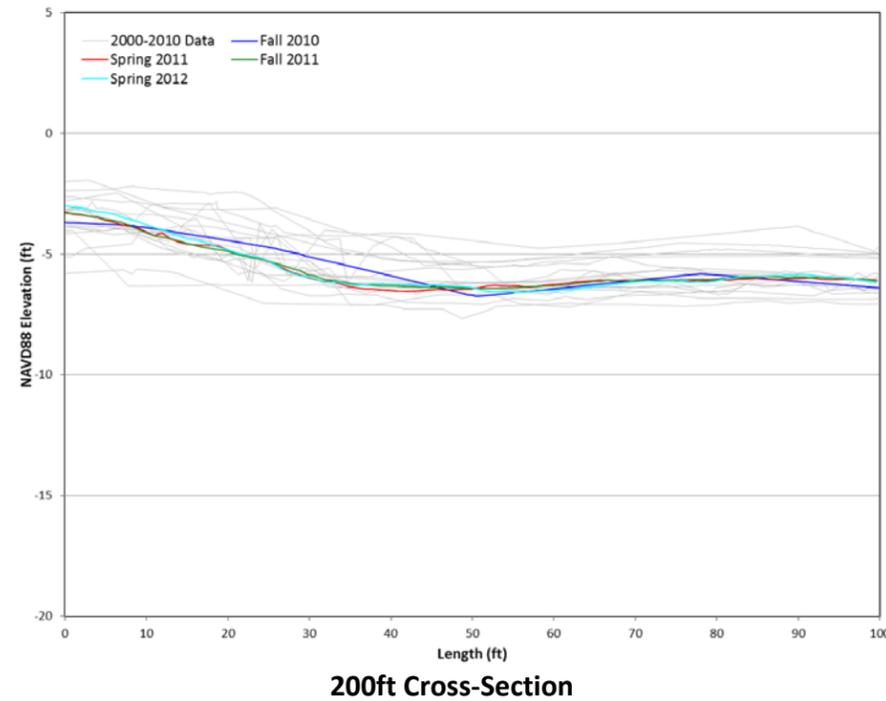
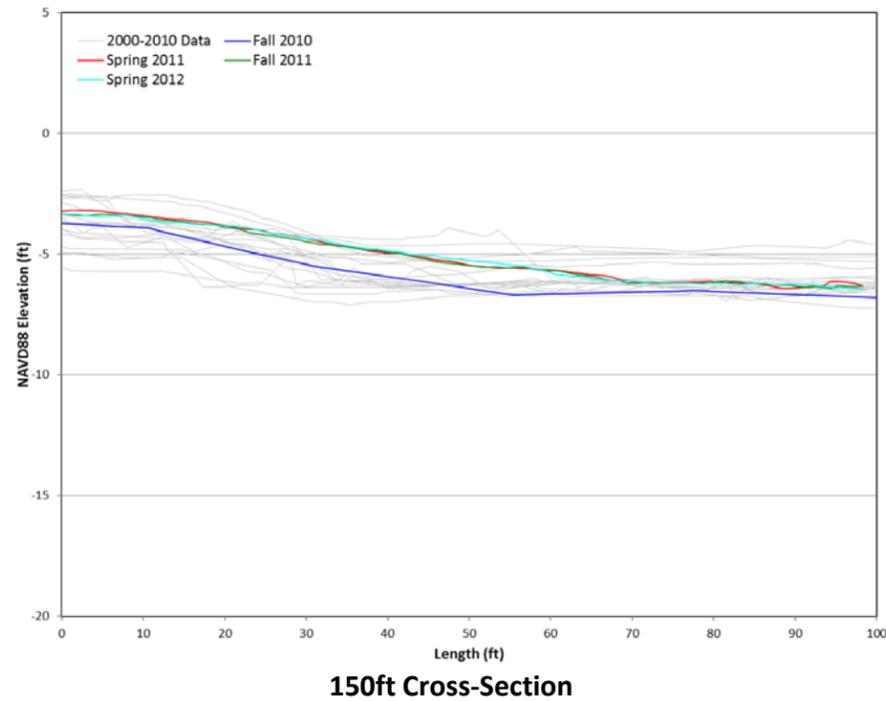
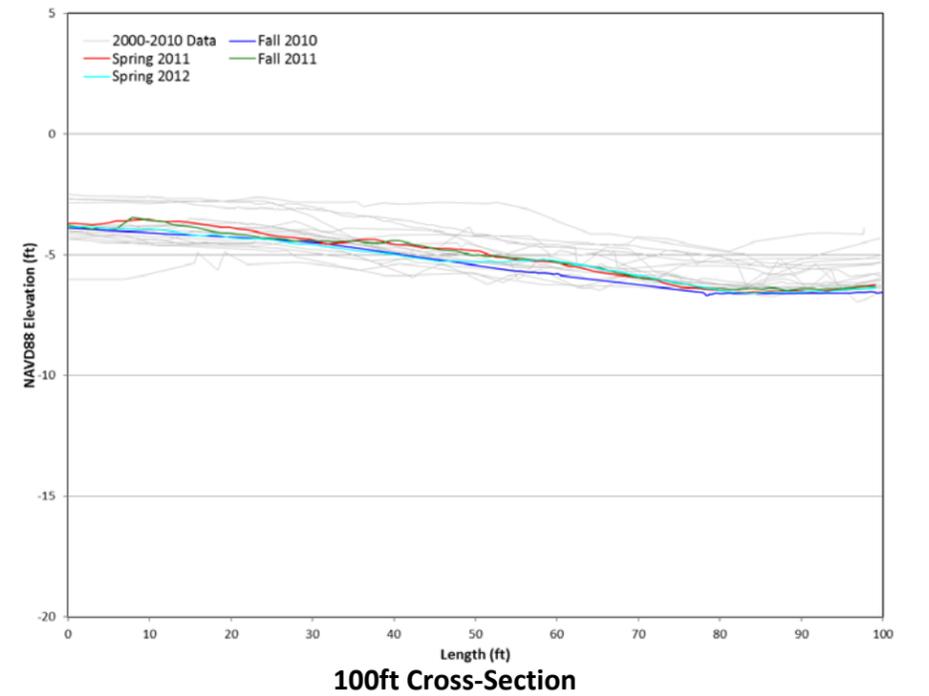
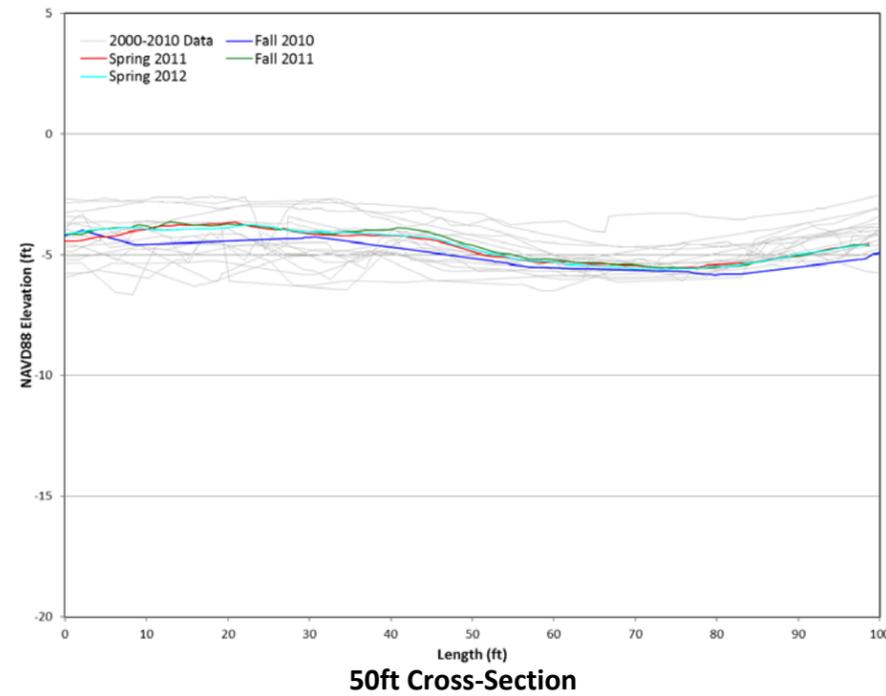
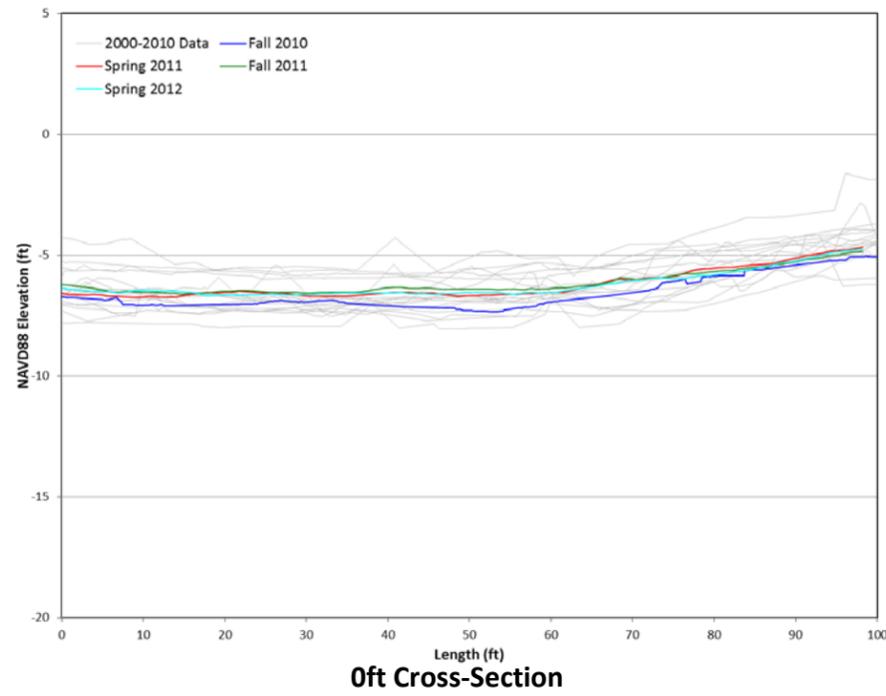
**200ft Cross-Section**



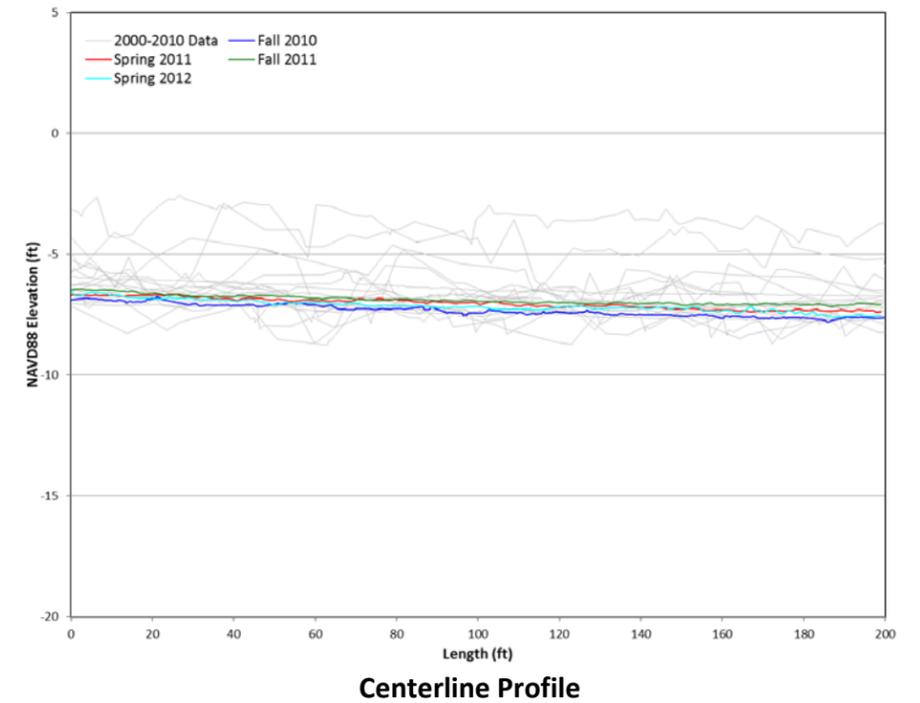
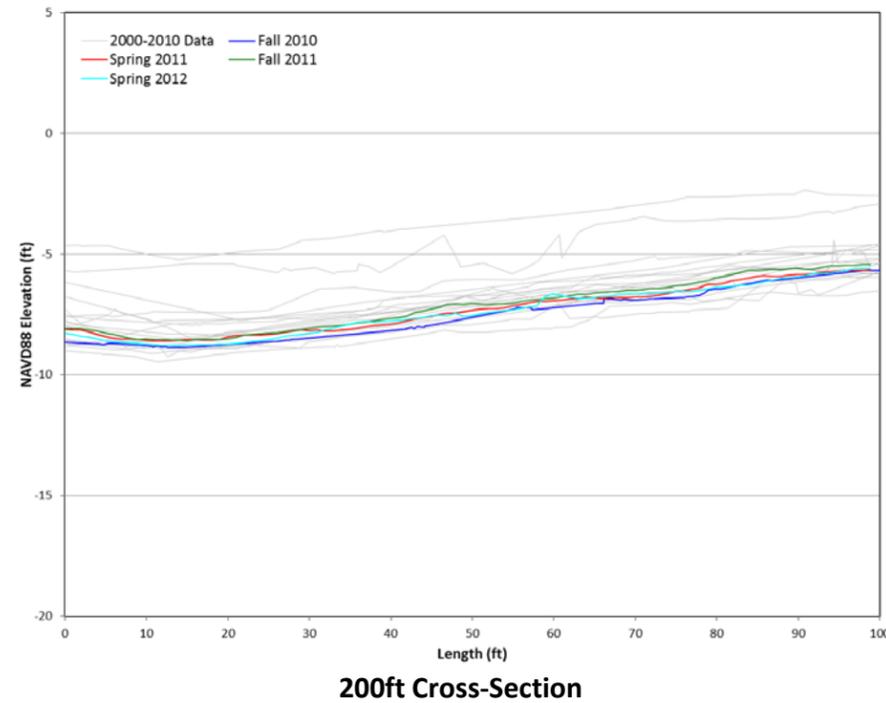
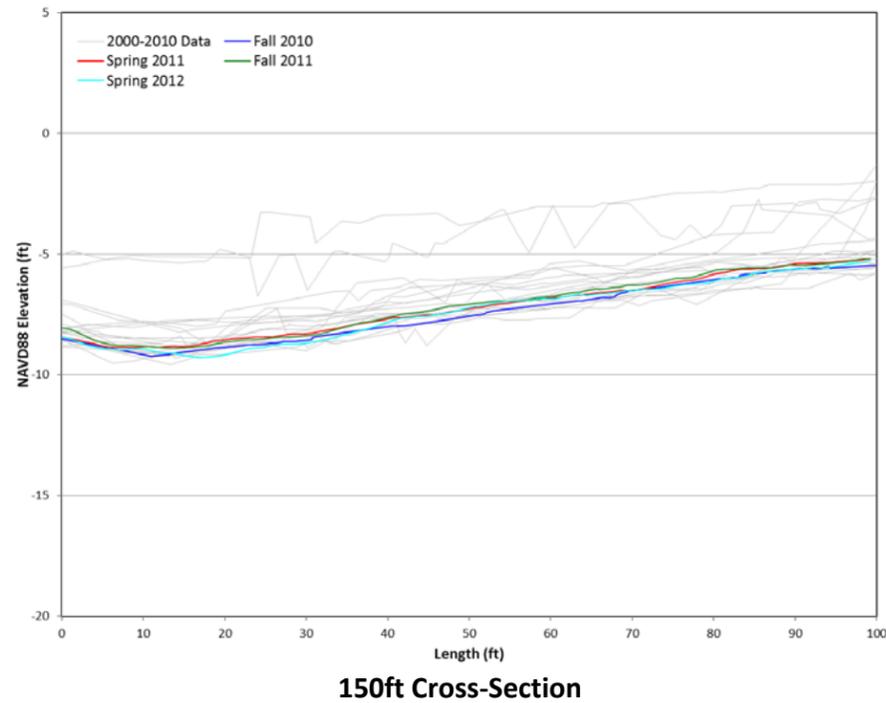
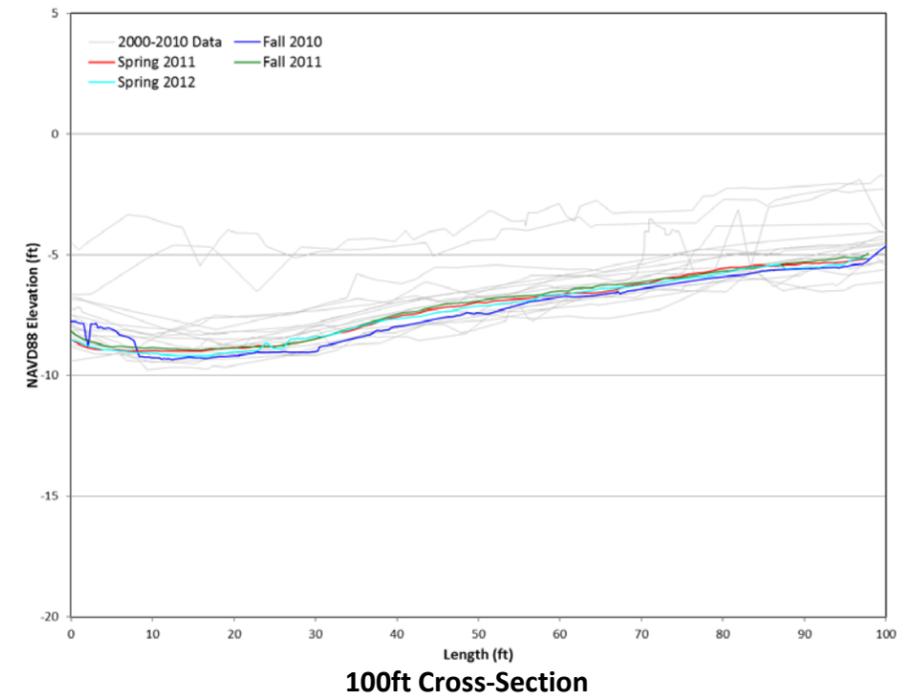
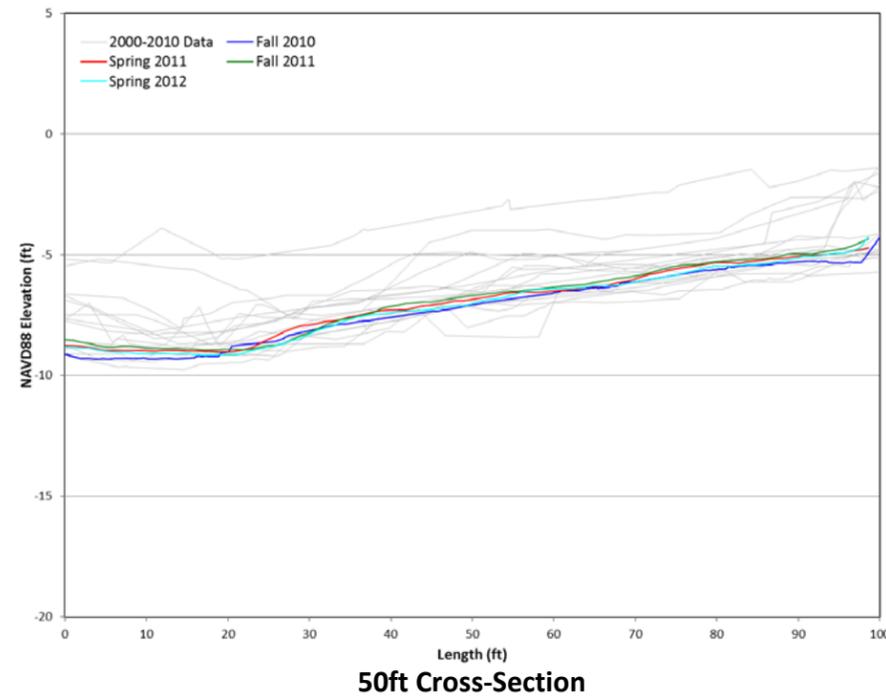
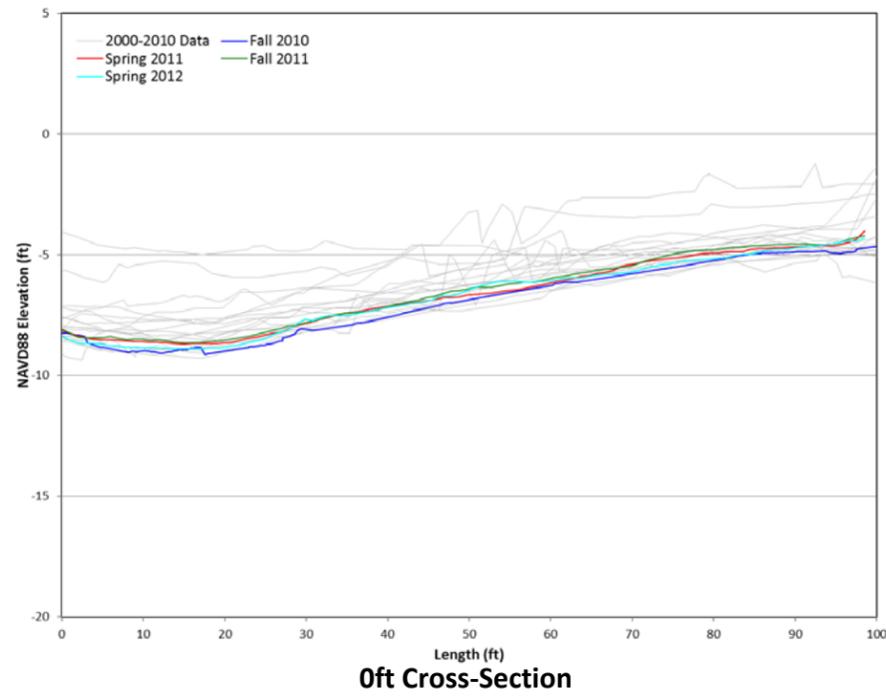
**Centerline Profile**



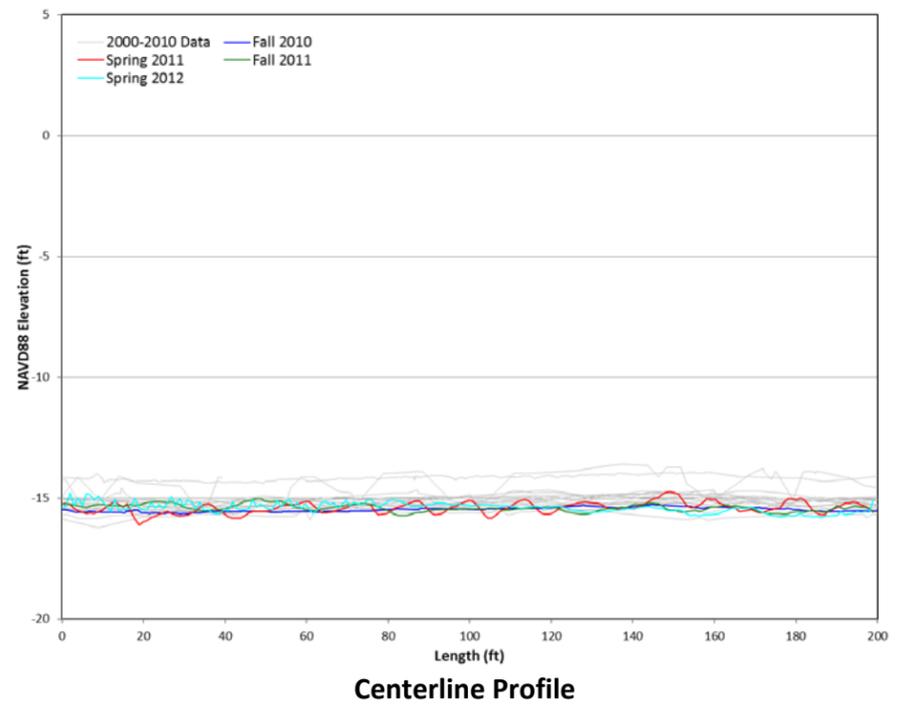
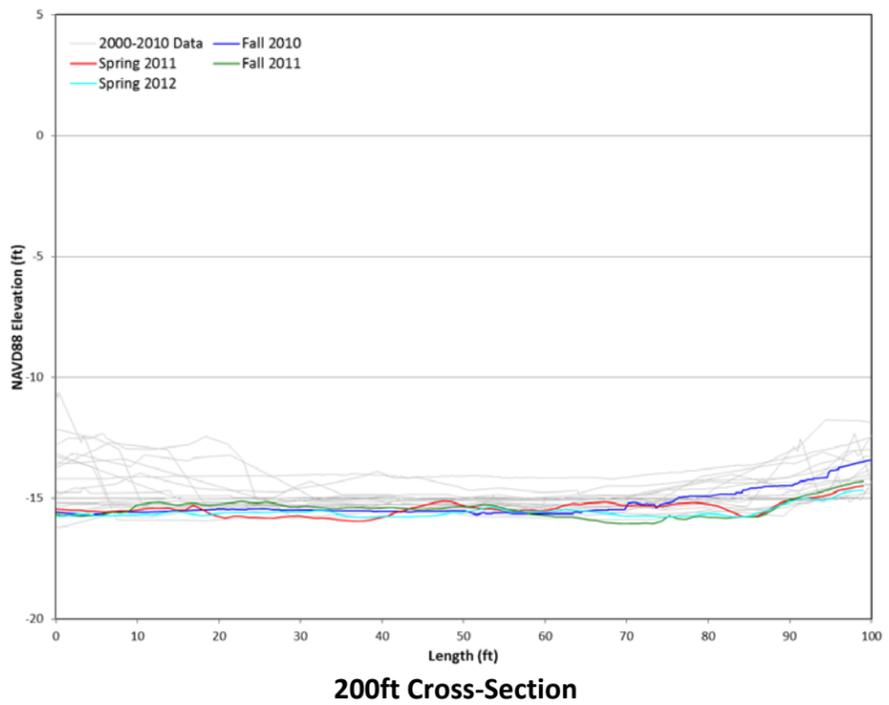
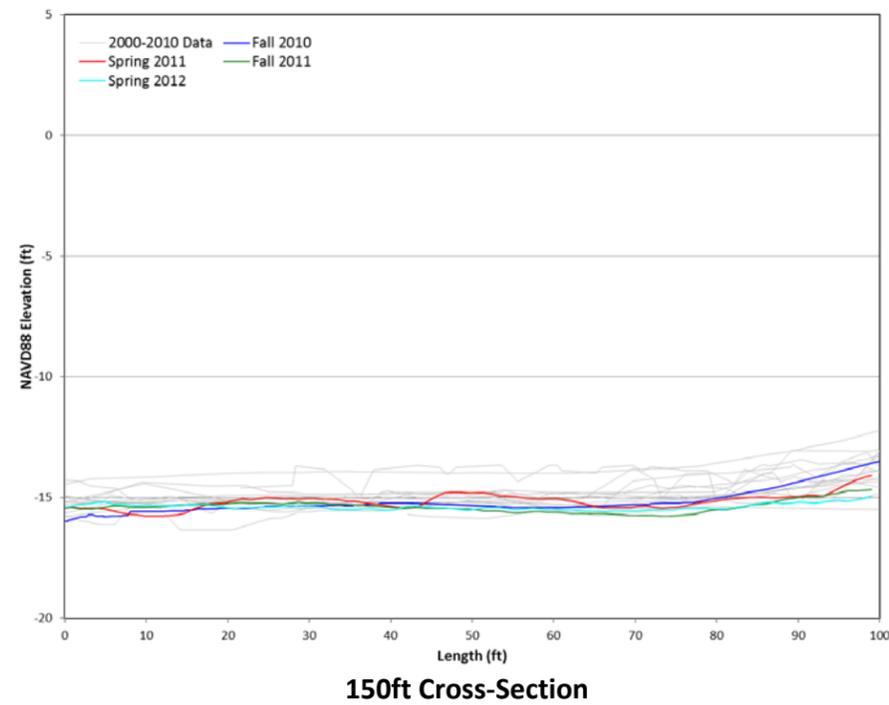
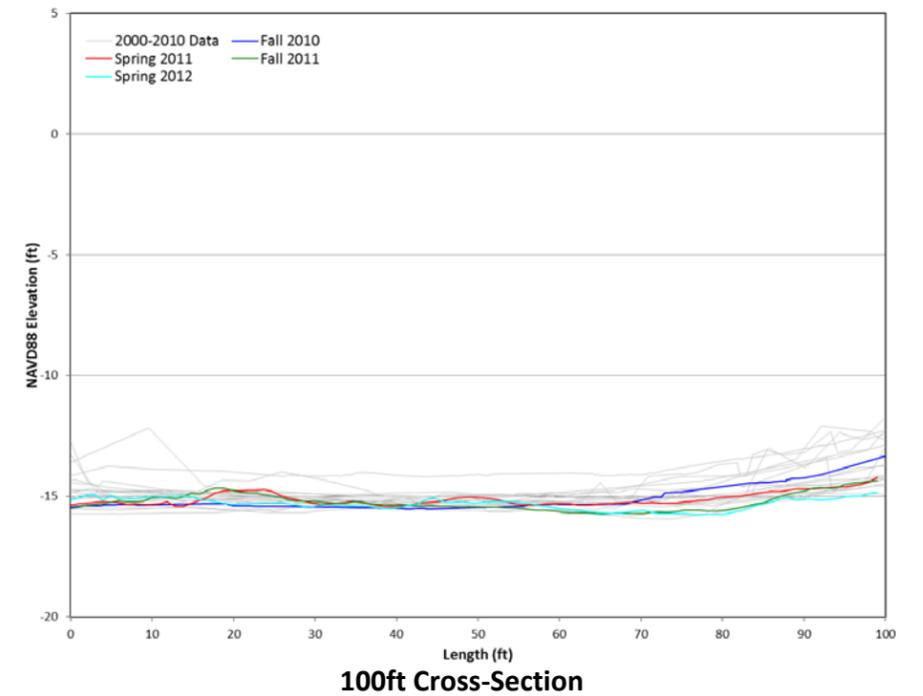
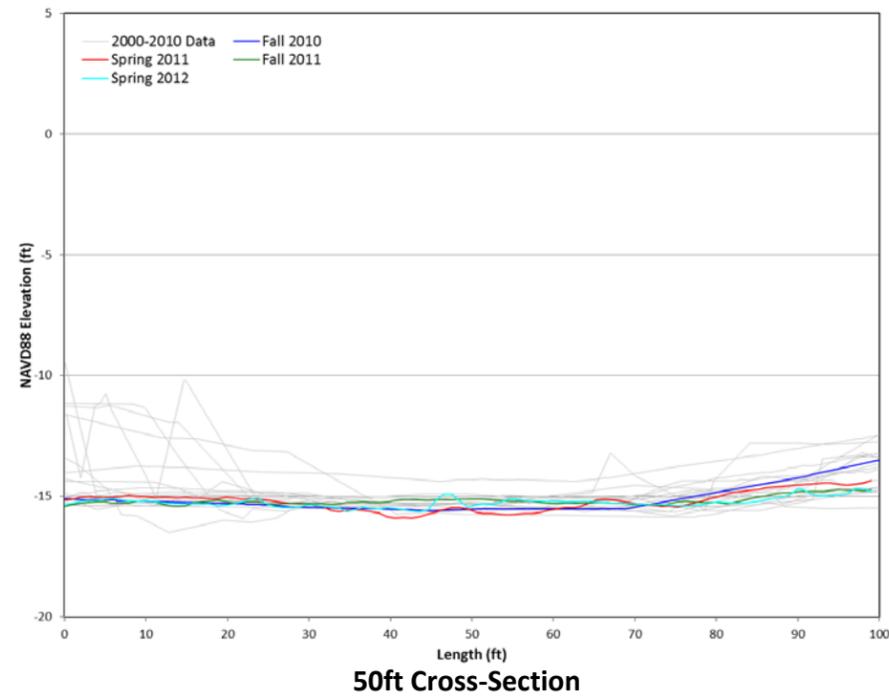
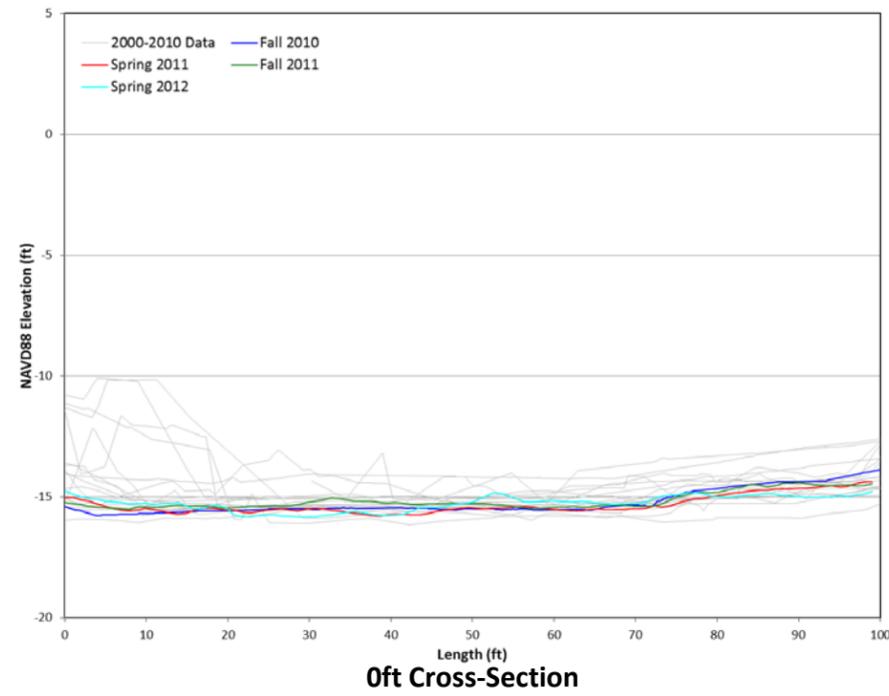
# Appendix H: OR-8 Semi-Annual Cross-Sections



# Appendix I: OR-9 Semi-Annual Cross-Sections



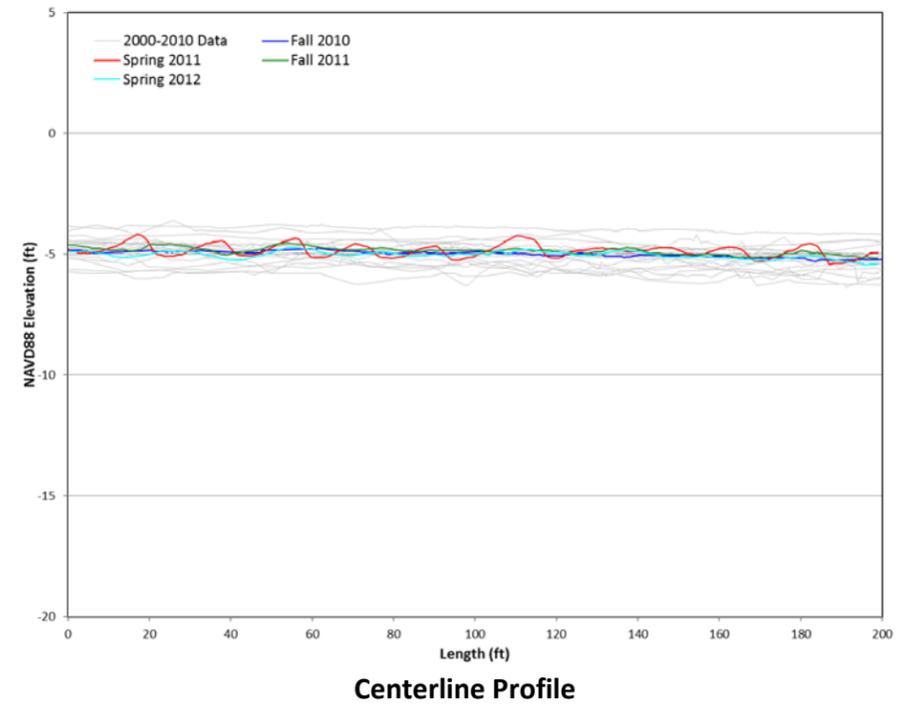
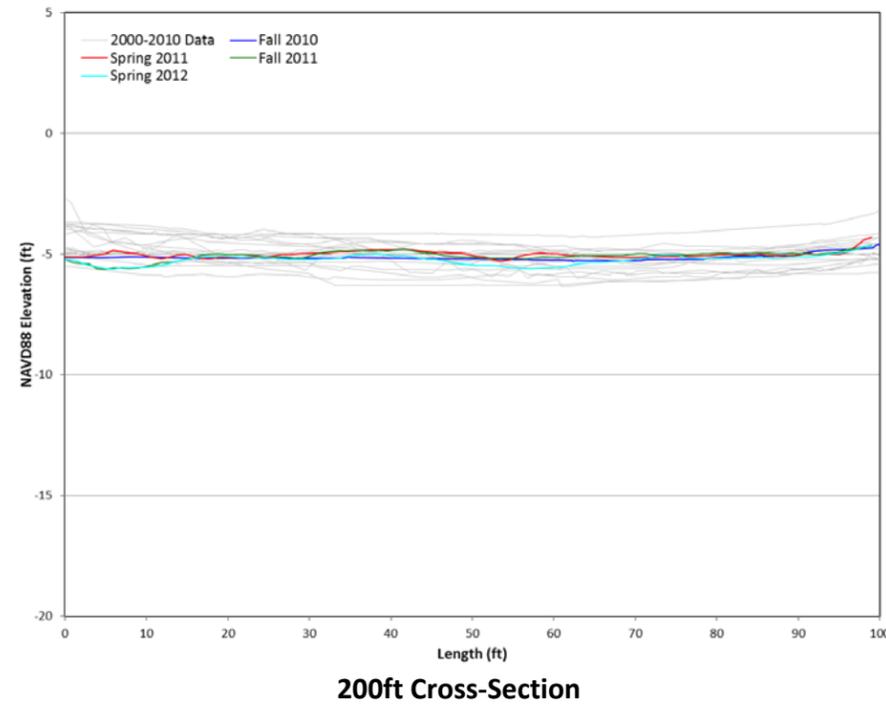
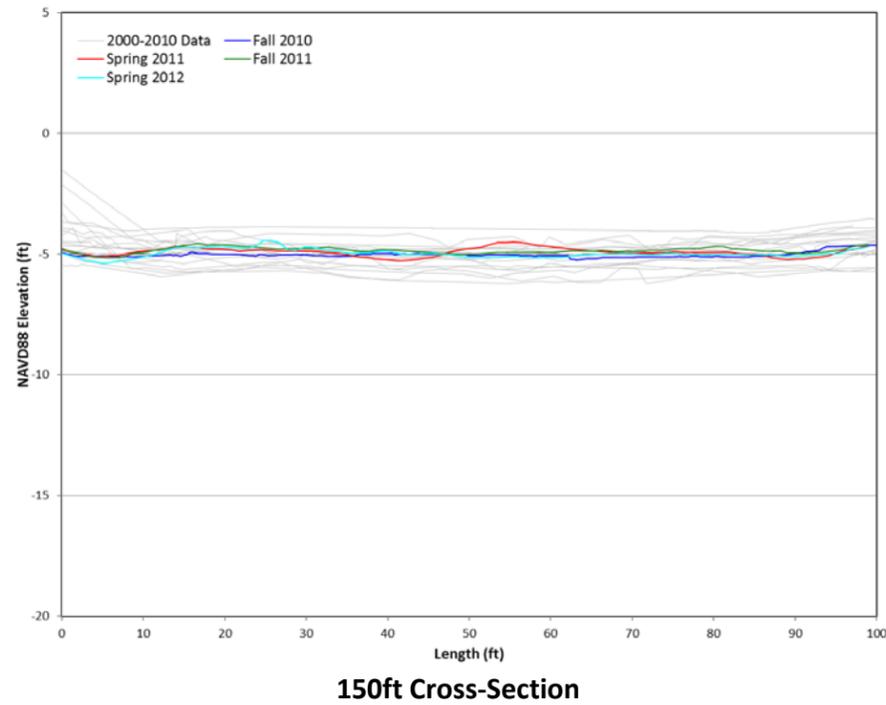
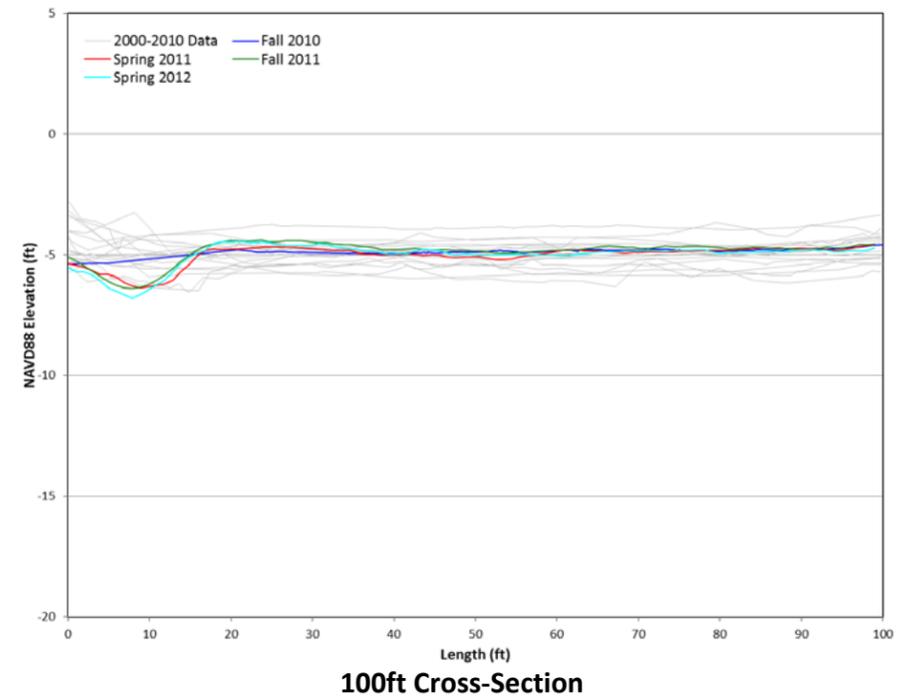
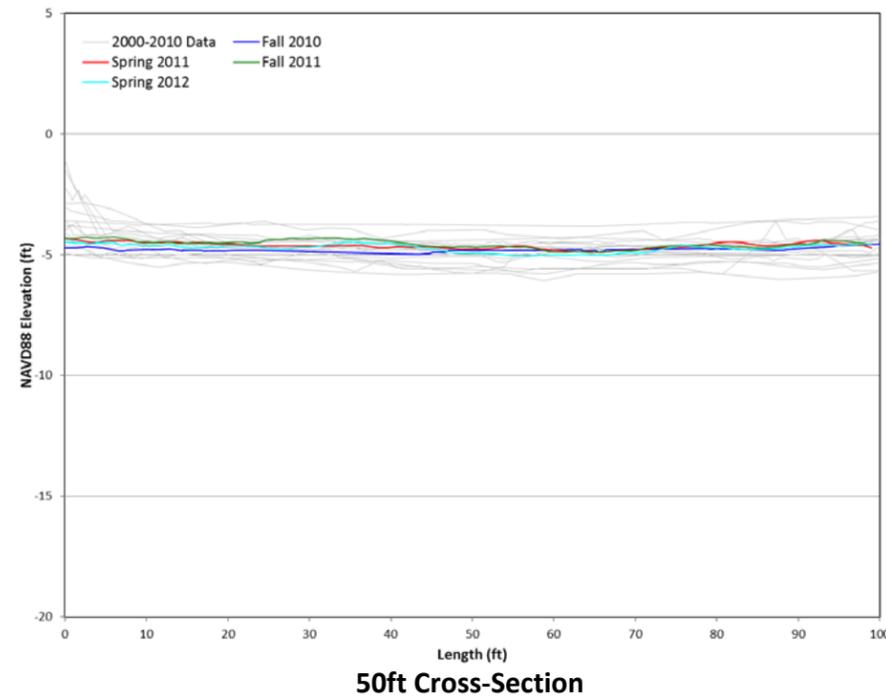
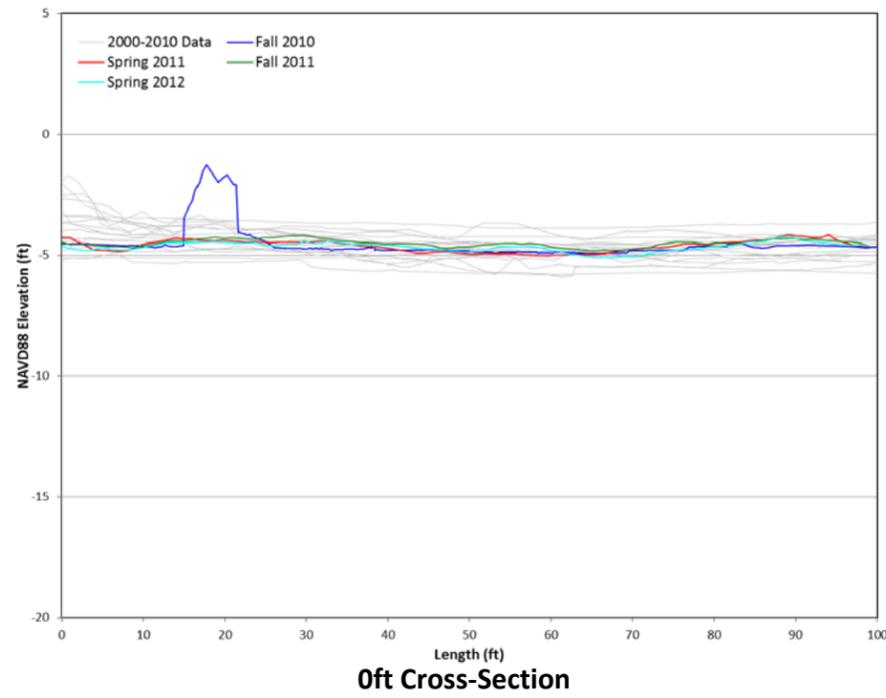
# Appendix J: GLC-1A Semi-Annual Cross-Sections



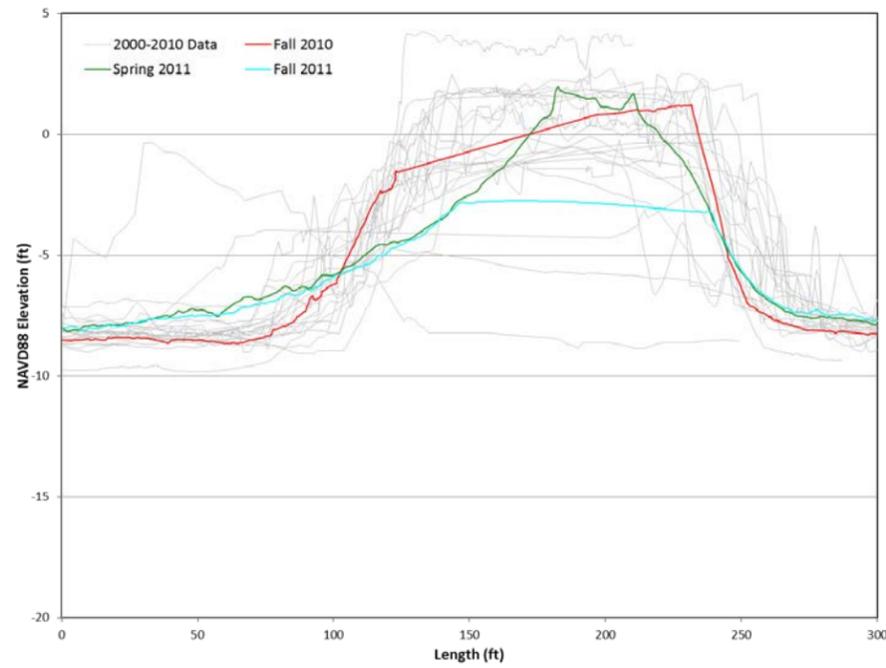
X



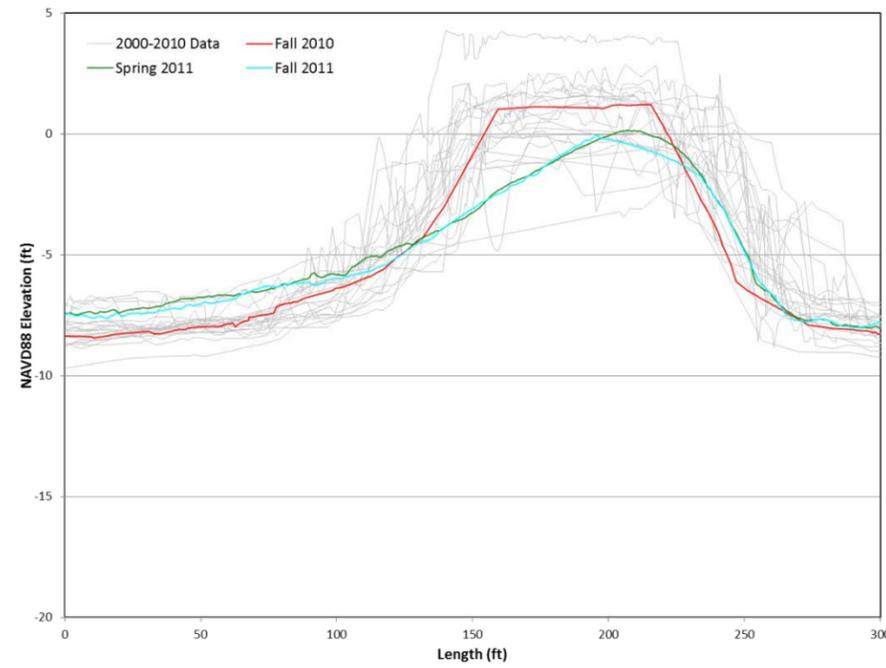
# Appendix K: GLC-1B Semi-Annual Cross-Sections



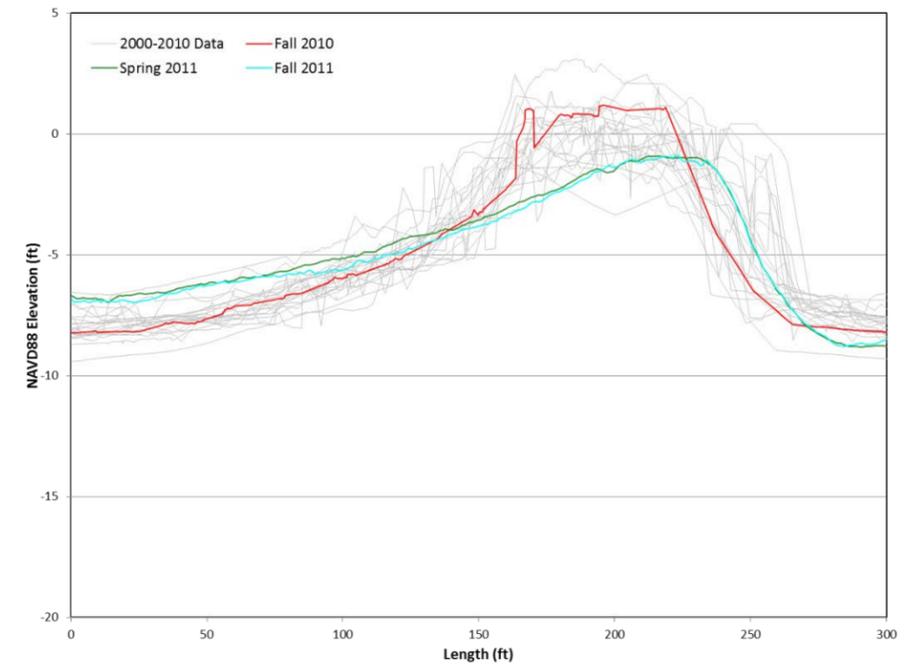
# Appendix L: GLC-2 Semi-Annual Cross-Sections



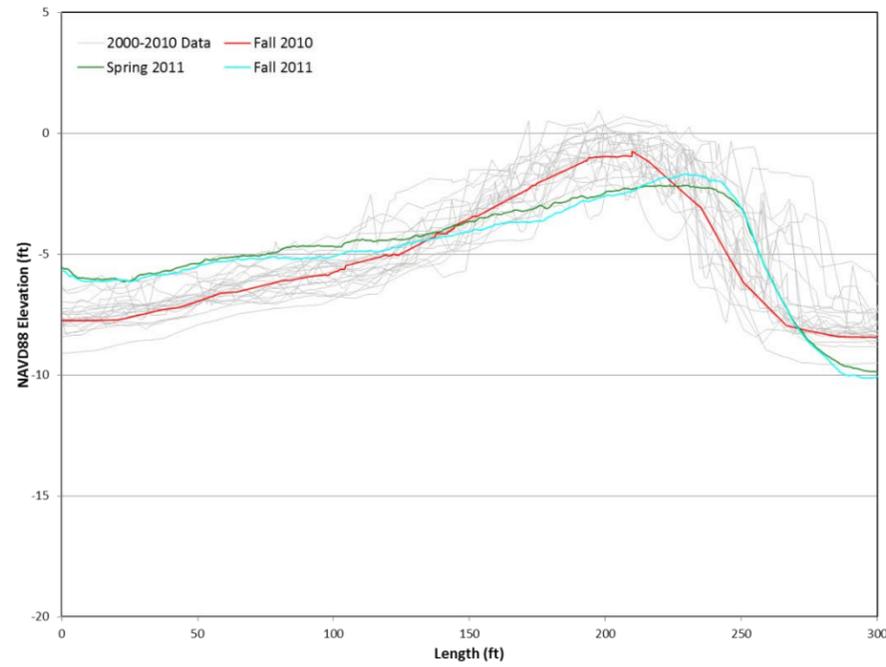
**0ft Cross-Section**



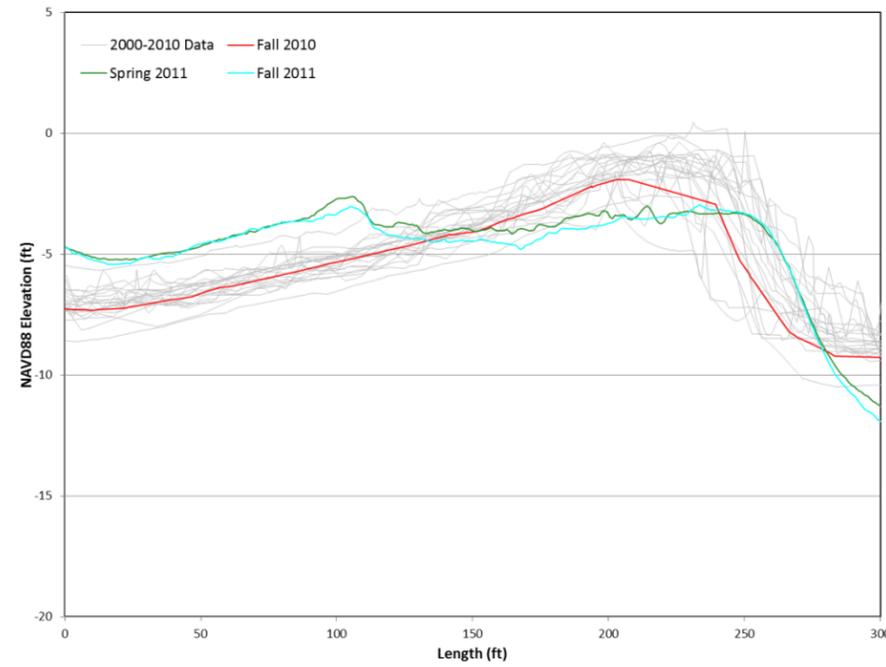
**50ft Cross-Section**



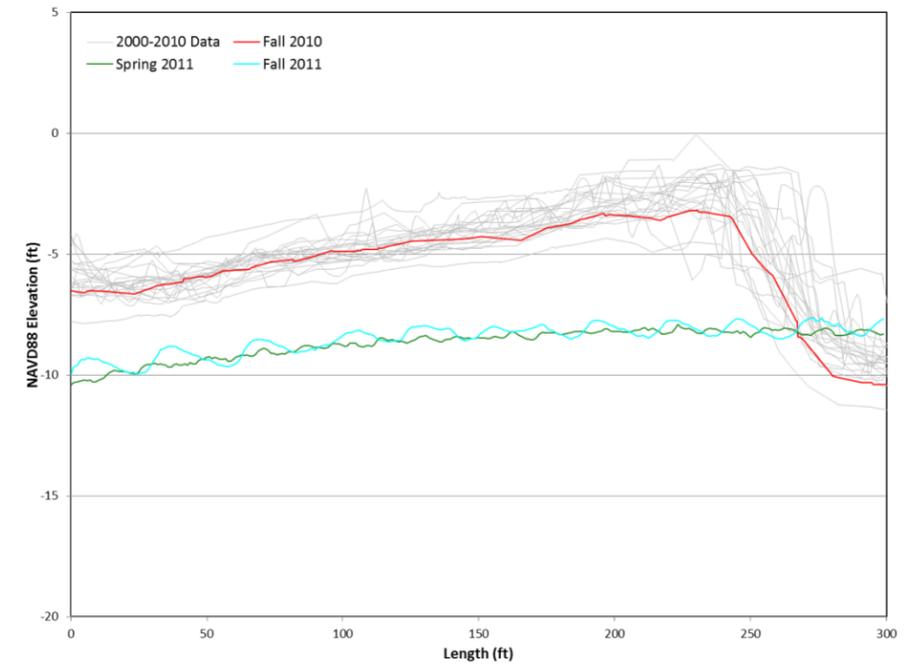
**100ft Cross-Section**



**150ft Cross-Section**

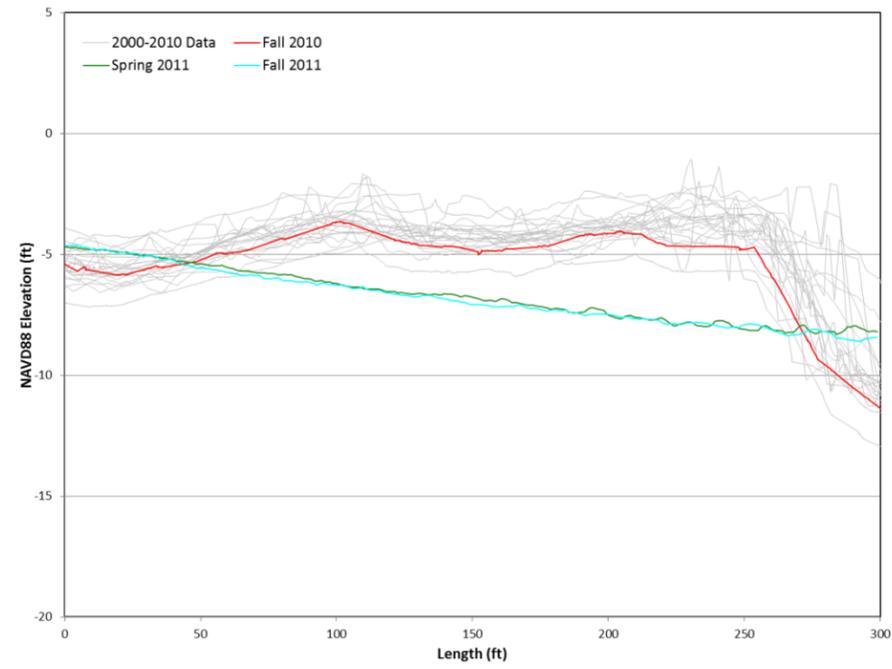


**200ft Cross-Section**

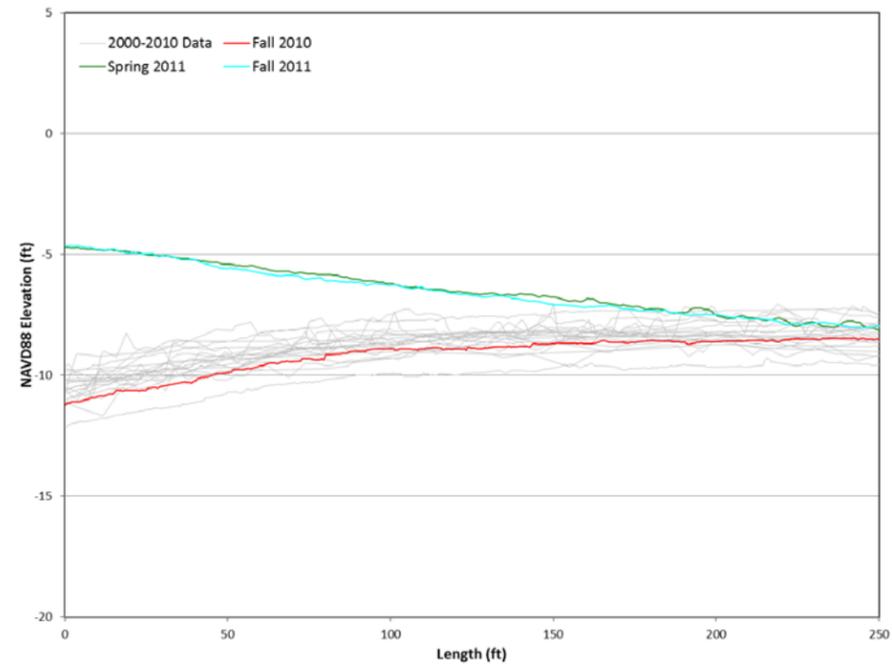


**250ft Cross-Section**





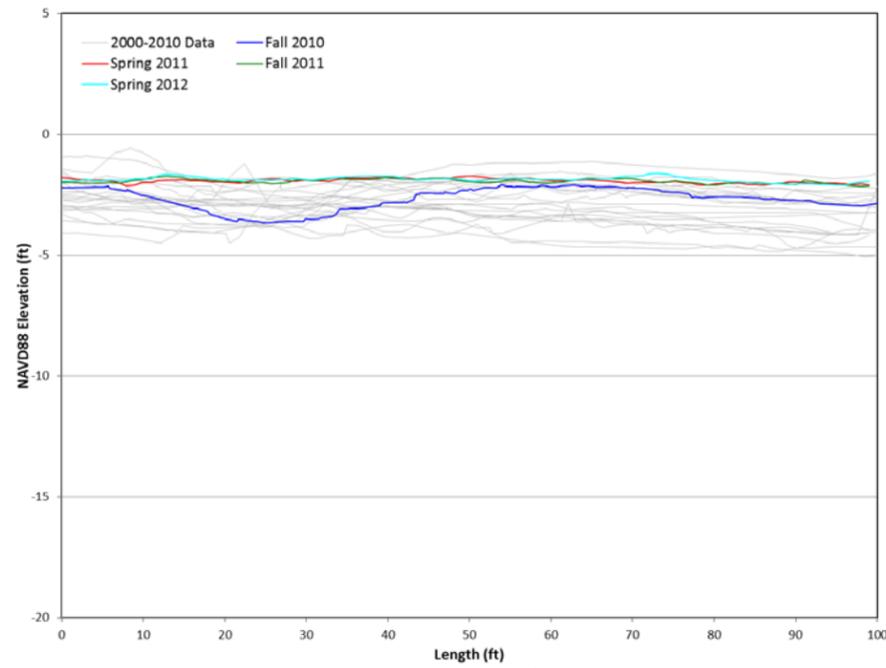
**300ft Cross-Section**



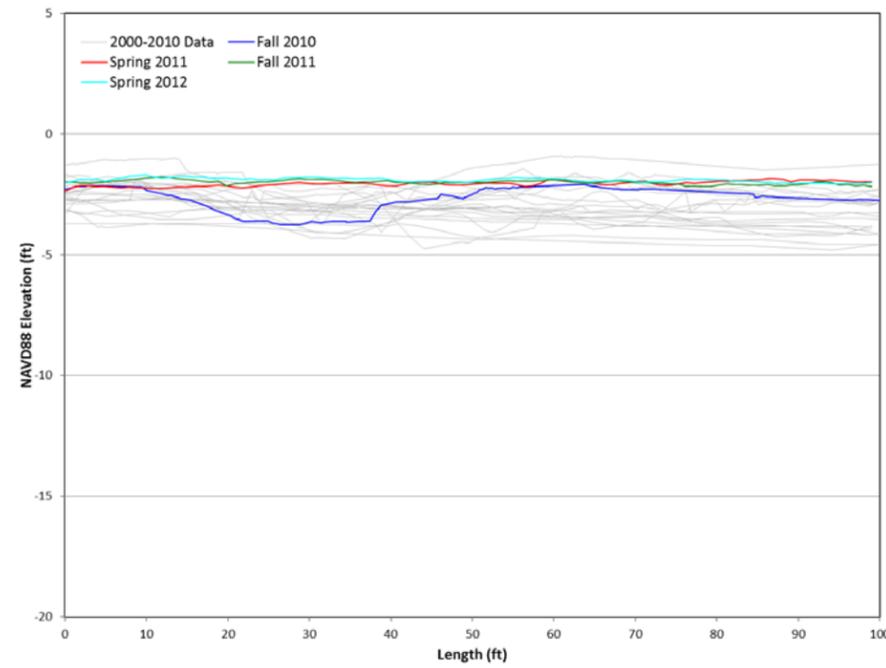
**Centerline Profile**



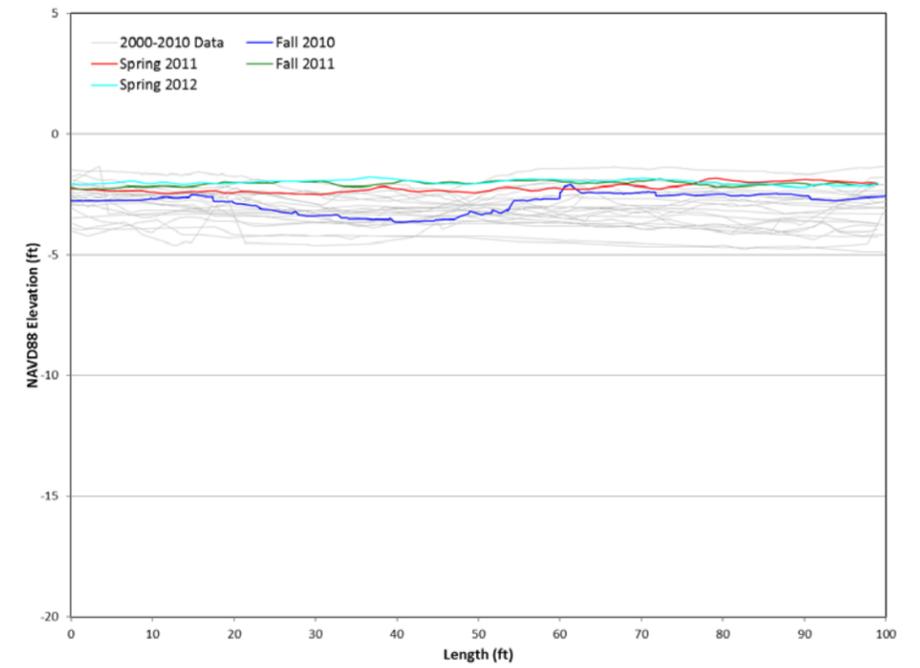
# Appendix M: GLC-3 Semi-Annual Cross-Sections



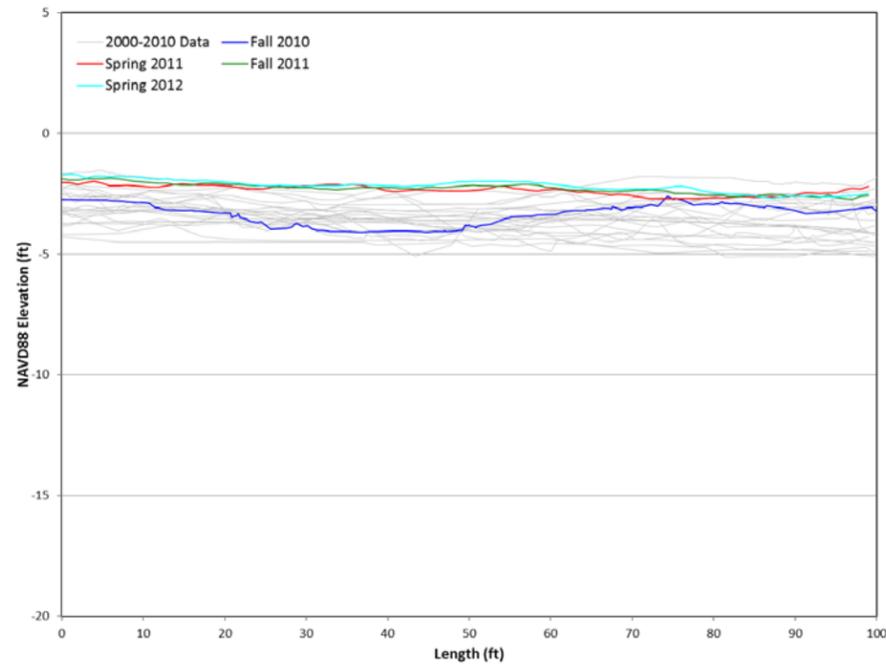
**0ft Cross-Section**



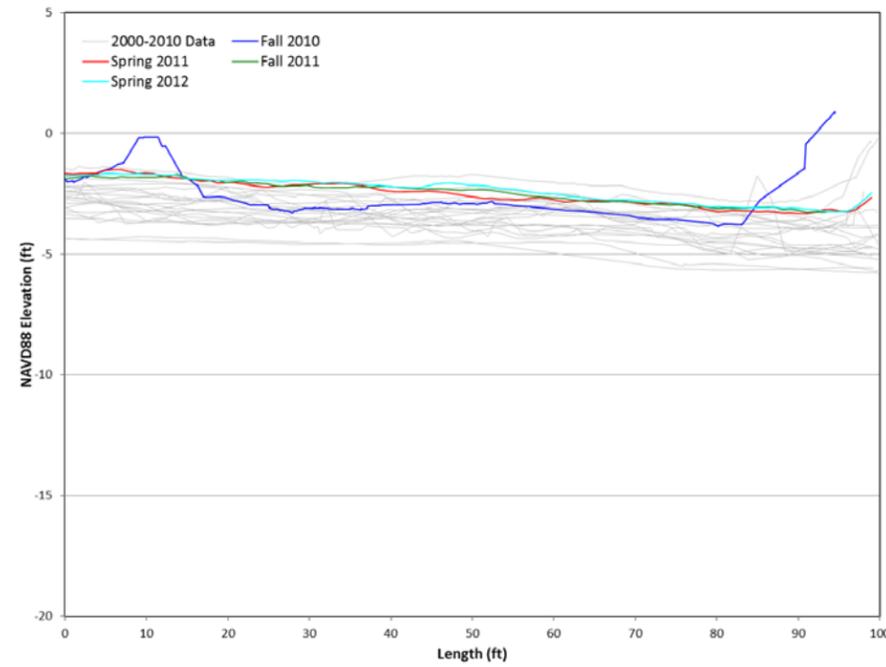
**50ft Cross-Section**



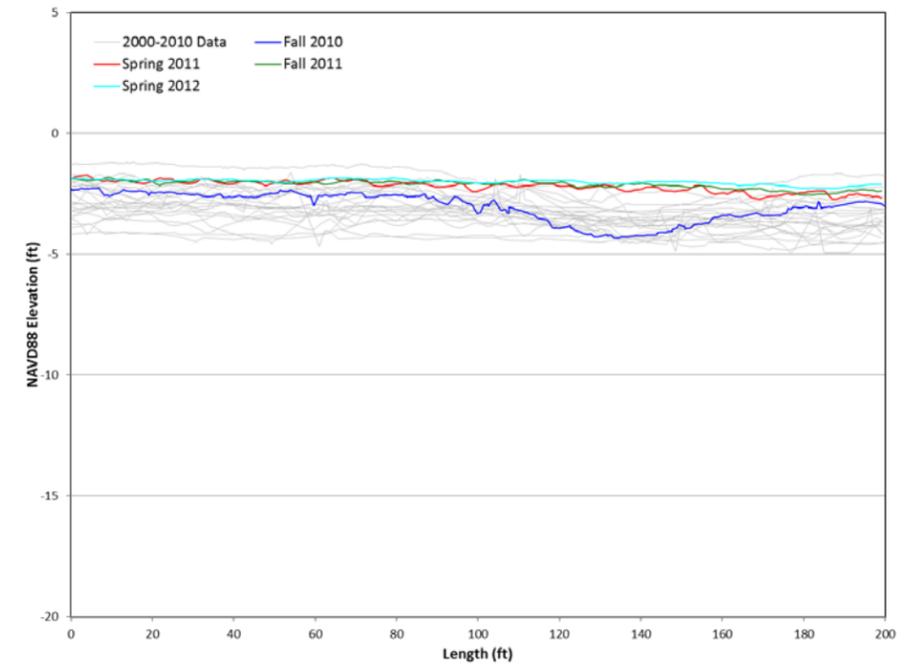
**100ft Cross-Section**



**150ft Cross-Section**



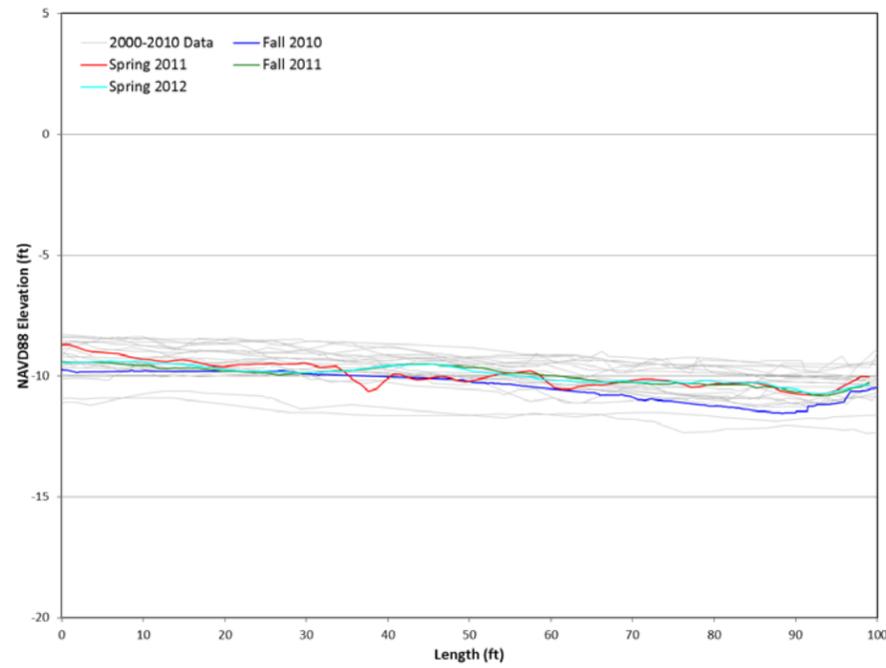
**200ft Cross-Section**



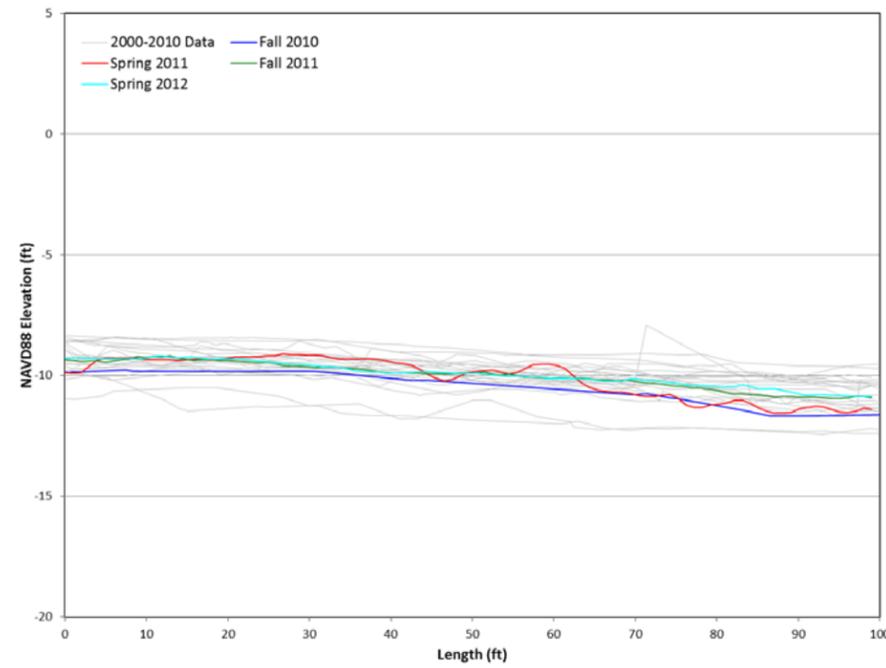
**Centerline Profile**



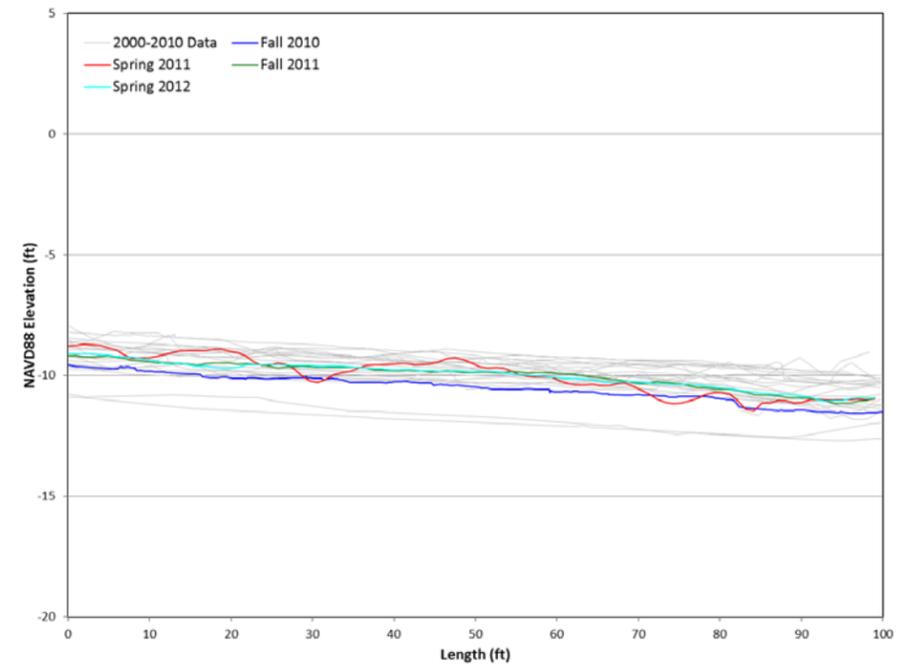
# Appendix N: GLC-4 Semi-Annual Cross-Sections



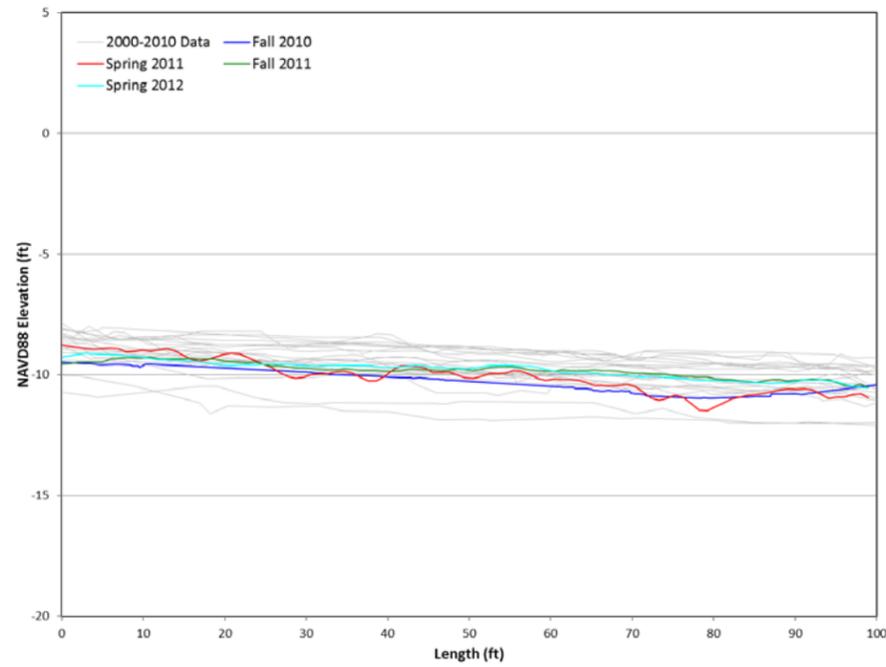
**0ft Cross-Section**



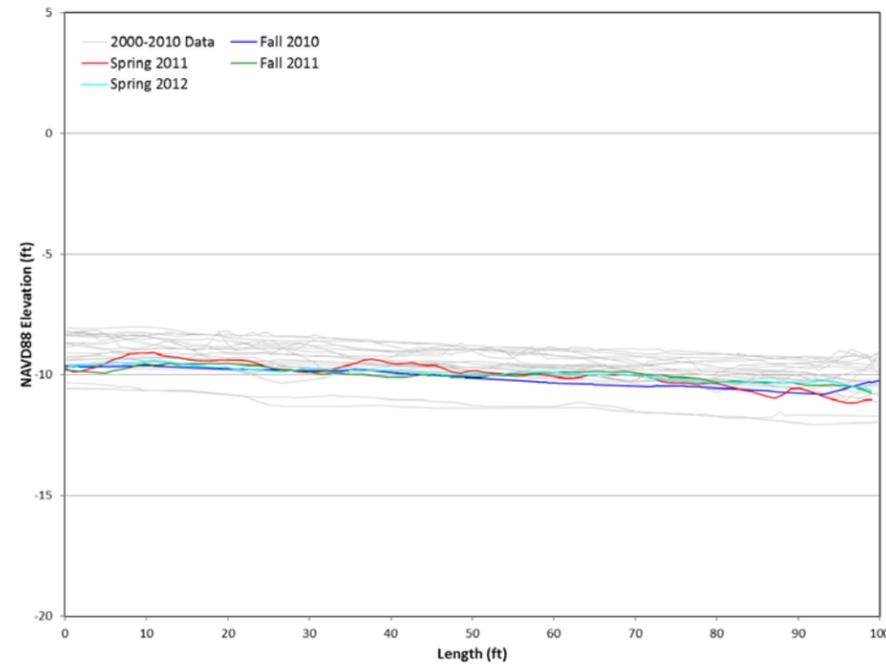
**50ft Cross-Section**



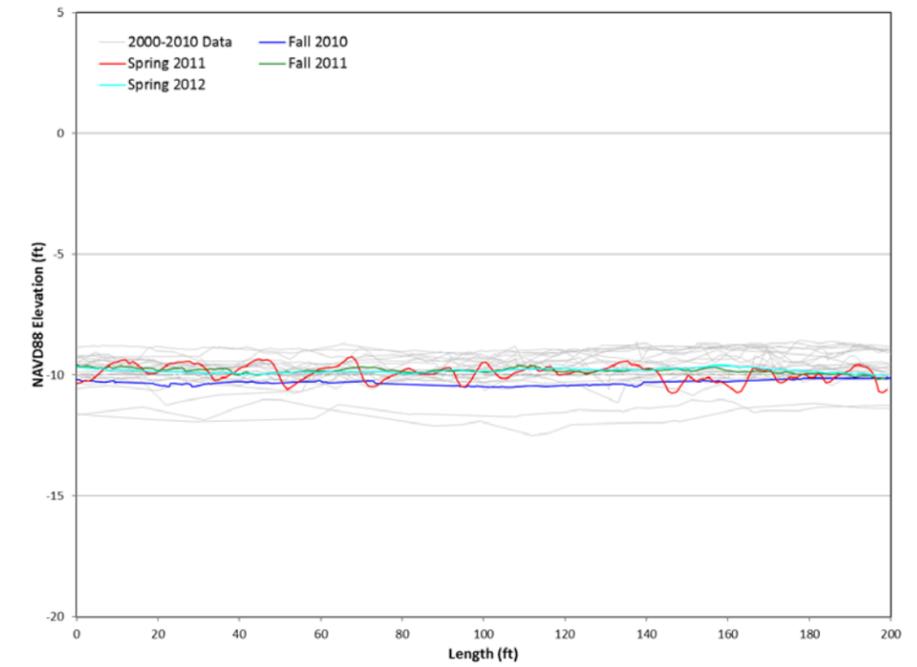
**100ft Cross-Section**



**150ft Cross-Section**



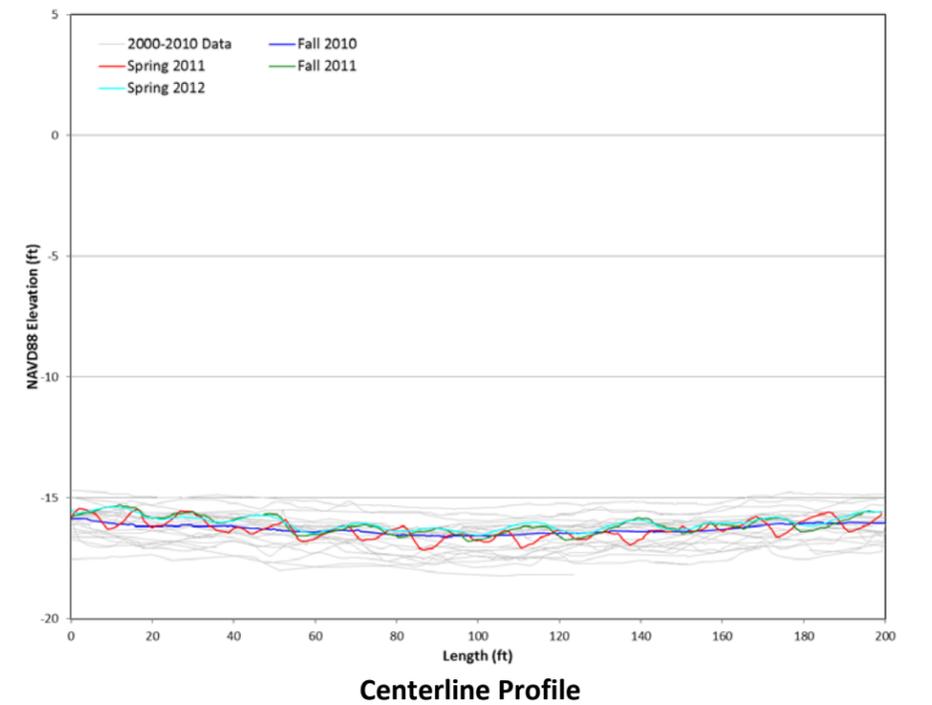
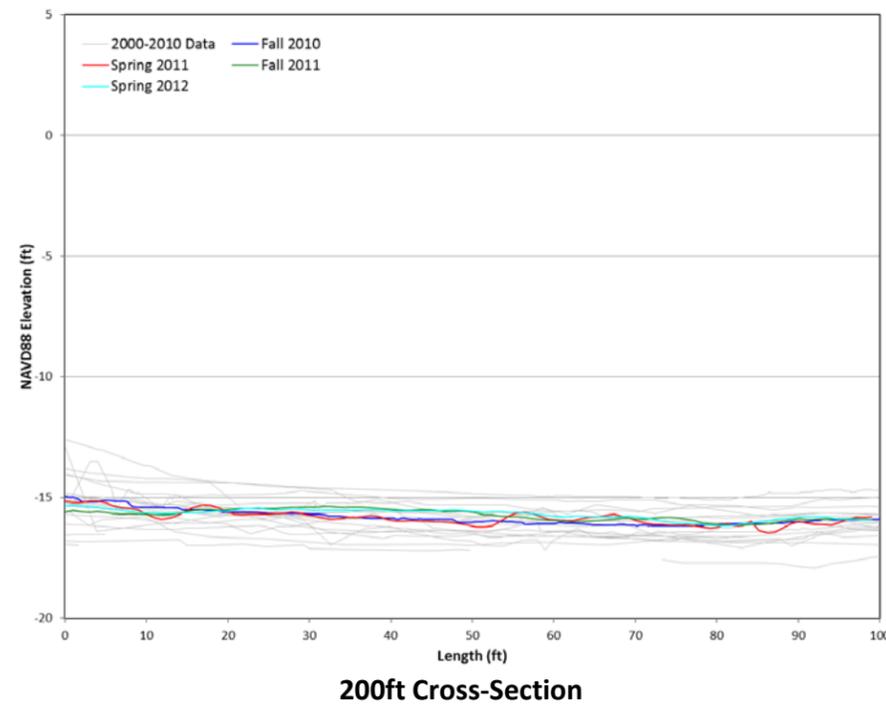
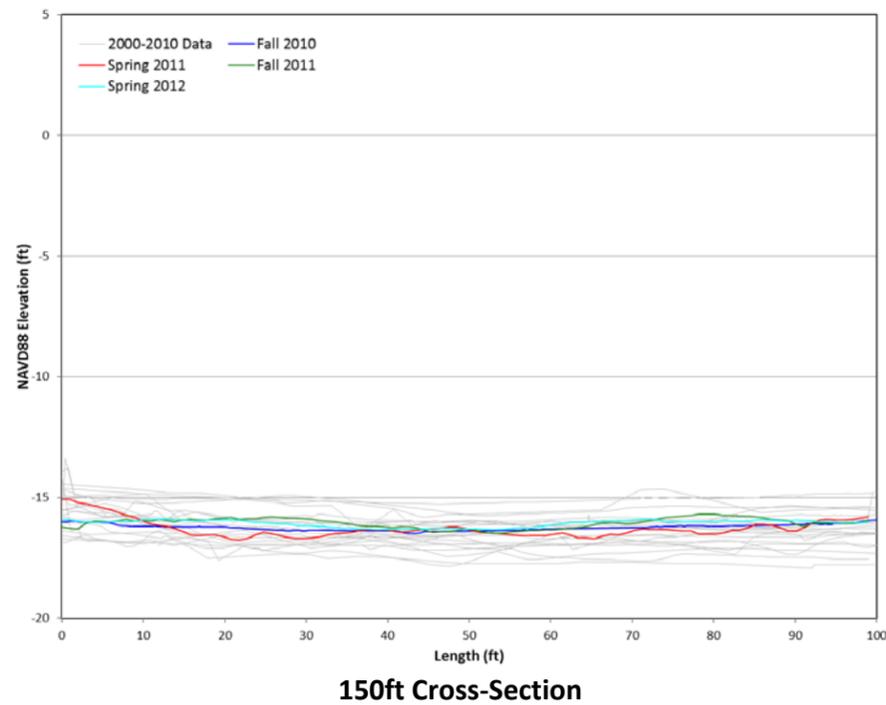
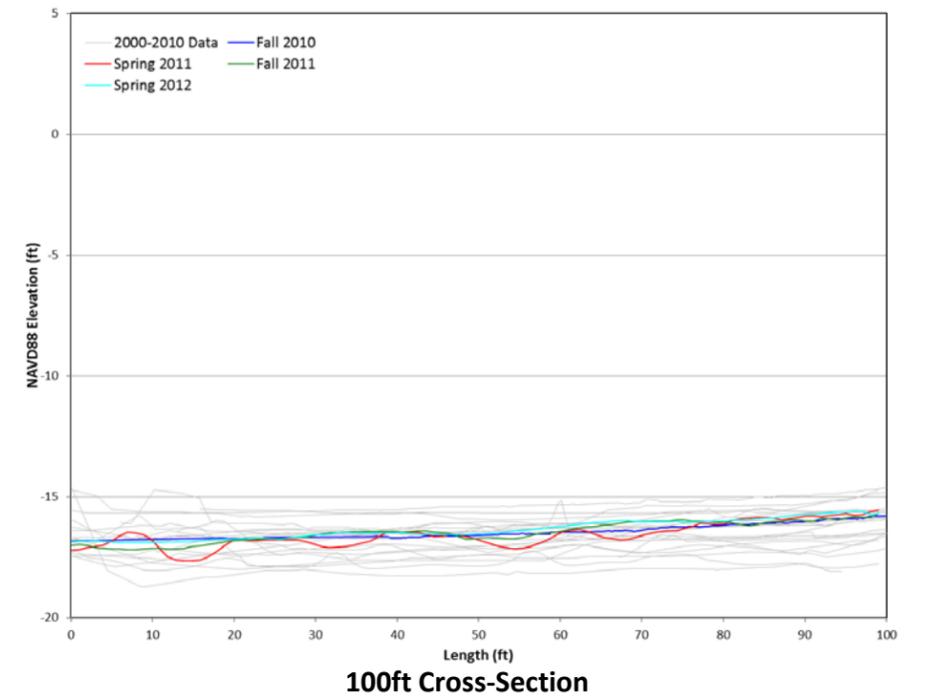
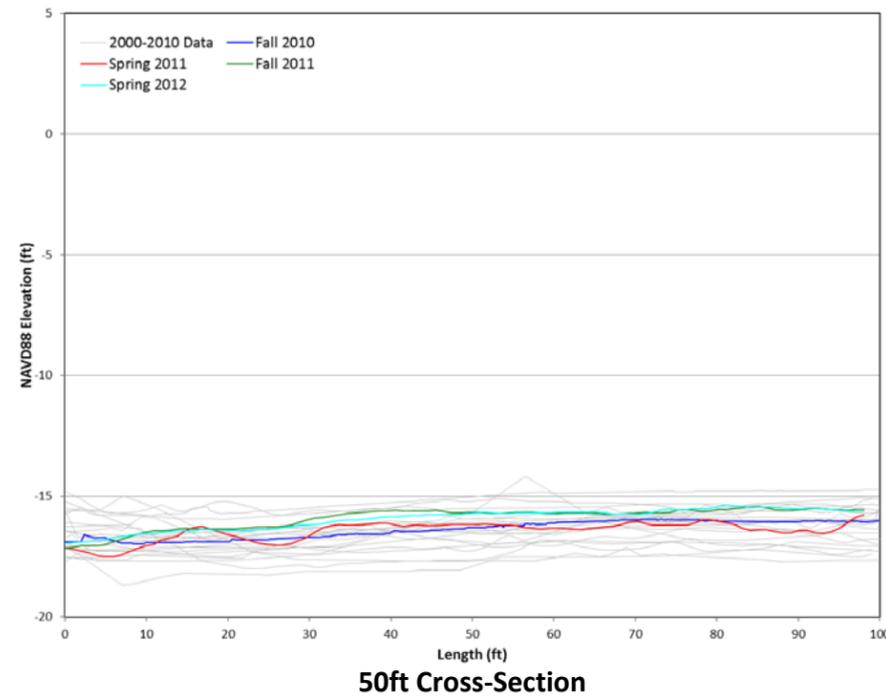
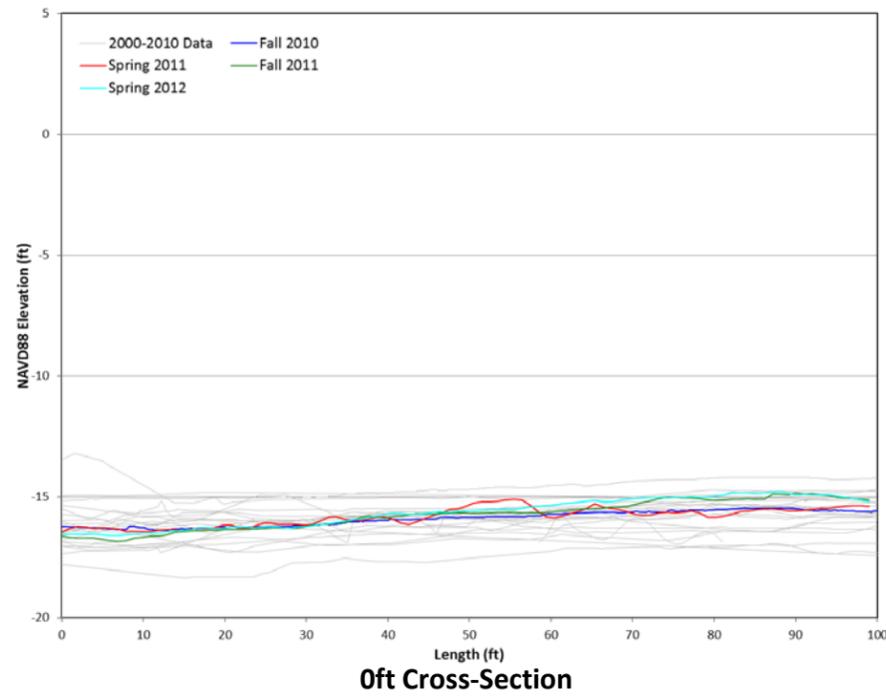
**200ft Cross-Section**



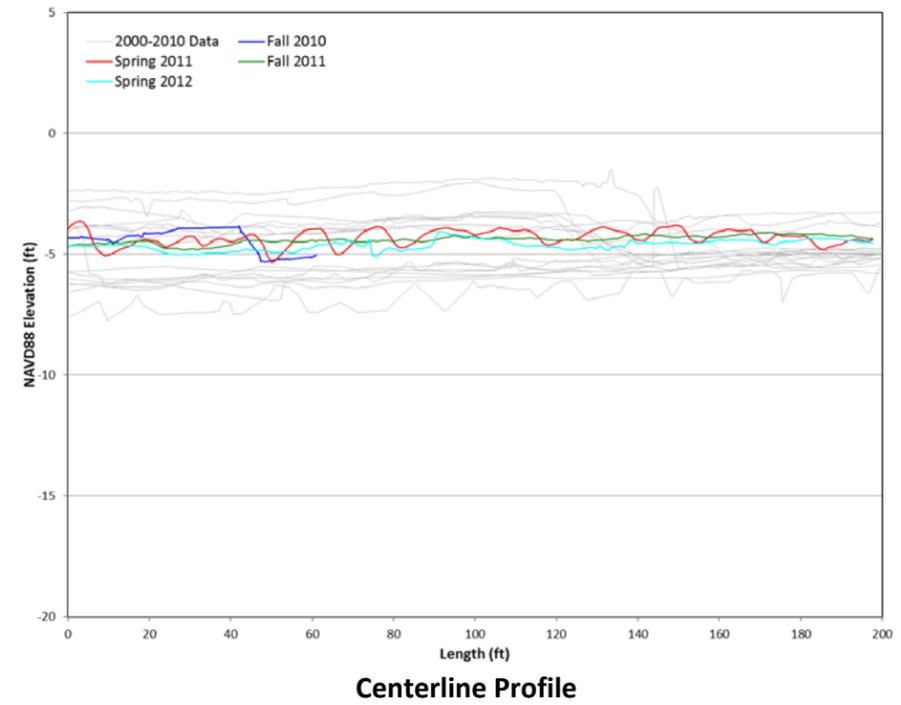
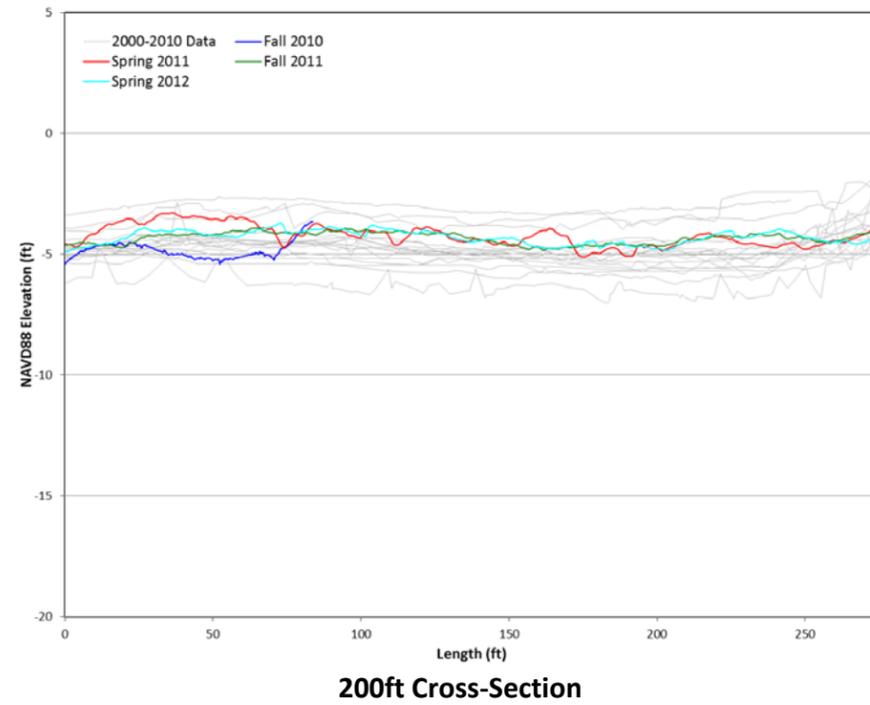
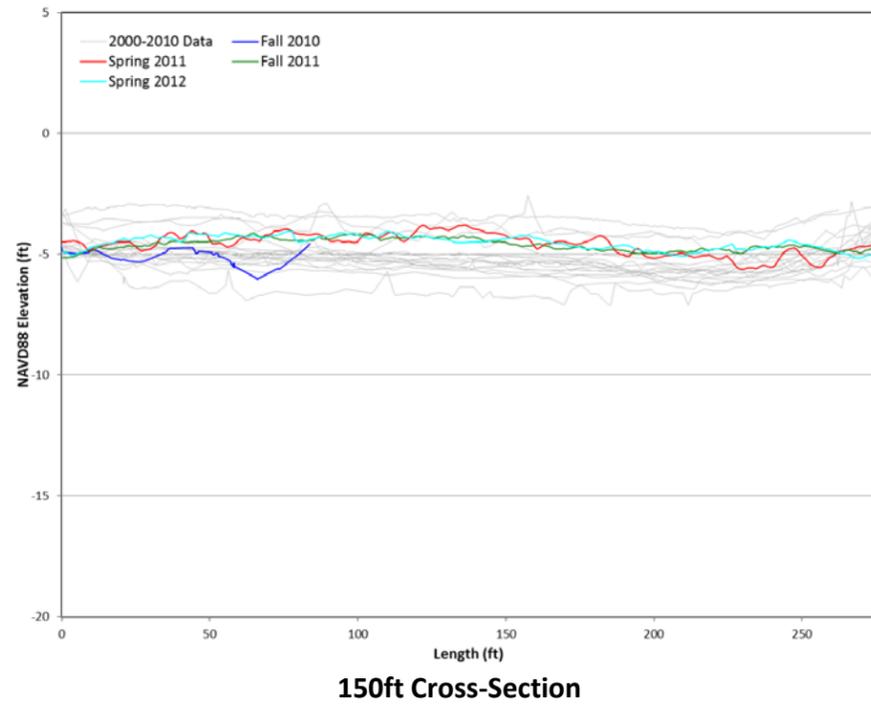
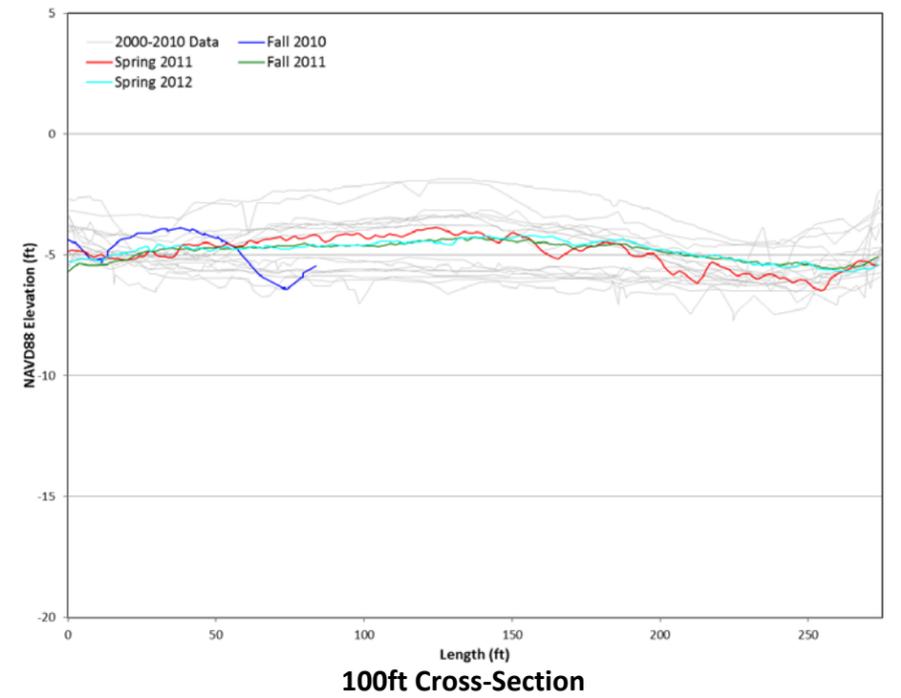
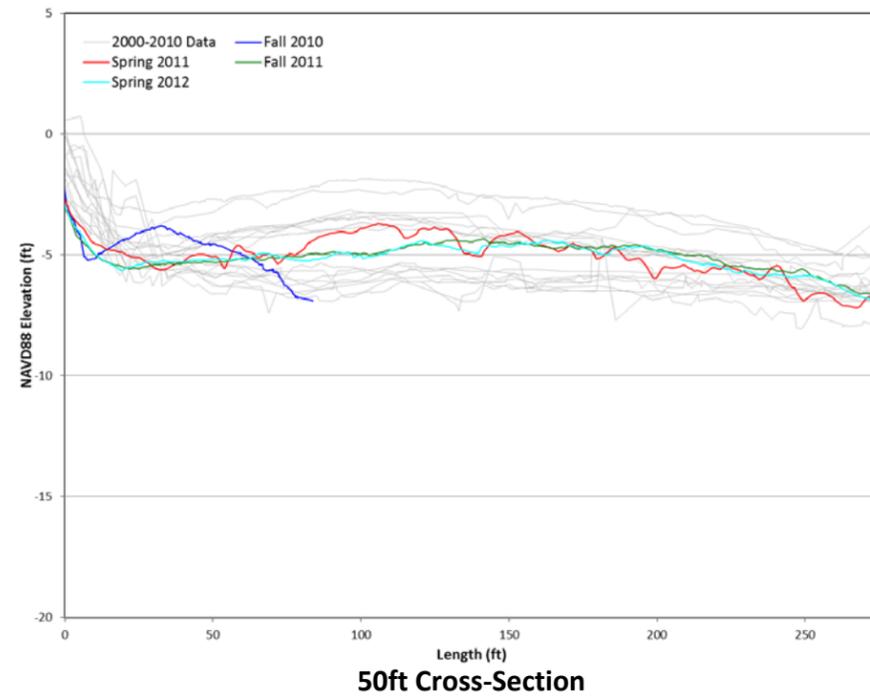
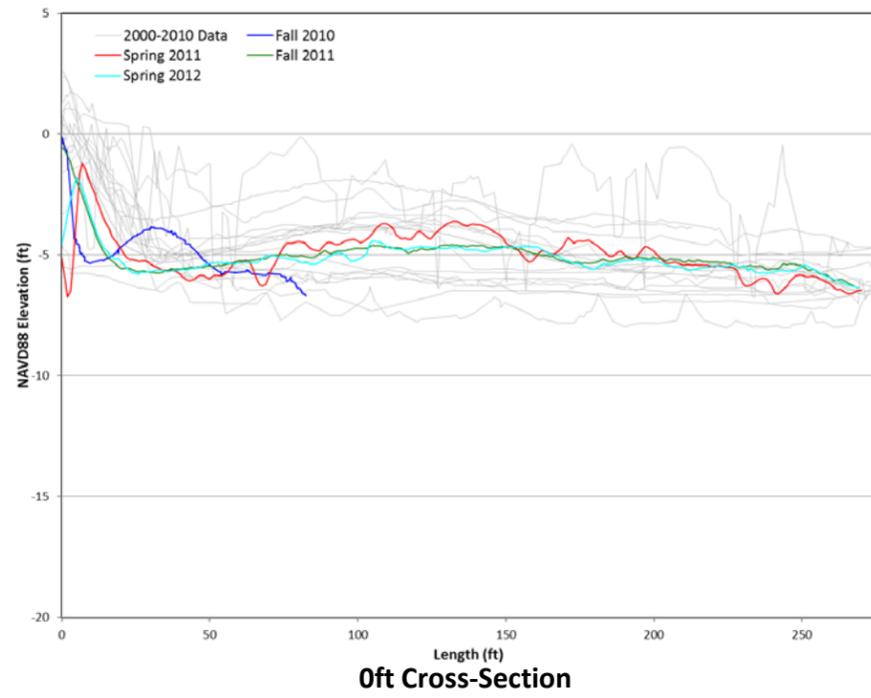
**Centerline Profile**



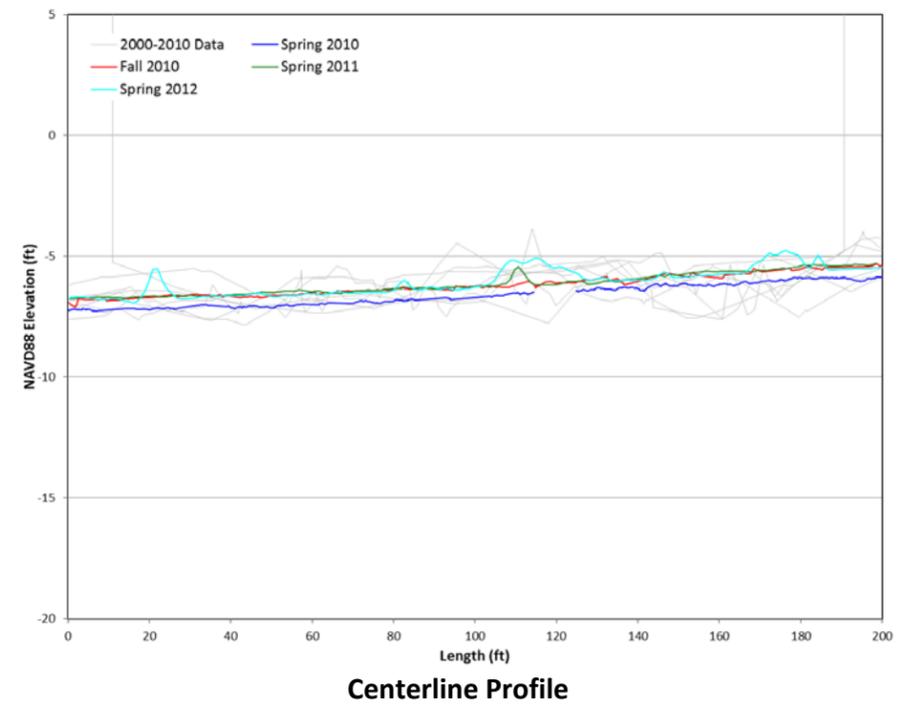
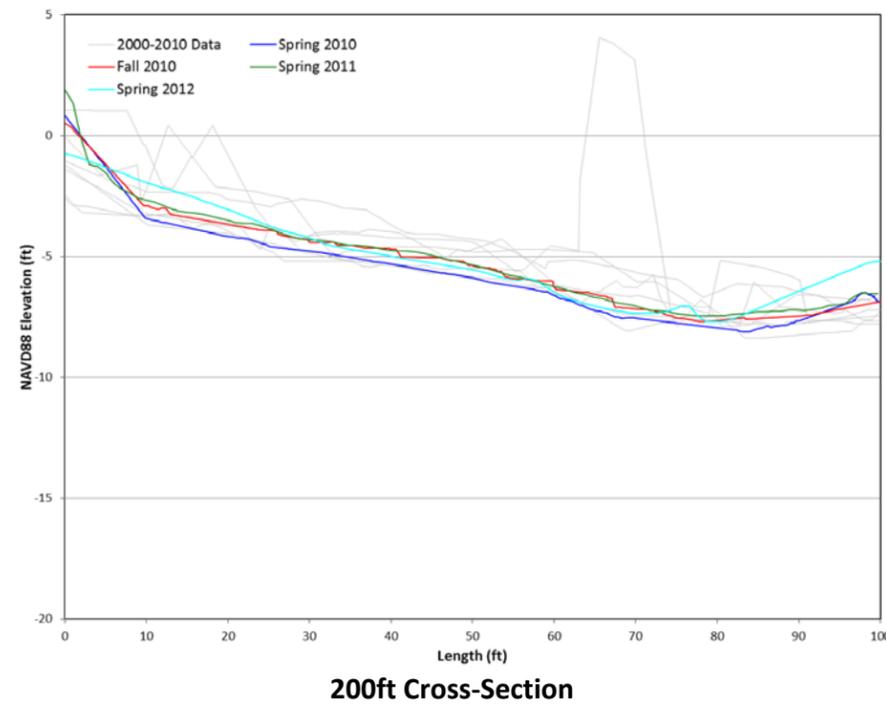
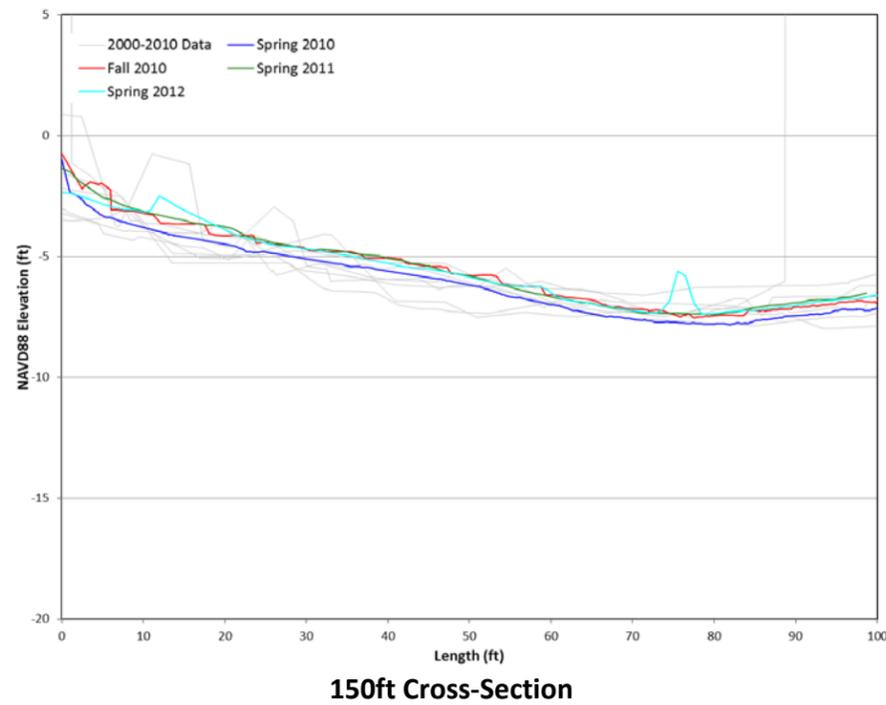
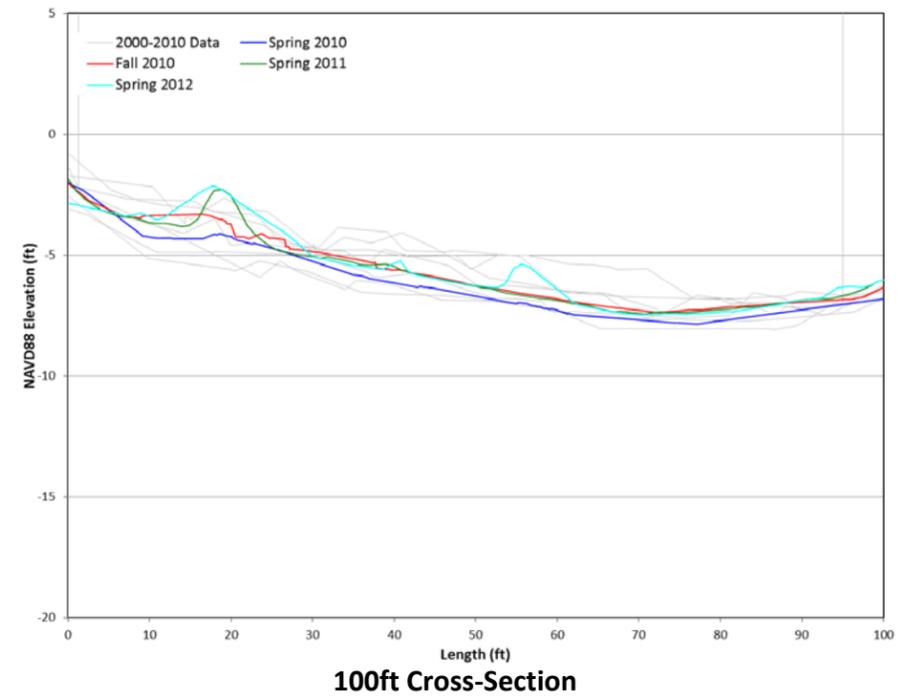
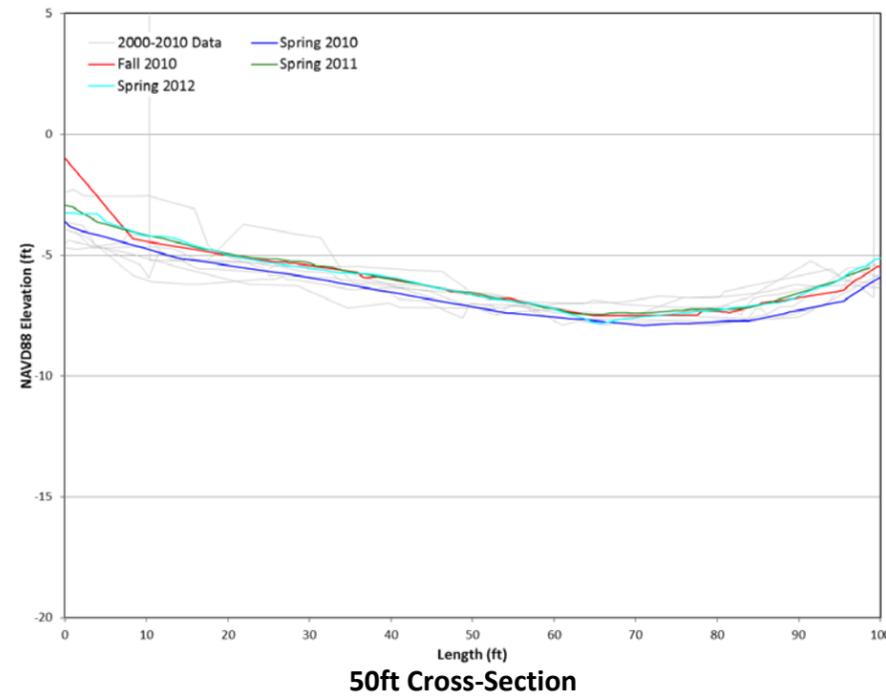
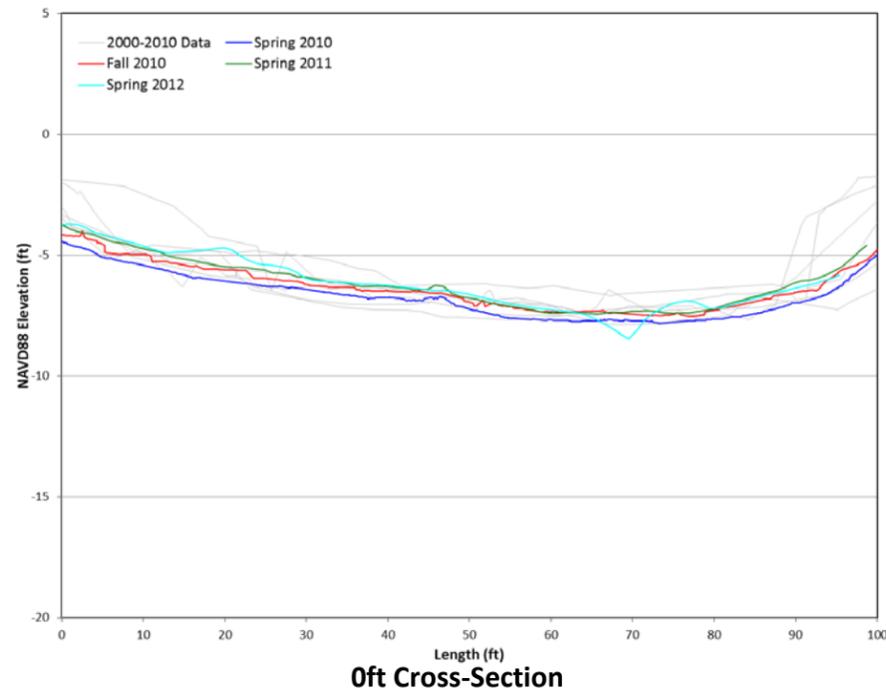
# Appendix O: GLC-5 Semi-Annual Cross-Sections



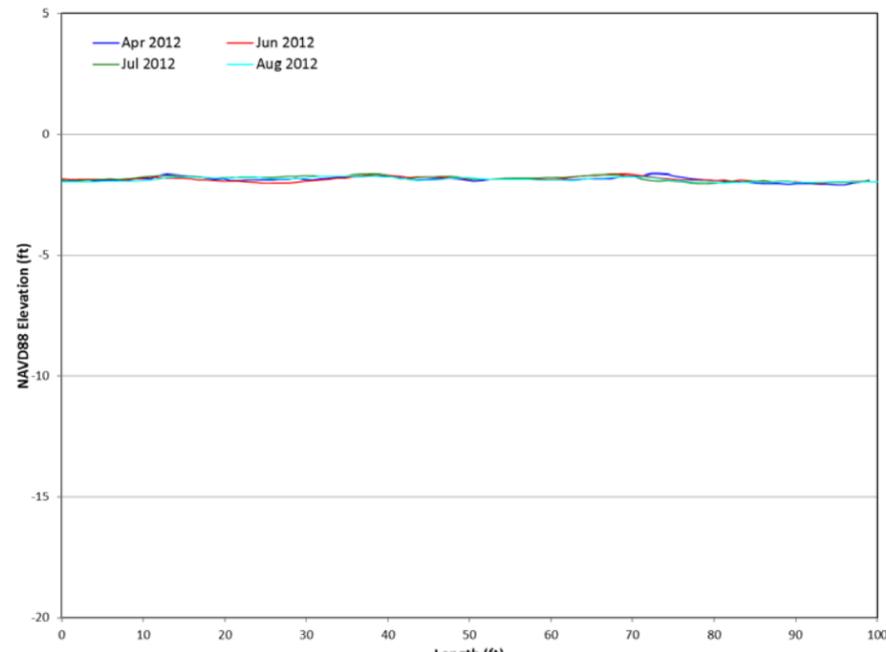
# Appendix P: DC-1 Semi-Annual Cross-Sections



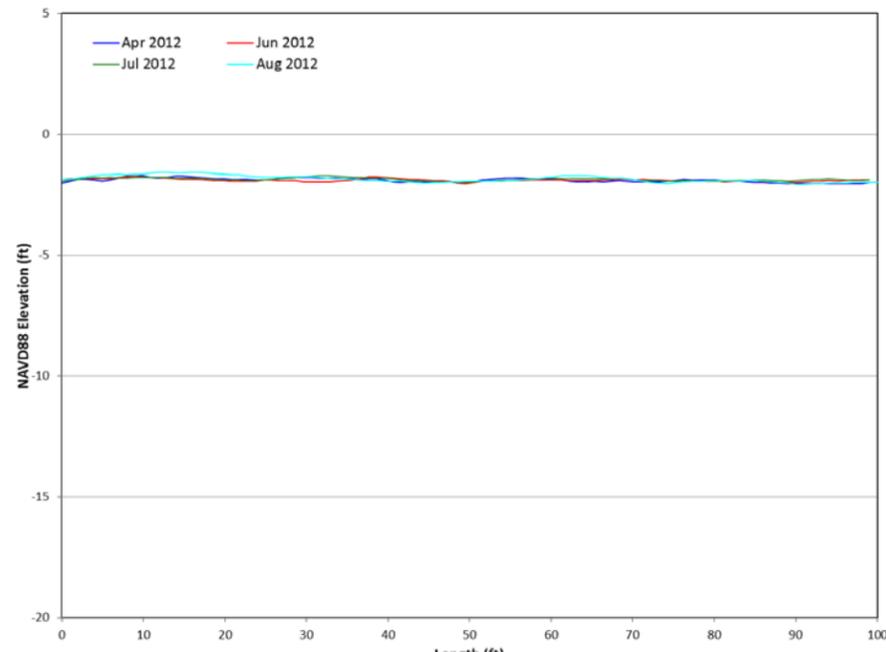
# Appendix Q: MR-1 Semi-Annual Cross-Sections



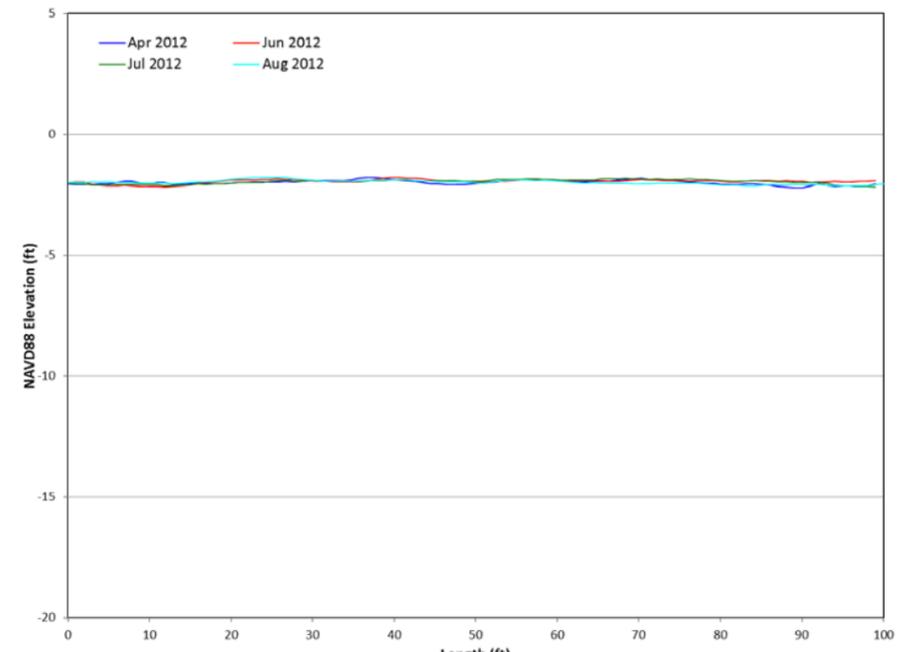
# Appendix R: GLC-3 Monthly Cross-Sections



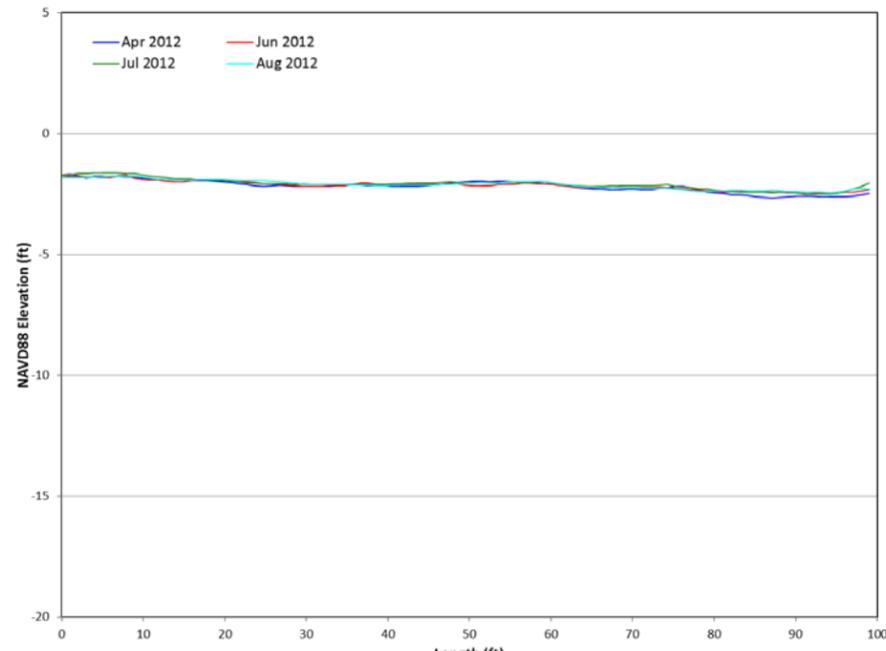
0ft Cross-Section



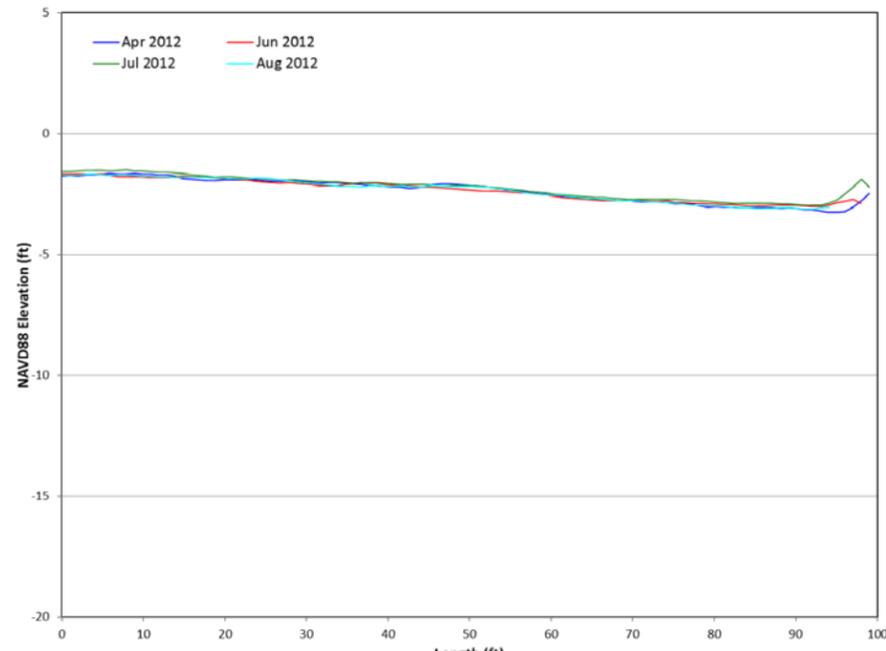
50ft Cross-Section



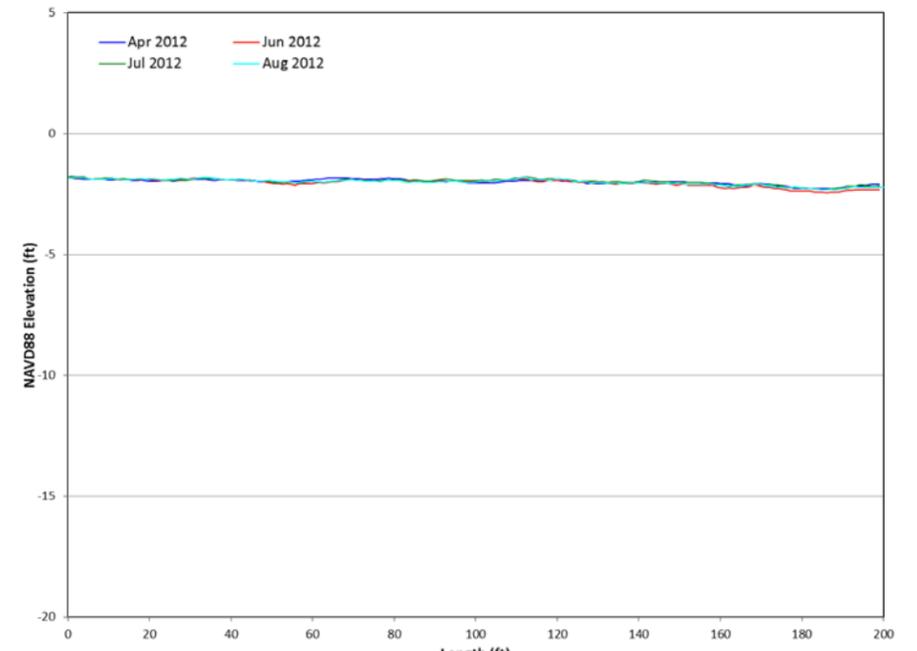
100ft Cross-Section



150ft Cross-Section



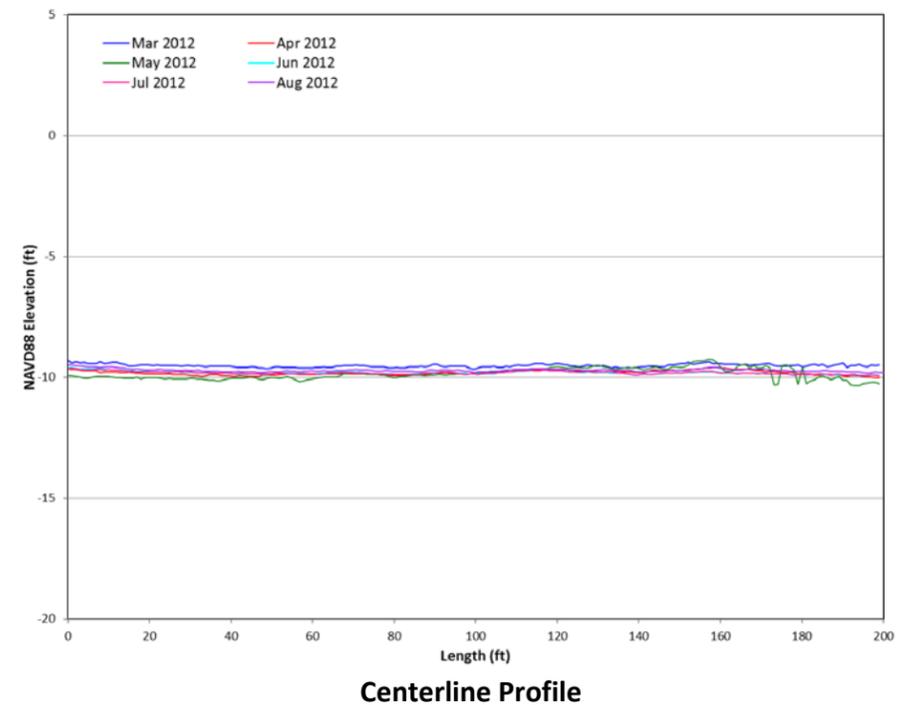
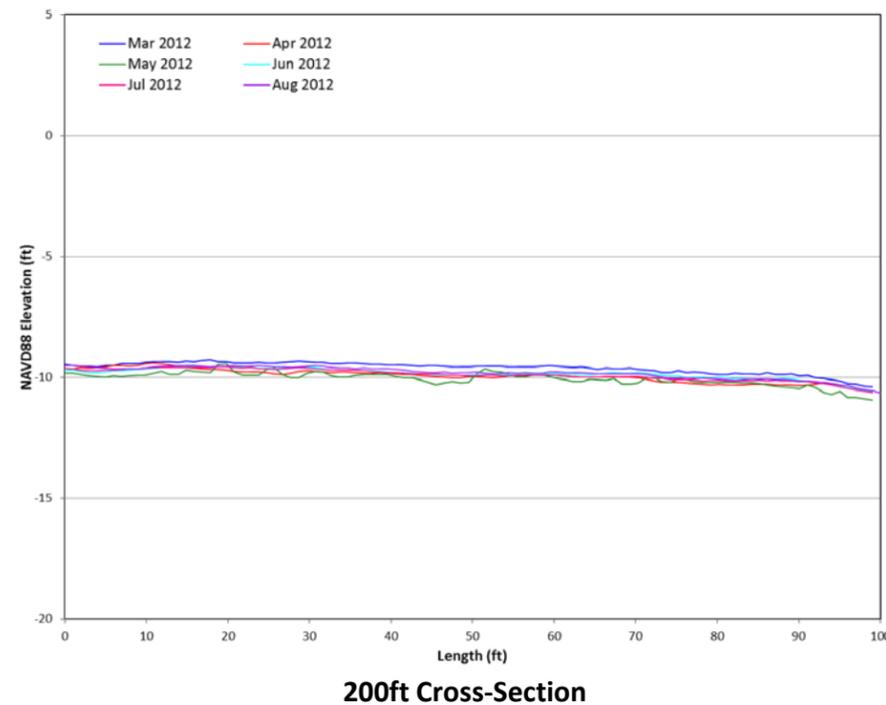
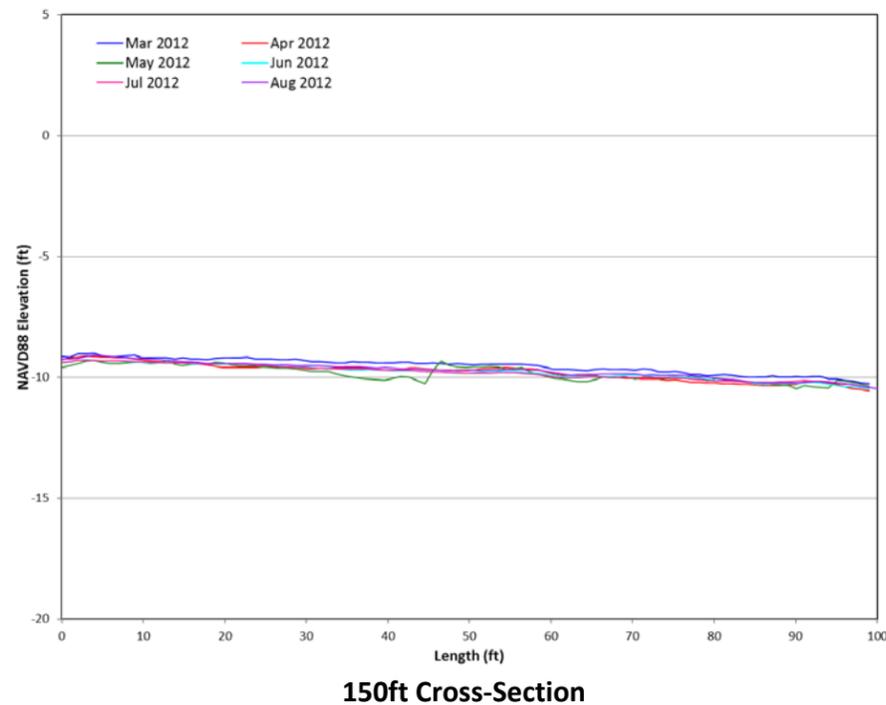
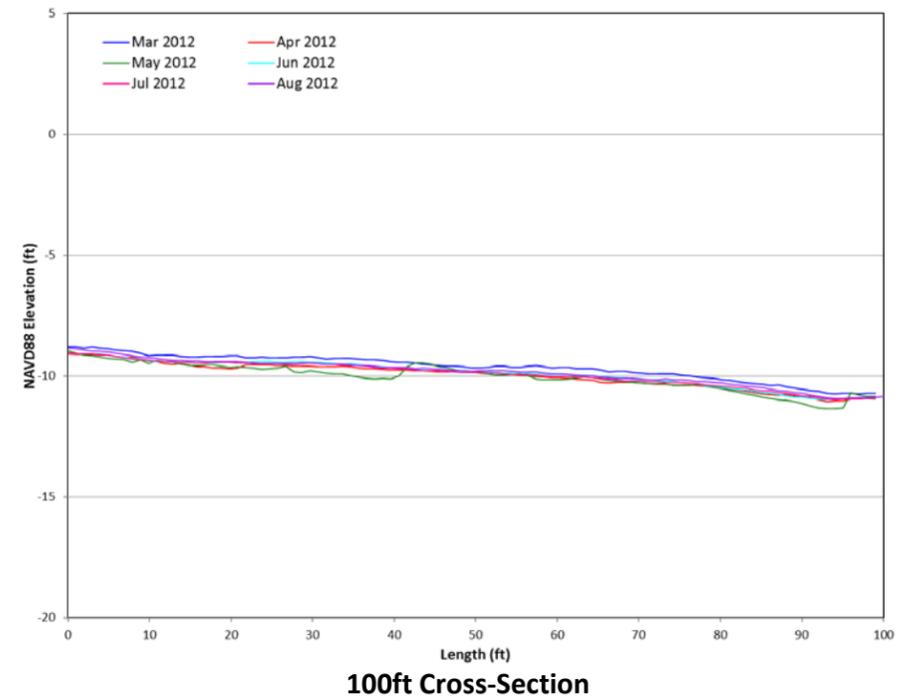
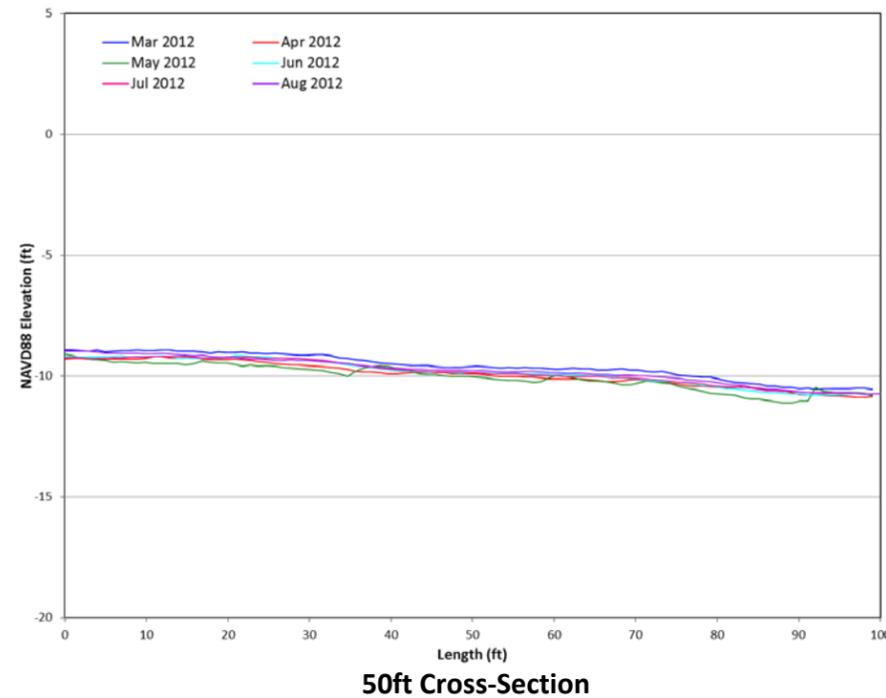
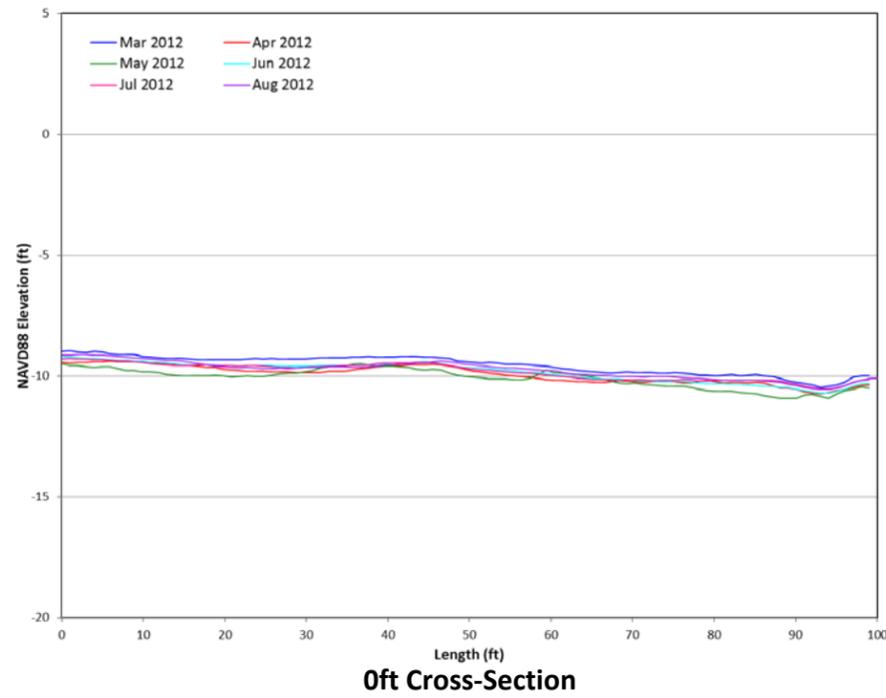
200ft Cross-Section



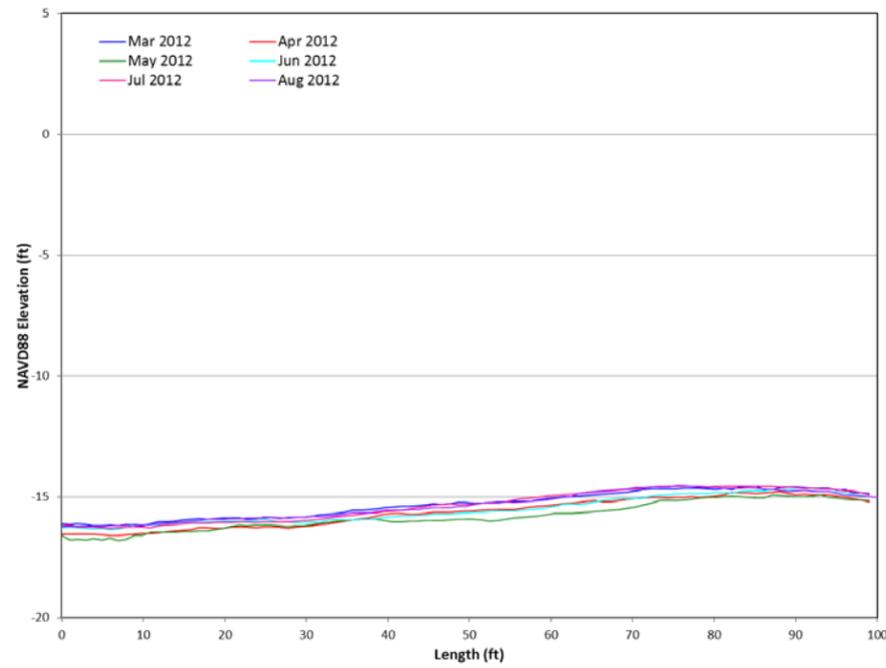
Centerline Profile



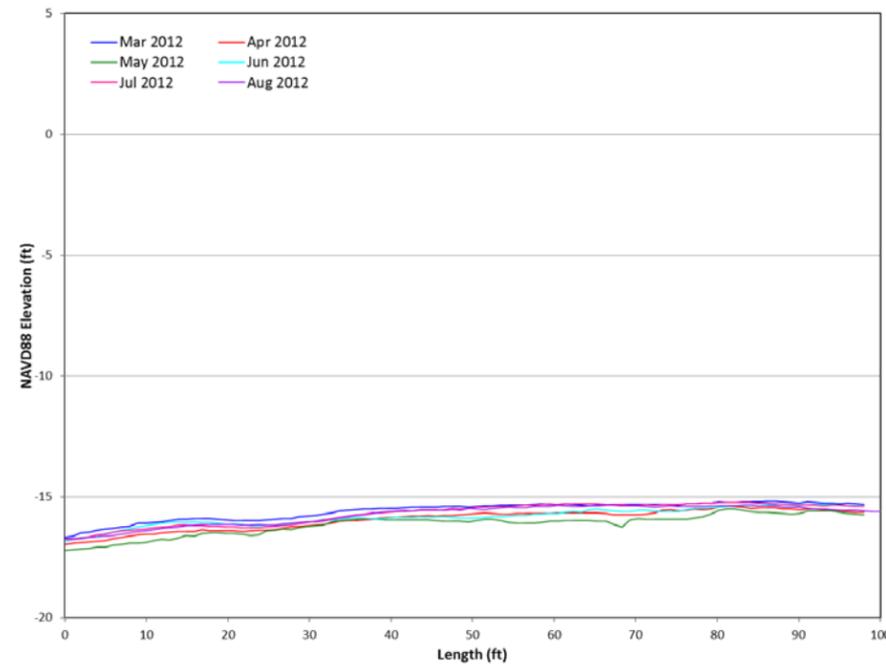
# Appendix S: GLC-4 Monthly Cross-Sections



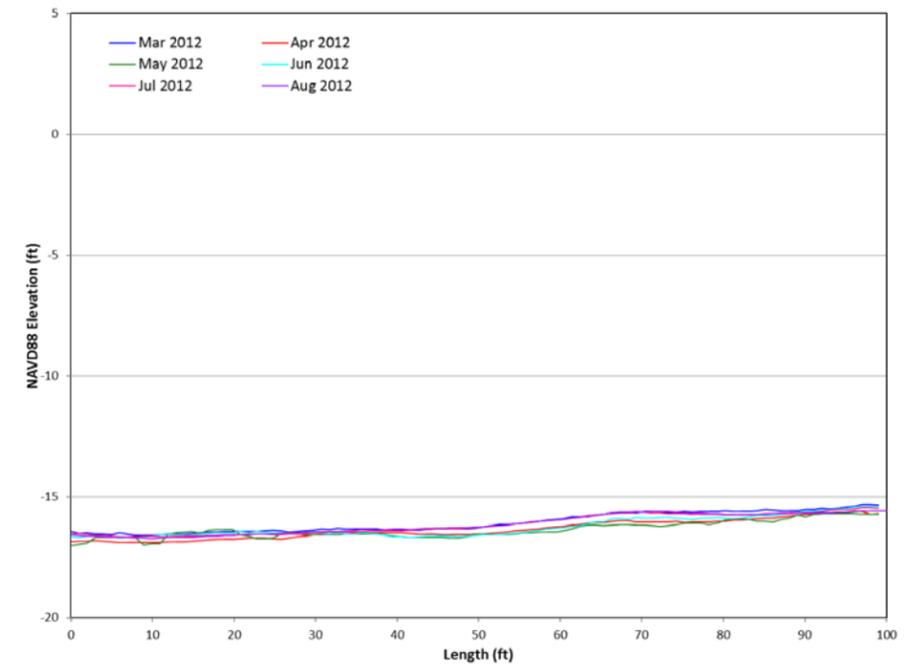
# Appendix T: GLC-5 Monthly Cross-Sections



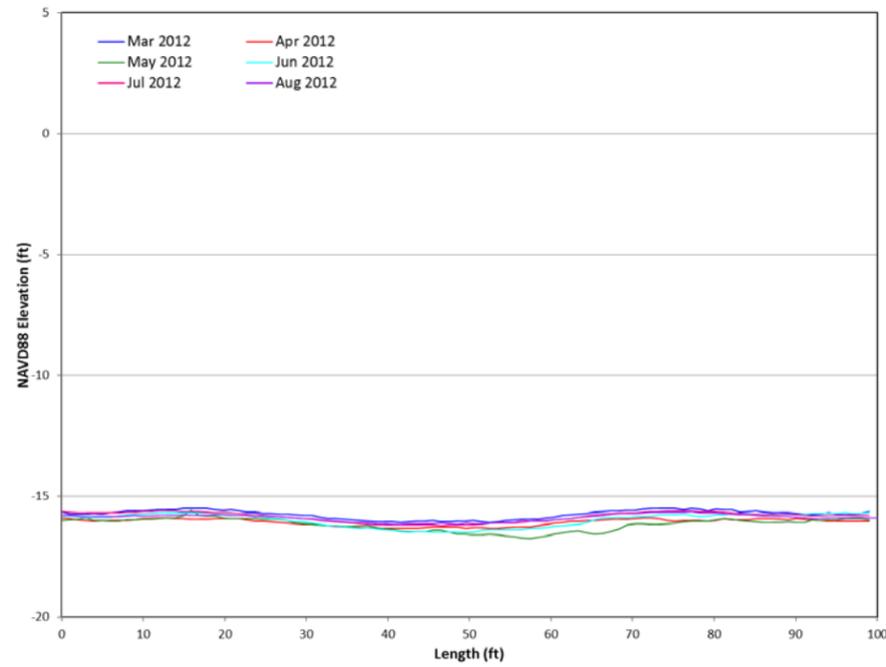
0ft Cross-Section



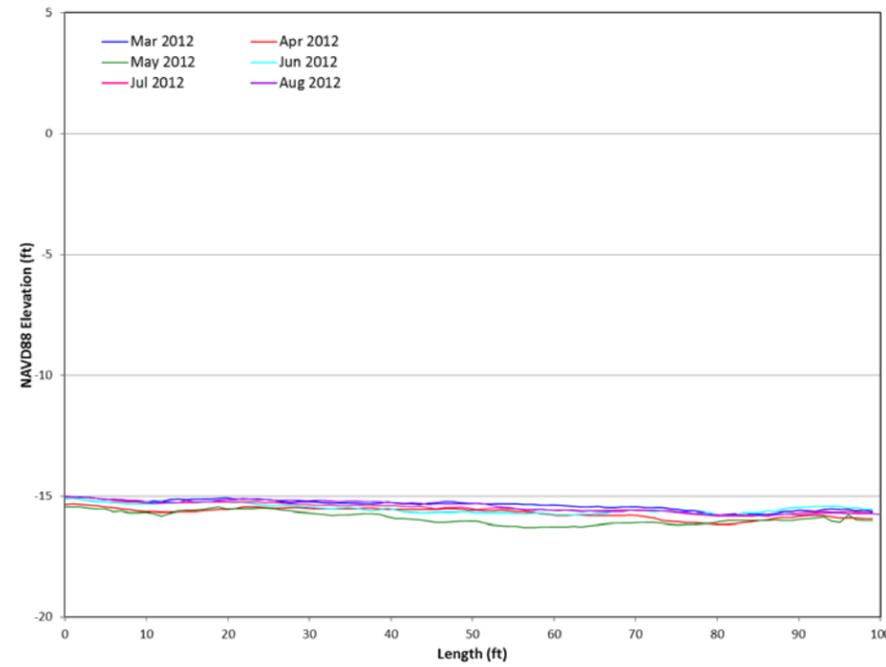
50ft Cross-Section



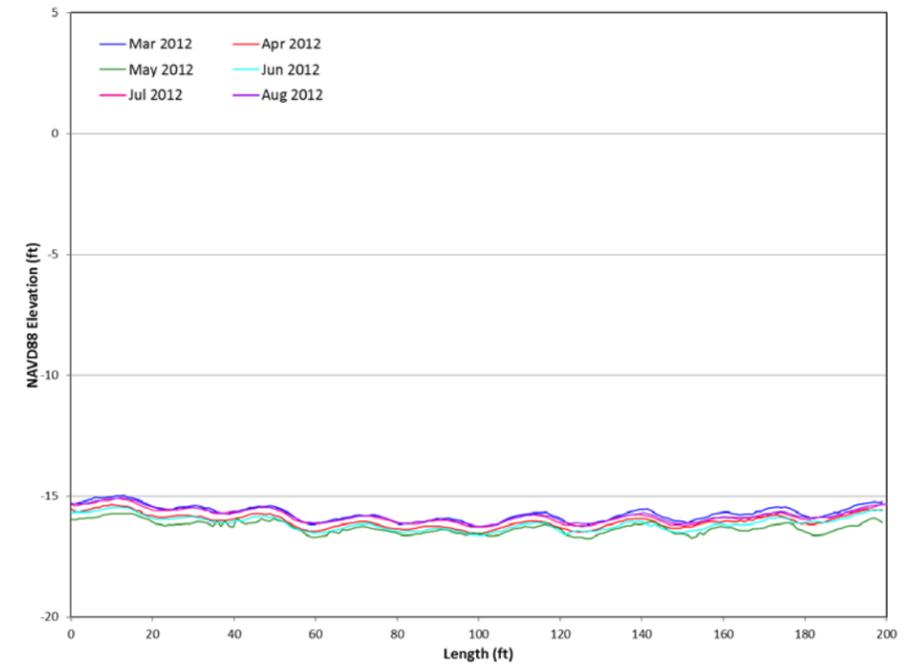
100ft Cross-Section



150ft Cross-Section



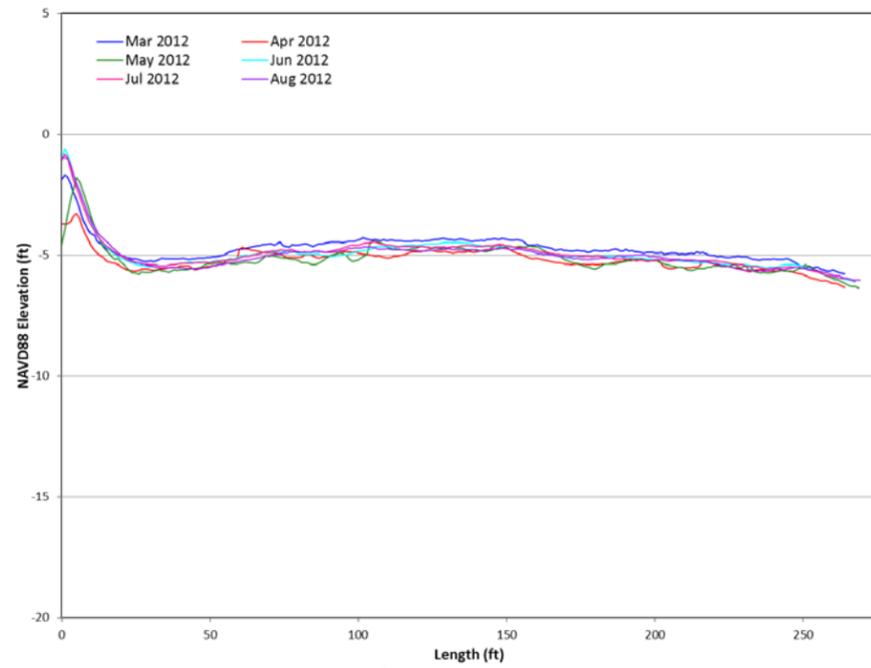
200ft Cross-Section



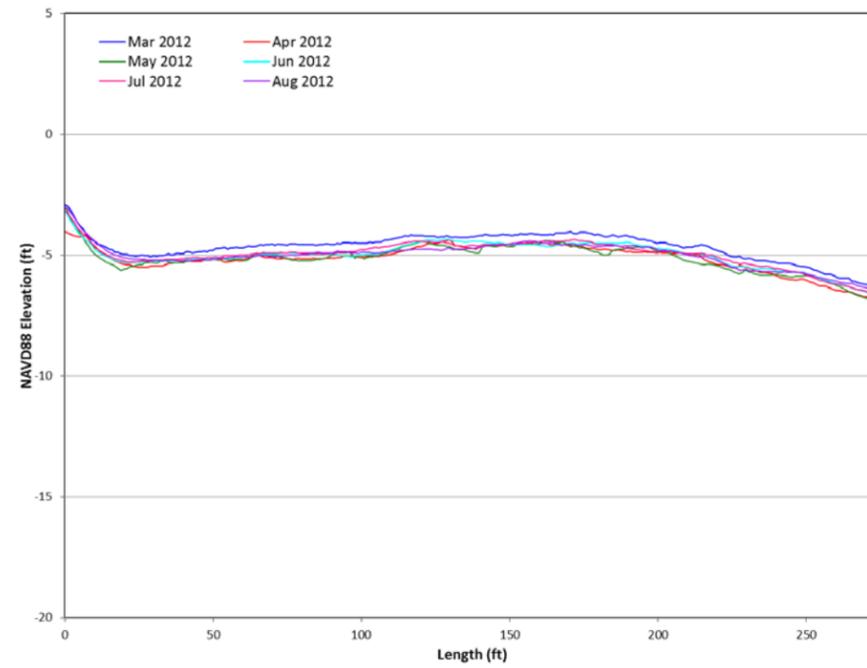
Centerline Profile



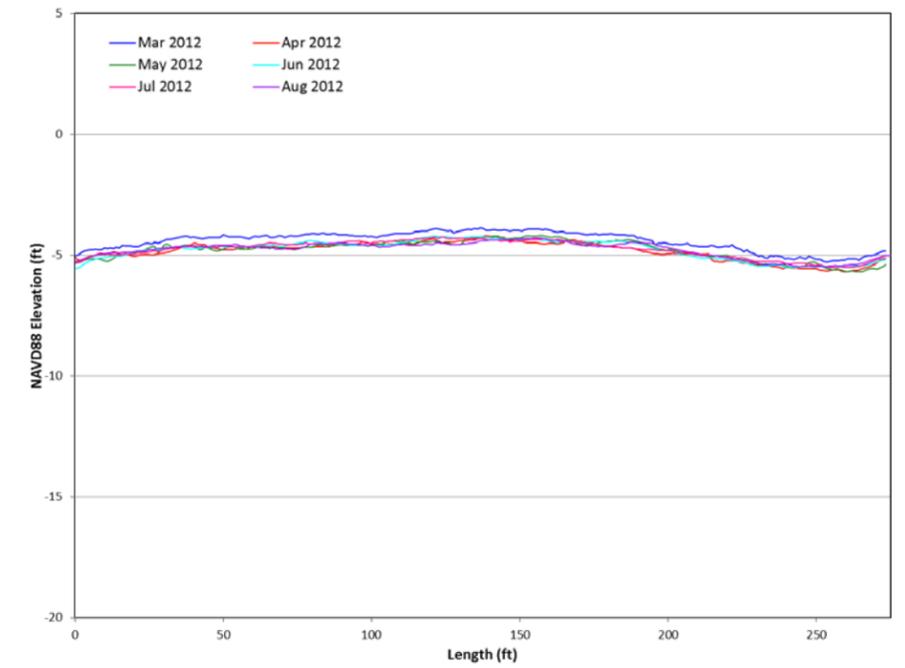
# Appendix U: DC-1 Monthly Cross-Sections



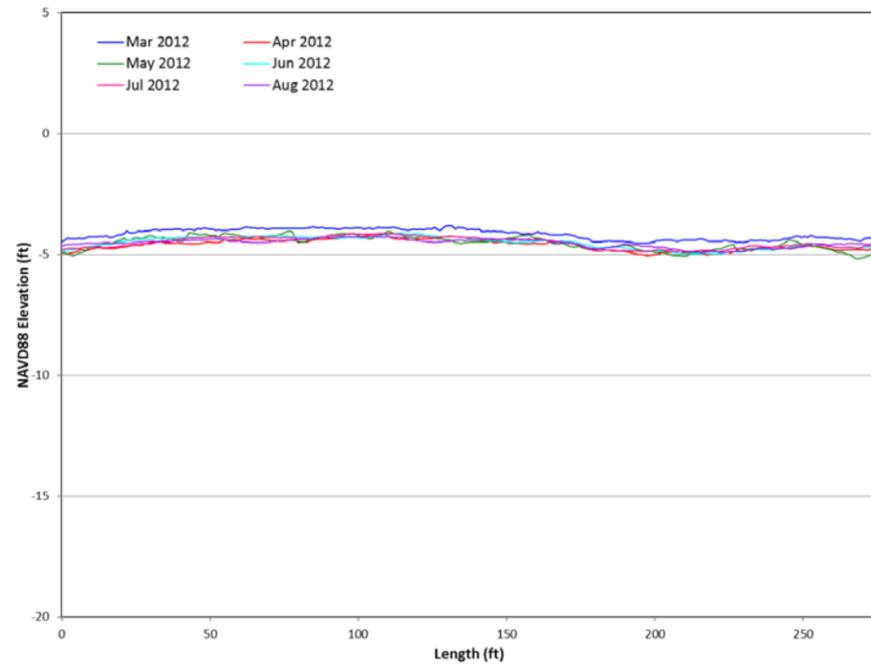
**0ft Cross-Section**



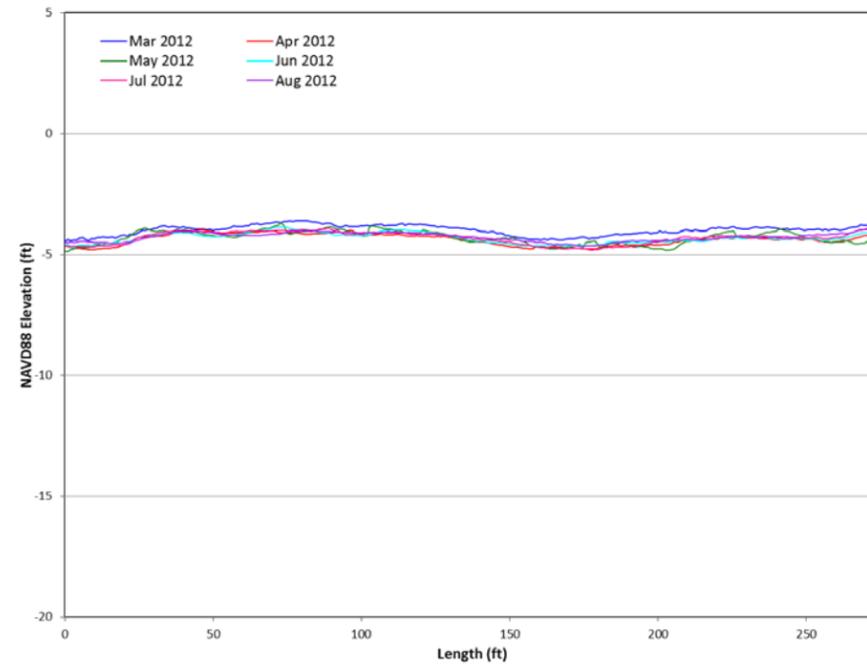
**50ft Cross-Section**



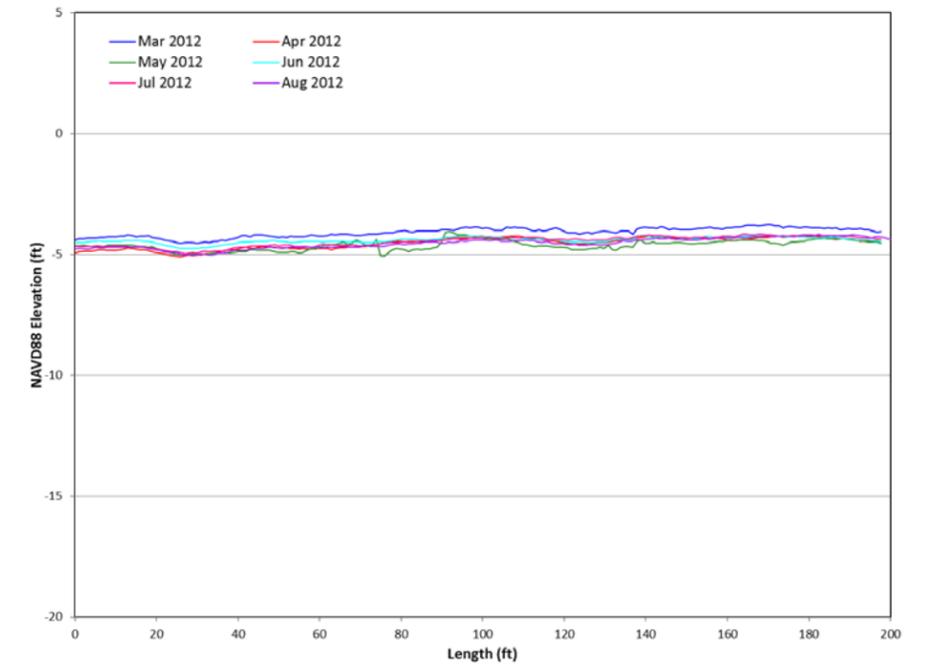
**100ft Cross-Section**



**150ft Cross-Section**



**200ft Cross-Section**



**Centerline Profile**

