

Memorandum

Date: December 23, 2013

To: William McLaughlin
South Delta Branch
Bay Delta Office

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North Central Regional Office
Division of Integrated Regional Water Management
From: Department of Water Resources

Subject: Memorandum Report - Bed Sediment Monitoring in the South Delta Fall 2012 - Spring 2013

Attached for your information and use is the Memorandum Report - Bed Sediment Monitoring in the South Delta Fall 2012 - Spring 2013, December 2013. This report presents sediment monitoring results at 18 sites in the south Delta between the Fall 2012 and Spring 2013.

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

DB 12/17/13

PC

12/19/13 PC

12/19/13

EH

12-19-13

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 18 sites is being conducted for the Bay-Delta Office in responses to public comments regarding the potential effects of proposed permanent barriers on sediment accumulation.

This report updates and expands on previous reports to include semi-annual survey data from fall 2012 through spring 2013, and monthly data from October 2012 through July 2013.

Semi-annual data for the last four surveys suggest that many sites are relatively stable. However, compared to historical semi-annual data sets it appears there may be slow long term changes happening at some sites.

The monthly surveys are allowing NCRO to evaluate the impact both the flows and barriers have on sediment transport. The limited monthly surveys only represent below normal or dry water years and one and one half cycles of barrier installation and removal. Based on the limited data set, it appears upstream flows and tidal flows have a significant impact on sediment movement. Ignoring the impact flow or the water year type may have, and based on the limited monthly data collected to date, it appears when the barriers are in place sediment accumulates, and when the barriers are removed study areas experience scour.

At this point the only new recommendation is the continuation of the monthly surveys, as the North Central Region Office works to implement past recommendations discussed with the Bay-Delta Office.

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Acronyms and Abbreviations

BDO	Bay Delta Office
BM	Benchmark
BTS	Bathymetry and Technical Support Section
CY	Cubic Yards
DC	Doughty Cut
DWR	Department of Water Resources
FT	Feet
GIS	Geographic Information System
GLC	Grant Line Canal
GPS	Global Positioning System
GWA&SS	Ground Water Supply Assessment and Special Studies Section
MR	Middle River
NCRO	North Central Region Office
OR	Old River
RTK	Real Time Kinematic



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 the 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 Project¹. In addition, beginning in March 2012, monthly bathymetric surveys were initiated and are being conducted at four locations near the barrier on Grant Line Canal. This report presents the bathymetric data collected between the fall of 2012 and July 2013.

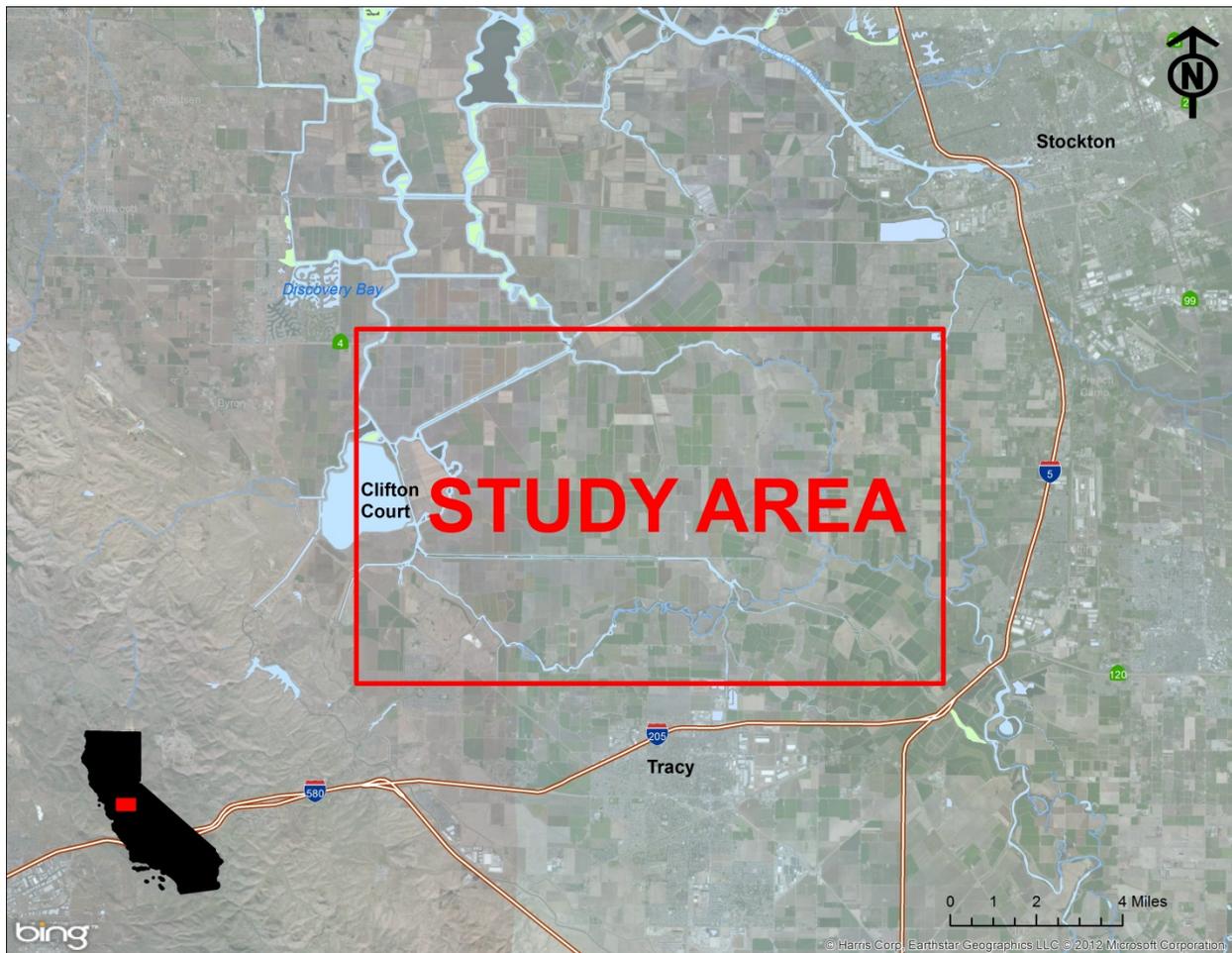


Figure 1-1: Vicinity Map

A total of eighteen sites are monitored on Old River, Grant Line Canal, Fabian Bell Canal, Middle River, and Doughty Cut. The locations of the 18 sites and the temporary barriers can be found on the Site Map, Figure 1-2. Benchmark location coordinates and elevations can be found in Table 1-1.

¹ http://baydeltaoffice.water.ca.gov/sdb/tbp/index_tbp.cfm



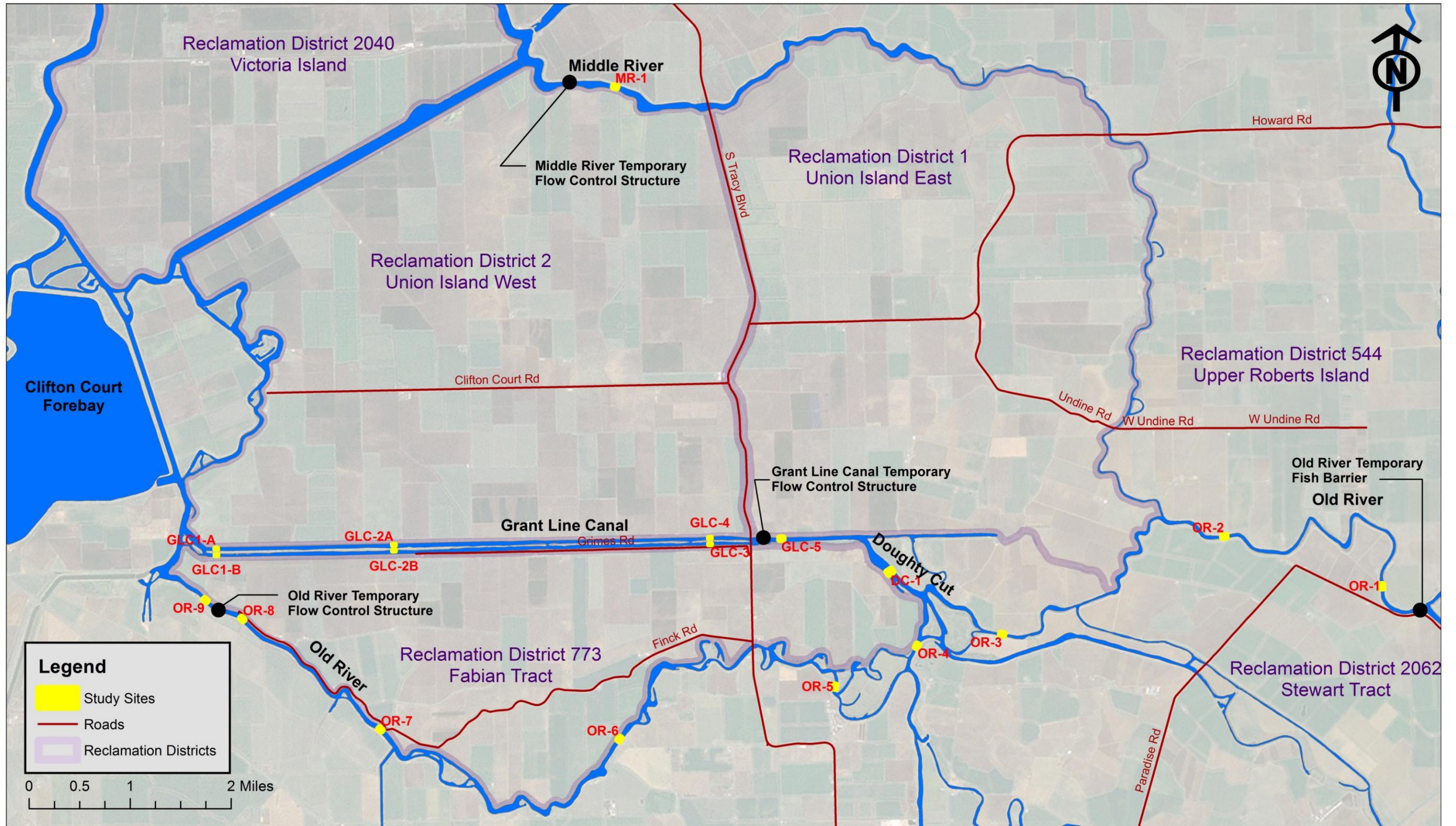


Figure 1-2: Site Map



Table 1-1: Benchmark Elevations and Locations

Benchmark	Elevation (feet)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	State Plane Easting-ft	State Plane Northing-ft
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.

**GLC-2a & GLC-2b do not have benchmarks, but they are located in the old GLC-2 study area.*

1.1 PREVIOUS REPORTS

Three previous reports have been submitted to the Bay-Delta Office (BDO). The following is a short summary of the findings from the previous reports.

- Bed Sediment Monitoring in the South Delta Memorandum Report (DWR 2004):** 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.
- Bed Sediment Monitoring in the South Delta Spring, 2003 – Fall 2010 (DWR 2011):** 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.

- **Bed Sediment Monitoring in the South Delta, Fall 2010 – Spring 2012 (DWR Mar 2013):** The DWR Mar 2013 report covered surveys from fall 2010 through spring 2012. Bathymetric data was collected at 17 sites on a semi-annual basis. Monthly data began being collected at four sites (GLC-3, GLC-4, GLC-5, DC-1) in March 2012, with data from March 2012 through August 2012 being reported. Based on the semi-annual surveys all but three sites showed a stable or decreasing trend in sediment levels. Based on the limited data from the monthly surveys, only GLC-3 had shown a net increase in sediment as of August 2012. It was recommended that the study plan be updated to reflect current technology and lessons learned. It was also recommended that monthly surveys be continued.

1.2 REPORT COMPONENTS

Data for the DWR 2004 and DWR 2011 consisted of semi-annual surveys and sediment sampling. Beginning with the DWR Mar 2013 report, monthly surveys at four sites were added and sediment sampling was removed. The data in this report consists of cross-sections, volumetric analysis, and channel bottom contour plots.

1.2.1 Cross Sections

Each time a study area is surveyed, for both semi-annual and monthly surveys, cross-sections and a centerline profile are created. Cross-sections are created every 50 feet, with the first cross-section starting on the upstream side of the study area. For the average 100ft by 200ft study area, there are five cross-sections: 0ft, 50ft, 100ft, 150ft, 200ft; and one centerline profile.

1.2.2 Volumetric Analysis

A volumetric analysis is performed on the monthly survey data. In the DWR 2011 report, volumes were determined based on the semi-annual surveys. The monthly surveys provide a smaller time step that makes following changes in sediment volumes easier to understand. Information gained from monthly surveys may allow for reliable future volumetric analysis of semi-annual surveys.

1.2.3 Channel Bottom Contour Plots

The bathymetric data collected is used to create raster images of the channel bottom. The raster images are used to create cross-sections and compare volumes. Applying a color scale showing relative depth to the raster images provides a visual, and possibly a more intuitive, way of looking at changes in sediment on the channel bottom.



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, staff no longer needs to survey the bench marks (BM) and the water surface, reducing measurement errors. There is, however, a base station and transmitter that needs to be monitored when using the RTK GPS.

Obtaining and maintaining temporary entry permits have proven to be a challenge for this project. It is costly to renew or obtain permits and some permits require yearly updating and/or have conditions tied to the permit such as submission of survey data and/or providing notice prior to entry.

2.2 DATA ANALYSIS

The analysis for this report is done using two programs, ArcGIS and Microsoft Excel. Data from the BTS is provided in the form of xyz point data. ArcGIS is used predominately to create raster surfaces, cross-section xy data, do basic volumetric comparisons, and produce maps. Excel is used to store the raw data provided by the BTS, create cross-sections from the xy data, and to do volumetric analysis.



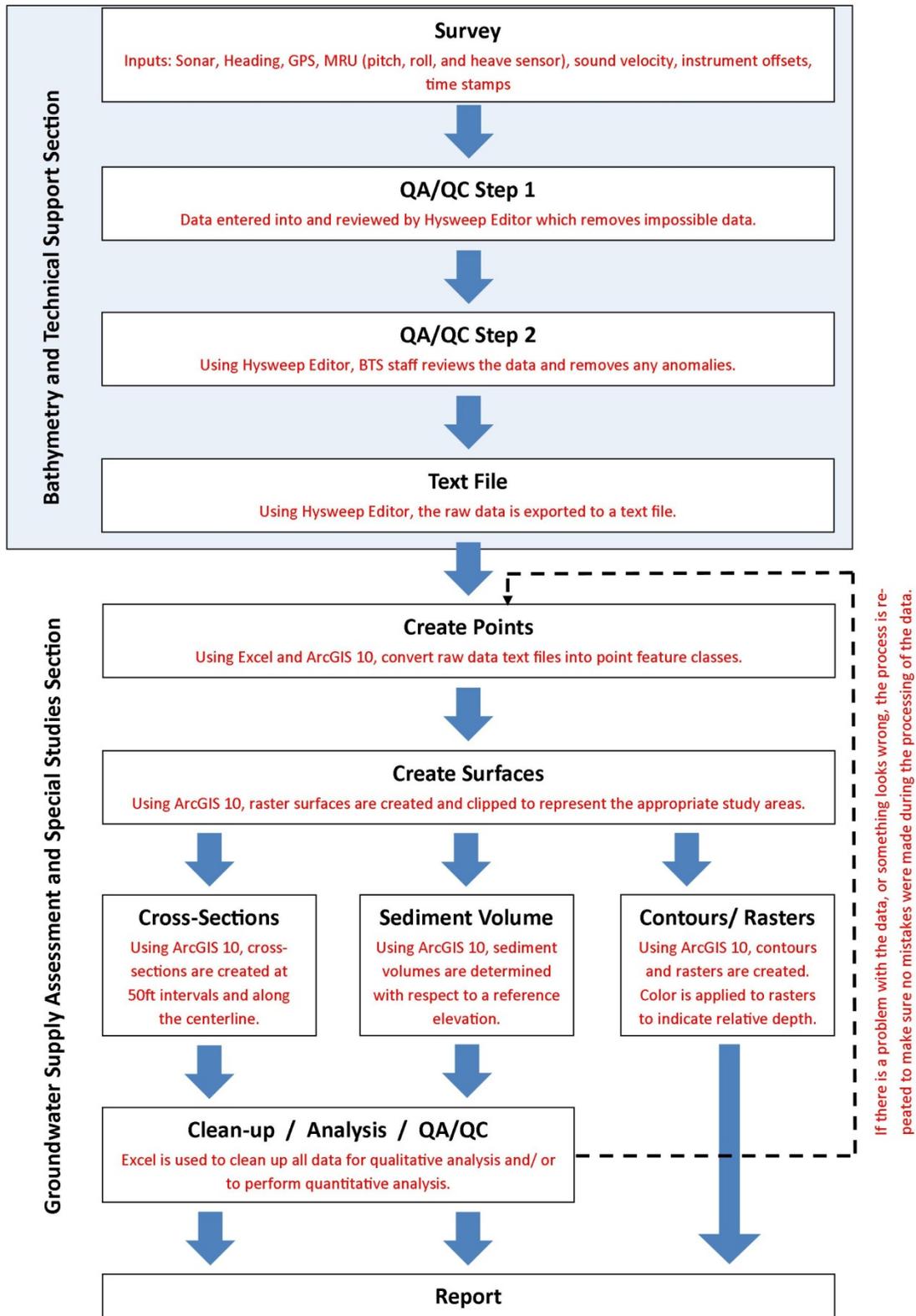


Figure 2-1: The Sediment Monitoring Process



2.2.1 Raster Images and Channel Bottom Contours

Data in the form of xyz points are imported into ArcGIS. Using a nearest neighbor raster interpolation method, a raster image is created from the points. The raster image is the foundation of the analysis, as all other calculations and plots are based off the raster image.

After the raster image is created, the image is clipped to the size of the study area, so that similar areas are compared. From the clipped image, cross-sections are created and a basic volumetric comparison is done using a reference raster with a constant elevation of -100ft NAVD88.

The last step, for monthly survey data, is the process of creating a contour map, and applying a color scale based on elevation. The color scale is such that **RED** is shallower and **GREEN** is deeper.

2.2.2 Cross-Sections

Cross-section plots show data from the four most recent surveys in color and all previous data (historic data) in light gray to provide a historic reference. All cross-section plots have the same vertical reference scale for easy comparison between study areas.

For each site, a subjective visual inspection of the cross-sections and centerline profiles were conducted for the semi-annual surveys in 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 four most recent surveys?
- 2.) How does the data for the four most recent surveys fit within the context of the historical data?

There were six possible responses for each of the above questions. Table 2-1: Visual Inspection Criterion, 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.

2.2.3 Volumetric Analysis

A month to month volumetric analysis was conducted for the four monthly survey 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 processing, and results are reported in both graphical and tabular formats.

During the surveying process, not all of a study area may have been surveyed. All efforts are made to survey the entire study area, but tide and obstacles such as branches can prevent some areas from being fully surveyed. To prevent comparing inconsistent areas, the surveyed areas are normalized to the actual area of the study site. All study areas, except for DC-1, have an area of 100ft by 200ft. DC-1 has an area of 200ft by 275ft. To address the portion not surveyed, an average elevation was taken from the surveyed portion and applied to the un-surveyed portion of the study area.



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 R. Table 3-1 contains the results of the visual inspection of the cross-sections and centerline profiles for the semi-annual surveys.

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

Site	Sediment Levels	Compared to Historic Data
OR-1	Unknown*	High Side of Historical*
OR-2	Stable*	Above & Below Historical*
OR-3	Stable*	Above & Below Historical*
OR-4	Stable*	Low Side of Historical
OR-5	Stable	Consistent w/ Historical
OR-6	Stable*	High Side of Historical*
OR-7	Possible Decrease*	Consistent w/ Historical
OR-8	Stable*	Consistent w/ Historical
OR-9	Stable	Low Side of Historical
GLC-1A	Stable	Below Historical*
GLC-1B	Stable	Consistent w/ Historical
GLC-2A	Stable ⁺	Insufficient History ⁺
GLC-2B	Stable ⁺	Insufficient History ⁺
GLC-3	Stable	Above Historical*
GLC-4	Stable	Low Side of Historical
GLC-5	Possible Increase*	High Side of Historical*
DC-1	Stable*	Consistent w/ Historical*
MR-1	Stable	Consistent w/ Historical

* These values have changed since the 2012 report.

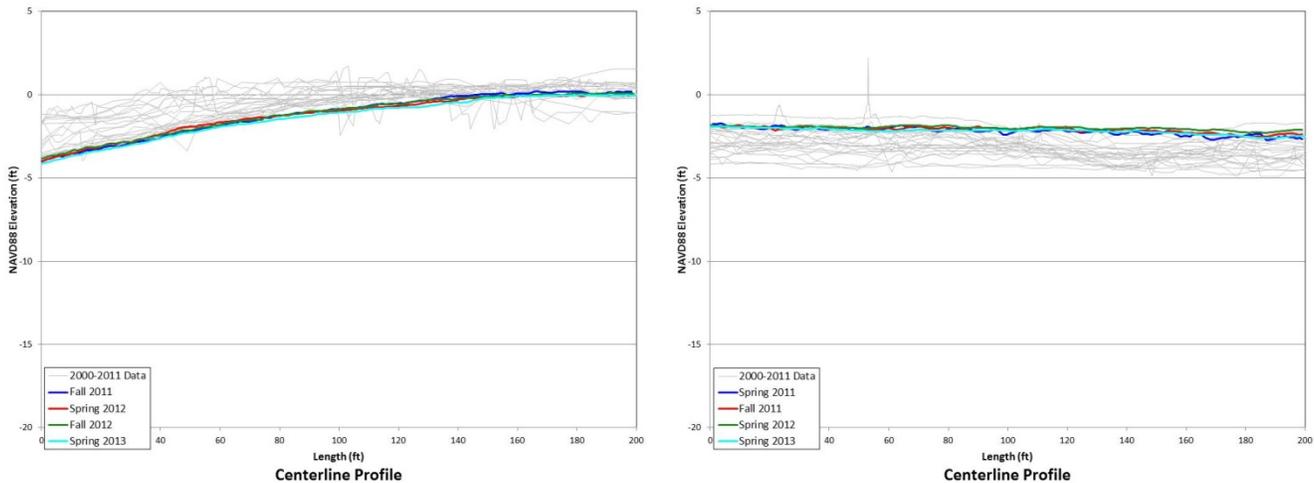
⁺ These sites are new since the DWR 2011 report.

The four most recent semi-annual surveys suggest that the sediment levels are relatively stable. While 15 sites have been labeled stable, 9 of those sites were not considered stable in the *DWR Mar 2013* report, and GLC-2A and GLC-2B, while stable, have only been surveyed three times.

When considering whether sediment levels are stable, how the recent data compares to historic data needs to be considered. While recent surveys might



appear to be stable, it is possible sediment levels are increasing or decreasing at rate that is difficult to discern. Both OR-4 and GLC-3 appear to have stable sediment levels (Table 3-1), however OR-4 is on the low end of the historical data and GLC-3 is on the high end, possibly indicating slow long term changes with very different results. The relevance of historic data can be seen in Figure 3-1 showing the centerline profile for both OR-4 and GLC-3.



OR-4 Centerline Profile

GLC-3 Centerline Profile

Figure 3-1: Relevance of Historical Data

3.2 MONTHLY SURVEY DATA

Monthly data began being collected in March of 2012 at four sites: GLC-3, GLC-4, GLC-5, and DC-1; and cross-sections for these surveys can be found in appendices S through V. Since March 2012, the temporary barrier on Grant Line Canal has been installed twice and removed once, and can be seen on the following *Monthly Changes in Sediment Volume* plots. The red boxes highlight the periods when barrier installation/removal took place.



3.2.1 GLC-3 Monthly Surveys

GLC-3 is a 100ft by 200ft study area located on Fabian Bell Canal approximately one half mile downstream of the barrier on Grant Line Canal near Tracy Boulevard (Figure 3-3). An island separates Fabian Bell Canal from Grant Line Canal, and GLC-4 is located across from GLC-3 on Grant Line Canal.

Monthly data did not officially begin to be collected on GLC-3 until June; the April data point was taken from the semi-annual survey (Figure 3-2, Table 3-2). In 2012, when the barrier was in place, there was minimal deposition or scour. During the barrier removal process, there was an increase in deposition, and following the removal of the barrier, there was a significant amount of scour (-198cy). In 2013, following the installation of the barrier, there was a large amount of deposition (+107cy).

As of July 2013, there has been a net loss of sediment volume since April 2012, around 34 cubic yards. For the GLC-3 study area, a 100 cubic yard change in sediment equates to an average change in depth of approximately 1.6 inches; therefore, during the period of April 2012 through July 2013, GLC-3 has become, on average, one half inch deeper. Month to month changes in sediment loads can be seen in the contour plots in Figure 3-4.

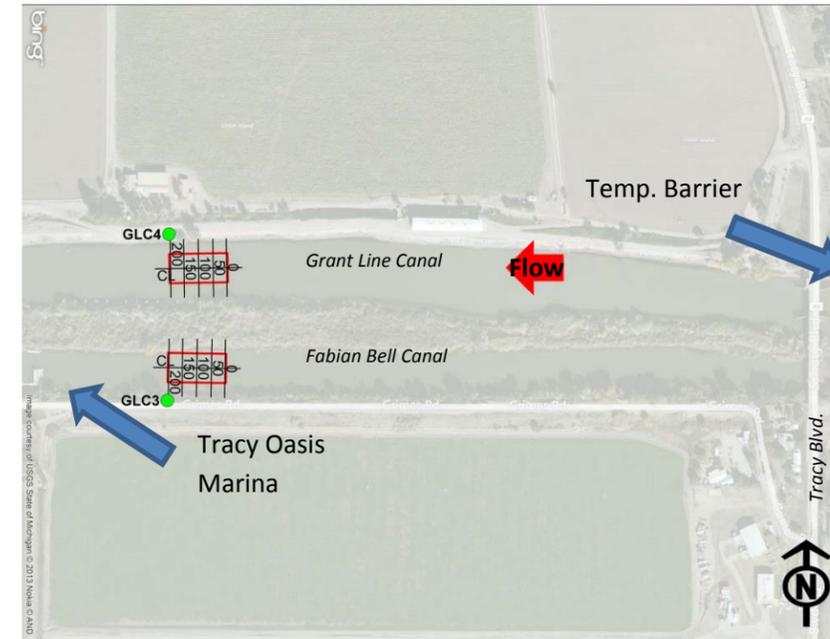


Figure 3-3: GLC-3 Site Map



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

Table 3-2: GLC-3 Monthly Volumetric Calculations

Survey Date	Mean Calculated Elevation NAVD88 [ft]	Cumulative Volume [yds ³]	Month to Month Volume Change [yds ³]	Cumulative Moving Average [yds ³]
04/10/12	-2.05	0	0	0
No Survey Done				
06/11/12	-2.03	14	14	7
07/25/12	-1.99	40	26	13
08/21/12	-2.02	22	-19	5
09/19/12	-2.06	-9	-30	-2
10/16/12	-2.01	27	36	5
11/07/12	-1.99	46	19	7
12/01/12	-2.25	-152	-198	-19
01/24/13	-2.25	-151	1	-17
02/21/13	-2.28	-173	-22	-17
03/12/13	-2.34	-217	-44	-20
No Survey Done				
05/02/13	-2.25	-151	67	-13
06/13/13	-2.24	-141	10	-11
07/25/13	-2.09	-34	107	-2



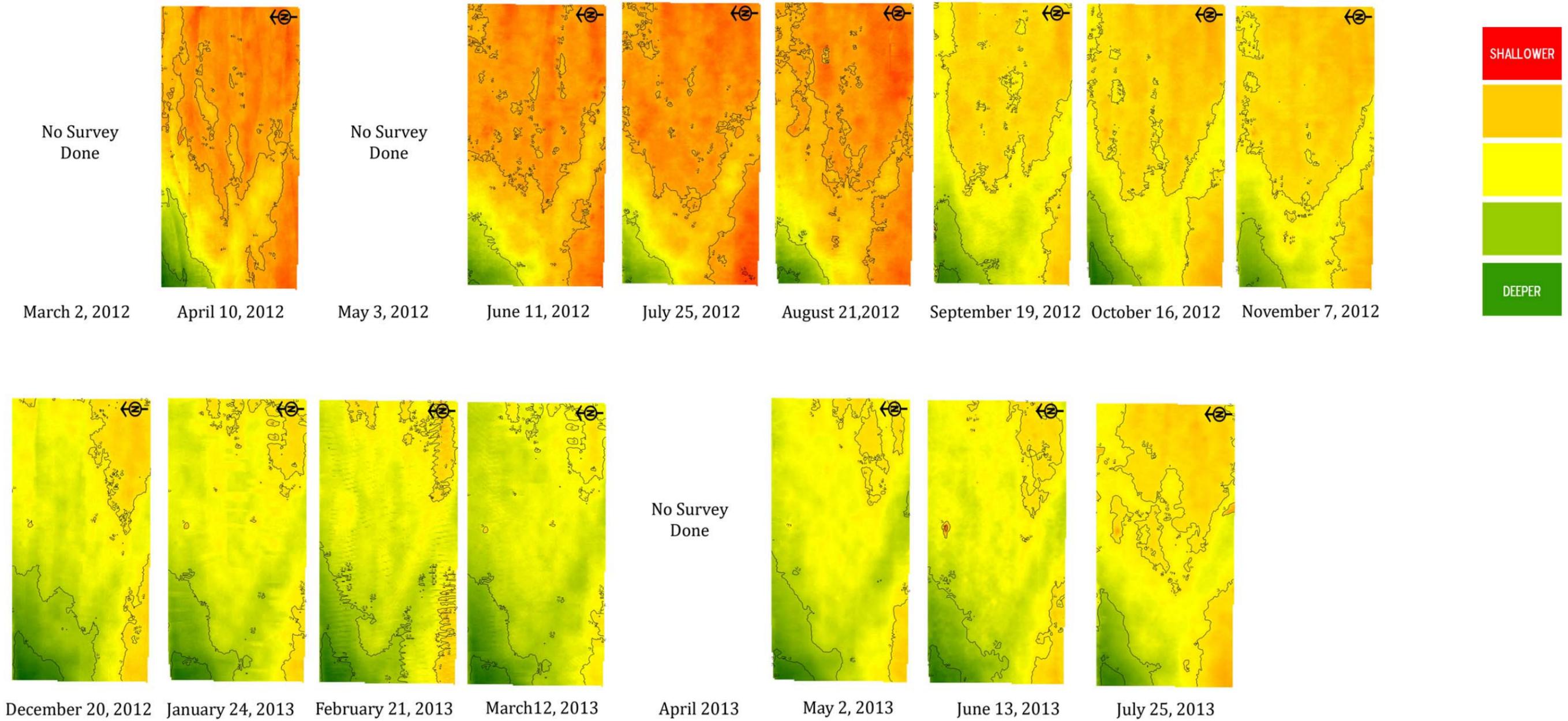


Figure 3-4: GLC-3 Monthly Contours

3.2.2 GLC-4 Monthly Surveys

GLC-4 is a 100ft by 200ft study area located on Grant Line Canal approximately one half mile downstream of the barrier on Grant Line Canal near Tracy Boulevard (Figure 3-6). An island separates Grant Line Canal from Fabian Bell Canal, and GLC-3 is located across from GLC-4 on Fabian Bell Canal.

The biggest month to month changes happened around the times when the barrier was being installed or removed (Figure 3-5, Table 3-3). After installation or removal, month to month sediment changes begin to taper off, until the cycle is started again.

Between May 2012 and October 2012, deposition occurred at GLC-4 (+300 cy), and during this time, the barrier on Grant Line Canal was in place and flows were low. Significant scour occurred between October 2012 and May 2013 (-366 cy); during this period, there was no barrier in place, and flows were the highest.

As of the July 2013 survey, the cumulative change in sediment volume, since March 2012, has been a reduction of approximately 370 cubic yards of sediment. For the period of March 2012 through July 2013, GLC-4 has become, on average, almost 6 inches deeper. The month to month change in sediment load can be seen in contour plots in Figure 3-7.

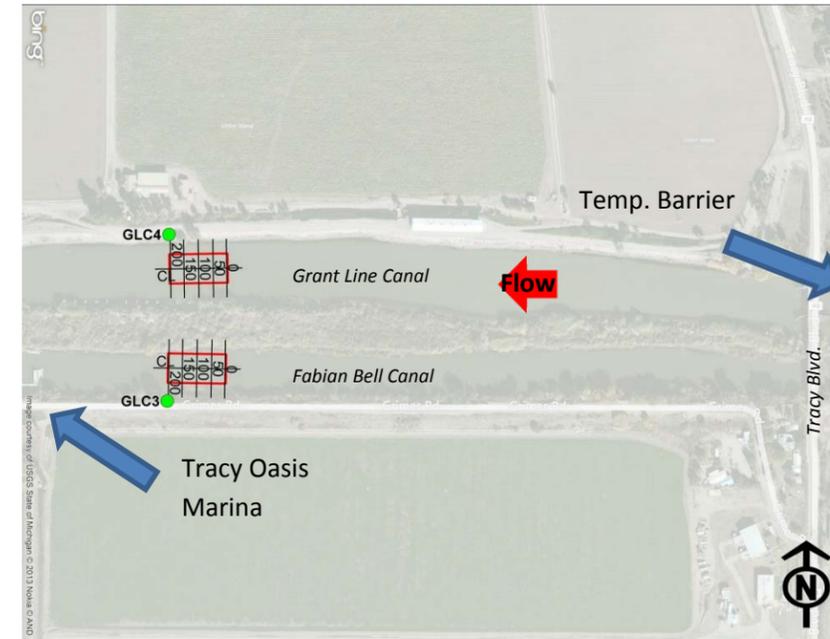


Figure 3-6: GLC-4 Site Map

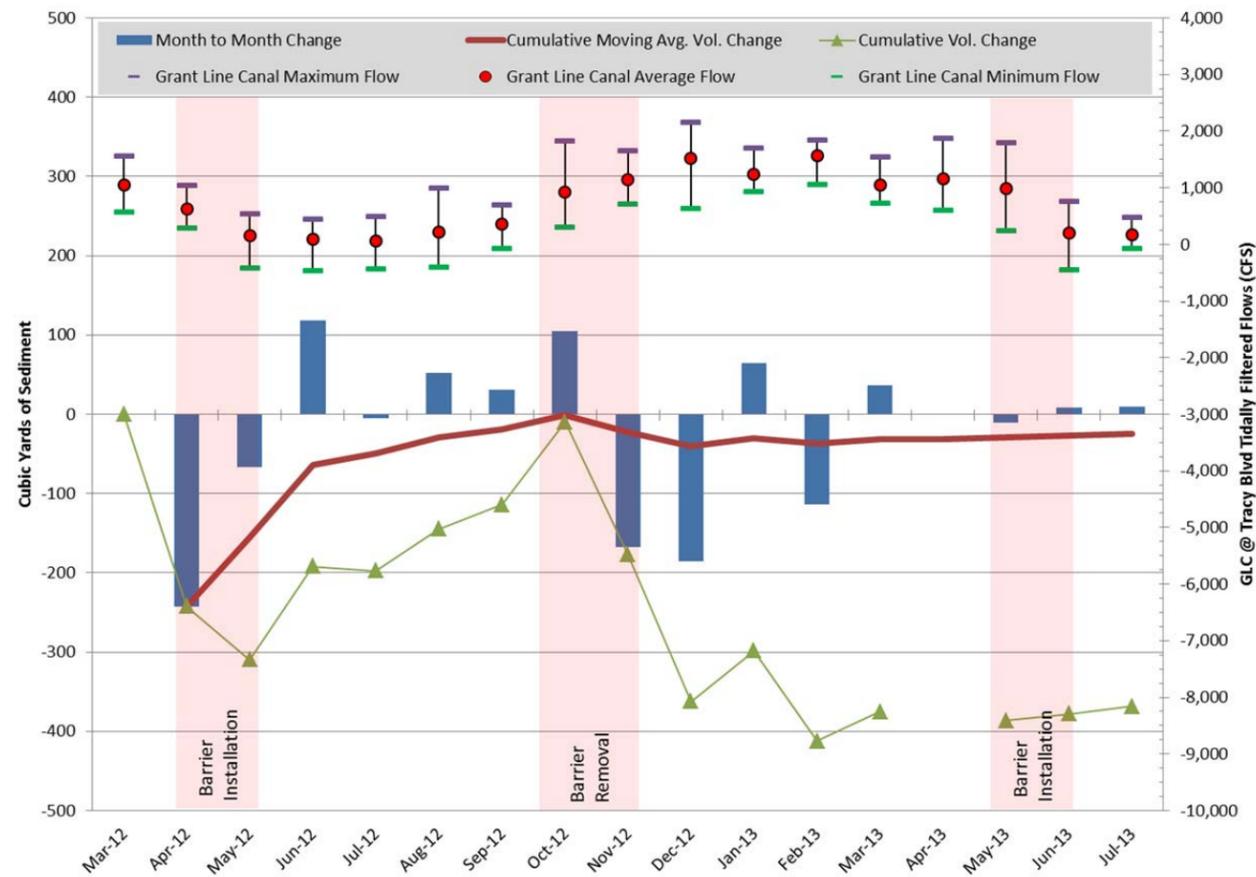


Figure 3-5: GLC-4 Monthly Changes in Sediment Volume

Table 3-3: GLC-4 Monthly Volumetric Calculations

Survey Date	Mean Calculated Elevation NAVD88 [ft]	Cumulative Volume [yds ³]	Month to Month Volume Change [yds ³]	Cumulative Moving Average [yds ³]
03/02/12	-9.59	0		
04/10/12	-9.92	-243	-243	-243
05/03/12	-10.01	-310	-67	-155
06/11/12	-9.85	-192	118	-64
07/25/12	-9.85	-197	-5	-49
08/21/12	-9.78	-145	52	-29
09/19/12	-9.74	-114	31	-19
10/16/12	-9.60	-10	105	-1
11/07/12	-9.83	-177	-168	-22
12/20/12	-10.08	-363	-185	-40
01/24/13	-9.99	-299	64	-30
02/21/13	-10.14	-413	-114	-38
03/12/13	-10.10	-376	37	-31
No Survey Done				
05/02/13	-10.11	-386	-11	-30
06/13/13	-10.10	-378	8	-27
07/25/13	-10.09	-369	10	-25



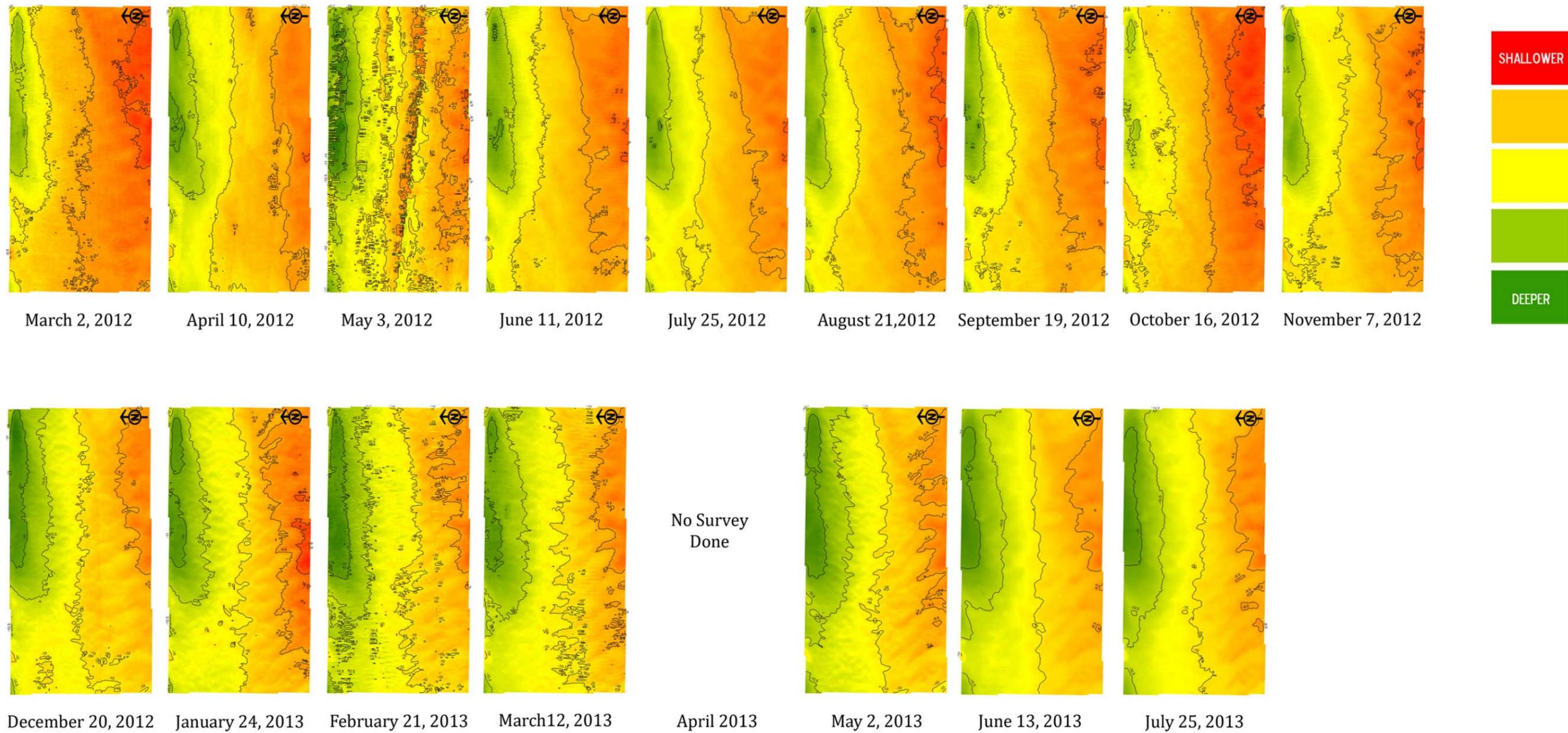


Figure 3-7: GLC-4 Monthly Contours

3.2.3 GLC-5 Monthly Surveys

GLC-5 is a 100ft by 200ft study area located on Grant Line Canal approximately 1200ft upstream of the barrier on Grant Line Canal near Tracy Boulevard (Figure 3-9). GLC-5 is approximately 1.25 miles downstream of DC-1.

Major month to month changes occurred around the installation and removal of the barrier, with spikes generally occurring the month following installation or removal ($\pm 100 - 200\text{cy}$). Based on the limited amount of data, it appears that deposition begins to occur after the barrier is installed. When the barrier was removed in 2012, a significant amount of scour occurred between November 2012 and December 2013 (-192cy).

Between March 2012 and July 2013, there has been a reduction in sediment volume by approximately 60 cubic yards (Figure 3-8, Table 3-4), or an average increase in depth of about an inch. Month to month changes in sediment load can be seen in the contour plots in Figure 3-10.



Figure 3-9: GLC-5 Site Map

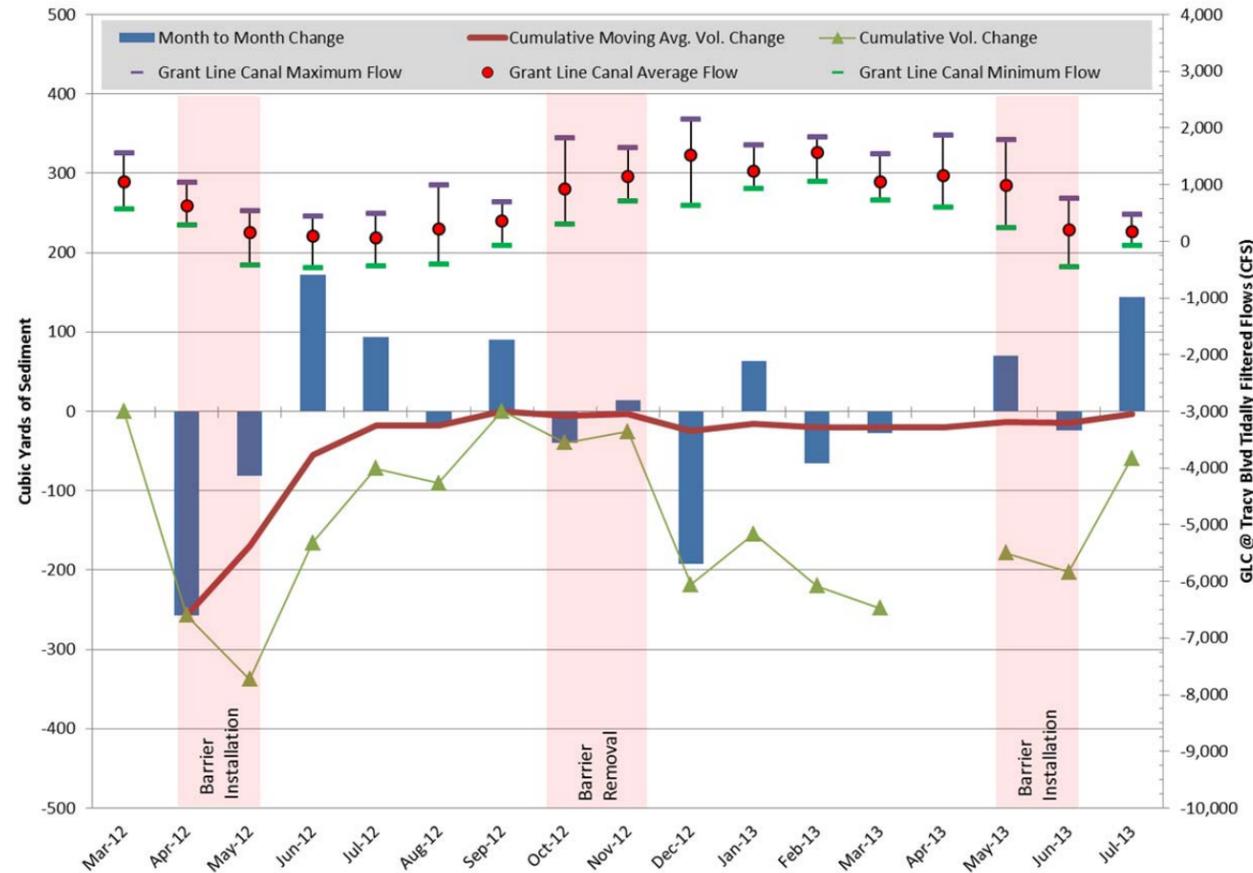


Figure 3-8: GLC-5 Monthly Changes in Sediment Volume

Table 3-4: GLC-5 Monthly Volumetric Calculations

Survey Date	Mean Calculated Elevation NAVD88 [ft]	Cumulative Volume [yds ³]	Month to Month Volume Change [yds ³]	Cumulative Moving Average [yds ³]
03/02/12	-15.68	0		
04/10/12	-16.03	-257	-257	-257
05/03/12	-16.14	-338	-81	-169
06/11/12	-15.91	-166	172	-55
07/24/12	-15.78	-72	94	-18
08/21/12	-15.81	-90	-18	-18
09/18/12	-15.68	0	91	0
10/16/12	-15.74	-39	-40	-6
11/07/12	-15.72	-26	14	-3
12/20/12	-15.98	-218	-193	-24
01/24/13	-15.89	-154	64	-15
02/21/13	-15.98	-220	-66	-20
03/12/13	-16.02	-248	-28	-21
No Survey Done				
05/02/13	-15.93	-179	70	-14
06/13/13	-15.96	-203	-24	-14
07/25/13	-15.76	-59	144	-4



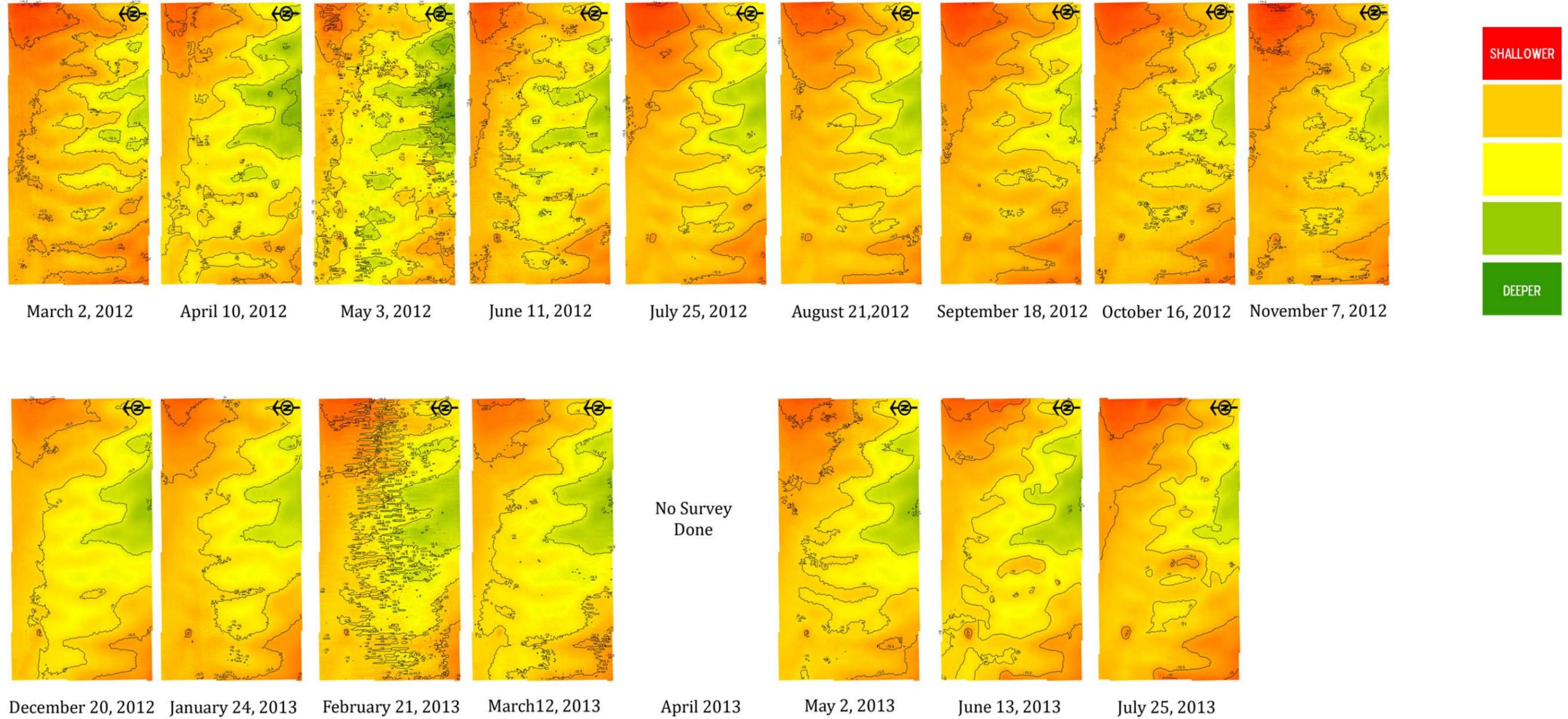


Figure 3-10: GLC-5 Monthly Contours

3.2.4 DC-1 Monthly Surveys

DC-1 is a 200ft by 275ft study area located on Doughty Cut, approximately 1.5 miles upstream of the barrier on Grant Line Canal (Figure 3-12). DC-1 is the furthest most upstream site that is surveyed monthly.

Large month to month changes occurred twice between March 2012 and July 2013 (Figure 3-11, Table 3-5), once the barrier was installed in 2012, and after the barrier was removed in 2012 (-523cy). After the barrier was installed in 2012, sediment deposition occurred (+440cy), until the barrier was removed. After the barrier was removed in October/ November 2012, there was a significant amount of scour that occurred between November and December (-523cy). December 2012 also had the largest maximum flow since the monthly surveys began, possibly accounting for the large reduction in sediment volume.

As of July 2013, there has been a significant amount of scour at DC-1, when compared to the first survey in March 2012. There has been a decrease of approximately 1,100 cubic yards of sediment from the study area; which translates to an increase in depth of approximately 5 inches. Month to month changes in sediment load can be seen on the contour plots in Figure 3-13.

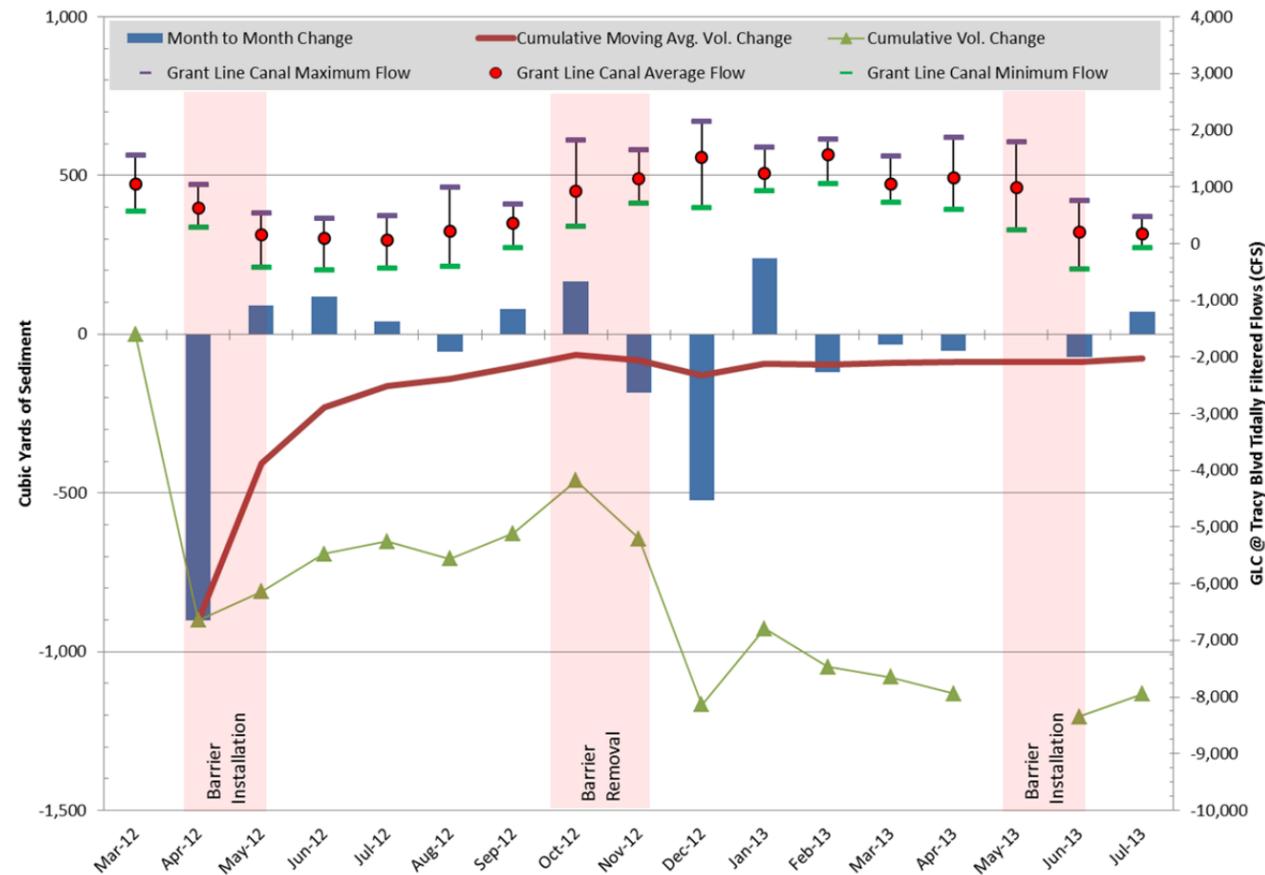


Figure 3-11: DC-1 Monthly Changes in Sediment Volume



Figure 3-12: DC-1 Site Map

Table 3-5: DC-1 Monthly Volumetric Calculations

Survey Date	Mean Calculated Elevation NAVD88 [ft]	Cumulative Volume [yds ³]	Month to Month Volume Change [yds ³]	Cumulative Moving Average [yds ³]
03/02/12	-4.41	0		
04/10/12	-4.85	-901	-901	-901
05/03/12	-4.80	-811	89	-406
06/11/12	-4.75	-692	119	-231
07/24/12	-4.73	-652	40	-163
08/21/12	-4.75	-707	-55	-141
09/18/12	-4.71	-627	80	-105
10/16/12	-4.63	-461	166	-66
11/07/12	-4.72	-645	-184	-81
12/01/12	-4.98	-1168	-523	-130
01/24/13	-4.86	-928	240	-93
02/21/13	-4.92	-1049	-120	-95
03/12/13	-4.94	-1080	-32	-90
04/11/13	-4.96	-1133	-52	-87
No Survey Done				
06/13/13	-5.00	-1205	-72	-86
07/25/13	-4.96	-1133	71	-76



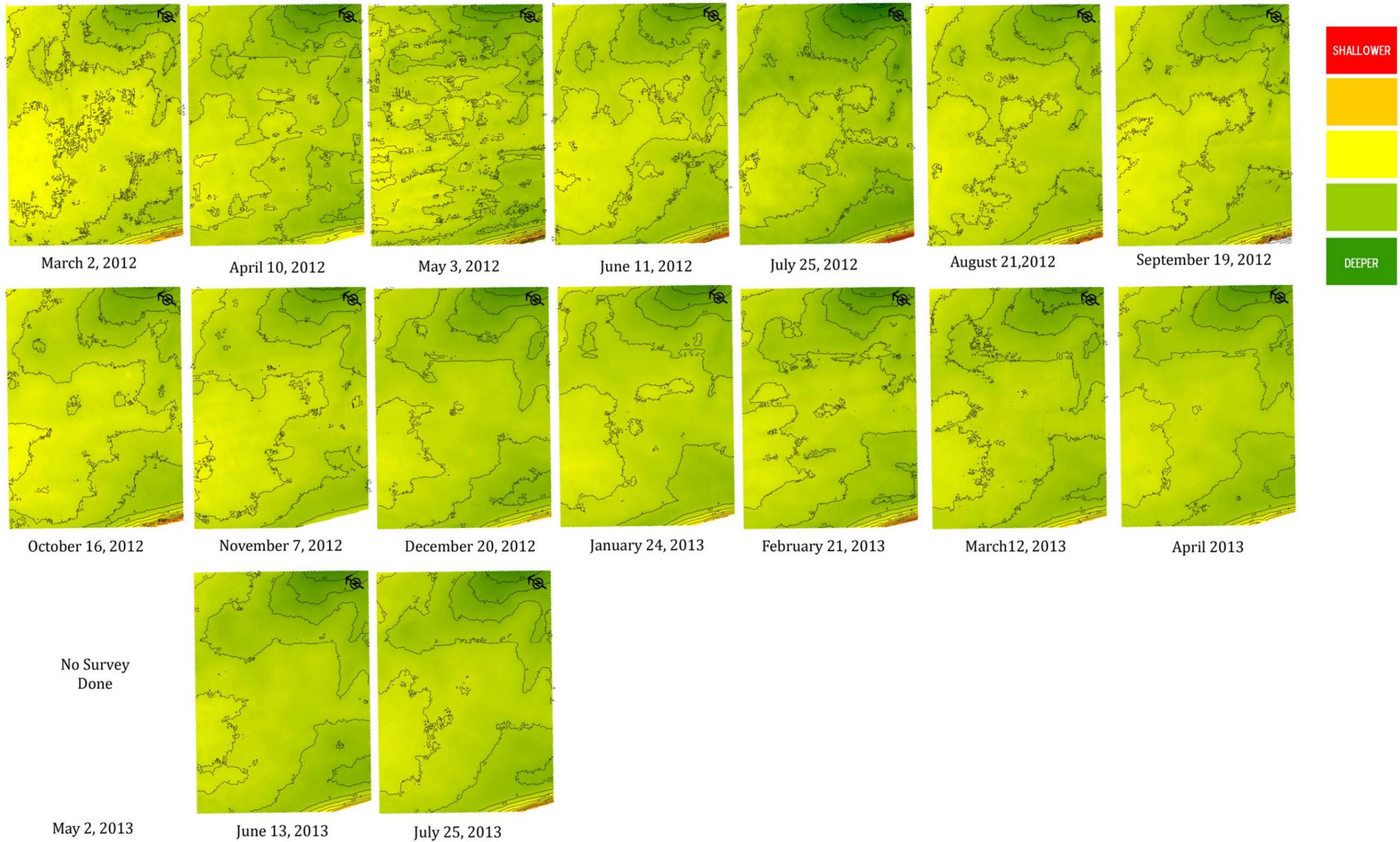


Figure 3-13: DC-1 Monthly Contours

3.2.5 The Monthly System

For the purpose of the monthly survey data, the system consists of GLC-3, GLC-4, GLC-5, the barrier on Grant Line Canal near Tracy Oasis Blvd, and DC-1.

Sediment volume at GLC-3, GLC-4, GLC-5 and DC-1 all seem to be impacted by the barrier; with increases in sediment volume when the barrier is in place and decreases in sediment volume when no barrier is in place. The barrier, however, is not the only parameter impacting sediment transport.

Tidal flows appear to have an impact on sediment transport, specifically for GLC-4. If the assumption is made that the barrier acts as a dam, the upstream water velocity would decrease as it approached the barrier, allowing suspended solids to settle out. If there was no flood tide, when the barrier was in place it would be reasonable to assume GLC-4 would see little to no accumulation and possibly scour when the barrier was in place. However, there is a flood tide and GLC-4 sees a consistent month after month increase in sediment levels when the barrier is in place. Applying the same barrier/dam assumption as above, but for the flood tide, it would explain why GLC-4 sees a consistent sediment accumulation month after month when the barrier is in place. The flood tide is moving sediment from downstream and that sediment load is settling out near the barrier as it impedes the flood tide

Sediment in the system appears to move both upstream and downstream, but how much of that sediment is new to the system is unknown. GLC-4 has a much slower rate of sediment accumulation in 2013 than in 2012; and the flood tide was weaker in 2013, based on the minimum flow in Grant Line Canal (Figure 3-5).

According to the Sacramento and San Joaquin Valley Water Year Indices, Water Year 2012 (Oct 1, 2011 – Sept 30, 2012) was considered Below Normal in the Sacramento Valley and Dry in the San Joaquin Valley². It appears the impact upstream flows have on flood flows influences downstream sediment accumulation when the barriers are in place.

4.0 Conclusions

The semi-annual surveys are developing a good qualitative baseline which is providing a historical range for future comparison. While 15 of the 18 sites have been deemed to be stable, only 7 sites were considered stable last year, and of those, only 3 sites are considered to be consistent with historical data. This suggests that any changes that may be occurring are happening slowly.

Monthly surveys have only been conducted since March 2012, but they have provided more detail than could have been had from a long time step surveys such as the semi-annual surveys. While the data set is still small, patterns have begun to

² Water year type based on the Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices (<http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST>).



emerge, such as the increase in sediment following the installation of the barriers, and scour after the barriers are removed. Tidal flows appear to impact the magnitude of sediment accumulation, and since 2012 and 2013 have been dry years as more data is collected and more water year types represented the impact upstream and tide flows may prove to be the determining factor in south Delta sediment transport, with the barriers possibly only having a superficial impact.

5.0 Recommendations

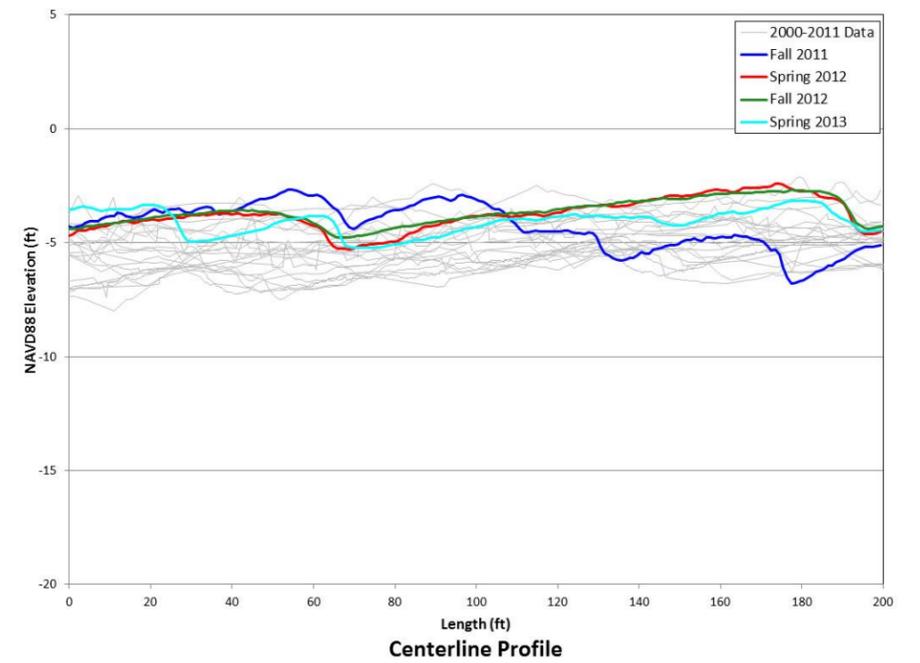
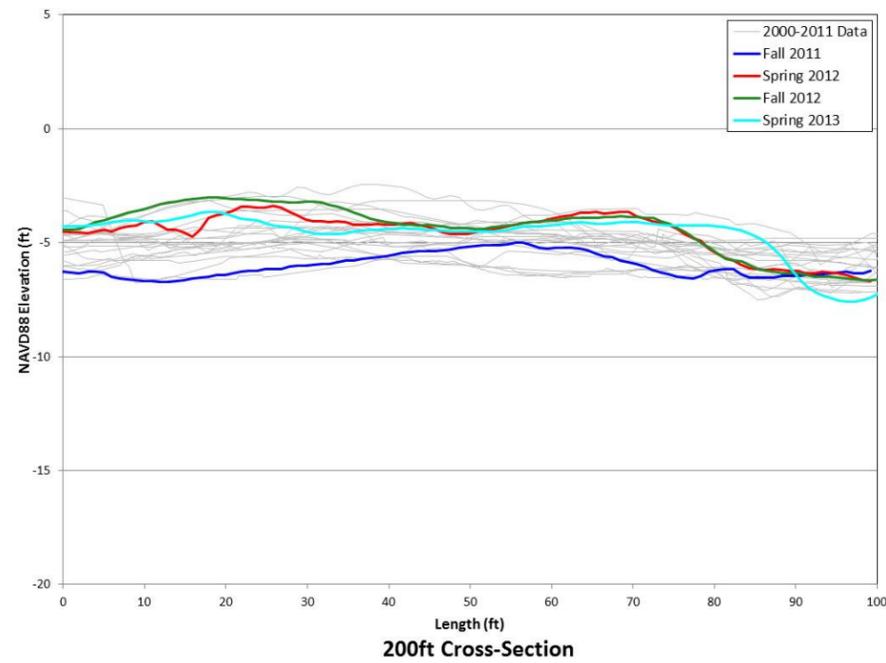
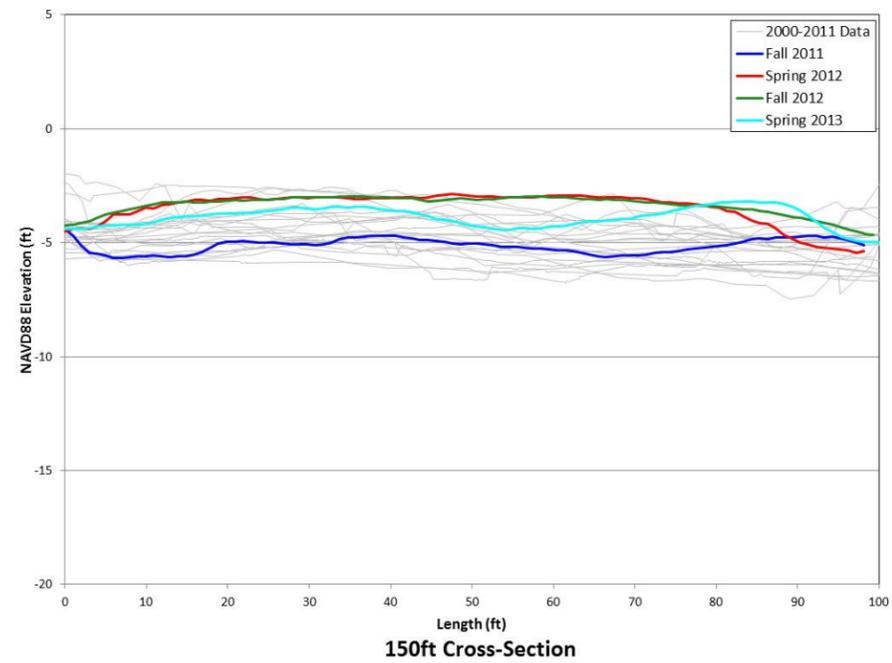
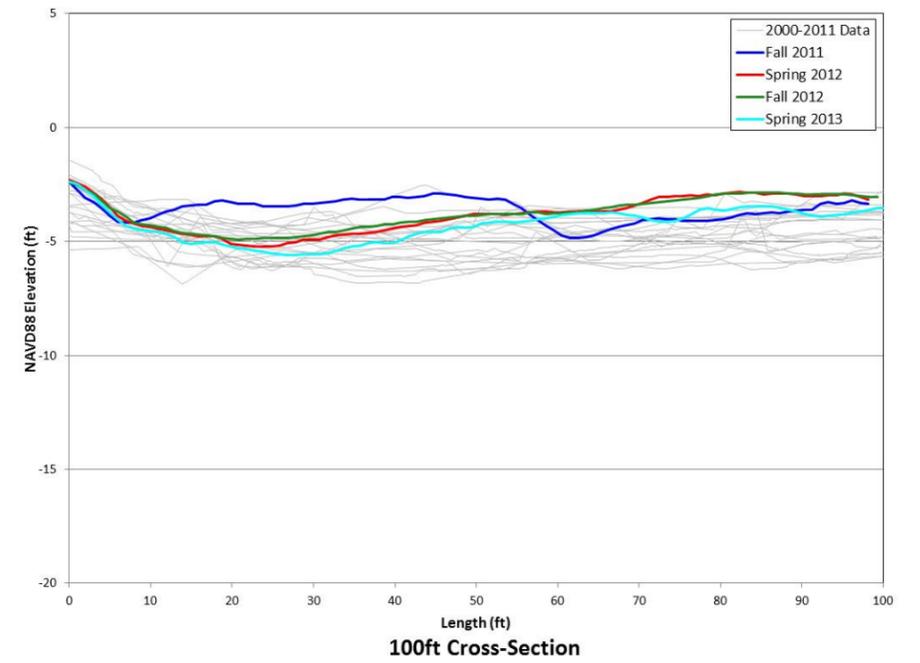
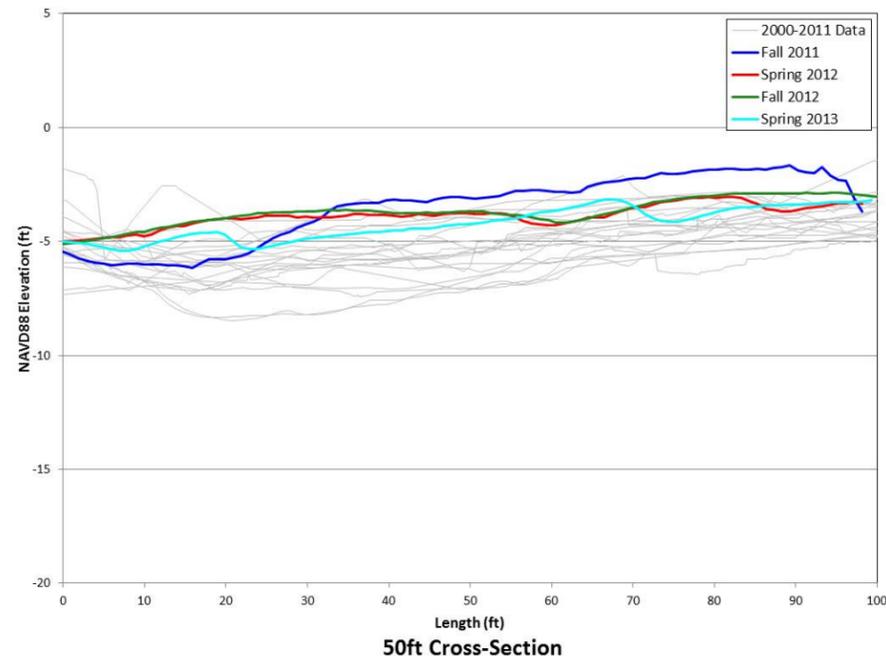
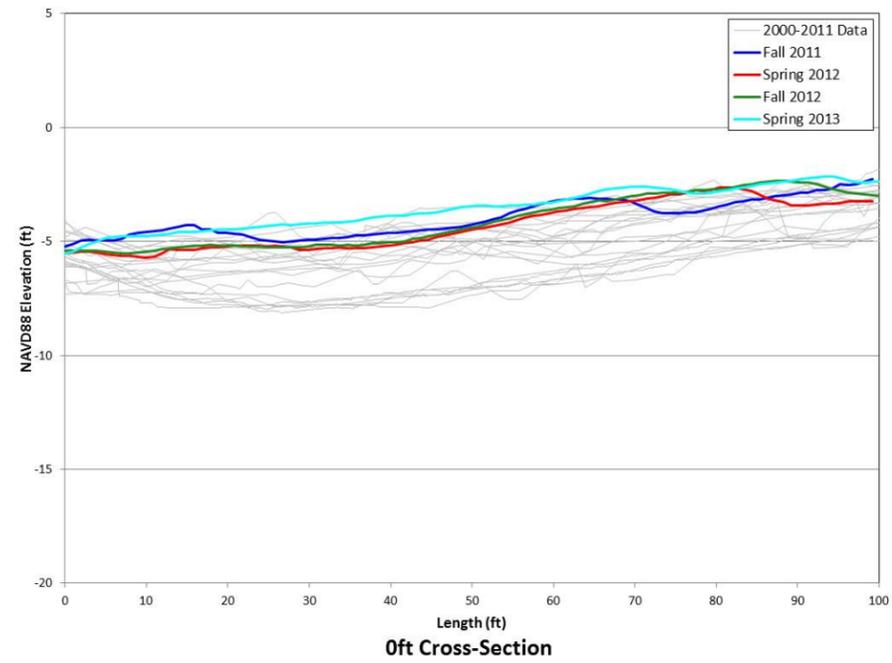
The monthly surveys have begun to provide data that will aid in the understanding of the magnitude of the impact the temporary barriers have on the sediment in the south Delta. It is recommended that monthly surveys continue until all water year types are represented.

There are no other recommendations at this time. Over the past year NCRO and the BDO have worked together to make modifications to the monitoring program based on recommendations from past reports. Below is a summary of the modifications that will be taking place in the near future:

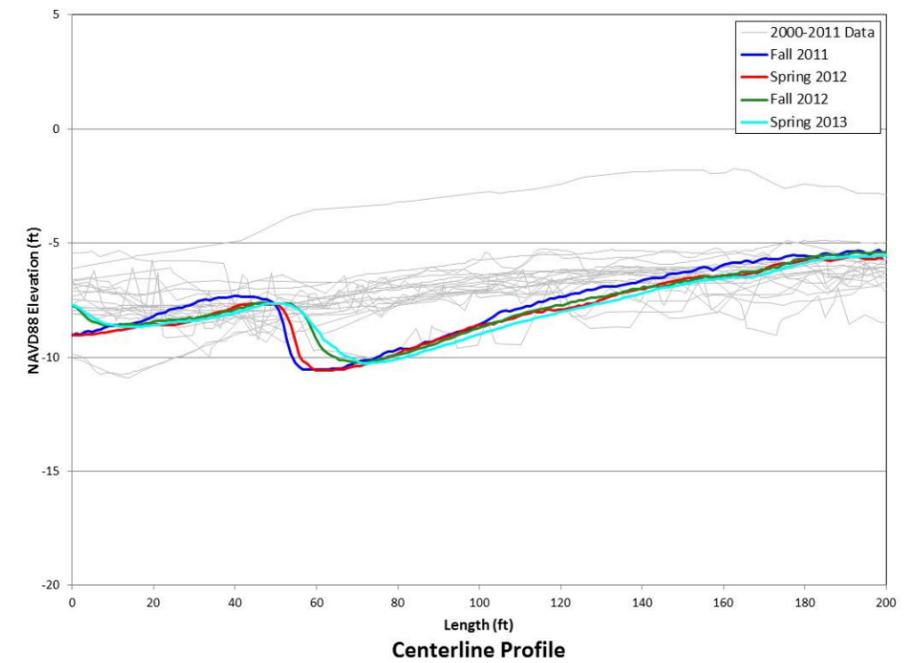
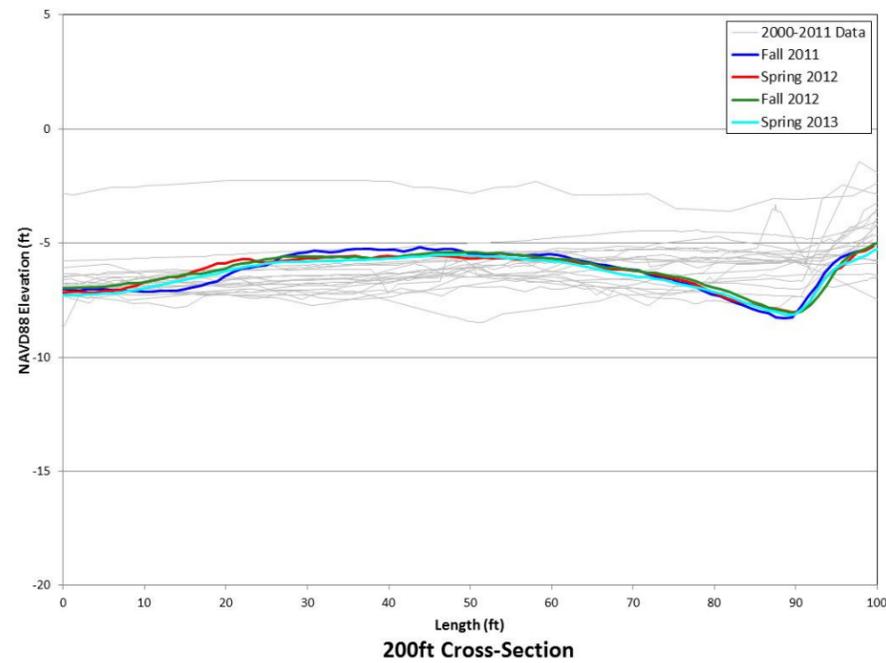
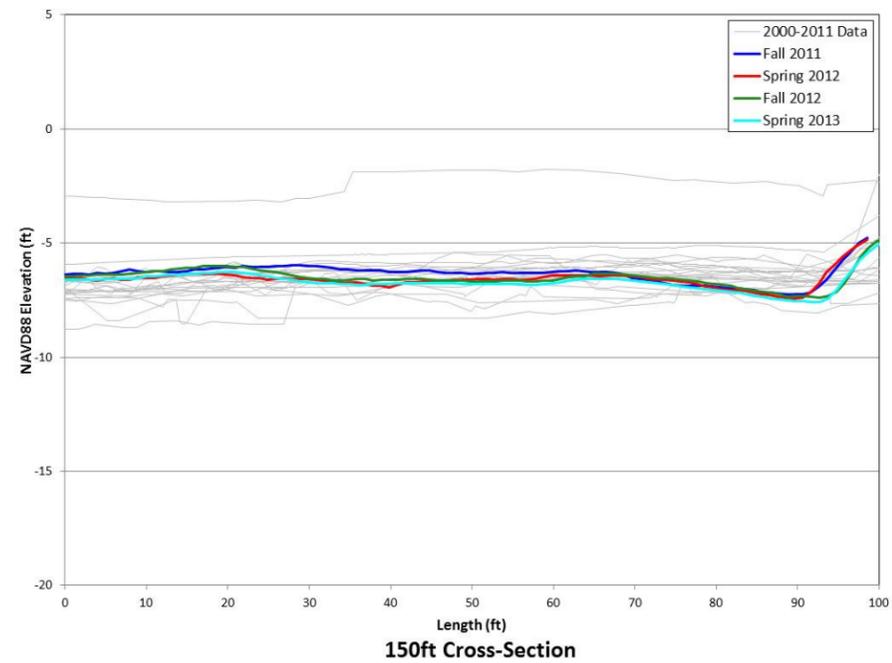
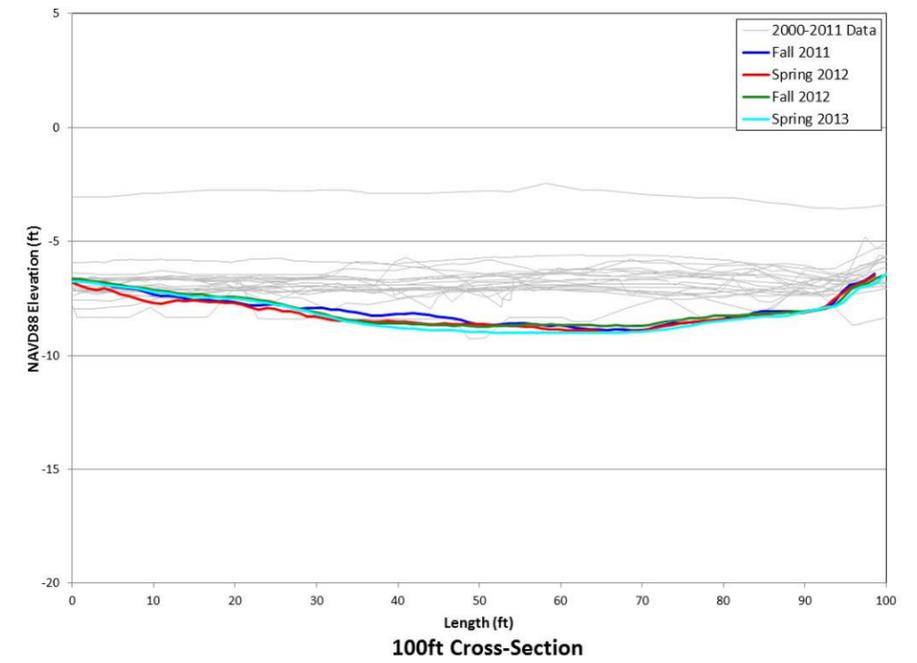
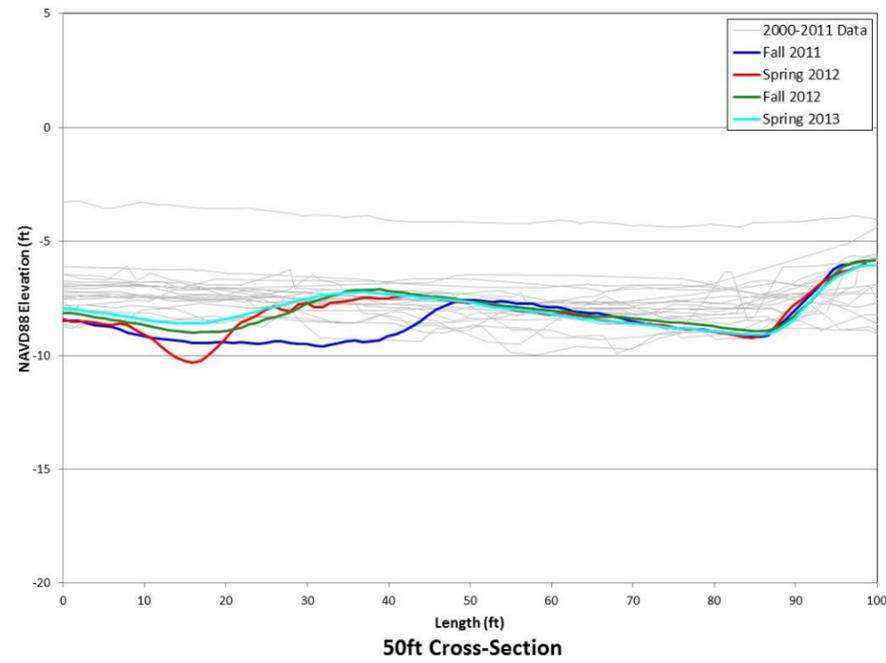
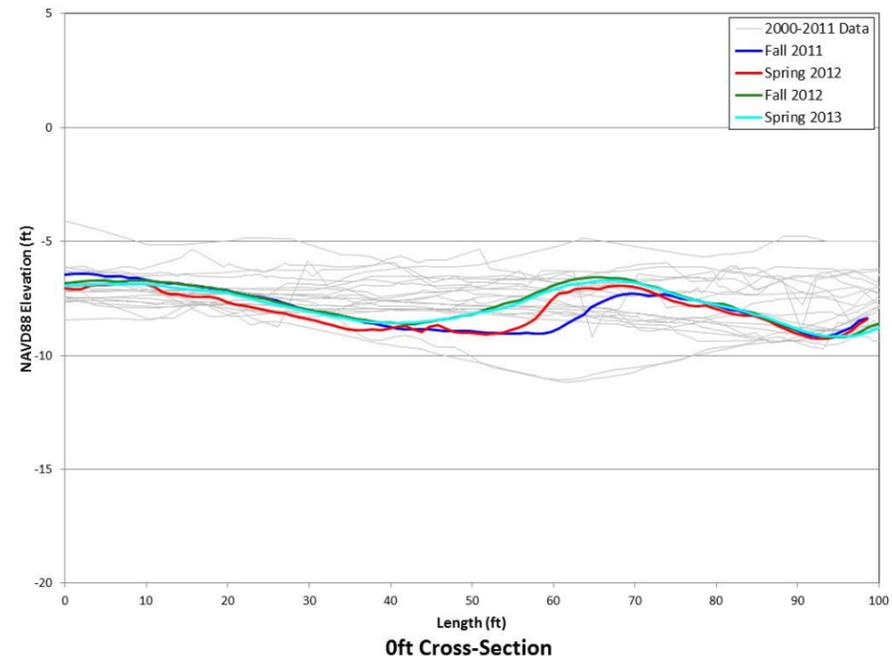
- The following sites will no longer be monitored semi-annually, but instead every three years: GLC-2A, GLC-2B, OR-2, OR-3, OR-5, OR-6, and OR-7.
- A new site, MR-2, will be added downstream of the barrier on Middle River.
- The study area of the remaining sites will be expanded to provide a better picture of what is happening in the channel.
- Monthly surveys at GLC-3, GLC-4, GLC-5, and DC-1 will continue until all water year types are represented.
- The preconstruction survey area will be expanded to match the new study area.
- An upstream pre-removal survey 1-2 weeks prior to barrier removal on Grant Line Canal will be added. A pre-removal survey will also be done downstream of the barrier for the first year.



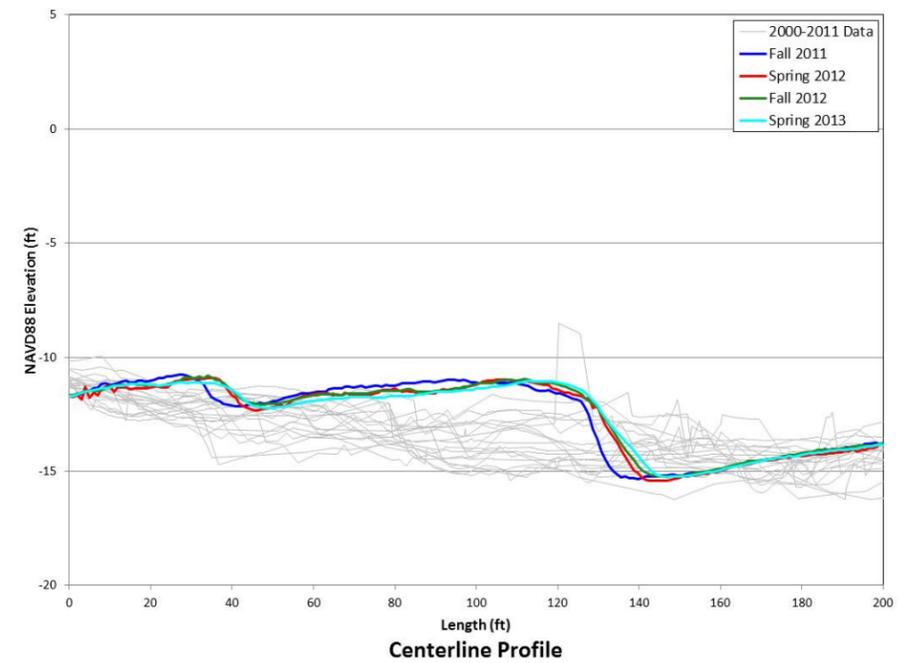
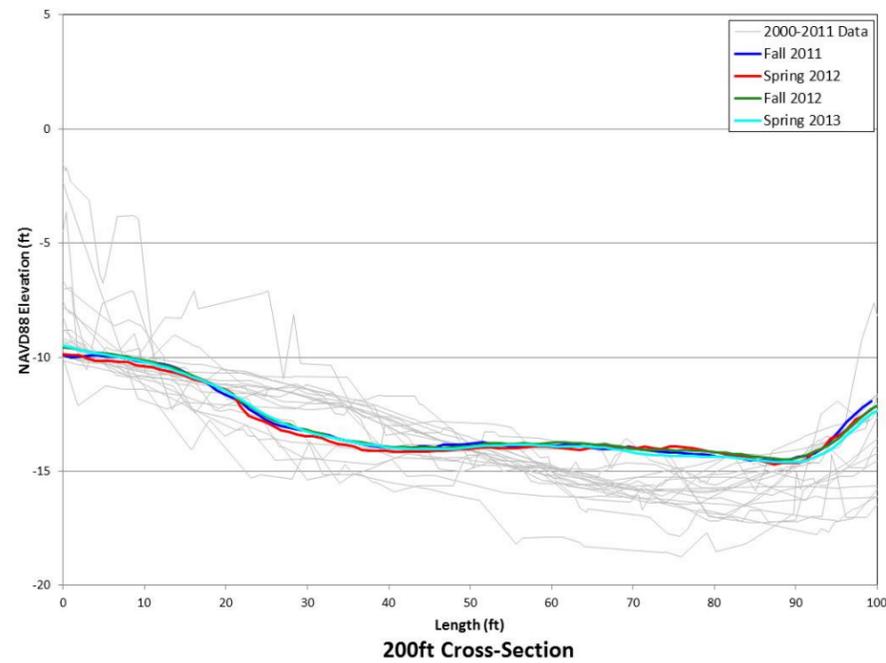
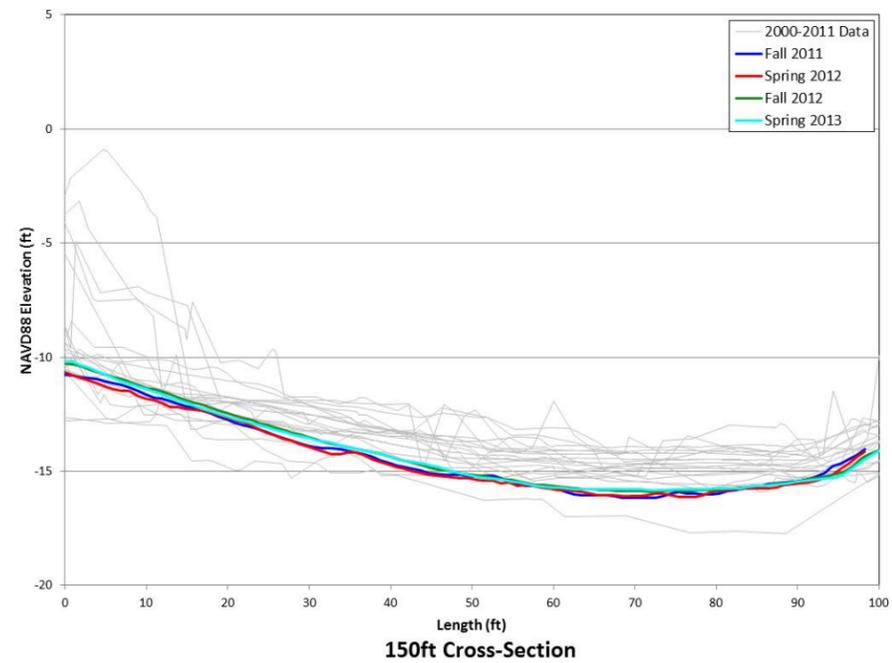
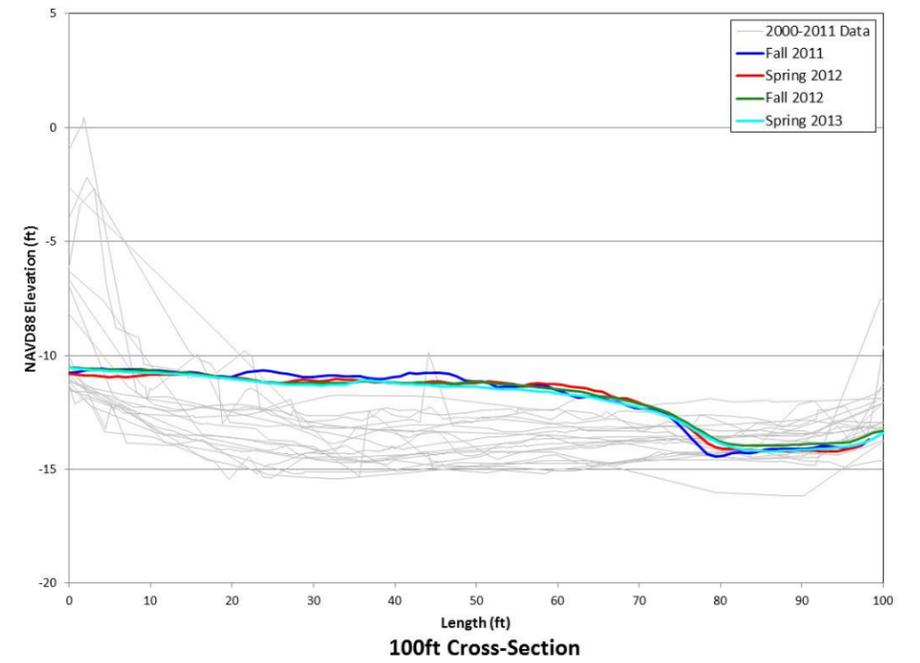
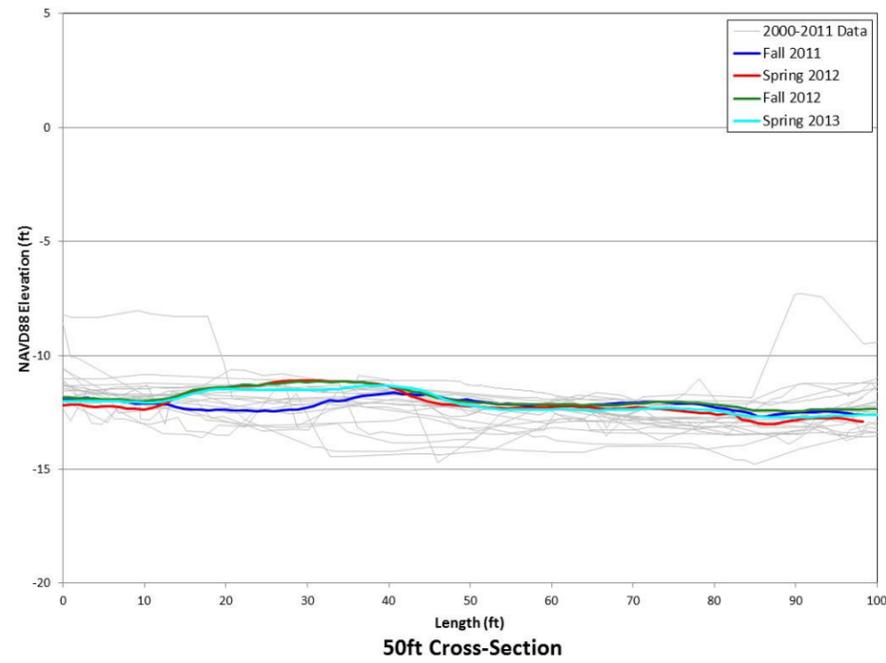
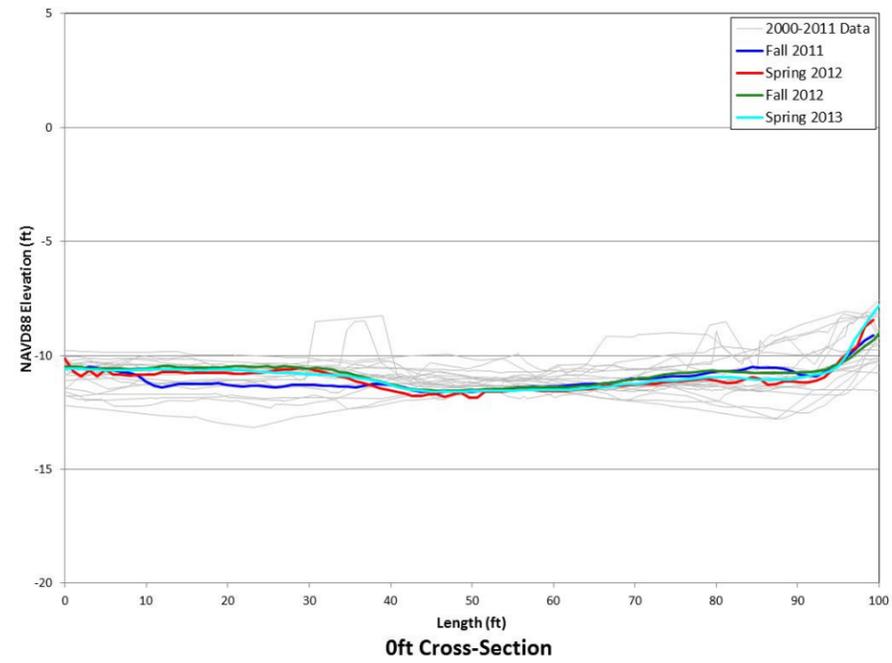
Appendix A: OR-1 Semi-Annual Cross-Sections



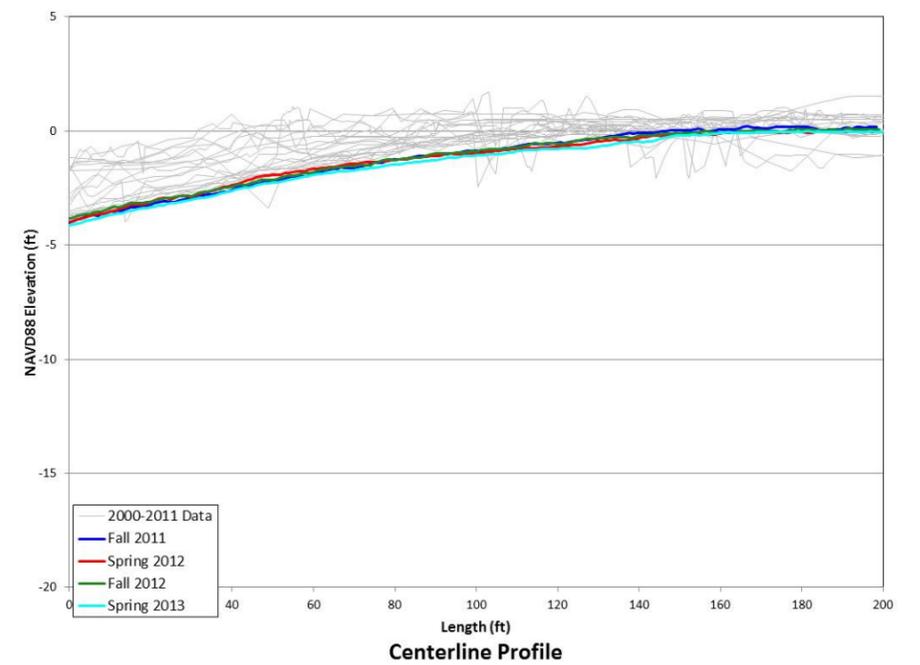
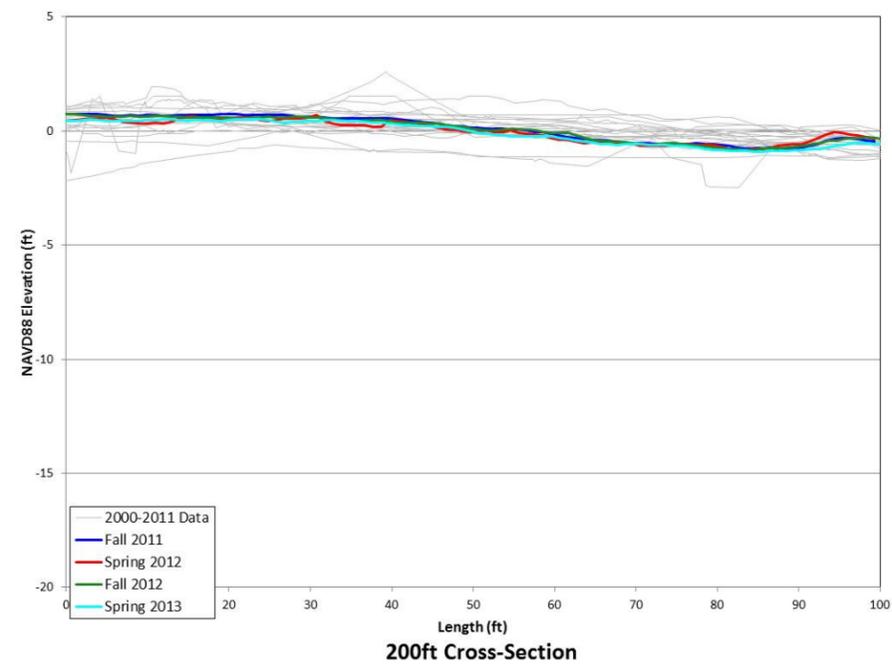
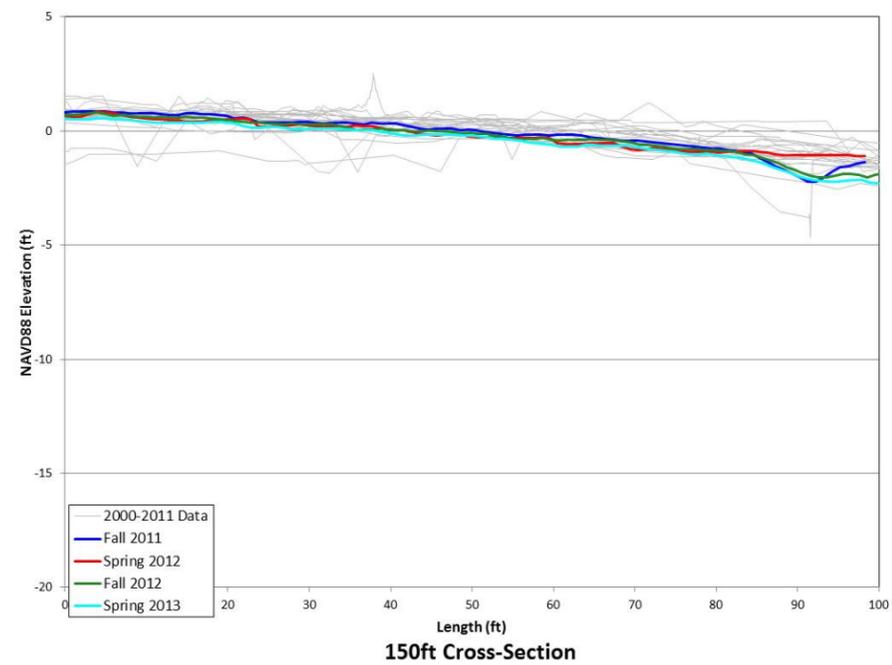
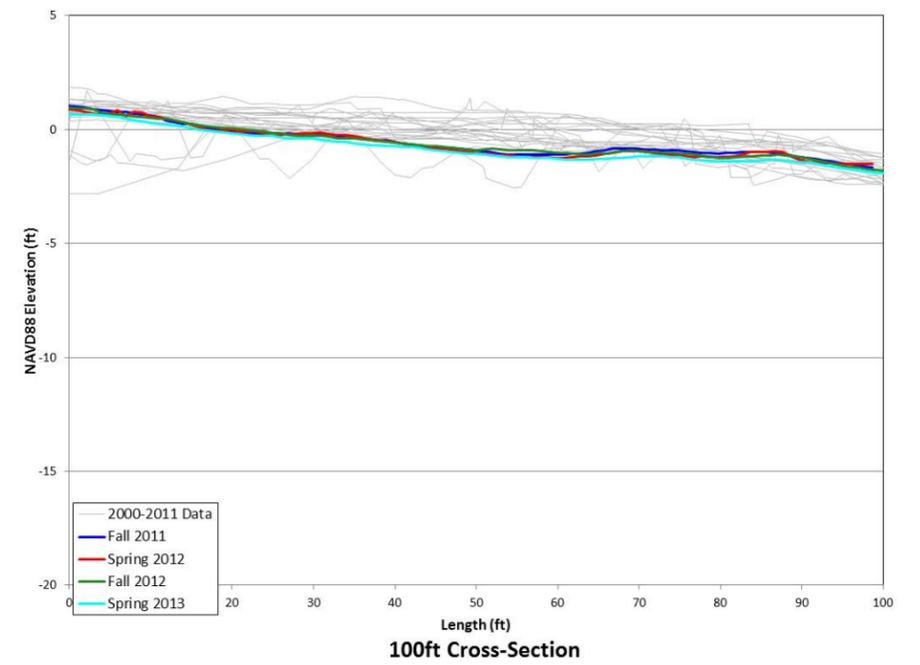
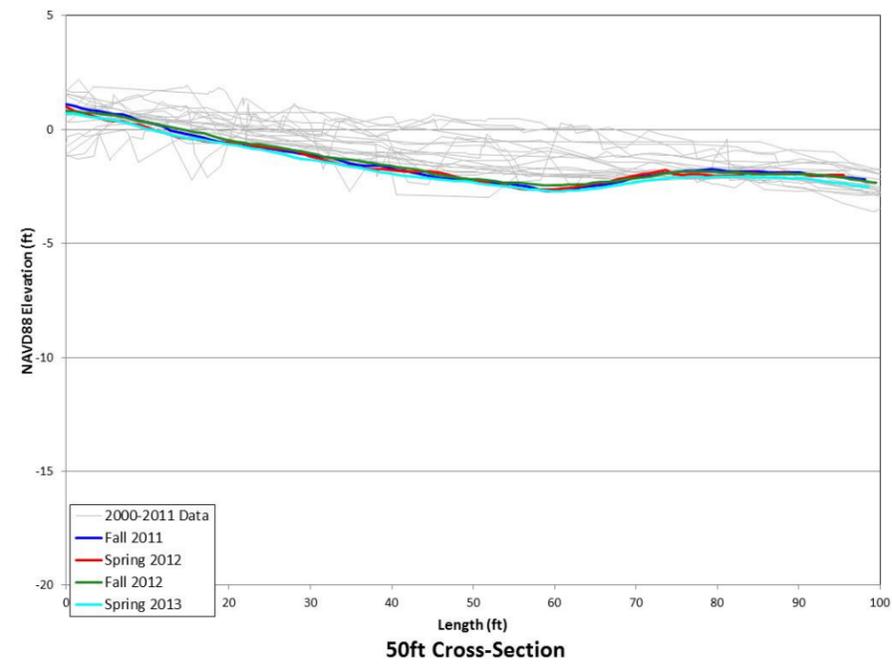
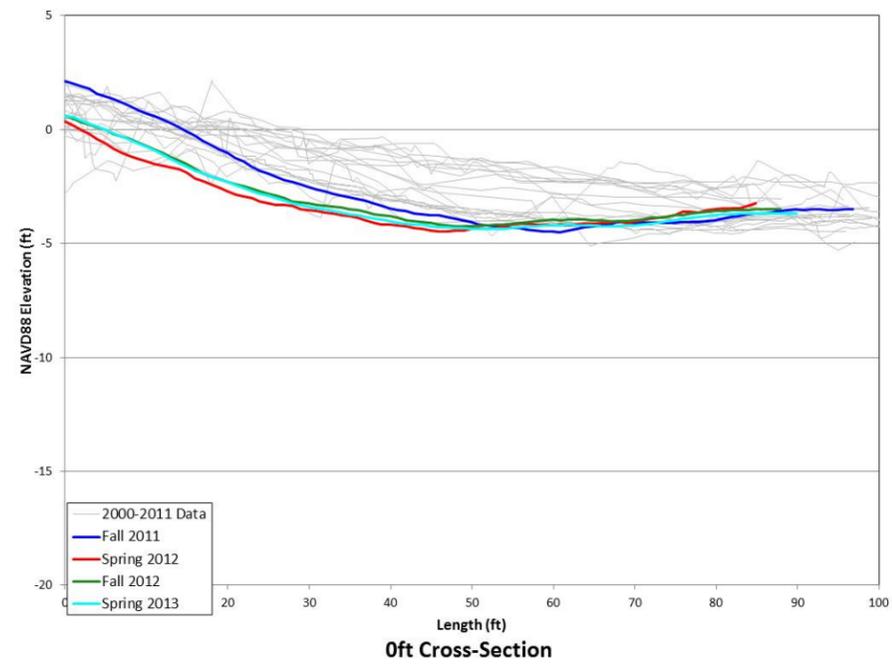
Appendix B: OR-2 Semi-Annual Cross-Sections



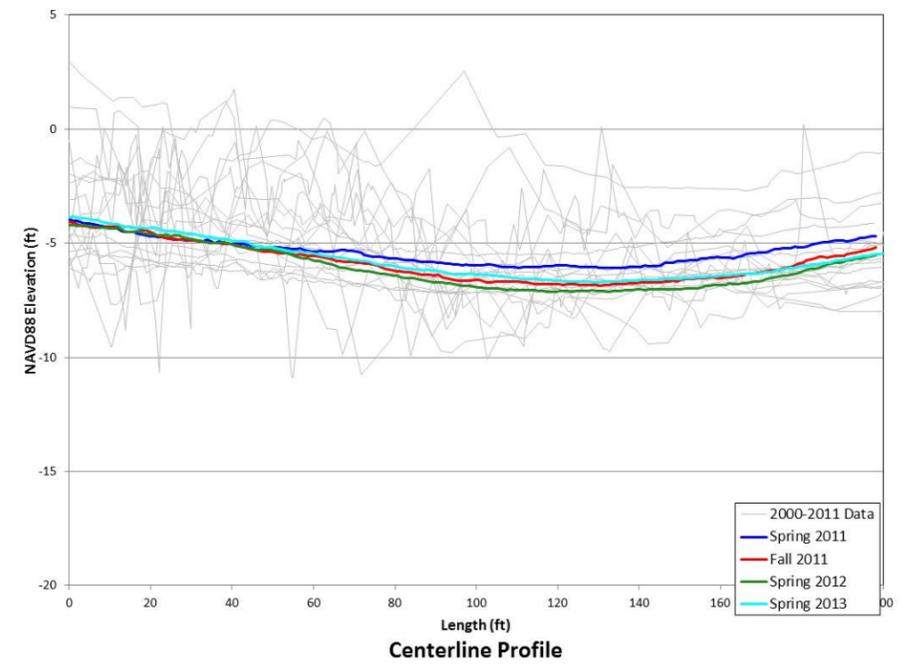
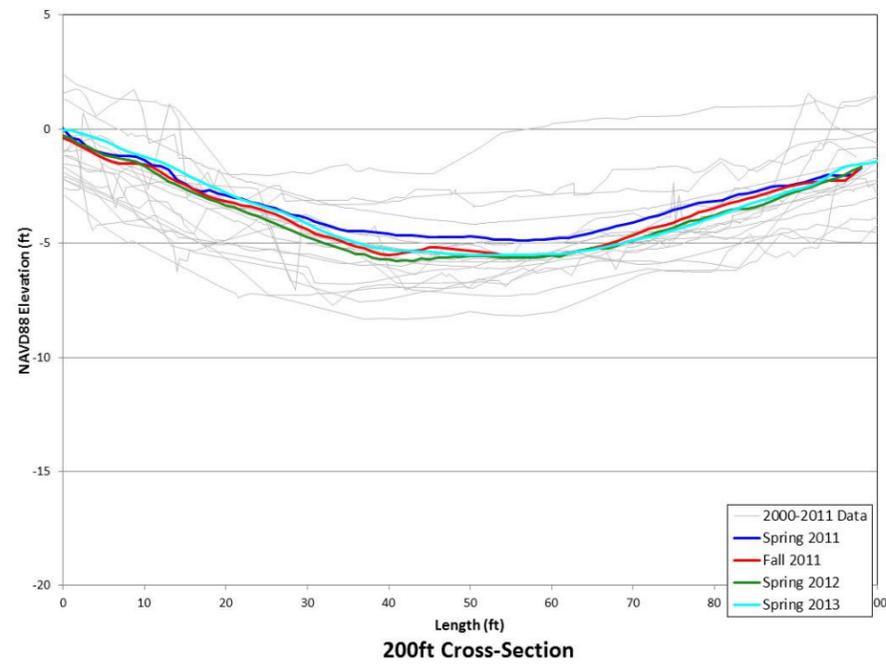
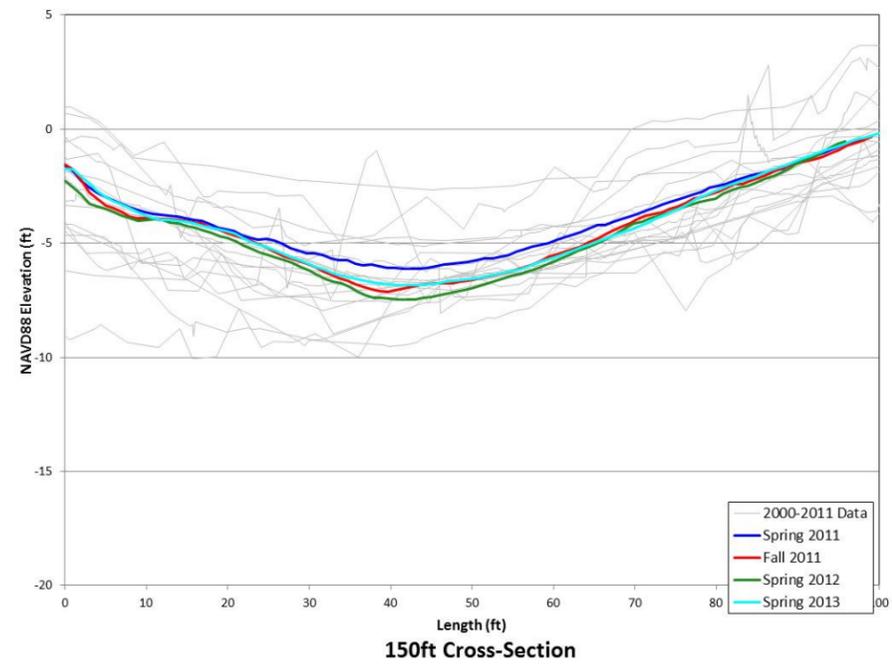
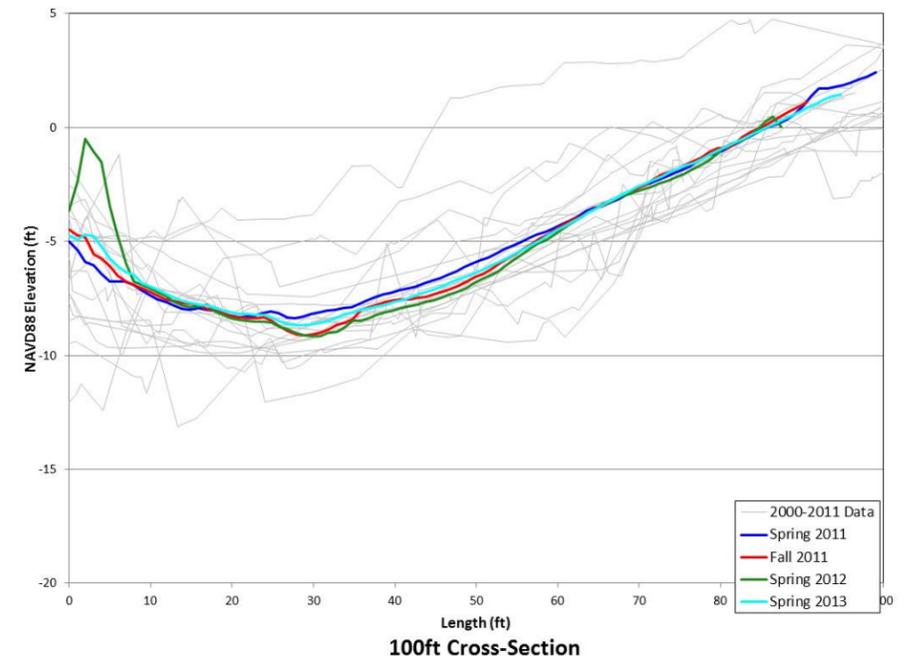
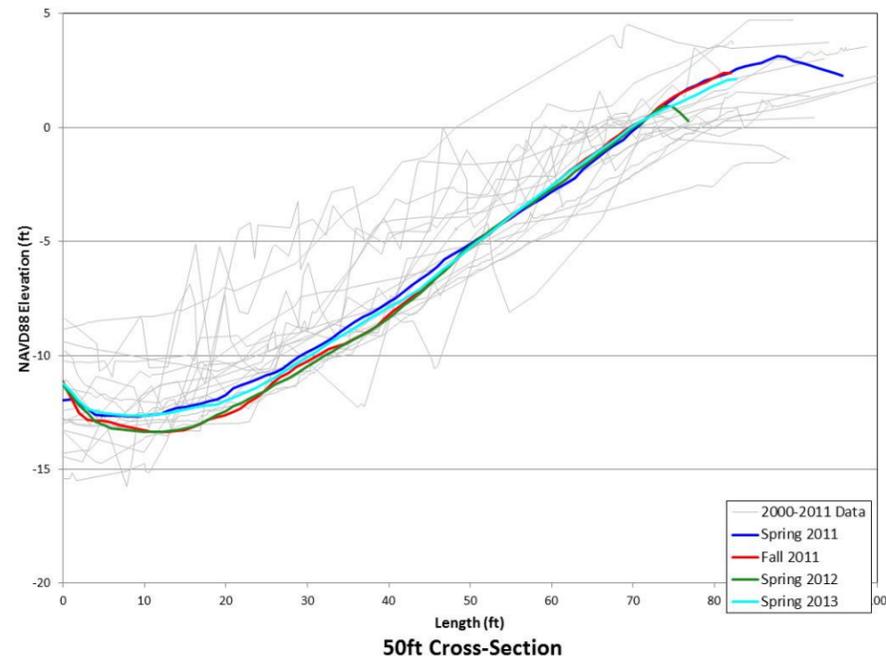
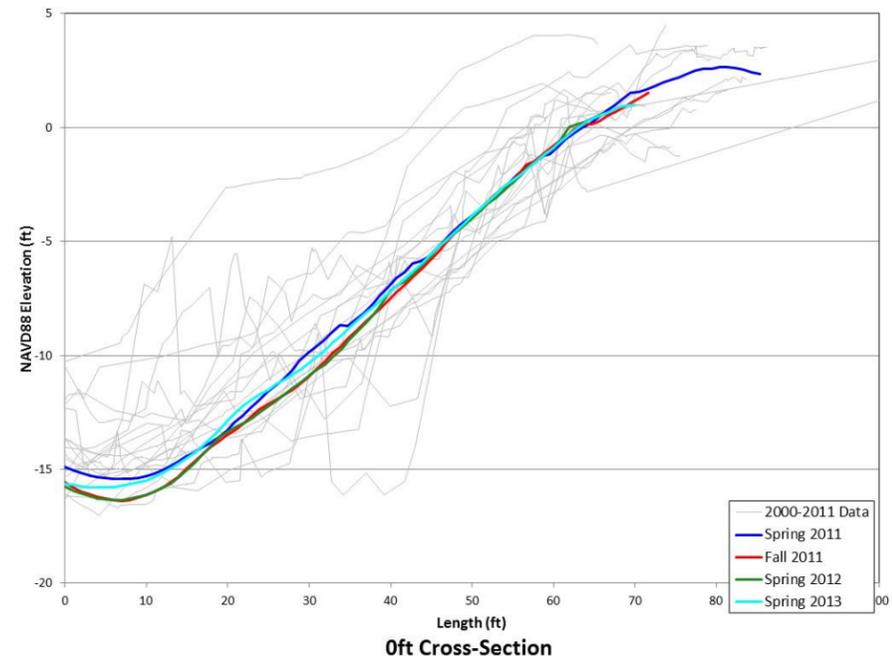
Appendix C: OR-3 Semi-Annual Cross-Sections



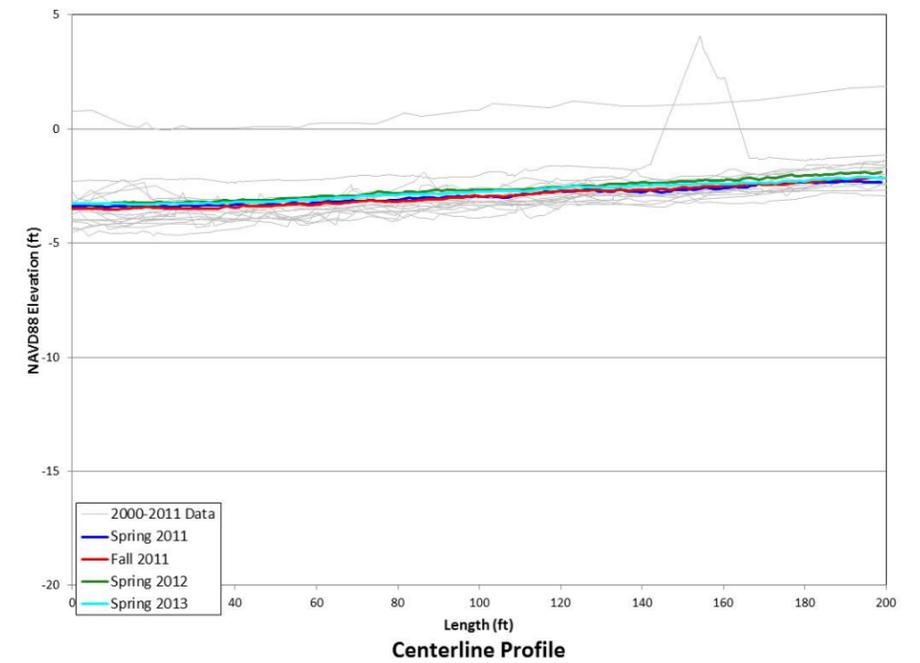
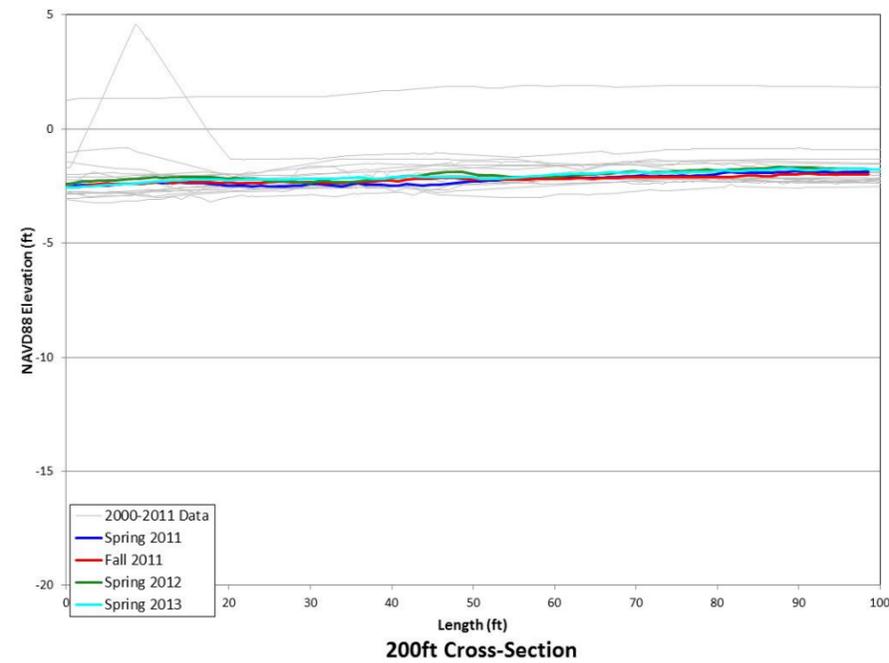
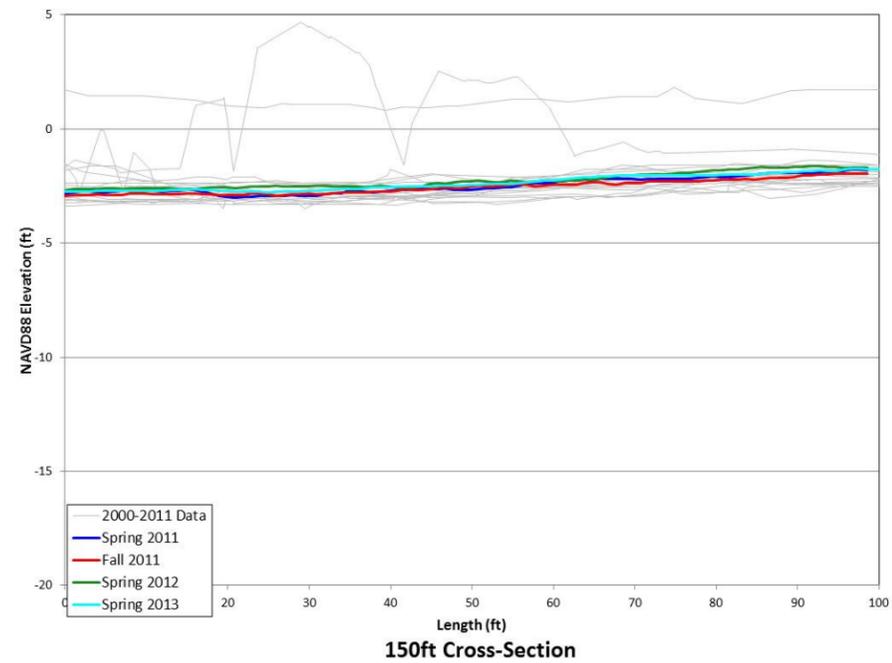
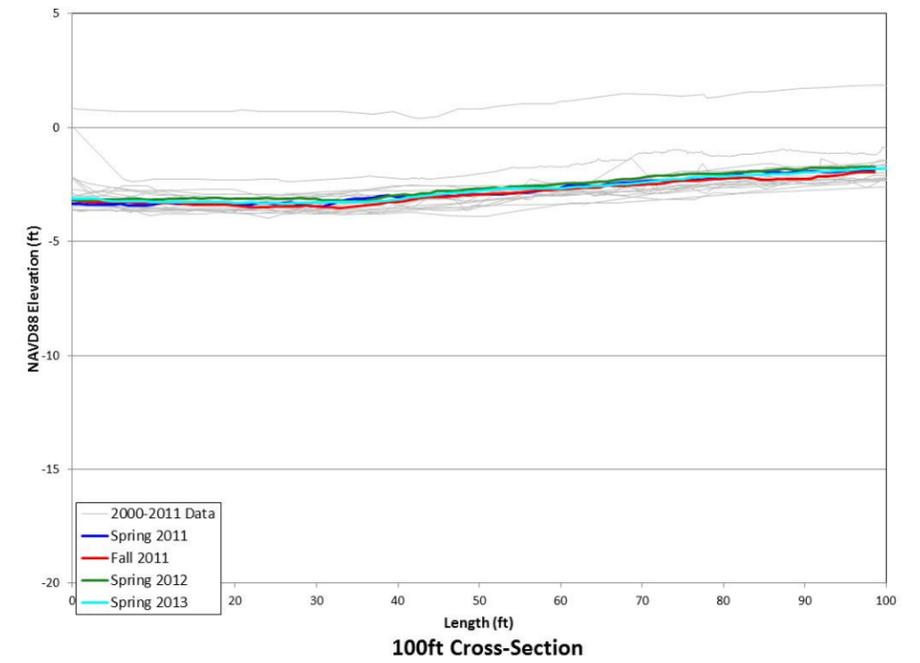
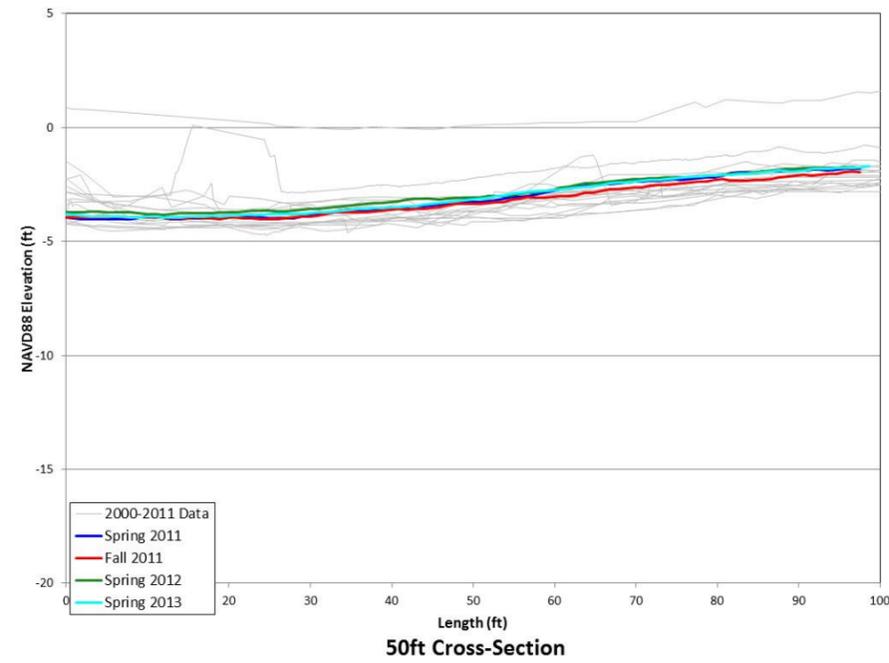
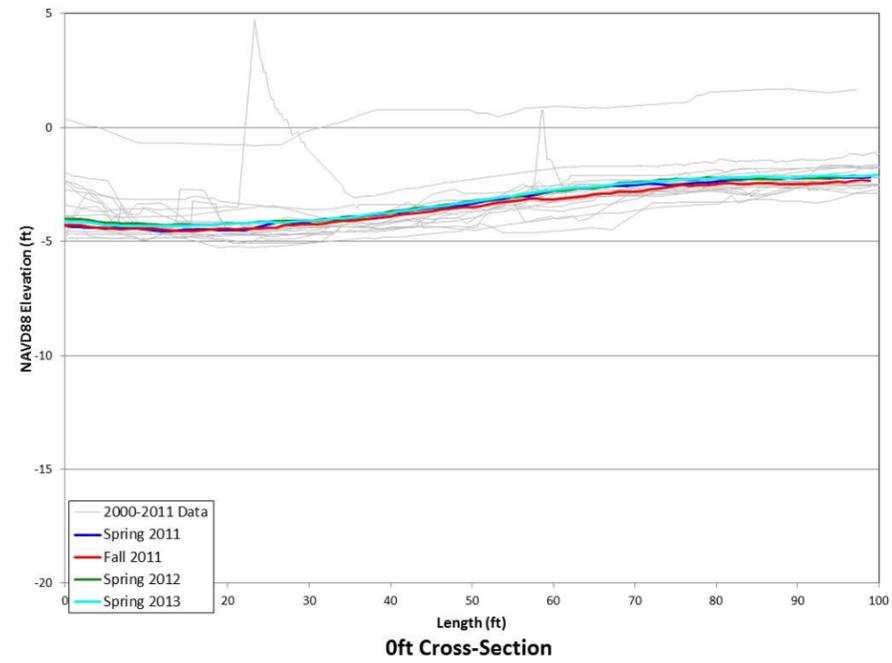
Appendix D: OR-4 Semi-Annual Cross-Sections



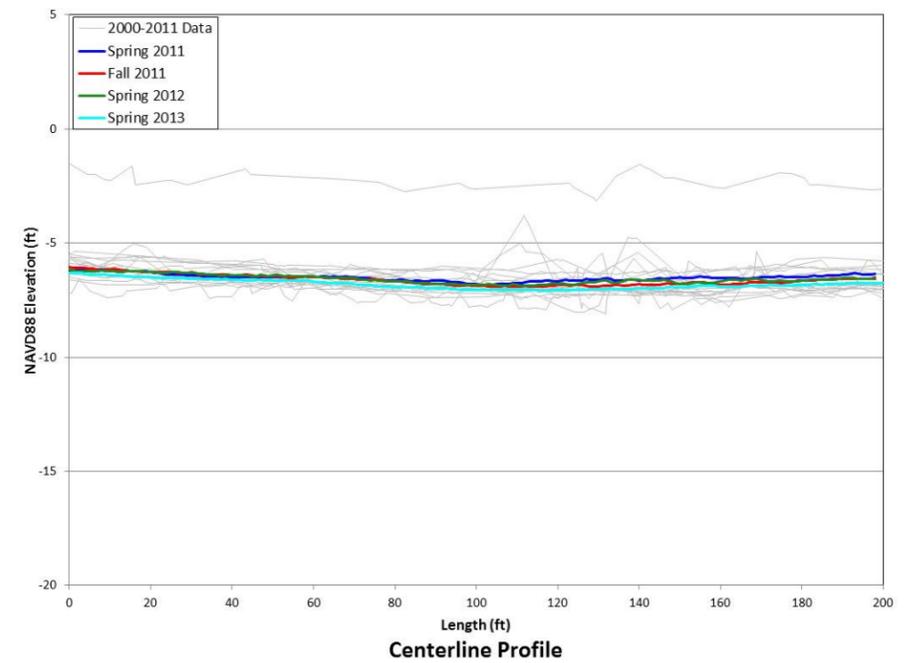
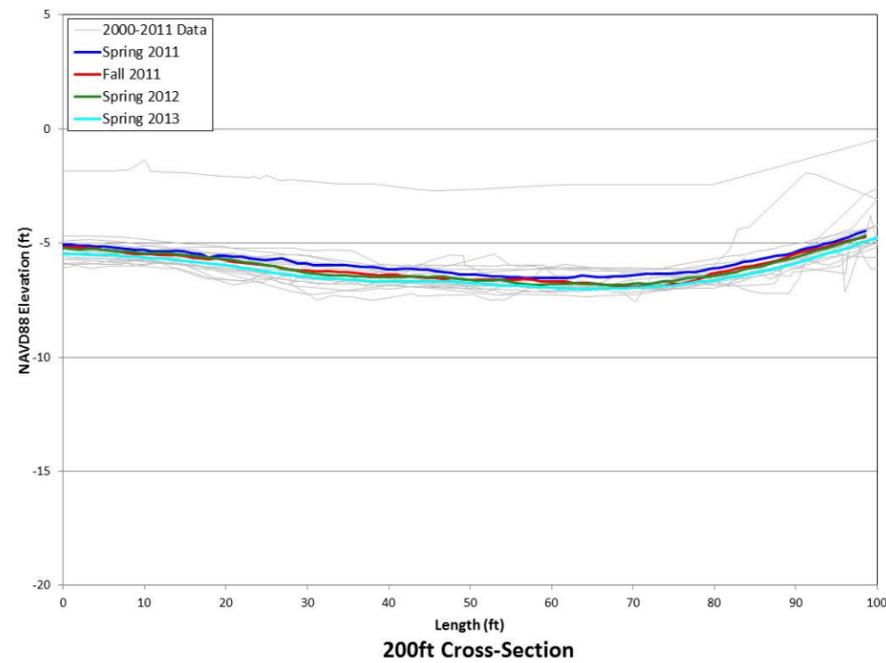
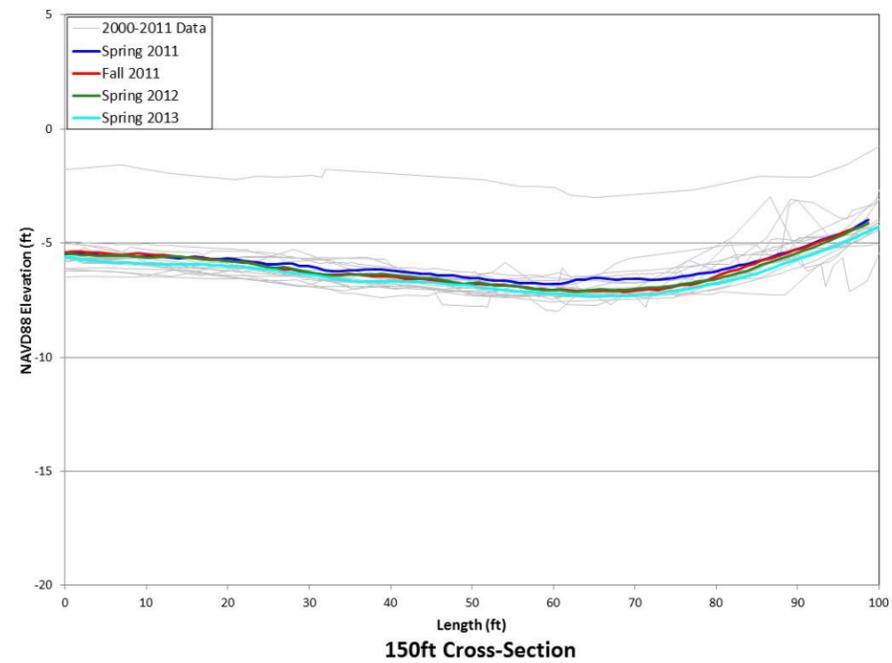
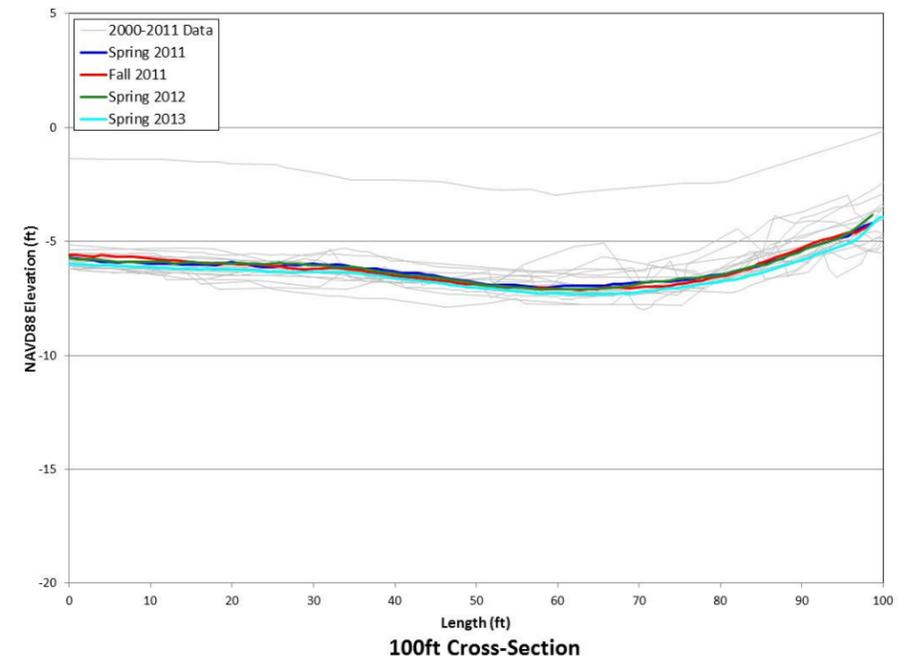
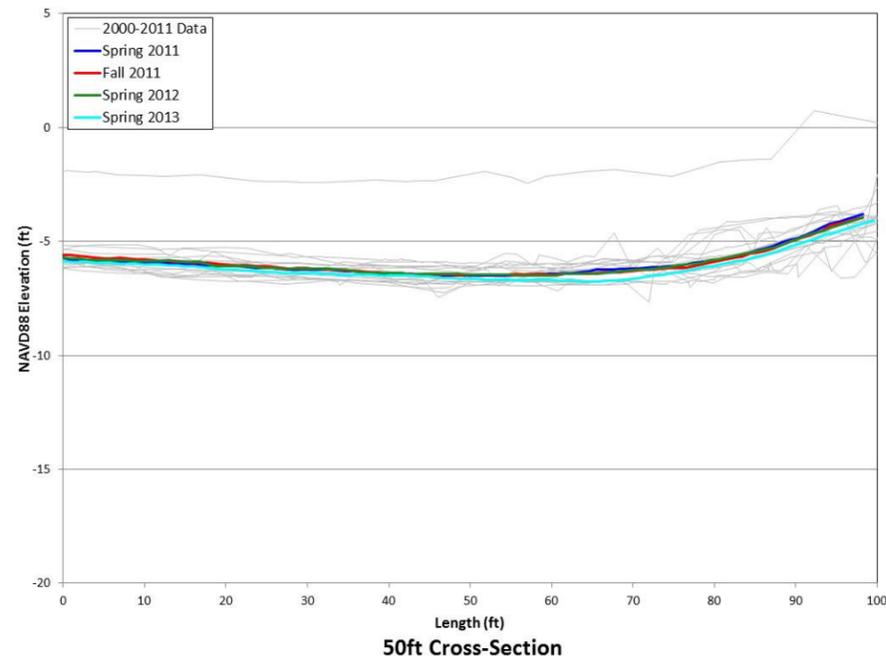
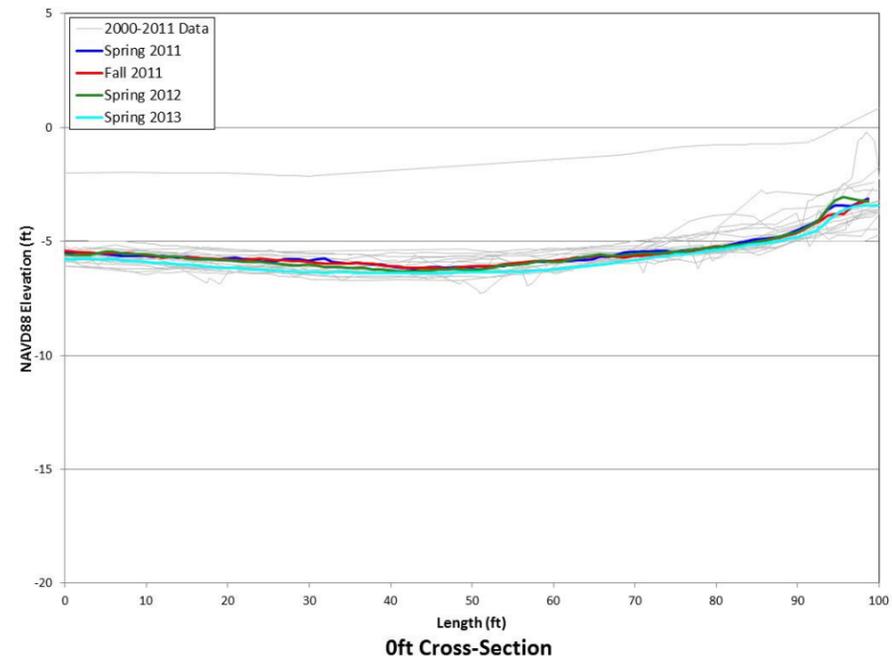
Appendix E: OR-5 Semi-Annual Cross-Sections



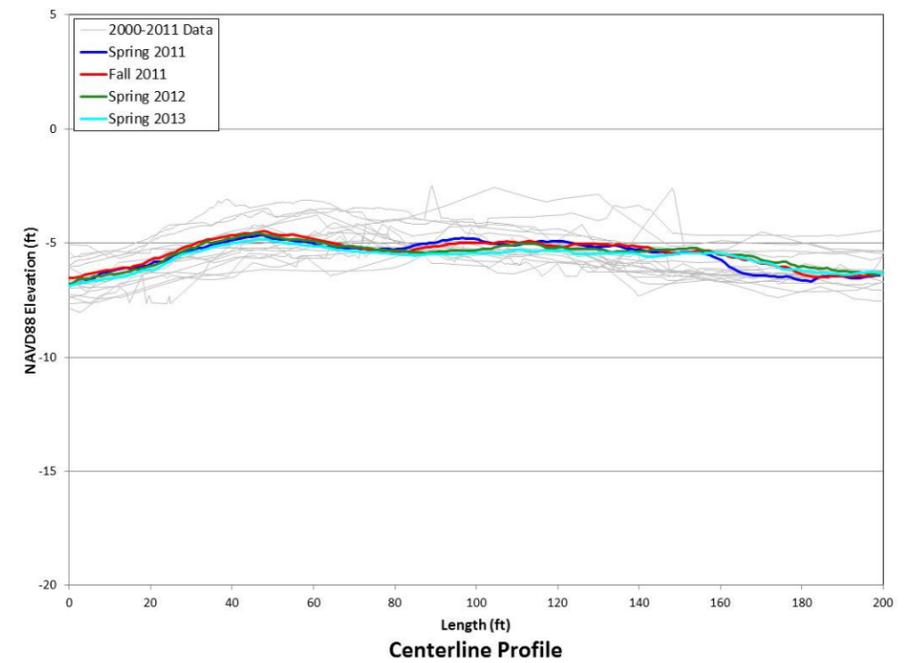
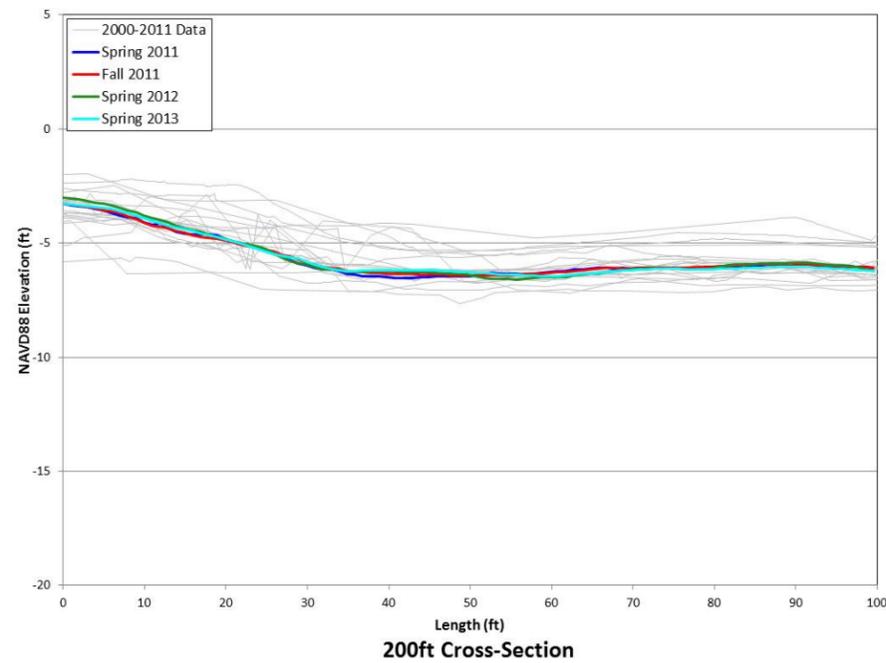
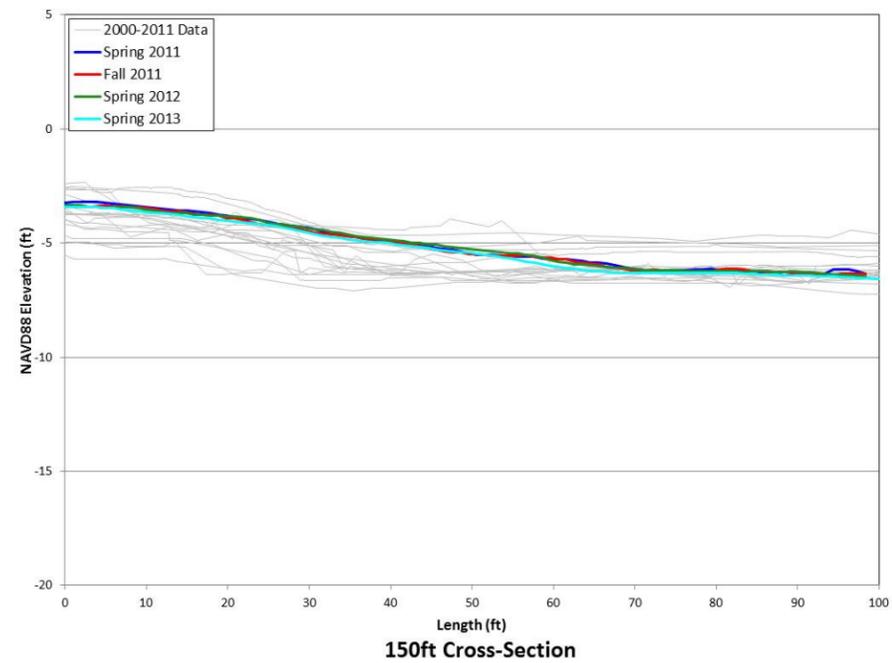
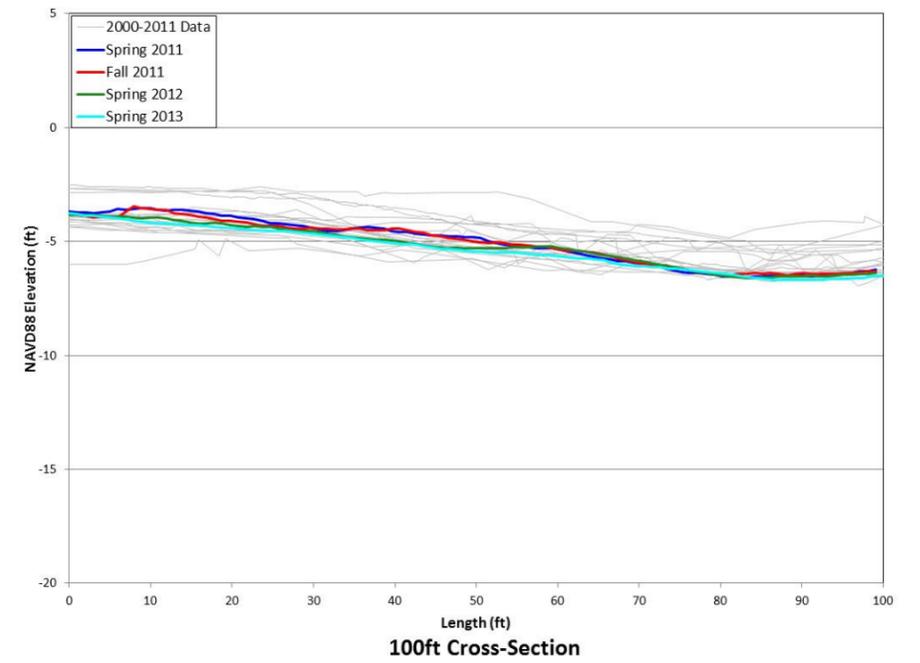
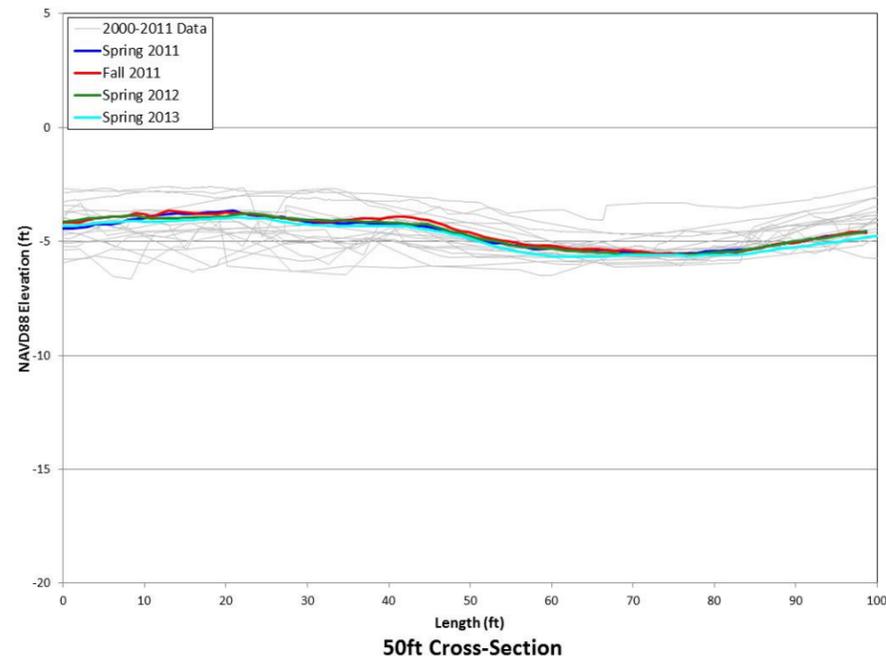
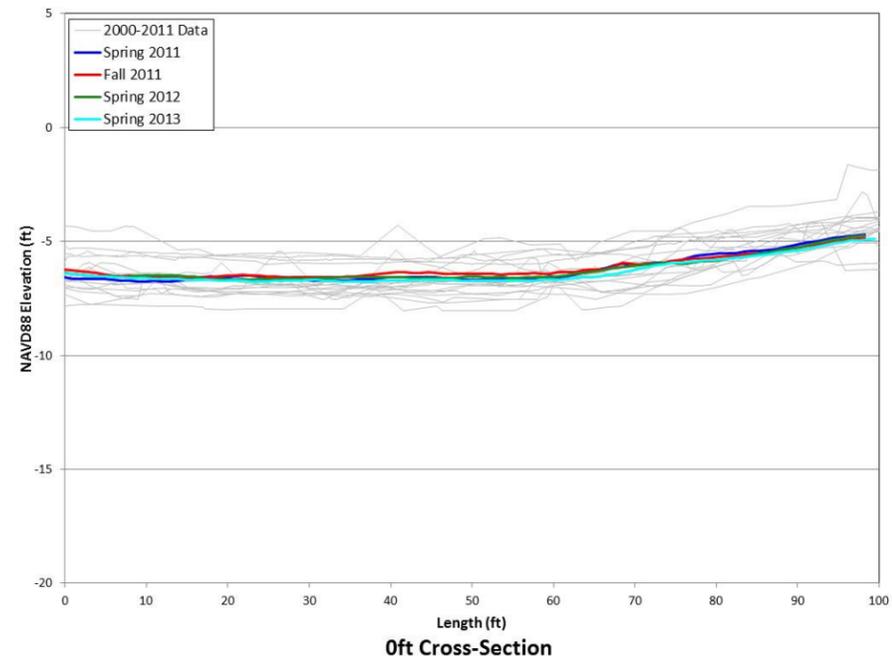
Appendix F: OR-6 Semi-Annual Cross-Sections



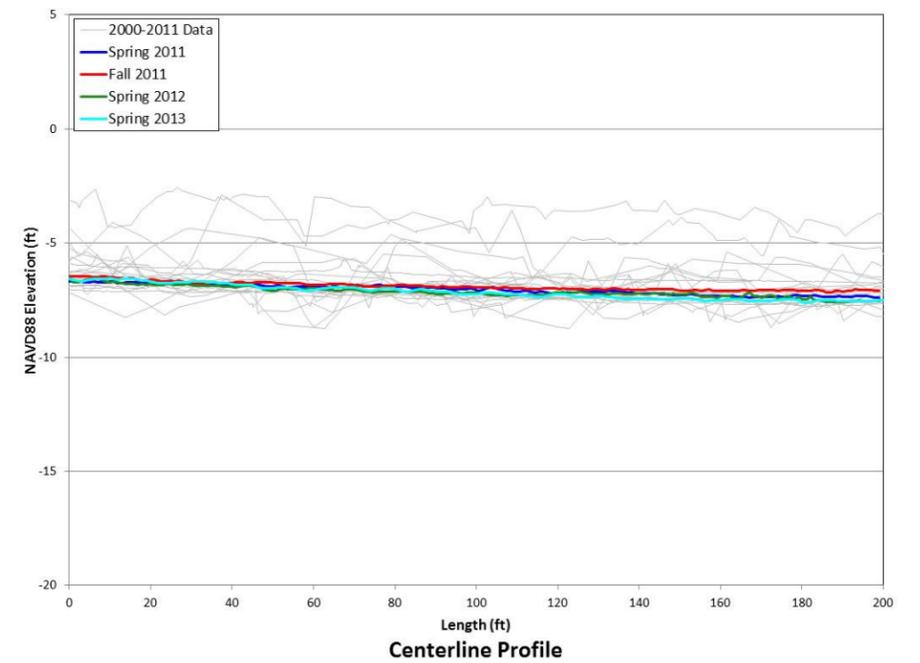
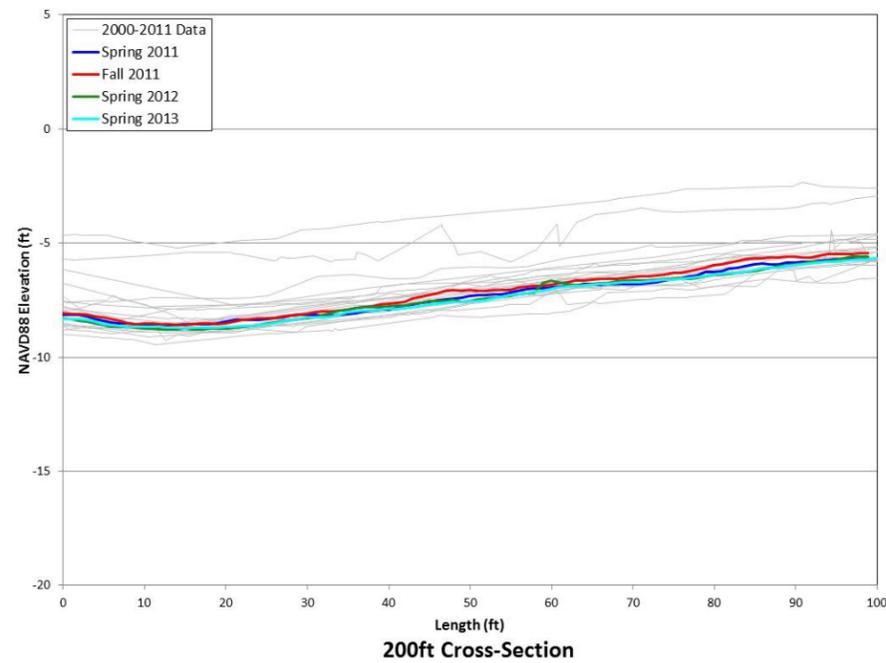
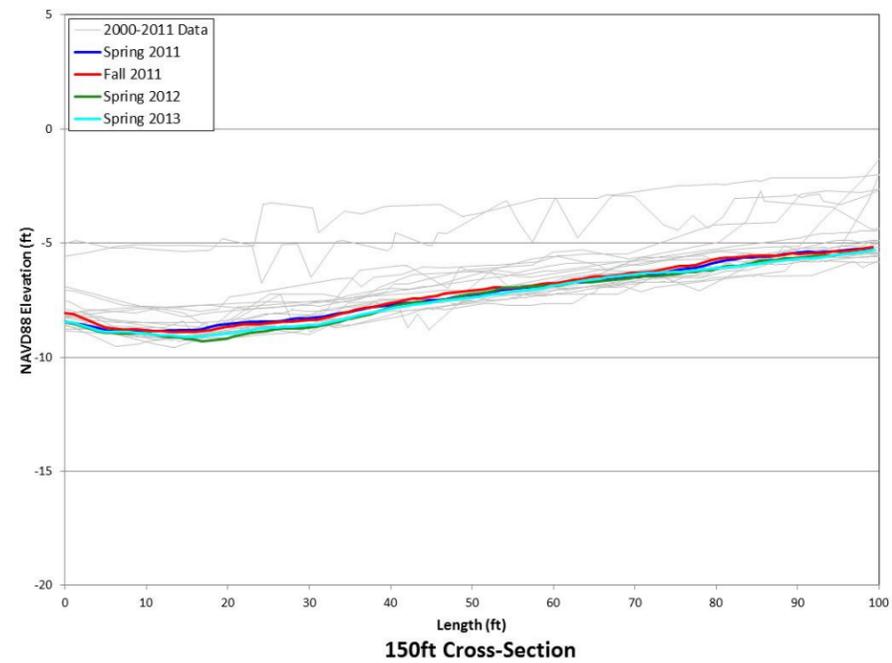
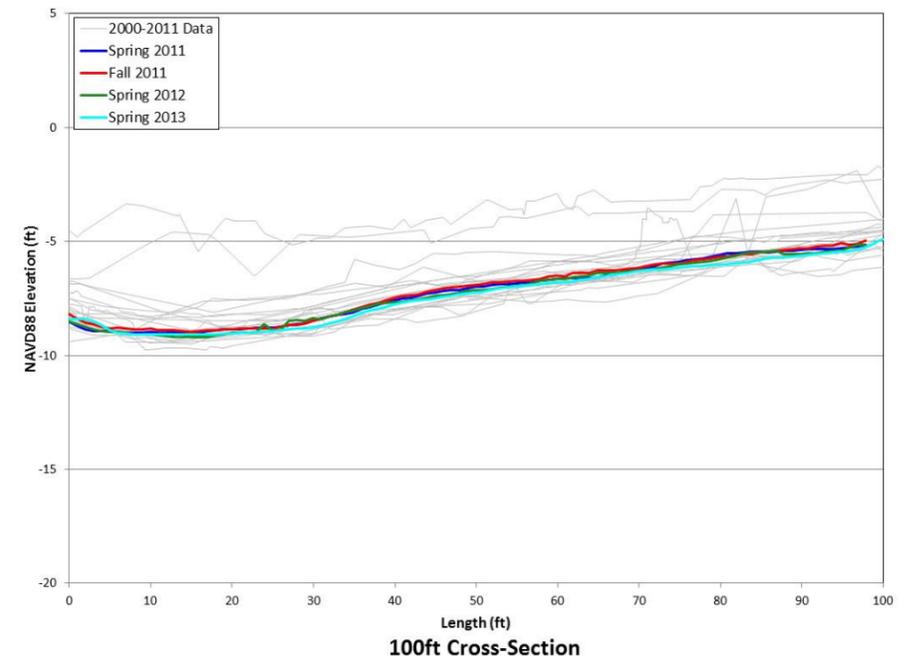
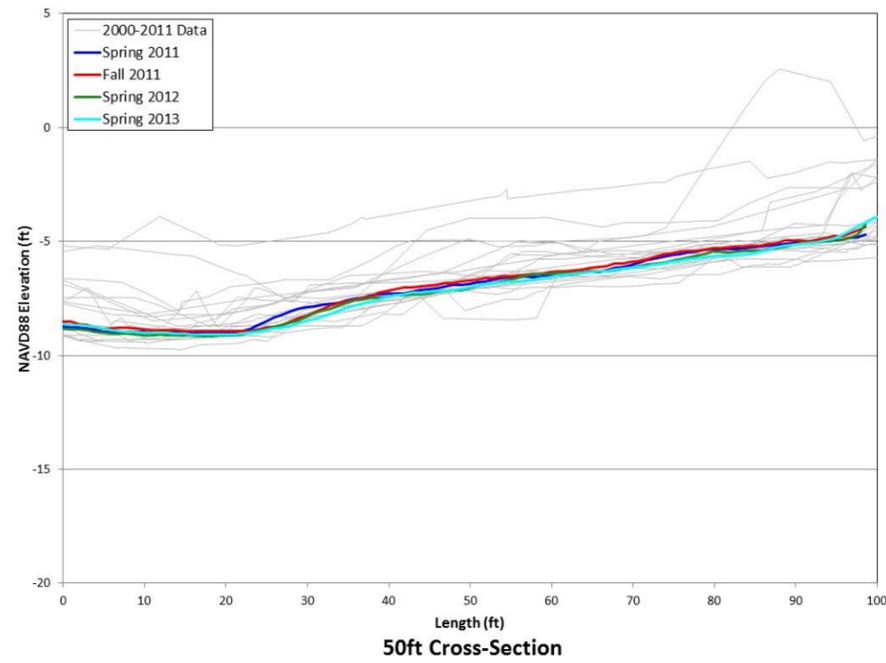
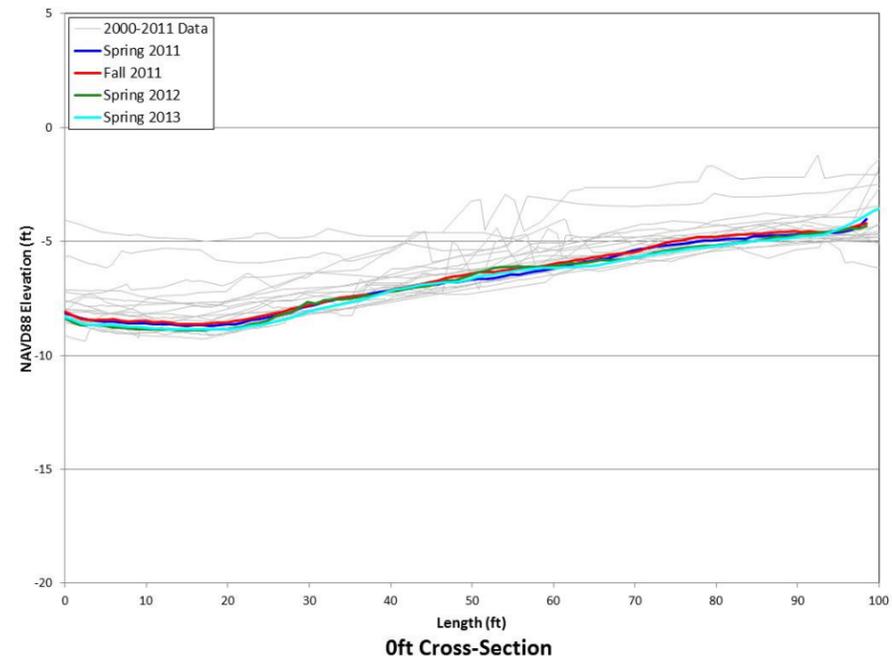
Appendix G: OR-7 Semi-Annual Cross-Sections



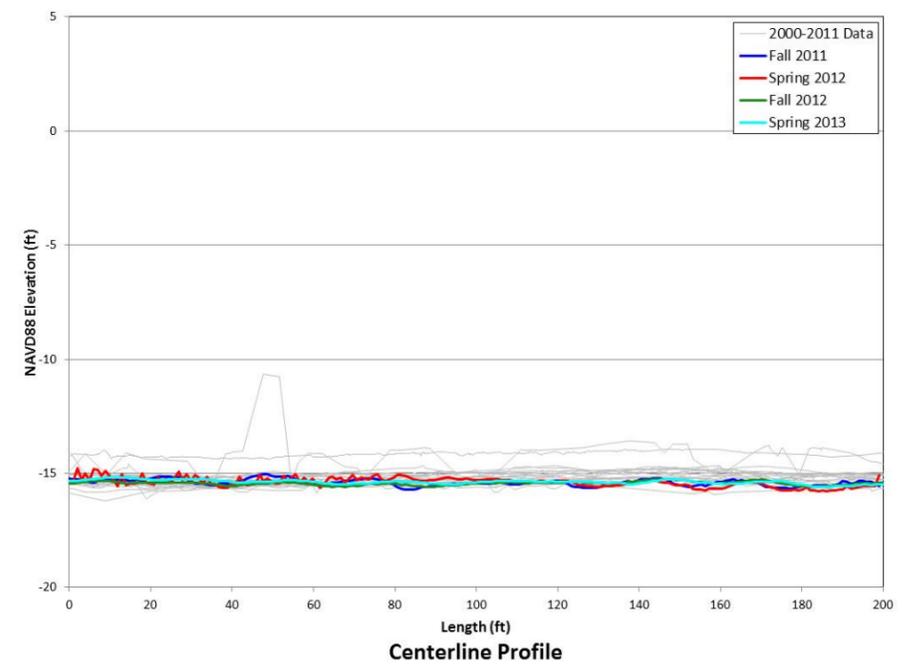
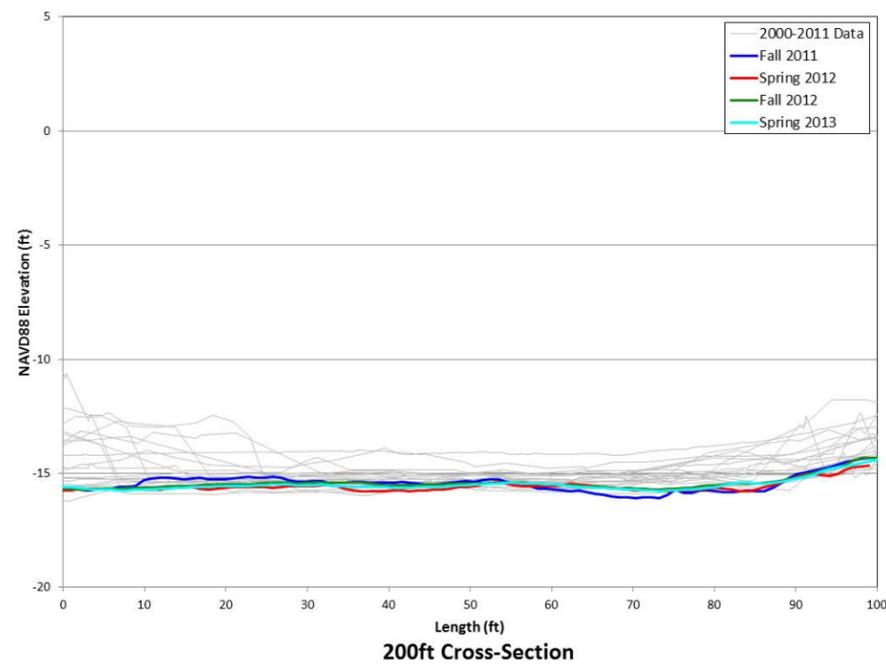
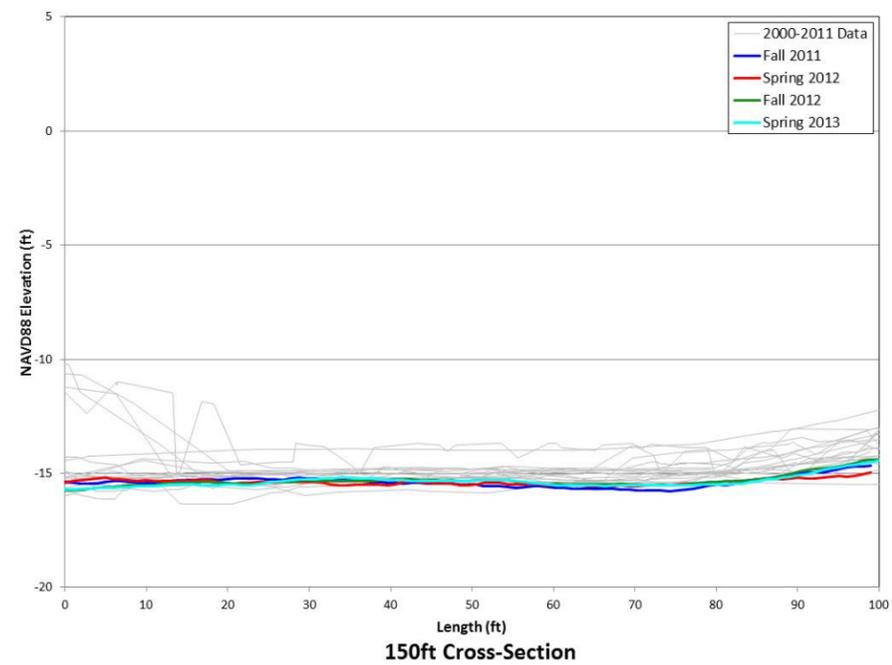
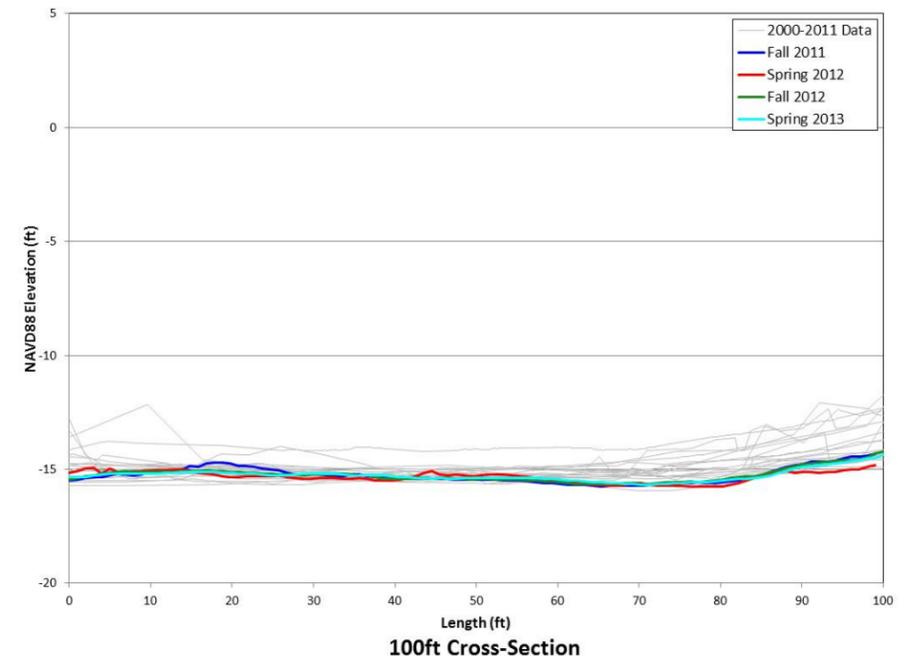
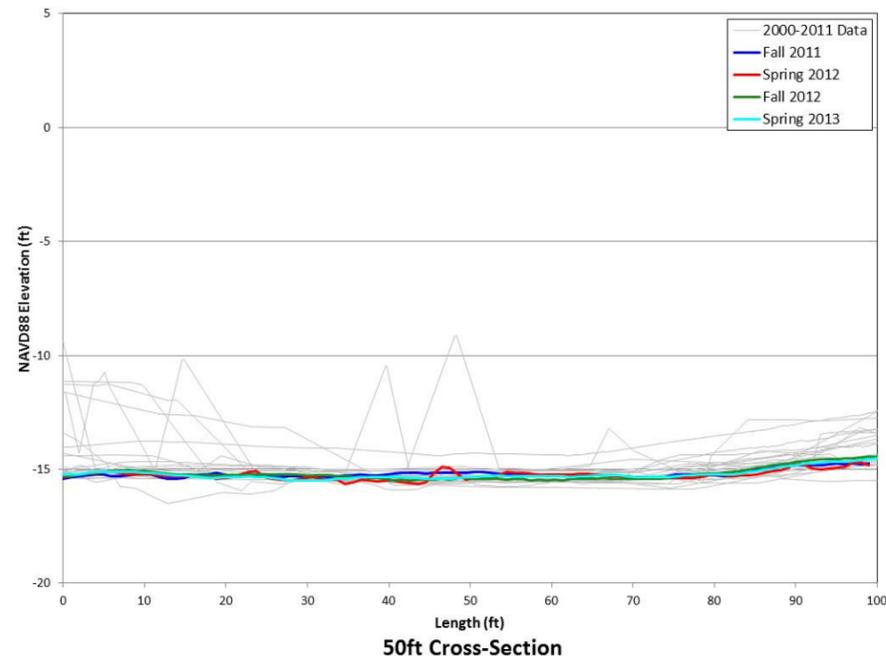
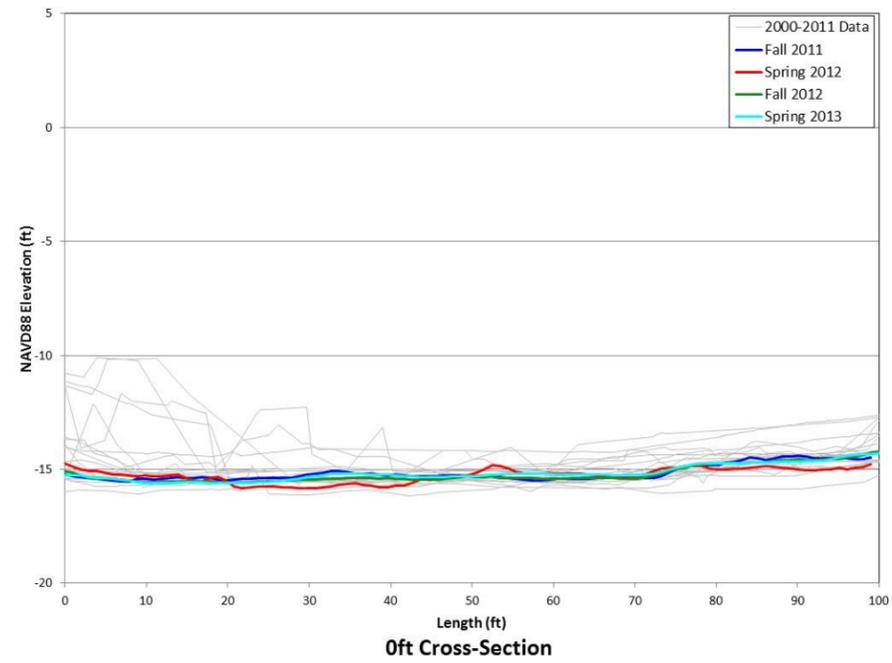
Appendix H: OR-8 Semi-Annual Cross-Sections



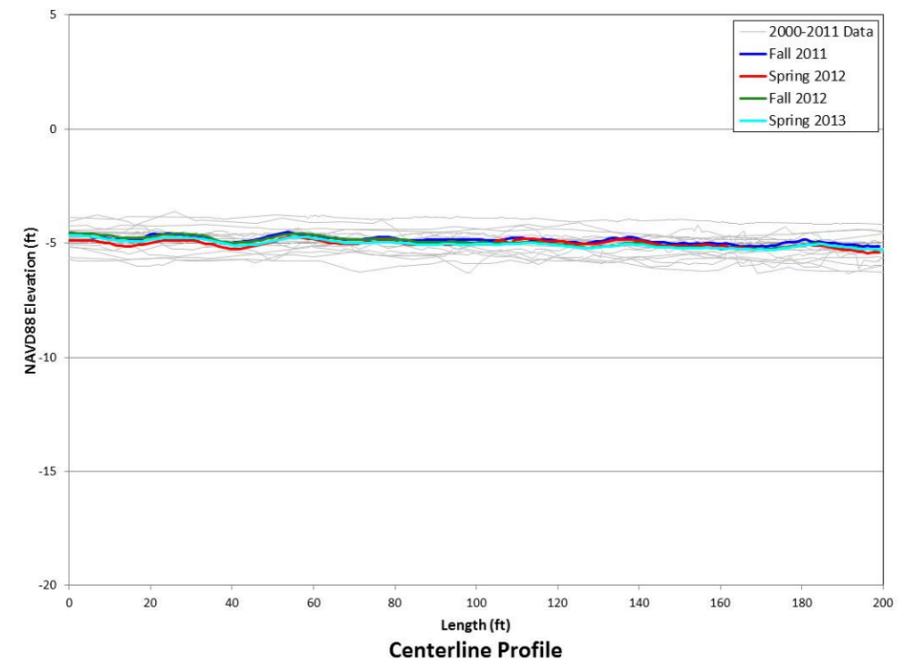
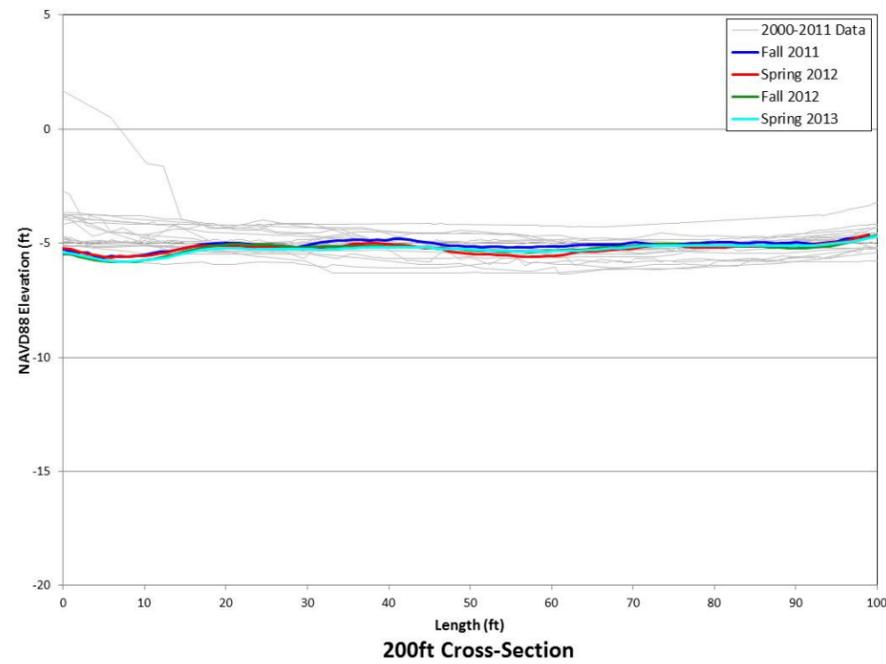
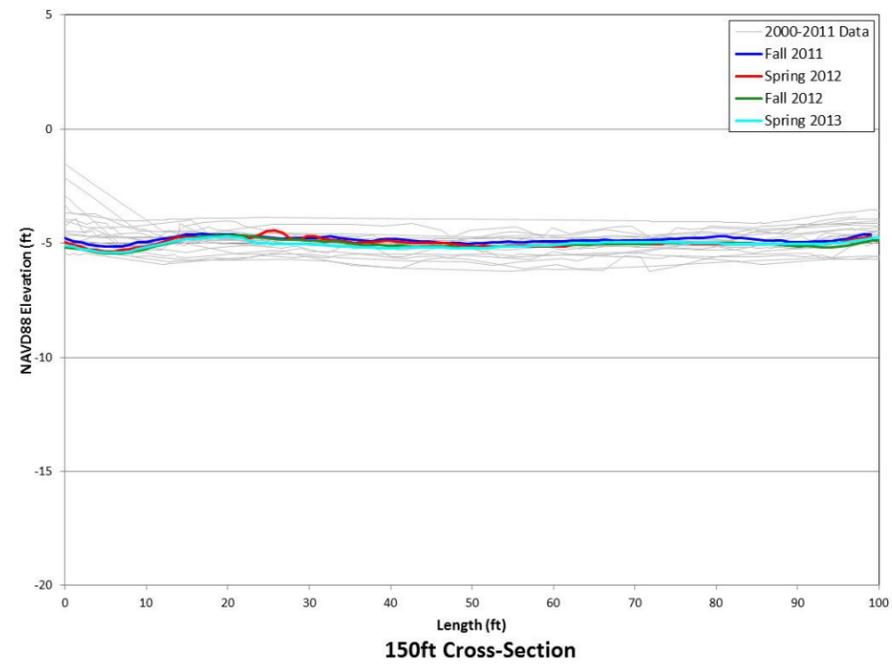
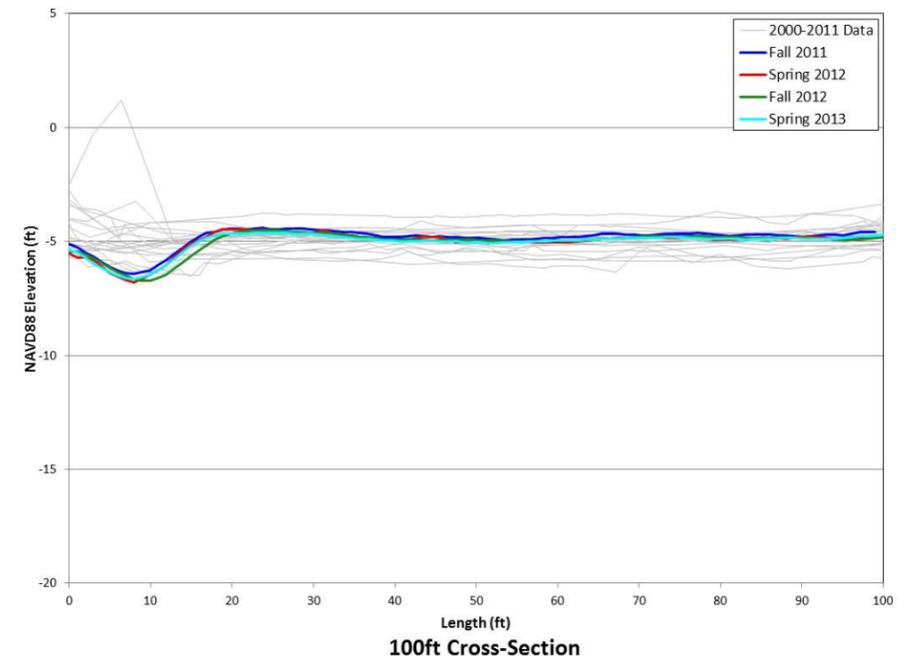
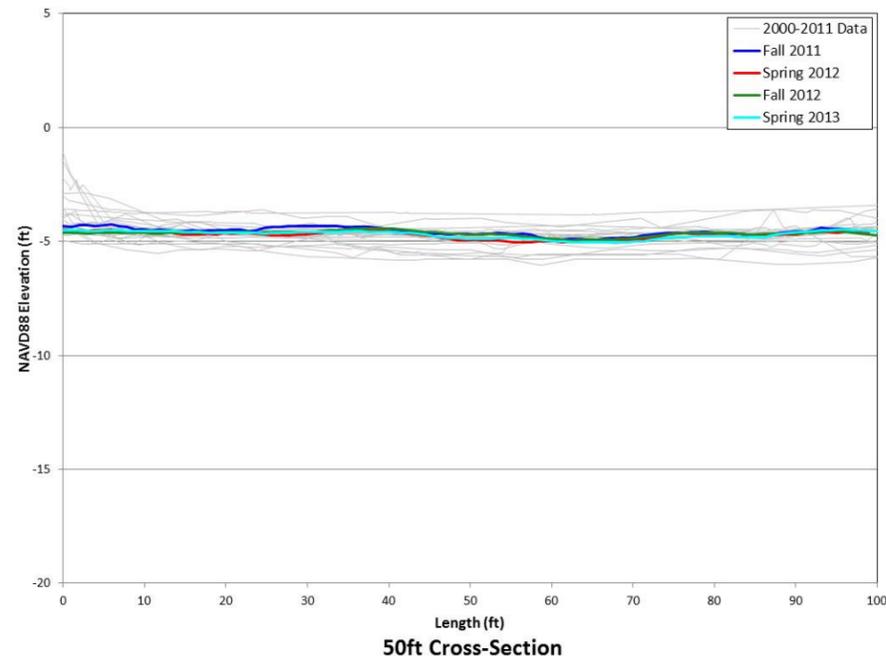
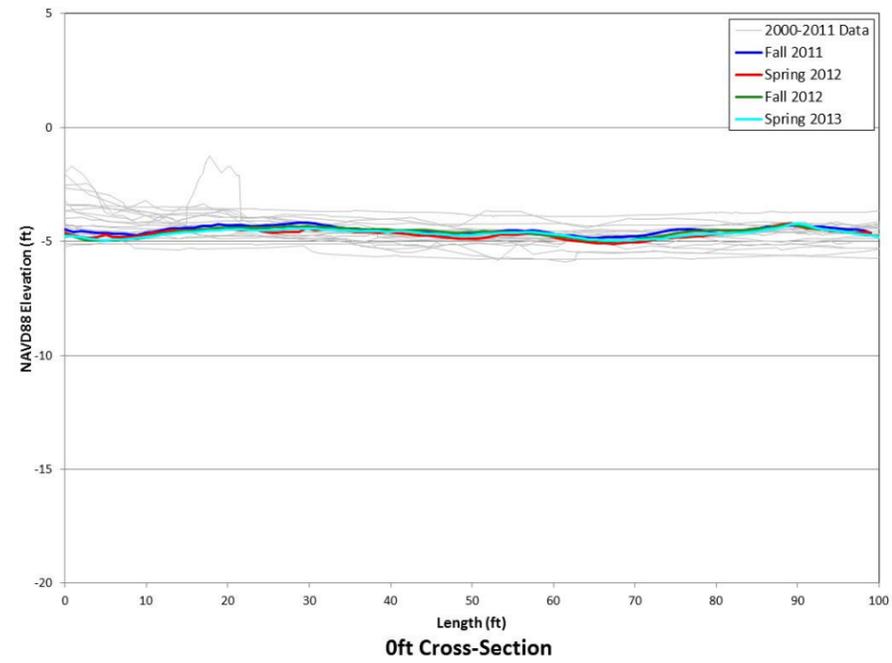
Appendix I: OR-9 Semi-Annual Cross-Sections



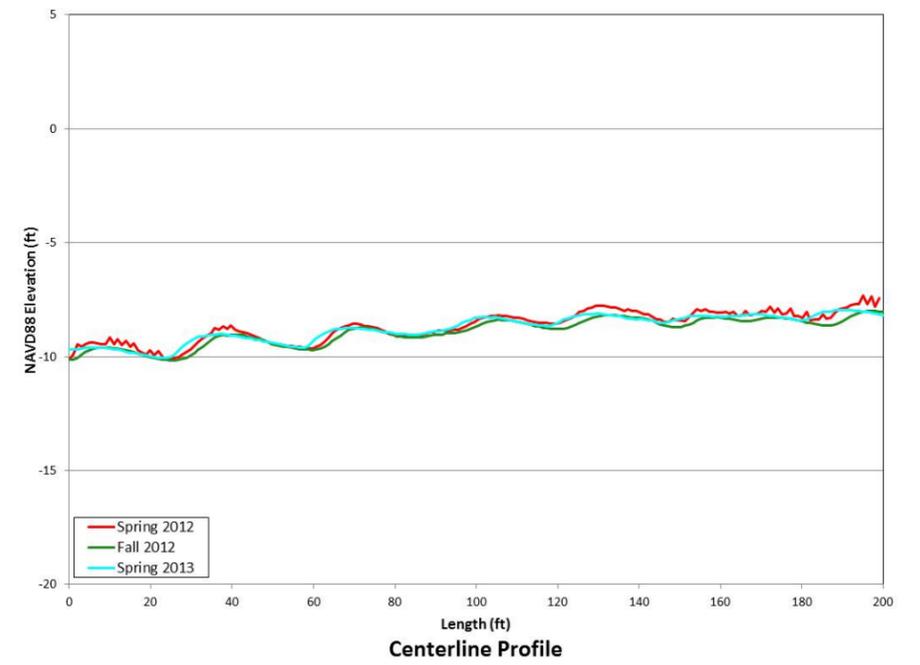
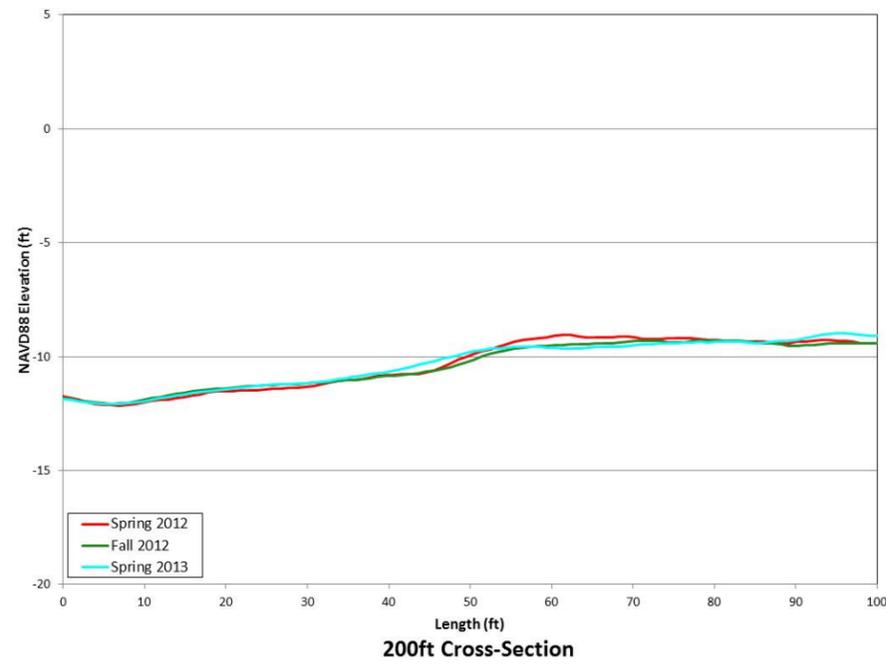
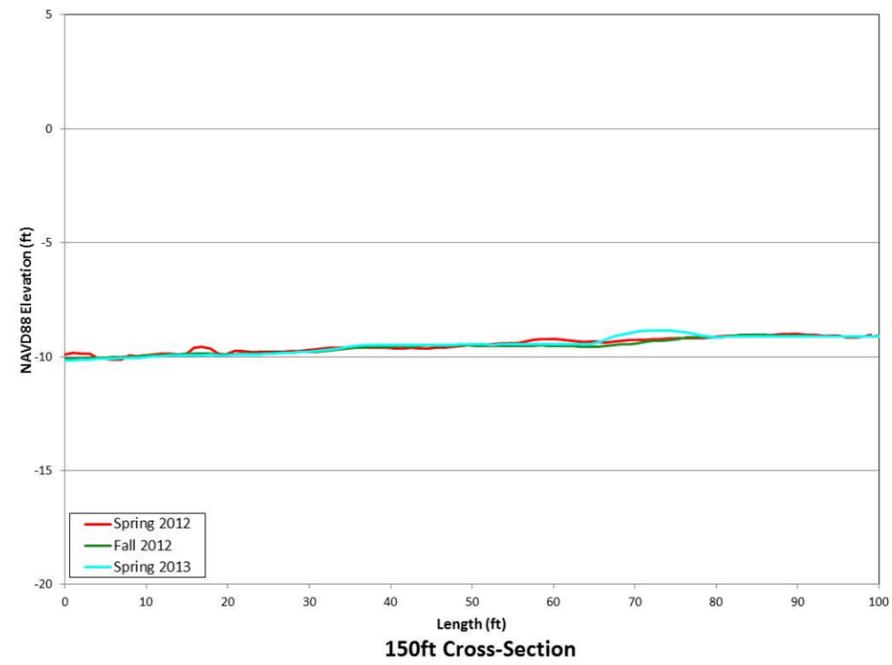
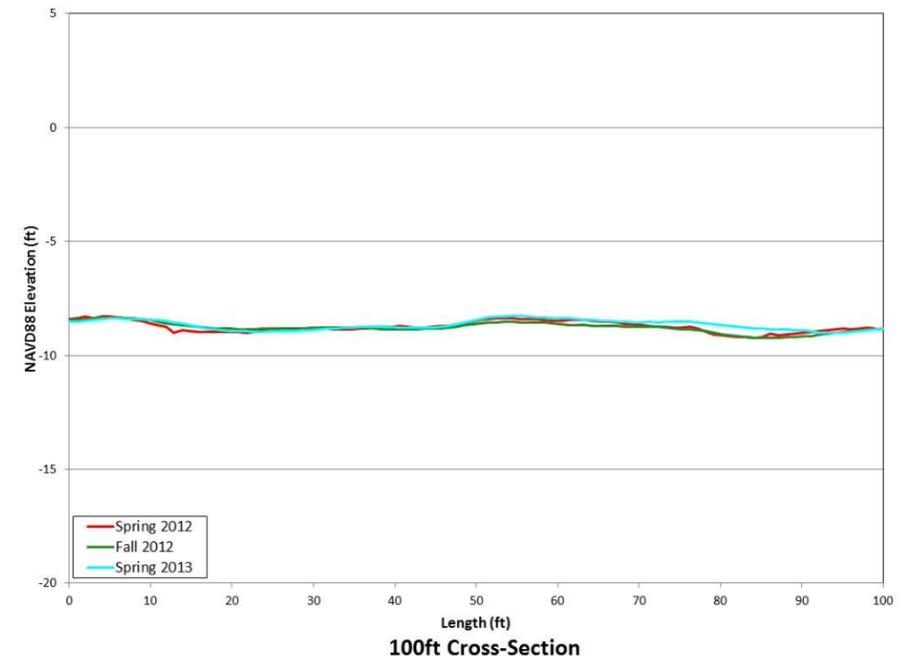
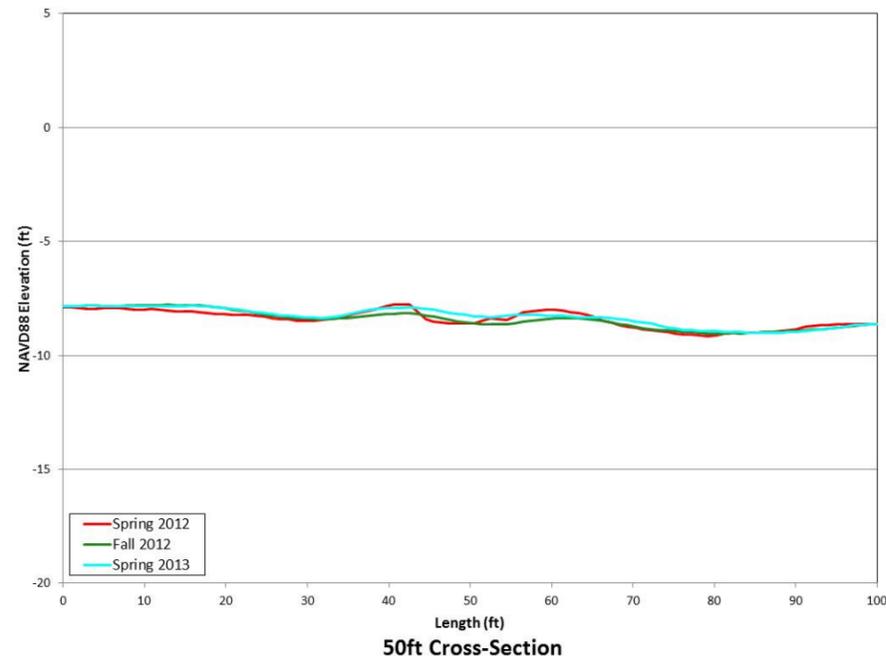
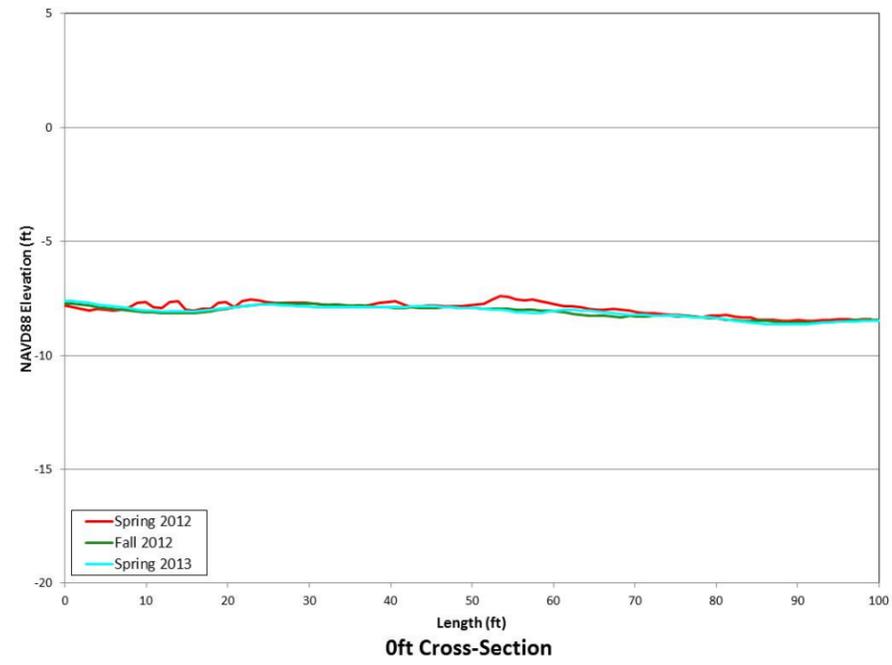
Appendix J: GLC-1A Semi-Annual Cross-Sections



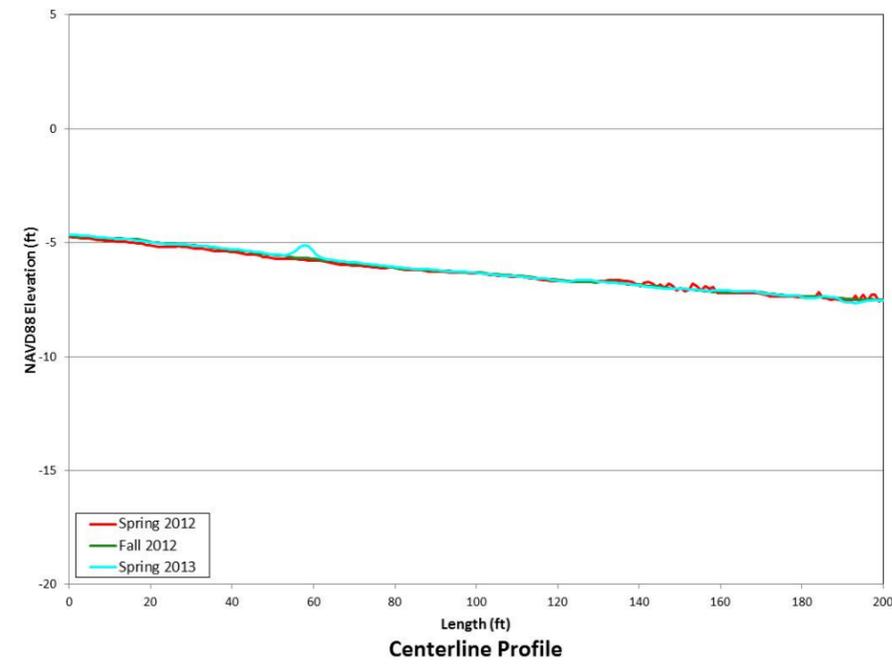
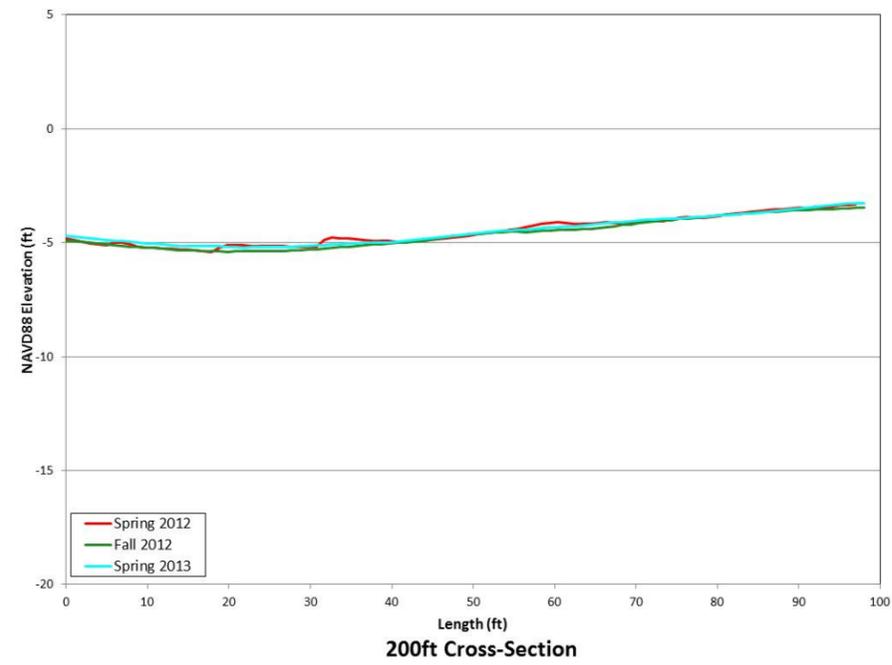
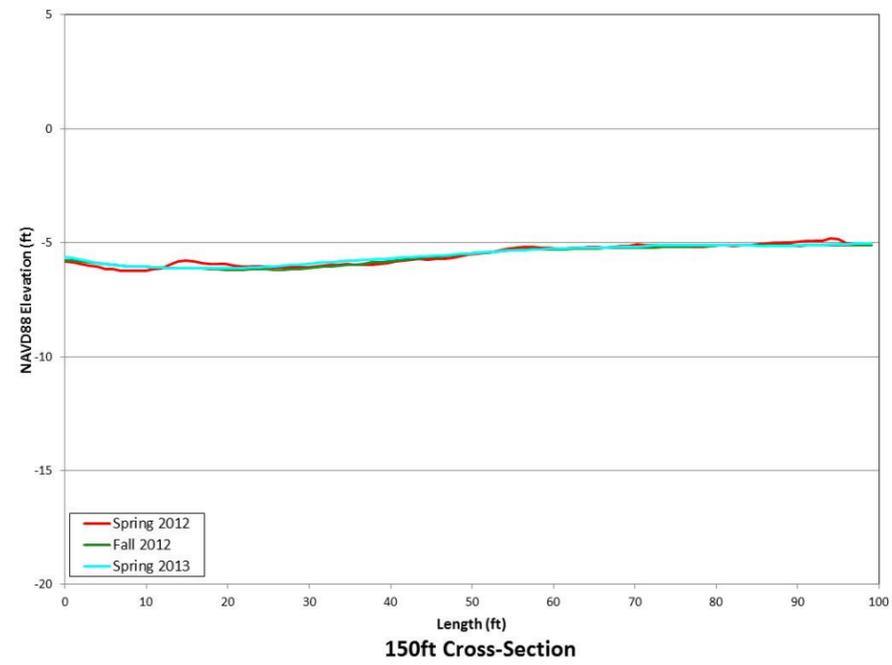
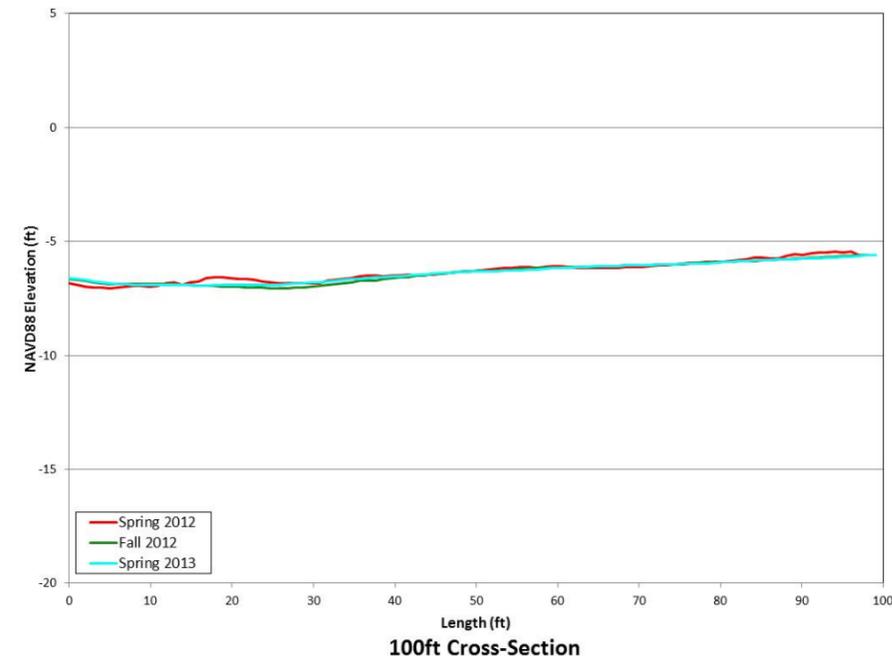
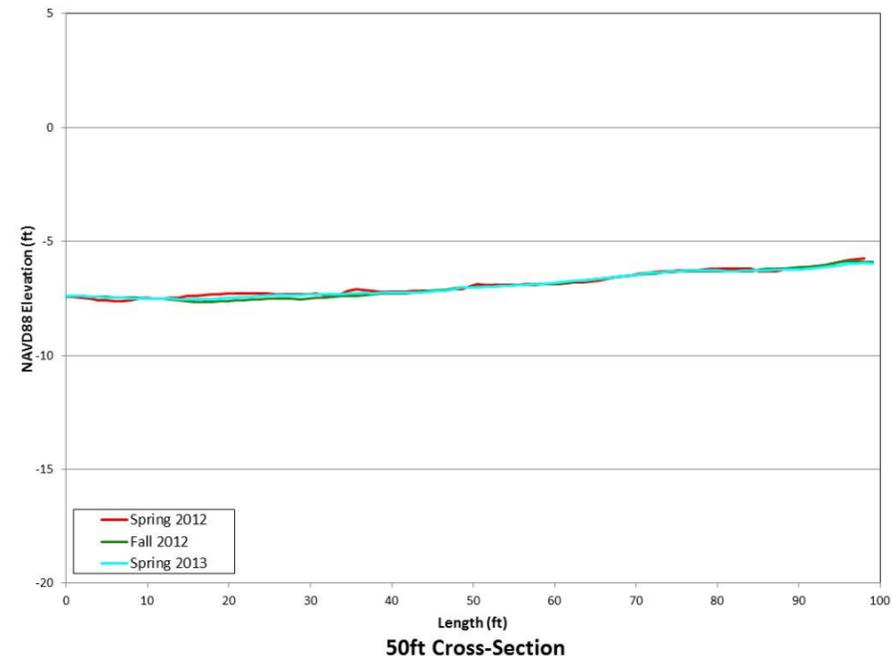
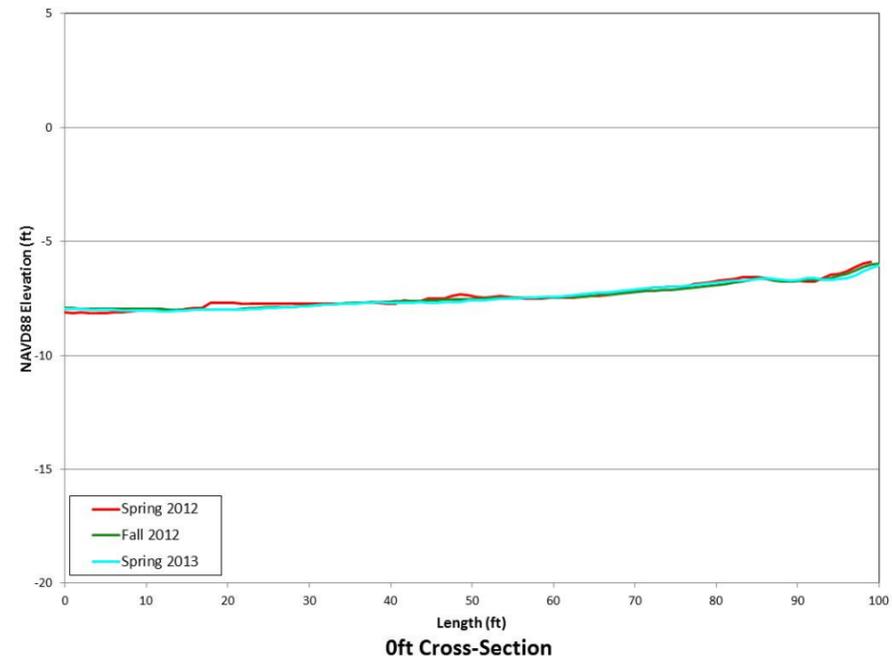
Appendix K: GLC-1B Semi-Annual Cross-Sections



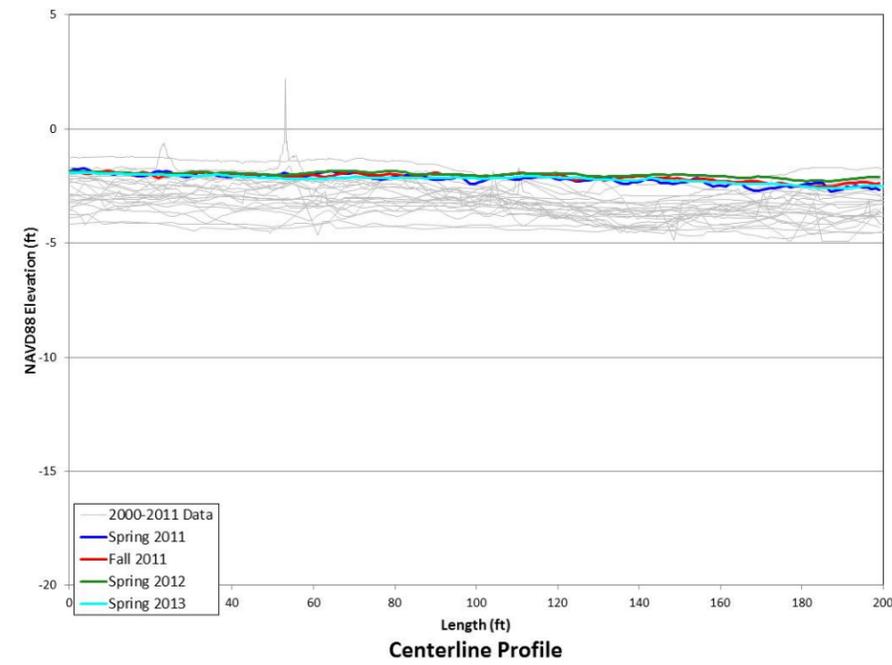
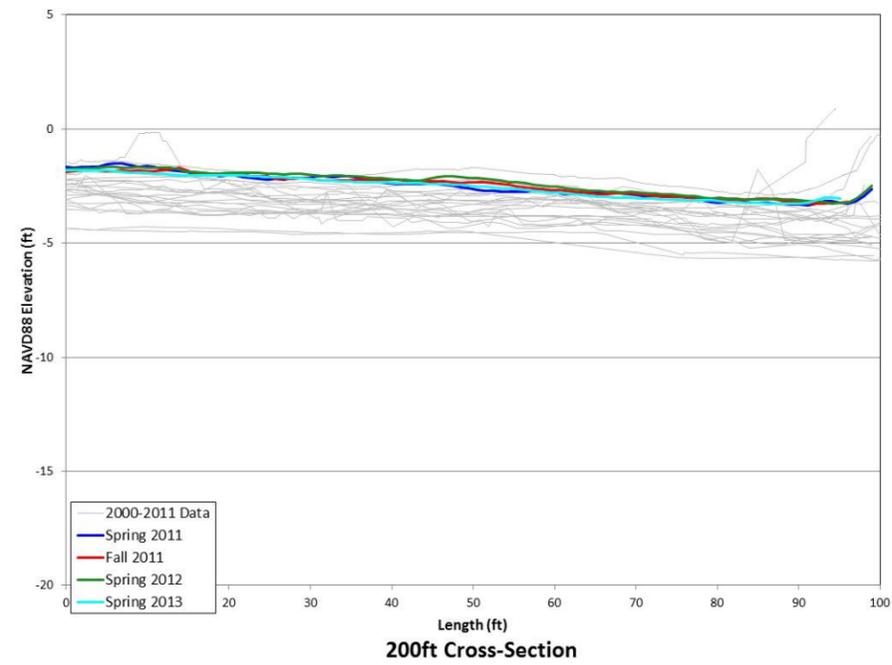
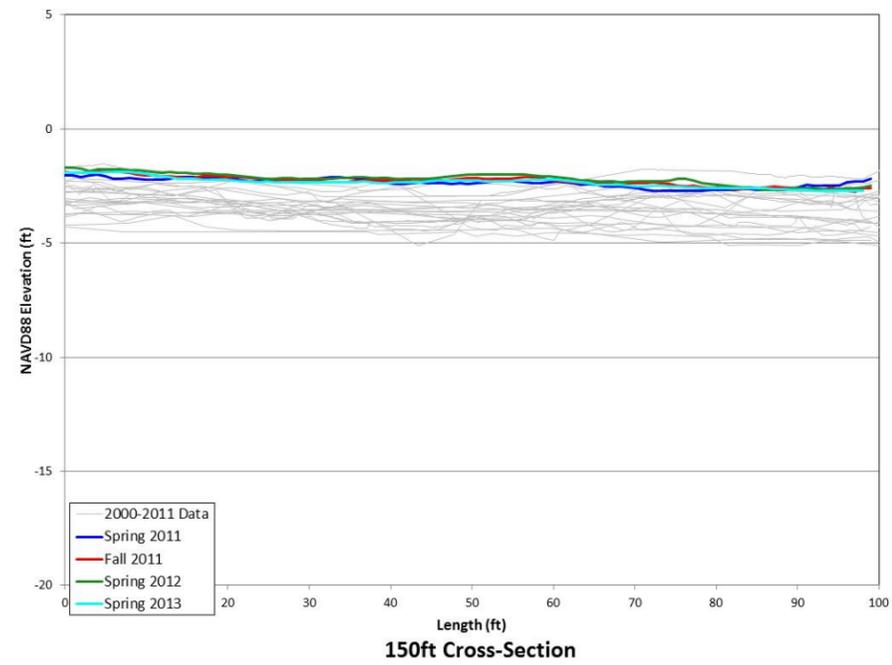
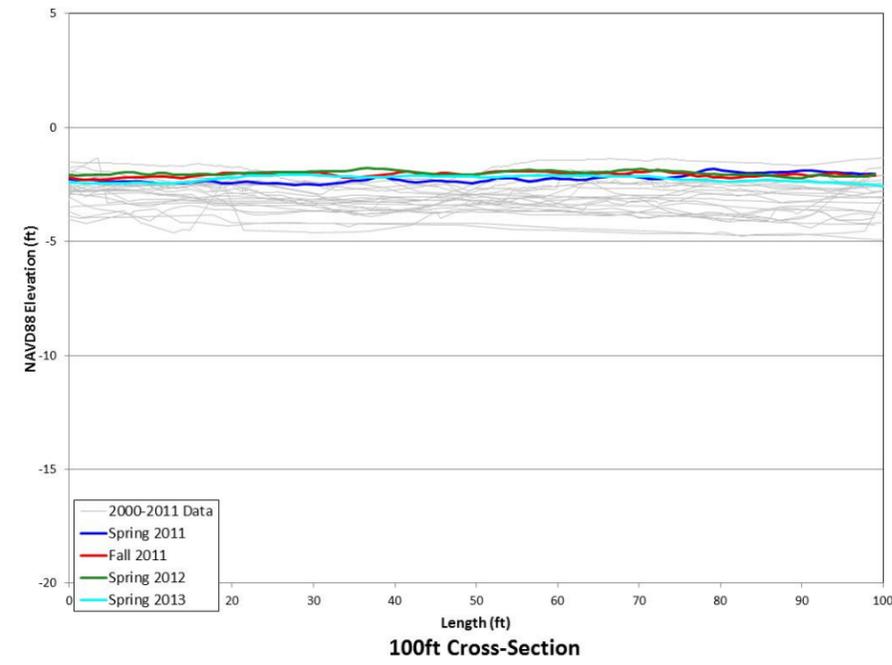
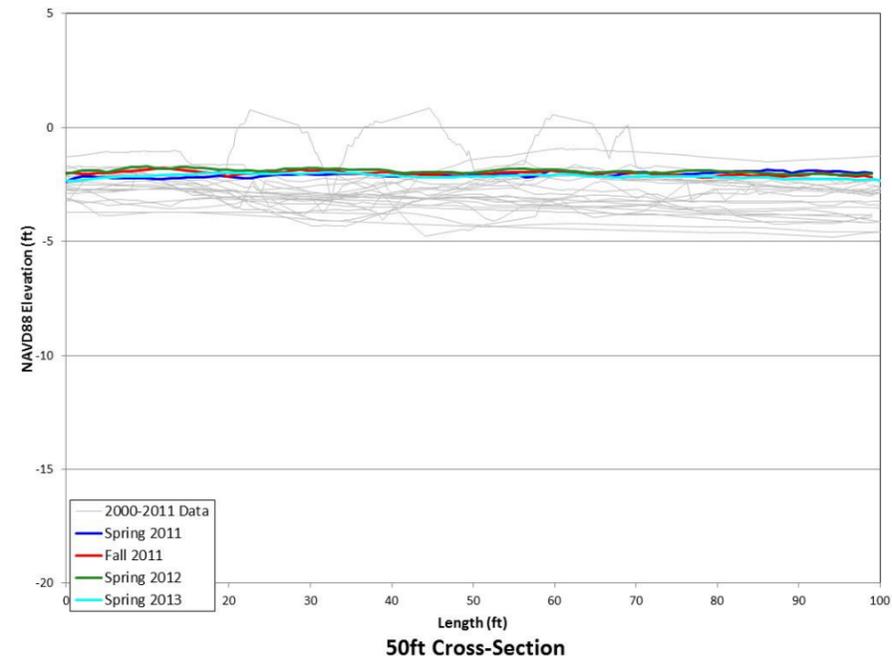
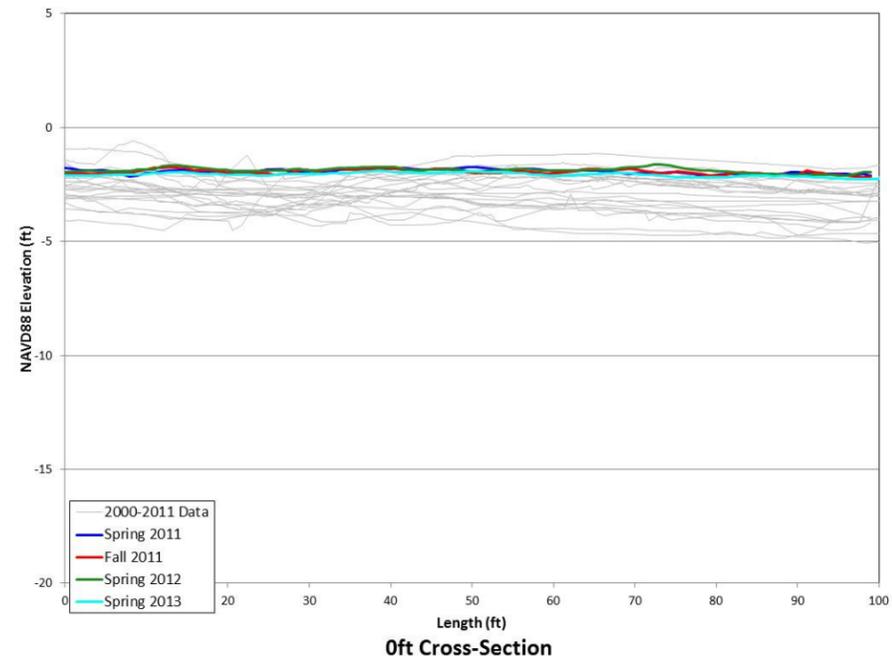
Appendix L: GLC-2A Semi-Annual Cross-Sections



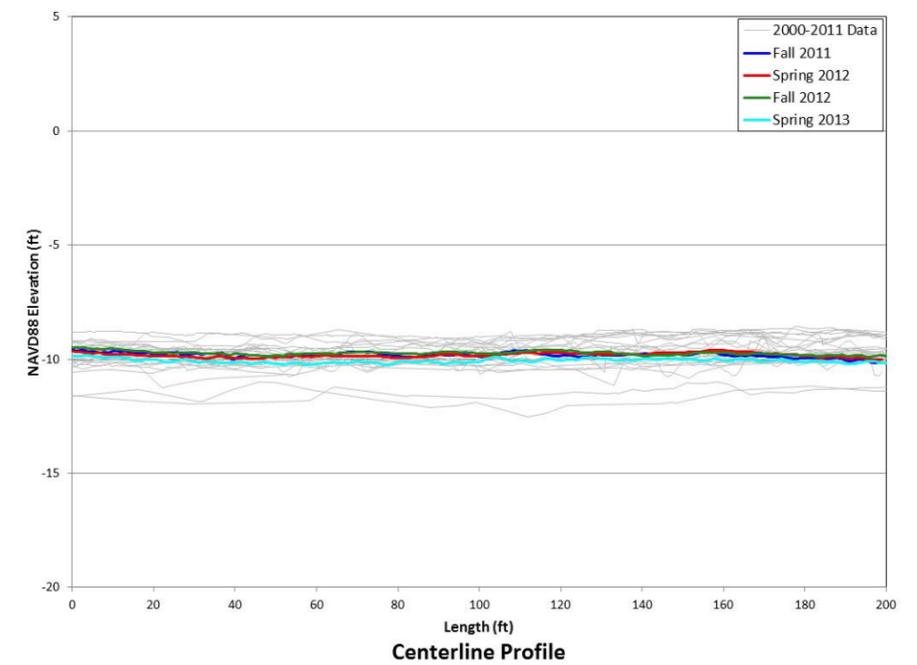
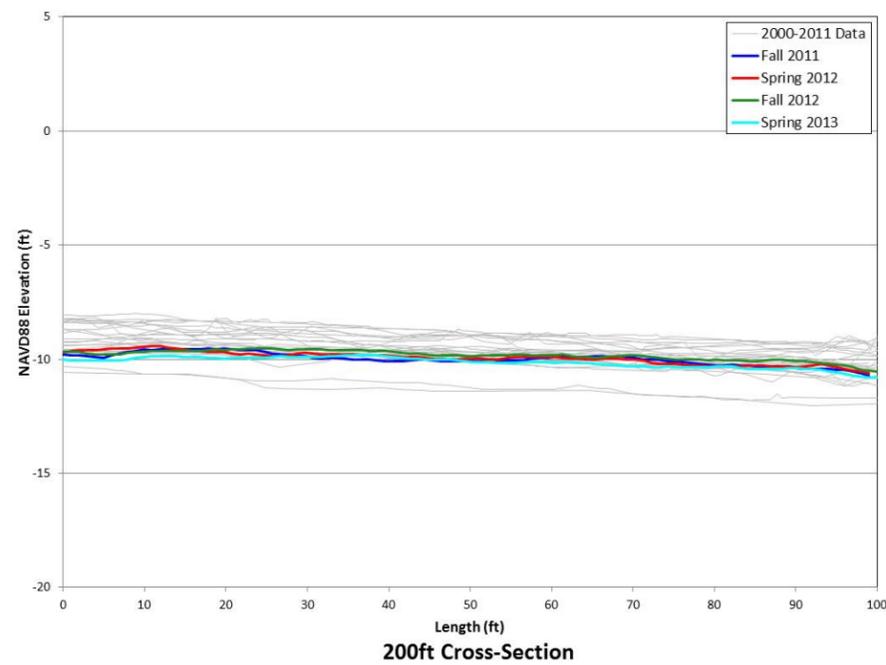
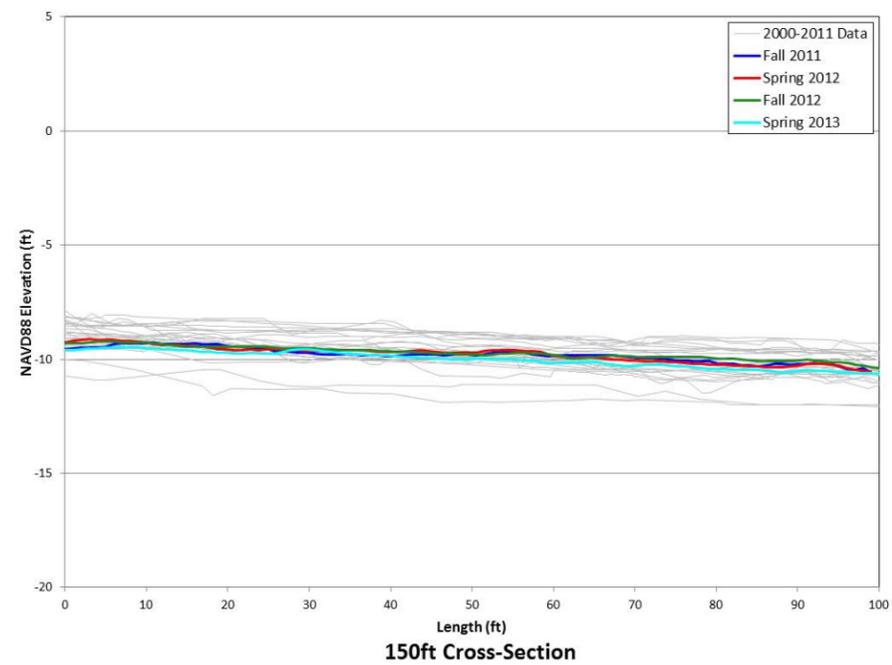
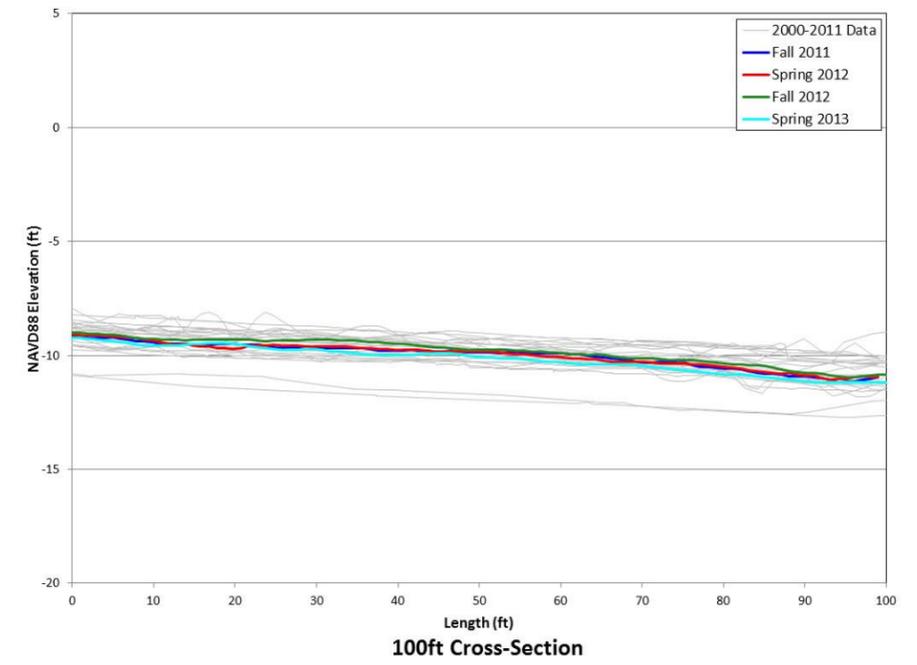
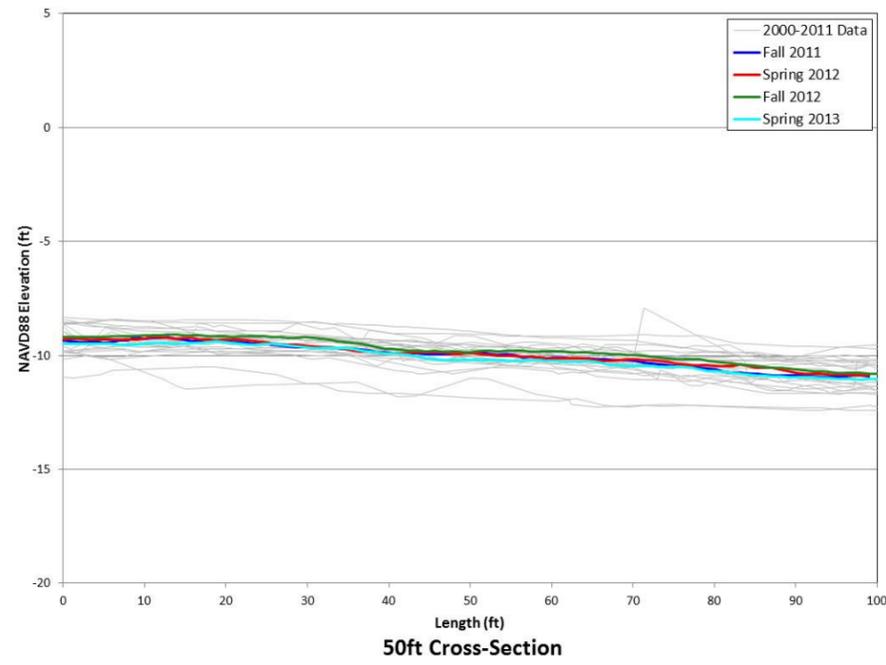
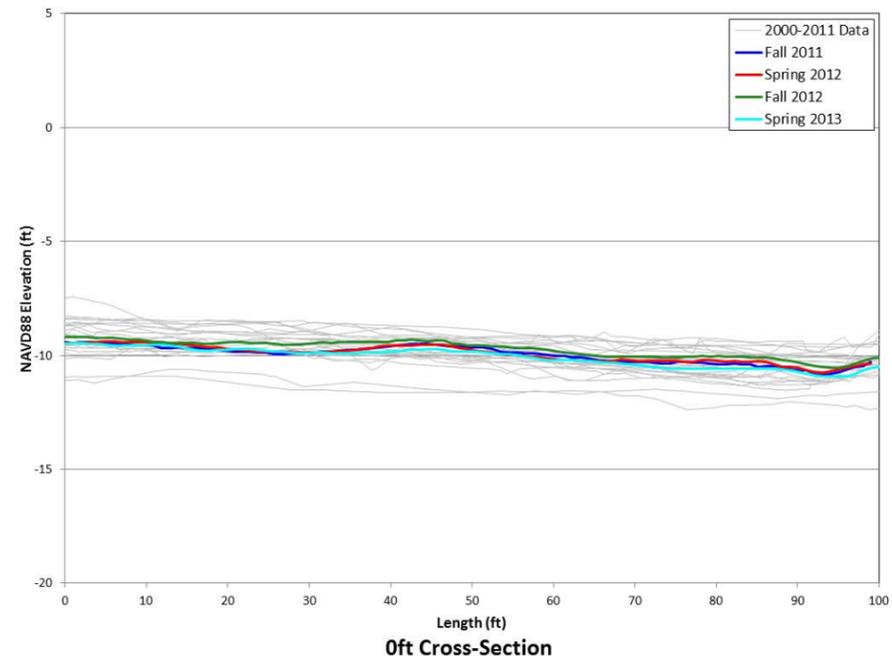
Appendix M: GLC-2B Semi-Annual Cross-Sections



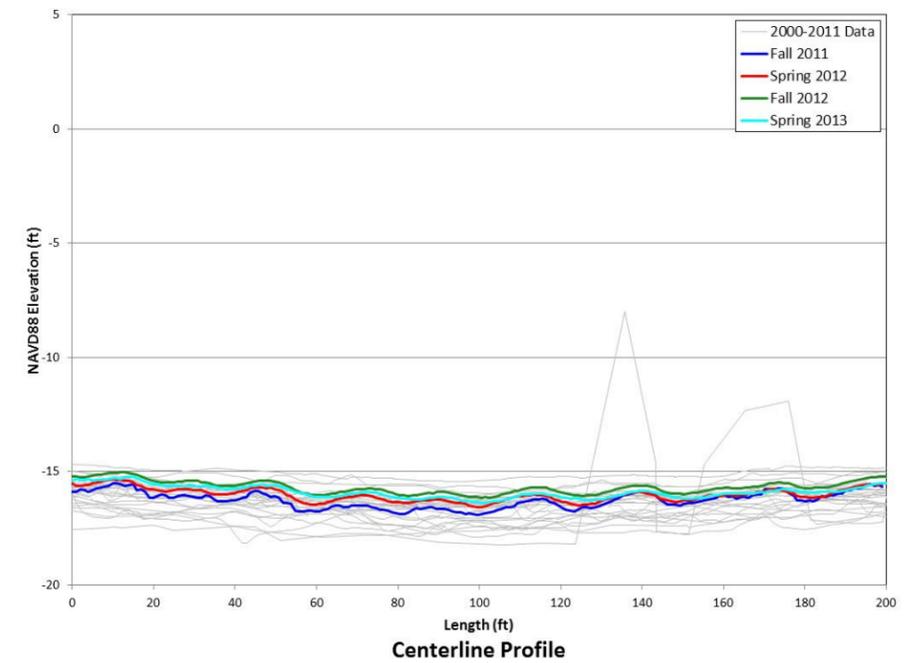
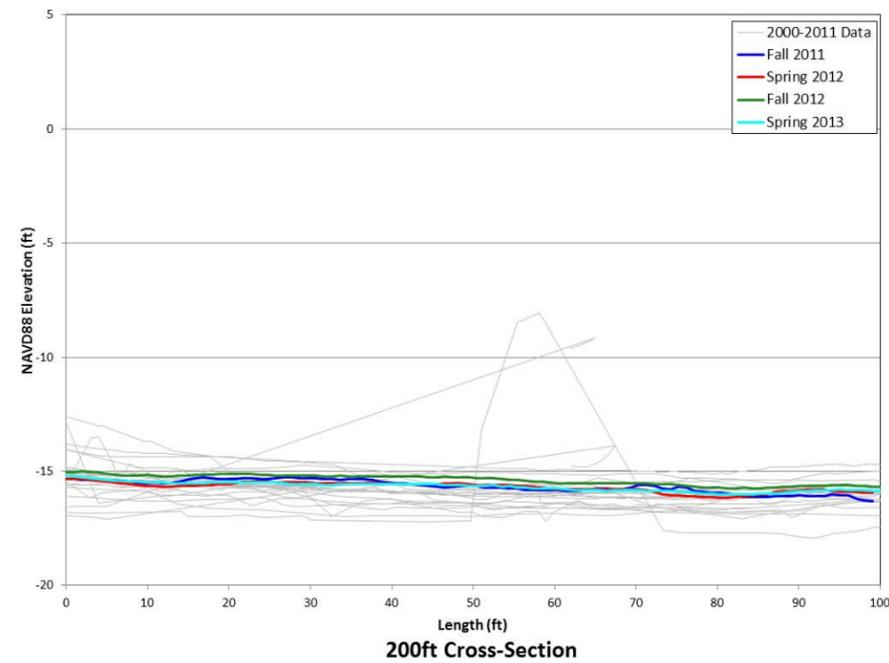
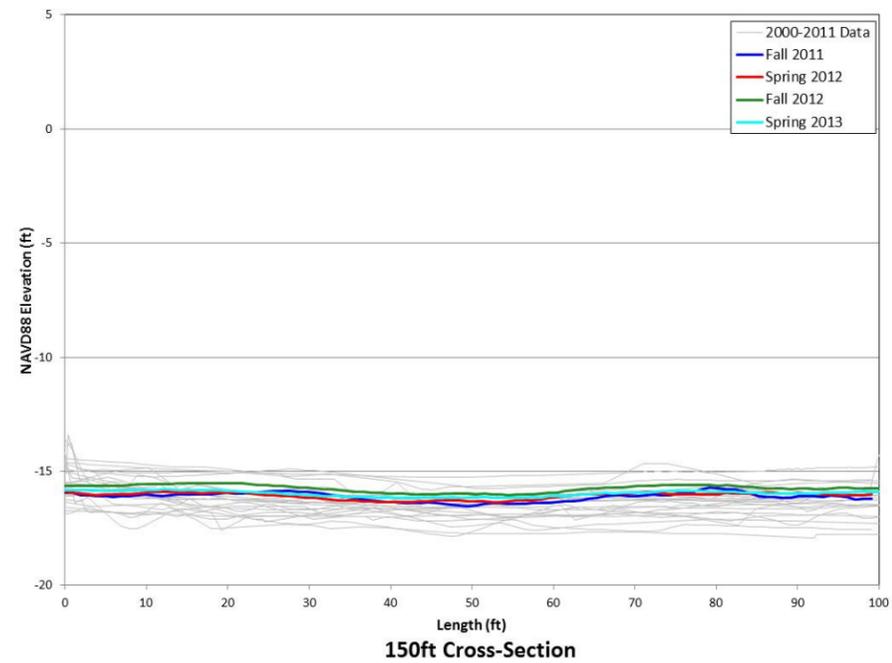
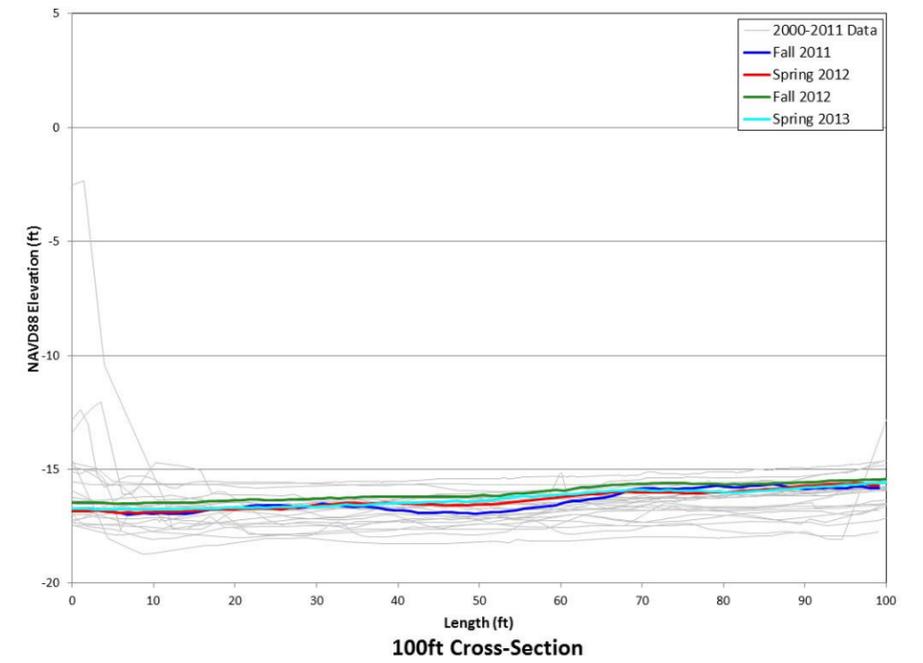
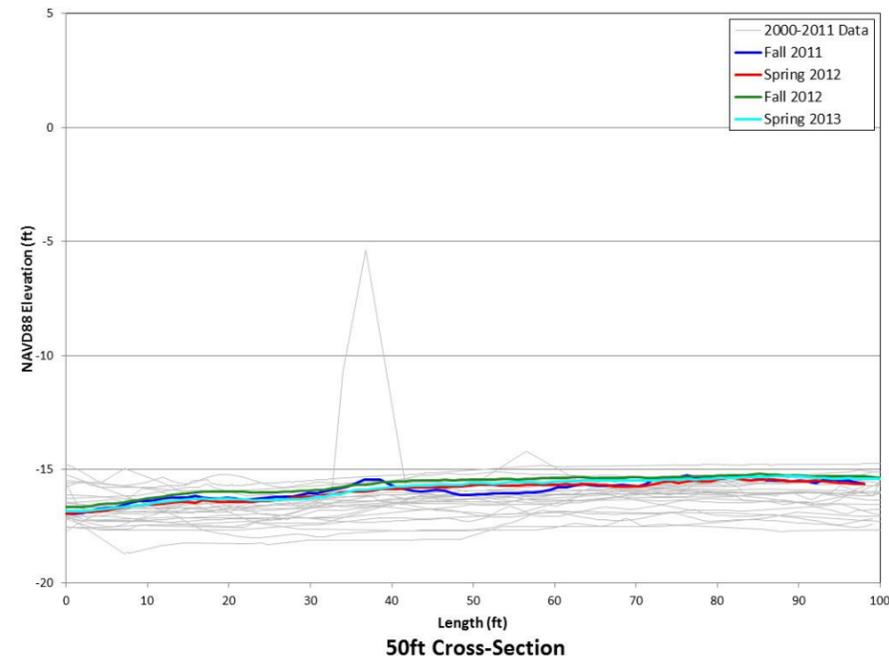
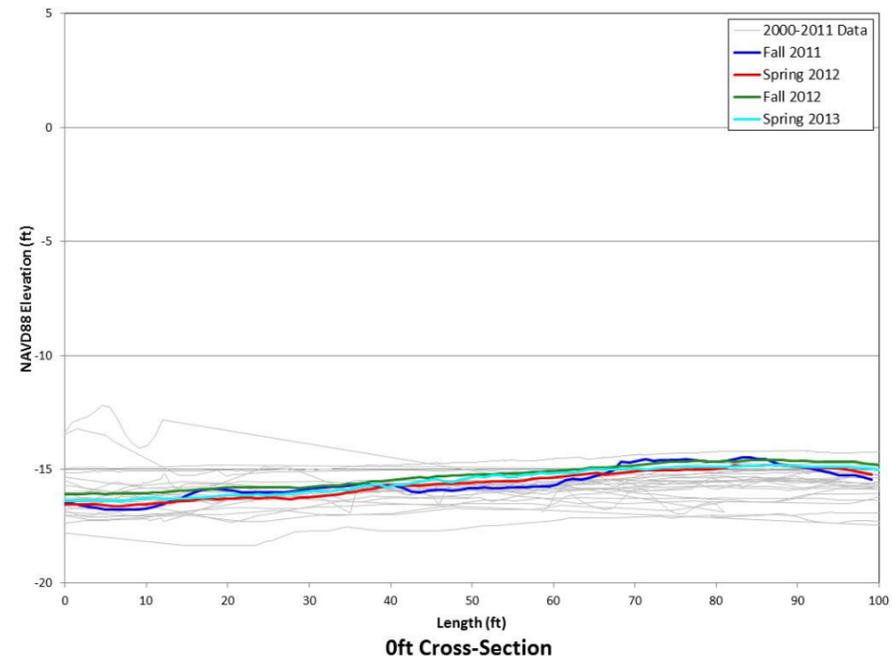
Appendix N: GLC-3 Semi-Annual Cross-Sections



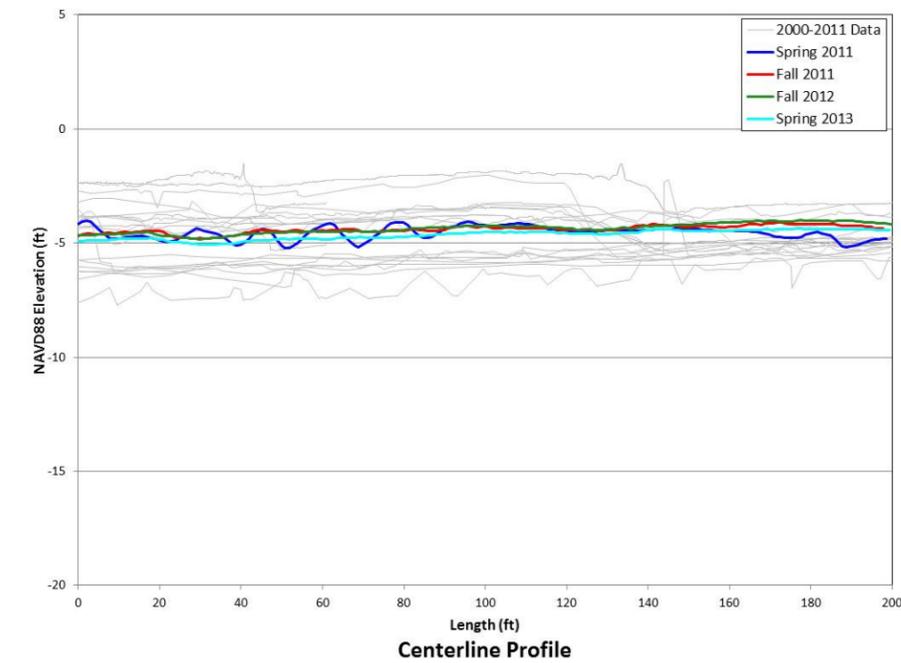
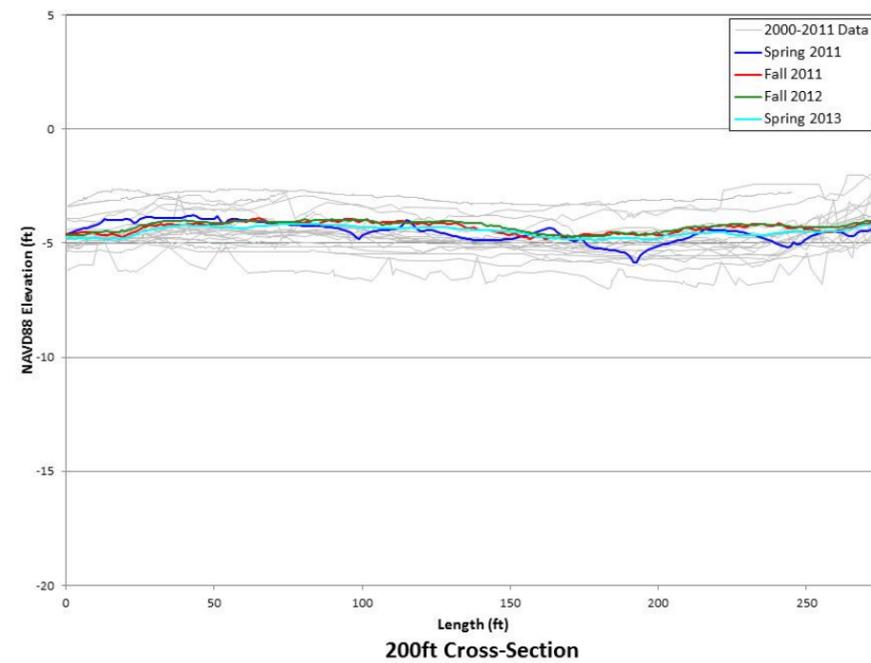
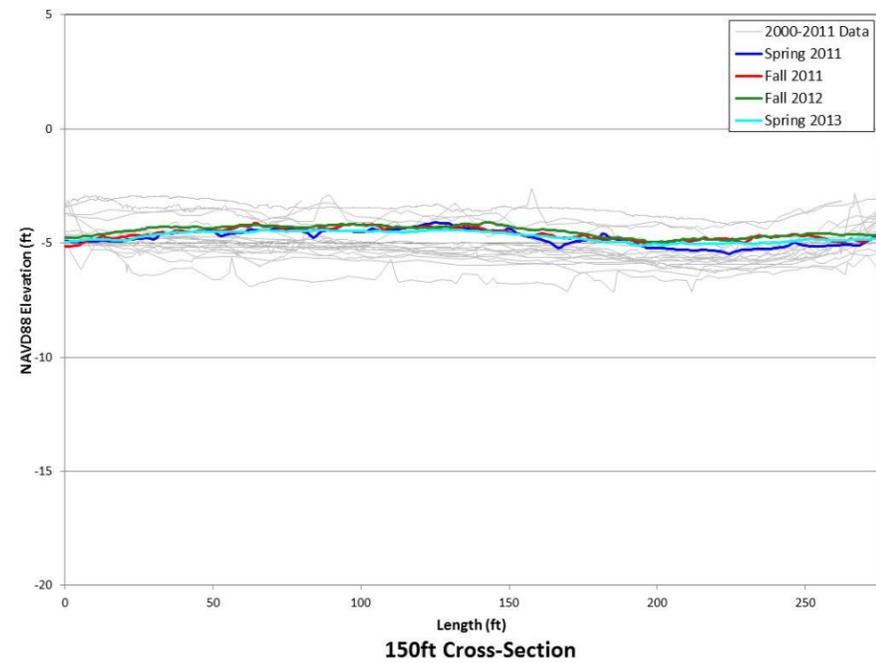
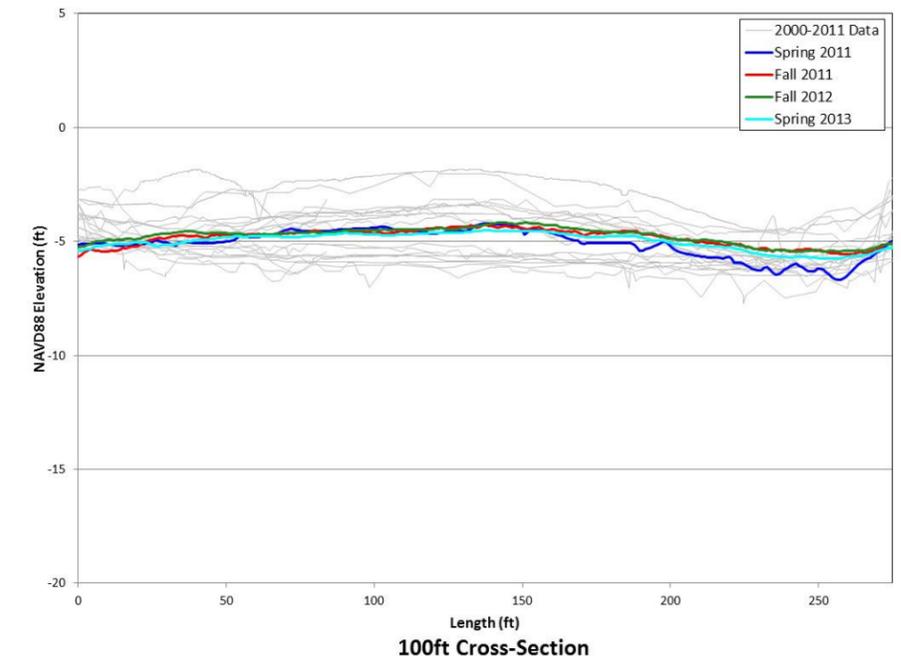
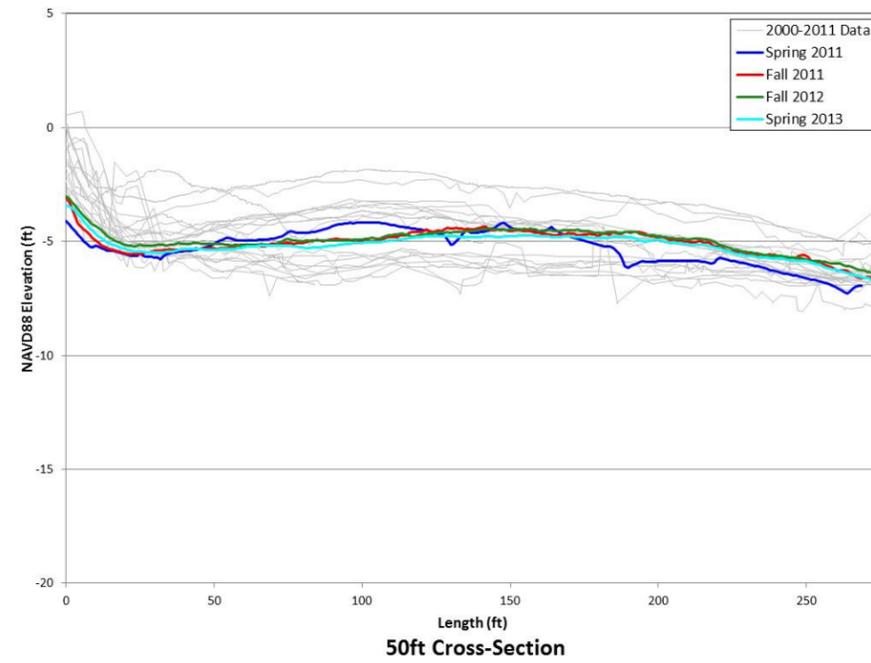
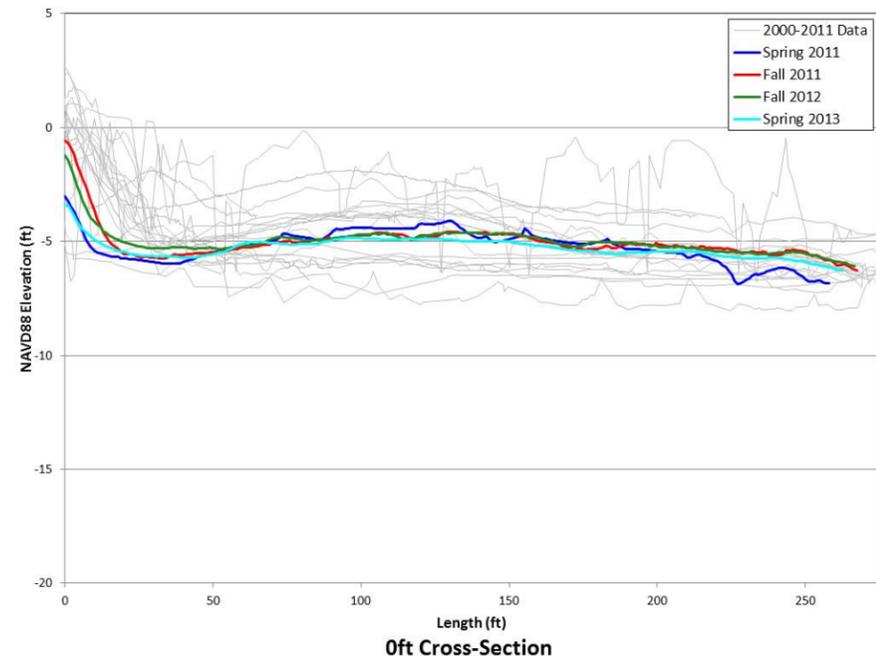
Appendix O: GLC-4 Semi-Annual Cross-Sections



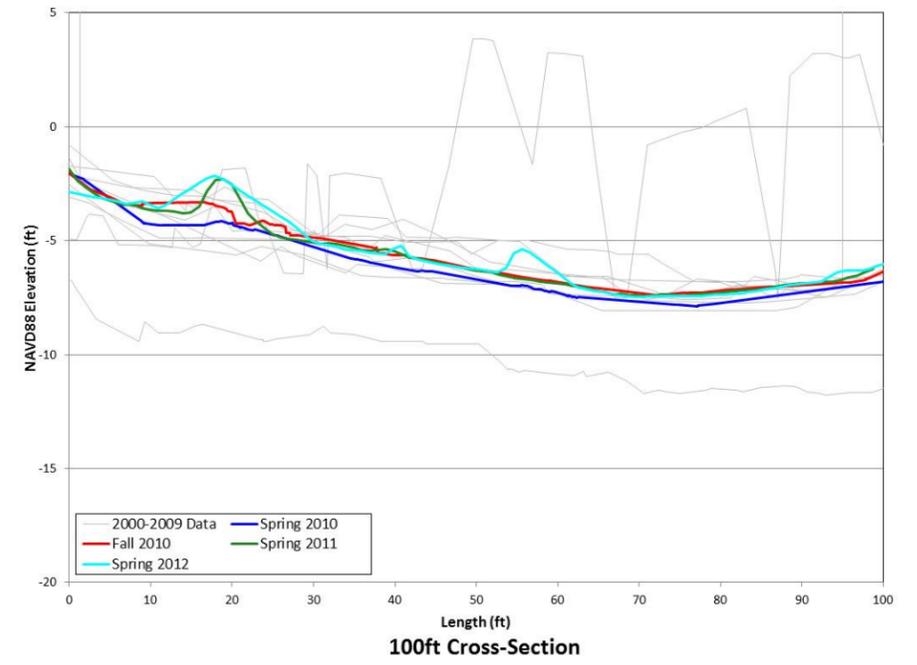
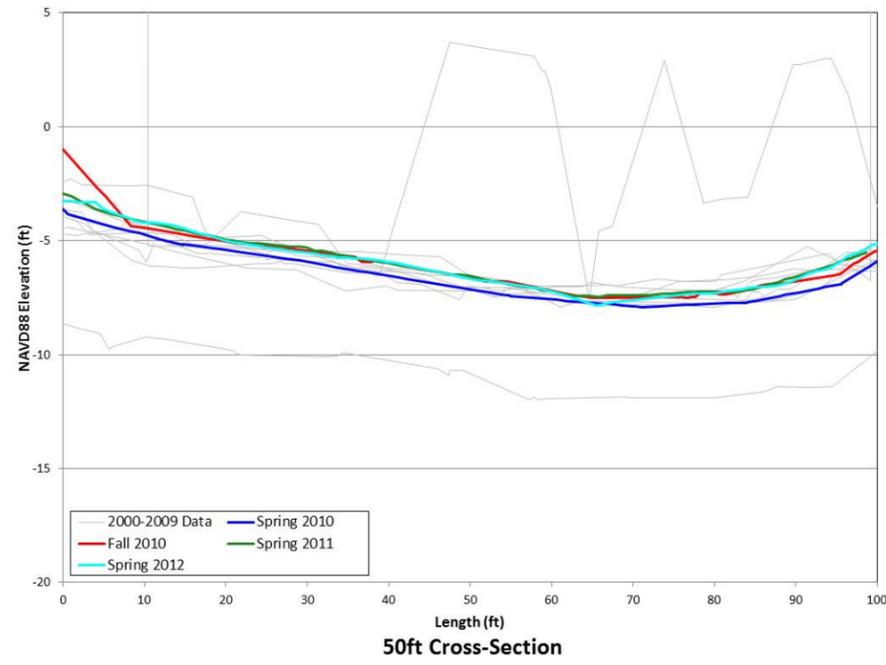
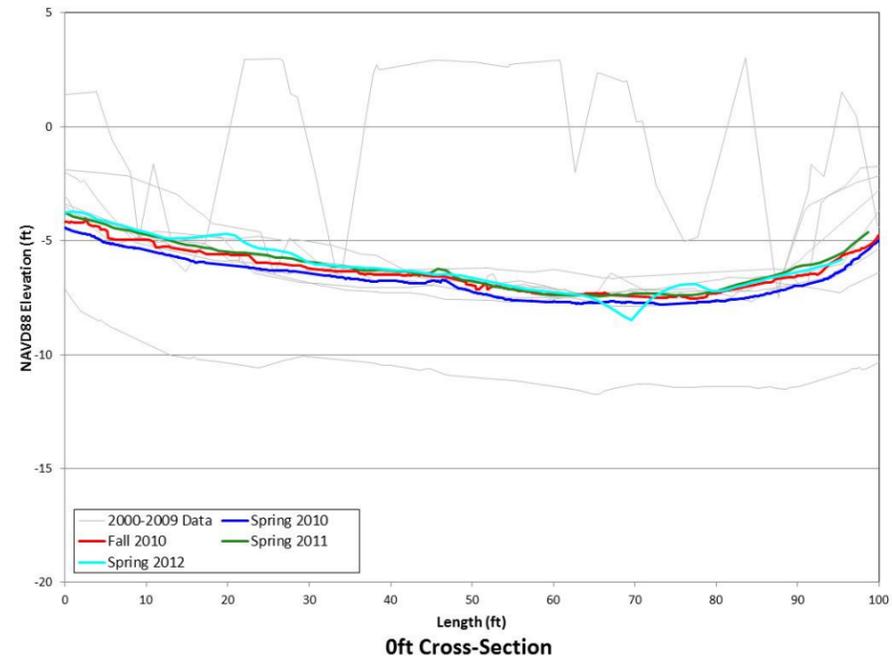
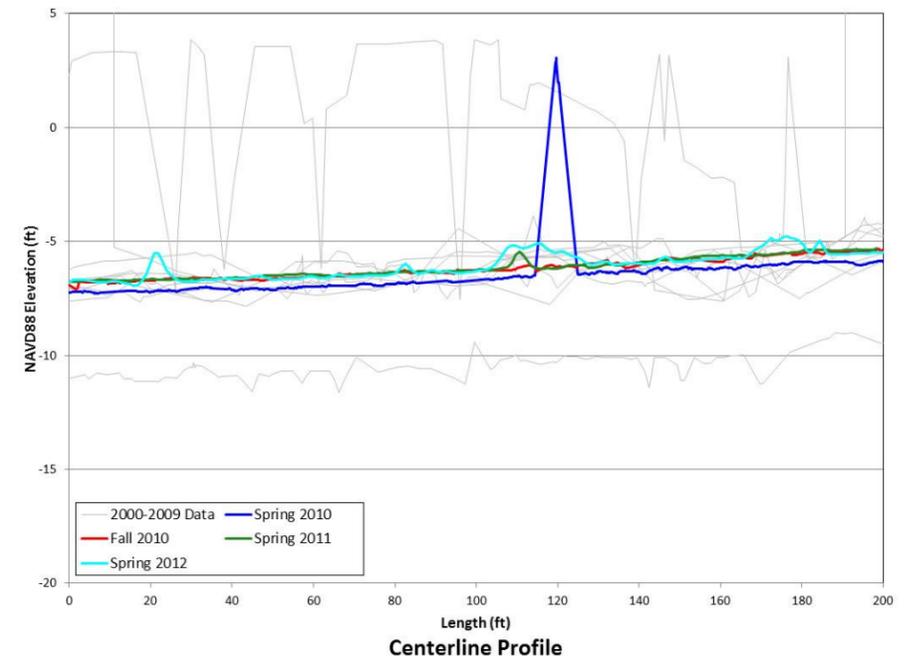
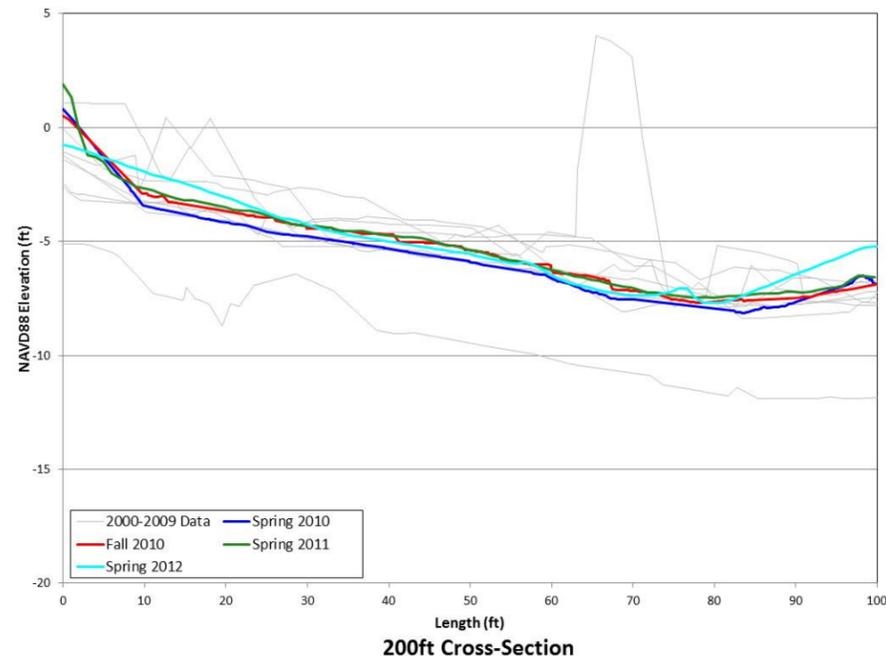
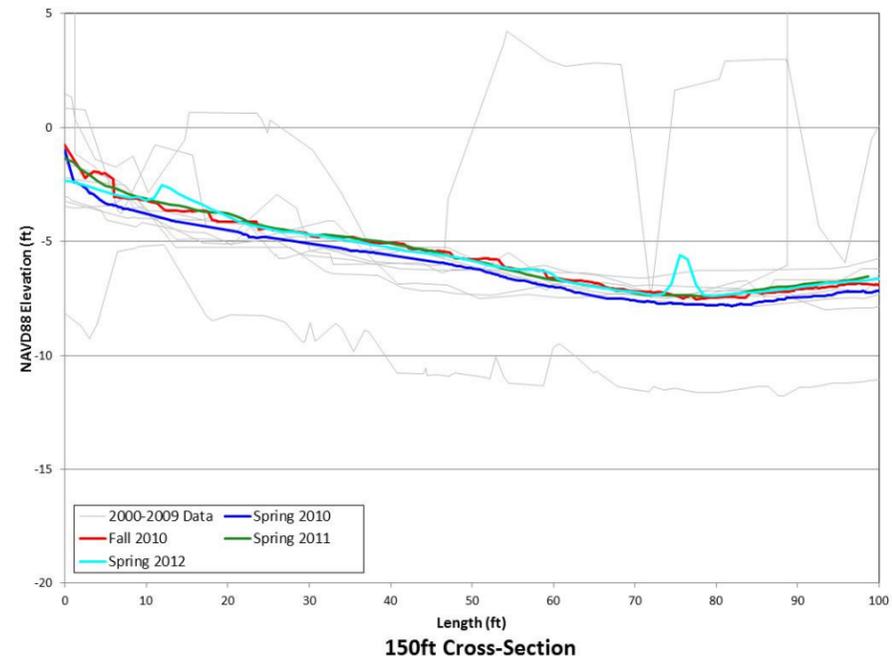
Appendix P: GLC-5 Semi-Annual Cross-Sections



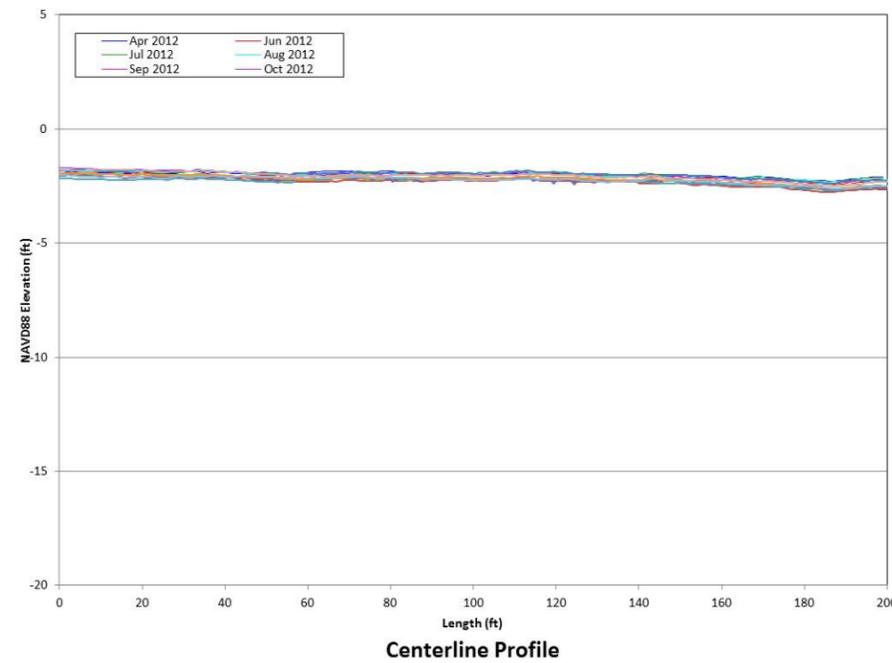
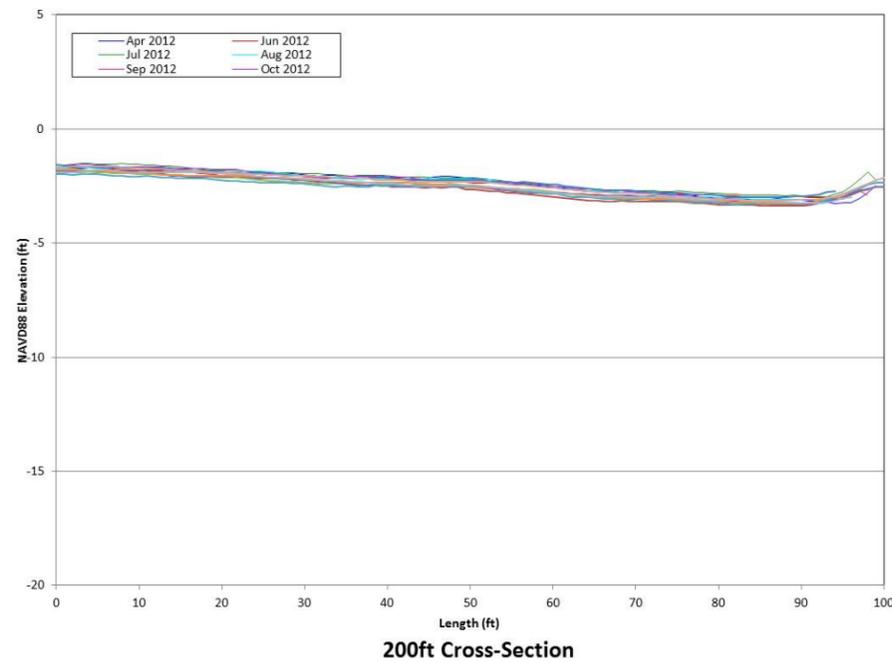
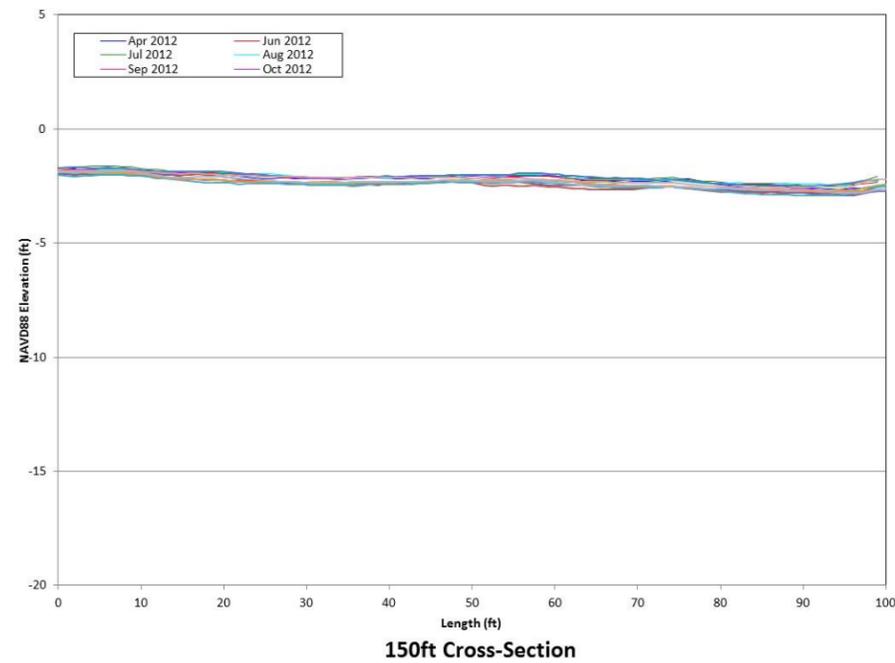
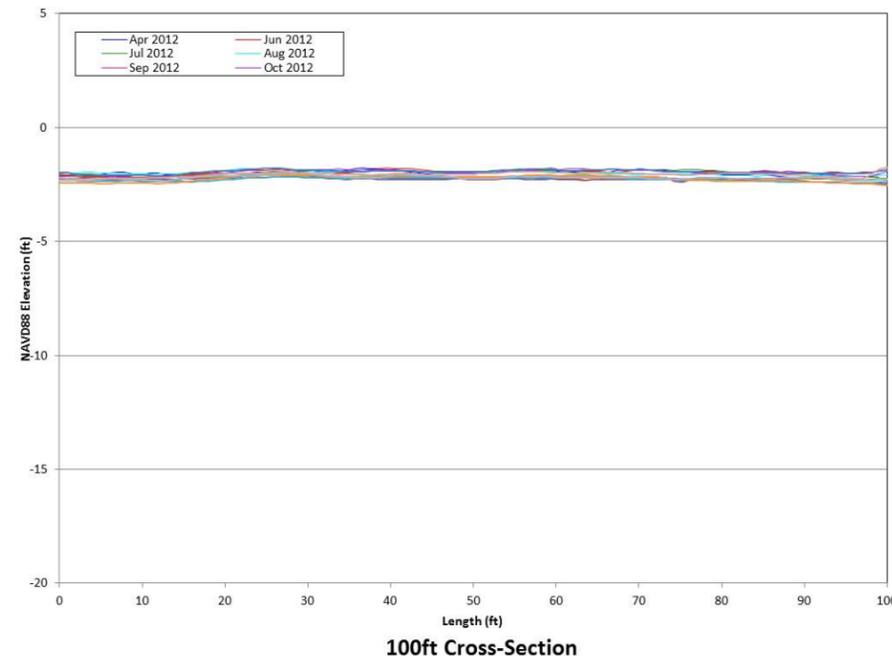
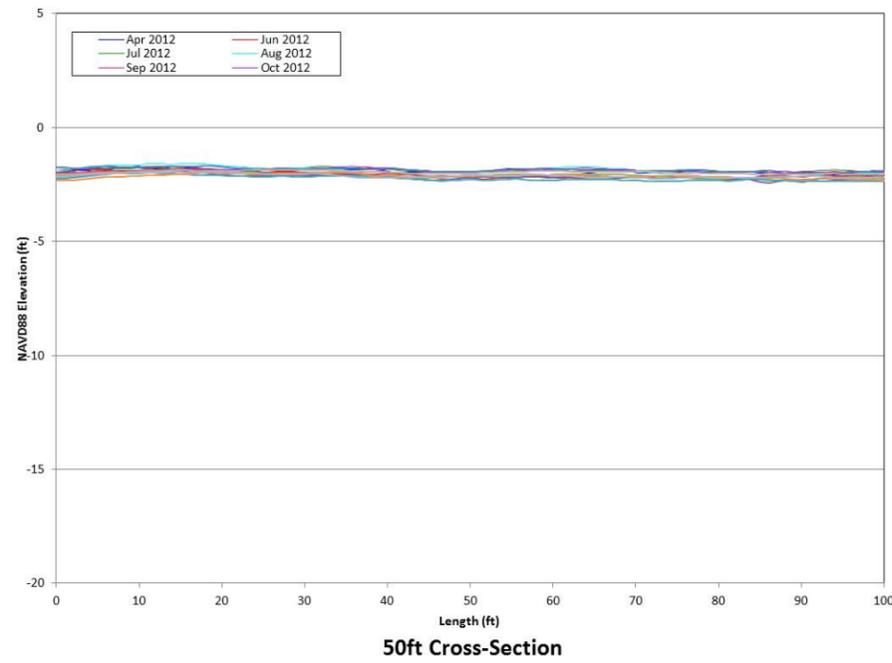
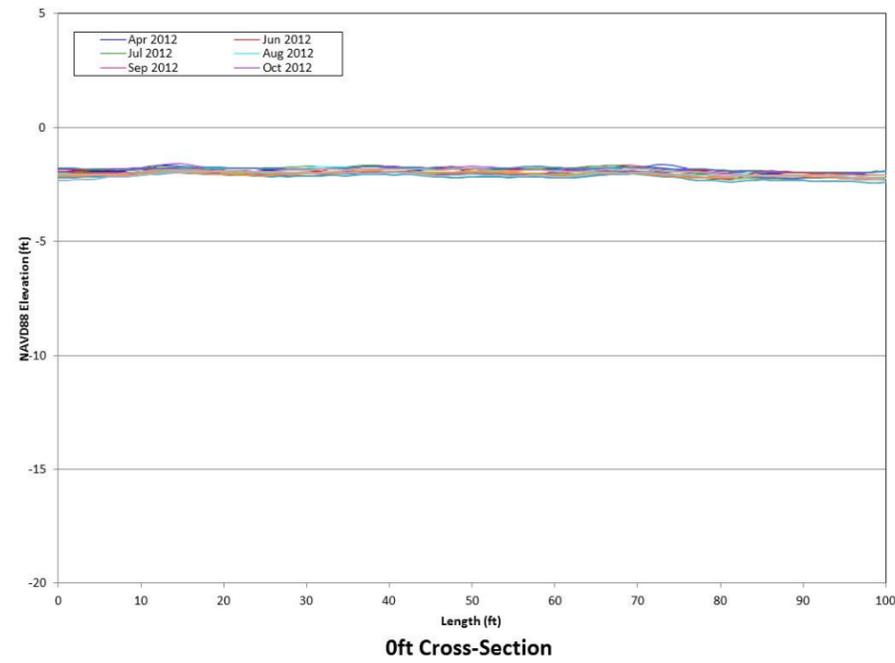
Appendix Q: DC-1 Semi-Annual Cross-Sections



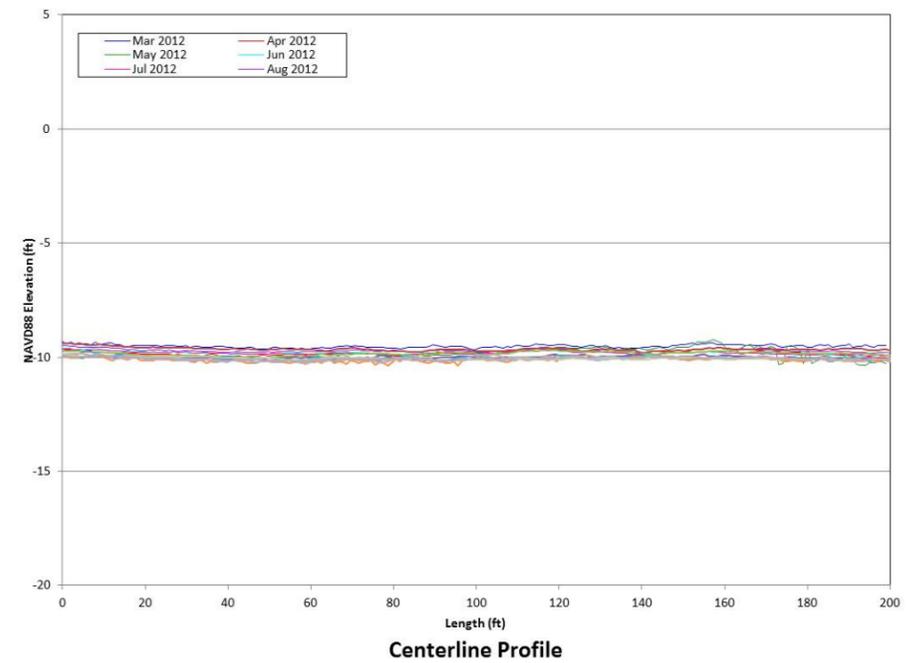
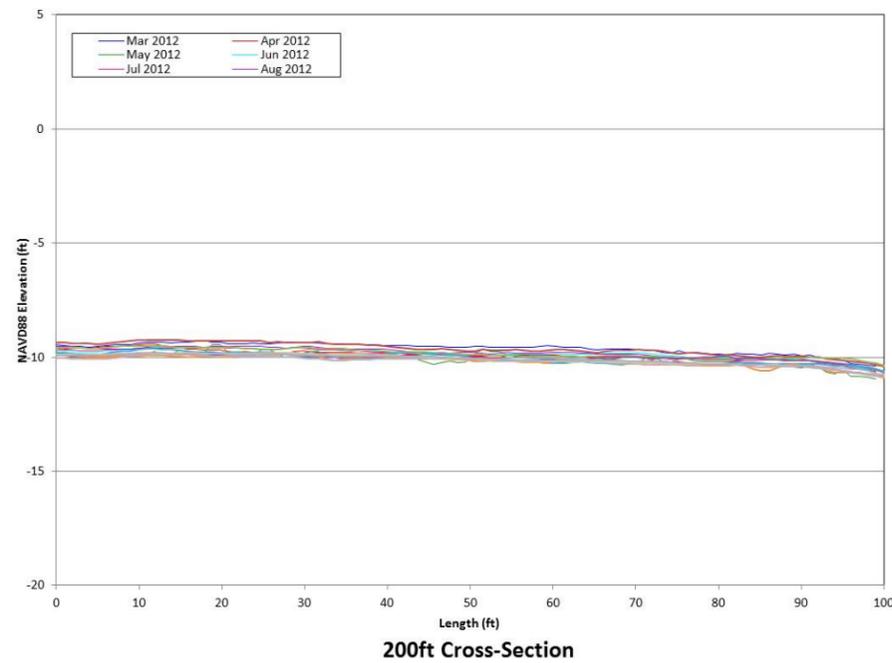
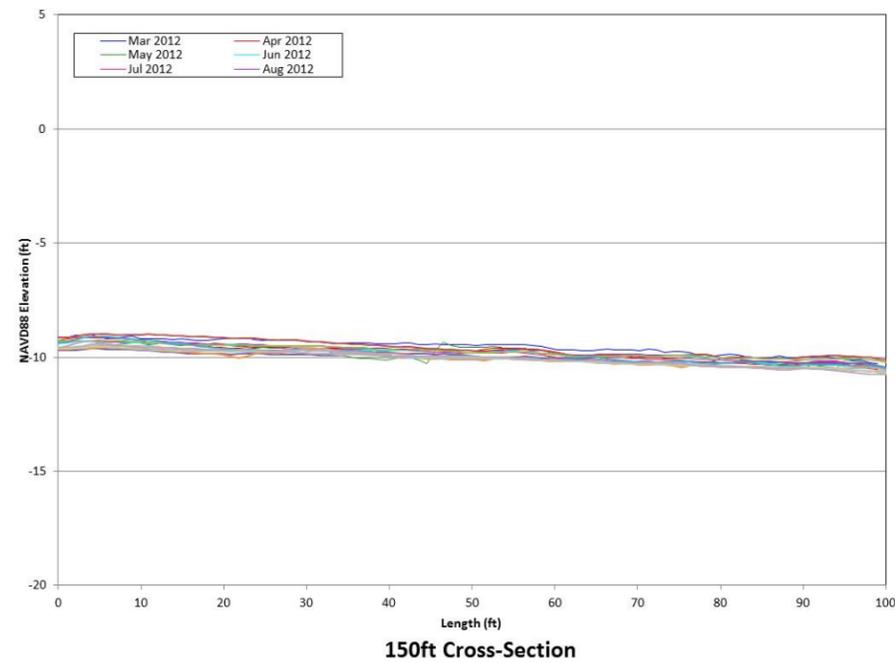
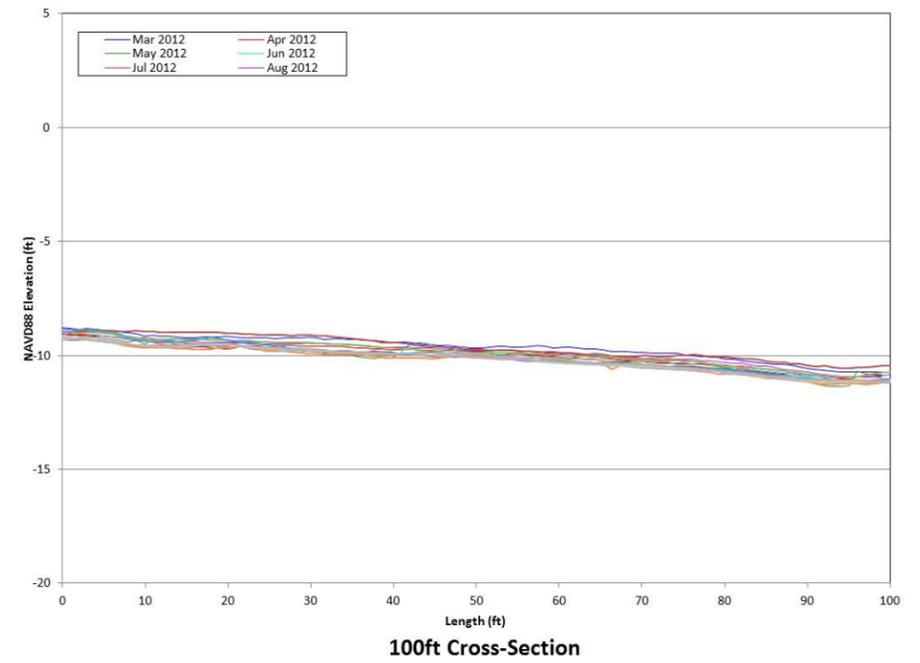
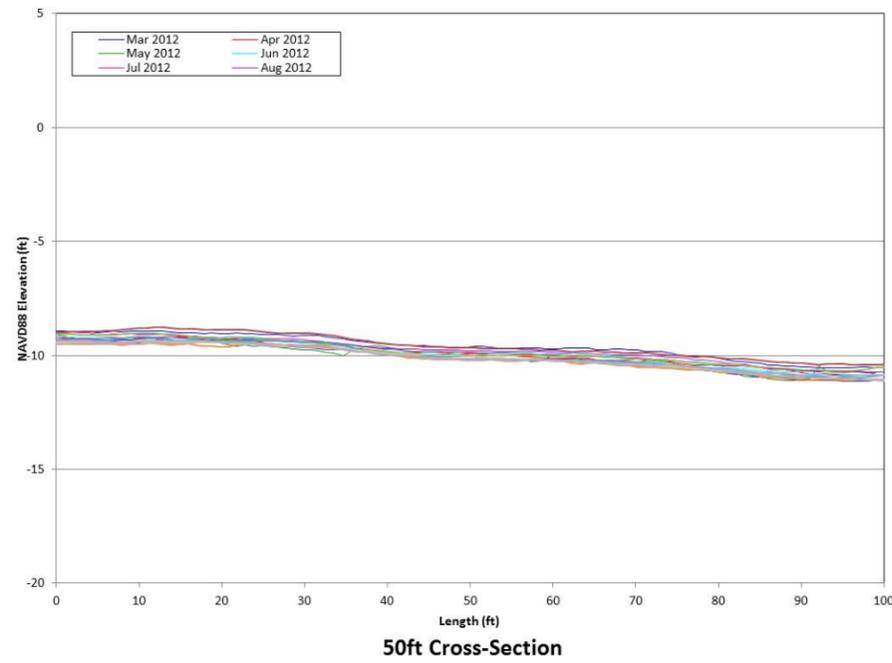
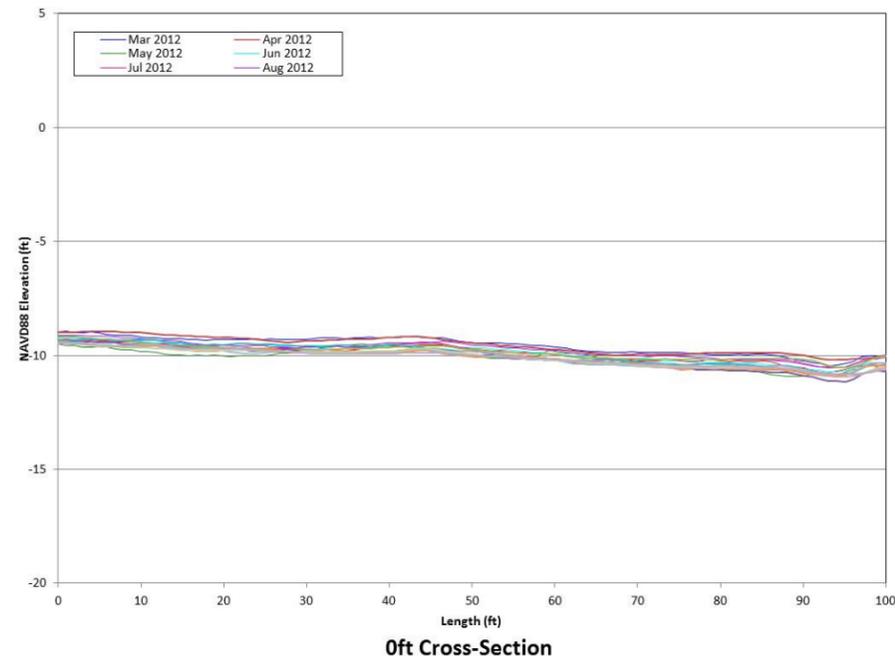
Appendix R: MR-1 Semi-Annual Cross-Sections



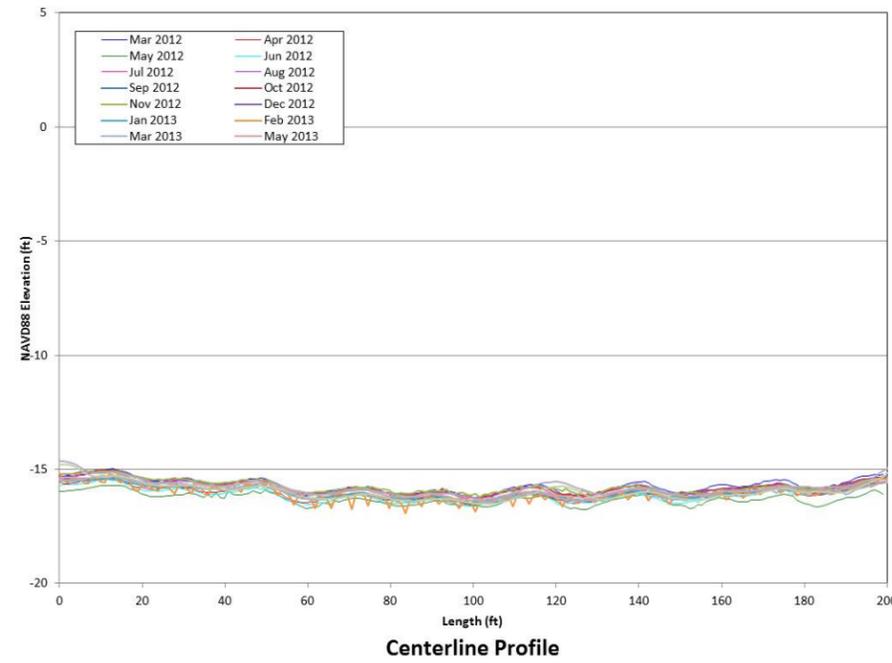
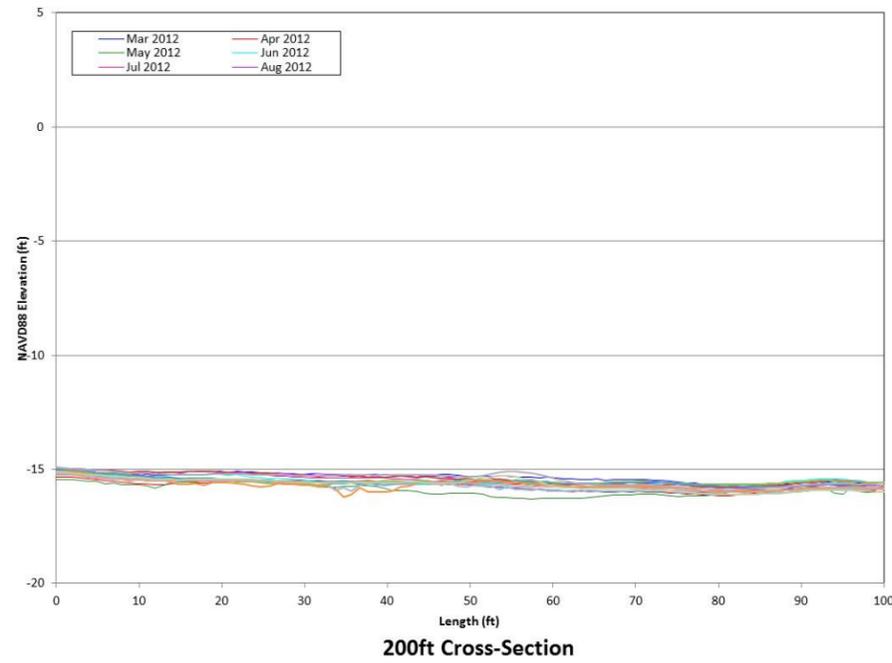
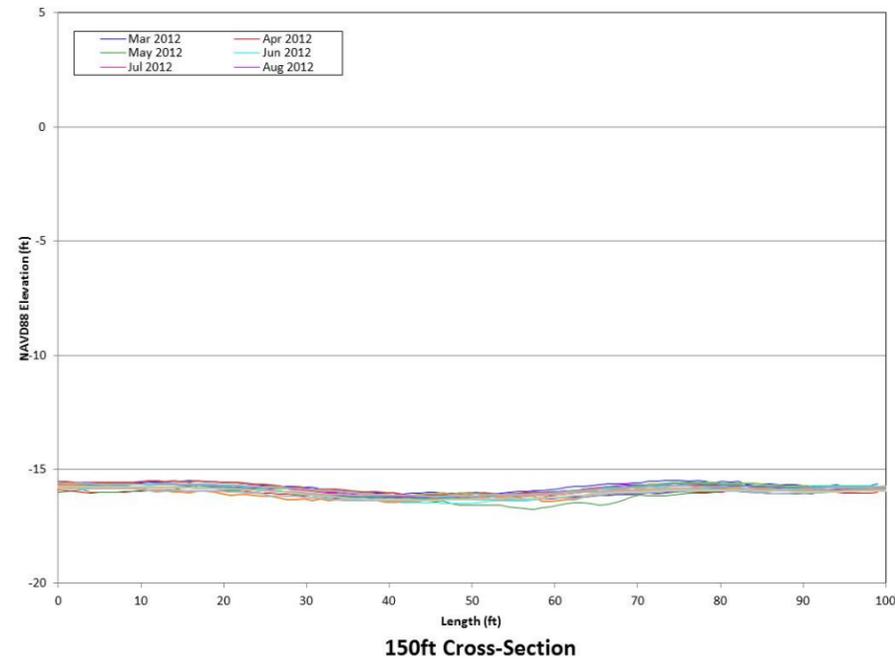
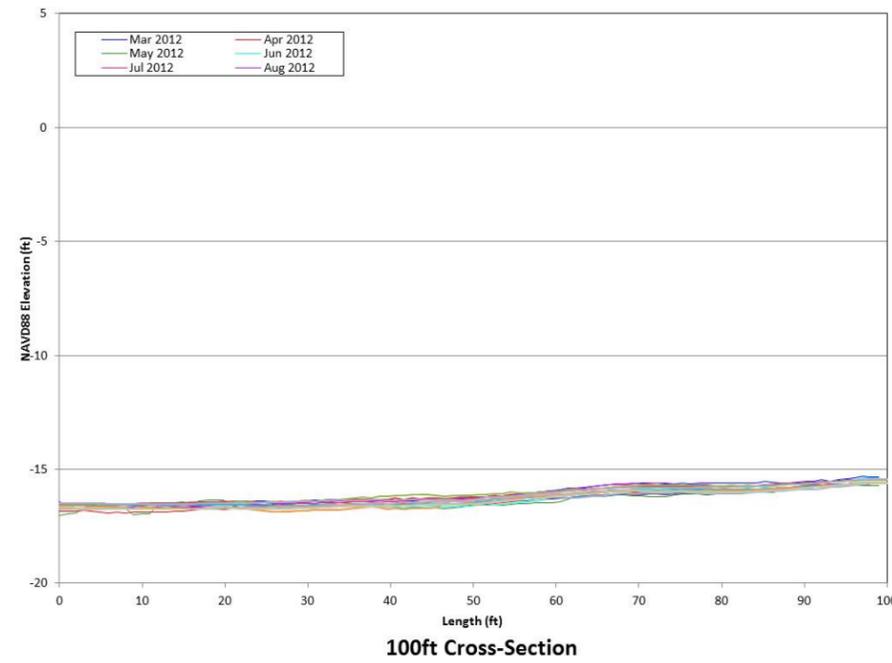
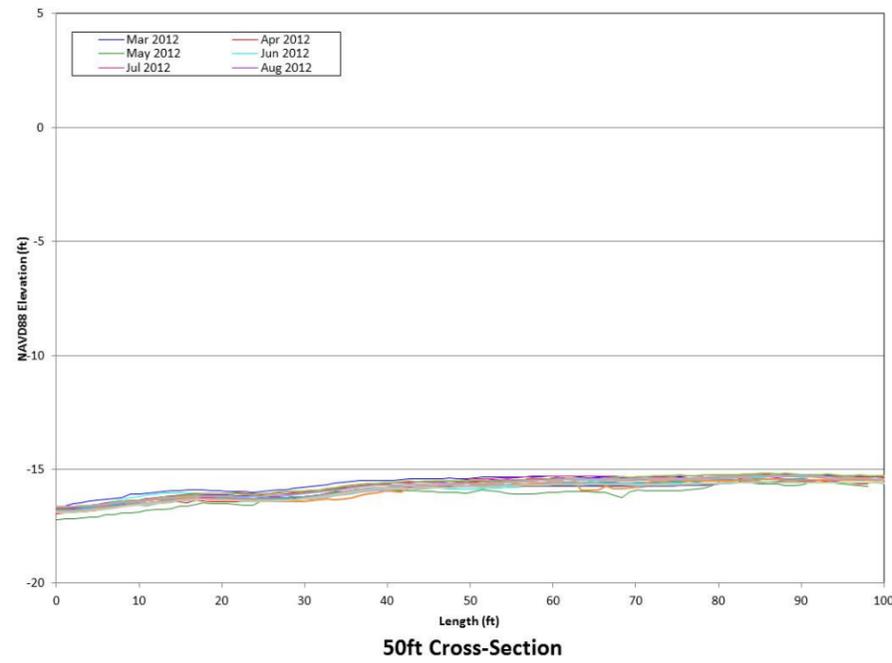
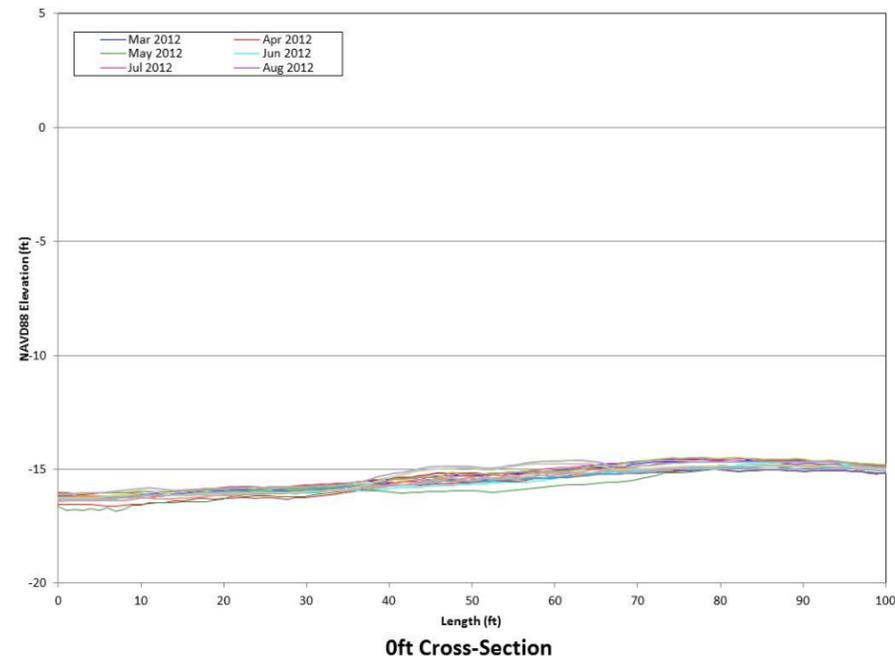
Appendix S: GLC-3 Monthly Cross-Sections



Appendix T: GLC-4 Monthly Cross-Sections



Appendix U: GLC-5 Monthly Cross-Sections



Appendix V: DC-1 Monthly Cross-Sections

