



# Memorandum

Date: October 19, 2011

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South Delta Branch  
Bay Delta Office

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From: Department of Water Resources

Subject: Memorandum Report - Bed Sediment Monitoring in the South Delta Spring 2003 - Fall 2010

Attached for your information and use is the Memorandum Report - Bed Sediment Monitoring in the South Delta Spring 2003 - Fall 2010, August 2011. This report presents sediment monitoring results at 17 sites in the south Delta between the Spring 2003 and Fall 2010.

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

# Executive Summary

The Department of Water Resources North Central Region Office (NCRO) 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 on the former Interim South Delta Program (ISDP) regarding the potential effects of proposed permanent barriers on sediment accumulation. The Temporary Barrier Project (TBP) is being used to evaluate the effects of the proposed permanent barriers. Four temporary rock barriers, consisting of three flow control barriers and one fish barrier, are installed each spring and removed each fall. Depending on flow conditions, the fish barrier may be installed and removed twice a year.

This report presents a summary of findings for the period of Spring 2003 through Fall 2010. A report presenting sedimentation trend information for the period 2000 through 2002 was submitted by the NCRO (formerly the Central District) in September 2004 entitled *Bed Sediment Monitoring in the South Delta Memorandum Report*. The 2004 report stated that, in general, the bed sediment monitoring sites exhibited erosion for the period between fall and the following spring and sediment accumulation for the period between spring and the following fall. Along with other general observations, the report indicated the period of record was insufficient to make an evaluation of the long-term effects on bed sediment volume changes.

The volumetric data analysis for data collected between 2003 and 2010 was inconclusive due to a number of factors, including a lack of site coverage, and aquatic growth. Future surveys using a multi-beam depth sounder will significantly improve coverage. Sites with significant aquatic growth may require using a rod to accurately sample the channel bottom. Cross-sections were used for a qualitative trend analysis of sediment levels in the south Delta. Between 2003 and 2010 spring and fall sediment levels were noticeably larger than sediment levels in 2000. Sediment levels were noticeably higher at sites directly upstream of the barriers; how far upstream the barriers influence extends is still unknown. Downstream, barrier influence appear to be isolated to sites immediately downstream of the barriers.

The 2004 report stated that the mean grain size of bed sediment samples showed minor, but detectable changes during the monitoring period. In most cases, sediment samples collected in the fall had a smaller mean grain size than sediment samples collected in the spring. Sediment sample data collected since 2002 suggests that, during periods of low flows in the San Joaquin River, finer sediments accumulated in the south Delta channels. During periods of high flows, of around 20,000 cubic feet per second, finer sediments were washed out of the south Delta channels. High flows occurred in water years 1998, 1999, 2005 and 2006.

It is recommended that MR-1 no longer be surveyed and sediment samples no longer be collected because there has been no significant long-term change in mean grain size. In addition, GLC-4, GLC-5 and DC-1 should be monitored monthly for a period of one year to observe how sediment levels change over a shorter time interval.

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# 1.0 Introduction

The Department of Water Resources (DWR) North Central Region Office (NCRO) is actively studying sedimentation levels in the south Delta in an effort to determine what impact, if any, the Temporary Barriers Project (TBP) has on sedimentation in the south Delta. This report presents the results of the bathymetric and soil sample data collected between the spring of 2003 to the fall of 2010 in an effort to understand the impact that the temporary barriers have on south Delta sediment levels.

## 1.1 BACKGROUND

In 1982, the South Delta Water Agency (SDWA) filed a lawsuit stating that the operation of the Central Valley Project (CVP) and State Water Project (SWP) had a negative impact on water levels and water quality in the SDWA service area. The Interim South Delta Program (ISDP) was proposed as a result of that lawsuit. The ISDP contained several components, one of which was the construction of four permanent barriers, consisting of three agricultural barriers that raise water levels in the SDWA service area and one fish barrier to restrict fish passage down Old River. These permanent barriers would replace the annually installed and removed TBP barriers.

Comments on the 1996 Draft ISDP EIR/EIS expressed concern that the proposed permanent barriers would increase south Delta sediment levels and have a negative impact on navigation and recreation. In response, DWR began monitoring sediment levels in Old River, Middle River, Doughty Cut and Grant Line Canal in 1998. Monitoring occurred twice a year, once in the spring before the barriers were installed and once in the fall before the barriers were removed. In 1998 and 1999, five cross-sections were measured at 17 sites. Beginning in 2000, changes in technology allowed for surveying of these sites using a depth sounder and Global Positioning System (GPS). In September 2004, *Bed Sediment Monitoring in the South Delta Memorandum Report* (DWR 2004) was submitted to the Bay-Delta Office covering data from fall 2000 through fall 2002. The DWR 2004 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.

A final EIR/EIS for the ISDP was never released. In 2005, a draft EIS/EIR for the South Delta Improvements Program (SDIP) was released, which described the continuation of the TBP. The TBP barriers are to be installed and operated until the permanent barriers (now referred to as “gates”) are constructed and the SDIP is implemented. A final EIS/EIR for the SDIP was released in 2006. The status of the SDIP and related documents can be found at the Bay-Delta Office (BDO) South Delta Branch website: [http://baydeltaoffice.water.ca.gov/sdb/sdip/index\\_sdip.cfm](http://baydeltaoffice.water.ca.gov/sdb/sdip/index_sdip.cfm).



### 1.1.1 Barrier Schedule

Two types of barriers are installed, agricultural barriers to improve water level and quality and a fish barrier to protect migrating San Joaquin Chinook Salmon. The agricultural barriers, located on Old River near the Delta-Mendota Canal (DMC), Middle River, and Grant Line Canal are generally in place between late spring and the end of summer. The fish barrier, located at the Head of Old River, may be installed twice a year, once in the spring and again in the fall, to help with fish migration. River flow and stage impact the installation and removal dates for all four barriers. Depending on the river conditions, the fish barrier has not always been installed. A non-physical fish barrier is currently being tested. For more information on the installation and removal of the barriers visit the TBP South Delta Branch website at [http://baydeltaoffice.water.ca.gov/sdb/tbp/index\\_tbp.cfm](http://baydeltaoffice.water.ca.gov/sdb/tbp/index_tbp.cfm).

## 1.2 STUDY AREA

The sedimentation study area (Figure 1-1) is located southwest of the City of Stockton and bordered on the east by I-5 (Interstate Highway 5), on the south by I-205 and the City of Tracy, and on the west by the Clifton Court Forebay. Sediment is monitored at 17 sites: nine sites on Old River, six sites on Grant Line Canal, one site on Doughty Cut, and one site on Middle River (Figure 1-2). Site names are based on the channel name, e.g., Old River (OR)-1, Grant Line Canal (GLC)-2, Doughty Cut (DC)-1 and Middle River (MR)-1.

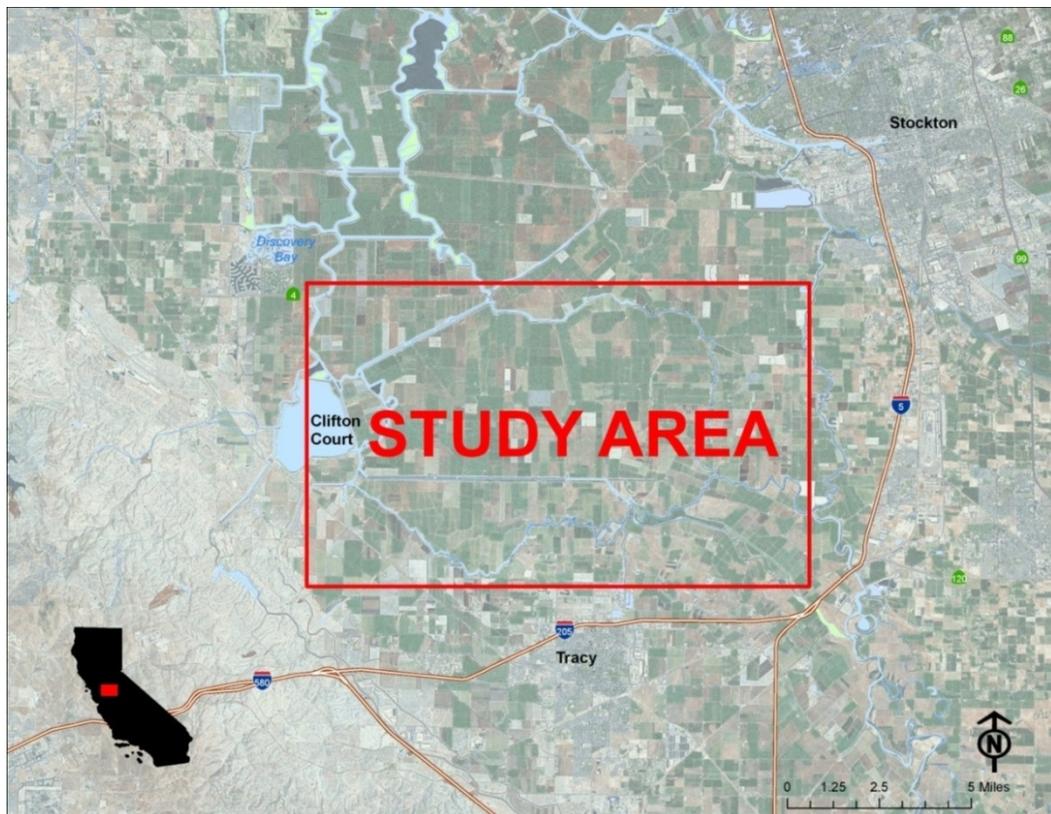


Figure 1-1: Vicinity Map



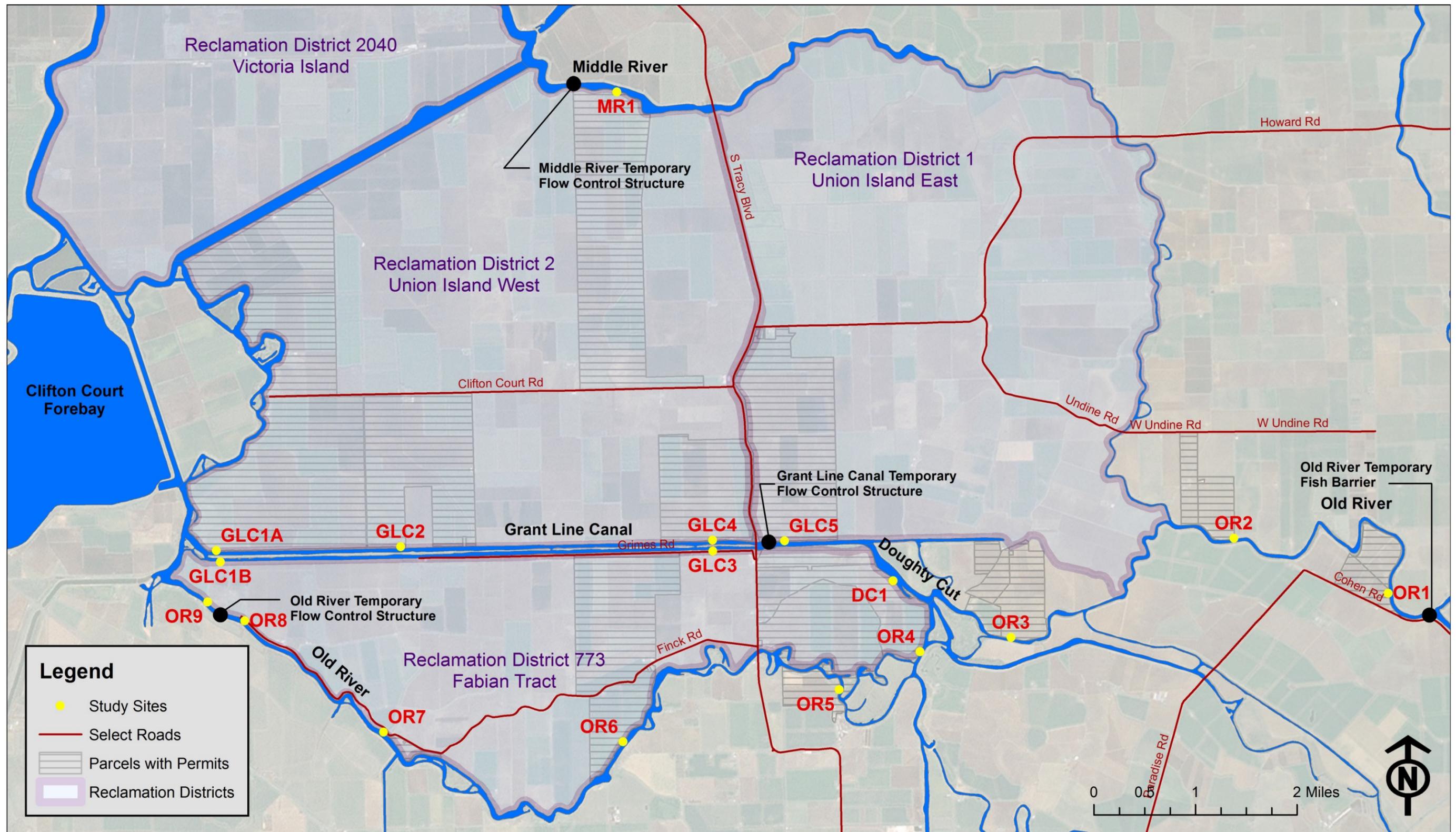


Figure 1-2: Site Map

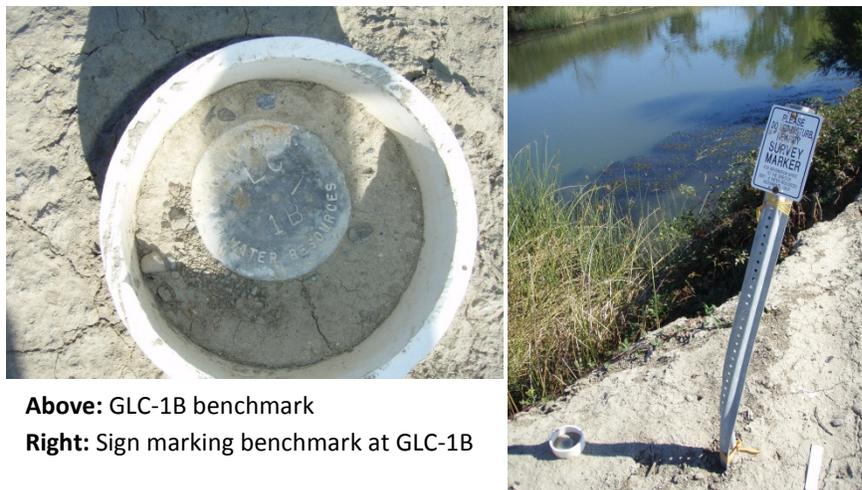


### 1.2.1 Site Selection

Survey sites near the barriers were initially selected to study the barriers impact on south Delta sedimentation. At the request of the United States Bureau of Reclamation (USBR) Technical Service Center, Sedimentation and Hydraulics Group, and to more completely cover the river systems, additional sites were added along Old River and Grant Line Canal. The USBR Sedimentation and Hydraulics Group also recommended that the length of the survey sites be at least twice as long as the width. As a result, most sites are 200feet long (parallel to flow) and 100feet wide. The final site selection was done using topographic maps to identify channel reaches that would meet the USBR recommendations. Site visits were performed to verify access and sites with limited access were moved

### 1.2.2 Site Preparation

In 1998, benchmark (BM) and rebar markers, separated 200 feet apart, were installed at each site. The BMs consist of a copper-clad rod with a brass cap stamped with the site name and *California Water Resources* (Figure 1-3). The BMs were again surveyed in June of 2006 to verify horizontal and vertical control.



**Above:** GLC-1B benchmark  
**Right:** Sign marking benchmark at GLC-1B

**Figure 1-3: Benchmark and Signage**

### 1.2.3 Temporary Entry Permits

Temporary entry permits were obtained for the initial installation of the BMs and rebar markers. Many of the permits were originally setup to continually auto-renew in one year increments after the initial expiration date to allow access for semi-annual surveys and site maintenance. Some of the permits have stipulations requiring DWR to submit survey data to the reclamation districts within 60 days of conducting the survey and/or provide notice of entry prior to accessing the site. NCRO makes every effort to conform to the temporary entry permit requirements.

## 2.0 Study Methodology

Semi-annual surveys of the 17 study sites (Figure 1-2), which began in 1998, are done to monitor sediment levels in the south Delta. Surveys are performed in the spring before the barriers are installed and in the fall before the barriers are removed. In 1998 and 1999, channel profiles were measured. In 2000, use of Global Positioning System (GPS) technology allowed staff to survey the study sites in greater detail than in prior years. Data from 1998 and 1999 is not used for comparison due to the lack of GPS coordinates.

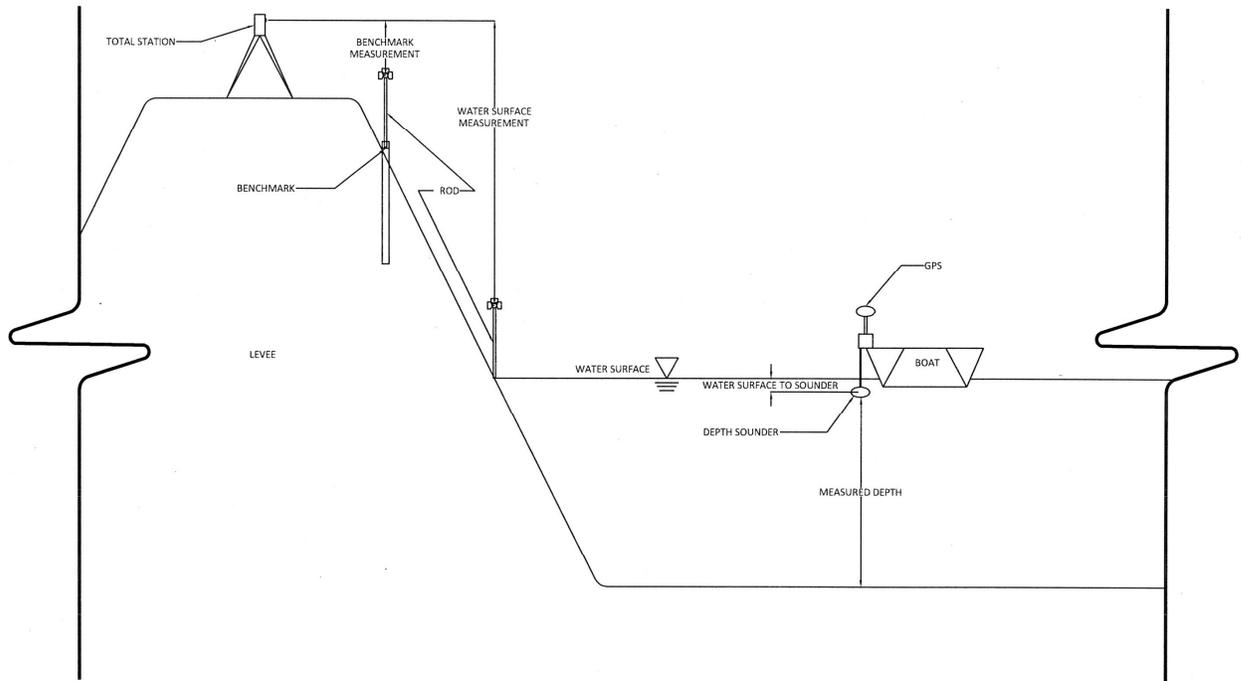
### 2.1 DATA COLLECTION

#### 2.1.1 Water Surface Elevations

Water surface elevation surveys are conducted at each site as the bathymetric surveys are performed. Accurate water surface elevation (WSE) measurements at the time of the bathymetric survey are critical for comparing data from different surveys. A two-person crew surveys the water surface relative to the BM. Prior to knowing the true elevation of the BM (1998-2005), the BM was assumed to have an elevation of 100ft. The WSE is surveyed multiple times during each bathymetric survey to account for variability caused by tidal changes, the operation of Clifton Court Forebay and waves. At least two WSE values are recorded, once at the start and once at the end of the bathymetric survey. If possible, additional WSE values are collected. An averaged WSE value is then used for analysis.

Figure 2-1 depicts the basic survey setup. To determine the WSE, a Total Station is used to measure the vertical difference between the BM and the Total Station and then the difference between the Total Station and water surface. Table 2-1 gives the BM elevations; all elevations are in reference to the North American Vertical Datum 88 (NAVD88).





**Figure 2-1: Data Collection Diagram**

### 2.1.2 Bathymetric Data

There have been several technological improvements in the course of this study to date. See Figure 2-2 for equipment details and timeline. The principle technology used to collect bathymetric data for this report was from a single beam depth sounder (sounder). The sounder, which is mounted directly below a GPS unit, is rigidly attached to a flat bottomed boat. The sounder measures the depth to the channel bottom and the GPS unit records the horizontal coordinates of that point. Both pieces of equipment, the sounder and GPS, are connected to a computer that records the data.

Factors influencing the accuracy of the data include wind, waves, boat speed and path, depth to channel bottom and obstacles like downed trees and aquatic plants. Surveys are performed on calm days, at slow speeds with straight-line passes, to minimize data distortion.



**Table 2-1: Benchmark Elevations and Locations**

<b>Benchmark</b>	<b>Elevation</b> <i>(feet)</i>	<b>Latitude</b> <i>(Decimal Degrees)</i>	<b>Longitude</b> <i>(Decimal Degrees)</i>	<b>State Plane</b> <i>X-ft</i>	<b>State Plane</b> <i>Y-ft</i>
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

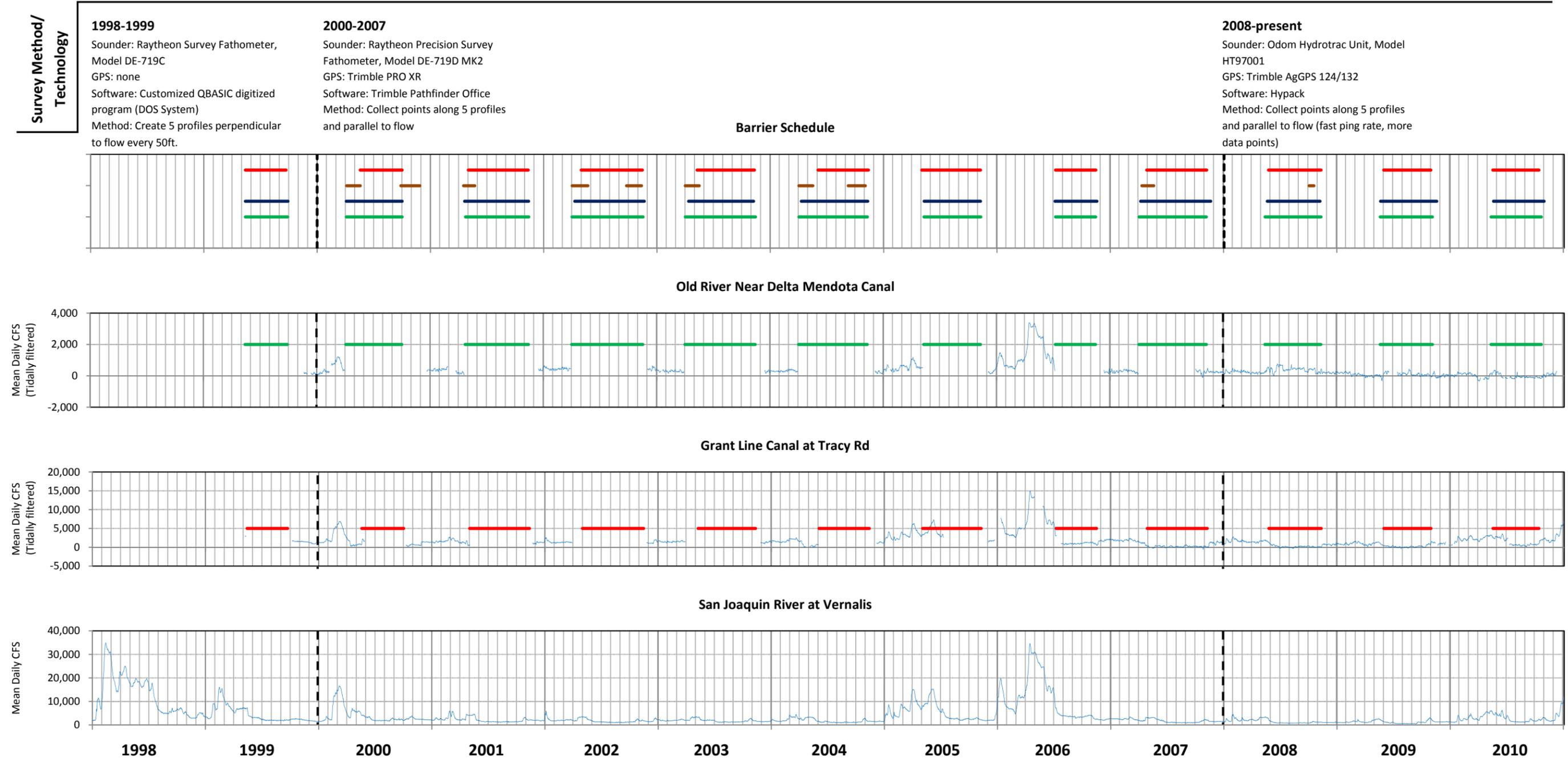
Surveyed On June 2006, Reference Datum: NAVD88.  
Latitude and Longitude converted from Northing and Easting.



**Legend:**

- Flow (Mean Daily CFS)
- Grant Line Canal physical barrier in place\*\*
- Head of Old River physical barrier in place\*
- Middle River physical barrier in place\*
- Old River DMC physical barrier in place\*
- - - - - Change in survey equipment/ method

Flows for Old River (USGS site: 11312968), Grant Line Canal (USGS site: 11313200) and San Joaquin River (USGS site: 11303500) are provided below. The data was downloaded from the USGS website: [water.usgs.gov](http://water.usgs.gov). The Old River and Grant Line Canal gages are located at the barrier site. All barriers are shown on the **Barrier Schedule** plot; the Old River barrier schedule has been shown on the flow plot for Old River, the same is true for Grant Line Canal. Until recently, only event flow data was collected by the Old River and Grant Line Canal gages. Barriers were not installed in 1998 for all sites as well as in spring of 2005 and 2006 at Head of Old River due to high flows in the San Joaquin River. Beginning in 2009, the physical barrier at Head of Old River was replaced with a non-physical bubble barrier. The installation of the non-physical barrier is not shown on the charts below because it is assumed that it has a minimal impact on the flow dynamics of the channel when compared to the physical barrier.



**Figure 2-2: Barrier Flows, Barrier Schedule and Bathymetry Technology**

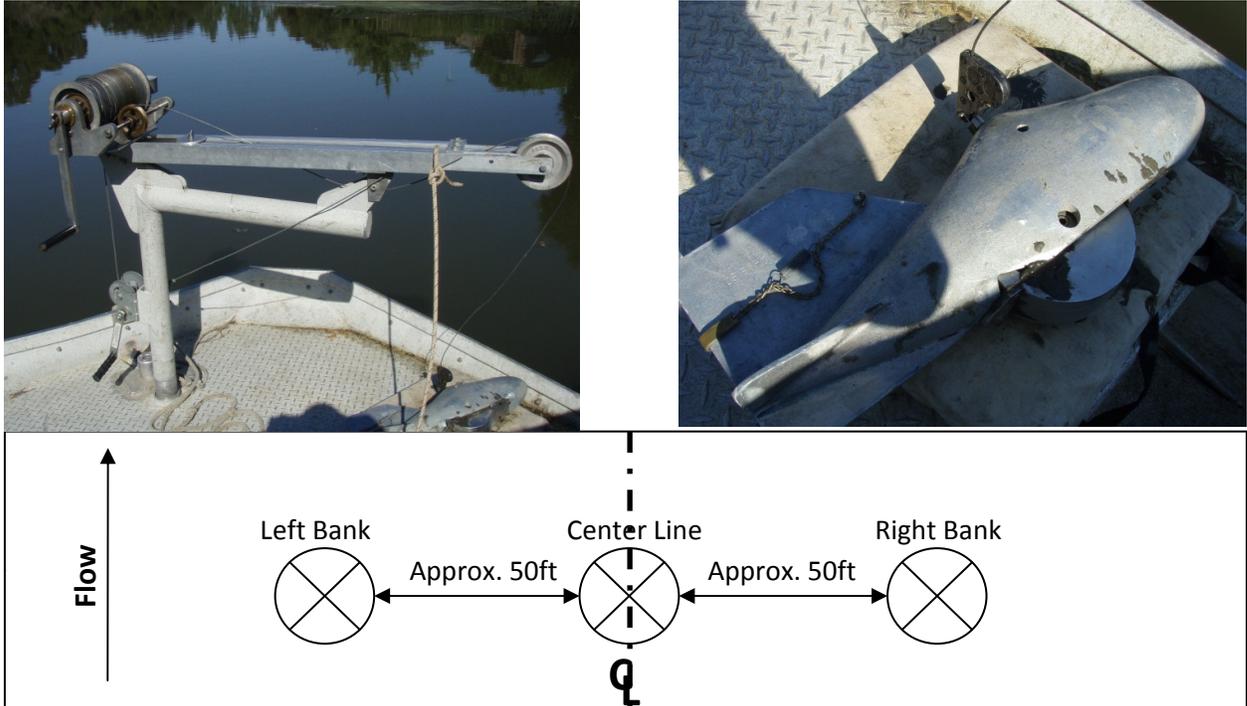
\*The barrier range represents the start of installation and the start of remove according to the **Temporary Barriers Operating Schedule** (<http://baydeltaoffice.water.ca.gov>).

\*\*The "Full" start date was used for Grant Line Canal start of installation.



### 2.1.3 Sediment Sample Collection

Three sediment samples were collected at each site using a BMH-60 bed sediment sampler (sampler). Samples are collected from the center of the channel and approximately 50 feet to the left and right of the channel centerline. The sampler (Figure 2-3) has a spring loaded bucket that closes on impact with the ground. Samples are bagged, labeled and delivered the DWR Soils and Concrete Laboratory (Lab) for analysis.



**Top Left:** A hand cranked wench is used to lower and raise the sampler.

**Top Right:** Soil sampler (BMH-60) with the sample bucket in the closed position.

**Bottom:** Channel soil sample grab sample diagram.

**Figure 2-3: Images of Sediment Sampling Equipment**

## 2.2 DATA ANALYSIS

### 2.2.1 Soil Samples

Soil samples were collected and sent to the lab for sieve analysis, including sieve No. 230, along with a hydrometer analysis. The analysis was performed according to the ASTM Test Designation D422-63 (2007), "Particle-Size Analysis of Soils." The Lab provided NCRO with tables summarizing the percent finer, by weight, for each sample.

The mean grain size for each sample was determined using Equation 1. See Appendix R for sample mean grain size calculations and Appendix S for the mean grain size plots for each site.

$$\text{Equation 1: Mean Grain Size}^1 = \frac{(\Phi_{16} + \Phi_{50} + \Phi_{84})}{3}$$

### 2.2.2 Bathymetric Data

The bathymetry for the 17 sites was analyzed to determine the volumetric change. While the use of a depth sounder and GPS has allowed for greater coverage, site coverage was still low ranging between 1% and 10%. For the purpose of this report coverage is defined as at least one data point per square foot in the study area. A custom Excel program was created to determine the average change in elevation and volumetric change in sediment. An average elevation was determined by applying a square foot grid to the study areas and averaging all data points within each square foot. When determining the average, only grid points with data were used. If no data points existed within a given square foot region, that area was not considered in the average for the entire site. See Appendix U for sample average elevation calculations. Because one of the concerns of sedimentation is reduced navigation, the average change in channel bed elevation is reported to demonstrate a possible decrease or increase in channel depth; see Appendix T for plots of the average change in channel bed elevation.

Cross-sections at 50foot intervals and a channel centerline profile were created for each site. In 1998, when the study first began, only cross-sections were measured. When a depth sounder and GPS started being used in 2000, the focus remained on the cross-sections, therefore providing a higher level of saturation along the cross-sections compared with the rest of the site. See Appendices A through Q for cross-sections and channel centerline profiles. Data for the base year (2000) and the present year (2010) are in color; all other years are represented with thin gray lines. This was done to minimize confusion while still providing some reference to the range of values from past surveys. The cross-sections were used for a qualitative trend analysis. Cross-sections and the centerline profile were created using ArcGIS 10. After creating a surface for each site and survey, the surface was trimmed so that anything outside of the study area was removed. Reference lines were then created and those lines were used to create the cross-sections and centerline profile at the same location for each survey. At some of the sites, boat access was limited due to depth or other physical obstacles, resulting in cross-sections that are smaller than the width of the study area. Where cross-sections appeared to show aquatic growth or erroneous data and not the channel bottom data points were removed from the cross-sections or the entire cross-section was removed.

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<sup>1</sup> Folk R.L., Ward W.C., 1957, Brazos River Bar: A Study of Significant Grain Size Parameters, Journal of Sedimentary Petrology 27: 3-26



## 3.0 Results and Discussion

The volumetric analysis for the 17 sites was inconclusive. There are many variables that impacted the measurements taken in the field, including aquatic plant growth, shallow water, waves, tidal changes, technological limitations, and human error. Small errors in the water surface elevation have significant impacts on sediment volume calculations; for every inch that the average elevation is off, due to any type of error, the resulting sediment volume is changed by 62 cubic yards for the 100' x 200' sites. Table 3-1 shows the change in average elevation since the fall 2000 survey, Table 3-2 the change in sediment volume since the fall 2000 survey and Table 3-3 shows the average elevation along the flow path. Figure 3-1 puts plots of the average elevation, over time, for each site on a map to provide visual and spatial context.

Cross-sections and centerline plots for the 17 sites provided some insight as to why, for the 2003-2010 data set, a volumetric analysis with a high level of confidence may not be possible. The cross-section plots (Appendices A through Q), at first glance show large ranges for the channel bottom from survey to survey. Some sites, such as OR-1, have a range of a few feet between surveys while other sites like GLC-1A are within a foot or less. The rough shape of many of the cross-sections over time is consistent.

Cross-sections from spring of 2000 tend to be some of the deepest cross-sections, which may suggest that there has been an increase in sediment since spring 2000. Spring 2010 cross-sections are generally higher than spring 2000 with a few exceptions. Fall cross-sections have not shown as large of a difference between the years 2000 and 2010. GLC-5, the site just upstream of the barrier on Grant Line Canal shows an increase in sediment for both spring and fall. DC-1, the second site upstream of the Grant Line Canal barrier, also shows an increase in sediment for the spring and fall. OR-8, just upstream of the Old River Delta-Medota Canal barrier (DMC), shows an increase in sediment in the spring as well as a small increase in sediment in the fall.

Grain size analysis for some of the sites showed that during and after periods of high flow, near 20,000 cfs, in the San Joaquin River (Figure 2-2) the mean particle size increased, suggesting that the finer sediments were being washed out. Flows in the San Joaquin River, near or above 20,000 cfs, occurred in 1998 and 2006. There does not appear to be any significant change in particle size long term.

### 3.1 TEMPORARY BARRIERS IMPACT ON SEDIMENTATION

The barriers on Grant Line Canal, and Old River near the DMC appear to influence sediment levels upstream, resulting in an increase in sediment. The Grant Line Canal barrier seems to impact the GLC-5 and DC-1 sites. The Old River DMC barrier appears to impact OR-8 and possibly OR-7. Due to lack of access in the fall and aquatic plant growth, data for MR-1 is inconclusive. The barriers may have a



small impact on sites immediately downstream of the barrier; sites further downstream do not appear to be impacted by the barriers.

Because surveys are only done twice a year it is difficult to determine how much of the change in sediment is potentially due to natural seasonal increases/ decreases or the barriers being in place. The rate at which sediment increases/ decreases may change with the installation of the barriers; but with the current surveying schedule this cannot be determined.



**Table 3-1: Change in Average Elevation Compared to Base Survey, Fall 2000 (inches)**

	DC-1	MR-1	GLC-1A	GLC-1B	GLC-2	GLC-3	GLC-4	GLC-5	OR-1	OR-2	OR-3	OR-4	OR-5	OR-6	OR-7	OR-8	OR-9
2003 S	11	-1	3	-5	11	5	1	4	-2	-5	-6	-3		-2	6	8	-40
2003 F	14	-6	-6	-9	2	12	1	12	1	11	8	2	37	0	9	7	-34
2004 S	9	6	-4	-1	4				-6	3	1	-2	10	1		17	-27
2004 F	11		-3	-14	15	13	4	4	-3	8	6	-2	17	-6	12	5	-39
2005 S	17	2	-1	-2	6					6	-4	-10		1	8	-2	-35
2005 F	13		-8	-1	6		4	6	-2		5	-2			9	10	-37
2006 S		-7	-9	1	-3	2	-6	-5	1	3	-18	-4		-6	3		-28
2006 F			-6	4	3	6	-10	-8	3	0	-5	-6	-10	-4	8	-1	
2007 S	20	-1	-6	-12	4	11	-8	-9	-14	8	-8	-6	1	-9	3	3	-43
2007 F	20			-10	-3	11	-7		-12	3	-2	-8	5	-11	4	6	-47
2008 S	19	-4	-8	-7	5	10	-9	-3	-10	2	-7	-5	-5	-9	2	1	-45
2008 F	21		-8	-3	-12	8	-7	-3	-11	9	-1	-8	2		5	7	-44
2009 S			-10	-3	4	10	-9	-4	-10	5	-5	-10	6	-7	3	6	-48
2009 F	18		-5	0	1	15	-4	0	-8	9	1	-8	4	-3	5	20	-38
2010 S	22	-8	5	9	16	22	6	2	2	17	5		24		13	18	-33
2010 F	17		-11	-3	-4	9	-11	-4	-9	3	-4	-10	-7	-6	1		-44

**Table 3-2: Change in Sediment Volume Compared to Base Survey, Fall 2000 (cubic yards)**

	DC-1	MR-1	GLC-1A	GLC-1B	GLC-2	GLC-3	GLC-4	GLC-5	OR-1	OR-2	OR-3	OR-4	OR-5	OR-6	OR-7	OR-8	OR-9
2003 S	1,930	-34	177	-330	4,095	333	82	237	-120	-316	-379	-182		-150	404	532	-2,610
2003 F	2,429	-396	-364	-578	722	858	36	773	92	722	522	130	2,466	-17	603	458	-2,214
2004 S	1,545	416	-247	-35	1,369				-368	230	80	-150	654	59		1,184	-1,773
2004 F	1,924		-188	-884	5,444	885	258	265	-180	523	414	-144	1,153	-399	743	341	-2,507
2005 S	3,079	115	-84	-103	2,325					382	-301	-713		94	521	-145	-2,268
2005 F	2,226		-538	-71	2,250		288	390	-148		329	-133			560	713	-2,392
2006 S		-492	-567	95	-931	124	-381	-352	50	206	-1,242	-250		-408	196		-1,827
2006 F			-403	262	1,163	410	-652	-494	190	19	-345	-444	-678	-261	508	-66	
2007 S	3,551	-75	-356	-766	1,314	736	-522	-616	-916	508	-522	-417	71	-600	168	185	-2,788
2007 F	3,596			-650	-1,220	770	-447		-795	193	-137	-521	337	-719	287	379	-3,060
2008 S	3,414	-279	-526	-425	1,729	715	-601	-171	-637	146	-461	-342	-354	-632	129	74	-2,899
2008 F	3,784		-516	-163	-4,451	521	-465	-188	-720	594	-79	-528	145		304	476	-2,835
2009 S			-666	-218	1,571	656	-630	-260	-660	306	-330	-710	400	-497	183	415	-3,097
2009 F	3,288		-334	-22	441	1,026	-254	-21	-519	588	93	-579	246	-182	325	1,341	-2,466
2010 S	41	-512	331	578	5,846	1,502	439	107	117	1,162	331		1,574		865	1,197	-2,129
2010 F	3,026		-712	-209	-1,471	639	-784	-284	-582	231	-276	-695	-488	-426	85		-2,812



**Table 3-3: Average NAVD88 Elevation (ft) Flow Path**

	2000 S	2000 F	2003 S	2003 F	2004 S	2004 F	2005 S	2005 F	2006 S	2006 F	2007 S	2007 F	2008 S	2008 F	2009 S	2009 F	
Flow Path (Old River)	OR-1	-4.1	-4.2	-4.3	-4.1	-4.7	-4.4	-3.4	-4.4	-4.1	-3.9	-5.3	-5.2	-5.0	-5.1	-5.0	-4.7
	OR-2	-7.3	-7.5	-7.9	-6.6	-7.2	-6.8	-7.0		-7.2	-7.5	-6.9	-7.2	-7.3	-6.7	-7.1	-6.7
	OR-3	-12.9	-12.6	-13.1	-12.0	-12.5	-12.1	-13.0	-12.2	-14.1	-13.1	-13.3	-12.8	-13.2	-12.7	-13.0	-12.5
	OR-4	-1.6	-0.5	-0.7	-0.3	-0.7	-0.7	-1.4	-0.7	-0.8	-1.1	-1.0	-1.1	-0.9	-1.2	-1.4	-1.3
	OR-5	-5.5	-6.1		-2.9	-5.1	-4.5				-6.9	-5.9	-5.5	-6.4	-5.7	-5.3	-5.4
	OR-6	-2.9	-2.3	-2.4	-2.3	-2.2	-2.7	-2.2		-2.8	-2.6	-3.0	-3.1	-3.0		-2.8	-2.5
	OR-7	-6.6	-6.6	-6.1	-5.9		-5.7	-5.9	-5.9	-6.4	-6.0	-6.4	-6.3	-6.5	-6.2	-6.4	-6.2
	OR-8	-6.2	-5.6	-5.0	-5.1	-4.2	-5.2	-5.8	-4.7		-5.7	-5.4	-5.2	-5.5	-5.0	-5.2	-4.0
	OR-9	-6.1	-3.4	-6.7	-6.3	-5.7	-6.6	-6.3	-6.5	-5.7		-7.0	-7.3	-7.1	-7.0	-7.4	-6.5
Flow Path (Old River/ Grant Line Canal)	OR-1	-4.1	-4.2	-4.3	-4.1	-4.7	-4.4	-3.4	-4.4	-4.1	-3.9	-5.3	-5.2	-5.0	-5.1	-5.0	-4.7
	OR-2	-7.3	-7.5	-7.9	-6.6	-7.2	-6.8	-7.0		-7.2	-7.5	-6.9	-7.2	-7.3	-6.7	-7.1	-6.7
	OR-3	-12.9	-12.6	-13.1	-12.0	-12.5	-12.1	-13.0	-12.2	-14.1	-13.1	-13.3	-12.8	-13.2	-12.7	-13.0	-12.5
	DC-1	-5.8	-6.4	-5.5	-5.3	-5.7	-5.5	-5.0	-5.4			-4.8	-4.7	-4.8	-4.7		-4.9
	GLC-5	-15.0	-15.8	-15.5	-14.8		-15.5		-15.3	-16.3	-16.5	-16.6		-16.0	-16.1	-16.2	-15.8
	GLC-4	-9.8	-9.5	-9.4	-9.4		-9.1		-9.1	-9.9	-10.3	-10.1	-10.0	-10.2	-10.0	-10.2	-9.8
	GLC-3	-3.7	-3.9	-2.6		-2.6			-3.5	-3.2	-2.8	-2.7	-2.8	-3.1	-2.9	-2.4	-1.8
	GLC-2	-5.7	-6.0	-5.2	-5.9	-5.8	-4.8	-5.6	-5.6	-6.3	-5.9	-5.8	-6.4	-5.7	-6.8	-5.4	-5.6
	GLC-1A	-15.0	-14.4	-14.2	-14.9	-14.7	-14.6	-14.5	-15.1	-15.1	-14.9	-14.9		-15.1	-15.1	-15.3	-14.8
	GLC-1B	-5.5	-4.5	-4.9	-5.2	-4.6	-5.7	-4.6	-4.6	-4.4	-4.2	-5.5	-5.3	-5.0	-4.7	-4.8	-4.5
	MR-1	-6.0		-5.5	-6.1	-5.0		-5.4		-6.1		-5.6		-5.9			

█ Sites on Fabian & Bell Canal, which is connected to and parallels Grant Line Canal.



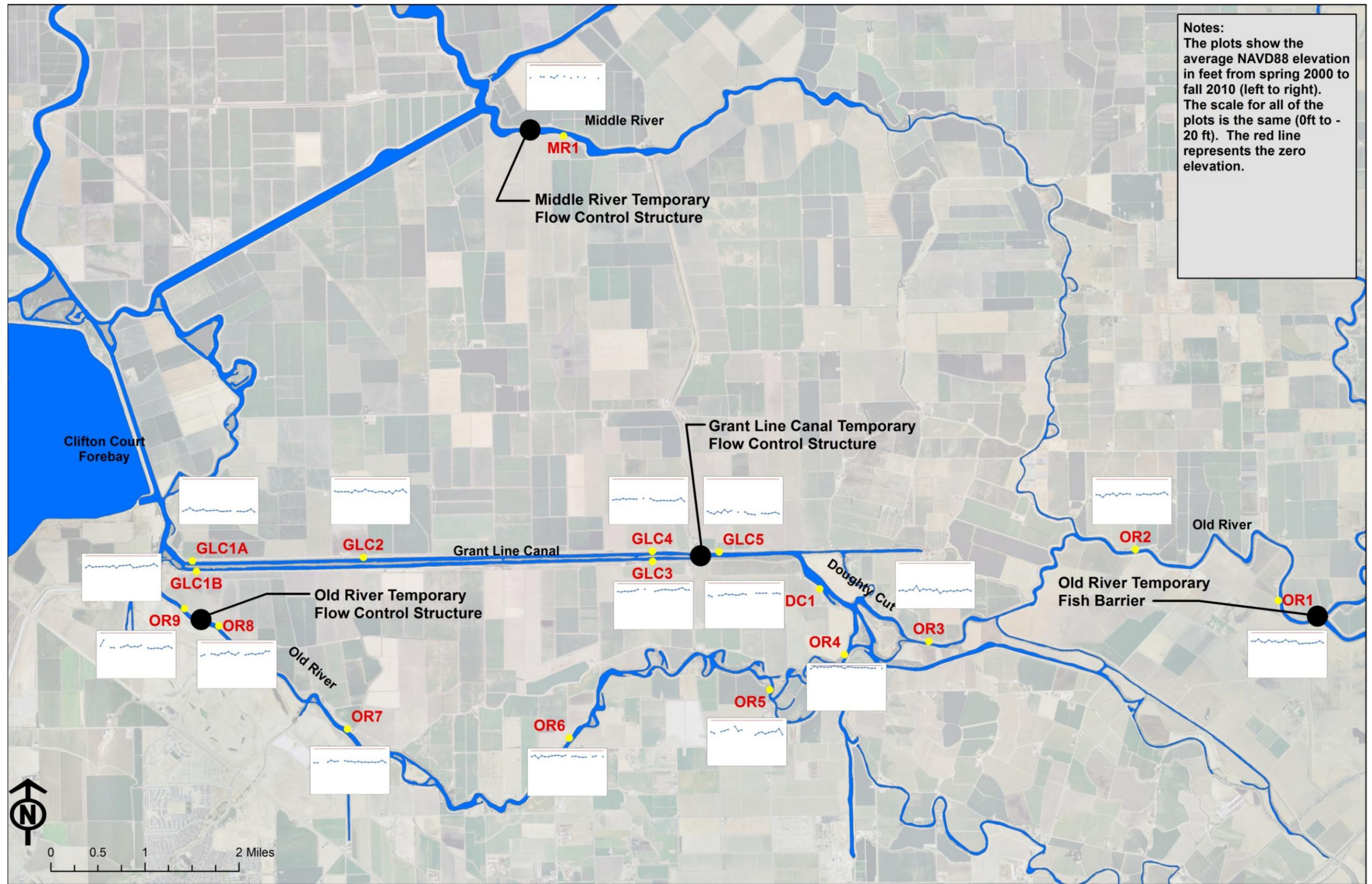


Figure 3-1: Average NAVD88 Elevation Map



## 4.0 Conclusions

Aquatic growth, technical limitations, and other factors made the volumetric analysis results inconclusive and unreliable. Site cross-sections provided a way to qualitatively analyze sediment trends at the sites.

Spring surveys show an increasing trend in channel bottom sediment levels at most sites. Fall sediment levels for 2010, when compared to fall 2000, were more mixed. Sites downstream of the Grant Line Canal barrier showed little change, while some sites upstream showed an increase in sediment and others a decrease when comparing fall 2010 to fall 2000. Most sites on Old River showed little change or a drop in fall sediment levels since 2000.

Sediment levels are increasing upstream of the barriers, but how far upstream is not clear. Sites immediately downstream of the barriers appear to be more likely to have a reduction in sediment between the spring and fall surveys.

Bed sediment sampling has shown minimal long term change in mean grain size since samples started being collected in 1998. Finer sediment accumulates during low flow periods, but tends to get washed out during the higher flows of wet years.

## 5.0 Recommendations

Given the apparent increase in sediment levels upstream of the temporary barriers this study should be continued. The following four modifications to the monitoring plan are being recommended to increase the effectiveness of the study and our understanding of the barriers effects on sediment transport in the south Delta.

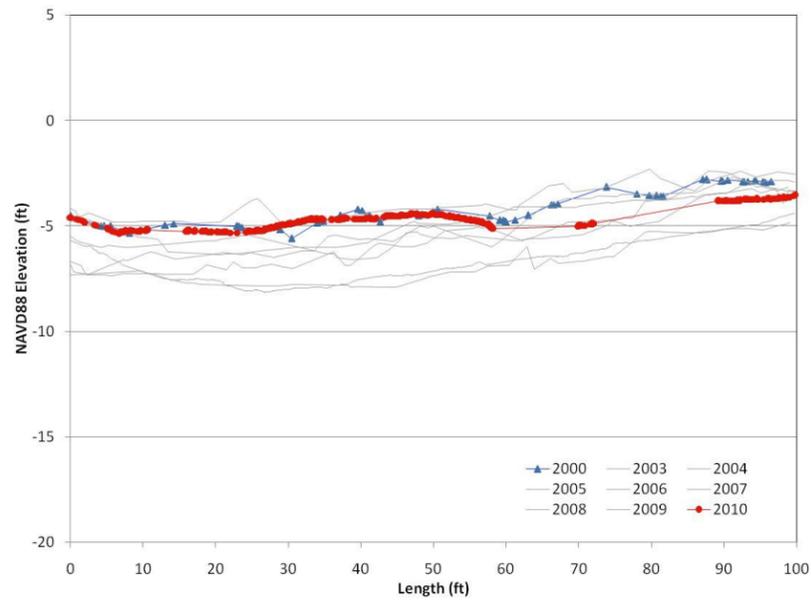
1. Bed sediment sampling should not be continued. Since sampling began in 1998 there has been no significant long-term change in the mean grain size at the 17 sites monitored.
2. MR-1 should no longer be surveyed. Limited site access and plant growth has limited the number and quality of the surveys and sediment samples collected.
3. GLC-2 should be broken up. The site should be broken into two separate sites, GLC-2A and GLC-2B, or the study area should be focused only on Grant Line Canal not Fabian & Bell Canal and the area between the islands where plant growth and shallow water prevents the collection of quality data.
4. GLC-4, GLC-5 and DC-1 should be surveyed monthly for one year. The trend of increased sediment upstream and depletion immediately downstream occurs at the flow control barriers on Grant Line canal and Old River. The sites upstream and downstream of the temporary barrier, on Grant Line Canal, show the clearest results and should be monitored on a monthly time step. Increased monitoring will provide information regarding the gradual changes in the sediment levels over time. The additional data will help



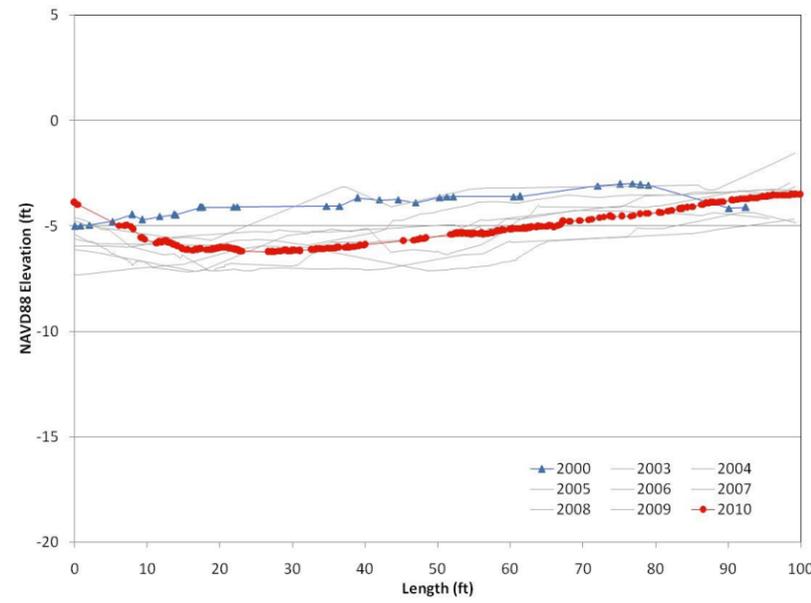
answer the question of whether or not the increase in sediment begins with the installation of the barrier.



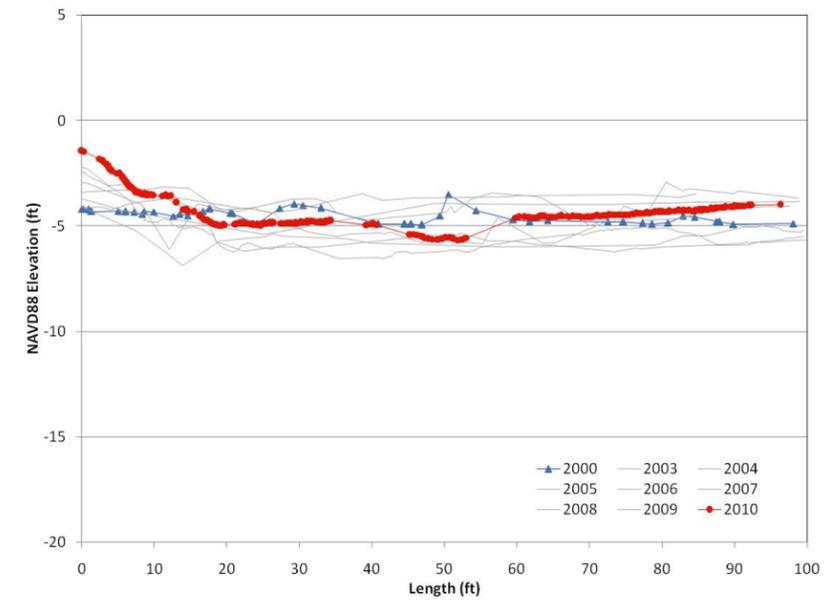
# Appendix A:OR-1 Cross-Sections



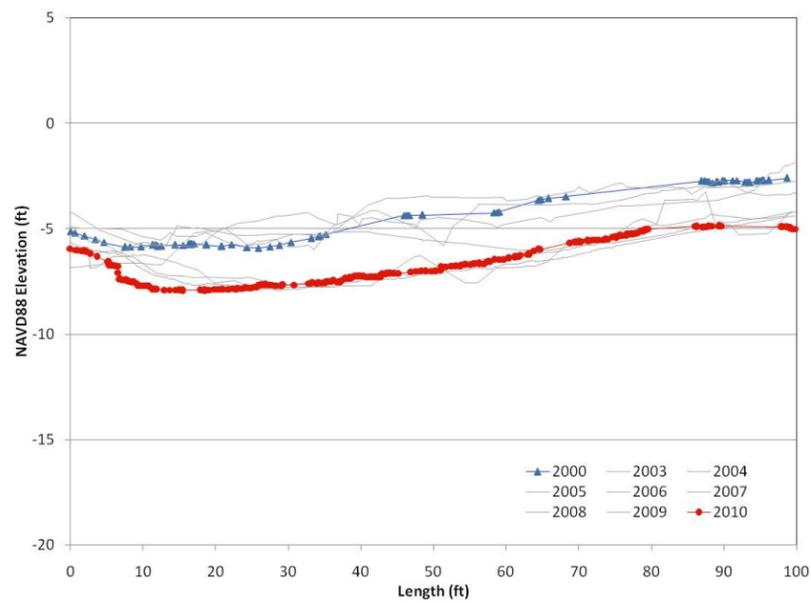
**OR-1 0ft Cross-Section  
Spring**



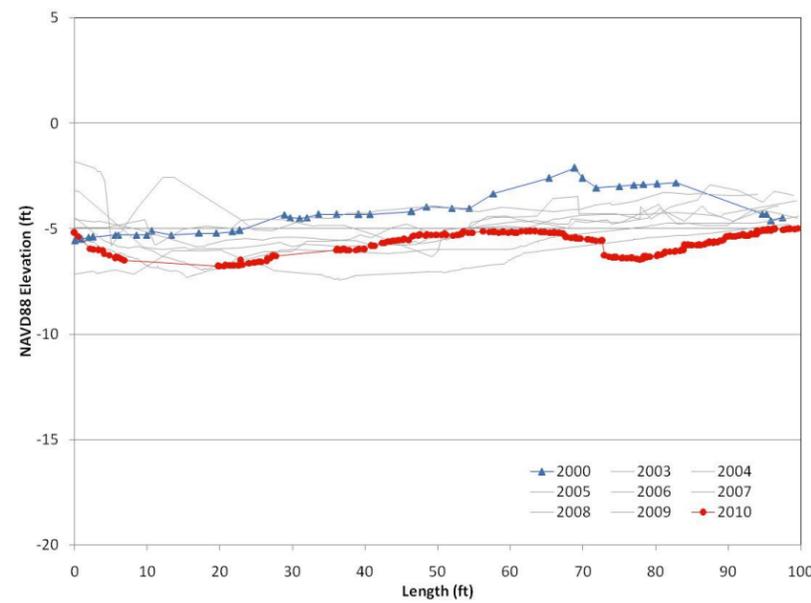
**OR-1 50ft Cross-Section  
Spring**



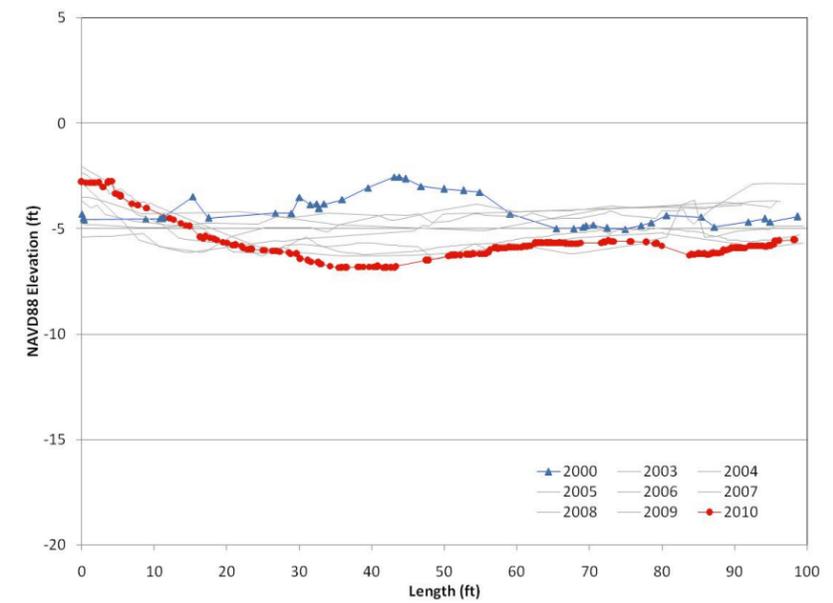
**OR-1 100ft Cross-Section  
Spring**



**OR-1 0ft Cross-Section  
Fall**

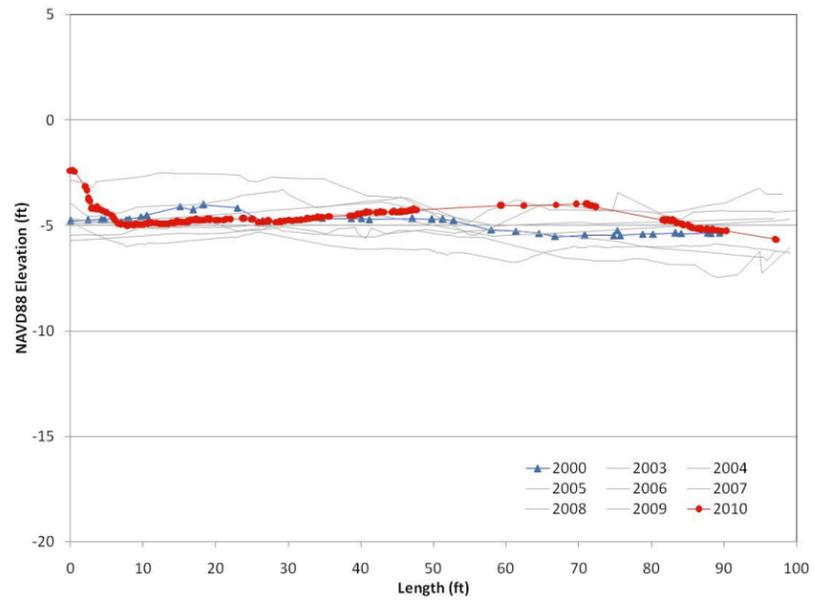


**OR-1 50ft Cross-Section  
Fall**

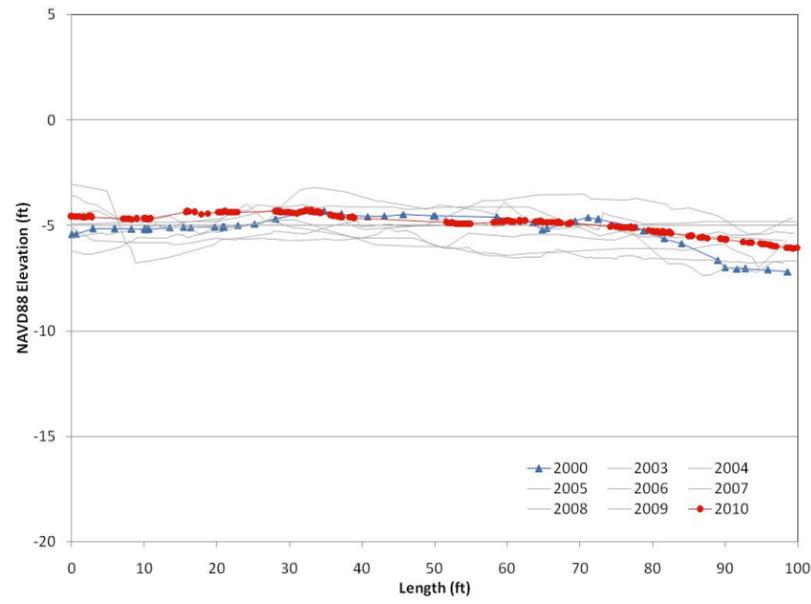


**OR-1 100ft Cross-Section  
Fall**

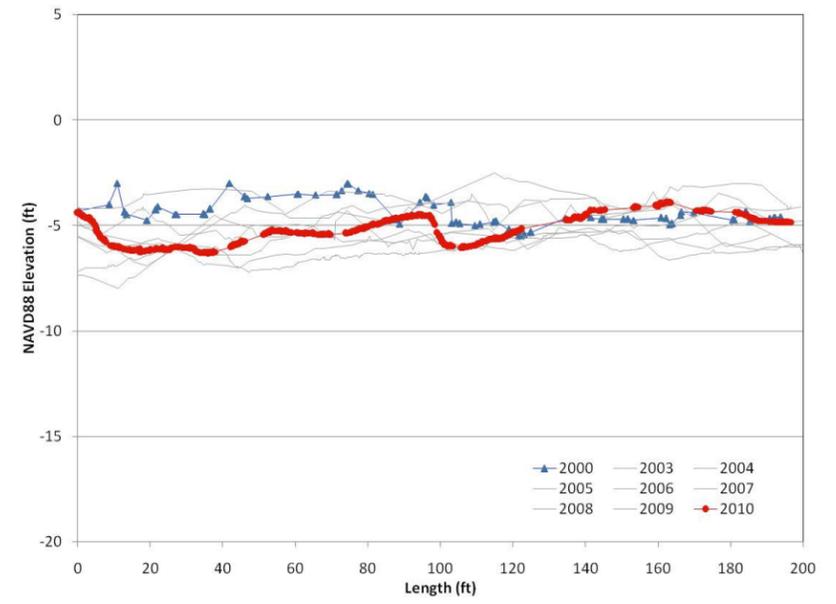




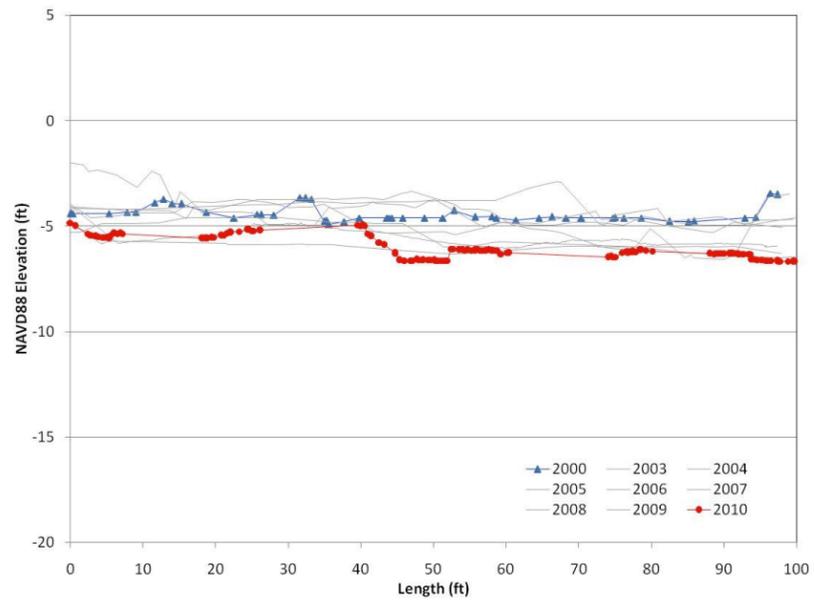
**OR-1 150ft Cross-Section  
Spring**



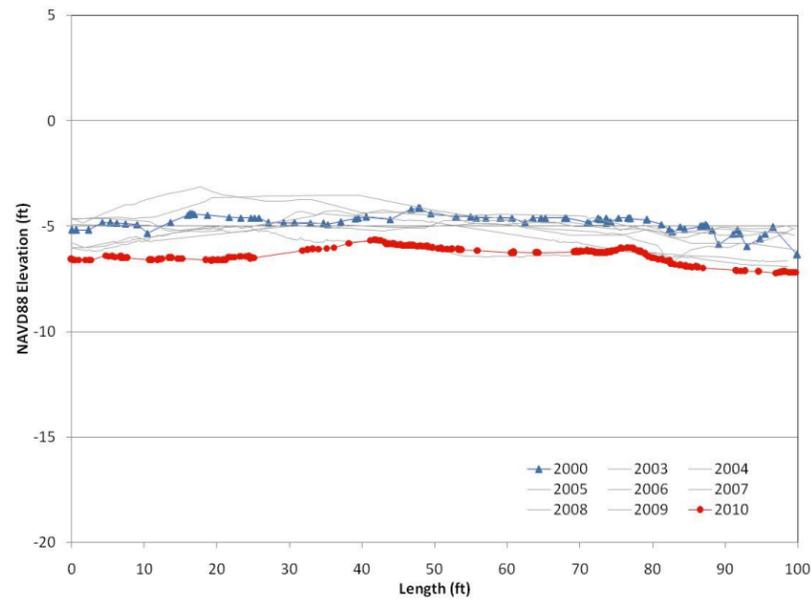
**OR-1 200ft Cross-Section  
Spring**



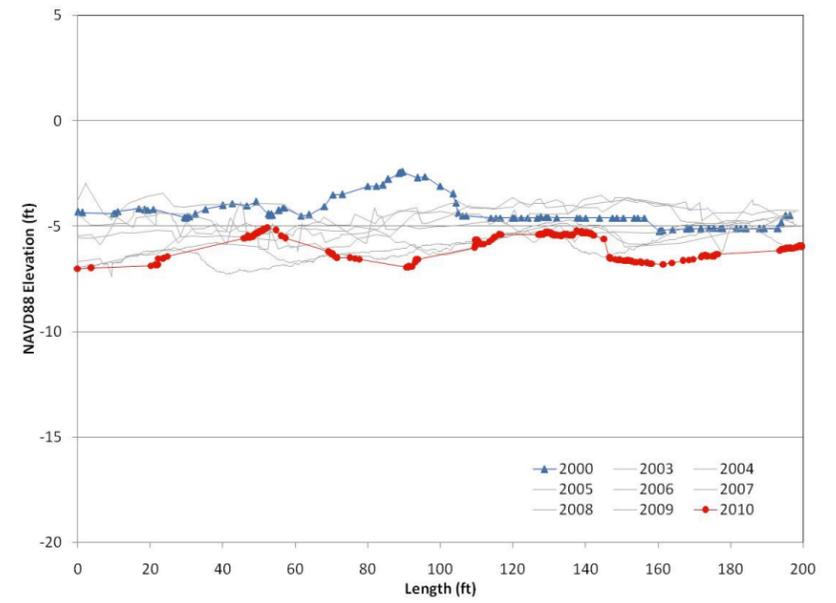
**OR-1 Centerline  
Spring**



**OR-1 150ft Cross-Section  
Fall**



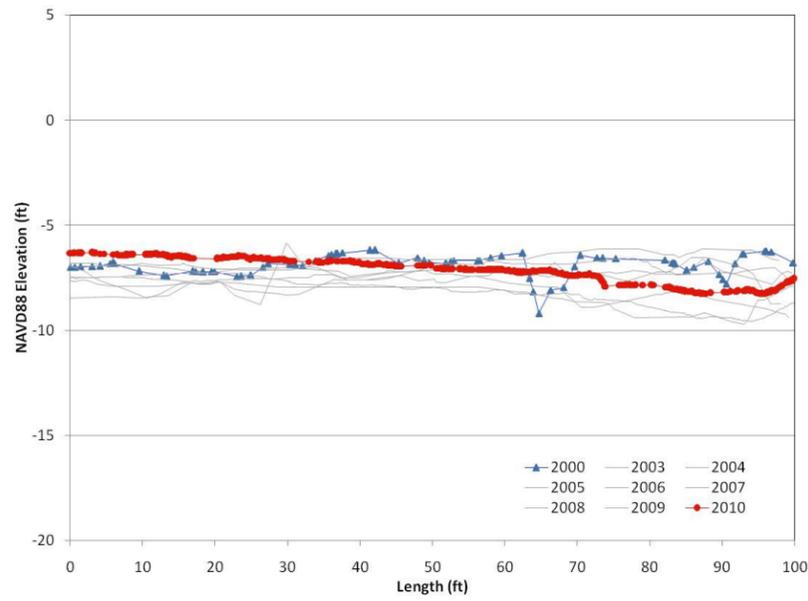
**OR-1 200ft Cross-Section  
Fall**



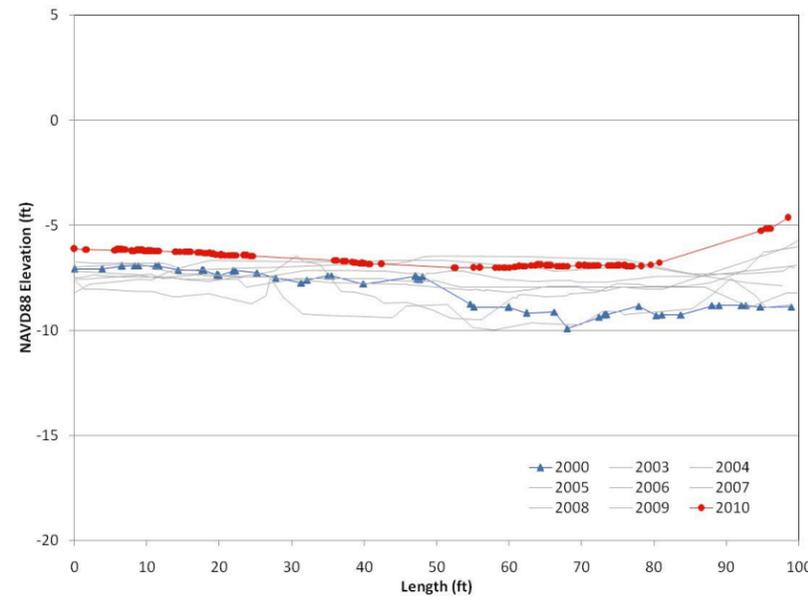
**OR-1 Centerline  
Fall**



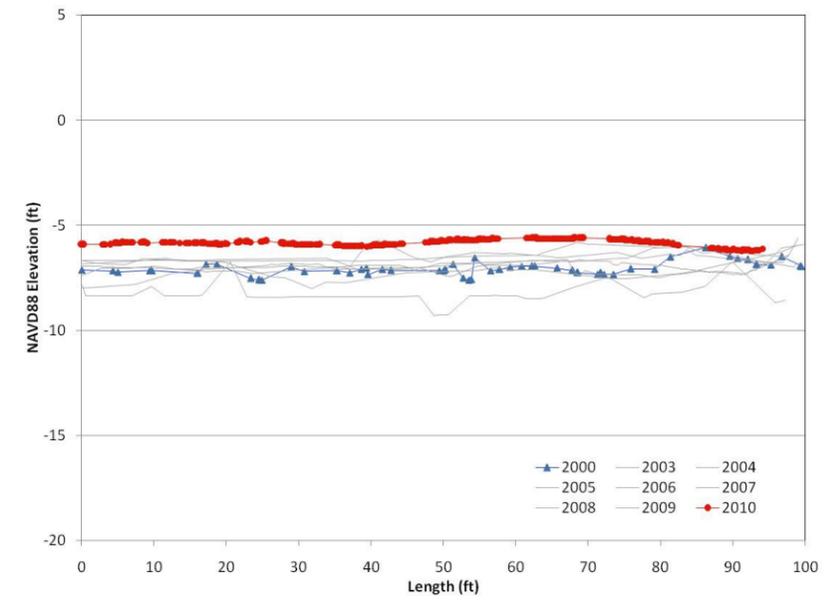
# Appendix B:OR-2 Cross-Sections



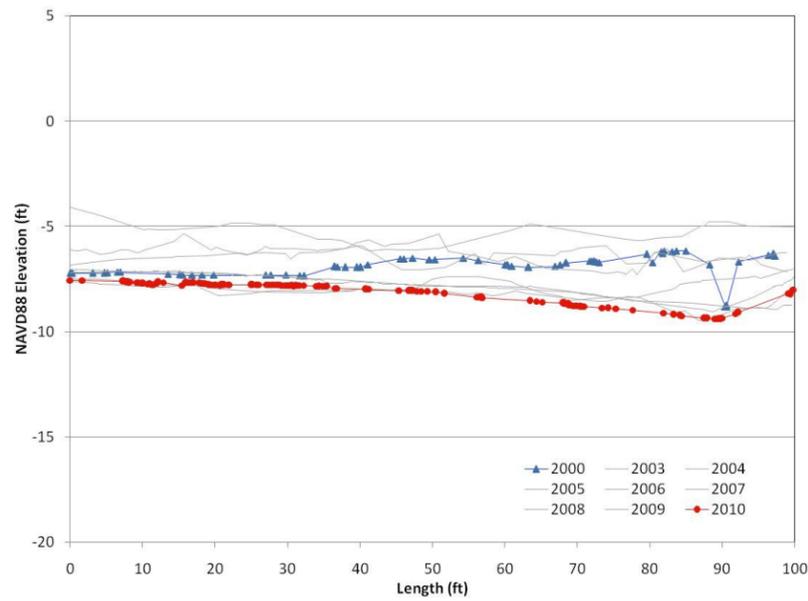
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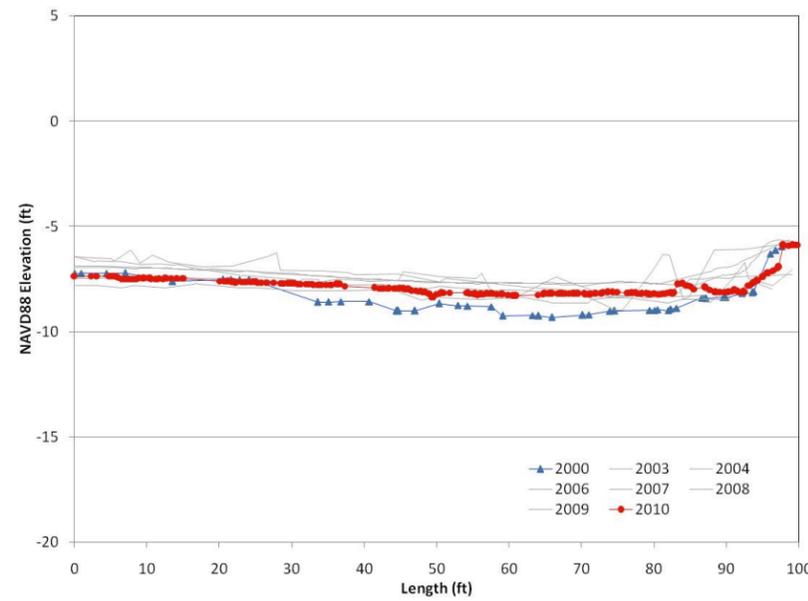
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Spring**



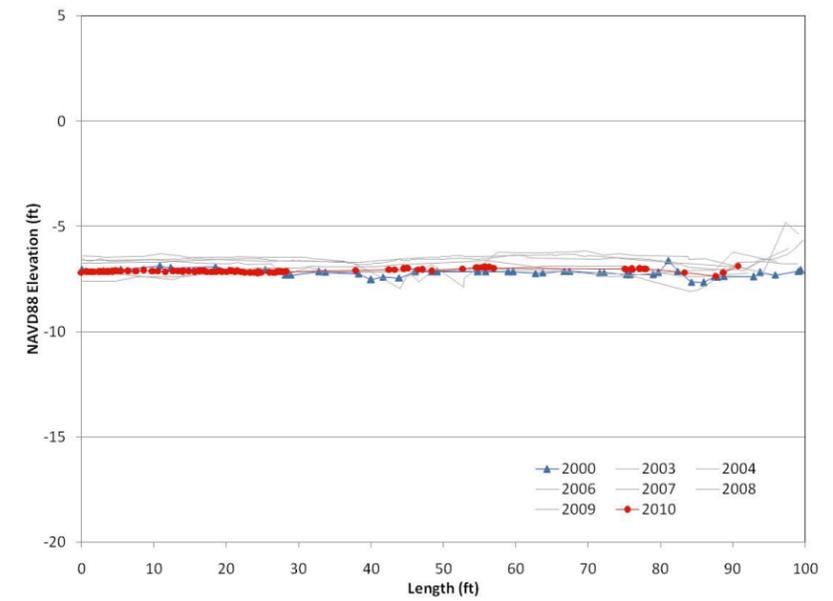
**OR-2 100ft Cross-Section  
Spring**



**OR-2 0ft Cross-Section  
Fall**

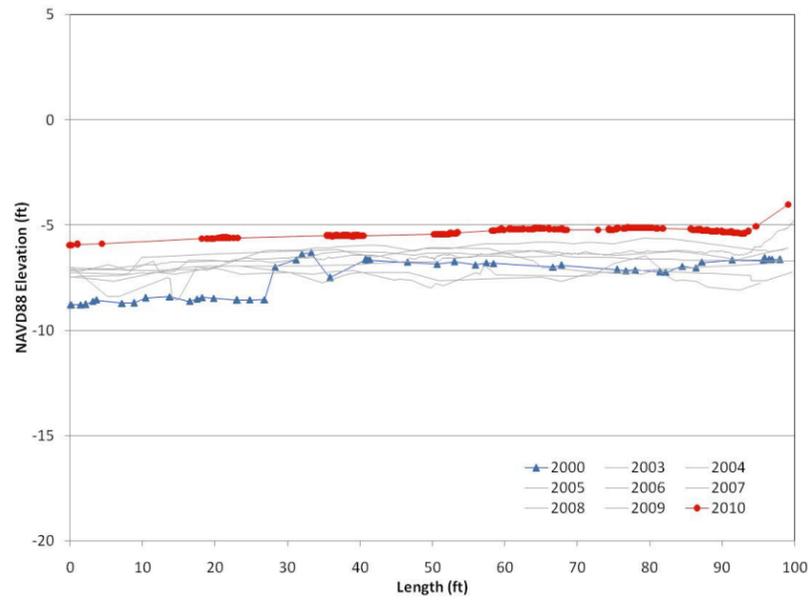


**OR-2 50ft Cross-Section  
Fall**

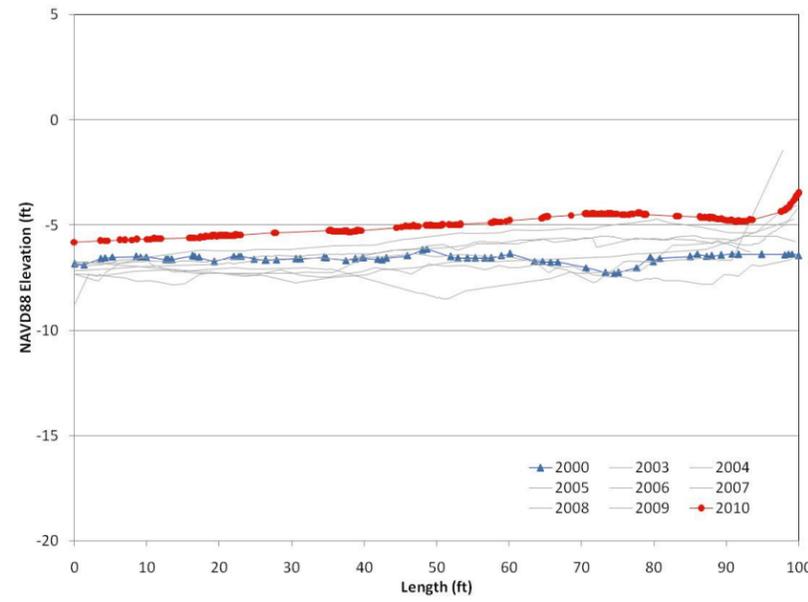


**OR-2 100ft Cross-Section  
Fall**

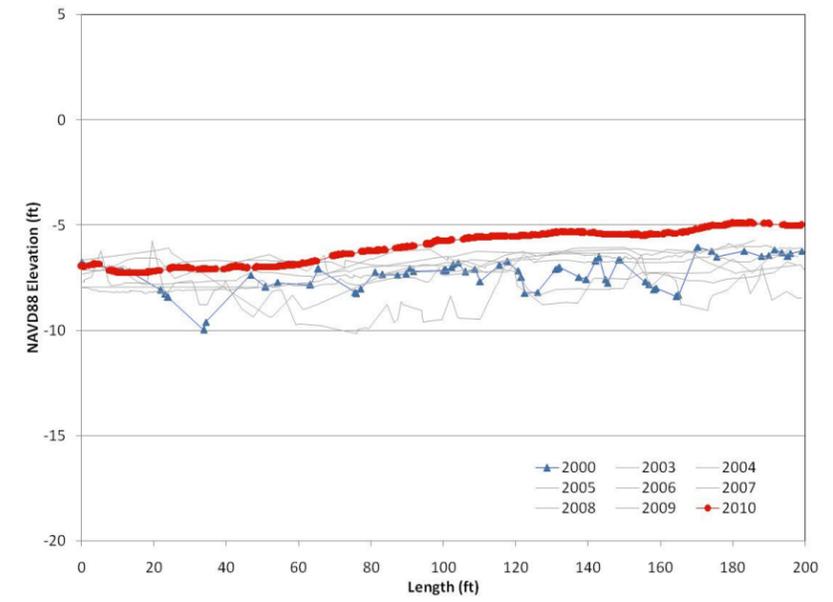




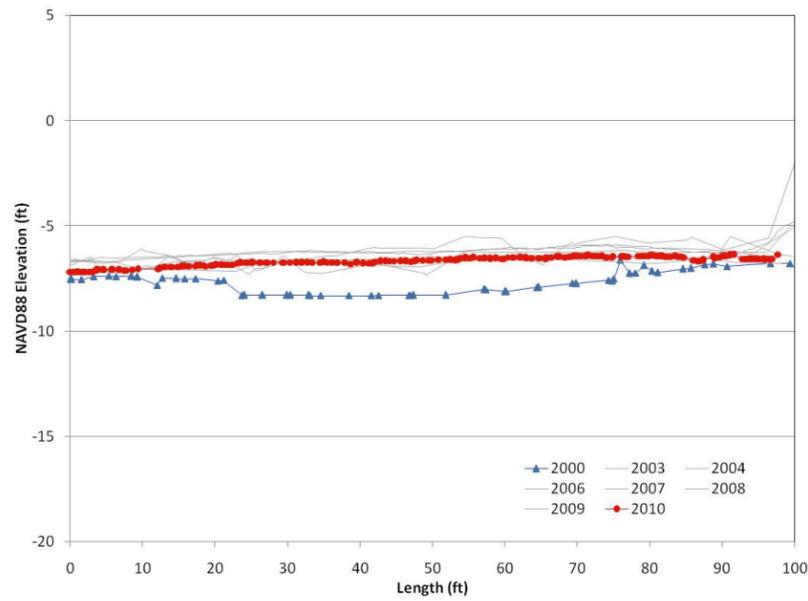
**OR-2 150ft Cross-Section  
Spring**



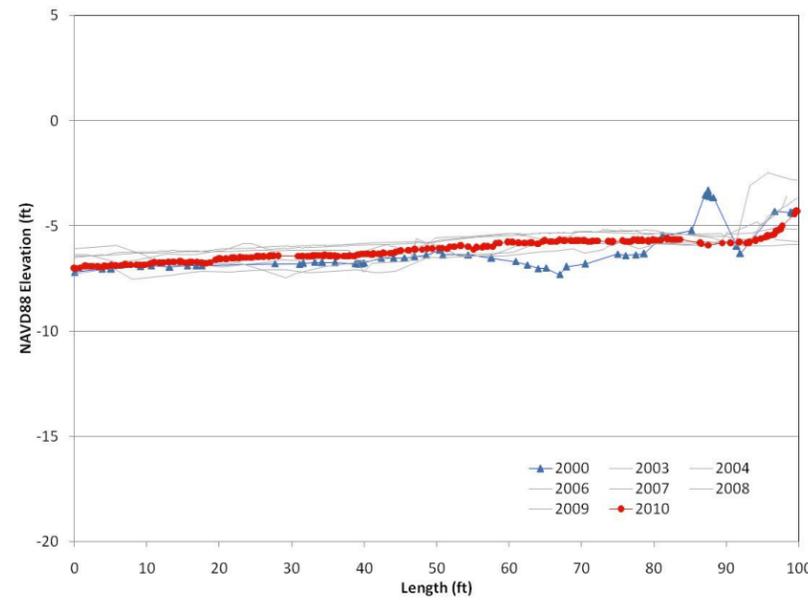
**OR-2 200ft Cross-Section  
Spring**



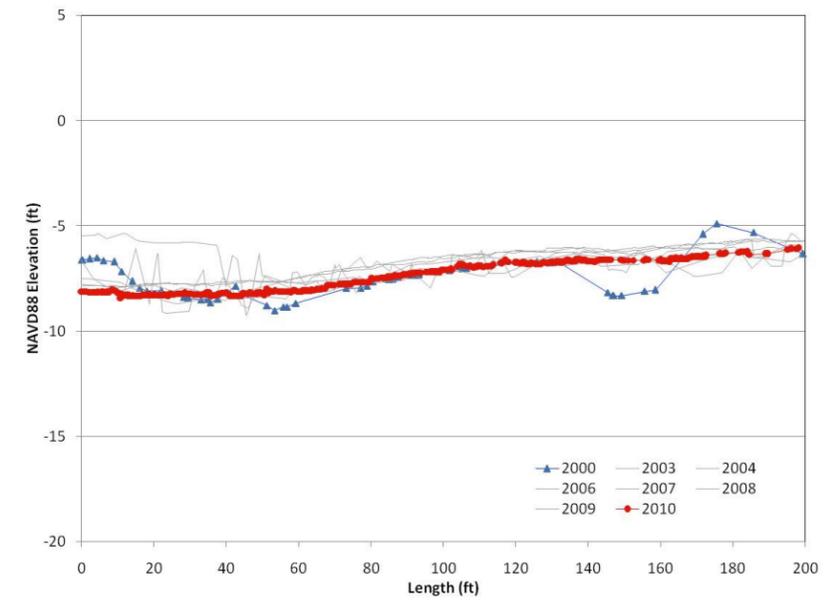
**OR-2 Centerline  
Spring**



**OR-2 150ft Cross-Section  
Fall**



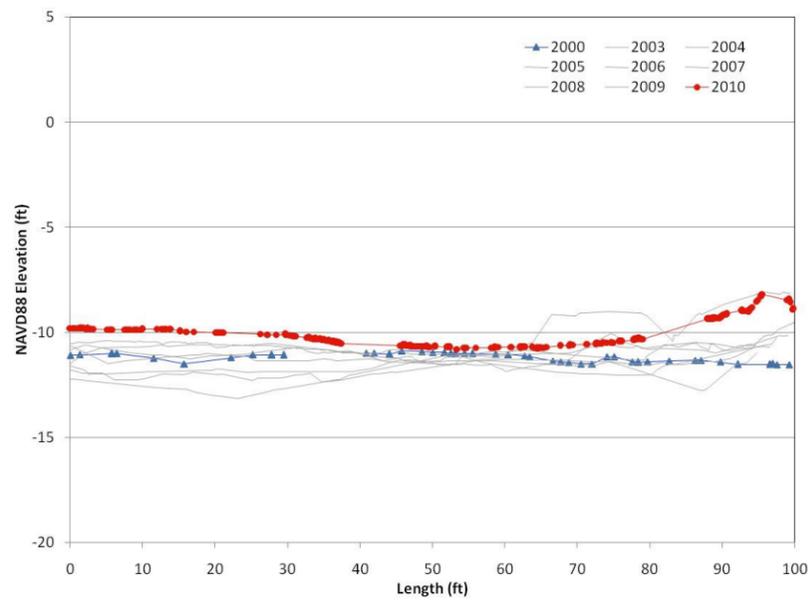
**OR-2 200ft Cross-Section  
Fall**



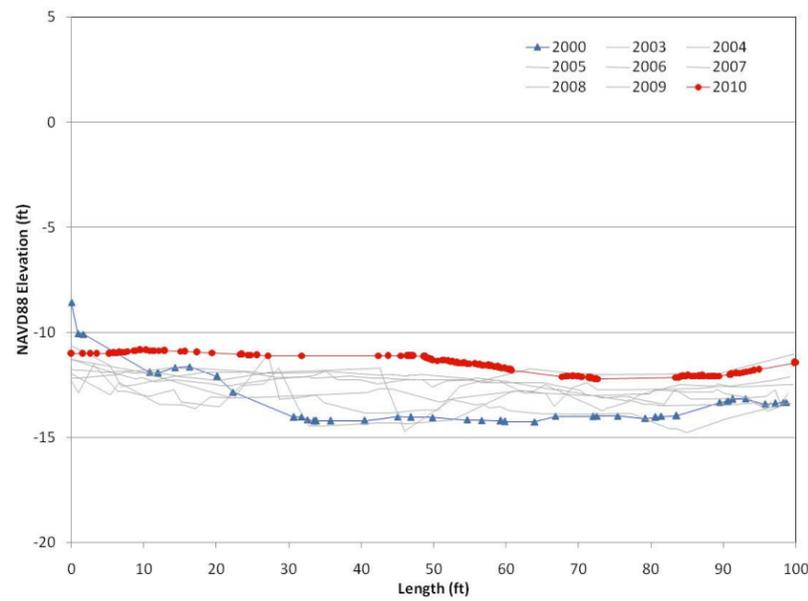
**OR-2 Centerline  
Fall**



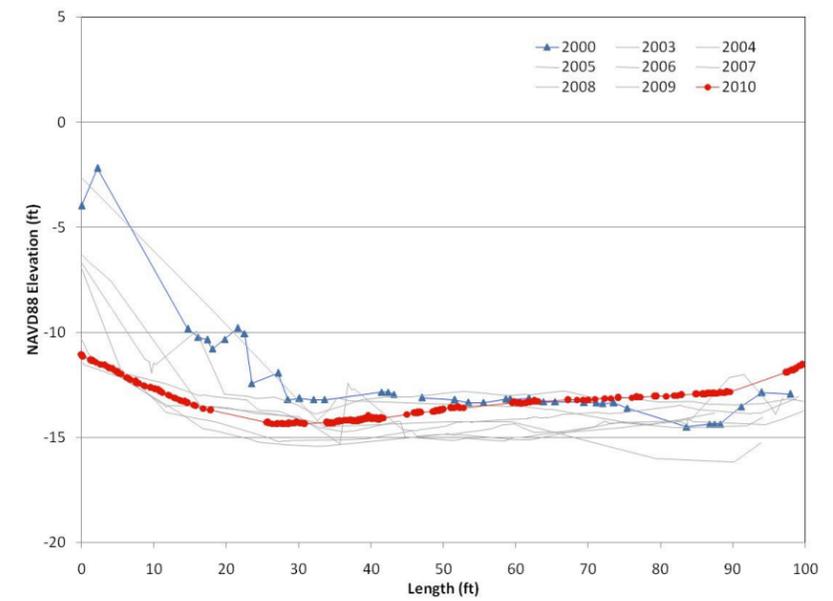
# Appendix C:OR-3 Cross-Sections



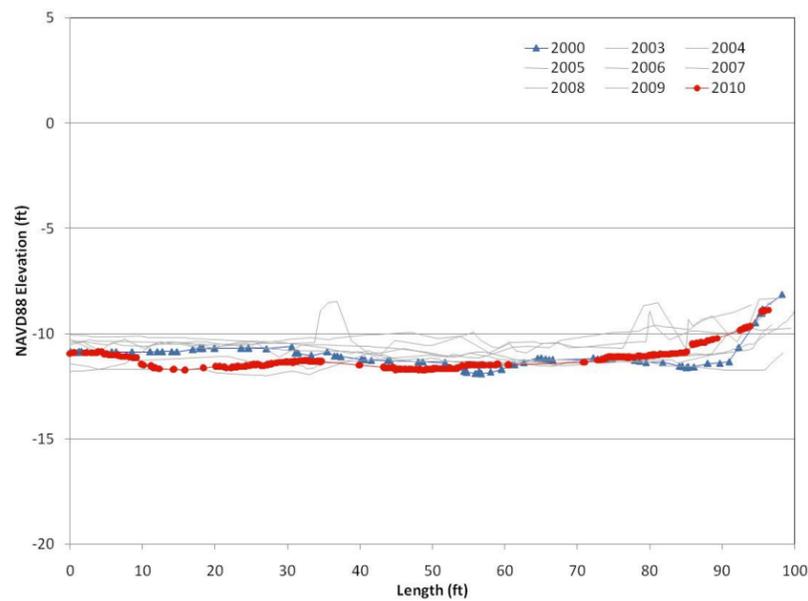
**OR-3 0ft Cross-Section  
Spring**



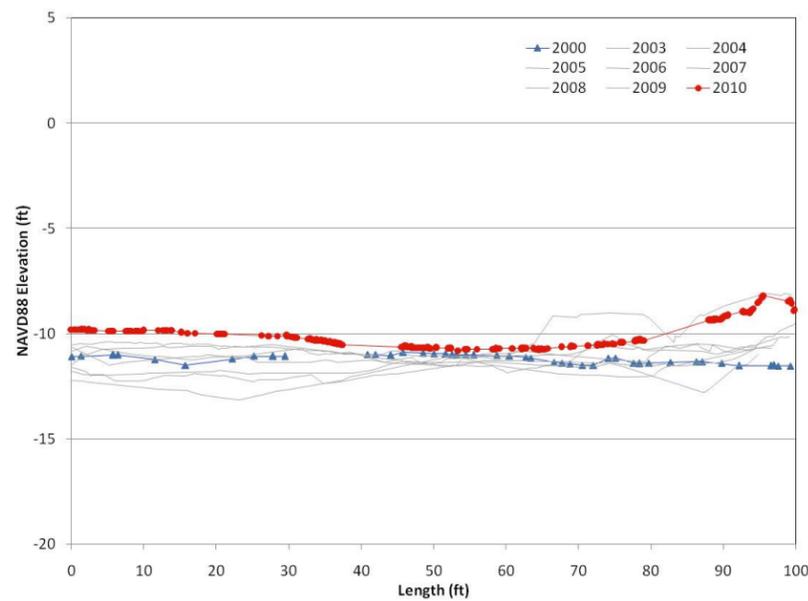
**OR-3 50ft Cross-Section  
Spring**



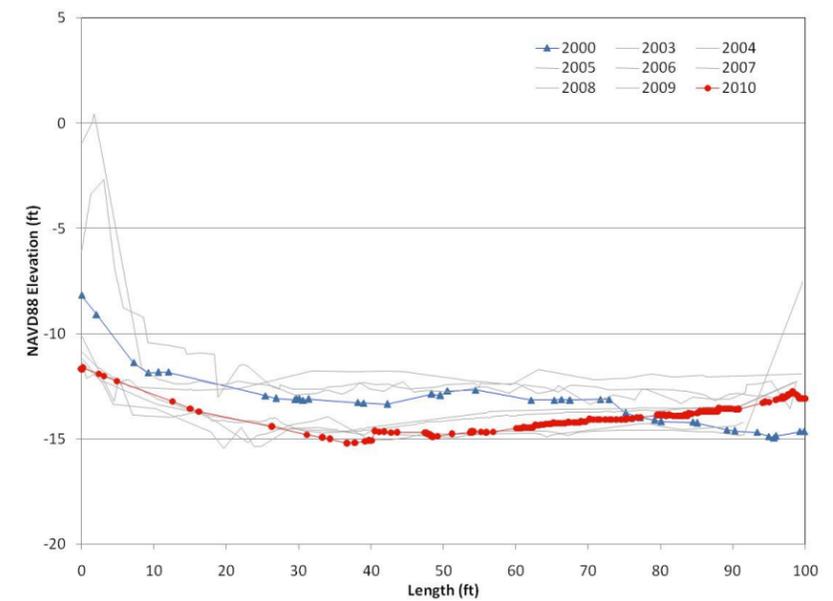
**OR-3 100ft Cross-Section  
Spring**



**OR-3 0ft Cross-Section  
Fall**

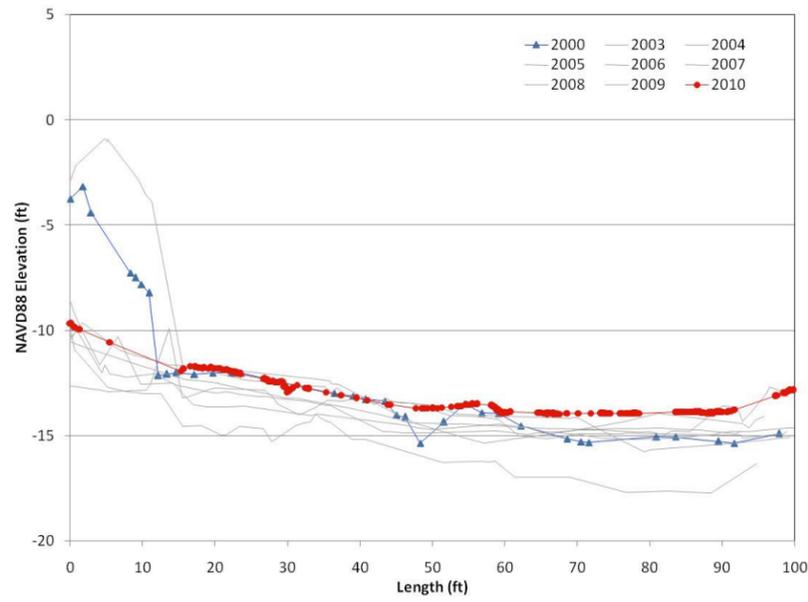


**OR-3 50ft Cross-Section  
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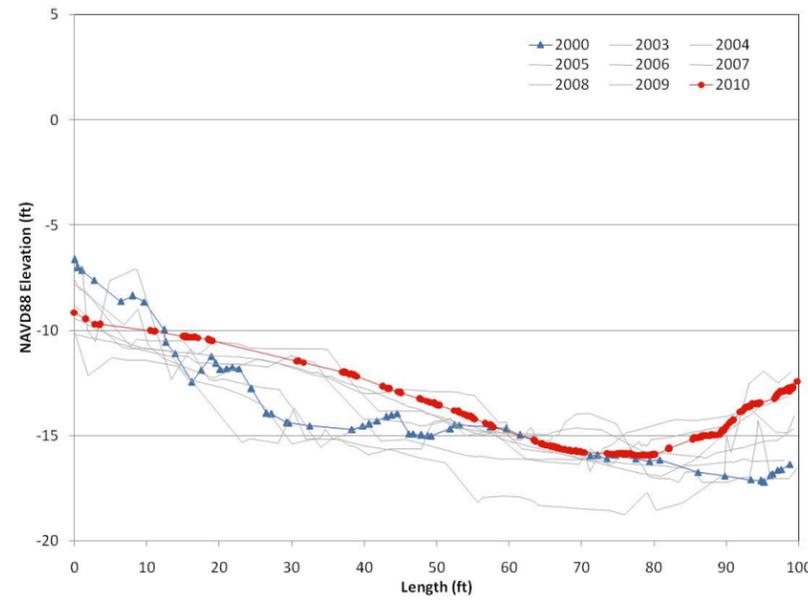


**OR-3 100ft Cross-Section  
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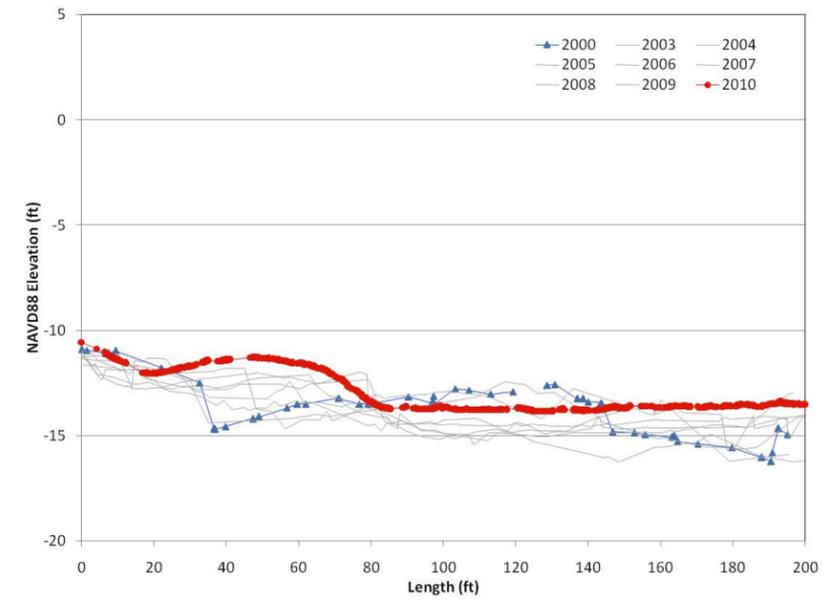




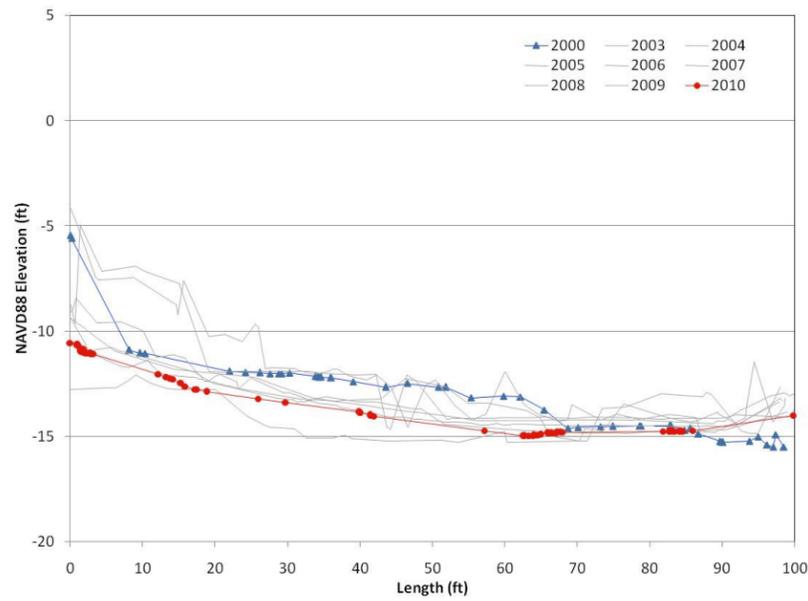
**OR-3 150ft Cross-Section  
Spring**



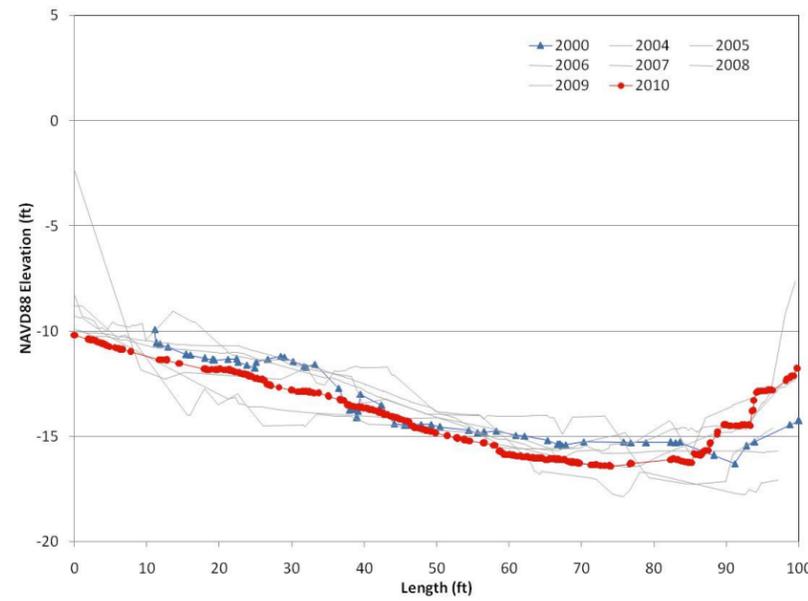
**OR-3 200ft Cross-Section  
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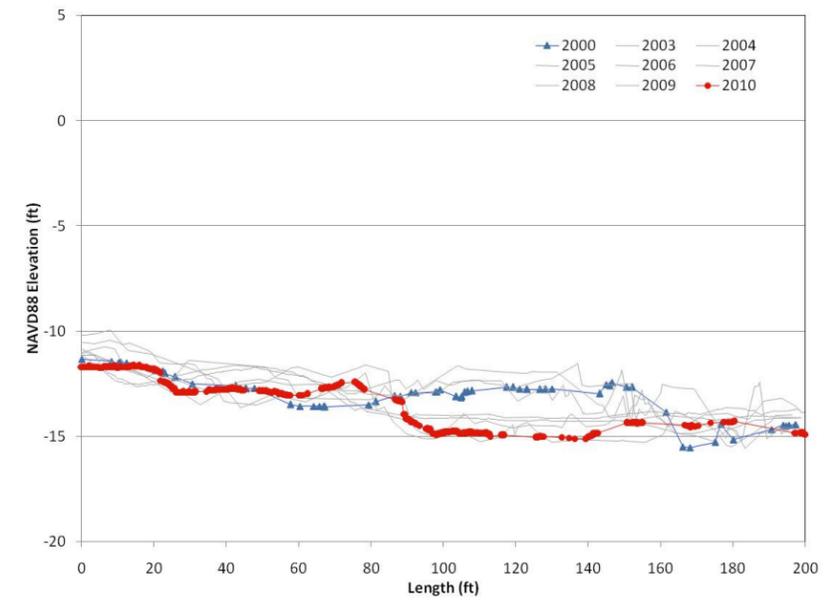
**OR-3 Centerline  
Spring**



**OR-3 150ft Cross-Section  
Fall**



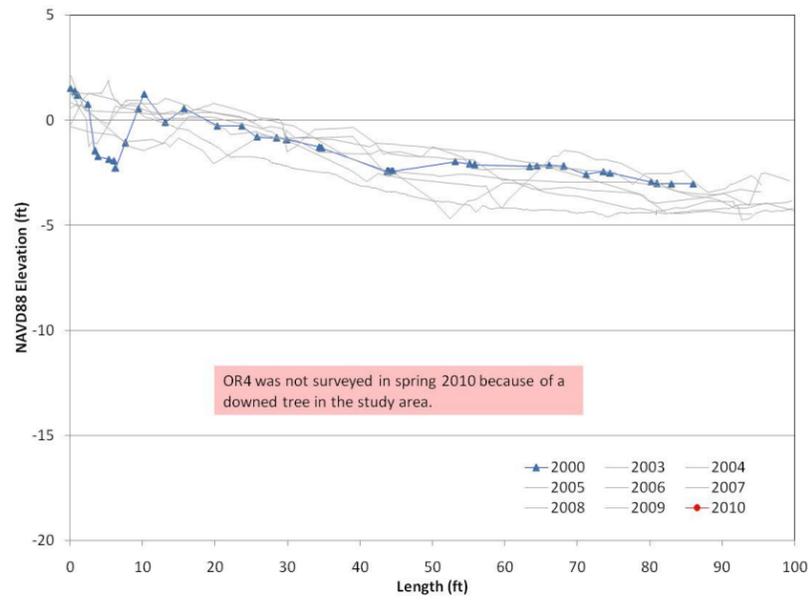
**OR-3 200ft Cross-Section  
Fall**



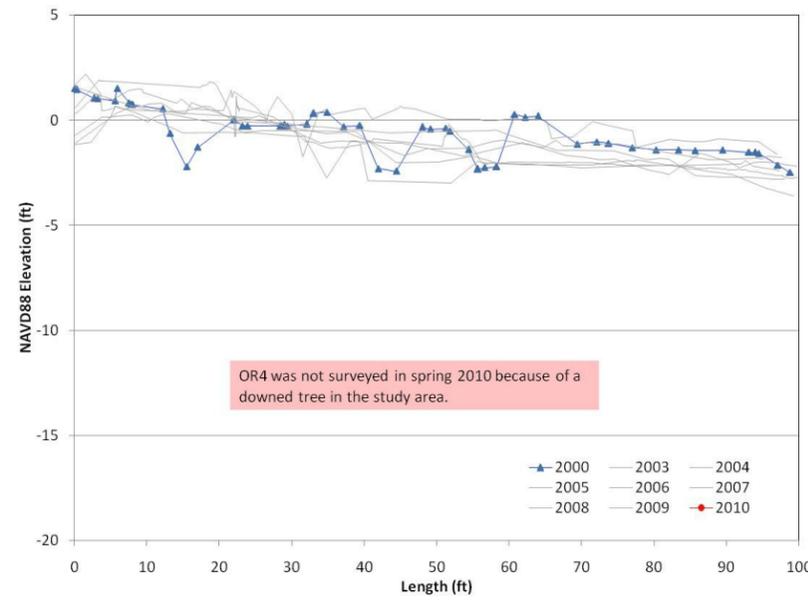
**OR-3 Centerline  
Fall**



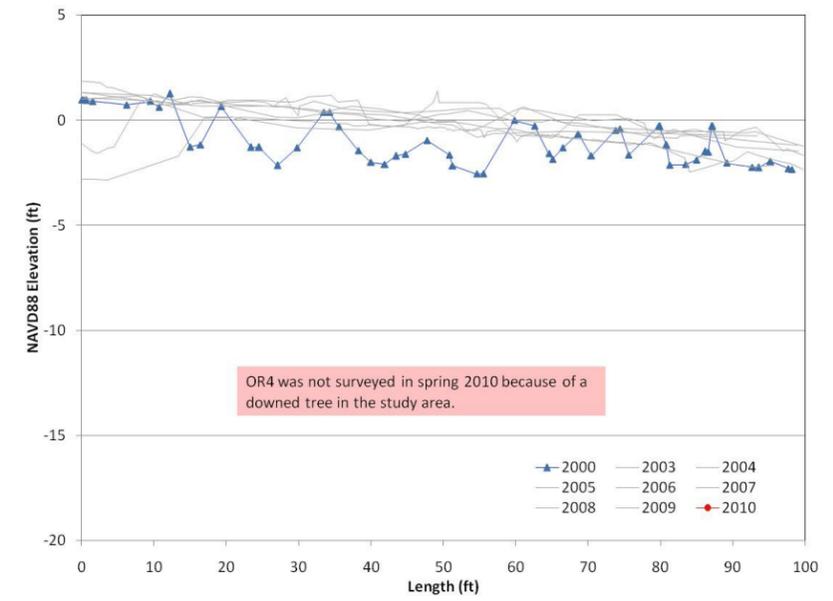
# Appendix D:OR-4 Cross-Sections



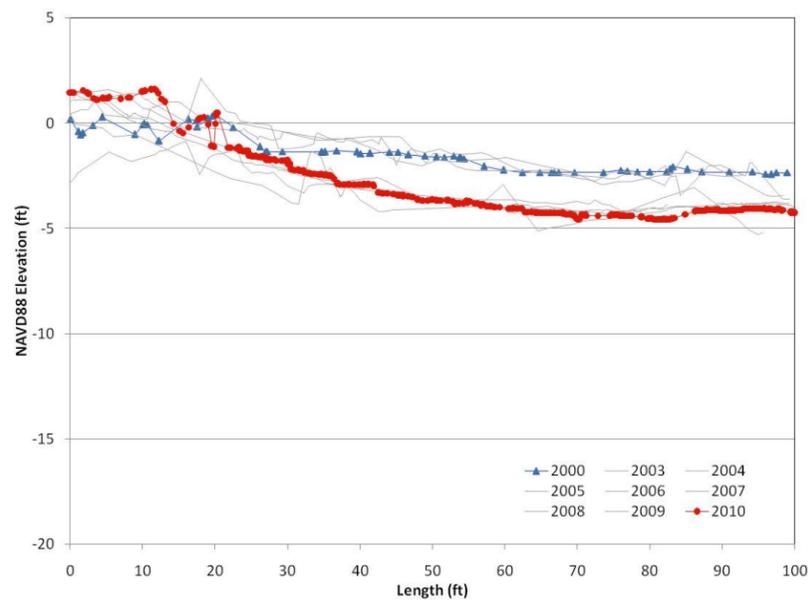
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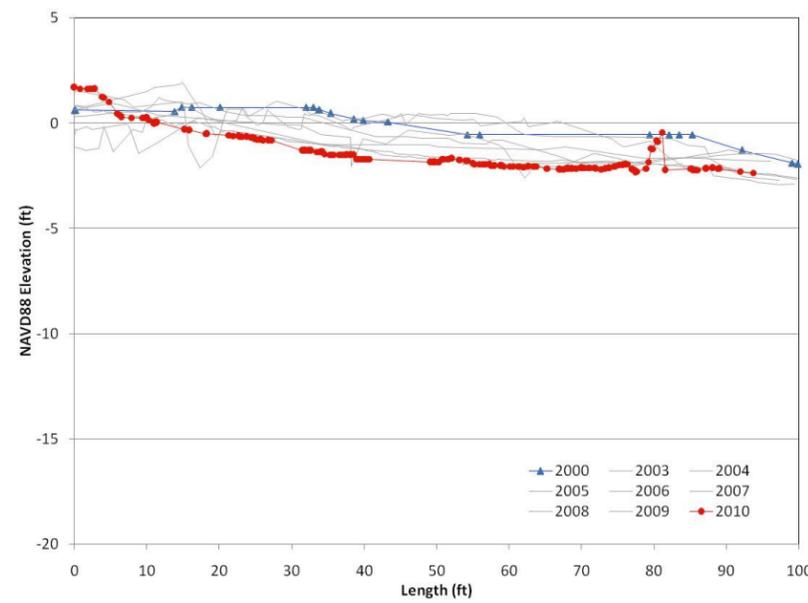
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Spring**



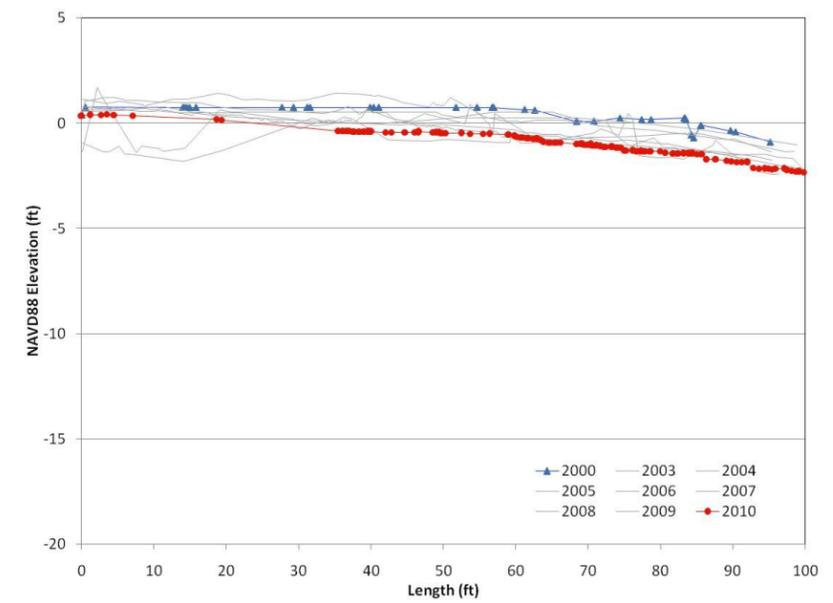
**OR-4 100ft Cross-Section  
Spring**



**OR-4 0ft Cross-Section  
Fall**

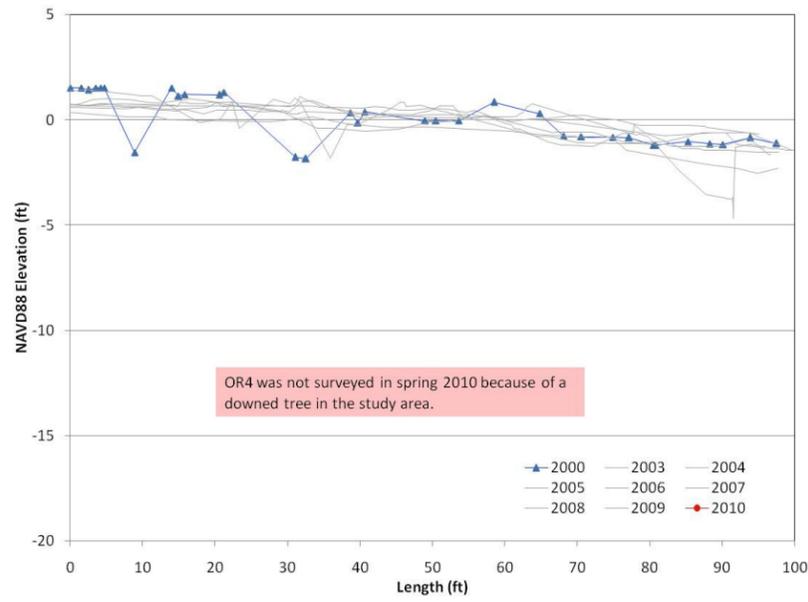


**OR-4 50ft Cross-Section  
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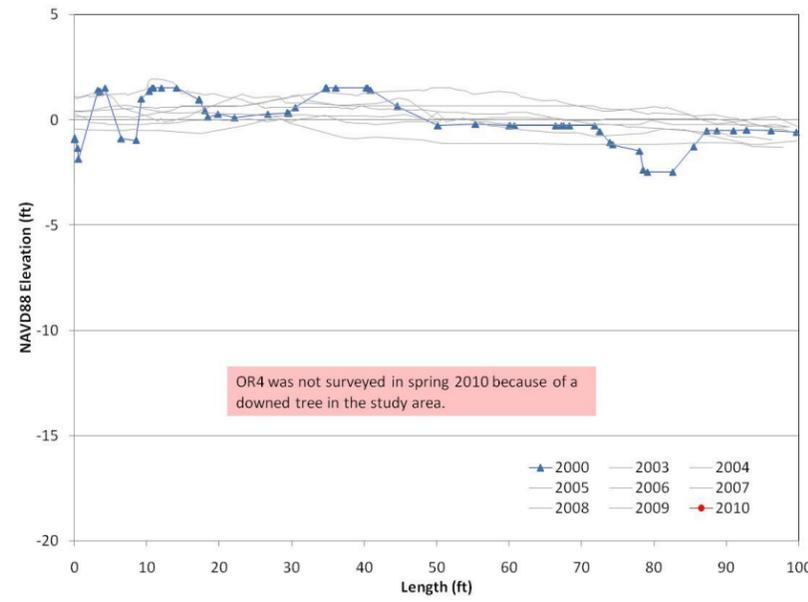


**OR-4 100ft Cross-Section  
Fall**

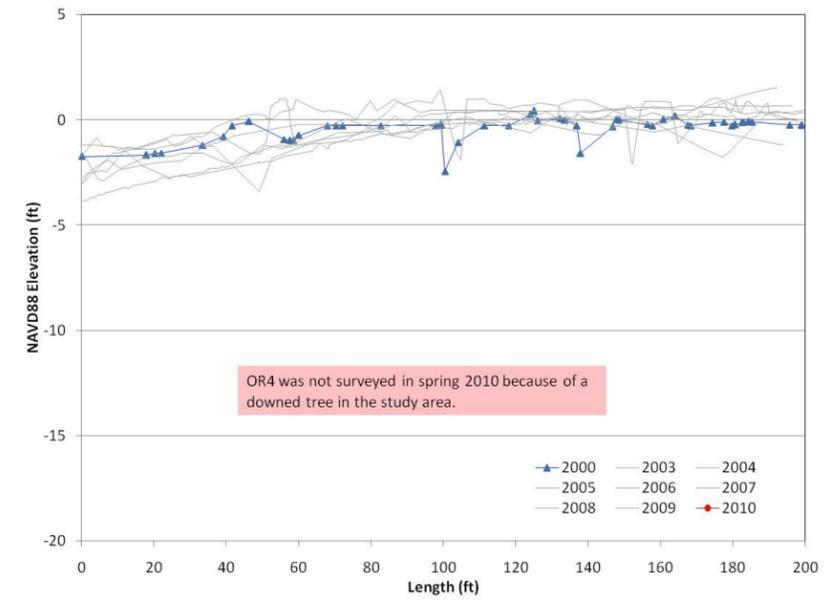




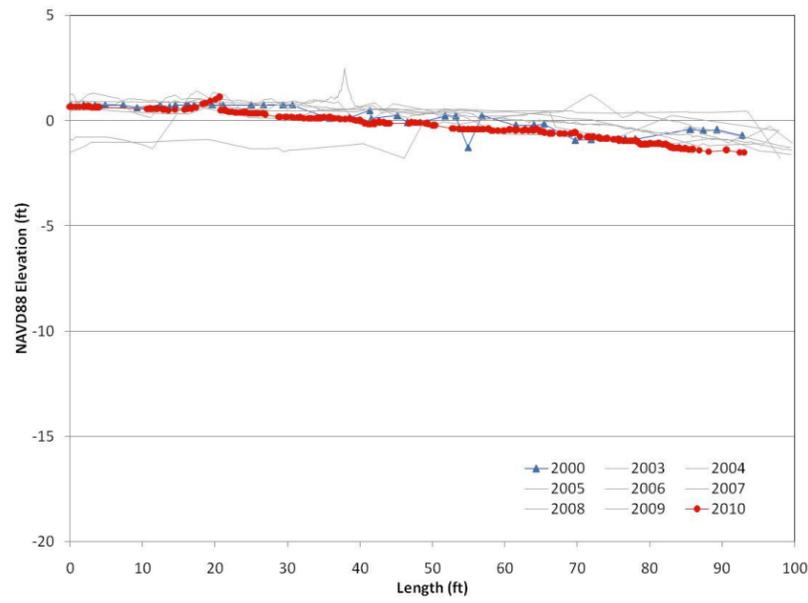
**OR-4 150ft Cross-Section  
Spring**



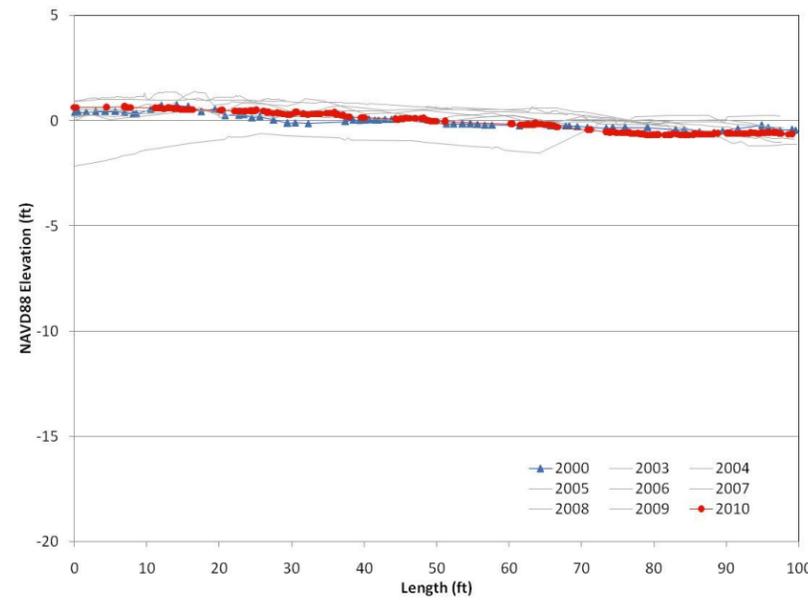
**OR-4 200ft Cross-Section  
Spring**



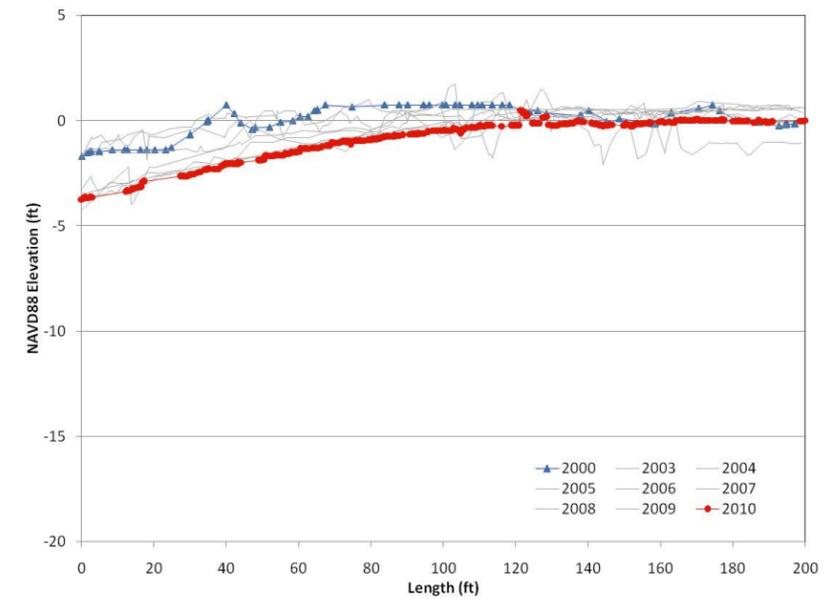
**OR-4 Centerline  
Spring**



**OR-4 150ft Cross-Section  
Fall**



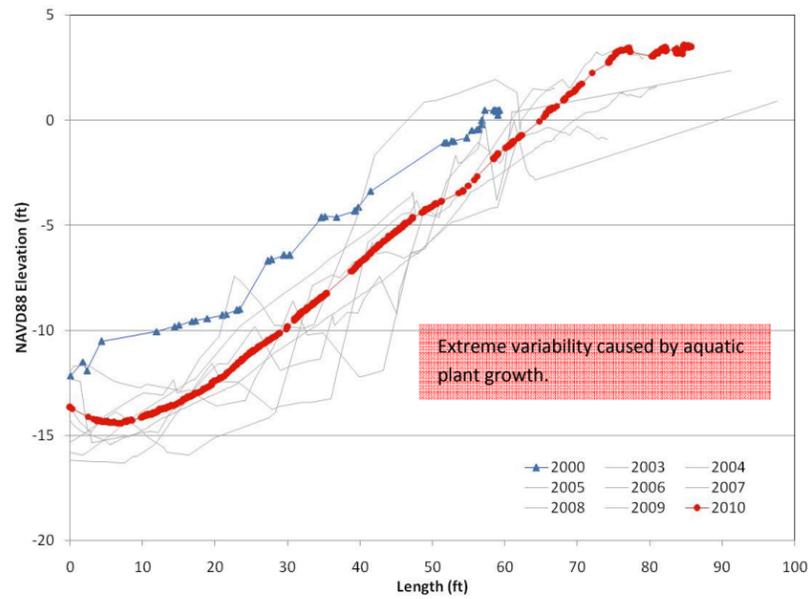
**OR-4 200ft Cross-Section  
Fall**



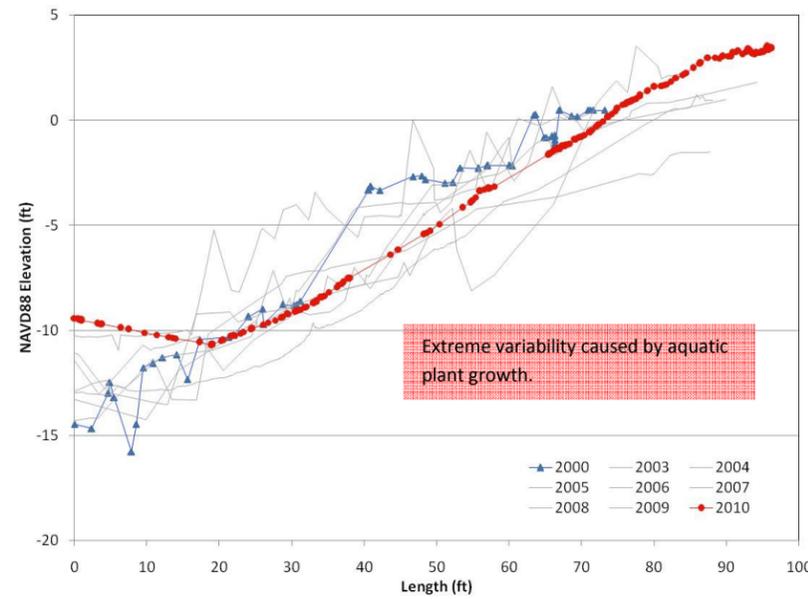
**OR-4 Centerline  
Fall**



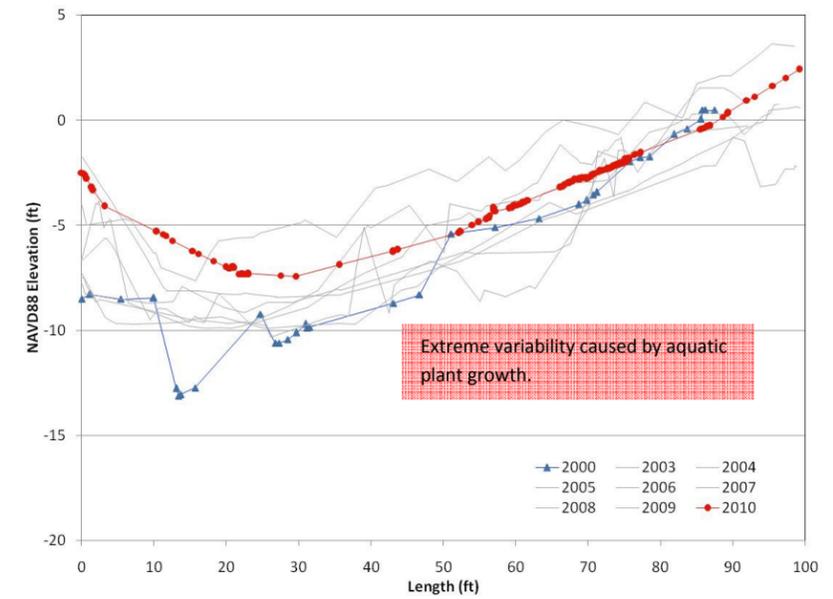
# Appendix E:OR-5 Cross-Sections



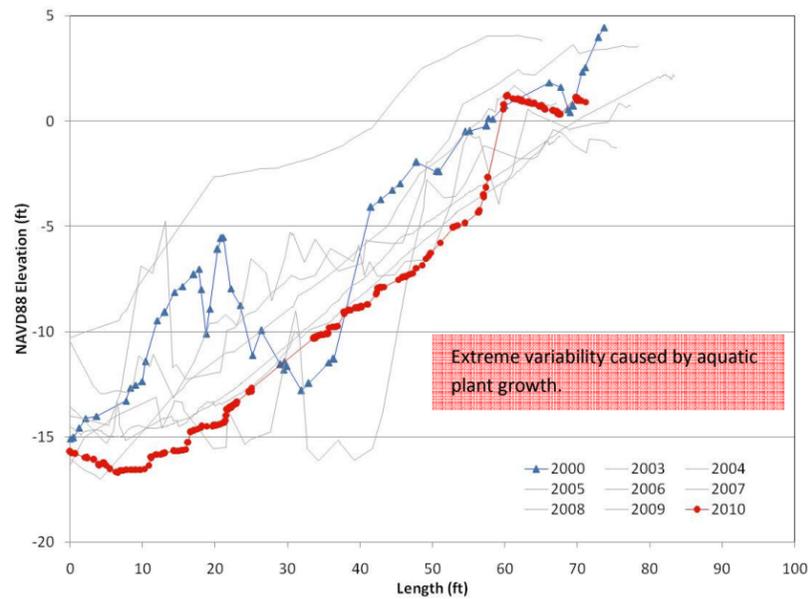
**OR-5 0ft Cross-Section  
Spring**



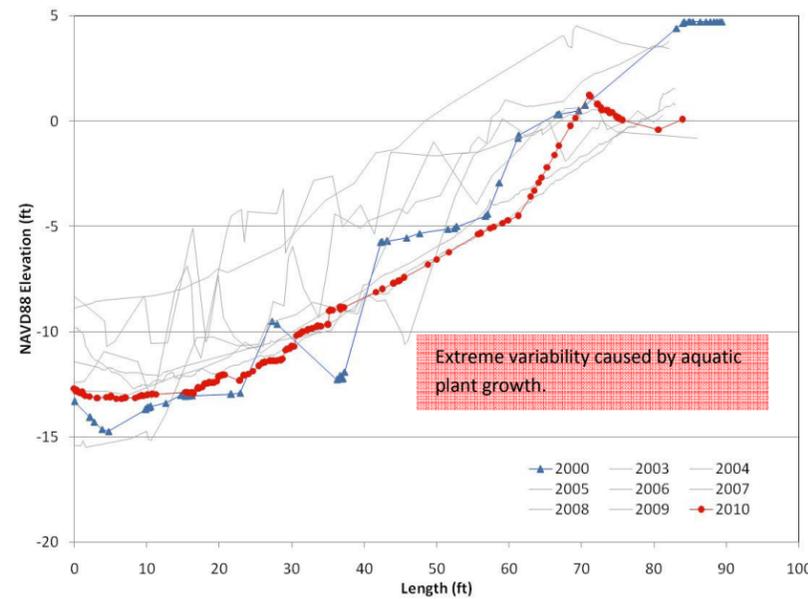
**OR-5 50ft Cross-Section  
Spring**



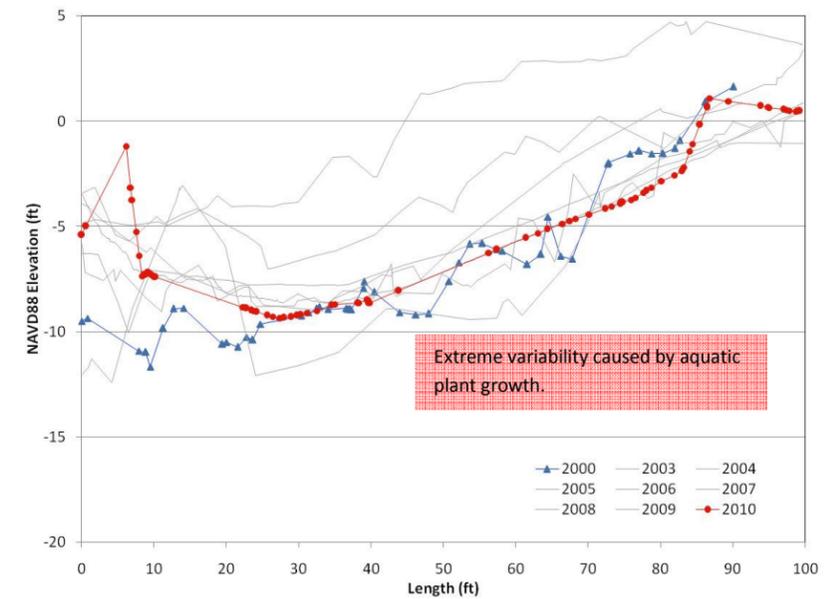
**OR-5 100ft Cross-Section  
Spring**



**OR-5 0ft Cross-Section  
Fall**

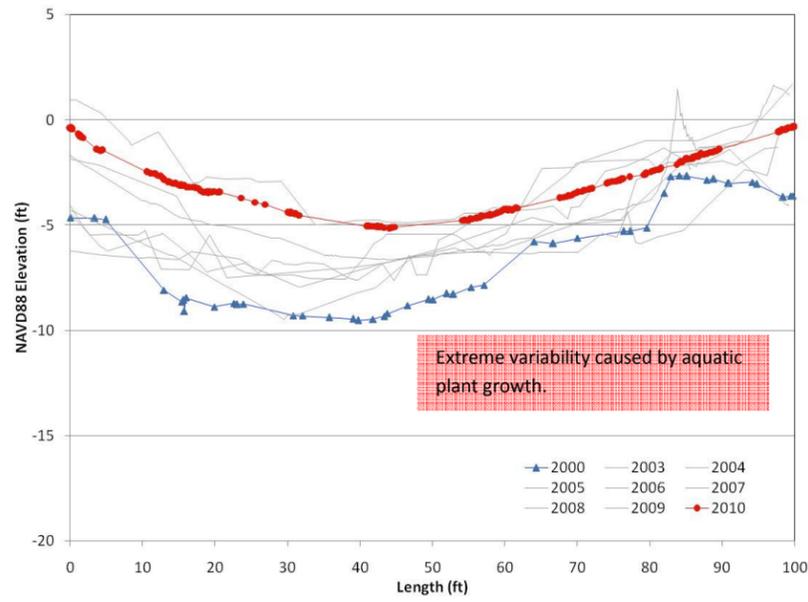


**OR-5 50ft Cross-Section  
Fall**

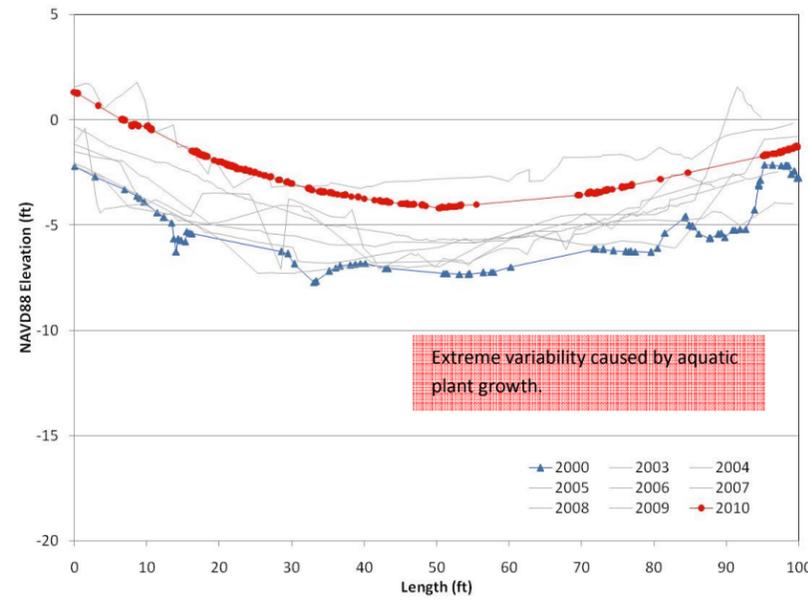


**OR-5 100ft Cross-Section  
Fall**

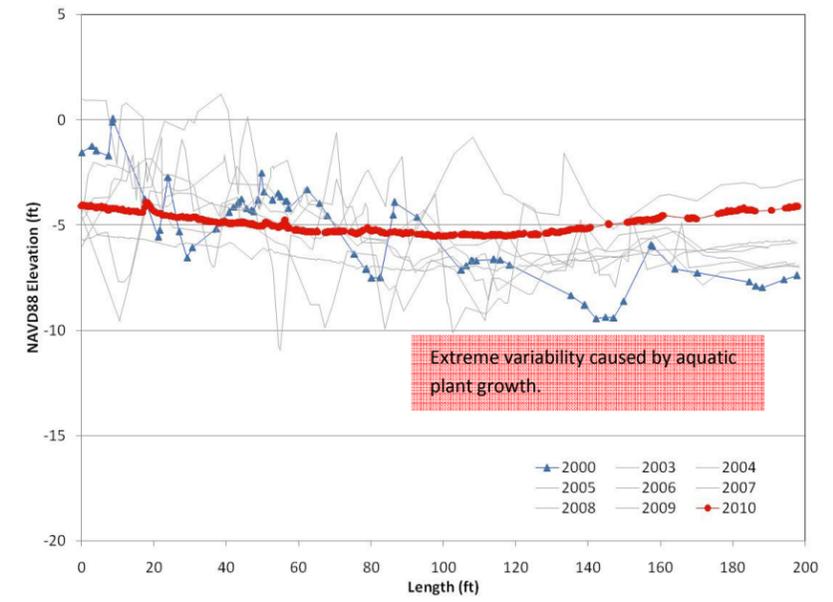




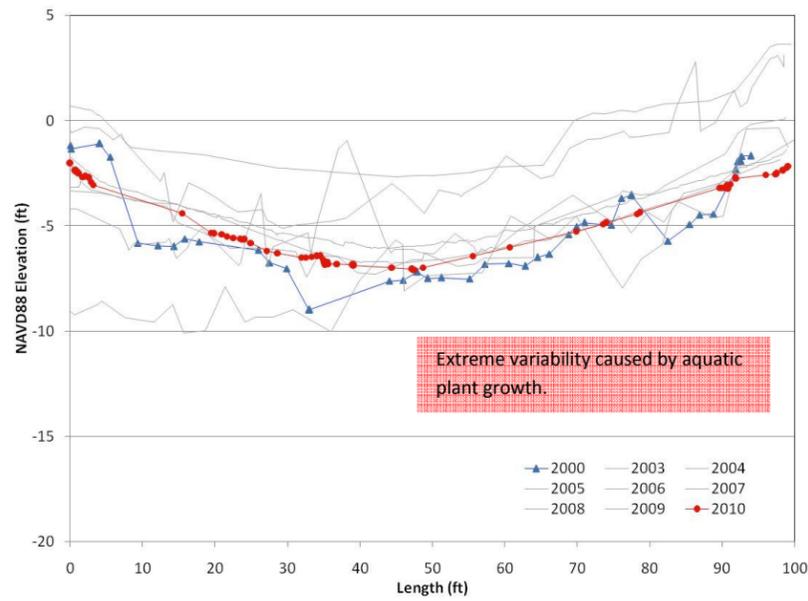
**OR-5 150ft Cross-Section  
Spring**



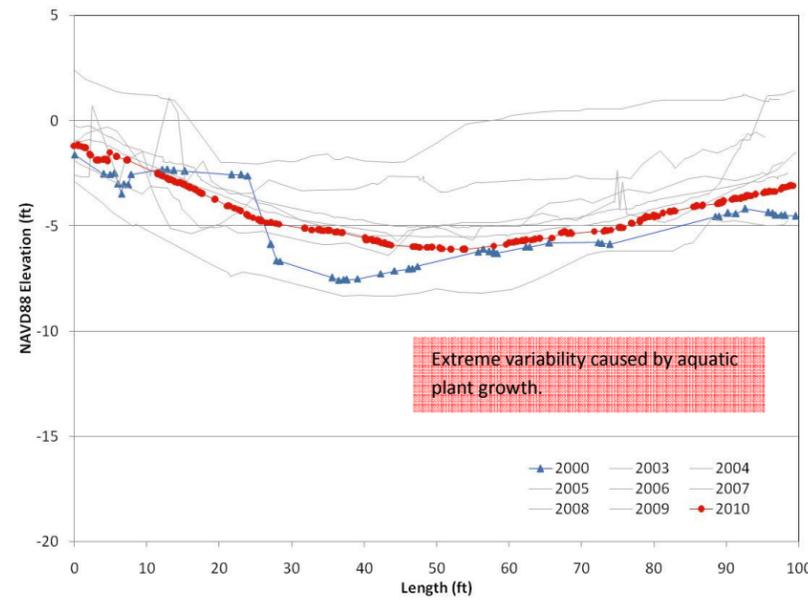
**OR-5 200ft Cross-Section  
Spring**



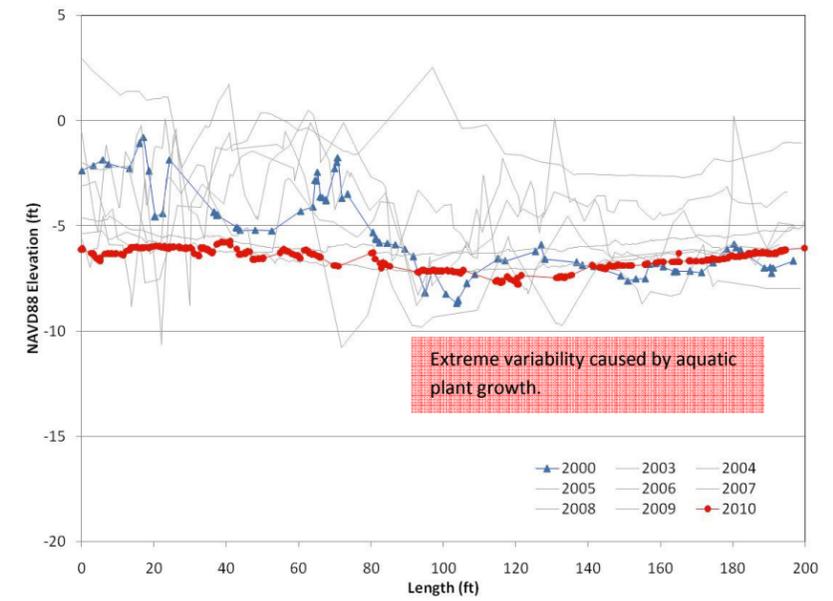
**OR-5 Centerline  
Spring**



**OR-5 150ft Cross-Section  
Fall**



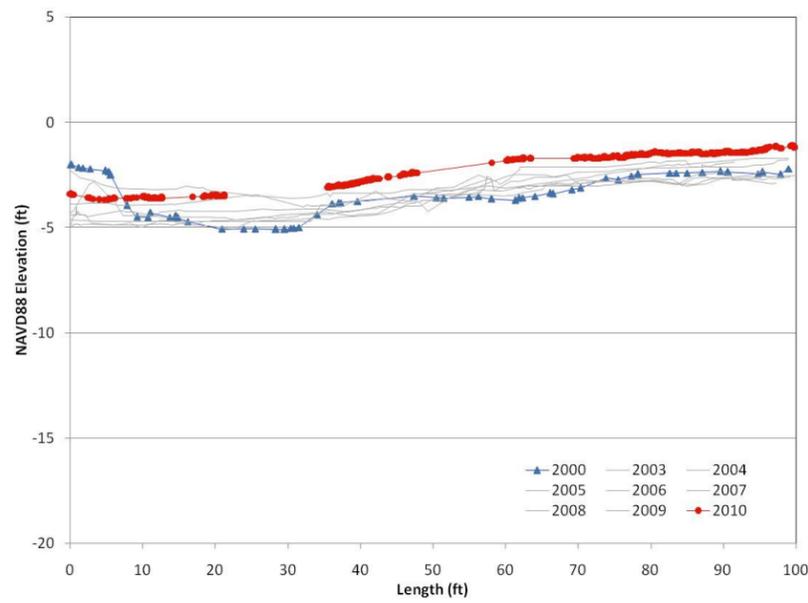
**OR-5 200ft Cross-Section  
Fall**



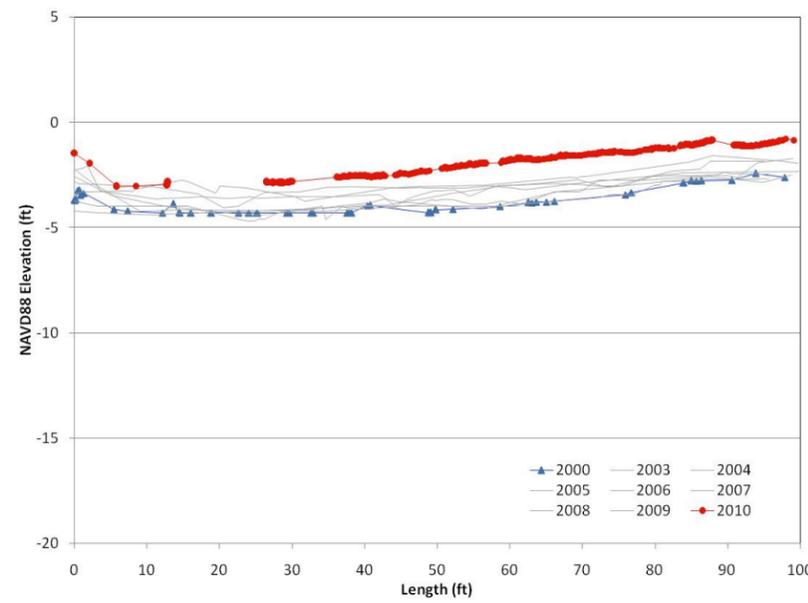
**OR-5 Centerline  
Fall**



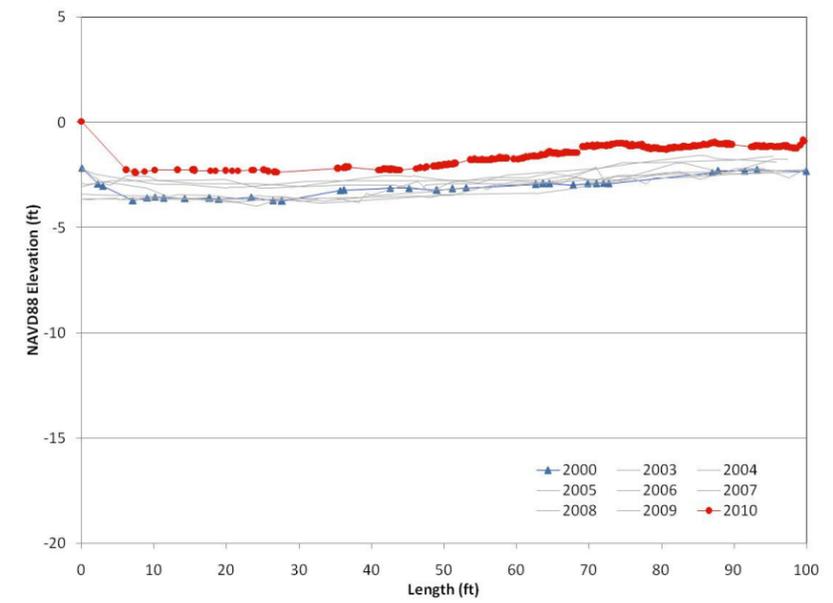
# Appendix F:OR-6 Cross-Sections



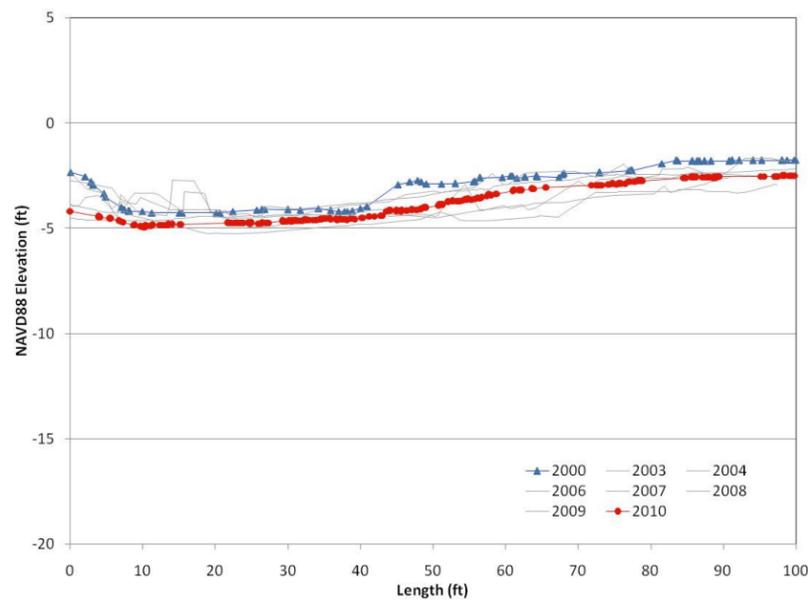
**OR-6 0ft Cross-Section  
Spring**



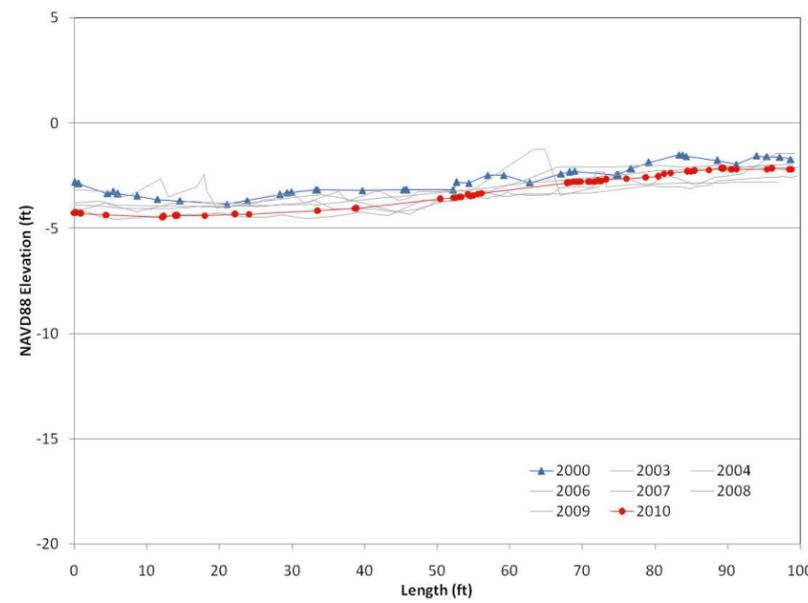
**OR-6 50ft Cross-Section  
Spring**



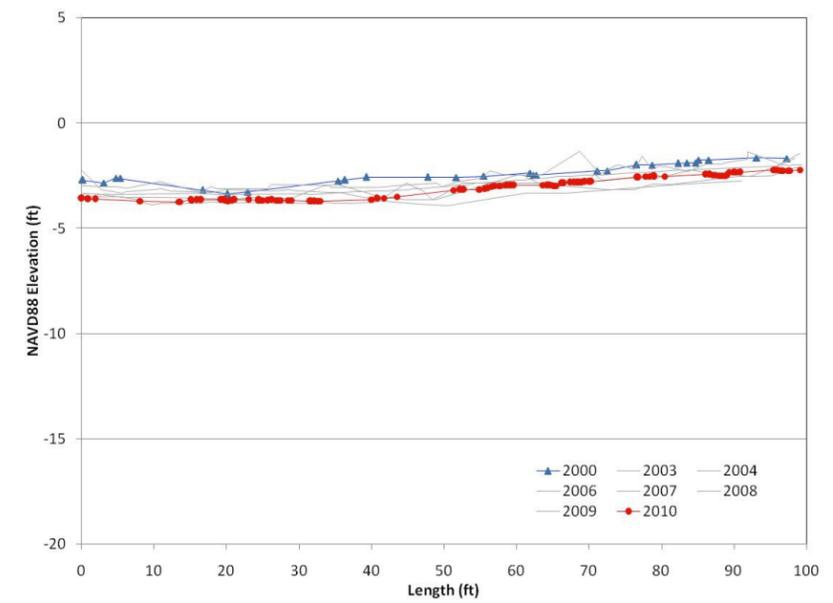
**OR-6 100ft Cross-Section  
Spring**



**OR-6 0ft Cross-Section  
Fall**

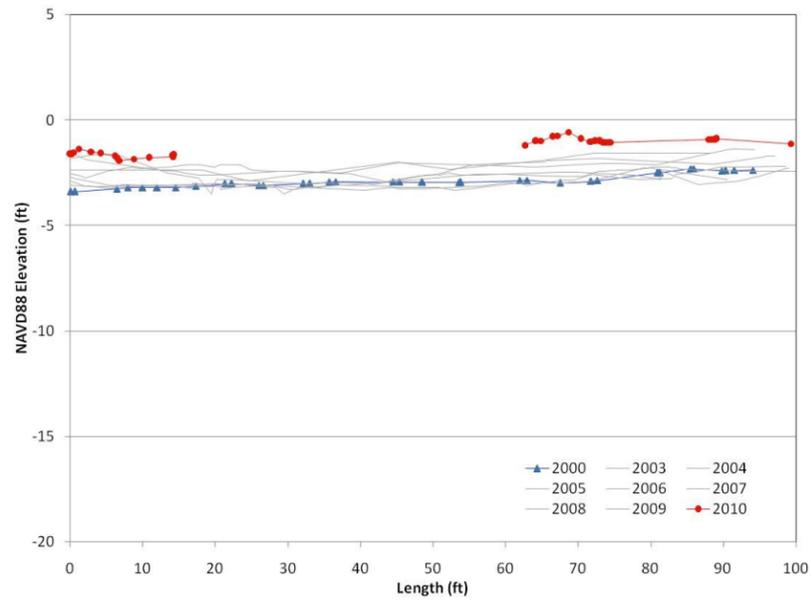


**OR-6 50ft Cross-Section  
Fall**

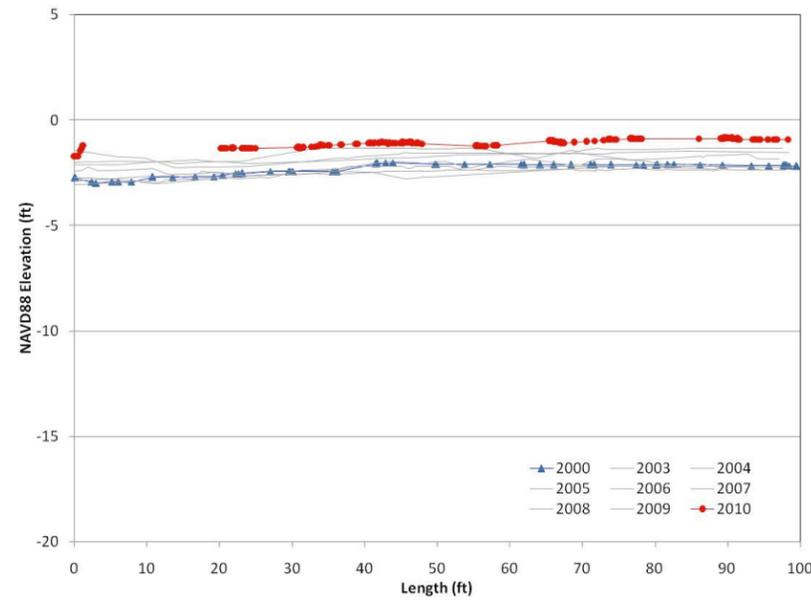


**OR-6 100ft Cross-Section  
Fall**

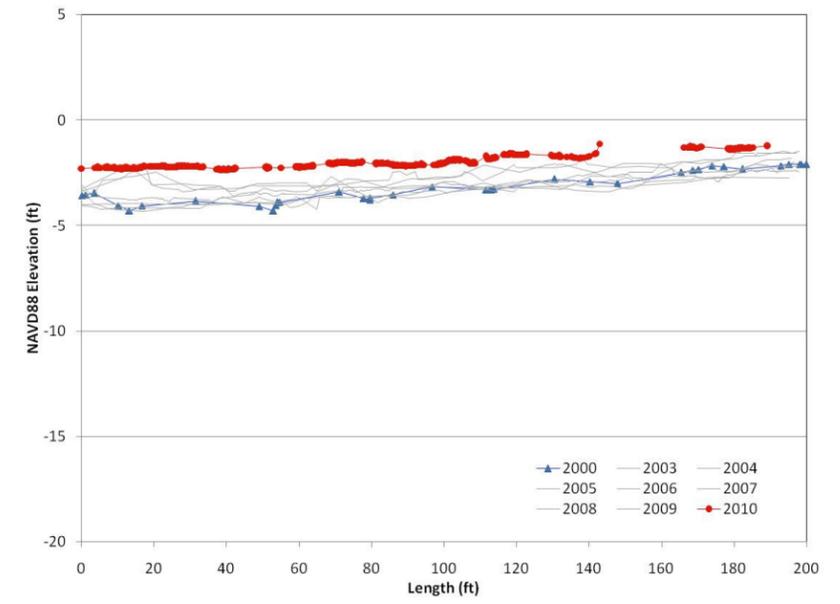




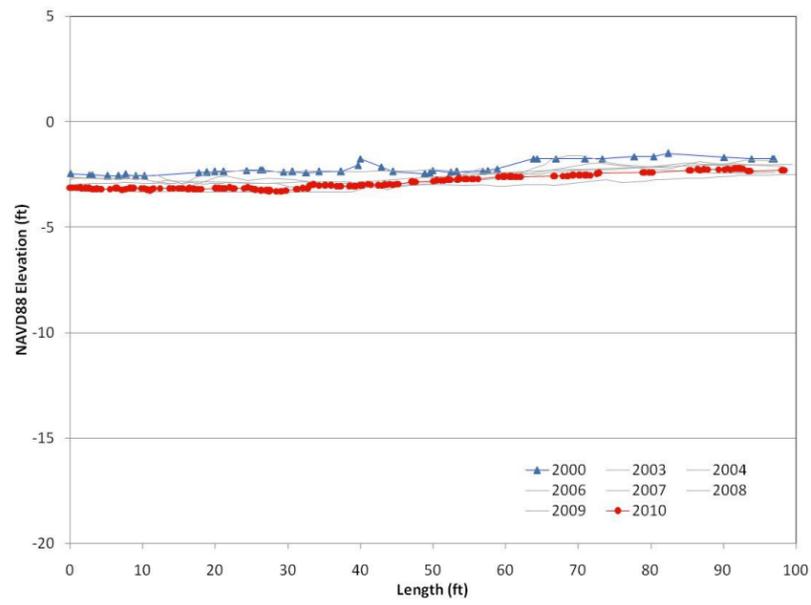
**OR-6 150ft Cross-Section  
Spring**



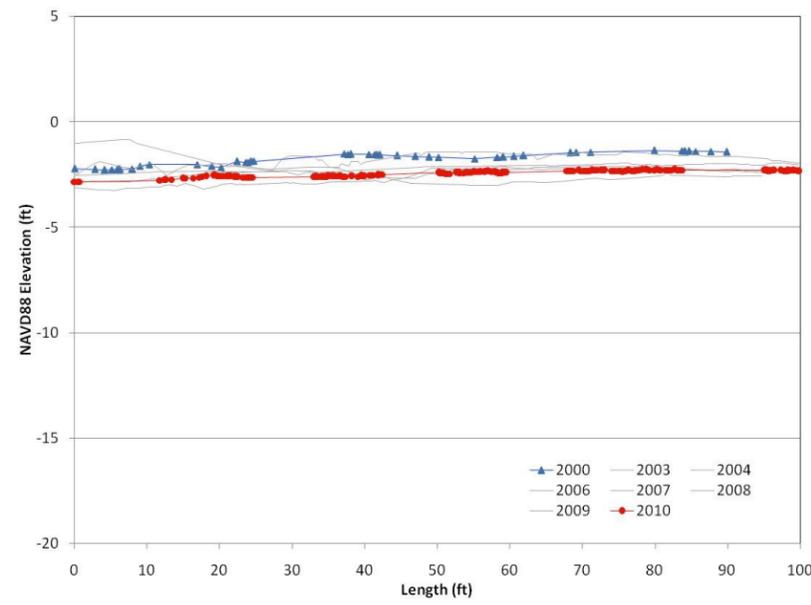
**OR-6 200ft Cross-Section  
Spring**



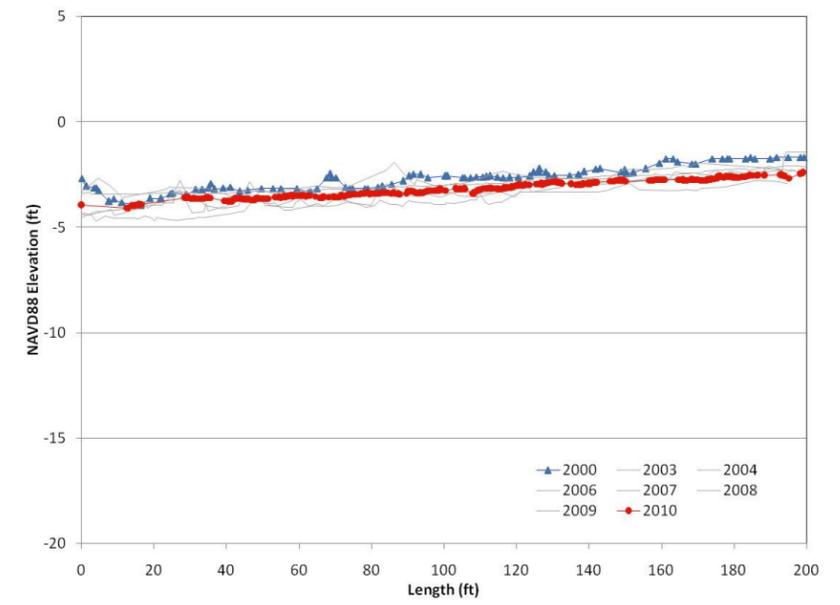
**OR-6 Centerline  
Spring**



**OR-6 150ft Cross-Section  
Fall**



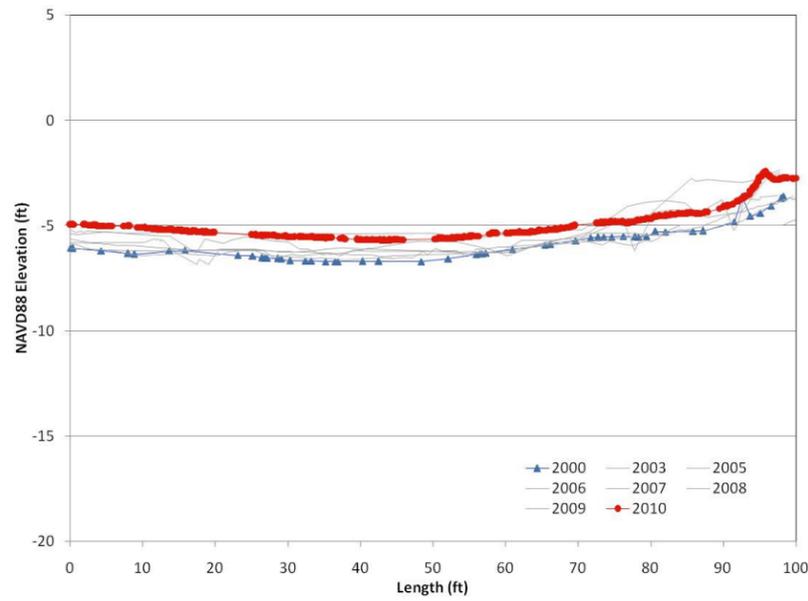
**OR-6 200ft Cross-Section  
Fall**



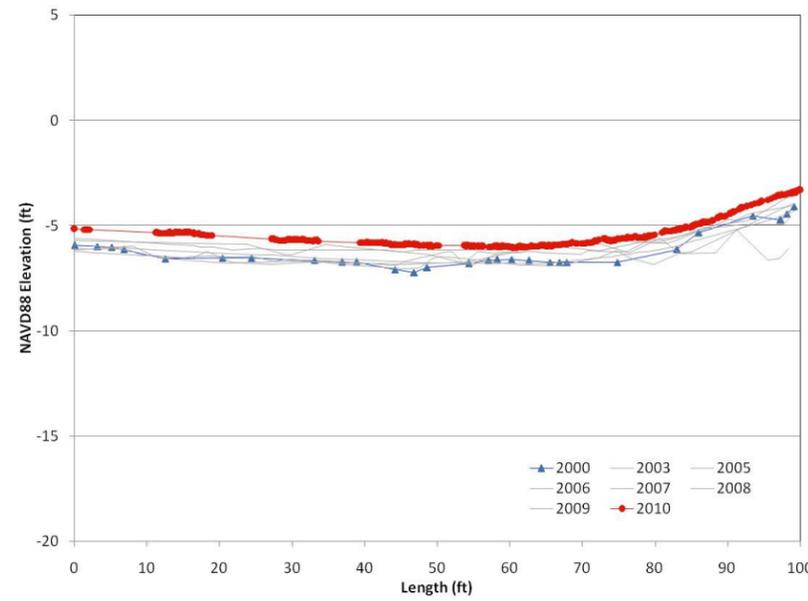
**OR-6 Centerline  
Fall**



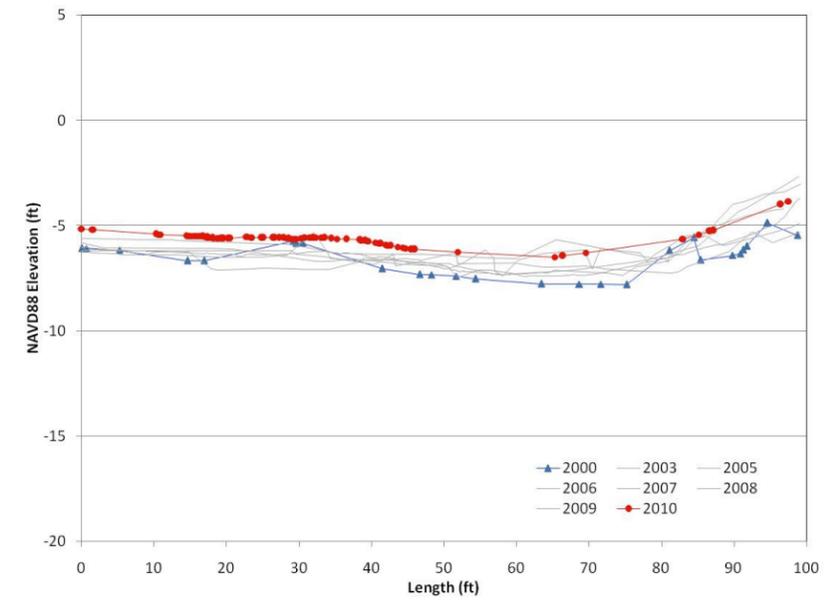
# Appendix G:OR-7 Cross-Sections



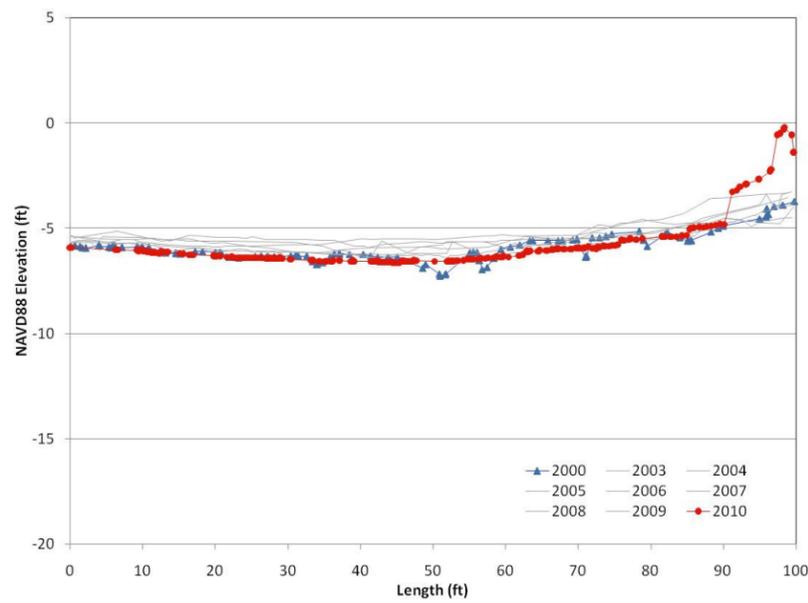
**OR-7 0ft Cross-Section  
Spring**



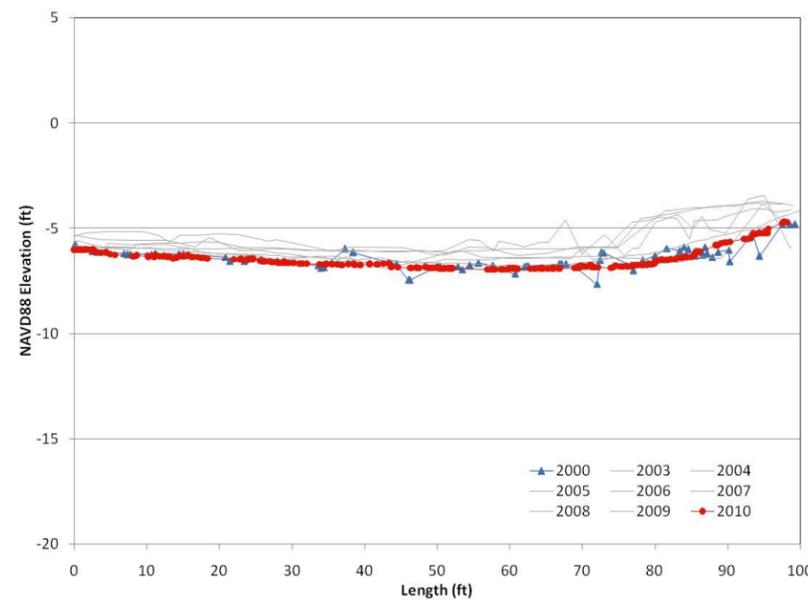
**OR-7 50ft Cross-Section  
Spring**



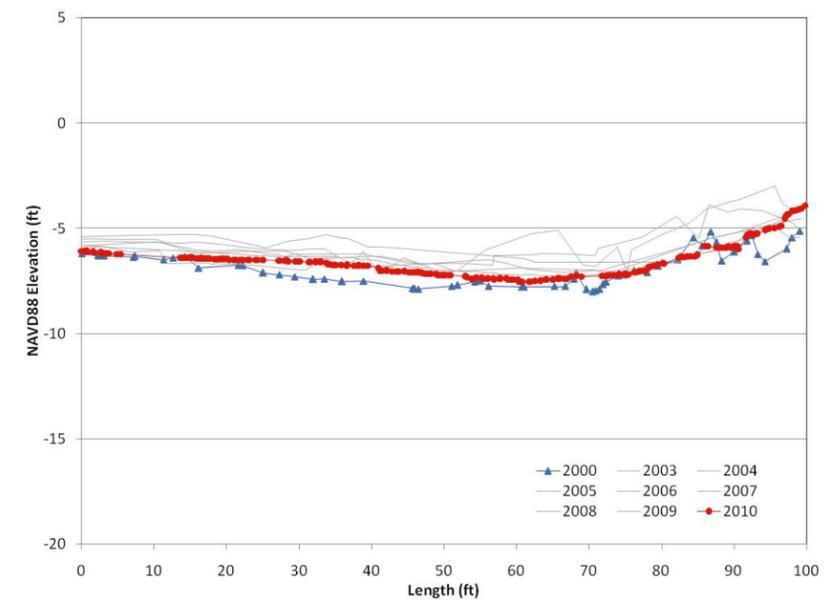
**OR-7 100ft Cross-Section  
Spring**



**OR-7 0ft Cross-Section  
Fall**

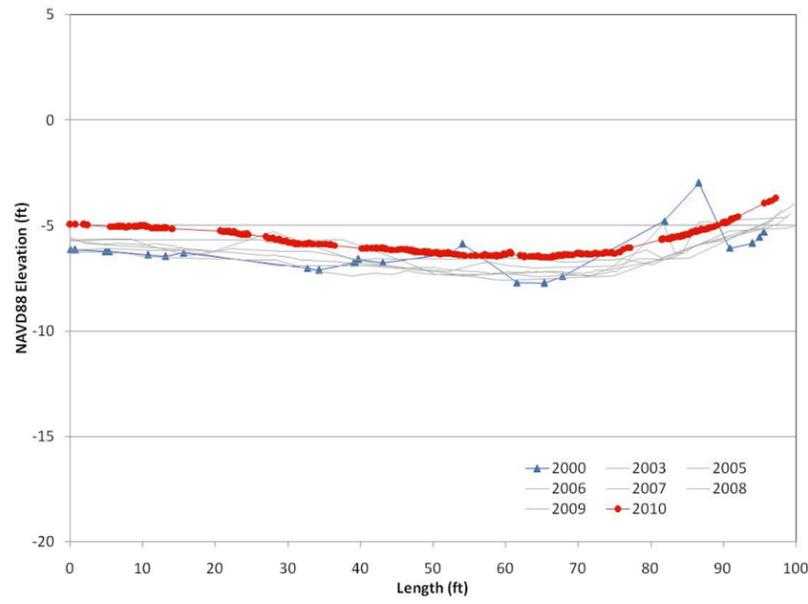


**OR-7 50ft Cross-Section  
Fall**

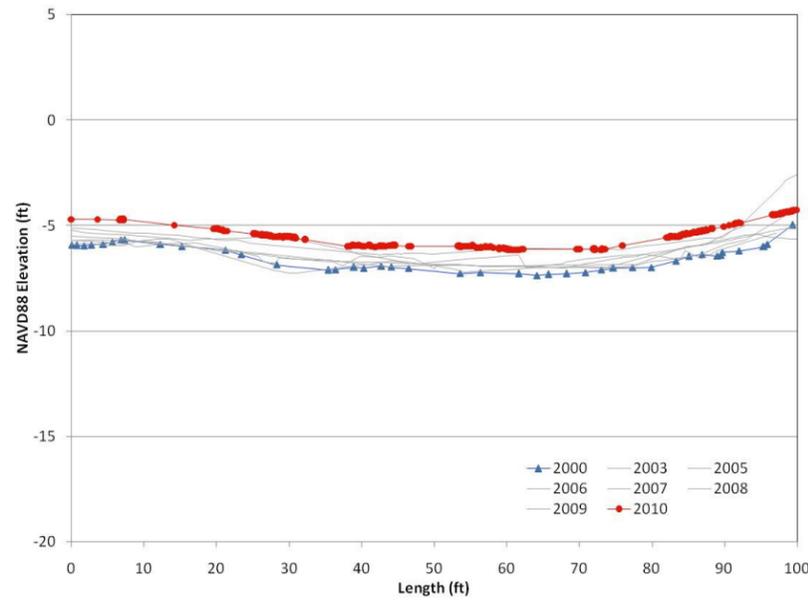


**OR-7 100ft Cross-Section  
Fall**

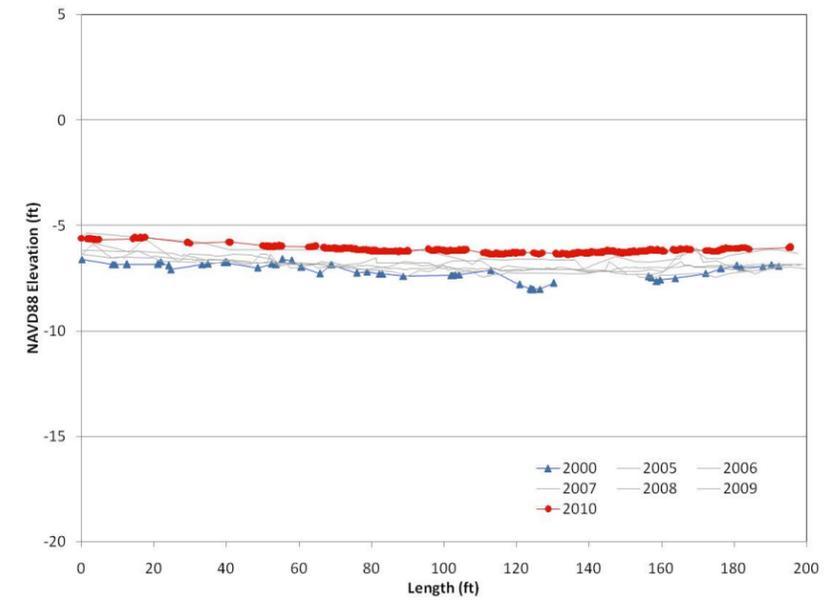




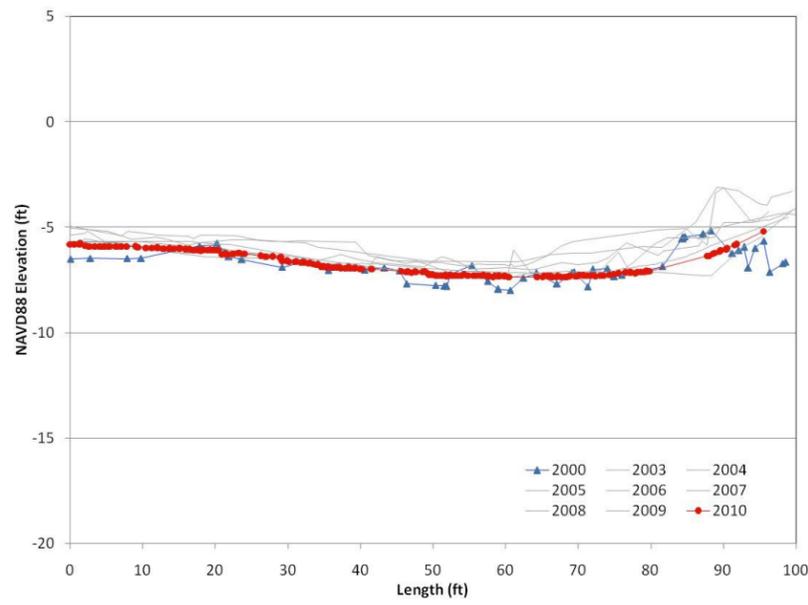
**OR-7 150ft Cross-Section  
Spring**



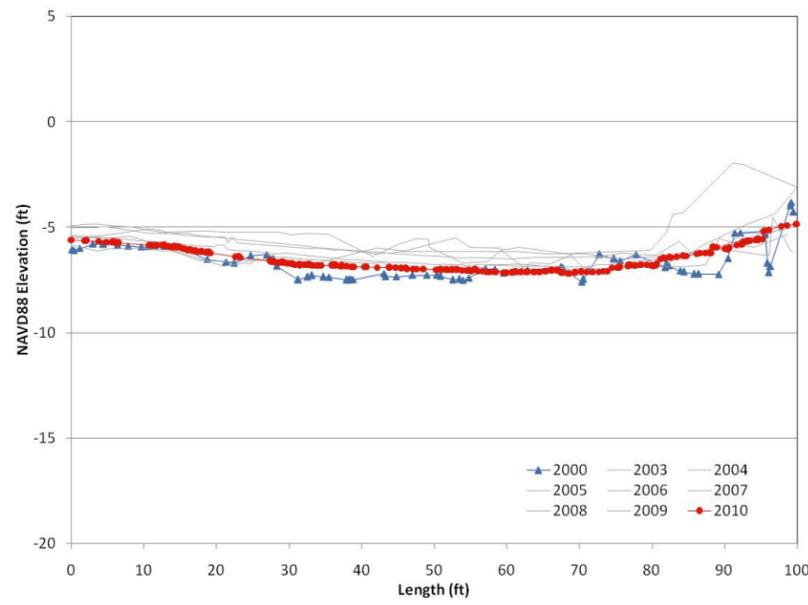
**OR-7 200ft Cross-Section  
Spring**



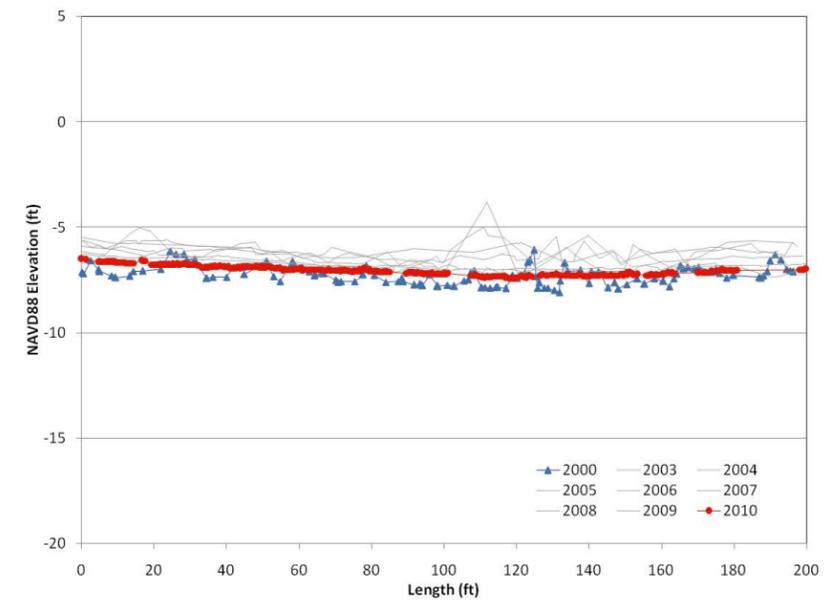
**OR-7 Centerline  
Spring**



**OR-7 150ft Cross-Section  
Fall**



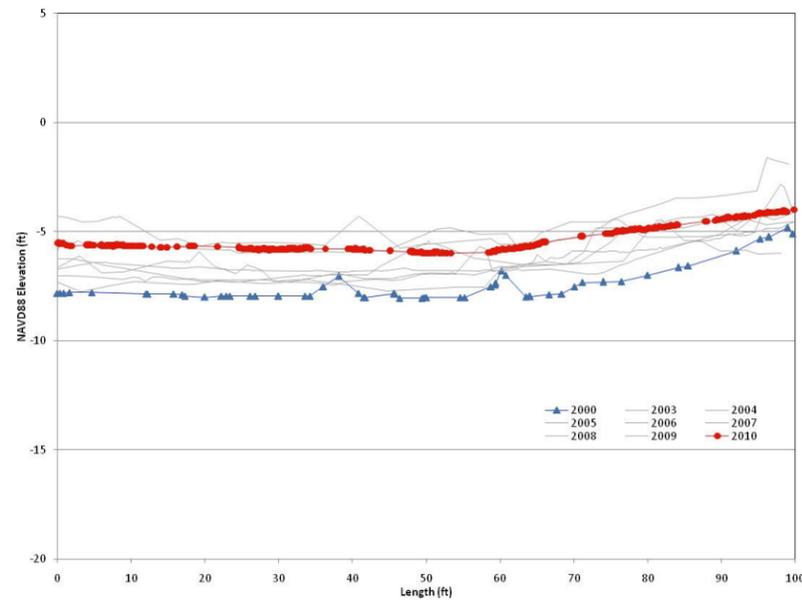
**OR-7 200ft Cross-Section  
Fall**



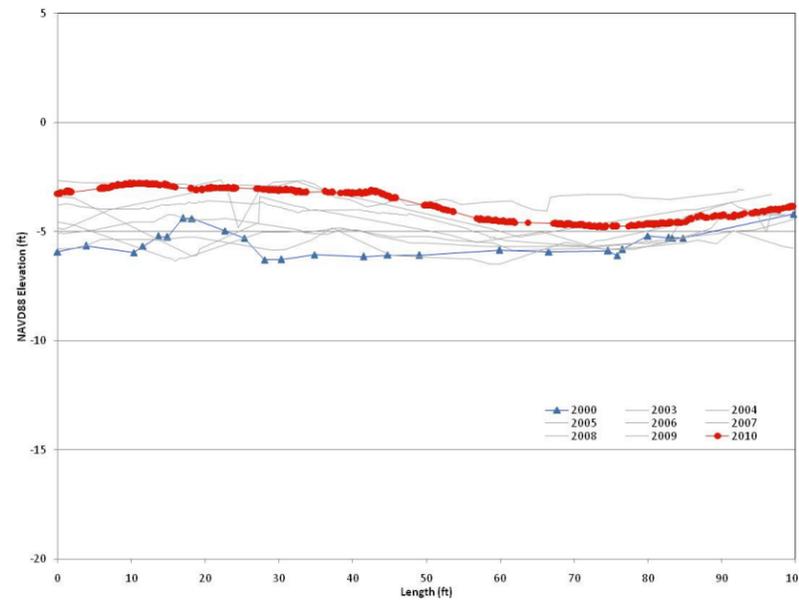
**OR-7 Centerline  
Fall**



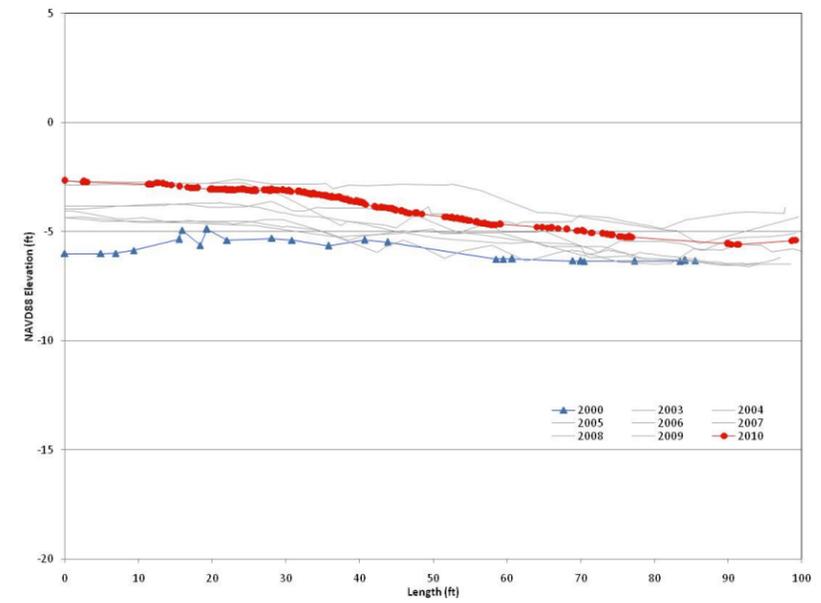
# Appendix H:OR-8 Cross-Sections



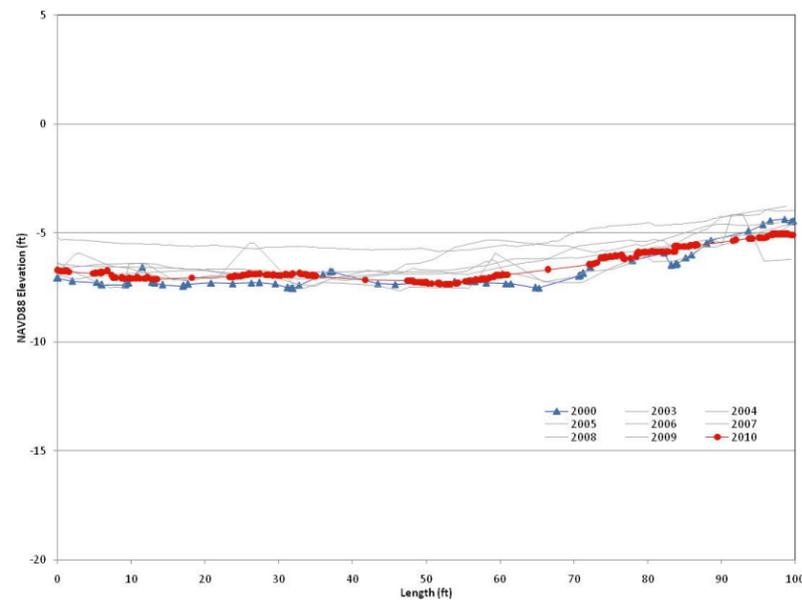
**OR-8 0ft Cross-Section  
Spring**



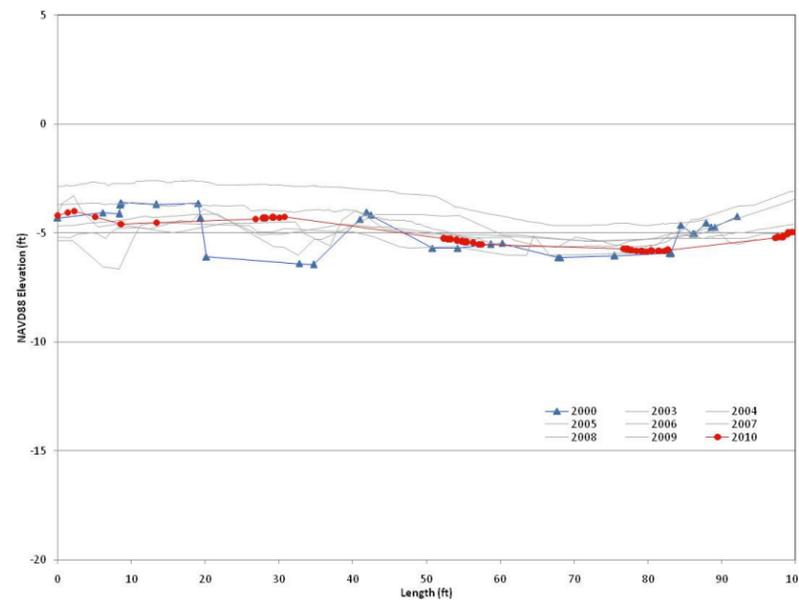
**OR-8 50ft Cross-Section  
Spring**



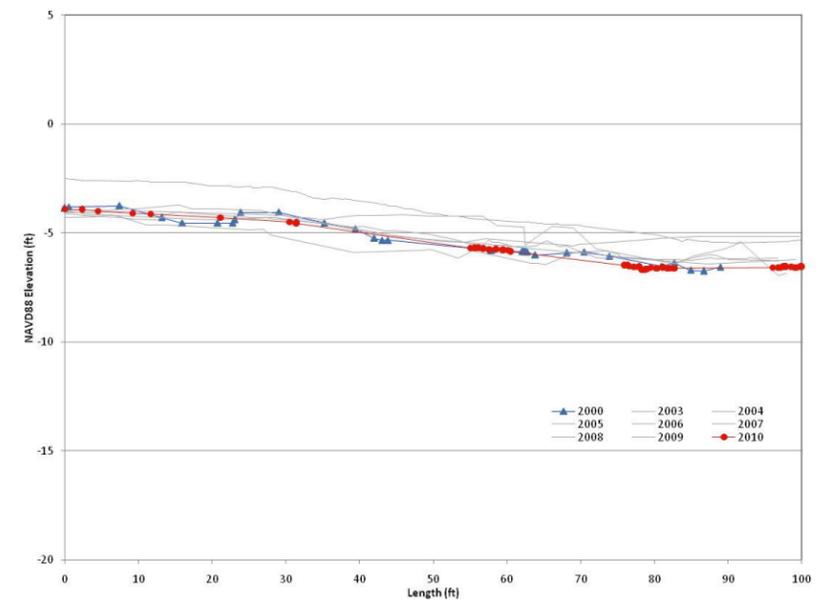
**OR-8 100ft Cross-Section  
Spring**



**OR-8 0ft Cross-Section  
Fall**

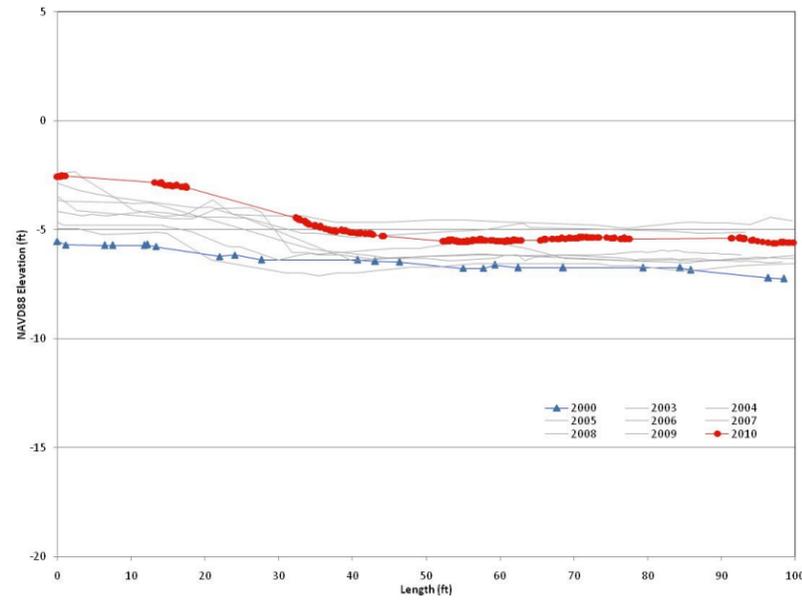


**OR-8 50ft Cross-Section  
Fall**

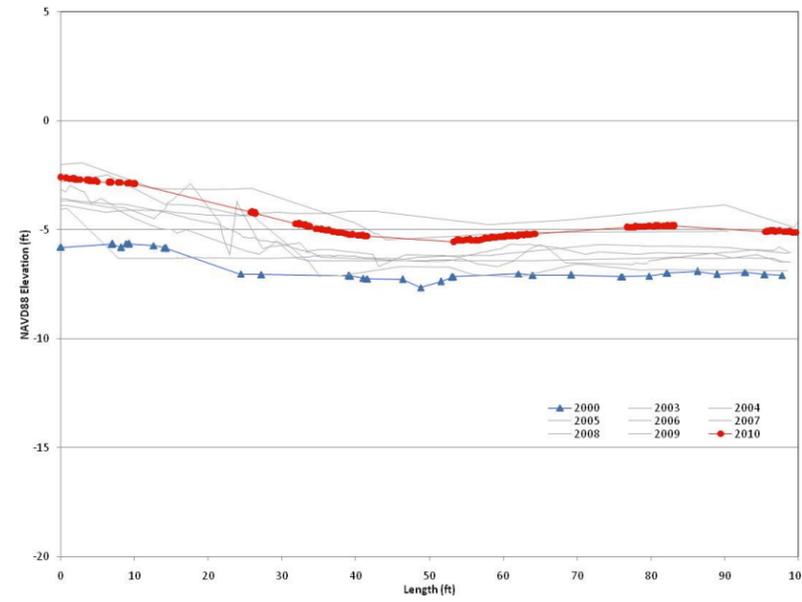


**OR-8 100ft Cross-Section  
Fall**

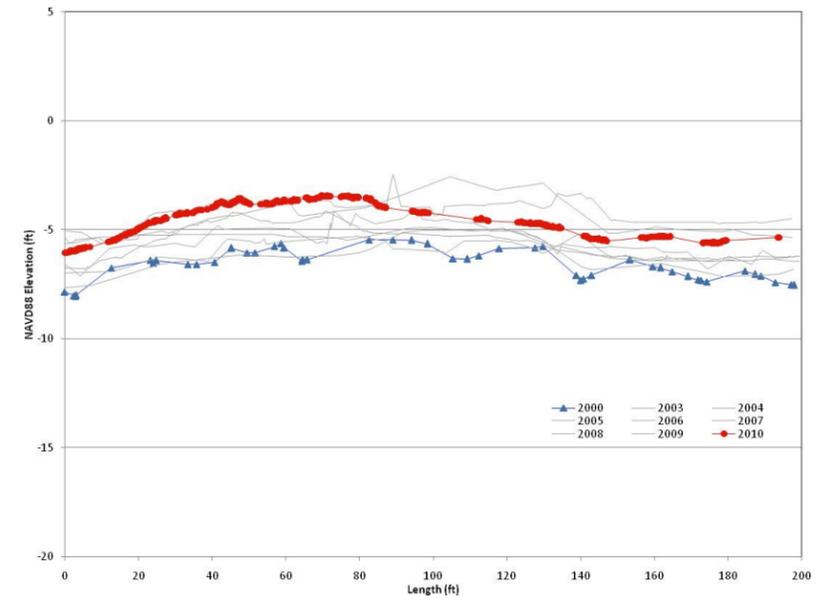




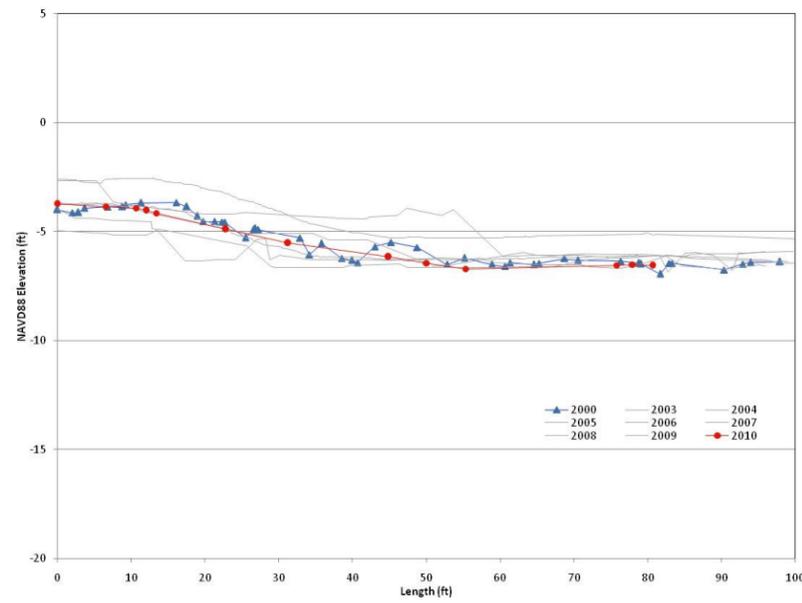
**OR-8 150ft Cross-Section  
Spring**



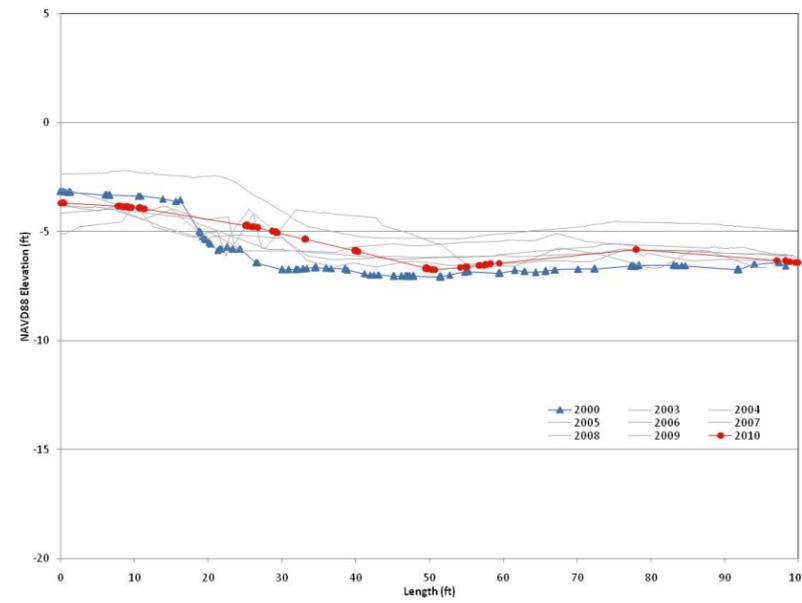
**OR-8 200ft Cross-Section  
Spring**



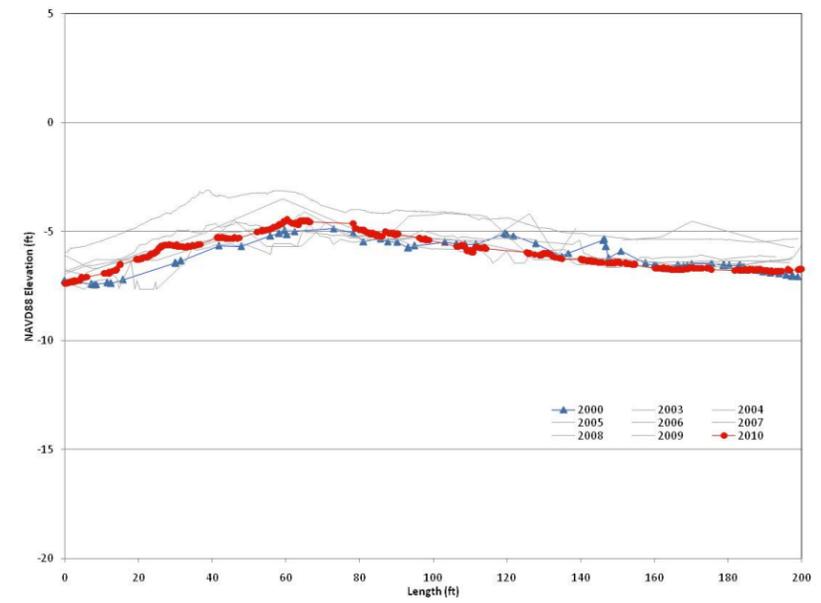
**OR-8 Centerline  
Spring**



**OR-8 150ft Cross-Section  
Fall**



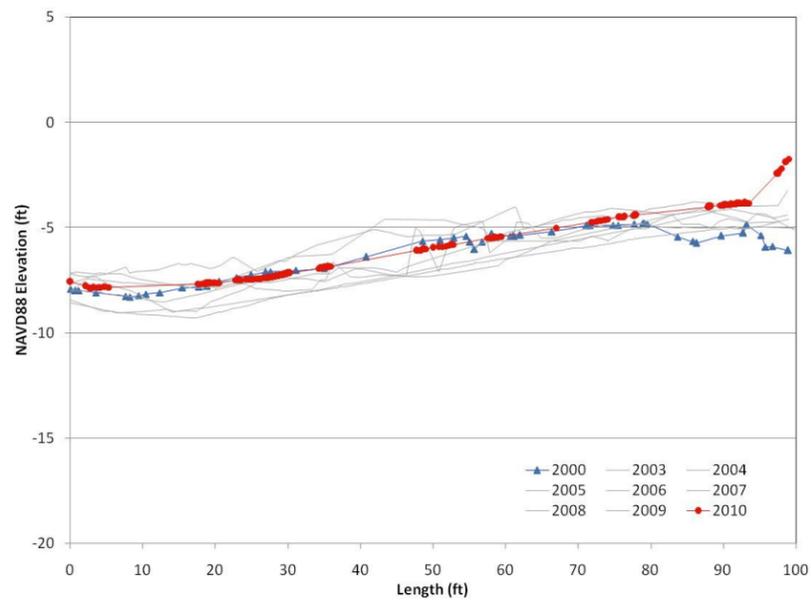
**OR-8 200ft Cross-Section  
Fall**



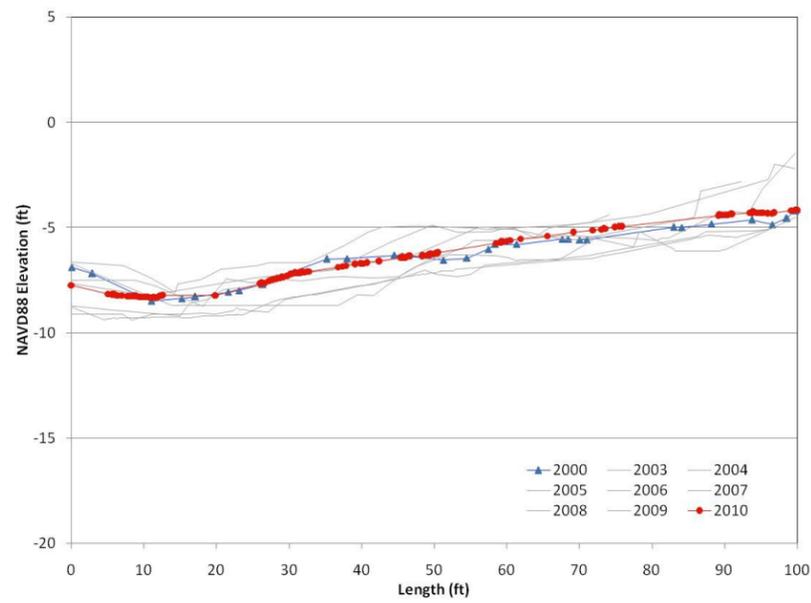
**OR-8 Centerline  
Fall**



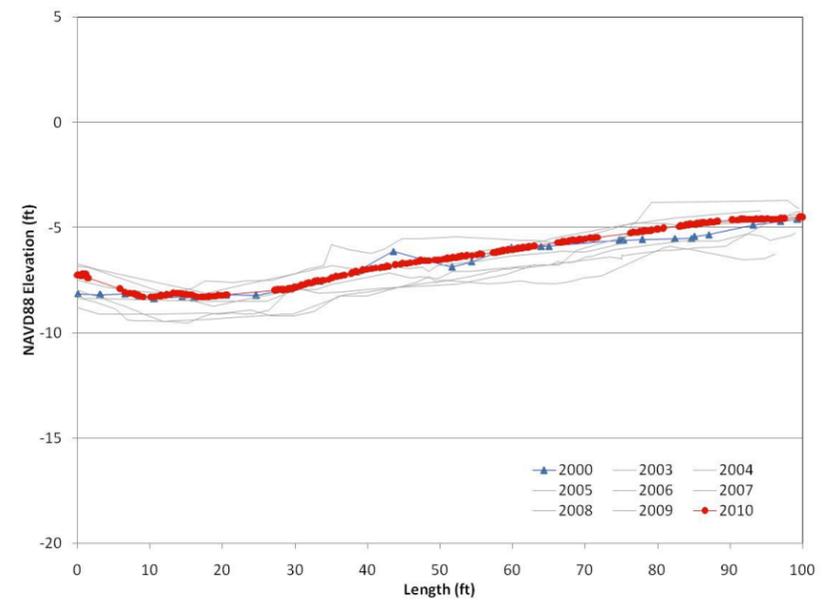
# Appendix I:OR-9 Cross-Sections



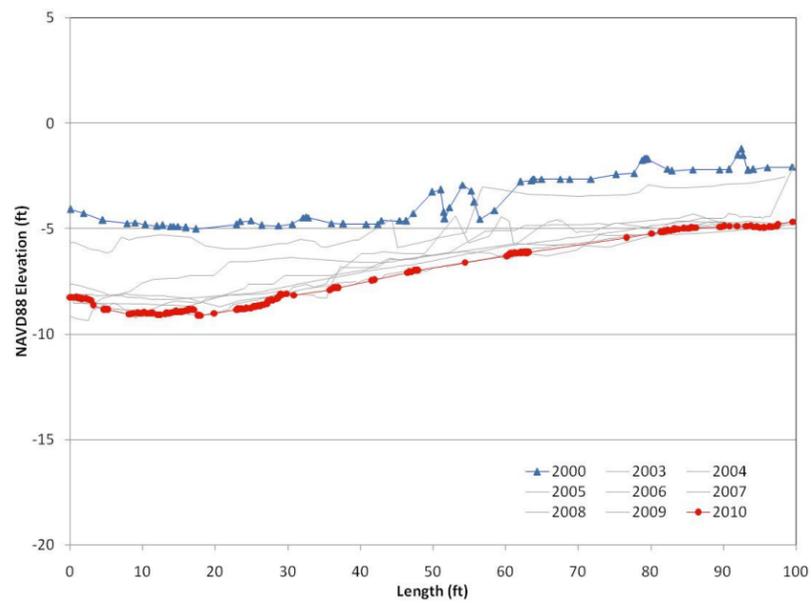
**OR-9 0ft Cross-Section  
Spring**



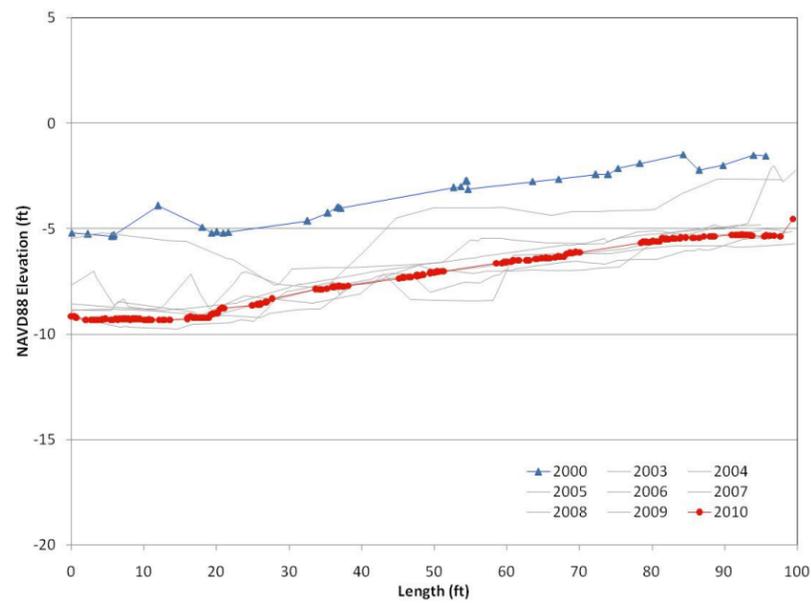
**OR-9 50ft Cross-Section  
Spring**



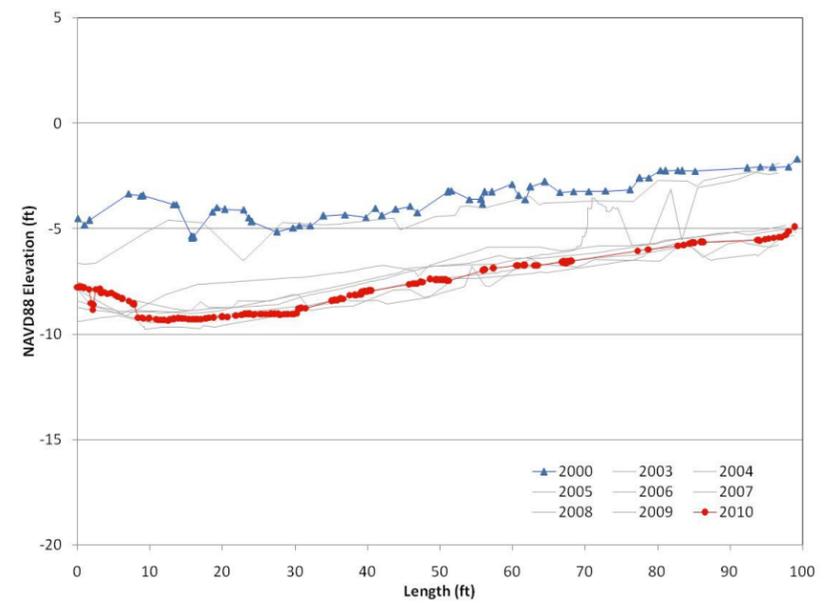
**OR-9 100ft Cross-Section  
Spring**



**OR-9 0ft Cross-Section  
Fall**

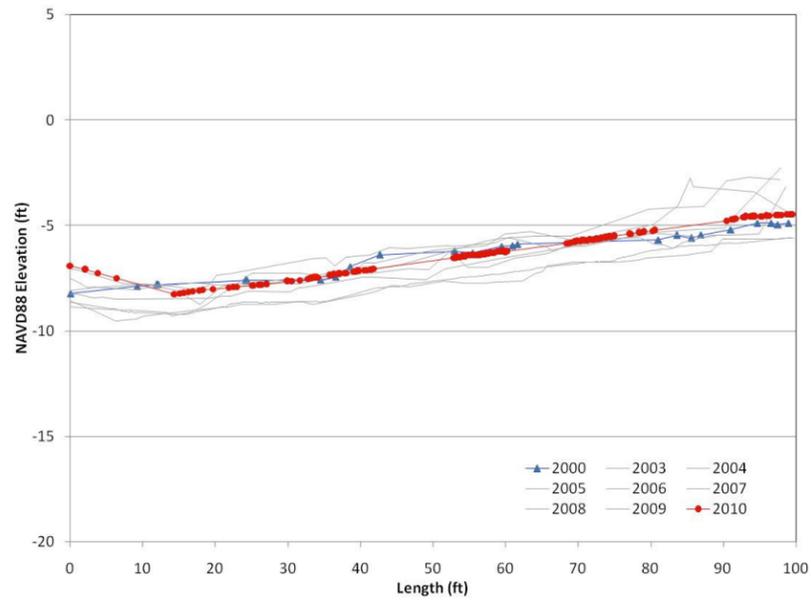


**OR-9 50ft Cross-Section  
Fall**

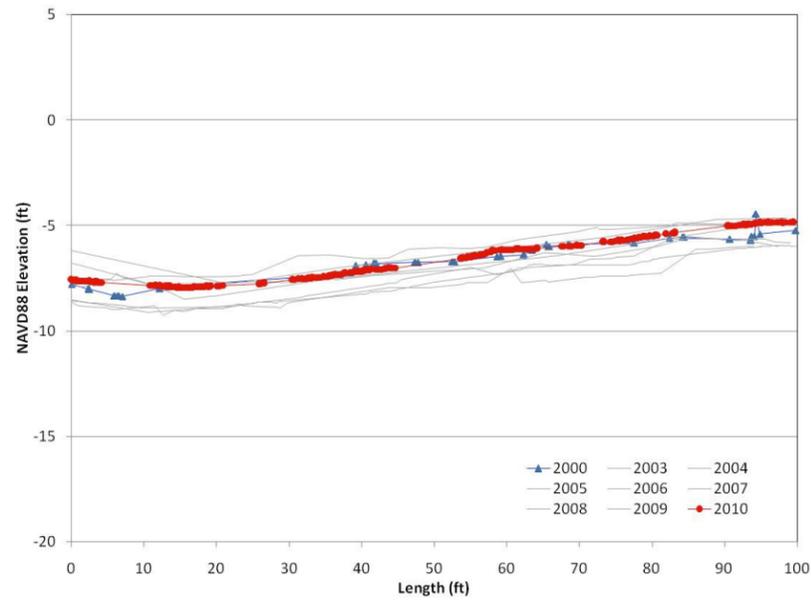


**OR-9 100ft Cross-Section  
Fall**

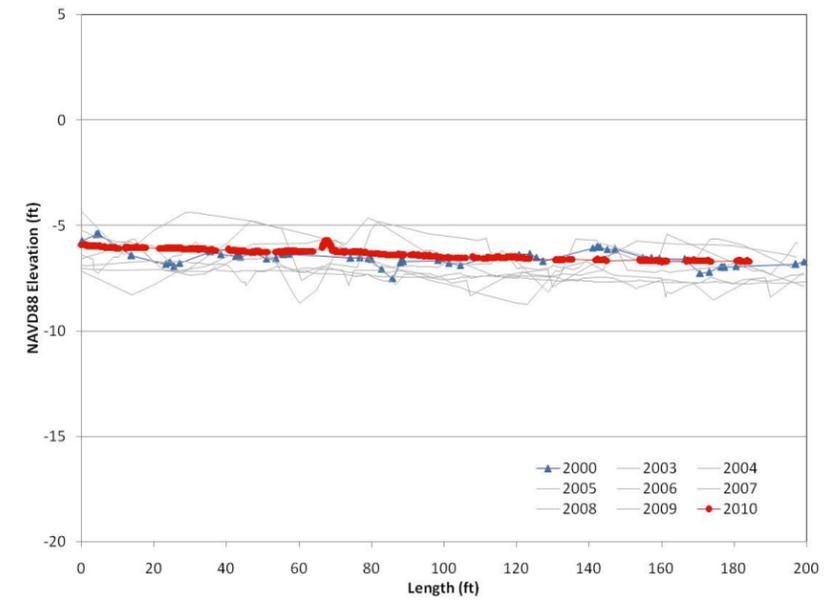




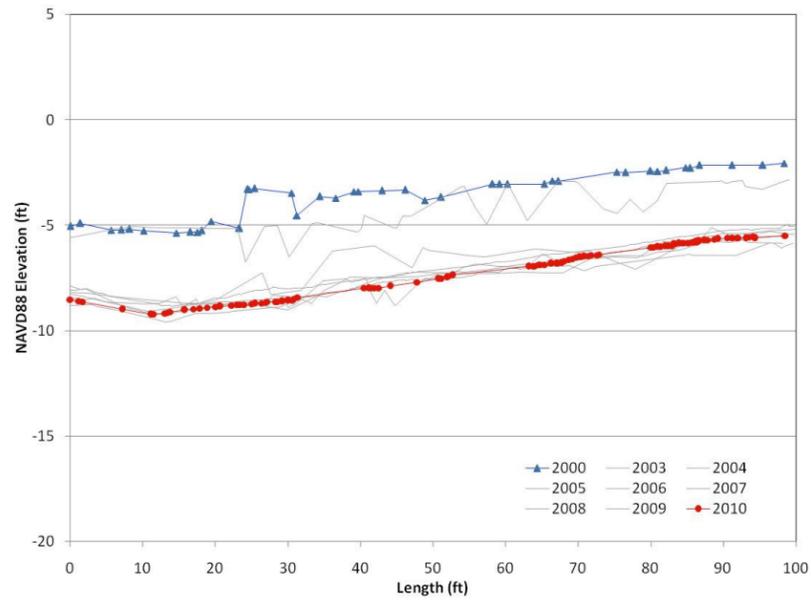
**OR-9 150ft Cross-Section  
Spring**



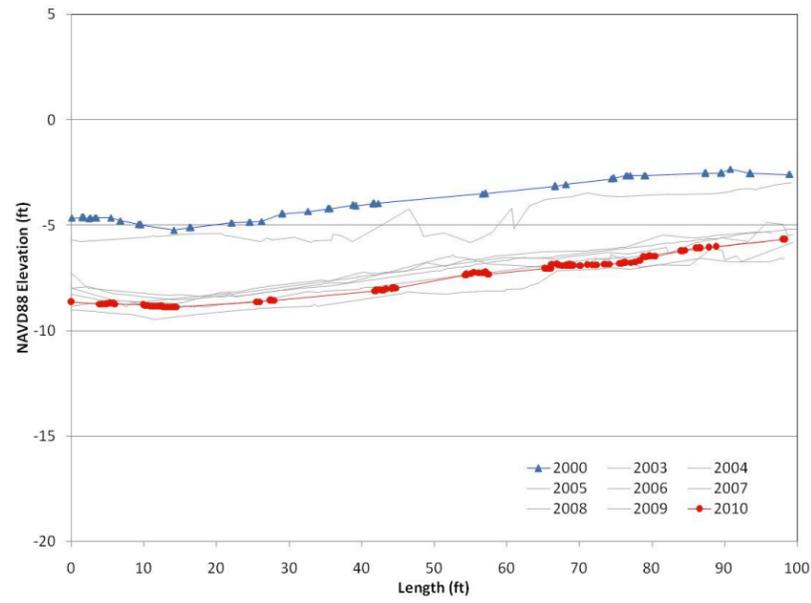
**OR-9 200ft Cross-Section  
Spring**



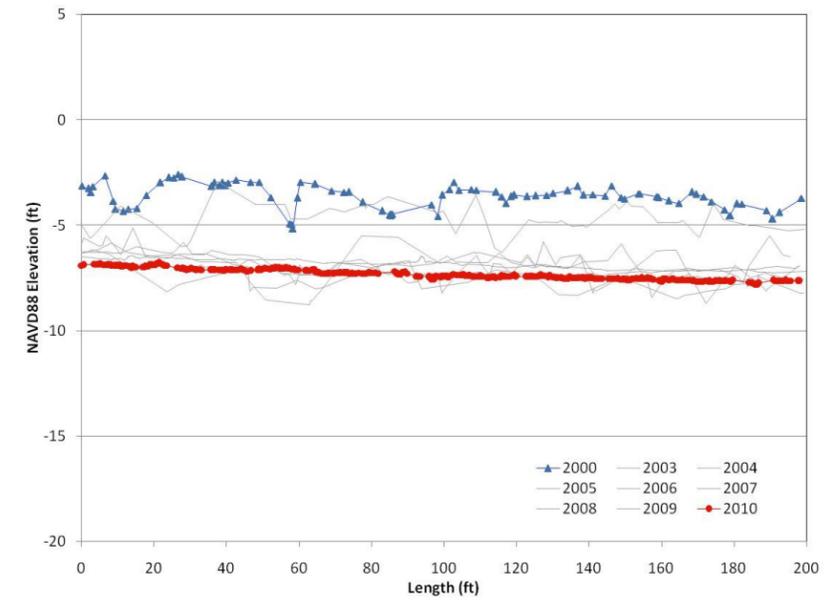
**OR-9 Centerline  
Spring**



**OR-9 150ft Cross-Section  
Fall**



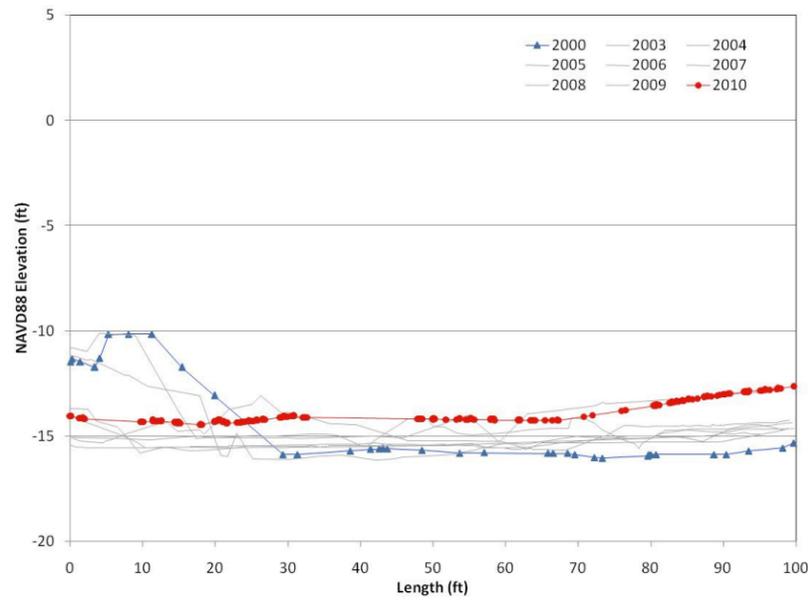
**OR-9 200ft Cross-Section  
Fall**



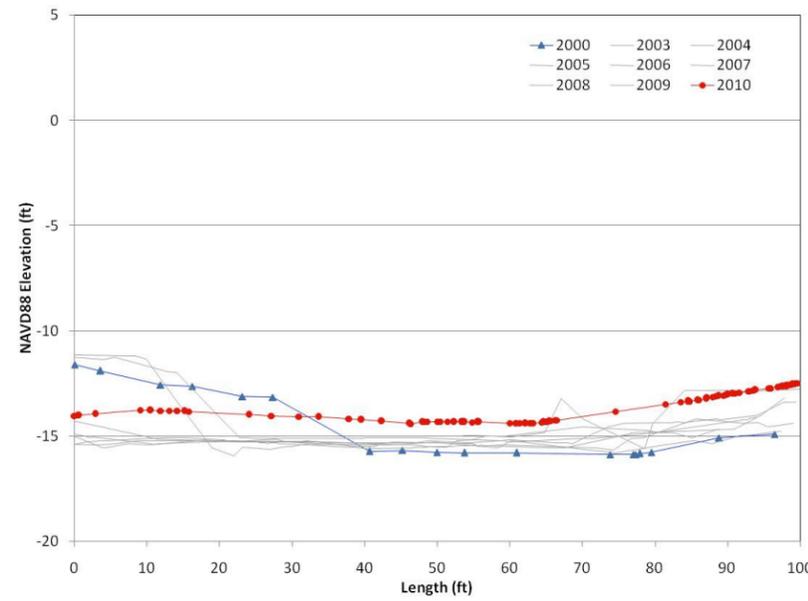
**OR-9 Centerline  
Fall**



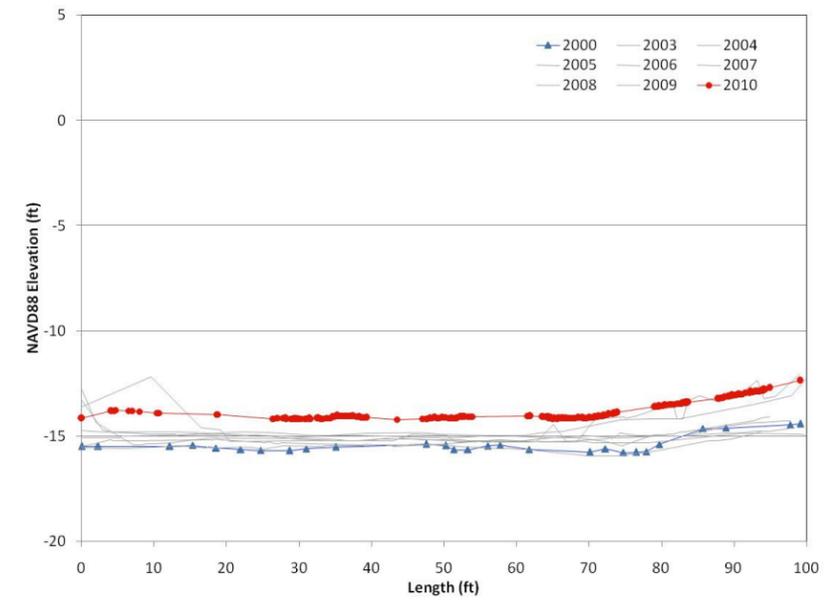
# Appendix J:GLC-1A Cross-Sections



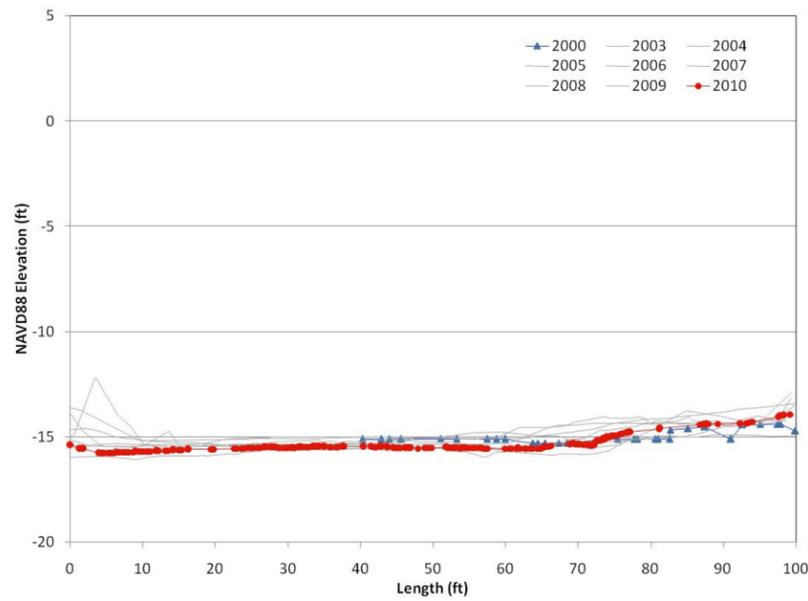
**GLC-1A 0ft Cross-Section  
Spring**



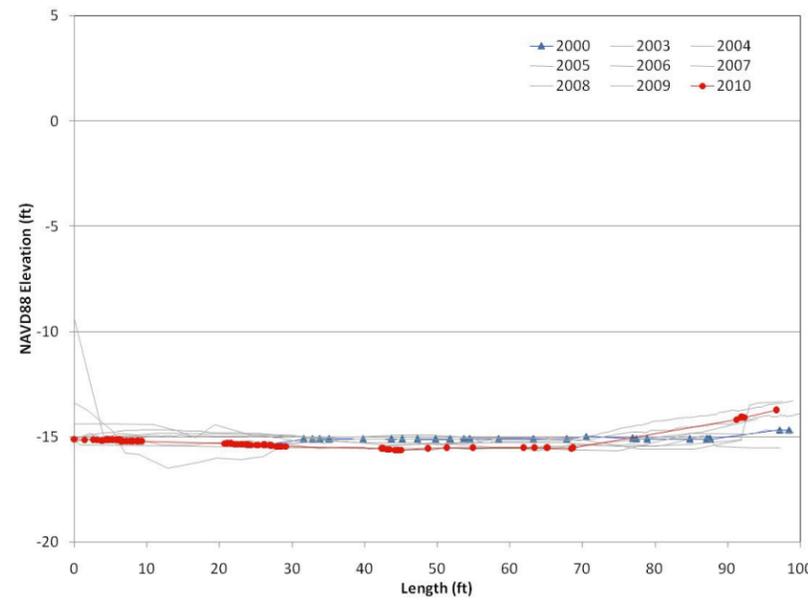
**GLC-1A 50ft Cross-Section  
Spring**



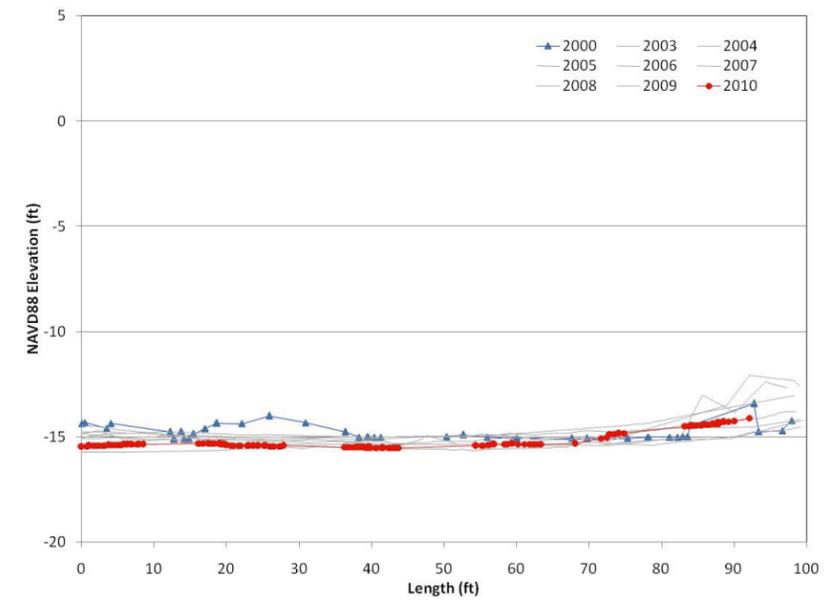
**GLC-1A 100ft Cross-Section  
Spring**



**GLC-1A 0ft Cross-Section  
Fall**

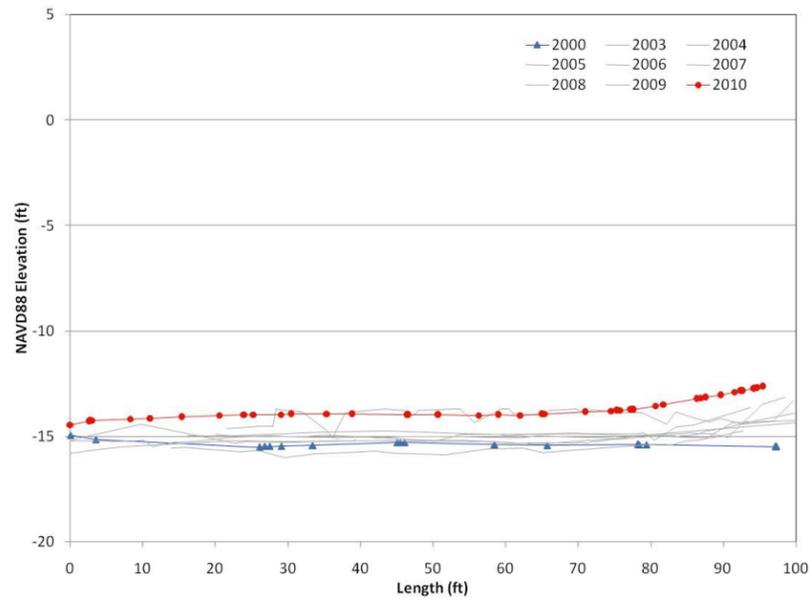


**GLC-1A 50ft Cross-Section  
Fall**

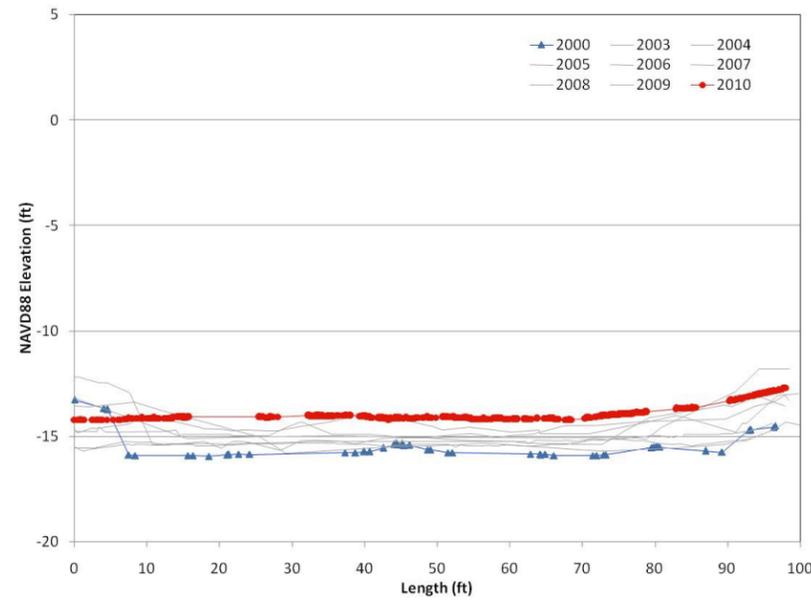


**GLC-1A 100ft Cross-Section  
Fall**

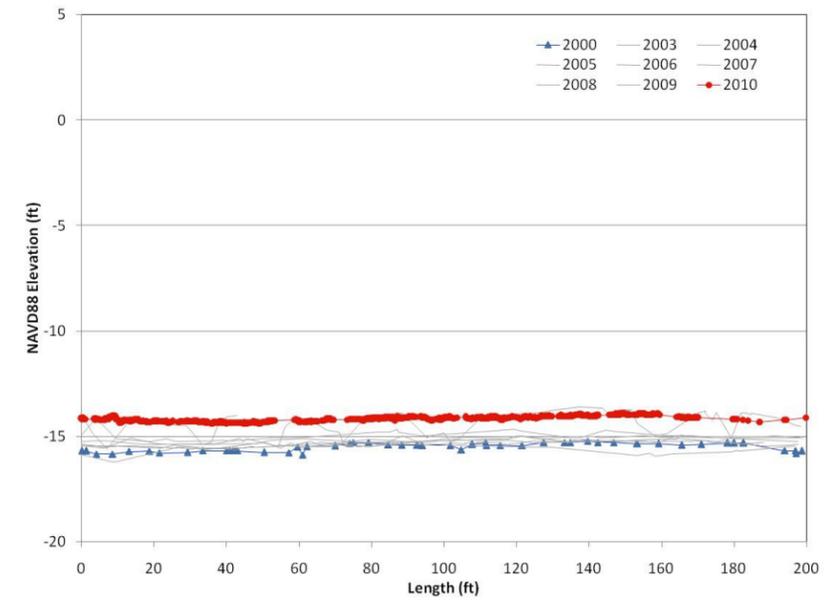




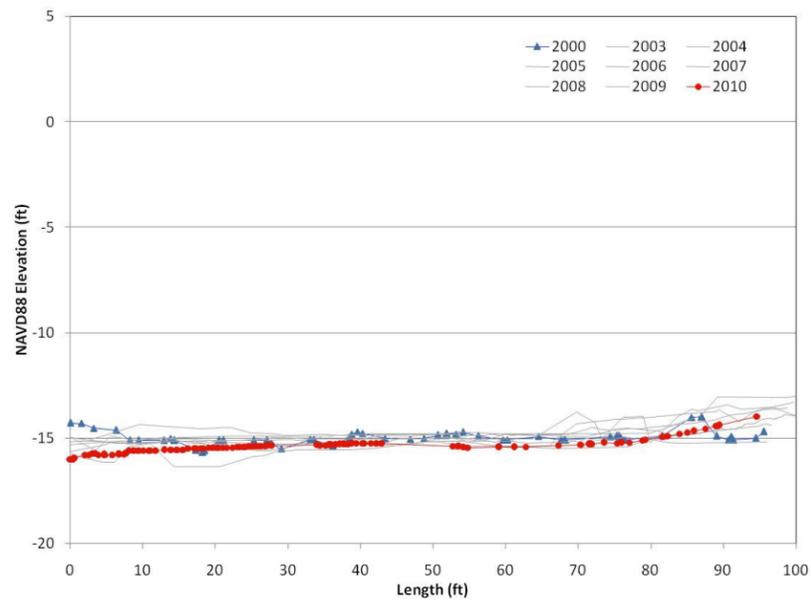
**GLC-1A 150ft Cross-Section  
Spring**



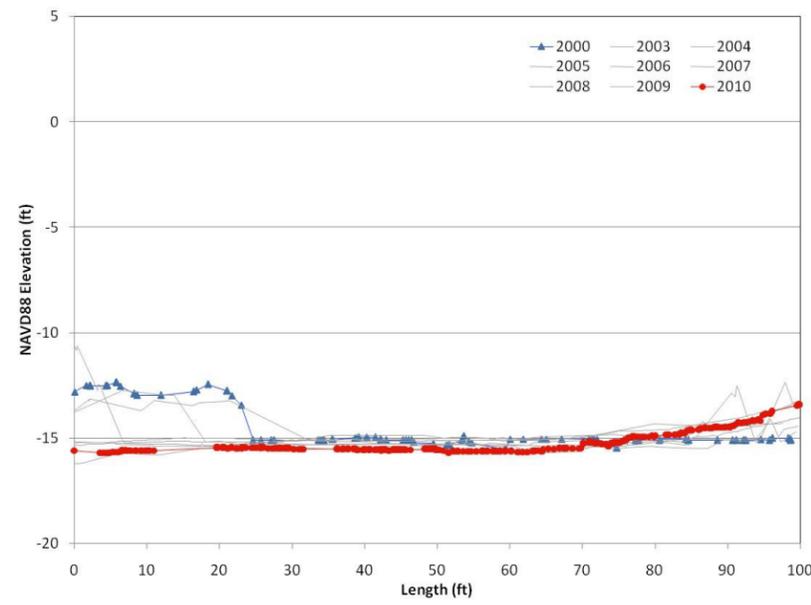
**GLC-1A 200ft Cross-Section  
Spring**



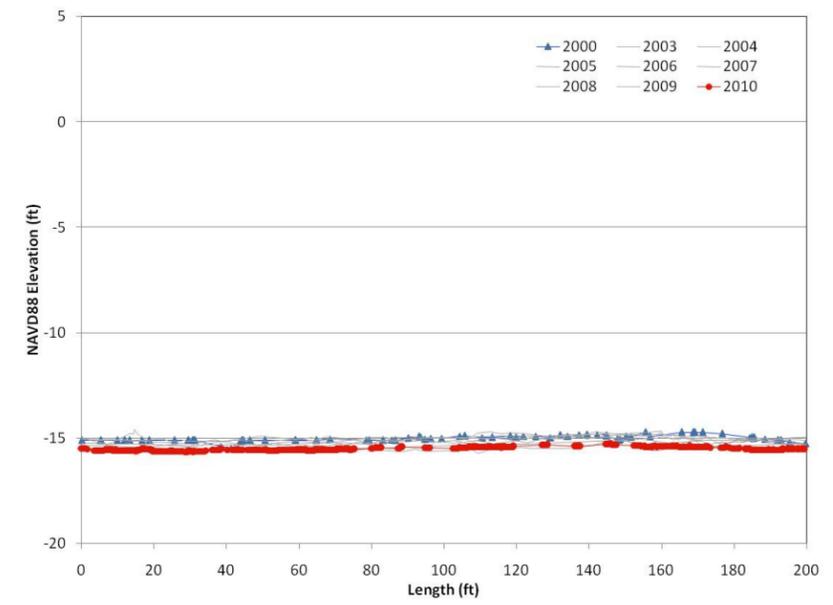
**GLC-1A Centerline  
Spring**



**GLC-1A 150ft Cross-Section  
Fall**



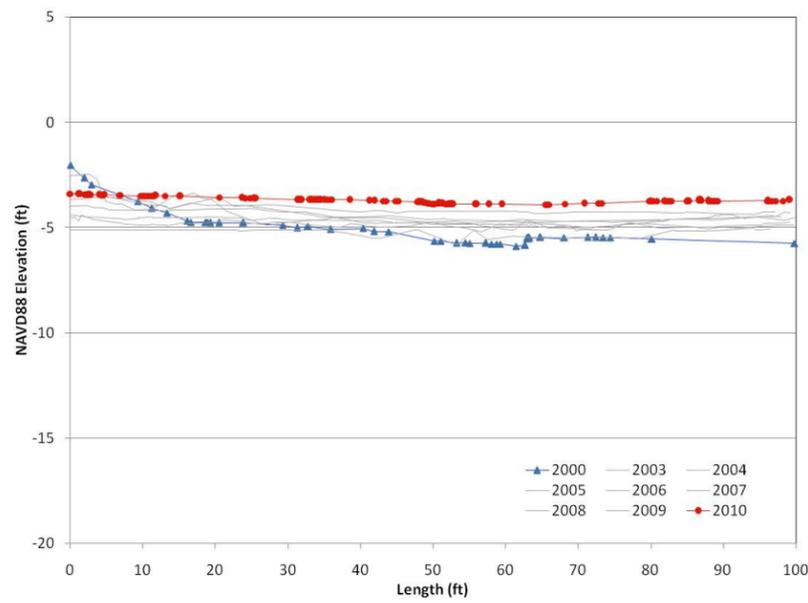
**GLC-1A 200ft Cross-Section  
Fall**



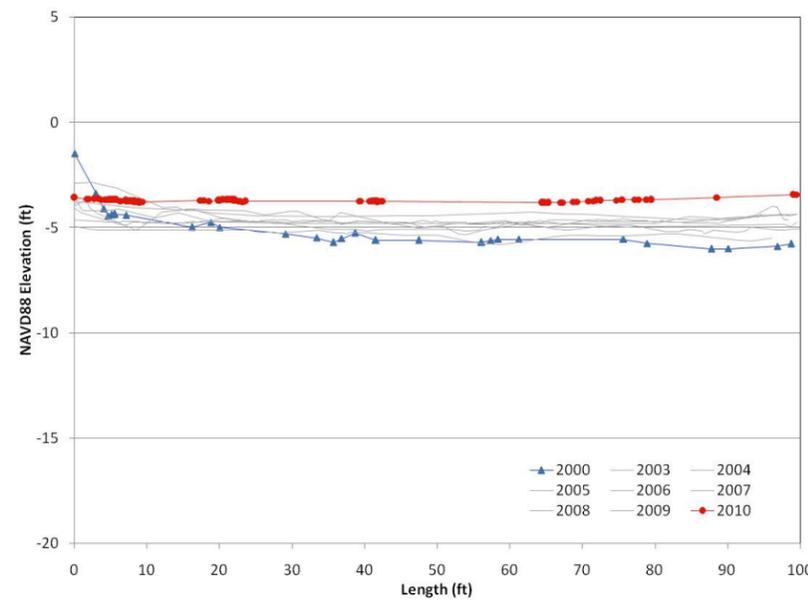
**GLC-1A Centerline  
Fall**



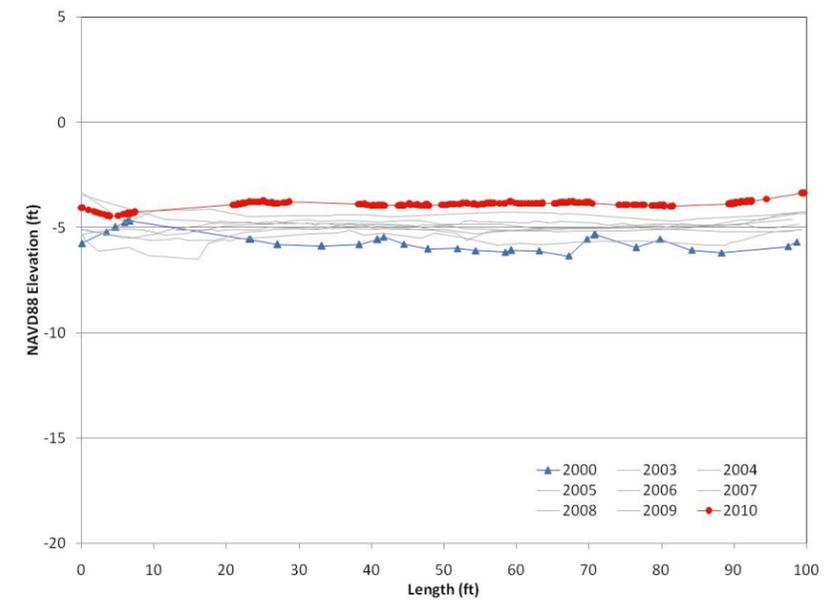
# Appendix K:GLC-1B Cross-Sections



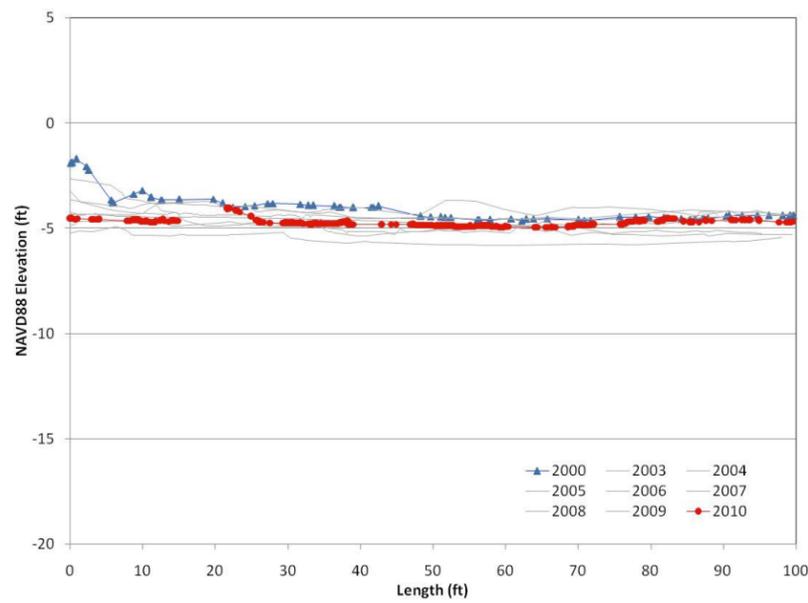
**GLC-1B 0ft Cross-Section  
Spring**



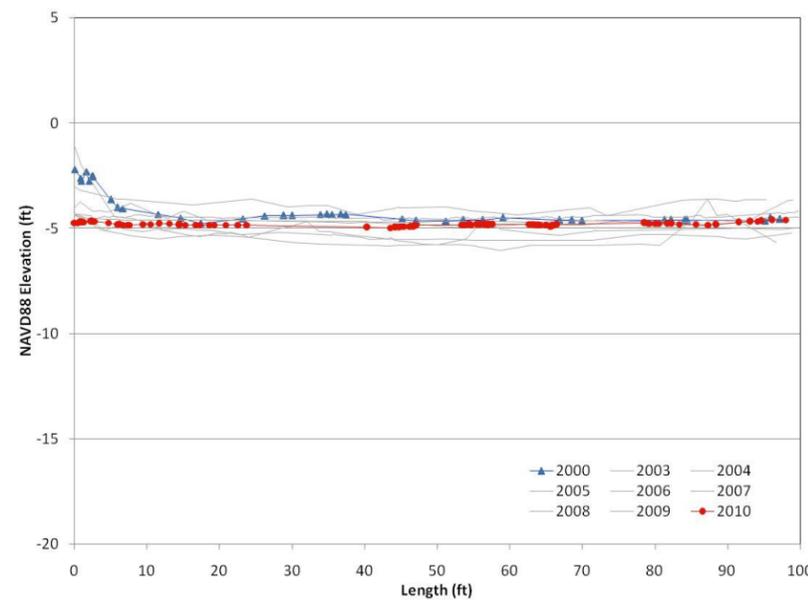
**GLC-1B 50ft Cross-Section  
Spring**



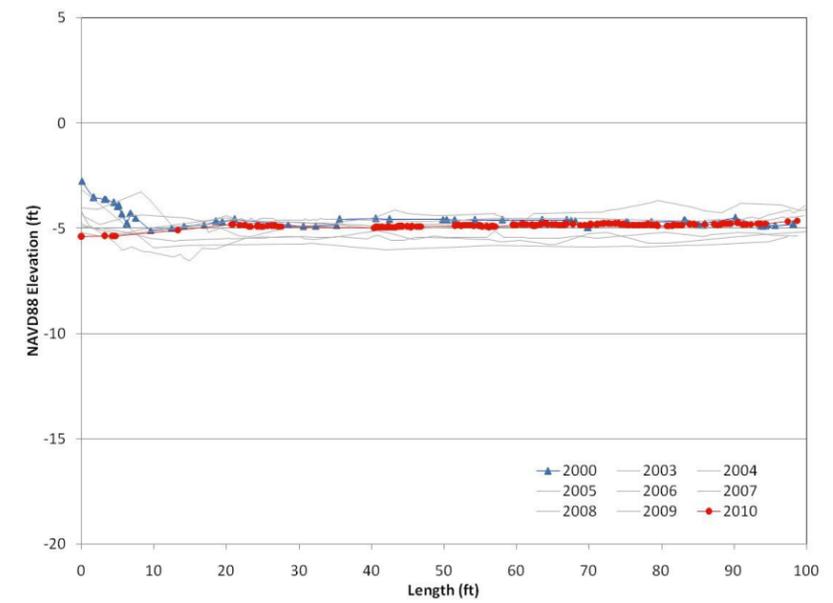
**GLC-1B 100 Cross-Section  
Spring**



**GLC-1B 0ft Cross-Section  
Fall**

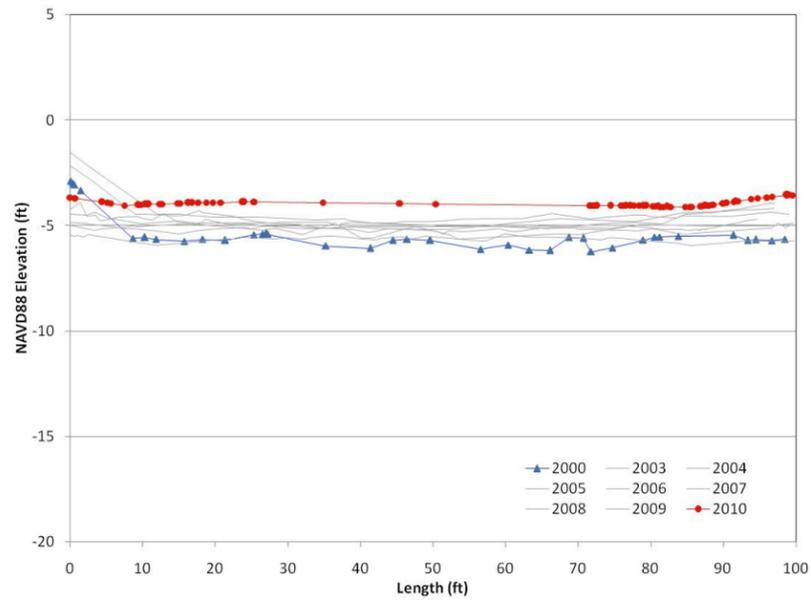


**GLC-1B 50ft Cross-Section  
Fall**

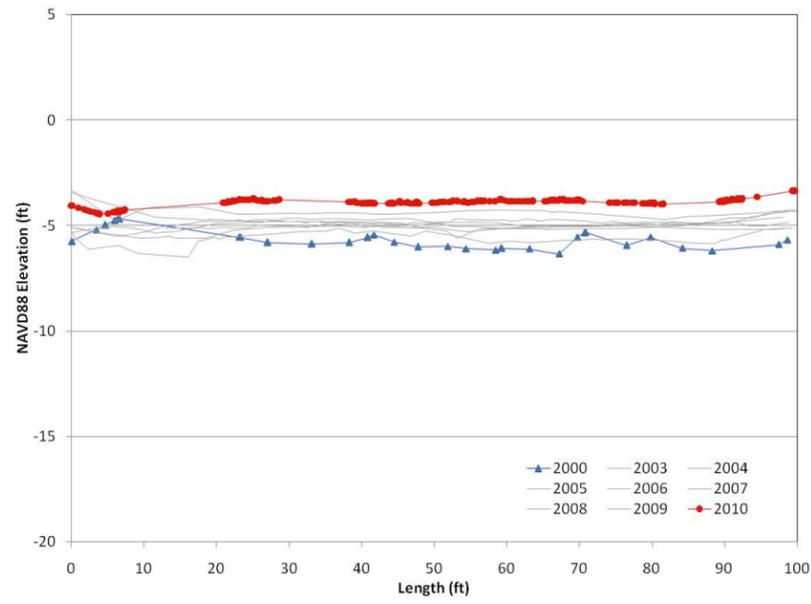


**GLC-1B 100ft Cross-Section  
Fall**

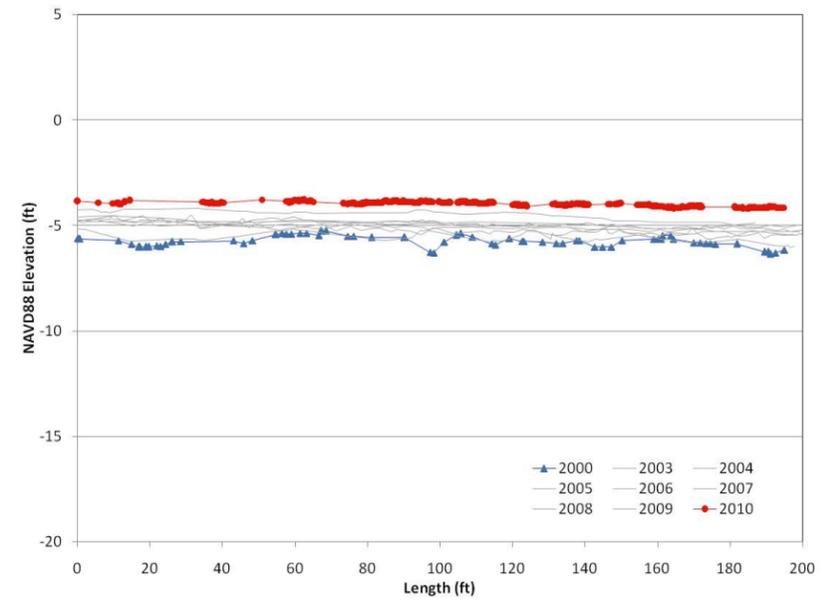




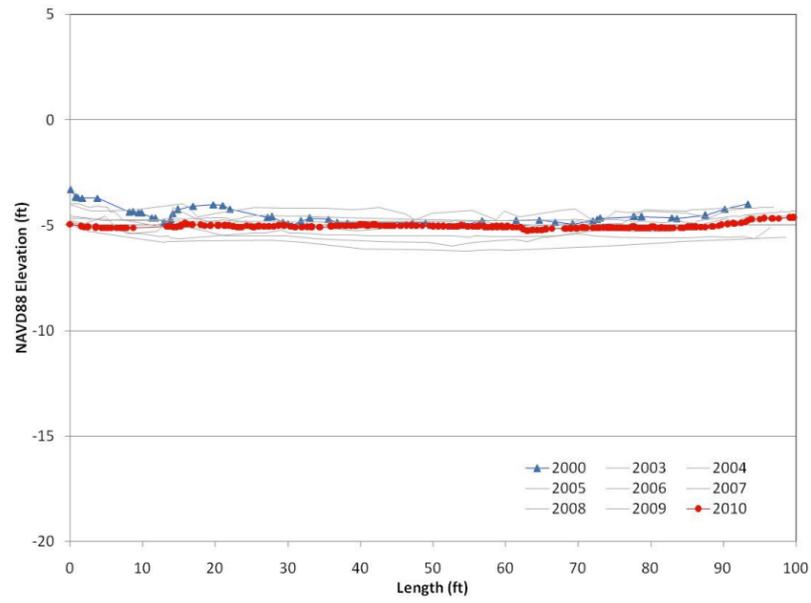
**GLC-1B 150ft Cross-Section  
Spring**



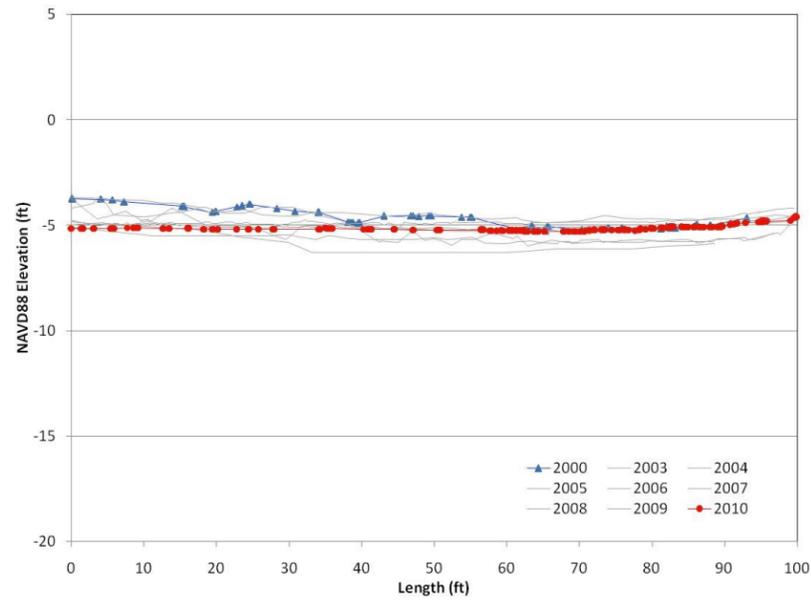
**GLC-1B 200ft Cross-Section  
Spring**



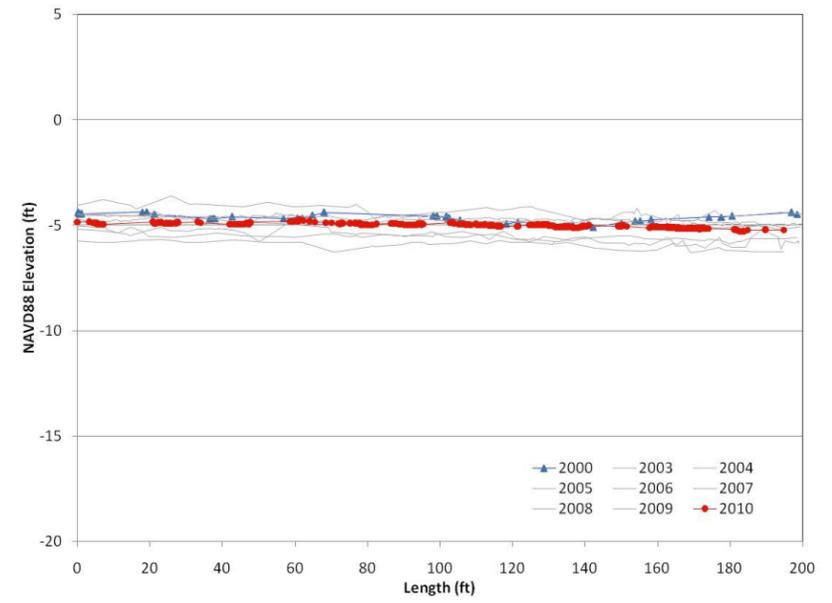
**GLC-1B Centerline  
Spring**



**GLC-1B 150ft Cross-Section  
Fall**



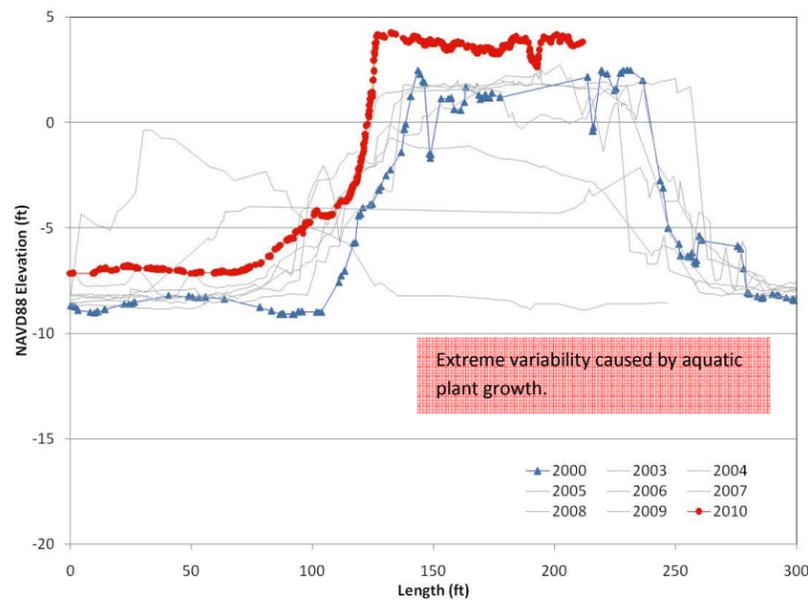
**GLC-1B 200ft Cross-Section  
Fall**



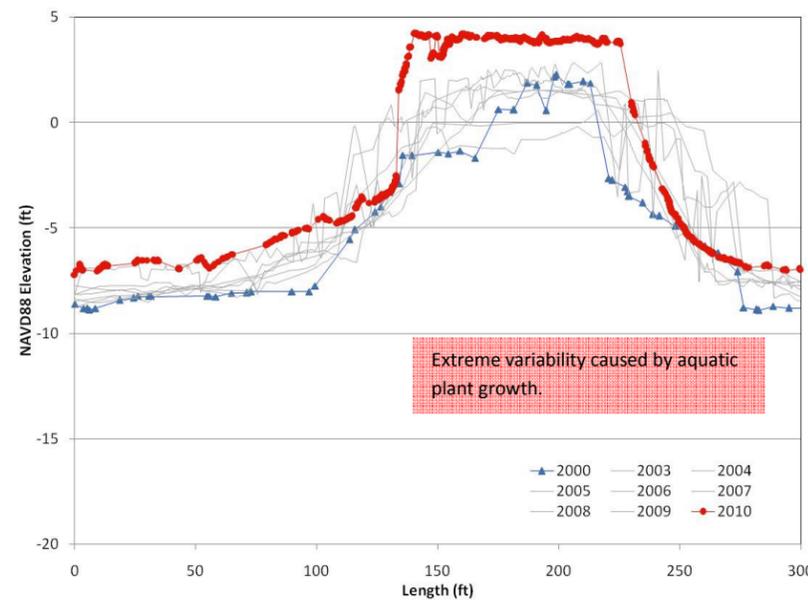
**GLC-1B Centerline  
Fall**



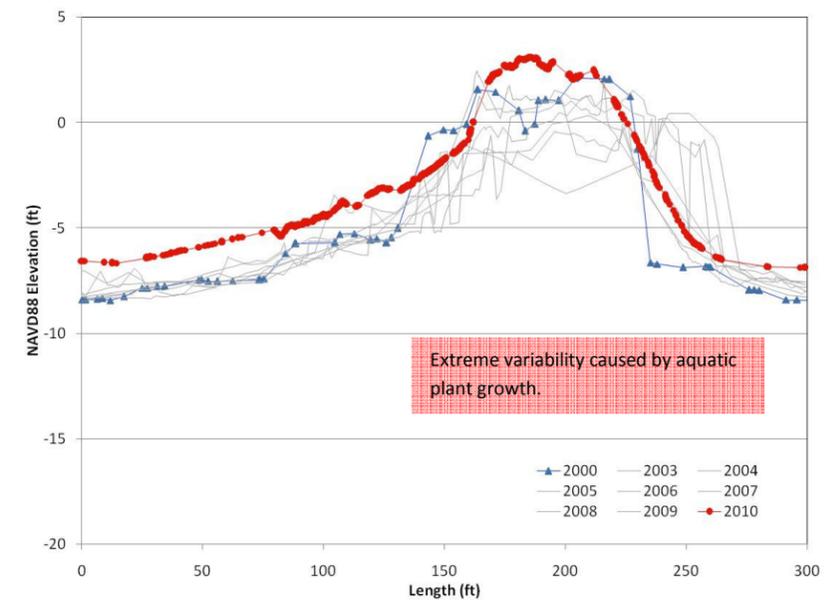
# Appendix L:GLC-2 Cross-Sections



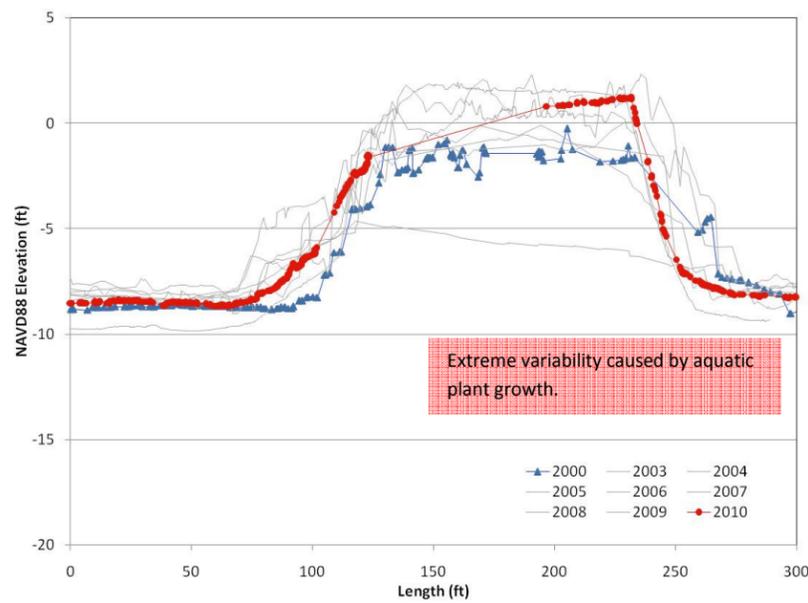
**GLC-2 0ft Cross-Section  
Spring**



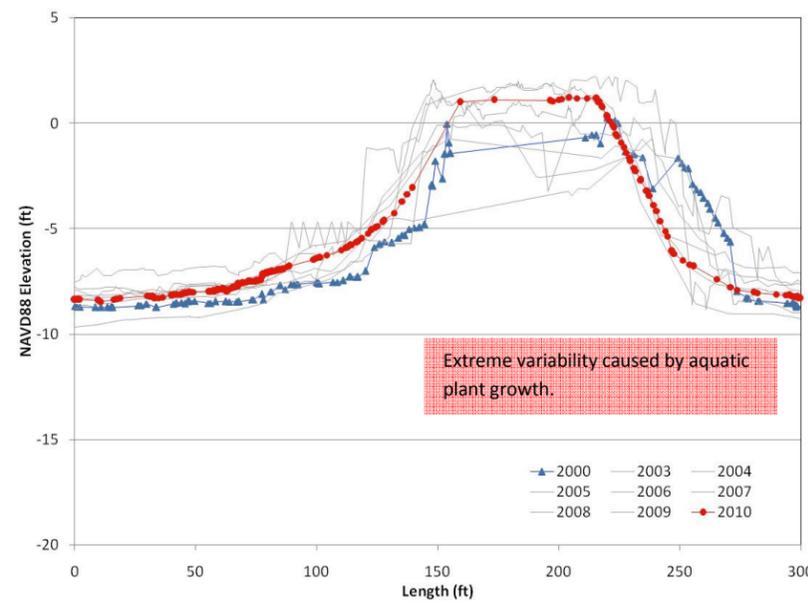
**GLC-2 50ft Cross-Section  
Spring**



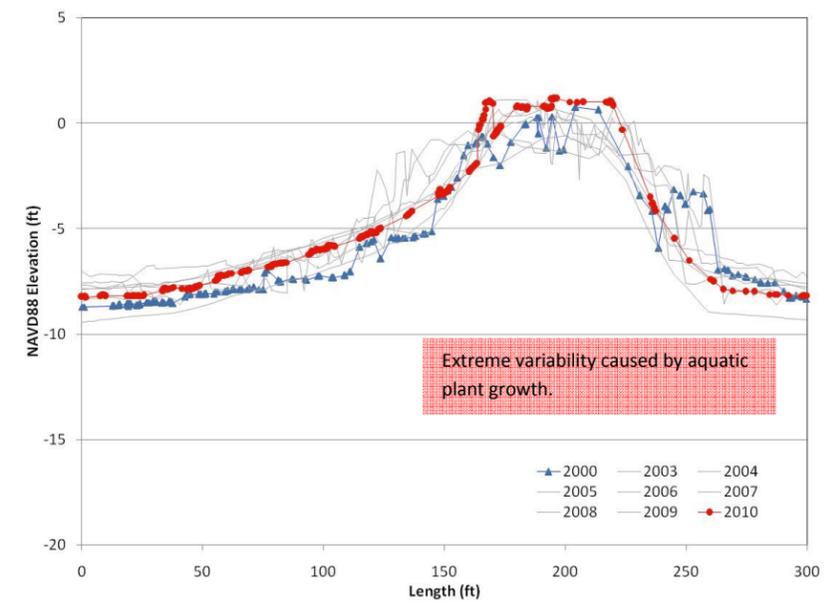
**GLC-2 100ft Cross-Section  
Spring**



**GLC-2 0ft Cross-Section  
Fall**

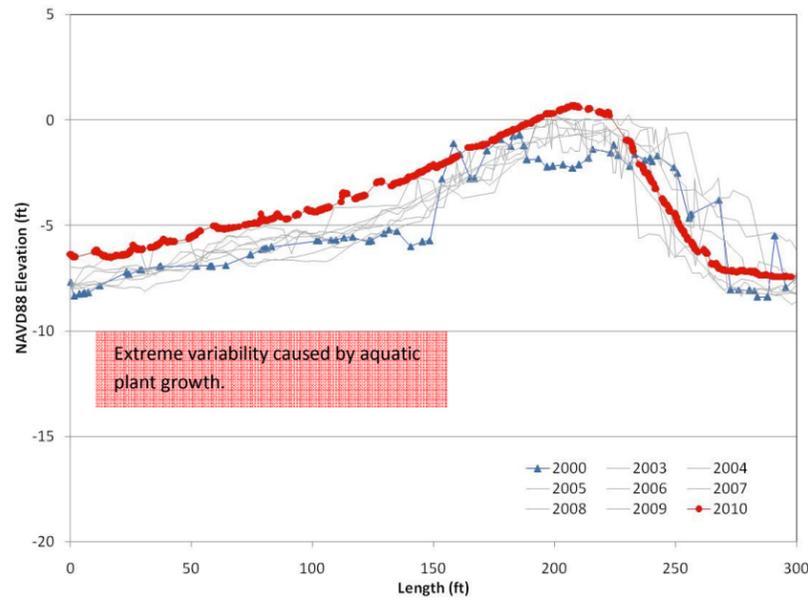


**GLC-2 50ft Cross-Section  
Fall**

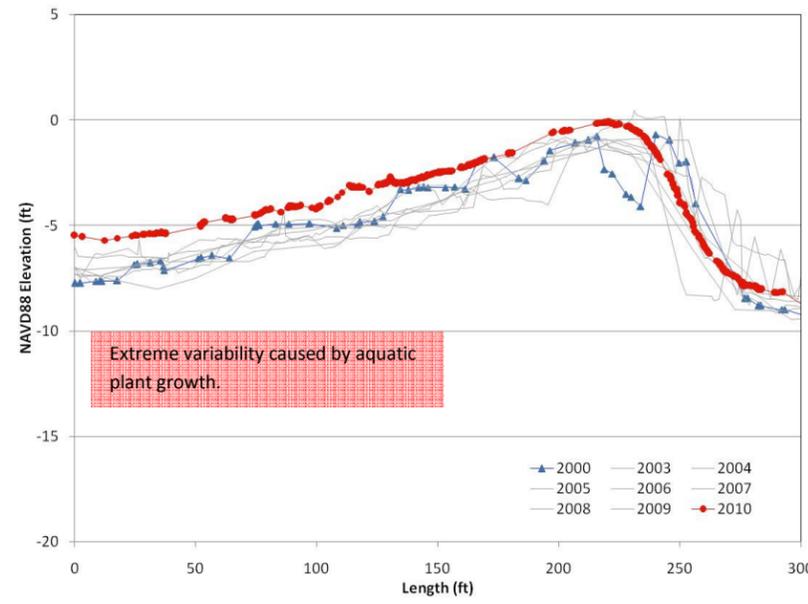


**GLC-2 100ft Cross-Section  
Fall**

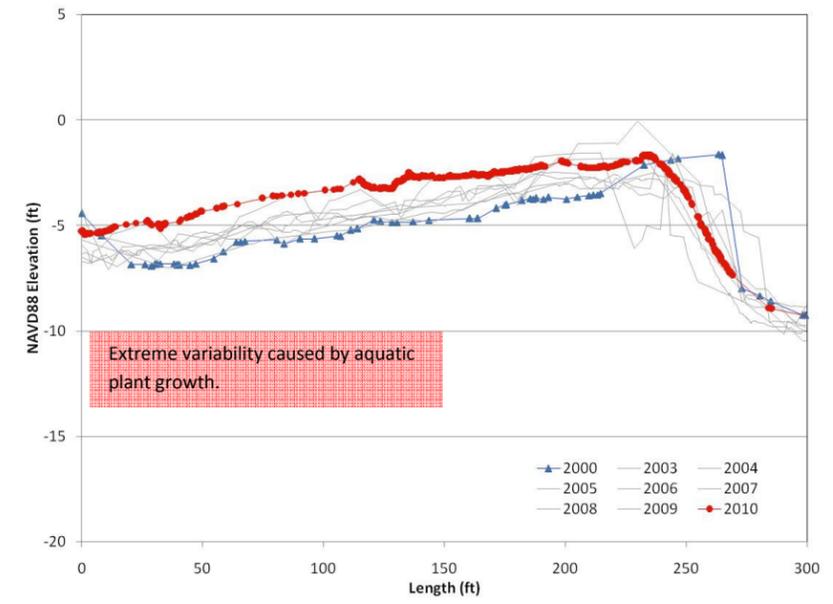




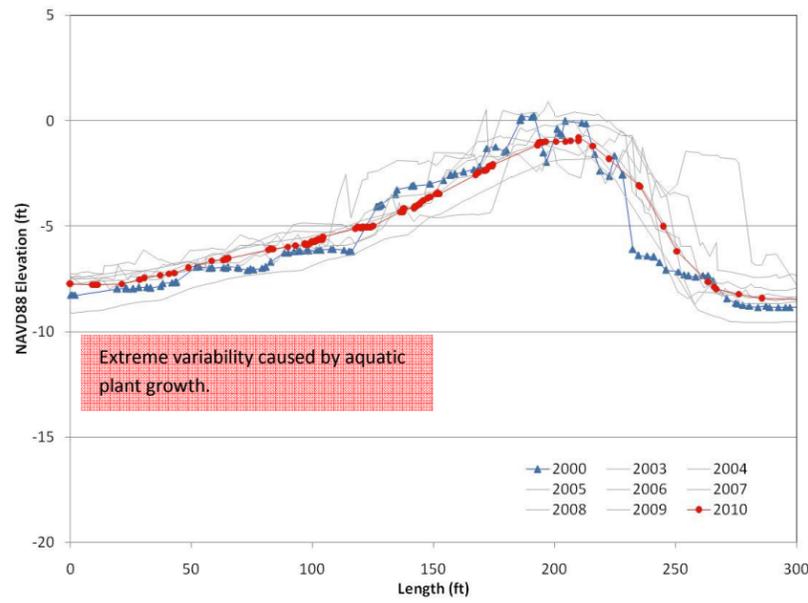
**GLC-2 150ft Cross-Section  
Spring**



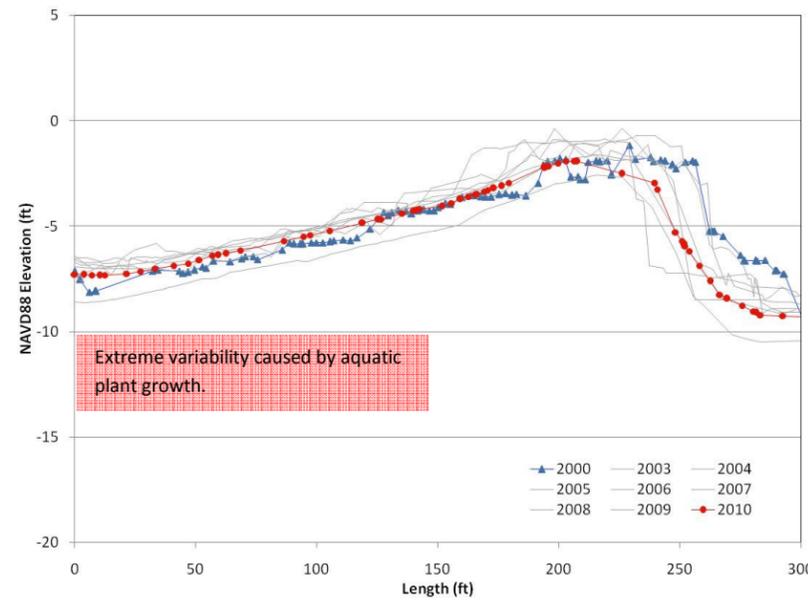
**GLC-2 200ft Cross-Section  
Spring**



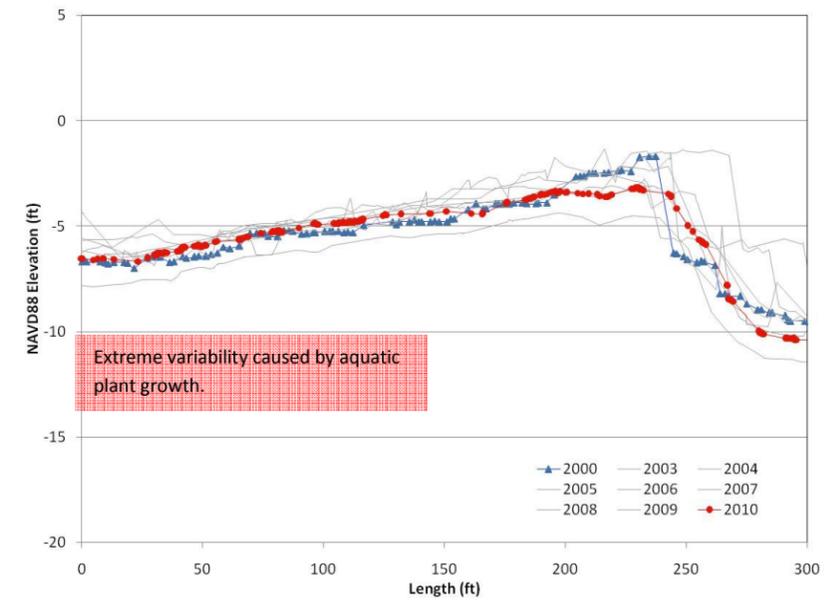
**GLC-2 250ft Cross-Section  
Spring**



**GLC-2 150ft Cross-Section  
Fall**

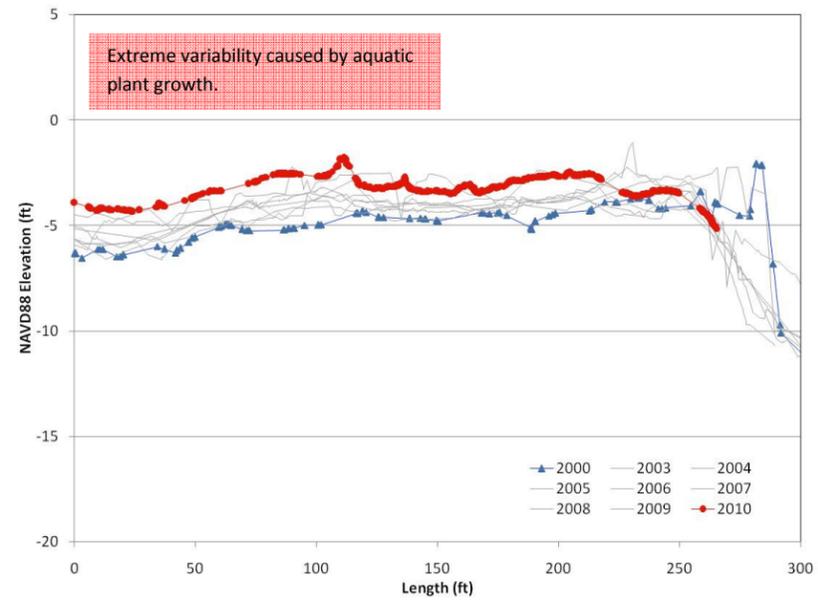


**GLC-2 200ft Cross-Section  
Fall**

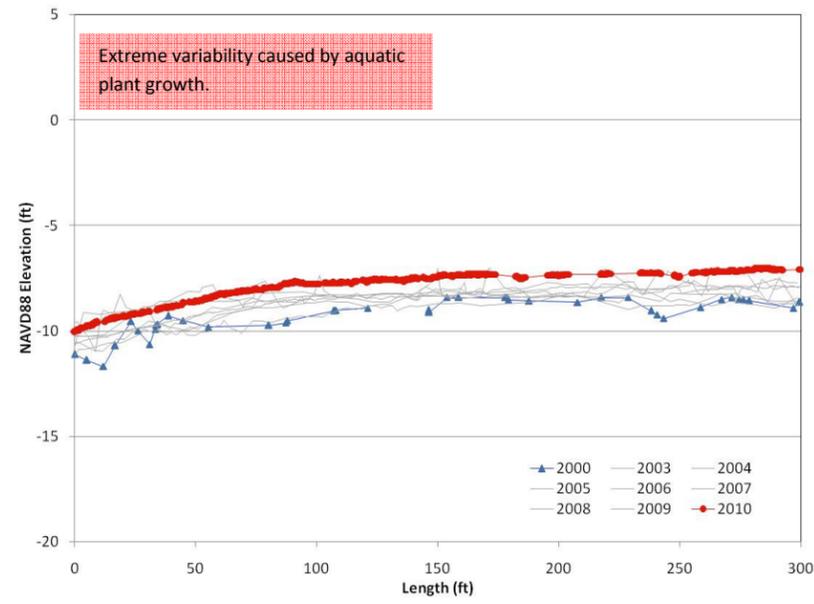


**GLC-2 250ft Cross-Section  
Fall**

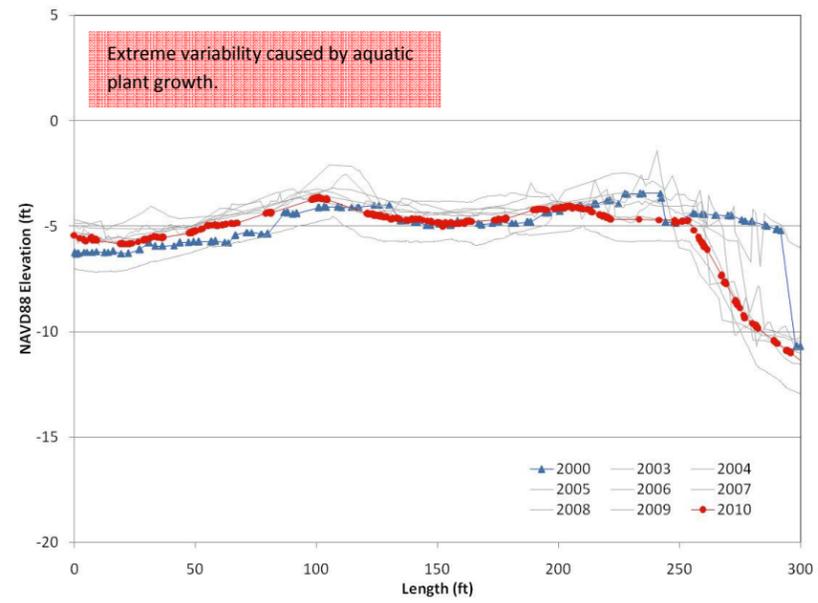




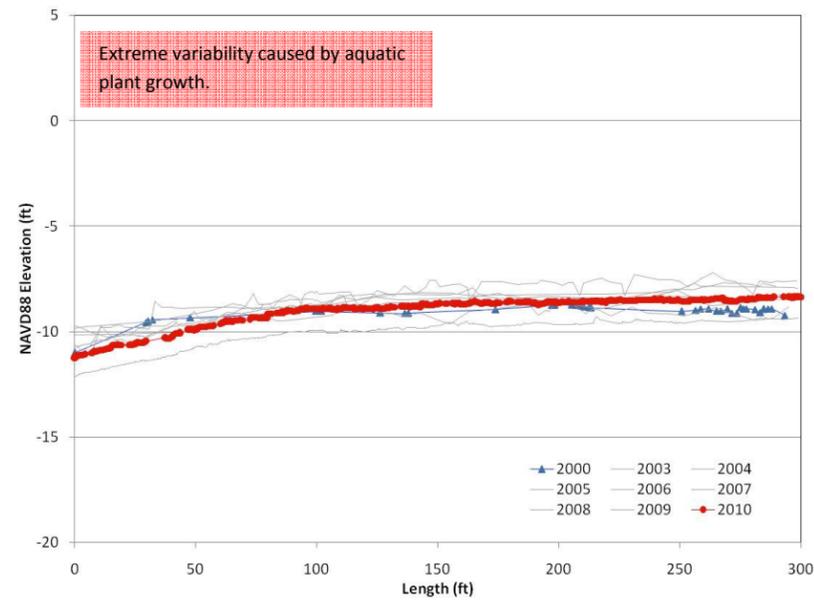
**GLC-2 300ft Cross-Section  
Spring**



**GLC-2 Centerline  
Spring**



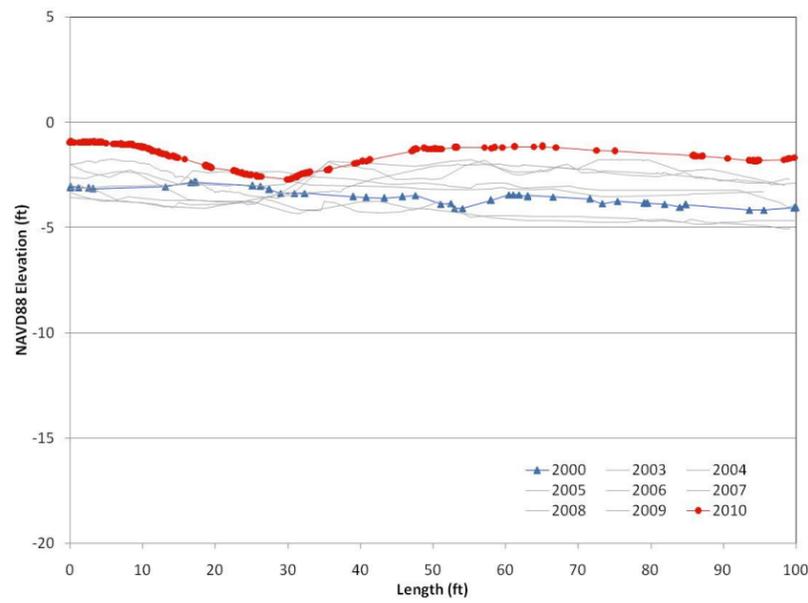
**GLC-2 300ft Cross-Section  
Fall**



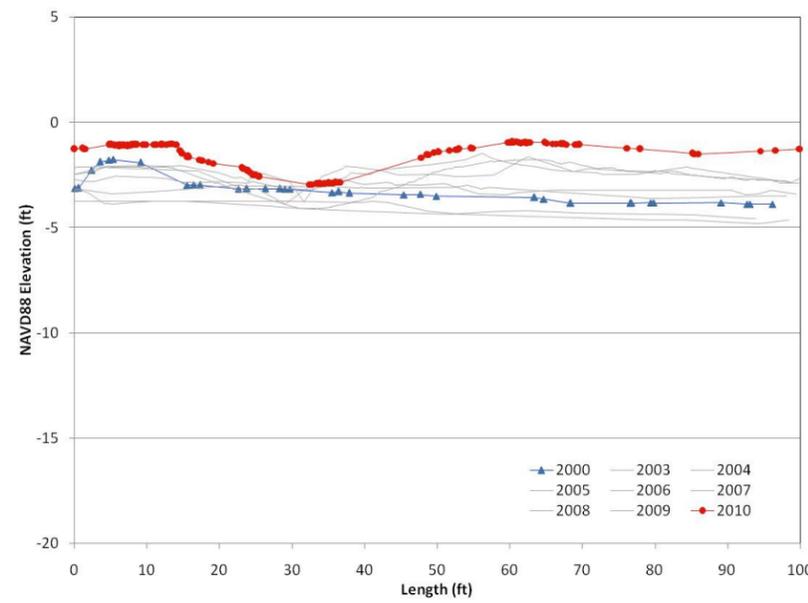
**GLC-2 Centerline  
Fall**



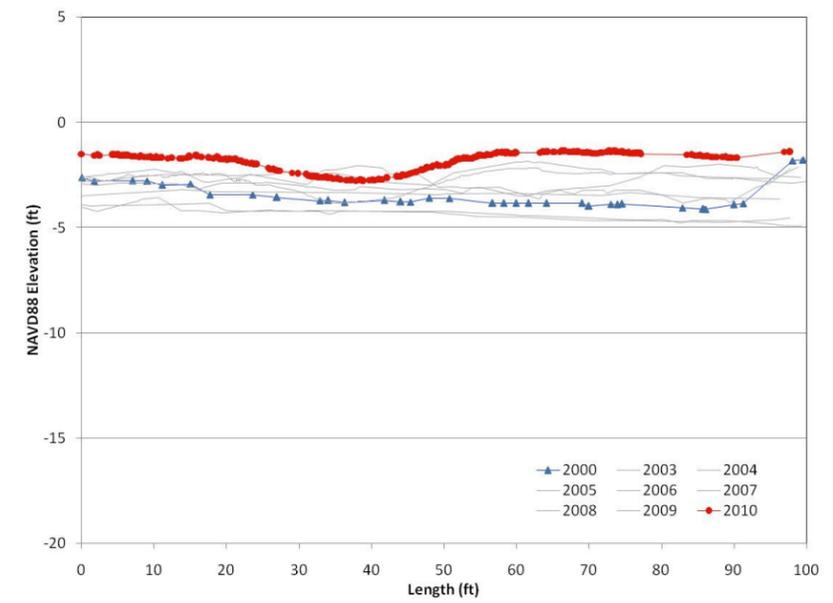
# Appendix M:GLC-3 Cross-Sections



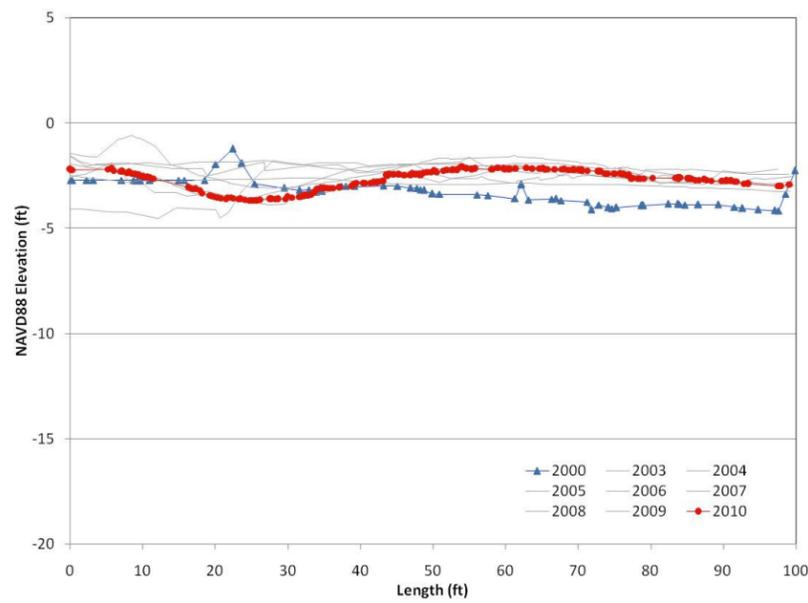
**GLC-3 0ft Cross-Section  
Spring**



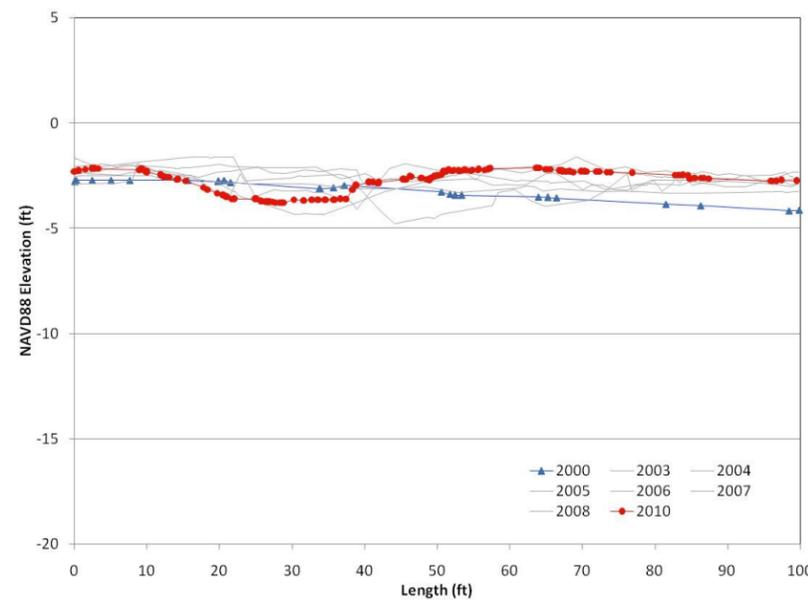
**GLC-3 50ft Cross-Section  
Spring**



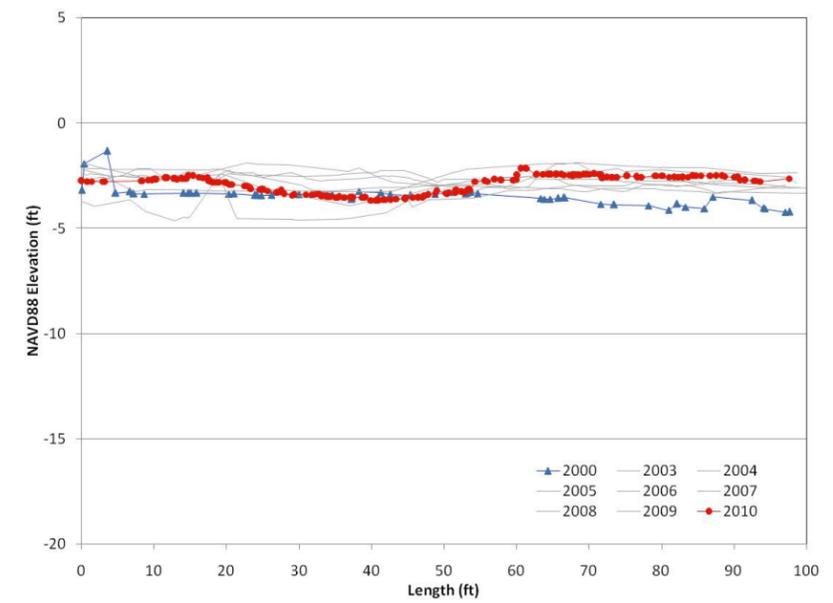
**GLC-3 100ft Cross-Section  
Spring**



**GLC-3 0ft Cross-Section  
Fall**

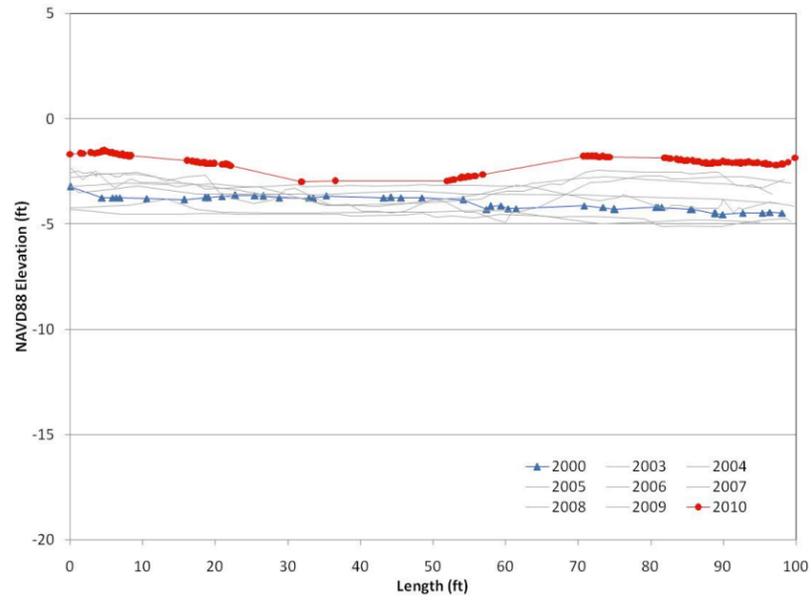


**GLC-3 50ft Cross-Section  
Fall**

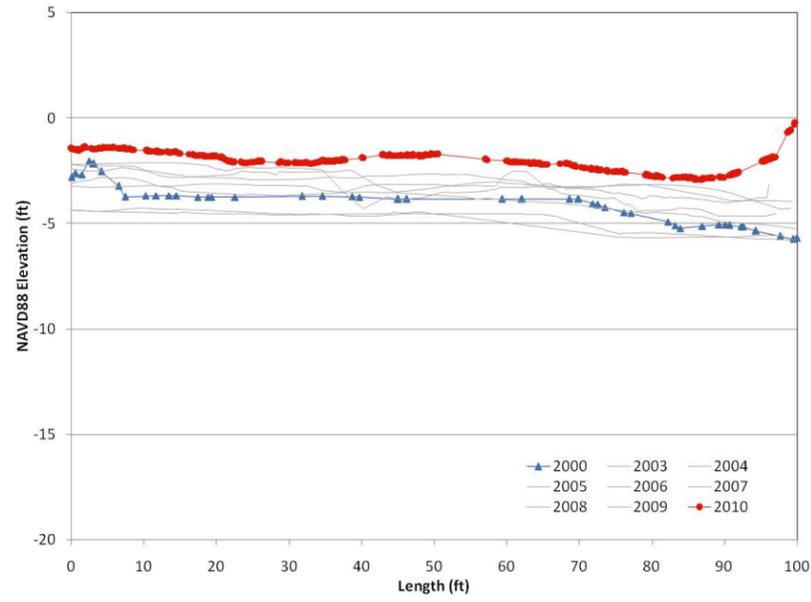


**GLC-3 100ft Cross-Section  
Fall**

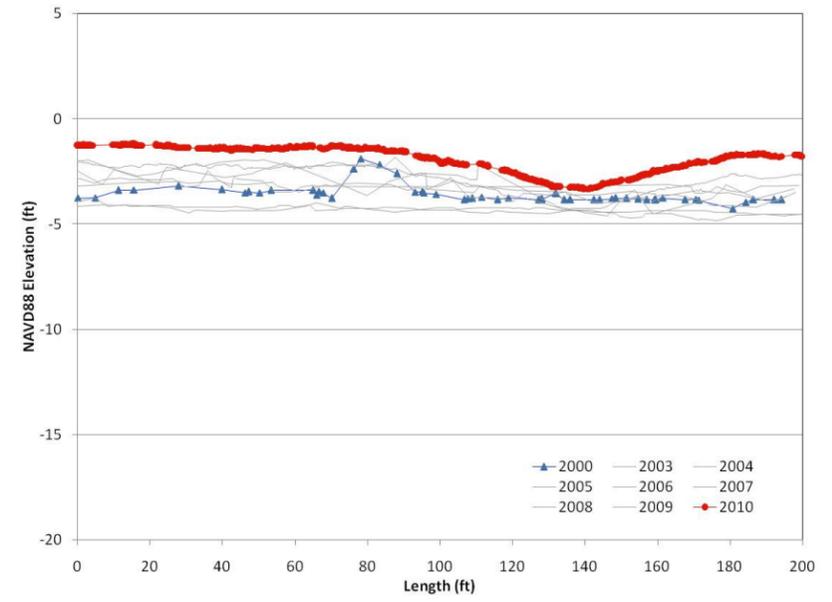




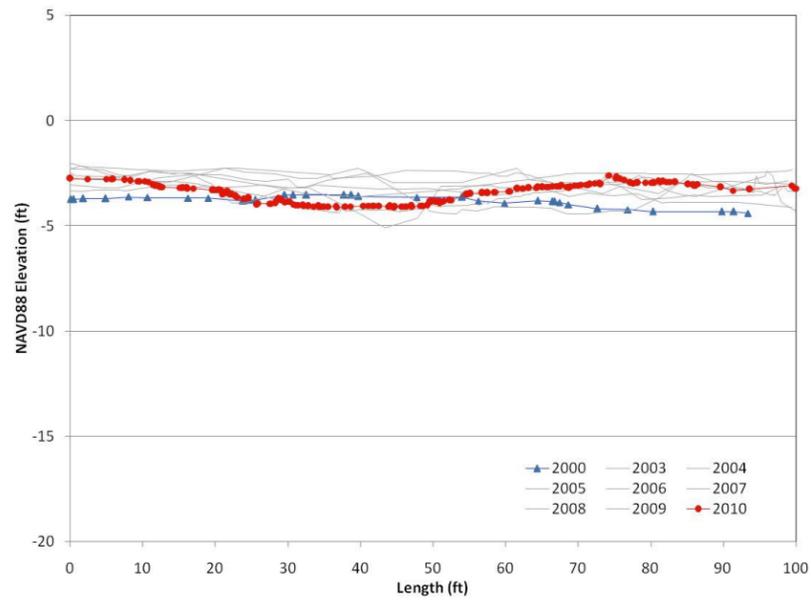
**GLC-3 150ft Cross-Section  
Spring**



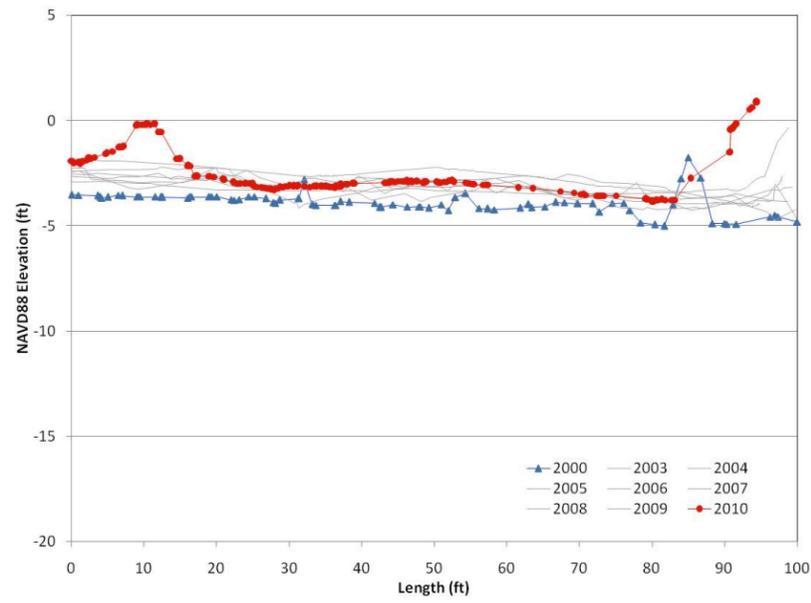
**GLC-3 200ft Cross-Section  
Spring**



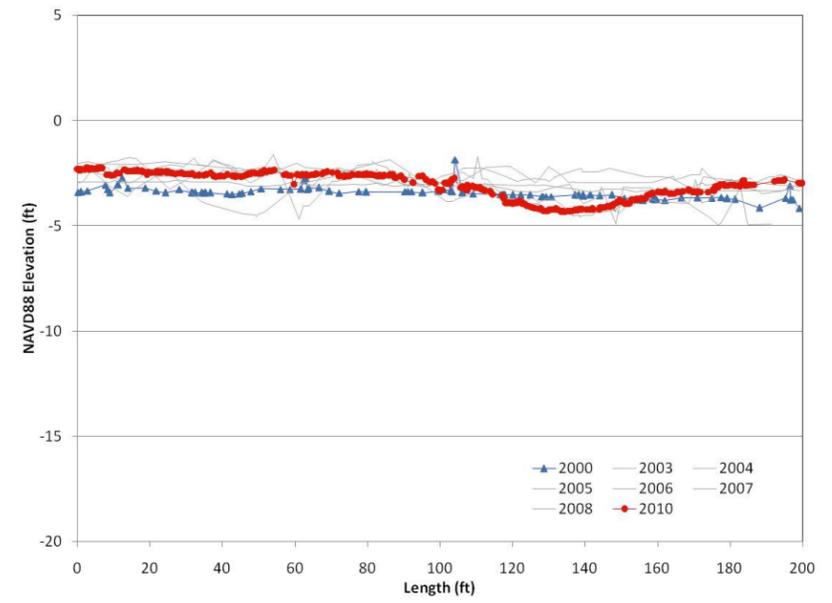
**GLC-3 Centerline  
Spring**



**GLC-3 150ft Cross-Section  
Fall**



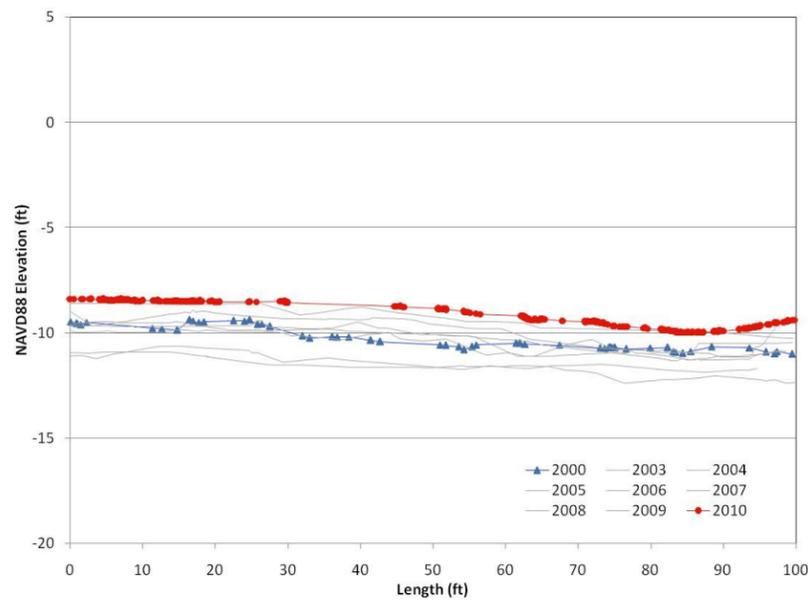
**GLC-3 200ft Cross-Section  
Fall**



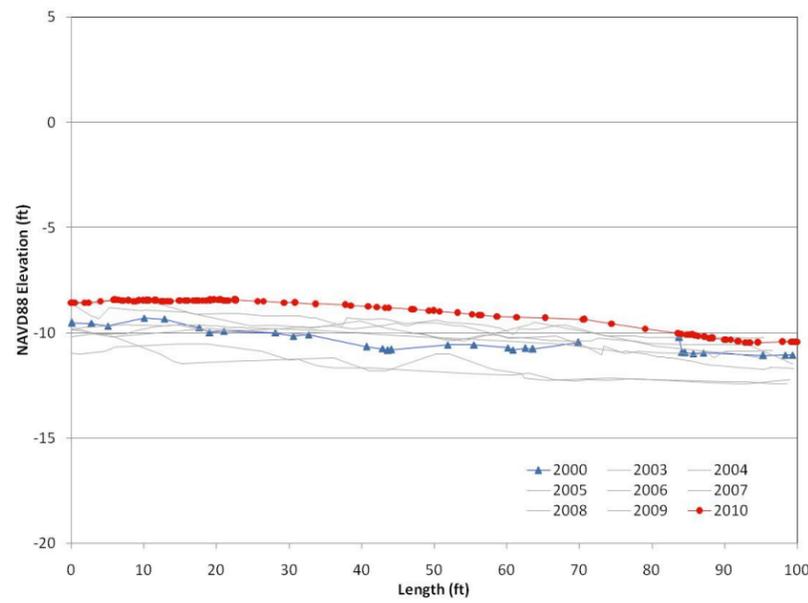
**GLC-3 Centerline  
Fall**



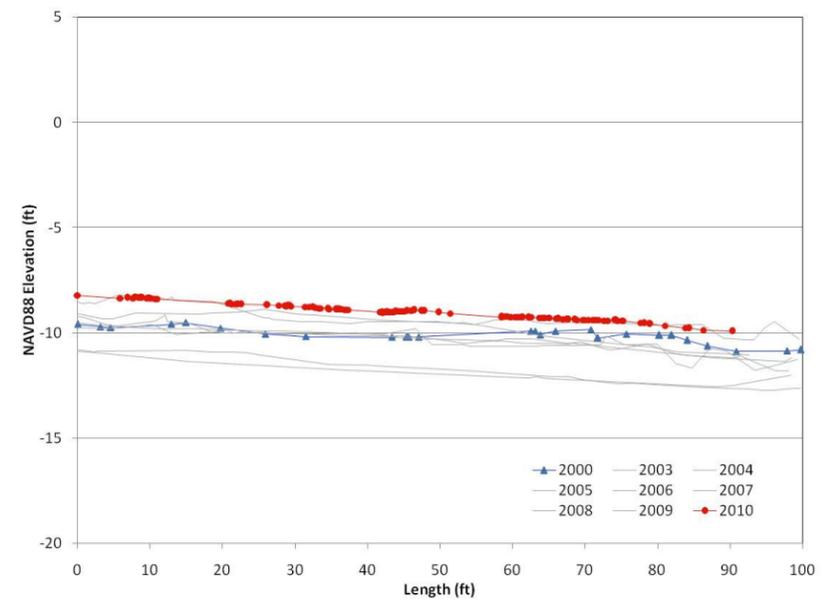
# Appendix N:GLC-4 Cross-Sections



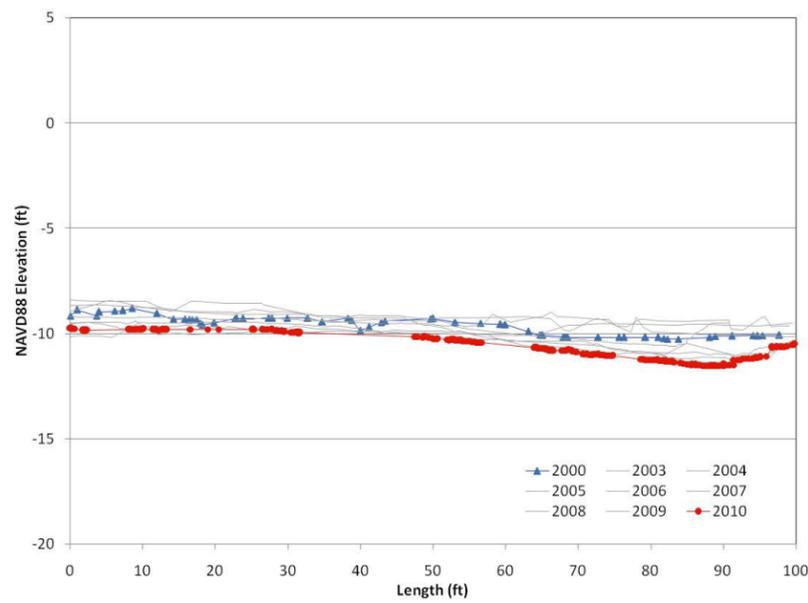
**GLC-4 0ft Cross-Section  
Spring**



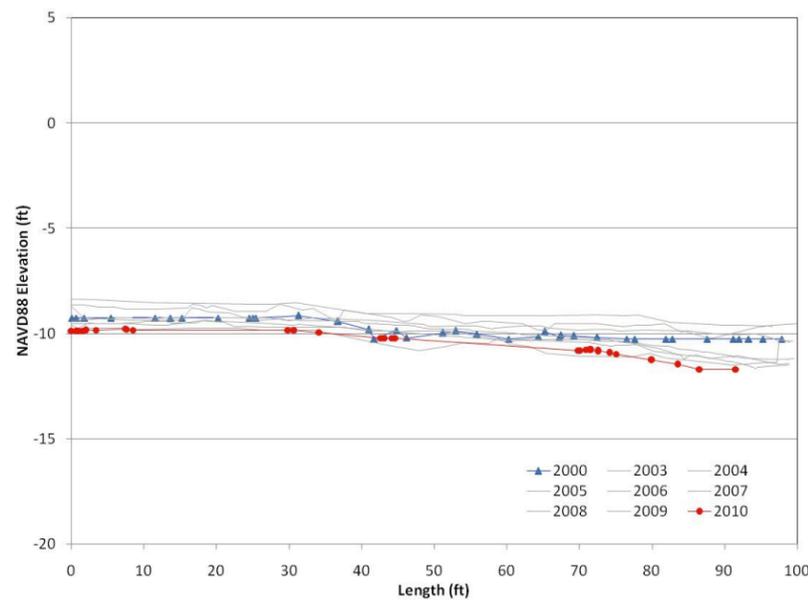
**GLC-4 50ft Cross-Section  
Spring**



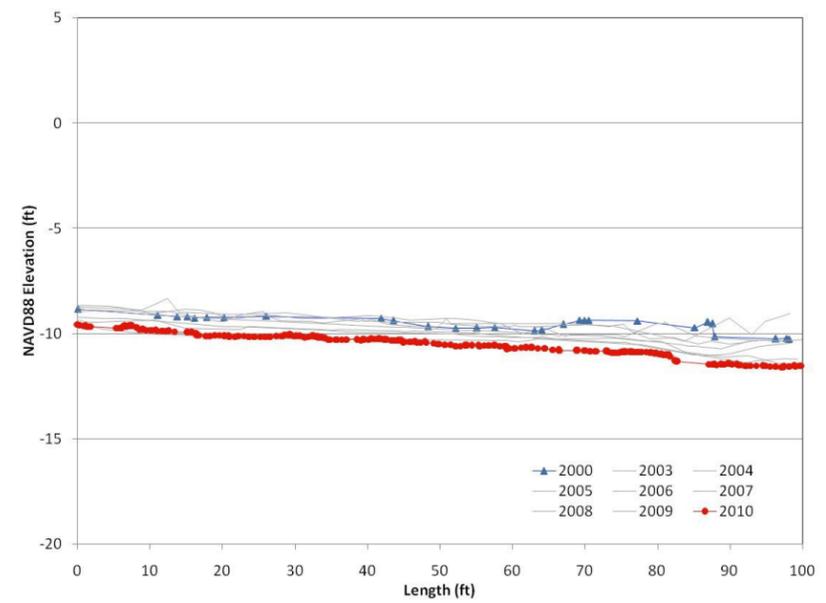
**GLC-4 100ft Cross-Section  
Spring**



**GLC-4 0ft Cross-Section  
Fall**

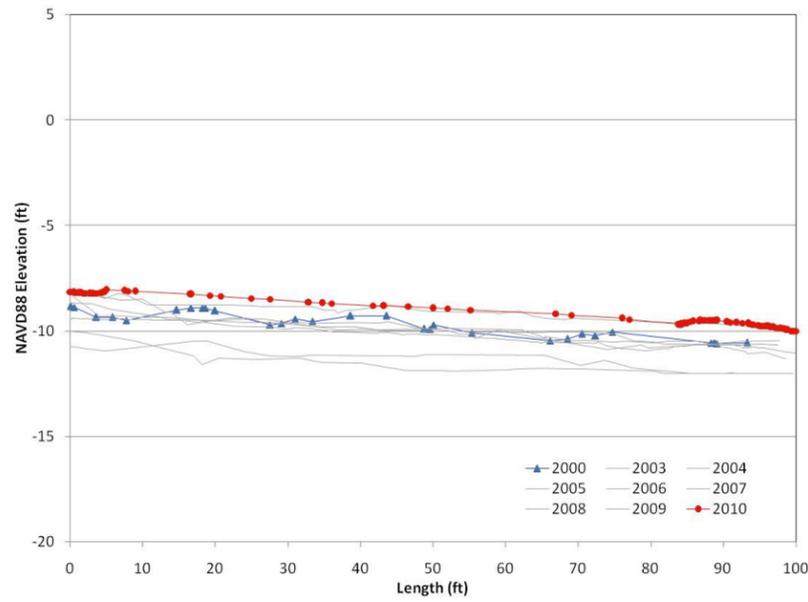


**GLC-4 50ft Cross-Section  
Fall**

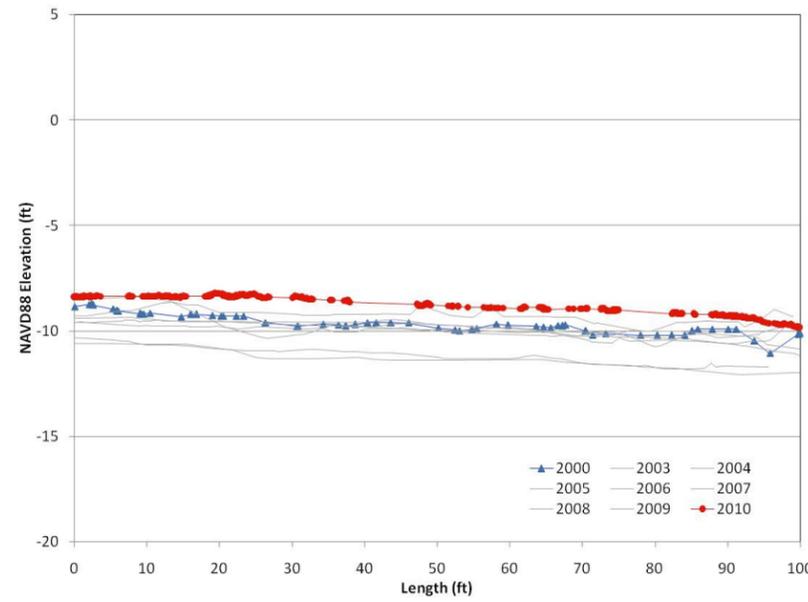


**GLC-4 100ft Cross-Section  
Fall**

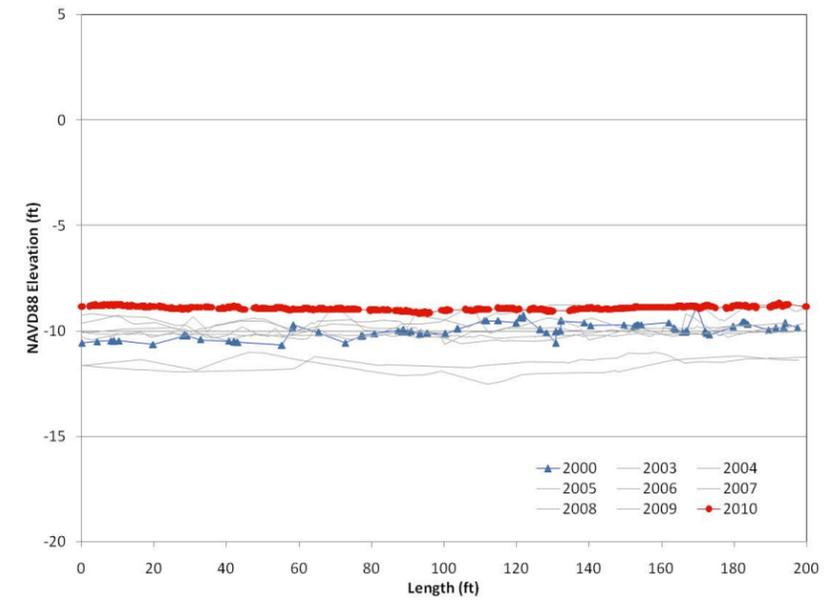




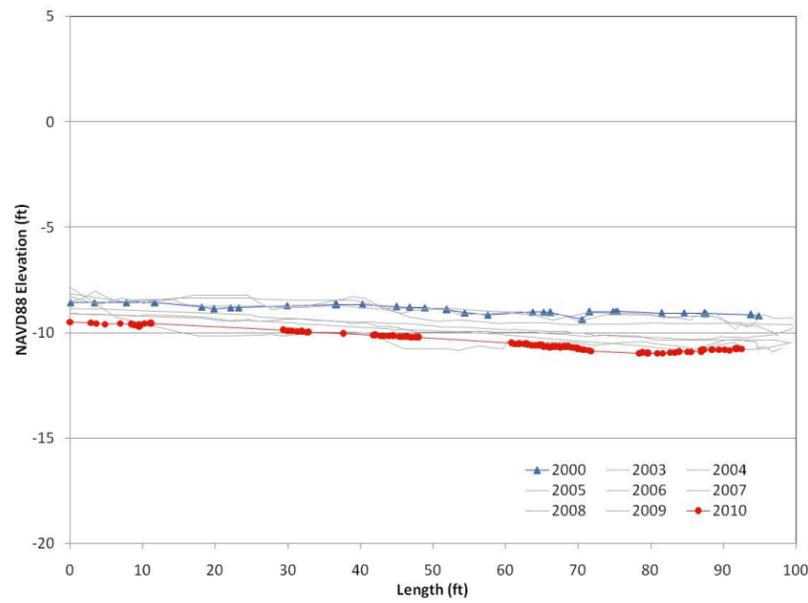
**GLC-4 150ft Cross-Section  
Spring**



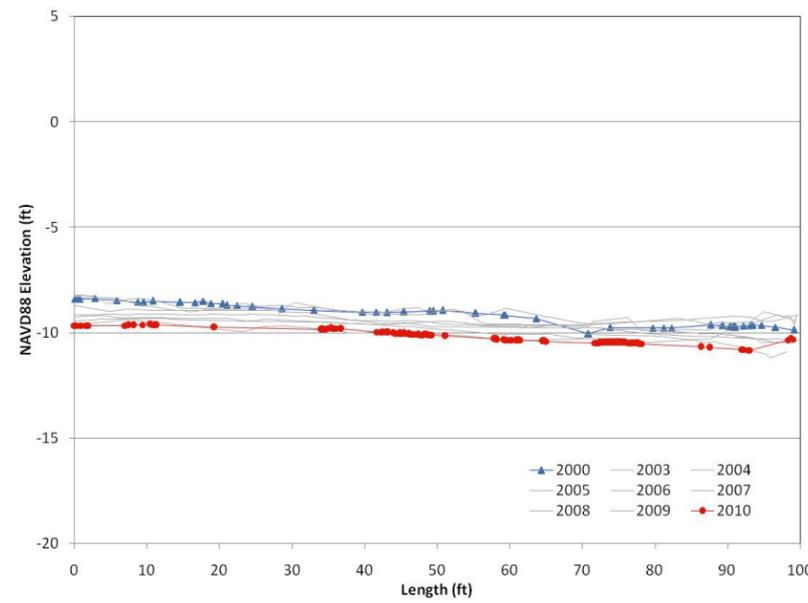
**GLC-4 200ft Cross-Section  
Spring**



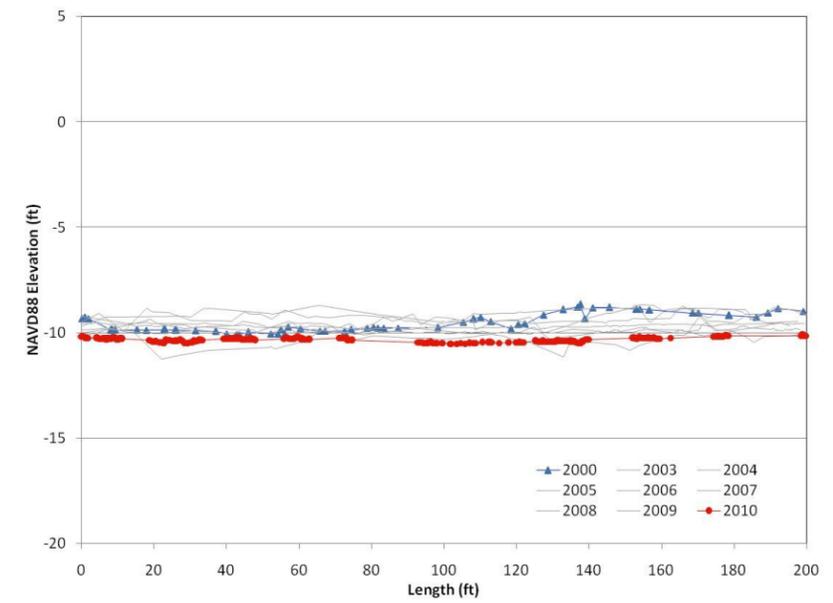
**GLC-4 Centerline  
Spring**



**GLC-4 150ft Cross-Section  
Fall**



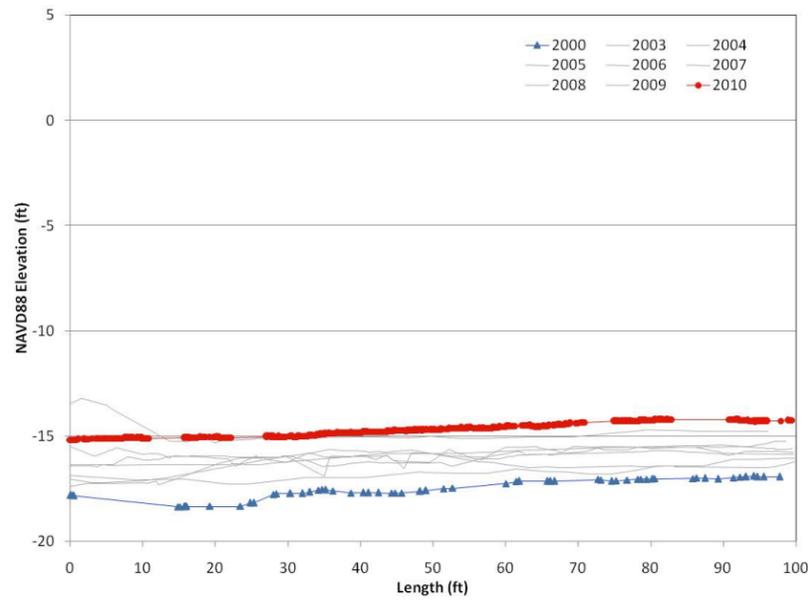
**GLC-4 200ft Cross-Section  
Fall**



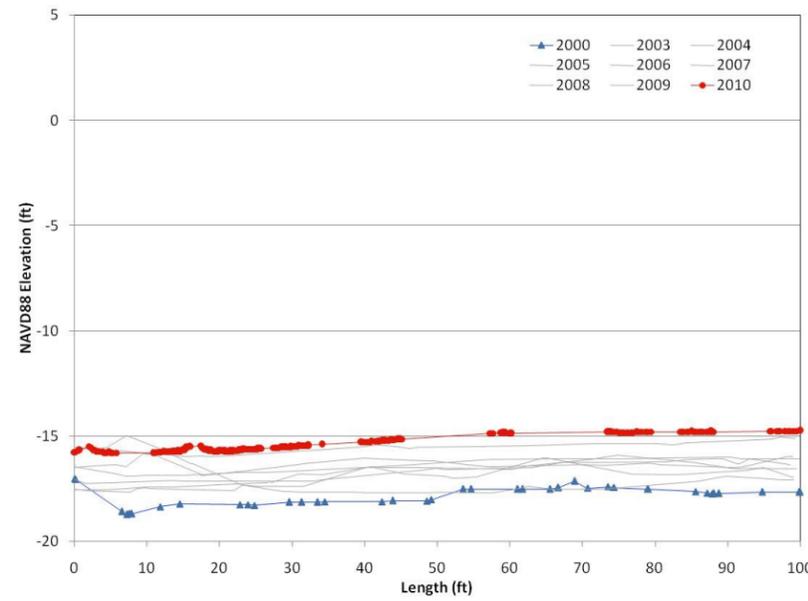
**GLC-4 Centerline  
Fall**



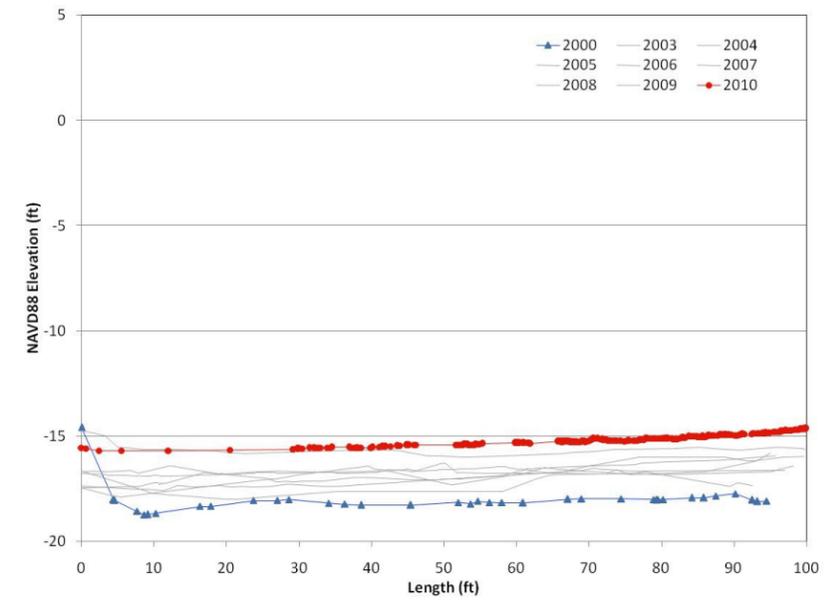
# Appendix O:GLC-5 Cross-Sections



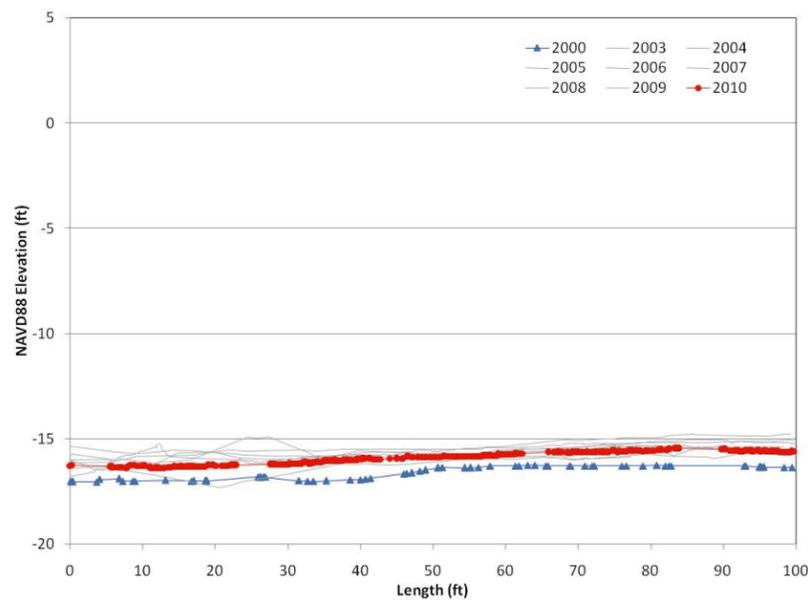
**GLC-5 0ft Cross-Section  
Spring**



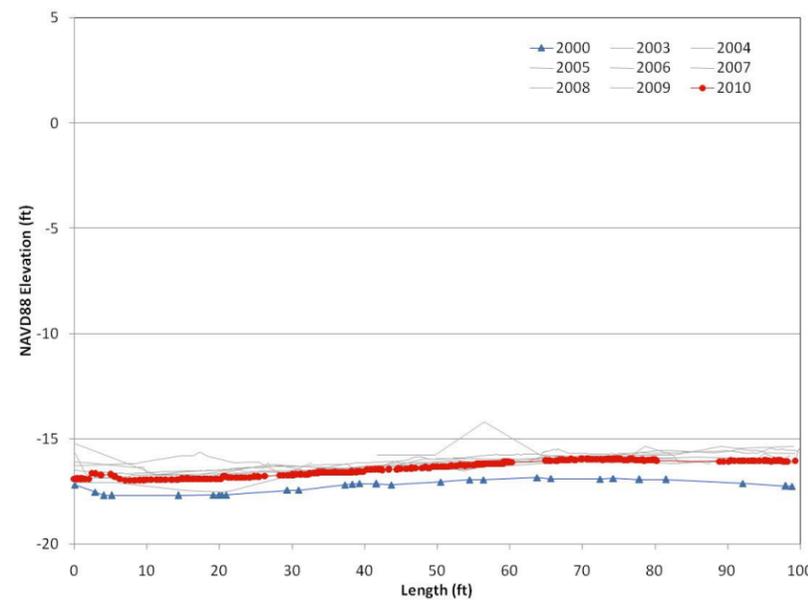
**GLC-5 50ft Cross-Section  
Spring**



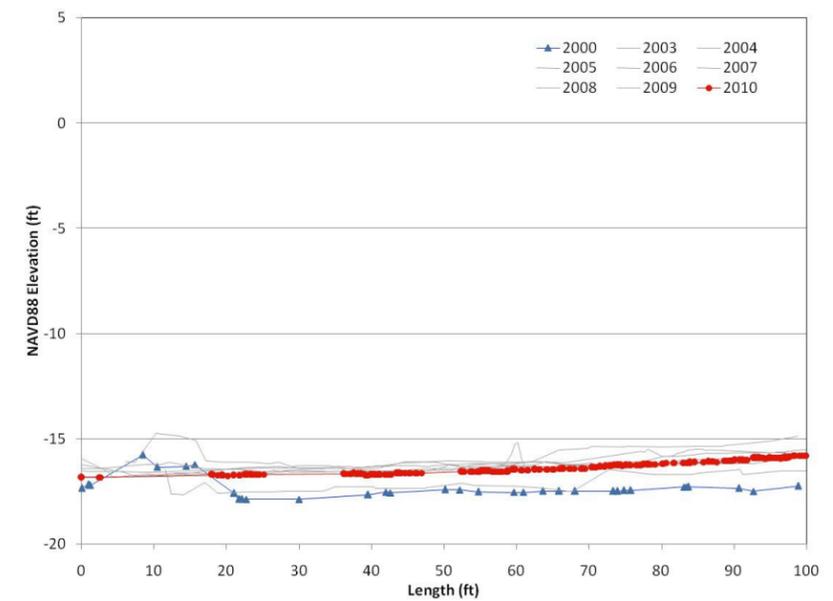
**GLC-5 100ft Cross-Section  
Spring**



**GLC-5 0ft Cross-Section  
Fall**

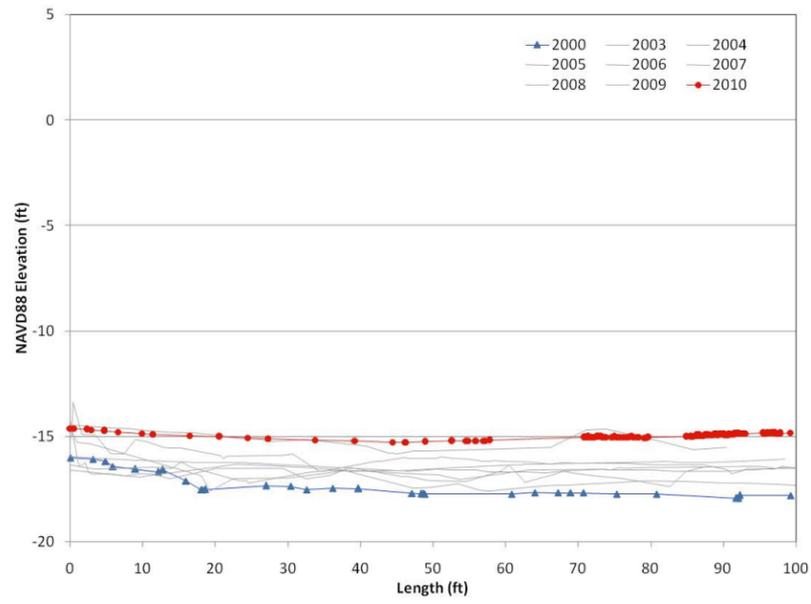


**GLC-5 50ft Cross-Section  
Fall**

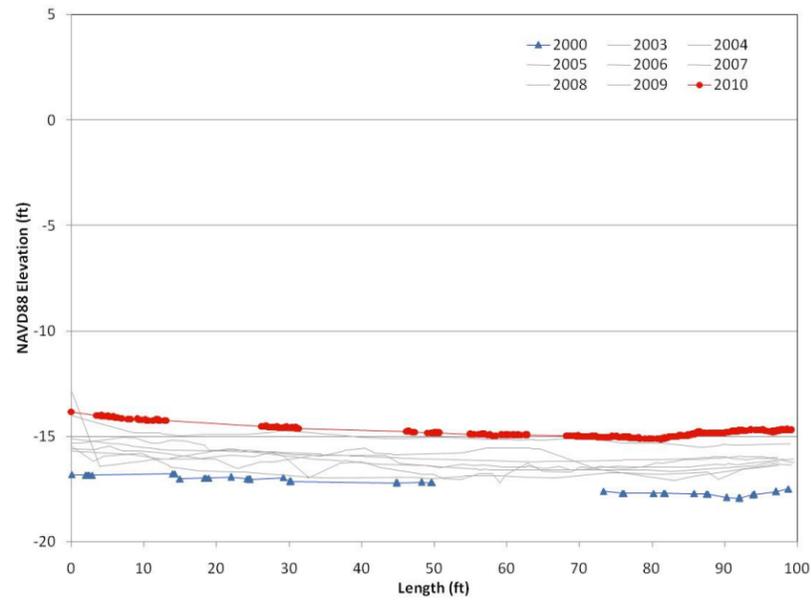


**GLC-5 100ft Cross-Section  
Fall**

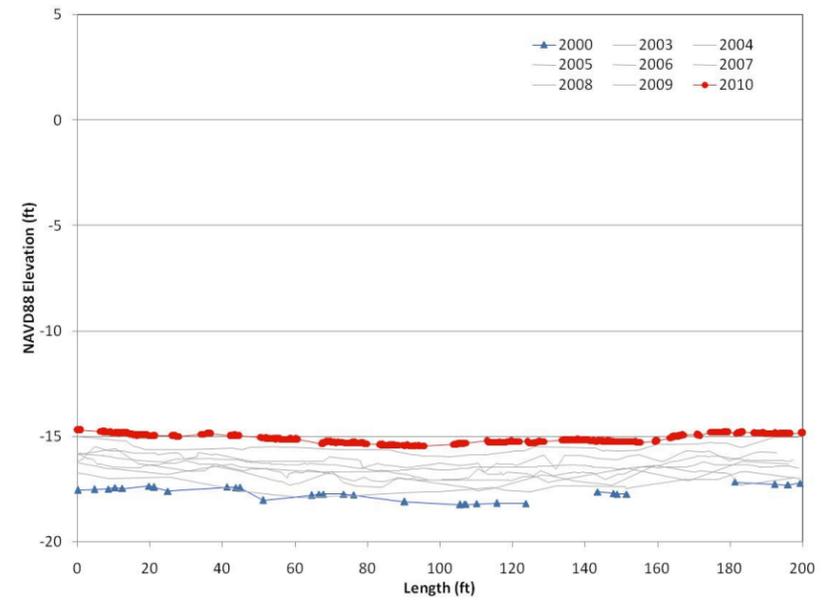




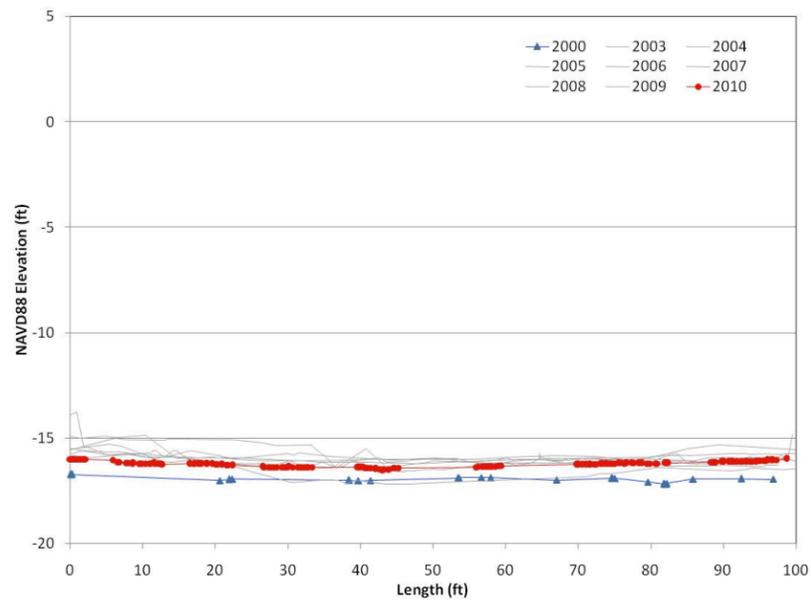
**GLC-5 150ft Cross-Section  
Spring**



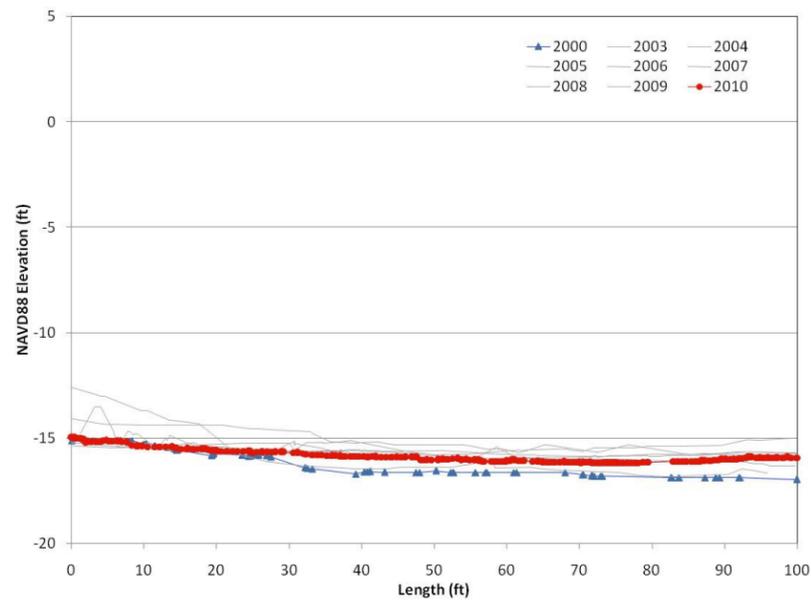
**GLC-5 200ft Cross-Section  
Spring**



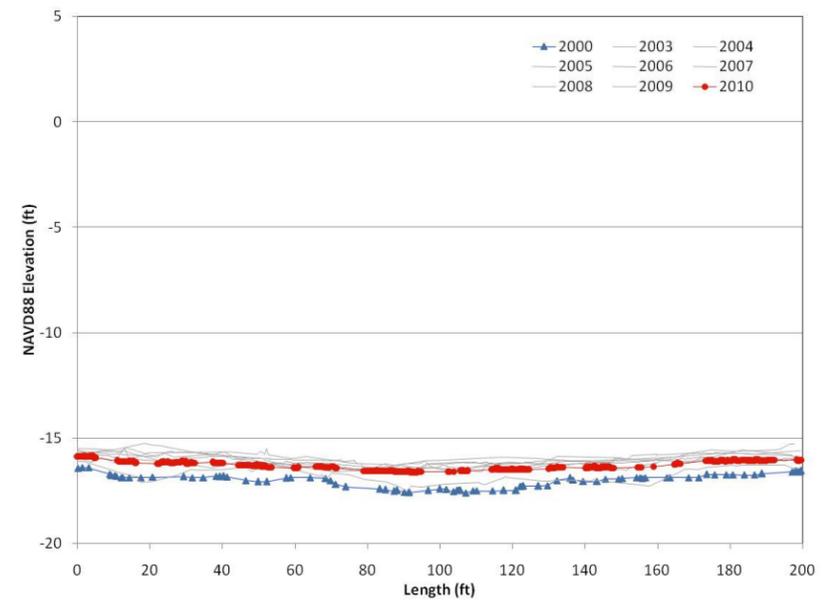
**GLC-5 Centerline  
Spring**



**GLC-5 150ft Cross-Section  
Fall**



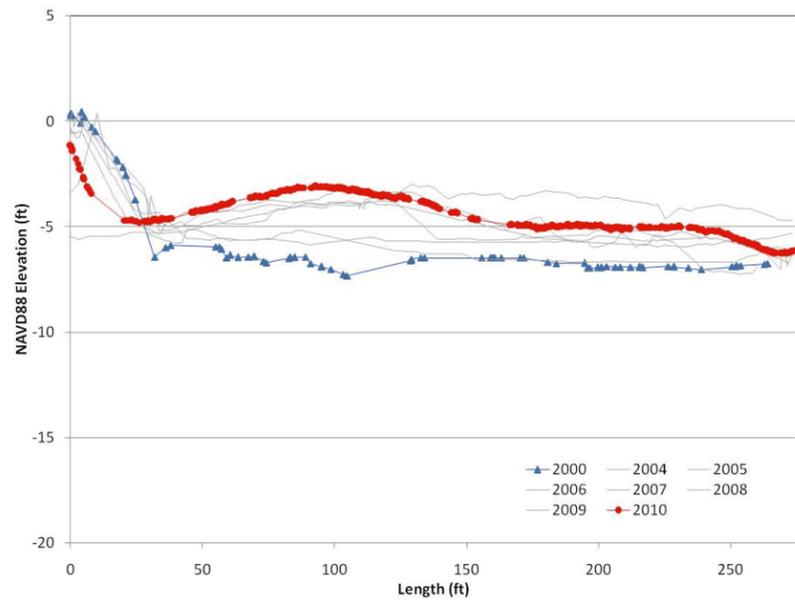
**GLC-5 200ft Cross-Section  
Fall**



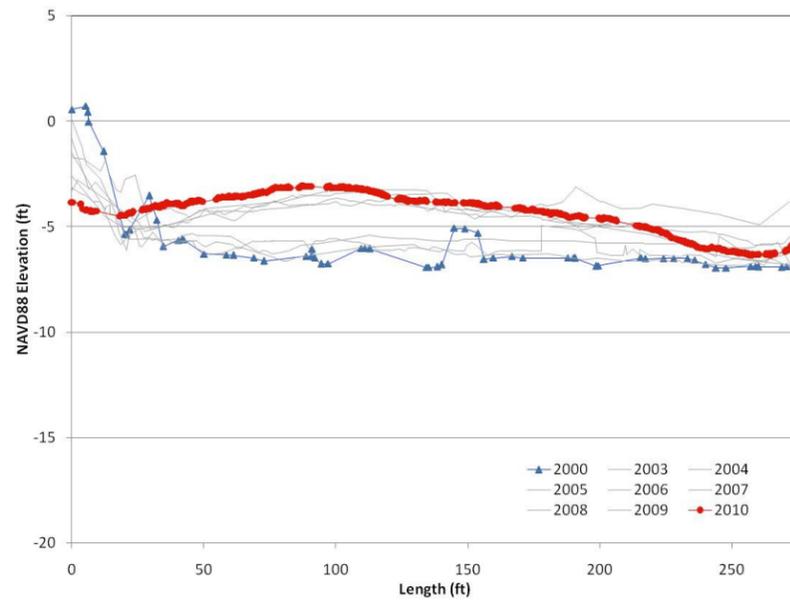
**GLC-5 Centerline  
Fall**



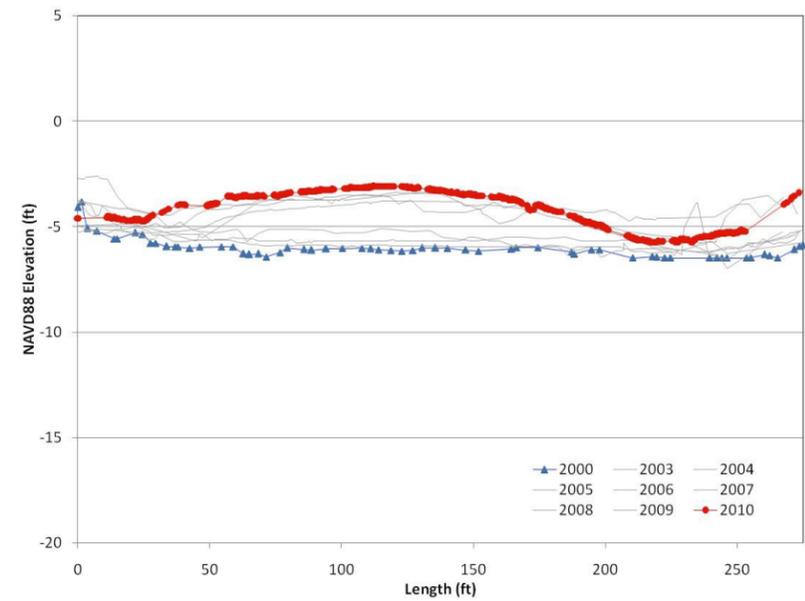
# Appendix P:DC-1 Cross-Sections



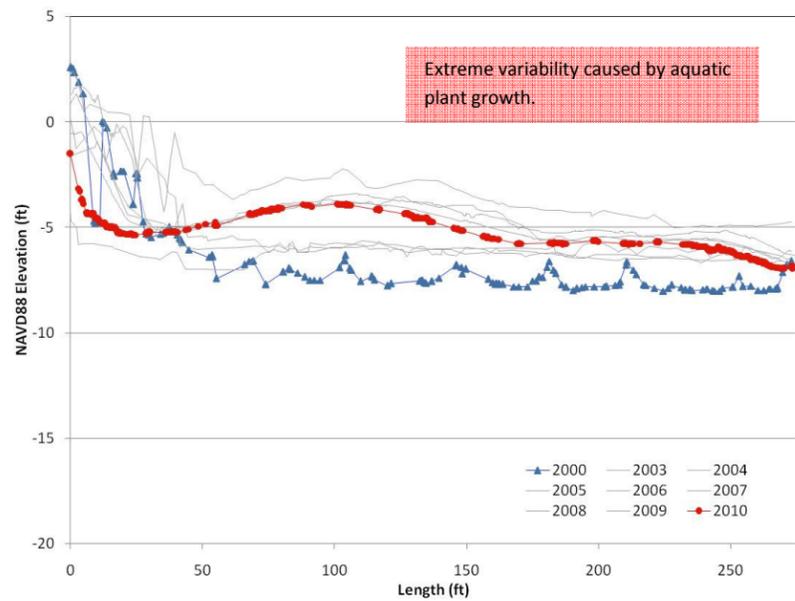
**DC-1 0ft Cross-Section  
Spring**



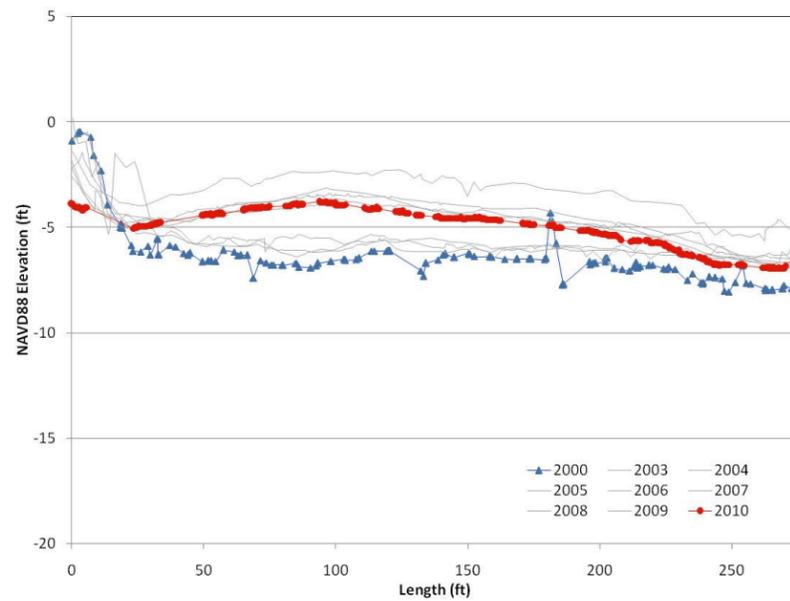
**DC-1 50ft Cross-Section  
Spring**



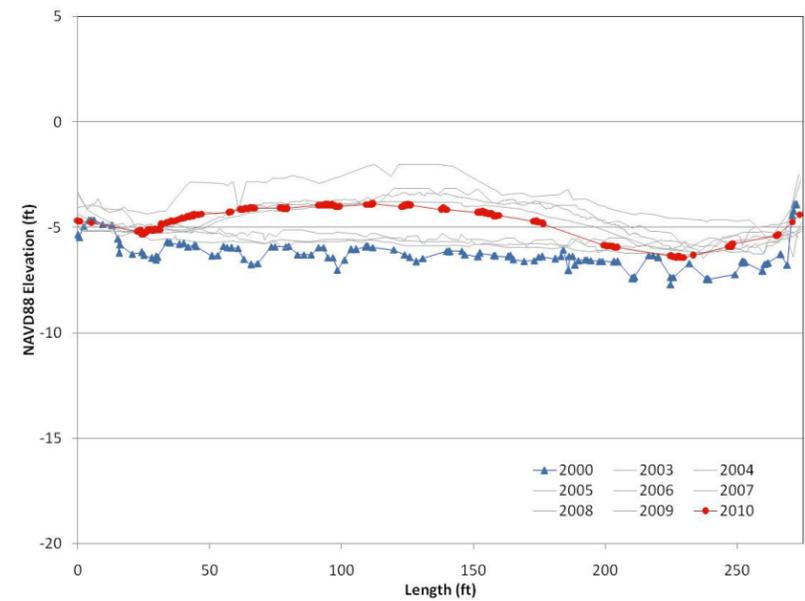
**DC-1 100ft Cross-Section  
Spring**



**DC-1 0ft Cross-Section  
Fall**

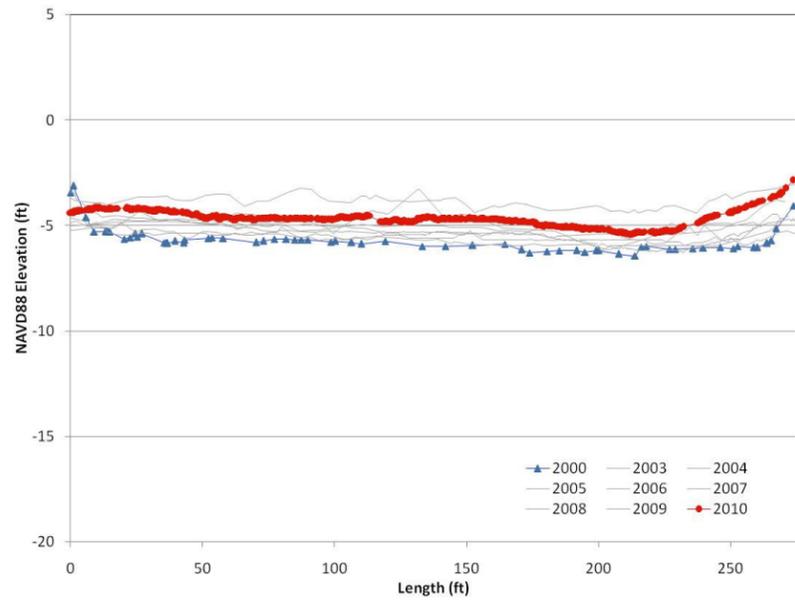


**DC-1 50ft Cross-Section  
Fall**

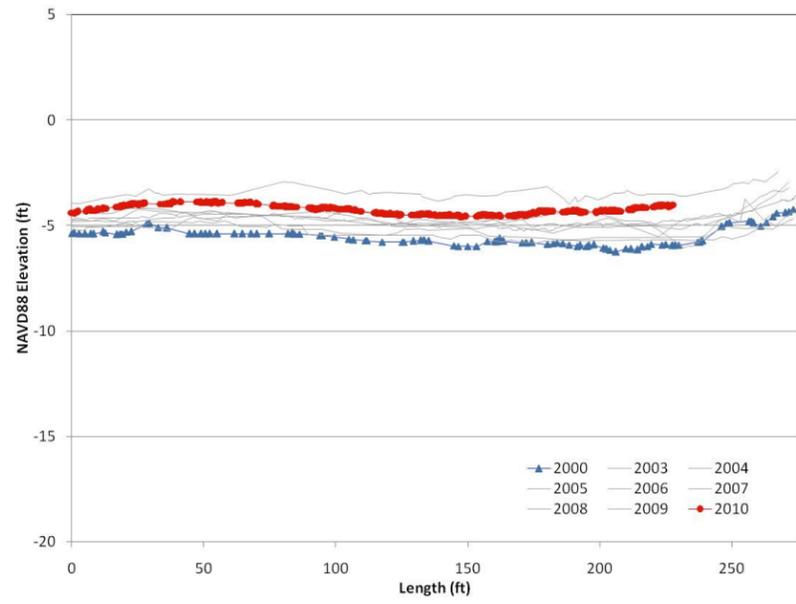


**DC-1 100ft Cross-Section  
Fall**

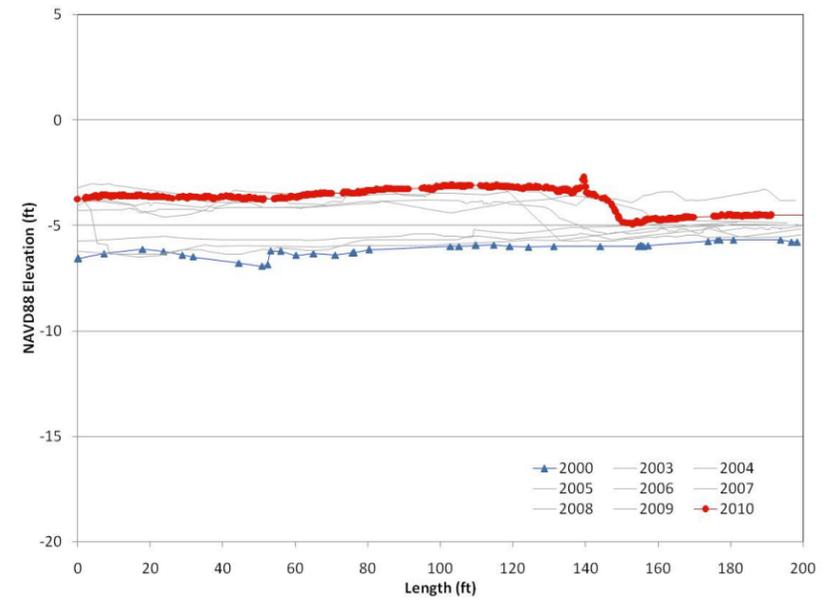




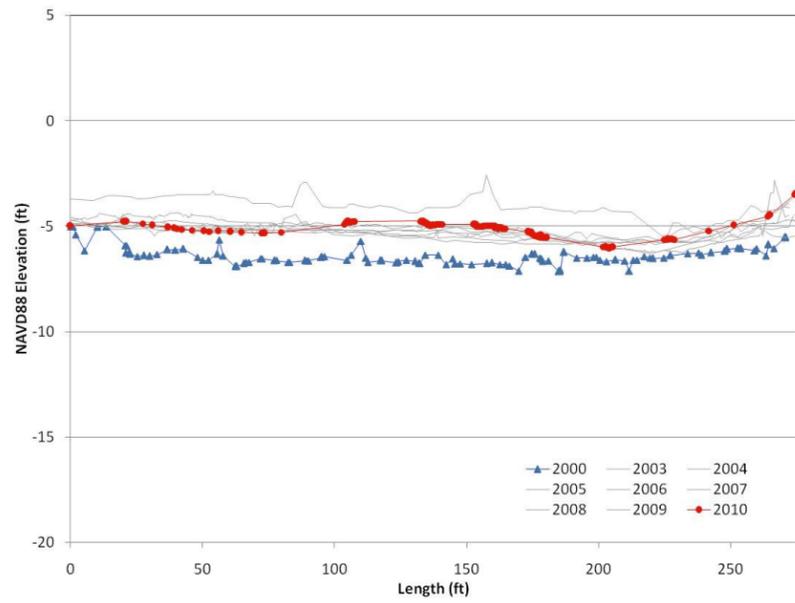
**DC-1 150ft Cross-Section  
Spring**



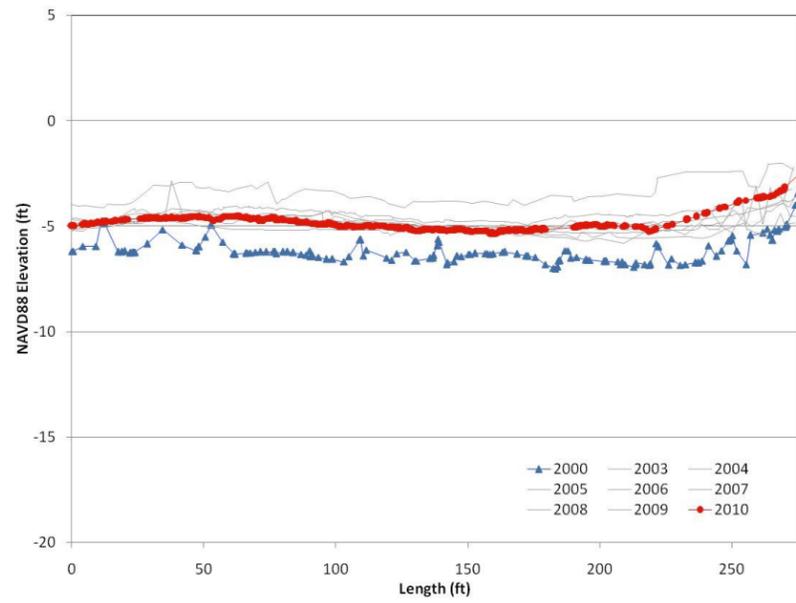
**DC-1 200ft Cross-Section  
Spring**



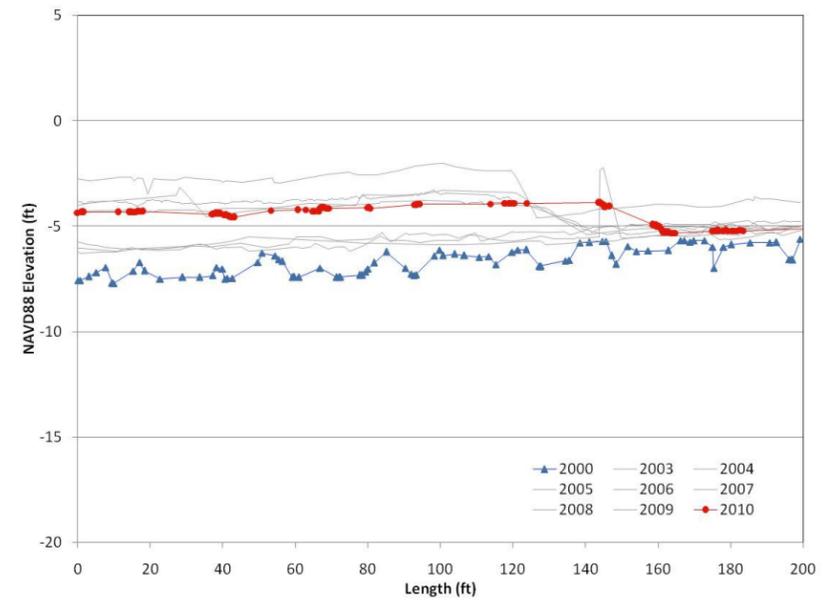
**DC-1 Centerline  
Spring**



**DC-1 150ft Cross-Section  
Fall**



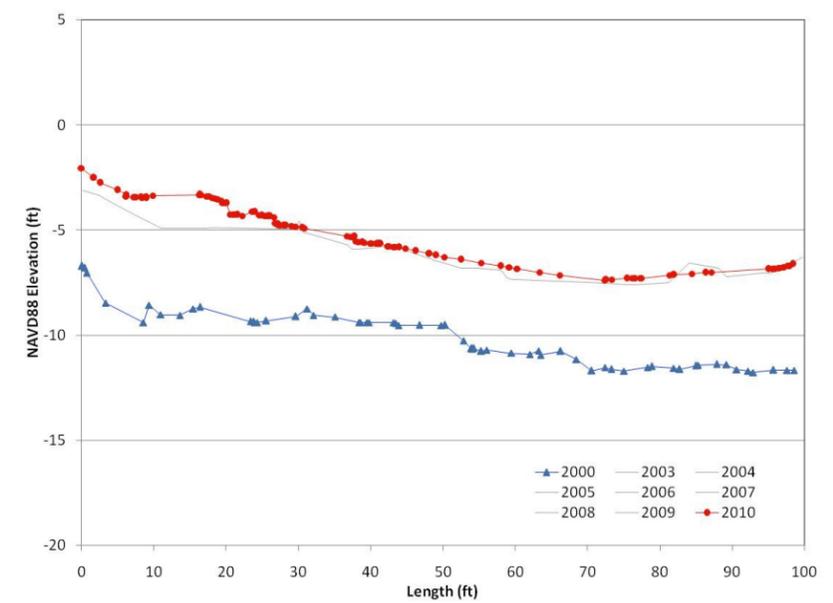
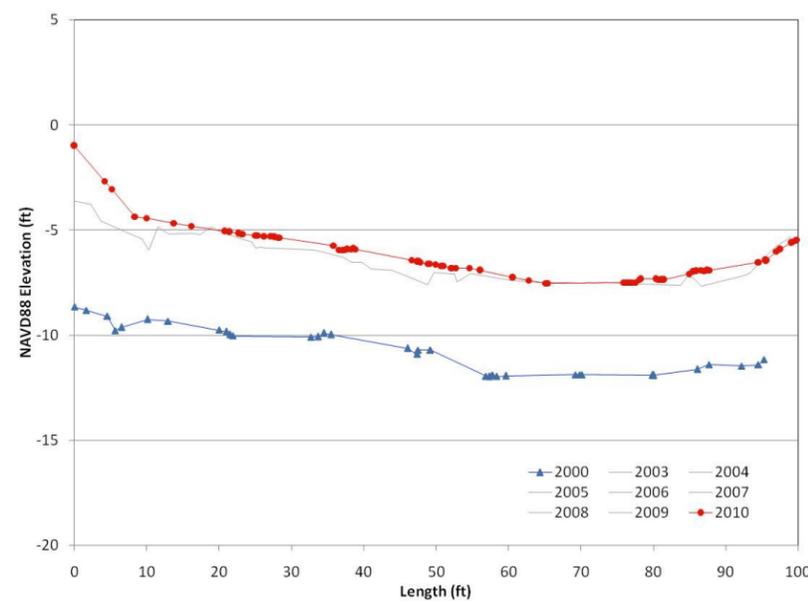
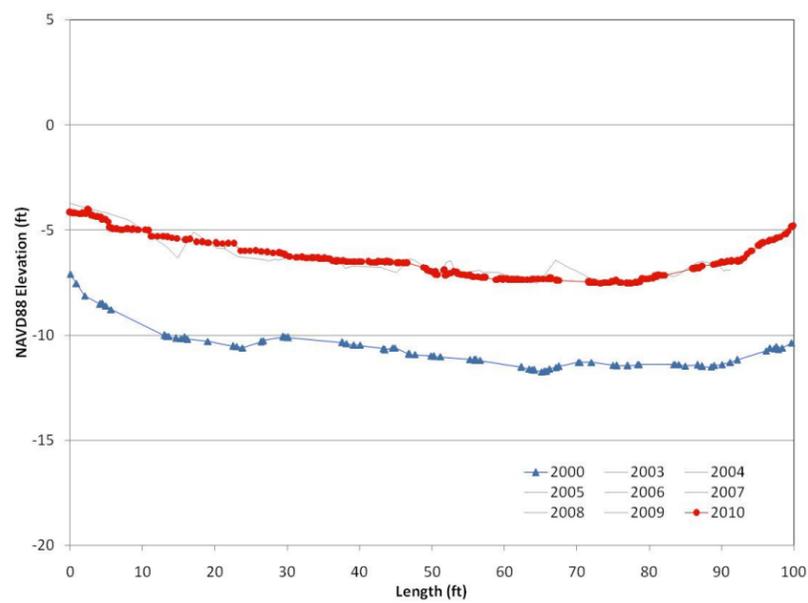
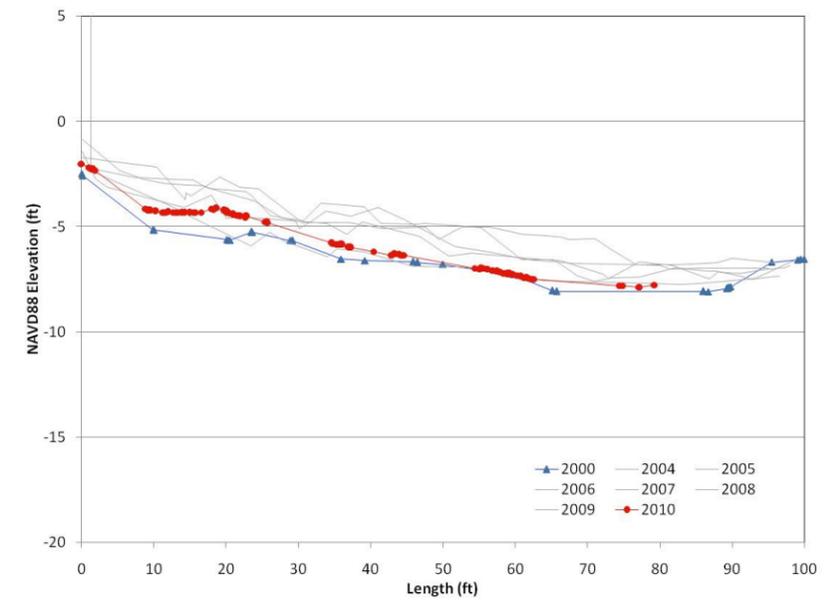
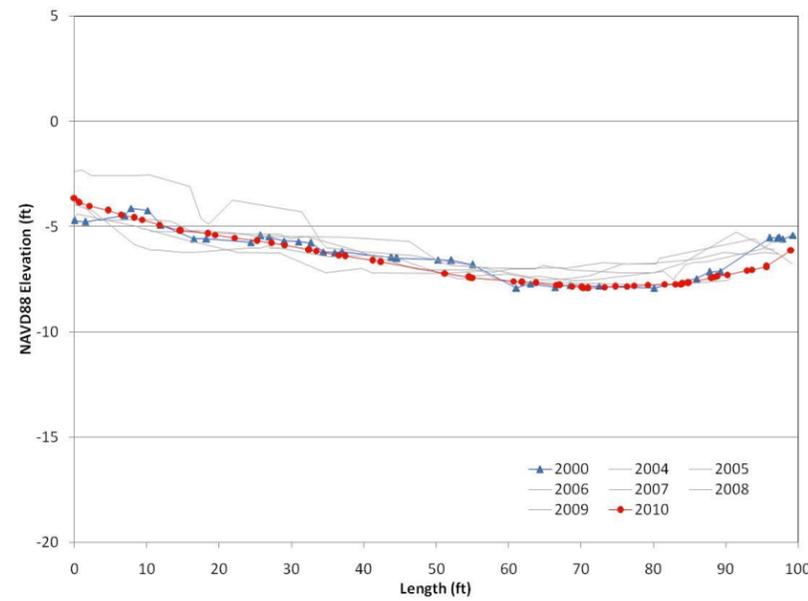
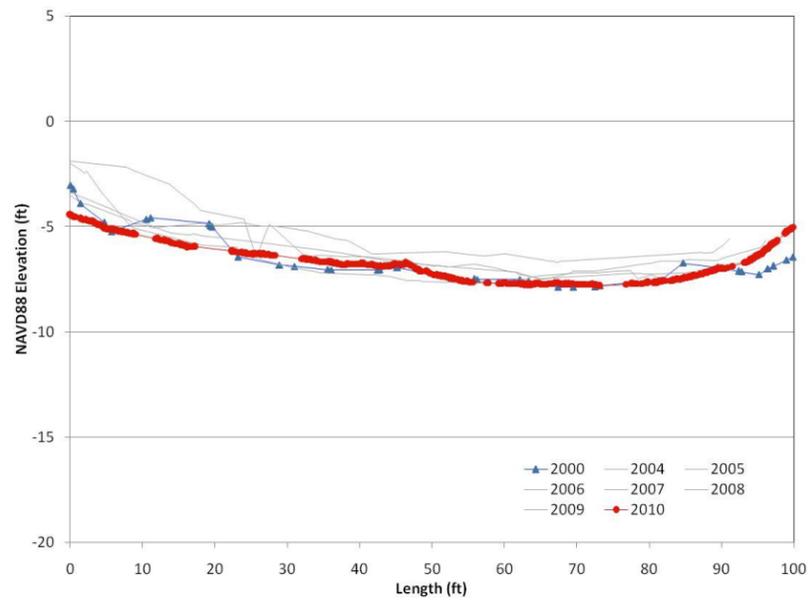
**DC-1 200ft Cross-Section  
Fall**

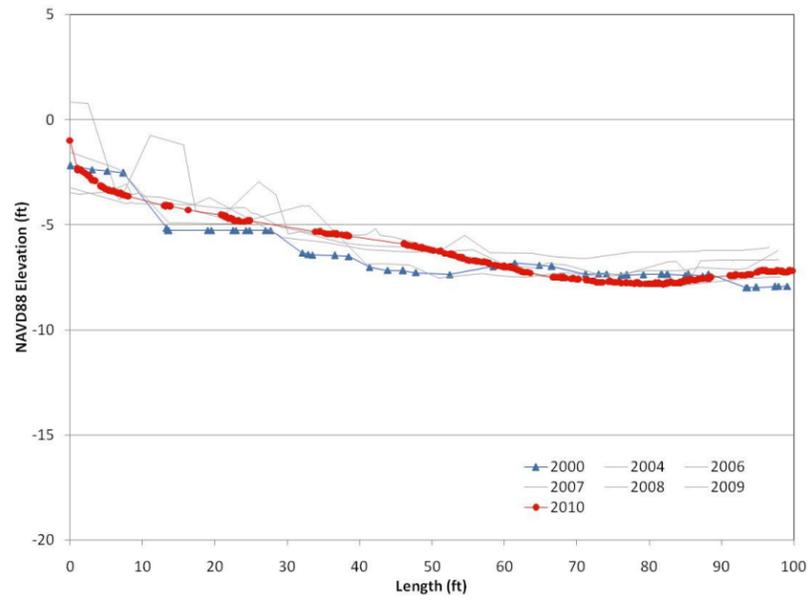


**DC-1 Centerline  
Fall**

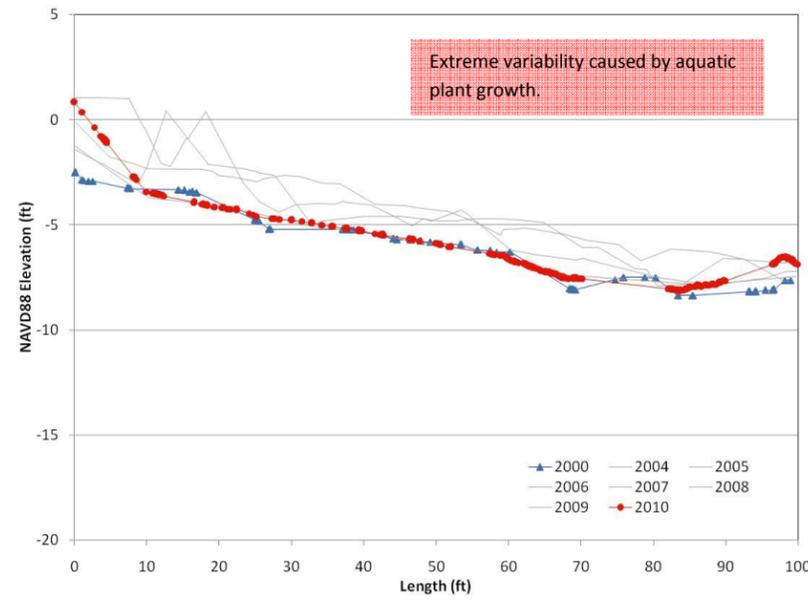


# Appendix Q:MR-1 Cross-Sections

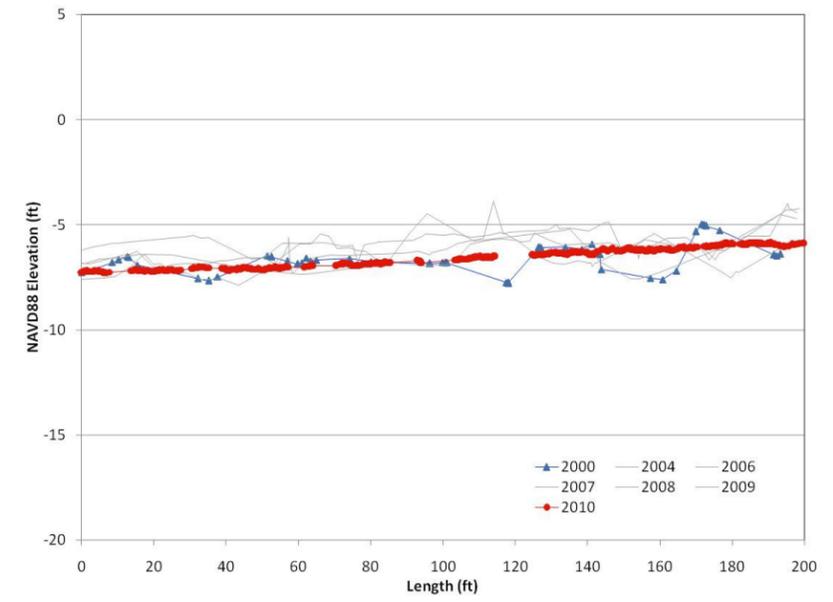




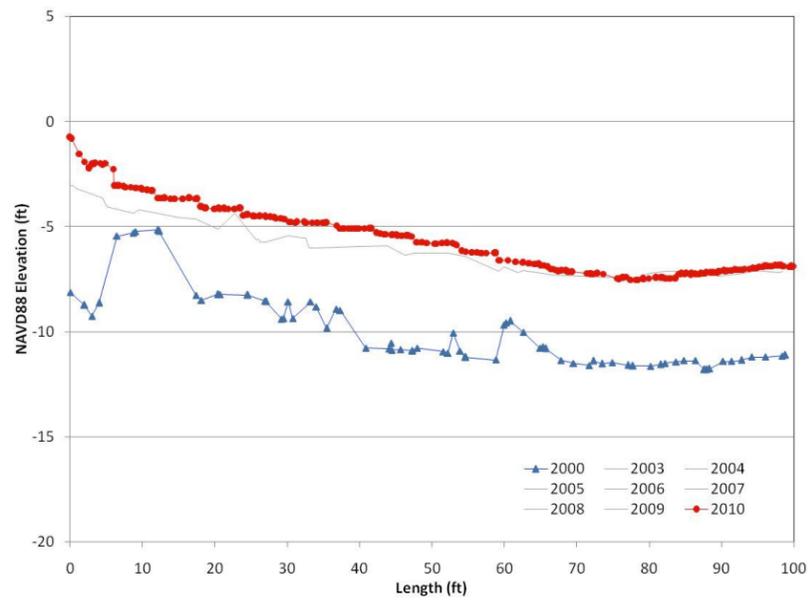
**MR-1 150ft Cross-Section  
Spring**



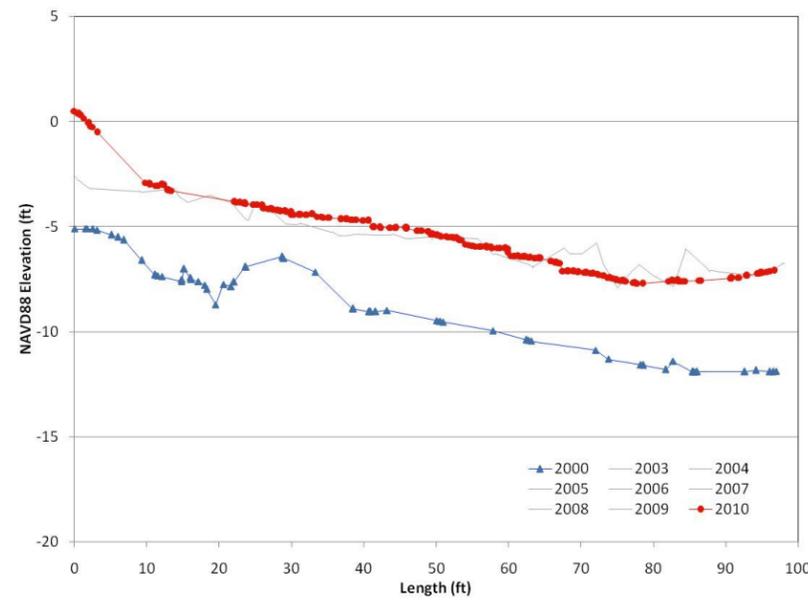
**MR-1 200ft Cross-Section  
Spring**



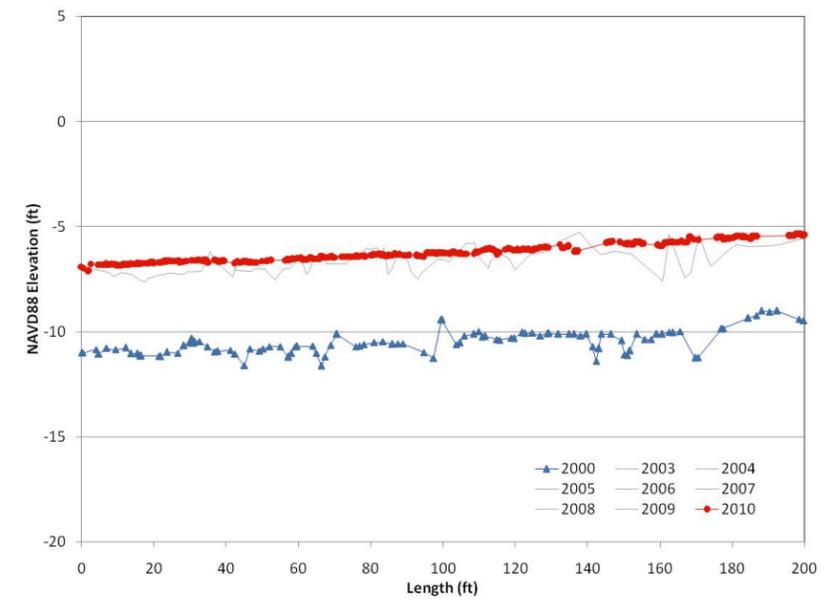
**MR-1 Centerline  
Spring**



**MR-1 150ft Cross-Section  
Fall**



**MR-1 200ft Cross-Section  
Fall**



**MR-1 Centerline  
Fall**



# Appendix R: Mean Grain Size Sample Calculations

Below are sample calculations for mean grain size of a sample taken from the center of the channel at OR-1 during the fall 2010 survey.

Step 1:

Percent finer data provided by the Lab.

Sieve Size (mm)	Percent Finer (%)	Sieve Size ( $\Phi$ )
0.075	2	3.737
0.15	2	2.737
0.3	14	1.737
0.6	97	0.737
1.18	100	-0.239

Step 2:

Convert Sieve Size to phi ( $\Phi$ ) using the following equation:

$$\Phi = \frac{-\ln(D)}{\ln(2)} \quad \text{Where } D \text{ is the diameter in millimeters.}$$

Example calculation:

$$\Phi = \frac{-\ln(0.075)}{\ln(2)}$$

$$\Phi = 3.7369 \quad \text{(Calculated values are in blue in above table.)}$$

Step 3:

Find the  $\Phi_{16}$ ,  $\Phi_{50}$  and  $\Phi_{84}$ . Where  $\Phi_{16}$  is the  $\Phi$  that occurs when the percent finer percentage is equal to 16. This can be done graphically or through interpolation. Interpolation was used for this report.

Example calculations:

$$\Phi_{16} = 1.737 + (0.16 - 0.14) \frac{(0.737 - 1.737)}{(0.97 - 0.14)}$$

$$\Phi_{16} = 1.71$$

$$\Phi_{50} = 1.737 + (0.50 - 0.14) \frac{(0.737 - 1.737)}{(0.97 - 0.14)}$$

$$\Phi_{50} = 1.30$$

$$\Phi_{84} = 1.737 + (0.84 - 0.14) \frac{(0.737 - 1.737)}{(0.97 - 0.14)}$$

$$\Phi_{84} = 0.89$$



Step 4:

Determine the mean grain size using the following equation:

$$\text{Mean Grain Size}^2 = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$$

Example Calculation:

$$\text{Mean Grain Size} = \frac{1.71 + 1.30 + 0.89}{3}$$

$$\text{Mean Grain Size } (\Phi) = 1.3$$

Step 5:

Convert the mean grain size from phi( $\Phi$ ) back to millimeters using the following equation:

$$\text{Mean Grain Size [mm]} = 2^{(-\Phi)}$$

Sample Calculation:

$$\text{Mean Grain Size} = 2^{(-1.3)}$$

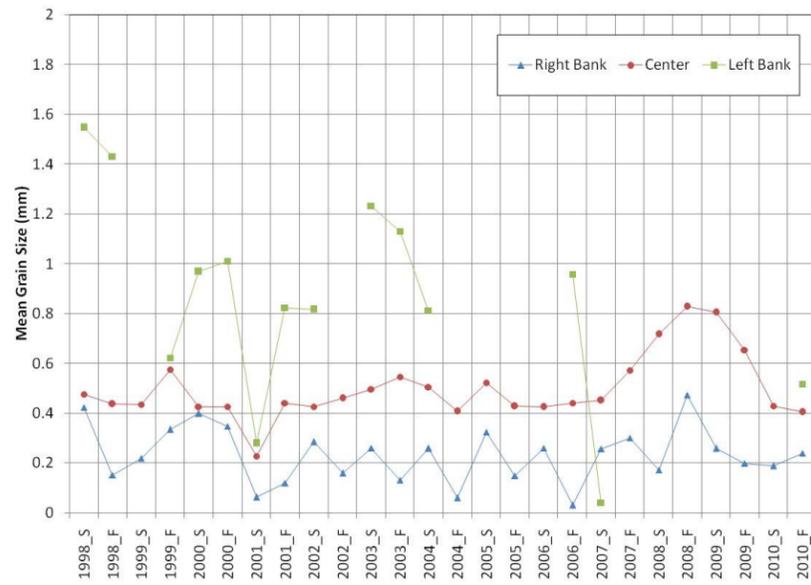
$$\text{Mean Grain Size} = 0.4 \text{ mm}$$

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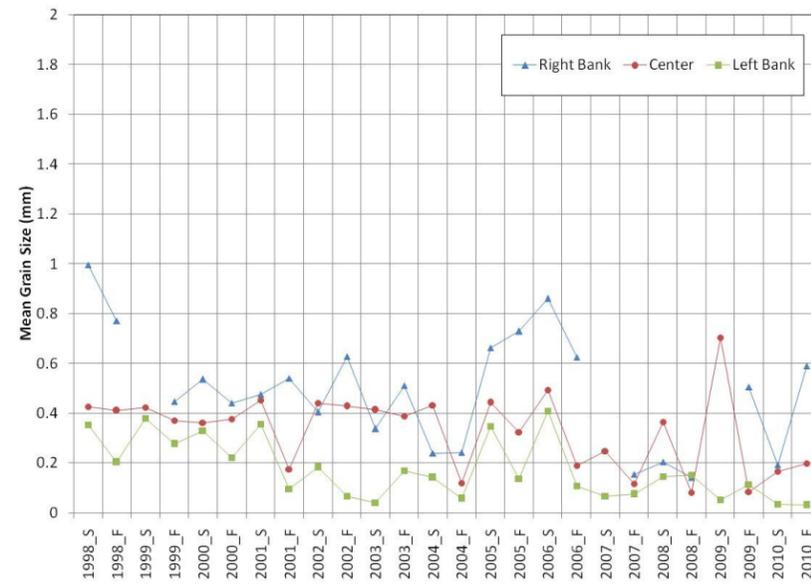
<sup>2</sup> Folk R.L., Ward W.C., 1957, Brazos River Bar: A Study of Significant Grain Size Parameters, Journal of Sedimentary Petrology 27: 3-26



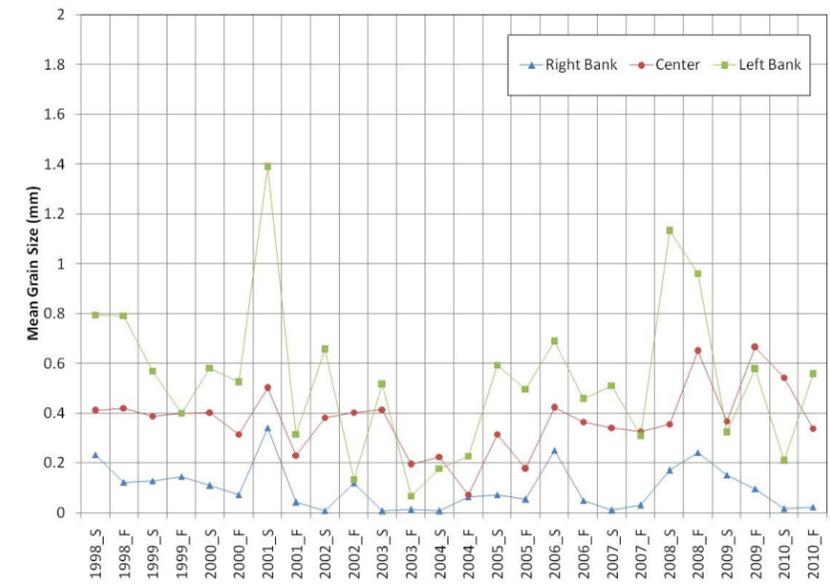
# Appendix S: Mean Grain Size Plots



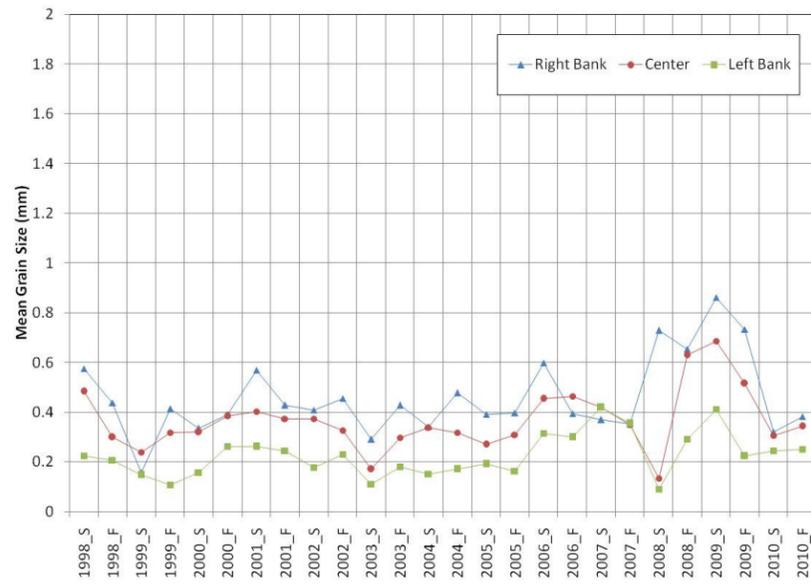
OR-1



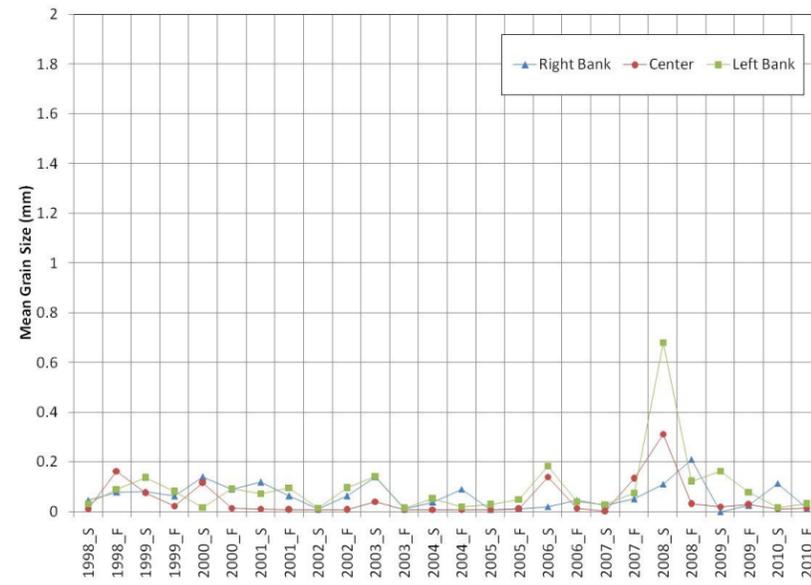
OR-2



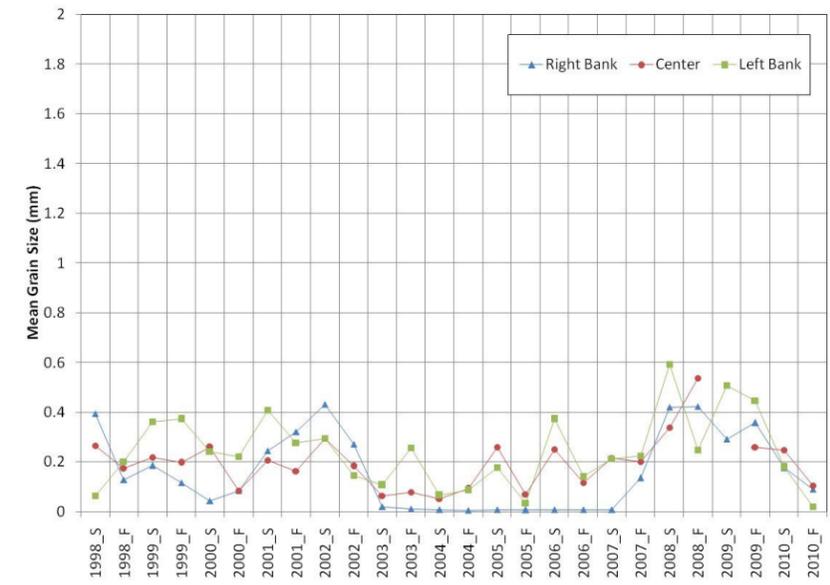
OR-3



OR-4

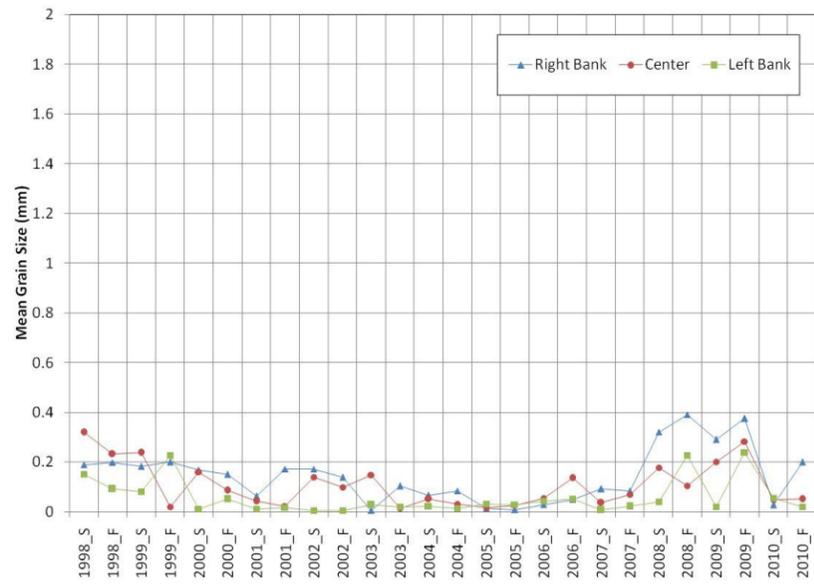


OR-5

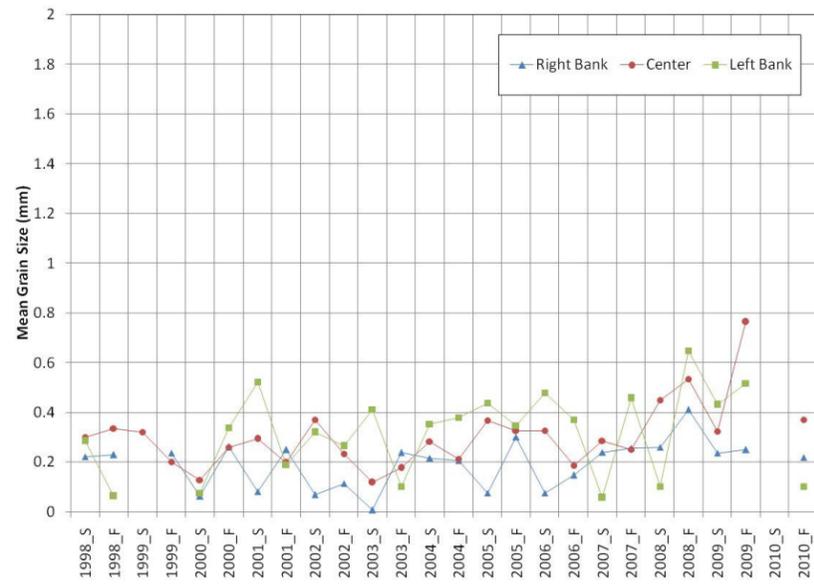


OR-6

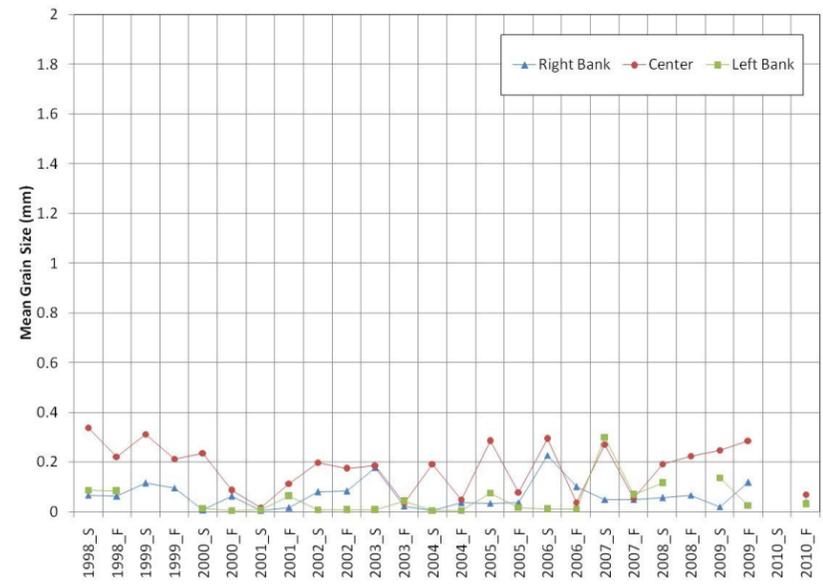




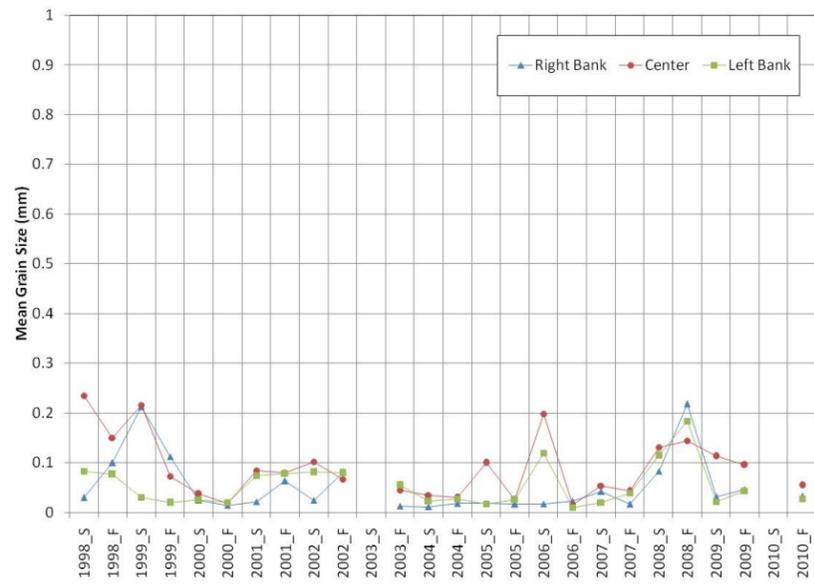
OR-7



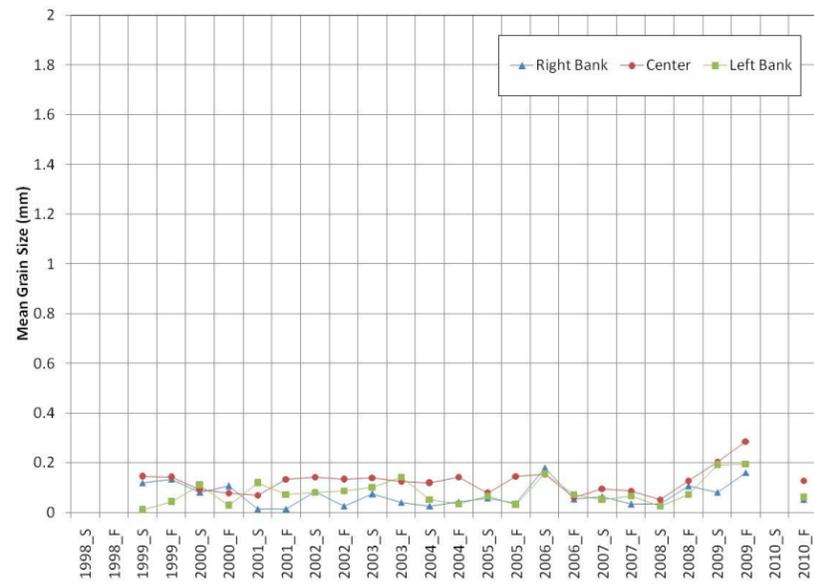
OR-8



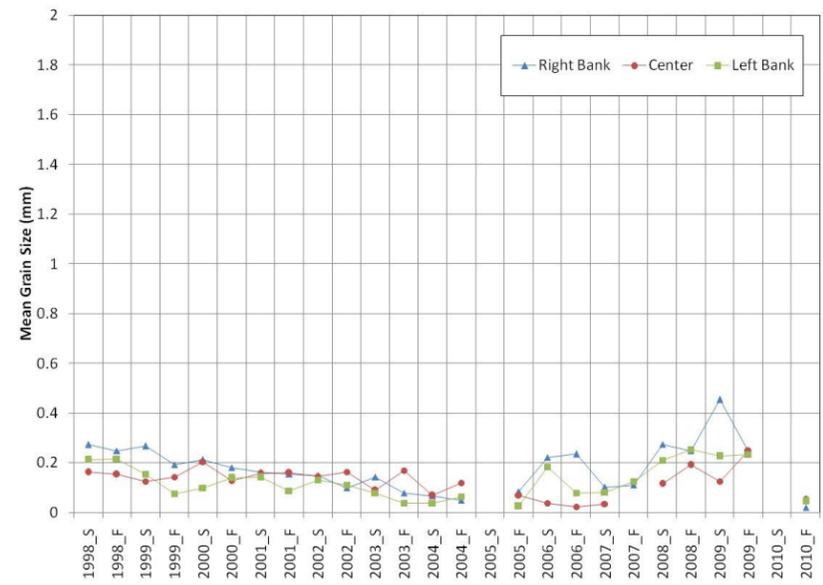
OR-9



GLC-1A

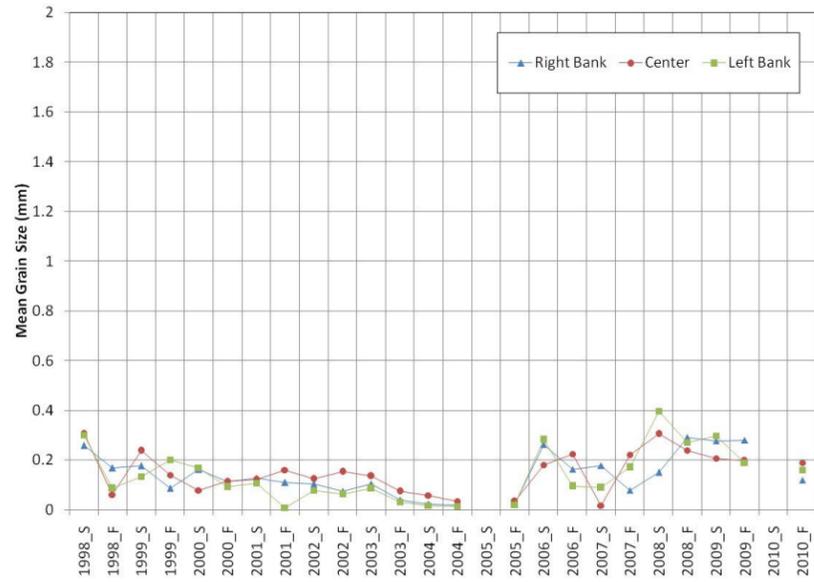


GLC-1B

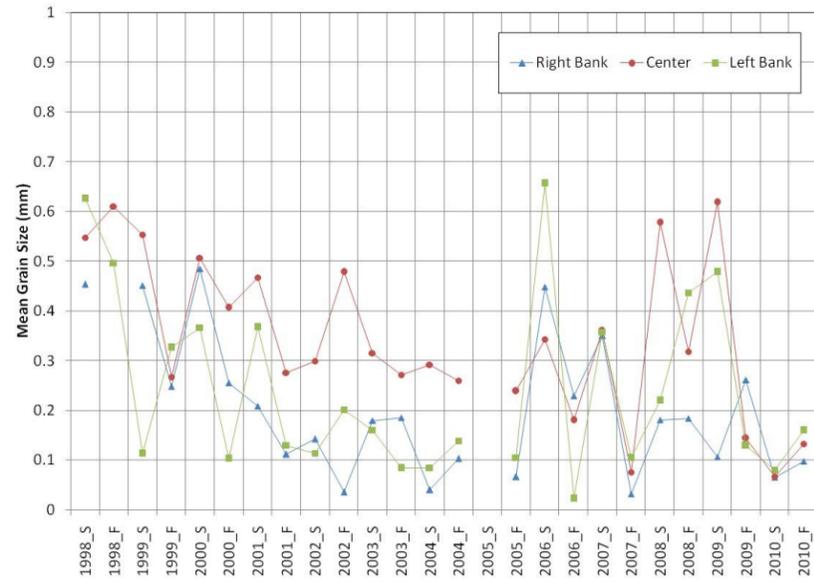


GLC-2

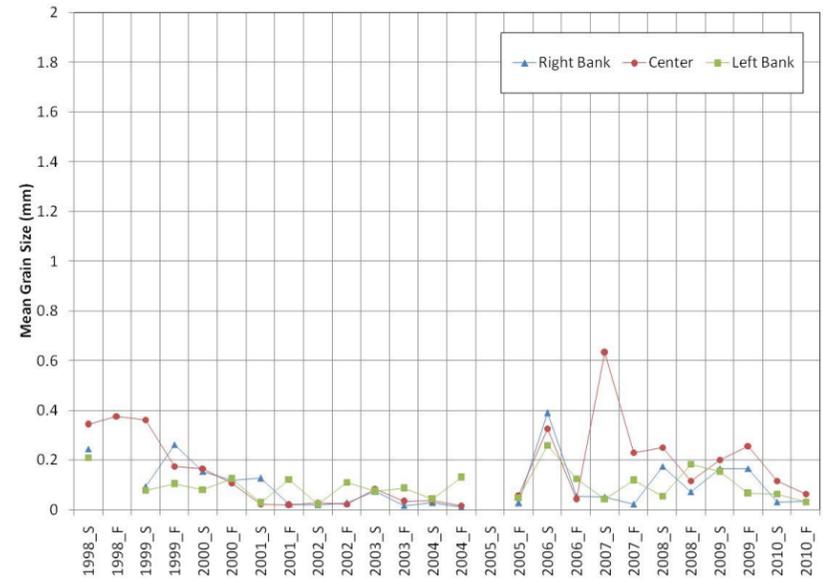




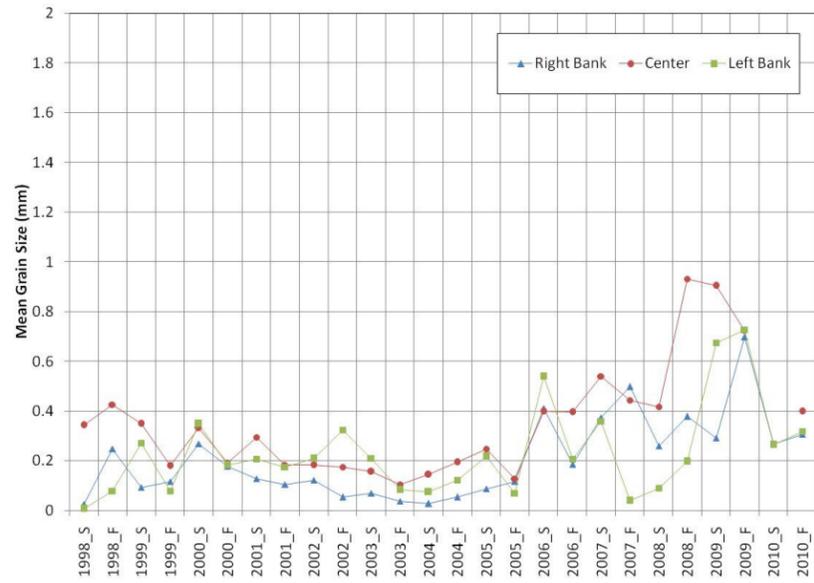
**GLC-3**



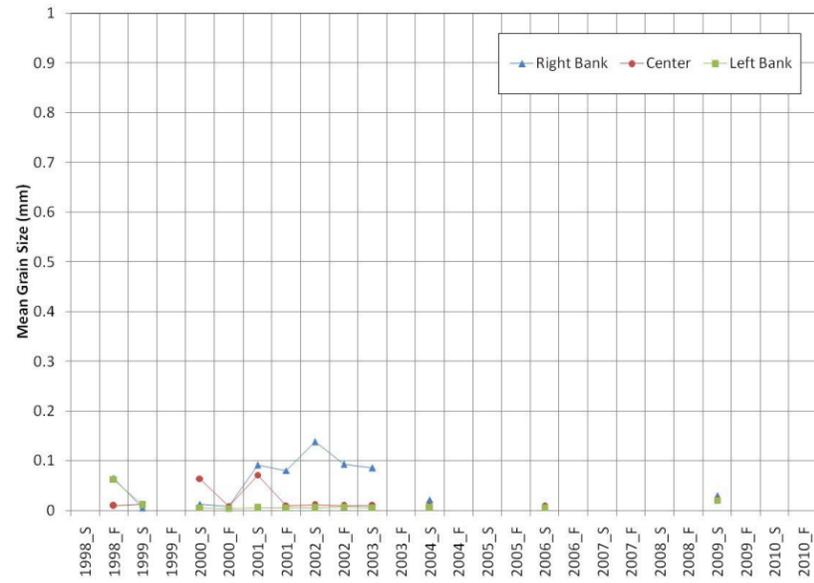
**GLC-4**



**GLC-5**



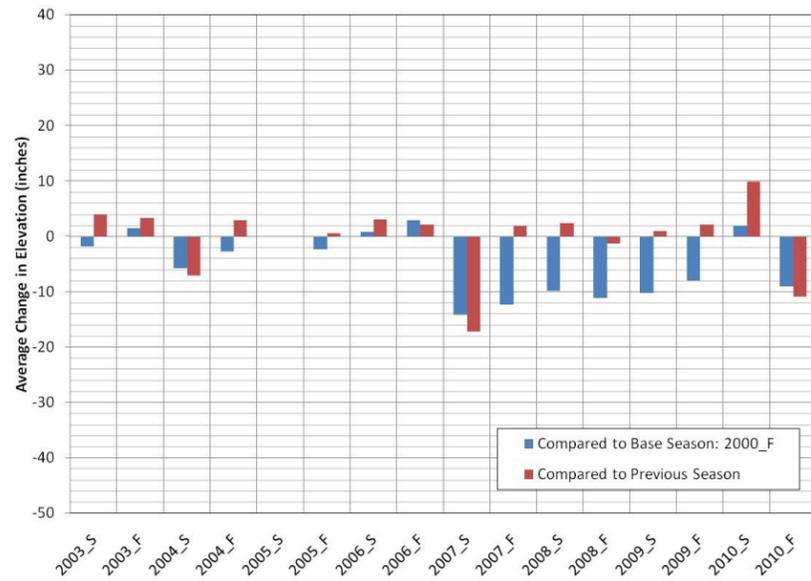
**DC-1**



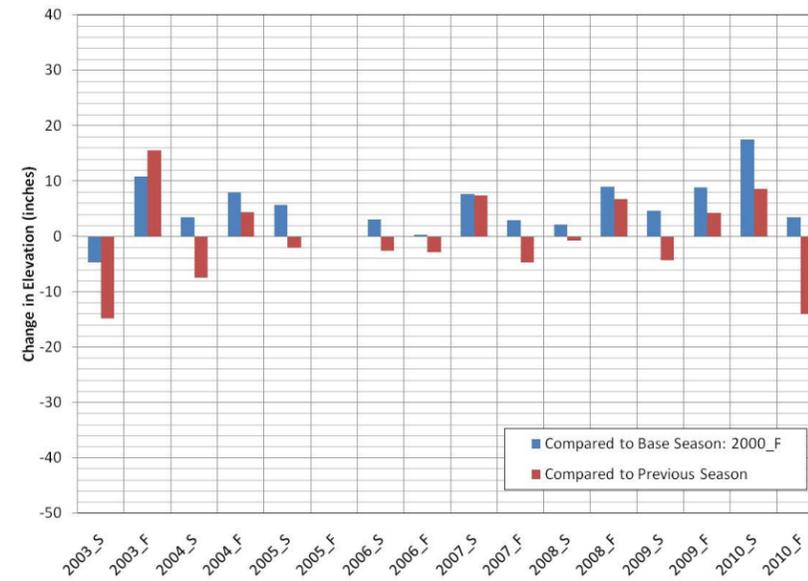
**MR-1**



# Appendix T: Average Channel Bed Change in Elevation



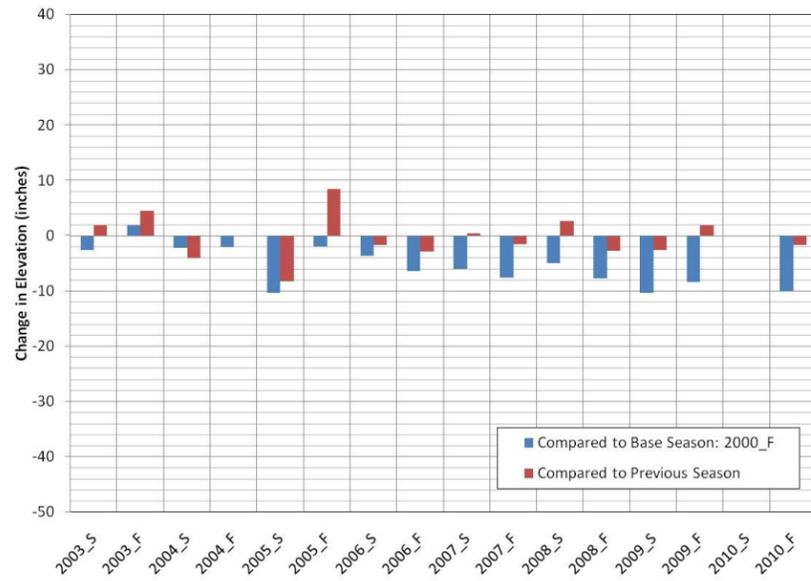
OR-1



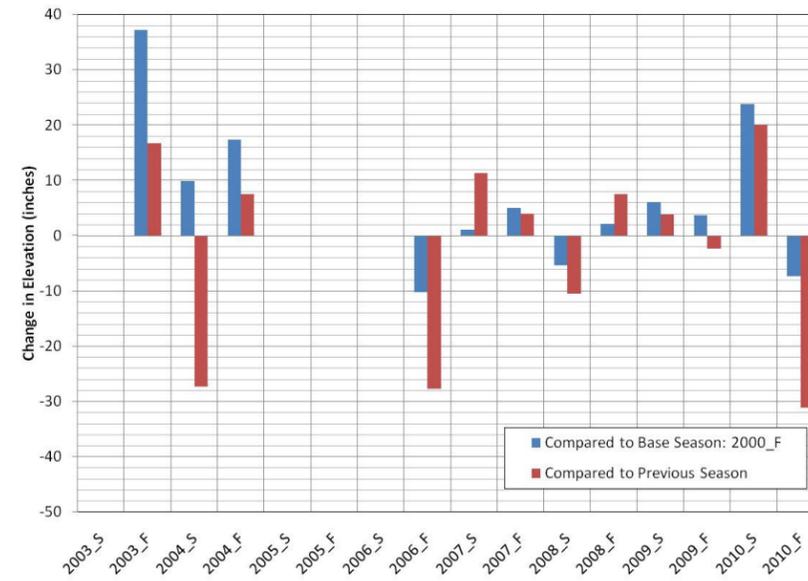
OR-2



OR-3



OR-4

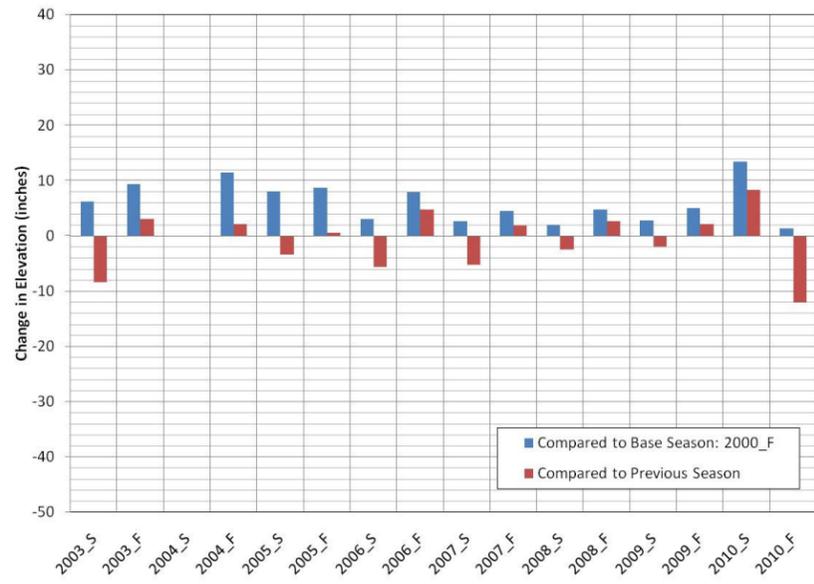


OR-5

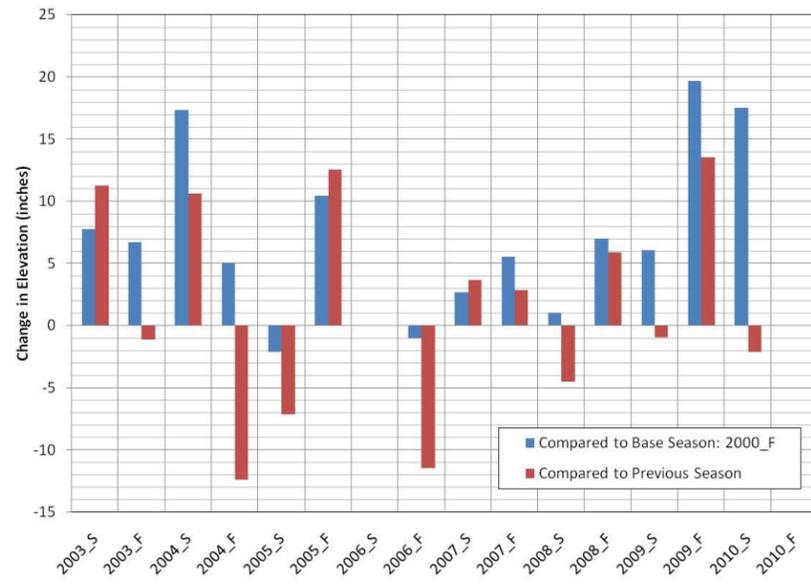


OR-6

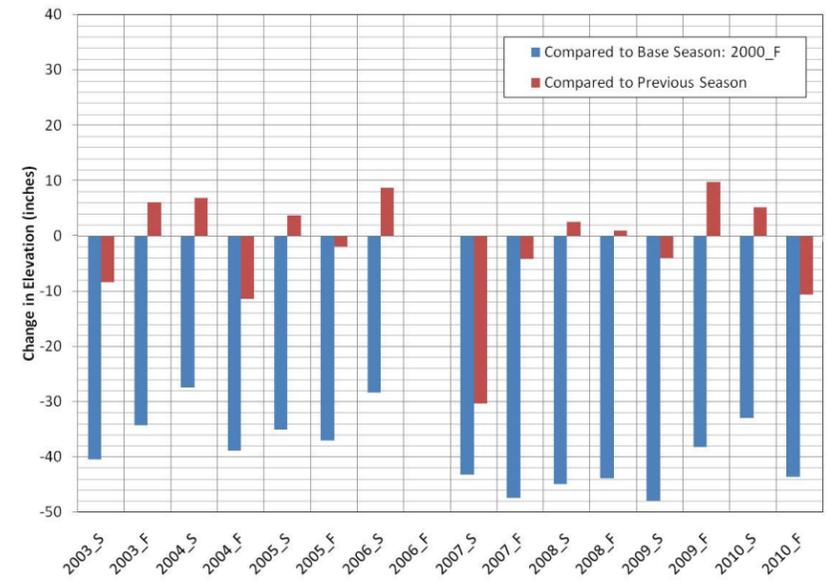




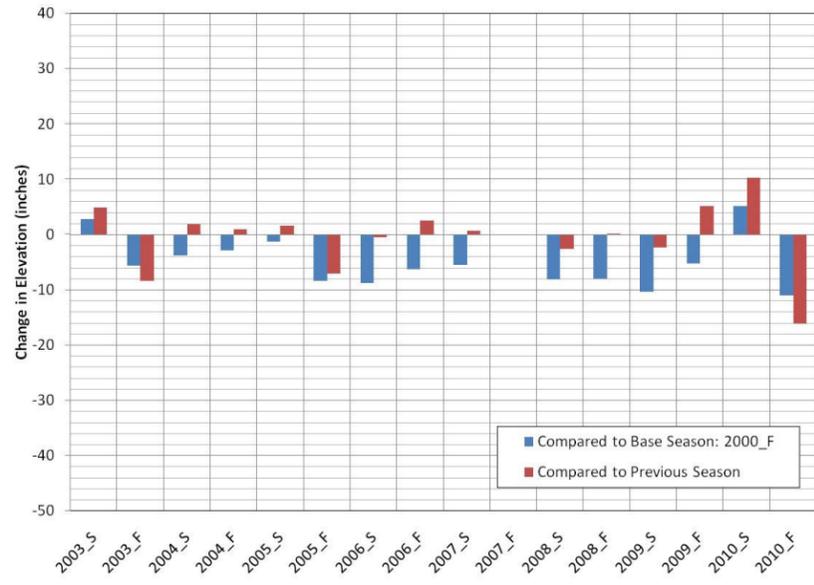
OR-7



OR-8



OR-9



GLC-1A



GLC-1B

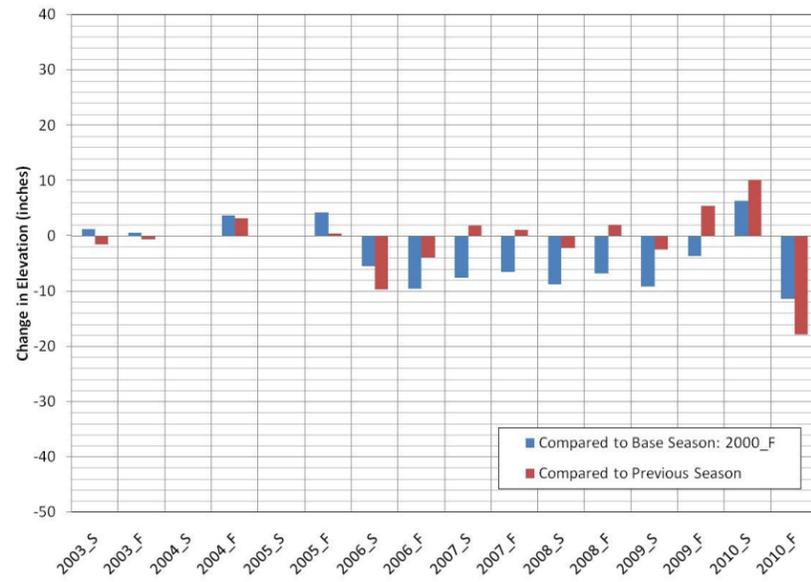


GLC-2





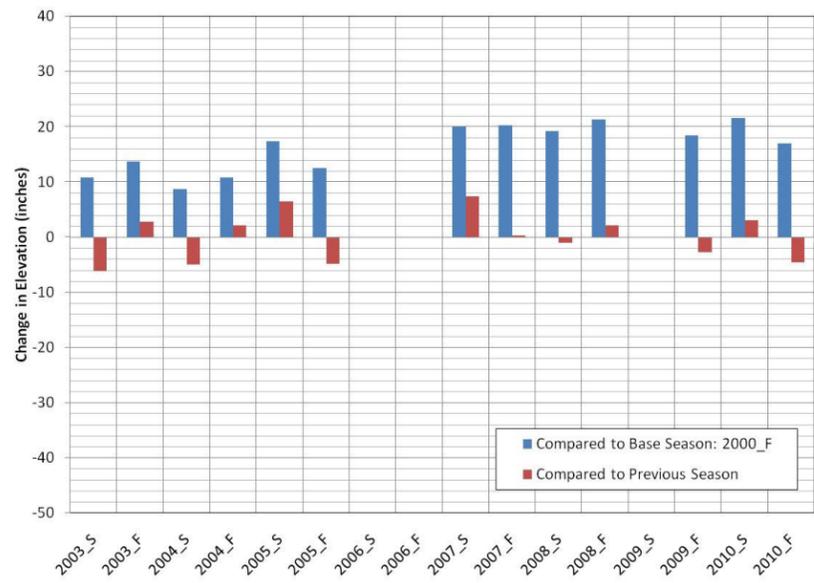
GLC-3



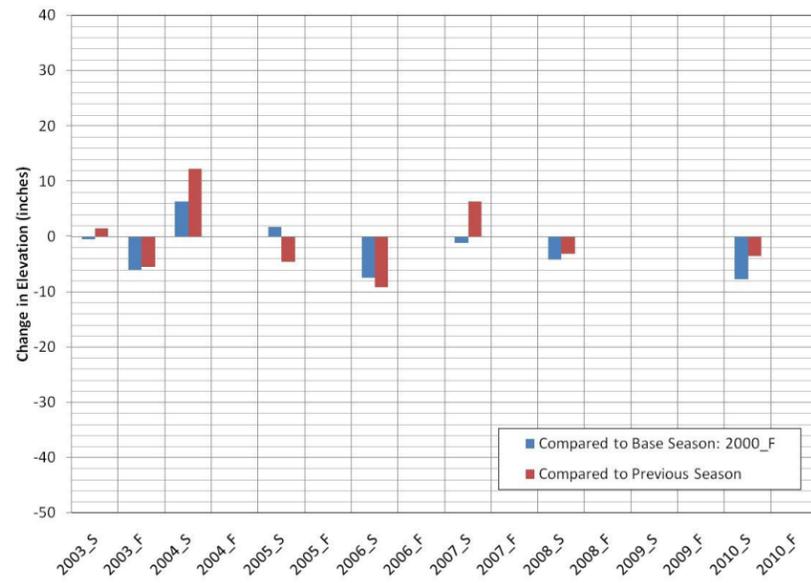
GLC-4



GLC-5



DC-1



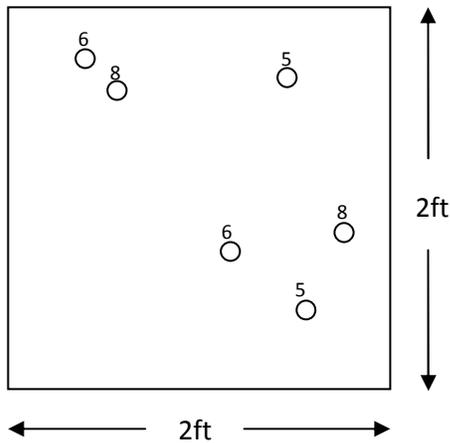
MR-1



# Appendix U: Average Elevation Sample Calculations

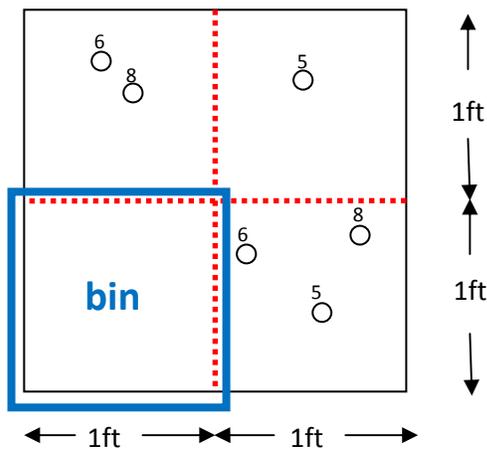
Below is a sample of the process used in determining the average elevation. To reduce the complexity and confusion of this sample, actual data will not be used. For this example a two foot by two foot (2ft x 2ft) study area will be used with 6 elevation data points. The 2ft x 2ft study area is analogous to the 100ft by 200ft site areas. The six data points used here represent the measured depth data and the NAVD88 elevation data.

Initial Site Area:



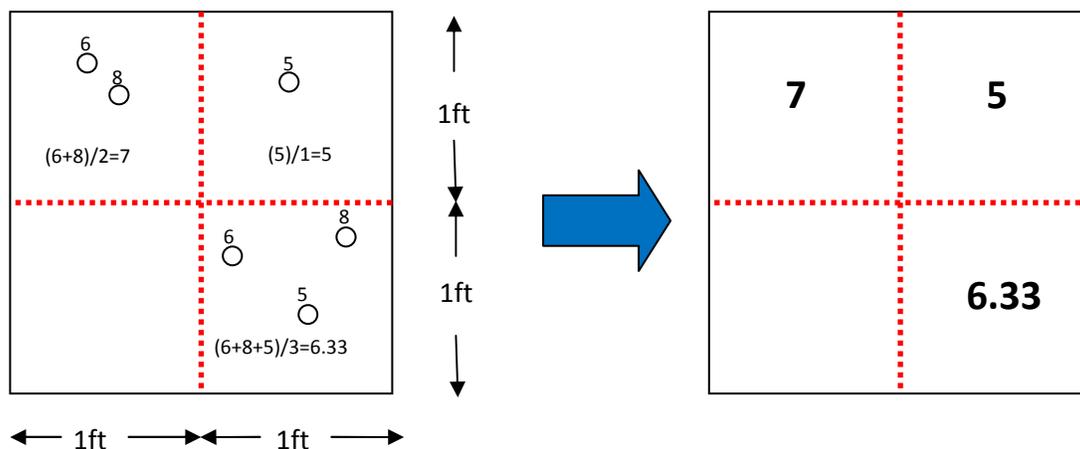
Step 1:

Apply a one square foot grid to study area. Each square foot is considered a bin.



Step 2:

All the values in each bin are averaged, so that each bin only has one value.



Step 3:

All of the bins with data are averaged to determine the average elevation. For this example, there are three bins with data, the average of those three bins will represent the average elevation for the entire 2ft x 2ft area.

Sample Calculation:

$$\text{Average Elevation} = \frac{(7 + 5 + 6.33)}{3}$$
$$\text{Average Elevation} = 6.11$$

