



Lake Solano Sediment Study – 2013 Update

February 2014



A. EXECUTIVE SUMMARY

A bathymetric survey of Lake Solano was conducted at the end of 2012, to determine the rate and location of sedimentation in the lake. The 2012 bathymetric survey was compared to the prior survey which was completed in 1997 by Northwest Hydraulic Consultants, Inc. (NHC) and documented in NHC's 1998 report titled Lake Solano Sediment Removal and Management Study. The purpose of this updated sediment report is to document existing conditions in Lake Solano after a long-term period of no flushing flows (identified as $Q \geq 4,000$ cfs in the NHC Study).

For the updated 2012 Lake Solano cross sections, extensive sedimentation was measured at the confluence of Pleasants Creek and in front of the Putah Diversion Dam. NHC's 1998 study noted extensive sedimentation at both of these locations, but also at the confluence of Proctors Draw.

For lake volume, the 2012 bathymetric survey showed that the total volume of Lake Solano was 633 acre-feet compared to 740 acre-feet in 1997. When comparing only the surveyed reach of Lake Solano (Pleasants Valley Road Bridge to the Putah Diversion Dam), the total volume in 2012 was 353 acre-feet compared to 460 acre-feet in 1997. The result is a 23% reduction in lake volume between the 2012 and 1997 survey. Over the 1973 – 2012 time period, this same section of Lake Solano decreased in volume from 626 to 353 acre-feet, a 43% reduction.

In looking at the hydrology of Lake Solano, the watershed is a “boom or bust” system where either the system experiences very high flow rates for almost all flow classifications, or the system experiences no flow rates above 1000 cfs. The system also experiences long dry or wet periods, often extending over several years. For the current study period (1997 – 2012), the hydrology consisted of 3 wet years, 3 moderate years, and 9 dry years. Furthermore, Lake Solano experienced overall net deposition across the entire lake, with the most significant deposition occurring at or immediately downstream of the Pleasants Creek confluence.

From 1973 – 2012 a total of 5 bathymetric / transect surveys were completed, allowing the period to be broken up into 4 distinct study periods. While the results are somewhat inconsistent, several key conclusions can be made.

- In very wet years (i.e. 1978-1983) scouring does occur throughout most of Lake Solano.
- In more moderate time periods, consisting of both wet and dry years, sediment deposition is occurring in Lake Solano.
- The sections of Lake Solano at or immediately downstream of the confluence of Pleasants Creek and Proctors Draw experience the greatest overall rate of sedimentation, but often not simultaneously.
- The lake appears to be in a state of net deposition rather than “dynamic equilibrium”.

Based on the recent bathymetric survey done on Lake Solano in 2012, many of the same trends that were concluded in NHC's 1998 study hold true today, with some important exceptions described above.

B. INTRODUCTION

B.1. Background

The Solano Project was constructed in the 1950's by the United States Bureau of Reclamation (USBR) to meet water needs for agriculture, municipal and military facilities within Solano County. The major physical facilities of the Solano Project include Monticello Dam impounding the 1.6 million acre-foot Lake Berryessa, the Putah Diversion Dam and the Putah South Canal. The USBR owns the Project and the Solano County Water Agency contracts with the USBR to maintain and operate the facilities. The Solano Irrigation District (SID) provides operating staff for the project. In addition, the SID owns and operates the 11.5 MW Monticello Powerhouse at Monticello Dam through which routine water releases from Lake Berryessa are made to meet downstream demands in the Putah South Canal and Putah Creek.

The Putah Creek watershed, with a drainage basin of 576 square miles above Monticello Dam, is the main source of water for the Solano Project. The Putah Diversion Dam, creating Lake Solano, is located on Putah Creek approximately six miles downstream of Monticello Dam. The drainage basin for Lake Solano downstream of Monticello Dam is approximately 38 square miles. Lake Solano is about 2.2 miles long with an original capacity of approximately 890 acre-feet for normal full pool at elevation 131.25 feet (NGVD29). The original "active storage" of the reservoir was estimated to be 440 acre-feet above elevation 126.25 feet.

The 1998 NHC Study was the last sediment study and bathymetric survey done for Lake Solano. The study concluded that since its construction, Lake Solano has accumulated approximately 257 acre-feet of sediment, a 29% loss of its initial capacity of 890 acre-feet. Furthermore, approximately 264 acre-feet of active storage capacity remain (176 acre-feet lost) between elevations 126.25 and 131.25 feet. The drainage basin downstream of Monticello Dam (i.e. Interdam Reach) is the primary source of sediment deposited into Lake Solano. To date, neither significant dredging of Lake Solano, nor any significant watershed or sediment source control programs have been implemented.

B.2. Current Concerns

Many of the concerns associated with Lake Solano in 1998 still remain issues today. These concerns include the abundance of aquatic vegetation, sedimentation, turbidity, screen cleaning, sedimentation in the Putah South Canal, and the annual canal cleanout. One major concern in 1998 that has not been encountered again, are bad taste and odors, which are primarily a result of a significant blue-green algae blooms. Many of the issues listed above are a result of sediment transport and deposition into both Lake Solano and the Putah South Canal.

B.3. Purpose

The purpose of this study is to document the amount and rate of sedimentation in Lake Solano from 1997 until present (2012). Furthermore, the 1998 NHC study determined that Lake Solano was in a state of dynamic equilibrium with respect to sedimentation and degradation. NHC determined that during years of low flow, Lake Solano would accumulate sediment, which would be flushed out during years of

high flow. NHC classified these flushing flows as $Q \geq 4,000$ cfs. This study aims to verify if Lake Solano is still in a state of dynamic equilibrium, and document existing conditions after a period of six years with no flushing flows.

C. EXISTING CONDITIONS

C.1. Bathymetric Survey

Traditional survey methods consisting of a total station and standard survey rod with reflective prism were used to survey Lake Solano. All surveying was done by SCWA personnel, primarily with the help of student interns and 1-2 senior water resource engineers. The surveying was done periodically between 10/30/2012 – 1/22/2013 for a total of 13 days of surveying. One additional day of surveying was done on 12/18/2013 for upper Lake Solano above the Pleasants Valley Road Bridge. No substantial flood flows occurred in Lake Solano during this time period. The USGS Gage 11454000 at Putah Creek did record several hydrologic events in December 2012, but with flows less than 600 cfs, indicating stable bathymetric conditions during this time period.

For the survey details, the total station was set up at several key points along the edges of Lake Solano. Two people were then deployed in a canoe, with one person maneuvering the canoe and one person holding the fiberglass survey rod, so that topographical points could be measured and collected by the Total Station. A handheld GPS unit was used to place survey flagging at start and end points along historic cross sections, for the canoe to follow. The Total Station was periodically moved to strategic line of sight locations, so that all of Lake Solano could be surveyed. The survey extent was from the Pleasants Valley Road Bridge downstream to the Putah Diversion Dam. The banks of Lake Solano were surveyed several feet above the water surface to reflect high water conditions, with the exception of the north bank. Along the north bank, topographic points were collected as far north as possible, before reaching a wall of thick riparian vegetation, primarily occurring in the lower half of the Lake. The main island of Lake Solano (near Proctors Draw) was also coarsely surveyed, primarily due to line of sight issues, as well as dense groves of poison oak and blackberry. Since much of this area is at or above the maximum water surface of Lake Solano, this level of effort was considered sufficient for the study.

A total of two USBR benchmarks at the Putah Diversion Dam were used to establish the horizontal and vertical control of the survey. The USBR brass disk, labeled SP 1-12 located near Gate 7 and the USBR brass disk, labeled 413-222-1 near the PSC Headwork Gate were used for this survey. The survey data used was from a recent survey by Laugenour and Meikle dated April 28, 2008. The Laugenour and Meikle data used a Horizontal Datum of NAD 83, State Plane Zone 2, and a Vertical Datum of NAVD 88. A copy of their benchmark sheet is attached to this report in Figure 4. For the Lake Solano Bathymetric Survey, the initial State Plane Coordinates were used to setup the survey, and the remaining topographical points were done using ground not grid based coordinates.

During the course of the survey there were several key issues, primarily: (i) overly thick tules, (ii) challenges with line of sight, and (iii) dense coverage of poison oak and blackberries. When the survey was started in late October, the tules were essentially impenetrable. As the winter progressed the tules began to die back, where the rodman could climb on top and slowly push through the tules.

Nevertheless, this was a very slow and inefficient process. The second challenge was finding good line of sight, which is needed when using a total station. This was primarily an issue for the upper 2/3 of the lake. From the Pleasants Valley Road Bridge down to the island, the total station was setup alternating between the left and right banks for each cross section, so that points could be collected on the north and south banks. While the middle of the lake had good line of sight, the shallow edges and banks were the most difficult to see, primarily because of thick over hanging tree cover and vegetation along the banks. At the island, the total station had to be setup on both the south bank (along Putah Creek Road) and near the north bank, behind the island, so that line of sight could be maintained. The last issue was associated with dense coverage of poison oak and blackberries on the island near Proctor's Draw. Blackberries were thick throughout the island, making access to and along the island quite challenging.

As a side note, other survey methods were considered for the Lake Solano survey. The Agency investigated the use of echosounders, and field tested a unit from BioSonics, an industry leader in this field. Field testing showed that this method was not feasible in Lake Solano because the aquatic vegetation was so thick in the lake, even during the winter months. The next consideration was for the Agency to rent a high accuracy GPS-RTK system. Unfortunately, the rental company uses a Sprint cellular network which is not available in the Lake Solano area. Furthermore, there was some concern about taking a GPS-RTK unit out over the water, as the unit is not water proof, and significant damage could occur if the unit was accidentally submerged. In the end, a Total Station was determined to be the best method available to survey the lake.

The complete bathymetric survey of Lake Solano with plan and profile views is shown in Figures 1 – 3 in the Appendix. The plan and profile views show key locations such as the Putah Diversion Dam, confluence of Pleasants Creek, Pleasants Valley Road Bridge, and the surveyed cross sections. As described above, the vertical datum for the bathymetric survey as well as the plan and profile views is NAVD 88. All other figures in this report use the older vertical datum of NGVD 29.

C.2. Cross Sections

Cross section plots were developed for a total of 14 transects of Lake Solano, with 13 transects between the Pleasants Valley Road Bridge and the Putah Diversion Dam, and one transect 1,550-feet upstream of the Pleasants Valley Road Bridge. The cross section plots are shown in Figures 7 – 20 at the end of this report. The location of the lower Lake Solano (between the Pleasants Valley Road Bridge and the Putah Diversion Dam) transects can be found in the plan and profile views in Figures 1 – 3. Of the 14 transects done, 10 overlap with historic cross sections (Cross Sections K, L, M, N, O, P, Q, R, S, T) while the remaining 4 sections (Cross Sections 6, 7, 8, 9) are historic sections where sediment samples were collected, but no historic bathymetric data. For the historic cross sections (Figures 7 – 16) both the 1997 and 2012 surveys are displayed.

In comparing the 2012 to the 1997 surveys, there were two cross sections in Lake Solano that showed substantial amounts of sediment deposition. The first section was Cross Section K (Figure 7), located just upstream of the Putah Diversion Dam. In comparison to the 1997 survey, this section shows deposition up to 5-ft deep, primarily along the south side directly in front of the Putah Diversion Dam.

Surprisingly, the north side of Section K, which is located in an area of tules and dense vegetation, showed no significant difference between the two surveys. The second cross section that showed significant sediment deposition was at Cross Section P (Figure 12), located at the confluence of Pleasants Creek. In comparison to the 1997 survey, this section shows sediment deposition up to 6-ft deep, over most of the cross section, with Pleasants Creek being the main sediment source. The remaining cross sections displayed very little difference between the 1997 and 2012 surveys.

The cross section changes and resulting sediment deposition for 2012 were similar to the trends observed in 1997. In NHC's study, significant deposition was noted just upstream of the Putah Diversion Dam, at the confluence of Proctors Draw, and at the confluence of Pleasants Creek. The only difference between the 1997 and 2012 sediment trends, was that in 2012 there was no significant sedimentation at Cross Sections N and O (Figure 10 and 11), which are located at the confluence of Proctors Draw. The results were somewhat surprising, as both Sections N and O are densely covered with tules, significant backwater areas, and likely spots for deposition. However, the survey results clearly show no significant sediment deposition occurred between the 1997 and 2012 surveys.

C.3. Lake Volume

Table 1 lists the incremental volume of Lake Solano between each of the historic cross sections (Sections K, L, M, N, O, P, Q, R, and S) for surveys done from 1956 – 2012. Data shown for the 1956 – 1997 time period was taken from the 1998 NHC Study. For the recent 2012 data set, the volumes between each section were calculated with AutoCAD Civil 3D, using the Contour Area Method. The resulting volumes for the 2012 survey are shown in Table 1. As a note, the volume of water in Lake Solano upstream of the Pleasants Valley Road Bridge was assumed to remain constant at 280 acre-feet. Prior surveys as shown in the NHC report and more recently by SCWA continue to show no significant changes in this upper reach.

During the period of this study (1997-2012), Lake Solano went through a net aggradation period, with volume reductions (i.e. sediment deposition) occurring in every section of the lake from the Pleasants Valley Road Bridge downstream to the Putah Diversion Dam. As shown in Table 1 for the 2012 survey, there was a reduction in lake volume for all 9 lake segments. The volume difference between the 1997 and 2012 surveys is also shown in Table 1. For 2012, the total volume of Lake Solano was 633 acre-feet compared to 740 acre-feet in 1997, reflecting a volume loss of 107 acre-feet. When focusing on Lake Solano downstream of the Pleasants Valley Road Bridge, this accounts for almost a 25% reduction in lake volume (460 down to 353 acre-feet). In looking at the volume differences for each lake segment, Section P to Q had the most significant reduction of 33.5 acre-feet. Almost 1/3 of the sedimentation experienced in Lake Solano for the study period, occurred within this reach. Section P to Q is located at the confluence of Pleasants Creek, and clearly demonstrates that for this time period, Pleasants Creek was a significant direct source of sediment to Lake Solano. Just downstream of the Pleasants Creek confluence, Section O to P experienced the second most significant volume reduction of 19.2 acre-feet, again most likely due to Pleasants Creek. The last section with the most significant volume reduction was Section K to L with a reduction of 16.3 acre-feet. This section is located just upstream of the Putah Diversion Dam, and reflects the significant sedimentation that was measured at Cross Section K, just

upstream of the Diversion Dam. In summary, for the current study period Lake Solano experienced significant volume loss (i.e. sedimentation) at and below the confluence of Pleasants Creek and just upstream of the Putah Diversion Dam.

Using the 2012 bathymetric data, an updated elevation-capacity curve was created for Lake Solano between the Putah Diversion Dam and the Pleasants Valley Road Bridge. The elevation-capacity curve is shown in Figure 5, and includes both the 2012 and 1997 capacity curves. The 1997 capacity curve data was obtained from the 1998 NHC Study. The minimum and maximum normal operating elevations are also included in Figure 5. The elevation-capacity curves show that in the active storage range, the total active storage in 1997 was 275 acre-feet and in 2012 the storage decreased to 264 acre-feet, reflecting a decrease of 11 acre-feet in active storage.

C.4. Hydrology and Sediment Deposition

Hydrology and specifically flow rates are an important component when looking at sediment deposition. For Lake Solano, the USGS Station 1145400 on Putah Creek was used to determine the flow rate into Lake Solano. The USGS station is located a few miles upstream of Lake Solano but downstream of Monticello Dam. Table 3 is a list of the annual hydrology and frequency of flow events for Lake Solano for the years 1973 – 2012. For Table 3, flows were classified as $Q > 1000$, 2000, 4000, and 6000 cfs. The table lists both the number of days and the percentage of days for each flow classification. In reviewing the table, several key trends are apparent. First, Lake Solano is a “boom or bust” system, where either the system experiences very high flow rates for almost all flow classifications, or the system experiences no flow rates above 1000 cfs. Secondly, the system will typically go through either a long dry or wet period, often extending over several years.

Looking at Table 3, for the study period (June 1997 – Dec. 2012) Lake Solano experienced high flow events in 1998, 2004, and 2006. The 1997 flows were not included, as the high flow events occurred in the first half of 1997, which is outside of the current study period. The study period also experienced substantial dry periods in 2000 – 2003 and 2007 – 2012. More moderate years occurred in 1999, 2003, and 2005 where Lake Solano did observe flows > 1000 cfs, but with no flows exceeding 2000 cfs. In summary, for this study period, there were a total of 3 wet years, 3 moderate years, and 9 dry years.

In Table 2 average hydrology and sediment deposition rates were calculated for 4 study periods, primarily based upon when bathymetric or transect survey data was collected. For the 1973 – 1978 time period the hydrology appears to be similar but slightly lower than the most recent study period. The 1978 – 1983 time period shows extremely high flow values, and is the wettest of the 4 time periods. Furthermore, 1983 was a record wet year throughout California. The 1983 – 1997 was the driest of the 4 periods, with a total of 10 dry years, with wide spread drought occurring in California during the early and mid-1990s. For the 1997-2012 time period the hydrology was the second wettest of the 4 study periods, but is more complex by having both long wet and dry periods.

Besides hydrology, Table 2 shows the average amount of sedimentation in several reaches of Lake Solano, over the same 4 study periods. The results are somewhat inconsistent between study periods, but several key conclusions can be drawn. First, in very wet years such as the 1978 – 1983 time period,

Lake Solano did experience overall scouring through most of the reservoir. In more moderate time periods consisting of both wet and dry years, sediment deposition is occurring in Lake Solano. For the 4 study periods looked at, 3 of the time periods experienced net deposition, with only one time period experiencing net scour. Lastly, the sections of Lake Solano at the confluence of Pleasants Creek (Section O to Section Q) and Proctors Draw (Section M to Section O) experience the greatest rate of sedimentation, but not consistently. For example, during the 1983 – 1997 time period, the Proctors Draw area accumulated 53.3 acre-feet of sediment while the Pleasants Creek area only accumulated 15.8 acre-feet. For the 1997 – 2012 time period the reverse trend occurred where the Proctors Draw area accumulated 16.1 acre-feet and the Pleasants Creek area accumulated 52.7 acre-feet.

For the lower (Dam to Section M) and upper (Section Q to Section S) portions of Lake Solano, the sediment deposition rates appeared to be fairly consistent for 3 out of the 4 study periods. For the lower portion of Lake Solano, the overall deposition rate was fairly consistent ranging between 19 – 25 acre-feet of sediment for 3 of the study periods, with the one exception being the very wet 1978 – 1983 time period, which only had 3.4 acre-feet of deposition. The upper portion of Lake Solano was also fairly consistent ranging between -0.4 to 3.9 acre-feet of sediment for 3 of the study periods, but with the most recent time period of 1997-2012 experiencing a significant increase of 17.9 acre-feet of deposition. Upstream of the Pleasants Valley Road Bridge, Lake Solano does not appear to have accumulated any significant sediment deposition, as evidenced by periodic stable surveys at Section T. Nevertheless, future bathymetric surveys of Lake Solano should include Lake Solano above the Pleasants Valley Road Bridge.

Lastly, Figure 6 shows the total volume of Lake Solano for 1973 – 2012. Over a period of almost 40 years the lake has continued to decrease in volume, with the exception of the very wet 1978 – 1983 time period. While the prior 1998 NHC study indicated that Lake Solano was in a “dynamic equilibrium condition” the current bathymetric data seems to show that the lake is continuing to experience sedimentation. However, some caution should be applied with the overall trend, as there have only been 5 transect surveys done over the last 40-years, covering periods of both wet and dry conditions. More frequent bathymetric and transect surveys should be done, especially at the end of long dry and wet periods.

D. CONCLUSIONS

Based on the recent Lake Solano bathymetric survey done in December 2012, many of the same trends that were concluded in NHC’s 1998 study hold true today, with some important exceptions. For the updated 2012 cross sections, extensive sedimentation was measured at the confluence of Pleasants Creek and in front of the Putah Diversion Dam. NHC’s study noted extensive sedimentation at both of these locations, but also at the confluence of Proctors Draw. For the lake volume, the updated 2012 volume of Lake Solano was 633 acre-feet compared to 740 acre-feet in 1997. When comparing only the surveyed reach of Lake Solano (Pleasants Valley Road Bridge to the Putah Diversion Dam), the total volume in 2012 was 353 acre-feet compared to 460 acre-feet in 1997. The result is a 23% reduction in lake volume between the 2012 survey and NHC’s 1997 survey. Over the 1973 – 2012 time period, this same section of Lake Solano decreased in volume from 626 to 353 acre-feet, a 43% reduction.

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From 1973 – 2012 a total of 5 bathymetric / transect surveys were completed, allowing the period to be broken up into 4 distinct study periods. While the results are somewhat inconsistent, several key conclusions can be made:

- In very wet years (i.e. 1978-1983) scouring does occur throughout most of Lake Solano.
- In more moderate time periods, consisting of both wet and dry years, sediment deposition is occurring in Lake Solano.
- The sections of Lake Solano at or immediately downstream of the confluence of Pleasants Creek and Proctors Draw experience the greatest overall rate of sedimentation, but often not simultaneously.
- The lake appears to be in a state of net deposition rather than “dynamic equilibrium”.

Lastly, to further improve our understanding of Lake Solano and the sedimentation process, several recommendations are proposed below.

- Conduct more frequent bathymetric and transect surveys of Lake Solano, especially at the end of a long dry and wet periods.
- For future bathymetric surveys, include upper Lake Solano, upstream of the Pleasants Valley Road Bridge.
- During a large storm event or Glory Hole Spill, conduct velocity transects in Lake Solano using one of the Agency’s ADCP units. Compare the velocity measurements to the velocity thresholds described in NHC’s 1998 report. Ideally, the velocity transects should be done at several flow classifications, including flows greater than 4000 cfs to verify “flushing flows.”
- Revisit NHC’s Sediment Pass Through (SPT) Operating Plan, as described in the 1998 report. The Flush Mode should be considered for high flow regimes.

E. APPENDIX

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Table 1: Lake Solano Volume by Section

Table 2: Hydrology and Sediment Deposition

Table 3: Annual Hydrology (Frequency)

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Figure 2: Plan and Profile (2 of 3)

Figure 3: Plan and Profile (3 of 3)

Figure 4: PDD Benchmarks

Figure 5: Lake Solano Capacity Curve

Figure 6: Lake Solano Volume by Year

Figure 7: Cross Section K

Figure 8: Cross Section L

Figure 9: Cross Section M

Figure 10: Cross Section N

Figure 11: Cross Section O

Figure 12: Cross Section P

Figure 13: Cross Section Q

Figure 14: Cross Section R

Figure 15: Cross Section S

Figure 16: Cross Section T

Figure 17: Cross Section 6

Figure 18: Cross Section 7

Figure 19: Cross Section 8

Figure 20: Cross Section 9

Table 1: Lake Solano Volume by Section

	1956 Contour Area Method	April 1973 Burrell Method	Aug. 1978 Burrell Method	Oct. 1983 Burrell Method	June 1997 Cotour Area Method	Dec. 2012 Contour Area Method	Volume Difference (1997-2012)
Lake Segment:							
Dam to Section K	12.6	11.2	10.7	10.2	10.1	9.7	-0.4
Section K to Section L	81.8	80.9	72.0	70.2	60.2	43.9	-16.3
Section L to Section M	76.6	77.1	67.8	66.6	51.7	48.4	-3.3
Section M to Section N	86.1	83.5	74.0	75.1	54.0	43.1	-10.9
Section N to Section O	86.3	97.3	80.2	91.8	59.6	54.4	-5.2
Section O to Section P	106.4	112.3	82.4	94.5	76.3	57.1	-19.2
Section P to Section Q	67.9	76.1	60.9	63.5	65.9	32.4	-33.5
Section Q to Section R	47.9	48.3	46.6	46.4	42.3	33.3	-9.0
Section R to Section S	43.9	39.6	38.8	39.3	39.6	30.7	-8.9
Lake Volume:							
Diversion Dam to Pleasants Valley Road Bridge	610	626	533	558	460	353	-107
Upstream of Pleasants Valley Road Bridge	280	280	280	280	280	280	0.0
Total Volume	890	906	813	838	740	633	-107

Note: Lake capacity changes between 1956 and 1973 may be the result of channel dredging and road realignment.

Table 2: Hydrology and Sediment Deposition

	Period			
	April 1973 To Aug 1978	Aug 1978 To Oct 1983	Oct 1983 To June 1997	June 1997 To Dec 2012
Hydrology of Time Period:				
Percent Time Flows Exceeded 6000 cfs	0.15	1.89	0.15	0.54
Percent Time Flows Exceeded 4000 cfs	0.66	3.94	0.57	1.14
Percent Time Flows Exceeded 2000 cfs	2.40	7.57	1.23	2.06
Percent Time Flows Exceeded 1000 cfs	4.39	7.62	2.44	5.06
Sediment Deposition per Segment (Acre Feet):				
Dam to Section M	18.8	3.4	25.0	20.0
Section M to Section O	26.6	-12.7	53.3	16.1
Section O to Section Q	45.7	-14.7	15.8	52.7
Section Q to Section S	2.5	-0.4	3.9	17.9
Total Deposition during Period (Acre Feet)	94	-24	98	107
Deposition Rate (Acre Feet / Year)	17.43	-4.66	7.59	6.88
Percent Reduction in Lake Volume per Year:				
Dam to Section M	2.1	0.4	1.3	1.1
Section M to Section O	2.7	-1.6	2.5	0.9
Section O to Section Q	4.5	2.7	0.8	2.4
Section Q to Section S	0.5	-0.1	0.4	1.4

Table 3: Annual Hydrology (Frequency)

Study Period: January 1973 - December 2012								
Year	d > 6000	% > 6000	d > 4000	% > 4000	d > 2000	% > 2000	d > 1000	% > 1000
1973							11	3.0%
1974	3	0.8%	13	3.6%	39	11%	69	19%
1975					8	2.2%	17	4.7%
1976								
1977								
1978								
1979								
1980								
1981								
1982	13	3.6%	20	5.5%	26	7.1%	36	9.9%
1983	25	6.9%	62	17%	78	21%	117	32%
1984			1	0.3%	8	21%	23	6.3%
1985								
1986	5	1.4%	19	5.2%	29	8.0%	45	12%
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996					14	3.8%	39	11%
1997	9	2.5%	17	4.7%	27	7.4%	42	12%
1998	20	5.5%	25	6.9%	32	8.8%	78	21%
1999							48	13%
2000								
2001								
2002								
2003							10	2.7%
2004	7	1.9%	15	4.1%	21	5.7%	28	7.7%
2005							21	5.8%
2006	4	1.1%	25	6.9%	64	18%	103	21%
2007								
2008								
2009								
2010								
2011								
2012								

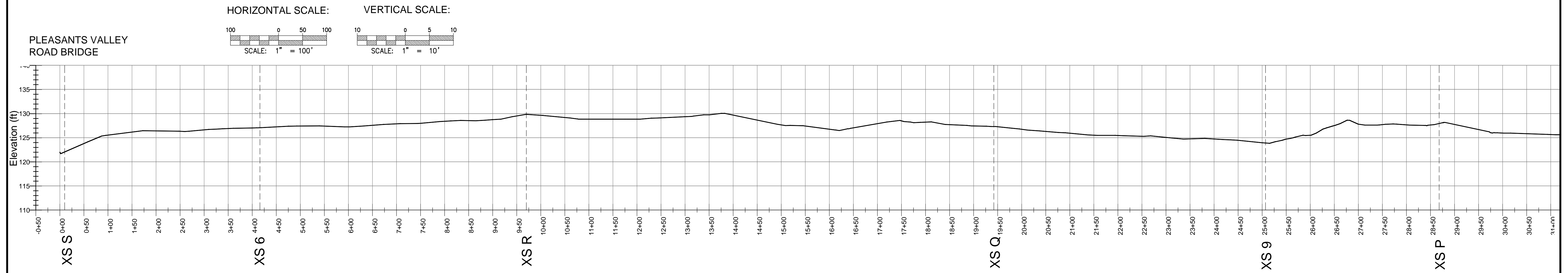
All flows (values) in cfs

All years are Calendar Year

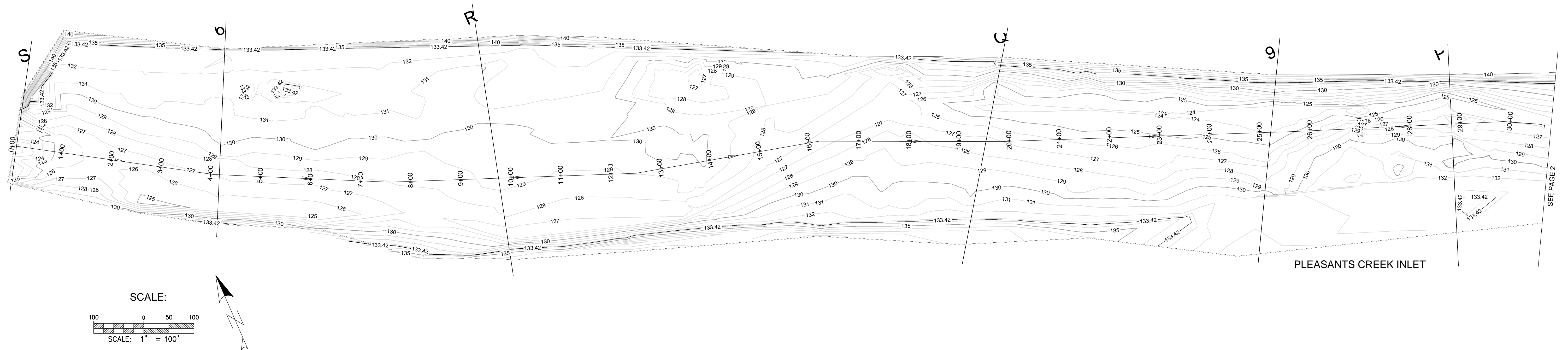
d - number of days average flow exceeds (value)

% - percentage of days average flow exceeds (value)

THALWEG PLAN/PROFILE, HISTORICAL SECTION LINES

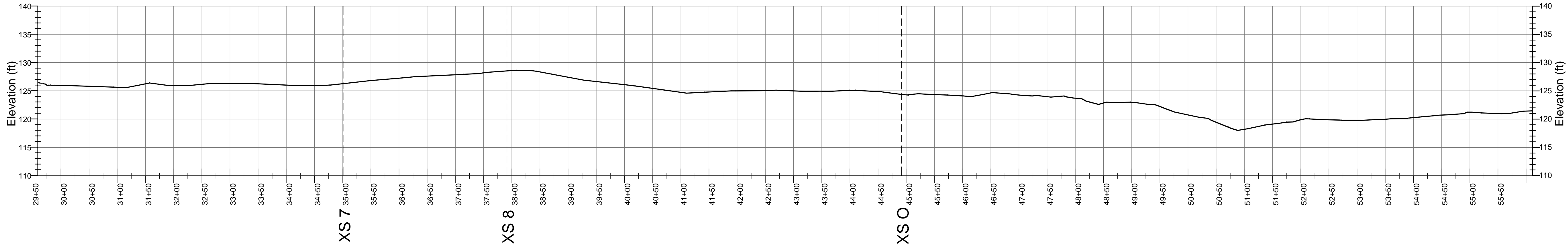
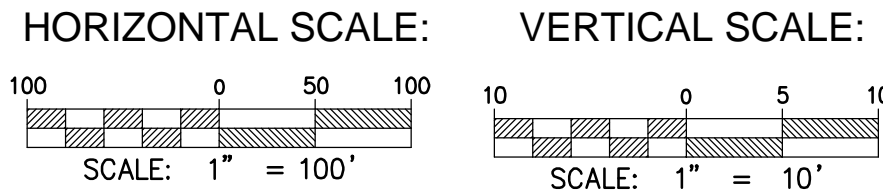


133.42' (NAVD88) is the Normal Operating High Water Elevation

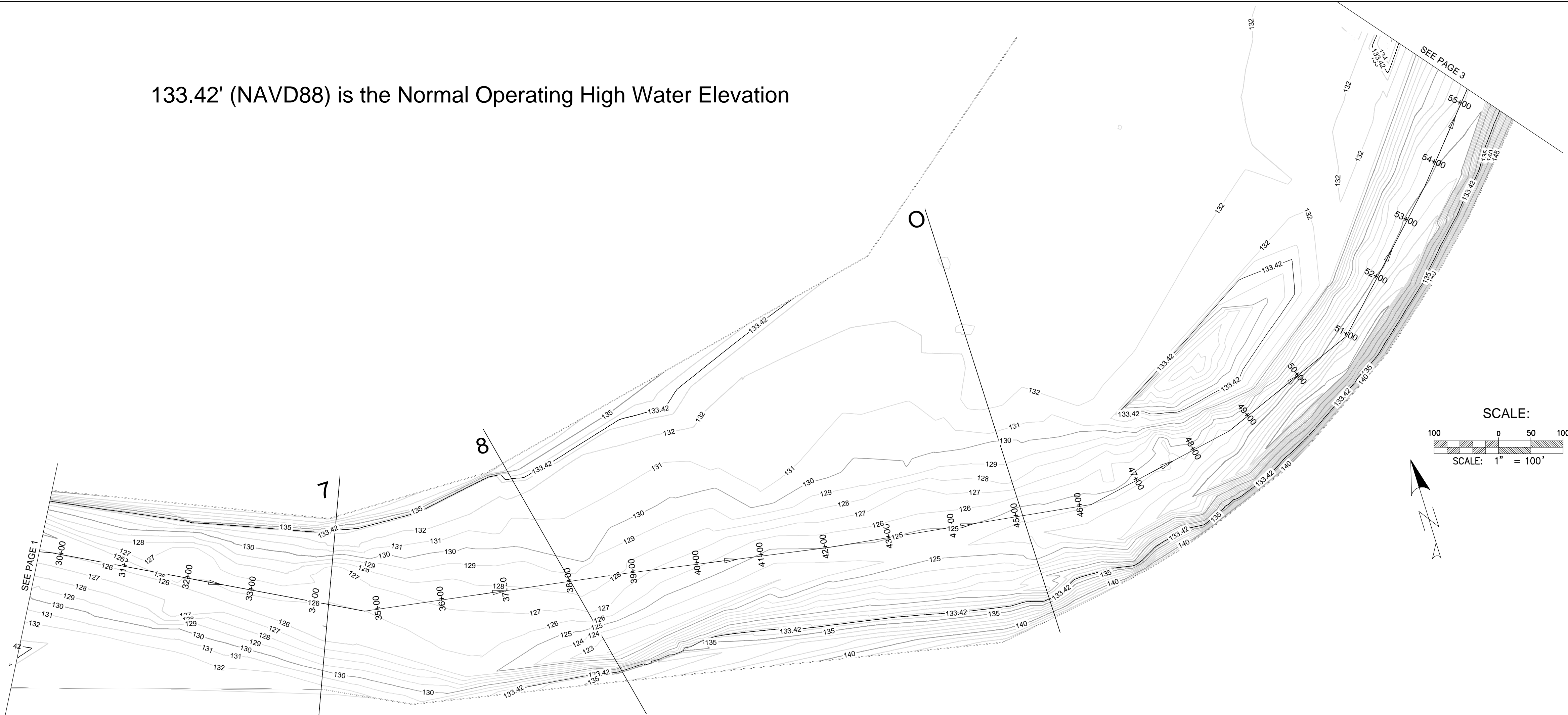


DESIGNED BY	AAR					COMMENTS:	 <p>SOLANO COUNTY WATER AGENCY 810 VACA VALLEY PARKWAY, SUITE 203, VACAVILLE, CA 95688 PHONE (707) 451-6090, FAX (707) 451-6099</p> 	<p><u>THALWEG PLAN/PROFILE</u></p> <p>SOLANO PROJECT LAKE SOLANO BATHYMETRY</p>	FIGURE:	SHEET
DRAWN BY	JB								FIGURE 1	1
CHECKED BY	AAR								DATE: 08-23-2013	OF
REV.	DATE	DESCRIPTION	BY	APP'D.					FILE NO. N/A	3

THALWEG PLAN/PROFILE, HISTORICAL SECTION LINES



133.42' (NAVD88) is the Normal Operating High Water Elevation

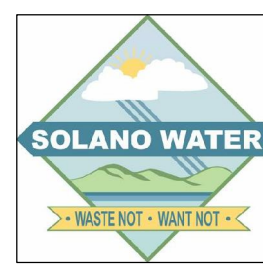


DESIGNED BY	AAR								
DRAWN BY	JB								
CHECKED BY	AAR								
		REV.	DATE	DESCRIPTION				BY	APP'D

COMMENTS:



SOLANO COUNTY WATER AGENCY
810 VACA VALLEY PARKWAY, SUITE 203,
VACAVILLE, CA 95688
PHONE (707) 451-6090, FAX (707) 451-6099



THALWEG PLAN/PROFILE
SOLANO PROJECT
LAKE SOLANO BATHYMETRY

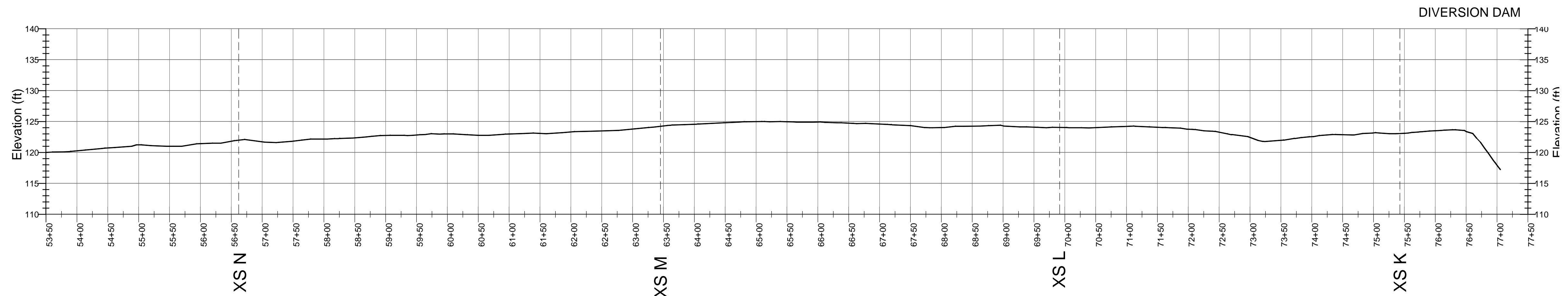
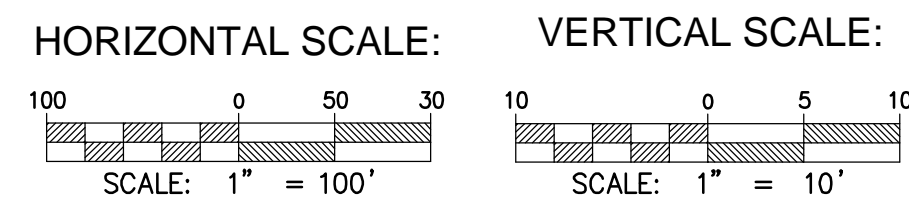
SOLANO COUNTY

CALIFORNIA

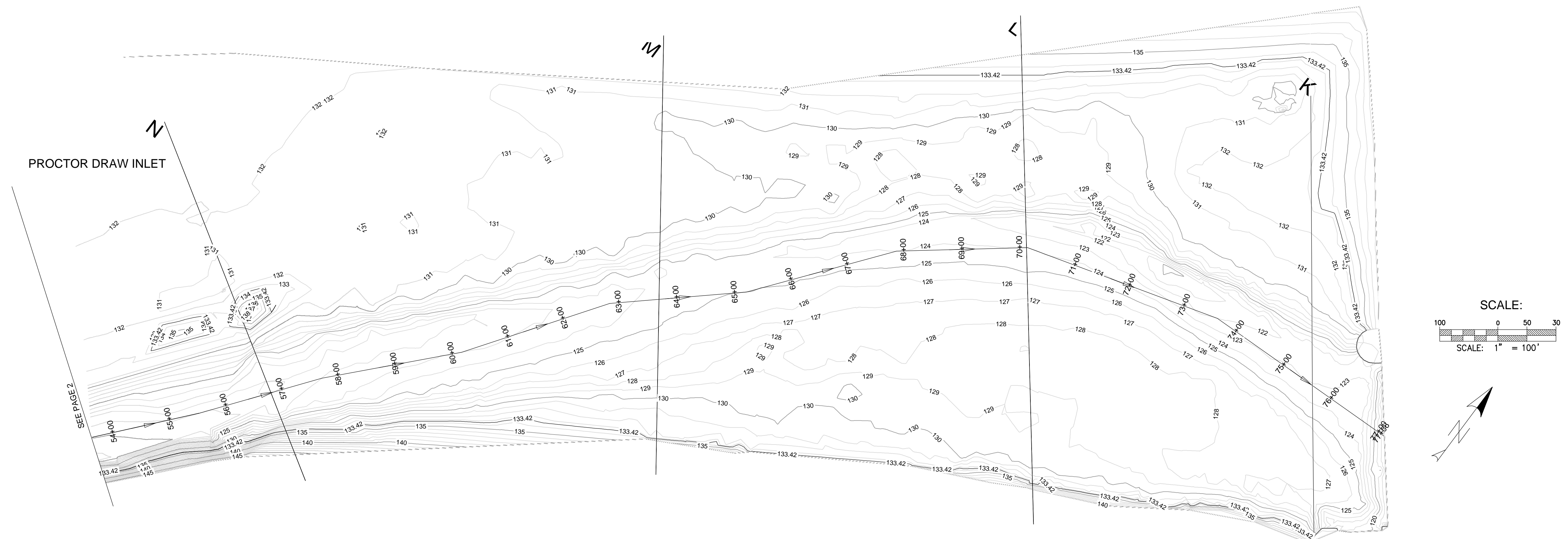
FIGURE:	
FIGURE 2	
DATE:	08-23-2013
FILE NO.	N/A

SHEET
2
OF
3

THALWEG PLAN/PROFILE, HISTORICAL SECTION LINES

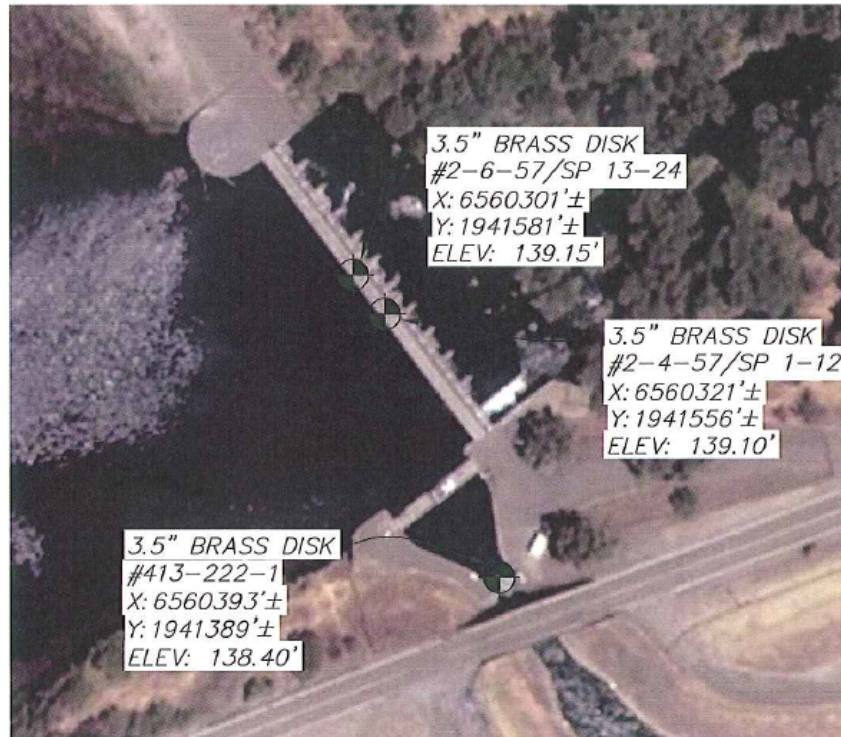


133.42' (NAVD88) is the Normal Operating High Water Elevation

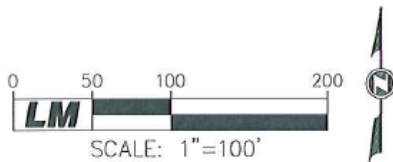


DESIGNED BY	AAR									COMMENTS:	 <p>SOLANO COUNTY WATER AGENCY 810 VACA VALLEY PARKWAY, SUITE 203, VACAVILLE, CA 95688 PHONE (707) 451-6090, FAX (707) 451-6099</p> 	<p><u>THALWEG PLAN/PROFILE</u></p> <p>SOLANO PROJECT LAKE SOLANO BATHYMETRY</p>	FIGURE:	SHEET
DRAWN BY	JB												FIGURE 3	3
CHECKED BY	AAR												DATE: 08-23-2013	OF
													FILE NO. N/A	3
		REV.	DATE	DESCRIPTION	BY	APP'D.								

Figure 4: PDD Benchmarks



HORIZONTAL DATUM: N.A.D. 83, 1.0'±
C.C.S. ZONE 2
VERTICAL DATUM: N.A.V.D. 88, 0.1'±



LM LAUGENOUR AND MEIKLE
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BENCHMARKS
PUTAH SOUTH CANAL OUTWORKS
FOR
SOLANO COUNTY WATER AGENCY
LOCATED IN PROJECTED SECTION 32
TOWNSHIP 8 NORTH, RANGE 1 WEST,
MOUNT DIABLO MERIDIAN,
SOLANO COUNTY, CALIFORNIA
SHEET 1 OF 1 APRIL 28, 2008

Figure 5: Lake Solano Capacity Curve

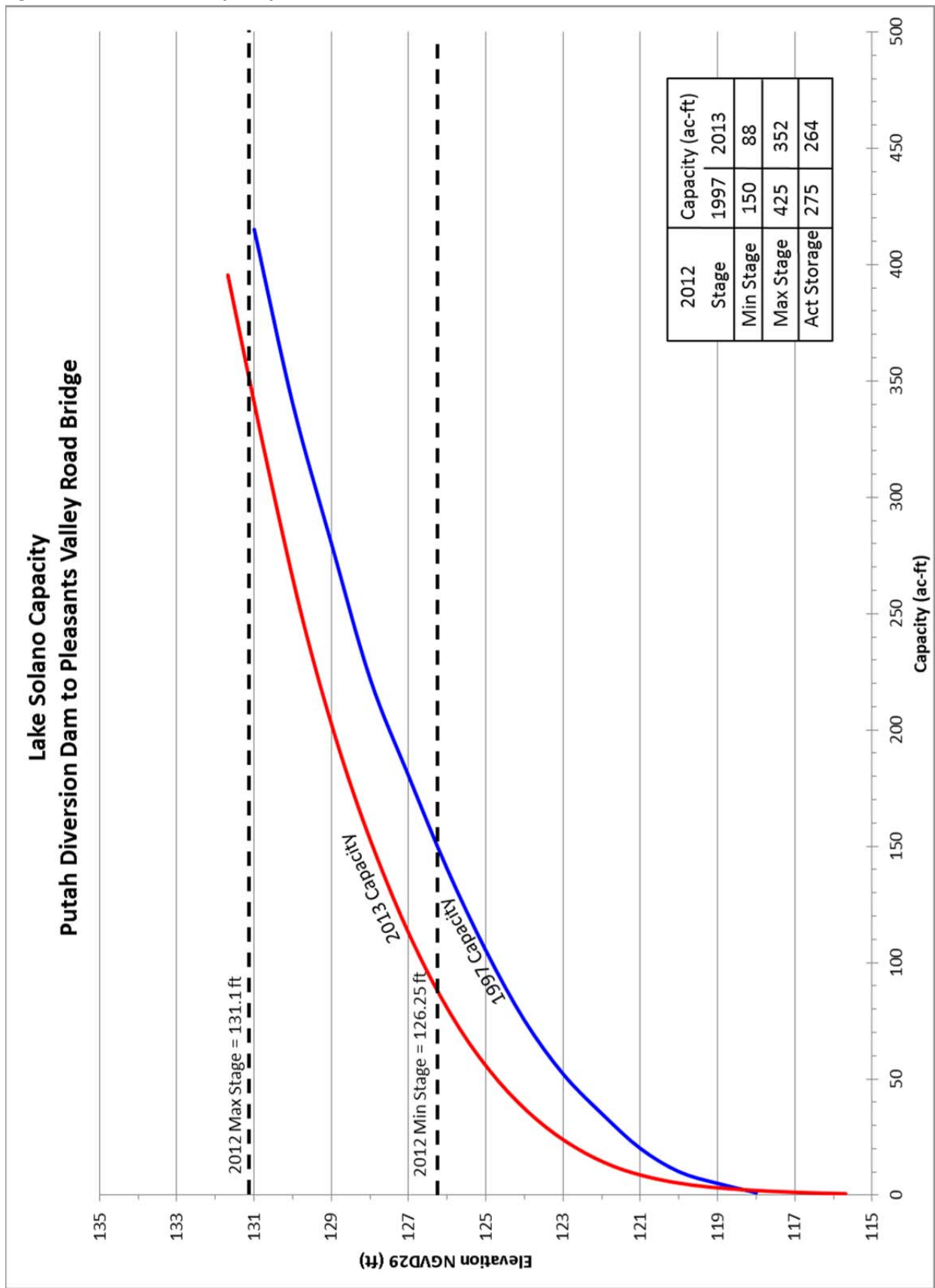


Figure 6: Lake Solano Volume by Year

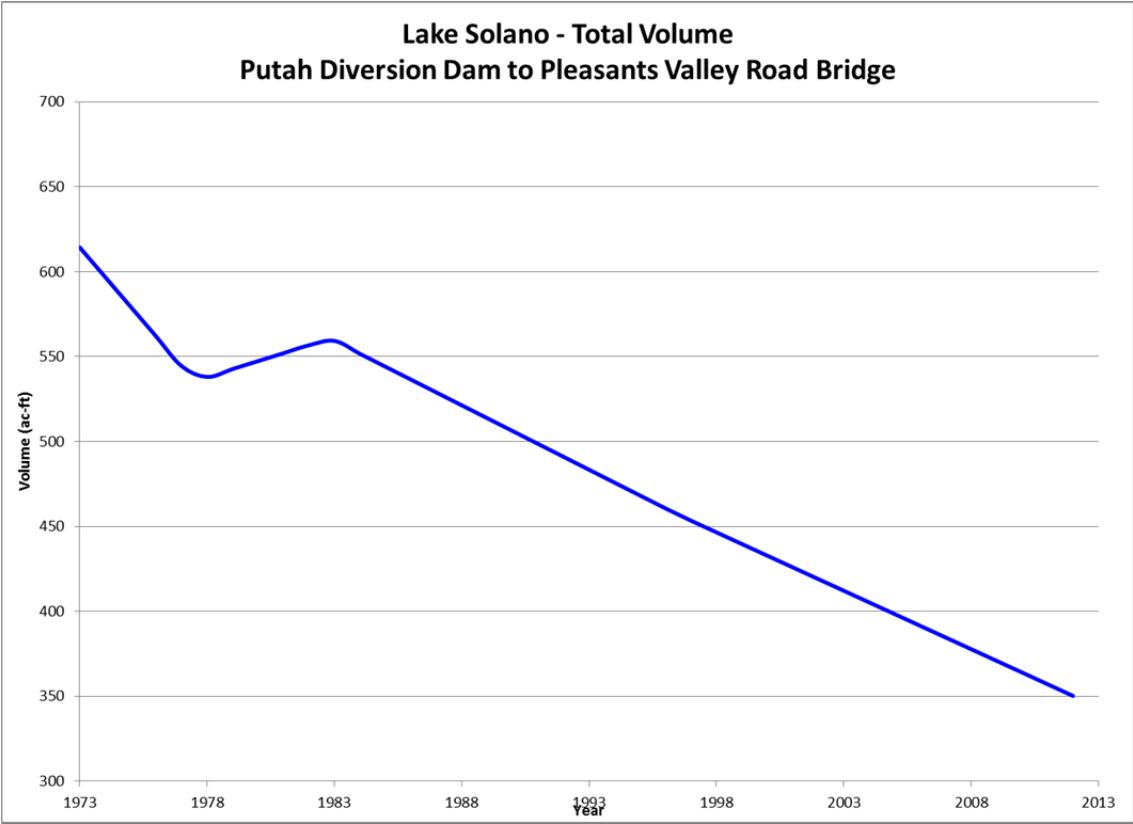


Figure 7: Cross Section K

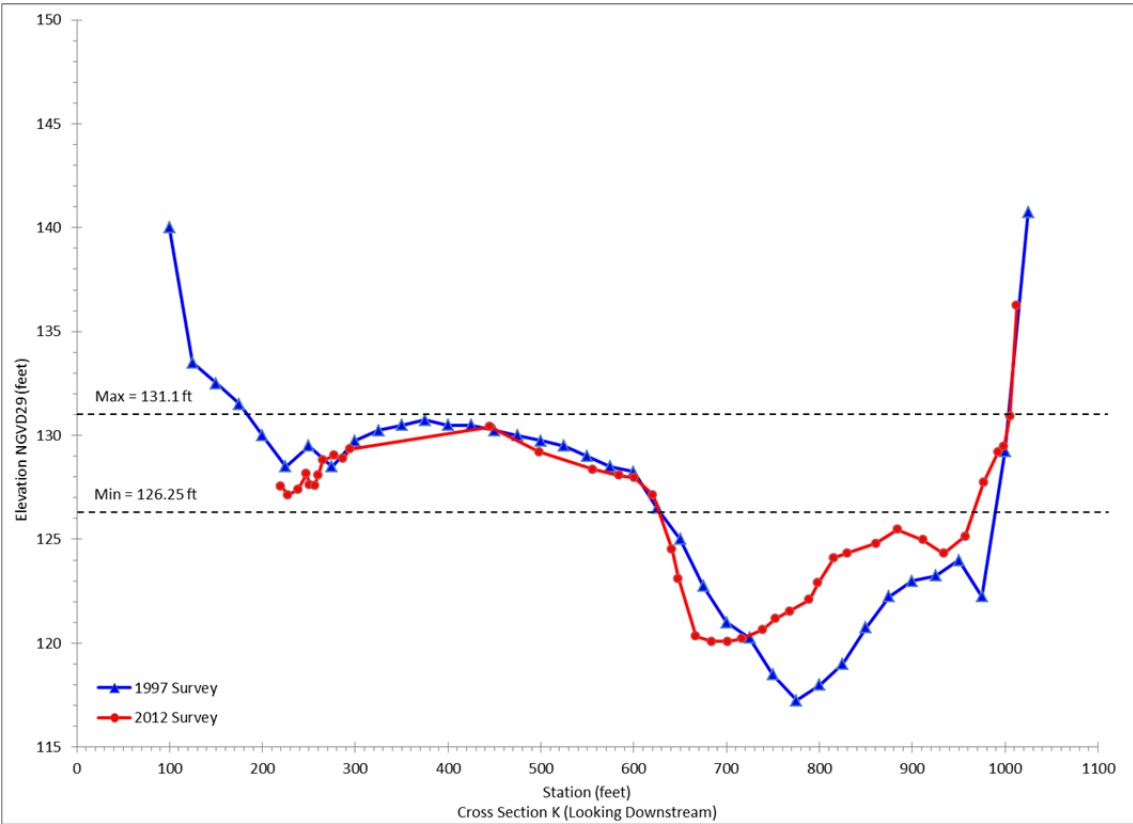


Figure 8: Cross Section L

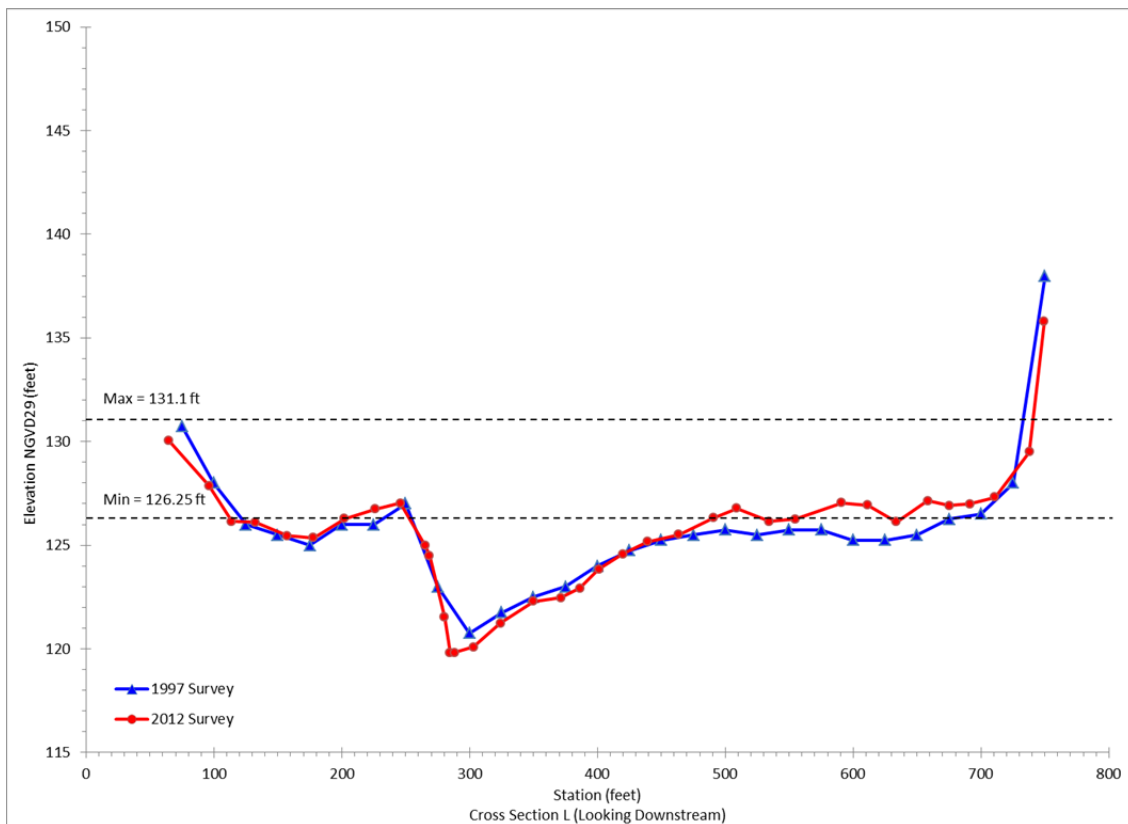


Figure 9: Cross Section M

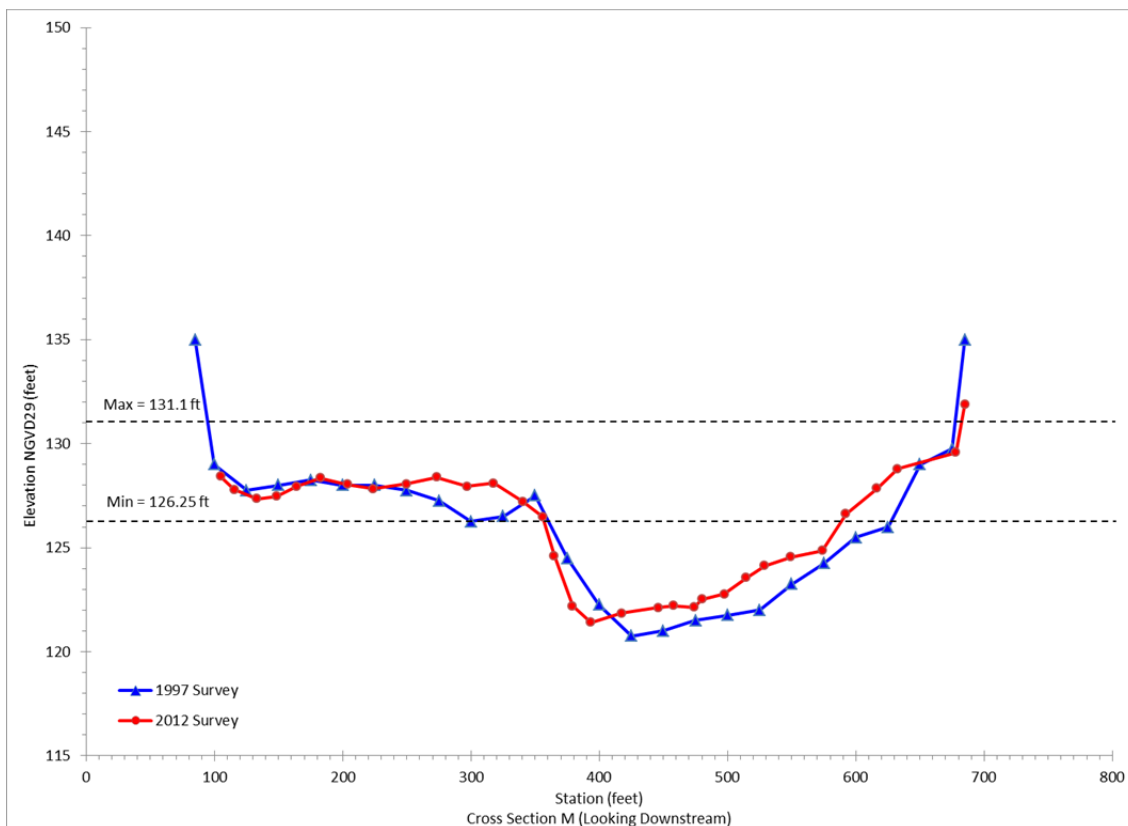


Figure 10: Cross Section N

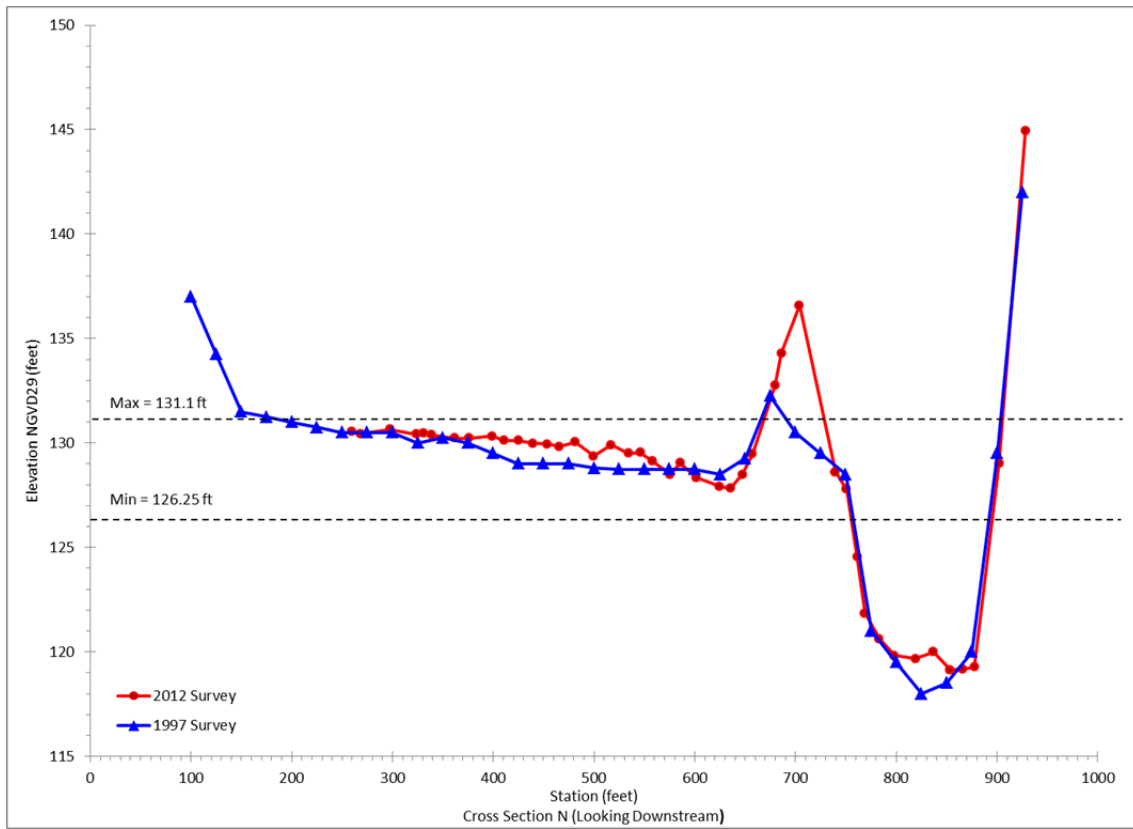


Figure 11: Cross Section O

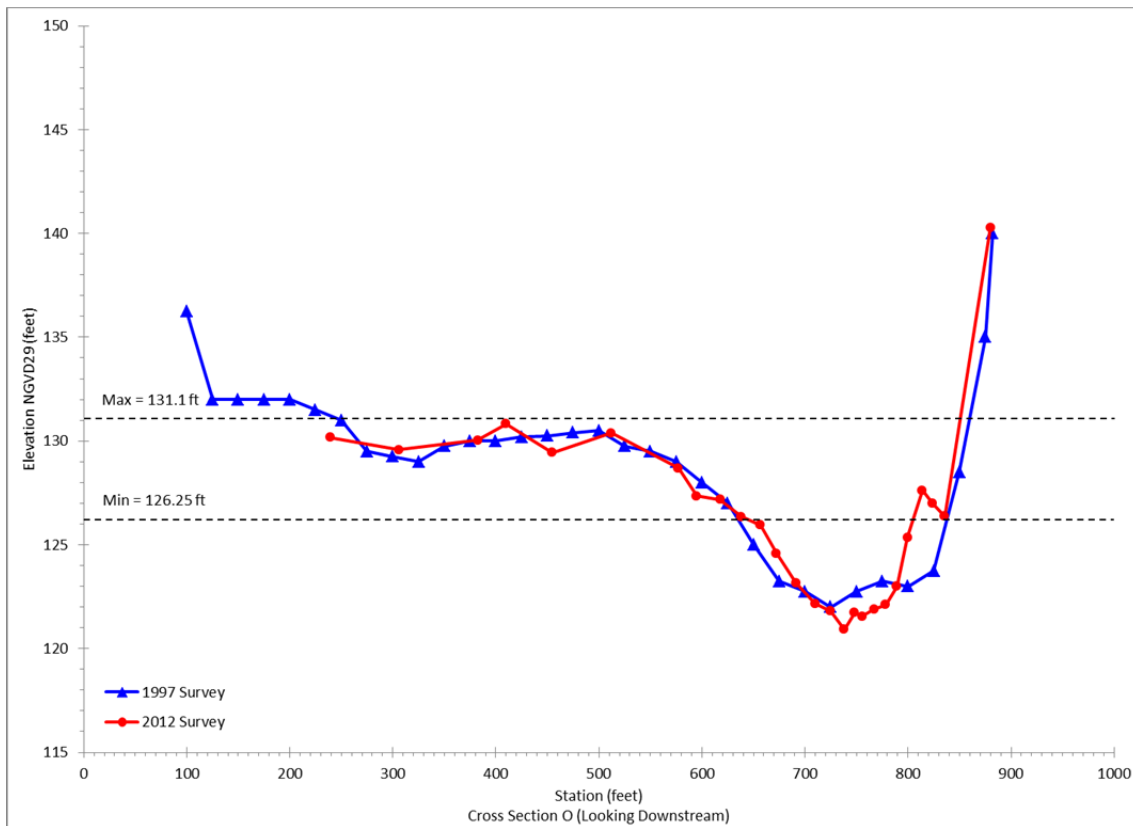


Figure 12: Cross Section P

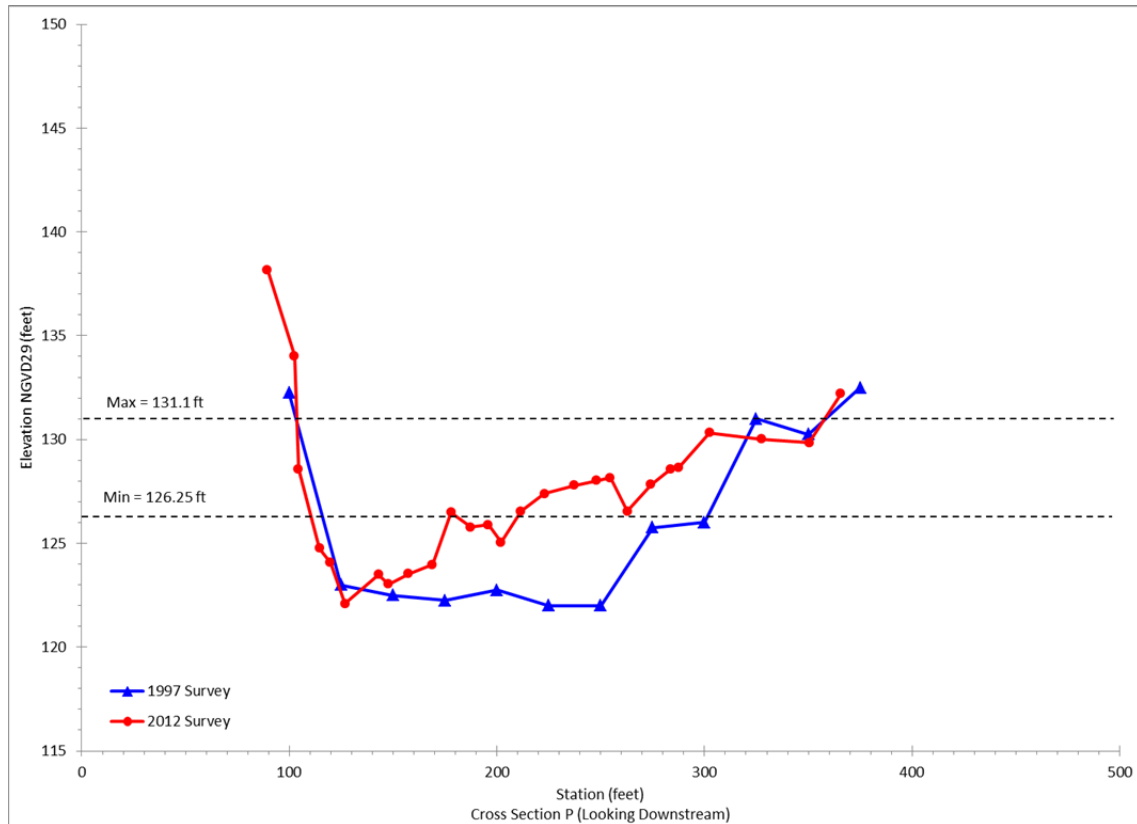


Figure 13: Cross Section Q

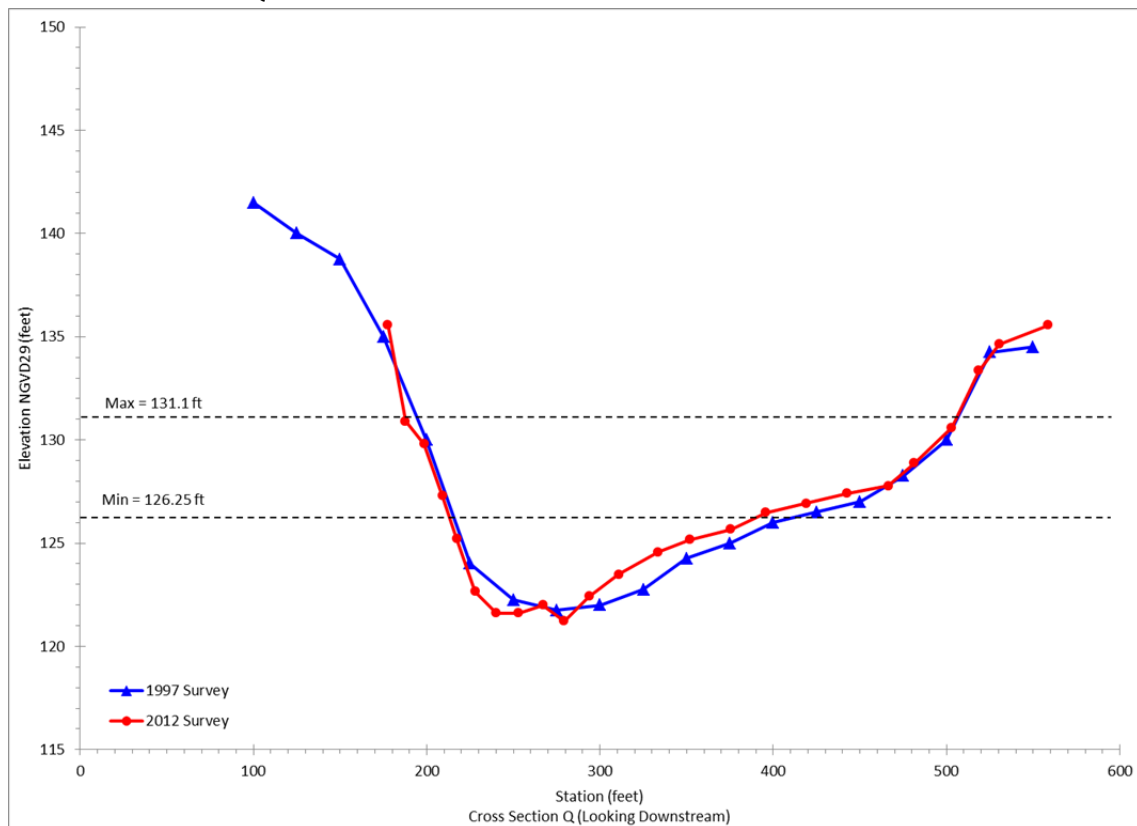


Figure 14: Cross Section R

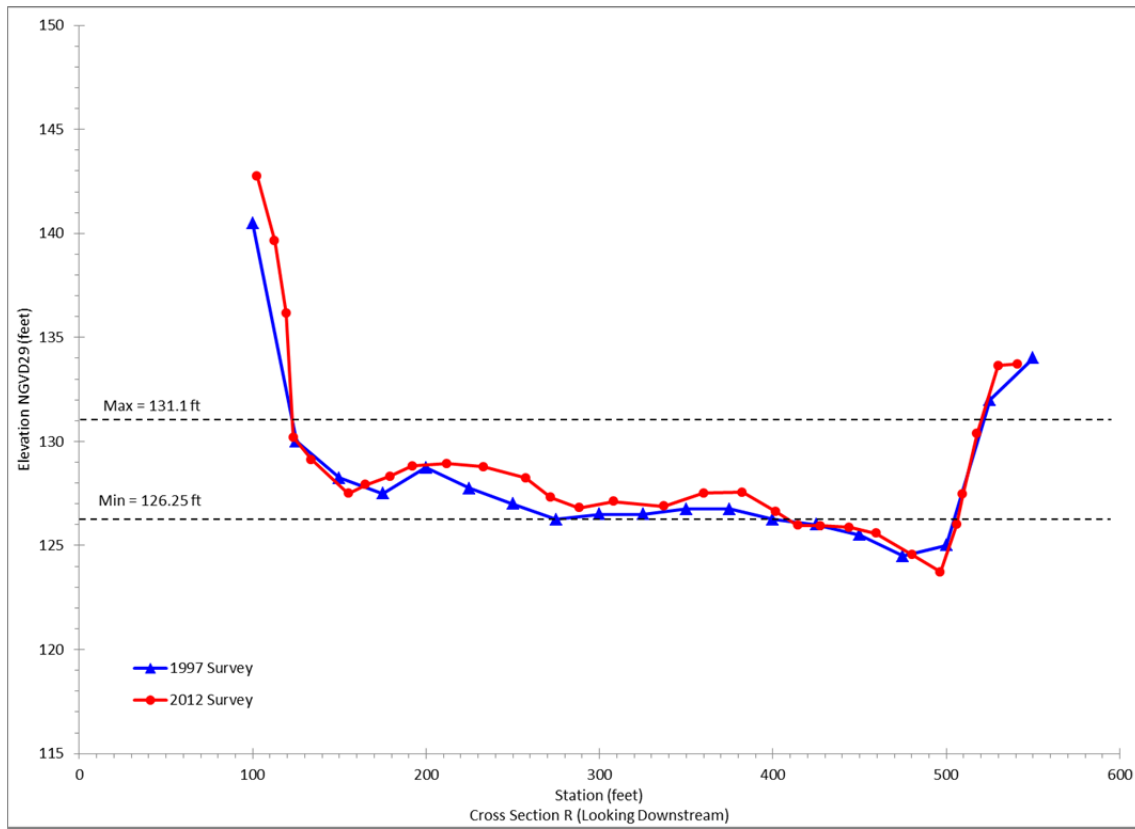


Figure 15: Cross Section S

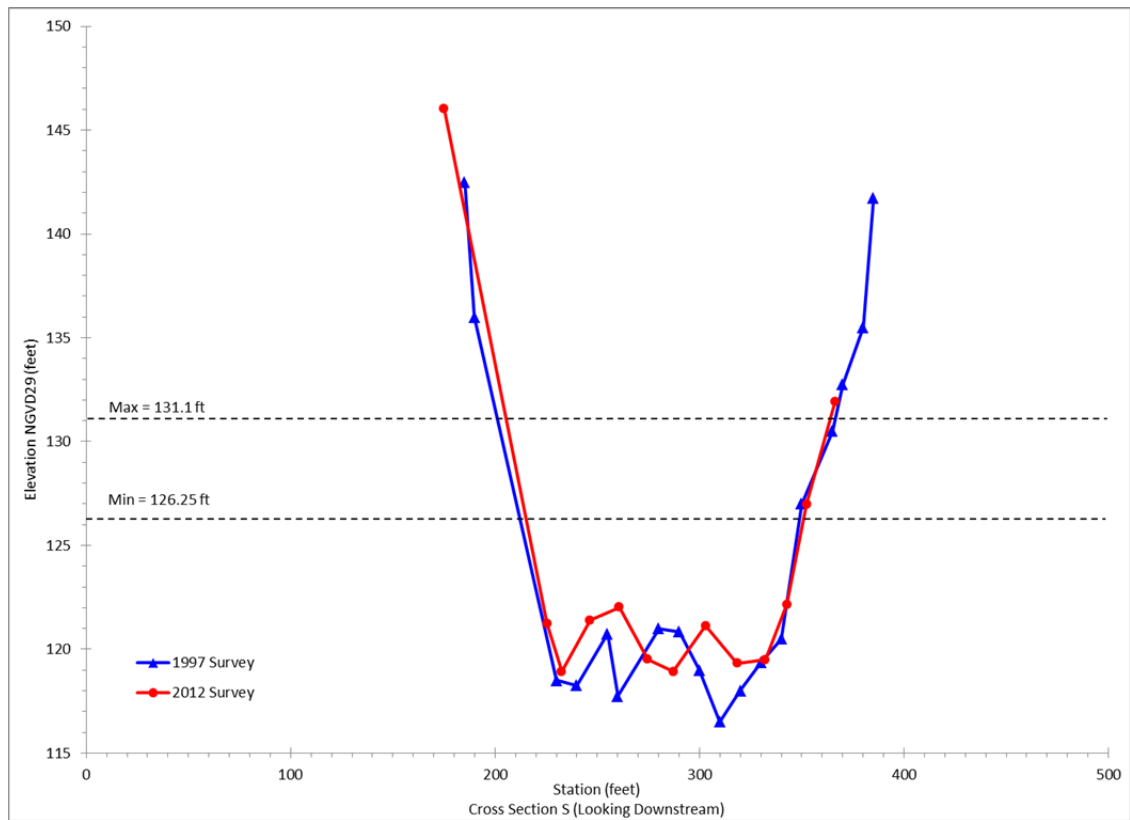


Figure 16: Cross Section T

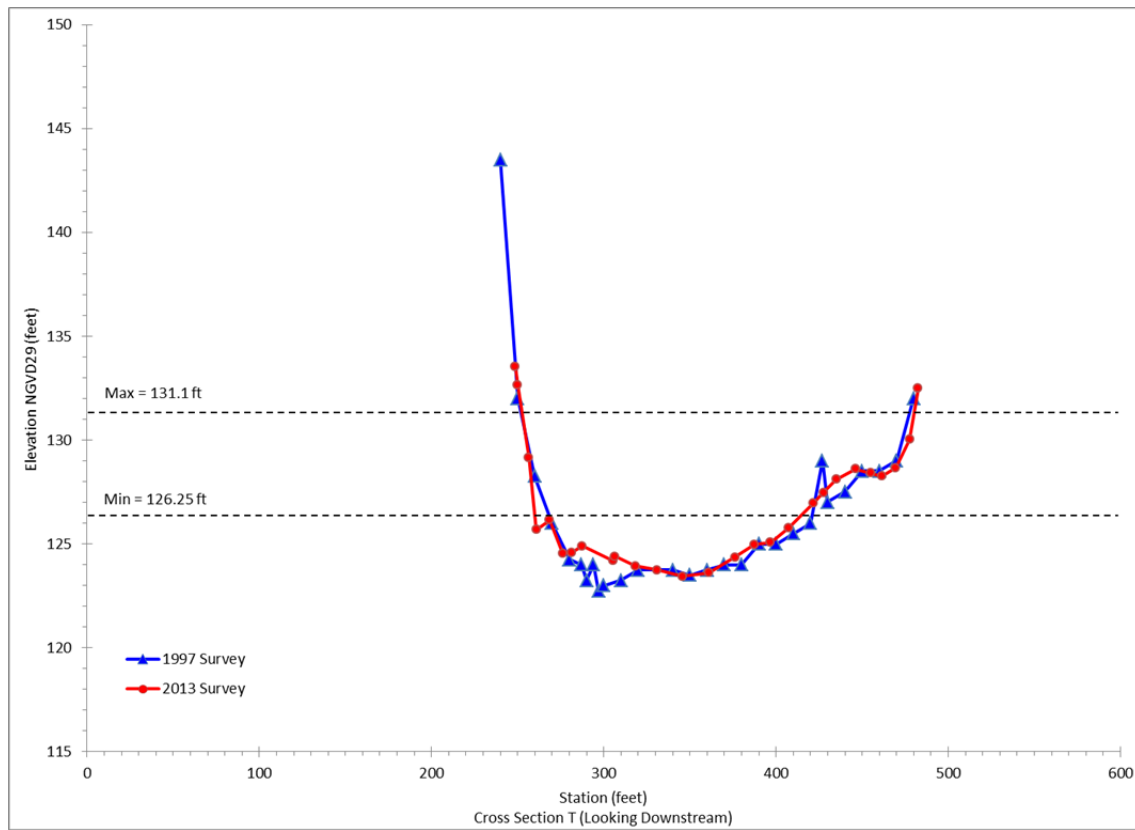


Figure 17: Cross Section 6

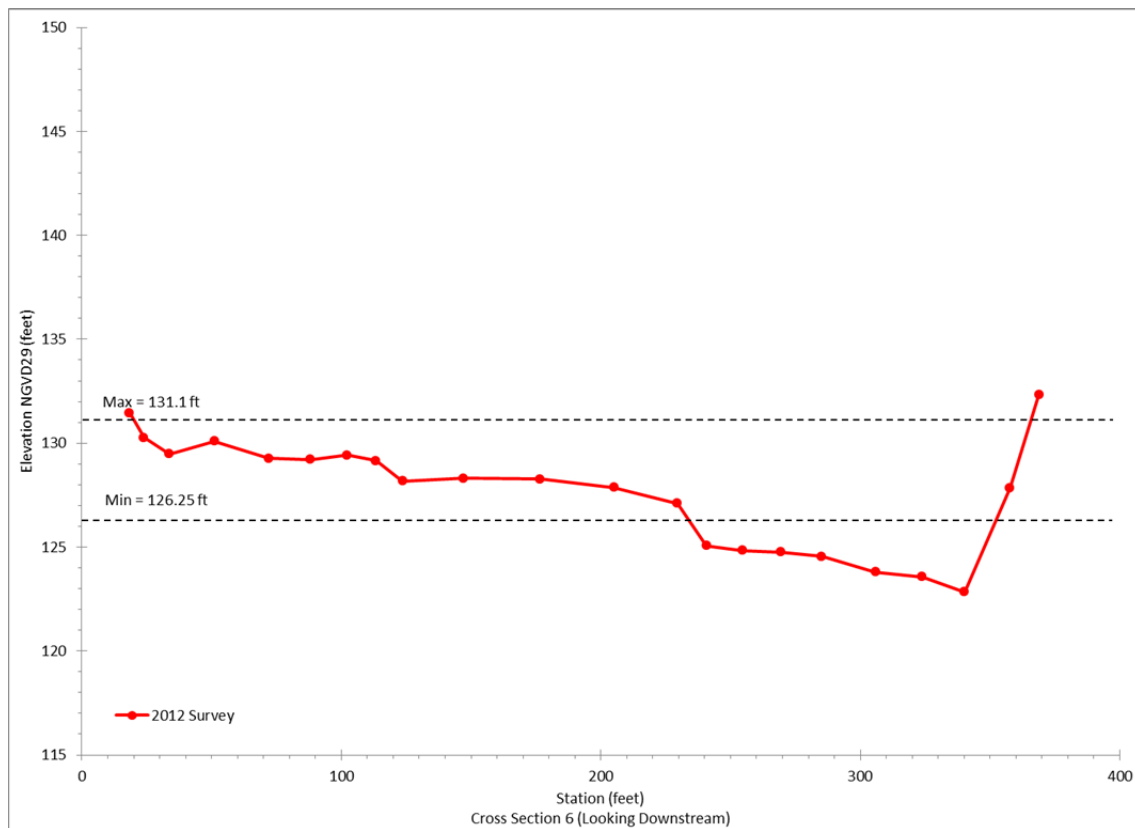


Figure 18: Cross Section 7

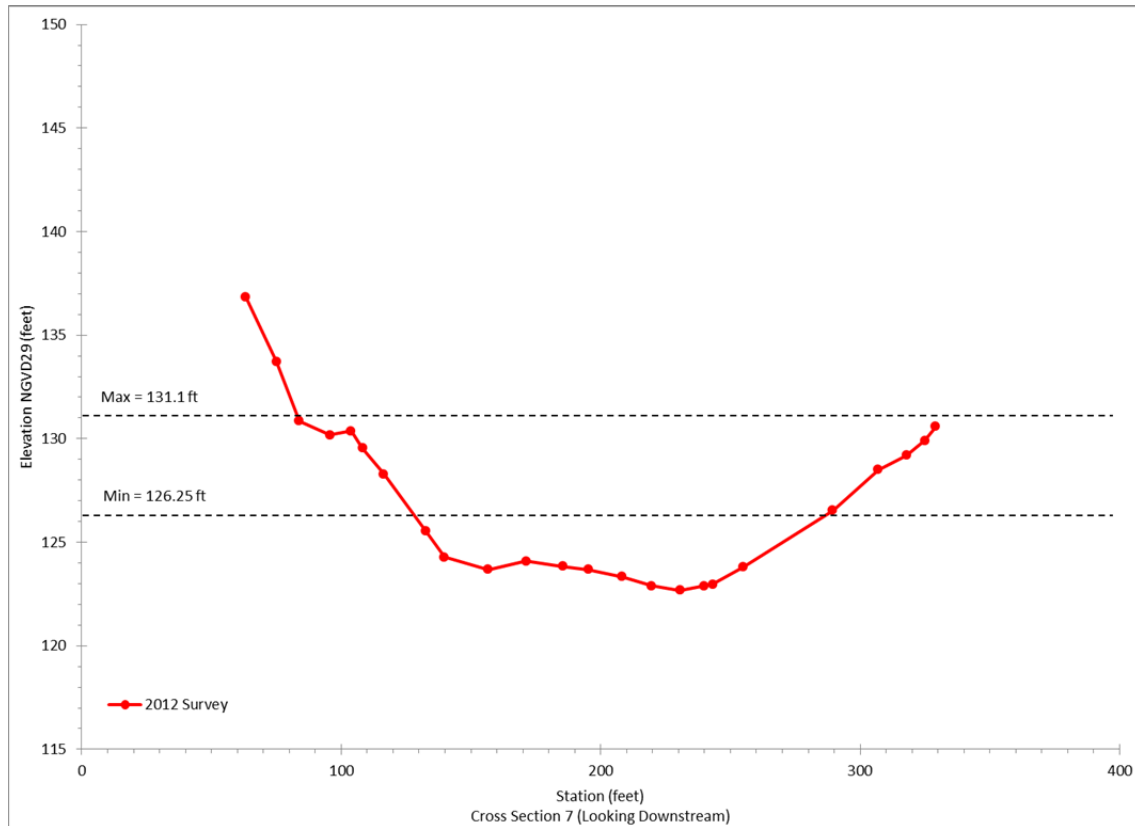


Figure 19: Cross Section 8

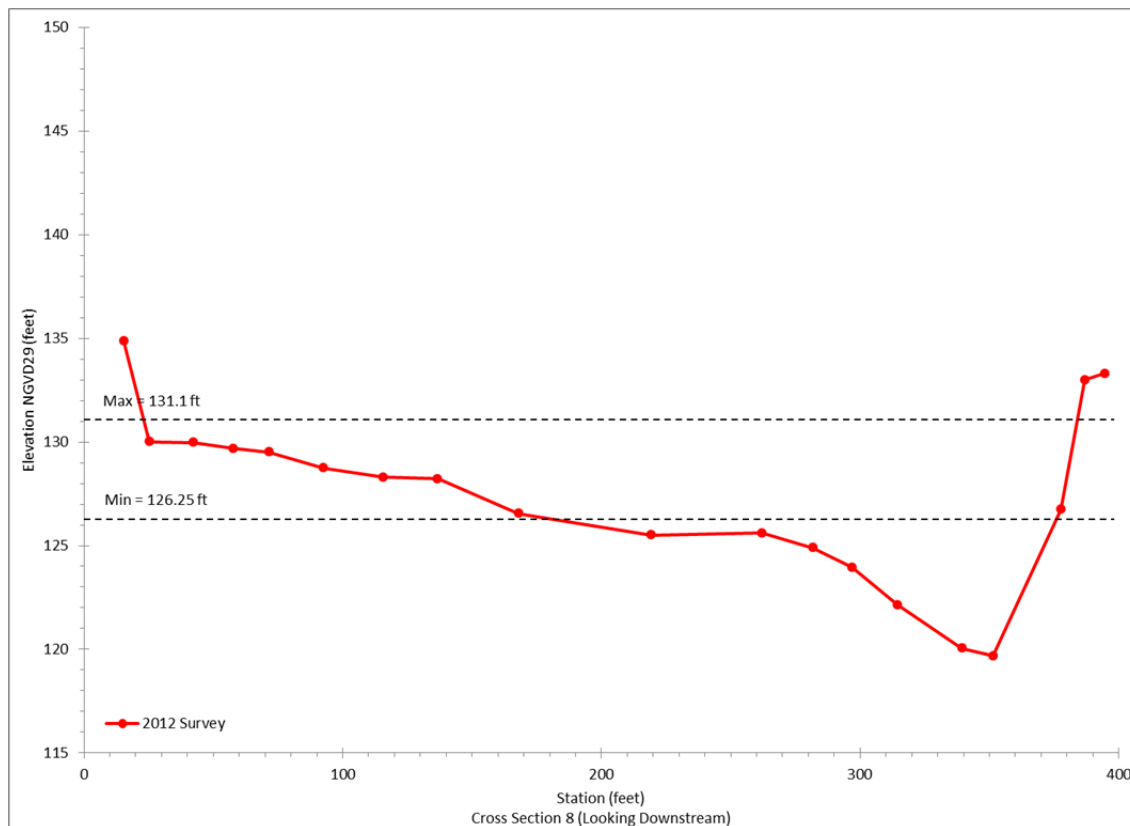


Figure 20: Cross Section 9

