Riverwise Engineering

February 14, 2014
Animas Consolidated Ditch Company and Partners
c/o Ed Zink
P.O. Box 3777
Durango, CO 81302

RE: Final Report for the Animas River Diversion Headgate Monitoring Study

Dear Mr. Zink,
It is Riverwise Engineering, LLC's (RWE) pleasure to provide a summary memo for the subject study. The memo provides fluvial geomorphological analysis and field data confirmation of the location and extent of a headcut located on the Animas River upstream of the Thomas Pit (See attached basemap shown in Appendix 1). The memo includes comparisons of historic data that, while fractured, provide supporting evidence of the headcut and the potential impacts to upstream diversions. The study provides baseline data that can be used for comparison to future field data. The future comparison may provide temporal estimates of the rate of propagation of the headcut and the timeframe before potential impacts to the diversion capabilities of the Animas Consolidated Ditch (ACD). The report is stand-alone, and no additional or future work was included with the Scope of Services.

This report is the Final Deliverable for the Water Supply Reserve Account grant, P.O. #OE PDA 131C000023.

The report addresses the three tasks in the scope of work – Task 1 Site Assessment, Task 2 Surveying, and Task 3 Research Historic Data – the results of which are described in the various sections below. The raw survey data collected by RWE is available upon request.

Our work included multiple data collection tasks including:

- Joining you on July 9th, 2013 for a site visit and discussion about the project, including the basis for the study and the expected deliverables. In addition, we reviewed the grant application supplied in a June 21, 2013 email.
- Contacting Mary Gillam, PhD, who appears to be the keeper of data relevant to gravel mining in the valley. Mary provided data relevant to the project and reviewed the findings.
- Contacting Scott Stonestreet, P.E. and Kara Hellige with the Sacramento District of the U.S. Army Corps of Engineers (USACOE). Scott completed a study in 2006 summarizing the fluvial geomorphological impacts in the valley from gravel mining. That study included the areas near both the ACD and Reid Ditch headgates. We acquired the hydraulic and sediment transport models associated with that study. They may be useful for future tasks.
- Contacting Rich Bechtolt of Bechtolt Engineering, LLC to acquire data collected between August 18, 2003 and December 2012.
- Collecting survey data at the locations of cross sections 35-45 (ten cross sections), as noted in the "Hydraulic Evaluation of Four Corners Materials, Bar-D Pit, In-Stream Gravel Mining proposal for Animas River, La Plata County, Colorado." Stonestreet, July 2006 (See Appendix 1). These cross sections are located from the Thomas Pit upstream to the Reid Ditch headgate. Each cross section included placement of two permanent control points near the 100-year floodplain elevation.
- Collecting five additional cross sections as determined by RWE staff in the field; near the apparent fluvial geomorphological headcut (Headcut) upstream of the Thomas Pit and near the ACD diversion, downstream of the Reid Ditch headgate, upstream of the Reid Ditch Headgate, and one "fill-in" section.

Following the data collection above, RWE researched the sediment transport and fluvial geomorphological situation in the vicinity of the Thomas Pit (near Station 240+00 on the basemap shown in Appendix 1). USACOE scientists suggest

the maximum excavation within the Thomas Pit resulted in a lowering of the thalweg elevation of up to 14 feet (Stonestreet, July 2006). The USACOE has noted that "significant" backfilling of the void within the Thomas Pit has occurred but the subreach is expected to be unstable with "Headcutting on the upstream end" (Stonestreet, July 2006). RWE's field observations are consistent with the Headcut premise taken by the USACOE.

Mary Gillam, PhD has completed unpublished research and review of historic air photos to determine mining impacts. Her findings suggest that post-mining restoration caused "short-term aggradation for some distance upstream, followed by renewed incision after the affected reach assumed a straighter planform with a steeper gradient". These findings suggest the changes in thalweg location and depth are a response to a complex set of events that are outside of the scope of this study. RWE's field observations are consistent with Mary Gillam's findings.

Field observations suggest there is a Headcut which is located just downstream of the ACD diversion. The terminus of the Headcut is currently located just downstream of Cross Section 39 (Station 282+00) (although some grade impacts are shown at Cross Section 39 and explained below).

Multiple data sources are presented in this memo. Unfortunately, some of the data sources are fractured, unreferenced, and incomplete. RWE has made every effort to ensure the accuracy of the data sets but cautions they have come from multiple sources, and that creates inherent errors and discrepancies. In addition, RWE has attempted to correct errors and only include data that is relevant to the project and useful for temporal and spatial comparisons. While difficult, ensuring continuity between future surveyors and data compilers is conducive to accurate data collection and analysis.

Headcut

A Headcut forms when the slope associated with a channel increases to the point that the shear stress exceeds the tractive force associated with the particles on the bed of the channel. The slope may change as a result of multiple causes, including removal of large amounts of material from within a stable channel. Once this occurs, the channel will erode and the bed material will move downstream to moderate the slope and create a new equilibrium. When the shear stress increases a significant amount, the channel erosion can move rapidly and propagate upstream until the Headcut either meets a grade controlling structure or the channel reaches a new dynamic equilibrium situation where the channel slope is reduced, upstream material fills the voids, or a combination of the two occurs. A grade control structure can be any structure that stops the upstream propagation of the area with increased slope. Common examples of grade control structures are bedrock outcrops, areas with significantly larger subgrade material, and man-made structures such as dams and navigational passages.

RWE observations during site visits suggest there is a Headcut located at approximately station 282+00 (just downstream of cross section 39). The Headcut appears to have an approximately 3-4 foot drop over a longitudinal distance of approximately 20 feet. Based on the field data collected in November 2013, it is not possible to estimate the rate the Headcut is propagating upstream, but analysis of Appendix 3 (the longitudinal profile) suggests that between the Bechtolt 2012 survey and the November 2013 survey, the thalweg elevation at Cross Section 38 dropped by 2.7 feet. Cross Section 38 is located just downstream of the Headcut noted by RWE. This value should be taken with caution because earlier surveys (2003-2010) showed comparable thalweg elevations to the November 2013 survey.

Sediment Transport

Very little sediment transport research has been completed for the Animas valley in the vicinity of the project. RWE's research resulted in acquisition of a sediment transport study completed by Stonestreet in 2006 using the US Army Corps of Engineers SAMWin software package. The package is good for reconnaissance level estimates. Stonestreet

estimated the reach upstream of Cross Section 45 produces approximately 76,000 to 92,000 cu. yds. of material per year.

Stonestreet noted that the Thomas Pit acts as a sediment pit and should collect the majority of the material produced from upstream. By his estimates in 2006, the pit included a void of 275,000 cu. yds. of material. Based on the material produced from upstream, he estimated the pit would be backfilled in 3.2 to 4.0 years. Findings and data collection by RWE suggest these estimates have either overestimated the material produced from upstream or underestimated the void within the Thomas Pit.

Data Analysis

Cross Section Temporal Plots

Following completion of the above tasks, RWE analyzed the data for each cross section. The cross section temporal plots are shown in Appendix 2. RWE offers the following preliminary assessments:

Cross Section 35: Cross Section 35 is located near the upstream terminus of the Thomas Pit. Field observations and data collected in November 2013 suggest the channel is located near the extreme left side of the channel (west). The thalweg appears to be approximately 0.3 feet lower than the survey in December 2012, but up to 1-foot higher than the thalweg in 2003-2004. In addition, the lower floodplain channel area (labeled on the Figure) appears to be approximately equal to December 2012 but much higher and lower in cross sectional area than 2003-2004, suggesting the channel is aggrading in this area. This is consistent with the geomorphological conclusions of Stonestreet 2006, which suggest the channel in the vicinity of the Thomas Pit should be aggrading.

Cross Section 36: Cross Section 36 is located just upstream of the Thomas Pit. Review of the data in Appendix 3 suggests the channel has aggraded from December 2012 to November 2013 approximately 2-feet. The data supports the hypothesis that material is being deposited (aggrading) to fill the void left following gravel extraction.

Cross Section 37: Cross Section 37 is located in a braided section of the Animas River. Review of the Figure suggests the extreme left channel (looking upstream) is likely the return flow from the ACD (and other) diversion. We feel the Thalweg December 2012 label is inappropriate and the mainstem of the Animas River was running on the right side of the Figure. Review of the thalweg and the cross sectional area in the mainstem channel suggests there was little-to-no change in the thalweg elevation from December 2012 to November 2013 and little-to-no change in the cross sectional area. The two cross sections are slightly skewed to each other, which could be explained by slightly different paths taken by the two survey crews.

Comparing the 2003-2004 data with the 2012-2013 data suggests the channel thalweg in this area has risen 2.0-2.5 feet and the channel has transformed from a deeper, thinner channel to a wider and shallower channel. One possible explanation for this change is that the Headcut moved through this area closer to the 2003-2004 period, has since moved upstream, and the area is beginning to aggrade and return to a dynamic equilibrium.

Cross Section 38: Cross Section 38 is located within a braided section of the Animas River downstream of the ACD diversion. Review of the cross section temporal plots in Appendix 3 suggests the thalweg of the channel is located on the right side of the figure. Comparing the December 2012 survey with the November 2013 survey suggests the channel thalweg is approximately two feet lower and erosion is occurring at this cross section. Comparing the cross sectional area from 2003-2004 to 2012 to 2013 suggests the channel has progressively increased in cross sectional area and the thalweg is lowering. Both these observations support the hypothesis of a Headcut near this location.

Cross Section 39: Cross Section 39 is located downstream of the ACD diversion. Review of the cross section temporal plot suggests the channel thalweg and area have changed little between December 2012 and November 2013 but the channel has incised approximately 2.5 feet since 2003-2004. In addition, the channel is notably more incised with a lower cross sectional area suggesting the Headcut is located near this cross section. RWE's visual observations found the terminus of the Headcut 100-200 feet downstream of this cross section.

Cross Section 40: Cross Section 40 is located just upstream of the ACD diversion. Review of the cross section temporal plot shows indefinite changes to both cross sectional area and thalweg elevation. These findings are consistent with the hypothesis that a Headcut is located downstream of this location.

Cross Section 41: Cross Section 41 is located just upstream of the ACD Ditch diversion and near the downstream extents of the Knuppel Pit. Review of the cross section temporal plot shows two channels are located at this location. The channel on the left shows some minor changes in both cross sectional area and thalweg elevation between 2003 and 2012/2013, but neither is indicative of channel morphology related to a Headcut. The channel on the right appears to be the downstream end of the historic Knuppel Pit and suggests there has been cross section and thalweg changes between 2003 and 2012/2013. RWE does not have any explanation for these changes and recommend further review of the Knuppel Pit, the material taken from the pit, and the remediation associated with that pit. These findings are consistent with the hypothesis that a Headcut is located downstream of this location.

Cross Section 42: Cross Section 42 is located within the area of the Knuppel Pit. Review of the cross section temporal plot suggests the cross section collected by RWE and the 2003/2004 data do not line up well and the 2003/2004 data may be transposed. RWE suspects this is due to the skewed nature of the cross section as shown on the basemap and mistakes made during data compilation and graphing. Because of this, the cross sections can be roughly compared with the understanding that the cross sections are shown transposed to each other. Because of this, RWE does not have comments related to the geomorphological changes in this area.

Cross Section 43: Cross Section 43 is located within the area of the Knuppel Pit. Review of the cross section temporal plot suggests the cross section collected by RWE is similar to the previously collected cross section and no geomorphological changes are evident.

Cross Section 44: Cross Section 44 is located just upstream of the Knuppel Pit. Review of the cross section temporal plot suggests the cross section collected by RWE is similar to the previously collected cross section and no geomorphological changes are evident.

Cross Section 45: Cross Section 45 data was collected by RWE, but no historic data was found during the data search. The cross section may be useful for future analysis.

Cross Section 38.25: Cross Section 38.2 is a supplemental cross section collected to provide more precise data in the vicinity of the Headcut. The cross section is located downstream of the Headcut terminus. RWE anticipates the cross sectional information will be useful in future analyses.

Cross Section 39.5: Cross Section 39.5 is a supplemental cross section collected just upstream of Cross Section 39. The location is important because it is located just downstream of the ACD diversion. Future fluvial geomorphological impacts to this cross section would be indicators of impacts to the ACD diversion.

Cross Section 42.1: Cross Section 42.1 is a supplemental cross section collected to acquire additional data between cross sections 42 and 43.

Cross Section 42.3: Cross Section 42.3 is a supplemental cross section located downstream of the Reid Ditch diversion that may be used for future comparisons.

Cross Section 42.7: Cross Section 42.7 is a supplemental cross section located upstream of the Reid Ditch diversion that may be used for future comparisons.

Thalweg Longitudinal Profile

In addition, RWE compiled and analyzed a thalweg longitudinal profile (See Appendix 3) through the project reach and offer the following preliminary assessments:

- The profile contains multiple data sources, some of which do not contain data over the entire reach and some of which RWE is not able to review for accuracy, but the plot has multiple locations that contain valuable information.
- In the vicinity of Sections 35 and 36, it appears the data collected by the USGS 1950/1960, the USACOE-1976 water surface, and the FEMA1981 data are significantly higher and suggest a relatively constant slope through the area during this period. The data from Aug-03 to present suggest the slope has greatly decreased near these two cross sections and aggradation is occurring. This finding is consistent with comparisons made in the cross section temporal plots.
- Between Section 36 and Section 38, the channel slope increases which is consistent with higher rates of transport and the Headcutting situation discussed in the cross section temporal plots. It is within this area that the most drastic changes in channel form are evident. It is also important to note the thalweg elevation at Cross Section 38 is approximately two feet lower than measurements shown by the Dec-12 plot. This two foot decrease in elevation in less than a year suggests significant Headcutting in this area.
- Above Section 38, the channel generally follows a trend of progressive aggradation moving upstream. This is consistent with prior sediment transport studies suggesting the area of the Animas River downstream of Baker's Bridge is a gaining reach with aggradation resulting from material transport from the higher gradient Upper Animas River. Detailed analysis is beyond the Scope of this study.

Conclusions

RWE compiled and analyzed multiple data sources relevant to the ACD diversion. The data sources were fractured, unreferenced and incomplete, but provided a snapshot of the project area between 1950/1960 and present with multiple data sources within the last ten years. The general trend shows a Headcut at approximately station 282+00 (just downstream of cross section 39). The headcut is apparent during field observations and after review of both cross sectional data and longitudinal data. The data suggests the headcut may have decreased the thalweg of the channel at Section 38 approximately 2-feet between December 2012 and November 2013. This is a significant change in thalweg elevation over a short period of time. While the data suggests changes to the channel are significant, they do not provide information on how quickly this specific headcut is moving upstream. Further analysis and collection of data is necessary to provide temporal estimates of headcut changes.

In anticipation of this issue, RWE collected supplementary data in the vicinity of the headcut that can be used for comparison to future data sets. Comparing the two data sets may provide additional information on the rate of travel of the headcut. Because the headcut is near to the diversion for the ACD, RWE recommends an aggressive monitoring program and additional tasks to stabilize the headcut in the event it reaches the diversion and affects the physical capabilities to divert adjudicated water rights at this location.

RWE is experienced with the design, permitting, and construction of grade stabilization structures related to irrigation diversions. Our experience suggests the process for completing this type of structure takes 2-3 years once funding is in

place and we have a notice to proceed. A structure of the size needed to stabilize the Animas River near the ACD diversion will costs $100,000 to $300,000 depending on permitting requirements, and the type and size of the structure.

Recommendations

RWE recommends the following:

1. Complete surveying of the area near the headcut following snowmelt runoff and/or significant runoff events. The surveying may include cross sections 38-40 to isolate changes in the direct vicinity of the headcut and lessen costs. These cross sections should provide the most valuable information about the movement of the headcut.
2. Complete an annual monitoring program that begins in the fall of 2014 (following recession of snowmelt runoff) to determine channel changes. Based on the findings in 2014, the timeframe can be adjusted to 1) More frequent monitoring if the headcut appears to be moving quickly, and 2) Annual monitoring if the headcut is relatively slow.
3. The monitoring may include surveying, staking the existing headcut location, and qualitative observations of channel thalweg locations, braid changes, and general sediment transport observations.
4. Research funding opportunities to help mitigate the impacts of the headcut. The mitigation may include grade stabilization structure(s), channel modifications, bank stabilization, bio-remediation, and further reclamation near the Thomas Pit.
5. Coordinate with adjacent landowners and educate them on the Headcut situation. Keep them informed of any mitigation plans suggested in #4 above.

Metadata

Shown below is the metadata associated with the project. This information should be provided to any, and all, consultants that may be involved in this issue.

Longitudinal Data sets in Stonestreet 2006, Mary Gillam, PhD provided data, and RWE longitudinal profiles

1. **"USGS 1950/1960":** This data set is supposed to show the places where topographic contours cross the water surface on USGS 7-1/2' topographic maps and does not represent the thalweg during that time. As described by Stonestreet (2006), the maps were based on air photos taken between 1950 and 1960 for the USGS Hermosa quadrangle and in 1960 for the USGS Durango North quadrangle. The data is valuable to show the general slope of the channel at that time, but comparison using the exact elevation at specific locations should not be made. Based on the comparison shown in #3 below, the elevations may be up to 2-feet low in some areas.

2. **"USACOE-1976" (really 1976 water surface):** As indicated in Stonestreet (2006), this is the water surface as depicted by 2-ft contours on topographic maps made from air photos taken on June 19, 1976. The elevation datum for the maps was NGVD29 so Stonestreet converted the elevations to NAVD88 by adding 4.18 ft., a value based on the average elevation change for three benchmarks in the area. Mary Gillam suggested elevation values in Stonestreet's original NGVD29 data are in 2-ft integers, as would be expected if they were taken from mapped contours. This data appear in the Corps of Engineers 1977 flood report only in map form. The data is

valuable to show the general slope of the channel at that time, but comparison using the exact elevation at specific locations should not be made, because the value show water surface elevations as opposed to thalweg elevations.

3. **Accuracy of plotted lines for 1950/60 and 1976 water surfaces:** Mary Gillam compared water surface elevations for the study area on hard copies of the USGS Hermosa 7-1/2' quadrangle and 1976 topographic maps. Differences between these elevations for one benchmark (see table below) suggest that overall elevations for the two maps are fairly consistent. Differences between water surface elevations (before the conversion from NGVD29 to NAVD88) are generally a bit smaller than implied by the vertical spacing between these lines as plotted. Direct map comparisons suggest that there was local aggradation from 1950/1960 in part of the reach between Bakers Bridge and the Thomas Pit but not as much as suggested by the plotted profiles. The most likely explanation for the distortions is that Stonestreet (2006) used inconsistent horizontal stationing distances for the two elevation data sets.

Elev. 1950/1960 (USGS)	Elev. 1976 topo (COE 1977)	Location notes
6760 (water surface)	≈6741 (water surface)	Above Bakers Bridge; May have scoured after 1960.
6740 (water surface)	≈6738 (water surface)	Below Bakers Bridge
9720 (water surface)	≈6728 (water surface)	Above xsect 45
6700 (water surface)	≈6705 (water surface)	Near xsect 42
6680 (water surface)	≈6678 (water surface)	Near xsect 36, above Thomas Pit
6660 (water surface)	≈6662 (water surface)	Near xsect 31, in Thomas Pit
6718 (benchmark)	≈6720	On a bend in County Rd 250

4. **FEMA-1981:** Mary Gillam has hard copies of both the 1977 COE and 1981 FEMA flood reports, and determined that Stonestreet must have interpolated these elevations from graphs showing the channel invert at cross sections that are designated in the 1981 report by two-letter codes. However, Mary Gillam also compared the graphed inverts in the two reports and found that they're identical. Modeled flood water surfaces are slightly different in the two reports, indicating that the later report presents new modeling likely based on the 1976 invert. Between about 2003 and 2005, Mary Gillam and consultants for Four Corners Materials agreed that the invert may have been measured in 1976 to allow time for its analysis before publication of the 1977 report. The actual dates of measurement aren't specified in the COE 1977 report and no copies of the original data used to generate the report have been located by interested parties, as known to Mary Gillam.

   Also around 2003 to 2005, Mary Gillam and consultants for Four Corners Materials discussed the accuracy of the invert measurements in reports and written comments to COE. It's Mary's opinion the consultants wanted the invert to be lower than shown in the 1977 and 1981 reports so that less mining-induced erosion would appear to have taken place by 2003. Mary Gillam discussed likely field methods for measuring the invert with a hydrologist at Goff Engineering, who said it was indeed possible that the invert could be lower than the few roughly measured values. Therefore, Mary Gillam considers this invert data to have an arbitrary 2-ft margin of error.

Cross Sectional Temporal Plots

A portion of the data associated with the cross section temporal plots was provided by Bechtolt Engineering, LLC in PDF format under project number 11200, created 12-07-09, and last modified 1-13-2013. PDF format is basically a picture, so no references, data sources, or metadata was included with the plots. RWE contacted Bechtolt to discuss the data and was informed the data was collected by an employee that no longer works for the company.

To use the data, RWE overlaid the November 2013 data on top of the PDF plots and scaled the data appropriately. Because of this, some of the annotations and callouts on the original PDF are not legible or may be covered with the November 2013 data. RWE was not able to find alternatives to avoid this situation and felt the data was valuable enough to pursue this plotting method.

Survey

The survey metadata is identical to the metadata published by Bechtolt Engineering, LLC during the December 2012 survey and is shown in Appendix 4.

Please feel free to contact me with questions or concerns.

Sincerely,

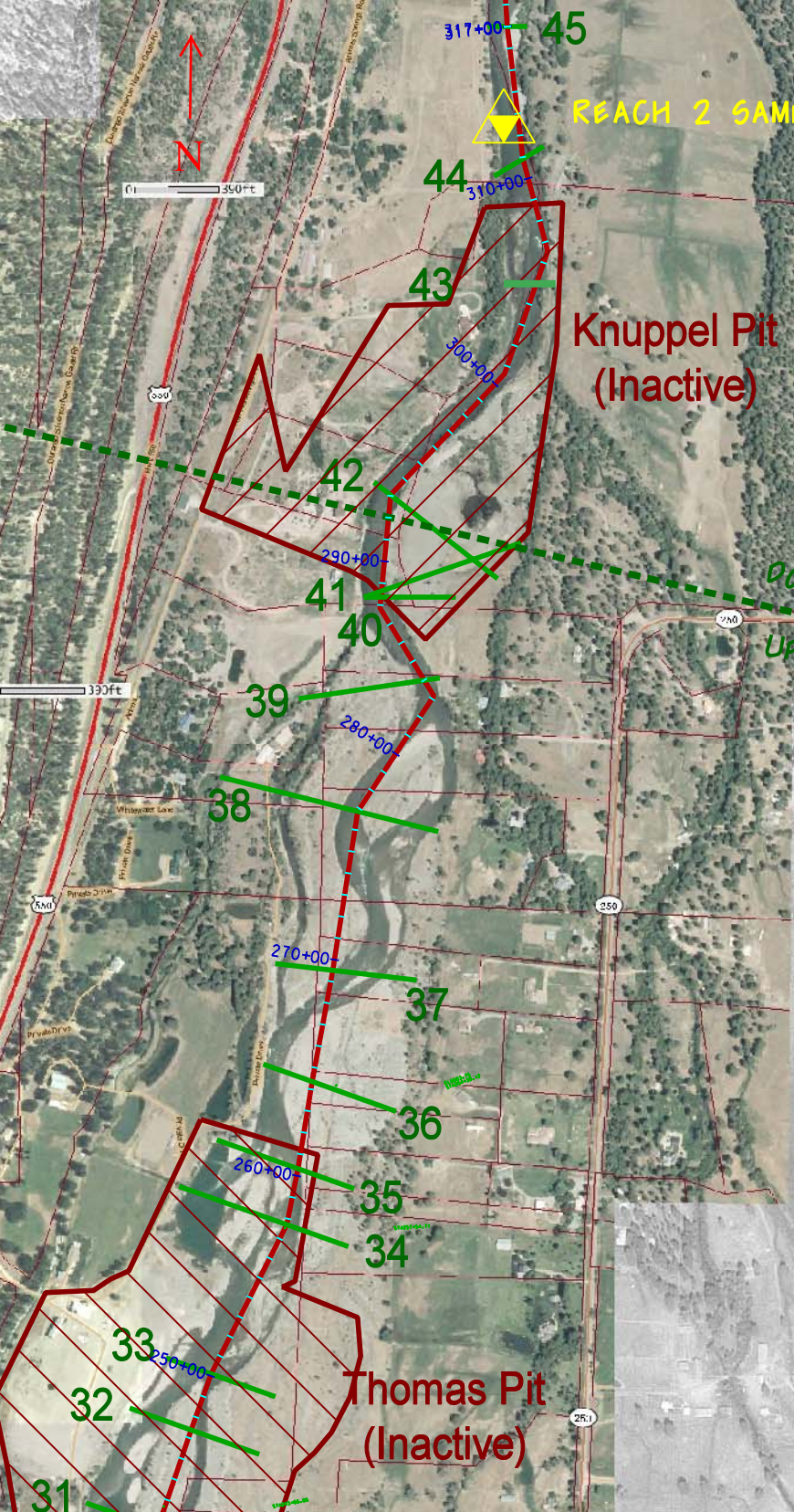
Shane Sigle, PE
Riverwise Engineering, LLC

Bibliography

Stonestreet, Scott, P.E., Hydraulic Evaluation of Four Corners Materials, Bar D Pit, in-Stream Gravel Mining Proposal for the Animas River, La Plata County, Colorado. CESPK-ED-DH. US Army Corps of Engineers Sacramento Field Office. Memorandum of Record 11 July 2006.

Appendices:
Appendix 1: Basemap
Appendix 2: Cross Section Temporal Plots
Appendix 3: Longitudinal Profile
Appendix 4: Survey metadata

Appendix 1: Basemap (Taken from Stonestreet, 2006)


317+00
45
REACH 2 SAM
44
310+00
43
Knuppel Pit
(Inactive)
300+00
42
290+00
41
40
39
280+00
38
270+00
37
36
260+00
35
34
33
250+00
32
Thomas Pit
(Inactive)
31
N
390ft
390ft

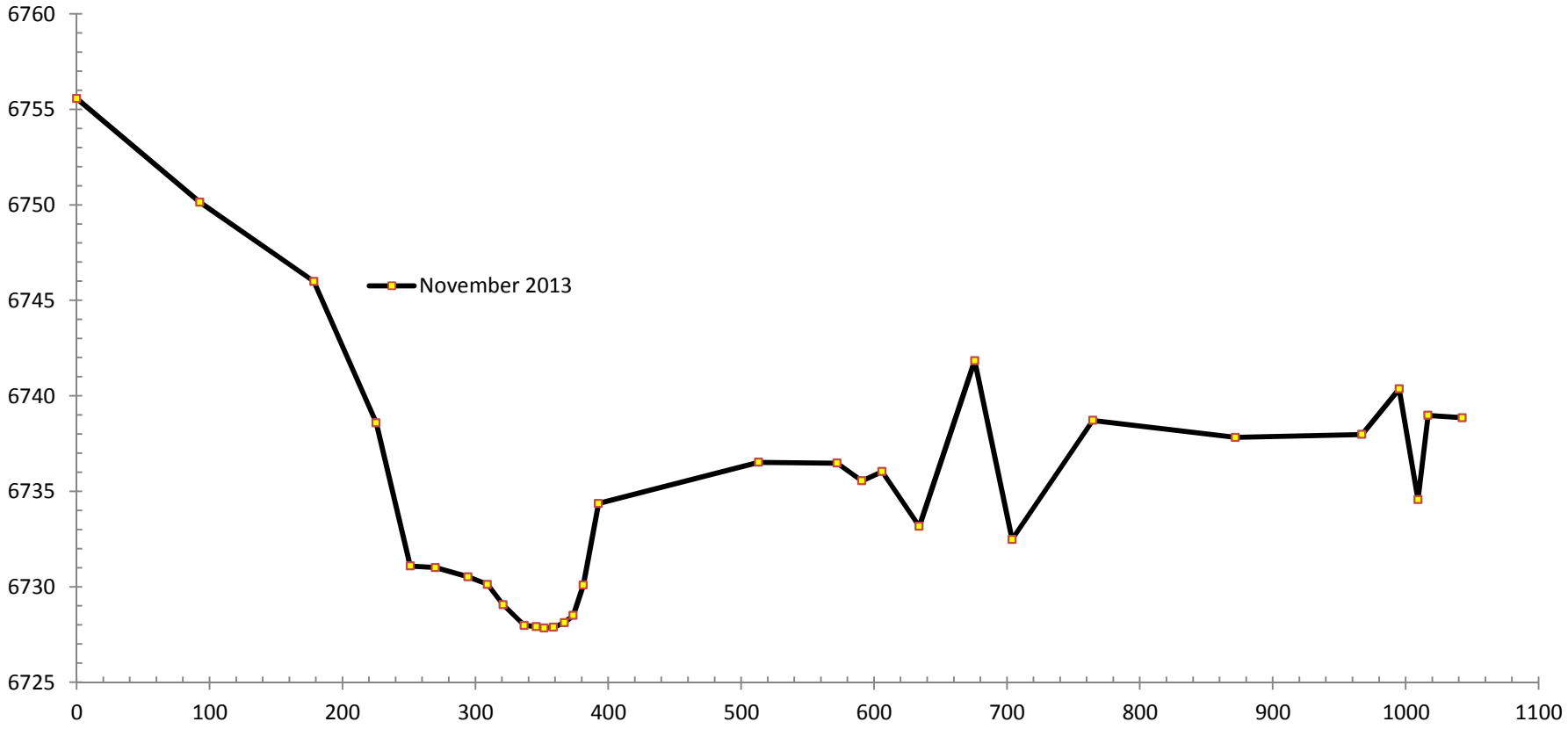
Appendix 2: Cross Section Temporal Plots

Animas River Diversion Headgate Monitoring Study

Animas River, Durango, CO

Cross Section Temporal Plots

Section 45
317+04.92



1) Data collected by Riverwise Engineering, LLC during November 2013. Reporting and metadata for the survey is available in a December 20, 2013 memo to Animas Consolidated Ditch Company and Partners.

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Ckd by SS
12/20/2013

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Cross Section Temporal Plots

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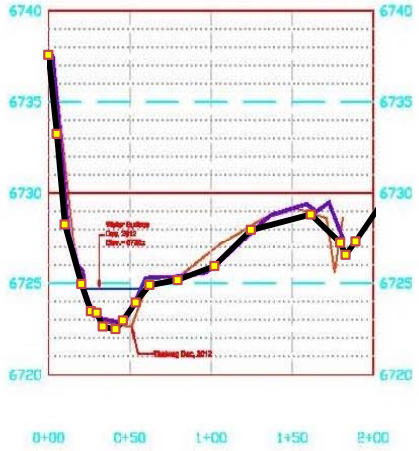
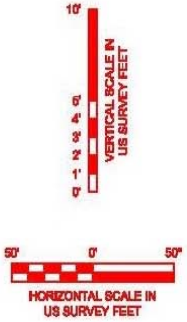
SECTION 44

310+97.05

Profile Legend
August 18 2003
December 2012
November 2013



View Looking Upstream



1) Base plot taken from a PDF created by Bechtolt Engineering, Inc. under project number 11200, created 12-07-09, and last modified 1-13-2013. All data on the figure was taken from this file except the November 2013 data which was collected by Riverwise Engineering , LLC and overlaid on the base plot.
2) minor variations may occur in the lateral placement of cross section November 2013 versus the others because the cross section was overlayed on the existing base plot.
3) The cross section was originally labeled at station 317+04.92 but further review suggested it is located at 310+97.05.

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Cross Section Temporal Plots

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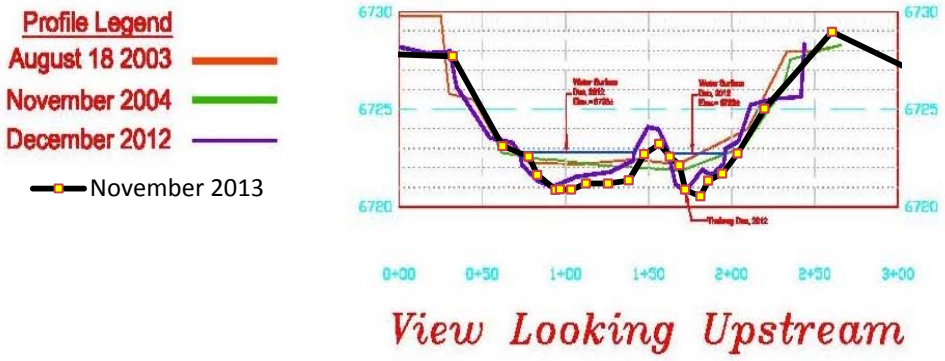
SECTION 43

305+00.0



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2) minor variations may occur in the lateral placement of cross section November 2013 versus the others because the cross section was overlayed on the existing base plot.
3) The cross section was originally labeled at station 310+97.05 but further review suggested it is located at approximately 305+00.00.

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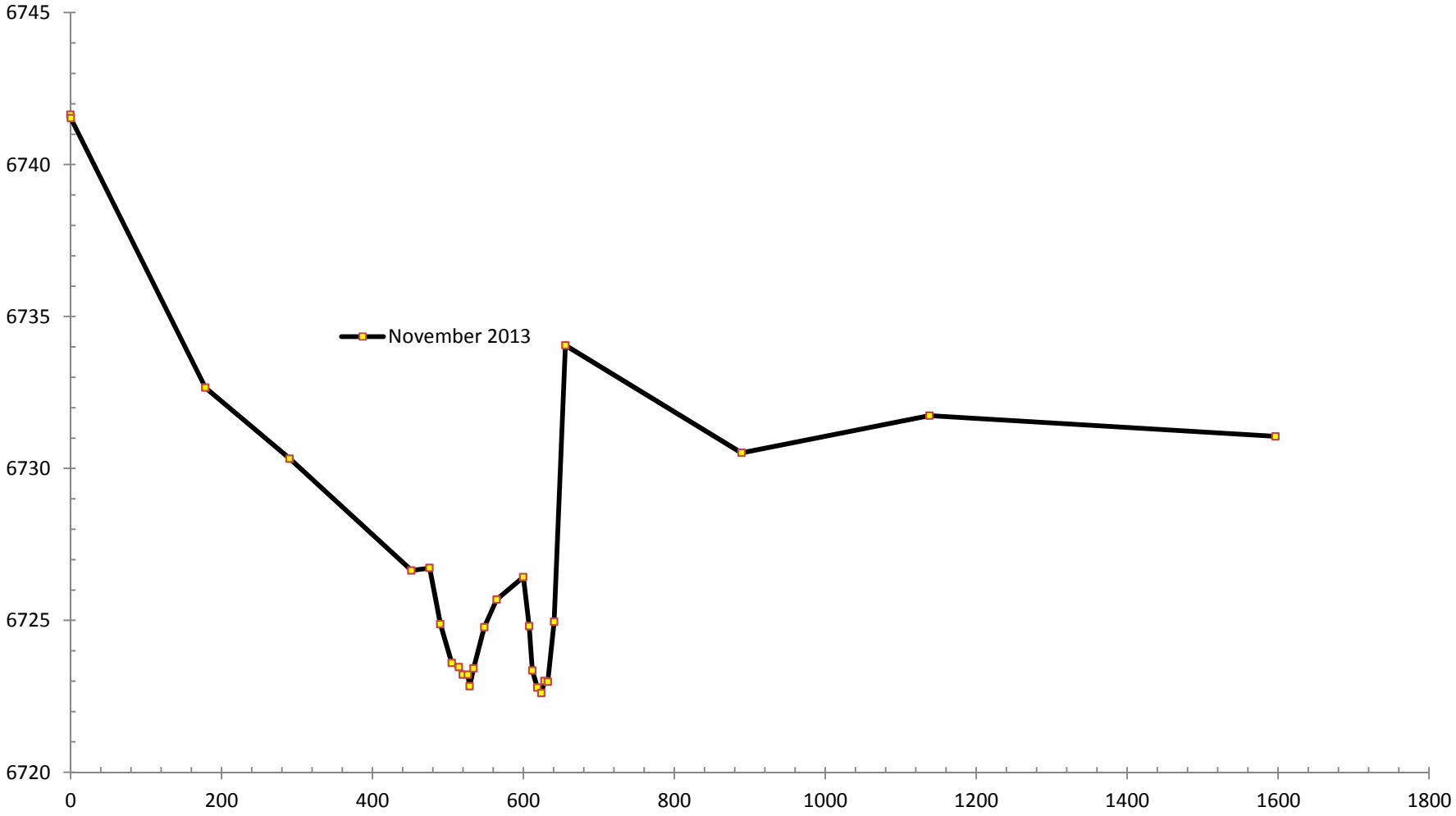
Cross Section Temporal Plots

Section 42.7



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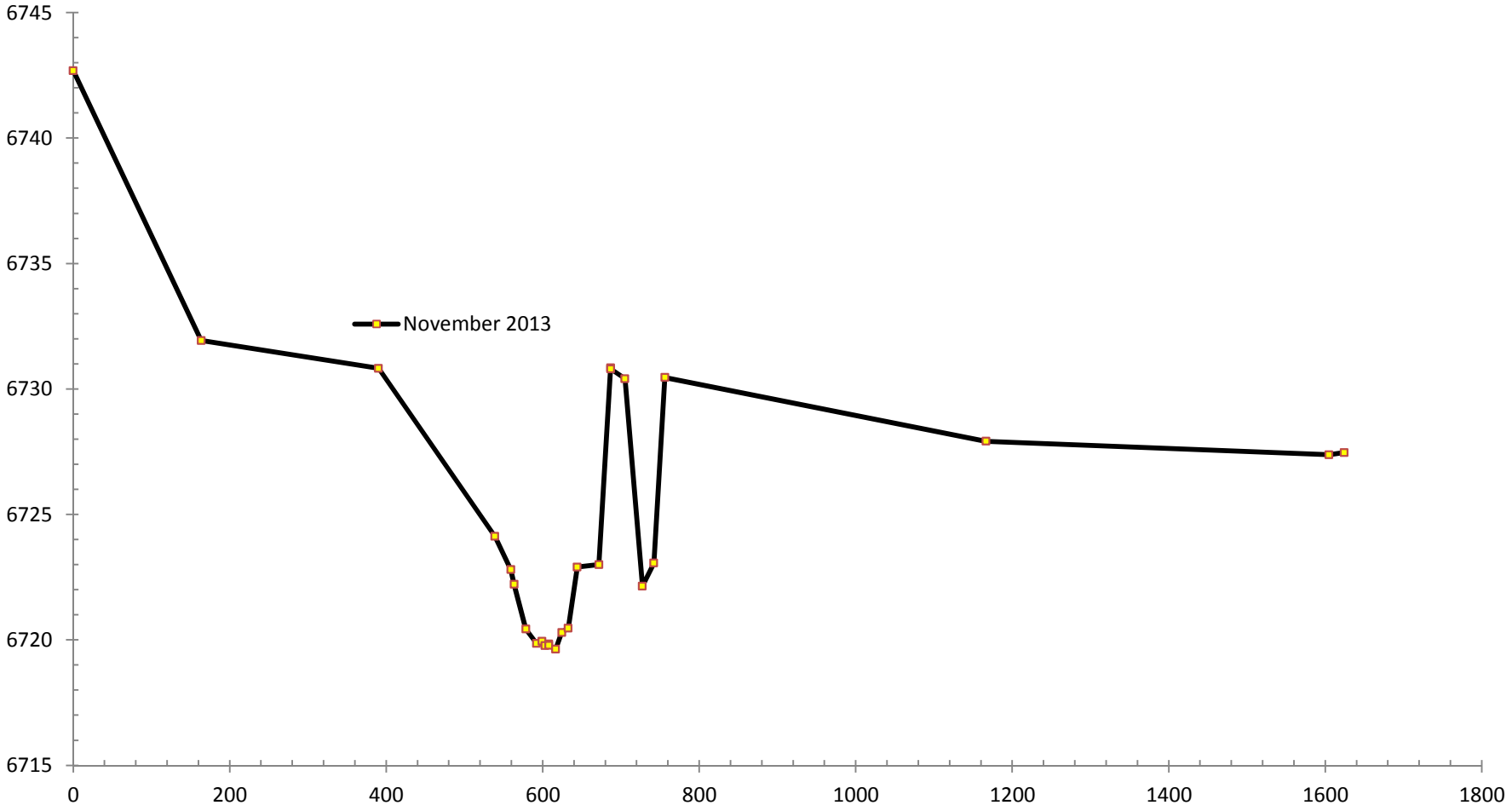
Cross Section Temporal Plots

Section 42.3



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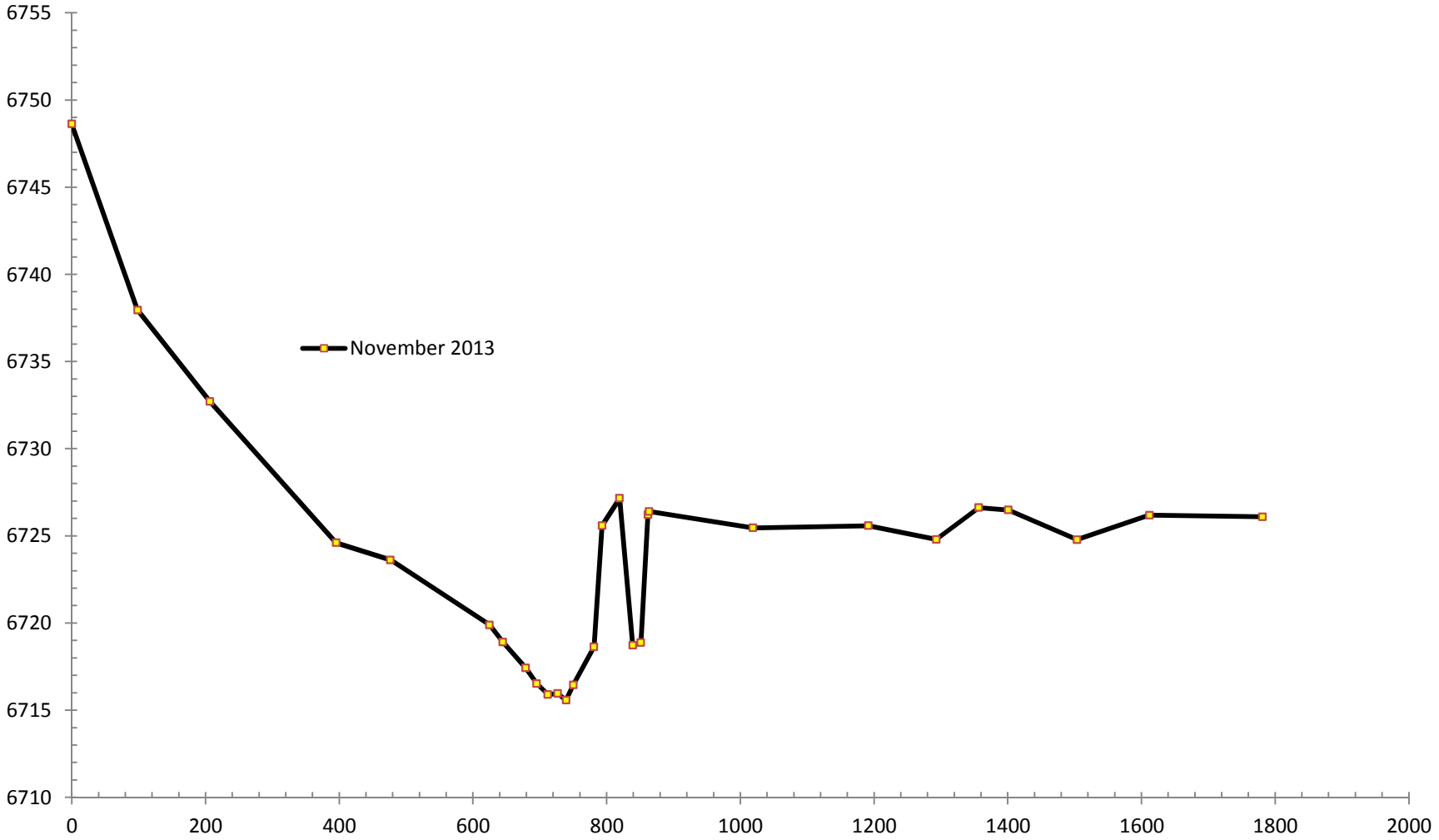
Cross Section Temporal Plots

Section 42.1



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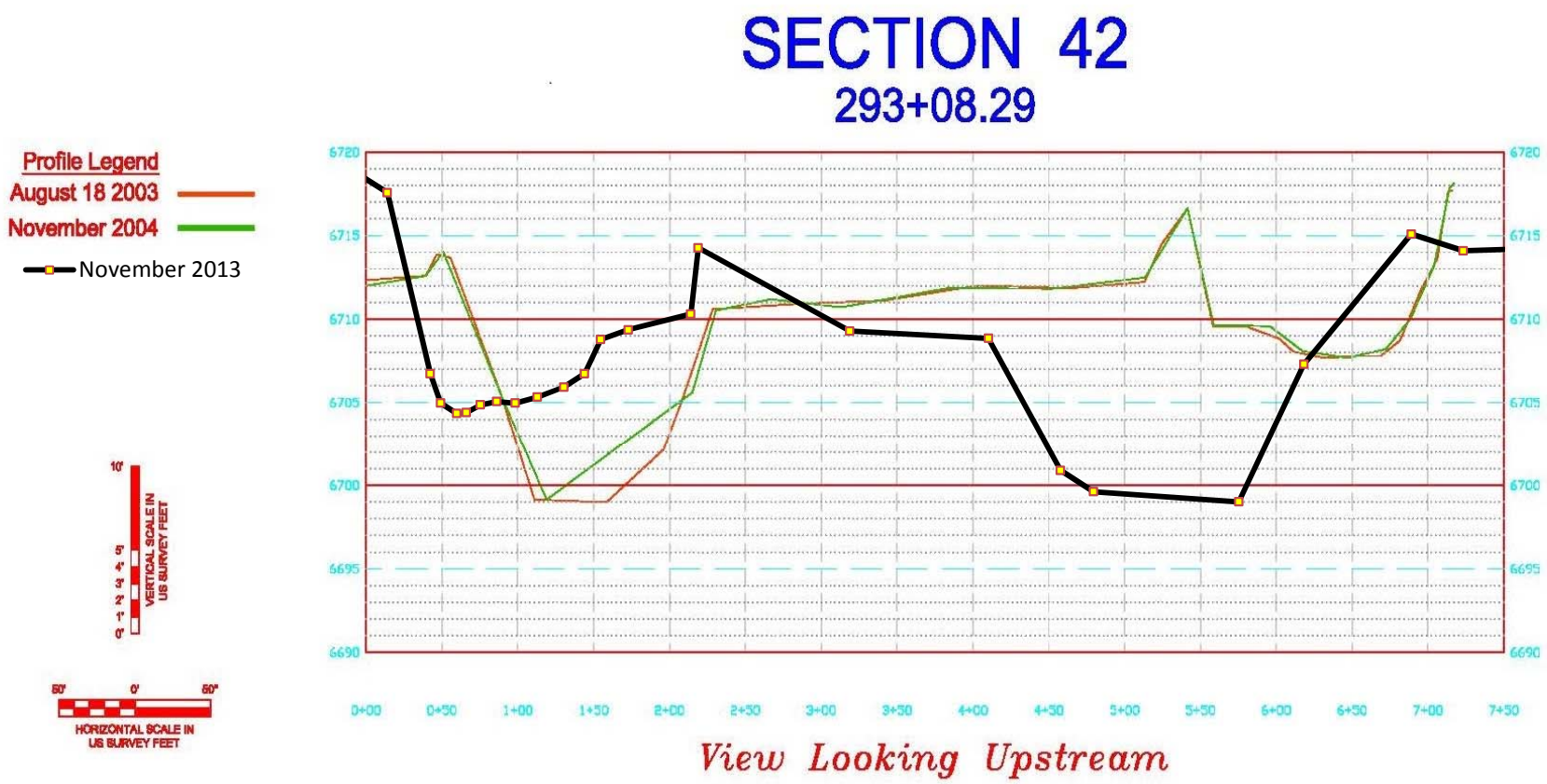
Cross Section Temporal Plots

Riverwise Engineering



1) Base plot taken from a PDF created by Bechtolt Engineering, Inc. under project number 11200, created 12-07-09, and last modified 1-13-2013. All data on the figure was taken from this file except the November 2013 data which was collected by Riverwise Engineering , LLC and overlaid on the base plot.
2) minor variations may occur in the lateral placement of cross section November 2013 versus the others because the cross section was overlayed on the existing base plot.

Riverwise Engineering, LLC
415 E. 5th Ave.
Durango, CO 81301

Des by IC, SS
Ckd by SS
12/20/2013

Animas River Diversion Headgate Monitoring Study

Animas River, Durango, CO

Cross Section Temporal Plots

Riverwise Engineering

SECTION 41

288+68.79

View Looking Upstream

1) Base plot taken from a PDF created by Bechtolt Engineering, Inc. under project number 11200, created 12-07-09, and last modified 1-13-2013. All data on the figure was taken from this file except the November 2013 data which was collected by Riverwise Engineering , LLC and overlaid on the base plot.
2) minor variations may occur in the lateral placement of cross section November 2013 versus the others because the cross section was overlayed on the existing base plot.

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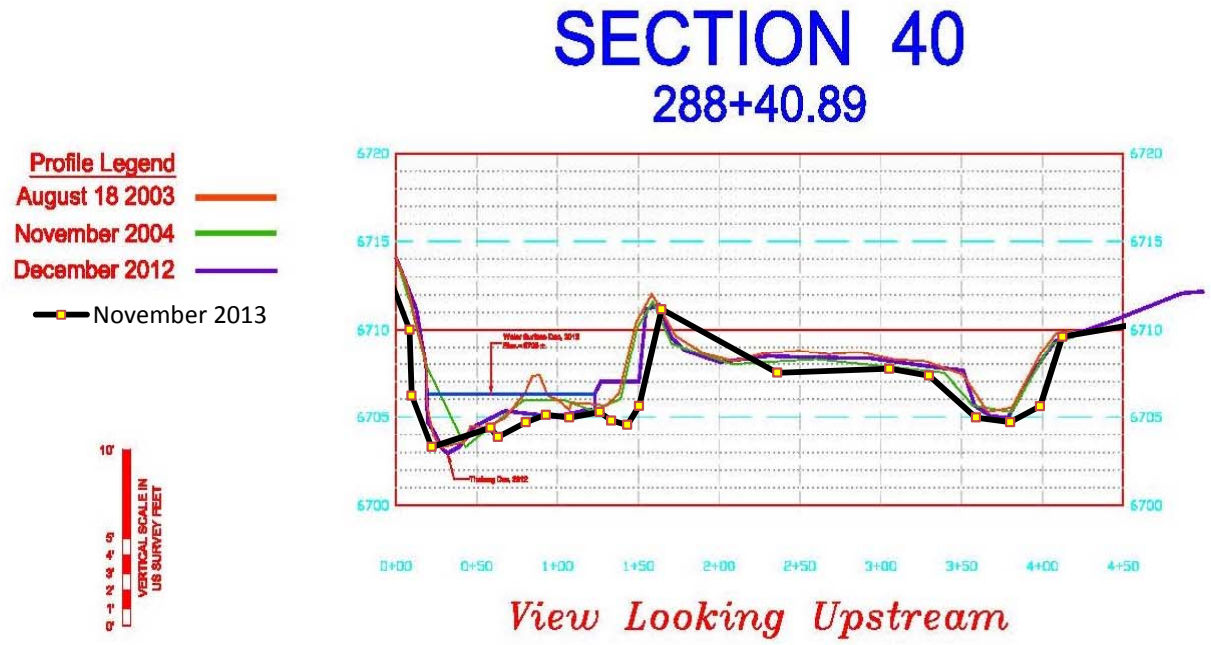
Cross Section Temporal Plots

Riverwise Engineering



1) Base plot taken from a PDF created by Bechtolt Engineering, Inc. under project number 11200, created 12-07-09, and last modified 1-13-2013. All data on the figure was taken from this file except the November 2013 data which was collected by Riverwise Engineering , LLC and overlaid on the base plot.
2) minor variations may occur in the lateral placement of cross section November 2013 versus the others because the cross section was overlayed on the existing base plot.

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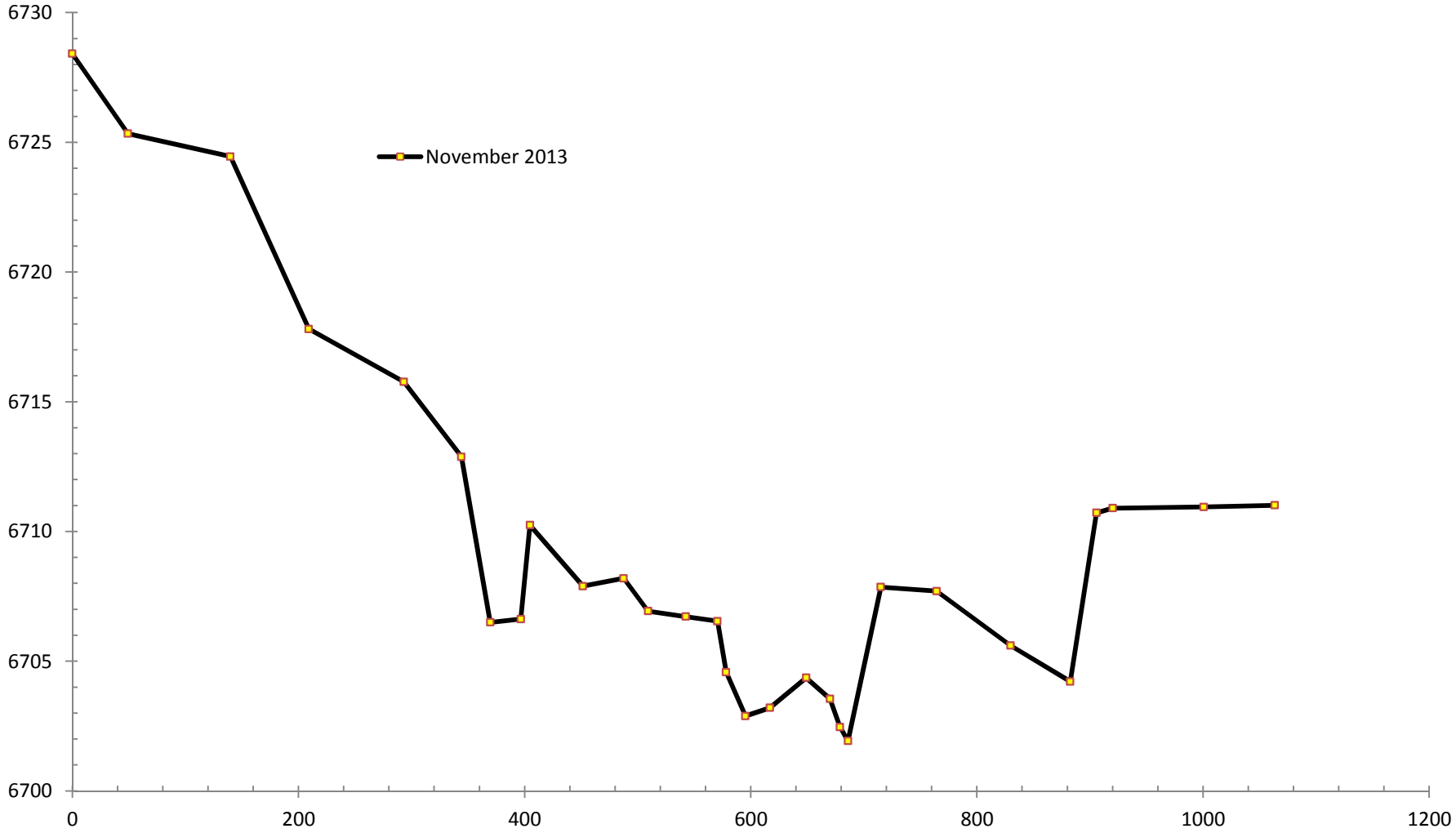
Cross Section Temporal Plots

Section 39.5



1) Data collected by Riverwise Engineering, LLC during November 2013. Reporting and metadata for the survey is available in a December 20, 2013 memo to Animas Consolidated Ditch Company and Partners.

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Cross Section Temporal Plots

Riverwise Engineering

SECTION 39

284+04.79

1) Base plot taken from a PDF created by Bechtolt Engineering, Inc. under project number 11200, created 12-07-09, and last modified 1-13-2013. All data on the figure was taken from this file except the November 2013 data which was collected by Riverwise Engineering , LLC and overlaid on the base plot.
2) minor variations may occur in the lateral placement of cross section November 2013 versus the others because the cross section was overlayed on the existing base plot.

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Cross Section Temporal Plots

Riverwise Engineering

SECTION 38

276+90.04

View Looking Upstream

Profile Legend
August 18 2003
November 2004
December 2012
November 2013

1) Base plot taken from a PDF created by Bechtolt Engineering, Inc. under project number 11200, created 12-07-09, and last modified 1-13-2013. All data on the figure was taken from this file except the November 2013 data which was collected by Riverwise Engineering , LLC and overlaid on the base plot.
2) minor variations may occur in the lateral placement of cross section November 2013 versus the others because the cross section was overlayed on the existing base plot.

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Cross Section Temporal Plots

Riverwise Engineering

SECTION 37

269+56.15

1) Base plot taken from a PDF created by Bechtolt Engineering, Inc. under project number 11200, created 12-07-09, and last modified 1-13-2013. All data on the figure was taken from this file except the November 2013 data which was collected by Riverwise Engineering , LLC and overlaid on the base plot.
2) minor variations may occur in the lateral placement of cross section November 2013 versus the others because the cross section was overlayed on the existing base plot.

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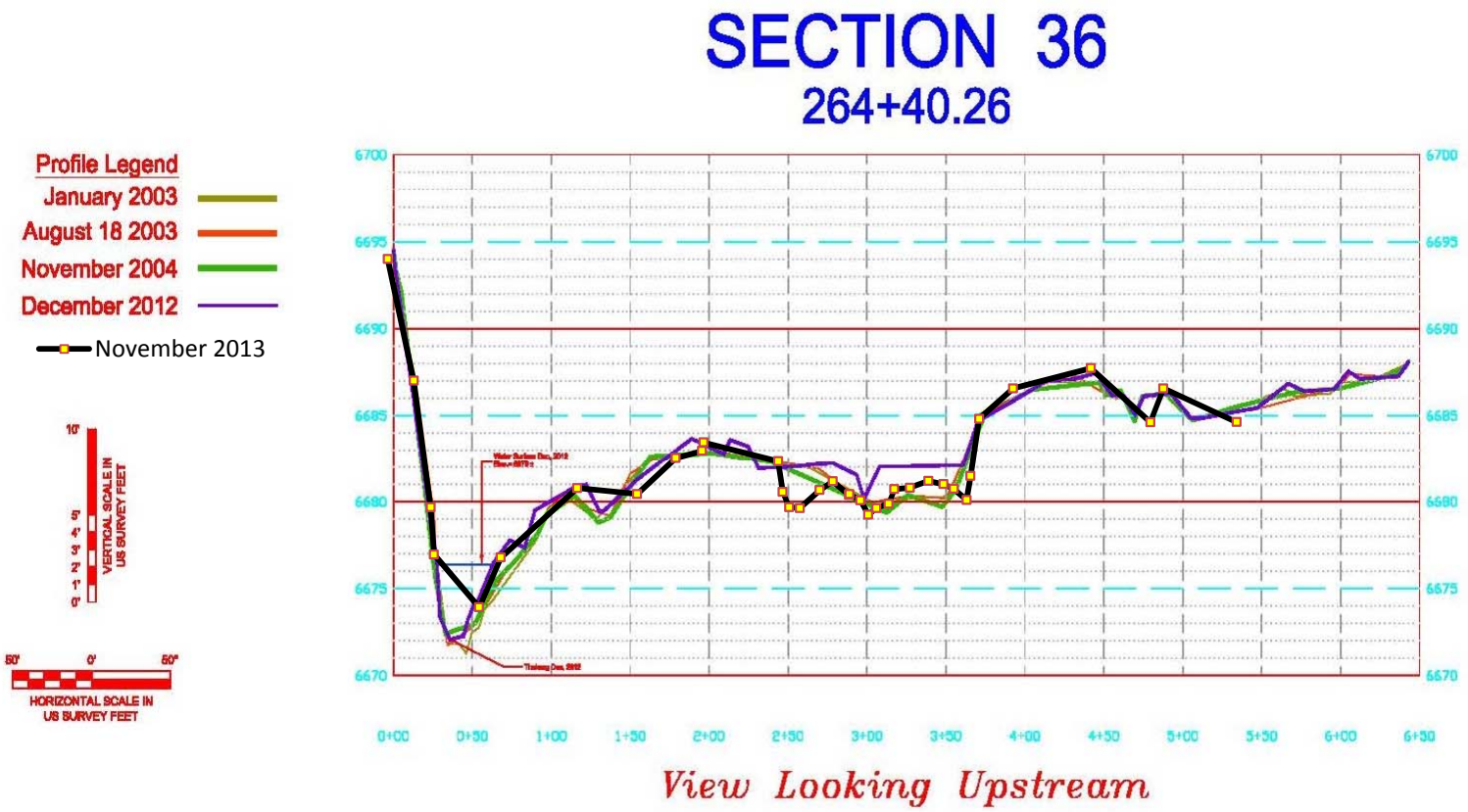
Animas River, Durango, CO

Cross Section Temporal Plots



1) Base plot taken from a PDF created by Bechtolt Engineering, Inc. under project number 11200, created 12-07-09, and last modified 1-13-2013. All data on the figure was taken from this file except the November 2013 data which was collected by Riverwise Engineering , LLC and overlaid on the base plot.

2) minor variations may occur in the lateral placement of cross section November 2013 versus the others because the cross section was overlayed on the existing base plot.

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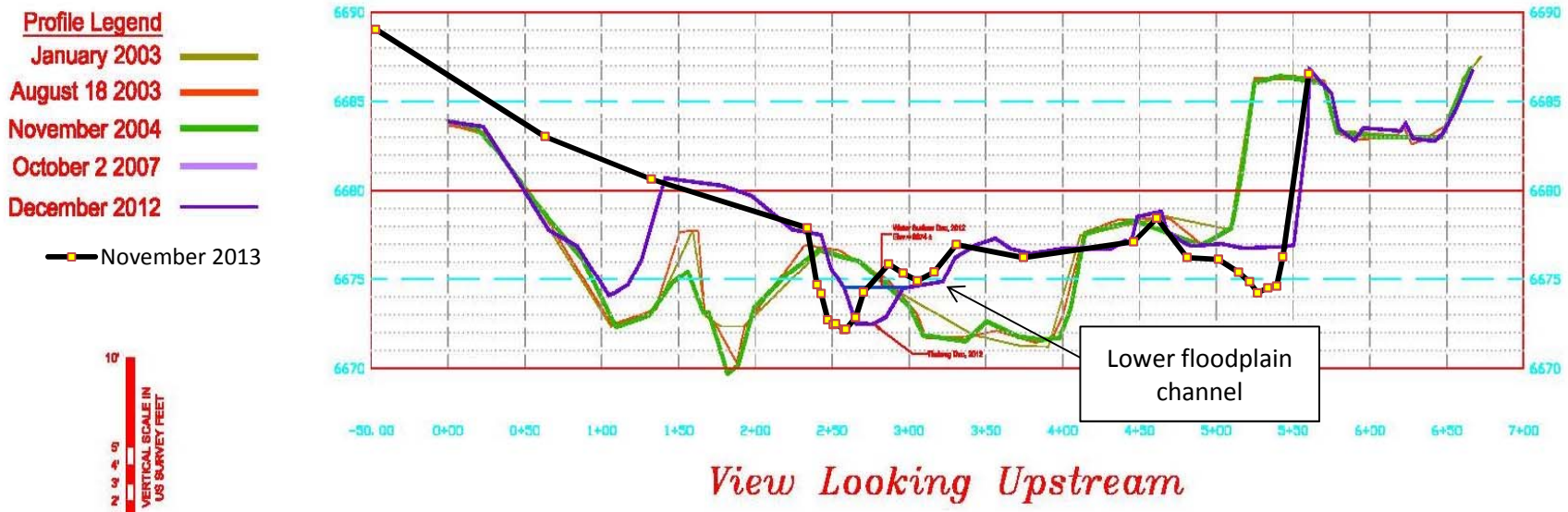
Animas River, Durango, CO

Cross Section Temporal Plots

Riverwise Engineering

SECTION 35

260+37.43



View Looking Upstream

1) Base plot taken from a PDF created by Bechtolt Engineering, Inc. under project number 11200, created 12-07-09, and last modified 1-13-2013. All data on the figure was taken from this file except the November 2013 data which was collected by Riverwise Engineering , LLC and overlaid on the base plot.
2) overbank data between Sections -50+00 and 1+25 in the November 2013 data set reflects the upland area surrounding a pit located in this area while the prior data reflects a portion of the pit.
3) minor variations may occur in the lateral placement of cross section November 2013 versus the others because the cross section was

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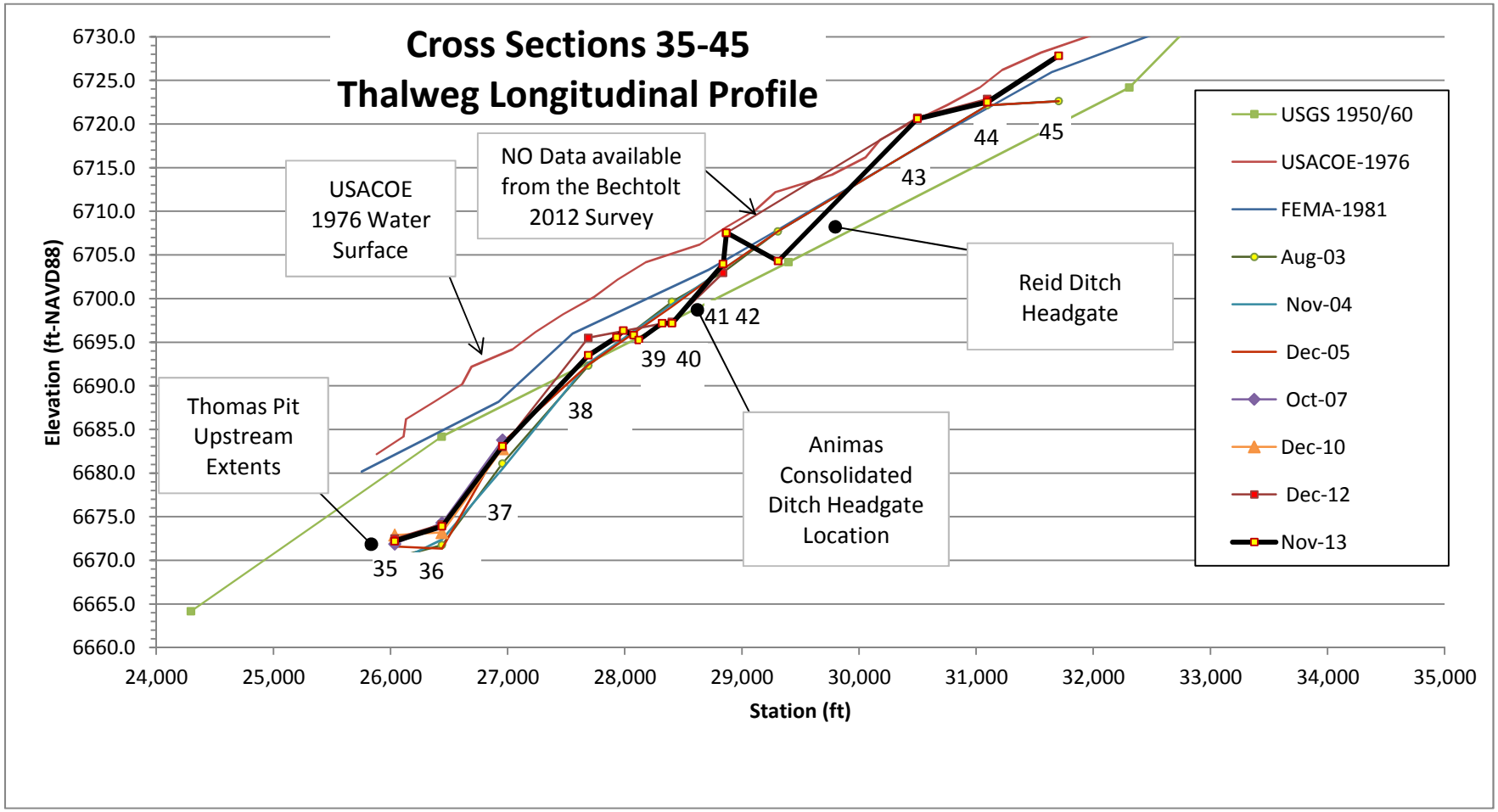
Appendix 3: Longitudinal Profile

Animas River Diversion Headgate Monitoring Study

Animas River, Durango, CO

Longitudinal Profile



Notes:

1) United States Army Corps of Engineers (USACOE) 1976 data is the water surface elevation from topographical mapping. The data is valuable to show the approximate slope of the channel during that time. Absolute elevations should not be directly compared to other data within the plot. 2) The metadata associated with the data sets is included in the memo written to the Animas Consolidated Ditch Company and Partners dated December 20, 2013.

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12/20/2013

Appendix 4: Survey Metadata

Coordinate System Details

Project : Bar D 11-23-2005

User name	mpeterson	**Date & Time**	8:31:20 AM 11/5/2013
Coordinate System	Projection from data collector	**Zone**	Zone from data collector
Project Datum	(WGS 84)		
Vertical Datum		**Geoid Model**	GEOID99 (Conus)
Coordinate Units	US survey feet		
Distance Units	US survey feet		
Height Units	US survey feet		

```
Coordinate System
Coordinate System : Projection from data collector
Zone              : Zone from data collector
Datum             : (WGS 84)
Ellipsoid Name    : (WGS 84)
Geoid Model       : GEOID99 (Conus)
Site              : Not selected


Ellipsoid
Ellipsoid Name   : (WGS 84)
Flattening 1/f   : 298.257
Semi Major Axis  : 20925604.4742sft


Datum Transformation : Three Parameter
WGS84 to (WGS 84)
Translation X    :  0.0000sft          Rotation X :             N/A
Translation Y    :  0.0000sft          Rotation Y :             N/A
Translation Z    :  0.0000sft          Rotation Z :             N/A
Scale Factor     :        N/A ppm


Lambert Conformal Conic Two Parallel Projection
Projection Origin                      False Origin
Latitude      :   36°40'00.00000"NFalse Northing  : 1000000.0000sft
Longitude     :  105°30'00.00000"WFalse Easting   : 3000000.0003sft
Height        :          N/A          False Elevation    :            N/A
Scale Factor  :          N/A


Shift grid name             :              None
Azimuth at projection centre :               N/A
Azimuth at equator          :               N/A
Projection Parallel 1       :   38°26'00.00000"N
Projection Parallel 2       :   37°14'00.00000"N
Projection Ferro Constant   :               N/A
Projection Point 1 Latitude :               N/A
Projection Point 1 Longitude :              N/A
Projection Point 2 Latitude :               N/A
```

Projection Point 2 Longitude	N/A
Projection grid name	N/A

Local site settings

Project latitude	?
Project longitude	?
Project height	0.0000sft
Ground scale factor	N/A
False northing offset	N/A
False easting offset	N/A

GPS Site Calibration Details

Horizontal Adjustment

North Origin	1285411.6757sft	Translation North	-1199556.6123sft
East Origin	2327563.9473sft	Translation East	-2299197.1351sft
Scale	1.00034496	Rotation	359°59'59.993009"

Vertical Adjustment

North Origin	96008.9770sft
East Origin	34806.0120sft
Vertical constant correction	-0.1030sft
Slope North	1.423ppm
Slope East	-11.176ppm

Network Adjustment Parameters

Longitude Deflection	N/A
Latitude Deflection	N/A
Azimuth Rotation	N/A
Network Scale	N/A
Distance Scale	N/A
Distance Constant	N/A
Height Constant	N/A

Back to top