Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

REVISED 2

UPDATE TO THE KICKING HORSE RIVER HYDRAULIC MODEL
GOLDEN, BRITISH COLUMBIA

Report Prepared for:
TOWN OF GOLDEN, BRITISH COLUMBIA

Prepared by:
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Report prepared for the Town of Golden, February 2014

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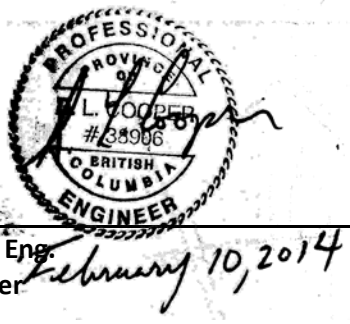

DISCLAIMER

We certify that this report is accurate and complete and accords with the information available during the site investigation. Information obtained during the site investigation or provided by third parties is believed to be accurate but is not guaranteed. We have exercised reasonable skill, care and diligence in assessing the information obtained during the preparation of this report.

This report was prepared for The Town of Golden. The report may not be relied upon by any other person or entity without our written consent and that of The Town of Golden. Any uses of this report by a third party, or any reliance on decisions made based on it, are the responsibility of that party. We are not responsible for damages or injuries incurred by any third party, as a result of decisions made or actions taken based on this report.

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1 INTRODUCTION

1.1 Background

The Town of Golden is situated on the alluvial delta of the Kicking Horse River, as shown in Figure 1 and 2. The river exits from a narrow canyon at the upstream east side of the town and flows into the north flowing Columbia River at the downstream west side of the town. An armoured dike system along the Kicking Horse River combined with the existing road and rail embankments along the Columbia River act as flood protection for the town.

A free active channel on an alluvial delta tends to continually shift and cut new channels. During high flows it flattens out by building up and depositing material over its fan. The development of the town and dike system has restricted and modified this natural alluvial process on the river. However, deposition in the restricted channel portion remains an ongoing potential concern to future flooding. The growth of gravel bars in the lower reaches of the river reduces the flow capacity of the channel and decreases the level of protection provided by the dikes. Historically, the town has maintained the channel capacity by periodically removing gravel in the lower reach near its mouth with the Columbia River. After the 1997 excavation, due to potential aquatic impacts and concerns, justification for channel or bar excavation work was required. In 2003, a guideline justifying the need for bar excavation was recommended as follows: "where the cumulative average sedimentation rate in the lower reach from sections K6 to K55 is 0.3 m or more over April 1997 conditions" (Hydroconsult 2003). Alternatively, hydraulic modeling and environmental assessments are required to justify the need for excavation. Based upon this guideline, the bars were last excavated in November 2008 (Matrix 2012) after the amount of deposition was 0.43 m in 2007.

Several previous hydraulic model studies, repeated river cross-section surveys over time and sedimentation assessment reports have been conducted on the Kicking Horse River through the town. These studies have defined flood risk levels, prepared risk mapping, and assessed the effects of sedimentation and various levels of excavation. A summary of the reports and surveys completed are as follows:

1. Hydraulic modelling and flood risk assessments: initial mapping was in 1979 (BC Ministry of Environment 1979), dike assessments with no updated mapping completed in 1989, channel capacity assessments with the dykes and various levels of excavation and deposition (Hydroconsult 1999), updated flood risk mapping (Hydroconsult 2004).

2. Historic river cross-section surveys: initial surveys in 1975 with updates in 1987, 1997 (2), 1998, 1999, 2000, 2002 (2), 2005, 2006, 2007, 2008 (2), 2009, 2012, 2013. The years 1997 and 2008 were

surveyed two times for pre- and post-excavation. A second survey in 2002 was used for modelling purposes.

3. Sedimentation level assessment reports: nine annual review reports completed between 2000 to 2013, based upon the above historic surveys.

1.2 Objectives

In view of recent increased flooding concerns, the Town of Golden retained Matrix to update the hydraulic model on the Kicking Horse River at Golden to assess flood level risks based upon more intensive hydraulic cross-section surveys. The hydraulic model was initially completed using sections surveyed in 2012. Due to an above average flood peak in June 2013 the main hydraulic sections were re-surveyed in October 2013 and the model was updated again to assess any differences.

This study includes: calibration of the model based on previously applied roughness values and the June 2012 high water data, conducting the analysis for various selected return periods, and documenting updated freeboard levels along both left and right side dikes.

1.3 Study Basis

The analyses and assessment is based on the following:

- numerous site visits and site photographs by Matrix (and formerly Hydroconsult EN3 Services Limited (Hydroconsult)) from 1999 to present
- 2013 top of dike surveys, and detailed river cross-section surveys completed in April and October 2012 and October 2013 by Focus Surveys Ltd.
- historical Water Survey of Canada (WSC) streamflow data for the Kicking Horse River at Golden (Station 08NA006) and the Columbia River at Nicholson (Station 08NA002)
- historical air photographs from 1953, 1996 and 2008 and site river photos
- bridge plans and design drawings for the Highway 95 bridge provided by BC Ministry of Transportation and Highways, for the CPR bridge provided by Canadian Pacific Limited and for the pedestrian bridge at 8th Avenue North provided by the Town of Golden
- review of previous hydrologic and hydraulic study reports for the Town of Golden and region.

2 HYDROLOGIC REVIEW

The designated design flood in British Columbia for floodplain mapping and assessment is the 200-year peak discharge. The 1999 Hydroconsult report provided a hydrologic analysis of the peak flows based on historical records of the maximum daily discharges at two WSC stations near the study area:

4. 08NA002 Columbia River at Nicholson (10.2 km upstream of the confluence with the Kicking Horse River) with a drainage area of 6,660 km² and 93-years of record (1903 to 1997) at the time of the study.

5. 08NA006 Kicking Horse River at Golden with a drainage area of 1,850 km² and 34-years of record (1912 to 1922 and 1974 to 1997) at the time of the study.

Maximum mean daily flows for various return periods were determined using the Log Pearson Type III distribution frequency analysis. Maximum instantaneous flows were calculated by multiplying the maximum daily flow values by the average instantaneous/daily ratio for the three largest recorded flow events (ratios of 1.003 and 1.064 were calculated for the Columbia and Kicking Horse rivers, respectively). The maximum instantaneous 200-year peak discharge for the Kicking Horse River at Golden was determined to be 570 m³/s.

Previous estimates of the 200-year peak discharge of the Kicking Horse River at this location have ranged from 475 m³/s to over 750 m³/s. The 2004 report (Hydroconsult 2004) provides a detailed listing of previous site-specific and regional studies as well as a summary of the seven largest flood events from 1916 to 1999. Further hydrological calculations were completed as part of the 2004 report including a single station flood frequency analysis, a two station comparison frequency analysis and an analysis based on the runoff depth approach as developed by Alberta Transportation.

Based on the 2004 review, the 200-year design discharge value of 570 m³/s was conservatively recommended, as previously used in the 1999. This current update of the hydraulic model will also use this design discharge value, as the recent flood events from 2004 to 2012 have not significantly altered flood frequency analysis results. The 500-year peak discharge was calculated using a logarithmic extrapolation of the lower return period flood events. Table A lists the resulting flood flow frequencies.

TABLE A Columbia River and Kicking Horse River Maximum Instantaneous Discharges

Return Period (Years)	Columbia River upstream of the confluence of the Kicking Horse River (m³/s)	Kicking Horse River at Golden (m³/s)
2	428	245
5	528	306
10	586	351
20	638	397
50	698	461
100	741	514
200	777	570
500	861	632

Figure 3 plots the annual maximum instantaneous and daily discharges recorded at Station 08NA006 up to 2012. The period of record consists of 33 years of instantaneous discharges and 50 years of daily discharges. The highest reported flow was a daily value of 402 m^3/s in 1916.

3 HYDRAULIC MODELLING

3.1 2004 Study

The current hydraulic analysis provides a comparison from Hydroconsult's 2004 report to assess any changes in the predicted 200-year flood profile and identify any potential impact of recent sedimentation. The 2004 study was based upon cross-section survey data up to November 2002. To compare with the 2004 study, annual sedimentation assessment reports based upon river cross-section surveys have tracked changes in the amount of sedimentation over time. The last formal review (Matrix Solutions 2012) presented a comparison of all historic surveyed sections up to April 2012. The historic surveys are therefore not repeated here. Since then the October 2012 and October 2013 section surveys were completed and an interim sedimentation review was conducted in August 2013 (email to the Town) based upon the October 2012 surveys. The extent of historic sedimentation based upon the section surveys is discussed later in Section 4.

3.2 Input Data

Two river hydraulic river models were constructed for the same reach of the river as the 2004 study. Initially modelling was based upon April and October 2012 section surveys but after an above average flood peak in June 2013, the sections were re-surveyed in October 2013 with additional sections inserted to re-model the river.

3.2.1 2012 Survey Model

The first model was based on the most recent data for each section prior to the 2013 freshet. This included 38 sections surveyed in October 2012 (1+974 to 0+000), four sections surveyed in April 2012 (2+742 to 2+213, upstream of Highway 95 bridge) and five sections not previously surveyed that still relied upon the 1987 sections (3+583 to 3+132 and 2+184 to 2+068).

This survey captured significantly more detail between station 1+974 (K5 near the downstream end of Gould's Island) and 0+000 (the confluence with the Columbia River). Previous surveys only had 11 sections within this reach compared to 38 sections at an average spacing of 50 m with this current survey. The purpose of this was to document if the increased detail showed any significant differences in the 200-year flood profile.

3.2.2 2013 Survey Model

A peak discharge of 280 m³/s was recorded on the morning of June 21, 2013. This discharge corresponds to between a 2 and 5-year recurrence interval flood event. A survey was completed in October 2013 to capture any changes to the river cross-sections as a result of this event and to update the sections that had not been surveyed since 1987 (K1, K52, K2, K11b and K11). Additionally, three new sections (designated as Section K60, K61 and K62) were surveyed at key locations to provide a more accurate model of the river profile. As a result, the 2013 survey provided a more detailed refinement of the model from that used in 2004 but with less detail in the lower reach than the 2012 survey.

3.2.3 Top of Bank Survey and Model Parameters

A June 2013 survey of the top of banks along the Kicking Horse River was also included to re-assess the current freeboard levels along the dikes.

All other hydraulic model parameters (e.g., roughness, expansion/contraction coefficients, bridge data, starting downstream water level, and calibrations) used in the 2004 and 1999 studies were repeated in the 2012 and 2013 section models. This includes assuming coincident flood peaks on the Columbia and Kicking Horse rivers to define maximum backwater effects. Backwater effects from the Columbia River and the timing of the peaks were discussed in the 1999 report. Assuming coincident peaks with the Columbia River is not significant because it only affects the lower 1 km long reach of the Kicking Horse River. There is minimal impact from this assumption because of the limited development in this lower reach and the Columbia will backflood the other side of the dike to a comparable flood level. The input data used in the present analysis are provided in Appendix A.

The flows listed in Table A were all run in the hydraulic analysis.

3.3 Model Calibration

An annual maximum instantaneous discharge of 352 m³/s was recorded during the night of June 6, 2012. It was the third highest recorded discharge since 1981. The peak water level at this time was observed to be approximately 0.2 m below the low point in the right berm at Station 1+990 downstream of Highway 95 bridge (Figure 2). The estimated elevation of the right bank at this location is 787.24 m resulting in an estimated water level of 787.04 m. This is an approximate estimate that was not surveyed in at the time.

This peak discharge event is equivalent to the 10-year peak discharge based upon the flood frequency values in Table A (Section 2). The modelled 10-year water level at this location (using the same hydraulic model parameters as previously used) corresponds to a water level of 786.87 m in the 2012 model and 786.86 m in the 2013 model. Therefore the modelled water level is 0.17 to 0.18 m lower than the observed June 2012 peak water level. To increase the modelled water level by this amount would require increasing the originally calibrated Manning's n value at this section from 0.025 to 0.030.

This adjustment in the roughness coefficient would result in a localized increase in the 200-year water level of 0.20 m at the section immediately upstream (K11B) and only 0.03 m at the next three sections upstream of K11B (K11 to K4). Considering lower channel n values are typically expected at higher flows, no adjustment was considered warranted for the higher 200-year flood flow based upon this one approximate data point. Therefore, the originally calibrated values used in the 1999 and 2004 studies were retained for use in the current study.

3.4 Model Assessment Results and Comparison with 2004 Study

3.4.1 Comparison between the 2004 and 2013 Studies

Table B compares predicted 200-year flood levels between the 2004 study and the present study. This table comparison shows localized differences ranging from -0.33 to +0.53 m with averaged overall differences balancing out.

The most dramatic differences were observed at or near the sections that had not been re-surveyed since 1987. These sections include K1, K52, K11 and K11B.

The most significant increase is at Station K11 where the modeled 200-year water level has increased by 0.53 m over 2004. This reflects the use of actual 2013 surveys at this section rather than the 1987 section survey that was used in the 2004 study. This section is located just downstream of the Highway 95 bridge and is a localized effect in the model. Higher levels are predicted just downstream and upstream of the bridge and slightly lower levels are predicted further downstream at sections K11B and K5.

The addition of new section K60 shows a locally higher predicted water level here than in 2004 (see the profile plot in Figure 4) reflecting the greater detail now in the model at this island.

The most significant water level decreases in modeled 200-year water level are observed at the downstream end of the reach (K53-K9) with an average decrease of approximately 0.17 m. This range of variation from plus or minus 0.2 m is expected due to natural bed level changes from year to year.

Overall, the more significant changes are more a reflection of refinement of the model at the islands and bridges and show the range of variation that is typical with the HEC-RAS model. This supports applying a 0.6 m minimum freeboard recommendation for the dike level to account for this level of model variation.

TABLE B Kicking Horse River Hydraulic Sections Compared With Previous Hydraulic Study Results

Section Name	Stationing (m)	200-year Water Surface Elev (m)			Difference between April/October 2012 and Present Study (m)	Difference between 2004 Study and Present Study (m)
		2004 Study	April /October 2012 Survey	Present Study		
K1	3583	794.74	794.80	794.65	-0.15	-0.09
K52	3519	794.85	794.93	794.53	-0.40	-0.32
K2	3132	792.67	792.57	792.64	0.07	-0.03
K50	2742	790.67	791.07	790.52	-0.55	-0.15
K60	2571	NS	NS	790.23	NS	
K51	2443	788.98	789.01	789.14	0.13	0.16
K4	2312	788.80	788.89	788.93	0.04	0.13
K10	2213	788.50	788.84	788.80	-0.04	0.30
Highway 95 Bridge						
K11	2184	788.13	788.47	788.66	0.19	0.53
K11B	2068	788.14	788.45	787.81	-0.64	-0.33
K5	1971	787.80	788.1	787.66	-0.44	-0.14
K61	1679	NS	NS	786.79	NS	
K6	1483	785.75	786.15	786.00	-0.15	0.25
K6A	1239	785.27	785.67	785.34	-0.33	0.07
K7	1106	785.04	785.37	785.15	-0.22	0.11
K7A	1015	784.87	785.16	784.84	-0.32	-0.03
K62	900	NS	NS	784.75	NS	
K7B	772	784.65	784.90	784.63	-0.27	-0.02
K8	643	784.49	784.75	784.48	-0.27	-0.01
K53	464	784.13	784.36	783.96	-0.40	-0.17
K54	410	784.22	784.41	784.06	-0.35	-0.16
CPR Bridge						
K9	275	784.16	784.12	783.98	-0.14	-0.18
				MEAN	-0.22	0.00

Note: NS = Not surveyed for 2004 or 2012 studies

3.4.2 Comparison between the 2012 and 2013 Sections

Table B also provides a comparison between the 2012 model and section data versus the 2013 section data. As described in Section 3.2.1, the 2012 model was constructed using a combination of surveys from 2012 and 1987 but with detailed sections in the lower reach downstream of Gould's Island.

This comparison shows a lower overall predicted 200-year flood level profile in 2013 compared to 2012 with local section differences ranging from -0.64 to +0.19 m. Again, the largest differences were observed at or near sections that had not been surveyed since 1987 (-0.64 m at Section K11B and -0.55 m at Section K50).

As with the comparison to the 2004 study, the downstream end of the reach (K7A to K9) predicts more significant decreases in the profile in 2013. The average decrease through this area was nearly 0.30 m from 2012 to 2013. This difference is primarily attributed to the increased detail in the number of sections used in the 2012 survey but is also somewhat due to local sediment flushing that occurred during the 2013 high flow event.

3.4.3 Available Freeboard

Table C lists all of the sections used in the model as well as the resulting water surface elevations for all of the modeled flow scenarios.

The left and right side dike freeboard is assessed here based upon the recent June 2013 detailed top of dike surveys and interpolating with the 2013 model 200-year water level results. The minimum freeboard recommended by the Ministry of Water Land and Air Protection of British Columbia is 0.6 m. Table C indicates the surveyed sections in red that have a freeboard less than this recommended minimum. Figure 5 provides a plot of the resulting freeboard in greater detail along the entire dike system compared with the 0.6 m recommended minimum freeboard. Figure 6 provides a layout and detailed list of all the reaches on each dike side where the freeboard is less than 0.6 m. The table in this figure could be used for designing minimum fill requirements. Section K9 (Station 0+275) is located just upstream of the confluence with the Columbia River and downstream of the town and is therefore not included in the freeboard analysis presented on Figure 6.

Due to the variations in potential sediment deposition (discussed in Section 4) and flood levels and ice jam risks, Matrix has previously recommended increasing the freeboard to 1 m as a medium to long-term target. As this may not be practical throughout the entire length of both dikes, higher priority reaches where the minimum 1 m freeboard target should be considered are indicated in Figure 7. These priority sections are all along the left side except for the low 210 m long right side section downstream of Highway 95 bridge where a long term solution will be required. The left side dike sections are as follows:

- upstream near the campground below Section K52 for 175 m
- along the island beside College of The Rockies at Section K50 for 180 m
- about 50 to 170 m upstream of Highway 95 bridge for 120 m
- downstream of Highway 95 bridge to the pedestrian bridge for 335 m

TABLE C Kicking Horse River Hydraulic Analysis Results - 2013 Model

Section	Stationing	Date of Survey	Thalweg	Right Top of Dike Elevation	Left Top of Dike Elevation	Flood Water Levels (m)								200--year Flood Freeboard (m)	
						2--year Flood	5--year Flood	10--year Flood	20--year Flood	50--year Flood	100--year Flood	200--year Flood	500--year Flood	Right Bank	Left Bank
K1	3+583	Oct--13	790.04	796.40	795.30	793.65	793.87	794.02	794.16	794.35	794.5	794.65	794.82	1.75	0.65
K52	3+519	Oct--13	791.25	796.64	795.30	793.38	793.61	793.77	793.93	794.14	794.33	794.53	794.78	2.11	0.77
K2	3+132	Oct--13	789.54	795.21	793.69	791.79	792.05	792.21	792.35	792.51	792.59	792.64	792.67	2.57	1.05
K50	2+742	Oct--13	787.63	792.30	791.60	789.8	789.88	789.94	790.02	790.22	790.36	790.52	790.72	1.78	1.08
K60	2+571	Oct--13	786.48	792.00	790.93	788.82	789.11	789.31	789.51	789.79	790.01	790.23	790.48	1.77	0.70
K51	2+443	Oct--13	785.34	789.85	790.46	787.99	788.25	788.42	788.59	788.8	788.97	789.14	789.34	0.71	1.32
K4	2+312	Oct--13	785.28	789.80	789.81	787.57	787.89	788.1	788.29	788.54	788.74	788.93	789.18	0.87	0.88
K10	2+213	Oct--13	784.25	790.32	790.24	787.34	787.66	787.88	788.09	788.36	788.59	788.8	789.07	1.52	1.44
Highway 95 Bridge															
K11	2+184	Oct--13	784.02	789.50	789.50	787.31	787.61	787.82	788.02	788.27	788.47	788.66	788.86	0.84	0.84
K11B	2+068	Oct--13	784.09	788.18	788.79	786.55	786.83	787.01	787.19	787.43	787.62	787.81	788.03	0.37	0.98
K5	1+971	Oct--13	783.78	788.41	788.50	786.33	786.63	786.82	787.01	787.26	787.46	787.66	787.88	0.75	0.84
K61	1+679	Oct--13	783.28	787.94	787.35	785.66	785.89	786.05	786.21	786.43	786.61	786.79	786.99	1.15	0.56
K6	1+483	Oct--13	783.17	787.78	787.80	785.26	785.44	785.55	785.66	785.8	785.9	786	786.09	1.78	1.80
K6A	1+239	Oct--13	782.15	786.77	786.33	784.51	784.68	784.8	784.92	785.08	785.21	785.34	785.49	1.43	0.99
K7	1+106	Oct--13	781.09	786.63	786.75	784.22	784.41	784.55	784.68	784.86	785	785.15	785.32	1.48	1.60
K7A	1+015	Oct--13	780.86	785.87	786.03	783.99	784.16	784.27	784.4	784.56	784.7	784.84	785.02	1.03	1.19
K62	0+900	Oct--13	780.79	785.76	785.22	783.87	784.03	784.15	784.27	784.45	784.6	784.75	784.94	1.01	0.47
K7B	0+772	Oct--13	780.57	785.31	784.97	783.57	783.78	783.92	784.08	784.29	784.46	784.63	784.85	0.68	0.34
K8	0+643	Oct--13	780.51	785.25	785.09	783.36	783.58	783.74	783.91	784.13	784.31	784.48	784.72	0.77	0.61
K53	0+464	Oct--13	780.55	784.58	786.87	782.94	783.12	783.25	783.41	783.63	783.8	783.96	784.24	0.62	2.91
K54	0+410	Oct--13	780.29	784.79	786.87	782.95	783.14	783.29	783.47	783.7	783.89	784.06	784.35	0.73	2.81
CPR Bridge															
K9	0+275	Oct--13	780.61	784.18	786.90	782.28	782.77	783.05	783.29	783.57	783.78	783.98	784.29	0.20	2.92

4 SEDIMENTATION RATES AND EFFECTS

Since 1997, Matrix (and formerly, Hydroconsult) has completed numerous assessments detailing the deposition (or scour) at repeated cross-sections at the downstream end of the reach, primarily downstream from Section K6. These assessments are intended to monitor sedimentation rates and assess if excavation or bar lowering is needed.

Historically, deposition has been identified as greatest between 0+643 and 0+899 (Sections K8 to K62).The current model however indicates that these sections have not significantly increased the 200-year flood level over the 2004 study. Previous reviews of sedimentation based upon sections up to October 2013 using areas and conveyance capacities only, without detailed hydraulic modeling, provides results similar to the hydraulic model (typically within ±0.1 m). Therefore, this form of annual review without detailed modeling is considered adequate to assess sedimentation effects over time.

The detailed section surveys in 2012 show that the predicted 200-year flood level from upstream of the CP Rail bridge to upstream of Highway 95 averages 0.295 m higher than the 2004 study results. By comparison, the average depth of deposition from the surveys to 2012 was comparable at 0.275 m. A detailed topographic survey of the existing gravel bars was completed in October 2013. When compared to the October 2012 survey, the volume of material deposited up on the bars was only 543 m^3 greater in 2013 and the area of the bars had decreased by about 5%, or over 1,000 m^2 at similar elevations from 2012 to 2013. Due to channel bed scour in 2013, the net amount of deposition decreased from 2012 to 2013 by 0.14 m such that the current cumulative level of deposition is now at +0.13 m compared to the 1997 reference level. This is indicated in the historical record in Figure 8. This is now adequately below the 0.30 m guideline originally proposed to trigger the need for gravel bar lowering.

5 CONCLUSIONS

Hydraulic modeling of the Kicking Horse River based on surveyed sections in 2012 and October 2013 show the effect of sedimentation on flood levels and the available freeboard. Overall there have been minimal changes in the predicted 200-year flood profile since the 2004 study to the 2013 surveys. The greatest differences are localized where new sections were added or where old sections have been updated.

The comparison between the detailed section surveys in 2012 and the 2013 models show a greater net decrease (0.18 m) in the flood profile than the comparison to the 2004 study. It is expected that this net decrease has been skewed due to the inclusion of the 1987 sections in the 2012 model. Due to the high flows in June 2013, it is not possible to quantitatively measure the impact of the greater intensity of surveyed sections at the downstream end of the reach. However, due to the relatively minor differences

in the flood profile, it is expected that the sections surveyed in October 2013 are sufficient to provide an accurate representation of the current state of the river.

Applying the provincial guidelines, the dike system has adequate freeboard (at least 0.6 m) in almost all locations above the designated 200-year flood level equivalent to a peak discharge of 570 m^3/s. Although the provincial guidelines specify the design flow for flood protection is the 200-year flow, the 500-year flow was also included in this analysis. The results show that the flow is still confined within the channel during this flood event throughout the majority of the reach. Previously assumed extreme case scenario evaluations show that dike overtopping can occur, likely as a result of a combination of extreme conditions (local sediment deposition, debris and increased values in assumed channel roughness as well as a flood peak exceeding 570 m^3/s).

6 RECOMMENDATIONS

The following recommendations are provided based upon these study results and the previous Matrix studies conducted on the Kicking Horse River in Golden:

1. Continue conducting and evaluating river cross-section surveys at least every two or three years in order to continue to monitor sedimentation conditions as an ongoing program. However, as the level of deposition is midway between zero and the 0.3 m guideline target for justification of bar lowering, depending upon high flow conditions next year, the need for surveys should be evaluated in the lower reach (K6 to K55) in the fall of 2014.

2. The sections surveyed in October 2013 and illustrated on the figures are considered to be sufficient for hydraulic modeling purposes. Further detailed section surveys (at 50 m spacing) are not considered warranted at this time.

3. Figure 6 illustrates the areas of both dikes where the existing freeboard is less than 0.6 m. Adding fill to these locations to achieve the minimum 0.6 m freeboard is recommended, as a minimum. Wherever practical, increasing the freeboard to 1 m is recommended. High priority dike sections to achieve this 1 m freeboard and the corresponding fill levels are provided in Figure 7.

4. Continue the ongoing dike monitoring and maintenance program consisting of: annually inspecting the dike side slopes, the protective riprap and the dike crest, and replacing /stabilizing the riprap, as required.

5. Continue to update and test the Emergency Preparedness Plan that is in place on a regular basis.

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Matrix Solutions Inc. 2006b. *Update Assessment of Sedimentation on the Kicking Horse River, Town of Golden*. Report prepared for the Town of Golden, 2006 Surveys. December 2006.

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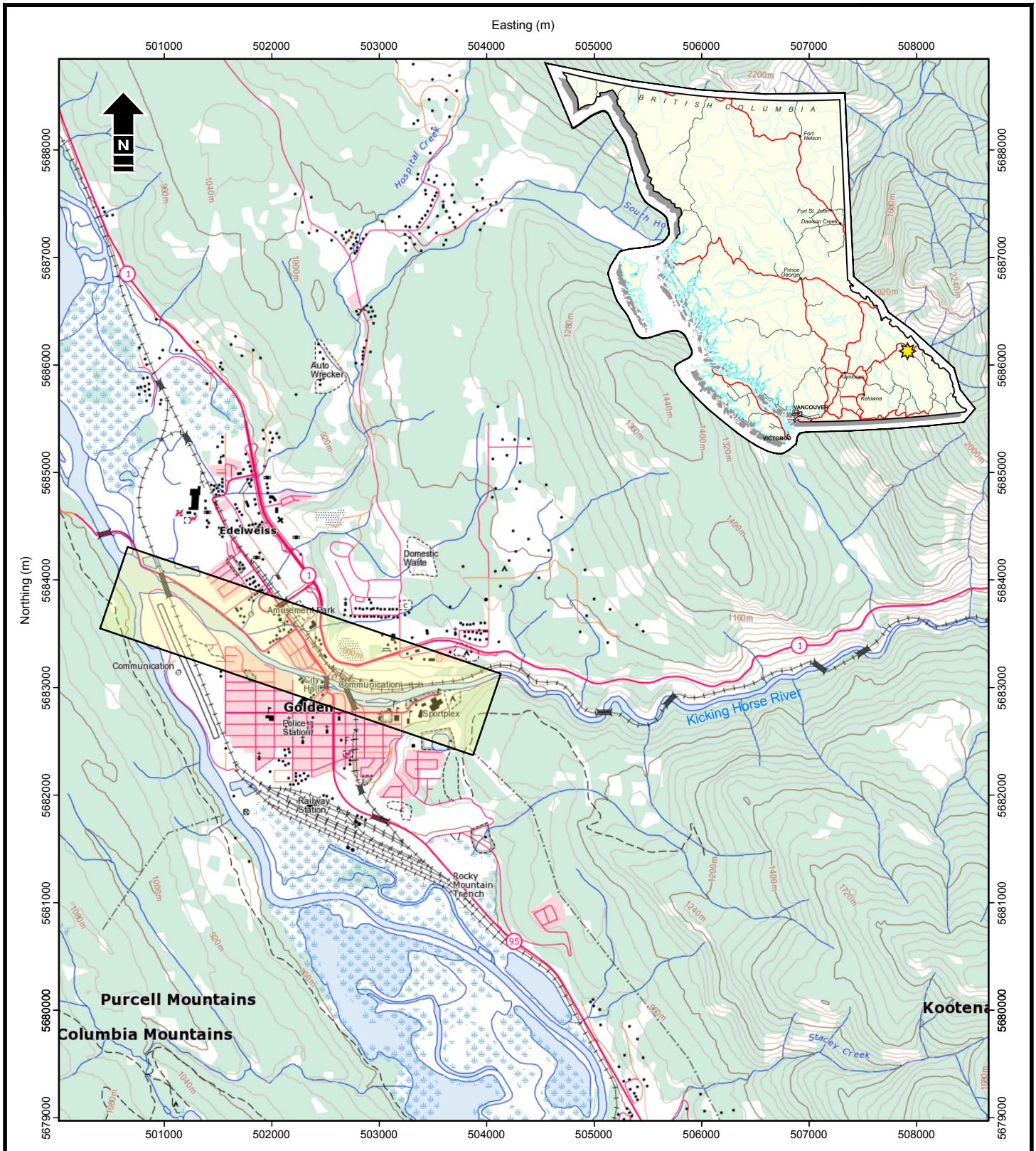

Site Location

1:50000 metres

500 0 500 1000

UTM83-11

REFERENCE: 82N07 (Golden), Edition 4, UTM Zone 11, NAD 83

Matrix Solutions Inc.
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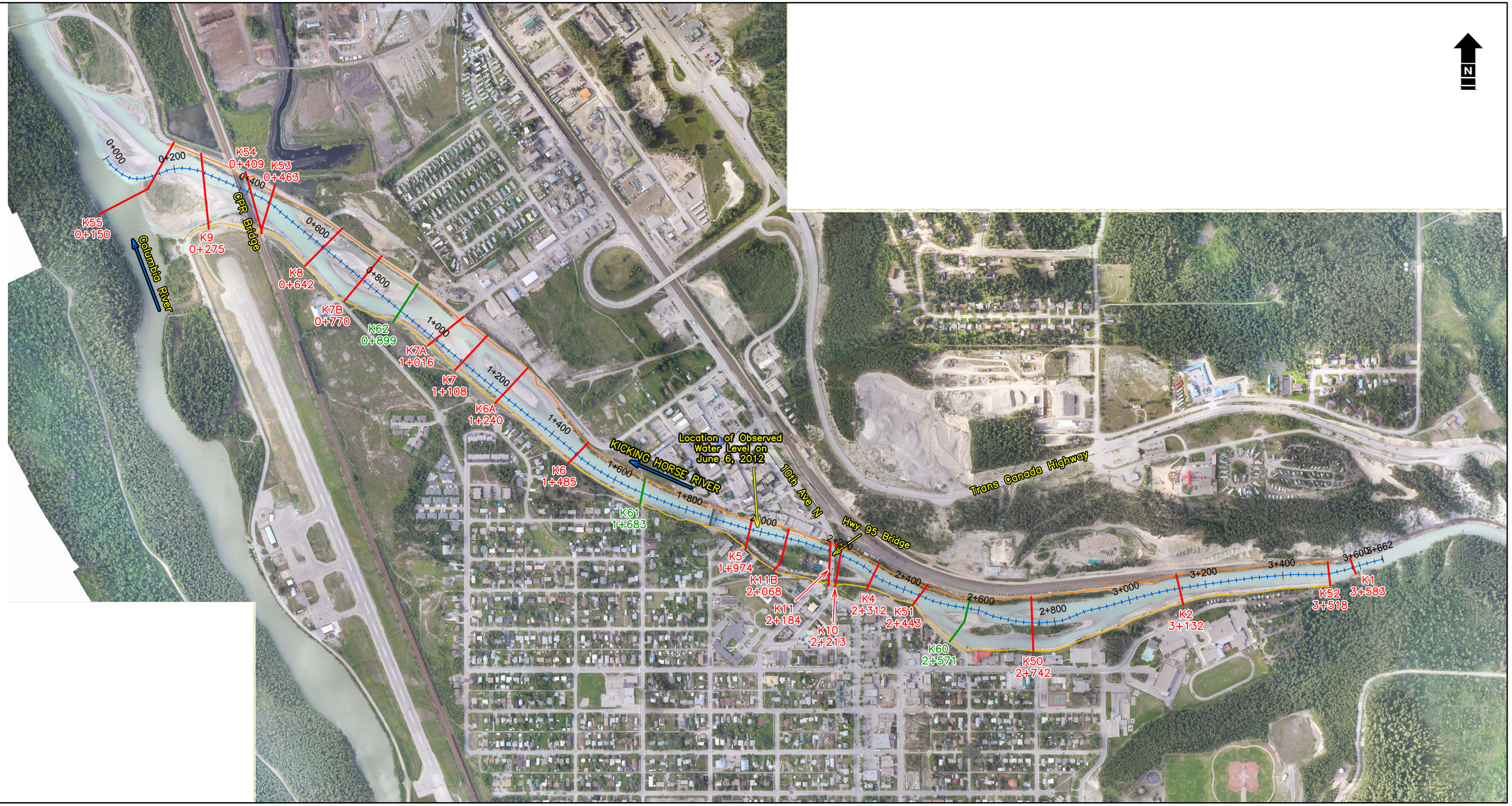
Town of Golden
Flood Risk Assessment Mapping

Site Location Map

Date:	Project:	Technical:	Reviewer:	Drawn:
February 2014	5635-LP-14	Z. Steele	D. Cooper	C. Zhang

Figure 1

Plot 1:1 = Tabloid (L)



New Section - Not Used in 2004 Study - Used in Present Study - Surveyed in October 2013

Section Used in 2004 Study - Re-Surveyed in October 2013

Surveyed Right Bank - June 2013

Surveyed Left Bank - June 2013

1:10000 Meters

100 0 100 200

UTM83-11

Reference:

STAMP	PERMIT
PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA W. L. HOOPER #28086 February 10, 2014	

No.	DATE	DESCRIPTION	BY
4	2014/02/10	Revised Final	DLC
3	2014/01/23	Re- Issued Final	DLC
2	2014/01/06	Re- Issued Final	DLC
1	2013/11/13	Final	JB
0	2013/08/13	Issued for Client Review	DLC

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

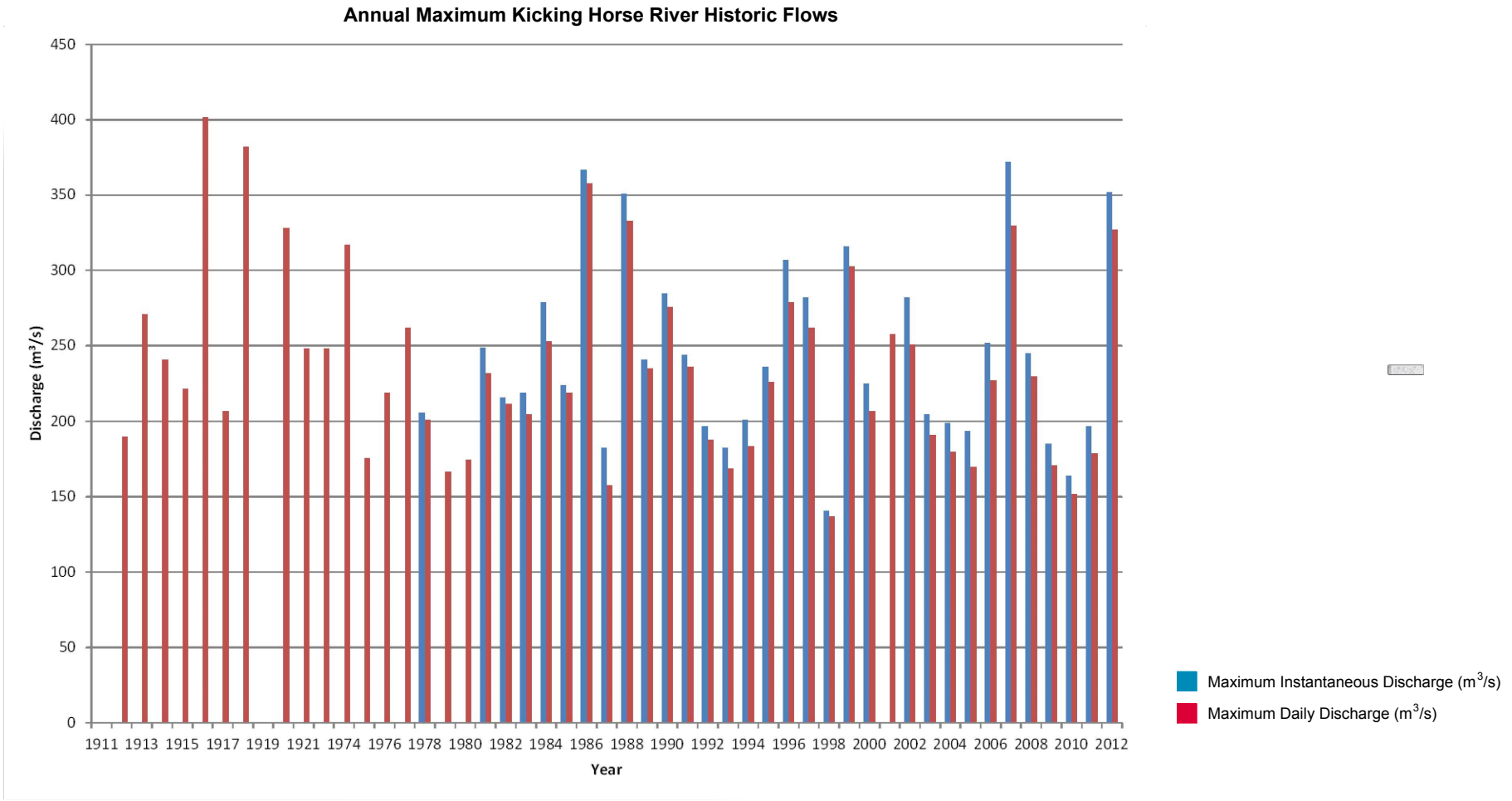
Town of Golden
Flood Risk Assessment Mapping

Kicking Horse River Study Reach

Date:	Project:	Technical:	Reviewer:	Drawn:
February 2014	5635-SP-C3D-14	J. Bigelow	D. Cooper	Z. Steele

Figure 2

F:\5635\Drafting\2014\5635-SP-C3D-14.dwg - StudyReach - Monday, February 10, 2014 2:39:02 PM - Gary Evenson



Reference:

STAMP	PERMIT	No.	DATE	DESCRIPTION	BY
PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA D.L. COOPER #34096 February 10, 2014		4	2014/02/10	Revised Final	DLC
		3	2014/01/23	Re- Issued Final	DLC
		2	2014/01/06	Re- Issued Final	DLC
		1	2013/11/13	Final	JB
		0	2013/08/13	Issued for Client Review	DLC

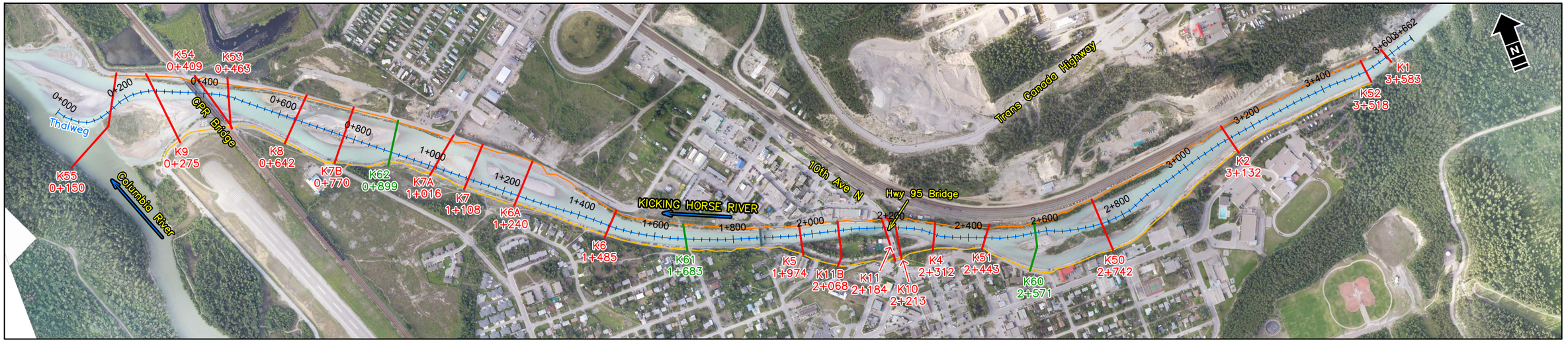
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Town of Golden
Flood Risk Assessment Mapping

Annual Maximum Kicking Horse River Historic Flows

Date:	Project:	Technical:	Reviewer:	Drawn:
February 2014	5635-SP-C3D-14	J. Bigelow	D. Cooper	Z. Steele

Figure 3



New Section - Not Used in 2004 Study - Used in Present Study - Surveyed in October 2013

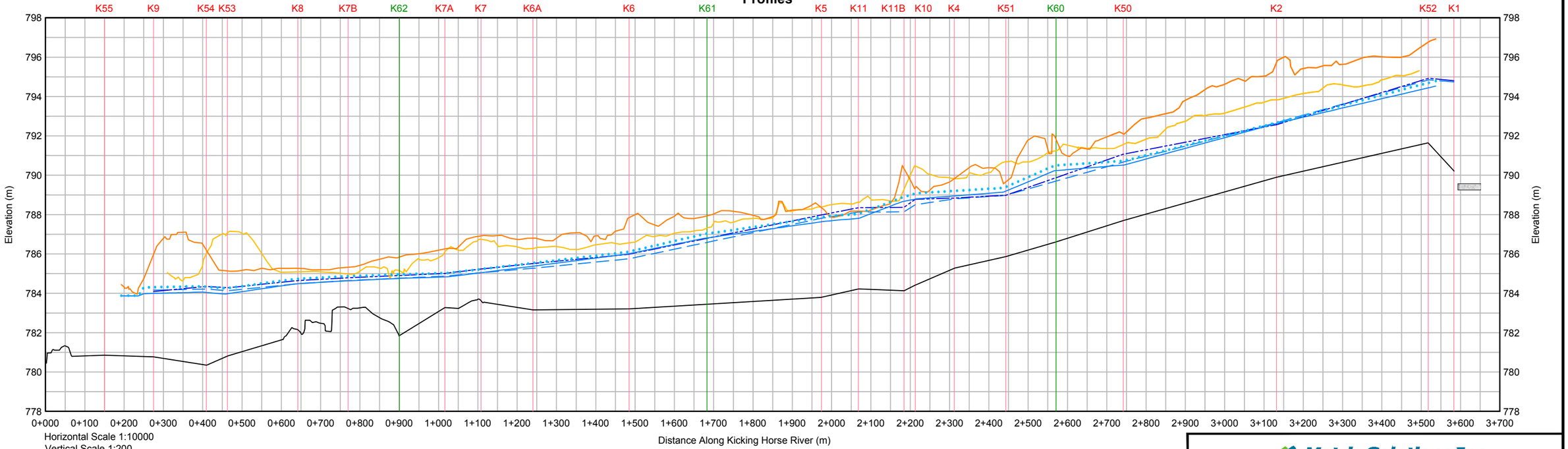
Section Used in 2004 Study - Re-Surveyed in October 2013

Surveyed Right Bank - June 2013

Surveyed Left Bank - June 2013

1:10000 Meters
100 0 100 200
UTM83-11

Profiles



Horizontal Scale 1:10000
Vertical Scale 1:200

Thalweg - October 2013
1:200 Year Flood Level - 2013 Study
1:200 Year Flood Level - 2004 Study
1:500 Year Flood Level - 2013 Study
1:200 Year Flood Level - 2012 Study

Reference:

STAMP	PERMIT
PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA D. L. COOPER #34985 February 10, 2014	

No.	DATE	DESCRIPTION	BY
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3	2014/01/23	Re- Issued Final	DLC
2	2014/01/06	Re- Issued Final	DLC
1	2013/11/13	Final	JB
0	2013/08/13	Issued for Client Review	DLC

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Town of Golden
Flood Risk Assessment Mapping

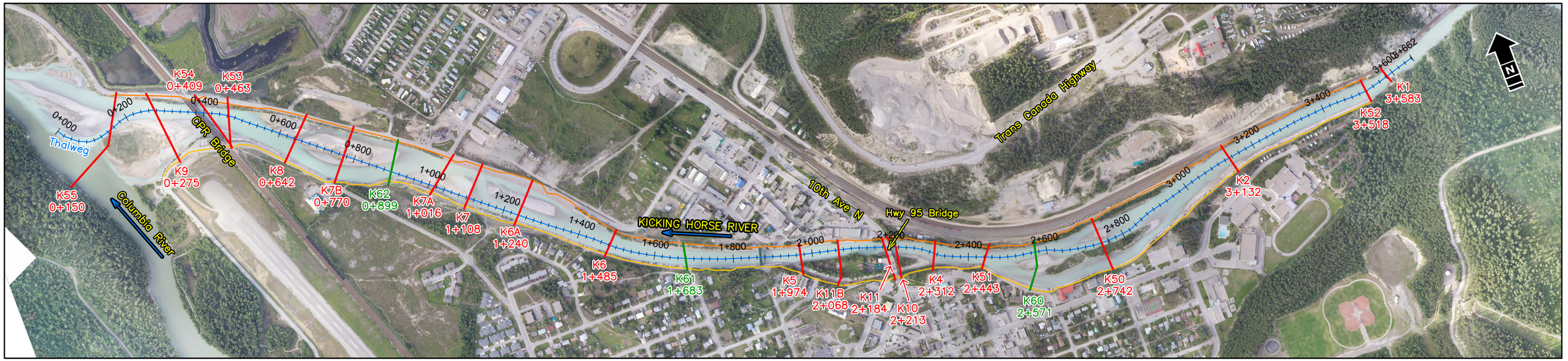
Bank Levels Versus Flood Discharge Levels

Date:	Project:	Technical:	Reviewer:	Drawn:
February 2014	5635-SP-C3D-14	J. Bigelow	D. Cooper	Z. Steele

Figure 4

Plot 1:1 = Tabloid (L)

F:\5635\Drafting\2014\5635-SP-C3D-14.dwg - Profile - Monday, February 10, 2014 2:39:02 PM - Gary Everson



New Section - Not Used in 2004 Study - Used in Present Study - Surveyed in October 2013

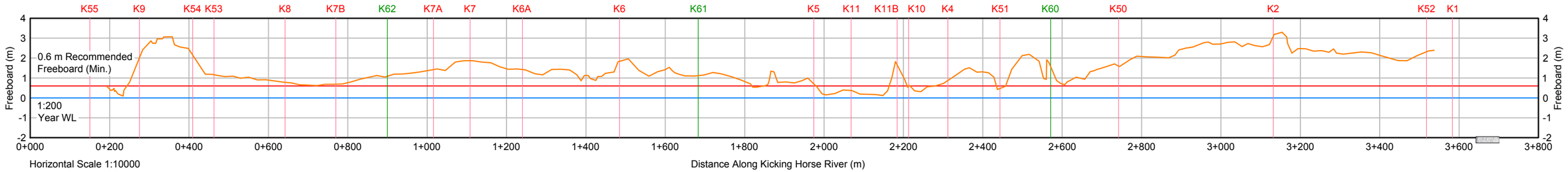
Section Used in 2004 Study - Re-Surveyed in October 2013

Surveyed Right Bank - June 2013

Surveyed Left Bank - June 2013

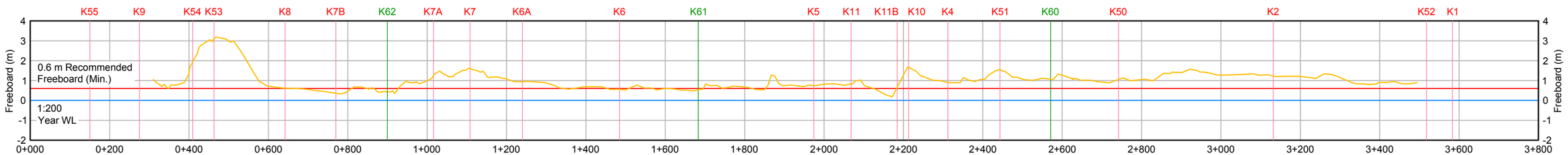
1:10000 Meters
100 0 100 200
UTM83-11

North (Right) Bank



Horizontal Scale 1:10000
Vertical Scale 1:200

South (Left) Bank



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Vertical Scale 1:200

Reference:

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PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA D. L. HOOPER #28006 February 10, 2014	

No.	DATE	DESCRIPTION	BY
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3	2014/01/23	Re- Issued Final	DLC
2	2014/01/06	Re- Issued Final	DLC
1	2013/11/13	Final	JB
0	2013/08/13	Issued for Client Review	DLC

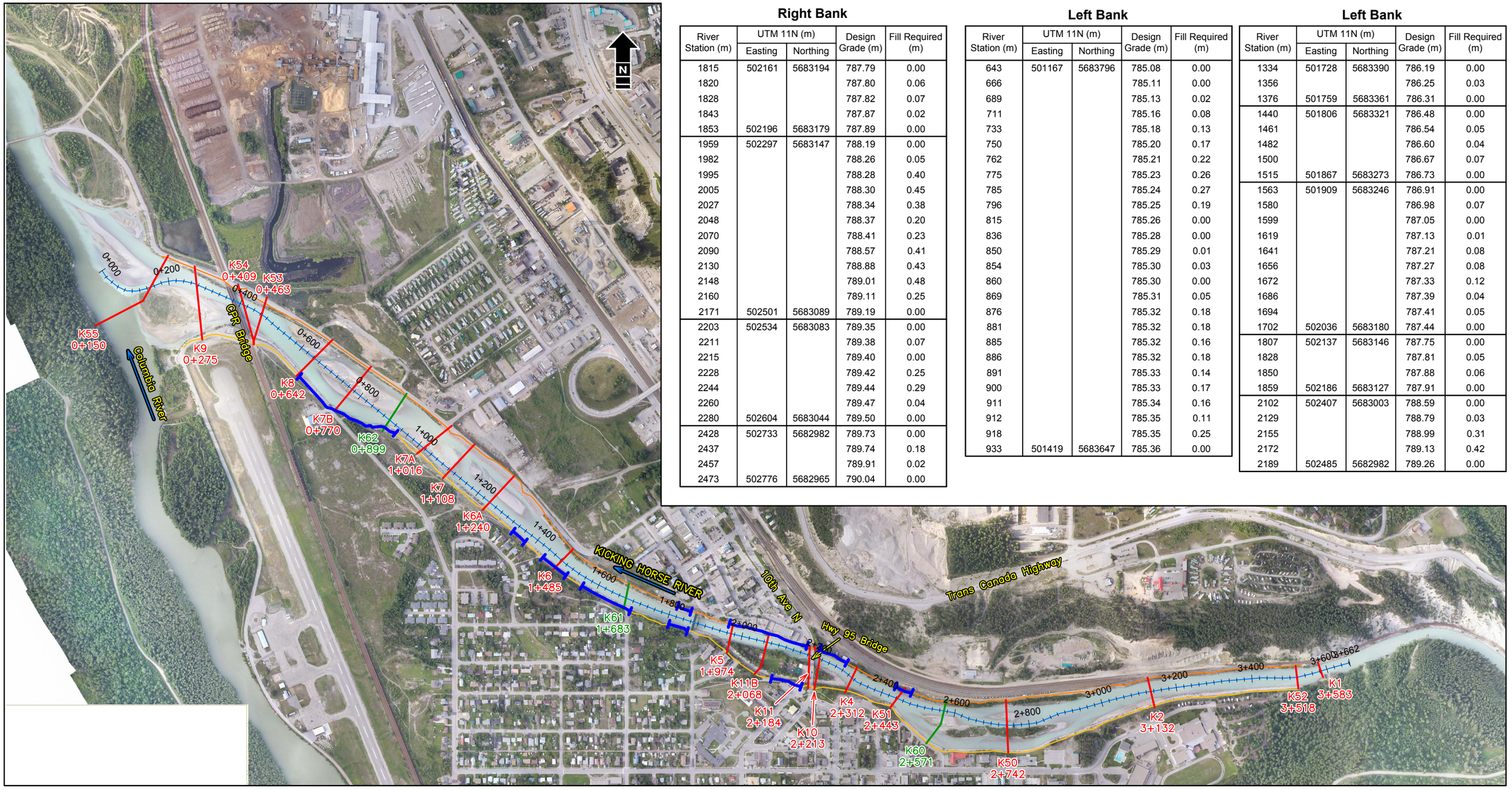
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Town of Golden
Flood Risk Assessment Mapping

Freeboard of Left and Right Dykes

Date:	Project:	Technical:	Reviewer:	Drawn:
February 2014	5635-SP-C3D-14	J. Bigelow	D. Cooper	Z. Steele

Figure 5



Right Bank

River Station (m)	UTM 11N (m)		Design Grade (m)	Fill Required (m)
	Easting	Northing		
1815	502161	5683194	787.79	0.00
1820			787.80	0.06
1828			787.82	0.07
1843			787.87	0.02
1853	502196	5683179	787.89	0.00
1959	502297	5683147	788.19	0.00
1982			788.26	0.05
1995			788.28	0.40
2005			788.30	0.45
2027			788.34	0.38
2048			788.37	0.20
2070			788.41	0.23
2090			788.57	0.41
2130			788.88	0.43
2148			789.01	0.48
2160			789.11	0.25
2171	502501	5683089	789.19	0.00
2203	502534	5683083	789.35	0.00
2211			789.38	0.07
2215			789.40	0.00
2228			789.42	0.25
2244			789.44	0.29
2260			789.47	0.04
2280	502604	5683044	789.50	0.00
2428	502733	5682982	789.73	0.00
2437			789.74	0.18
2457			789.91	0.02
2473	502776	5682965	790.04	0.00

Left Bank

River Station (m)	UTM 11N (m)		Design Grade (m)	Fill Required (m)
	Easting	Northing		
643	501167	5683796	785.08	0.00
666			785.11	0.00
689			785.13	0.02
711			785.16	0.08
733			785.18	0.13
750			785.20	0.17
762			785.21	0.22
775			785.23	0.26
785			785.24	0.27
796			785.25	0.19
815			785.26	0.00
836			785.28	0.00
850			785.29	0.01
854			785.30	0.03
860			785.30	0.00
869			785.31	0.05
876			785.32	0.18
881			785.32	0.18
885			785.32	0.16
886			785.32	0.18
891			785.33	0.14
900			785.33	0.17
911			785.34	0.16
912			785.35	0.11
918			785.35	0.25
933	501419	5683647	785.36	0.00

Left Bank

River Station (m)	UTM 11N (m)		Design Grade (m)	Fill Required (m)
	Easting	Northing		
1334	501728	5683390	786.19	0.00
1356			786.25	0.03
1376	501759	5683361	786.31	0.00
1440	501806	5683321	786.48	0.00
1461			786.54	0.05
1482			786.60	0.04
1500			786.67	0.07
1515	501867	5683273	786.73	0.00
1563	501909	5683246	786.91	0.00
1580			786.98	0.07
1599			787.05	0.00
1619			787.13	0.01
1641			787.21	0.08
1656			787.27	0.08
1672			787.33	0.12
1686			787.39	0.04
1694			787.41	0.05
1702	502036	5683180	787.44	0.00
1807	502137	5683146	787.75	0.00
1828			787.81	0.05
1850			787.88	0.06
1859	502186	5683127	787.91	0.00
2102	502407	5683003	788.59	0.00
2129			788.79	0.03
2155			788.99	0.31
2172			789.13	0.42
2189	502485	5682982	789.26	0.00

New Section - Not Used in 2004 Study - Used in Present Study - Surveyed in October 2013

Section Used in 2004 Study - Re-Surveyed in October 2013

Surveyed Right Bank - June 2013

Surveyed Left Bank - June 2013

Bank Low Areas

Note: The areas denoted on this figure indicate areas where the freeboard above the 200 year flood event is less than 0.6 m. The tables provide the fill required for each area to achieve 0.6 m freeboard.

1:10000 Meters
100 0 100 200
UTM83-11

Reference:

STAMP	PERMIT
PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA D.L. COOPER #28006 February 10, 2014	

No.	DATE	DESCRIPTION	BY
4	2014/02/10	Revised Final	DLC
3	2014/01/23	Re- Issued Final	DLC
2	2014/01/06	Re- Issued Final	DLC
1	2013/11/13	Final	JB
0	2013/08/13	Issued for Client Review	DLC

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Town of Golden
Flood Risk Assessment Mapping

Low Freeboard Areas <0.6m

Date:	Project:	Technical:	Reviewer:	Drawn:
February 2014	5635-SP-C3D-14	J. Bigelow	D. Cooper	Z. Steele

Figure 6

Right Bank

River Station (m)	UTM 11N (m)		Design Grade (m)	Fill Required (m)
	Easting	Northing		
1959	502297	5683147	788.59	0.00
1982			788.66	0.45
1995			788.68	0.80
2005			788.70	0.85
2027			788.74	0.78
2048			788.77	0.60
2070			788.81	0.63
2090			788.97	0.81
2130			789.20	0.83
2148			789.41	0.88
2160			789.51	0.65
2171	502501	5683089	789.62	0.00

Left Bank

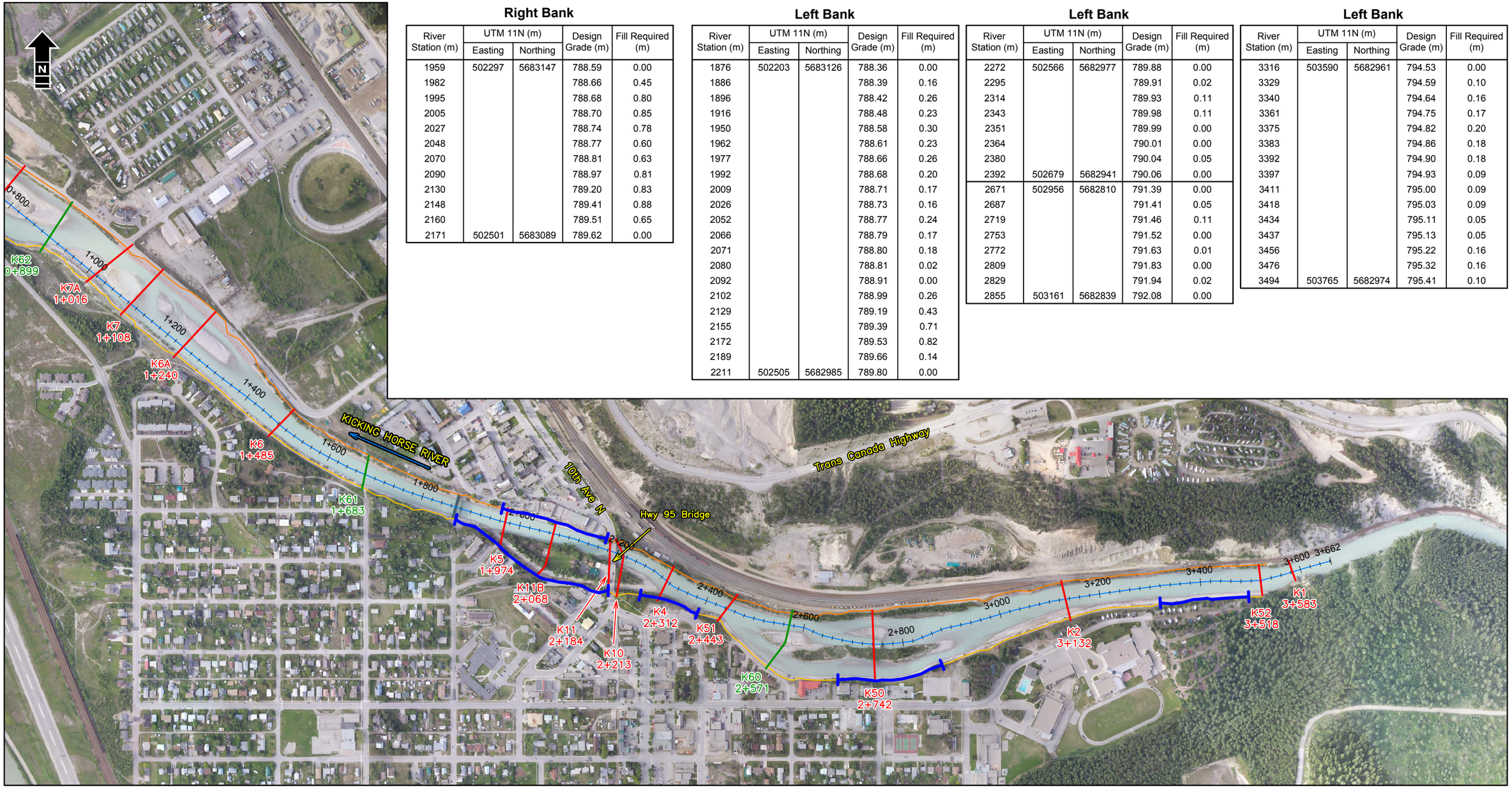
River Station (m)	UTM 11N (m)		Design Grade (m)	Fill Required (m)
	Easting	Northing		
1876	502203	5683126	788.36	0.00
1886			788.39	0.16
1896			788.42	0.26
1916			788.48	0.23
1950			788.58	0.30
1962			788.61	0.23
1977			788.66	0.26
1992			788.68	0.20
2009			788.71	0.17
2026			788.73	0.16
2052			788.77	0.24
2066			788.79	0.17
2071			788.80	0.18
2080			788.81	0.02
2092			788.91	0.00
2102			788.99	0.26
2129			789.19	0.43
2155			789.39	0.71
2172			789.53	0.82
2189			789.66	0.14
2211	502505	5682985	789.80	0.00

Left Bank

River Station (m)	UTM 11N (m)		Design Grade (m)	Fill Required (m)
	Easting	Northing		
2272	502566	5682977	789.88	0.00
2295			789.91	0.02
2314			789.93	0.11
2343			789.98	0.11
2351			789.99	0.00
2364			790.01	0.00
2380			790.04	0.05
2392	502679	5682941	790.06	0.00
2671	502956	5682810	791.39	0.00
2687			791.41	0.05
2719			791.46	0.11
2753			791.52	0.00
2772			791.63	0.01
2809			791.83	0.00
2829			791.94	0.02
2855	503161	5682839	792.08	0.00

Left Bank

River Station (m)	UTM 11N (m)		Design Grade (m)	Fill Required (m)
	Easting	Northing		
3316	503590	5682961	794.53	0.00
3329			794.59	0.10
3340			794.64	0.16
3361			794.75	0.17
3375			794.82	0.20
3383			794.86	0.18
3392			794.90	0.18
3397			794.93	0.09
3411			795.00	0.09
3418			795.03	0.09
3434			795.11	0.05
3437			795.13	0.05
3456			795.22	0.16
3476			795.32	0.16
3494	503765	5682974	795.41	0.10



New Section - Not Used in 2004 Study - Used in Present Study - Surveyed in October 2013

Section Used in 2004 Study - Re-Surveyed in October 2013

Surveyed Right Bank - June 2013

Surveyed Left Bank - June 2013

Recommended 1.0 m Freeboard Areas

Note: The areas denoted on this figure indicate areas where 1.0 m freeboard is recommended above the 200 year flood event. The tables provide the fill required for each area to achieve 1.0 m freeboard.

1:7500 Meters
75 0 75 150
UTM83-11

Reference:

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PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA D. L. COOPER #28006 February 10, 2014	

No.	DATE	DESCRIPTION	BY
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3	2014/01/23	Re- Issued Final	DLC
2	2014/01/06	Re- Issued Final	DLC
1	2013/11/13	Final	JB
0	2013/08/13	Issued for Client Review	DLC

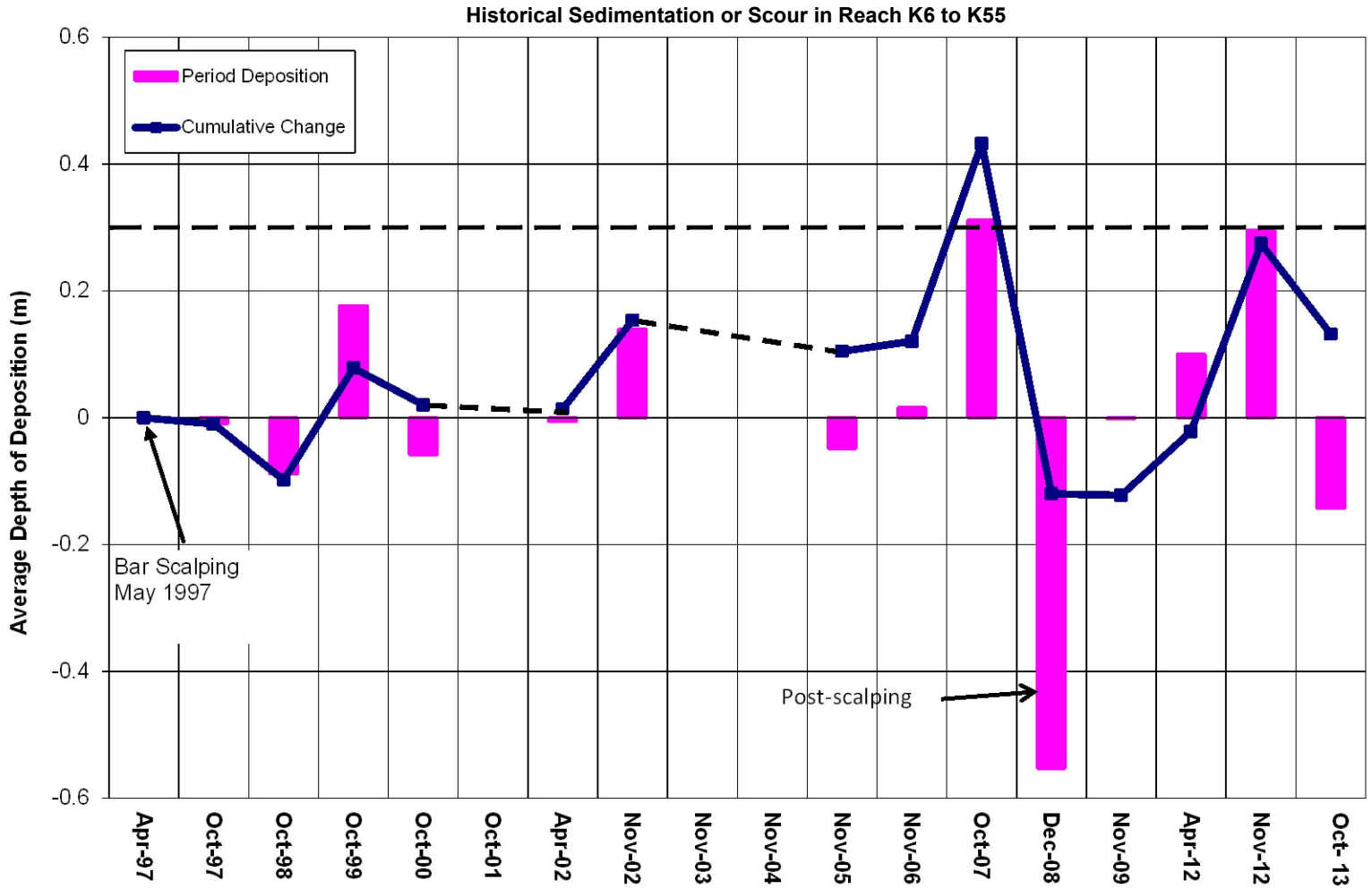
Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Town of Golden
Flood Risk Assessment Mapping

Recommended 1.0 m Priority Freeboard Areas

Date:	Project:	Technical:	Reviewer:	Drawn:
February 2014	5635-SP-C3D-14	J. Bigelow	D. Cooper	C. Zhang

Figure 7



Reference:

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		2	2014/01/06	Re- Issued Final	DLC
		1	2013/11/13	Final	JB
		0	2013/08/13	Issued for Client Review	DLC
		No.	DATE	DESCRIPTION	BY

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

Town of Golden
Flood Risk Assessment Mapping

Historical Sedimentation or Scour in Reach K6 to K55

Date:	Project:	Technical:	Reviewer:	Drawn:
February 2014	5635-SP-C3D-14	J. Bigelow	D. Cooper	Z. Steele

Figure 8

APPENDIX A

HEC-RAS INPUT AND OUTPUT DATA

HEC-RAS Version 4.1.0 Jan 2010
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X            X  X     X    X       X
X     X  X        X    X       X   X    X    X       X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
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PROJECT DATA
Project Title: KHR Nov2013
Project File : KHRNov2013.prj
Run Date and Time: 1/22/2014 11:00:39 AM

Project in SI units

Project Description:
Kicking Horse River at Golden - Cross sections from October 2013 surveys.

PLAN DATA

Plan Title: Plan 30
Plan File : f:\5635\2013 Nov Update\Hecras\KHRNov2013.p30

Geometry Title: Oct 2013
Geometry File : f:\5635\2013 Nov Update\Hecras\KHRNov2013.g29

Flow Title : Golden Flows
Flow File : f:\5635\2013 Nov Update\Hecras\KHRNov2013.f02

Plan Summary Information:
Number of: Cross Sections = 30 Multiple Openings = 0
Culverts = 0 Inline Structures = 0
Bridges = 3 Lateral Structures = 0

Computational Information
Water surface calculation tolerance = 0.003
Critical depth calculation tolerance = 0.003
Maximum number of iterations = 20
Maximum difference tolerance = 0.1
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: Golden Flows
Flow File : f:\5635\2013 Nov Update\Hecras\KHRNov2013.f02

Flow Data (m3/s)

River	Reach	RS	2-Yr-Flood	5-Yr-Flood	10-Yr-Flood	20-Yr-Flood	50-Yr-Flood	100 - Yr-Flood	200-Yr Flood	500-Yr Flood
Columbia	US	2	428	528	586	638	698	741	777	861
Columbia	Downstream	4	673	834	937	1035	1159	1255	1347	1493
Thalweg_AllSurve	Thalweg_AllSurve	3583	245	306	351	397	461	514	570	632

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
Columbia	Downstream	2-Yr-Flood	Normal S = 0.001	
Columbia	Downstream	5-Yr-Flood	Normal S = 0.001	
Columbia	Downstream	10-Yr-Flood	Normal S = 0.001	
Columbia	Downstream	20-Yr-Flood	Normal S = 0.001	
Columbia	Downstream	50-Yr-Flood	Normal S = 0.001	

GEOMETRY DATA

Geometry Title: Oct 2013
Geometry File : f:\5635\2013 Nov Update\Hecras\KHRNov2013.g29

Reach Connection Table

River	Reach	Upstream Boundary	Downstream Boundary
Columbia	US		Junction
Columbia	Downstream	Junction	
Thalweg_AllSurve	Thalweg_AllSurve		Junction

JUNCTION INFORMATION

```
Name: Junction
Description:
Energy computation Method

    Length across Junction             Tributary
     River          Reach               River          Reach        Length   Angle
Thalweg_AllSurveThalweg_AllSurve to Columbia        Downstream            0       0
Columbia        US               to Columbia        Downstream            0       0

CROSS SECTION


RIVER: Columbia
REACH: US                 RS: 2

INPUT
Description: X-Section C6b - South of Golden
Station Elevation Data    num=      29
     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev
    3000  783.763000.079   781.9 3001.25  780.77 3001.71 780.9313003.249  780.23
3005.371  779.233008.361 778.4293009.281 778.3313011.522 778.331 3015.24  778.13
 3020.01  777.883021.601  777.88 3024.46 777.831 3027.13 778.029 3035.01 778.231
 3038.92 778.4293043.458  778.38  3047.4  778.383049.311 778.4813050.569 778.529
3052.389  778.733053.849 778.9293060.021 779.9193062.981   780.73064.542 781.309
3065.752 781.9493065.971 782.2113067.879   782.83072.963 782.781

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    3000    .022    3000    .0223067.879    .022

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          30003067.879          109.999     120 124.998             .1       .3

CROSS SECTION


RIVER: Columbia
REACH: US                 RS: 1

INPUT
Description: X-Section C6 - South of Golden
Station Elevation Data    num=      29
     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev
    3000  783.763000.079   781.9 3001.25  780.77 3001.71 780.9313003.249  780.23
3005.371  779.233008.361 778.4293009.281 778.3313011.522 778.331 3015.24  778.13
 3020.01  777.883021.601  777.88 3024.46 777.831 3027.13 778.029 3035.01 778.231
 3038.92 778.4293043.458  778.38  3047.4  778.383049.311 778.4813050.569 778.529
3052.389  778.733053.849 778.9293060.021 779.9193062.981   780.73064.542 781.309
3065.752 781.9493065.971 782.2113067.879   782.83073.231 782.781

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    3000    .022    3000    .0223067.879    .022

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          30003067.879               0       0       0             .1       .3

CROSS SECTION


RIVER: Columbia
REACH: Downstream         RS: 4
```



```
INPUT
Description: K55 (2012)
Station Elevation Data    num=      63
     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev
       0 797.199   4.591 791.504   6.266 790.612   17.89 779.424  32.442  779.32
   40.56 779.902  57.324 779.915  67.941 779.876   75.19 779.682 102.884 780.403
 107.585 780.459 117.242 780.782 118.931 781.055 121.962 780.898 122.528 780.943
 125.444 780.926 128.731 781.171 129.302  781.23 130.581 781.338 130.742 781.316
 131.827 781.657 137.286 781.449  138.65 781.361 139.691 781.274 140.193 781.737
 140.317 781.974 142.626 781.426 143.163 781.005 154.061  780.61 154.748 780.585
 165.261 780.642 167.682 780.985 169.883 780.961 174.989 781.267 179.697 781.584
  182.11 781.616 182.264 781.603 188.488 781.851 191.119 781.929  201.33 781.793
 205.358  781.84 212.164 781.975 229.906 782.371 243.746 782.385 251.287 782.196
 251.387 782.193 261.785  781.65 261.971 781.647 272.607 781.564 288.242  781.12
 288.473 781.127 293.967 781.245 297.782 780.802 297.868 780.805 297.912 780.808
 297.921 780.816 305.839 782.313 319.141 782.712 319.388 782.685 323.283 782.233
 326.589 782.546     329 783.901 329.258 784.046

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .022       0    .022     329    .022

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     329              354     354     354             .1       .3

CROSS SECTION


RIVER: Columbia
REACH: Downstream         RS: 3

INPUT
Description: X-Section C7 (2003)
Station Elevation Data    num=      40
     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev
    3000 783.1013001.341 781.449 3003.06 780.069 3004.24 779.959 3008.05  778.56
3011.241  777.563012.439 777.661 3020.15  778.063026.329 778.4593028.819 778.261
3031.041 778.161 3037.92 778.761  3040.1 778.959 3043.87 778.9593045.851 778.859
3052.691 778.4593053.959 778.3593056.339  778.663057.979  778.66 3061.04  778.56
3063.722 778.761 3066.45 778.9593073.481 780.3893076.691 780.971 3080.58 781.111
3082.369  781.48 3082.89  781.65 3086.99 781.7513089.111 781.2913091.321 781.169
3094.202  781.263096.411   781.93098.691 781.8793104.979 783.2293109.938 782.059
3115.669 782.291 3117.72  783.473126.501 783.5743126.949  783.583129.031 782.729

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    3000    .022    3000    .0223126.501    .022

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          30003126.501              156     156     156             .1       .3

CROSS SECTION


RIVER: Columbia
REACH: Downstream         RS: 2

INPUT
Description:
Station Elevation Data    num=      49
     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev     Sta     Elev
    3000  787.173022.001 785.4213023.991  785.143024.241  783.793024.841  783.79
```

3024.841 783.4493027.898 781.5013030.051 780.6293032.839 779.243035.951 778.289
 3039.38 777.49 3040.81 777.289 3042.16 777.2893046.961 777.7093050.899 777.74
3054.541 777.9413059.061 778.09 3061.6 778.191 3063.63 778.2893066.831 778.849
3068.751 778.889 3072.43 778.74 3075.56 778.7913079.458 778.791 3082.29 778.74
3083.781 778.7913084.101 778.8893087.271 779.413090.041   779.3 3093.58 779.599
 3097.42 779.8613102.139 780.0693104.141 780.1513106.951 780.123110.061 780.291
 3114.55 780.389 3116.37 780.483119.601 780.4713121.481 781.0293122.841 781.48
 3124.49 782.839 3126.05 783.19 3126.23 783.793127.059 783.839 3127.15 784.97
 3128.47 784.869 3143.07 784.641 3151.47 784.043179.469 783.909

Manning's n Values   num=   3
     Sta   n Val   Sta   n Val   Sta   n Val
    3000   .0223023.991   .022 3128.47   .022

Bank Sta: Left   Right   Lengths: Left Channel   Right   Coeff Contr.   Expan.
      3023.991 3128.47   6   6   6   .1   .3

BRIDGE

RIVER: Columbia
REACH: Downstream   RS: 1.5

INPUT
Description: Columbia River Bridge - SW of Golden
Distance from Upstream XS =   1
Deck/Roadway Width   =   4.999
Weir Coefficient   =   1.44
Upstream Deck/Roadway Coordinates
    num=   2
     Sta Hi Cord Lo Cord   Sta Hi Cord Lo Cord
    3020   785.4   784.2   3130   785.4   784.2

Upstream Bridge Cross Section Data
Station Elevation Data   num=   49
     Sta   Elev   Sta   Elev   Sta   Elev   Sta   Elev   Sta   Elev
    3000 787.173022.001 785.4213023.991 785.143024.241 783.793024.841 783.79
3024.841 783.4493027.898 781.5013030.051 780.6293032.839 779.243035.951 778.289
 3039.38 777.49 3040.81 777.289 3042.16 777.2893046.961 777.7093050.899 777.74
3054.541 777.9413059.061 778.09 3061.6 778.191 3063.63 778.2893066.831 778.849
3068.751 778.889 3072.43 778.74 3075.56 778.7913079.458 778.791 3082.29 778.74
3083.781 778.7913084.101 778.8893087.271 779.413090.041   779.3 3093.58 779.599
 3097.42 779.8613102.139 780.0693104.141 780.1513106.951 780.123110.061 780.291
 3114.55 780.389 3116.37 780.483119.601 780.4713121.481 781.0293122.841 781.48
 3124.49 782.839 3126.05 783.19 3126.23 783.793127.059 783.839 3127.15 784.97
 3128.47 784.869 3143.07 784.641 3151.47 784.043179.469 783.909

Manning's n Values   num=   3
     Sta   n Val   Sta   n Val   Sta   n Val
    3000   .0223023.991   .022 3128.47   .022

Bank Sta: Left   Right   Coeff Contr.   Expan.
      3023.991 3128.47   .1   .3

Downstream Deck/Roadway Coordinates
    num=   2
     Sta Hi Cord Lo Cord   Sta Hi Cord Lo Cord
    3020   785.4   784.2   3130   785.4   784.2

Downstream Bridge Cross Section Data
Station Elevation Data   num=   56
     Sta   Elev   Sta   Elev   Sta   Elev   Sta   Elev   Sta   Elev
    3000 786.881 3023.54 785.3813025.701 785.15   3026 783.781 3026.5 783.812

  3026.5 782.543028.371 781.483030.051 780.513031.782 779.73 3032.01 780.181
3033.059 779.111 3035.82 778.4813040.459 777.4813042.309 777.179 3045.4 777.231
 3046.61 777.283047.071 777.081 3048.57 777.039 3049.75 777.283050.771 777.481
 3053.99 777.4293060.491 777.9813064.191 778.4813065.428 778.0813068.409 777.911
3071.061 778.2793076.499 778.6793078.349 778.679 3081.55 778.98 3082.68 779.081
3084.939 779.0293086.021 778.98 3086.13 778.983088.499 778.953091.669 779.029
3096.171 779.6213099.792 779.889 3100.52 779.843102.471 780.1113104.629 780.181
3107.899 780.193109.219 780.133113.739 780.163117.199 780.3313118.159 780.501
3121.161 780.453122.719 780.8493123.849 781.4893125.861 782.839 3127.73 783.049
3127.769 783.793128.659 783.7993128.699   7853130.198   784.93144.701 784.491
  3170.2 783.879

Manning's n Values   num=   3
     Sta   n Val   Sta   n Val   Sta   n Val
    3000   .0223025.701   .0223130.198   .022

Bank Sta: Left   Right   Coeff Contr.   Expan.
      3025.7013130.198   .1   .3

Upstream Embankment side slope   =   3.73 horiz. to 1.0 vertical
Downstream Embankment side slope   =   3.73 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =   .95
Elevation at which weir flow begins   =
Energy head used in spillway design   =
Spillway height used in design   =
Weir crest shape   = Broad Crested

Number of Piers = 4

Pier Data
Pier Station   Upstream=   3040   Downstream=   3040
Upstream   num=   2
    Width   Elev   Width   Elev
       1 780.919   1 789.21
Downstream   num=   2
    Width   Elev   Width   Elev
       1 780.919   1 789.21

Pier Data
Pier Station   Upstream=   3065   Downstream=   3065
Upstream   num=   2
    Width   Elev   Width   Elev
       1 780.919   1 789.21
Downstream   num=   2
    Width   Elev   Width   Elev
       1 780.919   1 789.21

Pier Data
Pier Station   Upstream=   3090   Downstream=   3090
Upstream   num=   2
    Width   Elev   Width   Elev
       1 780.919   1 789.21
Downstream   num=   2
    Width   Elev   Width   Elev
       1 780.919   1 789.21

Pier Data
Pier Station   Upstream=   3115   Downstream=   3115
Upstream   num=   2
    Width   Elev   Width   Elev
       1 780.919   1 789.21
Downstream   num=   2
    Width   Elev   Width   Elev

```
       1 780.919       1  789.21

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: Columbia
REACH: Downstream         RS: 1

INPUT
Description: X-Section C57 : Downstream of Bridge (2003)
Station Elevation Data    num=      56
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    3000 786.881 3023.54 785.3813025.701  785.15    3026 783.781  3026.5 783.812
  3026.5  782.543028.371  781.483030.051  780.513031.782  779.73 3032.01 780.181
3033.059 779.111 3035.82 778.4813040.459 777.4813042.309 777.179  3045.4 777.231
 3046.61  777.283047.071 777.081 3048.57 777.039 3049.75  777.283050.771 777.481
 3053.99 777.4293060.491 777.9813064.191 778.4813065.428 778.0813068.409 777.911
3071.061 778.2793076.499 778.6793078.349 778.679 3081.55  778.98 3082.68 779.081
3084.939 779.0293086.021  778.98 3086.13  778.983088.499  778.953091.669 779.029
3096.171 779.6213099.792 779.889 3100.52  779.843102.471 780.1113104.629 780.181
3107.899  780.193109.219  780.133113.739  780.163117.199 780.3313118.159 780.501
3121.161  780.453122.719 780.8493123.849 781.4893125.861 782.839 3127.73 783.049
3127.769  783.793128.659 783.7993128.699     7853130.198   784.93144.701 784.491
  3170.2 783.879

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    3000    .0223025.701    .0223130.198    .022

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
      3025.7013130.198          130.159 132.161 135.161             .1       .3

CROSS SECTION


RIVER: Columbia
REACH: Downstream         RS: 0

INPUT
Description: X-Section C57.0 Downstream X Section C57
Station Elevation Data    num=      56
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
3000.601 786.881 3028.24 785.381 3030.84  785.153031.138 783.7813031.641 783.812
3031.641  782.54 3033.51  781.483035.189  780.513036.921  779.733037.149 780.181
3038.201 779.1113040.959 778.4813045.601 777.4813047.451 777.1793050.539 777.231
3051.749  777.283052.209 777.0813053.709 777.0393054.888  777.28 3055.91 777.481
3059.131 777.429 3065.63 777.981 3069.33 778.481 3070.57 778.0813073.552 777.911
```



```
  3076.2 778.2793081.641 778.6793083.491 778.6793086.691  778.983087.819 779.081
3090.081 779.029 3091.16  778.98 3091.27  778.983093.641  778.953096.811 779.029
 3101.31 779.6213104.931 779.8893105.659  779.84 3107.61 780.1113109.771 780.181
3113.041  780.193114.361  780.133118.881  780.163122.341 780.3313123.301 780.501
  3126.3  780.453127.861 780.8493128.989 781.489     3131 782.8393132.872 783.049
3132.911  783.793133.801 783.7993133.841     785 3135.34   784.93152.739 784.491
3183.341 783.879

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
3000.601    .022 3030.84    .022 3135.34    .022

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
      3030.84 3135.34               0       0       0             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 3583

INPUT
Description: X-Section K1 - Oct 2013
Station Elevation Data    num=      36
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0   795.3     .92 793.956    1.39 793.708    1.91 793.859    2.01 793.799
    2.22  793.95    2.46 792.799    2.74 792.197     3.2 792.042    4.53 791.534
    5.79 791.467    6.79  791.41    7.19 791.126    7.41 791.022    7.68 790.874
    8.38 790.615    9.14 790.623    9.38 790.608   10.61 790.403   12.91 790.038
   16.37 790.187   18.76 790.289   21.35 790.316   21.63 790.319   22.34 790.428
   26.82 791.113   30.41 791.502   31.03  791.57   31.23 791.642   32.94  792.26
    35.3 793.509   35.56 793.646   35.91 793.914   39.17 796.396   39.37 796.399
   39.63 796.403

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .032       0    .032   39.17    .032

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
           0   39.17               72      65      59             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 3519

INPUT
Description: X-Section K52 - Oct 2013
Station Elevation Data    num=      38
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0   795.3     3.8 794.562    3.85 794.537    7.98 792.365    8.33 792.264
    9.21 792.029   10.34 791.618   10.61 791.516   15.95 791.442   16.18 791.439
   16.39 791.429    20.4 791.247   24.88 791.422   25.25 791.436   25.97 791.469
   29.76 791.643   30.43 791.676   31.82 791.745   34.36 791.746   35.64 791.747
   36.86 791.621   37.31 791.579      38 791.648   38.91 791.737   39.87 791.655
   41.74 791.493   42.85 791.692   43.03 791.723   43.21 791.688   44.26 791.461
   48.01 791.645   49.77 791.735   51.03 791.934   52.25 792.121   54.82 793.097
   56.74 793.841   59.52 796.179   60.07 796.641

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .032       0    .032   60.07    .032
```

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0   60.07              381     386     391             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 3132

INPUT
Description: Section K2 - Oct 2013
Station Elevation Data    num=      42
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
       0   793.8     4.88  793.69     5.19 793.597    11.07 791.845     11.6 791.725
   14.33 791.118    18.94  791.05    21.45 791.012    22.86  790.75    24.65 790.422
    27.2 790.269    27.98 790.222    29.52 790.375    29.56 790.379    29.59 790.374
   30.78 790.162    30.96  790.16    34.35 790.115    40.18 789.959    42.73 789.891
    43.6 789.977     44.9 790.105    45.59 789.998    46.32 789.887    48.63 789.832
   50.88 789.778    53.37 789.782    54.87 789.784    56.16 789.798    59.16 789.829
   60.58 789.729    61.52 789.664     62.5 789.698    63.58 789.735    65.02 789.636
   66.42 789.537    67.46 789.541    68.14 789.544     68.5 789.908    69.12   790.5
   72.51 792.571    76.91 795.211

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
       0    .032     4.88    .032    76.91    .032

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          4.88   76.91              385     390     377             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 2742

INPUT
Description: K50 - Oct 2013
K50
Station Elevation Data    num=      73
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
       0   791.6     3.15 791.092     3.16 791.092     3.18 791.093     4.39 790.698
    6.65 789.944     8.09 789.063     8.51  788.82     8.65 788.714     9.04 788.362
    9.84 788.341     10.5 788.321    11.52 788.428    12.09 788.486    15.22  788.59
   22.45 788.831    24.47 788.944    28.69 789.181    29.93 789.216    31.71 789.266
   33.37 789.204    34.87 789.149    36.82 788.922    38.41  788.74    39.48 788.758
   40.57 788.776    41.46 789.673    41.91 790.113    50.25 790.099    60.91 790.081
   61.36 789.495    62.15 788.528    62.91  788.28    63.27 788.164    64.93   788.1
   68.44 787.963    69.44 787.767    70.14  787.63    72.13  787.68    73.63 787.718
   74.57  787.75    76.53 787.816    78.14 788.064    78.79 788.159    79.89 788.385
   80.72 788.558    80.97 788.607    81.99 788.837    83.24 788.932    93.65 789.724
   96.07 789.662   100.68 789.545   104.06 789.215   104.29 789.192   104.95  789.17
  110.58  788.98   115.46 788.628   116.52 788.552    116.9 788.545   119.48   788.5
   120.3 788.588   124.01 788.982   124.51 789.335   125.47  789.91   126.23 790.933
  126.29 791.018   126.38  791.01   127.69 790.877   127.71 790.877   127.96 790.873
  128.22 790.869   139.31 791.079      140   792.3

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
       0    .032        0    .032      140    .032

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
```



```
             0     140               217     171     157             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 2571

INPUT
Description: K60 - Oct 2013
Station Elevation Data    num=      75
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
    4.47 790.928     4.69 790.944     4.88 790.946     5.08 790.948     5.16 790.949
    6.57 790.188     8.68 789.105     9.86 788.548    11.61 787.737    12.08 787.615
   12.81 787.389    19.18 787.678    20.93 787.757    21.22 787.766    23.96 787.855
   24.87 787.885    24.96 787.888     25.2 787.883    32.33 787.718    35.16 787.742
   35.53 787.745    35.73 787.723    40.73 787.206    42.44  787.06    42.74 787.034
   43.58 787.176    45.77 787.552    46.55  787.79    46.65 787.827    47.67 788.284
   48.38 788.603    62.59 788.772    63.44 788.782    63.64 788.781    63.82 788.779
   65.47 788.767    66.42 788.761    66.62 788.759    77.19  788.71    78.44 788.704
   80.39 788.221    82.12 787.791    84.13 787.551    84.27 787.539    84.29 787.535
   84.74 787.482    86.67 787.412    87.43 787.389    94.79 786.759    96.85 786.581
   97.43  786.59    98.88 786.612    101.2 786.545   103.49  786.48   105.89 786.623
  108.38 786.765   109.76 787.049   109.92 787.081   109.99 787.106   110.85 787.409
  111.46 787.565   111.74 787.679   112.11 787.748   113.06 787.887   113.19 787.907
  113.26 787.916      115 788.851   115.54 789.195    116.6 789.696   119.06 792.002
  119.17 790.729   119.49 790.718   119.81 790.707   119.82 790.708   129.04 790.354

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
    4.47    .032     4.47    .032   119.06    .032

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          4.47  119.06              133     128     115             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 2443

INPUT
Description: K51 - Oct 2013
Station Elevation Data    num=      41
     Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev      Sta    Elev
       0 790.427     4.44 790.463     4.68 790.459     4.81 790.457     8.72 788.177
    9.86 787.499    10.39 787.307    12.66 786.496    13.29 786.144    14.25 785.573
   15.55   785.4    16.02  785.34    17.88 785.367    19.99 785.398    20.39 785.434
    21.4 785.526    25.67 785.793    25.74 785.798    25.79 785.799    32.62  785.89
   35.77 786.111    36.09 786.133    36.27 786.145    38.16 786.274    44.08 786.428
   44.24 786.432    44.34 786.434    46.69 786.485     48.9 786.533       49 786.535
   49.02 786.537    49.96 786.614    50.31 786.781    52.24 787.646    53.68 788.522
   55.08 789.359    55.13 789.362    55.32 789.374    55.51 789.386    55.92 789.373
   65.55 789.849

Manning's n Values        num=       3
     Sta   n Val      Sta   n Val      Sta   n Val
       0    .032     4.44    .032    65.55    .032

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          4.44   65.55              133     128     115             .1       .3

CROSS SECTION
```

RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve RS: 2312

INPUT
Description: K4 - Oct 2013
Station Elevation Data num= 42

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	789.806	6.36	789.62	6.79	789.611	7.06	789.606	11.64	787.712
11.71	787.686	11.81	787.667	19.34	786.314	23.18	786.272	24.23	786.26
27	786.118	27.3	786.103	28.79	786.036	36.09	785.709	38.61	785.562
40.11	785.475	40.98	785.415	42.88	785.284	45.46	785.28	46.14	785.279
48.28	785.398	48.51	785.411	49.14	785.419	53.5	785.473	55.68	785.554
56.09	785.569	56.69	785.559	59.69	785.51	62.63	785.535	62.93	785.538
63.03	785.539	64.34	785.549	64.64	785.552	64.66	785.552	65.61	786.004
65.64	786.018	66.13	786.317	71.18	789.444	71.28	789.445	71.61	789.449
71.9	789.455	73	789.8						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.032	0	.032	73	.032

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
0	73	125	131	138	.1	.3

CROSS SECTION

RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve RS: 2213

INPUT
Description: K10 Oct 2013
Station Elevation Data num= 67

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	789.816	5	790.174	5.87	790.236	5.97	790.286	6.6	790.276
7.16	790.225	7.3	790.264	7.3	790.265	7.31	790.266	7.95	790.24
13.84	787.056	14.45	786.714	15.06	786.535	15.32	786.46	19.12	786.354
19.73	786.337	23.83	786.325	24.28	786.324	24.74	786.496	27.9	787.657
29.63	787.85	30.18	787.912	32.04	788.224	35.37	788.787	38.56	788.902
41.36	789.004	44.53	788.525	49.13	787.833	55.96	787.444	56.13	787.434
56.19	787.423	59.2	786.851	60.7	786.286	62.03	785.813	62.77	785.753
63.36	785.703	64.69	785.392	65.34	785.238	66.41	785.139	69.01	784.901
70.78	784.764	71.48	784.714	74.2	784.695	75.07	784.689	79.11	784.527
80.39	784.477	81.15	784.434	83.19	784.319	84.34	784.248	86.73	784.249
90.66	784.25	92.15	784.343	93.18	784.407	95.45	784.528	97.12	784.612
98.9	785.151	98.94	785.162	99.03	785.206	102.54	786.868	104.96	787.8
107.33	788.736	110.29	789.726	112.08	790.323	112.14	790.243	112.38	789.918
112.59	789.637	113.61	790.256						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.032	5.87	.032	112.08	.032

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
5.87	112.08	16	29	12	.1	.3

BRIDGE

RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve RS: 2212.8

INPUT
Description:
Distance from Upstream XS = 1.329
Deck/Roadway Width = 8.199
Weir Coefficient = 1.44
Upstream Deck/Roadway Coordinates
num= 8

Sta Hi Cord	Lo Cord	Sta Hi Cord	Lo Cord	Sta Hi Cord	Lo Cord
8	790.581	786	14	790.581	789.11	28.63	790.581	789.11
29.73	790.581	786	61.8	790.569	786	61.8	790.569	788.82
105.089	790.569	788.82	109	790.569	786.671			

Upstream Bridge Cross Section Data
Station Elevation Data num= 67

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	789.816	5	790.174	5.87	790.236	5.97	790.286	6.6	790.276
7.16	790.225	7.3	790.264	7.3	790.265	7.31	790.266	7.95	790.24
13.84	787.056	14.45	786.714	15.06	786.535	15.32	786.46	19.12	786.354
19.73	786.337	23.83	786.325	24.28	786.324	24.74	786.496	27.9	787.657
29.63	787.85	30.18	787.912	32.04	788.224	35.37	788.787	38.56	788.902
41.36	789.004	44.53	788.525	49.13	787.833	55.96	787.444	56.13	787.434
56.19	787.423	59.2	786.851	60.7	786.286	62.03	785.813	62.77	785.753
63.36	785.703	64.69	785.392	65.34	785.238	66.41	785.139	69.01	784.901
70.78	784.764	71.48	784.714	74.2	784.695	75.07	784.689	79.11	784.527
80.39	784.477	81.15	784.434	83.19	784.319	84.34	784.248	86.73	784.249
90.66	784.25	92.15	784.343	93.18	784.407	95.45	784.528	97.12	784.612
98.9	785.151	98.94	785.162	99.03	785.206	102.54	786.868	104.96	787.8
107.33	788.736	110.29	789.726	112.08	790.323	112.14	790.243	112.38	789.918
112.59	789.637	113.61	790.256						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.032	5.87	.032	112.08	.032

Bank Sta: Left	Right	Coeff Contr.	Expan.
5.87	112.08	.1	.3

Downstream Deck/Roadway Coordinates
num= 8

Sta Hi Cord	Lo Cord	Sta Hi Cord	Lo Cord	Sta Hi Cord	Lo Cord
0	790.581	786	8	790.581	789.11	22.6	790.581	789.11
23.66	790.581	786	66.95	790.569	786	66.96	790.569	788.82
109	790.569	788.82	113	790.569	786.671			

Downstream Bridge Cross Section Data
Station Elevation Data num= 62

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	789.5	.5	787.344	3.74	788.518	3.92	788.575	4.14	788.486
10.86	785.773	18.96	785.982	19.09	785.985	19.14	786.024	22.57	788.312
22.61	788.319	23.14	788.386	23.66	788.451	23.72	788.458	25.99	788.251
29.63	787.921	34.7	787.443	34.89	787.426	35.1	787.406	40.71	787.395
62.11	787.353	65.89	787.723	66.95	787.827	67.19	787.692	68.9	786.724
69.7	786.547	72.61	785.98	72.62	785.977	72.63	785.976	72.63	785.975
72.87	785.577	74.23	785.081	74.44	784.992	75.07	784.922	77.24	784.681
78.54	784.6	79.33	784.551	83.66	784.23	83.73	784.225	83.81	784.225
87.43	784.221	89.04	784.193	90.77	784.164	91.82	784.252	92.04	784.272
93.39	784.184	94.95	784.084	95.17	784.072	96.15	784.022	96.89	784.028
97.64	784.035	99.01	784.199	99.33	784.236	99.72	784.246	103.2	784.336
103.72	784.349	106.42	784.417	107.13	784.72	107.81	785.033	109.1	785.779
111.75	787.369	113	789.5						

Manning's n Values num= 3

```
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .032       0    .032     113    .032

Bank Sta: Left   Right    Coeff Contr.   Expan.
             0     113          .1       .3
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
   23.66   66.95   790.5       T

Upstream Embankment side slope              =    1.72 horiz. to 1.0 vertical
Downstream Embankment side slope            =       0 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .95
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
          inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 2184

INPUT
Description: Section K11 Oct 2013
Station Elevation Data    num=      62
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0   789.5      .5 787.344    3.74 788.518    3.92 788.575    4.14 788.486
   10.86 785.773   18.96 785.982   19.09 785.985   19.14 786.024   22.57 788.312
   22.61 788.319   23.14 788.386   23.66 788.451   23.72 788.458   25.99 788.251
   29.63 787.921    34.7 787.443   34.89 787.426    35.1 787.406   40.71 787.395
   62.11 787.353   65.89 787.723   66.95 787.827   67.19 787.692    68.9 786.724
    69.7 786.547   72.61  785.98   72.62 785.977   72.63 785.976   72.63 785.975
   72.87 785.577   74.23 785.081   74.44 784.992   75.07 784.922   77.24 784.681
   78.54   784.6   79.33 784.551   83.66  784.23   83.73 784.225   83.81 784.225
   87.43 784.221   89.04 784.193   90.77 784.164   91.82 784.252   92.04 784.272
   93.39 784.184   94.95 784.084   95.17 784.072   96.15 784.022   96.89 784.028
   97.64 784.035   99.01 784.199   99.33 784.236   99.72 784.246   103.2 784.336
  103.72 784.349  106.42 784.417  107.13  784.72  107.81 785.033   109.1 785.779
  111.75 787.369     113   789.5

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .032       0    .032     113    .032

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0     113              147     117     112             .1       .3
```



```
Ineffective Flow     num=       1
   Sta L   Sta R    Elev  Permanent
   23.66   66.95   790.5       T

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 2068

INPUT
Description: Section K11b Oct 2013
Station Elevation Data    num=      72
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 789.362    7.33  789.86    8.69 790.498    8.99 790.536    9.28 790.536
    9.45 790.536    9.76 790.536    9.84 790.328   10.28 788.561   10.44 788.297
    11.4 788.206   11.65 788.162   16.94 786.208   16.96   786.2   17.28 786.237
   18.45 786.375    18.5 786.374   23.98 786.278   26.19 787.004   27.43 787.405
   27.49 787.726      28 789.075   28.57 790.367   28.65 790.551   29.94 790.497
   30.74 790.463   39.99 790.417   41.32  790.41   42.66 790.418    51.8 790.472
   52.97 790.485   58.37 790.545   58.63 789.207   59.78 788.745   59.89  788.55
   59.91 788.551   59.97 788.528   62.07 787.725   62.08 787.723   63.64 787.514
   69.83 785.698   69.98 785.655   70.01 785.654   71.07 785.623   71.24  785.57
   72.63 785.138    73.4 784.913   73.51 784.879   74.15 784.834   78.55 784.522
   84.85 784.273   85.91 784.232   86.23 784.211   88.01 784.094   89.43 784.184
   89.77 784.205   90.28  784.19   92.18 784.132   94.93 784.371   95.31 784.404
   96.37 784.492   97.23 784.564   97.42 784.564   99.08 784.565  100.14 784.795
  101.85  785.14  101.92 785.137  102.04 785.133  104.16 785.547  105.78 785.836
   106.1 785.845  111.35 789.943

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .032    8.69    .032  111.35    .032

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          8.69  111.35               92      97      96             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 1971

INPUT
Description: K5 - Oct 2013
Station Elevation Data    num=      65
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0   788.5    7.37 787.826    7.84 787.838    8.31  787.85    8.43 787.853
   11.68 786.521   12.11 786.349   12.49 786.262   15.09 785.694   15.64 785.465
   15.74 785.417   16.13 785.389   17.65 785.273   18.76 785.189   19.01 785.169
   19.14 785.169   20.38  785.17   20.91 785.394   21.49 785.634   22.12 785.844
   24.72 786.626   25.05 787.093   25.15 787.257   25.58 787.357   27.17 787.805
   27.44 787.877   27.49 787.894      29 787.895   29.02 787.895   29.04 787.882
   29.38 787.677   30.45 787.027   30.52 786.987   30.67  786.94   32.71 786.297
   34.29 785.606   35.06 785.256   35.82 785.025   37.61 784.517   38.53   784.3
   39.99 783.944    41.9 783.984   41.97 783.986   43.05 783.994   46.08 784.017
   46.36 784.002   50.67 783.779   53.99 783.792   54.91 783.796   56.21 783.839
   60.72 783.989   62.19 784.036    68.2 784.226   68.35 784.409   68.46 784.566
    68.5 784.591   69.46 785.159   71.45  785.55   72.53 785.781   76.72 788.041
   77.01 788.199   77.02 788.199   77.18 788.198   77.34 788.197    77.8 788.415

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
```

```
       0    .025       0    .025    77.8    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0    77.8              296     292     287             .1      .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 1679

INPUT
Description: K61 - Oct 2013
Station Elevation Data    num=      47
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0 787.014    3.701  787.23     4.74  787.29     4.86 787.294     4.98  787.35
    5.02 787.299      5.7 787.083     6.43 786.865    10.63 784.783       12 784.155
   12.08 784.045   12.31 783.737   14.19 783.469   15.34 783.284   17.31 783.353
   19.46 783.429   24.73 783.467   25.41 783.472   27.31 783.457   29.82 783.438
   33.78 783.466   37.48 783.492   43.23 783.518   43.63  783.52   43.99 783.531
   47.64  783.64   48.05 783.884   48.13 783.938   48.29 783.962   49.24 784.131
    49.3 784.178   49.61 784.423   50.52 784.603   51.41 784.777   51.53 784.789
    55.8 785.195   55.94 785.229    57.9 785.649   58.03 785.687   59.71  786.17
   60.84 786.437    61.4 786.581   62.03 786.893   64.15 787.944    64.4 787.941
   64.66 787.938    67.5 787.923

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025    4.98    .025   64.15    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
          4.98   64.15              209     196     183             .1      .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 1483

INPUT
Description: K6 - Oct 2013
Station Elevation Data    num=      24
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0   787.8      .53 786.512    4.22 784.936    4.78 784.698    4.95 784.617
    6.24 784.051    6.87 783.704    7.47 783.387    9.77 783.282   10.92 783.226
   19.82 783.183   21.84 783.173   29.98 783.253   40.32 783.354   41.44 783.379
   48.11 783.526   52.02 783.946   52.89  784.04   54.43 784.591   54.77 784.711
   55.33 784.889   57.19 785.465    60.6 787.626   60.85 787.781

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025       0    .025   60.85    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0   60.85              244     244     245             .1      .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 1239

INPUT
```



```
Description: K6A - Oct 2013
Station Elevation Data    num=      47
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0 786.327      .11 786.325     .12 786.325    3.69 785.173    4.06 785.053
    4.23 784.931    5.58 783.908    6.18 783.649    7.84 782.948   12.61  783.03
   14.93 783.071    16.4 783.117   16.67 783.125   17.16 783.129   20.25 783.158
    20.9 783.164      21 783.165   21.19 783.172   27.25 783.403   31.18 783.685
   31.44 783.704   31.56 783.705   33.57 783.729    37.2 783.938   37.25 783.941
   37.41 783.944   47.13 784.125   57.22 784.113   61.79 784.107   63.58 783.967
   66.51  783.74   68.15 783.903   69.07 783.995   70.85 783.932   75.14  783.78
   78.88 782.868   79.05 782.826    79.1 782.818   83.44 782.145   89.23 782.209
   89.42 782.211   90.02  782.37   91.71  782.82   94.36 785.044   94.53 785.186
    94.8 785.284   98.95 786.771

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025       0    .025   98.95    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0   98.95              133     133     126             .1      .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 1106

INPUT
Description: K7 - Oct 2013
Station Elevation Data    num=      40
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0 786.751      .84 786.297    6.02 783.552    6.63 783.421    7.02 783.337
     7.1 783.344     8.34 783.446   11.22 783.508   15.94 783.608   20.75 783.689
   22.07 783.711   31.18 783.534   34.11 783.477    35.7 783.457   43.98 783.351
    49.7 783.221     52.6 783.156   59.07 782.939   62.41 782.826   65.49 782.756
   67.75 782.706   72.83 782.437   74.91 782.327   77.35 782.116   80.23 781.864
   81.28 781.618   81.42 781.587   81.53 781.569   82.34  781.43   87.24 781.228
   90.62 781.089   91.77 782.068    92.2 782.423   92.56 782.506   93.89 782.818
   95.34 784.239   95.58 784.476    96.2 784.719  101.02 786.627  101.12 786.628

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025       0    .025  101.12    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0  101.12               92      91      87             .1      .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 1015

INPUT
Description: K7A - Oct 2013
Station Elevation Data    num=      73
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0 786.025      .11 786.028    4.06 784.374    4.28 784.283    5.29 783.883
    6.81 783.279     7.38 783.246     7.4 783.245    7.44 783.251    8.49 783.409
    8.71 783.407    10.53 783.395    11.4 783.313   11.68 783.286   14.13 783.272
   18.68 783.246    20.77 783.158   22.68 783.077   23.66 783.023   25.04 782.949
   26.34 782.979    26.95 782.992   27.16 782.964   27.68 782.897    29.6 782.842
   29.73 782.838    30.88 782.905   30.91 782.907   30.92 782.905   31.56 782.816
```

```
   32.16 782.995   32.26 783.024   32.27 783.027   32.97 783.353   37.06 783.558
    37.3 783.571   37.45 783.569   40.02 783.535   41.43 783.652   42.44 783.735
   47.51 783.681   47.56  783.68    47.6 783.674   48.97 783.502   52.29 783.084
   52.41  783.07   52.44 783.063   53.51  782.78   54.89 782.475   57.32 781.935
   59.15 781.909   63.08 781.854      67 781.658   67.68 781.624   69.67 781.457
   69.91 781.438   69.96 781.434   70.34   781.4   79.89 780.938   81.53 780.855
   81.77 780.914   83.04 781.229   83.33 781.596   83.78 782.357   84.44 782.647
   84.72 782.781   85.28 783.273   85.49 783.445   87.52 784.337   90.94  785.85
   91.07 785.854   91.37 785.863   91.66 785.872

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025       0    .025   91.66    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0   91.66              112     116     143             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 899.86

INPUT
Description: K62 - Oct 2013
Station Elevation Data    num=      58
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
      .91  784.77    1.17 784.774    1.47 784.763    1.78 784.753    1.81 784.752
    4.34 784.879    6.23 784.989    7.14 785.038     8.2 785.104    9.16 785.133
   10.88 785.185   11.68 785.209   12.13 785.222   12.83 784.842   14.38  784.03
      15 782.847   15.38 782.172   15.75 782.068    16.1  781.96   17.01 781.595
   18.81  780.79   19.19 780.835   20.28 780.973   23.86 781.161   24.12 781.175
   25.77  781.26   25.95  781.27   28.46  781.26   29.08 781.257    31.7 781.049
    31.7 781.048   31.71 781.051   34.29 781.963   36.43 782.105   36.84 782.132
   53.72 782.656   55.71 782.718   57.58 782.734   65.07 782.796   70.75 782.835
   81.41 782.909    84.3  782.87   90.41 782.787   96.17 782.704  101.86 782.622
  102.77 782.544  103.69 782.467  104.66 782.659  105.39 782.806  105.82 783.116
   106.8 783.832  107.27 784.159  109.75 785.594  109.85 785.653  109.87 785.666
  111.12 785.706  111.83 785.738  112.39 785.759

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
      .91    .025   12.13    .025  112.39    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
         12.13  112.39              138     127     119             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 772

INPUT
Description: K7B - Oct 2013
Station Elevation Data    num=      45
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 784.967     .77 784.842     .78 784.839    4.96 781.819    5.64 780.859
    5.69 780.787    7.18 780.573     7.2 780.571    7.23 780.574    9.65 780.795
   14.93 781.024      15 781.027   15.04 781.027   18.14 781.002   21.41 781.045
   21.45 781.046   26.27 781.773   26.59  781.82   26.82 781.892   29.88 782.854
   36.25 783.256   36.41 783.266   36.68 783.264   48.51  783.16   51.63  782.98
    51.7 782.976      52 782.984   66.49 783.375   77.05 783.306   77.26 783.305
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```
   77.53 783.305   92.24 783.303   92.45 783.293  104.81 782.688  104.99 782.682
  116.13 782.312  116.26 782.308     125 782.007  125.45 782.072  125.83 782.127
  126.02 782.264  126.54 782.629  127.46 782.926  127.49 782.937  131.29 785.313

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025       0    .025  131.29    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0  131.29              133     129     124             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 643.15

INPUT
Description: K8 - Oct 2013
Station Elevation Data    num=      66
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 785.094     .25 784.858     .35 784.832    4.07  783.82    6.51 782.534
    6.59 782.491    6.67 782.484    7.43 782.413    9.68 782.204     9.9 782.184
   10.79 781.745   10.85 781.714   12.52 781.386   12.54 781.381   12.56 781.373
   13.32 780.849   13.87 780.934   14.46 781.026   17.49 781.042   17.61 781.043
   20.89 780.749      21 780.739   23.83 780.759   29.57 780.829   29.58 780.829
   29.59 780.829   35.59 780.513   35.64 780.515   37.12 780.563   40.53 781.267
   40.62 781.287   40.71 781.299    44.1 781.717    44.3 781.744   45.39  781.89
   47.11 782.004    47.4 782.024   48.35 781.991   53.84 781.801   55.21 782.063
    55.5  782.12   56.09 782.174   58.78 782.418   60.33  782.42   60.64 782.421
   60.94 782.442   62.44 782.546   68.24 782.756    68.6 782.769   72.89 782.801
   80.43 782.857   90.48 782.766   91.13  782.76   91.46 782.765    96.6  782.85
  101.21 782.674  101.52 782.662  101.72 782.647  104.32 782.456  105.39 782.469
   105.6 782.471  105.69 782.504  106.17 782.664  110.72 784.943  110.73 784.944
  110.87 785.253

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025       0    .025  110.87    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0  110.87              148     179     194             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 463.66

INPUT
Description: K53
Station Elevation Data    num=      32
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
       0 786.869      .3 786.883     .31 786.885      .5 786.779    2.94  785.42
    7.87 784.767    9.25 784.583   13.87 782.576   14.12 782.466   14.29  782.44
    16.9 782.034   21.03 782.201   21.46 782.219   24.74 781.989   24.78 781.986
   33.67 781.651      34 781.639   59.94 781.204   61.65 781.175   62.28 781.135
   71.39 780.552    75.9 780.621   76.29 780.627   76.52 780.648   78.99 780.876
   80.93 781.495   81.33 781.625   83.27 782.216   83.68 782.344   84.44 782.704
   87.92  784.34   89.91  784.58

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
```

```
       0    .025       0    .025   89.91    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0   89.91                3      54      69             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 410.07

INPUT
Description: K54 - Oct 2013
Station Elevation Data    num=      36
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0 786.874      .06 786.874      .14 786.873     1.71 786.277     5.45 784.859
   10.05 784.549    10.09 784.546    10.19 784.522    21.37 781.889     24.3 782.157
   24.34  782.16    24.39  782.16    28.43 782.186    60.31 781.655    61.01 781.643
   81.39 780.719    81.95 780.693    87.12 780.377    87.27 780.368    87.66 780.366
  101.29 780.292   101.31    780.3  102.15 780.561   102.52 780.695   103.84 781.176
  107.05 781.537   108.07 781.651   111.39  782.95   111.51 782.998   114.83 783.535
  114.95 783.555   115.07 783.599    118.4 784.794   118.85  784.78   119.89 784.749
  119.96 784.749

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025       0    .025   118.4    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
             0   118.4                18      18      18             .1       .3

BRIDGE


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 409

INPUT
Description:
Distance from Upstream XS =   1.999
Deck/Roadway Width        =    13.5
Weir Coefficient          =     1.4
Upstream  Deck/Roadway Coordinates
    num=       4
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0  788.45  784.68       0  788.45  785.55     150  788.45  785.55
     150  788.45  784.54

Upstream Bridge Cross Section Data
Station Elevation Data    num=      36
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0 786.874      .06 786.874      .14 786.873     1.71 786.277     5.45 784.859
   10.05 784.549    10.09 784.546    10.19 784.522    21.37 781.889     24.3 782.157
   24.34  782.16    24.39  782.16    28.43 782.186    60.31 781.655    61.01 781.643
   81.39 780.719    81.95 780.693    87.12 780.377    87.27 780.368    87.66 780.366
  101.29 780.292   101.31    780.3  102.15 780.561   102.52 780.695   103.84 781.176
  107.05 781.537   108.07 781.651   111.39  782.95   111.51 782.998   114.83 783.535
  114.95 783.555   115.07 783.599    118.4 784.794   118.85  784.78   119.89 784.749
  119.96 784.749

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025       0    .025   118.4    .025
```



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Bank Sta: Left   Right    Coeff Contr.   Expan.
             0   118.4             .1       .3

Downstream  Deck/Roadway Coordinates
    num=       4
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0  788.45  784.68       0  788.45  785.55     150  788.45  785.55
     150  788.45  784.54

Downstream Bridge Cross Section Data
Station Elevation Data    num=      36
     Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev      Sta     Elev
       0 786.874      .06 786.874      .14 786.873     1.71 786.277     5.45 784.859
   10.05 784.549    10.09 784.546    10.19 784.522    21.37 781.889     24.3 782.157
   24.34  782.16    24.39  782.16    28.43 782.186    60.31 781.655    61.01 781.643
   81.39 780.719    81.95 780.693    87.12 780.377    87.27 780.368    87.66 780.366
  101.29 780.292   101.31    780.3  102.15 780.561   102.52 780.695   103.84 781.176
  107.05 781.537   108.07 781.651   111.39  782.95   111.51 782.998   114.83 783.535
  114.95 783.555   115.07 783.599    118.4 784.794   118.85  784.78   119.89 784.749
  119.96 784.749

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025       0    .025   118.4    .025

Bank Sta: Left   Right    Coeff Contr.   Expan.
             0   118.4             .1       .3

Upstream Embankment side slope              =       2 horiz. to 1.0 vertical
Downstream Embankment side slope            =       2 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Piers =  3

Pier Data
Pier Station     Upstream=   28.43    Downstream=   28.43
Upstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
   2.624 776.118   2.624 778.249   2.624 780.099   2.624     786
Downstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
   2.624 776.118   2.624 778.249   2.624 780.099   2.624     786

Pier Data
Pier Station     Upstream=   60.43    Downstream=   60.43
Upstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
   2.624 776.118   2.624 778.249   2.624 780.099   2.624     786
Downstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
   2.624 776.118   2.624 778.249   2.624 780.099   2.624     786

Pier Data
Pier Station     Upstream=   93.29    Downstream=   93.29
Upstream     num=       4
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
   2.624 776.118   2.624 777.581   2.624 779.849   2.624     786
Downstream     num=       4
```

```
    Width   Elev    Width   Elev    Width   Elev    Width   Elev
   2.624 776.118   2.624 777.581   2.624 779.849   2.624     786

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
Selected Low Flow Methods = Highest Energy Answer

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 392

INPUT
Description: K54b - Oct 2013
Station Elevation Data    num=      36
      Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
        0 786.874     .06 786.874     .14 786.873    1.71 786.277    5.45 784.859
    10.05 784.549   10.09 784.546   10.19 784.522   21.37 781.889    24.3 782.157
    24.34  782.16   24.39  782.16   28.43 782.186   60.31 781.655   61.01 781.643
    81.39 780.719   81.95 780.693   87.12 780.377   87.27 780.368   87.66 780.366
   101.29 780.292  101.31   780.3  102.15 780.561  102.52 780.695  103.84 781.176
   107.05 781.537  108.07 781.651  111.39  782.95  111.51 782.998  114.83 783.535
   114.95 783.555  115.07 783.599   118.4 784.794  118.85  784.78  119.89 784.749
   119.96 784.749

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .025       0    .025   118.4    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.    Expan.
             0   118.4               117     117     113             .1       .3

CROSS SECTION


RIVER: Thalweg_AllSurve
REACH: Thalweg_AllSurve   RS: 274.99

INPUT
Description: K9 - Oct 2013
Station Elevation Data    num=      51
      Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
     1.59   786.9    1.93  783.26    1.94 783.261    2.46 783.254    2.93 783.248
     6.62 781.853    6.92 781.739    7.63 781.784   16.94 782.374   26.11 782.167
    33.38 782.002   34.44  782.24    35.3 782.433   38.96 782.689   39.21 782.707
    43.88 782.699   52.26 782.684   54.11 782.553   56.63 782.374   59.12 782.881
    59.37 782.932   61.58 782.575   61.68  782.56   61.87 782.557   66.69 782.488
     66.7 782.489   68.41 782.622   69.52 782.622   95.69 782.634   98.48 782.371
    98.54 782.365  102.51 782.157  102.53 782.156  107.55 781.593  107.58  781.59
   118.87 780.823  118.92  780.82  118.98  780.82  130.74 780.715  130.86 780.716
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   148.48 780.897   148.8 780.904  153.86  781.02  158.38 780.627  158.63 780.605
   158.65 780.611  161.25 781.562  161.31 781.594  163.24 782.719  166.01 784.021
   166.34 784.177

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
    1.59    .025    1.59    .025  166.34    .025

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.    Expan.
          1.59  166.34               0       0       0             .1       .3


SUMMARY OF MANNING'S N VALUES

River:Columbia

      Reach          River Sta.       n1        n2        n3

 US                  2                  .022      .022      .022
 US                  1                  .022      .022      .022
 Downstream          4                  .022      .022      .022
 Downstream          3                  .022      .022      .022
 Downstream          2                  .022      .022      .022
 Downstream          1.5          Bridge
 Downstream          1                  .022      .022      .022
 Downstream          0                  .022      .022      .022


River:Thalweg_AllSurve

      Reach          River Sta.       n1        n2        n3

 Thalweg_AllSurve    3583               .032      .032      .032
 Thalweg_AllSurve    3519               .032      .032      .032
 Thalweg_AllSurve    3132               .032      .032      .032
 Thalweg_AllSurve    2742               .032      .032      .032
 Thalweg_AllSurve    2571               .032      .032      .032
 Thalweg_AllSurve    2443               .032      .032      .032
 Thalweg_AllSurve    2312               .032      .032      .032
 Thalweg_AllSurve    2213               .032      .032      .032
 Thalweg_AllSurve    2212.8       Bridge
 Thalweg_AllSurve    2184               .032      .032      .032
 Thalweg_AllSurve    2068               .032      .032      .032
 Thalweg_AllSurve    1971               .025      .025      .025
 Thalweg_AllSurve    1679               .025      .025      .025
 Thalweg_AllSurve    1483               .025      .025      .025
 Thalweg_AllSurve    1239               .025      .025      .025
 Thalweg_AllSurve    1106               .025      .025      .025
 Thalweg_AllSurve    1015               .025      .025      .025
 Thalweg_AllSurve    899.86             .025      .025      .025
 Thalweg_AllSurve    772                .025      .025      .025
 Thalweg_AllSurve    643.15             .025      .025      .025
 Thalweg_AllSurve    463.66             .025      .025      .025
 Thalweg_AllSurve    410.07             .025      .025      .025
 Thalweg_AllSurve    409          Bridge
 Thalweg_AllSurve    392                .025      .025      .025
 Thalweg_AllSurve    274.99             .025      .025      .025
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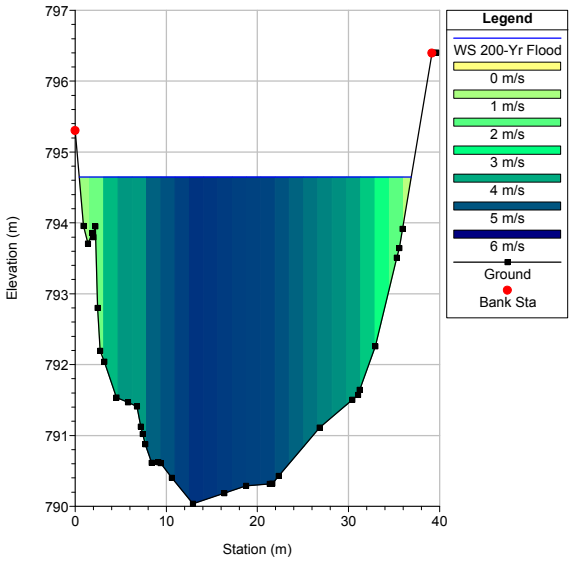
2013 HEC-RAS Results Summary Table

					200 year Flood Results									
Section Name	Stationing	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	Vel Chnl	Flow Area	Top Width	Froude # Chl	Left Bank	Left FB	Right Bank	Right FB
	m		(m3/s)	(m)	(m)	(m)	(m/s)	(m2)	(m)		elev (m)	(m)	elev (m)	(m)
K1	3583	200-yr	570	790.04	794.65		4.64	122.72	36.42	0.81	795.3	0.65	796.82	2.17
K52	3519	200-yr	570	791.25	794.53		4.02	141.78	53.69	0.79	795.64	1.11	796.64	2.11
K2	3132	200-yr	570	789.54	792.64	792.34	3.89	146.39	64.22	0.82	793.84	1.20	795.21	2.57
K50	2742	200-yr	570	787.63	790.52		3.21	177.71	121.02	0.84	791.6	1.08	792.3	1.78
K60	2571	200-yr	570	786.48	790.23		2.18	260.95	110.69	0.45	790.93	0.70	792	1.77
K51	2443	200-yr	570	785.34	789.14		4.29	132.84	47.63	0.82	790.64	1.50	789.85	0.71
K4	2312	200-yr	570	785.28	788.93		3.28	173.67	61.67	0.62	789.81	0.88	789.8	0.87
K10	2213	200-yr	570	784.25	788.80	787.49	2.48	230.1	89.95	0.49	790.3	1.50	790.32	1.52
Highway 95 Bridge														
K11	2184	200-yr	570	784.02	788.66		2.68	212.98	112.31	0.49	790.49	1.83	790.49	1.83
K11B	2068	200-yr	570	784.09	787.81		4.02	141.83	61.69	0.85	788.79	0.98	788.18	0.37
K5	1971	200-yr	570	783.78	787.66		3.4	167.82	64.33	0.67	788.5	0.84	788.6	0.94
K61	1679	200-yr	570	783.28	786.79		3.86	147.61	55.22	0.75	787.35	0.56	787.89	1.10
K6	1483	200-yr	570	783.17	786.00	785.79	4.27	133.35	56.29	0.89	786.6	0.60	787.82	1.82
K6A	1239	200-yr	570	782.15	785.34		3.46	164.77	91.78	0.82	786.33	0.99	786.8	1.46
K7	1106	200-yr	570	781.09	785.15		2.83	201.38	94.28	0.62	786.75	1.60	786.94	1.79
K7A	1015	200-yr	570	780.86	784.84		3.17	179.69	85.71	0.7	786.03	1.19	786.29	1.45
K62	900	200-yr	570	780.79	784.75		2.6	219	95.27	0.55	785.22	0.47	785.8	1.05
K7B	772	200-yr	570	780.57	784.63		2.26	252.52	129.12	0.52	784.97	0.34	785.31	0.68
K8	643	200-yr	570	780.51	784.48		2.24	254.75	108.17	0.47	785.09	0.61	785.25	0.77
K53	464	200-yr	570	780.55	783.96		3.14	181.7	76.45	0.65	787.12	3.16	785.14	1.18
K54	410	200-yr	570	780.29	784.06	782.98	2.24	254.51	104.24	0.46	787.12	3.06	786.59	2.53
CPR Bridge														
K9	275	200-yr	570	780.61	783.98		1.72	332.03	164.06	0.39	786.9	2.92	784.76	0.78

KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 3583 X-Section K1 - Oct 2013



KHR Nov2013 Plan: Plan 30 1/22/2014
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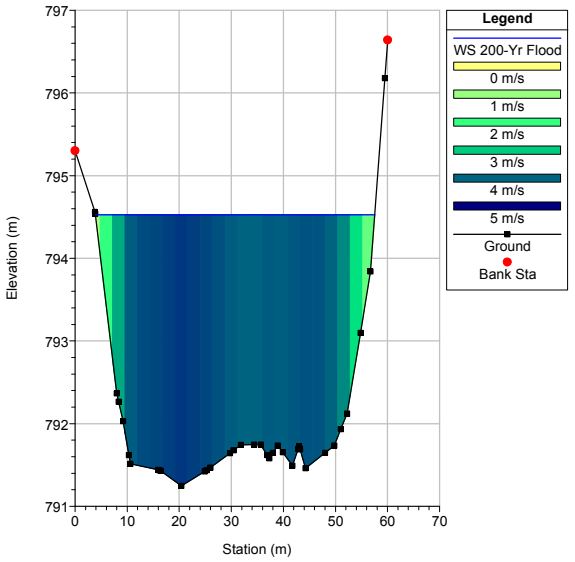

KHR Nov2013 Plan: Plan 30 1/22/2014
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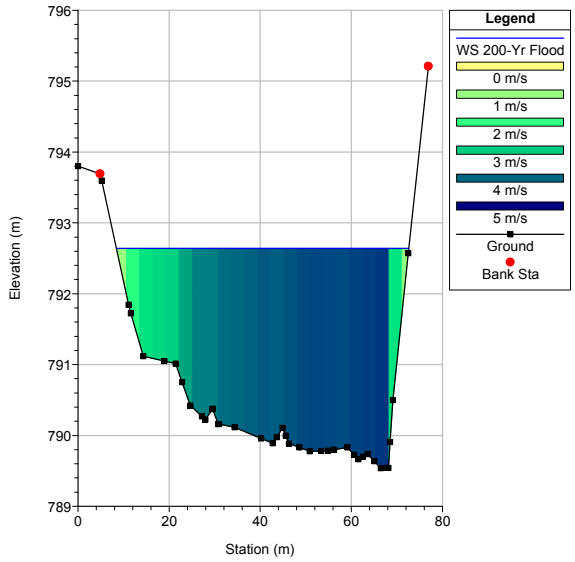

KHR Nov2013 Plan: Plan 30 1/22/2014
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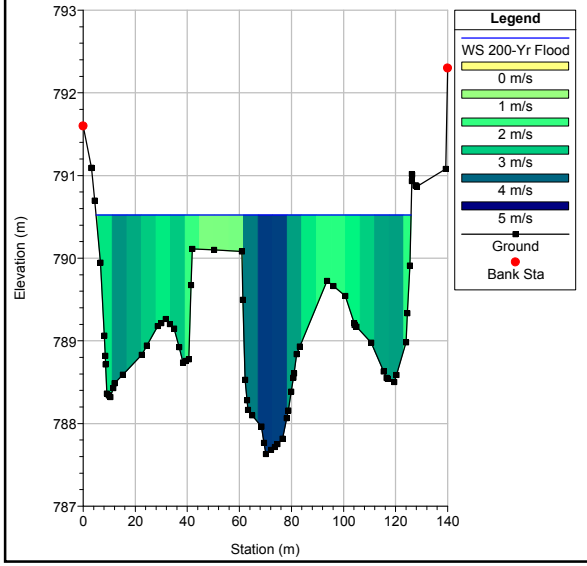
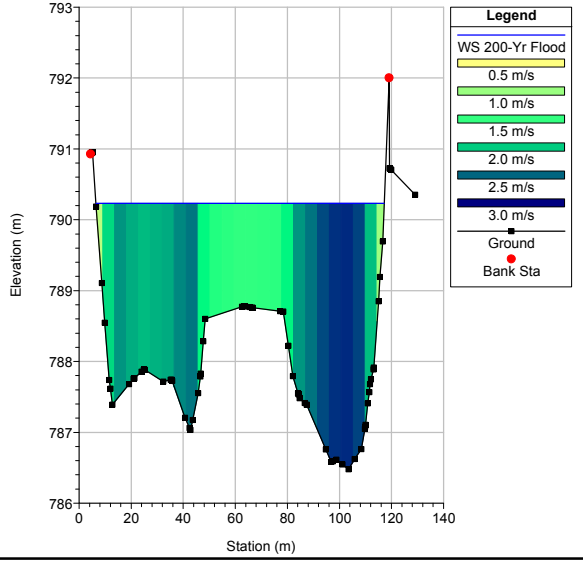
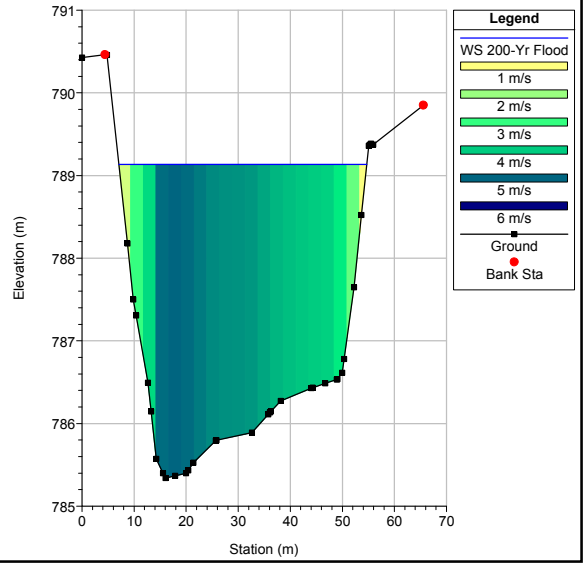


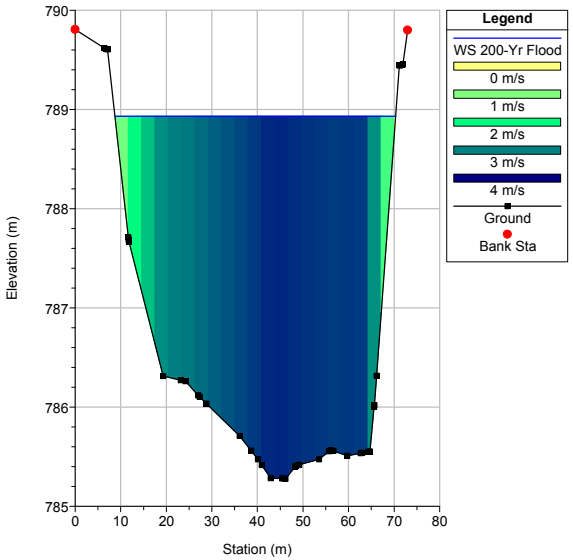
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 2571 K60 - Oct 2013



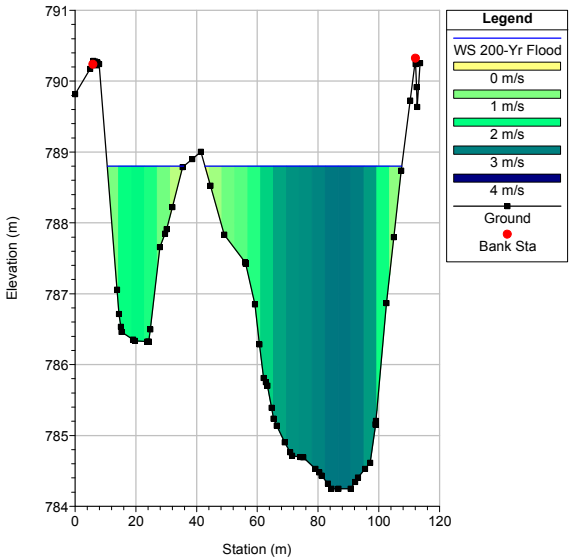
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 2443 K51 - Oct 2013



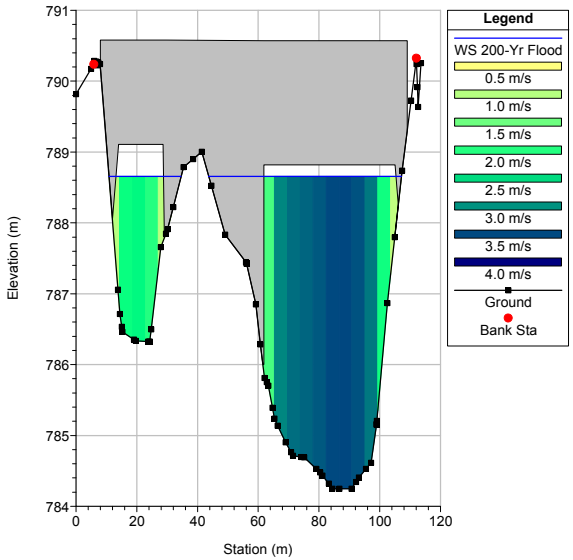
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 2312 K4 - Oct 2013



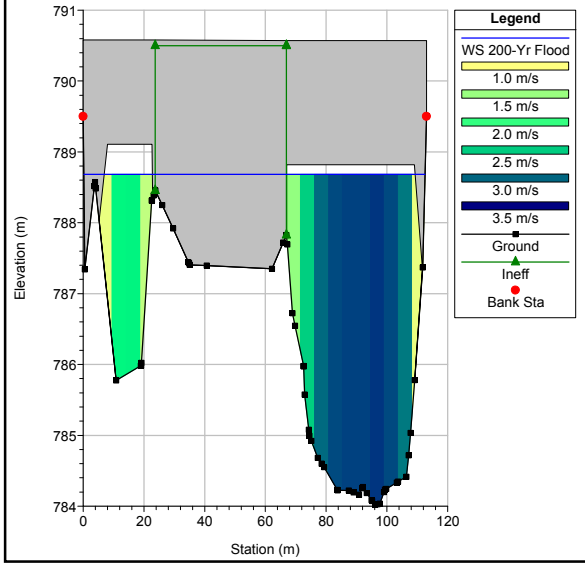
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 2213 K10 Oct 2013



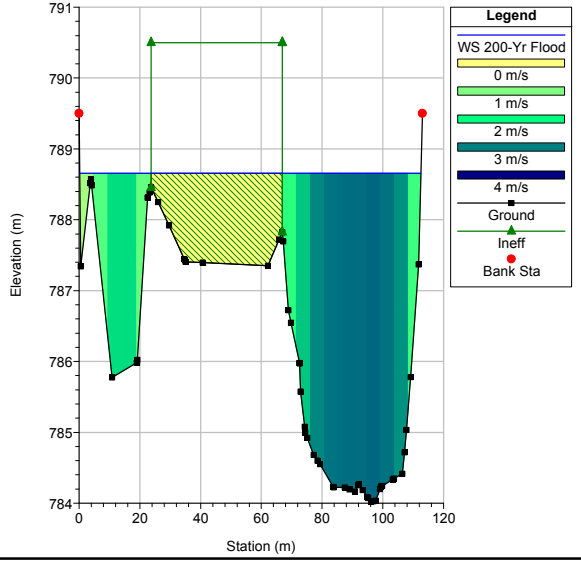
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 2212.8 BR



KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 2212.8 BR



KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 2184 Section K11 Oct 2013



KHR Nov2013 Plan: Plan 30 1/22/2014
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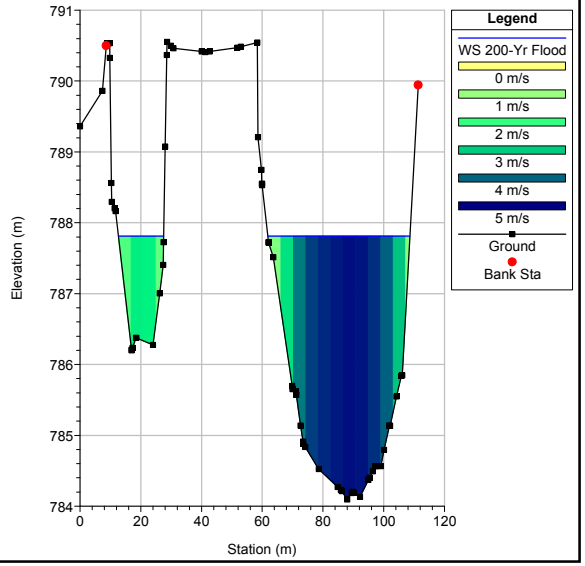
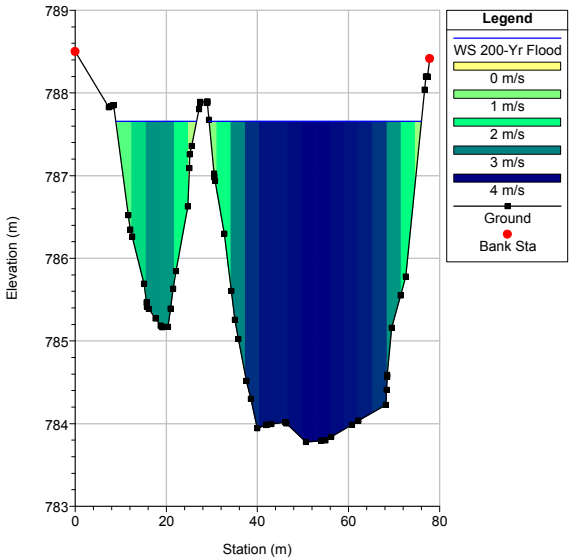
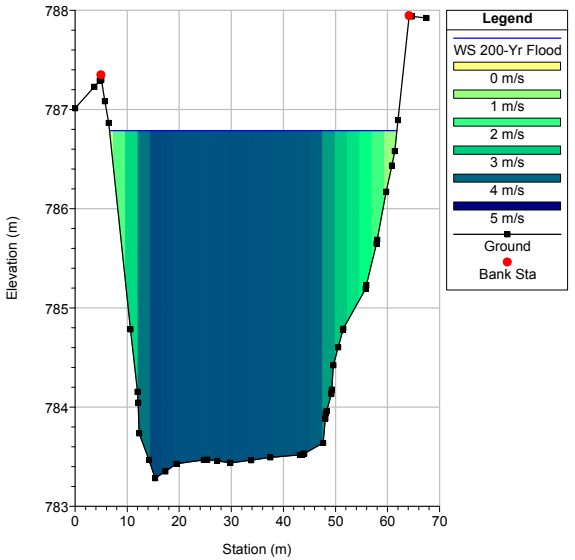


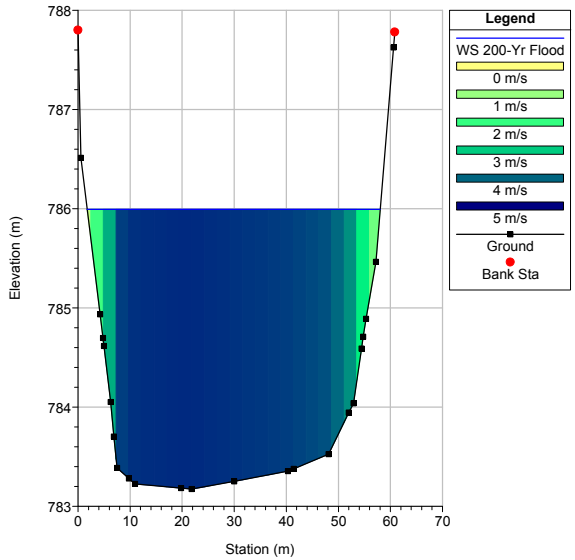
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 1971 K5 - Oct 2013



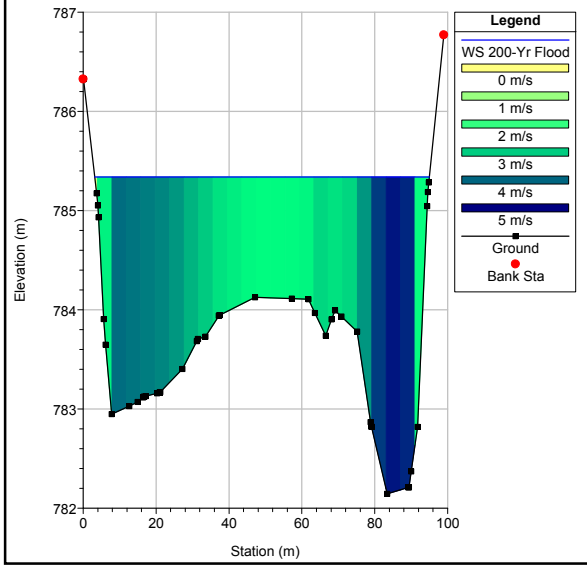
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 1679 K61 - Oct 2013



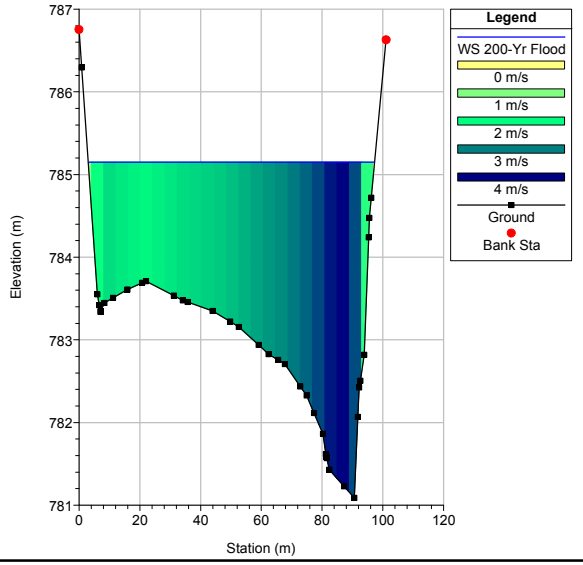
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 1483 K6 - Oct 2013



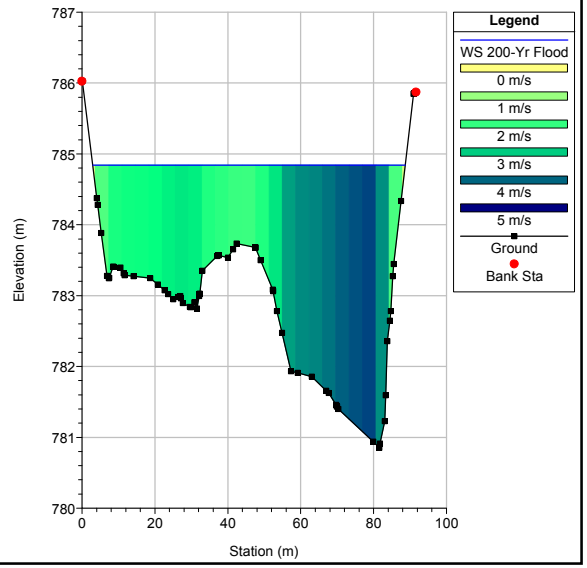
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 1239 K6A - Oct 2013



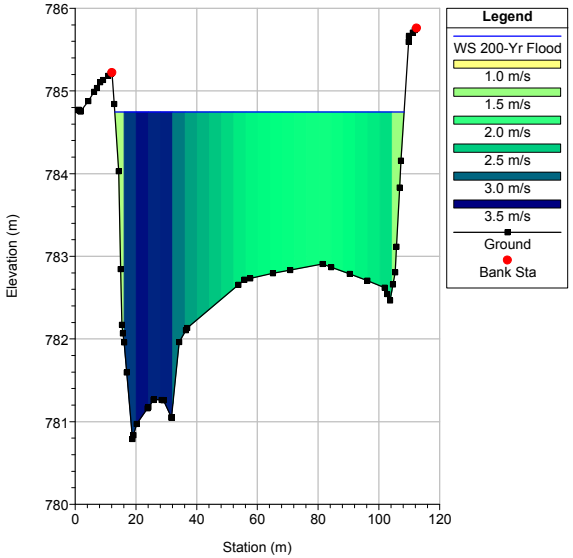
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 1106 K7 - Oct 2013



KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 1015 K7A - Oct 2013



KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 899.86 K62 - Oct 2013



KHR Nov2013 Plan: Plan 30 1/22/2014
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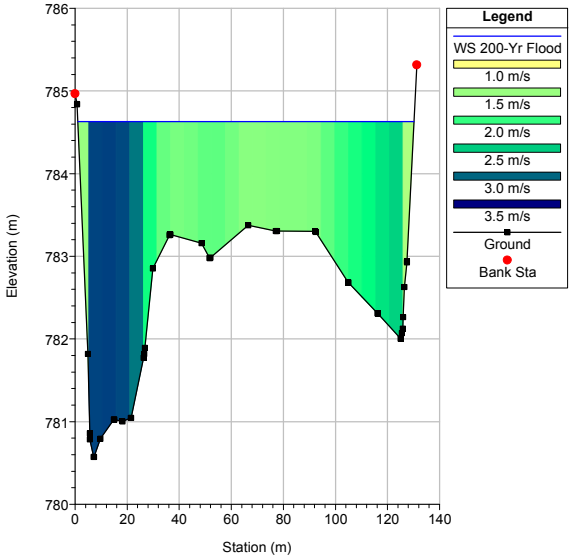
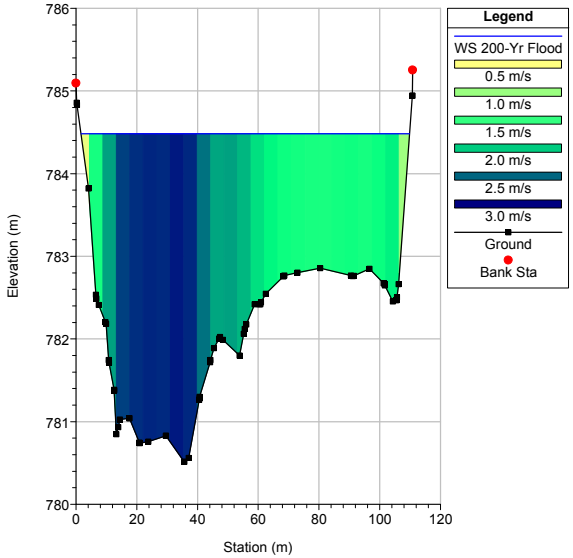


KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 643.15 K8 - Oct 2013



KHR Nov2013 Plan: Plan 30 1/22/2014
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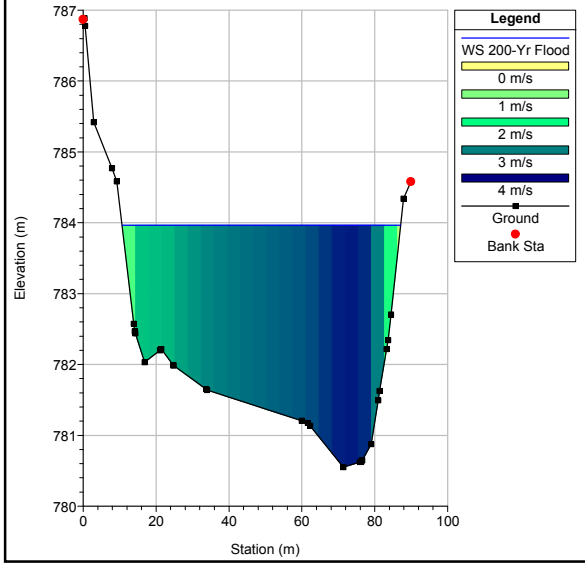
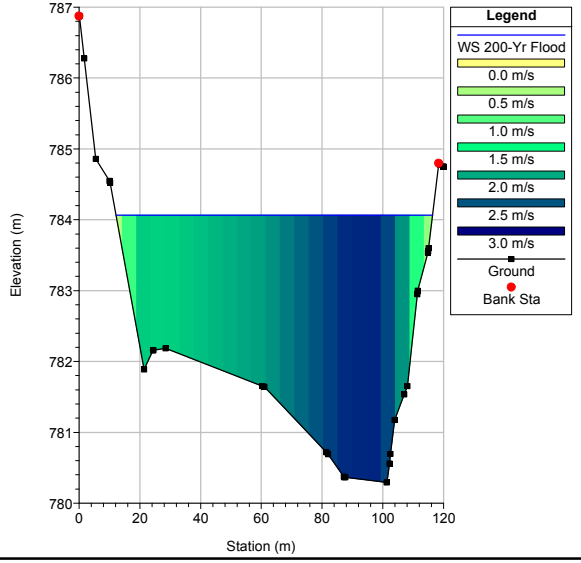
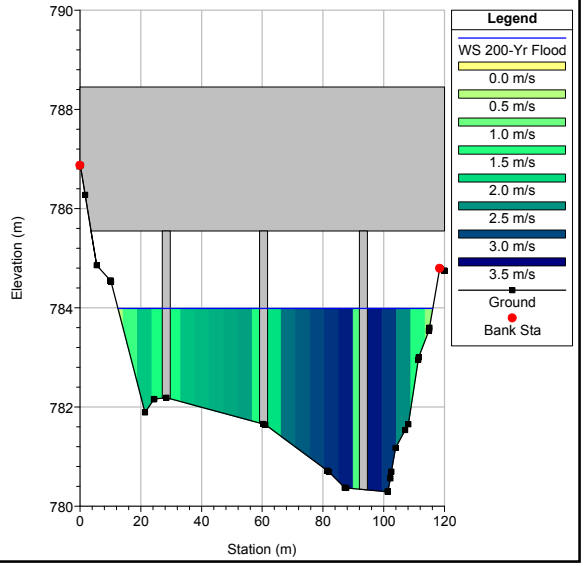


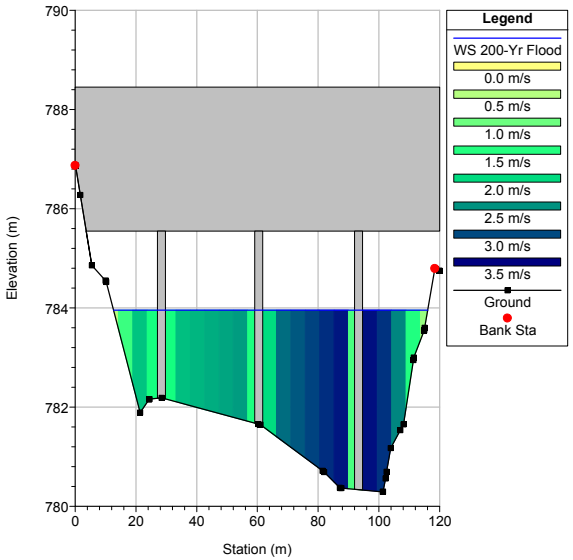
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 410.07 K54 - Oct 2013



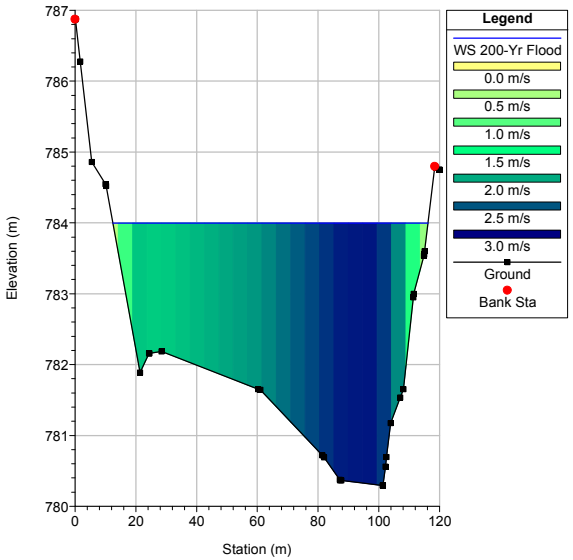
KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 409 BR



KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 409 BR



KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 392 K54b - Oct 2013



KHR Nov2013 Plan: Plan 30 1/22/2014
River = Thalweg_AllSurve Reach = Thalweg_AllSurve RS = 274.99 K9 - Oct 2013