UNIVERSITY AVENUE REHABILITATION AND WIDENING
CHENA RIVER BRIDGE NO. 263 HYDRAULIC & HYDROLOGIC STUDY

TASK 3
HYDRAULIC &HYDROLOGIC REPORT

Submitted to:
Alaska Department of Transportation & Public Facilities
Northern Region

AKSAS Project No. 63213

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ACRONYMS AND ABBREVIATIONS

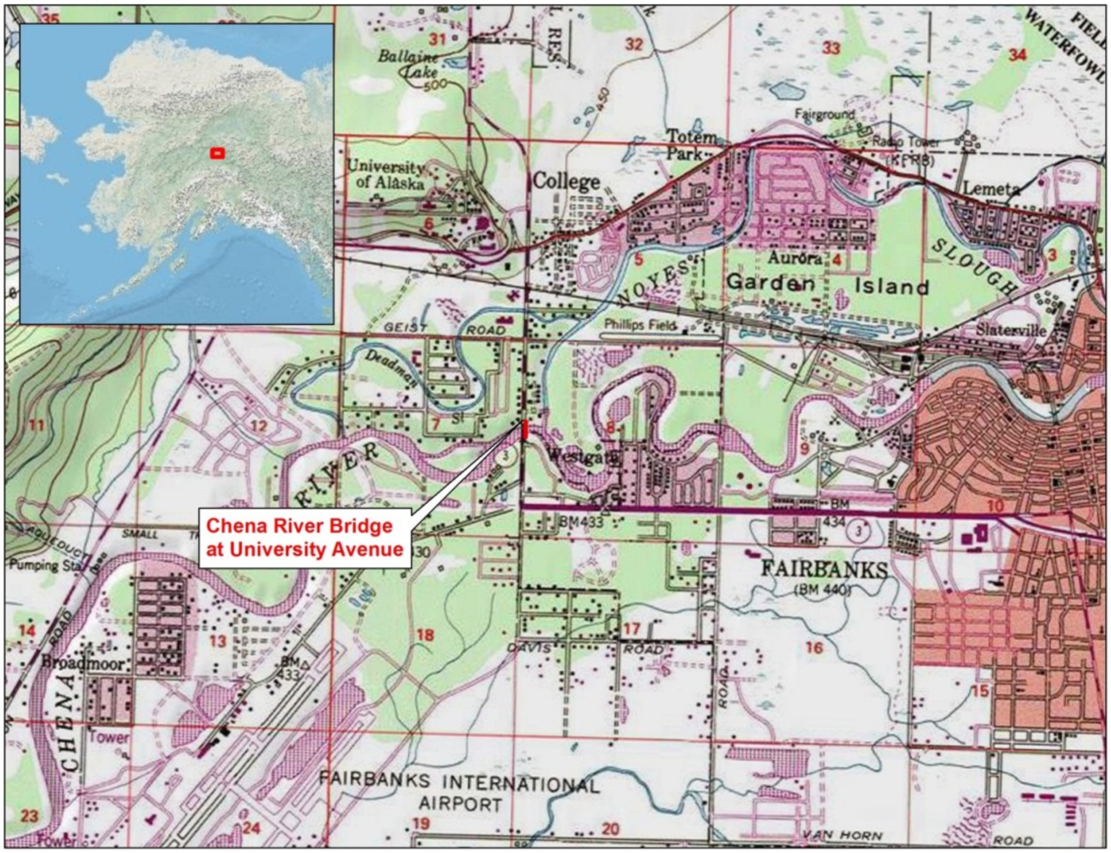
AASHTO	American Association of State Highway and Transportation Officials
BFE	Base flood water surface elevation
cfs	Cubic feet per second
Cy/lf	Cubic yard per linear foot
DOT&PF	Alaska Department of Transportation & Public Facilities
Department	DOT&PF Northern Region
DFIRM	Digital Flood Insurance Rate Map
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
H&H	Hydraulic and hydrologic
NFIP	National Flood Insurance Program
OHW	Ordinary high water
Project	Chena River Lakes Flood Control Project
TOB	Top of bank
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WSE	Water surface elevation

1 INTRODUCTION

This document presents the hydrologic and hydraulic (H&H) study of the Chena River crossing related to the University Avenue Rehabilitation and Widening project in Fairbanks, Alaska, conducted by Michael Baker Jr., Inc. for the Alaska Department of Transportation & Public Facilities (DOT&PF) Northern Region (the Department). The primary purpose of this H&H study is to establish hydraulic design criteria for the new Chena River Bridge No. 263.

1.1 LOCATION

The Chena River is a sinuous 100-mile long river which empties into the Tanana River after passing through the city of Fairbanks. All tributaries, including the Little Chena River, join the main section upstream of the study site. Within the city limits of Fairbanks, the river splits into a secondary channel, named Noyes Slough, which runs approximately 7 miles before rejoining the Chena River immediately upstream of the study site. Deadman's Slough, an inactive channel, branches off of Noyes Slough and discharges into the river downstream of the study site. At the study site, the river is confined to a well-defined channel. The Chena River is a navigable waterway used for recreational fishing and boating during the summer months.



Chena River Bridge at University Avenue

Figure 1 Study Location Map

1.2 PROPOSED WORK

The University Avenue Rehabilitation & Widening project consists of upgrading the University Avenue corridor in Fairbanks. The Department plans to construct the first segment of the project in 2015. Work will include replacing the Chena River Bridge No. 263, the location of which will be referred to hereafter as the study site (Photo 1).

Photo 1 Chena River Bridge at University Avenue looking northwest; May 20, 2013

The project proposes to replace the existing 264-foot long Chena River Bridge with a 310-foot long, 3-span, precast, pre-stressed concrete girder bridge. The proposed bridge will be 47 feet wider than the existing bridge to accommodate the proposed median and pedestrian facilities. The existing bridge abutments and piers are aligned perpendicular to the bridge deck. The proposed bridge abutments and piers will have a 10° skew, relative to the roadway alignment, to conform to the natural channel flow path.

Due to the grade raise and right-of-way constraints at the bridge, the preliminary bridge design incorporates retaining walls at the four corners of the bridge. The walls will confine the approach roadway fill in order to avoid adjacent park property and minimize impacts to residential properties. A drainage ditch along the southwest side of the bridge will accommodate stormwater outflow from storm drains along University Avenue to the south.

1.3 EXISTING BRIDGE CONDITION

A site visit on May 20, 2013 revealed minor erosion under the north abutment (Photo 2). The existing riprap revetment appeared to be in poor condition providing minimal protection.

Photo 2 Minor erosion and scattered riprap observed at the north abutment, looking east; May 20, 2013

The Final Underwater Inspection Report for the Chena River at University Avenue Bridge (URS 2010) provides information on erosion, scour, and in-channel debris at the study site. No significant pier scour was identified. The top of the footing of Pier #2 was exposed, but no undermining was noted. Streambed material at piers was identified as gravel and soft silt. In-channel debris at the upstream face of Pier #2 and Pier #3, in the form of natural woody debris, was identified and removed. Erosion was noted at each abutment, with undermining of the concrete pile caps and exposure of the H piles.

The Routine Inspection Report for the Chena River Bridge at University Avenue (Orbistondo and Murray 2012) provides a historic profile of the channel at the bridge crossing from 1998 to 2012 suggesting only moderate aggradation/degradation of the channel at the site.

2 HYDROLOGY

The flood of record for the Chena River occurred on August 15, 1967. Estimated flows for the Chena River and Little Chena River were on the order of 74,400 and 17,000 cubic feet per second (cfs), respectively (FEMA 1992). In 1968, congressional authorization was granted to begin work on the Chena River Lakes Flood Control Project (the Project). In 1979, the U.S. Army Corps of Engineers (USACE) implemented the Project. As part of the Project, flood flows on the Chena River are actively regulated by the Moose Creek Dam and Chena Diversion Floodway, located approximately 19 air miles east (40.5 river miles upstream) of the study site. Flows are either diverted through the floodway to the Tanana River, discharged via the Moose Creek Dam control works, or detained in the associated reservoir.

Current management actions performed by the UASCE and congressional authorization limits of allowable flow on the Chena River in Fairbanks, as part of the Chena River Lakes Flood Control Project, clearly define a maximum 100-year discharge of 12,000 cfs, which was selected as the design discharge. The location of the study site immediately downstream of the Noyes Slough confluence suggests that split flows in the Chena River and Noyes Slough should be considered. Other studies have taken the same approach of accounting for flow loss to Noyes Slough (Knapp 2009a; Burrows, Langley, and Evetts 2000; Anderson and Adamczak 2002). As Knapp points out, it can be inferred that the effective Flood Insurance Study (FIS) assumes this approach as well, though no specific discussion is presented on this matter. To maintain a maximum design discharge of 12,000 cfs at the new bridge site, flow loss to Deadman’s Slough was not considered. Anecdotal information from local residents and DOT&PF staff suggests that Deadman’s Slough has been blocked by earthen berms and does not actively convey flow.

The Noyes Slough, which branches off the Chena River approximately 4.8 miles upstream of the study site, discharges to the Chena River 450 feet upstream of the bridge crossing. A detailed review of Noyes Slough hydrology has been presented by Knapp (Knapp 2009a). In that report, Knapp distributed the 12,000 cfs regulated flow between the Chena River and Noyes Slough. Much of Knapp’s conclusions regarding model parameters were based on the U. S. Geological Survey (USGS) Water-Resources Investigation Report 00-4227 (Burrows, Langley, and Evetts 2000), which presents a detailed review of recent river history and the impact Noyes Slough has on flow conveyance through the Chena River basin. The report states that the Noyes Slough will receive a maximum discharge of 1,100 cfs at the regulated Chena River flow of 12,000 cfs.

The Little Chena River, located approximately 19.5 river miles upstream of the study site, is an unregulated channel. Climatological and river gaging stations located throughout the Chena River basin aid in planning and real-time regulation of flows to achieve no more than the congressionally authorized maximum of 12,000 cfs through the city of Fairbanks (FEMA 1992). A meeting with Crane Johnson of the USACE confirmed that the operational maximum discharge allowed on the Chena River in Fairbanks is not to exceed 12,000 cfs (Crane 2013). However, conditions may occur or warrant higher flows. The predicted 100-year flood discharge for the Little Chena River is 11,800 cfs limiting regulated flow from Moose Creek Dam to 200 cfs during such an event. Excessively high flows on the Little Chena River concurrent with increased release from the control works for operational safety or seepage flows under the control works may result in flows exceeding 12,000 cfs. Accordingly, a 500-yr discharge of 17,500 cfs was used as a risk assessment for developing design criteria. The 500-yr discharge combines the little Chena 500-yr peak of 14,500 cfs with an additional 3,000 cfs for anticipated seepage and other contributions from the Moose Creek Dam (FEMA 1992). The 500-yr flow distribution between the Chena River and Noyes Slough was determined based on regression equations presented in Burrows, Langley, and Evetts 2000. Table 1 presents the discharges used in this study.

Table 1 Design discharge and scour risk assessment discharge

Location	100-Year Discharge (cfs) (Design Conditions)	500-Year Discharge (cfs) (Risk Assessment)
Upstream Limit of Study		
Chena River	10,900	15,400
Noyes Slough	1,100	2,100
Downstream of Noyes Slough Confluence		
Bridge Crossing	12,000	17,500

The Chena River discharges to the Tanana River approximately 6.2 river miles downstream of the study site. Floods in the Tanana River cause a backwater effect in the vicinity of the study site (FEMA 1992) and were considered in this study.

3 HYDRAULIC ANALYSIS

The one-dimensional step backwater model HEC-RAS 4.1.0, developed by the USACE (USACE 2010), was used to model design flows and extract information for use in developing bridge design criteria. The model was also used to satisfy floodplain management policy as part of the National Flood Insurance Program (NFIP). An existing conditions model was developed using as-built bridge geometry. Once the existing conditions model was calibrated and validated, proposed bridge geometries provided by the Department were incorporated into the model, replacing the existing bridge geometries. All modeling was performed under steady state conditions with a subcritical flow regime.

3.1 CROSS SECTIONS AND BRIDGE GEOMETRY

In July 2013, Design Alaska surveyed 12 cross sections (edge of water and channel bathymetry): two (2) on Noyes Slough, five (5) on the Chena River upstream of the University Avenue Bridge and five (5) downstream of the bridge. In addition, the July survey delineated top of bank (TOB), ordinary high water (OHW) and the edge of water along the channel banks every 50 feet.

HEC-RAS geometry input data was developed in ArcGIS using the HEC-GeoRAS extension. HEC-RAS cross sections were aligned perpendicular to overbank flow and as near to perpendicular to channel flow as possible. The July bathymetric survey data was used for channel elevations and USACE Fairbanks North Star Borough LiDAR data was used for the cross section overbank topography. Bank stations were delineated along the surveyed TOB. The cross section, flow path and bank station geometry is plotted in Figure 2.

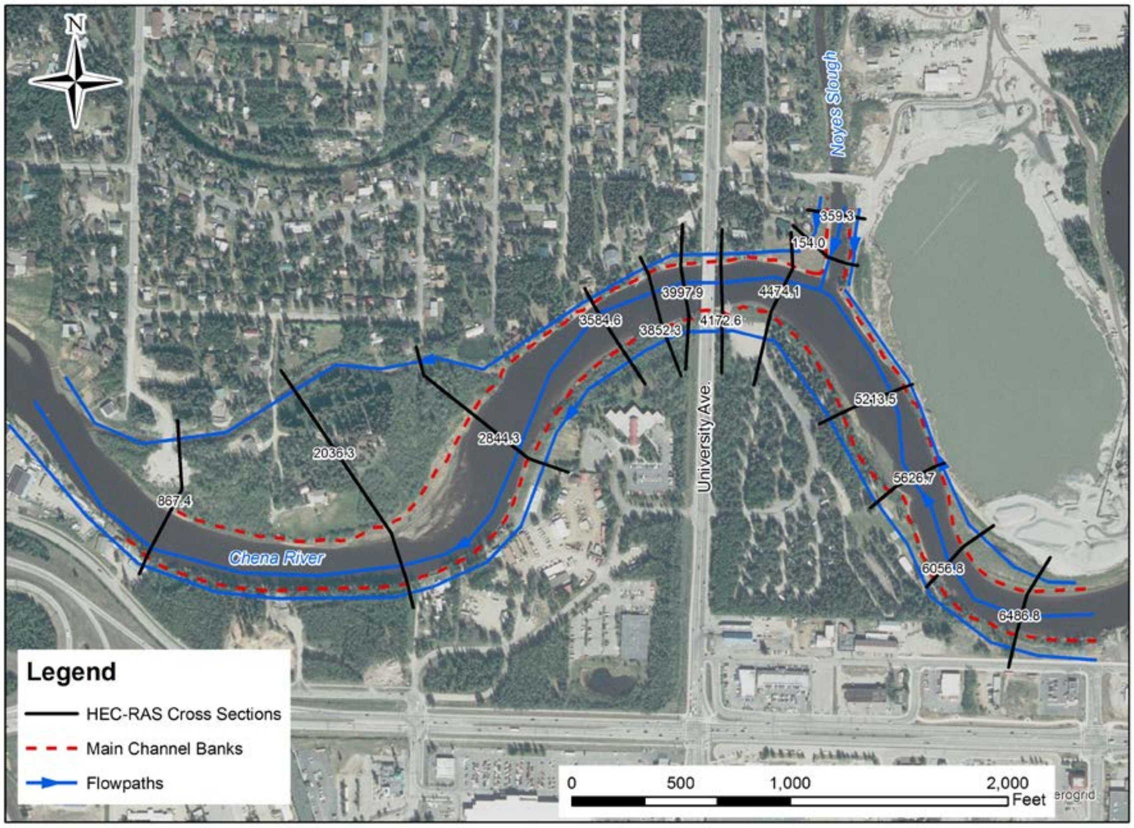


Figure 2 HEC-RAS Cross section locations and geometry

An additional cross section (3584.6) utilized bathymetry provided by the USACE. Cross section 6056.8 was interpolated in the HEC-RAS program to maintain a smooth energy grade line between cross sections 5626.7 and 6486.8. Where data sets overlapped, the LiDAR data and USACE bathymetric data was cross referenced with the July 2013 survey data to check consistency.

The existing bridge geometry was developed in the model from as-built drawings provided by the Department. The bridge geometry stationing was referenced to the upstream and downstream bounding cross sections (4172.6 and 3997.9) in HEC-RAS. Pier groups in HEC-RAS are interpreted as a single continuous pier that extends through the bridge deck and is parallel to the cross-sectional flow paths through the bridge opening. A user specified skew angle, relative to the flow paths increases the effective area of the piers. The bridge piers were assigned a 10° skew angle based on the oblique orientation of the pier group relative to the cross-sectional flow path through the bridge opening. The drag coefficient for the bridge piers was set to 1.33 to represent the existing elongated round nose shape. Internal bridge cross sections were incorporated into the model based on available bathymetry under the existing bridge deck. The model was configured to compute energy losses through the bridge using the energy equation (standard step method) and momentum balance, applying the greater of the two to the final solution. Ineffective flow areas, which balance conveyance upstream and downstream of the bridge, were assigned to upstream cross section 4172.6 and downstream cross section 3997.9 using contraction and expansion ratios of 1:1 and 1:4, respectively. Final model solutions were evaluated for equivalent conveyance upstream and downstream of the bridge.

3.2 MODEL CALIBRATION

The Chena River is currently gaged by the USGS (15514000) at the Steese Highway (Alaska Highway 2) bridge crossing, located upstream of the Noyes Slough split. The existing condition model was calibrated using USGS (15514000) recorded discharge data and surveyed water surface elevations. Model calibration was accomplished by adjusting channel hydraulic roughness coefficients to achieve a reasonable representation of observed hydraulic conditions.

The average USGS (15514000) recorded discharge of 1,000 cfs on July 30, 2013 was used as the upstream boundary condition. The recorded discharge value was verified with USGS staff prior to model calibration. Noyes Slough has no flow when Chena River flow drops below 3,000 cfs (Burrows, Langley, and Evetts 2000); therefore Noyes Slough contributions were not included in the calibration model. The known water surface elevation (WSE) at the downstream cross section (867.4), surveyed on July 30, 2013, was used as the downstream boundary condition. Assuming uniform flow conditions, a normal depth slope was computed from the modeled hydraulic grade line between downstream cross sections 867.4 and 2036.3. The model calibration parameters are presented in Table 2.

Table 2 HEC-RAS calibration results

Calibration Parameters		
	Channel	**Overbank**
Manning's Roughness (n)	0.025	0.055
Normal Depth Slope (S)	0.0002	

3.3 MODEL VALIDATION

The model was validated at the 100-yr design discharge using Federal Emergency Management Agency (FEMA) base flood water surface elevations (BFE) available in the effective FIS. The effective BFE data is currently based on the NGVD29 vertical datum. FEMA is developing Digital Flood Insurance Rate Map (DFIRM) data for the Fairbanks North Star Borough Alaska, under the Map Modernization initiative. During a Flood Study Review Meeting in Fairbanks, FEMA presented the vertical datum conversion factor of +5.1 feet that will be used for DFIRM development (FEMA 2012). FEMA's conversion factor of +5.1 feet was used for this analysis.

The model was validated with and without the Tanana River backwater influence. Backwater influences from the Tanana River were simulated by establishing a known WSE as the downstream boundary condition equivalent to the BFE at cross section 867.4. Conditions without Tanana River backwater influences were modeled by using the calibrated normal depth slope as the downstream boundary condition.

3.4 BRIDGE DESIGN MODEL

The proposed bridge geometries were provided by the Department as preliminary drawings. Internal bridge cross section geometry was updated in the model to account for the riprap revetment.

The riprap revetment was modeled at a 2H:1V slope commencing at the top of the embankment and extending to an approximate elevation of 428 feet on the left bank and 430 feet on the right bank. The revetment then transitions to a 5H:1V slope, extending to an approximate elevation of 422 feet where it terminates at natural grade. The revetment profile was designed to provide the adequate slope protection while minimizing excavation and maintaining the existing bank contours. The modeled bridge cross section, existing ground profiles and OHW for the upstream and downstream internal bridge cross sections are plotted in Figure 3 and Figure 4 respectively.

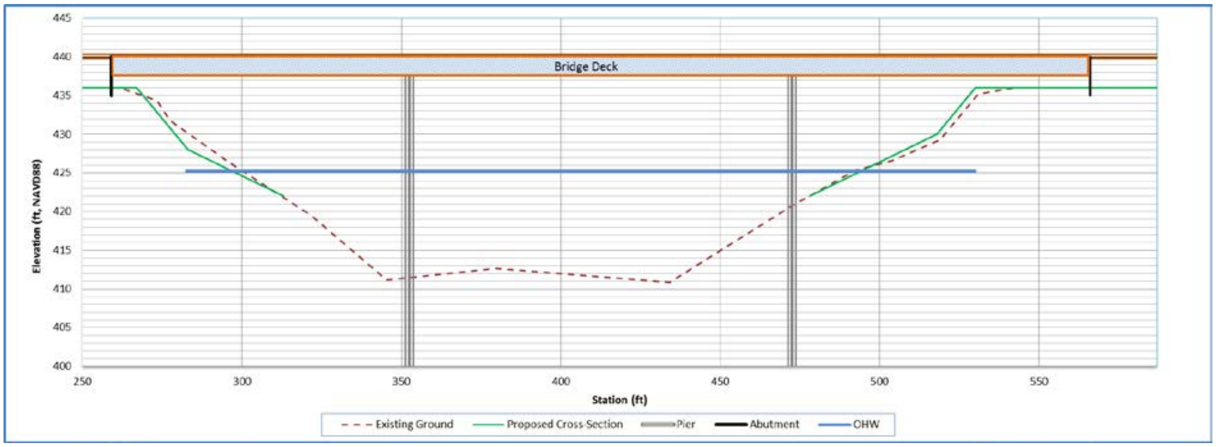


Figure 3 HEC-RAS upstream internal bridge cross section with existing ground and OHW

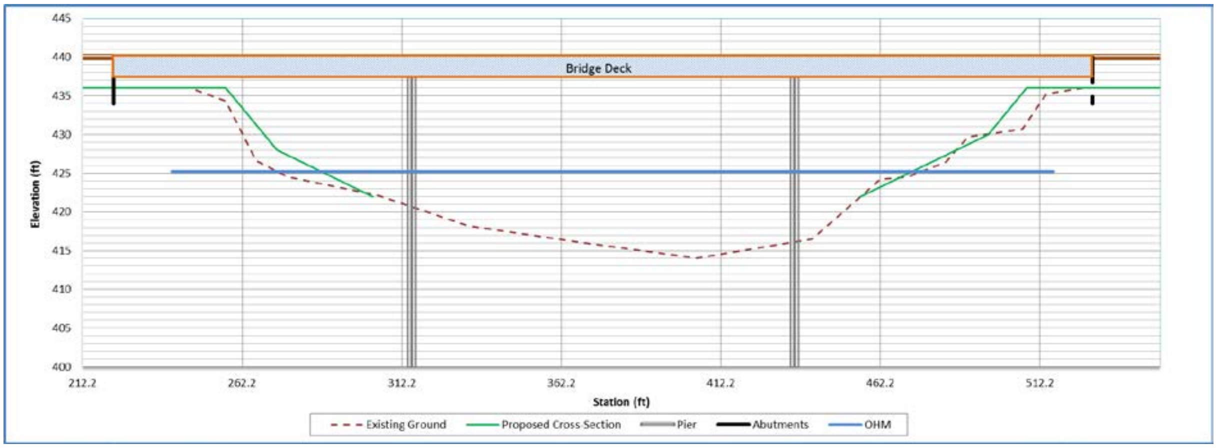


Figure 4 HEC-RAS downstream internal bridge cross section with existing ground and OHW

Modeled riprap was assigned a hydraulic roughness value of 0.04. The horizontal extent of the modeled riprap was limited to the internal bridge cross sections and the left and right banks of cross sections 3997.9 and 4172.6. The modeled horizontal extents account for a riprap apron extending upstream and downstream of the bridge as well as additional riprap placed at the drainage ditch on the southwest side of the bridge. The piers were repositioned and the diameters adjusted to the preliminary drawing specifications. The proposed piers in the preliminary plans are skewed 10° with respect to the roadway alignment and conform to the cross-sectional flow path through the bridge; therefore the pier skew angle was adjusted to zero in the model. The drag coefficient for the proposed piers was reduced to 1.2 to represent individual cylindrical piers.

The 100-yr design discharge was modeled with and without Tanana backwater influence to determine the maximum hydraulic conditions for consideration in the riprap design. In addition, backwater impacts resulting from the new bridge design were investigated by comparing results from the existing conditions model with the bridge design model. The model results indicate that no additional backwater attributed to the new bridge design is anticipated during the 100-yr design flood (Table 3).

Table 3 Modeled WSE (feet) comparison between existing conditions and the proposed bridge design for the 100-yr design flood

Reach	Cross Section	Existing Conditions Model		Bridge Design Model			
		With Tanana Backwater	Without Tanana Backwater	With Tanana Backwater		Without Tanana Backwater	
		WSE	WSE	WSE	Delta	WSE	Delta
Noyes Slough	359.3	432.28	431.80	432.25	-0.03	431.76	-0.04
	154.0	432.28	431.80	432.25	-0.03	431.76	-0.04
Upper Chena	6486.8	432.27	431.79	432.24	-0.03	431.75	-0.04
	6056.8	432.25	431.77	432.22	-0.03	431.73	-0.04
	5626.7	432.24	431.76	432.21	-0.03	431.73	-0.03
	5213.5	432.19	431.70	432.16	-0.03	431.66	-0.04
Lower Chena	4474.1	432.10	431.60	432.06	-0.04	431.56	-0.04
	4172.6	432.02	431.51	431.98	-0.04	431.47	-0.04
	Bridge						
	3997.9	431.82	431.29	431.82	0.00	431.29	0.00
	3852.3	431.71	431.16	431.71	0.00	431.16	0.00
	3584.6	431.60	431.01	431.60	0.00	431.01	0.00
	2844.3	431.59	430.99	431.59	0.00	430.99	0.00
	2036.3	431.43	430.79	431.43	0.00	430.79	0.00
	867.4	431.20	430.52	431.20	0.00	430.52	0.00

4 SCOUR ANALYSIS AND STREAM INSTABILITY

Scour is likely to occur at any drainage structure which alters the natural hydraulics of a channel. Furthermore, general channel degradation due to natural channel constrictions, erosive flow patterns in river bends or disruptions to the sediment supply may also lower the channel bed. The type and extent of scour are dependent upon the channel and flow characteristics, as well as the drainage structure design.

4.1 SEDIMENT CHARACTERISTICS

Prior to the construction of the Moose Creek Dam, the Chena River in Fairbanks received sediment laden flow from the Tanana River via the Chena Slough. With the dam in place, the Chena River has experienced a sediment deficiency as the Tanana River and upstream Chena River contributions are either diverted by the floodway or impounded behind the dam where suspended sediments settle before flood water is released into the Chena River (Burrows, Langley, and Evetts 2000). The sediment contributions from the Little Chena River, which is predominately clear water, are likely minimal. The potential downstream effects of the reduction in sediment load in the Chena River are channel degradation and general coarsening of the bed material. Channel degradation has been documented at the Wendell Street Bridge (upstream of the University Avenue Bridge), where deepening and widening of the channel has occurred after the construction of the Moose Creek Dam (Burrows, Langley, and Evetts 2000).

Observations during a site visit in May 2013, revealed the primary bed material along the channel banks and extending into the channel was medium sized gravel with an average diameter of approximately 0.03 feet (Photo 3 and Photo 4). Some sand deposition was apparent along the north bank at the bridge crossing.

Photo 3 Medium sized gravel along the southeast bank; May 20, 2013

Photo 4 Medium sized gravel extending into the channel, southwest of the bridge crossing; May 20, 2013

Historic profiles of the channel at the bridge crossing available in the most recent Routine Inspection Report (Orbistondo and Murray 2012) suggests only moderate aggradation/degradation of the channel at the site from 1998 to 2012. The observed gravel along the banks and the stable conditions of the channel bed suggests that channel degradation may be limited by a layer of armoring bed material of unknown size but is dependent on recent peak flow conditions. Since the construction of the Moose Creek Dam a maximum regulated streamflow of 11,400 cfs occurred in 1991 and 1992. This maximum flow was modeled in HEC-RAS to determine the dominate flow conditions at the bridge since the inception of the Moose Creek Dam. The estimated size of bed material to provide armoring and resist scour at the dominate flow conditions was computed using methods outlined in the Technical Guideline for Bureau of Reclamation- Computing Degradation and Local Scour (Pemberton and Lara 1984).

The resulting diameter of the armoring bed material was 0.03 feet, consistent with field observations, and was used as the D50 value for scour computations.

4.2 CONTRACTION SCOUR

Contraction scour was evaluated using the HEC-RAS bridge model results at the design discharge and following guidelines set forth in HEC No. 18 Evaluating Scour at Bridges and HEC No. 23 Bridge Scour and Stream Instability Countermeasures. The lack of available sediment from upstream sources warranted using clear water conditions for the contraction scour computations. There was no contraction scour for the 100- or 500-yr modeled flood events.

4.3 NATURAL SCOUR

Natural channel scour was evaluated using the HEC-RAS bridge model results at the design discharge and methods outlined in the Technical Guideline for Bureau of Reclamation Computing Degradation and Local Scour (Pemberton and Lara 1984). Several methods are presented including regime equations and empirical equations. As recommended, multiple methods were evaluated and an average of the results was used to determine the estimated scour depth. The natural scour for the 100-yr and the 500-yr events were 5.9 and 7.2-feet respectively.

4.4 PIER SCOUR AND ABUTMENT SCOUR

Local pier scour was evaluated using the HEC-RAS bridge model results at the design discharge and following guidelines set forth in HEC No. 18 Evaluating Scour at Bridges and HEC No. 23 Bridge Scour and Stream Instability Countermeasures. Local pier scour for both piers was computed using the maximum hydraulic conditions in the channel. The pier scour was evaluated using the Colorado State University method with a group of cylinders each having a width of 3-feet.

The most recent bridge inspection indicated that the streambed material at the piers was gravel and soft silt (Orbistondo and Murray 2012). Based on the results of the bridge inspection, pier scour was evaluated with and without a correction factor for armoring bed material. The pier scour without armoring bed material is reported as a conservative estimate and depicted in Figure 5. The pier scour for the 100-yr and the 500-yr events were 6.3 and 7.0-feet respectively. HEC-RAS pier scour results are provided in Figure 5.

The proposed extent of riprap to the base of the vertical abutments is considered to be adequate abutment scour protection; therefore no abutment scour is reported.

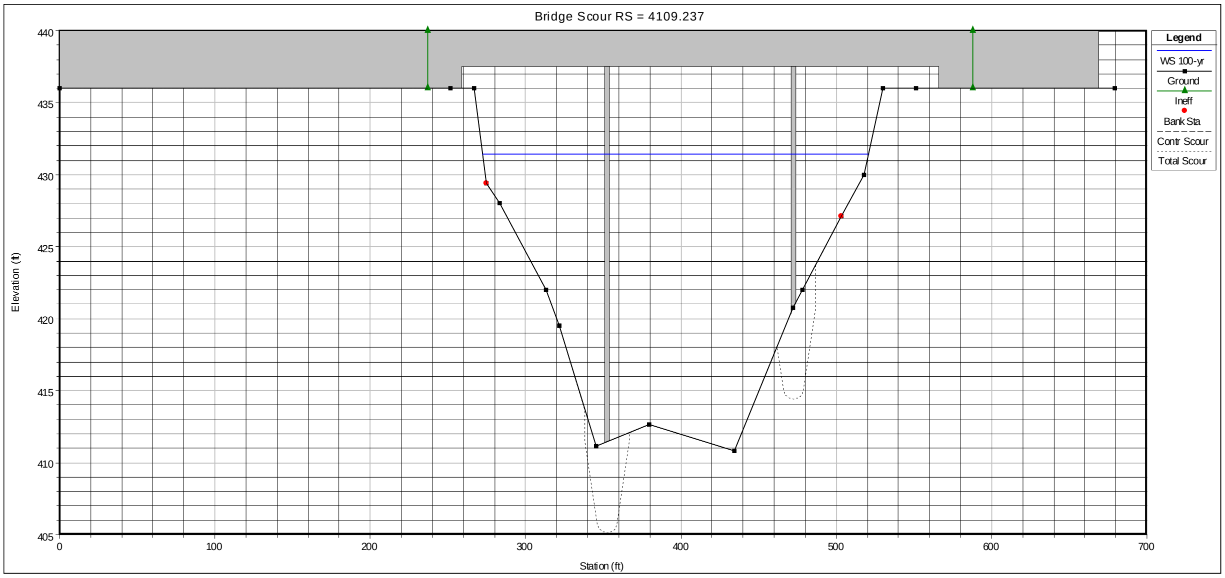


Figure 5 HEC-RAS 100-yr pier scour results without armoring bed material correction factor applied

4.5 BANK STABILITY

A qualitative streambank erosion analysis was performed using information from the May 2013 site visit and available aerial imagery. Bank migration with respect to the integrity of the proposed bridge was investigated as well as the streambank impacts of the new construction on neighboring property. Several site characteristics were considered including the channel sinuosity, bank face vegetation, bank materials and general bank profile shape.

No evidence or discussion of notable bank migration occurring in the study reach within the operational life of the existing bridge was found. A review of historic aerial imagery provided by GoogleEarth, between 1996 and 2013, shows no discernible bank migration.

The May 2013 site visit revealed stable conditions on both banks upstream and downstream of the bridge crossing. A well rooted, thick vegetative mat with grasses and willows was observed along the channel banks (Photo 5). The natural convex upwards bank profile is an indication of a stable bank with no recent bankline retreat (Rapp and Abbe 2003). The coarse bed material observed along the banks provides sufficient toe protection preventing any undercutting or toe scour.

Bank migration on the outside of the moderate bend at the bridge location would typically raise concern, however, under the current flood control policy; it is unlikely that a large flood event that could drive rapid bank migration would occur. The increased conveyance through the proposed bridge and the 10° pier and abutment skew ultimately reduce the streambank impacts of the new construction on neighboring property.

Photo 5 Well vegetated convex bank profile southwest of the bridge crossing, May 30, 2013

5 HYDRAULIC AND HYDROLOGIC SUMMARY

Table 4 Hydraulic and Hydrologic Summary Table

	100-yr (Design Discharge)	**500-yr (Risk Assessment)**
Flood Frequency (yr)	100	500
Exceedance Probability (%)	1	0.2
Discharge (cfs)	12,000[1]	17,500[2]
Velocity (ft/sec)	4.84	5.68
High Water Elevation (ft, NAVD88)	431.46	434.28
Anticipated Additional Backwater (ft)[3]	0	0
Contraction Scour (ft)	0	0
Natural Channel Scour (ft)	5.9	7.2
Pier Scour (ft)	6.3	7.0
Total Scour (ft)[4]	12.2	14.2

Notes:

1) Regulated Peak Discharge
2) Little Chena 500-yr Peak Discharge plus 3,000 cfs for seepage and other contributions from the Moose Creek Dam
3) Anticipated additional backwater is a result of the proposed bridge
4) Total scour = Natural Channel Scour + Pier Scour
5) Scour depth is applied below the thalweg elevation in anticipation of thalweg widening or migration

6 RIP RAP DESIGN

6.1 DESIGN CONSIDERATIONS

Methods outlined in HEC-11 were used to size the riprap, determine the extents and the methods for placement (FHWA 1989). Other conditions including wave action, superelevation in the channel bend and ice impacts were considered in the final riprap design.

6.1.1 DESIGN DISCHARGE

A median stone size, D_{50}, was initially calculated for the riprap revetment using maximum hydraulic parameters from the HEC-RAS bridge design model. The permissible tractive force method, in which channel velocity is the primary design parameter, was used to determine the D_{50}. The hydraulic parameters at the internal bridge cross sections and cross sections 3997.9 and 4172.6 were evaluated.

6.1.2 WAVE IMPACTS

Bank erosion due to wave action caused by boat traffic on the Chena River was considered in sizing the riprap. The close proximity of the bridge to the Chena River State Recreation Site boat launch increases exposure to waves generated by boat traffic. A one foot wave was used as the design condition based on research conducted on 23-foot V-hulled vessels in an intercoastal waterway (Fonseca and Amit 2012). The Hudson relationship, recommended in HEC-11, was used in determining the required size of the riprap to provide stability under wave action. Wave runup on the channel bank was also considered in determining the vertical extent of the riprap.

6.1.3 ICE IMPACTS

According to the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL 2013) ice jam database no historic ice jams have occurred at the project site. The lack of local ice jam data does not eliminate the potential for elevated high water due to ice jamming to occur. Breakup jams have been reported on the Chena River upstream at the Cushman St. crossing and the Nordale Rd. crossing.

The main ice concern at the project site is the movement of ice floes through the bridge opening and the excessive shearing forces that may develop along the riprap lined banks. A stability factor of 1.7 was applied to the D_{50} to increase the design rock size to resist ice impacts as recommended in HEC-11.

6.2 RESULTS

Table 5 presents the estimated median stone diameter for riprap armoring given the range of predicted hydraulic and wave conditions.

Table 5 Estimated median stone diameter, D_{50} (feet), for the predicted hydraulic conditions

Condition	XS	D_{50}
100-yr (without Tanana backwater)	4172.6	0.04
	4109.2 BR U	0.04
	4109.2 BR D	0.09
	3997.9	0.04
100-yr (with Tanana backwater)	4172.6	0.03
	4109.2 BR U	0.03
	4109.2 BR D	0.07
	3997.9	0.04
500-yr	4172.6	0.06
	4109.2 BR U	0.06
	4109.2 BR D	0.13
	3997.9	0.07
Waves		1.00
Note: D_{50} values include stability factors for ice impacts		

The largest estimated median stone diameter (D_{50}) required to armor the proposed University Avenue Bridge is 1.00 feet. Wave conditions resulting from anticipated boat wakes yield the greatest median stone diameter estimate. A D_{50} value of 1.3 feet, equivalent to the American Association of State Highway and Transportation Officials (AASHTO) Class B riprap, is suggested. Based on weight gradation of AASHTO Class B and DOT&PF specifications for riprap, a DOT&PF Class II riprap is required.

Guidelines established in Chapter 17 of the Alaska Highway Drainage Manual (DOT&PF 1995) identify methods for determining final riprap placement thickness. The final riprap armoring thickness should be the greater of D_{100} or two times D_{50}. This thickness should be increased by 50 percent when riprap is placed underwater, and increased by one foot when the riprap is subjected to debris or ice. The D_{100}, 100 percent passing a sieve of size D, is 1.8 feet under AASHTO Class B gradation. The AASHTO Class B D_{50} is 1.3 feet, resulting in a reasonable revetment thickness of 2.6 feet. In the event that water depth is greater than the proposed revetment thickness at the time of construction, and dewatering is not performed, stones should be placed to a thickness of 1.5 times the specified thickness or to the water surface, whichever is less. Ice and woody debris are a concern at the proposed bridge, thus requiring an additional foot of riprap, yielding a design riprap revetment thickness of 3.6 feet. This thickness should be conservatively maintained throughout the entire revetment to account for changes in velocity distribution, debris floes, and ice impacts. Stones larger than the specified maximum revetment thickness should not be used in construction of the revetment.

Failure of riprap revetments is often attributed to the undermining of toe protection due to natural channel degradation, contraction scour and local scour at the riprap toe. Based on the scour analysis the anticipated depth of natural scour for the 100-yr design discharge is 5.9 feet. Additional toe material should be placed within a trench or at the toe of the revetment to fill the scour hole and prevent undermining and subsequent failure of the revetment. A depth of 5.9 feet below the channel thalweg and thickness of 3.6 feet along a 2H:1V slope would require an additional volume of riprap of approximately 206 cubic feet per linear foot (206 ft^3/lf), or 7.6 cubic yards per linear foot (CY/lf) of revetment. It is unlikely that boat traffic would be operational if water levels dropped to the riprap toe elevation; therefore, the wave conditions that were used to determine the Class II riprap size are not a concern at the toe elevation. Consequently it may be prudent to reduce the size of riprap in the toe volume to Class I. The necessary excavation below OHW for installing the riprap toe will likely require a cofferdam to temporarily dewater the channel embankments.

Final revetment design specifications are as follows:

- Class II riprap
- Place riprap to thickness of 3.6 feet
- Placement side slope should not exceed 2H:1V
- Riprap toe volume of 7.6 CY/lf of revetment (Class I or Class II riprap)

The riprap placed under the bridge should extend to the vertical abutment. The freeboard of the riprap apron outside of the bridge should extend to a height of 3-feet above the design WSE or to the intersection of the vertical retaining wall on the bridge approach. The recommended freeboard height takes into consideration wave runup and the superelevation of the design high water in the channel bend. According to HEC-11 guidelines, the riprap revetment should be keyed into the bank a depth of 2 times the riprap thickness.

The riprap revetment should extend laterally to the boat ramp on the southeast side of the bridge, just beyond the drainage ditch on the southwest side of the bridge and to the right-of-way limits on the northeast and northwest sides of the bridge. Vegetation aligned with the revetment is advisable to reduce erosion at the interface of the revetment and existing ground elevation. The upstream and downstream flanks of the revetment should be keyed into the existing ground to prevent undermining at the transition to the natural bank. Where the revetment profile is lower than the adjacent bank profile, backfill on top of the riprap with native material should be used to smooth the transition between the riprap revetment and the adjacent bank. The riprap/soil interface was evaluated for stability and based on the riprap size and estimated native soil gradation, a filter is recommended. A granular filter consisting of a single, 6-inch layer of 1.5-inch well graded gravel will provide the necessary stability. As an alternative, a geotextile fabric filter, Class I, could be used. Placement of the riprap should be performed such that the geotextile filter is not disturbed or damaged. This includes limiting the drop height for riprap placement to under 3 feet. If the geotextile filter is installed below water, the fabric should be secured in place with stones prior to riprap placement. Further geotechnical investigations may determine that the native soil will provide sufficient stability for the recommended riprap.

The recommended stone size and extent of the riprap revetment was incorporated back into the model to check initial design criteria. There were no changes in WSE or velocities in the updated model that would alter the design results.

7 FLOOD IMPACTS

As part of NFIP policy (44 CFR 60.3(d)(3)), any project falling within effective floodway encroachments must be reviewed to determine if the project will increase flood levels. An engineering analysis must be conducted before a permit can be issued. Records of the analysis will be provided to the community in the form of a No-Rise Certification. The study must clearly show that construction of proposed infrastructure not increase water surface elevations above existing conditions. If a proposed project will increase flood water surface elevations, the community must receive FEMA's conditional approval in the form of a Conditional Letter of Map Revision prior to construction and a Letter of Map Revision following construction.

The exiting bridge geometry model reproduced the effective BFE within 0.5 feet with and without the Tanana River influence. The existing geometries were replaced with the proposed geometries including the proposed riprap revetment, and the model rerun to identify the direct impacts of the proposed project to relative to existing conditions. Based on the model results (Table 3), the proposed bridge geometries will not cause a rise in water surface elevation at the 100-yr design flood.

8 DECK DRAINAGE

The project proposes a curb and gutter system with storm drains for managing roadway drainage. The profile grade of the proposed bridge design incorporates a crown at mid span directing surface runoff into storm drain inlets near the four corners of the bridge. Deck drainage from the proposed bridge has been accounted for in the roadway designers drainage calculations. All storm water will be treated through vegetated bioswales before it is discharged into water bodies.

The drainage ditch along the southwest corner of the bridge will receive outflow from the University Avenue storm drains. The riprap revetment should extend laterally past the drainage ditch to provide scour protection at the drainage ditch outfall. Class II riprap should be keyed in where the drainage ditch intersects the top of the riprap revetment to prevent undercutting or washing out of the riprap revetment. The design discharge and velocity for the drainage ditch was acquired from the roadway designers. The Class II riprap is adequately sized for stability at the drainage ditch design discharge.

9 REFERENCES

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Appendix A. HEC-RAS OUTPUT DATA FOR THE CHENA RIVER AT UNIVERSITY AVENUE

```
                         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




PROJECT DATA
Project Title: 2013_UnivAve
Project File : 2013_UnivAve_HH_Rev2.prj
Run Date and Time: 11/12/2013 11:41:01 AM

Project in English units

Project Description:
Project contents: (expand and scroll down)
This is the hydraulic model for the
AKDOT Northern Region 2013 University Ave. Bridge/Chena River H&H
project. The
results from the model were reported in the H&H report. The model was
used for
simulating hydraulic conditions at the proposed University Ave. Bridge
reconstruction. The model was also used to demonstrate that the proposed
bridge
would not cause a rise in water surface elevations. This was accomplished
by
comparing the model results with the existing conditions with the design
conditions at the 100-yr flow profiles.
The model includes 2 geometry
files:

1) Existing Conditions - These are the existing bridge conditions
developed from as-built drawings.
2) Design Conditions - These are the
proposed bridge conditions interpreted from preliminary drawings provided
by
DOT.

The model includes 2 steady flow files:
1) 100-yr Design Q w/o Tanana
BW - 100-yr Design Discharge without any Tanana River backwater
considered.
```

```
2)
100-yr Design Q w/ Tanana BW - 100-yr Design Discharge with Tanana River
backwater considered.
3) Scour Q w/o Tanana BW - 100-yr Design Discharge and
500-yr risk assessment discharge for scour analysis.

Steady flow analysis
includes:
1) Existing Cond. 100-yr w/o BW - Existing condition model at design
discharge without Tanana River backwater
2) Existing Cond. 100-yr w/ BW -
Existing condition model at design discharge with Tanana River backwater
3)
Design Cond. 100-yr w/o BW - Existing condition model at design discharge
without Tanana River backwater
4) Design Cond. 100-yr w/ BW - Existing
condition model at design discharge with Tanana River backwater





PLAN DATA

Plan Title: Design Cond. 100-yr w/o BW
Plan File : C:\HECRAS\2013_UnivAve_HH_Rev2\2013_UnivAve_HH_Rev2.p03

           Geometry Title: Design_Conditions
           Geometry File :
C:\HECRAS\2013_UnivAve_HH_Rev2\2013_UnivAve_HH_Rev2.g02

           Flow Title    : 100-yr Design Q w/o Tanana BW
           Flow File     :
C:\HECRAS\2013_UnivAve_HH_Rev2\2013_UnivAve_HH_Rev2.f01

Plan Description:
Proposed University Ave. Bridge.
100-yr flow with Normal Depth S=0.0002 for
downstream BC. Use for no BW influence from Tanana River condition.


Plan Summary Information:
Number of:  Cross Sections =   14    Multiple Openings  =    0
            Culverts       =    0    Inline Structures  =    0
            Bridges        =    1    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    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: 100-yr Design Q w/o Tanana BW
Flow File : C:\HECRAS\2013_UnivAve_HH_Rev2\2013_UnivAve_HH_Rev2.f01

Flow Data (cfs)

  River           Reach           RS                  100-yr
  Chena           Upper           6486.79              10900
  Chena           Lower           4474.147             12000
  Noyes Slough    Noyes Slough    359.3467              1100


Boundary Conditions

  River           Reach           Profile                       Upstream
Downstream

  Chena           Lower           100-yr
Normal S = 0.0002




GEOMETRY DATA

Geometry Title: Design_Conditions
Geometry File : C:\HECRAS\2013_UnivAve_HH_Rev2\2013_UnivAve_HH_Rev2.g02

Reach Connection Table

  River            Reach               Upstream Boundary    Downstream
Boundary

  Chena            Upper                                      Noyes
  Chena            Lower                Noyes
  Noyes Slough     Noyes Slough                               Noyes


JUNCTION INFORMATION

Name: Noyes
Description:
Energy computation Method

    Length across Junction             Tributary
```

```
     River           Reach               River           Reach
Length   Angle
Chena           Upper            to Chena           Lower
739.4003
Noyes Slough    Noyes Slough     to Chena           Lower
299.0716

CROSS SECTION


RIVER: Chena
REACH: Upper               RS: 6486.79

INPUT
Description:
Station Elevation Data    num=     102
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  435.69    3.98  435.79    7.95  435.91   11.93  435.94   15.91
435.92
   19.88  435.78   23.86  435.65   27.84  435.76   31.81     436   35.79
436.15
   39.76  436.04   43.74  435.79   47.72  435.42   51.69     435   55.67
434.98
   59.65  435.19   63.62  435.29    67.6   435.4   71.58  435.49   75.55
435.56
   79.53  435.57   83.51  435.85   87.48  435.79   91.46  435.47   95.43
435.25
   99.41  435.15  103.39  435.02  107.36  434.86  111.34  434.73  115.32
435.15
  119.29  435.63  123.27  435.72  127.25  435.55  131.22  434.79   135.2
433.55
  139.18  431.36  143.15  428.99  147.13  428.13   151.1  427.52  153.79
426.82
  155.08  426.48159.0575 424.183165.4756 422.498189.6145 420.108 215.145
419.32
239.9292 406.699267.2231 409.768293.4559 414.572319.7313 422.309343.9082
424.325
  347.87  424.52  351.83  424.44  355.78  424.53  359.74  424.87   360.8
424.97
   363.7  425.23  367.66  425.51  371.62   425.6  375.57  425.87  379.53
426.38
  383.49  426.88  387.45  427.31  391.41   427.5  395.37  427.31  399.32
426.92
  403.28  426.92  407.24     427   411.2  427.15  415.16  427.24  419.12
427.21
  423.07  427.24  427.03  427.43  430.99  427.46  434.95  427.41  438.91
427.27
  442.87  427.18  446.82  427.02  450.78  426.92  454.74  426.88   458.7
426.79
  462.66  426.68  466.62  426.62  470.57   426.5  474.53  425.99  478.49
425.85
  482.45  426.36  486.41  427.51  490.37  428.61  494.32  429.26  498.28
429.62
```

```
  502.24  430.38   506.2  431.84  510.16  433.52  514.11  435.24  518.07
436.87
  522.03  437.77  525.99  438.53  529.95  438.97  533.91  439.23  537.86
439.3
  541.82  439.16  545.78  439.34

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055  153.79    .025   360.8    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
       153.79   360.8           476.29     430  353.45             .1
.3

CROSS SECTION


RIVER: Chena
REACH: Upper              RS: 6056.79*

INPUT
Description:
Station Elevation Data    num=     155
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0   435.3    3.52  435.33     4.6  435.34    7.03  435.38     9.2
435.38
   10.55  435.39    13.8  435.38   14.07  435.38   17.58  435.33    18.4
435.32
   21.09   435.3   23.01  435.35   24.61  435.37    27.6  435.46   28.12
435.48
   31.64  435.55    32.2  435.54   35.15  435.47   36.81  435.41   38.67
435.34
    41.4  435.19   42.19  435.15    45.7  434.95      46  434.95   49.22
434.92
    50.6  434.95   52.74  435.03   55.21  435.08   56.25  435.09   59.77
435.12
    59.8  435.12   63.28  435.13    64.4  435.14   66.79  435.18   69.01
435.19
   70.31  435.21    73.6  435.38   73.83  435.39   77.34  435.39    78.2
435.36
   80.86  435.25   82.81   435.2   84.37  435.18   87.41  435.18   87.89
435.18
   91.41  435.14      92  435.13   94.92   435.1   96.61  435.08   98.44
435.13
  101.21  435.41  101.96  435.46  105.47  435.75   105.8  435.76  108.98
435.77
  110.41  435.72   112.5  435.62  115.01  435.29  116.01  435.15  119.53
434.39
   119.6  434.37  123.05  433.01   124.2  432.52  126.56  431.45  128.81
430.91
  130.08   430.5  133.41  429.55  133.59  429.49  135.97  428.66  137.47
428.09
```

```
  137.52  428.07  141.03  426.42  142.09  426.08  144.54  425.63  148.04
425.11
  149.56  424.86  151.54  424.67  155.05  424.18  158.56   423.5  162.06
422.86
  169.05  420.03  177.63  420.09  191.52   420.6  207.31  418.59  212.58
416.84
  236.13  406.51  261.19  408.66  265.13  409.16  284.63  412.28     293
413.09
  309.37  415.53  320.91   418.1  333.94   419.7  346.59  422.26   350.8
423.05
  355.01   423.7   359.2  424.43  359.93  424.58  363.35  427.67  363.41
427.69
  364.53  428.11  366.23  428.39  368.55  428.74  370.86  428.99  372.71
429.26
  373.17   429.3  375.49   429.6   377.8   429.9  380.12  430.16  382.44
430.3
  384.75  430.25  385.23  430.22  387.06  430.05  389.38  430.03  391.69
430.05
  394.01   430.1  396.32  430.12  397.72   430.1  398.64  430.08  400.95
430.06
  403.27  430.12  405.58   430.1   407.9  430.04  410.21  429.94  412.53
429.91
  414.84  429.85  417.16  429.81  419.47  429.81  421.79  429.78  422.69
429.77
   424.1  429.75  426.42  429.73  428.73  429.69  431.04  429.46  433.36
429.4
  435.22  429.62  435.68  429.68  437.99  430.31  440.31   430.9  442.62
431.28
  444.93   431.5  447.25  431.93   447.7  432.08  449.57  432.72  451.88
433.63
  454.19  434.55  456.51  435.43  458.82  435.95  460.19  436.21  461.14
436.38
  463.45  436.63  465.77  436.79  468.08  436.85   470.4  436.81  472.71
436.94

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055  135.97    .025  364.53    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
        135.97  364.53           476.38  430.08  353.52             .1
.3

CROSS SECTION


RIVER: Chena
REACH: Upper               RS: 5626.711

INPUT
Description:
Station Elevation Data    num=      59
```

```
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  434.91       4  434.86    7.99  434.83   11.99  434.84   15.99
434.89
   19.99  434.99   23.98  434.96   27.98  434.94   31.98  434.89   35.97
434.88
   39.97  434.91   43.97  434.83   47.97   434.9   51.96  434.84   55.96
434.76
   59.96  434.82   63.95  434.93   67.95     435   71.95  435.05   75.95
435.2
   79.94  435.27   83.94  435.37   87.94  435.75   91.93  435.88   95.93
435.79
   99.93  435.58  103.92  435.23  107.92  434.47  111.92  433.38  115.92
431.54
  118.14  430.51  119.91  429.68  123.91  428.12  127.91  427.62   131.9
427.38
   135.9  427.02   139.9  426.34   143.9  425.26 147.893 424.297155.8589
419.216
181.4779 421.453205.4872 416.657232.3387 406.318258.8602 407.963283.6768
411.427
309.8686 411.954335.8794 416.066363.3973 424.563  367.02  430.48  368.27
431.25
  370.64  432.71  374.27  433.22  377.89  432.97  381.51  432.61  385.13
432.79
  388.76  432.99  392.38   433.5     396   434.2  399.63  434.53

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055  118.14    .025  368.27    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
        118.14  368.27           440.63  413.21  390.17             .1
.3

CROSS SECTION


RIVER: Chena
REACH: Upper              RS: 5213.506

INPUT
Description:
Station Elevation Data    num=      67
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  434.78    3.97  434.77    7.95  434.79   11.92  435.13   15.89
435.24
   19.86  435.36   23.84  435.52   27.81   435.5   31.78  435.34   35.75
435.25
   39.73  435.24    43.7  435.36   47.67  435.34   51.65  435.18   55.62
435.22
   59.59   435.3   63.56   435.4   67.54  435.41   71.51  435.26   75.48
435.33
```

```
   79.45  435.36   83.43  435.47    87.4  435.73   91.37  435.88   95.35
435.97
   99.32  435.87  103.29  435.92  107.26  435.71  111.24  434.93  115.21
432.19
  116.85  430.86  119.18  428.97  123.15  426.72  127.13  426.45   131.1
426.58
  135.07  426.68  139.04  426.56  143.02  426.49  146.99  426.56  150.96
426.65
  154.94  426.74  158.91  426.64  162.88  426.38166.8539 424.333170.2524
420.388
195.3038 420.477221.9197 421.894250.6105 421.579278.9969   420.7 306.735
415.557
333.9983 414.941359.8261 414.935386.6748 415.384416.5742 424.473  420.41
426.64
  423.62  427.58  424.26  427.77   428.1  429.08  431.94  432.05  435.78
435.27
  439.62  435.61  443.46  435.38   447.3  435.29  451.14  435.26  454.98
435.47
  458.82  435.57  462.66  435.77

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055  116.85    .025  423.62    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right      Coeff Contr.
Expan.
        116.85  423.62           483.61  739.36  572.72             .1
.3

CROSS SECTION


RIVER: Chena
REACH: Lower              RS: 4474.147

INPUT
Description:
Station Elevation Data    num=     142
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  436.41    3.98  437.18    7.95  437.41   11.93  437.36    15.9
437.09
   19.88  436.99   23.86   436.9   27.83   436.7   31.81  436.53   35.78
436.52
   39.76  436.56   43.74  436.64   47.71  436.61   51.69  436.27   55.67
435.88
   59.64   435.8   63.62  435.82   67.59   435.9   71.57  436.06   75.55
436.16
   79.52  436.18    83.5  436.26   87.47  436.32   91.45  436.19   95.43
435.87
    99.4  435.71  103.38  435.28  107.35  434.74  111.33  434.59  115.31
434.5
  119.28  434.57  123.26  434.59  127.23  434.62  131.21  434.68  135.19
434.57
```

```
  139.16   434.6  143.14  434.61  147.11  434.55  151.09  434.52  155.07
434.51
  159.04  434.44  163.02  434.46     167  434.53  170.97  434.56  174.95
434.55
  178.92  434.48   182.9  434.46  186.88  434.45  190.85  434.41  194.83
434.51
   198.8  434.48  202.78   434.3  206.76  434.24  210.73  434.22  214.71
434.19
  218.68  434.25  222.66  434.14  226.64  434.02  230.61  434.06  234.59
433.89
  238.56  433.88  242.54  433.97  246.52   433.7  250.49  433.82  254.47
433.9
  258.45  433.84  262.42  433.82   266.4  433.73  270.37  433.85  274.35
433.94
  278.33  434.01   282.3  433.98  286.28  434.06  290.25  434.04  294.23
433.93
  298.21  433.91  302.18  433.76  306.16  433.29  310.13  432.72  314.11
432.49
  318.09  432.37  322.06  432.24  326.04  431.79  330.01  430.42  333.34
428.63
  333.99  428.28  337.97  426.59  341.94  425.49345.9188 424.395352.0732
422.074
371.3559 421.134 396.995 420.307424.1775 419.623451.0731 417.539478.9955
412.379
504.1094 404.843529.1538 409.885554.6238 417.381568.1699 424.535  572.08
426.51
  575.99  427.91  578.96  428.52  579.91  428.71  583.82  429.47  587.73
429.81
  591.65   429.8  595.56   429.8  599.47  429.84  603.38  429.91   607.3
430.02
  611.21  430.16  615.12  430.35  619.03  430.55  622.95  430.71  626.86
430.81
  630.77  430.88  634.68  430.97   638.6  431.07  642.51  431.21  646.42
431.37
  650.33  431.48  654.25  431.66  658.16  431.79  662.07  431.99  665.98
432.33
   669.9  432.51  673.81  432.72  677.72  432.95  681.63  433.15  685.55
433.45
  689.46  433.74  693.37  434.02  697.28  434.45   701.2  434.91  705.11
435.37
  709.02  435.86  712.94   436.4  716.85   436.8  720.76  437.04  724.67
437.1
  728.59  437.15   732.5  437.25

Manning's n Values         num=       3
     Sta    n Val     Sta    n Val     Sta    n Val
       0     .055  333.34     .025  578.96     .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
        333.34  578.96            200.2  301.51  325.24             .3
.5

CROSS SECTION
```

```
RIVER: Chena
REACH: Lower              RS: 4172.639

INPUT
Description:
Station Elevation Data    num=     126
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  432.34    3.99   433.4    7.98  434.75   11.98   435.5   15.97
435.72
   19.96  435.87   23.95  435.98   27.94  436.08   31.94   436.1   35.93
436.04
   39.92  435.49   43.91  434.59    47.9  433.77    51.9  433.24   55.89
433.01
   59.88  432.47   63.87  432.23   67.87  432.37   71.86  432.79   75.85
433.25
   79.84  433.86   83.83  434.51   87.83  434.56   91.82  434.34   95.81
434.28
    99.8  434.31  103.79  434.28  107.79  434.29  111.78   434.3  115.77
434.26
  119.76  434.13  123.75  433.99  127.75  433.95  131.74  433.87  135.73
433.65
  139.72  433.54  143.71  433.61  147.71  433.64   151.7  433.79  155.69
433.69
  159.68  433.57  163.67  433.61  167.67  433.54  171.66  433.44  175.65
433.62
  179.64  433.75  183.64  433.85  187.63  433.84  191.62   433.7  195.61
433.51
   199.6  433.58   203.6  433.58  207.59  433.45  211.58   433.3  215.57
433.09
  219.56  433.02  223.56  432.98  227.55  432.89  231.54  432.88  235.53
432.87
  239.52  432.74  243.52  432.61  247.51  432.48   251.5  432.31  255.49
432.06
  259.48  431.85  263.48  431.55  267.47  431.22  271.46  430.81  275.45
430.24
  279.44  429.81  282.42   429.4  283.44  429.26  287.43  427.97  291.42
426.7
  295.41   426.1   299.4  425.21 303.397 424.278 334.645 418.793  362.74
415.53
 389.402 411.228 414.646  411.04 438.743 411.569 466.427  418.93 491.493
422.147
 503.736   424.2  507.69  424.87  511.64  426.05  515.53  427.09  515.59
427.11
  519.55  427.86   523.5  428.29  527.45  429.55   531.4  431.37  535.35
432.24
  539.31  433.12  543.26  434.11  547.21  435.07  551.16  435.88  555.11
436.34
  559.07  436.75  563.02  436.77  566.97  436.78  570.92  436.81  574.87
436.83
  578.83  436.76  582.78  436.44  586.73  436.22  590.68  436.14  594.63
435.84
```

```
  598.59  435.54  602.54  435.25  606.49  435.24  610.44  435.15   614.4
435.19
  618.35  435.23   622.3  435.21  626.25  435.39   630.2  435.59  634.16
435.78
  638.11  435.91  642.06   435.9  646.01  435.96  649.96  435.75 653.919
435.46
  657.87  435.18

Manning's n Values         num=       5
     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val     Sta
n Val
       0    .055  255.49     .04 334.645    .025 466.427     .04  543.26
.055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
        282.42  515.53            155.9  174.77  184.05              .3
.5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0  237.06     440       T
     588  657.87     440       T

BRIDGE


RIVER: Chena
REACH: Lower             RS: 4109.237

INPUT
Description:
Distance from Upstream XS =      10
Deck/Roadway Width        =   106.3
Weir Coefficient          =     2.6
Upstream  Deck/Roadway Coordinates
    num=       6
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0     440          259.06     440          259.06     440   437.5
     566     440   437.5     566     440           669.1     440

Upstream Bridge Cross Section Data
Station Elevation Data    num=      17
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0     436  251.76     436     267     436 274.543   429.4     283
428
     313     422 321.505  419.54 345.301  411.17 379.664  412.64 434.102
410.83
 472.433  420.75     478     422  503.45  427.09     518     430     530
436
  551.51     436 679.422     436

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

```
       0     .04     313    .025     478     .04

Bank Sta: Left   Right    Coeff Contr.   Expan.
       274.543  503.45             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0  237.06     440       T
     588 679.422     440       T

Downstream  Deck/Roadway Coordinates
    num=       6
     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord     Sta Hi Cord Lo Cord
       0     440          221.81     440          221.81     440   437.5
  528.75     440   437.5  528.75     440            669.1     440

Downstream Bridge Cross Section Data
Station Elevation Data    num=      16
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0     436 240.118     436     257     436  271.96  428.52     273
428
     303     422 304.643 422.162 332.981 418.232 369.977 415.942 404.698
414.052
 440.822 416.512     456     422     482   427.2     496     430     508
436
   669.1     436

Manning's n Values        num=       2
     Sta   n Val     Sta   n Val
       0     .04     456     .04

Bank Sta: Left   Right    Coeff Contr.   Expan.
        271.96     482             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0210.1925     440       T
540.3675   669.1     440       T

Upstream Embankment side slope              =       0 horiz. to 1.0
vertical
Downstream Embankment side slope            =       0 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 =  2

Pier Data
Pier Station     Upstream=  352.53    Downstream=  315.28
Upstream     num=       6
```

```
    Width   Elev    Width   Elev    Width   Elev    Width   Elev    Width
Elev
       3     397       3     401       3     401       3     404       3
404
       3   437.5
Downstream     num=       6
    Width   Elev    Width   Elev    Width   Elev    Width   Elev    Width
Elev
       3     397       3     401       3     401       3     404       3
404
       3   437.5

Pier Data
Pier Station     Upstream=  472.53    Downstream=  435.28
Upstream     num=       6
    Width   Elev    Width   Elev    Width   Elev    Width   Elev    Width
Elev
      12     397      12     401       9     401       9     404       3
404
       3   437.5
Downstream     num=       6
    Width   Elev    Width   Elev    Width   Elev    Width   Elev    Width
Elev
      12     397      12     401       9     401       9     404       3
404
       3   437.5

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
       Momentum               Cd   =     1.2
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: Chena
REACH: Lower              RS: 3997.873

INPUT
Description:
Station Elevation Data    num=     121
```

```
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  433.96    3.96  433.86    7.92  433.74   11.88  433.71   15.84
433.74
    19.8  433.72   23.76  433.36   27.73  432.94   31.69  432.73   35.65
432.79
   39.61  432.94   43.57   433.1   47.53   433.2   51.49   433.2   55.45
433.18
   59.41  433.15   63.37  433.16   67.33  433.15   71.29  433.14   75.25
433.15
   79.21  433.18   83.18  433.19   87.14  432.98    91.1  432.83   95.06
432.56
   99.02  432.21 102.981  432.06  106.94  431.94   110.9  431.72  114.86
431.51
  118.82  431.29  122.78  431.03  126.74     431   130.7  431.07  134.67
431.08
  138.63   431.2  142.59  431.14  146.55  431.13  150.51  431.12  154.47
431.13
  158.43  431.08  162.39  431.02  166.35  430.98  170.31  431.03  174.27
431.11
  178.23  431.15  182.19  431.15  186.16  431.04  190.12  431.01 194.078
430.68
  198.04  430.25     202  430.13  205.96   429.9  209.92  429.74  213.88
429.58
  217.84  429.47   221.8  429.43  225.76  429.33  229.42  428.52  229.72
428.45
  233.68   427.1  237.64  425.53 241.606 424.036 269.625 421.616 294.205
418.027
 322.234 418.302  347.16 416.812 374.025 416.207 401.328 415.334 428.668
418.347
 454.219 421.019 480.753  424.29  484.68  426.28  488.35   427.2   488.6
427.26
  492.53  427.76  496.45   429.1  500.38  431.56   504.3   433.1  508.23
433.56
  512.15  433.65  516.08  433.62     520  433.52  523.93  433.54  527.85
433.61
  531.77  433.63 535.701  433.67  539.62  433.75  543.55  433.82  547.47
433.85
   551.4  433.97  555.32  434.18  559.25  434.31  563.17  434.36   567.1
434.47
  571.02   434.6  574.95  434.69  578.87  434.64   582.8  434.53  586.72
434.5
  590.65  434.51  594.57  434.58   598.5  434.54  602.42   434.5  606.35
434.52
  610.27  434.57   614.2   434.6  618.12  434.55  622.04  434.55  625.97
434.5
  629.89  434.45  633.82   434.4  637.74  434.34  641.67  434.28  645.59
434.24
  649.52  434.34  653.44  434.53  657.37   434.5 661.288  434.47  665.22
434.45
  669.14  434.42

Manning's n Values        num=       5
```

```
     Sta   n Val     Sta   n Val     Sta   n Val     Sta   n Val     Sta
n Val
       0    .055  174.27     .04 269.625    .025 454.219     .04  508.23
.055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
        229.42  488.35           104.96  145.53  176.73              .3
.5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
       0210.1925     440       T
540.3675  669.14     440       T

CROSS SECTION


RIVER: Chena
REACH: Lower              RS: 3852.347

INPUT
Description:
Station Elevation Data    num=      96
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  434.07    3.95  433.95    7.91  433.89   11.86   434.1   15.81
434.05
   19.77  433.93   23.72  433.86   27.67  433.79   31.62  433.57   35.58
433.29
   39.53  433.09   43.48   433.1   47.44  433.19   51.39  433.18   55.34
433.36
    59.3  433.56   63.25  433.52    67.2  433.21   71.16  433.11   75.11
433.12
   79.06  433.17   83.01  433.18   86.97  433.05   90.92  432.84   94.87
432.76
   98.83  432.52  102.78  431.83  106.73  431.18  110.69  430.61  114.64
429.95
  118.59  429.92  122.55   429.9   126.5  429.81  130.45  429.78   134.4
429.91
  138.36  430.21  142.31  430.45  146.26  430.65  150.22  430.89  154.17
431.22
  158.12  431.68  162.08  431.74  166.03  431.15  169.98  430.68  173.93
430.52
  177.89  429.91  181.84  430.04  185.79  430.76  189.75  430.94   193.7
430.35
  197.65  429.24  201.61  428.42  205.56  428.26  209.51  428.11  213.47
427.97
  217.42  427.96  221.37   428.2  225.32  428.35  229.28  428.01  232.48
427.2
  233.23  427.01  237.18  425.73  241.14  424.87  245.09  424.31271.4799
421.79
300.0754 421.635324.9045 421.583353.3464 420.177378.3382 419.524 405.664
418.124
```

```
430.7618 418.796457.8266 420.686489.6442 424.106   493.6  425.93   494.5
426.89
  497.56  430.16  501.51  434.08  505.47  435.11  509.42  435.12  513.38
434.8
  517.34  434.65  521.29  434.51  525.25  434.31   529.2  434.15  533.16
433.99
  537.11   433.9  541.07   433.8  545.03  433.79  548.98  433.81  552.94
433.88
  556.89  433.95  560.85  433.99  564.81  434.09  568.76  434.21  572.72
434.34
  576.67  434.45

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055  232.48    .025   494.5    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
        232.48   494.5           197.11  267.79  290.05             .1
.3

CROSS SECTION


RIVER: Chena
REACH: Lower              RS: 3584.559

INPUT
Description:
Station Elevation Data    num=     105
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  434.18    3.94   434.2    7.88  434.19   11.81  434.19   15.75
434.17
   19.69  433.98   23.63  433.91   27.57  433.96   31.51  433.96   35.44
433.93
   39.38  433.82   43.32  433.57   47.26  433.21    51.2  432.93   55.14
432.6
   59.07  432.14   63.01  431.41   66.95  430.95   70.89   430.7   74.83
430.19
   78.77  429.44   82.71  429.37   86.64   429.7   90.58  430.07   94.52
430.32
   98.46  430.23   102.4  430.05  106.33  430.17  110.27  430.22  114.21
430.17
  118.15  430.15  122.09  430.07  126.03  429.93  129.96  429.82   133.9
429.31
  137.84  428.73  141.78  428.38  145.72  428.01  149.66  427.59  153.59
427.56
  157.53  427.62  161.47  427.54  165.41  427.33  169.35  427.01  173.29
426.94
  177.22  426.89  181.16   427.1   185.1  427.32  189.04  427.58  192.98
427.95
  196.18  428.16  196.92   428.2  200.85  427.12  204.79  425.25  208.73
424.2
```

```
  212.67  424.04  216.61  423.89  220.55  423.83  224.48  423.72  228.42
423.77
232.3612422.3901
249.218421.7075267.0365421.1313284.1725420.9458297.9587420.6432
313.0067
419.956327.6257419.6816337.9898419.5957343.4431419.3506352.8683419.6468
363.4637
419.884373.7558419.2532382.8573418.6155390.0587418.5292396.2577418.8805
400.5569419.5172407.8179420.0719415.5135420.4733
420.135420.9611425.0325422.5304
  428.97  424.28  432.88  424.97  436.79  426.52   440.3  428.53   440.7
428.75
  444.62  431.09  448.53  433.16  452.44  434.24  456.36  434.32  460.27
434.5
  464.18  434.63  468.09  434.68  472.01  434.79  475.92  434.64  479.83
434.56
  483.75  434.64  487.66  434.69  491.57   434.7  495.48  434.75   499.4
434.81
  503.31  434.81  507.22  434.77  511.14  434.74  515.05   434.7  518.96
434.67

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055  196.18    .025   440.3    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
        196.18   440.3           632.66  740.21  886.68             .1
.3

CROSS SECTION


RIVER: Chena
REACH: Lower              RS: 2844.347

INPUT
Description:
Station Elevation Data    num=     174
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  435.58    3.96  435.61    7.92  435.63   11.88  435.48   15.84
435.49
    19.8  435.36   23.76  435.05   27.73  434.96   31.69  434.84   35.65
434.56
   39.61  434.38   43.57  434.21   47.53  433.98   51.49  433.77   55.45
433.58
   59.41  433.41   63.37  433.35   67.33  433.39   71.29   433.2   75.25
433.13
   79.21   432.9   83.17  432.72   87.14  432.63    91.1  432.22   95.06
432.02
   99.02  432.14  102.98  432.31  106.94  432.37   110.9  432.36  114.86
432.34
```

```
  118.82  432.29  122.78  432.22  126.74  432.19   130.7   432.1  134.66
432.03
  138.62  431.87  142.59  431.67  146.55  431.39  150.51  431.12  154.47
430.82
  158.43  430.57  162.39   430.4  166.35  430.14  170.31  429.81  174.27
429.5
  178.23  429.15  182.19  428.67  186.15  427.93  190.11  426.96  192.02
426.26
194.0748 424.254198.4783  421.78224.0588 421.847248.5845 418.693277.0928
419.528
304.7779 419.444332.9922  419.68362.5375 420.328392.3852 420.045 417.057
420.661
443.5473 421.056471.6161 421.331497.9454 421.435511.4614 424.399  515.42
425.92
  519.39  426.83  523.35  427.06  525.31     427  527.31  426.95  531.27
426.73
  535.23  426.61   539.2  426.49  543.16  426.22  547.12  425.89  551.08
425.46
  555.04  425.54     559  425.58  562.97  425.31  566.93  426.52  570.89
427.34
  574.85  428.43  578.81   429.6  582.78  430.41  586.74  430.86   590.7
431.1
  594.66  431.22  598.62  431.39  602.59  431.81  606.55   431.8  610.51
431.81
  614.47  431.84  618.43  431.92   622.4  431.77  626.36   431.8  630.32
432.12
  634.28  432.18  638.24  432.24   642.2  432.45  646.17   432.5  650.13
432.54
  654.09  432.72  658.05  432.97  662.01  433.07  665.98  432.91  669.94
432.7
   673.9  432.79  677.86  432.77  681.82  432.78  685.79  432.92  689.75
432.95
  693.71  432.99  697.67  433.42  701.63   433.6   705.6  433.68  709.56
433.78
  713.52  433.86  717.48  433.87  721.44  433.67   725.4  433.49  729.37
433.47
  733.33  433.31  737.29  433.23  741.25  433.73  745.21  433.84  749.18
433.94
  753.14   434.2   757.1  434.58  761.06  434.46  765.02  434.22  768.99
433.91
  772.95  433.87  776.91  433.78  780.87  433.67  784.83  433.66  788.79
433.61
  792.76  433.55  796.72  433.44  800.68  433.33  804.64  433.19   808.6
433.16
   812.5  433.38  816.39  433.64  820.28  433.93  824.17  434.12  828.06
433.7
  831.95  432.81  835.84  431.83  839.73  430.64  843.62  429.01  847.51
428.07
   851.4  427.53  855.29  426.94  859.19   426.4  863.08     426  866.97
425.86
  870.86  425.87  874.75  425.65  878.64  425.33  882.53  424.87  886.42
424.56
  890.31  424.39   894.2  424.54  898.09  425.48  901.98  427.46  905.88
429.49
```

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  909.77  431.37  913.66  432.74  917.55  433.56  921.44  433.84  925.33
434.03
  929.22   434.3  933.11  434.53     937  434.64  940.89  434.77

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055  192.02    .025  525.31    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
        192.02  525.31           914.87  808.01  613.02             .1
.3

CROSS SECTION


RIVER: Chena
REACH: Lower               RS: 2036.342

INPUT
Description:
Station Elevation Data    num=     269
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0   435.5     3.9  435.47    7.79   435.2   11.69  434.89   15.59
434.63
   19.49  434.73   23.38  434.97   27.28  435.13   31.18  435.11   35.07
435.07
   38.97  434.81   42.87  434.66   46.76  434.55   50.66  434.61   54.56
434.57
   58.46   434.6   62.35  434.63   66.25  434.54   70.15   434.5   74.04
434.64
   77.94   434.7   81.84  434.89   85.74  435.38   89.63  435.26   93.53
434.92
   97.43  434.99  101.32  435.04  105.22  434.74  109.12  434.89  111.45
433.48
  113.01  432.53116.9118 424.115121.9313 421.992145.7774 419.778172.7717
419.302
199.1418 417.644224.4314 417.743251.3098 418.689277.5214 419.074304.3854
420.57
 329.234 422.122356.8591 424.136  360.85  424.34  364.84  424.61  368.83
424.89
  372.82  425.08  376.81  425.31   380.8  425.45  384.79  425.59  388.78
425.6
  392.77   425.5  394.18  425.51  396.76  425.53  400.75   425.8  404.74
425.84
  408.73  425.86  412.72  425.95  416.71  426.15   420.7   426.3  424.69
426.54
  428.68   426.6  432.67  426.82  436.66     427  440.66  427.39  444.65
427.84
  448.64  428.04  452.63  428.26  456.62  428.26  460.61  427.92   464.6
427.36
  468.59  426.95  472.58  427.13  476.57  427.59  480.56  428.02  484.55
428.37
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  488.54  428.46  492.53   428.4  496.52   428.5  500.51  428.61   504.5
428.71
  508.49  428.98  512.48  429.46  516.47  429.72  520.46  429.87  524.45
429.99
  528.44  430.04  532.43  430.03  536.42  429.91  540.41  429.78   544.4
429.84
  548.39  430.06  552.38   430.2  556.37  430.41  560.36  430.55  564.35
430.42
  568.34  430.34  572.33  430.38  576.32  430.59  580.31  430.77  584.31
430.81
   588.3  430.85  592.29  430.82  596.28  430.72  600.27  430.26  604.26
429.95
  608.25  429.81  612.24  429.76  616.23  429.76  620.22  429.73  624.21
429.73
   628.2  429.87  632.19     430  636.18  430.24  640.17  430.33  644.16
430.4
  648.15  430.47  652.14  430.98  656.13  431.44  660.12  432.04  664.11
432.21
   668.1  432.35  672.09  432.77  676.08  432.98  680.07  433.11  684.06
433.28
  688.05  433.64  692.04  434.08  696.03  434.36  700.02  434.38  704.01
434.27
     708  434.22  711.99  434.04  715.98  433.95  719.97  433.79  723.96
433.64
  727.95  433.55  731.94  433.63  735.93  433.64  739.92  433.71  743.92
433.83
  747.91  433.86   751.9   433.7  755.89  433.56  759.88  433.44  763.87
433.24
  767.86  433.16  771.85  433.28  775.84  433.33  779.83  433.25  783.82
433.38
  787.81     434   791.8     435  795.79  436.19  799.78   436.6  803.77
436.61
  807.76   436.5  811.75  436.29  815.74  435.96  819.73  435.62  823.72
435.31
  827.71  435.12   831.7  435.02  835.69  434.94  839.68  434.64  843.67
434.57
  847.66  434.45  851.65  434.23  855.64  434.13  859.63  434.01  863.62
434.03
  867.61  434.01   871.6  434.05  875.59  434.15  879.58   434.1  883.57
434.26
  887.56  434.36  891.55  434.37  895.54  434.42  899.54   434.5  903.53
434.59
  907.52  434.62  911.51  434.48   915.5  434.29  919.49  434.17  923.48
434.22
  927.47   434.1  931.46  433.83  935.45  433.56  939.44  433.22  943.43
433.07
  947.42  433.07  951.41  433.36   955.4  433.61  959.39  433.67  963.38
433.54
  967.37  433.42  971.36  433.44  975.35  433.52  979.34  433.32  983.33
432.92
  987.32  432.63  991.31  432.52   995.3  432.71  999.29  432.73 1003.28
432.97
 1007.27  433.19 1011.26  433.65 1015.25  434.13 1019.24  434.41 1023.23
434.66
```

```
 1027.22  434.79 1031.21  434.78  1035.2  434.08 1039.19  432.57 1043.18
431.48
 1047.17  431.44 1051.17  432.03 1055.16  432.05 1059.15  431.43 1063.14
431.03
 1067.13  431.11 1071.12  431.59 1075.11  431.85  1079.1  432.59 1083.09
433.36
 1087.08  433.49 1091.07  433.27 1095.06  432.86 1099.05  432.31 1103.04
431.96
 1107.03  431.92 1111.02  431.68 1115.01  431.07    1119  430.34 1122.99
430.7
 1126.98  430.61 1130.97  430.05 1134.96  429.03 1138.95  426.77 1142.94
425.59
 1146.93  424.86 1150.92  424.52 1154.91  424.14  1158.9  423.69 1162.89
423.27
 1166.88   423.2 1170.87  423.29 1174.86  423.55 1178.85  424.03 1182.84
424.45
 1186.83  425.07 1190.82  427.02 1194.81  430.05  1198.8  432.09 1202.79
433.9
 1206.78   435.2 1210.78  435.35 1214.77  435.05 1218.76  435.03 1222.75
435.03
 1226.74  434.98 1230.73   434.9 1234.72  434.76 1238.71  434.66  1242.7
434.38
 1246.69   434.2 1250.68  434.21 1254.67  434.22 1258.66  434.33

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055  111.45    .025  394.18    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
        111.45  394.18          1249.27 1168.94  588.38             .1
.3

CROSS SECTION


RIVER: Chena
REACH: Lower               RS: 867.4043

INPUT
Description:
Station Elevation Data    num=     145
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  434.31    3.94  434.38    7.88  434.48   11.82  434.49   15.76
434.29
    19.7  434.21   23.64  434.27   27.58  434.37   31.52  434.48   35.46
434.54
    39.4  434.35   43.34  434.19   47.28  434.39   51.22  434.68   55.16
434.95
    59.1  435.19   63.03  435.52   66.97  435.53   70.91  435.49   74.85
435.49
   78.79  435.45   82.73  435.08   86.67  434.56    88.2     434   90.61
433.12
```

```
   94.55  430.53   98.49  427.61102.4316 424.456106.9391 421.928130.7262
417.187
154.3358 417.429179.6225 417.778204.8618 417.703231.8306 417.967258.9266
418.056
283.5934  418.15 310.222  420.63330.5157 424.209  334.42  427.32  337.81
429.3
  338.32   429.6  342.22  430.61  346.12     431  350.02  431.18  353.92
431.26
  357.82  431.01  361.72  431.16  365.62  431.49  369.52  431.87  373.42
432.05
  377.32  432.11  381.22  432.18  385.12  432.41  389.03  432.53  392.93
432.63
  396.83  432.63  400.73   432.5  404.63  432.17  408.53  431.99  412.43
432.01
  416.33   432.1  420.23  432.32  424.13  432.55  428.03  432.58  431.93
432.56
  435.83  432.94  439.83  433.54  443.83  434.12  447.83  434.09  451.83
434.19
  455.83  434.21  459.83  434.35  463.83  434.23  467.83   434.1  471.83
434.18
  475.83  434.27  479.82   434.3  483.82   434.4  487.82  434.39  491.82
434.33
  495.82  434.26  499.82   434.1  503.82  433.94  507.82  433.77  511.82
433.79
  515.82  433.76  519.82  433.62  523.82  433.67  527.82  433.74  531.82
433.57
  535.81  433.54  539.81  433.49  543.81  433.54  547.81  433.63  551.81
433.71
  555.81  433.78  559.81  433.78  563.81   433.8  567.81   433.7  571.81
433.55
  575.81  433.36  579.81  433.14  583.81  432.95   587.8  432.97   591.8
433.33
   595.8  434.31   599.8  434.53   603.8  434.54   607.8  434.51   611.8
434.31
   615.8  433.01   619.8  431.26   623.8  429.24   627.8  427.95   631.8
426.28
   635.8  424.48  639.79  423.14  643.79  421.97  647.79  421.88  651.79
422
  655.79  422.09  659.79  422.71  663.79  423.05  667.79  423.93  671.79
424.25
  675.79  424.31  679.79  425.07  683.79  425.85  687.79  427.29  691.78
428.89
  695.78  430.14  699.78  430.76  703.78  431.14  707.78  431.29  711.78
431.47
  715.78  431.53  719.78  431.68  723.78  431.58  727.78  431.63  731.78
431.51
  735.78  431.77  739.78  431.86  743.78  432.28  747.77  432.79  751.77
433.27

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055    88.2    .025  337.81    .055
```

```
Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
          88.2  337.81           896.37   867.4  657.99             .1
.3

CROSS SECTION


RIVER: Noyes Slough
REACH: Noyes Slough       RS: 359.3467

INPUT
Description:
Station Elevation Data    num=      53
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  434.46    3.96  434.87    7.93  435.21   11.89  436.14   15.85
437.36
   19.82  437.51   23.78  437.41   27.74  438.29   31.71  439.69   35.67
440.77
   39.63  440.65    43.6  439.74   47.56  438.69   51.52  437.45   55.49
436.34
   59.45  434.36   63.41  431.23   67.15  428.85   67.38   428.7   71.34
427.2
75.30518 424.44779.65753 420.296104.2795 419.972129.2875 421.485155.1911
422.315
164.3635 424.272  168.31  426.28  172.25  427.64  176.19  429.51  177.98
430.16
  180.13  430.94  184.07     432  188.02  432.55  191.96  432.86   195.9
433.15
  199.84  433.32  203.79  433.48  207.73  433.62  211.67  433.84  215.61
434.02
  219.56  434.36   223.5   434.4  227.44  434.62  231.38  434.88  235.32
435.11
  239.27  435.36  243.21  435.74  247.15  435.87  251.09  435.86  255.04
435.98
  258.98  435.94  262.92  435.95  266.86  436.16

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055   67.15    .029  177.98    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
         67.15  177.98           217.39  205.37  144.26             .1
.3

CROSS SECTION


RIVER: Noyes Slough
REACH: Noyes Slough       RS: 153.9759

INPUT
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```
Description:
Station Elevation Data    num=      77
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta
Elev
       0  440.86     3.8  438.66     7.6  437.61    11.4  436.94    15.2
436.76
      19  436.73    22.8  436.78    26.6  436.88    30.4  437.01    34.2
435.99
      38  434.19    41.8  431.98   44.84  429.94    45.6  429.43    49.4
426.94
53.20506 424.67859.11894  420.9183.39875 419.253 109.918 419.159133.9704
419.039
141.5645 424.392  145.52  425.95  149.48  426.88  153.44  427.74  153.66
427.78
   157.4  428.43  161.35  429.14  165.31  429.48  169.27  429.78  173.23
429.95
  177.19  429.92  181.15  430.01   185.1  430.08  189.06  430.18  193.02
430.33
  196.98  430.39  200.94  430.42  204.89  430.37  208.85  430.39  212.81
430.5
  216.77  430.69  220.73  430.78  224.68  430.84  228.64  430.85   232.6
430.87
  236.56  430.92  240.52  431.02  244.47  431.09  248.43  431.06  252.39
431.24
  256.35  431.43  260.31   431.6  264.26  431.64  268.22  431.81  272.18
431.98
  276.14  432.07   280.1  432.25  284.06  432.47  288.01  432.77  291.97
432.98
  295.93  433.22  299.89  433.39  303.85  433.68   307.8     434  311.76
434.45
  315.72  434.77  319.68  435.18  323.64  435.56  327.59  436.02  331.55
436.26
  335.51  436.42  339.47  436.57  343.43  436.89  347.38  437.04  351.34
437.2
   355.3  437.34  359.26  437.43

Manning's n Values         num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
       0    .055   44.84    .029  153.66    .055

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.
Expan.
         44.84  153.66            99.97  153.98   36.35             .1
.3



SUMMARY OF MANNING'S N VALUES

River:Chena

      Reach          River Sta.       n1        n2        n3        n4
n5
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```
 Upper                6486.79           .055      .025      .055
 Upper                6056.79*          .055      .025      .055
 Upper                5626.711          .055      .025      .055
 Upper                5213.506          .055      .025      .055
 Lower                4474.147          .055      .025      .055
 Lower                4172.639          .055       .04      .025
.04      .055
 Lower                4109.237     Bridge
 Lower                3997.873          .055       .04      .025
.04      .055
 Lower                3852.347          .055      .025      .055
 Lower                3584.559          .055      .025      .055
 Lower                2844.347          .055      .025      .055
 Lower                2036.342          .055      .025      .055
 Lower                867.4043          .055      .025      .055


River:Noyes Slough

      Reach          River Sta.       n1        n2        n3

 Noyes Slough         359.3467          .055      .029      .055
 Noyes Slough         153.9759          .055      .029      .055




SUMMARY OF REACH LENGTHS

River: Chena

      Reach          River Sta.      Left     Channel    Right

 Upper                6486.79         476.29       430    353.45
 Upper                6056.79*        476.38    430.08    353.52
 Upper                5626.711        440.63    413.21    390.17
 Upper                5213.506        483.61    739.36    572.72
 Lower                4474.147         200.2    301.51    325.24
 Lower                4172.639         155.9    174.77    184.05
 Lower                4109.237     Bridge
 Lower                3997.873        104.96    145.53    176.73
 Lower                3852.347        197.11    267.79    290.05
 Lower                3584.559        632.66    740.21    886.68
 Lower                2844.347        914.87    808.01    613.02
 Lower                2036.342       1249.27   1168.94    588.38
 Lower                867.4043        896.37     867.4    657.99


River: Noyes Slough

      Reach          River Sta.      Left     Channel    Right

 Noyes Slough         359.3467        217.39    205.37    144.26
 Noyes Slough         153.9759         99.97    153.98     36.35
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SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Chena


      Reach          River Sta.     Contr.    Expan.

 Upper                6486.79         .1        .3
 Upper                6056.79*        .1        .3
 Upper                5626.711        .1        .3
 Upper                5213.506        .1        .3
 Lower                4474.147        .3        .5
 Lower                4172.639        .3        .5
 Lower                4109.237 Bridge
 Lower                3997.873        .3        .5
 Lower                3852.347        .1        .3
 Lower                3584.559        .1        .3
 Lower                2844.347        .1        .3
 Lower                2036.342        .1        .3
 Lower                867.4043        .1        .3

River: Noyes Slough


      Reach          River Sta.     Contr.    Expan.

 Noyes Slough         359.3467        .1        .3
 Noyes Slough         153.9759        .1        .3


Profile Output Table - Standard Table 1

  River          Reach          River Sta                        Profile    Q
Total   Min Ch El   W.S. Elev   Crit W.S.   E.G. Elev   E.G. Slope   Vel
Chnl   Flow Area   Top Width   Froude # Chl

(cfs)        (ft)        (ft)        (ft)         (ft)       (ft/ft)
(ft/s)     (sq ft)        (ft)

  Noyes Slough   Noyes Slough   359.3467                     100-yr
1100.00      419.97      431.76                  431.78     0.000023
1.06     1046.62      120.45           0.06
  Noyes Slough   Noyes Slough   153.9759                     100-yr
1100.00      419.04      431.76                  431.77     0.000015
0.94     1305.64      224.96           0.05
  Chena          Upper         6486.79                       100-yr
10900.00      406.70      431.75                  431.94     0.000106
3.52     3660.39      367.50           0.16
  Chena          Upper         6056.79*                      100-yr
10900.00      406.51      431.73                  431.89     0.000082
3.19     3562.08      320.25           0.15
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  Chena          Upper          5626.711                    100-yr
10900.00      406.32      431.73                  431.85     0.000061
2.82     3871.59      253.53           0.13
  Chena          Upper          5213.506                    100-yr
10900.00      414.94      431.66                  431.81     0.000109
3.10     3528.11      315.58           0.16
  Chena          Lower          4474.147                    100-yr
12000.00      404.84      431.56                  431.74     0.000095
3.37     3643.29      325.36           0.16
  Chena          Lower          4172.639                    100-yr
12000.00      411.04      431.47      420.32      431.68     0.000203
3.75     3249.13      267.35           0.18
  Chena          Lower          4109.237 University Ave.
Bridge
  Chena          Lower          3997.873                    100-yr
12000.00      415.33      431.29                  431.52     0.000167
3.89     3138.19      381.09           0.20
  Chena          Lower          3852.347                    100-yr
12000.00      418.12      431.16                  431.47     0.000267
4.51     2815.76      379.06           0.25
  Chena          Lower          3584.559                    100-yr
12000.00      418.53      431.01                  431.38     0.000334
4.93     2666.97      378.07           0.28
  Chena          Lower          2844.347                    100-yr
12000.00      418.69      430.99                  431.16     0.000147
3.38     4024.09      507.21           0.19
  Chena          Lower          2036.342                    100-yr
12000.00      417.64      430.79                  431.02     0.000207
3.97     3700.82      605.35           0.22
  Chena          Lower          867.4043                    100-yr
12000.00      417.19      430.52      423.00      430.79     0.000200
4.18     3175.92      324.33           0.22
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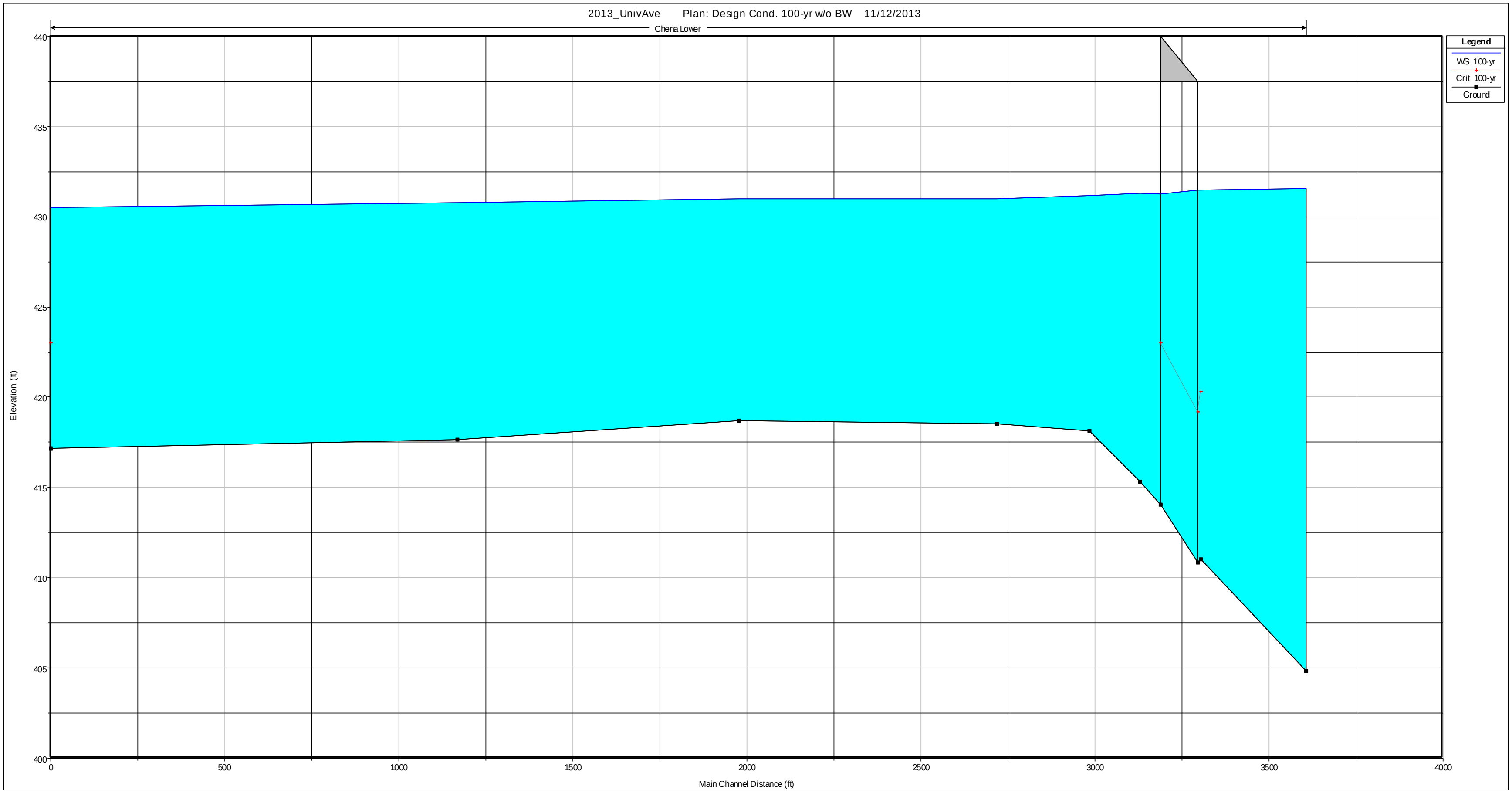
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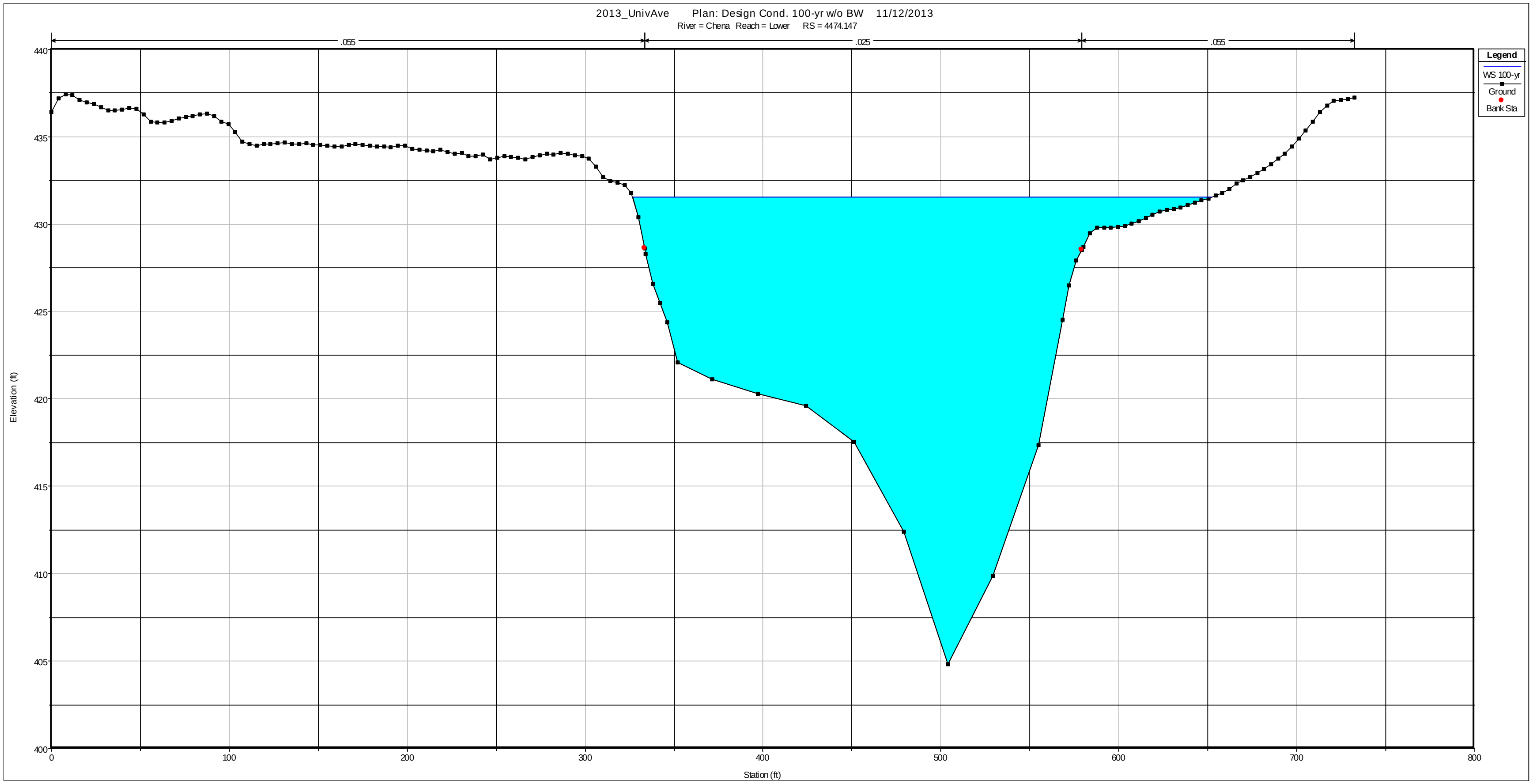
Chena Lower
Legend
WS 100-yr
Crit 100-yr
Ground
Elevation (ft)
440
435
430
425
420
415
410
405
400
0
500
1000
1500
2000
2500
3000
3500
4000
Main Channel Distance (ft)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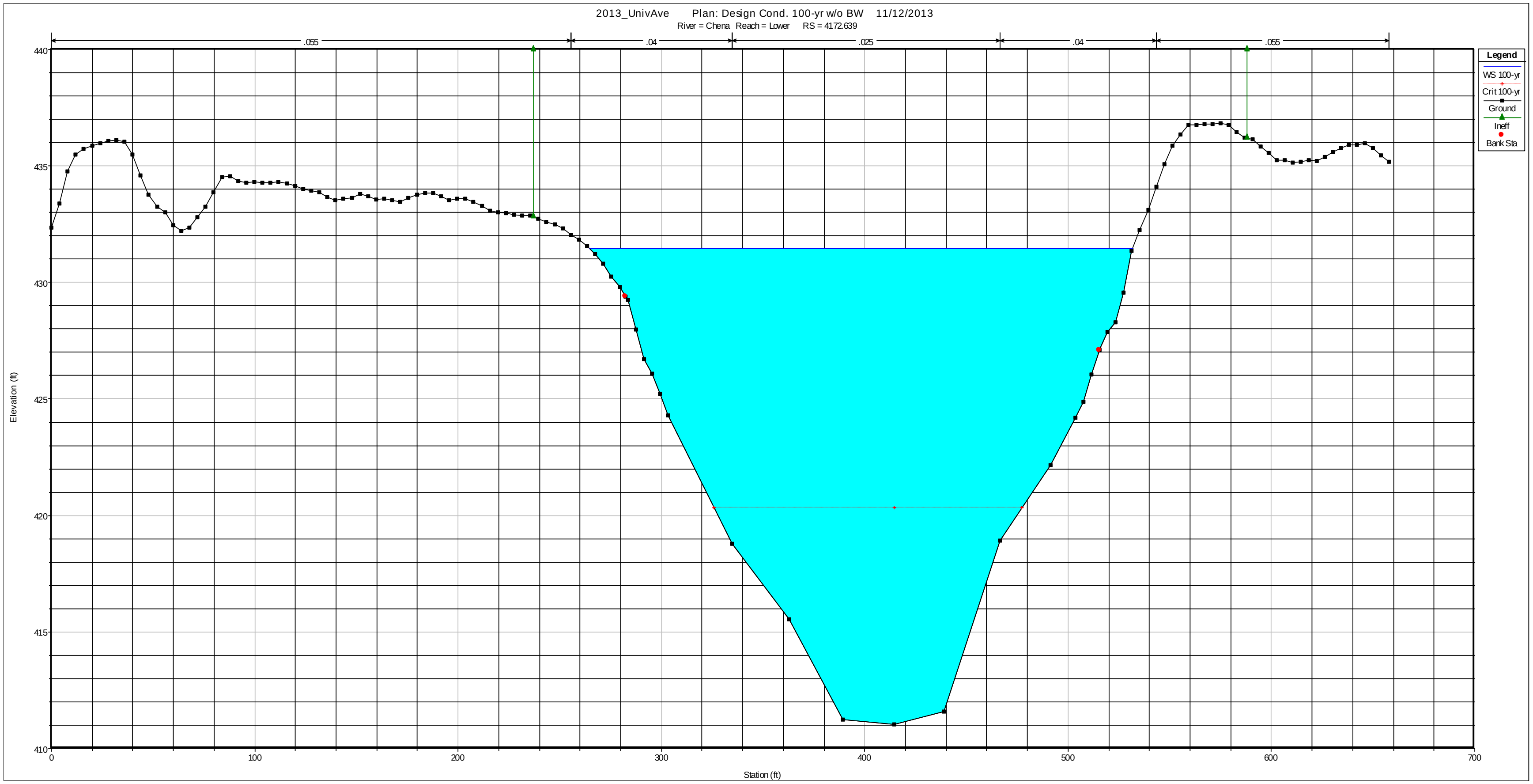
.055
.025
.055
Legend
WS 100-yr
Ground
Bank Sta
Elevation (ft)
440
435
430
425
420
415
410
405
400
Station (ft)
0
100
200
300
400
500
600
700
800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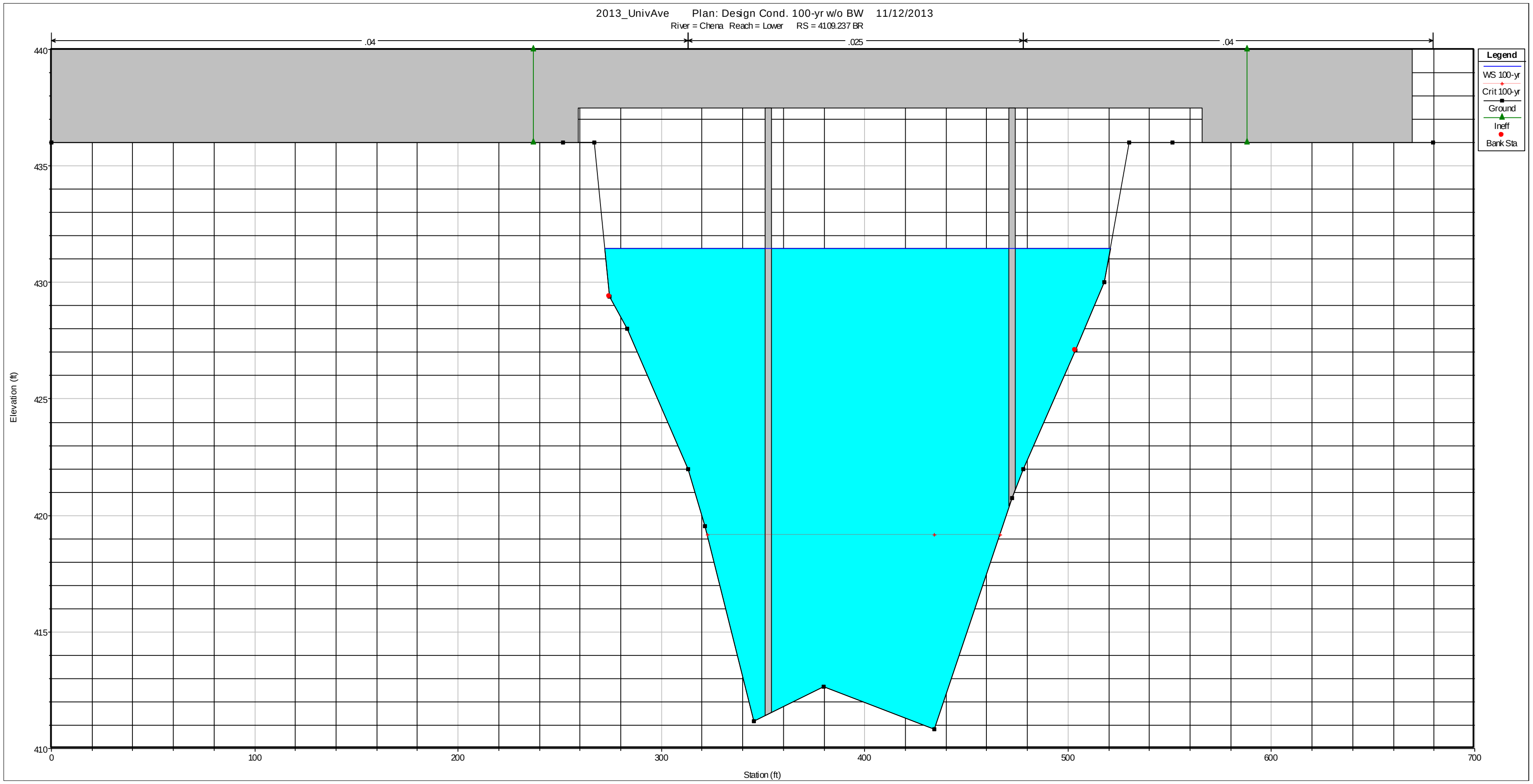
River = Chena Reach = Lower RS = 4172.639
.055
.04
.025
.04
.055
Legend
WS 100-yr
Crit 100-yr
Ground
Ineff
Bank Sta
Elevation (ft)
440
435
430
425
420
415
410
0
100
200
300
400
500
600
700
Station (ft)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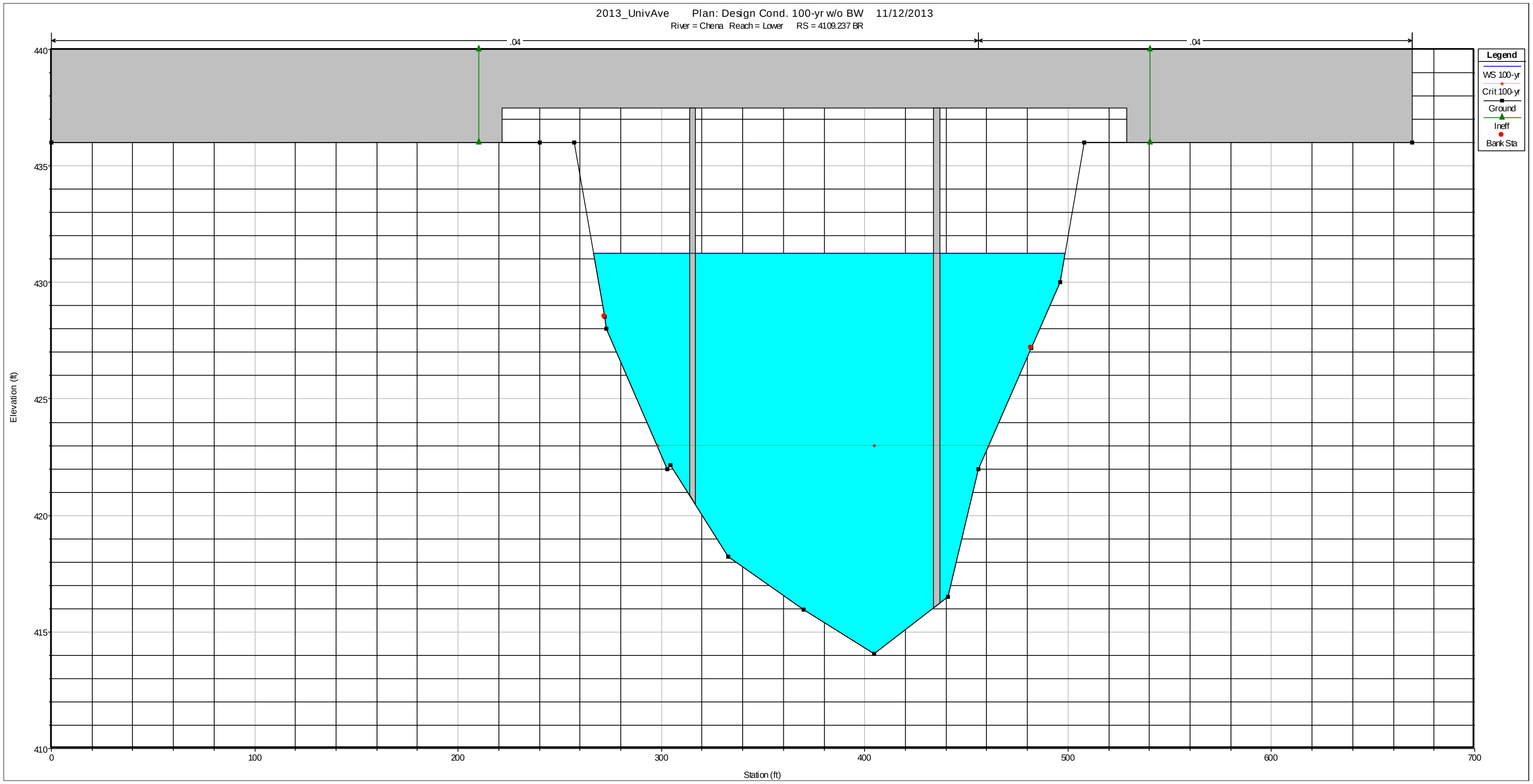
River = Chena Reach = Lower RS = 4109.237 BR
.04
.025
.04
Legend
WS 100-yr
Crit 100-yr
Ground
Ineff
Bank Sta
Elevation (ft)
440
435
430
425
420
415
410
Station (ft)
0
100
200
300
400
500
600
700


2013_UnivAve Plan: Design Cond. 100-yr w/o BW 11/12/2013
River = Chena Reach = Lower RS = 4109.237 BR
.04
.04
Legend
WS 100-yr
Crit 100-yr
Ground
Ineff
Bank Sta
Elevation (ft)
440
435
430
425
420
415
410
Station (ft)
0
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400
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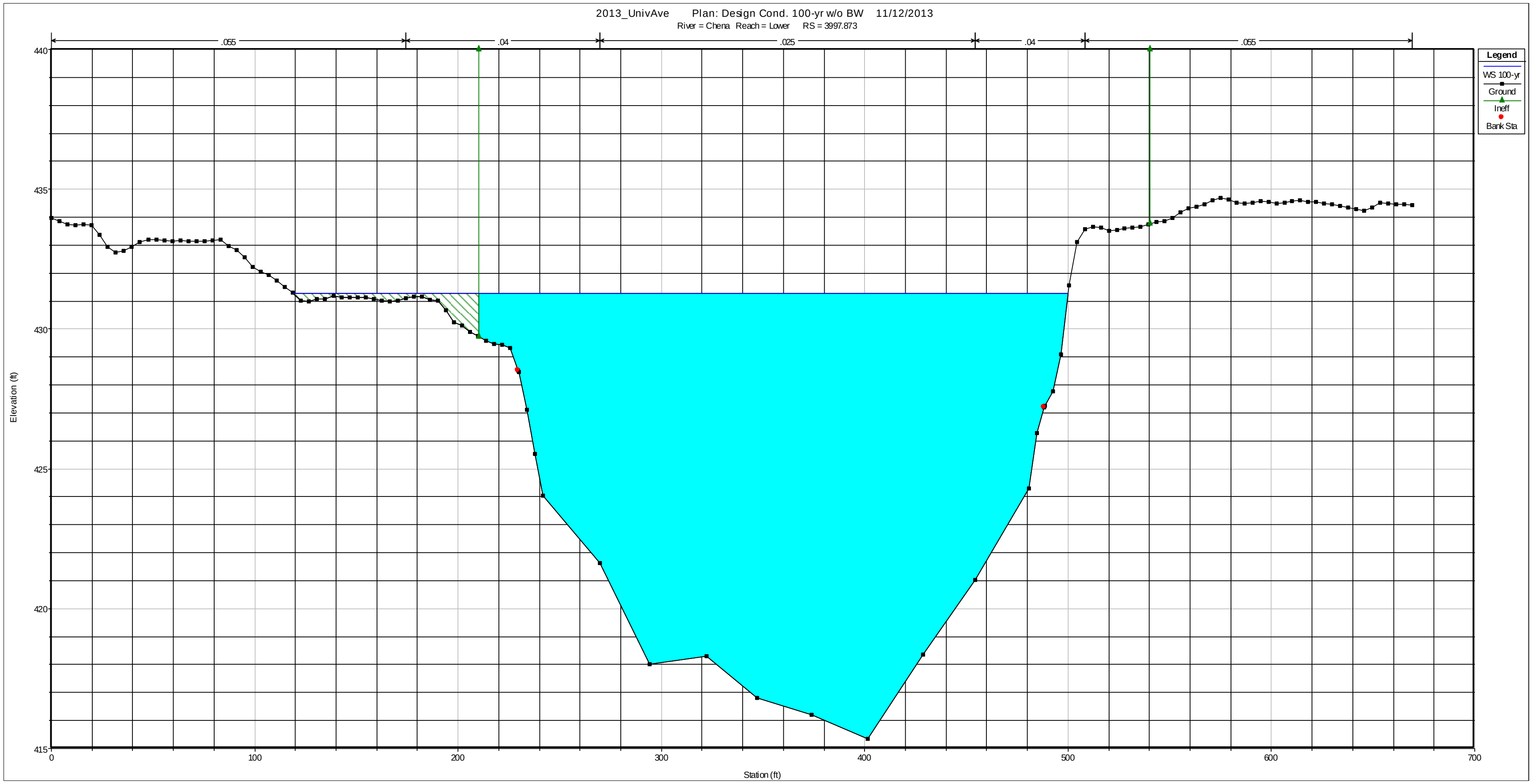
600
700



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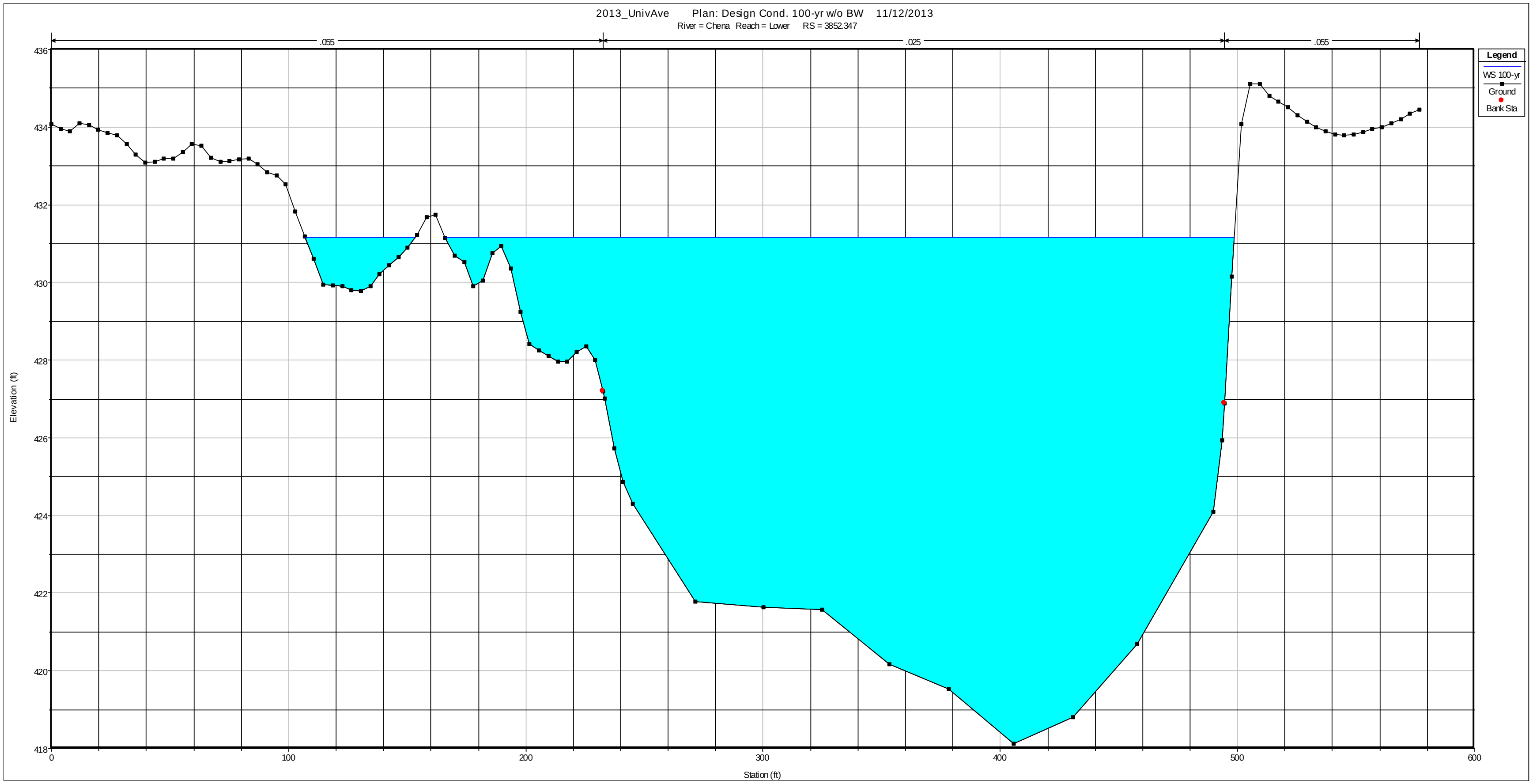
River = Chena Reach = Lower RS = 3997.873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River = Chena Reach = Lower RS = 3852.347
.055
.025
.055
Legend
WS 100-yr
Ground
Bank Sta
Elevation (ft)
436
434
432
430
428
426
424
422
420
418
Station (ft)
0
100
200
300
400
500
600

Appendix B. EROSION AND SEDIMENT CONTROL PLAN

EROSION AND SEDIMENT CONTROL PLAN (ESCP)

University Avenue Rehabilitation and Widening Project
Federal Project No. STP-RS-M-0617(3) / State Project No. 63213

1. General. The Department developed this plan based on its knowledge of construction sequencing, available materials and equipment, and other relevant factors. The plan contains information about the construction site that may be used by the Contractor in developing their SWPPP, as required under Section 641, Erosion, Sediment, and Pollution Control.

2. Site Description.

The project area is located at the Chena River Bridge along the University Avenue in Fairbanks, Alaska. University Avenue is a paved four lane undivided urban principal arterial that functions as the primary north-south transportation corridor on the west side of Fairbanks. It has existing sidewalks, with curb and gutter on each side from College Road to Rewak Drive. Travel along University Avenue is predominantly through-traffic. It provides access to the following residential areas outside of the project corridor:

- North – Farmer’s Loop Road and College Road
- West – Airport Way, Geist Road, Chena Pump and Chena Ridge Roads
- East – Airport Way and Johansen Expressway

The Chena River is a sinuous 100-mile long river which empties into the Tanana River after passing through the town of Fairbanks. All tributaries, including the Little Chena River, join the main section upstream of the project area. Within the city limits of Fairbanks, the river splits into a secondary channel, named Noyes Slough, which runs approximately 7 miles before rejoining the Chena River at the right bank approximately 450 feet upstream of the study site. Deadman’s Slough branches off of Noyes Slough and discharges into the river downstream of the study site. At the study site, the river is confined to a well-defined channel.

The Chena River discharges to the Tanana River approximately 6.2 river miles downstream of the study site. Floods in the Tanana River cause a backwater effect in the vicinity of the study site (FEMA 1992). Precipitation data collected at the Fairbanks International Airport indicates that the Fairbanks area receives the most precipitation between June and August (see Table 1.1).

Table 1.1: Fairbanks International Airport, Monthly Climate Summary

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Max Temperature (F)	3	11	25	44	61	71	72	66	54	32	12	7
Average Min Temperature (F)	-11	7	2	21	36	48	51	45	34	16	-2	-8
Average Total Precipitation (in)	0.58	0.5	0.27	0.31	0.64	1.76	2.34	2.08	1.31	0.91	0.77	0.68

Source: www.weather.com

Prior to the construction of the Moose Creek dam, the Chena River in Fairbanks received sediment laden flow from the Tanana River via the Chena Slough. With the dam in place, the Chena River has experienced a sediment deficiency as the Tanana River and upstream Chena River contributions are either diverted by the floodway or impounded behind the dam where suspended sediments settle before flood water is released into the Chena River (Burrows Langley and Evetts 2000). The sediment contributions from the Little Chena River, which is predominately clear water, are likely minimal. The potential downstream effects of the reduction in sediment load in the Chena River are channel degradation and general coarsening of the bed material. Channel degradation has been documented at the Wendell Street Bridge (upstream of the University Avenue Bridge), where deepening and widening of the channel has occurred after the construction of the Moose Creek Dam (Burrows Langley and Evetts 2000).

Observations during a site visit in May 2013, revealed the primary bed material along the channel banks and extending into the channel was medium sized gravel with an average diameter of approximately 0.02 feet. Some sand deposition was apparent along the north bank at the bridge crossing.

The water table fluctuates seasonally in response to precipitation, surface runoff and high or low river levels. During July 1993, the ground water surface fluctuated between 5-ft and 14.5-ft below the ground surface. In October 1993, the ground water surface fluctuated between 14-ft and 18-ft below the ground surface (ADOT&PF 2010).

The existing topography along the project corridor is relatively flat and level with drainage ditches carrying surface drainage to the Chena River and Noyes Slough. Over time, surrounding development has created obstructions to some of the natural drainage features.

A. Scope of Construction.

Construction activities associated with this project include the following:

- Replacement of the existing Chena River Bridge No. 263 on University Avenue with a 310-ft long, 3 span, precast, pre-stressed concrete girder bridge. The new bridge will be 47-ft wider than the existing bridge to accommodate the proposed median and pedestrian facilities.
- Enlargement of the existing river channel within the project area through excavation of the river banks. Grading of the bank surface to a face slope of 2:1. Rock riprap revetments to be installed as channel bank protection. Material for the toe will be placed in a toe trench along the entire length of the riprap blanket.

B. Area. The total area of the construction site, defined by the total area disturbed by clearing and reshaping slopes, excavation and placement of fill is estimated as 0.03 acres. Any clearing and grubbing will be completed to the slope limits of the highway (ADOT&PF 2005).

C. Hydrology. The area of soil disturbance will mainly occur along the banks below and directly upstream and downstream of the Chena River Bridge.

D. Receiving Water. Some runoff from the project will travel into the Chena River. Structural controls shall be used to protect the Chena River that may be encountered during construction.

3. Controls. This section of the plan addresses the various controls that will be implemented for each of the construction activities described in 2.A above.

A. Erosion and Sediment Controls.

(1). Stabilization Practices. Site plans shall be developed to ensure that existing vegetation is preserved where attainable and that disturbed portions of the site are stabilized. Stabilization practices may include: temporary and permanent seeding, mulching, geotextiles, vegetative buffer strips, protection of trees, preservation of mature vegetation, construction phasing and other appropriate measures. Stabilization measures shall be initiated as soon as practicable in portions of the site where construction activities have temporarily ceased. Stabilization measures shall not be delayed more than 14 days after the construction activity in that portion of the site has temporarily ceased unless construction activity will resume within 21 calendar days. Where snow cover precludes the initiation of stabilization measures, stabilization measures shall be initiated as soon as practicable thereafter.

Temporary stabilization practices shall include temporary seeding, surface roughening, mulching, and construction phasing.

The surfaces of the existing embankment slopes are medium gravel. After construction surfaces not armored with riprap revetments will remain medium gravel. Permanent stabilization practices consist of limited areas of permanent seeding as designated by the Engineer.

Between Airport Way and the Chena River, a grass lined ditch draining to the Chena River will be constructed on the west side of University Avenue. The ditch will treat runoff by filtering sediments, contaminants and trash before it enters the Chena River (ADOT&PF 2010).

Guidance for BMP's for temporary and permanent stabilization can be found at the EPA website and the DOT&PF website. Reference the current online edition of "Alaska Storm Water Pollution Prevention Plan Guide."

(2). Structural Practices. Structural practices that may be implemented to divert flows from exposed soils, store flows, or limit runoff and discharge of pollutants from the exposed areas of the site may include silt fences, earth dikes, drainage swales, sediment traps, check dams, reinforced soil retaining systems, gabions, and temporary or permanent sediment basins. The installation of these devices may be subject to Section 404 of the Clean Water Act.

Structural practices are described in more detail in "Contractor Guidance for Preparing and Executing Storm Water Pollution Prevention Plans", first edition, October 1992.

B. Storm Water Management. Steps that shall be taken during the construction process to control pollutants in storm water discharges that may occur after construction operations have been completed are described below. These measures may be subject to Section 404 of the Clean Water Act.

(1). Storm water retention structures; flow attenuation by use of open vegetated swales and natural depressions; infiltration of runoff on site; and sequential systems that combine several practices. The practices selected for implementation were determined on the basis of technical guidance in "AASHTO Drainage Guidance, Volume III: Erosion and Sediment Control in Highway Construction" (1992).

(2). Velocity dissipation devices shall be placed at discharge locations and along the length of any outfall channels as necessary to provide a non-erosive velocity flow from the structure to a water course so that the natural physical and biological characteristics and functions are maintained and protected.

Approximately 0.03 acres of Chena River bank would be impacted by the widened roadway and bridge. These riparian wetlands are described in the NWI as Rocky Shore Unconsolidated Bottom Permanently Flooded wetlands. A new storm water outfall would discharge runoff from a water quality improvement bioswale onto riprap at the southwest side of the bridge. The existing storm water outfall on the north side of the Chena River Bridge would be relocated to the Noyes Slough via a new bioswale, running along Goldizen Avenue. The riparian wetlands by the bridge provide limited habitat for fish and birds because of the modified conditions and surrounding residences and urban activity (ADOT&PF 2005).

C. <u>Other Controls.</u>

(1). Waste Disposal. No solid materials, including building materials, shall be discharged into waters of the State, except as authorized by a Section 404 Permit.

(2). The provisions of this plan shall ensure and demonstrate compliance with applicable State and/or local waste disposal, sanitary sewer or septic system regulations.

D. <u>Revisions.</u>
Revisions and/or additions to this Erosion and Sediment Control Plan shall be included in the Contractor's SWPPP.

4. Maintenance. The following is a description of procedures that are to be used to maintain vegetation, erosion, and sediment control measures and other protective measures identified in this plan:

- Monitor weather forecasts
- Cleaning of devices
- Regularly inspect installed structures
- Regularly review erosion control methods and procedures to evaluate effectiveness.

The Contractor will maintain temporary vegetation, erosion and sediment control measures and other protective measures identified in this plan. DOT&PF will provide maintenance of permanent erosion control systems.

5. Non-Storm Water Discharges. Except for flows from fire fighting activities, sources of non-storm water that are combined with storm water discharges associated with industrial activity addressed in this plan are described below. A number of provisions to lessen the environmental impacts of road construction are identified in this erosion and sediment control plan. These may include measures to ensure that exposed working surfaces are kept to a minimum, silt fences and sediment traps are optimally placed to prevent sediment from reaching drainage systems, vehicles are washed when leaving a construction site to remove excess mud, and temporary exit/entry roads to construction sites are provided with a coarse rock surface to prevent the transfer of soil offsite where it will be washed into nearby drainage channels. Appropriate pollution prevention measures, as described below, will be implemented for the non-storm water component(s) of the discharge.

- Water spread for dust control
- Water used for embankment compaction