Stantec Consulting Services Inc.
108 Church Street South East
Leesburg VA 20175-3003
Tel: (703) 777-0063
Fax: (703) 777-2480

December 8, 2010
File: 175650032

Carol Mahoney
Zone 7 Water Agency
100 North Canyons Parkway
Livermore, California 94551

Reference: Arroyo Mocho Planting Effects on Roughness Study

Dear Carol:

Stantec is pleased to provide our finding of the referenced study.

PROJECT BACKGROUND AND GOALS

As a regional flood protection entity and stream steward, the Zone 7 Water Agency (Zone 7) is actively involved in efforts to protect and/or restore streams and associated habitats and natural resources within the Alameda Creek Watershed. Zone 7 has targeted a particular reach of Arroyo Mocho (extending from Stanley Blvd to Isabel Ave) as a potential pilot project for the restoration planting of a constructed trapezoidal channel with riparian vegetation. Portions of this channel may be planted using mitigation dollars from private development or other public projects to examine if this is a viable option for similar future projects. The project described within this document was commissioned to 1) utilize a HEC-RAS model to study the effects of planting the channel on the 100-year(YR) water surface profile within the study reach as well as explore the utility of riparian plantings as a means of restoration within an constructed, trapezoidal channel that is approximately a mile in length; and 2) geomorphically characterize the channel and evaluate sediment transport capacity and bank stability. The goals are to 1) determine the roughness coefficient that causes the 100-YR discharge to overtop the corridor, 2) provide guidance on what types of planting densities/communities are associated with the condition and 3) determine how much of the cross section can be planted without causing the channel to overtop and/or alternatives to prevent overtopping. Zone 7 also requested an opinion on overall restoration strategies for the reach in question that include addressing sediment mobility/ transport capacity and potential fish passage issues. Stantec and the Urban Creeks Council (UCC) worked in concert to collect field data. UCC will be supplementing this document with an evaluation of planting options.

PROJECT SETTING

The project is located in the western portion of Livermore, California and extends from Stanley Blvd to Isabel Avenue. The project reach is approximately 6,000 feet long and is comprised of a constructed trapezoidal channel. The channel is essentially straight with five major grade control structures (see Attachment 1). Four of these grade control structures consist of placed and grouted rip rap with lateral rip rap abutments as shown in Figure 1. A fifth grade control structure consists of a concrete apron spanning the entire cross section of the stream augmented with offset block energy dissipaters (known as the dragon's tooth grade control structure) as shown in Figure 2. All five grade control structures are potential fish migration impediments and/or barriers. Significant infrastructure adjacent to the project includes two service roads (one on either side of the channel), a pedestrian bridge (not yet opened) and numerous utilities (most unmarked). An additional significant fish barrier is located upstream at the railroad bridge near Stanley Boulevard. Land use within the watershed ranges from commercial and high density urban in the area immediately upstream of the project reach to low density agriculture and undeveloped land further up the watershed.

Figure 1 View of Rip Rap Grade Control Structure

Figure 2 Dragon's Tooth Grade Control Structure

HEC-RAS MODELING

METHODOLOGY

The primary tool used to evaluate the changes to capacity of the channel caused by altering the vegetation community is the Hydrologic Engineering Center's River Analysis System (HEC-RAS) Version 4.1 model. This one-dimensional hydraulic model calculates water surface profiles and flow velocities along a river network using the one-dimensional energy equation. The primary inputs to the model are geometry (cross sections along the stream), boundary conditions (peak discharge, controlling water surface information), and modeling parameters (roughness coefficients, bridge modeling parameters, etc.). Stantec collected topographic data as well as geomorphic data for evaluation and input into the model. Hydrologic discharge information was provided by Zone 7.

Topographic data was collected using sub-centimeter GPS equipment by Stantec with assistance from UCC and was based on three surveyed control points provided by Kier & Wright Land Surveyors. Over 3,500 points collected along approximately 6,000 linear feet along Arroyo Mocho were used to develop the existing morphologic conditions of the study site. The survey data was used to create a more precise 3D surface model of current conditions within the study reach to insert into Zone 7's existing HEC-RAS analysis. The surface created from the Stantec survey (green contours in Attachment 1) was tied into Aerial Survey Data (2007 LIDAR) provided by Zone 7 (magenta contours in Attachment 1) to pick up key features that fell outside the study area. The green contours in Attachment 1 represent the three dimensional surface created from the survey data, the magenta contours lines are the aerial survey data that were ultimately combined with the Stantec data to create a single surface that was used to generate the cross-sections used in the HEC-RAS analysis. All modeling was performed using the 100-YR discharge of 4,783 cfs provided by Zone 7. HEC-RAS models upstream and downstream of the study reach were provided by Zone 7 and merged with the study reach model. River Stations 14+94 to 69+34 in the model were developed for the project area. Topographic information for the area outside the project were provided by Zone 7.

To perform the analysis, the Manning's roughness coefficient (Manning's n) of the channel was altered in the model both laterally and longitudinally to determine where riparian planting could be administered without overtopping the channel. Specifically, the Manning's n values were increased until the channel overtopped. Overtopping was defined as flow exiting the channel. One value for Manning's n was used to represent main channel (n_C) roughness while another value was used to represent bank roughness (n_B). Figure 3 illustrates the boundaries of lateral roughness variation applied in the model. The bank roughness was altered for two scenarios, including:

Option 1) planting down to the existing water edge; and

Option 2) planting only the upper half of the banks.

A value of 0.035 was used for n_C for Options 1 and 2 based on sediment data collected on-site (see "Geomorphic Results" section). A third option (Option 3) was considered whereby the main channel roughness was increased until the channel overtopped. A combination of Options 1 and 2 was also investigated by varying the planting pattern longitudinally along the reach to evaluate if areas that overtopped in a higher roughness condition would ultimately remain in the channel if a less aggressive planting approach was implemented in areas where conveyance was limited by channel geometry.

Specific details of the models include: Survey was completed in October 2010 using survey grade GPS from the limits of Stanley Blvd to Isabel Dr. The survey was done in the NAD83 Zone III California projection. Benchmarks were set up in the channel by Kier & Wright Engineers & Surveyors. The detailed survey limits were within the fence lines on both sides of the channel. Aerial survey data provided by Zone 7 was used to tie in the survey data to create a complete surface. Cross-Sections were generated from this surface for river stations 6934.19 to 1494.10 in the Arroyo Mocho Stantec Model HEC-RAS file. River stations 24130.20 to 8848.20 were generated from a previous model completed by Kier & Wright Civil Engineers & Surveyors, Inc. and was provided by Zone 7. River Stations 1408.1 – 700 were generated from a LOMAR data set provided by Zone 7.

Figure 3 Cross Section of Model Showing Limits of n_c and n_b

RESULTS OF HEC-RAS MODELING

For Option 1, the HEC-RAS model was executed for the 100-YR discharge provided by Zone 7 utilizing a Manning's *n* value of 0.035 for the channel (this assumes the channel bottom will not be planted with anything rougher than high grass) and assuming the region from the low flow channel to the top of the bank is planted (see Attachment 2). It should be noted that at a Manning's *n* value of 0.035 the existing channel does not overtop at the study 100-YR flow. The Manning's *n* of the banks was incrementally increased until the model indicated the channel could no longer contain the 100-YR discharge. The results suggest a Manning's *n* value of 0.08 for the banks is the maximum allowable roughness before the channel begins to overtop. According to the model, flow exits the channel at the grade control structures beginning with the dragon's tooth structure furthest downstream within the study area if the Manning's roughness coefficient is increased to 0.09. Specifically, the analysis showed from river stations 24+15 to 33+88 in the HEC-RAS model, the cross-sectional area and depths were significantly lower; using a manning's value of 0.08 for the banks would result in overflow of the channel in this reach (see the hatched area in Figure 4) by less than a foot. The model suggests that a maximum Manning's roughness coefficient of 0.05 is allowable for the banks to avoid out-of-bank conditions.

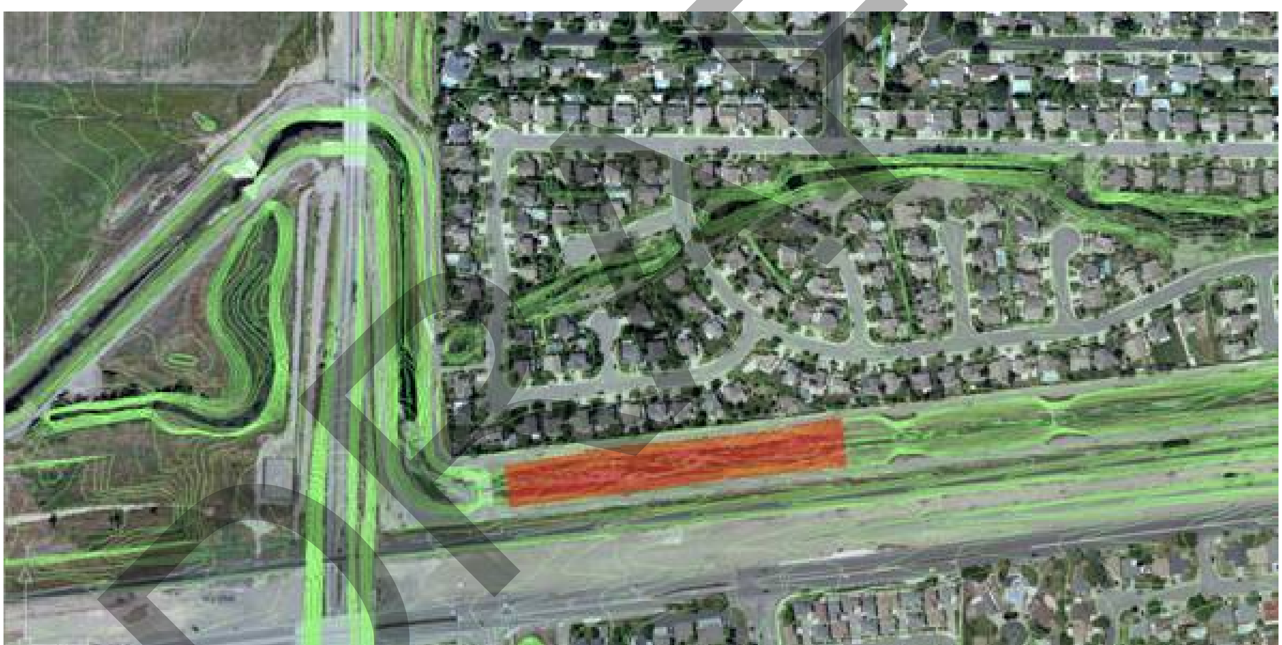


Figure 4 Shaded area showing region where model indicates Arroyo Mocho overtops first

For Option 2, the extent of the vegetation was limited to the upper half of the banks only. A Manning's *n* value of 0.035 was utilized for the channel bottom and lower half of the banks. The upper half of the banks was assigned a Manning's *n* of 0.08 (per the results of Option 1) for area of new planting. Planting only the upper half of the banks increases the channel capacity and results in a lower water surface than Option 1. Water surface elevations throughout the entire reach were reduced significantly by planting on only the upper half of the banks. A second model was run to evaluate the maximum Manning's *n* value that can be assigned to the banks if only the upper half is planted before overtopping. The results suggest the Manning's *n* value can be increased to 0.11 without overtopping the banks for Option 2 (only upper half of banks are planted).

Option 3 evaluated the maximum n_c for Option 1 outside of Stations 24+15 to 33+88 given a n_B of 0.08. The result of this analysis indicated that n_C could not exceed 0.055 without overtopping.

DISCUSSION OF RESULTS

Based on the HEC-RAS model, it appears that planting the banks of the channel such that Manning's roughness coefficient no greater than 0.08 is feasible, though it essentially provides no freeboard. A Manning's *n* value of 0.08 is indicative of a light brush and trees in summer scenario[1] as shown in Table 1. The channel banks can be planted with this type of community from the Stanley Boulevard Bridge to downstream of the fourth grade control structure. Between the fourth grade control structure and the dragon's tooth structure, the planting density would need to be considerably less such that the roughness coefficient is 0.05. This is indicative of moderate scattered brush and/or heavy weeds, which is similar to the current vegetation community at the site. A denser planting regime could potentially result in 100-YR flows overtopping the banks. The maintenance road would need to be raised approximately one foot to contain the 100-YR flow if the banks were planted such that the Manning's roughness coefficient was 0.08 (ignoring freeboard).

Table 1: Manning's n for Channels (Chow, 1959)

Type of Channel and Description	Minimum	Normal	Maximum
Natural streams - minor streams (top width at flood stage < 100 ft)			
1. Main Channels			
a. clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. same as above, but more stones and weeds	0.030	0.035	0.040
c. clean, winding, some pools and shoals	0.033	0.040	0.045
d. same as above, but some weeds and stones	0.035	0.045	0.050
e. same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. same as "d" with more stones	0.045	0.050	0.060
g. sluggish reaches, weedy, deep pools	0.050	0.070	0.080
h. very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. bottom: gravels, cobbles, and few boulders	0.030	0.040	0.050
b. bottom: cobbles with large boulders	0.040	0.050	0.070
3. Floodplains			
a. Pasture, no brush			
1.short grass	0.025	0.030	0.035
2. high grass	0.030	0.035	0.050
b. Cultivated areas			
1. no crop	0.020	0.030	0.040
2. mature row crops	0.025	0.035	0.045
3. mature field crops	0.030	0.040	0.050
c. Brush			

[1] See table of typical Manning's n values, taken from: http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm.

Table 1: Manning's n for Channels (Chow, 1959)

Type of Channel and Description	Minimum	Normal	Maximum
1. scattered brush, heavy weeds	0.035	0.050	0.070
2. light brush and trees, in winter	0.035	0.050	0.060
3. light brush and trees, in summer	0.040	0.060	0.080
4. medium to dense brush, in winter	0.045	0.070	0.110
5. medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. dense willows, summer, straight	0.110	0.150	0.200
2. cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. same as 4. with flood stage reaching branches	0.100	0.120	0.160

If only the upper half of the banks is planted, a much denser vegetation community could be utilized (for example if the banks are ten feet tall, only the top five feet would be planted). The HEC-RAS model indicated that a roughness coefficient of 0.11 could be achieved without overtopping, which is commensurate with the average value of medium to dense brush (grown to its state in the summer). The lower portion of the channel cross section, however, would need to be planted in such a fashion that the roughness coefficient is 0.035 or less, which is commensurate with high grass.

Table 2 provides important guidance for the roughness associated with various vegetation schemes. Zone 7 is currently evaluating the use of this reach as a mitigation planting site with the objective of enhancing habitat and cooling the stream by providing shade to the channel. It does appear that certain plant communities may provide shade without overtopping the channel. The most likely scenario for this would involve planting only the upper half of the channel and maintaining the lower half and bottom of channel such that only dense grass is growing there. A planting palette that maximizes shade, however, will likely involve shrubs and/or trees grown near the water line. The roughness associated with this type of vegetation regime would likely cause the channel to overtop. Thus, planting a vegetation community consisting of dense brush (similar to willow or other near-channel species that provide shade quickly and have a high survivability rate) is not recommended unless capacity is added or other parts of the channel are planted with species that do not increase roughness significantly. It should be noted that a thin stand of willow planted at the water's edge is not likely to significantly increase the overall roughness of the channel.

It should be noted that none of the options evaluated as part of this study explicitly examine the effects on or benefits to fish habitat and/or fish passage. Although increasing the riparian complexity through planting the channel will likely decrease stream temperatures and enhance habitat value for other species, it will not address the physical barriers of the dragon's tooth and third grade control structures that are likely too tall to accommodate salmonid migration upstream. Stantec understands that Zone 7 is working in conjunction with NMFS and other fisheries groups to understand and address future fish passage issues in the Livermore-Amador Valley; therefore, statements below related to fish passage are based on an assumption that the project reach could be determined to be a viable fish restoration project by others. The target species is understood to be steelhead trout.

The sediment observed within the channel was also analyzed for stability. Based on models of incipient motion, it is highly likely that the bed will mobilize during flood flows. Should a grass community be established from the water line down to the channel bottom, it is likely it would be washed away too during a 100-YR flood event along with much of the bed material.

GEOMORPHIC ASSESSMENT

METHODOLOGY

Geomorphic data in the form of cross sections and longitudinal profile was collected in the field and imported RIVERmorph© for calculation of the pattern, profile and dimension of the current existing conditions. In addition, the Bank Assessment for Non-Point Source Consequences of Sediment (BANCS) was performed. Sediment data (in-situ) in the form of a grab sample was collected from the channel bed (this material is the same as material found in depositional areas) and sent to RGH Consultants in Santa Rosa, California for Analysis. The geomorphic data was reduced to develop a stream classification and forms the basis of the bed transport competence analysis.

RESULTS OF GEOMORPHIC ASSESSMENT

Attachment 3 shows the classification, cross sections and longitudinal profile for the studied existing conditions reach and survey. The channel classification (Rosgen, 1996)[2] for the studied reach of Arroyo Mocho was determined to be an F4. The mean particle size of the channel bottom is 8.4mm, which is a medium gravel.

Bank Assessment for Non-Point source Consequences of Sediment or BANCS Model was preformed to quantitatively assess and estimate bank erosion for the reach. The BANCS model is comprised of the Bank Erosion Hazard Index (BEHI) and the Near Bank Stress (NBS) and evaluates streambank erodibility variables and energy distribution within the stream to predict (based on BEHI Rating and Near-Bank Stress) total tons of sediment per year for the reach generated by the banks. The BEHI rating is based on observations and measurements of the banks that evaluate parameters such as bank slope, vegetation density, soil composition, and root mass to derive a bank stability rating. This rating is compared to the near bank shear stress, which is based on the shear stress near the bank relative to the shear stress at the center of the channel, to generate a sediment rating curve. There are three published sediment rating curves that predict annual sediment yield from the banks based on calibrated observations. Table 2 and Attachment B show the results from the BANCS Model based on two of these curves: Colorado Curve and North Carolina Curve[3].

Table 2 - BANCS Model Results		
TOTALS		
NC	**15.691**	**Tons/Yr**
NC ER RATE	**0.003**	**Tons/ft/yr of River Bank**
NC ER RATE	**0.006**	**Tons/ft/yr of River Length**
CO	**26.445**	**Tons/Yr**
CO ER RATE	**0.005**	**Tons/ft/yr of River Bank**
CO ER RATE	**0.010**	**Tons/ft/yr of River Length**

The values shown in Table represent a typical range of sediment yield for Arroyo Mocho. Without validation, it is not valid to state one is more appropriate than the other; however, both models indicate a relatively low sediment yield per foot of channel (0.003 to 0.005 tons/ft/yr) thereby indicating the banks are stable. This is supported by visual observations of the channel and the relative lack of significant bank erosion.

[2] Rosgen, David 1996. Applied River Morphology. Pagosa, Colorado, Wildland Hydrology

[3] Colorado and North Carolina curves were used to predict erosion rates to provide a probable range of values for erosion rates. A third curve generated from Yellowstone River data is only appropriate for extremely high sediment regimes typically found in glacial outwash regions. The BANCS model does not currently have an erosion rate rating curve for California, though efforts to produce such a tool are currently underway. The values shown should therefore be considered a likely range of values and not absolute predictions of erosion rates.

RECOMMENDATIONS

Based on the results of this study, the following recommended alternatives are offered related to planting/configuration strategies for this reach of Arroyo Mocho. These recommendations are grouped into three general planting/configuration alternatives: 1) Plantings only, no channel modification, 2) Plantings with minor channel modifications, and 3) Plantings in conjunction with fish passage barrier/impediment assessment and/or modification. In general, it appears feasible that the vegetation community could be altered such that roughness is increased slightly without overtopping the channel on the 100-YR flow.

Alternative 1a: If Zone 7 opts to plant the entire study reach, the following recommendations apply:

- A moderately dense (maximum, see Table 2) vegetation community should be chosen to for the planting palette. The associate Manning's roughness coefficient should not exceed 0.08, which is commensurate with a shrub and grass community. The existing channel bottom should remain gravel/cobble with grasses. A large stand of willow and similar plants should be avoided; however, a thin line of willow along the water's edge may be acceptable.
- Planting only the banks does not address fish passage issues. This should be made clear within the Goals and Objectives of any project that involves planting the banks without addressing fish passage issues.
- The section of Arroyo Mocho between the fourth grade control structure and the dragon's tooth structure should be maintained essentially as it is (i.e. the community affecting channel roughness should remain the same). The particular plant community could be changed as long as it remains primarily a grass community with only sporadic shrubs and/or trees.
- It is our understanding that UCC will be developing the planting palette. UCC should closely consult the attached table and referenced documents when developing the planting palette.
- Once a riparian community has been developed, the reach should be re-evaluated to confirm the model predicts the channel will contain the 100-YR flow.

Alternative 1b: If Zone 7 opts to plant only the upper half (vertically) of the banks, the following recommendations apply:

- A dense vegetation community could be chosen for the planting palette. Since the associated roughness for the community can be nearly 0.11, it can consist of fairly dense shrubs and trees. The trees would ultimately be required to provide shading to the channel since ostensibly the objective of planting is to provide a cooling mechanism for the stream.
- If only the upper portion of the channel is planted, the section of Arroyo Mocho between the fourth grade control structure and the dragon's tooth structure should be maintained essentially as it is (i.e. the community affecting channel roughness should remain the same). The particular plant community could be changed as long as it remains primarily a grass community with only sporadic shrubs and/or trees.
- It is our understanding that UCC will be developing the planting palette. UCC should closely consult the attached table and referenced documents when developing the planting palette.
- Once a riparian community has been developed, the reach should be re-evaluated to confirm the model predicts the channel will contain the 100-YR flow.

Alternative 2: If Zone 7 opts to explore minimizing hydraulic deficiencies associated with increased roughness within the channel in concert with enhancing the riparian community:

- The maintenance road would need to be raised approximately one foot to accommodate a vegetation community with a Manning's roughness coefficient of 0.09.

- If a denser community was selected such that the Manning's roughness coefficient was 0.12 would require the maintenance road to be raised approximately three feet.

- Further HEC-RAS models should be developed once the specific planting palette is known.

Alternative 3: If Zone 7 opts to explore fully addressing hydraulic deficiencies associated with increased roughness within the channel in concert with enhancing the riparian community and immediately addressing fish passage issues:

- Further analysis should be performed on the contributions of the grade control structures on locally high velocities. The effects of removing the structures on the velocities within the channel should be performed. The analysis should also address removal of the dragon's tooth and the effects of its removal on velocities downstream at the bend. It is very likely that the structure is providing turbulence that decreases velocity at the bend. It should be explored if a similar type of turbulence inducing structure could be utilized that does not produce a fish passage barrier.
- An overall analysis on fish passage could be undertaken for the entire reach and should be based on accepted regulations regarding design flows, vertical drops, velocities and energy dissipation related to salmonid passage. To this end, close consultation with a fisheries biologist and/or an ecologist familiar with species of interest within the project area should be consulted as part of the design process.
- The grade control structures appear to be the points of incipient flooding for high flow events when the roughness of the channel is increased as discussed previously. It should be noted that the model did not indicate insufficient capacity in its current state. Additional analysis should be undertaken to evaluate the change to the hydraulic regime if these structures are removed.
- A holistic approach to restoring the channel would include evaluating components of restoration that would permit planting dense vegetation down to the water line as well as taller vegetation along the banks, or at least the south side of the channel to maximize shading on the channel. Other components of restoration could be aimed at restoring capacity lost through planting and would include re-configuring the banks by steepening through bioengineering or possibly more structural alternatives such as benched crib walls, wrapped earth lifts or similar approaches that may or may not include a vegetation component. It may also be effective to raise the grade of the service roads on each side of the channel to effectively serve as a levee. Another component may be creating additional lateral capacity by widening the channel such that one or both access road is removed.
- There are significant vertical drops created by the grade control structures. The restored stream will still need to accommodate the vertical change in grade from top to bottom. The drop could be mitigated by a series of smaller drops along the entire reach rather than a few large drops as currently configured.
- Stantec understand that Zone 7 has identified the drop at the railroad bridge upstream of the pedestrian bridge above the project site as a fish passage barrier. An overall restoration plan could also consider removal or other accommodation (fish ladder or similar in-stream structure) for this feature in this phase of the project to enhance the fish passage benefits of the reach.

PLANTING OPTIONS

The Urban Creeks Council will provide a discussion of the Planting options under separate cover. Prior to implementing the planting plan, Stantec recommends performing an additional HEC-RAS analysis based on the selected planting palette.

OPINION OF PROBABLE COST

To assist the evaluating the options presented herein, an opinion of probable costs has been prepared for raising the access road and removing the existing grade control structures and replacing them with structures often included in natural channel design options such as cross vanes. These costs were generated for raising the levee based on the Corps of Engineers typical cross section for a trail on a levee, which is shown in Attachment 4 as detail Number 3. The opinion of probable costs associated for replacing the grade control structures were generated based on typical costs encountered by Stantec on similar projects.

Raising the levee one foot is expected to cost approximately $190.00 per foot and a three foot vertical increase of the levee elevation would cost approximately $300.00 per foot. Thus, to raise the levees one foot in the vicinity of the dragon's tooth structure upstream to the fourth grade control structure would cost approximately $300,000. The levee would need to be extended around the bend thus the approximate footage required would be 1,500 linear feet. Raising this section three feet would cost approximately $471,000. These costs are for BOTH sides of the channel.

Removing the grade control structures and replacing them with two-drop cross vanes is estimated to cost approximately $2.16MM. This figure is based on replacing the existing structures in their entirety and includes design, permitting, construction management and remaining assessment requirements. Considering the footage between the pedestrian bridge and just past the bend downstream of the dragon's tooth structure, this equates to nearly $500 per linear foot, which is typical of urban restoration projects.

A breakdown of the derivations of these costs is included in Attachment 5.

Stantec greatly appreciates the opportunity to work with you on this project. If you have any further questions, please do not hesitate to contact me.

Sincerely,

STANTEC CONSULTING SERVICES INC.

Michael Adams Jr, PE, LEED AP
Project Manager
Tel: (703) 777-0063
Fax: (703) 777-2480
Michael.Adams@stantec.com

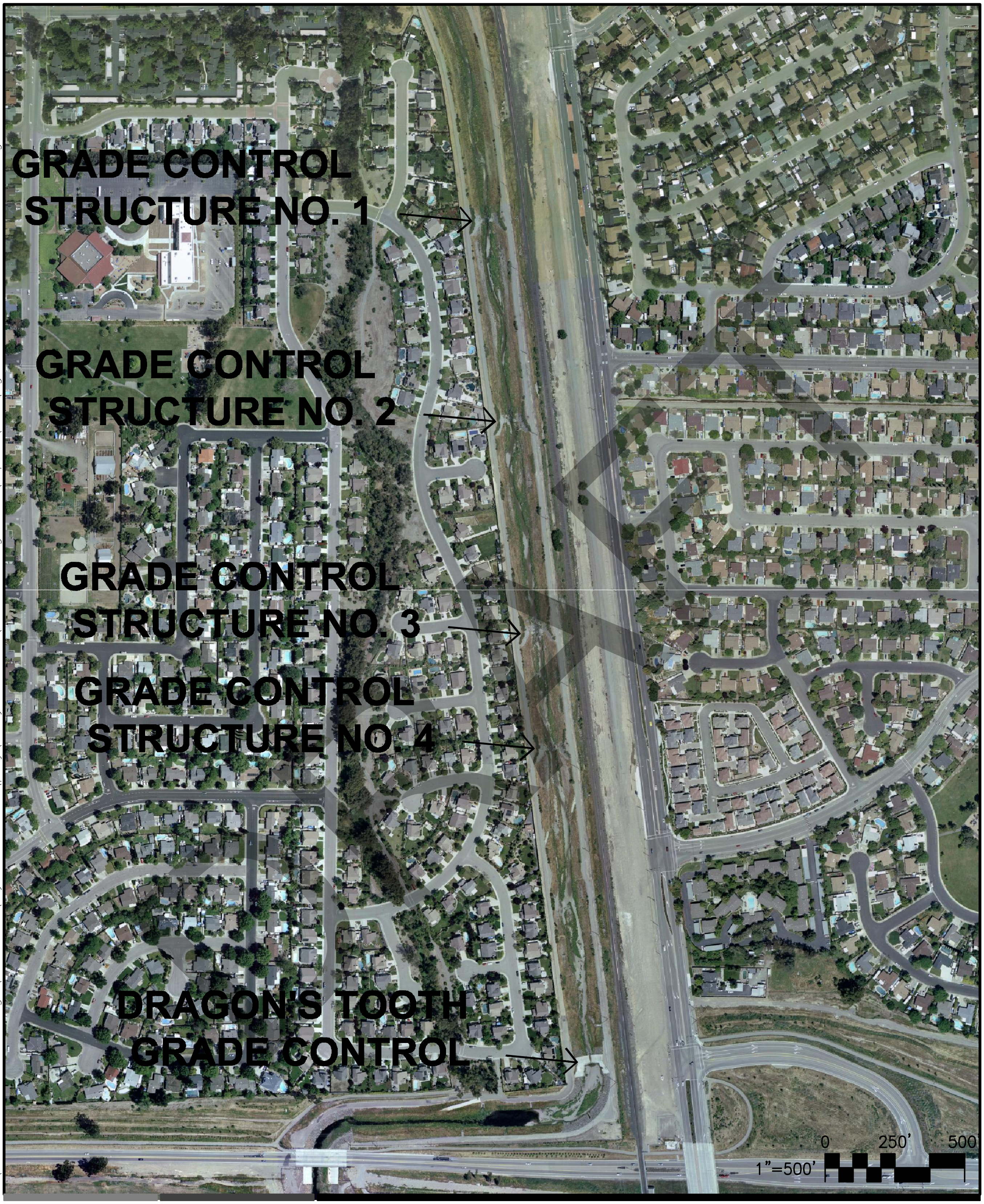
Attachments: 1. Project Map
2. HEC-RAS Output
3. Geomorphic Assessment

c. Mike Vukman, Urban Creek Council

Attachments

Attachment 1

Plan Views



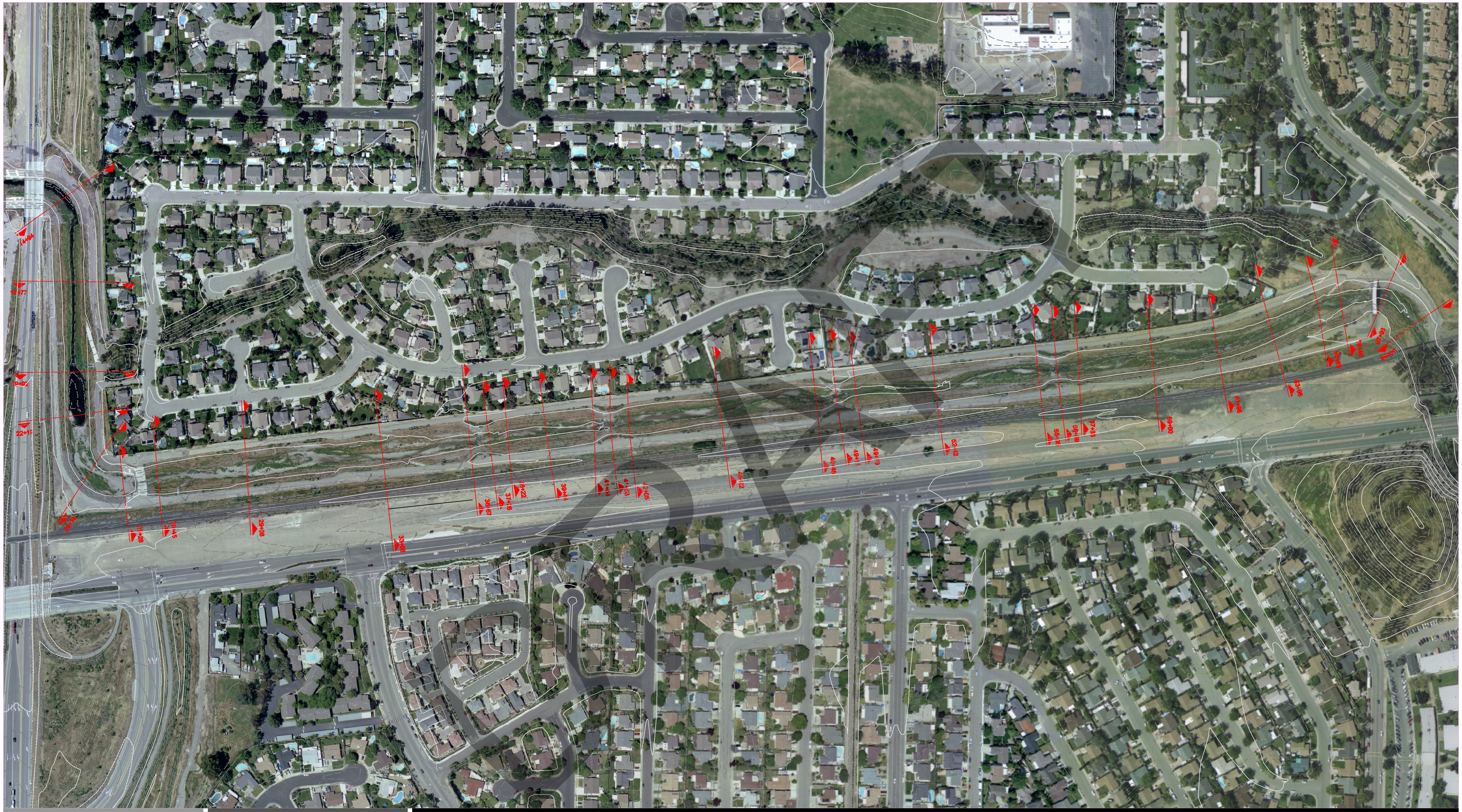
SaveDate: 2010/11/11 5:58 PM Login: Adams, Michael
c:\documents and settings\miadams\my documents\proj\arroyo mocho\files from geenen\report\cad\eg_stantec_surface_hec-ras.dwg

Stantec Consulting Services Inc.
108 Church Street SE
Leesburg, VA
20175
Tel. 703-777-0063
Fax. 703-777-2480
www.stantec.com

Client/Project
ZONE 7
ARROYO MOCHO
SEDIMENT STUDY

Figure No.
1.0

Title
PLAN VIEW



Revision	By	Appd.	YY.MM.DD

Issued	By	Appd.	YY.MM.DD
HEC-RAS Cross-Section Locations Map	Stantec		12.07.2010

Consultants

LIVERMORE-AMADOR VALLEY ZONE 7 19 57 WATER SUPPLY • FLOOD PROTECTION

Stantec
Street Address
Leesburg, VA
20175
Tel. 703.777.0063
Fax. 703.777.2480
www.stantec.com

Client/Project
ZONE 7

ARROYO MOCHO
HEC-RAS Study - Base Map

File Name: EG_Stantec_Surface_HEC-RAS	MJG	MA		12.07.2010
	Dwn.	Chkd.	Dsgn.	YY.MM.DD

Arroyo Mocho HEC-RAS Alignment and Cross-Section Locations

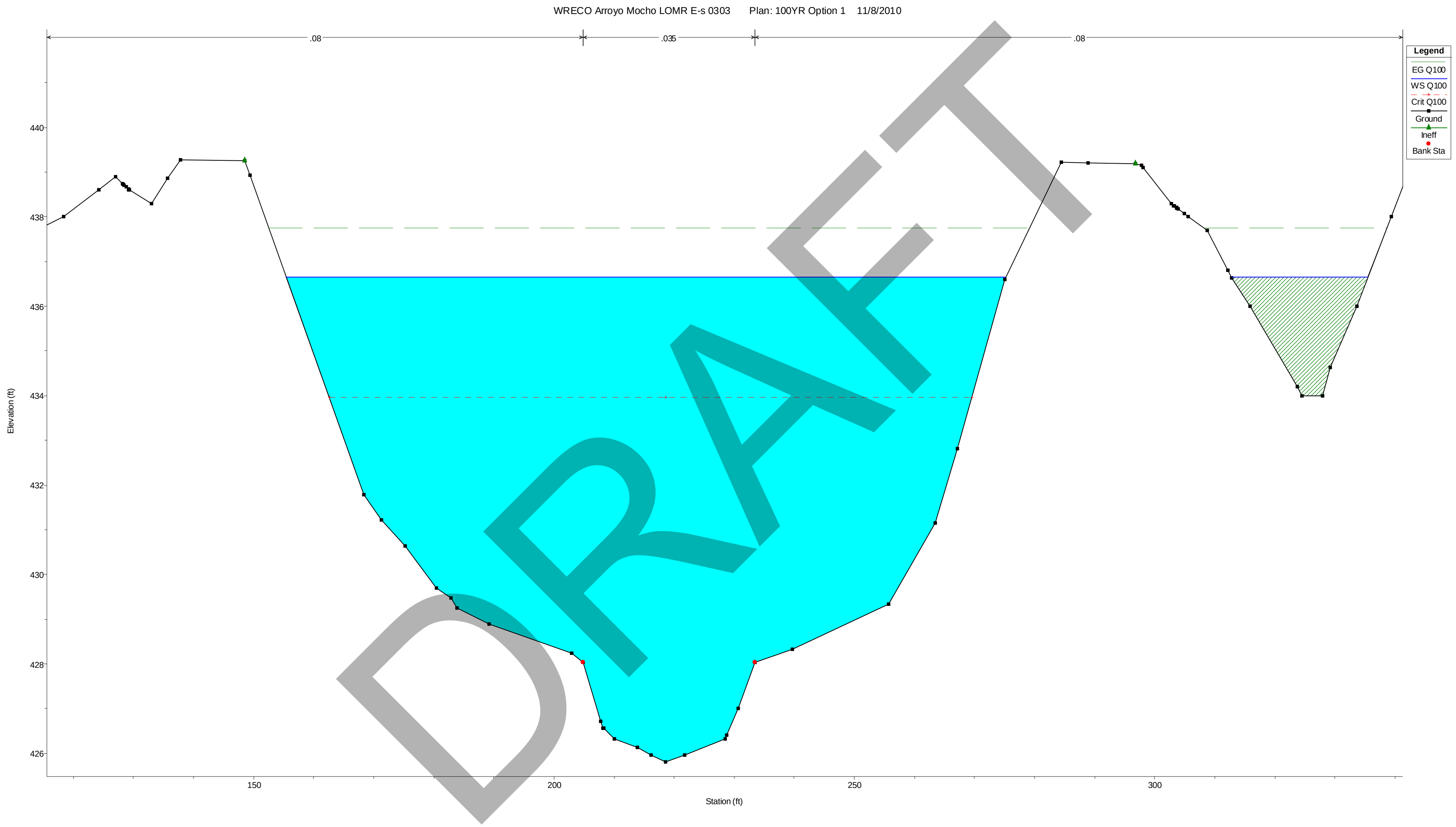
Project No.	Scale	
175650003	1:150	
Drawing No.	**Sheet**	**Revision**
1	1 of 1	0

C:\Civil 3D Projects\Arroyo_Mocho\CAD\EG_Stantec_Surface_HEC-RAS.dwg
2010/12/07 4:02 PM By: Geenen, Michael

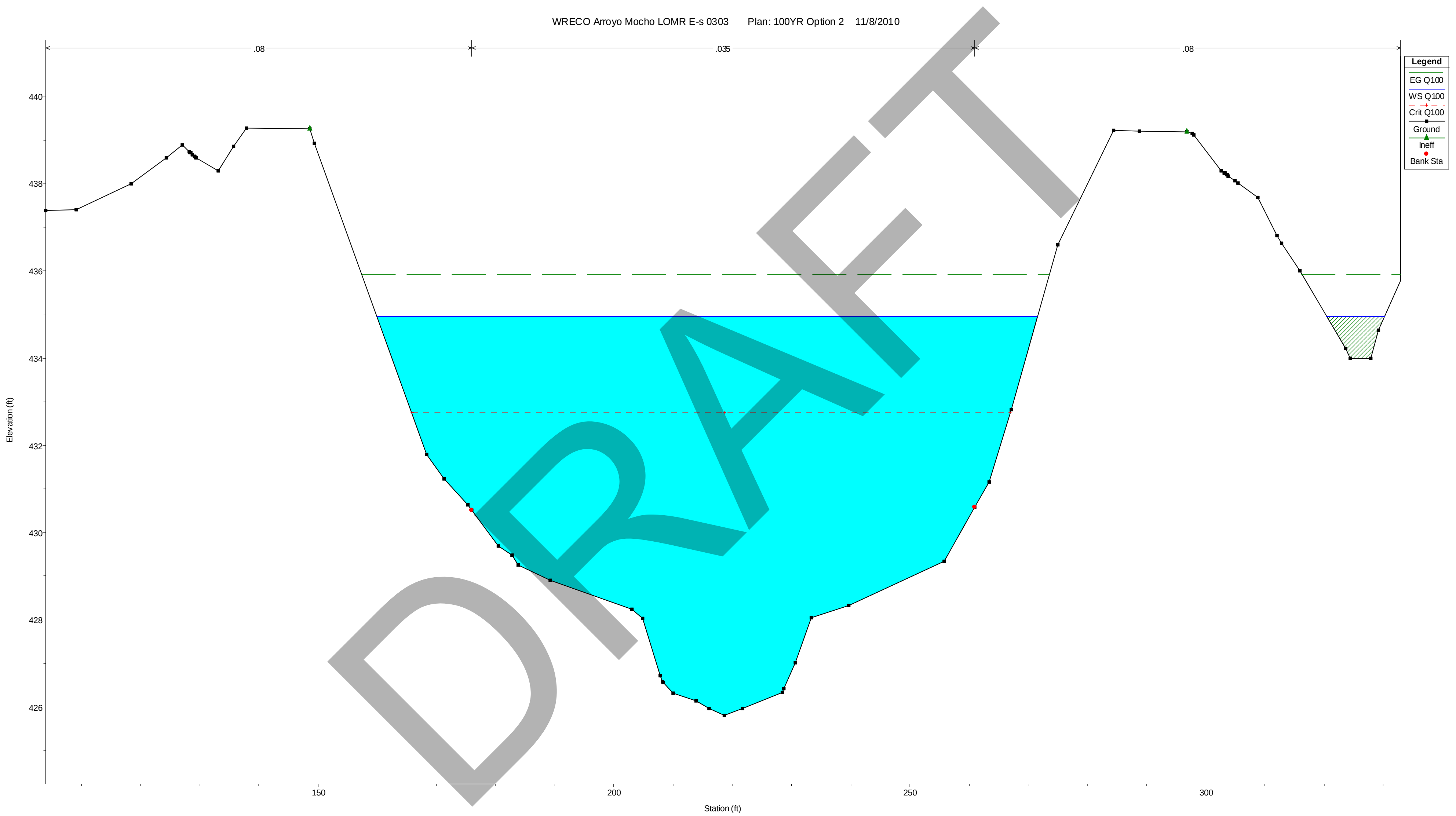
ORIGINAL SHEET – ANSI D HORIZ

Attachment 2

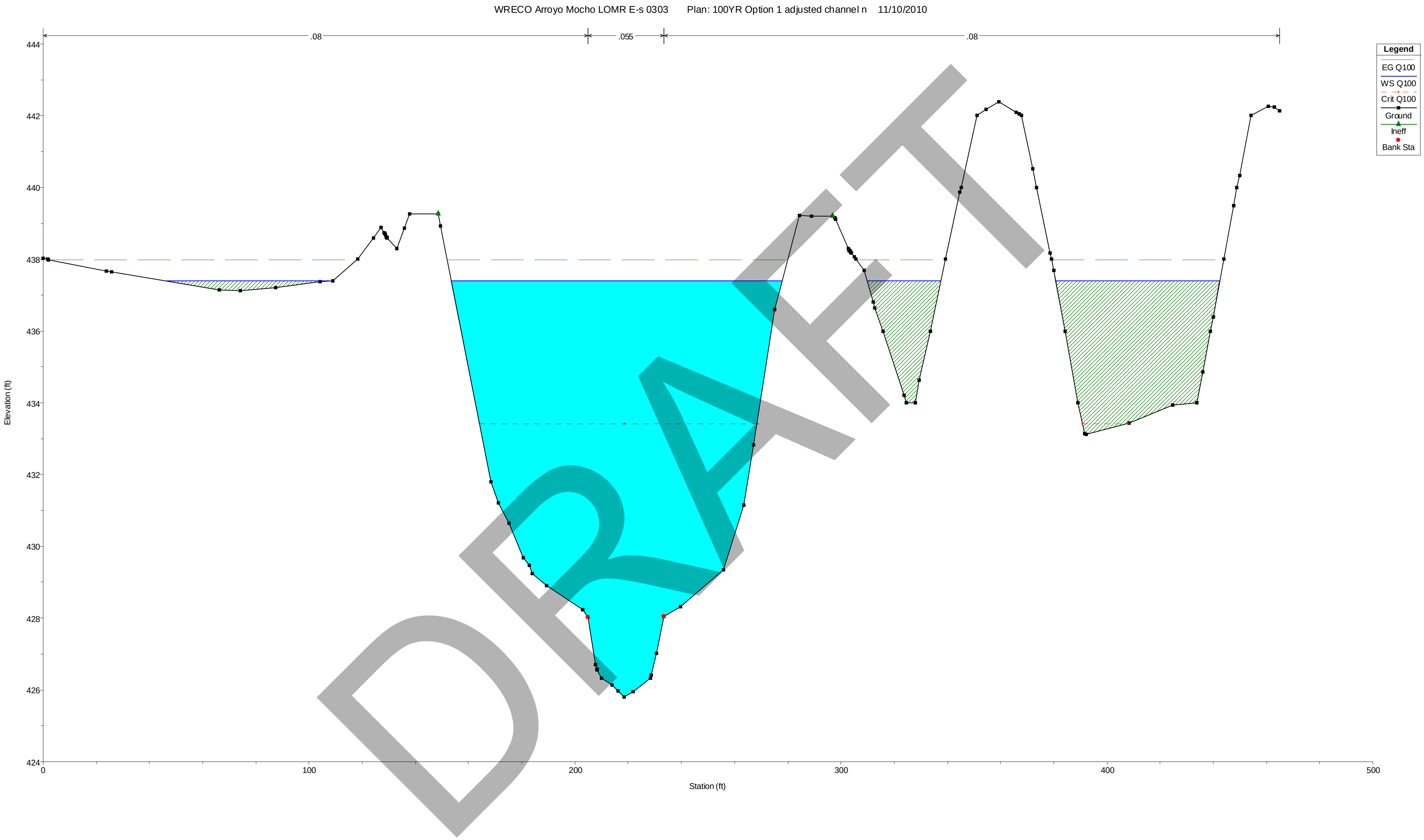
HEC-RAS Output



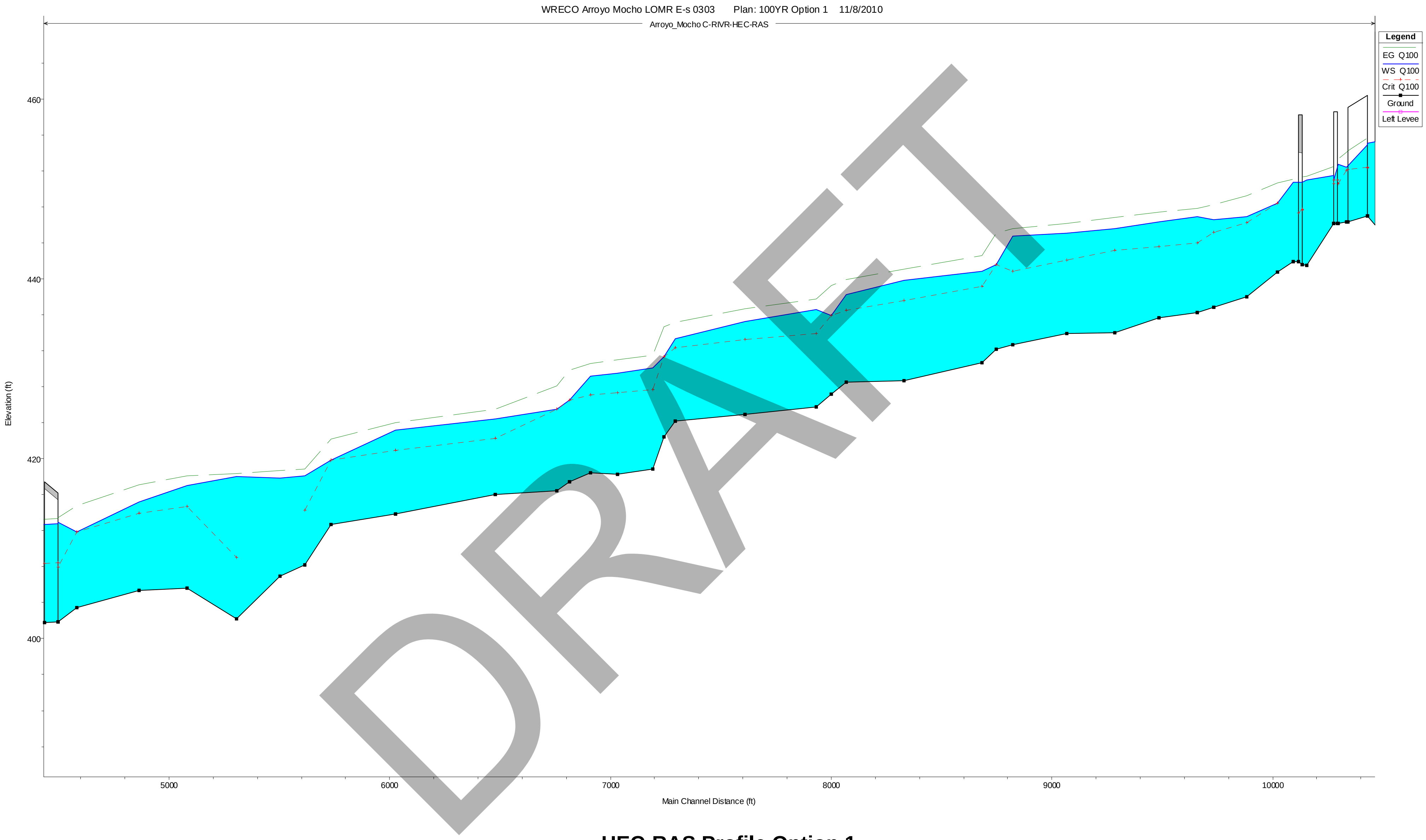
Sample HEC-RAS River Cross-Section Option 1



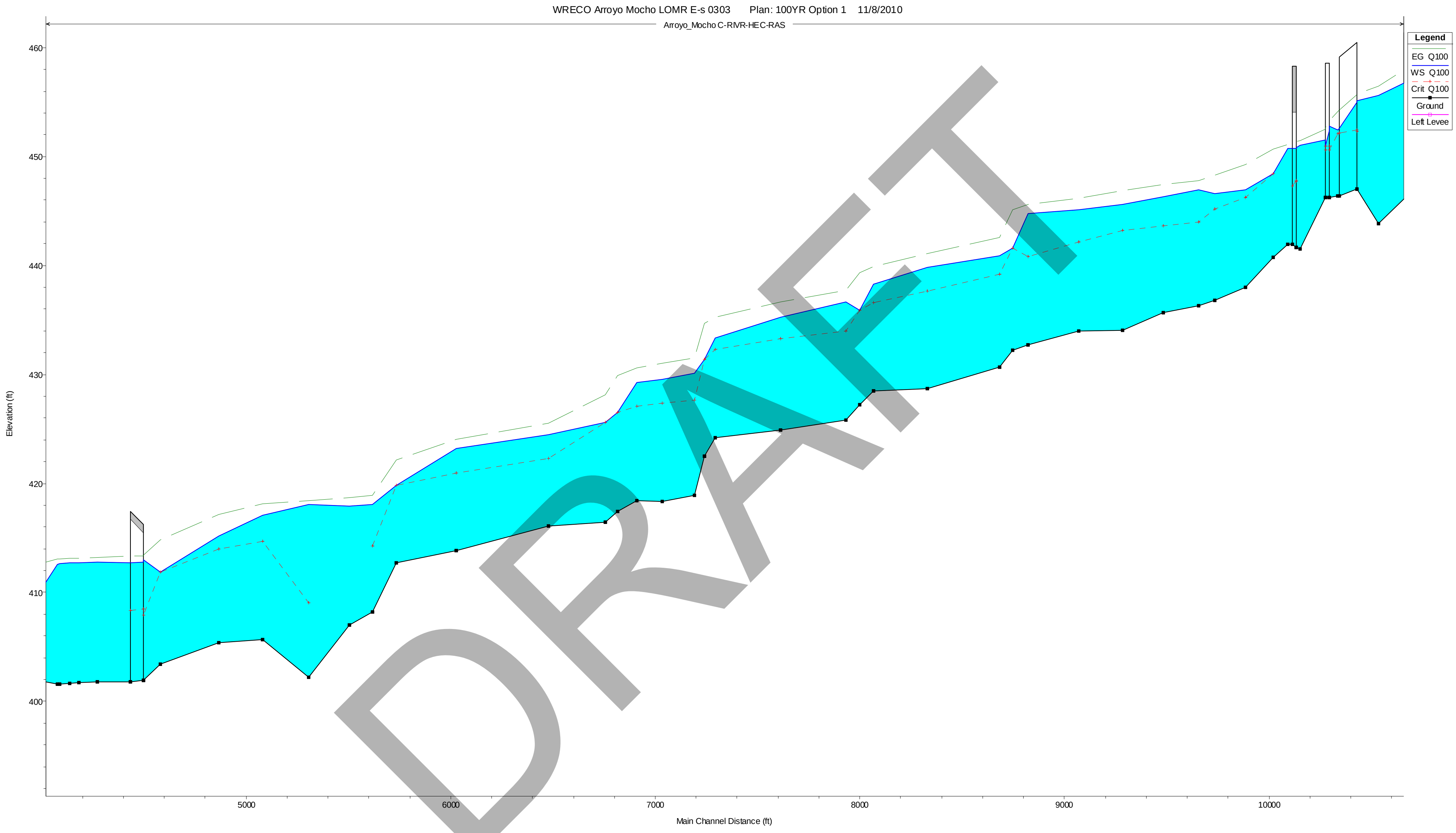
Sample HEC-RAS Cross-Section Option 2



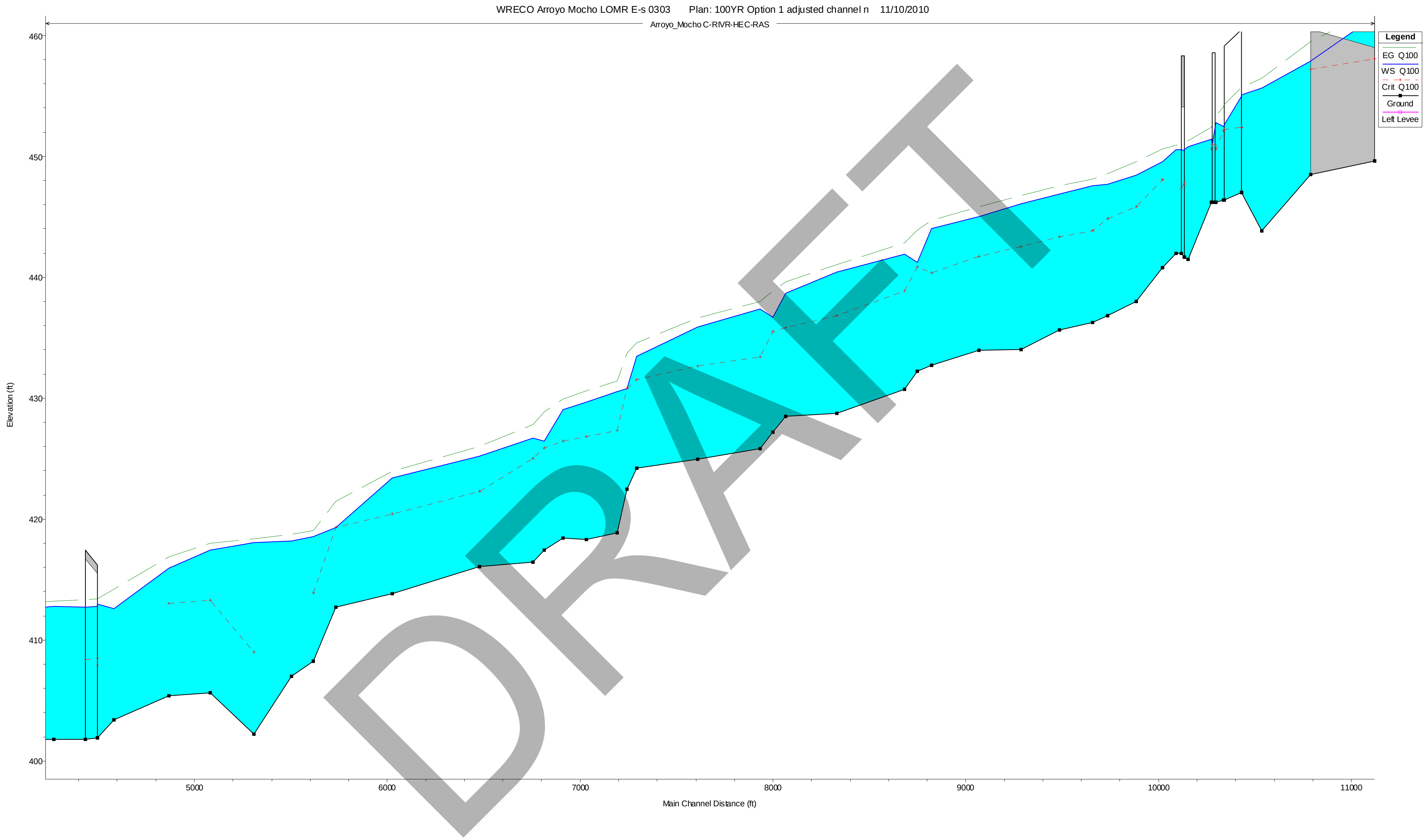
Sample HEC-RAS Cross-Section Option 3



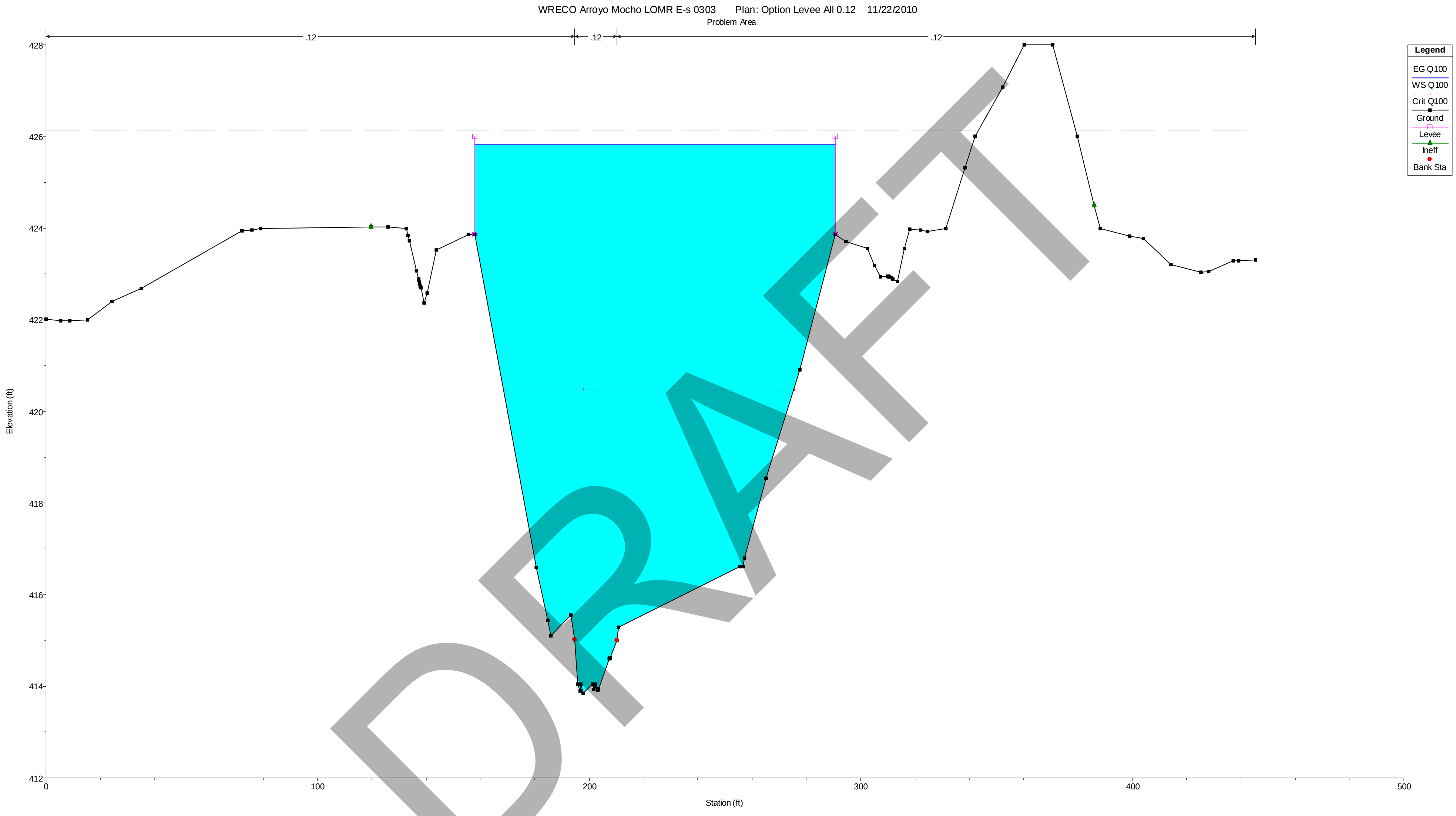
HEC-RAS Profile Option 1



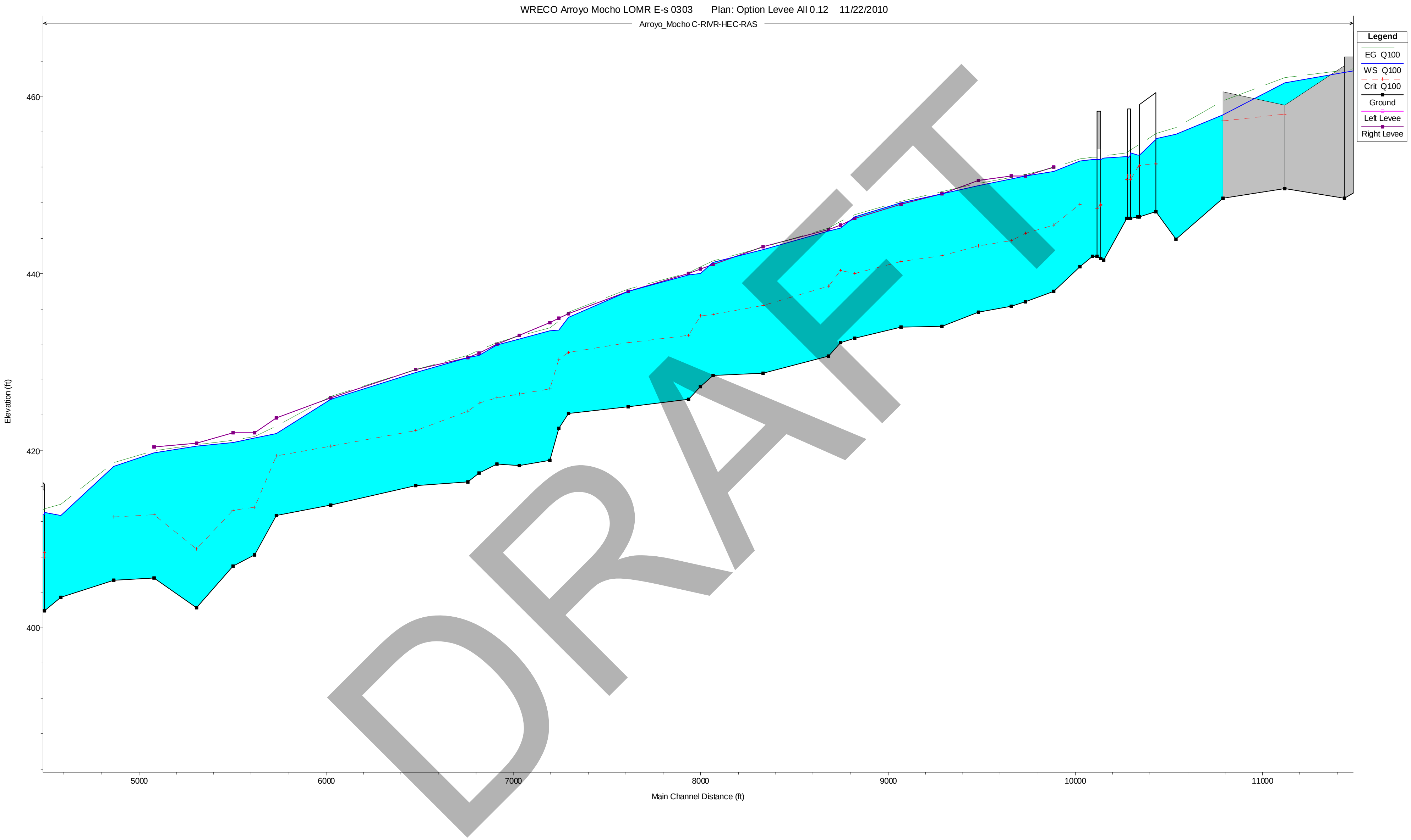
Profile Option 2



Profile Option 3



Option – Manning n 0.12 all channel
Raise Road from .5 - 3 ft



Profile with Levees

Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

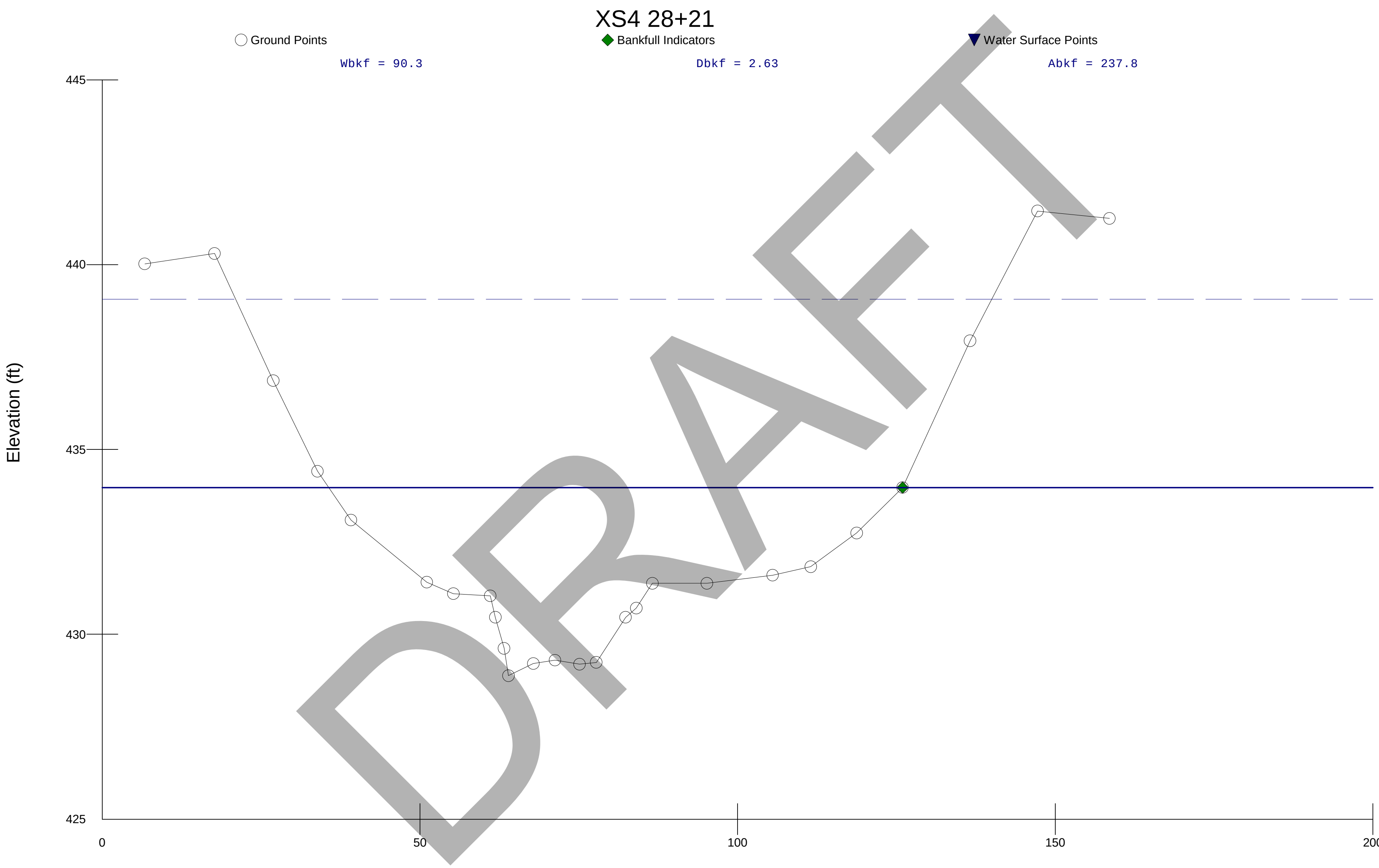
Stream:	**Arroyo_Mocho, Reach - Reach 1**		
Basin:	**Alameda Creek**	Drainage Area: **38400** acres	**60** mi^2
Location:	**Livermore, California**		
Twp.&Rge:	**;**	Sec.&Qtr.: **;**	
Cross-Section Monuments (Lat./Long.):			Date: **10/13/10**
Observers:	**MV, MG**		Valley Type: X

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**90.34**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**2.63**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**237.82**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**34.35**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**5.09**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**118.98**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.32**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**8**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.00528**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1**	

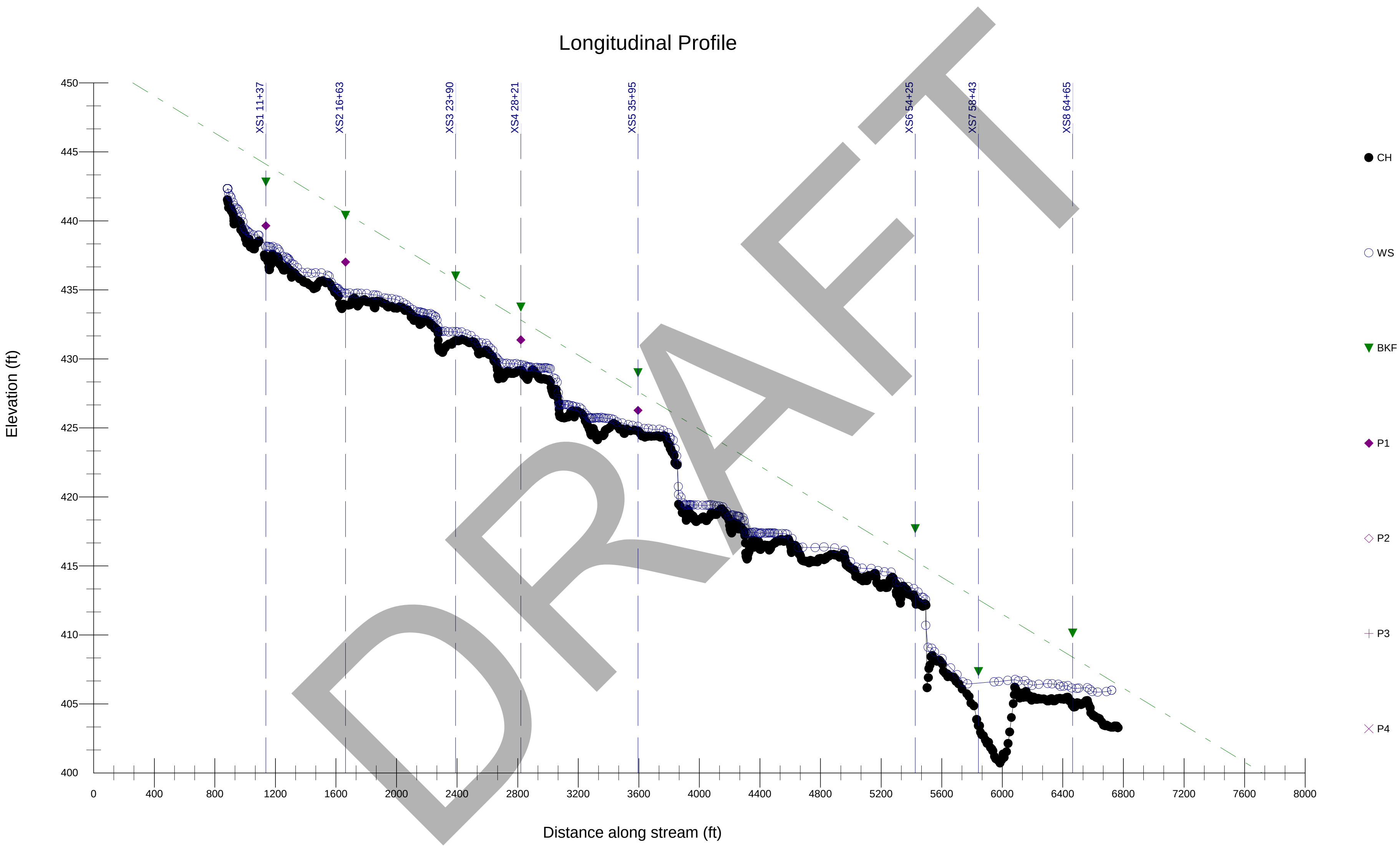
Stream Type **F 4** (See **Figure 2-14**)

Attachment 3

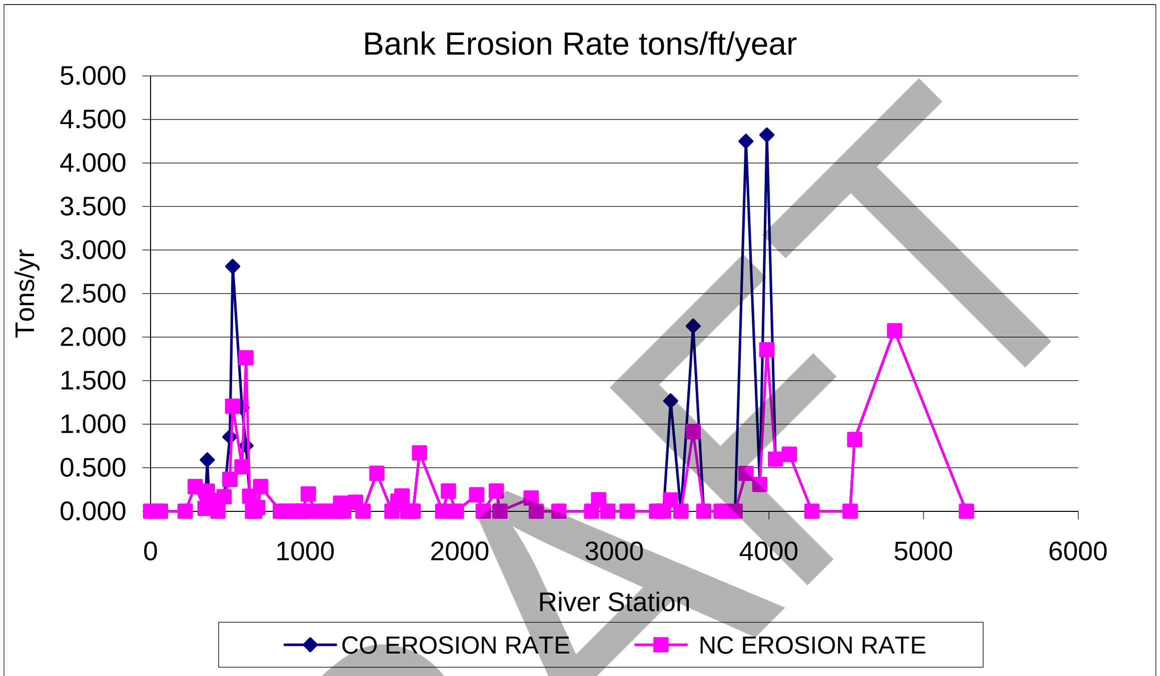
Geomorphic Assessment

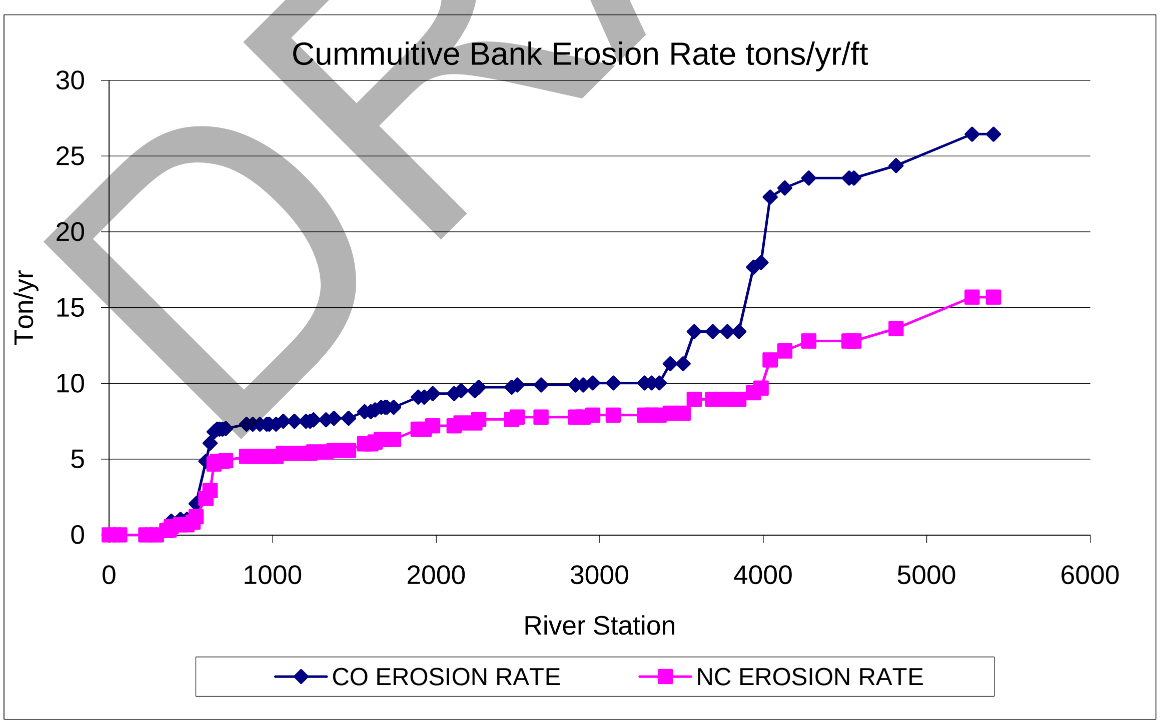


XS4 28+21
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 90.3
Dbkf = 2.63
Abkf = 237.8
445
440
435
430
425
0
50
100
150
200
Elevation (ft)
Horizontal Distance (ft)
DRAFT



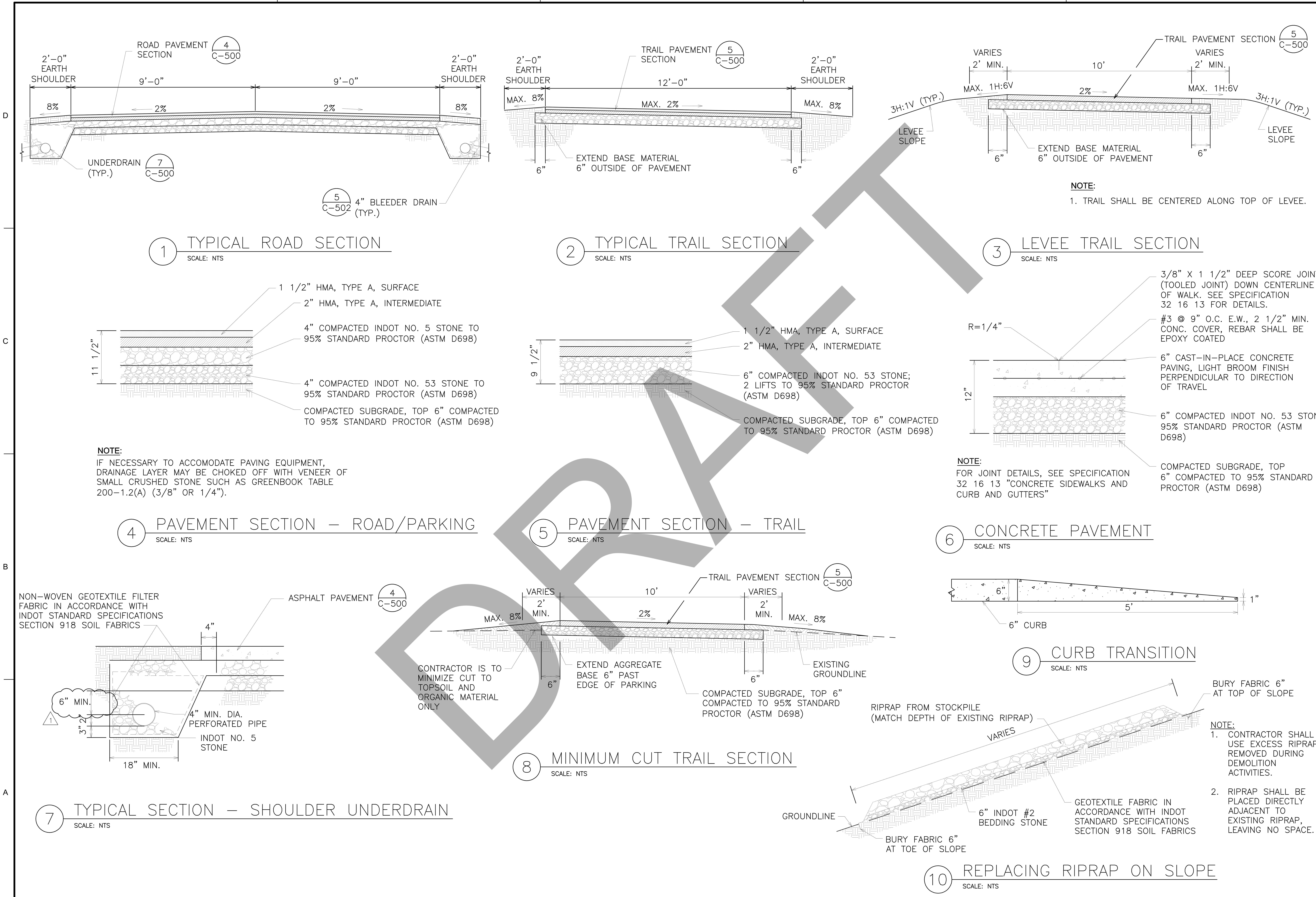
Longitudinal Profile
Elevation (ft)
Distance along stream (ft)
450
445
440
435
430
425
420
415
410
405
400
0
400
800
1200
1600
2000
2400
2800
3200
3600
4000
4400
4800
5200
5600
6000
6400
6800
7200
7600
8000
XS1 11+37
XS2 16+63
XS3 23+90
XS4 28+21
XS5 35+95
XS6 54+25
XS7 58+43
XS8 64+65
CH
WS
BKF
P1
P2
P3
P4
DRAFT


Bank Erosion Rate tons/ft/year
Tons/yr
5.000
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
0
1000
2000
3000
4000
5000
6000
River Station
CO EROSION RATE
NC EROSION RATE


Cummuitive Bank Erosion Rate tons/yr/ft
Ton/yr
30
25
20
15
10
5
0
0
1000
2000
3000
4000
5000
6000
River Station
CO EROSION RATE
NC EROSION RATE

Attachment 4

Typical Trail Cross Section



US Army Corps of Engineers® Louisville District

MARK	DESCRIPTION	DATE	APPR
1	Underdrain Detail Revised	11/12/2010	MCV

U.S. ARMY CORPS OF ENGINEERS LOUISVILLE DISTRICT LOUISVILLE, KENTUCKY

JOINT VENTURE Stantec HNTB

DESIGNED BY: M. VAUGHAN | DATE: 6/16/2010
DWN BY: R. PETTY | CKD BY: J. STORM | SOLICITATION NO.: W912QR-0197037
SUBMITTED BY: R. TAYLOR
PLOT SCALE: 1" = ' | PLOT DATE: 11/15/2010
SIZE: ANSI D | FILE NAME: 59042C-DT500-MD1.dwg

OHIO RIVER GREENWAY PUBLIC ACCESS PROJECT NEW ALBANY, IN

CIVIL DETAILS

SHEET IDENTIFICATION
C-500
SHEET 50 OF 96

READY TO ADVERTISE

Attachment 5

Opinion of Possible Cost Derivation

RAISE LEVEE 1 VERTICAL FOOT

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL	ASSUMPTIONS
Mobilization	LS	1	$30,000.00	$ 30,000.00	Assumed cost
Borrow Material Haul and Spread	CY	13,874	$17.97	$ 249,315.78	Spread, dozer, no compaction, 2 mile RT haul (common borrow)
Grading	CY	13,874	$2.38	$ 33,020.12	Grading by dozer
Compaction	CY	17,607	$0.50	$ 8,803.67	Riding, vibrating roller, 6" lifts, 2 passes
Aggregate Base	CY	3,733	$53.28	$ 198,912.00	Crushed stone 3/4"
Asphalt Base	SY	22,400	$10.54	$ 236,096.00	2" thickness
Asphalt Surface	SY	22,400	$8.90	$ 199,360.00	1.5" thickness
			Contingency (20%)	$ 191,101.51	
			TOTAL	**$ 1,146,609.08**	
			COST PER FOOT	$ 190.00	

Cost estimates are based on RS Means 2010 using a location factor for San Jose, CA

RAISE LEVEE 3 VERTICAL FEET

ITEM	UNIT	QUANTITY	UNIT COST	TOTAL	ASSUMPTIONS
Mobilization	LS	1	$30,000.00	$ 30,000.00	Assumed cost
Borrow Material Haul and Spread	CY	41,928	$17.97	$ 753,440.17	Spread, dozer, no compaction, 2 mile RT haul (common borrow)
Grading	CY	41,928	$2.38	$ 99,787.85	Grading by dozer
Compaction	CY	45,661	$0.50	$ 22,830.50	Riding, vibrating roller, 6" lifts, 2 passes
Aggregate Base	CY	3,733	$53.28	$ 198,912.00	Crushed stone 3/4"
Asphalt Base	SY	22,400	$10.54	$ 236,096.00	2" thickness
Asphalt Surface	SY	22,400	$8.90	$ 199,360.00	1.5" thickness
			Contingency (20%)	$ 308,085.30	
			TOTAL	**$ 1,848,511.82**	
			COST PER FOOT	$ 300.00	

Cost estimates are based on RS Means 2010 using a location factor for San Jose, CA

STREAM RESTORATION COSTS

Component	Quantity		Unit Cost	Total
Grade Control Structure Removal				
Dragons Tooth	570	CY	$ 125.00	$ 71,250.00
Structure 4	660	CY	$ 100.00	$ 66,000.00
Structure 3	660	CY	$ 100.00	$ 66,000.00
Structure 2	660	CY	$ 100.00	$ 66,000.00
Structure 1	660	CY	$ 100.00	$ 66,000.00
Boulder Placement of New Structures				
Dragons Tooth	1620	tons	$ 90.00	$ 145,800.00
Structure 4	540	tons	$ 90.00	$ 48,600.00
Structure 3	1350	tons	$ 90.00	$ 121,500.00
Structure 2	810	tons	$ 90.00	$ 72,900.00
Structure 1	540	tons	$ 90.00	$ 48,600.00
Ancillary Materials (20% of Boulder Costs)				
Dragons Tooth	1	LS	$ 29,160.00	$ 29,160.00
Structure 4	1	LS	$ 9,720.00	$ 9,720.00
Structure 3	1	LS	$ 24,300.00	$ 24,300.00
Structure 2	1	LS	$ 14,580.00	$ 14,580.00
Structure 1	1	LS	$ 9,720.00	$ 9,720.00
Excavation				
Dragons Tooth	31500	CY	$ 7.50	$ 236,250.00
Structure 4	5200	CY	$ 7.50	$ 39,000.00
Structure 3	28400	CY	$ 7.50	$ 213,000.00
Structure 2	11700	CY	$ 7.50	$ 87,750.00
Structure 1	6400	CY	$ 7.50	$ 48,000.00
Planting Trees and Shrubs				
Dragons Tooth	3800	EA	$ 2.75	$ 10,450.00
Structure 4	1300	EA	$ 2.75	$ 3,575.00
Structure 3	2200	EA	$ 2.75	$ 6,050.00
Structure 2	2000	EA	$ 2.75	$ 5,500.00
Structure 1	3200	EA	$ 2.75	$ 8,800.00
Planting Seed Mix including Cover Crop				
Dragons Tooth	380	lbs	$ 65.00	$ 24,700.00
Structure 4	130	lbs	$ 65.00	$ 8,450.00
Structure 3	220	lbs	$ 65.00	$ 14,300.00
Structure 2	200	lbs	$ 65.00	$ 13,000.00
Structure 1	320	lbs	$ 65.00	$ 20,800.00

Construction Sub Total	$ 1,599,755.00
Design, Permitting, Construction Management (15%)	$ 239,963.25
Construction Contingency (20%)	$ 319,951.00
Sub Total	$ 2,159,669.25
Budget	**$ 2,160,000.00**