80% Design Update
Basis of Design Report

For

South St. Vrain Creek Restoration

February 2017

Submitted by:

Matrix DESIGN GROUP

In association with:

HK associates, inc.

ERO

otak

Prepared for:

Boulder County, Colorado

Boulder County

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1. Updates to 30% Plan Set and Preliminary Basis of Design Report

Matrix Design Group, along with Otak, THK, ERO, and Blue Mountain Consultants, are proud to submit this update to the 30% design documents developed in the Fall of 2016, *Preliminary Basis of Design Report for South St Vrain Creek at Hall Ranch and South St Vrain Creek Restoration at Hall Ranch 30% Design Plans (Matrix, 2016)*. This update is to allow for more refined designs of the project components along with support for permitting and development of construction documents. This report is to be included as an appendix to the 30% Preliminary Basis of Design Report.

New work since the 30% design includes:

- project specifications,
- applications for various permits,
- refined designs,
- updated Preliminary Basis of Design Report,
- attendance at additional stakeholder meetings,
- Operations and Maintenance Plan,
- Construction Quality Assurance Plan,
- refined final construction cost estimate,
- review of comments, and
- project management.

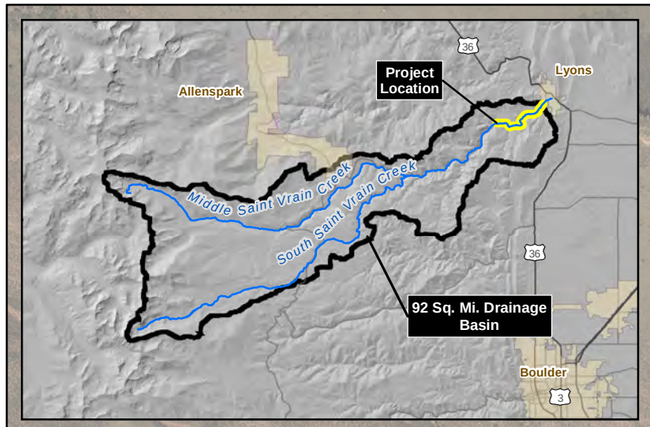
The contract also has additional tasks as authorized by Boulder County Parks and Open Space (BCPOS). Two tasks already authorized include supplemental field survey, and moving of the design limits upstream to the Andesite Bridge. Additional optional tasks include support for development of Conditional Letter of Map Revision (CLOMR) for floodplain permitting. At the time of this report this optional tasks have yet to be authorized.

The map on the following page shows extents of the proposed project. There are two reaches of the South St. Vrain that will be completed as part of the Emergency Watershed Protection (EWP) program noted as EWP 1 and EWP 2. The development of the 30% plans and reports covered a 3.2-mile reach of the South St Vrain Creek. At the onset of the project, EWP had delineated two project areas within this reach that were eligible for construction. The most upstream area was EWP #1, located in the central Hall Ranch area, while the downstream area, EWP #2, was located where Old St Vrain Road intersects with Highway 7.

a. Reason for Refined Designs

Refinement of the designs from 30% to 80% was completed to meet the goals of the EWP Program. The two EWP areas required intricate designs that were iterated multiple times based upon 2D hydraulic modeling. Below are a list of concerns and complex design issues that required evaluation as part of this design:

- EWP SSV1 and SSV2 are large, complex projects with multiple channels and changing topography.
- Robust design analyses were required to reduce uncertainty (which affected construction cost among other things) and increased the chance of success.
- Large wood structures were proposed for these projects, which required detailed calculations to successfully install logs at specific sites.
- Riffle structures were proposed and also required stability and sizing calculations for site specific conditions.



Longmont Diversion

Meadows / S. Ledge Diversion

Downstream Project Area

Upstream Project Area

Old St Vrain Road

Andesite Bridge Repairs

7

7

7

South St. Vrain Creek 80% Design Location Map

Boulder County, CO

N

0 850

Feet

FILE: G:\gis projects\Clear Creek Greenway\active\apps\80% Location Map.mxd, 12/14/2016, Scott Schreiber

- Remaining stakeholder coordination was anticipated to be significant based on levels of effort for the 30% design project; however, the Design Team budget only anticipated minimal participation. The fee estimate had limited stakeholder coordination (in the attached budget) to allow the Design Team to focus on technical needs. It is anticipated that BCPOS will supplement any needed stakeholder coordination.
- Survey used to develop 3.2 mile designs was based upon limited field survey and LiDAR from 2013, which had changed considerably in some areas.
- The EWP areas encompassed a total of at least 8 different channel alignments varying the form of the main channel to 1.5-year overflow channels and 5-year overflow channels.
- Critical floodplain benching designs were evaluated to develop accurate cut-fill estimates.
- EWP 1 is bounded by private properties and infrastructure on both sides of the river.
- EWP 1 has been an area of high contention since the flood with protection of private property and infrastructure.
- EWP 1 has a non-jurisdictional berm built by homeowners on BCPOS property that was thoroughly evaluated for floodplain impacts.
- EWP 1 had multiple sills along the corridor activated at various design elevations that all were developed.
- EWP 1 included a number of woody structures and sills that were designed to resist stream power effects through the corridor.
- EWP 1 had a large wetland area that could not be impacted but was made resilient.
- EWP 2 had a major water supply pipeline for the City of Longmont that was recently constructed and was protected.
- EWP 2 was bounded on the downstream end by a bridge.

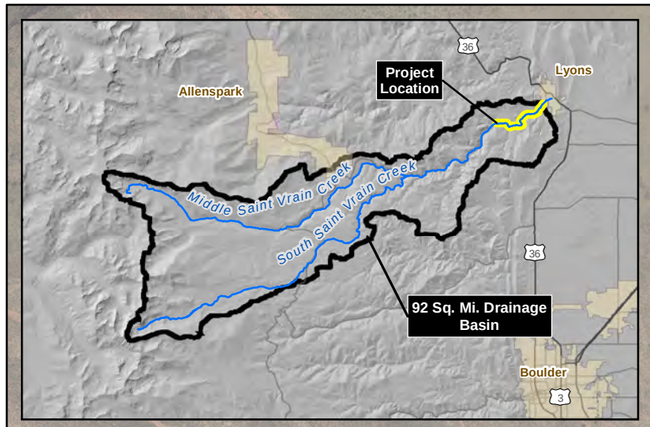
2. Modifications to Construction Limits

Both the upstream and downstream EWP project areas have been modified for this update. The modifications to EWP #1 and EWP #2 allowed for a more holistic design approach by having greater continuous sections of restoration along the South St Vrain Creek. The creek area in the vicinity of the Longmont Diversions did not include construction for multiple reasons discussed in the 30% Preliminary Basis of Design Report. Please see the map on the following page for location of the updated construction limits.

a. EWP #1

EWP #1 upstream construction limits were modified to extend upstream to the Andesite Bridge, approximately 900 feet. Currently, the Andesite Bridge is being design by JUB Engineers for Boulder County Transportation and construction is anticipated to start in the late summer 2017. Therefore, this project will extend upstream to the downstream extents of that project. This will allow for a continuous section of restoration to take place throughout the Hall Ranch project area. Furthermore, by moving the construction limits upstream, the Design Team is able to build upon the existing 30% designs by re-aligning the main creek through its pre-flood location. This will add increased sinuosity and reduce potential impacts to either highway 7 or Old St Vrain Road.

EWP #1 downstream construction limits were also modified to extend downstream for approximately 850 feet. Minimal work took place along the main alignment of the channel through the additional area. Modifications of the construction limits allowed for restoration of an overflow channel near Highway 7 to allow it to be activated on a more frequent basis.



Original EWP #2 Project Limits

Downstream Project

Longmont Diversion

Meadows / S. Ledge Diversion

Upstream Project Area

Old St Vrain Road

Andesite Bridge Repairs

Original EWP #1 Project Limits

7

7

7

South St. Vrain Creek 80% Design Modifications to Construction Limits

Boulder County, CO

N

0 850

Feet

FILE: G:\gis_projects\Clear_Creek_Greenway\active\apps\80% Modifications of Construction Limits.mxd 12/14/2016, Scott Schreiber

b. EWP #2

EWP #2 upstream construction limits were modified to extend upstream about 500 feet. Modifications of this construction limit allowed construction to take place further upstream on South St. Vrain Creek to a point were an existing overflow channel enters the main channel. This allowed for the addition of riffles, but also floodplain connectivity to reduce constriction and expansion issues at this confluence by removing deposited material.

EWP #2 downstream constructions limits were not modified, but remain at the Old St. Vrain Road bridge.

3. Supplemental Field Survey

The original survey of the South St Vrain Creek corridor for the 30% designs was preliminary and used to develop 30% conceptual designs. The original survey of the creek included only a thalweg survey and cross sections. This original survey was supplemented with LiDAR to develop a digital terrain model, covering both the channel bed and overbank areas.

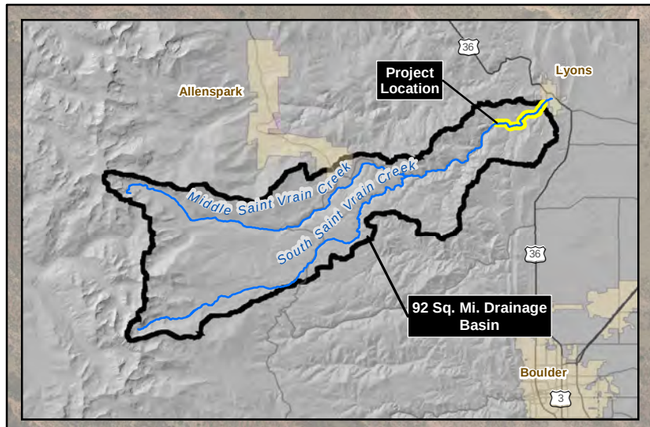
In furthering the design from 30% to 80%, the Design Team acquired additional survey throughout the modified construction limits. This complete survey included 1-foot topography acquired throughout the design areas along with various planimetrics, utilities and vegetation. This new survey supplemented the original and was integrated with the LiDAR to develop one holistic digital terrain model. Matrix's survey team performed the evaluation of the site, which took approximately three weeks to complete due to the large amount of vegetation in the area.

The updated survey did not include a boundary survey to evaluate existing right of ways, easements, or property lines for the entire project area. A boundary line survey was completed for parcels that were in close vicinity to the project limits to reduce impacts to nearby parcels not authorized for construction. The surveyed property lines are to be reviewed by the Boulder County Parks & Open Space Real Estate division prior to construction.

4. Updates to Modeling and Design

The overall intent and approach for 80% designs has not changed since the 30% designs were submitted. The majority of all aspects remain the same. Some adjustments to the main and overflow channel alignment have taken place. These changes were based upon reevaluation of the geomorphology along with comments from the DOLA and EWP Technical Assistance Teams. These changes increased the overall sinuosity of the creek while also moving the creek away from infrastructure in areas where it could be moved. Also, the overflow channels that referenced to either a 1.5- or 5-year storm event have been removed. These recurrence events were set at the 30% level to help convey information about how often they would be inundated. The design has become more refined to activate overflow channels based upon existing grades and feasibility of construction. All overflow channels still activate between a 1.5- and 5-year flood event.

Located in the Appendices is a map showing the variation from 30% to 80% designs. On the following page is a map outlining the updates to the 30% alignments of the main and overflow channels. The following subsections outline the design changes for each feature and the hydraulic modeling that took place.



Legend

- 80% MAIN CHANNEL ALIGNMENT
- 80% OVERFLOW CHANNEL ALIGNMENT
- 30% MAIN CHANNEL ALIGNMENT
- 30% OVERFLOW CHANNEL ALIGNMENT

7
County Rd 69
Red Gulch Rd
S St Vrain Dr
Old St Vrain Rd
Jasper Dr
7

South St. Vrain Creek 30% vs 80% Designs

Boulder County, CO

N

0 200 400

Feet

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5. Updates to 2D SRH Hydraulic Models

South St. Vrain Creek has many areas where overbank flows, at high discharges, can have many complex flow paths across the floodplain. Understanding the flow complexities through modeling is crucial, as the design relies on floodplain conveyance to reduce stream energy in the main channel and to moderate the incoming sediment load. Considering the inability of one-dimensional (1-D) hydraulic models to capture complex overbank flow characteristics, two-dimensional (2-D) models were developed. 2-D models compute transverse variations in water-surface elevations (WSE), velocities and momentum that are not captured in 1-D models. The results from a 2-D model are therefore much more comprehensive at defining hydraulic conditions in a complex hydraulic setting such as South St. Vrain Creek.

The Sedimentation and River Hydraulics – Two-Dimensional hydraulic model (SRH-2D) produced by Yong G. Lai of the Bureau of Reclamation in SMS 12.1.6 (Lai, 2008) was selected for the 2-D modeling of the Project Area. This program was selected for the powerful mesh creation capabilities of SMS and the stable computational engine that has been developed over three versions of the SRH-2D model.

The modeling performed for this project was done for the purposes of understanding channel and floodplain flow, as well as to support the design of channel structures and bedforms, bank treatments, and large wood structures.

a. Model Setup

Existing Conditions Model - An updated terrain model of the South St. Vrain Project Area was imported into SMS to develop the 2-D hydraulic model. The terrain model was developed from a combination of LiDAR data in the overbank areas and additional topographic survey. The additional survey allowed for an increase in the resolution of the terrain model in the wetted channel and increased detail in overbank locations misrepresented in the LiDAR data. All elevation data was extracted from this terrain to produce the mesh and for flow computations. Mesh generation began by defining the boundaries or breaklines of important features in the terrain. A combination of the hillshade terrain model and overlaid aerial imagery was utilized to delineate channel/side channel boundaries, floodplains, and roads. Meshes were developed using the paving mesh type, where the mesh is constructed using triangular elements between nodes. The mesh was inspected to meet details needed to capture in-channel variations and have quality non-irregular shaped mesh elements. The South St. Vrain mesh is shown below in Figure 1, and an example of the mesh overlaying the terrain model is presented in Figure 2.

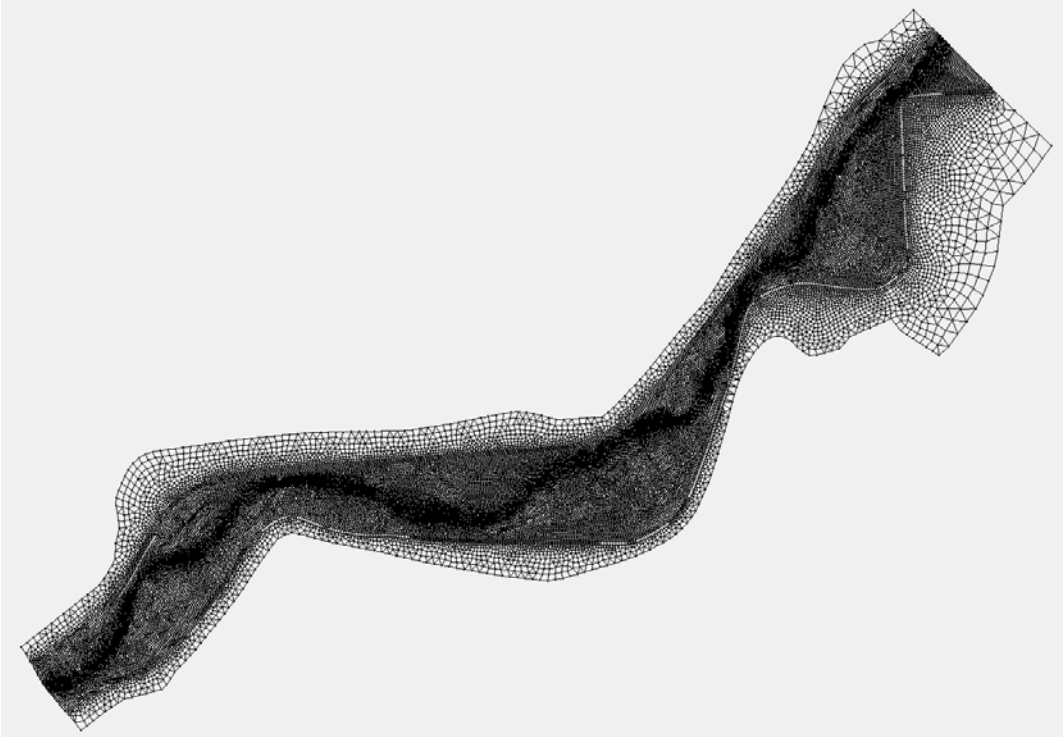


Figure 1. Screenshot of the mesh for the South St. Vrain model.

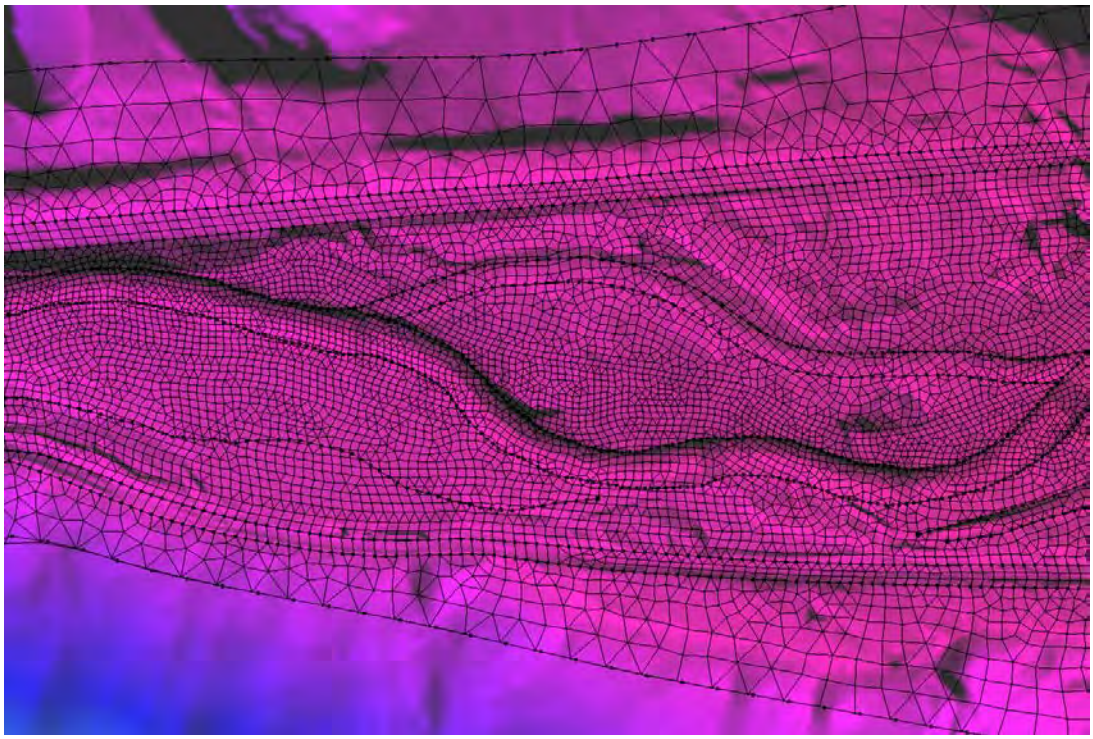


Figure 2. Example screenshot of the mesh overlaying the terrain model.

The boundary conditions for the 2-D model were set for the upstream and downstream edge of the mesh. An inlet-discharge time series curve was generated for the upstream boundary condition. The discharge is ramped up by doubling every half an hour of simulation until it reaches the design discharge of interest, and is then held constant (Figure 3). A rating curve of water surface elevation (WSE) versus discharge was chosen for the downstream boundary condition (Figure 4). The rating curve was derived from a pre-existing 1-D HEC-RAS (Otak, 2016) model that had WSE info for each design discharge tested in the model. The cross section that aligned with the downstream boundary was selected to extract the rating curve.

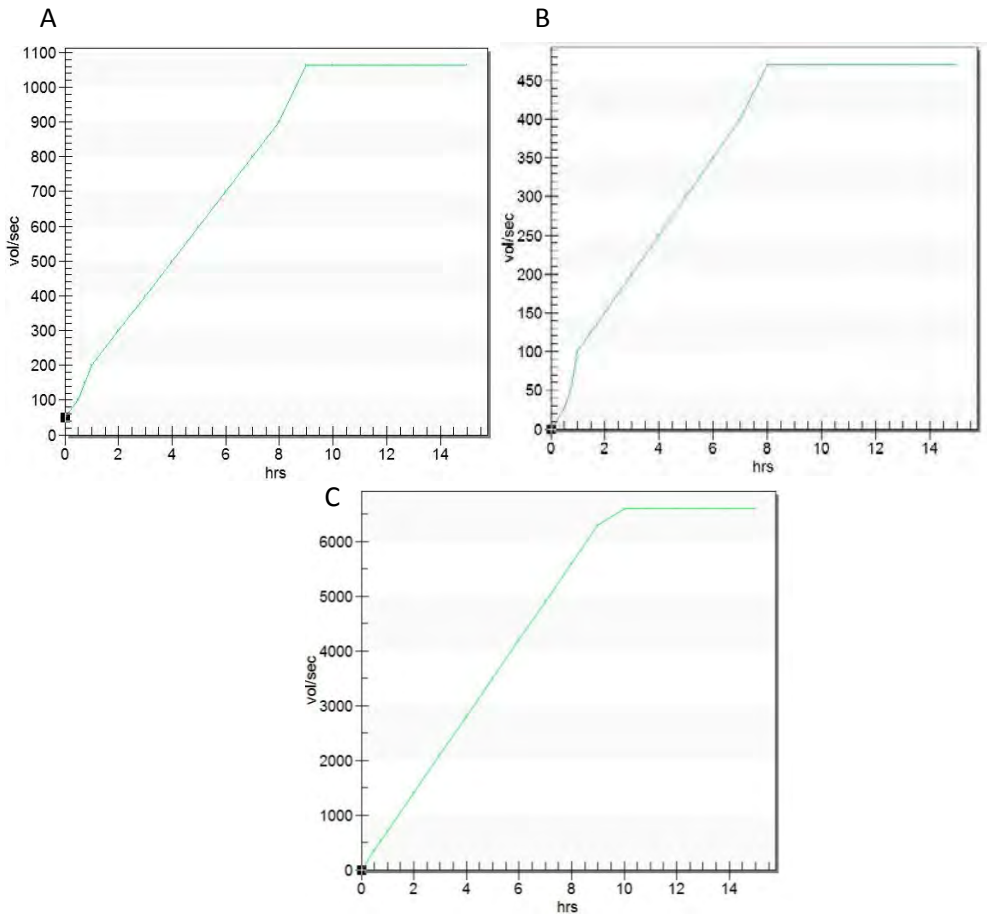


Figure 3. Upstream inlet discharge boundary condition for A) Q1.5, B) Q5, and C) Q100

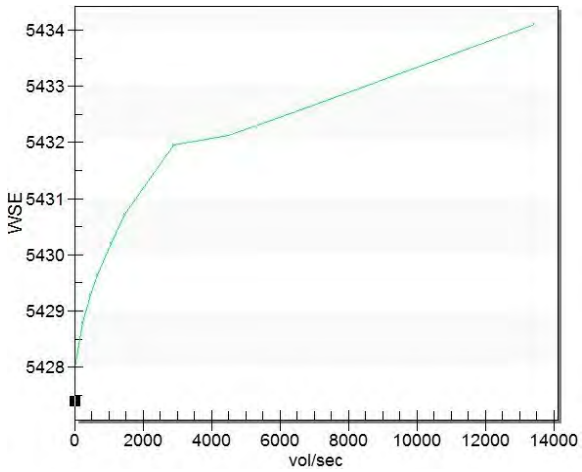


Figure 4. Downstream WSE rating curve boundary conditions from 1D HEC-RAS model.

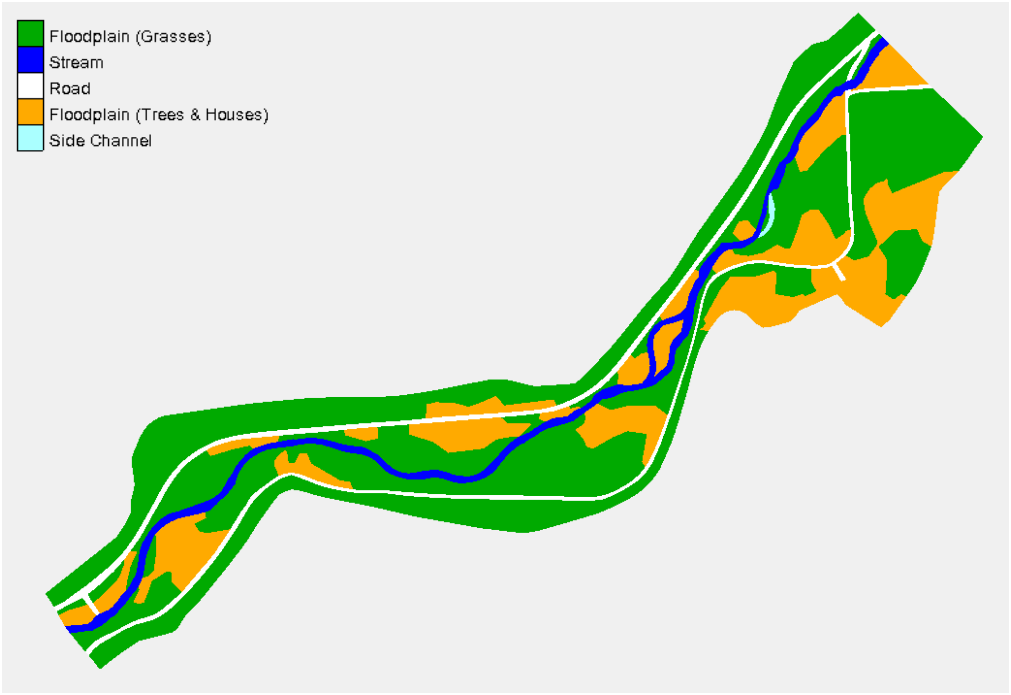


Figure 5. Roughness categories for the South St. Vrain model.

The areas delineated in the mesh generation process for the stream boundary, floodplain, and roads were used to assign roughness characteristics to be used in the 2-D computations. In addition, areas of high roughness, such as patches of trees and houses, were delineated using aerial imagery and assigned a separate roughness value. A Manning's n value of 0.045, 0.06, 0.08, and 0.025 were selected for the side channels, floodplain (grasses and shrubs), floodplain (trees and houses), and road roughness characteristics, respectively. The main channel Manning's n was selected as 0.035 for Q10 and above design flows and increased to 0.04 and 0.043 for the Q5 and Q1.5 to better represent the change in roughness characteristics at lower depths. The chosen values were held static and not vertically varied with increasing flows during the model simulations. The spatial reference for these categories used in the model is shown in Figure 5. These values were selected based on field observations, aerial photography, previous models, and engineering judgment in conjunction with calculations based on (Bathurst, 1985; Hey, 1979; Chow, 1959). The (Bathurst, 1985) and (Hey, 1979) equations along with previous models were used to select the in-channel roughness value. This value also took into account the increased ability of 2D models to account for bed forms and roughness at meander bends.

Existing conditions model results have been computed for the Q_5 and Q_{10} design discharges for at least 15 hours of simulation to reach a steady state solution for analysis.

Proposed Conditions Model - An updated proposed condition terrain model for South St. Vrain Creek was imported into SMS to develop the proposed conditions 2-D model. The same mesh generation process, boundary conditions methodology, and roughness values were used to set up the model for simulation.

Model results for the proposed conditions were computed for the $Q_{1.5}$, Q_5, Q_{10}, Q_{50}, and Q_{100} design discharges for at least 15 hours of simulation to reach a steady state solution for analysis and for comparison to the existing conditions output. The output WSE profiles for the $Q_{1.5}$, Q_5, and Q_{100} design discharges are shown below in Figure 6. Additional model outputs showing model performance and used for the refinement of the design can be found in Appendix G – Updated SRH Modeling of this report.

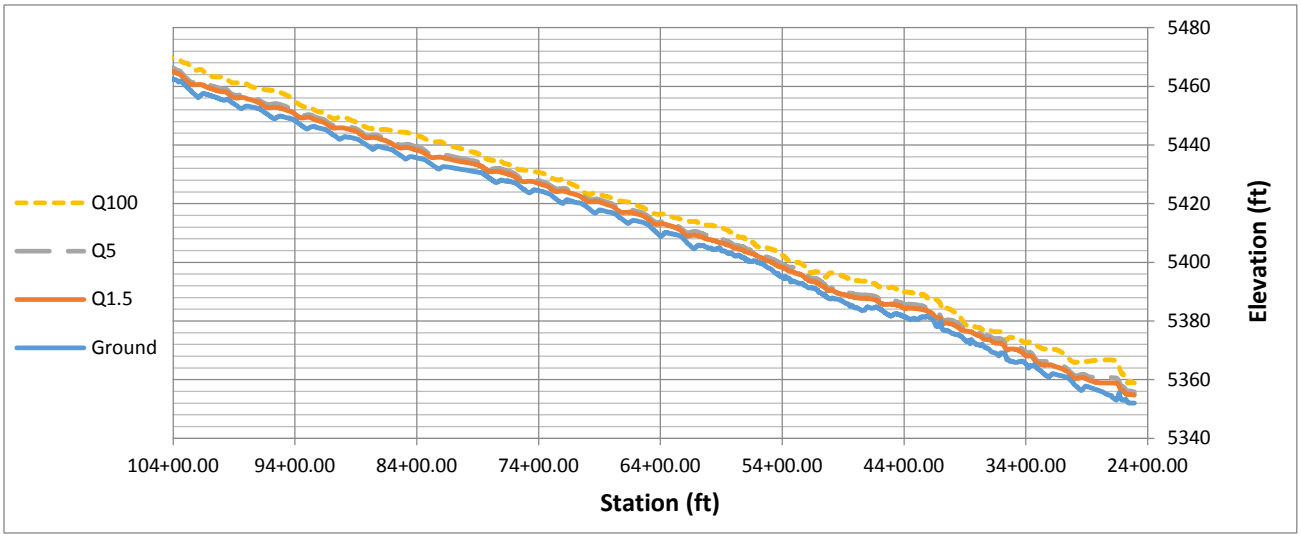


Figure 6. WSE profiles of Q1.5, Q5, and Q100 proposed conditions from SRH-2D model.

b. Simulation Results

The set-up process and simulations were matched for the existing and proposed models with the only difference being the terrain models. The upland and floodplain regions of the terrain models were extracted from existing 1-meter LiDAR data, and in-channel detail is extracted from survey data for the existing condition and through grading of design specifications for the proposed condition. The terrain models were inspected to meet the details necessary to capture in-channel flow variations and minimize irregular surface areas that can collect water in the model.

The outputs for the existing and proposed conditions model can be directly compared for each of the design discharges run in the simulations. The screenshots in Figure 7**.** show example outputs of SRH-2D for the Q_5 flow in a lower section of design interest along the South St. Vrain Creek for existing and proposed conditions (additional SRH-2D results can be found in Appendix G – Updated SRH Modeling). Model outputs were produced to evaluate the channel-floodplain connections and to support the analysis of various aspects of the design, including bank treatments, in-channel structures and bedforms, and large wood structures. The performance of the design relative to floodplain connectivity is elaborated upon below. Information relative to the design can be found in Section 6 Updates to Design of this report.

Floodplain Connectivity - Floodplain connectivity was identified as a primary project goal, with the main mode of reconnection being the use of floodplain benches and overflow channels. The reconnection to the floodplain was a goal of the design which can help mitigate the concentration of flood flows and reduce overall velocities in the channel that can help bring the sediment transport balance closer to an equilibrium state as discussed in the report covering the 30% design. The proposed design output shows greater floodplain connection and the initiation of several side channel flow paths as opposed to the existing conditions model (See figure 30). Some overflow channels were designed to be initiated at the $Q_{1.5}$ and others at higher flows approaching the Q_5 design discharge. The model outputs reflect these design intentions and suggest that overflow channels B, C and F are all initiated at the $Q_{1.5}$, and overflow channels A, D, and E are connected by the Q_5. However, it should be noted that the precise elevations and flows that the design overflow channels will be initiated at are restricted by the limitations and assumptions of the model. For example, the model is based on a fixed bed and does not account for changes in channel elevation or alignment due to erosion or deposition. We expect there to be significant bed mobilization at higher design flows which can alter the discharge and location at which overflow channels are initiated. The results for overflow channel initiation from the model are summarized below in Table 1.

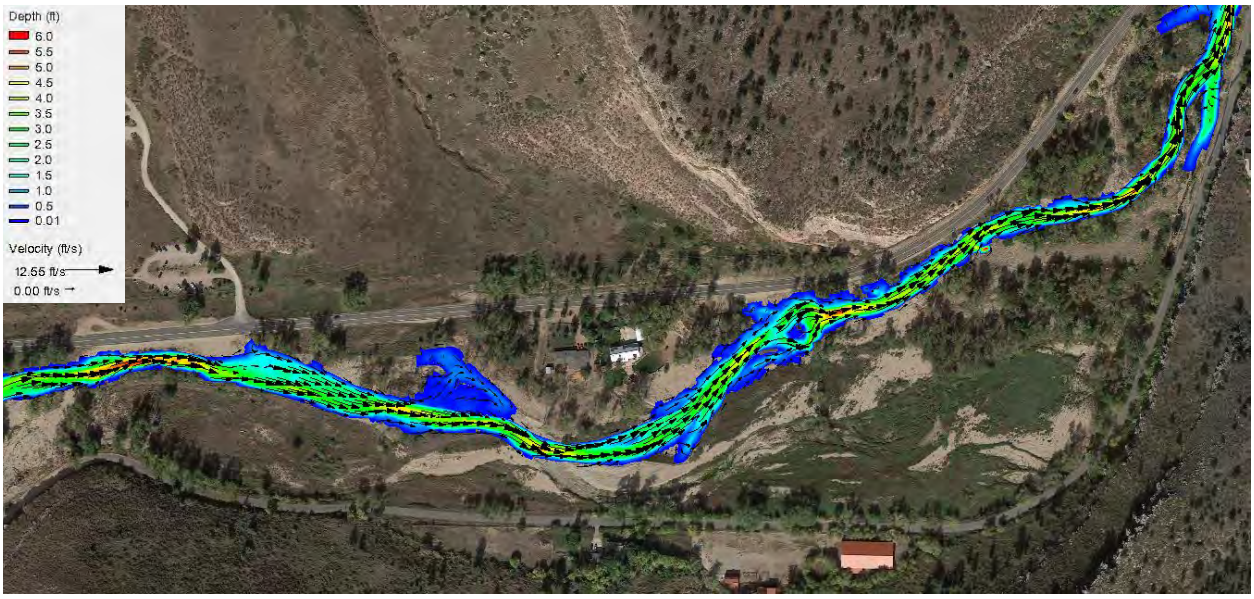


Figure 7. Q_5 depth contour map with velocity vectors for existing conditions.

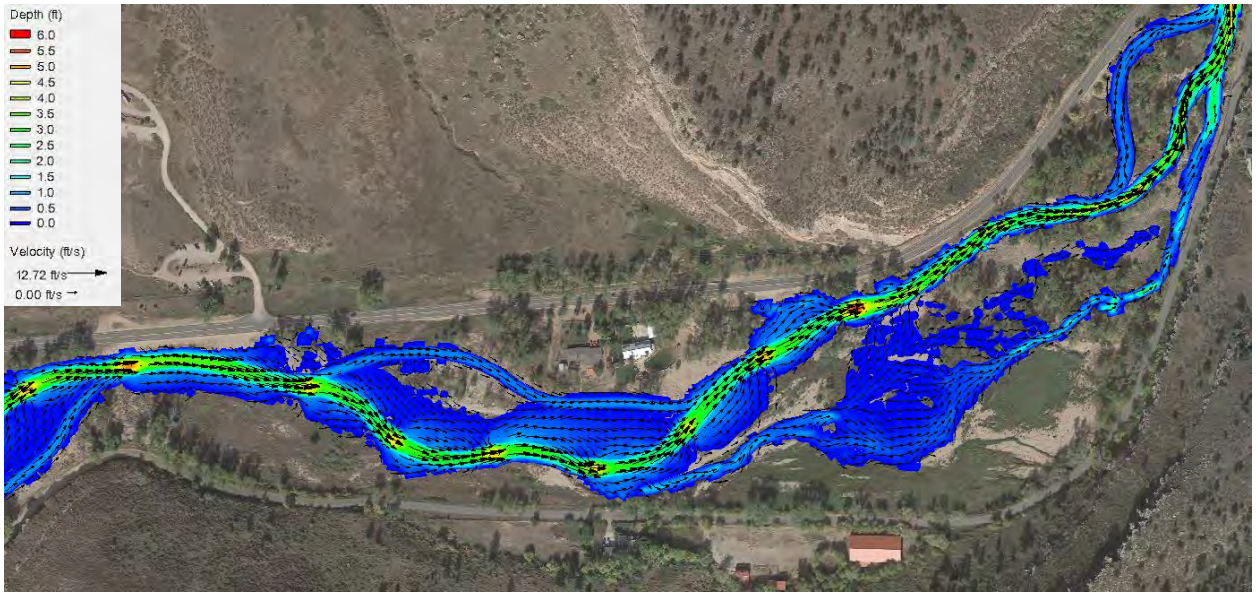


Figure 8. Q_5 depth contour map with velocity vectors for proposed conditions.

Table 1. Design discharges for which proposed overflow channels are initiated

Overflow Channel	Connected at $Q_{1.5}$	Connected at Q_5
A	No	Yes
B	Yes	Yes
C	Yes	Yes
D	No	Yes
E	No	Yes
F	Yes	Yes

6. Updates to Design

a. Main Channel

The proposed cross-section geometry was further refined to improve river function, flood conveyance, aquatic habitat, and facilitate fish passage. A multi-stage channel cross section was designed for a large portion of the project area to restore river processes (i.e., increase flood frequency in the overbank and bench areas, and deposit sediment along the margins of the channel) and accommodate flows from low flow to moderate flood events.

Hydraulic Geometry: Similar to the original design, the channel geometry was designed so the 1.5-year discharge would be conveyed by the bankfull channel. An additional hydraulic geometry equation for Front Range streams in Colorado (Livers and Wohl, 2015) was applied to refine the bankfull geometry (mean width and depth). This formula was used to estimate bankfull channel geometries based on other nearby fluvial streams, and it provides predictions for channel geometries within riffle-pool and riffle-run subreaches. After calculating channel geometries using this new formula, the results were combined with the previously performed hydraulic geometry analysis to develop a revised range of bankfull widths for the proposed main channel. As a result, the main channel design was revised to be slightly more narrow (typical bankfull widths decreased from 48 to 45) and slightly deeper (bankfull depth increased from 2.5 to 2.75 ft.). It is expected that the channel will adjust these dimensions naturally, as the watershed continues to respond to the flood. A summary of the proposed bankfull channel geometry is shown in Table 2. The equations, calculations, and results for these analyses can be found in Appendix H - Updated Design Calculations.

Table 2. Proposed Bankfull Channel Geometry

Description	Top Width (ft.)	Bed Width (ft)	Run Depth (ft.)	Low Flow Depth (ft.)	Max. Pool Depth (ft.)	Bank Slope (H:V)
Narrow Reach	40	28	3	1	4.5	3:1
Typical Reach	45	34.5	2.75	1	4	3:1
Wide Reach	50	40	2.67	1	3.67	3:1

Alignment and Profile: The proposed channel through the design reaches also had several major design revisions which have substantially increased the extent of proposed instream grading. Several subreaches have been realigned to increase sinuosity and reduce risks of flood damage to adjacent infrastructure. Adjustments are proposed to channel geometries and bed elevations through several other subreaches to increase flow conveyance capacity, alter sediment transport dynamics, and/or improve floodplain connectivity. In addition, more riffle structures are proposed to add hydraulic diversity to existing homogenous plane bed reaches and establish grade control. Some segments of the main channel have been left untouched in the final where the existing channel was considered stable and riffle features already are established.

Table 3. Summary of Main Channel (OFC) Revisions during the Final Design Phase

Station (Revised Alignment)		
Start	**End**	**Summary of Design Changes to Main Channel**
Bridge	33+53	Main channel has been realigned through the left floodplain. Two riffle structures are proposed.
33+53	44+49	No instream grading or riffle structures are proposed in this reach.
44+49	46+89	A riffle structure is proposed to increase hydraulic diversity.
46+89	60+04	No instream grading or riffle structures are proposed in this reach.
60+04	66+00	A new main channel alignment is proposed to replace a split flow path to improve fish passage during low flow and reduce bank erosion risk along Hwy 7. Two riffle structures are proposed.
66+00	76+30	The main channel will be realigned through the right floodplain to increase sinuosity. Four riffle structures are proposed.
76+30	82+00	The main channel in this narrow, incised reach will be widened to improve flow conveyance. The bed elevation will be slightly raised in the upper half of this reach to increase floodplain connectivity. One riffle structure is proposed.
82+00	94+00	A sinuous new channel alignment is proposed through a gap between the trees in the middle of the floodplain to reduce risk of flood damage to Hwy 7 and Old St. Vrain Road. Three riffle structures are proposed.
94+00	100+00	An over widened channel will be left in place to encourage sediment deposition between two proposed riffle structures.

b. Floodplain Connectivity Improvements

The proposed floodplain grading was further refined to improve floodplain function, increase high flow conveyance, and reduce the risk of flood damage to adjacent infrastructure.

Overflow Channels: Each of the overflow channels proposed during the 30% design phase have undergone significant revisions during the final design phase to further re-establish the overbank area as functioning floodplain and better protect assets in the vicinity. The old designation of 1.5-year and 5-year overflow channels has been removed from the final plans. Currently, all of the overflow channels are now hydraulically connected to the main stem at (or slightly above) the 1.5-year flow (Q1.5). Each overflow channel will have a typical top width of approximately 32 feet and a depth of 1.5 feet, although this geometry will vary in the field based on available space and proximity to protected trees. The only exception is the geometry of Overflow Channel E, which will be shaped to fit within the relatively narrow existing flow path. The proposed design revisions in the vicinity of each overflow channel described in

Table 4.

Floodplain Benches: The grading and extent of floodplain benches have also been significantly altered during the final design based on the updated topographic survey, modified channel alignments, and revised hydraulic modeling. Several overflow channels were converted into floodplain benches to achieve the same function of improving floodplain connectivity.

Table 4. Summary of Overflow Channel (OFC) Revisions during the Final Design Phase

OFC Alignment Name		
Final Design	**30% Design**	**Summary of Design Revisions to Overflow Channels**
A	6	Slight alignment shift near connections to revised main channel alignment. The channel will be hydraulically connected at flows that are slightly higher than Q1.5. An additional floodplain sill is proposed to provide grade control, and an overflow rock ramp has been added near the downstream confluence.
B	-	New overflow channel proposed in vicinity of old main channel alignment which will be hydraulically connected at Q1.5. This overflow alignment follows the pre-flood channel flow path. A floodplain sill is proposed to provide grade control near the upstream connection, and an overflow rock ramp will be constructed near the downstream confluence.
C	10	The lower portion of this overflow channel has been extended to further improve hydraulic capacity in the vicinity of the adjacent private home, although additional refinements to this alignment may be necessary prior to construction. The channel is now intended to be hydraulically connected at the Q1.5. An additional floodplain sill is proposed to provide grade control near the downstream end.
D	8 (Middle)	The alignment follows the plugged post-flood main channel alignment and provides a hydraulic connection to the extensive wetlands at slightly higher than Q1.5. The elevation of the relic channel will be raised to limit the volume of concentrated flow that will be conveyed by this overflow channel. A knickpoint stabilization structure is proposed to address a small existing headcut in the lower end of the channel.
Dminor	-	A new short spur is proposed near the downstream end of Overflow Channel D to connect to an existing headcut, which will be stabilized with a knickpoint stabilization structure.
E	8 (Lower)	The alignment follows an existing depression at the downstream end of the expansive wetland area. A series of headcuts will be stabilized with several knickpoint stabilization structures. Beaver dam analogs are proposed further downstream to expand backwater habitat.
F	12	Alignment remains unchanged, although the overflow channel will now be connected at a more frequent flow interval that is slightly higher than Q1.5. An overflow rock ramp will be constructed near the downstream confluence.
-	7, 9 & 11	Each overflow channel has been replaced with floodplain benching, which will provide essentially the same function of improving floodplain connectivity.
-	8 (Upper)	This overflow channel has been removed since it would have required extensive grading to achieve a relatively modest benefit to floodplain connectivity. Instead, the current design proposes to expand floodplain benching along the main channel.
-	15	New main channel alignment has been shifted to the general location of this old overflow channel path. Floodplain benching is proposed in the vicinity of the old main channel alignment.

c. Rock Structure Design

Two new types of rock structures were added during the final design stage: Overflow rock ramps and knickpoint stabilization structures. A description of both of these structure types is included in this section, along with a summary of the selected design rock mix gradations to construct all of the rock features proposed in this project.

Overflow Rock Ramps: The overflow rock ramps are intended to quickly transition the bed gradient at the downstream end of three overflow channels (A, B, and F) in order to create backwater habitat zones. These backwater habitat zones will be connected to the main stem at flows slightly higher than base spring runoff flows in order to create wetland hydrology. The rock crest and rock ramp are designed to reduce the risk of a headcut formation.

Knickpoint Stabilization Structures: The knickpoint stabilization structures were designed to resist headcut migration in the vicinity of the expansive wetland in the middle reach of the project. In addition to the series of knickpoint previously observed downstream of the wetland, two smaller headcuts were found near the upstream extent of the wetland. Rock grade control structures are proposed within three proposed overflow channel alignments (D, Dminor, and E) to halt knickpoint propagation which could threaten sensitive wetland habitat if left untreated. The channel in between the crests will be reconstructed using salvaged native streambed substrate. The pools and runs will have a layer of floodplain soils placed over native streambed substrate to promote the establishment of vegetation which will increase roughness.

Rock sizing: The rock crest of each proposed type of rock structure in the project was designed to remain stable during a flood event with a recurrence interval of 100 years. The rock faces and ramps of the instream and floodplain features were designed to remain stable during the 1.5 and 10-year flows, respectively. The required size of the rock was determined using Shield's method of incipient motion (NRCS, 2007), and informed by the SRH-2D hydraulic model for the project. The updated equations, calculations, and results for these analyses can be found in Appendix H - Updated Design Calculations.

Rock Design Mixes: For constructability, the rock mix gradations for the various rock structures proposed in the project were simplified to the four mixes shown in Table 5. Rock Mix Gradation Summary. The native streambed mix will be salvaged by stripping the top layer of substrate material from the main channel during construction. The coarser rock in the other mixes will preferentially be salvaged by the contractor during excavation through sorting and screening, although some imported material may be necessary for boulder size rocks.

Table 5. Rock Mix Gradation Summary

Rock Mix Type	Dmin	D16	D50	D84	Dmax
Native streambed mix	Sand	0.5 to 1	2 to 4	5 to 7	18 to 24
Coarse substrate mix	Sand	2	6	12	24
Floodplain sill mix	Sand	4	12	24	36
Boulder mix	24	30	36	42	48

d. Large Wood Structure Design

A total of sixty-four (64) large wood structures are proposed within the project limits to provide a variety of physical and ecological functions. Sixteen (16) multi-log instream large wood structures and nineteen (19) individual rootwad logs are proposed to enhance aquatic habitat and deflect flows away from actively eroding banks. An additional twenty-nine (29) large wood structures are proposed on the floodplain to increase overbank roughness and improve riparian habitat. A total of 210 key logs (>12" diameter at breast height) are proposed in the project reaches.

Instream Large Wood Structures: Three types of log configurations, referred to as Type 1, 2, and 3 Large Wood Structures, are being proposed in locations suitable for large wood accumulations. Each type of structure is designed with the purpose of increasing hydraulic diversity, scouring pool habitat, and stabilizing banks by deflecting flows. These structures are proposed in areas where pools are expected to form naturally, and they are expected to encourage bed scour to increase pool depth and provide cover habitat. Each structure will consist of 8 logs. Footer logs will be placed at the toe of the bank to reduce the risk of the structure being undermined by scour. Rootwads will be set flush with the streambank to reduce the entrapment hazards to potential boaters. The Type 1 and 2 structures have digger logs which extend into the channel and direct overtopping flow towards the center of the channel. The Type 1 structure is placed in reaches with lower banks, while the Type 2 structure is best suited for reaches with taller banks. The Type 3 structure has a vertically placed log that will mimic a natural snag and will serve as perching habitat for birds. Each type of structure is designed to allow some flexibility when selecting individual log sizes in the field.

The Type 4 structure consists of a single log placed at the toe of the bank with the rootwad exposed to flow. This type of structure can be placed in areas with low banks and they are often positioned next to other large wood structures to extend the bank coverage by deflecting flow in meanders that are especially susceptible to erosion.

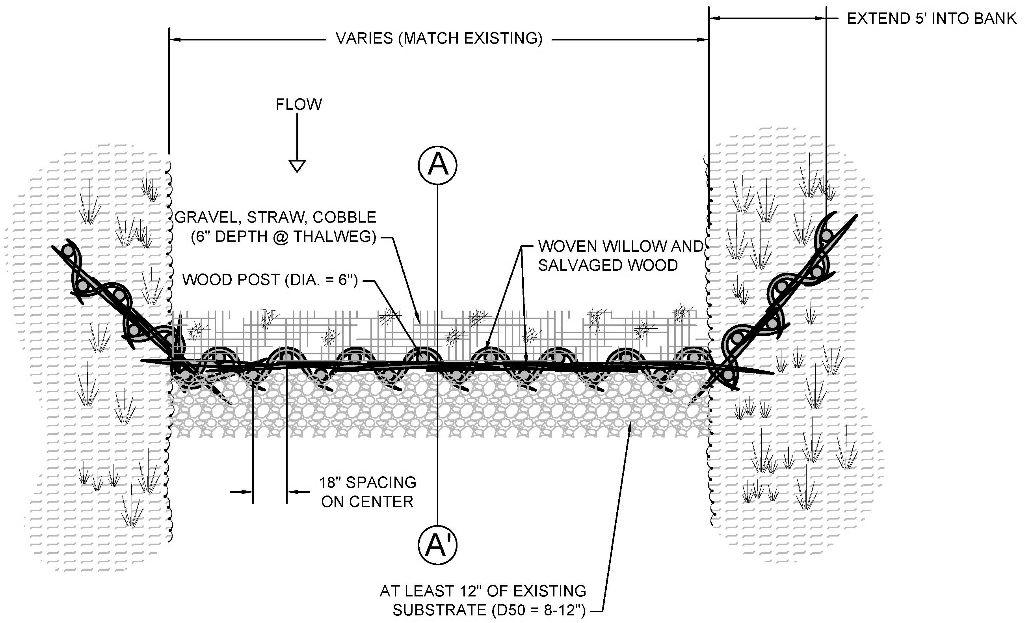
Floodplain Large Wood Structures: The Type 5 and 6 structures are proposed in the floodplain to increase floodplain roughness and improve terrestrial habitat. The Type 5 structures are proposed in relatively wide floodplain areas that have minimal existing vegetation. The Type 6 structures are intended to mimic natural flood debris wracked between groups of existing trees on the floodplain. Both of these structures will mostly be constructed with large wood material salvaged during site clearing and tree removal. The final quantity and configurations may vary based on the availability of suitable large wood material.

Anchoring: All large wood structures will be anchored using natural materials to remain stable during a storm event with a 50-year recurrence interval. In order to resist hydrodynamic forces, the first 5 types of structures will be stabilized with soil ballast through partial burial. Additional boulders will be used to increase the ballast weight where necessary to counteract buoyancy. The Type 6 structure consists of relatively small logs (less than 11-inch diameter) that are pinned between existing trees on the floodplain, and these structures are stabilized through complex geometries that trap the logs between these fixed features. A preliminary stability analysis was performed for each type of structure. Detailed structure stability evaluations will be completed once a full list of wood material is provided since the calculations are dependent on the specific wood characteristics (i.e., species, diameter, length).

e. Beaver Dam Analogues

Some of the project area prior to the flood was known to hold otter and beaver in small ponds throughout the corridor. A couple of historic beaver ponds were destroyed in the 2013 flood that provided a great wealth of habitat and biodiversity thorough the area. These beaver ponds will be reproduced with the use of Beaver Dam Analogues (BDA) installed as part of this project. BDAs are manmade structures that mimic beaver dams that are found in nature. These BDA' will span the small wetland area along Old St Vrain Road to allow small ponding of water to increase habitat.

BDAs are composed out of 6 to 12-inch diameter posts that are hammered into the ground as the base of the structure. Willows and other branches are then interwoven through the posts to act as a natural dam. The area near the posts are then backfilled with existing stream substrate to reduce percolation through the lower portions of the dam. These BDA's as part of this project will be 2.5 feet tall with posts buried approximate 5 feet into the ground. These are small structures, composed of natural materials to mimic pre-flood habitat.



BEAVER DAM ANALOGUE PLAN VIEW
NOT TO SCALE

Figure 9. Beaver Dam Analogue

f. Soil Conditioner

Immediately following the 30% Design, THK initiated a soil test by Triton Environmental. Soil samples were taken from three sites within the project area. Samples were taken from the following locations:

1. Old St. Vrain Bridge (Approximately STA: 98+00 of the proposed Main Channel alignment)
2. Existing Large Wetland (Approximately STA: 60+00 of the proposed Main Channel alignment)
3. Downstream Over Flow Channel (Approximately STA: 53+50 of the proposed Overflow Channel E)

Soil Test results show that the soils in selected areas are over 90% sand. This result dictated the soil conditioner treatments created as part of the 80% Design. THK worked with BCPOS to develop a soil conditioner for riparian areas and areas to be seeded with combined seeding and seeding (upland):

This soil conditioner that were developed are as follows:

Riparian Soil Conditioner:

- Fertilizer – Biosol Forte or approved equal applied at 1500-2000 lbs./acre
- Organic Weed Free Compost – Applied at six (6) cubic yards (CY) per 1,000 square feet
- Supplemental mycorrhizae – Quantum Growth VSC applied at 2 gal/acre and Quantum Growth Light applied at 1 gal/acre

Combined Seeding and Seeding (Upland) Soil Conditioner:

- Fertilizer – Biosol Forte or approved equal applied at 1500-2000 lbs./acre
- Organic Weed Free Compost – Applied at three (3) cubic yards (CY) per 1,000 square feet
- Supplemental mycorrhizae – Quantum Growth VSC applied at 2 gal/acre and Quantum Growth Light applied at 1 gal/acre

Biochar shall also be incorporated into the soil conditioner for 9,109 sf of Overflow Channel F at a rate of 5% by volume.

g. Revegetation

Revegetation measures and extents have changed based on new channel alignments and revised area of disturbance. All areas disturbed during the construction process shall be reseeded and planted with native trees and shrubs.

The planting palette and sizes of trees and shrubs was refined by BCPOS based on the plant material and sizes available through their RFP for Plant Material. Current sizes include, 14 inch containers, 40 cubic inch containers and poles.

Quantities of plant material available was provided by BCPOS Restoration Ecologist and submitted to THK in the following document:

South St. Vrain Creek	Boulder County Plant Materials RFP Quantities	Species with no contract	THK Quantities	Difference	New Numbers	
Scientific Name						
RIPARIAN SHRUBS AND TREES						
ACER GLABRUM			192	192	0	remove
ACER NEGUNDO		222				
ALNUS INCANA SSP. TENUIFOLIA	148		315	167	315	get more?
AMELANCHIER ALNIFOLIA		148	236	236	0	remove
AMORPHA FRUTICOSA			408	408	300	try and secure
BETULA OCCIDENTALIS	148		32	-116	148	use full amount
CELTIS RETICULATA						
CHRYSOTHAMNUS NAUSEOSUS			408	408	300	try and get 300
CORNUS SERICEA SSP. SERICEA	148		145	-3	148	
CRATAEGUS ERYTHROPODA						
CRATAEGUS MACRACANTHA VAR. OCCIDENTALIS						
HUMULUS LUPULUS VAR. NEOMEXICANUS	111		408	297	0	
POPULUS ANGUSTIFOLIA	247		285	38	285	
POPULUS DELTOIDES VAR. MONILIFERA	247		412	165	325	
PRUNUS AMERICANA	296		134	-162	296	
PRUNUS VIRGINIANA VAR. MELANOCARPA	370		207	-163	370	
RIBES AUREUM	148		1043	895	148	reduce
RIBES CEREUM	148		604	456	148	reduce
RIBES INERME			227	227	0	remove
ROSA WOODSII	370		620	250	370	reduce
SALIX AMYGDALOIDES	247		83	-164	125	in between
SALIX BEBBIANA		74				
SALIX EXIGUA	2630					
SALIX IRRORATA	1850					
SYMPHORICARPOS ALBUS			620	620	200	get some from CSFS seed
SYMPHORICARPOS OCCIDENTALIS	1480		620	-860	620	CSFS can't provide full amount
TOTALS	**4108**		**6999**	**2891**	**4098**	
WETLAND						
ASCLEPIAS INCARNATA	295		350	55		
ASCLEPIAS SPECIOSA	312		350	38		
CALAMAGROSTIS CANADENSIS			350	350		
CAREX EMORYII	1560		350	-1210		
CAREX NEBRASCENSIS	585		350	-235		
CAREX PELLITA	585		350	-235		
CAREX PRAEGRACILIS	195		349	154		
ELEOCHARIS PALUSTRIS			349	349		
GLYCERIA GRANDIS	195		349	154		
HELIANTHUS NUTTALII	312		349	37		
JUNCUS BALTICUS	936		349	-587		
JUNCUS TORREYI	195		349	154		
PANICUM VIRGATUM	1170		349	-821		
SCIRPUS MICROCARPUS			349	349		
SPARTINA PECTINATA	1170		349	-821		
VERBENA HASTATA	290		349	59		
TOTALS	**7,800**		**5590**	**-2210**		

THK worked with BCPOS Restoration Ecologist to finalize this plant list resulting in the following species and quantities shown below:

SOUTH ST. VRAIN CREEK PLANTING SCHEDULE:

SOUTH ST. VRAIN CREEK PLANTING
LARGE TREES AND SHRUBS

COMMON NAME	BOTANICAL NAME	SIZE	SPACING	REVEGETATION AREA	% COVERAGE (PER AC)	QTY (PER AC)	QTY (TOTAL)
TREES							
Water Birch	Betula occidentalis	40 Cl	AS SHOWN				148
Narrowleaf Cottonwood	Populus angustifolia	14 INCH/Pole	AS SHOWN				247
Plains Cottonwood	Populus Deltoides Var. Monilifera	14 INCH/Pole	AS SHOWN				325
Peach Leaf Willow	Salix amygdaliodes	40 Cl	AS SHOWN				125
						TOTAL:	845
EVERGREEN TREES							
Ponderosa Pine	Pinus ponderosa	40 Cl	AS SHOWN				55
						TOTAL:	55
SHRUBS							
Thinleaf Alder	Alnus incana ssp. Tenuifolia	40 Cl	AS SHOWN				252
Red-Osier Dogwood	Cornus sericea Ssp. Sericea	40 Cl	AS SHOWN				148
American Plum	Prunus americana	40 Cl	AS SHOWN				296
Chokecherry	Prunus virginiana Var. Melanocarpa	40 Cl	AS SHOWN				370
						TOTAL:	1066

SMALL SHRUBS

Leadplant	Amorpha fruiticosa	40 Cl	6' O.C.	RIPARIAN/UPLAND	1.64%	20	337
Rubber Rabbitbrush	Chrysothamnus nauseosus	40 Cl	6' O.C.	RIPARIAN/UPLAND	1.64%	20	337
Golden Currant	Ribes aureum	40 Cl	6' O.C.	RIPARIAN/UPLAND	0.81%	10	167
Wax Currant	Ribes cereum	40 Cl	6' O.C.	RIPARIAN/UPLAND	0.81%	10	167
Wood's Rose	Rosa woodsii	40 Cl	6' O.C.	RIPARIAN/UPLAND	2.02%	24	416
Common Snowberry	Symphoricarpos albus	40 Cl	6' O.C.	RIPARIAN/UPLAND	1.09%	13	224
Western Snowberry	Symphoricarpos occidentalis	40 Cl	6' O.C.	RIPARIAN/UPLAND	3.39%	41	697
				*11.40% COVERAGE PER ACRE		TOTAL:	2345

PERENNIAL (TUBELINGS)

Marsh Milkweed	Asclepias incarnata	10 Cl	2' O.C.				85
Showy Milkweed	Asclepias speciosa	10 Cl	2' O.C.				85
Bluejoint Reedgrass	Calamagrostis canadensis	10 Cl	2' O.C.				350
Emory's Sedge	Carex emoryii	10 Cl	2' O.C.				1210
Nebraska Sedge	Carex nebrascensis	10 Cl	2' O.C.				350
Woolly Sedge	Carex pellita	10 Cl	2' O.C.				235
Clustered Field Sedge	Carex praegracilis	10 Cl	2' O.C.				154
Creeping Spikerush	Eleocharis palustris	10 Cl	2' O.C.				349
American Mannagrass	Glyceria grandis	10 Cl	2' O.C.				170
Nuttall's Sunflower	Helianthus nattalii	10 Cl	2' O.C.				37
Baltic Rush	Juncus balticus	10 Cl	2' O.C.				595
Torrey's Rush	Juncus torreyi	10 Cl	2' O.C.				154
Switchgrass	Panicum virgatum	10 Cl	2' O.C.				870
Panicled Bulrush	Scirpus microcarpus	10 Cl	2' O.C.				349
Prairie Cordgrass	Spartina pectinata	10 Cl	2' O.C.				860
Blue Vervain	Verbena hastata	10 Cl	2' O.C.				64
						TOTAL:	5917

i. Seeding:

The seeding mixes for this project have not changed, since 30%, but their application has been more accurately defined. Seeding (Riparian) shall only be applied to disturbed areas less than 1.5' above the base flow water surface elevation (BFWSE). Combined Seeding (30% Riparian and 70% Upland) shall be applied to disturbed areas between 1.5' to 3' above the BFWSE and all areas are to be planted with Willow Cuttings and Mature Willows. Seeding (Upland) shall be applied to disturbed areas 3' above the BFWSE.

THK reviewed the 80% grading plans and 100 foot cross sections provided by Matrix to accurately understand the elevations of the floodplain benches above the BFWSE. The 100 foot cross sections were not available at the 30% design level. Based on this new information the areas of revegetation were updated.

ii. Perennial Tubelings:

Perennial Tubelings shall be installed in newly graded backwater areas located at Over Flow Channels A, B, and F. Additional Perennial Tubelings were planted in Over Flow Channel E in existing low lying areas. All Perennial Tubelings shall be planted at 2 foot on-center per BCPOS recommendations.

iii. Willow Cuttings and Mature Willows:

Due to increased pressure on Willow populations, our team was instructed by BCPOS to reduce the amount of Willows used on this project and find creative ways to use them. THK then worked with BCPOS, to develop a method to harvest both Willow Cuttings and Mature Willows that would be removed during clearing and grubbing. Willow Cuttings will be removed from the approved mature willow plants leaving a minimum of 12 inches above ground. The rootball and remaining plant material will be removed and transplanted into locations shown on plans.

iv. Wetland Sod:

Wetland sod was not included in the 80% design. The construction schedule did not fall within the recommended planting period and BCPOS recommended it be removed and perhaps installed at Over Flow Channel C at a later date.

v. Protection Fence:

Beaver Protection Fence and Vole Protection Fence were added to the 80% design at the request of BCPOS. Beaver Protection Fence shall be installed around all cottonwoods, alders and birch. Vole Protection Fence shall be installed around all cottonwoods, alders, birch, chokecherry, plum and dogwood.

vi. Bioengineering and Bank Stabilization Measures:

Bioengineering and Bank Stabilization Measures have been updated as part of the 80% design.

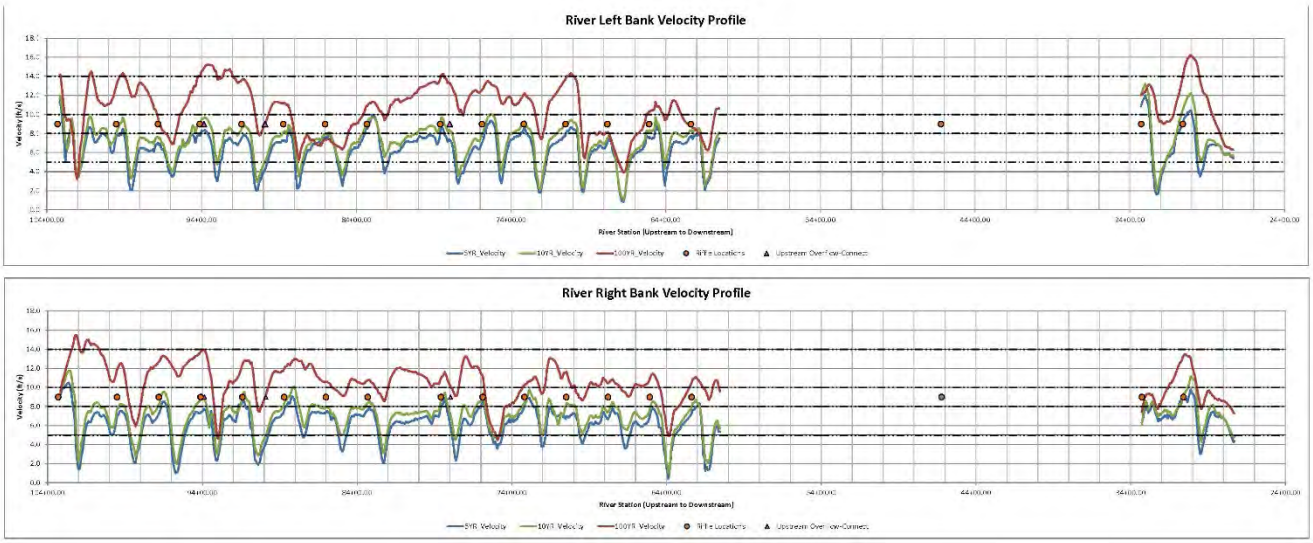
Bioengineering and Bank Stabilization Measures now only include:

- Willow Cuttings in Existing Riprap
- Willow Cuttings in Cobble Toe
- Fascines
- Boulder Toe

The design details of the Willow Cuttings in Cobble Toe and Boulder Toes were refined based on new calculations by OTAK. Size of material and tie into the bank/creek bed was recommended by OTAK. These recommendations were incorporated into the final details for both the Willow Cuttings in Cobble Toe and Boulder Toes.

The design of the Fascines was modified between 30% and 80%. Fascines shall consist of 2 layers: a core and an outer layer. The core of the Fascine shall be living or dead woody material harvested during the clearing and grubbing process and will vary between 1" to 4" in diameter and be a minimum of 5 feet long. The outer layer of the Fascine shall be live willow cuttings at least 3/8-inch diameter or larger and a minimum 5 feet long with the bottom end cut off at an angel and the top end with a straight cut.

Using the 2D SRH Model, OTAK developed profiles of each bank along the Main Channel. OTAK created graphs showing the proposed potential velocities and shear stresses along each profile. This information along with onsite observation and professional assessments determined the placement of bioengineering measures.



The total amount of Bioengineering and Bank Stabilization Measures included in the 80% Design is located on the following page:

Bank Stabilization: Bioengineering Treatments

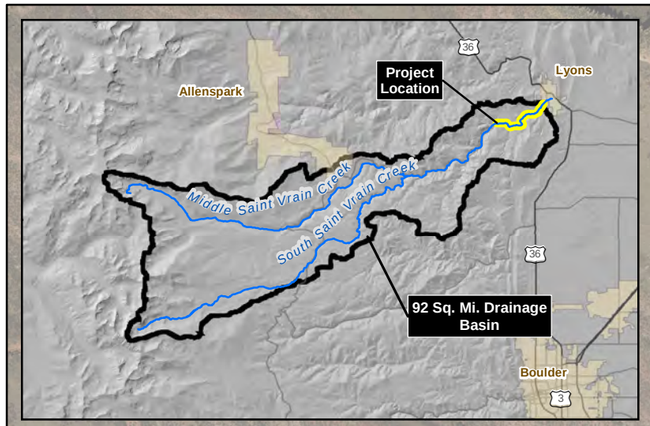
February 3, 2017

Item #	Bioengineering Treatment	Station Location		Left Bank	Right Bank	Total Length (L.F.)	SRH 2D Model Velocity (FT./S)	Initial Premissible Velocity (FT./S)	Established Premissible Velocity (FT./S)
		Station Start	Station End						
		Main Channel 102+00 - 88+50							
1	Willow Cuttings in Cobble Toe	99+40	97+00	-	R	260	4 to 10	5 to 10	10+
2	Willow Cuttings in Ex. Riprap	96+24	93+23	L	-	288	4 to 10	5 to 10	12+
3	Boulder Toe	94+30	92+94	L	-	149	10 to 16	14 to 18	18+
4	Willow Cuttings in Cobble Toe	92+34	92+24	L	-	10	4 to 10	5 to 10	10+
5	Willow Cuttings in Cobble Toe	91+29	88+50	-	R	297	4 to 10	5 to 10	10+
		Main Channel 88+50 - 76+50							
6	Willow Cuttings in Cobble Toe	88+50	87+23	-	R	134	4 to 10	5 to 10	10+
7	Willow Cuttings in Cobble Toe	82+25	82+80	L	-	256	4 to 10	5 to 10	12+
8	Willow Cuttings in Ex. Riprap	82+75	80+80	L	-	256	4 to 10	5 to 10	12+
9	Willow Cuttings in Cobble Toe	77+93	76+50	L	-	153	4 to 10	5 to 10	10+
		Main Channel 76+50 - 66+50							
10	Willow Cuttings in Cobble Toe	77+62	75+12	L	-	141	4 to 10	5 to 10	10+
11	Fascines	75+12	74+41	L	-	67	4 to 10	5 to 8	8 to 10+
12	Willow Cuttings in Cobble Toe	75+65	71+40	-	R	447	4 to 10	5 to 10	10+
13	Willow Cuttings in Cobble Toe	72+21	72+11	L	-	10	4 to 10	5 to 10	10+
14	Willow Cuttings in Cobble Toe	71+66	71+56	L	-	10	4 to 10	5 to 10	10+
15	Boulder Toe	70+80	66+50	-	R	465	10 to 16	14 to 18	18+
		Main Channel 66+50 - 54+00							
16	Boulder Toe	66+50	66+00	-	R	47	10 to 16	14 to 18	18+
17	Fascines	65+20	64+64	L	-	104	4 to 10	5 to 8	8 to 10+
18	Willow Cuttings in Cobble Toe	64+24	64+14	L	-	10	4 to 10	5 to 10	10+
19	Willow Cuttings in Cobble Toe	63+81	63+71	L	-	10	4 to 10	5 to 10	10+
20	Willow Cuttings in Cobble Toe	62+30	60+71	L	-	169	4 to 10	5 to 10	10+
21	Willow Cuttings in Cobble Toe	56+84	56+74	L	-	10	4 to 10	5 to 10	10+
22	Willow Cuttings in Cobble Toe	56+36	56+26	L	-	10	4 to 10	5 to 10	10+
		Main Channel 54+00 - 44+00							
23	Willow Cuttings in Cobble Toe	52+28	52+18	-	R	10	4 to 10	5 to 10	10+
24	Willow Cuttings in Cobble Toe	51+66	51+56	-	R	10	4 to 10	5 to 10	10+
		Main Channel 36+50 - 30+75							
25	Willow Cuttings in Cobble Toe	34+43	34+33	-	R	10	4 to 10	5 to 10	10+
26	Willow Cuttings in Cobble Toe	33+74	33+64	-	R	10	4 to 10	5 to 10	10+
27	Willow Cuttings in Cobble Toe	32+46	32+36	-	R	10	4 to 10	5 to 10	10+
28	Willow Cuttings in Cobble Toe	32+10	32+00	-	R	10	4 to 10	5 to 10	10+
		Main Channel 30+75 - 26+00							
28	Willow Cuttings in Cobble Toe	29+75	29+65	-	R	10	4 to 10	5 to 10	10+
29	Willow Cuttings in Cobble Toe	29+35	26+80	-	R	245	4 to 10	5 to 10	10+
		Overflow Channel A							
30	Willow Cuttings in Cobble Toe	03+56	03+36	L	-	19	4 to 10	5 to 10	10+

Total Willow Cuttings in Ex. Riprap	544
Total Willow Cuttings in Cobble Toe	2261
Total Boulder Toe	661
Total Fascines	171

Notes:

1. All bioengineering treatments and assicated permissable vocities were sourced from references in the Manual of Bioengineering Treatments for Colorado Streams.
2. Permissable velocity for Willow Stakes in Cobble Toe was approximated by using the information from Table 4 - Permissible Shear and Velocity for Slected Lining Materials (Fischenich, 2001) and Table 5 - Permissible Shear Stress and Velocity Levels for Streambank Bioengineering Treatments found in the Living Streambanks: A Manual of Bioengineering Treatments for Colorado Streams (Living Streambanks, 2016)



Legend

- 80% MAIN CHANNEL ALIGNMENT
- 80% OVERFLOW CHANNEL ALIGNMENT
- FLOODPLAIN BENCHING
- RIFFLES AND SILLS

S St Vrain Dr

Old St Vrain Rd

County Rd 69

Red Gulch Rd

Jasper Dr

7

7

South St. Vrain Creek 80% Designs

Boulder County, CO

N

0 200 400

Feet

FILE: G:\gis_projects\South_St_Vrain\active\apps\80_Percent_Designs.mxd, 12/18/2016, Scott_Schreiber

7. Specifications

Specifications were developed that are precise narrative descriptions that detail dimensions, type of materials used, qualifications and important requirements necessary to build a project to the intent of the designer. These specifications cover aspects of the work to be completed by any contractor, i.e. each pay item has a corresponding specification. The EWP technical assistance team has chosen to use CDOT style specifications for this project. The specifications generated as part of this project will be included with the Project Manual, along with information for bidders including notice to bid, contract language and summary of approximate quantities.

a. Project Specific Specifications

Project specifications were based upon guidance provided from the EWP Technical Assistance Team. The EWP construction eligible projects were requested to use CDOT style specifications so that projects across the Front Range could build upon existing specifications. Therefore, a set of project special provisions were developed for this project that built upon the CDOT system. This means that quantities and bid item codes will be based from the existing CDOT system with modifications. There are multiple project specific provisions included for detailed stream restoration techniques not normally developed in CDOT projects. These detail provisions should be reviewed careful for design intent.

8. Permitting

A number of permits are required for construction. The permits range from biological and ecological assessments to evaluated hydraulic conditions of the floodplain. Permits are being or need to be acquired from U.S. Army Corps of Engineers (USACE), Environment Protection Agency (EPA), Colorado Department of Public Health (CDPHE), Boulder County, US Fish and Wildlife Service (USFWS), and Colorado Department of Transportation (CDOT). Some of the permits will be acquired with assistance by the EWP Team. Due to modification of our construction limits, permits outside the EWP boundary had to be acquired directly by our Project Team. Each permit is discussed in detail in the following subsections. Included with this report are Appendices containing the preliminary permit application and supporting documentation.

Since this is a stream restoration project and there are a number of projects similar to this one currently planned for construction in 2017, streamlined versions of some of these permits are available. In other instances, some of the permits have been combined to reduce the number of submittals and reviews. Additional information on the permitting process along with contact information can be found in the initial 30% Preliminary Basis of Design Report.

a. Boulder County Stream Restoration Permit

The September 2013 flood impacted both the hydraulic and ecological conditions of many watersheds throughout Boulder County. As a result, Boulder County has developed a Stream Restoration Permit that combines the requirements of a number permits into one holistic document. The permit application will be submitted to the Building Safety and Inspection Services under the Boulder County Land Use Department. The Stream Restoration Permit application is required to obtain a Boulder County Grading Permit and a Boulder County Floodplain Development Permit for stream restoration projects. Below is a simplified list of the materials that are required for stream restoration projects:

- Completed Stream Restoration Permit Application.
- Planform Maps.
- Site Plan Maps.
- Site Specific Designs in plan, profile and cross-section views.
- Hydraulic Modeling Report.
- Approval of all necessary local, state, and federal permits.

A Boulder County Stream Restoration Permit application has been developed by the Design Team and will be submitted with the support of BCPOS. Included in the Appendices is the Stream Restoration Permit Deliverables Checklist, along with the application and supporting documentation. The permit requires contractor information, therefore will be updated as the project progresses.

b. Boulder County Floodplain Permit

A Boulder County Floodplain Development Permit (FDP) is required for any work within the floodplain. FDP are acquired through the Boulder County Transportation Department. All development and proposed improvements are required to conform to the Article 4-400, Floodplain Overlay District of the Boulder County Land Use Code. A detailed hydraulic report was generated that meets the Hydraulic Modeling Report Guide provided by Boulder County.

A floodplain evaluation was conducted by comparing existing conditions to proposed conditions water surface elevations. The existing conditions model was based on post-flood ground survey that was supplemented with post-flood LiDAR. The proposed conditions model was developed using proposed conditions grading developed for the 80% designs. An existing and proposed conditions floodway was also developed as part of this analysis since the pre-flood floodway is obsolete. The hydrology used for the floodplain evaluation is from CDOT's *Hydrologic Evaluation of the St Vrain Watershed (2014)* produced by Jacobs Engineering.

While our project does cause a rise at a few cross sections throughout our model, no rise is greater than 0.50 feet and the rises encountered do not effect insurable structures. It was determined from this evaluation that this permit will require a Boulder County Floodway Review. Included with the permit information is a list of all property addressee that are impacted by water surface elevation increased and the amount of increase expected on each property. A narrative in addition to standard floodplain submittal requirements will be required that documents:

- Why the project is necessary, given the flood impacts it creates?
- What specific project design elements are creating the increases?
- Whether an evaluation of alternative designs has been performed, and the results of that evaluation.

Included in the Appendices is the Floodplain Development Permit application along with the Hydraulic Modeling Report as required by the Floodplain Development Permit.

c. Boulder County Grading Permit

A Boulder Count Grading Permit is required for grading, excavation or placement of fill in excess of 50 cubic yards. Grading permits must be reviewed by the Planning and Zoning Division, the Transportation and Engineering Department, and Building Safety and Inspection Services through the Land Use Department. The stream restoration permit application initiates the process for obtaining the Grading Permit Submittal information required for this permit includes:

- Contours that indicate existing grade and finished grade.
- Calculations of the grading, excavation, or placement of fill to be moved.
- Grading Plans for a Limited Impact Special Use Review must be sealed by a qualified Colorado-licensed engineer.

The Boulder County Grading Permit has been combined into the Stream Restoration Permit and will be considered during that application process.

d. Boulder County Land Use Permit

A Boulder County Land Use Permit is required for this project through the Boulder County Land Use Department. A Limited Impact Special Use review has been developed for stream restoration projects through Boulder County to streamline the process. Included with the permit application were the following items:

- Description of flood damage.
- Detailed description of proposal
    - Why/How is this beneficial?
- Volume (cubic yards) of earthworks/grading:
    - What is getting removed from site?
    - What is imported into the site?
    - What is remaining on-site?
- Linear feet of work proposed along the stream channel and full length of reach.
- Clearly identify subject parcels.
- Reference Watershed Master Plan and briefly confirm project supports goals (how) or, if not, then why alternative treatment is being proposed.
- Identification of construction traffic access points.
- Identification of proposed haul routes.
- Estimate of construction duration and estimated start date.
- Identified areas where erosion control will be undertaken, along with erosion control details.
- Landscaping details such as plant selection, and any planned invasive species removal.
- Identification of staging areas.
- Statement of additional permits or communication that has or will occur with regulating agencies.
- Maps and plans.

A Boulder County Land Use Permit was applied for on 10/28/2016. Minor comments were received for the permit application and a copy of the application is included in the Appendices. The Boulder County commissioners granted a conditional approval 1/18/17, subject to several conditions.

e. Boulder County and CDOT Roadway Permit

A permit from Boulder County and CDOT was acquired for this project due to construction taking place within the roadway right-of-ways. Both Highway 7, and Old St. Vrain Road's right-of-ways will have construction taking place in them. The permits for these applications are both in the process with support from BCPOS. Information for these permits will need to be finalized before construction starts.

f. CDPHE Dewatering Permit

A Construction Dewatering Permit (COG070000) through the CDPHE has been developed for this project because construction dewatering will be necessary to provide a dry working area during construction. The dewatering and discharge activities will be considered in-stream where dewatering is conducted within the ordinary high water mark of the stream, and/or, on the bank of the stream and discharge back to the same water body.

Multiple dewatering operations are anticipated and their locations are provided on a map in the Appendix. It was determined from research of available data, that there are no open, leaking underground storage tanks within 0.5 mile, open Voluntary Cleanup sites within 0.5 mile, Environmental Covenants within 0.5 mile, Resource Conservation Recovery Act Corrective Action Sites within 0.5 mile, and Superfund Sites or National Priorities List Sites with associated groundwater contamination within 1.0 mile of the dewatering locations. Therefore, the dewatering permits fall within the requirements for a general Construction Dewatering Permit. If the site had met any of the above criteria with regard to a contaminated site, remediation activities of the discharged water would be required.

Included in the Appendices is the CDPHE Dewatering Permit Application. This application will need to be submitted to the CDPHE at least 10 days prior to construction. This permit should be applied for by the contractor or transferred to the contractor before the start of construction.

g. CDPHE Stormwater Discharges Associated with Construction Activity Permit

A Stormwater Construction Permit is required by State and Federal regulations for stormwater discharged from any construction activity that disturbs at least 1 acre of land. Construction activity refers to ground surface disturbing activities, which include, but are not limited to, clearing, grading, excavation, demolition, installation of new or improved haul roads and access roads, staging areas, stockpiling of fill materials, and borrow areas. A Stormwater Discharge Associated with Construction Activity Permit through the CDPHE is required for this project since the disturbance is greater than 1 acre. The approximate area of ground disturbing activities is 25.7 acres and the permit will need to be submitted through the Colorado Discharge Permit System (CDPS).

A Stormwater Management Plan (SWMP) was prepared based on guidance from CDPHE and included a set of plans along with a narrative report. The goal of our SWMP is to identify possible pollutant sources that may contribute pollutants to stormwater, and identify Best Management Practices (BMPs) that, when implemented, will reduce or eliminate any possible water quality impacts. The SWMP will be completed and implemented at the time the project breaks ground, and revised as construction proceeds, to accurately reflect the conditions and practices at the site.

BMPs encompass a wide range of erosion and sediment control practices, both structural and non-structural in nature, that are intended to reduce or eliminate any possible water quality impacts from stormwater leaving a construction site. The individual BMPs appropriate for this project have been developed based on types of potential pollutant sources present, the nature of the construction activity, and specific-site conditions. BMPs for this project include nonstructural and structural treatment processes. Site specific BMPs were developed using Urban Drainage and Flood Control District's Volume 3 of the Urban Storm Drainage Criteria Manual and CDOT Standard M&S Plans for temporary erosion control.

Included in the Appendices is the CDPHE Stormwater Discharge Permit Application. This application will need to be submitted to the CDPHE at least 10 days prior to construction. This permit should be applied for by the contractor or transferred to the contractor before the start of construction

h. USACE Clean Water Act Permit

The project team met with the USACE on November 1, 2016 to discuss 404 permitting for the project area. After describing the proposed project components with them, the Corps indicated that the project would likely be authorized under separate Nationwide Permits (NWP's). Proposed work within identified EWP Project areas (EWP areas 1 and 2) will likely be permitted under NWP 37 for Emergency Watershed Protection and Rehabilitation. The description and limits for NWP 37 are listed on page 127 *Preliminary Design Report*. Monitoring requirements are set by the funding agency (in this case the Natural Resources Conservation Service (NRCS).

The Corps indicated that restoration activities outside of the EWP project area would likely be permitted under a NWP 27 for Aquatic Habitat Restoration, Establishment, and Enhancement Activities. There are no impact thresholds under NWP 27, although this permit does not allow conversion of one aquatic resource to another (i.e. conversion of wetlands to open water). NWP 27 also does not authorize stream channelization.

Both NWP's would require notification to the Corps through submittal of a pre-construction notification (PCN). The PCN would include an overall description of the project, baseline conditions and potential impacts to the aquatic resource (South St. Vrain Creek or associated wetlands). In order for a Clean Water Act Section 404 permit to be authorized, the permittee must first obtain Section 7 of the Endangered Species Act and Section 106 of the National Historic Preservation Act clearances.

i. USFWS Threatened and Endangered Species Permit

The USFWS issued a letter of concurrence with the National Resources Conservation Service State Conservationist stating that EWP projects along 11 various watersheds, including South St. Vrain Creek EWP areas 1 and 2, may affect, but are not likely to adversely affect Preble's meadow jumping mouse (Preble's), Ute ladies'-tresses orchid (ULTO) and Colorado butterfly plant (CWP). The USFWS also determined that these project would have no-effect on other species potentially occurring in Boulder County, including greenback cutthroat trout, Mexican spotted owl, and Canada lynx.

Some level of consultation will be needed with the USFWS regarding the proposed project outside of the EWP Areas. Since other phases of the project will be similar in nature to the EWP projects, the Project team would recommend that the USFWS make the same determination that was made for the EWP portion of the project.

j. National Historic Presentation Act

Cultural resource surveys have been performed for EWP Areas 1 and 2. Cultural resource surveys will likely be required for project areas outside of the EWP areas. The Project team recommends coordination with the permitting agencies during the conceptual Project development phase. Early coordination with the agencies typically allows for more of a streamlined permitting process. Contracting a permitting specialist is recommended to help facilitate the environmental permitting process. The current Project team is capable of supporting these needs.

k. National Environmental Policy Act

Actions on federal lands or using federal funding must comply with the National Environmental Policy Act (NEPA) of 1969. This policy was created to ensure federal agencies consider the environmental impacts of their actions and decisions. Federal agencies are required to systematically assess the environmental impacts of their proposed actions and consider alternative ways of accomplishing their missions, which are less damaging to and protective of the environment. NEPA Section 101(b) states "it is the continuing responsibility of the federal government to use all practicable means, consistent with other essential considerations of national policy" to avoid environmental degradation, preserve historic, cultural, and natural resources, and "promote the widest range of beneficial uses of the environment without undesirable and unintentional consequences". Each agency designates a "responsible official" who must ensure NEPA issues are addressed as part of the agency's actions. All agencies must use a systematic interdisciplinary approach to environmental planning and evaluation of projects which may have an effect on the environment.

- The primary goals of NEPA (as per the NEPA handbook) include:
- Requiring every Federal agency prepare a detailed document of the effects of “major Federal actions significantly affecting the quality of the human environment.”
- An alternatives analysis of those actions conducted by the agencies.
- Use of an interdisciplinary approach in developing alternatives and analyzing environmental effects.
- Requiring that each agency consult with and obtain comments or permits of any Federal agency which has jurisdiction by law or special expertise with respect to potential environmental impacts.
- Requiring that any federal, local tribal or municipal permits, statements, or comments be made available to the public.

Environmental analysis documents, which must be made available to the public, include environmental impact statements (EISs) and environmental assessments (EAs) (40 CFR 1506.6(b)). Projects that are likely to include serious environmental effects require preparation of an EIS. If the environmental effects are unclear, an EA is prepared.

The NRCS obtained NEPA compliance for the EWP program through a programmatic EIS. Thirty-percent design funding for all project areas, including those outside the EWP boundaries, originate from Housing and Urban Development (HUD). Design costs under the CDBG-DR program are exempt from NEPA environmental review.

9. Operations and Maintenance Plan

A construction Quality Assurance Plan (QAP) has been developed based on guidance from NRCS and the EWP Team. Each EWP Phase II Financial Assistance (FA) agreement for project construction between the CWCB and NRCS includes requirements for Operations and Maintenance (O&M) for a 3-year period. The CWCB then transfers these O&M responsibilities to the local project sponsor via the project agreement. The purpose of the O&M plan is to protect the public's safety and interest, and to ensure that projects are performing as designed.

Operations refer to the administration, management, and performance of non-maintenance activities necessary to keep a practice safe and functioning as planned. Maintenance refers to ensuring that individual components and structures of a project are achieving objectives in terms of function and safety. Maintenance also consists of the recurring activities necessary to retain or restore a practice in a safe and functioning condition, including the management of vegetation, the control/removal of invasive vegetation, the repair or replacement of failed components, the prevention or treatment of deterioration, and the repair of damages caused by vandalism. Monitoring activities evaluate each installed feature's ability to achieve the larger goals of a project and facilitate process-based outcomes over the long term. Monitoring recommendations for the EWP program will be released in June 2016. In the interim, reference the CWCB Standard Operating Procedures for monitoring channel dimensions and location.

In order to meet the goals of the O&M plan, the project sponsor has a number of responsibilities to meet outlined below and begin once NRCS has determined the project is complete and will last a duration of 3 years:

- Obtain landowner permissions for access to carry out O&M.
- Comply with all applicable federal, state, and local laws (specifically permit requirements).
- Collaborate on O&M plan development as part of project design process.
- Submit O&M plan(s) with design documents for review by NRCS and CWCB.
- Sign O&M agreement with CWCB prior to receiving funding for project construction.
- Complete annual inspections and reports; submit to the NRCS.
- Conduct any required maintenance in the project area to maintain project function per original design.

Local sponsors cannot pass on this legal responsibility for O&M to the individual landowner or other parties. The NRCS recommend that the project sponsor reserve 1%-5% of the total construction cost. This should account for specific repairs, for addressing potential problems, and for staff time to conduct inspections and prepare reports. While not required, a comprehensive O&M plan should provide an estimate of O&M costs over the 3-year period.

10. Construction Quality Assurance Plan

A Construction Quality Assurance Plan (QAP) has been developed with guidance from NRCS and the EWP Team. The QAP has been developed by our Team to confirm each project is constructed according to site specific plans and specification. The QAP outlines the technical and administrative expertise required, identifies the individuals with that expertise, outlines the frequency and timing of technical assistance, estimate the contract completion date, and shall be approved by all responsible supervisors.

The QAP outlines various stream restoration measures to be used as part of this project, along with personnel that should be utilized to inspect the construction of these measures. The QAP defines the major stage quality control that shall take place and who should be included with these inspections. Also included in the document is an Inspection and Requirement Checklist that can be used by the Design Team to ensure quality control is routinely, and accurately performed by the correct personnel at the right frequency.

Included in the Appendices is the Construction Quality Assurance Plan.

11. Final Construction Cost Estimate

Anticipated construction costs have been developed as part of this 80% design. The costs presented below are based on 80% designs. Since there is potential for changes in the field for quantities, a 10% contingency has been added to the overall project budget. It is understood that a significant number of stream restoration projects will be beginning construction at about the same time in the spring/summer of 2017. Therefore, it is understood that there might be inflated construction costs due to the demand of contractors throughout the Front Range. This potential inflated costs occurrence will be accounted for with a 5% inflation increase.

For the purposes of estimating project costs, the project area was broken out into distinct areas based upon physical constraints, geographical location, and funding sources. Each overflow channel was evaluated separately along with dividing the main channel into multiple segments to allow for a more robust cost estimate. Since the construction limits have been modified since the 30% designs, Boulder County or other funding may be necessary for construction outside of the original EWP areas. Costs have been broken out in an effort to understand the cost of each individual feature to allow reduction in overall project scope if the budget is exceeded.

A breakout of the costs per area and total is shown on the following pages.

12. Performance Time

The amount of time anticipated for construction can be have a very wide range. Depending on the size of the contractor's team along with sub consultants can increase or decrease required construction time. Based upon funding guidelines all construction aspects must be complete by December 31, 2017. This includes revegetation aspects. The required time for construction can also be influenced by spring runoff and regulations with regards to sensitive ecological and biological concerns. It is estimated that construction could take 4-6 months depending on start time and revegetation schedule. It is anticipated that construction will start around June 2017.

13. Construction Oversight

In any stream restoration project construction oversight is necessary to ensure the intent of the designs are met. Due to complex stream restoration techniques and unknown changes in the field it is recommended that design team members perform routine construction oversight. While these designs have been furthered to 80%, this does not alleviate the need for potential field changes to adapt to site specific details and issues. Information with regard to required inspections and construction oversight is included in the specifications.

South St. Vrain Creek Restoration
Engineers' Estimate

Channel/Location	Station		EWP / BCPOS Area	201-00000 Clearing and Grubbing		202-00005 Removal of Structures and Debris		202-00010 Removal of Tree (6 to 12 inch DBH)		202-00011 Removal of Tree (12+ inch DBH)		203-00001 Unclassified Excavation (Stripping Native Streambed)		203-00002 Unclassified Excavation (Complete in Place)		203-00003 Unclassified Excavation (Haul Offsite)		203-00004 Alternate Bid Item - Unclassified Excavation (Extended Haul Offsite)		203-00005 Unclassified Excavation (Sort/Screen/Stockpile 6 to 12 inch Rock)	
				AC		LOAD		EA		EA		BCY		BCY		BCY		BCY		TON	
	From	To	UNIT COST	$1,000		$4,000		$100		$250		$8		$13		$15		$30		$60	
				QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL
Main Channel	100+30	88+50	BCPOS	3.2	$3,246	1	$4,000	7	$700	9	$2,250	2,273	$18,180	853	$11,089	6,669	$100,035	6,669	$200,070	204	$12,240
	88+50	76+50	EWP #1	4.1	$4,076	1	$4,000	9	$900	17	$4,250	3,000	$24,000	1,447	$18,811	11,721	$175,815	11,721	$351,630	204	$12,240
	76+50	66+50	EWP #1	4.4	$4,388	0	$0	2	$200	0	$0	2,500	$20,000	3,140	$40,820	10,889	$163,335	10,889	$326,670	204	$12,240
	66+50	54+00	EWP #1	3.2	$3,185	1	$4,000	4	$400	1	$250	1,490	$11,920	733	$9,529	3,440	$51,600	3,440	$103,200	204	$12,240
	54+00	44+50	EWP #1	0.6	$647	1	$4,000	0	$0	0	$0	475	$3,800	149	$1,937	234	$3,510	234	$7,020	204	$12,240
	36+50	30+75	EWP #2	0.9	$895	0	$0	6	$600	1	$250	633	$5,060	190	$2,470	1,434	$21,510	1,434	$43,020	204	$12,240
	30+75	26+00	EWP #2	1.2	$1,170	1	$4,000	2	$200	3	$750	860	$6,880	867	$11,271	2,074	$31,110	2,074	$62,220	204	$12,240
Overflow Channel A	11+45	2+97	EWP #1	1.8	$1,832	0	$0	0	$0	0	$0	0	$0	3,602	$46,826	0	$0	0	$0	204	$12,240
Overflow Channel B	10+52	2+54	EWP #1	1.2	$1,165	0	$0	10	$1,000	3	$750	0	$0	76	$988	3,042	$45,630	3,042	$91,260	204	$12,240
Overflow Channel C	11+71	1+25	EWP #1	2.4	$2,389	0	$0	14	$1,400	13	$3,250	0	$0	791	$10,283	3,600	$54,000	3,600	$108,000	204	$12,240
Overflow Channel D	13+50	2+15	EWP #1	1.3	$1,289	0	$0	0	$0	0	$0	0	$0	727	$9,451	0	$0	0	$0	204	$12,240
Overflow Channel E	8+26	0+88	EWP #1	0.4	$410	0	$0	9	$900	2	$500	0	$0	157	$2,041	0	$0	0	$0	204	$12,240
Overflow Channel F	14+21	0+00	EWP #1	1.0	$994	0	$0	0	$0	0	$0	0	$0	107	$1,391	1,695	$25,425	1,695	$50,850	204	$12,240
			EWP Subtotal	22.4	$22,441	4	$16,000	56	$5,600	40	$10,000	8,958	$71,660	11,986	$155,818	38,129	$571,935	38,129	$1,143,870	2,448	$146,880
			BCPOS Subtotal	3.2	$3,246	1	$4,000	7	$700	9	$2,250	2,273	$18,180	853	$11,089	6,669	$100,035	6,669	$200,070	204	$12,240
			Project Total	**25.7**	**$25,686**	**5**	**$20,000**	**63**	**$6,300**	**49**	**$12,250**	**11,230**	**$89,840**	**12,839**	**$166,907**	**44,798**	**$671,970**	**44,798**	**$1,343,940**	**2,652**	**$159,120**

		10% Contingency
EWP Subtotal	$2,341,934	$234,193
BCPOS Subtotal	$318,153	$31,815
Project Subtotal	**$2,660,087**	$266,009
EWP Total	$2,576,128	
BCPOS Total	$349,968	
Project Total	**$2,926,095**	

South St. Vrain Creek Restoration
Engineers' Estimate

Channel/Location	Station		EWP / BCPOS Area	203-00006 Unclassified Excavation (Sort/Screen/Stockpile 12 to 24 inch Rock)		203-00007 Unclassified Excavation (Sort/Screen/Stockpile 24+ inch Rock)		208-00001 Stormwater Management		209-00200 Time-Released Watering		211-03005 Dewatering		212-00005 Seeding (Upland)		212-00022 Seeding (Riparian)		212-00032 Soil Conditioner		213-00012 Spray-On Mulch Blanket	
				TON		TON		LS		EA		LS		AC		AC		AC		AC	
	From	To	UNIT COST	$60		$60		$75,000		$0.70		$100,000		$1,400		$2,300		$5,000		$3,400	
				QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL
Main Channel	100+30	88+50	BCPOS	62	$3,692	6	$360	0	$0	473	$331	0	$0	1.6	$2,226	0.4	$828	2.0	$9,750	2.0	$6,630
	88+50	76+50	EWP #1	62	$3,720	6	$360	1	$75,000	699	$489	1	$100,000	2.1	$2,954	0.6	$1,426	2.7	$13,600	2.7	$9,248
	76+50	66+50	EWP #1	62	$3,720	6	$360	0	$0	782	$547	0	$0	2.5	$3,444	0.8	$1,863	3.3	$16,350	3.3	$11,118
	66+50	54+00	EWP #1	62	$3,720	6	$360	0	$0	613	$429	0	$0	1.8	$2,492	0.7	$1,610	2.5	$12,400	2.5	$8,432
	54+00	44+50	EWP #1	62	$3,720	6	$360	0	$0	15	$11	0	$0	0.2	$252	0.0	$23	0.2	$950	0.2	$646
	36+50	30+75	EWP #2	62	$3,720	6	$360	0	$0	59	$41	0	$0	0.5	$630	0.1	$184	0.5	$2,650	0.5	$1,802
	30+75	26+00	EWP #2	62	$3,720	6	$360	0	$0	108	$76	0	$0	0.7	$994	0.1	$253	0.8	$4,100	0.8	$2,788
Overflow Channel A	11+45	2+97	EWP #1	62	$3,720	6	$360	0	$0	368	$258	0	$0	0.9	$1,232	0.9	$2,116	1.8	$8,950	1.3	$4,250
Overflow Channel B	10+52	2+54	EWP #1	62	$3,720	6	$360	0	$0	271	$190	0	$0	0.9	$1,218	0.2	$552	1.1	$5,550	1.1	$3,570
Overflow Channel C	11+71	1+25	EWP #1	62	$3,720	6	$360	0	$0	562	$393	0	$0	1.6	$2,212	0.7	$1,633	2.3	$11,450	2.0	$6,936
Overflow Channel D	13+50	2+15	EWP #1	62	$3,720	6	$360	0	$0	223	$156	0	$0	0.9	$1,190	0.3	$713	1.2	$5,800	1.2	$3,944
Overflow Channel E	8+26	0+88	EWP #1	62	$3,720	6	$360	0	$0	20	$14	0	$0	0.1	$182	0.2	$391	0.3	$1,500	0.2	$646
Overflow Channel F	14+21	0+00	EWP #1	62	$3,720	6	$360	0	$0	108	$76	0	$0	0.7	$966	0.2	$529	0.9	$4,600	0.8	$2,822
			EWP Subtotal	744	$44,640	72	$4,320	1	$75,000	3,828	$2,680	1	$100,000	12.7	$17,766	4.9	$11,293	17.6	$87,900	16.5	$56,202
			BCPOS Subtotal	62	$3,692	6	$360	0	$0	473	$331	0	$0	1.6	$2,226	0.4	$828	2.0	$9,750	2.0	$6,630
			Project Total	**806**	**$48,332**	**78**	**$4,680**	**1**	**$75,000**	**4,301**	**$3,011**	**1**	**$100,000**	**14.3**	**$19,992**	**5.3**	**$12,121**	**19.5**	**$97,650**	**18.5**	**$62,832**

EWP Subtotal	$2,341,934
BCPOS Subtotal	$318,153
Project Subtotal	**$2,660,087**
EWP Total	$2,576,128
BCPOS Total	$349,968
Project Total	**$2,926,095**

South St. Vrain Creek Restoration
Engineers' Estimate

Channel/Location	Station		EWP / BCPOS Area	214-00901 Perennial (Tubeling)		214-01011 Willow Cuttings in Existing Riprap		214-01015 Willow Cuttings		214-01026 Dormant Log Poles		214-01032 Fascines		214-01040 Beaver Protection Fence		214-01041 Vole Protection Fence		214-01050 Trees and Shrubs		214-01228 Large Wood Structure Type 1	
				SF		EA		EA		EA		LF		LS		LS		EA		EA	
	From	To	UNIT COST	$4		$70		$5		$20		$40		$20,000		$15,000		$12		$4,000	
				QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL
Main Channel	100+30	88+50	BCPOS	0	$0	48	$3,360	1,412	$7,060	29	$580	0	$0	0	$0	0	$0	473	$5,676	0	$0
	88+50	76+50	EWP #1	0	$0	43	$3,010	1,371	$6,855	9	$180	0	$0	1	$20,000	1	$15,000	699	$8,388	1	$4,000
	76+50	66+50	EWP #1	0	$0	0	$0	1,184	$5,920	0	$0	67	$2,680	0	$0	0	$0	782	$9,384	2	$8,000
	66+50	54+00	EWP #1	0	$0	0	$0	163	$815	0	$0	104	$4,160	0	$0	0	$0	613	$7,356	1	$4,000
	54+00	44+50	EWP #1	0	$0	0	$0	287	$1,435	0	$0	0	$0	0	$0	0	$0	15	$180	0	$0
	36+50	30+75	EWP #2	0	$0	0	$0	1,079	$5,395	0	$0	0	$0	0	$0	0	$0	59	$708	1	$4,000
	30+75	26+00	EWP #2	0	$0	0	$0	1,425	$7,125	12	$240	0	$0	0	$0	0	$0	108	$1,296	0	$0
Overflow Channel A	11+45	2+97	EWP #1	945	$3,780	0	$0	904	$4,520	0	$0	0	$0	0	$0	0	$0	368	$4,416	0	$0
Overflow Channel B	10+52	2+54	EWP #1	695	$2,780	0	$0	226	$1,130	27	$540	0	$0	0	$0	0	$0	271	$3,252	0	$0
Overflow Channel C	11+71	1+25	EWP #1	0	$0	0	$0	468	$2,340	21	$420	0	$0	0	$0	0	$0	562	$6,744	0	$0
Overflow Channel D	13+50	2+15	EWP #1	1,877	$7,508	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	223	$2,676	0	$0
Overflow Channel E	8+26	0+88	EWP #1	1,381	$5,524	0	$0	245	$1,225	0	$0	0	$0	0	$0	0	$0	20	$240	0	$0
Overflow Channel F	14+21	0+00	EWP #1	1,019	$4,076	0	$0	277	$1,385	0	$0	0	$0	0	$0	0	$0	108	$1,296	0	$0
			EWP Subtotal	5,917	$23,668	43	$3,010	7,629	$38,145	69	$1,380	171	$6,840	1	$20,000	1	$15,000	3,828	$45,936	5	$20,000
			BCPOS Subtotal	0	$0	48	$3,360	1,412	$7,060	29	$580	0	$0	0	$0	0	$0	473	$5,676	0	$0
			Project Total	**5,917**	**$23,668**	**91**	**$6,370**	**9,041**	**$45,205**	**98**	**$1,960**	**171**	**$6,840**	**1**	**$20,000**	**1**	**$15,000**	**4,301**	**$51,612**	**5**	**$20,000**

EWP Subtotal	$2,341,934
BCPOS Subtotal	$318,153
Project Subtotal	**$2,660,087**
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South St. Vrain Creek Restoration
Engineers' Estimate

Channel/Location	Station		EWP / BCPOS Area	214-01229 Large Wood Structure Type 2		214-01230 Large Wood Structure Type 3		214-01231 Large Wood Structure Type 4		214-01232 Large Wood Structure Type 5		214-01233 Large Wood Structure Type 6		215-01016 Transplanting Mature Willows		216-0030 Soil Retention Blanket (Special)		218-00000 Noxious Weed Management		240-00000 Protection of Migratory Birds	
				EA		EA		EA		EA		EA		EA		SY		LS		EA	
	From	To	UNIT COST	$4,000		$4,000		$7,000		$2,500		$600		$25		$4		$5,000		$5,000	
				QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL
Main Channel	100+30	88+50	BCPOS	3	$12,000	1	$4,000	4	$28,000	4	$10,000	2	$1,200	28	$700	0	$0	0	$0	0	$0
	88+50	76+50	EWP #1	0	$0	0	$0	7	$49,000	5	$12,500	1	$600	0	$0	0	$0	1	$5,000	1	$5,000
	76+50	66+50	EWP #1	0	$0	1	$4,000	8	$56,000	6	$15,000	2	$1,200	30	$750	0	$0	0	$0	0	$0
	66+50	54+00	EWP #1	0	$0	2	$8,000	0	$0	3	$7,500	2	$1,200	20	$500	0	$0	0	$0	0	$0
	54+00	44+50	EWP #1	2	$8,000	0	$0	0	$0	0	$0	0	$0	42	$1,050	0	$0	0	$0	0	$0
	36+50	30+75	EWP #2	1	$4,000	0	$0	0	$0	0	$0	0	$0	33	$825	0	$0	0	$0	0	$0
	30+75	26+00	EWP #2	1	$4,000	0	$0	0	$0	0	$0	0	$0	42	$1,050	0	$0	0	$0	0	$0
Overflow Channel A	11+45	2+97	EWP #1	0	$0	0	$0	0	$0	1	$2,500	0	$0	0	$0	2621	$10,484	0	$0	0	$0
Overflow Channel B	10+52	2+54	EWP #1	0	$0	0	$0	0	$0	0	$0	0	$0	103	$2,575	267	$1,068	0	$0	0	$0
Overflow Channel C	11+71	1+25	EWP #1	0	$0	0	$0	0	$0	2	$5,000	0	$0	0	$0	1241	$4,964	0	$0	0	$0
Overflow Channel D	13+50	2+15	EWP #1	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0
Overflow Channel E	8+26	0+88	EWP #1	0	$0	0	$0	0	$0	0	$0	0	$0	0	$0	532	$2,128	0	$0	0	$0
Overflow Channel F	14+21	0+00	EWP #1	0	$0	0	$0	0	$0	0	$0	1	$600	0	$0	392	$1,568	0	$0	0	$0
			EWP Subtotal	4	$16,000	3	$12,000	15	$105,000	17	$42,500	6	$3,600	270	$6,750	5,053	$20,212	1	$5,000	1	$5,000
			BCPOS Subtotal	3	$12,000	1	$4,000	4	$28,000	4	$10,000	2	$1,200	28	$700	0	$0	0	$0	0	$0
			Project Total	**7**	**$28,000**	**4**	**$16,000**	**19**	**$133,000**	**21**	**$52,500**	**8**	**$4,800**	**298**	**$7,450**	**5,053**	**$20,212**	**1**	**$5,000**	**1**	**$5,000**

EWP Subtotal	$2,341,934
BCPOS Subtotal	$318,153
Project Subtotal	**$2,660,087**
EWP Total	$2,576,128
BCPOS Total	$349,968
Project Total	**$2,926,095**

South St. Vrain Creek Restoration
Engineers' Estimate

Channel/Location	Station		EWP / BCPOS Area	506-03000 Riffle Structure		506-03001 Riffle Floodplain Sill		506-03002 Floodplain Sill		506-03004 Habitat Boulder		506-03005 Overflow Rock Ramp		506-03006 Knickpoint Stabilization Structure		506-00419 Willow Cuttings in Cobble Toe		506-00431 Boulder Toe		506-05000 Import 6 to 12 Inch Rock	
				EA		LF		LF		EA		EA		EA		LF		LF		TON	
	From	To	UNIT COST	$7,200		$20		$25		$35		$2,150		$2,000		$10		$30		$60	
				QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL
Main Channel	100+30	88+50	BCPOS	4	$28,800	165	$3,300	0	$0	125	$4,375	0	$0	0	$0	567	$5,670	149	$4,470	37	$2,220
	88+50	76+50	EWP #1	3	$21,600	80	$1,600	0	$0	65	$2,275	0	$0	0	$0	543	$5,430	0	$0	37	$2,220
	76+50	66+50	EWP #1	4	$28,800	200	$4,000	220	$5,500	85	$2,975	0	$0	0	$0	608	$6,080	465	$13,950	37	$2,220
	66+50	54+00	EWP #1	2	$14,400	105	$2,100	0	$0	40	$1,400	0	$0	0	$0	209	$2,090	47	$1,410	37	$2,220
	54+00	44+50	EWP #1	1	$7,200	0	$0	0	$0	20	$700	0	$0	0	$0	20	$200	0	$0	37	$2,220
	36+50	30+75	EWP #2	1	$7,200	25	$500	0	$0	20	$700	0	$0	0	$0	40	$400	0	$0	37	$2,220
	30+75	26+00	EWP #2	1	$7,200	0	$0	0	$0	20	$700	0	$0	0	$0	255	$2,550	0	$0	37	$2,220
Overflow Channel A	11+45	2+97	EWP #1	0	$0	0	$0	170	$4,250	0	$0	1	$2,150	0	$0	19	$190	0	$0	37	$2,220
Overflow Channel B	10+52	2+54	EWP #1	0	$0	0	$0	115	$2,875	0	$0	1	$2,150	0	$0	13	$130	0	$0	37	$2,220
Overflow Channel C	11+71	1+25	EWP #1	0	$0	0	$0	100	$2,500	0	$0	0	$0	0	$0	0	$0	0	$0	37	$2,220
Overflow Channel D	13+50	2+15	EWP #1	0	$0	0	$0	0	$0	0	$0	0	$0	2	$4,000	0	$0	0	$0	37	$2,220
Overflow Channel E	8+26	0+88	EWP #1	0	$0	0	$0	0	$0	0	$0	0	$0	4	$8,000	0	$0	0	$0	37	$2,220
Overflow Channel F	14+21	0+00	EWP #1	0	$0	0	$0	0	$0	0	$0	1	$2,150	0	$0	0	$0	0	$0	37	$2,220
EWP Subtotal				12	$86,400	410	$8,200	605	$15,125	250	$8,750	3	$6,450	6	$12,000	1,707	$17,070	512	$15,360	444	$26,640
BCPOS Subtotal				4	$28,800	165	$3,300	0	$0	125	$4,375	0	$0	0	$0	567	$5,670	149	$4,470	37	$2,220
Project Total				**16**	**$115,200**	**575**	**$11,500**	**605**	**$15,125**	**375**	**$13,125**	**3**	**$6,450**	**6**	**$12,000**	**2,274**	**$22,740**	**661**	**$19,830**	**481**	**$28,860**

EWP Subtotal	$2,341,934
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Project Subtotal	**$2,660,087**
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Project Total	**$2,926,095**

South St. Vrain Creek Restoration
Engineers' Estimate

Channel/Location	Station		EWP / BCPOS Area	506-05001 Import 12 to 24 Inch Rock		506-05000 Import 24+ Inch Rock		508-00001 Beaver Dam Analogue		607-11525 Fence (Plastic)		625-00000 Construction Surveying		626-00000 Mobilization		630-00012 Construction Zone Traffic Control		Channel/Location Total
				TON		TON		EA		LF		LS		LS		LS		
	From	To	UNIT COST	$70		$80		$5,000		$3		$15,000		$100,000		$10,000		
				QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL	QUAN	SUBTOTAL		SUBTOTAL	Subtotal
Main Channel	100+30	88+50	BCPOS	40	$2,800	181	$14,480	0	$0	1,302	$3,905	0	$0	0	$0	0	$0	$318,153
	88+50	76+50	EWP #1	40	$2,800	181	$14,480	0	$0	954	$2,861	1	$15,000	1	$100,000	1	$10,000	$743,687
	76+50	66+50	EWP #1	40	$2,800	181	$14,480	0	$0	1,947	$5,840	0	$0	0	$0	0	$0	$467,964
	66+50	54+00	EWP #1	40	$2,800	181	$14,480	0	$0	817	$2,450	0	$0	0	$0	0	$0	$199,448
	54+00	44+50	EWP #1	40	$2,800	181	$14,480	0	$0	652	$1,955	0	$0	0	$0	0	$0	$72,315
	36+50	30+75	EWP #2	40	$2,800	181	$14,480	0	$0	148	$443	0	$0	0	$0	0	$0	$96,083
	30+75	26+00	EWP #2	40	$2,800	181	$14,480	0	$0	1,871	$5,613	0	$0	0	$0	0	$0	$129,186
Overflow Channel A	11+45	2+97	EWP #1	40	$2,800	181	$14,480	0	$0	266	$797	0	$0	0	$0	0	$0	$134,370
Overflow Channel B	10+52	2+54	EWP #1	40	$2,800	181	$14,480	0	$0	261	$783	0	$0	0	$0	0	$0	$113,716
Overflow Channel C	11+71	1+25	EWP #1	40	$2,800	181	$14,480	0	$0	349	$1,047	0	$0	0	$0	0	$0	$152,781
Overflow Channel D	13+50	2+15	EWP #1	40	$2,800	181	$14,480	0	$0	653	$1,958	0	$0	0	$0	0	$0	$74,505
Overflow Channel E	8+26	0+88	EWP #1	40	$2,800	181	$14,480	2	$10,000	951	$2,852	0	$0	0	$0	0	$0	$72,373
Overflow Channel F	14+21	0+00	EWP #1	40	$2,800	181	$14,480	0	$0	603	$1,809	0	$0	0	$0	0	$0	$85,507
			EWP Subtotal	480	$33,600	2,172	$173,760	2	$10,000	9,468	$28,404	1	$15,000	1	$100,000	1	$10,000	$2,341,934
			BCPOS Subtotal	40	$2,800	181	$14,480	0	$0	1,302	$3,905	0	$0	0	$0	0	$0	$318,153
			Project Total	**520**	**$36,400**	**2,353**	**$188,240**	**2**	**$10,000**	**10,770**	**$32,309**	**1**	**$15,000**	**1**	**$100,000**	**1**	**$10,000**	$2,660,087

EWP Subtotal	$2,341,934
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14. Appendices

A. Appendix A - 80% Plan Set
B. Appendix B - Boulder County Stream Restoration Permit
C. Appendix C - Boulder County Floodplain Permit
D. Appendix D - Boulder County and CDOT Roadway Permit
E. Appendix E - CDPHE Construction Dewatering Permit
F. Appendix F - CDPHE Stormwater Discharges Associated with Construction Activity Permit
G. Appendix G – Updated SRH Modeling
H. Appendix H - Updated Design Calculations
I. Appendix I - Construction Quality Assurance Plan
J. Appendix J - Operations and Maintenance Plan

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Anniston, AL
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Colorado Springs, CO
Denver, CO
Niceville, FL
Parsons, KS
Phoenix, AZ
Pueblo, CO
Sacramento, CA
Tamuning, GU
Washington, DC

www.matrixdesigngroup.com

Point of Contact for
Matrix Design Group:

Scott Schreiber, PE
1601 Blake Street, Suite 200
Denver, CO 80202
Office 303-572-0200