Upper Coal Creek Watershed Restoration Master Plan

November 2014

Jefferson and Boulder Counties

The Environmental Group

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Table of Contents

List of Tables

Table of Contents Continued

List of Figures

Appendices

EXECUTIVE SUMMARY

Purpose and Objective

Between September 9 and September 15, 2013, a large rainfall event resulted in widespread flooding along the Colorado Front Range, including within Coal Creek Canyon. It was the largest flood on record, with flows estimated at approximately 3,900 cfs at the canyon mouth. This was equivalent to between a 100- and 200-year flood event. Higher up in the canyon, flows remained significant, at 1,100 cfs, and were estimated to be between a 25- and 50-year event. Highway 72, in Coal Creek Canyon, was washed out in multiple areas, and private infrastructure was also lost as a result of flooding. Existing riparian areas along the creek were damaged as a result of the large volume of runoff, reducing potential habitat and resiliency for future flood events.

The objectives of this report are to evaluate flood, geomorphic, and ecological risk to drainageways and infrastructure within the Upper Coal Creek Watershed, as well as to provide recommendations, guidance, and prioritization for restoration and rebuilding efforts. This report has been prepared by staff at ICON Engineering, DHM Design, and Ecological Resource Consultants. Funding for this study was made possible through a grant provided by the Colorado Water Conservation Board (CWCB) through The Environmental Group (TEG) as a community based 501c3 organization.

Planning Process & Criteria

Planning for this report began in May 2014. Field staff collected information related to stream characteristics and existing infrastructure, as well as observations related to remaining damages from the 2013 flood. Data was collected from multiple sources, including the Federal Emergency Management Agency (FEMA), the Colorado Water Conservation Board (CWCB), the Urban Drainage and Flood Control District (UDFCD), and the Colorado Department of Transportation (CDOT), and local counties, among others.

The development of the master plan has included outreach to the canyon community through social media, door to door interaction, and public meetings. A community task force was also assembled to provide input and plan review and various phases of the project. Public meetings were held on May 29th, August 20th, and November 6th, at the Coal Creek Canyon Improvement Association's Community Center. Members of the public provided an instrumental role in the planning for this project, through their input and comments on the plan. These meetings were used to gage public opinion on the various aspects of this plan, and to present the various canyon restoration alternatives.

Guidance has also been provided by public entities, including CDOT, Jefferson County and Boulder County. Criteria from these entities were considered in developing recommendations for project infrastructure and improvements.

Project Area Description

The Upper Coal Creek Watershed has a drainage area of approximately 15 square miles, located within Jefferson, Boulder, and Gilpin Counties, with the majority of the watershed located within Jefferson County. Upper Coal Creek itself is approximately 8 miles long with ancillary tributaries entering along Twin Spruce Gap Road (Beaver Creek), Crescent Park Drive (Crescent Park Tributary) and at Ranch Elsie Road (Ranch Elsie Tributary). A south branch of Beaver Creek (South Beaver Creek) was also studied as it follows Twin Spruce Gap Road further west.

The watershed consists of various forms of development, predominately focused along the stream corridors and the community center areas near Highway 72, Twin Spruce Gap Road, Crescent Park Drive, Skyline Drive and Ranch Elsie Road. Development is generally larger lot, mountain home sites, approximately 1 acre in size or larger. Beyond the residential and commercial areas, the watershed is a myriad of county parks and open space, conservation easements, private land, and pockets of national forest land and state parks. The watershed is bisected by Highway 72, which also encumbers a portion of the general stream corridor.

After the 2013 flood, CDOT acted quickly to repair damages to Highway 72, since many areas of the road were impassable. Many of these efforts are still ongoing. Private landowners have also completed repair work to driveway culverts, many of which were washed out during the flood. However, much of the in-stream restoration and debris removal has yet to be accomplished.

Flood Risk

With exception to near Plainview Road, regulatory floodplain mapping from FEMA for Coal Creek does not currently exist. For this study, an approximate level flood risk assessment for Coal Creek and its inflow tributaries was completed. This assessment estimated that approximately 48 structures are located within the limits of the 100-year floodplain, 34 structures are in the 25-year floodplain, and 10 structures are located within the 10-year floodplain. The highest risk areas are on Coal Creek between Highway 72 mile marker 14 and 16, downstream of Twin Spruce Gap Road, and between Twin Spruce Gap Road and Ranch Elsie Road. The Beaver Creek Tributary also presented significant flood risk between Highway 72 and the confluence with South Beaver Creek.

Limits for the approximate 100-year floodplain are depicted on project workmaps included with this study. Independent delineations were also completed for more frequent intervals (2-, 5-, 10-, 25-, and 50-year storm events) as well as for the 500-year storm event. Although the study is approximate in nature, the analysis did include an evaluation of existing infrastructure and should be considered in future floodplain management decisions at a local level. We recommend that local floodplain administrators refer to advisory information developed for this study when making floodplain management decisions along Coal Creek and its associated tributaries.

Geomorphology

In order to guide successful restoration of the stream corridors, geomorphic assessments were completed to identify deficiencies in the existing stream geometry, determine sizing criteria and dimensions for channel restoration, as well as applicable restoration techniques. Meeting geomorphic criteria will further ensure that Coal Creek, and its tributaries have the ability to convey a full range of discharges and transport sediment and debris more naturally, without experiencing the high levels of erosion and deposition that occurred during the September flood event. As part of this study, streams were classified into four groupings based on streambed gradient, meanders, stability and entrenchment. The vast majority of stream reaches in the corridor were classified as either

type A or B streams, reflecting straight, narrow, steep channels. Channel classifications were used along with the estimated discharges in order to approximate natural channel geometries. Given the natural variation in slope along the stream corridor, a range of channel geometries was determined. Streams lower in the watershed generally require a wider channel width to meet the recommended geomorphic conditions. Streams higher in the watershed are narrower, as flow potential is significantly reduced. For each stream segment, recommendations are provided for channel bankfull width, bankfull depth, and width at twice the bankfull depth. In most cases, the recommendations are larger than what currently exists.

Ecological and Riparian Assessment

Well vegetated riparian corridors provide important habitat for local wildlife and help protect the physical integrity of the aquatic environment. In many areas, riparian vegetation has been significantly reduced or eliminated, due the high velocity of the flood flows. Restoring these areas will help restore ecological integrity to the watershed, helping to reduce problems related to erosion and sedimentation, while contributing to bank stability.

As part of these assessments, the general condition of the post-flood riparian corridor was determined, including vegetation types and locations. These assessments identified a "reference condition" to guide local homeowners in the replanting of riparian areas. The typical riparian zone consists of three strata, the overstory, mid-story, and understory layers. Generally, the overstory consists primarily of a tree canopy including Narrowleaf Cottonwood, and Colorado Blue Spruce species, with sporadic patches of Quaking Aspen. Mid-story revegetation reflects more dense shrubbery such as willows. The understory consists of dense native grasses. Areas outside of the riparian zone consist of Ponderosa Pine (south-facing slopes) and Douglas Fir (north-facing slopes), with Lodgepole Pine higher in the watershed. Mid-story layers outside of the riparian zone consist of a variety of smaller shrubs such as mountain mahogany, American plum, and Woods' rose. Understory outside of the riparian zone also is dominated by dense native grasses.

The Coal Creek corridor was also screened for potential habitat for threatened and endangered species. It was determined that the canyon contains habitat suitable for several threatened and endangered species, including migratory birds, the Preble's Meadow Jumping Mouse, and the Ute Ladies'-tresses Orchid, among others. Additional species potentially within range of the project area include the Canada lynx and the Mexican Spotted Owl. During restoration and recovery efforts, it is recommended that close coordination with Colorado Parks and Wildlife is maintained, in order to provide clearance and/or permitting for potential projects.

Public Engagement/ Core Community Values

In order to gage public opinion, a survey poll consisting of ten core values was distributed at the initial public meeting. These values included immediate bank stability, fundable solutions, flood conveyance capacity (low level, medium level, high level), environmental health/ecology, recreation, Community Center protection, maximize private property and usable space, and transportation and emergency access. Community members were polled to determine the importance of these ten values, relative to one another. Immediate bank stability, fundable solutions, and transportation/emergency access were the highest rated values, followed by environmental health/ecology and moderate-level flood protection improvements.

Alternative Selection and Conceptual Design

Mitigation strategies and improvements were developed to address stream and infrastructure needs throughout the Upper Coal Creek watershed, as well as to provide guidance for restoration and rebuilding along the creeks and drainages. The development of project alternatives reflected a combined effort between the design team, external stakeholders, and canyon community. Primary goals for alternatives were to establish future resiliency through a combination of reducing the overall risk from flooding and geomorphic changes, as well as enhancing the ecological environment. A myriad of secondary objectives were also considered in determining solutions for the watershed, including: emergency access, which was a common problem during the flood, resiliency for Canyon's community center near Wondervu, and recreation. Alternatives focused on addressing both immediate and long term solutions for the corridor, as well identifying needs for both private landowners and public entities including CDOT, Jefferson and Boulder Counties.

Alternative categories were established to manage approach needs and physical improvements along each stream reaches. Reaches were further combined into Stream or Drainage Corridors reflecting similar needs or requirements. Stream Corridors include reaches with larger contributing drainage basins, more constant base flow, higher flood discharges, and stream characteristics more suitable to support riparian habitat and ecological enhancements. Stream Corridor reaches include the Coal Creek main stem from the downstream limits through Ranch Elsie Drive and Beaver Creek between the confluences with Coal Creek and South Beaver Creek. These reaches were the most damaged in September flood and remain the most susceptible to future flooding issues. These reaches also generally require a larger corridor width to effectively manage geomorphic and flood discharges, riparian habitat, and ecosystem. It is recommended that management of these stream corridors be done through an oversight stakeholder or coalition group to ensure consistency and compatibility of improvements within the watershed.

Drainage Corridors convey water into the stream corridors. In general, drainage corridors within the watershed are predominately dry throughout the year, less diverse, and flood risk to buildings and infrastructure is more minimal. Overall, the principal issues relate to capacity and conveyance issues versus full spectrum management of a riverine system.

Alternatives within the Stream Corridors include a full spectrum of: Public Safety, Corridor Management, Stream Restoration, Flood Management, Transportation/Emergency Access, and Recreation enhancements; whereas alternatives within the Drainage Corridors focused on addressing current maintenance needs and flood management needs by identifying capacity deficiencies for existing infrastructure.

Project alternatives were presented to stakeholders and community task force members at a review meeting, as well as to the general public at the second public open house and meeting. Feedback was incorporated into the alternatives shown as part of the final conceptual design plan.

In general master plan recommendations included the following concepts for Stream Corridors:

Public Safety: Add real-time flood warning and rainfall measuring devices;

Corridor Maintenance & Management: Perform needed flood debris removal. Establish stream corridor easements or management corridors to ensure consistency of future work. Stream corridor easements range from 40' to 60' in width and would be managed through an oversight stakeholder or coalition group.

Geomorphic Restoration & Stream Stabilization: Excavation and channel modifications associated with establishment of the geomorphic channel conditions and bank stabilization for eroded locations.

Flood Management: Flood management activities primarily focus on providing adequate flood capacity at bridges and culverts and bank stabilization to resist erosion adjacent to homes, buildings, and highways. Improvement recommendations were identified for the 10-, 25-, and 100-year level of protection, consistent with the community survey distributed. For private infrastructure, a 25-year level of capacity was selected. 25-year level infrastructure added capacity beyond the existing levels, exceeded County requirements, and was consistent with guidelines and standards set forth by CDOT for access locations off of state highways. Improvements generally reflect installing bridges or box culverts with larger spans, more efficient in conveying the bankfull discharge as well as passing sediment and debris than multiple cell pipe culverts. Along Highway 72, Stream Corridors, and locations imperative for emergency access, the 100-year level of infrastructure capacity was selected for public infrastructure, including highway elevations, bridges and culverts. Bank stabilization improvements also maintained similar attributes, with a mid-level (25-year) level of protection for private infrastructure and high-level (100-year) level of protection at critical for public facilities.

Environment and Ecology: Restoration activities will include the reestablishment riparian habitat throughout stream corridors.

Transportation and Emergency Access: The flood event demonstrated the importance of maintaining emergency access along the highways and critical roadway. Alternatives were developed to better manage flooding along Highway 72 and Twin Spruce Gap Road. In some locations, roadways are proposed to be raised above the 100-year elevation where the feasibility for adding channel capacity may be more limited, or costly. Conveyance from stream crossings along the transportation corridors has been included within the flood management alternatives, above.

Recreation: Recreation elements provide additional opportunities for funding for the watershed improvements and should be considered along the prescribed stream and transportation corridors and project implementation. Bicyclists use the canyon, safe routes should be integrated into the redevelopment of Highway 72.

As noted above, Drainage Corridor alternatives typically addressed corridor maintenance and flood management needs. A 25-year level of capacity was generally selected for both public and private infrastructure to improve flood resiliency, meet current standards, and to provide consistency throughout the watershed.

Costs to implement the recommended improvement along the Stream and Drainage Corridors are presented below. In addition to the Stream and Drainage Corridor improvements, ancillary needs related to the drainage within the watershed were noted by citizens at the community meetings. Additional community needs are summarized on the master plan exhibits, where applicable. These problems and potential solutions should be addressed with the construction of other adjacent improvements at these locations.

Table ES-1: Summary of Master Plan Costs

Reach	ID	Project Description	Cost ($)
Coal Creek Stream Corridor 1 (Reaches 1 through 5)			
1	A	Stream Restoration	$ 39,028
2	A	Stream Restoration & Bank Stabilization	$ 404,331
3	A	Stream Restoration & Bank Stabilization downstream of CO 72	$ 321,945
3	B	Replace CO 72 Culvert at MM 14	$ 1,440,000
3	C	Stream Restoration, Bank Stabilization, Culvert Improvements upstream of CO 72	$ 1,120,124
4	A	Stream Restoration & Bank Stabilization to MM 14.4	$ 114,517
4	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 14.5 to MM 15	$ 411,559
4	C	Replace CO 72 Culvert at MM 15	$ 1,440,000
4	D	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15 to MM 15.2	$ 560,204
4	E	Elevate CO 72, MM 14.4 to MM 14.9	$ 1,548,360
5	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.2 to MM 15.8	$ 1,783,912
5	B	Elevate CO 72, MM 15.3 to MM 15.4	$ 293,250
Coal Creek Stream Corridor 2 (Reaches 6 through 7)			
6	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.8 to MM 16	$ 834,681
6	B	Replace CO 72 Culvert at MM 16	$ 1,440,000
6	C	Stream Restoration & Bank Stabilization MM 16 to MM 16.4	$ 642,108
6	D	Replace CO 72 Culvert at MM 16.4	$ 1,440,000
6	E	Stream Restoration & Bank Stabilization MM 16.4 to MM 16.6	$ 245,853
7	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 16.6 to MM 17.6	$ 1,892,827
7	B	Replace Twin Spruce Gap Road Culvert at MM 17.6	$ 540,000
7	C	Elevate CO 72, MM 16.9 to MM 17.6	$ 1,805,760
Coal Creek Stream Corridor 3 (Reaches 8 through 9)			
8	A	Storm Sewer at Carl's Corner / CO 72	$ 506,640
8	B	Alt 2; Acquisition of Property for Closed Coffee Shop, Stream Restoration and Bank Stabilization	$ 261,520
8	C	Stream Restoration, Bank Stabilization, Culvert Improvements MM 17.7 to MM 17.9	$ 529,338
8	D	Alt 2; Acquisition of Quick Mart & Propane Site, Stream Restoration, Culvert Improvements	$ 932,176
8	E	Stream Restoration, & Bank Stabilization, MM 18.1	$ 41,841
9	A	Stream Restoration, & Culvert Improvements MM 18.1 to MM 18.3	$ 161,253
9	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 18.3 to MM 18.6	$ 978,474
9	C	Elevate / Relocate CO 72, MM 18.4 to MM 18.6	$ 619,344
Coal Creek Drainage Corridor (Reaches 10 through 11)			
10	A	Culvert Improvements, Ranch Elsie Road through MM 18.9	$ 295,440
11	A	Culvert Improvements, MM 18.9 to Copperdale Lane	$ 31,920
Beaver Creek Stream Corridor (Reach 12)			
12	A	Stream Restoration, Bank Stabilization & Culvert Improvements	$ 1,459,069
Beaver Creek Drainage Corridor (Reach 13 through 14)			
13	A	Stream Restoration and Bank Stabilization	$ 124,108
South Beaver Creek Drainage Corridor (Reach 15 through 16)			
15	A	Culvert Improvements	$ 222,600
16	A	Bank Stabilization and Culvert Improvements	$ 1,380,481
Ranch Elsie Drainage Corridor (Reach 17)			
17	A	Bank Stabilization and Culvert Improvements	$ 683,940
Crescent Park Drainage Corridor (Reach 18 through 20)			
18	A	Culvert Improvements	$ 103,560
19	A	Stream Restoration, Bank Stabilization, and Culvert Improvements	$ 477,490
20	A	Culvert Improvements	$ 5,532
		Sub-Total	**$ 27,133,184**
		Engineering (10%)	$ 2,713,318
		Management (5%)	$ 1,356,659
		Total	**$ 31,203,162**

Table ES-2: Additional Master Plan Costs

Flood Warning Devices	
Item	Total Cost
Flood Warning Gage at Twin Spruce Gap Road	$25,000
Automated Rain Gage - Beaver Creek Basin	$20,000
Total	$45,000

Debris Removal	
Item	Total Cost
Coal Creek Stream Cooridor 1 (1-5)	$41,268
Coal Creek Stream Cooridor 2 (6-7)	$15,600
Coal Creek Stream Cooridor 3 (8-9)	$7,500
Coal Creek Drainage Cooridor (10-11)	$17,148
Beaver Creek Stream Cooridor (12)	$12,000
Beaver Creek Drainage Cooridor (13-14)	$15,000
South Beaver Creek Drainage Cooridor (15-16)	$10,500
Ranch Elsie Drainage Cooridor (17)	$4,500
Crscent Park Drainage Cooridor (18-20)	$5,700
Total	$129,216

Project Prioritization

For this watershed, it is evident that the goals and objectives for each stream corridor are not identical for each reach, and that the overall values from the canyon community are equally important to this planning process. This makes it very difficult to distinguish projects and prioritize for the future. For this reason, a project prioritization matrix was created in order to identify and rank the multitude of potential projects identified. This matrix and prioritization only includes the stream corridors reaches, as these reaches encumber the majority of immediate needs and higher level expenses. Due to their exposure, the steam corridors are more likely to be funded through flood response grants or future public infrastructure projects. Higher priority projects along the drainage corridors have also been discussed and should be considered alongside any improvement to the adjacent stream corridors, or as the need arise.

A total of 31 projects were ranked along the stream corridors. Where options were presented (Corridor 3, Reach 8) alternatives with a higher overall ranking were carried forward into the final master plan. The prioritization matrix evaluates and weights the general reduction in risk as determined by the project team, as well as community values presented by the priority survey. A summary of the overall project descriptions and rankings are presented in Table ES-3. Further detail regarding prioritization is discussed in Section 8.0 of this report.

Table ES-3 – Project Prioritization

Reach	ID	Project Description	Total Value (Points)	Corridor Rank	Overall Rank
Stream Corridor 1 (Reaches 1 through 5)					
1	A	Stream Restoration	**263**	12	**29**
2	A	Stream Restoration & Bank Stabilization	**301**	8	**23**
3	A	Stream Restoration & Bank Stabilization downstream of CO 72	**265**	11	**27**
3	B	Replace CO 72 Culvert at MM 14	**344**	6	**17**
3	C	Stream Restoration, Bank Stabilization, Culvert Improvements upstream of CO 72	**408**	3	**8**
4	A	Stream Restoration & Bank Stabilization to MM 14.4	**325**	7	**22**
4	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 14.5 to MM 15	**453**	1	**5**
4	C	Replace CO 72 Culvert at MM 15	**364**	5	**14**
4	D	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15 to MM 15.2	**404**	4	**9**
4	E	Elevate CO 72, MM 14.4 to MM 14.9	**277**	10	**26**
5	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.2 to MM	**430**	2	**6**
5	B	Elevate CO 72, MM 15.3 to MM 15.4	**297**	9	**24**
Stream Corridor 2 (Reaches 6 through 7)					
6	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.8 to MM 16	**382**	1	**10**
6	B	Replace CO 72 Culvert at MM 16	**343**	5	**18**
6	C	Stream Restoration & Bank Stabilization MM 16 to MM 16.4	**372**	3	**13**
6	D	Replace CO 72 Culvert at MM 16.4	**335**	6	**21**
6	E	Stream Restoration & Bank Stabilization MM 16.4 to MM 16.6	**260**	7	**30**
7	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 16.6 to MM	**374**	2	**12**
7	B	Replace Twin Spruce Gap Road Culvert at MM 17.6	**254**	8	**31**
7	C	Elevate CO 72, MM 16.9 to MM 17.6	**354**	4	**15**
Stream Corridor 3 (Reaches 8 through 9)					
8	A	Storm Sewer at Carl's Corner / CO 72	**376**	5	**11**
8	B	Alt 1; Storm Sewer at Closed Coffee Shop upstream of Carl's Corner & CO 72	**340**	7	**19**
8	B	Alt 2; Acquisition of Property for Closed Coffee Shop, Stream Restoration and	**419**	4	**7**
8	C	Stream Restoration, Bank Stabilization, Culvert Improvements MM 17.7 to MM	**265**	10	**27**
8	D	Alt 1; 100-year Storm Sewer at Quick Mark / Skyline Drive	**468**	3	**4**
8	D	Alt 2; Acquisition of Quick Mart & Propane Site, Stream Restoration, Culvert	**475**	1	**2**
8	E	Stream Restoration, & Bank Stabilization, MM 18.1	**472**	2	**3**
9	A	Stream Restoration, & Culvert Improvements MM 18.1 to MM 18.3	**354**	6	**15**
9	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 18.3 to MM	**340**	7	**19**
9	C	Elevate / Relocate CO 72, MM 18.4 to MM 18.6	**295**	9	**25**
Stream Corridor 4 (Reach 12)					
12	A	Stream Restoration, Bank Stabilization & Culvert Improvements	**482**	1	**1**

Permitting & Other Considerations

As noted previously, we believe that the improvement recommendations presented herein are consistent with enforceable roadway & drainage design criteria set forth by local administration through Jefferson County, Boulder County and CDOT. Prior to construction, or commencing other work on private property or within the drainageways, it is recommended that individuals consult with the appropriate jurisdictions regarding the proposed changes and construction requirements, such as obtaining engineered plans, permitting requirements, erosion and sediment control, water quality and natural resource protection, easements or other items that may be required. The following websites address specific requirements set forth by local jurisdictions:

1. Jefferson County: Flood Recovery Website: http://jeffco.us/disaster-recovery/#rebuilding
2. Boulder County: Flood Recovery Website: http://www.bouldercounty.org/flood/pages/default.aspx
3. CDOT: Private Access Reconstruction Guide: http://jeffco.us/Disaster-Recovery/Documents/CDOT-Private-Access-Reconstruction-Guide-for-Residents/

Section 404 of the Clean Water Act (CWA) establishes a program to regulate the discharge of dredged or fill material into waters of the United States and wetland areas. Activities in waters of the United States regulated under this program include fill for development, water resource projects, infrastructure, and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States. Proposed activities are regulated through a permit review process. An individual permit is required for potentially significant impacts. Individual permits are reviewed by the U.S. Army Corps of Engineers, which evaluates applications under a public interest review, as well as the environmental criteria set forth in the CWA Section 404(b)(1) Guidelines, regulations promulgated by EPA. General permits may also be suitable. General permits are issued on a nationwide, regional, or State basis for particular categories of activities. Local agencies, including the COE should be consulted and required permits should be obtained prior to filling or dredging material in stream or drainageways within the Coal Creek watershed, on a both a permanent and temporary basis.

SECTION 1.0 INTRODUCTION

1.1 Funding and Authorization

Funding for this master plan effort has been made possible through a watershed planning grant funded through the State of Colorado, Colorado Water Conservation Board (CWCB). The Environmental Group (TEG) was the applicant and recipient of the CWCB watershed planning grant. ICON Engineering, Inc. (ICON) and their project team, including Ecological Resource Company (ERC) and DHM Design (DHM) were chosen by TEG to complete this study through a competitive selection process. ICON's team includes engineers, GIS specialists, scientists, ecologists, planners, and landscape architects with diverse and extensive backgrounds. ICON's contract with TEG was formalized on May 20, 2014 to begin work on this project.

1.2 Background

This past September, properties surrounding Coal Creek Canyon were devastated from a deluge of flooding extending across the mountain community. The Coal Creek corridor was particularly hard hit, with extensive flood damage along the Highway 72 corridor, extending from upstream of Twin Spruce Gap Road downstream through Highway 93. As documented by the National Weather Service, Annual Exceedance Probabilities (AEP's) for this rainfall event were estimated at 0.1%, or a 1,000-year level for the region. The rarity of this event resulted in bank erosion, sediment deposition, and channel migration along Coal Creek and its tributaries. As noted throughout Coal Creek Canyon, high moisture levels in the surrounding landscape produced a large number of landslides which added soil, rocks and debris to the already surcharging creek. Most importantly, significant damage occurred to homes and businesses, bridges, and roadways in the wake of the flooding.

The canyon corridor changed before everyone's eyes, leaving questions and concerns moving forward, about how to restore Coal Creek, and how this level of destruction can be prevented in the future. These questions have led to the need for this watershed master plan, which takes a multi-faceted approach to stormwater planning. Focal points include:

- identifying current flood and geomorphic risk;
- flood resiliency for both future storm events and spring runoff;
- restoring ecological heath;
- reviewing culvert and bridge capacity;
- river bank stabilization to protect property;
- wildlife and habitat improvements;
- coordination with ongoing recreation planning.

1.3 Purpose, Scope, Limitations

The purpose of this master plan is to provide technical and planning guidance to improve resiliency for stream networks within the Coal Creek watershed. Although local government partners have provided input into this master plan, sponsorship for the master plan is predominately community based. The plan in itself does not modify existing local regulations, or administer new requirements for property owners, but should be used for general guidance for changes along the riverine systems. All property owners are encouraged to consult with local communities regarding rebuilding requirements as well as current county, state and federal regulations.

Similarly, this master plan provides general guidance for conveyance improvement, stream and ecological restoration, and planning. Government or property owners considering changes to, within, or across drainageways are encouraged to consult a professional engineer prior to commencing work in order to complete a site-level assessment of the changes and review compatibility with the recommendations presented within this master plan.

The following task items were completed as part of this study:

- Community Engagement;
- Stream Corridor Evaluations
- Hydrologic assessment & recommendations;
- Hydraulic modeling and preparation of approximate floodplain mapping for varying flow events;
- Flood, ecosystem and geomorphic risk assessments;
- Identification of strategies and project alternatives to improve watershed resiliency;
- Project prioritization and funding opportunities.

1.4 Planning Process

It is important to recognize that Coal Creek and its tributaries reside primarily on private land; therefore values and input from the canyon community was instrumental in making the master plan successful. As such, the project team developed outreach protocols needed to engage the local community.

The planning process was inclusive of the entire community. It was highly participatory with good representation and comprehensively looked at all aspects of the watershed and core community values. Anyone with an interest or stake in the watershed was invited to become part of the process to create and refine this master plan. The process included three open community meetings and workshops, consultations with numerous stakeholders and agencies, and participatory review of draft materials through a community member task force. A strong emphasis was placed on making this plan a representative document that embraced and responded to the goals and concerns of all parties with a stake in, or potentially affected by the project.

Public Awareness/ Public Outreach

Public awareness was developed through a combined effort of public notices, door to door flyers, use of social media (Facebook), project website, community flyers posted throughout the Canyon, message boards along Highway 72 and at the CCCIA building, advertisements in the local paper (The Mountain Messenger), emails to attendee's at prior events.

Public outreach began early on, with team members realizing the critical role the public and individual landowners will play in the restoration of the Coal Creek corridor. The project team reached out to key members of the local community to help notify residents of the upcoming study and recovery efforts. Public meetings have been essential in engaging local stakeholders, identifying high-risk areas, educating the public, and gathering input from residents.

The first and second public meetings allowed attendee's to offer feedback through a priority assessment survey, comment cards, direct questions with the planning team and key agencies involved in the project, and through a community forum page on Facebook and the project Website. Group meetings were held throughout the planning process.

Feedback was presented in the form of a response matrix indicating community survey results and comments received. Feedback was incorporated in the development of alternatives and in selecting priority projects.

- Public Meeting #1; May 29, 2014
- Public Meeting #2; August 20, 2014
- Public Meeting #3/ Final presentation – November 6, 2014

Public Meeting #1

The first public meeting was held on May 29, 2014, with a turnout of approximately 50 attendees. The majority of the attendees were local residents, mixed with local officials from Jefferson and Boulder Counties. At this meeting, a general overview of the master planning process was outlined, as well as the short and long-term goals for the project. Community members expressed concerns and frustrations about the cleanup and rebuilding process, the roles of local agencies such as CDOT and Jefferson County, spoke about their post-flood rebuilding efforts, and were instrumental in identifying major and minor flood hazards throughout the canyon, including flow paths along Coal Creek and maintenance issues such as plugged culverts. Community comments are shown in the appendix.

The project team also presented maps of the approximate 100-year floodplain throughout the canyon, in order to inform local residents of high-risk areas.

To help assess community values, a survey was made of attendees at the initial project open house meeting, asking residents to rank their short and long-term priorities for the corridor. This survey helped the project team compare and contrast ten (10) core values being considered with the master plan. A scoring system was developed based on the number of responses and rank for each item. Thirty-three community members participated in the survey.

Results of the survey indicated that immediate bank stability and future project funding were the highest priority issues, with transportation/emergency access, and environmental health/ecology close behind. Conveyance capacity issues were a mid-priority item, with survey results indicating that a 10- or 50-year recurrence interval (medium cost) was the preferred alternative. These ten values and the results of the survey are discussed further in Section 7.0.

Figure 1.1 – Public Engagement Activities at Public Meeting #1

Public Meeting #2

A second public meeting was held on August 20, 2014, where the project team updated residents regarding progress of the master plan, including hydrologic and hydraulic analysis, stream corridor evaluations, environmental and geomorphic risk assessments, and mitigation strategies. A summary of the technical data briefed residents on the estimated flood discharges and approximate floodplain mapping. Results from the geomorphic assessment were discussed, and goals were outlined, based on the community survey from May. Feedback from the previous meeting was also discussed, and preliminary restoration alternatives were presented on a reach-by-reach basis. Break-out sessions were held, where residents could speak one-on-one with project team members.

Public Meeting #3

The final public was held on November 6, 2014 where the project team presented this watershed master plan. The presentation focused on how the plan incorporated community feedback in development of priorities paired with other criteria developed through the core values identified in the community survey results. Next steps were discussed on how to implement the watershed plan and keep momentum moving in funding, management, and completing projects.

1.5 Mapping & Survey

Topographic mapping was provided by FEMA and the CWCB for use on this project. It was collected in November of 2013, approximately two months after the flood. This mapping was completed on the NAVD88 vertical datum and NAD83 State Plane Colorado Central horizontal datum. Additional field measurements were completed by ICON Engineering in April and May of 2014 in order to determine culvert size, shape, and material, as well as to determine approximate overtopping depths.

1.6 Data Collection

Multiple data sources were collected from groups including CDOT, the CWCB, and the Urban Drainage and Flood Control District (UDFCD). These studies include:

- Draft Hydrology Evaluation, Coal Creek Headwaters to Jefferson/Boulder County Line, CDOT Region 4, May 2014
- CDOT/CWCB Hydrology Investigation Phase One – 2013 Flood Peak Flow Determinations, January 21, 2014
- Draft Coal Creek and Rock Creek Major Drainageway Plan, UDFCD, September 2014
- Flood Insurance Study, Jefferson County, Colorado, and Unincorporated Areas, February 5, 2014

1.7 Acknowledgements

This report was prepared with groups including TEG, ICON Engineering, DHM Design, Ecological Resource Consultants, Inc., Jefferson and Boulder Counties, CWCB, the Colorado Department of Transportation (CDOT), the Federal Emergency Management Agency (FEMA), Natural Resource Conservation Service (NRCS), Jefferson Conservation District (JCD), and the Coal Creek Canyon Parks and Recreation District (CCPRD). Project participants are listed below.

Table 1.1: Project Participants

Name	Representing	Assignment
Chris Garre	The Environmental Group	President
Emily Troisi	The Environmental Group	Non-profit Program Manager
Craig D. Jacobson, PE, CFM	ICON Engineering, Inc.	Principal, Project Manager
Brian LeDoux, PE, CFM	ICON Engineering, Inc.	Project Engineer
Terry Martin, PE, CFM	ICON Engineering, Inc.	Project Engineer
Andrew Espinosa, EI	ICON Engineering, Inc.	Project Engineer
Jack Danneberg, EI	ICON Engineering, Inc.	Project Engineer
Eben Dennis	ICON Engineering, Inc.	GIS Specialist
Mark Wilcox	DHM Design	Principal
Troy Thompson, PE	Ecological Resource Consultants, Inc.	President, Sr. Water Resource Engineer
David Blauch	Ecological Resource Consultants, Inc.	Vice-President, Sr. Ecologist
Chris Sturm	Colorado Water Conservation Board (CWCB)	Stream Restoration Coordinator
Jeff Crane	CWCB	Stream Master Plan Liason
John Conn, P.E.	Jefferson County	Department of Transportation
Denise Grimm, AICP	Boulder County	Sr. Planner
Steve Harelson, PE	CDOT	West Program Engineer
Joseph Hansen	Jefferson Conservation District	Conservation Forester
Steve Yochum, PhD, PE	NRCS	Hydrologist
Naren Tayal	FEMA Region VIII	Recovery Support Function Coordination Specialist
Katie Knapp, PE, CFM	Coal Creek Community	Community Task Force
Dan Knapp, PE, CFM	Coal Creek Community	Community Task Force
John Baich	Coal Creek Community	Community Task Force
Libby Howard	Coal Creek Community	Community Task Force

SECTION 2.0 PROJECT BACKGROUND

2.1 Project Area

The Upper Coal Creek watershed has a drainage area of approximately 15 square miles, located within Jefferson, Boulder, and Gilpin Counties, with the majority of the watershed located within Jefferson County. The watershed is bounded to the north by the South Boulder Creek watershed, and to the south by the Ralston Creek watershed. Although this study does examine Coal Creek to the upper watershed limit, it was truncated downstream at the Urban Drainage and Flood Control District (UDFCD) boundary, located near Plainview Road, approximately 1.7 miles west of the intersection of Highways 93 and 72. Upper Coal Creek itself is approximately 8 miles long with ancillary tributaries entering along Twin Spruce Gap Road (Beaver Creek), Crescent Park Drive (Crescent Park Tributary) and at Ranch Elsie Road (Ranch Elsie Tributary). A south branch of Beaver Creek (South Beaver Creek) was also studied as it follows Twin Spruce Gap Road further west.

Overall the watershed consists of various forms of development, predominately focused along the stream corridors and the community center areas near Highway 72, Twin Spruce Gap Road, Crescent Park Drive, Skyline Drive and Ranch Elsie Road. Development is generally larger lot, mountain home sites, approximately 1 acre in size or larger. Cluster development including a coffee shop, two gas stations, a convenience store, a liquor store, and auto repair shops are located in the community center areas between Twin Spruce Gap Road and Crescent Park Drive. Beyond the residential and commercial areas, the watershed is a myriad of county parks and open space, conservation easements, private land, and pockets of national forest land and state parks. The watershed is bisected by Highway 72, which also encumbers a portion of the general stream corridor.

Floodplain mapping has not been developed by FEMA for the Upper Coal Creek watershed, with exception of the downstream end of this study. The current FEMA flood limits extend to 2,800-feet upstream of the Union Pacific Railroad embankment at the mouth of the Canyon. Due to the approximate nature of this floodplain, discharges and other technical information were not available from the Flood Insurance Study (FIS) for Jefferson County. A more detailed study for Coal Creek does exist within Boulder County, approximately 5 miles further downstream.

2.2 Flood History

The September 12, 2013 flood in Coal Creek Canyon was the largest flood on record at the Plainview gaging station, located downstream of the UPRR crossing. Although the gage was inoperable during the flood, flood flows were estimated at 3,900-cfs from local high water marks. This was estimated to be between a 100- and 200-year flood recurrence interval [NRCS, Yochum 2014]. Upstream of Twin Spruce Gap Road, flows were estimated to be 1,100-cfs, and between a 25- and 50 year level [CWCB, Houck 2014]. Prior to September 2013, flooding was not common within the Upper Coal Creek watershed, but also not unprecedented. Flood flows in excess of 2,000-cfs were reported on May 7, 1969, coincidental with widespread flooding in the Boulder County region. According to published reports (The Denver Post, May through June 1969), an estimated 400 families were isolated in Coal Creek Canyon by impassible roads.

2.3 September 2013 Flood Event

As noted previously, the rainfall event on September 12, 2013, was unprecedented in the Coal Creek watershed. Damage throughout the corridor was widespread. In particular, downstream of Twin Spruce Gap Road, nearly every access culvert failed, was washed out, or was significantly damaged. The channel eroded significantly, leading to visible scour through the La Duwaik Estates and other central residential corridors. Highway culverts also plugged with debris, further exasperating flooding effects on the highway and downstream infrastructure. The culvert crossing at the Union Pacific Railroad (UPRR) did manage to pass the peak flows; however, a sedimentation zone was formed in the valley upstream of the culvert, where much of the eroded material was deposited. With the exception of the old Real Estate building at Twin Spruce Gap Road, no homes or buildings were destroyed in this area, although some were badly damaged. This building has since been demolished, and the land acquired by the Colorado Department of Transportation (CDOT).

Photo 1 – West of Twin Spruce Gap Road on Highway 72

The Coal Creek Canyon community center is located upstream of Twin Spruce Gap Road. Significant damage was also evident in this area, including structure inundation and culvert failures. Runoff from the Crescent Park Tributary eroded drainages and moved sediment through this corridor. Flood damage was widespread at both commercial and residential locations. A new channel was excavated at the intersection of Crescent Park Drive and Highway 72 to help direct discharges from the Crescent Park Tributary to Coal Creek.

Photo 2 – Driveway Culvert Failure on Coal Creek

Similar observations were made in the upper portions of Coal Creek and its tributaries, with damages along Twin Spruce Gap Road (Beaver Creek), Crescent Park Drive, and Ranch Elsie Road. Again, failure was noted at many driveway and access culverts, as well as damage to homes and other structures.

As with other historic flood events, highway and roadway access was limited during and after the flood event. Highway 72 reopened permanently approximately two months following the flood event. Access for residents to and from the front range was very limited over this time period and required extensive detouring to otherwise nearby areas.

Following the flood event significant efforts were made (and are still ongoing) to repair the destruction. Much of the repair work, such as private culvert replacement, has been completed by individual land owners. The NRCS has also provided assistance to qualified land owners in need of immediate assistance through their Emergency Watershed Protection (EWP) program. Repair work to public infrastructure has been led by groups including Jefferson and Boulder Counties.

Along Highway 72, CDOT has been active in repairing and reopening the highway. This work has included debris removal, roadway reconstruction/resurfacing, and bank reinforcement in areas adjacent to the highway with high erosive susceptibility. Much of this initial work was an immediate response to the flood event and CDOT is currently in the planning stages to provide more infrastructure improvements along Highway 72.

Photo 3 – One of Numerous Washouts along Highway 72

Figure 2.1 - Coal Creek Master Plan Watershed Map

Coal Creek Watershed
County Boundary
UDFCDBoundary
Union Pacific Railroad
Coal Creek Canyon Park
White Ranch Park
Open Space

0 1 2 miles

Boulder County
Jefferson County
Gilpin County
UDFCD Boundary
Coal Creek
Ranch Elsie Road Tributary
Crescent Park
Butte Drive
Beaver Creek
Twin Spruce Gap Rd
South Beaver Creek
Highway 72
Union Pacific Railroad
Plainview Road
Coal Creek
LaDuwaik Estates
Golden Gate
Eldorado Mountain
Scarlop Mountain
Blue Mountain
Coal Creek Canyon Rd
Indian Peak Rd
Ronnie Rd
Leon Ln
Elliot Ln
Rudi Ln
Brook Rd
Hillcrest Rd
Lillis Ln
Sylvan Rd
Ranch Elsie Rd
Skyline Dr
Hilltop Rd
Butte Dr
Buyland Rd
Circle Dr
Nadm Dr
Fisher Rd
Tunnel Rd
Stanton Dr
Dowdle Dr
Gap Rd
Chute Rd
Spruce Canyon Cir
Riveland Construction
Blue Mountain Dr
Prairview Rd
Railroad Access Rd
Coal Creek Peak
Camp Wondervu
COAL CREEK
COAL CREEK CANYON
1 2 3 4 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 31

SECTION 3.0 HYDROLOGY

3.1 Project Hydrology

Baseline Hydrologic Data

Hydrologic information for the Upper Coal Creek Watershed has been obtained and reviewed from a variety of sources. Hydrologic information for the study was based on a recent hydrology report for Coal Creek prepared in draft format for the UDFCD [RESPEC, 2012]. As part of this report, hydrology was based on rainfall-runoff simulations for approximately 27 sub-watersheds, computed using the Colorado Urban Hydrograph Procedure (CUHP) and routed using the EPA-SWMM 5.0 computer program. As part of this study, rainfall data was derived from local criteria, applied over the watershed, and adjusted for cumulative tributary areas in excess of 10 square miles as necessary. Sub-watershed characteristics included drainage area, centroid distance, length, slope, imperviousness, depression storage, and soil infiltration parameters. Computed results from the 2012 study were compared against past studies from both FEMA and the Soil Conservation Service (SCS). The 2012 RESPEC study was utilized at the onset of the master plan as the best available information.

NRCS Flood Frequency Analysis

A Flood Frequency Analysis (FFA) was completed by NRCS staff based on stream gage records for the gage station near Plainview Road. The FFA was based on 43 years of annual peak flow records, extending from 1959 through the most recent flood in 2013. Results of this analysis estimate 100-year flood flows of 2,620 cfs and 25-year flood flows of 842 cfs. This compares with 3,370 cfs and 870 cfs for the 100- and 25-year flood events, respectively, from the RESPEC report. Overall this comparison demonstrates reasonable confirmation of the 2012 RESPEC results using documented stream flow information.

CDOT/CWCB Peak Flow Estimates

Independent hydrologic modeling is currently underway by CDOT and the CWCB for flood affected regions of the state, including the Upper Coal Creek Watershed. Information presented to the watershed team has indicated that the CDOT/CWCB findings compare within 7 percent of the values presented by the 2012 RESPEC study, further validating the findings. The CWCB has requested that Jefferson and Boulder counties adopt either their new study information, or the 2012 RESPEC discharges, for use in master planning and future regulation of the drainageways.

Peak flow estimates are presented in the table below. It should be noted that the 2-, 5-, and 10-year peak discharges presented by the RESPEC report were very low, and not representative of the watershed size or equivalent values calculated from the FFA at the stream gage. More reasonable discharges were needed to estimate flood risk within the watershed and to provide appropriate recommendations regarding stream geomorphology. Therefore, for the purposes of the master plan, flow values for the 2-, 5-, and 10-year flood events were proportioned from the 25-year flood flows using the NRCS FFA. Equivalent proportioning was applied throughout the watershed.

Table 3.1, Recommended Discharges

Location		2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
River	Description	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Coal Creek	Near mile marker 12.7	53	180	374	870	1720	3370	6290
Coal Creek	Near mile marker 13.5	52	178	370	860	1700	3310	6140
Coal Creek	Near mile marker 15.2	53	180	374	870	1650	3120	5670
Coal Creek	Near mile marker 15.8	53	180	374	870	1620	3050	5500
Coal Creek	Near mile marker 16.6	53	180	374	870	1600	2960	5260
Coal Creek	Twin Spruce Gap Rd	62	211	439	1020	1750	3060	5090
Coal Creek	Crescent Park Drive	21	72	150	350	550	900	1450
Coal Creek	Ranch Elsie Road	21	72	150	350	540	870	1380
Coal Creek	Near mile marker 19	16	54	112	260	400	630	1000
Coal Creek	Copperdale Lane	7	25	52	120	170	250	390
Beaver Creek	South Beaver Creek confluence	38	130	271	630	1050	1810	3030
Beaver Creek	Approx. 1.2 mi upstream of confluence	21	72	150	350	570	970	1610
Beaver Creek	Upstream limits	16	54	112	260	420	690	1120
South Beaver Creek	Burke Road	16	56	116	270	460	770	1290
South Beaver Creek	Upstream limits	15	50	103	240	360	560	880
Ranch Elsie	Reach Limits	7	23	47	110	150	220	320
Butte Drive	Reach Limits	4	12	26	60	90	150	230
Crescent Park	Butte Drive	7	23	47	110	170	270	430
Crescent Park	Upstream Limits	3	10	21	50	80	130	200

SECTION 4.0 HYDRAULICS

4.1 Evaluation of Existing Facilities

Hydraulic analysis of Coal Creek was performed in order to determine the hydraulic capacity of the channel and roadway culverts and to determine the approximate floodplain extents. In order to determine the existing culvert and channel capacities, HEC-RAS was used, with the project hydrology mentioned above. This analysis is based on the post-flood condition, reflecting repairs completed after the September 2013 flood, which may not match the pre-flood or current conditions.

4.2 Existing Drainage Facilities

Existing drainage facilities along Coal Creek and its tributaries vary in size, shape, and material. Capacity throughout the canyon varies, and nearly every culvert is undersized compared to the 100-year discharges. Private culverts are

Photo 4 – Culverts range from small and mostly blocked to large box culvert roadway crossings

generally round corrugated metal pipe (CMP), with smaller capacities, whereas CDOT or other publicly-owned culvert crossings are generally concrete box culverts (CBC's) or round pipe (RCP). Condition also varies greatly, with some of the older culverts nearly full of sediment, while newer installations are cleaner. Individual culvert crossing sizes and dimensions were measured along each stream reach and incorporated into the hydraulic modeling for this report. Culvert dimensions were field verified by ICON in April and May of 2014.

Channel capacities and approximate floodplain boundaries were determined using HEC-RAS and the LiDAR topographic mapping described previously. A GIS interface was used to determine channel flow paths and cross-section locations, automating portions of the data gathering process over the approximately 13 miles of stream modeling completed for this study. Once the HEC-RAS model was completed, the same GIS interface was used to determine approximate floodplain boundaries.

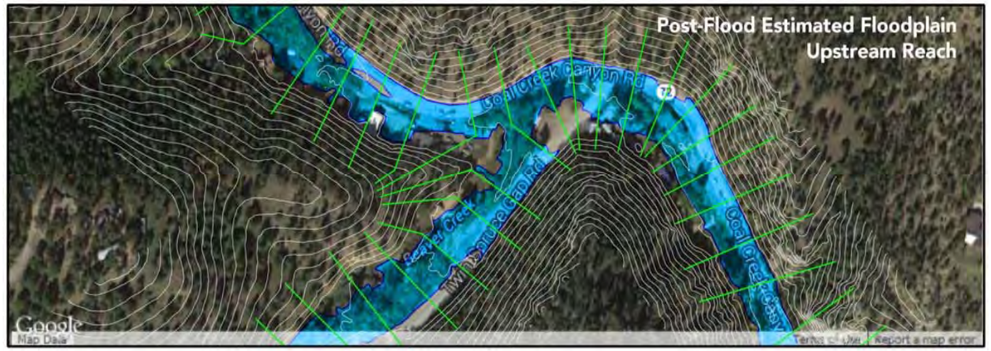


Figure 4.1 – Floodplain Modeling with GIS Interface

4.3 Floodplain Risk Analysis

As noted previously, current floodplain mapping does not exist for the Upper Coal Creek watershed, with exception to an approximate delineation prepared by FEMA for the lower 2,800 feet of the study limits. Therefore, new floodplain mapping was developed by ICON for use in this study. Similar to the FEMA delineation, approximate floodplain mapping methods were utilized.

Photo 5 – Highway Inundation at Twin Spruce Gap Road

Floodplain mapping was based on LiDAR topographic mapping provided by FEMA and the CWCB for use on this project. LiDAR data was collected in November of 2013, approximately two months after the flood. At this time, corridor rebuilding efforts were underway, therefore, in certain areas, LiDAR data may already be obsolete and not representative of current field conditions. However, it was determined to be the best available information at the time for use on this master plan.

Overall, a combination of approximately 48 buildings are estimated to be within the 100-year floodplain limits, as defined by the approximate floodplain mapping. The 25-year floodplain includes 34buildings, and 10 buildings are estimated to be within the approximate 10-year flood limits. Limited risk was identified for flooding from events less than 10-year levels. Homes and buildings with higher flood risk are generally located

between Highway 72 mile marker 14 and 16, downstream of Twin Spruce Gap Road, and between Twin Spruce Gap Road and Ranch Elsie Road on Coal Creek, and between Highway 72 and the confluence with South Beaver Creek on Beaver Creek.

Highway 72 and other county roadways are also periodically inundated by rainfall events less than the 100-year frequency. Flooding potential is prevalent at nearly all highway stream crossings west of the railroad crossing. Nearly 0.5 miles of highway is inundated at the bends near mile marker 15, and 0.6 miles of highway has the potential to become inundated east of Twin Spruce Gap Road, around the 'S' curves (mile marker 17). Further upstream flood risk was identified at the confluence with the Crescent Park Tributary, where improved culvert crossings only have an estimated 10-year capacity, and along Twin Spruce Gap Road, where much of the roadway is inundated downstream of the confluence with South Beaver Creek. Inundation of the roadways during flood events has the potential to not only damage the roadways, but also to prevent emergency access to the canyon community.

The approximate 100-year flood limits have been presented on project planning workmaps provided in this report and during public meetings.

Photo 6 - Flooding at Highway 72 and Crescent Park Drive

SECTION 5.0 GEOMORPHOLOGY

5.1 Background

In order to assess post-flood conditions and define objectives for potential restoration work, ERC evaluated channel morphology along Coal Creek and its tributaries. The purpose of the analysis was to establish conditions of the Coal Creek drainage both prior to and after the flooding and to define key geomorphic guidelines that can be used for future remediation. The study includes the main stem of Coal Creek and its major tributaries from the basin headwaters downstream to the overall master plan study limits. The assessment focused on defining general characteristics of the drainage as they relate to stream conditions and channel morphology. Information regarding the channel conditions was used to define typical channel geometries and features to guide future channel size and shape.

5.2 Stream Classification

Stream types were determined based on aerial mapping and field assessments for the full length of Coal Creek and its major tributaries using Google Earth (2013). The Rosgen stream classification system was selected for this initial assessment and is a widely used framework that defines stream types on the basis of geomorphic characteristics including channel slope, sinuosity, width/depth ratio, and entrenchment ratio. The classification system integrates geomorphic pattern with predominate bed material to identify different types of streams. (Rosgen 1996). The assessment considers the slope, sinuosity, and shape of a channel to characterize the stream type. All reaches of Coal Creek were determined to fall within the Aa+, A, B, or C stream types, as described below. The results of this assessment are shown on the Stream Assessment Map.

Photo 7 – Type Aa+ Tributary to Coal Creek

5.3 Stream Classification Results

A total of 18 different stream segments were classified within the study area. Individual reaches were delineated based on physical features, as defined by the Rosgen Classification System. The 18 stream segments include one tributary segment along Ranch Elsie Road, four segments along Crescent Park Drive and Butte Drive, six total segments on Beaver/South Beaver Creek and seven segments on the main stem of Coal Creek. The location of each of the different stream segments with the resultant stream classification is presented on Figure 5.1 with color coding used to identify different stream types. The four stream types that were found to occur based on the basic analysis are Types Aa+, A, B and C. Generic descriptions of each of these four stream types is given below.

Type Aa+

Stream Type Aa+ streams are defined as "very steep, deeply entrenched, cascading, debris transport, torrent streams," that have high relief and typical bedforms containing chutes, debris flows, and waterfalls (Rosgen 1996). Type Aa+ streams are steeper than Type A streams (average slopes greater than 0.10 ft/ft), and may have lower sinuosity (between 1.0 and 1.1). Photo 7 gives a representative example of a portion of a Type Aa+ channel that was observed in the study area.

Type A

Stream Type A streams are defined as "steep, entrenched, cascading, step/pool streams," with high energy and high debris-transport potential (Rosgen 1996). Type A streams are steeper than Types B and C (average slopes between 0.04 and 0.10 ft/ft), and have slightly lower sinuosity (between 1.0 and 1.2). The meander width ratio of Type A streams typically ranges between 1 and 3 (Rosgen 1996). Photo 8 gives a representative example of a portion of a Type A channel that was observed at Coal Creek.

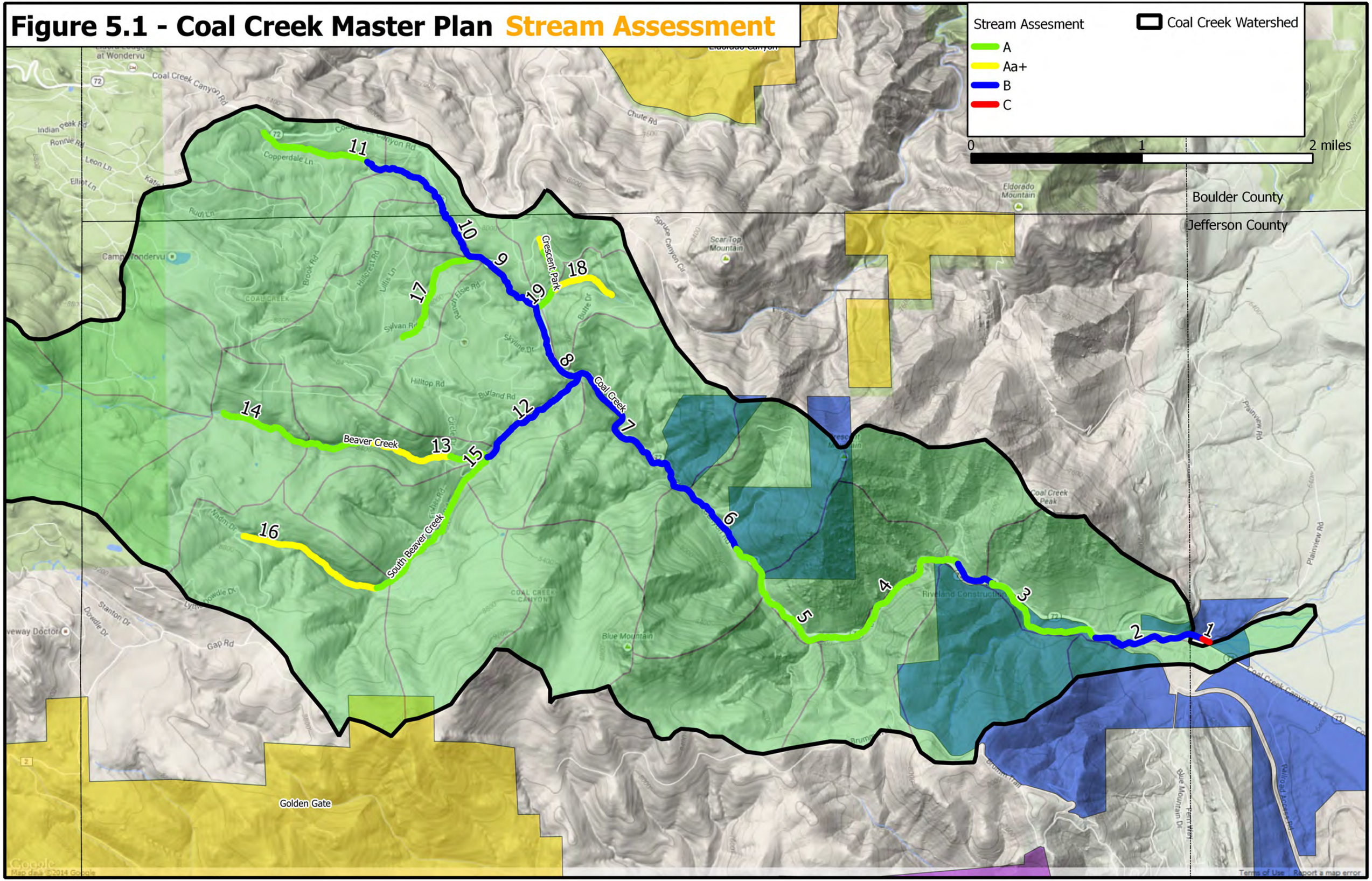
Photo 8 – Type A Section of Coal Creek

Type B

Type B streams are defined as having "moderately entrenched, moderate gradient, riffle-dominated channels, with infrequently spaced pools" (Rosgen 1996). The plan, profile, and banks of Type B streams are all considered to be stable. The sinuosity of these stream types are greater than 1.2, with an average slope between 0.02 and 0.039 ft/ft, and a typical meander width ratio between 2 and 8. Type B streams are usually seen in narrower, steeper valleys than Type C streams, and contain colluvial deposition in the reach. Rapids and scour pools are characteristic of Type B streams. Photo 9 gives a representative example of a portion of a Type B channel that was observed at Coal Creek.

Photo 9 - Type B Section of Coal Creek

Figure 5.1 - Coal Creek Master Plan Stream Assessment



Type C

A Rosgen Type C stream is typically characterized as being a "low gradient, meandering, point-bar, riffle/pool, alluvial channel with broad, well-defined floodplains" (Rosgen 1996). Type C streams have a sinuosity greater than 1.2, an average slope less than 0.02 feet per foot (ft/ft), and a meander width ratio (i.e., meander belt width divided by stream bankfull width) typically between 4 and 20. These streams are slightly entrenched with well-defined meandering channels and the floodplains typically consist of alluvial soils. No photos were taken on Coal Creek or its tributaries of a Type C reach. The only stretch of Type C stream in the project area is the very downstream section of the stream.

5.4 Aerial Photographic Analysis

Aerial images of Coal Creek, its tributaries, and the land surrounding the stream were evaluated to understand any macroscopic changes in channel morphology that may have occurred as a result of the 2013 flood event. For this analysis, aerial photos depicting the stream corridor taken prior to the flood were compared to aerial photos taken after the flood. Post flood aerials are based on imagery dated October 2013 while pre-flood images show conditions as of October 2012. Changes, which are presumed to be a result of the flood, were noted. Observed trends are discussed below.

Because the flood event occurred in September 2013, which was only one month before the post-flood condition aerial imagery was taken, comparing the pre- and post-flood condition aerial photos allows for a better understanding of the immediate damage caused by the flooding. The most noticeable change seen in the post-flood photos is scouring and vegetation loss along the stream. At several locations along Coal Creek, especially downstream from its confluence with Beaver Creek, the stream itself is not visible in the pre-flood condition aerials due to being obscured by the vegetation along the stream, however much of this vegetation was removed and transported by the event, causing the post-flood condition photos to clearly show much more of the stream and provide evidence of the channel and its banks having been scoured by the event.

Another noticeable change in the post-flood condition is damage to roadways, particularly driveways crossing the creek. Several residential structures exist along Highway 72 with Coal Creek running between the structures and the highway, and the post-flood aerial photos show many of the driveways crossing the creek to allow access to these structures were damaged or completely destroyed by the flooding. This type of damage is also observable along Twin Spruce Gap Road, where several driveways crossing Beaver Creek were demolished by the high flows. Deterioration to Highway 72 is also seen in the post-flood condition aerial photos, especially on the highway's shoulders in locations where the stream flows close to the road, and significant damage to the highway took place at its junction with Crescent Park Drive. This damage appears to have been caused by high flows in the tributaries running alongside Butte Drive and Crescent Park Drive, and not Coal Creek itself.

Moving upstream along Coal Creek, especially upstream of its main tributaries, the aerial photos show much less flood damage than the downstream reaches of the creek. Many of the upstream reaches of the creek have very few observable changes between the pre- and post-flood conditions.

5.5 Typical Channel Geometries

Information on channel classification along with estimated flows were used to approximate natural channel geometries along the corridor. Locations of these flow segments are shown in Figure 5.1. Typical values of width to depth ratios (width of the stream at bankfull conditions divided by the bankfull stream depth) and entrenchment ratios (width of the stream channel for a depth that is twice the bankfull width divided by the bankfull stream width) were used to help approximate natural channel geometry. Normal flow calculations were made to define the channel size where bankfull flow, channel slope, width/depth ratios and entrenchment ratios met the typical criterion described above. Given the range of slopes associated with each stream type, a range of channel geometries was determined.

A summary of recommended geometries for each primary channel type, within each individual reach is given in Table 5.2. These tables can be used to define the approximate channel geometries throughout the basin. All channel sections are assumed to be generally trapezoidal with a bottom width that is defined by the column "Base (ft)".

Table 5.1 – Target Slope Ranges, Width/Depth Ratios, and Entrenchment Ratios for Each Stream Classification

Stream Classification	Slope Range	Width/Depth Ratio	Approximate Entrenchment Ratio
Aa+	>10%	<12	1.2
A	4% - 10%	<12	1.3
B	2% - 4%	>12	1.8
C	0.1% - 2%	>12	3

These tabulated values provide average channel geometry information, but it is not the intent nor is it desired that the channel take on a uniform, defined cross section. Variability is inherent in any natural system and is desired for improvements along Coal Creek.

In addition to variability in cross section, variability in channel slopes is a characteristic of natural channels. Features such as step pools, scour pools, rapids and riffles/pool sequences occur naturally and provide variety from both a habitat and aesthetic standpoint.

Table 5.2 – Geometries for Primary Stream Types at Each Flow Location

		Minimum Slope Range					Maximum Slope Range				
Flow Location	Stream Type	Slope (%)	Base (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Width at 2x Bankfull Depth (ft)	Slope (%)	Base (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Width at 2x Bankfull Depth (ft)
1	B	2%	15	18	1.3	32	4%	13	15	1.1	27
2	B	2%	15	18	1.3	32	4%	13	15	1.1	27
3	A	4%	12	15	1.3	20	10%	10	12	1.1	16
4	A	4%	12	15	1.3	20	10%	10	12	1.1	16
5	A	4%	12	15	1.3	20	10%	10	12	1.1	16
6	B	2%	15	18	1.3	32	4%	13	15	1.1	27
7	B	2%	16	19	1.4	34	4%	14	17	1.2	31
8	B	2%	11	13	0.9	23	4%	9	11	0.8	20
9	B	2%	11	13	0.9	23	4%	9	11	0.8	20
10	B	2%	8	10	0.9	18	4%	7	9	0.8	16
11	A	4%	4	6	0.8	8	10%	4	6	0.6	8
12	B	2%	13	15	1.1	27	4%	12	14	1	25
13	A	4%	8	10	1	13	10%	6	8	0.9	10
14	A	4%	7	9	0.9	12	10%	5	7	0.8	9
15	A	4%	7	9	0.9	12	10%	5	7	0.8	9
16	A	4%	7	9	0.9	12	10%	5	7	0.8	9
17	A	4%	4	6	0.8	8	10%	4	6	0.6	8
18	Aa+	10%	3	4	0.6	5	15%	3	4	0.6	5
19	A	4%	4	6	0.8	8	10%	4	6	0.6	8
20	A	4%	3	4	0.6	5	10%	2	3	0.5	4

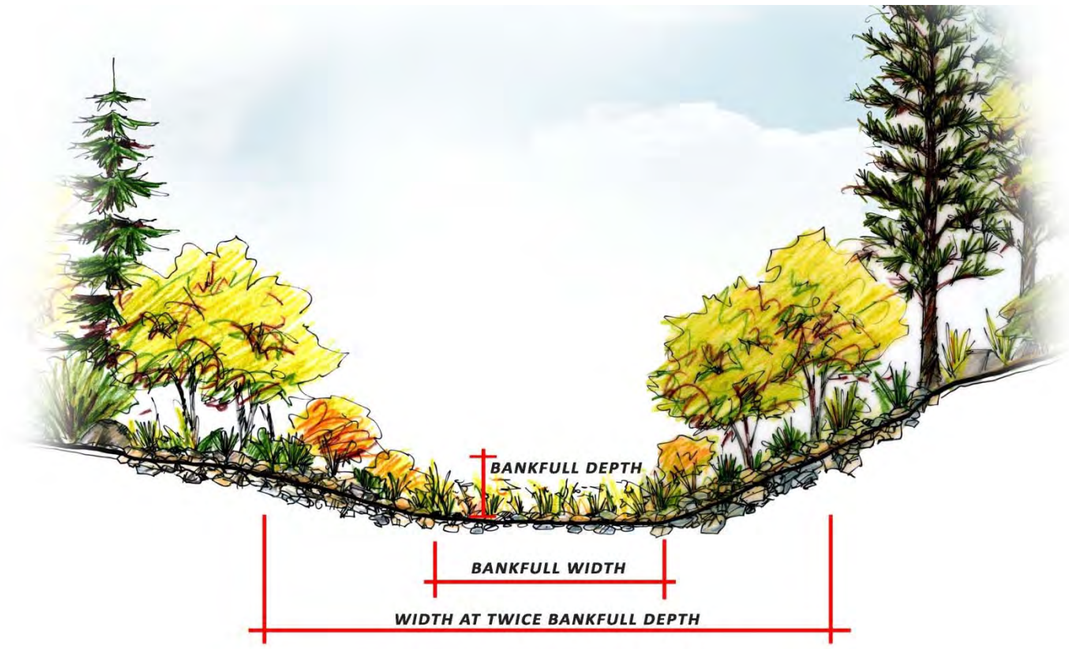


Figure 5.2 – Typical Coal Creek Cross-Section

SECTION 6.0 ECOLOGICAL & RIPARIAN ASSESSMENT

6.1 Background

During the initial flood recovery efforts, emergency stabilization measures focused more on hardened methods such as riprap, grout, boulders and infrastructure repair, which can be quickly deployed. As the focus shifts towards long-term stabilization, measures must also consider restoration of critical natural riparian ecosystem function.

The importance of a well-developed riparian corridor is well documented. Well vegetated riparian corridors provide important terrestrial wildlife habitat, aquatic habitat benefits, soil stabilization, and reduced problems from erosion, flooding and nutrients. A properly functioning riparian corridor protects the physical integrity of the aquatic environment.

As part of ICON's team, ERC completed a cursory baseline assessment of the post-flood riparian corridor within the project area. The general condition of the existing riparian corridor was assessed, including dominant vegetation community types remaining, species composition, and primary vegetation strata that remain or that may have been damaged or lost. In addition, the assessment defined a "reference condition" riparian community, representing the ideal riparian community that existed prior to the flood event. This reference condition should be a focus for re-establishment of vegetation during long-term recovery efforts. Critical wildlife habitat also should be considered during flood recovery efforts. This section of the report summarizes the riparian corridor existing conditions as well as a cursory screening of potential federal and state threatened and endangered species that may occur in or immediately surrounding the project area.

Importance of the Riparian Zone

A riparian corridor or "riparian zone" is defined as the transitional area or interface between upland terrestrial and aquatic habitats. A riparian zone is generally considered that portion of the landscape from the ordinary high water mark towards the adjoining uplands that affect or are affected by the presence of water. The riparian zone often varies within each watershed, containing notably different vegetation communities from the surrounding upland habitat. Properly functioning riparian zones of high ecological integrity contain an unfragmented, structurally diverse vegetation community, typically composed of three strata of trees, shrubs and grasses that are native to the region and that are adapted to the climatic, soil, and hydrologic conditions. The riparian zone has a variety of functions important to the stream or aquatic environment. Well vegetated riparian zones provide important terrestrial wildlife habitat, provide aquatic habitat benefits (shading, decreased water temperatures and instream cover), soil stabilization, and reduced problems from erosion and sedimentation. Riparian vegetation also contributes to bank stability by dissipating the energy of moving water and reducing velocity, which is imperative during typical flood events. A properly functioning riparian zone protects not only water quality but also the physical integrity of the aquatic environment.

6.2 Existing Condition of the Coal Creek Riparian Zone

Through the study area, Coal Creek is a steep walled perennial stream, typically comprised of dense riparian vegetation occurring along the drainage bottom, dominated by forested woodland overstory underlain by shrubs and herbaceous species. As a result of the September 2013 regional flood event, the existing riparian zone within the project area was significantly altered and in some areas completely lost. In various locations the creek migrated horizontally and vertically, with significant deposition and incision, to the point of destroying infrastructure. The effects included debris flows from hillsides, causing erosion and deposition of material in tributaries, along with conveyance and deposition of significant debris such as rocks, cobble, sand, trees, and household materials throughout the stream corridor.

Photo 10 – Debris within Coal Creek due to Sediment Flows

Floods can interact with vegetation in complex ways, both influencing and influenced by the structure and composition of the riparian zone (Johnson et al. 1999). The intensity of vegetation disturbance can be variable and influenced by factors such as pre-flood site conditions (i.e., type of vegetation present and channel constraints) and the interaction with flood dynamics (i.e., magnitude of flow and delivery of wood/sediment to a channel). Flood damage to riparian zone vegetation can occur by sediment and debris impact, scour or erosion of substrate, or through long-lasting change of hydrological conditions in the watershed. A less evident negative impact is a general decrease in plant vigor associated with post-stress reaction of plants to erosion (Toda et al., 2005). Flooding can damage trees indirectly by modifying soil characteristics. High stream flows can wash away soil, exposing roots or depositing soil around a tree, smothering the roots. In some cases, trees damaged from flooding can recover in as little as one growing season, while others do not recover at all. In addition, stressed trees can become more susceptible to secondary problems such as insect infestation or windthrow from the damaged root systems.

The post-flood condition of the riparian zone varies locally through the project area. In the upper reaches of the watershed where disturbance was low, more ideal riparian conditions are present characterized by dense forest canopy with willow and grass understory. These low disturbance areas are considered to be generally stable with little to no restoration required.

The mid to lower portions of the project area convey a larger portion of the watershed, and thus experienced higher flood flows and moderate disturbance. These areas exhibit various degrees of vegetation disturbance, particularly in the understory strata, ranging from 1) complete loss of riparian shrubs and grasses along large sections of the stream bank to 2) small isolated areas of riparian understory damage to 3) areas where shrubs remain intact with no understory grasses present. Loss of native soils is also widespread in these lower portions of the watershed. Areas of moderate disturbance may require physical streambank stabilization, import of soil material and/or re-vegetation of one or more strata to restore the native riparian community. Areas of high disturbance can be found throughout the mid to lower reaches of the watershed and are characterized by complete loss of all vegetation strata in the riparian zone. These areas will require more substantial restoration to provide long-term stabilization and re-

establishment of the riparian zone. Photos 11-14 are examples of the post-flood existing riparian zone conditions within the project area.

Photo 11 - Example of low disturbance to the riparian zone. This photo depicts a more ideal riparian zone vegetation community along Coal Creek at the downstream end of project area. In this section, the riparian zone is dominated by an overystory of narrowleaf cottonwood and ponderosa pine tree canopy intermixed with dense shrub understory with native grass species.

Photo 12 - Example of moderate disturbance to the riparian zone. This photo depicts a common condition in the middle to lower portions of the project area where scouring has removed herbaceous understory. A dense willow-dominated midstory is present which provides streambank stabilization however the lack of a stable understory can lead to soil erosion or root damage further limiting riparian functions.

Photo 13 - Example of high disturbance to the riparian zone. Flood flows and transport of large alluvial material/wood have eroded the channel of Coal Creek, completely removing vegetation within the riparian zone.

Photo 14 - Example of high disturbance to the riparian zone. High flows and debris have severely eroded the riparian zone shrub and understory community and damaged trees.

6.3 Riparian Zone Vegetation Community Reference Standard

The overall riparian zone vegetation community type within the project area is characteristic of the Rocky Mountain lower montane riparian woodland and shrubland. This community type is fairly common in the Foothills of the Colorado Front Range. In a more undisturbed, pre-flood condition, vegetation would be continuous along the entire corridor and occupy three strata (i.e., overstory, mid-story and understory). The vegetation along the immediate streambanks of Coal Creek and its tributaries through the riparian zone would be dominated by tree canopy shown in Table 6.1. These species would be intermixed with dense shrub mid-story comprised of species shown in Table 6.2. Smaller, sporadic patches of aspen (Populous tremuloides) also would also exist throughout in the riparian zone.

Willows species also have a unique ability to be harvested from onsite sources and installed as live stakes. Willow live staking consists of harvesting a cutting or single stem of a willow shrub. The stake is then inserted into the ground then will naturally root and develop above ground shoots. Willow live staking can be completed with best results if performed between February 1 and April 1, before budding stage. Cuttings should be harvested while dormant, soaked (completely submerged) a minimum of 24-hours prior to installation and kept moist at all times during preparation. Willow stakes can be installed in a variety of (moist) soils, above the ordinary high water mark.

Table 6.1 – Overstory & Canopy Riparian Species

Canopy - Primary Species	
Common Name	**Scientific Name**
Narrowleaf Cottonwood	*Populus angustifolia*
Colorado Blue Spruce	*Picea pungens*
Secondary Species	
Rocky Mountain Maple	*Acer glabrum*
Box Elder	*Acer negundo*
River Hawthorn	*Crataegus rivularis*
Quaking Aspen	*Populus tremuloides*
Peachleaf Willow	*Salix amygdaloides*

A dense herbaceous understory layer dominated by native grasses would be present along portions the streambanks above the ordinary high water mark. These species are shown in Table 6.3 below. Replicating the natural characteristics of the local Rocky Mountain lower montane riparian woodland and shrubland habitat type, including re-establishment of cottonwood tree overstory and a willow shrub mid-story with a mixed grassland understory should be the primary objective for riparian restoration efforts in order to restore the overall riparian zone function.

The mid to upper slopes of the project area above the riparian zone primarily consist of forested communities with ponderosa pine (at low elevations and on south-facing slopes) and with mixed conifer forest co-dominated by Douglas-fir on north-facing slopes. Lodgepole pine forest is predominant in the higher elevations of the watershed. These dry forested slopes of the corridor support a mosaic of understory shrubland species including mountain mahogany, American plum, juniper, Woods' rose and wax currant distributed within the ponderosa pine. The

herbaceous understory contains areas of grass and forb species including wheatgrass, blue grama, some cheatgrass, smooth brome, and dandelion.

Table 6.2 – Mid-Story Riparian Species

Mid-Story - Primary Species	
Common Name	**Scientific Name**
Narrowleaf Willow	*Salix exigua*
Geyer's Willow	*Salix geyeriana*
Bluestem Willow	*Salix irrorata*
Booth's Willow	*Salix boothii*
Drummond Willow	*Salix drummondiana*
Secondary Species	
Thinleaf Alder	*Alnus incana*
Western Serviceberry	*Amelanchier alnifolia*
Twinberry Honeysuckle	*Lonicera involucrata*
American Plum	*Prunus americana*
Chokecherry	*Prunus virginiana*
Woods' Rose	*Rosa woodsii*

Table 6.3 – Understory Riparian Seed Mix

Common Name	Scientific Name	Variety	% Species in Mix	# PLS Required/acre
Indian ricegrass	*Achnatherum hymenoides*	Native	20	6.18
blue grama	*Bouteloua gracilis*	Native, Lovington, Alma	10	0.53
Canada wildrye	*Elymus canadensis*	Native	10	3.79
slender wheatgrass	*Elymus trachycaulus*	Native, San Luis	25	6.85
switchgrass	*Panicum virgatum*	Blackwell, Nebraska 28	10	1.12
western wheatgrass	*Pascopyron smithii*	Native, Arriba	25	9.9
			100	**28.36**

6.4 Threatened and Endangered Species

ERC conducted a preliminary screening for federal and state threatened and endangered species within the project area. It will be important during long-term recovery and restoration efforts that protected species and habitats are considered. Close coordination with these agencies is recommended. In support of flood recovery efforts, the United States Fish and Wildlife Service (USFWS) recommends implementation of conservation measures from the Recommended Conservation Measures to Avoid and Minimize Impacts to the Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*), the Ute Ladies'-tresses Orchid (*Spiranthes diluvialis*), and the Colorado butterfly plant (*Guara neomexicana spp. Coloradensis*) from Emergency Flood Response Activities Along Streams, Rivers, or Transportation Corridors. Information can be found online at: http://www.fws.gov/endangered/esa-library/index.html#consultations.

Federal or state listed threatened and endangered species and/or habitat protected under the Endangered Species Act (ESA) or by the Colorado Division of Wildlife (CPW) under Colorado Statute Title 33 are summarized as follows. Raptor nest sites are further protected by the US Fish and Wildlife Service (UFWS)/CPW under the Migratory Bird Treaty Act (MBTA) therefore the applicable regulatory requirements are also summarized subsequently. Additional information can be found in the report appendices

Migratory Bird Treaty Act

Based upon literature review and an onsite assessment of the project area, ERC has determined that some migratory birds likely utilize the Site. These birds are protected under the MBTA, and killing or possession of these birds is prohibited. Future recovery and restoration efforts which remove vegetation should first ensure that active nests are not disturbed. Generally, the active nesting season for most migratory birds in this region of Colorado occurs between April 1 and August 31.

In addition, disturbance to raptor nest sites is further protected by the CPW. To provide additional clarity of what constitutes disturbance, the CPW has developed the 2008 guidance: Recommended Buffer Zones and Seasonal Restrictions for Colorado Raptors, which can be viewed online at: http://wildlife.state.co.us/SiteCollectionDocuments/DOW/WildlifeSpecies/LivingWithWildlife/RaptorBufferGuidelines2008.pdf). This document provides recommended tolerance limits or buffer zones for various species of raptors in addition to seasonal restrictions in response to human activity. Available CPW Species Activity Mapping (SAM) does not depict known mapped buffer zones within the project area (NDIS 2013), however raptors likely utilize the project area and may utilize the riparian zone trees for nesting. Future recovery and restoration efforts should be aware of any new raptor nest sites and consult with the CPW.

Species Protected under the Endangered Species Act (ESA) of 1973

Eleven species are identified to occur or historically occur within range of the project area in Jefferson County (USFWS 2014). Further evaluation of the eleven species' distribution and habitat requirements indicates that four species potentially occur within range of the project area (Table 6.4). During restoration and recovery efforts coordination with the USFWS is recommended.

State Threatened and Endangered Species

State listed threatened and endangered species were screened as potential inhabitants of the project area based on general habitat requirements and CPW tables (revised December 21, 2011), *Colorado Listing of Endangered, Threatened, and Wildlife Species of Special Concern*. Seventeen species are identified to occur or historically occur within Jefferson County (CPW 2011). Further evaluation of the seventeen species' distribution and habitat

requirements indicates that three species potentially occur within range of the project area (Table 6.5). During restoration and recovery efforts coordination with the CPW is recommended.

Table 6.4. Federal Threatened or Endangered Species Potentially within Range of Project Area

Common Name	Scientific Name	Status
Canada lynx	*Lynx canadensis*	Federally Threatened
Mexican spotted owl	*Strix occidentalis lucida*	Federally Threatened
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	Federally Threatened
Ute Ladies'-tresses orchid	*Spiranthes diluvialis*	Federally Threatened

Table 6.5. State Threatened or Endangered Species Potentially within Range of Project Area

Common Name	Scientific Name	Status
Canada lynx	*Lynx canadensis*	State Endangered
Mexican spotted owl	*Strix occidentalis lucida*	State Threatened
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	State Threatened

SECTION 7.0 RISK IDENTIFICATION AND ALTERNATIVE SELECTION

7.1 Alternative Categories

As noted by previous sections of this report, risk within the watershed is prevalent through many facets. This report section summarizes risk within the different reaches of each watershed and recommends alternatives to address key categories. Alternatives presented reflect an initial screening of ideas for discussion among the project team, sponsors, and interested stakeholders. Selected alternatives will be evaluated further and incorporated into the overall master plan for the Upper Coal Creek Watershed. Through the initial project screening process, alternatives are compared using Triple-Bottom-Line principles for balancing social, economic, and environmental aspects of each project. To assist with the selection, planning level cost estimates were also developed for comparable alternatives.

For this watershed, it is evident that the goals and objective for the stream corridors may not be identical for each reach and that the values from the canyon community also need to be considered. Several steps were taken to assist the project team in alternative selection and the master planning process.

First, it was necessary to distinguish between what may be considered a **Stream Corridor** versus a **Drainage Corridor**. In general, Stream Corridors include reaches with larger contributing drainage basins, more constant base flow, higher flood discharges, and stream characteristics more suitable to support riparian habitat and ecological enhancement. **Stream Corridor** reaches include the Coal Creek main steam from the downstream limits through Ranch Elsie Drive. A stream corridor was also identified along Beaver Creek between the confluences with Coal Creek and South Beaver Creek. These reaches were the most damaged in September flood and remain the most susceptible to future flooding issues. To be more resilient, these reaches also generally require a larger corridor width to effectively manage the full spectrum of geomorphic and flood discharges, as well as the riparian habitat and ecosystem. For these reasons, management of the corridor from an oversight stakeholder or coalition group should be considered to better ensure consistency and compatibility of improvements within the watershed. Opportunities within **Stream Corridors** are more diverse and may include:

1. Public Safety –needs for additional flood warning measures
2. Corridor management and maintenance –existing maintenance needs and easements to preserve stream conveyance and manage natural resources.
3. Stream restoration – establish channel dimensions per geomorphic recommendations.
4. Erosion setbacks- minimize risk through zoning changes for future development.
5. Environment and ecology –ecological restoration and ancillary needs related to water quality testing or treatment.
6. Flood management – address capacity deficiencies in bridges/culverts and stabilization measures to protect infrastructure;
7. Transportation and Emergency access – maintain access through major roadway corridors during a major flood event.
8. Recreation –identification of new or expended recreation needs.

At a smaller scale, **Drainage Corridors** convey water into the stream corridors. In general, drainage corridors within the watershed are predominately dry throughout the year, less diverse, and flood risk to buildings and infrastructure is more minimal. Overall, the principal issues relate to capacity and conveyance issues versus full spectrum management of a riverine system. Alternatives for the **Drainage Corridors** may include:

1. Corridor management and maintenance –Identify maintenance needs;
2. Flood management – address capacity deficiencies in bridges/culverts and stabilization measures to protect infrastructure;

Second, to help assess community values, a survey was made of attendees at the initial project open house meeting. This survey helped the project team compare and contrast ten (10) core values being considered with the master plan. These ten values are identified below. A scoring system was developed based on the number of responses and rank for each item. Thirty-three community members participated in the survey.

Table 7.1 – Community Priority Survey

		Number of Responses per Ranking (10-Highest, 1-Lowest)										Overall	
	Community Value	10	9	8	7	6	5	4	3	2	**1**	**Score**	**Rank**
1	Immediate Bank Stability/Erosion Protection	17	2	4	0	0	4	2	2	1	0	256	1
2	Fundable Solutions	7	5	5	4	4	4	4	0	0	0	243	2
3	Flood Capacity, 2 to 10 Year Level, Lower Cost	6	1	4	3	3	7	2	0	2	4	191	6
4	Flood Capacity, 10 to 50 Year Level, Mid-Cost	5	1	5	7	3	7	1	1	2	0	212	5
5	Flood Capacity, 100 Year + Level, High Cost	3	2	4	2	2	6	6	3	2	1	174	7
6	Environmental Health/Ecology	6	2	5	6	1	7	1	3	0	1	215	4
7	Recreation Added To Corridor	2	2	3	1	1	4	3	5	1	10	134	10
8	Strengthened Resiliency For Community Center Areas	2	0	3	3	3	5	4	2	6	4	146	9
9	Maximize Property And Usable Space	3	1	6	3	2	4	1	3	6	3	168	8
10	Transportation And Emergency Access	9	5	4	1	3	4	0	1	2	3	222	3

As demonstrated by the results above, the top scored community values related to addressing immediate bank stabilization and erosion protection. Other high scoring values related to developing fundable solutions, transportation and emergency access, and a mid-range level response to flood capacity and management.

Finally, as also indicated by the community members at the open house meetings, many of the current issues in the watershed relate to isolated drainage problems or needs that are not necessarily comparable with other corridor objectives. Therefore, ancillary community concerns have been noted. The majority of concerns related to on-going work being completed by CDOT along the highway corridor.

Figure 7.1 - Coal Creek Master Plan

Stream Corridors

Coal Creek Drainage Corridor

Ranch Elsie Drainage Corridor

Crescent Park Tributary Drainage Corridor

Coal Creek Stream Corridor 3

Beaver Creek Stream Corridor

Beaver Creek Drainage Corridor

Coal Creek Stream Corridor 2

South Beaver Creek Drainage Corridor

Coal Creek Stream Corridor 1

Streams

County Boundaries

Watershed Boundary

Coal Creek Canyon Park

White Ranch Park

State Parks

0 1 2 miles

Boulder County

Jefferson County

Golden Gate

Coal Creek Canyon Park

Eldorado Canyon

Eldorado Mountain

Scar Top Mountain

Blue Mountain

Coal Creek Peak

Camp Wondervu

Wondervu Cafe

Coal Creek Canyon K-8 School

Driveway Doctor

Riveland Construction

Coal Creek Canyon Rd

Chute Rd

Rudi Ln

Elliot Ln

Ronnie Rd

Camp Eden Rd

Crescent Park Dr

Hilltop Rd

Burland Rd

Gap Rd

Stanton Dr

Dowdle Dr

Standing Pine

Brumm Trail

Plainview Rd

Railroad Access Rd

Fern Way

Blue Mountain Dr

Ore Dr

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7.2 Alternative Development

Within each of the categories described above, alternatives were developed to address resiliency within the watershed. In general, alternative development progressed as follows:

Public Safety – Within each stream corridor, the need for additional public safety measures was assessed. Public safety measures were generally in the form of added rain or stream gages within the watershed to serve as flood warning.

Corridor Management and Maintenance – For all reaches, the need for near-term debris removal was identified. In addition, along stream corridors, management easements were proposed reflecting the width of the stream corridor required to accommodate geomorphic conditions, as well as preservation for flood conveyance. The recommended easements are not intended to contain the entirety of the 100-year flood limits, but intended to identify areas with higher conveyance potential that present a higher level of risk and hazard. To better ensure consistency with the plan recommendations, future work, or changes within easement corridors may require oversight by stakeholder or coalition groups, public entities, or a stream committee. Maintenance agreements between property owners and oversight groups may also address future maintenance efforts.

Geomorphic Restoration and Stream Stabilization – Idealized channel geometry has been recommended based on the prevailing geomorphic conditions identified along each stream segment and drainage corridor. Channel geometry was a balance considering stream classification, channel slope, channel forming discharges, and stream bed characteristics. For each location, recommendations have been provided for channel bankfull widths, bankfull depths, and widths at twice the bankfull depths (entrenchment). Using these guidelines during the restoration process will better ensure stream stability throughout the watershed. In most cases, the geomorphic channel recommendations are larger than currently exists.

Erosion Setbacks – Erosion setbacks have been recommended to address risk to future development beyond the stream corridor limits and the approximate 100-year floodplain. Erosion buffer limits are generally based on stream depth and future erosion using a 1h:1v ratio. For example, a six foot deep stream segment would include an additional six foot buffer beyond the 100-year floodplain limits to account for horizontal migration in the channel.

Environment and Ecology – Riparian habitat and wildlife is discussed in previous sections of this report. Restoration activities will include the reestablishment riparian habitat throughout the stream corridors and along drainage corridors, as recommended. Ecological restoration recommendations have been derived from represented samples within the Coal Creek corridor.

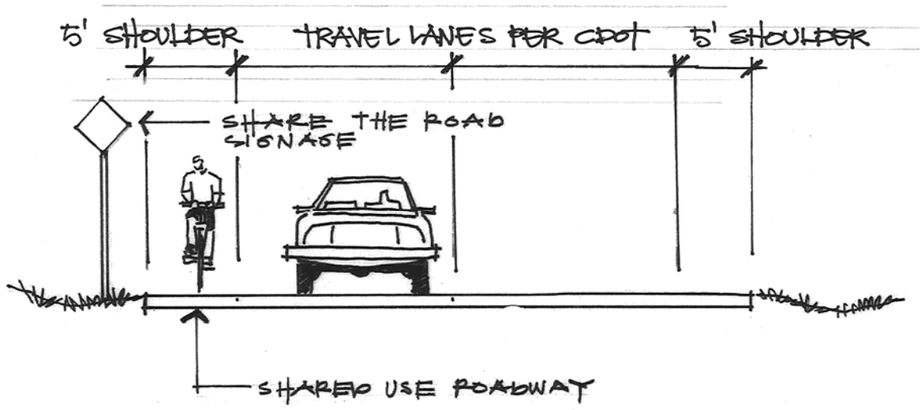
Flood Management – As part of building resiliency, varying degrees of flood management activities have been evaluated. Flood management activities primarily focus on providing adequate flood capacity at bridges and culverts and bank stabilization to resist erosion adjacent to homes, buildings, and highways. In some cases, added capacity within the stream corridors may also result in removal of buildings and infrastructure from the 100-year floodplain limits. Inadequacies related to bridge and culvert capacities have been identified at all stream crossing locations within the stream and drainage corridors. For the alternatives analysis, improvement recommendations were identified for the 10-, 25-, and 100-year level of protection, consistent with the community survey distributed. Typically, 10-year improvements for bridge and culverts reflect the addition of pipe culverts, similar to what currently exists onsite. This approach is effective for conveyance, but does not build added resiliency for more significant floods. For the 25- and 100-year levels, improvements generally reflect installing bridges with larger spans. Compared with multiple cell pipe culverts, bridges are also more efficient in conveying the bankfull discharge as well as passing sediment and debris. Bank stabilization recommendations have been prepared keeping in mind the varying flood depths and high velocities associated with the different storm events. Planning level cost estimates were generated for the different level improvements. It should be noted that flood management activities would be additive onto the restoration recommendations.

At certain locations, homes and buildings are located within close proximity to the stream corridors and remain susceptible to further damage from flooding or stream migration, or conflict with the natural alignment for the stream system. At these locations, property acquisition has been considered as an alternative to more expensive flood management infrastructure. Acquisition costs were based on current County Assessor information.

Transportation and Emergency Access – During the September flood event, Highway 72 and Twin Spruce Gap Road were closed due to flooding and roadway damage. As a result much of the canyon was isolated, emergency access was limited, and travel required extensive detouring to reach nearby communities along the Front Range. The flood event demonstrated the importance of maintaining emergency access along the highways and critical roadway facilities. Alternatives have been developed to better manage flooding along Highway 72 and Twin Spruce Gap Road. In some location, roadways are proposed to be raised above 100-year elevation where the feasibility for adding channel capacity may be more limited, or costly. Conveyance from stream crossings along the transportation corridors has been included within the flood management alternatives discussed above.

Recreation Evaluations/ Considerations - As noted by the community survey, adding recreation to the corridor was not a core community value. However, many discussions were held with community members regarding the unsafe conditions for bicyclists and other recreationalist on Highway 72 and as opportunities present themselves we should incorporate safe bicycle traffic within the canyon. As discussions with CDOT continue, the master plan should look at improving the highway and expanding the shoulder to accommodate safer on-street bike routes. The addition of recreation elements may provide multi-approach opportunities for funding for the watershed improvements and should be considered along the prescribed stream and transportation corridors and project implementation.

It has been the policy of CDOT to discourage bicycle or pedestrian use along State Highways—particularly due to reduced shoulders and fast traffic within the canyon. However CDOT has been evaluating the use of extending shoulders as a means for resiliency in traffic access in the event of another flood. Discussions with CDOT should continue to look at expanding the drive lane and shoulder to accommodate safe passage of vehicles and bicycles along Highway 72.



W11-1 / W16-1
Share the Road with Bicyclists assembly

Sign images from the Manual of Traffic Signs <http://www.trafficsign.us/>
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Figure 7.2 – Recreational Travel Details for Highway 72

COAL CREEK – STREAM CORRIDOR 1 (REACHES 1 THROUGH 5)

Stream Corridor 1 is a 3.5 mile section located between the downstream limits and Mile Marker 15.8 on Highway 72. This reach includes several crossings with Highway 72 and the crossing with the Union Pacific Railroad. Numerous homes and private stream crossings are located along this reach; most of which were destroyed in the September flood, but have since been reconstructed. Coal Creek Canyon Park and Open Space is common to the lower half of the corridor. Towards the downstream limits, stream susceptibility exists in the form of debris removal and restoration, including sediment removal upstream of the railroad culvert. Elsewhere within the corridor, both public and private culverts lack flood capacity even for moderate events. Several homes were damaged during the flood and still remain susceptible to future flooding as frequent as 10-year intervals. Channel restoration will address both stream stability and capacity issues. Many of the CDOT culverts below Highway 72 are inefficient for conveying water, debris, or sediment downstream. They are also more restrictive to aquatic and wildlife movement within the stream corridor. Both capacity and alignment recommendations are provided. Highway 72 is inundated around the bend upstream of MM 14 limiting emergency access.

Category	Alternative Description	Estimated Costs	Recommendations
Public Safety	At the downstream end of the basin, this section of Coal Creek is highly susceptible to future flood events, a real time flood warning device would increase warning time for residents of the canyon.	$25,000 (3 Stream Corridors)	Include
Corridor Management & Maintenance	Additional flood debris removal is still warranted within the watershed corridor. Establishment and management of stream corridor easements (approx. 60' wide) better ensure consistency of future work within the corridor and could be managed by an oversight party.	Approx. $42,000 for debris removal, easements are management expenses.	Include, debris removal will address in regular problems and issues in watershed. Consistent with community values. Promoting easements and oversight will maintain consistency with the master plan goals.
Geomorphic Restoration & Stream Stabilization	Geomorphic restoration is recommended throughout the corridor reach in the form of excavation and channel modifications associated with establishment of the bankfull geomorphic channel conditions. Restoration in this reach also includes stabilization between properties A through C, and D through F where substantial damage has occurred since the flood.	Approx. $1.1 Million, bankfull restoration	Include, limit prioritize development corridors prior to open space needs. Channel section can be used as guidance for the public as a means for addressing immediate needs along their property.
Erosion Setbacks	Setbacks of 8' to 10' beyond the floodplain limits are recommended to reduce susceptibility for future development.	Management Expenses	Include
Flood Management	In addition to general recommendations for bridge and culvert capacity, added capacity and realignment of CDOT culverts at MM 14 and MM 15 have been recommended. Riprap and other bank stabilization measures is also proposed immediately adjacent infrastructure in the corridor with softer stabilization where erosion can be accommodated.	10-Year Improvements: Approx. $1.3 Million,25-Year Improvements: Approx. $3.2 Million,100-Year Improvements: Approx. $9.9 Million	Provide 100-year improvements at state and County roadway crossings, 100-year stabilization along highway embankments. 25-year improvements for private infrastructure. This is also consistent with Community values
Environment and Ecology	The re-establishment of native riparian vegetation is recommended along disturbed sections of channel and along the restoration reaches.	Approx. $140,000	Include
Transportation and Emergency Access	Highway 72 is proposed to be raised above the 100-year flood elevation, between MM 14.4 and 14.9 and from MM 15.3 to 15.4 where channel modifications may be less practical due to right-of-way and sub-surface conditions.	Approx. $1.6 Million	Include, emergency access and transportation is also strong community value.
Recreation	Recreational elements should be considered with modifications to the transportation and stream corridors and within CCC Park.	Incidental Expenses with other items	Incidental Expenses with other items

COAL CREEK – STREAM CORRIDOR 2 (REACHES 6 THROUGH 7)

Stream Corridor 2, is a 2.0 mile section located between Mile Marker 15.8 on Highway 72 to Twin Spruce Gap Road. Although this stretch does include pockets of homes and private property, issues within the corridor predominately involve capacity issues associated with Highway 72. During the September flood, this reach received the convergence of floodwater from both Coal Creek as well as the Beaver Creek tributary. Floodwaters quickly exceeded the capacity of the channel and drainage culverts, and the highway itself became the means for conveyance downstream. Damage occurred to Highway 72, as well as erosion along the stream banks. The real estate building near the intersection with Highway 72 and Twin Spruce Gap Road was destroyed. Coal Creek crosses Highway 72 at two locations, near mile markers 16 and 16.4. Damage occurred downstream as flood waters entered and exited both of these culvert systems. The orientation for the culvert at mile marker 16.4 was particularly inefficient at conveying water, debris, or sediment downstream and clogged. The poor orientation also likely contributed to erosion of the downstream channel banks. Nearly all private culverts within this reach were destroyed but have since been reconstructed, although capacity still remains at 10-year levels or less. Homes in the corridor still remain susceptible to flooding and erosion.

Category	Alternative Description	Estimated Costs	Recommendations
Public Safety	This section of Coal Creek is highly susceptible to future flood events, a real time flood warning device would increase warning time for residents of the canyon.	$25,000 (2 Stream Corridors)	Include
Corridor Management & Maintenance	Additional flood debris removal is still warranted within the watershed corridor. Establishment and management of stream corridor easements (approx. 60' wide) better ensure consistency of future work within the corridor and could be managed by an oversight party.	Approx. $16,000 for debris removal, easements are management expenses.	Include, debris removal will address in regular problems and issues in watershed. Consistent with community values. Promoting easements and oversight will maintain consistency with the master plan goals.
Geomorphic Restoration & Stream Stabilization	Geomorphic restoration is recommended throughout the corridor to establish bankfull geomorphic channel conditions, particularly at and upstream of the 'S' curve where the cannel is more or less nonexistent. Restoration in this reach also includes stabilization adjacent to property locations G and H where substantial damage has occurred from the flood.	Approx. $1.2 Million, bankfull restoration	Include, prioritization should be made to restoring reaches near development areas and establishing an appropriately sized channel at and upstream of the 'S' curve.
Erosion Setbacks	Setbacks of 8' to 10' beyond the floodplain limits are recommended to reduce susceptibility for future development.	Management Expenses	Include
Flood Management	In addition to general recommendations for bridge and culvert capacity, added capacity and realignment of CDOT culverts at MM 16 and MM 16.4 have been recommended. Riprap and other bank stabilization measures is also proposed immediately adjacent infrastructure in the corridor with softer stabilization where erosion can be accommodated.	10-Year Improvements: Approx. $553,000, 25-Year Improvements: Approx. $980,000,100-Year Improvements: Approx. $4.5 Million	Provide 100-year capacity at state and county roadway crossings, 100-year stabilization along highway, 25-year improvements for private infrastructure. This is also consistent with Community values. Note CDOT and county culverts are majority of expenses
Environment and Ecology	The re-establishment of native riparian vegetation is recommended along disturbed sections of channel and along the restoration reaches.	Approx. $103,000	Include
Transportation and Emergency Access	Highway 72 is proposed to be raised above the 100-year flood elevation, from MM 17 through Twin Spruce Gap Road where channel modifications may be less practical due to right-of-way and sub-surface condition restrictions.	Approx. $1.6 Million	Include, emergency access and transportation is also strong community value. Roadway will likely need to be raised in addition to a geomorphic channel to meet capacity.
Recreation	Recreational elements should be considered with modifications to the transportation and stream corridors.	Incidental Expenses with other items	Incidental Expenses with other items

COAL CREEK – STREAM CORRIDOR 3 (REACHES 8 AND 9)

Stream Corridor 3, is a 1.1 mile section located between Twin Spruce Gap Road and Ranch Elsie Road. This reach represents the heart of the Coal Creek Canyon community where the retail and commercial enterprise is located. Amenities include two gas stations, a coffee shop, post office, liquor store, groceries, auto repair shops, propane storage and Jefferson County's maintenance facilities. Additionally the Fire Station is located at the intersection of Highway 72 and Crescent Park Drive. Although the amenities are limited, they are important assets to Coal Creek Canyon, given its isolated nature and long distance to outside resources. In September, damage through the community center was widespread. Near Twin Spruce Gap Road, the existing culvert below the Auto-repair/Gas station failed resulting in a large sink hole. The nearby upstream building (old coffee shop) also experienced significant flooding. Other buildings between Twin Spruce Gap Road and Skyline Drive were flooding, as did Quick Mart. With high runoff from Crescent Park, significant flooding overtopped Highway 72 near the fire station, and a new channel was excavated between the Liquor Store and nearby home to reduce the flooding impacts. Flood water also overtopped Highway 72. Upstream of the community center, sediment deposition was widespread with culverts still being cleared to provide original capacity. The channel is estimated to have a 10-year capacity throughout much of this reach with many homes subject to flooding in events less than a 25-year storm.

Category	Alternative Description	Estimated Costs	Recommendations
Public Safety	As noted, this reach contains several facilities housing hazardous materials near creek areas. Recommendations include monitoring stream flow for contamination.	$10,000	Include, likely grant funded. May result in additional funding
Corridor Management & Maintenance	The need for flood debris removal is less widespread within this reach, but still necessary to protect infrastructure. Establishment and management of stream corridor easements (approx. 40' wide) better ensure consistency of future work within the corridor and could be managed by an oversight party.	Approx. $7,500 for debris removal, easements are management expenses.	Include, debris removal will address in regular problems and issues in watershed. Consistent with community values. Promoting easements and oversight will maintain consistency with the master plan goals.
Geomorphic Restoration & Stream Stabilization	Geomorphic restoration is recommended throughout the corridor to establish bankfull geomorphic channel conditions and a more natural stream corridor.	Approx. $400,000 for bankfull restoration	Include
Erosion Setbacks	Setbacks of 6' to 10' beyond the floodplain limits are recommended to reduce susceptibility for future development.	Management Expenses	Include
Flood Management	In addition to general recommendations for bridge and culvert capacity, this plan considers conduit alternatives adjacent to the auto repair shop near TSGR and the Quick Mart / gas station. The conduits were proposed as base flows are less defined in this corridor and conduits require less space in an already tight corridor. An open channel option has also been proposed near the quick mart, but will require significant adjustments to the existing septic system.	10-Year Improvements: Approx. $375,000, 25-Year Improvements: Approx. $1.2 Million 100-Year Improvements: Approx. $3.0 Million	Provide 100-year capacity for location protecting state highway (Culvert 26). 25-year improvements for private infrastructure. Compare infrastructure expenses with buy-out options.
Environment and Ecology	The re-establishment of native riparian vegetation is recommended along disturbed sections of channel and along the restoration reaches.	Approx. $52,000	Include
Transportation and Emergency Access	Culvert improvements near the TSGR gas station will also help reduce flooding along the highway. No other improvements have been proposed.	Incidental to other items	Include
Acquisition	Purchase and buy-out of flood prone property should be considered for Locations J, L, and M and Q (for sale), compared to improvements.	Approx. $600,000	Compare with infrastructure expenses and other community benefits

COAL CREEK – DRAINAGE CORRIDOR (REACHES 10 THROUGH 11)

Coal Creek - Drainage Corridor, is a 1.70 mile section extending from Marker 18.9 on Highway 72 through Copper Dale Lane. Through this reach, Highway 72 is separated by elevation from the Coal Creek channel, therefore the highway has little susceptibility to damage from floodwaters. Several private culverts and homes are located along the creek, several of which are located within the estimated 100-year floodplain boundary. During the September flood, the culvert at Crescent Lake Road was damaged and since repaired by Boulder County.

Susceptibility in this reach generally is found in the form of:

- The stream is undersized from both a flood capacity and geomorphic perspective. Several homes are subject to flooding at the 25-year level.
- The capacity of the culvert at Ranch Elsie Drive only exceeds the 10-year level, whereas private access culverts generally have capacity less than the 10-year level, making them susceptible to frequent overtopping and failure.
- The capacity of the culvert at Crescent Lake Road is also less than the 25-year level, making it susceptible to frequent overtopping and failure.

Category	Alternative Description	Estimated Costs	Recommendations
Public Safety			
Corridor Management & Maintenance	Additional flood debris removal is still warranted within the watershed corridor.	Approx. $17,000 for debris removal	Include
Geomorphic Restoration & Stream Stabilization			
Erosion Setbacks			
Flood Management	General recommendations for bridge and culvert capacity have been provided.	10-Year Improvements: Approx. $46,000, 25-Year Improvements: Approx. $200,000,100-Year Improvements: Approx. $580,000	Provide 25-year improvements for public and private infrastructure. This is also consistent with Community values.
Environment and Ecology			
Transportation and Emergency Access			
Recreation			

BEAVER CREEK – STREAM CORRIDOR (REACH 12)

Beaver Creek - Stream Corridor extends from the confluence with Coal Creek to the confluence with the South Beaver Creek tributary. During the September flood significant damage occurred to many of the homes and properties along this reach. The capacity of existing culverts was quickly overwhelmed, and in many cases these structures washed out completely. Several homes were also inundated with flood water. At the confluence location, the tributary area for Beaver Creek nearly doubles that of the Coal Creek main stem. Flood discharges also reflect this observation, as the estimated flood flows are also twice as large as those in Coal Creek. Beaver Creek also shares it's alignment with a parallel county road and home sites. Nearly all residences and the First Baptist Church are located within the estimated 100-year flood zone and subject to flooding in events as small as the 25-year storm. Several homes in this area have made improvements using funding available through the NRCS. These improvements are considered an emergency response provision, not a long term solution to address drainageway needs in the area. Susceptibility in this reach still exists. Most of the private access culverts have been reconstructed; however they still remain below 10-year capacity. The stream is undersized from a geomorphic perspective. Several buildings and the roadway are located within close proximity to the drainageway and are susceptible to lateral channel migration and flooding.

Category	Alternative Description	Estimated Costs	Recommendations
Public Safety	This section of Beaver Creek is highly susceptible to future flood events, a rain gage warning system would increase warning time for residents.	$20,000	Include
Corridor Management & Maintenance	Additional flood debris removal is still warranted within the watershed corridor. Establishment and management of stream corridor easements (approx. 60' wide) better ensure consistency of future work within the corridor and could be managed by an oversight party.	Approx. $12,000 for debris removal, easements are management expenses.	Include, debris removal will address in regular problems and issues in watershed. Consistent with community values. Promoting easements and oversight will maintain consistency with the master plan goals.
Geomorphic Restoration & Stream Stabilization	Geomorphic restoration is recommended throughout the corridor to establish bankfull geomorphic channel conditions as well as area for flood flows. Restoration in this reach also includes stabilization adjacent to properties where substantial damage has occurred from the flood.	Approx. $430,000, bankfull restoration	Include
Erosion Setbacks	Setbacks of 6' to 8' beyond the floodplain limits are recommended to reduce susceptibility for future development.	Management Expenses	Include
Flood Management	General recommendations for bridge and culvert capacity have been provided. Riprap and other bank stabilization measures are also proposed immediately adjacent infrastructure in the corridor.	10-Year Improvements: Approx. $310,000, 25-Year Improvements: Approx. $540,000, 100-Year Improvements: Approx. $1.2 Million	Provide 25-year improvements for public and private infrastructure. This is also consistent with Community values.
Environment and Ecology	The re-establishment of native riparian vegetation is recommended along disturbed sections of channel and along the restoration reaches.	Approx. $46,000	Include
Transportation and Emergency Access	Culvert improvements at Burland Road and Joanie Drive are provided with the flood management recommendations. Restoration activities should consider removing the floodplain from Twin Spruce Gap Road for emergency access purposes.	Incidental Expenses with other items	Restoration activities should consider removing the floodplain from Twin Spruce Gap Road for emergency access purposes
Acquisition	Purchase of flood prone property should be considered (Locations A through F). Relocation or reconstruction of buildings also considered.	$1.2 Million	Compare improvement recommendations with acquisition or relocation expenses

BEAVER CREEK – DRAINAGE CORRIDOR (REACHES 13 THROUGH 14)

Beaver Creek - Drainage Corridor, is a 2.9 mile section extending from the confluence with Beaver Creek and extending west towards Gilpin County. This is a steep section of Beaver Creek that is mostly straight. Other than at the point of convergence with South Beaver Creek, Beaver Creek is void of development. A single property splits flow from Beaver Creek near the confluence and is susceptible to future flood damage due to its proximity to the 100-yr floodplain.

Few improvements are proposed for the corridor; however susceptibility exists in the form of:

- The stream is undersized from both a flood capacity and geomorphic perspective.
- The home located at the confluence with South Beaver Creek is subject to flooding at a moderate level.

Category	Alternative Description	Estimated Costs	Recommendations
Public Safety			
Corridor Management & Maintenance	Additional flood debris removal is still warranted within the watershed corridor.	Approx. $15,000 for debris removal	Include
Geomorphic Restoration & Stream Stabilization			
Erosion Setbacks			
Flood Management	General recommendations for bridge and culvert capacity have been provided.	10-Year Improvements: Approx. $27,000, 25-Year Improvements: Approx. $67,000,100-Year Improvements: Approx. $250,000	Provide 25-year improvements for public and private infrastructure. This is also consistent with Community values.
Environment and Ecology			
Transportation and Emergency Access			
Recreation			

SOUTH BEAVER CREEK – DRAINAGE CORRIDOR (REACHES 15 THROUGH 16)

South Beaver Creek - Drainage Corridor, is a 2.0 mile section extending from the confluence with Beaver Creek and extending west towards Gilpin County, along Twin Spruce Gap Road. This is a steep section of channel with slopes approaching 15% grade. Although he approximate floodplain limits do approach buildings, much of the flood risk along this reach relates to the Twin Spruce Gap Road, itself. In general, most culvert crossings along the roadway have capacity for less than the 10-year flood event.

Category	Alternative Description	Estimated Costs	Recommendations
Public Safety			
Corridor Management & Maintenance	Being close proximity to the county road, the need for debris removal is less apparent within this corridor.	Approx. $11,000 for debris removal	Include
Geomorphic Restoration & Stream Stabilization			
Erosion Setbacks			
Flood Management	General recommendations for bridge and culvert capacity have been provided.	10-Year Improvements: Approx. $470,000, 25-Year Improvements: Approx. $1.0 Million, 100-Year Improvements: Approx. $1.6 Million	Provide 25-year improvements for public and private infrastructure. This is also consistent with Community values.
Environment and Ecology			
Transportation and Emergency Access			
Recreation			

RANCH ELSIE – DRAINAGE CORRIDOR (REACH 17)

Ranch Elsie - Drainage Corridor, is a 0.7 mile section extending from the confluence with Coal Creek and extending west through Sylvan Road, along Ranch Elsie Road. This tributary behaves more like a local drainage collection system than a natural drainageway. During the September flood, however, flow from this region was large enough to damage culverts and several homes. Most culverts have been reconstructed since the flood event. Improvements through this reach relate to providing drainage capacity at county and privately owned crossings and protecting the roadway from further damage.

Category	Alternative Description	Estimated Costs	Recommendations
Public Safety			
Corridor Management & Maintenance	Being close proximity to the county road, the need for debris removal is less apparent within this corridor.	Approx. $4,500 for debris removal	Include
Geomorphic Restoration & Stream Stabilization			
Erosion Setbacks			
Flood Management	General recommendations for bridge and culvert capacity have been provided. Stabilization measures adjacent to the county road have also been considered.	10-Year Improvements: Approx. $214,000 25-Year Improvements: Approx. $620,000 100-Year Improvements: Approx. $820,000	Provide 25-year improvements for public and private infrastructure. This is also consistent with Community values.
Environment and Ecology			
Transportation and Emergency Access			
Recreation			

CRESCENT PARK – DRAINAGE CORRIDOR (REACH 18 THROUGH 20)

The Crescent Park Tributaries reflect local drainage systems more so than natural drainageways. During the September flood, however, flow from this region was large enough to overtop both Crescent Park Drive and Highway 72. Overflow contributed to flood damage within the intersection and further downstream. The damage observed in September emphasized the need to better manage runoff from Crescent Park. Since the flood, CDOT has reconstructed a number of facilities in these areas, including new inlets and culverts below Highway 72. Makeshift channel improvements were also constructed south of the intersection to reconnect flows from Crescent Park with Coal Creek. Although this work does provide connectivity, the facilities still remain undersized to convey substantial design flows. Stream capacity along Crescent Park Drive also becomes undersized towards the Highway 72 intersection and the corridor is still susceptible to similar flood problems to those experienced in September.

Recommended improvements though this corridor expand upon the concepts previously completed; however capacity will be increased to more effectively convey discharge to and across both Crescent Park Drive and Highway 72 intersection.

Category	Alternative Description	Estimated Costs	Recommendations
Public Safety			
Corridor Management & Maintenance	The need for debris removal is less apparent within this corridor.	Approx. $5,700 for debris removal	Include
Geomorphic Restoration & Stream Stabilization			
Erosion Setbacks			
Flood Management	The channel system is proposed to be enlarged north of Crescent Park Drive and an overflow swale is proposed to convey overflow on the south side of Crescent Park Drive that may bypass the upstream culverts system. Channel banks adjacent to the county road are also proposed to be stabilized. At Highway 72, recommendations have been provided to increase capacity deficiencies, below the highway through increasing the size of the northern culvert system and improving inlet conditions for the southern system. Similarly recommendations have been provided to address capacity deficiencies at Crescent Park Drive, near Butte Drive.	10-Year Improvements: Approx. $36,000 25-Year Improvements: Approx. $172,000 100-Year Improvements: Approx. $440,000	Provide 25-year improvements for public and private infrastructure, with exception to 100-year improvements are recommended at Highway 72 and the Crescent Park Drive crossing to improve flooding conditions to best manage flow across the highway and prevent future damage to the neighboring community center areas.
Environment and Ecology			
Transportation and Emergency Access			
Recreation			

SECTION 8.0 PROJECT SELECTION AND CONCEPTUAL DESIGN

8.1 Selection Process

A draft alternatives report for Coal Creek was presented to stakeholders and the community task force members at a meeting on July 23rd, 2014. Concepts presented in the alternatives analysis were also presented at a public meeting on August 20th. At both meetings, the project team explained the alternative concepts and recommendations for each corridor. Alternatives were developed to address resiliency within the watershed considering the preceding criteria: Public Safety, Corridor Management, Geomorphic Principles, Erosional Hazard, Flood Management, Environment and Ecology, Transportation and Emergency Access, and Recreation. Project recommendations address both current and long term needs for each corridor. The team's approach to developing the alternatives and summary of the plan recommendations was presented in Section 7.0 of this report.

Feedback from the stakeholder and public presentations are provided below. Overall, comments demonstrated support for the approach and recommendations suggested.

Stakeholder Comments (July 23rd Alternatives Meeting)
CDOT - Limited funds were available for relocating highway further into stream bank
CWCB - State will be requesting communities utilize the updated CWCB watershed hydrology, or equivalent findings.
Group - The use of erosion setbacks were appealing, but may be difficult to manage
Group - In September all routes in and out of the canyon were blocked, transportation would need priority for emergency access. 100-year improvements for public infrastructure along stream corridors and at critical access areas were appropriate. Burland Road was a main access point during the flood.
CDOT - Although recreation was not a priority from the community, it has been used to build resiliency on highways by expanding the paved areas and shoulders.
Group - The group agreed that a 60' span bridge, 100-year bridge for private property would not be practical. The single span (25-year) bridge added resiliency over the existing infrastructure
Group - Consideration would need to be given to not adversely affecting the floodplain in areas where the highway was proposed to be raised.
Group - The stakeholders recognized the value surrounding the Community Center area and flood hazards present. Further assessments were warranted to evaluate if other environmental hazards existed. The group agreed to plan around what current exists and set a framework for how the area could be reestablished around the flood hazards. It was agreed that the community center area was vital to the community.
ICON - Regional detention was not considered as a solution for Beaver Creek. As discussed it would present complications associated with cost, ownership, and state approval and therefore was not considered further.

Based on the stakeholder and public meetings, the general approach to the master plan was reinforced, or adjusted as discussed below:

1. Erosion setbacks would not be pursued further due to concerns with overall management of these zones. With the information presented by this study, each local government will have the ability to formalize erosion setback limits as they see fit and can legally be enforced through current and planned land use regulations.
2. 100-year improvements to public infrastructure will continue to be pursued along stream corridors to support transportation and emergency access needs. Primary access corridors include: Highway 72; Twin Spruce Gap Road between Coal Creek and Burland Drive; Burland Drive, Ranch Elsie Road (at Highway 72), and Crescent Park Drive at Highway 72 and at Butte Drive.
3. A minimum of 25-year improvements will be provided for private infrastructure, including private stream crossings and bank revetment. This level of protection is consistent with the community value and infrastructure criteria set forth through local governments in the watershed.
4. Within the stream corridors, bridge infrastructure is recommended. Bridge infrastructure provides an added degree of resiliency over multiple cell pipe culverts. Bridges are less susceptible to clogging and failure from upstream debris collection, as well as compatible with the ecologic and geomorphic concepts presented in this master plan.
5. Recreation opportunities exist in the form of paved bike lane/shoulders along Highway 72. CDOT has been pursuing these opportunities as a multi-objective tool to also increase flood resiliency.
6. Options to build resiliency within the community center area will be pursued considering both existing infrastructure, as well as future land use changes.

8.2 Master Plan Costs

Costs to implement the recommended improvement along the Stream and Drainage Corridors are presented below. Costs are based on engineering estimates for project implementation. With exception to the flood warning devices and debris removal, project costs generally include an addition of 20% contingency for unknown expenses. An additional 10% and 5% has been included in Table 8-3 to address engineering and project management fees, respectively.

Table 8-1: Summary of Flood Warning Costs:

Flood Warning Devices	
Item	Total Cost
Flood Warning Gage at Twin Spruce Gap Road	$25,000
Automated Rain Gage - Beaver Creek Basin	$20,000
Total	$45,000

Table 8-2: Summary of Debris Removal Costs:

Debris Removal	
Item	Total Cost
Coal Creek Stream Cooridor 1 (1-5)	$41,268
Coal Creek Stream Cooridor 2 (6-7)	$15,600
Coal Creek Stream Cooridor 3 (8-9)	$7,500
Coal Creek Drainage Cooridor (10-11)	$17,148
Beaver Creek Stream Cooridor (12)	$12,000
Beaver Creek Drainage Cooridor (13-14)	$15,000
South Beaver Creek Drainage Cooridor (15-16)	$10,500
Ranch Elsie Drainage Cooridor (17)	$4,500
Crscent Park Drainage Cooridor (18-20)	$5,700
Total	$129,216

8.3 General Recommendations

Prior to construction, or commencing other work on private property or within the drainageways, it is recommended that individuals consult with the appropriate jurisdictions regarding the proposed changes and construction requirements, such as obtaining engineered plans, permitting requirements, erosion and sediment control, water quality and natural resource protection, easements or other items that may be required. The following websites address specific requirements set forth by local jurisdictions:

1. Jefferson County: Flood Recovery Website: http://jeffco.us/disaster-recovery/#rebuilding
2. Boulder County: Flood Recovery Website: http://www.bouldercounty.org/flood/pages/default.aspx
3. CDOT: Private Access Reconstruction Guide: http://jeffco.us/Disaster-Recovery/Documents/CDOT-Private-Access-Reconstruction-Guide-for-Residents/

Section 404 of the Clean Water Act (CWA) established a program to regulate the discharge of dredged or fill material into waters of the United States and wetland areas. Activities in waters of the United States regulated under this program include fill for development, water resource projects, infrastructure, and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States. Proposed activities are regulated through a permit review process. An individual permit is required for potentially significant impacts. Individual permits are reviewed by the U.S. Army Corps of Engineers, which evaluates applications under a public interest review, as well as the environmental criteria set forth in the CWA Section 404(b)(1) Guidelines, regulations promulgated by EPA. General permits may also be suitable. General permits are issued on a nationwide, regional, or State basis for particular categories of activities. Local agencies, including the COE should be consulted and required permits should be obtained prior to filling or dredging material in stream or drainageways within the Coal Creek watershed, on a both a permanent and temporary basis.

Rebuilding and new construction activities within the watershed should consider best practices to reduce the loss of human life and property from flood and storm damage, as managed through local floodplain administration. General guidance has also been provided to flood impacted communities by the Colorado Association of Stormwater

Table 8-3: Summary of Improvement Costs:

Reach	ID	Project Description	Cost ($)
Coal Creek Stream Corridor 1 (Reaches 1 through 5)			
1	A	Stream Restoration	$ 39,028
2	A	Stream Restoration & Bank Stabilization	$ 404,331
3	A	Stream Restoration & Bank Stabilization downstream of CO 72	$ 321,945
3	B	Replace CO 72 Culvert at MM 14	$ 1,440,000
3	C	Stream Restoration, Bank Stabilization, Culvert Improvements upstream of CO 72	$ 1,120,124
4	A	Stream Restoration & Bank Stabilization to MM 14.4	$ 114,517
4	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 14.5 to MM 15	$ 411,559
4	C	Replace CO 72 Culvert at MM 15	$ 1,440,000
4	D	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15 to MM 15.2	$ 560,204
4	E	Elevate CO 72, MM 14.4 to MM 14.9	$ 1,548,360
5	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.2 to MM 15.8	$ 1,783,912
5	B	Elevate CO 72, MM 15.3 to MM 15.4	$ 293,250
Coal Creek Stream Corridor 2 (Reaches 6 through 7)			
6	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.8 to MM 16	$ 834,681
6	B	Replace CO 72 Culvert at MM 16	$ 1,440,000
6	C	Stream Restoration & Bank Stabilization MM 16 to MM 16.4	$ 642,108
6	D	Replace CO 72 Culvert at MM 16.4	$ 1,440,000
6	E	Stream Restoration & Bank Stabilization MM 16.4 to MM 16.6	$ 245,853
7	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 16.6 to MM 17.6	$ 1,892,827
7	B	Replace Twin Spruce Gap Road Culvert at MM 17.6	$ 540,000
7	C	Elevate CO 72, MM 16.9 to MM 17.6	$ 1,805,760
Coal Creek Stream Corridor 3 (Reaches 8 through 9)			
8	A	Storm Sewer at Carl's Corner / CO 72	$ 506,640
8	B	Alt 2; Acquisition of Property for Closed Coffee Shop, Stream Restoration and Bank Stabilization	$ 261,520
8	C	Stream Restoration, Bank Stabilization, Culvert Improvements MM 17.7 to MM 17.9	$ 529,338
8	D	Alt 2; Acquisition of Quick Mart & Propane Site, Stream Restoration, Culvert Improvements	$ 932,176
8	E	Stream Restoration, & Bank Stabilization, MM 18.1	$ 41,841
9	A	Stream Restoration, & Culvert Improvements MM 18.1 to MM 18.3	$ 161,253
9	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 18.3 to MM 18.6	$ 978,474
9	C	Elevate / Relocate CO 72, MM 18.4 to MM 18.6	$ 619,344
Coal Creek Drainage Corridor (Reaches 10 through 11)			
10	A	Culvert Improvements, Ranch Elsie Road through MM 18.9	$ 295,440
11	A	Culvert Improvements, MM 18.9 to Copperdale Lane	$ 31,920
Beaver Creek Stream Corridor (Reach 12)			
12	A	Stream Restoration, Bank Stabilization & Culvert Improvements	$ 1,459,069
Beaver Creek Drainage Corridor (Reach 13 through 14)			
13	A	Stream Restoration and Bank Stabilization	$ 124,108
South Beaver Creek Drainage Corridor (Reach 15 through 16)			
15	A	Culvert Improvements	$ 222,600
16	A	Bank Stabilization and Culvert Improvements	$ 1,380,481
Ranch Elsie Drainage Corridor (Reach 17)			
17	A	Bank Stabilization and Culvert Improvements	$ 683,940
Crescent Park Drainage Corridor (Reach 18 through 20)			
18	A	Culvert Improvements	$ 103,560
19	A	Stream Restoration, Bank Stabilization, and Culvert Improvements	$ 477,490
20	A	Culvert Improvements	$ 5,532
		Sub-Total	**$ 27,133,184**
		Engineering (10%)	$ 2,713,318
		Management (5%)	$ 1,356,659
		Total	**$ 31,203,162**

and Floodplain Managers (CASFM), through a white paper distributed on October 4, 2013. This white paper is available at http://www.casfm.org/2013_Flood/CASFM_media_summary_statement_2013-10-04.pdf.

As noted previously, the majority of Coal Creek and tributaries included in this master plan are not included in current FEMA flood hazard mapping. It is recommended that approximate-level floodplain information developed for this study be utilized to assist in rebuilding and floodplain management decisions until more detailed information is available. Specifically, this information should be utilized to generate Advisory Base Flood Elevations (ABFEs) for the 100-year event and that when possible, rebuilding activities occur outside the floodplain to reduce the potential for damage in the future.

8.4 Conceptual Design

A master plan of improvements is presented on exhibits provided in the appendix of this report. The master plan is described on a corridor-by-corridor basis below. Representative conceptual design elements are presented for each of the stream corridors following the master plan description. Design elements for the master plan shall consider the drainage, geomorphic, and ecological requirements discussed elsewhere in this study.

In addition to the master plan improvements, ancillary needs related to the drainage within the watershed were noted by citizens at the community meetings. Additional community needs have been identified on the master plan exhibits. These problems and potential solutions should be considered with the construction of other adjacent improvements at similar locations.

Flood Warning Measures

The lower reaches of Coal Creek are highly susceptible to future flood events. This master plan includes recommendations for the installation of a real time flood warning device to increase warning time for residents within the canyon reaches. This master plan also includes recommendations for the installation of real time rain gages to provide warning information within the Beaver Creek sub-basin.

Debris Removal and Corridor Maintenance

For all reaches, the need for debris removal still exists. This master plan identifies the need and includes costs associated with flood debris removal.

Stream Corridor Easements

Management easements have been proposed along stream corridors to accommodate geomorphic conditions, as well as preservation of the channel for flood conveyance. The recommended easements are not intended to contain the entirety of the 100-year flood limits, but intended to identify areas with higher conveyance potential which present a higher level of risk and hazard. To better ensure consistency with the plan recommendations, future work, or changes within easement corridors should be completed under the oversight by stakeholder or coalition groups, public entities, or a stream committee. Maintenance agreements between property owners and oversight groups would also address future maintenance efforts. 60’ corridor easements have been proposed for Coal Creek within Corridors 1 and 2, and along the Beaver Creek stream corridor. A 40’ corridor easement has been proposed for Coal Creek Corridor 3.

Coal Creek Stream Corridor 1 (Reaches 1 through 5)

Coal Creek Stream Corridor 1 consists of project reaches 1-5. This corridor includes several crossings with Highway 72 and the crossing with the Union Pacific Railroad (UPRR). Numerous homes and private stream crossings are located along this reach; most of which were destroyed in the September flood, but have since been reconstructed. Coal Creek Canyon Park and Open Space is common to the lower half of the corridor. Towards the downstream limits, stream susceptibility exists in the form of debris removal and restoration, including sediment removal upstream of the railroad culvert. Elsewhere within the corridor, both public and private culverts lack flood capacity even for moderate events. Several homes were damaged during the flood and still remain susceptible to future flooding as frequent as 10-year intervals. Many of the CDOT culverts below Highway 72 are inefficient for conveying water, debris, or sediment downstream. They are also more restrictive to aquatic and wildlife movement within the stream corridor. Highway 72 is inundated around the bend upstream of MM 14 limiting emergency access.

Master plan recommendations include stream restoration, bank protection, and the reconstruction of public and private infrastructure to add flood resiliency, restore geomorphic stability and enhance ecological health within the corridor. Within reaches 1 and 2, located in the lower portions of the watershed, Project 1A, 2A, and 3A focus on channel restoration and stabilization needs, following the geomorphic recommendations presented. Restoration along the depositional area upstream of the UPRR culvert may generate material for improvements at other locations. Culverts 1 and 2 (Hwy 72, UPRR) demonstrated capacity to pass the flood flows last September and remain in good shape. Therefore, no new improvements have been recommended at these locations. Projects 3B and 4C propose to realign the stream crossings with Highway 72 by removing the sharp bends and replacing the culverts with 100-year capacity bridge structures more effective in conveying flood flows, sediment and debris. The bridge structures will also better accommodate the geomorphic channel conditions without obstruction in addition to enhanced wildlife management. Highway 72 has also been proposed to be raised above the estimated 100-year flood elevations, in locations (Projects 4E, 5B) to provide emergency access. At this location, CDOT would be encouraged to relocate the highway further from the creek to increase stream capacity and offset floodplain impacts which may occur on private property.

Other projects along this reach focus on stream stabilization to manage the geomorphic needs for the watershed, bank protection adjacent to public and private infrastructure, and increases to culvert capacity meeting the goals outlined by this master plan. Most private access culverts have been proposed to be replaced with open span bridges, approximately 20’ in length, designed for the 25-year flood event. As discussed previously, compared with multiple cell pipe culverts, span bridges are more efficient in conveying the bankfull discharge as well as passing sediment and debris.

Four of the top ten project priorities are located in Coal Creek Corridor 1, making it a focal point for upcoming funding opportunities.

Coal Creek Stream Corridor 2 (Reaches 6 and 7)

Stream Corridor 2, is a 2.0 mile section located between Mile Marker 15.8 on Highway 72 to Twin Spruce Gap Road. Although this stretch does include pockets of homes and private property, issues within the corridor predominately involve capacity issues associated with Highway 72. During the September flood, this reach received the convergence of floodwater from both Coal Creek as well as the Beaver Creek tributary. Floodwaters quickly exceeded the capacity of the channel and drainage culverts, and the highway itself became the means for conveyance downstream. Coal Creek crosses Highway 72 at two locations, near mile markers 16 and 16.4. The orientation for the culvert at mile marker 16.4 is particularly inefficient at conveying water, debris, or sediment downstream. It clogged during the flood and likely contributed to erosion of the downstream channel banks. Nearly all private culverts within this reach were destroyed but have since been reconstructed. Homes in the corridor still remain susceptible to flooding and erosion.

Similar problems and projects to corridor 1 are located within corridor 2. Projects focus on stream stabilization to manage the geomorphic needs for the watershed, bank protection adjacent to public and private infrastructure, increases to culvert capacity, and providing emergency access along the highway corridor. Projects 6B, 6D, and 7B address capacity limitations in the existing culverts below Highway 72 and at Twin Spruce Gap Road. Private access culverts have been proposed to be replaced with open span bridges, approximately 20' in length designed for the 25-year flood event. Highway 72 has also been proposed to be raised above the estimated 100-year flood elevations downstream of Twin Spruce Gap Road, and through the existing 'S' bends areas. This work would be combined with restoration of Coal Creek (Project 7A) where the capacity of the channel is currently very limited. CDOT is encouraged to relocate the highway further from the creek to increase stream capacity.

Coal Creek Stream Corridor 3 (Reaches 8 and 9)

This reach represents the heart of the Coal Creek Canyon community where the retail and commercial enterprise is located. Amenities include two gas stations, a coffee shop, post office, liquor store, groceries, auto repair shops, propane storage and Jefferson County's maintenance facilities. Additionally the Fire Station is located at the intersection of Highway 72 and Crescent Park Drive. Although the amenities are limited, they are important assets to Coal Creek Canyon, given its isolated nature and long distance to outside resources. In September, damage through the community center was widespread. Near Twin Spruce Gap Road, the existing culvert below the Auto-repair/Gas station failed resulting in a large sink hole. The nearby, upstream building (old coffee shop) also experienced significant flooding. Other buildings between Twin Spruce Gap Road and Skyline Drive were flooding, as did the Quick Mart. With high runoff from Crescent Park, significant flooding overtopped Highway 72 near the fire station, and a new channel was excavated between the Liquor Store and nearby homes to reduce the flooding impacts. Flood water also overtopped Highway 72. Upstream of the community center, sediment deposition was widespread. The channel is estimated to have a 10-year capacity throughout much of this reach with many buuildings subject to flooding in events less than a 25-year storm.

Stream Corridor 3 contains multiple alternatives intended to improve stormwater conveyance and reduce future flood damages. Improvements in this area include culvert, bridge and stabilization recommendations, consistent with other reaches along Coal Creek. Acquisition of property to support redevelopment of the community center area in a manner more accommodating of the flood potential on Coal Creek was also considered. Acquisition for redevelopment of the Quick Mart, propane storage, and closed coffee shop upstream of Carl's Corner were recommended by the master plan since the acquisition solutions out ranked their flood conveyance counterparts. Flood conveyance alternatives should be considered as a solution if acquisition and redevelopment does not become a viable option for the area. Concept drawings related to redevelopment of the community center corridor are presented at the end of this section. It is believed that similar amenities to those removed can still be provided within the canyon, only at a location more suitable for the hazards that currently exist in the watershed. Costs reflect acquisition of property and removal of existing buildings or infrastructure. Relocation and construction of new businesses would require re-investment from the original owners or outside investors. It should be noted that the redevelopment concepts presented are in line with the *North Mountains Area Plan*, adopted by Jefferson County on October 9, 2013. This document should be referenced with future planning activities in the area.

Within Reach 9, upstream of the community center, the master plan focuses on stream stabilization, bank protection adjacent to public and private infrastructure, increases to culvert capacity, and maintaining emergency access along the highway corridor. Private access culverts have been proposed to be replaced with open span bridges or box culverts, approximately 12' in length designed for the 25-year flood event. Highway 72 has also been proposed to be raised above the estimated 100-year flood elevations downstream of Ranch Elsie Drive for emergency access. This work would be combined with restoration of Coal Creek (Project 9B) to offset any floodplain impacts on private property.

Four of the top ten project priorities are also located in this corridor, with Project 8D (Acquisition of the Quick Mart and Propane Site) and Project 8E (Stream restoration upstream of the Quick Mart) being ranked 2 and 3, respectively. This reach should be a focal point for upcoming funding opportunities.

Coal Creek Drainage Corridor (Reaches 10 and 11)

Several private culverts and homes are located along the creek, several of which are located within the estimated 100-year floodplain boundary. During the September flood, the culvert at Crescent Lake Road was damaged and since repaired by Boulder County. Susceptibility within this corridor still exists in the form of homes subject to flooding at the 25-year level and limited capacity for private culverts, the culvert at Crescent Lake Road, and the culvert at Ranch Elsie Drive, making them at risk for frequent overtopping and failure.

Projects through this corridor primarily reflect culvert improvements at public and private locations. With exception to at Ranch Elsie Road, private access culverts and public roadway crossings are proposed to be replaced with pipe or box culverts designed for the 25-year flood event. Ranch Elsie Road at Highway 72 is a primary access point to residences and therefore the master plan recommends replacing this culvert with a 100-year design.

Beaver Creek Stream Corridor (Reach 12)

During the September flood significant damage occurred to many of the homes and properties along this reach. The capacity of existing culverts was quickly overwhelmed, and in many cases these structures washed out completely. Several homes were also inundated with flood water. Nearly all residences and the old First Baptist Church building are located within the estimated 100-year flood zone and subject to flooding in events as small as the 25-year storm.

Several homes in this area have made improvements using funding available through the NRCS, although improvements are considered an emergency response provision, not a long term solution to address drainageway needs. Susceptibility in this reach still exists. Most of the private access culverts have been reconstructed; however they still remain below 10-year capacity. The stream is undersized from a geomorphic perspective. Several buildings and the roadway are located within close proximity to the drainageway and are susceptible to lateral channel migration and flooding.

Projects along this reach focus on stream stabilization to manage the geomorphic needs for stability and to increase stream capacity, bank protection adjacent to public and private infrastructure, and increases in capacity for the existing bridges and culverts. Private access culverts have been proposed to be replaced with open span bridges, approximately 14' in length designed to pass the 25-year flood event. The Burland Road crossing from Twin Spruce Gap Road is a primary access point for residents and therefore the master plan recommends replacing this culvert with a 100-year bridge. Culvert options may also need to be considered at this location to best direct flow away from the home downstream of Burland Road. With Burland Road providing emergency access, a 25-year design has been recommended at Joanie Drive.

This project reflects the highest ranking project priority for the watershed. Grant applications are already in place with the State's DOLA, CDBG-DR program and the project is awaiting news on the funding. Should the project not be funded, additional project alternatives may need to be considered to best address resiliency in this area.

Beaver Creek Drainage Corridor (Reaches 13 and 14)

Reaches 13 and 14, located on Beaver Creek, are mostly undeveloped, with no culvert crossings. Projects in this area focus on restoring stream capacity at the confluence location with South Beaver Creek to reduce flooding potential to the existing home in that area.

South Beaver Creek Drainage Corridor (Reaches 15 and 16)

Projects in these reaches focus on bank protection adjacent to public and private infrastructure and adding culvert capacity to public and private stream crossings. Private access culverts and public roadway crossings are proposed to be replaced with bridges or box culverts designed for the 25-year flood event to reduce the risk of future flooding.

Ranch Elsie Drainage Corridor (Reach 17)

This tributary behaves more like a local drainage collection system than a natural drainageway. During the September flood, however, flow from this region was large enough to damage culverts and several homes. Most culverts have been reconstructed since the flood event.

Projects in this reach focus on bank protection adjacent to public and private infrastructure and adding culvert capacity to public and private stream crossings. Private access culverts and public roadway crossings are proposed to be replaced with box culverts designed for the 25-year flood event to reduce the risk of future flooding.

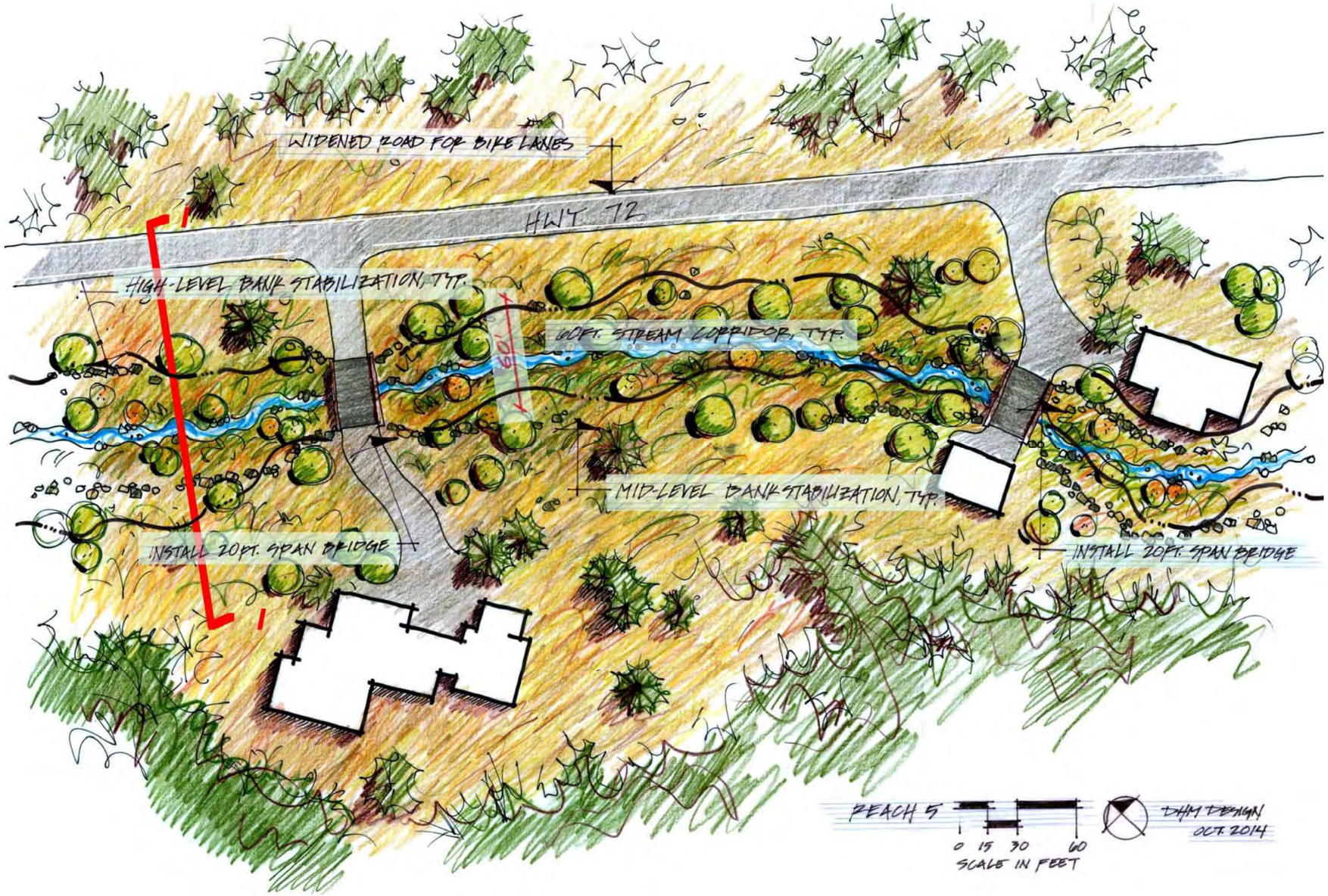
Crescent Park Drainage Corridor (Reaches 18 through 20)

The Crescent Park Tributaries reflect local drainage systems more so than natural drainageways. During the September flood flow from this region was large enough to overtop both Crescent Park Drive and Highway 72. The damage observed in September emphasized the need to better manage runoff from Crescent Park. Since the flood, CDOT has reconstructed a number of facilities in these areas, including new inlets and culverts below Highway 72. Makeshift channel improvements were also constructed south of the intersection to reconnect flows from Crescent Park with Coal Creek. Although this work does provide connectivity, the facilities still remain undersized to convey substantial design flows. Stream capacity along Crescent Park Drive also becomes undersized towards the Highway 72 intersection and the corridor is still susceptible to similar flood problems to those experienced in September.

Recommended improvements though this corridor expand upon the concepts previously completed; however capacity will be increased to more effectively convey discharge to and across both Crescent Park Drive and Highway 72 intersection. The master plan proposes to increase the overall channel capacity west of Crescent Park Drive, south of the Butte Drive fork, to a 100-year channel with 100-year culverts crossing Crescent Park Drive and Highway 72. As noted in September, flow in this area is steep and erosive, therefore bank protection is recommended along Crescent Park Drive. Bank protection on the east side is for the main channel flow; whereas, bank protection on the east side addresses overflows that may develop from the Crescent Park Drive culvert.

Other private access culverts are proposed to be replaced with pipe culverts designed for the 25-year flood event.

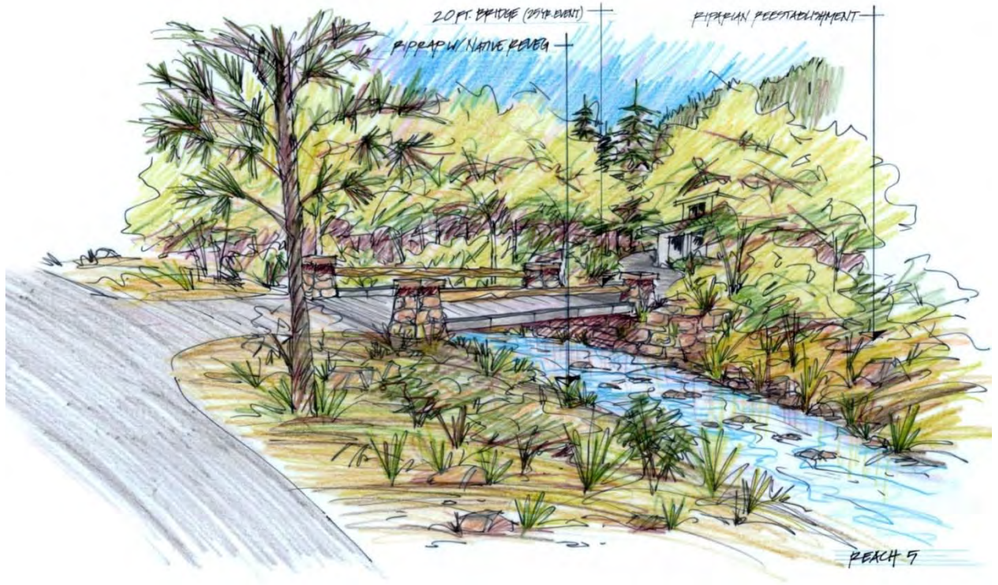
COAL CREEK STREAM COORIDOR 1 – CONCEPTUAL DESIGN



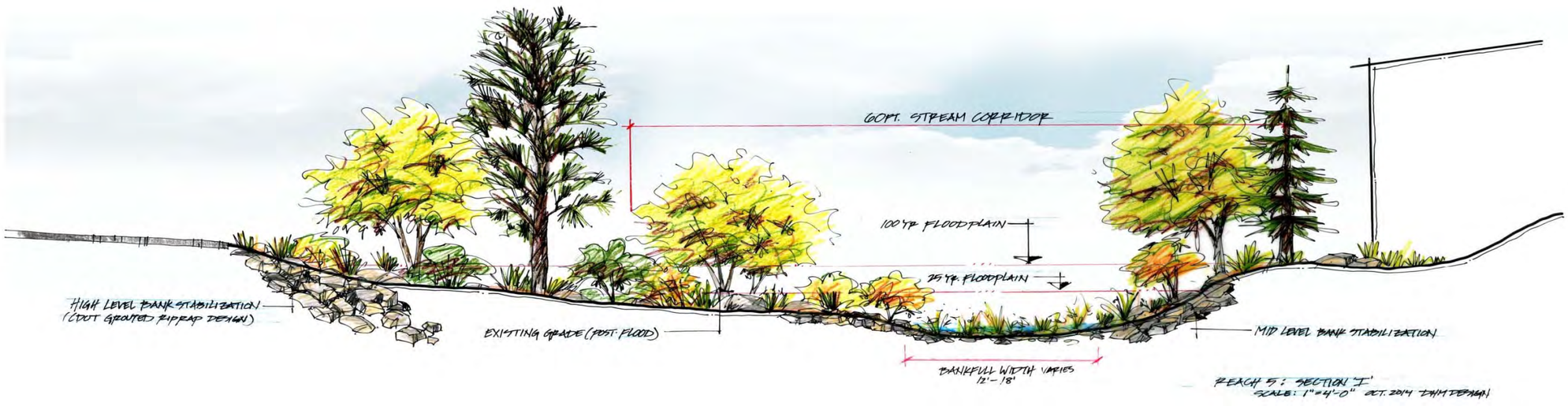
Stream Corridor 1 – Typical Plan Layout

COAL CREEK STREAM COORIDOR 1 – CONCEPTUAL DESIGN

Stream Corridor 1 – Current Conditions

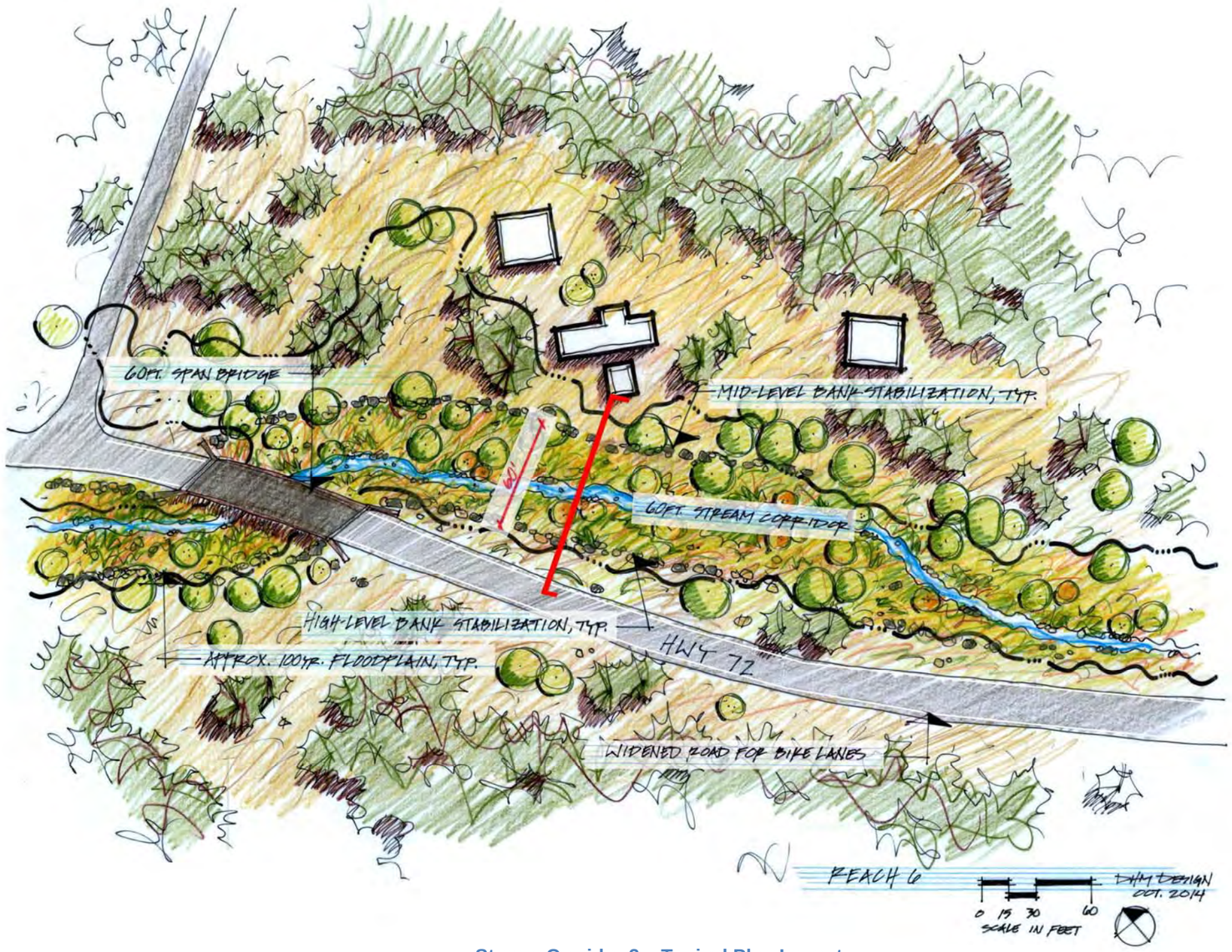


Stream Corridor 1 - Post-Project Rendering



Stream Corridor 1 – Typical Section

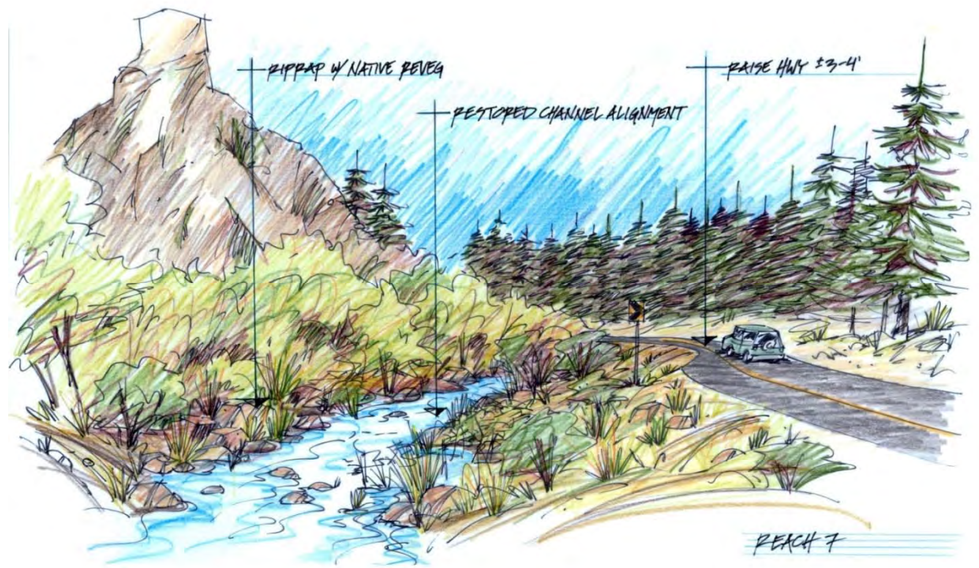
COAL CREEK STREAM COORIDOR 2 – CONCEPTUAL DESIGN



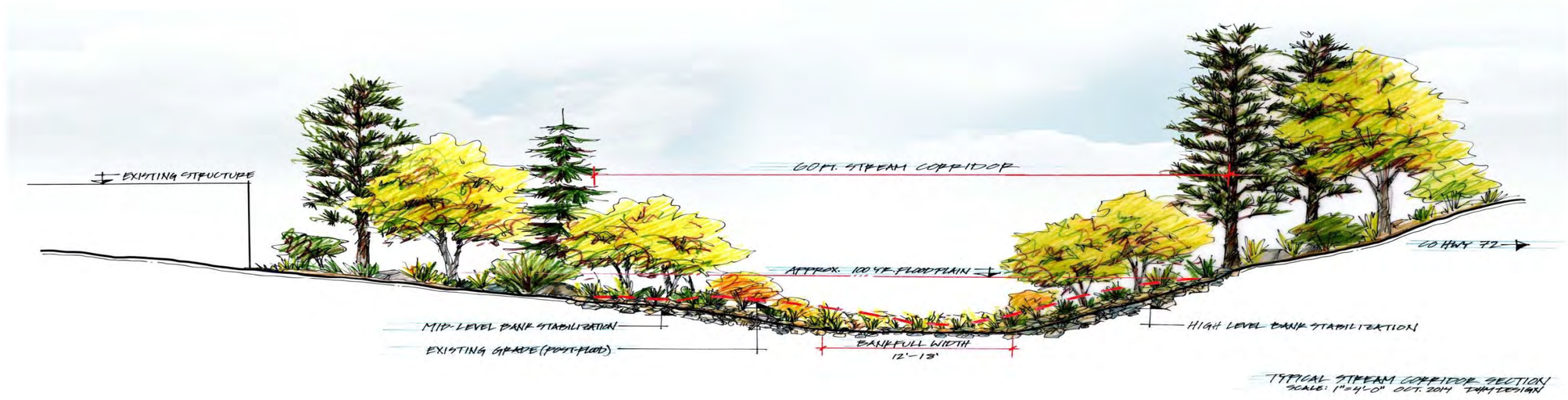
Stream Corridor 2 – Typical Plan Layout

COAL CREEK STREAM COORIDOR 2 – CONCEPTUAL DESIGN

Stream Corridor 2 ('S' Bend Corridor)– Current Conditions

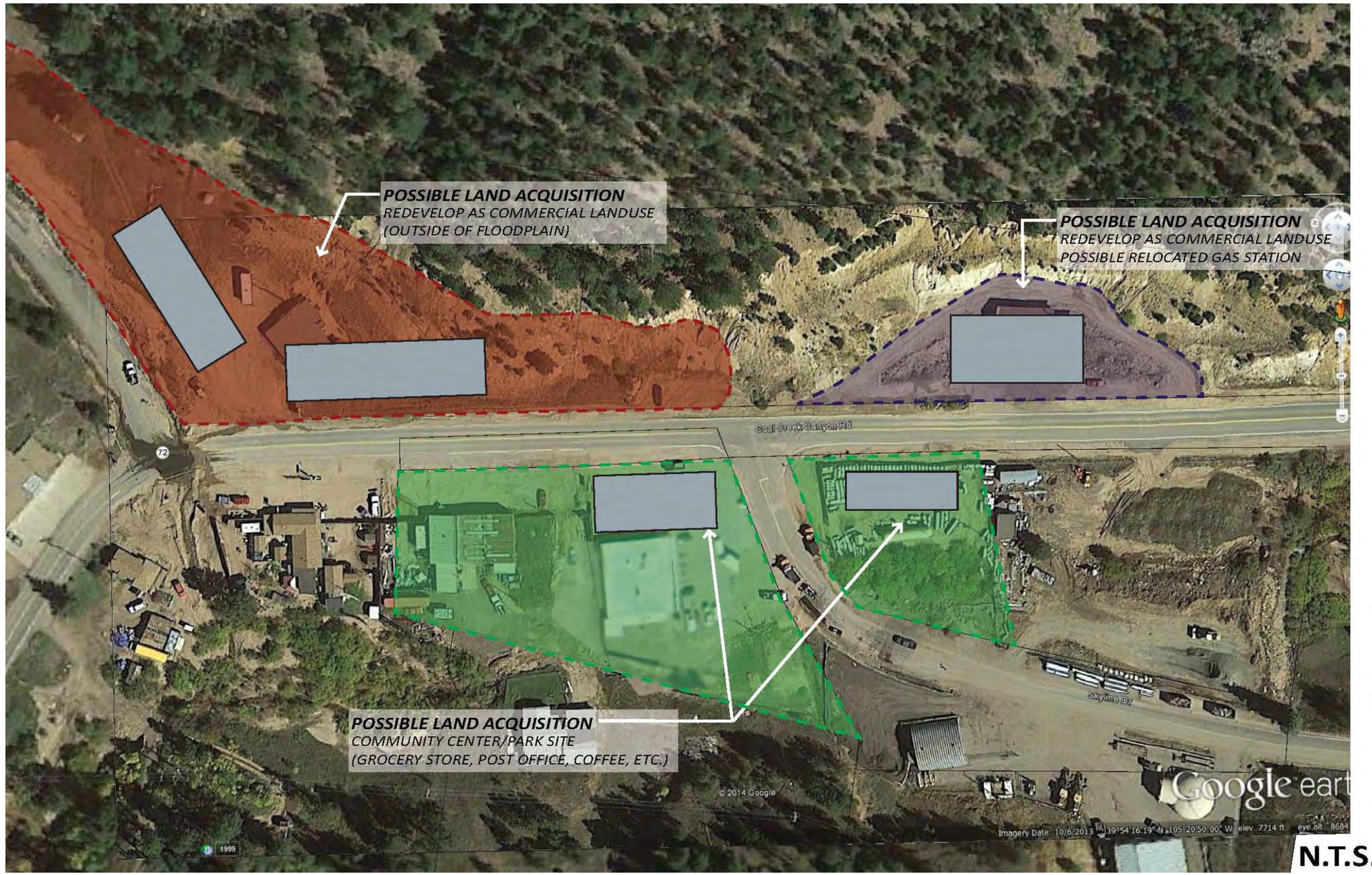


Stream Corridor 2 ('S' Bend Corridor) – Post-Project Rendering



Stream Corridor 2 – Typical Section

COAL CREEK STREAM COORIDOR 3 – CONCEPTUAL DESIGN



N.T.S.

Stream Corridor 3 – Potential Redevelopment Opportunities

COAL CREEK STREAM COORIDOR 3 – CONCEPTUAL DESIGN

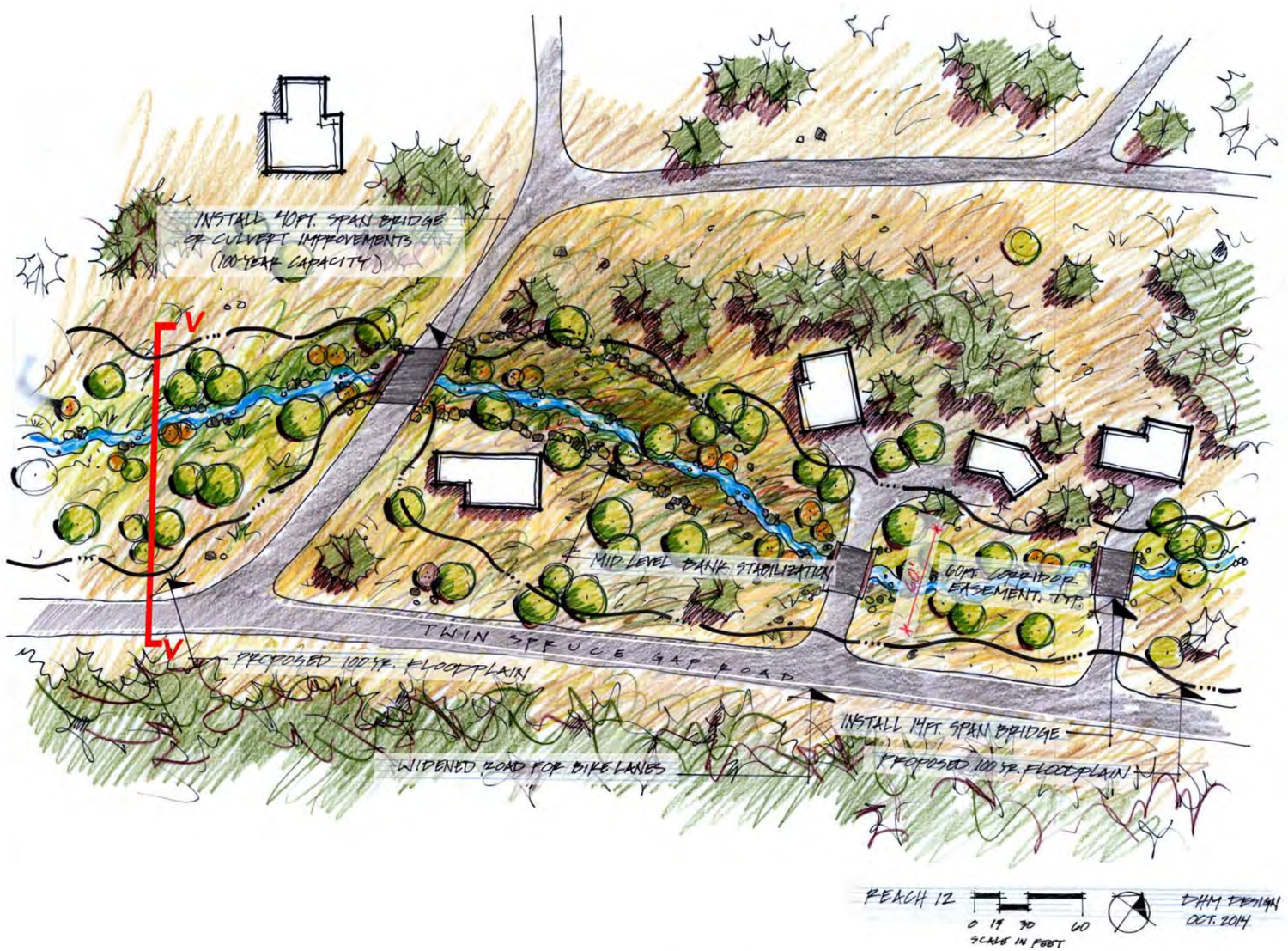
Stream Corridor 3 – Typical Redevelopment Plan Layout

COAL CREEK STREAM COORIDOR 3 – CONCEPTUAL DESIGN

Stream Corridor 3 – Current Conditions

Stream Corridor 3 - Post-Project Rendering

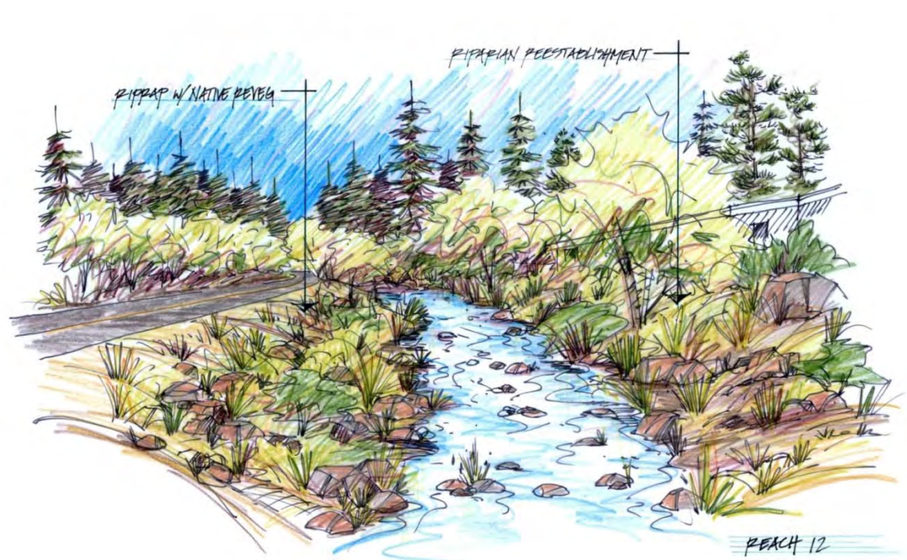
BEAVER CREEK STREAM COORIDOR 4 – CONCEPTUAL DESIGN



Stream Corridor 4 – Typical Plan Layout

BEAVER CREEK STREAM COORIDOR 4 – CONCEPTUAL DESIGN

Stream Corridor 4 (near Coal Creek)– Current Conditions



Stream Corridor 4 (near Coal Creek) - Post-Project Rendering

Stream Corridor 4 – Typical Section

SECTION 9.0 PROJECT PRIORITIZATION

9.1 Stream Corridor Project Prioritization

For this watershed, it is evident that the goals and objectives for each stream corridor are not identical for each reach, and that the overall values from the canyon community are equally important to the planning process. This makes it very difficult to distinguish projects and prioritize for the future. For this reason, a project prioritization matrix was created in order to identify and rank the multitude of potential projects identified throughout the watershed. This matrix and prioritization only includes the stream corridor reaches, as these reaches encumber the majority of immediate needs and higher level expenses identified throughout the watershed. Due to their exposure, the steam corridors are more likely to be funded through flood response grants or future public infrastructure projects. Higher priority projects along the drainage corridors have also been noted and should be considered alongside any improvement to the adjacent stream corridors, or independently.

A total of 31 projects were ranked along the stream corridors. Where options were presented (Corridor 3, Reach 8), alternatives with a higher overall ranking were carried forward into the final master plan. The prioritization matrix evaluates and weights the general reduction in flood and geomorphic risk, as determined by the project team, as well as community values presented by the priority survey. The full ranking matrix is provided in the appendix.

The prioritization matrix distinguishes three major categories – cost, primary mitigation needs, and community values. Each major category is broken into objectives, each of which is assigned a weight (value) and a score, typically between 0 and 10. There are a total of 12 sub-objectives across the 3 categories. A project's ranking is determined by multiplying by the weight by the score, and then summing the results, with the highest overall score ranked as the highest priority. Projects were scored based on a possible total of 800 points. Projects were ranked on a corridor-wide basis, as well as a watershed-wide basis.

Project cost was given the greatest weight making up a possible 200 points, 25% of the total achievable points. Individual project costs were compared on a dollars per mile basis, with a high score of 10 assigned to projects with $/mile costs below $500,000, and a 0 score assigned to projects with total costs exceeding $5,000,000/mile.

The primary mitigation needs category has three objectives, including reduced flood risk, reduced geomorphic risk, and improvement to ecology and habitat. Reduction in flood and geomorphic risks were given potential scores of 80 points. Project which reduced flood hazards or provide a higher level of flood capacity (i.e. culvert improvements along Highway 72) were scored higher. Similarly, projects reducing overall geomorphic risk or improving the overall ecology and habitat conditions were scored higher.

The community values and objectives were ranked by the community, in response to the Community Priority Survey. Community values, from highest to lowest, include immediate needs (highest weight), fundable solutions, emergency access, ecological value, mid-level flood protection, protection of private infrastructure, community center improvement, and recreation (lowest weight). Each project was scored based on how well the proposed project aligned with community values. Regarding fundable solutions, projects generally ranked if they were able to demonstrate compatibility with grant funding opportunities, such as through the CDBG-DR program, or anticipated to be funded through future CDOT improvements along Highway 72.

Table 9.1 – Project Prioritization

Reach	ID	Project Description	Total Value (Points)	Corridor Rank	Overall Rank
Stream Corridor 1 (Reaches 1 through 5)					
1	A	Stream Restoration	**263**	12	**29**
2	A	Stream Restoration & Bank Stabilization	**301**	8	**23**
3	A	Stream Restoration & Bank Stabilization downstream of CO 72	**265**	11	**27**
3	B	Replace CO 72 Culvert at MM 14	**344**	6	**17**
3	C	Stream Restoration, Bank Stabilization, Culvert Improvements upstream of CO 72	**408**	3	**8**
4	A	Stream Restoration & Bank Stabilization to MM 14.4	**325**	7	**22**
4	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 14.5 to MM 15	**453**	1	**5**
4	C	Replace CO 72 Culvert at MM 15	**364**	5	**14**
4	D	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15 to MM 15.2	**404**	4	**9**
4	E	Elevate CO 72, MM 14.4 to MM 14.9	**277**	10	**26**
5	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.2 to MM	**430**	2	**6**
5	B	Elevate CO 72, MM 15.3 to MM 15.4	**297**	9	**24**
Stream Corridor 2 (Reaches 6 through 7)					
6	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.8 to MM 16	**382**	1	**10**
6	B	Replace CO 72 Culvert at MM 16	**343**	5	**18**
6	C	Stream Restoration & Bank Stabilization MM 16 to MM 16.4	**372**	3	**13**
6	D	Replace CO 72 Culvert at MM 16.4	**335**	6	**21**
6	E	Stream Restoration & Bank Stabilization MM 16.4 to MM 16.6	**260**	7	**30**
7	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 16.6 to MM	**374**	2	**12**
7	B	Replace Twin Spruce Gap Road Culvert at MM 17.6	**254**	8	**31**
7	C	Elevate CO 72, MM 16.9 to MM 17.6	**354**	4	**15**
Stream Corridor 3 (Reaches 8 through 9)					
8	A	Storm Sewer at Carl's Corner / CO 72	**376**	5	**11**
8	B	Alt 1; Storm Sewer at Closed Coffee Shop upstream of Carl's Corner & CO 72	**340**	7	**19**
8	B	Alt 2; Acquisition of Property for Closed Coffee Shop, Stream Restoration and	**419**	4	**7**
8	C	Stream Restoration, Bank Stabilization, Culvert Improvements MM 17.7 to MM	**265**	10	**27**
8	D	Alt 1; 100-year Storm Sewer at Quick Mark / Skyline Drive	**468**	3	**4**
8	D	Alt 2; Acquisition of Quick Mart & Propane Site, Stream Restoration, Culvert	**475**	1	**2**
8	E	Stream Restoration, & Bank Stabilization, MM 18.1	**472**	2	**3**
9	A	Stream Restoration, & Culvert Improvements MM 18.1 to MM 18.3	**354**	6	**15**
9	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 18.3 to MM	**340**	7	**19**
9	C	Elevate / Relocate CO 72, MM 18.4 to MM 18.6	**295**	9	**25**
Stream Corridor 4 (Reach 12)					
12	A	Stream Restoration, Bank Stabilization & Culvert Improvements	**482**	1	**1**

9.2 Stream Corridor Prioritization per Entity

Stream Corridor projects presented in Table 9.1 have been ranked by primary entity responsible for the implementation of the improvements. A secondary beneficiary is also noted by each table, if applicable. It is recommended that coordination be made between each entity to facilitate the projects.

Table 9.2 – Project Prioritization for CDOT Led Projects

Reach	ID	Project Description	Cost ($)	Total Value (Points)	Overall Rank	PRIMARY ENTITY	SECONDARY ENTITY
6	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.8 to MM 16	$ 834,681	382	10	CDOT	Private
8	A	Storm Sewer at Carl's Corner / CO 72	$ 506,640	376	11	CDOT	Private
7	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 16.6 to MM 17.6	$ 1,892,827	374	12	CDOT	Private
4	C	Replace CO 72 Culvert at MM 15	$ 1,440,000	364	14	CDOT	
7	C	Elevate CO 72, MM 16.9 to MM 17.6	$ 1,805,760	354	15	CDOT	
3	B	Replace CO 72 Culvert at MM 14	$ 1,440,000	344	17	CDOT	
6	B	Replace CO 72 Culvert at MM 16	$ 1,440,000	343	18	CDOT	
6	D	Replace CO 72 Culvert at MM 16.4	$ 1,440,000	335	21	CDOT	
4	A	Stream Restoration & Bank Stabilization to MM 14.4	$ 114,517	325	22	CDOT	
5	B	Elevate CO 72, MM 15.3 to MM 15.4	$ 293,250	297	24	CDOT	
9	C	Elevate / Relocate CO 72, MM 18.4 to MM 18.6	$ 619,344	295	25	CDOT	
4	E	Elevate CO 72, MM 14.4 to MM 14.9	$ 1,548,360	277	26	CDOT	
		Total Cost	$ 13,375,380				

Table 9.3 – Project Prioritization for Jefferson County Led Projects

Reach	ID	Project Description	Cost ($)	Total Value (Points)	Overall Rank	PRIMARY ENTITY	SECONDARY ENTITY
2	A	Stream Restoration & Bank Stabilization	$ 404,331	301	23	Jefferson County	
3	A	Stream Restoration & Bank Stabilization downstream of CO 72	$ 321,945	265	27	Jefferson County	
1	A	Stream Restoration	$ 39,028	263	29	Jefferson County	
7	B	Replace Twin Spruce Gap Road Culvert at MM 17.6	$ 540,000	254	31	Jefferson County	CDOT
		Total Cost	$ 1,305,304				

Table 9.4 – Project Prioritization for Privately Led Projects

Reach	ID	Project Description	Cost ($)	Total Value (Points)	Overall Rank	PRIMARY ENTITY	SECONDARY ENTITY
12	A	Stream Restoration, Bank Stabilization & Culvert Improvements	$ 1,459,069	482	1	Private	Jefferson County
8	D	Alt 2; Acquisition of Quick Mart & Propane Site, Stream Restoration, Culvert Improvements	$ 932,176	475	2	Private	Jefferson County
8	E	Stream Restoration, & Bank Stabilization, MM 18.1	$ 41,841	472	3	Private	
8	D	Alt 1; 100-year Storm Sewer at Quick Mark / Skyline Drive	$ 891,360	468	4	Private	Jefferson County
4	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 14.5 to MM 15	$ 411,559	453	5	Private	
5	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.2 to MM 15.8	$ 1,783,912	430	6	Private	CDOT
8	B	Alt 2; Acquisition of Property for Closed Coffee Shop, Stream Restoration and Bank Stabilization	$ 261,520	419	7	Private	CDOT
3	C	Stream Restoration, Bank Stabilization, Culvert Improvements upstream of CO 72	$ 1,120,124	408	8	Private	CDOT
4	D	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15 to MM 15.2	$ 560,204	404	9	Private	CDOT
6	C	Stream Restoration & Bank Stabilization MM 16 to MM 16.4	$ 642,108	372	13	Private	CDOT
9	A	Stream Restoration, & Culvert Improvements MM 18.1 to MM 18.3	$ 161,253	354	15	Private	
9	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 18.3 to MM 18.6	$ 978,474	340	19	Private	CDOT
8	B	Alt 1; Storm Sewer at Closed Coffee Shop upstream of Carl's Corner & CO 72	$ 179,880	340	19	Private	CDOT
8	C	Stream Restoration, Bank Stabilization, Culvert Improvements MM 17.7 to MM 17.9	$ 529,338	265	27	Private	CDOT
6	E	Stream Restoration & Bank Stabilization MM 16.4 to MM 16.6	$ 245,853	260	30	Private	CDOT
		Total Cost	$ 9,127,430				

Note that the total cost for privately led projects excludes Project 8-D, Alt1 and Project 8-B, Alt 1, which were both ranked lower than their comparison counterparts. Overall project costs should also include engineering and management fees, estimated previously in this report.

9.3 Drainage Corridor Prioritization

As noted previously, the prioritization matrix was only utilized for the stream corridors reaches, which encumbered the majority of immediate needs and higher level expenses and were most likely to be funded through flood response grants or public infrastructure projects. Several higher priority projects along the drainage corridors include: the culvert crossing below Highway 72 at Crescent Park Drive, the upstream conveyance channel along Crescent Park Drive and associated upstream culvert crossing; stream stabilization at the confluence with Beaver Creek and South Beaver Creek; and the culvert crossing on Coal Creek at Ranch Elsie Road. In most cases, these higher priority projects can be implemented alongside adjacent stream corridors projects.

SECTION 10.0 IMPLEMENTATION STRATEGIES

10.1 Leadership/ Partnerships/ Watershed Coalition

Organization and leadership are the two most important considerations in taking a plan from concept to reality. Key functions of leadership include:

- Working with property owners, corridor improvement advocates and other stakeholders to communicate the vision and build support;
- The capacity to acquire and hold rights-of-way, easements and properties;
- The capacity to apply for and enter into an agreement with funding partners;
- Developing citizen advocacy and community leadership to champion the plan;
- Securing and assembling technical documents, agreements, legal charters and other institutional elements such as a designated public agency, special district or a watershed coalition to direct the process;
- Garnering resources and funds including grant writing;
- Staff oversight and advocacy to complete project tasks;
- Building and maintaining effective partnerships among agencies, jurisdictions and stakeholders;
- Oversight of design, planning, construction, maintenance and stewardship of improvements and properties.

Almost without exception, success hinges on having a committed individual (or a small group of individuals) to embrace and champion the plan. At this point, the Coal Creek Canyon community does not have a watershed coalition of this capacity in place. Creating a Coal Creek Canyon Watershed Coalition may begin with members from the community, non-profits such as TEG, special districts including the Jefferson Conservation District, extensions through the CWCB, and local municipalities, Jefferson and Boulder Counties. As seen with other watershed coalitions forming, this coalition is likely to exist in the form of an incorporated non-profit with tax-exempt status under Section 501 (c)(3) of the U.S. Internal Revenue Code. This would allow the group to accept private donations, apply for public grants, possibly hold easements and acquire lands, and provide other services to the effort. It is strongly recommended that the non-profit focus strictly on completing the projects identified for the Coal Creek Canyon Corridor.

A DOLA CDBG grant is expected to be available soon for the hiring of a full time watershed coalition manager. The Watershed Coalition manager may assist with several types of professional skills and services including:

- Fund raising;
- Grant administration,
- Right-of-way negotiation,
- Budget management,
- Hiring and supervising design and other technical consultants,
- Agency coordination,
- Project promotion and other services needed to implement the plan.

This also includes planning for, and overseeing, operations and maintenance of improvements as well as stewardship of properties.

Phasing and Next Steps

Prioritization of projects incorporated planning guidelines for phasing and next steps. The prioritization matrix evaluated values including addressing immediate needs and available funding. The following criteria and guidelines share a planning perspective to assist with guiding leadership in making decisions and building advocacy.

Experience in other communities with similar plans, shows that there are specific elements that comprise a successful implementation program. These include:

1. Agree upon a vision and action plan.
2. Commit community leadership and staff to champion and become advocates of the plan.
3. Build community support.
4. Recruit project administration and professional services.
5. Begin securing land agreements, rights-of-way and permits.
6. Identify and secure funding sources and partners.
7. Initiate pilot projects and a phasing scheme.
8. Plan for follow-through and long-term continuity.

Phasing of projects is best guided by several criteria including:

An immediate opportunity where a logical, usable project can be completed with current or readily available resources such as:

- Availability of rights-of-way and permitting.
- Availability of funding and/or grants to build and maintain improvements
- Catalytic projects that demonstrate the value of the project within the canyon corridor, build public support and help promote further community support and fund-raising such as…
- Projects that can be completed using volunteers or in-kind labor and resources.
- Projects that offer an exceptional experience and/or are highly visible to the public.

In strategizing implementation, several early action projects should be defined. The goal is to complete these in the next 1-3 years. The prioritization matrix identifies these early action projects that are either currently likely to be funded or scored higher than other projects. Other flags for early action may include:

- Identified by local communities and stakeholders as high priority;
- Broadest range of community and user benefits;
- Provides a vital hazard reduction opportunity (flood, contamination and erosion);
- Provides a vital resource preservation opportunity;
- Land or financing available or potentially available soon;
- Can be completed within a 1-5 year time frame;
- High visibility and demonstrates the concept and mission of the plan;
- Provides a vital resource preservation, or hazard (flood, contamination and erosion) reduction opportunity;
- Incorporates multiple objectives identified in the prioritization matrix (i.e. flood hazard/erosion/ conservation/economic development, health and fitness);

- Opportunity may be lost if not accomplished now.

Next Steps

There are several actions that can and should be taken immediately to initiate moving beyond this plan into concrete actions. These include:

- Identify the key staff project coordinators to continue implementation activities.
- Develop leadership, partnerships and review the options for development of a watershed coalition and hiring a watershed coalition manager.
- Engage elected officials in the plan and move toward timely acceptance of the plan.
- Refine a schedule and "roster of projects" for logical phased implementation of the projects identified. Develop a detailed cost estimate, preliminary designs, and environmental impact assessments for a 2015 or 2016 pilot project.
- Work to promote Canyon Restoration projects and build liaisons with key stakeholders such as business people, land owners, developers and public citizens who might be willing to contribute to the effort.
- Immediately pursue negotiation of rights-of-way along the corridor as necessary.
- Pursue state, and federal funding in the next grants rounds.
- Explore potentials for a long-term funding source such as a county open space sales tax.

10.2 Potential Funding Sources

The following lists are potential funding partners from local sources, government funding opportunities, stream restoration focused grants, and private sector grants. Program eligibility, deadlines, and amounts vary and are ever changing. Please contact the agencies administering the funds directly for up to date information as you pursue these opportunities. Note: Many of these opportunities have begun to be reviewed with the critical nature of the deadlines approaching for the release of immediate funds and to meet the grant cycle requirements; others have been researched and noted as having potential for funding within the Coal Creek Canyon.

The following list of potential funding sources has been organized by project types identified within the Coal Creek Canyon Watershed Master Plan and whether the grants apply for infrastructure needs on private properties, projects identified within CDOT rights-of-way, or within Jefferson or Boulder Counties rights-of-way.

NPS

The National Park Service offers a Rivers, Trails and Conservation Assistance Program. This is a grassroots program responding to community requests for support building grant applications, building capacity and offering collaboration in seeking grants. Their in-kind services qualify as a match for certain grant programs.

Infrastructure Needs on Private Properties

Watershed and Flood Protection Programs

Department of Local Affairs (DOLA) with funding through its Community Development Block Grant – Disaster Recovery (CDBG-DR) program.

Jefferson Conservation District submitted a NOI for a CDBG HUD grant earlier this year that was initially selected for funding. The planning team has submitted a full application under Round 1 of the CDBG-DR grant cycle for funds for improvements to Beaver Creek at Twin Spruce Gap Road, the top ranked project identified by this master plan. Funds are awaiting approval. A second round of grants are anticipated later in 2014 and early 2015. http://dola.colorado.gov/cdbg-dr/content/local-governments-eligibility-process

SB 14-179 Stream Restoration/ Debris Removal Grants (administered through CWCB)

The Colorado Water Conservation Board (CWCB) continues to provide and develop opportunities for funding restoration projects for our flood-affected areas. CWCB is managing funding for projects through Senate Bill SB14-179. Coal Creek Canyon was awarded $94,400 for restoration work at Twin Spruce Gap Road Junction with Coal Creek. http://cwcb.state.co.us/Pages/CWCBHome.aspx

NRCS EWP Grant Program

Through the Emergency Watershed Protection (EWP) program, the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) can help communities address watershed impairments that pose imminent threats to lives and property. NRCS may bear up to 75 percent of the construction cost of emergency measures. The remaining 25 percent must come from local sources and can be in the form of cash or in-kind services. Funding is subject to Congressional approval. Natural Resources Conservation Service (USDA) can provide technical consultation to private landowners. The NRCS assists lands landowners through conservation planning and assistance designed to benefit the soil, water, air, plants, and animals that result in productive lands and healthy ecosystems. Grants are available to assist with projects that offset impacts to the water quality and soils. Improvements that target selenium levels have particular potential to obtain grant funding.
http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/

FEMA - Hazard Mitigation Grant Program (HMGP).

The Hazard Mitigation Grant Program (HMGP) provides grants to States and local governments to implement long-term hazard mitigation measures after a major disaster declaration. Authorized under Section 404 of the Stafford Act and administered by FEMA, HMGP was created to reduce the loss of life and property due to natural disasters. The program enables mitigation measures to be implemented during the immediate recovery from a disaster. Applications for mitigation projects are encouraged as soon as possible after the disaster occurs so that opportunities to do mitigation are not lost during reconstruction. http://www.fema.gov/hazard-mitigation-grant-program

FEMA - Flood Mitigation Assistance Program (FMA)

The FMA program provides resources to assist states, tribal governments, territories and local communities in their efforts to reduce or eliminate the risk of repetitive flood damage to buildings and structures insurable under the National Flood Insurance Program. In FY 2014, the total amount of funds distributed under the FY 2014 FMA will be $89 million and will be distributed on a competitive basis. This is a national competitive grant program. http://www.fema.gov/flood-mitigation-assistance-program

US EPA REGION 8 – Urban Water Funding Sources

EPA restoration and watershed targeted funding sources offer grants, low interest loans, and potential partnering with American Recovery and Reinvestment Act (ARRA) funding for projects that improve water quality. ARRA website: (www.recovery.org) http://water.epa.gov/grants_funding/cwf/cwsrf_index.cfm
EPA has numerous grant programs to assist private homeowners with flood damage repair and restoration including grants for septic systems and wells, mold and moisture, flood cleanup and indoor air quality. Following are EPA resources for Flood Recovery.

EPA Urban Waters Small Grants: http://www2.epa.gov/urbanwaters/urban-waters-small-grants
EPA Green Infrastructure Technical Assistance: http://water.epa.gov/infrastructure/greeninfrastructure/
EPA Targeted Watersheds Grant Program: http://water.epa.gov/grants_funding/twg/initiative_index.cfm

Colorado Resiliency Planning Grant Program

Eligible Activities: Basic planning and studies, long range planning related to disaster recovery; flood recovery-related planning staff where alternative funds not available. **Priorities**: Urgent or time-sensitive community needs; contribution to community resiliency; consistency with local or regional goals or plans. **Eligible Applicants**: Colorado units of local government in federally-declared counties (2013 floods); government entity can apply on behalf of partner entities as long as they are willing to serve as fiscal agent (80% of funds must be allocated to communities in Boulder, Larimer, and Weld County).

Department of Local Affairs, Division of Local Government Energy and Mineral Impact Grant Program

Administrative Grants – Flood Disaster Recovery

Eligible Activities: Community planning, comprehensive planning, preliminary engineering and architectural design for projects directly related to 2013 Flood Disaster Recovery. **Cash Match Requirements**: Flexible match requirements (determined by DOLA staff through review of the local government's financial hardship). **Eligibility Requirements:** These funds address immediate needs of flood-impacted communities. These funds are only eligible for projects that have no other source of funding for completion in a timely fashion, such as FEMA and CDBG-DR. **Eligible Applicants**: Projects in counties, municipalities and special districts directly related to flood disaster recovery efforts. **Deadlines**: Requests and awards occur on an on-going basis until all 2013 flood disaster recovery administrative projects have been addressed. **Maximum grant amount**: $200,000 http://dola.colorado.gov/impact

Community Center Open Space Preservation/ Park Development/ Recreation Development

Greater Outdoors Colorado (GOCO)

Grant Funding from GOCO applies a portion of the state lottery funds to preserve, protect, enhance and manage Colorado's park, wildlife, river, trails and open space heritage. The Legacy Grant in particular has the potential to provide capital improvement funding extending over several phases to help purchase, develop and manage improvements. Refer to www.goco.org for descriptions of grant programs, applications, and schedules. Trail funding from GOCO often comes through the State Trails program that also distributes funds from the U.S. Land and Water Conservation Fund and other sources. GOCO can award up to $200k for Large Construction /Maintenance Grants. 20-30 grant applications exceeding $5 million may be awarded up to $1.5 million in grant funds. The applicant must provide a 30% match of which 10% must be cash, rest can be in-kind contributions. Periodically GOCO awards **special grants** for outdoor projects. Earlier this year, 2014, GOCO opened up their grant applications to include flood and natural river riparian restoration opportunities in the amount of $250,000. **GOCO/ State Trails Planning/Support Grant Applications** award up to $45k for trail planning grants. These grants are competitive and the applicant must provide a 30% match, of which 10% must be cash, rest can be in-kind contributions. http://www.goco.org/

State Trails Land and Conservation Program

The LCP Program also provides a Small Construction maintenance grant up to $45k. The applicant must provide a 30% match, of which 10% must be cash, rest can be in-kind contributions.

Land and Water Conservation Fund (LWCF)

The LWCF state assistance program provides matching grants to help states and local communities protect parks and recreation resources. Running the gamut from wilderness to trails and neighborhood playgrounds, LWCF funding has benefited nearly every county in America, supporting over 41,000 projects. This 50:50 matching program is the primary federal investment tool to ensure that families have easy access to parks and open space, hiking and riding trails, and neighborhood recreation facilities.
http://www.lwcfcoalition.org/about-lwcf.html

Fishing and Wildlife Habitat Restoration Grants

Colorado State Parks Colorado State Trails Grant Programs

Fishing is Fun

The Fishing Is Fun program provides up to $400,000 in matching grants annually to local and county governments, park and recreation departments, water districts, angling organizations and others for projects to improve angling opportunities in Colorado. This unique program involves local communities in a three-way partnership with the Colorado Parks and Wildlife and Federal Sportfish Restoration Act monies. Eligible applicants can apply and compete for financial assistance for specific projects. Applicants must match their Fishing is Fun award with non-federal cash or in-kind services.
http://cpw.state.co.us/aboutus/Pages/FishingIsFunProgram.aspx

Wetland Wildlife Conservation Program

The Wetland Wildlife Conservation Program is a voluntary, incentive-based program to protect wetlands and wetland-dependent wildlife on public and private land. Since its inception in 1997, the Colorado Wetlands Program has preserved, restored, enhanced or created almost 220,000 acres of wetlands and adjacent habitat and more than 200 miles of streams. The partnership is responsible for almost $40 million in total funding devoted to wetland and riparian preservation in Colorado.
http://cpw.state.co.us/aboutus/Pages/Wetlands.aspx

Stream Restoration/ Wetland Restoration Grants

Colorado Department of Public Health and Environment (CDPHE) Water Quality Control Division

The Nonpoint Source Management Area (NPS Program) of the Colorado Department of Public Health and Environment funds nonpoint source projects as a result of receiving a federal grant under section 319(h) of

the federal Clean Water Act (CWA). The funding is distributed to project sponsors through cost reimbursement contracts with the State for projects chosen through an annual, competitive process that begins with a Funding Announcement. The NPS Program is looking for projects that will help achieve its two overarching objectives: restore waterbodies not meeting water quality standards by addressing nonpoint source water quality impacts; and protect existing water quality from future nonpoint source pollution.
http://npscolorado.com/applying-for-a-grant/

Clean Water Act Section 319(h) funds
Clean Water Act Section 319(h) funds are provided only to designated state and tribal agencies to implement their approved nonpoint source management programs. State and tribal nonpoint source programs include a variety of components, including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and regulatory programs. Each year, EPA awards Section 319(h) funds to states in accordance with a state-by-state allocation formula that EPA has developed in consultation with the states. In accordance with guidance issued by EPA under Section 319 of the Clean Water Act, Section 319(h) funding decisions are made by the states. States submit their proposed funding plans to EPA. If a state's funding plan is consistent with grant eligibility requirements and procedures, EPA then awards the funds to the state. http://water.epa.gov/polwaste/nps/cwact.cfm

EPA Region 08 Wetland Program Development Grants
The goals of the EPA's wetland program include increasing the quantity and quality of wetlands in the U.S. by conserving and restoring wetland acreage and improving wetland condition. In pursuing these goals, the EPA seeks to build the capacity of all levels of government to develop and refine effective, comprehensive programs for wetland protection and management. http://www2.epa.gov/sites/production/files/2014-02/documents/wpdg_rfpfy14fy15.pdf

EPA 5 Star Restoration Program
The Five Star Restoration Program brings together students, conservation corps, other youth groups, citizen groups, corporations, landowners and government agencies to provide environmental education and training through projects that restore wetlands and streams. The program provides challenge grants, technical support and opportunities for information exchange to enable community-based restoration projects. Funding levels are modest, from $5,000 to $20,000, with $10,000 as the average amount awarded per project. However, when combined with the contributions of partners, projects that make a meaningful contribution to communities become possible. At the completion of Five Star projects, each partnership will have experience and a demonstrated record of accomplishment, and will be well-positioned to take on other projects. http://water.epa.gov/grants_funding/wetlands/restore/index.cfm

Fish and Wildlife Service North American Wetlands Conservation Act Standard Grant Program
The Standard Grants Program is a competitive, matching grants program that supports public-private partnerships carrying out projects in Canada, the United States, and Mexico. These projects must involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats. Total funding for the Standard Grants Program in FY 2013 is $64.2 million. Individual country totals can be found on each country-program's webpage.http://www.fws.gov/birdhabitat/grants/NAWCA/Standard/index.shtm

Fish and Wildlife Service North American Wetlands Conservation Act Small Grant Program
The Small Grants Program is a competitive, matching grants program that supports public-private partnerships carrying out projects in the United States that further the goals of the North American Wetlands Conservation Act (Act). These projects must involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats for the benefit of all wetlands-associated migratory birds. This program supports the same type of projects and adheres to the same selection criteria and administrative guidelines as the U.S. Standard Grants Program. However, project activities are usually smaller in scope and involve fewer project dollars. Grant requests may not exceed $75,000, and funding priority is given to grantees or partners new to the Act's Grants Program. For FY 2014 is authorized up to $5 million contingent on quality and number of proposals received and funding available.
http://www.fws.gov/birdhabitat/grants/NAWCA/Small/index.shtm

Andrus Family Fund – private foundation
Eligibility: Non-profits, **Project Focus**: Grants are awarded to organizations working to resolve: conservation conflict; identity-based conflict; police-community conflict. AFF will fund community reconciliation projects within the United States that put the transition model to the test in addressing one of AFF's three priority issues (listed above). AFF does not make grants to/for endowments, capital improvements, fundraising events/sponsorships, international projects, scholarships, loans, or individuals. http://affund.org/

Colorado Tree Coalition Grant Program
Geographic Focus: Colorado, **Project Focus:** These grants are for tree-related projects and community forestry promotional activities only. An educational component should be included in each project. Projects which enhance good community tree planting, care or maintenance, are eligible. In general, projects must be on public property, but projects on private property that provide public benefit and access are acceptable. Grant dollars will be divided into 4 tiers (Management/Maintenance; Media; Tree Planting; and Xcel Utility) http://www.coloradowater.org/Private%20Funding%20Opportunities/#Colorado Tree

Audubon Rockies
Audubon Rockies' has received a very generous funding opportunity, through the Terra Foundation, to help fund Colorado Audubon Chapters in projects that assist local Colorado communities on water-related issues. Contact their headquarters in Fort Collins directly for new and ongoing grant opportunities for watershed related projects, riparian planting funds and for utilizing volunteer opportunities to assist with local projects. rockies.audubon.org

Community Grant and Support Programs

New Dream Neighborhood Challenge
NewDream is a neighborhood challenge community grant program that provides assistance and direction for communities to raise money for projects and will match dollar for dollar raised up to $2,000.

http://www.newdream.org/programs/collaborative-communities/get2gether/neighborhood-challenge

Projects Identified within CDOT rights-of-way and Jefferson County rights-of-way

FHWA Highway and Enhancements funds

The Federal Highway Administration is authorized $27.5 billion for competitive grants for infrastructure projects including highway rehabilitation and restoration, bridge repair, and projects to improve highway safety and resurfacing. The bill also allows for up to 3% of each state's allocation to be used towards Transportation Enhancements projects (about $800 million nationwide). These projects allow opportunities for park and recreation agencies as well as cities to directly apply for funding for trail, bike, and pedestrian projects. For more details see www.fhwa.dot.gov/economicrecovery.

Department of Energy grants may fund bike/ped facilities

The energy efficiency and conservation Block Grant (EECBG) program is a new program created in late 2007 and funded for the first time through the ARRA. The program provides funding for local governments and states to support projects that improve energy efficiency in all sectors, including transportation. Because the funding comes through ARRA, additional goals which focus on job creation and economic stimulus have been added. Two of the goals of EECBG funding are right in line with bicycle, pedestrian, and Safe Routes to School projects, and could be beneficial to communities who want to develop bicycling and pedestrian networks and improve access to work, school, and retail. In addition, at a later date, the Department of Energy will be releasing a separate Funding Announcement for $455 million in competitive grants. A list of eligible localities and estimated allocations are available at www.eecbg.energy.gov/grantalloc.html

Private Sector Funding Opportunities

Private Funding Opportunities include a range of funding foundations that invest in watershed health, restoration and education. Private donations including individuals, philanthropic foundations and corporate donors. Right-of-way dedications and improvements by private land owners, developers and homeowner associations. In-kind contributions of land and volunteer labor resources. Others including service clubs, youth groups, recreational groups and fraternal organizations

SECTION 11.0 REFERENCES

1. U.S. Environmental Protection Agency, *EPA SWMM version 5.0 Storm Water Management Model and Help Manual*, Build 5.0.022
2. U.S. Army Corps of Engineers, HEC-RAS River Analysis System, Version 4.1.0, January 2010
3. LiDAR Acquisition for the Flooding in Central and Northern Colorado, Photo Science, USGS, October 2013
4. RESPEC Consulting & Services, DRAFT *Coal Creek and Rock Creek Major Drainageway Plan,* September 2012
5. URS Corporation, *Coal Creek – Headwaters to Jefferson/Boulder County Line*, *Hydrology Evaluation, CDOT Region 4, August 28, 2014*
6. Jefferson County, Planning and Zoning Division, *North Mountains Area Plan* - October 2013
7. Ecological Resource Consultants, Inc.*, Coal Creek Channel Morphology Report*, July 30, 2014
8. Ecological Resource Consultants, Inc., *Coal Creek Master Plan, Riparian Zone and Threatened and Endangered Species Summary*, June 30, 2014

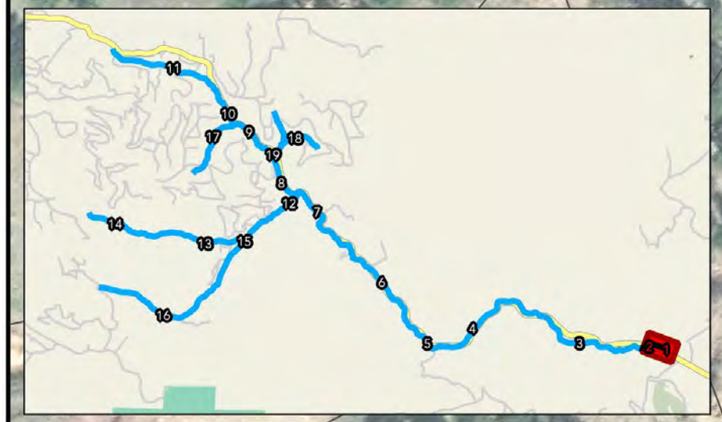
PHOTO CREDITS (NOT PROVIDED BY PLANNING TEAM)

1. Photo 1 - http://www.itsnewanddifferent.com/2013/09/18/colorado-floods/
2. Photo 2 - http://flashpointsurvival.com/colorado-floods-coverage/
3. Photo 3 - http://www.coalcreekcanyonfd.org/wp-content/uploads/2013/09/Highway72.jpg
4. Photo 5 - http://www.itsnewanddifferent.com/2013/09/18/colorado-floods/
5. Photo 6 - http://www.itsnewanddifferent.com/2013/09/18/colorado-floods/
6. Photo 10 - http://controversialdocumentaries.blogspot.com/2013/09/colorado-floods-triggered-by.html, © Reuters

APPENDIX A

CONCEPTUAL DESIGN MAPS

Coal Creek Master Plan
Corridor 1 - Reach 1



0 50 100 150 200 ft

1 inch = 100 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Project Rank

- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-31

Reach 1A
Description: Stream Restoration
Cost: $39,000
Rank: 29

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	374	870	3370
Geomorphic Properties			
Primary Stream Type - B Slope: 2% to 4%; A = 15' to 18'; B = 27' to 32'; C = 1.1' to 1.3' Secondary Stream Type - C Slope: 1% to 2%; A = 16' to 20'; B = 48' to 60'; C = 1.1' to 1.3'			

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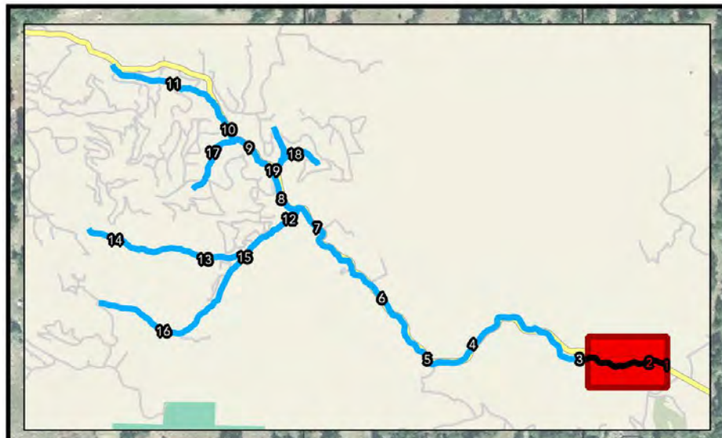
Coal Creek Master Plan
Corridor 1 - Reach 2



0 125 250 375 500 ft

1 inch = 250 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Project Rank

- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-31

Coal Creek Canyon Rd

Reach 2A

Description: Stream Restoration & Bank Stabilization
Cost: $404,000
Rank: 23

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	375	860	3310

Geomorphic Properties

Primary Stream Type - B
Slope: 2% to 4%; A = 15' to 18'; B = 27' to 32'; C = 1.1' to 1.3'
Secondary Stream Type - A
Slope: 4% to 10%; A = 12' to 18'; B = 16' to 20'; C = 1.1' to 1.3'

Bridges and Culverts

ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
1	14' x 14' RCBC	na	na	Do Nothing
2	180" CMP	na	na	Do Nothing

Reflects Master Plan Recommendations

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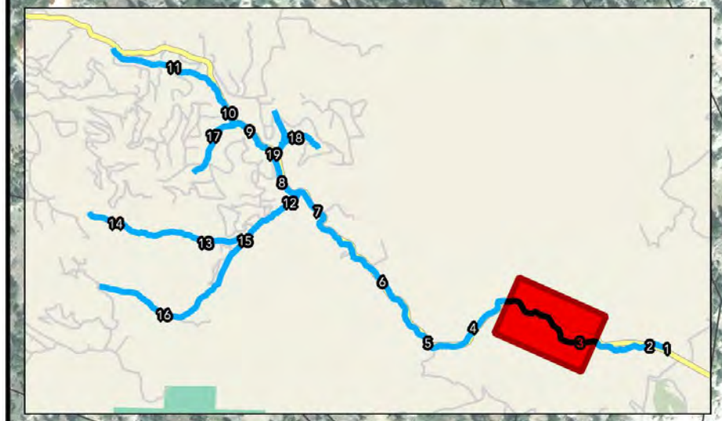
Coal Creek Master Plan
Corridor 1 - Reach 3



0 150 300 450 600 ft

1 inch = 300 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Project Rank

- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-31

Reach 3B
Description: Replace CO72 Culvert at MM 14
Cost: $1,440,000
Rank: 17

Reach 3C
Description: Stream Restoration, Bank Stabilization
Replace Culverts 4, 5, and 6
Cost: $1,120,000
Rank: 8

Reach 3A
Description: Stream Restoration & Bank Stabilization downstream of CO72
Cost: $322,000
Rank: 27

Coal Creek Canyon Rd

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	374	870	3250
Geomorphic Properties			
Primary Stream Type - A Slope: 4% to 10%; A = 12' to 15'; B = 16' to 20'; C = 1.1' to 1.3' Secondary Stream Type - B Slope: 2% to 4%; A = 15' to 18'; B = 27' to 32'; C = 1.1' to 1.3'			
Bridges and Culverts			
ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
3	9'6" x 8'2" double RCBC	na	na	**60' bridge**
4	66" double CMP	na	**20' bridge**	60' bridge
5	90" CMP	add 30" Pipe	**20' bridge**	60' bridge
6	80" Pipe & 48" CMP	na	**20' bridge**	60' bridge
	Reflects Master Plan Recommendations			

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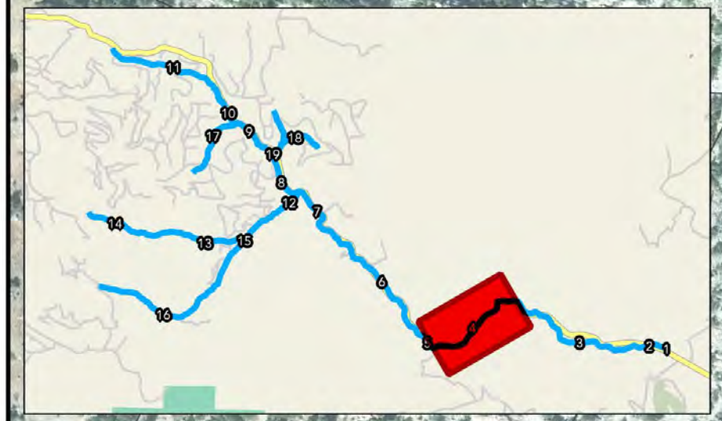
Coal Creek Master Plan
Corridor 1 - Reach 4



0 125 250 375 500 ft

1 inch = 300 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Project Rank

- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-31

Reach 4A
Description: Stream Restoration & Bank Stabilization to MM 14.4
Cost: $115,000
Rank: 22

Reach 4B
Description: Stream Restoration, Bank Stabilization, Culvert Improvements MM 14.5 to MM 15
Cost: $412,000
Rank: 5

Reach 4D
Description: Stream Restoration, Bank Stabilization, Culvert Improvements MM 15 to MM 15.2
Cost: $560,000
Rank: 9

Community Comment:
Need for revegetation along creek

Community Comment:
Address inflows & sedimentation from side channel/landslide area

Reach 4C
Description: Replace CO 72 Culvert at MM 15
Cost: $1,440,000
Rank: 14

Reach 4E
Description: Elevate CO 72, MM 14.4 to MM 14.9
Cost: $1,548,000
Rank: 26

Coal Creek Canyon Rd

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	374	870	3120
Geomorphic Properties			
Primary Stream Type - A Slope: 4% to 10%; A = 12' to 15'; B = 16' to 20'; C = 1.1' to 1.3'			
Bridges and Culverts			

ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
7	66" CMP & 60" Pipe	add 42" Pipe	**20' bridge**	60' bridge
8	12' x 4' Double RCBC	na	na	**60' bridge**
9	66" double CMP	na	**20' bridge**	60' bridge
10	66" double CMP	na	**20' bridge**	60' bridge
11	72" double CMP	na	**20' bridge**	60' bridge
12	washed out	8' x 6' RCBC	**20' bridge**	60' bridge

Reflects Master Plan Recommendations

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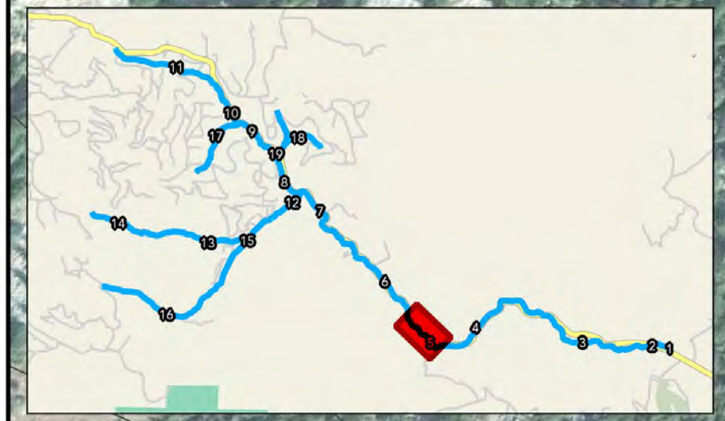
Coal Creek Master Plan
Corridor 1 - Reach 5



0 75 150 225 300 ft

1 inch = 150 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Project Rank

- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-31

Reach 5B
Description: Elevate CO 72, MM 15.3 to MM 15.4
Cost: $293,000
Rank: 24

Coal Creek Canyon Rd

Reach 5A
Description: Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.2 to MM 15.8
Cost: $1,784,000
Rank: 6

Community Comment:
Need for sediment management, stablization, and increased channel capacity/width

Design Data				
		Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge		374	870	3050
Geomorphic Properties				
Primary Stream Type - A Slope: 4% to 10%; A = 12' to 18'; B = 16' to 20'; C = 1.1 'to 1.3'				
Bridges and Culverts				
ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
13	washed out	8' x 6' RCBC	**20' bridge**	60' bridge
14	10' x 3'8" RCBC	add 3' x 4" RCBC	**20' bridge**	60' bridge
15	6' x 4.8' CMP	8' x 6' RCBC	**20' bridge**	60' bridge
16	72" double CMP	na	**20' bridge**	60' bridge
17	96" CMP	na	**20' bridge**	60' bridge
18	washed out	8' x 6' RCBC	**20' bridge**	60' bridge
	Reflects Master Plan Recommendations			

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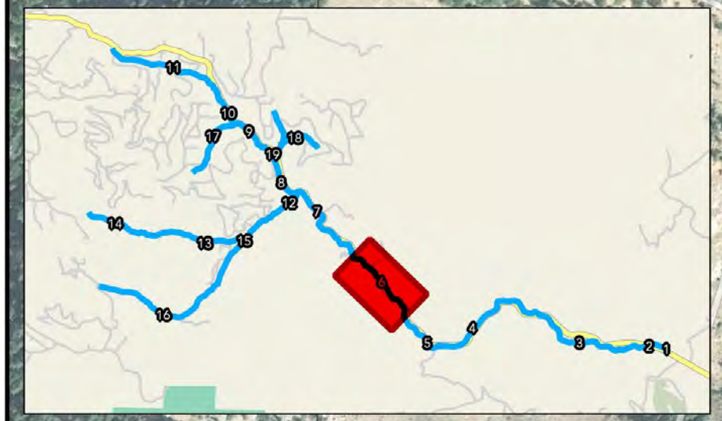
Coal Creek Master Plan
Corridor 2 - Reach 6



0 125 250 375 500 ft

1 inch = 250 feet

Legend
- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Project Rank
- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-31

Cattle Trail Dr

Coal Creek Canyon Rd

Coal Creek

H

G

22

21

20

19

18

Reach 6E
Description: Stream Restoration & Bank Stabilization MM 16.4 to MM 16.6
Cost: $246,000
Rank: 30

Reach 6D
Description: Replace CO 72 Culvert at MM 16.4
Cost: $1,440,000
Rank: 21

Reach 6C
Description: Stream Restoration & Bank Stabilization MM 16 to MM 16.4
Cost: $642,000
Rank: 13

Reach 6B
Description: Replace CO 72 Culvert at MM 16
Cost: $1,440,000
Rank: 18

Reach 6A
Description: Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.8 to MM 16
Cost: $8 35,000
Rank: 10

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	374	860	2960
Geomorphic Properties			
Primary Stream Type - B Slope: 2% to 4%; A = 16' to 19'; B = 27' to 32'; C = 1.1' to 1.3' Secondary Stream Type - A Slope: 4% to 10%; A = 12' to 18'; B = 16' to 20'; C = 1.1' to 1.3'			
Bridges and Culverts			
ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
19	double 7' x 7' RCBC	na	**Do Nothing**	60' bridge
20	double 12' x 6'6" RCBC	na	na	**60' bridge**
21	washed out	8' x 6' RCBC	**20' bridge**	60' bridge
22	15' x 10' RCBC	na	na	**60' bridge**
		Reflects Master Plan Recommendations		

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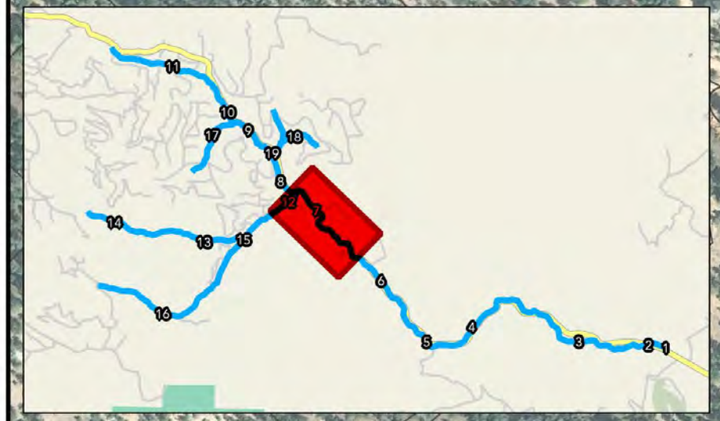
Coal Creek Master Plan
Corridor 2 - Reach 7



0 150 300 450 600 ft

1 inch = 300 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Project Rank

- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-31

Reach 7C

Description: Elevate CO 72, MM 16.9 to MM 17.6
Cost: $1,806,000
Rank: 15

Reach 7B

Description: Replace Twin Spruce Gap Road Culvert at MM 17.6
Cost: $540,000
Rank: 31

Reach 7A

Description: Stream Restoration, Bank Stabilization, Culvert Improvements MM 16.6 to MM 17.6
Cost: $1,893,000
Rank: 12

Coal Creek Canyon Rd

Twin Spruce Road

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	439	1020	3060
Geomorphic Properties			
Primary Stream Type - B Slope: 2% to 4%; A = 15' to 18'; B = 31' to 34'; C = 1.2'to1.4'			
Bridges and Culverts			
ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
23	48" CMP	10' x 6' RCBC	**20' bridge**	60' bridge
24	30" CMP	10' x 6' RCBC	**20' bridge**	60' bridge
25	8'3" x 6' RCBC	add 4' x 6' RCBC	add 12' x 8' RCBC	**60' bridge**
	Reflects Master Plan Recommendations			

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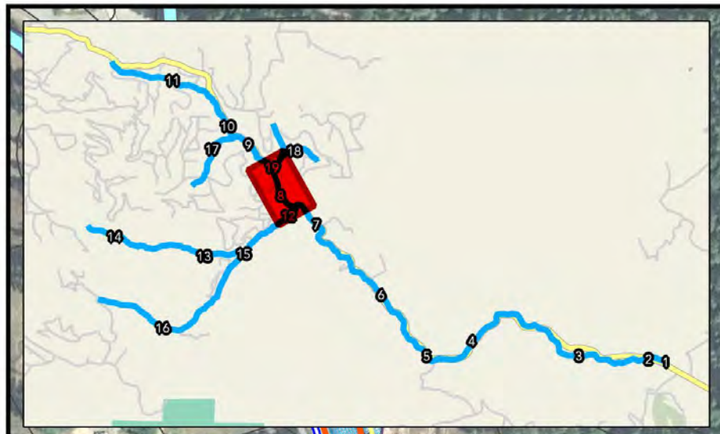
Coal Creek Master Plan
Corridor 3 - Reach 8



0 100 200 300 400 ft

1 inch = 200 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Project Rank

- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-31

Reach 8D-2
Description: Alt 2; Acquisition of Quick Mart & Propane Site, Stream Restoration, Culvert Improvements
Cost: $932,000
Rank: 2

Reach 8A
Description: Storm Sewer at Carl's Corner / CO 72
Cost: $507,000
Rank: 11

Reach 8E
Description: Stream Restoration & Bank Stabilization, MM 18.1
Cost: $42,000
Rank: 3

Reach 8C
Description: Stream Restoration, Bank Stabilization, Culvert Improvements MM 17.7 to MM 17.9
Cost: $529,000
Rank: 27

Reach 8B-2
Description: Acquisition Property for Closed Coffee Shop, Stream Restoration, Bank Stabilization
Cost: $262,000
Rank: 7

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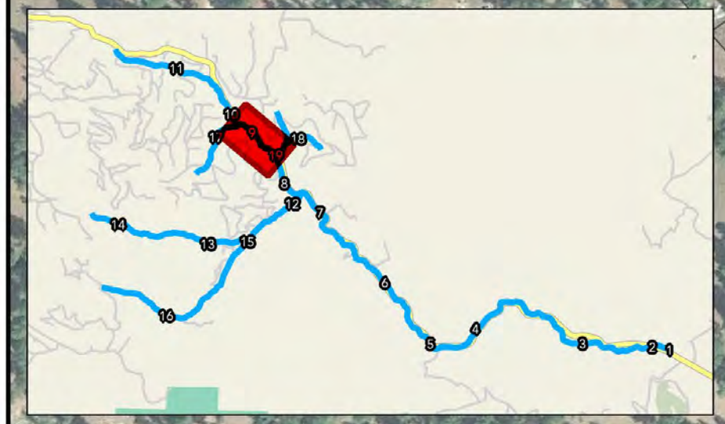
Coal Creek Master Plan
Corridor 3 - Reach 9



0 100 200 300 400 ft

1 inch = 200 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Project Rank

- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-31

Reach 9C
Description: Elevate/Relocate CO 72 from MM 18.4 to MM 18.6
Cost: $619,000
Rank: 25

Community Comment:
Improve drainage with highway changes to pass flow in culvert and prevent ice buildup

Reach 9B
Description: Stream Restoration, Bank Stabilization, Culvert Improvements MM 18.3 to MM 18.6
Cost: $978,000
Rank: 19

Reach 9A
Description: Stream Restoration, & Culvert Improvements MM 18.1 to MM 18.3
Cost: $161,000
Rank: 15

Coal Creek Canyon Rd
Ranch Elsie Road
Crescent Park Circle

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	150	350	870
Geomorphic Properties			
Primary Stream Type - B Slope: 2% to 4%; A = 11' to 13'; B = 20' to 23'; C = 0.8' to 0.9'			
Bridges and Culverts			

ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
35	36" CMP	6' x 4' RCBC	**12' x 5' RCBC**	20' bridge
36	30" CMP	6' x 4' RCBC	**12' x 5' RCBC**	20' bridge
37	washed out	6' x 4' RCBC	**12' x 5' RCBC**	20' bridge
38	36" CMP	6' x 4' RCBC	**12' x 5' RCBC**	20' bridge
39	36" CMP	6' x 4' RCBC	**12' x 5' RCBC**	20' bridge
40	6'6" x 4' bridge	na	**12' x 5' RCBC**	20' bridge
41	60" CMP	na	**12' x 5' RCBC**	20' bridge
42	30" CMP	6' x 4' RCBC	**12' x 5' RCBC**	20' bridge
43	60" CMP	na	**12' x 5' RCBC**	20' bridge
44	12' x 5'6" bridge	na	Do Nothing	20' bridge

Reflects Master Plan Recommendations

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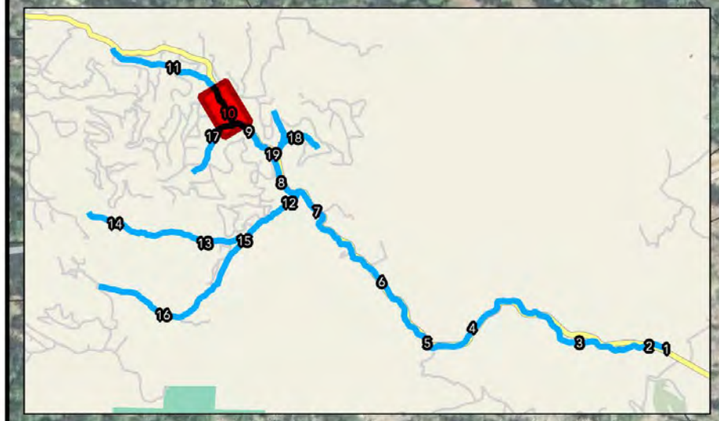
Coal Creek Master Plan

Drainage Corridor - Reach 10



0 75 150 225 300 ft

1 inch = 150 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Coal Creek Canyon Dr.

Coal Creek Canyon Rd

Coal Creek Canyon Rd

Ranch Elsie Road

Ranch Elsie Road

49 48 47 46 45 44 43 42 41 40 79 80 81

Community Comment:
Flood debris removal in this area

Reach 10A

Description: Culvert Improvements, Ranch Elsie Road through MM 18.9
Cost: $295,000

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	112	260	630
Geomorphic Properties			
Primary Stream Type - B Slope: 2% to 4%; A = 9' to 10'; B = 16' to 18'; C = 0.8' to 0.9'			
Bridges and Culverts			

ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
45	60" CMP	na	add 60" Pipe	**Install (2) 8' x 5' RCBC**
46	42" CMP	add 42" Pipe	**8' x 5' RCBC**	14' bridge
47	48" CMP	add 36" Pipe	**8' x 5' RCBC**	14' bridge
48	36" CMP	add 48" Pipe	**8' x 5' RCBC**	14' bridge
49	48" CMP	add 36" Pipe	**8' x 5' RCBC**	14' bridge
	Reflects Master Plan Recommendations			

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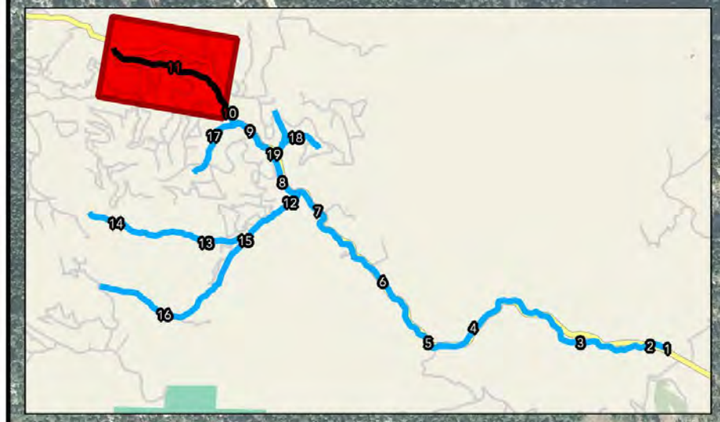
Coal Creek Master Plan

Drainage Corridor - Reach 11



0 200 400 600 800 ft

1 inch = 400 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Coal Creek Canyon Dr.

Coal Creek Canyon Dr.

Hummingbird Lane

Copperdale Lane

Community Comment:
Erosion is common along driveway. Additional drainage needs to prevent erosion and ice buildup.

51

50

49

48

Gross Dam Road

Crescent Lake Road

Crescent Lake Road

Crescent Lake Road

Copperdale Lane

Copperdale Lane

The Lane Road

Divide View Dr.

Ridge Road

Reach 11A

Description: Culvert Improvements, MM 18.9 to Copperdale Lane
Cost: $32,000

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	52	120	250

Geomorphic Properties

Primary Stream Type - A
Slope: 4% to 10%; A = 6' to 6'; B = 8' to 8'; C = 0.6' to 0.8'
Secondary Stream Type - B
Slope: 2% to 4%; A = 7' to 8'; B = 13' to 14'; C = 0.5' to 0.6'

Bridges and Culverts

ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
50	48" CMP	na	**add 48" Pipe**	10' x 4' RCBC
51	48" CMP	na	**add 48" Pipe**	10' x 4' RCBC

Reflects Master Plan Recommendations

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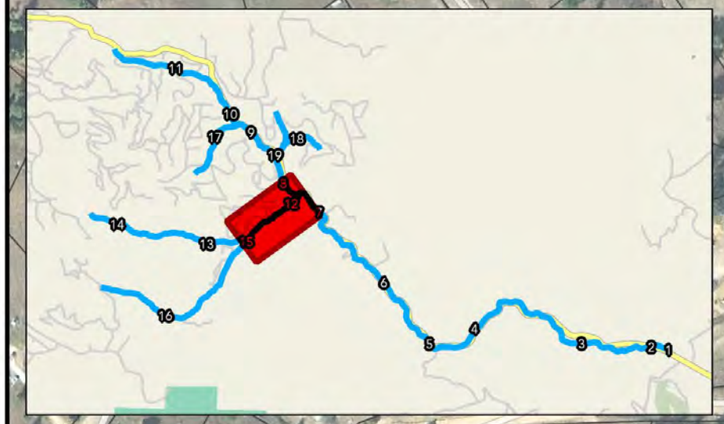
Coal Creek Master Plan
Corridor 4 - Reach 12



0 125 250 375 500 ft

1 inch = 250 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Project Rank

- 1-5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-31

Community Comment:
Roadway/Culvert changes should address inflow ftom west drainage

Blue Mountain Road
Burland Dr.
Burland Road
Joanie Road
Joanie Dr.
Twin Spruce Road
Twin Spruce Road
Twin Spruce Rd

Reach 12A

Description: Stream Restoration, Bank Stabilization & Culvert Improvements
Cost: $1,459,000
Rank: 1

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	271	630	1810
Geomorphic Properties			
Primary Stream Type - B Slope: 2% to 4%; A = 14' to 15'; B = 25' to 27'; C = 1.0' to 1.1'			
Bridges and Culverts			

ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
52	54" Pipe	8' x 5' RCBC	**14' bridge**	40' bridge
53	36" double CMP	8' x 5' RCBC	**14' bridge**	40' bridge
54	bridge	8' x 5' RCBC	**14' bridge**	40' bridge
55	washed out	8' x 5' RCBC	**14' bridge**	40' bridge
56	washed out	8' x 5' RCBC	**14' bridge**	40' bridge
57	60" CMP	add 60" Pipe	**14' bridge**	40' bridge
58	66" CMP	add 60" Pipe	14' bridge	**40' bridge**
59	72" CMP	add 54" Pipe	**14' bridge**	40' bridge
60	48" double CMP	add 54" Pipe	**14' bridge**	40' bridge
61	30" double CMP	8' x 5' RCBC	**14' bridge**	40' bridge

Reflects Master Plan Recommendations

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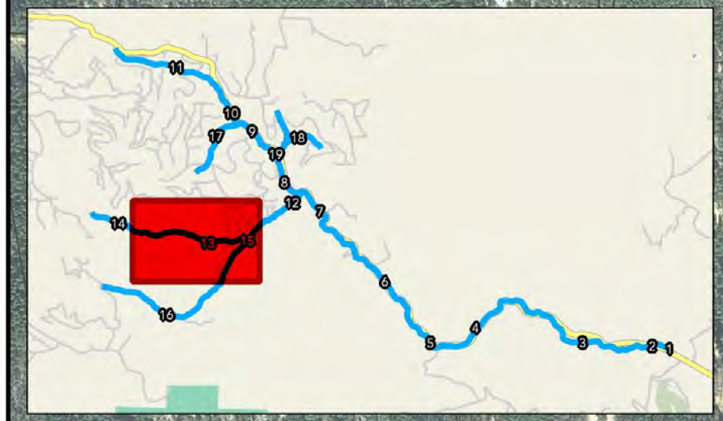
Coal Creek Master Plan

Drainage Corridor - Reach 13



0 200 400 600 800 ft

1 inch = 200 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Reach 13A

Description: Stream Restoration and Bank Stabilization
Cost: $124,108

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	150	350	970
Geomorphic Properties			
Primary Stream Type - A Slope: 4% to 10%; A = 8' to 10'; B = 10' to 13'; C = 0.9' to 1.0' Secondary Stream Type - A+ Slope: 10% to 15%; A = 7' to 8'; B = 8' to 10'; C = 1.1' to 1.1'			

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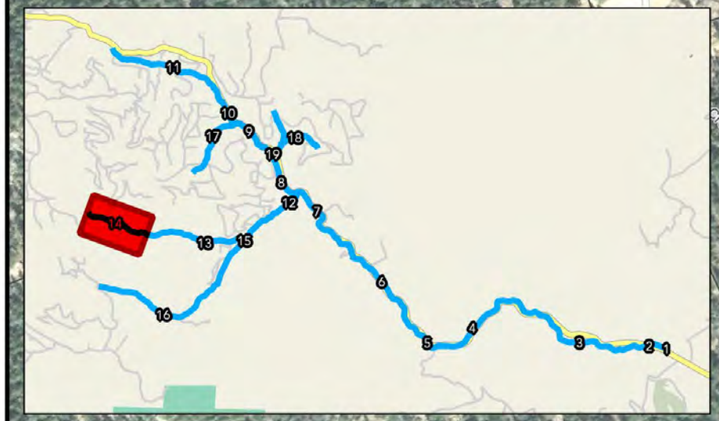
Coal Creek Master Plan

Drainage Corridor - Reach 14



0 100 200 300 400 ft

1 inch = 200 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Reach 14A

Description: Do Nothing

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	112	260	690
Geomorphic Properties			
Primary Stream Type - B Slope: 2% to 4%; A = 7' to 9'; B = 9' to 12'; C = 0.8' to 0.9'			

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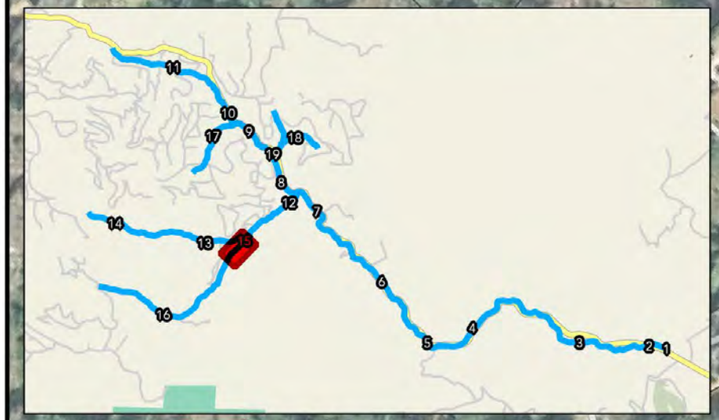
Coal Creek Master Plan

Drainage Corridor - Reach 15



0 50 100 150 200 ft

1 inch = 100 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Burke Road

Twin Spruce Road

Twin Spruce Road

Z

Y

69 68 67 66 65 64 63 62

Reach 15A

Description: Culvert Improvements
Cost: $222,600

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	116	270	770
Geomorphic Properties			
Primary Stream Type - A Slope: 4% to 10%; A = 7' to 9'; B = 9' to 12'; C = 0.8' to 0.9'			
Bridges and Culverts			

ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
62	36" double CMP	add 36" Pipe	**8' x 5' RCBC**	20' bridge
63	36" CMP	add double 48" Pipes	**8' x 5' RCBC**	20' bridge
64	40" CMP	add 48" Pipe	**8' x 5' RCBC**	20' bridge
65	40" CMP	add 48" Pipe	**14' bridge**	20' bridge
66	washed out	add double 48" Pipes	**8' x 5' RCBC**	20' bridge
67	washed out	7' x 3' RCBC	**8' x 5' RCBC**	20' bridge

Reflects Master Plan Recommendations

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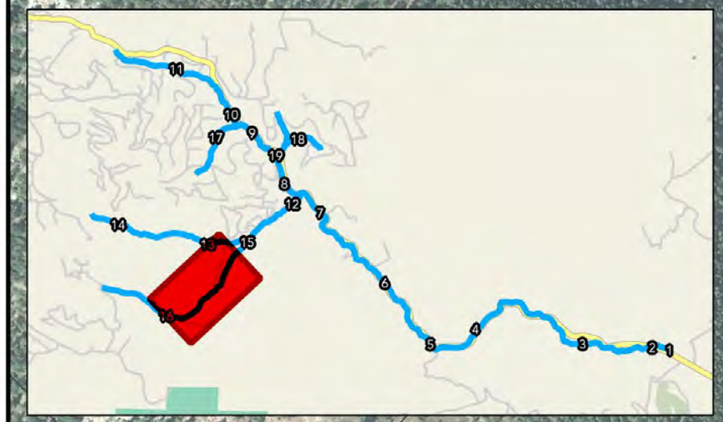
Coal Creek Master Plan

Drainage Corridor - Reach 16 (1 of 2)



0 150 300 450 600 ft

1 inch = 300 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Reach 16A

Description: Bank Stabilization and Culvert Improvements
Cost: $1,380,000

Twin Spruce Road

Fisher Road

Burke Road

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	103	240	560
Geomorphic Properties			
Primary Stream Type - A Slope: 4% to 10%; A = 7' to 9'; B = 9' to 12'; C = 0.8' to 0.9' Secondary Stream Type - A+ Slope: 10% to 15%; A = 1' to 7'; B = 7' to 8'; C = 1.0' to 1.0'			
Bridges and Culverts			

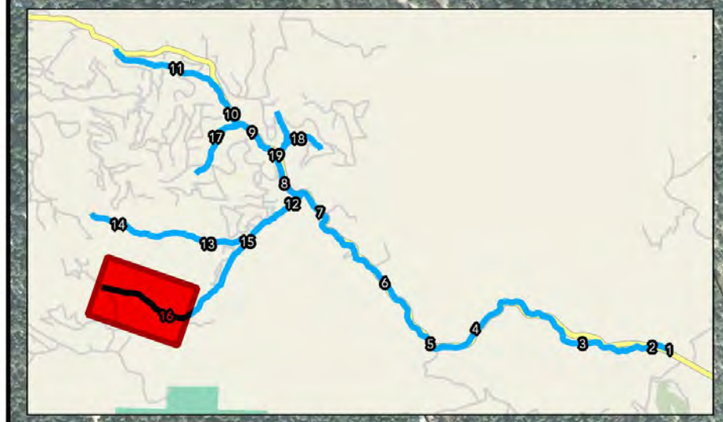
ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
68	washed out	7' x 3' RCBC	**10' x 4' RCBC**	12' x6' RCBC
69	washed out	7' x 3' RCBC	**10' x 4' RCBC**	12' x6' RCBC
70	54" CPP	add 36" Pipe	**10' x 4' RCBC**	12' x6' RCBC
71	42" CMP	add 48" Pipe	**10' x 4' RCBC**	12' x6' RCBC
72	48" CMP	add 42" Pipe	**10' x 4' RCBC**	12' x6' RCBC
73	48" CMP	add 42" Pipe	**10' x 4' RCBC**	12' x6' RCBC
74	48" CMP	add 42" Pipe	**10' x 4' RCBC**	12' x6' RCBC
75	36" CMP	add 54" Pipe	**10' x 4' RCBC**	12' x6' RCBC
76	36" CMP	add 54" Pipe	**10' x 4' RCBC**	12' x6' RCBC

Reflects Master Plan Recommendations

ICON ENGINEERING INC

Coal Creek Master Plan

Drainage Corridor - Reach 16 (2 of 2)



0 150 300 450 600 ft

1 inch = 300 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Twin Spruce Road

Gap Road

78

77

76

Twin Spruce Road

Gap Road

Reach 16A

Description: Bank Stabilization and Culvert Improvements

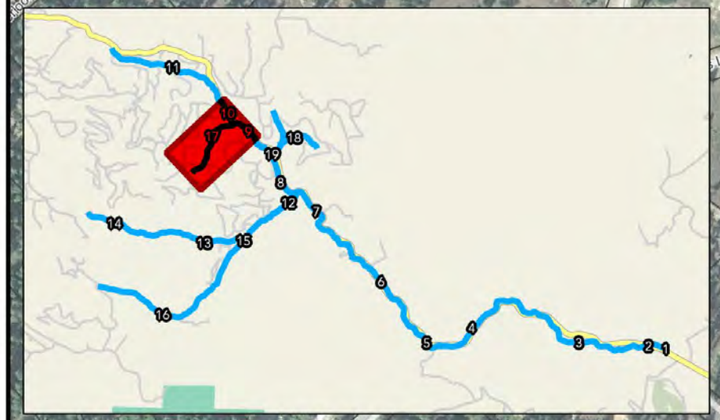
Cost: $1,380,000

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	103	240	560
Geomorphic Properties			
Primary Stream Type - A Slope: 4% to 10%; A = 7' to 9'; B = 9' to 12'; C = 0.8' to 0.9' Secondary Stream Type - A+ Slope: 10% to 15%; A = 1' to 7'; B = 7' to 8'; C = 1.0' to 1.0'			
Bridges and Culverts			
ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
77	36" CMP	add 54" Pipe	**10' x 4' RCBC**	12' x6' RCBC
78	36" CMP	add 54" Pipe	**10' x 4' RCBC**	12' x6' RCBC
		Reflects Master Plan Recommendations		

ICON ENGINEERING, INC

Coal Creek Master Plan

Drainage Corridor - Reach 17



0 125 250 375 500 ft

1 inch = 250 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Reach 17A

Description: Bank Stabilization, and Culvert Improvements
Cost: $684,000

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	103	240	560
Geomorphic Properties			
Primary Stream Type - A Slope: 4% to 10%; A = 6' to 6'; B = 8' to 8'; C = 0.6' to 0.8'			
Bridges and Culverts			

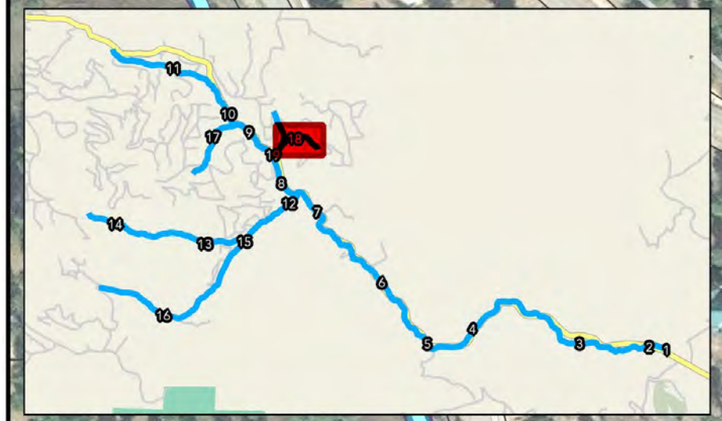
ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
79	36" CMP	add 36" Pipe	8' x 5' RCBC	12' Bridge
80	36" CMP	add 36" Pipe	8' x 5' RCBC	12' Bridge
81	36" CMP	add 36" Pipe	8' x 5' RCBC	12' Bridge
82	42" CMP	add 24" Pipe	8' x 5' RCBC	12' Bridge
83	36" CMP	add 30" Pipe	8' x 5' RCBC	12' Bridge
84	42" CMP	add 24" Pipe	8' x 5' RCBC	12' x 6' RCBC
85	36" CMP	add 36" Pipe	8' x 5' RCBC	12' Bridge
86	24" CMP	add 42" Pipe	8' x 5' RCBC	12' Bridge
87	30" CMP	add 36" Pipe	8' x 5' RCBC	12' Bridge
88	24" CMP	add 42" Pipe	8' x 5' RCBC	12' Bridge
89	24" CMP	add 42" Pipe	8' x 5' RCBC	12' Bridge

Reflects Master Plan Recommendations

ICON ENGINEERING, INC

Coal Creek Master Plan

Drainage Corridor - Reach 18



0 75 150 225 300 ft

1 inch = 150 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Crescent Park Dr.

Butte Dr.

Butte Dr.

Butte Dr.

Spruce Canyon Dr.

91

94

90

93

92

Reach 18A

Description: Culvert Improvements

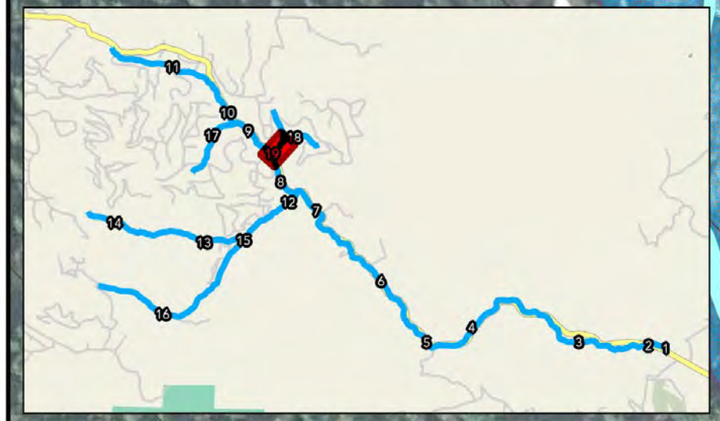
Cost: $104,000

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	26	57	145
Geomorphic Properties			
Primary Stream Type - A+			
Slope: 10% to 15%; A = 4' to 4'; B = 5' to 5'; C = 0.6' to 0.6'			
Bridges and Culverts			
ID / Existing Structure	10-yr Design	25-yr Design	100-yr Design
90 — 36" CMP	na	add 30" Pipe	**6' x 4' RCBC**
91 — 48" CMP	na	**Do Nothing**	add 48" Pipe
92 — 24" CMP	add 24" Pipe	**add 48" Pipe**	6' x 4' RCBC
Reflects Master Plan Recommendations			

ICON ENGINEERING INC

Coal Creek Master Plan

Drainage Corridor - Reach 19



0 50 100 150 200 ft

1 inch = 100 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Coal Creek Canyon Rd

Crescent Park Dr

Skyline Dr

Coal Creek Canyon Rd

36 35 34 93 94 90

Reach 19A

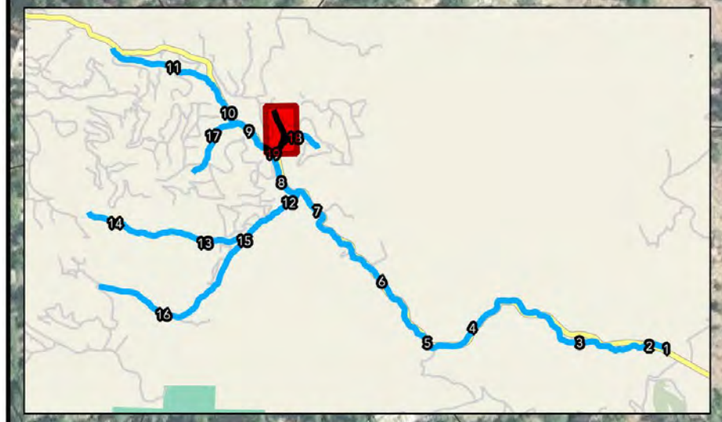
Description: Stream Restoration, Bank Stabilization, and Culvert Improvements
Cost: $477,000

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	47	106	270
Geomorphic Properties			
Primary Stream Type - A Slope: 4% to 10%; A = 6' to 6'; B = 8' to 8'; C = 0.6' to 0.8'			
Bridges and Culverts			
ID	Existing Structure	10-yr Design	25-yr Design	100-yr Design
93	36" CMP	na	7' x 3' RCBC	**8' x 5' RCBC**
	Reflects Master Plan Recommendations			

ICON ENGINEERING, INC

Coal Creek Master Plan

Drainage Corridor - Reach 20



Reach 20A

Description: Culvert Improvements
Cost: $5,500

75 150 225 300 ft
1 inch = 150 feet

Legend

- Project Reaches
- Restored Channel Alignment
- Culverts
- Highway Access Improvements
- Bank Stabilization - High Level
- Bank Stabilization - Moderate Level
- County Boundary
- Parcels
- Approximate 100-Year Floodplain

Spruce Canyon Dr.
Crescent Park Dr.
Burley Dr.
Crescent Park Dr.
Crescent Park Dr.
Crescent Park Circle
Coal Creek Canyon Rd.

Design Data			
	Q10 (cfs)	Q25 (cfs)	Q100 (cfs)
Discharge	21	49	125
Geomorphic Properties			
Primary Stream Type - A Slope: 4% to 10%; A = 3' to 4'; B = 4' to 5'; C = 0.5' to 0.6'			
Secondary Stream Type - A+ Slope: 10% to 15%; A = 4' to 4'; B = 5' to 5'; C = 0.6' to 0.6'			
Bridges and Culverts			
ID Existing Structure	10-yr Design	25-yr Design	100-yr Design
94 36" CMP	na	**add 30" RCP**	6' x 4' RCBC
Reflects Master Plan Recommendations			

ICON ENGINEERING, INC

APPENDIX B

PRIORITIZATION AND RANKING

TABLE B-1: PROJECT PRIORITIZATION MATRIX

			Relative Cost Comparison					Primary Mitigation Needs									Community Values																		Total Value	Corridor	Overall		
								Flood Risk			Geomorphic Risk			Ecology & Habitat			Addresses Immediate Needs		Presents a Fundable Solutions		Improves Transportation and Emergency Access		Community Ecological Value		Community Flood Value (Score 10: Low-level, 30: Mid-level, 20 High-level)		Protects Private Infrastructure		Community Center Value		Recreation								
Reach	ID	Project Description	Length (mi)	Cost ($)	Cost per mi ($/mi)	Score	Value (200pts)	Existing Score	Proposed Score	Value (80pts)	Existing Score	Proposed Score	Value (80pts)	Existing Score	Proposed Score	Value (40pts)	Score	Value (100pts)	Score	Value (90pts)	Score	Value (80pts)	Score	Value (30pts)	Score	Value 30pts)	Score	Value (30pts)	Score	Value (30pts)	Score	Value (10pts)	(Points)	Rank	Rank	PRIMARY ENTITY	SECONDARY ENTITY
Stream Corridor 1 (Reaches 1 through 5)																																							
1	A	Stream Restoration	0.10	$ 39,028	$ 390,279	10	**200**	2	2	**0**	4	3	**8**	6	10	**16**	1	**10**	1	**9**	0	**0**	4	**12**	0	**0**	0	**0**	0	**0**	8	**8**	**263**	12	**29**	**Jefferson County**	
2	A	Stream Restoration & Bank Stabilization	0.87	$ 404,331	$ 464,748	10	**200**	2	2	**0**	7	4	**24**	4	10	**24**	1	**10**	1	**9**	1	**8**	6	**18**	0	**0**	0	**0**	0	**0**	8	**8**	**301**	8	**23**	**Jefferson County**	
3	A	Stream Restoration & Bank Stabilization downstream of CO 72	0.70	$ 321,945	$ 459,922	10	**200**	2	2	**0**	5	3	**16**	4	6	**8**	1	**10**	1	**9**	1	**8**	2	**6**	0	**0**	0	**0**	0	**0**	8	**8**	**265**	11	**27**	**Jefferson County**	
3	B	Replace CO 72 Culvert at MM 14	0.02	$ 1,440,000	$ 72,000,000	0	**0**	5	1	**32**	9	4	**40**	0	2	**8**	3	**30**	10	**90**	10	**80**	2	**6**	20	**20**	5	**15**	5	**15**	8	**8**	**344**	6	**17**	**CDOT**	
3	C	Stream Restoration, Bank Stabilization, Culvert Improvements upstream of CO 72	0.37	$ 1,120,124	$ 3,027,361	2	**40**	9	3	**48**	9	5	**32**	4	10	**24**	9	**90**	8	**72**	3	**24**	6	**18**	30	**30**	10	**30**	0	**0**	0	**0**	**408**	3	**8**	**Private**	**CDOT**
4	A	Stream Restoration & Bank Stabilization to MM 14.4	0.13	$ 114,517	$ 880,902	8	**160**	2	2	**0**	10	6	**32**	0	6	**24**	4	**40**	4	**36**	0	**0**	6	**18**	0	**0**	5	**15**	0	**0**	0	**0**	**325**	7	**22**	**CDOT**	
4	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 14.5 to MM 15	0.43	$ 411,559	$ 957,114	8	**160**	5	3	**16**	9	5	**32**	0	6	**24**	8	**80**	6	**54**	3	**24**	6	**18**	30	**30**	5	**15**	0	**0**	0	**0**	**453**	1	**5**	**Private**	
4	C	Replace CO 72 Culvert at MM 15	0.02	$ 1,440,000	$ 72,000,000	0	**0**	5	1	**32**	10	5	**40**	0	2	**8**	5	**50**	10	**90**	10	**80**	2	**6**	20	**20**	5	**15**	5	**15**	8	**8**	**364**	5	**14**	**CDOT**	
4	D	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15 to MM 15.2	0.23	$ 560,204	$ 2,435,669	3	**60**	5	3	**16**	8	3	**40**	0	6	**24**	5	**50**	8	**72**	8	**64**	6	**18**	30	**30**	10	**30**	0	**0**	0	**0**	**404**	4	**9**	**Private**	**CDOT**
4	E	Elevate CO 72, MM 14.4 to MM 14.9	0.45	$ 1,548,360	$ 3,440,800	2	**40**	3	1	**16**	4	3	**8**	0	0	**0**	0	**0**	10	**90**	10	**80**	0	**0**	20	**20**	0	**0**	5	**15**	8	**8**	**277**	10	**26**	**CDOT**	
5	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.2 to MM 15.8	0.52	$ 1,783,912	$ 3,430,600	2	**40**	7	3	**32**	8	3	**40**	4	10	**24**	8	**80**	8	**72**	8	**64**	6	**18**	30	**30**	10	**30**	0	**0**	0	**0**	**430**	2	**6**	**Private**	**CDOT**
5	B	Elevate CO 72, MM 15.3 to MM 15.4	0.10	$ 293,250	$ 2,932,500	3	**60**	3	1	**16**	4	3	**8**	0	0	**0**	0	**0**	10	**90**	10	**80**	0	**0**	20	**20**	0	**0**	5	**15**	8	**8**	**297**	9	**24**	**CDOT**	
Stream Corridor 2 (Reaches 6 through 7)																																							
6	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.8 to MM 16	0.24	$ 834,681	$ 3,477,839	2	**40**	6	3	**24**	7	3	**32**	2	10	**32**	8	**80**	8	**72**	3	**24**	8	**24**	30	**30**	8	**24**	0	**0**	0	**0**	**382**	1	**10**	**CDOT**	**Private**
6	B	Replace CO 72 Culvert at MM 16	0.02	$ 1,440,000	$ 72,000,000	0	**0**	5	1	**32**	9	4	**40**	0	2	**8**	2	**20**	10	**90**	10	**80**	2	**6**	20	**20**	8	**24**	5	**15**	8	**8**	**343**	5	**18**	**CDOT**	
6	C	Stream Restoration & Bank Stabilization MM 16 to MM 16.4	0.35	$ 642,108	$ 1,834,594	4	**80**	3	2	**8**	7	3	**32**	0	10	**40**	6	**60**	6	**54**	3	**24**	10	**30**	20	**20**	8	**24**	0	**0**	0	**0**	**372**	3	**13**	**Private**	**CDOT**
6	D	Replace CO 72 Culvert at MM 16.4	0.02	$ 1,440,000	$ 72,000,000	0	**0**	4	1	**24**	8	4	**32**	0	2	**8**	4	**40**	10	**90**	10	**80**	2	**6**	20	**20**	4	**12**	5	**15**	8	**8**	**335**	6	**21**	**CDOT**	
6	E	Stream Restoration & Bank Stabilization MM 16.4 to MM 16.6	0.22	$ 245,853	$ 1,117,513	7	**140**	4	3	**8**	4	3	**8**	0	6	**24**	2	**20**	2	**18**	3	**24**	6	**18**	0	**0**	0	**0**	0	**0**	0	**0**	**260**	7	**30**	**Private**	**CDOT**
7	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 16.6 to MM 17.6	1.00	$ 1,892,827	$ 1,892,827	4	**80**	8	5	**24**	7	3	**32**	2	6	**16**	4	**40**	8	**72**	6	**48**	4	**12**	30	**30**	0	**0**	5	**15**	5	**5**	**374**	2	**12**	**CDOT**	**Private**
7	B	Replace Twin Spruce Gap Road Culvert at MM 17.6	0.02	$ 540,000	$ 27,000,000	0	**0**	5	1	**32**	9	4	**40**	0	2	**8**	2	**20**	2	**18**	10	**80**	2	**6**	20	**20**	0	**0**	10	**30**	0	**0**	**254**	8	**31**	**Jefferson County**	**CDOT**
7	C	Elevate CO 72, MM 16.9 to MM 17.6	0.63	$ 1,805,760	$ 2,866,286	3	**60**	8	1	**56**	4	3	**8**	0	0	**0**	0	**0**	10	**90**	10	**80**	0	**0**	20	**20**	0	**0**	10	**30**	10	**10**	**354**	4	**15**	**CDOT**	
Stream Corridor 3 (Reaches 8 through 9)																																							
8	A	Storm Sewer at Carl's Corner / CO 72	0.07	$ 506,640	$ 7,237,714	0	**0**	5	1	**32**	4	3	**8**	0	2	**8**	3	**30**	8	**72**	10	**80**	2	**6**	20	**20**	30	**90**	10	**30**	0	**0**	**376**	5	**11**	**CDOT**	**Private**
8	B	Alt 1; Storm Sewer at Closed Coffee Shop upstream of Carl's Corner & CO 72	0.02	$ 179,880	$ 8,994,000	0	**0**	8	1	**56**	8	5	**24**	0	2	**8**	3	**30**	4	**36**	5	**40**	2	**6**	20	**20**	30	**90**	10	**30**	0	**0**	**340**	7	**19**	**Private**	**CDOT**
8	B	Alt 2; Acquisition of Property for Closed Coffee Shop, Stream Restoration and Bank Stabilization	0.02	$ 261,520	$ 13,076,000	0	**0**	8	0	**64**	8	3	**40**	0	6	**24**	10	**100**	2	**18**	5	**40**	6	**18**	30	**30**	15	**45**	10	**30**	10	**10**	**419**	4	**7**	**Private**	**CDOT**
8	C	Stream Restoration, Bank Stabilization, Culvert Improvements MM 17.7 to MM 17.9	0.31	$ 529,338	$ 1,707,543	4	**80**	5	3	**16**	6	4	**16**	4	10	**24**	2	**20**	4	**36**	0	**0**	6	**18**	10	**10**	10	**30**	5	**15**	0	**0**	**265**	10	**27**	**Private**	**CDOT**
8	D	Alt 1; 100-year Storm Sewer at Quick Mark / Skyline Drive	0.08	$ 891,360	$ 11,142,000	0	**0**	8	1	**56**	9	6	**24**	0	2	**8**	10	**100**	6	**54**	10	**80**	2	**6**	20	**20**	30	**90**	10	**30**	0	**0**	**468**	3	**4**	**Private**	**Jefferson County**
8	D	Alt 2; Acquisition of Quick Mart & Propane Site, Stream Restoration, Culvert Improvements	0.08	$ 932,176	$ 11,652,200	0	**0**	8	1	**56**	9	4	**40**	0	10	**40**	10	**100**	6	**54**	10	**80**	10	**30**	20	**20**	5	**15**	10	**30**	10	**10**	**475**	1	**2**	**Private**	**Jefferson County**
8	E	Stream Restoration, & Bank Stabilization, MM 18.1	0.05	$ 41,841	$ 836,822	8	**160**	6	3	**24**	9	4	**40**	4	10	**24**	8	**80**	4	**36**	0	**0**	6	**18**	30	**30**	10	**30**	10	**30**	0	**0**	**472**	2	**3**	**Private**	
9	A	Stream Restoration, & Culvert Improvements MM 18.1 to MM 18.3	0.29	$ 161,253	$ 556,044	9	**180**	4	2	**16**	4	2	**16**	4	8	**16**	2	**20**	6	**54**	0	**0**	4	**12**	10	**10**	5	**15**	5	**15**	0	**0**	**354**	6	**15**	**Private**	
9	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 18.3 to MM 18.6	0.23	$ 978,474	$ 4,254,234	1	**20**	6	4	**16**	4	2	**16**	4	8	**16**	8	**80**	8	**72**	6	**48**	4	**12**	30	**30**	10	**30**	0	**0**	0	**0**	**340**	7	**19**	**Private**	**CDOT**
9	C	Elevate / Relocate CO 72, MM 18.4 to MM 18.6	0.18	$ 619,344	$ 3,440,800	2	**40**	5	1	**32**	3	2	**8**	0	0	**0**	0	**0**	10	**90**	10	**80**	0	**0**	20	**20**	0	**0**	5	**15**	10	**10**	**295**	9	**25**	**CDOT**	
Stream Corridor 4 (Reach 12)																																							
12	A	Stream Restoration, Bank Stabilization & Culvert Improvements	0.68	$ 1,459,069	$ 2,145,690	3	**60**	10	6	**32**	9	4	**40**	6	10	**16**	10	**100**	10	**90**	9	**72**	4	**12**	30	**30**	10	**30**	0	**0**	0	**0**	**482**	1	**1**	**Private**	**Jefferson County**

APPENDIX C

COST SUMMARIES

Plan Summary - Reach 1, Coal Creek: Downstream of Highway 72				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	586	LF	$3	$1,758
Project 1A: Stream Restoration				
Unclassified Excavation	868	CY	$33	$28,649
Wetland Planting	0.12	AC	$32,000	$3,874
Contingency			20%	$6,505
			Total	$39,028

Reach 2 - Coal Creek, Highway 72 through Union Pacific Railroad				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	3844	LF	$3	$11,532
Project 2A: Stream Restoration & Bank Stabilization				
Unclassified Excavation	4480	CY	$33	$147,840
Wetland Planting	0.79	AC	$32,000	$25,415
Bank Stabilization - Moderate Level	675.00	CY	$105	$70,875
Bank Stabilization - High Level	687.50	CY	$135	$92,813
Contingency			20%	$67,388
			Total	$404,331

Reach 3 - Coal Creek, Union Pacific Railroad through La Duwaik Estates				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	5526	LF	$3	$16,578
Alternative 3A - Stream Restoration & Bank Stabilization Downstream of CO72				
Unclassified Excavation	2000	CY	$33	$66,000
Wetland Planting	0.66	AC	$32,000	$21,000
Bank Stabilization - Moderate Level	185	CY	$105	$19,425
Bank Stabilization - High Level	1260	CY	$135	$170,100
Contingency			20%	$45,420.55
			Total	$321,945
Alternative 3B - Replace CO 72 Culvert at MM14				
Culv 3: Install 60' Span Bridge	4800	SF	$250	$1,200,000
Contingency			20%	$240,000
			Total	$1,440,000

Alternative 3C - Stream Restoration, Bank Stabilization,Culvert Improvements upstream of CO 72				
Unclassified Excavation	8000	CY	$33	$264,000
Wetland Planting	0.36	AC	$32,000	$11,476
Bank Stabilization - Moderate Level	1750.00	CY	$105	$183,750
Bank Stabilization - High Level	2446.00	CY	$135	$330,210
Culv 4: Install 20' Wide Bridge	240	SF	$200	$48,000
Culv 5: Install 20' Wide Bridge	240	SF	$200	$48,000
Culv 6: Install 20' Wide Bridge	240	SF	$200	$48,000
Contingency			20%	$186,687
			Total	$1,120,124

Reach 4 - Coal Creek, La Duwaik Estates through Mile Marker 15.2				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	2300	LF	$3	$6,900
Alternative 4A - Stream Restoration & Bank Stabilization to MM 14.4				
Unclassified Excavation	775	CY	$33	$25,582
Wetland Planting	0.24	AC	$32,000	$7,629
Bank Stabilization - Moderate Level	275	CY	$105	$28,875
Bank Stabilization - High Level	247	CY	$135	$33,345
Contingency			20%	$19,086
			Total	$114,517
Alternative 4B- Stream Restoration, Bank Stabilization, Culvert Improvements MM 14.5 to MM 15				
Unclassified Excavation	1406	CY	$33	$46,384
Wetland Planting	0.43	AC	$32,000	$13,832
Bank Stabilization - Moderate Level	1013	CY	$105	$106,365
Bank Stabilization - High Level	951	CY	$135	$128,385
Culv 7: Install 20' Wide Bridge	240	SF	$200	$48,000
Contingency			20%	$68,593
			Total	$411,559
Alternative 4C - Replace CO 72 Culvert at MM 15				
Culv 8: Install 60' Span Bridge	4800	SF	$250	$1,200,000
Contingency			20%	$240,000
			Total	$1,440,000
Alternative 4D - Stream Restoration, Bank Stabilization, Culvert Improvements MM 15 to MM 15.2				
Unclassified Excavation	869	CY	$33	$28,683
Wetland Planting	0.27	AC	$32,000	$8,553
Bank Stabilization - Moderate Level	1249	CY	110	$137,390
Bank Stabilization - High Level	911	CY	110	$100,210
Culv 9: Install 20' Wide Bridge	240	SF	$200	$48,000
Culv 10: Install 20' Wide Bridge	240	SF	$200	$48,000
Culv 11: Install 20' Wide Bridge	240	SF	$200	$48,000
Culv 12: Install 20' Wide Bridge	240	SF	$200	$48,000
Contingency			20%	$93,367
			Total	$560,204
Alternative 4E - Transportation and Emergency Access, Elevation Highway 72: mm 14.4 to 14.9				
Item	Quantity	Unit	Unit Cost	Total Cost
Remove and Replace Existing Asphalt	7333	SY	$22	$161,333
Road Base (2' fill)	4889	CY	$65	$317,778
Roadway Asphalt	7333	SY	$65	$476,667
Traffic Detour	1	LS	$334,522	$334,522
Contingency			20%	$258,060
			Total	$1,548,360

Reach 5 - Coal Creek, Mile Marker 15.2 through 15.8				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	1500	LF	$3	$4,500
Alternative 5A - Stream Restoration & Bank Stabilization				
Item	Quantity	Unit	Unit Cost	Total Cost
Unclassified Excavation	5000	CY	$33	$165,000
Wetland Planting	0.53	AC	$32,000	$17,043
Culv 13: Install 20' Wide Bridge	240	SF	$200	$48,000
Culv 14: Install 20' Wide Bridge	240	SF	$200	$48,000
Culv 15: Install 20' Wide Bridge	240	SF	$200	$48,000
Culv 16: Install 20' Wide Bridge	240	SF	$200	$48,000
Culv 17: Install 20' Wide Bridge	240	SF	$200	$48,000
Culv 18: Install 20' Wide Bridge	240	SF	$200	$48,000
Bank Stabilization - Moderate Level	3924	CY	$105	$412,020
Bank Stabilization - High Level	4478	CY	$135	$604,530
Contingency			20%	$297,319
			Total	$1,783,912
Alternative 5B - Transportation and Emergency Access, Elevation Highway 72: mm 14.4 to 14.9				
Item	Quantity	Unit	Unit Cost	Total Cost
Remove and Replace Existing Asphalt	1389	SY	$22	$30,556
Road Base (2' fill)	926	CY	$65	$60,185
Roadway Asphalt	1389	SY	$65	$90,278
Traffic Detour	1	LS	$63,356	$63,356
Contingency			20%	$48,875
			Total	$293,250

Reach 6 - Coal Creek, Mile Marker 15.8 through 16.8				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	3000	LF	$3	$9,000
Alternative 6A - Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.8 to MM 16				
Unclassified Excavation	3832	CY	$33	$126,471
Wetland Planting	0.29	AC	$32,000	$9,222
Culvert 19: Maintain Existing				
Bank Stabilization - Moderate Level	350	CY	$105	$36,750
Bank Stabilization - High Level	3875	CY	$135	$523,125
Contingency			20%	$139,114
			Total	$834,681
Alternative 6B - Replace Co 72 Culvert at MM 16				
Culv 20: Install 60' Span Bridge	4800	SF	$250	$1,200,000
Contingency			20%	$240,000
			Total	$1,440,000
Alternative 6C - Stream Restoration and Bank Stabilization MM 16 to MM 16.4				
Unclassified Excavation	5388	CY	$33	$177,800
Wetland Planting	0.41	AC	$32,000	$12,965
Bank Stabilization - Moderate Level	1260	CY	$105	$132,300
Bank Stabilization - High Level	1215	CY	$135	$164,025
Culv 21: Install 20' Wide Bridge	240	SF	$200	$48,000
Contingency			20%	$107,018
			Total	$642,108
Alternative 6D - Replace CO 72 Culvert at MM 16.4				
Item	Quantity	Unit	Unit Cost	Total Cost
Culv 22: Install 60' Span Bridge	4800	SF	$250	$1,200,000
Contingency			20%	$240,000
			Total	$1,440,000
Alternative 6E - Stream Restoration and Bank Stabilization MM 16.4 to MM 16.6				
Item	Quantity	Unit	Unit Cost	Total Cost
Unclassified Excavation	3480	CY	$33	$114,829
Wetland Planting	0.26	AC	$32,000	$8,373
Bank Stabilization - High Level	605	CY	$135	$81,675
Contingency			20%	$40,975
			Total	$245,853

Reach 7 - Coal Creek, Mile Marker 16.6 through Twin Spruce Gap Road				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	2200	LF	$3	$6,600
Alternative 7A - Stream Restoration, Bank Stabilization, Culvert Improvements MM 16.6 to MM 17.6				
Unclassified Excavation	17200	CY	$33	$567,600
Wetland Planting	1.55	AC	$32,000	$49,756
Culv 23: Install 20' Bridge	240	SF	$200	$48,000
Culv 24: Install 20' Bridge	240	SF	$200	$48,000
Bank Stabilization - High Level	6400	CY	$135	$864,000
Contingency			20%	$315,471
			Total	$1,892,827
Alternative 7B - Replace Twin Spruce Gap Road Culvert at MM 17.6				
Culv 25: Install 60' Span Bridge	1800	SF	$250	$450,000
Contingency			20%	$90,000
			Total	$540,000
Alternative 7C - Transportation and Emergency Access, Elevate Highway 72 MM 16.9 to 17.6				
Item	Quantity	Unit	Unit Cost	Total Cost
Remove and Replace Existing Asphalt	7333	SY	$22	$161,333
Road Base (3' fill)	7333	CY	$65	$476,667
Roadway Asphalt	7333	SY	$65	$476,667
Traffic Detour	1	LS	$390,133	$390,133
Contingency			20%	$300,960
			Total	$1,805,760

Reach 8 - Coal Creek, Twin Spruce Gap Road through Crescent Park Drive				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	1000	LF	$3	$3,000
			Total	$3,000
Alternative 8A - Storm Sewer at Carl's Corner / CO 72				
Culv 26: Install (2) 8'x6' RCBCs	1	LS	$422,200	$422,200
Contingency			20%	$84,440
			Total	$506,640
Alternative 8B-1 - Alt 1; Storm Sewer at Closed Coffee Shop upstream of Carl's Corner & CO 72				
Item	Quantity	Unit	Unit Cost	Total Cost
Culv 27: Install (2) 8'x6' RCBCs	1	LS	$149,900	$149,900
Contingency			20%	$29,980
			Total	$179,880
Alternative 8B-2 - Alt 2; Acquisition of Property for Closed Coffee Shop, Stream Restoration and Bank Stabilization				
Item	Quantity	Unit	Unit Cost	Total Cost
Acquisition Location I	1	LS	$186,800	$186,800
Contingency			40%	$74,720
			Total	$261,520
Alternative 8C - Stream Restoration, Bank Stabilization, Culvert Improvements MM 17.7 to MM 17.9				
Item	Quantity	Unit	Unit Cost	Total Cost
Unclassified Excavation	1808	CY	$33	$59,664
Wetland Planting	0.50	AC	$32,000	$16,126
Bank Stabilization - Moderate Level	675	CY	$105	$70,875
Bank Stabilization - High Level	1070	CY	$135	$144,450
Culv 28: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 29: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 30: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 31: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 33: Install 12'x5' RCBC	1	LS	$50,000	$50,000
Contingency			20%	$88,223
			Total	$529,338
Alternative 8D-1 - Alt 1; 100-year Storm Sewer at Quick Mark / Skyline Drive				
Item	Quantity	Unit	Unit Cost	Total Cost
Culv 34: Install (2) 8'x6' RCBCs	1	LS	$742,800	$742,800
Contingency			20%	$148,560
			Total	$891,360
Alternative 8D-2 - Alt 2; Acquisition of Quick Mart & Propane Site, Stream Restoration, Culvert Improvements				
Item	Quantity	Unit	Unit Cost	Total Cost
Unclassified Excavation	2000	CY	33	$66,000
Wetland Planting	0.42	AC	$32,000	$13,440
Culv 34: Install 20' Bridge	800	SF	$250	$200,000
Acquisition Location L	1	LS	$59,500	$59,500
Acquisition Location M	1	LS	$326,900	$326,900
Contingency			40%	$266,336
			Total	$932,176
Alternative 8E - Stream Restoration, & Bank Stabilization, MM 18.1				
Unclassified Excavation	452	CY	$33	$14,916
Wetland Planting	0.13	AC	$32,000	$4,032
Bank Stabilization - Moderate Level	270	CY	$105	$28,350
Contingency			20%	$9,460
			Total	$41,841

Reach 9 - Coal Creek, Crescent Park Drive through Ranch Elsie Road				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	1500	LF	$3	$4,500
Alternative 9A - Stream Restoration & Culvert Improvements MM 18. 1 to MM 18.3				
Unclassified Excavation	1663	CY	$33	$54,889
Wetland Planting	0.14	AC	$32,000	$4,488
Culv 35: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 36: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 37: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Contingency			20%	$26,875
			Total	$161,253
Alternative 9B - Stream Restoration, Bank Stabilization, Culvert Improvements MM 18.3 to MM 18.6				
Item	Quantity	Unit	Unit Cost	Total Cost
Unclassified Excavation	5887	CY	$33	$194,261
Wetland Planting	0.50	AC	$32,000	$15,883
Bank Stabilization - Moderate Level	1250	CY	$105	$131,250
Bank Stabilization - High Level	2400	CY	$135	$324,000
Culv 38: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 39: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 40: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 41: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 42: Install 12'x5' RCBC	1	LS	$25,000	$25,000
Culv 43: Install 12'x5' RCBC	1	LS	$25,001	$25,001
Culv 44: Maintain Existing				
Contingency			20%	$163,079
			Total	$978,474
Alternative 9C - Elevate / Relocate CO 72, MM 18.4 to MM 18.6				
Item	Quantity	Unit	Unit Cost	Total Cost
Remove and Replace Existing Asphalt	2933	SY	$22	$64,533
Road Base (2' fill)	1956	CY	$65	$127,111
Roadway Asphalt	2933	SY	$65	$190,667
Traffic Detour	1	LS	$133,809	$133,809
Contingency			20%	$103,224
			Total	$619,344

Reach 10 - Coal Creek, Ranch Elsie Road through Mile Marker 18.9				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	2216	LF	$3	$6,648
Alternative 10A - Culvert Improvements, Ranch Elsie Road through MM 18.9				
Culv 45: Install (2) 8' x 5' RCBC	1	LS	$174,600	$174,600
Culv 46: Install 8' x 5' RCBC	1	LS	$17,900	$17,900
Culv 47: Install 8' x 5' RCBC	1	LS	$17,900	$17,900
Culv 48: Install 8' x 5' RCBC	1	LS	$17,900	$17,900
Culv 49: Install 8' x 5' RCBC	1	LS	$17,900	$17,900
Contingency			20%	$49,240
			Total	$295,440

Reach 11 - Coal Creek, Mile Marker 18.9 to Copperdale Lane				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	3500	LF	$3	$10,500
Alternative 11A - Culvert Improvements, MM 18.9 to Copperdale Lane				
Culv 50: Add 48" RCP	1	LS	$7,500	$7,500
Culv 51: Add 48" RCP	1	LS	$19,100	$19,100
Contingency			20%	$5,320
			Total	$31,920

Reach 12 - Beaver Creek, Coal Creek to South Beaver Creek				
Alternative A - Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	4000	LF	$3	$12,000
Alternative 12A - Stream Restoration, Bank Stabilization & Culvert Improvements				
Unclassified Excavation	10650	CY	$33	$351,450
Wetland Planting	1.12	AC	$32,000	$35,826
Bank Stabilization - Moderate Level	503	CY	$105	$52,815
Bank Stabilization - High Level	1200	CY	$135	$162,000
Culv 52: Install 14' Bridge	168	SF	$200	$33,600
Culv 53: Install 14' Bridge	168	SF	$200	$33,600
Culv 54: Install 14' Bridge	168	SF	$200	$33,600
Culv 55: Install 14' Bridge	168	SF	$200	$33,600
Culv 56: Install 14' Bridge	168	SF	$200	$33,600
Culv 57: Install 14' Bridge	168	SF	$200	$33,600
Culv 58: Install 40' Bridge	1200	SF	$200	$240,000
Culv 59: Install 14' Bridge	420	SF	$250	$105,000
Culv 60: Install 14' Bridge	168	SF	$200	$33,600
Culv 61: Install 14' Bridge	168	SF	$200	$33,600
Contingency			20%	$243,178
			Total	$1,459,069

Reach 13 - Beaver Creek, Convergence with South Beaver Creek 1.15 miles West				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	3000	LF	$3	$9,000
Alternative 13A - Stream Restoration and Bank Stabilization				
Unclassified Excavation	350	CY	$33	$11,550
Wetland Planting	0.11	AC	$32,000	$3,673
Bank Stabilization - Moderate Level	840.00	CY	$105	$88,200
Contingency			20%	$20,685
			Total	$124,108

Reach 14 - Beaver Creek, 1.15 miles West to 1.7 miles West				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	2000	LF	$3	$6,000

Reach 15 - South Beaver Creek, 0.2 Miles upstream of confluence				
Alternative A - Stream Restoration				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	1000	LF	$3	$3,000
Alternative15 A - Culvert Improvements				
Culv 62: Install 8' x 5' RCBC	1	LS	$16,100	$16,100
Culv 63: Install 8' x 5' RCBC	1	LS	$16,100	$16,100
Culv 64: Install 8' x 5' RCBC	1	LS	$16,100	$16,100
Culv 65: Install 14' Bridge	420	SF	$250	$105,000
Culv 66: Install 8' x 5' RCBC	1	LS	$16,100	$16,100
Culv 67: Install 8' x 5' RCBC	1	LS	$16,100	$16,100
Contingency			20%	$37,100
			Total	$222,600

Reach 16 - South Beaver Creek, 0.2 Miles upstream of confluence to Gap Rd.				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	2500	LF	$3	$7,500
Alternative 16A -Bank Stabilization and Culvert Improvements				
Item	Quantity	Unit	Unit Cost	Total Cost
Bank Stabilization - Moderate Level	3060	CY	$105	$321,300
Culv 68: Install 10' x 4' RCBC	1	LS	$17,400	$17,400
Culv 69: Install 10' x 4' RCBC	1	LS	$17,400	$17,400
Culv 70: Install 10' x 4' RCBC	1	LS	$108,500	$108,500
Culv 71: Install 10' x 4' RCBC	1	LS	$17,400	$17,400
Culv 72: Install 10' x 4' RCBC	1	LS	$108,500	$108,500
Culv 73: Install 10' x 4' RCBC	1	LS	$17,400	$17,400
Culv 74: Install 10' x 4' RCBC	1	LS	$108,500	$108,500
Culv 75: Install 10' x 4' RCBC	1	LS	$108,500	$108,500
Culv 76: Install 10' x 4' RCBC	1	LS	$108,500	$108,500
Culv 77: Install 10' x 4' RCBC	1	LS	$108,500	$108,500
Culv 78: Install 10' x 4' RCBC	1	LS	$108,501	$108,501
Contingency			20%	$230,080
			Total	$1,380,481

Reach 17 -Ranch Elsie Rd., Coal Creek to Sylvan Rd.				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	1500	LF	$3	$4,500
Alternative 17A: Bank Stabilization and Culvert Improvements				
Bank Stabilization - Moderate Level	2550	CY	$105	$267,750
Culv 79: Install 8' x 5' RCBC	1	LS	$16,000	$16,000
Culv 80: Install 8' x 5' RCBC	1	LS	$16,000	$16,000
Culv 81: Install 8' x 5' RCBC	1	LS	$16,000	$16,000
Culv 82: Install 8' x 5' RCBC	1	LS	$13,000	$13,000
Culv 83: Install 8' x 5' RCBC	1	LS	$16,000	$16,000
Culv 84: Install 8' x 5' RCBC	1	LS	$89,000	$89,000
Culv 85: Install 8' x 5' RCBC	1	LS	$16,000	$16,000
Culv 86: Install 8' x 5' RCBC	1	LS	$16,000	$16,000
Culv 87: Install 8' x 5' RCBC	1	LS	$16,000	$16,000
Culv 88: Install 8' x 5' RCBC	1	LS	$16,000	$16,000
Culv 89: Install 8' x 5' RCBC	1	LS	$72,200	$72,200
Contingency			20%	$113,990
			Total	$683,940

Reach 18- Butte Drive				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	1000	LF	$3	$3,000
Alternative 18A: Culvert Improvements				
Culv 90: Install 6' x 4' RCBC	1	LS	$80,600	$80,600
Culv 91: Do Nothing				
Culv 92: Add 48" Pipe	1	LS	$5,700	$5,700
Contingency			20%	$17,260
			Total	$103,560

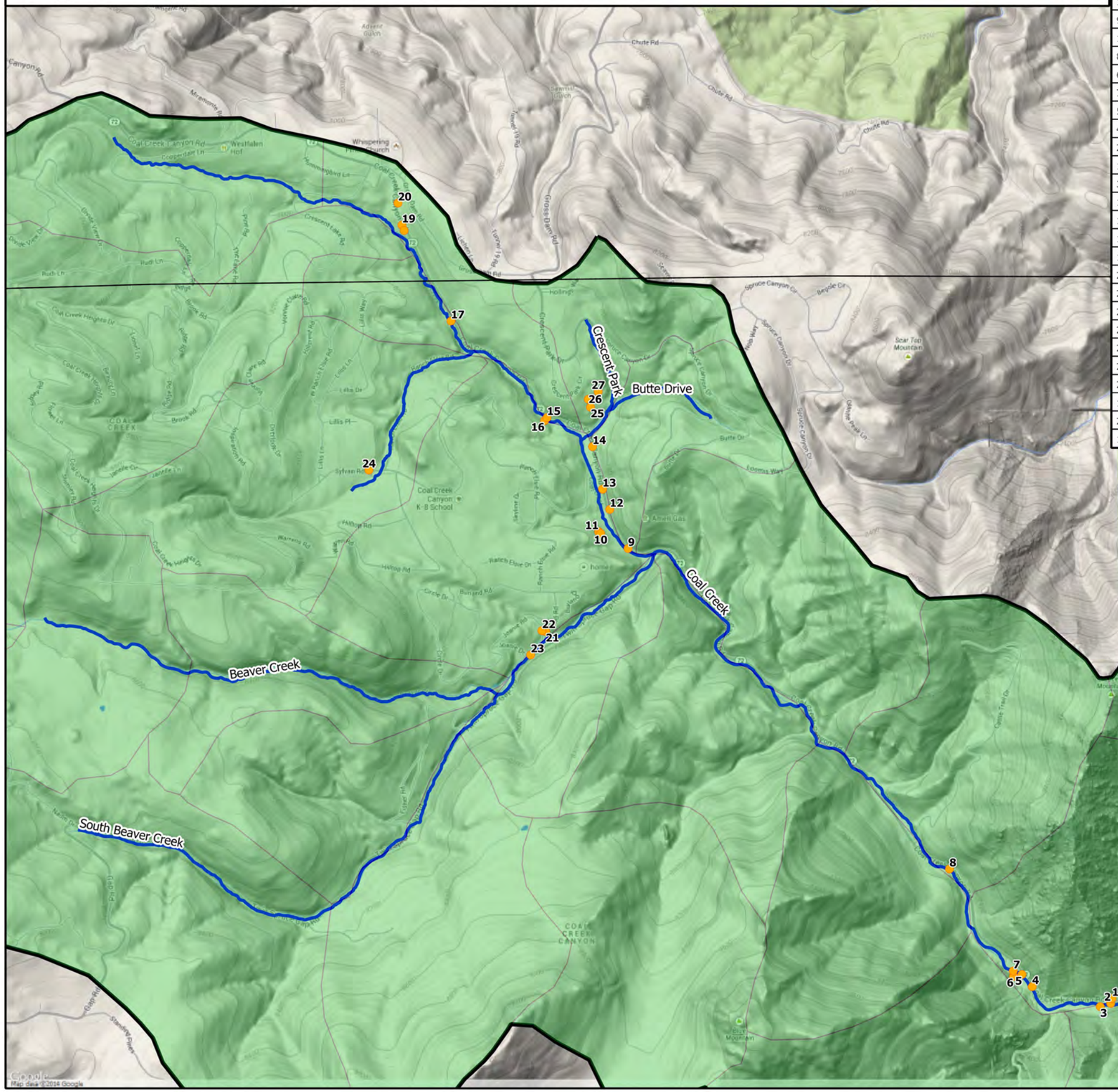
Reach 19 -Crescent Park Tributary, Coal Creek to Butte Drive Tributary				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	400	LF	$3	$1,200
Alternative 19A - Stream Restoration, Bank Stabilization, and Culvert Improvements				
Item	Quantity	Unit	Unit Cost	Total Cost
Unclassified Excavation	2200	CY	$40	$88,000
Wetland Planting	0.17	AC	$32,000	$5,583
Bank Stabilization - Moderate Level	1925	CY	$105	$202,125
Culv 93: Install 8' x 5' RCBC	1	LS	$102,200	$102,200
Contingency			20%	$79,582
			Total	$477,490

Reach 20- Butte Dr. to Spruce Canyon Dr.				
Debris Removal				
Item	Quantity	Unit	Unit Cost	Total Cost
Debris Removal	500	LF	$3	$1,500
Alternative 20A - Culvert Improvements				
Culv 94: Add 30" RCP	1	LS	$4,610	$4,610
Contingency			20%	$922
			Total	$5,532

APPENDIX D

COMMUNITY COMMENT AND CORRESPONDENCE

Figure 1.2 - Coal Creek Master Plan Community Comments



id	Notes
11	Wildlife crossed through; used to be willows and grass; no habitat there at all (all rock) need topsoil. Don't want invasive weeds to take hold then wash downstream.
13	Flat, Depositional, Channel Management Options
9	Flat, Depositional, Channel Management Options
12	Culvert Improvements
8	Bank Stabilization
6	Upstream Culverts Capacity
7	Channel Width Requirements
5	Bank Stabilization and Channel Capacity
4	Sedimentation in Culverts from Recent Work
2	Reestablishment of Vegetation
1	Sediment Transportation Management
3	Management of Runoff from Side Channel
14	Flood Overflow Across Highway
10	Culvert Capacity and Deposition
16	Ice damming in winter time
15	Culvert Capacity
26	Constant runoff in this area
27	Constant runoff in this area
25	Area of Ponding Water
21	Flow passing below culvert rather than through
23	Flow passing below culvert rather than through
22	Soil Movement Near Home
24	Flooding along Sylvan Rd for approximately 250 feet
17	Need for Debris Removal
20	Add Drainage to Collect Runoff/Prevent Ice Collection
19	Recent CDOT Improvements are Undercut

MEETING ATTENDANCE ROSTER

Project Name: Coal Creek Master Plan
Project No.: 14-019-CCM-415
Meeting Purpose: Project Kick-off Meeting
Date: April 16, 2014

NAME	REPRESENTING	PHONE	FAX
MARK WILCOX	DHM DESIGN	303 892 5560	303 892 4784
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Brian LeDoux	ICON	303.638.2304	
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		E-mail:	

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COAL CREEK MASTER PLAN
PROJECT KICK-OFF MEETING
APRIL 16, 2014 9:00 AM
ICON OFFICE

Minutes

Attendees:	Mark Wilcox,	DHM Design
	Emily Troisi,	The Environmental Group (TEG)
	Chris Garre,	The Environmental Group (TEG)
	Susan Bates (phone),	The Environmental Group (TEG)
	John Conn,	Jefferson County
	Jeff Crane,	Representing Colorado Water Conservation Board (CWCB)
	Troy Thompson,	Ecological Resource Consultants, Inc. (ERC)
	Craig Jacobson,	ICON Engineering Inc. (ICON)
	Brian LeDoux,	ICON Engineering Inc. (ICON)
	Jeremy Deischer,	ICON Engineering Inc. (ICON)

Meeting Minutes:

- Introductions for all parties were made.
- Additional stakeholders of the project were discussed
  - Craig noted Steve Harelson, West Program Engineer for Colorado Department of Transportation (CDOT), expressed his interest in the project but had a conflict and could not attend the kick-off meeting.
  - Jeff Crane mentioned the following people as possible additional stakeholders:
    - Linda Martin, Coal Creek Canyon Recreation District
    - Joseph Hanson, Jefferson County Conservation District
    - Boyd Byelich, National Resources Conservation Service (NRCS) Conservation District Manager.
    - Dave Wolf, NRCS Engineer, Exigent sites
  - Jeff stated the community members were also vital members of this project, and it was critical to get as close to a community consensus as possible.
  - Chris added the owner of the Sinclair gas station would also key individual in the project given the location along the drainageway and contacts with the rest of the community.
- Chris spoke about his role during the project. He noted how critical it was to separate this project from the Gross Reservoir/Moffat Expansion, another project TEG has been active with in the area.
- The group discussed who will host and update the project website, along with best forms of communication to update and engage with the community.
  - It was decided that ICON/DHM would host the page and TEG would have a landing page on their site that directs people to the official page site.
  - Jeff suggested a format resembling Little Thompson Watershed Restoration Coalition (LTWRC) Journal. He noted it was a great way to engage all communities which is very important in this project due to the scattered nature of people within the watershed.

COAL CREEK MASTER PLAN
PROJECT KICK-OFF MEETING
APRIL 16, 2014 9:00 AM
ICON OFFICE

Minutes

- Chris suggested several sources of outreach:
  - The Coal Creek Canyon Facebook page would be a great source to get the initial word about the project to the community. Chris noted how active the page was during the flooding last year.
  - The fire department has an email list for residents that would be a good resource for outreach. Susan has the contact information for Joseph Ceurvorst, the District Fire Chief, and will pass the information along to the project team.
  - The Mountain Messenger, which is a monthly community newsletter published the first week of the month. Chris explain the deadline for submittal for this paper is quickly approaching and believed the latest deadline to get any information in the May newsletter would be April 20th.
  - Highlander Monthly is another monthly resource that is displayed within the community.
  - The coffee shop would be a good location to place flyers.
  - The billboard in front of the Coal Creek Canyon Improvement Association (CCCIA) building could be used to get exposure for public meetings. Chris did express concern that not all residents get exposure to the billboard.
  - A mobile billboard at the bottom of the canyon. This is very successful in the past to get exposure to all residents. John will look into possible use of a Jefferson County mobile billboard for the project, when needed.
- John will help coordinate acquiring parcel information from Jefferson County.
- Jeff expressed his concern how important semantics would be during this project. The focus of the project should be described as community planning instead of a strictly watershed based planning study.

- The extents of the project were discussed
  - Craig expressed the hydrology of the study would encompass the entire watershed. Floodplain mapping would focus on the drainageways where damage was observed. These areas would predominately include Coal Creek from just upstream of the Boulder County limits to the UDFCD limits downstream; Beaver Creek and South Beaver Creek drainages, as they follow and divert from Twin Spruce Gap Road, approximately to a limit 1.5 miles southwest of the confluence with Coal Creek; and the Crescent Park drainage as it follows Crescent Park Drive.
  - Susan expressed concern about the project focusing where there was observed damage along the channel. She recommended community input on where the damage occurred within the watershed. Craig agreed that it was important to get input to these areas, but also distinguish between the major versus local drainage issues. Craig noted that there was limited time allocated for the study and the team would need to stay on track. The team also discussed how the more common local drainage issues could be addressed through guidelines, criteria and best management practices (BMP) for the area residents. Many of these guidelines may already exist in Jefferson County. Updated hydrology will also assist the residents with future planning.
  - Jeff stressed the importance of not using any political boundaries as study limits.

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COAL CREEK MASTER PLAN
PROJECT KICK-OFF MEETING
APRIL 16, 2014 9:00 AM
ICON OFFICE

Minutes

  - John stated a point of interest being Crescent Park Dr. just upstream of the Sinclair station. John noted even though it was localized, there was incredible damage in the area.
- Craig suggested a biweekly progress meeting schedule given the schedule of this project. The group agreed to intermix face-to-face and conference calls for most of the meetings.
- Craig introduced Troy Thompson, with ERC, noting their efforts would focus around the stream geomorphology and ecology. Mark Wilcox with DHM will manage community outreach.
- Craig discussed the schedule for the project
  - Three public meetings/workshops were estimated.
    - The first one occurring in late May will be held once the risks have been developed.
    - The second one occurring after the alternative analysis will collect public input before the cost analysis for conceptual design.
    - The third will occur during conceptual design.
  - The draft of the master plan will be completed around July 4th. The draft will focus on alternative analysis and improvement options at a more large scale than conceptual design.
- Mark explained his thoughts on how to proceed with the first public meeting.
  - He noted that the first meeting was the most important. It should include a brief presentation on the corridor having time for public comments. The idea of breaking the group into smaller groups might encourage some people to share their input that are not comfortable in a large group setting.
  - The second meeting would be to convey alternatives to the public, not expecting to reach a consensus, but to gain input.
- Jeff stated the importance of keeping the community interested and updated after the first public meeting. The Facebook page was discussed along with something similar to the LWTRC Newsletter.
- John questioned what topographical data was available for this project. Craig noted that post-flood FEMA LiDAR would be utilized for this project. Field measurements would be taken but the LiDAR data would be used to document the channel conditions.
- Craig noted the final product for this project would be more in line with an approximate FEMA FIRM level study. The product would be compatible with a more detailed level FIRM study (Base-flood-elevations, floodways) if more detail was added into the future. Jeff stated that was very important to the Jefferson County Commissioners to eventually end up with a FIRM but was not expecting it as part of this project. Having compatibility seemed appropriate.
- Craig discussed the hydrology for the basin. He noted CWCB used a HEC-HMS model to translate the storm flow into design frequency and how a UDFCD study compared very similarly. Since they were close, CWCB was recommending use of the UDFCD study as a starting point. Craig and Jeff discussed that CWCB had collected some data regarding flow estimates and may have some field cross-sections for which the hydraulic models could be calibrated to.
- Jeff wondered if there were fish in the project area, the group stated the upper reaches of Coal Creek only had seasonal flows but it was possible there were fish downstream in Coal Creek. Troy would examine this further and make recommendations regarding possibilities,

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COAL CREEK MASTER PLAN
PROJECT KICK-OFF MEETING
APRIL 16, 2014 9:00 AM
ICON OFFICE

Minutes

- The group discussed the possibility of any funding or grants available
  - Jeff stated funding would be available through the Colorado State Legislature and the NRCS.
  - A fundraising workshop occurring next Monday will be attended by Emily and she will forward any relevant information on obtaining grants for the area. ICON's team may attend as well.
  - The project group agreed the best strategy is to apply as the project progresses, maximizing the opportunity for grants and not waiting for project completion.
- Craig asked about the location of the exigent sites in the area. Jeff explained he had a site map but it would be best to contact Boyd Byelich for the site map. Jeff passed Boyd's contact information along to ICON. It was believed NRCS was about to go to bid for 5 projects in the area.
- Craig explained that the CWCB's automated floodplain mapping did not cover this area. ICON will contact CWCB to confirm if it has/been or could be included under CWCB's scope. If not, ICON will plan on completing this task.
- It was agreed the first public meeting would be held May 29th from 6 pm – 9 pm. Chris will reserve the CCCIA building from 5-9 to allow time for setup.
- Before the public meeting Mark and Chris will engage the Sinclair gas station owner and the propane company owner, just downstream. The team will gauge their interest in being part of a community task force in addition to a gentleman who had experience in managing water and septic systems within the community. This task force may help within the community to gather input and create interest in the project. This task force could be a vital part of the project given the Sinclair owner's influence in the community, as the station is a place where people congregate and the station also serves as the post office.

ACTION ITEMS:

1. ICON/DHM will develop a project description to be approved by TEG and submitted to local newsletters to inform the community about the project and the upcoming public meeting.
2. ICON/DHM will create the project website
3. The team will work to establish a community task force will be established before the public meeting
4. Chris will schedule the CCCIA building for the first public meeting occurring May 29th from 5-9 with the public meeting starting at 6 pm.

ICON ENGINEERING, INC

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COAL CREEK MASTER PLAN
PROJECT KICK-OFF MEETING
APRIL 16, 2014 9:00 AM
ICON OFFICE

Minutes

- END OF MEETING –

To the best of my knowledge, these minutes are a factual account of the business conducted, the discussions that took place, and the decisions that were reached at the subject meeting. Please direct any exceptions to these minutes in writing to the undersigned within ten (10) days of the issue date appearing herein. Failure to do so will constitute acceptance of these minutes as statements of fact in which you concur.

Minutes prepared by: Jeremy Deischer

Jeremy Deischer
ICON Engineering, Inc.

April 16, 2014

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TEG The Environmental Group ICON ENGINEERING, INC. DHM DESIGN

COMMUNITY WORKSHOP #1 - SIGN-IN SHEET

Project Name: Coal Creek Watershed Master Plan
Date: May 29, 2014

Name	Address / Organization	Contact Information
Nathan Mattas	1194 Camp Eden Rd	Phone: 720-883-5185 E-mail: natemattas@icloud.com
Joe Allen	11679 Ridge Rd	Phone: 303 642 0285 E-mail: Joe.B.Allen@gmail.
Patti Raush	30800 Hwy 72	Phone: 720-771-0873 E-mail: patriciaraush@msn.com
John Conn	Jeffco	Phone: 303-271-8496 E-mail:
Tony Carmeli	11740 Spruce Canyon Circle CPCHOA	Phone: 303.642-7537 E-mail: tony.carmeli@gmail.com
Susan Schenel	11956 Spruce Can Circle	Phone: 3036427300 E-mail: schenel@q.com (Q)
Bambi Hanson		Phone: E-mail:
Sandy Link	28170 HWY-72	Phone: 303 642 0898 E-mail: jay.link49@gmail.com
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Tatiana Sazonova	11162 Circle Dr.	Phone: 303-642-0766 E-mail: peskov53@hotmail.com
Jody Dickson	621 DIVIDEVIEW DR	Phone: x3568 E-mail: JODY@DICKSON.ORG
Kathryn Nicolella	28620 Hwy 72	Phone: 303-642-0479 E-mail: nicolktn@gmail.com
Curt Linville	636 Divide View Dr	Phone: 642-7895 E-mail: Curtis.linville@isotank.com
Data Link	28170 Hwy 72	Phone: E-mail: jay.link49@gmail.com
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		Phone: E-mail:

TEG The Environmental Group ICON ENGINEERING, INC. DHM DESIGN

COMMUNITY WORKSHOP #1 - SIGN-IN SHEET

Project Name: Coal Creek Watershed Master Plan
Date: May 29, 2014

Name	Address / Organization	Contact Information
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Don Cross	31927 Sylvan Rd. Golden	Phone: 303 642 3839 E-mail: dscross@q.com
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Kathy Keating	123 BLACK BEAR TR	Phone: 303-642-1133 E-mail:
DAN KNAPP	11620 INSPIRATION RD	Phone: 303 601 7839 E-mail: dknapp@exhaustion
Katie Knapp	"	Phone: 303-642-0235 E-mail: KnappK@bouldercolorado.gov
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Denise Wilson	34316 Gap Rd Golden	Phone: 303-642-0510 E-mail: deniseclairewilson@gmail.com
Marilyn Mumby	33858 Ave de Pines	Phone: 303-642-9404 E-mail: mumby@mric.net

COMMUNITY WORKSHOP #1 - SIGN-IN SHEET

Project Name: Coal Creek Watershed Master Plan
Date: May 29, 2014

Name	Address / Organization	Contact Information
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Sue Fields	11558 Ranch Elsie Rd Golden CO80403	Phone: 3/642 3140 E-mail: susancfields@hotmail.com
Carolyn Sargent Kim Huffman	325 Tunnel 19 Rd.	Phone: 3/642/0415 E-mail: Kimhk12@Gmail.com
JOHN & BRUCE BEVIRS	11781 RANCH ELSIE RD	Phone: 303 642-3565 E-mail: BBEVIRS@MSN.COM
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Wade Klein	31448 HWY 72	Phone: 3 642-3722 E-mail: kleinranch2@q.com
Brian Young	Canyon Cares	Phone: 303-642-0378 E-mail: wpchurchbrian@gmail.com
Tom Mulvany	CCCIA - Pres 31277 Burke Rd	Phone: 303-642-7121 E-mail: tmulvany@live.com
RCameron KIM CAMERON	11567 Brook Rd Golden	Phone: 3/719-9333 E-mail: KPUBC@MSN.COM
Rich & Helen Keen	34296 Gap Rd Golden	Phone: 303 642-7721 E-mail: rrichardkeen@colorado.edu
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		Phone: E-mail:

COMMUNITY WORKSHOP #1 - SIGN-IN SHEET

Project Name: Coal Creek Watershed Master Plan
Date: May 29, 2014

Name	Address / Organization	Contact Information
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Glenda Guss	315 Ronnie Rd	Phone: 303-642-3281 E-mail: glenda.guss@q.com
Dae Schemel	11856 SPRUCE CANYON CIRCLE	Phone: 303-642-2305 E-mail: DAVESCHEMELPHTO@Q.COM
monte mccoda	1258 Rudi Lane	Phone: E-mail:
John Ainsworth	3 Ronnie Rd.	Phone: 303-531-5218 E-mail: maidenmtaco@gmail.com
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Beverly Regen	4100 W 44th PL Denver, Co 80033	Phone: 303-837-2005 E-mail:
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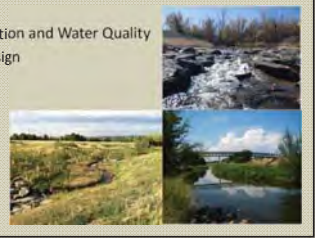
Carol Woodall	30390 Hwy 72	Phone: 303-642-0842 E-mail: CWoodall@Yahoo.com
COLLEEN AMBROZY	11740 Spruce Canyon Circle	Phone: -7537 E-mail: CAMBROZY@HOTMAIL.COM
Kayla Stauder	Colorado Spirit	Phone: 720-470-0819 E-mail: kayla.s@jcmh.org
		Phone: E-mail:
		Phone: E-mail:

INTRODUCTION
ICON Engineering, Inc.

- Specialists in Stormwater and Floodplain Management Projects
  - Floodplain modeling / mapping
  - Hydrologic and Hydraulic Analysis
  - River Master Plans
  - Stream Stabilization, Restoration and Water Quality
  - Utility and Infrastructure Design
  - Roadway design
  - GIS Capabilities



INTRODUCTION
Consultant Team:

Craig D. Jacobson, PE, CFM
Principal, Project Manager

Troy Thompson, PE
President, Sr. Water Resource Engineer

Mark Wilcox, RLA, ASLA
Principal

Partnerships and Project Stakeholders:

TEG, CWCB, Jefferson County, Boulder County, CDOT, FEMA, NRCS, Jefferson Conservation District……..Canyon Community (Public)

INTRODUCTION
Consultant Team

ICON ENGINEERING, INC	Ecological Resource Consultants, Inc.	DHM DESIGN
• Project Management	• Ecosystem Assessments	• Stakeholder Outreach
• Hydrologic Modeling	• Geomorphology	• Planning Process
• Floodplain Analysis	• Stream Restoration	• Framework Strategies
• Mitigation Strategies	• Mitigation Strategies	• Recreation
• Conceptual Design		• Phasing & Prioritization
• Phasing & Prioritization		• Funding Opportunities

Geomorphology *– classification of the Earth landforms and features. Defines the relationship between channel structure, flow, and movement of sediment and bed materials.*

11/10/2014

PROJECT OVERVIEW
September 2013 – Flood Event

PROJECT OVERVIEW
How Big Was This Flood?

PROJECT OVERVIEW
How Big Was This Flood?

STATE OF COLORADO

Colorado Water Conservation Board
Department of Natural Resources

TO: Johnny Olson
CDOT Incident Command

FROM: Kevin Houck
Chief, CWCB Watershed & Flood Protection Section

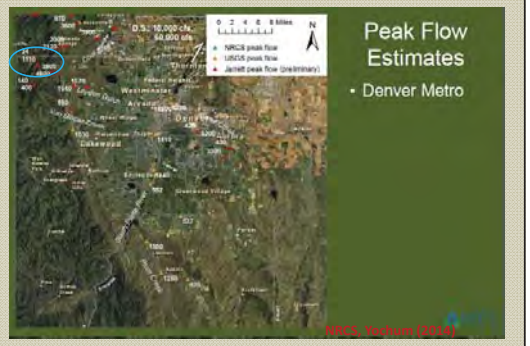
DATE: January 21, 2014

SUBJECT: **CDOT/CWCB Hydrology Investigation**
Phase One – 2013 Flood Peak Flow Determination

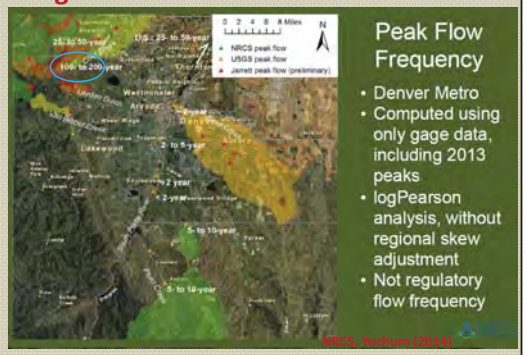
TABLE 1 – SUMMARY OF OBSERVED DISCHARGES AND FREQUENCY ESTIMATES

Location	Drainage Area (sq mi.)	Regulatory Discharges (cfs) 10-Year	50-Year	100-year	500-Year	2013 Peak Discharge Estimate (cfs)	2013 Estimated Frequency
South Platte River							
South Platte River at Fort Lupton	5,043	10,000	22,000	29,000	52,000	10,100	10 Year
South Platte River at Kersey	9,650	11,000	24,500	32,500	57,500	55,000	500 Year
Coal Creek							
Coal Creek at ARC2 Near Wondervu	10.1	72	1,580	2,090	3,240	2,110	25-50 Year
Coal Creek Near Plainview Road	15.1	87	1,690	3,340	6,280	3,990	~100 Year

PROJECT OVERVIEW
How Big Was This Flood?



PROJECT OVERVIEW
How Big Was This Flood?



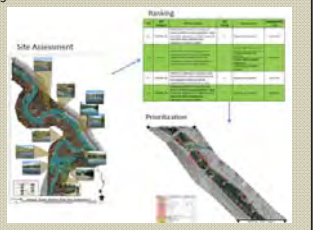
PROJECT OVERVIEW
Coal Creek Master Plan

PROJECT OVERVIEW
How Big Was This Flood?

Runoff Intensity (cfs/sqmi) – NRCS, Yochum (2014)

PROJECT OVERVIEW
Coal Creek Master Plan

- Plan for Resiliency and Stability within Watershed:
- Multiple Objectives Including:
  - Identify long term risk, susceptibility;
  - Immediate impacts and needs
  - Stream stabilization
  - Floodplain management
  - Ecological health
  - Transportation
  - Recreation
  - Public safety
  - Aesthetics
- Collaborative Effort
- Prioritization and Funding



PROJECT OVERVIEW
Project Timeline

- Kickoff Meeting – April 16th
- Task 1 – Public Engagement, Coordination, Reporting - Ongoing
- Task 2 – River Corridor Evaluations – April / May
- Task 3 –Risk Assessment – May
- Task 4 – Mitigation Strategies - June/July
  - DRAFT Master Plan July 2014
- Task 5 – Conceptual Design - August/September
  - DRAFT Conceptual Design September 2014
- Task 6 – Project Phasing Plan – September
- Task 7 – Final Master Plan Development – October

PROJECT GOALS
Public Outreach

- http://jeffco.us/disaster-recovery/faqs/

PROJECT GOALS
Public Outreach

- www.uppercoalcreek.com
- https://www.facebook.com/pages/Upper-Coal-Creek-Watershed/682218381981990
- https://www.facebook.com/pages/Coal-Creek-Canyon-Colorado/178730142157495
- http://tegcolorado.org/watershed
- http://jeffco.us/disaster-recovery/faqs/

PROJECT GOALS
Public Outreach

- Community involvement within planning process
- Opportunity for comment and feedback
- Community fliers
- Notice of events posted at CCCIA, Mountain Messenger
- Questionnaire/ survey
- 2 more Community Meetings – dates TBD


PROJECT GOALS
Planning Process
• Overall Goal of Building Resiliency of future flood damage


PROJECT GOALS
Manage Risk
• How to best manage risk of damage from future storm events within the watershed


PROJECT GOALS
Short Term and Immediate Needs
• Immediate Bank Stability/ Erosion Protection


PROJECT GOALS
Short Term and Immediate Needs
• Fundable Solutions

PROJECT GOALS
Flood Infrastructure Planning


- Flood Capacity, 2 to 10 year Level, Lower Cost
- Flood Capacity, 10 to 50 year Level, Mid-Cost
- Flood Capacity, 100 Year + Level, High Cost

PROJECT GOALS
Community Planning

- Recreation added to Corridor

PROJECT GOALS
Community Planning

- Environmental Health/ Ecology

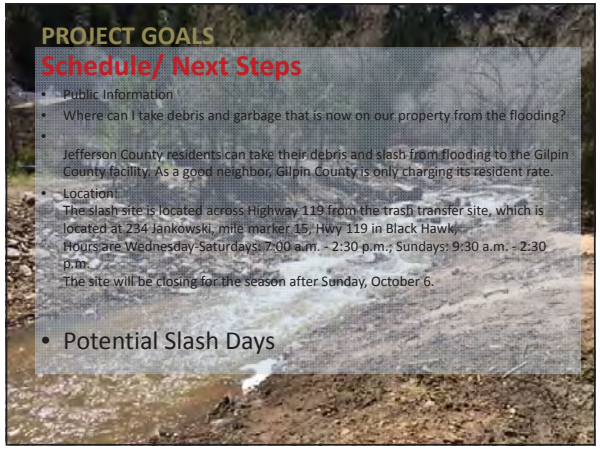
PROJECT GOALS
Community Planning

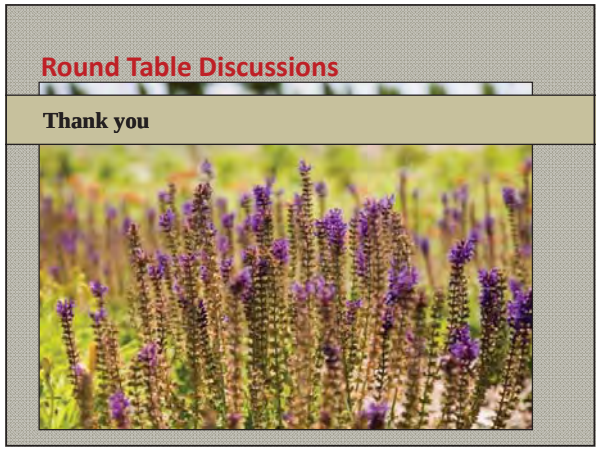

- Strengthened Resiliency for Community Center Areas


PROJECT GOALS
Community Planning
• Maximize Property and Usable Space


PROJECT GOALS
Community Planning
• Transportation and Emergency Access


PROJECT GOALS
Schedule/ Next Steps
• In-kind labor/ Contributions
• Potential Slash Days


PROJECT GOALS
Schedule/ Next Steps
• Public Information
• Where can I take debris and garbage that is now on our property from the flooding?
• Jefferson County residents can take their debris and slash from flooding to the Gilpin County facility. As a good neighbor, Gilpin County is only charging its resident rate.
• Location:
The slash site is located across Highway 119 from the trash transfer site, which is located at 234 Jankowski, mile marker 15, Hwy 119 in Black Hawk.
Hours are Wednesday-Saturdays: 7:00 a.m. - 2:30 p.m.; Sundays: 9:30 a.m. - 2:30 p.m.
The site will be closing for the season after Sunday, October 6.
• Potential Slash Days



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COAL CREEK MASTER PLAN
ALTERNATIVES REVIEW MEETING
JULY 23, 2014 AT 2:00 PM
CCCIA

Minutes

Attendees:	**John Conn,**	**Jefferson County**
	Emily Troisi,	**The Environmental Group (TEG)**
	Troy Thompson,	**Ecological Resource Consultants, Inc. (ERC)**
	Craig Jacobson,	**ICON Engineering Inc. (ICON)**
	John Baich,	**Community Task Force**
	Katie Knapp,	**Community Task Force**
	Naren Tayal,	**Federal Emergency Management Agency (FEMA)**
	Dan Knapp	**Community Task Force**
	Mark Wilcox	**DHM**
	Jeff Crane	**Colorado Water Conservation Board (CWCB)**
	Steve Harelson	**Colorado Department of Transportation (CDOT)**
	Jack Danneberg	**Icon Engineering (ICON)**

MEETING MINUTES

- Attendees introduced themselves
- Craig gave an overview of the project and highlighted the purpose.
  - Create a master plan that outlines the problems of the watershed.
  - Presents alternatives that improve the resiliency of the watershed.
- Craig noted that the purpose of the meeting was to updating the group to the progress in the project and obtain feedback on alternatives suggested.
- The next step will include a public meeting on August 20th. This meeting will overlap with a CDOT presentation that was planned previously.
- Jeff asked if CDOT was going to make the canyon wider. Steve said that there is some money in the budget for upcoming work.
- Craig gave an update to the status of the grants that been applied for.
  - CWCB Grant
    - The grant that had been applied for through CWCB, was reportedly accepted. This consisted of $92,000 for the area that was the old Real Estate Office.
    - Components of project include, reconstructing the natural channel as a demonstration project.
    - This project will have CDOT cooperation.
    - Jeff said that an official award of the grant would be sent out soon.
  - CDBG Grant
    - There is some confusion whether this grant was awarded or not. The selection of notice-of-intents was sent out recently.
    - Phase 1 of this grant may need to be submitted by September 9th.
    - Katie said she would look into if City of Boulder staff had heard anything regarding the next steps for applications.

COAL CREEK MASTER PLAN
ALTERNATIVES REVIEW MEETING
JULY 23, 2014 AT 2:00 PM
CCCIA

Minutes

- Mark said that CDBG would look at high priority areas.
- Jeff suggested contacting Andy Hill with DOLA for confirmation
- Naren brought up left over Presidential money from Hurricane Sandy.
  - This money is to be awarded to projects that improve resiliency.
  - The agencies that applied didn't meet the intense criteria, hence the leftover money.

- Craig discussed the draft alternatives report prepared for the meeting:
- Hydrology:
  - The hydrology was based on a report prepared in 2012, by Urban Drainage.
  - CDOT and CWCB are also collaborating on hydrology for this area. This report compares within 7% of Icon's hydrology.
  - Steve Yochum (NRCS) provided data related to the downstream stream gage near Plainview Road. Estimated flows in September were around 3300 cfs.
  - Jeff said that CWCB wants to see updated hydrology for watersheds.
  - The hydrology that Icon prepared was very comparable to that of the NRCS.
  - Craig mentioned that state was going to require local municipalities use either the updated CDOT hydrology or Urban Drainage hydrology for analysis and design decisions moving forward.
- Floodplains were discussed, as there are no FEMA regulatory floodplains in most of the canyon.
  - There is a regulatory floodplain that ends near the mouth of the canyon.
  - Jefferson County wants to see a regulatory floodplains come out of this project, if possible.
  - Craig said that at a minimum the County could utilize the approximate floodplains generated.
- Jeff asked if there is an estimate for return period of the September storm.
  - Craig said that upstream it was estimated to be between 10 to 50-yr event, but downstream it was estimated to exceed the 100-yr event.
  - Steve said that he looked at the box culvert below Railroad and estimated it at around 2,800 cfs.
- Troy (ERC) summarized geomorphology aspects.
  - Troy and ERC reviewed the streams, documenting the channel and environmental impacts from the September flood. ERC also reviewed wetlands and endangered species in the corridors.
  - Stream sections were categorized by slope which was then used to suggest a channel width.
  - Craig made it clear that it was not the projects goal to channelize, but integrate the geomorphic design elements to properly size the channel.
- Jeff asked how the reaches were separated.
  - Troy explained that the reaches were separated by flow changes and natural breaks.
- Craig outlined the project approach which included the grouping of stream reaches into corridors. A stream corridor was categorized as an area that water was being transported with high flows and a high risk of future damage. A drainage corridor was categorized by an area that contributed runoff with more moderate problems.
  - Management of a stream corridor would be much more comprehensive compared to drainage corridors.
- Erosion setbacks were discussed. The concept of having buffers beyond the floodplain was appealing to the group but management sounded difficult at local level.

ICON ENGINEERING INC 8100 South Akron Street, Suite 300, Centennial, CO 80112 - Phone (303) 224-0802 / Fax (303) 224-1019

COAL CREEK MASTER PLAN
ALTERNATIVES REVIEW MEETING
JULY 23, 2014 AT 2:00 PM
CCCIA

Minutes

- Steve noted that CDOT does not own the stream corridor so it makes management much more difficult from CDOT's perspective as well.
- Transportation corridors were discussed. During the September storm almost all of the main routes out of the canyon were blocked. Burland road was critical, mentioned by John Baich.
  - In the master plan Transportation corridors will be given a high priority.
- At the start of this project a questionnaire was issued asking residents about the priorities of certain issues. These priorities were discussed, with immediate needs being the highest ranked and recreation given the lowest priority.
  - When discussed Steve mentioned that bike lanes have been encouraged by CDOT as a way to create resiliency against future floods and roadway damage.
  - To date, CDOT was only able to install expanded shoulders where the road was destroyed, but they are considering other areas in the long term planning.
- Emily asked whether any of the alternatives were conflicting.
  - Craig answered that these alternatives reflect many different options and he imagined that a combination of the alternatives would be selected.
- Steve mentioned that the third culvert from the bottom also passed the September flood flows.
- It was discussed that many of the new culverts that have been installed since the September floods are not sized to pass larger design storms and a need to increase capacity existed. Steve mentioned that hydrology was estimated early on in the rebuilding process and these numbers were different than the current values.
- Breakaway bridges were discussed as a way to not have to replace culverts every large storm. These could be considered with final design, if appropriate.
- Craig addressed the fact that 60' bridges for the 100-year event on private property were likely too large and expensive to fit most properties. The final solutions were likely a compromise with something less than 100-year requirements.
- Craig discussed alignment issues related to the CDOT culverts.
  - Many of the culverts that cross under roadways have inlets and outlets that are almost perpendicular to the direction of flow. This has caused erosion and sedimentation problems.
  - By straightening these culverts some of these issues can be resolved.
  - Steve mentioned that bridges reduce angle changes.
- In places suggestions were made to raise the road.
  - This brought up the concern that this would just push the floodplain more onto private property and that if implemented CDOT may need to manage offsite floodplain impacts.
- Katie asked if we were looking into TIP (Transportation Improvement Plan) funding.
  - Steve seemed to think that TIP funding may not be applicable since CDOT was involved.
- The community center area was discussed, as multiple solutions existed. Many of the establishments in this area offer community value. There are obvious hazards in the area surrounding the Sinclair station and propane sales yard.
  - The master plan may include environmental assessments, to understand other hazards.

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COAL CREEK MASTER PLAN
ALTERNATIVES REVIEW MEETING
JULY 23, 2014 AT 2:00 PM
CCCIA

Minutes

- Acquisition was discussed as a means for purchasing property to help formulate solutions.
- Environmental hazards could make this more complicated.

- Emily noted that it was important to maintain the existence community center for the support into the future.
- Beaver Creek area was discussed in detail. This is an area that is off the main stem of Coal Creek. At the confluence with Coal Creek, Beaver Creek's drainage area is twice the size of Coal Creek.
  - There are many homes and road crossings in this area with a high flood potential.
  - Regional detention in the Beaver Creek drainage corridor was mentioned, but ultimately it seemed that there would be further complications with property acquisitions and permitting at the state level.
- The use of corridor easements was discussed throughout the meeting. For most stream corridors a width of 40 to 60 feet is being recommended. Drainage corridors would not require these easements.

- END OF MEETING--

To the best of my knowledge, these minutes are a factual account of the business conducted, the discussions that took place, and the decisions that were reached at the subject meeting. Please direct any exceptions to these minutes in writing to the undersigned within ten (10) days of the issue date appearing herein. Failure to do so will constitute acceptance of these minutes as statements of fact in which you concur.

Minutes prepared by:

Jack Danneberg, EI
ICON Engineering, Inc.

July 23rd, 2014

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TEG The Environmental Group | ICON ENGINEERING, INC. | DHM DESIGN

COMMUNITY WORKSHOP #2 - SIGN-IN SHEET

Project Name: Coal Creek Watershed Master Plan
Date: August 20, 2014

Name	Address / Organization	Contact Information
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Sharon Nicholson	11868 Bagdad Cir	Phone: 303.642.9358 E-mail: snichol@anurdog.com
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Ursula Treves	12025 Spruce Canyon Ct	Phone: 303-642-3090 E-mail: treves.u@gmail.com
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1/1

COMMUNITY WORKSHOP #2 - SIGN-IN SHEET

Project Name: Coal Creek Watershed Master Plan
Date: August 20, 2014

Name	Address / Organization	Contact Information
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COMMUNITY WORKSHOP #2 - SIGN-IN SHEET

Project Name: Coal Creek Watershed Master Plan
Date: August 20, 2014

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		Phone: E-mail:
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		Phone: E-mail:

11/10/2014

Consultant Team:

ICON ENGINEERING INC
Ecological Resource Consultants, Inc.
DHM DESIGN

Craig D. Jacobson, PE, CFM
Principal, Project Manager

Troy Thompson, PE
President, Sr. Water Resource Engineer

Mark Wilcox, RLA, ASLA
Principal

Partnerships and Project Stakeholders:
TEG, CWCB, Jefferson County, Boulder County, CDOT, FEMA, NRCS, Jefferson Conservation District……..Canyon Community (Public)

Agenda

6:00 PM to 6:45 PM
- Presentation of Consultant Team
- Introductions of Key Agencies and Role
- Planning Process
  - Timeline/ Planning Process
  - Coal Creek Watershed Overview
- Coal Creek Master Plan
  - Public Outreach - Public Survey Results and Feedback
  - Summarize Technical Data
  - Flood Resiliency
  - Overview of Project Alternatives
  - Future Opportunities for Public Comment
- Funding and Grant Opportunities
- Implementation Strategies

6:45 PM to 7:00 PM Q&A
7:00 PM to 7:30 PM Break-out Session
7:30 PM to 7:45 PM Colorado Spirits Review of Resiliency
7:45 PM to 8:00 PM CDOT/ CWCB Presentation
8:00 PM to 8:30 PM Break-out Session for Q&A with CDOT/ CWCB

Key Agencies and Roles

TEG

CWCB

CDOT

Jefferson County

Colorado Spirit

Jefferson Conservation District

Planning Process

Timeline

- Task 1 – Public Engagement, Coordination, Reporting- Ongoing
  - First Public Meeting – May 29, 2014
- Task 2 – Stream Corridor Evaluations – Complete
- Task 3 – Flood, Ecosystem, and Geomorphic Risk Assessment - Complete

Planning Process

Timeline

- Task 5 – Conceptual Design - August/September
  - DRAFT Conceptual Design September 2014
  - - Community Meeting #3 to review draft master plan and incorporated community feedback – Late September/ Early October

Planning Process

Timeline

- Task 4 – Mitigation Strategies - June/July
  - DRAFT Master Plan August 2014

- Community Meeting #2 to review draft alternates and incorporated community feedback – August 20, 2014

Planning Process

Timeline

- Task 6 – Project Phasing Plan – September
  - General funding opportunities
  - Implementation Strategies

Planning Process

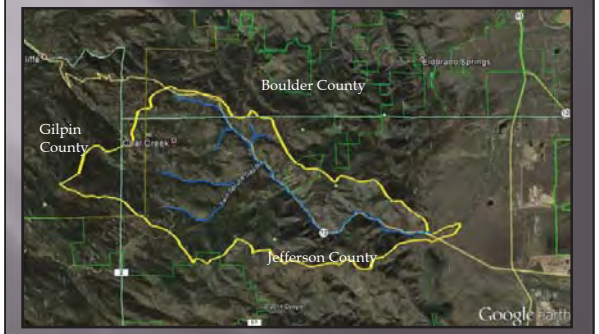
Timeline

- Task 7 – Final Master Plan Development – October
  - Recommended Projects
  - Partnerships, Coalition, etc.

Coal Creek Watershed

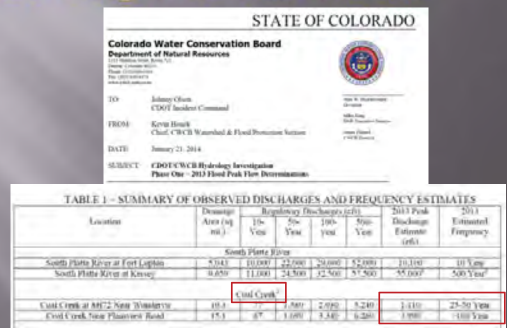
- Characteristics
  - Watershed Basin Area – 15 sq mi
  - Main Channel – 8 mi
- Communities
  - Coal Creek Canyon / Wondervu
  - Jefferson County
  - Areas of Boulder & Gilpin Counties
- Other Entities
  - Jefferson Conservation District
  - Coal Creek Canyon Parks and Recreation
- No FEMA defined floodplains

Coal Creek Watershed



September 2013 – Flood Event

How Big Was This Flood?


STATE OF COLORADO

Colorado Water Conservation Board
Department of Natural Resources

TO: Johnny Olson
CDOT Incident Command

FROM: Kevin Houck
Chief, CWCB Watershed & Flood Protection Section

DATE: January 21, 2014

SUBJECT: **CDOT/CWCB Hydrology Investigation**
Phase One – 2013 Flood Peak Flow Determinations

TABLE 1 – SUMMARY OF OBSERVED DISCHARGES AND FREQUENCY ESTIMATES

Location	Drainage Area (sq mi.)	Regulatory Discharges (cfs)				2013 Peak Discharge Estimate (cfs)	2013 Estimated Frequency
		10-Year	50-Year	100-year	500-Year		
South Platte River							
South Platte River at Fort Lupton	5,043	10,000	22,000	29,000	52,000	10,100	10 Year
South Platte River at Kersey	9,659	11,000	24,500	32,500	57,500	55,000[2]	500 Year[2]
Coal Creek[3]							
Coal Creek at SH72 Near Wondervu	10.3	[illegible]	1,500	2,090	5,240	[illegible]	25-50 Year
Coal Creek Near Plainview Road	15.1	67	1,160	3,340	6,260	[illegible]	[illegible]

Hydrology

- Distribution of flow within a watershed
- Statistic based approach to defining risk of occurrence
  - 100 Year Storm - 1% chance per year
  - 50 Year Storm – 2% chance per year
  - 25 Year Storm – 4% chance per year
  - 10 Year Storm – 10% chance per year, etc.
- May be determined from a combination of:
  - Review of Historic Flows (Flood Frequency Analysis)
  - Rainfall Runoff Analysis
    - Rainfall statistics, sub-catchment watershed computer models
  - Regional Regression
- Approach for Master Plan
  - Use existing information;
  - Reconcile results between sources

Coal Creek Master Plan

- Plan for Resiliency and Stability within Watershed:
- Multiple Objectives Including:
  - Identify long term risk, susceptibility;
  - Immediate impacts and needs
  - Stream stabilization
  - Floodplain management
  - Ecological health
  - Transportation
  - Recreation
  - Public safety
  - Aesthetics
- Collaborative Effort
- Prioritization and Funding

Hydrology

- Sources for Master Plan
  - 2012 – Hydrology Report for UDFCD, Boulder County Locations
    - Rainfall Runoff for entire watershed;
    - Calibrated to published information in downstream locations
    - Basis for flows in Master Plan
  - NRCS Flood Frequency Analysis
    - Stream gage near Plainview Road (downstream end)
    - 43 years of record
  - CWCB / CDOT Hydrology Study (DRAFT)
    - Ongoing study in DRAFT Format
    - State requesting local jurisdictions regulate from this, or comparable source.

11/10/2014

Hydrology

- Discharge Recommendations:

2014 Master Plan Recommended Discharges

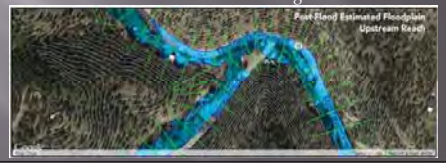
Location		2-Year	5-Year	10-Year	25-Year	50-Year	100-Year	500-Year
River	Description	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Coal Creek	Near mile marker 12.7	53	180	374	870	1720	3370	6290
Coal Creek	Near mile marker 13.5	52	178	370	860	1700	3310	6140
Coal Creek	Near mile marker 15.2	53	180	374	870	1650	3120	5670
Coal Creek	Near mile marker 15.8	53	180	374	870	1620	3050	5500
Coal Creek	Near mile marker 16.6	53	180	374	870	1600	2960	5260
Coal Creek	Twin Spruce Gap Rd	62	211	439	1020	1750	3060	5090
Coal Creek	Crescent Park Drive	21	72	150	350	550	900	1450
Coal Creek	Ranch Elsie Road	21	72	150	350	540	870	1380
Coal Creek	Near mile marker 19	16	54	112	260	400	630	1000
Coal Creek	Copperdale Lane	7	25	52	120	170	250	390
Beaver Creek	South Beaver Creek confluence	38	130	271	630	1050	1810	3030
Beaver Creek	Approx. 1.2 mi upstream of confluence	21	72	150	350	570	970	1610
Beaver Creek	Upstream limits	16	54	112	260	420	690	1120
South Beaver Creek	Burke Road	16	56	116	270	460	770	1290
South Beaver Creek	Upstream limits	15	50	103	240	360	560	880
Ranch Elsie	Reach Limits	7	23	47	110	150	220	320
Butte Drive	Reach Limits	4	12	26	60	90	150	230
Crescent Park	Butte Drive	7	23	47	110	170	270	430
Crescent Park	Upstream Limits	3	10	21	50	80	130	200

Geomorphic Analysis

- Review of channel characteristics;
- Guidance for stream size as it relates to:
  - Channel shaping discharges;
  - Flow velocities;
  - Stream bed slope;
  - Stream bed and bank material;
  - Historical review of stream conditions.
- Foundation in the Master Plan
  - Stable channel geometry
  - Resiliency to full range of flood discharges

Hydraulics

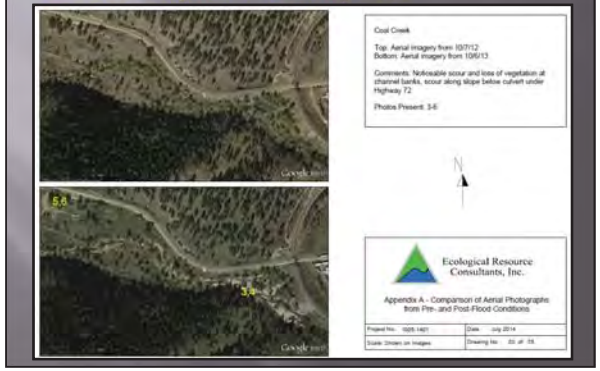
- Floodplain Analysis;
- Define risk at different flood levels;
- Immediate identifiers for projects and problems areas;
- Master Plan Approach
  - Completed for the 10-year through 100-year flood events;
  - 100-year shown on alternative maps;
  - Uses approximate methods;
  - Added detail for culverts and existing features.



Geomorphic Analysis

- Progression
  - Field Review;
  - Historical Review;
  - Stream Classification;
  - Guidance for stream size & width

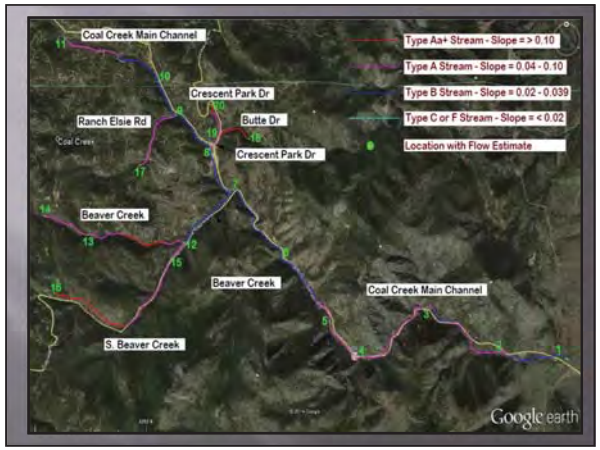
Geomorphic Analysis



Geomorphic Analysis

Geometries for Primary Stream Types at Each Flow Location

		Minimum Slope Range					Maximum Slope Range				
Flow Location	Stream Type	Slope (%)	Base (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Width at 2x Bankfull Depth (ft)	Slope (%)	Base (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Width at 2x Bankfull Depth (ft)
1	B	2%	15	18	1.3	32	4%	13	15	1.1	27
2	B	2%	15	18	1.3	32	4%	13	15	1.1	27
3	A	4%	12	15	1.3	20	10%	10	12	1.1	16
4	A	4%	12	15	1.3	20	10%	10	12	1.1	16
5	A	4%	12	15	1.3	20	10%	10	12	1.1	16
6	B	2%	15	18	1.3	32	4%	13	15	1.1	27
7	B	2%	16	19	1.4	34	4%	14	17	1.2	31
8	B	2%	11	13	0.9	23	4%	9	11	0.8	20
9	B	2%	11	13	0.9	23	4%	9	11	0.8	20
10	B	2%	8	10	0.9	18	4%	7	9	0.8	16
11	A	4%	4	6	0.8	8	10%	4	6	0.6	8
12	B	2%	13	15	1.1	27	4%	12	14	1	25
13	A	4%	8	10	1	13	10%	6	8	0.9	10
14	A	4%	7	9	0.9	12	10%	5	7	0.8	9
15	A	4%	7	9	0.9	12	10%	5	7	0.8	9
16	A	4%	7	9	0.9	12	10%	5	7	0.8	9
17	A	4%	4	6	0.8	8	10%	4	6	0.6	8
18	Aa+	10%	3	4	0.6	5	15%	3	4	0.6	5
19	A	4%	4	6	0.8	8	10%	4	6	0.6	8
20	A	4%	3	4	0.6	5	10%	2	3	0.5	4



Geomorphic Analysis

Coal Creek Master Plan

- Plan for Resiliency and Stability within Watershed:
- Multiple Objectives Including:
  - Identify long term risk, susceptibility;
  - Immediate impacts and needs
  - Stream stabilization
  - Floodplain management
  - Ecological health
  - Transportation
  - Recreation
  - Public safety
  - Aesthetics
- Collaborative Effort
- Prioritization and Funding

Coal Creek Master Plan

- Stream Corridors:
  - Coal Creek – Ranch Elsie through Coal Creek Canyon;
  - Beaver Creek - Joanie Drive through Coal Creek
- Drainage Corridors:
  - Coal Creek – Upstream of Ranch Elsie;
  - Beaver Creek - Upstream of Joanie Drive;
  - South Beaver Creek – Upstream of Joanie Drive;
  - Ranch Elsie Tributary;
  - Crescent Park Tributaries.

Coal Creek Master Plan

Coal Creek Master Plan

- Stream Corridors:
  - Reaches with larger contributing basin;
  - More constant base flow;
  - Higher flood discharges;
  - Stream characteristics suitable for riparian habitat and ecological enhancement;
  - Most damaged in September flood;
  - Remain the most susceptible to future flooding.
  - Require a larger corridor width to manage geomorphic and flood discharges.
  - Require consistent management .

Coal Creek Master Plan

- Goal for Stream Corridors:
  - Public Safety –needs for additional flood warning measures
  - Corridor management and maintenance –existing maintenance needs and future easements.
  - Stream restoration – establish channel dimensions per geomorphic recommendations.
  - Erosion setbacks- minimize risk through zoning changes for future development.
  - Environment and ecology –ecological restoration, water quality testing or treatment.

Coal Creek Master Plan

- Goal for Stream Corridors (continued):
  - Flood management – address capacity deficiencies in bridges/culverts and stabilization measures to protect infrastructure;
  - Transportation and Emergency access – maintain access through major roadway corridors;
  - Recreation –identification of new or expended recreation needs.

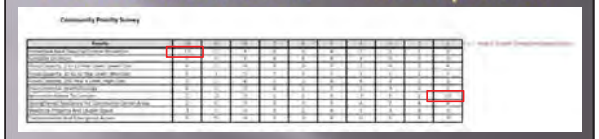
Coal Creek Master Plan

- Drainage Corridors:
  - Smaller predominately dry throughout the year;
  - Less diversity;
  - Less flood risk to buildings and infrastructure;
  - Principle issues relate to capacity and conveyance
- Drainage Corridor Goals:
  - Corridor management and maintenance –Identify maintenance needs;
  - Flood management – address capacity deficiencies in bridges/culverts and stabilization

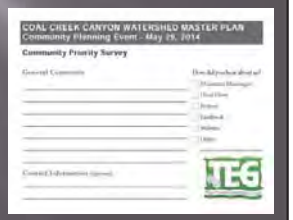
Public Outreach – Awareness

- Community involvement within planning process
- Opportunity for comment and feedback
- Community fliers
- Notice of events posted at CCCIA, Mountain Messenger, message board
- https://www.facebook.com/pages/Upper-Coal-Creek-Watershed/682218348481990
- www.uppercoalcreek.com
- www.tegcolorado.org
- Other?

Public Outreach – Participation



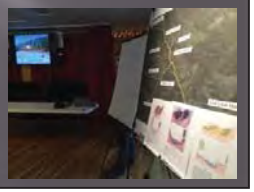

COAL CREEK CANYON WATERSHED MASTER PLAN
Community Planning Event - May 29, 2014
Community Priority Survey


COAL CREEK CANYON WATERSHED MASTER PLAN
Community Planning Event - May 29, 2014
Community Priority Survey

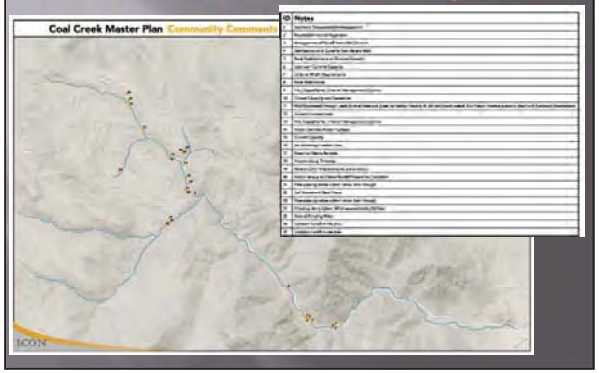
Public Outreach – Feedback

Comments from Comment Cards

- Doing major dirt work w/bobcat-do not want to conflict with master plan but cannot wait too
- Wildfire mitigation, inventory emergency response pathways, protect & enhance riparian corridors = best flood protection & bank stabilization
- Good community involvement
- It would be helpful to know how the proposed 100-YR floodplain was developed
- We, my neighbors and I, are most interested in removing debris so that the stream (waterway) is clean and that land values are returned to pre-flood values
- Need to coordinate plan with CDOT & Jeffco/Boulder public workers & XCEL Energy w/gas main & gas service lines



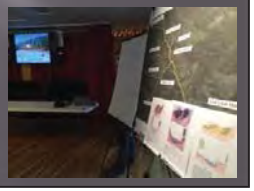
Public Outreach – Participation


Coal Creek Master Plan Community Comments

Public Outreach – Feedback

Comments from Comment Cards

- Residential use not allowed in 100-Yr floodplain, recreational use along streambed is important, water quality improvements is important
- Protect liberty, no new taxes, minimize regulation, and focus on road & public safety
- Great project organization
- Thank you for developing this plan



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Public Outreach – Feedback

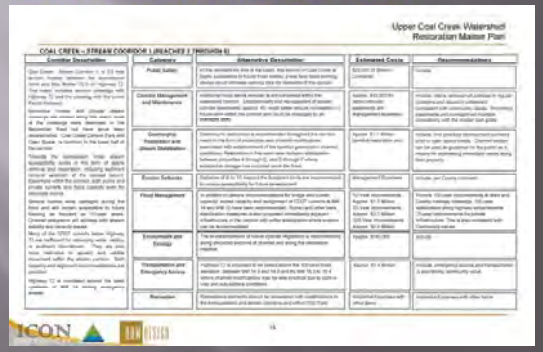
Consultant Team Questions

CDOT Questions

XCEL Questions

Coal Creek Master Plan

Coal Creek Master Plan



Coal Creek Master Plan

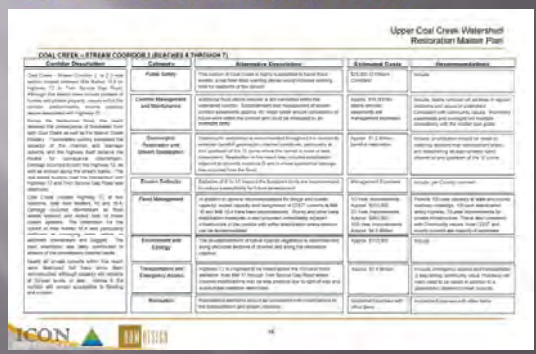
Coal Creek Master Plan

Coal Creek Master Plan

Coal Creek Master Plan

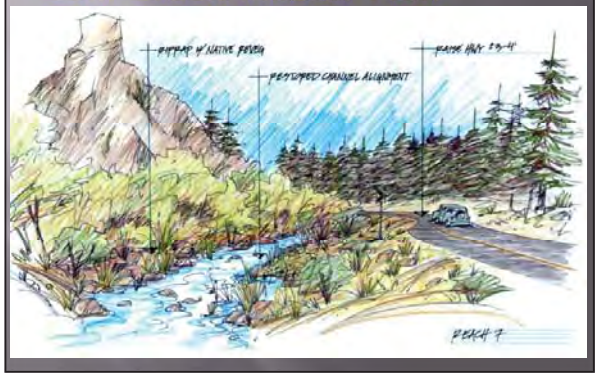
Coal Creek Master Plan

Upper Coal Creek Watershed
Restoration Master Plan



Coal Creek Master Plan

Coal Creek Master Plan



Coal Creek Master Plan

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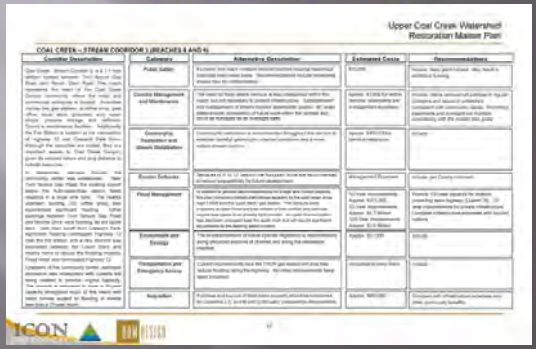
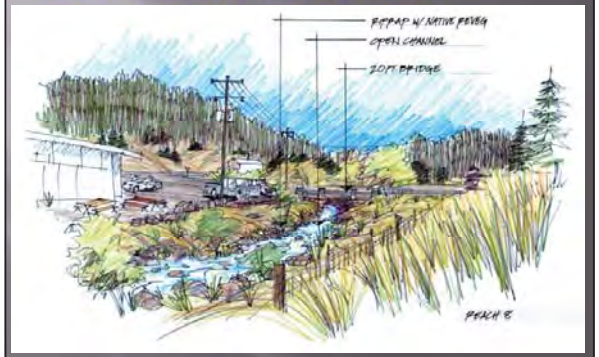


Coal Creek Master Plan

Coal Creek Master Plan



Coal Creek Master Plan

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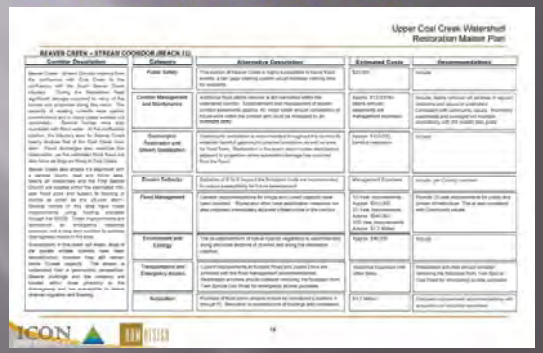

Coal Creek Master Plan

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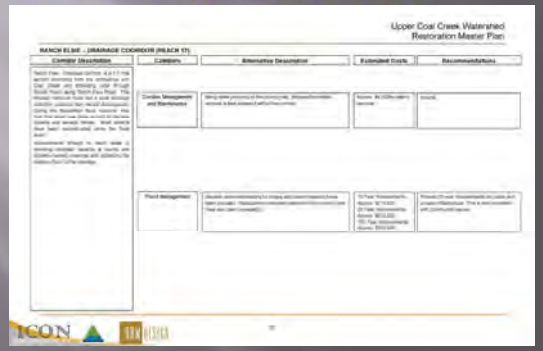
Coal Creek Master Plan



Coal Creek Master Plan

Summary of Costs for Master Plan:

River	Corridor	Reaches	Safety	Debris removal	Geomorphic Restoration	Flood Management 10-yr	Flood Management 25-yr	Flood Management 100-yr	Environment	Transportation	Acquisition
Coal Creek	Stream Corridor 1	1 to 5	$ 25,000	$ 42,000	$ 1,100,000	$ 1,300,000	$ 3,200,000	$ 9,900,000	$ 140,000	$ 1,600,000	
Coal Creek	Stream Corridor 2	6 to 7	$ 25,000	$ 16,000	$ 1,200,000	$ 553,000	$ 980,000	$ 4,500,000	$ 103,000	$ 1,600,000	
Coal Creek	Stream Corridor 3	8 and 9	$ 10,000	$ 7,500	$ 400,000	$ 375,000	$ 1,200,000	$ 3,000,000	$ 52,000		$ 600,000
Coal Creek	Drainage Corridor	10 and 11		$ 17,000		$ 46,000	$ 200,000	$ 580,000			
Beaver Creek	Stream Corridor	12	$ 20,000	$ 12,000	$ 430,000	$ 310,000	$ 540,000	$ 1,200,000	$ 46,000		$ 1,200,000
Beaver Creek	Drainage Corridor	13 and 14		$ 15,000		$ 27,000	$ 67,000	$ 250,000			
South Beaver Creek	Drainage Corridor	15 and 16		$ 11,000		$ 470,000	$ 1,000,000	$ 1,500,000			
Crescent Park	Drainage Corridor	18 to 20		$ 5,700		$ 36,000	$ 172,000	$ 440,000			
Ranch Elsie	Drainage Corridor	17		$ 4,500		$ 214,000	$ 620,000	$ 820,000			
		Total	$ 80,000	$ 130,700	$ 3,130,000	$ 3,331,000	$ 7,979,000	$ 22,190,000	$ 341,000	$ 3,200,000	$ 1,800,000

Coal Creek Master Plan

Funding and Grant Opportunities

- Grant secured through CWCB
- Pursuing opportunities through State/CDBG for catalyst project
- Expect more $$ through NRCS EWP program in future.
- Expect another wave of CDBG to fund watershed restoration, aid in formulation of a watershed coalition
- Other opportunities

Implementation Strategies

- Easements
- Drainage management
- Maintenance
- Watershed Coalition
- Strategic Partnerships

Agenda

6:00 PM to 6:45 PM
- Presentation of Consultant Team
- Introductions of Key Agencies and Role
- Planning Process
  - Timeline/ Planning Process
  - Coal Creek Watershed Overview
- Coal Creek Master Plan
  - Public Outreach - Public Survey Results and Feedback
  - Summarize Technical Data
  - Flood Resiliency
  - Overview of Project Alternatives
  - Future Opportunities for Public Comment
- Funding and Grant Opportunities
- Implementation Strategies

6:45 PM to 7:00 PM Q&A
7:00 PM to 7:30 PM Break-out Session
7:30 PM to 7:45 PM Colorado Spirits Review of Resiliency
7:45 PM to 8:00 PM CDOT/ CWCB Presentation
8:00 PM to 8:30 PM Break-out Session for Q&A with CDOT/ CWCB

Questions and Answers?

6:45 pm to 7:00 pm

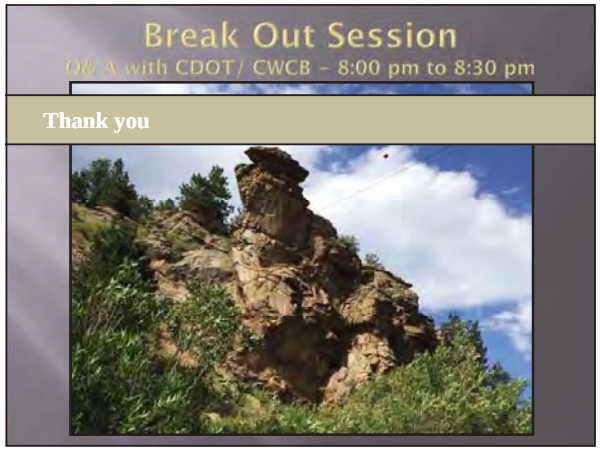
Thank you

Break Out Session

7:00 pm to 7:30 pm


Colorado Spirits
7:30 pm to 7:45 pm


CDOT/ CWCB
7:45 pm to 8:00 pm


Break Out Session
Q& A with CDOT/ CWCB – 8:00 pm to 8:30 pm
Thank you

ICON ENGINEERING, INC 8100 South Akron Street, Suite 300, Centennial, CO 80112 - Phone (303) 224-0802 / Fax (303) 224-1019

COAL CREEK MASTER PLAN
MASTER PLAN REVIEW MEETING
NOVEMBER 3, 2014 AT 2:00 PM
CCCIA

Minutes

Attendees:	Craig Jacobson,	ICON Engineering Inc. (ICON)
	Mark Wilcox,	DHM Design
	Troy Thompson	Ecological Resource Consultants
	Chris Garre,	The Environmental Group (TEG), phone
	John Conn,	Jefferson County
	Steve Harelson,	CDOT
	Jeff Crane	Crane Associates, CWCB
	Naren Tayal	FEMA
	John Baich,	Community Task Force
	Katie Knapp,	Community Task Force
	Dane Knapp,	Community Task Force
	Denise Grimm	Boulder County, phone
	Joseph Hansen	Jefferson Conservation District, phone

MEETING MINUTES

- Craig noted that the purpose of this meeting was to review the draft master plan ahead of the upcoming public meeting. This meeting will provide an overview review of the master plan, but more specifically discuss project ranking and prioritization.
- Chris explained that the final public meeting was set for Thursday, November 6th. This meeting will be combined with a report from local children who have been involved in the TEG River Watch grant program on Coal Creek. TEG also hopes to solicit help from community members in representation for the organization and with upcoming watershed coalition needs.
- Two applicable grants within the watershed were discussed. Specifically, the CWCB grant for restoration of a small area near Gap Road and Coal Creek had been discussed in detail prior to this meeting. Specifics from that meeting, included:
  - TEG will work on contracting with CWCB for the work;
  - ICON/ERC will coordinate with CDOT regarding data and survey that may be available for the site.
  - ERC/ICON/TEG/CWCB/JeffCo will continue to coordinate on scope and next steps.
- Joseph confirmed that he had not received an update on the CDBG grant along Beaver Creek since the last wave of emails, approximately a month ago.
- Jeff explained the timeline for watershed coordinators for the coalitions. He noted CWCB's goal was to have the coalitions established by the end, applications for the coordinators made in January, and the coordinators on-board by March. He mentioned that the coordinator positions are likely to be funded for a two to three year span.

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COAL CREEK MASTER PLAN
MASTER PLAN REVIEW MEETING
NOVEMBER 3, 2014 AT 2:00 PM
CCCIA

Minutes

- Craig reviewed where the alternatives meeting left off, explaining:
  - The establishment of stream versus drainage corridors,
  - Easements and management methods,
  - Resiliency levels for private infrastructure (25-year level) and public infrastructure along the key transportation routes (100-year level),
  - Review of these items at the second public open house.
- Craig then provided an overview of the master pan presentation and items included within the report, including: report sections, hydrology tables, geomorphic design information, alternative selection, prioritization, and funding opportunities. The conceptual design renderings provided for the stream corridors was also discussed, along with the master plan exhibit sheets.
- Craig explained how relevant community comments had been incorporated into the Master Plan exhibits.
- The prioritization matrix and approach to prioritization was discussed. Craig explained how project costs, mitigation priorities, and community needs were combined into to scoring matrix to distinguish individual projects along the stream corridors, which could be used for planning decisions into the future. Craig noted that the prioritization was previously presented to TEG during a progress meeting for input.
- The prioritization matrix was only done for stream corridor projects, as the drainage corridors were less distinguished between one another.
- From the prioritization, projects were categorized based on the primary entity involved, such as CDOT, Jefferson County, and private entities. Craig noted that the upcoming watershed coalition would likely be the voice for the privately led projects.
- Total costs for the stream corridors (excluding engineering and project management) were approximately $23.8 million, distributed by
  - CDOT: $13.4 million
  - Jefferson County: $1.3 million
  - Private: $9.1 million
- The total master plan costs for the entire watershed, including the drainage approached $31,000,000.
- Craig noted that the prioritization scoring allowed the team to distinguish comparison projects at the same location. As an example, even though it was more expensive, projects related to acquisition within the Community Center corridor displayed increased added value versus their flood control counterparts. Therefore, the acquisition projects were carried forward.

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COAL CREEK MASTER PLAN
MASTER PLAN REVIEW MEETING
NOVEMBER 3, 2014 AT 2:00 PM
CCCIA

Minutes

- The highest ranked project was along Beaver Creek in the area of the current CDBG grant. Craig explained that the scoring here was coincident with the grant application, although the project team did believe early on that there was a clear need at this location.
- The next highest ranked projects were within the Community Center area, followed by restoration/infrastructure projects downstream within Corridor 1.
- The lowest ranked priority was at the Coal Creek Culvert on Twin Spruce Gap Road. Although this alternative received top scores for emergency access, it scored low relative to cost, immediate needs, fundability and other values.
- In general, the group agreed with the approach to the master plan and presentation to the public.
- Dan Knapp mentioned the possibility of flood proofing the Sinclair Station, as opposed to redevelopment. The group generally agreed that that approach may out value the structure itself.
- Katie mentioned that the team should review current recommendations for the Community Center area established through recent Jefferson County planning efforts.

- END OF MEETING--

To the best of my knowledge, these minutes are a factual account of the business conducted, the discussions that took place, and the decisions that were reached at the subject meeting. Please direct any exceptions to these minutes in writing to the undersigned within ten (10) days of the issue date appearing herein. Failure to do so will constitute acceptance of these minutes as statements of fact in which you concur.

Minutes prepared by:

Craig Jacobson
ICON Engineering, Inc.

Date: November 6, 2014

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TEG The Environmental Group | ICON ENGINEERING, INC | DHM DESIGN

COMMUNITY WORKSHOP #3 - SIGN-IN SHEET

Project Name: Coal Creek Watershed Master Plan
Date: November 6, 2014

Name	Address / Organization	Contact Information
S. LINK	28170 Hwy 72 Golden	Phone: 303 642 0898 E-mail:
MIKE NICOLELLA	28620 Hwy 72	Phone: 303-642-0479 E-mail:
KT. Nicolella	" " "	Phone: E-mail: nicolktn@Gmail.com
Kirsten Springer	31746 Lillis Ct	Phone: 970 389 4833 E-mail: kirstenspringer58@gmail.com
John Conn	Jefferson County	Phone: 303-271-8496 E-mail: JCONN@JEFFCO.US
Tony Sarvu	386 Church Golden	Phone: 303-642-9642 E-mail:
Bruce Bevint	Environmental Investigations	Phone: 3 642 3565 E-mail:
Cindy Pieropan	Bldr County	Phone: 3.441 3906 E-mail: CPieropan@bouldercounty.org
JANE + MIKE MARSOLEK	11143 TWIN SPRUCE Jeffco	Phone: 3129 E-mail: marsolek@q.com
John J Baich	30879 Jarvis Drive Golden, CO 80403	Phone: jjbaich@gmail.com E-mail:
Dan Cross	3927 SYLVAN RD GOLDEN, CO 80403	Phone: 303 642 - 3839 E-mail: dscross@q.com
Suzy Schemel	CCCIA	Phone: - 7300 E-mail: Schemel@q.com
BRANDI MCCARTY		Phone: E-mail:
JODY DICKSON	621 DIVIDE VIEW TER GOLDEN, CO 80403	Phone: 303-642-3568 E-mail: JODY@DICKSON.ORG
Bambi Hansen		Phone: E-mail:
Adam Walter		Phone: E-mail:
George Lehmkuhl		Phone: E-mail:

11/10/2014

Consultant Team:

ICON ENGINEERING, INC
Ecological Resource Consultants, Inc.
DHM DESIGN

Craig D. Jacobson, PE, CFM
Principal, Project Manager

Troy Thompson, PE
President, Sr. Water Resource Engineer

Mark Wilcox, RLA, ASLA
Principal

Partnerships and Project Stakeholders:
TEG, CWCB, Jefferson County, Boulder County, CDOT, FEMA, NRCS, Jefferson Conservation District……..Canyon Community (Public)

Agenda

6:00 PM to 6:30 PM

- Presentation by Consultant Team
- Introductions of Key Agencies and Role
- Planning Process
  - Timeline/ Planning Process
  - Coal Creek Watershed Overview
- Coal Creek Master Plan
  - Public Outreach - Public Survey Results and Feedback
  - Summarize Technical Data
  - Flood Resiliency
  - Summarize Project Corridors and Approach to Alternatives
  - Project Selection and Prioritization
- Implementation Strategies
- Funding and Grant Opportunities

Key Agencies and Roles

TEG

CWCB

CDOT

Jefferson County

Colorado Spirit

Jefferson Conservation District

FEMA

Planning Process

Timeline

- Task 1 – Public Engagement, Coordination, Reporting- Ongoing
  - First Public Meeting – May 29, 2014
- Task 2 – Stream Corridor Evaluations – Complete
- Task 3 – Flood, Ecosystem, and Geomorphic Risk Assessment - Complete

Planning Process

Timeline

- Task 5 – Conceptual Design - October
  - - Community Meeting #3 to review master plan – November 6, 2014

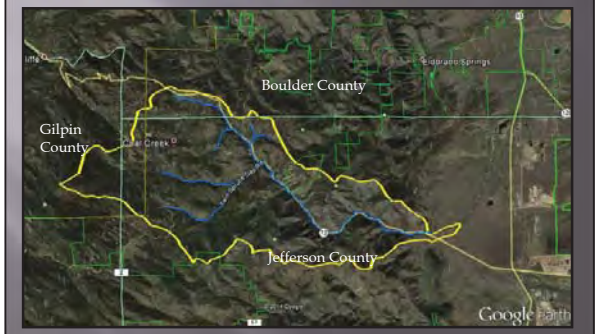
Planning Process

Timeline

- Task 4 – Mitigation Strategies - June/July
  - DRAFT Master Plan August 2014

- Community Meeting #2 to review draft alternates and incorporated community feedback – August 20, 2014

Coal Creek Watershed



Coal Creek Watershed

- Characteristics
  - Watershed Basin Area – 15 sq mi
  - Main Channel – 8 mi
- Communities
  - Coal Creek Canyon / Wondervu
  - Jefferson County
  - Areas of Boulder & Gilpin Counties
- Other Entities
  - Jefferson Conservation District
  - Coal Creek Canyon Parks and Recreation
- No FEMA defined floodplains

September 2013 – Flood Event

Coal Creek Master Plan

- Plan for Resiliency and Stability within Watershed:
- Multiple Objectives Including:
  - Identify long term risk, susceptibility;
  - Immediate impacts and needs
  - Stream stabilization
  - Floodplain management
  - Ecological health
  - Transportation
  - Recreation
  - Public safety
  - Aesthetics
- Collaborative Effort
- Prioritization and Funding

Coal Creek Master Plan

Coal Creek Master Plan

- Stream Corridors:
  - Coal Creek – Ranch Elsie through Coal Creek Canyon;
  - Beaver Creek - Joanie Drive through Coal Creek
- Drainage Corridors:
  - Coal Creek – Upstream of Ranch Elsie;
  - Beaver Creek - Upstream of Joanie Drive;
  - South Beaver Creek – Upstream of Joanie Drive;
  - Ranch Elsie Tributary;
  - Crescent Park Tributaries.

Coal Creek Master Plan

- Stream Corridors:
  - Reaches with larger contributing basin;
  - More constant base flow;
  - Higher flood discharges;
  - Stream characteristics suitable for riparian habitat and ecological enhancement;
  - Most damaged in September flood;
  - Remain the most susceptible to future flooding.
  - Require a larger corridor width to manage geomorphic and flood discharges.
  - Require consistent management .

Coal Creek Master Plan

- Goal for Stream Corridors:
  - Public Safety –needs for additional flood warning measures
  - Corridor management and maintenance –existing maintenance needs and future easements.
  - Stream restoration – establish channel dimensions per geomorphic recommendations.
  - Erosion setbacks- minimize risk through zoning changes for future development.
  - Environment and ecology –ecological restoration, water quality testing or treatment.

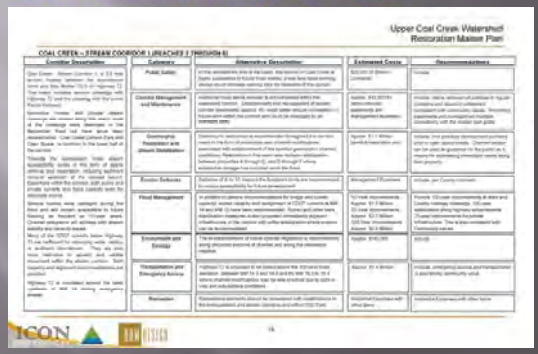
Coal Creek Master Plan

- Goal for Stream Corridors (continued):
  - Flood management – address capacity deficiencies in bridges/culverts and stabilization measures to protect infrastructure;
  - Transportation and Emergency access – maintain access through major roadway corridors;
  - Recreation –identification of new or expended recreation needs.

Coal Creek Master Plan

- Drainage Corridors:
  - Smaller predominately dry throughout the year;
  - Less diversity;
  - Less flood risk to buildings and infrastructure;
  - Principle issues relate to capacity and conveyance
- Drainage Corridor Goals:
  - Corridor management and maintenance –Identify maintenance needs;
  - Flood management – address capacity deficiencies in bridges/culverts and stabilization

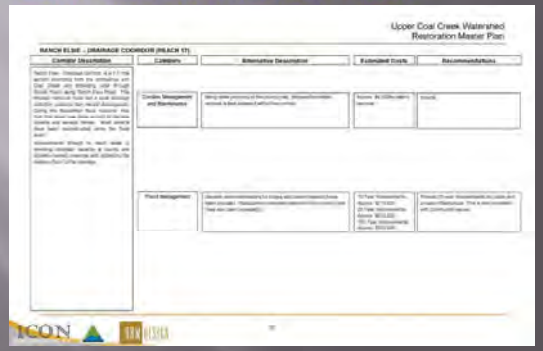
Coal Creek Master Plan



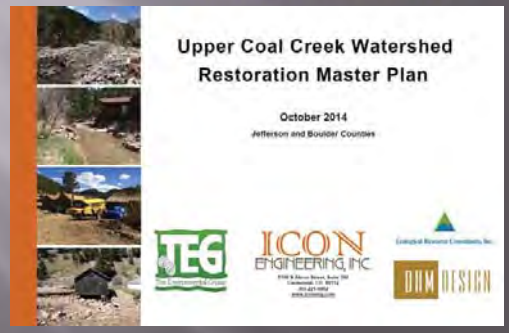
Coal Creek Master Plan

Coal Creek Master Plan

Coal Creek Master Plan



Coal Creek Watershed Master Plan



Coal Creek Master Plan

Summary of Costs for Master Plan:

River	Corridor	Reaches	Safety	Debris removal	Geomorphic Restoration	Flood Management 10-yr	Flood Management 25-yr	Flood Management 100-yr	Environment	Transportation	Acquisition
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Coal Creek Watershed Master Plan

General Background:

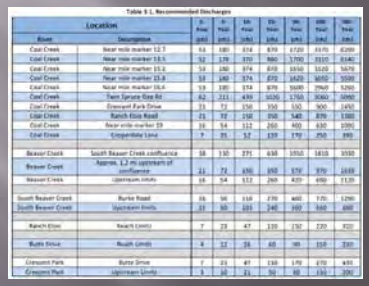
2.3 September 2013 Flood Event

As noted previously, the rainfall event on September 12, 2013, was unprecedented in the Coal Creek watershed. Damage throughout the corridor was widespread. In particular, downstream of Twin Spruce Gap Road, nearly every access culvert failed, was washed out, or was significantly damaged. The channel eroded significantly, leading to visible scour through the La Duwalk Estates and other central residential corridors. Highway culverts also plugged with debris, further exasperating flooding effects on the highway and downstream infrastructure. The culvert crossing at the Union Pacific Railroad (UPRR) did manage to pass the peak flows; however, a sedimentation zone was formed in the valley upstream of the culvert, where much of the eroded material was deposited. With the exception of the old Real Estate building at Twin Spruce Gap Road, no homes or buildings were destroyed in this area, although some were badly damaged. This building has since been demolished, and the land acquired by the Colorado Department of Transportation (CDOT).

Photo 1 – West of Twin Spruce Gap Road on Highway 72

Coal Creek Watershed Master Plan

Hydrologic Data:



Coal Creek Watershed Master Plan

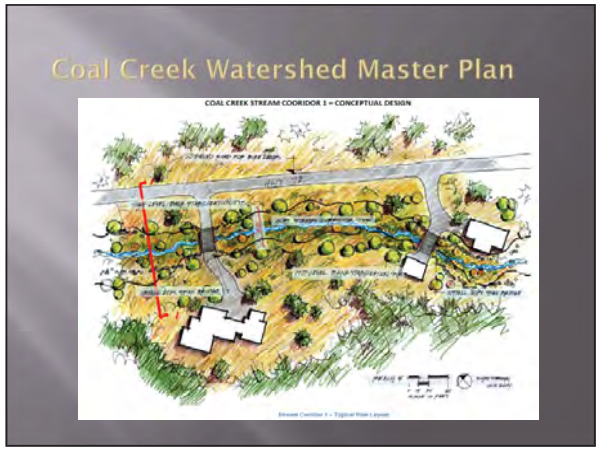
Natural Resource Guidelines:

Coal Creek Watershed Master Plan

Geomorphic Information / Channel Requirements:

Coal Creek Watershed Master Plan


Coal Creek Watershed Master Plan
Coal Creek Master Plan
Corridor 4 - Reach 12


Coal Creek Watershed Master Plan
COAL CREEK STREAM COORIDOR 1 – CONCEPTUAL DESIGN


Coal Creek Watershed Master Plan
Coal Creek Master Plan


Coal Creek Watershed Master Plan
COAL CREEK STREAM COORIDOR 1 – CONCEPTUAL DESIGN

11/10/2014

Coal Creek Watershed Master Plan

Coal Creek Watershed Master Plan

Coal Creek Watershed Master Plan

Coal Creek Watershed Master Plan

Coal Creek Watershed Master Plan

Project Prioritization

Identifier | Relative Cost | Primary Mitigation Value | Community Value | Score/ Rank | Entity

Coal Creek Watershed Master Plan

Project Prioritization

			Relative Cost Comparison				
Reach	ID	Project Description	Length (mi)	Cost ($)	Cost per mi ($/mi)	Score	Value (2Major)
1	A	Stream Restoration	0.10	$ 39,028	$ 390,279	10	200
2	A	Stream Restoration & Bank Stabilization	0.87	$ 404,332	$ 464,748	10	200
3	A	Stream Restoration & Bank Stabilization downstream of CO 72	0.70	$ 321,845	$ 459,612	10	200
3	B	Replace CO 72 Culvert at MM 14	0.02	$ 1,440,000	$ 72,000,000	0	0
3	C	Stream Restoration, Bank Stabilization, Culvert Improvements upstream of CO 72	0.87	$ 1,120,124	$ 1,027,384	2	40
4	A	Stream Restoration & Bank Stabilization to MM 14.4	0.13	$ 114,517	$ 880,902	8	160
4	B	Stream Restoration, Bank Stabilization, Culvert Improvements MM 14.5 to MM 15	0.43	$ 411,599	$ 957,114	8	160
4	C	Replace CO 72 Culvert at MM 15	0.02	$ 1,440,000	$ 72,000,000	0	0
4	D	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15 to MM 15.2	0.21	$ 509,204	$ 2,415,589	1	80
4	E	Elevate CO 72, MM 14.4 to MM 14.9	0.45	$ 1,548,360	$ 3,440,800	2	40
5	A	Stream Restoration, Bank Stabilization, Culvert Improvements MM 15.2 to MM 15.8	0.52	$ 1,793,912	$ 3,430,600	2	40
5	B	Elevate CO 72, MM 15.3 to MM 15.4	0.10	$ 293,250	$ 2,932,500	3	60

Project Prioritization

Primary Mitigation Needs

Flood Risk			Geomorphic Risk			Ecology & Habitat		
Existing Score	Proposed Score	Value (80pts)	Existing Score	Proposed Score	Value (80pts)	Existing Score	Proposed Score	Value (40pts)
2	2	0	4	3	8	6	10	16
2	2	0	7	4	24	4	10	24
1	1	0	5	3	16	4	6	8
5	1	32	9	4	40	0	2	8
9	3	48	9	5	32	4	10	24
2	2	0	10	6	32	0	6	24
5	3	16	9	5	32	0	6	24
5	1	32	10	5	40	0	2	8
5	3	16	8	3	40	0	6	24
3	1	16	4	3	8	0	0	0
7	3	32	8	3	40	4	10	24
3	1	16	4	3	8	0	0	0

Public Outreach – Awareness

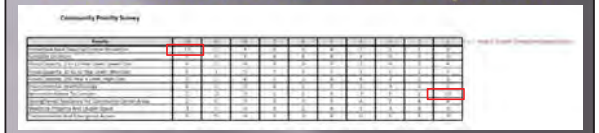
- Community involvement within planning process
- Opportunity for comment and feedback at public meetings
- Community fliers
- Notice of events posted at CCCIA, Mountain Messenger, message board
- https://www.facebook.com/pages/Upper-Coal-Creek-Watershed/682218348481990
- www.uppercoalcreek.com
- www.tegcolorado.org
- Other?

Project Prioritization

Community Values

Addresses Immediate Needs		Presents a Feasible Solutions		Improves Transportation and Emergency Access		Community Ecological Value		Protects Private Infrastructure		Community Center Value		Recreation	
Score	Value (100pts)	Score	Value (90pts)	Score	Value (80pts)	Score	Value (30pts)	Score	Value (30pts)	Score	Value (30pts)	Score	Value (10pts)
Stream Corridor 1 (Reaches 1 through 5)													
1	10	1	9	1	8	4	12	0	0	0	0	0	0
1	10	1	9	1	8	3	18	0	0	0	0	0	0
1	10	1	9	1	8	2	6	0	0	0	0	0	0
9	90	10	90	10	80	7	6	10	30	5	15	5	5
9	90	8	72	3	24	6	18	10	30	10	30	5	0
4	40	4	36	0	0	3	18	5	0	5	15	0	0
3	30	6	54	3	24	6	18	10	30	3	15	0	0
5	50	10	90	10	80	7	6	10	30	5	15	5	5
3	30	8	72	8	64	6	18	10	30	10	30	0	0
0	0	10	90	10	80	0	0	10	30	5	15	5	5
9	90	8	72	8	64	6	18	10	30	10	30	0	0
0	0	10	90	10	80	0	0	10	30	5	15	5	5

Public Outreach – Participation



Public Outreach – Feedback

Consultant Team Questions

CDOT Questions

Project Prioritization

Project Prioritization

Funding Needs by Entity

CDOT Led - $13,400,000

County Led - $1,300,000

Private Led - $9,100,000

NEXT STEPS

Immediate Actions

- Identify the key staff project coordinators / projects
- Develop leadership ,partnerships, and community support!
- Refine a schedule and "roster of projects" for logical phased implementation of the projects identified.
- Develop a detailed cost estimate, preliminary designs, and environmental impact assessments for a 2015 or 2016 pilot project.
- Work to promote Canyon Restoration projects and build liaisons with key community stakeholders.
- Immediately pursue negotiation of rights-of-way along the corridor as necessary.
- Pursue state, and federal funding in the next grants rounds.

Funding and Grant Opportunities

- Grant secured through CWCB
- Pursuing opportunities through State/CDBG for catalyst project
- Expect more $$ through NRCS EWP program in future.
- Expect another wave of CDBG to fund watershed restoration, aid in formulation of a watershed coalition

Funding and Grant Opportunities

- Other Opportunities for Funding:
  - FEMA
  - NPS
  - Resiliency Planning Grants
  - GOCO
  - State Conservation Programs
  - Wildlife & Habitat Resources
  - Stream Restoration & Wetlands
  - Clean Water / EPA
  - Community Grants
  - Federal Highways
  - Private sector interests
  - Many more grants to come!

NEXT STEPS

Leadership / Partnerships / Coal Creek Canyon Watershed Coalition

- Advocate for community and property owners
- Assemble partnerships to make projects happen
- Gather resources and funding
- Become a vital community resource!
- Hiring a Watershed Manager

Questions and Answers?

Thank you

APPENDIX E

COAL CREEK CHANNEL MORPHOLOGY REPORT

Ecological Resource Consultants, Inc.
35715 US Hwy. 40, Suite D204 ~ Evergreen, CO ~ 80439 ~ (303) 679-4820

Technical Memorandum

Date: July 30, 2014

To: ICON Engineering

From: Troy Thompson/Ryan Hummel, ERC

Re: Coal Creek Channel Morphology Report

Introduction

Ecological Resource Consultants, Inc. (ERC) evaluated channel morphology as an integral component of assessing post-flood conditions and defining objectives for potential restoration work. The purpose of the analysis was to establish conditions of the Coal Creek drainage both prior to and after the flooding and to define key geomorphic guidelines that can be used for future remediation. The study includes the main stem of Coal Creek and its major tributaries from the basin headwaters downstream to the overall master plan study limits.

The assessment focused on defining general characteristics of the drainage as they relate to stream conditions and channel morphology. Information regarding typical channel conditions was used to define typical channel geometries and features to guide future channel improvements.

Stream Classification

Stream types were determined based on aerial mapping for the full length of Coal Creek at its major tributaries using Google Earth (2013). The Rosgen stream classification system was selected for this initial assessment and is a widely used framework that defines eight Level I stream types on the basis of geomorphic characteristics including single thread or multiple channel condition, channel slope, sinuosity, width/depth ratio, and entrenchment ratio. Level I stream types are identified by letters, such as A, B, and C. The classification system integrates geomorphic pattern with predominate bed material to define 42 Level II stream types, identified by letters and numbers, such as B3, C3, C4, etc. (Rosgen 1996). Numbers one through six are used to sequentially describe bedrock, boulders, cobble, gravel, sand, and silt and clay as the predominate bed material.

All stream type classification for this report was completed as a desktop study using available aerial imagery and reconnaissance level field assessments. A true Level I classification requires defining a stream's entrenchment ratio and its width/depth ratio, which cannot be accurately determined from aerial images. The Level I stream classifications completed for this assessment were defined based on desktop analysis of large regions where stream slope and sinuosity were determined. Entrenchment and width/depth ratios were not determined from this analysis thereby limiting the detail of results. Given the limitations of defining stream types purely from aerial imagery, stream sinuosity, slope and single versus multiple thread streams were the parameters that were considered for this assessment. As a

result, stream segments with sinuosity less than 1.2 were defined as either Stream Type A or D based on whether they were multiple or single thread systems. Stream segments with sinuosity greater than or equal to 1.2 were defined as Type B if their slopes were between 0.02 and 0.04 and they were a single thread channel. Stream segments were defined as Type C if their sinuosity was greater than or equal to 1.2 and their slopes were between 0.001 and 0.02 and were a single thread channel. Segments were defined as Type D if they were a multiple thread channel with a slope with high sinuosity. Stream Types E, F, and G were not used in this analysis as entrenchment ratio and width/depth ratio are needed to differentiate those stream types from the others. For this reason, the stream types defined in this report should be considered indicators of the stream type only and may not meet all criteria for assigned stream type.

Sediment sampling was not completed as part of the master plan evaluation, however observation of the stream suggests that a majority of stream segments are dominated by larger substrate including bedrock, boulders and other coarse alluvial materials.

ERC conducted a Level I assessment of Coal Creek and its major tributaries within the study area based on the classification method and limitations described above. The assessment considers the slope, sinuosity, and shape of a channel to characterize the stream type. All reaches of Coal Creek were determined by ERC to fall within the Aa+, A, B, or C stream types. All stream segments were found to be predominately single thread channels, so no Type D segments were identified. The results of this Level I assessment are provided in **Tables 1-8**, which provides measured and computed results for different reaches. The river stationing used in the tables begins at the downstream end of the study area and increases in the upstream direction, and is based on the cross-section stationing provided to ERC by ICON. The sinuosity of each reach was determined by dividing the length of the stream reach by the length of the valley the stream flows through. The average slopes were calculated by dividing the change in elevation in each reach by the horizontal length of the stream reach.

As the tables demonstrate, 18 different stream segments were classified within the study area. Individual reaches were delineated based on physical features, as defined by the Rosgen Classification System. The 18 stream segments include one tributary segment along Ranch Elsie Road, four segments along Crescent Park Drive and Butte Drive, six total segments on Beaver/South Beaver Creek and seven segments on the main stem of Coal Creek. As shown in **Table 1**, the downstream-most reach of Coal Creek did not fit within the classification of any stream type due to its combination of low slope and low sinuosity. For the purposes of this report, ERC classified this stretch as a Type C stream. It is ERC's belief that slope is the more dominant factor in this assessment compared to sinuosity, especially in this type of desktop study where streamside vegetation can make it difficult to follow the stream path from aerial imagery.

The location of each of the different stream segments with the resultant stream classification is presented on **Figure 1** with color coding used to identify different stream types.

Table 1 – Level I Stream Assessment Results for Coal Creek

Stream Station (ft)	Reach Length (ft)	Valley Length (ft)	Start Elev (ft)	End Elev (ft)	Average Slope (ft/ft)	Sinuosity	Stream Type
41,928 to 38,316	3,612	3,400	8,271	7,971	0.083	1.06	A
38,102 to 19,450	18,652	15,580	7,955	7,364	0.032	1.20	B
19,302 to 9,283	10,019	8,874	7,357	6,884	0.047	1.13	A
9,153 to 8,084	1,069	886	6,882	6,849	0.031	1.21	B
8,024 to 3,724	4,300	3,880	6,843	6,624	0.051	1.11	A
3,623 to 397	3,226	2,502	6,622	6,498	0.039	1.29	B
288 to 54	234	228	6,496	6,492	0.019	1.03	C

Table 2 – Level I Stream Assessment Results for Beaver Creek Above the S. Beaver Creek Confluence

Stream Station (ft)	Reach Length (ft)	Valley Length (ft)	Start Elev (ft)	End Elev (ft)	Average Slope (ft/ft)	Sinuosity	Stream Type
8,847 to 3,941	4,906	4,620	8,514	8,227	0.059	1.06	A
3,768 to 1,297	2,471	2,390	8,210	7,885	0.131	1.03	Aa+
1,146 to 274	872	814	7,867	7,795	0.082	1.07	A

Table 3 – Level I Stream Assessment Results for Beaver Creek Below the S. Beaver Creek Confluence

Stream Station (ft)	Reach Length (ft)	Valley Length (ft)	Start Elev (ft)	End Elev (ft)	Average Slope (ft/ft)	Sinuosity	Stream Type
4,064 to 113	3,951	3,114	7,773	7,625	0.038	1.27	B

Table 4 – Level I Stream Assessment Results for S. Beaver Creek Above the Beaver Creek Confluence

Stream Station (ft)	Reach Length (ft)	Valley Length (ft)	Start Elev (ft)	End Elev (ft)	Average Slope (ft/ft)	Sinuosity	Stream Type
14,353 to 9,554	4,799	4,710	8,617	8,125	0.102	1.02	Aa+
9,253 to 4,108	5,145	5,045	8,104	7,777	0.064	1.02	A

Table 5 – Level I Stream Assessment Results for Ranch Elsie Drive

Stream Station (ft)	Reach Length (ft)	Valley Length (ft)	Start Elev (ft)	End Elev (ft)	Average Slope (ft/ft)	Sinuosity	Stream Type
3,722 to 70	3,652	3,342	8,026	7,781	0.067	1.09	A

Table 6 – Level I Stream Assessment Results for Butte Drive

Stream Station (ft)	Reach Length (ft)	Valley Length (ft)	Start Elev (ft)	End Elev (ft)	Average Slope (ft/ft)	Sinuosity	Stream Type
2,919 to 867	2,052	1,845	7,950	7,739	0.103	1.11	Aa+

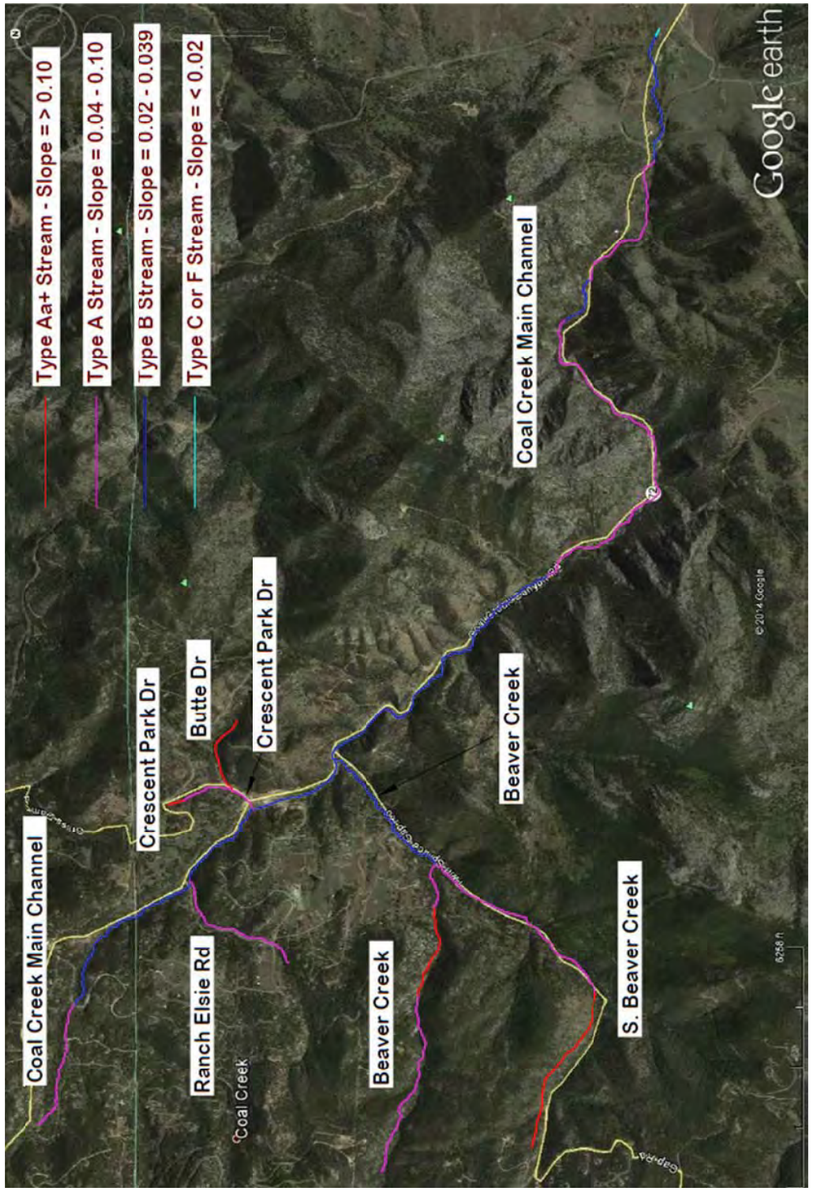
Table 7 – Level I Stream Assessment Results for Crescent Park Drive Above Butte Drive Confluence

Stream Station (ft)	Reach Length (ft)	Valley Length (ft)	Start Elev (ft)	End Elev (ft)	Average Slope (ft/ft)	Sinuosity	Stream Type
1,747 to 1,275	472	440	7,884	7,831	0.111	1.07	Aa+
1,130 to 250	880	852	7,819	7,751	0.077	1.03	A

Table 8 – Level I Stream Assessment Results for Crescent Park Drive Below Butte Drive Confluence

Stream Station (ft)	Reach Length (ft)	Valley Length (ft)	Start Elev (ft)	End Elev (ft)	Average Slope (ft/ft)	Sinuosity	Stream Type
124 to 196	891	802	7,742	7,702	0.046	1.11	A

Figure 1 – Stream Classification Results



The four stream types that were found to occur based on the Level I analysis are Types Aa+, A, B and C. Generic descriptions of each of these four stream types is given below:

Type Aa+

Stream Type Aa+ streams are defined as "very steep, deeply entrenched, cascading, debris transport, torrent streams," that have high relief and typical bedforms containing chutes, debris flows, and waterfalls (Rosgen 1996). Type Aa+ streams are steeper than Type A streams (average slopes greater than 0.10 ft/ft), and may have lower sinuosity (between 1.0 and 1.1). **Photo 1** gives a representative example of a portion of a Type Aa+ channel that was observed in the study area.

Photo 1 – Type Aa+ Tributary to Coal Creek

Type A

Stream Type A streams are defined as "steep, entrenched, cascading, step/pool streams," with high energy and high debris-transport potential (Rosgen 1996). Type A streams are steeper than Types B and C (average slopes between 0.04 and 0.10 ft/ft), and have slightly lower sinuosity (between 1.0 and 1.2). The meander width ratio of Type A streams typically ranges between 1 and 3 (Rosgen 1996). **Photo 2** gives a representative example of a portion of a Type A channel that was observed at Coal Creek.

Photo 2 – Type A Section of Coal Creek

Type B

Type B streams are defined as having "moderately entrenched, moderate gradient, riffle-dominated channels, with infrequently spaced pools" (Rosgen 1996). The plan, profile, and banks of Type B streams are all considered to be stable. The sinuosity of these stream types are greater than 1.2, with an average slope between 0.02 and 0.039 ft/ft, and a typical meander width ratio between 2 and 8. Type B streams are usually seen in narrower, steeper valleys than Type C streams, and contain colluvial deposition in the reach. Rapids and scour pools are characteristic of Type B streams. **Photo 3** gives a representative example of a portion of a Type B channel that was observed at Coal Creek.

Photo 3 – Type B Section of Coal Creek

Type C

A Rosgen Type C stream is typically characterized as being a "low gradient, meandering, point-bar, riffle/pool, alluvial channel with broad, well-defined floodplains" (Rosgen 1996). Type C streams have a sinuosity greater than 1.2, an average slope less than 0.02 feet per foot (ft/ft), and a meander width ratio (i.e., meander belt width divided by stream bankfull width) typically between 4 and 20. These streams are slightly entrenched with well-defined meandering channels and the floodplains typically consist of alluvial soils. No photos were taken on Coal Creek or its tributaries of a Type C reach, although as was seen in **Figure 1**, the only stretch of Type C stream in the project area is the very downstream section of the stream (about 234 feet long, from **Table 1**).

Aerial Photographic Analysis

Aerial images of Coal Creek, its tributaries, and the land surrounding the stream were evaluated to understand any macroscopic changes in channel morphology that may have occurred as a result of the 2013 flood event. For this analysis, aerial photos depicting the stream corridor taken prior to the flood were compared to aerial photos taken after the flood. Post flood aerials are based on imagery dated October 2013 while pre-flood images show conditions as of October 2012. Changes, which are presumed to be a result of the flood, were noted. Observed trends are discussed below. **Appendix A** provides a side-by-side comparison of pre- versus post-flood conditions based on these aerials. Some of the post-flood condition images are annotated with numbers. These numbers refer to the location of photographs taken during the post-flood site inspection conducted by ERC. These photographs, labeled with the corresponding numbers form **Appendix A**, are provided at the end of this report in **Appendix B**.

Because the flood event occurred in September 2013, which was only one month before the post-flood condition aerial imagery was taken, comparing the pre- and post-flood condition aerial photos allows for a better understanding of the immediate damage caused by the flooding. The most noticeable change seen in the post-flood photos is scouring and vegetation loss along the stream. At several locations along Coal Creek, especially downstream from its confluence with Beaver Creek, the stream itself is not visible in the pre-flood condition aerials due to being obscured by the vegetation along the stream, however much of this vegetation was removed and transported by the event, causing the post-flood condition photos to clearly show much more of the stream and provide evidence of the channel and its banks having been scoured by the event.

Another noticeable change in the post-flood condition photos is damage to roadways, particularly driveways crossing the creek. Several residential structures exist along Highway 72 with Coal Creek running between the structures and the highway, and the post-flood aerial photos show many of the driveways crossing the creek to allow access to these structures were damaged or completely destroyed by the flooding. This type of damage is also observable along Twin Spruce Gap Road, where several driveways crossing Beaver Creek were demolished by the high flows. Several instances of this damage can be seen from the photographs in **Appendix B**, which were taken in the spring of 2014 and show the state of these access points many months after the flood. Deterioration to Highway 72 is also seen in the post-flood condition aerial photos, especially on the highway's shoulders in locations where the stream flows close to the road, and significant damage to the highway took place at its junction with Crescent Park Drive. This damage appears to have been caused by high flows in the tributaries running alongside Butte Drive and Crescent Park Drive, and not Coal Creek itself.

Moving upstream along Coal Creek, especially upstream of its main tributaries, the aerial photos show much less flood damage than the downstream reaches of the creek. Many of the images presenting the

upstream reaches of the creek in **Appendix A** have very little observable changes between the pre- and post-flood conditions.

Typical Channel Geometries

Information on channel classification along with estimated flows were used to approximate natural channel geometries along the length of 20 stream locations with flow estimates. Locations of these flow segments are shown in **Figure 2**. Bankfull flows, which were approximated using the 2-year flow, were used to help estimate the geometry of the active channel. Typical values of width to depth ratios (width of the stream at bankfull conditions divided by the bankfull stream depth) and entrenchment ratios (width of the stream channel for a depth that is twice the bankfull width divided by the bankfull stream width) were used to help approximate natural channel geometry.

For each of these 20 locations with flow estimates, the bankfull flows were used in combination with channel types to define typical channel geometries. This information is provided in **Table 9**. Primary and secondary stream classifications refer to stretches of Coal Creek or its tributaries where the downstream reach from one flow location to next one contains multiple stream types. The primary classification represents the type of stream that most of the reach would be classified as, and the secondary classification is the stream type observed in the rest of the reach. Target width/depth ratios and entrenchment ratios used to establish standard channel geometries are provided in **Table 10**.

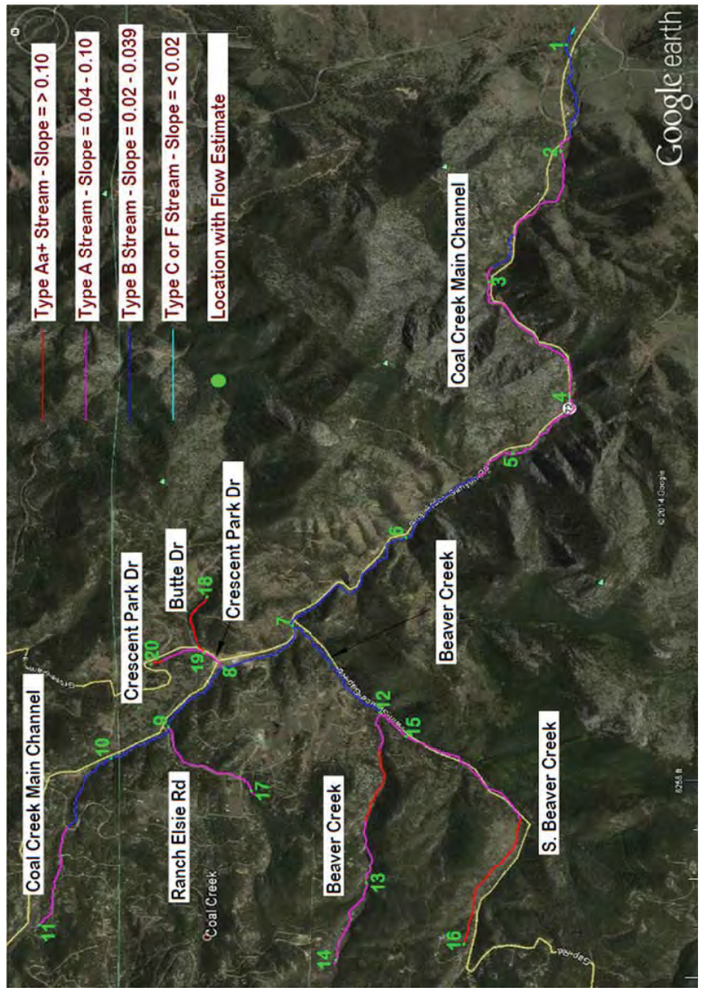
Table 9 – Bankfull Flows and Stream Classifications at Locations with Estimated Flows

Flow Location	Bankfull Flow (cfs)	Primary Stream Classification	Secondary Stream Classification
1	53	B	C
2	52	B	A
3	53	A	B
4	53	A	NA
5	53	A	NA
6	53	B	A
7	62	B	NA
8	21	B	NA
9	21	B	NA
10	16	B	NA
11	7	A	B
12	38	B	NA
13	21	A	Aa+
14	16	A	NA
15	16	A	NA
16	15	A	Aa+
17	7	A	NA
18	4	Aa+	NA
19	7	A	NA
20	3	A	Aa+

Table 10 – Target Slope Ranges, Width/Depth Ratios, and Entrenchment Ratios for Each Stream Classification

Stream Classification	Slope Range	Width/Depth Ratio	Approximate Entrenchment Ratio
Aa+	>10%	<12	1.2
A	4% - 10%	<12	1.3
B	2% - 4%	>12	1.8
C	0.1% - 2%	>12	3

Figure 2 – Stream Classification Results along with Locations of Flow Estimates



Normal flow calculations were made to define the channel size where bankfull flow, channel slope, width/depth ratios and entrenchment ratios met the typical criterion described above. Given the range of slopes associated with each stream type, a range of channel geometries was determined. Manning's equation was used for normal flow calculations and the Manning's n value for each stream type was estimated using Jarrett's equation (Jarrett 1985), with a single value selected for each stream type. A Manning's n value of 0.16 was used for Type Aa+ streams, 0.11 was used for Type A streams, 0.09 was used for Type B streams and 0.07 was used for Type C streams. Note that these values are believed to provide reasonable estimates for flow calculations at bankfull flow levels and below but are not applicable when evaluating water surface profiles during peak flood flows.

A summary of recommended geometries for each primary channel type, within each individual reach is given in **Table 11**. **Table 12** provides the same information for secondary channel types that exist in some of the reaches. These tables can be used to define the approximate channel geometries throughout the basin. All channel sections are assumed to be generally trapezoidal with a base width that is defined by the column "Base (ft)".

Table 11 – Geometries for Primary Stream Types at Each Flow Location

		Minimum Slope Range					Maximum Slope Range				
Flow Location	Stream Type	Slope (%)	Base (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Width at 2x Bankfull Depth (ft)	Slope (%)	Base (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Width at 2x Bankfull Depth (ft)
1	B	2%	15	18	1.3	32	4%	13	15	1.1	27
2	B	2%	15	18	1.3	32	4%	13	15	1.1	27
3	A	4%	12	15	1.3	20	10%	10	12	1.1	16
4	A	4%	12	15	1.3	20	10%	10	12	1.1	16
5	A	4%	12	15	1.3	20	10%	10	12	1.1	16
6	B	2%	15	18	1.3	32	4%	13	15	1.1	27
7	B	2%	16	19	1.4	34	4%	14	17	1.2	31
8	B	2%	11	13	0.9	23	4%	9	11	0.8	20
9	B	2%	11	13	0.9	23	4%	9	11	0.8	20
10	B	2%	8	10	0.9	18	4%	7	9	0.8	16
11	A	4%	4	6	0.8	8	10%	4	6	0.6	8
12	B	2%	13	15	1.1	27	4%	12	14	1	25
13	A	4%	8	10	1	13	10%	6	8	0.9	10
14	A	4%	7	9	0.9	12	10%	5	7	0.8	9
15	A	4%	7	9	0.9	12	10%	5	7	0.8	9
16	A	4%	7	9	0.9	12	10%	5	7	0.8	9
17	A	4%	4	6	0.8	8	10%	4	6	0.6	8
18	Aa+	10%	3	4	0.6	5	15%	3	4	0.6	5
19	A	4%	4	6	0.8	8	10%	4	6	0.6	8
20	A	4%	3	4	0.6	5	10%	2	3	0.5	4

Table 12 – Geometries for Secondary Stream Types at Each Flow Location

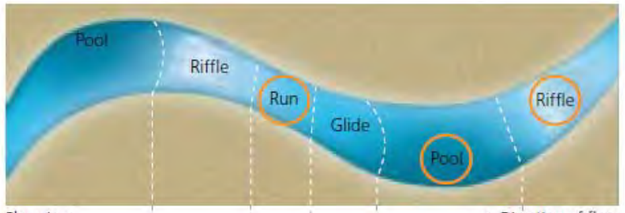
		Minimum Slope Range					Maximum Slope Range				
Flow Location	Stream Type	Slope (%)	Base (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Width at 2x Bankfull Depth (ft)	Slope (%)	Base (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Width at 2x Bankfull Depth (ft)
1	C	1%	17	20	1.3	60	2%	14	16	1.2	48
2	A	4%	12	15	1.3	20	10%	10	12	1.1	16
3	B	2%	15	18	1.3	32	4%	13	15	1.1	27
4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	A	4%	12	15	1.3	20	10%	10	12	1.1	16
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	B	2%	7	8	0.6	14	4%	6	7	0.5	13
12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13	Aa+	10%	6	8	1.1	10	15%	5	7	1.1	8
14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	Aa+	10%	5	7	1	8	15%	4	6	1	7
17	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
19	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
20	Aa+	10%	3	4	0.6	5	15%	3	4	0.6	5

These tabulated values provide average channel geometry information, but it is not the intent nor is it desired that the channel take on a uniform, defined cross section. Variability is inherent in any natural system and is desired for improvements along Coal Creek.

In addition to variability in cross section, variability in channel slopes is a characteristic of natural channels. Features such as step pools, scour pools, rapids and riffles/pool sequences occur naturally and provide variety from both a habitat and aesthetic standpoint.

Riffle/pool sequences are alternating stretches of shallow, fast-moving sections (riffles) and deeper, slower pools, with glides or runs in between the end of a pool and beginning of the next riffle to allow for gradual bedform transformation. Riffle/pool sequences are typical bedforms seen in meandering, Type C streams (Rosgen 1996). A schematic of a riffle/pool sequence, along with glides and runs, is shown below in **Figure 3** (obtained from the Public Works Research Institute's Aquatic Restoration Research Center, 2004). A photo of a riffle and pool sequence on a stream is shown in **Figure 4** (public domain, 2007).

Figure 3 – Riffle/Pool Schematic



Zone	Riffle	Run	Glide	Pool
Water depth	Shallow	Shallow	Rather deep	Deep
Water surface	Whitecaps	Wrinkles	Calm	Calm
Current velocity	Very fast	Fast	Slow	Very Slow
River bed	Lying loosely on the top	Embedded	Sand and gravel	Sand and mud

Figure 4 – Example of Riffle/Pool Sequence

Rapids and scour pools are typical bedforms of Type B streams (Rosgen 1996). These bedforms have steeper gradients than riffle/pool sequences and larger bed material. This results in a rougher water surface in the rapids section as water crashes over boulders and cobbles in the channel bed, and irregularly-located scour pools, sometimes called pocket water, exist between the rapids. **Figure 5** shows an example of rapids and scour pools in a stream (image obtained from Deneki Outdoors, 2010).

Figure 5 – Example of Rapid and Scour Pool Sequence

Step/pool sequences are the dominant bedform in Type A streams (Rosgen 1996). Step/pools consist of a series of deep pools with irregularly spaced drops into the pools below. The overall gradient of these channels is steeper than that in Type B or C streams. **Figure 6** demonstrates the plan and profile of a step/pool bedform (Colorado State University, 2014). A photo of a typical step/pool system is shown in **Figure 7** (Image obtained from Moses 2010).

Figure 6 – Step/Pool Schematic

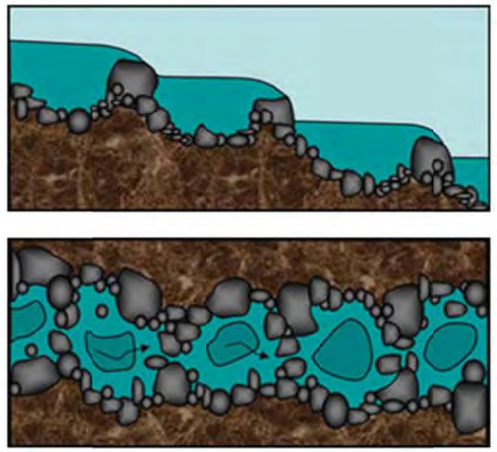


Figure 7 – Example of Step/Pool Sequence

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Appendices

Appendix A

Comparison of Aerial Photographs from Pre- and Post- Flood Conditions

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and loss of vegetation at channel banks

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 01 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and loss of vegetation at channel banks

Photos Present: 1 and 2

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 02 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and loss of vegetation at channel banks, scour along slope below culvert under Highway 72

Photos Present: 3-6

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 03 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and loss of vegetation at channel banks

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 04 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and loss of vegetation at channel banks, especially at channel bend as it follows the highway

Photos Present: 7 and 8

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 05 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and loss of vegetation at channel banks, bridge crossing the creek north of the highway has been destroyed

Photos Present: 9-16

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 06 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Large amounts of deterioration to the right channel bank along the highway, and to the highway itself

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 07 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Large amounts of deterioration to the right channel bank along the highway, and to the highway itself

Photos Present: 17 and 18

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 08 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and vegetation loss at channel banks, driveways to houses destroyed, amount of damage upstream of the highway crossing is inconclusive due to vegetation impeding the view, although heavy scouring appears likely

Photos Present: 19-24

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 09 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and vegetation loss at channel banks, driveways to houses destroyed, deterioration to highway on opposite side of the road from the creek

Photos Present: 25-28

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 10 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and vegetation loss at channel banks, driveways to houses destroyed

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 11 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and vegetation loss at channel banks, driveways to houses destroyed

Photos Present: 29 and 30

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 12 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and vegetation loss at channel banks, driveways to houses destroyed, deterioration of roadways higher uphill may have potentially impacted the creek as well

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 13 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and vegetation loss at channel banks, roadway crossing the creek northeast of the highway destroyed, highway crossing over the creek still intact, although scour and deterioration present at outfall

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 14 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

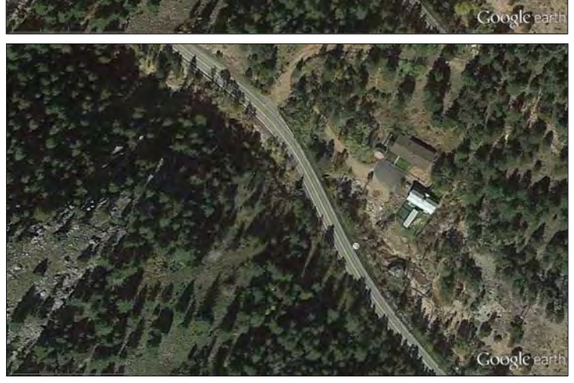
Comments: Noticeable scour and vegetation loss at channel banks, deterioration of highway shoulder on the side adjacent to the creek

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 15 of 55



Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and vegetation loss at channel banks, no apparent damage to highway crossing over the creek

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 16 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Some scour evident, difficult to observe the creek in both aerials due to surrounding vegetation and shadows in the imagery

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 17 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and vegetation loss along channel banks, roadway crossing the creek west of the highway destroyed, deterioration of roadways up on the hill west of the creek potentially may have impacted the stream

Photos Present: 31-33

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 18 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scour and deterioration evident on driveway and surrounding land on the opposite side of the highway from the stream. Noticeable damage to left bank of the creek where it abuts against the highway

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 19 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Deterioration evident on both shoulders of the highway

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 20 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Some scour and vegetation loss present, deterioration of highway shoulder on the side of the creek potentially impacted the stream

Photos Present: 34 and 35

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 21 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

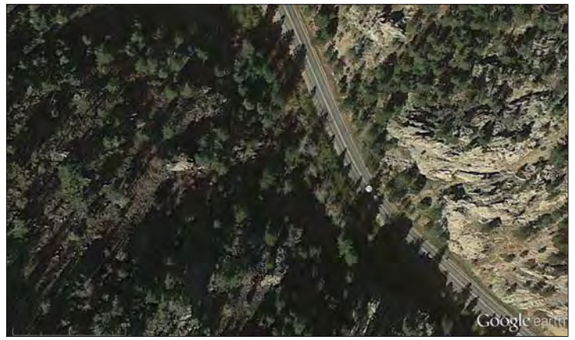
Comments: Some scour evident at channel banks, difficult to observe deterioration at creek due to vegetation and shadows obscuring imagery

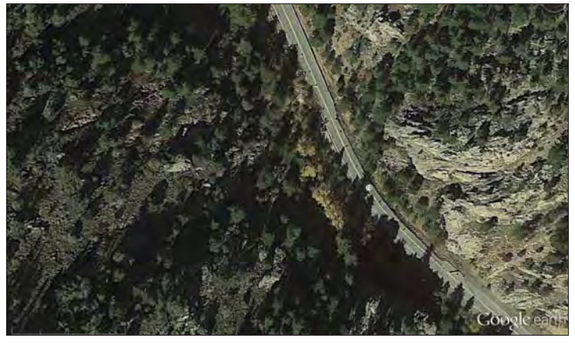
N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 22 of 55





Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Damage to highway seen on side opposite of the creek

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 23 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scour observed at channel banks, deterioration of highway and side roads leading to possible change in creek flow path at time of flooding, although if that occurred, it has already been repaired

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 24 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour along the highway, smaller driveway destroyed, failure observed to culvert under larger driveway, exposing the creek to the surface

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 25 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Driveway over creek appears to have remained intact, difficult to determine level of scour in channel

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 26 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Dirt road crossing the creek has failed, sediment deposition has occurred at this location

Photos Present: 36 and 37

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 27 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scour present at culvert outfall, no apparent damage upstream of culverts

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 28 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Noticeable scour and vegetation loss along channel banks and in overbanks on both sides of the creek

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 29 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Low visibility of creek itself, although scouring of the overbanks is evident. Large failure of the highway where it crosses a side channel (since repaired), potentially impacting the main creek as flows from this side channel entered the creek

Photos Present: 38-42

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 30 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Possible scour of channel banks, no apparent deterioration of overbanks

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 31 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Possible scour of channel banks, noticeable deterioration of both highway shoulders

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 32 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scour along channel banks, failure of driveway crossing the creek southwest of the highway

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 33 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

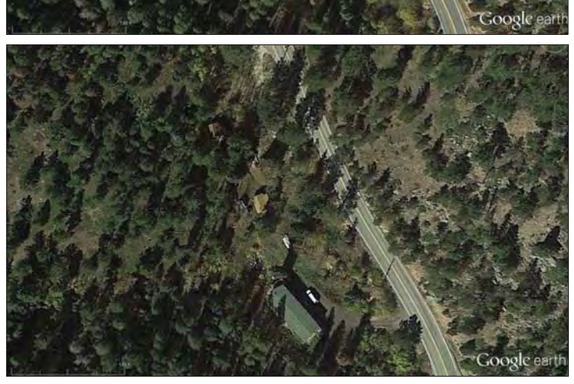
Comments: Some scouring around culvert under road crossing, but culvert appears to have remained intact

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 34 of 55



Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Little apparent damage present, driveway crossing creek remains intact

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 35 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

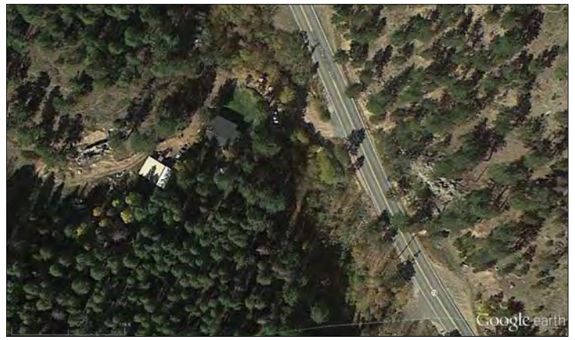
Comments: Some deterioration around driveways possible, little other changes observable

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 36 of 55



Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scouring along the highway on the opposite side from the creek

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 37 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scouring along the highway on the opposite side from the creek, some erosion on the left overbank between the creek and the highway

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 38 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scouring along the channel banks at some locations, failure of small bridge crossing creek behind houses

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 39 of 55

Coal Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: No apparent deterioration of the creek

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 40 of 55

Tributary along Crescent Park Drive

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Severe scouring along Crescent Park Drive, damage to Highway 72

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 41 of 55

Tributary along Butte Drive

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scouring evident upstream and downstream of driveway to the south of the road

Photos Present: 50 and 51

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 42 of 55

Tributary along Crescent Park Drive

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Minor scouring evident along road. No significant vegetation loss noticeable.

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 43 of 55

Tributary along Crescent Park Drive

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Some scouring has occurred below the culvert crossing under Crescent Park Drive

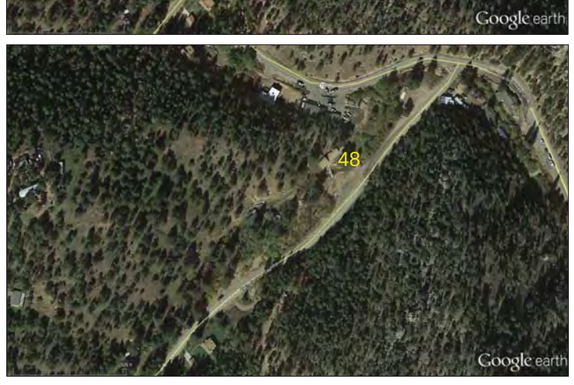
Photos Present: 52

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 44 of 55



Beaver Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Driveways crossing over the tributary were destroyed by the flooding

Photos Present: 48

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 45 of 55

Beaver Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scouring and vegetation loss apparent upstream of Burland Drive

Photos Present: 49

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 46 of 55

Beaver Creek and S. Beaver Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Backyard pond of residential structure north of road has been washed away

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 47 of 55

Beaver Creek and S. Beaver Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Degradation present at residential driveways crossing the stream

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 48 of 55

S. Beaver Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Apparent scouring to the channel is present. No significant loss of vegetation evident

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 49 of 55

S. Beaver Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scouring to channel is evident along the left bend the stream makes along the road

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 50 of 55

S. Beaver Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Road appears to have deteriorated along the stream

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 51 of 55

S. Beaver Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: No noticeable degradation to road, channel, or vegetation

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 52 of 55

S. Beaver Creek

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: No noticeable degradation to road, channel, or vegetation

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 53 of 55

Tributary along Ranch Elsie Road

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scouring evident in channel, residential driveways crossing tributary were damaged or destroyed

Photos Present: 43 and 44

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 54 of 55

Tributary along Ranch Elsie Road

Top: Aerial imagery from 10/7/12
Bottom: Aerial imagery from 10/6/13

Comments: Scouring evident in channel, residential driveways crossing tributary were damaged or destroyed

Photos Present: 45-47

N

Ecological Resource Consultants, Inc.

Appendix A - Comparison of Aerial Photographs from Pre- and Post-Flood Conditions

Project No.: 1005-1401	Date : July 2014
Scale: Shown on Images	Drawing No. : 55 of 55

Appendix B

Photographs from Post-Flood Site Inspection

Coal Creek

Photos 1 and 2 – The south slope of the railroad existing north of Coal Creek (the creek) and Highway 72 (the highway) showed locations of severe scour and erosion, cutting a new flowpath running to the south from the base of the railroad slope down to the highway. During the flood event, it is likely that the material eroded away to create this flowpath was transported to Coal Creek and deposited somewhere in the channel.

Photo 1 – Scouring of the railroad's south bank

Photo 2 – New flowpath created by erosion, shown where it reaches the highway

Photos 3 and 4 – Large amounts of debris are present in the creek and its floodplain. Scouring has occurred at the channel banks, while the deposition of larger sized material appears to have taken place within the channel.

Photo 3 – Scouring of the creek's right bank

Photo 4 – View of debris and deposited material looking downstream

Photo 5 – Scour at culvert outfall

Photo 6 – Eroded material deposited on hillside

Photos 5 and 6 – Extreme scouring took place at the outfall of a culvert crossing under the highway. A new flowpath about 1-2 feet deep was created down the steep highway bank, and eroded material was deposited along the hillside as the slope becomes less steep. The new flowpath does not currently reach the creek, however the large flows of the flood event likely did run all the way from the culvert to the creek, potentially carrying eroded material with it.

Photos 7 and 8 – The creek at this location has been reconstructed, with banks rebuilt out of cobble and boulder material. Vegetation loss in the overbanks is apparent, however most of the debris was either transported downstream or has been removed. The concrete box culvert allowing the creek to pass under the highway appears to have withstood the impacts of the flooding, and is still functioning adequately.

Photo 7 – Reconstructed channel as it approaches the highway crossing

Photo 8 – Upstream entrance to box culvert under highway

Photos 9-11 – A new roadway and culverts have been implemented where the creek crossing to the residential structures had been destroyed by the flood event. The channel has been reconstructed both upstream and downstream of the culverts, and both overbanks are mostly devoid of vegetation.

Photo 9 – New roadway and culverts

Photo 10 – Reconstructed creek upstream of culverts

Photo 11 – Reconstructed creek downstream of culverts

Photo 12 – A new right channel bank has been constructed, abutting the highway. Grouted riprap has been installed to stabilize the bank. Scour and vegetation loss is evident along the creek.

Photo 12 – Freshly installed grouted riprap between creek and highway

Photo 13 – The left channel bank has been severely scoured by the flood event. Vegetation along the slope of the bank has mostly been removed, and vegetation at the top of the bank has been undercut, with roots now exposed. New boulder riprap has been installed along the highway abutment which makes up the right bank of the creek.

Photo 13 – Severely scoured left channel bank, and newly constructed right channel bank

Photos 14-16 – Channel banks have been scoured, with vegetation removed or undercut. Large boulders are present in the channel at this location, which appear to have entered the channel via the small canyon adjacent to the creek to the west. The right channel bank adjacent to the highway consists mostly of exposed dirt, with little to no vegetation or rock material to stabilize it.

Photo 14 – Scoured channel banks with undercut vegetation; boulders present in channel

Photo 15 – Canyon opening to the west of the creek

Photo 16 – Exposed dirt on right channel bank abutting the highway

Photos 17 and 18 – A new driveway has been constructed to allow access to residential northwest of the creek. The driveway contains two culverts conveying flow from the creek. The channel has been rebuilt at this location upstream of the culverts, with riprap stabilizing the bank in front of the structures.

Photo 17 – New driveway and culverts installed after the flood event

Photo 18 – Reconstructed channel, with riprap stabilizing the left bank

Photos 19-20 – Severe scouring has taken place alongside the highway in front of residential structures, undercutting the structures themselves. The water that accumulates at this location enters the creek via a culvert, which likely plugged up during the flood event due to debris, and had plenty of debris present in it still at the time of these photos.

Photo 19 – Scour and undercutting alongside residential structures

Photo 20 – Culvert conveying water in front of structures to the creek; currently partially filled with debris

Photos 21-24 – The creek crosses the highway at this location via a concrete box culvert. The culvert itself appears to still be structurally sound, although it has been reinforced with grouted riprap on its upstream end. **Photo 21** shows the outlet of the culvert pipe shown previously in **Photo 20**. Vegetation loss and scouring of the banks has occurred both upstream and downstream of the box culvert, but most of the debris in the channel appears to have been removed.

Photo 21 – Downstream outlets of the concrete box culvert and the culvert pipe from Photo 20

Photo 22 – Grouted riprap added to upstream end of box culvert since the flood event

Photo 23 – Creek immediately upstream of the box culvert

Photo 24 – Creek immediately downstream of the box culvert

Photos 25-28 – Several residential driveways along the highway were destroyed by the flooding. Some of the driveways have been reconstructed with new culvert pipes, while others have not. Also present in these images is the scouring and vegetation loss which occurred along the creek at this location, as well as the amount of debris which is still present in the channel.

Photo 25 – Destroyed driveway which has not been reconstructed

Photo 26 – New driveway and culverts installed at one residential structure

Photo 27 – Relatively bare channel banks downstream of one set of culverts; fallen trees still lying in channel

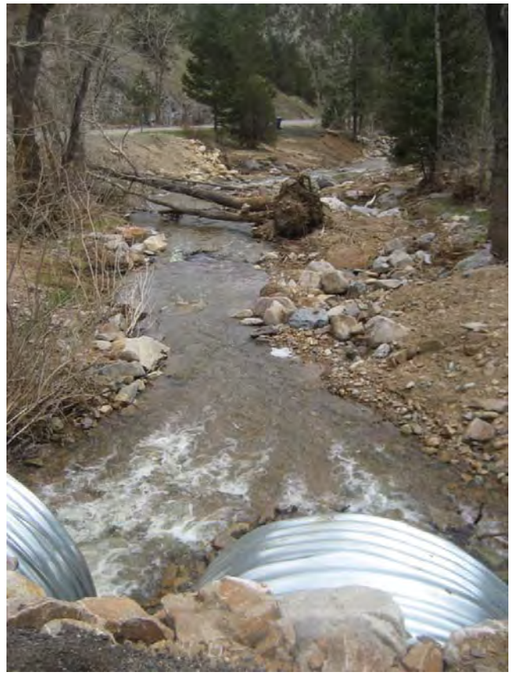


Photo 28 – Scoured channel banks and debris in channel; another reconstructed driveway visible upstream

Photos 29-30 – Many locations along the creek showed significant scour at places where roads coming down the hillside intersected the stream. This is possibly due to large amounts of runoff traveling down the roadway unimpeded, and entering the channel at high velocities. **Photo 29** shows one such instance of this. **Photo 30** demonstrates the extreme vegetation loss and debris observed on the floodplain between the highway and the creek, just downstream from where this side road crosses the stream.

Photo 29 – Destroyed roadway which formerly crossed the creek at this location

Photo 30 – Vegetation loss and debris in floodplain

Photos 31-33 – Channel bank slopes have been severely undermined on the outside of the creek's bend. Vegetation has been uprooted from the overbanks, and large amounts of debris have piled up outside of the creek's low flow channel.

Photo 31 – Eroded banks and accumulated debris

Photo 32 – Undermined banks on outside bend, accumulated debris on inside bend

Photo 33 – Accumulated debris along overbanks

Photos 34 and 35 – Channel banks have been significantly undermined at this location. More vegetation is still present in the overbanks than at farther downstream locations, however tree roots have been exposed along the banks, and the higher right bank appears unstable. Debris has covered the overbanks, and has also accumulated at various spots in the stream itself.

Photo 34 – Undermined, unstable banks; debris collected in overbanks

Photo 35 – Undermined banks; debris accumulated in stream

Photos 36 and 37 – The dirt road crossing the creek to the east of the highway has been destroyed. This is the first location since the extreme downstream sections of stream where significant sediment deposition has occurred. Large amounts of sand are present in the channel and overbanks, and the culvert between the main channel and the highway is mostly filled with sediment.

Photo 36 – Destroyed roadway formerly crossing the creek

Photo 37 – Sand deposition in the channel; culvert mostly filled with sediment

Photo 38 – New patch of road on Highway 72 where it intersects with Crescent Park Drive

Photo 39 – New culverts under the highway and channel leading to Coal Creek

Photos 38-42 – The section of highway that was destroyed by the flood event has since been replaced. New culverts were installed under the highway, and the channel conveying the tributary flow to Coal Creek has been re-formed. Large quantities of sand have deposited in the left overbank along the creek. Residential yards existing in the floodplain also accumulated large amounts of sediment.

Photo 40 – Confluence of tributary channel with Coal Creek

Photo 41 – Deposited sediment along Coal Creek

Photo 42 – Accumulated sediment in floodplain

Photos 43 and 44 – New culverts have been installed just downstream of the confluence of Coal Creek and its tributary that runs along Ranch Elsie Road. The culverts appear undersized, as the water level was near the top of the pipes at the time the photographs were taken, when flows were much lower than flooding conditions. Deterioration of the banks and accumulation of debris due to the flooding is evident, although not as significant as other locations farther downstream.

Photo 43 – Newly installed culvert under driveway, seemingly undersized; debris in overbank

Photo 44 – Culvert already near its capacity, even with relatively low flows

Tributaries

Photos 45-47 – The flood event also caused scouring and degradation along Coal Creek's tributaries. **Photos 45-47** show degradation around a culvert passing under a driveway alongside Ranch Elsie Road. **Photo 45** shows the upstream end of the culvert, where the banks of the channel have been undermined, but the culvert itself appears to still be functional. **Photo 46** shows the downstream end of the culvert, which has been completely undermined. The pipe is still in place, but the driveway bank has eroded around it. **Photo 47** shows the channel just downstream of the culvert, where the banks have been undermined where the channel bends.

Photo 45 – Upstream end of culvert on Coal Creek tributary alongside Ranch Elsie Road

Photo 46 – Downstream end of the culvert, where the bank has eroded away

Photo 47 – Immediately downstream of the culvert, banks have been undermined

Photo 48 – This driveway crossing Beaver Creek, a few hundred feet upstream of its confluence with Coal Creek, has been rebuild since the flood event. The culvert has been undermined, and the downstream banks appear unstable, as there is little vegetation or armoring present to stabilize them.

Photo 48 – Undermined culvert on Beaver Creek

Photo 49 – Farther upstream on Beaver Creek, channel banks are bare of vegetation or armoring and appear unstable. Debris in the floodplain gives an indication of how high the water had been during the flood event.

Photo 49 – Beaver Creek; unstable banks and debris in floodplain

Photos 50 and 51 – These photos show the upstream and downstream ends of a culvert conveying flow from the Coal Creek Tributary running alongside Butte Drive. It is unclear if this culvert was in place before the flood event, or if it was installed after. Channel banks upstream of the culvert have been scoured and undermined, and debris has collected in the channel. Below the culvert outfall, large rock material has settled below the pipe, possibly having fallen down the bank of the road.

Photo 50 – Upstream view of culvert for tributary alongside Butte Drive

Photo 51 – Downstream view of culvert for tributary alongside Butte Drive

Photo 52 – This culvert passes under Crescent Park Drive, and conveys flows for the Coal Creek tributary that runs along that road until it reaches the highway and joins with Coal Creek. The culvert pipe appears undamaged from the flood event, and a well-defined flowpath downstream of the culvert is evident, there does not appear to have been significant scouring or deterioration of this channel.

Photo 52 – Culvert passing under Crescent Park Drive

APPENDIX F

COAL CREEK RIPARIAN ZONE AND THREATENED & ENDANGERED SPECIES SUMMARY

Ecological Resource Consultants, Inc.
35715 US Hwy. 40, Suite D204 ~ Evergreen, CO ~ 80439 ~ (303) 679-4820

Technical Memorandum

Date: June 30, 2014

To: ICON Engineering

From: Ecological Resource Consultants, Inc.

Re: **Coal Creek Canyon Watershed Master Plan**
Riparian Zone and Threatened and Endangered Species Summary

During the historic regional flood event in September 2013, Coal Creek Canyon experienced high peak flows for an extended duration which resulted in extensive changes in the creek corridor along with significant infrastructure damages. This memo, as part of the Coal Creek Canyon Watershed Master Plan, specifically addresses the general condition of the existing riparian communities within the Coal Creek corridor after the flooding and provides recommendations for re-establishment (or restoration) of the riparian zone as flood recovery efforts continue within the project area.

During the initial flood recovery efforts, emergency stabilization measures focused more on hardened methods such as riprap, grout, boulders and infrastructure repair. As the focus shifts towards long-term stabilization, measures must also consider restoration of critical natural riparian ecosystem function.

The importance of a well-developed riparian corridor is well documented. Well vegetated riparian corridors provide important terrestrial wildlife habitat, provide aquatic habitat benefits, soil stabilization, and reduced problems from erosion, flooding and nutrients. A properly functioning riparian corridor protects the physical integrity of the aquatic environment.

ERC completed a cursory baseline assessment of the existing post-flood riparian corridor within the project area. The general condition of the existing riparian corridor was assessed including dominant vegetation community types remaining, species composition and primary vegetation strata that remain or that may have been damaged or lost. In addition, the assessment defined a "reference condition" riparian community or in other words the ideal riparian vegetation community that existed prior to the flood event and that should be a focus for re-establishment of vegetation during long-term recovery efforts. **Section 1.0** of this memo summarizes the riparian corridor existing conditions and long-term management recommendations.

The riparian corridor of the Coal Creek Canyon project area also provides critical wildlife habitat that should be considered during flood recovery efforts. **Section 2.0** of this memo includes a cursory

screening of potential federal and state threatened and endangered species that may occur on or immediately surrounding the project area.

SECTION 1.0 RIPARIAN ZONE ASSESSMENT

IMPORTANCE OF THE RIPARIAN ZONE

A riparian corridor or "riparian zone" is defined as the transitional area or interface between upland terrestrial and aquatic habitats. A riparian zone is generally considered that portion of the landscape from the ordinary high water mark towards the adjoining uplands that affect or are affected by the presence of water. The riparian zone is often unique within a watershed such as Coal Creek containing notably different vegetation communities from the surrounding upland habitat. Properly functioning riparian zones of high ecological integrity contain an unfragmented, structurally diverse vegetation community, typically composed of three strata of trees, shrubs and grasses that are native to the region and that are adapted to the climatic, soil, and hydrologic conditions. The riparian zone has a variety of functions important to the stream or aquatic environment. Well vegetated riparian zones provide important terrestrial wildlife habitat, provide aquatic habitat benefits (shading, decreased water temperatures and instream cover), soil stabilization, and reduced problems from erosion, and sedimentation. Riparian vegetation also contributes to bank stability by dissipating the energy of moving water and reducing velocity, which is imperative during typical flood events. A properly functioning riparian zone protects not only water quality but also the physical integrity of the aquatic environment.

PROJECT AREA SETTING

The project area is located in Coal Creek Canyon along Hwy 72, approximately two miles west from of Hwy 93, in Jefferson County, Colorado (**Latitude 39.877049° North, Longitude -105.274064° West**). The project area encompasses the Coal Creek watershed which includes the main stem of Coal Creek and five tributaries. The main stem of Coal Creek originates along Colorado Highway 72 near Copperdale Lane and extends 6.5 miles through the project area. The topographic elevation throughout the project area ranges from approximately 8,600 feet above mean sea level (AMSL) towards the upstream limits and along the hilltops to approximately 6,000 feet AMSL towards the downstream (east) end of the project area.

This area is considered a semi-arid environment with an average annual precipitation of 26.1 inches. Snowfall is greatest in March and April, spring/summer rains peak in April and August. The average annual maximum temperature is 51.7 °F and the average annual minimum temperature is 28.7 °F. The frost-free season is about 151 days (CNHP 2013).

EXISTING CONDITION OF RIPARIAN ZONE

Coal Creek through the canyon is a steep walled perennial stream typically comprised of dense riparian vegetation occurring along the drainage bottom that is dominated by forested woodland overstory underlain by shrubs and herbaceous species. As a result of the September 2013 regional flood event, the

existing riparian zone within the project area was significantly altered and in some areas completely lost. In various locations the creek had migrated horizontally, experienced significant deposition and incision, and migrated or scoured to the point of destroying infrastructure. The effects included debris flows from hillsides that caused erosion and deposition of material in tributaries, along with conveyance and deposition of significant debris such as rocks, cobble, sand, trees, and household materials throughout the stream corridor.

Floods can interact with vegetation in complex ways, both influencing and influenced by the structure and composition of the riparian zone (Johnson et al. 1999). The intensity of vegetation disturbance can be variable and influenced by factors such as pre-flood site conditions (i.e., type of vegetation present and channel constraints) and the interaction with flood dynamics (i.e., magnitude of flow and delivery of wood/sediment to a channel). Flood damage to riparian zone vegetation can occur by sediment and debris impact, scour or erosion of substrate or long-lasting change of hydrological conditions caused by changes in floodplain morphology and channel displacement. A less evident negative impact is a general decrease in plant vigor associated with post-stress reaction of plants to erosion (Toda et al., 2005). Flooding can damage trees indirectly by modifying soil characteristics. High stream flows can wash away soil, exposing roots or deposit soil around a tree, smothering the roots. In some cases, trees damaged from flooding can recover in as little as one growing season while others do not recover at all. In addition, stressed trees can become more susceptible to secondary problems such as insect infestation or windthrow from the damaged root systems.

The post-flood existing condition of the riparian zone varies locally through the project area. In the upper reaches of the watershed where disturbance was low, more ideal riparian conditions are present characterized by dense forest canopy with willow and grass understory. These low disturbance areas are considered to be generally stable with little to no restoration required.

The mid to lower portions of the project area, which contain a larger watershed and thus experienced higher flood flows and moderate disturbance, exhibit various degrees of vegetation disturbance, particularly in the understory strata, ranging from 1) complete loss of riparian shrubs and grasses along large sections of the stream bank to 2) small isolated areas of riparian understory damage to 3) areas where shrubs remain intact with no understory grasses present. Loss of native soils is also widespread in these lower portions of the watershed. Areas of moderate disturbance may require physical streambank stabilization, import of soil material and/or re-vegetation of one or more strata to restore the native riparian community.

Areas of high disturbance can be found throughout the mid to lower reaches of the watershed and are characterized by complete loss of all vegetation strata in the riparian zone. These areas will require more substantial restoration to provide long-term stabilization and re-establishment of the riparian zone. Refer to **Photos 1-4** for examples of the post-flood existing riparian zone conditions within the project area.

Photo 1. Example of low disturbance to the riparian zone. This photo depicts a more ideal riparian zone vegetation community along Coal Creek at the downstream end of project area. In this section, the riparian zone is dominated by an overystory of narrowleaf cottonwood and ponderosa pine tree canopy intermixed with dense shrub understory with native grass species.

Photo 2. Example of moderate disturbance to the riparian zone. This photo depicts a common condition in the middle to lower portions of the project area where scouring has removed herbaceous understory. A dense willow-dominated midstory is present which provides streambank stabilization however the lack of a stable understory can lead to soil erosion or root damage further limiting riparian functions.

Photo 3. Example of high disturbance to the riparian zone. Flood flows and transport of large alluvial material/wood have eroded the channel of Coal Creek, completely removing vegetation within the riparian zone.

Photo 4. Example of high disturbance to the riparian zone. High flows and debris have severely eroded the riparian zone shrub and understory community and damaged trees.

RIPARIAN ZONE VEGETATION COMMUNITY REFERENCE STANDARD

The overall riparian zone vegetation community type within the project area is characteristic of the Rocky Mountain lower montane riparian woodland and shrubland. This community type is fairly common in the Foothills of the Colorado Front Range. In a more undisturbed, pre-flood condition, vegetation would be continuous along the entire corridor and occupy three strata (i.e., overstory, mid-story and understory). The vegetation along the immediate streambanks of Coal Creek and its tributaries through the riparian zone would be dominated by narrowleaf cottonwood (*Populus angustifolia*) and Colorado blue spruce *(Picea pungens)* tree canopy intermixed with dense shrub mid-story comprised of narrowleaf willow (*Salix exigua*), bluestem willow (*Salix irrorata*), Geyer willow (*Salix geyeriana*), Booth's willow (*Salix boothii*) and drummond willow (*Salix drummondiana*). Smaller, sporadic patches of aspen (*Populous tremuloides*) also would exist throughout in the riparian zone. A dense herbaceous understory layer would be present along portions the streambanks above the ordinary high water mark.

The mid to upper slopes of the project area above the riparian zone primarily consist of forested communities with ponderosa pine (*Pinus ponderosa*) (at low elevations and on south-facing slopes) and with mixed conifer forest co-dominated by Douglas-fir (*Pseudotsuga menziesii*) on north-facing slopes. Lodgepole pine (*Pinus contorta*) forest is predominant in the higher elevations (western section) of the watershed. These dry forested slopes of the corridor support a mosaic of understory shrubland species including mountain mahogany (*Cercocarpus montanus*), American plum (*Prunus Americana*), juniper (*Juniperus communis*), Woods' rose (*Rosa woodsii*) and wax currant (*Ribes cereum*) distributed within the ponderosa pine. The herbaceous understory contains areas of grass and forb species including wheatgrass (*Pascopyrum smithii*), blue grama (*Chondrosum gracile*), some cheatgrass (*Anisantha tectorum*), smooth brome (*Bromopsis inermis*) and dandelion (*Taraxacum officinale*).

RIPARIAN ZONE RESTORATION GUIDELINES

The framework for any successful riparian zone restoration effort is understanding the local (reference standard) community that is either present or known to have existed in the local area, in order to restore the functional integrity and biodiversity of the riparian zone. As stated in the previous section, the reference community or primary habitat type recommended for restoration within this project area which is locally native and appropriate for the environmental setting is the Rocky Mountain lower montane riparian woodland and shrubland.

Specific to the project area, an ideal riparian vegetation community consists of three strata; 1) a forest canopy overstory dominated by tree species such as narrowleaf cottonwood and blue spruce; 2) a mid-story dominated by willow and alder shrubs and 3) an understory dominated by native grasses. Vegetation typically should extend from the water's edge landward providing bank stability and aquatic habitat benefits. **Figure 1** depicts the components of a properly functioning and structurally diverse riparian community.

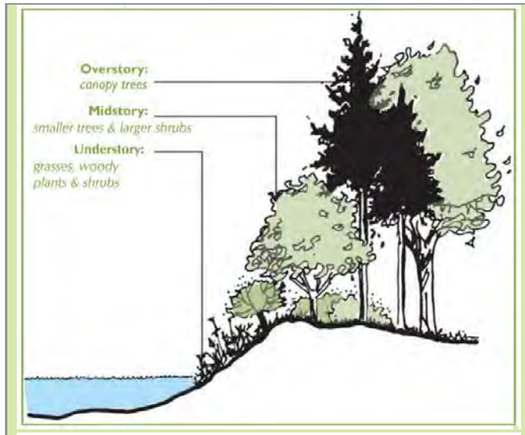
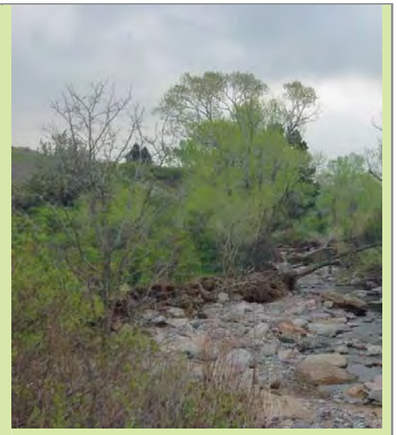


FIGURE 1. NATURAL RIPARIAN CORRIDORS OF HIGH ECOLOGICAL INTEGRITY TYPICALLY CONTAIN THREE DISTINCT LAYERS OF VEGETATION – OVERSTORY FOREST CANOPY OF TREES, UNDERSTORY OF SHRUBS AND AN UNDERSTORY OF GRASSES. (MODIFIED FROM: MONTGOMERY COUNTY PLANNING COMMISSION 2006).



COAL CREEK: EXAMPLE OF HIGH ECOLOGICAL INTEGRITY RIPARIAN FOREST HABITAT – DOMINATED BY COTTONWOOD OVERSTORY WITH WILLOW MIDSTORY AND GRASS UNDERSTORY.

Replicating the natural characteristics of the local Rocky Mountain lower montane riparian woodland and shrubland habitat type including re-establishment of cottonwood tree overstory and a willow shrub mid-story with a mixed grassland understory should be the primary objective for riparian restoration efforts in order to restore the overall riparian zone function.

Successful riparian zone restoration is dependent on a thorough understanding of numerous environmental factors and site-specific conditions. Soil moisture, groundwater table, soil chemistry and sun-orientation are all critical elements to consider. Any restoration efforts should carefully consider such factors which should generally be defined by an expert to ensure greater success. Site-specific restoration plans can be developed which specify planting locations, soil amendments and appropriate species types. While site specific plans should be developed by experts the following provides some generalized guidelines for restoration of the riparian zone within the project area.

OVERSTORY – FOREST CANOPY ESTABLISHMENT

Restoration or planting efforts should focus on re-establishing the overstory or forest canopy that has be lost. The narrowleaf cottonwood tree is one of the primary species of the forest canopy regionally as well as the largest tree reaching heights of up to 60 feet with trunk diameters of 2.5 feet. Cottonwoods are now primarily found along drainages and streams of the region. Cottonwood stands provide habitat for 82% of all bird species breeding in northeastern Colorado (Simonin 2001). This species establishes quickly under ideal conditions and is tolerant of frequent and prolonged flooding as well as seasonal low water conditions. Other trees species that are appropriate in conjunction with narrowleaf cottonwood may include those species listed in **Table 1** below. The re-establishment of the forest canopy will provide

significant bank stabilization benefits due to binding of soil with their roots and can also block or deflect high flow stream currents. Many of the large mature cottonwoods of the project area appear to be relatively stable after the September 2013 flooding, however many have been damaged and populations may start to decline over time. The planting of second generation stands of narrowleaf cottonwood and other species during recovery efforts will ensure the continued existence of this valuable habitat type.

Table 1. Representative Native Riparian Zone Tree Species for the Coal Creek Canyon Project Area.

Tree Species	
Scientific Name	**Common Name**
Acer glabrum	Rocky Mountain maple
Acer negundo	box elder
Crataegus rivularis	River hawthorn
Picea pungens	Colorado blue spruce
Populus angustifolia	narrowleaf cottonwood
Populus tremuloides	quaking aspen
Salix amygdaloides	peachleaf willow

*All tree species should only be planted above the ordinary high water mark where moist soil conditions are present during a majority of the growing season.

Tree species are generally obtained from a commercial nursery as potted containers or balled and burlapped and are ideally planted during the latter part of the dormant season between February 1 and April 1, one to two weeks before budding stage. A typical diagram for tree plantings is provided in **Figure 2**. Tree planting efforts should also consider a monitoring and maintenance program that includes temporary irrigation, weed management and herbivory prevention.

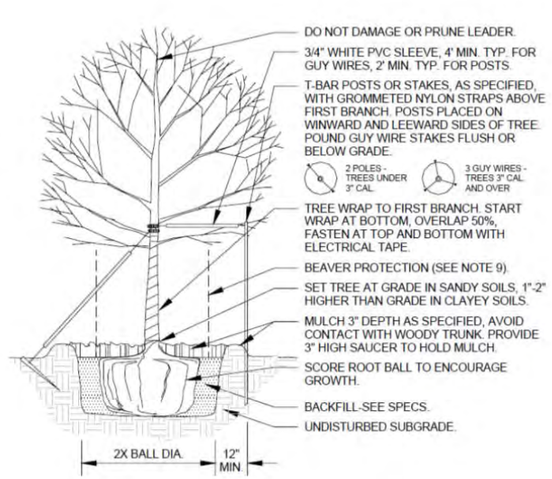


Figure 2. Typical Detail for Tree Plantings (UDFCD 2001).

MIDSTORY - SHRUBS ESTABLISHMENT

Shrubs are considered one of the most valuable strata in a natural riparian zone. Shrubs generally form dense thickets with extensive root systems immediately along the water's edge and can tolerate fluctuating flows.

Willows are a widely-distributed shrub species throughout lower montane habitats in the region. Species can range from 6.5 to 20 feet tall forming large colonies with up to 95% cover. Roots of willows are wide and spreading, forming and extensive root system, especially with the development of large clones. Willow can be both drought resistant and very tolerant of flooding. The ability to generate new roots on the original root or submerged stem is important to riparian restoration. Narrowleaf willow, particularly, colonizes rocky, gravelly, and sandy stream edges, moist, well-drained alluvial terraces, and recently deposited sand and gravel bars that are below the high-water mark, where it is subject to annual flooding, and associated scouring and deposition (Anderson 2006). Where cottonwoods are not present, other willows (Geyer willow, yellow willow, Drummond willow), may become the climax vegetation as narrowleaf willow communities promote bank building and soil development, preparing hospitable sites for other species (Anderson 2006). Midstory shrub species not only provide bank stability but also increased biomass, structural habitat and complexity for wildlife. Shrub species that are considered appropriate for native riparian zone restoration are listed in **Table 2** below.

Table 2. Representative Native Riparian Zone Shrub Species for the Coal Creek Canyon Project Area.

Shrub Species	
Scientific Name	**Common Name**
Alnus incana	thinleaf alder
Amelanchier alnifolia	western serviceberry
Lonicera involucrata	twinberry honeysuckle
Prunus americana	American plum
Prunus virginiana	chokecherry
Rosa woodsii	Woods' rose
Salix boothii	Booth's willow
Salix drummondiana	Drummond willow
Salix exigua	narrowleaf willow
Salix geyeriana	Geyer's willow
Salix irrorata	bluestem willow

*All shrub species should be planted above the ordinary high water mark where moist soil conditions are present during a majority of the growing season.

Shrub species are generally obtained from a commercial nursery in varying pot sizes from 1-quart to 5-gallons and ideally planted during the latter part of the dormant season between February 1 and April 1, one to two weeks before budding stage. Shrub planting efforts should also consider a monitoring and maintenance program that includes temporary irrigation, weed management and herbivory prevention.

Willows species also have a unique ability to be harvested from onsite sources and installed as live stakes. Willow live staking consists of harvesting a cutting or single stem of a willow shrub. The stake is then inserted into the ground then will naturally root and develop above ground shoots. Willow live staking can be completed with best results if performed between February 1 and April 1, before budding stage. Cuttings should be harvested while dormant, soaked (completely submerged) a minimum of 24-hours prior to installation and kept moist at all times during preparation. Willow stakes can be installed in a variety of (moist) soils, above the ordinary high water mark. A typical detail for a shrub planting and willow live stake planting is provided in **Figures 3 and 4,** respectively.

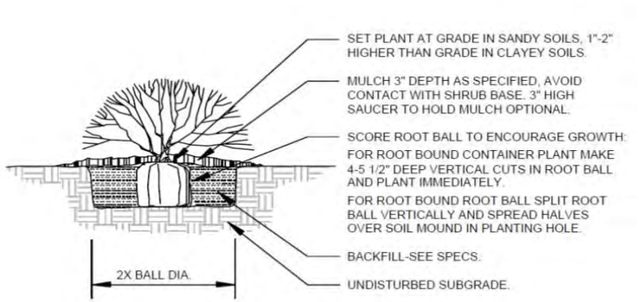


Figure 3. Typical Detail for Shrub Planting (UDFCD 2001).

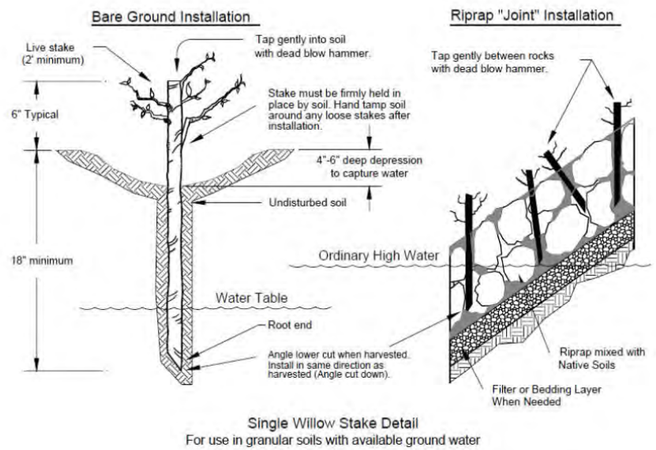


Figure 4. Typical Detail for Single Willow Stake (UDFCD 2001).

UNDERSTORY - NATIVE SEEDING

An established understory community provides numerous environmental benefits including soil stabilization, overland runoff filtration as well as forage and cover for wildlife. During restoration efforts native seeding should focus on quickly establishing a groundcover to stabilize soil, minimize establishment of invasive species and promote long-term successional development. In restoration areas, the ground surface should be seeded with specialized riparian seed mix that promotes species diversity, contains locally native species that germinate rapidly and provides complete groundcover over a wide variety of hydrologic conditions. Generally in areas to be seeded, 3 to 6 inches of suitable topsoil is recommended.

Table 3. Representative Native Riparian Zone Grass Seed Mix for the Coal Creek Canyon Project Area.

Seed Mix				
Scientific Name	**Common Name**	**Variety**	**% Species in Mix**	**# PLS Required/acre**
Achnatherum hymenoides	Indian ricegrass	Native	20	6.18
Bouteloua gracilis	blue grama	Native, Lovington, Alma	10	0.53
Elymus canadensis	Canada wildrye	Native	10	3.79
Elymus trachycaulus	slender wheatgrass	Native, San Luis	25	6.85
Panicum virgatum	switchgrass	Blackwell, Nebraska 28	10	1.12
Pascopyron smithii	western wheatgrass	Native, Arriba	25	9.90
			100	**28.36**

"Notes:
Quantity assumes 100 seeds per square foot broadcast seeded.
Quantity assumes 1 acre (43,560 sf) of riparian reclamation. Quantity should be adjusted based on seeding area size.
Final species composition and rates subject to availability. "

Seeding is typically most successful when conducted in late fall or early spring between October 15 and May 15. Seed can be obtained by local retail vendors (refer to the vendor list provided subsequently). Seed is generally worked into a soft ground surface and covered with a mulch (i.e., straw, erosion blanket or hydro-mulch). Mulch secured over a seeded area will increase the success rate of the planting. Native seeding efforts should also consider a monitoring and maintenance program that includes temporary irrigation, weed management and herbivory prevention.

NATIVE PLANT STOCK NURSERIES AND SEED SUPPLIER

Following is a list of native riparian zone plant stock nurseries and seed suppliers considered appropriate for the project area. This list is not inclusive of all regionally available native plant suppliers.

North Fork Native Plants
1499 S 6000 W
Rexburg, ID 83440
Phone: (208) 354-3691
http://www.northforknativeplants.com/

Conservation Seeding & Restoration, Inc. dba Rocky Mountain Native Plants
3780 County Rd. 233
Rifle, CO 81650-8740
Phone: (208) 423-4835
Toll-Free: (877) 423-4835
http://www.csr-inc.com/

Little Valley Wholesale Nursery
13022 E 136th Ave
Brighton, CO 80601
Phone: (303) 659-6708
https://www.lvwn.com/

Arkansas Valley Seed
4333 Hwy 68
Longmont, CO 80504
Phone: (877) 907-3337
www.avseeos.com

Pawnee Buttes Seed
805 251h Street
Greeley, CO 80632
Phone: (970) 358-7002
www.pawneebuttesseed.com

Western Native Seed
P.O. Box 188 Coaldale, CO 81222
Phone: (719) 942-3935
www.westernnativesed.com

SECTION 2.0 THREATENED AND ENDANGERED SPECIES

ERC conducted a preliminary screening for federal and state threatened and endangered species within the project area. It will be important during long-term recovery and restoration efforts that protected species and habitats are considered. Close coordination with these agencies is recommended. In support of flood recovery efforts, the USFWS recommends implementation of conservation measures from the Recommended Conservation Measures to Avoid and Minimize Impacts to the Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*), the Ute Ladies'-tresses Orchid (*Spiranthes diluvialis*), and the Colorado butterfly plant (*Guara neomexicana spp. coloradensis*) from Emergency Flood Response Activities Along Streams, Rivers, or Transportation Corridors. Information can be found online at: http://www.fws.gov/endangered/esa-library/index.html#consultations.

Federal or state listed threatened and endangered species and/or habitat protected under the Endangered Species Act (ESA) or by the Colorado Division of Wildlife (CPW) under Colorado Statute Title 33 are summarized as follows. Raptor nest sites are further protected by the US Fish and Wildlife Service (UFWS)/CPW under the Migratory Bird Treaty Act (MBTA) therefore the applicable regulatory requirements are also summarized subsequently.

MIGRATORY BIRD TREATY ACT

Migratory birds are protected under the Migratory Bird Treaty Act (MBTA) (16 U.S.C. 730-712). The MBTA makes it illegal for anyone to take, possess, import, export, transport, sell, purchase barter, or offer for sale, purchase, or barter any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid permit issued pursuant to Federal regulations. In Colorado, all birds except for the European starling (*Sturna vulgaris*), house sparrow (*Passer domesticus*) and rock dove (*Columba livia*) are protected under the MBTA. A total of 523 migratory bird species are known to occur in the Mountain-Prairie Region (USFWS Region 6, Montana, Wyoming, Utah, North Dakota, South Dakota, Nebraska, Kansas and Colorado); 320 of the 523 migratory bird species are known to breed in USFWS Region 6.

- Based upon literature review and an onsite assessment of the project area, ERC has determined that some migratory birds likely utilize the Site. These birds are protected under the MBTA, and killing or possession of these birds is prohibited. Future recovery and restoration efforts which remove vegetation should first ensure that active nests are not disturbed. Generally, the active nesting season for most migratory birds in this region of Colorado occurs between April 1 and August 31.

- In addition, disturbance to raptor nest sites is further protected by the CPW. To provide additional clarity of what constitutes disturbance, the CPW has developed the 2008 guidance: Recommended Buffer Zones and Seasonal Restrictions for Colorado Raptors (http://wildlife.state.co.us/SiteCollectionDocuments/DOW/WildlifeSpecies/LivingWithWildlife/RaptorBufferGuidelines2008.pdf). This document provides recommended tolerance limits or buffer zones for various species of raptors in addition to seasonal restrictions in response to

human activity. Available CPW Species Activity Mapping (SAM) does not depict known mapped buffer zones within the project area (NDIS 2013), however raptors likely utilize the project area and may utilize the riparian zone trees for nesting. Future recovery and restoration efforts should be aware of any new raptor nest sites and consult with the CPW.

SPECIES PROTECTED UNDER THE ENDANGERED SPECIES ACT (ESA) OF 1973

The ESA of 1973 was enacted by the United States to conserve endangered and threatened species and the ecosystems that they depend on. Under the ESA, species may be listed as either "endangered" or "threatened"; both designations are protected by law. The ESA is administered by the USFWS. The USFWS has developed project specific species lists, available online by request, identifying threatened, endangered, and proposed species, designated critical habitat, and candidate species protected under the ESA that may occur within the boundary of the proposed project and/or may be affected by the proposed project (USFWS 2014) (Tracking Number: 06E24000-2014-SLI-0736). Eleven species are identified to occur or historically occur within range of the project area in Jefferson County (USFWS 2014). Further evaluation of the eleven species' distribution and habitat requirements indicates that four species potentially occur within range of the project area (**Table 4**). During restoration and recovery efforts coordination with the USFWS is recommended.

US Fish and Wildlife Service – Ecological Services Field Office
P.O. Box 25486
Denver Federal Center (MS 65412)
Denver, Colorado 80225
Telephone: (303) 236-4773
Colorado Field Supervisor: Susan Linner
Email: Susan_Linner@fws.gov
http://www.fws.gov/coloradoes/

Table 4. Federal Threatened or Endangered Species Potentially within Range of Project Area.

Common Name	Scientific Name	Status
Canada lynx	*Lynx canadensis*	Federally Threatened
Mexican spotted owl	*Strix occidentalis lucida*	Federally Threatened
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	Federally Threatened
Ute Ladies'-tresses orchid	*Spiranthes diluvialis*	Federally Threatened

STATE THREATENED AND ENDANGERED SPECIES

Species identified as state threatened or endangered are protected by the CPW under Colorado Statute Title 33. State regulations prohibit "*any person to take, possess, transport, export, process, sell or offer for sale, or ship and for any common or contract carrier to knowingly transport or receive for shipment*" any species or subspecies listed as state endangered or threatened. State listed threatened and endangered species were screened as potential inhabitants of the project area based on general habitat requirements and CPW tables (revised December 21, 2011), *Colorado Listing of Endangered,*

Threatened, and Wildlife Species of Special Concern. Seventeen species are identified to occur or historically occur within Jefferson County (CPW 2011). Further evaluation of the seventeen species' distribution and habitat requirements indicates that three species potentially occur within range of the project area (**Table 5**). During restoration and recovery efforts coordination with the CPW is recommended.

Colorado Parks and Wildlife – Northeast Region Office
6060 Broadway
Denver, Colorado 80216
Telephone: (303) 291-7227
http://cpw.state.co.us/aboutus/Pages/ContactUs.aspx

Table 5. State Threatened or Endangered Species Potentially within Range of Project Area.

Common Name	Scientific Name	Status
Canada lynx	*Lynx canadensis*	State Endangered
Mexican spotted owl	*Strix occidentalis lucida*	State Threatened
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	State Threatened

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