Fourmile Creek Watershed Master Plan

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COLLABORATIVE DECISION RESOURCES

Boulder County

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

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Term	**Definition**
Aggradation	The depositing of sediment within the channel bottom (also see Deposition)
Avulsion	The process by which significant erosion occurs at the downstream end of a Reach which results in a drastically different channel alignment
Bedform	A shape of the surface feature on the bottom of a stream that is formed by the flow of water and the movement of bed material. Examples include riffles, runs, pools, and glides.
Biology/Biologic	The science/study of living matter
cfs	Abbreviation for Cubic Feet per Second, is a standard measure of water discharge
Check Structure	A structural provision installed in the bottom of a channel to prevent erosion from propagating upstream
Degradation	The removal of sediment within the channel bottom (also see Erosion)
Deposition	The depositing of sediment within the channel bottom (also see Aggradation)
Detention	The storage of flood water with a controlled release for the purposes of reducing flood-related impacts
Drop Structure	A structural provision installed within the channel to transition the channel from a higher elevation to a lower elevation in a short horizontal distance in an attempt to establish a stable channel slope
Ecology/Ecologic	The branch of biology dealing with the relations between organisms and their environment
Ecosystem	A system formed by the interaction of a community of organisms with their environment
Embankment	A bank, mound, or similar feature designed to hold back water, carry a roadway, etc.
Erosion	The removal of sediment within the channel bottom (also see Degradation), from channel banks, or across various land surfaces
Floodplain	The land adjacent to the channel that becomes inundated with water during a flood event
Flow path	The direction that water will travel within a channel or floodplain
Geomorphology/Geomorphic	The study of the characteristics and development of channel features such as shape, slope, and layout
Hydraulics	The depth, width, and velocity of water within a channel and floodplain
Hydrology/Hydrologic	Quantity of surface water runoff generated from a specific rainfall event
Infrastructure	Features such as roads, bridges, utilities, etc.
LiDAR	Technology utilizing plane-mounted laser apparatus to collect high-resolution topographic information
Low-Flow Channel	A smaller channel within a larger channel that is intended to convey runoff that is generated from more frequently-occurring rainfall events
Natural Channel Design	An engineering design method by which the natural characteristics of a stream are restored using natural materials and an understanding of what the channel looked like prior to becoming damaged
Planform	Horizontal channel pattern, typically informed by historical aerials
Riparian	Of, on, or relating to the banks of a natural course of water
Runoff/Stormwater	Surface water that is generated during a rainfall event and not absorbed by the ground or evaporated into the atmosphere
Topography/Topographic	The detailed elevation mapping of terrain surfaces
Watershed	Area of land where all the water that is under it or drains off of it goes to the same place ultimately
Wetland	A lowland area such as a marsh or swamp that is saturated with water

1. INTRODUCTION

1.1 *Purpose*

Boulder County's Comprehensive Creek Planning Initiative (CCP) is helping the county move forward with long-term creek recovery by initiating watershed-level master planning processes throughout the county, including Fourmile Creek Watershed. The Master plans will assist in recovery efforts by providing post-flood risk analysis, facilitating key decisions about creek alignment, and identifying actions for stream restoration and flood risk management. Boulder County is guiding the effort through an interdepartmental planning team with significant input from property owners; local, state, and federal agencies; and other watershed stakeholders. The Master Plan will be supported by local stakeholders who will work to coordinate the Fourmile Creek Watershed Master Plan with other Master Plans in the Boulder Creek Watershed and carry out the long-term vision of the Plan.

1.2 *Background*

In September 2013, Fourmile Creek experienced catastrophic flooding which destroyed large sections of local roads, residential properties, and private residential accesses along the Fourmile Creek corridor. The high flows combined with the extended duration of the event and sediment/debris inputs from landslides/debris flows resulted in dramatic changes in the creek corridor and significant infrastructure damage, both public and private. The watershed experienced stream migration, in-stream and off-channel deposition and erosion, loss of riparian ecological function, and destruction or significant damage to homes, roads, embankments, bridges, and other infrastructure.

In the aftermath of the flood, land owners, land management and transportation agencies, and others responded by undertaking actions, many short-term and temporary, in order to address the damage caused by the flood. Efforts of this nature ranged from constructing emergency access and temporary roads, installing temporary berms, reestablishing channel conveyance, and stabilizing stream channels. These site-specific efforts continue to take place along different reaches in the Fourmile Creek Watershed and are generally oriented toward meeting immediate needs or mitigating imminent threats.

While local short term solutions have and are being implemented, there is also a recognized need to conduct long-term planning for Fourmile Creek at a watershed scale. Planning at the watershed scale is necessary in order to incorporate local residents' needs and broader stakeholder interest into an approach to flood risk reduction and stream restoration.

The Fourmile Watershed Master Plan will play an important role in restoring and protecting the communities and ecological services that define the creek corridor. Ultimately, this planning effort will support project stakeholders in the implementation of identified project recommendations including drainage improvements, floodplain management and hazard mitigation activities, and other land-use controls. Moreover, the Plan provides a framework for building local and regional resilience and strengthens the capacity of watershed communities to adapt to changing flood risk over time.

1.3 *Project Scope*

The Fourmile Creek Watershed – which includes the Fourmile Creek, Gold Run, and numerous smaller tributaries – is a narrow and steep creek valley in the Colorado Front Range. It is unique in its wealth of historic and cultural features with numerous historic townsites established as early as the 1850's to support the then growing mining industry. Moreover, it is cherished by the residents for the mountain lifestyle and solitude it provides separate from the City of Boulder, and for the numerous wildlife and ecological benefits afforded by the creek and its corridor.

Master planning is a process that establishes the framework and key elements of a site plan. The Fourmile Creek Watershed Master Plan synthesizes restoration components, flood risk reduction, community resilience, and improved ecological function and enhanced aesthetics. Additionally, the Plan supports grant and loan applications. The purpose of the Master Plan is to guide the county, individual landowners, and other stakeholders in the identification and prioritization of stream rehabilitation and restoration projects, as well as activities related to economic recovery, hazard mitigation, and recreation. It is also meant to inform the public, property owners, stakeholders, and local decision makers about the current conditions of the watershed so that they are better able to identify and prioritize risk reduction projects.

The Master Plan articulates the vision of the community for the future of the watershed and guides future planning and development activity by highlighting recommended projects and alternatives that align with diverse community priorities.

A large level of planning and effort was undertaken by both public and private entities immediately following the September 2013 flood and during the flood recovery phase. Whenever possible, the planning team looked to existing plans (including local flood recovery action plans; parks, recreation, and trails master plans; multi-hazard mitigation plans, and more) to inform recommendations, shape planning goals, and to evaluate the alternatives along the stream corridors. As part of long-term flood recovery and resilience-building efforts, Boulder County hired consultants Michael Baker Jr., Inc. and CDR Associates (the Baker Team) to complete a Master Plan for the Fourmile Creek Watershed.

The scope of work for the Master Plan project was developed with Boulder County in conjunction with input from various watershed stakeholders. The following tasks have been completed as part of the development of the Fourmile Creek Watershed Master Plan:

- Development and implementation of a collaborative, locally-driven community engagement strategy;
- Review and integration of best available data including: GIS data and maps, pre- and post-flood aerial photos and topographic (LiDAR) data, existing reports and studies on drainage facilities;
- Review of the previously completed hydrologic analyses;
- Comprehensive assessment of existing ecological, geomorphic, and flood risk conditions; including site investigations to identify drainage structures, existing problem locations, and post-flood hydraulic parameters;
- Development of a post-flood hydraulic analysis and associated flood risk mapping;
- Review and integration of existing zoning and land ownership plans, current and future land use plans, and other land-use management documents;
- Integration of the Master Plan with the ongoing roadway design;
- Development of watershed alternatives that address future needs of diverse stakeholders;
- Evaluation of alternatives based on public feedback, estimated construction costs, potential flooding, planning constraints and/or other related issues

The Fourmile Creek Watershed is an important part of the rich regional system of human communities and ecological services that defines the Colorado Front Range. Its well-being is critical to maintaining the health, biodiversity, and character of the historic communities within the watershed. This planning effort will support project stakeholders and other users in the implementation of drainage improvements, inter-agency coordination, floodplain management, hazard mitigation, and other land-use controls as needed

to reduce potential damages and adverse development in flooded areas. Moreover, it strengthens the capacity of watershed to adapt to changing flood risk and provides a framework for building local and regional resilience.

While the Master Plan will provide the road map for long-term recovery, implementation of the projects outlined in the Master Plan still require funding, detailed design, permitting, right-of-way acquisition, etc. It is the intent that local stakeholders will champion the implementation phase and serve as stewards of the Fourmile Creek Watershed's health moving forward.

2. PLANNING OBJECTIVES

2.1 *Planning Objectives*

Immediately following the 2013 September floods, residents and stakeholders within the Fourmile Creek Watershed began the long process of recovery. Part of the recovery process involved identifying future directions for the watershed and proposing ways to build back better. Master planning contributes significantly to these goals by providing post-flood analysis of flood risk, facilitating key decisions about creek alignment, and identifying actions for stream restoration and flood risk management. In the Fourmile Creek Watershed, the master planning process has been an open and collaborative effort among public agencies, property owners, stakeholders, and the general public. Additionally, the Fourmile Creek Watershed master planning process facilitated a watershed-wide conversation about long-term recovery and local resilience building.

The core objectives of the Master Plan are to:

- Identify a clear vision of the future for the Fourmile Creek watershed
- Inform the public, property owners, stakeholders, and local decision makers about the current condition of the watershed's major drainageways
- Identify future flood risks and propose projects that both reduce flood risk and increase long-term watershed resilience (this includes engaging local stakeholders throughout the planning process to identify priorities, needs, and goals)
- Identify projects for potential funding

The Master Plan has incorporated the following themes by developing strategies, exploring alternatives, and identifying projects with multiple local and regional benefits:

- Community Recovery and Resiliency
- Flood Mitigation and Hazard Risk Reduction
- Stream Hydrology and Stability
- Physical and Structural Protection
- Biology and Environment
- Historic Preservation
- Feedback for the good of the whole watershed

The details of the watershed master planning process, including participants, project timeline, and the relationship of the master plan to other community planning efforts, are described in the following paragraphs.

2.2 *Planning Process*

The historic September 2013 flood reshaped waterways across the northern Front Range of Colorado and made major changes to both the natural and built environment in the region. Over the past year planners, community members, and local decision makers and agencies have worked together to manage immediate and long-term flood recovery activities. Early on in the recovery process the Boulder County Comprehensive Creek Planning Initiative (CCP) was established as the main entity guiding the County's creek rehabilitation and stabilization process. The CCP was developed to help the county move forward with long-term creek recovery by initiating watershed-level master planning processes throughout the region.

The Fourmile Creek Watershed Master Plan marked the transition point from short-term flood recovery activity to the long-term sustainability planning for the entire Fourmile Creek Watershed. An interdepartmental planning team led the planning effort with the support of Boulder County staff (Table 2.1). The planning team recommended resident and stakeholder engagement activities, facilitated existing data collection, and assisted in the identification, evaluation and prioritization of the Master Plan project alternatives. The Master Plan will be supported by the local stakeholders who will champion the implementation phase of the Plan.

After the initial project kickoff meeting, the project team held semi-structured interviews with stakeholders in the watershed to identify broad needs, opportunities, priorities, and challenges that should be addressed through the master plan. Additionally, information gathered during the interviews and kickoff meeting was used to further define effective stakeholder engagement strategies and opportunities. As was established at the start of the planning process, watershed stakeholders worked collaboratively to develop this master plan, which identifies and prioritizes projects that not only reduce risk to public and private infrastructure, but also preserve, enhance, and restore the creek's natural environment and provide for historical preservation opportunities where appropriate and desired. The following stakeholders and agencies were interviewed at the start of the Fourmile Creek Watershed master planning process.

Table 2.1 Fourmile Creek Watershed Master Plan — Boulder County Interdepartmental Planning Team	
Julie McKay	Boulder County – Program Manager
Diane Malone	Boulder County – Program Coordinator
Stacey Proctor	Boulder County – Communications Coordinator
Denise Grimm	Boulder County – Land Use
Claire DeLeo	Boulder County – Parks and Open Space
Varda Blum	Boulder County – Transportation, Floodplain Program
Erin Dodge	Boulder County – Public Health
Dan Delange	Boulder County –Transportation

Table 2.2 Fourmile Creek Watershed Master Plan — Roster of Stakeholder Interview Participants	
Interviewee	Agency / Affiliation
Claire DeLeo	Boulder County - Parks and Open Space
David Sutley and Dawn Gladwell	FEMA Region VIII
Robert DeHass	Pine Brook Water
Peter Swift and others	Gold Hill Town Council
Shea Thomas; Kevin Stewart	Urban Drainage and Flood Control District
Dan Cenderelli; Sylvia Clark	USDA - Forest Service, Arapaho / Roosevelt Natl. Forest
Boyd Byelich	USDA - Natural Resources Conservation Service
Bret Gibson (Fourmile Fire Dept.); Grace Miller (Long Term Flood Recovery Group – LTFRG); Brian Schuler, Eric Stevens	Fourmile/Salina Community
Sheila Murphy (USGS); Susan Martino; Scott Coulson; Erin Dodge	Boulder County Public Health

Table 2.2 Fourmile Creek Watershed Master Plan — Roster of Stakeholder Interview Participants	
Interviewee	Agency / Affiliation
Julie McKay; Varda Blum; Cindy Pieropan; Dan DeLange; Anita A. Riley; Chad Schroeder	Boulder County Transportation and Floodplain Management
Denise Grimm, Dale Case, Kim Sanchez, Bryan Harding and Abby Shannon	Boulder County – Land Use
Denise Grimm, Michael O'Neil, Marti Anderson, Steven Barnard	Historic Preservation Community
Jeff Crane	Colorado Water Conservation Board
Deward Walker	Logan Mill Ranch Tree Farm

The planning process for the Fourmile Creek Watershed Master Plan began in mid-July, 2014. An initial kickoff meeting was held with the planning team on July 21st, followed by a series of interviews during which information was exchanged between planning team members and the Baker Team. The project timeline for the Fourmile Creek Watershed Master Plan is presented below:

Table 2.3 Fourmile Creek Watershed Master Plan — Project Timeline		
Project Milestone	Date	Details
Project Team Kickoff Meeting	7/21/2014	• Refine the scope and objectives of the Fourmile Creek Watershed Master Plan • Obtain feedback on the proposed planning approach • Clarify project team coordination with Boulder County • Refine interview plan
Stakeholder Interviews	7/23/2014 – 9/3/2014	• Discuss key watershed and planning focus areas • Identify additional data sources and plans relevant to the master planning effort • Obtain input on community engagement strategies
Community Kickoff Meeting	9/3/2014	• Clarify goals and scope of the Master Plan • Set expectations for what the plan will achieve • Present an overview of the planning process with a focus on how the public can stay involved and provide input over time • Describe what has been done to date • Gather input on general and specific project opportunities in the Master Plan, including reach-specific break-out sessions
Community Meetings	11/5/2014 & 11/6/2014	• Introduce the draft Plan, how the Plan was developed, and how Community input was incorporated; • Discuss the recommended projects in the draft Plan; • Gather input on the recommended projects and the Plan in general.
Public Comment Period	11/3/2014 – 11/14/2014	• Opportunity for the public and stakeholders to provide comments on the plan

2.3 *Relationship of Master Plan to Other Planning Documents*

Following the 2013 flood, stakeholders within the Fourmile Creek Watershed (including residents, property owners, and public and private sector organizations) began to tackle difficult decisions about where and how to rebuild. In addition to local activity immediately following the flood, other stakeholders and various agencies have initiated work and planning efforts to promote a sustainable, livable, and economically vibrant creek corridor.

The Fourmile Creek Watershed Master Plan is designed to fit within existing community and land use planning programs and strategies. It does not change local policies or procedures related to project implementation, nor does it override existing management plans. Additionally, the Master Plan does not affect FEMA maps or flood insurance rates.

The Master Plan integrates and leverages existing land use management and planning efforts with a vision for long-term flood recovery plan. The plan roll-up (described in Chapter 4) facilitated this process and gave the planning team a comprehensive understanding of pre- and post-flood efforts. Additionally, in-depth interviews with stakeholders at the start of the planning process provided key information related to the ongoing planning activities and management goals of a diverse group of individuals with interest(s) in the watershed including recreation plans, land use management, parks and open space land use management strategies and more.

Due to the large volume of ongoing recovery activities throughout the watershed, all Master Plan activities are being coordinated with the entities performing the work. Some examples include but are not limited to: coordination with the Environmental Protection Agency (EPA) on exposed mine tailings pile plans, Boulder County on permanent road/bridge improvements; USDA - Natural Resources Conservation Service on completed flood recovery projects in the watershed and potential future projects.

3. PLANNING AREA DESCRIPTION

3.1 *Planning Area*

The Fourmile Creek Watershed is located on the eastern slope of the Rocky Mountains and covers 24 square miles and approximately 13 miles of creek (see Figure 3.1 for watershed Planning Area map). Fourmile Creek flows eastward from the mountains into Boulder Creek west of the City of Boulder. The topography of the planning area is primarily forested mountain terrain with large-lot, single family residences along the creek corridors (Figure 3.2). Watershed elevations range from 10,400 feet on Niwot Ridge to 5,700 feet at the confluence of Fourmile Creek and Boulder Creek.

The Fourmile Canyon Fire (September 6-10, 2010) burned 23 percent of the Fourmile Creek Watershed, destroyed more than 160 homes, and was one of the costliest wildfires in Colorado history. The wildfire left the watershed at significant risk of flooding, substantial erosion and debris flows, and water quality degradation. 'Typical' summer thunderstorms in 2011 and 2012 produced flash floods that transported a significant amount of sediment and debris providing clear evidence of the updated risk in the watershed. While post-fire vegetation establishment was favorable by 2014 (pre-flood), the flood risk within the watershed was still elevated because of the lengthy time required for tree regeneration.

The upper part of the watershed is primarily public property (Figure 3.3) with private residences lining the creek corridor. The Gold Run reach is a mixture of public and private property, while the lower part of the watershed is a primarily private property. Lower Fourmile Creek and Gold Run are generally confined by the existing topography and transportation infrastructure.

Because this watershed master plan is meant to address the reaches of the Fourmile Creek Watershed that were significantly impacted by the September 2013 flood, it differentiates between the *Analysis Area* and the *Planning Area*.

The *Analysis Area* for the Master Plan is the entire watershed and is the geographic area for data collection and analysis. The Analysis Area is the geographic scope for evaluating existing plans and post-flood conditions, performing and/or assessing hydrologic analysis, and for stakeholder and public engagement.

The *Planning Area* is smaller than the Analysis Area and defines the area within which the project team conducted all master planning tasks, including: assessment of existing post-flood conditions, conducting creek corridor evaluations and risk assessments, identification of plan strategies and alternatives, and project prioritization and implementation.

The following historic communities are included in the Planning Area:

- Crisman
- Salina
- Wallstreet
- Sunset
- Summerville

3.2 *September 2013 Flood*

Beginning on September 11th, 2013, significant flash flooding occurred in north-central Colorado on the eastern side of the Continental Divide. The September 2013 flood revealed infrastructure limitations as well as areas of significant risk. Larimer, Weld, and Boulder counties were among the most devastated of the 18 Colorado counties included in the September 24, 2013 Presidential Disaster Declaration. The historic rainfall, which reached over 17 inches of rain recorded by September 15th, brought yearly precipitation levels to over 30 inches (the most rain recorded in 120 years of hydrological record).

Along the Fourmile Creek corridor the flood destroyed large sections of local roads, residential properties, and private residential accesses. A high percentage of local residents were heavily affected by the flood and some were stranded for extended periods of time. Together, the high peak flows, the long duration of the event, and the sediment and debris inputs from landslides/debris flows resulted in significant infrastructure damage, both public and private. In addition to damaged infrastructure, the flood impacts on the creek corridor included migrations of the stream and significant in-stream and off-channel deposition and erosion.

The flood impacts on tributaries in the drainage caused substantial changes not only to the Fourmile Creek and Gold Run corridors, but also to the upland tributary creek drainages. These changes included damaging debris flows from fire-affected hillsides, destruction of tributary culverts, heavy erosion and deposition of material in tributaries, and the conveyance and deposition of debris included rocks, cobble, sand, trees, and trash throughout the stream corridor.

3.3 *Overview of Reaches*

To facilitate the alternative development process, The creeks in the Planning Area were divided into several smaller reaches along the length of the watershed. This allowed the planning team to focus on the needs and characteristics of specific portions of the creek and to better organize ongoing public engagement activity. Reach locations and limits are shown in Figure 3.1 and descriptions for each reach are provided below:

Reach 1: Fourmile Creek from the confluence with Boulder Creek to Poorman Road. This reach of the creek is constrained by existing topography and transportation infrastructure. A large percentage of the property along the creek corridor is private. The creek did not migrate significantly in this reach, but the reach did experience bank erosion, sediment deposition, and flooding damages.

Reach 2: Fourmile Creek from Poorman Road to Mile Marker 4 (Upstream of Logan Mill Road). This reach of the creek is well below Fourmile Canyon Rd and many residential structures for the majority of the reach and is less constrained than the lower reach. This reach filtered out a significant amount of sediment and debris during the floods, preventing it from impacting lower Fourmile. This reach also contains the only public crossing of Fourmile Creek in the Planning Area.

Reach 3: Fourmile Creek from Mile Marker 4 to Mile Marker 5 and Gold Run from Salina Junction to Summerville. This reach was among the hardest hit by the flood. It experienced significant channel migration, erosion, deposition of sediment, and destruction of properties along with public and private infrastructure. This reach is severely constrained by existing topography, infrastructure, and historic structures.

Reach 4: Fourmile Creek from Mile Marker 5 to Sunset. This reach of the creek experienced a wide range of damages, although the damages were not as severe as Reach 3. Approximately 40% of the private crossings in this reach were destroyed and others were damaged. The creek and floodplains in this reach is less constrained than Reach 1 or 3.

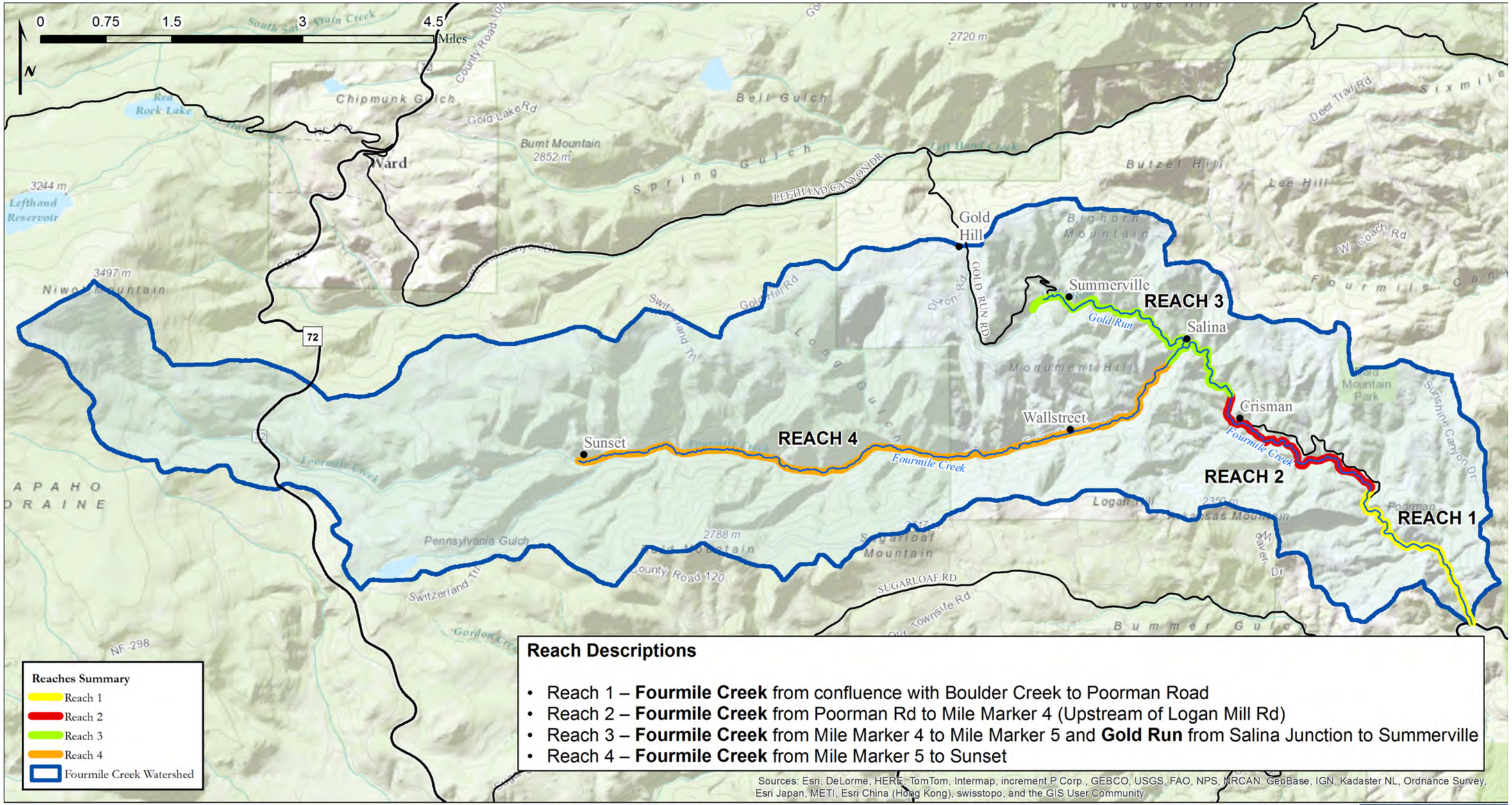

Figure 3.1: Planning Area Map

FOURMILE CREEK WATERSHED MASTER PLAN

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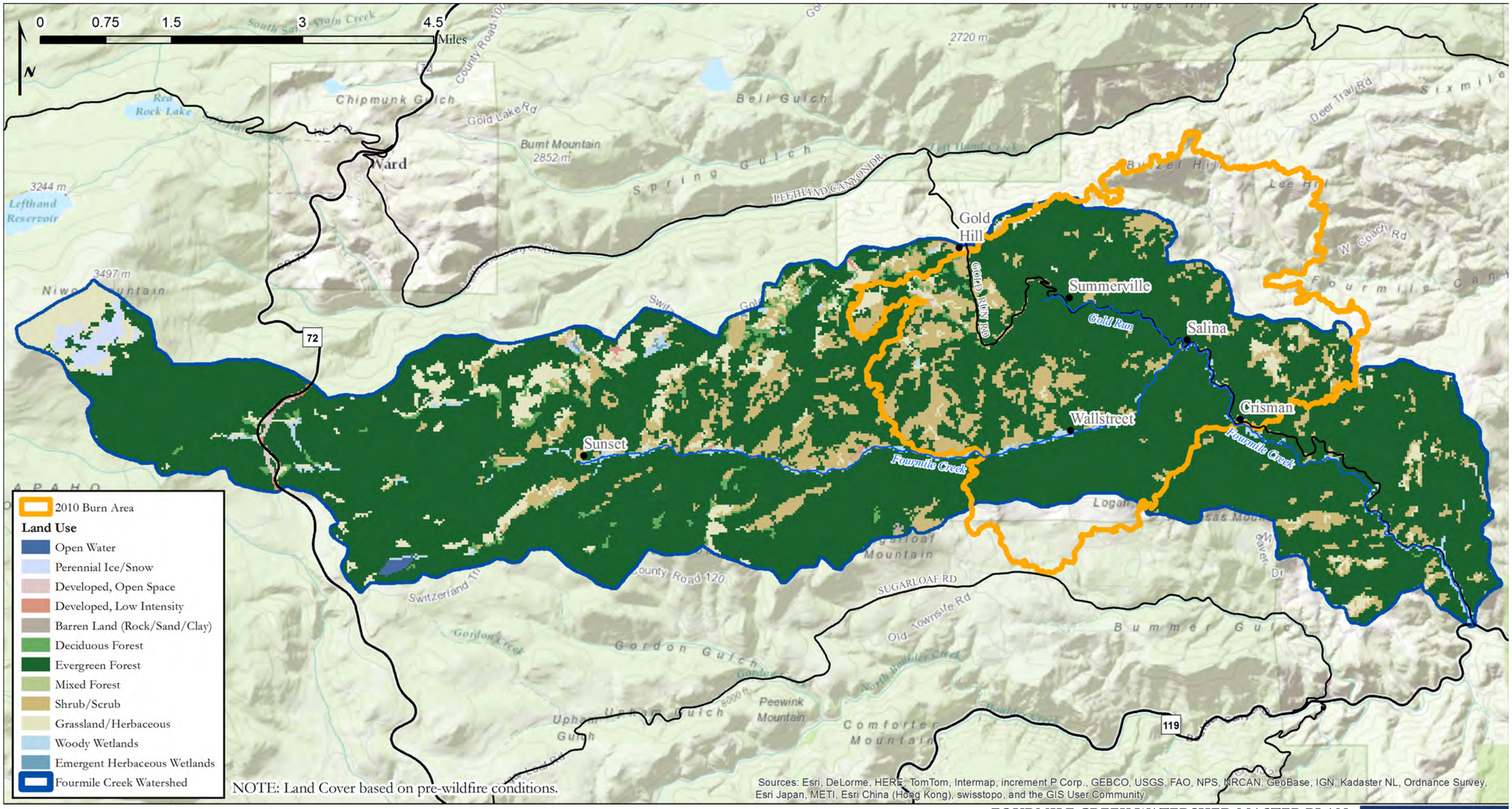

Figure 3.2: Land Cover Map

FOURMILE CREEK WATERSHED MASTER PLAN

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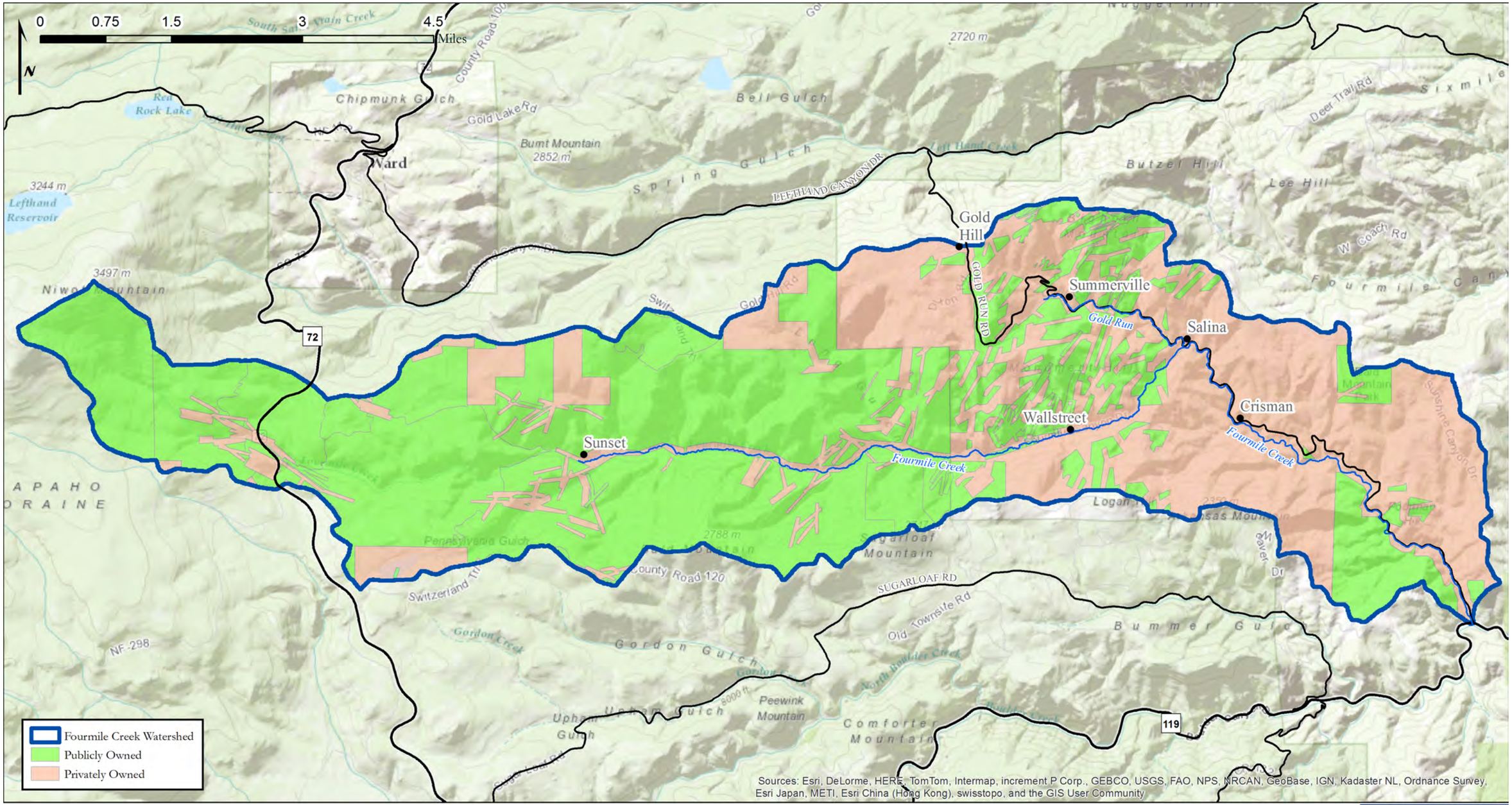

Figure 3.3: Land Ownership Map

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4. DATA COLLECTION

Effective master planning projects typically begin with research and data collection, and end with a solid guide for future improvements that address the needs of multiple stakeholders and can be used as a reference document for years to come. The data collection process for this report included the synthesis of existing data, plans, and studies as well as technical analysis, engineering calculations, agency and public coordination, and attention to the environment and the priorities of diverse stakeholders.

Through the assistance of planning team members and other stakeholders, the project team collected GIS and engineering data, as summarized in this Section. Limited new data was collected specifically for this planning effort; however, the plan represents a compilation of existing data into one location for use by community members and local constituents. While data was available for the majority of the study area, some of the data has limited applicability and efficacy due to:

- Age of the data and/or the methodologies used;
- Data gaps exist due to the reality that, in some areas, field research has not previously been conducted; and
- In some areas, data collection efforts have already been funded and scheduled for a later date.
- Impacts from the flood (aggradation, erosion, etc.), or the flood recovery effort (construction of flood recovery and stabilization projects), resulting in an invalidation of the existing flood risk data.

While every effort was taken to ensure that the information used in this plan is the most current and the most accurate, it is possible that additional data sources exist that were not discovered as part of this effort. Additionally, in many cases there is a need for future site-specific data collection and analysis to assist with scoping and project design details.

Despite the aforementioned data limitations, the watershed assessment provided in this plan represents a comprehensive view of the Fourmile Creek watershed, and includes recommendations detailing how flood risk should be addressed within the watershed. Over time, the assessment should continue to be updated with current information as it becomes available in order to establish a holistic framework for the prioritization of plan alternatives, resource management efforts, and future development plans.

4.1 *GIS Data*

Geographic Information System (GIS) layers were obtained from Boulder County, the Colorado Water Conservation Board (CWCB), the Colorado Department of Transportation (CDOT), the Federal Emergency Management Agency (FEMA), the U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS), the Bureau of Land Management (BLM), and the U.S. Geological Survey (USGS) for the study area.

The projection used in preparation of this data is the Universal Transverse Mercator (UTM) zone 13. The horizontal datum is NAD 1983 HARN State Plane Colorado Central North. All topographic data are referenced to the North American Vertical Datum of 1988 (NAVD 88).

The follow list include a sampling of geographic data sets leveraged: post-flood damages, post-flood stream channel, post-flood inundation areas, flood debris, recovery berms, recovery planning areas, FEMA FIRM, CWCB floodplains, parcels, pre- and post-flood topographic (LiDAR) data, pre and post-flood orthoimagery ,roadways, road setbacks, wetlands, mine locations, historic structures, and stream habitat connectors.

4.2 *Engineering Data*

4.2A *Existing Hydrologic Studies*

The current FEMA regulatory discharges for Fourmile Creek are based on a 1977 study performed for FEMA by the United States Army Corps of Engineers (description below). Gold Run is not mapped as a regulatory floodplain, and therefore does not have published regulatory discharges. However, recent hydrologic analyses have been performed on Gold Run in response to the Fourmile Canyon Fire. The following are the previous hydrologic analysis for Fourmile Creek and Gold Run that were reviewed as part of the Master Plan

Effective FEMA Flood Insurance Study – USACE (1977)

The Effective FEMA Flood Insurance Study on Fourmile Creek is based on study performed in 1977 by the USACE entitled, "Water and Related Land Resources Management Study, Metropolitan Denver and South Platte River and Tributaries, Colorado, Wyoming, and Nebraska, Volume V – Supporting Technical Reports Appendices, Appendix H – Hydrology (USACE, 1977 and Review Report, Boulder Creek." The study estimated discharges for the 10, 4, 2, 1, and 0.2 percent annual chance events along Boulder Creek and Fourmile Creek utilizing rainfall-runoff modeling (EPA's SWMM model for the upper basin). The study did not include any published discharges for Gold Run.

Hydrology Verification Report for Boulder Creek – Anderson Consulting Engineers, Inc (2009)

As part of an updated hydraulic study on Boulder Creek for the City of Boulder, Anderson Consulting was asked to evaluate the 1977 USACE hydrologic model for the Boulder Creek watershed. The effort was performed to determine whether or not a revised hydrologic modeling effort would be justified prior to conducting the hydraulic analysis. Anderson concluded that the 1-percent annual chance discharges produced by the 1977 USACE study are reasonable and appropriate for conducting the current hydraulic analysis for Boulder Creek.

Fourmile Canyon Post-Fire Hydrology – WWE (2011)

Wright Water Engineers, Inc. (WWE) performed a hydrologic analysis of the post-wildfire Fourmile Canyon watershed for the Boulder County Transportation Department. The analysis computed discharges utilizing rainfall-runoff modeling as employed by the USACE HEC-HMS model. The Curve Numbers used in the model represented the extremely high runoff potential in the post-wildfire condition. The modeling included discharge estimates for numerous locations along Fourmile Creek and Gold Run.

Boulder Creek Hydrologic Analysis – CH2MHILL (August 2014)

The Colorado Department of Transportation (CDOT) worked, in partnership with the Colorado Water Conservation Board (CWCB), on development of new hydrologic models in the watersheds affected by the September 2013 floods. This involved creation of new hydrologic models using a rainfall-runoff methodology as employed by the USACE HEC-HMS model. A significant amount of data was captured during the flood event and this data was used in calibrating the new models. In addition, the newly collected topographic (LiDAR) data and new rainfall data from the recently released NOAA Atlas 14 was used.

The primary purpose of the CDOT/CWCB work was to create models for CDOT's use in repair of damaged infrastructure. However, it was the State's hope that the models could be utilized by communities for future regulatory purposes. The State has stated there is no mandatory requirement to use the new model results for design or floodplain management purposes.

The hydrologic analysis for the Boulder Creek watershed, which includes Fourmile Creek and Gold Run was finalized August 29, 2014.

The CDOT/CWCB August 2014 study recommends a relatively large decrease in peak flows in the Fourmile Creek watershed relative to regulatory discharges. The recommended discharges could have a significant impact in the Fourmile Creek Watershed from both a design and floodplain management perspective. A summary of discharges from the various studies is included in Table 4.1.

Table 4.1 Summary of 100-yr Discharges for Existing Studies on Fourmile Creek and Gold Run				
Location	FEMA Effective Study (1977)	WWE Post-Wildfire Hydrology (2011)	CDOT/CWCB Hydrology (2014)	2013 Flood Estimated Discharges
Fourmile Creek @ mouth	6,230 cfs	5,550 cfs	3,430 cfs	2,510 cfs[1]
Fourmile Creek Downstream of Emerson Gulch	4,470 cfs	1,780 cfs	1,734 cfs	1,070 cfs[2]
Fourmile Creek Upstrem of Burned Area	2,310 cfs	817 cfs	949 cfs	490 cfs[2]
Gold Run @ Salina Junction	-	2,260 cfs	403 cfs	-
Gold Run @ Summerville	-	520 cfs	-	-

1 USGS Manual measurement
2 Peak Discharges for the September 2013 flood in Selected Foothills Region Streams, South Platte River Basin, Colorado (Jarrett)

4.2B *Existing Hydraulic Studies*

In support of the Fourmile Creek Watershed Master Plan, the Baker Team has collected the following hydraulic analysis performed in the watershed. The current FEMA regulatory hydraulic model and floodplain mapping for Fourmile Creek are based on a 1981 study performed for FEMA by the CWCB (description below). Gold Run is not modeled or mapped as a regulatory floodplain.

Effective FEMA Flood Insurance Study – CWCB (1981)

The Effective FEMA Flood Insurance Study on Fourmile Creek is based on study performed in 1981 by Gingery Associates, Inc. for CWCB entitled, "Floodplain Information Report - Upper Boulder Creek and Fourmile Creek." Although the study serves as the basis for the regulatory FEMA flood maps, the modeling and mapping has not been updated in the last 30 years, reflect pre-flood conditions and digital versions of the model are not available. Therefore, using elevations and/or exact inundation limits from this dataset is not advised. The benefit of this analysis is limited to evaluating floodplain management implications.

Flood Recovery Mapping – CWCB (2014)

CWCB (Atkins) prepared post-flood hydraulic models for Fourmile Creek and Gold Run. The models (HEC-RAS) were developed using automated procedures with little or no manual input. Discharges for the models are a combination of effective discharges from the FEMA Flood Insurance Study (USACE 1977) and computed discharges from USGS regional regression equations. A review of the models and mapping revealed issues with the results that stemmed from the automated development of the model including lack of bridges and culverts, incorrectly placed cross sections, discontinuous floodplains, and large discrepancies in discharges. As a result of the issues discovered during the review of this analysis, using elevations and inundation limits from this dataset was not recommended.

Fourmile Canyon Drive Roadway Project Hydraulic Modeling – Baker (2014)

Several short reaches of hydraulic models (HEC-RAS) were prepared as part of the Fourmile Canyon Drive Roadway Project. These include updated models for Salina Junction and the Logan Mill Road crossing based on post-flood topographic information and field survey.

4.2C *Topographic Data*

The USACE, in cooperation with FEMA and CWCB, is planning on collecting updated LiDAR topographic information in the fall of 2014 to supplement the 2013 post-flood LiDAR due to channel work performed during emergency activities subsequent to the original post-flood data collect. This new topographic information will be an updated depiction of existing conditions and be invaluable in regards to updating flood hazard analysis moving forward.

4.3 *Application of Engineering Data*

Due to schedule and resource constraints, the intent of the Fourmile Master Plan was to rely almost entirely on the existing best available engineering data to inform flood risk evaluations in the watershed. This included the combination of regulatory and non-regulatory datasets described above. After reviewing the available data, it was determined that existing hydrologic analysis could be utilized; however, an updated hydraulic model would need to be developed to adequately represent the post-flood risk in the watershed.

4.3A *Hydrology*

Our review of previous studies in the watershed indicated that the effective FEMA study on Fourmile Creek based on the 1977 USACE study may be conservative. In addition, the effective FEMA study does not recommend any discharges for Gold Run. The recommended discharges from the CDOT/CWCB study are consistent with the WWE post-wildfire study (2011) for locations upstream of the burn area and the modeling is calibrated to the 2013 event. Several agencies reviewed the CDOT/CWCB results and some of them expressed concerns with some of the input parameters used to calculate discharges. The Baker Team discussed these concerns with the agencies making them, and concurred that an elevated level of concern was reasonable. To further investigate the appropriateness of the CDOT/CWCB discharges, the Baker Team performed a sensitivity analysis on some of the inputs in question in order to evaluate their impact, and also to compare the impact on water-surface elevations of the CDOT/CWCB vs. FEMA discharges.

As a result of the steepness and constrained nature of Fourmile Creek and Gold Run, the CDOT/CWCB discharges do not have a significant impact on flood risk inundation limits when compared to the regulatory discharges. However, utilizing the CDOT/CWCB discharges could have a significant impact in the Fourmile Creek Watershed from a design perspective. Until the regulatory discharges are changed through an updated FEMA Flood Insurance Study, they are still the governing discharges from a floodplain management perspective. For that reason, the Baker Team included both the effective regulatory discharges (FEMA) and the CDOT/CWCB discharges in the hydraulic model.

4.3B *Hydraulics*

After reviewing the CWCB Flood Recovery Modeling/Mapping, it was determined that it could not be used as the base for the flood risk analysis. Issues were identified with the modeling and mapping results that indicated the post-flood risk was not being adequately identified by the analysis. It was determined that a new hydraulic model would be developed by the Baker Team for the entire study reach of Fourmile Creek and Gold Run.

The post-flood hydraulic model has been developed utilizing the USACE's HEC-RAS modeling software in the following way:

- Discharges – The HEC-RAS model developed for this Master Plan calculated water surface elevation profiles for the 10-, 50-, 100-, and 500-year events based on the effective regulatory (FEMA) discharges for Fourmile Creek and for the 10-, 25-, 50-, 100-, and 500-year events based on the CDOT/CWCB discharges for Fourmile Creek and Gold Run.
- Topographic information – Post-flood topographic (LiDAR) data was collected by Photo Science in October of 2013. The topographic (LiDAR) data was combined with field survey (collected as part of the roadway project) to create a single 3-dimmensional surface. The HEC-RAS hydraulic model was based on this combined surface.
- Private and Public Structures – As part of the data collection, The Baker Team collected a table prepared by Boulder County on Pre-Flood vs Post-Flood creek crossing comparison, GIS layers from Boulder County on the locations of private and public structures, and an inventory on pre-flood creek crossing from the Fourmile Fire Department. Baker combined

these data sources, field confirmed all structures, and created a GIS layer summarizing the location and information. Baker also collected survey on the Salina Junction and Logan Mill Road crossings and obtained as-built plans from CDOT on the Hwy 119 crossing.

» Boundary Conditions - The model was run in the sub-critical regime so only downstream boundary conditions were required. The downstream boundary condition for Fourmile Creek was established using the Normal Depth approach with an energy grade line slope of 0.03, while Gold Run used a slope of 0.08. These slopes were calculated via inspection of the topographic data.

» Model Coefficients – The Manning's Roughness Coefficients were determined by visual inspection of post-flood aerial photos and horizontally varied at each cross section. Roughness values varied from 0.015 to 0.08. Expansion and Contraction coefficients were modified at bridges and culverts to account for the losses transitioning in and out of the structures. Expansion and Contraction coefficients were set to 0.5 and 0.3 (respectively) at all crossings. All other locations were set to 0.3 and 0.1.

» Model Set Up – The hydraulic model was developed utilizing the public and private structures locations as a guide. Cross sections were manually placed upstream and downstream of all identified structures. Additional cross sections were placed in between structures as required to develop a reasonable hydraulic model. Cross section locations from the effective FEMA study were used as a guide for placing intermediate cross sections. The Salina Junction, Logan Mill Rd, and Hwy 119 crossings were inserted into the model based on the survey and as-built data. Additional crossings were added to the model as detailed by Table 4.2.

The results of the post-flood hydraulic analysis are included in Appendix D.

Table 4.2 Fourmile Creek and Gold Run Structure Inventory

Location	Type	Owner Type	Included in the Model	Source of Structure Information
Hwy 119	Culvert	Public	Yes	As-built Plans
91 Fourmile (1)	Bridge	Private	Yes	Fourmile FDP Measurements
91 Fourmile (2)	Pedestrian Bridge (Small)	Private	No	NA
91 Fourmile (3)	Bridge	Private	Yes	Fourmile FDP Measurements
265/267 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
297 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
347 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
386 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
421 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
593/595/597 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
635 Fourmile	Pedestrian Bridge (Small)	Private	No	NA
635 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
683 Fourmile	Pedestrian Bridge (Large)	Private	No	NA
703 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
785 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
821 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
853 Fourmile	Pedestrian Bridge (Large)	Private	Yes	Estimated Size
907 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
887 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
1033 Fourmile	Bridge	Private	Yes	Estimated Size
1057/1061 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
1107/1109 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
1175/1177 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
1685 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
Betasso	Bridge	Public	No	NA
43 Crisman	Bridge	Private	Yes	Fourmile FDP Measurements
104 Crisman	Bridge	Private	Yes	Fourmile FDP Measurements
Logan Mill Rd	Culvert	Public	Yes	Field Survey
4367 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
4389 Fourmile	Bridge	Private	No	NA
5089 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
5161 Fourmile	Pedestrian Bridge (Small)	Private	No	NA
5216 Fourmile	Pedestrian Bridge (Small)	Private	No	NA
5411 Fourmile	Bridge	Private	No	NA
5851 Fourmile	Bridge	Private	Yes	Estimated Size
5927 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
6149 Fourmile	Culvert	Private	Yes	Estimated Size
6229 Fourmile	Culvert	Private	Yes	Estimated Size
6455 Fourmile/15 Alpine Gulch	Culvert	Private	Yes	Estimated Size
7315 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
7979 Fourmile	Culvert	Private	Yes	Estimated Size
8200 Fourmile	Culvert	Private	Yes	Estimated Size
8455 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
8887 Fourmile	Culvert	Private	Yes	Estimated Size
9083 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
9141 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
9685 Fourmile	Culvert	Private	Yes	Fourmile FDP Measurements
10147 Fourmile	Bridge	Private	Yes	Fourmile FDP Measurements
10221 Fourmile	Culvert	Private	Yes	Fourmile FDP Measurements
19 Switzerland	Culvert	Private	Yes	Field Measured

Table 4.2 Fourmile Creek and Gold Run Structure Inventory

Location	Type	Owner Type	Included in the Model	Source of Structure Information
17 Gold Run	Culvert	Public	Yes	Field Survey
84 Gold Run	Culvert	Public	Yes	Field Measured
175 Gold Run	Culvert	Public	Yes	Field Measured
217 Gold Run	Culvert	Private	Yes	Field Measured
219 Gold Run	Culvert	Private	Yes	Field Measured
223 Gold Run	Culvert	Private	Yes	Field Measured
311 Gold Run	Culvert	Private	Yes	Field Measured
315 Gold Run	Culvert	Public	Yes	Field Measured
411 Gold Run	Culvert	Public	Yes	Field Measured
637 Gold Run	Culvert	Private	Yes	Field Measured
839 Gold Run	Culvert	Public	Yes	Field Measured
864 Gold Run (1)	Culvert	Private	Yes	Field Measured
864 Gold Run (2)	Culvert	Public	Yes	Field Measured
1007 Gold Run	Pedestrian Bridge (Small)	Private	No	NA
1116 Gold Run	Culvert	Public	Yes	Field Measured
1158 Gold Run	Culvert	Private	Yes	Field Measured
1483 Gold Run	Culvert	Public	Yes	Field Measured

FDP = Fire Department

4.4 *Unmet Needs / Recommendations*

Due to the age of the existing flood hazard analyses, the highly erosive nature of the September 2013 floods, the lack of current flood risk information for Gold Run, and the subsequent recovery work in the watershed, most reaches of existing stream corridor are in need of updated flood hazard modeling and mapping. It is recommended that the CDOT/CWCB hydrology be utilized for all flood hazard updates in the future.

The updated flood risk analysis performed as part of this Master Plan can be utilized to support updating the effective FEMA Flood Insurance Rate Maps as an Approximate (Zone A) study. Survey of all structures (bridges/culverts) would need to be performed and updated topographic information would need to be collected in areas modified after the 2013 LiDAR data was collected in order to represent the results of the updated flood risk analysis as a Detailed (Zone AE) study on the FEMA Flood Insurance Rate Maps. Table 4.3 summarizes the unmet flood hazard hydraulic and FEMA flood mapping needs if a Detailed (Zone AE) level of study is preferred. Priorities are defined as follows:

- High - Urgent need due to ongoing and imminent design projects and/or large amount of infrastructure at risk of subsequent flood event.
- Medium - Need exists but some updated information is already available or currently being prepared by others and/or moderate infrastructure at risk.
- Low - Need exists but being addressed by others with minimal infrastructure at risk.

4.4A *Recommendations for Addressing Needs*

Accurate and up-to-date flood hazard information is critically important to informing residents of their current level of risk and to implementing the projects outlined in the Fourmile Creek Watershed Master Plan. The conceptual designs outlined in Chapter 7 will benefit greatly from the updated topographic information (including the new post- flood LiDAR and future supplemental surveying); future updated hydraulic modeling/floodplain mapping; and updated FEMA regulatory products.

The following recommendations are listed chronologically with respect to updated flood hazard data:

- Coordinate with CWCB to designate and approve the flood risk information developed for Gold Run as part of this Master Plan;
- Coordinate with FEMA Region VIII to have the effective FEMA Flood Insurance Rate Maps for Fourmile Creek and Gold Run updated (Zone A) based on the flood risk analysis performed as part of this Master Plan and the CDOT/CWCB discharges;
- Collect structure (bridge/culvert) surveys as part of the Fourmile Canyon Drive and Gold Run roadway improvement projects and update the hydraulic model with the collected survey;
- Obtain new post-flood USACE LiDAR when it becomes available (estimated summer 2015) and update the hydraulic model with the new LiDAR data;
- Assess the changes to the flood risk information based on the collected survey and updated LiDAR information; and
- If the changes are significant, collect remaining structure (bridge/culvert) surveys and coordinate with FEMA Region VIII to have the FEMA Flood Insurance Rate Maps for Fourmile Creek and Gold Run updated to a detailed level of study (Zone AE).

Table 4.3 Fourmile Creek Watershed – Flood Hazard Data Unmet Needs

Flooding Source	Extents (downstream to upstream)	Update Needed?	Priority	Reason	Estimated Hydraulics Cost	Estimated FEMA Map Update Cost
Fourmile Creek	Confluence with Boulder Creek to Salina Junction	Partial	Medium	Updated (post-flood) hydraulic model and mapping is adequate for a FEMA Zone A (Approximate) SFHA. Structure (bridge/culvert) surveys and updated topographic information for areas modified after the current topographic information was collected would be needed for a FEMA Zone AE (Detailed) SFHA.	$57,000	$27,000
Fourmile Creek	Salina Junction to Sunset	Partial	Medium	Updated (post-flood) hydraulic model and mapping is adequate for a FEMA Zone A (Approximate) SFHA. Structure (bridge/culvert) surveys and updated topographic information for areas modified after the current topographic information was collected would be needed for a FEMA Zone AE (Detailed) SFHA.	$54,000	$37,000

Table 4.3 Fourmile Creek Watershed – Flood Hazard Data Unmet Needs						
Flooding Source	Extents (downstream to upstream)	Update Needed?	Priority	Reason	Estimated Hydraulics Cost	Estimated FEMA Map Update Cost
Gold Run	Confluence with Fourmile Creek to Summerville	Partial	Medium	Updated (post-flood) hydraulic model and mapping is adequate for a FEMA Zone A (Approximate) SFHA. Structure (bridge/culvert) surveys and updated topographic information for areas modified after the current topographic information was collected would be needed for a FEMA Zone AE (Detailed) SFHA.	$36,000	$23,000
				Subtotal	$147,000	$87,000
				Grand Total	$234,000	

4.5 *Threatened and Endangered Species*

The Endangered Species Act (ESA) declares the intention of Congress to protect federally-listed threatened and endangered species and designated critical habitat of such species. United States Fish and Wildlife Service (USFWS) is the primary regulatory agency responsible for ESA compliance. Using the USFWS Information, Planning, and Conservation System (IPaC), eleven species were identified as having a potential to occur in the Fourmile Creek Watershed. Table 4.4 contains a list of these species along with their status, preferred habitat, and whether suitable habitat for the species is found within the potential project areas.

Table 4.4 Threatened and Endangered Species				
Common Name	Scientific Name	Status	Habitat	Potential Project Impact
Canada lynx	*Lynx canadensis*	T	Moist boreal forests that have cold, snowy winters and a high-density snowshoe hare prey base.	May affect, Not likely to adversely affect; suitable habitat may be present.
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	T	Well-developed riparian habitat with adjacent, relatively undisturbed grassland communities, and a nearby water source. Riparian habitat includes a dense combination of grasses, forbs and shrubs and/or trees.	May affect, Not likely to adversely affect; suitable habitat may be present.
Colorado butterfly plant	*Gaura neomexicana var. coloradensis*	T	Occurs on subirrigated, alluvial soils on level or slightly sloping floodplains and drainage bottoms at elevations of 5,000–6,400 feet. Low depressions or along bends in wide, active, meandering stream channels a short distance upslope of the actual channel. Habitat is open, without dense or overgrown vegetation.	May affect, Not likely to adversely affect; suitable habitat may be present.
Ute ladies'-tresses	*Spiranthes diluvialis*	T	Primarily found in moist meadows associated with perennial stream terraces, floodplains, and oxbows at elevations between 4,300-6,850 feet.	May affect, Not likely to adversely affect; suitable habitat may be present.
Mexican spotted owl	*Strix occidentalis lucida*	T	Old-growth or mature forests that possess complex structural components. Canyons with riparian or conifer communities. Rock walls with caves, ledges, and other areas provide protected nest and roost sites	No effect; suitable habitat not present.

Source: http://ecos.fws.gov/ipac/wizard/chooseLocation!prepare.action
Status Key:
T - Federally Listed Threatened
E - Federally Listed Endangered

No critical habitat is present within or near the potential project areas. Potential habitat for federally-listed species may be present for Canada lynx, Preble's meadow jumping mouse, Colorado butterfly plant, and Ute ladies'-tresses. Within potential project areas along Four Mile Creek, habitat for these species may be present. It is recommended that before a project is commenced, site specific surveys are conducted to determine the existence of potential habitat for the species. Projects may affect, but are not likely to adversely affect the Canada lynx, Preble's meadow jumping mouse, Colorado butterfly plant, and Ute ladies-tresses. Conservation measures to avoid and minimize impacts to the Preble's meadow jumping mouse, Colorado butterfly plant, and Ute ladies'-tresses will be implemented based on the document "Frequently Asked Questions and 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 ssp. coloradensis*) from Emergency Flood Response Activities Along Streams, Rivers, or Transportation Corridors in Colorado".

Fourmile Creek lies within the South Platte River Basin. Water-related activities/use in the South Platte River Basin may affect listed species in Nebraska and therefore these activities/uses are subject to the provisions of the ESA. In 1997, the Governors of Nebraska, Colorado and Wyoming signed a Cooperative Agreement with the US Department of Interior that details a plan for basinwide recovery efforts. The Platte River Recovery Implementation Program (PRRIP) is the result of these planning efforts. The goals of the PRRIP (2014) are to increase stream flows in the central Platte River during relevant time periods; enhance, restore and protect habitat lands for the target bird species; and accommodate certain new water-related activities. Table 4.5 lists the five species that would be considered under the ESA for water-related activities/use. Coordination with the USFWS would be necessary to determine whether a project would fall under a water-related activities/use.

Table 4.5 Threatened and Endangered Species to be considered for water-related activities/use in the N. Platte, S. Platte and Laramie River Basins which may affect listed species in Nebraska

Common Name	Scientific Name	Status	Habitat	Impact
Pallid sturgeon*	*Scaphirhynchus albus*	E	Large, turbid, free-flowing rivers with a strong current and gravel or sandy substrate.	No effect; suitable habitat not present.
Least tern*	*Sterma antillarum*	E	Sandy/pebble beaches with sparse to no vegetation on lakes, reservoirs, and rivers.	No effect; suitable habitat not present.
Piping Plover*	*Charadrius melodus*	T	Sandy lakeshore beaches and river sandbars. They prefer sparsely vegetated open sand, gravel, or cobble for a nest site.	No effect; suitable habitat not present.
Whooping crane*	*Grus Americana*	E	Utilizes a variety of wetland and other habitats, including coastal marshes and estuaries, inland marshes, lakes, ponds, wet meadows and rivers, and agricultural fields	No effect; suitable habitat not present.
Western prairie fringed orchid*	*Platanthera praeclara*	T	Is a perennial orchid of the North American tall grass prairie and is found most often on unplowed, calcareous prairies and sedge meadows	No effect; suitable habitat not present.

Source: http://ecos.fws.gov/ipac/wizard/chooseLocation!prepare.action
Status Key:
T - Federally Listed Threatened
E - Federally Listed Endangered

The South Platte River Water Related Activities Program (SPWRAP) is a Colorado nonprofit corporation that partners with the State of Colorado to implement the PRRIP in central Nebraska. SPWRAP assists in the recovery of listed species under the ESA in a manner that ensures the State of Colorado's compliance with PRRIP. Colorado water users may participate in the SPWRAP to obtain ESA compliance in regards to listed species that may be affected by water-related activities/use. More information about SPWRAP and the benefits of participating in the program can be found on their website at www.spwrap.org.

Migratory Birds

The Migratory Bird Treaty Act (MBTA) of 1918 provides for the protection of birds classified as migratory birds by the USFWS. In Colorado, most birds, except for the European Starling (*Sturnus vulgaris*), House Sparrow (*Passer domesticus)*, Rock Dove (*Columbia livia*) (Pigeon), and common grouse/pheasant species (*Order Galliformes*), are protected under the MBTA. The Migratory Bird Permit memorandum issued in April 2003 stipulates there is no prohibition against destruction of inactive nests. Additionally, any disturbance to these nesting areas must follow the stipulations outlined in the MBTA. Specific protection for Bald and Golden Eagles is authorized under the Eagle Protection Act (16 USC 668) which provides additional protection to these species from intentional or unintentional harmful conduct. The watershed contains suitable habitat that may provide opportunities for forage, roosts, and nesting to migrating birds, such as raptors and passerines.

If an active nest containing eggs or young birds is found, all work that could result in abandonment or destruction of the nest will be avoided until the young have fledged or the nest is unoccupied as determined by a qualified biologist. General bird nesting season lasts from March through August.

4.6 *Vegetation and Wildlife*

Vegetation

The vegetation present in the watershed is typical for a foothills/montane habitat. Vegetation within and surrounding the project area consists of mature trees with herbaceous understory. Dominant trees and vegetation within the project area include:

- Ponderosa pine (*Pinus ponderosa*)
- Douglas fir (*Pseudotsuga menziesii*)
- Quaking aspen (*Populus tremuloides*)
- Narrowleaf cottonwood (*Populus angustifolia*)
- Plains cottonwood *(Populus deltoids*)
- Willow species (*Salix sp.*)
- Choke cherry (*Prunus virginiana*)
- Chinese elm (*Ulmus parvifolia*)
- Rocky Mountain juniper (*Juniperus scopulorum*)

Herbaceous vegetation within the project area consisted of a variety of native and non-native species, including:

- Smooth brome (*Bromus inermis*)
- Common mullein (*Verbascum thapsus*)
- Intermediate wheatgrass (*Thinopyrum intermedium*)
- Russian thistle (*Salsola tragus*)
- Scotch thistle (*Onopordum acanthium*)
- Common sunflower (*Helianthus annuus*)
- Common cocklebur (*Xanthium strumarium*)
- Canada thistle (*Cirsium arvense*)
- Mountain snowberry (*Symphoricarpos oreophilus*)

Removal of existing trees and vegetation during as the result of any proposed projects should be limited. Access routes, staging areas, etc. will be located within previously disturbed areas to the extent possible. Disturbed areas will be restored using native plant materials.

Noxious Weeds

The US Department of Agriculture (USDA) and the Colorado Department of Agriculture are responsible for officially designating noxious weeds. Noxious weeds are invasive species that by federal and state law must be controlled. Noxious weeds can produce significant changes to vegetation, composition, structure, or ecosystem function. The Colorado Noxious Weed Act §§ 35-5.5-101 through 119, C.R.S. (2003) as amended, states that an organized and coordinated effort must be made to stop the spread of noxious weeds.

To help combat noxious weeds, the State of Colorado developed a noxious weed list that designates and classifies noxious weeds into categories for immediate eradication, containment, and suppression:

- List A species were designated by the Commissioner for eradication.
- List B species are species the Commissioner, in consultation with the state noxious weed advisory committee, local

governments, and other interested parties, developed and implemented state noxious weed management plans designed to stop the continued spread of these species.

» List C species are species for which the Commissioner, in consultation with the state noxious weed advisory committee, local governments, and other interested parties, will develop and implement state noxious weed management plans designed to support the efforts of local governing bodies to facilitate more effective integrated weed management on private and public lands.

Boulder County has also formulated and implemented a countywide noxious weed control program designed to prevent and control noxious weeds. The Boulder County Noxious Weeds Management Plan states that it is everyone's duty to manage noxious weeds if they are likely to be damaging to the land of neighboring landowners. Boulder County currently has 22 species of plants that are listed in the Boulder County Noxious Weed Management Plan. Table 4.6 contains a list of these species.

Table 4.6 Boulder County Noxious Weed List

Common Name	Scientific Name	List
Orange Hawkweed	*Hieracium aurantiacum*	A
Spotted Knapweed	*Acosta maculosa*	A
Japanese Knotweed	*Polygonum cuspidatum*	A
Purple Loosestrife	*Lythrum salicaria*	A
Mediterranean Sage	*Salvia aethiopis*	A
Rush Skeletonweed	*Chondrilla juncea*	A
Cypress Spurge	*Euphorbia cyparissias*	A
Myrtle Spurge	*Euphorbia myrsinites*	A
Yellow Starthistle	*Centaurea solstitialis*	A
Dyer's Woad	*Isatis tinctoria*	A
Houndstongue	*Cynoglossum officinale*	B
Diffuse Knapweed	*Acosta diffusa*	B
Russian Knapweed	*Acroptilon repens*	B
Leafy Spurge	*Euphorbia esula*	B
Tamarisk	*Tamarix ramosissima, Tamarix parviflora*	B
Common Teasel	*Dipsacus follonum*	B
Bull Thistle	*Cirsium vulgare*	B
Canada Thistle	*Cirsium arvense*	B
Musk Thistle	*Carduus nutans*	B
Scotch Thistle	*Onopordum acanthium*	B
Dalmation Toadflax	*Linaria genistifolia var. dalmatica*	B
Yellow Toadflax	*Linaria vulgaris*	B

Source: http://www.bouldercounty.org/doc/parks/weedlist.pdf

In compliance with the Colorado Noxious Weed Act and local guidance, Best Management Practices and approved preventive measures should be used to prevent the spread of noxious weeds and minimize the potential effects from control treatments during construction of any proposed projects. These measures and practices include, but are not limited to, minimizing soil disturbance to the maximum extent possible, cleaning construction equipment before arriving on-site, using certified weed-free and cheatgrass free mulch, and checking seed mixes for undesirable weeds or contaminant species.

Wildlife

Common wildlife within the project area includes chipmunks (*Tamias sp.*), rabbits (*Sylvilagus sp.*), mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), moose (*Alces alces*), turkeys (*Meleagris gallopavo*), ravens (*Corvus corax*), and stellar jays (*Cyanocitta stelleri*) and other various migratory birds. There have also been many sightings of mountain lions (*Puma concolor*) and black bears (*Ursus americanus*).

The Colorado Parks and Wildlife (CPW) designated bald eagle winter range area is located within portions of the watershed. The watershed or portions of it also lies within designated elk winter range, mule deer summer and winter range, and wild turkey winter range.

4.7 *Existing Plans*

Throughout the planning process, the Fourmile Creek Watershed project team consulted existing plans, studies, and reports to the to inform the recommendations and analyses included in this Plan. The project team conducted a review of existing plans, studies, and reports at the start of the project. A tabular plan "roll-up" method was used to manage the large amount of data and help identify gaps and data needs. A total of 31 plans, reports, and studies were included in the plan roll-up. The following pre-flood studies and reports were included in the plan roll-up and were used as references for this Plan.

» Fourmile Canyon Post-Fire Hydrology (Draft) – Routed Runoff Model (Wright Water Engineers, 2011) – Boulder County Transportation
» Boulder County Storm Drainage Criteria Manual (1984) – Boulder County
» Fourmile Canyon Post-Fire Hydrology and Discussion of Conceptual Mitigation Measures: Summary of Findings (2011) – Boulder County Transportation
» Probability and Volume of Potential Post-Wildfire Debris Flows in the 2010 Fourmile Burn Area (2010) – USGS
» Map book of structures, water sources, and evacuation zones within the Fourmile Fire Protection District (2004) – Fourmile Fire Protection District
» Fourmile Fire Department Creek Crossings: Inventory of pre-flood private bridges (2011) – Fourmile Fire Protection District
» Riparian Inventory and Assessment (2009) – BCPOS
» Survey of Critical Biological Resources in Boulder County (2009) – CSU Natural Heritage Program
» State of the Watershed: Water Quality of Boulder Creek (2006) – City of Boulder, USGS
» Wildfire Effects on Source-Water Quality: Lessons from Fourmile Canyon Fire, and Implications for Drinking-Water Treatment (2012) – USGS
» Fourmile Canyon Fire Rehabilitation Report (2011) – BCPOS
» Fourmile Fire Treatment Implementation and Evaluation Report (2013) – Boulder County
» Fourmile Emergency Stabilization Burned Area Report (excerpt from the Fourmile Canyon Fire Emergency Stabilization Plan, 2013) – BCPOS

The following plans were included in the plan-roll matrix up and have been used as references for this Plan:

» Boulder County Comprehensive Plan (2nd Edition, 1999) – Boulder County Land Use Department
» Boulder County Natural Hazard Mitigation Plan (2013 DRAFT) – Boulder County
» Boulder County Multi-Hazard Mitigation Plan (2008) – Boulder County

- » Boulder County Comprehensive Plan Update (Environmental Resources Element, 2013) – Boulder County
- » Boulder Valley Comprehensive Plan (2010) – City of Boulder
- » Boulder County Transportation Master Plan (2012) – Boulder County
- » Boulder County Multimodal Transportation Standards (2011) – Boulder County
- » Arapaho and Roosevelt National Forests and Pawnee National Grassland's Revision of the Land and Resource Management Plan (1997) – US Forest Service
- » Betasso Preserve Management Plan (2009) – Boulder County Parks and Open Space

In the days and months following the September 2013 flooding event, a number of data collection and damage assessment efforts were initiated to assess damage, evaluate risk, and understand the physical conditions in the region that led to the flooding event. The following post-flood studies and reports were included in the plan roll-up matrix and were used as references for this Plan:

- » Colorado Front Range Flood of 2013: Peak Flow Estimates at Selected Mountain Stream Locations (2013) – NRCS
- » Boulder Creek Hydrologic Analysis (August, 2014) – CDOT/CWCB
- » Situational Awareness Meeting Materials: St. Vrain Runoff (2014) – CWCB
- » September 2013 Boulder Rainfall Analysis (2014) – City of Boulder
- » Project Worksheet for the Fourmile pedestrian bridge project on the Betasso Property (2013) – BCPOS
- » Project Worksheet for the Wall Street Assay Office Museum Property (2014) – BCPOS

The following post-flood planning documents were included in the plan-roll up matrix and were used as references for this Plan:

- » Boulder County Land Use Code - Article 4 (4-400 Floodplain Regulations)
- » Private Access White Paper -- Path Forward on Private Access/Floodplain Development Permitting in Mountain Canyons (2014 Draft) (Boulder County)

The plan roll-up method gave the planning team a comprehensive understanding of pre- and post-flood planning and assessment efforts. Appendix E contains the details of the plan roll-up.

4.8 *Other Data Collection*

Once data gaps were identified, the Baker Team began collecting the additional data needed to inform the master plan. The Baker Team carried out a number of data collection efforts to supplement what was already available:

Interviews with Watershed Stakeholders: The Baker Team held semi-structured interviews with individual Watershed Stakeholders, including the Federal Emergency Management Agency (FEMA), Pine Brook Water, the Urban Drainage and Flood Control District (UDFCD), the United States Forest Service (USFS), the Natural Resources Conservation Service (NRCS), Boulder County Historic Preservation Advisory Board (HPAB), the Colorado Water Conservation Board (CWCB), Boulder County and numerous residents of the watershed. The purpose of the interviews was to refine the scope and objectives of the Plan, to discuss key focus areas, and to obtain input on community engagement strategies. Interview summaries were developed by the Baker Team and provided to the project team for review before being incorporated into the planning process. One of the key messages shared by stakeholders during the interviews was the importance of engaging with the property owners and the general public during the duration of the planning process.

Creek Corridor Evaluation and Risk Assessments: Ecological field assessments were conducted by the Baker Team in order to develop existing conditions assessments for the watershed. The team used the Stream Visual Assessment Protocol (SVAP2) developed by the NRCS. This assessment evaluated 16 elements in each reach of the creek including: pool presence and condition, canopy and creek shading, riparian vegetation quantity and quality, in-stream complexity, bank conditions, and abnormal presence of fine sediment. The results of the SVAP2 assessment were used to identify critical riparian ecosystem elements that were damaged or absent from the creek system, as well as to identify highly degraded areas. The ecological assessments led to a strong understanding of the vulnerabilities certain key species may have in the post-flood environment and helped the planning team identify appropriate restoration strategies.

The results of the creek corridor ecological assessment are included in Appendix B.

Geomorphological Assessments: Geomorphological assessments were conducted by the Baker Team to characterize post-flood channel morphology for several reaches within the watershed. Geomorphic evaluations consisted of:

- » Historical and post-flood planform analysis
- » Approximation of channel migration zone widths
- » Identification of avulsion hazard areas
- » Identification of erosion hazard areas
- » Stream classifications

The results of the geomorphological assessments were used for developing stable-channel alternatives for each reach. The results of the geomorphological assessments are included in Appendix C.

Flood Risk Assessments: Flood risk assessments include floodplain mapping and identification of flood-damaged infrastructure. The flood risk assessments performed to date reflect the aforementioned application of engineering date described earlier in this report. The flood risk assessment has been combined with an assessment of erosion and deposition areas based on a comparison of pre-flood and post-flood topographic data. The combination of the flood risk assessment and erosion/deposition mapping allow the Team to identify areas and structures that are at increased risk because of post-flood conditions.

5. PUBLIC ENGAGEMENT PROCESS

5.1 Purpose and Scope

Continual stakeholder engagement and collaborative decision making were essential to creating a meaningful, locally relevant, and implementable watershed master plan for the Fourmile Creek Watershed. During the development of the plan, local citizens and stakeholders were proactively engaged in the planning effort through a diversity of channels. Participating stakeholders shared their specific concerns, goals, and ideas for moving forward from immediate flood-recovery to address long-term solutions.

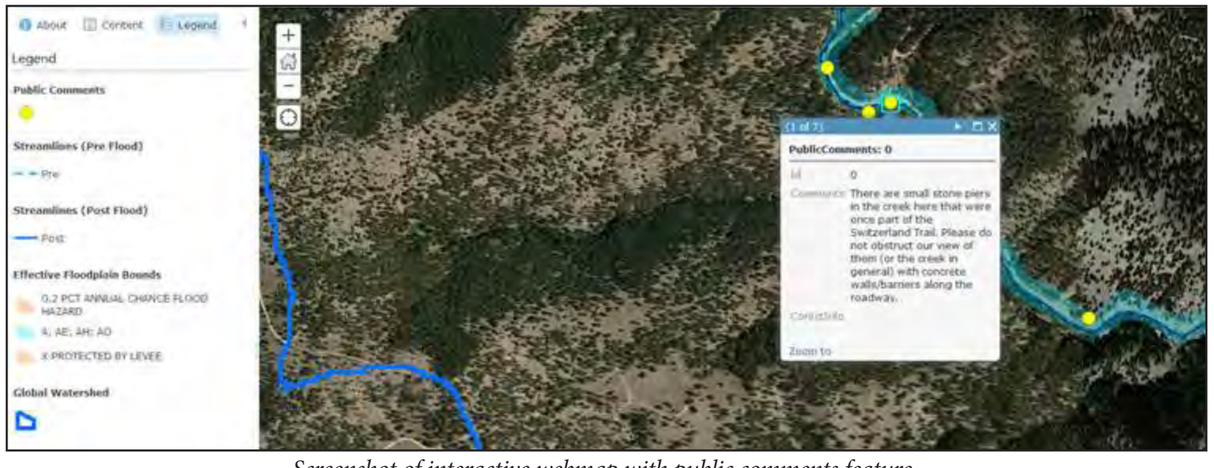
In developing the community engagement strategy for the master plan, the planning team committed to the following guiding principles:

- To provide the public with an understanding of the master planning process and opportunities for participation;
- To provide accurate, understandable, and accessible information to the public throughout the planning process;
- To provide multiple ways of participating in the planning process to ensure the accessibility of different stakeholders and segments of the public including socially vulnerable groups;
- To maintain ongoing two-way communication channels with stakeholders and the public throughout the entirety of the planning project.

The goal of the Fourmile Creek Watershed Master Plan's stakeholder engagement activity was not meant solely to educate community members about flood risk and their regional watershed system. Rather, it was designed to garner stakeholder input and incorporate that input into the master plan information base, findings, and recommendations. A broad spectrum of stakeholders and other interested parties were invited to participate in the development of the master plan and community members were encouraged to share their input, photos and experiences for use during the master planning process.

5.2 Process

In the beginning of the master planning project, the Baker Team created an interactive website to facilitate the public engagement process. Before drafts of the planning document were made available to the public, the website included a project overview, a project timeline, announcements, a comments section and mailing list, and an interactive map that allowed users to geographically identify and communicate specific concerns throughout the watershed.



Screenshot of interactive webmap with public comments feature

In the first month of the master plan process the project team conducted 14 key stakeholder interviews with over 36 representatives from various groups to learn more about the stakeholders over-arching visions for the Fourmile Creek Watershed Master Plan. These interviews also provided valuable information for what alternative factors or issues areas were of most importance to the various stakeholders as well as how to best coordinate the public involvement effort in the watershed.

In September 2014, the project team held a Kick-off Community Meeting to announce that the master planning process was beginning, to communicate to residents what it would include, and to answer questions that participants had about the long-term planning process. It was also an opportunity to let community members know how they could provide input throughout the process, for the project team to obtain additional stakeholder input to help refine the focus of the master plan, and to provide an update and respond to questions about the permanent roadway design and how they are integrated with the master planning process.

The primary public communication channels for the Fourmile Creek Watershed Master Plan included the following:

- The project website was constantly updated with new information and also served as a two way communication channel where individuals submitted comments and input to the project team;
- The project team email address and hotline put residents and key stakeholders directly in touch with the project team. All comments and calls were documented and directly answered or responses were typically provided within 24 hours;
- Media advisories and project information were provided periodically to the Public Information Officer in Boulder County for distribution through their communication channels;
- Email communication was sent to communicate new information to the project contact database. The project website provided visitors the opportunity to sign up for a list serve to receive the email updates;
- Post cards were sent to residents in the watershed to provide information on upcoming public meetings;
- The project team met on-site and in-person with any individuals who wanted to discuss their flood related impacts;

In early November 2014, with the planning process in fill-swing, two additional community meetings were held to bring together members of the public for an open discussion about the progress of the plan. The primary purpose of the community meetings was to share draft alternatives and project recommendations with the community and to collect feedback. Members of the Fourmile Creek Watershed community provided input on how well the recommendations addressed their concerns, they offered addition information and data, and they helped to ensure that the plan recommendations reflected the community's vision for the future of the watershed.

The November meetings began with a brief presentation to review the master planning process. This included an overview of how community input was used, the assessment results, the process used to develop project alternatives, and next steps. The project team also provided a brief update on roadway improvements.

After the introduction, meeting attendees broke into reach-specific groups to review the plan alternatives for their area. This was an opportunity for individuals to talk directly with technical team members to ask questions and share input. Feedback was recorded on both maps and comment cards, all of which were reviewed closely by the Project Team and incorporated into the Plan as appropriate. These comments have been included in Appendix A. Meeting participants asked a diversity of questions related to the planning process, implementation, and roadway improvements. A summary of questions, as well as their answers, is also included in Appendix A.

The draft of the Master Plan was available for community review and feedback from November 3-14. Community members could download it from the project website and hard copies were also available at the Salina School and at the Boulder Public Library.

5.3 Public Input Summary

Public input provided to the project team was collected by the ways described above and focused on the following key issues of significant importance to watershed stakeholders:

The key messages heard during the stakeholder interviews included the following:

- Protect homes and other key infrastructure: There is a concern that the current creek alignment presents a risk to houses and other infrastructure. This is a major concern in the Salina area, where there has been a recent history of post-wildfire flood events.
- Inform roadway and private access design/construction activities: The planning process should inform Boulder County's roadway design. The risk assessment should inform requirements for private property upgrades for crossings and access, which is a concern for the Upper Fourmile/ Wall Street area. It was noted that many bridges are still functional, but their abutments may not have long term stability.
- Ensure access to water: Some wells are not producing due to drop in the creek profile and sedimentation in wells, and some creek diversions were lost during the flood, thereby affecting ponds. Also, the flood destroyed many of the Fourmile Fire Department's water supply points.
- Incorporate impacts from the Fourmile Fire: The Plan should consider land stabilization needs, resulting from the Fourmile Fire, and consider opportunities to improve land management, such as encouraging an open forest with understory vegetation to better hold soil. Many people described fire as the highest risk for the watershed.
- Consider abandoned mine impacts: There are abandoned mine sites throughout the watershed, some of which were uncovered and/or eroded during the flood. Specific areas include Salina Junction, Gold Run, Ingram Gulch and near Emerson Gulch. These abandoned locations are potential sources of point pollution.
- Protect water quality: There appears to be higher levels of pollutants in the creeks post-flood, which is likely connected to tailings piles. There have also been increased levels of manganese, nitrate, carbon and sediment in the creeks. Many wells have high uranium levels and increased sediment.
- Prevent and/or mitigate mud flows and sediment loading: Sediment loading is an issue in the post-wildfire watershed, however, sediment loading from the burn area has decreased over time.
- Prevent and/or mitigate channel erosion or migration: The plan should identify locations where erosion will take place and make recommendations on how to prevent it.
- Maintain historic aesthetic of communities: Project recommendations should strive to preserve the historic aesthetic and community character. There may also be opportunities to protect structures with historical significance.
- Restore aquatic and riparian habitat: There have been considerable impacts to fisheries from channelization and the removal of woody materials during emergency flood restoration. The planning process should focus on re-establishing ecosystem function.
- Provide input for policy, programmatic, and regulatory issues: The Plan should help address some regulatory questions, including:
  - Floodplain Management: The plan should determine which FEMA maps are still relevant for specific stream stretches for obtaining rebuilding floodplain development and other permits, insurance, etc. It should also identify which maps need to be updated, what are the priority areas for remapping, and what data is required to meet FEMA's standards and criteria for remapping.
  - Hazard Areas: The plan should identify hazard areas and provide suggestions for how the county might explore new approaches to planning for and regulating development in hazard areas.

At the Community Kick-off meeting and via an online survey after the meeting, the public were asked to provide feedback on two key questions:

1. What do you most value about the creek in terms of your long-term vision for the watershed?

Table 5.1 Creek Values as Ranked by Public Stakeholders	
Answer Options	Ranking
Natural setting / quality of life	1
Ecosystem health / habitat	2
Water quality	3
Recreation (e.g., fishing, hiking)	4

2. How do you value the following types of projects, in terms of identifying and prioritizing long-term recovery projects?

Table 5.2 Value of Project Types as Ranked by Public Stakeholders	
Answer Options	Ranking
Mitigating risks to private property damage from future flooding	1
Ensuring/enhancing water quality	2
Mitigating debris flows and sediment leading	3
Enhancing long-term oversight of the watershed	4
Protecting against erosion and/or creek migration	5
Ensuring access to water supply	6
Informing roadway and private access design	7
Restoring natural stream corridor	8
Mitigating risks to public infrastructure	9

Table 5.2 Value of Project Types as Ranked by Public Stakeholders	
Answer Options	Ranking
Restoring aquatic/riparian habitat	10
Protecting historic structures and character	11
Preventing weed transport	12

Some additional reach specific feedback received at the Community Kick-off meeting included:

Reach 1 (Confluence with Boulder Creek to Poorman Road)

- » Prevent culverts from backing up and blocking roads, access, and causing flooding.
- » Trees along the creek are constricting the channel.
- » Concern about woody debris that remains in the channel.
- » Need channel stabilization for homeowners (not just road stabilization).
- » Need to consider how upstream channel issues and changes affect downstream residents.
- » Identify whether funding sources are available to cover repair costs that FEMA didn't cover.

Reach 2 (Poorman Road to Mile Marker 4)

- » Maintain wildlife crossings.
- » Tree preservation/planting and re-vegetation, especially on burn areas.
- » Stabilize tributaries to make them more resilient.
- » Address debris dams (e.g., culverts that backed up with debris).
- » Contamination from mine tailings (coordinate with EPA).
- » Identify historical artifacts and landmarks and preserve them.
- » Include information for community members on the potential risks of living by the creek.

Reach 3 (Mile Marker 4 to Mile Marker 5 and Gold Run)

- » Reducing debris flow in general is a major issue.
- » Need improved design for culverts.
- » Water quality is important in both wells and creek.
- » Protect historic nature of the buildings and area.
- » Need for re-vegetation - loss of vegetation resulted in loss of privacy
- » Want natural, not 'engineered', solutions.

Reach 4 (Mile Marker 5 to Sunset)

- » Private crossings are needed to rebuild and regain access to property.
- » Concerns about County imposing high cost repairs due to expensive regulatory requirements
- » Migration of stream channels have created mosquito breeding issues and could impact the long-term health of trees.
- » Re-vegetation.
- » Important to maintain natural look, want to avoid concrete or other engineered-looking solutions.

6. ALTERNATIVE DEVELOPMENT & EVALUATION

6.1 Overview

The goal of the alternative development process was to identify problem areas within each reach and develop a wide-range of alternatives to meet the project goals. Alternatives which did not provide adequate flood mitigation or were not practical to implement were also identified and eliminated from further development early in the process. During the Alternative Development Process feasible and non-feasible alternatives were screened accordingly so that the "best" alternate plans could be identified for more detailed evaluation.

To initiate the alternative development process, this report divides Fourmile Creek and part of Gold Run into four shorter reaches. The divisions were based on the needs and characteristics of specific portions of the creek. This division allowed the alternatives to better address the specific flooding problems in each reach, as well as providing guidance for future partnering to fund and oversee the improvements themselves.

6.2 Alternative Development

The initial activity to determine the full range of potential alternatives was accomplished by pre-screening the following categories within each reach:

- Status Quo – Maintains existing configuration.
- Stream Restoration (Natural Channel Design), Habitat –Natural channel design, habitat improvements, etc.
- Structural Improvements and Additions –Drop structures, flood control, etc.
- Conveyance Improvements –Increase channel capacity.
- Roadway Crossings –Public bridges and culverts improvements.
- Detention/Sediment Basin –Dams, detention/sedimentation ponds, etc.
- Debris Management – Debris racks, debris barriers, etc.
- Bank Stabilization – Stabilization to prevent erosion or migration.
- Recreation Improvements –In-stream activities, fishing access, trails, etc.
- Acquisition of Floodprone Properties –High flood risk properties.
- Water Quality Enhancements – Point source pollution prevention.
- Non-structural Measures – Higher lever of floodplain management, educations, etc.

Alternatives considered for each reach were evaluated based on the following factors:

- Whether there was a need for flood mitigation;
- Whether flood mitigation could be achieved by conveyance or upstream detention;
- How the alternative would fit into the existing drainage way based on right-of-way, general consistency in long-term floodplain management along the corridor;
- Environmental considerations; and
- Whether the alternative was feasible.

Alternatives which were considered feasible were then further evaluated and that evaluation process is described in this Chapter. A summary table of the alternatives analysis pre-screening process is provided in Table 6.2.

6.3 Qualitative Evaluation Procedure

The alternatives that were deemed favorable after the qualitative prescreening assessment were further evaluated based on specific criteria and constraints to implementation. Upon implementation, some proposed alternatives are likely to face multiple challenges related to right-of-way acquisition, cost, constructability, long term maintenance issues, environmental impacts and public acceptance. These constraints have been considered as part of the alternative development process. Before deciding on the final planning recommendations for each reach, the project team used the following fifteen criteria to identify alternatives:

Table 6.1 Fourmile Creek Watershed – Alternative Evaluation Criteria

Factor	Description
Addresses other Reach Objectives	Does the alternative address/incorporate other objectives and priorities for the reach?
Natural Channel Restoration	Does the alternative incorporate natural channel restoration methods? Does it focus on restoring natural dimensions, patterns, and profiles to the greatest extent possible, using natural materials for in-stream structures?
Recreation	Does the alternative promote diverse recreational uses (trails, fishing access, whitewater, etc.)?
Fish Habitat	Does the alternative preserve, enhance, and/or restore fish habitat?
Flood Conveyance	To what degree does the alternative convey flood flows (100-yr, 50-yr, 25-yr, etc.)?
Flood Mitigation	Does the alternative address needed repairs to damaged infrastructure and property?
Environmental Restoration	Does the alternative restore environmental components such as the riparian zone, mammal/bird/reptile habitat, etc.?
Public Safety	To what degree does the alternative restore or improve public safety?
Transportation	Does the alternative meet the objectives of adjacent transportation (bridge, roadway, etc) projects?
Aesthetics	To what degree is the alternative visually pleasing to residents and visitors?
Permitting Requirements	How extensive are the permitting requirements for the alternative?
Right Of Way (ROW) Acquisition / Easements	How much ROW / Easements are required to implement the alternative?
Operations and Maintenance (O&M)	How extensive are O&M requirements (cost, labor, etc.) for the alternative?
Agricultural / Irrigation	Does the alternative benefit or harm agricultural and/or irrigation stakeholders?
Consistency with Local Policies & Plans	Is the alternative consistent with existing local policies and plans?

The alternatives recommended in this plan achieve the goal of lowering the flood, ecological, or geomorphic risk, and are considered feasible to implement.

Table 6.2 Fourmile Creek Watershed Master Plan Alternatives Analysis – Prescreen

Reach	1	2	3	4
Description	Fourmile Creek from the confluence with Boulder Creek to Poorman Road	Fourmile Creek from Poorman Road to Mile Marker 4 (Upstream of Logan Mill Road)	Fourmile Creek from Mile Marker 4 to Mile Marker 5 and Gold Run from Salina Junction to Summerville	Fourmile Creek from Mile Marker 5 to Sunset
Status Quo – Maintain Existing Conditions	Not an option because of increased flood risk, active bank erosion, and channel erosion/deposition.	Potentially an option in some locations where flood risk to structures/infrastructure is minimal and channel improvements are not critical.	Not an option because of increased flood risk, active bank erosion, and channel erosion/deposition.	Potentially an option in some locations where flood risk to structures/infrastructure is minimal and channel improvements are not critical.
Stream Restoration – Natural Channel Design, Habitat Improvement	Site-specific channel and habitat restoration is a possibility, full-scale channel and habitat restoration is limited by existing structural constraints. Revegetation throughout reach is possible.	Some parts of this reach would benefit from restoration. Need to consider access issues. Reach through Crisman is severely constrained.	On Fourmile, site-specific restoration is possible. On Gold Run, restoration opportunities are limited.	Restoration is possible throughout reach.
Structural Improvements and Additions	Potential for structural wall in conjunction with roadway improvements.	Potential need for in-stream grade control through Crisman.	Potential for structural walls to assist with flood mitigation and protection of historic structures.	In-stream structures would only be necessary if NCD is not a possibility.
Conveyance Improvements	Possible only in areas of post-flood deposition.	Not needed. Post-flood deposition has not increased flood risk to structures/infrastructure.	Conveyance opportunities appear to be limited. Benefit need to be further evaluated.	Possible in areas of post-flood deposition and where flood risk needs to be reduced.
Roadway Crossings	No public crossings.	Logan Mill Road crossing design in progress. Monitor progress.	Need for crossing assessments/improvements has been identified.	No public crossings.
Detention / Sediment Basin	No feasible location.	Benefit would be minimal because of location in watershed and negative ecological impact.	Unlikely due to location and property/physical constraints.	No feasible location.
Debris Management	Promote debris management through non-structural measures.	Promote debris management through non-structural measures.	Evaluate condition of debris racks and need for additional debris mitigation measures.	Evaluate condition of debris racks and need for additional debris mitigation measures.
Bank Stabilization	Possible throughout reach as needed.	Possible throughout reach as needed.	Possible throughout reach as needed.	Possible throughout reach as needed.
Recreation Improvements	Opportunity/need for improvements is limited.	Betasso Link Trail crossing improvement.	Opportunity/need for improvements is limited.	Opportunity/need for improvements is limited.
Acquisition of Floodprone Properties	Potential as some residential structures are in the floodplain.	Potential as some residential structures are in the floodplain.	Potential as some residential structures are in the floodplain.	Potential as some residential structures are in the floodplain.
Water Quality Enhancements	Still being investigated.	Still being investigated. Algae identified through Crisman.	Coordination with EPA on tailings pile near Salina Junction.	Still being investigated.
Non-structural Measures	Promote floodplain management, public education, flood awareness, good housekeeping, debris management, drainageway crossing maintenance, etc.	Promote floodplain management, public education, flood awareness, good housekeeping, debris management, drainageway crossing maintenance, etc.	Promote floodplain management, public education, flood awareness, good housekeeping, debris management, drainageway crossing maintenance, etc.	Promote floodplain management, public education, flood awareness, good housekeeping, debris management, drainageway crossing maintenance, etc.

Probable Alternative
Requires Additional Evaluation
Not Applicable / Limited Potential

7. RECOMMENDATIONS AND CONCEPTUAL DESIGN STRATEGIES

7.1 Recommendations

The recommendations in this plan were selected based on a technical analyses as well as input from various watershed stakeholders. The recommendations for each reach are presented in Chapters 8 through 11. An overview of the conceptual design strategies recommended for the various reaches is provided in section 7.2. The flood risk assessment, ecological assessment, and geomorphic assessment helped the Baker Team identify areas of need, while the input we received from various stakeholders through the public meetings, project website, the interactive map, and face-to-face meetings in the field helped the Team refine the ideas in the plan.

There are similarities with the goals and objective for the various reaches of the Fourmile Creek Watershed; however, each reach and recommended project site has its own issues and set of constraints and the stakeholders in the various reaches have their own unique values. These constraints include multiple adjacent property owners, structures, limited access, roadways, existing mature tree stands, and utilities crossings. Additionally, the presence of natural or cultural resources dictates project constraints that must be incorporated into the design. All constraints are evaluated and used as a guide in recommending technically sound, environmentally sensitive, and cost effective solutions. Steps were taken ensure that the recommended plan took both a holistic approach at creating recommendations for the good of the entire watershed, while also customizing solutions for the individual reaches.

When considering implementation of projects within the scope of this plan, it is important to consider other water quality programs and efforts underway in Boulder County. One example is the watershed monitoring plans the Keep It Clean Partnership is coordinating. These plans provide a sound scientific understanding of baseline water quality conditions, identify reaches of streams in need of water quality and aquatic life improvements, and support prioritization of improvements expected to improve water quality and aquatic life. Boulder County departments engaged in similar efforts include Transportation, Public Health, and Parks and Open Space.

7.2 Conceptual Design Strategies

A stream and its floodplain comprise a dynamic environment where the floodplain, channel, and bedform evolve through natural processes. Weather and hydraulic processes erode, transport, sort, and deposit alluvial materials throughout the riparian system. The size and flow of a stream are directly related to its watershed area and other factors, including geology, land use, soil types, topography, and climate. The morphology, or size and shape, of the channel reflect all of these factors.

In addition to transporting water and sediment, natural streams provide habitat for many aquatic organisms. Native vegetation along the banks provides a food source and regulates water temperatures. Channel features such as pools, riffles, steps, and undercut banks provide diversity of habitat, bedforms, oxygenation, and refuge. Stream restoration projects can help improve these features in concert with the return of a stable dimension, pattern, and profile, while also helping to lower flood risk. The following conceptual design strategies are recommended for various areas of the Fourmile Creek Watershed to help create a self-sustaining riparian system.

Incorporate/Stabilize a Low Flow Channel Section and Floodplain Bench: The low flow/bankfull channel (Figure 7.1) is an essential element to a healthy and stable stream channel. The bankfull discharge, or discharge that fills the low flow/ bankfull channel, is the flow at which natural channel maintenance is most effective. Bankfull discharges correspond to a discharge with a recurrence interval between 1 and 2 years. The low flow/bankfull channel would be designed to carry this event. To further reduce energies and shear stress placed on stream banks, the channel cross-section will be modified to incorporate a floodplain bench (Figure 7.2). This approach decreases the stress placed on banks by decreasing flow velocities and depth for a given discharge. Beyond helping to stabilize the channel, this approach also increases the cross-sectional area of the overall flood channel, potentially decreasing the flood stage during storm events as compared to the current condition. At a minimum, the proposed excavation of floodplain benches would provide increased storage capacity during storm events, aiding in the attenuation of storm flows. The floodplain benches can be vegetated with native seeding, willow staking, cottonwood poles, and other native transplants.

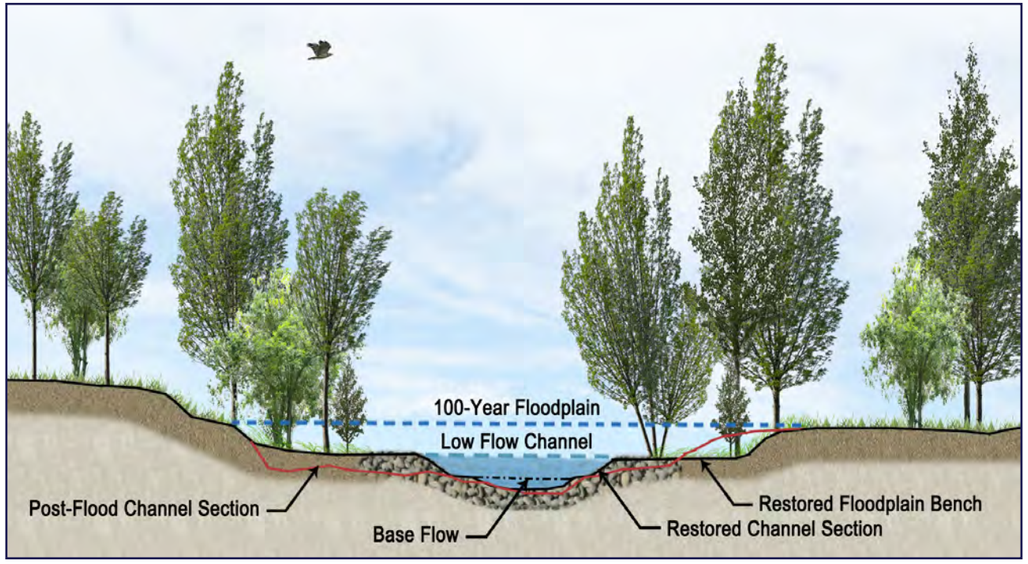


Figure 7.1 Typical Channel Restoration Section*

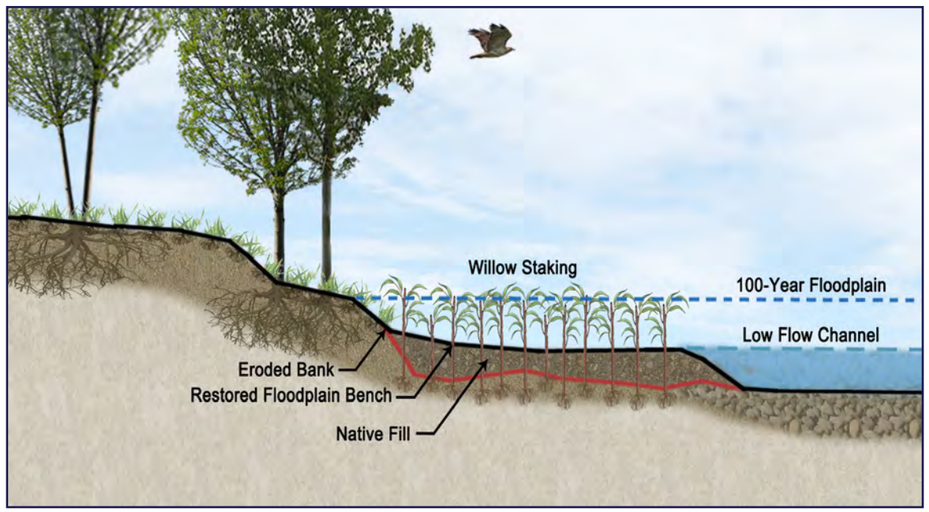


Figure 7.2 Floodplain Bench Detail*

* Low Flow Channel is synonymous with Bankfull Channel

Bank Protection: The type of bank protection recommended by this plan varies depending on the location of the protection and what is being protected. Boulder bank protection (Figure 7.3) is the recommended bank protection in high risk areas such as banks in the vicinity of bridge abutments, culvert inlets and outlets, roads, and existing structures. Boulder bank protection provides reliable and immediate channel bank protection. The bank protection should include a boulder key to prevent the toe of the protection from scouring, and a filter layer that prevents fine grained native materials from piping through the boulders while still allowing seepage.

The use of root wads and large woody debris (Figures 7.4 and 7.5) is recommended for bank protection in lower risk areas where structures and infrastructure are not present. The use of these structures incorporates native woody material into a submerged channel bank to replicate natural stable channel banks and add flow resistance for bank protection. The root wads are cantilevered over foundation logs to provide an undercut bank for in-stream and overhead cover for aquatic habitat. Woody material is placed over and between the toe logs, and backfill and riparian vegetation are placed over the toe material up to the bankfull stage.

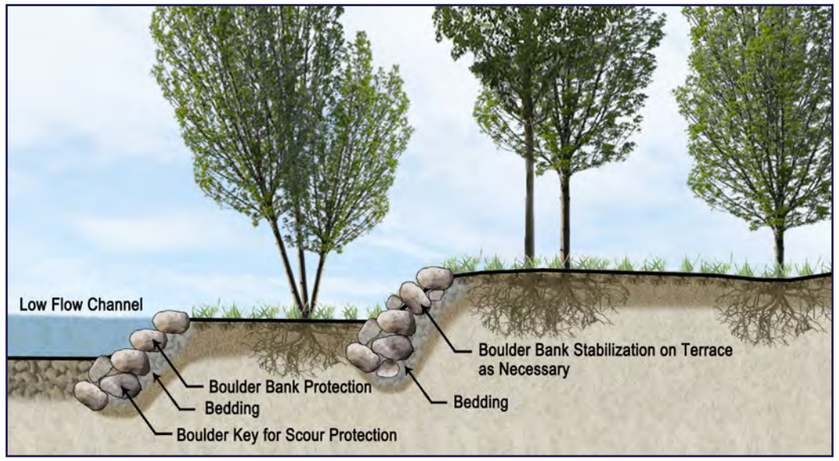


Figure 7.3 Boulder Bank Protection Detail*

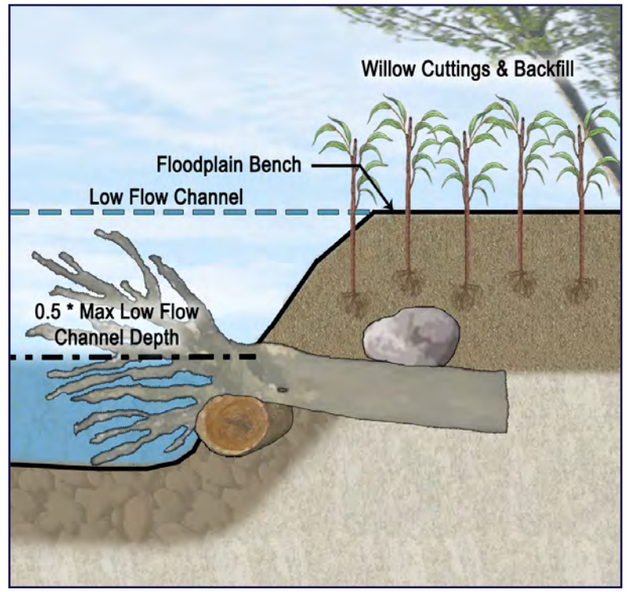


Figure 7.4 Large Woody Debris Bank Protection Detail*

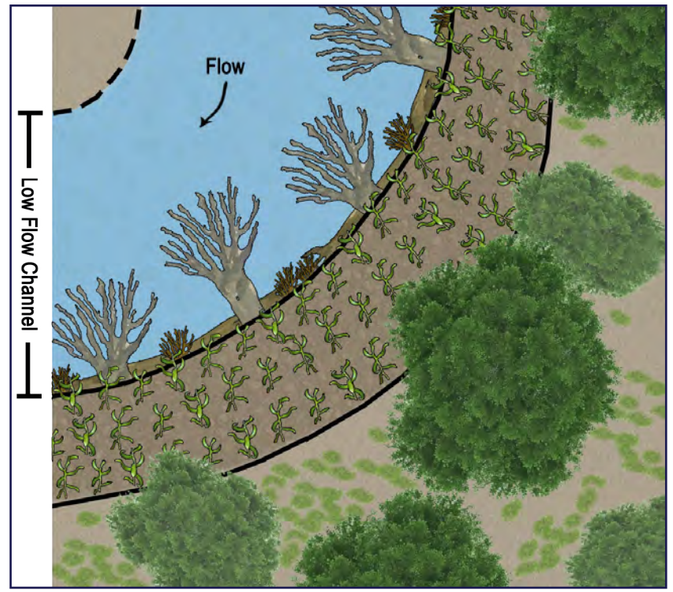


Figure 7.5 Large Woody Debris Bank Protection Plan View*

* Low Flow Channel is synonymous with Bankfull Channel

Increasing In-Stream Habitat Complexity: Several types of in-stream features are commonly utilized for stream restoration projects to not only provide grade control and stream bank protection, but also improve in-stream habitat and bed form diversity (Figure 7.6). In-stream features typically consist of natural materials, predominantly large rock and wood. The rock materials used range from gravel to boulders, while the wood materials are comprised of trees, including the root wads (or root balls), tree trunks, as well as the smaller materials from branches and tree tops. In-stream features constructed from logs are typically limited to those applications where the wood materials remain permanently saturated such that those materials do not rot and deteriorate prematurely. In some situations, natural materials used for the construction of in-stream features can be harvested on-site during the construction process. For example, trees removed during the clearing phase of construction can often be "recycled" into an in-stream feature such as Large Woody Debris (LWD) or root wads. Some examples of in-stream features that can be used to increase habitat complexity include.

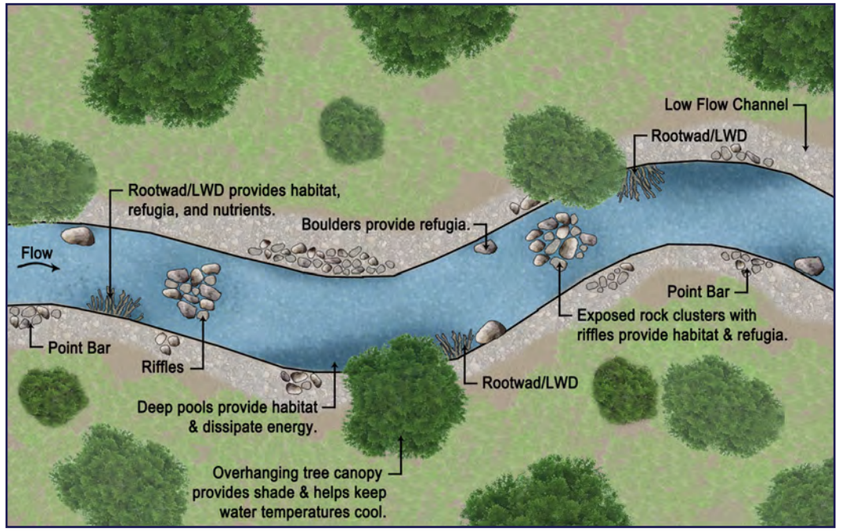


Figure 7.6 In-Stream Stability and Habitat Examples*

» Constructed Riffles - A constructed riffle is created by placing well-graded material (gravel, cobble, and small boulders) in the stream at specific riffle locations along the profile. The purpose of this structure is to provide initial and/or permanent grade control and establish riffle bedforms within the restored channel. Constructed riffles function in a similar way as natural riffles; the gravel and cobble surfaces and interstitial spaces are crucial to the life cycles of many aquatic macroinvertebrate species. From a stability standpoint, riffles establish the overall grade for a stream reach and maintain the low water surface slopes of the upstream pools.

» Pools – Pools are an important feature in a channel's bed form diversity. Pools are deep areas created by scour that have slopes that are much less than the reach average slope. For fish, these pools form areas of refuge due to increased water depth, and prime feeding areas as food items are washed into the pool from the riffle or step directly upstream.

» Step-Pools –– Step-pools naturally exist in higher gradient channels, and are used to provide grade control and bed form diversity. Step-pools are constructed by installing abutting courses of footer and header rocks in a formation of cascading or stepped, alternating pools with stepped sills in between. The sills are installed at the same elevation as the streambed, but should not be installed such that they back up water in the channel like a weir. Step-pool structures are constructed out of large boulders and not riprap. The pool's depth is site specific and varies depending on the configuration of the structure, flow velocity and gradient, and bed material of the stream.

» Root Wads and Large Woody Debris – Root Wad and Large Woody Debris structures may be constructed using a combination of native materials such as logs, branches, brush, live cuttings, and large root wads. The structures help ensure long-term stability against eroding banks and provide a more natural appearance than hard armoring. The structures can be a cost-effective solution for bank protection while restoring channel dimensions and floodplain connection. In addition to providing stream bank stability, the structures enhance aquatic and terrestrial habitat within the pool area by establishing a source of detritus and large woody debris.

» In-Stream Boulders – Boulders are naturally deposited in the channel of mountain streams and help to provide channel complexity. Natural boulders may be placed in the stream in areas of faster moving water (e.g. riffles) to provide refuge for fish.

Stream Crossings: It is recommended that stream crossings be designed to minimize the negative impacts on stream stability, sediment transport, aquatic habitat and fish passage while meeting prescribed hydraulic and structural criteria. The goal is to construct a stable channel system that neither scours nor aggrades. The recommended approach includes maintaining the consistency of dimension, pattern and profile of the stream with particular attention to avoid obstructing the low-flow channel width. Where feasible, the use of bridges or arch culverts to minimize floodplain restrictions is recommended. Alternatively, culvert systems should consider the use floodplain culverts, to provide additional hydraulic capacity and limit downstream scour and erosion at the main culvert (Figure 7.7). It should be noted that all stream crossings need to meet current permit requirements.

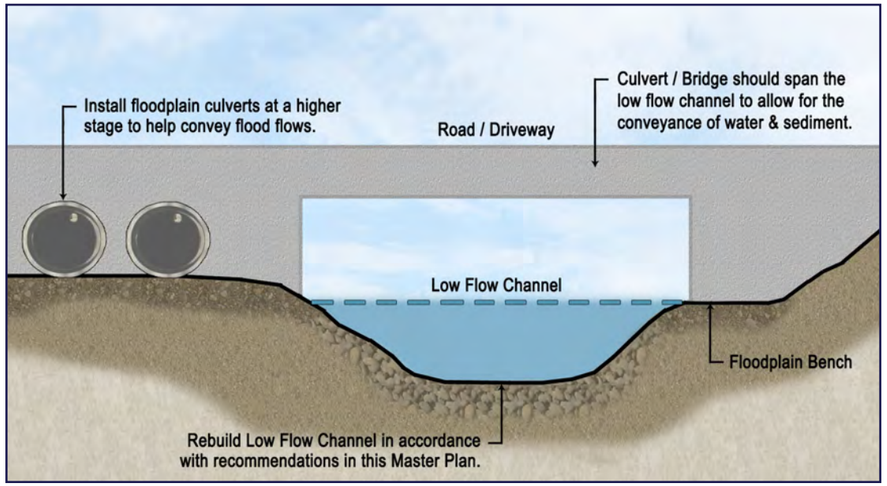


Figure 7.7 Stream Crossing Configuration Detail*

* Low Flow Channel is synonymous with Bankfull Channel

Bioengineering

Bioengineering methods are used to provide lateral stability to channel banks. Bioengineering can be implemented as a stand-alone practice, or in combination with in-stream structures. Although the use of bioengineering methods is not identified for specific sites in the plan, the use of these methods should be considered during the final design of any improvements.

Within the context of natural channel design, bioengineering is simply defined as the specialized use of plant materials to stabilize stream bank soils. Bioengineering provides stabilization through the accelerated establishment of vegetation along the stream banks. The vegetation growing out of the stream banks acts like flexible armoring against erosive stream flow, and the associated root mass growing into the stream banks adds "structural reinforcement" by holding the stream bank soils together. Examples of common bioengineering techniques include brush mattresses, brush layers, live stakes, geolifts, fascines, transplants, and erosion control matting.

Beyond stabilizing the stream banks, the use of bioengineering provides many other benefits. These benefits include adding biomass to the stream system, stream shading, quicker vegetation establishment, lower costs for establishing vegetation by utilizing native and/or local materials, improved aesthetics, improved riparian and in-steam habitat, increased infiltration, and increased sediment deposition.

The main component common to all appropriate bioengineering techniques is native species vegetation. Species selection is important, as not all species are well suited for use in bioengineering practices. In some situations, the native species vegetation can be harvested on-site during construction. This vegetation can typically be harvested from areas of the project site that are to be restored, abandoned, cleared, or otherwise be impacted during the construction process. Such potential should always be considered during the planning and design phases of stream restoration projects. Consult local biologists, botanists, forestry professionals, or other qualified practitioners to determine which species are suitable for use in bioengineering practices

The decision to use one bioengineering technique over another technique should be based on the erosion protection that the technique provides and the relative cost. The table below (7.1) provides guidance on selecting common bioengineering practices based on the relative strength that the practice provides and the relative cost.

Table 7.1 Guidance for Selecting and Bioengineering Bank Stabilization Practice

Bioengineering Method	Relative Strength to Provide Bank Protection	Relative Cost
Brush Mattress	Moderate	Moderate to High
Brush Layers	Moderate	Moderate to High
Live Stakes	Low	Low
Geolifts	High	High
Fascines	Moderate	Moderate
Transplants	High	Low (Must come from on-site)
Erosion Control Matting	Low to Moderate	Low to Moderate

Brush Mattresses & Brush Layers:

Brush mattresses are placed on bank slopes for stream bank protection. Layers of live, woody cuttings are wired or tied together and staked into the bank. The woody cuttings are then covered by a fine layer of soil. The plant materials quickly sprout during the growing season and form a dense root mat across the treated area, securing the soil and reducing the potential for erosion. Within one to two years, a dense stand of vegetation can be established that, in addition to improving bank stability, provides shade and a source of organic debris to the stream system. Deep root systems often develop along the waterline of the channel, offering another source of organic matter and a food source to certain macroinvertebrate species, as well as cover and ambush areas for fish species. Brush mattresses are typically placed along the outer meander bends, areas where bank sloping is constrained, and areas susceptible to high velocity flows.

Brush layers are very similar to brush mattresses, except that they are placed on the top of bank instead of on the bank slopes for stream bank protection. Brush layers are therefore used in conjunction with other bank protection structures or measures such as vanes or root wads, as brush layers do not provide immediate protection of the toe of the bank.

Live Stakes:

Live stakes are live cuttings, typically dormant season, from native species woody plants that are directly planted into the stream banks. Some species are better suited than others for use as live stakes, with willows and some dogwood species typically performing the best. Live stakes can often be harvested on site, particularly with proper planning during both the design and construction phases. They should be harvested from live, healthy, vigorous, well-rooted plants. Proper handling and storage of live stake material is also vital. Live stakes are normally installed in areas of higher stress, such as along the outside of meander bends, but can also be installed anywhere along the stream channel where accelerated vegetation growth is desired. They are usually installed through the erosion control matting, directly into the restored stream bank. Each live stake is installed approximately two feet into the ground, with not more than one foot exposed above the ground. The intent is to install them as deep as possible and as close to the water table as possible. Live stakes are thus installed within the limits of the low flow/bankfull channel and are installed by pushing or hammering them into the stream banks. Live stakes provide all of the advantages associated with establishing riparian vegetation at relatively low cost and are most commonly using in conjunction with other in-stream structures, and not as a stand-alone measure.

Geolifts:

Geolifts are a bioengineering measure used to stabilize stream banks. Geolifts are most commonly used along the outside of stream meander bends. They are basically a series of large overlapping soil "burritos," or lifts, constructed using coir fiber erosion control matting and native soils. Often, live cutting materials from specific woody native species plants are planted in the layers between the lifts. A stone toe base is typically installed to provide protection at the toe of the stream bank and to provide a foundation for the geolifts. The geolifts are installed on top of the stone base to comprise the entire restored stream bank up to the low flow/bankfull channel elevation. Geolifts can be used to effectively stabilize restored stream banks for all sizes of streams simply by varying the number of lifts required to form the stream bank.

Fascines:

Fascines are bundles of long live cuttings, typically dormant season, from native species woody plants that are planted to help stabilize the stream banks. Some species are better suited than others for use as fascines, with willows and some dogwood species typically performing the best. Fascines can often be harvested on site, particularly with proper planning during both the design and construction phases. They should be harvested from live, healthy, vigorous, well-rooted plants. Proper handling and storage of fascine materials is also vital. Fascines are normally installed in areas of higher stress, such as along the outside of meander bends, but can also be installed anywhere along the stream channel where accelerated vegetation growth is desired. They are usually installed laterally along the toe of the stream bank or at elevations within the low flow/bankfull channel and securely staked in trenches, with their tops being exposed just above the ground. Fascines provide all of the advantages associated with establishing riparian vegetation at relatively low cost and are most commonly used in conjunction with other in-stream structures, and not as a stand-alone measure.

Transplants:

Transplants are used to increase lateral stability by providing instant living root mass within the stream bank. They are living native plants that are excavated and replanted on site and are typically harvested from areas of the project site that are to be restored, abandoned, cleared, or otherwise be impacted during the construction process. These areas include the existing stream banks, existing flood plain, haul roads, staging and stockpile areas, etc. Native plants that are suited to stream bank areas and can be successfully harvested and replanted along the restored stream banks may be good candidates for transplanting, understanding that some species transplant better than others. Consult local biologists, botanists, forestry professionals, or other qualified practitioners to determine which species are suitable for transplanting. Because transplants are harvested from areas where the existing vegetation would be impacted or removed as a result of construction, transplanting tends to be a relatively inexpensive way to help prevent lateral instability, while also salvaging and recycling on-site materials.

Transplants are harvested with the root ball and the surrounding soil intact and are quickly re-planted along the stream banks and the flood plain to avoid drying out the roots. They can be planted as a stand-alone measure to provide stream bank protection, or installed in conjunction with other in-stream structures, such a log vanes and root wads, where they are typically planted at the interface where the in-stream structure ties into the stream bank. Transplants have mature root systems that re-establish in their new location, much quicker than the smaller commercially grown or harvested planting stock typically used for stream bank planting. This accelerated rate of vegetation establishment allows the root system from the transplants to help hold the stream bank together and help prevent stream bank erosion. Transplants also significantly contribute to in-stream habitat as they provide a permanent source of shading and contribute organic material to the stream system.

Erosion Control Matting:

Coir (coconut) fiber matting is the type of erosion control matting most commonly used to stabilize restored stream banks. This type of erosion control matting is available in many different styles and weights. The most common used for stream bank restoration is the 700-gram matting. This erosion control matting is fabricated from 100 percent coir twine woven into a high strength blanket. Erosion control matting is installed on all of the newly constructed stream banks, from the toe or edge of water, up to the top of the stream bank or low flow/bankfull elevation. After the proposed stream channel construction is complete, temporary and permanent seed, fertilizer and other soil amendments, and mulch are applied. The erosion control matting is then immediately installed on top to hold everything in place. The matting is secured in place using specified wood or metal stakes. Both the temporary and permanent vegetation germinate faster and grow more vigorously when installed with mulch under the erosion control matting. Erosion control matting is installed along all of the restored stream banks as described. A possible exception is that sometimes the point bars on the inside of the meander bends are not matted, as these are depositional features and therefore not typically subject to erosion.

8. REACH 1

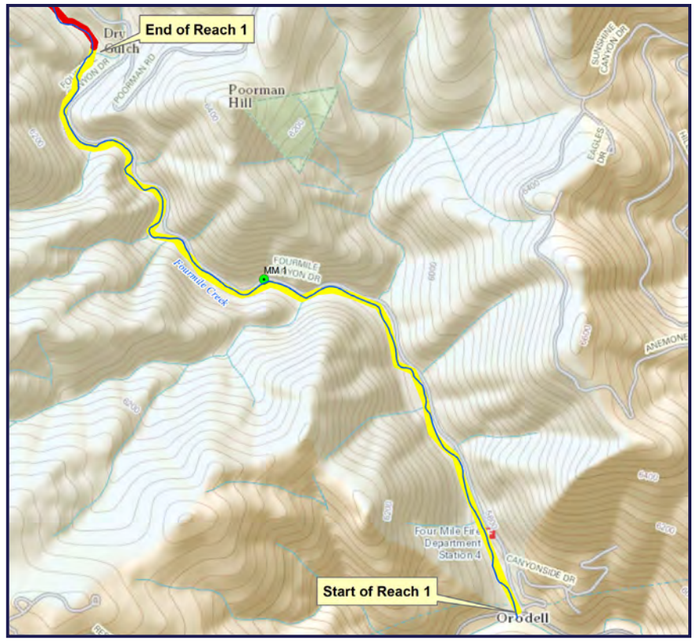
8.1 Overview

Reach 1 includes Fourmile Creek. It begins at the confluence with Boulder Creek and ends at Fourmile Canyon Drive and Poorman Road. Reach 1 is steep with slopes of the creek generally ranging from 1% to 5%. This reach of the creek is also significantly constrained by existing topography, development, and transportation infrastructure. A large percentage of the property along the creek corridor is private. The creek did not migrate significantly in this reach, but the reach did experience bank erosion, sediment deposition, and flooding damages. This reach has numerous private stream crossings, but most of the private crossings in this reach survived the flood with minimal or no damage. Only a few crossings had to be entirely replaced.

8.2 Assessment

The results of the ecological assessment show that this reach is in "Fair" condition with overall ecological assessment scores of 5.6 – 6.6 out of 10. The riparian corridor within this reach has been reduced by adjacent development and/or damaged by the September 2013 flood. Additionally, there are periodic gaps of vegetation along the reach, limited diversity of native plant species, and areas of channel instability.

The results of the geomorphic assessment for this reach show that Fourmile Creek consists of a cobble-bed system with low to moderate sinuosity that flows to the southeast in a narrow alluvial valley. Development exists adjacent to the right bank of the reach and Fourmile Canyon Drive is adjacent to the left bank. Portions of development and Fourmile Canyon Road are within the 100-year floodplain and are restricting lateral channel movement. The channel in this reach is generally attempting to widen, which is evidenced by the fact that there are several locations where bank stabilization has been implemented throughout the reach, generally consisting of concrete and rip rap. There are small portions of this reach that have degraded to the point where the floodplain is entrenched, and is resulting in local channel instability in some areas. The existing bed form consists of riffle-pool sequences; however, some of these features have been damaged or washed out as a result of recent flooding. The results of the erosion and deposition mapping show minor deposition and few sporadic pockets of deep erosion.



The results of the flood risk assessment of this reach show that numerous private residences are at risk during larger flood events. Some of the residences and infrastructure in this reach are at an increased risk in the post-flood environment because of significant deposition in the channel. The maps in this section show the results of the updated flood risk analysis for Fourmile Creek based on the current regulatory (FEMA) discharges. The results of the updated flood risk analysis based on both the regulatory (FEMA) discharges and CWCB/CDOT discharges is presented in Appendix D.

8.3 Roadway Improvements

The current Fourmile Canyon Drive in this reach is approximately 1.7 miles long with a paved 20-foot wide section. As of the date of this report, a design for road improvements is currently underway for the section of Fourmile Canyon Drive from Mile Marker 1 to Poorman Road (approximately 3,600 ft). The goal of the project is to relaign the road to reduce impacts to Fourmile Creek. The current design includes 27 ft of pavement (4 ft uphill shoulder, 2-11 ft lanes, 1ft creek side shoulder), accommodation of clear zone on both sides, consideration of a roadside ditch, and updated analysis on all tributary cross culverts. As a result of the existing constrained nature of Fourmile Creek, attempts are being made to not further encroach on the creek. Close coordination is occurring between this planning process and the roadway design to ensure that, where encroachments on the creek are unavoidable, their impact is minor and there is no impact of increased risk to residential structures.

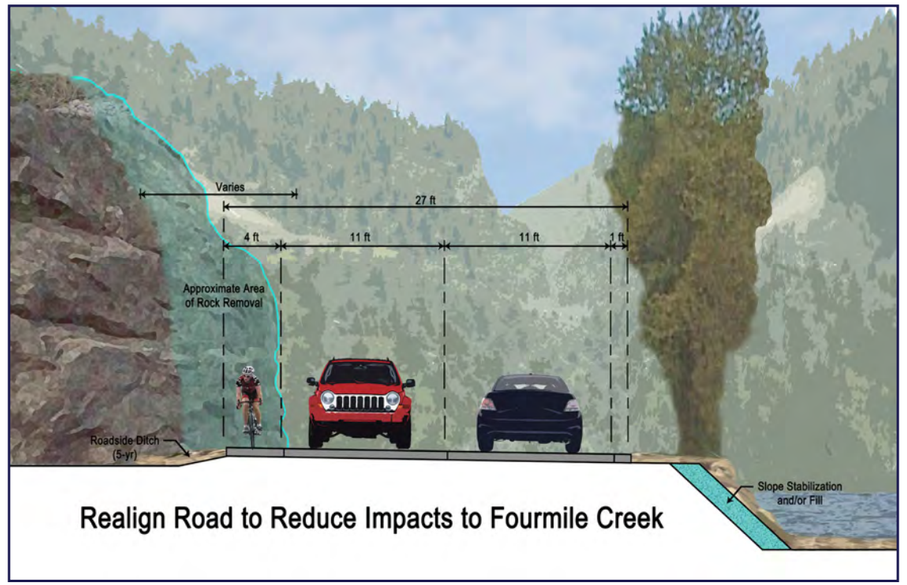


Figure 8.1 Conceptual Fourmile Canyon Drive Road Design

8.4 Planning Recommendations

Reach 1, because of its constrained nature, did not experience much migration of the creek channel. The primary issues in this reach included bank erosion, sediment deposition/aggradation, destruction or damage to the transportation infrastructure, debris accumulation, some damage to residential structures and private crossings, and damage to the riparian corridor.

Some of the priorities identified by stakeholders in this reach included: Mitigating risks to private property damage from future flooding, stabilizing the channel and banks for homeowners in addition to the roadway, removing non-native materials (e.g. concrete) that was used to stabilize banks post-flood, and identifying and preserving historical artifacts.

The recommended plan for Reach 1 is included on Reach 1 maps 1 through 4. The recommended plan includes the following projects:

» Incorporating and stabilizing a low flow channel section throughout the reach with the following design parameters:

Reach 1: Design Parameter	Range or Average
Low Flow Channel Top Width	40 ft - 50 ft
Low Flow Channel Top Width-to-Depth Ratio	Avg. 33
Sinuosity	Avg. 1.2
Slope	0.015 ft/ft - 0.025 ft/ft

» Increasing in-stream habitat complexity by incorporating pools, boulders, rock clusters, and large woody debris throughout the reach.

» Re-vegetating the riparian corridor with native species where vegetation has been stripped by the flood.

» Removing concrete/riprap bank protection and replace with natural materials or native boulders.

» Site-specific bank protection to protect resiDntial structures and transportation infrastructure in areas where the banks are currently unstable, current protection is inconsistent, or temporary measures were employed to protect the banks.

» Site-specific bank protection to protect areas of the historic Switzerland Trail from approximately Mile Marker 1.3 to Mile Marker 1.6.

» Removal of sediment aggradation from the channel near Mile Marker 1.1 to reduce the flood risk that was increase because of the flood.

The recommended projects in this plan integrate designs for sustainable stream restoration design and construction with the roadway reconstruction. As a result of the physical constraints of the canyon in this reach, restoring a meandering pattern to dissipate stream energies is generally not be practical. Therefore, the recommendations include incorporating and stabilizing a low flow channel, increasing in-stream habitat complexity, and site specific bank protection. The bank protection and habitat complexity features help to provide lateral stability and grade control. The incorporation of a low flow channel section decreases the stress placed on banks by decreasing flow velocities and depth for a given discharge. Beyond helping to stabilize the channel, this approach can also increases the cross-sectional area of the overall channel, decreasing the water surface profile during larger storm events as compared to the current condition.

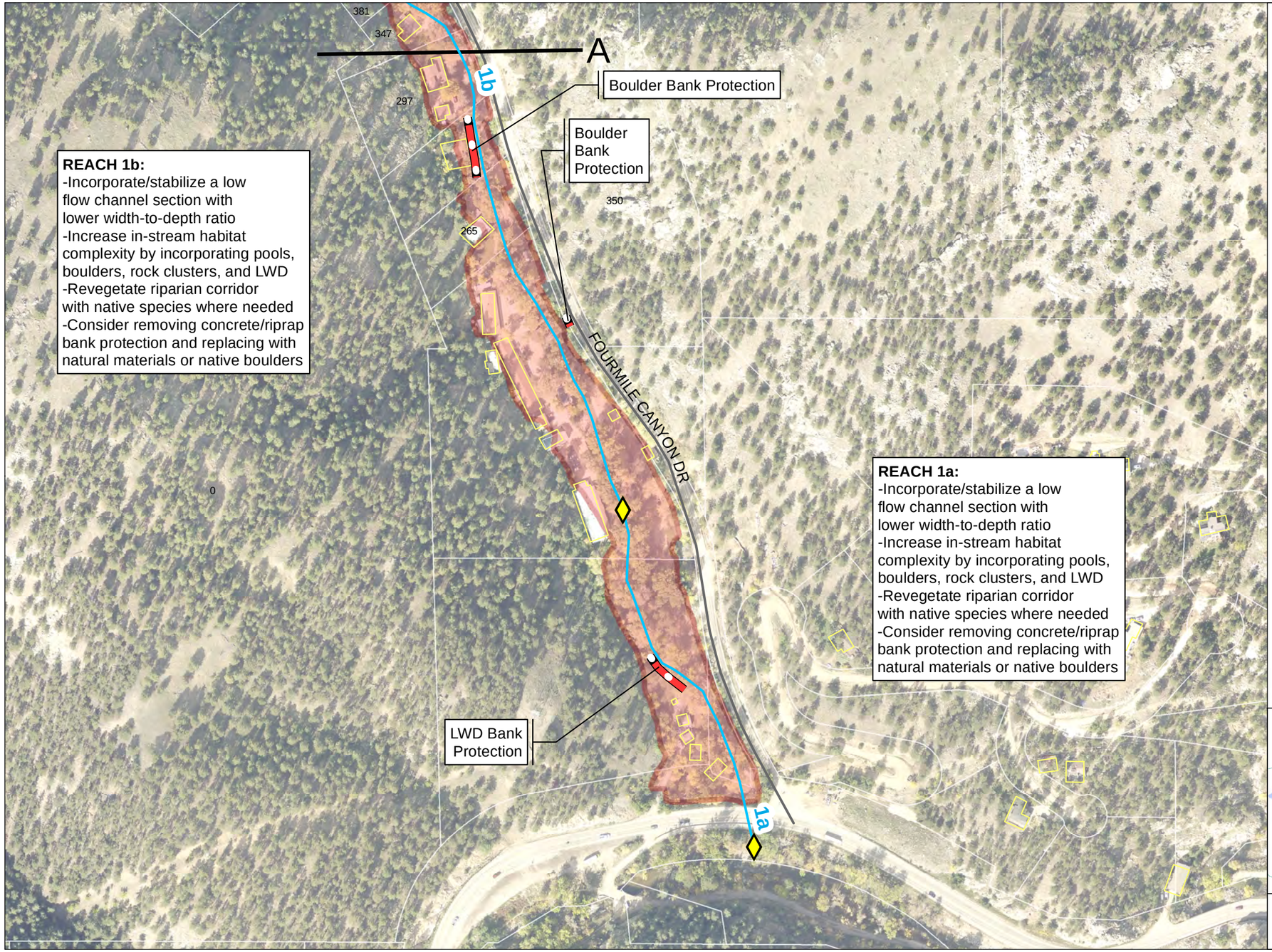
In addition to the projects listed above and shown on the plans, Boulder County was notified on July 25, 2014 that they were awarded a Stream Restoration Grant to restore approximately 900 ft of Fourmile Creek immediately downstream of Poorman Road. The post-flood channel as it exists today is a highly degraded with severely undersized channel capacity. The September 2013 flood deposited a significant amount of sediment in this reach, reducing the overall capacity and destroying riparian vegetation. An analysis of the post-flood channel capacity showed that Four Mile Canyon Drive could be inundated with discharges slightly above average spring runoff discharge. The project will not only restore capacity to the channel, but will also restore the unstable and degraded channel to a stable dimension, pattern and profile. The project will be completed in conjunction with the roadway project. The use of a natural channel design approach will be used, with long term goals to reduce sediment loading, prevent further channel incision that is currently observed along this reach, restore riparian vegetation, restore hydraulic capacity, and stabilize the existing eroding banks to provide long-term stability.

8.5 Estimated Cost of Unmet Needs

Estimated costs for unmet needs were prepared to capture the capital that could be required to implement plan recommendations. These estimated costs do not include projects that are currently being completed or that are programmed. The estimated costs for unmet needs in this reach are provided in Table 8.1.

Table 8.1 Estimated Costs for Reach 1

Reach 1 - Boulder Creek to Poorman Rd.	QTY	UNIT	UNIT COST	COST
Low Flow Channel Restoration	10,000	LF	$350	$3,500,000
Fill & Revegetate	0	SF	$4	$0
Revegetate	0	Acre	$20,000	$0
Excavation	920	CY	$10	$9,200
Bank Protection - Boulder	1,020	LF	$275	$280,500
Bank Protection - Root Wad	850	LF	$165	$140,250
Debris Rack	0	LS	$30,000	$0
Flood Wall	0	SF	$250	$0
Channel Realignment	0	LF	$350	$0
Fourmile Creek Restoration Project (Unmet Amount)	1	LS	$80,000	$80,000
			Subtotal:	**$4,009,950**
Engineering	15%			$601,493
Legal/Administrative	5%			$200,498
Contract Admin/Construction Management	10%			$400,995
Contingency	25%			$1,002,488
			Total:	**$6,215,423**
Fourmile Creek Restoration Project				$160,000*
*CWCB Grant for $80,000 received for this project				



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 1

MAP 1 OF 4

LEGEND

- Sub-Reach Breakline
- Mile Marker
- Post-Event Creek
- Bank Protection
- Channel Realignment
- Flood Wall
- Stream Restoration
- Proposed Road
- Proposed Wall
- Cut
- Debris Rack
- Fill & Revegetate
- Revegetation
- 100 Year Floodplain
- Match Lines

All proposed watershed activities need to comply with all federal, state, and local requirements prior to implementation. This includes but is not limited to: detailed engineering design, permitting, local land use and property ownership; and local public processes.

0 Feet 200

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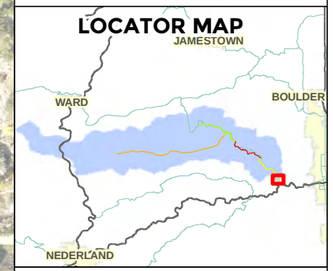
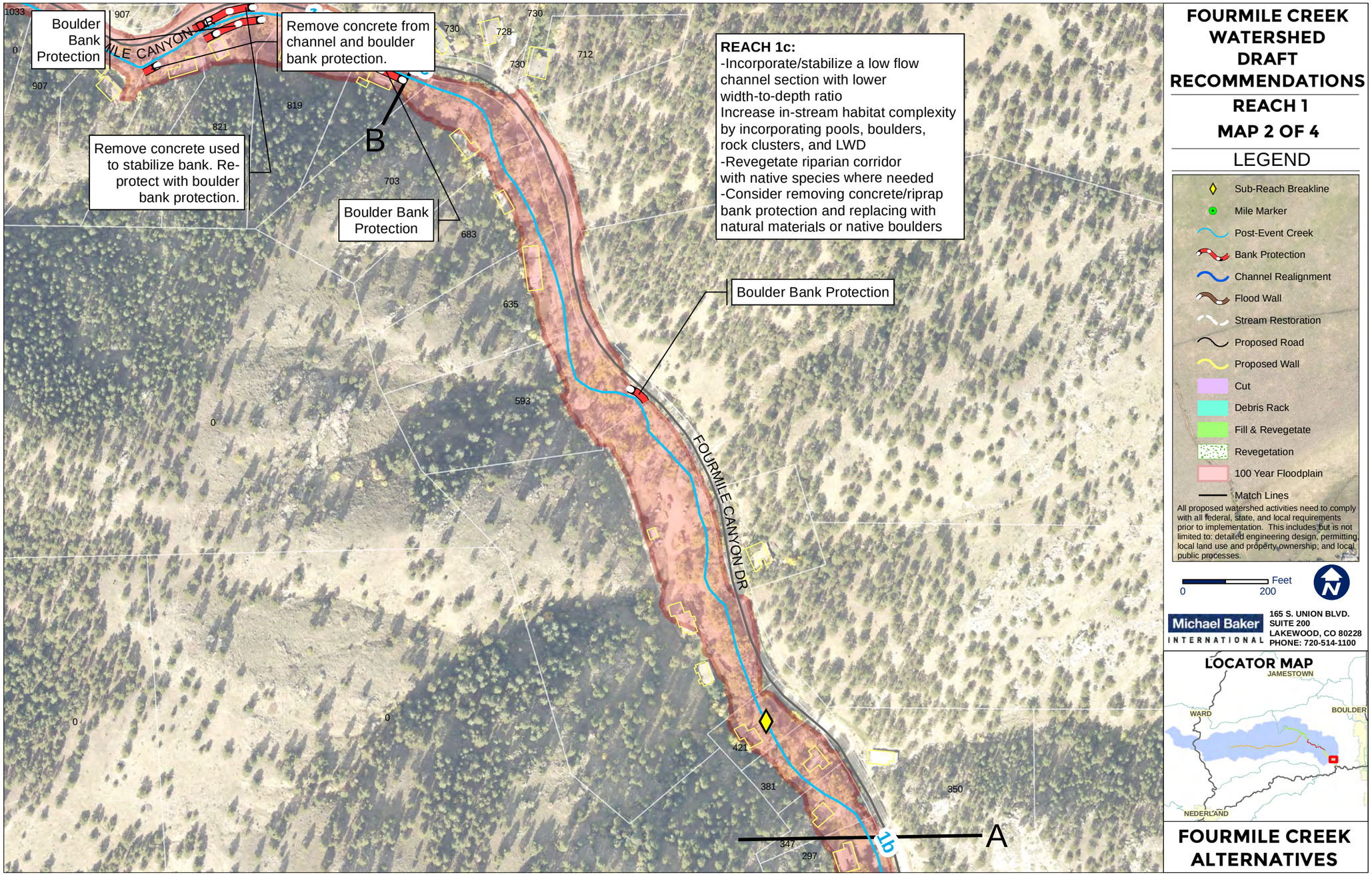
LOCATOR MAP



FOURMILE CREEK ALTERNATIVES



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 1

MAP 2 OF 4

LEGEND

- Sub-Reach Breakline
- Mile Marker
- Post-Event Creek
- Bank Protection
- Channel Realignment
- Flood Wall
- Stream Restoration
- Proposed Road
- Proposed Wall
- Cut
- Debris Rack
- Fill & Revegetate
- Revegetation
- 100 Year Floodplain
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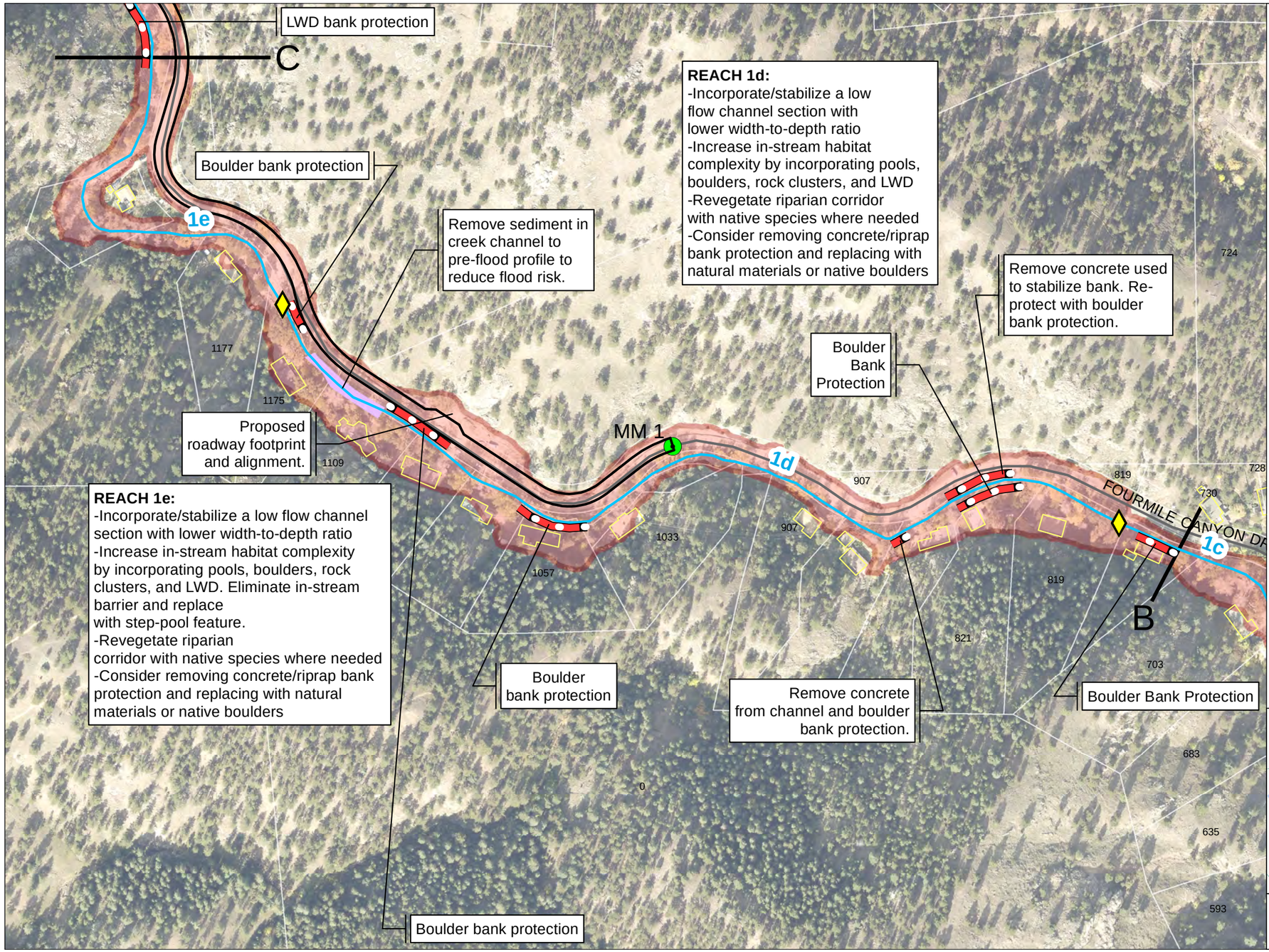
LOCATOR MAP

FOURMILE CREEK ALTERNATIVES



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 1

MAP 3 OF 4

LEGEND

- Sub-Reach Breakline
- Mile Marker
- Post-Event Creek
- Bank Protection
- Channel Realignment
- Flood Wall
- Stream Restoration
- Proposed Road
- Proposed Wall
- Cut
- Debris Rack
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0 200 Feet

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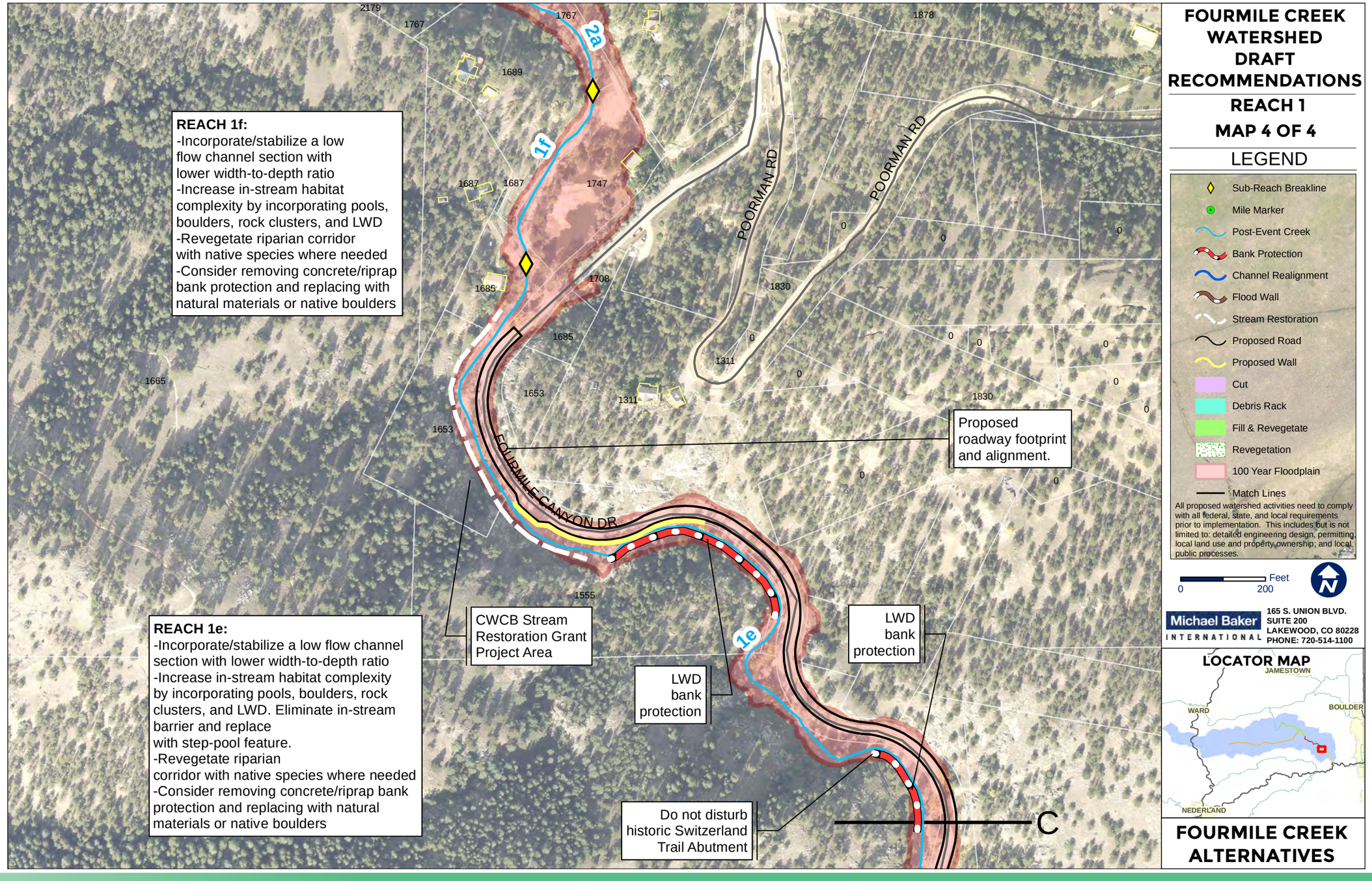
LOCATOR MAP

FOURMILE CREEK ALTERNATIVES



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 1

MAP 4 OF 4

LEGEND

- Sub-Reach Breakline
- Mile Marker
- Post-Event Creek
- Bank Protection
- Channel Realignment
- Flood Wall
- Stream Restoration
- Proposed Road
- Proposed Wall
- Cut
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0 Feet 200

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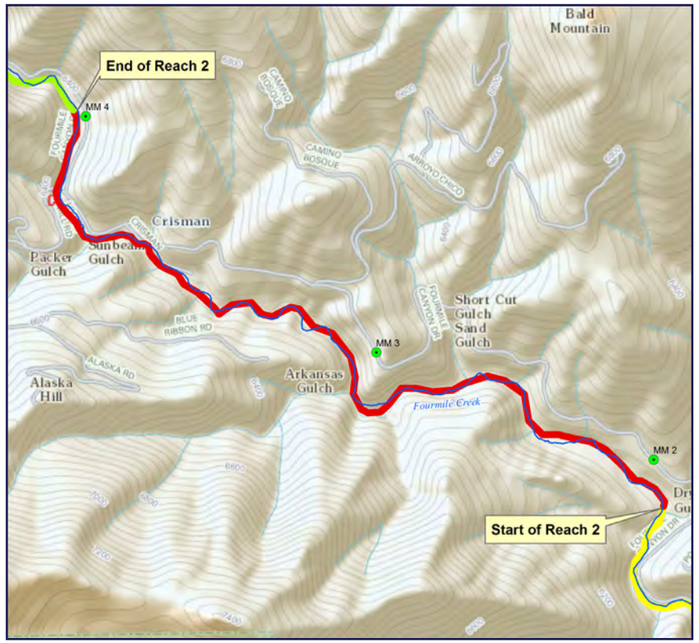
LOCATOR MAP

FOURMILE CREEK ALTERNATIVES

9. REACH 2

9.1 Overview

Reach 2 includes Fourmile Creek. It begins at Fourmile Canyon Drive and Poorman Road and goes upstream to Mile Marker 4 on Fourmile Canyon Drive. Reach 2 is very steep with slopes of the creek generally ranging from 1% to 7%. This reach of the creek is well below Fourmile Canyon Rd and many residential structures for the majority of the reach and is less constrained than the lower reach. This reach filtered out a significant amount of sediment and debris during the floods, preventing it from impacting lower Fourmile. The creek had some localized areas of migration, but generally did not migrate significantly in this reach. The reach did experience bank erosion, sediment deposition, and flooding damages. The Logan Mill Road Bridge and Betasso Link Trail pedestrian bridge were both washed out during the flood.



9.2 Assessment

The results of the ecological assessment show that this reach is in “Poor” to “Good” condition, depending on the sub-reach, with overall ecological assessment scores of 4.5 - 8.5 out of 10. The lower part of this reach received a “good’ ecosystem score because of the minimal floodplain development along with a high quantity and diversity of native plant species in the riparian corridor. Additionally, the lower part of this reach generally contains good in-stream habitat conditions. The upper part of the reach exhibited less vegetation and diversity of vegetation, and part of the reach exhibited some algal growth. The riparian corridor within this reach has been reduced by adjacent development and/or damaged by the September 2013 flood.

The results of the geomorphic assessment for this reach show that Fourmile Creek consists of a cobble-bed system with low to moderate sinuosity that flows to the southeast in a narrow alluvial valley. Development and infrastructure do not confine this reach until the reach enters Crisman, where both development and Fourmile Canyon Drive restrict lateral channel movement. Most of the development in Crisman is within the 100-year floodplain. The bottom half of this reach is stable. However, the upper half of the reach is unstable with some sub-reaches being severely aggraded, actively incising, and widening. There are small portions of this reach that have degraded to the point where the floodplain is entrenched, and is contributing to local channel instability. The existing bed form in the stable portions of this reach consists of riffle-pool sequences; however, some of these features have been damaged or washed out as a result of recent flooding. The results of the erosion and deposition mapping show moderate erosion and deposition throughout the entire reach.

The results of the flood risk assessment of this reach show that there is minimal risk to private residences during larger flood events in the lower part of the reach. The residential structures in the lower part of the reach are well above the creek. There are some residential structures in the Crisman area that are at risk during larger flood events. Post-flood deposition or channel migration does not appear to have increased the risk to residential structures in this reach. The maps in this section show the results of the updated flood risk analysis for Fourmile Creek based on the current regulatory (FEMA) discharges. The results of the updated flood risk analysis based on both the regulatory (FEMA) discharges and CWCB/CDOT discharges is presented in Appendix D.

9.3 Roadway Improvements

The pre-flood bridge carrying Logan Mill Road over Four Mile Creek was washed-out during the September 2013 floods. This bridge is located at the intersection of Logan Mill Road and Four Mile Canyon Drive at approximate Mile Marker 3.9. The pre-flood bridge was a single-span timber bridge approximately 20 feet long and 22 feet wide.

After the flood, a temporary road and small culvert were constructed to restore vehicular access prior to the Winter Road rehabilitation effort. Prior to peak spring run-off, the hydraulic capacity of the temporary crossing was increased by replacing the small culvert with (3) precast 7’x7’ concrete box culverts placed side-by-side.

As of the date of this report, a design for a permanent replacement of the temporary concrete box culverts is underway. The goal of the design is to provide a new structure that can pass a larger flood event and reduces the maintenance needs for the crossing. Close coordination is occurring between this planning process and the design of the Logan Mill Road crossing to determine the appropriate opening and minimize floodplain impacts.

9.4 Planning Recommendations

The lower part of Reach 2 has a low level of flood risk and good ecological score. As such, minimal work is being recommended for the lower part of Reach 2. The primary issues in the upper part of Reach 2 include destruction or damage to the transportation infrastructure, debris accumulation, and damage to vegetation and the riparian corridor.

Some of the priorities identified by stakeholders in this reach included: Tree preservation and planting, re-vegetation, improving the Logan Mill Road crossing, and addressing debris dams.

The recommended plan for Reach 2 is included on Reach 2 maps 1

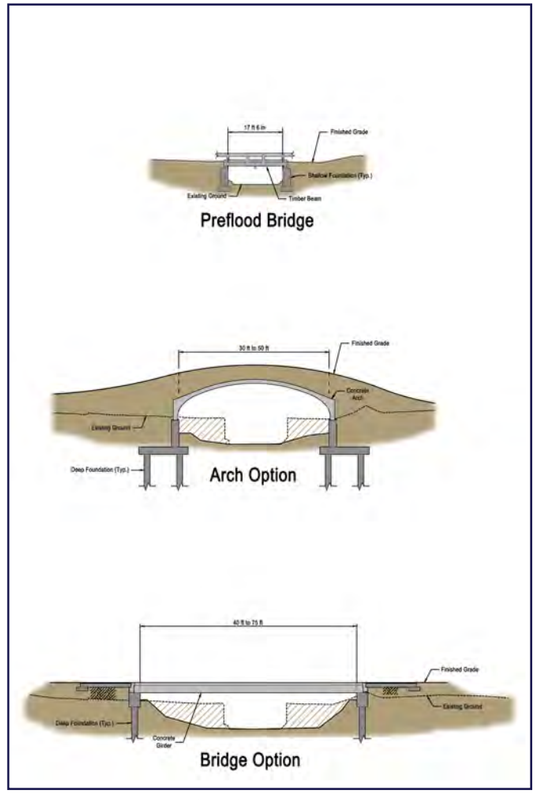


Figure 9.1 Logan Mill Preliminary Bridge/Culvert Options

through 4. The recommended plan includes the following projects:

- Incorporating and stabilizing a low flow channel section from Crisman to Mile Marker 4 with the following design parameters:

Reach 2: Design Parameter	Range or Average
Low Flow Channel Top Width	35 ft - 40 ft
Low Flow Channel Top Width-to-Depth Ratio	Avg. 33
Sinuosity	Avg. 1.2
Slope	0.015 ft/ft - 0.025 ft/ft

- Increasing in-stream habitat complexity by incorporating pools, boulders, rock clusters, and large woody debris throughout the reach from Crisman to Mile Marker 4.
- Re-vegetating the riparian corridor with native species where vegetation has been stripped by the flood from Crisman to Mile Marker 4.
- Filling the pre-flood channel in one site-specific location to reduce the risk of future avulsions.
- Re-vegetating a large area of floodplain adjacent to Fourmile Canyon Drive just upstream of Logan Mill Road.

The recommended projects in this plan integrate designs for sustainable stream restoration design to aid in long-term road protection. As a result of the physical constraints of the canyon in this reach, restoring a meandering pattern to dissipate stream energies is generally not be practical. Therefore, the recommendations include incorporating and stabilizing a low flow channel and increasing in-stream habitat complexity. the habitat complexity features help to provide lateral stability and grade control. The incorporation of a low flow channel section decreases the stress placed on banks by decreasing flow velocities and depth for a given discharge. Beyond helping to stabilize the channel, this approach can also increases the cross-sectional area of the overall channel, decreasing the water surface profile during larger storm events as compared to the current condition.

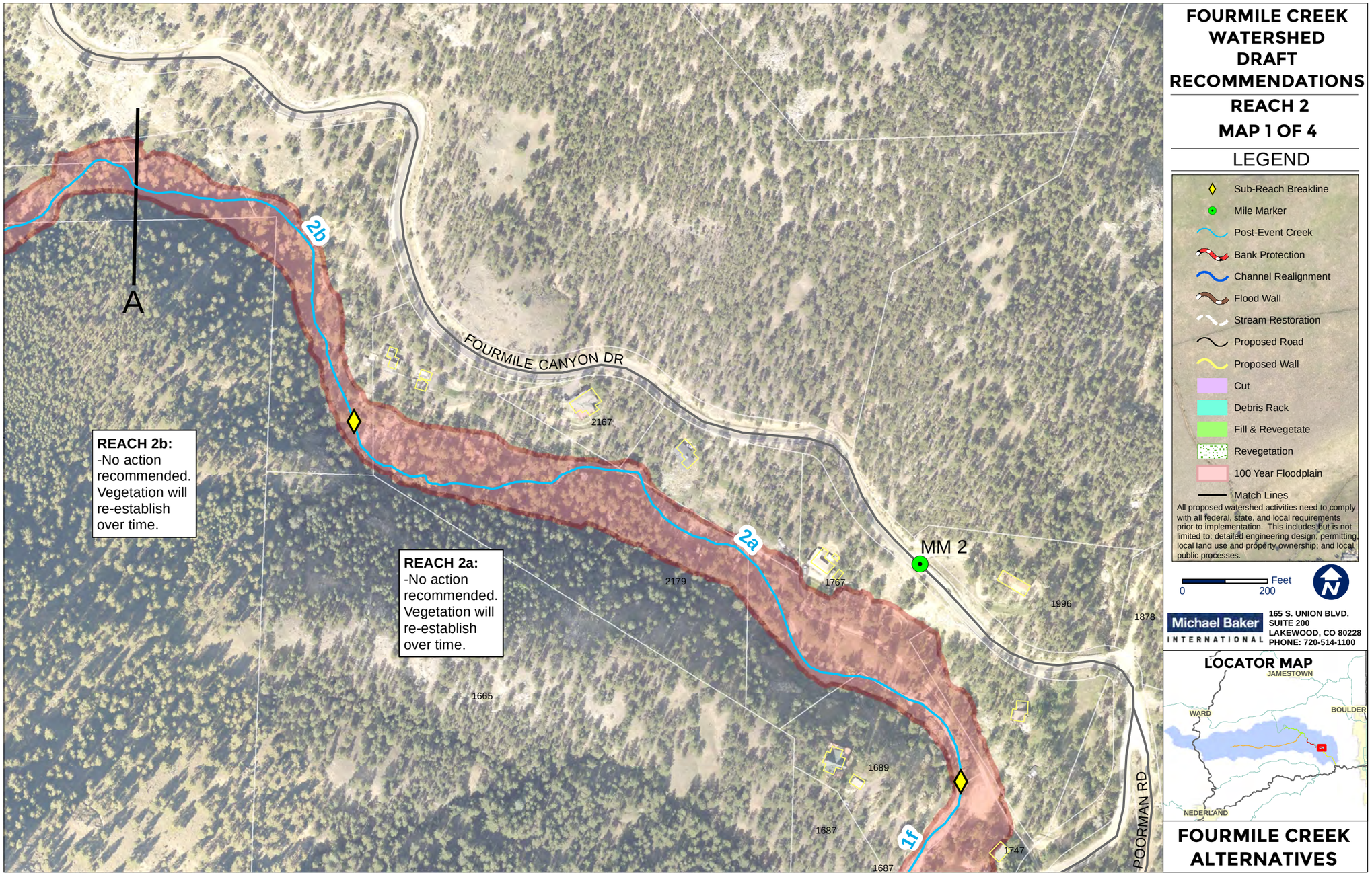
In addition to the projects listed above and shown on the plans, Boulder County Parks and Open Space is planning on replacing the pedestrian bridge over Fourmile Creek at the Betasso Link trail. The Colorado Water Conservation Board (CWCB) also approved a grant in mid-July 2014 to complete the Sunbeam Gulch Stream Restoration Project. This project consisted of a number of flood recovery tasks. As of November 2014, almost 75% of the project has been completed. The damaged ponds on the property have been re-established and the stream has been returned to the channel. As of November 2014, roughly 3/4 of the length of the creek had been cleared of debris and road restoration was near complete. The long term restoration goals within this area include reforestation and removal of burned timber for long-term flood and wildfire hazard mitigation benefits; erosion mitigation and road repair; and restoration of native fish to multiple damaged ponds.

9.5 Estimated Cost of Unmet Needs

Estimated costs for unmet needs were prepared to capture the capital that could be required to implement plan recommendations. These estimated costs do not include projects that are currently being completed or that are programmed. The estimated costs for unmet needs in this reach are provided in Table 9.1.

Table 9.1 Estimated Costs for Reach 2

Reach 2 - Poorman Rd to Mile Marker 4	QTY	UNIT	UNIT COST	COST
Low Flow Channel Restoration	5,240	LF	$350	$1,834,000
Fill & Revegetate	6,810	SF	$4	$27,240
Revegetate	0.5	Acre	$20,000	$10,000
Excavation	554	CY	$10	$5,540
Bank Protection - Boulder	0	LF	$275	$0
Bank Protection - Root Wad	0	LF	$165	$0
Debris Rack	0	LS	$30,000	$0
Flood Wall	0	SF	$250	$0
Channel Realignment	0	LF	$350	$0
			Subtotal:	**$1,876,780**
Engineering	15%			$281,517
Legal/Administrative	5%			$93,839
Contract Admin/Construction Management	10%			$187,678
Contingency	25%			$469,195
			Total:	**$2,909,009**


A
2b
2a
1f
FOURMILE CANYON DR
POORMAN RD
MM 2
2167
2179
1767
1996
1878
1665
1689
1687
1747
1687
REACH 2b:
-No action recommended. Vegetation will re-establish over time.
REACH 2a:
-No action recommended. Vegetation will re-establish over time.
FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS
REACH 2
MAP 1 OF 4
LEGEND
Sub-Reach Breakline
Mile Marker
Post-Event Creek
Bank Protection
Channel Realignment
Flood Wall
Stream Restoration
Proposed Road
Proposed Wall
Cut
Debris Rack
Fill & Revegetate
Revegetation
100 Year Floodplain
Match Lines
All proposed watershed activities need to comply with all federal, state, and local requirements prior to implementation. This includes but is not limited to: detailed engineering design, permitting, local land use and property ownership; and local public processes.
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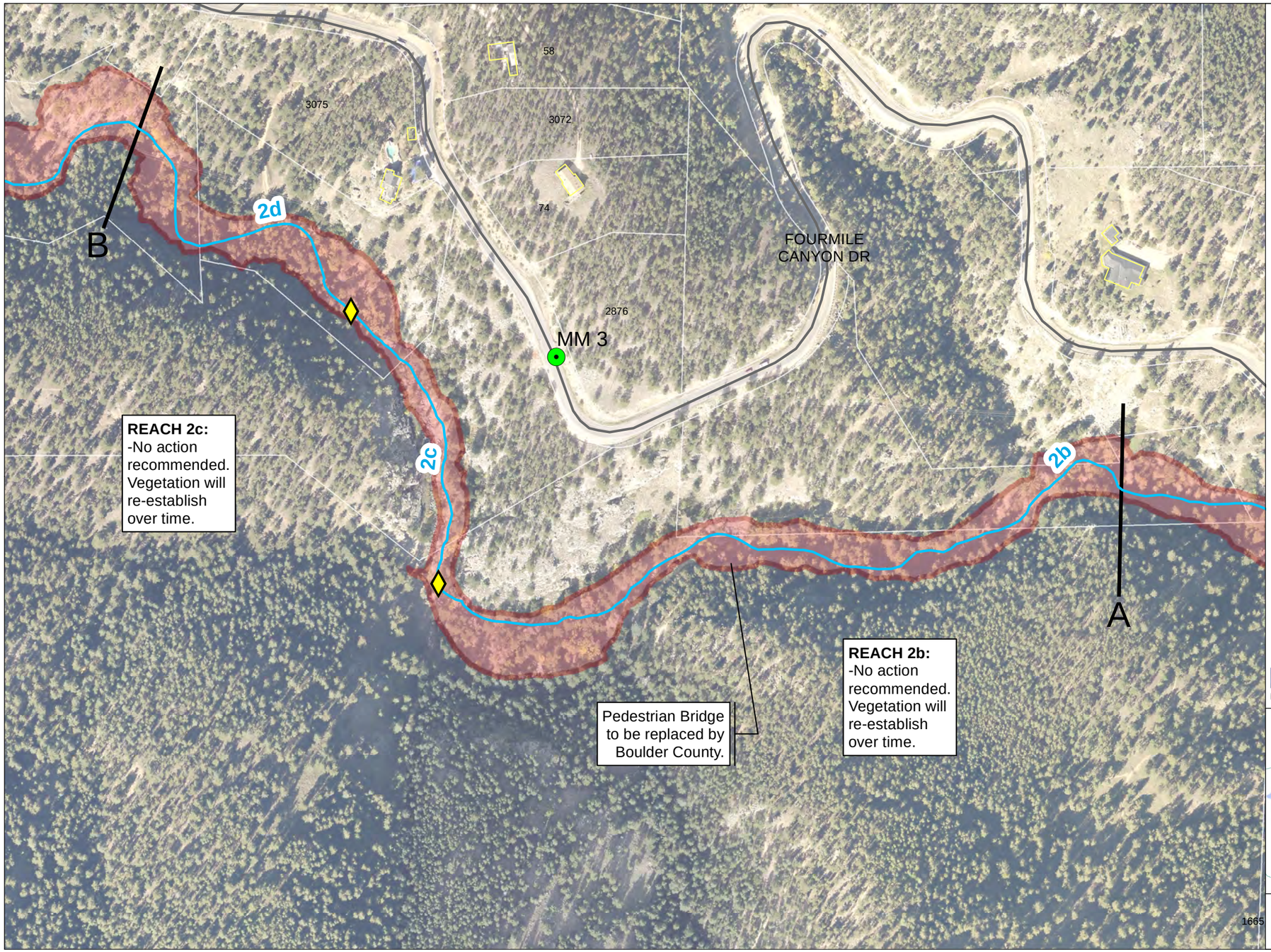
Michael Baker INTERNATIONAL
165 S. UNION BLVD.
SUITE 200
LAKEWOOD, CO 80228
PHONE: 720-514-1100
LOCATOR MAP
JAMESTOWN
WARD
BOULDER
NEDERLAND
FOURMILE CREEK ALTERNATIVES



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 2

MAP 2 OF 4

LEGEND

- Sub-Reach Breakline
- Mile Marker
- Post-Event Creek
- Bank Protection
- Channel Realignment
- Flood Wall
- Stream Restoration
- Proposed Road
- Proposed Wall
- Cut
- Debris Rack
- Fill & Revegetate
- Revegetation
- 100 Year Floodplain
- Match Lines

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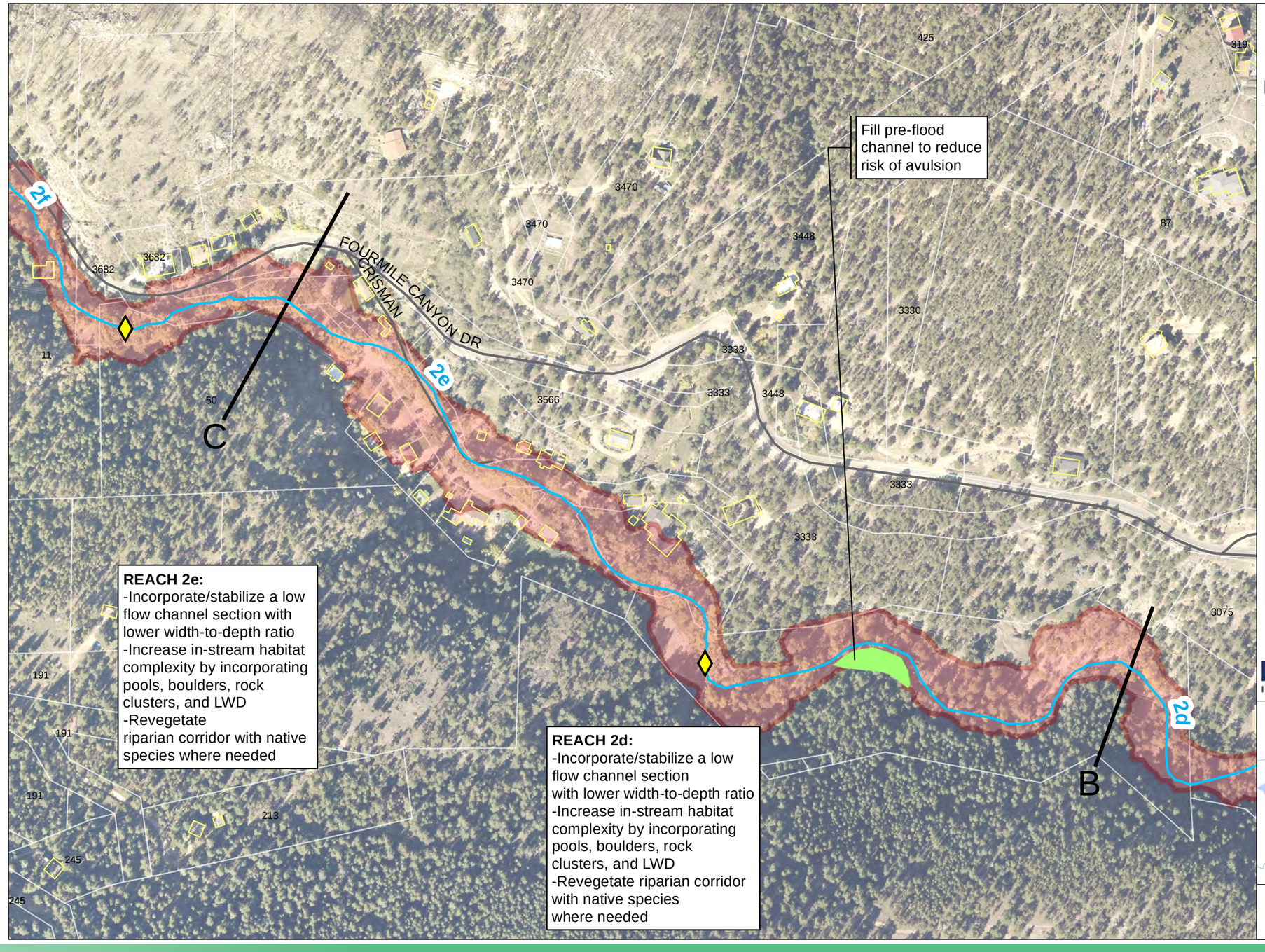
LOCATOR MAP

FOURMILE CREEK ALTERNATIVES



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 2

MAP 3 OF 4

LEGEND

- Sub-Reach Breakline
- Mile Marker
- Post-Event Creek
- Bank Protection
- Channel Realignment
- Flood Wall
- Stream Restoration
- Proposed Road
- Proposed Wall
- Cut
- Debris Rack
- Fill & Revegetate
- Revegetation
- 100 Year Floodplain
- Match Lines

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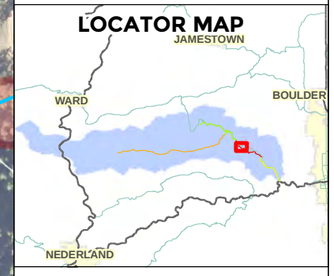
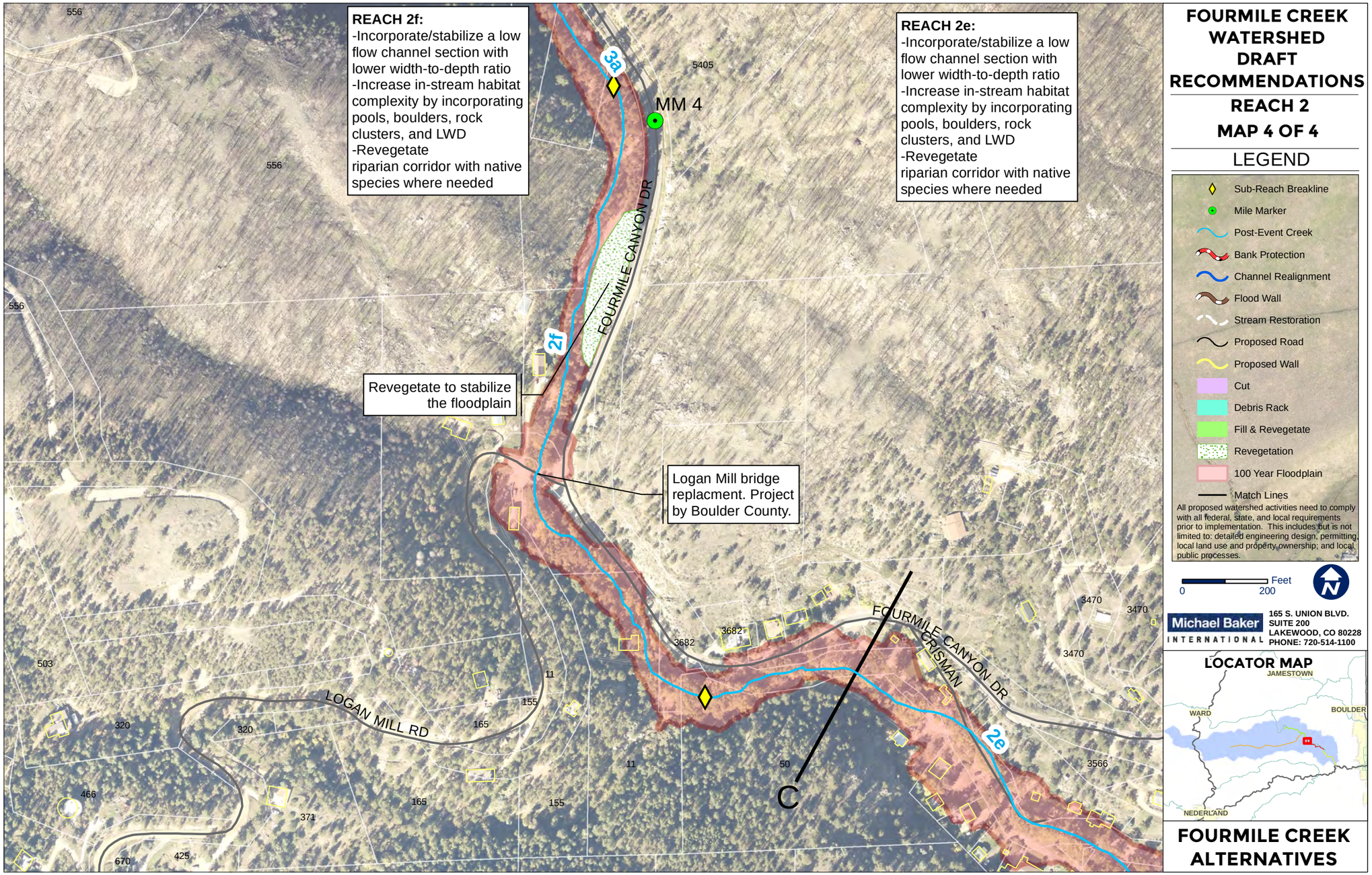


FOURMILE CREEK ALTERNATIVES



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 2

MAP 4 OF 4

LEGEND

- Sub-Reach Breakline
- Mile Marker
- Post-Event Creek
- Bank Protection
- Channel Realignment
- Flood Wall
- Stream Restoration
- Proposed Road
- Proposed Wall
- Cut
- Debris Rack
- Fill & Revegetate
- Revegetation
- 100 Year Floodplain
- Match Lines

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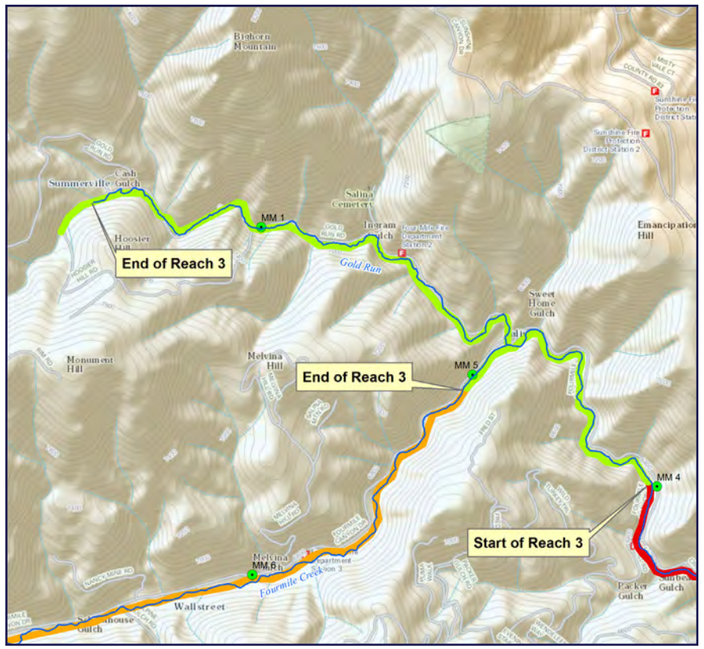
FOURMILE CREEK ALTERNATIVES

10. REACH 3

10.1 Reach Description

Reach 3 includes Fourmile Creek and Gold Run. The Fourmile Creek reach begins at Mile Marker 4 along Fourmile Canyon Drive and extends to Mile Marker 5 and the Gold Run reach begins at the confluence with Fourmile Creek and extends to Summerville. Fourmile Creek in Reach 3 is very steep with slopes of the creek generally ranging from 1.5% to 7%. Gold Run in Reach 3 is extremely steep with slopes of the creek ranging from 4% to greater than 10%. This reach of the creek is extremely constrained by existing topography, development, transportation infrastructure, and historic structures. A large percentage of the property along the creek corridor is private. This reach was among the hardest hit by the flood. It experienced significant channel migration, erosion, deposition of sediment, and destruction of properties along with public and private infrastructure. This reach has numerous private stream crossings which were damaged or destroyed by the flood.



10.2 Assessment

The results of the ecological assessment show that this reach is in “Poor” to “Good” condition, depending on the sub-reach, with overall ecological assessment scores of 3.5 - 8.5 out of 10. The Fourmile Creek sub-reaches all received a score of “fair” because the riparian corridor has been reduced by adjacent development and/or damaged by the September 2103 flood. Additionally, there is limited diversity of native plant species and areas of channel instability within this part of the reach. The lower portions of Gold Run received scores of “poor” because the riparian corridor has mostly been eliminated due to adjacent development and there is a general lack of native vegetation. The riparian corridor in the upper reach of Gold Run has generally not been impacted by development and was not damaged by the flood. The quantity and quality of riparian vegetation in this reach is good and in-stream habitat conditions are favorable. It received an overall ecosystem score of “good.”

The results of the geomorphic assessment for this reach show that Fourmile Creek consists of a cobble-bed system with moderate sinuosity that flows to the southeast in a narrow alluvial valley. A small amount of development exists adjacent to the right bank of the reach and Fourmile Canyon Drive is adjacent to the left bank. Portions of Fourmile Canyon Road are within the 100-year floodplain and are restricting lateral channel movement. The channel in this reach appears to have gone through a widening process and is now transitioning towards more of a stable condition. Most portions of this reach have degraded to the point where the floodplain is entrenched, and is resulting in local channel instability in all sub-reaches. The existing bed form consists of riffle-pool step-pool sequences; however, some of these features have been damaged or washed out as a result of recent flooding. The results of the erosion and deposition mapping show significant zones of both erosion and deposition.

The results of the geomorphic assessment for this reach show that Gold Run mostly consists of an engineered channel that was constructed during post-flood restoration efforts. The channel sinuosity is moderate in most locations. Development exists adjacent to both channel banks and Gold Run Road is adjacent to the left bank. Both the development and Gold Run Road are mostly within the 100-year floodplain and are restricting lateral channel movement. The channel in this reach is generally attempting to widen, which is evidenced by the fact that there are several locations where bank stabilization has been implemented throughout the reach, generally consisting of concrete and rip rap. There are no natural identifiable channel bed form features except for the upper sub-reach, where some step-pool features exist. The results of the erosion and deposition mapping show significant erosion throughout the reach.

The results of the flood risk assessment of this reach show that numerous private residences are at risk during flood events. Review of photographs and videos for this reach during flood events in 2011, 2012, and 2013 indicate that the hydraulic analysis may underrepresent the true risk, specifically in Gold Run. Past flood events have been dominated by significant debris flows, debris dams at culverts, and significant migration of the channel. These types of risk are highly variable and hard to predict. This information was taken into account when planning recommendations to reduce the overall risk. The maps in this section show the results of the updated flood risk analysis for Fourmile Creek based on the current regulatory (FEMA) discharges and the results of the updated flood risk analysis for Gold Run based on the CWCB/CDOT discharges. The results of the updated flood risk analysis based on both the regulatory (FEMA) discharges and CWCB/CDOT discharges for Fourmile Creek is presented in Appendix D.

10.3 Roadway Improvements

As of the date of this report, there are three roadway improvement projects in this reach. The projects include:

- Fourmile Canyon Drive: The current Fourmile Canyon Drive in this reach is 1 mile long with a paved 20-foot wide section. A design for road improvements is currently underway for the section of Fourmile Canyon Drive from approximately Mile Marker 4.1 to Salina Junction (approximately 3,000 ft). The current design includes 27 ft of pavement (4 ft uphill shoulder, 2-11 ft lanes, 1ft creek side shoulder), accommodation of clear zone on both sides, consideration of a roadside ditch, and updated analysis on all tributary cross culverts. As a result of the existing constrained nature of Fourmile Creek, attempts are being made to not further encroach on the creek. Close coordination is occurring between this planning process and the roadway design to ensure that, where encroachments on the creek are unavoidable, their impact is minor and there is no impact of increased risk to residential structures.

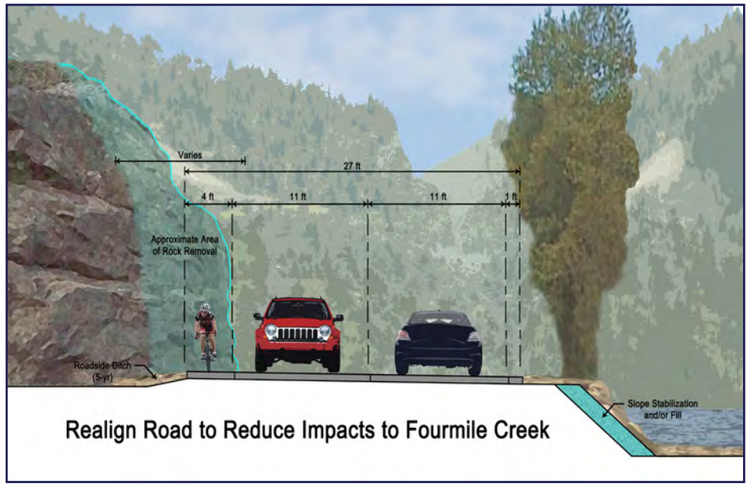


Figure 10.1 Conceptual Fourmile Canyon Drive Road Design

» Salina Junction: Flood repairs at Salina Junction are currently in design and are planned to include modifications to Gold Run from the junction with Four Mile Creek to approximately 280 feet upstream. The intersection of the two creeks was inundated with water from both Fourmile Creek and Gold Run. The resulting overtopping of the intersection caused significant property damage and stranded many residents of the area as the roadway was impassible. The current design includes expansion of the culvert under Four Mile Canyon Drive to accommodate a 25-year flood, construction of an energy dissipation outlet structure at the outlet of the box culvert, and reconstruction of Gold Run from the inlet of the box culvert for approximately 280 feet upstream. Because the road repairs require modifications to the creek channel, the design and construction of the road should incorporate the recommendations of this creek master plan to the extent possible.

Figure 10.2 Salina Junction Outlet Structure Plan

» Gold Run Road: As a result of the flooding, significant damage occurred along Gold Run Road from Salina Junction to Summerville. The flooding resulted in substantial alteration to the roadway location both horizontally and vertically. In many locations the existing channel meandered and changed sides as well as eroding the existing roadway bench. A project to recommend roadway improvements from Salina Junction to Summerville has commenced, however, the design of the roadway improvements has not started. As a result of the extremely constrained nature of Gold Run, close coordination will occur between this planning process and the roadway design to ensure that encroachments on Gold Run are avoided as much as possible.

10.4 Planning Recommendations

Reach 3 experienced the most significant flood damages including: channel migration, erosion, deposition of sediment, debris dams, and destruction of properties along with public and private infrastructure. The existing Gold Run channel does not have sufficient capacity to convey larger events and the risk is heightened by the large amount of debris the watershed has historically generated during flood events. Given the extremely constrained nature of the reach and the extremely steep watershed and flooding sources, the risk in this reach cannot be eliminated. The recommendations of this plan focus on mitigating risk within the constraints of the reach.

Some of the priorities identified by stakeholders in this reach included: Reducing debris flow, improving water quality, protecting the historic nature of the buildings and area, and for re-vegetating the creek corridor.

The recommended plan for Reach 3 is included on Reach 3 maps 1 through 5. There are limited creek restoration opportunities within this reach because of the extremely constrained nature of the channel; however, some activities can be performed to improve the in-stream habitat and riparian zone. The creek migrated significantly in this reach, particularly in Gold Run where the creek is, in some cases, on the opposite side of Gold Run Road. The plan does not recommend major channel realignment, preferring to keep the channel in the post-flood location in most of the reach. The recommendation not to realign the channel is based on assessment of the stability of the current channel location, the current and anticipated roadway location, and conversations with residents about how the stream migrated in previous events. Minor adjustments to the channel location may need to be made as the roadway improvements design commences. The recommended plan includes the following projects:

» Incorporating and stabilizing a low flow channel section for the Fourmile Creek reach and Upper Gold Run reach with the following design parameters:

Reach 3 - Fourmile Creek: Design Parameter	Range or Average
Low Flow Channel Top Width	35 ft - 40 ft
Low Flow Channel Top Width-to-Depth Ratio	Avg. 25
Sinuosity	Avg. 1.2
Slope	0.025 ft/ft - 0.040 ft/ft

Reach 3 - Gold Run: Design Parameter	Lower Gold Run	Upper Gold Run
Low Flow Channel Top Width	20 ft	15 ft
Low Flow Channel Top Width-to-Depth Ratio	20 ft	33 ft
Sinuosity	1.2	1.3
Slope	0.065 ft/ft	0.050 ft/ft

- Increasing in-stream habitat complexity by incorporating pools, boulders, rock clusters, and large woody debris for the Fourmile Creek reach and Upper Gold Run reach.
- Re-vegetating the riparian corridor with native species where vegetation has been stripped by the flood for all reaches.
- Relocating Fourmile Creek downstream of Salina Junction to its pre-flood location to move it away from the existing mine tailings pile and prevent future road damage.
- Removing concrete/riprap bank protection and replace with natural materials or native boulders for the Fourmile Creek reach.
- Site-specific bank protection to protect residential structures and transportation facilities in areas where the banks are currently unstable.
- Installing debris racks and stabilizing the banks of Ingram Gulch upstream of Gold Run to prevent debris from larger events from entering Gold Run.
- Filling and re-vegetating several site specific areas where avulsions occurred to prevent future avulsions.
- Assessing the stability of existing walls in Gold Run and modifying if necessary. There are a number of existing and historic rock walls in the Gold Run corridor. Many of the walls failed during the September flooding because they were not designed and constructed to withstand large flooding events. The existing walls and wall locations could be utilized as flood walls if designed and constructed appropriately. These walls could be designed to look like historic walls while providing a significant risk reduction to residential and historic structures.

The recommended projects in this plan integrate designs for sustainable stream restoration design and construction with the roadway reconstruction. As a result of the physical constraints of the canyon in this reach, restoring a meandering pattern to dissipate stream energies is generally not be practical. Therefore, the recommendations include incorporating and stabilizing a low flow channel, increasing in-stream habitat complexity, and site specific bank protection. The bank protection and habitat complexity features help to provide lateral stability and grade control. The incorporation of a low flow channel section decreases the stress placed on banks by decreasing flow velocities and depth for a given discharge. Beyond helping to stabilize the channel, this approach can also increases the cross-sectional area of the overall channel, decreasing the water surface profile during larger storm events as compared to the current condition.

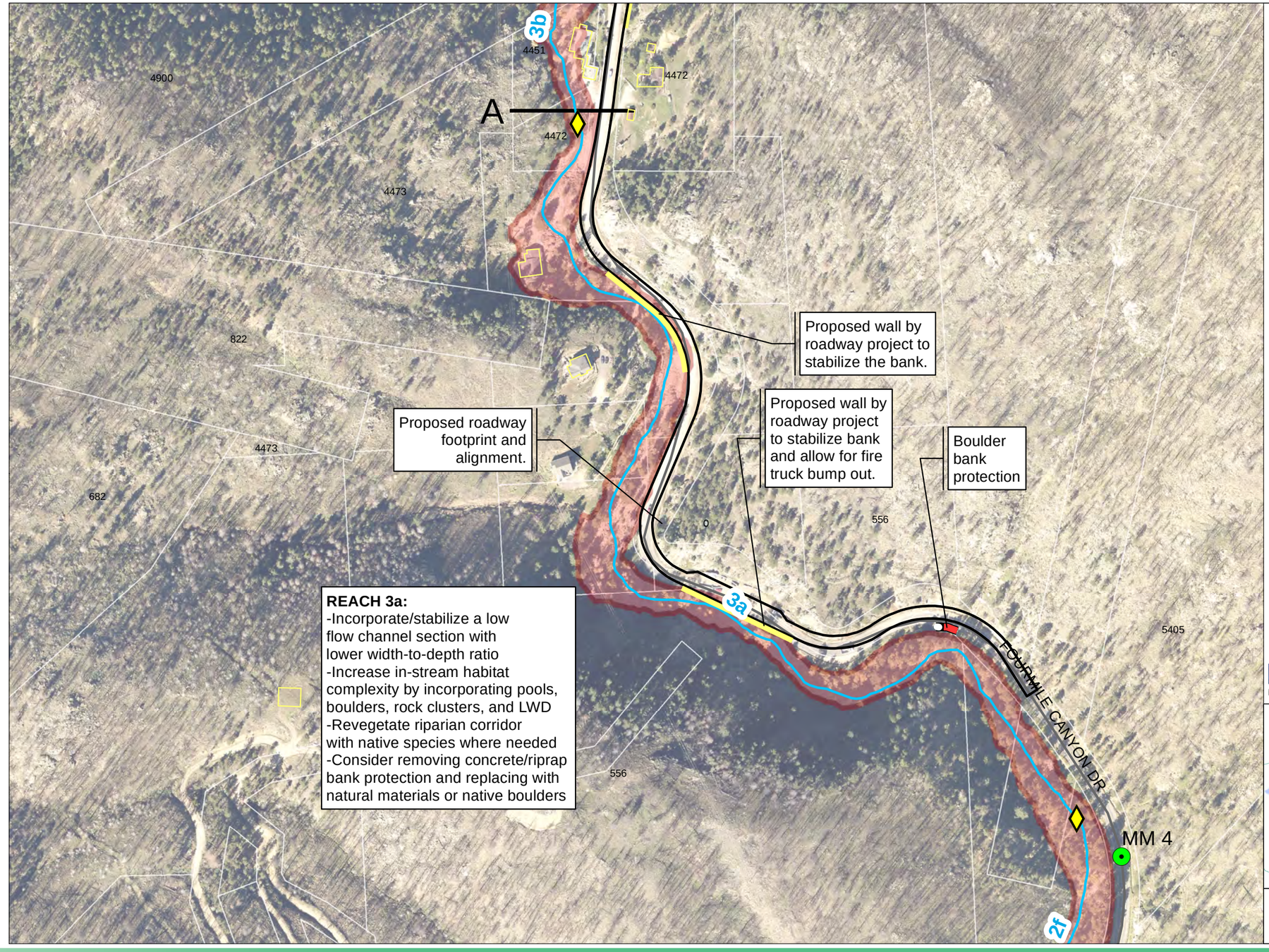
In addition to the projects listed above and shown on the plans, the Environmental Protection Agency (EPA) is planning to remove some of the mine tailings at the large and recently exposed tailings pile just downstream of Salina Junction. The EPA will cap the remaining tailings that they cannot remove as part of their project. We are coordinating with the EPA on the planned removal in this area and are coordinating with the roadway design in this reach to ensure that the two projects to not adversely impact the flood risk downstream of the Junction.

10.5 Estimated Cost of Unmet Needs

Estimated costs for unmet needs were prepared to capture the capital that could be required to implement plan recommendations. These estimated costs do not include projects that are currently being completed or that are programmed. The estimated costs for unmet needs in this reach are provided in Table 10.1.

Table 10.1 Estimated Costs for Reach 3

Reach 3 - MM 4 to MM 5 and Gold Run	**QTY**	**UNIT**	**UNIT COST**	**COST**
Low Flow Channel Restoration	15,100	LF	$350	$5,285,000
Fill & Revegetate	11,210	SF	$4	$44,840
Revegetate	0	Acre	$20,000	$0
Excavation	0	CY	$10	$0
Bank Protection - Boulder	1,220	LF	$275	$335,500
Bank Protection - Root Wad	0	LF	$165	$0
Debris Rack	3	LS	$30,000	$90,000
Flood Wall	5,000	SF	$250	$1,250,000
Channel Realignment	310	LF	$350	$108,500
			Subtotal:	**$7,113,840**
Engineering	15%			$1,067,076
Legal/Administrative	5%			$355,692
Contract Admin/Construction Management	10%			$711,384
Contingency	25%			$1,778,460
			Total:	**$11,026,452**



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 3

MAP 1 OF 5

LEGEND

- Sub-Reach Breakline
- Mile Marker
- Post-Event Creek
- Bank Protection
- Channel Realignment
- Flood Wall
- Stream Restoration
- Proposed Road
- Proposed Wall
- Cut
- Debris Rack
- Fill & Revegetate
- Revegetation
- 100 Year Floodplain
- Match Lines

All proposed watershed activities need to comply with all federal, state, and local requirements prior to implementation. This includes but is not limited to: detailed engineering design, permitting, local land use and property ownership; and local public processes.

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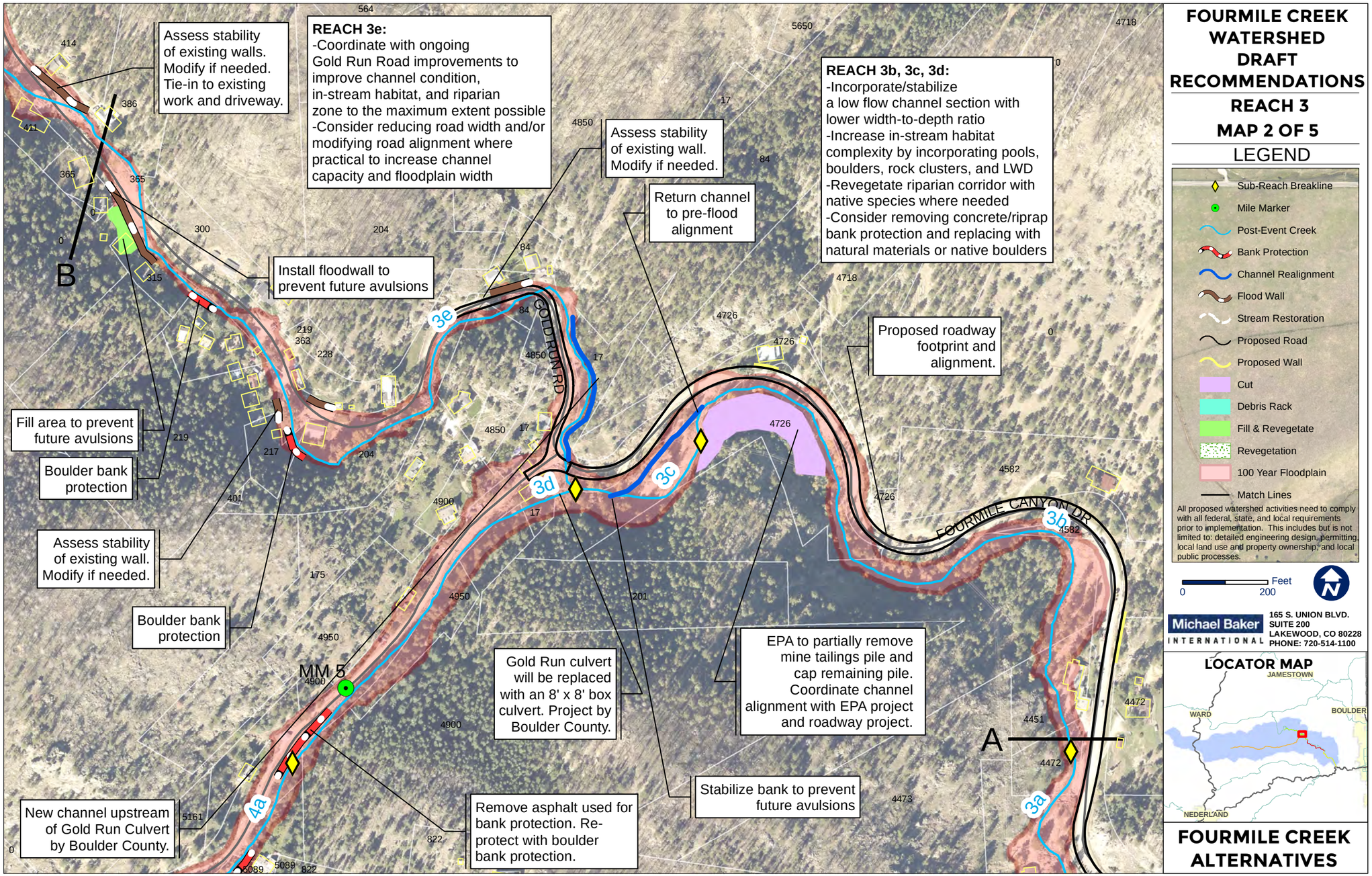
FOURMILE CREEK ALTERNATIVES


Assess stability of existing walls. Modify if needed. Tie-in to existing work and driveway.
REACH 3e:
-Coordinate with ongoing Gold Run Road improvements to improve channel condition, in-stream habitat, and riparian zone to the maximum extent possible
-Consider reducing road width and/or modifying road alignment where practical to increase channel capacity and floodplain width
Assess stability of existing wall. Modify if needed.
Return channel to pre-flood alignment
REACH 3b, 3c, 3d:
-Incorporate/stabilize a low flow channel section with lower width-to-depth ratio
-Increase in-stream habitat complexity by incorporating pools, boulders, rock clusters, and LWD
-Revegetate riparian corridor with native species where needed
-Consider removing concrete/riprap bank protection and replacing with natural materials or native boulders
Install floodwall to prevent future avulsions
Proposed roadway footprint and alignment.
Fill area to prevent future avulsions
Boulder bank protection
Assess stability of existing wall. Modify if needed.
Boulder bank protection
Gold Run culvert will be replaced with an 8' x 8' box culvert. Project by Boulder County.
EPA to partially remove mine tailings pile and cap remaining pile. Coordinate channel alignment with EPA project and roadway project.
New channel upstream of Gold Run Culvert by Boulder County.
Remove asphalt used for bank protection. Re-protect with boulder bank protection.
Stabilize bank to prevent future avulsions
COLD RUN RD
FOURMILE CANYON DR
MM 5
A
B
3a
3b
3c
3d
3e
4a
FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS
REACH 3
MAP 2 OF 5
LEGEND
Sub-Reach Breakline
Mile Marker
Post-Event Creek
Bank Protection
Channel Realignment
Flood Wall
Stream Restoration
Proposed Road
Proposed Wall
Cut
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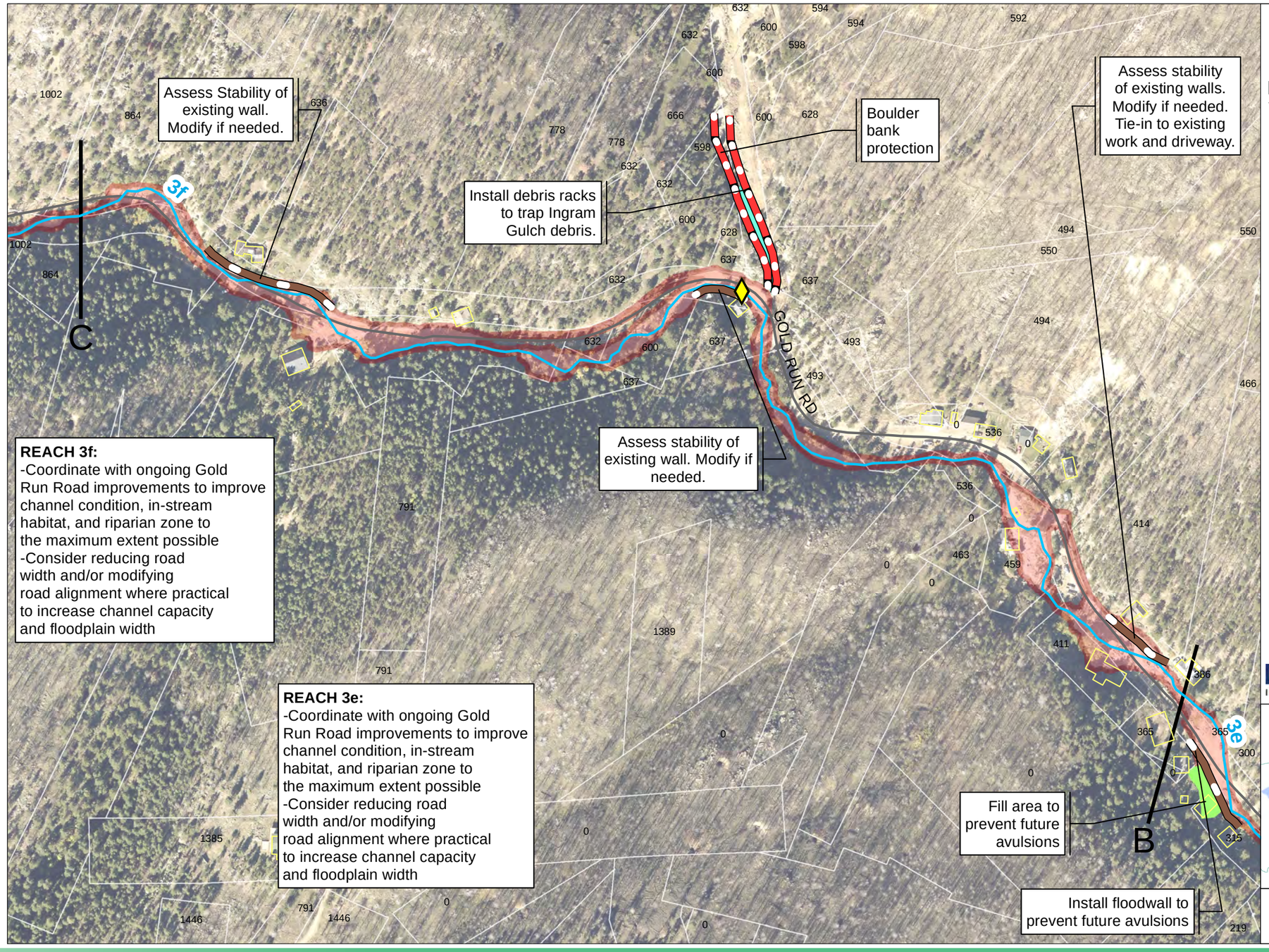
NEDERLAND
FOURMILE CREEK ALTERNATIVES



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 3

MAP 3 OF 5

LEGEND

- Sub-Reach Breakline
- Mile Marker
- Post-Event Creek
- Bank Protection
- Channel Realignment
- Flood Wall
- Stream Restoration
- Proposed Road
- Proposed Wall
- Cut
- Debris Rack
- Fill & Revegetate
- Revegetation
- 100 Year Floodplain
- Match Lines

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0 Feet 200

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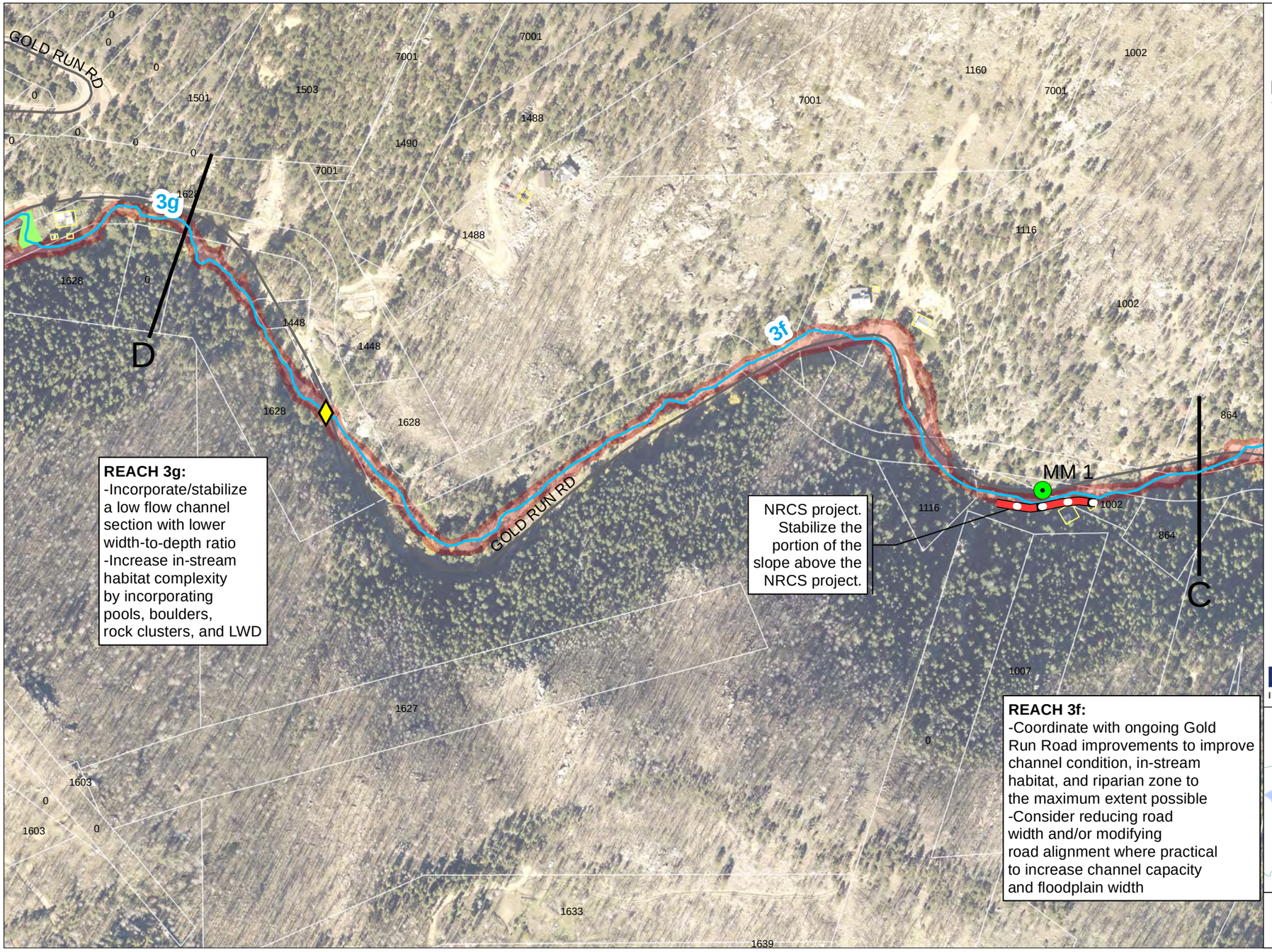
PHONE: 720-514-1100

LOCATOR MAP

FOURMILE CREEK ALTERNATIVES



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 3

MAP 4 OF 5

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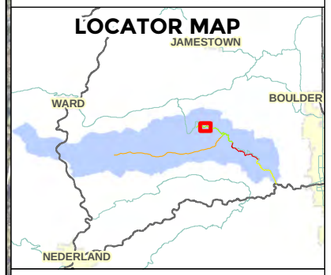

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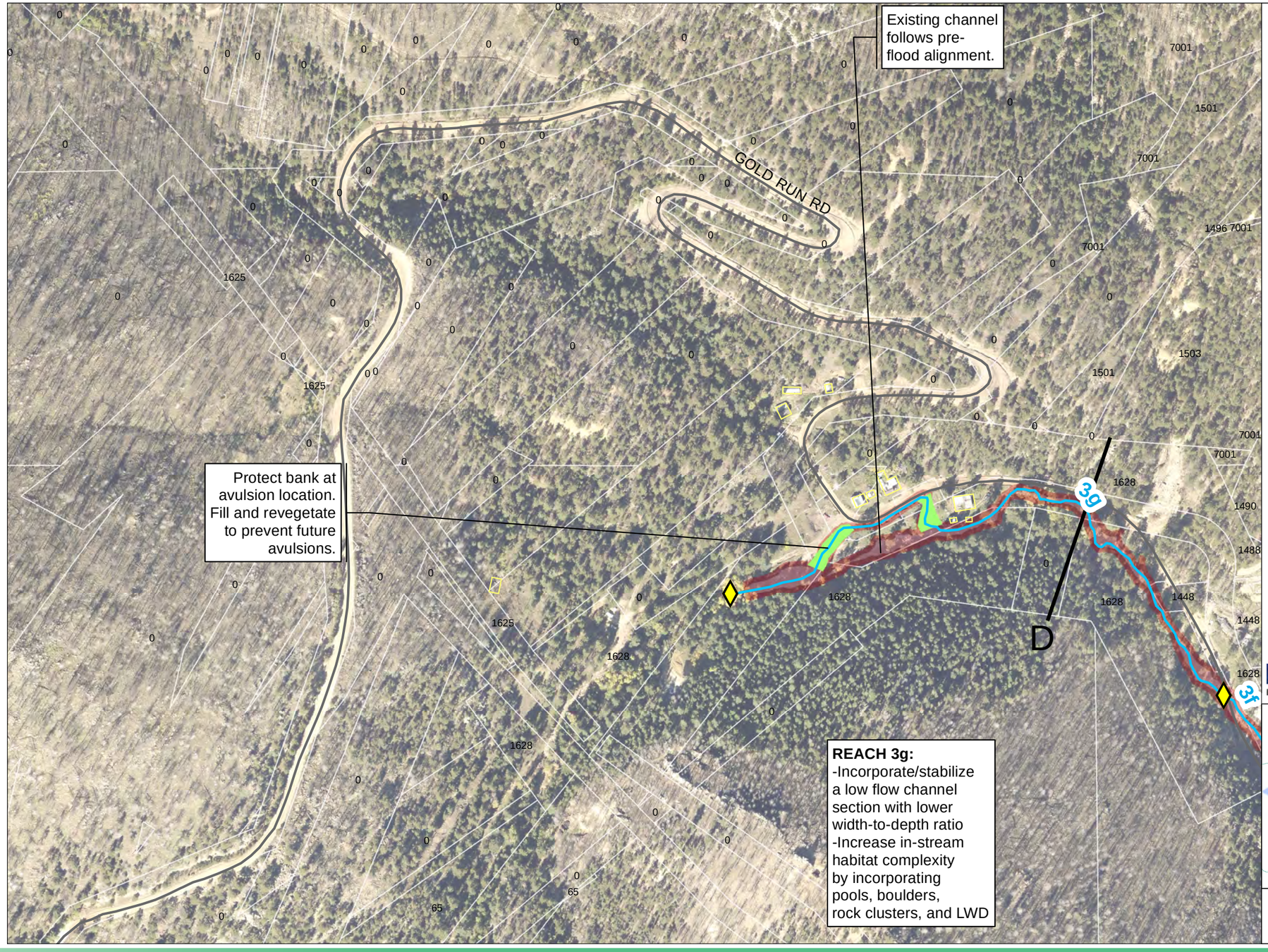

FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 3

MAP 5 OF 5

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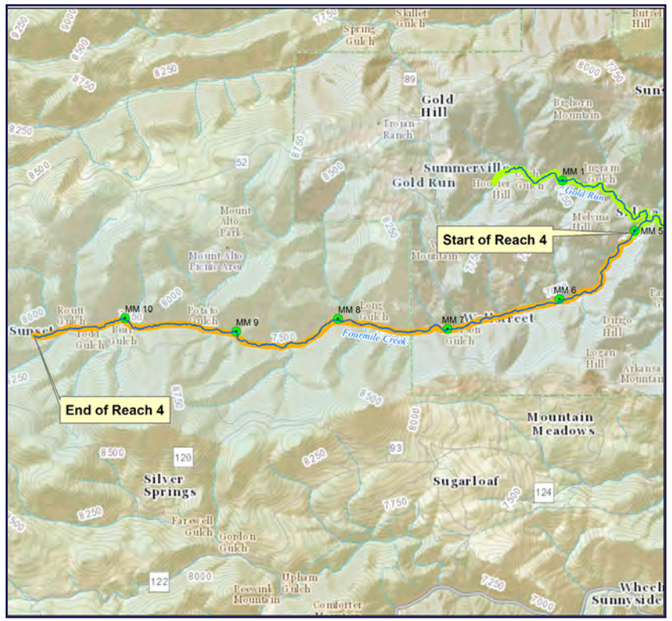
FOURMILE CREEK ALTERNATIVES

11. REACH 4

11.1 Overview

Reach 4 includes Fourmile Creek. It begins at Mile Marker 5 on Fourmile Canyon Drive and goes upstream to Sunset. Reach 4 is steep, but less steep than the other reaches with slopes of the creek generally ranging from 1% to 4%. The creek and floodplain in this reach is less constrained than Reach 1 or Reach 3. This reach of the creek experienced a wide range of damages including channel migration, bank erosion, sediment deposition, and flooding damages to structures and infrastructure, although the damages were not as severe as Reach 3. A significant amount of private crossings of Fourmile Creek were damaged or destroyed in this reach.



11.2 Assessment

The results of the ecological assessment show that this reach is generally in "Good" condition, with the exception of the very downstream sub-reach which received a "Fair" rating. Overall ecological assessment scores ranged from 6.3 – 8.2 out of 10 with the upper sub-reaches all above 7. The upper reaches of Fourmile Creek are generally less constrained and have good vegetative diversity. Additionally there are minimal barriers to movement and good channel pool formation for most of this reach.

The results of the geomorphic assessment for this reach show that Fourmile Creek consists of a cobble-bed system with low to moderate sinuosity that flows to the northeast in a narrow alluvial valley. Although the valley floor is still narrow in this reach, it is nearly twice as wide as in the lower reaches. Development generally exists adjacent to the right bank of the reach and Fourmile Canyon Drive is adjacent to the left bank. Portions of development and Fourmile Canyon Road are within the 100-year floodplain and are restricting lateral channel movement. The channel is stable or stabilizing for over half of the reach length, and widening in the remaining sections. There are small portions of this reach that have degraded to the point where the floodplain is entrenched, and is resulting in local channel instability. The existing bed form consists of riffle-pool and step-pool sequences; however, some of these features have been damaged or washed out as a result of recent flooding. The results of the erosion and deposition mapping show moderate deposition and erosion areas up to Mile Marker 8.

The results of the flood risk assessment of this reach show that there are private residences at risk during larger flood events; however, the number of structures is less than Reach 1 or Reach 3 because of the lower density of development in this reach. In most locations the post-flood sediment deposition and channel migration did not significantly increase the flood risk to structures or infrastructure. The maps in this section show the results of the updated flood risk analysis for Fourmile Creek based on the current regulatory (FEMA). The results of the updated flood risk analysis based on both the regulatory (FEMA) discharges and CWCB/CDOT discharges is presented in Appendix D.

11.3 Roadway Improvements

Four Mile Canyon Drive from Salina to Sunset is approximately 5 miles with small sections of a paved surface, but predominantly non-paved, gravel surface beginning in the vicinity of Mile Marker 7. The roadway width is highly variable depending on location of the 5 mile stretch, but in general the roadway width is approximately 18-foot wide. A project to recommend roadway improvements from Salina Junction to Sunset has commenced, however, the design of the roadway improvements has not started. The roadway width will be evaluated as part of roadway and drainage design to balance cross section with special constraints such as private property, topography, and vegetation. The design will also include an updated analysis on tributary cross culverts. This reach of Fourmile Creek is generally less constrained, and the roadway footprint is narrower. As a result, the anticipated impact of the roadway improvements on Fourmile Creek in this reach is minimal.

11.4 Planning Recommendations

Reach 4 in general has a lower level of flood risk and fair to good ecological score. As such, minimal work is being recommended for the Reach 4. However, the Reach did experience areas of bank erosion, sediment deposition/aggradation, destruction or damage to the transportation infrastructure, damage to residential structures and private crossings, and damage to the riparian corridor. The plan does not recommend major channel realignment, preferring to keep the channel in the post-flood location in most of the reach. The recommendation not to realign the channel is based on assessment of the stability of the current channel location, the post-flood alignment does not increase the risk to private residences or public infrastructure and the cost to realign the channel would not provide additional benefits.

Some of the priorities identified by stakeholders in this reach included: Help with property access and private crossings, the long-term health of trees along the riparian corridor, re-vegetation of the riparian corridor, and the desire for improvements to maintain a natural look.

The recommended plan for Reach 4 is included on Reach 4 maps 1 through 12. The recommended plan includes the following projects:

» Incorporating and stabilizing a low flow channel section in various sub-reaches with the following design parameters:

Design Parameter	Range or Average
Low Flow Channel Top Width	20 ft - 40 ft
Low Flow Channel Top Width-to-Depth Ratio	Avg. 33
Sinuosity	Avg. 1.2
Slope	0.025 ft/ft - 0.040 ft/ft

» Increasing in-stream habitat complexity by incorporating pools, boulders, rock clusters, and large woody debris throughout the reach in various sub-reaches.

» Re-vegetating the riparian corridor with native species where vegetation has been stripped by the flood in various sub-reaches.

» Site-specific bank protection to protect residential structures and transportation infrastructure in areas where the banks are currently unstable, current protection is inconsistent, or temporary measures were employed to protect the banks.

- » Removal of sediment aggradation from the channel near Mile Marker 5.1 to increase channel capacity.
- » Removal of sediment aggradation from the channel near Mile Marker 5.8 to reduce the flood risk to residential structure that was increase because of the flood.
- » Re-vegetating a large area of the floodplain near Mile Marker 6. This is a location where the channel migrated and a significant amount of sediment was deposited in the pre-flood channel. The plan does not recommend relocation the channel to its pre-flood location because it does not create an increased risk in its post-flood location. Rather, maintaining the current post-flood channel location and re-vegetating the deposition area.
- » Removing sediment (cut) and re-vegetating a large area of floodplain near Mile Marker 6.3. This is location where the channel migrated and a significant amount of sediment was deposited in the pre-flood channel. The plan does not recommend relocation the channel to its pre-flood location because it does not create an increased risk in its post-flood location. Rather, maintaining the current post-flood channel location, removing sediment to restore floodplain capacity, and re-vegetating the deposition area.
- » Removing an unstable temporary berm that was constructed adjacent to the channel near Mile Marker 7.2 and protecting the road embankment.
- » Removing a debris jam in a high avulsion risk area near Mile Marker 7.7 and stabilizing the channel and floodplain.

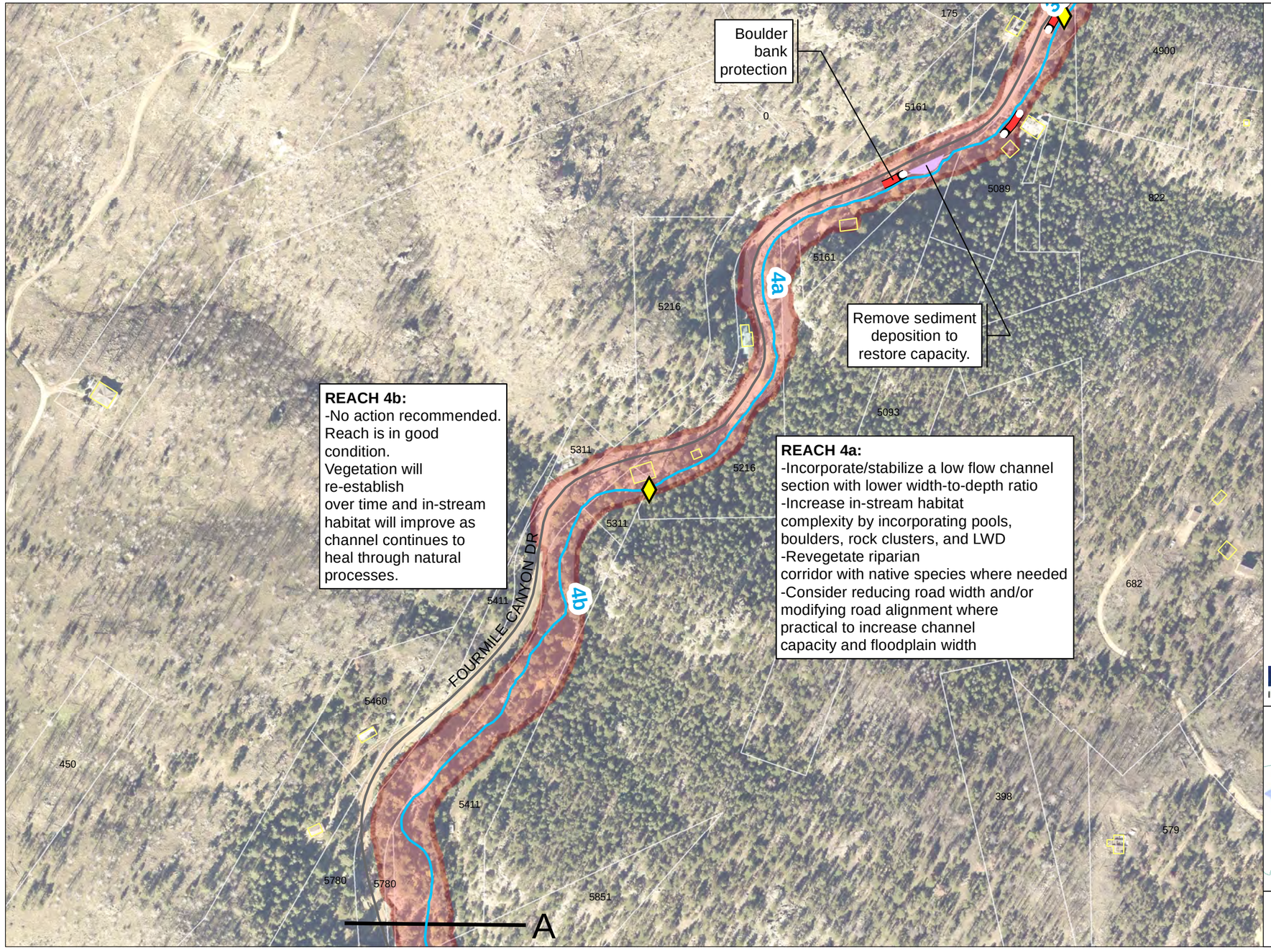
The recommended projects in this plan integrate designs for sustainable stream restoration design and construction with the roadway reconstruction. As a result of the physical constraints of the canyon in this reach, restoring a meandering pattern to dissipate stream energies is generally not be practical. Therefore, the recommendations include incorporating and stabilizing a low flow channel, increasing in-stream habitat complexity, and site specific bank protection. The bank protection and habitat complexity features help to provide lateral stability and grade control. The incorporation of a low flow channel section decreases the stress placed on banks by decreasing flow velocities and depth for a given discharge. Beyond helping to stabilize the channel, this approach can also increases the cross-sectional area of the overall channel, decreasing the water surface profile during larger storm events as compared to the current condition.

Table 11.1 Estimated Costs for Reach 4

Reach 4 - MM 5 and Sunset	QTY	UNIT	UNIT COST	COST
Low Flow Channel Restoration	14,350	LF	$350	$5,022,500
Fill & Revegetate	0	SF	$4	$0
Revegetate	1.3	Acre	$20,000	$26,000
Excavation	6,200	CY	$10	$62,000
Bank Protection - Boulder	2,420	LF	$275	$665,500
Bank Protection - Root Wad	0	LF	$165	$0
Debris Rack	0	LS	$30,000	$0
Flood Wall	0	SF	$250	$0
Channel Realignment	0	LF	$350	$0
			Subtotal:	**$5,776,000**
Engineering	15%			$866,400
Legal/Administrative	5%			$288,800
Contract Admin/Construction Management	10%			$577,600
Contingency	25%			$1,444,000
			Total:	**$8,952,800**

11.5 Estimated Cost of Unmet Needs

Estimated costs for unmet needs were prepared to capture the capital that could be required to implement plan recommendations. These estimated costs do not include projects that are currently being completed or that are programmed. The estimated costs for unmet needs in this reach are provided in Table 11.1.



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 1 OF 12

LEGEND

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0 Feet 200

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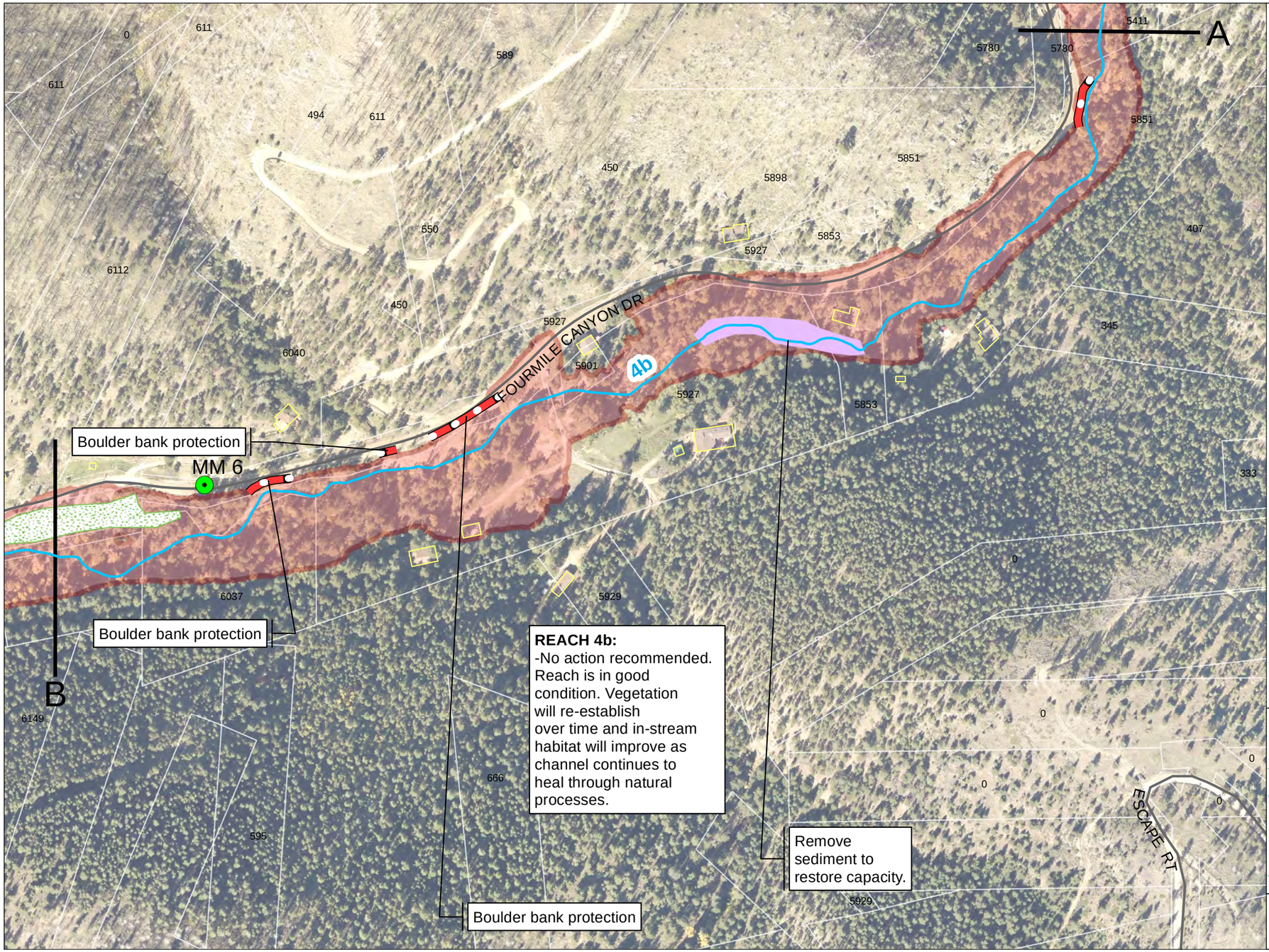
LOCATOR MAP

FOURMILE CREEK ALTERNATIVES



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 2 OF 12

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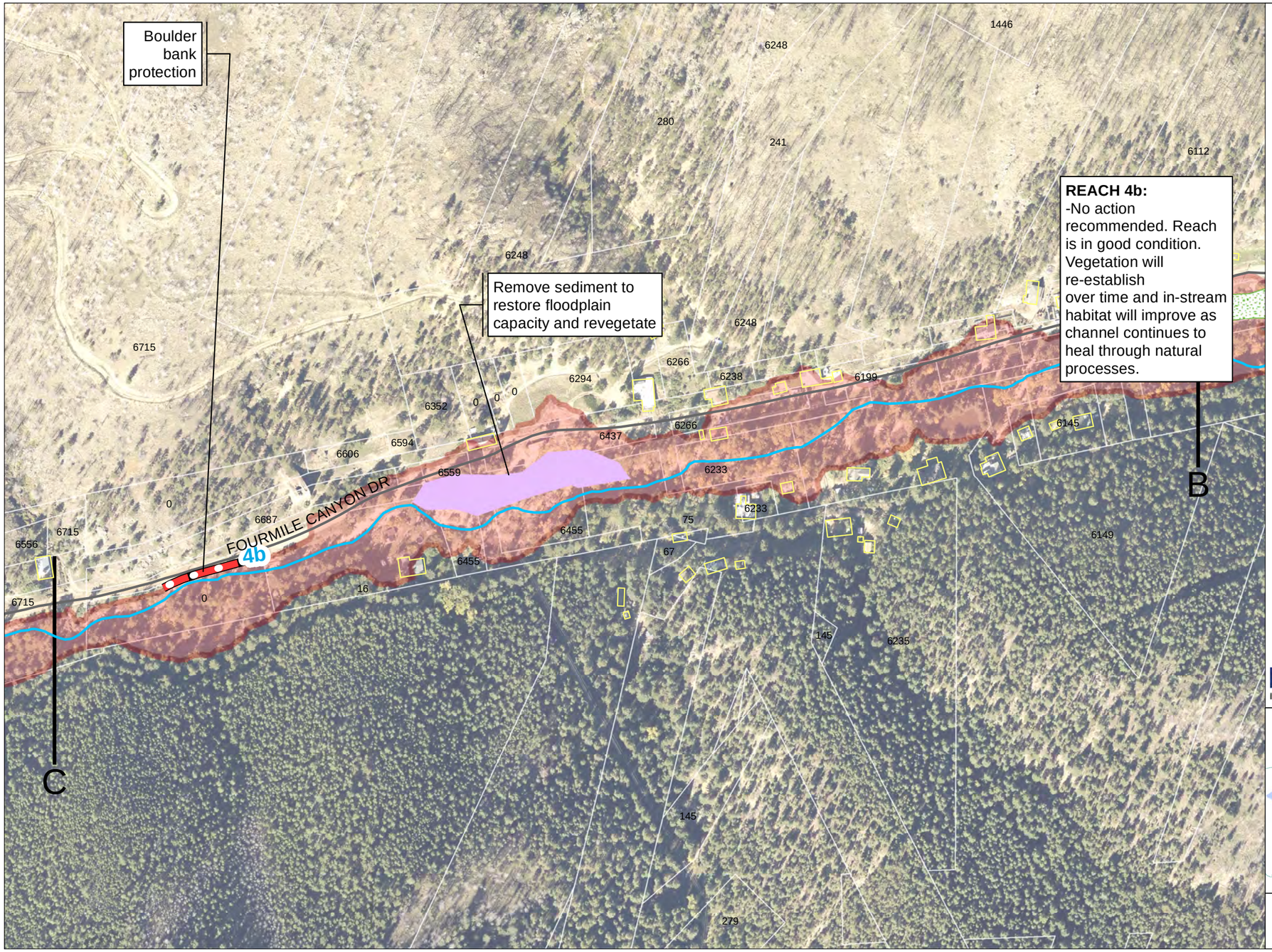
FOURMILE CREEK ALTERNATIVES



FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 3 OF 12

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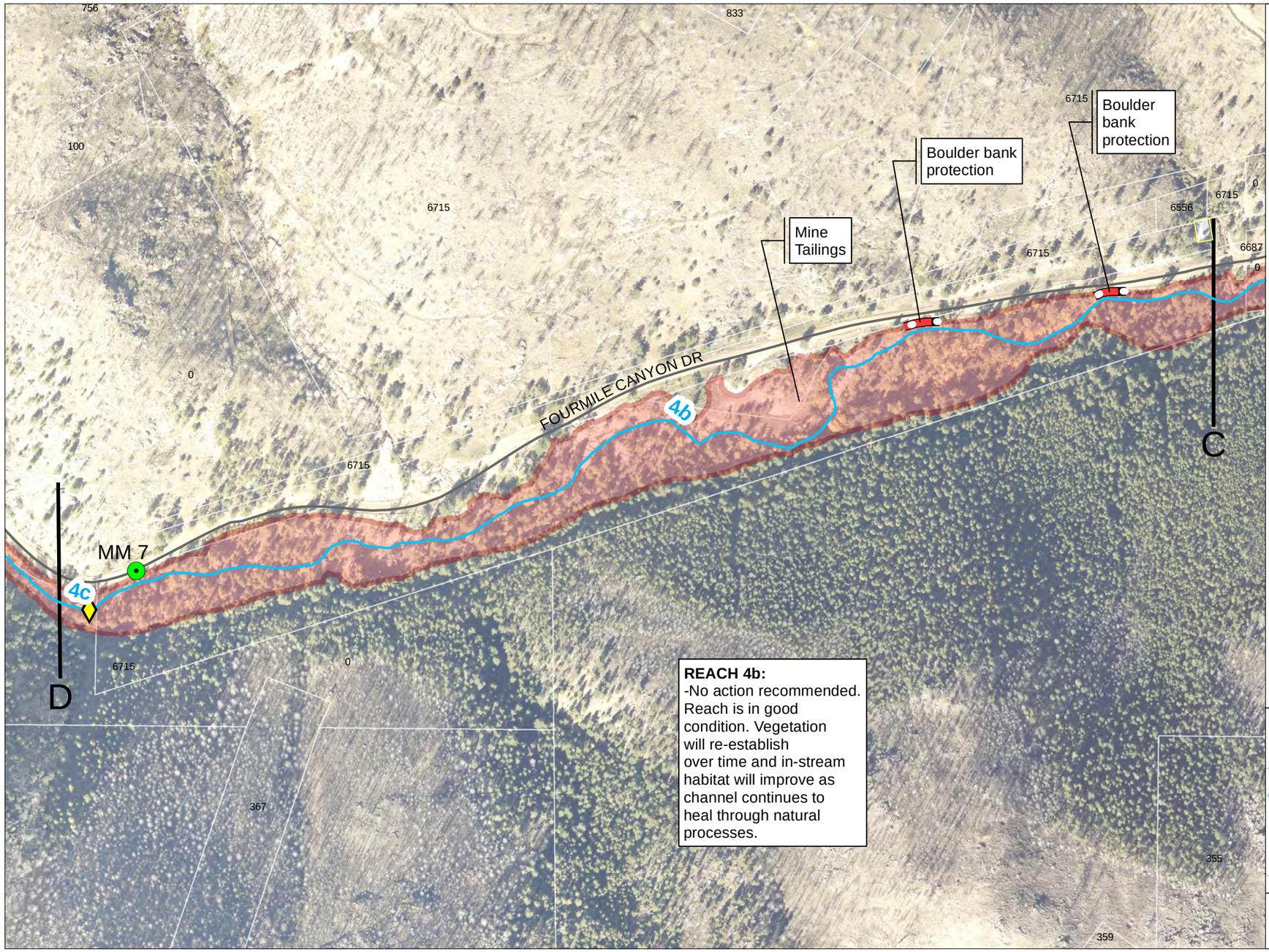

FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 4 OF 12

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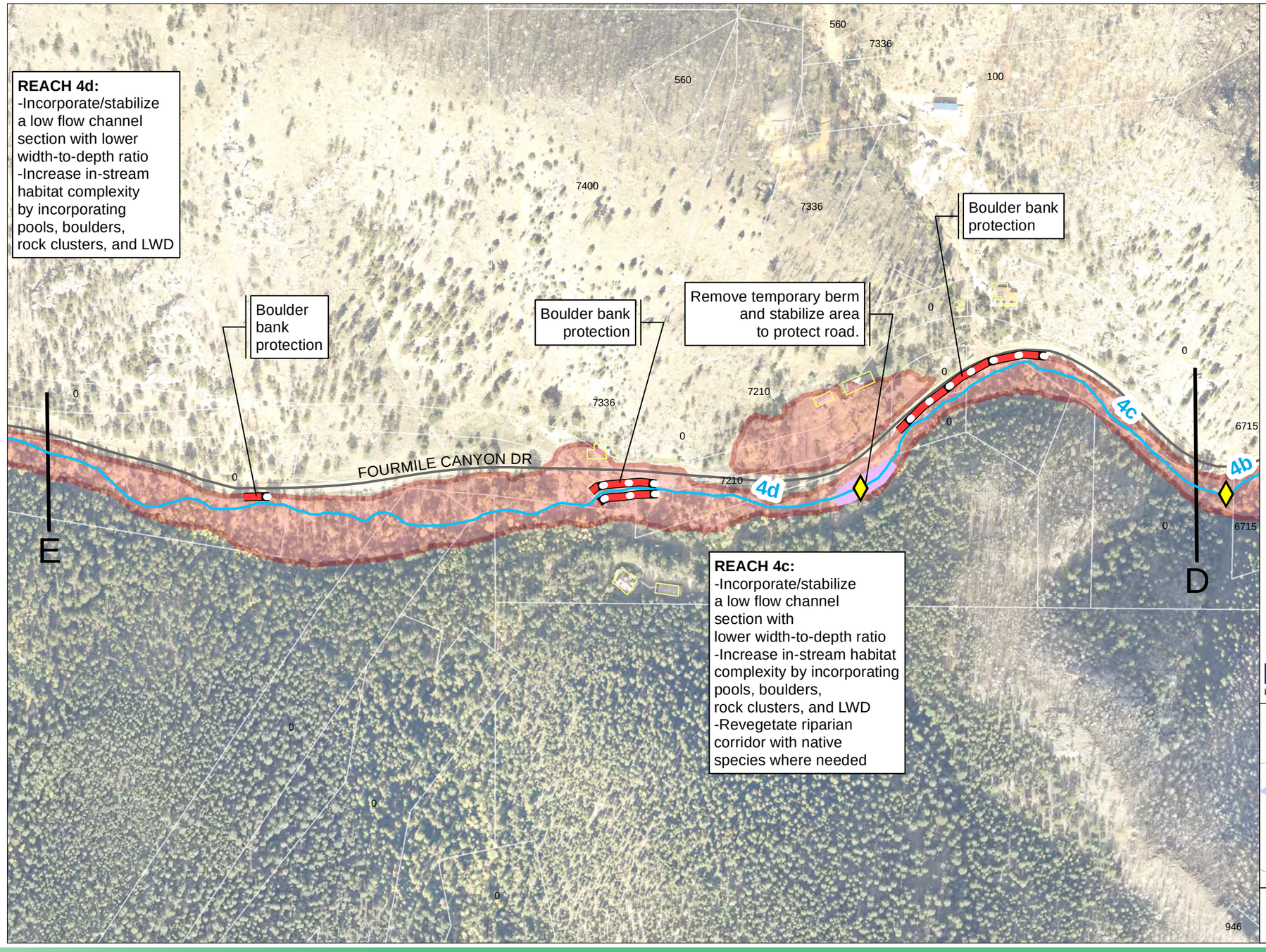

FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 5 OF 12

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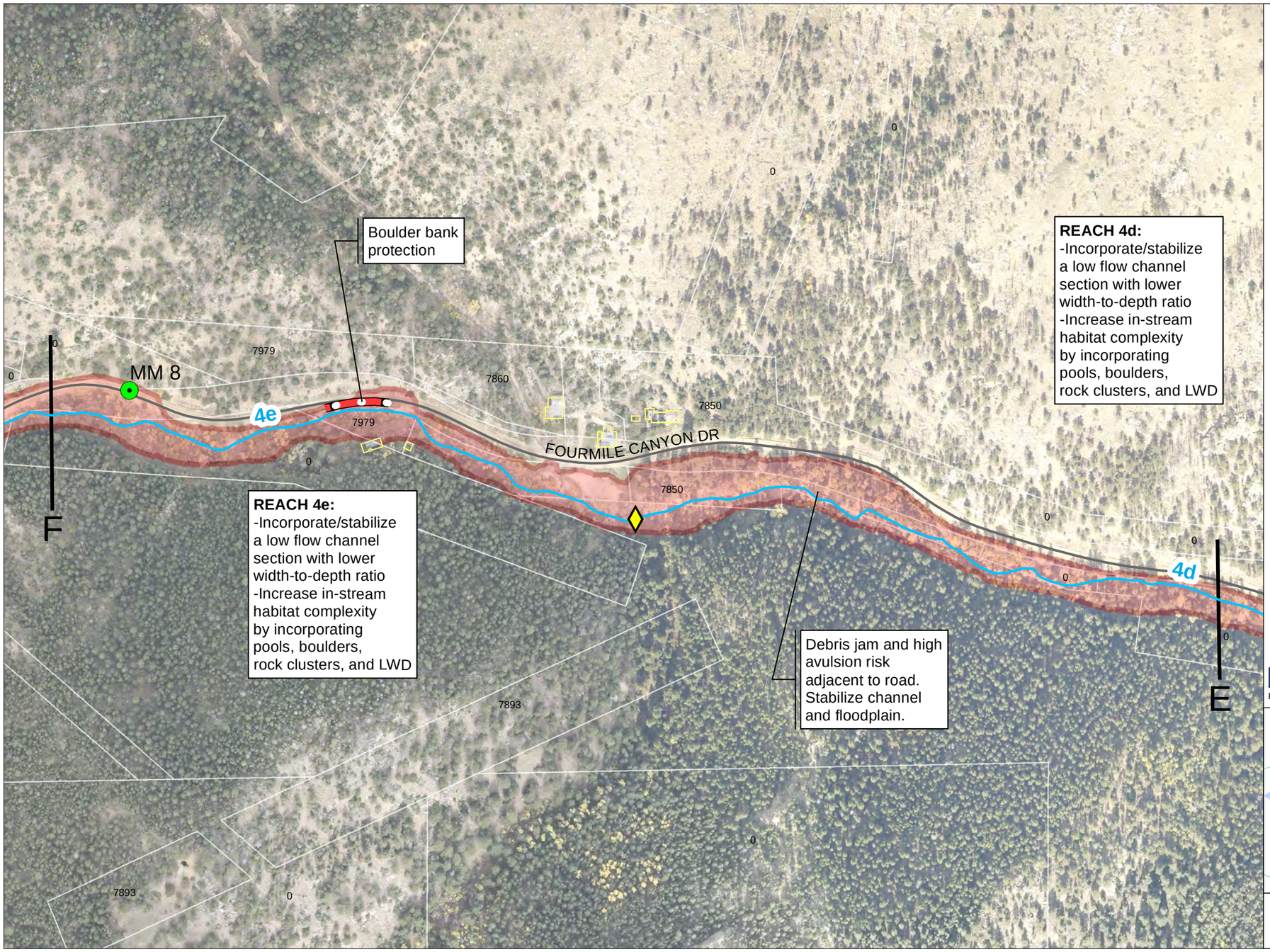

FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 6 OF 12

LEGEND

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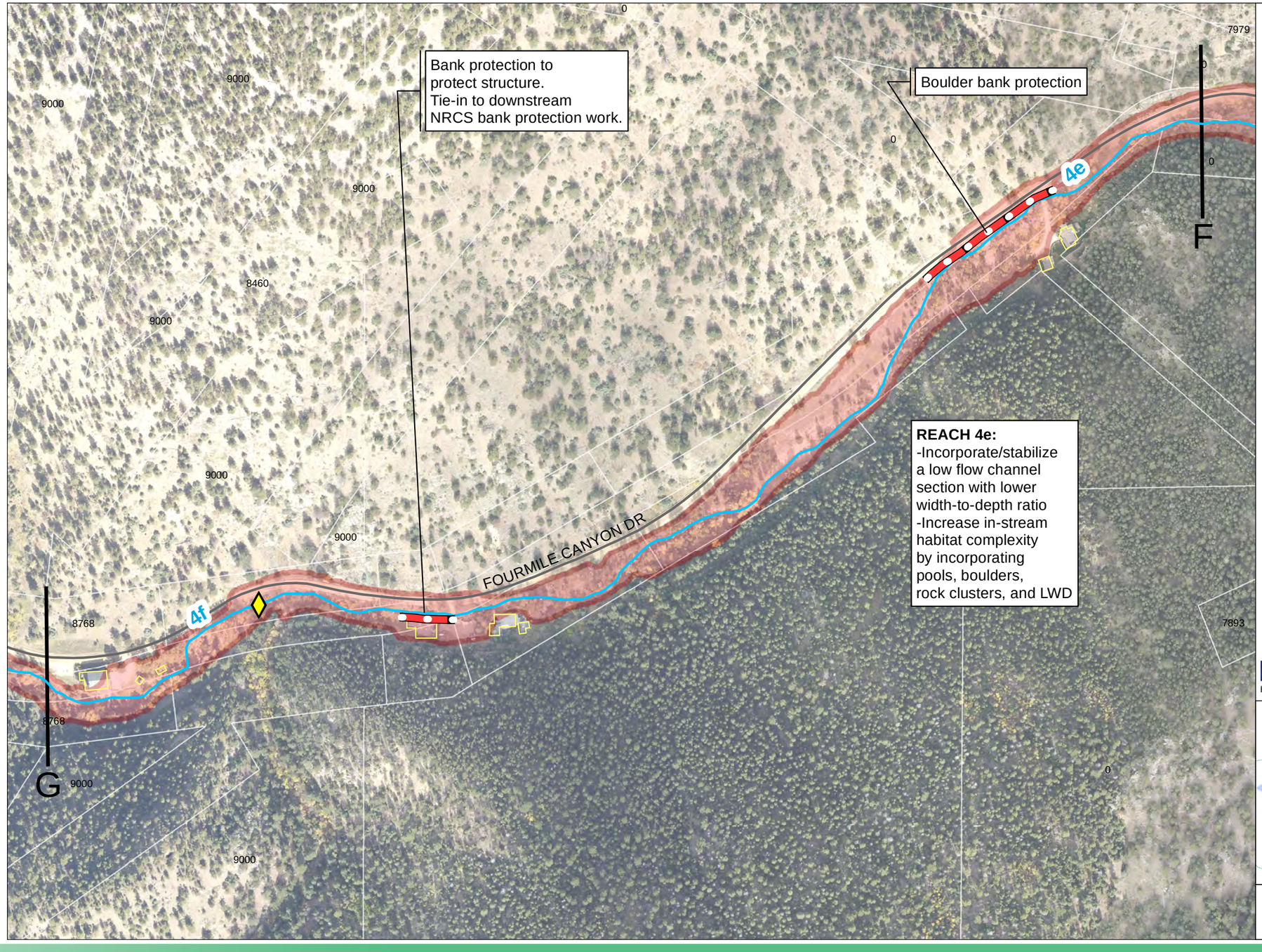

FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 7 OF 12

LEGEND

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LOCATOR MAP

FOURMILE CREEK ALTERNATIVES

FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 8 OF 12

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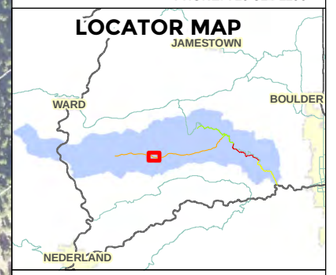

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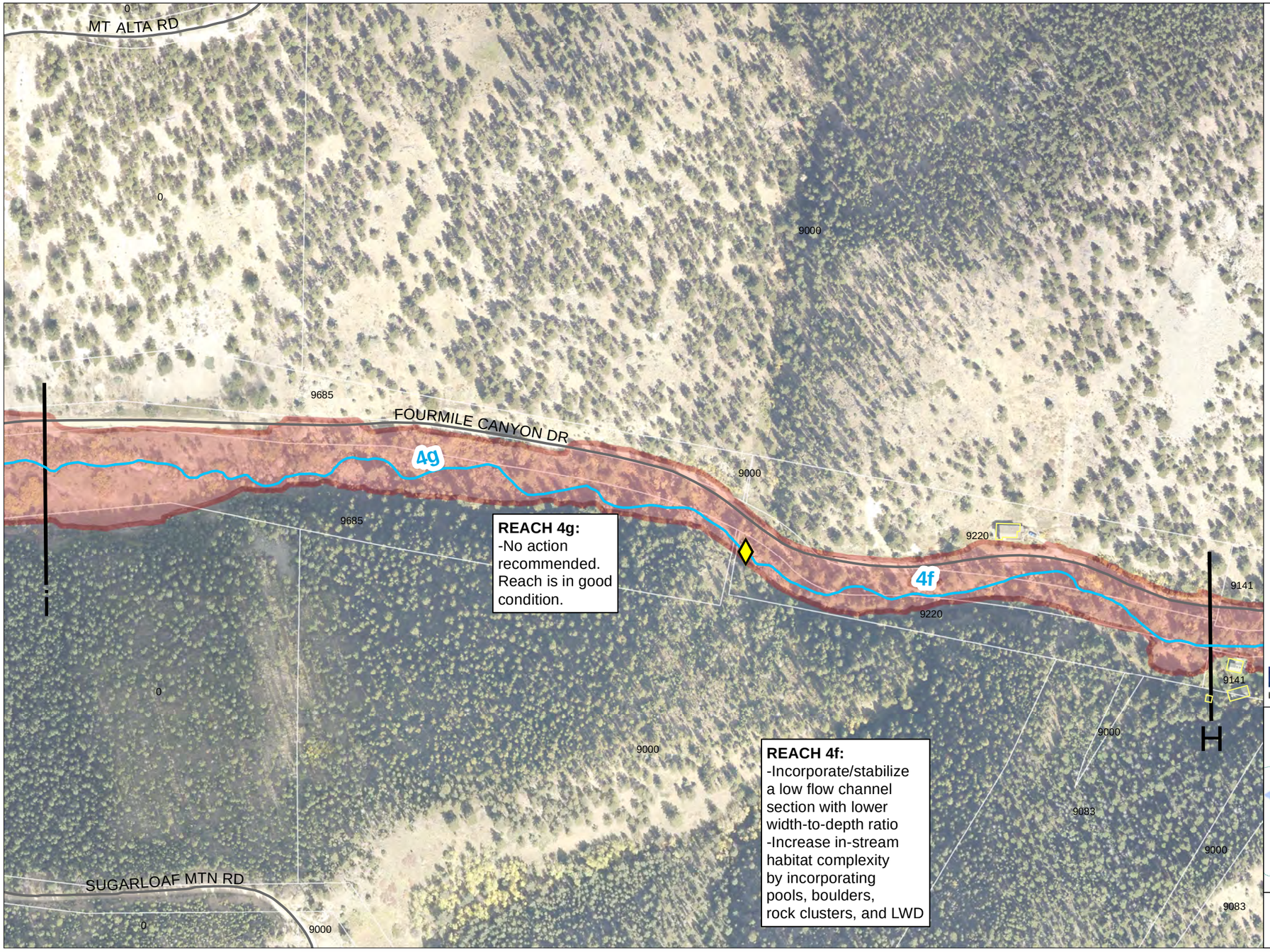

FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 9 OF 12

LEGEND

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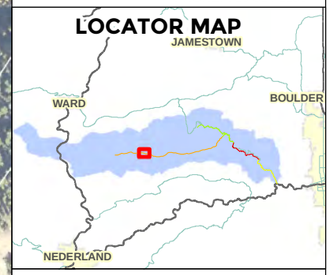

FOURMILE CREEK ALTERNATIVES

FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 10 OF 12

LEGEND

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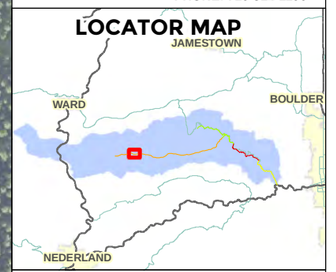

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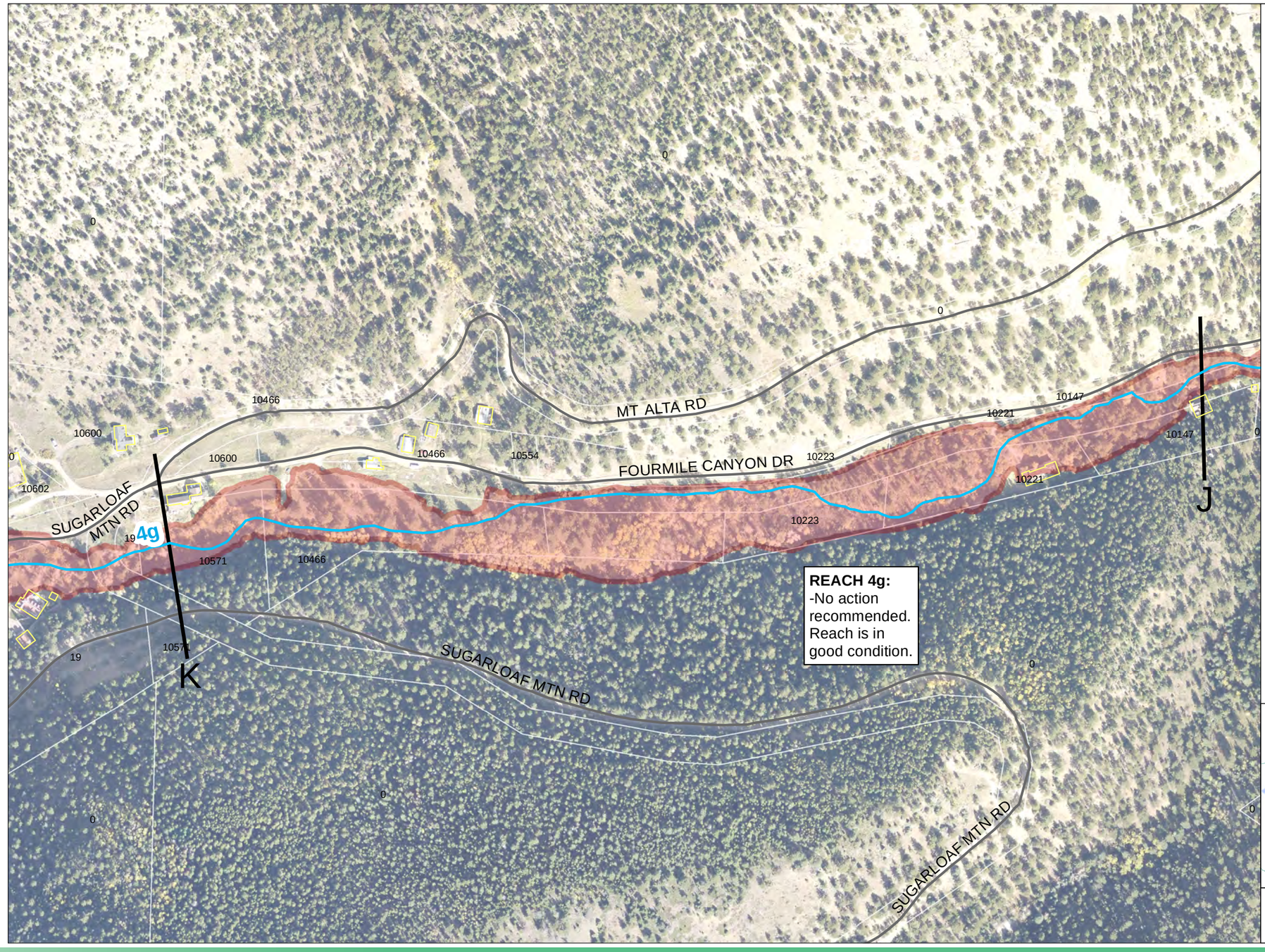

FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 11 OF 12

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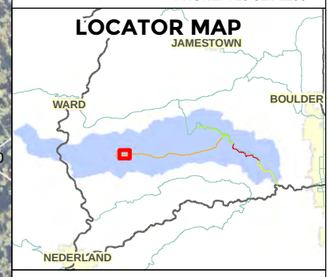

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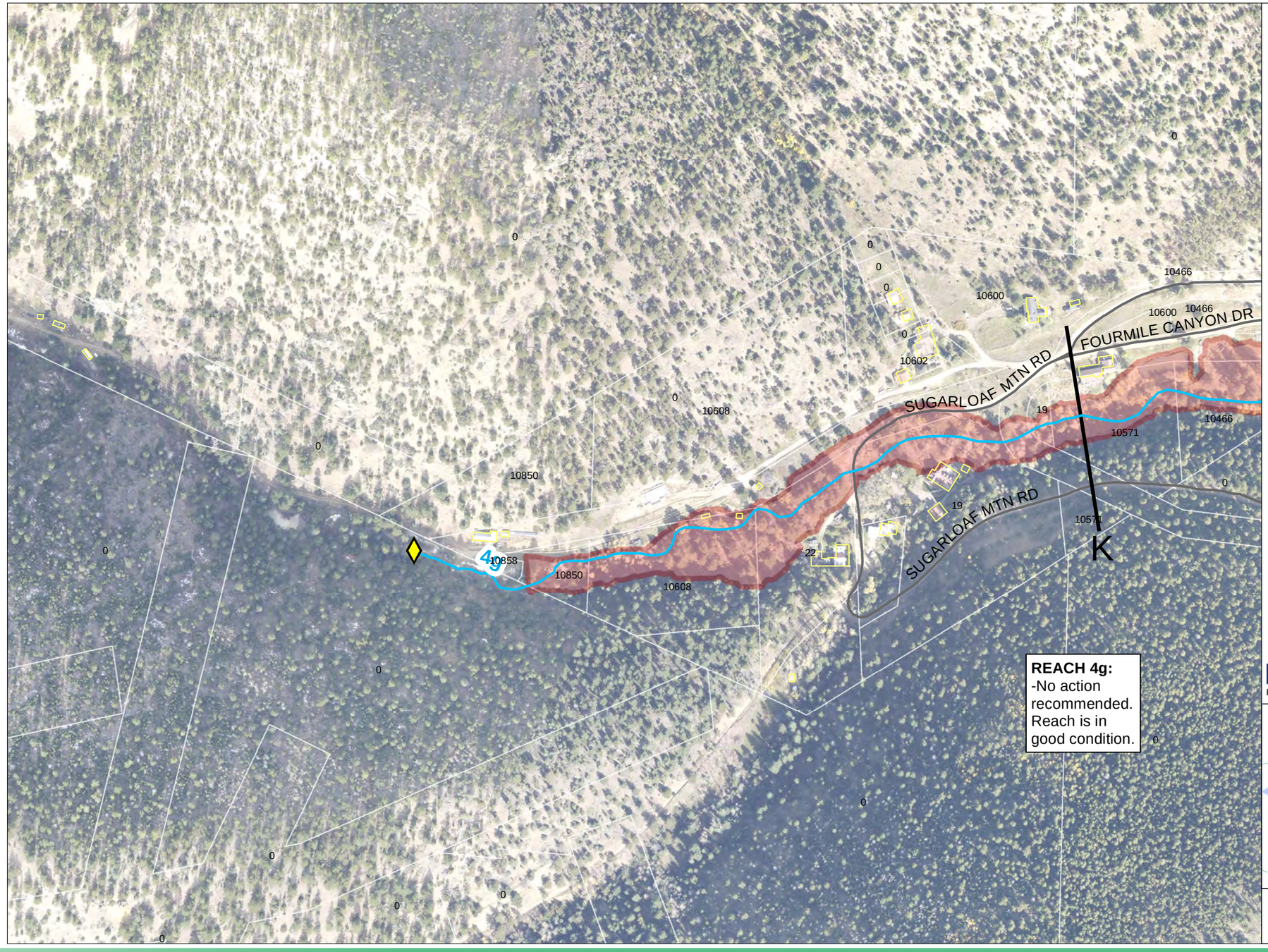

FOURMILE CREEK WATERSHED DRAFT RECOMMENDATIONS

REACH 4

MAP 12 OF 12

LEGEND

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LOCATOR MAP

FOURMILE CREEK ALTERNATIVES

12. PRIORITIZATION AND IMPLEMENTATION

The Fourmile Creek Watershed Master Plan is a guidance document for property owners, agencies, and stakeholders within the watershed while they repair, develop, and redevelop property and infrastructure within the creek corridor. Its development is the first step in the process of collaborative project development, community engagement, and long-term resilience building. As a "living" flood-recovery guide, this plan will come to life as the recommended projects are implemented over time. Projects recommended by the Master Plan could be completed by individual property owners, groups of neighbors or in cooperation with the County or other agencies or by a possible watershed coalition. Some projects may be eligible for grant funding and others may need to be privately funded.

The following sections offer guidance for managing the logistical details associated with plan implementation. They include floodplain management and development mechanisms, permitting considerations, probable costs and funding.

12.1 Prioritization and Phasing of Projects

12.1A Project Priorities

Prioritization and thoughtful phasing of the projects shown in this plan will be vital to successful implementation. As changes in the watershed occur, either as recommended improvements are implemented or as development progresses, the balance between water and sediment will shift in response. A coordinated, proactive approach to implementation will reduce the likelihood of channel improvements in one area adversely affecting neighboring areas. With this in mind, three priority levels have been identified for the implementation of recommendations shown in the conceptual design. While this provides guidance to prioritize implementation of projects, actual sequencing of projects will occur taking into account the necessary balance between current risk, available funding, and local support.

Tier 1 - Projects reducing flood risk to life, property, and infrastructure due to post-flood conditions

- Reach 1 – Remove sediment aggredation from the channel near Mile Marker 1.1
- Reach 1 – Fourmile Creek restoration project (existing CWCB Grant)
- Reach 3 – Assess the stability of existing walls and modify if necessary
- Reach 3 – Fill and revegetate avulsion areas
- Reach 3 – Install debris racks and stabilize the banks of Ingram Gulch
- Reach 4 – Remove sediment aggredation from the channel and floodplain near Mile Markers 5.1, 5.8, and 6.3
- Reach 4 – Remove a debris jam in a high avulsion risk area near Mile Marker 7.7

Tier 2 - Projects that improve stream stability and promote ecological recovery

- All Reaches – Low flow channel restoration
- All Reaches – Increase in-stream habitat
- All Reaches – Revegetate
- Reaches 1, 3, and 4 – Bank Protection
- Reach 3 – Relocate Fourmile Creek downstream of Salina Junction
- Reach 4 – Remove a temporary berm near Mile Marker 7.2 and bank protection

Tier 3 - Projects that affect areas with low risk to infrastructure

- Reach 2 – Fill the pre-flood channel to reduce avulsion risk

12.1B Phasing

General phasing of projects should occur from upstream to downstream within each reach. As projects are implemented, detailed analysis of both upstream and downstream impacts should be considered in all cases to ensure no adverse impacts. However, due to the unique flood recovery aspect of this master plan, projects will occur based on timing of funding and resource availability. It's recommended the following guidance be applied as projects are implemented:

- Roadway and stream project integration – Integrating the roadway improvements with stream projects identified in this report has already occurred for the stream restoration reach just downstream of Poorman Rd (CWCB Grant project). Efficiencies can be realized in other areas by continuing to integrate the roadway improvements with projects identified in this plan such as the site specific bank protection. Additionally, the restoration of Gold Run should occur in close coordination with the planned roadway improvements to try to identify opportunities to increase the significantly limited channel capacity where possible.
- Fourmile Creek relocation at Salina Junction - The relocation of Fourmile Creek at Salina Junction should not be performed until the EPA project to remove and cap the mine yailings pile at Salina Junction has been completed. The final alignment of the creek and road in this reach is dependent on how much of the mine tailings pile is removed by the EPA.
- Bridge Improvements - Coordinate crossing configuration, capacity, and timing of construction with channel restoration aspects.

12.2 Floodplain Management

The National Flood Insurance Program (NFIP) is based on a cooperative agreement between the community and FEMA. FEMA can only make flood insurance available in those communities that agree to regulate future development in the floodplain. Participation in the NFIP is voluntary. There is no Federal law that requires a community to join, although some states have requirements. However, a nonparticipating community faces sanctions, such as loss of Federal aid for insurable buildings in the floodplain. These make participation a very important decision for many communities.

To join, a community must adopt a resolution of intent to participate and cooperate with FEMA. The community agrees to "maintain in force…adequate land use and control measures consistent with the [NFIP] criteria" and to:

- Assist the Administrator in the delineation of the floodplain,
- Provide information concerning present uses and occupancy of the floodplain,
- Maintain for public inspection and furnish upon request, for the determination of applicable flood insurance risk premium rates within all areas having special flood hazards, elevation and floodproofing records on new construction,
- Cooperate with agencies and firms which undertake to study, survey, map, and identify flood plain areas, and cooperate with neighboring communities with respect to the management of adjoining flood plain areas in order to prevent aggravation of existing hazards;
- Notify the Administrator whenever the boundaries of the community have been modified by annexation or the community has otherwise assumed or no longer has authority to adopt and enforce flood plain management regulations for a particular area.

The community must also adopt and submit a floodplain management ordinance that meets or exceeds the minimum NFIP criteria. Boulder County is a participating community in the NFIP. The NFIP requirements can be found in Chapter 44 of the Code of Federal Regulations (44 CFR). In addition, Boulder County has an effective Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRM) (dated December 18, 2012).

Due to the highly erosive nature of the September 2013 flood, many of the mapped regulatory flood hazards shown on effective FIRMs no longer reflect existing conditions. In response to the challenges this poses to NFIP communities trying to enforce their ordinances in the flood recovery phase, the CWCB issued a memo to FEMA Region VIII dated September 21, 2014 providing guidance to deal with the unique challenges (memo located in Appendix H). Application of this memo by Boulder County is critical to ensure compliance during the implementation of the projects outlined in this report.

12.3 Permitting

There are a number of regulatory compliance and permitting considerations that are important to the implementation of the Fourmile Creek Master Plan. Permits are required for stream restoration projects both big and small, and infrastructure projects both public and private. The following section lists the potential permits and regulations that may be required for the alternatives recommended in this plan. When it is time to implement local projects, detailed analysis will be required in order to define specific permit requirements and necessary compliance measures.

12.3A The Clean Water Act - Section 404

Section 404 of the Clean Water Act establishes a permitting process that regulates the discharge of dredged or fill material into waterways in the U.S. The term "waterways" includes rivers, lakes, streams and most wetlands.

When landowners apply for a permit, they must show that they have taken steps to avoid wetland/stream impacts; minimized potential impacts to wetlands/streams; provided compensation for any remaining, unavoidable impacts; engaged in thorough activities to restore or create wetlands/streams. Boulder County requires submission of a 404 permit response from U.S. Army Corps of Engineers (USACE) indicating that the project is either permitted or exempt before they will issue a Floodplain Development Permit.

There are some exempt activities under Section 404 that pertain specifically to normal farming and harvesting activities that are part of established, ongoing farming and forestry operations. Exempt activities include, but are not limited to:

- Plowing, seeding, and cultivating
- Minor drainage
- Upland soil and water conservation practices
- Maintenance (but not construction) of drainage ditches
- Construction and maintenance of irrigation ditches, farm or stock ponds, and farm and forest roads, in accordance with best management practices
- Maintenance of structures, such as dams, dikes, and levees

When projects constitute a new use of a wetland or waterway, and the activity would result in a reduction or impairment of flow (or disruption of the circulation of regulated waters) the activity is not exempt from Section 404 permitting requirements. Regulated activities include fill for development, water resource projects (including dams and levees), infrastructure development (i.e. highways and airports), and conversion of wetlands to uplands for farming and forestry.

Boulder County and the USACE will defer to the United States Fish and Wildlife Service (USFWS) to ensure that proposed projects are in compliance with the Endangered Species Act (ESA).

12.3B County Requirements

If you are a property owner of a destroyed or severely damaged property and wish to repair or rebuild, please contact the Flood Rebuilding and Permitting Information Center at 303-441-1705 or floodrecovery@bouldercounty.org to determine which review process and permits apply to your situation. You may also contact the Boulder County Land Use Department for County permitting questions 303-441-3930 or planner@bouldercounty.org. You can search on the county's website for more information on any of the following types of reviews or permits at www.bouldercounty.org.

The most common County review processes include:

Hazard Mitigation Review (HMR)

The Board of County Commissioners adopted interim rules for repairing or rebuilding homes that were destroyed or severely damaged in the aftermath of the flooding and mudslides that occurred during the September 2013 flood and also for grading of 50-500 cubic yards and/or whenever a floodplain development permit is required. The purpose of the interim regulations is to guide the rebuilding of severely damaged or destroyed structures in a safe manner and they allow property owners to restore and rebuild structures at the same size or smaller and at a safer location, as determined by a Hazard Mitigation Review planning process. The regulations allow flexibility for damaged structures to be rebuilt in different locations if the new location significantly reduces flood risk. That said, the new structures must comply with the County's existing Floodplain Development regulations. Hazard Mitigation Review (HMR) is outlined in Article 19-300 of the Boulder County Land Use Code.

Site Plan Review (4-800)

For projects that aren't eligible for the HMR process, Site Plan Review (SPR) may be required. SPR, outlined in Article 4-800 of the Boulder County Land Use Code, is a review process required in order to issue a variety of residential or nonresidential building permits. Examples of projects include:

- Any development requiring a building permit on vacant parcels
- Cumulative increases in floor area of more than 1,000 sq ft over that which existed on the parcel as of September 8, 1998
- Cumulative increases in residential floor area which results in a total residential floor area of more than 125% of the median residential floor area for the defined neighborhood in which the parcel is located
- Changes in use unless the change in use is to a residential use
- Certain grading projects
- Projects requiring a floodplain development permit

Grading Permit

A grading permit is required for grading, excavation, or placement of fill in excess of 50 cubic yards. A Site Plan Review, Limited Impact Special Review or Hazard Mitigation Review may also be needed for project approval. Grading Permits are reviewed by the Land Use Department, the Transportation Department, and the Building Inspection Division.

Stormwater Quality Management Permit (Land Use Code Article 7-904)

The purpose of Article 7-904 is to protect and enhance the water quality of Boulder County's (and Colorado's) waters. The Stormwater Quality Management permitting process also supports compliance with the Clean Water Act, the Colorado Water Quality Control Act – including the state Water Quality Control Division's (WQCD) Colorado Discharge Permit System (CDPS) Stormwater Management Program – and other related County water quality and land use authority. Ultimately, these efforts protect the health, safety, and welfare of Boulder County citizens by controlling the discharge of construction and development-generated stormwater.

A Stormwater Quality Management Permit (administered by the County Engineer) is required for construction activity that results in one or more acres of disturbed area (or possibly a smaller area if near a watercourse or if it is part of a larger development proposal.) In addition to the requirements of the Stormwater Quality Management Permit, stormwater quality and discharge of pollutants into the municipal separate storm sewer system are subject to regulation under Boulder County Public Health's Ordinance 2012-4 "An Ordinance Concerning Illicit Discharge and Stormwater Quality."

Floodplain Development Permit

A floodplain development permit is required for all development within the Floodplain Overlay District and must be obtained from the Transportation Department before the start of construction and prior to obtaining a building permit. Projects that may require a Floodplain Development Permit include:

- New construction
- Paving and excavation
- Drilling, driving of piles, and dredging
- Land clearing/grading
- Modifications, improvements and repairs to homes and other buildings

» Permanent storage for equipment and materials

All development and proposed improvements within the floodplain are required to conform to Article 4-400 Floodplain Overlay District of the Boulder County Land Use Code. Minor work and routine maintenance to homes and structures may be exempt from obtaining a Floodplain Development Permit. The County Floodplain Administrator can clarify permitting requirements and provide more information about code specifications applicable to specific projects.

Flood Recovery, Restoration, and Repair Permit

The 2013 Flood Recovery, Restoration and Repair Permit is for flood repairs and restoration of flood-damaged (not destroyed or severely damaged) buildings to pre-flood configuration. Eligible (flood-damaged) components include replacement of drywall and insulation, doors, windows, siding, roof recovering, replacement of furnaces, boilers, water heaters, electrical wiring and equipment, gas piping, and plumbing. Remodeling and finishing of basements are not included.

Private Access Permitting

The September 2013 flood damaged or destroyed many private water crossings (bridges and culverts). After the flood, Boulder County began issuing Flood Recovery Access Permits (FRAP). FRAPs are permits which allow owners to construct a temporary access to their property where it is feasible and safe. Eventually, all accesses constructed with or without a FRAP will need to obtain a permanent permit for the post-flood crossing, which may require that the access be replaced to ensure compliance with all requirements.

Boulder County is now issuing permits for permanent access where possible. In most cases, if the access does not include a water crossing, a Transportation Access Permit may be issued without additional work required. When the access involves a water crossing, several elements must be considered such as whether the road construction adjacent to the crossing has been completed and whether there are planned projects in the creek that may change how the creek flows.

Each crossing will require a site-specific analysis to determine if it is currently possible to issue a permit for permanent access or if the FRAP expiration date needs to be extended by the County Engineer.

More information about permit requirements can be found at:

http://www.bouldercounty.org/roads/permits/pages/bridgeconstructionpermit.aspx

http://www.bouldercounty.org/flood/property/pages/privateroads.aspx

12.4 Implementation

12.4A Probable Costs

The total estimated costs for the recommendations outlined in this plan are tabulated by reach in Table 12.1. Detailed itemized breakdowns of these costs are included in the conceptual design in Chapters 8 through 11. In addition, these costs represent "unmet needs", meaning all FEMA post-flood funding, CDBG-DR funded projects, CWCB grants, and FHWA recovery funds are not included in the estimates. These costs are based on the best available data at the time of this plan and will benefit from more robust technical analysis as more up-to-date and accurate survey, topographic, engineering, ecological, and miscellaneous data becomes available.

Table 12.1 Fourmile Creek Watershed Master Plan Estimated Probable Costs

Reach	Name	Sub-Total
1	Fourmile Creek from Boulder Creek to Poorman Rd	$ 6,215,423
2	Fourmile Creek from Poorman Rd to Mile Marker 4	$ 2,909,009
3	Fourmile Creek from Mile Marker 4 to Mile Marker 5 and Gold Run	$ 11,026,452
4	Fourmile Creek from Mile Marker 5 and Sunset	$ 8,952,800
	Total:	**$ 29,103,684**

12.4B Public Participation and Volunteer Engagement

In addition to plan implementation, disaster resilience is based largely upon individuals taking their share of responsibility for identifying, preparing for, responding to, and recovering from disasters at the community level. For this reason, the success of the Fourmile Creek Master Plan depends on continued public participation. Not only does individual citizen involvement provide a greater understanding of local concerns, it also ensures a higher degree of success by fostering community "buy-in" from those directly affected by the alternatives proposed in this master plan.

As a strategy for systematic public involvement, volunteer engagement has great potential to enhance and sustain flood recovery efforts in the Fourmile Creek Watershed. Not only do volunteers leverage limited resources by lowering project costs, the process of volunteer engagement builds a strong, committed constituency of local people with a deep understanding of, and connection to, the restored place.

The following are a number of key recommendations for incorporating volunteerism into the Fourmile Creek Watershed Master Plan implementation strategy:

Plan volunteerism into flood recovery projects from the beginning: Proactive planning for volunteer engagement allows critical lead time to mobilize resources. The goal is to have "capacity without the chaos" when large surges of volunteers are needed.

If volunteer and community engagement is a goal of a project, it is essential to design it in before RFPs and RFQs are put out for bid. This way, portions of a project can be set aside specifically volunteers. If volunteer engagement is a desired subset of a much larger design/build scope of work, specific requirements should be articulated in the RFP.

Provide infrastructure to support volunteers: To get the most from volunteers, adequate infrastructure is needed to support them – this includes tools, equipment, food, materials, technical expertise, trained leaders, insurance, etc. Without the appropriate infrastructure, engaging a large group of volunteers can be counter-productive. Local community partners with pre-existing expertise and resources to mobilize, equip, train, lead and insure volunteers are an invaluable resource.

Attract more than a labor force, attract people with useful advanced skills: Depending on the project, volunteer specialists can be recruited to provide their time and assistance. Strategic volunteer team building should happen as early in the project timeline as possible.

There are a diversity of tasks that volunteers can take on to assist with flood recovery and restoration. The chosen projects depends on the level of expertise the volunteers have, the resources available to support them, insurance coverage, and perceptions of appropriateness by local leaders and community members. Some examples of volunteer tasks include:

» Debris and trash removal.
» Seed and mulch disturbed areas.
» Plant native tree/shrub container stock.
» Harvest and plant willow poles/stakes.

- » Harvest plant materials and seed for grow out programs that will provide large scale quantities of locally adapted plant material for long-term restoration.
- » Remove invasive species.
- » Reconstruct fences

Example more advanced tasks for more qualified volunteers include:

- » Restoration design
- » Baseline vegetation and wildlife surveys and site monitoring
- » Heavy equipment operation

Some examples of local organizations that currently provide structure and resources for the types of volunteer efforts outlined above include Volunteers for Outdoor Colorado and Wildlands Restoration Volunteers. Organizations like these are an important asset to the Fourmile Creek Watershed. These organizations have experience recruiting and supporting volunteers, and with organizing large-scale volunteer projects. Ultimately, volunteer efforts will be most effective by establishing partnerships early and by leveraging preexisting volunteer networks and organizers.

12.5 Funding

As the go-to document to help guide future flood recovery efforts in the watershed, The Fourmile Creek Watershed Master Plan represents an important step towards long-term disaster resilience. A living document, this plan is expected to adapt and change to meet the needs and goals of an ever-evolving community. An important part of plan implementation involves identifying and securing sufficient funding for priority projects. The following funding matrix (Table 12.2) provides a list of potential funding sources and applicable projects/project types. Because funding sources are constantly changing and evolving, this list is not the definitive source for local, regional, and national funding opportunities. Rather, it is a resource that is meant to be supplemented and edited as funding cycles change, as new opportunities emerge, and as specific project needs become clearer.

Table 12.2 Potential Funding Matrix

Funding Sources	Program Name	Overview	Potential Application(s) to the Four Mile Creek Plan	Funding Amounts, Other Considerations
HUD	CDBG-DR	Funds may be used for necessary expenses related to disaster relief, long-term recovery, and restoration of infrastructure, housing, and economic revitalization First allocation of $62.8 million covers only the CO Floods of 2013. Second allocation includes wildfires ($199 Million	TBD	Two remaining grant allocations: 2nd allocation of $199 Million (includes wildfires: Federal Register Vol.79 No.106; Jun 3, 2014 3rd allocation of $58 Million: TBD
HUD	National Disaster Resilience Competition (NDRC)	The NDRC will make funds available to communities that have been struck by natural disasters in recent years. The year-long competition is structured in two phases: (1) risk assessment and planning; and (2) design and implementation. State of CO is in the process of gathering data and applying for Phase 1 CO DOLA has s draft action plan with identified "unmet needs"	TBD - funding is available for "resilient recovery activities." Applicants will be evaluated on the degree to which their proposed projects enable them to recover and prepare to mitigate future hazard risks.	$1 billion of CDBG-DR funds available Minimum award amount for Phase 2 winners is $1,000,000 Phase 1 applicants that are not selected for Phase 2, but who meet all of the requirements of the NOFA, are eligible to receive additional CDBG-DR funds March 16th 2015: Phase 1 Application Deadline March - June 2015: HUD review & Phase 2 invitations extended June - Oct. 2015: Phase 2 Applications prepared October 2015: Phase 2 Application Deadline December 2015: Announcement of Phase 2 winners (funding levels announced for all successful applicants) Early 2016: Grant agreements sent to successful applicants
Great Outdoors Colorado (GOCO)	Local Government Park and Outdoor Recreation Grants	Grants to help construct and enhance community parks, outdoor recreation amenities and environmental education facilities. This program includes Mini Grants for smaller projects costing $60,000 or less.	TBD	http://www.goco.org/grants
Great Outdoors Colorado (GOCO)	Open Space Grants	Grants to help preserve Colorado's open spaces, including land along river corridors, urban parcels, agricultural lands and wildlife habitat. This funding could be used for wetland protection and restoration if it can be shown to improve wildlife habitat	TBD	Offered twice a year, once in Spring (March application due date) and once in Fall (August application due date)
Great Outdoors Colorado (GOCO)	Planning Grants	Grants to help develop strategic plans that create, protect, and enhance open space, wildlife habitat, parks and trails.	TBD	Planning Grants are offered twice each year, once in the spring and once in the fall. Applications for our spring grant cycle are typically due in March, with grant decisions made by the GOCO Board in June; applications for our fall cycle are typically due in August, with decisions made in December.
Great Outdoors Colorado (GOCO)	Trails Grants	Offered annually through the Colorado State Trails Program to develop recreational trails for hiking, biking, horseback riding and other non-motorized activities.	TBD	Offered once a year through the CO State Trails Program
Great Outdoors Colorado (GOCO)	Flood Recovery Grants	To help affected communities repair or rebuild damaged parks, trails and open spaces.	TBD	http://www.goco.org/grants/flood-recovery
CWCB	Water Supply Reserve Account (WSRA)	Grants and loans to assist CO water users in addressing their critical water supply issues and interests: Technical assistance regarding permitting, feasibility studies, and environmental compliance Studies or analysis of structural, nonstructural, consumptive and non-consumptive water needs, projects, or activities Structural or nonstructural water projects or activities	TBD	Must obtain approval from the basin roundtable in which the project will occur. Grant proposal must be submitted 60 days prior to the CWCB Board meeting via email. http://cwcb.state.co.us/LoansGrants/water-supply-reserve-account-grants/Pages/main.aspx
CWCB	Fish and Wildlife Resources Fund	Money granted to existing water supply facilities to help preserve a balance between development of the state's resources and the protection of the state's fish and wildlife resources. The grant money is awarded for mitigation of existing water diversion, delivery or storage facilities. Grants from the Fish and Wildlife Fund can be accepted for: » The appropriation of water rights to preserve, or the acquisition of water rights to preserve or improve the natural environment to a reasonable degree to mitigate the impact of an existing water facility. All acquisitions or appropriations must be in compliance with Instream Flow Rules and state water laws. » River restoration feasibility studies and construction projects designed to directly mitigate or significantly improve the environmental impacts of existing water facilities. » An appropriate combination of river restoration and water right acquisition or appropriation.	Appropriation/acquisition of water rights to preserve/improve the natural environment and mitigate the impact of an existing water facility. River restoration feasibility studies and construction projects designed to mitigate or improve environmental impacts of existing water facilities.	http://cwcb.state.co.us/LoansGrants/fish-and-wildlife-resources-fund-grants/Pages/main.aspx Funding amounts very by year between $28,000 - $560,000 Applicants are encouraged to contact staff to discuss funding amounts and limitations
FUNDING RECEIVED				

Table 12.2 Potential Funding Matrix

Funding Sources	Program Name	Overview	Potential Application(s) to the Four Mile Creek Plan	Funding Amounts, Other Considerations
CWCB	Colorado Healthy Rivers Fund Grants	Supports local watershed organizations in their efforts to provide clean water, protect habitat, and improve recreation and accessibility Two categories of grants are available under the Program: 1. Project Grants: For projects that promote the improvement and/or protection of the condition of the watershed. Includes: water quality and/or water quantity monitoring; participation in the development and/or implementation of total maximum daily loads (TMDLs); implementation of watershed-related best management practices; flood protection; channel stability; and a wide variety of other riparian, streambank and habitat restoration efforts. 2. Planning Grants: For the planning of successful watershed restoration or protection projects. Includes: data collection and assessment; analysis of project alternatives; project permitting; acquisition of funding for a project; and outreach efforts to ensure the education, involvement and support of the local community.	TBD	Applications due in April of each year Funding amounts vary by year
CWCB	Watershed Restoration Grants	Provides grants for watershed/stream restoration and flood mitigation projects throughout the state Grant money may be used for planning and engineering studies, including implementation measures, to address technical needs for watershed restoration and flood mitigation projects throughout the state. Special consideration is reserved for planning and project efforts that integrate multi-objectives in restoration and flood mitigation. This may include projects and studies designed to: » Restore stream channels, » Provide habitat for aquatic and terrestrial species, » Restore riparian areas, » Reduce erosion, » Reduce flood hazards, or » Increase the capacity to utilize water	TBD	Grant cycle for Sept 2013 flood recovery projects will be announced in November 2014 http://cwcb.state.co.us/LoansGrants/colorado-watershed-restoration-grants/Pages/main.aspx
NRCS	Emergency Watershed Protection Program (EWPP)	Financial and technical assistance for sediment and debris removal, stream bank and channel stabilization, or dike/levee repairs. Some limited potential to assist for stream channel repairs associated with irrigation structures. EWP is an emergency recovery program. All projects undertaken, with the exception of the purchase of floodplain easements, must have a project sponsor.	EWPP provides varying amounts of technical assistance and 75% of cost for installing eligible recovery measures. Recovery measures may be temporary or permanent measures	Project eligibility limits. Funding availability is subject to congressional appropriation. The Sponsor applies for NRCS assistance via a letter the NRCS State Conservationist within 60 days of the flood. Sponsor and NRCS work with affected land owners to identify and prioritize recovery funding needs NRCS EWPP Program Contact: John Andrews 720-544-2834
NRCS	Emergency Watershed Protection Floodplain Easements (EWP-FPE)	Financial and technical assistance to purchase a permanent easement and restore the floodplain to natural conditions where it is a more economical and prudent approach to reducing a threat to life or property	NRCS will pay up to 100% of the easement value and up to 100% of the costs for easement restoration. For residential housing NRCS will pay up to 100% of the easement value and up to 100% of the structure's value if the landowner chooses to have it demolished or relocated.	Agricultural landowners apply directly to NRCS local offices. For properties with residential or other land use requiring removal of structures the landowners work with a local EWP Sponsor to make an application to NRCS. NRCS EWP-FP Program Contact: John Andrews. 720-544-2834
NRCS	Environmental Quality Incentive Program (EQIP)	Financial and Technical assistance for repair or replacement of farm irrigation systems. Some limited potential for off-farm irrigation systems. Potential for land reclamation of agricultural land damaged by overland flood flows.	Assistance provided to individuals for use on agricultural land	Program availability for new contracts may be altered by pending legislation to reauthorize the Farm Bill. NRCS EQIP Program Contact: Dawn Jackson. 720-544-2805
NRCS	Wildlife Habitat Incentive Program (WHIP)	Assistance provided to individuals for use on agricultural and nonindustrial private forest land.	Potential use for bank stabilization, channel modification, vegetation establishment to develop and improve wildlife habitat.	Applications for new projects are on-hold pending legislation to reauthorize the Farm Bill. WHIP fund availability is aligned to National & State priorities. Preble's Mouse habitat is a priority issue in the flooded areas. NRCS WHIP Program Contact: Dawn Jackson. 720-544-2805
FSA	Emergency Conservation Program (ECP)	Assistance provided to individuals for use on agricultural lands. Financial assistance for debris removal, fence restoration, grading, shaping and re-leveling agricultural land, and restoring conservation structures.	TBD	Individuals submit an application for assistance through their local FSA Office. FSA ECP Program Contact: Jenny Peterson 720-544-2895
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. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster.	Mitigation projects, hazard mitigation planning, management costs	Funding amounts vary depending on federal budget
FUNDING RECEIVED				

Table 12.2 Potential Funding Matrix

Funding Sources	Program Name	Overview	Potential Application(s) to the Four Mile Creek Plan	Funding Amounts, Other Considerations
FEMA	Public Assistance (PA) - Section 406 Funding	Through the Public Assistance (PA) Program, FEMA provides supplemental federal disaster grant assistance for debris removal, emergency protective measures, and the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain Private Non-Profit (PNP) organizations. Purpose of the PA program is to provide enough funding to restore a damaged facility to its pre-disaster design, function and capacity. During the repair efforts, mitigation opportunities may present themselves. The 406 program is implemented in conjunction with the PA program; additional funding may be authorized to modify the damaged facility in order to mitigate potential future damage. The cost effective mitigation measure must be applied on the parts of the eligible facility that were actually damaged by the disaster and must directly reduce the potential of future, similar disaster damages. Some examples include: » replacing a bridge with a low-water crossing, » burying power lines, » or installing gabion baskets, riprap, and/or geotextile fabric to control erosion.	Public bridge and culvert crossings along Fourmile Creek and Gold Run	Funds provided on a 75% federal, 25% non-federal cost share basis. Funding under the PA program is only allowed for eligible damage in designated areas that occurred during the incident period. The federal cost share is at least 75 percent. Funding amounts vary depending on federal budget
FEMA	Public Assistance (PA) - Section 404 Funding	The 404 program does not necessarily apply to damaged facilities resulting from the current declared disaster. It focuses, rather, on repetitive damages from past disasters and funds new or improved facilities. The State receives a percentage of the PA program declared disaster damage amount, which it uses to fund projects anywhere in the State, regardless of where the declared disaster occurred or the disaster type	TBD	Funds provided on a 75% federal, 25% non-federal cost share basis. Funding under the PA program is only allowed for eligible damage in designated areas that occurred during the incident period. The federal cost share is at least 75 percent. Funding amounts vary depending on federal budget
FEMA	Using Section 406 and 404 funding together	Sometimes, a combination of Section 406 and 404 funding may be appropriate, where Section 406 hazard mitigation funding is used to provide protection to the parts of the facility that were damaged and Section 404 hazard mitigation funding is used to provide protection to the undamaged parts of the facility. For example, the City of St. George is using Section 406 funds on sections of Virgin River that were damaged during the DR-1955 disaster, and they are using Section 404 funds from the DR-4011 disaster to perform similar mitigation activities at nearby locations.	TBD	Funding amounts vary depending on federal budget
EPA	Watershed Protection Grants	Catalogue of Funding Sources for Watershed Protection: https://ofmpub.epa.gov/apex/watershedfunding/f?p=fedfund:1	TBD	Funding amounts vary depending on federal budget
CDPHE	Drinking Water State Revolving Fund	Provides funding for: » water treatment plants of improvements to existing facilities » water line extensions to existing underserved properties » addressing or preventing Safe Drinking Water Act exceedances » replacing aging infrastructure » system capacity » land acquisition	TBD	The State Revolving Fund (SRF) finances the design and construction of Colorado water and wastewater infrastructure. CDPHE administers the SRF with the Department of Local Affairs and the Colorado Water Resources and Power Development Authority. They administer environmental review, engineering and design approval, and overall project management. The authority manages the finances and loan approvals. Local Affairs staff members work with applicants on credit reviews and reports. All projects funded with a State Revolving Fund Loan must include the state's specifications in the bid package. Included in these specifications is information on Davis-Bacon and Disadvantaged Business Enterprise requirements. Contact your SRF project manager with any questions. 2014 application deadlines are Sept. 15 and Dec. 15. 2015 application deadlines are Jan. 15, April 15, June 15, Aug. 15, Oct. 15 and Nov. 15 The SRF application process will be changing starting January 1, 2015. Please contact your region's project manager for more details
CDPHE	Water Pollution Control Revolving Fund	Provides funding for: » Treatment facilities. » Interceptor/collection lines. » Biosolid facilities. » Storm water improvements. » Reuse facilities. » Non-point source projects.	TBD	
CDPHE	Planning and Design Grant Program	Money to small communities to help cover costs associated with the Drinking Water Revolving Fund and Water Pollution Control Revolving Fund requirements. Funds can be used for engineering planning documents, environmental reviews, technical, managerial and financial capacity assessments, design documents and/or plans and specifications	TBD	Financial assistance up to $10,000 can be awarded to a governmental entity 2014 applications were accepted in January
FUNDING RECEIVED				

Table 12.2 Potential Funding Matrix

Funding Sources	Program Name	Overview	Potential Application(s) to the Four Mile Creek Plan	Funding Amounts, Other Considerations
CDPHE	Small Systems Training and Technical Assistance Grants (SSTTA)	Helps small systems with costs associated with planning and designs. Grants are available to communities with populations under 10,000 and with median household income (MHI) less than 80 percent of Colorado or where current/post-project water monthly rates are equal to or greater than the state average. Applications will be prioritized based on the criteria in the Drinking Water IUP, Appendix A or G.	TBD	No Request for Application for this grant fund will be released in 2014 Communities can apply for financial assistance up to $20,000
CDPHE	Water Quality Improvement Fund (WQIF) Grants	Provides money for water quality improvement projects using civil penalties from water quality violations. Include storm water management training and best practices training to prevent or reduce the pollution of state waters. Eligible applicants: » Governmental agencies » Publicly owned water systems. » Private not-for-profit public water systems. » Not-for-profit watershed groups. » Not-for-profit storm water program administrators » Not-for-profit training providers. » Private landowners impacted by a water quality violation Governmental agencies are eligible only for Category 3 funding.	TBD	No Request for Application for this grant fund will be released in 2014
CDPHE	Nutrients Management Grant Program	Funding available for municipal wastewater and sanitation districts throughout Colorado Grant money helps with planning, design, and construction of facility improvements to meet new nutrient standards	TBD	$14.7 million available $80,000 maximum for planning $1,000,000 maximum for design and construction
CDPHE / EPA	Brownfields Funding	The Brownfields program provides public and private property owners with resources to facilitate cleanups at abandoned industrial facilities, long-forgotten gas stations and other potentially contaminated properties that would otherwise languish and hinder economic development In addition to cleanup plan reviews, the Brownfields Program offers assistance to property owners in the form of: » Environmental site assessments. » Tax credits. » Revolving loans.	TBD	Up to $250,000 a year in statewide project funding.
DOLA	Conservation Trust Fund (CTF)	Funding can be used for the acquisition, development, and maintenance of new conservation sites or for capital improvements or maintenance for recreational purposes on any public site.* New conservation sites are defined in statute as being interests in land and water, acquired after establishment of a conservation trust fund, for park or recreation purposes, for all types of open space, including but not limited to flood plains, green belts, agricultural lands or scenic areas, or for any scientific, historic, scenic, recreation, aesthetic or similar purpose (CRS 29-21-101). A public site is defined by the department as a publicly owned site, or a site in which a public entity/local government holds an interest in land or water.	TBD	40% of the net proceeds of the Colorado Lottery are directed to the CTF for distribution to municipalities and counties and other eligible entities for parks, recreation, and open space purposes
FUNDING RECEIVED				

Table 12.2 Potential Funding Matrix

Funding Sources	Program Name	Overview	Potential Application(s) to the Four Mile Creek Plan	Funding Amounts, Other Considerations
CPW	Fishing is Fun	Projects supported through Fishing Is Fun include: » stream and river habitat improvements, » public access easements to angling waters, » pond and lake habitat improvements, » new fishing pond development, » parking areas and trails, » needed amenities such as benches, shade shelters and restrooms. Project sponsors must provide non-federal matching funds or in-kind contributions equal to at least 25 percent of the total project cost. Additional match will help make a proposal more competitive in the review and ranking process; historically project partners have provided roughly 40 percent of project costs.	TBD	Grant range from $2,500 to $400,000 with an overall average of $85,000 Application period typically opens in November with applications due by early March Potential applicants are strongly encouraged to contact their local District Wildlife Manager or Aquatic Biologist for input into the proposal prior to submittal.
CPW	Wetlands Partnership and the Wetland Wildlife Conservation Program	The Colorado Wetlands for Wildlife Program is a voluntary, collaborative, and incentive-based program to restore, enhance and create wetlands and riparian areas in Colorado. Funds are allocated annually to the program - and projects are recommended for funding by a Parks and Wildlife committee with final approval by the Director.	TBD	Notices posted on the CPW website when future wetland/riparian funding opportunities are available
CPW	Non-Motorized Trails Grant Program	The Colorado State Recreational Trails Grant Program funds projects for large recreational trail grants, small recreational trail grants, trail planning, and trail support grants.	TBD	Availability of funds for successful applicants may vary due to legislative processes, fiscal year parameters and/or written authorization of spending authority. Awarded funds are for 2 to 2 1/2 years. The non-motorized trail grant selection process follows a three-tiered recommendation and approval process. Applications are first scored and evaluated by State Trails Subcommittee members, volunteer outside reviewers and trails program staff, who rank the applications in an order of recommended funding priorities. The ranked applications are submitted to the State Trails Committee which evaluates and recommends projects to the Parks and Wildlife Commission and Great Outdoor Colorado Board for final approval.
CPW	Habitat Partnership Program: Habitat Improvement Grant	This grant is designed to implement large scale habitat improvement projects which, when completed, will provide benefits to livestock, private land owners, land managers, big game animals and other wildlife species. Habitat improvement projects include using mechanical and chemical tools to improve/increase available habitat and forage. Typical habitat improvement projects done by HPP include: » brush manipulation (hydroaxing, roller chopping, Lawson aerating, burning, etc), » weed control using biological and chemical means, » water developments (maintaining existing water sources and developing new ones), » fertilizing and reseeding.	stream restoration	5 grants awarded Minimum $100,000, Max $500,000 Applications due Monday, Feb 2, 2015
CPW	Outdoor Classroom Grants	Small matching grants available to support Outdoor Classrooms/learning centers Student-led, student-oriented projects Grants designed to increase communities' use and enjoyment of their public outdoor space	Recreation, community engagement, resilience building, risk education and ecosystem/habitat improvement	Matching grants of up to $1,000 Grant applications are due by February 28th. Decisions will be announced by March 14th
National Fish and Wildlife Foundation (NFWF)	Bring Back the Natives/More Fish	The National Fish and Wildlife Foundation is requesting proposals to restore, protect, and enhance native populations of sensitive or listed fish species, especially for areas on or adjacent to federal agency lands. Support for this program is provided by the U.S. Fish and Wildlife Service (USFWS), Bureau of Land Management (BLM), U.S. Forest Service (USFS), Orvis, Bass Pro Shops, and Brunswick Foundation.	Habitat restoration with a focus on Western Native Trout – (focus on Lahontan cutthroat trout, Apache trout, Colorado cutthroat trout recovery)	Up to $1,250,000 in grant funds is available. Grant awards generally range in size from $50,000 to $100,000, although grants greater than $100,000 will be considered on a case by case basis
FUNDING RECEIVED				

Table 12.2 Potential Funding Matrix

Funding Sources	Program Name	Overview	Potential Application(s) to the Four Mile Creek Plan	Funding Amounts, Other Considerations
USCAE	Project Modifications for Improvement of the Environment (CAP Section 111)	Work under this authority provides for modifications in the structures and operations of water resources projects constructed by the Corps of Engineers to improve the quality of the environment. Additionally, the Corps may undertake restoration projects at locations where an existing Corps project has contributed to the degradation. The primary goal of these projects is ecosystem restoration with an emphasis on projects benefiting fish and wildlife.	TBD	The project must be consistent with the authorized purposes of the project being modified, environmentally acceptable, and complete within itself FY 2014 Funding Level - $10.5 million
USACE	Small Flood Damage Reduction Projects (CAP Section 205)	Work under this authority provides for local protection from flooding by the construction or improvement of structural flood damage reduction features such as levees, channels, and dams. Non-structural alternatives are also considered and may include measures such as installation of flood warning systems, raising and/or flood proofing of structures, and relocation of flood prone facilities	TBD	FY 2014 Funding Level - $15 million Typical max award - $3.9 million Typical median award - $191,023 For structural flood damage reduction projects-the non-Federal sponsor is responsible for a minimum of 35% to a maximum of 50% of total project costs and the Federal Government is responsible for the remainder of total project costs. For non-structural flood damage reduction projects - the cost share is 65% Federal and 35% non-Federal. The Federal share of planning, design, and construction cannot exceed $7,000,000 per project
USACE	Aquatic Ecosystem Restoration (CAP Section 206)	Work under this authority may carry out aquatic ecosystem restoration projects that will improve the quality of the environment, are in the public interest, and are cost-effective. There is no requirement that an existing Corps project be involved	TBD	The study cost share is 50% Federal and 50% non-Federal. The Design/Construction cost share is 65% Federal and 35% non-Federal. The Federal share of planning, design, and construction cannot exceed $5,000,000 per project Funding Level FY 2014 - $8 million Typical max award - $4.6 million Typical median award - $199, 592
USACE	Beneficial Uses of Dredged Material (CAP Section 204)	Work under this authority provides for the use of dredged material from new or existing Federal projects to protect, restore, or create aquatic and ecologically related habitats, including wetlands	TBD	The cost share is 75% Federal and 25% non-Federal of the incremental cost above the least cost method of dredged material disposal consistent with engineering and environmental criteria Funding Level FY 2014 - $7 million Typical max award - $1.8 million Typical median award - $130, 241
Colorado Department of Agriculture	Colorado Weed Management Grants	Weed Management Fund: provide additional financial resources to counties, communities, weed control districts, or other entities engaged in cooperative efforts to eradicate and/or contain state, regionally, or locally rare, noxious weed species populations and to prevent the spread of high priority weed populations. Natural Disaster Noxious Weed Management: Funds to respond to wildfire, flood or other natural disasters in FY 2014-2015 Provides money to counties, communities, HOAs, NGOS, and weed control districts for addressing the occurrence, movement, and spread of noxious weeds as a direct result of surface disturbance caused by wildfire, flooding, or other event. All proposals must emphasize on-the-ground management action but may also have education and outreach as grant components Grants awarded on an as-needed basis	TBD	Natural Disaster Noxious Weed Management: Funds CDA has allocated $100,000 for the FY 14-15 Funds available until June 30, 2015
FUNDING RECEIVED				

Table 12.2 Potential Funding Matrix

Funding Sources	Program Name	Overview	Potential Application(s) to the Four Mile Creek Plan	Funding Amounts, Other Considerations
Trout Unlimited	Embrace a Stream (EAS)	EAS is a matching grant program administered that awards funds to TU chapters and councils for coldwater fisheries conservation. Goal is to helping restore stream habitat, improve fish passage, and protect water quality For the 2014-15 funding cycle, TU chapters and councils are asked to submit proposals for projects that best address the needs of native and wild trout following TU's Protect, Reconnect, Restore, and Sustain conservation model. EAS intended as a source of funding for the early stages of projects, not as a multi-year funding mechanism	Stream/habitat restoration	$10,000 maximum award Required a minimum 1-1 match Two years to complete the project Significant grassroots involvement is required October 15, 2014: Online training call to discuss EAS applications at 8:00 p.m. Eastern, contact Jeff Yates (jyates@tu.org) or click here to RSVP November 12, 2014: Deadline for initial contact with EAS Committee Representative about proposed project December 9, 2014: Final deadline for applications (postmark/fax/e-mail date)
Federal Highway Administration (FHWA)	Risk and Resiliency Grants	FHWA is soliciting descriptions of proposed pilot projects from State Departments of Transportation (State DOTs), Metropolitan Planning Organizations (MPOs), Federal Lands Management Agencies (FLMAs), and Tribes addressing one of two areas related to climate change and extreme weather adaptation: » Assessments of transportation vulnerability to climate change and extreme weather events, or » Options for improving resiliency of transportation facilities or systems to climate changes and/or extreme weather events. This pilot program is jointly sponsored by the Office of Environment, Planning and Realty, and the Office of Infrastructure.	TBD	
Longmont Community Foundation	Community Grants Program	Awards granted annually to nonprofit organizations that benefit residents of the St. Vrain Valley, including Longmont and surrounding areas. Grants are awarded annually in four major focus areas: » Arts and Culture » Health » Human Services » Civic and Education	Potential Applicant – Wildlands Restoration Volunteers: http://www.wlrv.org/ Contact: Ed Self	Grant requests for the next grant cycle will be due on December 5, 2014. The new application and guidelines should be available in mid-October. Decisions are made in the spring of the following year. The Longmont Community Foundation encourages all applicants to contact The Foundation to discuss any project idea or question related to your application.
The Nord Family Foundation	Civic Affairs and Health and Social Services Grants	Health and Social Services Grants http://www.nordff.org/category/health-and-social-services-13 Civic Affairs Grants http://www.nordff.org/category/civic-affairs-13	sheltering homeless population concerns	
The Boettcher Foundation	Capital Grants	Since its founding, the Boettcher Foundation has been making capital grants to Colorado's most forward-thinking nonprofits. With more than $320 million in grants given since 1937		http://www.boettcherfoundation.org/home/capital-grants
The Gates Family Foundation	Capital Grants	The Foundation supports capital projects that: » invest in land and water protection that safeguards important natural resources, habitat, and the health of natural systems » help preserve the state's ranching and agricultural legacy and encourage smart land use patterns » construct and improve urban and mountain parks and open space for public recreation and access » maintain the state's urban and mountain trail systems » provide recreation, environmental education and leadership opportunities for young people » encourage the spirit of scientific inquiry as well as the preservation of natural habitat	Funding examples include land conservation and easement purchases, greenways and trail systems, outdoor/ indoor recreation facilities, urban public spaces and community gardens	GFF will not be accepting capital grant applications during the 3rd quarter of 2014. Applications will be accepted in the fourth quarter (October 1 submittal deadline, decisions in mid-December) Capital projects are typically defined as building purchases, new construction, expansion, renovation, and/or land acquisition.
The Gates Family Foundation	Initiatives: Water Resources and Smarter, Greener, Healthier Urbanism	Supports land conservation, water resource protection and management, increased land trust capacity, citizen stewardship and ecosystem services demonstration opportunities		http://www.gatesfamilyfoundation.org/reports
Maki Foundation	Small Grants	Foundation priorities: » wilderness and wildlands protection » river and wetlands conservation » biological diversity conservation » public lands management		$1,000 - $10,000 grants Application Deadline: The Board of Directors meets once a year in mid-summer. To be considered in the current year, proposals must be received by May 1. Awards will be announced by September 15. http://www.makifoundation.org/guidelines.html
FUNDING RECEIVED				

Table 12.2 Potential Funding Matrix

Funding Sources	Program Name	Overview	Potential Application(s) to the Four Mile Creek Plan	Funding Amounts, Other Considerations
Laura Jane Musser Fund	Environmental Initiative Program	To promote public use of open space that improves a community's quality of life and public health, while also ensuring the protection of healthy, viable and sustainable ecosystems by protecting or restoring habitat for a diversity of plant and animal species.	Grants of up to $35,000 may be made for programs in this program. New or existing programs or projects Programs in the planning or implementation phase Capital expenses	Environmental Initiative Deadline: March 2015 - Online proposals will be accepted starting February 2015. http://www.musserfund.org/index.asp?page_seq=11
Laura Jane Musser Fund	Rural Initiative Program	Planning Grant (up to $5,000) - These funds may support costs like: consultant or staff time, meeting costs, mailings, secretarial support, refreshments, local travel, childcare, etc. This is not a required phase prior to applying for or receiving an implementation grant. Implementation Grant (up to $25,000) – Funds to implement projects planned by the local community.		Proposals will be accepted starting October 1, 2014 and must be submitted online by November 1, 2014. Funding decisions will be announced by February 2015. Limits: The applicant community must have a population of 10,000 or fewer and must be able to demonstrate the rural characteristics of their location
FUNDING RECEIVED				
Funding Received				