US Army Corps
of Engineers ®
Omaha District

FEASIBILITY REPORT

GOOSE CREEK AT BOULDER, COLORADO

SECTION 206

U.S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT

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GOOSE CREEK AT BOULDER, COLORADO SECTION 206
FEASIBILITY REPORT EXECUTIVE SUMMARY

This Feasibility Study/Environmental Assessment (FS/EA) is submitted under the authority of Section 206 of the Water Resources Development Act of 1996, as amended (33 U.S.C. 2201). The purpose of this study is to identify potential riparian ecosystem restoration alternatives for South Goose Creek, located in the City of Boulder, Boulder County, Colorado. The goal of the FS/EA is to evaluate each proposed alternative and, through coordination between the U.S. Army Corps of Engineers (USACE), the non-Federal, Local Sponsor, and participating agencies, develop a recommended National Ecosystem Restoration (NER) plan for the proposed study site. The study area is in Congressional District 2, which is represented by Congressman Jared Polis. Senator Michael Bennet and Senator Mark Udall also represent the study area. The study area covers approximately 17 acres and includes South Goose Creek and Cottonwood Pond in the city of Boulder, Colorado.

Goose Creek is a tributary of Boulder Creek, which in turn is a tributary of the South Platte River. The study area extends from immediately upstream of Foothills Parkway to the confluence with Boulder Creek and encompasses approximately 4,000 feet of South Goose Creek and Cottonwood Pond. The purpose of the study is to determine if the proposed restoration of the aquatic ecosystem of Goose Creek and the associated wetlands and Cottonwood Pond are feasible, given National Ecosystem Restoration goals and the economic cost.

South Goose Creek and Cottonwood Pond are included in the Aquatic Ecosystem Restoration program due to their degraded condition, and the potential to restore wetland habitat, migratory bird habitat, and stream aquatic habitat, all in proximity to current populations of endangered animal and plant species. The potential project area also offers unique opportunities to connect restored riparian reaches and restore some of the scarce riparian ecosystem in the semi-arid high plains adjacent to the Front Range of the Rocky Mountains. Quality riparian habitat is relatively rare on the high plains of Colorado, yet it is vital to many native and migratory species. Restoration of this impaired ecosystem will offer an opportunity to rid the Boulder Creek watershed of an invasive plant “hot spot” and replace it with native aquatic and riparian species. Together with Cottonwood Pond, South Goose Creek offers an opportunity to increase the amount, quality and connectivity of scarce habitat and potentially expand the range of endangered species that dwell nearby. Cottonwood Pond, in particular, offers an opportunity to restore pre-development riparian and wetland conditions in the floodplain adjacent to Boulder Creek.

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AAHU – Average Annual equivalent Habitat Unit
AC—Acre
APE – Area of Potential Effect
BWR – Boulder and White Rocks
CDOW – Colorado Division of Wildlife
CE/ICA – Cost Effectiveness/Incremental Cost Analysis
Cfs – cubic feet per second
CY – Cubic Yard
D&I – Design and Implementation
EA – Environmental Assessment (USACE)
ECP – Environmental Condition of Property
EGM – Economic Guidance Memorandum
EGM – Economic Guidance Memorandum
EPA – Environmental Protection Agency
ER – Ecosystem Restoration
ER – Engineer Regulation (USACE)
FEMA – Federal Emergency Management Agency
FIS – Flood Insurance Study
FONSI – Finding of No Significant Impact
FS/EA – Feasibility Study/Environmental Assessment
FWCA – Fish and Wildlife Coordination Act
GIS – Geographic Information System
HEC – Hydrologic Engineering Center (USACE)
HQI – Habitat Quality Index
HTRW- Hazardous Toxic and Radiological Waste
HU – Habitat Unit
IWR – Institute for Water Resources
LERRD – Lands, Easements, Relocations, Rights-of-way and Disposal areas
M-CACES – Micro-Computer Assisted Cost Estimating System (USACE)
NATA – National Air Toxics Assessment
NEPA – National Environmental Policy Act
NER – National Ecosystem Restoration
NRCS – Natural Resource Conservation Service
O&M – Operation and Maintenance
OMRR&R – Operation, Maintenance, Repair, Replacement and Rehabilitation
P&G – Policy and Guidance
PCA – Project Cost share Agreement
PMP – Project Management Plan
PPA—Project Partnership Agreement
RAS – River Analysis System (USACE)
RBP – Rapid Bioassessment Protocols
SF – Square Foot
SHPO – State Historical Preservation Officer
SY – Square Yard

T&E – Threatened and Endangered
TMDL – Total Maximum Daily Load
T—Tons
UDFCD – Urban Drainage and Flood Control District
UDV – Unit Day Value
USACE – U.S. Army Corps of Engineers
USDA – U.S. Department of Agriculture
USFWS – U.S. Fish and Wildlife Service
USGS – U.S. Geological Survey
UDD – Unit Day Value
VSI – Visibility Standard Index
WRDA – Water Resources Development Act

1.0 STUDY BACKGROUND

1.1 STUDY AUTHORITY AND PURPOSES

1.1.1 Authority

This study is conducted under the authority of Section 206 of the Water Resources Development Act (WRDA) of 1996, as amended, Public Law 104-3030, which states:

> *"The Secretary is authorized to carry out an aquatic ecosystem restoration and protection project if the Secretary determines that the project (1) will improve the quality of the environment and is in the public interest, and (2) is cost-effective."*

1.1.2 Sponsorship and Cost Sharing

The Federal costs to carry out such a project shall not exceed $5,000,000 without specific authorization by Congress. Cost sharing for this project under the Sec 206 regulations at the time of its initiation in 2006 is 65% Federal, 35% non-Federal for total project costs. Operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) is a 100% non-Federal responsibility. Real estate costs are expressed as the cost of Lands, Easements, Right-of-Way, Relocations and Disposal, or LERRDs, are the responsibility of the local cost share partner. Up to 35% of the total project cost can be credited to the local cost share partner for LERRDs. The non-Federal Sponsor of the proposed aquatic restoration project is the City of Boulder in Boulder County, Colorado.

1.1.3 Purpose and Need

Section 206 projects specifically address aquatic ecosystem restoration activities. The section of Goose Creek and Cottonwood Pond encompassed by the study has been negatively affected by human activities and development upstream of and within the project site. The morphology (physical characteristics and shape) of the stream and the aquatic community have been altered by development and are exhibiting signs of degradation.

Goose Creek is included in the Aquatic Ecosystem Restoration program due to the degraded condition, of both stream and wetland aquatic habitats, potential to contribute to scarce migratory bird habitat if restored and its importance in connecting restored riparian reaches (See Figure 1-3). According to the U.S. Fish and Wildlife Service (USFWS), riparian areas make up less than 3% of land masses in Colorado, yet 75% of the wildlife species known to occur in Colorado are dependent on riparian areas during all or a portion of their life cycle (USFWS, 2008). Together with Cottonwood Pond, South Goose Creek offers an opportunity to increase the amount, quality and connectivity of scarce habitat and potentially expand the range of endangered species that dwell nearby.

Goose Creek has been severely degraded by channel straightening for flood control, the effects of urbanization, and the presence of invasive species, yet lies between a restored upstream reach of Goose Creek and partially restored Boulder Creek. The channel is bounded by busy Pearl

Parkway and commercial establishments. The location and flow of the main channel is constrained by man-made structures and the fixed locations of tributary inflows entering from storm sewers and drainage pipes. The channel is incised below the floodplain, is completely artificial and is no longer undergoing natural geomorphic processes. Overall, riparian diversity is low, constrained primarily by adjacent land uses and the lack of a flood plain connection.

A flood control project constructed in the 1980s split Goose Creek into South Goose Creek, which somewhat follows the path of pre-development Goose Creek, and North Goose Creek, which is normally a dry overflow channel which was constructed for flood control purposes and is not included in this restoration project. See Figures 1-2 and 1-3.

A portion of Goose Creek that is included in this project runs through an abandoned gravel pit known as Cottonwood Pond near its confluence with Boulder Creek. The pond is not a natural body of water. It features undifferentiated shoreline and is home to many invasive species, including Russian olive and Eurasian water milfoil. Extension of Goose Creek restoration from Foothills Parkway to Boulder Creek would greatly increase the length of a contiguous riparian corridor within Boulder. Pre-development aerial photos provide a template for the restoration of the riparian and wetland ecosystem adjacent to Boulder Creek in Cottonwood Pond. Restoration of wetland habitat in Cottonwood Pond has the potential to improve wetland diversity within the greater Boulder Creek aquatic system as well as serve as a ”refugia” adjacent to Boulder Creek.

The federally listed threatened Preble’s meadow jumping mouse requires well-developed riparian vegetation along creeks and ditches. Preble’s meadow jumping mouse is present on other tributaries to Boulder Creek in the Boulder area, including South Boulder Creek which joins Boulder Creek less than one mile downstream from the mouth of Goose Creek. Although this species is not believed to inhabit the immediate project area under current conditions, restoration of the riparian area could restore suitable habitat to extend its current range.

Lower South Boulder Creek is also home to a significant colony of the Ute ladies’-tresses orchid. Potential habitats for Ute ladies’-tresses within the study area include the restored reach of South Goose Creek below Reynolds Corner and in the Cottonwood Wetland. Current conditions for this species are suboptimal; however South Goose Creek and Cottonwood pond are fed by groundwater inflow and a restored riparian wetland community may offer suitable habitat for colonization.

The need for this project on Goose Creek has been established as the significant degradation to natural stream processes, the establishment of non-native species, and degradation and dissection of native species habitats and corridors have been documented in earlier publications, which are cited in this report. More detail regarding the direct loss and degradation experienced by this ecosystem is provided in Section 2.0, Environmental Conditions. The purpose of this project is to restore degraded stream form, function and dynamic processes, re-establish connectivity of habitats, reduce invasive species, improve wetlands diversity and establish and improve habitat for federally listed species.

1.1.4 Significant Resources

The significance of the proposed aquatic ecosystem restoration of lower South Goose Creek is derived from the following:

- Scarcity of Riparian Forested Wetlands in the Arid High Plains – Palustrine wetlands and other riparian areas occupy only 3% of the land area in Colorado, yet are essential to at least one life stage of 75% of migratory and resident wildlife species in Colorado (USFWS, 2008). Restoration of woody riparian habitat also supports efforts to implement the International Migratory Bird Treaty Act. (Technical Significance).

- Connectivity of Existing Restored Reaches of stream aquatic ecosystem – The city of Boulder has previously restored the reach of Goose Creek immediately adjacent to and upstream of the reach proposed for restoration and is restoring Boulder Creek downstream of this reach. See Figure 1-3. Restoration of the proposed reach would permit the expansion of the stream aquatic ecosystem into a riverine corridor, which is critical for wildlife connection and dispersal (USFWS, 2003a). The riverine corridor can facilitate the expansion of ranges of existing riparian species, currently inhibited by the poor quality of the reach, including species of special concern, listed by the State of Colorado and/or Boulder County. (Public, Technical, and Institutional Significance).

- Integration in well developed Sponsor Master Restoration Plans – The city of Boulder has an active Greenways restoration program. This aquatic ecosystem restoration effort on South Goose Creek is intimately linked to overall ecosystem restoration goals in the city and surrounding Boulder County including the city of Boulder's Greenways Master Plan and Boulder County's Lower Boulder Creek and Coal Creek Open Space Master Plan. Goose Creek had been identified as one of the two highest priority degraded riparian reaches needing restoration within the city of Boulder's Greenways Master Plan (December 2001). (Public Significance).

- Active ecosystem restoration programs by the city of Boulder and Boulder County also lend additional significance to the restoration of Goose Creek as gains in riparian quality and reductions in invasive species in this watershed can be leveraged through the Boulder Creek basin. See Figure 1-1.

- Opportunity to address an invasive species hot spot – Presently, Cottonwood Pond is home to an active and aggressive population of Eurasian water milfoil. Efforts to eradicate this persistent aquatic weed within the greater Boulder Creek ecosystem are compromised by the Cottonwood Pond population. Eradication of this population would allow greater success in treating the entire watershed. (Public Significance).

- Opportunity to replace non-native riparian woodland species, including Russian olive, with native species, including native cottonwoods and willows that have become increasingly scarce in Colorado, but are very important for resident and migratory bird habitat and are considered by the USFWS' Mountain-Prairie Region to be a critical wildlife resource (USFWS, 2003a). (Technical Significance).

- Proximity to Existing Habitat of Threatened and Endangered Species – Populations of two threatened and endangered species currently exist in similar nearby habitat in the lower portion of the South Boulder Creek watershed. The species include Preble's Meadow Jumping Mouse and Ute Ladies' Tresses. An improved Goose Creek aquatic ecosystem has the potential for future colonization by these species. (Institutional Significance).

According to Corps policy guidance on aquatic ecosystem restoration projects, significance is increased for projects strong in the following attributes (Corps, 2007) which are quoted from the document as follows:

- Scarcity = The scarcity of the habitat to be restored. This criterion is based on trend information and relative abundance of the habitat.
- Connectivity = This criterion addresses the extent to which a project facilitates the movement of native species by contributing to the connection of other important habitat pockets within the ecosystem, region, watershed or migration corridor.
- Special Status Species = The projects ability to provide a significant contribution to some key life requisite of a special status species.
- Plan Recognition = This criterion recognizes Corps ecosystem restoration projects that contribute to watershed or basin plans as emphasized in the "Civil Works Strategic Plan."
- Self-Sustaining = While data used as a proxy for this criterion is only required during the PED and Construction phases, the concept should be considered during plan formulation. The ideal goal of most restoration is a self-sustaining ecosystem consisting of natural processes.

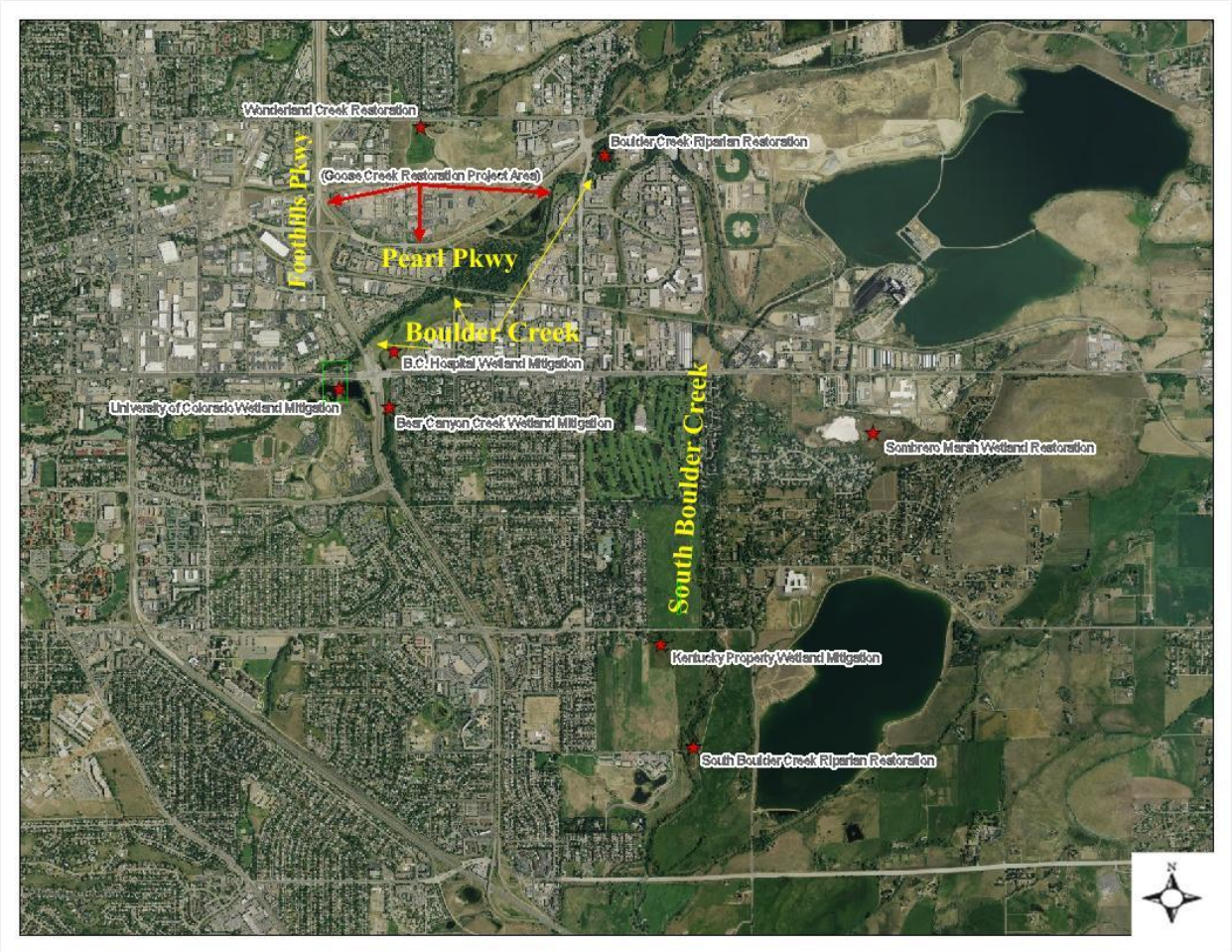

Figure 1-1: Project Location in Context of other Boulder Area Ecosystem Restoration Projects.

1.2 PROJECT LOCATION

1.2.1 Study Area Location and Description

The study area is approximately 33.72 acres and includes lower Goose Creek and Cottonwood Pond in the city of Boulder, Colorado. The total drainage area of Goose Creeek at the confluence with Boulder Creek is 5.46 square miles. Goose Creek has extensive reaches without well-defined channels (FEMA,2002). The lack of well defined channels is a result of the urbanized nature of the watershed. During development, the channels of the upper Goose Creek watershed were graded over and drainage was diverted to storm sewers. Boulder is located approximately 30 miles northwest of Denver, Colorado. The location of the project reach is within the larger Boulder Creek watershed, and its location within Boulder and relative to Denver, Colorado, is shown in Figure 1-2.

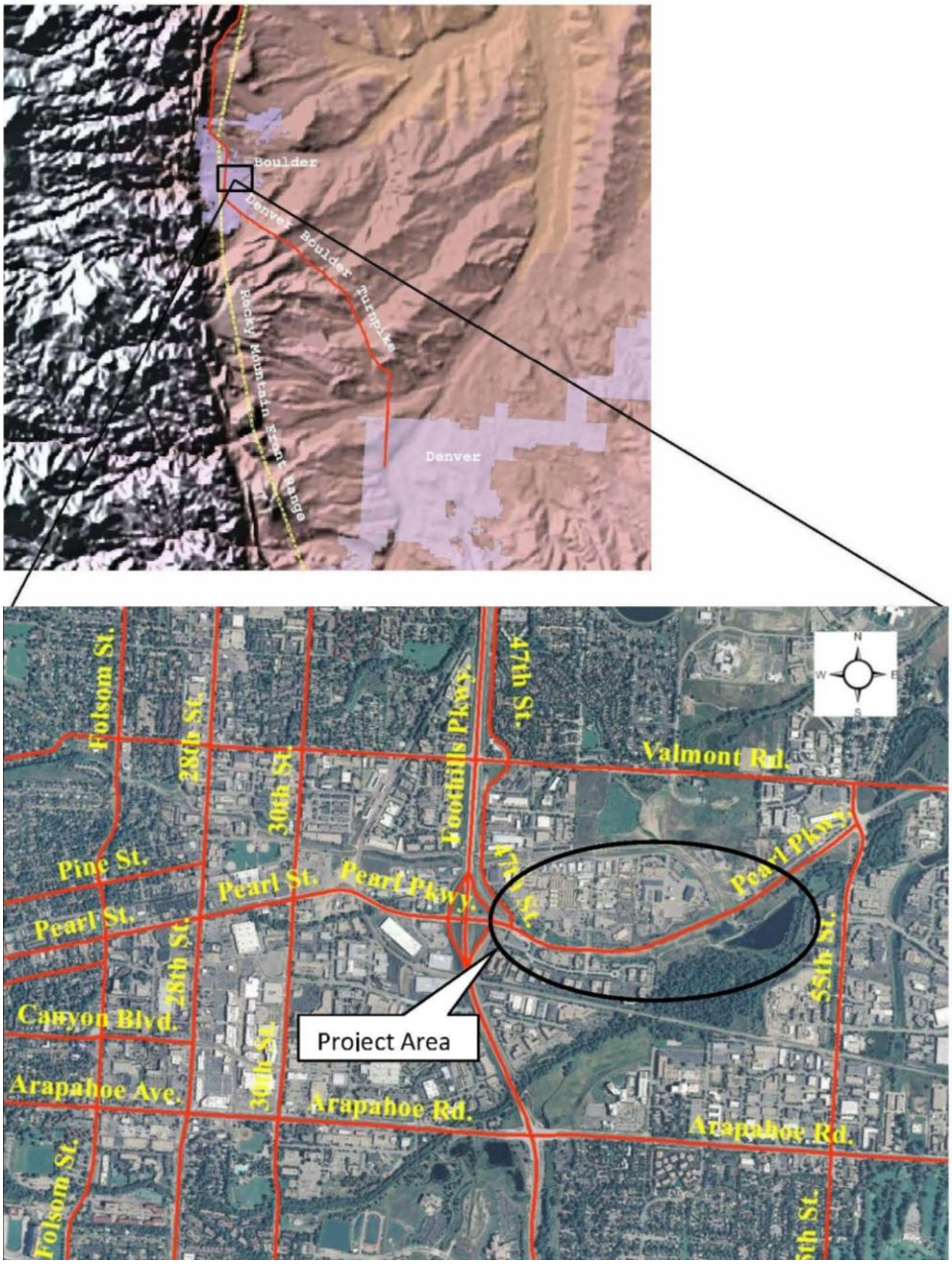

Figure 1-2: Project Location near Denver, Colorado

The legal description is Township 1 North, Range 70 West, Section 28. Goose Creek is a left bank tributary of Boulder Creek, which in turn is a left bank tributary of the South Platte River. The study area extends from Foothills Parkway to the confluence with Boulder Creek and encompasses approximately 4,000 feet of South Goose Creek and Cottonwood Pond. North Goose Creek is a normally dry overflow flood control channel and is not included in the restoration plan. The location of the project, relative to Boulder Creek and other features, is shown in Figure 1-3.

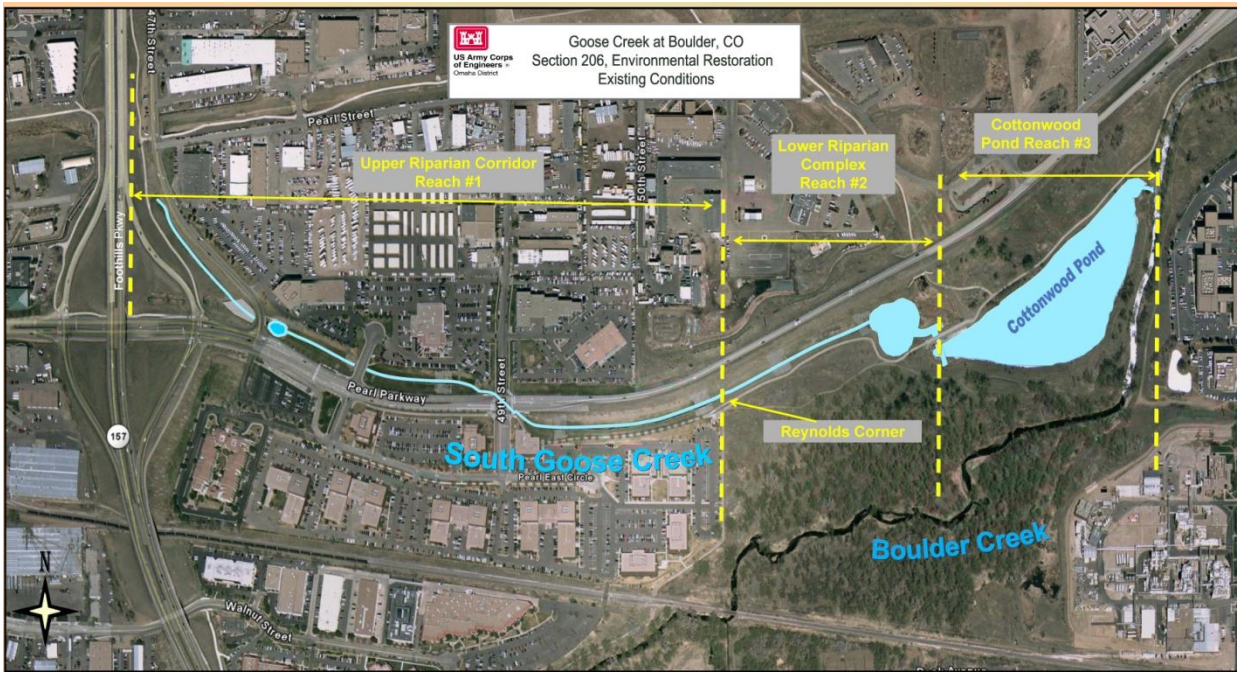

Figure 1-3: Goose Creek Project Area

Goose Creek is an urban stream that rises on the high plains at the edge of the foothills of the Rocky Mountains, to the west of Broadway Drive. As noted on Figure 1-1, the Goose Creek Basin also includes Wonderland Creek, which flows into North Goose Creek just upstream of Cottonwood Pond, as well as Twomile Canyon Creek and Elmer's Twomile Creek. Twomile Canyon Creek drains the foothills at the edge of the Front Range, but the channel between the canyon and Goose Creek has been paved over and the remaining hydrologic connection is by storm sewer or overland flow in the event of a major storm event. There is some base flow in upper Goose Creek, but that flow is diverted into the Boulder and White Rock Irrigation Canal near Folsom Street. Consequently, the upper basin does not provide inflow to the study reach except in times of flood.

Goose Creek splits just above Foothills Parkway into North and South Goose Creek. North Goose Creek was dug as a manmade flood overflow channel; allowing peak flood flows to divide, resulting in lower stages along the developed South Goose Creek near Pearl Parkway. North Goose Creek connects with lower Wonderland Creek, returning overflows to Goose Creek, just above Cottonwood Pond.

1.2.2 Congressional District

The study area is in Colorado Congressional District 2, which is represented by Congressman Jared Polis. Senator Michael Bennet and Senator Mark Udall also represent the study area.

1.3 STUDY BACKGROUND

1.3.1 Basin History and Physical Setting

Flows in Boulder Creek and tributaries, before mining activities began in the mid-1800's, likely featured higher mean annual discharges and a distribution of dissolved solids that was lower in the mountains and higher in the plains tributaries. Mining operations and other development increased both sediment yield and dissolved solids from the mountains, while erosion control and urbanization reduced the introductions of suspended and dissolved solids on the plains relative to pre-settlement times. Bacteria levels in the streams were likely lower overall prior to development. Drinking water came directly from streams, wells and diversions, and there was no treatment.

Later in the 1800's numerous gold and silver mines began operating in the upper Boulder Creek basin. Mill tailings and toxic chemicals were disposed of on the ground or directly into streams. Timber harvesting quickly followed, and associated activities included blasting to remove large boulders and streamside vegetation to improve passage on Boulder Creek, which was used to deliver lumber downstream. Gravel mining operations were conducted in the floodplains of Boulder Creek and tributaries to harvest the valuable aggregate for use in making concrete. Gravel mining at the mouth of Goose Creek in the late 20th century led to the excavation of Cottonwood Pond in an area that had historically been a wetland adjacent to Boulder Creek. An increase in erosion from a variety of operations released sediments and dissolved solids into streams. Water treatment was begun in the early 1900's due to these problems aggravated by disposal of human waste.

Following development, water has been diverted from Boulder Creek and its tributaries for irrigation and other uses. This is true of Goose Creek. Presently two canals cross Goose Creek. The Boulder and White Rocks Ditch is connected to Goose Creek upstream of the project area at Folsom Street. The canal is capable of diverting from or spilling water into Goose Creek. The North Boulder Farmers Ditch crosses Goose Creek just upstream of Foothills Parkway and the upper end of the project.

Urban growth results in the fragmentation and loss of natural wildlife habitat. The Goose Creek basin has changed from a natural high plains watershed to a basin that is essentially 100% urbanized since settlement. Before settlement, high plains watersheds such as Goose Creek were characterized by semi-arid grasslands with some tree growth along waterways. The waterways served as breaks in the grasslands and supported developed riparian plant and animal communities. The establishment of extensive growth of woody plants along streams was limited by frequent prairie fires. The stream channels themselves remained in rough equilibrium, with little net scour or fill over time. In recent years, wildlife habitat and migration corridors have been reestablished in parts of the high plains portion of Boulder Creek basin as part of the city's greenways program.

By the mid-20th century, runoff from urban uses (lawn watering, car washing, etc.) began to augment low flows during the warm season. Lacking a significant hydrologic connection to the Rocky Mountains, an important source of water in Goose Creek is urban runoff from high plains

snowmelt or rainfall events. During winter and early spring, runoff occurs from snowmelt during warm spells. In the late spring and summer, runoff from afternoon thunderstorms often provides a fairly consistent source of stream flow, especially during the early summer period of monsoonal advection. Flash flooding can result from the heavier storms.

Agricultural activities have also resulted in drastic changes to wildlife habitat and habitat diversity in small watersheds along the foothills. Activities such as draining wetlands, eliminating idle fields, fencing, and other agricultural practices have significantly reduced habitat. Irrigation has resulted in the base flows of many streams being diverted, including those of Goose Creek. Land development has had a significant impact on natural ecosystems, even outside the developed areas. Construction of buildings, roads, fences and other obstructions destroy wildlife habitat and restrict wildlife migration. Heavy runoff from paved surfaces erodes riparian areas and introduces pollutants into the waterways.

Before the mid-1800's, the only trees along Boulder Creek and its high plains tributaries were cottonwoods and peach-leaved willows. These trees "germinate slowly, do not regenerate in their own understory and depend on periodic disturbances to create suitable germination areas" (Gershman 1999). Over the years, natural disturbances have been reduced, allowing these native species to be out-competed by non-native trees.

1.3.2 Study Sponsor and Study History

The sponsor for the Goose Creek Study is the city of Boulder, Colorado. The Goose Creek Feasibility Study began with a Letter of Request in August 2002. Goose Creek had been identified as one of the two highest priority degraded riparian reaches needing restoration within the city of Boulder's Greenways Master Plan (December 2001). An initial assessment of project feasibility was initiated in 2003 and a Preliminary Restoration Plan pointing to a feasible project was completed in July 2004. A Letter of Intent was prepared by the City of Boulder in July 2004 as well. Funding was received to begin the Feasibility Study in February 2006 and work began on the study.

1.3.3 Relationship to Prior Studies

Two reports, in particular, paved the way for this Ecosystem Restoration Feasibility Study. They were the "Preliminary Restoration Plan Section 206 Goose Creek Restoration, Boulder, Colorado," August 2004, and the City of Boulder's "Greenways Master Plan, December 2001." Additional information on these studies and other studies related to this current effort are noted in Appendix K, "Previous Studies."

2.0 EXISTING CONDITIONS (AFFECTED ENVIRONMENT)

The "existing conditions" of a project site are a basis for projecting future conditions, which in turn are the baseline for measuring effectiveness of the proposed changes that would result from an implemented project. Accurate delineation of the "baseline" and projected future conditions for the environment, engineering characteristics of the site, and social and economic attributes of the community must be completed before measures for improvement are formulated.

2.1 ENVIRONMENTAL CONDITIONS

While having much potential as an aquatic oasis on the semi-arid high plains, the stream can be considered to be degraded by most measures of ecosystem health. Its proximity to urban features negatively affects its ecology while at the same time creating an appreciation for its potential.

The reach of Goose Creek being evaluated for restoration in this study flows through an urban area characterized by office parks, car dealerships and light industry. The stream channel is incised below the flood plain, and the channel is bounded by busy Pearl Parkway and commercial establishments. The location and flow of the main channel is constrained by man-made structures and the fixed locations of tributary inflows entering from storm sewers and drainage pipes. Cottonwood Pond and the existing small wetland at the confluence of North and South Goose Creek were created as a result of gravel mining operations. The pond and wetland are located in the flood plain near the confluence of Goose Creek and Boulder Creek and are bounded by undeveloped land (open space) on the south side and by Pearl Parkway on the north.

The South Goose Creek channel and associated floodplain have been dramatically altered in the study area through changes in the hydrologic regime, natural channel form, and native vegetation communities. The channel is completely artificial and is no longer undergoing natural geomorphic processes. Riparian and flood plain zones associated with the channel are very narrow and are largely disconnected hydrologically from channel interaction. Overall, riparian diversity is low. The diversity is constrained primarily by adjacent land uses (urban/landscaped/mowed) and the lack of a flood plain connection.

2.1.1 Ambient Surface Conditions

2.1.1.1 Climate

The combination of high elevation and mid latitude interior continent geography results in a cool, dry but invigorating climate (Doesken, Pielke, Sr., and Bliss 2003). There are large seasonal swings in temperature and large day-to-night changes. During summer, there are hot days in the plains, often followed by afternoon thunderstorms. Mountain regions are cool most of the time. Humidity is generally quite low which favors rapid evaporation. The thin atmosphere allows greater penetration of solar radiation. At night, temperatures drop quickly, and freezing temperatures are possible in some mountain locations every month of the year. Table 2-1 shows the average climatic conditions of the City of Boulder.

Table 2-1: Boulder Climate Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Max. Temp. (F)	45.5	48.2	53.9	62.7	71.8	81.8	87.6	85.6	77.7	67.1	53.4	47.1	65.2
Avg. Min. Temp. (F)	20.6	23.5	28.0	35.7	44.5	52.8	58.6	57.3	48.9	39.1	28.5	23.0	38.4
Avg. Total Precip. (in.)	0.69	0.77	1.76	2.45	3.04	2.17	1.82	1.65	1.61	1.30	1.21	0.67	19.14
Avg. Total Snowfall (in.)	10.7	10.9	17.8	11.7	1.5	0.0	0.0	0.0	1.5	5.0	13.3	10.2	82.7
Avg. Snow Depth (in.)	1	1	1	0	0	0	0	0	0	0	1	1	0
Percent of possible observations for period of record (8/1/1948 – 12/31/2005). Max. Temp.: 95.4% Min. Temp.: 95.4% Precipitation: 95.7% Snowfall: 95.6% Snow Depth: 92.3%													

Source: Western Regional Climate Center http://www.wrcc.dri.edu

2.1.2 Water Quality

A number of storm water discharges into Goose Creek have degraded water quality. The storm sewer outfall to Goose Creek at 49th Street was classified as having the second worst pollution load in the city; the third worst was a culvert outflow into Wonderland Creek at Foothills Parkway; and a the fourth worst was a culvert upstream at the Transit Village site (Boulder Stormwater Master Plan, 2007). The low quality of the urban storm sewer runoff currently limits the potential species that can thrive in the aquatic ecosystem.

Boulder Creek just below Goose Creek is classified (based on designated use categories) as Water Supply, Recreation 1A, Agriculture, and Aquatic Life Cold Class 1 (CDPHE 2005). The water supply designation means that surface waters are suitable for drinking-water supplies after standard treatment, and are suitable for crop irrigation and for livestock drinking water. Recreation Class 1A is for primary contact, where ingestion of water is likely (swimming, kayaking, tubing, etc.). Class 1 aquatic life waters are capable of sustaining a wide variety of aquatic life, including sensitive species.

Most segments of Boulder Creek below Goose Creek are on the Monitoring and Evaluation list for aquatic life, E. coli, and other parameters. Boulder Creek below Goose Creek does not meet designated uses for water quality (without standard treatment, which does exist as noted in the paragraph above). The reach of Boulder Creek just below Goose Creek is on the 303(d) (impaired) list for E. coli and a Total Maximum Daily Load (TMDL) is required. Further down Boulder Creek ammonia is an issue.

In July 2007, the City of Boulder commissioned Test America Laboratory to test water and sediment obtained from Cottonwood Pond and the adjacent wetland for heavy metals and other containments. The analytical report was submitted to the Corps on August 2, 2007. Table 2-2 summarizes the results. Appendix A-2 contains the complete report.

Table 2-2: Cottonwood Pond Water Quality July 2007

dissolved oxygen	6.9 mg/l to 8.77 mg/l
pH	7.27 to 7.75
Temperature	18.03 to 19.32 degrees C.
turbidity	4 to 4.6 ntu

2.1.3 Vegetation and Habitat

2.1.3.1 Stream

Natural conditions in the watershed can be harsh for fish and other aquatic life. High plains streams are slower moving than mountain streams and are subjected to intense sunlight, causing temperature, dissolved oxygen and pH to vary drastically, especially in late summer. Also, there are many water diversions, so there is less water to dilute pollutants. Nutrient loading is higher due to wastewater effluent, fragmentation of the habitat, and the introduction of non-native fish. Goose Creek and much of adjacent Boulder Creek were channelized for flood control, which removed most pools and riffles. These conditions lead to a relatively low number of native fish species able to survive in the watershed. Wetlands along the stream, or those that the stream must flow through, can serve to improve the quality of water in urban stream systems such as Goose Creek.

South Goose Creek currently maintains some base water flow during periods of no runoff. A large portion of the channel in the project area contains a flat concrete bottom lined by boulders, which lacks sufficient habitat diversity to support abundant aquatic life. There are some small pools that contain small fish. Fish have been observed moving up and down the downstream portion of the channel although water depths are not typically deeper than a few inches.

The bike trail and embankment separating Cottonwood Pond from Goose Creek is a barrier to fish movement except during flood events when sufficient water passes over the structure and through a box culvert. This barrier is located between the North and South Goose Creek confluence and Cottonwood Pond.

2.1.3.2 Wetlands

Wetlands in the study area were impacted by several factors. Gravel mining erased historic oxbow depressions. Channelization precluded the meandering that could create new oxbows. Levees reduced flooding which could provide water to wetlands. From interpretation of aerial photos from 1937, 1958, 1972 and 1982 it appears that oxbow and depressional wetlands of approximately 8 to 24 acres historically occupied part of a larger riparian and wetland corridor. Figure 2-1 is a 1937 aerial photograph showing historic meandering and wetlands. The methodology of the historic wetland delineation is in Appendix A.

Today, at the lower end of the southern channel of Goose Creek (confluence of North and South Goose Creek) there is a large cattail stand of about 1.7 acres with some open water that receives inflows from both Goose Creek channels as well groundwater inflow. It is thought to have developed during the gravel mining activities that created Cottonwood Pond. About 70% of the

wetland is vegetated with predominately cattails, with some coyote willow and a little wooly sedge. Open water covers the remaining 30%. The wetland provides high value for several functions, including flood storage/flood flow alteration (it receives storm water runoff and can store a significant volume of water), sediment trapping/retention, nutrient retention, food chain support, and passive recreation. It does not function for groundwater recharge, but it does provide moderate value for groundwater discharge, shoreline stabilization, fish habitat/aquatic diversity, and wildlife habitat.

The Hazardous, Toxic and Radiological Waste (HTRW) assessment, performed by the Corps in 2009 (Section 2.2.3 and Appendix K), revealed that contamination of the wetlands from the nearby Syntex Chemicals Inc. (pharmaceutical manufacturing company) site would be unlikely. Current threats to that wetland ecosystem include: invasion of noxious weeds and other alien plant species; water quality issues, including runoff from nearby paved surfaces; and increasing human and pet use.

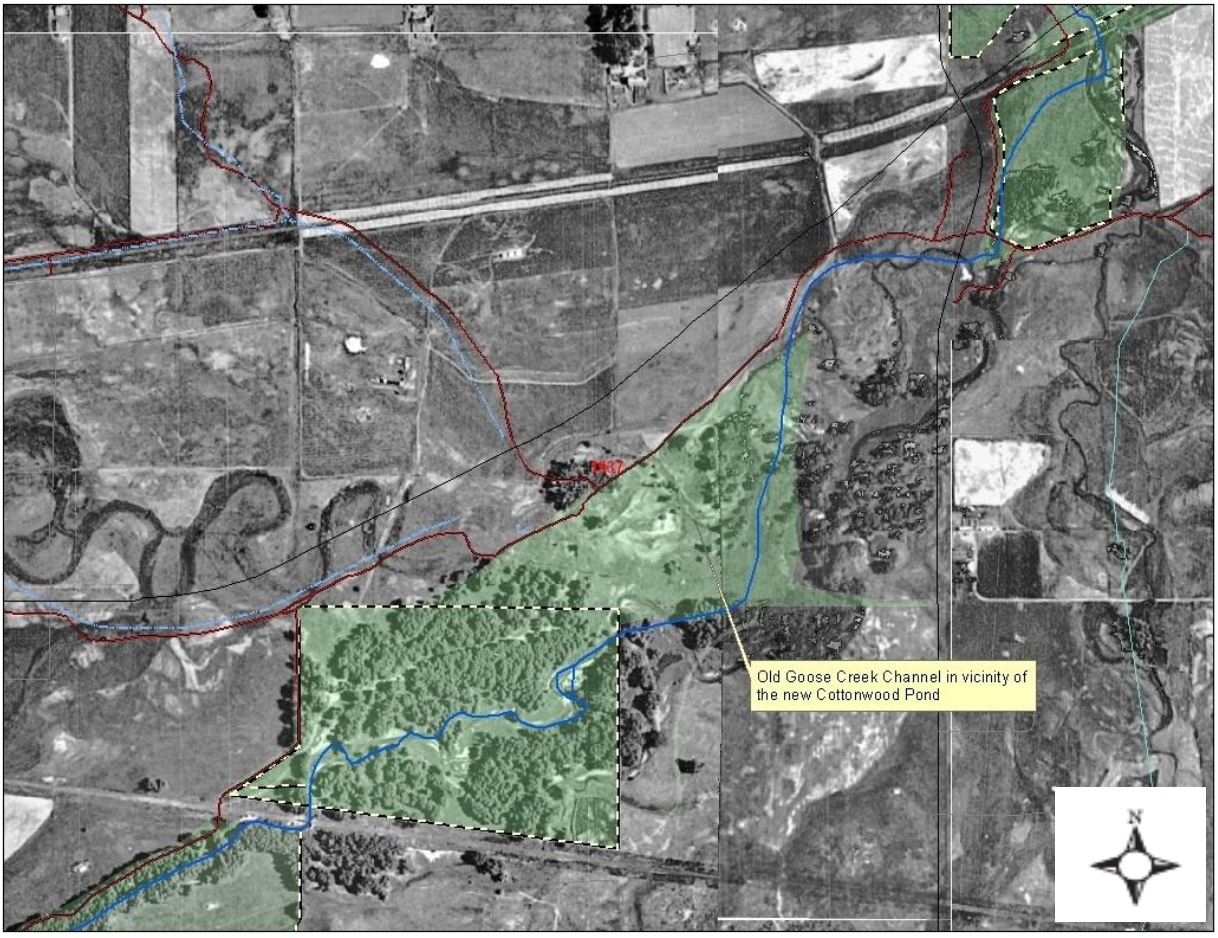

Figure 2-1: 1937 Aerial Photo of Lower Goose Creek before Cottonwood Pond Excavation

2.1.3.3 Cottonwood Pond

Cottonwood Pond is a 7-acre pond that lies between the confluence of North and South Goose Creek and Boulder Creek. It was created as the result of gravel mining in the Boulder Creek

floodplain. This activity obliterated an existing riparian woodland and wetland area at the location of present-day Cottonwood Pond (See Figure 2-1).

Cottonwood Pond fish habitat includes submerged vegetation and a combination of deep and shallow water habitats. However, there is a fabri-dam barrier to fish passage at the outlet of the pond where it reaches Boulder Creek. During low-flow periods, fish are prevented from passing between the pond and the creek. This feature is constructed of geo-fabric and "T" posts and is temporary in construction and can be removed if desired. The purpose of this barrier is to reduce the spread of Eurasian water milfoil from Cottonwood Pond to Boulder Creek. Much of the shoreline of Cottonwood Pond lacks shaded habitats with the exception of some non-native Russian olive trees. Other items that marginally limit wildlife use are limited depth range, little shoreline variation, and low overall vegetation shoreline protection. The vegetation that is present on site provides some shoreline protection and wildlife cover value; however, this value is limited due to lack of diversity. Overall, Cottonwood Pond offers some quality habitat available for local native vegetation. The presence of exotic/invasive species, primarily Eurasian water milfoil, Russian olive and brome grass, greatly reduces the habitat quality within this area, limiting wildlife usage.

2.1.3.4 Riparian

The floodplain habitat bounding South Goose Creek is predominately urban. There is little natural floodplain habitat, except for the reach downstream from Reynolds Corner which is incised through open space. Pearl Parkway, a heavily-traveled urban road with associated connector roads, bounds South Goose Creek in the floodplain along its entire reach. Parking lots, car dealerships and a business park also bound the South Goose Creek riparian area. Additionally, a concrete bike trail extends along the right bank for much of the stream length in the project area.

In the right bank reach downstream of Reynolds Corner, urban impacts are less severe in the surrounding floodplain, but it is a highly disturbed utilities corridor. Notable features of this reach include a concrete bike trail, dirt "social" or eroded dirt bike trail, storm sewer drainage access ports, prairie dog colonies, and crack willow trees.

The city of Boulder's Tributary Greenways Program Riparian Habitat Assessment Vegetation Evaluation Report provided a vegetation assessment (Gershman, 1999). The assessment identified plant species composition for the entire Greenways Program and provided a general characterization of the project area. Vegetation along South Goose Creek is predominantly herbaceous non-native species at the upstream end, which parallels Foothills Parkway. The vast majority of the common herbaceous species are weedy exotics, consisting of bounding bet and Canada thistle. The portion near the automobile dealerships is landscaped grass and shrub area. Ground cover consists mostly of exotic pasture grasses (smooth brome, orchard grass, fall fescue and quack grass) and landscaping trees and shrubs include Russian olive, apple, black locust and privet. Other common tree species consist mostly of saplings, represented by natives such as plains cottonwood, peach-leaved willow and box elder and exotics such as Chinese elm and green ash. Sprinkler systems have been installed at several locations along the channel to maintain the non-native grass and ornamental vegetation.

The 1999 Gershman report estimated native plant habitat to be poor to very good, bird habitat to be very poor to good and vegetative bank stability to be poor to fair, depending on specific location around South Goose Creek (Gershman, 1999).

2.1.4 Wildlife

2.1.4.1 Stream and Pond

Non-native rainbow, brown and brook trout are the principal fish species in the mountain streams of the watershed and within the city of Boulder. Fathead minnow and johnny darter were associated with glide habitat; longnose dace and longnose sucker were associated with riffle habitat (Zeullig, 2001). The dominance of glide habitat was associated with the presence of fewer species.

Zuellig's study (2001) also included sampling of the fish and macroinvertebrates of lower Goose Creek. Stream width was a minimum of 2.04 meters (6.7 feet) and maximum of 5.05 meters (16.6 feet). Depth ranged from 0.01 to 0.1 meters (0.4 to 4 inches) during the study (but is often more during thunderstorms). The riparian area ranged from 0.4 to 0.75 meters (1.3 to 2.5 feet) wide. Of the habitat variables investigated, glide habitat, - which is often created by storm water projects by straightening, deepening and widening the stream channel to increase the efficiency of flow during high water events - was associated with tolerant organisms (mayflies and caddisflies). Glide habitat often has non-turbulent flow with low-to-moderate constant velocity and lacks features associated with pools. Percent of glide habitat ranged from 81 to 100%, and riffles ranged from 0 to 19%. Within the creek itself, there was no pool habitat. Nor were there any areas of undercut bank, woody debris or root wads.

Zeullig's results (2001) reported fathead minnow and white sucker were the only two species found in Lower Goose Creek, both in plentiful quantities. Macroinvertebrates in Lower Goose Creek ranged to a high of 26 species, dominated by midges, tubifex worms, snails, amphipods, bivalves and crayfish, with little representation of mayflies or caddisflies. The dominant macroinvertebrate groups are often associated with degraded streams and were associated with sites that have high percent glide habitat and low percent pool habitat. For example, an increased ratio of aquatic worms or midges to other aquatic insects can be indicative of nutrient enrichment or low dissolved oxygen, or a decrease in mayflies can indicate sedimentation (Plafkin et al, 1989; Rosenberg and Resh, 1993; Klemm et al, 1990). The reported a Habitat Quality Index (HQI) score of 65 out of 260, which might be explained by the presence of mostly tolerant taxa that can exploit a wide range of habitat types.

Cottonwood Pond supports aquatic life, including fish (primarily game fish), but is greatly limited by a severe infestation of Eurasian water milfoil. Migration of aquatic species is also limited between Cottonwood Pond and Boulder Creek due to the fabri-dam, installed to restrict the spread of Eurasian water milfoil.

In addition to brook trout, non-native species threatening ecosystems in Boulder Creek include Eurasian water milfoil and New Zealand mud snail. A native species of algae (the *diatom Didymosphenia geminata*) is also affecting Boulder Creek.

2.1.4.2 Riparian

According to a bird inventory, which was conducted by the city of Boulder as part of the Tributary Greenways Program Riparian Habitat Assessment (Stone, 1999), the project area was considered to be a "cold spot" in terms of its very low bird biodiversity scores.

Wildlife species found in the project area consist of species tolerant of human presence including coyote (*Canis latrans*), black-tailed prairie dog (*Cynomys ludovicianus*), beaver, and various bird species. There is a prairie dog colony located within the project area, which is protected by state and local regulations and policies.

Prairie dogs inhabit both banks of South Goose Creek and both sides of North Goose Creek intermittently. Between site visits in May 2006 and September 2006, the prairie dog colonies had spread into areas that had not been inhabited during the earlier site visit, including the south bank of the stream and the area between Cottonwood Pond and the bike trail. Vegetation within the colonies consists of invasive grasses, weedy forbs and other non-native herbaceous plants. Vegetation in densely populated colonies is overgrazed, and plant species diversity is low. The city of Boulder has in place screens to prevent the prairie dogs' visual access to adjacent areas. The screens are intended to prevent colonization of new areas. The city of Boulder Urban Wildlife Management Planning Plan emphasizes humane, non-lethal control of wildlife. During a field inspection, a single mink (Figure 2-2) was observed within the project area near Cottonwood Pond. It is likely that this is an area resident, perhaps migrating between Boulder Creek and Goose Creek. While prairie dogs are not typically part of a mink's diet, since the colony occurs in the mink's traditional habitat, they have most likely become a food source. Mink also prey on muskrats and supplement their diet with fish, frogs, crayfish, snakes, birds and other rodents. Females stay within 30 acres of the den site; which usually consists of log cavities, stumps, or cavities under tree roots. Male mink will travel twice the distance as females from the den site. The presence of mink is an indicator that there is adequate shoreline vegetation and a reliable food source nearby, although urban areas present particular challenges to mink due to extensive channelization and vegetation removal.

Figure 2-2: Mink along West Shoreline of Cottonwood Pond

2.1.5 Threatened and Endangered Species

Two federally listed species are known to occur in nearby riparian habitats in the Boulder, Colorado, area and could potentially occur in the project area. These are the Preble's meadow jumping mouse (*Zapus hudsonius preblei*) and Ute ladies' tresses orchid (*Spiranthes diluvialis*). Both are threatened species under the provisions of the U.S. Endangered Species Act. A recent vegetation study (Gershman, 1999) observed no suitable habitat for either species within the project area in its current condition. This was confirmed during a site visit by a USFWS official (Plage, personal communication, 2008).

2.1.5.1 Preble's Meadow Jumping Mouse

The Preble's meadow jumping mouse is found in foothills riparian habitat from southeastern Wyoming to south-central Colorado, including the nearby South Boulder Creek watershed. It inhabits dense, herbaceous riparian vegetation that may have an over story canopy layer with a fairly dense combination of grasses, forbs and shrubs. They routinely use wetlands and prairie buffer grasslands adjacent to riparian habitat. They may be dependent on some open water nearby. The species are usually captured in areas with multiple-storied cover in an understory of grasses and/or forbs. Willow is often the shrub canopy, but it may also consist of snowberry (*Symphoricarpos sp.*), chokecherry (*Prunus virginiana*), hawthorn (*Crataegus sp.),* Gambel's oak (*Quercus gambelli*), alder (*Alnus incana*), river birch (*Betula fontinalis*), skunkbrush (*Rhus trilobata*), wild plum (*Prunus americana*), lead plant (*Amorpha canescens*), dogwood (*Cornus sericea*) and others (USFWS, 2003).

Various vegetation types on the adjacent uplands are used by the mouse, ranging from open grasslands to ponderosa pine woodlands. A fairly dense combination of grasses, forbs and shrubs appears to be ideal. Shrub patches set back from the drainage and downed woody debris have been used, as have riparian patches with thick cover that are interspersed with more open patches (USFWS, 2003). It is thought that plant richness and sub-shrub cover are primary factors in mouse habitat utilization. Hibernation nests have been found under the shrubs mentioned above, as well as under sumac, thistle, and alyssum. Seasonal streams, low moist areas, dry gulches, agricultural ditches and wet meadows and seeps near streams are some features providing habitat for the mouse. They have been found in habitat ranging from large perennial rivers to small ephemeral drainages 3 to 10 feet in width.

2.1.5.2 Ute Ladies' -Tresses

Most occurrences of the Ute ladies'-tresses are along riparian edges, gravel bars, old oxbows, and moist-to-wet meadows along perennial streams, but they can also occur near freshwater lakes or springs. They seem to need permanent sub-irrigation in floodplain areas where the "water table is near the surface throughout the growing season and into the late summer or early autumn." They colonize early successional riparian habitats, and the orchid persists in those areas where continual dampness is maintained in the rooting zone throughout the growing season. They grow primarily in areas where the vegetation is not dense and is relatively open, but some are found in riparian woodlands (USFWS, 1995).

Soils supporting the Ute Ladies' Tresses orchid usually range from fine silt/sand to gravels and cobbles, but the orchid is sometimes found in highly organic or peaty soils. It tolerates flooding and flood disturbances and other water movement through floodplains over time. Some of the naturally wet meadows or those that are irrigated where the orchid has been found are currently grazed (late winter/early spring) or mowed for hay.

One of the easternmost large populations of orchid exists in mesic riparian meadows of relict tall-grass prairie and irrigated pastures near South Boulder Creek at the southeast edge of the city of Boulder. The City of Boulder Open Space Department manages Colorado's largest population of the Ute ladies'-tresses by restricting the use of chemicals and using integrated weed management (biological control, late spring grazing) in the area of known orchid habitat and retaining/monitoring the effect of agricultural activities such as grazing, irrigation, and haying. It appears that the orchid persists in a floodplain meadow that is grazed each year from February to May, is irrigated in the spring and early summer, and is mown in the summer starting in July. The Greenways Master Plan also notes that the orchid is found in nearby wetlands adjacent to Pearl Street Business Park in the Boulder Creek reach between Goose Creek and Foothills Parkway. The Recovery Plan for the Ute ladies'-tresses identifies Boulder Creek as a key watershed encompassing an important regional population of the species.

2.2 ENGINEERING BASELINE CONDITIONS

Restoration of the riparian environment in an urban area presents unique challenges. These challenges serve as constraints on an urban ecosystem restoration project and are discussed as such later in this report. Among them is the need to avoid costly impacts to existing infrastructure. Care must be taken that the project does not increase flood elevations, lead to the

erosion of roadway embankments or otherwise damage infrastructure or property. Any impacts to infrastructure would need to be mitigated and would be a significant cost to the project, which, in turn, would decrease the cost-effectiveness of the restoration measures.

2.2.1 Hydrology and Hydraulics

The purpose of the hydraulic analysis is to make sure that the ecosystem restoration features are compatible with the forces exerted by a range of flows in the stream and that these features do not increase flooding on nearby property. Existing conditions relative to flood behavior on South Goose Creek were defined by previous hydrologic and hydraulic analysis which was performed to define the floodplains and floodways within the city of Boulder.

2.2.1.1 Discharge Frequency

Hydrologic analysis for the Flood Insurance Study (FIS) was completed using the Denver Urban Drainage and Flood Control District's (UDFCD's) CUHP-B hydrologic analysis program for determining the hydrograph and routed with USACE HEC-1 through the reach. The total drainage area for Goose Creek at the confluence with Boulder Creek is 5.46 square miles.

As seen in Figure 2-3, just above Foothills Parkway, Goose Creek bifurcates into North and South Goose Creek. The inverts of the culverts to the South Goose Creek channel are set lower than those for North Goose Creek, and thus the initial flood rise on Goose Creek goes into South Goose Creek. There is more culvert capacity beneath Foothills Parkway feeding North Goose Creek, so once the flood flows get larger, ultimately the North Goose Creek flood control channel carries the most flow from upstream portions of the Goose Creek watershed. Wonderland Creek joins the North Goose Creek flood control channel upstream of Pearl Parkway and the wetland upstream of Cottonwood Pond. Wonderland Creek contributions are lumped into the North Goose Channel discharges without a listed flow change in the original FIS table shown as Table 2-2 in this report. No attempt was made to separate the Wonderland Creek flows in this study.

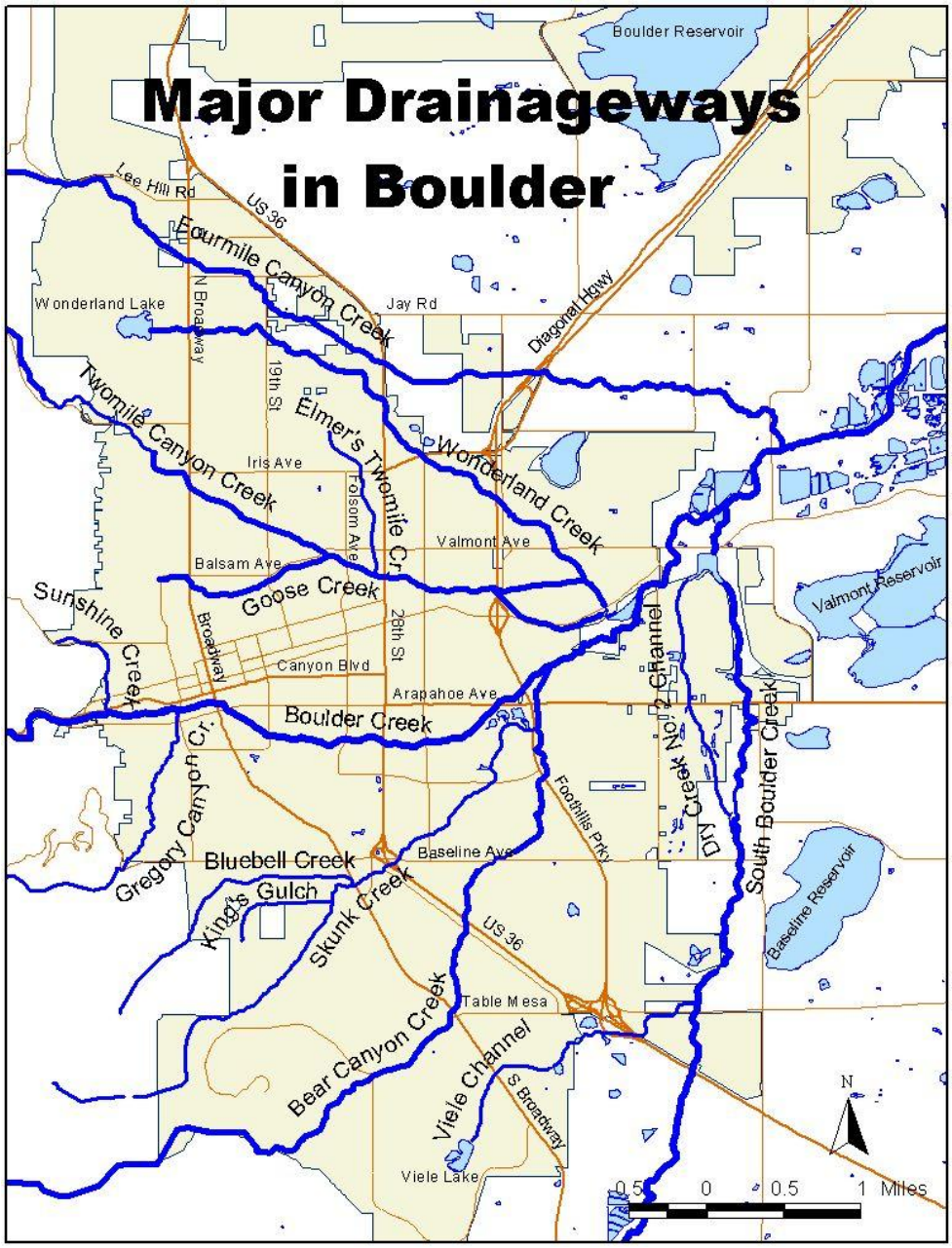

Figure 2-3: Major Drainageways in Boulder

The split flows are accounted for just below Foothills Parkway at the North and South Goose Creek channel diversion structure. This was done by optimizing the flows for the 10- and 50-year (0.1 and 0.02 annual chance of exceedance) floods through the two sets of box culverts under Foothills Parkway in the HEC-RAS model. For this study, the 100 and 500-year (0.01 and 0.002 annual chance of exceedance) discharges were not reevaluated, as changes in those higher discharges could imply a floodplain different than the one shown on the regulatory floodplain maps. A review of the FIS was beyond the scope of this ecosystem restoration study effort. Additionally, the performance of the ecosystem restoration project is relatively insensitive to minor changes in the stage and velocity of floods, once they spread out across the entire

floodplain. In the original FIS, North Goose Creek discharges had been set at the 100-year event for the north channel, which was not correct for the more frequent floods. The peak discharges for a range of flood events are located in Table 2-3.

Table 2-3: Flood Discharge-Frequency Distribution for Goose Creek (cfs)

GOOSE CREEK AT BOULDER, CO				
RETURN PERIOD	10-YR	50-YR	100-YR	500-YR
ANNUAL EXCEEDANCE PROBABILITY	0.1	0.02	0.01	0.002
LOCATION				
Goose Creek upstream of Foothills Parkway	1050	2100	2680	4300
North Goose Creek Flood Channel (Incl. Valmont Creek)	1510	2855	3865	6075
South Goose Creek	1355	2180	2450	3250
Goose Creek at Confluence with Bolder Creek	2865	5065	6315	9325

2.2.1.2 Existing Conditions Hydraulic Model

A hydraulic study was conducted on South Goose Creek in order to establish the baseline condition in order to make sure that features of the ecosystem restoration project did not induce flood damages on surrounding property. The hydrology and hydraulic models were prepared for a Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) that was completed in 2002. That study used information from surveys completed in 1989.

The hydraulic modeling was conducted to define existing conditions of Goose Creek within the city of Boulder. The hydraulic modeling effort extended from near 30th Street to the confluence with Boulder Creek, a reach of approximately 1.5 miles in length. Computations were performed to evaluate stages and confirm flood boundaries for existing conditions. Flow rates and water surface profiles for the study reach were computed using the standard step backwater program HEC-RAS. Computations were performed for a range of flow events. Split flow data from the previous FIS has been employed to separate flows between the North and South Goose Creek channels. Goose Creek occupies a narrow corridor through the city, and any future development should have little impact on the Goose Creek peak 100-year (0.01 annual chance of exceedance) flow rate through Boulder given that the basin is already urbanized. Results of the with-project condition analysis may be found in Section 8.11, which discusses floodplain impacts. A detailed description of the Hydraulic Analysis can be found in Appendix G.

The results of the baseline hydraulic analysis are summarized as follows:

- Comparison to the existing FIS data indicates the HEC-RAS model performs satisfactorily and may be used as an effective base model to analyze the impacts of project alternatives.
- The 100-year (0.01 annual chance of exceedance) water surface profile comparison between models can be viewed on Table 4 of Appendix G, the Hydraulics appendix.
- For the 100-year event, the existing South Goose Creek channel is designed to maintain all discharges within its banks until it approaches its confluence with Boulder Creek and Cottonwood Pond. All channel modifications must maintain this condition.

- FIS Flood outlines for the 100-year event are illustrated in Figure 2-4.
- Full hydraulic calculation variables and outputs are included in Appendix G.

2.2.1.3 Floodplain Mapping

Floodplain and floodway boundaries have been defined by the Federal Emergency Management Agency. The most recent Flood Insurance Study for Boulder County, including the Goose Creek study reach in Boulder, was completed in 2002. Floodplain mapping for the Goose Creek Watershed, and the delineation of current flood elevations for the 10,50, 100 and 500-year (0.1, 0.02, 0.01 and 0.002 chance of annual exceedance) flood events in the project area provided a constraint on the ecosystem restoration project, in that the water surface elevations, post project, could not exceed those under existing conditions, without compensation for damages being required. Since the entire project is within the floodplain, and most of it within thee floodway, the floodplain zone delineations also impacted the value of the real estate LERRDs credit in this urbanized setting. The portion of the floodplain map depicted in Figure 2-4 is from that study.

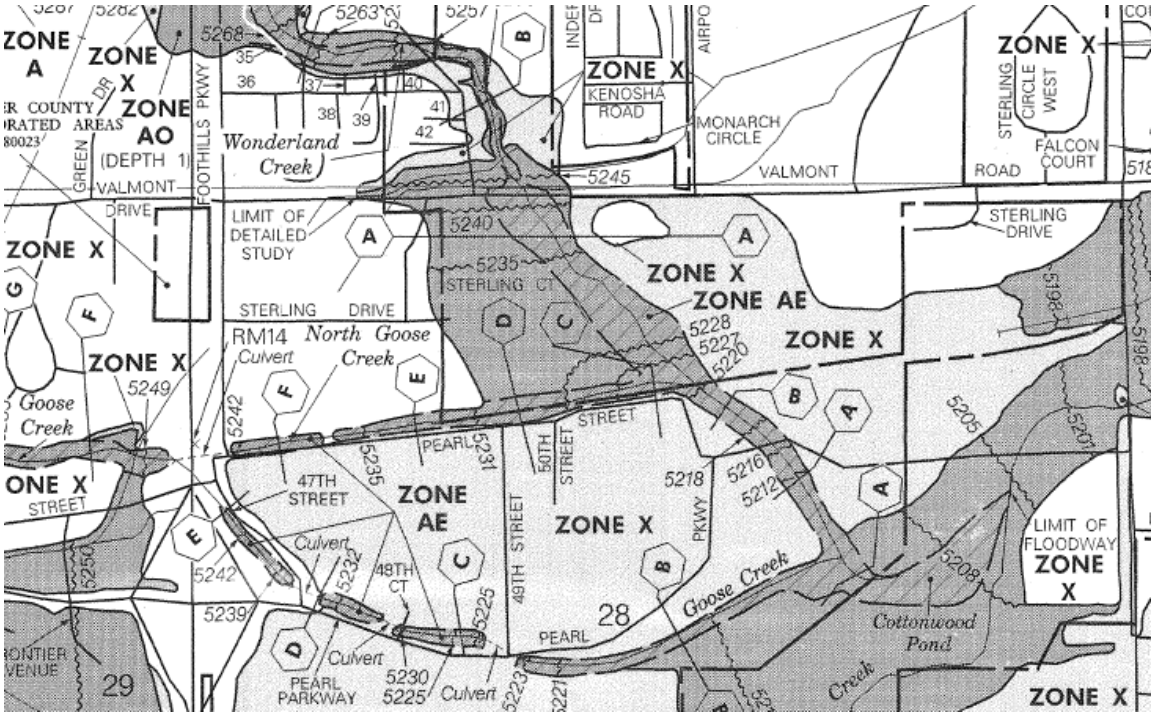

Figure 2-4: Flood Plain Delineation Along Lower Goose Creek

2.2.1.4 Channel Stabilization and Grade Control

The South Goose Creek channel and associated floodplain has been dramatically altered within the study area in terms of hydrologic regime, natural channel plan form, and native vegetation communities. The channel is completely artificial and is not being shaped by natural geomorphic processes. Riparian and floodplain zones associated with the channel are very limited and disconnected from channel interaction.

In the late 1980s, Goose Creek was modified for flood flow conveyance by the city of Boulder in cooperation with Denver's Urban Drainage and Flood Control District (UDFCD), an organization developed for the purpose of assisting local governments in the Denver

metropolitan area with multi-jurisdictional drainage and flood control problems. The goal of the project was to constrain South Goose Creek to a fixed channel and prevent damage to nearby roads and other infrastructure. These efforts have proved to be effective, but also contribute greatly to the lack of a natural riparian environment along South Goose Creek. An example of grade control and channel stabilization measures in South Goose Creek is shown in Figure 2-5.

Figure 2-5: South Goose Creek Channel Stabilization and Grade Control Measures

Presently, UDFCD is responsible for the maintenance of the Goose Creek channels to continue flood conveyance. North Goose Creek was constructed as an overflow channel to reduce flows on the urbanized south channel. Both branches were channelized between property lines, roadways, and encroaching utilities. The cross sections of the channels were made trapezoidal to convey flows through the channels as quickly as possible. All native vegetation was removed from the channels, and the banks were replanted with grasses, many of which are non-native species. A number of vehicle crossings and boulder edging of the low-flow channel were constructed (the boulder edging has recently been removed from the north channel). The south channel also had a concrete lining installed for the low-flow channel. The profiles of the channels were altered to have a very flat gradient for stretches with boulder and concrete drop structures at intervals to dissipate the hydraulic energy of flood flows. The channel does not maintain a continuous open-water low-flow channel to Boulder Creek due to the barrier (with the bike trail) at the inlet to Cottonwood Pond.

The Boulder and White Rocks Ditch (BWR) was constructed near the start of the 20th century and crosses the Goose Creek Watershed. Until recently, Goose Creek itself was cut off and routed through the Boulder and White Rocks ditch. The ditch diverted all of the native Goose Creek flows at the present Folsom Street location, and the creeks were likely dry for extended periods of the growing season. Currently, the first 26 cfs of water flowing in Goose Creek is diverted into the BWR ditch before any additional flows are passed downstream into the project reach. The BWR is lined with concrete, thus reducing the potential for return flows from the ditch to the creek channels.

The creek is in a very urbanized area and storm-produced discharges run directly into the channel. This increased the flooding frequency and peak flows compared with the expected natural flow regime. As a result of urbanization and irrigation demand, the current channel function is primarily flood conveyance, and it has been channelized to efficiently perform this function. To prevent down-cutting, or incision associated with channelization, grade controls have been placed in the channel bed. To prevent the bank erosion associated with the incision process, the banks have been artificially hardened. South Goose Creek lacks a base flow from upstream reaches, an active floodplain connection, riparian zone, and provides limited support for aquatic life.

2.2.2 Soils and Groundwater

2.2.2.1 Physiography, Geology, and Soils

This section contains information on the general physiographic and subsurface conditions that influence the Goose Creek ecosystem. Additional information on geology, soils and the potential ecosystem and engineering implications of subsurface conditions can be found in Appendix E.

Emerging gradually from the plains of Kansas and Nebraska, the high plains of Colorado slope gently upward for a distance of some 200 miles from the eastern border to the base of the foothills of the Rocky Mountains (Doesken, Pielke, Sr. and Bliss, 2003). The eastern portion of the State is generally level to rolling prairie broken by occasional hills and bluffs. Although subtle when compared to the high mountains of the Rockies, there are also important topographic features across eastern Colorado. The South Platte River is the major river valley dissecting northeastern Colorado. Boulder Creek is a tributary to the South Platte River. Goose Creek is a tributary to Boulder Creek.

Northeastern Colorado is generally considered as the territory stretching northward from Denver and eastward from the east flank of the Rocky Mountains, a north-south line that divides the State into approximately equal halves. It includes a narrow strip of hogback foothills, a large part of the Colorado Piedmont, and a considerable portion of the High Plains (Mather et al, 1928). The City of Boulder is located at the edge of the foothills region, with most of the city spread out across the adjacent high plains.

The Goose Creek watershed lies at the base of the foothills and the channel meanders across the gravel-rich alluvium that was created over time by flood discharges from the canyons of the Boulder Creek watershed. According to the Boulder Stormwater Management Plan (2007) the

city of Boulder's "underlying geologic unit is classified as young quaternary deposits of stream gravels and sand, slope wash, terrace gravels and landslides." Surface soils are characterized as "poorly cemented and unconsolidated sands and gravels."

The regional geology of the high plains of northeastern Colorado is dominated by a broad structural depression known as the Denver/Julesburg Basin. Boulder is located on the western edge of the basin. In the vicinity of Goose Creek, the surficial geology is primarily Holocene Piney Creek Alluvium and Broadway Alluvium (USGS, 2005). The Piney Creek Alluvium consists of dark gray, humic sandy to gravelly alluvium containing organic matter such as roots. It typically underlies terraces whose surfaces are 10 to 20 feet above the floodplain. The upper part is characterized by weakly developed brown soil that grades into colluvium upslope and are not usually covered by flood waters (Colton, 1978). The Pleistocene Broadway Alluvium is typically 50% sand, 25% granules and 25% pebbles deposited by streams and may locally contain gravels (Colton, 1978). Below the alluvium lies the Upper Shale Member of the Pierre Shale, and is evidenced by several outcrops in the area. This rock is typically gray, concretionary silty shale.

According to the USDA Natural Resource Conservation Service (NRCS), two soil types, Niwot and Loveland soils, occur in the area. The NRCS's Web Soil Survey website (http://websoilsurvey.nrcs.usda.gov/app/) provides soil types and characteristics for the upper surface soils (soils to a depth of 5 ft.). In the study area, the upper soils are classified by the NRCS as Niwot soils, with the exception of the northern 1/3 of the Cottonwood Pond north shoreline area and the northern corner of the riparian wetland where the upper soils are classified as Loveland soils. Niwot soils are defined as loam (clay, silt, and sand) for the upper 14 inches and gravelly sand from 14 to 60 inches below ground surface. Loveland soils are defined as clay loam for the upper 11 inches; clay loam, silty clay loam, and loam from 11 to 30 inches; and very gravelly sand, gravelly sand, and gravelly coarse sand from 30 to 60 inches below ground surface.

Niwot soils have a 0 to 1% slope, have a depth to restrictive feature of more than 80 inches, and are classified as poorly drained. This soil type is found in areas of occasional flooding, such as the Goose Creek and Boulder Creek floodplains, and has a low available water capacity (about 4.4 inches). The parent material is loamy alluvium. The presence of this soil is indicative of a wet meadow type setting. Loveland soils have a 0 to 1% slope with a depth to restrictive feature, such as bedrock, of more than 80 inches and are classified as poorly drained. This soil type occurs in areas of occasional flooding and has a very high available water capacity (about 17.4 inches). It is of non-saline to very slightly saline (2.0 to 4.0 mmhos/cm) and is approximately 15% calcium carbonate. Soil maps and additional data can be found in Appendix E.

2.2.2.2 Regional Groundwater

Water table elevations generally range from 5,600 feet mean sea level (msl) at the western edge of Boulder to 5,190 feet msl northeast of the city. Groundwater flow is controlled locally to some extent by several streams in the area, including Boulder Creek and South Boulder Creek. The bedrock in the area generally yields small amounts of groundwater of varying quality. Table 1 of Appendix E indicates the general groundwater properties of the various rock units of the area. The primary groundwater sources in the area are from the Laramie Formation and

unconsolidated deposits of alluvial origin. The Laramie Formation yields low to moderate quantities of water that is generally considered soft. The unconsolidated alluvial deposits yield moderate to large quantities of water. In either event, water quality and quantity generally decreases with depth and distance from the source.
The project area receives a minor amount of inflow from the groundwater table and is generally considered to be a "gaining reach" as far as base flow. Base flow during the spring may be supported by seasonal perched water tables. Man-made runoff, such as storm sewer inflows resulting from over-watering of lawns and other urban uses also provide flow to Goose Creek.

2.2.2.3 Channel under Drains

Included in the design of UDFCD's South Goose Creek flood conveyance project was the construction of an under-drain system beneath the concrete-lined channels. The under-drain system consists of twin 6" or 8" perforated polyvinyl tubing spaced at various distances apart, and buried approximately 2-5 ft below the invert elevation of the concrete-lined trickle channel. The under-drain system was designed to lower the water table for construction and for future maintenance of the project. More information about this system is provided in the Geotechnical Appendix (Appendix E).

2.2.3 Hazardous Waste

An analysis was performed regarding the potential for encountering hazardous, toxic and radiological waste (HTRW), within the project area. No evidence of hazards that could impact efforts to restore the ecosystem of South Goose Creek and Cottonwood Pond was found. This analysis was conducted on the basis of a site visit, correspondence with key personnel with knowledge of the site and a query of environmental databases. More details of this investigation are contained in a separate report entitled "Environmental Condition of Property, Goose Creek Boulder, Colorado (2009), which is contained in Appendix K.

2.3 COMMUNITY BASELINE CONDITIONS

2.3.1 Socioeconomic

The population of the city of Boulder, Colorado was 97,385 in 2010, up from 94,673 in 2000 (U.S. Census Bureau, 2011). In 2006-2008, the median age in Boulder was 29.4 years. In 2006-2008, about 95% of Boulder residents at least 25 years old had graduated from high school, and 68.9% had at least a bachelor's degree. The median household income in 2008 was $52,277; the median family income was $92,437; and the per capita income was $37,380. In 2008, 6.5% of families and 20.6% of individuals lived below the poverty level. The city of Boulder had 40,882 housing units in 2008, of which 19,235 were owner-occupied homes with a median value of $471,700 (U.S. Census Bureau, 2010a), and by 2010 the number of housing units had risen to 43,479. Ethnic composition in 2010 was 88% White, 8.7% Hispanic or Latino (of any race), 4.7% Asian, 0.9% African-American, 0.4% Native American, 0.1% Native Hawaiian or Other Pacific Islander, 3.2% some other race, and 2.6% two or more races (U.S. Census Bureau, 2011).

The population of Boulder County, Colorado was 294,567 in 2010, up from 291,288 in 2000 (U.S. Census Bureau, 2011). The total acreage in Boulder County is 474,320 acres, and

approximately 65% of the county's land is publicly held. The number of housing units in Boulder County was 124,087 in 2008 (U.S. Census Bureau, 2010b), and the number of housing units had increased to 127,071 by 2010 (U.S. Census Bureau, 2011). The 2007 median age in Boulder County was 35.8 years (U.S. Census Bureau, 2008). Ethnic composition of Boulder County residents in 2010 was 87.2% White, 13.3% Hispanic or Latino (of any race), 4.1% Asian, 0.9% African-American, 0.6% Native-American, 0.1% Native Hawaiian or Other Pacific Islander, 4.5% some other race, and 2.7% two or more races (U.S. Census Bureau, 2011). Approximately 94% of the county's residents at least 25 years old in 2006-2008 were high school graduates, 58% held a Bachelor's degree or higher, and 24% held a graduate degree. The 2006 median area income for a family of four was $81,600 and the per capita income was $45,944. The 2007 poverty level for a family of four in Boulder County was $20,650; approximately 11.8% of individuals and 6% of families lived below the poverty level (U.S. Census Bureau, 2008).

2.3.2 Cultural Resources

A file search at the Colorado Historical Society revealed no Historic Properties recorded within the Area of Potential Effect (APE) for the proposed South Goose Creek and Cottonwood Pond project. In addition, a preliminary evaluation was made by the State Historic Preservation Officer (SHPO) of the State of Colorado Historical Society, and described in a letter dated November 2, 2007. The SHPO opined that the potential for locating historic properties within the APE was low, and that an archeological survey was not required. This letter is contained in Appendix C.

2.3.3 Recreational Resources

Recreational facilities are extremely important in Boulder and are heavily used. Recreation within the project area consists of bike trails and access to Cottonwood Pond and Boulder Creek.

2.3.3.1 Recreational Facilities

A system of interconnecting bicycle/pedestrian trails covers the city of Boulder, Colorado. The Boulder Creek Trail runs adjacent and parallel to the Corps' proposed Aquatic Ecosystem Restoration project, and connects North Goose Creek Trail and the trail along Foothills Parkway. The trails receive high visitor use. Boulder Creek Trail use adjacent to the project was estimated at over 288,000 visitor-days per year.

The Boulder Creek Trail, a concrete bicycle/pedestrian trail approximately 10 feet wide, traverses most of the project area adjacent to South Goose Creek and also the north side of Cottonwood Pond. The trail links up with other trails in the city of Boulder's trail system. It runs generally along Boulder Creek but diverges near the Reynolds Corner mini-park/rest area to also run along South Goose Creek. Reynolds Corner consists of naturalistic, semicircular seating ideal for interpretive presentations to small and medium-sized groups and a nearby drinking fountain. A two-block-long break in the trail occurs on the north side of Pearl Parkway; in this segment, trail users wishing to remain on a hard surface cross to the south side of the street and use the sidewalk. At Foothills Parkway, the trail intersects other trails that run north (and then east along Pearl Street, near North Goose Creek), south and west through a lighted tunnel under

Foothills Parkway, towards downtown Boulder. A yellow centerline is painted on the trail where needed to minimize user conflicts and increase public safety. Social trails (dirt paths) have been worn by foot traffic from the southwest end of Cottonwood Pond: 1) to the pond's intermittent connection with Boulder Creek; and 2) along the edge of the wooded area to Reynolds Corner. At least two social trail-spurs lead to the banks of Boulder Creek, which likely provide informal fishing access. Shoreline fishing at Cottonwood Pond used to be popular, but very little fishing currently occurs there. Due to the effect of Eurasian water milfoil on the fishery in Cottonwood Pond and the reduced chance of fishing success at the pond, most angling in the Cottonwood Pond area currently takes place on the banks of Boulder Creek near the pond.

2.3.3.2 Existing Annual Recreational Benefits

The dollar value per day of general recreation was estimated for without-project (existing) conditions using the Unit Day Value (UDV) method. Because the amount of fishing at Cottonwood Pond is negligible, point values were assigned based on visitor enjoyment and willingness to pay using the table "Guidelines for Assigning Points for General Recreation." This is Table 6-29 of Engineer Regulation 1105-2-100, Planning Guidance Notebook, dated December 28, 1990; and Table 1 of the attachment to Economic Guidance Memorandum (EGM) 11-03, Unit Day Values for Recreation, Fiscal Year 2011, dated November 5, 2010. The point value of 31 points for existing conditions was established by consensus during conference calls August 17 and 24, 2006, with city of Boulder staff representing the following Departments: Parks and Recreation; Open Space and Mountain Parks; Transportation; and Public Works. The 31 points equated to $5.51 per day of general recreation based on EGM 11-03. With 288,000 annual visitors using the portion of the Boulder Creek Trail that runs adjacent to the project, the annual recreation benefits under existing conditions total $1,586,880.

2.3.4 Real Estate, Utilities and Water Rights

All land within the anticipated project footprint is publically owned. It is either the property of the City of Boulder or of Boulder County. It is anticipated that there will not be a need for acquisition of additional private property to augment the public land to be used in the project. An ownership map of the project area is provided in Figure 2-6.

The Sponsor (City of Boulder) manages much of the project site as greenways and adopted the Greenways Master Plan in December 2001, which outlines land management decisions and maintenance responsibilities. Sponsor holdings in the study area encompass almost the entire project area, consisting of drainage way easements and urbanized lands used for City maintenance facilities. Colorado State Highways owns a portion of the land within a right-of-way (ROW) easement for Highway 157 (Foothills Parkway). There is a significant utility corridor along the south side of Cottonwood Pond. Due to high land values, the Sponsor would voluntarily waive any credit for the Lands, Easements, Relocation, Right-of-way and Disposal areas (LERRD) beyond its cost share needs, and will indicate this in its letter of intent as required for a standard Project Partnering Agreement (PPA). Work on Open Space property may require approval of the Open Space Board of Trustees.

Under current Colorado State law, practices that increase water surface or change use of water could require augmentation of water rights. State Engineer guidance on a similar Section 206

project in the area is that restoration of wetlands up to a surface area less than or equal to historic acreage would not require water rights unless there is a change of use. Coordination with the State Engineer is ongoing for the Goose Creek Project through the public draft of the report and public involvement through the NEPA process. The Sponsor is aware that they would be required to provide any augmentation water rights required as a real estate component of the project.

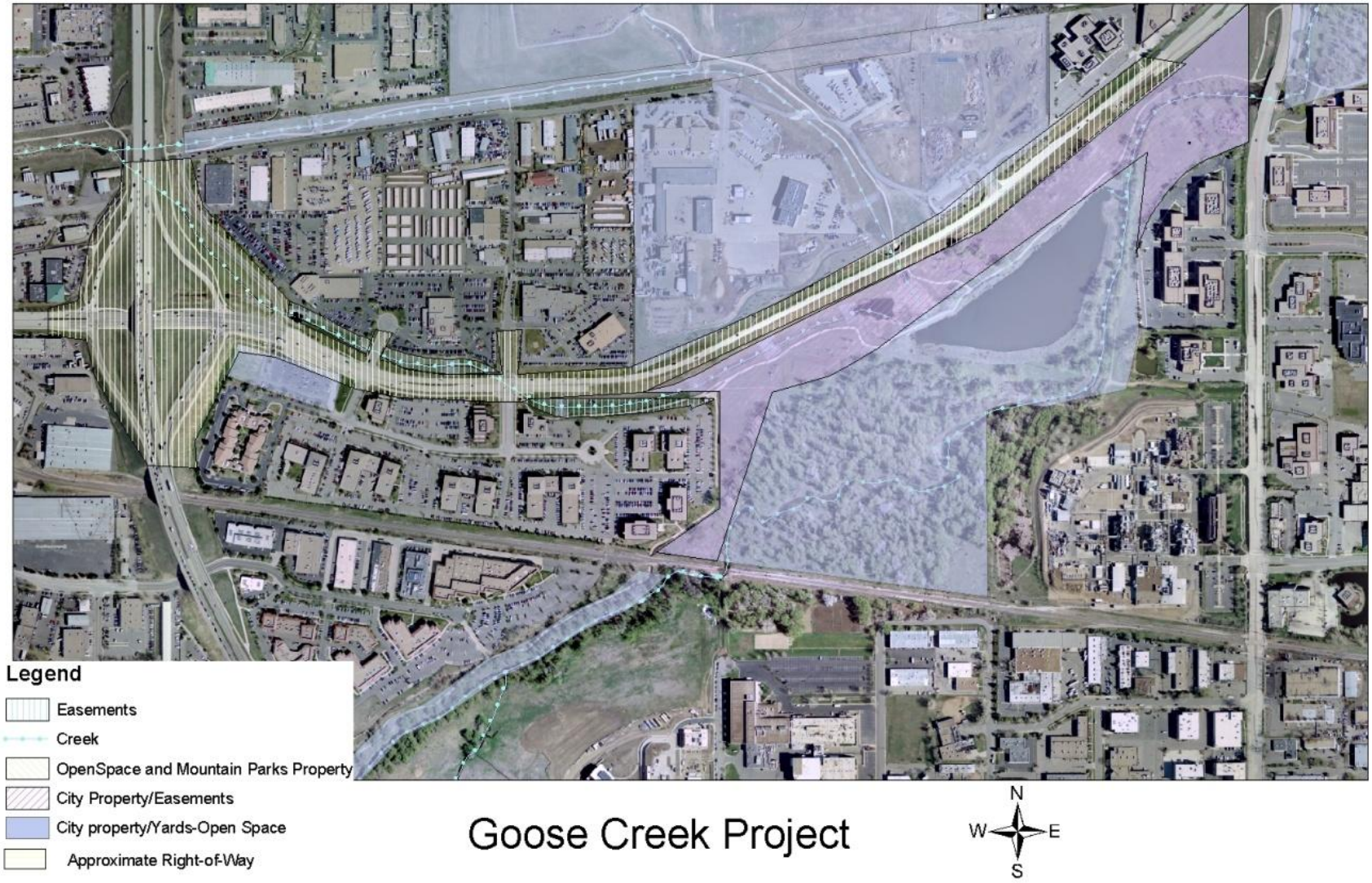

Figure 2-6: Property Ownership and Easements in the Project Area.

The City of Boulder's Utilities Department owns approximately 53 shares in the Boulder and White Rocks (BWR) Ditch. Each share is equivalent to 1.2 acre-feet and is valued at approximately $2,000 a share. The average seasonal operation of the BWR ditch is from May 1 to July 10, or approximately 70 days. If all 53 shares were transferred to supply water for Goose Creek, approximately 0.5 cfs, or 0.9 acre-feet, per day of water would flow in Goose Creek for the BWR season. The cost of the shares from utilities to the project would be approximately $100,000 for the shares.

2.3.5 Relationships of this Project to Other Community Projects and Plans

The ecosystem restoration project for South Goose Creek and Cottonwood Pond was conceived within the framework of an overall plan by the city of Boulder and Boulder County to improve the functionality of riparian environments in and near the urban area. Additional information is available in the City of Boulder Greenways Master Plan.

- The City of Boulder's Greenways Program, designed to protect and restore riparian areas along the tributaries of Boulder Creek, has identified over 60 reaches for potential restoration under the Greenways Master Plan.
- Valmont City Park, located adjacent to and north of North Goose Creek, is currently undergoing various phases of construction and park improvements.
- Wonderland Creek, flowing through the Valmont City Park and tributary to North Goose Creek, was restored in 2001 and may have more plantings as part of future phases of improving the Park.
- A pedestrian underpass located at Foothills and Pearl Parkway, along Goose Creek, has also been installed which provides direct public access to the project reach from a restored riparian reach upstream.
- The Goose Creek channel is currently maintained by UDFCD for flood conveyance.

3.0 FUTURE WITHOUT PROJECT CONDITIONS

The future condition is expected to be similar to slightly worse than the current condition without a project. The rate of land use change in the Goose Creek watershed is expected to be proportionately small in the future, since the basin is already urbanized. Much of the land not currently built upon in the watershed has been preserved as open space or conservation easements. The conclusion that the future condition of the Goose Creek watershed over the economic life of the project will be similar to, or potentially more deteriorated than, the existing condition, is discussed in the following sections.

3.1 ENVIRONMENTAL

The overall environmental quality of Goose Creek and Cottonwood Pond is expected to decline over time. Principal reasons for the projected decline include the spread of invasive species and the impact of unfiltered urban runoff through the system. The deterioration of Cottonwood Pond can be slowed by aggressively treating the Eurasian water milfoil at considerable expense and continued isolation of that body of water from Boulder Creek using the existing fabri-dam barrier at the confluence of the Cottonwood Pond outfall to Boulder Creek.

3.1.1 Ambient Conditions

There is the potential for changes to occur on a geographic scale much larger than the Goose Creek watershed over the economic life of the project (~50 years) and beyond. These changes to the surrounding environment can influence the sustainability of ecosystem restoration measures employed on Goose Creek.

3.1.1.1 Regional Climate Change

The degree of the impact of potential climate change on the Goose Creek watershed cannot be accurately predicted over the economic life of the project. As a result, quantitative impacts of climate change cannot be factored into the formulation of plans or post-project adaptive management with sufficient certainty to impact project selection, delineation of project costs and ecosystem outputs. Climate change, though, remains part of the risk and uncertainty that must be qualitatively considered in project formulation.

Given the existing trends toward higher ambient temperatures and shorter winters along the Front Range, it is prudent to consider the impact of longer, hotter and drier summers in the design of the restored ecosystem and the selection of native plant species. Additionally, the high plains climate has varied considerably during post glacial times, and has been much hotter and drier than the current climate; therefore the selection of native plant species and the assumption of a more arid environment for the finished project are prudent in light of the current measured trends in temperature and greenhouse gases.

Goose Creek, itself, remains less vulnerable to impacts of climate change due to its size and location. As it is not directly connected to the Front Range of the Rockies, it will not be influenced by potential changes in the timing and volume of snowmelt runoff from the higher elevations. Additionally, the surface water and the groundwater supply and distribution in the

Goose Creek watershed are greatly influenced by pre-existing development. Runoff from man-made sources such as lawn watering and leakage from the canals that crisscross Goose Creek provide a source of base flow to South Goose Creek and Cottonwood Pond that may resist change over shorter periods of time.

3.1.1.2 Potential Changes to the Upper Boulder Creek Watershed

While the upper Boulder Creek watershed is protected from significant development by public ownership, covenants and easements, the Mountain Pine Beetle has no respect for ordinances. Having destroyed trees throughout much of the western intermountain regions, it has now entered the upper South Boulder Creek watershed. In time, the beetle has the potential to destroy stands of old timber across the Boulder Creek watershed, setting up a fire hazard. Twomile Canyon, a Foothills tributary to Goose Creek, could suffer a sudden loss of forestation and the increased runoff and debris flows that accompany such an event. Nearby watersheds suffered considerable forest fire damage in 2010. Due to the fact that the upper Goose Creek channel is paved over, it is likely that most of the additional runoff from a storm event on a fire damaged basin, and the accompanying debris, would be attenuated by the time it reached the box culverts under Foothills Parkway and the project area. Those culverts also serve as a barrier to flood flows and the wetland upstream of Foothills Parkway serves as a settlement area for debris and sediment from upstream areas. It is not anticipated that changes in the upper Boulder Creek watershed would impact the formulation of ecosystem restoration alternatives for Goose Creek.

3.1.2 Expected Changes to the Goose Creek Ecosystem

Future land use in the Goose Creek project area is addressed in the Boulder Valley Comprehensive Plan. The stream corridor of Goose Creek is identified as open space, which is surrounded by established commercial, industrial and transportation land use, as well as additional designated open space. This land use pattern is expected to continue into the future.

Among the largest potential environmental change in the future is the continued colonization of South Goose Creek in general and Cottonwood Pond in particular by non-native invasive species. Among plants in particular, invasive species from northern parts of the Eurasian land mass, such as Russian olive and Eurasian water milfoil, have gained the greatest toehold. The trend towards a greater proportion of the total plant population consisting of non-native species is likely to continue absent an ecosystem restoration project.

The Recovery Plan for the Ute-ladies'-tresses (USFWS 1995) states that the activities associated with urban development that has heavily affected the riparian and wetland habitats required by this species are "expected to intensify, threatening remaining Ute ladies'-tresses populations and habitats" (USFWS 1995). Other threats include increasing demand for agricultural, industrial, and municipal uses, recreational uses of streams and riparian areas, invasion of exotic species, and localized catastrophic events, such as forest fires. Although the Ute ladies' -tresses orchid is not presently found in the Goose Creek watershed, a restored South Goose Creek channel and associated Cottonwood Wetland may provide opportunities to establish small colonies of this endangered plant in the future. For example, a Ute ladies'-tresses population along Goose Creek would be less vulnerable to damage from forest fire debris flows that may pass down Boulder and South Boulder Creeks.

Widespread habitat loss and fragmentation due to development, water diversions, and gravel and sand mining have resulted in a rapid decline in Preble's meadow jumping mouse populations east of Colorado's Front Range. These threats continue to increase due to rapid residential, commercial, agricultural, and industrial development within nearly all of the mouse's range.

3.2 ENGINEERING CONSIDERATIONS

In general, no significant changes are anticipated in the hydrologic, hydraulic and slope stability of South Goose Creek during the next few decades. As the Goose Creek basin is entirely urbanized, rainfall-runoff patterns observed now should continue. Slightly higher instantaneous peak discharges from large rainfall events may result from the development of the Transit Village plan upstream. Storm water retention planned for the development would likely restrain any increase in more frequent runoff events. There are no significant sites within the basin where sizable impoundments are likely to be built that would store larger, infrequent flood flows. The channelization and grade stabilization structures built by the UDFCD would also be expected to last during the coming decades as they have shown little deterioration over the past 25 years.

Goose Creek and Cottonwood Pond lie at the lower end of a watershed that has been altered by canal diversions. Tributaries, such as Twomile Canyon Creek, which flow into Goose Creek, and Wonderland Creek, that flows into North Goose Creek above Cottonwood Pond, are diverted into the White Rocks Canal. Presently, low and moderate flows from these sub-basins cannot reach the project area. Only larger flood flows from upstream areas can impact the project area. Among future projects proposed for the Wonderland Creek sub-basin is one that would separate Wonderland Creek from the White Rocks Canal upstream of Foothills Parkway. If implemented, this change could result in slightly more base flow and storm runoff from the Wonderland Creek Basin reaching Cottonwood Pond.

Twomile Canyon Creek, which drains a small portion of the foothills, traditionally flowed into Goose Creek, but has been intercepted by diversions and storm sewers. Currently, it is unlikely that runoff from Twomile Canyon Creek would reach Goose Creek and Cottonwood Pond except in extreme floods, when excessive runoff would flow through streets and could reach South Goose Creek. Presently, upper Goose Creek between North Boulder Park and Folsom Street has been identified as one of the areas of Boulder that has the most flooding due to storm sewers that are under-designed for inflows. There are plans to increase the storm sewer capacity in the upper Goose Creek watershed (Boulder Stormwater Plan, 2007). This may allow a little more water to reach South Goose Creek than presently allowed for the more frequent events (5-year "0.2 chance of annual exceedance" frequency or less), but should produce little change in large floods as future storm sewers are not designed to handle the more extreme runoff events and Foothills Parkway regulates larger flood flows from the west.

Twomile Canyon Creek has also been largely developed and platted, with the mix of land use unlikely to change in the future. In the event of a forest fire in this foothills sub-basin, there would be changes to the watershed that would last for a substantial time, and could result in much higher runoff from rainfall events until revegetation occurred. It is unlikely that there would be much impact on Goose Creek and Cottonwood Pond from this potential future

condition, as both the additional discharge and the sediment and debris load would be largely intercepted and dissipated in its overland journey through streets and neighborhoods and at the entrance to the Foothills Parkway box culverts.

Climate change has the potential to impact the distribution of precipitation and the hydrology of the region. Given that the basin is largely urbanized, the effects of a warmer and drier climate, for example, may be muted. Additionally, since the ecosystem restoration planned for South Goose Creek and Cottonwood Pond is to return it to a more natural, semi-arid high plain aquatic system, a shift to a warmer and drier climate would be within the historical climatic adaptability of the plant and animal communities represented.

In summary, future without project conditions in South Goose Creek and Cottonwood Pond are likely to resemble current conditions from an engineering perspective, due to the fact that the upstream watershed has already been developed and is subject to only minor shifts in land use over time. Removal of the upper portions of the watershed by canal diversion and storm sewer projects also serve to largely insulate the lower watershed from upstream events that could impact the hydrology of the project area.

3.3 COMMUNITY CONSIDERATIONS

The primary community consideration in the overall project area is recreation. In the future, use of the Boulder Creek Trail is expected to be even higher. The North Goose Creek Trail will form the western boundary of Valmont Park when the park is expanded south to Pearl Parkway. Consequently, it is anticipated that many Valmont Park users will use the Boulder Creek Trail and North Goose Creek Trail to access Valmont Park. Without a Corps project that includes Cottonwood Pond restoration, Eurasian water milfoil would not be controlled. Consequently, the Cottonwood Pond fishery would be expected to decline still further, and shoreline fishing activity at Cottonwood Pond may cease to exist in the future. However, there are many other fishing opportunities nearby, including shoreline fishing at Boulder Creek; in addition, a fishing pond may be one of the new facilities developed in the expanded Valmont Park.

Future visitation is expected to increase even without the aquatic ecosystem restoration project. The Boulder Creek Trail intersects with the North Goose Creek Trail on the northwest side of Cottonwood Pond. Many trail users are expected to access Valmont Park by using the Boulder Creek and North Goose Creek trails. No projections of future visitation at the Boulder Creek Trail along South Goose Creek were available in January 2011 because the public involvement process regarding the specific facilities to be developed in the expanded Valmont Park have not been completed. Additional trail use is also expected by residents of Transit Village that is planned for development along Goose Creek upstream of the North Goose Creek Trail.

4.0 PLANNING CONSTRAINTS, PROBLEMS, OPPORTUNTIES, GOALS AND OBJECTIVES

Plan formulation is a process of evaluating problems and opportunities and establishing goals and objectives in order to formulate plans to solve the problems and take advantage of opportunities for betterment within the limits of the constraints. "Constraints" are general or specific issues that can limit or even prohibit the implementation of a particular solution to a problem. The "problems" are characteristics that are presently wrong with the Goose Creek/Cottonwood Pond Ecosystem or can be reasonably anticipated to be wrong with it in the future. Problems can be checked against comparable good "reference" stream reaches, ponds and wetlands, so that the problems can be quantified and compared to stream features that are considered to be good within the region. The "opportunities" are factors that could support positive change to the Goose Creek/Cottonwood Pond ecosystem. Planning "goals" encompass the overall ecosystem improvements that are sought and are related to Corps National Ecosystem Restoration (NER) goals. Planning "objectives" are the specific improvements, which can be measured, by which the goals will be met.

4.1 PLANNING CONSTRAINTS

The Constraints are those factors that limit the extent of improvements to Cottonwood Pond, South Goose Creek, as well as the overall project. For this set of constraints, it is assumed that the Eurasian water milfoil will not be eradicated before the start of construction of the Goose Creek Ecosystem Restoration Project. Existing and future without project constraints are assumed to be the same for this developed basin.

4.1.1 Overall Project

- Urbanized setting limits many options for ecosystem restoration.
- Existing infrastructure and high ambient real estate values constrains the option of increasing the size of the project footprint.
- Prairie dog towns are established and growing. Their protected status constrains the ecosystem restoration project features from expanding into the prairie dog town area or the prairie dogs must be moved.
- Water quality and quantity are both limited by upstream watershed conditions, cost and by prior water right appropriations under Colorado water law.
    - Wetland creation or restoration must be limited to approximately the amount of historic wetlands on the site to avoid needing water rights augmentation.
    - Overbank flows cannot be captured in depressions; this could be considered a change in type of water use.
    - No groundwater can be intentionally surfaced by excavation. This would be considered a "well" which would require augmentation. Flow augmentation from any available sources would add substantially to the cost of the project.
    - The Sponsor prefers not to purchase water rights for this project. An analysis will be performed to ensure action alternatives fall within the water rights limitations at the site.
- Tree plantings would need beaver protection to be sustainable.

- Total Federal project cost is limited to $5,000,000.
- Improvements must be consistent with the long-term sustainability of restored ecosystem functions.
- Design considerations should be consistent with the long-term sustainability of the Sponsor's ability to pay expected OMRR&R costs.
- Invasive species must be evaluated when establishing connectivity between project reaches and reaches that are upstream of this project, so that restoration methods do not aid in their propagation and project outputs can be sustained throughout project life.

4.1.2 South Goose Creek

- Flood conveyance must be maintained for the base flood and for lesser floods. Thus ecosystem improvements must not cause a net increase in flood stages along South Goose Creek.
- Erosion of the channel bed and bank must not be increased.
- Location of roads, storm drains, culverts and utilities cannot be altered.
- Project changes to the stream environment must not negatively impact the nearby car dealerships and Business Park. Native riparian buffer plantings would need to be short, so as not to block the view of each business from the street.
- The base flow in Goose Creek is limited and the amount that this flow can be increased is also limited. Purchasing of any additional water would require purchasing a water right and would be expensive. The Sponsor prefers not to purchase water rights for this project.

4.1.3 Cottonwood Pond

- The bike trail embankment separates the pond from the wetland and effectively serves as a barrier to the movement of aquatic species. This separation also currently blocks the upstream movement of the Eurasian water milfoil, so that its removal could cause more spread of this invasive species.
- Were the bike trail embankment removed, it would need to be replaced by a bridge at considerable cost to the project. In addition, project goals would not be served to any significant degree by connecting the existing wetland at the confluence of North and South Goose Creeks to Cottonwood Pond or Wetland.
- Replacement of the bike trail and embankment separating Goose Creek and Cottonwood Pond with a pedestrian bridge would be expensive to build and maintain and the local Sponsor has noted that project features are to be designed to minimize maintenance costs.
- The existence of Eurasian water milfoil in the pond limits the extent of aquatic restoration in Cottonwood Pond and the potential for low flow connectivity with upstream Goose Creek and the existing wetland, unless the Eurasian water milfoil is eradicated, with negligible prospects for re-colonization.
- A power line and other utilities are located along the south shore of Cottonwood Pond. According to the power easement terms, no trees can be planted that would exceed 20 feet tall at maturity within a 75-foot wide zone centered on the power poles.
- If a portion or all of Cottonwood Pond is filled, the City of Boulder would require a 1:1

replacement of the open water (e.g. similar acreage of wetland creation). The Corps PDT and Sponsor will coordinate with the City to ensure action alternatives meet these requirements.

4.2 PROBLEMS

4.2.1 Overall Project

- Invasive species are outcompeting native species.
- Existing habitat quantity is inadequate to support most listed species known to occur near the project area.
- Prairie dogs denude soil in the flood plain and transitional bank areas.
- No flood plain connectivity occurs except during very high flows. Nearly all of the recipient flood plain is non-natural, so flood overflows do not nurture wetlands.
- Reed canary grass is present in upstream reaches of Goose Creek, so successful eradication in the overall project reach would depend upon eradication upstream.

4.2.2 South Goose Creek

- Riparian corridor "connectedness" between reaches separated by storm water culverts is a challenge for some species. Some mammals have difficulty moving through the dark, wet concrete lined box culverts. Aquatic species are often not able to "climb" into the culvert, due to scour holes at the downstream end.
- The creek is mostly just a drainage ditch with an engineered low-flow channel.
- Non-natural erosion control methods were used to stabilize the channel.
- No effective riparian corridor exists for the entire stream reach.
- Grasslands adjacent to the stream consist mostly of Kentucky bluegrass and occur along the low flow channel only.
- No effective riparian buffer area exists along South Goose Creek.
- Minimal riparian wetlands exist, with occurrences limited to culvert inlets/outlets and sewer outfalls, with the exception of the larger cattail wetland at the confluence with North Goose Creek.
- An unnatural concrete stream bed was constructed for the low flow channel.
- There is little diversity of aquatic habitat. Very minimal occurrence of pools and riffles, depth variability, structure and cover can be found.
- A barrier to aquatic habitat connectivity/fish passage exists between Cottonwood Pond and South Goose Creek.
- Wetland vegetation at the North-South Goose Creek confluence is mainly a monoculture of cattails, with minimal woody plants.

4.2.3 Cottonwood Pond

- Eurasian water milfoil has colonized Cottonwood Pond.
- Bank erosion is evident along 10% of the shoreline, and non-natural erosion control methods have been used on another 5% of the shoreline.

- Inadequate depth diversity exists.
- Connection with Boulder Creek is limited.
- The presence of exotic and invasive species, primarily Eurasian water milfoil, Russian olive and brome grass, greatly reduces the habitat quality within this area, limiting native wildlife usage.
- Limited depth and shoreline variation also marginally limit wildlife usage.

4.3 OPPORTUNITIES

4.3.1 Overall Project

- There is a history of strong public and institutional support for ecosystem restoration projects in Boulder.
- There are multiple restoration projects, completed, ongoing or planned elsewhere in the Boulder Creek Basin. An opportunity exists to manage the varied restored areas as a "system", and to pursue the control of invasive species.
- There is an established and successful Boulder Greenways Program. As a result Boulder has demonstrated the past ability of the community to maintain a project of this type once built.
- There is ongoing local support for the Corps' Lower Boulder Creek Ecosystem Restoration Project, (which is also in the Feasibility Study phase), and for a potential new General Investigation Study on South Boulder Creek (presently in the reconnaissance phase).
- Potential exists to restore an effective restored riparian corridor along most of Goose Creek that connects with the riparian corridor along Boulder Creek via Cottonwood Pond.
- If the milfoil problem can be solved, there is the potential to redesign the low flow culvert connection between Cottonwood Pond and Goose Creek to facilitate the movement of aquatic species. Existing low flow culverts are buried in riprap.
- Potential exists to restore habitat for Federally-listed, regional threatened and endangered species and state species of concern. The Greenways Master Plan notes that *Spiranthes diluvialis* (Ute ladies'-tresses orchid) is found in nearby wetlands (adjacent to Pearl Street Business Park in the Boulder Creek reach between Goose Creek and Foothills Parkway). One of the easternmost large populations of orchid exists in mesic riparian meadows of relict tall-grass prairie and irrigated pastures near South Boulder Creek at the southeast edge of the city of Boulder. Additionally, *Zapus hudsonius preblei* (Preble's meadow jumping mouse) is found on nearby South Boulder Creek. Both species are also Federally-listed as threatened.
- There is an opportunity to remove barriers to wildlife travel by using simple wooden walkways through culverts. This method has been used in nearby streams to enable species such as Preble's meadow jumping mouse to move through box culverts.
- There are opportunities to increase environmental education and interpretation regarding ecological features, and ecosystem restoration and wildlife habitat/travel corridors.

4.3.2 South Goose Creek

- Most upstream portions of Goose Creek have already been restored, so potential exists for increasing riparian corridor connectivity for some species.
- The existing bike trail can be relocated by removing a hazardous bend, providing more area for the benefit of the ecosystem restoration project.
- With the relocation of the bike trail, the opportunity exists to widen the stream reach downstream of Reynolds Corner to include meander bends, lateral flood plain connectivity, and riparian wetlands.
- In upstream reaches, there is the opportunity to make the low flow channel more sinuous between boulders, etc. to restore some benefits of a meandering channel.
- There is the opportunity to "soften" engineered grade control structures without losing their needed functionality. The majority of those structures, such as the concrete weirs, can be retained but covered with vegetation.
- Upstream features reduce the threat of damaging floods and flood debris deposition in South Goose Creek.
- Existing hydraulic controls in place upstream of Foothills Parkway (including the North Goose Creek flood channel) limit the flood flow, flood velocities and flood scour potential to lower values, providing greater sustainability to constructed riparian wetlands and other features.
- An opportunity exists to remove hydraulic hard points (weir and boulders) immediately upstream of the wetland to construct meandering channels, as the bike trail embankment/wetland already provide the high flow hydraulic control and grade stabilization for that reach.
- Investigations have determined that the South Goose Creek channel under-drain system was not constructed for water rights purposes. This allows for making modifications of the system if needed. The existence of the under-drains would support continued dewatering during construction.
- There are opportunities to educate the public about wetlands and invasive species.
- Due to the poor water quality of storm sewer outfalls within and upstream of the project area, there could be opportunities to provide buffer/filtering functions through localized wetland enhancement

4.3.3 Cottonwood Pond

- There are opportunities to improve a pond that presently offers limited fish and wildlife habitat. Successful restoration depends upon the eradication of the invasive Eurasian water milfoil.
- There is also an opportunity to restore Cottonwood Pond, which is not a natural pond, to a wooded riparian wetland with higher ecosystem outputs. This would support the essential goals of the Section 206 Program, and is a central goal of ecosystem restoration efforts in the semi-arid high plains region.
- There are opportunities to enhance the ability of a pond or wetland adjacent to Boulder Creek to serve as refugia for aquatic animals in the larval stage.

- There are opportunities to increase recreational access to the pond or wetland for the handicapped.
- There are opportunities to educate the public about aquatic nuisance species.

4.4 PLANNING GOALS

The goal of the Section 206 Program is aquatic ecosystem restoration where a federal (National Ecosystem Restoration or NER) interest can be demonstrated. Restoration can be accomplished to support the survival of threatened and endangered species, provide migratory bird habitat, and restore aquatic stream habitat and riparian wetlands. The overall goal of the Goose Creek aquatic ecosystem restoration project is to improve the riparian ecosystem functionality and connectivity of Goose Creek and Cottonwood Pond within the greater ecosystem of the high-plains portion of the Boulder Creek watershed. Project goals include:

- Improve stream structure, function and dynamic processes.
- Improve the quality and quantity of native riparian and wetland habitat.
- Improve quality and quantity of wetlands along South Goose Creek.
- Restore aquatic ecosystem of Cottonwood Pond.
- Improve connectivity between riparian areas, including wetlands, in the Boulder Creek watershed.
- Provide environmental sustainability for improved aquatic habitat.

4.5 PLANNING OBJECTIVES

The Objectives are the statements that describe the goals of the completed project that would solve the problems within the project constraints. The portion of the Goose Creek watershed covered in these objectives includes Cottonwood Pond, South Goose Creek and the existing wetland, as well as goals pertaining to the overall watershed.

4.5.1 Overall Project

- Reestablish a Riparian Corridor – Restore connectivity throughout the riparian corridor from Boulder Creek to upper Goose Creek (upstream of Foothills Parkway). The riparian corridor would facilitate the movement of many species including invertebrates, small mammals, reptiles and amphibians through improved habitat. Additionally the importance of species diversity is recognized, and improved riparian habitat has the potential to support a much wider variety of plant and animal species.
- Preserve and restore diverse, functional wetland communities – Reestablish hydrologic, channel and biologic conditions favorable to the existence and expansion of healthy riparian wetland ecosystems.
- Improve Sustainability for Native Species – Reestablish self-sustaining native riparian ecosystems. Reintroduce hardy native species into the aquatic, riparian and wildlife corridor habitat that would be self sustaining under post-project conditions.

- Improve Habitat for Regional T&E and Listed Species – Incorporate landform and bio-habitat features that encourage the expansion of nearby important regional native species into the completed project area.
- Minimize Impacts to Protected Species – Minimize potential adverse impacts to the existing prairie dog colony that may occur because of the proposed project and contain the colony and its habitat.
- Improve Overall Functional Integrity – Install buffer plantings where feasible, to reduce disturbance and add improved native plantings to support a diverse native wetland community.
- Improve Riparian Aesthetics (Passive Recreation) - Through the use of native species and natural channel restorative efforts, change Goose Creek and Cottonwood Pond from their present unnatural state into a stream flowing through a riparian environment that resembles, as much as possible a natural stream on the high plains of Colorado.

4.5.2 South Goose Creek

- Enhance Stream Structure – This can be done by increasing the frequency of riffles and introducing meanders and variations in width, depth and velocity.
- Improve Stream and Riparian Lands Interaction – Restore terrace-level flood plain connectivity and increase channel sinuosity within the overall flood control channel.
- Improve Water Quality/Temperature – Improve the water quality and temperature regime. This can be done by adding flow (dilution), adding shade (lower summer temperature) and channeling side tributary inflow through riparian wetlands (absorption/filtration).
- Improve Riparian Species Mix – Improve low bank vegetation, remove exotic species, and add species that favor natural High Plains' riparian communities.
- Improve Recreation – Straighten existing bike trail by rerouting bike trail to social trail, which would eliminate a safety hazard as well as increasing the land area available for ecosystem restoration.
- Improve Wetland Plant and Animal Diversity - Plant native plants to provide over story shading vegetation and micro-habitat features that support the survival of small native aquatic species in the wetland.

4.5.3 Cottonwood Pond

- Improve Wetland – Improve wetland areas that exist around the perimeter of the pond or consider restoring wetlands on a larger scale.
- Improve Shoreline – Improve shoreline habitat by controlling erosion and replicating a natural shoreline by using native plant species and reshaping to add points and inlets.
- Improve Bed - Restore depth and substrate variability and improve the substrate quality and aquatic plant diversity.
- Improve Pond Ambient Environment – Improve the riparian buffer zone and reduce shoreline area impacted by man's activities, by improving recreation (including handicapped access) at controlled locations.

- Improve Pond Water Quality and Aquatic Plant and Animal Diversity – Control erosion where possible and filter more of the inflow through additional wetlands. Eradicate invasive plants and animals and replace with native species.

5.0 ALTERNATIVE FORMULATION

Alternative plans for ecosystem restoration are evaluated according to the Principles and Guidelines as defined in ER 1105-2-100 and its various appendices and amendments. ER 1105-2-100, as it applies to this project, defines the implementation of the Congressionally-authorized goals of Section 206, Aquatic Ecosystem Restoration, WRDA 1996. A central goal of the guidelines is to make sure that riparian ecosystem restoration activities carried out under the Section 206 program support established National Ecosystem Restoration (NER) goals, and that the restoration alternatives produce cost effective and sustainable results.

Individual alternative restoration measures were identified. These were brought together in various combinations to create alternative plans. Each alternative plan provides a unique set of restoration outputs and costs. The plans were evaluated in terms of cost per unit of output, and compared to each other to identify the best plans. An NER plan is a selected alternative that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective. The selected plan must be shown to be cost effective and justified to achieve the desired level of output.

5.1 DELINEATION OF RESTORATION REACHES

The restoration alternatives were formulated on the basis of project reaches. Initially the Project Delivery Team (PDT) identified as many as 8 separate reaches. During the formulation process, the reaches were gradually reduced to 4 reaches having similar problems, opportunities and constraints. One of the remaining 4 reaches, the Transit Village reach, was not incorporated into this restoration effort after careful consideration, due to time, synchronization of construction and funding constraints.

5.1.1 Initial Study Reaches.

The approximately 1-mile-long study area for ecosystem restoration was initially divided into 7 reaches for more detailed studies. Those study areas, which were used in 2006 and 2007, are noted below and on Figure 5-1:

Reach 1 – Foothills Parkway. This area included the reach of South Goose Creek which lies between the frontage road and the on-ramp to Foothills Parkway. Its upstream end is the downstream end of the box culvert under Foothills Parkway and its downstream limit is the frontage road. Its defining characteristic is the stream's incorporation into the highway drainage system.

Reach 2 – Auto Sales. This area included the reach of South Goose that is sandwiched in between Pearl Parkway on the right high bank and auto dealerships on the left high bank. Its upstream end is the frontage road along Foothills Parkway and its downstream end is the long box culvert under Pearl Parkway. Its defining characteristic is the non-native lawn grasses planted on the channel banks adjacent to the Parkway and the auto dealerships.

Reach 3 – Business Park. This area included the reach of South Goose Creek with office buildings adjacent to its right high bank. Its upstream end is the long box culvert under Pearl

Parkway and its downstream end is the Reynolds Corner mini-park near the office buildings. Its defining characteristic is the extensive prairie dog colony along the left bank near Pearl Parkway.

Reach 4 – Riparian Stream. This area included the portion of South Goose Creek that lies along Pearl Parkway. Its upstream end is the Reynolds Corner mini-park adjacent to the Business Park and its downstream end is the riparian wetland. The reach is characterized by its greater open space to the south, which could provide ecosystem restoration opportunities.

Reach 5 – Riparian Wetland. This area included the existing wetland and a reach of South Goose Creek. This area is bounded on the upstream end by the transition from the stream to the wetland and on the downstream end by the bike trail along Cottonwood Pond. Its defining characteristics are the existing wetlands and the city-owned land adjacent to the right bank of South Goose Creek that could be used in a riparian wetland restoration plan.

Reach 6 – Lower North Goose Creek. This area included the extreme lower end of North Goose Creek, downstream of Pearl Parkway. Its upstream end is the outlet of the culvert under Pearl Parkway and its downstream end is the existing riparian wetland on South Goose Creek and the bike trail along Cottonwood Pond. Its defining characteristic is that it is a normally dry channel on public land located between a riparian wetland and Cottonwood Pond.

Reach 7 – Cottonwood Pond. This area included the pond and the outlet of Goose Creek to Boulder Creek. This area is bounded on the upstream end by the bike trail that separates Cottonwood Pond from the wetland and on the downstream end by Boulder Creek. Its defining characteristic is that it is a pond.

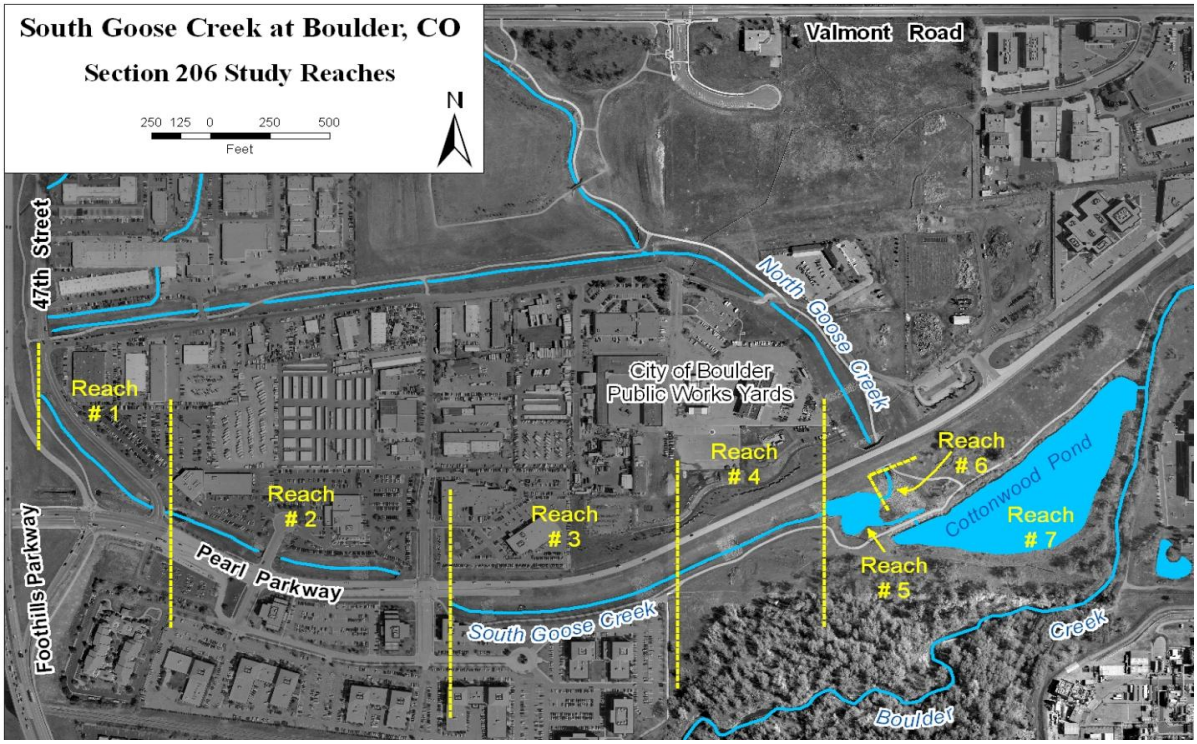

Figure 5-1: Initial Goose Creek Study Reaches

5.1.2 Transit Village Reach

As the study progressed, Transit Village was first added and then was removed from consideration in 2008 due to schedule and budget reasons. Figure 5-2 shows the Transit Village Reach in conjunction with other reaches.

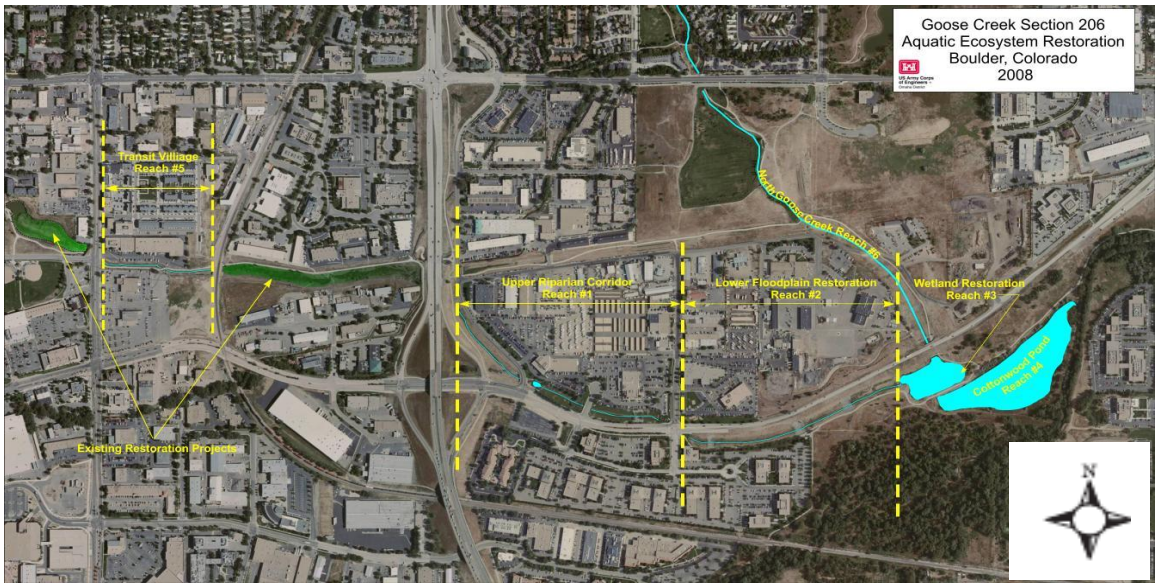

Figure 5-2: The Transit Village Reach is shown relative to South Goose Creek Reaches

5.1.3 Merged or Eliminated Reaches

Reach 6 (Bottom of North Goose Creek) was eliminated from consideration because of hydrologic limitations and an assessment that project efforts could provide few benefits. Reach 5 (existing wetland) was eliminated as a separate reach. Panel discussion led to the determination that restoration efforts implemented to increase the quality of this wetland would not produce significant environmental benefits and could potentially decrease the existing quality. Therefore, wetland restoration efforts as a result of project implementation would focus only on expansion of the existing wetland. The existing wetland is considered the lower portion of the current Reach 2, and no construction activity is recommended for that area.

5.1.4 Final Reach Configuration

Following the departure of the Transit Village Reach, the project study area was reconfigured into 3 reaches as shown in Figure 5-3 and discussed below. South Goose Creek was split into Reaches 1 and 2 at Reynolds Corner, due to the change in potential restoration opportunities and restoration measures.

Reach 1 (Former Reaches 1, 2 and 3) – Upper Riparian Complex – This area includes the reach of South Goose Creek downstream from Foothills Parkway (including the tunnel under Foothills Parkway) downstream to Reynolds Corner mini-park. It is characterized by urbanization and tight boundaries of roads and developed businesses properties.

Reach 2 (Former Reaches 4, and 5) – Upper Riparian Complex – This area includes the reach of South Goose Creek from Reynolds Corner to Cottonwood Pond.

Reach 3 (Former Reach 7) – Cottonwood Pond – This includes the abandoned gravel mining pit known as Cottonwood Pond, the surrounding riparian area bounded by the bike trail to the North and the cottonwood grove to the south and southwest, and also includes the outlet of Goose Creek to Boulder Creek.

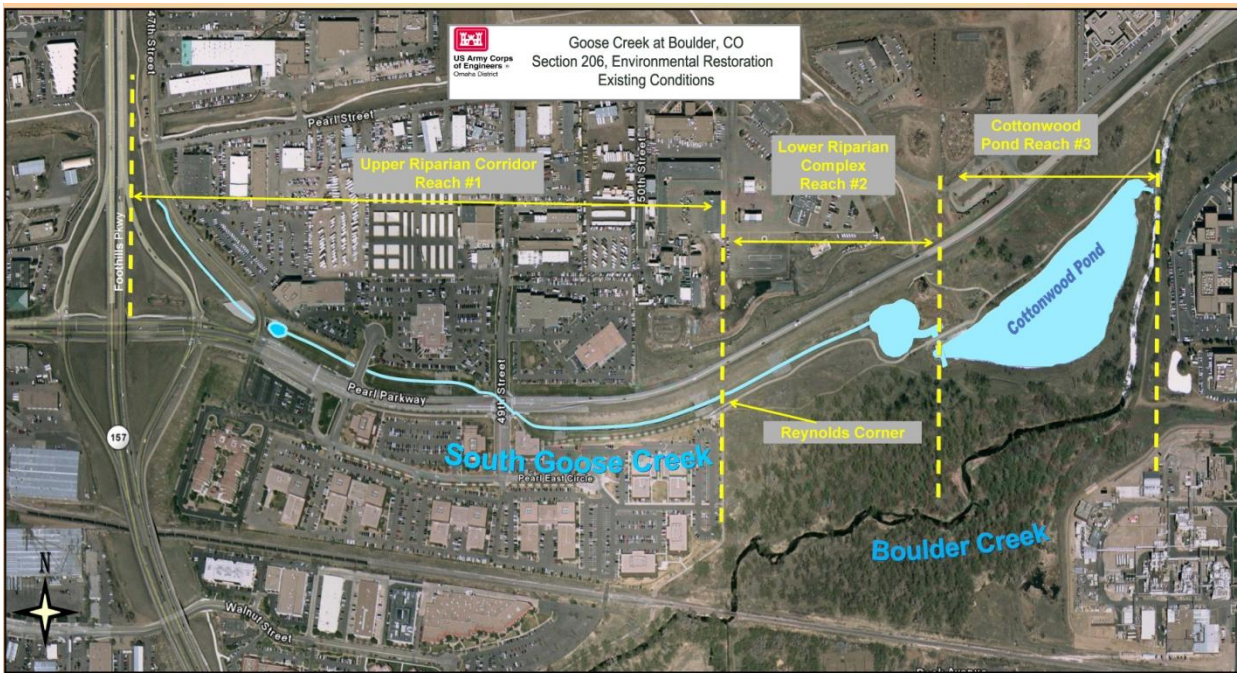

Figure 5-3: Final Goose Creek Plan Formulation Reaches

5.2 CONSIDERATION OF RESTORATION MEASURES – OVERALL PROJECT

5.2.1 No Action

The Corps considers the option of no action as one of the study alternatives. This alternative assumes that no project would be implemented by the Federal Government or by local interests to achieve the planning objectives. This "No Action" alternative, which is synonymous with the "Without Project Condition," forms the basis from which all other alternatives are measured; and it is also done to comply with the requirements of the National Environmental Policy Act (NEPA).

5.2.2 Base Flow Modifications

Adding water to support appropriate native species year-round or as critical season support for native species was considered. Two canals cross the basin upstream of the South Goose Creek restoration reach and additional water potentially could be purchased and spilled into Goose Creek above Foothills Parkway. This option was evaluated by the Sponsor and Corps team but

was ultimately not pursued as it was determined that the restoration outputs would not be large by adding the quantities of flow that could be purchased, the likelihood of a considerable percentage of the flow being lost in transit from the canal spills to the restoration reach and the complexity and cost of pursuing ownership of water rights for the project.

5.3 PRELIMINARY MEASURES BY REACH

The project team formulated measures for restoration of the stream, ponds, and wetlands within the Goose Creek Project Area. These measures were formulated using the following processes and techniques:

- An initial scoping meeting.
- Site visits and field data collection.
- Initial formulation of solutions to problems on South Goose Creek and Cottonwood Pond.
- Use of a Panel of Experts.
- Internal meetings within the project team.
- Meetings between representatives of the project Sponsor and members of the project team, including teleconferences.
- Public involvement and stakeholder meetings.

5.3.1 Preliminary Measures: Stream and Adjacent Riparian Area (Reaches 1 and 2)

5.3.1.1 Improve Riparian Vegetation Community and Remove Invasive Species

This establishment of a native, riparian corridor along the creek would provide substantial habitat and increased protective vegetative buffer in a highly urban area. An enhanced riparian zone would also improve connectivity between Goose Creek and the corridor along Boulder Creek. Care would be taken to work within limits of flood conveyance (e.g. low-lying, supple species that would not result in reduced channel capacity during high flows). This became a primary measure carried forward.

5.3.1.2 Increase Frequency of Riffles

This measure would add stones (utilizing boulders onsite) at the riffle crests, creating dynamic shallow rocky areas. Pools could be excavated to restore deeper, calmer areas within the stream. This measure would provide habitat diversity through a variety of depths and velocities. The energy of the stream during reasonably frequent flood flows was seen as sufficient to scour out man-made riffles, quickly returning the stream bed configuration to those durable features previously constructed by UDFCD. Considering the urban setting, short reach length, and the channel geomorphology and hydrology, implementing this measure was eliminated.

5.3.1.3 Restore Meanders

Restoring meanders in the channel improves velocity and depth combinations and allows the stream to create its own microhabitats. Additional excavation could allow the stream to return to a floodplain bench area, which would increase riparian habitat diversity. The opportunity to do so is severely limited in the project area. The upper portion of the project is bordered by

business development, including car dealerships, to the north, and Pearl Parkway to the south. Additionally, the channel had been designed by UDFCD to be stable for a range of flood flows. Restoration of meanders in the narrow flood channel could potentially create areas of scour and erosion that could lead to large-scale bank erosion and damage to adjacent property. In Reach 2 (the portion below Reynolds Corner), it would be possible to restore meanders without the threat to public infrastructure and private property if the bike trail to the south was moved. Therefore, this measure was carried forward in part in Reach 2 and with appropriate limitations as that portion of the project is still bordered by Pearl Parkway to the north.

5.3.1.4 Restore Scour through Addition of Rock/Root Wad Weirs

This measure also restores holes or areas of low velocity, providing microhabitats for spawning, foraging and cover. This measure, similar to directly creating meanders from the low flow portion of the flood control channel, has the potential to redirect high-velocity flows and create scour holes which could undermine the banks causing damage to adjacent property and infrastructure. The measure was given consideration for Reach 2, where the opportunity to widen the channel could be provided by moving the bike trail. After evaluation, it was decided that some rock could be placed where flows were directed southward out of the low flow channel downstream of Reynolds Corner. However, it was determined that the placement of root wads would not yield sufficient aquatic habitat improvement, due to limitations presented by the relatively low base flow (ranging 1 to 2 cubic feet per second). Historical evidence also indicated that root wads were not part of South Goose Creek. Therefore, the addition of limited rock weirs was carried into detailed consideration for Reach 2.

5.3.1.5 Place Boulders in Base Flow Channel

This measure would restore flow diversity and microhabitat. This measure also has the potential to redirect high-velocity flows and create scour holes which could undermine the banks causing damage to adjacent property and infrastructure. This measure was carried forward on a limited basis in Reach 2.

5.3.1.6 Remove Concrete Lining and Replace with Local Cobbles

This measure utilizes local sources of cobble to replace the concrete lined channel. It was determined that given the high velocity of flood flows in this reach that the cobbles would likely be washed out, and if the concrete lining were removed, that there would be a significant risk of local scour holes with progression of the erosion to the adjacent banks occurring. The cost of jack hammering and removing the concrete from the channel was also considered. The extensive cost of implementing this measure and maintenance issues, compared to low anticipated benefits, resulted in this measure not being carried forward.

5.3.1.7 Removing Existing Boulders to Increase Stream Movement

This alternative would increase channel sinuosity and improve pool substrate characteristics. Removing 75% to 25% of the boulders was considered. However, allowing the stream to meander extensively near Pearl Parkway, or near business development or parking lots, could endanger that infrastructure, and having to hardpoint particular areas seemed counterproductive. During site visits, it was evident that some boulders had already been moved by the force of water during floods and there had been no significant erosion damage caused to the surrounding low flow channel. Furthermore, small aquatic species were observed making use of the

microhabitat. It became evident that small gaps could occur in the boulder lining of the channel were there were straight reaches with a wider adjacent low flow channel bottom. So, it was determined that small inundated areas (microhabitat/wetland) could be encouraged by selectively removing boulders where the adjacent channel was very stable. This measure was only carried forward to that extent.

5.3.1.8 Construct Wetlands at Outfalls

Multiple outfalls that exist along the creek provide opportunities to restore small wetland patches. These areas often already have some additional growth, although it is mostly invasive species. Removing the invasive species, re-grading to increase the outfall dispersal area, and re-planting with native species and a wetland mix that could also help attenuate pollutants would be beneficial. This measure was carried forward.

5.3.1.9 Install Woody Debris

Trees removed from the project could be used to install logs or rootwads at various intervals throughout the channel. Care would need to be taken to not utilize invasive species that could propagate in this manner. It was determined that the force of the water in the flood control channel, coupled with the limited aquatic habitat benefits, were major deterrents to this measure. Smaller woody debris would be merely swept away with the first large in-bank flood and larger anchored woody debris might author bank erosion. Therefore, this measure was not carried into detailed consideration.

5.3.1.10 Replace/Cover Grade Stabilization Structures

Replacing or covering the current rock grade structures would provide a foundation for riparian planting, improve micro-habitat and add aesthetic value. Replacing the structures was removed from consideration due to the fact that it would likely result in massive erosion damage and even head cutting in South Goose Creek, and would be costly to implement. However, covering the structures with biostabiliztion mats and planting over with native plants was carried forward.

5.3.1.11 Increase Floodplain Connectivity through Sloping Banks and/or Adding Flood Plain Terrace.

Measures to increase area that is inundated provides for habitat diversity and native plant establishment. Opportunities for changing the slope of the banks in this area are severely limited due to concerns related to surrounding infrastructure of Pearl Parkway and nearby businesses. However, in Reach 2 below Reynolds Corner, the opportunity exists to restore a flood plain terrace that could be inundated, if the bike trail is relocated to the south. The measure of adding a flood plain terrace was carried forward, for the area below Reynolds Corner.

5.3.2 Preliminary Measures – Cottonwood Pond

5.3.2.1 Improve Riparian Vegetation Community & Remove Invasive Species

Removal of invasive tree species (primarily crack willow) and the establishment of a native, riparian zone around the pond would provide substantial habitat, increased habitat diversity and increased protective vegetative buffer in a highly urban area. Plantings would include enhancing the cottonwood riparian zone to the southwest of the pond. Addressing invasive Eurasian water milfoil (aquatic) could also be investigated. There is evidence that a native, diverse seed bank

exists within the project area already (including various willows, sedges, cattails, bulrush, bur reed, and water plantain). This measure was carried forward.

5.3.2.2 Increase Wetland Community

Opportunities exist to enhance shallow perimeter wetlands, and to increase their size through filling portions of the pond and grading to various depths. This measure was carried forward.

5.3.2.3 Improve Depth Diversity

Depth diversity provides a variety of habitats for cover, foraging and spawning. Variation could be achieved through the excavation of deeper holes, grading to various depths, and creating irregular edge habitat through filling and shaping. This measure was carried forward.

5.3.2.4 Habitat Structures

Additional habitat diversity could be provided through the addition of felled trees, pallets or other structures. This measure was carried forward.

5.4 FINAL MEASURES

A set of measures carried forward from preliminary formulation, and others that were combined or added, formed a final set of measures considered. Adopted measures are those that were universally adopted as essential either in the stream or the pond for any plan, some because they form the basis of the restoration, and others because they provide some of the only opportunities for improvement in parts of the project area that are very constrained. These were not evaluated separately but were adopted and included in the design and cost of all alternatives. Evaluated measures are those that provided distinct opportunities for restoration (and benefits). Ultimately, the adopted and evaluated measures were combined to create the final array of Alternatives.

5.4.1 Adopted measures – Stream

5.4.1.1 Riparian vegetation restoration

Essential for riparian habitat restoration would be the planting or seeding of appropriate vegetation along with removal of exotics. Ornamental/landscaping grasses and shrubs would be replaced with a mix of native trees (dominated by willows), shrubs, grasses and forbs. Maturing native communities will gain resistance to nonnative intrusion, but nonnative control would remain an ongoing management need.

5.4.1.2 Remove Selected Boulders

Removing selected boulders in a limited number of locations along the creek could encourage the stream to form small inundated to semi-inundated areas, providing important microhabitat for cover and foraging, and for diverse vegetation. This can be accomplished without changing the planform of the creek or endangering surrounding infrastructure, making it one of the few stream modifications that could be pursued in the majority of the project area.

5.4.1.3 Construct Wetlands at Outfalls

Eleven outfalls are located along the creek. These offer opportunities to remove exotics and restore small, localized wetlands. This can be accomplished without changing the planform of

the creek or endangering surrounding infrastructure, making it one of the few stream modifications that could be pursued in the majority of the project area.

5.4.1.4 Modify Rock Structures

Covering the current rock grade structures would provide a foundation for riparian planting and add aesthetic value. This measure also complements the riparian vegetation restoration, and can be pursued without impacting channel grade control or flood conveyance.

5.4.1.5 Enhance Perimeter of Rock at Wetted Edge

This measure was added as somewhat of a combination of removing boulders, constructing wetlands and modifying (covering) rock structures. There are a few areas in the project that are rocked for stabilization outside of the stream, that offer similar opportunities to remove boulders to allow for occasional inundation or to cover the rock with biostabiliztion material and plant over. It was considered important to take advantage of these opportunities to complement riparian planting and provide native species the best opportunity to establish.

5.4.1.6 Install Culvert Migration Structures

This measure was added to address connectedness within the project. Four culvert structures are located for the stream to move under Pearl Parkway and 48th Street. An opportunity to provide connectivity for many species, including the Preble's meadow jumping mouse, along the Goose Creek riparian corridor and in the larger Boulder Creek watershed is seen as essential in this restoration effort. Structures would be added within the culverts to allow unhindered movement through them.

5.4.2 Adopted measures – Cottonwood Pond

5.4.2.1 Improve Riparian Vegetation Community & Remove Invasive Species

Removal of invasive tree species (primarily Russian olive and crack willow) and the establishment of a native, riparian zone around the pond, including the enhancement of the cottonwood riparian zone to the southwest of the pond, are considered essential.

5.4.3 Evaluated measures – Stream

Final measures which were deemed to need evaluation are summarized below:

5.4.3.1 Restore Meanders and Floodplain Terrace

These two measures were combined, increasing lateral floodplain connectivity by allowing the base flow channel to meander through a lowered floodplain with terraces and create multiple flow paths to the existing cattail wetland.

5.4.3.2 Restore Scour through Addition of Rock Weirs

The rock weirs would be used to divert flow from the existing concrete and boulder-lined low flow channel to the meander zone to the south.

5.4.3.3 Place Boulders in Base Flow Channel

This measure was added to the meander channel system downstream of Reynolds Corner to add diversity in the meander zone.

5.4.4 Evaluated Measures - Cottonwood Pond

5.4.4.1 Enhance Wetland Community

Opportunities exist to enhance shallow perimeter wetlands, and to increase their size through filling portions of the pond and grading to various depths. However, this measure alone does not address the invasive Eurasian water milfoil issue, and in fact may make the condition worse.

A variation of this measure would be to fill the pond completely and excavate to restore a wooded riparian wetland complex similar to the historic planform of the channel, including a channel and remnant features.

5.4.4.2 Improve Depth Diversity

If the pond were simply enhanced, depth variation could be achieved through the excavation of deeper holes, grading to various depths and creating irregular edge habitat through filling and shaping. However, if the pond was filled and a wetland complex restored, improved depth diversity could also be achieved through grading to achieve elevations desirable for a diverse community.

5.4.4.3 Habitat Structures

If the pond were simply enhanced, additional habitat diversity could be provided through the addition of felled trees, pallets or other structures. These would not be needed, however, if the wetland complex was restored.

5.5 FINAL ARRAY OF GOOSE CREEK RESTORATION ALTERNATIVES

Restoration alternatives were formulated for comparison prior to the selection of an ecosystem restoration plan. Each alternative presents a unique combination of restoration outputs and economic costs. In the feasibility phase, the restoration outputs are developed in detail to determine if the alternatives meet NER goals. Costs are developed from an assessment of quantities, real estate and utilities costs, and construction methods in sufficient detail to develop a realistic cost estimate for each alternative for the purpose of comparing alternatives and budgeting for project construction. Costs were prepared using the Corps Micro-Computer Assisted Cost Estimating System (M-CACES).

5.5.1 Overview

An overview of the restoration alternatives for the project reach is summarized as follows. Note that acres per restoration reach below may be smaller than the project footprint recorded in the real estate sections. Biological measures were not employed over the entire area impacted by construction activities (e.g. project boundary, staging areas, etc.)

5.5.1.1 Upper South Goose Creek (Reach 1) – No Action plus 1 Action Alternative:

- Alternative #1 (7.70 acres) – This alternative utilizes all six of the adopted stream measures discussed in 5.4.1. Because the opportunities in this reach are so limited, the team chose to utilize all six adopted (essential) measures to create the only action alternative for this reach. The riparian habitat would be enhanced by removing invasive

species and establishing a new, natural streamside corridor by increasing the quantity and quality of small wetlands and their connectivity with the stream. Selective boulders would be removed to restore microhabitats. Rock structures would be modified, or "softened" through covering and planting over them. Wetlands would be developed at culvert outfalls and at rock perimeters outside of the stream channel.

5.5.1.2 Lower South Goose Creek (Reach 2) – No Action plus 2 Action Alternatives:

- Alternative #1 (1.71 acres) – Entails the same six adopted stream measures discussed in 5.4.1 (noted above for Reach 1).
- Alternative #2 (4.14 acres) – Entails the same adopted six stream measures discussed in 5.4.1 (noted above for Reach 1) and incorporates all of the evaluated stream measures discussed in 5.4.3. Alternative 2 covers more area than Alternative 1, as it includes additional features on a larger footprint. The features include a new meandering channel and a wide floodplain terrace where the bike trail was previously located. In addition, the rock weirs and in stream boulders would be included as the primary method to encourage the stream into the newly excavated channel.

5.5.1.3 Cottonwood Pond or Wetland (Reach 3) – No Action plus 2 Action Alternatives:

- Alternative #1 (16.65 acres) – This alternative incorporates the adopted Cottonwood Pond measure discussed in section 5.4.2 of riparian zone enhancement (removal of invasive species, improving shoreline buffer zones, reestablishing native vegetation), and also adds other pond enhancement features discussed in the evaluated measures in section 5.4.4. These include excavating deeper holes for depth diversity and adding fish habitat features.
- Alternative #2 (16.65 acres) – This alternative incorporates the adopted Cottonwood Pond measure discussed in section 5.4.2 of riparian zone enhancement (removal of invasive species, improving shoreline buffer zones, reestablishing native vegetation), and also adds restoring Cottonwood Pond to its pre-mining status as a wooded riparian wetland adjacent to Boulder Creek, as discussed in section 5.4.4.

5.6 DETAILED DESCRIPTIONS OF RESTORATION ALTERNATIVES

Alternative restoration plans were formulated to meet restoration goals in terms of the ambient hydraulic conditions, stream morphology and ecology. The final selected alternative is required to meet legal and planning constraints that may include but are not necessarily limited to water rights, flooding, property lines, and final land use considerations. This section describes the alternatives in detail, including a discussion of restoration methods, layout and quantities. The "R" numbers, such as "R10", refer to the plan as used in the cost effectiveness and incremental cost analysis (CE/ICA) in subsequent sections of this report. The alternatives are discussed assuming the existence of the "No Action Alternative = **R10R20R30**", which is the same as the "Future without-project" Alternative.

5.6.1 Reach 1 of South Goose Creek (1 Action Alternative = R11)

Reach 1, Alternative 1 (noted as Alternative #1c in the M-CASES cost computations) comprises an area of approximately 7.70 acres. This reach is highly constrained by urban development (city infrastructure and businesses) and restoration efforts are constrained to the existing flood

control channel. In Reach 1, the primary re-vegetation goal was to replace the non-native lawn grasses with a native mix of riparian and prairie species to create an effective restored riparian corridor along Goose Creek that connects with other restored reaches of Goose Creek and the riparian corridor along Boulder Creek. This alternative includes drill seeding to minimize ground disturbance (which otherwise could attract invasive species) and terminating sprinkler irrigation to enhance competitiveness of the native species compared to the existing ornamental lawn grasses. Specific stream-side plantings can take advantage of low channel backwater areas and storm sewer outfall zones to provide greater diversity. It is noteworthy that constructed wetlands were recommended in the Boulder Stormwater Management Plan (2007) at locations of storm sewer outfalls to South Goose Creek along Pearl Parkway. Opportunities exist in Reach 1 to remove select boulders along the low flow channel to naturally restore additional meander and backwater areas adjacent to the flowing stream. The concrete weirs (in stream rock/grade structures) and associated boulder fields can be retained but would be covered with vegetation. The installation of culvert migration structures in Reach 1 culverts and under Foothills Parkway to the previously restored reach of Goose Creek upstream provides connectivity for a larger number of species.

The primary measures selected for Reach 1 include riparian zone improvement, construction of wetlands at storm sewer outfalls, modification of rock structures (including some of those bounding the low flow channel), removal of exotic trees, and installation of wildlife migration structures under road crossings. Depictions of the "before" and "after" cases are shown in Figures 5-4 and 5-5.

Figure 5-4: South Goose Creek Channel Section before Restoration

Figure 5-5: Conceptual Depiction of Channel Section Using the Methods of Channel Alternative 1 (not to scale)

Much of this reach is planted with Kentucky bluegrass or other ornamental/lawn grasses. This alternative would retain the existing alignment of the channel; however some of the bordering channel boulders and the in-stream rock structures would be modified, chiefly by covering and planting (See Plates 1, 2 and 3). Riparian zone improvements would include the drill seeding of the existing lawn grasses with native grasses and prairie plants and the removal of invasive species. Mulching and minor grading would also be incorporated.

Riparian zone improvement would include planting the upper slopes as a wetland prairie buffer and would require approximately 17,000 square yards (SY) of seeding. The wet prairie transition near the low channel banks would require 3,250 SY of seeding and erosion control. The wetland edge areas would entail 745 SY of seeding and erosion control. Wetland construction at storm sewer outfalls would require 130 cubic yards (CY) of earth moving at 13 outfalls.

Modifying the in-stream rock erosion control structures would entail placing 500 CY of stockpiled topsoil over 1,240 SY of boulders to cover them with topsoil. Those areas totaling

1,240 SY would then be lightly graded and seeded with a wet prairie/transition mix and provided with temporary erosion control.

Modifications to the low water channel would consist of selectively removing 315 tons (T) of riprap, some of it to be reused in reach 3, but with 200 CY of rock hauled to elsewhere on the project. As part of the low water channel modification, gaps will be left in the present low water channel boundary, where it will not induce bank erosion.

Exotic tree and shrub removal would total about 0.25 acre of area in Reach 1. That vegetation would then be replaced by approximately a dozen native shrubs or small trees. Native shrub and tree varieties would be chosen that would not cause significant impediment to flow in the channel or on its banks.

Finally, four culvert wildlife migration structures would be installed in Reach 1 consisting of 475 feet of material that can be transited by a variety of species, including Pebble's meadow jumping mouse. Those structures would be similar to structures previously installed on tributaries to South Boulder Creek. The most upstream of the wildlife migration structures would be placed in one of the box culverts under Foothills Parkway, providing connectivity with the restored reach of Goose Creek immediately upstream. The most downstream of the wildlife migration structures would be installed in the box culvert under Pearl Parkway.

5.6.2 Reach 2 of South Goose Creek (2 Action Alternatives = R21, R22)

Alternative 1 (R21):

Reach 2, Alternative 1 comprises an area of approximately 1.71 acres. The primary measures include riparian zone improvement; construction of wetlands at storm sewer outfalls; modification or covering of rock structures, including some of those bounding the low flow channel; and removal of exotic plant species. Near Reynolds Corner on the right bank is an outlet area that releases waters high in iron, which causes the stream at that point to be stained orange. Restoring a wetland or transition zone at this point would assist in absorption before the waters reach the stream. Plate 3 (showing the lower portion of Reach 1) and Figure 5-3 provide an illustration of proposed restoration efforts with this alternative.

This area presently includes poor quality channel and bank vegetation, which is a mixture of native grasses and invasive species. This alternative would retain the existing alignment of the low flow channel as well as the existing bike trail, but similar to Reach 1, it focuses on riparian zone improvement and some channel structure modifications as noted in Figures 5-1 and 5-5.

Riparian zone improvement would include planting the upper slopes as a wetland and riparian prairie buffer and would require approximately 15,700 SY of seeding. The wet prairie transition near the low channel banks would require 2,330 SY of seeding and erosion control. The wetland edge areas would entail 774 SY of seeding and erosion control. Wetland construction at outfalls would require 30 CY of earth moving and emergent wetland construction in the channel would require 720 SY of seeding and erosion control.

Modifying the in-stream rock erosion control structures would entail placing 541 CY of stockpiled topsoil over 1,350 SY of boulders to cover them with topsoil. Those areas totaling 1,350 SY would then be lightly graded and seeded with a wet prairie transition mix and provided with temporary erosion control.

Modifications to the low water channel would take the form of selectively removing 315 tons (T) of riprap, with approximately 200 CY of rock hauled to Reach 3.

Exotic tree and shrub removal would total about 940 SY of area in Reach 2. That vegetation would then be replaced by roughly 18 native shrubs or small trees. Native shrub and tree varieties would be chosen that would not cause significant impediment to flow in the channel or on its banks.

Alternative 2 (R22):

This alternative for Reach 2 comprises an expanded area of approximately 4.14 acres. The central restoration theme for this reach entails moving the existing bike trail to the south (further from the right bank of South Goose Creek), and excavating a new, meandering channel with an expanded, hydrologically-connected wide right-bank terraced floodplain bench to the south. The meander would also increase the low-water channel stream length by adding sinuosity. Additional restoration features include riparian zone improvement, construction of wetlands at storm sewer outfalls, including the one with the rusty discharge; modification of rock structures (including those bounding the low flow channel); and the removal of exotic plant species. Plates 4 and 5 provide a conceptual plan for this alternative.

The low terraces along the restored stream channel should be densely planted with a variety of wetland, transitional, and prairie plants to simulate natural streamside habitat. On higher terraces, establishing a riparian buffer area of dense willows and other woody vegetation would help prevent establishment by invasive species such as Russian olive. Native plant species selection would be screened to ensure that the selected plant species are not excessive in height or rigidity in order to not greatly increase channel roughness for flood conveyance. Native grasses, forbs and smaller willow varieties that hold the soil and bend during periodic floods are preferred over larger woody species.

The relocation of the bike trail would require removal of 8,100 SF of trail in the reach, entailing the removal of 92 CY of concrete debris by dump truck. The bike trail would be relocated southward to an existing dirt social trail. The new bike trail would consist of 976 SY of base course and 8,780 SF of wire mesh-reinforced concrete 4" thick.

Once the bike trail has been removed, meander bends would be excavated between Reynolds Corner and the existing cattail wetland. Prior to construction, water would need to be diverted by pumping from South Goose Creek near Reynolds Corner to Boulder Creek. This would require 1,440 feet of pipe. This would require the removal and transport of 13,600 CY of soil that could be used elsewhere on the project. The existing channel would be "opened up" to allow for the meandering into the excavated wetland and low floodplain terrace. At the last weir structure, the right (southern) portion of the structure would be removed to allow multiple meander channels to enter the existing wetland. This would entail moving 315 T of boulders

from the channel, 210 T of boulders from the lower weir and 30 CY of concrete. The remaining portions of the rock weirs in Reach 2 would be softened by the placement of 541 CY of topsoil. Of rock removed, 35 T would be used for erosion control at key meander bend locations in Reach 2.

Within the newly excavated reach with wetlands, meander bends and lowered floodplain terraces, 1,350 SY of wet prairie and transition seeding would be done, with an additional 2,330 SY of this mix applied along the channel elsewhere in Reach 1. Additionally, 774 SY of transition/wetland edge seeding and 719 SY of emergent wetland would be created by light grading and seeding. The floodplain terraces and prairie buffer would require 15,700 SY of land to be graded and seeded to native mix. Native riparian shrubs and trees would account for 936 SY of plantings within Reach 2. Three storm sewer outfall wetlands would be created which would include 30 yards of excavation to prepare them.

5.6.3 Reach 3 Cottonwood Pond or Wetland (2 Action Alternatives = R31, R32)

Alternative 1(R31):

Cottonwood Pond (Reach 3) offers a larger area for riparian restoration than either Reach 1 or Reach 2. Alternative 1 would entail improving the pond, which would impact 16.65 acres including 7.13 acres of pond and 9.52 acres of edge habitat, with the remainder being partially wooded buffer lands. The presence of exotic and invasive species, primarily Eurasian water milfoil, Russian olive and brome grass, greatly reduces the habitat quality within this area, limiting wildlife usage. Limited depth and shoreline variation also marginally limit wildlife usage and overall vegetation protection for aquatic species. The vegetation present is of limited value due to lack of diversity.

This alternative focuses on improving the diversity of habitat and vegetation of the pond. Proposed pond restoration measures include the excavation of deep holes, re-grading the shoreline for habitat diversity, replanting the shore with native vegetation, installation of fish habitat, installation of additional riparian habitat consisting of boulder piles placed in the lake, and the removal of exotic and invasive species. Plate 6 provides a conceptual overview of this alternative.

Prior to construction, Cottonwood Pond would need to be dewatered by pumping from Cottonwood Pond into Boulder Creek. This would require diversion of the Goose Creek inflow using a pump and up to 500 feet of pipe. This process is expected to take up to 60 days and would need to be done outside of thunderstorm season. Dewatering and major grading activities would need to be completed outside the thunderstorm season and will require a site evaluation of the wildlife that could be impacted by earthmoving efforts. Following dewatering, deep holes would be excavated, with an estimated 5,140 CY of bed material removed. Small islands (some submerged) would be constructed in shallow portions of the lake to further topographic diversity. Island construction would make use of 100 T of rock material removed and hauled from South Goose Creek.

Existing non-native trees and shrubs would be removed from the pond shoreline and the adjacent riparian buffer zone. At least 30 trees, including crack willows and Russian olive trees would be

removed. Draining the lake for construction could kill most of the Eurasian water milfoil, but potential re-infestation could depend on shallow wetting or inundation by groundwater which could provide the milfoil the ability to survive and spread again. Application of a herbicide to any remaining stagnant pools would further reduce the survival of this water weed. Since the habitat in the restored Cottonwood Pond would remain attractive to re-infestation of Eurasian water milfoil from other sources in the Boulder Creek watershed, control of that invasive plant will require on-going maintenance.

In addition, 3,080 SY of shoreline would be re-graded to provide more natural bank irregularity to improve aquatic habitat. Shoreline and bed features would also be added that would support a more diverse fish population. This would include 10 T of riprap material placed as pallet cribs. Root wads would also be placed along the shore, taken from among the larger selective non-native trees removed from roughly 2 acres (AC) on site. Approximately 30 larger non-native trees are anticipated to be cut down. The root wads would be placed in the bank, requiring a minor amount of earthwork. The 2 AC of shoreline and transition would then be replanted to native tree and shrubs. Following major earthwork and boulder relocation, 14,500 square feet (SF) of bank would be graded and seeded to native plants and appropriate erosion control material placed. Access points for fishing in the pond would be developed adjacent to the bike trail along the northwest shore. Approximately 1,500 feet of fencing would be used to protect the remainder of the bank from foot traffic erosion adjacent to the bike trail.

Alternative 2 (R32):

This alternative (noted as M-CACES Re-designed Wetlands in the cost analysis) involves decreasing the pond depth to restore wetland features along a meandering stream to replicate pre-gravel mining conditions. The wetland restoration effort would involve the 7.13 acre pond and adjacent land within the overall 16.65 acre zone. The primary restoration feature for this alternative is to restore this former gravel pit to the riparian ecosystem that existed prior to the late 20th Century. This would be accomplished by dewatering the pond and filling much of its area, excavating a meandering channel for Goose Creek, establishing wetland and transitional plantings and removing exotic and invasive species. This alternative would result in 7.13 acres of water and 9.52 acres of riparian edge habitat. Plate 7 provides a conceptual overview of this alternative.

Immediately after restoration is complete, a stream channel will exist in the wetland. However, given the small base flow (1 to 2 cfs) flat stream gradient and the ability of wetland plants to colonize slow moving watercourses, it is anticipated that within 1 to 2 years of restoration, that the stream will be choked with reeds and cattails. Absent a measurable velocity, the stream will resemble the rest of the wetland in its hydrologic charactaristics. The remnanat stream channel may carry slightly higher velocities during flood flows, but given the large cross sectional area of the ambient future wetland, even high flows will be characteristic of wetland hydrology and not of a flowing stream.

Cattail and bulrushes are native and desirable at certain abundance; however, long-term management of these aggressive plants would be necessary. A combination of broadcast seeding and planting plugs of native emergent wetland species is recommended to quickly establish cover in the restored wetlands. The area bordering Cottonwood Pond to the south and east

contains a large quantity of invasive Russian olive trees and crack willows. This area can be restored to a greater density of cottonwood trees with native understory. Irrigation would only be considered if establishment of new plants seems at risk due to extremely dry conditions and addressed in the Risk and Uncertainty Section (Section 7.10).

Prior to construction, Cottonwood Pond would need to be dewatered by pumping water from the pond into Boulder Creek. This would require diversion of the Goose Creek inflow using a pump and up to 500 feet of pipe. This process is expected to take up to 60 days and would need to be done outside the thunderstorm season. To eliminate the Eurasian water milfoil, the bed of the pond would be completely backfilled with 33,400 CY of fill to form the wetland surface. The fill would include 975 CY of topsoil to be placed on top of the other material, including boulders salvaged from South Goose Creek. Detailed grading would be needed to form the wetland channels and would involve the additional movement of 8,400 CY of material, including 800 CY of topsoil. Donor fill sites would be certified to be free of noxious weeds and non-native seeds, and would most likely be OSMP or Colorado Division of Wildlife owned lands. This material would then be graded and compacted to match the wetland shape shown on Plate 8.

To improve connectivity with Boulder Creek and flood conveyance during large Goose Creek floods, an overflow berm would be excavated in the existing bank of Cottonwood Pond adjacent to Boulder Creek. The design crest elevation of this overflow section would be well above low to even moderate stages in Cottonwood Wetland. Construction of the overflow berm would involve 817 CY of excavation and the placement of 654 T of riprap, to protect the overflow section during the passage of a large flood through Cottonwood Wetland. The existing opening from Cottonwood Wetland to Boulder Creek, which has a base elevation near the normal water surface elevation of Boulder Creek, would not be altered.

Existing non-native trees and shrubs would be removed within and near the footprint of the wetland. At least 30 trees, including crack willows and Russian olive trees, would be removed. Tree and shrub removal activities would occur on roughly 2 acres distributed over the site. Native shrubs and trees would replace the removed non-native trees and shrubs over that area. In addition to that planting effort, specific wetland zones would be planted. A cottonwood/willow riparian zone would be planted, accounting for 7,580 SY of the wetland. 8,100 SY of transitional wetland grasses and forbs would be planted near the meandering channels in the new wetland zones. These zones would be bounded by an additional 8,900 SY of wet prairie, which would also be graded and seeded. The surrounding drier land, consisting of 40,400 SY, would be planted to provide a prairie buffer for the riparian area. Approximately 1,500 feet of fencing would be used to protect the wetland from foot traffic erosion adjacent to the bike trail.

6.0 ALTERNATIVE PLANS EVALUATION AND COMPARISON

6.1 METHODS OF MEASURING RESTORATION SUCCESS

Methods of measuring restoration success according to NER guidelines require that a particular restoration plan have inputs in dollars and outputs which are recognized and measured according to some generally accepted scale of ecosystem value. According to Appendix E of ER 1105-2-100 (30 Mar 2005, Page E-168), "The roles of various plant and animal populations and related habitats shall be considered in the larger context of community and ecosystem frameworks rather than maximizing habitat benefits for a single species or resource commodity." Given the ambient conditions of Goose Creek, the small size of the project footprint, and the prior use of the methodology in the city of Boulder, the EPA's Rapid Bioassessment methodology was used and adapted for the purpose of measuring riparian ecosystem improvements for this project.

Success in the restoration of South Goose Creek and Cottonwood Pond is measured by the net gain in Habitat Units (HUs) from the Future without-project condition (as projected from the pre-project existing condition) to the projected Future with-project condition. The estimation of the annualized cost of implementing the measures to produce the desired future condition (including annualized O&M), allows various ecosystem restoration measures to be compared using the IWR Planning Suite computer program. IWR Planning Suite features two steps. The first is an evaluation of the cost effectiveness of all plans and the second is the incremental cost analysis of all cost effective plans, to identify the "best buy" plans Further details of the methodology used are provided in sections 6.2 and 6.3 and in Appendix D; Economics.

6.2 COST EFFECTIVENESS/INCREMENTAL COST- ANALYSIS

A basis for determining the relative "value" of an ecosystem restoration plan is through the process of cost effectiveness/incremental cost analysis or CE/ICA. Alternative plans consisting of combinations of alternative measures that would be implemented in 0, 1, 2, or 3 reaches are formulated; then they are ordered according to net ecosystem restoration outputs (benefits), from zero (the no-action alternative) to the highest net environmental output. Benefits are then compared at ascending costs, to define the cost-effective plans. The cost-effective plans are then compared based on incremental (additional) cost per unit of incremental output to determine a series of "best buy" plans. In this series, as the amount of output increases, the cost per added unit of output also increases. The "best buy" plans are compared to identify whether any plan's additional output entails a significant jump in cost during the process of selecting a plan which produces the greatest net ecosystem restoration benefits that are considered to be "worth the cost". This process facilitates identification of the NER "best buy" plan from among a matrix of alternative plans. The CE/ICA was conducted using the IWR Planning Suite program, version 2.0.1.0 Beta, 26 February 2009,. Details of the analysis and results are provided in section 6.2.

6.2.1 Description of Methodology for Goose Creek

Various alternative management measures proposed for three adjoining reaches of Goose Creek were formulated and evaluated for ecosystem restoration. Each plan that is input into the CE/ICA includes an alternative measure (including no action) for each of the three different reaches of Goose Creek. These measures are mutually exclusive within a reach, but all measures

within a reach are mutually compatible with any alternative measure analyzed for the other reaches within the segment of Goose Creek proposed for ecosystem restoration.

6.2.2 Delineation of Outputs/Benefits

6.2.2.1 Habitat Assessment - Introduction

Existing, future without-project and future with-project ecosystem restoration conditions were analyzed or projected for each alternative using a modified version of the Environmental Protection Agency's (EPA's) Rapid Bioassessment Protocols (RBPs) (Barbour et al., 1999). According to the EPA document "EPA 941-B-99-002," the RBPs were established in the mid-1980s due to the need for cost-effective biological survey techniques. Among the goals of the protocols were that they are environmentally benign, cost-effective, yet scientifically valid assessment techniques which could be easily translated in scientific reports for use by management and the public. The methodology provided a vehicle to meet the goals outlined in Appendix E of ER 1105-2-100, as it pertains to "evaluating the larger context of community and ecosystem frameworks" for this smaller project in an urban setting.

6.2.2.2 Application to Goose Creek and Cottonwood Pond

The methodology has gained wide acceptance in the past 25 years, and had been employed in earlier studies in the Boulder area including evaluations of Goose Creek in Boulder. One such study, the Zuellig (2001) Thesis "Macroinvertebrate and Fish Communities along the Front Range of Colorado and their Relationship to Habitat in the Urban Environment," is considered foundational to this ecosystem restoration project. Zuellig used a modified version of EPA's RBPs which was developed for use in smaller streams. Among the habitat characteristics measured were stream width, riparian width, percent run, percent riffle pool, percent glide, area of root wads, percent undercut banks and amount of woody debris. The output of an evaluation of a riparian ecosystem was expressed in terms of "Habitat Attributes."

Application of this methodology to evaluating outputs from the Goose Creek ecosystem restoration effort was discussed with the City of Boulder, Colorado Division of Wildlife (CDOW) and U.S.Fish and Wildlife Service (USFWS) during initial meetings and correspondence in the spring of 2006. It was also discussed with Northwestern Division in November of 2006, and with a panel of experts, convened in May 2008 (See Appendix A-4, Attachment 3). In addition to those listed above, the panel of experts included the Natural Resources Conservation Service (NRCS), EPA and the U.S. Army Corps of Engineers ERDC Lab. In August 2010, members of the panel reconvened to discuss a newly proposed alternative for Reach 3, Cottonwood Pond. All concurred that this methodology was appropriate for this project. These discussions were also coordinated with the Corps' Ecosystem Restoration Planning Center of Expertise (ECO-PCX) located in the Mississippi Valley Division (MVR).

The habitat attributes used for this project were taken from the EPA RBA as well as customized by the panel of experts. Nine of a possible 13 attributes were utilized from the RBA, and 7 attributes were added by the panel (A detailed description of this modification is in the Habitat Assessment Appendix A-4). The attributes were selected for measurement on the basis of their importance to a healthy high plains ecosystem, their ability to reflect implementation of Corps National Ecosystem Restoration (NER) goals, such as connectivity and sustainability, and

representation of an urbanized stream. The habitat attributes depicted in Table 6-1 were evaluated for the existing and future without project conditions and again for the future with project conditions for each alternative and each reach. As noted in the table, attributes which related specifically to the stream reaches were removed from the analysis of the Cottonwood Pond alternatives. Detailed information regarding each attribute is provided in Appendix A-4 (Habitat Assessment).

Table 6-1: Habitat Quality Index (HQI) Habitat Attributes

Attribute	Description	Stream	Pond
Water Quality	Water quality is important to fish, amphibians, invertebrates and plants. In addition to pollutants, dissolved oxygen and extreme temperatures can limit species.	X	X
Frequency of Riffles	Critical for maintaining variety & abundance of insects in most high-gradient streams. Riffles & runs offer diversity of habitat through variety of particle size.	X	
Velocity/Depth Comb.	Diversity of depths provides refugia for invertebrates/fish.	X	X
Pool/Pond Substrate Characteristics	Firmer, diverse sediment types (gravel/sand) and rooted aquatic plants support more organisms than pool substrate dominated by mud or bedrock and no plants. Streams with uniform substrate in pools support fewer organisms.	X	X
Epifuanal Substrate & Available	Relative quantity & variety of natural structures (rocks/woody debris). Provides macro-invertebrates with niches, increasing habitat diversity & potential recovery after disturbance.	X	X
Embeddedness	Embeddedness is a measure of how embedded larger streambed material is in streambed sediment. Greater embeddedness means less surface area for macro-invertebrates and fish for shelter, spawning and egg incubation.	X	
Channel Sinuosity	High degree of sinuosity provides for diverse habitat and fauna. Stream is better able to handle surges when it fluctuates as a result of storms. Protects from excessive erosion & flooding, provides refugia for invertebrates and fish.	X	
Floodplain Connectivity	The ability of a stream to interact with the flood plain and bank. Flood terraces are important to many plant & animal species.	X	
Shoreline Stability (pond only)	Measures whether banks are eroded or have the potential for erosion. Steep banks are more likely to suffer from erosion and are considered unstable. Signs include crumbling, unvegetated banks, exposed tree roots, exposed soil.		X
Riparian Vegetative Zone Width	Buffers pollutants entering stream from runoff. Controls erosion, provides habitat and nutrient input.	X	
Riparian Corridor	A riparian corridor is a linear ecosystem that permits species to range and interact with regions upstream and downstream of the project area.	X	
Vegetated Buffer	A terrestrial buffer zone begins at top of bank & is needed for some species in addition to the stream and riparian vegetative zone.	X	X
Vegetative Protection	Root systems hold soil in place, allow uptake of nutrients by plants, control in-stream scouring and shade the stream. Banks with full, natural plant growth are better for fish and macro-invertebrates than those without or those with rip-rap.	X	X
Riparian Vegetative Quality	Riparian wetlands trap sediment by slowing down the water. Nutrients attached to the sediemt or in the water are metabolized by wetland plants and reduce eutrophication of phonds.	X	X
Exotic Species	Invasive species crowd out native species and can harm the survival of native T&E species.	X	X
Threatened & Endangered Species	Includes Federally listed Endangered, Threatened and Candidate species. Also includes any State listed species of concern.	X	X

Existing ecosystem conditions within the three reaches were assigned Habitat Quality Index (HQI) scores based upon field observation and were refined through the evaluations by the Panel of Experts. A normalized scale was used to evaluate ecosystem parameters with the qualitative and quantitative valuations of the parameters related as follows in Table 6-2:

Table 6-2: Habitat Quality Index (HQI) Scale

Habitat Quality Index	Verbal Equivalent
0.0 < 0.29	Poor
0.30 < 0.59	Marginal
0.60 < 0.89	Good/Sub-optimal
0.9 < 1.0	Optimal

6.2.2.3 Existing Condition Habitat Assessment Results

For each alternative, existing conditions for each potential reach were evaluated. Individual attribute scores, HQI and HUs are presented in Appendix A-4, Table 4.

Reach 1 covers about 7.7 acres, and is estimated to provide poor habitat (HQI = 0.13). This results in 0.98 Habitat Units (HUs). Reach 2 covers about 1.71 acres, and is estimated to provide poor habitat (HQI = 0.13). This results in 0.22 HUs. Reach 3, Cottonwood Pond, covers about 16.65 acres, and is estimated to provide marginal habitat (HQI = 0.36). This results in 5.99 HUs. This is summarized in Table 6-3 below.

6.2.2.4 Future Without-Project Habitat Assessment Results

For each alternative Future without-project conditions were evaluated. Individual attribute scores, HQI and HUs for Future without-project conditions are presented in Appendix A-4, Table 3.

In Reach 1 (7.7 acres) future without-project conditions are expected to decline. HQI is expected to decline from 0.13 (poor habitat) to 0.12. This results in a decline in HUs from 0.98 to 0.93.

In Reach 2 (1.71 acres), future without-project conditions are expected to decline. HQI is expected to decline from 0.13 (poor habitat) to 0.12. This results in a decline in HUs from 0.22 to 0.21.

In Reach 3, Cottonwood Pond (16.65 acres), future without-project conditions are expected to decline. HQI is expected to decline from 0.36 (marginal habitat) to 0.35. This results in a decline in HUs from 5.99 to 5.74.

Table 6-3 presents the HQI score under existing and Future without-project conditions for each reach, and the resulting HUs using the acreage for each action alternative.

Table 6-3: Existing Condition and Future Without-Project HQI Scores and Habitat Units

	Existing Condition HQI	Existing Condition Habitat Units	Future Without-Project Condition HQI	Future Without-Project Habitat Units
Reach 1 (7.7 ac)	.13	0.98	.12	0.93
Reach 2 (1.71 ac)	.13	0.22	.12	0.21
Reach 3 (16.65 ac)	.36	5.99	.35	5.74

6.2.2.5 Future with-project Habitat Assessment Results

For each alternative, existing and future-without conditions for each potential reach were evaluated for 1, 5, 10 and 15 years for comparative purposes with Future with-project expectations (see Appendix A-4 Section 4.1). The panel then assumed that the maximum benefits achieved by year 15 would extend throughout the life of the project (50 years). This evaluates conditions for years when changes would be first apparent as well as points when vegetation conditions could reach full maturity or a full cycle of succession, and then be sustained for the 50-year project life. The experts considered the score at 15 years to be a good estimate of the score at 50 years. Individual Habitat Attribute scores, Habitat Quality Index (HQI) scores, and habitat units (HUs) are presented in Appendix A-4, Tables 5 and 6. Changes in the HQI scores and HUs over time reflect changes in the ecological conditions in a reach and can show anticipated ecological effectiveness of an implemented ER alternative.

There is much greater opportunity to increase riparian corridor width and diversity, increase stream length by reintroducing sinuosity back into the channel, particularly in Reach 2 where the bike trail could be relocated and more space is available to implement additional habitat features. Moving the existing bike trail to the south (further from the right bank of South Goose Creek) and excavating a new, meandering channel with a hydrologically-connected wide right-bank terraced floodplain bench to the south comprises an expanded area of approximately 4.14 acres (from 1.71 acres future without-project).

The changes in HQI scores and HUs by year 15 are shown in Table 6-4. Improvements in Reach 1 (7.7 acres) are estimated to improve habitat conditions from poor (HQI = 0.12) to marginal (HQI = 0.49). Improvements to Reach 2, Alternative 1 (1.71 acres) are estimated to improve habitat conditions from poor (HQI = 0.12) to marginal (0.49), and to Reach 2, Alternative 2 (4.14 acres; bike trail moved, expanded excavated area) from poor (HQI = 0.12) to good/suboptimal (0.60). Improvements made to Cottonwood Pond, Reach 3, Alternative 1 (16.65 acres) are estimated to improve habitat conditions within the marginal range, HQI = 0.35 to HQI = 0.53, and to Alternative 2 (16.65 acres) from marginal (HQI = 0.35) to good/suboptimal (HQI = 0.76).

Table 6-4 presents the HQI score under future-without and Future with-project conditions for each reach, and the resulting HUs using the acreage for each action alternative.

Table 6-4: Future without-project (FWOP) and Future with-project (FWP) HQI Scores and Habitat Units

	FWOP HQI	FWOP HUs	Year 15 FWP HQI	Year 15 FWP HUs	Increase in HUs
Reach 1, A1 (7.7 ac)	.12	0.93	.49	3.79	2.86
Reach 2, A1 (1.71 ac)	.12	0.21	.49	0.84	0.63
Reach 2, A2 (Future With-Project 4.14 ac)	.12	0.21	.60	2.49	2.28
Reach 3, A1 (16.65 ac)	.35	5.74	.53	8.87	3.12
Reach 3, A2 (16.65 ac)	.35	5.74	.76	12.72	6.98

Figure 6-1 summarizes the increase in Habitat Units achievable by the different alternatives.

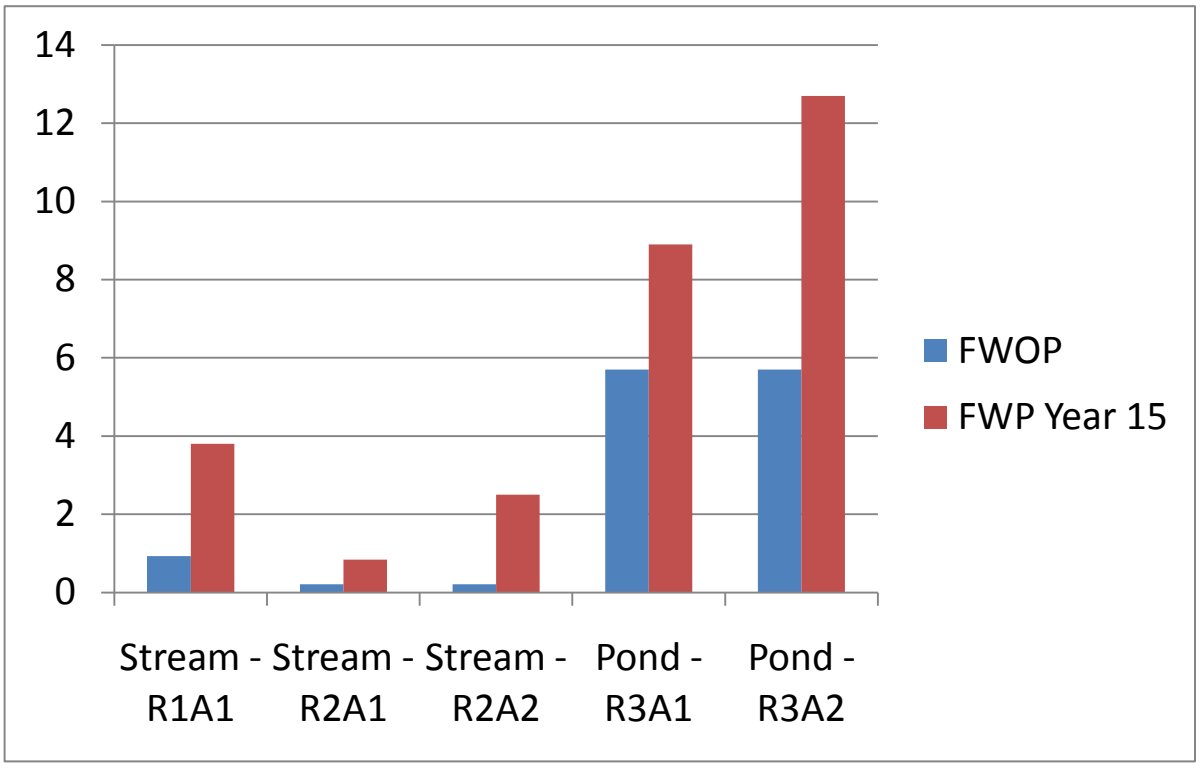

Figure 6-1: Goose Creek – Habitat Units Future Without Project & Future With Project (Year 15)

6.2.2.6 Use of These Environmental Outputs/Benefits in the CE/ICA

The HQI scores for future without project and the HQI scores for 1, 5, 15, and 50 years with-project were used to calculate the cumulative HUs over 50 years for each reach-based alternative. These calculations are further explained in section 6.3.2. The 50-year cumulative HUs were divided by 50 to produce average annual equivalent HUs (AAHUs) for each

alternative. Each alternative's environmental benefit is its net AAHUs (the difference between its AAHUs and the AAHUs without-project in that reach).

6.2.3 Delineation of Costs

Costs were computed from quantities estimated by the feasibility study team. The primary quantification tool was the feasibility design plan that was developed by Geotechnical Branch. The plan view drawings allowed the estimation of areas in square feet or square yards as noted in Section 5.3. Surface models and cross sections, depicting depth of cuts, and height of fills permitted the estimation of volumes in cubic yards. Plates 8 and 9 are an example of the design drawings for the Cottonwood Wetland Alternative. Other quantities were developed based upon the desired ecosystem restoration outputs and professional judgment.

Drawings and quantities were then provided to the Cost Engineering Branch. Construction costs were prepared using the latest cost data in the Corps of Engineers TRACES MII Version 4.0 (M-CACES). Unit costs for the various construction features were computed, and then appropriate costs for the design and implementation phase and supervision and administration of the contract were added to develop the total construction cost estimate for each alternative.

Real estate costs were based on a gross appraisal and were estimated for the footprint of each reach. Real estate costs are expressed as the cost of Lands, Easements, Rights-of-Way, Relocations and Disposal, or LERRDs. The PDT and Sponsor analysis projects that the State Engineer guidelines will be followed so that no water rights would need to be acquired; however, coordination with the Colorado State Engineer is ongoing through the draft of the report and public involvement during the NEPA process.

The total first cost of each alternative is the construction cost (including engineering and design, supervision and administration, and contingencies) and the cost of interest during construction added to the LERRDs cost. These first costs are annualized over the 50-year life of the project using the FY11 interest rate of 4.125%. To these annualized costs are added the annualized costs of monitoring and preparation of the O&M Manual after construction is completed, and the annual OMRR&R costs; the sum is the total annual cost. The first (investment) costs and the annualized costs are provided by category for each alternative in Table 6-5. Rounding errors may be present.

Table 6-5: Total Implementation Costs ($) and Annualized Costs ($) by Alternative Plan (Jan 2011 prices, 4.125%, 50 years)

Alternative Plan	Con-struction Cost	Engin-eering & Design	Super-vision & Ad-minis-tration	Contin-gency	Year 1 EWM Treat-ment	Real Estate incl Admin/Le-gal Costs for Fed & Non-Fed	IDC for 1 Yr at 4.125 %	Total First Costs (incl $80K PM/ PDT labor in Constr. Phase)	Annu-alized Cost at 4.125% 50 Yrs	Annu-alized O&M Manual Monitor Costs	Annual Cost of OMR R&R	Total Annual Costs
No Action	0	0	0	0	0	0	0	0	0	0	0	0
Rch (R) 1	64,130	7,342	3,848	13,596	0	496,750	21,350	687,015	32,668	1,196	11,217	45,081
Rch 2 Alt 1	71,335	8,166	4,280	15,123	0	311,866	14,900	505,670	24,045	948	2,491	27,484
Rch 2 Alt 2	304,902	34,905	18,294	64,639	0	311,866	21,530	836,136	39,758	1,048	6,031	46,837
Rch 3 Alt 1	188,792	21,613	11,328	40,024	4,765	552,492	26,920	925,933	44,028	1,271	17,400	62,699
Rch 3 Alt 2	464,791	53,209	27,887	98,536	0	552,492	34,730	1,311,646	62,369	1,566	24,569	88,504
R1 + R2, A1	135,465	15,508	8,128	28,718	0	808,616	34,610	1,111,045	52,830	1,266	13,708	67,805
R1 + R2, A2	369,032	42,247	22,142	78,235	0	808,616	41,240	1,441,511	68,544	1,367	17,249	87,159
R1 + R3, A1	252,922	28,955	15,175	53,619	4,765	1,049,242	46,630	1,531,308	72,814	1,589	28,618	103,021
R1 + R3, A2	528,921	60,551	31,735	112,131	0	1,049,242	54,440	1,917,021	91,154	1,884	35,787	128,825
Rch 2, Alt 1+ Rch 3, Alt 1	260,126	29,779	15,608	55,147	4,765	798,058	37,790	1,281,273	60,925	1,342	19,892	82,158
Rch 2, Alt 1+ Rch 3, Alt 2	536,126	61,376	32,168	113,659	0	798,058	45,600	1,666,985	79,265	1,636	27,060	107,962
Rch 2, Alt 2+ Rch 3, Alt 1	493,694	56,518	29,622	104,663	4,765	798,058	44,420	1,611,739	76,638	1,442	23,432	101,512
Rch 2, Alt 2+ Rch 3, Alt 2	769,693	88,114	46,182	163,175	0	798,058	52,230	1,997,452	94,979	1,737	30,600	127,316
R1 +R2 Alt 1 +Rch 3, Alt 1	324,256	37,121	19,455	68,742	4,765	1,294,808	57,500	1,886,648	89,710	1,660	31,109	122,479
R1 +R2 Alt 1 +Rch 3, Alt 2	600,256	68,717	36,015	127,254	0	1,294,808	65,310	2,272,361	108051	1,955	38,278	148,284
R1 +R2 Alt 2 +Rch 3, Alt 1	557,824	63,860	33,469	118,259	4,765	1,294,808	64,130	2,217,114	105424	1,760	34,649	141,833
R1 +R2 Alt 2 +Rch 3, Alt 2	833,823	95,456	50,029	176,770	0	1,294,808	71,940	2,602,827	123764	2,055	41,818	167,637

6.3 COMPARISON OF ALTERNATIVE PLANS

6.3.1 Overview of IWR Planning Suite

The analysis of the cost effectiveness and incremental cost of alternative plans was accomplished using the Institute for Water Resources' (IWR) program IWR Planning Suite. IWR Planning Suite first analyzed cost effectiveness, screening out any plans whose output could be exceeded by another plan with the same or lower cost. In addition to the "No Action" plan, 12 plans emerged as cost effective. These are shown in Table 6-6. The IWR Planning Suite program compared the incremental annualized cost and incremental output among the cost-effective plans. Each cost-effective plan was first compared to the "No Action" plan and ranked on the cost per unit of incremental (additional) output. The ranking revealed the first "best buy" plan. Each remaining plan with a larger output than the first best buy plan was similarly ranked by its incremental cost per incremental output above that of the first best buy plan to yield the second best buy plan, and so on. Any of the "best buy" plans can be chosen as the preferred alternative, based upon limitations set on total project cost and with justification for each jump in incremental costs for added output. The following 18 alternative plans were evaluated using IWR Planning Suite:

- R10R20R30 – No Action;
- R11R20R30 – Reach 1;
- R10R21R30 – Reach 2, Alternative 1;
- R10R22R30 – Reach 2, Alternative 2;
- R10R20R31 – Reach 3, Alternative 1;
- R10R20R32 – Reach 3, Alternative 2;
- R11R21R30 – Reach 1 and Reach 2, Alternative 1;
- R11R22R30 – Reach 1 and Reach 2, Alternative 2;
- R11R20R31 – Reach 1 and Reach 3, Alternative 1;
- R11R20R32 – Reach 1 and Reach 3, Alternative 2;
- R10R21R31 – Reach 2, Alternative 1 and Reach 3, Alternative 1;
- R10R21R32 – Reach 2, Alternative 1 and Reach 3, Alternative 2;
- R10R22R31 – Reach 2, Alternative 2 and Reach 3, Alternative 1;
- R10R22R32 – Reach 2, Alternative 2 and Reach 3, Alternative 2;
- R11R21R31 – Reach 1, Reach 2, Alternative 1 and Reach 3, Alternative 1;
- R11R21R32 – Reach 1, Reach 2, Alternative 1 and Reach 3, Alternative 2;
- R11R22R31 – Reach 1, Reach 2, Alternative 2 and Reach 3, Alternative 1; and
- R11R22R32 – Reach 1, Reach 2, Alternative 2 and Reach 3, Alternative 2.

6.3.2 Inputs to IWR Planning Suite

The inputs to IWR Planning Suite include annualized costs and benefits for each alternative plan represented. For this analysis, the initial implementation (investment) costs are the sum of construction costs (including engineering and design and supervision and administration) plus real estate (LERRDs costs, including non-Federal labor costs for acquisition; plus Federal administrative costs for certification of fair market value and crediting) and interest during

construction. Those values then are annualized, which amortizes the total cost over the life of the project using the FY11 interest rate (50 years at 4.125%). Annualized costs of monitoring, annualized costs of preparing the O&M Manual, and annual costs of operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) are then added to the amortized investment costs to determine the total annual costs. The benefits (net environmental outputs) are calculated in several steps. First, HQI scores in a reach are obtained for the no action alternative and action alternatives (each consisting of a combination of measures within that reach) under six time periods: future without project conditions, when ER construction would be anticipated to occur; year 1 after expected time of ER project completion; and 5, 10, 15, and 50 years after expected completion of ER. The HQI scores for each alternative are multiplied by the number of acres in the reach to form habitat units (HUs). For each reach-based alternative, HUs were calculated for each time interval (0-1, 1-5, 5-10, 10-15, and 15-50 years) using formulas developed by the U.S. Fish and Wildlife Service (USFWS) for Habitat Evaluation Procedures (HEP) analyses (USFWS, 1980). These interval-based riparian HUs were summed to form 50-year cumulative HUs. The 50-year cumulative FUs were divided by 50 to obtain the average annual equivalent habitat units (AAHUs). The difference in AAHUs between an action alternative and the no-action alternative for that reach (net AAHUs) is the environmental output of that action alternative. The annualized costs and benefits of the 18 ER plans (combinations of alternative measures) for South Goose Creek are depicted in Table 6-6.

6.3.3 IWR Planning Suite Outputs

In conjunction with the environmental analysis of potential projects, cost effectiveness and incremental cost analyses (CE/ICA) are required. IWR Planning Suite provides output tables and graphs related to the cost effectiveness and incremental cost analyses it performs. Cost effectiveness analysis is conducted to ensure that the least cost solution is identified for each level of environmental output. Inefficient alternative plans are eliminated based on comparing plans regarding total environmental output and total average annual equivalent cost. Table 6-6 identifies the Goose Creek plans that are cost effective, non-cost effective, and best buy plans (a subset of the cost effective plans). A plan is not considered cost effective if:

- The same output level could be produced by another plan at less cost;
- A larger output level could be produced by another plan at the same cost; or
- A larger output level could be produced by another plan at less cost.

Table 6-6: Goose Creek Restoration Plans' Costs, Benefits and Cost Effectiveness

Name of Plan	Cost ($1000)	Output (Net AAHUs)	Cost Effective
No Action Plan	0	0	Best Buy
R11R20R30: Reach 1 - Drill-seed native grass	45.081	2.70	Yes
R10R21R30: Reach 2, Alt 1 - Narrow floodplain	27.484	0.60	Yes
R10R22R30: Reach 2, Alt 2 - Wider floodplain	46.837	2.15	No
R10R20R31: Reach 3, Alt 1 - Pond restoration	62.699	3.00	Yes
R10R20R32: Reach 3 Alt 2 - Wetland, not pond	88.504	6.56	Best Buy
R11R21R30: Reach 1 + Reach 2, Alt. 1	67.805	3.30	Yes
R11R22R30: Reach 1 + Reach 2, Alt. 2	87.159	4.85	Yes
R11R20R31: Reach 1 + Reach 3, Alt. 1	103.021	5.70	No
R11R20R32: Reach 1 + Reach 3, Alt. 2	128.825	9.26	Best Buy
R10R21R31: Reach 2, Alt 1 + Reach 3, Alt 1	82.158	3.60	Yes
R10R21R32: Reach 2, Alt 1 + Reach 3, Alt 2	107.962	7.16	Yes
R10R22R31: Reach 2, Alt 2 + Reach 3, Alt 1	101.512	5.15	No
R10R22R32: Reach 2, Alt 2 + Reach 3, Alt 2	127.316	8.71	Yes
R11R21R31: Reach 1 +Reach 2 Alt 1 +Reach 3 Alt 1	122.479	6.30	No
R11R21R32: Reach 1 +Reach 2 Alt 1 +Reach 3 Alt 2	148.284	9.86	Yes
R11R22R31: Reach 1 +Reach 2 Alt 2 +Reach 3 Alt 1	141.833	7.85	No
R11R22R32: Reach 1 +Reach 2 Alt 2 +Reach 3 Alt 2	167.637	11.41	Best Buy

Figure 6-2 displays all 18 Goose Creek alternative plans differentiated by cost effectiveness. In Figure 6-2, costs are average annual equivalent costs, in thousands of dollars; outputs are net average annual equivalent habitat units (AAHUs).

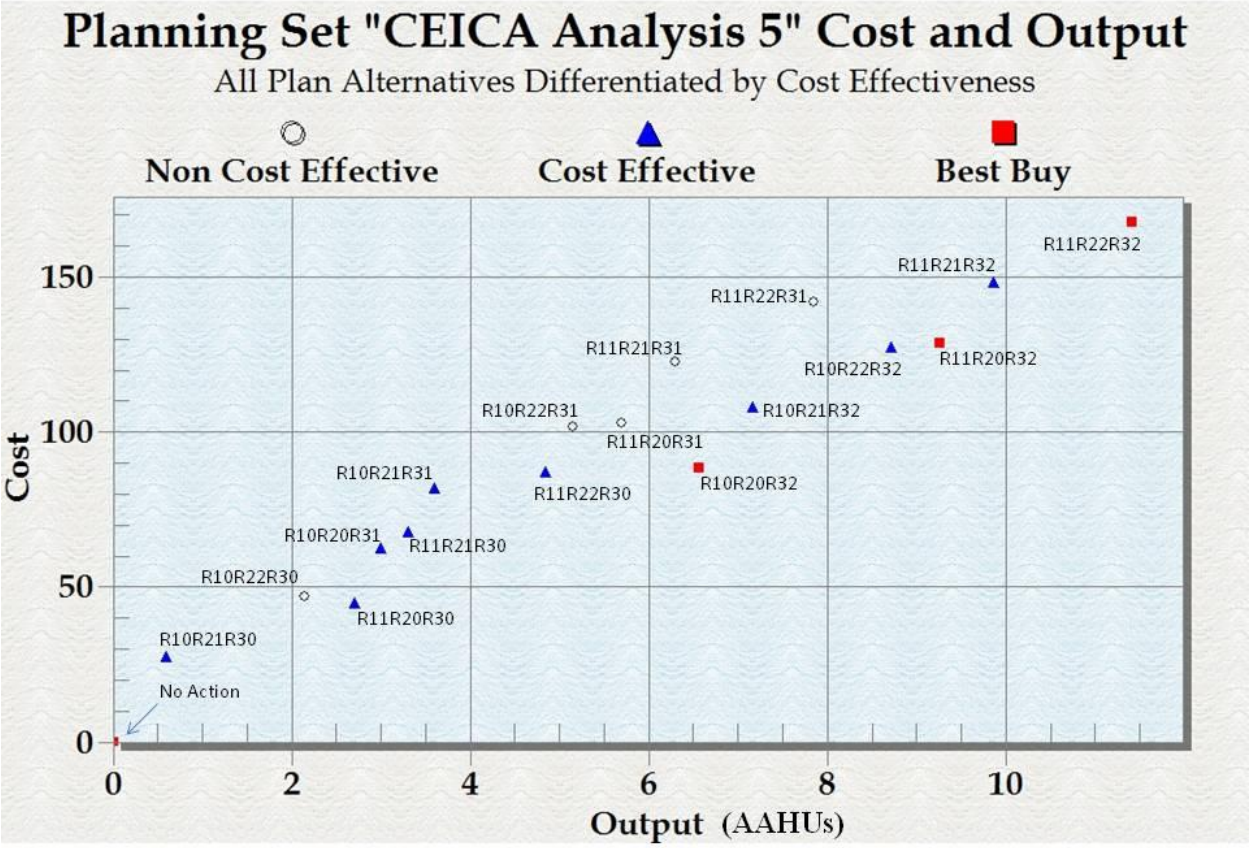

Figure 6-2: Cost Effectiveness of Alternative Plans, Goose Creek Ecosystem Restoration.

Figure 6-2 shows that five alternative plans were not cost effective because they had a higher cost for a given level of environmental outputs. These five plans were eliminated from further consideration. Table 6-7 displays the 13 cost effective plans, listed in ascending order of average annual equivalent environmental outputs. Average annual equivalent costs are based on January 2011 prices, the FY11 interest rate of 4.125 percent, and a 50-year period of analysis.

Table 6-7: Cost-Effective Alternative Plans, with Net AAHUs, Average Annual Equivalent Costs, and Average Annual Equivalent Cost per AAHU

ALTERNATIVE PLANS	AAHUs	AVERAGE ANNUAL EQUIVALENT COSTS	AVG. ANNUAL EQUI-VALENT COST / AAHU
No Action	0.00	$ 0	$0
Reach 2, Alt. 1	0.60	$27,484	$45,807
Reach 1	2.70	$45,081	$16,697
Reach 3, Alternative 1	3.00	$62.699	$20,900
Reach 1 + Reach 2, Alt. 1	3.30	$67,805	$20,547
Rch 2, Alt. 1 + Rch 3, Alt 1	3.60	$82,158	$22,822
Reach 1 + Reach 2, Alt. 2	4.85	$87,159	$17,971
Reach 3, Alt. 2	6.56	$88,504	$13,491
Rch 2, Alt.1 + Rch 3, Alt. 2	7.16	$107,962	$15,078
Rch 2, Alt. 2 + Rch 3, Alt 2	8.71	$127,316	$14,617
Reach 1 + Reach 2, Alt. 2	9.26	$128,825	$13,912
R1 + R2, Alt. 1 + R3, Alt. 2	9.86	$148,284	$15,039
R1 + R2, Alt. 2 + R3, Alt. 2	11.41	$167,637	$14,692

Table 6-7 serves as the basis for the incremental cost analysis, which is conducted on the cost-effective plans to show changes in costs as levels of environmental outputs are increased. It provides data for decision-makers to decide if the next higher level of output is worth the cost. It measures the incremental or additional cost of the next additional level of environmental output. IWR Planning Suite identifies as "best buys" the subset of cost-effective plans that provide the greatest increase in output levels for the least increase in cost. The no-action plan is by definition a best buy plan. The first calculation compares the incremental costs per unit of incremental output of each cost-effective action plan to the no action plan. Incremental cost per unit is the plan's incremental cost (difference between its cost and that of no action) divided by its incremental output (difference between its output and that of no action). The plan with the lowest incremental cost per unit of incremental output is the first selected best buy plan. The first best buy plan's total outputs and total average annual equivalent costs are set as the new "base" for determining the next round of incremental costs and incremental outputs. In sequence, subsequent best buys are selected from the remaining plans that have outputs greater than the most recently selected best buy, based on the lowest incremental cost per unit of incremental output. The step is repeated until all best buy plans have been identified. Figure 6-3 summarizes the results of the final incremental cost analysis; it shows only best buys.

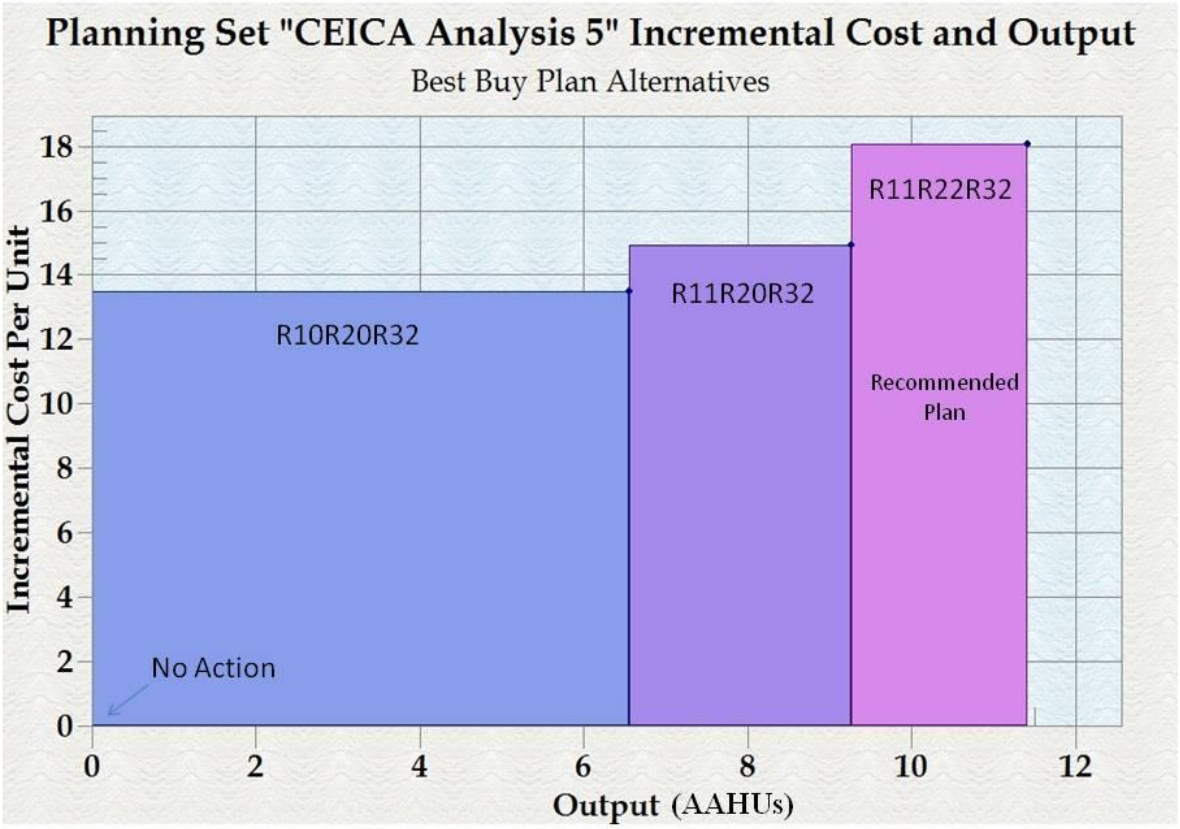

Figure 6-3: Comparison of Best Buy Plans

In Figure 6-3, incremental costs per unit of output are average annual equivalent costs in thousands of dollars; outputs are net average annual equivalent habitat units (AAHUs).

The total output of a best buy plan is the sum of its incremental output and those of any best buy plan(s) to its left on the graph. The greater the vertical "step" between plans, the greater the difference in incremental cost per unit of additional output. The presence of a breakpoint when the Reach 1 plan is added to the Reach 3, Alternative 2 plan and then again when the Reach 2, Alternative 2 plan is added to the previouws combined plan indicates that a detailed rationale may be needed to justify selection of either of these combined plans. Notably, the percentage increase in outputs is nearly twice the percentage increase in incremental costs per incremental unit of output in both cases where a plan is added to a plan or plans previously selected as best buys. All three plans would meet the criteria of being cost effective and incrementally justified.

6.4 PLAN SELECTION

Plan selection is based on comparing the outputs, total costs, the incremental cost per unit of incremental output, and specific features and attributes of the ecosystem restoration alternatives that are displayed as best buy plans in Figure 6-3. The attributes for each action best buy plan and combination of best buy plans, and an assessment of whether the increase in incremental cost per unit of incremental output as the number of best buy components in the plans increase is "worth it" in terms of acceptability, completeness, effectiveness, and efficiency, are presented in the following paragraphs.

Based on the results of the cost effectiveness and incremental cost analyses, and as shown in Figure 6-3, the Reach 3, Alternative 2 plan appears to be the most cost-effective single-reach plan. Eliminating and/or controlling non-native species such as crack willow and Russian olive, and invasive species such as Eurasian water milfoil, and replacing them with native species such as cottonwoods and native willows and native wetland plants will increase the quality of fish and wildlife habitat near the confluence of South Goose Creek with Boulder Creek. Ecosystem restoration to wooded wetlands at the existing Cottonwood Pond area would be expected to greatly increase the connectivity between the downstream end of South Goose Creek and Boulder Creek from the standpoints of lateral connectivity between Boulder Creek and its floodplain; wildlife travel corridors would also be enhanced by the development of palustrine wetlands, which can provide excellent rearing habitat for fish, reptiles, amphibians, shorebirds, some varieties of songbirds and some mammals (such as the resident mink),. Populations of the federally listed Ute ladies'-tresses orchid and Preble's meadow jumping mouse are found along South Boulder Creek, which enters Boulder Creek less than a mile downstream from the South Goose Creek confluence. Restoration of Cottonwood Pond to a wooded wetland could provide habitat suitable for these two species and the Colorado butterfly plant *(Gaura neomexicana spp. Coloradensis)* (another federally listed species), as well as a number of State-Listed species and State Species of Concern. The creation of palustrine wetlands to replace the Eurasian water milfoil-infested pond and enhancement of other riparian areas is very important for fish, migratory birds, and other wildlife species; 75% of the wildlife species in Colorado are dependent on riparian areas during all or a portion of their life cycle, yet riparian areas make up less than 3% of the land mass in Colorado (USFWS, 2008).

When ecosystem restoration in Reach 1 is combined with the Reach 3, Alternative 2 plan, the incremental cost per incremental AAHU increases by approximately 11 percent; however, the net AAHUs increase by over 41 percent. The rise in the HQI in Reach 1 after restoration

indicates improvement in riparian habitat quality for a variety of wildlife due to replacing non-native species such as exotic lawn grasses with native prairie, wetland, and shrub species, which in turn reduces habitat fragmentation of native plant communities. Establishing several small wetlands near the stream and at storm sewer outfalls in Reach 1 would provide additional filtering capacity and cover to aid water quality and improve fish and wildlife habitat (Ellis 2008a, 2008b, 2008c). Four wildlife travel structures will be placed at culverts, including the culvert under Foothills Parkway; these will greatly increase connectivity between the segments within Reach 1 as well as increase connectivity between South Goose Creek and the previously restored reach of Upper Goose Creek, immediately upstream of Foothills Parkway.

When ecosystem restoration in Reach 2, Alternative 2 is added to the Reach 3, Alternative 2 and Reach 1, Alternative 1 combined plan, the incremental cost per incremental AAHU increases by nearly 21 percent, but the number of net AAHUs increases by over 23 percent. Adding ecosystem restoration in Reach 2, Alternative 2 appears to be worth the additional cost for several reasons. First, longitudinal connectivity would be greatly increased by formation of a continuous restored wildlife corridor encompassing the restored reach of Upper Goose Creek, all three reaches of South Goose Creek, and Boulder Creek. Second, lateral connectivity of South Goose Creek with its riparian floodplain would also be established in Reach 2 by relocation of the bicycle trail farther south, away from the existing south bank, and excavating to form floodplain benches and terraces as well as modifying rock structures in the stream to enhance aquatic habitat and allow the stream to meander. In addition, habitat fragmentation would be further reduced and habitat quality would be improved for a variety of wildlife species by replacing non-native species with a diversity of native species on the terraces. This includes planting native cottonwoods and willows on the upper terraces of the excavated riparian floodplain; the U.S. Fish and Wildlife Service's (USFWS) Mountain-Prairie Region considers riparian cottonwood-willow associations to be a critical wildlife resource (USFWS, 2001).

Ecosystem restoration in all three reaches may be justified as the National Ecosystem Restoration (NER) plan for several reasons. First, removal of exotic woody species and replacing them with native tree and shrub species, especially cottonwoods and /or willows, would be accomplished in all three reaches. Second, ecosystem restoration in all three reaches would enhance connectivity within the South Goose Creek wildlife corridor and extend the wildlife corridor downstream to Boulder Creek; it would be the most complete of the three best buy plans because it would result in a continuous corridor of improved wildlife habitat between the upstream end of the restored Upper Goose Creek reach all the way to Boulder Creek. "Riverine corridors often serve as critical wildlife connection and dispersal corridors. They frequently involve a high diversity of vegetation, providing nourishment, shade, cover, breeding grounds, and critical wintering grounds for a number of wildlife species" (USFWS, 2003a, pp. 15-16), including Colorado State Species of Concern. Third, the creation of palustrine wetlands to replace the Eurasian water milfoil-infested pond and enhancement of other riparian areas will complement the existing cattail wetland in the vicinity of where South Goose Creek flows into Cottonwood Pond and also the establishment of several small wetlands near the stream and at storm sewer outfalls in Reach 1. The number, variety, and proximity of the areas of quality wetlands habitat could function in a synergistic manner to enhance availability of local wetlands seed banks for natural wetland plant propagation and to attract fauna that prefer wetlands habitats. All the measures in the three-reach action plan add to this synergy, resulting in

formation of a continuous restored riparian wildlife corridor encompassing the restored reach of Upper Goose Creek and all three reaches of South Goose Creek that functions as a critical wildlife connection and dispersal corridor (USFWS, 2003a).

Based on the analysis above that involved considerations of acceptability, completeness, and effectiveness as well as efficiency, Corps study team recognized that the best buy plan with action alternatives in all three reaches of South Goose Creek would be the NER Plan. City of Boulder staff decided separately, after receiving the CE/ICA results, that this same three-reach plan would be the Sponsor-Preferred Plan. Therefore, the plan that included Reach 1, Alternative 1; Reach 2, Alternative 2; and Reach 3, Alternative 2 was determined to be the NER Plan and Selected Plan.

6.5 COMPLIANCE OF SELECTED PLAN WITH THE PRINCIPLES AND GUIDELINES (P&G)

Acceptability, completeness, effectiveness and efficiency are the four evaluation criteria specified in the P&G (Paragraph 1.6.2(c)) in the screening of alternative plans. The following paragraphs demonstrate how the Selected Plan meets those four criteria.

Acceptability is demonstrated by the fact that the Corps-recommended plan is acceptable to State and Federal resources agencies and to our local sponsor as determined by public and agency involvement meetings during plan formulation. This plan was also prepared with assistance from the multi-agency Panel of Experts and is consistent with other reaches of Goose Creek previously restored (ER 1105-2-100, Paragraph E-38.a). The plan is technically feasible and implementable according to technical, environmental, economic, financial, political, legal, institutional and social factors (ER 1105-2-100, Paragraph E-3.a(4(a1))). Hydraulic analysis of the proposed project indicates compliance with flooplain regulations (Section 8.11 of this report).

Completeness is demonstrated by the Selected Plan's having both lateral connectivity (between stream and floodplain) and longitudinal connectivity (among the three South Goose Creek reaches, and between the Goose Creek project and the restored reach of Upper Goose Creek upstream as well as Boulder Creek downstream). Monitoring and adaptive management have also been incorporated into this plan.

The Selected Plan is effective, as it benefits all significant resources listed in section 1.1.4. Effectiveness in regard to improvements in ecosystem habitat quality provided by the Selected Plan is demonstrated by the increase in Habitat Quality Index (HQI) scores in each reach from year 0 (future without project condition) to 50 years after Goose Creek ER project construction. Its effectiveness also involves decreasing the scarcity (i.e. increasing the amount) of ecological resources and increasing connectivity of wildlife habitat; both are documented in section 6.4. The Selected Plan improves chances of recovery for Federally Listed and other protected and/or special concern species by providing a contribution to one or more key life requisites, verified in sections 8.3.1, 8.3.2, and 8.3.3. It also contributes to the goals of other federal, state, county, or municipal plans, as documented in section 2.3.5. It is consistent with the seven Environmental

Operating Principles (documented in section 8.14), which includes sustainability that is facilitated by a monitoring plan and adaptive management plan (provided in section 7.7.2).

Efficiency is ensured by using the Cost Effectiveness/Incremental Cost Analysis (CE/ICA) results. Using the IWR Planning Suite program ensures that any alternative that is not cost effective (i.e. produces fewer environmental outputs at a total cost equal to or greater than another alternative) is eliminated from further consideration. The ICA identifies the incremental cost per unit of incremental output among cost-effective alternatives and arrays them in terms of efficiency. These "best buy" plans are then compared to each other to assess whether the increase in cost per additional unit of output is "worth the cost" in order to obtain a greater amount of environmental outputs. To determine whether a jump in incremental cost per unit of incremental output is "worth it", the acceptability, completeness, and ecological effectiveness of the best buy plans are considered in conjunction with their incremental and total costs.

6.6 WITH-PROJECT RECREATION FACILITY PLAN OPTIONS, BENEFITS AND ECONOMIC JUSTIFICATION

The recreational benefits are included and are incrementally justified, but final quantities, placement and details will be left to the design phase. The dollar value per day of general recreation was estimated for several alternative with-project recreation facility plans using the Unit Day Value (UDV) method. Point values were assigned based on visitor enjoyment and willingness to pay using the table "Guidelines for Assigning Points for General Recreation." This is Table 6-29 of Engineer Regulation 1105-2-100, Planning Guidance Notebook, dated December 28, 1990; and Table 1 of the attachment to Economic Guidance Memorandum (EGM) 11-03, Unit Day Values for Recreation, Fiscal Year 2011, dated November 5, 2010. The point values were assigned during conference calls August 17 and 24, 2006, with city of Boulder staff representing the following Departments: Parks and Recreation; Open Space and Mountain Parks; Transportation; and Public Works. The point values were converted to dollars per day of general recreation based on EGM 11-03. The point values for each recreation facility plan and their corresponding dollar values per day are provided in Table 6-8.

Table 6-8: Recreation Facility Alternatives and Their Benefit Values (FY11 $) per Visitor-Day and Annually

Recreation Facility Plan	UDV Points	$/Day/ Visitor	Recreation Benefit/Yr*	Net Recreat. Benefit/Yr**
Remove 2 doglegs in trail; Fence between trail and Cottonwood Wetland	43	$6.99	$2,013,120	$426,240
Remove 2 doglegs in trail; Fence between trail & C. Wetland; 1 educ./interpretive sign	44	$7.08	$2,039,040	$452,160
Remove 2 doglegs in trail; Fence between trail & C. Wetland; 2 educ./interpretive signs	45	$7.17	$2,064,960	$478,080
Remove 2 doglegs in trail; Fence between trail & C. Wetland; 3 educ./interpretive signs	46	$7.26	$2,090,880	$504,000
Remove 2 doglegs in trail; Fence between trail & C. Wetland; 4 educ./interpretive signs	47	$7.35	$2,116,800	$529,920

*Total with-project recreation benefits are based on 288,000 trail visitors per year.

**Net recreation benefits are equal to the annual recreation benefits with-project minus $1,586,880 in annual recreation benefits without-project.

As part of the NER plan, the concrete trail along the south bank of South Goose Creek in Reach 2 would be removed and would be reconstructed along the "social" trail alignment, farther from South Goose Creek. The trail relocation cost is estimated at $56,345 in M-CACES at January 2011 price levels. The trail relocation is part of the ER project, and the cost is part of LERRDs. Fencing between the trail and the Cottonwood Wetland is also considered part of the ER project. The only recreational facilities would be the educational / interpretive signs, which are also considered as part of the ER project and have costs so minimal they are included in the contingency costs for the ER project. A sign with a trail map near Reynolds Corner would cost $4,000 (including installation). Three additional signs made of high-pressure laminate would cost up to $1,500 each, for a total of $4,500 (including installation). Steel pedestals would cost up to $400 for each sign, totaling up to $1,600. City of Boulder staff would design the signs, so total first cost would be $10,100 plus design costs. The signs would be replaced as needed by the City of Boulder but require no other OMRR&R. Even if trail visitation does not increase, the over $400,000 in net annual recreation benefits easily economically justifies the cost of up to four interpretive signs.

7.0 RECOMMENDED PLAN

7.1 PLAN DESCRIPTION

The recommended plan (R11R22R32) is to restore the Reach 1 channel, move the bike trail and develop a channel with meander bends and floodplain with multiple terraces in Reach 2 and to convert Cottonwood Pond to habitat similar to its predevelopment state as a wooded wetland. This plan was selected from the array of "best buy" plans based upon its: efficiency (the increase in output for the second and third best buy plan selected were both greater than the percent increase in incremental cost per additional unit of output); completeness (restoring all three reaches (Figure 1-3) greatly enhances connectivity, both lateral (stream-floodplain, especially in reach 2, the last reach added in the NER plan) and longitudinal (between Goose Creek reaches, as the last-added reach 2 connects with both reaches 1 and 3; and with reaches upstream and downstream from South Goose Creek); effectiveness (providing the greatest output of all plans, and meeting the overall aquatic ecosystem restoration objectives for the Boulder Creek watershed); and acceptability (having the support of the Sponsor, as well as being technically feasible and consistent with all applicable laws and regulations and local and regional plans).

Implementation of the recommended plan would provide for a continuous restored reach of South Goose Creek and Cottonwood Pond that would link the previously restored reach of Goose Creek west of Foothills Parkway with the riparian habitat along Boulder Creek. This would provide connectivity for species movement into the upper reaches of this tributary by the development of sustainable ecosystem restoration where a flood control channel and gravel pit pond now exists.

The restoration plan for Reach 1 involves the aquatic habitat improvement of 7.70 acres of South Goose Creek flood control channel. The primary measures include riparian zone improvement, construction of wetlands at storm sewer outfalls, modification of rock structures (including some of those bounding the low flow channel), removal of exotic trees, and installation of wildlife migration structures under four road crossings. This restoration plan is depicted in Plates 1 through 3 and in Figure 5-3.

The restoration plan for Reach 2 consists of the aquatic restoration of 4.14 acres of flood control channel and adjacent perched floodplain. The central restoration theme for this reach entails moving the existing bike trail to the south (further from the right bank of South Goose Creek), and excavating a new, meandering channel with a wide right bank floodplain bench with multiple terraces to the south. The excavation plan would also increase the low water channel stream length by adding sinuosity. Additional restoration features include riparian zone improvement, construction of wetlands at storm sewer outfalls, modification of rock structures (including those bounding the low flow channel) and the removal of exotic plant species. Plates 4 and 5 provide a conceptual plan for this alternative.

The restoration plan for Reach 3 (Cottonwood Pond) involves decreasing the pond depth to restore historical wetland habitat. The wetland restoration effort would involve the 7.13-acre pond and adjacent land within the overall 16.65 acre zone. The primary restoration feature for this alternative is to restore this former gravel pit to the riparian ecosystem that existed through

most of the 20th century (Figure 2-1). The wooded aquatic ecosystem would connect and greatly expand the riparian habitat of Boulder Creek by recreating the wetland at the confluence of the two streams. Restoration of the ecosystem would be accomplished by dewatering the pond and filling much of its basin, excavating a meandering channel, establishing wetland and transitional plantings, and the removal of exotic and invasive species. Plate 7 provides a conceptual overview of this alternative.

7.2 ECONOMIC COSTS AND COST SHARING

Costs including construction costs and real estate costs were developed in sufficient detail to develop a realistic cost estimate for each alternative. Construction costs were prepared using the Corps Micro-Computer Assisted Cost Estimating System (M-CACES). LERRD costs are based on a gross appraisal for real estate interests and the Real Estate Plan baseline cost estimate (Real Estate Appendix I).

The recommended plan is expected to cost roughly $3,204,000 - to plan, design, and implement and will be cost shared at 65% Federal and 35% Local Sponsor. This amount includes construction-phase costs estimated to be roughly $1,326,000, including costs of engineering and design (E&D), supervision and administration (S&A), and construction contracts, with contingencies, which includes a total of $56,345 in trail relocation LERRDs; “non-S&A” costs for updating the Project Management Plan (PMP), conducting other project management and coordination activities, and preparing fair market value certifications and crediting of other non-Federal LERRDs costs; and the present value costs of monitoring and preparing the O&M Manual. Non-Federal real estate costs were estimated to be approximately $1,249,000, with $1,121,000 creditable, bringing the implementation cost to approximately $2,447,000. The maximum credit for LERRDs is 35% of the total project cost in a Model Project Partnership Agreement. The total cost-shared project costs also includes the costs of preparing the PMP, Feasibility Study, Feasibility-level design and real estate evaluation, Review Plan, and Project Partnership Agreement (PPA) ($757,000). These cost-shared project costs are provided in Table 7-1.

Table 7-1: Cost-Shared Costs of the Goose Creek Ecosystem Restoration Project

SELECTED PLAN ^	TOTAL	CORPS	CITY OF BOULDER, COLORADO		
			Cash/Work in Kind	LERRD Credit	Total
Feasibility Study & Develop PPA	$757,000	$757,000			
Design & Implementation	$2,447,046	$1,325,630	$0	$1,121,416	$1,121,416
Plans & Specifications (E&D) ^^	$112,686				
Construction Contracts ^^	$984,332				
Constr. Phase non-S&A Labor *	$126,328				
Contract S&A ^^	$59,060				
PV, Monitoring & O&M Manual	$43,224				
LERRD Credit	$1,121,416				
TOTAL	$3,204,046	$2,082,630	$0	$1,121,416	$1,121,416

^The selected plan costs include only those for ecosystem restoration, including educational/interpretive signage, the costs for which are minimal and are included in the contingencies; no recreational facilities eligible for 50% Federal cost sharing will be constructed.

^^The construction contract, E&D, and S&A costs shown include contingencies.

*Construction phase non-S&A labor includes Corps Real Estate administrative and legal costs to certify fair market value of LERRDs and credit LERRDs-related labor costs provided by the non-Federal sponsor; and costs by the Project Manager and PDT to update the PMP/ perform other management and coordination tasks.

The cost of the Feasibility Study, non-updated Project Management Plan, Review Plan, and Project Partnership Agreement are financial costs but are not included in economic costs. Table 7-2 provides the economic first costs (investment costs) of the project, including Interest During Construction (IDC), which is an economic cost but not a financial cost. The annualized costs and annual OMRR&R costs are also provided in Table 7-2. The annual OMRR&R costs were not included in Table 7-1 because they are a non-Federal responsibility that is not cost-shared. Economic calculations are based on January 2011 price levels, 4.125 percent interest rate, and a 50-year project life.

Table 7-2: First Costs and Annualized Economic Costs of the Selected Plan

Economic Data – January 2011 Price Levels; 50 Year Project Life; Interest Rate =	0.04125
(Excludes Feasibility Study Costs)	
Construction Cost including Trail Relocation	$833,823
Engineering and Design	$95,456
Supervision and Administration	$50,029
Contingency	$176,770
Non-Federal Real Estate Acquisition, Administrative, and Legal Costs	$1,248,480
Federal Real Estate Administrative/Legal Costs	$46,328
Other Const. Phase Non-S&A Labor (PM, PDT.)	$80,000
Interest During Construction (1 year, 4.125%)	$71,940
Total First (Investment) Costs	$2,602,827
Annualized Costs (50 years, 4.125% interest)	$123,764
Annual Non-Fed OMRR&R Costs	$41,818
Annualized Monitoring Costs	$1,178
Annualized Costs to Prepare O&M Manual	$877
Total Annual Economic Costs	$167,637
Average Annual Equivalent Benefits	11.41 AAHUs
Net Average Annual Equivalent Habitat Units (Net AAHUs)	11.41 AAHUs
Cost / Net AAHU	$14,692

7.3 SCHEDULE

After report approval, the project would be eligible for design and implementation (D&I) phase funding. Once the D&I phase is funded, the Corps and the Sponsor will first update the project management plan (PMP) and enter into a Project Partnership Agreement (PPA). This PPA would bind the Corps and the Sponsor to meet their Federal and non-Federal responsibilities for implementing, operating and maintaining the project.

The Corps would then complete final design of the project and prepare contract plans and specifications. The Corps would request that the Sponsor document necessary real estate interests. Following Corps certification of Sponsor real estate and Corps completion of plans and specifications, the construction contract would be advertised. The Corps would award, supervise and administer the construction contract. After construction, the Corps will transfer the project to the non-Federal Sponsor for operation and maintenance and will provide an operation and maintenance manual. The Corps would continue to participate in the monitoring phase of the project for a period of 5 years. The estimated schedule for project implementation is shown in Table 7-3 and will be documented in the updated PMP.

Table 7-3: Implementation Schedule

MILESTONE	DATE
Detailed Project Report Approval	May-11
Receipt of Design and Implementation Funds	June-11
Project Management Plan Agreed	June-11
PPA Executed	June-11
Real Estate Interests Certified	July-11
Plans and Specifications	September -11
Advertisement, Award and Notice to Proceed	September-11
Initiate Construction	September-11
Construction Complete	May-13
OMRR&R Manual	June-13
Project Turnover to Sponsor	August-13
Monitoring Complete	August-18

7.4 COST SHARING AND SPONSORSHIP

The total project cost will be shared between the Corps and the local Sponsor, with the cost breakdown being 65% Federal and 35% non-Federal. This study was "grandfathered" when feasibility study cost-sharing became required under new Corps rules established in Federal Fiscal Year 2006. The Goose Creek Feasibility Study was conducted at 100% Federal costs, but will be cost-shared retroactively as part of total project cost. The Corps will prepare all design plans and specifications, or administer their preparation under contract.

The Sponsor will provide all needed real estate interests which would be credited toward the Sponsor's share of the project. Project lands in the Sponsor's ownership prior to the date of the PPA execution is determined by the fair market value of the real property interests as of the date the non-Federal Sponsor provides the Government with the authorization for entry for construction purposes. The fair market value of lands acquired by the Sponsor after the effective date the PPA for the project is the fair market value of the real property interests at the time of acquisition. The Sponsors will retain the land interests in public ownership in perpetuity for project purposes. The non-Federal Sponsor will be responsible for operation, maintenance and repair, replacement and rehabilitation of the project after completion. This will include occasional maintenance of project features, invasive weed control and periodic inspections.

Prior to the signing of the Project Partnering Agreement (PPA) the Sponsor will express its support for the project and attest that it is ready, willing and able to sponsor the project. This is done in a "Letter of Intent" which covers the following topics:

- Sponsor's self-certification of financial capability.
- Statement of Sponsor's authority to implement its responsibility under the PPA.
- Sponsor states that it will accept the applicable model PPA, including:
  1. Applicable cost-sharing and financial policies.
  2. Policies regarding the provision and valuation of non-Federal lands, easements, right-of-way, and disposal areas provided by non-Federal Sponsors.
  3. Policies governing non-Federal project construction.
  4. Other provisions required by law and policy for new start construction projects.
  5. Waiver of lands, easements, relocations, rights-of-way and disposal areas (LERRD) values beyond those needed for the 35% cost share.

7.5 REAL ESTATE

7.5.1 Project Footprint

7.5.1.1 Reach 1

Reach 1 is a flood control channel that extends from the inlet to the box culvert at the upstream (western) side of Foothills Parkway to Reynolds Corner. The real estate used for the Reach 1 ecosystem restoration lies entirely within the designated FEMA floodway for South Goose Creek (see Figure 2-3). This flood conveyance channel was improved in the 1980s to increase the hydraulic conveyance of the channel and provide erosion control and channel stability. The flood channel is entirely on publicly owned land and is bounded by bike trails, roads, car dealerships and a business park.

Figure 7-1: Reach 1 Project Footprint

7.5.1.2 Reach 2

Reach 2 is a flood control channel with an imbedded existing wetland that extends from Reynolds Corner on the upstream (western) side to Cottonwood Pond. The real estate used for the Reach 2 ecosystem restoration lies entirely within the designated FEMA floodway for South Goose Creek. This flood channel was improved in the 1980s to increase the hydraulic conveyance of the waterway and provide erosion control and channel stability. The flood channel is entirely on publicly owned land and is bounded by roads and existing publicly-owned greenways adjacent to Boulder Creek.

Figure 7-2: Reach 2 Project Footprint

7.5.1.3 Reach 3

Reach 3 is a gravel pit and adjacent floodplain that extends from the bike trail on the upstream (western) side to Boulder Creek. The real estate used for the Reach 3 ecosystem restoration lies entirely within the designated FEMA floodway for South Goose Creek and the Boulder Creek floodplain. The gravel pit was excavated after 1980 to extract materials for construction, and then abandoned (see Figure 5-4 for pre-existing condition of property). The flood channel is entirely on publicly owned land and is bounded by bike trails and existing publicly owned greenways adjacent to Boulder Creek.

Figure 7-3: Reach 3 Project Footprint

7.5.2 Ownership and Real Estate Interests

All land within the anticipated project footprint is publically owned. It is either the property of the City of Boulder or Boulder County. It is anticipated that there will not be a need for acquisition of additional private property to augment the public land to be used in the project. The future project ownership will remain the same as the existing project ownership, which was presented in Section 2.3.4. An ownership map of the project area is provided in Figure 2-6.

As discussed previously, wetlands can be a source of evapotranspiration losses, and creation of wetlands can require water rights. However, the Colorado State Engineer has stated for a similar Section 206 project in Boulder County that if a restored water surface area is equal to or less than historic water surface area, water rights are not required. Coordination with the State Engineer is ongoing through the draft report and public involvement during the NEPA process. Measurement of wetland signatures on aerial photos from 1937, 1958, 1972 and 1982 suggested that wetlands in the project and nearby catchment area occupied from 8 to 24 acres over that time, but were destroyed by gravel mining, channelization and urban development (See Figure 2-1 for 1937 photo). The aerial photos were analyzed using ESRI ArcGIS 9.3. They were geo-referenced to a current aerial photo to maintain consistent area and scale. Wetland signatures

were identified, including depressions, swales, oxbows, old stream channel cut-offs, areas noted on soil maps as river-wash or flowage easement, and unfarmed crop field sites. Signature development criteria for photo interpretation included shape, size, tone/hue, texture, shadow and site. Hydric soils were identified in county soil surveys and National Wetland Inventory maps to check some years. The 24 acres estimated for 1972 could have been due to a high water year, therefore the 1937 estimation of 19 acres was assumed to be the historic acres of wetlands. The detailed methodology of the historic wetland delineation is in Appendix A.

The approximately 7 to 10 acres of wetland to be restored in the Cottonwood Pond area, and the approximately 3 acres to be restored in Reaches 1 and 2, including the stream, would total less than the historic stream and wetland area. Therefore, based on guidance from the State Engineer, it is the best professional judgment of the Corps PDT and the Sponsor that water rights would not be required. Coordination with the State Engineer will be ongoing through the public/agency review period associated with the release of the draft report.

7.5.3 Hazardous Substance Review

An Environmental Condition of Property (ECP) Phase 1 evaluation and report were completed for hazardous substances (see Appendix K). The study concluded that there was no evidence of hazardous substances or petroleum products within the 24 acre area of the project footprint. The conclusions of the analysis were made following a site visit, conversations with key site personnel and a query of environmental databases. According to the criteria of ASTM 5746-98 (2002), the Goose Creek property was characterized as a Type 1 property, with little to no potential for environmental contamination from past or present activities or use. Based upon the findings of the evaluation, there is no limit or restriction placed upon the proposed use (ecosystem restoration) of the property.

7.5.4 Value

Land values in Boulder are high relative to the national average. This results in relatively high real estate valuations, even for public lands in the floodplain and floodway. A gross appraisal was performed earlier in the study (in 2008) and was ultimately redone, due to the time that elapsed following that effort and a need to revisit the high cost of lands in Reach 1. Estimates prepared subsequent to that appraisal indicate land values in the range of $17,000 to as much as $70,000 per acre. A second gross appraisal was completed in February 2011 and made use of more detailed project mapping.

The actual value of the land will be computed after the PPA has been signed, to determine the appropriate credit to the Sponsor for the lands to be held in permanent easement as part of this project. Based upon the higher per acre figures for real estate, LERRD values may exceed the needed 35% share of total project costs. Corps policy suggests that the Sponsor should waive credit for any LERRD values that exceed the needed Sponsor share, so that the Federal Government is not in the position of paying cash to Sponsors who have above-national average land values. The Sponsor has agreed in principle to this waiver and it will be part of the PPA.

7.6 CONSTRUCTION

The project site is easily accessed by public roads. On-site access for construction would likely be from Pearl Parkway and adjacent side streets on public land. There is the potential that additional access could be secured from a private parking lot belonging to a business park if found to be cost-effective. Additional access to parts of the project site can be obtained via the bike trails which enter the project area. The existing soils, outside of wetland areas, are adequate to support construction machinery and trucks.

Construction should be timed to avoid the thunderstorm season and the nesting season for protected birds found on site. Care of water would require rerouting the flow from South Goose Creek, North Goose Creek and the incremental groundwater inflow during grading operations. The construction area is considered to be a groundwater "gaining reach" within the Goose Creek watershed. It should be noted that the existing man-made South Goose Creek channel has a system of under-drains which were placed there to facilitate the construction of a concrete lined channel by intercepting the groundwater flow.

7.7 POST PROJECT COMPLETION ACTIVITIES AND RESPONSIBILITIES

7.7.1 Recommendations Regarding Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

Costs and activities relative to the operation, maintenance, repair, replacement and rehabilitation (OMRR&R) of the finished project are the responsibility of the Sponsor. These are activities other than monitoring and adaptive management. Operation is the control of constructed features whose regulation or other manipulation is intended or necessary to ensure the project's performance. Maintenance includes those activities of a routine nature that hold the project in a well-kept condition, to keep it functioning as intended and to deter more damaging or costly repair or replacement needs. Repair is the resolution of unexpected failures and problems as they arise. Replacement covers those activities necessary to bring a deteriorated project back to its original condition. RR&R actions are to conform to the project's "as-built" plans and specifications unless other arrangements are made with the District Commander.

It is anticipated that the primary reason for RR&R actions on this project would be large infrequent flood events in the Goose Creek Basin. Care in design and construction will be taken to produce a finished product capable of withstanding flooding. However, given the unpredictability of the action of flood waters at individual locations within the project due to debris or localized disturbances, it may be necessary to repair features following a major flood. Additionally, a weed management plan will be part of the OMRR&R plan, as woody volunteer plants will need to be removed from the main channel to avoid decreased flood conveyance due to debris trapping and greater channel roughness.

When the Corps determines that the entire project is complete except for monitoring, the Corps will notify the city of Boulder and will furnish the city with an OMRR&R Manual including "as-

built" drawings. From that time, the non-Federal Sponsor will operate, maintain, repair, rehabilitate and replace the project in accordance with the PPA.
Total OMRR&R for this project is expected to average $41,818 per year.

7.7.2 Adaptive Management

As provided for in Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007), Corps ecosystem restoration projects are to include a plan for Monitoring. Monitoring is the systematic collection and analysis of data for assessing project performance and determining whether ecological success has been achieved or adaptive management is needed to attain project benefits. Monitoring information would be used by the Omaha District in consultation with the Sponsor, Federal and State agencies, and the Corps' Division office to guide decisions on operational or structural changes (adaptive management) that may be needed to ensure that the project meets success criteria. If the results of the monitoring program supported the need for physical modifications to the project, the cost of any changes would need concurrence from the non-Federal Sponsor and would be cost shared with the non-Federal Sponsor. Monitoring and adaptive management are not the same as inspections or operation and maintenance, for which the Sponsor would be responsible even during the monitoring period.

For this project, measures of ecological success will include establishment of the vegetation community, and functionality of the aquatic habitat structure. Monitoring will not cover actual response of international migratory birds or aquatic life to the habitat constructed, because organism response involves variables other than habitat structure, and baseline data is minimal or absent. The key parameters and data include measurements of variables from the habitat model:

- increasing riparian/vegetative zone width, crown cover, and vegetative protection, as these are key variables in the habitat model
- increasing channel sinuosity, pool substrate characterization and epifaunal substrate and available cover, particularly in Reaches 2 and 3, Alternative 2 for both
- increasing floodplain connectivity in Reaches 2 and 3, Alternative 2 for both

Monitoring for plantings and the channel would occur 1 and 4 years after completion of construction and the estimated annualized cost (over the 50-year period of analysis, at 4.125% interest) after present valuing is shown in the table below. This is part of the total project cost shared between the Corps and the Sponsor. Implementation responsibilities for the monitoring plan will be identified in the Project Partnership Agreement.

Table 7-4: Monitoring Cost Estimate for Alternative Plans.

Alignment	Monitoring Cost (present valued, then annualized)
R1A1	$318
R2A1	$71
R2A2	$171
R3A1	$394
R3A2	$689

The adaptive management (contingency) plan assumes potential minor project adjustments, in accordance with the moderate scale of the project. The nature and cost of potential adjustment measures are explicitly described below:

- Replanting failed vegetation, approximately 1/4 of the total, at a cost of $72,500

These adjustment measures would be dependent on appropriations from Congress for the Sec. 206 Program and on the rules applicable at that time regarding funding of adjustment measures. Corps project closeout would occur five years after completion of construction, under the expected scenario that monitoring indicates that ecological success had been reasonably achieved.

7.8 LEGAL OR POLICY ISSUES, OPTIONS CONSIDERED AND TENTATIVELY RECOMMENDED SOLUTIONS

No legal issues are known to exist for this project.

One policy concern might be that the proposed restoration benefits are not all aquatic, but include riparian benefits. Given that the riparian floodplain community is a water-related community, the restored riparian environment is ecologically supportive of a healthy aquatic system, which optimizes the aquatic benefits in the selected plan.

Another potential policy concern may be that the land values will be close to or exceed the 35% of total project cost exceeding the Sponsor's estimated share of total costs. The high per-acre value of the land in Boulder accounts for this. In plan formulation, no additional real estate areas were acquired adjacent to the public lands in order to avoid driving costs upward. The situation of high land values is sufficiently addressed by the model PPA for the Section 206 Program, which will be used for this project. The PPA provides for a voluntary Sponsor waiver of reimbursement of LERRD value in excess of the Sponsor's percentage share for the project.

7.9 QUALITY REVIEWS

A review plan was prepared for this project and was approved on December 3, 2010. Reviews for this project will include the initial quality review by the project team, the quality check review by District supervisors and subject matter experts and the Sponsor team, the agency technical review (ATR) to be performed by Corps personnel from outside the Omaha District and the Alternative Formulation Briefing (AFB) with the Corps' Northwestern Division Office. Substantive elements of the review will be conducted in "Dr Checks," which is an online review management tool.

7.10 RISK AND UNCERTAINTY

In the formulation of a project, potential risks to proper or expected performance of the project are evaluated. Most of the risks to this project can be addressed within the context of OMRR&R. There are some areas of uncertainty which could impact the performance and value of the project once completed. Risks during construction are discussed in the Cost Engineering Appendix B.

7.10.1 Erosion Potential

The erosion control and hydraulic structures built in the Goose Creek and South Goose Creek channels by the Denver Urban Drainage and Flood Control District have kept the stream from eroding the banks and endangering nearby property and Pearl Parkway. On South Goose Creek, the potential for erosion is limited by discharge control and structural grade and lateral erosion controls. The flood discharge entering South Goose Creek is effectively controlled by the box culverts upstream of Foothills Parkway, with larger flood flows diverted to the North Goose Creek overflow channel, bypassing Reach 2. There should be no impact to peak discharges carried by the South Goose channel due to the project. Flooding on the small urbanized watershed is infrequent and of short duration. The extremely short duration of these major floods also helps deter severe erosion within the channel. It is accepted that minor bank erosion and deposition would be anticipated due to planned meander development in Reach 2, however the short duration of high flows combined with the anticipated vegetative growth are not conducive to severe planform shifting.

The grade control features installed by Denver Urban Drainage in the 1980s have proven effective through several subsequent larger floods. The majority of those structures on South Goose Creek will remain as they are, with the only significant modification being at the most downstream weir section where the channel would be allowed to meander to the south with more natural riparian conditions in force, including erosion. Given that during larger flows, this area would be within the backwater of the wetland and bike trail, resulting in slower velocities, it is considered unlikely that sufficient scour would be attained to erode that area once vegetation has become established. The greatest risk at that site, as well as elsewhere in the project is that a major flood would take place before the vegetation has become established. If this were to occur, repair, rehabilitation and replacement costs could be larger than anticipated in the first year or two.

7.10.2 Climate Change

The impact of climate change on the project was discussed in the Future Without-Project section. While the evidence of considerable climate fluctuation has been documented historically through the post ice age period in the high plains region and evidence of ongoing climate change can be found today, the ecosystem restoration project by its very nature would tend to minimize the impact of climate change. This is because the project would favor an ecosystem that has adapted to the harsh high-plains environment over time and has demonstrated that it can thrive despite wide swings in temperature and precipitation. The greatest risk to the project would be a very hot and dry year following project completion, which would inhibit plant growth needed to resist erosion when large rains returned. In the event of a drought immediately after project completion, a watering plan for newly planted and seeded native species may be worthy of consideration, but would add to initial OMRR&R costs.

7.10.3 Eurasian Water Milfoil

This aquatic plant has been a major problem in Cottonwood Pond, and elsewhere within the Boulder Creek Basin, due to crowding out of native species, inhibiting fish forage and water quality impacts. The inability to easily eradicate this invasive water weed was central in the need to formulate an alternative plan for Cottonwood Pond involving its conversion to a wetland. It is anticipated that the wetland as currently designed will largely eliminate the competitive advantages that have been enjoyed by the milfoil to date. Best Management Practices (BMPs) will be followed to reduce the risk of spreading milfoil during dewatering of the pond. Since the aquatic weed requires moderate pond depths and sunshine, the conversion of the pond to a forested wetland would remove both favorable water depths and lighting conditions that have allowed it to thrive. If wet years were to immediately follow project completion, resulting in sustained larger than normal inflows (and greater water depths) in Cottonwood Wetland, milfoil could reestablish itself within the water plant community. Excavating the outflow channel from the wetland to Boulder Creek could provide a solution to the reestablishment of the milfoil by reducing the depth in the wetland to a level that would be unfavorable to the weed.

8.0 ENVIRONMENTAL IMPACTS, REVIEWS AND COMPLIANCE

8.1 TEMPORARY CONSTRUCTION IMPACTS

Construction timing would be adjusted, if needed, around important times for wildlife, such as nesting periods. Still, at any time of year, heavy machinery and work crews would present temporary disturbances to wildlife. Construction activities and noise would likely displace wildlife while crews are active. During construction, exhaust, dust and other factors may minimally affect local air quality. Disturbances to the stream may also affect water quality on a temporary basis. Increases in sedimentation, erosion and displacement of aquatic and riparian wildlife are all possibilities. Still, as construction disturbances are temporary, their effects should dissipate quickly, and they should not have any significant long-term effects to wildlife at the site.

Construction would have considerable impact on the use of the bike trails that cross the project site, particularly the bike trail that would be relocated to the path of the social trail east of Reynolds Corner. Impacts to Boulder's bike trail system can be minimized by building the new trail first before removing the old one.

8.2 SOCIOECONOMIC IMPACTS

8.2.1 Aesthetics

The aesthetic quality of an area is a subjective and individual perception, but a vegetated "softer" looking channel is generally perceived as more pleasant than an engineered flood control ditch, such as currently exists on South Goose Creek. It is less certain how the public would view Cottonwood Wetland relative to the existing Cottonwood Pond. Though it is clearly a man-made pond that resulted from gravel extraction, the Cottonwood Pond has some aesthetic value. Replacing the pond with a wetland would please some of the population that highly value riparian wooded wetlands, such as birdwatchers, but the view may be less pleasing to those who wish to fish.

8.2.2 Bike Trail

Changes to the existing bike trail which involve relocating the concrete paved trail to roughly the path of a dirt social trail should result in an improved biking experience. Presently, the bike follows the engineered South Goose Creek eastward from Reynolds Corner before crossing the embankment separating Cottonwood Pond from the existing wetland. In its approach to the crossing, the trail has a sharp bend. This sharp bend would be replaced by a straight run of trail with more a more gentle turn onto the embankment. In addition to the greater ease for bikers, the replacement of the current view of drainage ditch on one side and a thin grove of crack willows on the other, would be replaced by a meandering stream and wetland and a riparian forest following implementation of the Goose Creek ecosystem restoration and other planned improvements by the city of Boulder in the Boulder Creek floodplain.

8.2.3 Conversion of Pond to a Wetland

The largest single change that would result from the ecosystem restoration of South Goose Creek would be the conversion of Cottonwood Pond to a wetland. This would result in a change of use of that public land from activities such as fishing to more passive uses such as bird watching. However, shoreline fishing may be engaged in at a number of sites in Boulder, including the shores of Boulder Creek near Cottonwood Pond.

8.2.4 Mosquitoes

The Colorado Department of Public Health and Environment reports that 6 cases of West Nile virus (WNV) were diagnosed in Boulder County and 12 were diagnosed in neighboring Weld County; these total 30% of all Colorado cases in 2010. Any enhanced or restored wetlands could support a variety of invertebrates including mosquitoes that could carry WNV. Adult mosquitoes emerging here could easily disperse over one square mile, reaching several residences. Application of larvacides would be a management option for the Sponsor. Adulticides are less desirable due to incidental impacts to bees and the greater difficulty of achieving control of adults.

8.2.5 Water depletions

South Goose Creek is normally a gaining stream (discharge point for groundwater) at low and average stream flows; thus no stream losses would occur at low and average flows. The stream would be a losing stream (recharges the overburden materials) during periods of sustained, high stream flows - where incremental flow losses are related to the increase in infiltration area and duration. Since Goose Creek is a small urban watershed, flood discharge hydrographs are short and sharp, giving little time for infiltration losses to occur. Additionally, there are no documented floods of long duration, since the larger peak discharges are the result of thunderstorm runoff from this small basin. In general, any infiltrated water would likely return to South Goose Creek for a majority of the project length and to Boulder Creek in the vicinity of Cottonwood Pond.

Proposed changes to South Goose Creek would not cause depletions through infiltration losses, at low and average flows, even though the proposed project would slightly increase stream length. Data indicate that groundwater elevation is normally above the elevation of the proposed new channel bed; thus, the new alignment would be a gaining stream reach just as the existing alignment is.

In the upstream portion of the project (Reach 1), the "with-project" South Goose Creek flood behavior will be similar to the existing condition, as the conveyance of the flood channel remains unaltered. Above average flows would escape the new channel slightly less frequently in the middle reach (Reach 2), due to the widened low floodplain bench and greater flood conveyance in that reach resulting from the selected plan. In Cottonwood Pond (Reach 3), the flood behavior will be similar to the existing condition, once it is converted to a wetland. Flood flows will spread out and slow down crossing the wetland in route to Boulder Creek, in similar fashion as they do now crossing Cottonwood Pond. In all cases, the frequency of out of bank flows will be

similar to, or less than the current condition. Given the similarity of the pre and post-project channel/floodplain conveyance, and the flashy nature of flood hydrographs moving through South Goose Creek/Cottonwood Wetland, it is anticipated that infiltration losses will be essentially unaltered by this project.

Discharges from this small urban watershed are very small relative to those on the South Platte River and Platte River. Typical base flows on South Goose Creek range from 1 to 2 cubic feet per second. This discharge is small enough to be lost in the rounding of daily discharge computations for most flows measured at the South Platte River Gage at Kersey, Colorado. During a South Platte Basin-wide flood event, Goose Creek discharges will also be very small relative to the flood discharges measured on the South Platte River. Since changes in both the base and flood flow discharges of Goose Creek will be negligible following project implementation, this project is not forecast to have any impact on Platte River depletions.

The Corps has provided this information to the USFWS and has asked for informal consultation regarding a determination that the project would not adversely affect federally listed species and designated critical habitat associated with the Platte River in Nebraska.

8.2.6 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, provides that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. "

The U.S. Army Corps of Engineers is committed to the principles of environmental justice. Due to the nature of the activities proposed and the location of the construction site away from any residential areas, there would be no impacts to the above-stated populations.

8.2.7 Cumulative Impacts

Cumulative impacts are those that result from the added incremental effects of an action when taken in the context of the past, present and reasonably foreseeable future actions within a region. An analysis of the cumulative impacts of the proposed project requires an evaluation of the actions that have already taken place on Goose Creek and Cottonwood Pond, which have caused or contributed to the decline of native riparian habitat and wetlands which historically have occurred in this tributary to Boulder Creek. Urbanization, channelization and gravel mining have resulted in dramatic loss of natural aquatic habitat. The geographic extent of this analysis is limited to those actions occurring within an approximate 2-mile radius of this project which have affects on aquatic and associated terrestrial habitat. Future actions planned or recently completed in or near the proposed project include the placed of a power pole near Reynolds Corner, the widening of Pearl Parkway, Valmont Park development, and the development of Transit Village.

8.2.7.1 Power Pole Movement along South Goose Creek

A power pole placement near Reynolds Corner, adjacent to Cottonwood Pond occurred in 2009. This action resulted in a minor, temporary disturbance within the proposed project area; however, the new pole did not result in adverse, long-term impacts to the project area.

8.2.7.2 Widening of Pearl Parkway

The potential widening of Pearl Parkway along the boundary of the proposed project would result in the loss of approximately 2.5 acres currently open lands near the northeast boundary of the project. The effect of this project would be a loss of habitat constructed along the parkway.

8.2.7.3 Planned Valmont Park Improvements

The 132-acre Valmont City Park is the largest park within the current Boulder urban parks system. It is located north and south of the intersection of Valmont and Airport Roads. The City completed site acquisition in April 1999 and annexed the property in December 1999. This area extends from just north of North Goose Creek to the north side of Pearl Parkway, within easy walking distance of South Goose Creek and Cottonwood Pond.

The Parks and Recreation Advisory Board adopted the following statement regarding the mission for Valmont City Park, to be considered in relation to the Parks and Recreation Department mission and goals: "Valmont City Park will seamlessly integrate a broad spectrum of traditional and non-traditional, active and passive uses, creating a community focal point that blends the current and future needs with values of citizens and the natural world. In celebration of Boulder's unique character, the focus of the park is on flexible land use and locations for intensive high-use recreational facilities in harmony with the other park goals. Through innovative processes for pioneering partnerships and attention to high-quality design, construction, management and maintenance; the park will achieve lasting economic, environmental and operational success. "

Phase 1 was completed in 2003. Phase I provides a large open multi-use turf area, walks and trails, sitting and picnic facilities, restroom facilities, wildlife enhancement plantings, and infrastructure. Phase 1 incorporates the new Wonderland Creek Channel and Greenway trail constructed by Public Works. Phase 2 was substantially completed in May of 2005. Phase 2 provides a 1.5 acre raw water irrigation pond, pump house, and irrigation infrastructure. The City will use this raw water pond and infrastructure system to irrigate the park landscape with North Boulder Farmer's Ditch water. Use of non-potable water for landscape irrigation provides a more environmentally sustainable irrigation solution. The pond and the surrounding landscape restoration provide native habitat and cover for wildlife and a soft surface trail and sitting areas for passive recreation uses. A development plan for Valmont Park is shown in Figure 4-2.

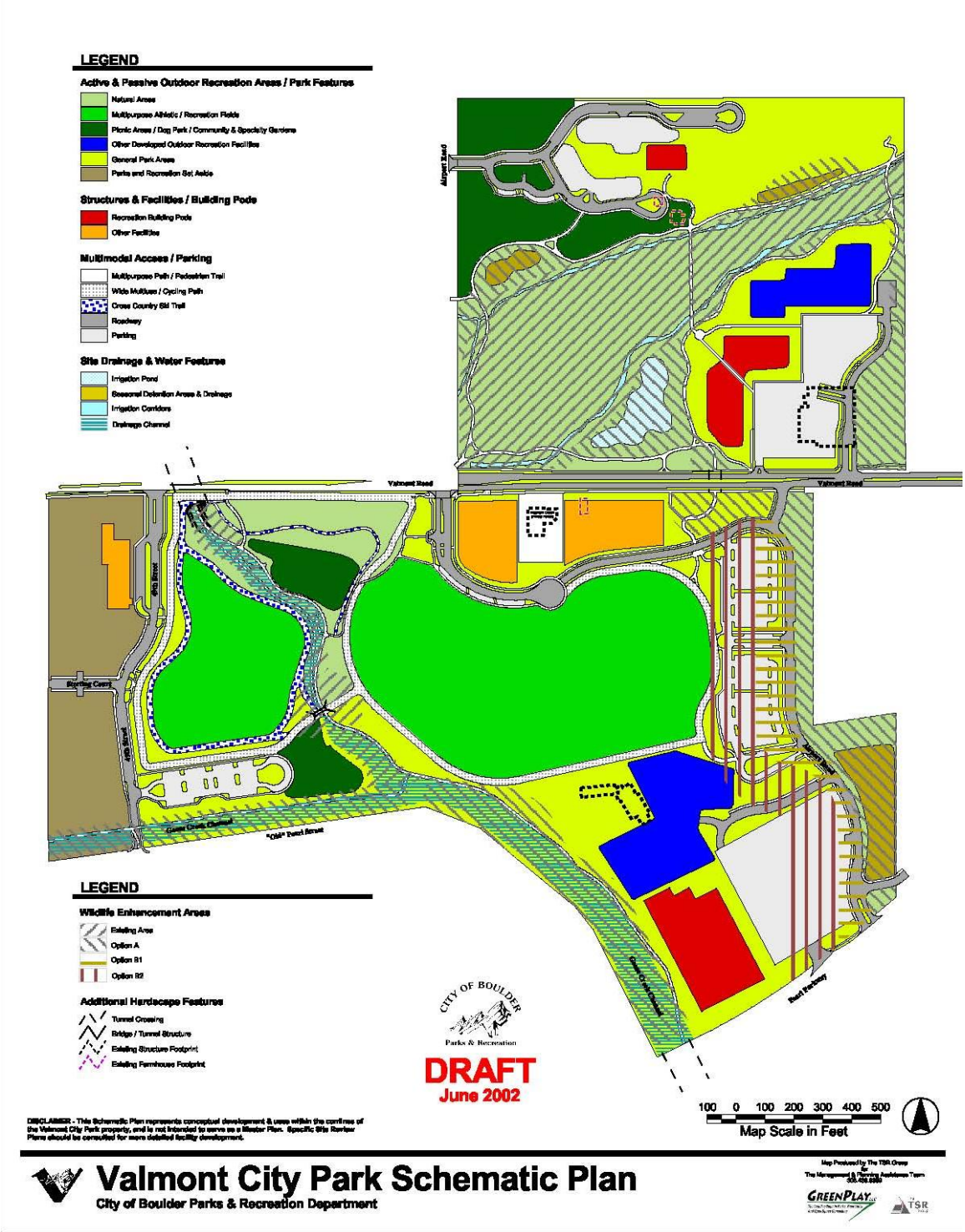

Figure 8-1: Valmont City Park Schematic Plan

8.2.7.4 Transit Village

The city of Boulder approved a Planned Urban Development on 160 acres of the upper Goose Creek watershed, roughly 1,600 feet upstream of the South Goose Creek project reach. It is to be located between 30th Street to east of 32nd street. Another restored reach of Goose Creek lies

between Transit Village and the project. Of the 160 acres, 11 acres would be dedicated to bus and commuter rail stations. Goose Creek runs through the middle of the parcel. Part of the Transit Village plan includes retention features for storm water runoff. The greatest impact on the watershed is likely to be during construction, when heavy thunderstorm runoff has the greatest ability to move soils, debris and sediment.

8.2.7.5 Cumulative Impacts Conclusion

The proposed project alternative would remove invasive vegetation, re-establish native vegetation and restore aquatic habitat and riparian wetlands. All of these actions would help attenuate impacts of the surrounding urban environment and potentially reverse the negative effect of years of cumulative impacts. The cumulative effects of the project are anticipated to be positive for the environment.

8.3 PROTECTED STATUS SPECIES

The proposed project would be in compliance with the Endangered Species Act. Listed species do not occur on the project site but do occur in the surrounding vicinity, or are riparian species that use downstream portions of the Platte River Watershed. The project would not modify or destroy any important or critical habitat and would likely improve the habitat suitability for many of those species noted as follows:

8.3.1 Ute Ladies' -Tresses

Ute ladies'-tresses is a perennial orchid listed as threatened under the Endangered Species Act. Potential habitats for Ute ladies'-tresses within the study area include the restored reach of South Goose Creek below Reynolds Corner and in the Cottonwood Wetland. Current conditions for this species are suboptimal; however the South Goose Creek and Cottonwood pond are fed by groundwater inflow which is a natural condition supportive of this threatened plant. A qualified biologist would conduct a field survey to determine the absence or presence of Ute ladies'-tresses immediately preceding construction. If the species were found on site, the Corps would coordinate with the CDOW and/or the USFWS Ecological Field Office. No adverse impact is anticipated, and the potential of an overall, long-term benefit to this species is anticipated.

8.3.2 Colorado Butterfly Plant

Colorado butterfly plant is listed as a threatened species. Potential habitat for this species exists along the Boulder Creek floodplain in mesic meadows and within the stream channel. Habitat within the study area is not optimal because potential habitat areas have been modified by gravel mining activity and through changes in the stream channel and flow regimes. A qualified biologist would conduct a field survey to determine the absence or presence of Colorado butterfly plant immediately preceding construction. If it were found on site, the Corps would coordinate with the CDOW and/or the USFWS Ecological Field Office. No adverse impact is anticipated, and the potential of an overall, long-term benefit to the species is anticipated as a result of restoration activities.

8.3.3 Preble's Meadow Jumping Mouse

The study area is within the range of the Preble's meadow jumping mouse, a federally threatened species that inhabits well-developed riparian areas along the Front Range. Preble's meadow jumping mouse has been found along South Boulder Creek, south and east of the study area, which contains areas with dense shrub cover. Of the endangered species currently in the area, Preble's meadow jumping mouse may be among the first able to colonize the restored South Goose Creek and Cottonwood Wetland riparian area due the proximity of its current range to the restoration project. Because populations of this species are not found on the site, the species would not be expected to benefit from ecosystem restoration at the site at the current time. Therefore, this study did not formulate for benefits to this species. A qualified biologist would conduct a field survey of the affected habitats to determine the absence or presence of Preble's meadow jumping mouse preceding construction. If they were found on site, the Corps would coordinate with the CDOW and/or the USFWS Ecological Field Office. No adverse impact is anticipated, and the potential of an overall, long-term benefit to the species is anticipated.

8.3.4 Interior Least Tern

The interior least tern is federally listed as endangered. Although least terns nest on the shorelines of several reservoirs of southeast Colorado and on islands in the Platte River, least terns are not known to occur in Boulder County. Boulder Creek drains into the South Platte River which is important habitat for the terns, and an impact analysis needs to consider potential depletion impacts to Platte River flows. Due to restrictions on storage and use of water, the Goose Creek project is already being formulated to avoid flow depletions to downstream regions of the Platte River Basin, so the project should not contribute to potential depletions of the flow upon which the tern depends.

The Corps has provided this information to the USFWS and has asked for informal consultation regarding a determination that the project would not adversely affect federally listed species and designated critical habitat associated with the Platte River in Nebraska. No adverse impacts to interior least terns are anticipated.

8.3.5 Pallid Sturgeon

The pallid sturgeon is listed as an endangered species. This fish is found in the lower Platte and Missouri rivers, where its preferred habitat is submerged sand flats and gravel bars. The Goose Creek Project is not likely to provide opportunities to benefit this species. Goose Creek ultimately drains into the Platte River which is important habitat for the sturgeon and an impact analysis needs to consider potential depletion impacts to Platte River tributary flows. Due to restrictions on storage and use of water, the Goose Creek project is already being formulated to avoid flow depletions to downstream regions of the Platte River Basin, so the project should not contribute to potential depletions of the flow upon which the sturgeon depends.

The Corps has provided this information to the USFWS and has asked for informal consultation regarding a determination that the project would not adversely affect federally listed species and

designated critical habitat associated with the Platte River in Nebraska. No adverse impacts to pallid sturgeon are anticipated.

8.3.6 Piping Plover

Piping Plovers are federally listed as threatened. Nesting habitat in Colorado includes sandy lakeshore beaches, sandbars in riverbeds or even sandy wetland pastures. Although Boulder Creek drains into the South Platte River, which is important habitat for the plovers, plovers are not known to occur in Boulder County. Boulder Creek drains into the South Platte River which is important habitat for the plovers, and an impact analysis needs to consider potential depletion impacts to downstream flows. Due to restrictions on storage and use of water, the Goose Creek project is already being formulated to avoid flow depletions to downstream regions of the Platte River Basin, so the project should not contribute to potential depletions of the flow upon which the plover depends.

The Corps has provided this information to the USFWS and has asked for informal consultation regarding a determination that the project would not adversely affect federally listed species and designated critical habitat associated with the Platte River in Nebraska. No adverse impacts to piping plovers are anticipated from this project.

8.3.7 Whooping Crane

The Whooping crane is an endangered species. Whooping cranes have not been seen in Colorado since 2002; however, they do pass through the Platte River basin, which is important habitat for the cranes, downstream in Nebraska, where they use shallow, sparsely vegetated streams and wetlands to feed and roost during their migration. Boulder Creek drains into the South Platte River, and an impact analysis needs to consider potential depletion impacts to Platte River flows. Due to restrictions on storage and use of water, the Goose Creek project is already being formulated to avoid flow depletions to downstream regions of the Platte River Basin, so the project should not contribute to potential depletions of the flow upon which the crane depends. The Corps has provided this information to the USFWS and has asked for informal consultation regarding a determination that the project would not adversely affect federally listed species and designated critical habitat associated with the Platte River in Nebraska. No adverse impacts to whooping cranes are anticipated.

8.3.8 Bald Eagle

While previously listed as "threatened" under the ESA, the Bald Eagle was de-listed on June 28, 2007 (effective August 8, 2007). However, this species is still protected under the Bald and Golden Eagle Protection Act as well as the Migratory Bird Treaty Act. These birds tend to construct their nests in mature trees near aquatic habitats, especially in cottonwood trees, and do nest downstream within the South Platte Basin, particularly in adjacent Weld County. Bald Eagle nests are also located in Boulder County, with the closest nest to the project located approximately 4 miles downstream along Boulder Creek. The National Bald Eagle Management Guidelines (NBEMG) provides recommendations for avoiding disturbance to nesting sites consistent with the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. In

the Goose Creek area, the nesting season runs from November 1 to July 31. Accordingly, during this period, construction would avoid active nests by a maximum distance of 660 feet if the activity would be visible from the nest. A qualified biologist would coordinate with the USFWS Colorado Ecological Services Field Office in Denver, Colorado, to survey the area prior to the clearing and other construction activities and also if a nest is suspected in the project area. No adverse impacts are anticipated.

8.3.9 State Listed Species

The State of Colorado lists species as State threatened or endangered. The listed species for Boulder County are some of the same species that are federally listed. State listed species and their listing status are shown in Table 8-1. Expected impacts to each species were discussed including the likelihood of finding each species and whether it would be impacted by the Goose Creek project.

Table 8-1: State Listed Species

Species	Status
Canada lynx	T
Colorado butterfly plant	T
Greenback cutthroat trout	T
Least tern (interior population)	E
Mexican spotted owl	T
Pallid sturgeon	E
Piping plover	T
Preble's meadow jumping mouse	T
Ute ladies'-tresses	T
Whooping crane	E

T = Threatened; E = Endangered

8.3.10 County Species of Special Concern

Boulder County maintains a list of species of special concern (BCPOS, 1998). The project site provides riparian habitat for less common bird species or "species of special concern" (BCPOS, 1998), including yellow warbler, yellow-headed blackbird, wood duck, and marsh wren.

Most of these species would benefit from stream and riparian habitat restoration, and indirectly from wetland development in the lower portion of South Goose Creek or from a restored Cottonwood wetland.

Two of the county listed species, the burrowing owl and the prairie falcon, could be indirectly impacted to a minor degree. The management recommendation for them is to maintain prairie dog colonies; whereas the project would excavate an existing prairie dog colony. Depending on the method of prairie dog management determined under the multiple use policy of the city, the colony could be eliminated. However, the colony is small, is not a sizable portion of colonies in the area and could become reestablished after construction. The prairie dog colony would be surveyed for burrowing owls by a wildlife biologist prior to the removal of the prairie dogs and

subsequent filling of the area. No prairie dog control (non-lethal or lethal) would be undertaken if burrowing owls were present. All activities would occur during the non-nesting season for the burrowing owl, which runs from November 1st - March 15th, or after confirmation that a nest had failed or that nesting owls were no longer present.

8.4 WATER QUALITY

Impacts to water quality could include increase in turbidity during construction, however, this is anticipated to be a temporary construction affect and not be significant. In addition, establishment of native riparian vegetation and restoration of wetlands will provide enhanced buffering capability adjacent to the stream and could have beneficial impacts. Best Management Practices (BMPs) will be followed to reduce risk of the spread of milfoil during dewatering of the pond. Not significant impacts are anticipated.

8.5 VEGETATION AND RIPARIAN HABITAT

The restoration of native vegetation in Reach 1 would impact about 6.4 acres of riparian vegetation and buffer, but would primarily be drill seeded to minimize impacts or bare soil conditions that could encourage invasive establishment. The number of invasive trees to be removed could be counted individually, rather than in acres. The alignment of channel meanders and terraced floodplain in Reach 2 would impact about 2.3 acres of riparian vegetation and buffer. On the north side of the channel this would be drill seeded in a similar fashion as Reach 1. Where the channel would meander and terraces created, the area would be excavated, graded and replanted. A meandering channel with forested wetland in Reach 3 would impact approximately 6.65 to 9.3 acres of riparian vegetation. Reaches 1 and 2 currently provides poor habitat value (HQI of 0.14) and Cottonwood Pond currently provides marginal value (HQI of 0.37). Both areas are expected to continue to decline in habitat value. These areas would be transitioned into habitat that provides good habitat values (Reach 1, HQI of 0.58; Reach 2, HQI of 0.61; Reach 3 HQI of 0.75) (Appendix A-3).

Removal of exotic crack willow and Russian olive trees would decrease available habitat for riparian nesting birds, for the period until new plantings of native species can achieve similar size and cover. The loss of trees is anticipated to be a small count of individual trees, and would be offset by the approximately 17 acres of riparian habitat to be planted. No significant impacts to riparian or wetland buffer vegetation are anticipated.

Extensive expansion of the riparian corridor would provide substantial benefits to almost all types of wildlife through an increase in breeding habitat, food, shelter, and dispersal means.

8.6 WETLANDS

An aerial photo from 1937 (Figure 2-1) was used to quantify riparian and wetland corridor acreage in the historic meander belt of South Goose Creek. This riparian and wetland acreage equaled approximately 19 acres at that time (See Appendix A for methodology). Total acreage of wetlands at the site has not declined, but gravel mining destroyed the seasonal and intermittent wetlands at the mouth of Goose Creek, and created instead the current open water pond (7.1

acres), linear drainage ways, and the large (1.7 acre) cattail area at the confluence of North and South Goose Creeks.

Construction could impact a small amount of existing stream- or pond-side wetlands, estimated to be under 0.1 acre total. The existing vegetative community provides the hydrology and seed source needed to easily re-colonize impacted sites.

The creation or enhancement of outfall wetlands and edge habitat in Reach 1 (1.34 acres), of stream meanders with terraced floodplain bench in Reach 2 (1.84 acres), and the re-creation of a meandering stream surrounded by forested wetland (7.33 – 10 acres) could restore between 10.5 – 13 acres of wetland. The area would be designed to not exceed the 19 acres of historic wetland and riparian corridor, and to not require augmentation of water rights. The City of Boulder is anticipated to request a 1:1 replacement of the open water lost by filling the pond. The 7.33 – 10 acres of wetland restored will offset the 7.1 acres of open water in the pond. The creation would offset any minor impacts to existing wetlands; no significant impact or net loss of wetlands is anticipated; a net gain is expected.

8.7 TERRESTRIAL AND AQUATIC WILDLIFE

Riparian and wetland vegetation would be disturbed as outlined in Sections 8.4 and 8.5 above; however, these disturbances are anticipated to be mostly during construction, and short term, although some areas may need several growing seasons to reach improved habitat potential. Overall, extensive expansion of the riparian corridor would provide substantial benefits to almost all types of wildlife through an increase in breeding habitat, food, shelter, and dispersal means.

A colony of prairie dogs lives on both sides of Goose Creek in the area downstream of Reynolds Corner, including in the area that could be excavated to provide channel meanders and a floodplain terrace for Reach 2, Alternative 2. Prairie dogs will be managed by the sponsor in accordance with the City of Boulder Wildlife Ordinace, which focuses on relocation, but can include lethal means (http://www.bouldercolorado.gov/files/Wildlife/finalordance.pdf). Because burrowing owls are associated with prairie dog colonies, a survey would be coordinated with the sponsor and the CDOW before clearing and construction activities.

Because the stream would remain in its existing channel until diverted into a new alignment, and construction would be timed during winter/low flow months (Alignments 2 and 3), only minor adverse impacts to fish species are anticipated. Excavation and grading could occur in a staggered fashion, replacing substrate as work moved downstream. Fish could be disturbed or impacted during this construction, but spring recruitment could be restorative. No significant impacts are anticipated.

Macroinvertebrate communities in the existing channel would be disturbed during during the time of construction, but would be expected to re-colonize quickly. No substantial adverse impacts are anticipated.

8.8 ENDANGERED SPECIES ACT (ESA)

In accordance with Section 7 of the Endangered Species Act of 1973, as amended, the Corps requested in a letter dated July 7, 2008 that the USFWS provide a list of federally listed threatened and endangered species that may be found in the proposed project area. The USFWS responded with a letter dated August 12, 2008. The Preble's meadow jumping mouse and the Ute ladies'-tresses orchid are known to occur nearby within the Boulder Creek drainage, but are unlikely on the project site in its current condition. In addition, it is understood the USFWS may request that any action on the project site be addressed that could impact listed species or critical habitat in the central Platte River in Nebraska. No adverse impacts to the Platte River are anticipated, and continued coordination with the USFWS will take place during the open comment period with the public draft of the document.

8.9 FISH AND WILDLIFE COORDINATION ACT (FWCA)

The Corps requested in a letter dated July 7, 2008that the USFWS provide a list of federally listed threatened and endangered species that may be found in the proposed project area. The USFWS responded with a letter dated August 12, 2008. The letter addressed both potential presence of listed species and other resources of Federal interest, wetlands, migratory birds and aquatic life. This letter serves as a Planning Aid Letter under the Fish and Wildlife Coordination Act. In addition, the USFWS will review the Draft report and is expected to provide final comments at that time.

8.10 MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703-712: Ch. 128 as amended) provides protection to migratory birds and prohibits the destruction of their active nests or nestlings. Construction activities that would otherwise result in the taking of migratory birds, eggs, young, and/or active nests should be avoided and be completed outside the primary nesting season.

The active nesting season for most migratory bird species in Colorado is between April 1 and August 15, which coincides with the peak construction season. However, some birds are known to nest outside of the primary nesting period, and construction activities may occur during any part of the year. Specific Colorado nesting seasons to consider include the bald eagle (November 1 – July 31), cliff nesting raptors (February 1 - July 31), burrowing owls (March 15 - October 31), osprey (March 15 – September 10), and ground nesting birds (May – July 31).

Care would be taken during project construction to avoid any disruption to migratory birds. Clearing and grubbing ideally should be scheduled to occur outside the primary nesting period, between August 16 and March 31. If construction of the project has to occur during the primary nesting season or at any other time that may result in the taking of nesting migratory birds, a qualified biologist would conduct a field survey of the affected habitats to determine the absence or presence of nesting migratory birds. Surveys would be conducted during the nesting season and immediately preceding the proposed construction activities. Should nests or nestlings of migratory birds be identified, construction activities would be modified to avoid disturbance and the USFWS Colorado Ecological Services Field Office in Denver, Colorado, would be contacted

immediately for further guidance and assistance. If nests are active, construction activities that would directly impact the nest, or that would encroach close enough to cause adult birds to abandon the nest during the breeding season, would be restricted. No significant impact is anticipated, and the potential of an overall, long-term benefit to migratory bird species is anticipated.

8.11 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

An environmental assessment is being integrated within this report. A Finding of No Significant Impact (FONSI) will be signed by the District Commander after public interest review, including NEPA compliance and Section 404 authorization. The FONSI will be located in Appendix A.

8.11.1 Public Involvement

8.11.1.1 Public Involvement Prior to Delineation of NER Plan

Scoping for the South Goose Creek Section 206 Environmental Restoration Project was conducted during November and December 2003. The public meetings were advertised in a press release dated November 2, 2003 that was sent to the Daily Camera, Nederland Mountain Ear, Denver Post, Associated Press, United Press, Colorado Daily and Longmont Times.

Public Involvement and Stakeholder Meetings were held in Boulder in September 2007 to discuss preliminary restoration concepts and potential impacts. Restoration alternatives were presented at a meeting with the Boulder Greenways Advisory Board in August 2010.

An open public meeting was held on the evening of September 19, 2007 and was attended by several members of the public as well as government officials. Meetings with stakeholders were held on site earlier that afternoon. At the evening meeting, the Corps made a presentation discussing work-to-date and the project vision. Comment forms were handed out, but no responses were received.

A stakeholder meeting was held the afternoon of September 19, 2007. Businesses located along South Goose Creek were invited. The meeting was held on site and included a walking tour beginning at the McCaddon Auto Dealership. The following issues were raised during this meeting:

- The riparian restoration should not block the ability of people traveling on Pearl Parkway from seeing businesses and inventory. For McCaddon Auto, this means that there should not be any large native plants that extend above the top of the channel banks. Any plantings on the banks or the top of bank should be chosen with this height requirement in mind. Native plants should be short and attractive and require little maintenance. There are plans to extend a sidewalk/bike trail eastward along the north side of Pearl Parkway and the right top of bank of South Goose Creek. Discussions centered on the design of the sidewalk relative to the need to preserve flood conveyance and the impact on the envisioned riparian ecosystem improvement.

- The likelihood that at least 3 mature non-native trees would have to be removed at the top

of bank across from the Auto Dealership.

An open public meeting with the Boulder Greenways Advisory Board was held August 31, 2010. A briefing on the Goose Creek restoration alternative plans was presented during this meeting. Advance notice of the meeting was published. On October 27, 2010 the Boulder Open Space and Mountain Parks Board reviewed the alternative plans at another open public meeting. At that meeting the Open Space Board approved the staff's recommendations to endorse Alternative 2, Reach 2 and Alternative 2, Reach 3. Those alternatives are listed as follows:

- Alternative 2, Reach 2 provides for excavation of a new meandering channel downstream from Reynolds Corner, enlarging the riparian habitat and relocating the existing bicycle trail southward to the vicinity of the social trail.
- Alternative 2, Reach 3 provides for restoring Cottonwood Pond to its pre-gravel mining status as a forested wetland at the confluence of Goose Creek and Boulder Creek.

8.11.1.2 Public Involvement after Delineation of NER Plan

This Draft DPR/EA will be made available for public comment from May 16 – 25, 2011. A press release is planned for the Boulder City and County media, and the document is available under "Related Documents" at:
http://www.nwo.usace.army.mil/html/pd-p/Goose_Creek/index.html.

8.11.2 Institutional Involvement

8.11.2.1 General Institutional Involvement

During the feasibility study, coordination was conducted with the USFWS, Colorado Division of Wildlife, the Colorado Department of Health, the NRCS, USGS and the Colorado State Historic Preservation Office. All of their recommendations have been given full consideration. This Draft DPR/EA will be made available for agency and public comment from May 16 – 25, 2011. A press release is planned for the Boulder City and County media, and the document is available under "Related Documents" at:
http://www.nwo.usace.army.mil/html/pd-p/Goose_Creek/index.html.

After comments are received, the views of Federal and regional agencies will be summarized, and considered in preparation of the Final document.

8.11.2.2 Panel of Experts

The purpose of the Panel of Experts was to bring together biologists from Federal, State and Local Government to define the "existing conditions" for the South Goose Creek and Cottonwood Pond Ecosystem. Since defining the quality of a riparian ecosystem has both qualitative and quantitative aspects, the use of a Panel of Experts was selected to bring together those with the most experience in evaluating similar ecosystems. Other goals included establishing an actual or theoretical reference reach for a high plains urban stream and to discuss the value of proposed restoration measures. The panel completed on-site scoring of the ecosystem, and participated in discussions about the employment and effectiveness of ecosystem restoration measures by members of various agencies. The panel was convened on May 8, 2008. The panel consisted of the following agencies:

- City of Boulder
- Natural Resources and Conservation Service (NRCS).
- Colorado Division of Wildlife (CDOW).
- U. S. Fish and Wildlife Service (FWS)
- Environmental Protection Agency (EPA)
- U.S Army Corps of Engineers ERDC Lab
- U.S Army Corps of Engineers, Omaha District

8.12 NATIONAL HISTORIC PRESERVATION ACT

There are no historic properties recorded in the project APE. Due to the amount of disturbance which has occurred during gravel mining activities, adjacent road and building construction and the construction of the flood control channel, it is the Corps' opinion that the proposed work would not impact any historic properties. The Corps invited the SHPO to concur with a No Historic Properties Affected determination. The SHPO concurred on _____.

According to the letter from the dated November 2, 2007 (Appendix C), the review of the State's database, no archaeological or historic surveys have occurred in the Area of Potential Effects (APE). The SHPO further noted that the potential of locating archaeological sites within the APE is low and that an archaeological survey is not needed. The letter noted that should archaeological resources be discovered during construction, work would need to be interrupted until the resources have been evaluated in terms of the National Register criteria 36 CFR 60.4 in consultation with the Colorado SHPO.

8.13 EXECUTIVE ORDER 11988, FLOODPLAIN MANAGEMENT GUIDELINES

8.13.1 Background on Floodplain Regulations and Application to this Project

Executive Order 11988, Floodplain Management Guidelines, May 24, 1977 outlines the responsibilities of Federal agencies in the role of floodplain management. Each agency shall evaluate the potential effects of actions on floodplains and should avoid undertaking actions that directly or indirectly induce growth in the floodplain. Given the goals, objectives and real estate constraints of this project, the project is unlikely to directly or indirectly induce growth in the floodplain.

Flood profiles and floodplain boundaries were developed and analyzed to determine if any negative impacts would occur on property and facilities adjacent to the proposed project area. The project area itself is presently used for flood conveyance, so the major objective was to make sure that the post-project conveyance would be similar to the existing condition and to make sure that additional flood damages would not be induced on adjacent businesses and Pearl Parkway.

8.13.2 Evaluation of the Floodplain Impacts of Selected Restoration Plan

Results from the existing Boulder County Flood Insurance Study (FIS) were used to calibrate a HEC-RAS model to evaluate existing and project condition stage profiles for the four input

storms used in the FIS, including the 10-, 50-, 100- and 500-year (0.1, 0.02, 0.01 and 0.002 annual chance of exceedance) flood events. The computed stage profiles provide a comparison of the water surface elevations between existing and project conditions, while floodplain boundary results compare the extent of flooding for each flow with previous regulatory floodplain mapping. Results of the hydraulic analysis indicate negligible or no net rise (in some cases a net drop) in water surface elevations throughout the Goose Creek study area and adjacent reaches. More details on the procedures followed and results of this analysis are provided in Appendix G.

8.14 STATE AND LOCAL PERMITS

Boulder County issues land use permits under its "Areas and Activities of State Interest (1041) Review." Application will be prepared by the Sponsor to the Land Use Department Planning Division, which would subject the proposal to a public hearing. The application must address flood hazard impact, environmental impact, agricultural productivity impact, water resource mapping and descriptions and impacts, and wildlife and habitat impacts among other issues. After hearing any comments from State agencies, mineral owners, and the public, the Land Use Department would determine whether the application is satisfactory and makes its recommendation to the County Board of Commissioners. The Board of Commissioners would also raise the proposal at a public meeting.

8.15 CLEAN WATER ACT

8.15.1 Section 404(b) Clean Water Act Evaluation

The objective of the Clean Water Act is to restore and maintain the chemical, physical and biological integrity of the Nation's waters (33 U.S.C. 1251). Section 404 requires authorization to place dredged or fill material into water bodies or wetlands. It is anticipated the proposed project would be eligible under a type of General Permit for stream and wetland restoration. The draft report will be sent to the Corps Denver Regulatory office to ensure the appropriate Section 404 authorization.

8.15.2 Water Quality Certification from the Colorado Department of Health

According to Colorado Water Quality Control Act, under Part 3, Administration, "General or nationwide permits under section 404 of the federal act shall be certified for use in Colorado without the imposition of any additional state conditions." Because the proposed project is anticipated to be eligible under a type of General Permit for stream and wetland restoration, CDPHE would not be required to issue a state water quality certification. Coordination with the Corps Denver Regulatory office and the CDPHE will continue through the draft document and agency comment period.

8.15.3 Section 402 Permit

A stormwater discharge, nonpoint source, NPDES permit or its equivalent for nonpoint-source discharge would be the responsibility of the construction contractor to secure.

8.16 ENVIRONMENTAL OPERATING PRINCIPLES (EOPs)

The project has been formulated with the seven environmental operating principles of the U.S. Army Corps of Engineers. These principles are to be integrated into all Corps projects, and for an aquatic ecosystem restoration project, can be considered paramount to successful formulation.

- Strive to achieve environmental sustainability: Environmental sustainability will be advanced by increasing the ability of the stream to perpetually recreate new habitat and support plant community regeneration. Design will provide for stream gradients that do not aggrade nor degrade. The low floodplain bench will help sustain riparian habitat by increasing seedbed formation and inundation and increasing accessibility of groundwater. Monitoring and adaptive management plans have been included to help achieve success.

- Consider environmental consequences. This feasibility study has considered environmental consequences not only by proposing restoration of past habitat values, but also through NEPA evaluation of any potential adverse effects of the final array of alternatives.

- Seek balance and synergy. The project would seek balance and synergy by restoring natural connectivity between the stream and its floodplain riparian community, restoring structure and dynamics to the stream so that it can interact beneficially with the riparian community.

- Accept responsibility. Accountability has been met by stating clear objectives to be met for each proposed project measure, and by identifying the respective responsibilities of the Corps and the Sponsor in this report and in the draft Project Partnership Agreement.

- Mitigate impacts. The proposed environmental restoration project has been formulated to require no formal mitigation but rather to improve environmental conditions at the site. The project fits within exemptions from Colorado water rights requirements and from Platte River depletion assessment because it reverses historic impacts through restoration. The project has also been formulated to meet a request by the City of Boulder to replace the open water lost by filling Cottonwood Pond on a 1:1 ratio; the wetlands restored in the Cottonwood Pond area will more than offset the open water acres filled.

- Understand the environment. Improved understanding of environmental and cultural conditions was obtained from coordinating with a variety of expert resources such as the Boulder Greenway's Program and Open Space, the U.S. Fish and Wildlife Service, Colorado Division of Wildlife, and others.

- Respect other views. The study effort respected others' views by inviting input from the general public and from affected agencies, and by incorporating to the extent feasible the input of those agencies and public who did provide input to this study.

9.0 RECOMMENDATIONS

A thorough Feasibility study has been conducted regarding aquatic ecosystem restoration opportunities along South Goose Creek and Cottonwood Pond in the city of Boulder, Colorado. Justified plans have been identified which would provide benefits in the federal interest including improvements to migratory bird habitat and riparian aquatic habitat. The proposed plan would restore the South Goose Creek flood control channel to a more meandering alignment with incidental benefits to wetlands, and restore an abandoned gravel pit to aquatic habitat conditions representative of those before mining activity.

I have given consideration to all significant aspects in the overall public interest. Those aspects considered include environmental, social, and economic effects; engineering feasibility; the unique capabilities and strengths of the Corps to study, design, and implement such a project; capabilities and interests of the cost-share Sponsor; and other elements. The non-Federal Sponsor, the city of Boulder, has stated that prior to implementation it will, through signing of the Project Partnership Agreement, agree to perform the required items of cooperation.

I recommend that the plan proposed herein for aquatic ecosystem purposes be approved and implemented as a Federal project.

This recommendation reflects the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch.

_____

Robert J. Ruch
Colonel, Corps of Engineers
District Commander

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