Stream Habitat Investigations and Assistance

Federal Aid Project F-161-R20

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Job Progress Report

Colorado Parks & Wildlife

Aquatic Research Section

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

JOB PROGRESS REPORT

State: Colorado Project Number: F-161-R-20

Project Title: Stream Habitat Investigations and Assistance

Period Covered: July 1, 2013 through June 30, 2014

Principal Investigators: Matthew C. Kondratieff and Eric E. Richer

Project Objective: To evaluate fishery response to stream aquatic habitat treatments; to evaluate the physical response of streams to aquatic habitat treatments and water development; to evaluate the barrier potential of in-stream obstacles; and to provide technical assistance for statewide aquatic habitat improvement projects and fish passage and barrier designs.

STUDY PLAN A: DESIGN, CONSTRUCTION AND EVALUATION OF STREAM HABITAT RESTORATION TREATMENTS AND IN-STREAM STRUCTURES

Job A.1. Fishery Response to Stream Aquatic Habitat Treatments.

Job Objectives: Stream habitat improvements will be evaluated to quantify changes in salmonid biomass (quantity) and individual fish size (quality). Before-After/Control-Treatment (BACT) studies will be conducted at appropriate site locations. A combination of field and modeled results will be used to evaluate the fishery response to stream habitat treatments. Research findings will quantify how much improvement in the fishery can be expected from stream restoration projects. Results from this study will refine stream habitat restoration techniques to improve sport fisheries and benefit anglers.

Objective 1.1: Develop list of candidate stream segments to conduct pre- and post- stream habitat improvement studies. Select appropriate study site location(s) for evaluation.

ACCOMPLISHMENTS

The list of candidate stream segments for conducting BACT studies of fish response to habitat treatments was updated to reflect new projects identified during the previous year (Table 1.1). Candidate sites for BACT monitoring studies must have the following characteristics: fish populations have stabilized post-whirling disease infection, at least two years of baseline fish data have been collected prior to stream restoration, Colorado Parks and Wildlife (CPW) leases or owns public fishing access, proposed restoration sites have been identified, prioritized and funded allowing adequate time to collect sufficient “before” data prior to construction, and CPW personnel will be able to work closely with contractors on design and implementation of habitat treatments (design-build).

Table 1.1. List of proposed stream segments for studying fish populations pre- and post- stream habitat improvements.

Stream	Construction Years	Project Status	Length (mile)	Primary Treatments	Treatment Reach*	Control Reach*	Project Description
South Platte River: Buckley Ranch	1991	Completed	0.4	Reduce channel width, excavate pools, enhance trout habitat	2/23	2/23	Upper Spinney SWA/Lower end of Badger Basin perpetual easement
South Platte River-Phase 1 & 2	1993 & 1998	Completed	0.6	Reduce channel width, increase adult fish cover (vegetative cover and deep pools), stabilize eroding banks and improve in-stream habitat complexity.	1/9	No control reach	South Platte River Downstream of Spinney Reservoir
Upper Conejos	2000	Completed	1.0	Reduce channel width, increase over-winter habitat (deep pools), stabilize eroding banks and improve in-stream habitat complexity.	TBD	TBD	Conejos River below town of Platoro
Tarryall Creek	2005	Completed	0.6	Increase trout biomass and number of quality-sized trout (>14"), stabilize eroding banks, reduce channel width, increase habitat complexity	2/2	No control reach	Tarryall Creek on Tarryall SWA
Rio Grande River	2006	Completed	4.4	Reduce channel width, develop pools, enhance trout habitat	8/6	0/4	Wason and La Garita Ranches
Middle Fork of South Platte River: Badger Basin	2007-2011	Completed	2	Reduce channel width, develop pools, enhance trout habitat	0/3	2/21	Upper Spinney SWA/Lower end of Badger Basin perpetual easement
Upper Arkansas River	2013-2014	In progress	3	Reduce channel width, develop pools, enhance trout habitat	16/0	16/0	Upper Arkansas NRDA project

South Platte River-Phase 5	2013-2015	In progress	1.5	Reduce channel width, excavate pools, enhance trout habitat	1/0	1/0	Lower Spinney SWA (Dream Stream)
Clear Creek, Twin Tunnels Project	2015	Future Project	0.5	Reduce channel width, excavate pools, enhance trout habitat, floodplain connectivity	1/0	2/0	Twin Tunnels Project along Interstate 70 corridor
Gunnison River, Gunnison SWA	2015-2016	Funded	2.7	Improve diversion structures, enhance trout habitat, floodplain connectivity	1/0	1/0	Gunnison River SWA near Gunnison Colorado
Crystal River, Wexner Property	2015-2016	Future project	0.6	Improve diversion structures, enhance trout habitat	TBD	TBD	Wexner Property
North Platte River, Verner SWA	2015-2016	Future project	1.3	Stabilize eroding banks, reduce channel width, excavate pools, enhance trout habitat	TBD	TBD	Verner State Wildlife Area near Walden, Colorado
Tomichi Creek, Tomichi Creek SWA	2015-2016	Future project	4.4	Stabilize eroding banks, reduce channel width, excavate pools, enhance trout habitat	TBD	TBD	Tomichi Creek State Wildlife Area near Gunnison, Colorado
South Platte River	2015-2017	Future project	1	Reduce channel width, excavate pools , enhance trout habitat	0/0	0/0	River segment Downstream of Park Co. Rd 59
South Fork of South Platte River	Delayed	Future project	1	Reduce channel width, excavate pools, enhance trout habitat	2/0	2/0	River reach upstream of Badger Basin HQ - Lower end of Badger Basin perpetual easement
Hartsel Townsite	Delayed	Future project	0.6	Reduce channel width, excavate pools, enhance trout habitat	2/0	2/0	Hartsel Townsite between Highway 24 and Highway 9

*Years of fish data collected “Before” work started / Years of fish data collected “After” work completed

Objective 1.2: During summer and fall months, conduct electrofishing sampling to determine salmonid biomass, densities and individual fish lengths in control and treatment study sites.

ACCOMPLISHMENTS

We collected fish sampling data on select pre- and post-treatment stream reaches to monitor fish response to aquatic treatments with assistance from area aquatic biologists and research scientists. Fish sampling was conducted at the following study locations:

Rio Grande River:

We collected fish sampling data on treated sections of the Rio Grande River on Wason Ranch (3.8 miles) and untreated portions of the Rio Grande River on La Garita Ranch (2.4 miles) by electrofishing with two rafts equipped with throw electrodes (Figure 1.1). Data collected included fish population estimates, fish size by relative abundance, and species composition. Four years of fish data have been collected on the Wason Ranch since Dave Rosgen completed work in 2006.

Figure 1.1. Raft electrofishing on Upper Wason section of the Rio Grande River, October 2014.

A catastrophic fire occurred in the Rio Grande River basin upstream of the project reach in the summer of 2013. Subsequent rainfall events increased deposition of black ash, sediment, and debris on the bed and banks of the long-term monitoring reaches. This material was still apparent during fish sampling in October 2013. Landowners and other government agencies were concerned that ash and fine sediments deposited by the fire would negatively influence fish and invertebrate populations within the monitoring reaches. Interestingly, fish numbers were actually the same or higher within our long-term monitoring reaches in spite of the ash deposits. Compared to previous sampling efforts, giant stonefly (*Pteronarcys californica)* abundance was also higher at all sites. At one site on the Rio Grande, we estimated the second-highest *Pteronarcys* abundance ever recorded in Colorado since monitoring began state-wide. These findings suggest that the input of organic material and ash from the fire may have increased productivity of insects and fish within the locations we monitored on the Rio Grande River.

Data were collected during October 7-10, 2013 and data analysis was completed the following winter. As previous studies suggest five to six years are required for fisheries to stabilize post-restoration activities, we plan to continue monitoring for one more year (i.e., 2015) prior to concluding the study and publishing results. This study has unique value because it is being conducted on a large river system, while most published habitat restoration evaluations are conducted on much smaller streams. See Figures 1.2-1.5 for fish sampling results from 2013.

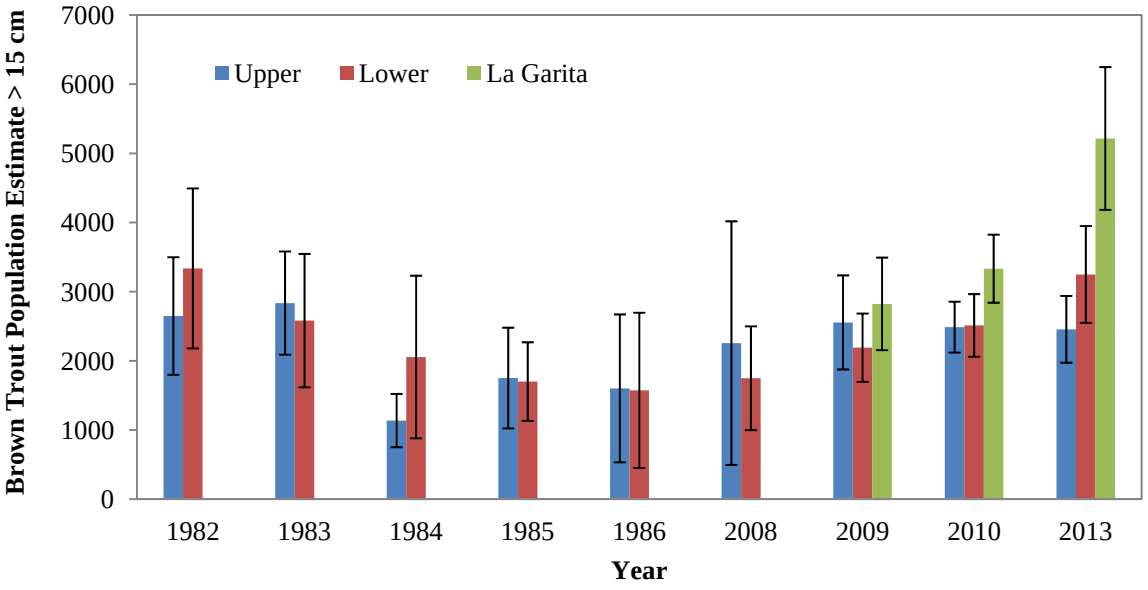


Figure 1.2. Population estimates for adult brown trout (>15 cm) in the Upper Wason, Lower Wason and La Garita reaches. Pre-restoration sampling estimates include years: 1982, 1983, 1984, 1985 and 1986. Post-restoration sampling estimates include years: 2008, 2009, 2010 and 2013. Black vertical bars represent 95% CI for the estimate.

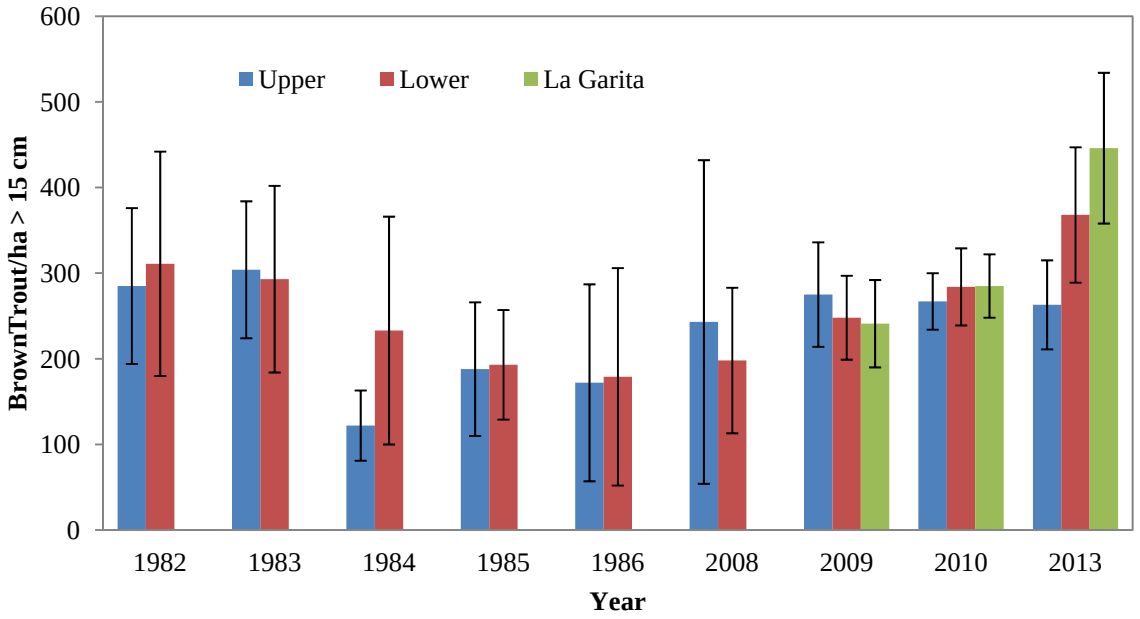


Figure 1.3. Population density estimates for adult brown trout (>15 cm) in the Upper Wason, Lower Wason and La Garita reaches. Pre-restoration sampling estimates include years: 1982, 1983, 1984, 1985 and 1986. Post-restoration sampling estimates include years: 2008, 2009, 2010 and 2013. Black vertical bars represent 95% CI for the estimate.

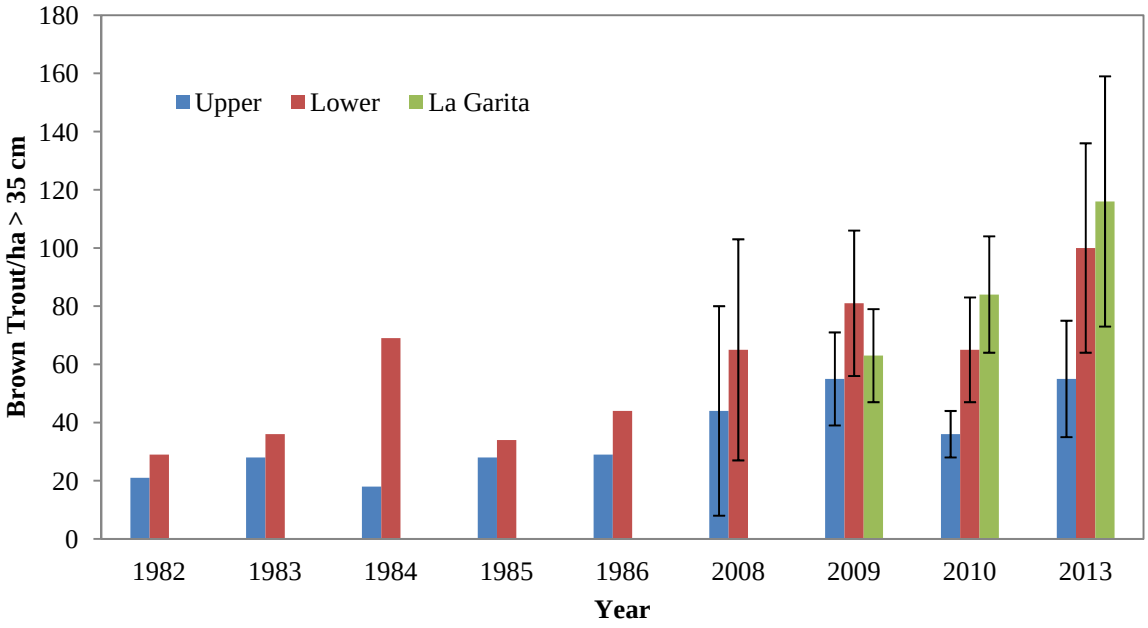


Figure 1.4. Density (trout/ha) of quality-sized brown trout (>35 cm) in the Upper Wason, Lower Wason and La Garita reaches. Pre-restoration sampling estimates include years: 1982, 1983, 1984, 1985 and 1986. Post-restoration sampling estimates include years: 2008, 2009, 2010 and 2013. Black vertical bars represent 95% CI for the estimate.

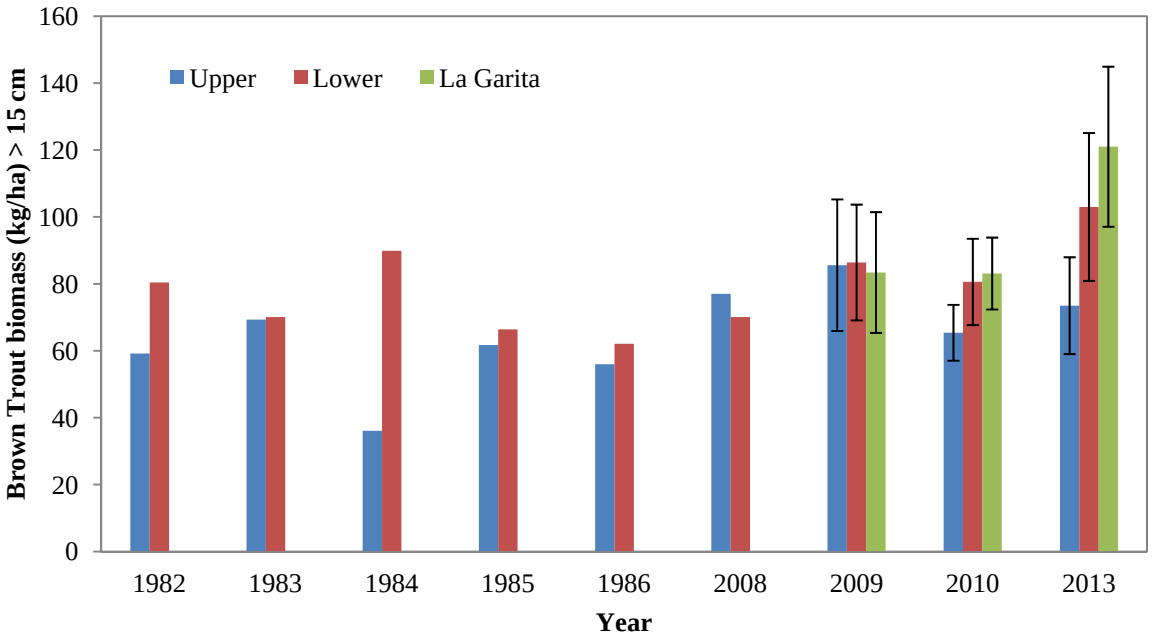


Figure 1.5. Biomass (kg/ha) of adult brown trout (>15 cm) in the Upper Wason, Lower Wason and La Garita reaches. Pre-restoration sampling estimates include years: 1982, 1983, 1984, 1985 and 1986. Post-restoration sampling estimates include years: 2008, 2009, 2010 and 2013. Black vertical bars represent 95% CI for the estimate.

A monitoring study was initiated in summer of 2011 to determine if river restoration activities negatively influenced abundance of giant stoneflies (*Pteronarcys californica)* on a reach-wide scale. The giant stonefly serves as an important food source for resident trout. Stonefly exuviae were collected and counted in 15 different 100-foot stations above (control sites), within (treatment sites), and below (control sites) the Wason Ranch study area. To continue our evaluation, we repeated this monitoring study in 2014 for 12 of the 15 sites. Removal methods were used to estimate relative abundance of *Pteronarcys californica* across four different reaches. Data were collected during June 2014 and will be analyzed by the next reporting period.

South Platte River:

Charlie Meyers SWA:
Fish sampling did not occur this year on the Charlie Meyers SWA. Sampling will occur again in 2014 (even years) instead of an every-year basis to provide data on fish abundance and species composition.

Buckley Ranch:

Historic monitoring sites: Fish sampling did not occur this year on the Buckley Ranch site (boulder and control stations). Sampling will occur again in 2014 (even years) instead of an every-year basis to provide data on fish abundance and species composition.

Toe-wood / sod-mat sites: The toe-wood / sod-mat treatment segment (approximately 200 linear feet of toe-wood treated banks of the 1000 foot electrofishing station) was sampled during October 2013, but spring sampling (April) was not possible due to high flows and excessive turbidity. Data collected included fish population estimates, fish size by relative abundance, and fish species composition. Fisheries response data collected from this reach will be compared with data collected from the control/treatment reaches on the Buckley Ranch located just 0.15 miles downstream from the Badger Basin project boundary.

Reference reach sites: We collected fish sampling data on the Middle Fork of South Platte River on the Tomahawk SWA during the fall and spring of 2013. Data collected included fish population estimates, fish size by relative abundance, and fish species composition. Fish biomass and density data collected from this site and one site upstream will serve as "reference reaches" and help set target levels for expected fisheries response at treated (or restored) locations downstream. Detailed habitat surveys from these locations along with fisheries data will serve as reference conditions for impaired sites within the South Platte River basin.

Upper Arkansas River NRDA Habitat Enhancement Project:

None of the fish monitoring sites within the Upper Arkansas River Natural Resource Damage Assessment (NRDA) Habitat Enhancement project extent were sampled in 2013 due to instream construction activities. This project is unique in that some fish sampling sites have more than 16 years of baseline data collected prior to implementing the habitat enhancement project. These data provide baseline information for comparison to fish population data following project implementation. All fish monitoring sites will be sampled in August 2014 for the first year of post-implementation monitoring.

Clear Creek, Twin Tunnels Project:

The physical habitat characteristics of Clear Creek near Idaho Springs, Colorado, have been highly modified from historic conditions. As the river runs parallel with a major Interstate highway (I-70), most of the river has been channelized with rip-rap banks. There are very few locations left that have any functional floodplain area. Primary project goals are to restore natural processes along a long river bend that will improve floodplain connectivity, establish deep lateral scour pools, and enhance trout habitat for the benefits of anglers. Fish population data were collected during fall 2012 and 2013 from the proposed treatment site to establish baseline conditions. This site will be monitored again during fall 2014. These sampling efforts will provide three years of baseline data prior to construction activities, which are scheduled for spring 2015.

North Platte River, Verner SWA:

Implementation of a 1.3 mile stream rehabilitation project within the Verner SWA was tentatively scheduled to begin in 2014. However, the project has been suspended pending funding for implementation. The site was over-grazed in the past, but the riparian area is now fenced to restrict cattle access. However, cattle were observed grazing in the reach during

summer 2014. The objectives of rehabilitation include stabilizing degraded banks, re-establishing riparian vegetation, and enhancing brown trout habitat. Baseline fish sampling was to be conducted at two to three sites within the proposed treatment reach for a BACT study that evaluates changes in brown trout quality and quantity. Data collection was planned to include fish population estimates, length/frequency data, and species composition. Additional baseline fish sampling will be postponed until this project receives funding for implementation. A minimum of two years of pre-project fish data will be collected to establish an adequate basis for comparison.

Tomichi Creek, Tomichi Creek SWA:

Implementation of a 4.4 mile stream rehabilitation project within the Tomichi Creek SWA was tentatively scheduled for 2014. However, the project has been suspended pending funding for implementation. Fish sampling was conducted in 2013 at both control and treatment sites to provide the first year of baseline data prior to stream rehabilitation and habitat enhancement. Treatment sites were established and surveyed to evaluate the effectiveness of toe-wood treatments and channel realignment. The Bratton site will be used for the control site. Data collected included fish population estimates, length/frequency, and species composition. Fish sampling was conducted with the goal of collecting a minimum of two years of baseline data for evaluating potential habitat improvements once funding becomes available.

Gunnison River, Gunnison River SWA:

Implementation of a 2.5 mile stream rehabilitation project within the Gunnison River SWA is tentatively scheduled for 2015-2016. Funding for the project was approved in 2014. Fish sampling data were collected on two separate stream reaches using raft electrofishing and mark/recapture techniques on the Gunnison River during the fall of 2013 to establish the first year of baseline fisheries data. The Almont site was used for the control reach and the Van Tuyl site will serve as the treatment reach. Data collected included fish population estimates, fish size by relative abundance, and fish species composition. Fish biomass and density data collected from these sites will provide baseline data for later comparisons once the project is completed. A minimum of two years of baseline fisheries data will be collected before the habitat improvement project is initiated. Detailed habitat surveys were conducted in addition to the fish sampling work for conducting pre- and post-habitat enhancement comparisons.

Upper Conejos River:

Implementation of a 0.7 mile stream rehabilitation project on the Upper Conejos River below Platoro Reservoir is tentatively scheduled for 2015-2016. Construction and operation of the reservoir has altered both flow and sediment regimes, leading to degraded habitat conditions for resident and spawning trout. An initial site assessment for the proposed treatment reach took place in 2012. Fish sampling was conducted in 2013 to establish the first year of baseline data prior to stream rehabilitation and habitat enhancement. Data collected included fish population estimates, length/frequency, and species composition in control and treatment reaches. A minimum of two years of baseline fisheries data will be collected before the habitat improvement

project is initiated. However, further fish sampling will be postponed until the project receives funding for implementation.

Wexner Property, Crystal River:

Donation of a perpetual fishing easement on the Wexner Property along the Crystal River will provide public fishing access to 0.6 river miles. An initial site assessment was conducted in 2012 and determined that the rainbow trout fishery would benefit from habitat enhancement. Fish sampling was planned for fall 2013 to establish baseline data prior to stream rehabilitation and habitat enhancement. However, sampling was not conducted in 2013 due to exceptionally high flows. Fish sampling is scheduled for fall 2014.

Job A.2. Physical Response of Streams to Aquatic Habitat Treatments.

Job Objectives: The physical response of streams to habitat improvements will be evaluated by quantifying changes in channel morphology, sediment, and water temperature. Topographic and sediment surveys will be used to evaluate changes in longitudinal profile, cross-sections, sediment size and transport, and habitat suitability. BACT studies will be conducted at appropriate site locations to evaluate changes in channel morphology and water temperature following habitat treatments. For select sites, an Acoustic Doppler Current Profiler (ADCP) will be use to evaluate hydraulic conditions and habitat suitability. Research findings will elucidate how habitat treatments improve channel form and function. Results from this study will help refine techniques to maximize the benefit of rehabilitation projects on trout fisheries and stream functions.

Objective 2.1: Develop and maintain list of candidate stream segments for stream habitat improvement studies.

ACCOMPLISHMENTS

The list of candidate sites for stream habitat improvement studies was updated to include projects identified or completed in the previous year (Table 2.1). The revised list includes 22 completed projects, three active or ongoing projects, and nine proposed projects of which three have funding. This list will also be used to select sites for evaluating the longevity of different habitat treatments (see Job A.3, Objective 3.2).

Table 2.1. List of candidate stream segments for habitat improvement and treatment longevity studies.

Number	Project	River	Status	Year
1	Buckley Ranch	South Platte River	Completed	1991
2	Dream Stream (Phase 1)	South Platte River	Completed	1993
3	Big Thompson River	Big Thompson River	Completed	1997
4	Dream Stream (Phase 2)	South Platte River	Completed	1998
5	Grape Creek	Grape Creek	Completed	1998
6	Antero	South Fork of South Platte River	Completed	1999
7	Upper Conejos River (Phase 1)	Conejos River	Completed	2000

8	Threemile Creek	Threemile Creek	Completed	2000
9	Dream Stream (Phase 3)	South Platte River	Completed	2001
10	Lefthand Creek	Lefthand Creek	Completed	2001
11	Knight-Impler	South Fork of South Platte River	Completed	2002
12	Hartsel	South Fork of South Platte River	Completed	2002
13	Aurora	South Platte River	Completed	2003
14	Dream Stream (Phase 4)	South Platte River	Completed	2004
15	Tarryall SWA	Tarryall Creek	Completed	2005
16	Wason Ranch	Rio Grande River	Completed	2006
17	Badger Basin SWA	Middle Fork of South Platte River	Completed	2008
18	South Boulder Creek	South Boulder Creek	Completed	2011
19	Bear Creek SWA	Bear Creek	Completed	2012
20	Dolores River SWA	Dolores River	Completed	2013
21	Upper South Boulder Creek	South Boulder Creek	Completed	2013
22	Below Stagecoach Reservoir	Yampa River	Completed	2013
23	Hidden Mile	Conejos River	Ongoing	2014
24	Upper Arkansas NRDA	Arkansas River	Ongoing	2014
25	Dream Stream (Phase 5)	South Platte River	Ongoing	2014
26	Gunnison River SWA	Gunnison River	Funded	2015
27	Twin Tunnels	Clear Creek	Funded	2015
28	Flood Restoration	Big Thompson River	Funded	2016
29	Wexner Property	Crystal River	Proposed	2016
30	Tomichi Creek SWA	Tomichi Creek	Proposed	2016
31	Windy Gap Enhancement	Colorado River	Proposed	2016
32	West Plum Creek	Plum Creek	Proposed	2017
33	Upper Conejos River (Phase 2)	Conejos River	Proposed	2017
34	Little Hills SWA	Dry Creek	Proposed	2017

Objective 2.2: Research theoretical techniques for evaluating the effectiveness of stream restoration treatments, including modeling (e.g., HEC-RAS, PHABSIM, River2D, MDSWIMS, IBMs), ADCP technology, and/or use of reference reach data to determine which methods are best for predicting changes in habitat suitability following stream habitat enhancement.

ACCOMPLISHMENTS

River2D Studies:

The Upper Arkansas River NRDA project was identified as an ideal opportunity to conduct a BACT study on the effectiveness of habitat enhancement treatments. The Upper Arkansas trout fishery was previously degraded due to the presence of historical mine tailings throughout riparian areas. These mine tailings have since been remediated by the Environmental Protection Agency (EPA), and fish populations have increased dramatically in response to improved water quality. The next phase of the project is focused on restoring and enhancing instream habitat. Habitat modeling with River2D will be used to evaluate the effectiveness of habitat treatments. River2D is a two-dimensional, depth average hydrodynamic and fish habitat model developed

for use in natural streams and rivers (Steffler and Blackburn, 2002). To configure baseline River2D models, all fish monitoring sites within the project reach were surveyed during fall 2013 to establish baseline habitat suitability prior to instream habitat enhancement (Appendix A). These sites will be surveyed again in 2014, 2016, and 2018 to evaluate the effectiveness of habitat enhancement. Analyses of baseline (i.e., 2013) and post-implementation (i.e., 2014) habitat models will take place during winter 2014-2015.

References:

Steffler, P. and J. Blackburn. 2002. River2D: Two-dimensional depth averaged model of river hydrodynamics and fish habitat, introduction to depth averaged modeling and user's manual. University of Alberta. 120 pp.

Acoustic Doppler Current Profiler (ADCP):

ADCP is being utilized at the Charlie Meyers SWA to evaluate changes in channel morphology and velocity distributions before and after implementation of the stream rehabilitation and habitat enhancement project. An ADCP was used to survey five pools within the project reach during spring 2013, prior to instream construction. These surveys will be repeated during fall 2015 after in-stream construction is completed. The SonTek RiverSurveyor with HydroSurveyor software was purchased in June 2013. Pilot studies have demonstrated the utility of the ADCP system for surveying and evaluating habitat, particularly in large river systems that cannot be surveyed by wading. This state-of-the-art equipment was used to survey riffle habitat on the Colorado River, calculate stream discharge, and measure in-channel velocity distributions (Figure 2.1 and 2.2). This piece of equipment was also used to survey baseline morphology and hydraulic conditions at the proposed whitewater park site in Montrose, Colorado (see Job A.5).

Figure 2.1 Surveying riffle morphology with the SonTek ACDP HydroSurveyor on the Colorado River near Pumphouse.

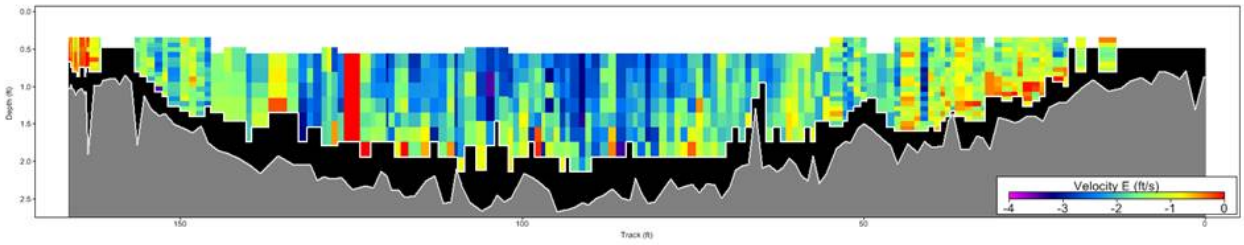


Figure 2.2. Cross-section velocity distribution measured at Pumphouse, Colorado River.

Objective 2.3: Conduct topographic surveys to evaluate geomorphology and aquatic habitat in control and treatment sites to evaluate stream restoration and habitat enhancement projects. Ideally, studies will utilize a BACT design with surveys before and after project implementation to evaluate project goals and objectives. Topographic surveys will be collected on select pre- and post-treatment stream reaches with assistance from area aquatic biologists/researchers.

ACCOMPLISHMENTS

South Platte River, Charlie Meyers SWA:

The Charlie Meyers SWA on the South Platte River is a popular fishing destination in Colorado, commonly referred to as the Dream Stream. This reach of the South Platte is located between Spinney and Elevenmile Reservoirs. Riparian vegetation was the primary control on bank erosion along the upper South Platte River, but historical grazing activities removed most of the woody riparian vegetation along this reach. The combination of altered hydrology from operation of the upstream reservoir and degraded riparian vegetation have resulted in accelerated bank erosion and degraded river processes, such as maintenance of lateral scour pools and point bars. Due to the economic benefit from fishing, Park County identified the Charlie Meyers SWA as an ideal site for stream rehabilitation and habitat enhancement. Previous habitat enhancement efforts were completed upstream of the site in four phases from 1993-2003. The Charlie Meyers SWA project will be the fifth and final phase of the Dream Stream project.

The project will be implemented in cooperation with the Vocational Heavy Construction Technology (VHCT) program. The VHCT program was formed in a cooperative effort between the Colorado Department of Corrections (CDOC), Colorado Parks and Wildlife (CPW), and Colorado Contractors Association (CCA) to rehabilitate degraded stream habitats while providing heavy construction training for inmates committed to changing the direction of their lives. This partnership provides a means to implement stream restoration projects with substantially reduced cost, while reducing recidivism rates for VHCT participants by 80% compared to other inmates in the Colorado penal system.

In-stream construction began in fall 2013 and should be completed in fall 2014. To monitor the effectiveness of habitat enhancement activities, survey-grade GPS and an ADCP were used to collect data on channel morphology and velocity distributions prior to instream construction activities. Additional cross-sections were surveyed in 2013 prior to construction. Survey data for monitoring cross-sections are included in Appendix A. All cross-sections, the longitudinal

profile, and ADCP-measured velocity distributions will be resurveyed after construction for a before-after comparison of physical habitat quality. Prior to construction, we also conducted pebble counts at specific cross-sections to monitor sediment gradation pre- and post-construction.

South Platte River, Badger Basin SWA:

The as-built survey for this project was not completed during this period due to other higher-priority obligations, including ongoing construction projects and flood-recovery assistance.

Clear Creek, Twin Tunnels Project:

Much of Clear Creek has been channelized to provide space for the I-70 corridor. Channelization resulted in disconnected floodplains and degraded riparian areas. The Twin Tunnels construction project is managed by the Colorado Department of Transportation (CDOT) and will provide additional eastbound and westbound lands on I-70. During construction of the new tunnels, I-70 will be redirected onto to a temporary frontage road around the Twin Tunnels site. Once construction of the new tunnels has been completed, the temporary frontage road will be removed, providing a unique opportunity for riparian restoration within the I-70 corridor. The project will develop a riparian bench to facilitate exchange of sediment and nutrients between the river channel and floodplain. In addition, instream habitat treatments will be constructed to provide velocity refuge and holding water for trout. The effects of establishing riparian connectivity and improving fish habitat will be evaluated by monitoring fish populations pre- and post-treatment.

Topographic surveys were conducted in 2012 to develop a site assessment and conceptual rehabilitation design. CDOT and project consultants used the conceptual design to develop preliminary and final designs with input from CPW. The riparian restoration and habitat enhancement phases of the project were delayed until spring 2015 due to ongoing construction at the Twin Tunnels. Due to the delay, no physical survey data were collected within this grant period. Topographic surveys will be repeated in 2015 following project implementation.

North Platte River, Verner SWA:

The Verner SWA on the North Platte River experienced riparian degradation due to decades of heavy grazing. The reach is mostly devoid of woody riparian vegetation on the outside of meander bends. This lack of bank-stabilizing vegetation has led to substantial bank erosion, which in turn has created a wide and shallow channel with poor habitat quality. Despite the need for riparian and instream habitat restoration, funding for the project was denied by the North Platte Basin Roundtable. Therefore, additional topographic surveys for this project will not be conducted until alternative funding is secured.

Gunnison River, Gunnison River SWA:

Residential development along the Gunnison River has decreased the extent of riparian forests by 50% near Gunnison, Colorado. In addition, agricultural water diversion structures have

accelerated stream bank erosion, land loss, downstream sedimentation, and altered riparian plant communities. In response to these issues, the Gunnison SWA was identified as an ideal site for riparian rehabilitation and instream habitat enhancement. The goals of the Gunnison River and Riparian Rehabilitation Project are to:

1) Increase wild brown and rainbow trout biomass and densities;
2) Improve conditions for quality-sized adult trout;
3) Improve fishing access with a trail system;
4) Assist water rights holders in improving and/or relocating diversion structures to improve habitat, stability, and channel alignment;
5) Create deep in-channel pools to provide lower velocity holding areas;
6) Explore the potential for reconnecting the floodplain with the existing channel to improve river function, flood capacity, and aquifer recharge;
7) Assess aggradation and degradation near bridges;
8) Maintain the existing river planform to maintain property boundaries;
9) Incorporate in-channel habitat improvement structures while not raising flood stage on properties adjacent to and downstream of the project area where floodplain connectivity is undesirable;
10) Planting native woody vegetation in riparian areas to improve river function and wildlife habitat;
11) Improve and manage boater access.

During spring 2013, a topographic survey was conducted for 2.7 river miles within the Gunnison SWA to develop a site assessment and conceptual rehabilitation design. The site assessment and conceptual design (see Appendix B) were finalized during fall 2013 and presented to the Gunnison Basin Roundtable and Colorado Water Conservation Board (CWCB) for funding. In March 2014, the Gunnison Basin Roundtable and CWCB approved a total of $445,540 for implementation of the project. Additional survey work will be completed and final design documents will be developed during 2014-2015. Instream construction is currently scheduled for fall 2015.

Upper Conejos River below Platoro, Colorado:

Additional survey and design work for this project were not completed during this period due to lack of funding. This project will remain on hold until stakeholders can secure funding for project implementation.

Crystal River, Wexner Property:

The Wexner Property will provide 0.6 miles of public fishing access along Crystal River. The majority of the flows in the Crystal River are diverted during the growing season, leaving little in-channel habitat for fish. During low flow periods, water temperatures in the river elevate and diversion ditches can become more attractive habitat for fish. Entrainment of fish in ditches can lead to decreased populations and adversely impact the fishery. The goals of the habitat enhancement project are to:

1) Rehabilitate trout habitat throughout the reach;
2) Develop pools to provide temperature refuge during low flow periods;
3) Reconstruct a diversion structure to accommodate sediment transport, fish passage, and reduce maintenance frequency.

In fall 2012, we conducted a baseline survey including a longitudinal profile and cross-sections. Sediment data were also collected to help characterize the proposed treatment reach. Additional topographic data were collected during fall 2013 (Appendix A). CPW also provided design criteria to the landowner for a cross-vane diversion structure (Rosgen, 2006). Further work on this project will be contingent upon the status of funding and public access. The site assessment and conceptual rehabilitation plan will be completed once funding and public fishing access have been secured.

References:

Rosgen, D.L. 2006. Cross-vane, w-weir, and j-hook vane structures: description, design and application for stream stabilization and restoration. Wildland Hydrology, Fort Collins, Colorado: 32 pp.

Objective 2.4: Monitor water temperature at rehabilitation sites where temperature has been identified as a potential limiting factor on trout fisheries. Temperature loggers will be deployed to evaluate the effects of stream rehabilitation and habitat enhancement on in-stream water temperature.

ACCOMPLISHMENTS

Tomichi Creek, Tomichi Creek SWA:

Water temperature loggers were deployed throughout the proposed project reach to monitoring baseline water temperatures. However, funding for the rehabilitation project has not yet been secured. Therefore, the BACT study will be on hold until funding is obtained for project implementation. Water temperature monitoring will continue in the interim.

South Platte River, Badger Basin SWA:

The Badger Basin SWA experienced degradation of riparian vegetation due to historical grazing practices. The reach was selected for a rehabilitation and habitat enhancement project that was completed in 2011. One of the goals of the project was to stabilize eroding banks to facilitate re-establishment of woody riparian vegetation. To achieve this goal, eroding banks were stabilized with a variety of techniques and planted with a mixture of willow stakes and bare-root willow plantings. Pool habitat was also enhanced to provide deeper, and cooler, holding water for brown trout. We hypothesize the combination of improved shading from re-establishing willows and a deeper channel will result in cooler water temperatures. To test this hypothesis, we deployed temperature loggers directly upstream and downstream of the project reach in the spring of 2013. Temperature data were recorded hourly (Figure 2.3) and analyzed for statistical difference with a

paired t-test (Table 2.2). Although we observed a statistically significant decrease in water temperature between the upstream (mean = 6.63 °F) and downstream (mean = 6.52 °F) locations, the difference in mean temperatures was less than the specified accuracy of the instrument (i.e., ±0.79 °F). Nevertheless, temperature loggers will be maintained at the site for at least two to three more years to monitor the impact of willow growth, improved W/D (width/depth) ratios, and undercut banks on instream temperature. We also deployed additional temperature loggers upstream of the Badger Basin SWA during spring 2014 to evaluate temperature conditions in reference (i.e., Tomahawk SWA) and un-restored stream reaches.

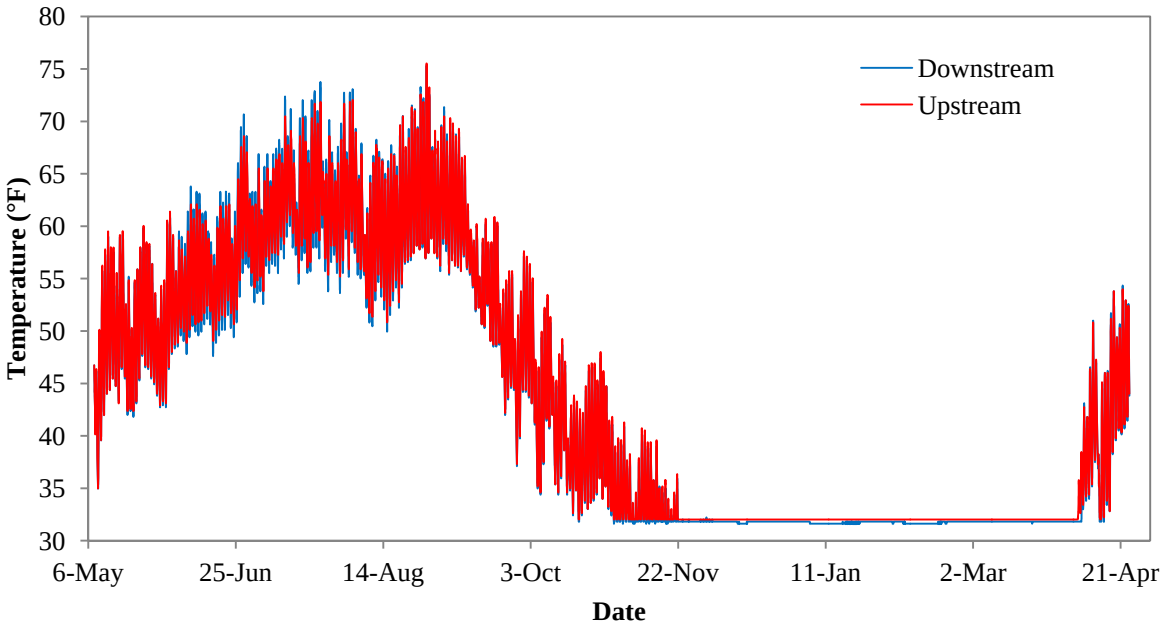


Figure 2.3. Hourly water temperature data for locations upstream and downstream of the Charlie Meyers SWA habitat enhancement project.

Table 2.2. Results from student t-test, paired two-sample for means, comparing water temperature at locations upstream and downstream of the Badger Basin SWA restoration project.

	BB1- Upstream	*BB2 - Downstream*
Mean	6.64	6.52
Variance	49.6	50.4
Observations	8425	8425
Pearson Correlation	0.998	
Hypothesized Mean Difference	0	
df	8424	
t Stat	25.4	
P(T<=t) one-tail	1.34E-137	
t Critical one-tail	1.645	
P(T<=t) two-tail	2.68E-137	
t Critical two-tail	1.960	

North Platte River, Verner SWA:

The Verner SWA on the North Platte River experienced riparian degradation due to decades of heavy grazing. The reach is mostly devoid of woody riparian vegetation on the outside of meanders bends. This lack of bank-stabilizing vegetation has led to substantial bank erosion, which in turn has created a wide and shallow channel with minimal shade. Irrigation practices in the area decrease streamflows during the growing season. The combination of decreased flows and wide channel can lead to increased water temperatures. As the reach is a candidate site for stream restoration and habitat enhancement, a water temperature logger was deployed on the upstream boundary of the site during spring 2013 to establish baseline water temperature conditions. Water temperature monitored is ongoing at this site. However, the riparian rehabilitation and habitat enhancement project was denied funding by the North Platte Basin Roundtable. Therefore, monitoring efforts for this project have decreased in priority.

Objective 2.5: Conduct physical habitat surveys to enhance understanding of fish response to stream habitat treatments. Field surveys and habitat mapping for pre- and post-treatment stream reaches will be conducted with assistance from CPW biologists and engineering staff.

ACCOMPLISHMENTS

South Platte River:

Baseline habitat surveys for the South Fork and reference habitat surveys for the Middle Fork, Tomahawk SWA, were not completed during this segment due to other, higher-priority projects, including instream construction projects on the Charlie Meyers SWA and Upper Arkansas River as well as assistance with post-flood reconstruction in the Colorado Front Range.

Upper Arkansas River NRDA Project:

The monitoring and evaluation plan for the instream habitat restoration project was prepared and submitted to project stakeholders for review. Topographic surveys for 2D hydraulic modeling were conducted at control and treatment sites within the Reddy and Hayden reaches. The results from 2D modeling will be used to evaluate changes in habitat suitability following stream rehabilitation and habitat enhancement. In-stream construction began in July 2013 and should be completed during fall 2014. Baseline surveys were completed for all control and treatment sites during fall 2013 prior to restoration (Appendix A).

Job A.3. Effectiveness of Stream Aquatic Habitat Treatments within Functional Categories.

Job Objectives: The effectiveness of specific habitat treatments will be evaluated by addressing the following research questions: how do fish utilize the treatment, what is the life expectancy of the treatment, what maintenance is required to keep the treatment functioning properly, what is the initial cost in terms of labor and materials to install the treatment, and how immediate is a given treatment able to provide the desired benefit? A variety of methods will be tested (snorkel survey, underwater video and photography, PIT tag arrays, and electrofishing sampling) to

determine how fish utilize specific treatments. Individual treatments and cross-sections will be surveyed, monitored and inspected over time to determine their life expectancies, maintenance costs and how quickly they are able to provide the desired benefits. The material costs and length of time to install particular treatments will be recorded to determine overall costs for installation of particular treatments. Various treatments will be compared within functional groups to assess their relative costs and benefits.

Objective 3.1: Fish utilization of various treatment types

During summer and fall months, conduct pilot studies using a variety of potential fish monitoring techniques including some or all of the following: PIT tagging, radio telemetry, snorkel surveys and underwater video and photography for evaluating fish use of specific aquatic habitat treatments.

ACCOMPLISHMENTS

PIT Tagging Studies:

Studies using PIT tagging technologies with fixed antenna systems have been effectively applied to monitor fish movements. To evaluate fish utilization of habitat enhancement treatments, we are developing a mobile PIT tag array that incorporates GPS and temperature sensors. The system utilizes an Oregon RFID single antennae reader, Campbell Scientific CR1000 Datalogger, Garmin GPS sensor, and Campbell Scientific temperature sensor. The system is configured to record the PIT tag number, GPS position, and water temperature whenever a tagged fish is detected. The system is being designed for deployment from a small raft, but could be deployed from a backpack as well. The data logger program has been written and a variety of antenna configurations have been tested. To evaluate the accuracy of the system, a controlled field experiment will be conducted during fall 2014. Once this initial test has been completed and evaluated, we plan to run the system through the Badger Basin SWA to evaluate fish utilization of different habitat enhancement treatments.

Underwater Video and Photography:

We have continued the use of underwater video to evaluate fish utilization of various habitat treatments. This method shows promise for evaluating habitat treatments, although turbid conditions can limit the utility of underwater video. Pilot work with underwater video will continue through 2014 and 2015. Initial results suggest that conducting underwater video at different times of day would be valuable, but will require the use of underwater dive lights. Combining snorkel surveys with underwater video could provide valuable information regarding the effectiveness of various habitat treatments. We are also utilizing repeat photography to document habitat improvements from instream construction in accordance with ACOE permitting. In addition, time-lapse photography is being used to document the construction sequence for specific habitat treatments. No pilot studies with radio telemetry or snorkel surveys were used during this period.

Objective 3.2: Treatment longevity

Cross-sections at specific aquatic habitat treatment locations for which we have before, as-built and post-monitoring data will be re-surveyed to monitor treatment longevity and evaluate stability over time.

ACCOMPLISHMENTS

Historical Cross-Sections:

Additional surveys of historical cross-sections on the South Platte River were not conducted during this period. However, monumented cross-sections were established for the Upper Arkansas River NRDA and Charlie Meyers SWA Habitat Enhancement projects (see Appendix A). These cross-sections will be resurveyed following completion of instream construction and monitored for a minimum of five years.

Rapid Assessment Procedure:

The evaluate longevity and effectiveness of restoration and habitat enhancement treatments, a rapid assessment procedure developed by Miller and Kochel (2012) will be used to asses instream structures on the Upper Arkansas NRDA project. Bank treatments and in-stream habitat structures will be monitored to assess stability and function. In-stream habitat structures include boulder clusters, boulder structures (e.g., J-hooks and cross-vanes), and stream bank structures (e.g., toe-wood, log vanes, and other toe-protection treatments). Structure and treatment types that will be monitored with the rapid assessment procedure are described along with their fishery benefits in Table 3.1.

Table 3.1. Types of in-stream structures and habitat treatments.

Structure or Treatment	Description	Fisheries Benefits
Brush-toe	Bank stabilization treatment consisting of layered brush material that is covered with fill material and locally harvested sod-mats.	• Stabilize eroding stream banks • Provide bank cover among bush material • Capture fine sediment • Provide organic material and nutrients for benthic macroinvertebrates
Boulder cluster	Generally 2-3 boulders placed on footer boulders near the channel thalweg.	• Provide mid-channel holding and refuge cover • Develop feeding lanes in flow separation zones • Increase habitat complexity
Cross-vane[1]	Channel spanning boulder structure designed to establish grade control, reduce bank erosion, create a stable width/depth ratio, and maintain channel capacity, while maintaining sediment transport capacity and competence.	• Increase bank cover from differential raise in water surface in bank region • Create pool for holding and refuge cover during high and low flows • Develop feeding lanes in flow separation zones • Create spawning habitat in the glide portion of the pool
"Fish condo"	Bank stabilization and habitat	• Stabilize eroding stream banks

	enhancement treatment consisting of logs and rootwads that are covered with fill material and locally harvested sod-mats, similar to wood-toe treatment but with an enhanced undercut bank.	• Increase overhead cover by creating an undercut bank • Develop feeding lanes in flow separation zones • Increase habitat complexity • Provide organic material and nutrients for benthic macroinvertebrates
J-hook[1]	Upstream directed boulder and/or log structure on the outside of stream bends designed to reduce bank erosion by decreased near-bank slope, velocity, velocity gradient, stream power, and shear stress. The vane portion of the structure occupies 1/3 of the bankfull width, while the hook occupies the center 1/3.	• Increase bank cover from differential raise in water surface in bank region • Create pool for holding and refuge cover during high and low flows • Develop feeding lanes in flow separation zones • Create spawning habitat in the glide portion of the pool
Log-vane	Bank stabilization and fish habitat treatment comprised of upstream directed log structure used to deflect flows away from the bank and increase habitat complexity.	• Increase bank cover from differential raise in water surface in bank region • Create pool below the vane for holding and refuge cover • Develop feeding lanes in flow separation zones • Increase habitat complexity • Provide organic material and nutrients for benthic macroinvertebrates
Point bar development / channel realignment	Treatment used to address stream channels with unnaturally high width/depth ratio or sinuosity that has been adversely modified. Bed material is imported or excavated from pool areas and used to develop point bars, leading to increased velocity and depth along the point bar.	• Increase spawning habitat • Increase depth and holding habitat • Improve hydraulics, sediment transport, and geomorphology
Pool development	Treatment that involves excavation of pools and redistribution of excavated material back into the stream to address habitat degradation associated with sedimentation. Often used in conjunction with point bar development and/or channel realignment. Establishing channel dimensions that maintain sediment continuity is critical for sustaining excavated pools.	• Create pools for holding and refuge cover during high and low flows • Develop feeding lanes in flow separation zones • Develop spawning habitat on the glide portion of the pool
Sod mat	Sod mats are transplanted from local riparian areas to provide top soil and vegetation at bank locations disturbed during construction, typically used in conjunction with wood-toe or at locations where in-stream structures are keyed into the bank.	• Provide “instant” riparian vegetation along newly constructed stream banks • Improve function and condition of riparian vegetation, which improves habitat for terrestrial insects • Improve overhead cover along banks
Willow, transplant	Individual or groups of willow plants transplanted from local riparian areas to improve vegetative cover and stability at bank locations disturbed during construction, typically used in	• Provide “instant” riparian vegetation along newly constructed stream banks • Improve bank stability • Improve function and condition of riparian vegetation, which improves

	conjunction with wood-toe or at locations where in-stream structures are keyed into the bank.	habitat for terrestrial insects • Decrease in-stream temperature • Improve overhead cover along banks
Willow, stakes	Willow cuttings that are harvested from local riparian areas to improve vegetative cover and stability at bank locations disturbed during construction or that have experienced riparian degradation.	• Improve bank stability • Improve function and condition of riparian vegetation, which improves habitat for terrestrial insects • Decrease in-stream temperature • Improve overhead cover along banks
Willow, bare root or containerized	Willow plants that are grown in nurseries and planted along riparian areas to improve vegetative cover and stability at bank locations disturbed during construction or that have experienced riparian degradation.	• Improve bank stability • Improve function and condition of riparian vegetation, which improves habitat for terrestrial insects • Decrease in-stream temperature • Improve overhead cover along banks
Wood-toe	Bank stabilization treatment consisting of anchored root-wads that are covered with fill material and locally harvested sod-mats.	• Stabilize eroding stream banks • Increase overhead cover by creating an undercut bank • Develop feeding lanes in flow separation zones • Increase habitat complexity • Provide organic material and nutrients for benthic macroinvertebrates

[1] Rosgen (2006)

References:

Miller, J.R. and R.C. Kochel. 2012. Use and performance of in-stream structures for river restoration: a case study from North Carolina. Environmental Earth Science, doi:10.1007/s12665-012-1850-5.

Rosgen, D.L. 2006. Cross-vane, w-weir, and j-hook vane structures: description, design and application for stream stabilization and restoration. Wildland Hydrology, Fort Collins, Colorado: 32 pp.

Objective 3.3: Treatment maintenance and costs

Project restoration costs will be evaluated with the following criteria: material and labor costs for various habitat treatments, length of time to install specific aquatic habitat treatments, maintenance costs associated with specific treatments, and how quickly specific habitat treatments provide their intended function. Various aquatic habitat treatments will be compared within functional groups to assess their relative costs and benefits.

ACCOMPLISHMENTS

Data collection on restoration costs from various CPW stream restoration projects is ongoing. We will continue to collect and analyze data related to treatment construction and maintenance to determine how various habitat treatments compare using a cost/benefit analysis. Treatment-

specific costs were compiled using contractor bids for the Upper Arkansas River NRDA project. Actual costs will be evaluated following completion of the project in fall 2014 and compared to other ongoing or completed restoration projects. Methods for evaluating the benefits of different treatment types will be developed to facilitate cost/benefit analyses.

Job A.4. Angler Use in Restored Versus Un-restored River Channels.

Job Objectives: Creel studies will be conducted to determine how angler use has changed in restored compared to un-restored river channels.

Segment Objective 4.1: Historic creel data

Aquatic biologists will be consulted to determine what data (if any) exist at proposed river restoration locations to quantify pre-restoration angler use. Collection of creel data from biologists is ongoing.

ACCOMPLISHMENTS

Aquatic biologists were consulted for any existing creel data that might exist to quantify angler use in proposed river restoration reaches. No historical creel data were identified for use in evaluating changes in angler use for proposed river restoration reaches.

Segment Objective 4.2: Creel studies

ACCOMPLISHMENTS

Since no historic creel data exists, we will conduct creel surveys to quantify angler use specific to the un-restored river channel segment. Once stream restoration is completed, we will continue conducting creel studies to quantify angler use specific to the restored river channel segment for comparison. Creel studies were planned in pre- and post- treatment stream reaches during spring/summer 2012.

Upper Arkansas River NRDA Project: Creel studies were planned and conducted successfully on the Upper Arkansas River to establish baseline data for comparing angler use and fisheries response pre- and post- restoration on the Upper Arkansas River basin from May 1, 2012 through October 30, 2012. Summary data on angler use will be useful in determining the economic benefits of habitat enhancement projects pre- and post- construction once the Upper Arkansas Habitat Improvement project is completed.

South Platte Basin Projects: A three-month creel was completed from April 1, 2013 through June 30, 2013 on the South Platte River between Spinney Mountain Reservoir and Elevenmile Canyon Reservoir (Dream Stream). The entire reach was broken into three discreet segments including: Segment 1, a 2.0 mile treated reach below Spinney Mountain Reservoir Dam to the end of the treated section; Segment 2, a 1.5 mile proposed project reach from the end of the treated section to County Rd 59; and Segment 3, a 2.0 mile control reach between County Rd 59 and the confluence of the South Platte River with Elevenmile Canyon Reservoir. These data will

be useful in comparing angler use before and after completion of the Charlie Meyers SWA habitat enhancement project. Data has not yet been analyzed from this creel study. Once the project is completed, a second creel study will be repeated using the same study design to evaluate any changes in angler use.

An additional future creel study on the South Platte would include the reference reach (Tomahawk SWA), completed project reach Badger Basin SWA (Middle Fork of South Platte below Badger Basin Headquarters), proposed project reach Badger Basin SWA (South Fork of South Platte above Badger Basin Headquarters) and completed project reach Buckley Ranch (South Platte River). Ongoing creel studies for additional proposed sections within South Park will be contingent on future budget amounts.

Job A.5. Identification, Evaluation and Development of Fish Barriers for Protecting Colorado Fishes.

Job Objectives: Develop field and theoretical techniques for evaluating the barrier potential of in-stream obstacles. This study will involve multiple years of data collection statewide. Specific projects will result from consultations with aquatic biologists requesting assistance with measuring the barrier potential of in-stream structures. Examples include evaluation of fish barrier function to protect cutthroat trout populations from whirling disease or non-native salmonids, evaluation of native and sport-fish passage through whitewater park (WWP) structures and evaluation of diversion, low-head dam and culvert structures for passage of various Colorado fishes. Data collected from field sites will be useful in developing species-specific fish passage criteria, evaluating existing in-stream obstacles, refinement of monitoring techniques for fish passage at potential barrier sites and improvement of theoretical techniques for evaluating fish passage.

Objective 5.1: Continue working with aquatic biologists to evaluate the barrier potential of in-stream obstacles to Colorado fishes. Develop publishable fish passage criteria for correcting potential barriers (i.e., culverts, diversions, WWP structures). Conversely, continue evaluations to assist with new barrier designs or modification of existing barriers to protect native Colorado sport fish from downstream threats.

ACCOMPLISHMENTS

Fish Barrier Studies:

Studies related to barriers designed to protect native cutthroat trout in Colorado were not conducted during this period. Management directions for cutthroat trout in Colorado will be finalized once research on cutthroat trout lineage and genetics are completed. CPW has been working to identify potential locations for re-introduction of native cutthroat trout species. Research on the effectiveness of natural and engineered barriers will begin once these re-introduction projects take place.

Fish Passage Studies, Colorado Front Range Floods of 2013:

The Colorado Front Range was impacted by severe flooding in September 2013 in response to a 1000-year precipitation event. The intensity and duration of precipitation saturated watersheds and caused unprecedented runoff events in many rivers, which led to substantial loss of life and property. 25 to 500-year floods were observed in the Cache la Poudre, Big Thompson, St. Vrain, Lefthand, and Boulder watersheds. Over 160 diversion structures were damaged during the flood. These structures typically consist of grouted boulders or concrete walls that span the width of the river channel. These structures are designed to create upstream backwater with enough differential head to maintain flows into irrigation ditches, and consequently have many negative effects on in-channel processes and ecological functions. In particular, diversion structures in Colorado often create barriers to the upstream migration of trout and can entrain fish in irrigation ditches.

Following the 2013 floods, CPW worked with the Natural Resource Conservation Service (NRCS), Colorado Water Conservation Board (CWCB), US Fish and Wildlife Service (USFWS), and Federal Emergency Management Agency (FEMA) to address issues with fish passage at diversion structures. These efforts culminated in a Fish Passage Workshop and Webinar that is currently hosted on the FEMA website. This workshop provided information on different approaches to achieving fish passage at diversion structures, including design criteria for rock ramps and alternative approaches to diversion structure design, such as the cross-vane diversion structure (Figure 5.1). In addition to design criteria, we developed maps that prioritized streams for fish passage in the South Platte basin (Figure 5.2). Unfortunately, efforts to establish fish passage at diversion structures were largely unsuccessful due to issues with permitting and funding. But CPW is continuing to work with state and federal agencies to address permitting issues prior to another flood.

To better understand the effects of diversion structures on trout population in the Colorado Front Range, we inserted PIT tags into brown and rainbow trout during post-flood electrofishing surveys in the Cache la Poudre River. The Cache la Poudre River has at least 24 diversion structures that are potential barriers to movement over 56 miles from the lower canyon to the confluence with the South Platte. We hypothesize that these diversion structures are preventing or impairing upstream migration to spawning habitat and are entraining trout in ditches during downstream migration to over-winter habitat. At least 50 trout were PIT tagged at all electrofishing stations surveyed during the fall of 2013. All fish sampled during 2014 will be scanned for PIT tags to evaluate the extent of upstream and downstream movement in the system. In addition, PIT tag readers and antennae were installed upstream and downstream of the CPW diversion structure for the Watson Fish Hatchery to monitor movement over this structure. Due to the large power requirements of this antenna system, a solar charging system was installed to maintain power for the system. Unfortunately, both antennae were damaged during spring runoff in 2014 and will need to be repaired once flows drop to a safe level.

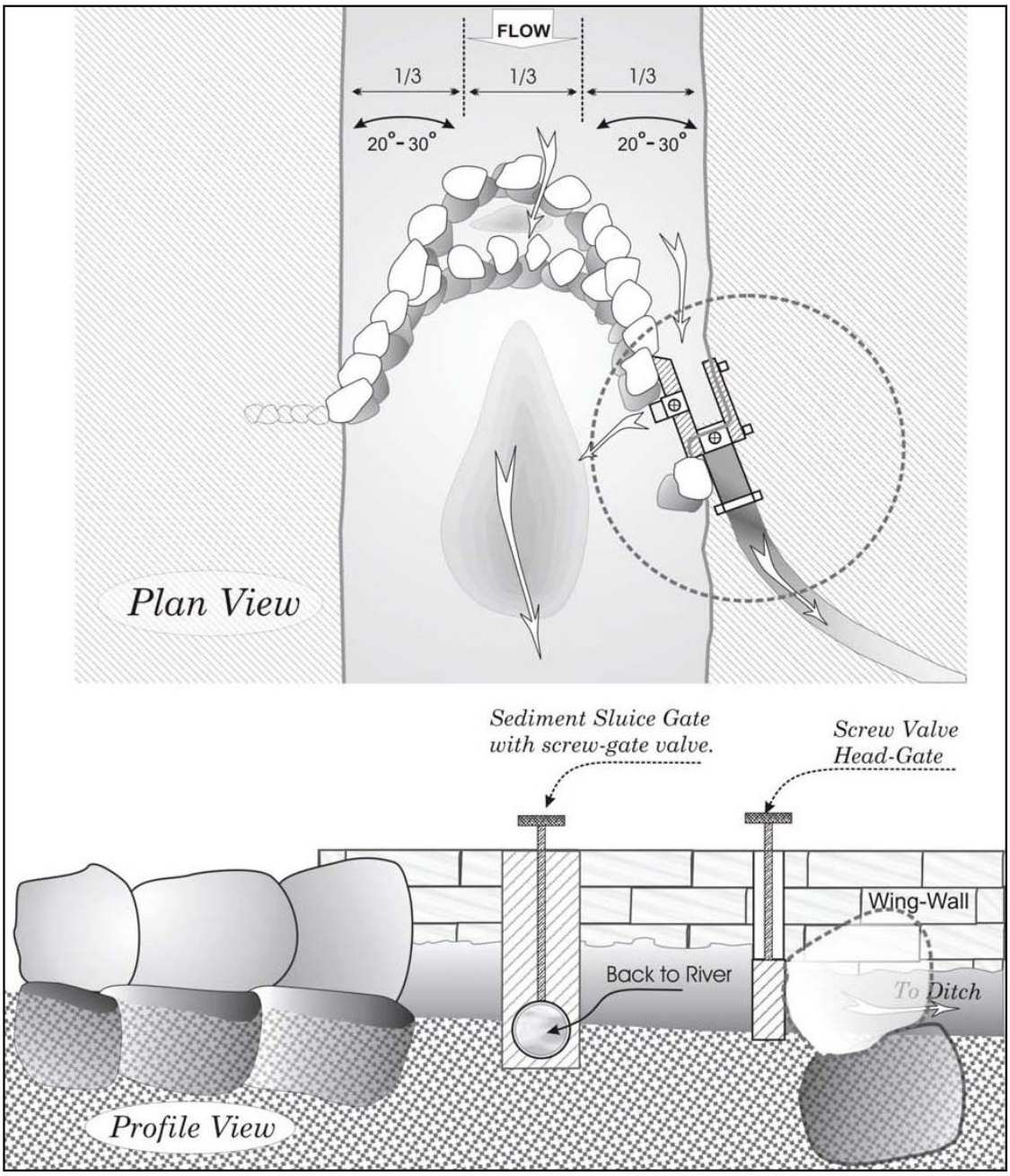


Figure 5.1. Conceptual example of a cross-vane diversion structure with irrigation head gate and sediment sluice (Rosgen, 2006).

References:

Rosgen, D.L. 2006. Cross-vane, w-weir, and j-hook vane structures: description, design and application for stream stabilization and restoration. Wildland Hydrology, Fort Collins, Colorado: 32 pp.

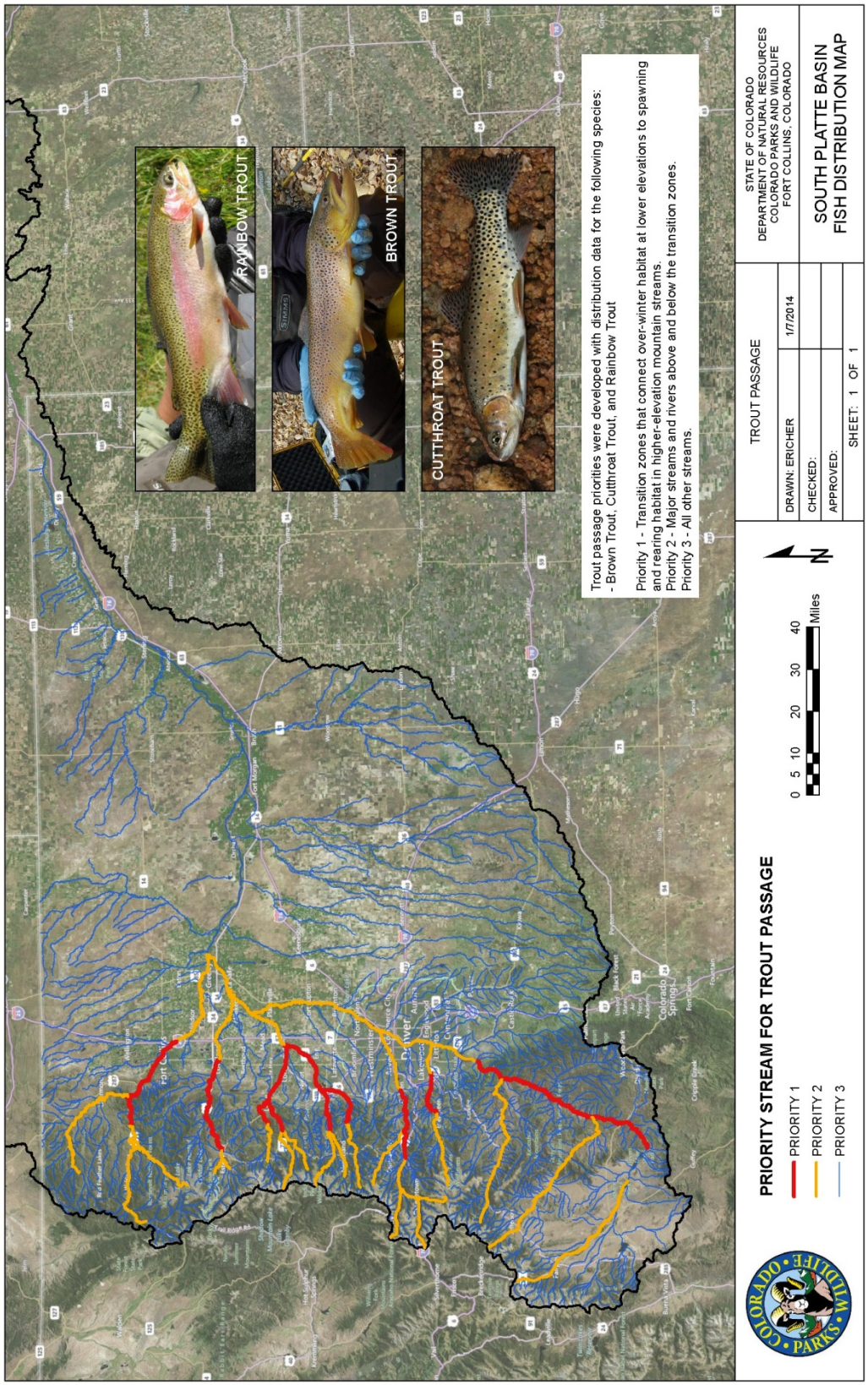


Figure 5.2. Priority streams for trout passage in the South Platte Basin, Colorado.

Fish Passage Studies, White Water Parks:

A creel study was conducted in the vicinity of the "G-wave" WWP in Glenwood Springs, Colorado to evaluate changes in angler use around an existing WWP and to assess angler perceptions related to WWPs on the Colorado River. Another portion of this creel study collected baseline data of angler use and perceptions of WWPs within the vicinity of a proposed WWP location near Basalt, Colorado on the Roaring Fork River (Gold Medal trout fishing water). The goal of this creel study was to provide a baseline for comparing how angler use might change once a WWP is built at the proposed location in Basalt. The creel study was conducted during the spring and summer of 2012. Results will be analyzed and reported for the next reporting cycle.

We conducted a baseline topographic habitat survey for the proposed WWP on the Uncompahgre River in Montrose, Colorado. The survey data will be used to compare habitat suitability before and after construction of the WWP, which is scheduled for winter 2014-2015. Following construction of the WWP, we will conduct another topographic survey to evaluate changes in habitat quality. Instream hydraulics will be modeled with River2D to evaluate changes in habitat suitability and effectiveness of fish bypass channels. Baseline survey data are included in Appendix A.

We assisted a CPW biologist and the Bureau of Land Management (BLM) with a design review for the proposed Gore Canyon Whitewater Park at Pumphouse on the Colorado River. This project will set a precedent in Colorado for WWP implementation in a natural river channel. To evaluate the effects of the WWP on habitat quality, we plan to conduct topographic surveys before and after project implementation, which is scheduled for winter 2014-2015. Topographic survey data will be used to evaluate habitat suitability. The Montrose WWP and Gore Canyon WWP studies will provide valuable information on the effects of WWPs on trout habitat and passage.

Fish passage and barrier studies utilizing graduate students Ashley Ficke, Brian Fox, and Nell Kolden are completed or near completion. Publications are currently being prepared for submission to peer-reviewed journals. A publication studying WWPs and their influence on pool habitat quality for salmonids is currently being prepared for submission. This study will include monitoring of trout abundance within WWP pools across three separate years in the spring and fall (six separate occasions). The study combines fish sampling results from WWP and natural pools with hydraulic measurements of velocities and turbulence collected at the same pool sites using an Acoustic Doppler Current Profiler (ADCP).

Two additional projects related to WWPs and their potential to impair upstream fish passage are currently being conducted by graduate students at Colorado State University through the Civil Engineering Department and Dr. Brian Bledsoe. These studies include follow up research on aspects of WWP function. We continue to assist graduate students with these projects and anticipate publishing these results once their research is completed. The Lyons WWP was destroyed during flooding in September 2013. However, the town of Lyons intends to rebuild the park. If reconstruction of the Lyons WWP moves forward, we hope to replicate the previous study conducted at this location.

STUDY PLAN B: TECHNICAL ASSISTANCE

Job B.1. Stream Restoration Assistance to CPW Personnel and other State and Federal Agencies.

Job Objectives: Primary objectives for technical assistance are to provide expertise, consultation, evaluation and training related to stream habitat restoration project identification, selection, design and permitting to CPW and other state and federal personnel as requested. CPW and other State and Federal personnel are frequently in need of technical assistance related to stream habitat restoration projects. Technical assistance related to stream habitat restoration project identification, selection, design, evaluation, and permitting will be provided to CPW and external agencies. Technical assistance includes review of stream restoration project designs for aquatic biologists and district wildlife managers (DWMs), site visits to proposed stream restoration locations, consultations with various agencies on stream restoration opportunities associated with highway and bridge improvement projects, project management of aquatic habitat treatment construction during highway bridge replacements or Fishing is Fun (FIF) projects, consultations and technical support related to stream mitigation work for 404 permit violations, technical and physical assistance related to fish barrier design and construction, and teaching at various technical training sessions for CPW and other state and federal personnel.

Job activities included: presentations to CPW (internal) and non-CPW (external) personnel, technical assistance to CPW area biologists and DWMs, technical assistance to non-CPW external government agencies and private consultants, technical assistance related the Upper Arkansas NRDA project, technical assistance to the Upper Colorado Wild & Scenic Stakeholder Group, technical assistance related to design, construction, and monitoring of fish barriers, providing training to CPW personnel and acquiring additional technical expertise and professional job skills.

ACCOMPLISHMENTS

Presentations, CPW (Internal)

Presentations to CPW personnel were delivered with the goal of increasing interactions and communication with Regional CPW staff (i.e., local Area meetings) and providing current research finding to the CPW Aquatic Section (Aquatic Biologists and Senior Aquatic Staff).

Kondratieff, M.C. 2014. Whitewater Parks: Fish, Anglers, and the River. Area 8 Meeting concerning RICDs and proposed WWP on Colorado River, Glenwood Springs, CO. May 16, 2014.

Richer, E.E. 2014. Colorado Front Range flood of 2013: the good, the bad, and the ugly. Aquatic Biologist and Researcher Workshop, Loveland, Colorado. February 5, 2014.

Presentations, non-CPW (External)

Presentations to non-CPW personnel were delivered with the goal of communicating recent research findings to interested parties and educating students and professionals on river restoration techniques.

Kondratieff, M. C. 2013. Charlie Meyer SWA habitat enhancement project update. Land and Water Trust Fund meeting, Park County Board of County Commissioners, Bailey, CO. Updated Park County LWTFB on progress from research and construction during year 2013. Board approved funding and continued support of fish habitat enhancement research and construction on the South Platte River below Spinney Mountain Reservoir. November 7, 2013.

Kondratieff, M. C. 2014. The Flood and Fish Passage: Introduction. Front Range Flood Recovery Fish Passage Workshop & Webinar, Berthoud, CO. January 8, 2014.

Kondratieff, M. C. 2014. The Flood: Making Water Diversions Fish Passable. 63rd Great Plains Fishery Works Association Meeting /Annual Aquatic Biologist Meeting, Fort Collins, CO. February 5, 2014.

Kondratieff, M. C. 2014. Restoring Colorado Rivers and Introduction to Fisheries Science and Management. Wildlife Management Short Course 2014, Colorado State University, Colorado State University, Fort Collins, CO. April 1, 2014.

Kondratieff, M. C. 2014. What Makes A Healthy Trout Stream Work? 2014 Trout Unlimited Annual Rendezvous, Redstone, CO. April 5, 2014.

Kondratieff, M.C. 2014. Charlie Meyers SWA Habitat Enhancement Project. High Plains Drifters, Red and Jerry's, Sheridan, CO. May 21, 2014.

Kondratieff, M.C. 2014. What Makes A Healthy Trout Stream? Southwest Stream Restoration Conference, San Antonio, TX. May 30, 2014.

Kondratieff, M.C. 2014. Whitewater Parks: Fish, Anglers, and the River. Glenwood Springs Town Council Meeting, Glenwood Springs, CO. June 5, 2014.

Kondratieff, M. C., Fox, B., Kinzli, K., and N. Kolden. 2014. Whitewater Park Hydraulics: Implications for Fish. 9th Annual 2014 International Conference on Engineering & Ecohydrology for Fish Passage, University of Wisconsin, Madison, WI. June 10, 2014.

Richer, E.E. 2014. Stream restoration in Colorado: common issues and approaches to restoration. Guest lecture for RP 101, Aquatic Biology, Front Range Community College, Fort Collins, Colorado. April 28, 2014.

Technical Assistance, CPW Staff (Senior Biologists, Area Biologists, Engineers, property technicians, DWMs, and AWMs)

We provided technical assistance to CPW internal staff as requested. Technical assistance included work related to evaluating fish passage at white water parks, culverts and other potential barriers, writing CPW position papers on a variety of fish habitat-related topics (e.g., white water parks), reviewing habitat restoration construction plans related to river restoration and trout habitat enhancement as part of the ACOE 404 permitting process, assisting with physical habitat surveys and equipment, assisting various property technicians on how to manage CPW properties with rivers in mind (e.g., appropriate locations for water gaps for cattle grazing), designing and reviewing fish barrier construction designs to protect native cutthroat trout populations, providing aquatic biologists with cost estimates for specific habitat treatments to enhance sport fish populations in streams, providing technical expertise related to fish passage, providing technical expertise related to proposal review and selection of stream habitat restoration firms, writing grants to generate funding for future habitat improvement projects, providing field consultation services to CPW staff related to potential stream habitat improvement projects and providing technical expertise related to river impacts from large-scale water development projects in Colorado (i.e., Windy Gap and Moffat Firming Project). We devoted a significant amount of time to flood-recovery assistance, including site visits and surveys for CPW properties damaged during the flood (see Watson Lake SWA and Big Thompson Ponds SWA surveys in Appendix A).

Technical Assistance, non-CPW external government agencies and private consultants

We provided technical assistance to non-CPW external government agencies and consultants as requested. Technical assistance included developing monitoring plans for evaluating stream habitat projects in South Park, CO, presenting fisheries concerns associated with WWP development, assisting with fish barrier designs and developing conceptual ideas for trout habitat improvement. Technical assistance to non-CPW external government agencies included the Army Corps of Engineers (ACOE), Colorado Department of Transportation (CDOT), United State Fish and Wildlife Service (USFWS), Natural Resource Conservation Service (NRCS), Federal Emergency Management Agency (FEMA), BLM, and USFS. Assistance was specifically related to potential impacts of WWP to fisheries, flood-recovery, fish passage at diversion structures, and stream restoration guidelines.

Technical Assistance, Upper Arkansas NRDA Project

We provided technical assistance to various agencies and organizations involved in the Upper Arkansas NRDA project as requested. Technical assistance included: participation in Upper Arkansas Project trustees coordination meetings, LCOSI (Lake County Open Space Initiative) meetings and I-team meetings, technical and logistical planning with Brian Bledsoe (CSU Engineering Professor), Tracy Kittell (CPW Design Engineer), and Greg Policky (CPW Aquatic Biologist). Review of publications, reports, and other relevant literature related to the Upper Arkansas River NRD project and presenting information regarding river restoration plans and research monitoring to interested publics and CPW staff as requested.

Technical Assistance, Upper Colorado Wild & Scenic Stakeholder Group

The Upper Colorado Wild & Scenic Stakeholder Group was formed as a collaborative effort to protect and enhance the outstandingly remarkable values (ORVs) of the upper Colorado River in ways that coordinate with federal agency management. The group represents a variety of interests groups, including American Whitewater, Aurora Water, Blue Valley Ranch, Colorado Parks and Wildlife, Colorado River Outfitters Association, Colorado River Water Conservation District, Colorado Springs Utilities, Colorado Water Conservation Board, Colorado Whitewater Association, Denver Water, Eagle County, Grand County, Northern Colorado Water Conservancy District, Northwest Colorado Council of Government, Summit County, The Wilderness Society, and Trout Unlimited. As a member of the Channel Maintenance Work Group, we assisted with developing recommendations for a suite of channel maintenance flows, including flushing flows, channel maintenance flows, and riparian maintenance flows.

Technical Assistance: Design, Construction, and Monitoring of Fish Barriers

1) Assist area aquatic biologists to monitor fish barrier performance at existing sites.

George and Cornelius Creeks:

Assisted Boyd Wright (CPW Native Fish Biologist) with site selection, design, and monitoring of potential fish barriers on George Creek (tributary of North Fork of Cache la Poudre River) to assess potential for reclaiming George and Cornelius Creeks as native cutthroat trout fisheries.

Continuing Education: Training to gain additional technical expertise and professional job skills

USFWS. Completed online Electrofishing Safety Training course. Fort Collins, CO. November 2013.

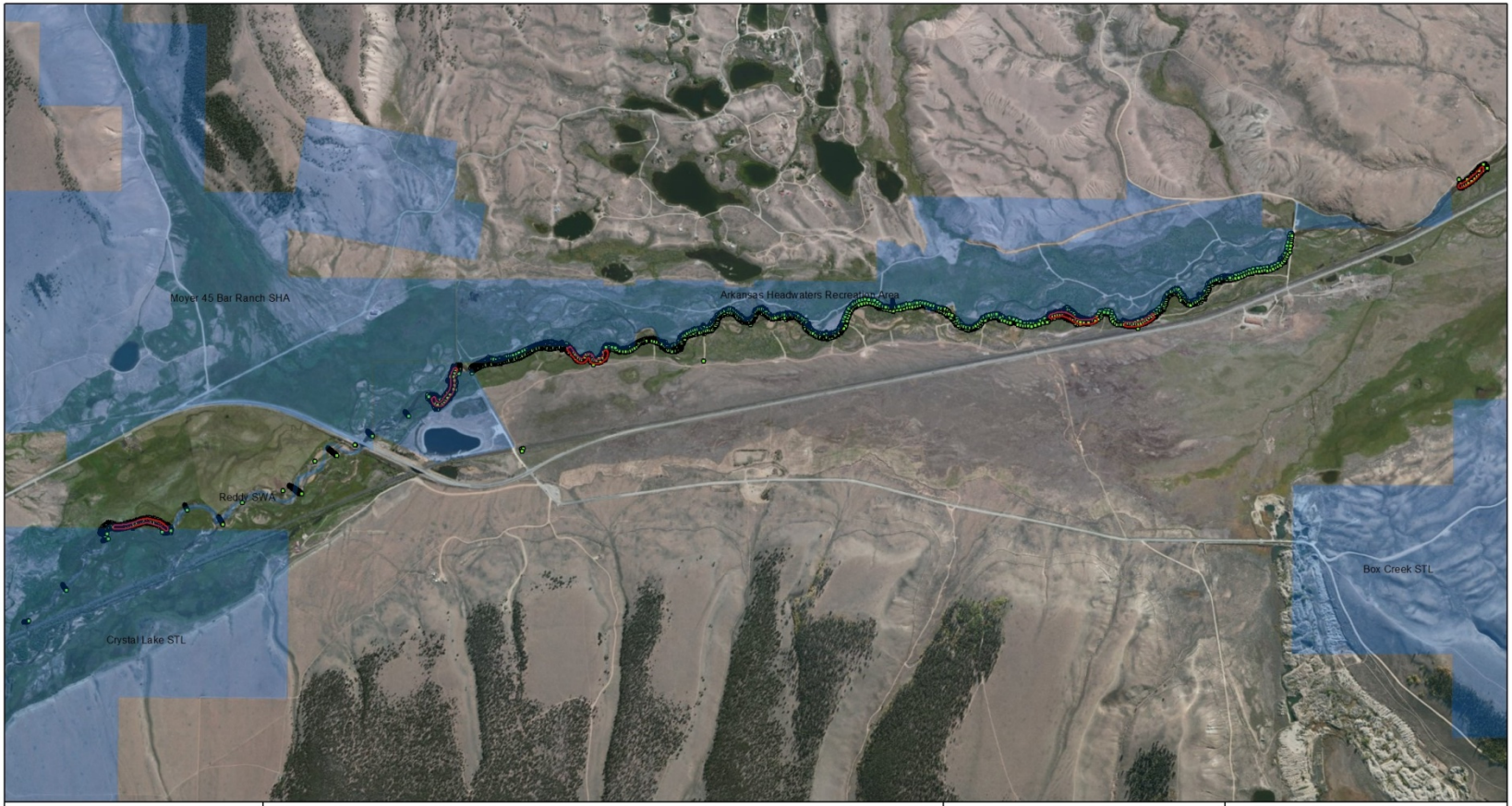
CWCB, FEMA, Trout Unlimited, NRCS, and CPW. Attended Fish Passage Workshop and Webinar. Berthoud, CO. January 8, 2014.

City of Longmont. Attended training on Concepts for Post-Flood River Corridor Restoration Relating to the Front Range Floods of September 2013. Longmont, CO. Assisted with site selection for field tour. February 25-26, 2014.

Colorado Stream Restoration Network. Attended Post-flood Runoff Preparation Workshop. Longmont, CO. May 14, 2014.

Appendix A

Topographic Surveys for Stream Rehabilitation and Habitat Enhancement Projects



Legend

- CPW Properties
- Fish Monitoring Sites
- Survey Data (2013)

0 425 850 1,700 2,550 3,400 Feet

SURVEY DATA	
DRAWN: ERICHER	8/1/2014
CHECKED:	
APPROVED:	
SHEET: 1 OF 1	

STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

UPPER ARKANSAS RIVER
NRDA HABITAT RESTORATION
PLAN VIEW

Legend

- Survey Data (2013)
- Survey Data (2010)

0 75 150 300 450 600 Feet

N

BASELINE SURVEY DATA	
DRAWN: ERICHER	8/1/2014
CHECKED:	
APPROVED:	
SHEET: 1 OF 1	

STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

SOUTH PLATTE RIVER
CHARLIE MEYERS SWA
PLAN VIEW

Legend

- Survey Data (2013)
- Survey Data (2012)

0 70 140 280 420 560 Feet

BASELINE SURVEY DATA	
DRAWN: ERICHER	8/1/2014
CHECKED:	
APPROVED:	
SHEET: 1 OF 1	

STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

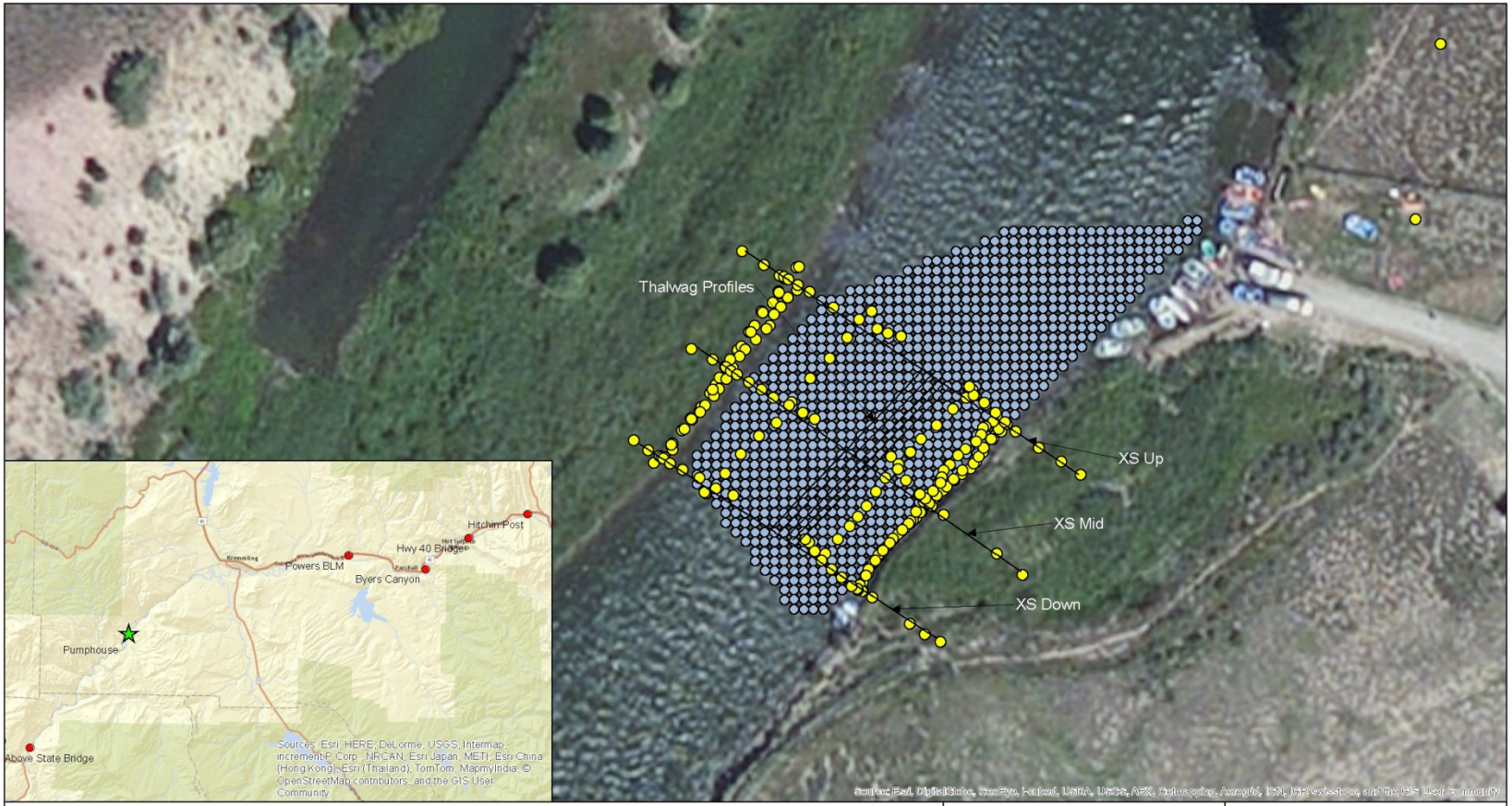
CRYSTAL RIVER
WEXNER PROPERTY
PLAN VIEW

Legend

- Survey Data (2014)
- HydroSurveyor Data (2014)

0 25 50 100 150 200 Feet

BASELINE SURVEY DATA		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: ERICHER	8/1/2014	
CHECKED:		UNCOMPAHGRE RIVER MONTROSE WHITEWATER PARK PLAN VIEW
APPROVED:		
SHEET: 1 OF 1		



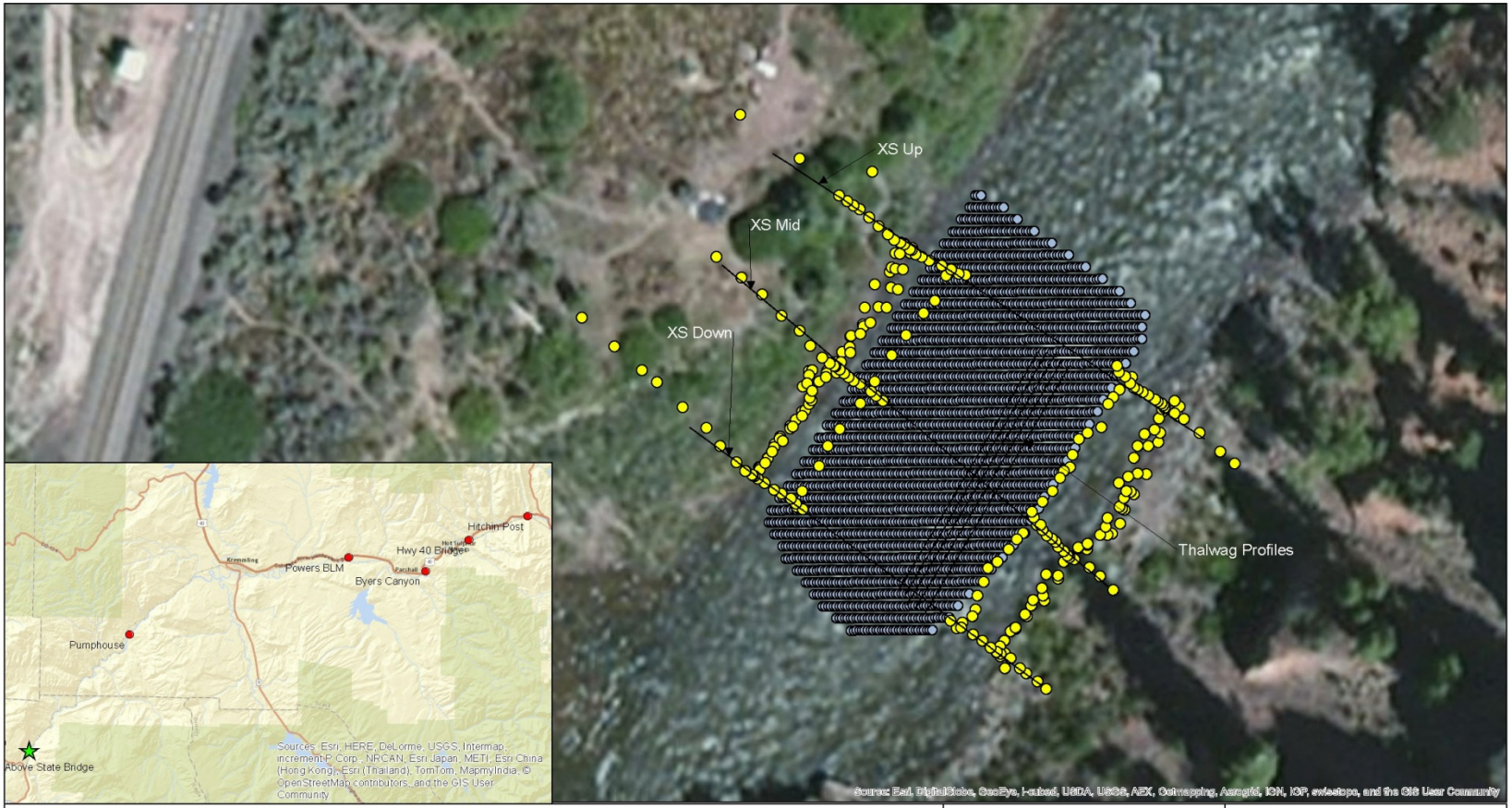
Legend

- Survey Points
- Bathymetry Points

0 10 20 40 60 80 Feet

N

SURVEY POINTS		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: TBARNES	7/11/2014	
CHECKED:		COLORADO RIVER STONEFLY PROJECT PUMPHOUSE
APPROVED:		
SHEET: 1 OF 1		



Legend

- Survey Points
- Bathymetry Points

0 5 10 20 30 40 Feet

N

SURVEY POINTS		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: TBARNES	7/11/2014	
CHECKED:		COLORADO RIVER STONEFLY PROJECT ABOVE STATE BRIDGE
APPROVED:		
SHEET: 1 OF 1		

Legend

5147.2 - 5163.0	5131.4 - 5135.6	5123.0 - 5124.8	5117.2 - 5120.2
5140.9 - 5147.2	5127.7 - 5131.4	5121.6 - 5123.0	Survey Data
5135.6 - 5140.9	5124.8 - 5127.7	5120.2 - 5121.6	

SURVEY DATA	
DRAWN: ERICHER	8/1/2014
CHECKED:	
APPROVED:	
SHEET: 1 OF 1	

STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

WATSON LAKE SWA
BATHYMETRY SURVEY
PLAN VIEW

Interpolated Bathymetry (ft)

4841.9 - 4843.2	4844.0 - 4844.3	4844.9 - 4845.2
4843.2 - 4843.6	4844.3 - 4844.6	4845.2 - 4845.4
4843.6 - 4844.0	4844.6 - 4844.9	4845.4 - 4845.6

N

SURVEY POINTS

DRAWN: ERICHER	8/1/2014
CHECKED:	
APPROVED:	

SHEET: 1 OF 1

STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

BIG THOMPSON PONDS
POST-FLOOD SURVEY
PLAN VIEW

Appendix B

Conceptual Design Drawings for Stream Rehabilitation and Habitat Enhancement Projects

COLORADO PARKS AND WILDLIFE

Gunnison River and Riparian Rehabilitation Project: Gunnison State Wildlife Area

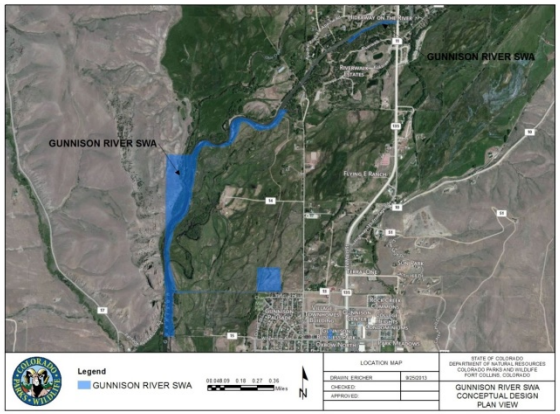
Conceptual Design Drawings

Prepared for:

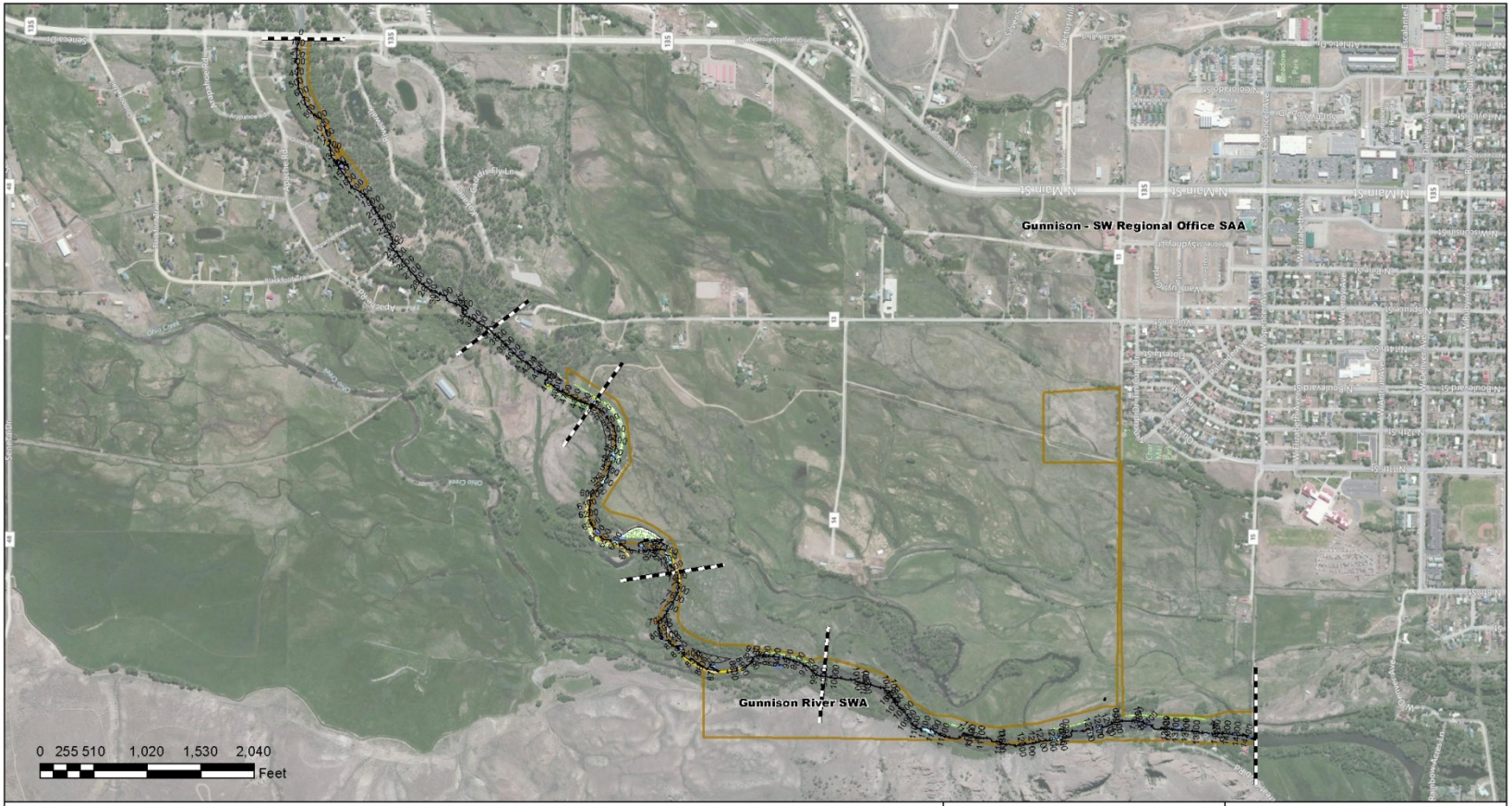
Colorado Water Conservation Board
Water Supply Reserve Account Grant Application
Gunnison Basin Roundtable

Prepared by:

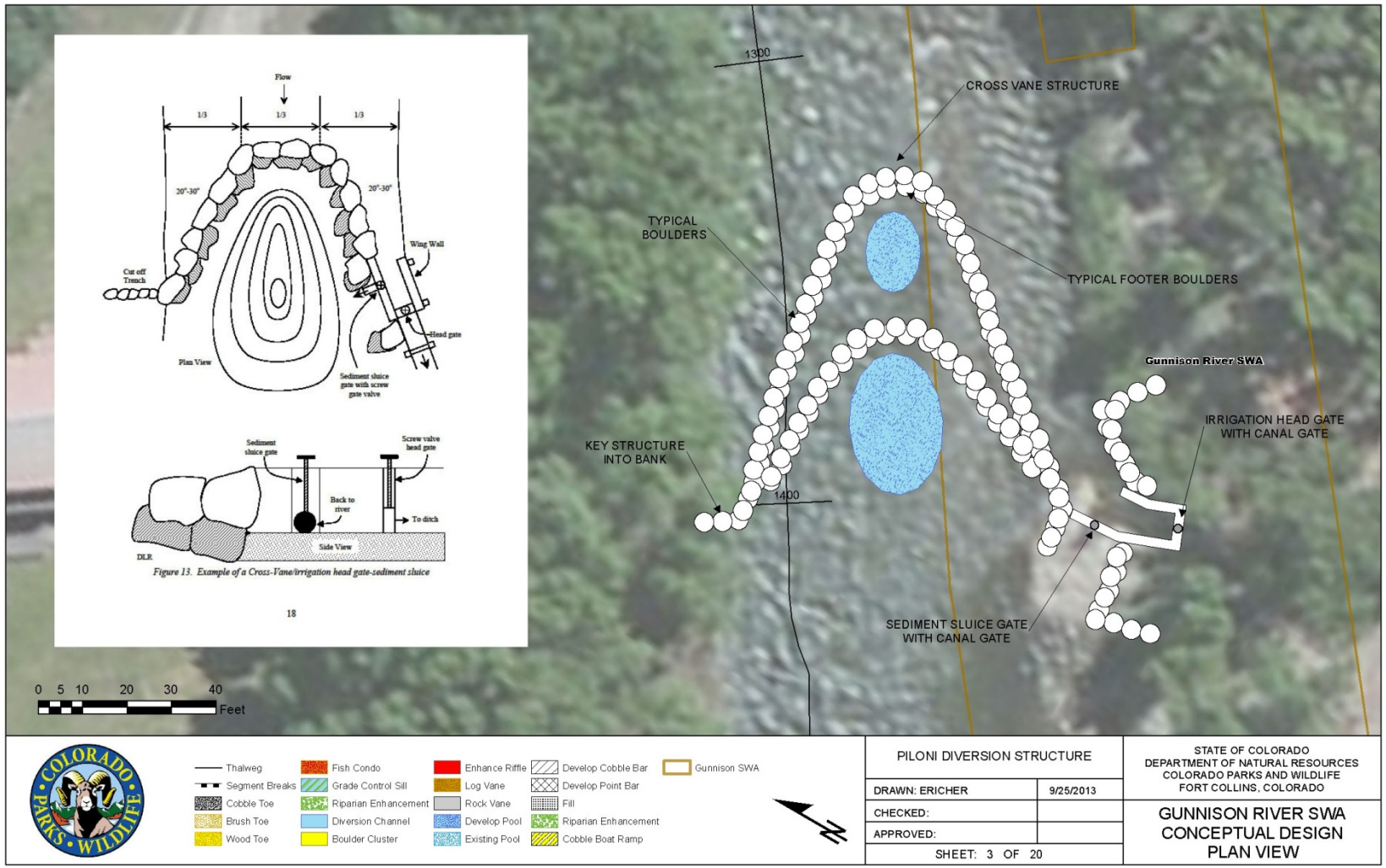
Colorado Parks and Wildlife
September 25, 2013

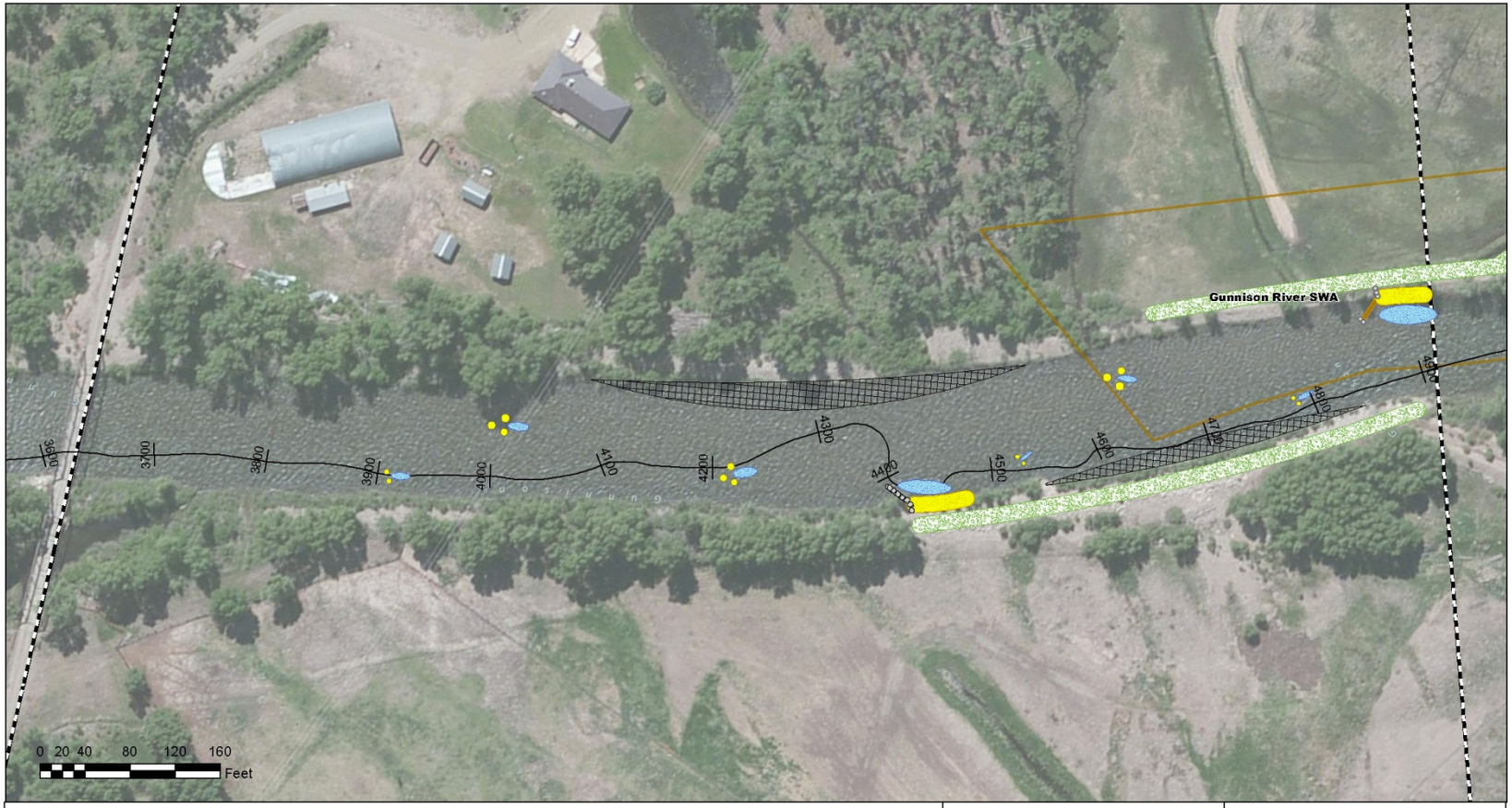


STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO


Gunnison - SW Regional Office SAA
Gunnison River SWA
0 255 510 1,020 1,530 2,040
Feet
Thalweg
Segment Breaks
Cobble Toe
Brush Toe
Wood Toe
Fish Condo
Grade Control Sill
Riparian Enhancement
Diversion Channel
Boulder Cluster
Enhance Riffle
Log Vane
Rock Vane
Develop Pool
Existing Pool
Develop Cobble Bar
Develop Point Bar
Fill
Riparian Enhancement
Cobble Boat Ramp
Gunnison SWA
PROJECT OVERVIEW
DRAWN: ERICHER
9/25/2013
CHECKED:
APPROVED:
SHEET: 1 OF 20
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
GUNNISON RIVER SWA
CONCEPTUAL DESIGN
PLAN VIEW

SEGMENT 1		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: ERICHER	9/25/2013	
CHECKED:		GUNNISON RIVER SWA CONCEPTUAL DESIGN PLAN VIEW
APPROVED:		
SHEET: 2 OF 20		


Flow
1/3
1/3
1/3
20°-30°
20°-30°
Cut off Trench
Wing Wall
Head gate
Plan View
Sediment sluice gate with screw gate valve
Sediment sluice gate
Screw valve head gate
Back to river
To ditch
Side View
DLR
Figure 13. Example of a Cross-Vane/irrigation head gate-sediment sluice
18
1300
CROSS VANE STRUCTURE
TYPICAL BOULDERS
TYPICAL FOOTER BOULDERS
Gunnison River SWA
IRRIGATION HEAD GATE WITH CANAL GATE
KEY STRUCTURE INTO BANK
1400
SEDIMENT SLUICE GATE WITH CANAL GATE
0 5 10 20 30 40
Feet
Thalweg
Segment Breaks
Cobble Toe
Brush Toe
Wood Toe
Fish Condo
Grade Control Sill
Riparian Enhancement
Diversion Channel
Boulder Cluster
Enhance Riffle
Log Vane
Rock Vane
Develop Pool
Existing Pool
Develop Cobble Bar
Develop Point Bar
Fill
Riparian Enhancement
Cobble Boat Ramp
Gunnison SWA
PILONI DIVERSION STRUCTURE
DRAWN: ERICHER
9/25/2013
CHECKED:
APPROVED:
SHEET: 3 OF 20
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
GUNNISON RIVER SWA
CONCEPTUAL DESIGN
PLAN VIEW

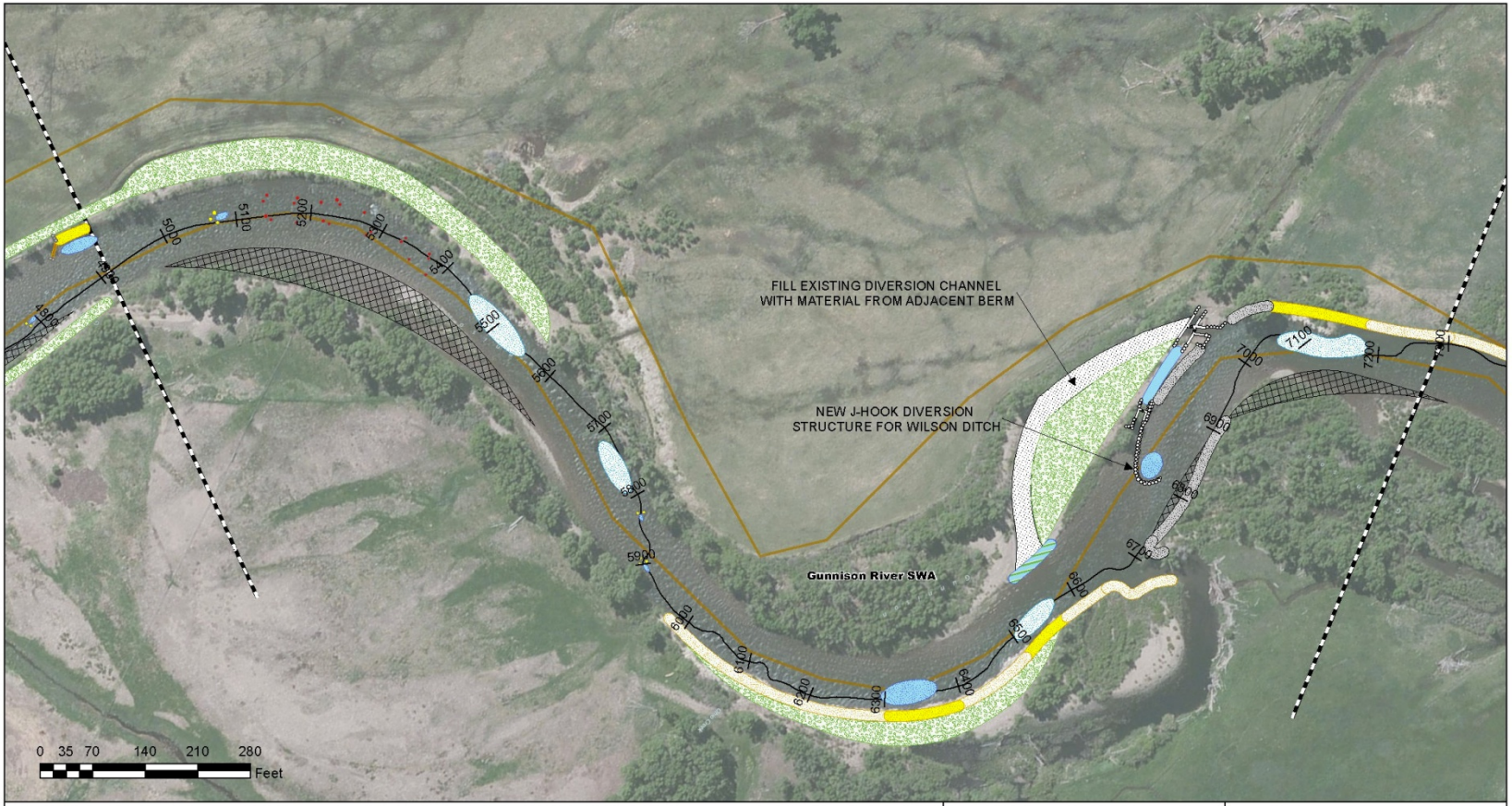


Thalweg
Segment Breaks
Cobble Toe
Brush Toe
Wood Toe
Fish Condo
Grade Control Sill
Riparian Enhancement
Diversion Channel
Boulder Cluster
Enhance Riffle
Log Vane
Rock Vane
Develop Pool
Existing Pool
Develop Cobble Bar
Develop Point Bar
Fill
Riparian Enhancement
Cobble Boat Ramp
Gunnison SWA

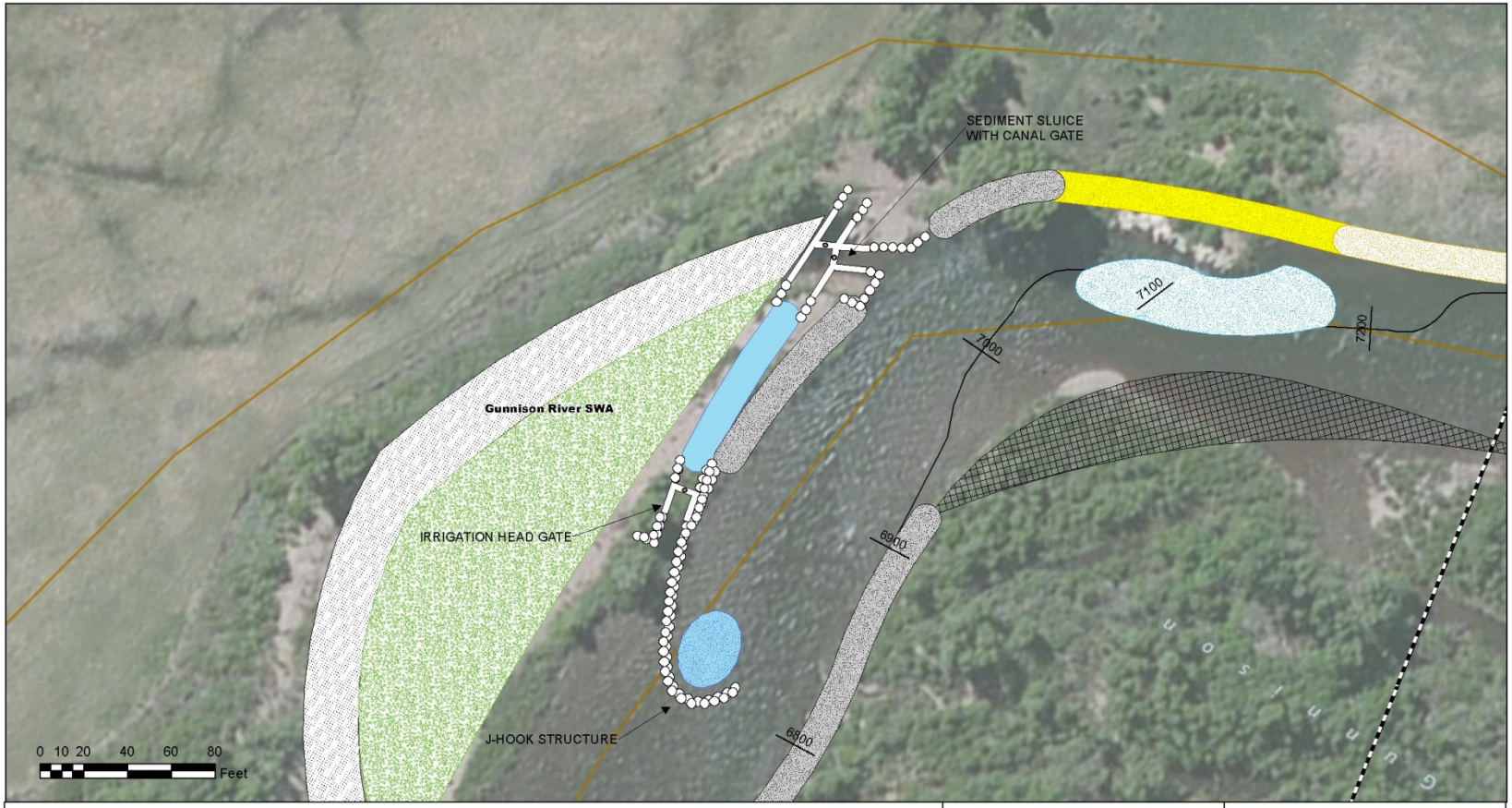
SEGMENT 2	
DRAWN: ERICHER	9/25/2013
CHECKED:	
APPROVED:	
SHEET: 4 OF 20	

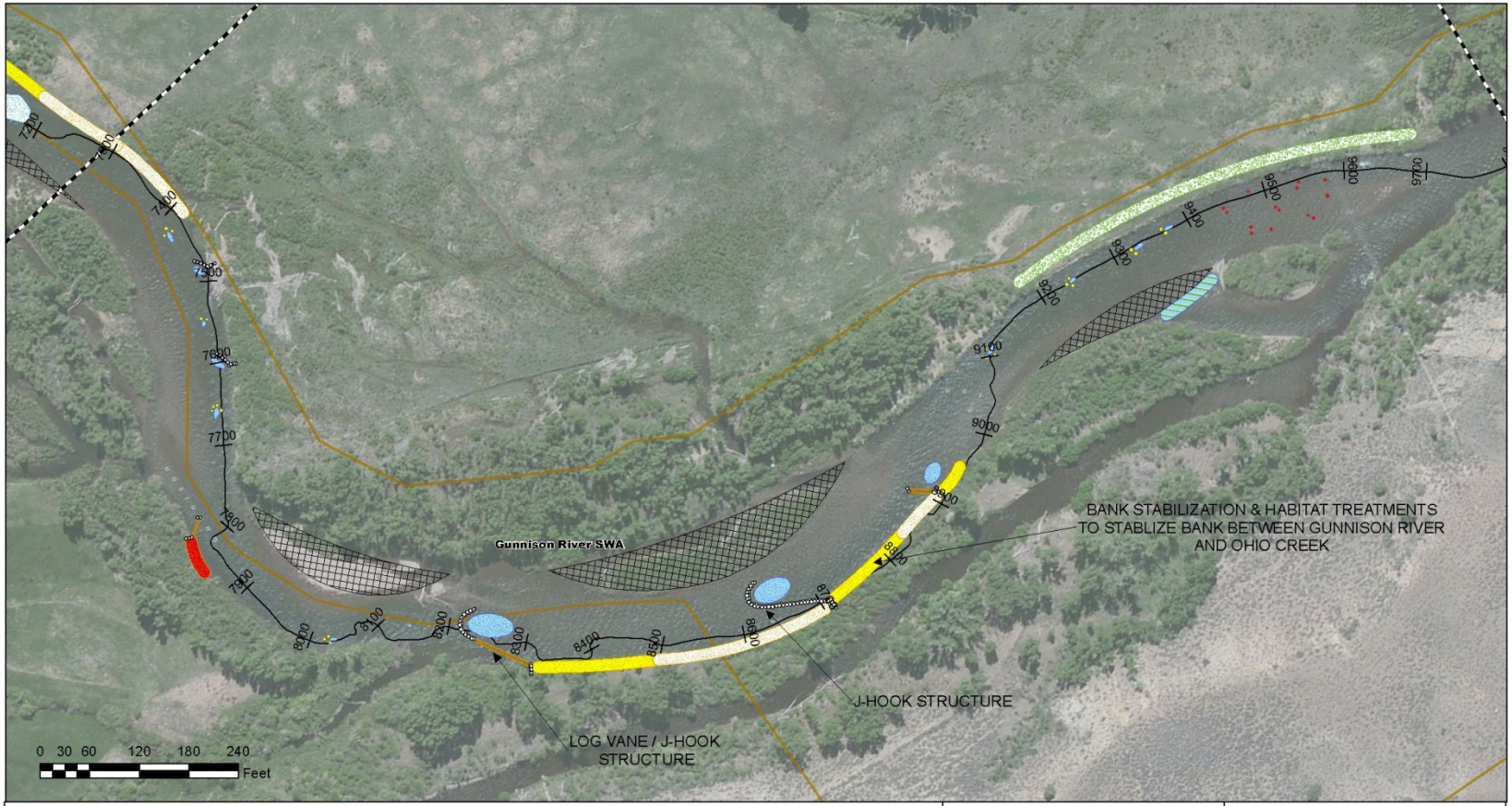
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

GUNNISON RIVER SWA
CONCEPTUAL DESIGN
PLAN VIEW



SEGMENT 3		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: ERICHER	9/25/2013	GUNNISON RIVER SWA CONCEPTUAL DESIGN PLAN VIEW
CHECKED:		
APPROVED:		
SHEET: 5 OF 20		


SEDIMENT SLUICE
WITH CANAL GATE
Gunnison River SWA
IRRIGATION HEAD GATE
J-HOOK STRUCTURE
7100
7200
7000
6900
6800
0 10 20 40 60 80
Feet
Thalweg
Segment Breaks
Cobble Toe
Brush Toe
Wood Toe
Fish Condo
Grade Control Sill
Riparian Enhancement
Diversion Channel
Boulder Cluster
Enhance Riffle
Log Vane
Rock Vane
Develop Pool
Existing Pool
Develop Cobble Bar
Develop Point Bar
Fill
Riparian Enhancement
Cobble Boat Ramp
Gunnison SWA
N
WILSON DITCH INTAKE
DRAWN: ERICHER
9/25/2013
CHECKED:
APPROVED:
SHEET: 6 OF 20
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
GUNNISON RIVER SWA
CONCEPTUAL DESIGN
PLAN VIEW



SEGMENT 4		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
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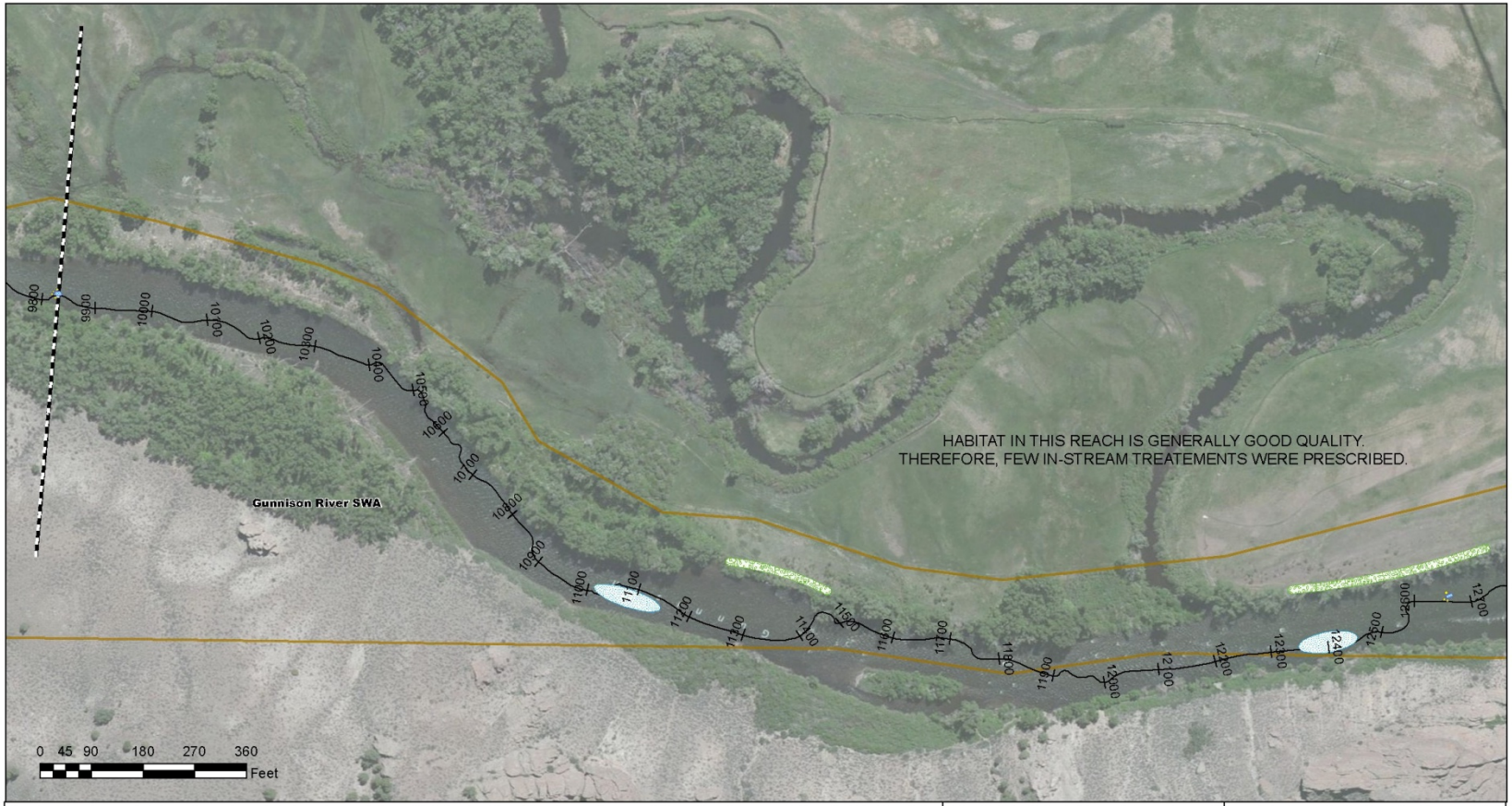
CHECKED:		
APPROVED:		
SHEET: 7 OF 20		



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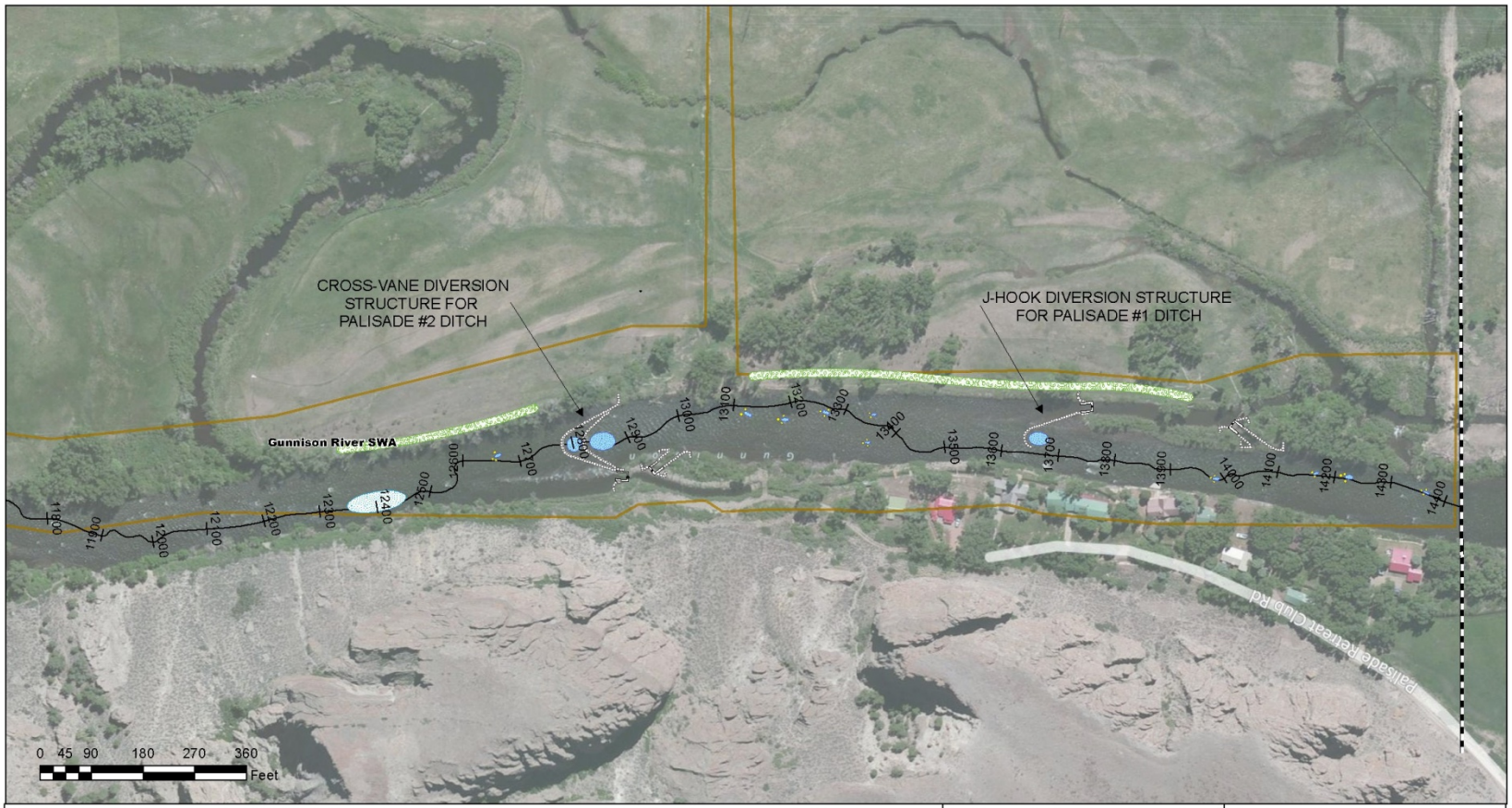
DRAWN: ERICHER	9/25/2013
CHECKED:	
APPROVED:	
SHEET: 8 OF 20	

STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

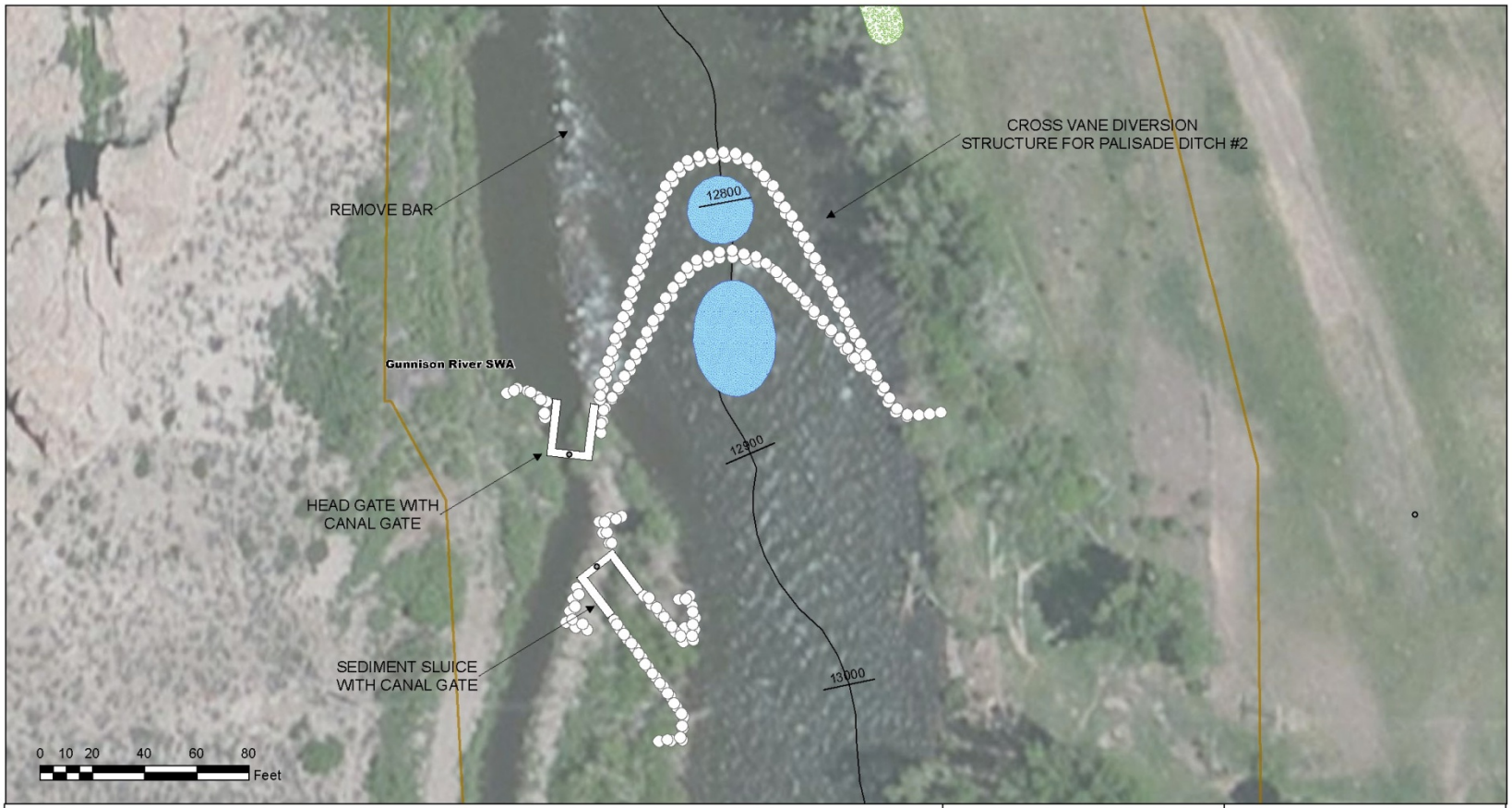
GUNNISON RIVER SWA
CONCEPTUAL DESIGN
PLAN VIEW



SEGMENT 5 - LOWER	
DRAWN: ERICHER	9/25/2013
CHECKED:	
APPROVED:	
SHEET: 9 OF 20	

STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

GUNNISON RIVER SWA
CONCEPTUAL DESIGN
PLAN VIEW


CROSS VANE DIVERSION
STRUCTURE FOR PALISADE DITCH #2
REMOVE BAR
12800
Gunnison River SWA
12900
HEAD GATE WITH
CANAL GATE
SEDIMENT SLUICE
WITH CANAL GATE
13000
0 10 20 40 60 80
Feet
Thalweg
Segment Breaks
Cobble Toe
Brush Toe
Wood Toe
Fish Condo
Grade Control Sill
Riparian Enhancement
Diversion Channel
Boulder Cluster
Enhance Riffle
Log Vane
Rock Vane
Develop Pool
Existing Pool
Develop Cobble Bar
Develop Point Bar
Fill
Riparian Enhancement
Cobble Boat Ramp
Gunnison SWA
N
PALISADE #2 DIVERSION
DRAWN: ERICHER
9/25/2013
CHECKED:
APPROVED:
SHEET: 10 OF 20
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
GUNNISON RIVER SWA
CONCEPTUAL DESIGN
PLAN VIEW

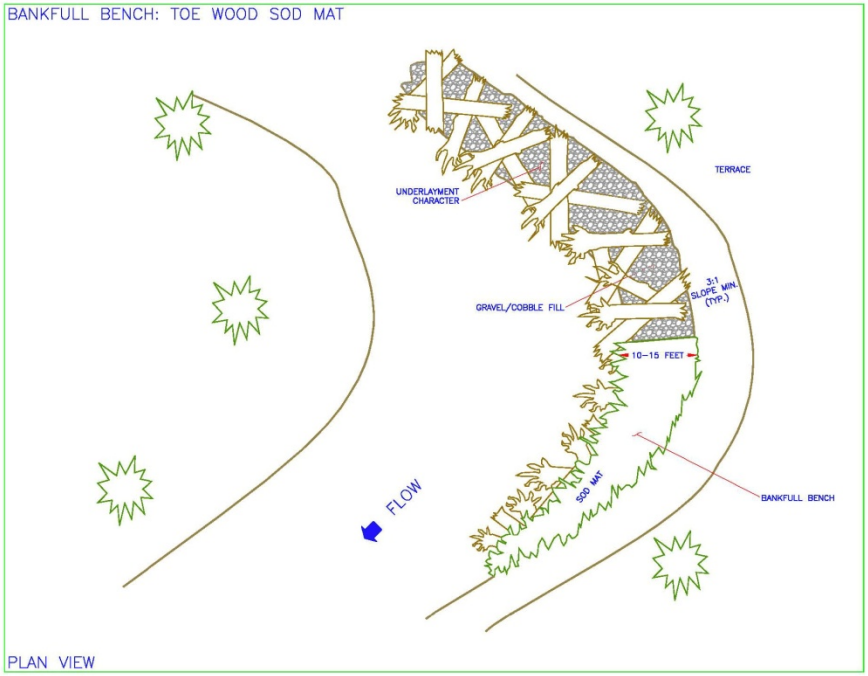

13600
13700
13800
13900
14000
14100
Palisade Retreat Club Rd
Gunnison River SWA
J-HOOK DIVERSION STRUCTURE
FOR PALISADE DITCH #1
HEAD GATE WITH
CANAL GATE
SEDIMENT SLUICE
WITH CANAL GATE
0 15 30 60 90 120
Feet
Thalweg
Segment Breaks
Cobble Toe
Brush Toe
Wood Toe
Fish Condo
Grade Control Sill
Riparian Enhancement
Diversion Channel
Boulder Cluster
Enhance Riffle
Log Vane
Rock Vane
Develop Pool
Existing Pool
Develop Cobble Bar
Develop Point Bar
Fill
Riparian Enhancement
Cobble Boat Ramp
Gunnison SWA
N
PALISADE #1 DIVERSION
DRAWN: ERICHER
9/25/2013
CHECKED:
APPROVED:
SHEET: 11 OF 20
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
GUNNISON RIVER SWA
CONCEPTUAL DESIGN
PLAN VIEW

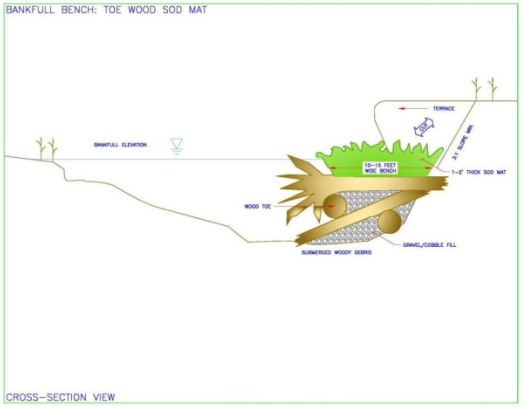
Thalweg
Segment Breaks
Cobble Toe
Brush Toe
Wood Toe
Fish Condo
Grade Control Sill
Riparian Enhancement
Diversion Channel
Boulder Cluster
Enhance Riffle
Log Vane
Rock Vane
Develop Pool
Existing Pool
Develop Cobble Bar
Develop Point Bar
Fill
Riparian Enhancement
Cobble Boat Ramp
Gunnison SWA

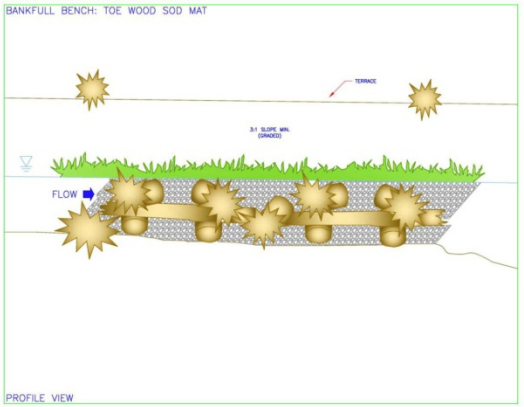
SEGMENT 6	
DRAWN: ERICHER	9/25/2013
CHECKED:	
APPROVED:	
SHEET: 12 OF 20	

STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

GUNNISON RIVER SWA
CONCEPTUAL DESIGN
PLAN VIEW

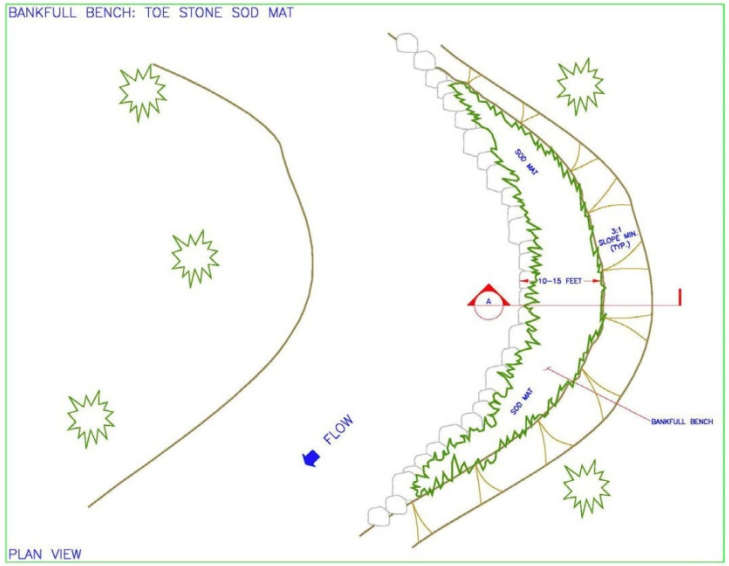


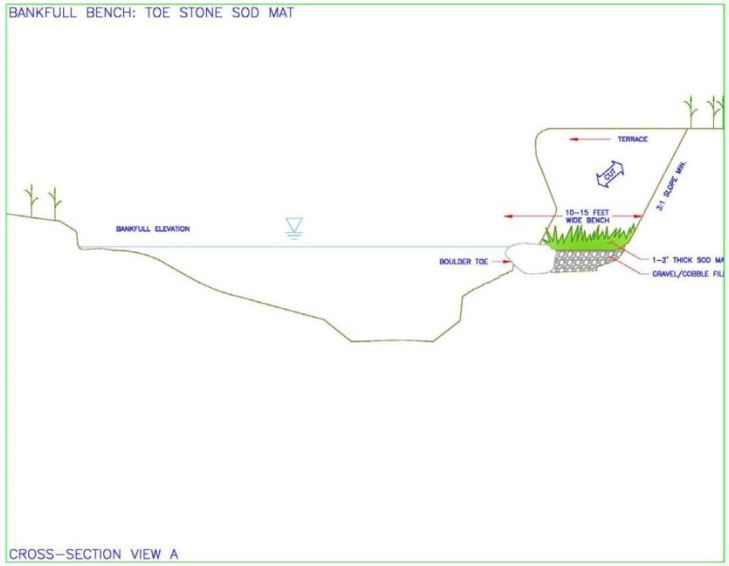




NOT TO SCALE

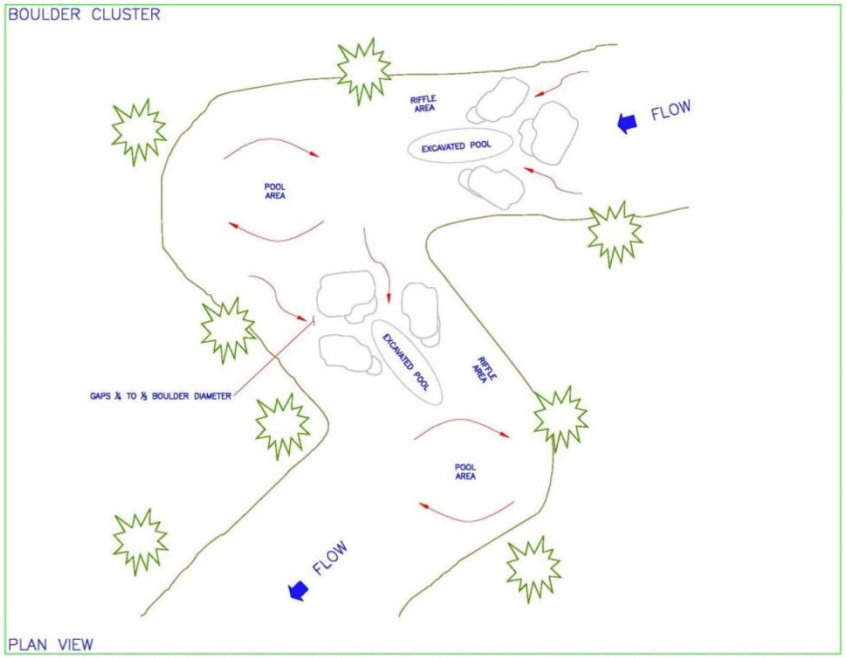
WOOD TOE / SOD MAT DETAIL		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: ERICHER	9/25/2013	
CHECKED:		GUNNISON RIVER SWA CONCEPTUAL DESIGN DETAIL DRAWINGS
APPROVED:		
SHEET: 13 OF 20		

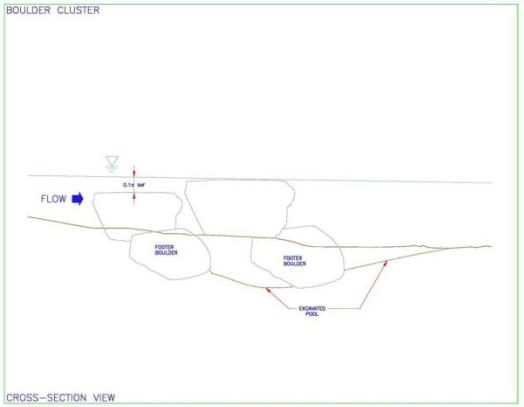


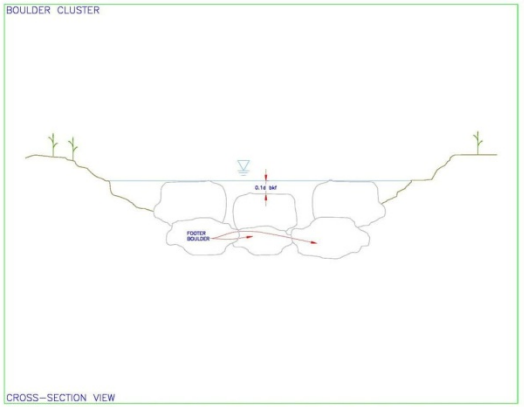


NOT TO SCALE

COBBLE/BOULDER TOE DETAIL		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: ERICHER	9/25/2013	
CHECKED:		GUNNISON RIVER SWA CONCEPTUAL DESIGN DETAIL DRAWINGS
APPROVED:		
SHEET: 14 OF 20		







NOT TO SCALE

BOULDER CLUSTER DETAIL	
DRAWN: ERICHER	9/25/2013
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SHEET: 15 OF 20	

STATE OF COLORADO
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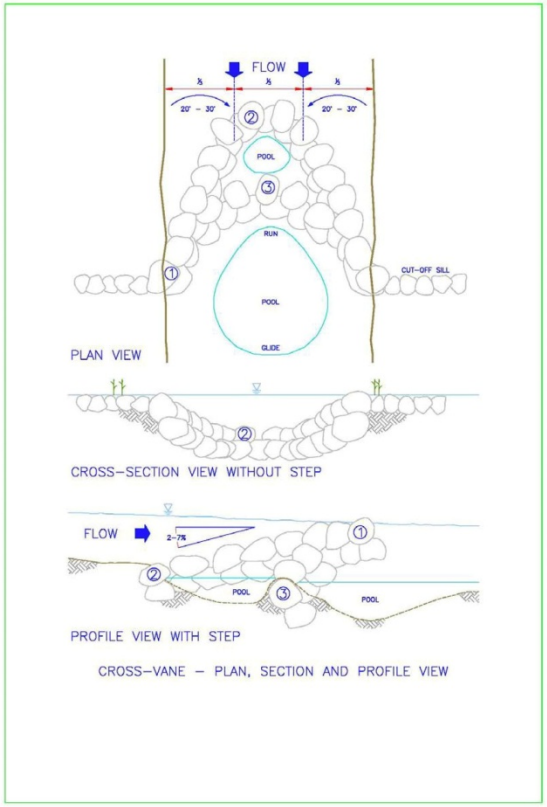
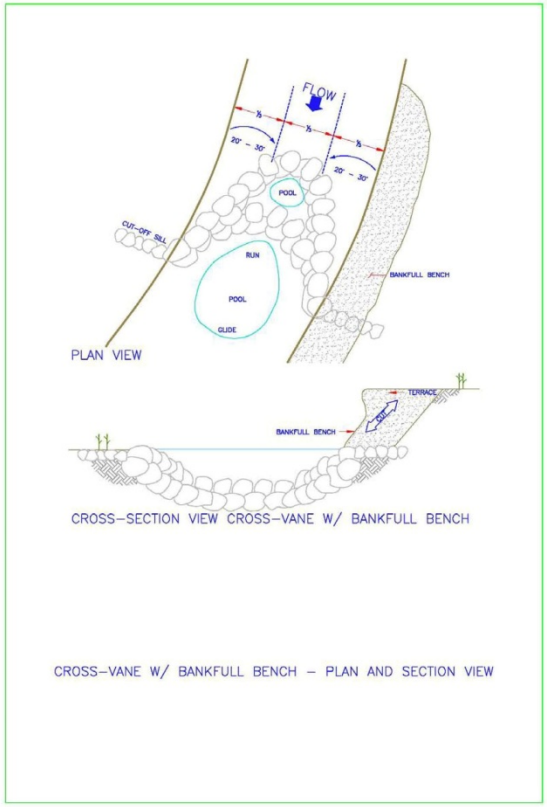
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

GUNNISON RIVER SWA
CONCEPTUAL DESIGN
DETAIL DRAWINGS



CROSS–VANE – PLAN, SECTION AND PROFILE VIEW



CROSS–VANE W/ BANKFULL BENCH – PLAN AND SECTION VIEW

NOT TO SCALE

CROSS-VANE DETAIL		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
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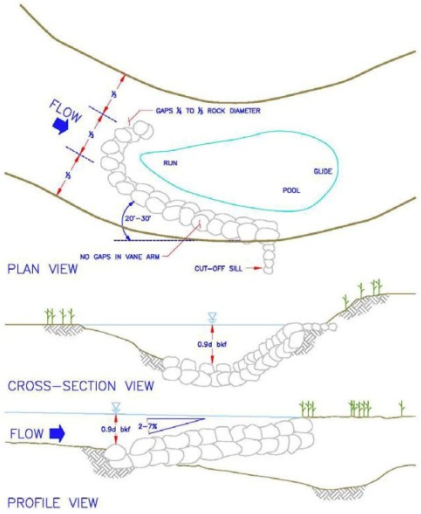
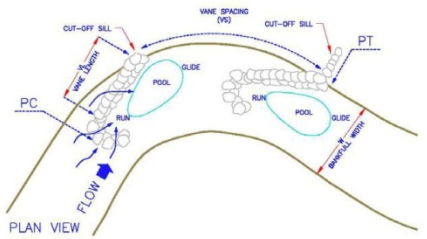
SHEET: 16 OF 20		



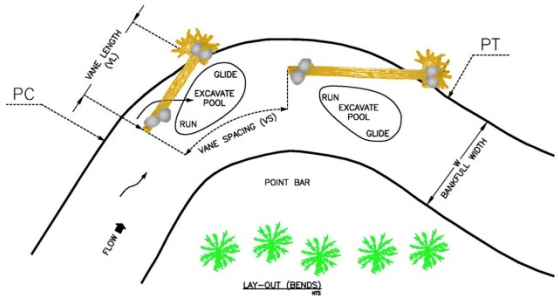
J-HOOK VANE – PLAN, SECTION AND PROFILE VIEW

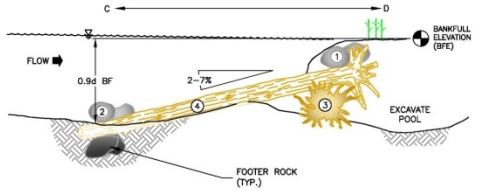


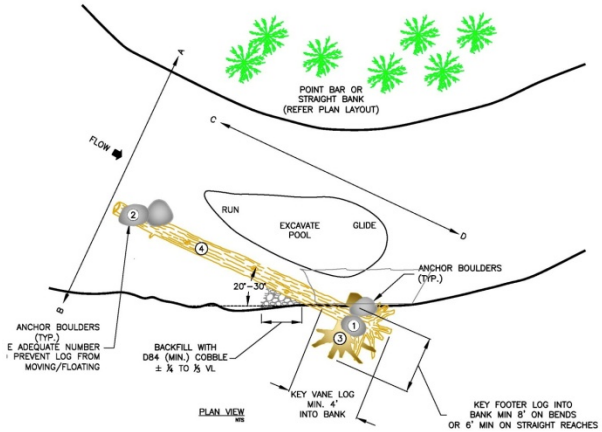
J-HOOK VANE SPACING

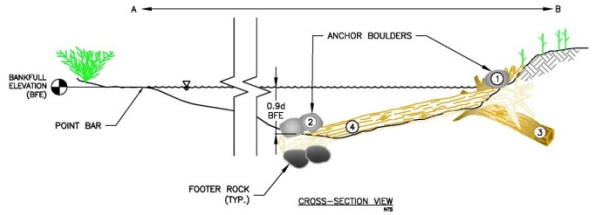
NOT TO SCALE

J-HOOK DETAIL		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: ERICHER	9/25/2013	
CHECKED:		GUNNISON RIVER SWA CONCEPTUAL DESIGN DETAIL DRAWINGS
APPROVED:		
SHEET: 17 OF 20		









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LOG-VANE DETAIL	
DRAWN: ERICHER	9/25/2013
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STATE OF COLORADO
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GUNNISON RIVER SWA
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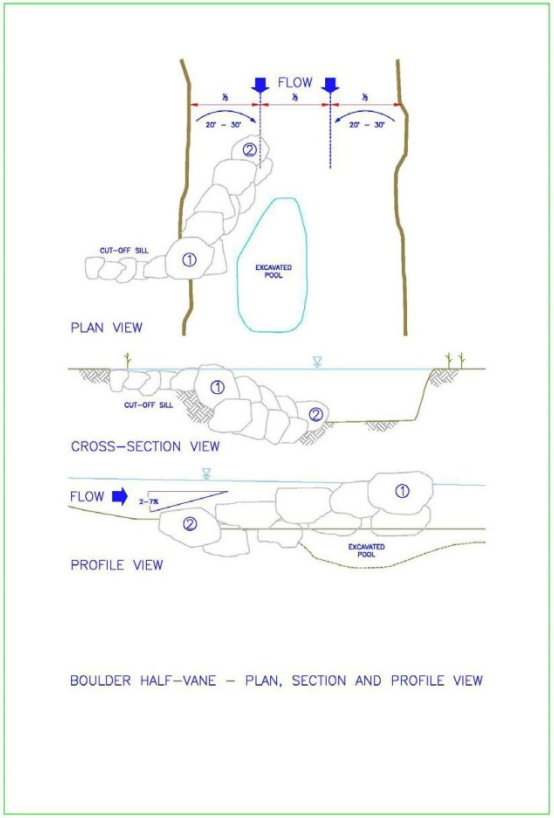

BOULDER HALF–VANE – PLAN, SECTION AND PROFILE VIEW

NOT TO SCALE

ROCK VANE (HALF-VANE) DETAIL		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
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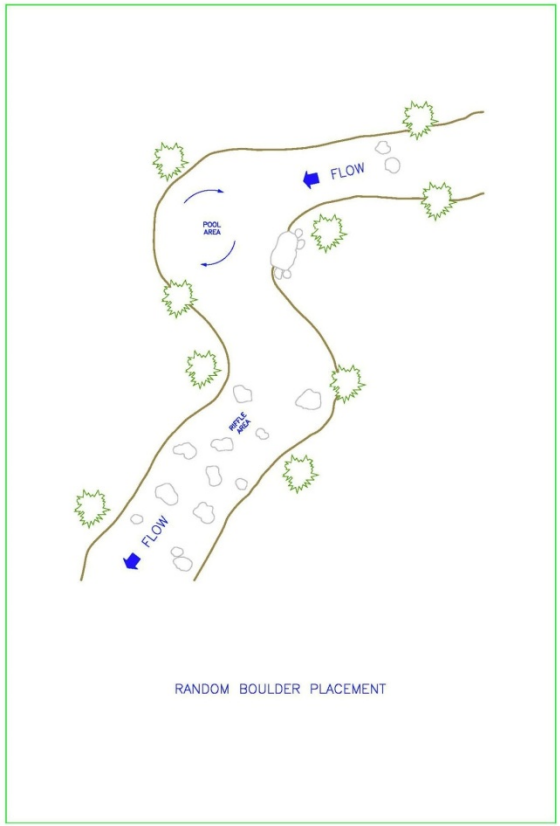
CHECKED:		GUNNISON RIVER SWA CONCEPTUAL DESIGN DETAIL DRAWINGS
APPROVED:		
SHEET: 19 OF 20		



RANDOM BOULDER PLACEMENT

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ENHANCED RIFFLE DETAIL	
DRAWN: ERICHER	9/25/2013
CHECKED:	
APPROVED:	
SHEET: 20 OF 20	

STATE OF COLORADO
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CONCEPTUAL DESIGN
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