Stream Habitat Investigations and Assistance

Federal Aid Project F-161-R21

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Federal Aid in Fish and Wildlife Restoration

Job Progress Report

Colorado Parks & Wildlife

Aquatic Research Section

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The results of the research investigations contained in this report represent work of the authors and may or may not have been implemented as Colorado Parks & Wildlife policy by the Director or the Wildlife Commission.

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JOB PROGRESS REPORT

State: Colorado

Project Number: F-161-R-21

Project Title: Stream Habitat Investigations and Assistance

Period Covered: July 1, 2014 through June 30, 2015

Principal Investigators: Matt 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; to evaluate effectiveness of stream habitat treatments; to evaluate angler use at stream restoration sites; to evaluate the barrier potential of instream structures; and to provide technical assistance for statewide aquatic habitat improvement projects, fish passage structures, 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

Stream habitat improvements will be evaluated to quantify changes in salmonid biomass (quantity), individual fish size (quality), and utilization of habitat treatments in restored versus un-restored river segments. Before-After/Control-Treatment (BACT) studies will be conducted at appropriate site locations. A combination of field and theoretical results will be used to evaluate the fishery response to stream habitat treatments. Research findings will generate useful information for quantifying improvement in trout fisheries following 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, 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, and CPW personnel will be able to work closely with contractors on design and implementation of habitat treatment (design-build).

Table 1.1. List of proposed stream segments for studying fish populations before and after 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	2/11	2/11	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.	1/10	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	0/5	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	2/11	Upper Spinney SWA/Lower end of Badger Basin perpetual easement
Upper Arkansas River	2013-2014	Completed	5	Reduce channel width, develop pools, enhance trout habitat	16/2	16/2	Upper Arkansas NRDA project
Stagecoach Project	2013	Completed	0.25	Reduce channel width, excavate pools, enhance trout habitat	14/1	No control reach	Tailwater section downstream of Stagecoach Reservoir
Chuck Lewis SWA Project	2013	Completed	0.6	Stabilize eroding banks, reduce channel width, excavate pools, enhance trout habitat	3/0 (Phase 3)	2/0 (Phase 2)	Chuck Lewis SWA near Steamboat Springs, CO

Clear Creek, Twin Tunnels Project	2015	Completed	0.5	Reduce channel width, excavate pools, enhance trout habitat, floodplain connectivity	3/0	2/0	Twin Tunnels Project along Interstate 70 corridor
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)
Gunnison River, Gunnison SWA	2015-2016	In progress	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	1/0	1/0	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: Research techniques for evaluating the biological effects of stream restoration treatments, including modeling (e.g., PHABSIM, River2D, MDSWIMS, IBMs), and/or use of reference reach data to determine which methods are best for predicting changes in fish populations following stream habitat enhancement.

ACCOMPLISHMENTS

The techniques outlined in Objective 1.2 integrate the analysis of biological and physical components of trout streams. Therefore, all accomplishments related to the biological and physical effectiveness of stream restoration and habitat enhancement are summarized under Objective 2.2.

Objective 1.3: 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:

A large-scale habitat enhancement project was conducted on a 3.8-mile privately-owned reach of the Rio Grande River flowing through the Wason Ranch near Creede, CO. Landowners believed that poor habitat conditions were responsible for declining trout quality and quantity over time. Project goals included: 1) improve fish quality (increase trout >35cm), 2) improve fish quantity (increase trout density and biomass), 3) reduce bank erosion, 4) reduce width/depth ratio (i.e., increase river depths), 5) establish bedform features at correct spacing, 6) improve adult fish holding and overwinter habitat (i.e., develop deep pools) and 7) re-vegetate banks. After project completion in 2006, CPW has monitored trout and giant stonefly *(Pteronarcys californica*) response to habitat enhancements. Giant stonefly abundance was monitored because they provide an important food source for resident trout, they are a riffle-dependant species, and they are relatively easy to estimate abundance through exuviae counts.

Research goals were: 1) to determine how the habitat project influenced trout population biomass (kg/ha), density (trout $\geq$ 15 cm/ha), and numbers of quality–sized trout (trout $\geq$ 35 cm/ha) and 2) to determine if river enhancement activities increased giant stonefly abundance on a reach-wide scale. Three reaches were identified for monitoring trout and four reaches for monitoring invertebrate response to varying intensities of habitat treatments. All reaches experienced the same historic land uses (over-grazing, water quality issues from mining, and logging impacts). The Upper Wason Reach (3.1 km; heavy-treated) contains the most instream structures with frequent large, deeply-excavated pools. The Lower Wason Reach (2.9 km; light-treated) consists mainly of randomly distributed boulders with fewer instream structures and deeply-excavated pools. The La Garita Reach (3.8 km; natural) and Airport Reach (1.3 km) both contain no instream structures and serve as downstream and upstream controls, respectively. Fish sampling was conducted by electrofishing with two rafts equipped with throw electrodes. Data collected

included fish population estimates based on mark/recapture techniques, fish size by relative abundance, age and growth (scales), and fish species composition data. Removal methods were used to estimate stonefly abundance in study reaches. Exuviae were collected and counted in 12 different 100-foot stations above (controls), within (treatment sections), and below (controls) the Wason Ranch study area. This study has unique value because it was conducted on a large river system, while most published habitat enhancement evaluations are conducted on smaller streams.

Fish Sampling: We collected fish sampling data on two treated reaches of the Rio Grande River on Wason Ranch (3.8 miles) and one untreated reach 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. Six 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.

Data were collected during October 6-9, 2014 and data analysis was completed the following winter. Flow conditions during 2014 fish sampling were higher than on any previous sampling occasion with flows ranging from 600-750 cfs. As a result, capture probabilities for fish were low and thus our estimates of abundance and biomass were not very precise (see Figures 1.2-1.5 95% C.I.s for 2014). As previous studies suggest five to six years are required for fisheries to stabilize post-restoration activities, this sampling effort will be the last one prior to concluding the study and publishing results. See Figures 1.2-1.5 for fish sampling results from 2014.

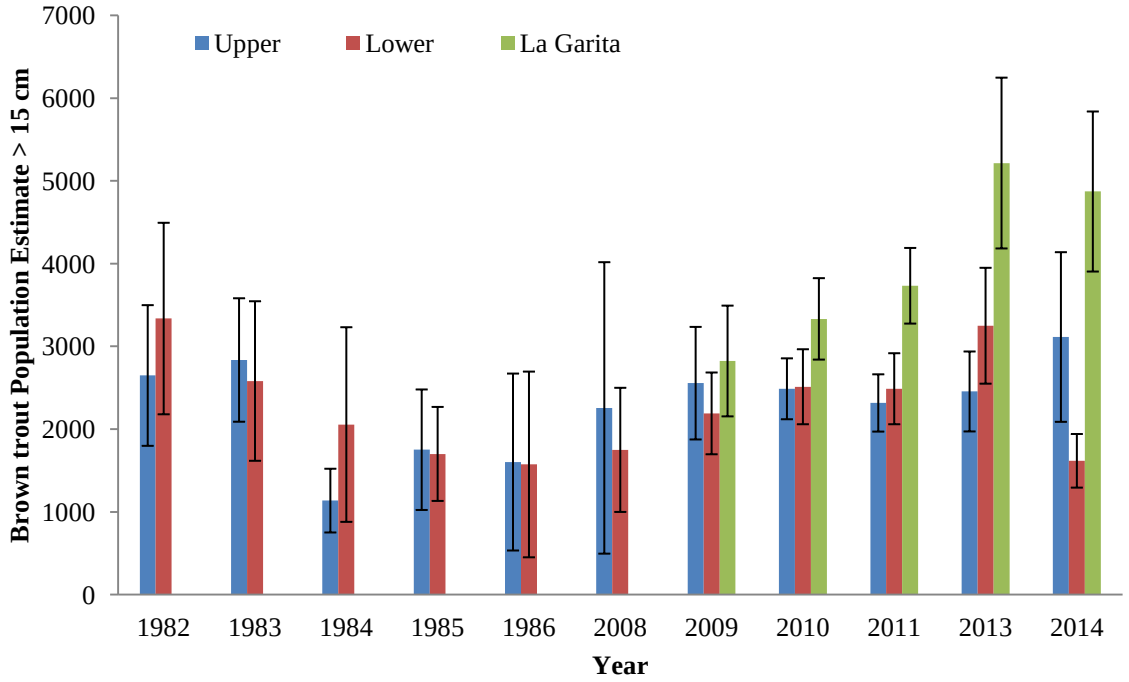


Figure 1.2. Population estimates for adult brown trout (>15 cm) in the Upper Wason, Lower Wason and La Garita reaches. Pre-restoration sampling estimates include years: 1982, 1983, 1984, 1985 and 1986. Post-restoration sampling estimates include years: 2008, 2009, 2010, 2013, and 2014. Black vertical bars represent 95% CI for the estimate.

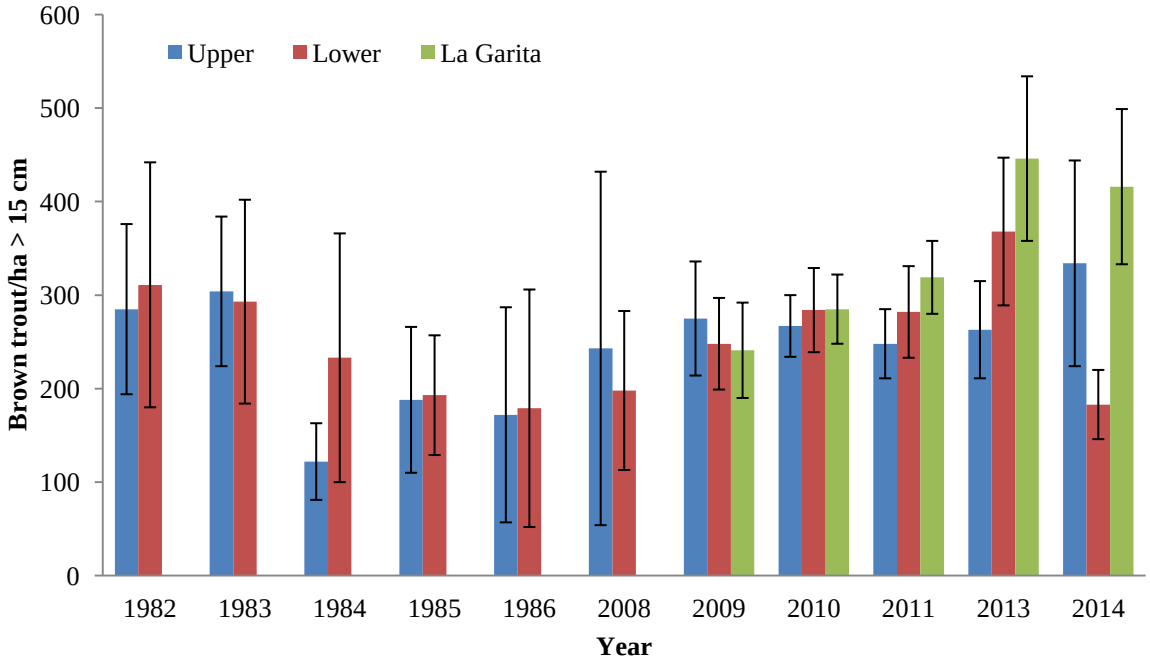


Figure 1.3. Population density estimates for adult brown trout (>15 cm) in the Upper Wason, Lower Wason and La Garita reaches. Pre-restoration sampling estimates include years: 1982, 1983, 1984, 1985 and 1986. Post-restoration sampling estimates include years: 2008, 2009, 2010, 2013, and 2014. Black vertical bars represent 95% CI for the estimate.

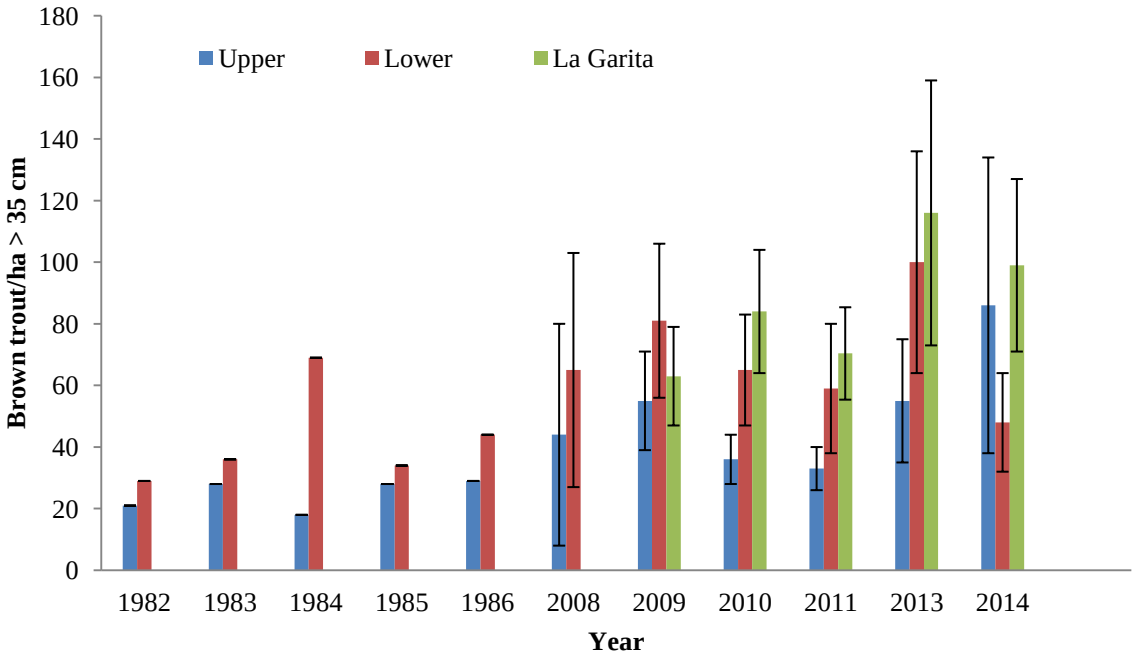


Figure 1.4. Density (trout/ha) of quality-sized brown trout (>35 cm) in the Upper Wason, Lower Wason and La Garita reaches. Pre-restoration sampling estimates include years: 1982, 1983, 1984, 1985 and 1986. Post-restoration sampling estimates include years: 2008, 2009, 2010, 2013 and 2014. Black vertical bars represent 95% CI for the estimate.

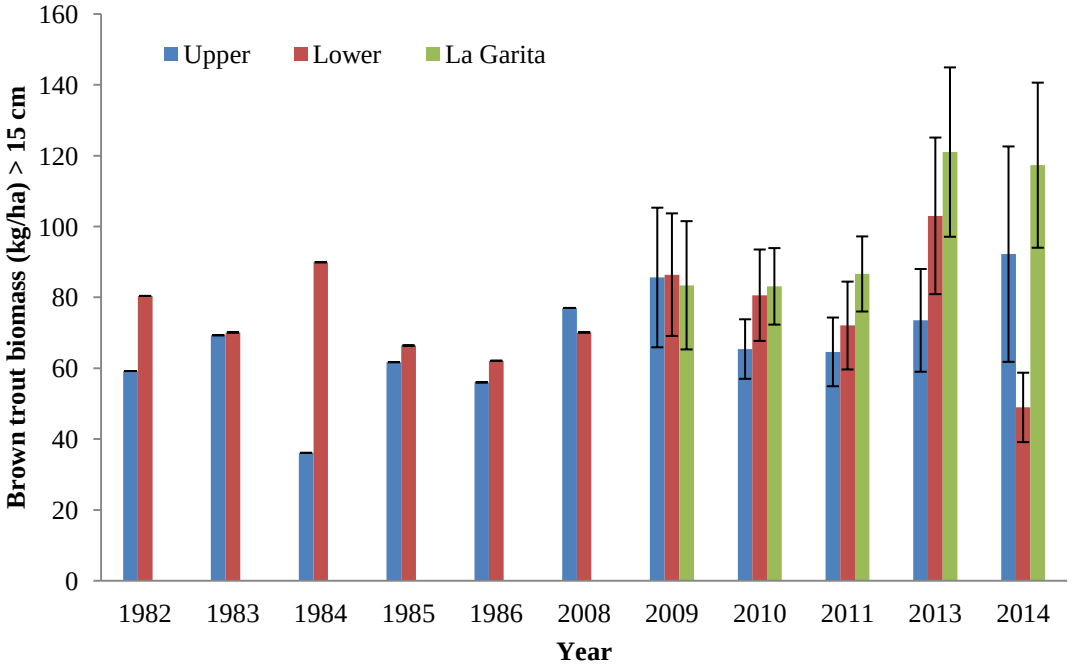


Figure 1.5. Biomass (kg/ha) of adult brown trout (>15 cm) in the Upper Wason, Lower Wason and La Garita reaches. Pre-restoration sampling estimates include years: 1982, 1983, 1984, 1985 and 1986. Post-restoration sampling estimates include years: 2008, 2009, 2010, 2013 and 2014. Black vertical bars represent 95% CI for the estimate.

Pteronarcys sampling: A monitoring study was initiated in summer of 2011 to determine if river restoration activities that placed a major emphasis on frequently-spaced, deeply-excavated pools might have had unintended negative consequences by reducing giant stoneflies (*Pteronarcys californica)* abundance on a reach-wide scale. The giant stonefly serves as an important food source for resident trout on the Rio Grande River. 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 at 12 of 15 different sites during 2014 and 2015. Removal methods were used to estimate relative abundance of *Pteronarcys californica* across four different reaches. Physical habitat data (such as riffle slope, substrate size, and embeddedness) associated with each sampling location will be collected during fall 2015. This habitat data will be incorporated into the overall stonefly abundance study and analyzed during the next reporting period.

South Platte River, Charlie Meyers SWA:

Fish sampling did not occur during 2014 on the Charlie Meyers SWA because the project is still under construction. Higher than average flows in the South Platte River delayed construction. However, routine fish sampling was conducted just upstream within Phase 1 and 2 of the South Platte River Habitat Improvement project. The purpose of this monitoring was to determine fish abundance and biomass at a control and habitat improvement site located just 0.75 miles and 1.0 miles downstream of Spinney Mountain Reservoir Dam. Sampling will occur again in 2016 (even years) instead of an every-year basis to provide data on fish abundance and species composition.

South Platte River, Buckley Ranch:

Historic monitoring sites: Fish sampling was conducted at two sites on the South Platte River as part of a long-term effort measuring fish response from the Buckley Ranch habitat improvement project. Fish surveys were conducted on the Buckley Ranch including two sampling stations (treatment and control) on October 16, 2014. The Buckley Ranch habitat project consisted of primarily boulder-type treatments. Nearly 25 years of fish sampling data have been collected at the treatment and control sites. This project will be compared to the adjacent toe-wood/sod-mat treatment site (Badger Basin habitat improvement project) and a reference reach site (Tomahawk SWA) located farther upstream.

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 not sampled in 2014.

Reference reach sites: The reference reach site located on the Middle Fork of South Platte River on the Tomahawk SWA was not sampled in 2014. However, detailed habitat surveys using GPS equipment and an Acoustic Doppler Current Profiler (ADCP) were completed on reference reach sites as part of a mobile RFID-GPS study in South Park.

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 and armored with rip-rap. There are very few locations remaining with functional floodplain. The Twin Tunnels construction project was initiated by the Colorado Department of Transportation (CDOT). Once construction of the new tunnels was completed, a temporary frontage road was removed, providing a unique opportunity for riparian restoration within the I-70 corridor. The riparian restoration and in-stream habitat project was completed in April 2015. Primary project goals were to restore natural processes along a long river bend that will enhance brown trout (*Salmo trutta*) habitat for the benefits of anglers by improving floodplain connectivity, enhancing inchannel habitat features, and establishing deep lateral scour pools. Before and after photos are shown in Figures 1.6 and 1.7, respectively. Fish population data were collected during fall 2012, 2013, and 2014 from the proposed treatment site and an adjacent downstream control site. This data established three years of baseline data prior to construction activities. Future monitoring of the two sites will be used to evaluate fisheries goals and objectives specific to this project.

Crystal River, Wexner Property:

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 (*Oncorhynchus mykiss*) fishery would benefit from habitat enhancement. Fish sampling will be postponed until the project receives funding for implementation.

Yampa River, Stagecoach Reservoir Tail Water and Chuck Lewis SWA:

Habitat enhancement projects were completed in 2013 on two separate reaches of the Yampa River to improve conditions for rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). Fish sampling was conducted prior to habitat enhancement for baseline data comparison. Monitoring of fish populations, length/frequency, and species composition was not completed in 2014 due to maintenance of structures and presence of heavy equipment. Fish sampling will occur in both reaches in fall 2015.

Gunnison River, Gunnison River SWA:

This project was not included in the grant narrative due to uncertainty over funding. However, funding for the project was approved in 2014, so the project has been added to this report. Implementation of a 2.5 mile stream rehabilitation project within the Gunnison River SWA is scheduled for 2015-2016. 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. Detailed habitat surveys were conducted in addition to the fish sampling work to support pre- and post-habitat enhancement comparisons. Fish sampling surveys will be repeated during the fall 2015.

Figure 1.6. Pre-construction photo of the Twin Tunnels project site on Clear Creek.

Figure 1.7. Post-construction photo of the Twin Tunnels project site on Clear Creek.

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. 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 25 completed projects, three active or ongoing projects, and seven proposed projects.

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	2011
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	Chuck Lewis SWA	Yampa River	Completed	2013
24	Upper Arkansas NRDA	Arkansas River	Completed	2014
25	Twin Tunnels	Clear Creek	Completed	2015
26	Dream Stream (Phase 5)	South Platte River	Ongoing	2015
27	Hidden Mile	Conejos River	Ongoing	2015
28	Gunnison River SWA	Gunnison River	Ongoing	2015-2016
29	Flood Restoration	Big Thompson River	Proposed	2016
30	Wexner Property	Crystal River	Proposed	TBD
31	Tomichi Creek SWA	Tomichi Creek	Proposed	TBD
32	Windy Gap Enhancement	Colorado River	Proposed	TBD
33	West Plum Creek	Plum Creek	Proposed	TBD
34	Upper Conejos River (Phase 2)	Conejos River	Proposed	TBD
35	Little Hills SWA	Dry Creek	Proposed	TBD

Objective 2.2: Research 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 for Objectives 1.2 and 2.2 are reported below.

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 brown trout (*Salmo trutta*) fishery was previously degraded due to the presence of historical mine tailings throughout riparian areas. Mine tailings have since been remediated by the Environmental Protection Agency (EPA), and fish populations have increased dramatically in response to improved water quality. Historic land use and flow regulation have also impacted instream habitat for brown trout. Therefore, habitat restoration and enhancement was initiated in 2013 and completed in summer 2014. As-built drawings for the habitat enhancement project are included in Appendix A.

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 metrics prior to instream habitat enhancement. These sites were surveyed again in 2014 to evaluate the effectiveness of habitat enhancement. All sites will be re-surveyed in 2016 and 2018 for analysis with River2D. Configuration and analysis of baseline (i.e., 2013) and post-implementation (i.e., 2014) habitat models is ongoing (Figures 2.1 and 2.2).

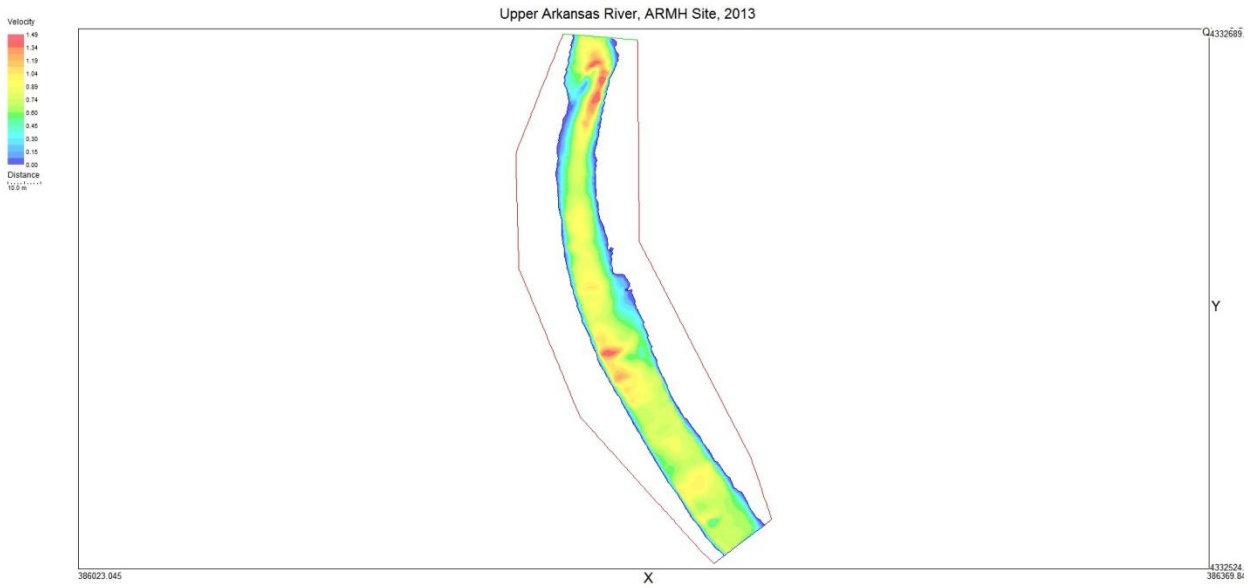


Figure 2.1. Preliminary River2D results showing pre-construction (2013) velocity (m/s) distribution for site AR-MH, Upper Arkansas River NRDA project.

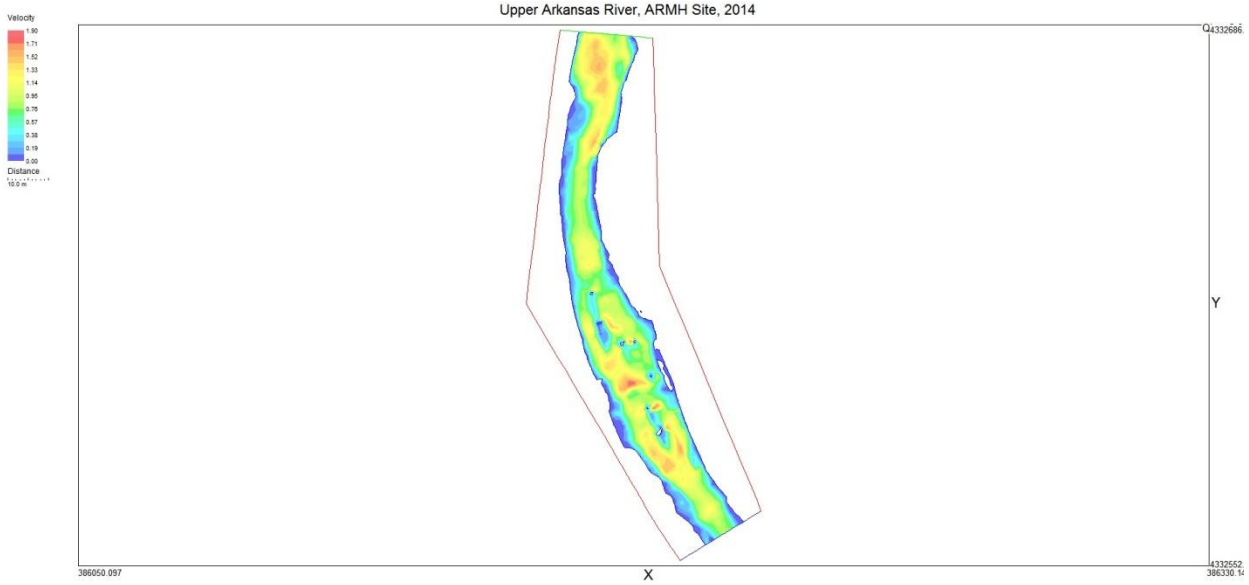


Figure 2.2. Preliminary River2D results showing post-construction (2014) velocity (m/s) distribution for site AR-MH, Upper Arkansas River NRDA project.

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):

Pilot studies have demonstrated the utility of ADCP systems for surveying and evaluating hydraulic conditions and aquatic habitat, particularly in large river systems that cannot be surveyed by wading. The ADCP was utilized to evaluate channel morphology and velocity distributions at the following project sites during 2014-2015:

1. Montrose Whitewater Park, Uncompahgre River
2. Gore Canyon Whitewater Park, Colorado River (Figure 2.3)
3. Reference reach, Tomahawk SWA, Middle Fork South Platte River
4. Habitat enhancement reach, Badger Basin SWA, Middle Fork South Platte River
5. Upper Arkansas NRDA Project, Arkansas River
6. Stonefly monitoring sites, Gunnison River

Figure 2.3. Baseline ADCP survey at the Gore Canyon Whitewater Park prior to project implementation, September 2014.

Survey data from the whitewater parks sites will used to compare channel morphology and hydraulics for pre- and post-project conditions. Interpolated depths and velocities from the ADCP will also be used to calibrate 2D models, which will be used to evaluate the effects of whitewater park implementation on habitat suitability for brown trout (*Salmo trutta*). Survey data from the Middle Fork South Platte will be used to compare brown trout habitat in un-restored reference reaches and habitat enhancement reaches. The ADCP was also used to survey bathymetry and water velocity on the Upper Arkansas River and Gunnison 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 and haying practices 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. CPW identified the location between Spinney Mountain Reservoir and Elevenmile Canyon Reservoir as a high priority for habitat restoration. 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 is being 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 costs, 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, continued during fall 2014, and is scheduled to be completed in fall 2015. 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. All cross-sections, the longitudinal profile, and ADCP-measured velocity distributions will be resurveyed in fall 2016.

South Platte River, Badger Basin SWA:

The as-built survey for this project was completed in October 2014 using survey-grade GPS and an ADCP. The final project covered 1.3 river miles on the main channel and resulted in over 1,600 linear feet of toe-wood, almost 33,000 square-feet of pool development, and 21 habitat structures. An additional 0.6 river miles were developed as juvenile and rearing habitat on a secondary channel. The complete summary of habitat treatment for the projects is presented in Table 2.2 and as-built drawings are shown in the Appendix A.

Table 2.2. Summary of installed habitat treatments for the Badger Basin SWA habitat enhancement project on the Middle Fork South Platte.

Treatment	Total	Units
Toe-wood Bank Revetment	1,623	ft
Horizontal Log Bank Revetment	546	ft
Spawning and Rearing Channel	3,170	ft
Pool Development	32,898	ft^2
Point Bar Development	37,009	ft^2
Willow Planting: Bare root	50,000	plants
Willow Planting: Cuttings	5,000	stakes
Constructed Riffle	4	structures
Boulder Cross-Vane Structure	1	structures
Boulder J-hook Structure	8	structures
Log-Vane J-hook Structure	2	structures
Boulder Cluster	5	structures
Boulder Garden	1	structures

Rio Grande River, Wason and La Garita Ranches:

Topographic and habitat surveys were not completed during this period due to scheduling difficulties. Surveys are currently scheduled for October 2015.

Gunnison River, Gunnison River SWA:

This project was not included in the grant narrative due to uncertainty over funding. However, funding for the project was approved in 2014, so the project has been added to this report. 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 include:

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.

The project received full funding in March 2014. During spring 2015, additional survey data were collected within the Gunnison SWA to support floodplain analysis and design development. Phase I of the project will focus on replacing the Piloni Diversion structure, which currently consist of the push-up dam that requires frequent maintenance, with a boulder cross-vane diversion structure. This structure should enhance instream habitat and reduce the frequency of maintenance activities that disturb the streambed and affect aquatic habitat. One-dimension hydraulic modeling with HEC-RAS is being used to evaluate the impact of the proposed structure on flooding. The floodplain analysis and project design should be finalized in 2015, and instream construction for Phase I is scheduled for fall 2015 or spring 2016.

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

South Platte River, Badger Basin SWA:

The Badger Basin SWA experienced degradation of riparian vegetation due to historical grazing and haying 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 (*Salmo trutta*). We hypothesize the combination of improved shading from re-establishing willows, enhanced floodplain connectivity, and a deeper channel will result in cooler water temperatures. To test this hypothesis, we deployed temperature loggers directly upstream (BB1) and downstream (BB2) of the project reach in the spring of 2013. In April 2015, three additional temperature logger were deployed upstream of the project reach. Two additional loggers (TH1 and TH2) were deployed in an upstream reference reach within the Tomahawk SWA, and one additional logger was deployed in an upstream, degraded control reach (BBC1). Average monthly temperature increased from upstream to downstream, with the exception of the Badger Basin habitat enhancement reach (Figure 2.4). In the upstream reference reach, water temperature increased by 0.26°F/mile between TH1 and TH2. In the degraded control reach, water temperature increased by 0.68°F/mile between BBC1 and BB1. In the habitat enhancement reach, water temperature decreased by 0.19°F/mile between BB1 and BB2. The locations of water temperature monitoring sites are shown in Figure 2.5. These results suggest that stream restoration activities that include reconnecting of the active channel to the floodplain, channel

narrowing to fit the present bankfull discharge, and re-vegetation efforts that improve shading effects could have the potential to stabilize or lower stream temperatures for the benefit of cold-water fish species.

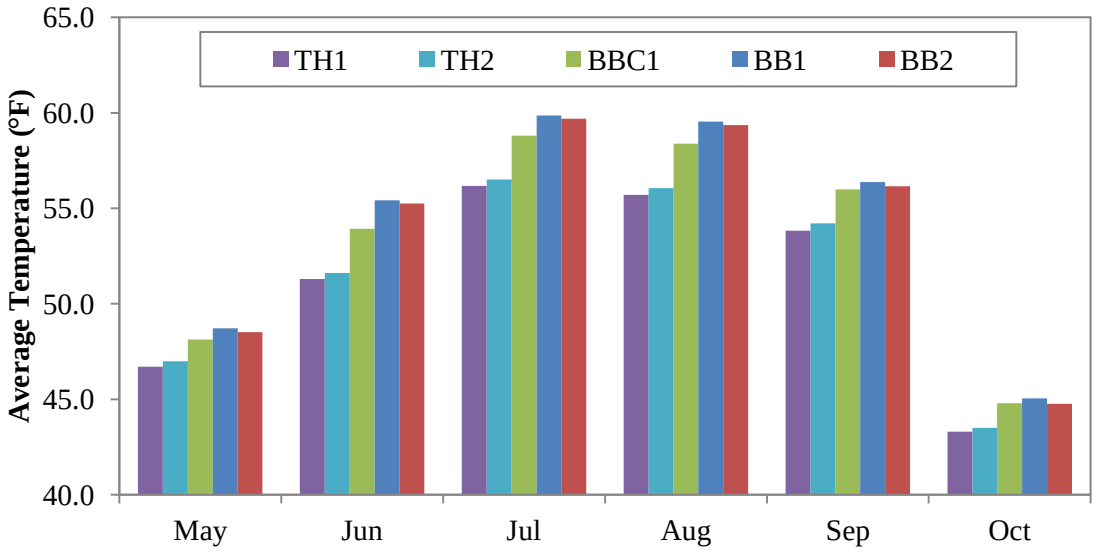


Figure 2.4. Average monthly water temperature for five sites on the Middle Fork South Platte River, 2014. Sites are listed from upstream to downstream: Tomahawk 1 (TH1), Tomahawk 2 (TH2), Middle Fork South Platte 1 (MFSP1), Badger Basin 1 (BB1), and Badger Basin 2 (BB2).

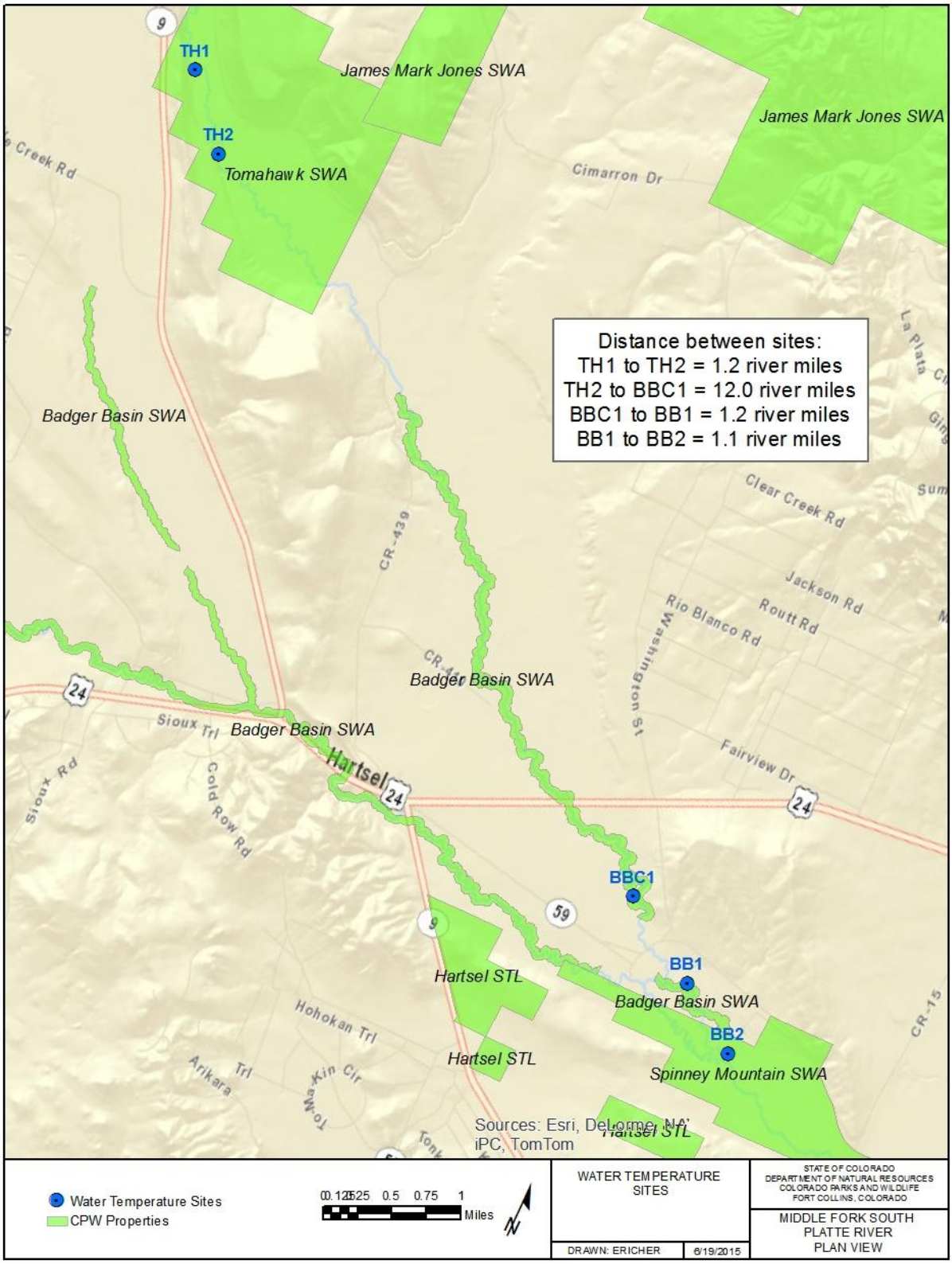


Figure 2.5. Location of water temperature monitoring sites on the Middle Fork South Platte River.

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 radio frequency identification (RFID) and passive integrated transponder (PIT) technology have been effectively applied to monitor fish movements. Most studies have utilized fixed antenna systems. To evaluate fish migration and utilization of habitat enhancement treatments, we are developing a mobile RFID system that incorporates GPS and temperature monitoring. The system utilizes an Oregon RFID single antennae reader, Campbell Scientific CR1000 Datalogger, Garmin GPS sensor, and Campbell Scientific temperature sensor. The RFID-GPS system was configured to record the PIT tag number, GPS position, and water temperature whenever a tagged fish is detected. The system was designed for deployment from a small raft, but could be deployed from a backpack as well. To evaluate the accuracy of the system, a controlled field experiment using PIT-tagged rocks was conducted to evaluate accuracy of the GPS sensor during fall 2014. To further development of the system, pilot field tests were conducted on PIT-tagged fish in October 2014 within the Tomahawk SWA and Badger Basin SWA on the Middle Fork South Platte River (Figure 3.1). Habitat surveys were conducted concurrently to evaluate if the system can successfully determine what proportion of PIT-tagged fish were detected in different habitat types. Preliminary results were presented by Richer et al. (2015) and Barnes et al. (2015).

Figure 3.1. Deployment of the RFID-GPS system on the Middle Fork South Platte River.

References:

Barnes, T., E. Richer, E. Fetherman, and M. Kondratieff. 2015. Incorporating GPS and radio-frequency identification (RFID) technology to evaluate fish movement and habitat utilization. 2015 Annual Meeting of the Colorado-Wyoming Chapter of the American Fisheries Society, Fort Collins, Colorado, February 25, 2015.

Richer, E., E. Fetherman, and M. Kondratieff. 2015. RFID-GPS system development. CPW Aquatic Biologist Meeting, Cripple Creek, Colorado, January 22, 2015.

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 in 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 established for the Upper Arkansas River NRDA project were re-surveyed during fall 2014 to document post-construction conditions.

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 were monitored with the rapid assessment procedure in November 2014 following completion of instream construction. The rapid assessment procedure will be repeated each fall from 2015-2018 on the Upper Arkansas River to evaluate the effectiveness and longevity of habitat enhancement treatments.

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.

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. Actual costs will be compared between 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

As 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.

South Platte Basin Projects: A three-month creel study 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, additional creel studies will be repeated two and five years after the completion of the project 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 cutthroat trout native from downstream threats.

ACCOMPLISHMENTS

Fish Barrier Studies, Barrier Design:

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 Barrier 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. High magnitude floods ranging from 25 to 500-year events 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.

To evaluate passage at a typical water diversion structure, two PIT-tag antennae were installed at the Watson diversion structure on the Cache la Poudre River. Unfortunately, both antennae were damaged beyond repair during runoff in 2014. However, the solar power system, data loggers, and tuning boxes remain intact. New antennae will be installed as the site in the fall of 2015.

CPW has been supporting a number of post-flood fish passage projects in the South Platte Basin, including St. Vrain Creek, Big Thompson River, Boulder Creek, and Cache la Poudre River. All of these projects are being designed to provide fish passage for native species, brown trout (*Salmo Trutta*), and rainbow trout (*Oncorhynchus mykiss*).

Fish Barrier Studies, Trout Migration in the Middle Fork South Platte River:

The objective of this project is to monitor fish movement on the Middle Fork of the South Platte River in South Park, CO. The Middle Fork is predominately free of barriers above Spinney Reservoir, and trout are hypothesized to move more than 15 miles upstream during spawning runs. Data from this project will be used to document natural movement patterns in an unimpeded system, which will provide valuable information for evaluating limiting factors in rivers with high levels of habitat fragmentation from in-stream barriers (e.g., water-diversion structures, culverts, WWPs). The study will utilize fixed PIT-tag antennae and the RFID-GPS system (see Objective 3.1) to detected PIT-tagged fish within three reaches of the Middle Fork South Platte River and evaluate seasonal migration patterns for brown trout (*Salmo Trutta*) and rainbow trout (*Oncorhynchus mykiss*). All three reaches were surveyed with the RFID-GPS system in October 2014 and April 2015. Additional surveys are scheduled for September and October 2015.

Fish Passage Studies, White Water Parks:

We conducted a post-implementation topographic habitat survey for the new WWP on the Uncompahgre River in Montrose, Colorado (Figure 5.1). We also conducted pre-implementation surveys for the proposed Gore Canyon WWP at Pumphouse on the Colorado River. Construction the Gore Canyon WWP was completed in spring 2015 (Figure 5.2). Post-implementation surveys for the Gore Canyon Whitewater Park will be conducted in summer and fall of 2015. Survey data will be used to compare habitat suitability before and after construction of the WWPs. Instream hydraulics and will be modeled with River2D and the ADCP to evaluate changes in brown trout (*Salmo trutta*) habitat suitability and effectiveness of fish bypass channels. The Montrose WWP and Gore Canyon WWP studies will provide valuable information on the effects of WWPs on trout habitat and passage.

Figure 5.1. Conducting the post-implementation survey for the Montrose WWP, February 2015.

Figure 5.2. Gore Canyon Whitewater Park at Pumphouse on the Colorado River, February 2015.

CPW has funded, provided assistance, and directed research projects through several graduate students involving studies on fish passage, fish habitat, and barrier potential in the vicinity of WWP and water diversion structures. Results from their work will inform the design of in-channel structures like WWPs and diversions to improve passage for sportfish and minimize aquatic habitat degradation. Findings will help regulatory agencies determine if the impact of in-channel structures on fish passage and aquatic habitat should justify mitigation for damages. Ashley Ficke, Brian Fox, Nell Kolden, Tim Stephens, and Erin Ryan have all completed Master's theses or PhD dissertations and are in various stages of publishing their results in peer-reviewed journals. A publication studying the WWP in Lyons, Colorado, and the influence of WWP structures on pool habitat 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. The study combines fish sampling results from WWP and natural pools with hydraulic measurements of velocities and turbulence collected with an ADCP. 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.

White Water Park Creel Study:

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 component of this study collected baseline data on 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 fishery). 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.

Fish Passage Criteria:

CPW recommendations for fish passage criteria were revised for three species assemblages with different swimming and jumping capabilities (Table 5.1). Hydraulic design criteria have been provided to project stakeholders and government agencies as requested.

Table 5.1. Hydraulic design criteria for fish passage structures in the Colorado Front Range.

Species Assemblage	Velocity (ft/s)	Minimum Depth (ft)	Vertical Drop (ft)	Turbulence (*EDF)
Native minnows and darters	1-2	0.5	0.0	<7
Native dace and suckers	3-4	0.5	0.0	<7
Trout	3-6	0.5-1.0	0.5-1.0	<7

* Energy Dissipation Factor (EDF) = (γQS)/A (Laiho, 2014)

References:

Laiho, D.R. 2014. Engineering river diversions to include fish passage. Presented at the *Fish Passage Workshop and Webinar*, Northern Water Headquarters, Berthoud, Colorado.

STUDY PLAN B: TECHNICAL ASSISTANCE

Job B.1: Stream Restoration Assistance to CPW Personnel and 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 for 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., E.E. Richer, D. Kowalski, E.R. Fetherman, and R.B. Nehring. January 22, 2015. Influence of boulder habitat structures on giant stonefly abundance. Colorado Parks and Wildlife Aquatic Biologist Meeting. Cripple Creek, Colorado.

Kondratieff, M.C. April 2, 2015. What makes a healthy trout stream? Colorado Parks and Wildlife Technician In-Service Meeting 2015. Frisco, Colorado.

Richer, E.E., E.R. Fetherman, and M.C. Kondratieff. January 22, 2015. RFID-GPS system development. Colorado Parks and Wildlife Aquatic Biologist Meeting. Cripple Creek, Colorado..

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.

Barnes, T., E. Richer, E. Fetherman, and M. Kondratieff. February 24-27, 2015. Incorporating GPS and radio-frequency identification (RFID) technology to evaluate fish movement and habitat utilization. Poster Paper. 2015 Annual Meeting of the Colorado/Wyoming Chapter of the American Fisheries Society. Fort Collins, Colorado.

Kondratieff, M.C. August 18, 2014. Toe-wood sod mat techniques for stabilizing banks and enhancing fish habitat. Boulder County Open Space, Boulder, Colorado.

Kondratieff, M.C., E.E. Richer, D. Kowalski, E.R. Fetherman, and R.B. Nehring. February 25, 2015. Influence of stream habitat enhancement on trout and giant stonefly abundance on the Wason Ranch, Rio Grande River, CO. 2015 Annual Meeting of the Colorado/Wyoming Chapter of the American Fisheries Society. Fort Collins, Colorado.

Kondratieff, M.C. March 9, 2015. Charlie Meyer SWA Habitat Enhancement Project. Land and Water Trust Fund Board Meeting, Bailey, Colorado.

Kondratieff, M.C. March 18, 2015.. What Makes A Healthy Trout Stream? Evergreen Chapter of Trout Unlimited, Evergreen, Colorado.

Kondratieff, M.C. March 24, 2015. Restoring Colorado Rivers and Introduction to Fisheries Science and Management. Wildlife Management Short Course 2015, Colorado State University, Colorado State University, Fort Collins, Colorado.

Kondratieff, M.C. April 9. 2015. Limiting factors and trout. Colorado State University, Dr. Bledsoe's Stream Rehabilitation Design CIVE613 course, Fort Collins, Colorado.

Kondratieff, M.C. April 23, 2015. What makes a healthy trout stream? Front Range Community College Aquatic Fisheries Course (Jennifer Lee Instructor), Fort Collins, Colorado.

Richer, E. and M. Kondratieff. October 22, 2014. Matching the hatch get the catch: matching channel morphology with hydrology optimizes fishery benefits. South Platte Forum, Longmont, Colorado.

Richer, E., M. Kondratieff, B. Swigle, A. Treble, and F.B. Wright. February 26, 2015. The effects of post-flood recovery on fisheries in the Colorado Front Range. Colorado-Wyoming American Fisheries Society Annual Meeting, Fort Collins, Colorado.

Wynne, K., B. Logan, C. Wolf, E. Richer, and R. Buirgy. June 3, 2015. Flushing and channel maintenance flows workshop. Upper Colorado River Wild & Scenic Stakeholder Group Meeting, Keystone, Colorado.

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 fish passage consultations.

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.

No assistance was requested during this reporting period.

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

Completed *Plains Fish Identification Course*. July 2-3, 2014. Colorado State University, Fort Collins, Colorado. Kevin Bestgen instructor.

Completed *Trimble GNSS Survey Training*. July 8-9, 2014. Fort Collins, Colorado.

Completed *Rosgen Level 1 Applied Fluvial Geomorphology Short Course*. August 25-29, 2014. Estes Park, Colorado.

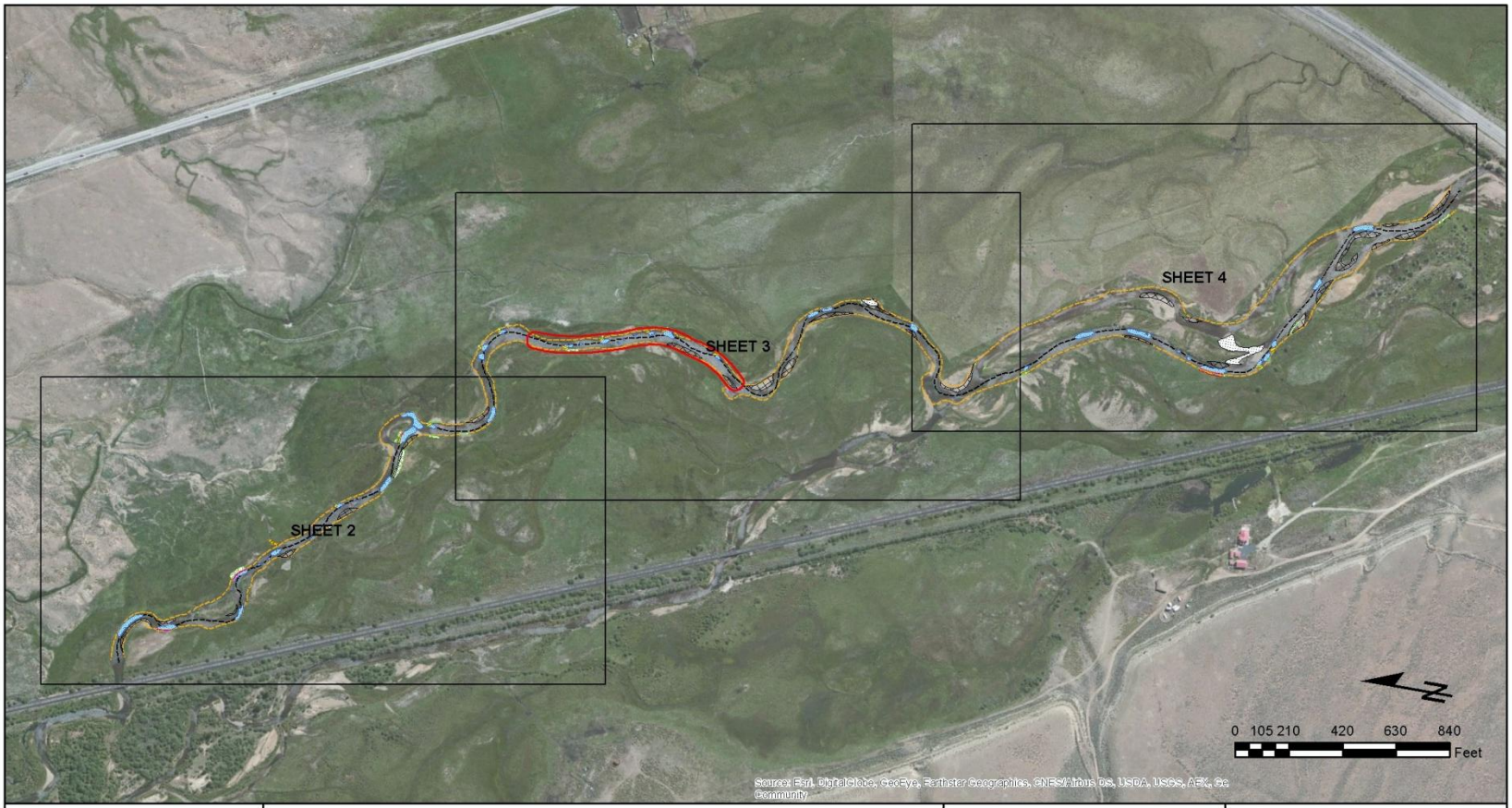
Completed *USFWS Division of Wildlife & Sportfish Restoration Program, Project Leaders Course*. February 23-24, 2015. Fort Collins, Colorado.

Completed *Boat U.S. Foundation's Online Boating Safety Course*. March 27, 2015. Online.

Completed *Public Speaking Workshop.* Dr. Gene Decker (instructor). December 10, 2014. Fort Collins, Colorado.

APPENDIX A:

As-Built Drawings for Stream Rehabilitation and Habitat Enhancement Projects



River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
Boulder Structure
Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
Develop Pool
Develop Point Bar / Lateral Bar
Fill
Erosion Control

AS-BUILT DRAWINGS

DRAWN: ERICHER	4/22/2015
CHECKED:	
APPROVED:	

SHEET: 1 OF 4

STATE OF COLORADO
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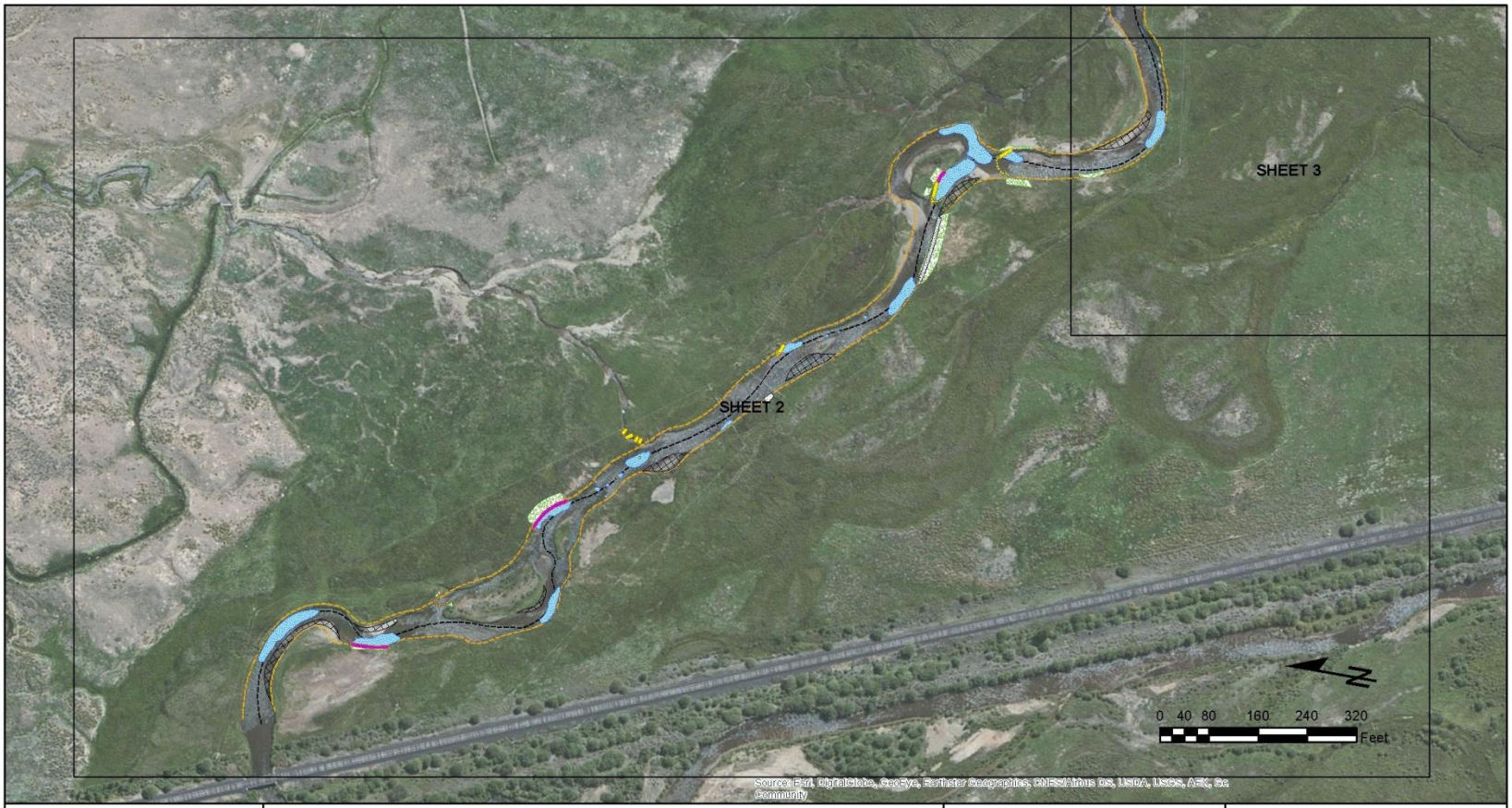
FORT COLLINS, COLORADO

UPPER ARKANSAS RIVER NRD
AQUATIC HABITAT PROJECT
CRYTAL/REDDY REACH



River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
Boulder Structure
Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
Develop Pool
Develop Point Bar / Lateral Bar
Fill
Erosion Control

AS-BUILT DRAWINGS

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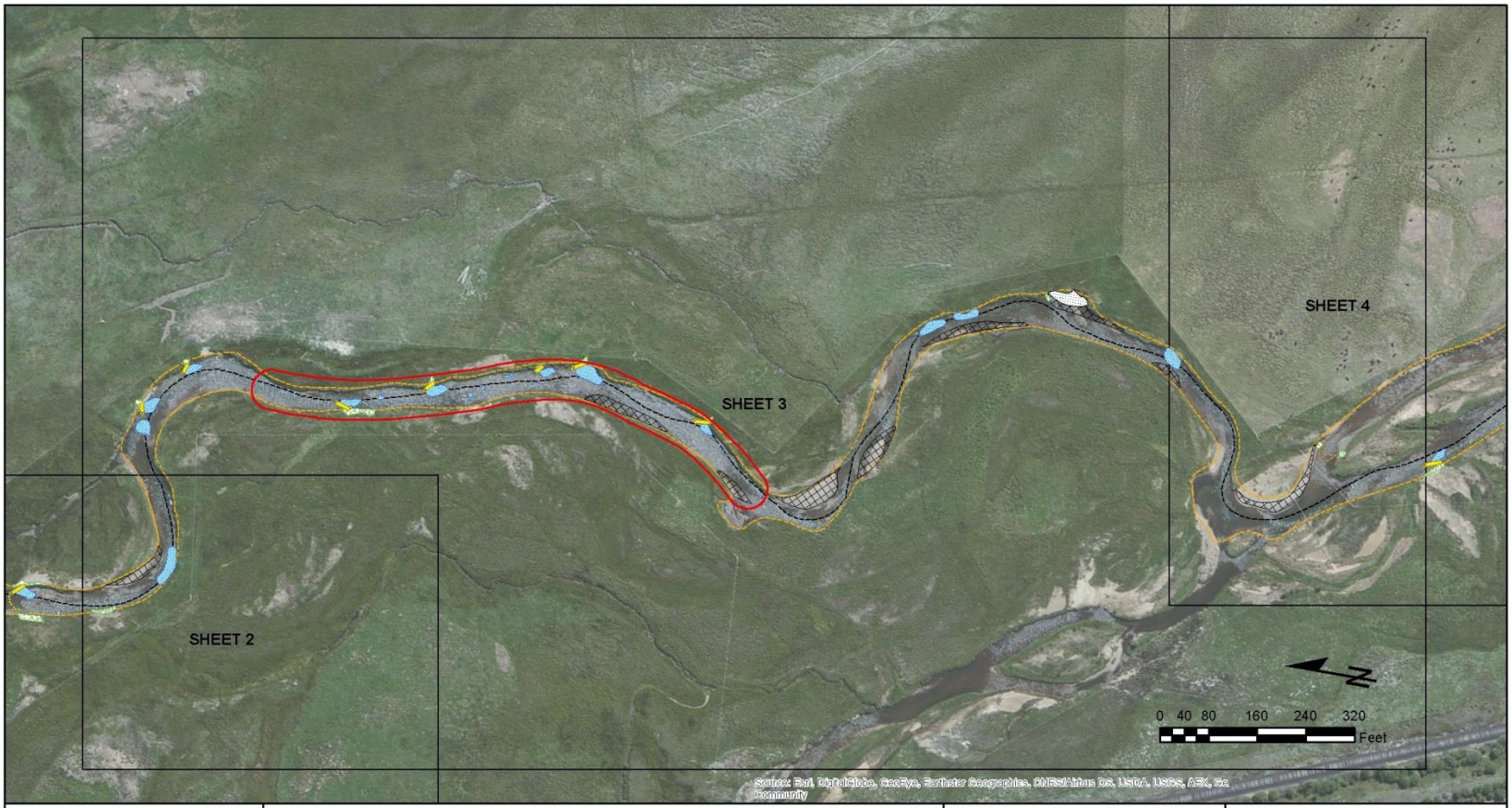
FORT COLLINS, COLORADO

UPPER ARKANSAS RIVER NRD
AQUATIC HABITAT PROJECT
CRYTAL/REDDY REACH



River Alignment
Thalweg
Fish Monitoring Sites
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Boulder Structure
Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
Develop Pool
Develop Point Bar / Lateral Bar
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Erosion Control

AS-BUILT DRAWINGS	
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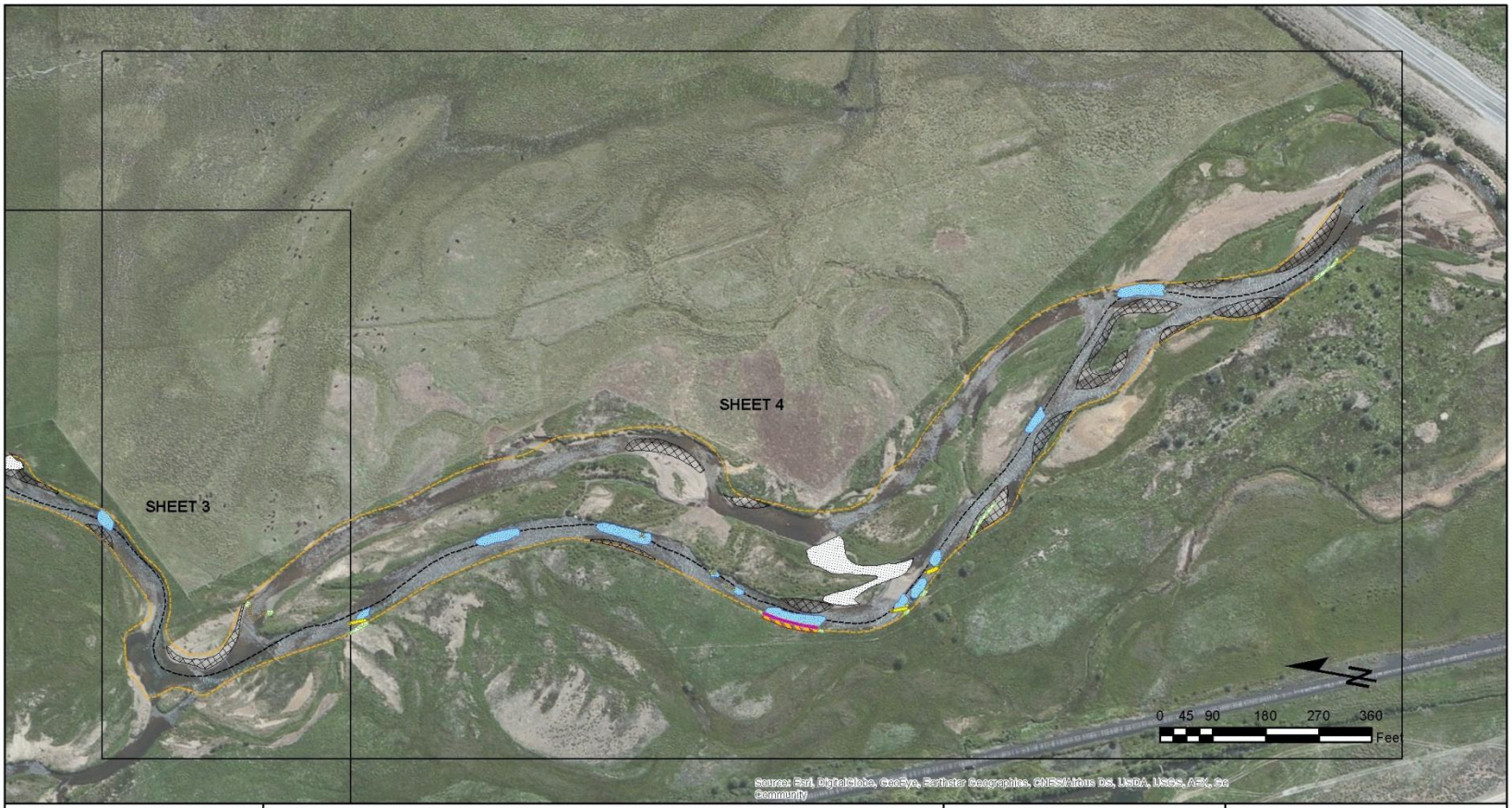
FORT COLLINS, COLORADO

UPPER ARKANSAS RIVER NRD AQUATIC HABITAT PROJECT CRYTAL/REDDY REACH



River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
Boulder Structure
Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
Develop Pool
Develop Point Bar / Lateral Bar
Fill
Erosion Control

AS-BUILT DRAWINGS	
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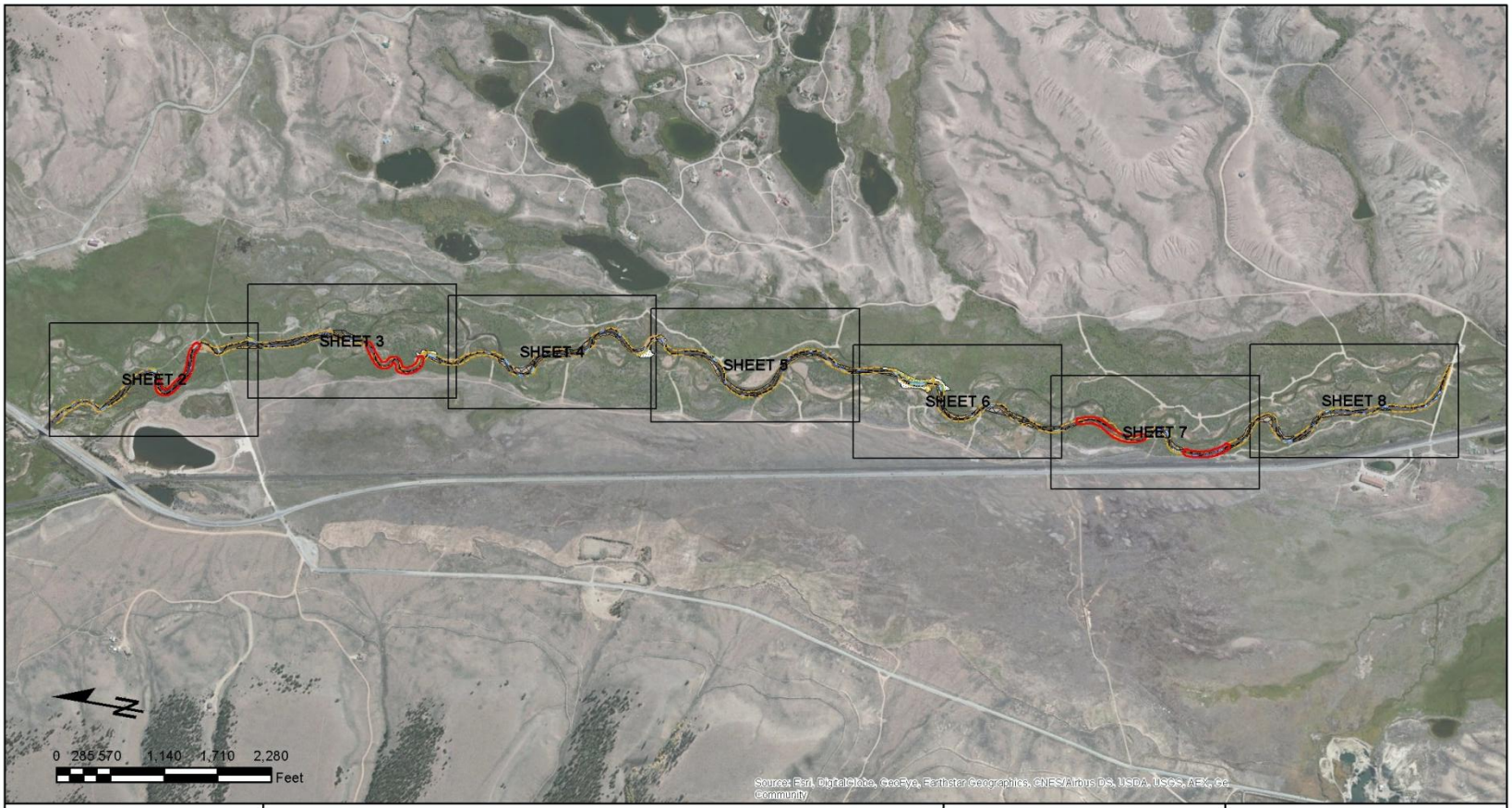
UPPER ARKANSAS RIVER NRD
AQUATIC HABITAT PROJECT
CRYTAL/REDDY REACH



River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
Boulder Structure
Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
Willow Transplants
Develop Pool
Develop Point Bar
Develop Lateral Bar
Fill

AS-BUILT DRAWINGS	
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SHEET: 1 OF 8	

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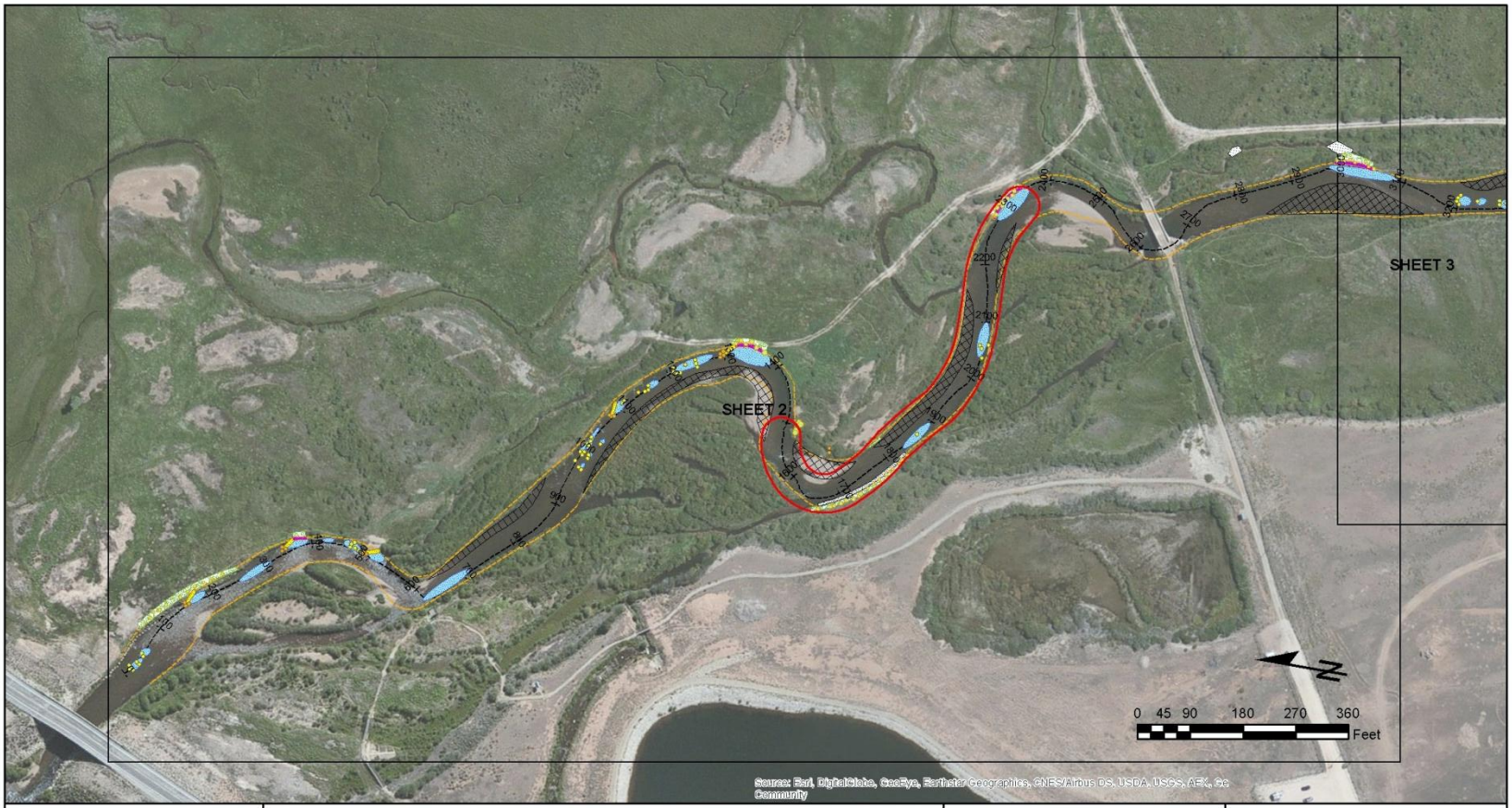
FORT COLLINS, COLORADO

UPPER ARKANSAS RIVER NRD AQUATIC HABITAT PROJECT HAYDEN REACH



River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
Boulder Structure
Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
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Develop Pool
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Fill

AS-BUILT DRAWINGS	
DRAWN: ERICHER	4/22/2015
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APPROVED:	
SHEET: 2 OF 8	

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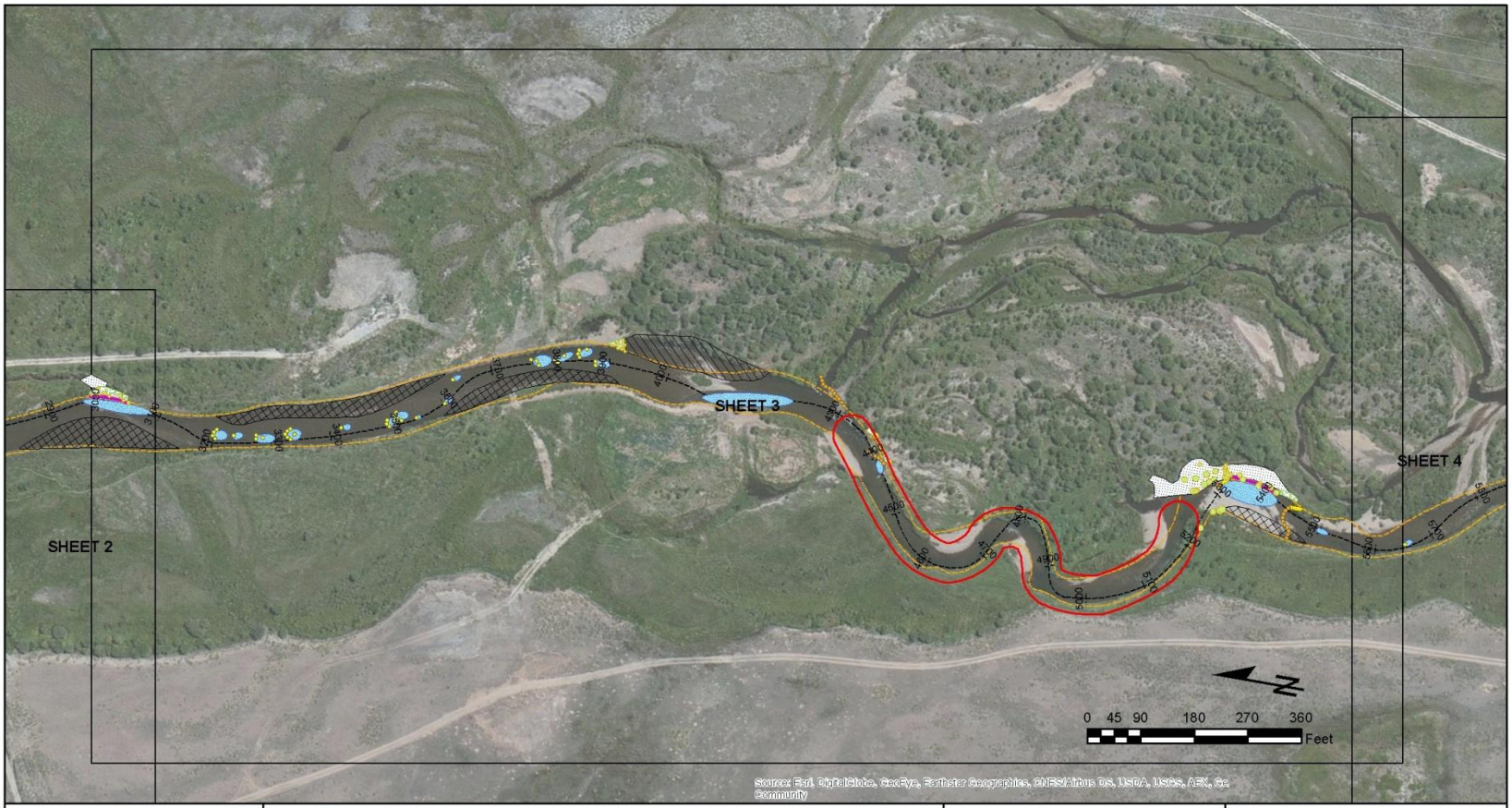
FORT COLLINS, COLORADO

UPPER ARKANSAS RIVER NRD
AQUATIC HABITAT PROJECT
HAYDEN REACH



River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
Boulder Structure
Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
Willow Transplants
Develop Pool
Develop Point Bar
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AS-BUILT DRAWINGS

DRAWN: ERICHER	4/22/2015
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APPROVED:	

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STATE OF COLORADO
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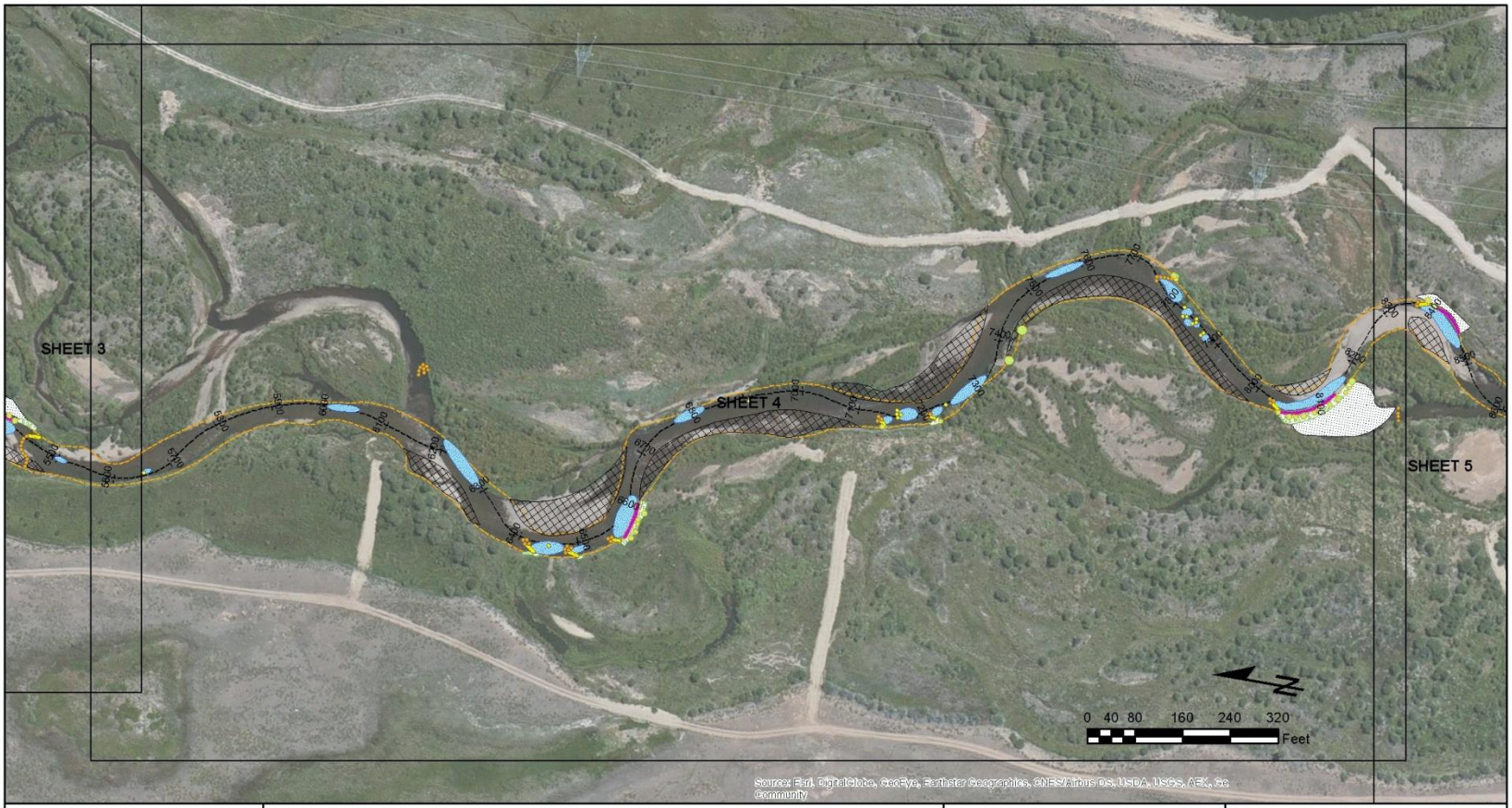
FORT COLLINS, COLORADO

UPPER ARKANSAS RIVER NRD AQUATIC HABITAT PROJECT HAYDEN REACH



River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
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Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
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Develop Pool
Develop Point Bar
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Fill

AS-BUILT DRAWINGS	
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APPROVED:	
SHEET: 4 OF 8	

STATE OF COLORADO
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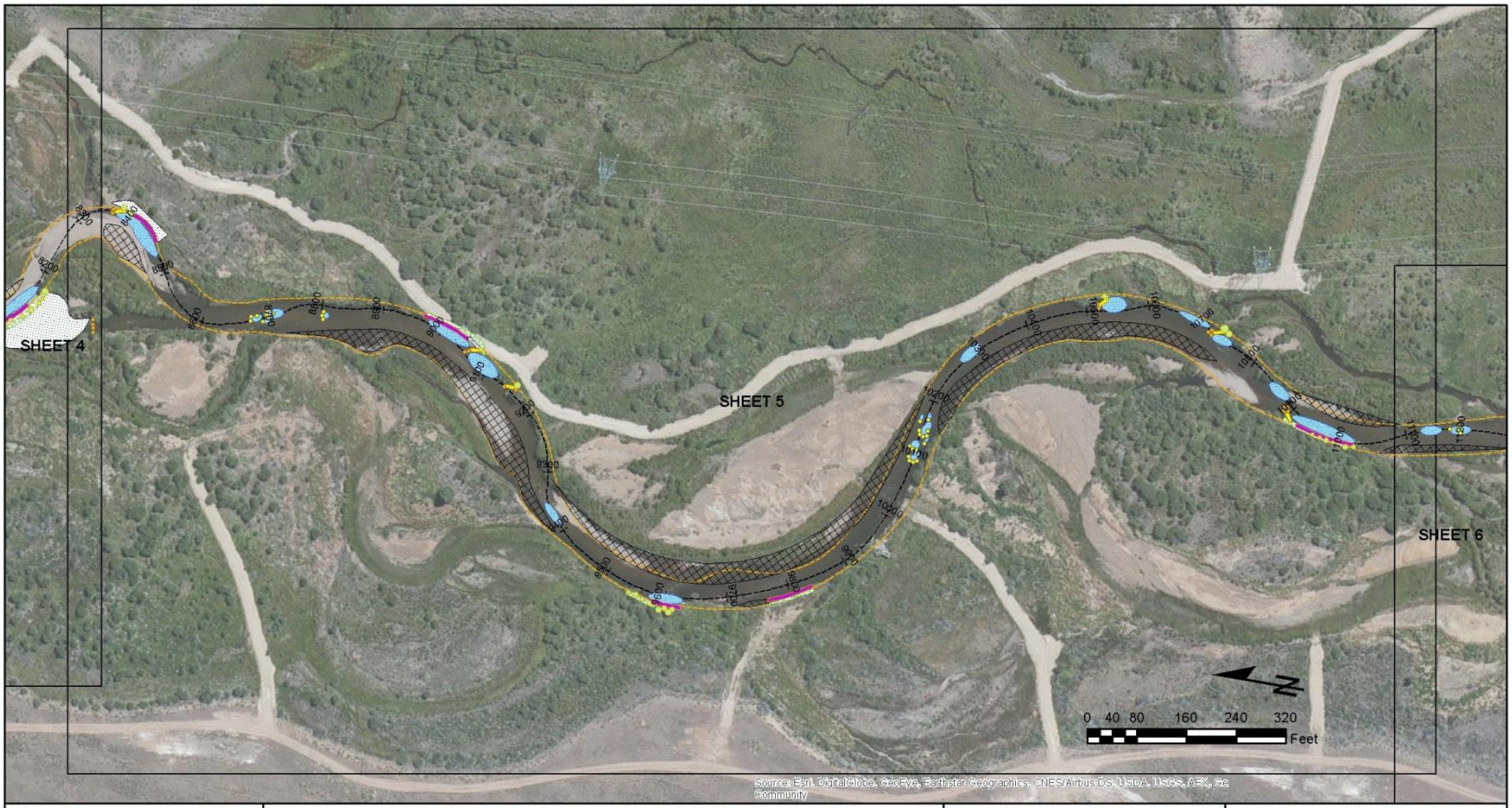
FORT COLLINS, COLORADO

UPPER ARKANSAS RIVER NRD
AQUATIC HABITAT PROJECT
HAYDEN REACH



River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
Boulder Structure
Cobble Toe
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Wood Toe
Sod Mat / Riparian Bench
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Develop Pool
Develop Point Bar
Develop Lateral Bar
Fill

AS-BUILT DRAWINGS	
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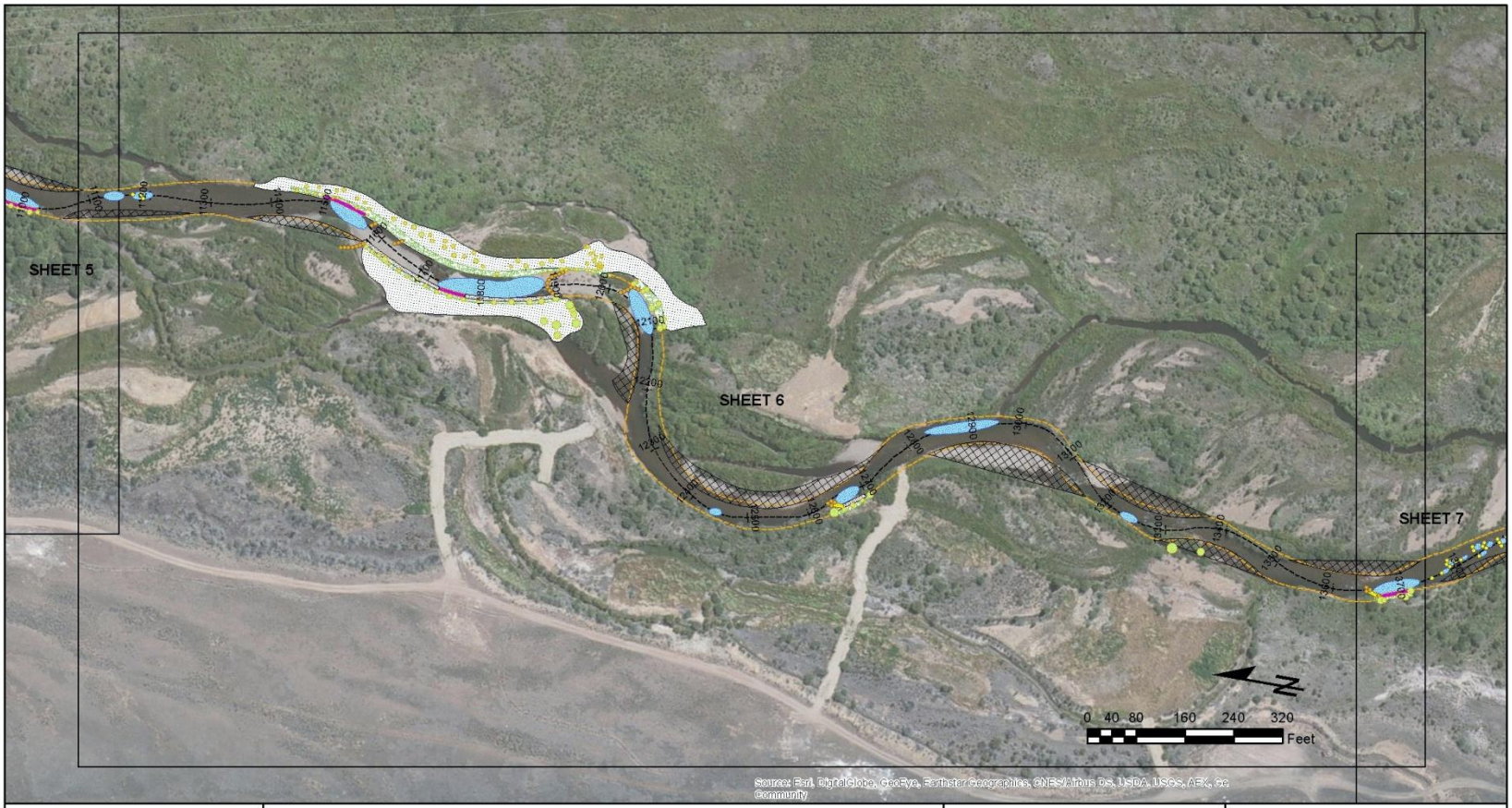
APPROVED:	
SHEET: 5 OF 8	

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

UPPER ARKANSAS RIVER NRD
AQUATIC HABITAT PROJECT
HAYDEN REACH

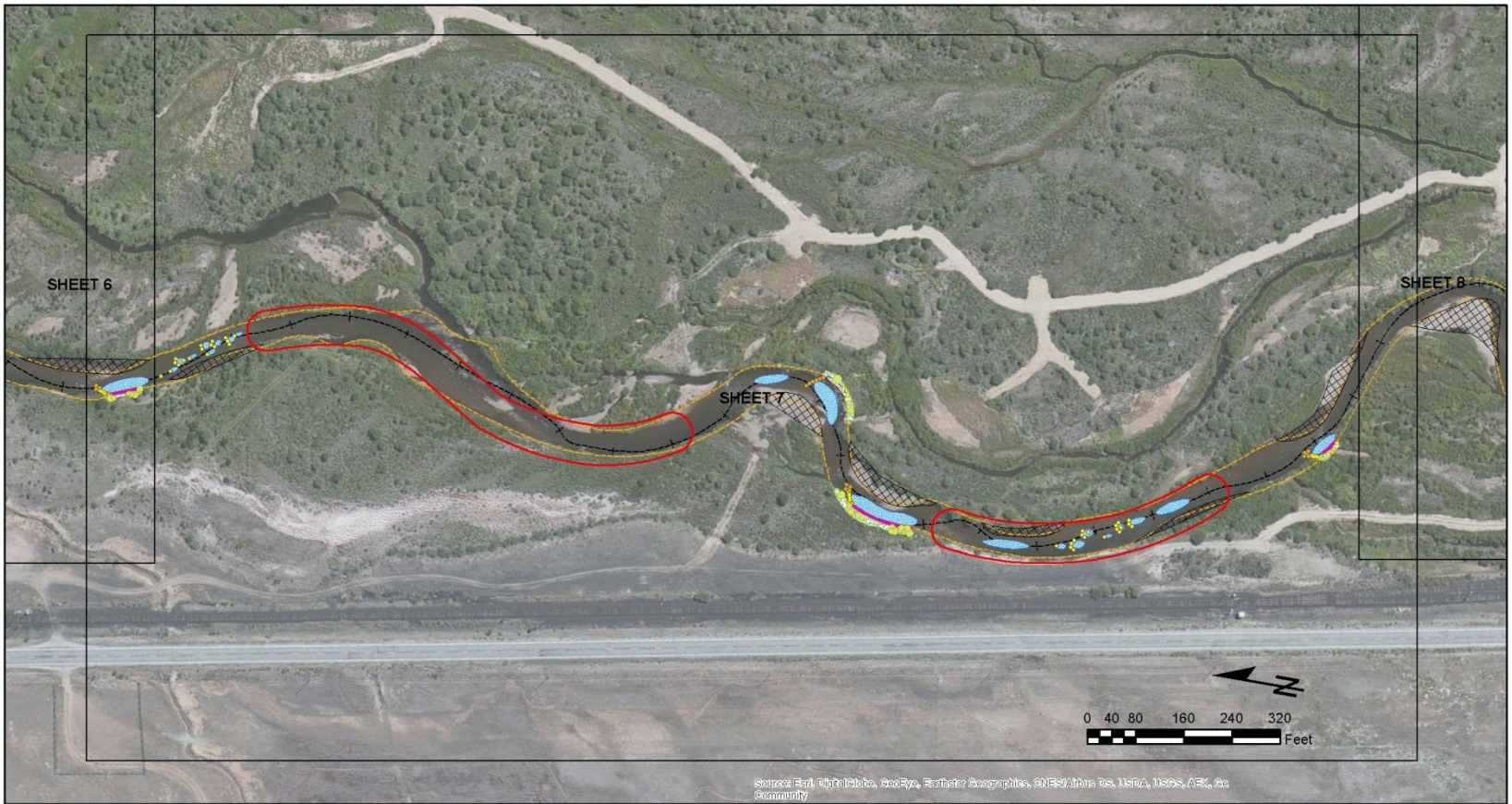


River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
Boulder Structure
Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
Willow Transplants
Develop Pool
Develop Point Bar
Develop Lateral Bar
Fill

AS-BUILT DRAWINGS	
DRAWN: ERICHER	4/22/2015
CHECKED:	
APPROVED:	
SHEET: 6 OF 8	

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

UPPER ARKANSAS RIVER NRD AQUATIC HABITAT PROJECT HAYDEN REACH



River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
Boulder Structure
Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
Willow Transplants
Develop Pool
Develop Point Bar
Develop Lateral Bar
Fill

AS-BUILT DRAWINGS	
DRAWN: ERICHER	4/22/2015
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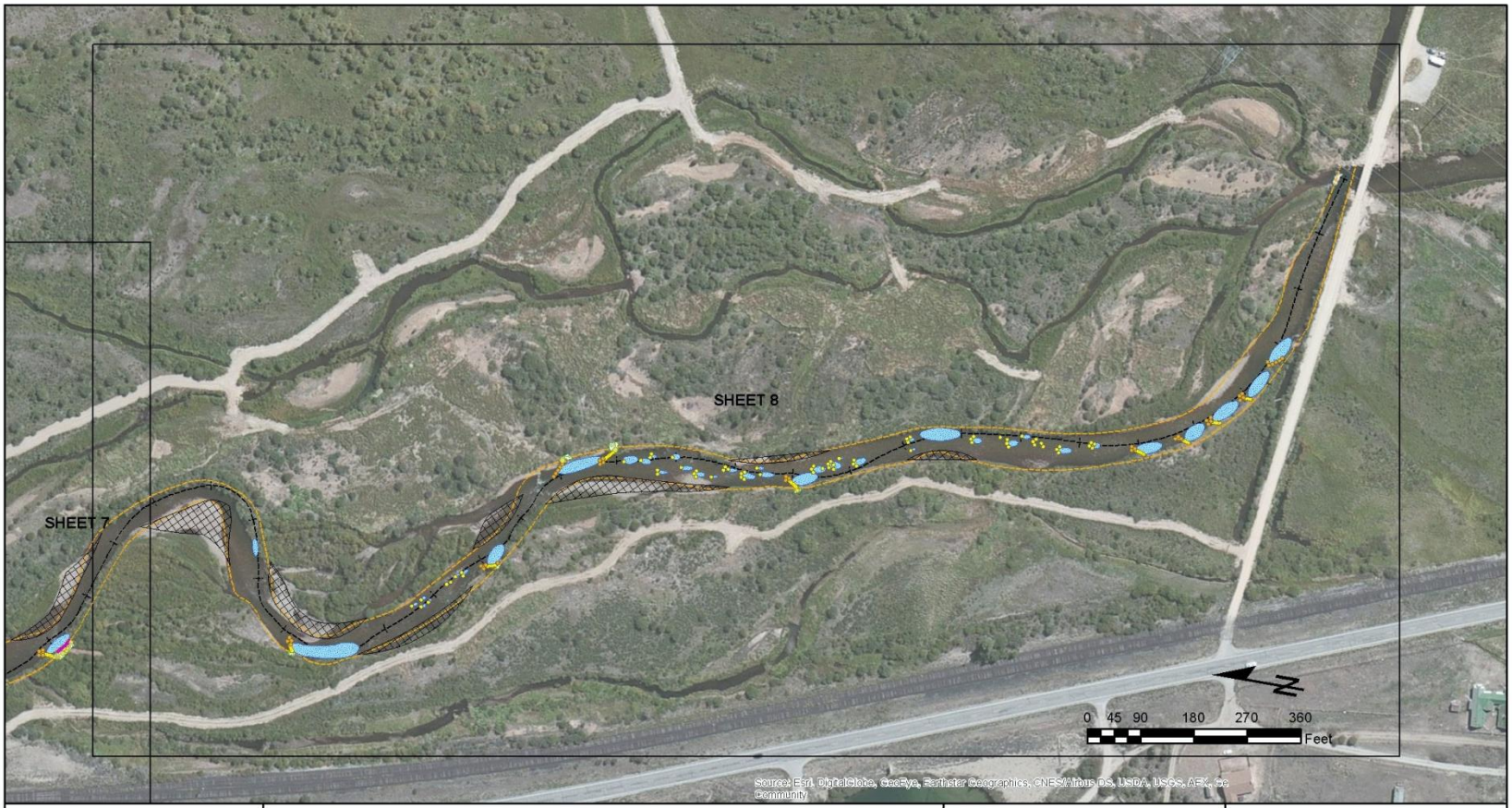
SHEET: 7 OF 8	

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

UPPER ARKANSAS RIVER NRD
AQUATIC HABITAT PROJECT
HAYDEN REACH



River Alignment
Thalweg
Fish Monitoring Sites
Boulder Cluster
Boulder Structure
Cobble Toe
Log Vane
Wood Toe
Sod Mat / Riparian Bench
Willow Transplants
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Fill

AS-BUILT DRAWINGS

DRAWN: ERICHER	4/22/2015
CHECKED:	
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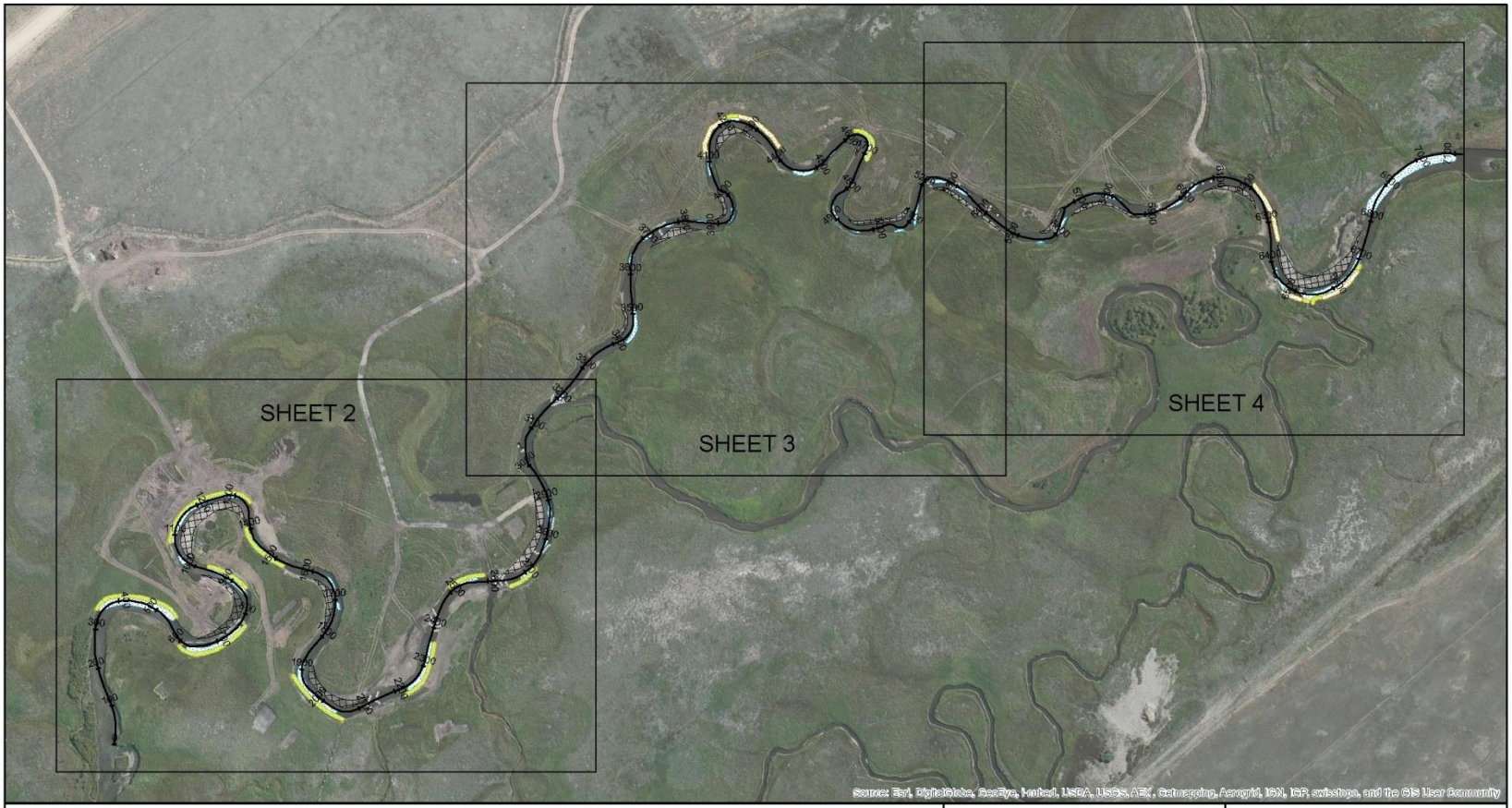
SHEET: 8 OF 8

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

UPPER ARKANSAS RIVER NRD
AQUATIC HABITAT PROJECT
HAYDEN REACH



Legend

- Wood Toe
- Horizontal Log
- Boulder Cluster
- Boulder Structure
- Log Structure
- Point Bar Development
- Pool Development

0 65 130 260 390 520 Feet

AS-BUILT DRAWING	
DRAWN: TBARNES	1/5/2015
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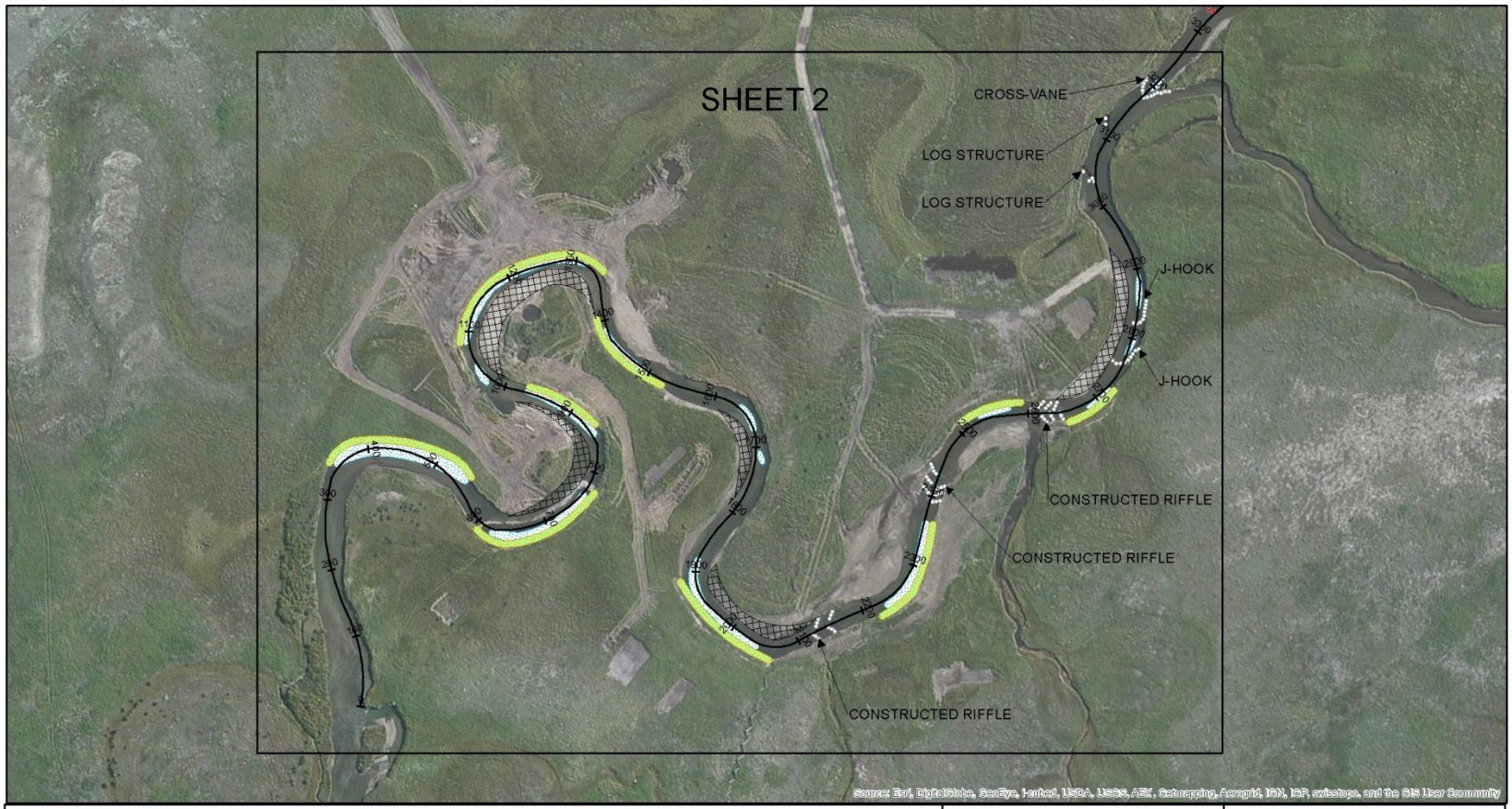
APPROVED:	
SHEET: 1 OF 4	

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

SOUTH PLATTE RIVER
BADGER BASIN SWA

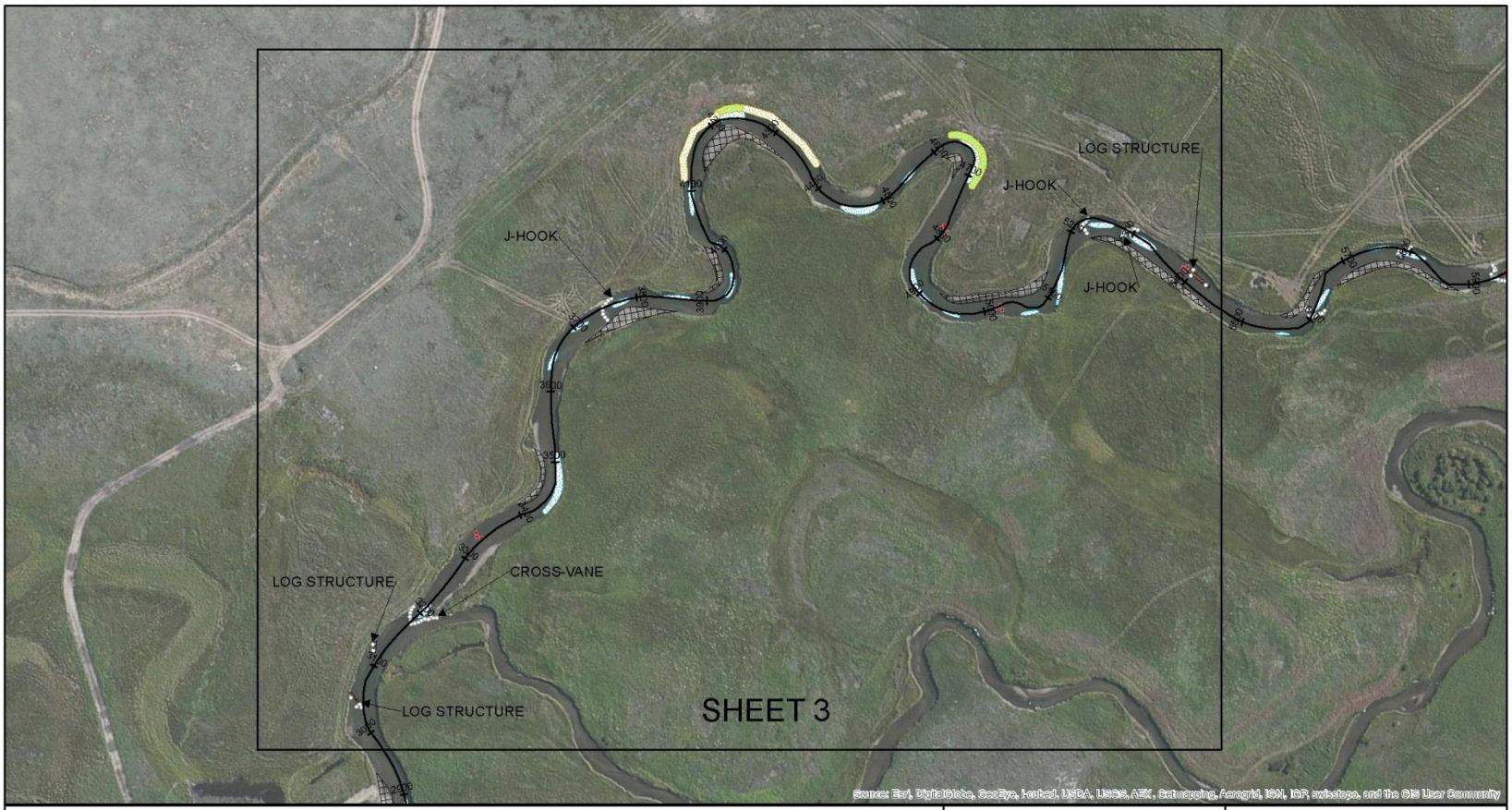


Legend

- Wood Toe
- Horizontal Log
- Boulder Cluster
- Boulder Structure
- Log Structure
- Point Bar Development
- Pool Development

0 37.5 75 150 225 300 Feet

AS-BUILT DRAWING		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: TBARNES	1/5/2015	
CHECKED:		SOUTH PLATTE RIVER BADGER BASIN SWA
APPROVED:		
SHEET: 2 OF 4		



Legend

- Wood Toe
- Horizontal Log
- Boulder Cluster
- Boulder Structure
- Log Structure
- Point Bar Development
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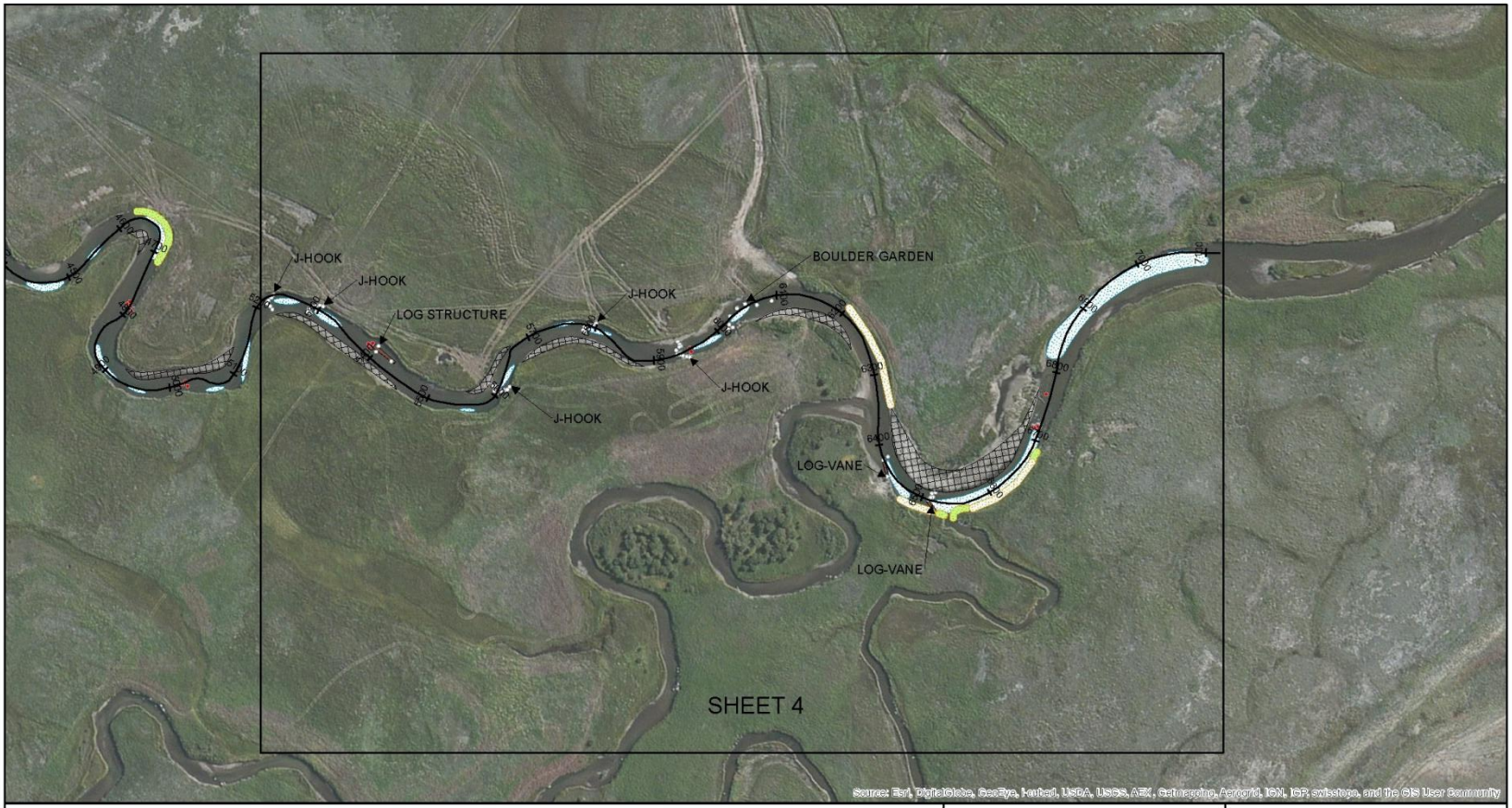
0 37.5 75 150 225 300 Feet

AS-BUILT DRAWING		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: TBARNES	1/5/2015	
CHECKED:		SOUTH PLATTE RIVER BADGER BASIN SWA
APPROVED:		
SHEET: 3 OF 4		



Legend

- Wood Toe
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- Boulder Cluster
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0 37.5 75 150 225 300 Feet

AS-BUILT DRAWING		STATE OF COLORADO DEPARTMENT OF NATURAL RESOURCES COLORADO PARKS AND WILDLIFE FORT COLLINS, COLORADO
DRAWN: TBARNES	1/5/2015	
CHECKED:		SOUTH PLATTE RIVER BADGER BASIN SWA
APPROVED:		
SHEET: 4 OF 4		