Stream Habitat Investigations and Assistance

Federal Aid Project F-161-R24

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Federal Aid in Fish and Wildlife Restoration

Performance Report

Colorado Parks & Wildlife

Aquatic Research Section

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STATE OF COLORADO

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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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PERFORMANCE REPORT

State:	Colorado
Project Number:	F-161-R-24
Project Title:	Stream Habitat Investigations and Assistance
Period Covered:	July 1, 2017 through June 30, 2018
Principal Investigators:	Matt C. Kondratieff and Eric E. Richer

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Project Objectives:

Job 1: Stream Restoration and Habitat Enhancement Studies

Need

Rivers and streams in Colorado have experienced substantial anthropogenic changes over the past 200 years. These changes were largely due to historic land-use activities and water development, such as beaver trapping, placer and gravel mining, flow regulation, timber harvest and tie drives, and construction of roads and railroads (Wohl 2011). Many streams have been channelized in an attempt to convey floods, accommodate roads and railways, protect infrastructure, and maximize crop production. Grazing of livestock in riparian areas has also led to accelerated bank erosion, loss of riparian vegetation, and impaired aquatic habitat. These impacts have resulted in degradation of aquatic habitat and loss of stream functions from the watershed to reach scale. Fortunately, stream restoration efforts show promise as a means to support species recovery, improve water quality, and create new areas for wildlife habitat and recreational activities (Bernhardt et al. 2005). However, additional research on restoration methods and outcomes is needed to understand which techniques are most effective and sustainable.

Objectives

1. Survey and quantify salmonid populations at three project sites by June 30, 2018.
2. Survey salmonid habitat at three project sites by June 30, 2018.

Approach

Action #1:

- Level 1 Action <u>Category</u>: Data Collection and Analysis
- Level 2 Action <u>Strategy</u>: Research, survey or monitoring – fish and wildlife populations
- Level 3 Action <u>Activities</u>: Abundance determination; Age, size, and sex structure

Utilize Before-After Control-Treatment (BACT) study designs to monitor and evaluate stream restoration and habitat enhancement projects. During summer and fall months, we will conduct electrofishing sampling to determine salmonid biomass and individual fish lengths and weights in control and treatment sites. Fisheries data will be collected and/or analyzed from select pre- and post-treatment stream reaches with assistance from aquatic biologists and researchers. Project sites include the (1) Wason and LaGarita Ranches, Rio Grande River, (2) Twin Tunnels Project, Clear Creek, (3) Upper Arkansas River, (4) Middle Fork South Platte River, and (5) Yampa River below Stagecoach Reservoir

Action #1 Accomplishments:

Fish inventory surveys were conducted at three of the five sites listed above, including Clear Creek, Upper Arkansas River, and Yampa River with the goal of monitoring and evaluation of stream restoration and habitat enhancement projects. Electrofishing sampling was conducted during summer and fall months in cooperation with CPW biologists to determine salmonid biomass, densities, and individual fish lengths and weights in control and treatment sites. Analysis of fisheries data collected on the Rio Grande River and Middle Fork South Platte River is ongoing.

Rio Grande River

A large-scale habitat enhancement project was conducted on a 3.8-mile 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 from 2008-2014. Giant Stonefly abundance was monitored because they provide an important food source for resident trout, are a riffle-dependent species, and are relatively easy to estimate abundance through exuviae counts. 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.

Research goals were: (1) to determine how the habitat project influenced trout population biomass (kg/ha), density (trout ≥15 cm/ha), and numbers of quality–sized trout (trout ≥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 (2.0-mile; heavy-treated) contains the most instream structures with frequent large, deeply-excavated pools. The Lower Wason Reach (1.8-mile; light-treated) consists mainly of randomly distributed boulders with fewer instream structures and deeply-excavated pools. The La Garita Reach (2.4 mile; natural) and Airport Reach (0.8-mile) both contain no instream structures and serve as downstream and upstream controls, respectively. Topographic surveys for each study reach were conducted using GPS survey equipment and an ADCP to characterize habitat conditions for comparison. 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. *Pteronarcys* abundance estimates collected as part of this Wason Ranch study were recently included in a larger regional study comparing spatial and temporal variation in Giant Stonefly emergence (biomass) and the importance of aquatic insect emergence to sustaining various components of healthy terrestrial and aquatic ecosystems (Walters et al. 2017). Field data survey and collection have been completed for fish, insects (*Pteronarcys*) and habitat (topographic surveys and pebble counts). Data analysis for trout, aquatic insects, and physical habitat is ongoing.

Clear Creek

Physical habitat characteristics of Clear Creek near Idaho Springs, Colorado, have been highly modified from historic conditions. The stream is generally confined along most of the stream corridor by a major Interstate highway (I-70) on one side and a historic railway grade on the other. As most of Clear Creek has been channelized and armored with riprap to accommodate infrastructure, there are very few locations with functional floodplains resembling historic conditions. 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 0.4-mile riparian restoration and in-stream habitat project was completed in April 2015. Project goals were focused enhancing habitat for Brown Trout *Salmo trutta*, improving conditions and access for anglers, and restoring natural processes. Specific objectives included: removing armored riprap, improving floodplain connectivity by converting the existing two-stage channelized river to a nested, four-stage channel, establishing riparian vegetation, enhancing in-channel habitat features (e.g., spawning gravel substrate within enhanced glides), and excavating deep lateral scour pools. Baseline data were collected prior to construction activities. Fish population estimates, length-frequency distribution, and species composition will be monitoring for a total of five years (2015-2020) to evaluate project effectiveness.

Pre-construction baseline data were collected during the fall of 2012, 2013, and 2014 at two locations; upstream and downstream of the Doghouse Bridge at proposed high- and low-intensity habitat treatment sites. Pre-construction baseline data were collected at the high-intensity (two years) and low-intensity (three years) treatment sites. Fish sampling surveys established fish population composition, fish age-classes/sizes (length-frequency analysis), fish population size (number/mile), and fish biomass (lbs/acre) for populations within the project reach. Project effectiveness monitoring and analysis was based on data for Brown Trout only since they are wild and self-sustaining (not stocked), a popular game species for anglers, and fairly robust to other confounding variables such as whirling disease (i.e., Brown Trout are more resistant to whirling disease than Rainbow Trout *Oncorhynchus mykiss*).

The high-intensity treatment site is an approximately 1,300 foot long stream segment upstream of the Dog House Bridge. Primary treatments within this site consisted of riprap removal and removal of excess bank material to create a new flood plain and shape a new active channel that would align with the current channel-forming discharge (bankfull Q). This involved conversion of the existing highly-confined, channelized and riprapped, two-stage Rosgen F-stream type (confinement ratio <1.4; channel slope < 2%) to a moderately-confined, four-stage Rosgen Bc-stream type (confinement ratio 1.4-2.2; channel slope= 0.9%). Confinement was defined as the width of the valley at two times the average depth at bankfull (bkf) elevation divided by the bankfull (bkf) channel width. The pre-construction two-stage channel was converted to a post-construction four-stage channel with functional floodplain. The average confinement pre-construction within the high-intensity treatment reach was 1.2 (Figure 1.1; highly-confined channel). The average confinement post-construction was increased to nearly 2.0 (Figure 1.2; moderately-confined channel) due to the removal of riprap and expansion of floodplain area by removal of fill material. Other treatments within the high-intensity site included: addition of 153 habitat boulders (65% of total for the project or 153 of 234 total), installation of eight boulder structures (J-hooks, boulder half vanes, and cross vanes; 89% of total for the project or eight of nine total), 2,458 linear feet (lf) of boulder toe (91% of total for the project or 2,458 lf of 2,708 lf total), 10 constructed pools (71% of total number of pools for the project or 10 out of 14 total), 5,420 square feet (sf) of point bar development (100% of total for the project), and 18,775 sf of riparian bench development (100% of total for the project).

The low-intensity treatment site consisted of an approximately 650 ft long stream segment located downstream of the Dog House Bridge. Unlike the high-intensity site, the channel geometry was not altered in this reach (no removal of riprap, conversion of two-stage to four-stage channel, point bar development, or riparian bench development). The average confinement for this reach before (Figure 1.3) compared with after (Figure 1.4) the project did not change (1.2). The low-intensity treatment site remained highly confined, riprapped, and constrained between two roadways. Treatments in the low-intensity segment included addition of habitat boulders (35% of total for the project or 81 of 234 total), installation of one boulder structure (cross-vane; 11% of total for the project or one of nine total), 250 lf of boulder toe (9% of total for the project or 250 lf of 2,708 lf total), and four constructed pools of which three were located off the main channel in a side-channel (Figures 1.5 and 1.6; 29% of total number of pools for the project or four out of 14 total). No point bar development or riparian benches were constructed within the low-intensity treatment segment.

Three years of post-project monitoring of Brown Trout populations suggest that habitat treatments have resulted in an increase in Brown Trout density and biomass related to the fish habitat improvements in both high- (Figures 1.7 and 1.8) and low-intensity treatment sites (Figures 1.9 and 1.10). However, the magnitude of change within the high-intensity treatment site was higher for the total number of Brown Trout (Table 1.1; 152% increase) compared with the low-intensity treatment site (Table 1.1; 56% increase). Brown Trout biomass, the total pounds of Brown Trout per area, increased even more within the high-intensity treatment site (Table 1.1; 401% increase) as compared with the low-intensity site (Table 1.1; 51% increase). This suggests that the Brown Trout population within the high-intensity site not only had more fish per linear distance (density increase) than the low-intensity site, but also the population within the high-intensity site experienced a shift toward larger, adult fish within the

Figure 1.1. Pre-construction photo of the highly-confined "high-intensity" stream site as part of the Twin Tunnels project on Clear Creek.

Figure 1.2. Post-construction photo of the moderately-confined "high-intensity" stream site as part of the Twin Tunnels project on Clear Creek.

Figure 1.3. Pre-construction photo of the downstream "low-intensity" stream site as part of the Twin Tunnels project on Clear Creek.

Figure 1.4. Post-construction photo of the downstream "low-intensity" stream site as part of the Twin Tunnels project on Clear Creek.

Figure 1.5. Pre-construction photo of the downstream “low-intensity” stream site (side-channel treatment) as part of the Twin Tunnels project on Clear Creek.

Figure 1.6. Post-construction photo of the downstream “low-intensity” stream site (side-channel treatment) as part of the Twin Tunnels project on Clear Creek.

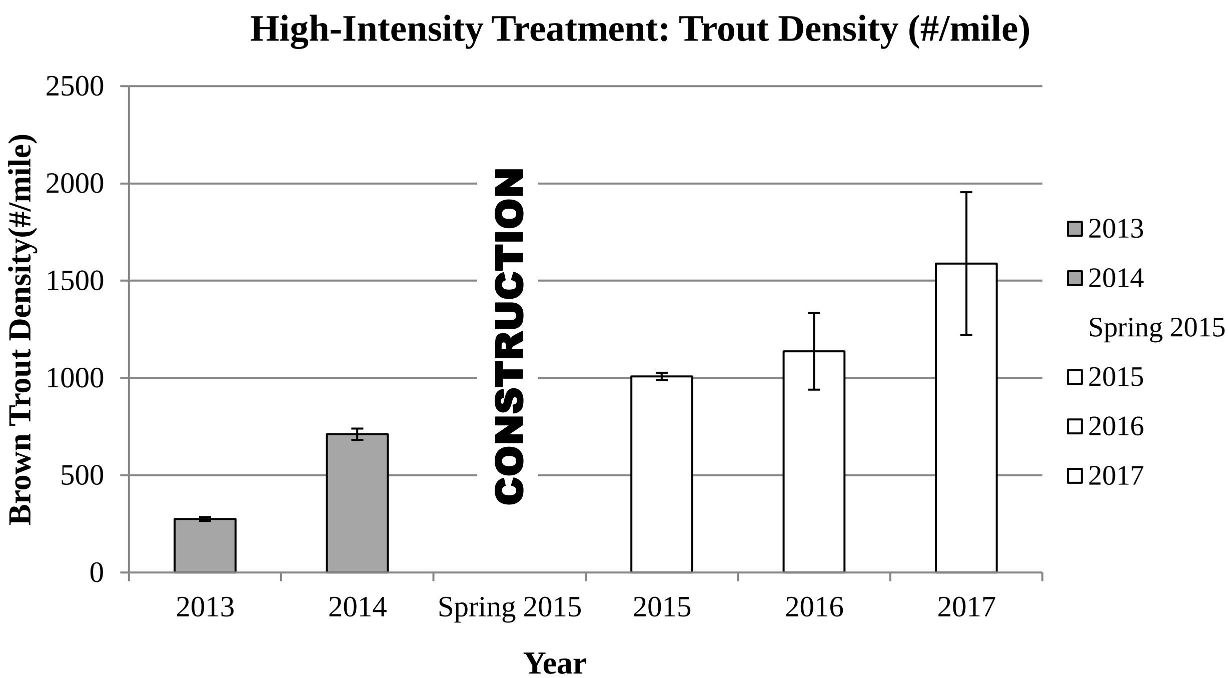

Figure 1.7. Brown Trout density (number/mile) within the "high-intensity" treatment site for pre- (shaded; 2013-2014) and post- (white; 2015-2017) construction years.

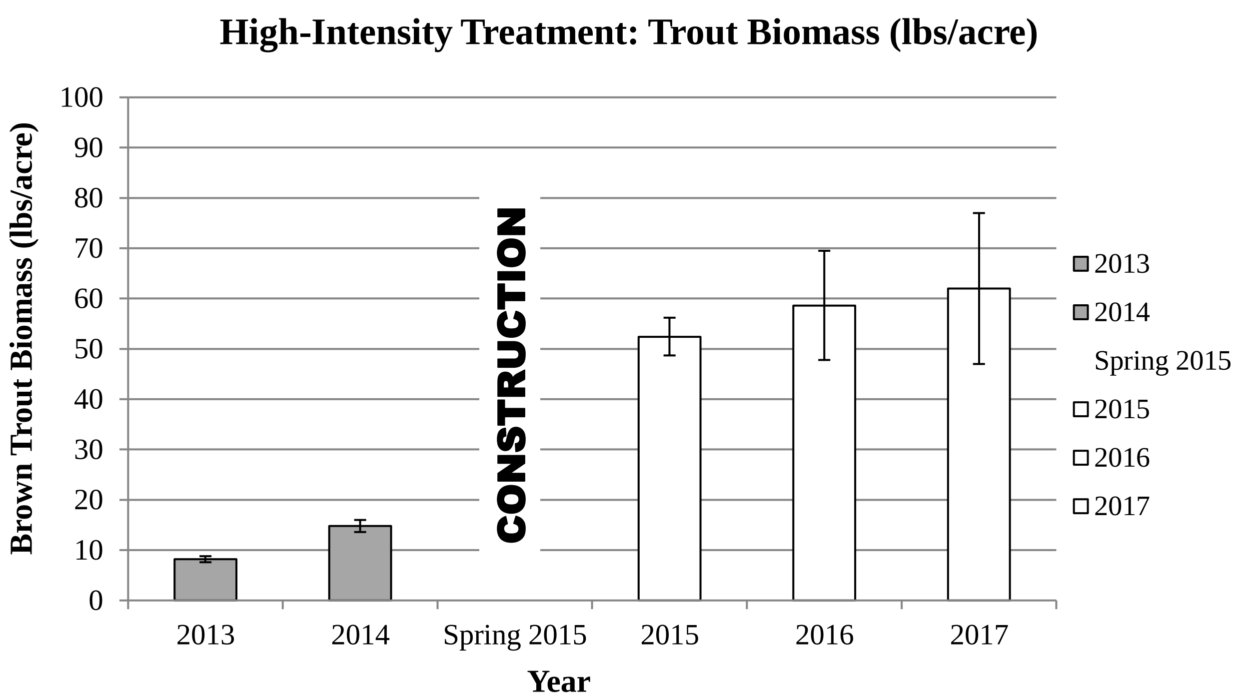

Figure 1.8. Brown Trout biomass (lbs/acre) within the "high-intensity" treatment site for pre- (shaded; 2013-2014) and post- (white; 2015-2017) construction years.

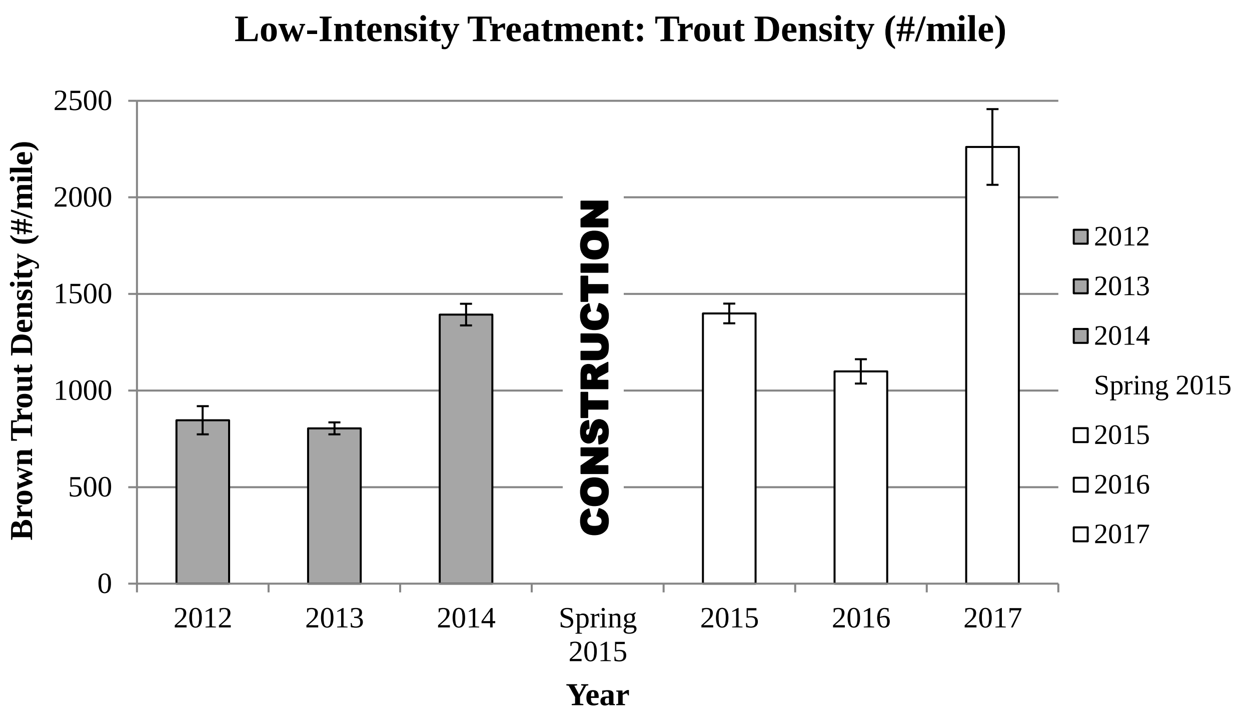

Figure 1.9. Brown Trout density (number/mile) within the "low-intensity" treatment site for pre- (shaded; 2013-2014) and post- (white; 2015-2017) construction years.

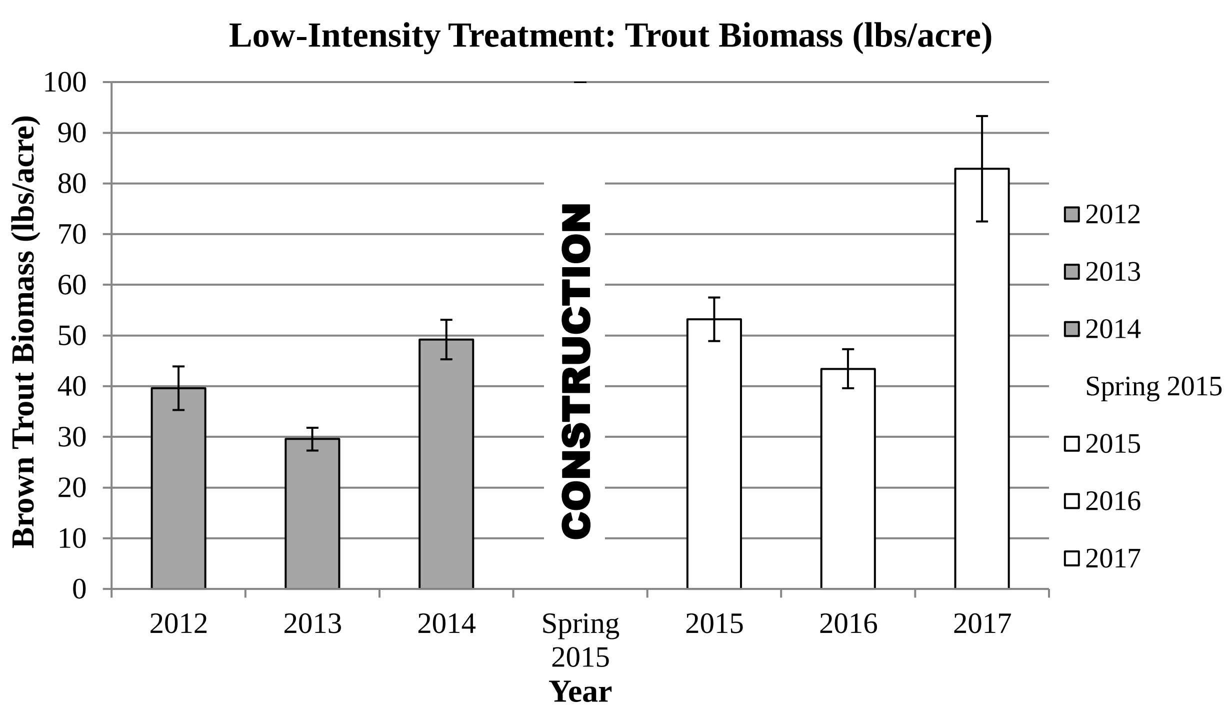

Figure 1.10. Brown Trout biomass (lbs/acre) within the "low-intensity" treatment site for pre- (shaded; 2013-2014) and post- (white; 2015-2017) construction years.

Table 1.1. Summary of Brown Trout density (n≥150 mm/mile) and biomass estimates (lb/acre) and statistics for the heavy-treated (Upper Reach) and lightly-treated (Lower Reach) of Clear Creek, Twin Tunnels stream restoration project. 95% confidence intervals for density and biomass estimated are shown in parentheses. Pre-construction and post-construction surveys were conducted during fall 2012, 2013, and 2014 and fall 2015, 2016, and 2017, respectively.

Year	High-Intensity: Upper Reach		Low-Intensity: Lower Reach	
	Density (n/mile)	Biomass (lb/acre)	Density (n/mile)	Biomass (lb/acre)
	Pre-Habitat Improvement Treatment Period			
2012	N/A	N/A	846 (773-919)	39.6 (35.3-43.9)
2013	275 (265-285)	8.2 (7.6-8.8)	804 (773-835)	29.6 (27.3-31.8)
2014	711 (682-740)	13.6 (13.6-16.0)	1,393 (1337-1449)	49.2 (45.3-53.1)
Average	**493**	**11.5**	**1,014**	**39.5**
	Post - Habitat Improvement Treatment Period			
2015	1,008 (989-1027)	52.4 (48.7-56.2)	1,399 (1348-1450)	53.2 (48.9-57.5)
2016	1,137 (940-1,334)	58.6 (47.8-69.5)	1,099 (1,036-1,162)	43.4 (39.6-47.3)
2017	1,588 (1,221-1,955)	62.0 (47-77)	2,261 (2,065-2,457)	82.9 (72.5-93.3)
Average	**1,244**	**57.7**	**1,586**	**59.8**
% Change (Magnitude)	**+152.3% (+2.5×)**	**+401.7% (+5.0×)**	**+56.4% (+1.6×)**	**+51.4% (+1.5×)**

high-intensity treatment site (much larger increase in total Brown Trout biomass) as compared with the low-intensity treatment site. Monitoring of both sites will continue for the next two years for a total of five years post-construction.

Yampa River

With some of the highest trout densities and biomass anywhere in Colorado, the Yampa River downstream of Stagecoach Reservoir is one of the most popular tailwater trout fishing destinations in the United States. Bank failure due to trampling from angler use, loss of stabilizing vegetation, and non-functional, in-channel boulder check dam features were the primary causes of habitat degradation and loss of trout productivity over time. Limiting factors to trout habitat included spawning habitat (exceedingly shallow depths or high concentrations of fine sediment), cover for adults (few undercut banks, deep pools, over-hanging bank vegetation, and large wood), and limited in-channel habitat complexity (in-channel structure to create resting areas and increase habitat complexity). Many of these limiting factors were addressed by a 0.25-mile habitat enhancement project that was completed in 2013. Target species for habitat enhancement include Rainbow Trout and Brown Trout.

Fish sampling was conducted for 14 years prior to habitat enhancement, providing a robust baseline dataset for post-project comparison. The second year of post-construction fish sampling was conducted in the fall of 2016 as part of a five-year monitoring study. Monitoring data will be used to evaluate fish population estimates, length-frequency distributions, and species composition in response to habitat enhancement activities. Since this is a unique tailwater reach, no suitable control site was located for comparison purposes. Therefore, habitat and fisheries response will be monitored as a before-after comparison only.

This project is being used as part of a larger research effort that began in the fall of 2017 to determine the relative contribution of habitat enhancement, fish stocking, and manipulation of competitive Brown Trout populations with the goal of re-establishing a wild Rainbow Trout fishery in the larger channel reach. A total of four distinct stream segments have been identified for detailed study, including the restored Stagecoach Tailwater reach. Data collection is ongoing. Further details about this larger-scale study and plan for surveying habitat attributes of each study reach are found in Fetherman et al. (2018).

Arkansas River

The Upper Arkansas River Habitat Restoration Project near Leadville, Colorado, was implemented in 2013-2014 to address degraded fish habitat. Historic mining activities severely degraded water quality within the upper watershed and limited trout population abundance and growth rates in the Upper Arkansas River. As water quality treatment measures have been implemented, fish populations have recovered to a degree. Fisheries biologists have determined the next steps in recovering trout populations will come from addressing fish habitat limitations. Six fish monitoring sites (including three untreated, control sites) were established within the project reach to measure the effectiveness of habitat restoration. This project is unique in that some fish sampling sites have more than 16 years of baseline data collected prior to project implementation. These data provide baseline information for comparison with post-construction monitoring. Post-construction fish surveys were initiated in 2014 following completion of instream construction activities and will continue annually for five years. Fish population estimates, length-frequency distributions, and species composition were surveyed in August 2017. Additional fish surveys are scheduled for 2018 (year-5), 2020 (year-7), and 2023 (year-10) to support long-term evaluation of the project. Preliminary results from fish population monitoring were presented by Richer et al. (2017).

South Platte River

Different "approaches" for trout-habitat enhancement (i.e., boulder vs. large-wood treatments) are being evaluated with a long-term BACT study on the South Platte River and Middle Fork South Platte River in South Park, Colorado. Four long-term monitoring sites include an upstream reference reach site (Tomahawk SWA), toe-wood and large wood-dominated treatment site (Badger Basin SWA), boulder-dominated treatment site (Badger Basin SWA), and a downstream impaired control site (Badger Basin SWA). Data have been collected at the boulder-treated and downstream control since 1990. All four of the long-term monitoring sites were sampled during the fall of 2016 but not in 2017 due to personnel changes. Fish population estimates, length-frequency distribution, and species composition will be monitored during the next reporting cycle as part of a long-term (20+ years) effort to measure the effectiveness of different approaches to fish habitat enhancement.

Action #2:

- Level 1 Action <u>Category</u>: Data Collection and Analysis
- Level 2 Action <u>Strategy</u>: Research, survey or monitoring – habitat
- Level 3 Action <u>Activities</u>: Baseline inventory; Monitoring

Topographic and sediment surveys will be used to evaluate changes in longitudinal profile, cross-sections, sediment, and habitat suitability. BACT studies will be conducted at appropriate site locations to evaluate changes in channel morphology following restoration. For select sites, an Acoustic Doppler Current Profiler (ADCP) will be use to survey bathymetry and hydraulics. Project sites include the (1) Wason and LaGarita Ranches, Rio Grande River, (2) Twin Tunnels Project, Clear Creek, (3) Upper Arkansas River, and (4) Charlie Meyers SWA, South Platte River.

Action #2 Accomplishments:

Collection and/or analysis of topographic and sediment data were successfully conducted at three of the sites listed above: Clear Creek, Upper Arkansas River, and South Platte River. Surveys for the Wason and LaGarita Ranches on the Rio Grande River were completed during previous reporting periods, but data analysis and reporting is still in process. Accomplishments for each project are described in more detail below.

Rio Grande River

Topographic and bathymetric surveys were conducted at the Wason and LaGarita Ranches on the Rio Grande River during the fall of 2015. Survey data were used to configure and calibrate HEC-RAS models to evaluate habitat characteristics (e.g., width, depth, velocity, and slope) across a range of flows. Survey data and hydraulic models will also be used to evaluate longitudinal profiles and cross-sections for each study reach. Data analysis and reporting for this project is ongoing.

Clear Creek

Topographic and sediment surveys for the 0.4-mile Twin Tunnels Stream Restoration Project on Clear Creek were successfully completed during October 2016. Goals and objectives for the Twin Tunnels project were presented under Job 1, Action #1 in this report. Survey data were used to produce as-built drawings for the project, which are presented in Appendix A. Longitudinal profiles and cross-sections are compared for pre-construction and post-construction conditions in the as-built drawing. As-built quantities for restoration treatments are presented in Table 1.2. Treatments included over 230 habitat boulders, three log vanes, and nine boulder structures. Boulder structures include six half-vanes (ribs) to enhance complexity in the upstream riffle, as well as two J-hook structures and one cross-vane to support pool development. Boulder toe, point-bar development, and riparian benches were used to improve floodplain connectivity in the reach upstream of the bridge. Improved floodplain connectivity is illustrated at cross-sections 1-5 in the as-built drawings (Appendix A).

Sediment surveys were conducted by measuring the intermediate axis for ~100 pebbles at select cross sections. Cumulative grain-size distributions were analyzed for each cross section individually and for all cross section pooled together. Values for the D_{16}, D_{50}, and D_{84} were derived using the Size-Class Pebble Count Analyzer developed by Potyondy and Bunte (2002) and are reported in Table 1.3. When composited across all cross sections, sediment size appears to be finer following implementation of the restoration project, with the D_{16} decreasing from 45 mm to 16 mm (-64%), the D_{50} decreasing from 127 mm to 78 mm (-39%), and the D_{84} decreasing from 287 mm to 269 mm (-28%). The D_{50} and D_{84} did not change sediment size classes between pre- and post-construction surveys, as they remained classified as small cobble and large cobble, respectively. However, the D_{16} did change from coarse gravel to medium gravel. As 10-70 mm gravels are considered "Class A" spawning gravels for Brown Trout *Salmo trutta* (Raleigh et al. 1986), the reduction in sediment size following restoration activities indicates that spawning habitat within the project reach may be improved over pre-construction conditions. Reduced sediment size following restoration could be related to decreased sediment transport capacity associated with improved floodplain connectivity. In-channel shear stress during high flows should be lower in the post-restoration channel with its functional floodplain when compared to the artificially confined and armored pre-restoration channel. This reduction in shear stress could result in deposition of finer material within the project reach. However, finer sediment may also be related to sampling bias associated with pebble count procedures.

Table 1.2. As-built quantities for restorations treatment at the Twin Tunnels Stream Restoration Project on Clear Creek, Colorado.

Treatment	Quantity	Units
Habitat Boulder	234	Each
Log Vane	3	Each
Boulder Structure	9	Each
Boulder Toe	2,708	LF
Pool Development	11,192	SF
Point-Bar Development	5,420	SF
Riparian Bench	18,775	SF

Table 1.3. Sediment gradation values (mm) for pre-construction (2012) and post-construction (2016) pebble counts conducted at selection cross sections within the Twin Tunnel project reach, including composite values for all cross sections and the percent change between surveys.

Cross Section	2012			2016			Percent Change		
	D_{16}	D_{50}	D_{84}	D_{16}	D_{50}	D_{84}	D_{16}	D_{50}	D_{84}
1	0.5	110	218	6	68	150	1131%	-38%	-32%
2	14	112	215	14	63	133	-2%	-44%	-38%
3	49	121	187	35	96	193	-28%	-20%	4%
7	96	159	267	6	99	183	-93%	-38%	-31%
8	61	126	241	2	59	149	-97%	-53%	-38%
11	62	124	287	23	63	206	-64%	-49%	-28%
12	60	144	287	34	109	269	-44%	-25%	-6%
All	45	127	245	16	78	176	-64%	-39%	-28%

Arkansas River

Annual longitudinal and cross-section surveys were completed for the 5.0-mile Upper Arkansas River Habitat Restoration Project during the fall of 2017. Surveys will be repeated during the fall of 2018, which will represent the fifth year of post-restoration monitoring. Results from all monitoring efforts will be analyzed and synthesized into a comprehensive monitoring report to evaluate effectiveness of the restoration project. The five-year monitoring report should be published in 2019, along with various peer-review publications. During this reporting period, preliminary monitoring results were presented at the Sustaining Colorado Watershed Conference (Richer and Gates 2017) and for the U.S. Fish and Wildlife Service National Conservation Training Center Restoration Webinar Series (Richer 2017).

South Platte River

As-built surveys for the 1.2-mile Charlie Meyers SWA Habitat Enhancement Project were completed during August 2016. Survey data were used to produce as-built drawings and 1D hydraulic models to support before-after habitat evaluation. As-built drawings for the project show the location of restoration treatments and comparison of pre-construction and post-construction longitudinal profiles (Appendix A). As-built quantities for restoration treatments are presented in Table 1.4. Treatments included 14 habitat boulders, three log/rock vanes, and nearly of mile of wood toe. Restoration of riparian vegetation was one of the primary objectives for the project, and almost an acre of stream bank was treated with willow stakes or transplants. To enhance bedform diversity and holding habitat for trout, approximately 1.7 acres of point bar development and 1.4 acres of pool development were conducted during project implementation. The effects of pool development are evident in the post-construction longitudinal profile included with the as-built drawings in Appendix A. Results from hydraulic modeling are still being analyzed to evaluate changes in width/depth ratio and bedform diversity.

Table 1.4. As-built quantities for restorations treatment implemented for the Charlie Meyers SWA Habitat Enhancement Project, South Platte River, Colorado.

Treatment	Quantity	Unit
Habitat Boulder	14	Each
Log/Rock Vane	3	Each
Cobble Toe	2,623	LF
Wood Toe	5,254	LF
Fill	23,375	SF
Point Bar Development	72,650	SF
Pool Development	58,837	SF
Willow Stakes	36,252	SF
Willow Transplants	3,179	SF

Expected Results and Benefits

Research findings will elucidate how stream restoration and habitat treatments improve fishery resources, as well as channel form and function. Study results will help refine techniques and maximize the benefit of habitat restoration on stream functions and Rainbow Trout and Brown

Trout fisheries. Results from multiple habitat-improvement projects will be synthesized to provide guidance for future restoration projects as part of a multi-year analysis.

References

Bernhardt, E. S., M. A. Palmer, J. D. Allan, G. Alexander, K. Barnas, S. Brooks, J. Carr, S. Clayton, C. Dahm, J. Follstad-Shah, D. Galat, S. Gloss, P. Goodwin, D. Hart, B. Hassett, R. Jenkinson, S. Katz, G. M. Kondolf, P. S. Lake, R. Lave, J. L. Meyer, T. K. O'Donnell, L. Pagano, B. Powell, E. Sudduth. 2005. Synthesizing U.S. river restoration efforts. Science 308: 636-637.

Fetherman, E. R., G. J. Schisler, and B. W. Avila. 2018. Sport Fish Research Studies. Federal Aid Project F394-R17. Federal Aid in Fish and Wildlife Restoration, Job Progress Report. Colorado Parks and Wildlife, Aquatic Wildlife Research Section. Fort Collins, Colorado.

Potyondy, J., and K. Bunte. 2002. Analyzing pebble count data collected by size classes (MS Excel Spreadsheet). Downloaded from the USFS National Stream and Aquatic Ecology Center on October 3, 2016.

Raleigh, R. F., L. D. Zuckerman, and P. C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: Brown Trout. Biological Report 82 (10.124). National Ecology Center, Division of Wildlife and Contaminant Research, U.S. Fish and Wildlife Service, Washington, DC.

Richer, E. E., and E. A. Gates. 2017. Using long-term monitoring to inform adaptive management for the Upper Arkansas River habitat restoration project. Sustaining Colorado Watersheds Conference, Avon, Colorado. October 11, 2017.

Richer, E. E. 2017. Using long-term monitoring to inform adaptive management for the Upper Arkansas River habitat restoration project. Restoration Webinar Series, National Conservation Training Center, U.S. Fish and Wildlife Service. December 7, 2017.

Walters, D. M., J. S. Wesner, R. E. Zuellig, D. A. Kowalski, and M. C. Kondratieff. 2017. Holy flux: spatial and temporal variation in massive pulses of emerging insect biomass from western U.S. rivers (The Scientific Naturalist). Ecology.

Wohl, E. 2011. Seeing the forest for the trees: wood in stream restoration in the Colorado Front Range, United States. Pages 339–418 in Simon A., S.J. Bennett, J.M. Castro, eds. *Stream Restoration in Dynamic Fluvial Systems: Scientific Approaches, Analyses, and Tools*. American Geophysical Union.

Job 2: Fish Passage Studies

Need

Upstream migration is a vital component of the salmonid life cycle. Trout are known to migrate upstream to find ideal spawning habitat and then move back downstream to over-winter in warmer, lower-velocity, and more productive waters. Connectivity between spawning, rearing, and feeding habitats, as well as refuge from environmental extremes such high flows or water temperatures, are essential components of a trout fishery (Schlosser and Angermeir 1995). Instream obstacles, such as waterfalls, culverts, and water-diversion structures, can have anthropogenic impacts on fisheries by fragmenting critical habitats. Therefore, it is important that fisheries managers identify and evaluate the impact of instream migration barriers on fish populations.

Objectives

1. Provide guidance and technical assistance for two fish-passage feasibility studies by June 30, 2018.

Approach

Action #1:
- Level 1 Action Category: Technical Assistance
- Level 2 Action Strategy: Technical Assistance
- Level 3 Action Activities: With individuals and groups involved in resource management decision making

Implementing fish passage at diversion structures in Colorado is a challenging process, due to design, funding, permitting, and legal constraints (Richer et al. 2015). Given these challenges, feasibility studies have been identified as a means to evaluate conceptual alternatives for fish passage while building support among project stakeholders. We will provide technical assistance for the following feasibility studies: (1) the Whitney and BH Eaton Fish Passage Project on the Cache la Poudre River and (2) the Fish Passage and Ditch Diversion Resiliency Project on St. Vrain Creek. The objective of these projects is to provide fish passage for all species present in the project reaches, including Rainbow Trout *Oncorhynchus mykiss*, Brown Trout *Salmo trutta*, and various forage species.

Action #1 Accomplishments:

We provided technical assistance for both of the feasibility studies listed above. The Whitney and BH Eaton Fish Passage Feasibility Study was completed during the fall of 2016. Implementing fish passage at both diversion structures would reconnect 13.1 miles of fish habitat within the Cache la Poudre River. The feasibility study provided 30% design alternatives for implementing fish passage at both structures. CPW provided fish passage criteria, baseline fisheries survey data, and technical guidance for the feasibility study. Project implementation is on hold until both ditch companies agree to acceptable designs from the feasibility study and funding sources for implementation are identified.

The Fish Passage and Ditch Diversion Resiliency Project on St. Vrain Creek is focused on developing a 90% design for fish passage at the Niwot Ditch and conducting a conceptual alternatives analysis for fish passage at the South Flat Ditch. The U.S. Fish and Wildlife Service (USFWS) provided funding for the feasibility study in partnership with Trout Unlimited (TU), Boulder County, CPW, private landowners, and ditch companies. CPW has provided technical assistance to support project coordination, design, and permitting. Implementing fish passage at both diversion structures will reconnect 2.6 miles of critical fish habitat in St. Vrain Creek. The 60% design for the Niwot Ditch is being revised to address stakeholder concerns about water delivery and structural integrity. Once the 60% design is approved by all stakeholders, the 90% design will be finalized with the intention of starting construction during the fall of 2018. The conceptual alternatives analysis for the South Flat has been completed. Project stakeholders are waiting on successful implementation of the Niwot project before moving forward with additional work on the South Flat diversion structure.

Expected Results and Benefits

Most rivers in the Colorado are fragmented by numerous diversion structures that prevent upstream migration of sportfish, adversely affect sediment transport, entrain downstream migrating fish in irrigation ditches, and sporadically dry up river segments during periods of drought or baseflow. The loss of Rainbow Trout and Brown Trout from fragmentation and entrainment is economically costly and represents a loss of public recreation opportunity when fish are unavailable for capture and/or harvest. Fish passage research is focused on evaluating the effectiveness of fish passage structures and the impact of diversion structures on aquatic habitat, as well as the development of species-specific design criteria to improve connectivity in Colorado rivers and streams.

References

Richer, E. E., M. C. Kondratieff, and B. D. Swigle. 2015. Post-flood recovery assessment and stream restoration guidelines for the Colorado Front Range. Colorado Parks and Wildlife, Fort Collins.

Schlosser, I. J., and P. L. Angermeier. 1995. Spatial variation in demographic processes for lotic fishes: conceptual models, empirical evidence, and implications for conservation. American Fisheries Society Symposium 17:392-401.

Job 3: Whitewater Park Studies

Need

With more whitewater parks than any other state, Colorado has become the epicenter for whitewater park design and construction. Whitewater parks contribute to local communities by providing revenue from tourism, promoting public interest in rivers, and creating additional recreational opportunities. However, whitewater parks can create hydraulic conditions that impair upstream migration of fish (Stephens et al. 2015; Fox et al. 2016) and create unfavorable fish habitat (Kolden et al. 2015). As a variety of whitewater park designs are being used throughout Colorado, CPW will build upon previous research by studying different types of structures and their effects on Rainbow Trout *Oncorhynchus mykiss* and Brown Trout *Salmo trutta* populations and habitat.

Objectives

1. Survey and quantify salmonid populations at two whitewater parks sites to evaluate impacts on fish passage and habitat by June 30, 2018.
2. Survey channel morphology and hydraulics at two whitewater parks sites to evaluate impacts on fish passage and habitat by June 30, 2018.
3. Results and analysis will be collated from multiple studies with the goal of producing management tools for development of fish-friendly whitewater parks (multi-year analysis).

Approach

Action #1:

- Level 1 Action <u>Category</u>: Data Collection and Analysis
- Level 2 Action <u>Strategy</u>: Research, survey or monitoring – fish and wildlife populations
- Level 3 Action <u>Activities</u>: Abundance determination; Age, size, and sex structure

Conduct Before-After studies on two new whitewater parks. Study sites are the Montrose Whitewater Park on the Uncompahgre River and the Gore Canyon Whitewater Park at Pumphouse on the Colorado River. Fish populations will be monitored with the assistance of biologists and researchers before and after construction of the whitewater parks to evaluate their impact on trout fisheries.

Action #1 Accomplishments:

The Montrose Whitewater Park was constructed during the winter of 2015-2016 and includes six channel-spanning structures. Each structure consists of a pre-cast concrete block placed in center of the channel with boulder wing walls extending laterally to each bank. Fishways were incorporated into one of the boulder wing walls at each structure. Fish sampling sites were established upstream, within, and downstream of the Montrose Whitewater Park. Upstream and downstream sites were not impacted during whitewater park construction and will serve as control sites for comparison to the whitewater park reach. One year of baseline monitoring data was collected at all three sites prior to construction. The third and final year of post-construction fish sampling was completed in November 2017. Monitoring data will be used to determine if the whitewater park structures alter fish populations, habitat, or passage.

The Gore Canyon Whitewater Park at Pumphouse consists of a single channel-spanning structure that splits flows into two chutes. One chute was intended to accommodate fish and drift-boat passage. The other chute was designed to provide whitewater recreation for kayaks and stand-up paddleboards (SUP). Construction of the project was completed during the spring of 2015. Fish sampling was conducted within the project reach during the fall of 2014 to establish one year of baseline, pre-construction data. The third and final year of post-construction fish sampling was completed in September 2017. Fisheries data will be used to determine if the whitewater park structure has altered fish populations upstream or downstream of the structure and provide evidence if the structure inhibits upstream fish passage.

Action #2:

- Level 1 Action Category: Data Collection and Analysis
- Level 2 Action Strategy: Research, survey or monitoring – habitat
- Level 3 Action Activities: Baseline inventory; Monitoring

Impacts to habitat quality and fish passage will be assessed by surveying water depth and velocity with an ADCP before and after project construction. In addition, topographic surveys will be conducted before and after construction to evaluate changes in channel morphology. Survey data will also be used to configure 2D hydraulic models for assessing changes in habitat suitability and fish passage across a range of flows. Results for ADCP measurements and 2D modeling will be combined to elucidate if whitewater park construction has affected fish passage or habitat quality at these study sites.

Action #2 Accomplishments:

Survey data from the Montrose Whitewater Park on the Uncompahgre River were used to configure and calibrate HEC-RAS models for both pre-project and post-project conditions. Results from HEC-RAS models were used to evaluate changes in channel morphology and hydraulics, as well as inform boundary conditions for River2D habitat models. Configuration and calibration of 2D models was completed during this reporting cycle. Results from hydraulic modeling are being used to evaluate the impact of whitewater park implementation on habitat suitability and fish passage. Data analysis and synthesis for the Montrose Whitewater Park should be completed during the next reporting cycle.

Multiple surveys were conducted at the Gore Canyon Whitewater Park at Pumphouse on the Colorado River during previous reporting periods. Topographic and bathymetric surveys were conducted to document pre-project and post-project channel morphology. An ADCP was used to measure water depths and velocities throughout the project reach to provide calibration and validation data for hydraulic and habitat models. Survey data were used to configure and calibrate HEC-RAS and River2D models for both pre-construction and post-construction conditions. The before-after comparison will evaluate the impact of whitewater park implementation on habitat suitability and fish passage.

Fish passage at both study sites is being evaluated by comparing modeled depths and velocities to fish passage criteria for juvenile, average-adult, and large-adult Brown Trout, Mottled Sculpin *Cottus bairdii*, and White Sucker *Catostomus commersonii*. Velocities and depths were extracted from 2D modeling results along potential passage pathway derived with the Least Cost Path tool in ArcGIS. The maximum velocity and minimum depth along each path is compared to passage criteria for both before and after conditions to evaluate changes in fish passage. Data processing has been completed at both study sites, but analysis and reporting is ongoing. Preliminary results from fish passage evaluations were presented at the Western Division AFS Meeting (Brubaker et al. 2018). Fish passage and habitat analyses for the Pumphouse and Montrose whitewater park studies will be synthesized into peer-review papers that should published in 2018 or 2019.

Action #3:

- Level 1 Action Category: Technical Assistance
- Level 2 Action Strategy: Technical Assistance
- Level 3 Action Activities: With individuals and groups involved in resource management and decision making

As research scientists, our responsibilities include disseminating research results to promote science-based resource management decisions to whitewater park designers, water management agencies, and aquatic resource management agencies.

Action #3 Accomplishments:

Previous whitewater park research was conducted at the Lyons Whitewater Park on the North Fork of St. Vrain Creek. These research projects produced three peer-reviewed publications (Kolden et al. 2015, Stephens et al. 2015; Fox et al. 2016) and five theses (Fox 2013; Kolden 2013; Stephens 2014; Ryan 2015; Hardee 2017) to provide the foundation for scientifically defensible management tools and development of fish-friendly whitewater parks. These publications provide insight into potential impacts on fish passage, fish habitat, and methods for assessing fish passage using 2D and 3D hydraulic modeling methods.

The latest thesis was completed by Travis Hardee (Hardee 2017), a graduate student from Colorado State University, and included two separate analyses. The first chapter of his thesis involved a comparison of less-expensive, simpler and data-intensive 2-dimensional (2D) hydraulic modeling techniques with 3-dimensional (3D) hydraulic modeling techniques. The second chapter of his thesis involved using the 2D hydraulic modeling techniques to evaluate the newly constructed whitewater park structures that were re-constructed after the 2013 flood on St Vrain Creek. The newly constructed structures incorporated a “fish notch” that was intended to provide upstream passage through the structure. The third chapter of his thesis provides guidance and methodology on how to apply the 2D hydraulic models to any other whitewater park structure for fish passage evaluation.

As part of the 2D vs. 3D hydraulic model evaluation, fish swimming paths were extracted from 2D models and evaluated for depth and velocity criteria for fish passage to yield a fraction of potential flow paths corresponding to any range of discharges for a given WWP structure. Results from the 2D analysis were used to predict fish passage at WWP structures for which we have collected real fish passage movement data from PIT tagged fish. Results from his study suggested that 2D models were at least as good or better at predicting upstream fish passage as more expensive and data-intensive 3D models. The 2D models were useful for evaluating the complex hydraulic conditions fish encounter at WWP structures at scales relevant to upstream fish movement.

The second part of Travis' study involved evaluating the transferability of the 2D methods to the newly reconstructed Lyons Whitewater Park structures that were destroyed during the 2013 flood. The reconstruction of the Lyons Whitewater Park in 2016 provided an opportunity to compare fish passage analyses for the old and new whitewater parks using similar methodology. Part of this analysis includes developing management tools for evaluating whitewater parks and informing fish-friendly whitewater park designs. Fish passage analyses for the new Lyons Whitewater Park and development of management tools is ongoing.

Expected Results and Benefits

Information from this study is being used to determine the impact of whitewater park construction on Rainbow Trout *Oncorhynchus mykiss* and Brown Trout *Salmo trutta* populations, habitat, and movement. In addition, results will be used to develop design guidelines for whitewater parks that optimize both recreational and ecological benefits.

References

Brubaker, A. E., E. E. Richer, D. A. Kowalski, and M. C. Kondratieff. 2018. Making waves: the effects of whitewater parks on fish passage. Western Division American Fisheries Society 43rd Annual Meeting, Anchorage, Alaska. May 22, 2018.

Fox, B. 2013. Eco-hydraulic evaluation of whitewater parks as fish passage barriers. M.S. Thesis, Department of Civil and Environmental Engineering, Colorado State University.

Fox, B. D., B. P. Bledsoe, E. Kolden, M. C. Kondratieff, and C. A. Myrick. 2016. Eco-hydraulic evaluation of whitewater parks as a fish passage barrier. Journal of the American Water Resources Association. DOI: 10.1111/1752-1688.12397.

Hardee, T. L. 2017. Evaluating fish passage at whitewater parks using a spatially explicit 2D hydraulic modeling approach. M.S. Thesis, Department of Civil and Environmental Engineering, Colorado State University.

Kolden, E. 2013. Modeling in a three-dimensional world: Whitewater park hydraulics and their impact on aquatic habitat in Colorado. M.S. Thesis, Department of Civil and Environmental Engineering, Colorado State University.

Kolden, E., B. D. Fox, B. P., Bledsoe, and M. C. Kondratieff. 2015. Modelling whitewater park hydraulics and fish habitat in Colorado. River Research and Applications, DOI: 10.1002/rra.2931.

Ryan, E. R. 2015. Effects of hydraulic structures on fish passage: an evaluation of 2D vs 3D hydraulic analysis methods. M.S. Thesis, Department of Civil and Environmental Engineering, Colorado State University.

Stephens, T. A. 2014. Effects of whitewater parks on fish passage: a spatially explicit hydraulic analysis. M.S. Thesis, Department of Civil and Environmental Engineering, Colorado State University.

Stephens, T. A., B. P. Bledsoe, B. D. Fox, E. Kolden, and M. C. Kondratieff. 2015. Effects of whitewater parks on fish passage: a spatially explicit hydraulic analysis. Ecological Engineering 83:305-318.

Job 4: Development and Evaluation of a Radio Frequency Identification and GPS System

Need

Mobile radio-frequency identification (RFID) systems that detect passive integrated transponder (PIT) tags can be used to analyze survival of aquatic species, fish movement patterns, and habitat utilization (Fetherman et al. 2014). RFID systems have been used in small, wadeable rivers to detect fish using both stationary and mobile designs (Fetherman et al. 2014). Incorporating mobility and GPS technology into RFID systems can link the spatial distribution of fish to individual characteristics, such as species, length, and weight. Combining individual characteristics with spatial data has a vast range of research possibilities, including seasonal fish migration patterns, the effects of instream barriers on fish migration, habitat utilization by species and age-class, mark-recapture population estimates, the response of aquatic organisms to climate change, as well as the impact of land use on aquatic species. Mobile RFID systems may also be used to evaluate PIT tag retention and inform the design of future fish movement studies.

Objectives

1. Conduct one study that utilizes the mobile RFID-GPS system to evaluate seasonal movement patterns for Rainbow Trout *Oncorhynchus mykiss* and Brown Trout *Salmo trutta* by June 30, 2018.

Approach

Action #1:

- Level 1 Action Category: Data Collection and Analysis
- Level 2 Action Strategy: Research, survey or monitoring – fish and wildlife populations
- Level 3 Action Activities: Movement

The RFID-GPS system will be deployed on the Middle Fork South Platte River near Hartsel, Colorado. The system will be deployed in study reaches at select times to evaluate seasonal movement patterns, reach-scale habitat utilization for trout, and issues with PIT-tag retention.

Action #1 Accomplishments:

The RFID-GPS system was deployed seasonally within project reaches from October 2014 through October 2016. Detection data from the RFID-GPS system will be combined with detection data from four fixed antenna sites to evaluate trout movement patterns. Data collection for this project was completed during the spring of 2017 when all fixed antenna sites were decommissioned. Preliminary results indicate that some Brown Trout *Salmo trutta* are migrating at least 25 river miles to access spawning habitat, whereas some Rainbow Trout *Oncorhynchus mykiss* are migrating at least 21 river miles to access spawning habitat. These finding are critically important for evaluating the importance of longitudinal connectivity in Colorado rivers and streams, where the prevalence of diversion structures and other barriers has severely fragmented aquatic habitat. Methods development for the RFID-GPS system was published in the North American Journal of Fisheries Management during this reporting period (Richer et al. 2017).

The RFID-GPS system has also proven useful for evaluating issues with PIT-tag retention in salmonids. Protocols for evaluating the prevalence of ghost tags, PIT tags that are no longer inside fish due to expulsion or mortality, were applied in the fall of 2015 and 2016 in select study reaches. Preliminary results from ghost tag evaluations were presented at the Western Division AFS Meeting (Richer et al. 2018). Over 480 ghost tags were detected in study reaches, representing 36% of all Brown Trout that were PIT-tagged for the movement study. Ghost tags were detected for all size classes of tagged trout, and provided valuable information regarding the fate of individual fish. Ghost tags were detected up to 18.5 miles upstream and 11.6 miles downstream of release locations. Failure to account for ghost tags may bias estimates for tagged populations, vital rates, and movement patterns. Future research will focus on comparing trout movement patterns to individual characteristics (species, length, spotting-pattern, age, sex, genetics, and diet) with the intention of producing additional peer-review publications by 2020.

Expected Results and Benefits

This study will help identify the strengths and limitations of the mobile RFID-GPS system for detecting PIT-tagged fish in natural river systems. In addition, detection data should elucidate seasonal migration patterns for Rainbow Trout and Brown Trout. Data will be used to evaluate migration patterns, reach-scale habitat utilization by species and size class, and PIT-tag retention by species and size class.

References

Fetherman, E. R., B. W. Avila, and D. L. Winkelman. 2014. Raft and floating radio frequency identification (RFID) systems for detecting and estimating abundance of PIT-tagged fish in rivers. North American Journal of Fisheries Management 34(6): 1065-1077, DOI: 10.1080/02755947.2014.943859.

Richer, E. E., E. R. Fetherman, M. C. Kondratieff, and T. A. Barnes. 2017. Incorporating GPS and mobile radio frequency identification to detect PIT-tagged fish and evaluate habitat utilization in streams. North American Journal of Fisheries Management 37(6):1249-1264, DOI: 10.1080/02755947.2017.1374312.

Richer, E. E., E. R. Fetherman, and M. C. Kondratieff. 2018. Haunted rivers: application of mobile RFID-GPS systems to evaluate the prevalence of ghost PIT tags. Western Division American Fisheries Society 43rd Annual Meeting, Anchorage, Alaska. May 23, 2018.

Job 5: Technical Assistance

Need

CPW and other state and federal personnel are frequently in need of technical assistance related to stream habitat restoration, fish passage, whitewater park, and post-flood recovery projects. Technical assistance for projects will be provided as needed, including project identification, selection, design, evaluation, and permitting. Technical assistance includes design review for CPW 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, consultations and technical support related to stream mitigation work for 404 permits, technical assistance related to fish passage design and construction, and teaching at various technical training sessions for CPW and other state and federal personnel.

Objectives

1. Provide at least 10 technical assistance reviews to CPW personnel, NGOs, and Federal agency personnel as requested by June 30, 2018.

Approach

Action #1:

- Level 1 Action <u>Category</u>: Technical Assistance
- Level 2 Action <u>Strategy</u>: Environmental Review
- Level 3 Action <u>Activities</u>: Review of proposed projects

Review proposed stream habitat restoration and fish passage projects, including design, contractor selection, and permitting for CPW and other state and federal personnel as requested. Review proposed designs for post-flood road reconstruction and stream restoration for the Colorado Department of Transportation (CDOT) as requested. Provide training to CPW and other state and federal personnel on stream restoration techniques and fish passage design criteria, including guidance for permitting.

Action #1 Accomplishments:

We provided technical assistance for the following stream restoration, fish passage, and whitewater park projects:

1) Colorado River Headwaters Project
2) Watson Lake Fish Passage and Fish Screening Project, Cache la Poudre River
3) State Highway 14 Bank Stabilization Project, Cache la Poudre River
4) Army Corps of Engineers Regional General Permit 37 Review
5) Halfmoon Creek Stream Restoration Project
6) Canon City Whitewater Park, Arkansas River
7) Fort Collins Whitewater Park, Cache la Poudre River
8) Durango Whitewater Park, Animas River

9) Del Norte Whitewater Park, Rio Grande River
10) Aquatic Habitat Improvement Project, South Platte River below Chatfield Reservoir
11) River Health Metrics to support Stream Management Planning
12) Granby Flume Replacement, Colorado River
13) Moffat Mitigation Project, Williams Fork River
14) Halligan Water Supply Project, North Fork Cache la Poudre River
15) Colorado Stream Quantification Tool (SQT)
16) Lower Latham Ditch Diversion and Fish Passage Project, South Platte River
17) Fossil Creek Reservoir Inlet Diversion Fish Passage Project, Cache la Poudre River
18) Flint Riverfront and Grand River Whitewater Park Projects, Michigan Department of Natural Resources
19) Des Moines and Raccoon River Whitewater Park Projects, Iowa Department of Natural Resources
20) Clark Fork River Max Wave Whitewater Park Project, Montana Trout Unlimited
21) Eagle and Roaring Fork Rivers Whitewater Park permitted monitoring requirements with USACOE
22) Middle Fork South Platte River Habitat Improvement Project, Stafford Ranch
23) South Platte River between Spinney Mountain Dam and Elevenmile Canyon Reservoir, Three-mile Creek Flood Damage Assessment
24) Prairie Ditch Fish Passage Assessment, Rio Grande River
25) Renegade Ranch Aquatic Habitat Restoration Project, Colorado River
26) Substrate and Flow Workgroup, Upper Colorado Wild and Scenic Stakeholder Group
27) Big Thompson River Confluence Mitigation Bank
28) Bohn Park Habitat Restoration Project, South Fork St. Vrain Creek
29) South Platte River, Charlie Meyer SWA willow planting utilizing TU volunteers
30) Arkansas River below Pueblo Reservoir willow planting utilizing TU volunteers
31) Northern Integrated Supply Project, Cache la Poudre River
32) Gunnison River and Riparian Rehabilitation Project, Gunnison River SWA
33) Highway 34 Reconstruction and Stream Restoration Project, Big Thompson River

Expected Results and Benefits

As research scientists, part of our job is disseminating research results to promote science-based resource management decisions to resource users and other management agencies.

Personnel:

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Technician	CPW, Technician	
James Guthrie	CPW, Financial Initiatives Program Manager	303-291-7563
George Schisler	CPW, Aquatic Research Leader	970-472-4361

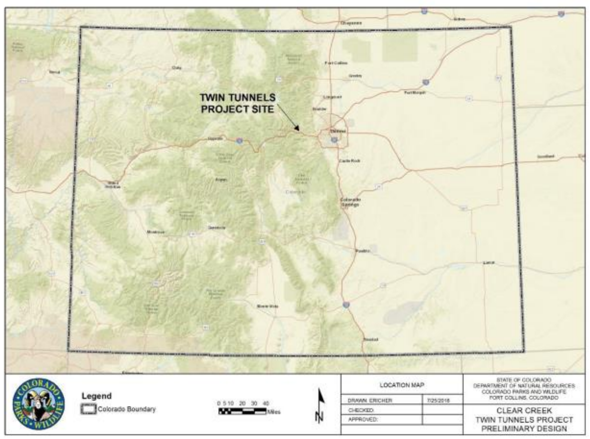
Appendix A:

As-Built Drawings for Stream Restoration and Habitat Enhancement Projects

COLORADO PARKS AND WILDLIFE

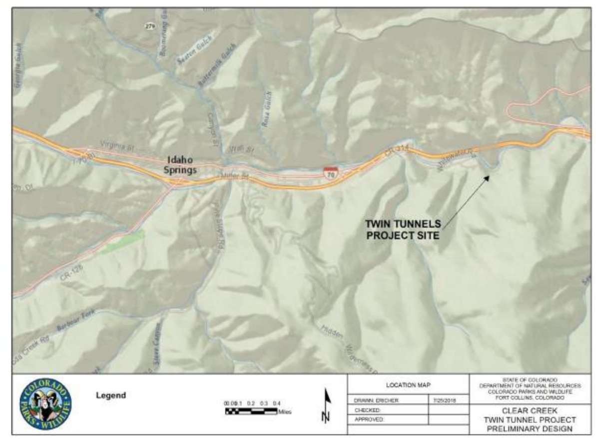
Twin Tunnels Stream Restoration Project: Clear Creek, Colorado

As-Built Drawings

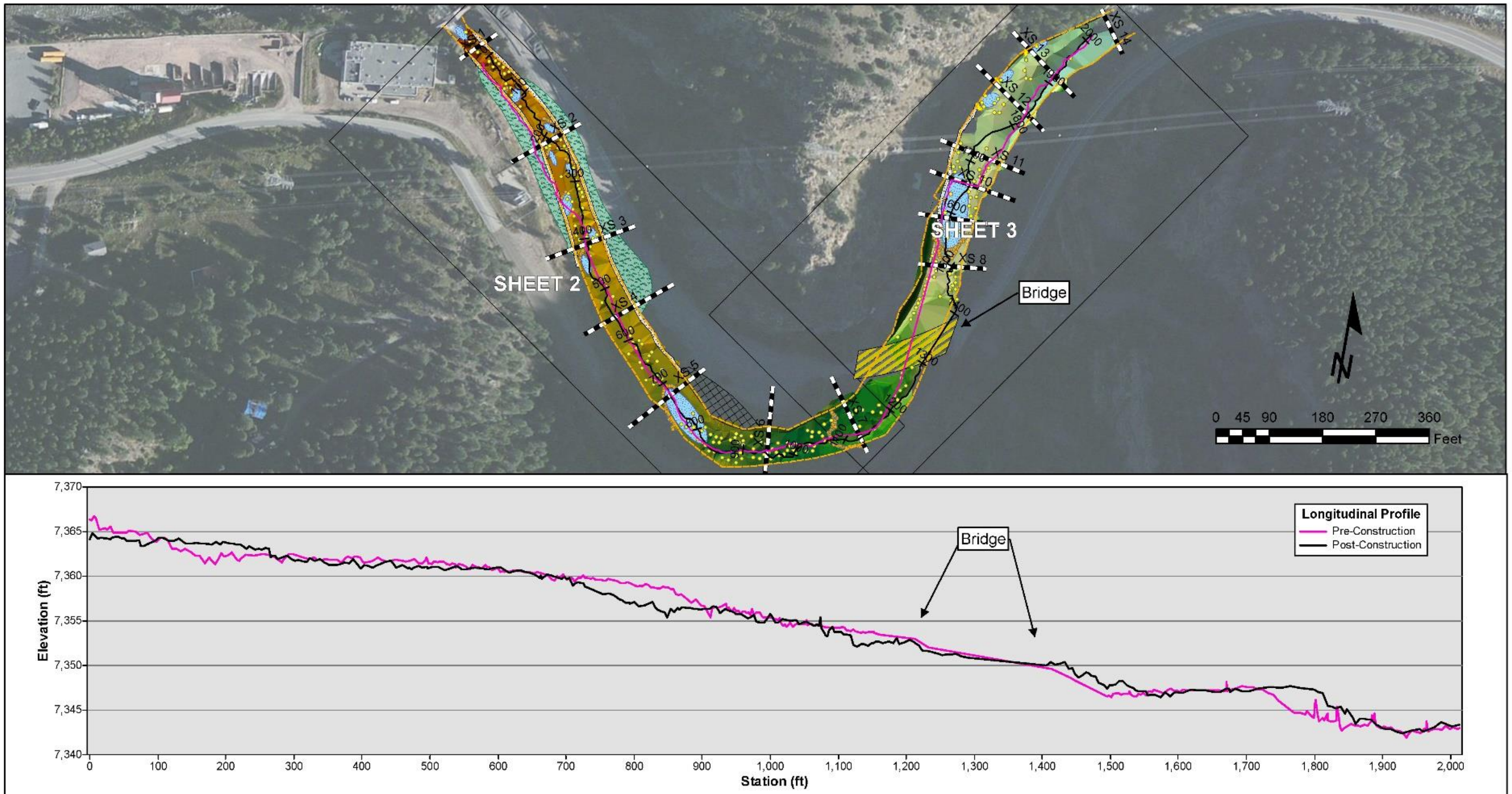


Prepared by:
Colorado Parks and Wildlife
Aquatic Research Section
317 W. Prospect Road
Fort Collins, CO 80526

July 23, 2018



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

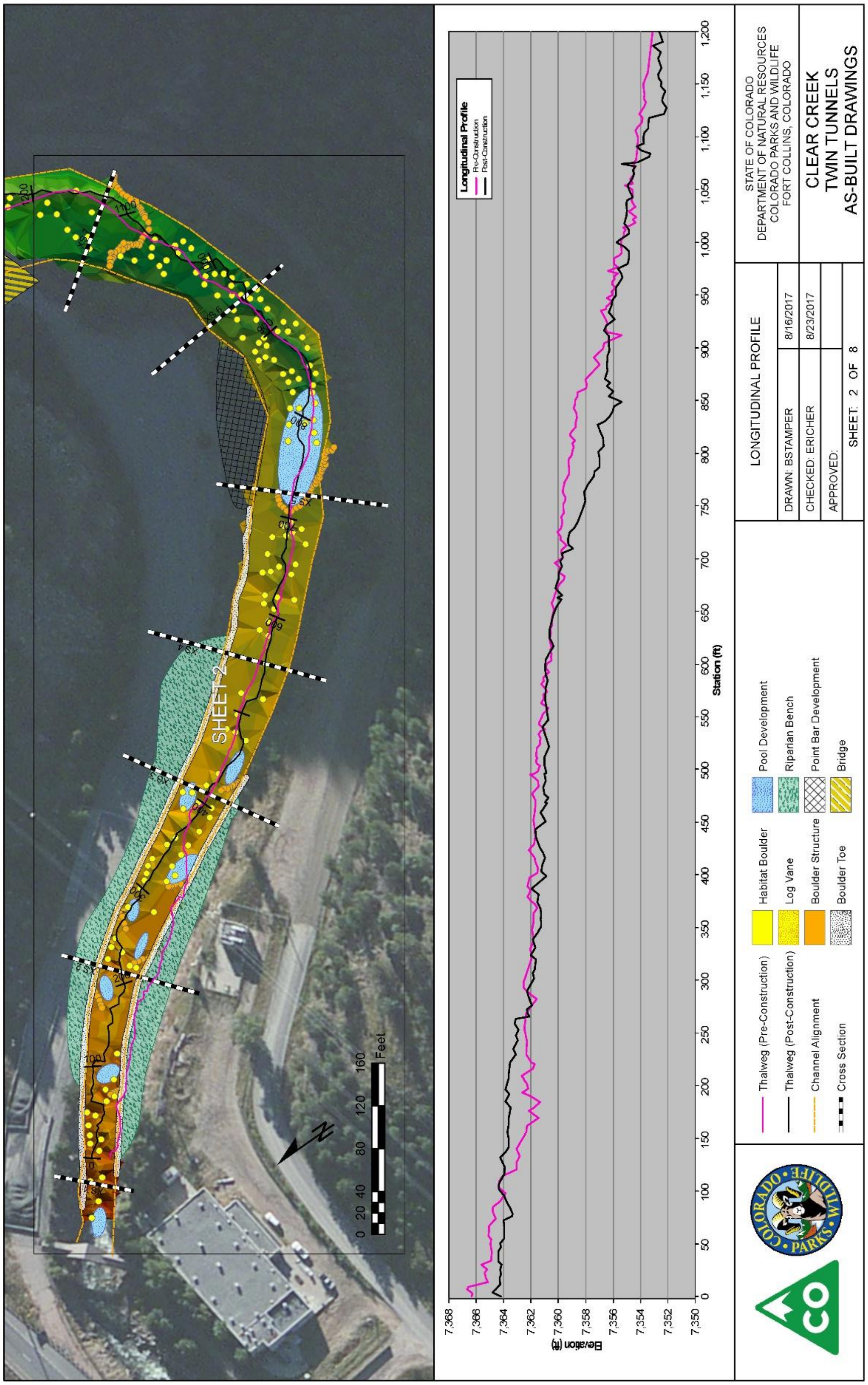


Thalweg (Pre-Construction)
Thalweg (Post-Construction)
Channel Alignment
Cross Section
Habitat Boulder
Log Vane
Boulder Structure
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge

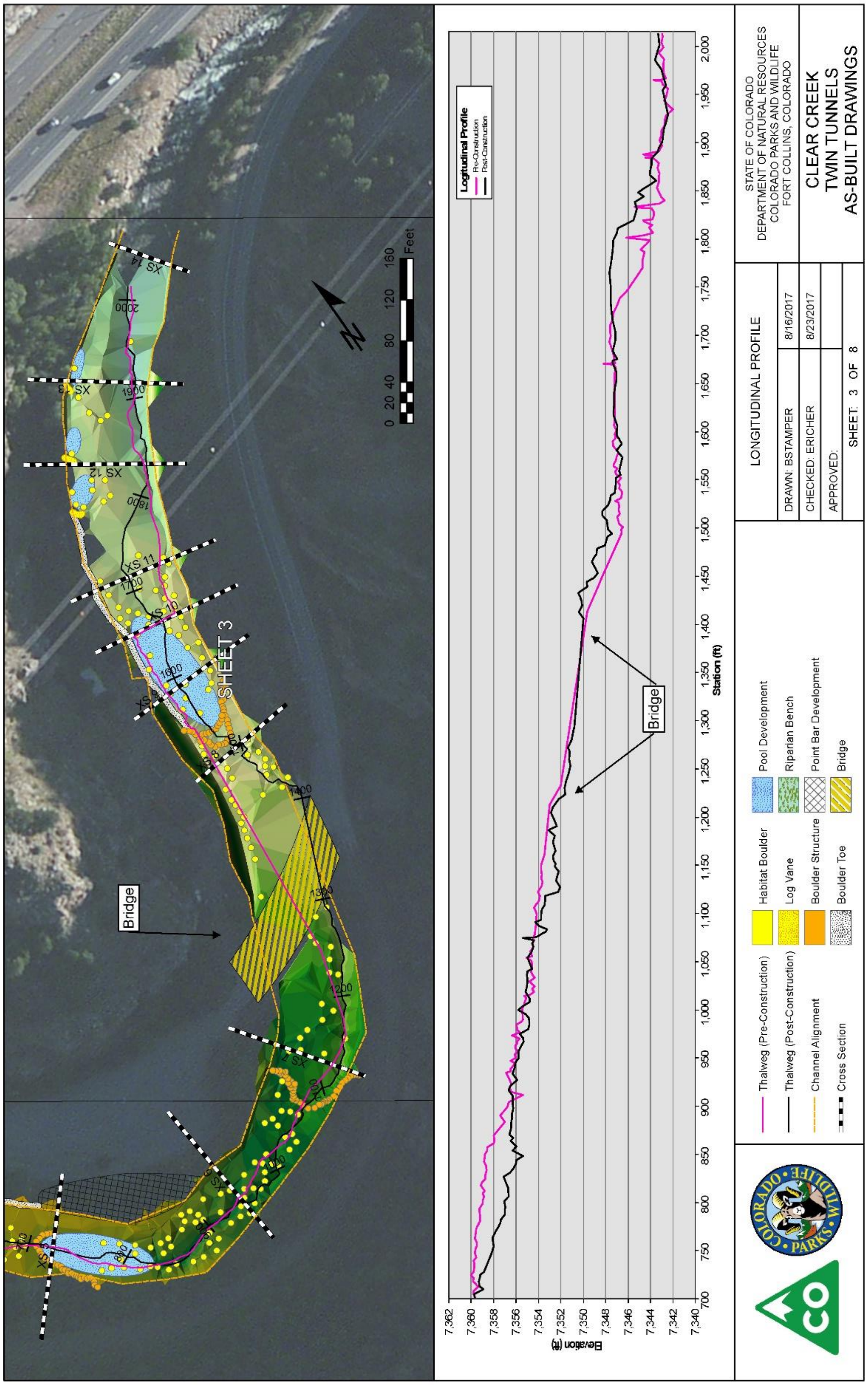
OVERVIEW	
DRAWN: BSTAMPER	8/16/2017
CHECKED: ERICHER	8/23/2017
APPROVED:	
SHEET: 1 OF 8	

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

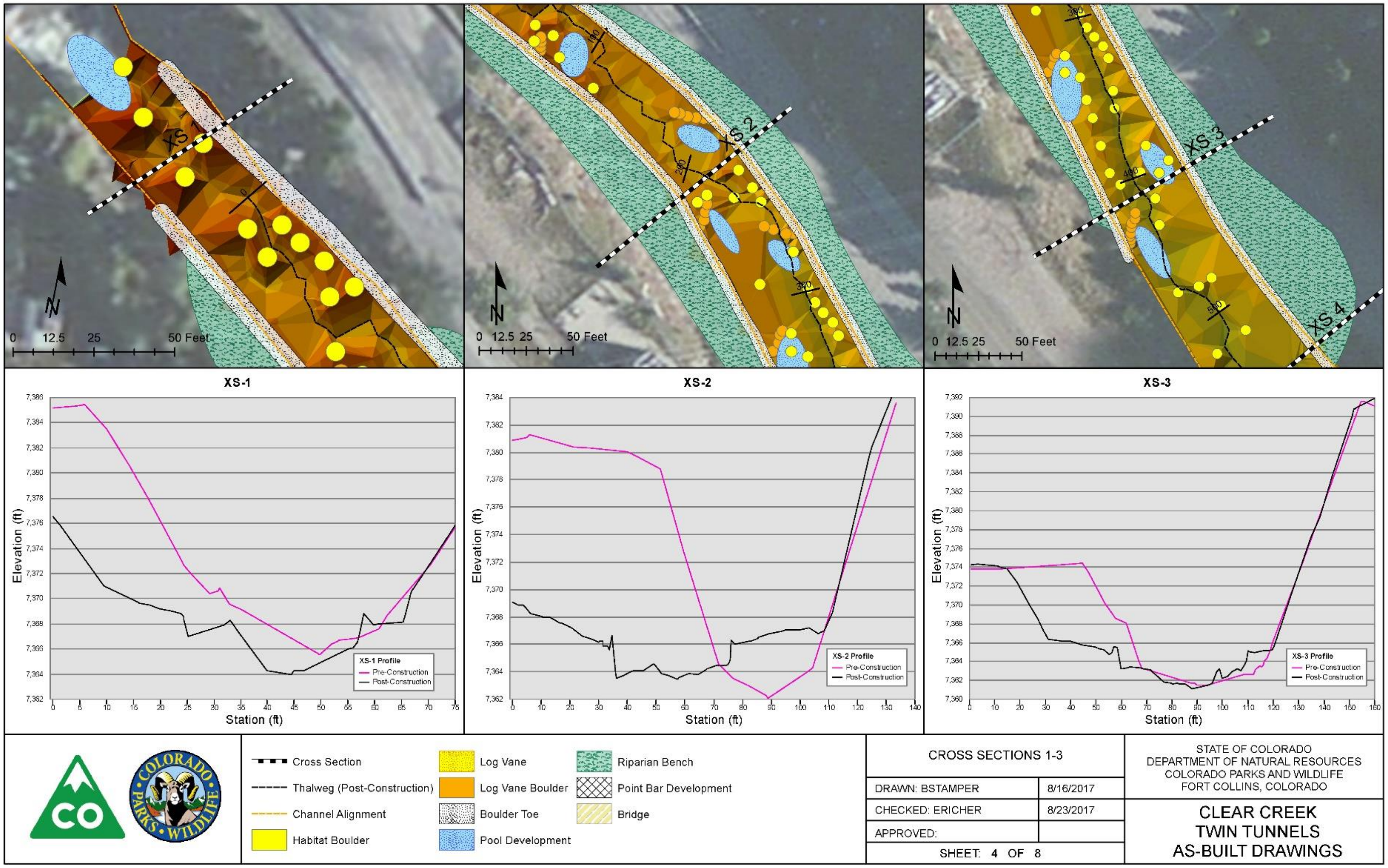
CLEAR CREEK
TWIN TUNNELS
AS-BUILT DRAWINGS



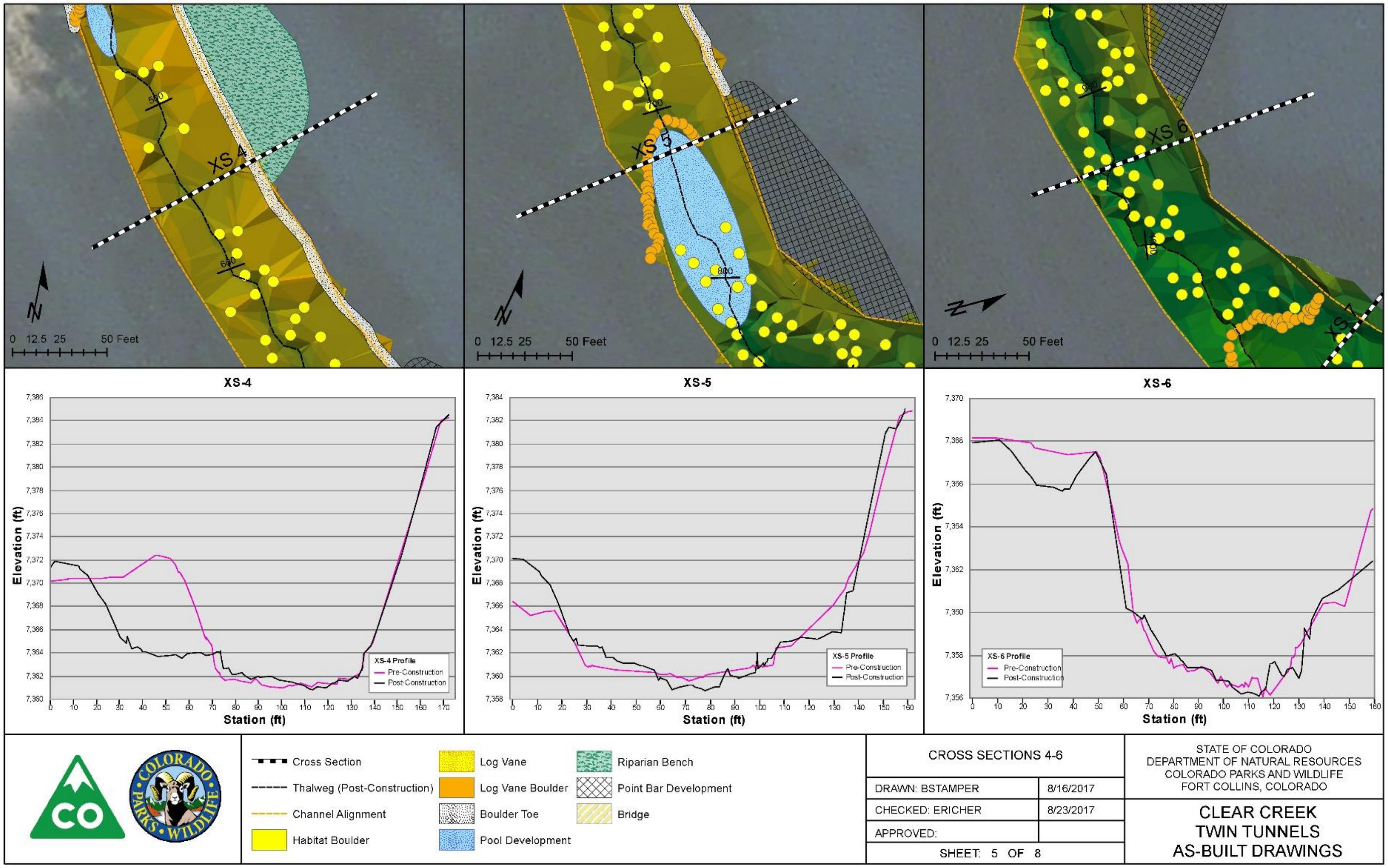
SHEET 2
Longitudinal Profile
Pre-Construction
Post-Construction
Elevation (ft)
Station (ft)
Feet
Thalweg (Pre-Construction)
Thalweg (Post-Construction)
Channel Alignment
Cross Section
Habitat Boulder
Log Vane
Boulder Structure
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge
LONGITUDINAL PROFILE
DRAWN: BSTAMPER 8/16/2017
CHECKED: ERICHER 8/23/2017
APPROVED:
SHEET: 2 OF 8
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
CLEAR CREEK
TWIN TUNNELS
AS-BUILT DRAWINGS



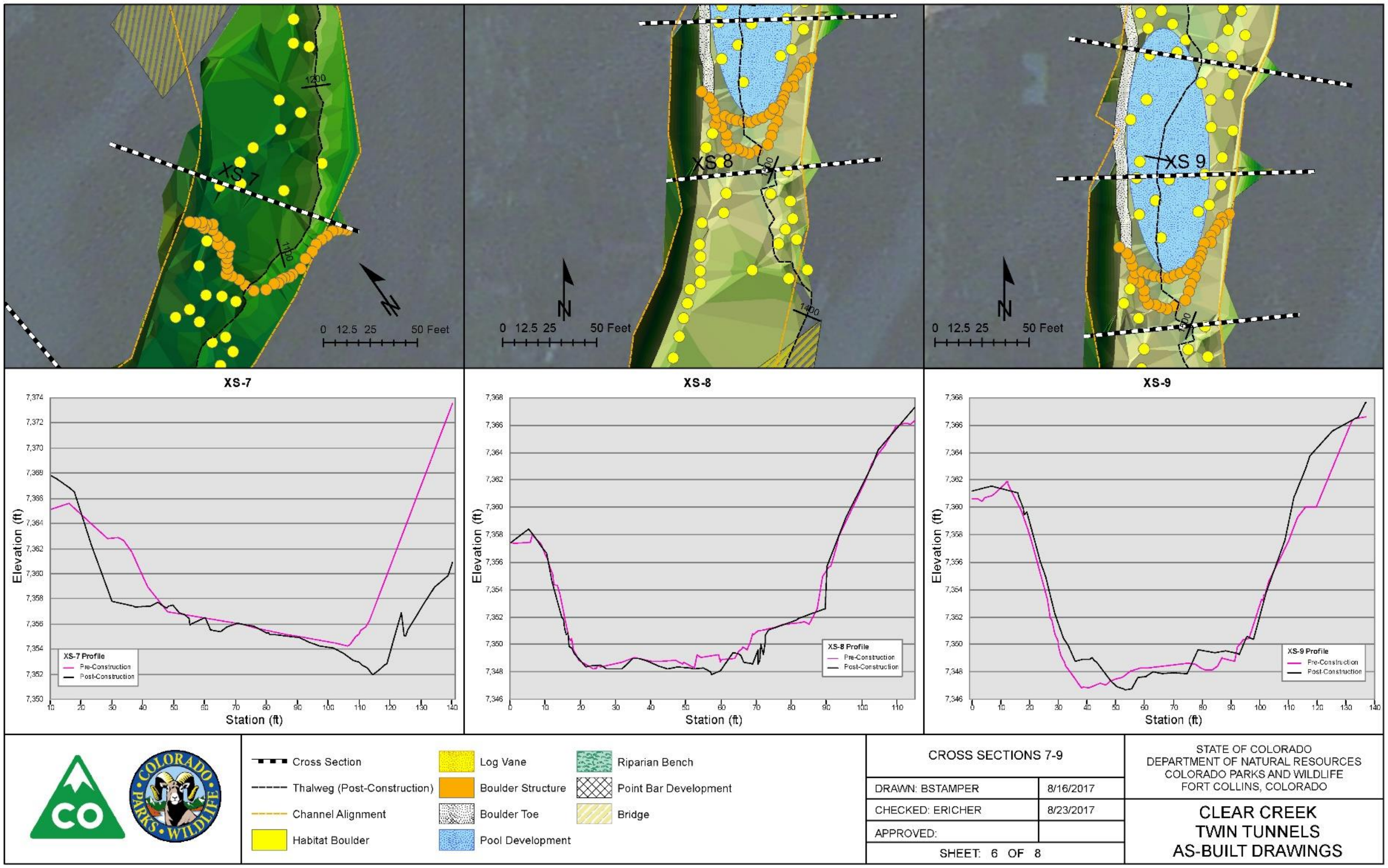
Bridge
SHEET 3
XS 14
XS 13
XS 12
XS 11
XS 10
XS 7
0 20 40 80 120 160 Feet
Longitudinal Profile
Pre-Construction
Post-Construction
Elevation (ft)
Station (ft)
Thalweg (Pre-Construction)
Thalweg (Post-Construction)
Channel Alignment
Cross Section
Habitat Boulder
Log Vane
Boulder Structure
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
LONGITUDINAL PROFILE
DRAWN: BSTAMPER 8/16/2017
CHECKED: ERICHER 8/23/2017
APPROVED:
SHEET: 3 OF 8
CLEAR CREEK
TWIN TUNNELS
AS-BUILT DRAWINGS



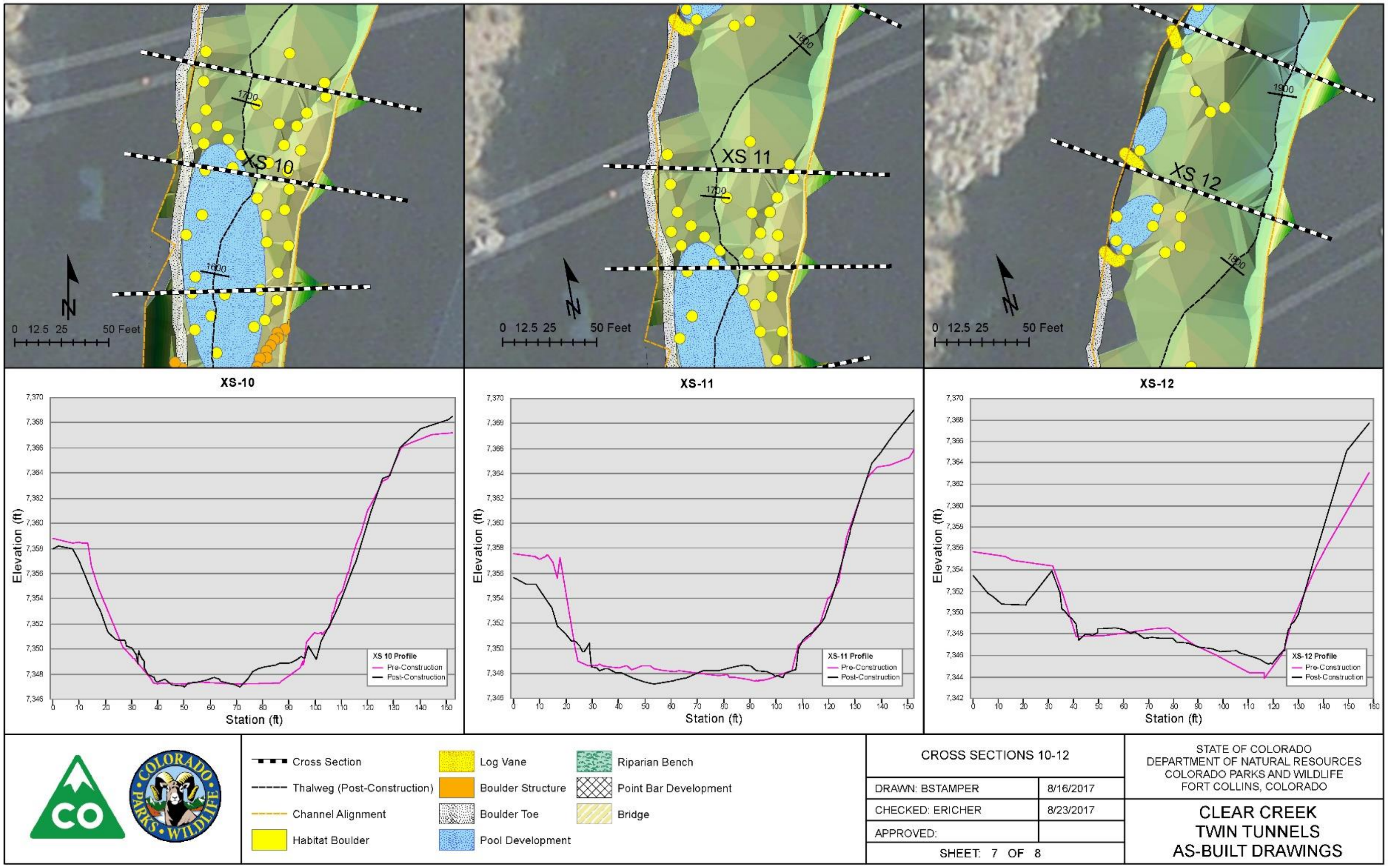
XS 1
XS 2
XS 3
XS 4
0 12.5 25 50 Feet
N
XS-1
XS-2
XS-3
Elevation (ft)
Station (ft)
XS-1 Profile
XS-2 Profile
XS-3 Profile
Pre-Construction
Post-Construction
Cross Section
Thalweg (Post-Construction)
Channel Alignment
Habitat Boulder
Log Vane
Log Vane Boulder
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge
CROSS SECTIONS 1-3
DRAWN: BSTAMPER 8/16/2017
CHECKED: ERICHER 8/23/2017
APPROVED:
SHEET: 4 OF 8
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
CLEAR CREEK
TWIN TUNNELS
AS-BUILT DRAWINGS



XS 4
500
600
XS 5
700
800
XS 6
XS 7
0 12.5 25 50 Feet
XS-4
XS-5
XS-6
Elevation (ft)
Station (ft)
XS-4 Profile
Pre-Construction
Post-Construction
XS-5 Profile
Pre-Construction
Post-Construction
XS-6 Profile
Pre-Construction
Post-Construction
Cross Section
Thalweg (Post-Construction)
Channel Alignment
Habitat Boulder
Log Vane
Log Vane Boulder
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge
CO
COLORADO PARKS & WILDLIFE
CROSS SECTIONS 4-6
DRAWN: BSTAMPER 8/16/2017
CHECKED: ERICHER 8/23/2017
APPROVED:
SHEET: 5 OF 8
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
CLEAR CREEK
TWIN TUNNELS
AS-BUILT DRAWINGS



XS 7
XS 8
XS 9
0 12.5 25 50 Feet
XS-7
XS-8
XS-9
Elevation (ft)
Station (ft)
XS-7 Profile
XS-8 Profile
XS-9 Profile
Pre-Construction
Post-Construction
Cross Section
Thalweg (Post-Construction)
Channel Alignment
Habitat Boulder
Log Vane
Boulder Structure
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge
CROSS SECTIONS 7-9
DRAWN: BSTAMPER 8/16/2017
CHECKED: ERICHER 8/23/2017
APPROVED:
SHEET: 6 OF 8
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
CLEAR CREEK
TWIN TUNNELS
AS-BUILT DRAWINGS


XS 10
XS 11
XS 12
1700
1600
1800
0 12.5 25 50 Feet
XS-10
XS-11
XS-12
Elevation (ft)
Station (ft)
XS 10 Profile
XS-11 Profile
XS-12 Profile
Pre-Construction
Post-Construction
Cross Section
Thalweg (Post-Construction)
Channel Alignment
Habitat Boulder
Log Vane
Boulder Structure
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge
CROSS SECTIONS 10-12
DRAWN: BSTAMPER 8/16/2017
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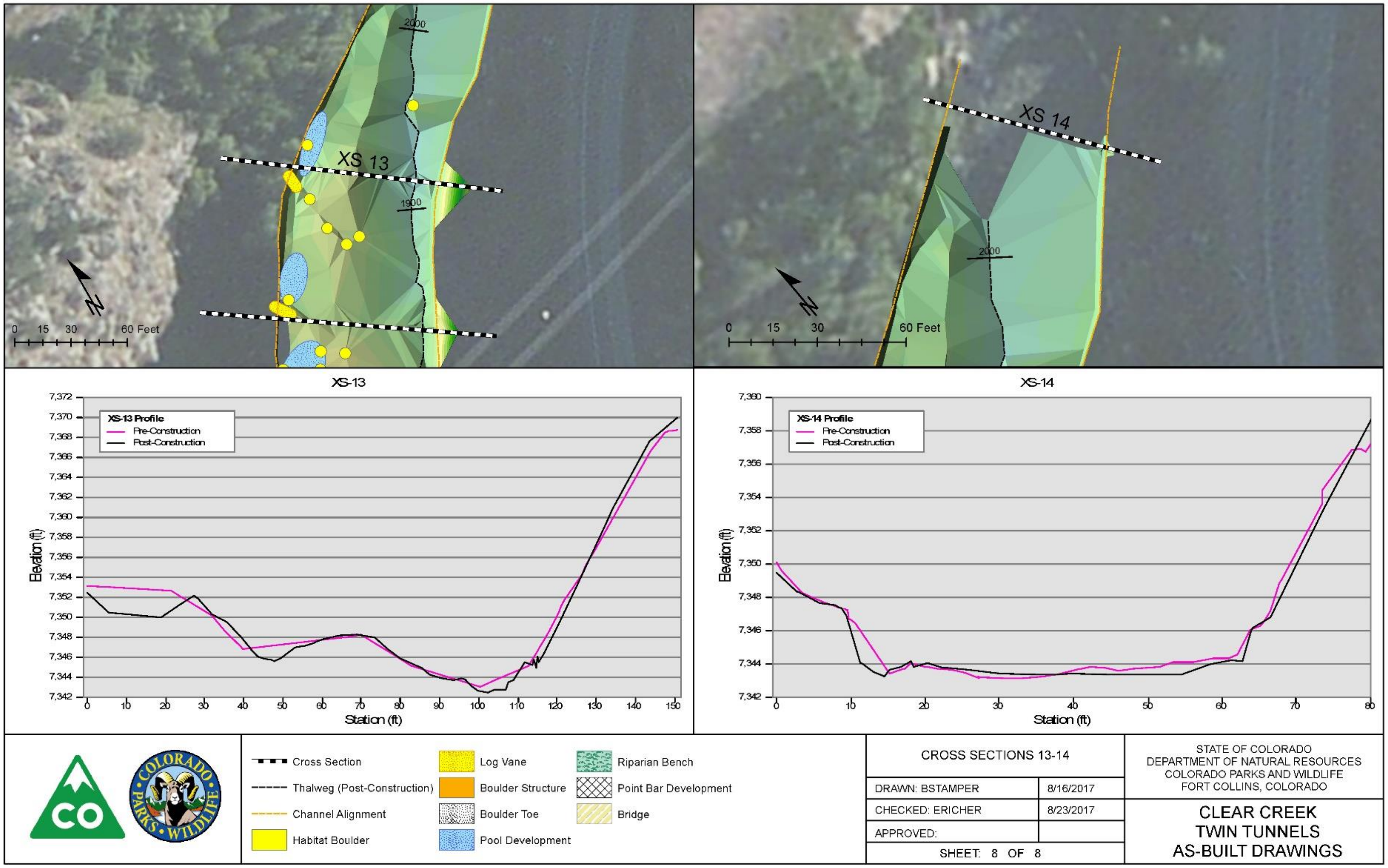
APPROVED:
SHEET: 7 OF 8
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
CLEAR CREEK
TWIN TUNNELS
AS-BUILT DRAWINGS

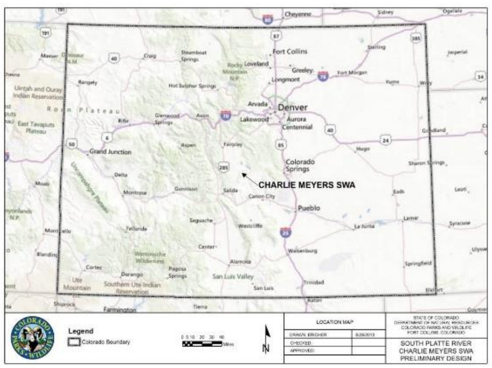


XS 13
2000
1900
0 15 30 60 Feet
XS 14
2000
0 15 30 60 Feet
XS-13
XS-13 Profile
Pre-Construction
Post-Construction
Elevation (ft)
7,372
7,370
7,368
7,366
7,364
7,362
7,360
7,358
7,356
7,354
7,352
7,350
7,348
7,346
7,344
7,342
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Station (ft)
XS-14
XS-14 Profile
Pre-Construction
Post-Construction
Elevation (ft)
7,360
7,358
7,356
7,354
7,352
7,350
7,348
7,346
7,344
7,342
0 10 20 30 40 50 60 70 80
Station (ft)
Cross Section
Thalweg (Post-Construction)
Channel Alignment
Habitat Boulder
Log Vane
Boulder Structure
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge
CROSS SECTIONS 13-14
DRAWN: BSTAMPER 8/16/2017
CHECKED: ERICHER 8/23/2017
APPROVED:
SHEET: 8 OF 8
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
CLEAR CREEK
TWIN TUNNELS
AS-BUILT DRAWINGS

COLORADO PARKS AND WILDLIFE

South Platte River Habitat Enhancement Project: Charlie Meyers State Wildlife Area

As-Built Drawings



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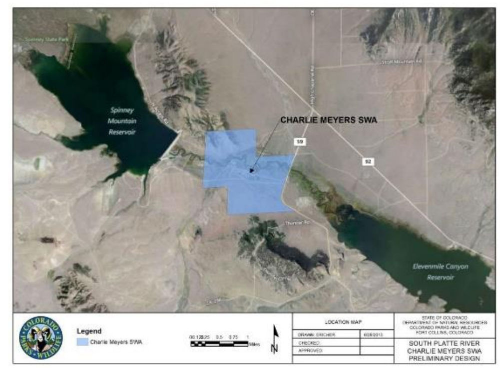
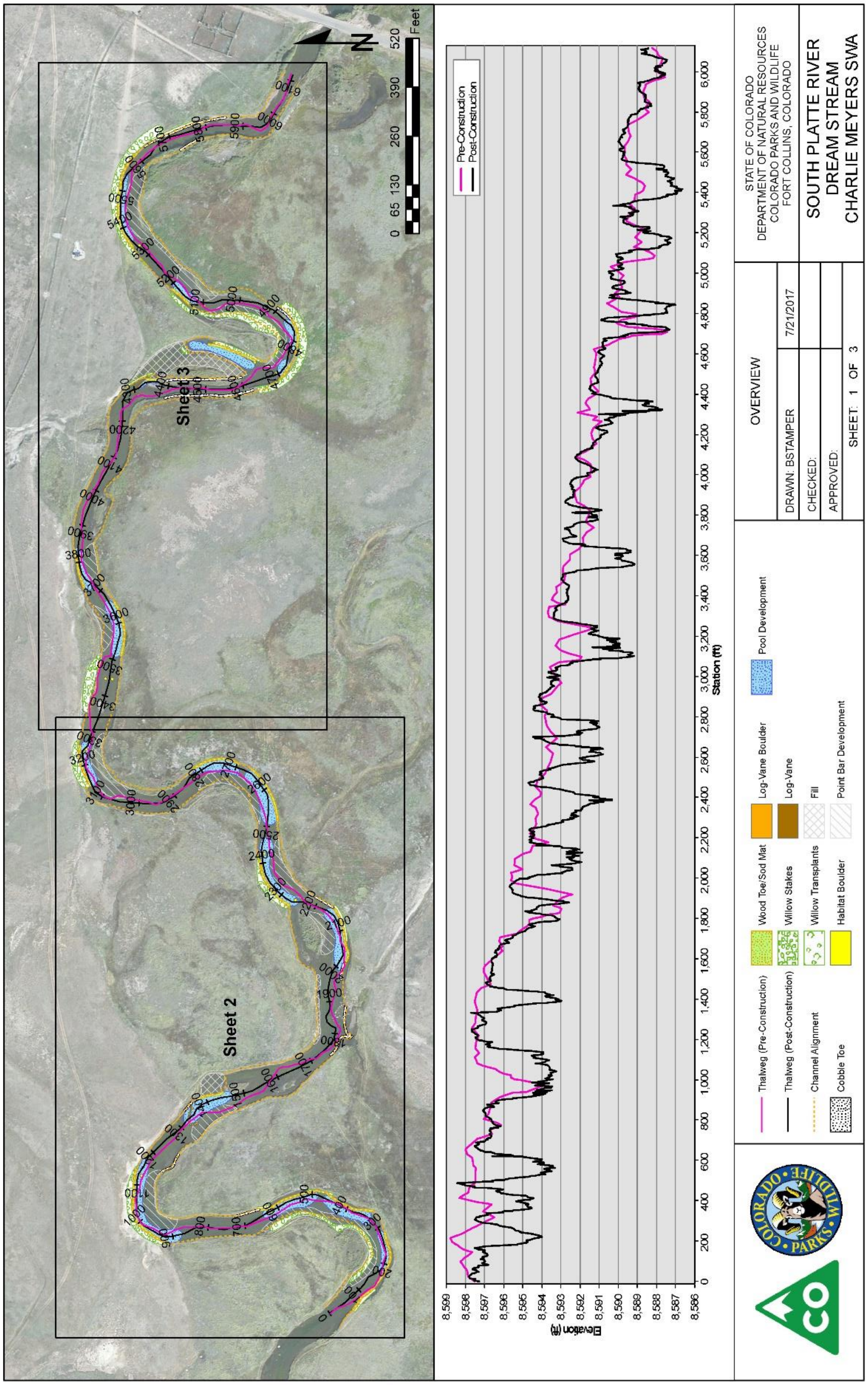
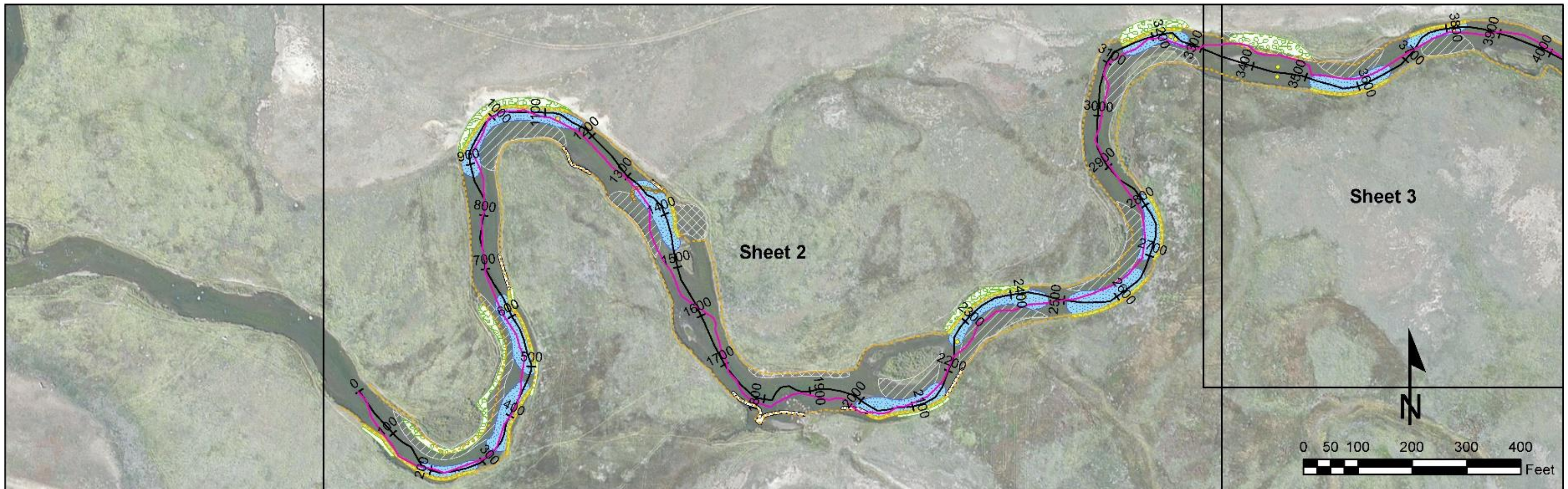
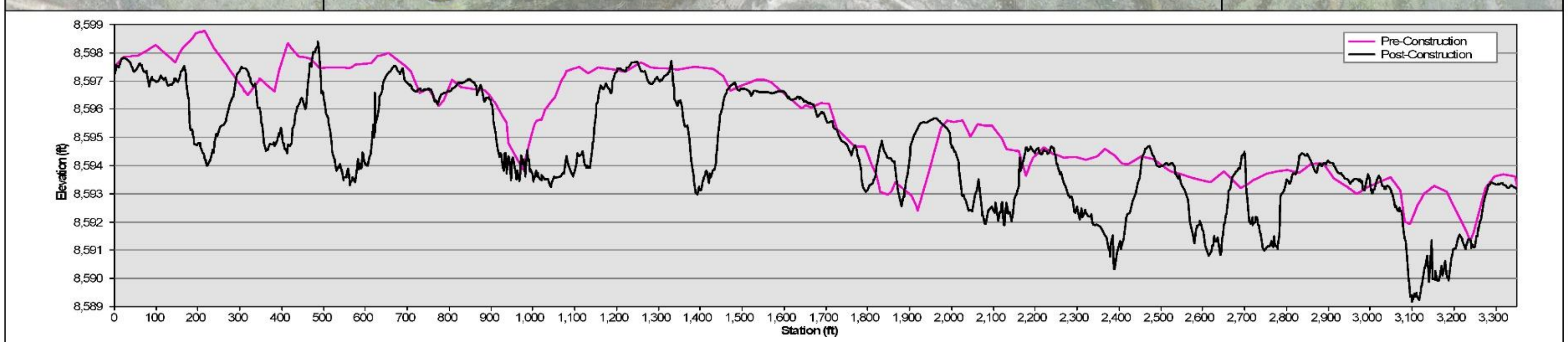
July 26, 2018



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


Sheet 2
Sheet 3
0 65 130 260 390 520 Feet
Pre-Construction
Post-Construction
Elevation (ft)
Station (ft)
Thalweg (Pre-Construction)
Thalweg (Post-Construction)
Channel Alignment
Cobble Toe
Wood Toe/Sod Mat
Willow Stakes
Willow Transplants
Habitat Boulder
Log-Vane Boulder
Log-Vane
Fill
Point Bar Development
Pool Development
COLORADO PARKS & WILDLIFE
OVERVIEW
DRAWN: BSTAMPER
7/21/2017
CHECKED:
APPROVED:
SHEET: 1 OF 3
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
SOUTH PLATTE RIVER
DREAM STREAM
CHARLIE MEYERS SWA





Thalweg (Pre-Construction)
Thalweg (Post-Construction)
Channel Alignment
Habitat Boulder
Log-Vane Boulder
Log-Vane
Fill
Point Bar Development
Pool Development
Cobble Toe
Wood Toe/Sod Mat
Willow Stakes
Willow Transplants

SHEET 2	
DRAWN: BSTAMPER	7/21/2017
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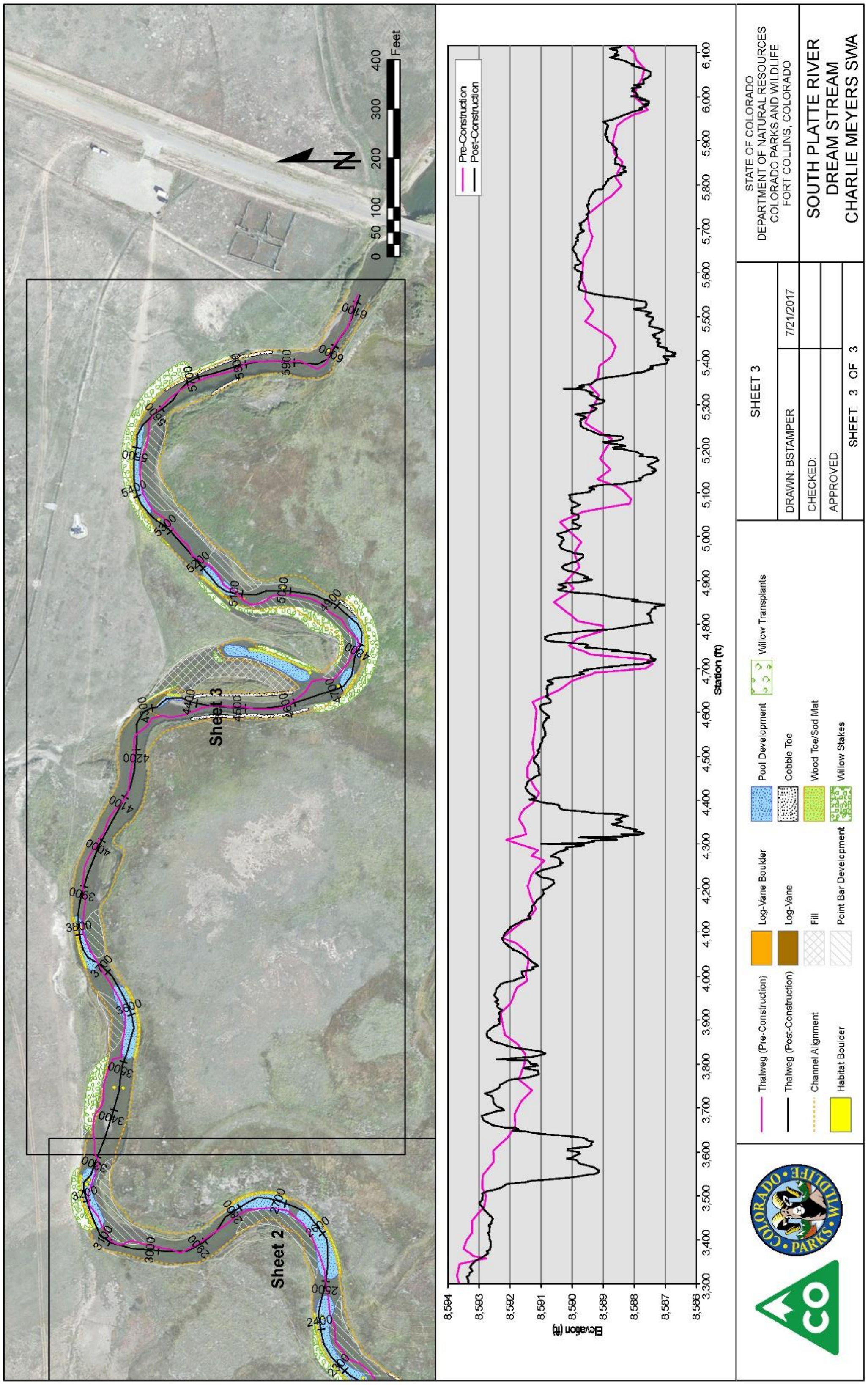
APPROVED:	
SHEET: 2 OF 3	

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

SOUTH PLATTE RIVER
DREAM STREAM
CHARLIE MEYERS SWA



STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO
SOUTH PLATTE RIVER
DREAM STREAM
CHARLIE MEYERS SWA
SHEET 3
DRAWN: BSTAMPER
7/21/2017
CHECKED:
APPROVED:
SHEET: 3 OF 3
Thalweg (Pre-Construction)
Thalweg (Post-Construction)
Channel Alignment
Habitat Boulder
Log-Vane Boulder
Log-Vane
Fill
Point Bar Development
Pool Development
Cobble Toe
Wood Toe/Sod Mat
Willow Stakes
Willow Transplants
Pre-Construction
Post-Construction
Station (ft)
Elevation (ft)
Sheet 2
Sheet 3
Feet