Future Fisheries Improvement Program Monitoring

2016

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1 Introduction

In 1995, the Montana Legislature created the Future Fisheries Improvement Program (FFIP) to restore essential habitats for the growth and propagation of wild fish populations in lakes, rivers, and streams. In 1999, the legislature expanded the FFIP by adding funding from the Resource Indemnity Trust (RIT), and directed a portion of the funding to projects that specifically enhance bull trout and cutthroat trout, with emphasis on mineral reclamation projects. In 2013, the RIT funding was expanded to cover all of Montana's native fish species.

Twice a year, the FFIP solicits grant proposals for projects intended to improve fish habitat. Typical projects include changes in livestock management to protect streams, mechanical restoration of disturbed reaches of stream, riparian plantings, construction of barriers to protect nonhybridized populations of native fish, and installation of screens to prevent fish from entering irrigation canals. FFIP also contributes to projects that increase irrigation efficiency, or maintain in-stream flows. Applicants are encouraged to secure additional funds, or provide labor as an in-kind match.

The goal of this effort was to document the condition of projects on 21 streams in the Yellowstone River watershed that received funding from the FFIP (Figure 1-1). When available, background information was compiled for each project. Sources included FWP's database and the local biologists' internal files. Information obtained included pre-project photos, fish survey data, and project designs. This information often provided a baseline of pre-project conditions that allowed evaluation of the success of the specific project.

One or more field observers visited each site, and filled out an assessment form that included descriptions of fields of conditions at the project site, and whether the project met the terms of the agreement. Photos provided additional documentation of site conditions, and the coordinates of the locations of the photos were obtained with a handheld GPS unit.

Following field data collection, the field observer prepared a narrative that described the project area, and compared baseline conditions to current conditions. Other components of the narrative were compliance with the terms in the agreement, an assessment of whether the project was successful in meeting project goals, and recommendations for improvements. Mapping locations of photo points on an aerial photos linked field conditions to a recent aerial view of the project area.

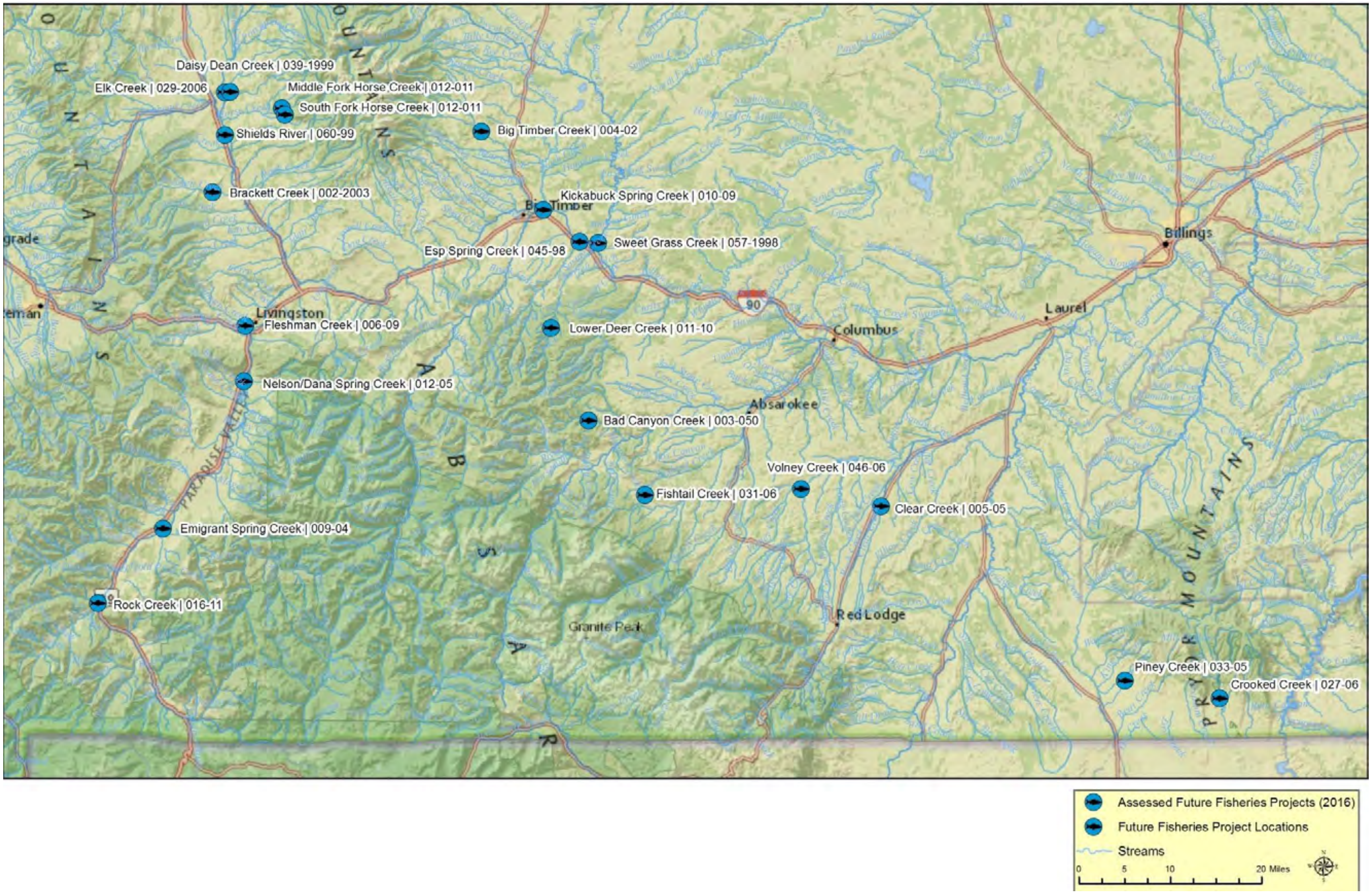

Figure 1-1. Map of assessed projects.

Synthesis of pre-project information and field observations allowed determination of the success of the project. Evaluation of projects also documented shortcomings and failures, and provided recommendations for improvements or future study.

A number of native fishes benefit from FFIP projects in the Yellowstone River watershed. Yellowstone cutthroat trout, a species of concern, is the driving force behind many of the projects described here. Of course, other native species benefit from improvements in habitat and water quality, and these include mountain whitefish, sculpin, and several species in the sucker and minnow families. Nonnative, but economically and recreationally important species including brown trout, rainbow trout, and brook trout also benefit. These popular game fishes attract anglers worldwide, and investments in improving habitat for these species bring considerable benefit to local communities.

2 Assessments

2.1 Bad Canyon Creek barrier repair (003-2005)

2.1.1 Background

Bad Canyon Creek is a tributary of the Stillwater River, located 5 miles north of Nye. Bad Canyon Creek supported populations of nonhybridized Yellowstone cutthroat trout and brown trout, with Yellowstone cutthroat trout increasing in abundance in the upstream reaches of the creek. FWP, the Custer Gallatin National Forest (CGNF) and the Bureau of Land Management (BLM) began collaborating on Yellowstone cutthroat trout conservation in 1996. Initially, a partial barrier was enhanced to prevent upstream movement of brown trout, with the intent of protecting about 7 miles of stream for Yellowstone cutthroat trout (Figure 2-1). Subsequent mechanical removal of brown trout was ineffective, and the barrier waterfall began to erode, which threatened to allow more brown trout to invade the protected reach. In addition, Yellowstone cutthroat trout numbers were on the decline, prompting the need for action.

Figure 2-1. Unaltered natural barrier on Bad Canyon Creek.

Protecting this nonhybridized population of Yellowstone cutthroat trout entailed several components. A temporary repair of the barrier prevented upstream passage of fish, until a permanent barrier could be installed. Afterwards, Yellowstone cutthroat trout were salvaged from Bad Canyon Creek, and held outside of the project area, while the stream was treated with rotenone to remove the remaining fish. Brown trout were eradicated with a single rotenone treatment, and salvaged Yellowstone cutthroat trout were returned to Bad Canyon Creek. To augment population size and genetic diversity, nonhybridized LeHardy Rapids strain Yellowstone cutthroat trout were also introduced to Bad Canyon Creek.

FWP secured this FFIP grant to contribute to the establishment a permanent barrier to upstream movement of fish. The approach was to secure the existing barrier of large boulders by sealing the loose material around and upstream of the barrier falls, with a combination of grout and a fabric liner (Figure 2-2 and Figure 2-3). Low flow and high flow channels were constructed to focus flows over the center boulder that formed the waterfall. Grout was applied to spaces between large boulders that formed the falls to fortify the feature. Additional rock was obtained by blasting portions of the adjacent cliff face.

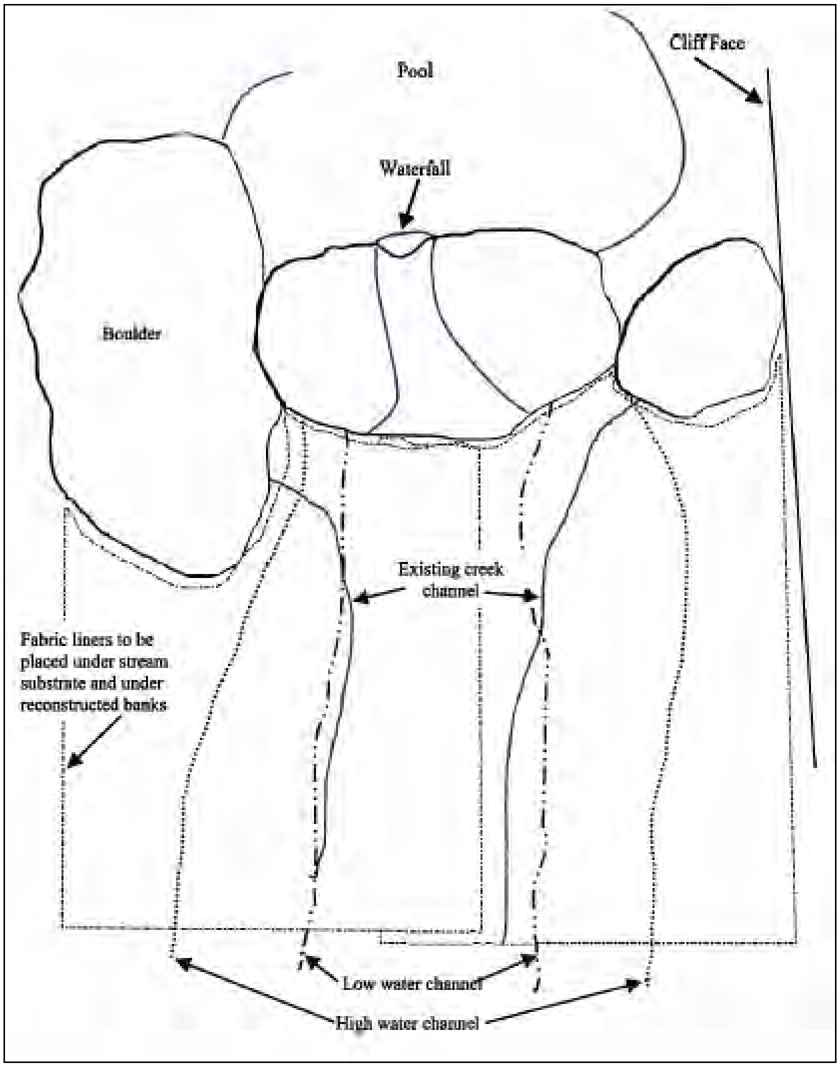

Figure 2-2. Plan view of natural barrier stabilization.

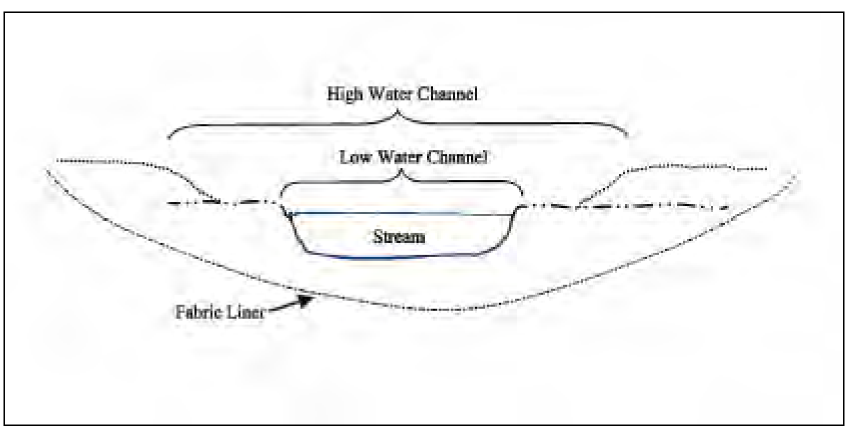

Figure 2-3. Cross-sectional view of natural barrier stabilization.

Fish surveys conducted after barrier construction and rotenone treatment indicate this project was successful. Sampling in 2006, the year following piscicide treatment, found no brown trout. Yellowstone cutthroat trout were present at relatively low numbers, which was expected for a population recently restored with salvaged and stocked fish. In contrast, sampling in 2013 found Yellowstone cutthroat trout to be 10 times more abundant than before piscicide treatment, and average lengths had also increased. No brown trout have been captured upstream of the barrier since the single rotenone treatment.

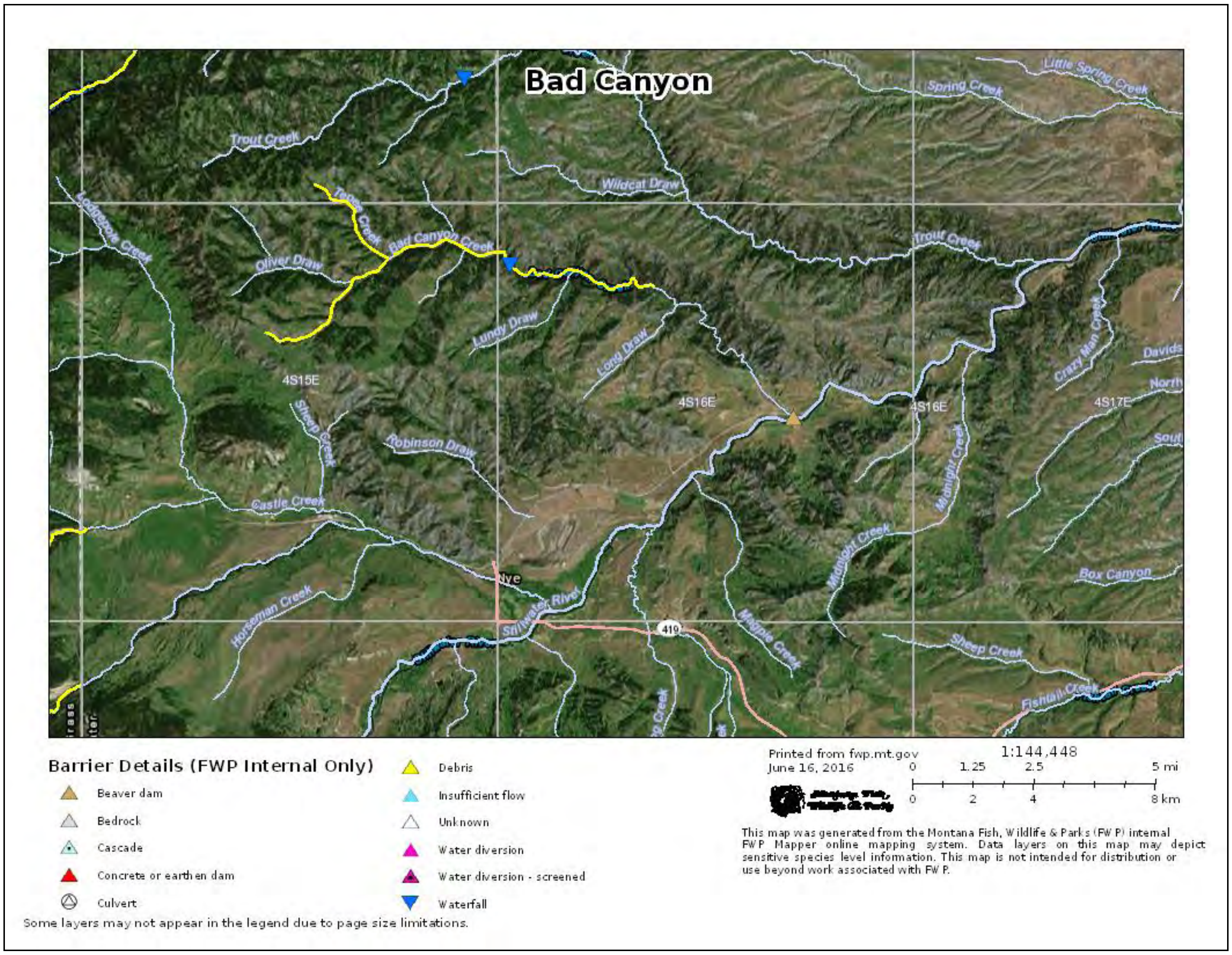

Figure 2-4. Distribution of Yellowstone cutthroat trout in Bad Canyon Creek, and location of the fortified natural barrier. Yellowstone cutthroat trout distribution is shown in yellow.

2.1.2 Field Assessment 2013/Maintenance & Repair 2014

Jason Rhoten, a fisheries biologist with FWP, visited the Bad Canyon Creek barrier in July 2013, and found maintenance and repair was warranted. A log jam had formed approximately 20 yards downstream of the barrier, and had the potential to backwater flows leading up to the barrier, which could allow brown trout to leap over. In addition, water was flowing under the barrier near the left bank. This flow could jeopardize the integrity of the barrier, by eroding under and around the boulders and rock walls.

Actions to protect the barrier's ability to block fish began in 2013, with removal of the debris jam. In 2014, several repairs were made to the barrier. Installation of large rock and concrete blocked the flows through the boulders, and prevented potential failure of the barrier. Combined, these actions preserved the structural integrity of the barrier, and eliminated the potential for backwatered flows to decrease the leap height over the barrier, which could otherwise allow brown trout to reinvade Bad Canyon Creek.

Figure 2-5. Bad Canyon barrier after repair and maintenance.

2.1.3 Conclusions

The Bad Canyon Creek fish barrier project has met its goals of removing brown trout, preventing their reinvasion, and providing a secure haven for Yellowstone cutthroat trout. The accumulation of debris, and water flow through the barrier, underscore the need for periodic maintenance of barriers. This population of nonhybridized Yellowstone cutthroat trout has considerable conservation value, so ensuring the barrier remains impassible over the long-term warrants regular site visits, particularly after large flow events.

2.2 Big Timber Creek (004-2002)

2.2.1 Background

Big Timber Creek is a tributary of the Yellowstone River, and its confluence with the Yellowstone River is near Boulder. The fish community within the project area includes brown trout, mountain whitefish, mottled sculpin, and common carp. The South Fork Big Timber Creek joins Big Timber Creek about 1 mile upstream of the property. This tributary supports nonhybridized Yellowstone cutthroat trout in its headwaters, and may contribute Yellowstone cutthroat trout to waters downstream.

The reach of Big Timber Creek flowing through the Cloud Ranch experienced substantial mechanical disturbance in years before the project. Following a fall flood, the previous landowner bulldozed 0.5 miles of channel in a misguided attempt to mitigate for future flood disturbance. These modifications straightened and widened the channel, and bed material was used to create dikes along much of the left bank. Combined, these alterations divorced the stream from its floodplain, resulting in degradation of riparian and wetland areas and a braided channel. In addition, these modifications simplified habitat, and eliminated pools and other important habitat features for fish.

Restoration of the disturbed reach occurred in 2002. A nearby reference reach provided the parameters to develop design specifications for the altered reach. The design objective was to return the existing braided channel (Rosgen D3 classification), to a single thread C3 channel, with riffle/pool morphology. Design specifications followed the channel geometry and plan view of the reference reach.

Figure 2-6. Channelized reach of Big Timber Creek

2.2.2 Field Assessments 2016

On July 6, 2016, Shannon Bockmon visited the project area, accompanied by Tom Coleman, the consultant who designed and provided oversight during the restoration. The channel was dramatically different than the pre-construction condition. Instead of the overly wide, braided, straight channel, the stream had meanders, greatly enhanced pool habitat, and recruitment of shrubs on point bars (Figure 2-7). This project was successful in restoring natural morphology to the stream, and improving fish habitat.

Figure 2-7. View of restored reach of Big Timber Creek, 2016.

2.2.3 Conclusions

This project greatly improved the quality habitat for fish and water quality. The narrower, deeper channel had a natural plan form that provided pool habitat on outer meander bends, which may have resulted in greater density of brown trout. The decrease in surface area exposed to sunlight will contribute to cooler water temperatures. Recruitment of willows on point bars is another indicator of recovery.

2.3 Brackett Creek (002-2003)

2.3.1 Background

Brackett Creek is a tributary of the Shields River, and joins the river near Clyde Park. Brackett Creek supports nonhybridized and hybridized Yellowstone cutthroat trout, although at relatively low densities within the project area. Brown trout, mountain whitefish, rainbow trout, sculpin, longnose dace, and lake chub are abundant in this reach. Brown trout and mountain whitefish from the Shields River likely migrate into Brackett Creek for spawning, and brown trout redds are commonly observed in fall.

This project addressed 2 alterations that had negative effects on stream morphology and fish passage. At some point after 1954, the stream was diverted from the floodplain, and pushed against the south valley wall (Figure 2-8). This channelization resulted in considerable loss of stream length, and loss of the natural pool/riffle sequence that was present before channelization.

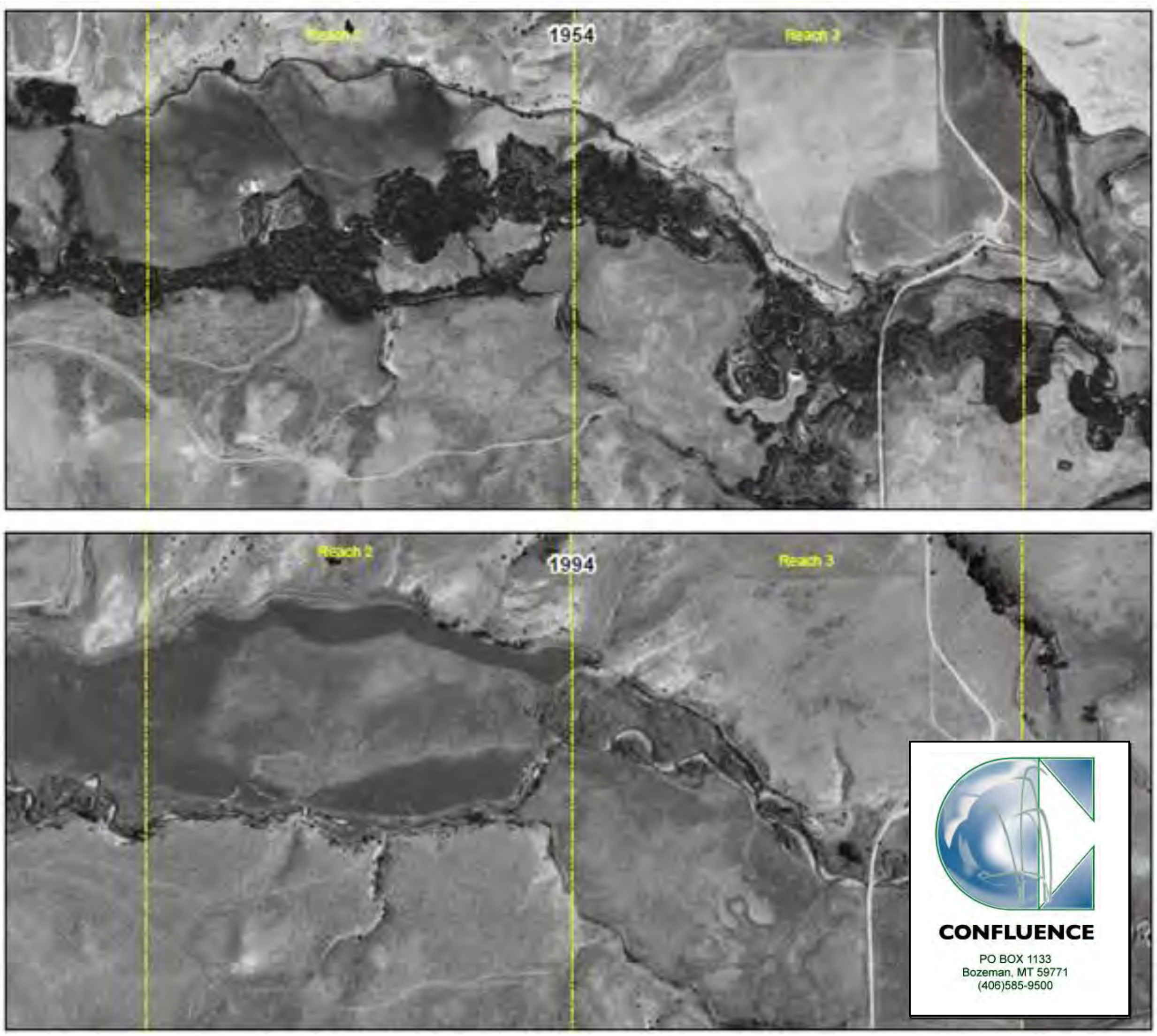

Figure 2-8. Historical and recent aerial photos of Brackett Creek through the project area.

The goals were to restore Brackett Creek to the location it occupied before channelization, and to create high quality habitat for fish. A sinuous channel with a longitudinal profile that created riffles and pools was constructed within the meander scars of the historical channel. Banks were sloped at an approximately 30% grade, and were revegetated with sod harvested during channel excavation (Figure 2-9). Willows were harvested locally, and transplanted along the newly constructed banks.

Figure 2-9. Brackett Creek re-naturalization immediately post-construction.

The second alteration was abandonment of an irrigation diversion that was at least a partial barrier to the upstream movement of fish (Figure 2-10). In the early 2000s, opening passage to allow Yellowstone cutthroat trout to move freely throughout the watershed was a management priority, so rerouting the stream away from the diversion was desirable. Since then, the presence of rainbow trout in the adjacent Shields River and Brackett Creek has changed the conservation strategy for Yellowstone cutthroat trout, with protecting the genetic integrity of Yellowstone cutthroat trout being the highest priority. Nevertheless, the project followed the management objectives of the time, and the channel was moved away from the diversion structure.

Figure 2-10. Irrigation diversion blocking fish passage on Brackett Creek (2003).

Weather and flow are important considerations in evaluating the success of this project. Soon after construction was completed, Brackett Creek experienced a flood that inundated the entire floodplain, and was an 80-year recurrence interval event (Matt Klara, Herrera Environmental Consultants, personal communication). This flood put considerable erosive pressure on newly constructed banks. In addition, restoration and willow transplanting occurred during an especially hot summer, with temperatures frequently exceeding 100 °F, which resulted in harsh conditions for transplanted willows.

In 2007, FWP conducted a field evaluation of the project. The assessment concluded that the new channel was a striking improvement over its former, channelized position, although 2 problems were obvious. Notably, the large flood that occurred soon after construction exerted considerable shear stress on outer meander bends, resulting in extensive areas of bank erosion. Nonetheless, plan form remained intact, and lateral adjustments were relatively minor. The longitudinal profile of the streambed was indistinguishable from a natural channel, and had high quality pools and extended gravel dominated pool tails and riffles. The channel was vertically stable, with no down-cutting. The stream could readily access its floodplain during high flows.

The second shortcoming was failure of willows to become reestablished along the stream channel. Finding willows was challenging, as they were widely scattered. Most willows present were short, solitary shrubs that were stunted by browsing. Livestock had not grazed this pasture following restoration, although elk were often present along the stream; therefore, browsing by wildlife was the factor most likely limiting recovery of riparian shrubs.

2.3.2 Field Assessment 2016

On June 16, 2016, FWP field observers Shannon Bockmon and Carol Endicott visited Brackett Creek. The ranch manager accompanied the observers and provided background on current livestock use, management objectives, and trends.

The site visit began where the plug of dense willows was placed to divert the water away from the old, straightened into the re-naturalized channel (Figure 2-11). Dense shrubs obscured the upstream end of the channelized reach, and provided an impenetrable barrier against the stream returning to its former location, and abandoning the reconstructed channel.

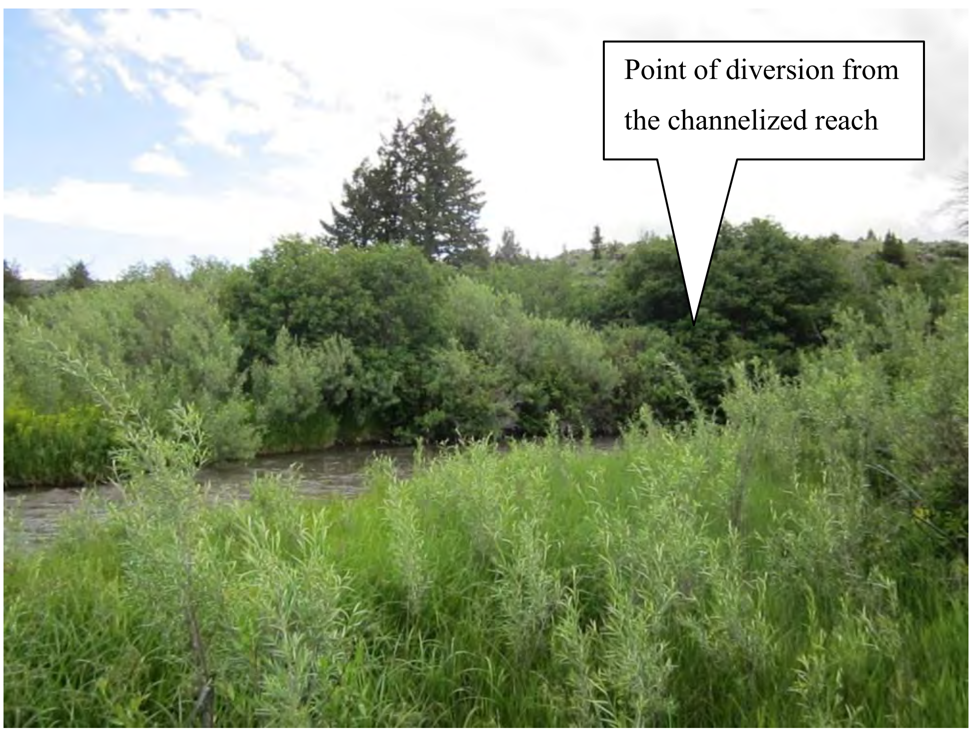

Figure 2-11. Location of plug that diverted water away from the old channel into the re- naturalized channel.

Thick, high, nonnative grasses, such as Timothy and smooth brome occupied the entire floodplain. According to the ranch manager, he grazes about 300 head of cattle in that pasture for 1 month. The great abundance of grass keeps the cows off the stream banks. We noted only 1small, isolated spot where livestock accessed the stream, and hoof shear was otherwise absent from stream banks. Livestock grazing under this strategy has no harmful effect on riparian health and function, bank stability, or stream morphology. Grazing strategies that are compatible with riparian health and function without the use of fencing are especially attractive. The landowner does not have to maintain the fencing, and wildlife movements are unrestricted near the stream.

Recruitment of riparian shrubs had improved since 2007; however, most of the stream remained devoid of woody vegetation (Figure 2-12). Individual willows were sparsely distributed along much of the channel, with isolated willows showed heavy browse. Nonetheless, several stands of sandbar willow had become established since 2007 (Figure 2-13). Despite continued heavy browse pressure, willows were beginning to gain more of a foothold along the stream channel.

Figure 2-12. Aerial imagery of re-naturalized stream (2015) showing intact plan form, limited recovery of shrubs.

Figure 2-13. Brackett Creek showing willow recruitment on left bank. Note bank stability where sedges occupy the channel margin.

As observed in the 2007 assessment, the 80-year flood that occurred soon after channel re-naturalization resulted in considerable erosive pressure on outer meander bends, causing numerous reaches of eroding bank (Figure 2-14). Shallow-rooted grasses, such as smooth brome and Timothy, occupied the tops of banks, and these species do not contribute to recovery of banks, except in cases where clods of vegetated dirt calve into the stream. These vegetated clumps have potential to trap sediments, and build a new bank adjacent to the existing eroding bank; however, these features are vulnerable during floods. The ranch manager expressed concern over losing land from bank erosion. Other reaches of Brackett Creek have much higher bank retreat rates; however, the loss of land, delivery of fine sediment, channel widening, and loss of high quality bank line habitat for fish are legitimate concerns for fish and agriculture.

Figure 2-14. Example of eroding outer meander bend on the re-naturalized reach on Brackett Creek.

Stream flow was relatively high and turbid during the field visit; however, stream bed material was visible at most places. Brackett Creek has sorted its gravel so that spawning size gravel was present in the pool tails. Fine sediment filled spaces within the gravel substrate. The fines could be coming from nearby eroding banks or from erosion of banks and terraces upstream of the project area. The watershed restoration plan for the Shields River watershed identifies lower Brackett Creek as being among the 10 greatest contributors of fine sediment from bank erosion, so deposition of fine sediment was not unexpected.

Although bank erosion was a significant feature along the re-naturalized reach, substantial portions of stream were stable, with dense sedges providing protection from elevated flows (Figure 2-15). These reaches were narrower and deeper than areas with eroding banks, and were consistent with the channel morphology designed for this re-naturalization project.

Figure 2-15. Reach of re-naturalized channel showing banks stabilized with sedges, and narrower channel.

Noxious weeds, specifically leafy spurge and Canada thistle, have been a long-term problem on this property. The current ranch manager has an aggressive weed control program, and weeds, especially leafy spurge, appeared to have decreased substantially since 2007.

2.3.3 Conclusions

The re-naturalized reach of Brackett Creek is a marked improvement from the straightened alignment, as it considerably increased channel length and habitat complexity. In addition, the re-naturalized channel has retained its sinuous plan form, and the alternating pools and riffles that are typical of streams occupying floodplain valleys. The sorting of gravel in pool tails has substantially increased the amount of spawning habitat.

Although the re-naturalized stream is preferable to the previous, channelized condition, several problems remain. Flooding eroded considerable stretches of bank, and these have not healed. The shallow roots of nonnative grasses do not provide protection from the erosive power of high flows, and these grasses are highly competitive, so riparian species are unable colonize these areas. The grass-lined, eroding banks are laterally mobile, and the channel is overly wide in these locations. The associated erosion contributes fine sediment, which diminishes the quality of habitat for aquatic invertebrates, and clogs spawning gravels.

The relatively wide and shallow channel, and lack of a riparian overstory, limits the quality of habitat for fish, and contributes to warmer water temperatures. Brackett Creek ranks as a periodically dewatered stream, which further increases the tendency for warmer stream temperatures.

Although noxious weeds are a longstanding problem on this property, an aggressive weed management program is underway. The weed management strategy employs herbicides and introduction of insects evolved to consume specific weeds. The multiple lines of defense will likely continue to diminish noxious weeds on the property.

Although flooding likely contributed to the failure of willow transplants to thrive, seasonality also was a factor. Willow transplants occurred during an exceptionally hot summer, and plants were not dormant. Dormant plants are resilient to the disturbance associated with planting, and are more likely to become established after they break dormancy.

Finding a solution to restore eroding banks with limited ability to heal on their own is a primary recommendation. Restoring stability to these banks would benefit water quality, fish, and protect valuable agricultural land from erosion. As a priority watershed for sediment reduction, grant funds could be available to address the erosion, subsequent sediment loading, and impairment of fish habitat.

Potential actions that would stabilize the eroding banks vary in expense and potential for failure. One approach would be to slope the banks to the angle of repose, then place wetland sod mats and sprig willows on the banks. This approach would be relatively expensive, as it would require heavy equipment to slope banks, and harvest sod mats. These banks would be vulnerable to erosion if high flows occur before the sedge mats establish the deep, dense root mass that helps maintain bank stability. The original restoration followed this approach, and would likely have been successful if not followed by a substantial flood.

Sprigging willow stems into the existing eroding banks may also assist in the stabilization of these banks. Pounded deep into the water table, at a 45° angle, the willows may provide sufficient roughness for trapping of sediments, and ultimate repair of eroding banks. Although comparatively inexpensive, this method has a high risk of failure if the stream floods before the willows become established.

An alternative is to plant willow sprigs away from the channel margin using a Waterjet Stinger™, which uses a high-pressure pump to drill narrow holes through soil into the alluvial gravels and water table (http://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/idpmcarwproj17.pdf). Willows do not thrive in good soil, but do well when their roots reach saturated gravel. Willow sprigs planted in these holes would establish a thick stand of riparian shrubs that would guard against bank erosion when the soil between the stream bank and new willow stand eroded. Under the existing grazing management strategy, the channel will naturally narrow and deepen, and provide high quality habitat for fish. Protective sheaths and wildlife repellent spray are recommended to discourage elk and deer from browsing willow stems.

Bank retreat rates are an important consideration in determining placement of willows transplanted with a Waterjet Stinger. Review of several vintages of aerial photos to evaluate bank retreat rates, and calculation of flood recurrence intervals, would allow for informed decision making on how far banks may move during floods of different magnitudes. Although laterally mobile, banks on this reach of Brackett Creek do not experience drastic retreats during floods, and transplanted willows would have better probability of becoming established and functional, if placed at a sufficient distance from the existing channel.

2.4 Clear Creek (005-2004 & 005-2005)

2.4.1 Background

Clear Creek is a tributary of Rock Creek, and the confluence of these streams is near the town of Roberts. Groundwater from natural springs and irrigation return flows maintain adequate water during peak demands for water. Neighboring Rock Creek experiences chronic dewatering, and Clear Creek had potential to provide temperature refugia and spawning habitat for fish in Rock Creek, if fish could access the stream. A perched box culvert blocked fish from accessing this high quality habitat.

The objective of this project was to provide fish passage by constructing a series of step-pools that would allow fish to swim up to and through the culvert. Clear Creek had the potential to provide spawning habitat for brown and rainbow trout. Moreover, native fishes such as mountain sucker, longnose sucker, mountain whitefish, and sculpin would also benefit from improved access to high quality habitat in Clear Creek. The resident fishery in Clear Creek and migratory fish in Rock Creek were the populations targeted to benefit from this project.

Pre-project photos illustrate the features that limited the ability to swim through the structure (Figure 2-16). An abrupt drop downstream of the outlet of the concrete box culvert was likely a leap barrier. In addition, rapid laminar flow and shallow water depths potentially presented a velocity barrier to the fish that were capable of leaping into the culvert.

Figure 2-16. Impassible culvert on Clear Creek.

Providing passage to and through the culvert entailed narrowing the channel, and constructing a series of step-pools. Construction occurred in the fall of 2005. The step-pools provided a series of smaller leaps that provided lower velocity resting areas upstream of the leap (Figure 2-17). The bed elevation immediately downstream of the outlet of the culvert was raised above the existing elevation, so that fish would not have to leap to get to the culvert, and flows through the culvert were backwatered, which increased the depth, and decreased the velocity through the culvert.

Figure 2-17. Post-construction photo of step-pool sequence providing passage up to, and through, the

2.4.2 Field Assessment 2016

On July 24, 2016, Shannon Bockmon visited the Clear Creek fish passage project. Dense riparian vegetation obscured much of the stream; however, the step-pools were visible, and rocks armoring the stream banks remained in place (Figure 2-18). Although some of the rocks forming the step-pools had moved, the channel modifications were still functioning to provide fish passage. The stream has not re-scoured a plunge pool at the outlet of the box culvert, and the streambed is at the same grade as the floor of the culvert (Figure 2-19).

Figure 2-18. View of step-pool sequence providing passage on Clear Creek.

Figure 2-19. Outlet of box culvert on Clear Creek

2.4.3 Conclusions

Based on visual inspection, the modifications to the banks and bed of the stream downstream of the box culvert continued to provide fish passage since the project was constructed over 10 years ago. The movement of some of the rock forming pools indicates periodic inspection and maintenance should be ongoing.

Several fish surveys have been conducted before and after construction of the step-pools; however, differences in seasonality and methodology do not allow for inference on the effect of this project on fish populations in Clear Creek or Rock Creek. If resources allow, installation of trap upstream of the culvert during periods of low flow would determine if fish were capable of moving through the culvert, and evaluate if fish were moving into Clear Creek from Rock Creek when water temperatures were stressful. Likewise, redd counts or fry trapping would provide information on the importance of Clear Creek as a spawning stream.

2.5 Crooked Creek fish barrier (027-2006)

2.5.1 Background

Crooked Creek originates in the Pryor Mountains, and flows south into Wyoming. Crooked Creek supports an aboriginal population of Yellowstone cutthroat trout in its headwaters. Natural barriers had prevented the invasion of nonnative fishes into waters occupied by Yellowstone cutthroat trout; however, 2 invasions placed brook trout, then brown trout, just downstream of cutthroat trout bearing waters. Wildfires resulted in debris flows that eliminated brook trout; however, the extent of the disturbance resulted in concern over the permanence of the natural barriers. A temporary barrier was installed to prevent reinvasion of these waters, until a permanent barrier could be constructed. Brown trout breached the temporary barrier, which again placed the resident Yellowstone cutthroat trout at risk. Numerous attempts at mechanical removal were ineffective in removing or depleting brown trout, so construction of a permanent barrier, along with removal of brown trout using piscicide, were the actions selected to protect the headwaters population of Yellowstone cutthroat trout.

The FFIP contributed funds towards construction of the barrier within the Crooked Creek canyon (Figure 2-20). The barrier was a weir with a v-notch on a flat front. The apron was angled towards the center, and wing walls were constructed to prevent scour around the barrier. Public comment on the barrier included concerns over aesthetics, so the concreted was tinted and textured to match the surrounding red sandstone canyon walls.

Figure 2-20. Newly constructed barrier on Crooked Creek, 2008.

Application of rotenone followed in October of 2009. A detoxification station established at the barrier limited toxic concentrations of rotenone to the distance that stream flow traveled in 30 minutes. Follow up monitoring over the course of several years has found no brown trout, indicating 1 application of piscicide was effective in removing brown trout.

2.5.2 Field Assessment 2016

On July 27, 2016, Shannon Bockmon visited the Crooked Creek barrier with the area biologist Mike Ruggles. Specific concerns relating to barrier projects include the structural stability of the weir, the creation of conditions that would allow fish the ability to breach the barrier, and the ability of the structure to transport bed load and woody debris.

The Crooked Creek barrier showed slight signs of wear, but no structural instability. No scouring of the concrete of the apron, or splash pad, was evident (Figure 2-21). In the first decade after construction, bed load had been relatively slow to fill in behind the front wall of the weir, with fine sediment being the dominant particle size, and water remaining deep behind the wall for several years. By 2016, larger material had accumulated within the impounded portion of the stream, and it is now possible to walk across the accumulated cobble and gravel (Figure 2-22).

Figure 2-21. Splash pad of the Crooked Creek barrier.

Figure 2-22. View upstream of the face of the weir showing accumulation of cohesive bed load.

Formation of a plunge pool at the downstream end of the apron was a concern, as the turbulence could allow fish a vantage to leap over the weir. The streambed on the downstream end of the apron remained well armored with large boulders (Figure 2-23). The combination of the lack of pool habitat, and shallow, high velocity flows on the apron is desirable in preventing fish from being able to pass over the barrier.

Figure 2-23. Downstream end of apron showing lack of a plunge pool.

In addition to inspection of the structure, the site visit included electrofishing upstream of the barrier to determine if Yellowstone cutthroat trout from the headwaters had recolonized the stream in its lower reaches, to determine if the barrier was passable, and reevaluate if the piscicide treatment had been successful. Yellowstone cutthroat trout had not yet recolonized the lower reaches since the piscicide application in 2008. Nevertheless, spawning gravels have sorted in pool tails since catastrophic debris flows, and blowout of natural barriers, so the habitat will be suitable for propagation of Yellowstone cutthroat trout, when they disperse downstream. No nonnative trout were found upstream of the barrier. The lag in recolonization of Yellowstone cutthroat trout is unsurprising given the cold, nutrient-limited nature of Crooked Creek.

2.5.3 Conclusions

Crooked Creek has been the subject of several actions to conserve the isolated, nonhybridized Yellowstone cutthroat trout in its headwaters. The barrier is 10 years old, and shows slight wear but no structural instability. The single application of piscicide was effective in removing nonnative brown trout. Although Yellowstone cutthroat trout have yet to recolonize the available habitat in substantial numbers, they remain protected, and will likely expand in distribution and numbers over time. This project has been successful securing a population of nonhybridized Yellowstone cutthroat trout from nonnatives, which is Montana's high priority in cutthroat trout conservation.

2.6 Daisy Dean Creek off stream watering and fencing (039-1999)

2.6.1 Background

Daisy Dean Creek is a small tributary of the Shields River that supports nonhybridized Yellowstone cutthroat trout. The goal of this project was to preserve, protect, and enhance fluvial geomorphic processes, biological resources, and property values, while accommodating agricultural land uses. Specific actions included development of off-stream stock water, development of a grazing management strategy, and installation of riparian fencing. The pre-project photo showed concentration of cattle on a severely impaired stream, and sparse herbaceous and woody vegetation (Figure 2-24).

Figure 2-24. Pre-project photo of Daisy Dean Creek

2.6.2 Field Assessment 2016

On June 14, 2016, Shannon Bockmon visited the project site to evaluate if project goals had been met, and if the conditions of the agreement were met. The landowner had installed 3 off-channel watering devices (Figure 2-25). Fencing excluded livestock from the stream channel, and thick stands of willows or sedges covered the stream banks (Figure 2-26). The channel was a narrow and deep, which are features that promote transport of sediment. The streambed is mostly fine sediment; however, this is likely the result of a limited supply for gravel recruitment, and not necessarily related to sediment inputs from upstream.

Figure 2-25. Example of off-stream stock water.

Figure 2-26. Recovered riparian area and stream channel on Daisy Dean Creek.

2.6.3 Conclusions

The Daisy Dean stock water and riparian protection project has been successful in meeting project goals. Sources of fine sediment, nutrients, and thermal loading have been drastically reduced. The stream channel is narrow and deep, and has considerable lengths of undercut banks. Despite its small size, Daisy Dean Creek has high conservation value for Yellowstone cutthroat trout. Significantly, the landowner is pleased with the outcome

2.7 Elk Creek channel stabilization (029-2006)

2.7.1 Background

Elk and Daisy Dean creeks are small streams that flow west out of the Crazy Mountains, until their confluences with the Shields River near Wilsall. Fisheries data are limited for Elk Creek. Sampling near the mouth in the 1970s found Yellowstone cutthroat trout, brown trout, longnose sucker, and white sucker. Genetic analysis of a single trout from a tributary indicated it was a hybrid. Daisy Dean Creek has been documented to support nonhybridized Yellowstone cutthroat trout.

A landowner applied for FFIP funding to reduce sediment loading, and improve riparian health and function, reaches of Elk and Daisy Dean creeks that had experienced considerable channel down cutting, and degradation of the riparian area (Figure 2-27). Specific actions included installation of riparian fencing and off-channel stock water, and sloping vertical banks caused by down-cutting, and installing sod mats to stabilize the altered banks (Figure 2-28).

Figure 2-27. Example of channel down cutting, and a vertical bank slated for sloping.

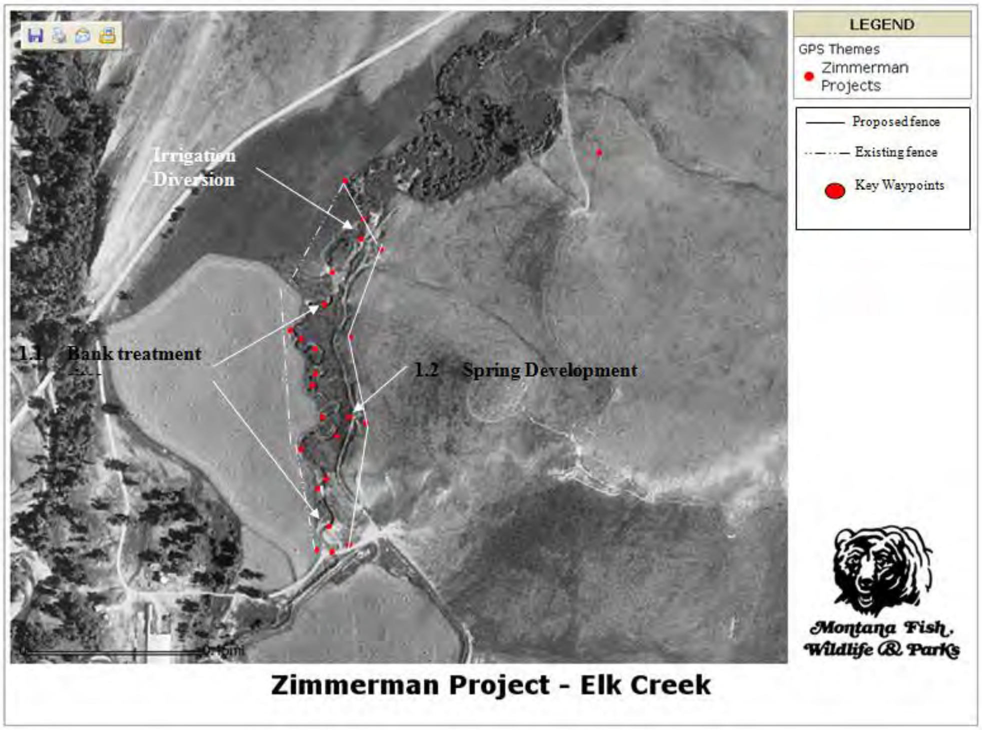

Figure 2-28. Plan view of actions implemented in Elk Creek.

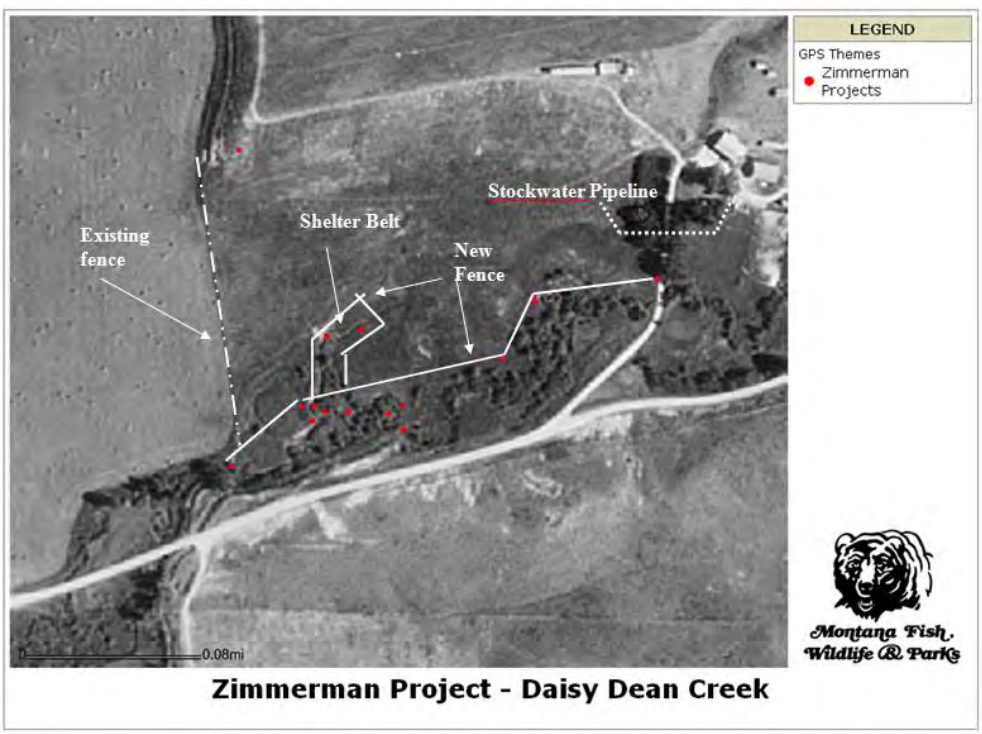

Figure 2-29. Plan view of actions implemented in Daisy Dean Creek.

On January 23, 2007, Carol Endicott visited the project sites, accompanied by the landowner. Most of the restoration actions had been implemented at this time; however, snow and ice obscured much of the bank restoration and sod mats. This site visit was too soon after project implementation to evaluate recovery of vegetation. Moreover, winter field conditions do not reflect the health and function of a riparian area during the peak of the growing season, which also confounded evaluation of recovery. Nonetheless, the fencing, bank sloping, and off-channel water components of project were in place. A concern that emerged during this site visit was for the stability of the head gate, which was perched at the head of the down-cut reach

Figure 2-30. Perched head gate on Elk Creek.

On 6/20/2007, another site visit allowed evaluation of the state of the projects with more time for the vegetation to recover. The bank sloping eliminated the bare, vertical walls, and vegetation was becoming established on the sloped banks, and within the riparian area (Figure 2-31). As expected for a recently disturbed site, weeds had colonized the sloped banks; however, these plants were holding soil much better than the pre-restoration condition.

Figure 2-31. Riparian fencing, sloped banks, and early stage recovery of riparian vegetation on Elk Creek in June 2007.

2.7.2 Field Assessment 2016

On August 9, 2016, Shannon Bockmon visited the project site with the landowner. All components had been implemented at this time. The riparian area has made a strong recovery in both streams (Figure 2-32), and grazing is limited to light grazing during the non-growing season. Remaining banks that had not been sloped have not migrated, and are minor features, especially compared to pre-restoration conditions.

Figure 2-32. Example of reduced erosion and recovery of riparian vegetation along a mechanically sloped bank.

The landowner identified 2 concerns for these project areas. The irrigation diversion on Daisy Dean Creek has begun to undercut, and he will seek a 310 permit to armor the structure. In addition, the off-channel stock water freezes in early winter, and requires frequent chipping to remove ice to supply water to cattle.

2.7.3 Conclusions

The FFIP investment on Elk and Daisy Dean creeks has provided benefits to fish and water quality, with improved riparian health and function, and greatly reduced sediment loading to streams. Armoring the head gate is desirable from the landowner's perspective, and will also prevent its failure, which would have negative consequences on fish habitat and water quality. Replacing the existing off-channel water with heated livestock waterers would maintain a constant source of fresh water throughout the winter months, and eliminate the need for ice removal.

2.8 Emigrant Spring Creek (009-2004)

2.8.1 Background

Emigrant Spring Creek is an unmapped stream that joins the Yellowstone River between Emigrant and Corwin Springs. Before restoration, livestock had considerable negative effect on riparian health and function, substrate composition, stream morphology, and habitat for fish (Figure 2-33). Field surveys found low numbers of Yellowstone cutthroat trout and rainbow trout spawning in Emigrant Spring Creek, but neither species appeared to spawn in the stream yearly. Because it maintains adequate flow throughout the summer, this stream had potential to support a spawning run of Yellowstone cutthroat trout and rainbow trout.

Figure 2-33. Emigrant Spring Creek before restoration.

Restoration of Emigrant Spring Creek included several components. Improvements in irrigation efficiency decreased the water used, while maintaining crop production. The savings in water augmented water flowing through the stream. Because livestock were the primary disturbance, fencing the riparian corridor allowed for management of livestock's access to the stream. A water gap provided water to the cattle in the neighboring pasture. Grazing pressure was substantially reduced within the stream corridor, with a dramatic decrease in stocking rates and duration of use. All improvements were completed by 2003.

Channel restoration entailed deepening and narrowing the channel with an excavator, and removing a considerable volume of nutrient rich muck. Spawning gravel was imported to the site. New banks were constructed using stacked sod mats, with wetland sod being harvested on site.

In 2007, FWP counted redds and made observations on the health and function of the riparian area, channel stability, and streambed material. Yellowstone cutthroat trout and rainbow trout were likely using

Emigrant Spring Creek, and the great size of some of the redds suggested superimposition of several redds (Figure 2-34). Most of the redds were downstream of the restored reach, although “test redds” or digs, were found throughout the restored reach (Figure 2-35). For much of the stream, bed material was suitable for spawning, the riparian area was functioning, and the channel was stable. The light grazing pressure did not have an appreciable effect on stream conditions.

Figure 2-34. Example of newly constructed redd in Emigrant Spring Creek in 2007.

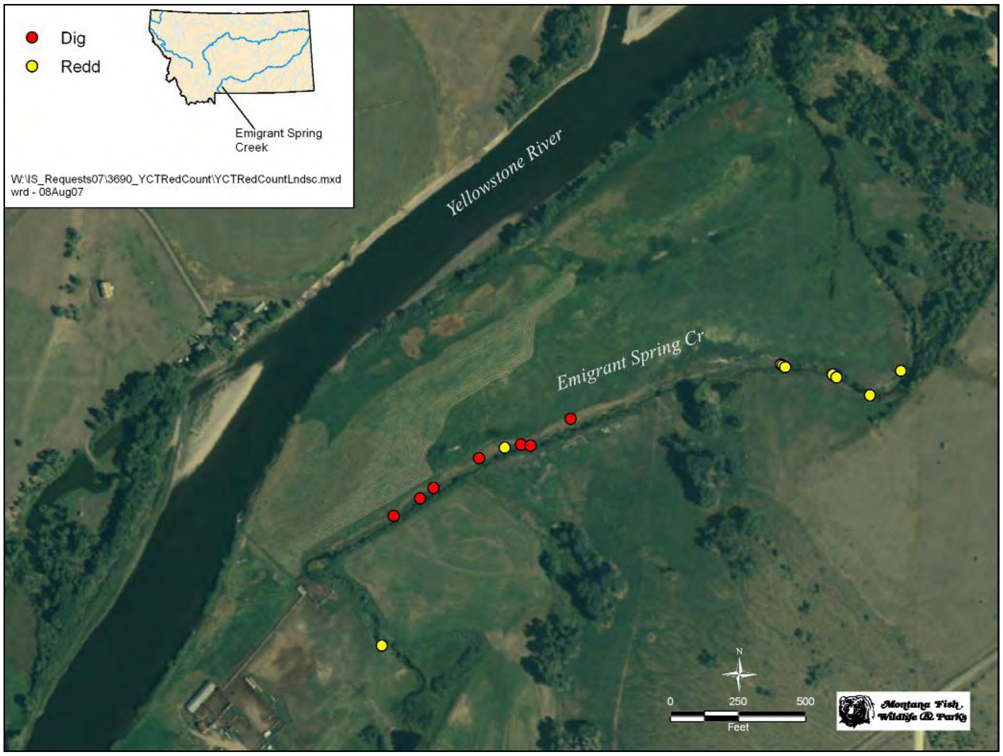

Figure 2-35. Map of redds and digs ("test redds") on Emigrant Spring Creek, June 2007.

2.8.2 Field Assessment 2016

On May 26, 2016, FWP field observers Shannon Bockmon and Carol Endicott walked the length of the riparian exclosure and restored reach. Riparian vegetation, primarily sedges, which are typical of spring creeks with saturated soils, remained dense, and effective at protecting stream banks from erosion (Figure 2-36). The grazing management plan allowed for grazing within the riparian exclosure. Manure within the exclosure indicated cattle grazing occurred within the riparian exclosure; however, grazing pressure was light, and there was no evidence of hoof shear, or other disturbance to stream banks. Sandhill cranes had a nest adjacent to the stream, within the dense sedges.

Figure 2-36. Example of restored reach showing the narrow and deep channel, and dense sedges stabilizing banks.

A substantial change in bed material occurred since the 2007 assessment. In 2007, clean spawning gravel was present along most of the restored reach, and in relatively high gradient reaches downstream of the restored reach. By 2006, the gravel bed in the restored reach had been buried under 4 to 6 inches of muck, which rendered this reach unsuitable for spawning (Figure 2-37). Suitable spawning gravel remains in the higher gradient reach downstream of the restored reach (Figure 2-38).

Figure 2-37. Example of extreme siltation of streambed in restored reach.

Figure 2-38. Gravel suitable for spawning downstream of the restored reach.

A component of the grazing management plan was installation of a water gap to allow cattle limited access to the stream (Figure 2-39). The water gap is effective at controlling livestock, while providing stock water. The water gap restricts cattle to about 20 feet of stream in order to access water.

Figure 2-39. Water gap allowing cattle access to water.

In mid-May, FWP installed a fish trap at the downstream end of the riparian exclosure. Typically, when trout are ascending a tributary to spawn, they stage in deeper water; however, no staging fish were observed during the near daily check of the fish trap. In addition, no fish were captured in the fish trap between its installation in mid-May and removal in mid-July. During the field assessment, a single rainbow trout that had likely ascended Emigrant Spring Creek to spawn was present. No redds were observed in the stream.

On July 14, 2016, FWP electrofished 1000 ft of Emigrant Spring Creek, beginning at the fish trap. Brown trout were the most abundant species, with nearly 60 fish captured. These fish ranged in size from 2.5 to 12 inches, with only 12 fish exceeding 4.5 inches. The presence of 4 rainbow trout less than 2 inches suggested some successful spawning by rainbow trout, although no redds were observed. In its current condition, Emigrant Spring Creek provides substantial rearing habitat for brown trout.

On July 27, 2016, Carol Endicott, Michelle McGree (the FFIP officer), and Jonathan Ferree (FWP's fluvial geomorphologist) revisited Emigrant Spring Creek to delve further into the apparent lack of spawning, deep accumulation of fine sediment on the streambed, and channel widening. Width-to-depth ratios were greater than the design specifications, and the existing channel was unable to transport fines. The pliable nature of sedge-lined bank margins may allow water pressure to push banks laterally at higher flows, thereby increasing channel width, and decreasing sediment transport.

2.8.3 Conclusions

Initially, the Emigrant Spring Creek restoration project showed promise, with an assessment in 2007 finding numerous large redds and exposed gravel along most of the stream. By 2016, several inches of muck had covered the gravel streambed along most of its restored length, with the wider channel geometry being unable to transport the fines. The remaining exposed gravel was outside of the restored reach of channel. No fluvial fish were captured during the approximately 3 months a trap was deployed.

Multiple sources may be contributing to accumulation of fine sediment within the restored reach. Given enough time, atmospheric deposition of fines may be sufficient to create the current conditions, and as a spring creek, the stream does not experience flushing flows to transport fines out of the stream. Alternatively, the fines could be sourced from the channel margin as the higher flows widened the channel. Loading from the nearby corrals is likely negligible, as a substantial herbaceous buffer lies between the corrals and the stream.

The restored reach no longer provides suitable spawning habitat. Nevertheless, the higher gradient reach downstream that had numerous redds in 2007 also lacked any evidence of spawning. Whirling disease is a potential causal factor, and the cool temperatures and deep mud provide ideal habitat for *Tubifex tubifex*, the worm host for infective parasite.

Although the project has not met its conservation goal of providing spawning habitat over the longer-term, the project has been beneficial in terms of water quality, and habitat for wildlife. The amount of sediment and nutrients has been reduced with riparian fencing. Suspended sediment has been greatly reduced. In addition, the thick sedges provide high quality nesting habitat for ducks and sandhill cranes. Maintaining in-stream flow has also been advantageous in supporting habitat for resident fish and rearing brown trout, which is consistent with FFIP goals.

2.9 Esp/Chambers Spring Creek (045-1998 & 011-2002)

2.9.1 Background

Esp Spring Creek (sometimes called Chambers Spring Creek) is a small spring-fed tributary to the Yellowstone River that joins the Yellowstone River about 10 miles downstream of Big Timber, MT.

Yellowstone cutthroat trout, brown trout, rainbow trout, sculpin, longnose dace, brook stickleback, white sucker, and mountain sucker occupy its 0.3 mile length.

The goal of this project was to provide fish passage and spawning habitat for fluvial Yellowstone cutthroat trout. Barriers near the mouth of the stream prevented upstream migration of Yellowstone cutthroat trout. Furthermore, the habitat in Esp Spring Creek was degraded to the point that mechanical channel restoration was warranted. No pre-project photos were available; however, design drawings detail the existing conditions, and restoration design (Figure 2-40). Restoration included providing passage through construction of step-pools, constructing a deeper, more sinuous channel, creating spawning habitat, and restoring riparian vegetation health and function by controlling livestock adjacent to the stream.

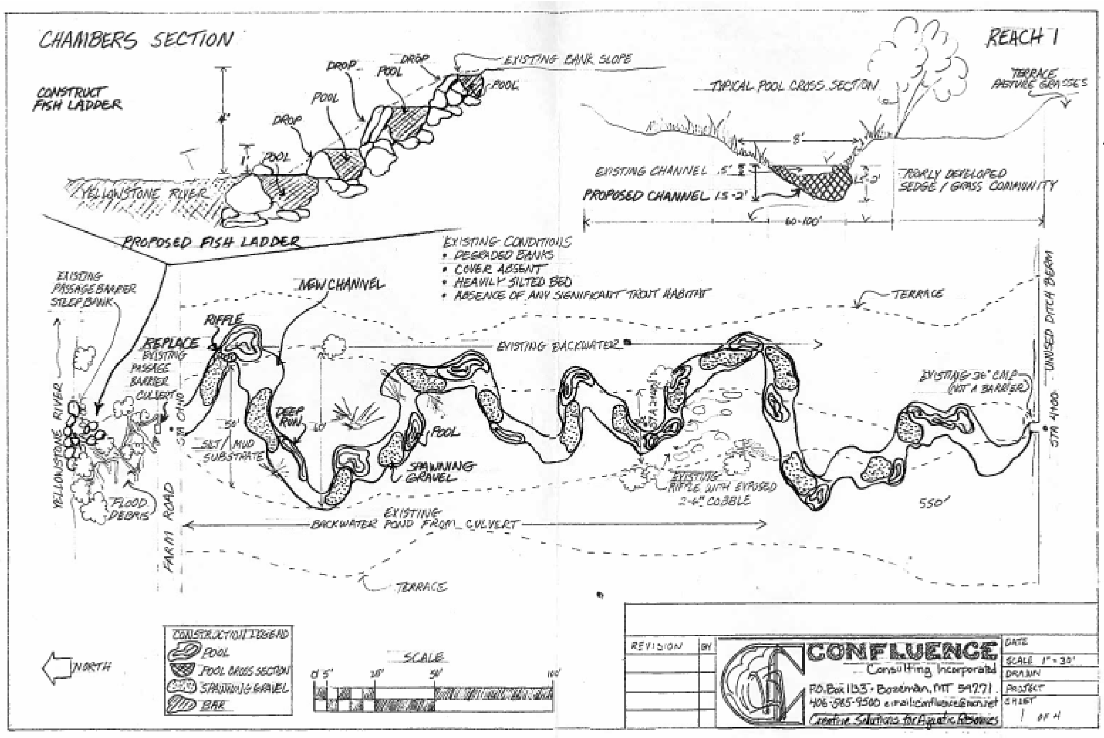

Figure 2-40. Example of designs for fish passage and channel restoration in Esp Spring Creek.

2.9.2 Field Assessment 2016

On August 10, 2015, Shannon Bockmon, and Charles Roloff, District Conservationist with the NRCS, visited the Esp Spring Creek project. Mr. Roloff collaborated with FWP on this project, and provided valuable historical perspective.

The step-pool feature constructed at the mouth of Esp Creek had largely been washed away, likely from the force of ice jams and flood flows (Figure 2-41). Passage is likely possible at this location; however, elimination of the step-pools has decreased the ability of fish to access Esp Spring Creek.

Figure 2-41. Confluence of Esp Spring Creek with the Yellowstone River, showing absence of constructed step-pools.

Channel reconfiguration, riparian area recovery, and availability of spawning habitat continued to meet the goals for high quality habitat. Dense willows occupied the riparian area, and substantially exceeded what was present pre-project (Figure 2-43. Restored and fenced reach of Esp Spring Creek. Fencing livestock off the channel, except for at a water gap (Figure 2-42), promoted riparian health and vigor. Hardening with addition of gravel would decrease sediment loading from this discrete location. Likewise, the channel retained the constructed plan form and width-to-depth ratios. The stream supported numerous areas with high quality spawning gravel (Figure 2-44). Macrophytes occupied much of the stream; however, stream flow is sufficient to limit growth of aquatic plants, and flush sediment through the stream.

Figure 2-42. Water gap on Esp Spring Creek.

Figure 2-43. Restored and fenced reach of Esp Spring Creek.

Figure 2-44. Patch of spawning gravel

2.9.3 Conclusions

The goal of the Esp Spring Creek restoration project was to provide spawning habitat for Yellowstone cutthroat trout. Yellowstone cutthroat trout have become relatively rare in that reach of the river, and too few fish may be present to support a run. On the other hand, channel restoration and grazing management have greatly improved stream health and fish habitat from the pre-project state. These improvements benefit the resident fishery, and fish from the Yellowstone River may still be able to access the stream. Trapping spawners or fry, or conducting redd counts would be useful in evaluating the extent to which fish are spawning in Esp Spring Creek. Note that this project is now 20 years old and many of the restoration goals are still being met.

2.10 Fishtail Creek corral relocation (031-2006)

2.10.1 Background

Fishtail Creek is a tributary of West Rosebud Creek, which is in the Stillwater River watershed. Fishtail Creek joins West Rosebud Creek near Fishtail. Brown trout are abundant, and rainbow trout, suckers, and longnose dace are also present. As it retains adequate flows through the summer months, Fishtail Creek supports a recreational fishery of substantial value.

The goal was to improve water quality, by decreasing nutrient, sediment, and thermal loading to Fishtail Creek. This project entailed moving a corral off-stream, and providing stock water at the new location. The corral experienced heavy use by livestock, and had considerable accumulation of manure, and negligible vegetation to trap sediment or nutrients before entering the stream (Figure 2-45). Runoff from the new corrals would be diverted away from the stream. Other components included installation of watering devices within the new, off-channel corrals.

Figure 2-45. View of the corral that was on Fishtail Creek.

2.10.2 Field Assessment 2016

On August 11, 2016, Shannon Bockmon, accompanied by the landowner, evaluated the Fishtail Creek corral relocation project. The corral had been moved, and the berm that redirected runoff away from the stream had been constructed, and remained functional. The riparian area had improved substantially since project implementation, and aspens were beginning to recruit (Figure 2-45). Weeds remained a problem within the footprint of the former corral, although efforts to control weeds are ongoing. The landowner found the off-channel watering devices to be superior to watering stock from the stream. With the exception of last winter, the holding tank has not frozen. Determination of whether the watering device has a heated element to keep stock water from freezing would be useful. These features are optional in commercially available livestock waterers.

Figure 2-46. Former location of corrals on Fishtail Creek.

Figure 2-47.Off-stream livestock watering device in the corral adjacent to Fishtail Creek.

2.10.3 Conclusions

The Fishtail Creek corral relocation was successful and appropriate use of FFIP funds. By moving an area of concentrated animal use off-stream, and diverting run-off away from the stream, the project resulted in considerable reduction in sediment and nutrient loading to the creek. In addition, the riparian area has been healing, and regaining its health and function. The off-channel watering devices are an effective means to provide stock water yearlong, and ensure livestock get sufficient water, while limiting their access to riparian areas and stream banks.

2.11 Fleshman Creek channel and riparian restoration (006-2009)

2.11.1 Background

Fleshman Creek is a tributary of the Yellowstone River, and originates in the Bangtail Mountains, west of Livingston. In its upper reaches, Fleshman Creek flows through agricultural and rangelands, and supports apparently nonhybridized Yellowstone cutthroat trout in its headwaters. Its last 2 miles flow through the City of Livingston. Fleshman Creek has been the subject of several restoration actions, with most focusing on the reach through Livingston. This project area was in the lowermost agricultural reach on Fleshman Creek, and was just upstream of where Fleshman Creek entered residential neighborhoods. Combined, these projects have the goal of improving water quality, flood conveyance, fish habitat, and increase the use of Fleshman Creek for spawning by fluvial fish from the Yellowstone River, including Yellowstone cutthroat trout. Other species include rainbow trout, brown trout, rainbow × Yellowstone cutthroat trout hybrids, and native suckers and minnows.

Livestock use in the project area had been heavy for decades, resulting in severe degradation of riparian health and function, extreme siltation, and a lack of channel definition for much of its length (Figure 2-48). The deep accumulation of mud within the existing channel made electrofishing challenging, as fieldworkers wading the stream would get bogged in the mud. In addition, actively eroding terraces were contributing large quantities of fine sediment (Figure 2-49). Decades of accumulation of manure adjacent to the stream was a source of nutrients, which further contributed to degraded water quality.

Figure 2-48. Pre-restoration view of Fleshman Creek.

Figure 2-49. Example of an eroding terrace on Fleshman Creek within the project area.

Actions to restore Fleshman Creek included installing riparian fencing, fenced stream crossings, and off-stream stock water, which allowed control of livestock in and around the stream. Given the extent of the channel degradation, a lack of locally available wetland sod, and absence of a gravel substrate, the channel restoration component required construction of a new channel, and importation of materials from off-site.

In constructing a new channel, the old channel was mostly abandoned, with spoils from the newly excavated channel used in filling the old channel. A narrower, deeper channel was constructed, and gravel was trucked in, and installed in the new channel. Stream banks were constructed of coir fabric encapsulated soil lifts (Figure 2-50). The fenced stream crossings were constructed using a bottomless arch culvert, along with 2 overflow pipes set at the bank full elevation. Bottomless arch culverts are desirable for aquatic organism passage, as they have the same substrate as the neighboring streambed, and have a ledge of rock constructed at the bank full elevation.

Figure 2-50. Example of newly constructed channel on Fleshman Creek and stream crossing with bottomless arch culvert and overflow pipes.

The revegetation component entailed collaboration among the NRCS, FWP, and Park High School. These parties collected willow stems from the Yellowstone River, while in fall dormancy. The NRCS soaked the willow stems over winter, and the same collaborators installed the dormant willow sprigs into the bank full margins of the newly constructed channel the following spring. As the entire pasture was denuded of vegetation, or had considerable infestations of weeds, the area was seeded with a native seed mix.

2.11.2 Field Assessment 2016

On June 2, 2016, Shannon Bockmon and Carol Endicott visited the Fleshman Creek restoration project, and documented remarkable improvement from pre-project conditions, and evidence that the restoration efforts were effective in restoring Fleshman Creek. The riparian fencing was in place (Figure 2-51), as were the off-channel water sources.

Figure 2-51. Riparian fencing installed to control livestock around Fleshman Creek.

The channel was relatively narrow and deep, and other than the formation of desirable, undercut banks, minimal lateral movement had occurred since the channel was constructed in 2009 (Figure 2-52). Willow survival and recruitment was impressive, with well established stands of willows exceeding 9 feet occurring along most of the stream. In the few locations where willows had not become established, the coir fabric and seeding was effective in creating a stream bank that was indistinguishable from a natural bank (Figure 2-53).

Figure 2-52. Example of constructed riffle, established willows, and undercut banks on Fleshman Creek.

Figure 2-53. Outer meander bend showing stable bank constructed with coir fabric encapsulated soil lifts. (Note that photo was taken in early June, and ground cover was beginning to grow for the season.)

Although the current condition was a marked improvement from pre-project conditions, livestock were having a small, but noticeable effect on stream banks. Localized areas of bank trampling and stock trails were present at several locations. Consultation with NRCS on the grazing management strategy developed for this site, and evaluation of modifications to limit trailing are warranted to protect the investment.

Figure 2-54. Bank trampling and stock trails on Fleshman Creek.

2.11.3 Conclusions

The Fleshman Creek restoration project resulted in tremendous improvements in a reach of stream that had been highly degraded. The constructed channel had maintained its plan form and longitudinal profile, despite being subjected to a substantial flood in 2011. Riparian health and function had been restored from bare soil, manure, and weeds, to relatively dense stands of maturing and recruiting willows. The seeding had been successful in establishing sedges and grasses along the banks and elsewhere within the pasture.

Fencing has been largely effective in controlling livestock around the stream; however, limited grazing within the fenced riparian pasture is part of the grazing management strategy. Further investigation into the sufficiency of the strategy to protect the stream is warranted.

The road crossings were effective in allowing the producer to move cattle, while protecting the riparian zone and stream channel. The bottomless arch culverts were effective in providing stream habitat under the crossing, fish passage, and debris conveyance. Yearly inspection of the overflow pipes in spring, before runoff, is recommended, as plant growth can obscure the pipes, and limit their ability to convey high flows.

An ancillary component of this project relates to the educational opportunities it provides students at Park High School. In addition to being involved in restoration, high school students are monitoring water quality, and other measures of stream health in the restored reach of Fleshman Creek. Combining restoration with educational opportunities fosters scientific knowledge and an understanding of the importance of conservation in the next generation.

2.12 Kickabuck Spring Creek spawning habitat enhancement (010-2009)

2.12.1 Background

Kickabuck Spring Creek is a small, unmapped spring creek that joins the Yellowstone River downstream of Big Timber. The goal of the project was to provide spawning habitat for Yellowstone cutthroat trout in the Yellowstone River downstream of its confluence with the Shields River. This reach of river maintained relatively high numbers of Yellowstone cutthroat trout through the late 1990s, but the population had diminished considerably since. Kickabuck Spring Creek had poor quality habitat for spawning; however, flow appeared sufficient during the Yellowstone cutthroat trout spawning, incubation, and outmigration periods to support a run. Moreover, as a spring creek, water temperatures would be within the optimal range for growth of cutthroat trout. The landowners were highly supportive of an enhancement project to provide suitable spawning habitat.

Before project implementation, channel morphology and gradient varied along the length of Kickabuck Spring Creek. In its upper half, the stream had low gradient, a relatively wide and shallow channel, and a mud streambed (Figure 2-55). In the lower half of the stream, the channel became deeper and narrower (Figure 2-56). The higher gradient exposed gravel suitable for spawning (Figure 2-57).

Figure 2-55. Typical channel morphology in the upper half of Kickabuck Spring Creek before enhancement.

Figure 2-56. Typical channel morphology in lower half of Kickabuck Spring Creek.

Figure 2-57. Streambed in the lower half of Kickabuck Spring Creek.

The stream has an atypical flow pattern. The channel conveys little water from late winter through early spring. The initial rise in stream flow and groundwater follow spring runoff in the Boulder and Yellowstone rivers, with water quantity increasing as these rivers saturated their alluvial aquifers. Irrigation return flows from the Boulder River likely keep flows elevated into winter.

Kickabuck Spring Creek has been visited several times since construction. For several years, the channel cross-sectional dimensions (Figure 2-58) and plan form (Figure 2-59) remained unchanged, and spawning gravel was exposed and clean. In late fall of 2009, the stream teemed with juvenile mountain whitefish, which was atypical, as whitefish typical seek larger water to overwinter. Subsequent visits during the Yellowstone cutthroat trout spawning season did not yield observations of fluvial fish or redds.

Figure 2-58. Reconstructed channel and imported spawning gravel.

Figure 2-59. View of the reconstructed plan form on Kickabuck Spring Creek.

2.12.2 Field Assessment 2016

On June 1, 2016, Shannon Bockmon and Carol Endicott visited the Kickabuck Spring Creek enhancement project. Channel geometry had changed significantly, with the channel being considerably wider, and aquatic and terrestrial plants were growing within the channel during this period of low stream flow. In many places the accumulation of fine sediment was greater than 6 inches deep. Despite poor habitat and low flow, small fish, which were potentially brown trout fry, were exceptionally abundant. Two weeks later, we deployed minnow traps baited with Balls O'Fire™ fish bait; however, the fry were no longer present. The traps captured sculpin and a longnose dace.

On July 27, 2016, Carol Endicott, Michelle McGree, and Jonathan Ferree, all from FWP, visited Kickabuck Spring Creek to evaluate the cause of channel widening and extreme sedimentation. Among the observations was that the Kickabuck Spring Creek, and its wet meadow, is perched above the level of the Yellowstone River, resulting in a lush area with floating sedge meadows. Stream flows increase considerably through late summer and fall, and appear to exert lateral force on the soft, yielding sedge banks. As a result, the channel has become wider and shallower than what was constructed.

2.12.3 Conclusions

Kickabuck Spring Creek has not been successful in meeting its original goal of establishing a spawning area for fluvial Yellowstone cutthroat trout. Factors affecting this outcome include a decrease in fluvial Yellowstone cutthroat trout in neighboring Yellowstone River, the entombment of spawning gravels under several inches of muck, along with the widening of the constructed channel. The potential for spawning by brown trout needs more investigation. No redds have been seen during fall months; however, the abundant small fish present in June suggests brown trout spawn in the stream. Additional attempts at redd counts in fall, and trapping fry in spring are warranted to evaluate Kickabuck Spring Creek's potential to contribute to brown trout recruitment.

2.13 Lower Deer Creek fish barrier (011-2010)

2.13.1 Background

Lower Deer Creek is a tributary of the Yellowstone River that joins the Yellowstone about 8 miles downstream of Big Timber. Yellowstone cutthroat trout and brown trout reside in Lower Deer Creek, with brown trout outnumbering Yellowstone cutthroat trout, although Yellowstone cutthroat trout increased in relative abundance in the headwaters. Genetic analyses found only nonhybridized Yellowstone cutthroat trout until 2005, when 8 hybridized fish were found on private lands about 3 miles downstream from the Custer Gallatin National Forest boundary. As protection of nonhybridized populations of Yellowstone cutthroat trout is the highest conservation priority, the presence of hybrids resulted in an urgent need to intervene. In 2010, FWP constructed a barrier on state land, and the FFIP contributed towards the cost of design and construction. The barrier location provided over 11 miles of protected habitat, which would allow for a relatively large population size, with the ability to persist over the long-term, in absence of nonnative species.

Figure 2-60. Newly constructed barrier on Lower Deer Creek.

A second element of protecting this isolated population of Yellowstone cutthroat trout was removal of brown trout. Yellowstone cutthroat trout had persisted alongside brown trout for 60 years in Lower Deer Creek; however, their relative abundance was decreasing. A marked reversal in the relative abundances of Yellowstone cutthroat trout and brown trout in other streams suggested long-term persistence of Yellowstone cutthroat trout was at risk due to the presence of brown trout. Constructing a barrier and removing brown trout provided the nonhybridized Yellowstone cutthroat trout in Lower Deer Creek the best chance at long-term persistence.

The barrier was constructed in November 2010. In spring of 2011, high snowpack and spring rains resulted in peak flows approaching a 500 year flood. Examination of the barrier after this event found the pool upstream of the barrier had filled in entirely with cobbles, which was desirable, as flow and debris will not exert pressure on the wall in future floods. Conversely, cobbles had accumulated on the downstream apron, which caused concerns for backwatering or providing roughness that would allow nonnatives to breach the barrier. An old wheelbarrow became jammed against the upstream wall of the barrier, and bed load transported over the wheelbarrow scoured a hole in the concrete of the apron. This scour hole was repaired the following summer.

Rotenone treatment occurred in late August 2010. Electrofishing crews salvaged as many Yellowstone cutthroat trout as possible over 4 days. The rotenone treatment lasted 4 days, and the Yellowstone cutthroat trout were returned to Lower Deer Creek as soon as treatment stopped.

2.13.2 Field Assessment 2014

In 2014, Jason Rhoten the area fisheries biologist with FWP visited the barrier location. His objectives were to evaluate 2 aspects of the project: was the barrier structural stable, and was it functioning to prevent invasion of nonnative species. The structure remained structurally sound and functionally operational as a fish barrier. Periodic inspection, especially following large flow events, is warranted to inspect for damage, clear debris, and conduct repairs as warranted.

In addition to barrier construction, Mr. Rhoten and his field crew electrofished several miles of Lower Deer Creek and Placer Gulch, a known spawning tributary. Yellowstone cutthroat trout were abundant, an array of year classes were present, and size and fitness of fish suggested a plentiful forage base. Age-1 fish were super-abundant in Placer Gulch, indicating this stream remained an important, productive spawning area and nursery for Yellowstone cutthroat trout. No brown trout were found, nor have anglers reported catching brown trout; therefore, the single rotenone treatment was likely successful in removing this nonnative species. Overall, indicators of the health of this fishery were consistent with a thriving population of Yellowstone cutthroat trout that was free from threats of nonnative species.

2.13.3 Conclusions

The Lower Deer Creek project has been successful in securing a substantial amount of stream habitat for nonhybridized Yellowstone cutthroat trout, without pressure from nonnative species. The lack of brown trout in the 2014 sampling event indicates the single rotenone treatment was successful in removing this nonnative species. The barrier has prevented upstream movement of nonnatives since its construction. The explosive growth of the Yellowstone cutthroat trout population is typical of populations that are freed from competition with nonnative species. As securing nonhybridized populations of cutthroat trout is the highest priority for cutthroat conservation in Montana, this project is an important conservation success.

In terms of barrier management, the tendency for cobbles to accumulate on the apron of the barrier underscores the need for periodic maintenance of barriers, especially after high flows. In addition, future barrier design should consider steeper aprons that would have more energy to transport bed load.

2.14 Nelson/ Dana Spring Creek channel restoration (012-2005)

2.14.1 Background

Nelson/Dana Spring Creek (also known as Nelson Ditch) is a small stream that joins the Yellowstone River just south of Livingston, MT. Several springs feed this stream, and historically, the entire site likely was a patchwork of emergent wetlands within ancient river meanders. The flows had been routed through several channels that had been substantially altered from their historical condition, and did not provide suitable habitat for fish (Figure 2-61). Presumably, the ditches were excavated to capture and route groundwater, which would lower the water table, and replace wetland with pastureland. The channels were overly wide, and had a mud substrate. Riparian vegetation was limited to sedges growing in a swampy, channel-adjacent strip. The channels converged for the last 500 feet of channel before entering the Yellowstone River.

Figure 2-61. Pre-project photo of an excavated channel feeding the Nelson/Dana Spring Creek.

The landowners were interested in enhancing the fish and wildlife resource values of this aquatic feature, with emphasis on creating spawning habitat for Yellowstone River resident fish. Specific actions varied among the 7 reaches delineated within the project area (Figure 2-62). Typical treatments included narrowing and deepening channels, excavating pools, providing woody debris, construction of new banks with sod mats, construction of reaches of channel, and willow plantings.

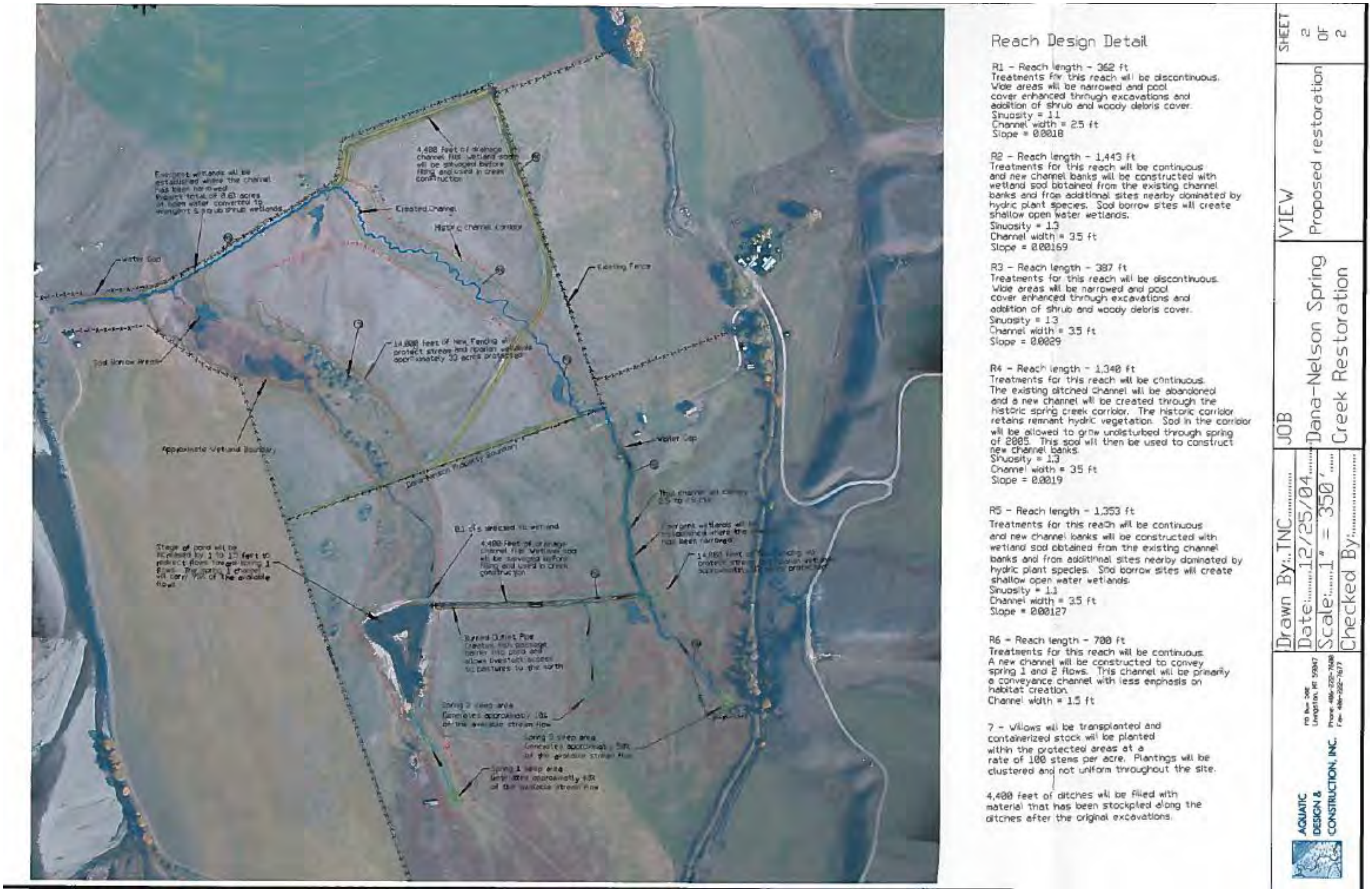

Figure 2-62. Designs for the Nelson/Dana Spring Creek restoration.

2.14.2 Field Assessment 2016

On July 5, 2016, Shannon Bockmon visited the Nelson/Dana Spring Creek project, accompanied by the landowner. A beaver dam near the mouth was the first feature noted (Figure 2-63). According to the landowner, high flows in the Yellowstone River remove beaver dams near the mouth in most years; however, low peak flows did not flush out the dam. He also reported seeing Yellowstone cutthroat trout ascending the spring creek in most years.

Figure 2-63. Beaver dam on Nelson/Dana Spring Creek

Installation of a hardened water gap was a component of the project that allowed livestock access to water, while protecting the riparian area and stream banks (Figure 2-64). Outside this small area of livestock access, the riparian area was thriving. A mature, thick stand of willows provided considerable benefit to the stream and fisheries by shading the stream, providing overhead cover, and maintaining channel stability.

Figure 2-64. Water gap for watering livestock on Nelson/Dana Spring Creek.

The constructed and enhanced stream channel had maintained its narrow and deep cross-sectional morphology for the stream's entire length (Figure 2-65). The sedge banks provided considerable undercut bank habitat. Aquatic macrophytes, which are typical of spring creeks, were dense in places; however, sufficient flow existed to limit their cover, and areas of spawning gravel remained exposed.

Figure 2-65. Typical view of the constructed and enhanced channel on Nelson/Dana Spring Creek.

Figure 2-66. Spawning gravel in Nelson/Dana Spring Creek.

2.14.3 Conclusions

The Nelson/Dana Spring Creek restoration and enhancement project has been successful in terms of providing high quality, small stream habitat. The landowner reported regular spawning runs of Yellowstone cutthroat trout; however, no data have been collected to document the size of the run, and relative numbers of fry recruited. Moreover, this stream supports a resident fishery, and no data are available on the resident fish population. Trapping adult spawners, fry trapping, and electrofishing would be useful in evaluating use by fluvial fish, fry production, and the health of the resident fishery.

2.15 Piney Creek pool and habitat enhancement (033-2005 & 034-2009)

2.15.1 Background

Piney Creek is a small spring creek that emerges in juniper scrubland on the west side of the Pryor Mountains, south of Billings. The stream flows for about ¾ miles before being diverted into several irrigation canals (Figure 2-67). Piney Creek supports population of nonhybridized Yellowstone cutthroat trout. Piney Creek is the only stream in Shoshone River 4th code HUC (Figure 2-68), an area that encompasses the main stem of the Shoshone River watershed and minor tributaries, that supports an aboriginal population of Yellowstone cutthroat trout. Piney Creek comprises 1% of the historically occupied habitat in this HUC. As a nonhybridized population of Yellowstone cutthroat trout, securing this population is the highest priority under Montana's conservation strategy for cutthroat trout.

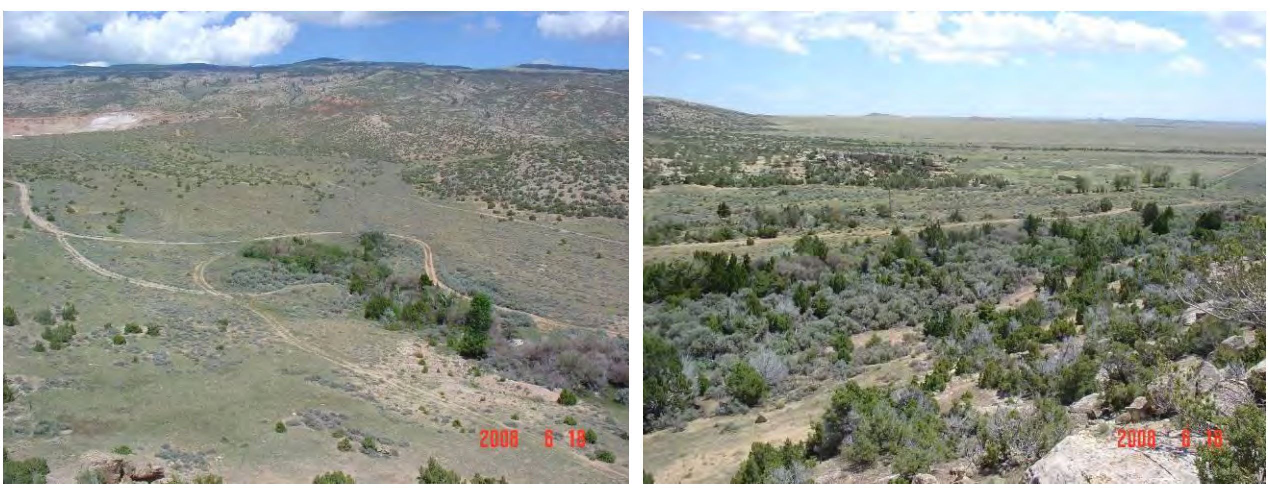

Figure 2-67. Head of Piney Creek and its valley.

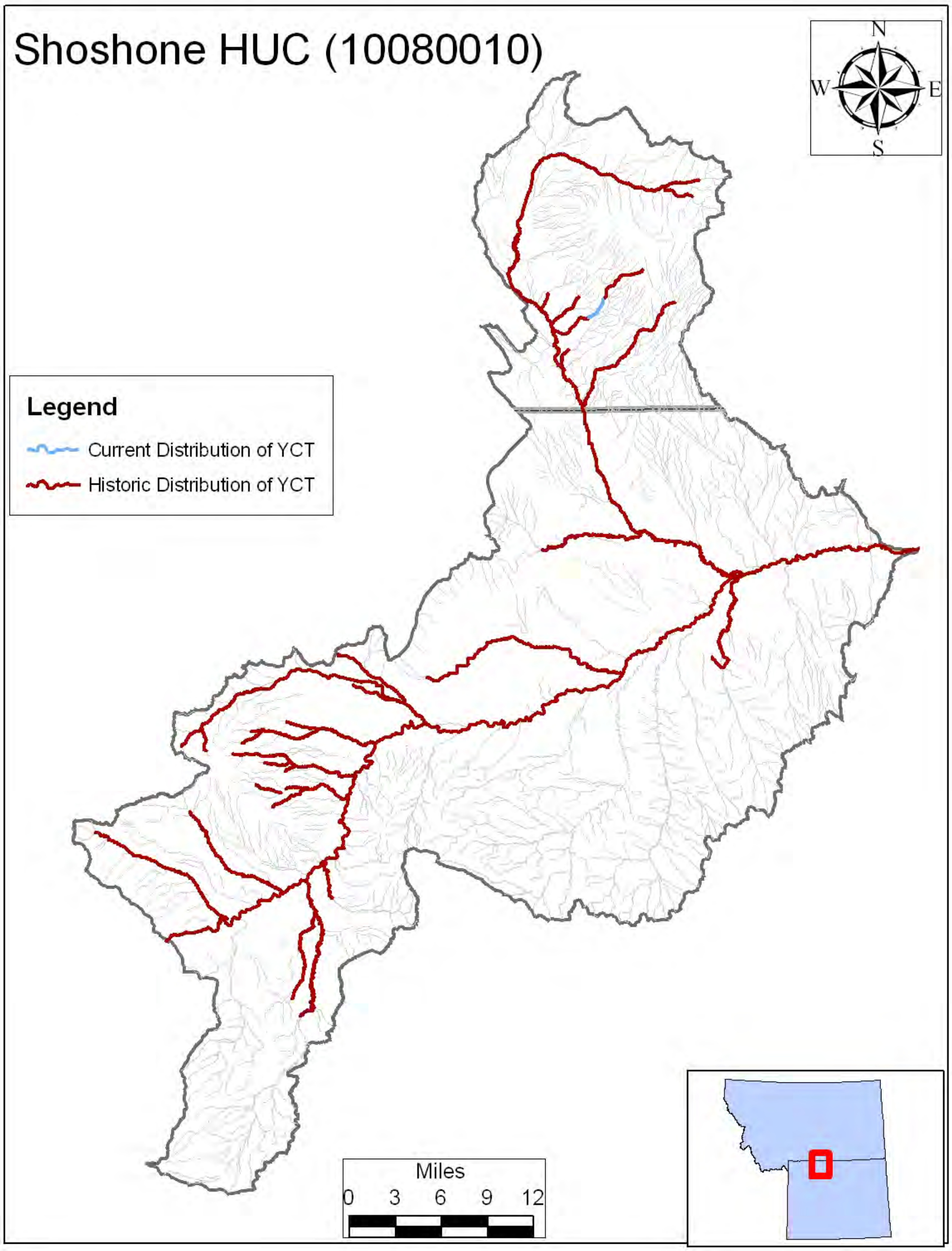

Figure 2-68. Historical and current distribution of aboriginal Yellowstone cutthroat trout in the Shoshone River HUC

The extreme isolation, small population size, comprised habitat and documented loss to the irrigation ditches put Yellowstone cutthroat trout in Piney Creek at extreme risk for extirpation. The short extent of occupiable stream has the potential to support a tiny population, which could lead to problems associated with inbreeding. Likewise, no neighboring populations have access to Piney Creek in the event that a catastrophic event or the results of inbreeding were to eliminate the population. Comparison of electrofishing data from the 1990s and 2000s caused concern that drought had severely depressed Piney Creek's Yellowstone cutthroat trout population. The dense, low riparian canopy makes sampling Piney Creek difficult, as only a handful of discrete locations can be accessed, so fish density within areas of heavy riparian cover is indeterminable. However, markedly fewer fish were captured in the 2000s, compared to the mid-1990s, and extended drought was a probable stressor on the fish population. The BLM captured only 4 Yellowstone cutthroat trout in 2004.

A lack of high quality habitat presented another limitation on Piney Creek's Yellowstone cutthroat trout population. Pools were rare, and present in a few locations where large rock or other structure allowed for scouring of the streambed. In addition, livestock grazing along portions of the stream impaired the health and function of riparian vegetation, and degraded habitat.

Along its short length, Piney Creek flows through national forest, BLM lands, and private property. The private landowners, FWP, CGNF, and BLM collaborated on efforts to improve habitat and prevent loss of fish to irrigation diversions. FFIP provided funds for prevention of entrainment and pool creation. The CGNF and BLM worked on grazing management, which included riparian fencing. In addition, the BLM added woody debris to promote scour of pool habitat.

In 2005, FFIP provided funds for the excavation of pools, to reverse the extreme shortage of this important habitat feature within Piney Creek. Given the small size of the stream, hand excavation using shovels was the chosen method. Unfortunately, the streambed was well armored, and shovels could not penetrate it in order to excavate pools. As a result, this project did not meet the objective of increasing pool habitat in Piney Creek.

Prevention of entrainment entailed construction of a berm to reactivate a pond in an existing depression, and installing standpipes that delivered water to the irrigation canals (Figure 2-69 and Figure 2-70). Waterman gates controlled inflows to the pipes. Fry and juvenile fish would be unlikely to be in the water column, near the top of the standpipe, and would not risk entrainment. Likewise, adult fish would be less likely to enter the standpipes, compared to the irrigation ditches, which were indistinguishable from natural streams. The creation of a large pool stored water for irrigation, but also increased overwintering habitat, and provided standing water habitat that was not present previously.

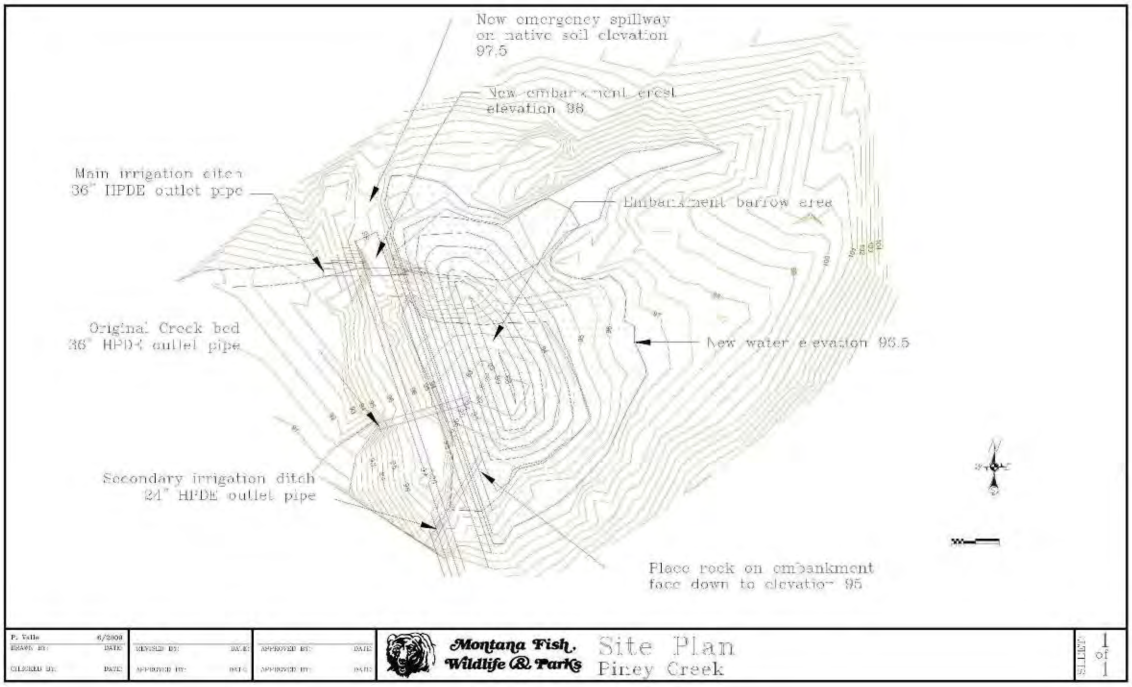

Figure 2-69. Design for fish entrainment prevention on Piney Creek.

Figure 2-70. Storage pond and gated stand pipes soon after construction.

2.15.2 Field Assessment 2016

On July 21, 2016, Shannon Bockmon and Mike Ruggles, FWP's area fisheries biologist evaluated entrainment prevention and habitat improvements on Piney Creek. In addition, they spot electrofished where possible, to evaluate Yellowstone cutthroat trout numbers in the stream. They collected fin clips from 50 Yellowstone cutthroat trout to evaluate the genetic status of this population.

The pond was full and delivering water to the canal through the gated stand pipes (Figure 2-71). Numerous, relatively large Yellowstone cutthroat trout were visible in the pond. Willows had colonized the perimeter of the pond. This type of aquatic feature is rare to absent in this arid landscape, and provides a patch of habitat diversity.

Figure 2-71. Stand pipe diversion, and inlet of Piney Creek into the storage pond.

Given the density of the riparian vegetation, electrofishing was confined to discrete spots; however, over 50 fish were captured, which is a marked increase from the 4 that were captured in 2004. An apparently substantial increase in the number of fish in the stream, and the additional fish-bearing habitat in the pond indicates this project has been successful in increasing population size, which increases its resilience to disturbance and inbreeding.

The woody debris installed in Piney Creek had been effective in scouring new pools into the stream bed. Increased number and depth of pools improved the quality of habitat, and likely increased the carrying capacity, or number of fish the stream could support.

2.15.3 Conclusions

The Piney Creek habitat enhancement and entrainment prevention projects met the goals of increasing fish numbers in Piney Creek, and preventing loss of fish to irrigation and stock water systems. Although isolation and small population size remain as threats to the long-term persistence of this population, these actions have substantially increased the ability of the population to withstand environmental stressors. Continued evaluation of the genetic diversity of the population is warranted, with augmentation with nonhybridized brood stock occurring as deemed necessary by FWP's fish geneticist.

2.16 Rock Creek culvert fish passage (016-2011)

2.16.1 Background

Rock Creek is a tributary of the Yellowstone River, and is located downstream of Corwin Springs, in upper Paradise Valley. In the early 1900s, the Northern Pacific Railroad Company constructed a concrete culvert that funneled Rock Creek under the rail line that ran from Livingston to Gardiner. This culvert was 70 feet long and had a slope of 7.5%. The combined length and velocity of water flowing through this structure made it a barrier to upstream movement, and fluvial Yellowstone cutthroat trout were excluded from spawning in Rock Creek. In the late 1970s, a fish ladder was installed, and connectivity was restored for several years, and substantial numbers of Yellowstone cutthroat trout fry were documented outmigrating from Rock Creek. This ladder failed in the early 1980s. As the culvert floor scoured, and debris clogged the culvert, some Yellowstone cutthroat trout were likely able to swim through the culvert, owing to the increased complexity and roughness. Nevertheless, these would need to be especially strong swimmers. Fry monitoring in 2009 found no fry upstream of the culvert.

Figure 2-72. Railroad culvert on Rock Creek.

Protecting migratory life-history strategies is a high conservation priority under Montana's agreement for cutthroat trout conservation. The population in the upper Yellowstone River has substantial conservation value, as nonhybridized fish remain, despite presence of rainbow trout. The genetic status of these fish elevates the population to the highest conservation priority in securing cutthroat trout. Therefore, this project brings substantial conservation benefit. Moreover, Yellowstone cutthroat trout are common in the neighboring reach of the Yellowstone River, and provide a valued recreational fishery for anglers. Being able to catch large, native cutthroat trout, in a spectacular setting is a rare and special opportunity.

The solution to provide passage into Rock Creek was to remove the culvert, and construct a series of step-pools through the former footprint of the steep culvert (Figure 2-73). Design considerations included ensuring rock was large enough to remain in place, and placed so that current refugia existed at the channel margins at high flows.

Figure 2-73. Newly constructed step-pool sequence.

To evaluate how early a spawning run of Yellowstone cutthroat trout would be established in Rock Creek, FWP implanted PIT tags in Yellowstone cutthroat trout, rainbow trout, and their hybrids caught in the Yellowstone River near Rock Creek. PIT tags use technology similar to microchips in pets. Two antennae installed under the county road bridge would register when a fish swam over the antennae, and identify the specific fish. The 2 antennae allowed for determination of direction.

The culvert removal and step-pool construction occurred in 2011, and in the following spawning season, PIT tag antennae registered 6 individual Yellowstone cutthroat trout, 2 rainbow trout, and 1 hybrid. The number of specifically identifiable fish increased in 2013, with 22 individual Yellowstone cutthroat trout passing under the bridge, and 7 rainbow trout. As fish in this reach of river have the choice of several tributaries, recolonization of Rock Creek the next 2 springs was sign of success. The progeny of these spawners will home to Rock Creek, and the run should grow within a few years.

In 2014, Michelle McGree, Jim Darling, and Carol Endicott evaluated the step-pool and the recovery of vegetation planted on the surrounding railroad berm. The boulders remained in place, and the feature appeared passable. Willows were beginning to recruit along the stream margin, and upland plantings on the re-sloped sides of the berm were doing well.

Figure 2-74. Step-pool sequence constructed to provide fish passage into Rock Creek.

2.16.2 Field Assessment 2016

As the step-pool structure had remained unchanged since the last assessment, monitoring in 2016 focused on fry recruitment. From August 3, 2016 through August 12, 2016, a fry trap was deployed upstream of the county road bridge (Figure 2-75). Fry traps consist of a rectangular frame, with a funnel net that leads to PVC pipes that in turn empty into a perforated, plastic box (Figure 2-76). The frame is set where it can capture the bulk of the stream flow.

Figure 2-75. Location of fry trap on Rock Creek, upstream of constructed step-pools. Shannon Bockmon is ready to process trapped fry.

Figure 2-76. Example of a fry trap.

Although fry outmigration usually occurs later in August, warm temperatures pushed many ecological phases earlier. On the first night of fry trapping, over 300 fry were captured in the fry trap (Figure 2-77). Numbers decreased for 2 days, and then rose again to almost 300. The outmigration was over by August 12, 2016. Tissue samples were collected from a number of mortalities to verify species, although the timing suggests Yellowstone cutthroat trout, and obviously rainbow trout fry were considerably larger.

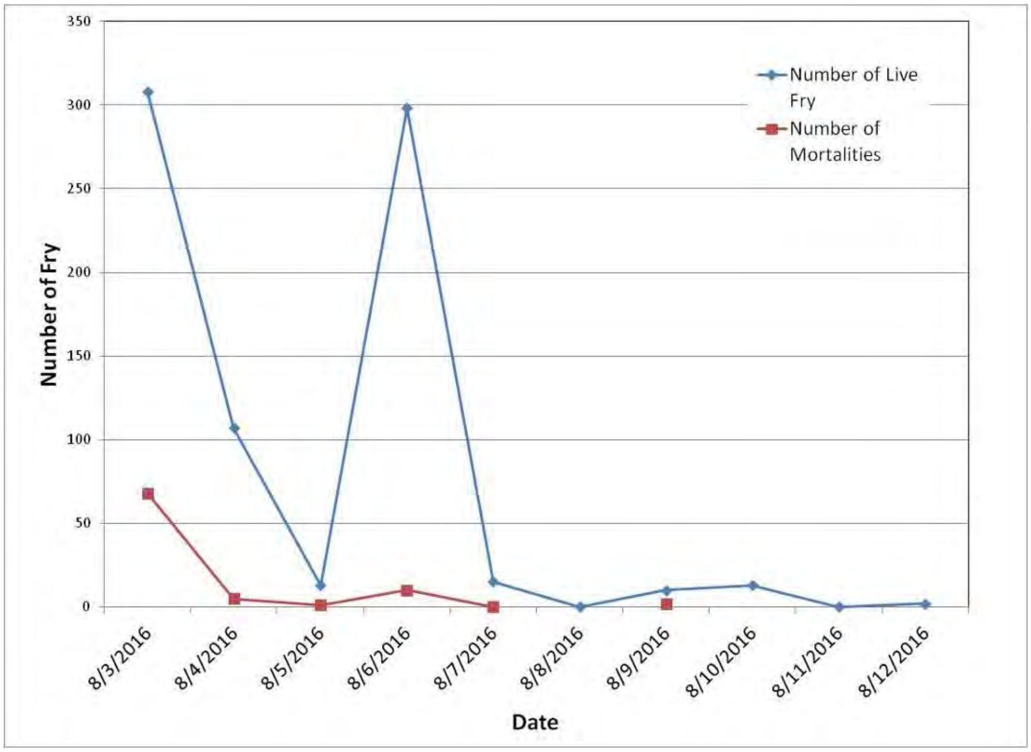

Figure 2-77. Number of fry captured in the fry trap deployed in Rock Creek.

2.16.3 Conclusions

The Rock Creek fish passage project has shown tremendous success to date, with the step-pool structure remaining passable, Yellowstone cutthroat trout ascending the feature, and substantial numbers of fry outmigrating to the Yellowstone River. Although results that will verify genetic composition of outmigrating fry are pending, this project has potential to meet the highest conservation priorities for cutthroat trout conservation in Montana, namely, securing migratory life-histories and nonhybridized populations. Such success decreases justification to protect Yellowstone cutthroat trout under the Endangered Species Act, and provides excellent angling opportunities in the Yellowstone River.

2.17 Shields River (060-1999)

2.17.1 Background

The Shields River is a major tributary of the Yellowstone River, and its confluence with the Yellowstone River is downstream of Livingston. The Shields River watershed has considerable conservation value for Yellowstone cutthroat trout, as nonhybridized Yellowstone cutthroat trout remain widespread in its streams, although some hybridization is present. Other conservation concerns include bank erosion, which contributes considerable amounts of fine sediment to the river, and the Shields River corridor is a high priority for projects to decrease sediment loading.

The first attempt at bank restoration was in 1999. The goal of this project was to stabilize approximately 600 feet of stream bank. Actions included installation of riparian fencing, root wads, and tree revetments along the eroding banks. In addition, development of a spring, and piping water to a stock tank located outside of the fenced riparian provided an alternative source of stock water away from the river.

Evaluation of aerial photos upstream of the project area, and within the project area, provides insight into the cause of the lateral movements of stream banks. Approximately 1/3 of a mile of stream channel was likely straightened in the relatively distant past (Figure 2-78). Closer view of the channelized reach shows old meander scars, which support the assumption that the stream occupied more of its floodplain, and humans had altered the channel (Figure 2-79).

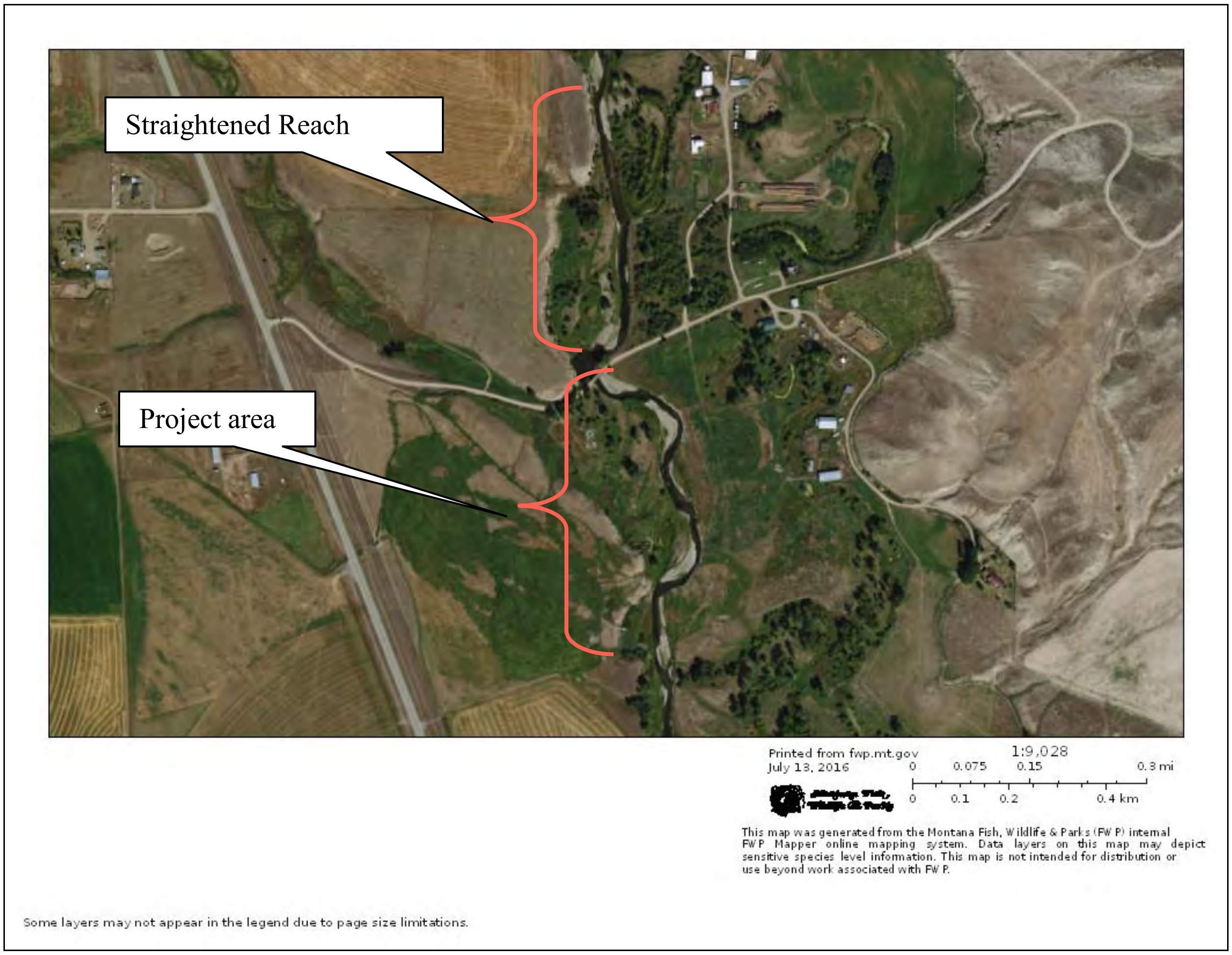

Figure 2-78. Aerial photo of project area and the straightened reach located upstream.

Figure 2-79. Close-up of channelized reach upstream of the project area.

Straight channels have greater stream power during high flows, as they lack meanders to dissipate flow velocities. As a result, bed load movement of gravel and cobbles is substantial, and these particles do not accumulate on point bars within the straightened channel. When the flows hit the more sinuous reach, the water slows down, and the gravel and cobble settle out to form large point bars. (Figure 2-78). These point bars divert high flows into the opposite bank, which results in greater erosive pressure than the banks can handle.

Follow-up monitoring in 1999 found the root wads and revetments were not successful in maintaining bank stability, and many of these installed features washed out. The assessment concluded that stabilization efforts rivers with high bed load and frequent flooding, like the Shields River, is challenging. The project did not meet the bank stabilization goals; however, livestock management efforts were successful in improving riparian health and function.

2.17.2 Field Assessment 2016

On July 12, 2016, Shannon Bockmon and Carol Endicott revisited the site, along with the landowner. After failure of the root wads and revetments, the landowner obtained permits to apply relatively large rock along the toe eroding banks (Figure 2-80). Sod mats place along re-sloped banks provided protection above the bank full margin. This work was done at his own expense.

Figure 2-80. Example of bank stabilization on the Shields River after failure of the root wads and tree revetments.

Within the restored reach, point bar development indicated an imbalance in transport and deposition of bed load (Figure 2-81 and Figure 2-78), and growth of point bars put more pressure on the opposing banks, which were the subject of restoration efforts. Bank armoring, although not desirable from fisheries or river form and function perspectives, was successful in protecting land. Nonetheless armoring did extend the area of disturbance by exerting pressure on banks downstream of the project area, contributing to a small area of bank erosion.

Figure 2-81. Example of large point bar within project area.

With the exception of the large point bars, the livestock grazing management component of the project continued to be successful in promoting a healthy, functional riparian area, with recruitment of woody vegetation. In contrast, the amount of bed load deposited on the large point bars, and their elevation above the water table makes recruitment of woody vegetation difficult. Young willows and cottonwoods are buried by deposited rock. In addition, as seedlings, these species need to keep their tap roots in contact with groundwater as the flows subside in the summer. Water levels drop relatively quickly in these elevated and porous point bars, and the young plants die of desiccation, despite being within the active channel.

2.17.3 Conclusions

This project did not meet the project goal of using supposedly "softer" approaches to restore bank stability, reduce sediment loading, or improve fish habitat. The revetments and root wads failed to achieve the desired stream bank conditions, and in hindsight, their use on a stream as flashy as the Shields River was inappropriate. The subsequent use of relatively large rock was successful in protecting land, although this approach runs the risk of increasing erosive forces downstream. The fencing was successful in promoting recruitment of shrubs, and willows were contributing to stabilizing banks within the project area.

This project provides an example of the benefit of looking beyond the area of concern, to determine if upstream geomorphic changes are contributing to degradation within a project area. Viewing projects from the perspective of river form and function on a larger scale is essential in restoring reaches within the project area. In this case, channelization upstream had increased the force and delivery of bed load to the project area. An alternative or adjunct to bank restoration in the project area would be to return the straightened channel upstream to its former, sinuous channel, which would dissipate flow velocities, and avoid downstream development of large point bars that divert stream flows into the opposite bank.

Several considerations affect the feasibility of taking this larger view of river restoration. Often, the land upstream may be under different ownership, and that landowner may not be interested in channel alterations on his or her property. Cost is another consideration. Restoring the channel to its former configuration would require considerable design, the use of heavy equipment within the project area, and an aggressive re-vegetation plan. Conversely, armoring banks with large rock is also expensive, as the rock must often be purchased, moved to the site, and installed using heavy equipment.

From the perspective of the Future Fisheries Improvement Program goals, channel re-naturalization would bring fisheries benefits. The channelized reach is unlikely to provide pools, and other habitat features that are important to fish. Returning sinuosity to the channel would result in lateral scour pools, and sorting of gravels to provide spawning habitat. Likewise, the formation of large point bars downstream does not allow riparian vegetation opportunity establish near the stream. Therefore, functional attributes such as shading, woody debris recruitment, and formation of undercut banks are unlikely to occur.

2.18 South Fork & Middle Forks Horse Creek channel stabilization (012-2011)

2.18.1 Background

Horse Creek is a tributary of the Shields River that joins the Shields River downstream of Wilsall, MT. Horse Creek has 3 major tributaries that originate in the Crazy Mountains, and converge in the valley. The goals of this project were to reverse impaired riparian health and function, improve degraded fish habitat, and eliminate several significant sources of fine sediment on the south and middle forks of Horse Creek.

Both forks of Horse Creek support nonhybridized Yellowstone cutthroat trout, which makes habitat restoration and protection a priority. Yellowstone cutthroat trout live in sympatry with brook trout in the south fork, and brook trout can easily displace Yellowstone cutthroat trout. Decreasing sedimentation may give Yellowstone cutthroat trout a little more resilience in the face of competition with brook trout.

The Middle Fork Horse Creek project addressed sediment delivered from where the stream abutted a vertical, eroding terrace, and a lack of willows within the project area (Figure 2-82). This pasture was likely used during calving by previous owners, and cattle had removed much of the riparian vegetation. The landowners at the time did not plan to use this pasture for grazing, so it had several years of rest. Nonetheless, willows had not recovered, and weeds infested most of the floodplain.

Figure 2-82. Middle Fork Horse Creek project area before project implementation.

Similar to Middle Fork Horse Creek, South Fork Horse had several reaches where the stream exerted considerable force on vertical, eroding terraces (Figure 2-83). In addition, current grazing practices were damaging stream banks, and impairing the health and function of the riparian area. Cattle accessed the stream at numerous locations, resulting in hoof shear, and exposed dirt (Figure 2-84). Riparian shrubs were absent from a considerable portion of the stream, and many banks were actively eroding (Figure 2-85). The suspended sediment load was substantial, as the stream was turbid, even during low flows.

Figure 2-83. Example of stream abutting an eroding terrace on South Fork Horse Creek.

Figure 2-84. Example of cattle access point.

Figure 2-85. Example of lack of riparian shrubs and eroding banks on South Fork Horse Creek.

On both streams, the strategy to reduce erosion from high vertical terraces entailed construction of a floodplain bench between the stream and the terrace (Figure 2-86). The benches removed the shear stress at the toe of the terrace, and provided a floodplain with roughness that dissipates the erosive force of flood flows. The banks were built from wetland sod mats that were harvested from within the project area.

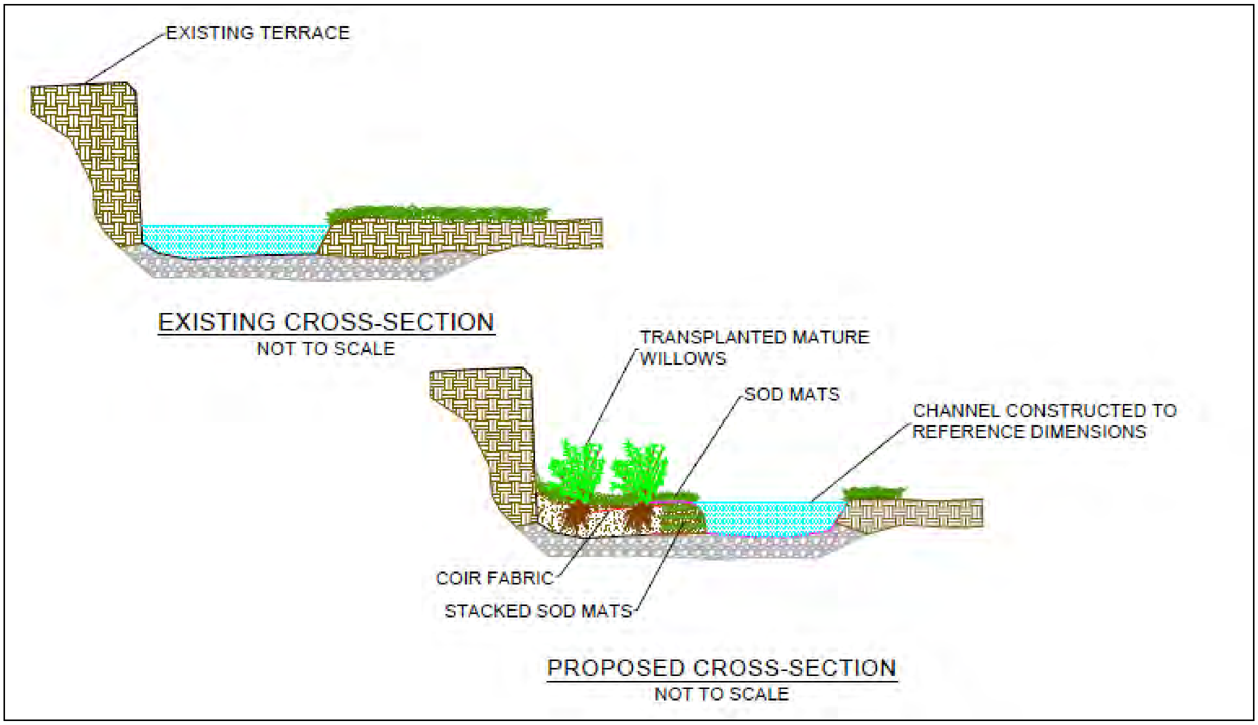

Figure 2-86. Conceptual plan for construction of floodplain bench.

Deposition of fine sediment occurred along most of the channel (Figure 2-87). This siltation reduces the suitability of the gravel for spawning, and limits invertebrate production, as the spaces among gravel particles are clogged with sediment. Even relatively high gradient, narrow and deep portions of channel had substantial amounts of fine sediment.

Figure 2-87. Sedimentation of streambed in a relatively high gradient portion of South Fork Horse Creek.

A separate component of this project addressed livestock management on the ranch. The landowner chose to exclude cattle in the project area of the Middle Fork Horse Creek, so livestock would not alter riparian vegetation, or access the stream banks. Actions on South Fork Horse Creek included installation of a fence to control the ability of cattle to access the riparian area and stream, development of a ranch-wide grazing management plan, and installation of off-stream stock water. The landowner worked with the Natural Resources and Conservation Service on these activities.

Disturbance is common in streams, and the South Fork Horse Creek flooded the spring after construction (Figure 2-88), resulting in considerable shear stress on the newly constructed benches. These flows also resulted in abandonment of existing channels, formation of multiple channels, and a substantial head cut, where the stream bed made a dramatic drop in elevation (Figure 2-89).

Figure 2-88. Declining limb of flood, spring 2012.

Figure 2-89. Head cut on South Fork Horse Creek caused by flood.

2.18.2 Field Assessment

On June 7, 2016, Shannon Bockmon and Carol Endicott visited the restoration projects on the middle and south forks of Horse Creek. Overall, these projects have made profound improvements in the quality of fish habitat, and have dramatically decreased sediment loading.

The Middle Fork Horse Creek floodplain bench is serving its purpose of reducing sediment delivery to streams, and the adjacent channel is considerably more narrow and deeper than the pre-project channel (Figure 2-90). Keeping erosive forces off the toe of the vertical terrace has allowed the upper portion of the terrace to settle into an angle of repose. Furthermore, this formerly vertical wall is growing vegetation, albeit weeds, but the plants will continue to stabilize the bare soil. Willows are recruiting on the bench, and the transplanted sedge mats are indistinguishable from a natural bank.

Figure 2-90. Floodplain bench 5 years after construction.

Marked improvements were also present on the South Fork Horse Creek. Similar to the middle fork, construction of floodplain benches had eliminated the erosive force on the toes of the eroding terrace, and these benches are vegetated with sedges and willows (Figure 2-91). Moreover, the vertical walls were settling, and becoming vegetated.

Figure 2-91. Constructed floodplain bench on South fork Horse Creek.

Resting this reach of stream from livestock grazing has resulted in profound improvements in riparian health and function (Figure 2-92). A decrease in deposition of fine sediment was also striking condition, compared to pre-project sedimentation (Figure 2-93). Cleaner substrate should increase spawning success and the forage base for fish.

Figure 2-92. Healthy riparian vegetation and recolonization on gravel bars.

Figure 2-93. Example of streambed 5 years after project implementation showing marked decrease in fine sediment (compare to Figure 2-87).

2.18.3 Conclusions

This project has resulted in profound improvements in several measures of stream health. Rest from grazing has resulted in recovery of riparian vegetation, which allowed substantial lengths of eroding stream bank to heal naturally. Construction of the floodplain benches was also beneficial, and has greatly decreased sediment loading to these streams. The floodplain benches have also allowed the vertical, eroding terraces to settle to a lower angle, and vegetation is colonizing areas where the steepness and constant sloughing had prevented establishment of vegetation before restoration. The decrease in sediment loading appears to have resulted in a cleaner streambed, which is more suitable for spawning, and production of aquatic invertebrates. Overall, this project has been a huge success, and a well spent use of FFIP funds.

2.19 Sweet Grass Creek fencing (057-1998)

2.19.1 Background

Sweet Grass Creek is a tributary of the Yellowstone River that joins the river about 9 miles downstream of Big Timber. The project area lies about ½ miles from the confluence of the Yellowstone River. This portion of Sweet Grass Creek is transitional between a warm-water and cold-water fishery, and supports a diversity of fishes including brown trout several species of the minnow family, mountain white fish, shorthead redhorse, mountain sucker, sculpin and stonecat.

The goal of the project was to improve habitat for fish and wildlife. Cattle exerted considerable pressure on banks and riparian vegetation. In addition, flooding had removed riparian fencing. Specific actions included fencing the riparian area, and installing water gaps to allow access for stock water.

The project was implemented in 1998, and within 4 years, the riparian area and stream channel recovered markedly (Figure 2-94 and Figure 2-95). In its pre-project condition, the banks mostly were exposed cobble, and the channel was overly wide and inefficient in transporting bed load or sediment. With rest from livestock grazing, plants become established on the bare banks. These plants created roughness that trapped sediment during high flows, which is the mechanism through which stream banks are built. With deposition of soil building banks, the channel became narrower. Narrower channels have greater capacity to transport sediment, and the stream carved a deeper channel within the new bank full margin. The consequences of the narrower, deeper channel are improved habitat for fish, and likely slowed warming of water temperatures, with a decrease in the stream's surface water exposed to sunlight. This rate at which the stream recovered is typical of how quickly streams repair themselves when released from continued disturbance.

Figure 2-94. Pre-project photo of the Sweet Grass Creek project area (1998).

Figure 2-95. Post-project photo of the Sweet Grass Creek project area (2002)

2.19.2 Field Assessment 2016

On July 2, 2016, Shannon Bockmon and the landowner evaluated the status of the project. Fencing to control cattle access to the stream was still in place (Figure 2-96), and the landowner reported grazing occurred within the riparian exclosure for short duration each year. An overview of the stream channel from the uplands indicated livestock management continued to maintain stream channel morphology and riparian vegetation (Figure 2-96), and recovery was continuing. Evidence of livestock near the stream was minimal, with isolated hoof shear near banks.

Figure 2-96. Riparian fencing on Sweet Grass Creek.

Figure 2-97. Overview of the middle portion of the project.

A substantial area of bank erosion was present associated with cultivation of irrigated hay adjacent to the channel (Figure 2-98); however, the landowner was unconcerned with the amount of bank erosion. Should erosion along this bank accelerate, construction of a floodplain bank adjacent to the eroding bank may be appropriate to take pressure off the eroding bank, and provide more floodplain area for dissipation of the erosive force of floods.

Figure 2-98. Area of bank erosion adjacent to hay pasture.

2.20 Volney Creek corral relocation (046-2006)

2.20.1 Background

Volney Creek is a small tributary of Red Lodge Creek, which ultimately feeds Cooney Reservoir. Volney Creek flows through rangeland, and is too warm to support a thriving cold-water fishery. Native minnows and suckers, and the occasional brook or brown trout are present in Volney Creek.

The project entailed moving corrals off Volney Creek, and developing wells to replace Volney Creek as a source of stock water. The goal of this project included improving water quality and fisheries values in Volney Creek, but the expected outcomes extended into Red Lodge Creek and Cooney Reservoir. Red Lodge Creek supports an important brown trout fishery. Cooney Reservoir supports a popular recreational fishery for trout and pan fish, such as black crappie. Nutrient loading into Cooney Reservoir results in periodic algal blooms, which can impair fishing and aesthetics, or result in periods of low dissolved oxygen when the algae decomposes. Concentrating cattle within the corrals had resulted in a severely degraded riparian area, and an overly wide channel that did not provide habitat suitable for a healthy fishery. The corrals were a source of nutrients, and eliminating these inputs would have far reaching advantages, extending from the project site into Cooney Reservoir.

Figure 2-99. On-stream corrals on Volney Creek.

2.20.2 Field Assessment 2016

On July 11, 2016, Shannon Bockmon evaluated conditions within the Volney Creek corral relocation project area. All components of the project had been implemented. In the 10 years since project implementation, a narrowing and deepening of the channel was the most apparent sign of recovery (Figure 2-100). Recovery of the shrub community has lagged, although a source for seeds or eventual vegetative recruitment is nearby. As is common in areas with long-term disturbance, noxious weeds continue to infest the project area. The landowner sprays herbicide where she can, and hand pulls weeds close to the stream.

Figure 2-100. Narrow channel and vegetated banks within the former corrals on Volney Creek.

2.20.3 Conclusions

The Volney Creek corral relocation project has been successful in eliminating a point source of nutrients to Volney Creek, and eventually Red Lodge Creek and Cooney Reservoir. In addition, fish habitat has improved markedly within the project area, with substantial narrowing and deepening of the channel. Under the current management, riparian shrubs will likely recruit over time. In addition, continuing weed management will be beneficial to range health within the project area, and reduce spread of noxious weeds.

3 Conclusions

Evaluation of the 19 projects provides insight into the benefits of specific projects, and allows for evaluation of specific approaches to restoration. Identification of approaches with limited success fosters an adaptive approach to stream restoration, in which lessons learned on a given project inform stream practitioners and landowners on practices that are likely to be successful, or actions that may not be appropriate for a given site. Conversely, successful projects provide a model for future efforts, and a showcase for the benefits of fish conservation.

Across all projects involving livestock grazing, controlling animals' access to the stream was an effective component of restoring health and function to riparian areas, improving water quality, and habitat for fish. Numerous options are available, and the selected options should be site specific, and incorporate the producer's resources and goals. Riparian fencing is a commonly employed method, and is highly effective; however, the same results can be attained through grazing management strategies that manage timing, duration, and intensity of grazing within stream adjacent pastures. Fencing has disadvantages in terms of maintenance needs, and blocking wildlife movements, although wildlife friendly fencing can mitigate for the effects of fencing. The NRCS's technical assistance in developing grazing management strategies can be invaluable in promoting stream health, while incorporating the health and vigor of uplands, and the nutritional needs of livestock.

Providing stock water, while limiting access to streams is another universally effective approach. Off-stream stock watering devices and water gaps are effective measures. Constructing water gaps that are sufficiently hardened, while being easy for cattle or horses to walk on, will ensure they are used, and will reduce sediment loading from an area of heavy use.

Restoration, enhancement, or creation of stream habitat in spring creeks had variable results. Esp Spring Creek and Nelson/Dana Spring Creek retained the constructed channel morphology in the years since construction, and provided high quality habitat for resident fish, if not fluvial spawners. In contrast, Kickabuck Spring Creek and Emigrant Spring Creek experienced considerable lateral bank movement, and the resulting overly wide channels were unable to transport fine sediment, resulting in deep accumulations of muck. The pliability of the stream banks appears to be an important factor in the ability of these streams to maintain their channel geometry. Because of their cool summer temperatures, spring creek restoration can bring numerous benefits to all life history stages; however, restoration design should consider the factors allowing banks to be deformable, but not overly mobile.

FFIP frequently provides funding for bank and stream restoration projects entailing mechanical alteration of banks, reconfiguration of stream channels, and riparian plantings on streams with a flashy hydrograph. Among the goals of these projects is to make these streams more resilient to disturbance; however, snow melt and rainfall events result in expected, but unpredictable floods that can undo channel and bank modifications if they occur before riparian vegetation has recovered its function. Designs need to consider geomorphic processes, such as the need for deformable banks, yet acknowledge and plan for the potential for a post-project flood. Brackett Creek provides an example of a project that has been overall beneficial, although a large flood that occurred soon after restoration resulted in considerable bank erosion that has not healed in the decade since the flood, even though Brackett Creek had easy access to its floodplain. The middle and south forks of Horse Creek also experienced a substantial flood in the spring following restoration; however, the damage was relatively limited, and all the constructed floodplain benches remain functional.

Prescribing specific approaches is beyond the scope of this document; however, post-project monitoring identified several points to be considered. A crucial yet complicated consideration is determining how laterally immobile a newly constructed channel or stream bank should be. Armoring the toe of a newly constructed bank with rock that would be movable at a flood of a selected recurrence interval is an option; however, determining the dimension of that flood entails judgment, and an agreed on level of acceptable risk. Likewise, encasing sod mats in coir fabric may provide additional security to the newly constructed banks, yet coir fabric may not be appropriate in all locations, and some restoration designers are decreasing their use of this material. Evaluation of the success or failure of restoration projects elsewhere in the state should inform design parameters. In addition, restoration designers, landowners, fluvial geomorphologists, and stream permitting personnel need to be in collaboration, and determining an acceptable level of risk early in the design process.

The initial failure of the “soft” restoration approach on the Shields River is largely an artifact of limiting the view of the project to the immediate area. By not considering upstream channel alterations, the factors contributing to bank erosion were not fully understood. Livestock grazing practices may have contributed to bank instability; however, an over-abundance of bed load transported at high velocity into the project area was probably more influential.

Another consideration that is difficult to evaluate in retrospect is whether the use of root wads and revetments was appropriate for this site. These bank treatments were commonly used in the 1990s; however, additional methods have been developed in the intervening years, and some of these may have more effective on a flashy river with potential to scour around structures. In general, bank restoration on highly active channels, such as those present on larger, bed load rich rivers, bring challenges and increased risk of failure.

Installation or fortification of fish barriers, combined with treatment with piscicide as warranted, is an effective means to provide secure habitat for native Yellowstone cutthroat trout. Periodic evaluation and maintenance of the structural stability of the barriers, and removal of debris captured on barriers or accumulating downstream, are essential to the long-term success of these projects, and these actions have protected the considerable investment in constructing barriers, and removing nonnatives. Lower Deer Creek, Crooked Creek, and Bad Canyon Creek are examples where these actions have been successful in providing substantial habitat for native cutthroat, and nonnatives have not been able to reinvade in the years since barrier installation and piscicide treatment. In each case, these projects protected an aboriginal population of nonhybridized Yellowstone cutthroat trout. From a cutthroat trout conservation perspective, these were critically important projects. Range-wide and state-wide conservation planning places protection of nonhybridized cutthroat populations as the most important conservation objective. These projects help meet requirements to conserve cutthroat trout under state and federal law, and reduce the justification for including Yellowstone cutthroat trout for protection under the Endangered Species Act.

Providing fish passage through construction of step-pools had variable success. At the mouth of Esp Spring Creek, ice jams or high flows removed the large rock. Despite the failure of the installed steps, the stream may still be accessible during the spring spawning period. On Clear Creek, the large rocks in the step-pools have shifted, but appear to remain functional, and flows through the culvert remain backwatered, and therefore are likely deep and slow enough to allow fish to swim through.

So far, the Rock Creek fish passage project has been highly successful at providing passage. PIT tag monitoring indicated nonhybridized Yellowstone cutthroat trout, rainbow trout, and hybrids ascended this feature in the first spawning period after they were installed. Fry trapping in 2016 captured 766 fry over 10 nights of trapping, and as the greatest number was trapped on the first night, considerably more fry likely outmigrated to the Yellowstone River this year. Periodic monitoring of fry outmigration is warranted to evaluate the establishment of a spawning run into Rock Creek