Future Fisheries Improvement Program Monitoring

2017

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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 16 projects that received funding from the FFIP (Figure 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. Other projects were slated for evaluation; however, difficulties in contacting landowners, or failure to get permission to access the sites limited the number projects visited.

One or more field observers visited each site, and filled out an assessment form that included descriptions 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 or observers 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 aerial photos linked field conditions to a recent aerial view of the project area.

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

Projects evaluated included those benefiting native, species of concern, including Yellowstone Cutthroat Trout and Westslope Cutthroat Trout. Of course, other native species benefit from improvements in habitat and water quality, and these include Mountain Whitefish, Rocky Mountain Spotted 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.

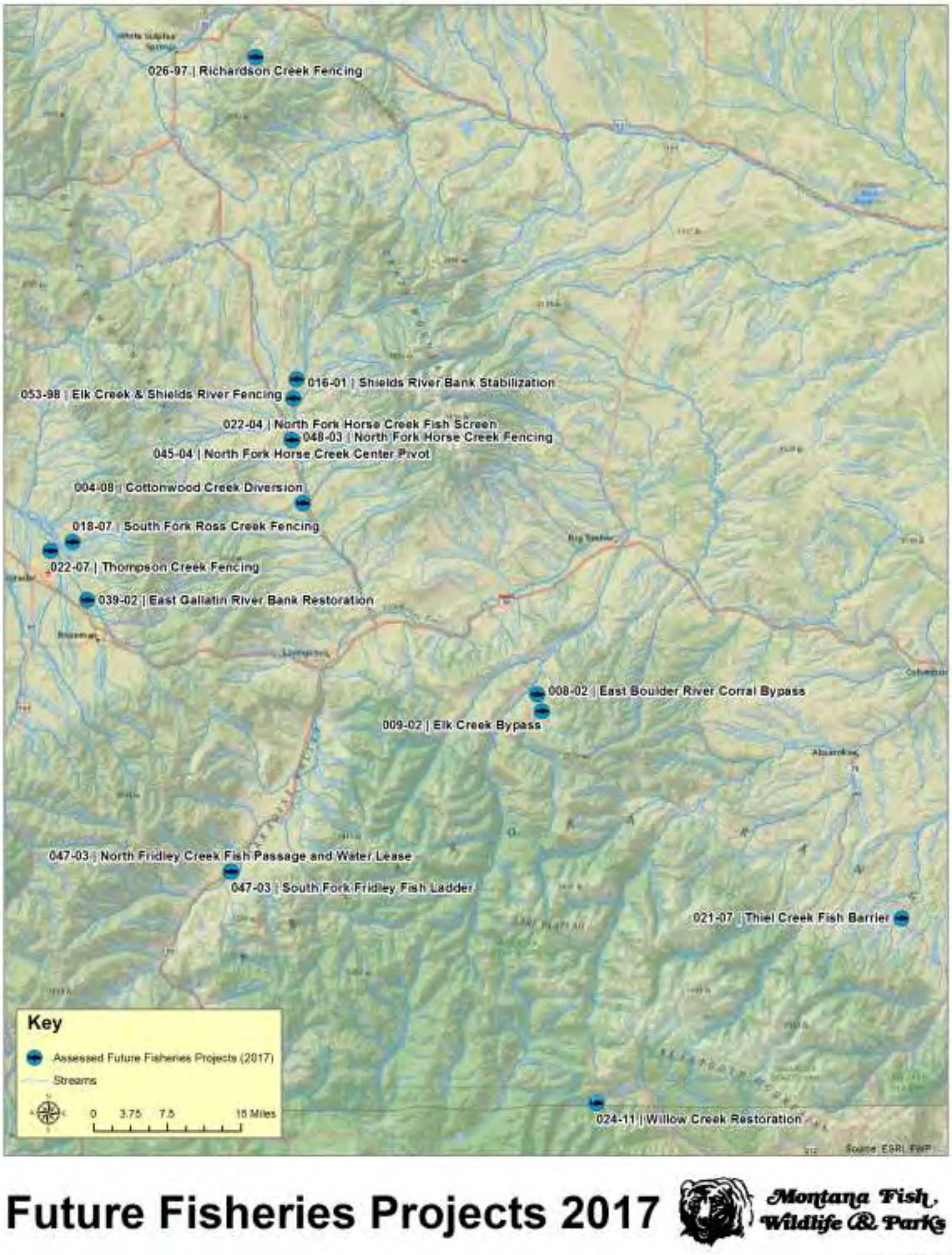

Figure 1. Map of assessed projects.

2 Assessments

2.1 Cottonwood Creek Diversion Replacement (004-08)

2.1.1 Introduction

Cottonwood Creek is a tributary of the Shields River that originates in the Crazy Mountains at Cottonwood Lake and joins the Shields River near Wilsall, MT. Cottonwood Creek supports slightly hybridized Yellowstone Cutthroat Trout, along with Brook Trout, Brown Trout, and likely Rocky Mountain Spotted Sculpin. Cottonwood Creek is a chronically dewatered stream, and flows near its mouth are often nearly or entirely depleted by late summer.

Ron Hoaglund, the Natural Resources Conservation Service (NRCS) district conservationist, who was in the Livingston office at that time, was working with the landowner to replace the existing structure with a check dam equipped with a Denil fish ladder to allow fish passage, and a screw gate at the diversion to decrease water loss through the existing leaking check boards. He requested grant application assistance from Carol Endicott, FWP’s Yellowstone Cutthroat Trout conservation biologist, to procure $5,000 towards the screw gate and Denil fish ladder. He stated the diversion structure would be designed following the biological requirements and structural elements the NRCS was using to replace irrigation diversions in the Big Hole River watershed that were blocking movement of Arctic grayling and leaking water when not in use (Figure 2). Although it is not clear what contribution the NRCS made to the project, as the FFIP application at that time did not require reporting the sources of matching funds, the FFIP application noted the NRCS was providing technical and financial assistance to the project through their Technical Service Provider Program and the Environmental Quality Incentives Program, or EQIP.

Figure 2. Example of pin and plank irrigation diversion equipped with Denil fish ladder and screw gate typical of those being installed in Big Hole River watershed to protect Arctic grayling, and the stated conceptual approach for the diversion on Cottonwood Creek.

Pre-project photos document large logs with tarps backwatered the stream to deliver to the diversion (Figure 3). Considerable water leaked through the check boards at the head gate (Figure 4). The water savings with replacement of the leaking check boards with a Waterman gate would be beneficial and an appropriate use of FFIP funds.

Figure 3. Logs checking Cottonwood Creek's flows to deliver water to the pin and plank head gate.

Figure 4. Water leaking into ditch on Cottonwood Creek when check boards were blocking flow.

2.1.2 Field Visit 2017

On August 23, 2017, Krysten Wolterstorff visited the site to evaluate the condition of the diversion and determine if the Denil fish ladder and Waterman gate had been installed, as required by the agreement. Neither feature was present (Figure 5). The diversion dam was a wooden pin and plank structure spanning the stream. A notch where a check board was not present could provide passage to some species and age classes of fish at certain flows, but placing a board in this location would block upstream movement of fish. Water leaking through the check boards at the diversion resulted in considerable flow within the canal.

Figure 5. Irrigation diversion on Cottonwood Creek.

2.1.3 Conclusions

This project did not meet the design or contractual requirements of the FFIP grant program. The existing structure does not provide the same level of fish passage as a Denil fish ladder, and the check boards in the head gate allow water to continue to leak. This project provided no benefit to fish in Cottonwood Creek.

2.2 East Boulder Spring Creek Stream Relocation and Stock Water (008-02)

2.2.1 Introduction

The East Boulder Spring Creek is a small, unmapped tributary of the East Boulder River. Within the project area, the stream flowed through corrals, which resulted in damage to the stream banks and contributed sediment and nutrients that would eventually reach the East Boulder River. The proposed project entailed diverting 500 ft. of the spring around existing corrals into a historical channel and providing off-stream sources of water for livestock. Five automatic stock waters would provide an alternative source of water to livestock. Species of fish expected to benefit included Rainbow Trout, Brown Trout, and potentially Yellowstone Cutthroat Trout.

Pre-project photos illustrate the heavy use by livestock, trampled banks, and near lack of vegetation along the stream and within the corrals (Figure 6 and Figure 7). This corral meets the EPA's criteria as a point source of pollution, and the combination of bank erosion and accumulation of manure made this stream a source of nutrients and sediment to the East Boulder River. In addition, it its pre-project condition, the stream provided exceptionally poor habitat for fish.

Figure 6. Pre-project photo for the East Boulder Spring Creek channel realignment and stock water project.

Figure 7. Corrals on East Boulder Spring Creek.

2.2.2 Field Visit 2017

On August 16, 2017, Kyrsten Wolterstorff visited the project site to evaluate if the project was consistent with the FFIP application and to determine if the project had been beneficial to fish. Fencing had been installed, and cattle had no access to the creek. The riparian area was primarily a sedge community with little recruitment of riparian shrubs. Often, spring creeks do not provide suitable conditions for establishment of woody vegetation, so sparse woody vegetation was likely natural. The restored stream channel was relatively narrow and deep, consistent with a Rosgen E channel. The watering devices were in place; however, they were dry, as cattle were not currently occupying the corrals.

Figure 8. Current view of the relocated spring creek.

Figure 9. Example of an off-stream water source for corrals installed as part of this project.

2.2.3 Conclusions

Projects that either reroute streams from corrals, or move corrals off-stream are relatively inexpensive and have pronounced benefits to stream health, fish habitat and water quality. This project is no exception, and the actions taken restored health to this small spring creek and eliminated a point source of nutrients and sediment that would ultimately pollute the East Boulder River. FFIP funds were well spent on this project.

2.3 East Gallatin River Bank Restoration (039-02)

2.3.1 Introduction

The East Gallatin River originates east of Bozeman, with Rocky Creek, Kelly Creek, and Bridger Creek being major tributaries. This popular fishery supports Rainbow Trout, Brown Trout, Mountain Whitefish, Longnose Sucker, Longnose Dace, and Sculpin. Recreational use of this stream is substantial, and in 2013, this stream ranked as the 15th most heavily fished body of water in FWP's Region 3, an area encompassing numerous renowned trout streams and rivers.

The East Gallatin River faces numerous pressures. Historically, agriculture had been the primary land use along the stream, and livestock grazing and forage crop production had reduced riparian function, and caused bank erosion along portions of the river. In recent decades, residential development has boomed along the river. Some landowners favor Kentucky bluegrass lawns to the streams edge, and this shallow-rooted grass provides poor bank protection.

Agricultural producers and new residential owners share interest in preventing erosion of valuable land. Reinforcing banks using large rock, or riprap, had been a traditional means of stabilizing eroding banks; however, this approach has numerous disadvantages, such as arresting natural fluvial processes, concentrating the force of flows on banks downstream, reducing aesthetics and being costly. In some cases, streams have eroded around riprap, leaving the rock stranded, and resulting in considerable loss of land. In addition, rock hardened banks do not provide the same beneficial function as a healthy riparian zone. Nevertheless, persuading design engineers and landowners to use softer, bioengineered approaches, in the face of rapidly retreating banks, was challenging at the time of this project.

Patrick Byorth, now with Trout Unlimited, was the FWP biologist managing this project, and he provided photos and project background. The goal of this project was to provide a showcase for alternatives to bank armoring. The project occurred along 3 eroding banks on a single property. These vertical, eroding banks were retreating rapidly and threatening a bridge and buildings. The fluvial processes resulting in shear stress on banks varied among the banks. For banks 1 and 2, a mid-channel bar was diverting flood flows into these banks, in what was an otherwise straight reach (Figure 10 and Figure 11). This mid-channel bar was recontoured with the intent of restoring riffle/pool periodicity and improving sediment transport.

Figure 10. Mid-channel bar that was exerting pressure on banks 1 and 2 on the East Gallatin River.

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Figure 11. Mid-channel bar that was exerting pressure on banks 1 and 2 on the East Gallatin River.

The third bank was on the outside of a meander bend and had vertical, eroding banks with slight protection afforded by woody debris and sparse shrubs. The cottonwoods were from an earlier attempt to stabilize this reach by anchoring large wood into the bank. Much of the large wood had been swept away, and the bank was laterally mobile.

Figure 12. Bank 3 on the East Gallatin River, showing cabled in cottonwoods that were part of an earlier bank stabilization effort.

Bank 1: Armor the Toe of the Bank and Re-Slope with Fabric and Shrubs

The first eroding bank had the potential to redirect flows against the footing of the bridge. The bank above the bank full margin was re-sloped to a 3:1 slope or less, and covered with biodegradable erosion control blanket. Willows and dogwoods were planted at bank full edge, and the upper bank was planted with native grasses and sedges. The toe of the bank, below the bank full margin, was armored with natural cobble materials sized to resist the estimated 20-year flood modeled for that part of the river.

Figure 13. Post-construction photo of bank 1.

Bank 2: Fabric Encapsulated Soil Lifts

In addition to restoring a naturally functioning stream bank, this treatment was designed to protect an existing bridge and adjacent farm buildings. Compacted soil lifts wrapped in biodegradable erosion control fabric were constructed on a 2:1 slope. The soil lifts were vegetated with native grasses, sedges, and shrubs. Cobbles estimated to resist a 50-year flood event were installed along the toe of the bank.

Figure 14. Example of fabric-encapsulated soil lifts on bank 2.

Bank 3: Juniper or Straw Bale Revetment

Earlier efforts to stabilize this bank entailed cabling large cottonwood trunks into the shoreline. Some cottonwoods were still in place and had slowed the bank erosion to a limited extent, but additional treatment was considered necessary to reduce flow velocities at the bank interface. The bank treatment entailed attaching juniper revetments to the existing cottonwood bank treatments. Revetments were commonly used in the 1990s and early 2000s. The conceptual approach was to provide bank protection and increase roughness, which would trap sediments, allowing banks to build on the installed features.

Figure 15. Juniper revetments cabled into bank 3.

2.3.2 Field Visit 2017

On June 29, 2017, Kyrsten Wolterstorff visited the project site, accompanied by a landowner. She evaluated the condition of the 3 treated banks and received insight from the landowner, who was a collaborator on the project and has been watching the performance of the 3 approaches to bank restoration since project implementation in 2002. An aerial view of the project area is informative in evaluating the response of the channel and stream banks to the different bank restoration approaches (Figure 16).

Figure 16. Aerial view of the project area showing locations of the three treated banks.

As described above, bank 1 was re-sloped, covered with erosion control fabric, revegetated, and stabilized at the toe with installation of rock modeled to be mobile at a 20-year recurrence interval event. This bank was stable with grasses and sedges providing most of the vegetative cover (Figure 17). The erosion control fabric was no longer visible and had likely decomposed with recovery of the bank vegetation, as is the intent when using this biodegradable material. The bank margin was vertical, with a 10-inch, 90° bank angle. The rock placed at the toe had been transported from under the bank, resulting in a stable undercut, which is an important habitat feature for fish. Fencing protected the bank from livestock over-use, and hoof shear or obvious types of disturbance from livestock were absent. A gravel bar had formed closed to the opposite bank; however, it was considerably smaller than the bar that had been excavated, and was not apparently exerted erosive force on banks 1 and 2.

Figure 17. Bank 1 on the East Gallatin River bank restoration project, viewed from downstream.

Figure 18. Reestablished gravel bar near bank 1.

The second bank was treated with soil lifts encapsulated with erosion control fabric, revegetated, and cobbles large enough to be mobilized by a 50-year recurrence interval flood were placed at the toe of the bank. This treatment resulted in conditions like the first bank, with a bank angle of 90°, banks stabilized with grasses and sedges. The erosion control fabric decomposed with establishment of vegetation, and according to the landowner, the fabric has not been visible in years (Figure 19). Like the first bank, the rock toe had been transported away, resulting in an undercut bank.

Figure 19. Bank 2 on the East Gallatin River restoration project.

The third bank treatment entailing cabling juniper revetments to existing cottonwood logs was unsuccessful. Most of the cottonwood and junipers had washed away, the vertical, eroding banks were about 5-ft. high, and a hanging fence post were indicative substantial lateral adjustments (Figure 20). The juniper revetment treatment was unsuccessful in meeting project objectives.

Figure 20. Bank 3 on the East Gallatin River bank restoration project.

Figure 21. Vertical exposed stream bank and evidence of lateral movement, as indicated by the hanging fence post.

2.3.3 Conclusions

This demonstration project of 3 alternatives to riprap is an example of adaptive management, where different approaches allow evaluation of effectiveness, and identify actions that do not work. The first 2 treatments, which entailed bioengineered approaches of re-sloping banks, installing soil lifts, revegetation, and installation or rock toes, were successful, whereas the revetment approach was not. Revetments were a popular approach in the 1990s and early 2000s; however, revetments have fallen out of favor after multiple failures. A confounding factor in evaluating the causes of failure of this approach, compared to the others, it that this bank was on the outside of a meander bend, which naturally receives more shear stress during high flows, compared to straighter reaches. Nevertheless, a mid-channel bar had contributed to erosion on banks 1 and 2, and these banks remained stable, despite the reestablishment of a small in-channel gravel bar following recovery of riparian vegetation.

The size of rock installed in the toe of banks is a judgment call that requires evaluation of the acceptable level of risk. Vegetation may take a few years to stabilize banks, and these new banks may fail if a large flood occurs soon after restoration. Installation of rock toes can maintain bank stability until vegetation recovers. Smaller rock brings greater risk if a flood of significant magnitude washes them away before the banks recover. Conversely, larger rock may prevent the banks from being deformable for a longer period, and alter fluvial processes if not adequately deformable. Project planners need to evaluate regional regression equations of flood recurrence intervals, and confer with FWP biologists in selecting the appropriate size rock, especially in flashy, flood prone streams.

The undercut banks on banks 1 and 2 suggest that a flow of at least a 50-year recurrence interval occurred after restoration. Gage station data for the East Gallatin River covers only the past 2 years. Nevertheless, the East Gallatin River has had notable floods that have inundated stream adjacent properties. In 2008, the Bozeman Daily Chronicle reported a flood that was estimated to be less than a 20-year recurrence interval flood that flooded numerous nearby homes, and the paper reported major flooding in 2011, but did not estimate the magnitude of the flood. Despite significant flooding, banks 1 and 2 withstood relatively large flood events and flood waters removed the rock, leaving undercut banks in its place.

The use of erosion control fabric was successful in this project; however, conversations with stream restoration practitioners indicate a recent move away from the use of this material. Making generalized statements about the relative merits of erosion control fabric is beyond the scope of this report; however, for this project, the fabric held the first 2 banks together long enough for vegetation to become established, and it has since biodegraded, or is no longer visible.

Despite the failure of bank 3 to remain stable, this project was a suitable use of FFIP funds. The project demonstrated softer approaches to bank restoration can be effective and showed revetments to be a practice with considerable potential to fail. FFIP monitoring in 2016 found similar results for cottonwood revetments installed in the Shields River.

In addition to the learning experience, restoring these banks reduced sediment loading to the East Gallatin River and improved habitat for fish along their margins. In contrast, the continued lateral erosion of bank 3 is detrimental to fish habitat and water quality, as it results is a wider, shallower channel and increases sediment and thermal loading. Moreover, this erosion results in loss of valuable land, which is detrimental to the landowner. Encouraging a strategic approach to bioengineered bank restoration along the East Gallatin River through locally led planning would be beneficial to the health of the river and in the interest of adjacent landowners.

2.4 Elk Creek Spring Corral Bypass (009-02)

2.4.1 Introduction

Elk Creek is a tributary of the East Boulder River, near McLeod, MT. A small spring creek flowed through corrals on before entering Elk Creek and carried a substantial load of fine sediment and nutrients into Elk Creek, and ultimately the East Boulder River, which is less than 500 yards downstream of the project area. The East Boulder River is a popular recreational fishery supporting Brown Trout, Rainbow Trout, and the occasional Yellowstone Cutthroat Trout. The goal of this project was to reduce loading of sediment and nutrients to Elk Creek and the East Boulder River.

Pre-project photos a small, straightened spring creek that had experienced heavy, long-term disturbance by cattle. The stream was surrounded by bare ground, or closely cropped grasses (Figure 22). Hoof shear was present and contributed to loading of sediment into the stream. Concentrating livestock on this small stream resulted in accumulation of manure. The absence of a healthy riparian area meant the functional attributes of filtering sediment and nutrients, providing shade and fish cover, and maintaining channel form and function were entirely disrupted.


Figure 22. View of the spring creek before project implementation.

The solution to reduce or eliminate contributions of sediment and nutrients from this spring creek was to divert 80 ft. of the stream into an underground pipe. Installation of a stock tank provided an alternative water source. A fence was installed to manage cattle's access to Elk Creek.

2.4.2 Field Visit 2017

On August 16, 2017, Kyrsten Wolterstorff visited the Elk Spring Creek bypass project. She noted that fencing to protect Elk Creek had been installed, and although in slight disrepair, it was functioning to control livestock's access to the stream channel (Figure 23). The riparian area supported abundant shrubs, and all age classes of shrubs were present. This area appears to be the 50-ft. buffer between the corrals and Elk Creek mentioned in the application that was to filter runoff from the area of animal concentration.

Figure 23. Riparian fencing limiting livestock access to Elk Creek and the buffer strip between the corrals and surface water.

Kyrsten verified the stream had been piped under the corrals, and that alternative stock water had been provided. The inlet and outlet of the pipe were easily located (Figure 24 and Figure 25). In addition, the stock water component of the project had been installed (Figure 26), and cattle no longer relied on surface water, which eliminated bank trampling and near-stream sources of sediment and nutrients. The operator reported the waterer occasionally clogged, but regular maintenance easily remedied this problem.


Figure 24. Inlet of pipe that passes the unnamed spring creek under the corrals adjacent to Elk Creek.


Figure 25. Outlet of pipe that passes the unnamed spring creek under the corrals adjacent to Elk Creek.

Figure 26. Off-stream stock water of the Elk Creek spring creek bypass project.

2.4.3 Conclusions

This project met its objectives by eliminating, or substantially reducing sediment loading, to Elk Creek and the East Boulder River by placing this small spring creek in a pipe under the corrals. Although it met its objectives and likely had a positive effect on receiving waters, the practice of placing a spring creek in a pipe underground brings some undesirable outcomes. Small spring creeks have ecological functions and values disproportionate to their size. Small spring creeks can provide spawning habitat, support a diversity of aquatic life, and their riparian areas provide valuable habitat to a host of species. By burying the spring creek, these functions were eliminated. Moreover, the 80-ft. pipe is possibly a barrier to fish movement, which prevents fish from accessing much of the habitat this spring provides.

The rationale for piping the stream under the corrals instead of moving the corrals off-stream, or rerouting the stream around the corrals, was not included in the FFIP application. Cost and site-specific conditions may have influenced this decision. Nevertheless, piping the spring creek comes at an ecological cost. In addition, this approach may not be allowable under the Streambed Protection Act, or 310 law, for many streams. At the time this project was implemented, the Sweet Grass Conservation

District did not consider a stream of this size jurisdictional under the 310 law. Therefore, this project would not have undergone the permitting process. Their criteria for determining which streams are jurisdictional have changed since 2002, and the Streambed Protection Act may now apply to this type of stream.

Regardless of the jurisdictional status of a stream, projects funded by the FFIP should restore the values and functions of the stream being altered. These days, the FFIP panel would likely consider these factors in awarding funds, with diversion of the stream around corrals, as was done in the East Boulder Spring Creek project described above, or moving the corrals off-stream, being preferable alternatives.

2.5 North Fork Fridley Creek Fish Passage and Water Lease (047-03)

2.5.1 Introduction

North Fork Fridley Creek is a tributary to the Yellowstone River near Emigrant, MT. Its connectivity with the Yellowstone River was eliminated in the 1930s with construction of the Park Branch Canal, which intercepted North Fork Fridley Creek's flow about 100 yards from its confluence with the Yellowstone River. This loss of connectivity eliminated North Fork Fridley Creek as a spawning stream for fluvial Yellowstone Cutthroat Trout. Moreover, capturing the stream's flow into the canal left the channel downstream of the canal dry.

The North Fork Fridley Creek project addressed the loss of connectivity and dewatering through several actions implemented in 2004. North Fork Fridley Creek was placed in a 25-meter-long culvert under the Park Branch Canal (Figure 27). Channel grading and installation of a series of step pools upstream of the culvert (Figure 28) controlled the grade, so the culvert was at grade and not overly steep, which would have presented a velocity barrier through the culvert.

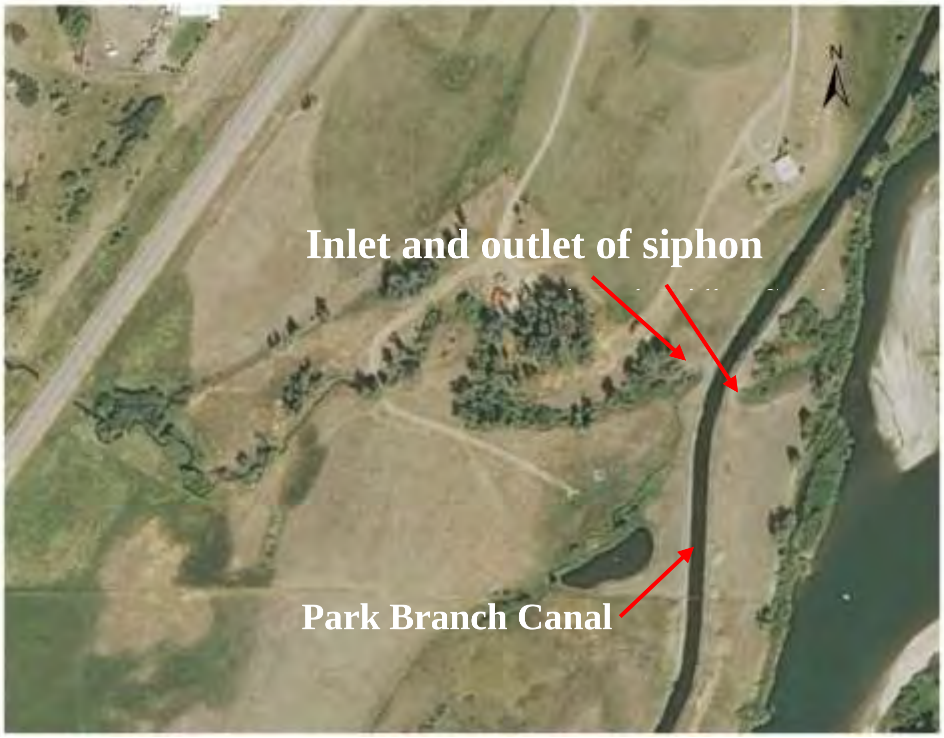

Figure 27. Aerial view of North Fork Fridley Creek and the Park Branch Canal.

Figure 28. Step/pool sequence constructed upstream of the culvert diverting North Fork Fridley Creek under the Park Branch Canal, to match pre-project grade and provide fish passage from the Yellowstone River.

Maintaining in-stream flows entailed converting from flood irrigation to sprinklers. Hay pastures had been flood-irrigated with water diverted from Fridley creek during late season, low flows. The project included drilling a groundwater well and installing 2 micro-pivot sprinklers to replace water obtained from North Fork Fridley Creek. The water user's water right was the senior-most right on North Fork Fridley Creek, and the alternative water source allowed the water rights holder to convert their irrigation right to maintain in-stream flows.

This project garnered considerable attention, as it demonstrated collaborative conservation with in-kind funds and services provided by the landowner, FWP, the NRCS, Trout Unlimited, the Gallatin Valley Land Trust, and Land and Water Consulting. A short video featuring this project, among others, was shown locally at several public events, and is still available on YouTube (Water Partners).

Post-project fish sampling occurred on in April of 2005 and 2013, and August of 2012 (Figure 29). Sampling downstream of the siphon found the assemblage of salmonid species present in the adjacent Yellowstone River and Rocky Mountain Spotted Sculpin. Rainbow Trout and Brown Trout were the most abundant trout. Juvenile Yellowstone Cutthroat Trout were captured immediately below the siphon in 2005. Yellowstone Cutthroat Trout were also present in 2012. These fish ranged from 2 to 3 inches in length, which indicates they were not spawners staging to migrate upstream, but may have been recruits from North Fork Fridley Creek.

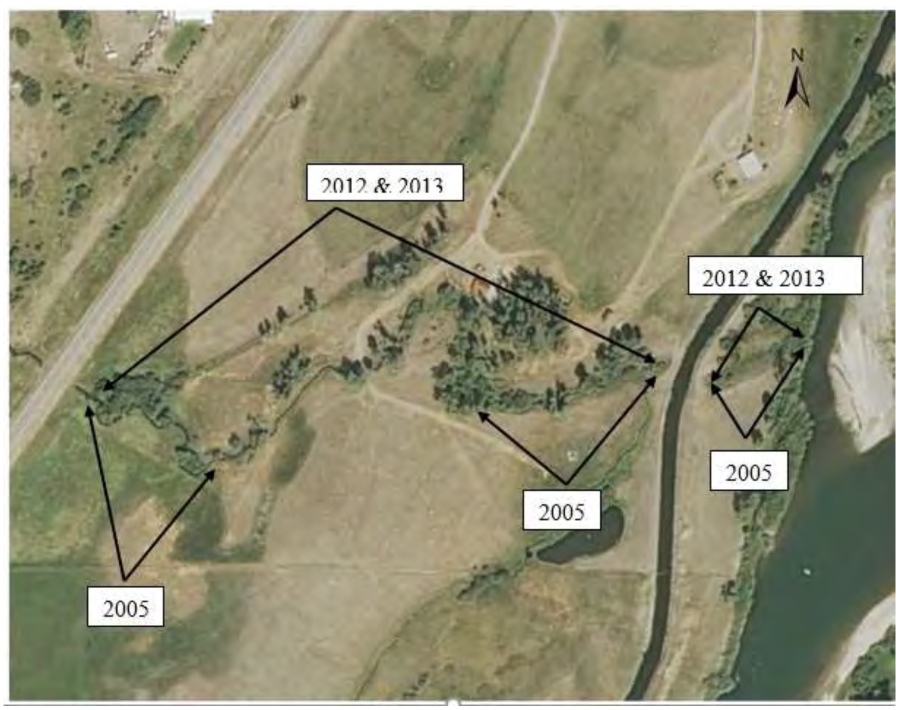

Figure 29. Aerial view of North Fork Fridley Creek showing sampling sections.

Table 1. Number of fish captured in the downstream section of North Fork Fridley Creek in April 2005 and 2013, and August 2012.

Species	***2005***	***2012***	***2013***	***Total***
Brook Trout	4		1	5
Brown Trout	30	4	14	48
Mountain Whitefish	4			4
Rainbow Trout	34		22	56
Yellowstone Cutthroat Trout	12		1	13
Total	84	4	38	126

The spring sampling events are of interest, as Yellowstone Cutthroat Trout, the species targeted to benefit from the project are spring spawners. Upstream of the siphon, Yellowstone Cutthroat Trout were rare or missing during the 3 sampling events, and 2 Rainbow Trout × Yellowstone Cutthroat Trout were captured (Table 2). Brown Trout and Rainbow Trout were relatively abundant, and Brook Trout were comparatively rare. During the 2013 sampling event, the presence of several ripe male and gravid female Rainbow Trout exceeding 15 inches in length suggested the project was successful in providing passage through the constructed step/pools and siphon under the Park Branch Canal. The Yellowstone Cutthroat Trout present in 2012 and 2013 were small fish, less than 6 inches in length, indicating their presence was unrelated to spawning, but could be recruits from North Fork Fridley Creek upstream of the siphon.

Table 2. Number of fish caught in the upper section of North Fork Fridley Creek in April in 2005 and 2012, and August 2012.

Species	***2005***	***2012***	***2013***	***Total***
Brook Trout	4		3	7
Brown Trout	13	14	16	43
Rainbow Trout	6	16	8	30
RBT × YCT	1		1	2
Yellowstone Cutthroat Trout		1	1	2
Total	***24***	***31***	***29***	***84***

The apparent absence of fluvial Yellowstone Cutthroat Trout upstream of the Park Branch Canal may not be a function of inability to access North Fork Fridley Creek through the constructed step pools and siphon. Fluvial Rainbow Trout were capable of such movement. The sampling was early in the spawning period, and potentially missed any Yellowstone Cutthroat Trout spawning run, as they spawn later in the spring.

2.5.2 Field Visit 2017

Kyrsten Wolterstorff visited the project site on June 30, 2017 and was accompanied by the landowner, who has had considerable interest in the success of this project. The step/pool sequence was still present and appeared unchanged since its post-construction condition (Figure 30). In addition, the siphon conveying North Fork Fridley Creek under the Park Branch Canal was still in place and remained at the constructed grade. Although not part of the FFIP grant, the landowner had installed a hotwire fence to exclude livestock. The riparian area was in excellent condition, with cottonwoods, alders, willows, and sedge-lined banks. The streambed was a mix of silt and gravels, although silt comprised most of the particles. On a subsequent visit on July 24, 2017, Krysten found 3 redds, and this timing coincided with the Yellowstone Cutthroat Trout spawning period.

Figure 30. North Fork Fridley Creek downstream of siphon under Park Branch Canal.

Figure 31. North Fork Fridley Creek emerging from downstream end of siphon under Park Branch Canal.

The water savings portion of the project was also implemented and still being used. Aerial photos show the center-pivots and location of the well that supplied the pivots with water (Figure 32). On-the-ground observations further confirmed the presence of the irrigation system installed to replace water diverted from North Fork Fridley Creek (Figure 33 and Figure 34).

Figure 32. Aerial view of the project area on North Fork Fridley Creek showing implementation of all elements of the project.

Figure 33. Center pivot installed as a water savings measure for North Fork Fridley Creek.

Figure 34. Pumping station supplying water to center pivots.

2.5.3 Conclusions

All elements of the North Fork Fridley Creek project were implemented as required, and installation of a hot wire fence was an additional measure that protected the stream from over use by livestock. The presence of fluvial Rainbow Trout upstream of the Park Branch Canal indicates the project was successful in providing passage to North Fork Fridley Creek after about 70 years of being inaccessible. The well and center pivots provide an alternative source of water, which allows water to remain in North Fork Fridley Creek, so fish can access the stream and fry can out-migrate.

The timing of fish sampling confounds conclusions of whether fluvial Yellowstone Cutthroat Trout access North Fork Fridley Creek for spawning. Sampling occurred in April, which coincides with the Rainbow Trout spawning run, but may be too early to find Yellowstone Cutthroat Trout fluvial spawners. The presence of observable redds in late July suggests Yellowstone Cutthroat Trout do use North Fridley Creek for spawning. As evidenced by the rapid return of a spawning run to Rock Creek with removal of a passage barrier in 2010, Yellowstone Cutthroat Trout can pioneer previously inaccessible streams. Capture of ostensible Yellowstone Cutthroat Trout juveniles below the culvert suggest that some recruitment may have occurred upstream of the siphon.

Recommendations to provide more information on the use of North Fork Fridley Creek by Yellowstone Cutthroat Trout include electrofishing later in the spring, installing a fish trap upstream of the siphon, and deploying fry traps to coincide with outmigration of Yellowstone Cutthroat Trout fry.

The high levels of fine sediment may be a limiting factor for Yellowstone Cutthroat Trout spawning success in North Fork Fridley Creek. Examination of aerial photos suggest the sediment is naturally sourced, as the riparian corridor appears to be well-vegetated along its entire length. Nevertheless, opportunities to decrease sediment loading may be available and should be pursued with landowner collaboration.

2.6 North Fork Horse Creek Center Pivot (045-04)

2.6.1 Introduction

North Fork Horse Creek originates on the west flanks of the Crazy Mountains, and flows west until its confluence with Middle Fork Horse Creek, which soon meets the south fork, forming the main stem. North Fork Horse Creeks supports nonhybridized Yellowstone Cutthroat Trout. This project is 1 of 3 occurring on the same property

The purpose of the project was to maintain in-stream flows in North Fork Horse Creek. The existing irrigation system was in disrepair and the ditch lost water to evaporation and infiltration. Grant funds from several sources went into purchase of a center pivot and the pipelines, pumps, and electronic components of the irrigation system. In exchange for the contributions towards the pivot, the landowner agreed to limit the use of his water from May 1 to June 25, except for a 10-day period after July 15. In addition, he agreed to ensure flows did not drop below 1 cfs.

2.6.2 Field Visit 2017

On June 22, 2017, Kyrsten Wolterstorff visited the project site. The center pivot was in place and being used to irrigate a hay pasture (Figure 35). Although not photographed, the pipe diverting water to the center pivot was in place at the fish screen (2.8 North Fork Horse Creek Fish Screen (022-04)) and delivering water through the pipe eliminated evaporative water loss or seepage.

Figure 35. Center pivot near North Fork Horse Creek.

2.6.3 Conclusions

A center pivot had been installed, along with a more efficient way of delivering water to the pivot. Compliance with the water use agreement was not possible with a 1-day site visit; however, the landowner reports compliance. Given the investment in North Fork Horse Creek, more monitoring is warranted to evaluate if in-stream flows are being maintained. In addition, a fish sampling would be useful in determining if Yellowstone Cutthroat Trout have benefited from the projects implemented in North Fork Horse Creek.

2.7 North Fork Horse Creek Fencing (048-03)

2.7.1 Introduction

Riparian fencing was another component of the multiple actions taken to benefit the nonhybridized Yellowstone Cutthroat Trout in North Fork Horse Creek. Actions included replacing fencing that excluded livestock from a steep, erodible bench adjacent to the stream and installation of new fence to protect the stream at the downstream end of the property. Pre-project photos show the fence in need of repair (Figure 36), and heavy grazing in the riparian area in the reach adjacent to the bench resulting in closely cropped herbaceous vegetation, reduced recruitment of riparian shrubs, and channel widening (Figure 37).

Figure 36. Fence at top of bench in need of repair.

Figure 37. Evidence of incompatible livestock grazing on North Fork Horse Creek.

Figure 38. Degraded stream habitat

Figure 39. Downstream end of property slated for riparian fencing.

2.7.2 Field Visit 2017

On June 22, 2017, Kyrsten Wolterstorff and Carol Endicott visited the property to determine if the fencing had been installed and evaluate the condition of the stream and riparian area. A robust fence had been constructed down-gradient from the bench and was an effective barrier to livestock (Figure 40). This hillslope showed no evidence of disturbance by livestock. This area had a dense, coniferous overstory, with a robust understory of herbaceous vegetation and mixed-aged shrub community (Figure 41).

Figure 40. New fence installed to prevent livestock from accessing North Fork Horse Creek from bench.

Figure 41. Typical view of the fenced off hill slope protected by fencing installed along the top of the bench.

North Fork Horse Creek apparently benefited from reduced disturbance from livestock accessing the stream from the bench. The stream was a healthy foothills stream with a gravel streambed, stable banks, and a robust riparian area vegetated with sedges, forbs, and dense shrubs (Figure 42). The opposite bank is under different ownership, and the residence is relatively close to the stream. This residential reach lacked a dense shrub community; however, herbaceous vegetation maintained bank stability, and the stream channel was stable. The conditions on the cross-stream neighbor's property had improved with implementation of the project.

Figure 42. Typical view of North Fork Horse Creek in reach protected by fence installed on the bench.

Fencing and installation of off-channel stock water had a positive effect on the riparian pasture at the downstream end of this property. Tall grasses within the pasture obscure much of the riparian fence; however, posts are visible at several locations (Figure 43). This photo replicates a pre-project photo (Figure 39). Indicators of improvement in the health of the riparian area include an apparent increase in density of willows, and the existing willows no longer have the umbrella-shaped morphology typical of grazed riparian areas. With exclusion of livestock from the riparian area, an alternative source of stock water was required. Kyrsten noted 2 automatic waterers within the fenced area (Figure 44). Combined, the fencing and off-stream water supply are complementary best management practices for sustainable livestock production adjacent to streams.

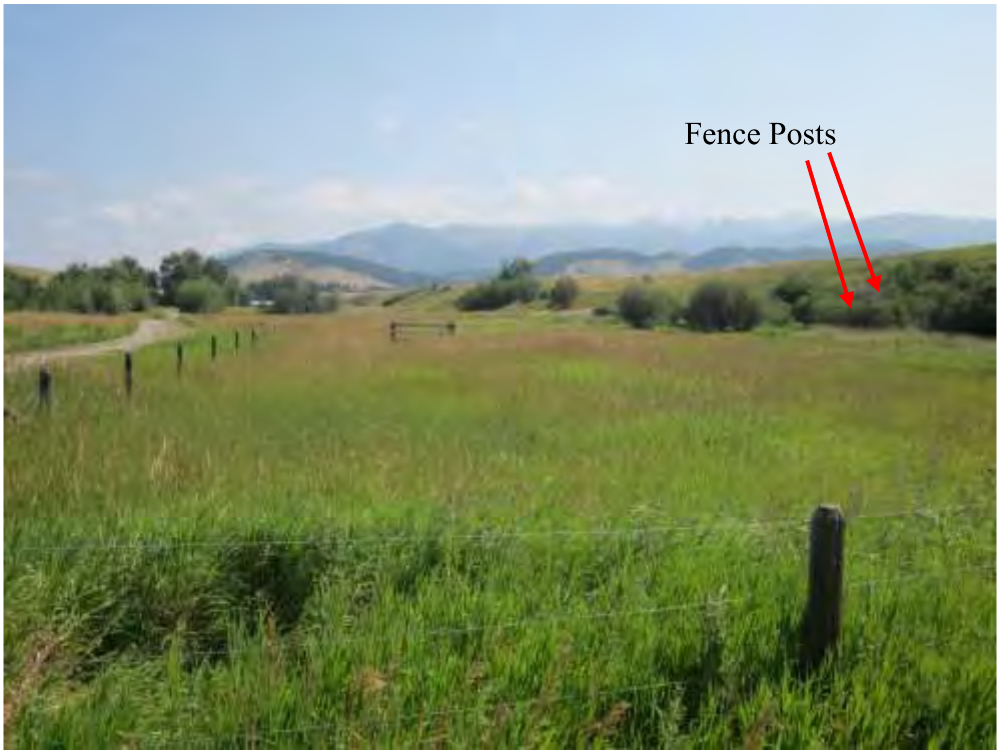

Figure 43. Pasture at downstream of property with riparian fencing.

Figure 44. Off-stream stock waterer.

2.7.3 Conclusions

Installation of fencing to control livestock's access to riparian areas, and providing off-stream water, are an effective and low-cost measures to maintain stream health and fisheries on working ranches. These projects are effective uses of FFIP funds and their effectiveness is repeatedly demonstrated in post-project monitoring.

While evaluating the North Fork Horse Creek fencing project, Kyrsten noted areas of heavy livestock use, and resulting degradation of riparian areas and bank erosion on an adjacent property. If the landowner is willing, implementing similar actions on this property would further increase the ability of North Fork Horse Creek to continue to support a healthy population of Yellowstone Cutthroat Trout.

2.8 North Fork Horse Creek Fish Screen (022-04)

2.8.1 Introduction

The goal of this project was to increase water use efficiency and prevent entrainment of nonhybridized Yellowstone Cutthroat Trout into an irrigation system on North Fork Horse Creek. The existing diversion was a wooden pin and plank structure that delivered water to an open ditch (Figure 45). Diversions that closed with check boards are notoriously leaky. Moreover, the ditch was an inefficient mode of delivering water, as it leaked and loss water to evaporation.

Figure 45. Pin and plank irrigation diversion on North Fork Horse Creek.

The entire irrigation delivery system was replaced with a new diversion, fish screen, and delivery pipe (Figure 46). A Waterman head gate replaced the leaky wooden structure (Figure 47). The head gate delivered water to a pipe, which led to a turbulent fountain fish screen (Figure 48). These screens are placed in a concrete frame or corrugated metal tank. Water delivered to the screen flows up through a fountain pipe, then flows over a screen that delivers water to the irrigation system. A bypass pipe delivers fish back to the stream (Figure 49). On North Fork Horse Creek, a wooden structure spanned the stream that allowed placement of check boards to divert water into the head gate at lower flows.

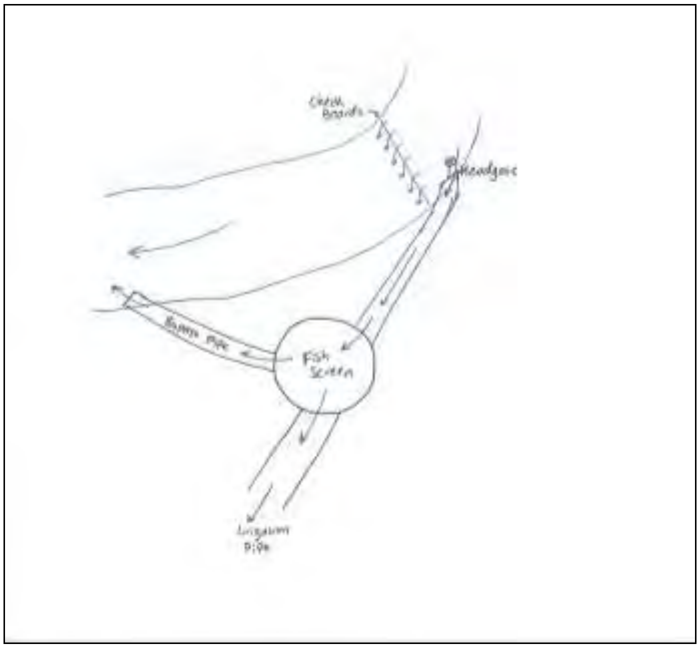

Figure 46. Plan view of new irrigation diversion system for North Fork Horse Creek.

Figure 47. Waterman head gate on North Fork Horse Creek

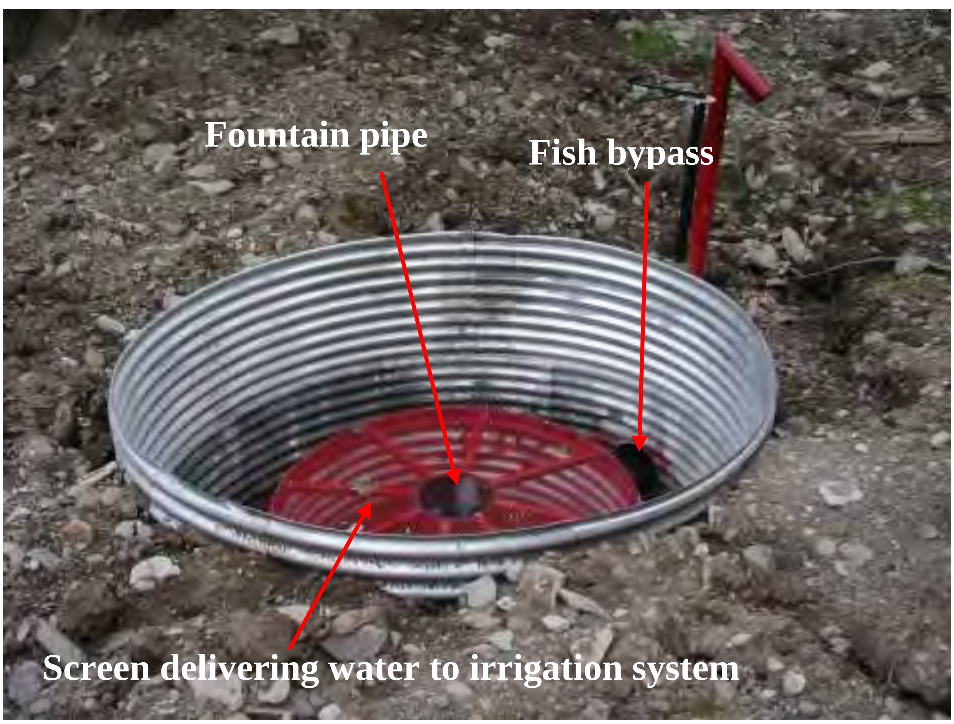

Figure 48. Turbulent fountain screen on North Fork Horse Creek after installation.

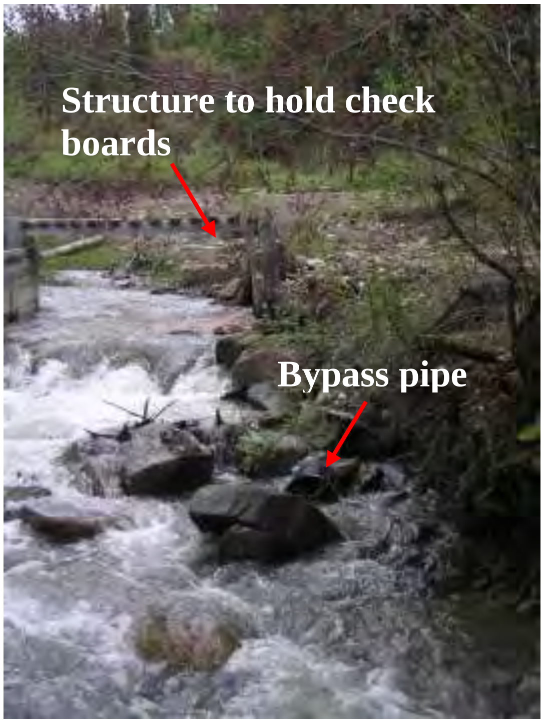

Figure 49. Bypass pipe and structure installed to place check boards to divert water to head gate during low flows.

2.8.2 Field Visit 2010 and 2017

The fish screen on North Fork Fridley Creek has been visited several times. On August 11, 2010, Carol Endicott viewed the screen while it was not in use. Some detritus had settled on the face of the screen, but no fish were impinged. The detritus may have collected as the irrigation ceased for the season and flows decreased. The absence of dead fish on the screen suggested the turbulence was sufficient to flush fish off the screen. In addition, no dead fish were present in the tank surrounding the fountain, indicating the bypass pipe has sufficient draw to move fish back to the stream.

Figure 50. Turbulent fountain screen when not in use.

On June 22, 2017, Kyrsten Wolterstorff and Carol Endicott checked on the function of the screen. The turbulence was substantial and appeared to be sufficient to move detritus and fish off the screen (Figure 51). A substantial amount of water flowed through the bypass pipe (Figure 52). The check boards were in place and were likely a temporary barrier to fish movement (Figure 53).

Figure 51. Turbulent fountain screen on North Fork Horse Creek in use.

Figure 52. Bypass pipe,

Figure 53. Check boards impounding flows to deliver water to the head gate.

2.8.3 Conclusions

Fish screens perform the important function of preventing entrainment of fish into irrigation canals; however, they can be problematic. Turbulent fountain screens have the advantage of no moving parts, but they may be unsuitable in detritus-rich streams, abrasive to fish, and require careful design. Engineered designs are not available for this screen. Nevertheless, the landowner reported this screen has been functioning well to deliver water to the irrigation ditch for a decade and required no maintenance.

The potential for the check boards to block fish movement is another consideration. According to the FFIP application, the previous diversion had been a total barrier to fish movement. The difference with the current checking of water is that the duration of diversion was decreased by a month as a condition of funding. Instead of diverting from May 1 through July 15, the water user agreed to restrict use to May 1 through June 25, with a 10-day period of use after July 15. This timing coincides with the spawning period for Yellowstone Cutthroat Trout. However, flows may not be checked during much of the spawning period, as it coincides with spring runoff, when flows are elevated.

Recommendations for this project, along with the complementary actions of water savings and riparian fencing, address the opportunity to evaluate the response of the Yellowstone Cutthroat Trout population in North Fork Horse Creek to the cumulation of conservation actions. A follow-up fish survey would be informative. Likewise, installing a trap at the out flow of the bypass pipe on the fish screen would be useful in evaluating if fish are being bypassed, and if the screen causes injury.

2.9 Richardson Creek Riparian Fencing (026-97)

2.9.1 Introduction

Richardson Creek is a tributary in the Fourmile Creek drainage within the Castle Mountains, east of White Sulphur Springs. This project was part of a larger effort to restore riparian health and function, and stream morphology, to several streams within grazing allotments in the Lewis and Clark National Forest. Surveys conducted by USFS personnel found these streams to be impaired due to uncontrolled access by livestock, with 1.6 miles of Richardson Creek deemed to need recovery and protection. Riparian exclosures and development of off-stream stock water were the prescribed actions to improve function and health of these streams.

The health of Richardson Creek is of specific concern, because it supports slightly to nonhybridized Westslope Cutthroat Trout. Westslope Cutthroat Trout are exceptionally rare in the upper Missouri River watershed. Risks to the Westslope Cutthroat Trout living in the Fourmile Creek watershed include isolation, which does not allow for gene flow or recolonization following catastrophic events, and sympatry with Brook Trout. Brook Trout regularly outcompete Westslope Cutthroat Trout, especially in headwater streams.

Available information includes pre-project photo points from 1996, matched with follow-up photos from 2005. The stream and riparian area had recovered substantially with installation of riparian fencing. Vertical eroding banks had stabilized with dense stands of sedges and willows (Figure 54). Although seasonality can bias interpretation of the photos, the stream and riparian area had recovered substantially. Herbaceous vegetation was closely cropped in the pre-fencing photo, but was tall and dense after 8 years of rest. A second pair of before and after photos showed similar recovery following exclusion of livestock, with banks not showing signs of trampling, and riparian shrubs being more robust and dense (Figure 55).

Figure 54. Pre- and post-fencing photos taken on a meander bend on Richardson Creek, 1996 and 2005

Figure 55. Pre- and post-fencing photos of Richardson Creek, 1996 and 2005.

2.9.2 Field Visit 2017

On August 3, 2017, Kyrsten Wolterstorff visited the restoration project on Richardson Creek. GPS data indicated she examined the entire length of the fenced area. The riparian exclosures were still in place, and a healthy riparian area and stable stream channel were present within the fenced area (Figure 56 and Figure 57). A water gap between fenced areas showed indications of heavy use by livestock (Figure 58)

Figure 56. Riparian fencing on Richardson Creek.

Figure 57. Stream channel within riparian exclosure on Richardson Creek.

Figure 58. Water gap between fenced reaches on Richardson Creek.

2.9.3 Conclusions

The Richardson Creek fencing project was among the earliest projects funded under the FFIP. Marked improvements were evident in the post-project photos taken in 2005. In 2017, the fence was still in place, and functioning to limit cattle access to the stream and riparian area. Controlling livestock around streams is an effective way of improving habitat and water quality, and an effective use of FFIP funds.

2.10 Shields River Bank Stabilization (016-01)

2.10.1 Introduction

The Shields River is a major tributary of the Yellowstone River, located northeast of Livingston. The river supports a popular recreational fishery for Brown Trout and Mountain Whitefish, although low numbers of Yellowstone Cutthroat Trout are present in the main stem. Other native species include 2 species of sucker, Rocky Mountain Spotted Sculpin, Longnose Dace, and low numbers of Brook Trout.

Eroding banks are common on the Shields River, and the cause of bank erosion varies, with mechanical alterations to the river plan form, reduction in riparian health and function, encroachment of roads, bridges, and railroad berms contributing locally. Moreover, the Shields River has naturally high bed load supply, flashy hydrograph, and considerable recruitment of large woody debris, as much of the mainstem is within a cottonwood gallery forest. These natural factors can also exert pressure on stream banks.

This project addressed an eroding bank on the Shields River that was cutting a 7-ft high, vertical-walled terrace. Reports on the location of the eroding bank are conflicting. The FFIP database places with project in T4N R9E section 29, whereas, a professional paper prepared by a graduate student working on the project places the treated bank several miles upstream. Project photos are consistent with the FFIP database, as they show a road close to the eroding bank, and aerial photos do not show an adjacent road on the site shown in the professional paper. Nevertheless, comparisons of on-the-ground photos with aerial photos do not allow for certainty of the location of the treated bank. Because the bank could not be field verified, this report is conjectural, and an additional site visit is recommended to confirm the location and assess the success of the restoration effort.

This project used an experimental approach to bank restoration with an emphasis on bioengineered bank stabilization, augmented with temporary use of concrete blocks to allow riparian vegetation to become established over 1 to 2 growing seasons (Figure 59). The blocks were installed along the bank line, a 10-ft wide floodplain was constructed behind the blocks, the vertical terrace was sloped to a 2:1 grade. The floodplain was to be covered with locally harvested sod mats; however, only 50% of sod mats were usable, as the soils within the sod were a silty loam that lacked cohesivity. Because the sod mats were damaged and unusable, much of the area was seeded with a Timothy and orchard grass seed mix. Three hundred sandbar willow root stock were planted using a sharp shooter shovel to dig the holes. Supplemental irrigation with a small pump and hose was used to promote establishment of willows, as their roots were slightly above the water table. Three weeks after project construction, a progress report stated the willows and grasses were doing well.

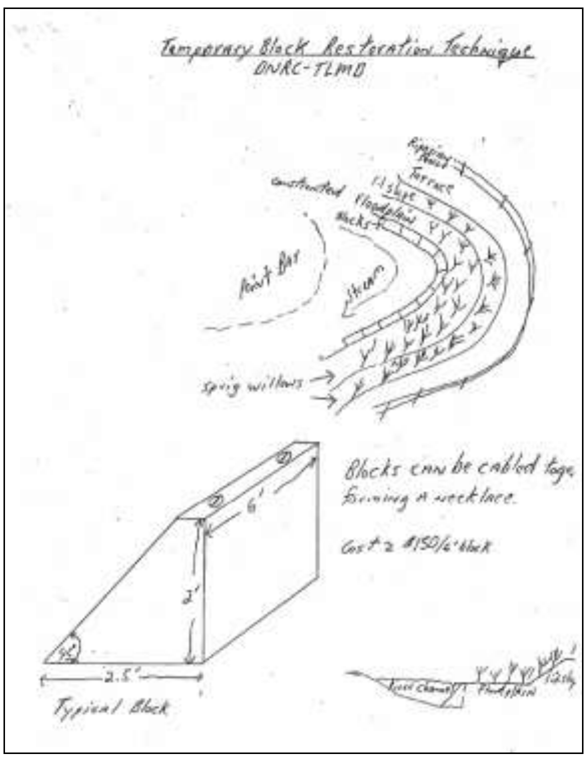

Figure 59. Conceptual approach to stabilizing banks with temporary use of concrete blocks to protect the re-sloped and vegetated bank and floodplain until vegetation became established.

Photos from the construction show eroding banks, the constructed floodplain and the 2:1 slope to the terrace, along with installation of concrete blocks (Figure 60). The length of treated area was not reported; however, project photos indicated this bank was of considerable length (Figure 61).

Figure 60. Project construction photo showing existing eroding bank from a PowerPoint presentation prepared in 2002.

Figure 61. Concrete blocks installed along the bank line from a PowerPoint presentation prepared in 2002.

Post-construction photos show a dense mixed stand of nonnative grasses and sandbar willow adjacent to the concrete barriers (Figure 62). Apparently, a cobble toe was installed along the length of the bank treatment, as cobble extends onto the concrete and is at the toe of an eroding reach that was not covered with concrete blocks. The outer meander bend is an erosional area, not a depositional area, so it is unlikely that cobbles accumulated naturally. Neither the application nor post-project report mention installation of a cobble toe.

Figure 62. Stabilized bank on the Shields River.

Photos illustrating the removal of the concrete barriers show the barrier left a bare, vertical bank (Figure 63). The nonnative agricultural grasses did not provide the root mass typical of riparian species, which promote soil cohesion and resilience against erosion. A cobble toe was clearly installed as part of the project, although this action was not described in background materials or the project budget.

Figure 63. Removal of Concrete block and installation of a rock toe.

Background information includes photos that were apparently taken several years after removal of the concrete blocks (Figure 64). Willow survival was negligible, although the nonnative grasses had colonized the constructed floodplain. Remnants of the installed rock toe were still visible, but much of it had apparently been washed away, leaving undercut banks. As shallow-rooted, nonnative grasses line the banks, the long-term stability of this bank is questionable.

Figure 64. Post-project photo dated 2007

2.10.2 Field Visit 2017

On August 22, 2017, Kyrsten Wolterstorff and Carol Endicott visited the project site. As noted, determining the bank that had been treated was problematic. A portion of the bank considered most likely to be the treated bank supported a community of nonnative grasses and Canada thistle (Figure 65). A cobble toe was present, as opposed to the raw dirt that was present before treatment. Nevertheless, the bank had receded several feet. Large woody debris had been deposited at the site and was providing bank protection. More aggressive efforts at bank stabilization were apparent with riprap being present at the downstream end of the bank (Figure 66).

Figure 65. Stream bank potentially being the restored bank.

Figure 66. Bank armoring and large woody debris.

Looking upstream at the putative restored bank, reed canary grass had invaded the riparian area (Figure 67). This nonnative species is exceptionally invasive and hard to control. Although it functions to maintain bank stability, it does not provide the same ecological values as a native shrub community.

Figure 67. Reed canary grass infestation along putatively restored bank.

2.10.3 Conclusions

Uncertainty as to which bank was the subject of restoration confounds determining the effectiveness of the approach to stabilize eroding banks. Survey of a considerable length of Shields River within the designated property, and examination of aerial and on-the-ground photos did not confirm with certainty that the area evaluated was the bank shown in Figure 60. Although not included as part of this project, the riparian area was fenced, so disturbance from livestock was no longer altering banks, which would promote natural recovery.

Conclusions on the suitability and expense of using concrete blocks to provide temporary protection are possible with the available information. Notably, the FFIP application and project completion letter include scope and budget for installation and removal of concrete blocks as the only armoring occurring in this project; however, project photos show installation of a substantial cobble toe along the bank margin and potentially along the row of concrete blocks. Consequently, bank recovery cannot be attributed to the use of concrete blocks, as a rock toe was installed to protect the vertical, dirt banks formed by the blocks. The cobble may have been obtained locally; however, it still would need to be transported to the bank and installed with an excavator, which would substantially increase costs.

The project claimed to be a bioengineered approach; however, the concrete blocks are not consistent with bioengineered bank restoration in current practice. Construction of a floodplain bench adjacent to an eroding terrace is a common approach used currently; however, aggressive bank armoring, such as was employed in the project, is not. Projects vary in their use of toe armoring and erosion control fabric, and these are site specific, and based on hydrologic modeling and magnitudes of floods of selected recurrence intervals. Each bank restoration project faces the risk of a flood disturbing the restored bank before vegetation has the time to become established. Stream practitioners must weigh risks of failure against over-armoring banks, so that they are not deformable. A substantial risk with the concrete block approach is that the stream can cut behind the row of block and flush away the new floodplain.

A final consideration in evaluating this process is whether a 310 permit could be obtained for installing concrete blocks for the duration described in the application. Concrete blocks or Jersey barriers may be placed in stream channels during the irrigation season to funnel water towards a diversion. Nevertheless, they must be removed when irrigation ceases for the season. This approach is likely illegal under Montana Natural Streambed and Land Preservation Act, or 310 law.

In conclusion, the experimental use of concrete blocks in providing temporary protection of recently constructed and vegetated floodplain benches would likely have been unsuccessful without supplemental installation of the substantial rock toe. The concrete blocks left the face of the bank highly susceptible to erosion. Furthermore, bank armoring of this degree has the potential to force flood flows to jump behind the concrete blocks. Finally, seeding with shallow-rooted nonnative grasses would do little to promote bank stability.

2.11 Shields River and Elk Creek Fencing (053-98)

2.11.1 Introduction

This project was initiated by the Upper Shields Watershed Association and Park Conservation District on the behalf of numerous landowners on the Shields River near Wilsall, and Elk Creek, a small tributary. The Shields supports Yellowstone Cutthroat Trout and a popular recreational fishery for Brown Trout and Mountain Whitefish, in addition to other members of the native fish assemblage. Elk Creek supports a population of nonhybridized Yellowstone Cutthroat Trout.

The project was a relatively large-scale effort to implement best management practices (BMPs) associated with cattle production on several ranches. BMPs included installation of riparian fencing along 2 miles of the Shields River and establishment of stock water in the uplands. The goals were to recover the health, vitality, and vigor of the riparian areas, reduce sediment loading to the Shields River and Elk Creek, protect natural fluvial processes, and improve private property values, while accommodating agricultural land uses adjacent to these streams.

Across these properties, more than 800 cattle and other livestock grazed the riparian zones. Pre-project photos of the Shields River portion of the project are limited. One photo shows portion of a mature cottonwood gallery forest with closely cropped grasses and livestock within the riparian area (Figure 68). The second photo is an overview of the portion of the Shields River used as winter pasture. Determining the influence of livestock throughout the project area is not possible from these photos. The lack of an extensive photographic record of pre-project conditions is common with projects that predated common use of digital cameras and limits the ability to demonstrate recovery. Nevertheless, 800 cattle can exert considerable pressure on riparian areas, stream banks, and channel morphology, so substantial disturbance and degradation was likely.

Figure 68. Pre-project photo of the riparian area along the Shields River slated for implementation of BMPs.

Figure 69. Portion of Shields River used for winter pasture.

Other photos are dated 2000 and 2002, and document conditions soon after implementation of BMPs. Photos include documentation of a stock tank (Figure 70). Photos are that are likely from Elk Creek show variable conditions, with healthy reaches (Figure 71), areas where the channel was overly wide and devoid of riparian shrubs (Figure 72), and a reach with considerable down cutting and an exposed, highly erodible terrace (Figure 73). Historically, beavers likely had considerable influence on Elk Creek, and much of the stream was impounded by beaver dam complexes. Near extinction of beavers in the mid-1800s removed their influence on streams across the landscape of the West. These streams tend to be especially susceptible to channel down-cutting, as beaver dams trapped sediments for millennia, resulting in fine-grained banks that are susceptible to erosion and head-cutting.

Figure 70. Stock tank installed as part of BMPs for the Shields River and Elk Creek project.

Figure 71. Healthy riparian area and intact stream morphology on Elk Creek in 2002.

Figure 72. Overly wide channel, bank erosion, and riparian degradation on Elk Creek 2002.

Figure 73. Channel downcutting on Elk Creek in 2002.

The Shields River is more resilient to disturbance than Elk Creek, as its cobble bed is not susceptible to vertical adjustments, and cobbles in the stream banks make them more resilient to trampling. Photos from 2002 show a mature cottonwood gallery forest, but little recruitment of cottonwoods from suckering and a lack of riparian shrubs (Figure 74). Another photo from 2002 shows a bank devoid of riparian vegetation, vegetated with closely cropped grasses (Figure 75), which suggests continued, heavy use by livestock.

Figure 74. Fenced reach of the Shields River in 2002.

Figure 75. Fenced reach of the Shields River in 2002.

2.11.2 Field Visit 2017

Kyrsten Wolterstorff walked reaches of fenced stream on 3 properties on the Shields River, but did not access the Elk Creek portion of the project. She walked the entire reach of each property and interviewed 2 of the landowners.

Property 1

Kyrsten evaluated this portion of the project on August 17, 2017 and mapped the fencing and stock watering devices installed through this project (Figure 76). Riparian fencing was installed on the east side of the river. The west side was not fenced, but did not appear to be grazed. The landowner reported he was currently grazing 20 heifers in the riparian area.

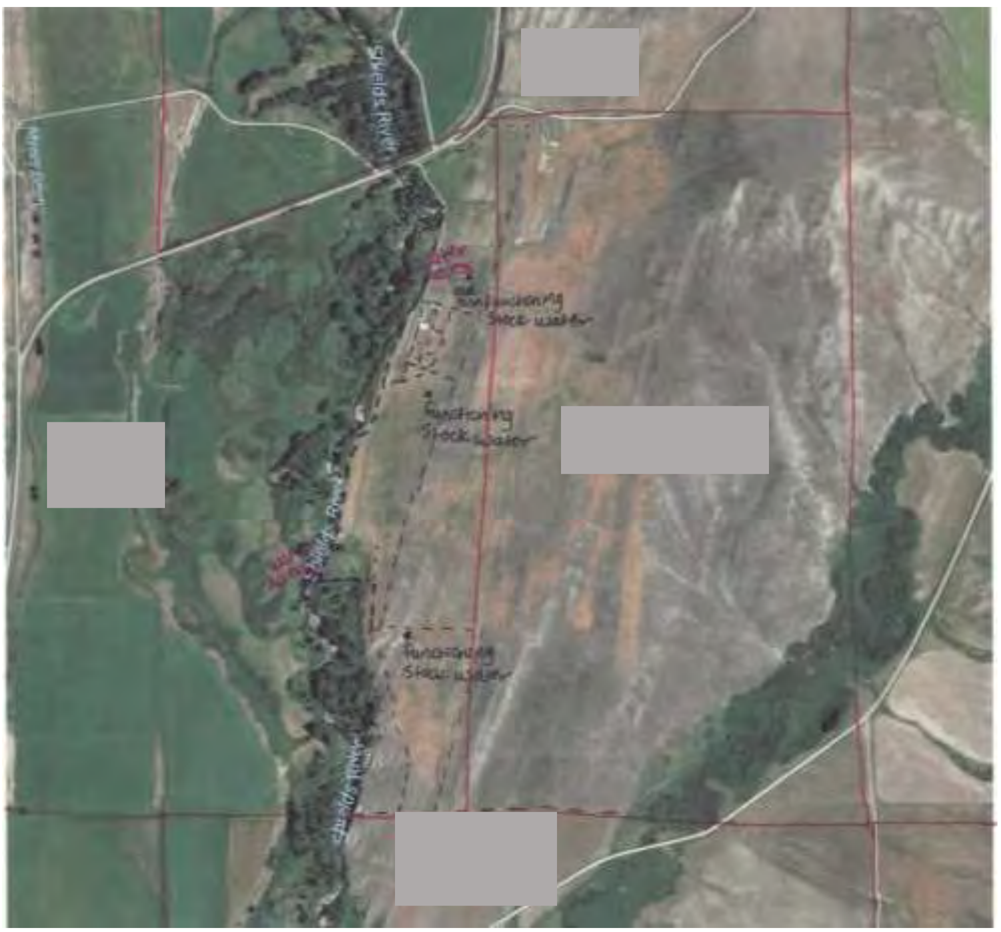

Figure 76. Aerial view of the property at the downstream end of the property. The red line east of the river shows the eastern extent of the property.

The fence was in good condition, and grazing pressure within the riparian area was light. Much of the riparian area was within a mature cottonwood gallery forest; however, shrubs and cottonwoods were recruiting on point bars (Figure 77). Owing to the substantial bed load supply, the channel was braided in some areas, but occupied a single thread in others (Figure 78). Dense riparian understory was present and afforded high quality habitat for wildlife (Figure 79). A hay field encroached on the stream bank on the west side of the river, and banks were calving due to lack of root protection, the cobble toe provided some protection against erosion

Figure 77. View of fenced section of the Shields River showing recruitment of woody vegetation on point bars.


Figure 78. Fenced portion of the Shields River on property 1.


Figure 79. Riparian area with dense understory.

Figure 80. Hay pasture on west bank of river and bank erosion.

The landowner reported the fence worked well in allowing him to manage grazing within the riparian area. The off-channel stock tanks have been problematic, with 1 failing, and others going out intermittently. He installed stanchion type water access points to provide stock water when the tanks are not working. He lost 7 calves with failure of a stock tank, and said they are costly to run.

Property 2

The next property was adjacent to property 1, with a bridge over the Shields River being the boundary (Figure 81). The fencing was installed and functional. Cattle had access to the river in some sections, as evidenced by slight hoof sheer and manure, but they were not having a negative effect on riparian vegetation, stream banks, or channel stability. Fish were abundant in this reach. Other species of wildlife included kingfishers, assorted songbirds, a long-eared owl, and boreal toads. Canada thistle was abundant, and knapweed and reed canary grass were also present.

Figure 81. Properties 2 and 3 on the Shields River.

The Shields River flows through a cottonwood gallery forest, and is single thread throughout the property (Figure 82). An old attempt at bank stabilization using riprap was only partially protecting the stream, as the channel had moved away from a considerable length of the applied rock (Figure 83). Although not locally derived, the streambed was heavily silted throughout this reach (Figure 84). The Shields River is listed as impaired for siltation on Department of Environmental Quality's list of impaired streams, and the watershed group has a plan to reduce sediment loading from bank erosion, hill slope erosion, and roads.

Figure 82. Typical view of property 2.

Figure 83. Old riprap that was no longer near the channel.

Figure 84. Siltation of the Shields River's streambed.

Property 3

Although fencing and development off-stream stock water benefited the length of the Shields River treated in this project (Figure 81), Kyrsten observed this reach to have the best habitat of all the reaches (Figure 85 and Figure 86). The channel was stable, had high quality pools with large woody debris. Some light browse was present, although there were no signs that cattle accessed the stream. The landowner does not produce livestock, but does grow irrigated hay. Localized infestation of reed canary grass was the only feature that detracted from the functions and values of the riparian area (Figure 87). Likewise, the streambed was heavily silted; however, the fine sediment was likely contributed from upstream sources.

The landowner was enthusiastic about the portion of river flowing through his property, and its ecological and recreational values. He stated the fishing was phenomenal and was continually improving. He claimed he caught mostly Yellowstone Cutthroat Trout of considerable size. Field observations indicated high quality for wildlife in general, with presence and sign of moose, black bear, and plentiful white-tailed deer. Chokecherries were abundant and providing an important late summer food source for bears and birds.

Figure 85. High quality pool, with large woody debris and recruitment of woody vegetation on recent alluvial bars.

Figure 86. Shields River in property 3 with mixed conifer and cottonwood overstory.

Figure 87. Infestation of reed canary grass on property 3.

2.11.3 Conclusions

The project was among the earliest funded through the FFIP, and is often the case with these early projects, baseline information is limited. Few photos are available, and no narrative description of site conditions exist, which limits the ability to describe the extent to which the river and riparian area responded to implementation of BMPs. Nevertheless, 800 cattle with full access to the stream likely reduced vegetated cover, limited recruitment of woody species, trampled banks, and otherwise contributed to loading of nutrients and sediment. Evidence of use by livestock is limited or unapparent within the project area, and the stream and riparian area are typical of a healthy valley river. Invasion of reed canary grass and siltation were the only obvious deviations from an unaltered state. Wildlife thrived within this portion of the Shields River, which is a testament of the stewardship of the landowners involved in the project.

The failure of some of the stock tanks is of concern. It is unclear how water was delivered to the tanks and the reason for failure. Technical assistance through the NRCS is recommended for future projects to ensure stock tanks are using the latest technology and are unlikely to fail. Loss of calves to inoperable stock tanks is unacceptable.

The high levels of fine sediment on the streambed in this portion of the Shields River does not appear to be the result of local contributions of fine sediment or related to decreased sediment transport capabilities because of an overly wide channel. The headwaters of the Shields River are naturally rich in fine sediment, and sources of sediment loading from human activities have been identified and their relative contributions have been estimated. This reach is downstream of 2 5^{th}-code watersheds that are in the top 10 contributors for sediment loading from stream banks, according to the watershed restoration plan developed for the Shields River watershed. Future restoration planning should focus on approaches to decrease sediment loading, as it will be beneficial to this reach of the Shields River, as it has high aesthetic, recreational, and conservation values.

2.12 South Fork Fridley Fish Ladder (047-03)

2.12.1 Introduction

South Fork Fridley Creek is a tributary of the Yellowstone River located upstream of Emigrant in Paradise Valley. An irrigation diversion that used check boards to divert its flows into an irrigation canal was a barrier to upstream movement of fluvial spawners (Figure 88). The solution was to replace the existing diversion with a similar diversion equipped with a Denil fish ladder, and this ladder was constructed in 2008. The ladder was constructed with cast concrete, with wooden baffles installed at 45° angles.

Figure 88. Irrigation diversion on South Fork Fridley Creek.

Figure 89. Newly constructed fish ladder on South Fork Fridley Creek


Figure 90. Wooden baffles in the South Fork Fridley Creek fish ladder.

Soon after construction was completed, South Fork Fridley Creek experienced a flood of significant magnitude. Emergency riprap was installed to keep the stream from cutting around the new structure. This flood also embedded the baffles with cobble, making them impossible to remove without mechanical assistance.

The water user leaves the boards in until July 4 in most years, and the Yellowstone Cutthroat Trout spawning run usually extends beyond that date. Yellowstone Cutthroat Trout were observed spawning upstream of the ladder on July 24, 2009, so the stream has potential to be a source of recruitment of Yellowstone Cutthroat Trout fry, when the check boards are out.

2.12.2 Monitoring 2017

Assessment of the South Fork Fridley fish screen included visual inspection of the ladder, installation of a trap to capture fluvial fish ascending the ladder, and trapping fry out-migrating downstream of the fish ladder. The Denil fish ladder was designed according to the established standard, with closely spaced baffles that create turbulence that dissipates energy. Visual inspection of the ladder found highly turbulent water; nevertheless, the velocity appeared to be substantial in the ladder and may exceed the burst swimming ability of fish. Other observations were that cobbles had embedded the baffles, which are now immobile. In addition, the baffles are wooden and have swollen. Digging out the cobbles or using a mechanical winch may be advisable to reset the baffles. A second set of baffles is stored at the Livingston Fisheries Office; however, metal baffles may be an improvement, as they would not swell, and may be easier to extract in cleaning the ladder, despite their greater weight.

Figure 91. Denil fish ladder on South Fork Fridley Creek.

Kyrsten operated a fish trap at the upstream end of the ladder to see if fish were using it to access South Fork Fridley Creek. The trap was in place beginning in June and was pulled at the end of the irrigation season around July 4, 2017.

2.12.3 Conclusions

The ability for fish to pass through the South Fork Fridley fish ladder is questionable. The diversion is in operation until around July 4th each year, and Rainbow Trout and Yellowstone Cutthroat Trout can be expected to move into spawning streams in this time. The lack of fish captured at the upstream end of diversion suggests fish cannot swim through the ladder, or they are not attracted to the ladder. Flows through the ladder may be a velocity barrier, and perhaps the cobbles filling the bottom are preventing the baffles from providing sufficient turbulence to provide areas with slower moving water. Nevertheless, Yellowstone Cutthroat Trout have been seen spawning in South Fork Fridley Creek, so fish are accessing the stream when the check boards are out.

Recommendations include clearing the cobble and removing the baffles to check their condition. Another set can be installed if they are damaged. In addition, personnel with expertise in fish passage should evaluate if the ladder is passable in its current condition.

2.13 South Fork Ross Creek (018-07)

2.13.1 Introduction

South Fork Ross Creek is a small spring creek that flows into Smith Creek, a tributary of the East Gallatin River. This portion of the Gallatin River watershed is rich in spring creeks, and these streams have considerable potential ecological value. Spring creeks are summer cool and winter warm, and often maintain a thermal regime that is ideal for growth of salmonid fishes year-round. Likewise, spring creeks help maintain cooler temperatures in their receiving waters through their surface flow and groundwater contributions, which is important during late season low flows and may help these streams be resilient to our changing climate. Spring creeks can provide high quality spawning streams.

Spring creeks often have high recreational value. Fish can grow large in their cool, productive waters. Game species may move into spring creeks seasonally to escape warmer waters in neighboring free-stone streams.

South Fork Ross Creek and a small, unnamed tributary were the subject of several restoration actions to improve fisheries values, transport fine sediment, provide for fish passage, and increase in-stream flows. Application materials indicated livestock grazing, dewatering, and beavers had increased the amount of fine sediment in South Fork Ross Creek and its tributary. Proposed actions included regrading 1,430 feet of South Fork Ross Creek and 1,000 feet of its tributary, restoring a natural plan form, and narrowing and deepening the channel. Installation of sod mats would create banks in the reconfigured and deepened channel. A 100 to 300-ft buffer would be established between the stream and agricultural activities, primarily hay production.

Accumulations of 1 to 3 feet of fine sediment on the streambed was a primary concern, and increasing the sediment transport capacity of the channel, by narrowing and deepening the channel would improve holding and spawning habitat. Pre-project photos are unlabeled, so interpretation is conjectural.

Nevertheless, South Fork Ross Creek appeared to be relatively overly wide, with heavy siltation of the streambed (Figure 92). Other photos showed highly turbid flows (Figure 93) or a poorly defined channel, suggesting relatively recent use by livestock, or inadequate stream flow for channel maintenance (Figure 94). Nevertheless, thick sedges maintained stable banks, and mature willows were present.

Figure 92. Pre-project view of South Fork Ross Creek.

Figure 93. Turbidity in South Fork Ross Creek.

Figure 94. Hummocky, poorly defined channel.

Photos presumably of the unnamed tributary show sedge covered stream banks and variability in channel width (Figure 95 and Figure 96). Willows were rare to absent along the channel. Formation of a sedge covered, mid-channel bar suggested insufficient energy to maintain a narrow, deep E channel that is typical of spring creeks.

Figure 95. Unlabeled photo potentially showing unnamed tributary.

Figure 96. Unlabeled photo potentially showing unnamed tributary.

2.13.2 Field Visit 2017

On August 4, 2017, Kyrsten Wolterstorff visited the South Fork Ross Creek project site, accompanied by the landowner. The channel had reverted to its overly wide configuration, and accumulation of fine sediment was again substantial (Figure 97). A robust stand of undisturbed sedges occupied the bank line, so lateral adjustments were not the result of bank erosion. Fine sediment did not fill in the entire channel, as a discrete reach maintained clean gravel (Figure 98).

Figure 97. Overly wide channel on restored portion of South Fork Ross Creek.

Figure 98. Accumulation of fine sediment in the restored reach of South Fork Ross Creek.

Figure 99. Exposed gravel in restored reach of South Fork Ross Creek.

The photographic coverage of post-treatment of the unnamed tributary of South Fork Ross Creek is limited and does not provide information on substrate or channel dimensions. Field notes indicate horses have access to this stream, and channelization and down-cutting is present upstream of the project area.

The landowner reported that in a few years after restoration, he witnessed considerable use of South Fork Ross Creek by spawning fish. The stream morphology reverted to pretreatment conditions within a few years. Despite the failure of this project to secure high quality spawning and holding habitat for fish, wildlife benefited, especially waterfowl.

2.13.3 Conclusions

Spring creek restoration presents challenges, and these projects have often not been an effective use of FFIP funds, and have not resulted in a sustained high-quality spring creek habitat. Reasons for the lack of success of these projects remain conjectural; however, the pliability of sedge dominated banks may be related. Historically, spring creeks were groundwater fed, and irrigation return flows were not a factor in their hydrology. A cause of the retreat of sedge-dominated banks is that irrigation return flows augment late season flows, and push the pliable banks laterally, thereby decreasing depth and increasing width.

As the FFIP and other funding sources have contributed substantially to spring creek restoration, and these streams have high ecological and conservation value, approaches to spring creek restoration need thorough review, application of an adaptive approach, where stream restoration practitioners learn from successes and failures.

2.14 Thiel Creek Barrier (021-07)

2.14.1 Introduction

Thiel Creek is a small stream flowing north from the foothills of the Beartooth Mountains, until its confluence with West Red Lodge Creek. The goal of this project was to protect a nonhybridized population of Yellowstone Cutthroat Trout in Lower Deer Creek, which is about 30 miles northwest of Thiel Creek. In 2006, the Derby Fire burned much of the Lower Deer Creek watershed. The severity of the burn was sufficient to cause fisheries managers to plan for potential mass wasting and ash flows that could extirpate Yellowstone Cutthroat Trout from Lower Deer Creek.

The goal was to secure a subpopulation of Yellowstone Cutthroat Trout from Lower Deer Creek in another location, and these fish could be used to repopulate Lower Deer Creek if catastrophic disturbance extirpated the stream's fish. Thiel Creek was selected as the sanctuary for brood stock, as a small, relatively inexpensive barrier could be constructed, and the site was easily accessible by road.

Thiel Creek is relatively low gradient and located within an unconfined valley. Ideally, a barrier construction site is constrained laterally by rock walls, which prevent the stream from cutting around the structure at high flows. The risk to Lower Deer Creek's Yellowstone Cutthroat Trout population offset concerns for the potential for the barrier to fail during floods, as it was needed to be functional for a few years, although reestablishment of a Yellowstone Cutthroat Trout in Thiel Creek would be also be a desirable outcome, if the barrier survived over the long-term.

The design called for a concrete barrier to span the Thiel Creek's floodplain (Figure 100). A metal apron would prevent formation of a scour pool downstream of the barrier. The structure was to be a leap barrier over most flows.

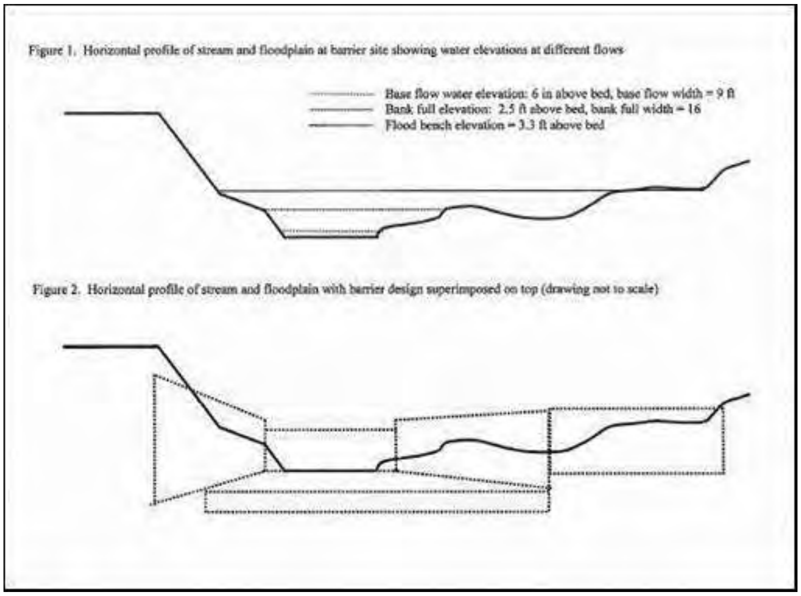

Figure 100. Conceptual design for the Thiel Creek barrier.

Thiel Creek supported an abundance of brook trout, and this species is incompatible with Yellowstone Cutthroat Trout. Before introduction of Yellowstone Cutthroat Trout salvaged from Lower Deer Creek, a substantial brook trout removal effort occurred upstream of the barrier, with over 3,000 brook trout removed from 2 miles of stream and placed downstream of the barrier. Yellowstone Cutthroat Trout from Lower Deer Creek were stocked upstream of the barrier in 2007.

Subsequent electrofishing efforts indicated Yellowstone Cutthroat Trout did not stay in Thiel Creek. Thiel Creek is a small, gravel-bed stream flowing through rangeland (Figure 101), and Lower Deer Creek is a montane stream with a predominantly cobble substrate (Figure 102). As the habitat in Thiel Creek was considerably different than Lower Deer Creek, the Yellowstone Cutthroat Trout likely left. Efforts to establish or reestablish Yellowstone Cutthroat Trout since this project has used egg boxes or remote site incubators, so fry become imprinted on the new stream.

Figure 101. Typical view of Thiel Creek upstream from the constructed barrier.

Figure 102. Typical view of Lower Deer Creek.

2.14.2 Field Visit 2017

Kyrsten Wolterstorff and a field crew went to the Thiel Creek barrier on June 21, 2017. Their objectives were to determine the condition of the barrier and sample fish upstream. The electrofishing effort upstream of the barrier yielded only Brook Trout, reconfirming the attempt to establish a population of Lower Deer Creek outside of their natal watershed was unsuccessful.

The fish barrier was present (Figure 103); however, it is in disrepair. Concrete on the right side of the barrier was crumbling (Figure 104). In addition, Kyrsten observed the potential for large flows to cut around the left side of the barrier. Otherwise, the barrier was built as described in the FFIP application, with exception that the apron was concrete, not metal, as proposed in the application.

Figure 103. The Thiel Creek fish barrier.

Figure 104. Crumbling concrete on right side of barrier.

2.14.3 Conclusions

The Thiel Creek barrier was built according to the specifications described in the FFIP application, except that a concrete apron was installed in place of a metal apron. The project goal of securing Yellowstone Cutthroat Trout outside of the Lower Deer Creek was unsuccessful. The Yellowstone Cutthroat Trout apparently left soon after being transferred to Thiel Creek. The substantial differences in habitat and water chemistry may have caused the translocated fish to find this habitat unsuitable. Recent efforts at translocating Cutthroat Trout to new waters use egg boxes or remote site incubators, so the fry are imprinted on that stream.

Currently, the barrier is not providing benefit for fish. It is likely detrimental to the resident Brook Trout, as it blocks movement. Moreover, it is in disrepair and has potential to fail, with the left side being vulnerable to erosion, and the right side experiencing spalling of the concrete. Its location in open rangeland make it considerably less secure than a barrier confined by rock walls.

FWP biologists in Region 5 should reexamine the need for this structure, evaluate the risk of its failure, and consider alternative uses, should it be reparable and secured. Mechanical removal of Brook Trout was unsuccessful in Thiel Creek, and its dense shrub cover would likely impede additional efforts at Brook Trout removal. If reestablishment of a population of Yellowstone Cutthroat Trout is desired, chemical removal of Brook Trout would likely be necessary. Thiel Creek provides about 7 miles of stream habitat upstream of the barrier, which exceeds the recommended minimum of 5 miles of habitat to promote long-term persistence of an isolated population.

2.15 Thompson Creek (022-07)

2.15.1 Introduction

Thompson Creek is a spring creek that flows north from Belgrade to its confluence with the East Gallatin River. It flows mostly through irrigated hay pasture and rangeland, and livestock grazing had resulted in degradation of riparian health and vigor, and bank erosion. Unfortunately, no photos are available to illustrate the pre-project state of the stream and riparian area; however, an aerial photo details the plan for fencing and water access points. A similar project was slated for neighboring Story Creek; however, we were unable to contact the landowner.

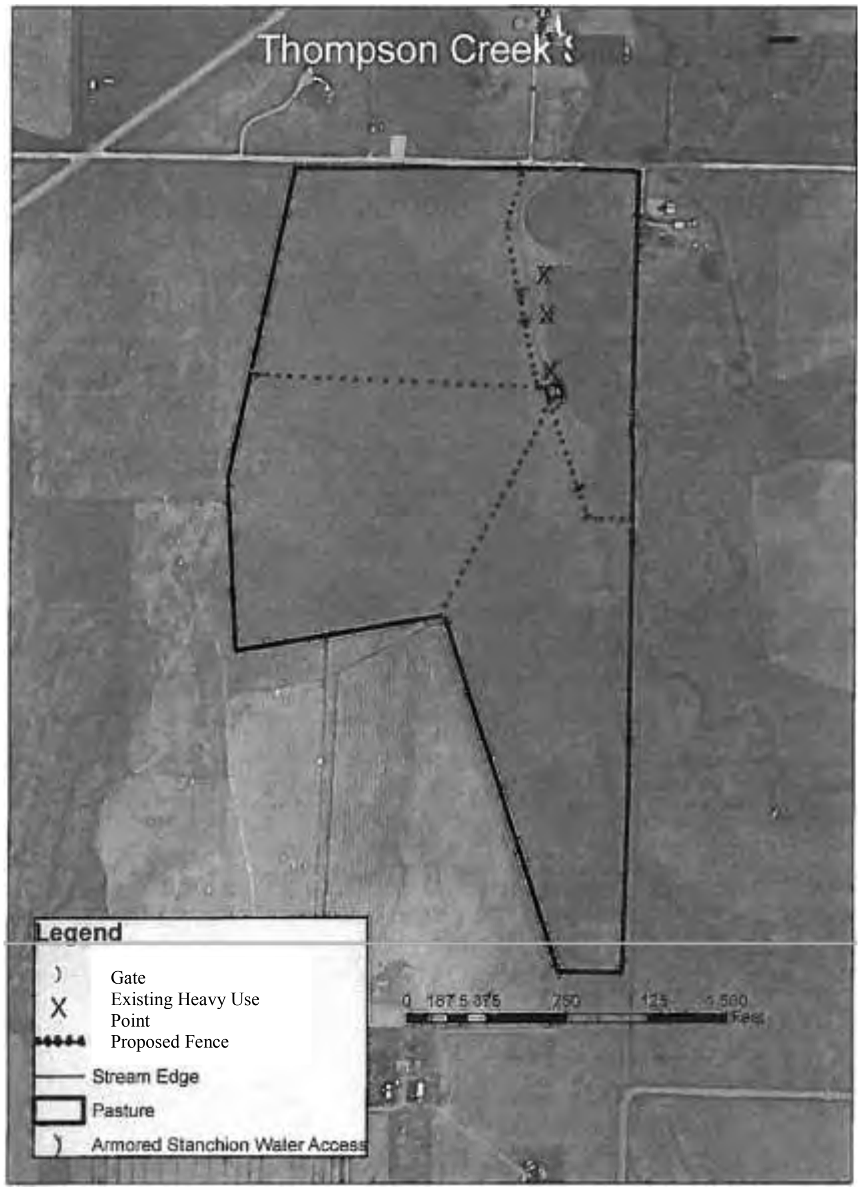

Figure 105. Aerial photo of plan to control livestock around Thompson Creek.

The goal of the project was to protect Thompson Creek's riparian area and stream channel. Thompson Creek is a tributary of the East Gallatin River, and improving stream habitat could be beneficial to spawners migrating from the East Gallatin River.

2.15.2 Field Visit 2017

Kyrsten Wolterstorff visited the Thompson Creek project on August 8, 2017. The riparian area was fenced (Figure 106), although not according to the FFIP application. Some hoof shear and manure were present, but grazing pressure was otherwise light (Figure 107).

Figure 106. Riparian fencing on Thompson Creek.

Figure 107.Slight trampling by livestock along Thompson Creek.

Armored water gaps had been installed as described in the FFIP application (Figure 108). Although it was unclear if the grazing followed a developed grazing management plan, the combination of fencing, water gaps, and limited use of the riparian area resulted in dense herbaceous vegetation within the riparian area. Shrubs were sparse to absent; however, many spring creeks do not provide habitat suitable for establishment of riparian shrubs.

Figure 108. Armored water gap on Thompson Creek.

The amount of fine sediment choking the streambed was a factor limiting the ability of Thompson Spring Creek to meet project goals of providing spawning habitat for fish migrating from the East Gallatin River (Figure 106 and Figure 109). The channel was relatively shallow and wide. Combined with the buffered flows typical of spring creeks, the stream lack the energy to transport fine sediment from its bed.

Figure 109. Thompson Creek's streambed, showing high levels of fine sediment and sparse gravel.

2.15.3 Conclusions

This project demonstrates the effectiveness of fencing and establishing protected water sources for cattle in promoting riparian health and reducing erosion, and the general failure of many spring creek projects to meet the goals of providing high quality habitat and spawning. Although Thompson Spring Creek is unlikely to be a source of recruitment of trout to the East Gallatin River, controlling livestock near the stream has likely reduced sediment and nutrient loading. The benefits extend to the East Gallatin River, which is on DEQ's list of impaired waters for sediment and nutrients.

2.16 Willow Creek (024-11)

2.16.1 Introduction

Willow Creek is a small unmapped spring creek near Silver Gate, Montana. Long-time residents reported an impressive spawning run of Yellowstone Cutthroat Trout from Soda Butte Creek, and likened the activity to salmon runs in Alaska. The run collapsed in the years following the 1988 wildfires that burned in and around Yellowstone National Park. The steep, adjacent hillslopes were severely burned, and erosion following the fire resulted in loading of fine sediment that exceeded this small stream's ability to transport. Yellowstone Cutthroat Trout still spawned in the stream, but only in isolated areas where width, depth, and gradient allowed for exposed gravel. The community, the Beartooth Alliance, and the Magic City Fly Fishers were instrumental in raising awareness and funds to restore Willow Creek's spawning run of Yellowstone Cutthroat Trout.

The stream flows through residences and business in Silver Gate. For much of its length, the riparian area was functioning and healthy, but the channel was overly wide, and the streambed mucky (Figure 110 and Figure 111). Dense stands of aquatic macrophytes further trapped and held sediment. The reaches that still supported spawning were considerably more narrow, deep, and had a gravel substrate (Figure 112). Although the impressive runs were gone, Yellowstone Cutthroat Trout still spawned in Willow Creek (Figure 113), and it supported some resident Yellowstone Cutthroat Trout.

Figure 110. View of Willow Creek showing the overly wide configuration typical of much of the channel.

Figure 111. Another view of Willow Creek with poor spawning habitat.

Figure 112. Reach of Willow Creek used for spawning.


Figure 113. Spawning Yellowstone Cutthroat Trout.

The restoration approach was to excavate the channel 1-ft deeper than the desired bed elevation, construct a narrow and deep channel, using straw wattles at the edge of the banks. The muck excavated from the existing channel was placed behind the wattles, and planted with container stock of sedges and rushes (Figure 114). Much of the muck substrate appeared to be soot delivered from the surrounding hillsides after the 1988 wildfires. Spawning size gravel was imported to the stream, and was 1-ft deep, providing substantial depth for Yellowstone Cutthroat Trout to dig redds. Several culverts were replaced with larger, squashed pipes to improve flow and sediment conveyance. Restoration occurred in May of 2013.

Figure 114. New bank built with straw wattle and back filled with sediment excavated from channel.

2.16.2 Field Visit 2017

Carol Endicott and Kyrsten Wolterstorff visited Willow Creek on August 24, 2017. Beavers had impounded the upper 70 feet of channel (Figure 115). Otherwise, the channel had retained its constructed dimensions (Figure 116). Substantial amounts of fine sediment had accumulated in some areas; however, significant portions had clean gravel that was suitable for spawning (Figure 117). No fish were observed in Willow Creek; however, Soda Butte Creek had been treated with rotenone in 2015, as part of a Yellowstone Cutthroat Trout conservation effort aimed at eradicating invasive Brook Trout. Nevertheless, locals reported few sightings of Yellowstone Cutthroat Trout in Willow Creek after construction, and the ability of fish to swim into Willow Creek from Soda Butte Creek was questioned, given a substantial drop near the confluence, and accumulation of a large cobble bar in Soda Butte Creek upstream of the confluence. Carol Endicott had noted the abrupt change in channel grade during a previous visit; however, Willow Creek's slope towards Soda Butte Creek was gradual during this site visit.


Figure 115. Beaver impounded reach of Willow Creek.


Figure 116. Typical reach of Willow Creek, retaining its cross-sectional dimensions.

Figure 117. Gravel substrate in Willow Creek.

2.16.3 Conclusions

Willow Creek is one of the few spring creek restoration projects assessed over the past 2 years that has not shown substantial changes in width and depth of the restored channel. Moreover, although fine sediment was present at levels higher than desirable, the streambed was a marked improvement from the muck dominated bed that had been in place.

Yellowstone Cutthroat Trout had 2 years to return to Willow Creek to spawn before application of piscicide, and some of the salvaged fish were returned to Willow Creek. Nevertheless, the low number of Yellowstone Cutthroat Trout following the piscicide project means their apparent absence is because the stream is inaccessible, or the habitat is unsuitable. Continued monitoring as the fishery recovers, and imprinting Yellowstone Cutthroat Trout on Willow Creek using remote site incubators may jump start the return of a spawning run to Willow Creek.

3 Conclusions

Projects evaluated in 2017 included a range of types of project including providing for fish passage, controlling cattle's access to streams and riparian areas, bank and stream restoration, and increasing water use efficiency to maintain in-stream flows. Success was variable among projects, and in some cases, additional evaluation or modifications are warranted.

Projects that exclude or limit livestock from streams and riparian areas continue to be effective ways to promote riparian health and function, maintain high quality habitat for fish, and reduce loading of pollutants. These simple and relatively low costs projects are repeatedly shown to be effective and FFIP funds are well spent on these projects.

Fish passage projects varied in their success. FFIP provided funds for a fish ladder and Waterman gate on an irrigation diversion on Cottonwood Creek in the Shields River watershed; however, these elements were not installed, in violation of the agreement signed by the landowner. This unfortunate case emphasizes the need to have sound verification that the project was instructed according to the agreement before the landowner is paid. Fish passage on North Fork Fridley Creek was successful in allowing fluvial Rainbow Trout to access the stream under the Park Canal siphon. Future monitoring should coincide with the Yellowstone Cutthroat Trout spawning period. The ability for fish to pass through the Denil ladder on South Fork Fridley Creek. The end of irrigation diversion on this stream may precede the Yellowstone Cutthroat Trout spawning run; however, the absence of Rainbow Trout from the traps suggest it is not passable. Additional investigation on water velocity and hydraulics is warranted,

Bank restoration projects varied in success. The bioengineered approach using coir fabric, seeding, willow sprigging, and installation of rock toes were successful on the East Gallatin River. Nevertheless, bank restoration technology continues to evolve, and projects should follow adaptive management by evaluating a wide variety of approaches that succeeded or failed. Juniper revetments are a technology that has a high probability of failure. The project on the Shields River that used concrete blocks as a temporary means to maintain bank stability left a vertical bare bank, and required installation of a rock toe. In general, stream restoration practitioners should emphasize natural channel design with the degree of armoring at the toe of the bank balance the need for deformability against the risk for failure.

Spring creeks have potential for high ecological value, with thermal regimes in the range that is optimal for growth of salmonids, and a tendency to support high biomass of aquatic invertebrates. Spring creeks are sensitive to disturbance and do not have the power to rework their channel and transport fine sediment when relieved of excessive grazing pressure. Spring creek restoration projects have mixed success, with many being failures. The reconstructed channels often do not maintain the constructed deep, narrow cross sections, and they become choked with fine sediment. Future spring creek restoration projects should be evaluated considering the factors that have resulted in success or failure, with FFIP funds being spent on projects most likely to be successful.

Several projects included elements to increase water use efficiency to maintain in-stream flows. Except for the Cottonwood Creek diversion project, where the efficient head gate was not installed, other projects replaced diversion of surface water with ground water, or voluntarily decreased water use in exchange for financial assistance towards purchase of a center pivot and piping to more efficiently deliver water. The effect of these projects on stream flows have not been quantified, and stream flow monitoring is advisable.

FFIP funds are often spent on construction of barriers to secure populations of native Cutthroat Trout. The barrier on Thiel Creek did not result in a protected population of Yellowstone Cutthroat Trout and is at risk of failing. FWP needs to develop a strategy for what to do with this structure.

4 Appendix: Field Evaluation Forms and Photos