Broadwater Power Project Fisheries Mitigation Monitoring Report (2017 -2022)

Montana Fish, Wildlife & Parks
Prepared by:

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Acknowledgements

The monitoring efforts and restoration work in the Deep Creek Watershed was made possible with the assistance of Broadwater Conservation District, The Deep Creek Landowner Advisory Group, NRCS, MTDEQ, MTDNRC, Broadwater County, and Big Sky Watershed Corp. The streamflow monitoring expertise of Jim Beck has been critical to understanding the hydrology of Deep Creek and Mr. Beck's data is the cornerstone of this report. The oversight of the Broadwater Conservation District Board of Supervisors and the Deep Creek Landowner Advisory Council provided important balance between agricultural and aquatic objectives. Coordination efforts by Denise Thompson of the Broadwater Conservation District insured enthusiastic and cooperative efforts by all parties involved. The innovative NRCS staff (Justin Meissner, Eric Wyatt, Ryan Marr) in Broadwater County "created the water" to serve agriculture while restoring natural flow. Robert Ray and Ann McCauley of DEQ were key to writing the watershed restoration plan and obtaining funding for the 319 grant. David Lofftus and Brian Holling provided assistance from DNRC-SWPB. Andy Brummond (FWP water program specialist) spent hundreds of hours attempting to legally secure instream flow generated from this project. Travis Horton (former FWP Regional Fisheries Program Manager) provided consistent support for focusing resources on a relatively small geographic area.

Introduction

The Missouri River originates near Three Forks Montana at the confluence of the Madison and Jefferson Rivers and flows 43 miles before entering Canyon Ferry Reservoir. This reach includes 21 miles of river below Toston Dam, which was designated a "blue ribbon" fishery (Brown 1965). Toston Dam and associated irrigation canals were constructed to provide irrigation water to about 21,000 acres and was first operated in 1941. The dam was retrofitted to add a hydroelectric facility capable of generating about 10 MW of electricity in 1989. Potential impacts of the hydroelectric facility on the resident fishery of the Missouri River was the basis for FERC-directed fisheries mitigation. Montana Department of Natural Resources and Conservation (DNRC) received a license to operate the plant from the Federal Energy Regulating Commission (FERC) and the plant is operated by DNRC's State Water Projects Bureau (SWPB). DNRC-SWPB contracts with Montana Fish, Wildlife & Parks (FWP) to evaluate fishery response to mitigation projects.

The primary fisheries mitigation project evaluated in this reporting period (2017 – 2022) was focused on streamflow/fisheries relationships at Deep Creek. Previous 5-year monitoring reports documented fish migration into Deep Creek following installation of an irrigation canal siphon beneath the streambed of Deep Creek, which replaced structures that previously interrupted fish movement between Deep Creek and the Missouri River. This FERC-approved siphon project implemented in 1991 was effective at providing fish passage and was documented in previous reports. The current monitoring report specifically includes streamflow and fisheries data collected during 2022 due to important mitigation actions implemented in 2022.

The health of Deep Creek upstream of the fish passage project (Montana Ditch Siphon), however, has been a concern since 1991 when the siphon project was completed. Seasonal dewatering of the stream and excessive fine sediment loading have impacted the fishery for decades, and several actions to address these problems began after 1991 (Table 1). The renewed focus on habitat improvement in Deep Creek was formalized in 2012 when the revised FERC order directed mitigation to improving aquatic health, and in 2014, FWP and DNRC-SWPB revised the evaluation plan to evaluate aquatic health specifically in Deep Creek.

This report includes monitoring results for the following components as outlined in the fisheries mitigation and evaluation plan approved by FERC in January 2015:

- Counting brown trout redds, conducting juvenile trout surveys, and trapping spawning adults in Deep Creek to determine spawning success;
- Installing and maintaining a staff gage in Deep Creek to monitor flows to evaluate the success in maintaining a 3 cubic feet per second minimum flow;
- Installing a thermograph and chart recorder to measuring abiotic variables from March to October;
- Conducting fish population surveys in the Missouri River via electrofishing; and
- Conducting other studies within the effects of the project as MFWP deems necessary in agreement with the licensee;

Deep Creek restoration activities have involved several partners since 1991. Mitigation funding to install the Deep Creek siphon (approximately $220,000) resulted in decades of additional work on the stream to improve upstream habitat conditions in Deep Creek. The partnerships, especially with private landowners, provide a basis for long term effectiveness of habitat enhancement projects.

Methods

Detailed monitoring and operation procedures are described in the Deep Creek SOP and SAP (Kreiner, 2015; Appendix A). These documents define methods of evaluation to meet the standards of monitoring for MTDEQ and other partners involved in the restoration of Deep Creek. Appendix A describes methods for all aspects of Deep Creek monitoring.

Study Area

The Missouri River is impounded by the Broadwater Hydroelectric Project 21 miles upstream of Canyon Ferry Reservoir. This reach of Missouri River and the associated tributary streams is the fishery enhancement and mitigation area located downstream of the hydroelectric project. Deep Creek, the focus of current mitigation efforts, enters the river 7 miles upstream of Canyon Ferry Reservoir.

Numerous sites were monitored at Deep Creek (Figure 1). The majority of monitoring locations evaluated in this report are located on private land in the lower 20 miles of Deep Creek. A list of monitoring locations, irrigation diversion points, and other helpful landmarks at selected river mile (RM) points is provided in Table 1.

Deep Creek arises on the west slope of the Belt Mountains at an elevation of 6,520 feet and flows for about 29 miles to the Missouri River south of Townsend, Montana. The mean gradient is 94 feet per mile. The stream width at low flow averages about 23 feet. Major tributaries include North Fork Deep Creek, Cabin Gulch, Sulfur Bar Creek, and the Russell Fork. About 7 miles of Deep Creek lie within the Helena National Forest; the entire drainage area is approximately 88 square miles.

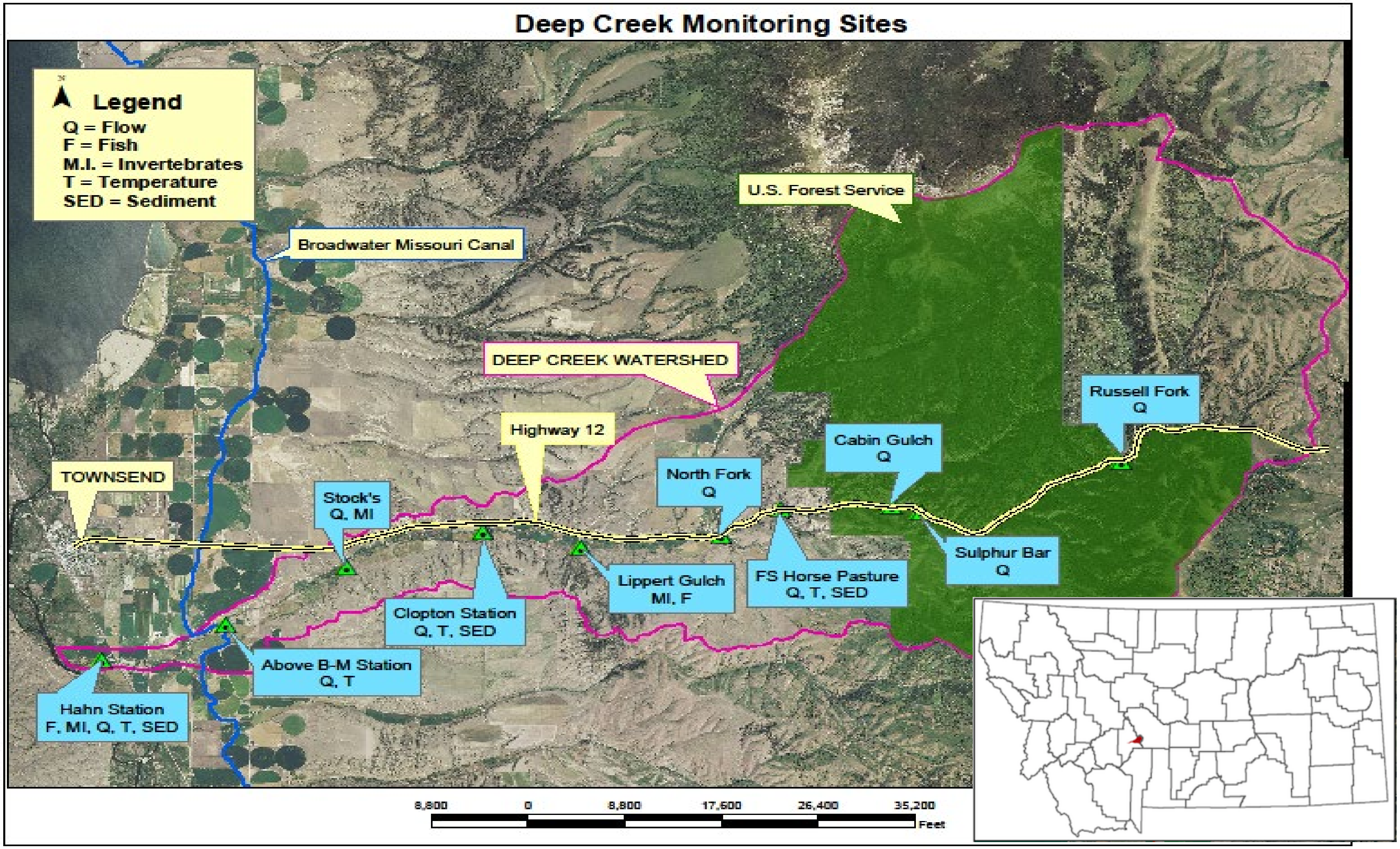


Figure 1. Map of Deep Creek watershed (88 square miles) and water sampling stations.

Table 1. River mile reference for Deep Creek sampling locations and selected landmarks.

RM (River Mile)	Location	Description
0	Confluence with Missouri River	Confluence of Deep Creek and Missouri River
0.4	Near Montana Ditch Siphon	Juvenile Outmigration monitoring with rotary screw trap
0.5	Near Montana Ditch Siphon	Adult spawning migration trap
0.5	Montana Ditch Siphon	
0.6	Hahn Gauge	Hahn Flow gauge. flow, fish, and temperature monitoring.
3.1	Hahn, Price, Scoffield Diversion	Diversion Removed in 2015
4.4	Broadwater-Missouri Canal (BMC) Siphon	Temperature and inflow into Deep Creek monitoring
4.4	Deep Creek Above BMC Gauge	Above BMC gauge monitoring flow, temperature, and fish
4.5	Spill Ditch Diversion from DC to BMC	Inflow into BMC from Deep Creek monitored
6.7	McArthur Irrigation Pump	Pump site upgraded in 2016
8.4	Stock's Bridge Gauge	Stock's Flow gauge above creek bridge crossing. Flow, fish, and temperature monitoring
9.5	Flynn Diversion	Diversion "retired" in 2013 and 2016
10.0	Antonick Bridge	
13.2	Clopton Lane Gauge	Clopton Flow gauge at bridge crossing. Flow, fish and temperature monitoring
14.6	Lippert Gulch	Confluence of Lippert Gulch and Deep Creek
17.8	Flume Gulch	Riparian Vegetation Removal Boundary. Top of Rehab reach.
19.9	Highway 12 Bridge	DCHWY12 Flow gauge (without daily recorder)
20.9	North Fork of Deep Creek	Confluence of North Fork and Deep Creek. Flow monitoring.
22.4	Forest Service "Horse Pasture" Gauge	Flow and sediment monitoring
24.7	Cabin Gulch Gauge	Flow gauge
25.4	Sulfur Bar Gauge	Flow gauge
29.6	Russell Fork Gauge	Flow gauge

Results and Discussion

Streamflow Monitoring

Deep Creek is one of 278 streams in Montana identified by FWP's chronically dewatered streams list (MTFWP 2003). The lower 9.5 miles of stream have experienced dewatering problems due to summer irrigation demands for decades, and this dewatering was a primary limiting factor for the fishery and aquatic health of Deep Creek. Fishery impacts due to low flow was also a central issue of FERC approval of mitigation actions. In the November 1991 FERC order, the Director required the licensee to improve streamflow in lower Deep Creek.

In the past 30 years, Deep Creek water management took an approach to irrigation delivery that eliminated open ditches and minimized the quantity of "unconsumed water" after diversion. Direct pumping of water from Deep Creek which was applied to crops by center pivots and wheel lines (and a few small handlines). Evaluation of this water diversion practice was complicated by the fact that 400 acres (Flynn Project) of irrigated cropland was no longer served by Deep Creek starting in 2013. Water demand from the creek decreased, and not surprisingly, summer streamflow improved. Irrigated acreage along a 15-miles reach of Deep Creek between the upper (RM 19.9) and lower (RM 4.4) streamflow gauges was effectively reduced by 28% from 1400 acres to 1000 acres during 2013.

Snowpack in the Big Belt Mountains generally plays a large role in predicting summer flow in Deep Creek. The NRCS snotel site at Boulder Mountain provides the closest high elevation snowpack index that can be applied to Deep Creek. The average May 1 snow water equivalent value at this site was 20.5 inches and has been below average 6 of the past 8 years (Figure 2). Snowpack was significantly above average during one year in the current report – 2018.

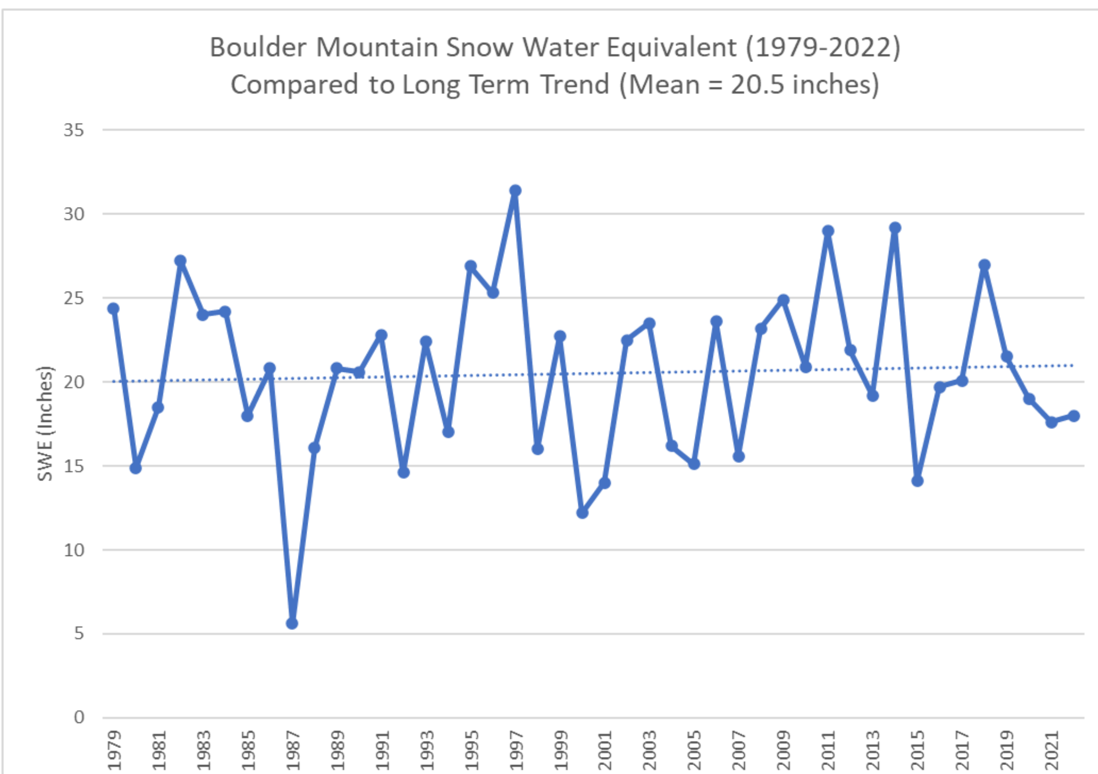


Figure 2. May 1st snow water equivalent at Boulder Mountain snotel site near the Deep Creek watershed, 1979-2022.

Streamflow monitoring at Deep Creek documented streamflow at 9 stations over multiple years. The 2012-16 report documented flow trends at many of these sites in detail. This report is intended to provide a more general summary of flow trends at three locations (Figure 3). The three streamflow monitoring locations are:

1. DCHWY 12 at River Mile 19.9. The station is upstream of all mainstem water diversion.
2. DCABM at River Mile 4.4. The station is operated by DNRC/BOR with real time data. It is located upstream of Broadwater-Missouri Canal (BM Canal). This site was often completely dewatered during dry years.
3. DCHAHN at River Mile 0.6. The station is located below all inflows and diversions and can be influenced by releases of BM Canal water.

The streamflow monitoring locations provide before and after project evaluation of flow changes due to irrigation infrastructure improvements. The stations at RM 4.4 and 0.6 also serve to evaluate compliance with an instreamwater lease. The primary approach for improving streamflow using infrastructure improvements at four irrigation ditches (Figure 3) was based on the following rationale and timing:

- Antonick ditch was converted to direct pump sites during the late 1980's due to landowner problems maintaining the canal;
- Dagnell ditch was converted to direct pumping sites during the early 1990's due to a highway project that impacted the ditch. Montana Dept. of Transportation assisted the landowner with ditch retirement and pump installation to benefit both the landowner and the highway.

The early irrigation infrastructure projects were not specifically evaluated for streamflow and fishery response. The ditch retirement and pump site installation approximately 30 years ago provided observations and experience for other water users to consider. More recent system improvements from 2012-15 were intended to benefit both water users and the fishery and were funded by a variety of partners (landowners, NRCS, Broadwater CD, DEQ, DNRC, and FWP). Streamflow monitoring at Deep Creek primarily evaluate flow response to the following two projects (Figure 3):

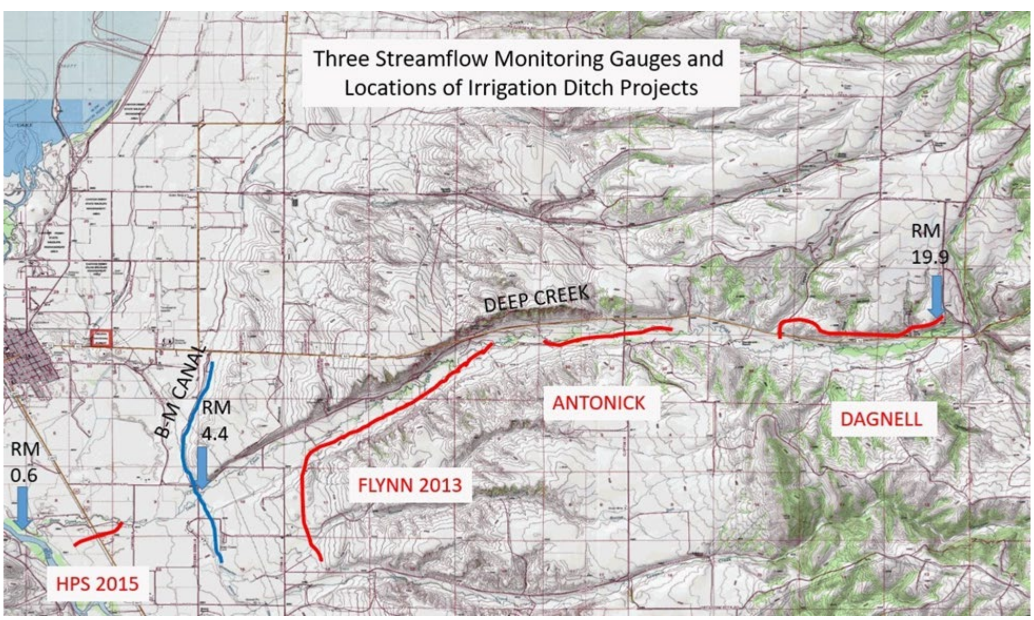


Figure 3. Map of Deep Creek streamflow monitoring sites and locations of irrigation diversion projects.

- Flynn-McArthur ditch was retired at the end of 2012, and McArthur moved to a direct pumpsite two miles downstream of the headgate and Flynn began pumping from BM Canal. Hence, 400 acres of irrigation demand was moved away from Deep Creek;
- The Hahn-Price-Scoffield diversion below the BM Canal was moved to BM Canal and fitted with a gravity irrigation system to serve three landowners. About 277 acres of irrigation demand was moved off Deep Creek.

Photographs of Deep Creek at DCABM (RM 4.4) during 2012 and 2022 illustrate Deep Creek streamflow changes over time (Figure 4). The last year of flow monitoring before infrastructure was improved (2012), and the first year of legally protecting instream flow via a water lease (2022) represents a 10 year span when coordination with partners, private landowners and the legal process finally provided legal protection of instream flow.

Figure 4. DCABM (RM 4.4) before irrigation infrastructure project in 2012 (TOP) compared to August 27, 2022 photo (BOTTOM) when the water lease was implemented.

The streamflow contrast displayed in photographs between 2012 and 2022 was also quantified. In 2022 (post project) streamflow at RM 4.4 was at or above 4.15 cfs during most of the summer and the minimum flow observed was only less than 3 cfs on 5 August prior to the Water Commissioner restricting junior water rights (Figure 5).

In 2012, despite having an equal or higher water supply compared to 2022, the stream ceased to flow for over a week during late August/early September (Figure 5). A 4 cfs improvement (minimum) in summer streamflow at a critical location of Deep Creek was observed. Streamflow upstream of diversions was similar in 2012 and 2022 (Figure 6). Note: Daily average flow data in 2022 is provisional, and data for the above diversions chart were approximated using DCHWY12 (RM 19.9) and DCUSFS (RM 22.4) flow trends (daily flow data for 2022 will be presented in a future report).

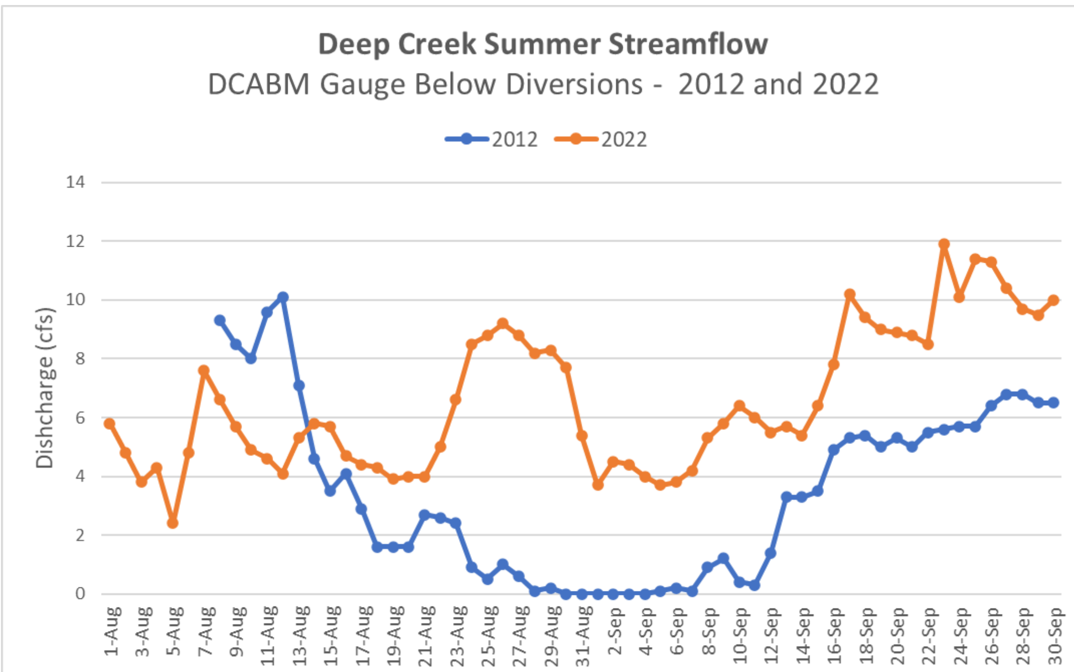


Figure 5. Mean daily discharge at DCABM Gauge during 2012 and 2022. Data collection began 8 August in 2012. Data source during 2022 from DNRC real time gauge (provisional).

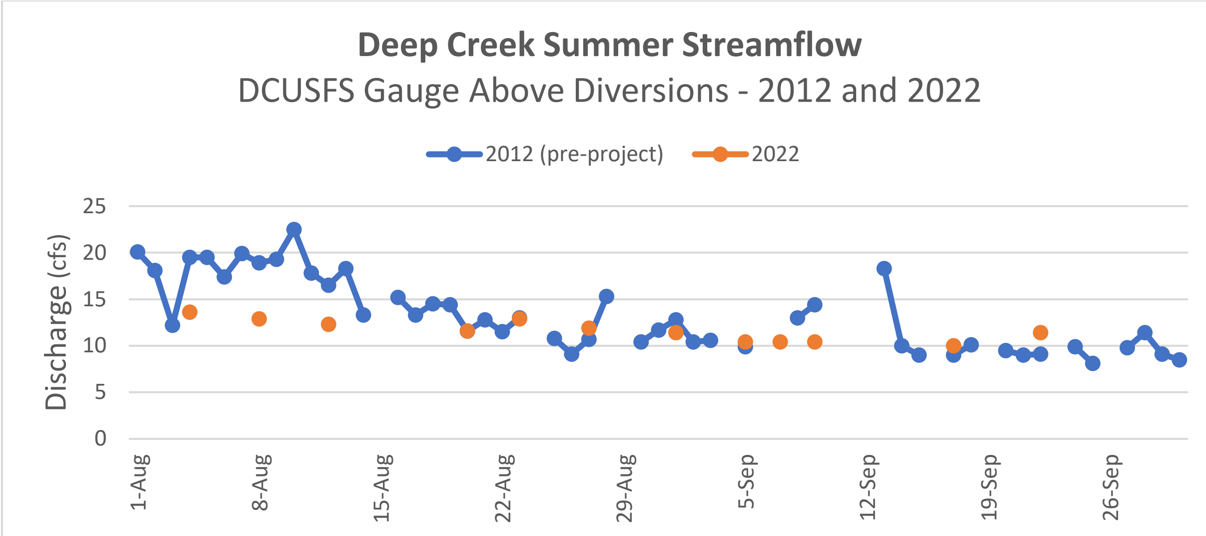


Figure 6. Mean daily discharge during 2012 at DC USFS Horse Pasture Gauge and estimated flow at DC USFS Horse Pasture Gauge using intermittent gauge observations interpolated from the DCHWY 12 Gauge. Data for 2022 is provisional.

From the late 1980's until 2012, a 5-mile reach of Deep Creek above RM 4.4 was either dry or flow was often less than 3 cfs during average or dry years (Figure 7). McClure and White (1990) noted complete absence of flow in areas upstream of RM 4.4 for 74 days. Additional documentation of low flow was found in reports related to the Deep Creek TMDL monitoring reports (Hydrotech 2004). Extremely wet years such as 1993 provided rare exceptions when flow was healthy throughout Deep Creek. Beginning in 2013, the most severely dewatered reach of Deep Creek from RM 9.5 to 4.4 was no longer completely dewatered but had occasional brief periods of critically low flow.

From 2013 to 2022 flow never ceased in any reach of Deep Creek and was only less than the recommended 3 cfs during two extremely dry years (Figure 7). Mean August streamflow at DCABM exceed the pre-project (2012) August mean each year (Figure 8). During the past 10 years, streamflow during late summer was often less than the preferred 9 cfs instream flow recommendation outlined in FWP's Upper Missouri Water Reservation, but infrastructure improvement and water leasing likely prevents acute dewatering events in a stream reach with historic flow limitations.

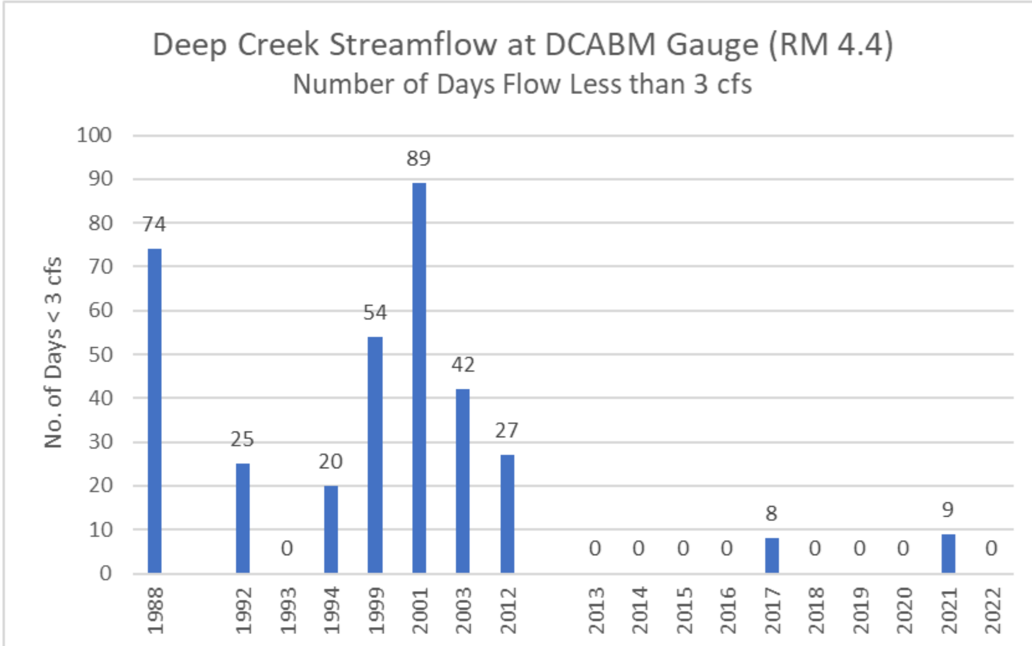


Figure 7. Number of days Deep Creek streamflow was less than 3 cfs at DCABM.

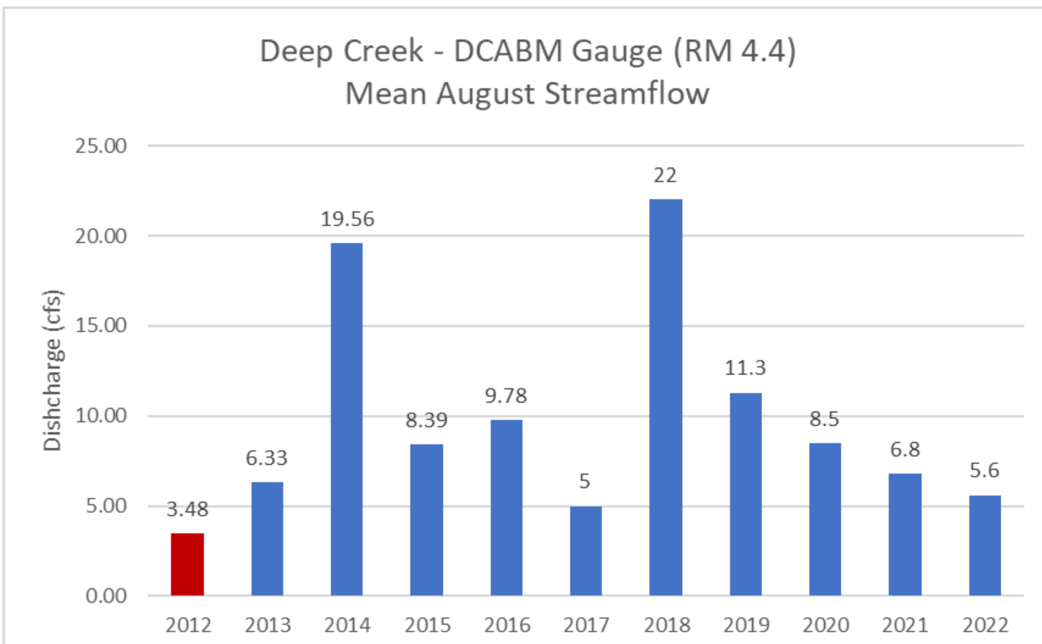
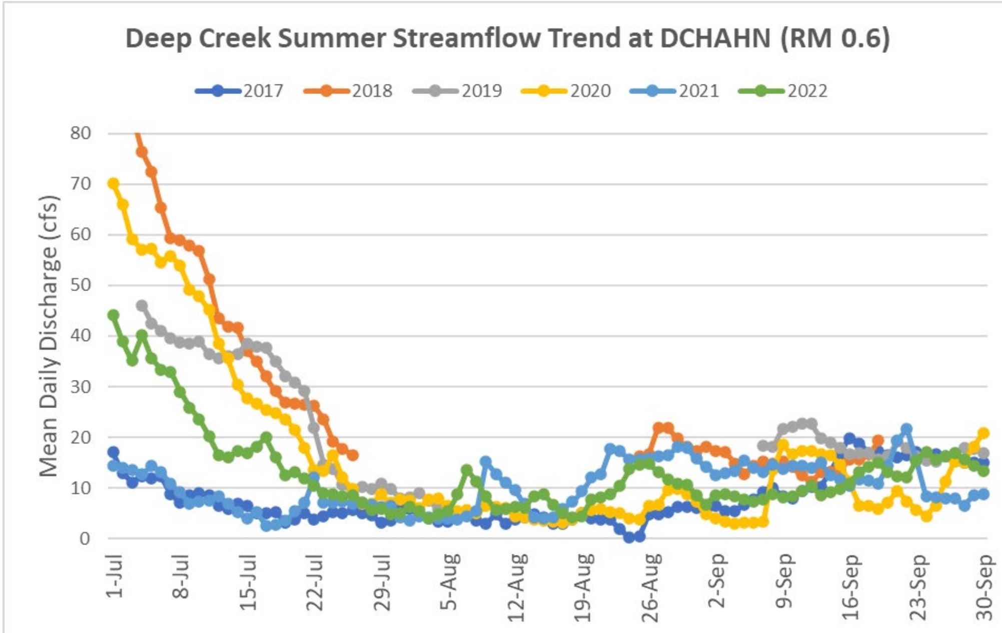


Figure 8. Mean August streamflow at DCABM in 2012 (pre-project) compared to 2013-22.

Monitoring of streamflow at the DCABM gauge was the focus of flow restoration efforts and the current report. Streamflow at DCHAHN (RM 0.6) is also important for documenting water lease compliance during 2022, and mean daily flow exceeded 4.15 cfs after the water commissioner restricted junior users in early August (Figure 9). Data from the other flow monitoring stations at Deep Creek are available for future reference but were not necessary to interpret or document flow recovery efforts from 2017-22. Water releases from BM Canal into Deep Creek below DCABM influence flow and temperature data at the Hahn Gauge.



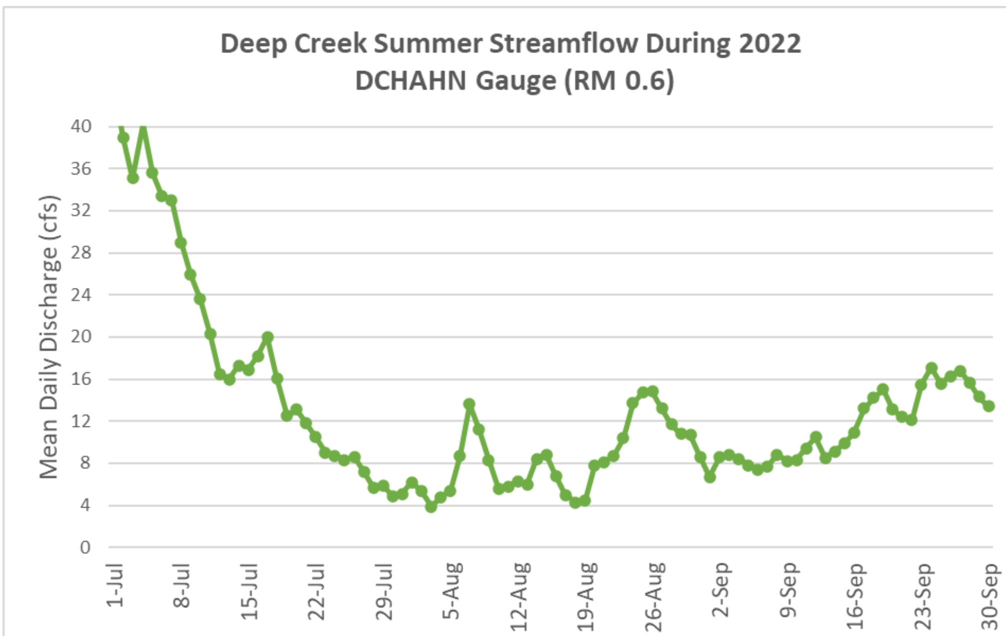


Figure 9. Summer streamflow at DCHAHN Gauge from 2017-22 (TOP) and during 2022 when the instream lease was implemented (BOTTOM).

Irrigation Infrastructure Summary

<u>Major Streamflow Events at Deep Creek 1988 to 2022</u>

- 1988: Extreme drought and Deep Creek completely dewatered for months (not merely less than 3 cfs)
- 1991: First year of BPP Mitigation and Deep Creek siphon installation. DNRC release a minimum of 3 cfs into lower deep creek (below BM Canal) to assist with dewatering problems.
- 1992-2012: Frequent flow depletion above the BM Canal (RM 4.4).
- 2013: NRCS/FWP/BCD partnership to improve flow and other stream health at Deep Creek.
- 2015: Requested DNRC-SWPB to assist with legal protection of water after ditches were retired and pump sites installed (including two pump sites relocated to Broadwater Canal after removed from Deep Creek).
- 2022: First year of legal protection of instream flow based on the Davis Water Lease.

The primary method for reducing irrigation withdrawals was replacing open ditches with direct pumping of irrigation water to supply wheel lines and center pivots. After 2015, the only open ditch remaining on Deep Creek is the "spill ditch" located at RM 4.5 which supplies Broadwater Missouri Canal with Deep Creek surface water. The spill ditch was inactive from prior to 1990 to 2012. It resumed operation in 2013, but generally ceased diversion in mid-July. The operation of the "spill ditch" is a high priority future project.

Streamflow enhancement of Deep Creek due to infrastructure projects was benefitted by the availability of an alternative water source (Broadwater Missouri Canal). The Flynn Diversion (upstream of BM Canal) and the Hahn-Price-Scoffield Diversion (downstream of BM Canal) ceased diverting in 2013 and 2015, respectively. The Flynn Project involved about 400 acres of irrigated cropland, and the HPS project involved 277 acres (Figure 10).

Based on occasional electrofishing surveys, all open ditches on Deep Creek entrained fish in the past, and some open ditch diversions restricted upstream movement of fish seasonally. The photograph of the HPS Diversion, which was retired in 2015, provides an example of how movement could be restricted (Figure 11). Fish bypass structures and fish screens were not necessary to prevent entrainment due to ditch retirement.

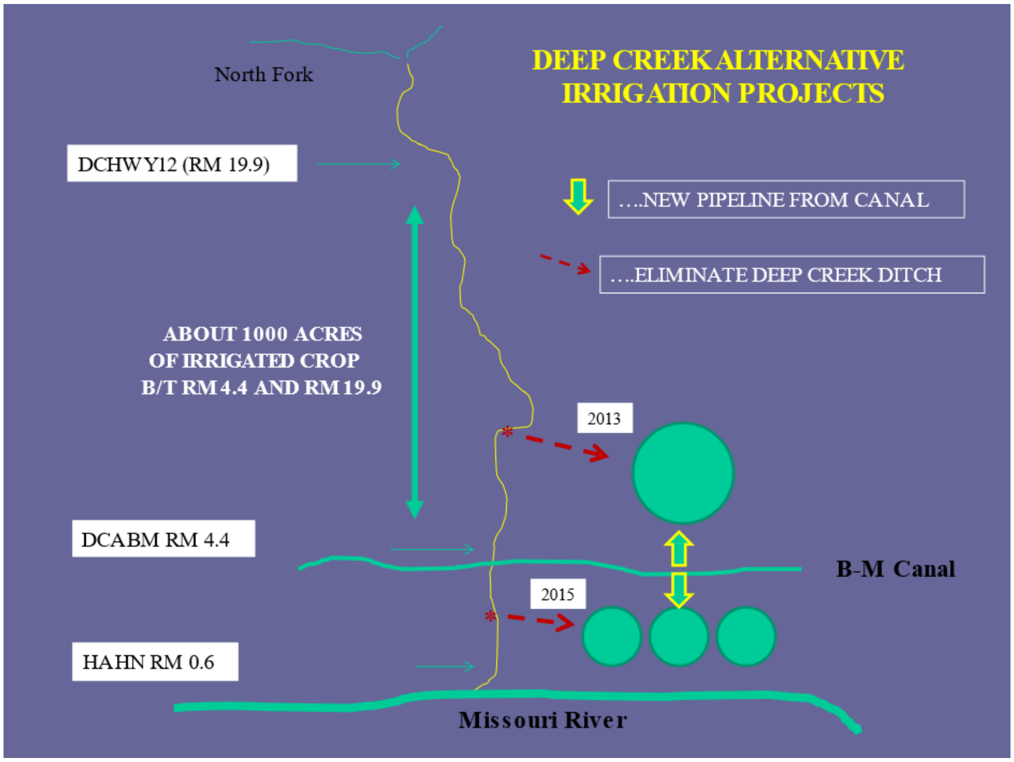


Figure 10. Conceptual map of Deep Creek irrigation infrastructure projects. The B-M Canal began providing irrigation water to replace Flynn diversion in 2013 serving about 400 acres of cropland, and B-M Canal provided water to replace the HPS diversion in 2015 serving 277 acres of cropland.

Figure 11. Photograph of HPS Diversion in 2013 prior to “retirement”.

Water Lease Implementation – 2022

After infrastructure projects providing increased instream flow was achieved, the need to legally protect water was apparent. Instream flow gains were likely to be lost if not legally protected, and legally securing water was the primary recommendation of the 2012-16 monitoring report. The licensee assisted FWP with legal water protection during 2022 with the first implementation of an instream flow lease at Deep Creek. Some water lease details are:

- A water lease was obtained from a single user on Deep Creek with a point of diversion above RM 4.4.
- The water right has a 5/1/1868 priority date.
- The term of the lease to FWP is 10 years.
- FWP secured replacement water from BM Canal to deliver to this water user in lieu of payment.
- BM Water Users Association approved this change in 2017.
- DNRC assisted with this replacement water arrangement in 2022.
- DNRC water rights bureau approved the lease details in 2022 to protect 4.15 cfs.
- About 14 water rights are senior to the 1868 right leased by FWP, and about 8 current water users with relatively small acreage have junior water rights potentially subject to water restrictions during dry years when flow at the mouth of Deep Creek falls below 4.15 cfs.

During 2022, Montana FWP received approval from MT DNRC water rights bureau for a water lease agreement for legal protection of Deep Creek streamflow. The water lease had no effect on senior water rights on Deep Creek, but potentially restricted junior users when or if flows declined to 4.15 cfs. Since all water users diverted water with direct pumps from the stream to operate center pivots, wheel lines, or hand lines, it was possible to quantify water use simply viewing the stream corridor from the road and counting the number of irrigation units operating. This survey was done at least once per week during low flow periods.

In 2022, there were 36 total irrigation units on Deep Creek between DCHWY 12 and DCABM. An irrigation unit was defined as a single wheel line, center pivot or a group of small handlines. During maximum irrigation use prior to 4 August when the water commissioner began to restrict water rights junior to the instream lease right, 19 units were operating (Figure 12). During August 12 and 19, when flow at DCABM was approximately 4 cfs, 5 irrigation units were turned off and 39% of the wheel lines/pivots/handlines were operating. A thunderstorm event near 26 August increased water supply and caused excessive turbidity from rain on the 2021 burn area. This likely caused some pumping stations to turn off and flow increased significantly.

This example of flow management with pump stations and sprinkler irrigation demonstrates relatively high management flexibility. During the 1990’s, open ditches with multiple users on each ditch would have resulted in a more complicated task for the water commissioner. On 8 August, the reduction of units from 19 to 16 resulted in flow increasing at DCABM by about 2 cfs.

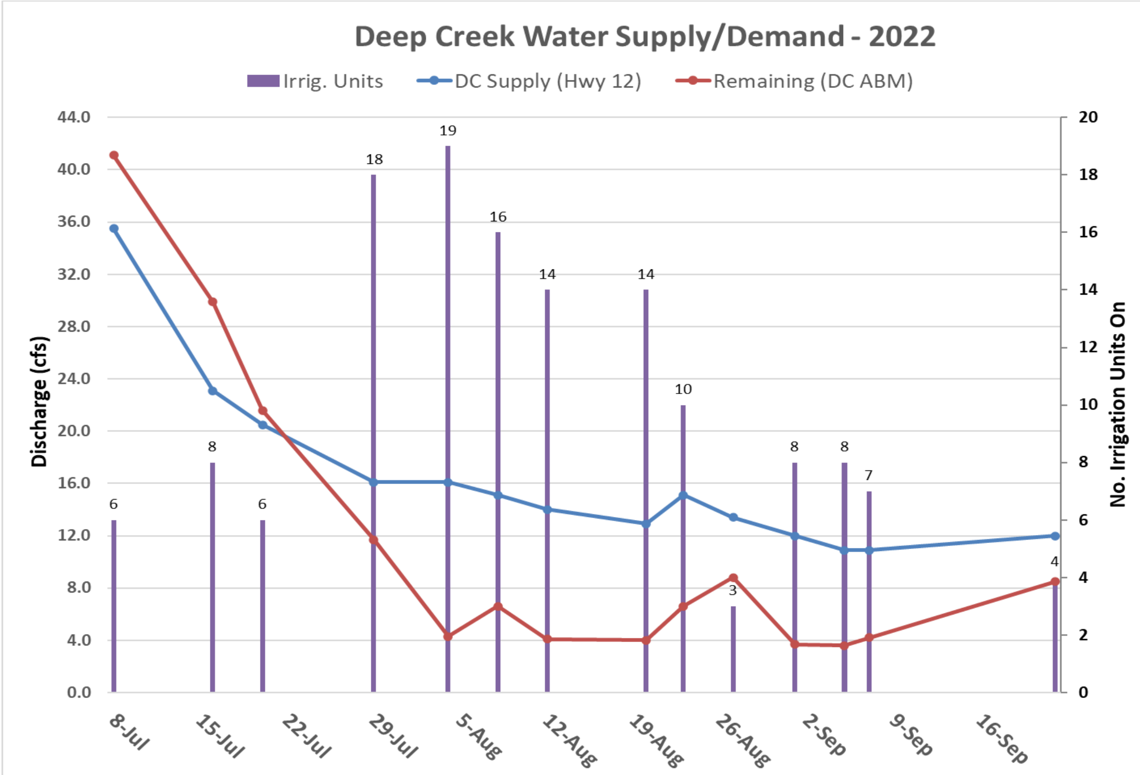


Figure 12. Deep Creek water supply and demand surveys conducted at least weekly during the irrigaton season.

Since streamflow at Deep Creek tends to gradually decline after 1 July, and recovers after 15 September, it can help water managers to view the irrigation season as a relatively short period to coordinate use during predictable events such as hay cutting periods. Streamflow at DCABM was less than 4 cfs during early August during extremely dry years (2017 and 2021), but was maintained at or above 4 cfs during 2022 when the water commissioner restricted use (Figure 13). From 2017-22, the highest demand for water was during late July of early August (Figure 14).

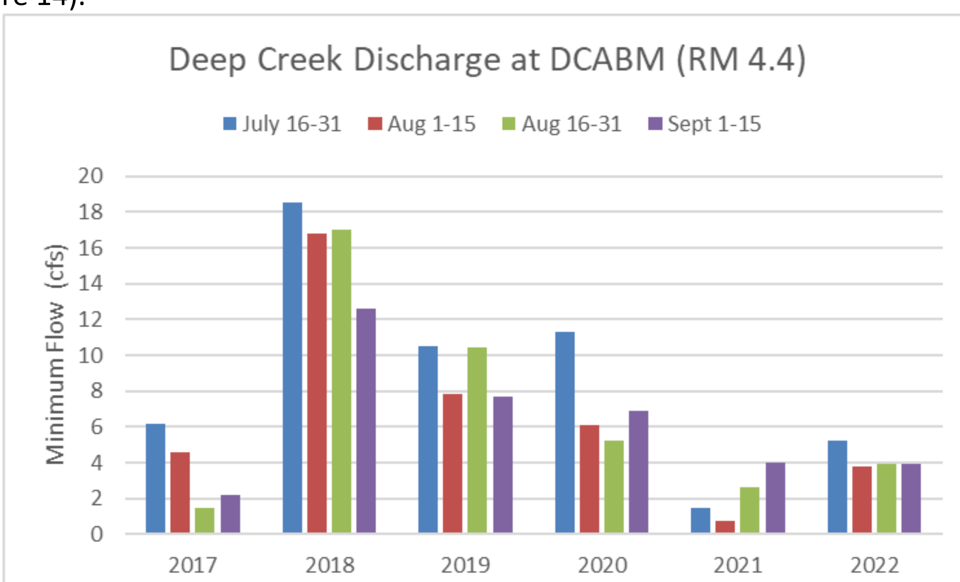


Figure 13. Biweekly streamflow averages at DCABM Gauge from 2017-22.

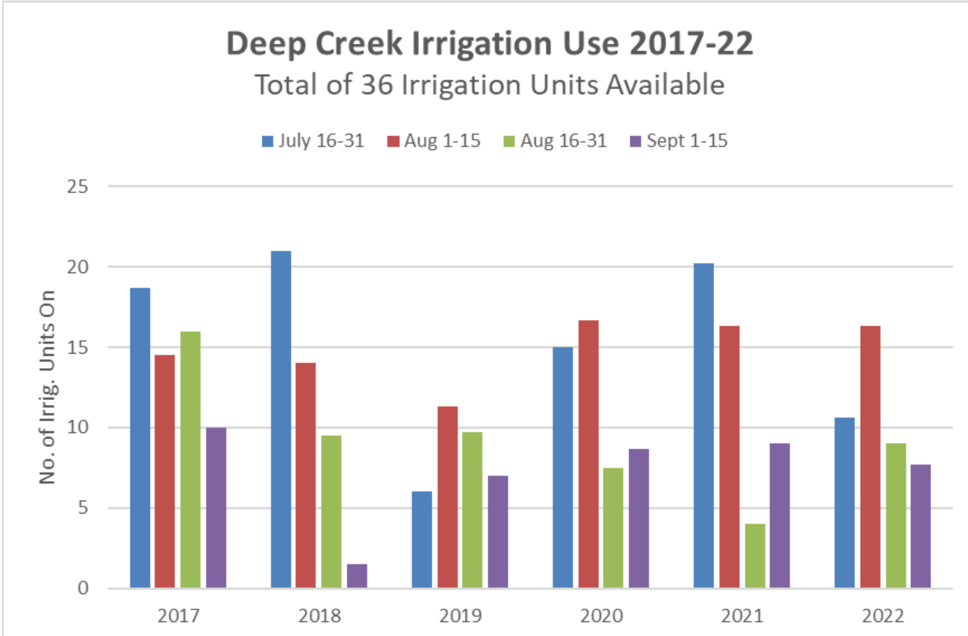


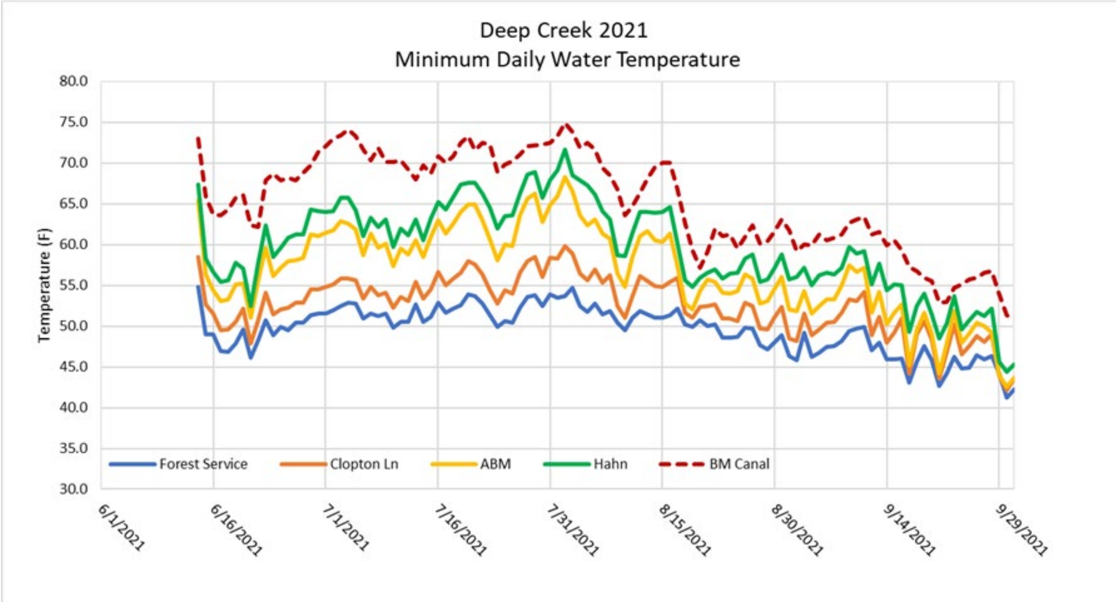
Figure 14. Index of biweekly irrigation demand based on counts of irrigation units.

In contrast to serving water use with at least 4 open canals during the 1980's, Deep Creek is now served with about 12 pump sites to operate 36 irrigation units (wheel lines, hand lines and pivots). In general, less than 60% of the units are operated at any one time. The highest demand is generally late July or early August. After 4 August 2022, the water commissioner restricted 6 owners who operate about 10 irrigation units. This likely allowed the flow at DCABM to generally exceed 4 cfs during late summer in 2022.

Future monitoring of both streamflow and fishery response to flow changes may determine that assumptions of the past were not correct. FWP determined during the Instream Flow Reservation Process that primarily used Wetted Perimeter Methodology to recommend flow, that a flow in Deep Creek of 9 cfs during summer provided healthy conditions for the fishery (MTFWP 1985). Cawlfield (1991) determined that short term minimum streamflow of 3 cfs would allow juvenile trout to move between pools or migrate to the Missouri River. The current water lease of 4.15 cfs was selected, in part, because it exceeded 3 cfs. Continued monitoring of fishery and streamflow trends at Deep Creek may result in modifying future streamflow goals.

Water Temperature Monitoring

During summer months, stream temperature in Deep Creek increased progressing downstream from the Forest Service Boundary (RM 22) to the Hahn Gauge (RM 0.6) near the confluence with the Missouri River based on 5 temperature monitoring locations operated from 2017-22. Daily maximum and minimum temperature during 2021 illustrates the warming trend from the upper reaches of Deep Creek to the mouth, and a complete summary of trends from 2017 to 2022 will be provided in the 2023 annual report (Figure 15). A common observation from 2017-22 was the relatively warm night-time temperature of BM Canal water near the Deep Creek diversion.



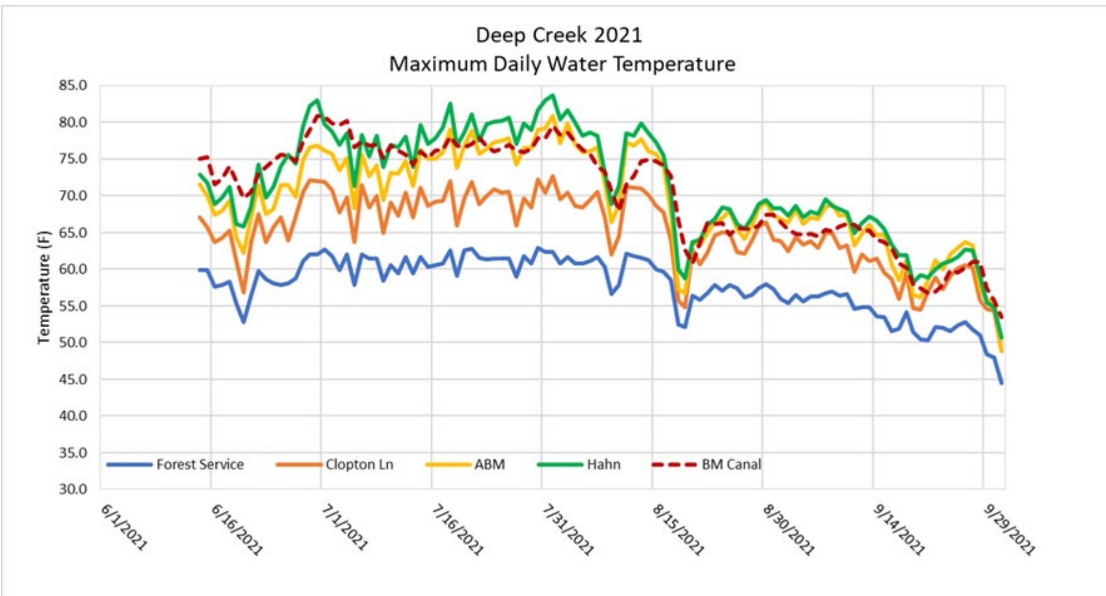


Figure 15. Maximum (top) and minimum (bottom) daily water temperature of Deep Creek and the Broadwater-Missouri Canal during 2021.

From 2012 to 2022, the relatively high flow years (2014 and 2018) resulted relatively cool water at DCABM Gauge with few days exceeding 75 F (Figure 16). During 2022, when the water lease generally maintained flow at or over 4 cfs, water temperature exceeded 75 F for over 20 days of the summer.

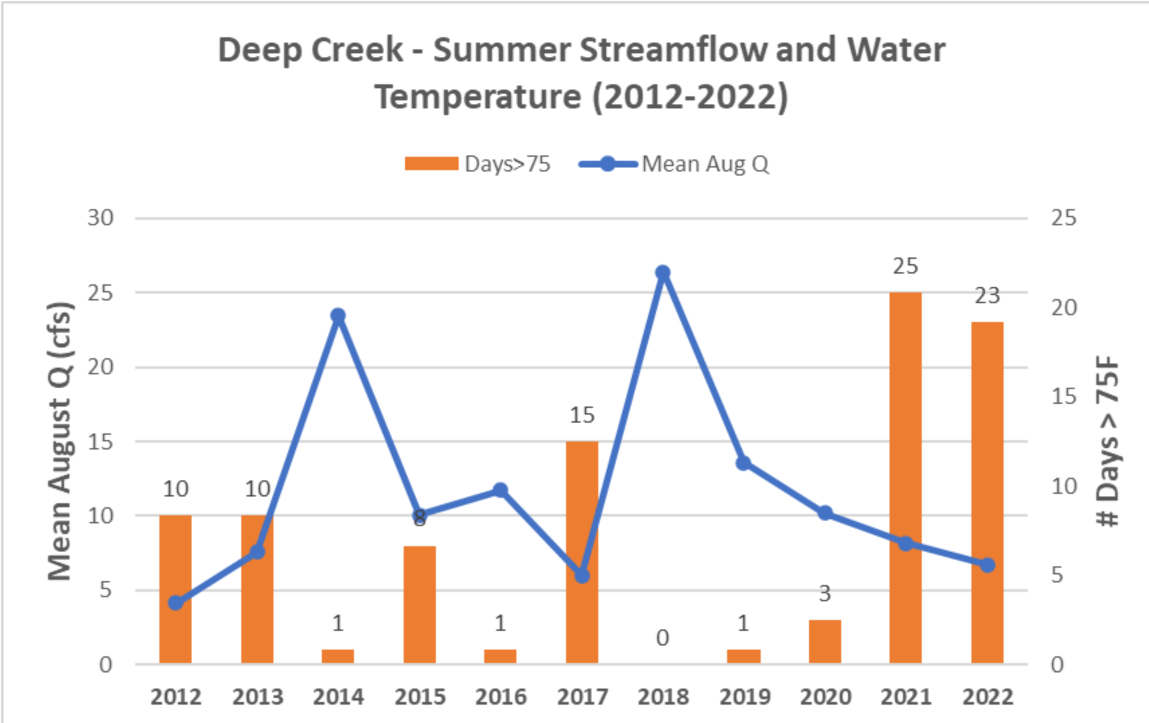


Figure 16. Comparison of mean August discharge at DCABM to the number of days water temperature exceeded 75 degrees F. Temperature data in 2012-13 approximate due to incomplete temperature records.

Fishery Management and Population Trends

The Upper Missouri River near Toston Dam (Broadwater Power Project) is managed with a focus on sustaining a wild trout fishery. This reach of the Missouri River is one of just twelve major rivers in Montana where water rights (Murphy Rights) for a high value trout fishery was established in 1969. Large numbers of Brown Trout and Rainbow Trout from Canyon Ferry Reservoir concentrated below Toston Dam during spring and fall creating a rare fishery with both high abundance and large size. The abundance of Brown Trout declined during the 1980's.

Fishery management is currently directed by the Upper Missouri River Reservoir Fisheries Management Plan (2020-29). According to the plan, "The goal for managing the Missouri River between Toston Dam and Canyon Ferry Reservoir is to provide naturally reproducing brown and rainbow trout populations in the Missouri River and associated tributaries for recreational fishing opportunities, and to provide important spawning and rearing conditions from Toston Dam to Canyon Ferry Dam. In addition, a migratory walleye population increasingly provides recreational fishing opportunities……."

Fish species found in the Missouri River near Toston Dam include:

Game Species	**Nongame Species**
Rainbow Trout	Common Carp
Brown Trout	Longnose Sucker
Cutthroat Trout	White Sucker
Brook Trout	Mountain Sucker
Mountain Whitefish	Longnose Dace
Walleye	Fathead Minnow
Burbot	Redside Shiner
Largemouth Bass	Flathead Chub
Smallmouth Bass	Utah Chub
Kokanee	Mottled Sculpin
Yellow Perch	Stonecat
Northern Pike	Bluegill
Black Crappie	

Brown and Rainbow Trout have been a focus on both the Fishery Management Plan and the Broadwater Power Project Fishery Mitigation objectives. The initial FERC license in 1991 established quantitative goals for juvenile production of Brown Trout and Rainbow Trout. Brown Trout continue to be a good indicator species for the health of the Missouri River due to their migratory life history and relatively sensitive habitat requirements.

The oldest data set in the project area is based on 33 sinking gill nets (experimental mesh) that were first set in Canyon Ferry Lake soon after the reservoir filled. Brown Trout were commonly captured in this netting series for the first 30 years of sampling (1955 to 1984) (Figure 17). A significant decline in Brown Trout abundance was observed after 1984, and the gradual decline of this species is ongoing.

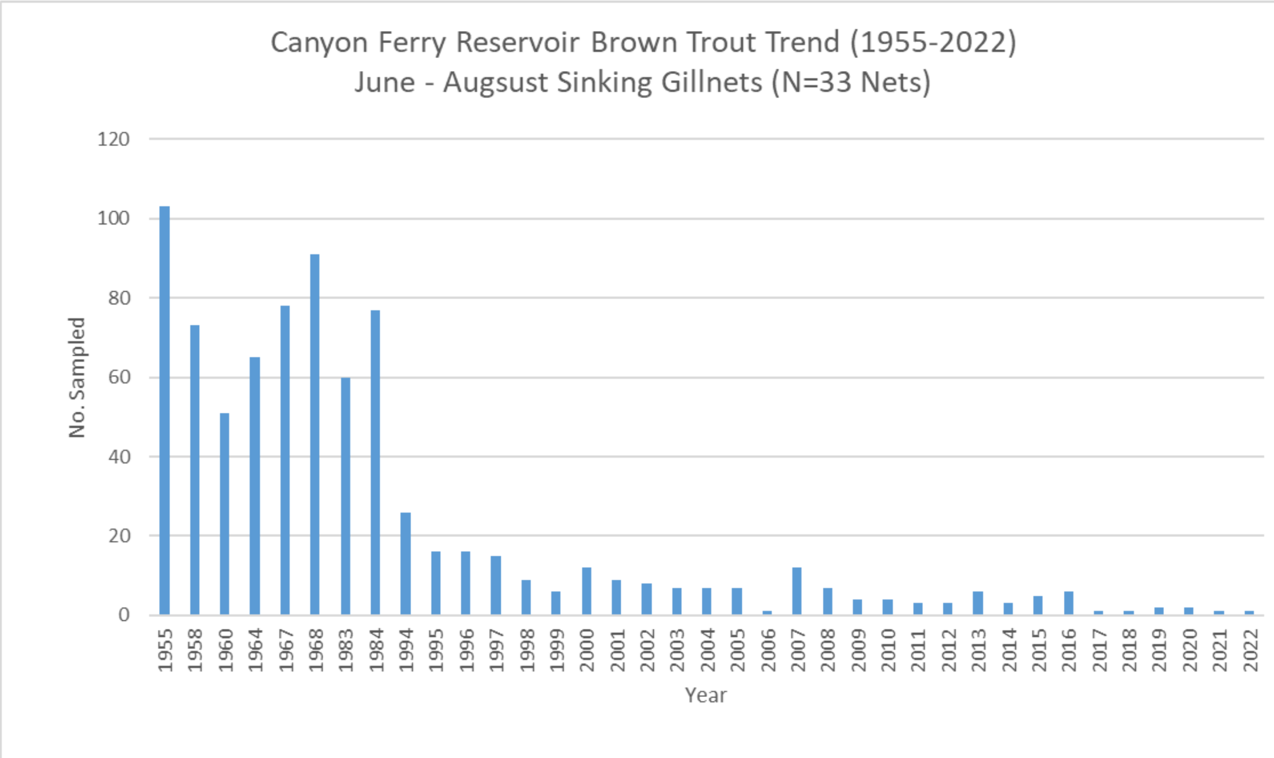


Figure 17. Brown Trout abundance in gill nets set in Canyon Ferry Reservoir, 1955-2022.

Missouri River Fishery Monitoring

Historic fishery population monitoring below Toston Dam showed a declining population trend from 1979 to 1992, and the density of brown trout reached an historic low of 55 Brown Trout per mile in 1992 (MFWP 2006). Population estimate efforts were ceased after 1992 due to difficulty obtaining reliable sample size for estimate calculation. After 1994, Catch-Per-Unit-Effort (CPUE) surveys were conducted during fall to provide an index of abundance for Brown Trout and other species (Figure 18).

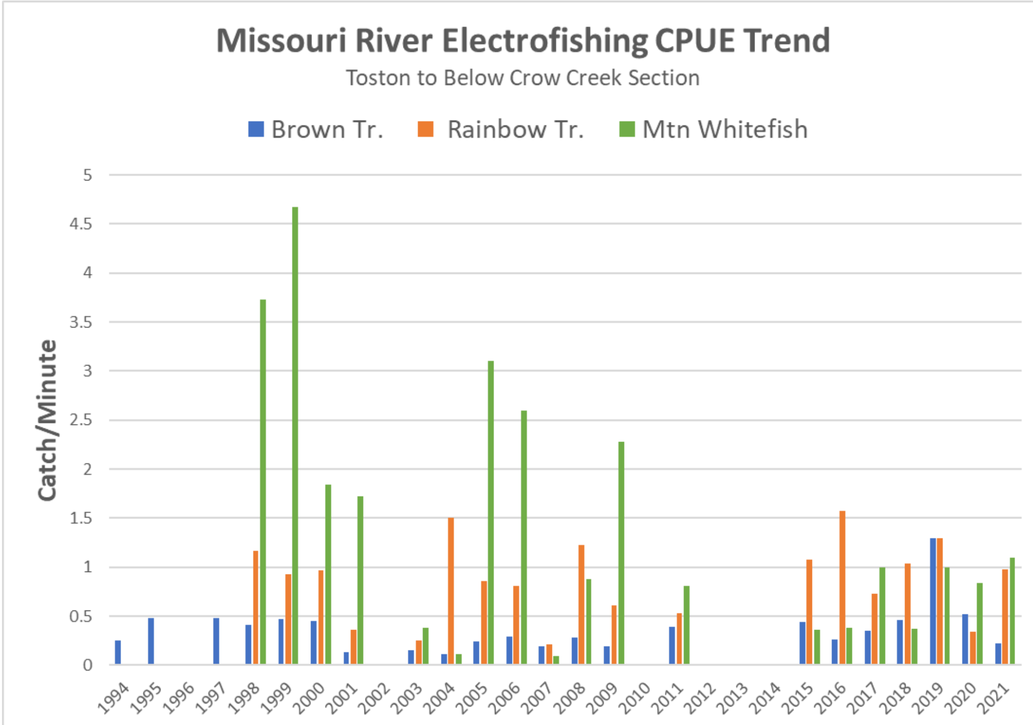


Figure 18. Missouri River CPUE electrofishing trend from 1994 to 2021.

Although these data were variable and lack sampling efficiency correction, a general trend of fish decline following low streamflow periods such as the drought of 2000-2006. Brown Trout abundance in the Missouri River appears to recover to some degree during periods of improved streamflow (Figure 19).

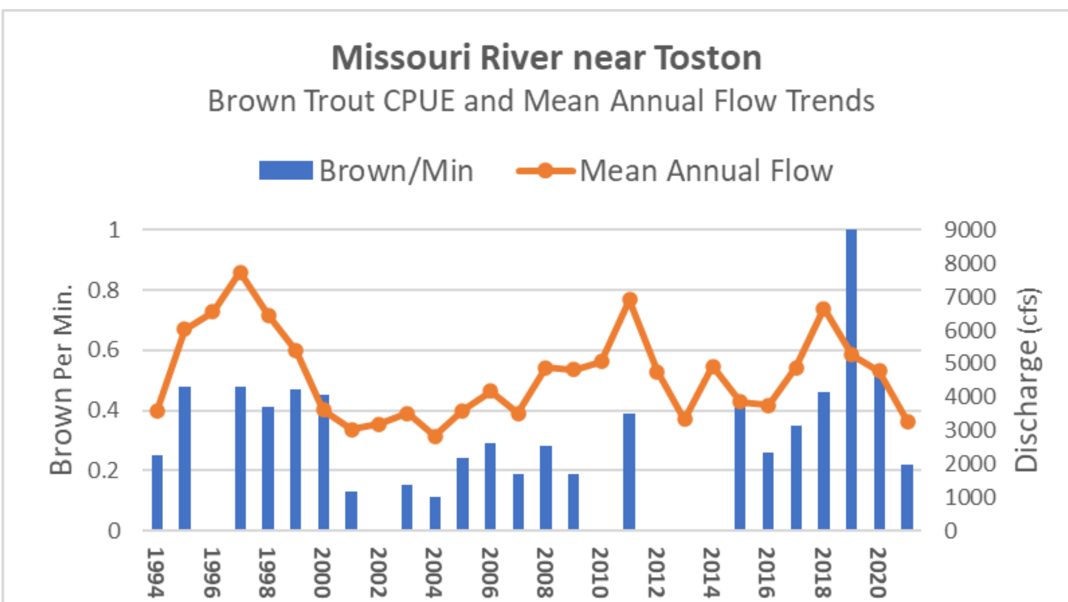


Figure 19. Brown Trout catch-per-unit-effort electrofishing results compared to mean annual streamflow of the Missouri River at Toston (1994-2021).

Population trends for Brown Trout residing in the Missouri River approximately 20 miles upstream of Toston Dam (Trident Section) provide a reference to evaluate population trends below the dam. Brown Trout abundance was nearly the same in the two sections during 2018 but was generally higher at Trident in previous sampling (Figure 20). FWP and Montana State University began a radio telemetry study in 2022 to determine Brown Trout movement patterns above and below Toston Dam. Pre-spawning, mature Brown Trout captured below the dam will be placed upstream and monitored during 2022-23.

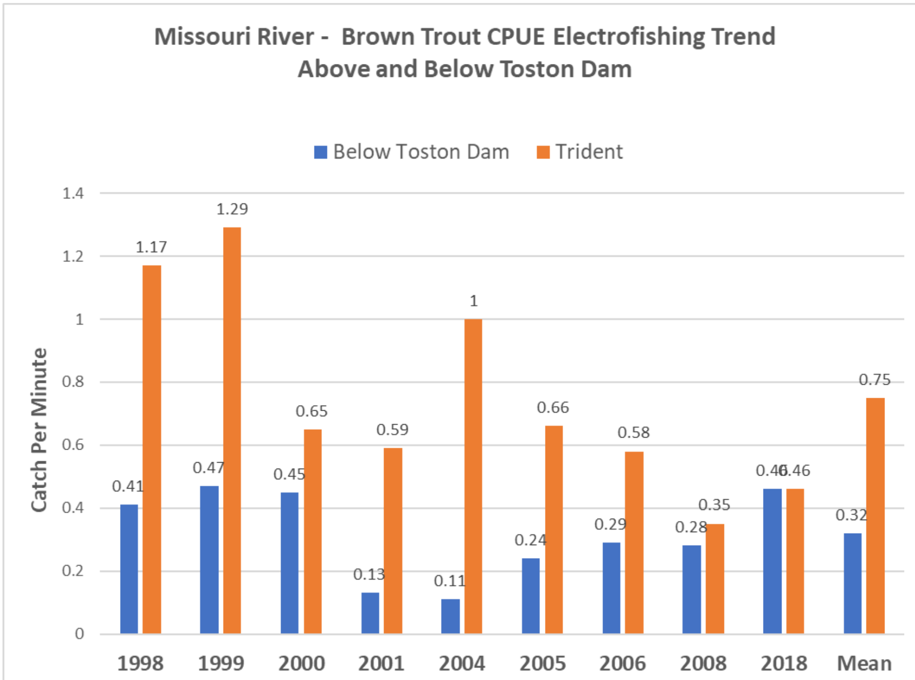


Figure 20. Brown Trout catch-per-unit electrofishing results for the Missouri River above Toston Dam (near Trident) and below Toston Dam (near Toston).

Deep Creek Fisheries Monitoring

Evaluation of fisheries trends in Deep Creek involved several monitoring efforts directed at different live history stages:

1. **Resident trout abundance.** Determine resident Brown Trout and Rainbow Trout population trends for fish residing year-around in Deep Creek in a long-term population estimate section (1988-2022).
2. **Rainbow Trout Spawning Migration.** Rainbow Trout spawning movements from the Missouri River into Deep Creek using the trapping weir (1992-2008);
3. **Brown Trout Spawning Use.** Long term Brown Trout redd counts to identify key spawning locations, resident population trend, and migratory Brown Trout use of Deep Creek (1991-2021);
4. **Juvenile trout movement from Deep Creek to the Missouri River.** Brown Trout and Rainbow Trout juvenile outmigration from Deep Creek using a rotary screw trap (2003-22 during April to July).

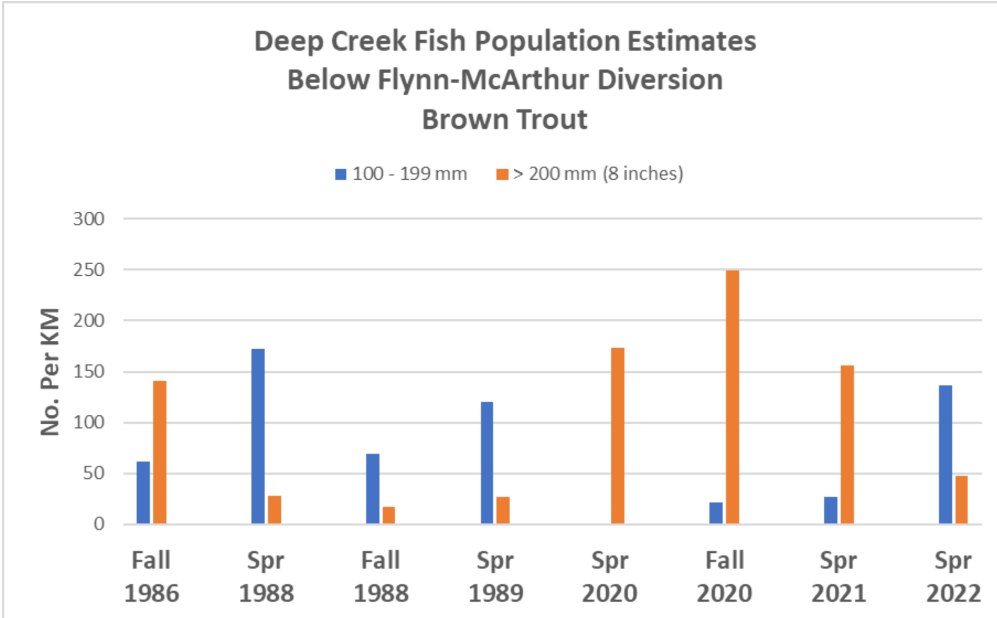
Resident Trout Population Monitoring

Many rivers and streams in Southwest Montana were impacted by the drought and extremely low streamflow observed in 1988. Deep Creek was severely dewatered during 1988 and effects were observed by an unrelated fishery study at Deep Creek from 1986-89 (McClure and White, 1992). The study documented resident trout abundance before and after the 1988 event which completely dewatered the study area for 74 consecutive days upstream of RM 4.4.

The McClure and White population estimate section was located at about RM 6.5. This section could not be duplicated in recent years due to access issues, and a monitoring section was established on State Lands at RM 8.0 (about 1.5 miles upstream of the 1986-89 sampling location). Both sections represent similar streamflow characteristics since they were below the Flynn-McArthur Diversion located at RM 9.5. This diversion significantly reduced streamflow in lower Deep Creek and often resulted in complete cessation of flow during low-flow years. Habitat quality of the Below Flynn-McArthur Diversion Section sampled in 2020-2022 was likely superior to the old study section of McClure and White (Figure 21).

Figure 21. Photograph of “Below Flynn-McArthur Diversion” Section of Deep Creek during October 2022 showing healthy riparian habitat.

Both Brown Trout and Rainbow Trout populations were reduced by low streamflow during summer 1988 (Figure 22). As expected, trout abundance of all sizes declined after complete dewatering. However, recovery of both Brown Trout and Rainbow Trout was relatively rapid considering the severity of the 1988 event. The study section below the Flynn-McArthur diversion (RM 9.5) was frequently dewatered until 2013 when the ditch was retired. Resident Brown Trout abundance from 2020-22 population estimates were not significantly improved from population estimates from the late 1980's. Rainbow Trout abundance of larger adult fish appeared to increase in recent years, but juvenile abundance was similar to the late 1980's.



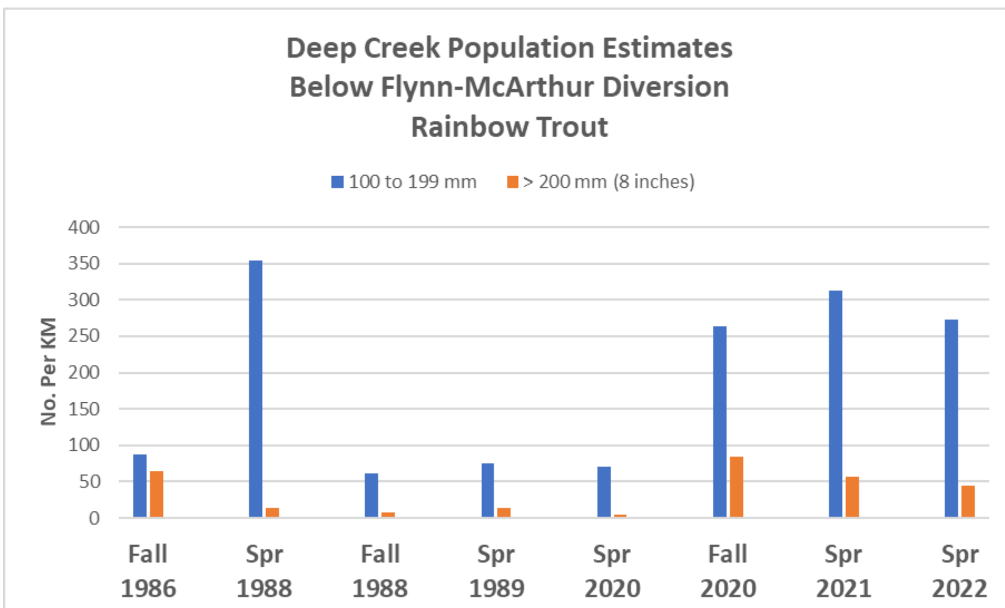


Figure 22. Brown Trout (TOP) and Rainbow Trout (BOTTOM) population estimates at Deep Creek from 1986 to 2022. The study section during 1986-89 was at approximately RM 6.5 and was relocated to RM 8.0 from 2020-22.

Fish Movement into Deep Creek

Spawning migrations of Rainbow Trout, and to a lesser extent, Brown Trout from the Missouri River into Deep Creek took place within one year of the installation of the Montana Ditch siphon that blocked most fish passage for decades. Up to 2000 Rainbow Trout spawners entered the Deep Creek fish trap during the spring (Figure 23). Trap operation ceased after 2008 when the connection of Deep Creek and the Missouri River was well understood. Spawning Brown Trout from the Missouri River were also observed in Deep Creek within one year of barrier removal, but numbers of fish were generally less than 100 per year based on occasional electrofishing surveys and observations of Brown Trout concentrated below beaver dams near the mouth of Deep Creek. Although monitoring of spawning fish movements into Deep Creek are not intensively monitored, the Montana Ditch siphon continues to function and fish continue to move freely in and out of Deep Creek.

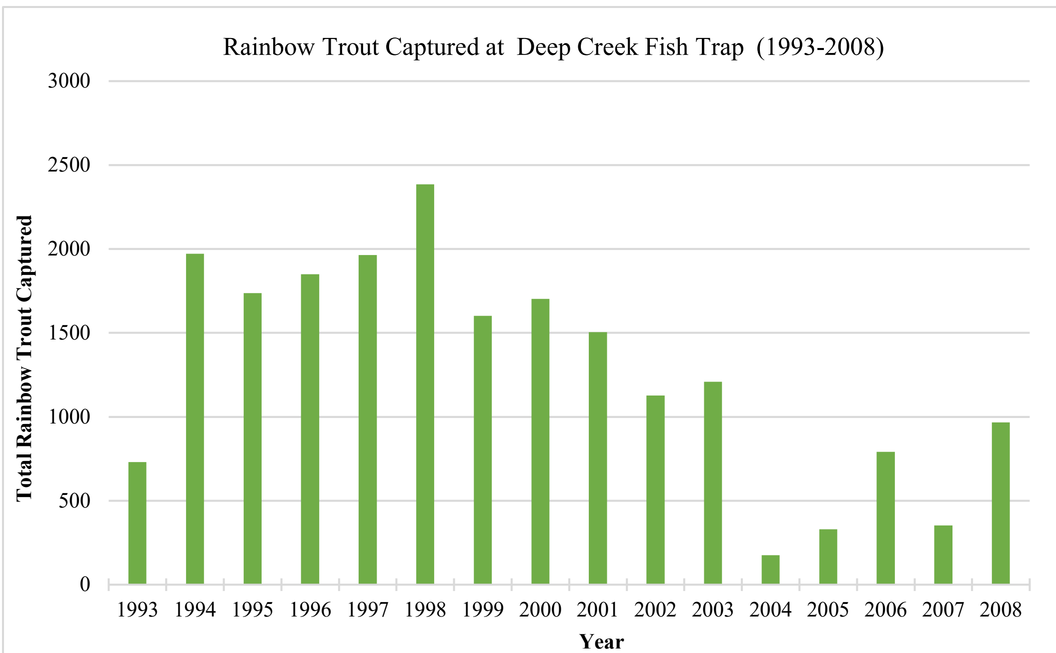


Figure 23. Rainbow Trout capture at the Deep Creek fish trap, 1993-2008.

Brown Trout Redd Counts

Brown Trout redd counts were conducted annually in Deep Creek to assess adult abundance, resident and migratory contributions to the spawning population, spatial variability in spawning site selection, and overall fishery health related to restoration projects. Redd counts are commonly used to create an index of population trends within a region (Rieman et al., 1997; Dunham et al, 2001; Al-Chokhachy et al., 2005). The use of redd surveys to assess Brown Trout populations is a less disruptive surveying method, it is more economical than alternative methods, and a thorough survey can capture many fishery variables. Brown Trout spawning occurs in during fall (October-November).

FWP first monitored Brown Trout redds in 1991, and the survey included the entire lower 20 river miles of Deep Creek. This inventory was repeated in 2016 to provide a more complete view of Brown Trout redd construction in all reaches of Deep Creek. From 1992-2015, redd counts were conducted on selected reaches and did not include the entire 20 river mile reach.

Total number of redds in 2016 (593) increased significantly from 1991 (204). The most significant increase in redds occurred in the severely dewatered reach, between river mile 4.4 and 8.5. Since 2012, this reach was most benefited from streamflow improvement projects (Table 1). Although Brown Trout can migrate significant distances to spawning areas, the presence of numerous downstream fish passage barriers (primarily beaver dams) generally limited migrant spawners to the lower 9 miles of Deep Creek. The majority of observed redds were constructed by Deep Creek residents.

Beaver dam counts were recorded during Brown Trout redd surveys (Figure 24). FWP observed 33 beaver dams during the 2016 survey. The largest concentration of beaver dams was below RM 3.0 near the mouth of Deep Creek. These dams limited upstream movement of migrant spawners from the Missouri River and impassable dams contributed to relatively high redd density in the lower reaches of Deep Creek.

Figure 24. Photographs of beaver dams in Deep Creek.

Brown Trout redds in upper Deep Creek (RM 13-20) increased from 76 in 1991 to 343 in 2021 (Figure 25). The upper reach had two irrigation ditches retired in the early 1990's and was the location of extensive Clean Water Act (319) implementation to reduced sediment supply with fencing and juniper revetment projects. The number of redds over the 30-year sampling effort clearly show an increase in Brown Trout spawning use of the reach. Since most spawners were likely resident fish, the increase likely represents an increase in fish abundance within the study reach.

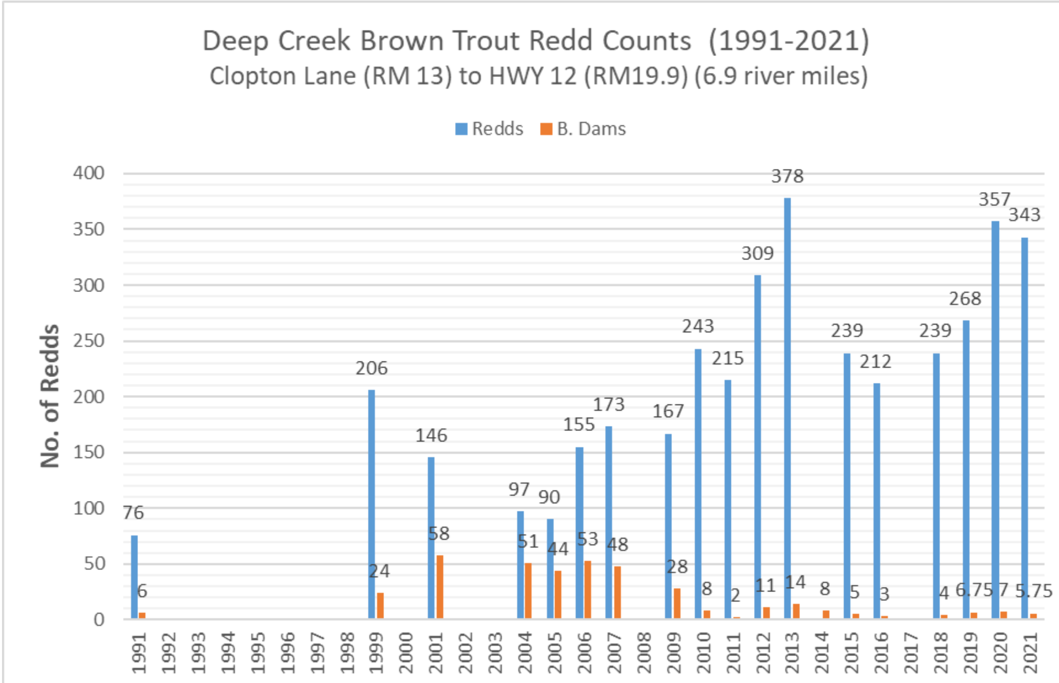


Figure 25. Brown Trout redd counts in Upper Deep Creek, 1991-2021

Brown Trout redds also increased in the middle reach of Deep Creek since 1991 (Figure 26). The approximately 350 redds in the upper reach (about 51/mile) was similar to the 40-70 redds per mile observed in the middle reach of Deep Creek in recent years. The population estimate section “Below Flynn-McArthur Diversion” is located within this reach. Also, Brown Trout spawners from the Missouri River have occasionally been observed in this reach including a radio-tagged fish during 2015 described in a previous report.

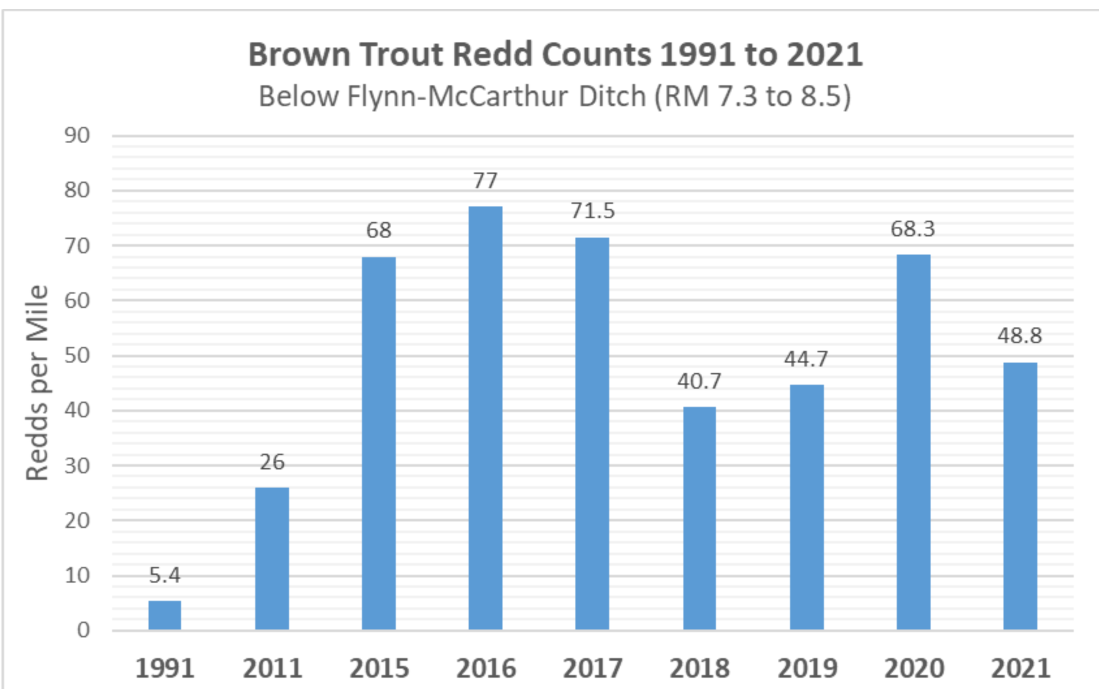


Figure 26. Brown Trout redd counts in Deep Creek (RM 7.3-8.5) below Flynn-McArthur Diversion (RM 9.5) which was retired in 2013.

The large increase in redd density near RM 8.5 (McArthur to Stocks Reach) was the most significant change in redd observations since surveys began in 1991 when only 5 redds were observed in the reach (Figure 26). After 2011, redd densities of about 40 to 77 redds per mile are similar to redd densities of the upper watershed.

Juvenile Trout CPUE Surveys

One pass electrofishing surveys after the irrigation season (October/November) were used to provide an index of trout survival in 11 spawning tributaries of the Upper Missouri River, including three sections at Deep Creek. This sampling provides only general information on young-of-the-year (YOY) survival during the first year of rearing.

The average catch per minute of YOY Rainbow Trout and Brown Trout during 2015-2021 in three sections of Deep Creek show a general pattern of higher abundance in upper reaches of the Deep Creek (Figure 27). The healthier reaches of tributary streams in upper reaches, and the associated higher fish abundance, is a common occurrence for many trout streams in Southwest Montana. Conversely, decreased streamflow and increased streambed sediment in lower reaches frequently reduce juvenile trout abundance, which was observed at Deep Creek in recent years.

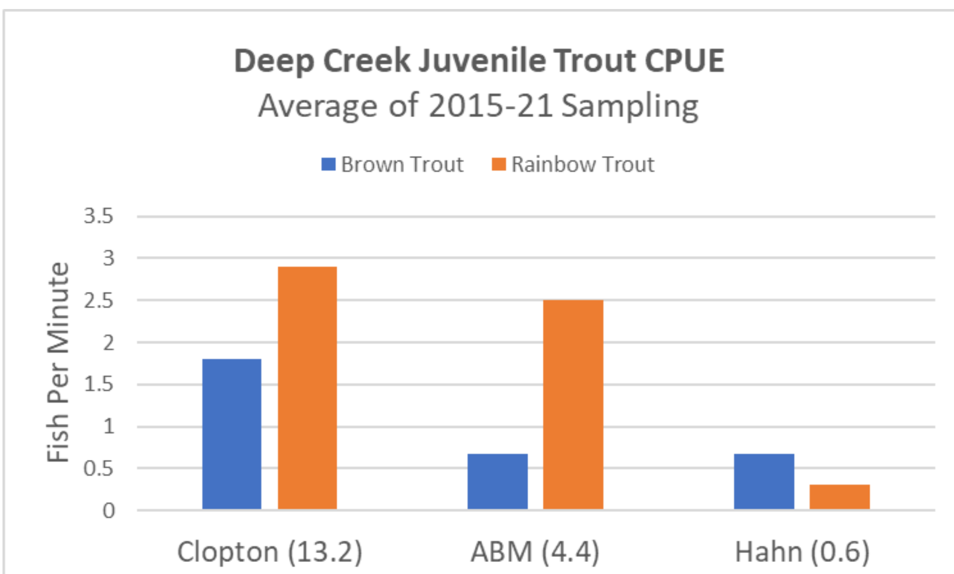


Figure 27. Deep Creek CPUE sampling for juvenile trout in three sections of Deep Creek (Clopton Lane – RM 13.2; Above BM Canal – RM 4.4; Hahn (RM 0.6).

Rotary Screw Trap

Outmigration or downstream movement of fish was monitored 12 years from 2003 to 2022 at Deep Creek during the spring period (April-July) when flow was adequate to operate the rotary screw trap. The trap was located at (RM 0.6) near the confluence with the Missouri River (Figure 28). Sampling includes 4 years prior to recent irrigation infrastructure projects (2003-2008) and 8 years after projects were completed. In addition to streamflow improvements (displayed in the streamflow section of the report), the projects removed 2 major open ditches (Flynn-McArthur Ditch and the Hahn-Price-Scofield Ditch), which entrained trout.

Figure 28. Rotary screw trap used to monitor fish outmigration from Deep Creek.

Total trout capture at the trap was relatively low during all years and the supply of juvenile trout to the Missouri River was less than expected. However, trapping results during the past three years indicate that production of juvenile rainbow trout has increased in Deep Creek recently (Figure 29). The increased capture of juvenile rainbow trout (2020-22) coincides with a reduced occurrence of observed whirling disease deformities (Figure 30). It is not known if the apparent increase in Rainbow Trout catch is due to changes in habitat, disease status, or other factors, but the occurrence of head deformities due to Whirling Disease declining to less than 5 % for three consecutive years may be important.

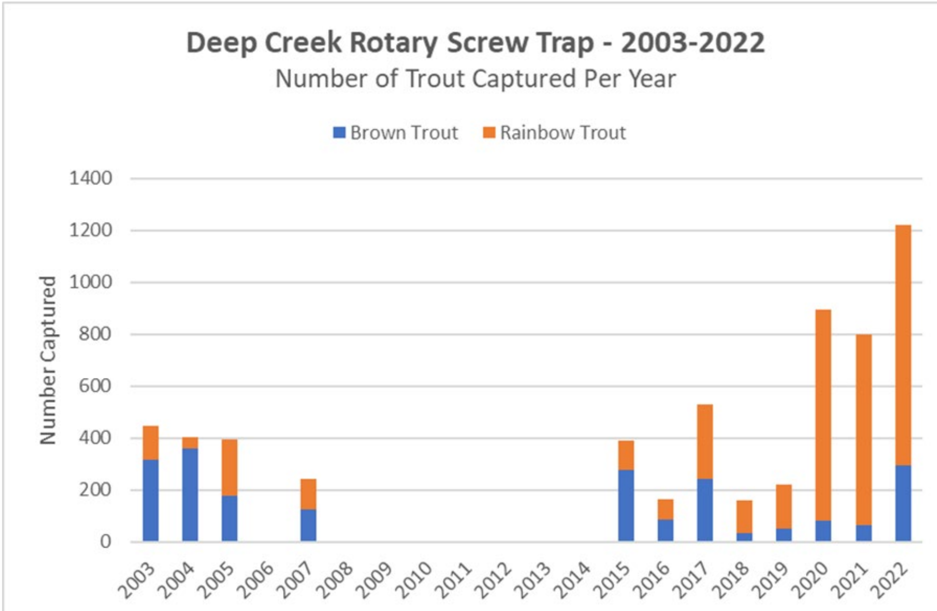


Figure 29. Trout capture at the Deep Creek rotary screw trap from 2003-22.

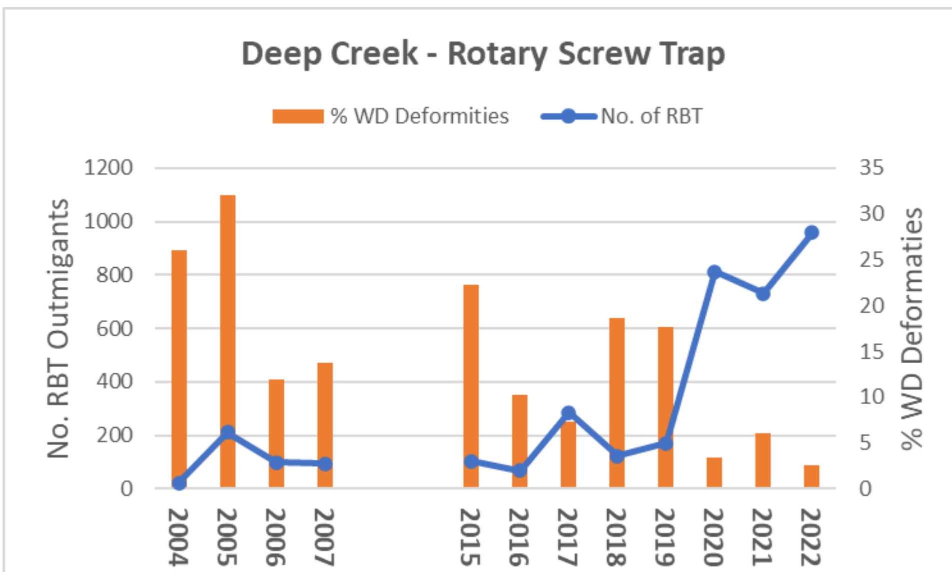


Figure 30. Percentage of rainbow trout with head deformities at the Deep Creek rotary screw trap compared to number captured from 2004-2022.

Age of trout captured at the screw trap was approximated by size distribution. The most common age of Rainbow Trout captured was Age I and Age II (Figure 31). Age 0 and I Brown Trout were the most common ages captured during the April-July sample.

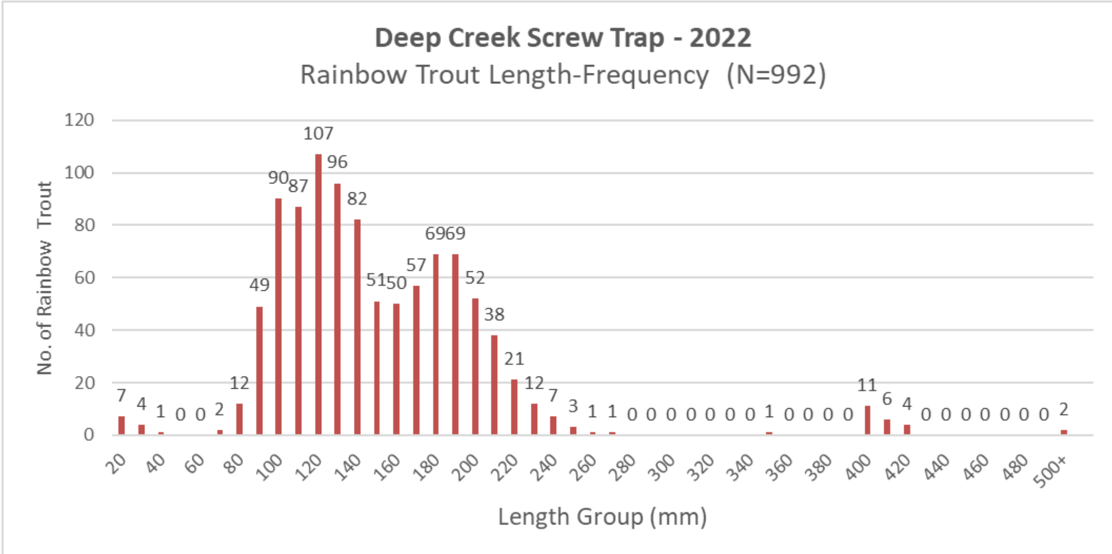


Figure 31. Length-frequency of Rainbow Trout (TOP) and Brown Trout (BOTTOM) captured at the Deep Creek screw trap during 2022.

Screw trap operation in Deep Creek was only possible during relatively high spring flow conditions (approximately April through June), which generally coincides with timing of peak trout emigration from tributaries to mainstem systems (Stauffer 1972; Erman and Leidy 1975). The estimation of trout emigration using the screw trap method depends on accurate trap efficiency assessments. Marking captured trout and releasing fish upstream from the trap to determine recapture rates was the primary method for calculating capture efficiency. In general, recapture rates for trout during multiple years of trapping data ranged from as low as 10% to approximately 30% depending on streamflow level and turbidity.

Screw trap data from 2003 to 2007 indicated that about 1000 to 3000 trout migrated downstream to the Missouri River during spring run-off (Table 4). More recent sampling using the screw trap (2015-22) did not show a significant difference in the number of Brown Trout migrating to the Missouri River, but the total estimated number of Rainbow Trout increased in recent years and ranged from about 2500 to almost 10,000 fish per year.

Table 4. Estimated Number of trout emigrating from Deep Creek from 2003 to 2022

	# Brown Trout Captured	# Rainbow Trout Captured	Est. Number Brown Trout*	Est. Number Rainbow Trout*
2003 *4/4 to 6/26* *40 trap nights*	317	129	1057 to 3170	430 to 1290
2004 *5/28 to 7/6* *36 trap nights*	360	45	1080 to 3600	135 to 450
2005 *5/18 to 7/5* *45 trap nights*	176	218	528 to 1760	654 to 2180
2007 *4/24 to 7/3* *31 trap nights*	123	120	410 to 1230	400 to 1200
2015 *4/2 to 6/22* *48 trap nights*	276	116	920 to 2760	387 to 1160
2016 *5/5 to 6/24* *35 trap nights*	88	78	293 to 880**	260 to 780**
2017 *3/24 to 7/3* *55 Trap Nights*	241	287	803 to 2410	957 to 2870
2018 *4/20 to 7/20* *29 trap nights*	36	123	120 to 360	410 to 1230
2019 *4/10 to 7/18* *52 trap nights*	51	170	169 to 510	566 to 1700
2020 *4/16 to 7/20* *69 trap nights*	80	813	263 to 740	2707 to 7810
2021 *4/8 to 6/23* *57 trap nights*	63	734	210 to 630	2447 to 7340
2022 *5/10 to 7/11* *54 trap nights*	305	968	1017 to 3050	3227 to 9680

**Estimate based on 10% to 30% range of trapping efficiency*

*** Low trapping efficiency due to low water velocity at trap site.*

In addtion to trout emigration, a variey of other species were captured at the Deep Creek screw trap (Table 6). Some species, such as stonecat are known to venture into lower Deep Creek during spawning and are captured in the trap despite not residing in Deep Creek. In recent years, walleye resident to Canyon Ferry Lake were found in lower Deep Creek presumably due to the reliable forage supply since no sexually mature fish have been observed.

Table 5. Total catch of fish species at Deep Creek rotary screw trap from 2003 to 2022.

	NUMBER CAPTURED											
	LL	**RB**	**RB PS***	**LND**	**SU**	**FH**	**SCU**	**MWF**	**SCAT**	**EBT**	**WE**	**MISC.**
2003 *4/4 to 6/26* *40 trap nights*	**317**	**129**	**26**	**774**	**257**	**216**	**14**	**194**	**1**	**0**	**0**	YP LING UT CHUB
2004 *5/28 to 7/6* *36 trap nights*	**360**	**45**		**2125**	**297**	**48**	**2**	**4**	**0**	**0**	**0**	
2005 *5/18 to 7/5* *45 trap nights*	**176**	**218**	**5**	**343**	**268**	**145**	**0**	**35**	**0**	**2**	**0**	
2006												
2007 *4/24 to 7/3* *31 trap nights*	**123**	**120**	**6**	**377**	**183**	**735**	**7**	**15**	**5**	**0**	**0**	
2015 *4/2 to 6/22* *48 trap nights*	**276**	**116**	**14**	**1145**	**812**	**342**	**28**	**1408**	**38**	**0**	**0**	CARP
2016 *5/5 to 6/24* *35 trap nights*	**88**	**78**	**5**	**542**	**245**	**319**	**6**	**7**	**45**	**0**	**0**	
2017 *3/24 to 7/3* *55 Trap Nights*	**241**	**287**	**16**	**795**	**540**	**289**	**8**	**17**	**118**	**1**	**0**	
2018 *4/20 to 7/20* *29 trap nights*	**36**	**123**	**9**	**307**	**80**	**36**	**4**	**16**	**172**	**0**	**0**	1 CARP
2019 *4/10 to 7/19* *53 trap nights*	**51**	**170**	**8**	**955**	**268**	**1266**	**15**	**79**	**64**	**1**	**1**	
2020 *4/16 to 7/20* *69 trap nights*	**80**	**813**	**10**	**3751**	**1254**	**1249**	**26**	**388**	**80**	**4**	**1**	1 Carp 1 WCT 1 RS Shiner
2021 *4/8 to 6/23* *57 trap nights*	**63**	**734**	**11**	**1284**	**774**	**58**	**33**	**97**	**60**	**5**	**0**	1 WCT 1 RS Shiner
2022 *5/10 to 7/11* *54 trap nights*	**305**	**968**	**24**	**2744**	**1180**	**278**	**7**	**9**	**247**	**0**	**2**	1 Carp 1 WCT 9 RS Shiner
Mean Total	**176.3**	**316.8**	**12.2**	**1261.8**	**513.2**	**415.1**	**12.5**	**189.1**	**69.2**	**1.1**	**0.3**	

*post spawn adults

Species include: LL-Brown Trout; RB-Rainbow Trout; LND-Longnose Dace; SU-Sucker Spp.; FH-Fathead Minnow; SCU-Sculpin; MWF-Mountain Whitefish; SCAT-Stonecat; EBT-Brook Trout; WCT-Cutthroat Trout; WE-Walleye; YP-Yellow Perch; RS-Redside Shiner.

Conclusions and Recommendations

When Deep Creek was selected to implement fisheries mitigation due to impacts from Broadwater Power Project, it functioned as more of a waterway than a natural stream. It was cut-off from the Missouri River by Montana Ditch. Each spring, Broadwater Canal dumped its sediment load into Deep Creek during start-up. Water users took the last drop during dry summers. When the costly siphon was installed with mitigation funds in 1991 to restore natural flow and fish past Montana Ditch near the Missouri River, the easy part was done. Attention turned to making it a stream worthy of a large investment after a FERC Director and others suggested the stream needed help. This report evaluates monitoring data from 2017-22, and perhaps more importantly, attempts to put the past 30 years of activities in context. The stream is clearly healthier compared to the 1990's and future work should include maintaining and renewing many of the past activities and agreements.

Restoration and enhancement efforts at Deep Creek have significantly improved aquatic habitat (especially streamflow) in the tributary. Fishery response to recent restoration efforts are mixed with Brown Trout redd counts showing increases, resident fish abundance stable, and migration to the Missouri River improved only for Rainbow Trout. The past and current goals of fishery mitigation have been to provide a significant sources of trout recruitment to the Missouri River below the Broadwater Hydroelectric Project, and the future FERC license should maintain this focus.

Reconnecting Deep Creek to the Missouri River through the Deep Creek Siphon installation in 1991 began the collaborative efforts of various partners and landowners to improve function in Deep Creek. These efforts have resulted in numerous other projects improving riparian habitat, streamflow, water temperature, and water quality. Past streamflow monitoring in 2012-16 showed gains in flow would not likely persist without some level of legal protection of instream flow. In 2022, FWP and DNRC-SWPB implemented the first year of a 10-year water lease that provided over 4 cfs of streamflow at a critical location. Continued monitoring of the fish/flow relationship will direct future managers on how to proceed before the current water lease expires in 9 years.

The 2012-2016 evaluation of the Deep Creek fishery and a variety of stream habitat variables (streamflow, water temperature, streambed sediment, riparian health) document an improving trend. Over $2 million dollars of non-mitigation funding was expended during this time period, including a significant investment by private landowners/water users.

Together, these projects resulted in measurable improvements to several key indicators of stream health:

- Summer streamflow increased by at least 3 cfs in dewatered reaches.
- Water temperature in Deep Creek was moderated by improved streamflow.
- Streambed sediment decreased to the degree that DEQ delisted fine sediment as a water quality impairment to the stream.
- Brown Trout redd counts in the lower 20 miles of Deep Creek increased significantly since 1991 when work began.

The project partners working on aquatic health conditions in Deep Creek included landowners, Broadwater-Missouri Water Users Association, Broadwater Conservation District, Natural Resource Conservation Service, The Deep Creek Landowner Advisory Committee, DNRC Conservation District Bureau, and the Department of Environmental Quality and Environmental Protection Agency via the 319 program. In 2022, DNRC's commitment of the remaining mitigation funding ($54,000) and providing a pathway to legally protect Deep Creek water, helped protect flow improvements at Deep Creek for the long term.

FWP recommends the following actions:

1) The licensee and FWP should continue to focus evaluation efforts on aquatic health of Deep Creek for the remainder of the current FERC license. Fishery response to changes in streamflow and other factors should continue to be monitored at Deep Creek at a reduced level to be determined by all involved parties.
2) Future fisheries mitigation related to the Broadwater Power Project should continue to focus on tributary stream restoration. Experience from the Deep Creek project indicate that tangible products and results can be achieved at tributary streams.
3) Costs of continuing Deep Creek restoration activities (Water replacement from BM Canal for the water lease, Water Commissioner, Streamflow Gauging, etc.) should eventually be absorbed by future fisheries mitigation funds and current FWP costs on these items should be gradually reduced.
4) In addition to maintaining the current Deep Creek water and habitat projects into the future FERC license, issues related to the "Spill Ditch" should be a future priority for fisheries and streamflow improvement. This diversion from Deep Creek into the BM Canal (via the Spill Ditch) to serve water users located north of Deep Creek has been proven to be unnecessary based on lack of operation for decades. The renewed use of this open ditch when streamflow improved in recent years restricts upstream movement of fish, entrains downstream fish migrants, and impacts streamflow in lower Deep Creek. Reducing/eliminating the impacts of the Spill Ditch in a way that is positive/neutral for water users should be a mitigation priority.

Appendix A (Methods)

Sampling Frequency - The Watershed Restoration Plan (WRP) contains a proposed short-term and long-term monitoring schedule, which was used to formulate duration goals for this monitoring plan. Table 1A below lists these duration goals as well as the sampling frequency for each parameter. Data collection began in 2015. Some parameters will cease to be monitored in 2020, but flow and temperature will be collected until 2025 at designated priority sites.

Table 1A: List of the sampling frequency and duration goal for each monitoring parameter

Monitoring Parameter	Sampling Frequency and Duration
Flow	Weather permitting, current meter discharge measurements will be made once a month and on an annual basis from April through November. Continuous stage recorders will be activated in April. Duration goal: Discharge data will be collected for the next 10 years, at a minimum of 3 priority sampling sites (Hahns, Above BM, Clopton)
Temperature	Hobo data loggers will be activated annually between April-June, when conditions allow. Duration goal: Temperature data will be collected for the next 10 years, at a minimum of 3 sampling sites (Hahns, Above BM, Clopton)
Cross-sections	Sites will be resurveyed on a rotating basis over the next 5-10 years, as needed to evaluate channel changes Duration goal: Conducted annually for the next 5-10 years; minimum of 5 years
Photopoints	Established photopoints will be documented once annually in conjunction with cross-section surveys Duration goal: Conducted annually for the next 5-10 years; minimum of 5 years
Fish counts	Each of the 3 fish counts (redds, juvenile, out-migrant, resident trout) will be completed at least 2x over the span of 5 years Duration goal: Conducted periodically over the next 5 years
Redd/Beaver dam counts	This assessment will be conducted annually in November Duration goal: Conducted annually over the next 5 years
Macroinvertebrate sampling	At least one macroinvertebrate assessment will be conducted, in conjunction with 2019 DEQ assessment. Duration goal: Conducted once in the next 5 years

Sampling Methods - The WRP proposes the use of several monitoring parameters to evaluate the success of this project and determine if targets are being achieved. Both this guidance and past monitoring efforts were used to determine the monitoring goals and methods described in this SAP. Note: not all of the parameters suggested in Element 9 will be monitored in this study, as the project team has determined that they would not provide relevant data for addressing the goals and objectives of this plan.

The methods for collecting data on each parameter are briefly described below. Refer to the SOP for in-depth guidance and direction for data collection methods of each.

Flow **-** Each of the nine flow monitoring sites have established bank pins that serve as the permanent location for current meter flow measurements. Manual flow measurements will be collected at these sites once a month during the field season. Continuous staff gauge recorders will be activated in April. A stage discharge rating curve will be created using continuous staff gauge measurements and flow data to obtain an estimation of overall flow at these sites.

Temperature – Hobo continuous temperature recorders will be installed and activated every year after high flow season. These will allow temperatures to be captured at these sites during lower flows in summer and fall. The loggers will be set to collect data every half hour during the deployment so they are likely to represent maximum and minimum daily temperatures accurately.

Cross-sections – At some point in 2019 - 2020, project partners will attempt to acquire another LiDAR flight of Deep Creek. Upon receiving this data, channel evolution changes will be analyzed by comparing 2014 to 2019/20 aerial imagery. Additionally, cross-section surveys will be conducted at 23 cross-section sites periodically over the next five years to provide *supplemental ground-truthing*. BCD may also calculate channel entrenchment and width/depth ratios, as able. Cross-section assessments will be conducted according to MT DEQ's Water Quality Planning Bureau's Field Procedures Manual.

Photopoints – Photographs at cross-section sites will be taken once a year in late summer/early fall. Shots will include upstream, downstream, and cross-sections views.

Fish counts – A 5-foot diameter rotary screw trap will be installed at the Hahn's Overflow site to capture an out-migrant trout estimate in Deep Creek. An electrofishing backpack unit will be used to complete both the juvenile and resident trout population estimate fish counts. See appendix 5 for a thorough explanation of the methods that will be used to complete these fish counts and a justification for their use.

Macroinvertebrate sampling – MDEQ will conduct macroinvertebrate data collection in 2019 following accepted agency methodology for beneficial use assessment. BCD and/or FWP partners will conduct an EPA Rapid Bioassessment Protocol (RBP) following methodology used in the 1997 and 2003 macroinvertebrate assessments on Deep Creek (Hydrotech, 2004). This rapid assessment will be done at the same time and place as the MDEQ data collection to serve two purposes: comparison to past data and comparison to future data. RBP will allow for interpretation of 2019 conditions in the context of 1997 and 2003 conditions but also to acknowledge that the more rigorous DEQ methods will likely be collected more consistently moving forward. Overlap in data collection at the same place and time will allow for qualitative comparison of the results from the two methods.

Beaver dam and redd counts – The number of beaver dams and redds will be assessed from Clopton Lane bridge to Highway 12 bridge annually in November. This will be done by simply walking the stream and recording the numbers observed.

Riparian revegetation assessment – Immediately following revegetation projects, the location of the revegetated areas will be identified and recorded with a GPS unit and sample plots will be selected at random to account for 20% of the entire planting area. After the end of at least one growing season the sites will be revisited, and percent woody vegetation survival will be determined via a stem count in all sample plots. Existing woody percentages will be compared to *performance targets* (SAP, Kreiner), and if these targets aren't met additional action will be taken to address revegetation concerns. Additionally, permanent photopoints of sample plots will be established and photos of the entire planting area will be taken.

Sediment reduction estimation methods – The amount of sediment prevented from moving downstream will be estimated at specific WRP project locations. This includes the reach 8 channel restoration project, riparian fencing, off-site water tank placement, and revegetation projects. An explanation of how sediment load reduction will be estimated for the reach 8 channel restoration project is provided in the appendix section (Appendix 6). The amount of sediment saved from implementing the latter three riparian-specific projects will be estimated using NRCS RUSLE2 modeling.

MDEQ Sediment reductions estimates – Sediment load reductions estimates may be performed by DEQ on an as-needed basis.

Sampling Equipment - For a complete list of all materials and equipment to be used in this study, refer to Sampling Methods sections SOP. Table 2A provides a list of technical equipment that will be used to carry out monitoring.

Table 2A: List of technical equipment

Monitoring Parameter	Technical Equipment
Flow	Flow meters: MarshMcBirney Flo-mate 2000 and Hach FH950
	Continuous flow recorders: Float chart recorder (2), Bubbler chart recorder (1), Tru Track water level recorder (5)
Temperature	Hobo Temp Pro v2 data loggers (5)
Fish counts	5-meter rotary screw trap and Smith-Root Backpack Electrofishing unit
Photopoints	GPS enabled camera (model TBD; still needs to be purchased)

More Detailed plans and procedures can be found in the following documents:

Deep Creek Watershed Sampling and Analysis Plan, 2015, Holly Kreiner.

Deep Creek Standard Operating Procedures, 2015, Holly Kreiner.

Deep Creek Watershed Restoration Plan, 2014, Denise Thompson and Ron Spoon.

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