Broadwater Conservation District

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Deep Creek
Watershed Restoration Plan

TEAMWORK MAKES THE STREAM WORK

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- Broadwater County

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LIST OF ACRONYMS

AFO – Animal Feeding Operation

BCD – Broadwater Conservation District

B-M Canal – Broadwater-Missouri Canal

BMP – Best Management Practices

BSWC – Big Sky Watershed Corps

CFS – Cubic feet per second

CMZ – Channel Migration Zone

CWMP – Cooperative Weed Management Plan

DEQ – Montana Department of Environmental Quality

DNRC – Montana Department of Natural Resources and Conservation

EPA – Environmental Protection Agency

EQIP – NRCS Environmental Quality Incentives Program

FEMA - Federal Emergency Management Agency

FWP – Montana Fish, Wildlife, and Parks

LAG – Deep Creek Landowner Advisory Group

MDT – Montana Department of Transportation

MWCC – Montana Watershed Coordination Council

NPS – Nonpoint Source Pollution

NRCS – U.S. Natural Resources and Conservation Service

NWQI – National Water Quality Initiative

RM – River Mile

TMDL – Total Maximum Daily Load

TSS – Total Suspended Solids

USFS – U.S. Forest Service

WRP – Watershed Restoration Plan

EXECUTIVE SUMMARY

The Deep Creek Watershed Restoration Plan (WRP) provides management recommendations for Deep Creek to address problems with high sediment loading, elevated water temperature, and low summer streamflow. Deep Creek has been the focus of watershed restoration for over 20 years. The intent of this current WRP is to offer a restoration framework that incorporates lessons learned from past activities to help direct cost-effective long term solutions to benefit the health of the stream and for landowners living adjacent to this dynamic waterway.

Two comprehensive assessments were conducted in recent years (Skidmore and Boyd, 2013; NRCS, 2013). Data from both assessments were used to prepare this WRP and provide baseline conditions for future monitoring. In addition to recommending a new approach to address erosion impacts in the lower watershed (primarily private land), the WRP also attempts to improve understanding of the upper watershed (primarily public land).

The Deep Creek Landowner Advisory Group and numerous agency personnel endorse the use of a common sense approach to protecting landowner interests and enhancing the natural function of Deep Creek. The WRP recommends the following management activities:

1. **Delineate a management corridor**. A management corridor, within which voluntary land use practices minimize constraints and impacts to natural stream processes, will increase long-term benefits and reduce costs associated with property interests and protection.

2. **Concentrate infrastructure**. Concentration of infrastructure (e.g. crossings, utilities, diversions, and pumps) at select and limited locations within the stream corridor reduces costs of maintenance and reduces the constraints on natural processes.

3. **Allow natural adjustment following flood**. Natural dynamic channel processes are more pronounced for a number of years following flood disturbance as the stream adjusts and stabilizes. Specific management actions are more likely to be successful if they are designed and conducted after the stream channel has had opportunity to adjust.

4. **Use geologic context to guide management actions**. Watershed and geologic factors influence stream processes and should guide the selection of management actions.

5. **Gather hydrologic data and establish best management practices (BMPs) for contributing watershed**. BMPs for the contributing watershed should be integrated in management plans for the Deep Creek corridor.

6. **Improve efficiency of irrigation water diversion**. Whenever possible, look for opportunities to provide irrigation water with improved efficiency and enhance summer streamflow using “salvaged” water.

7. **Develop a long term strategy for noxious weed management**. Attempt to integrate weed management efforts throughout the entire watershed on public and private lands.

CHAPTER 1. Introduction and Background

This WRP represents an evolution of stream management practices spanning over two decades. During the early 1990s, methods to manage streams with high sediment loading generally involved intensive channel treatments and bank stabilization. A Total Maximum Daily Load (TMDL) document was completed for the lower Deep Creek watershed in 1996 by the Montana Department of Environmental Quality (DEQ) and TMDL implementation occurred between 1997 and 2003. Implementation focused on treating over 100,000 square feet of eroding bank using relatively soft practices (sloping, revegetation, and juniper revetments). Concurrently, several miles of riparian fence were installed to manage grazing and assist revegetation efforts.

Landowners along Deep Creek, and many other streams in Montana, have a justifiable expectation that they need to protect their infrastructure (houses, out-buildings, roads, fences, crop lands, and irrigation structures). Finding the balance between protecting infrastructure and providing adequate room for streams to naturally migrate is the primary challenge for landowners and agency professionals in developing and implementing long-term restoration plans.

After 15 years of observation and monitoring, a significant flood event in 2011 that damaged several bank stabilization structures and undermined riparian fences at dozens of locations, and two recent assessments of the lower watershed, landowners and agency professionals view the stream corridor differently. Rather than proposing extensive repair of unstable stream banks and reconstructing existing riparian fences, this plan recommends remedies that recognize the need for natural streams to migrate within the floodplain.

Following the 2011 flood event, private landowners, Broadwater Conservation District, Broadwater County, USDA Natural Resource Conservation Service (NRCS), Montana Department of Natural Resources and Conservation (DNRC), DEQ, Montana Fish, Wildlife and Parks (FWP), Montana Department of Transportation (MDT), and the Helena National Forest, came together to supply funding and manpower for a renewed Deep Creek restoration effort.

In 2011, NRCS and a local working group identified Deep Creek as a Priority One Watershed, thus beginning an effective, coordinated approach to addressing watershed and water quality concerns in Deep Creek. A geomorphic stream assessment of lower Deep Creek was conducted by Peter Skidmore and Karin Boyd in summer 2012 with the assistance of a DNRC planning grant and FWP funds, and NRCS conducted a riparian assessment of lower Deep Creek in spring 2013. Both of these assessments provided a number of general and project-specific recommendations to improve water quality and overall stream and riparian health in the watershed. These recommendations are the basis for the restoration approaches and projects proposed in this WRP. In fall 2013, Broadwater Conservation District applied to DEQ’s 319 program and received a three-year award (2014-2017) to assist in implementing a number of these recommendations. Additionally, the state NRCS office chose Deep Creek as the designated National Water Quality Initiative (NWQI) watershed for 2014-2016 (proposed timeframe). This designation will provide additional NRCS funding in the Deep Creek watershed to implement conservation practices to improve water quality.

Goals of the Deep Creek WRP are to: (1) improve water quality by addressing sediment, dewatering concerns, and temperature issues, (2) provide long-term riparian protection and habitat enhancement, (3) accommodate landowner interests and needs, (4) expand support for improving watershed health, and (5) gain further understanding of the hydrology and water quality issues in the upper watershed to prepare and develop restoration projects with partners.

Deep Creek Watershed and Geologic Setting

Deep Creek is a tributary to the Missouri River (Figure 1), with a watershed area of 87.7 square miles (DEQ, 2011). Lower Deep Creek, predominately private land, extends downstream from the mouth of a relatively confined canyon at the junction of North Fork Deep Creek west to its confluence with the Missouri River southwest of Townsend, MT, for a distance of roughly 20.7 stream miles.

Upstream of the canyon mouth is predominantly U.S. Forest Service-Helena National Forest land, though there are a number of private lands and in-holdings as well as a small section of Bureau of Land Management (BLM) land. The National Forest land consists of mixed alpine meadows and forest, with the dominant land uses being forestry, grazing, and recreation.

Figure 1. Deep Creek watershed. Project Reach refers to the TMDL implementation and recent assessment area for lower Deep Creek.

Geologic Setting (summarized from Skidmore and Boyd, 2013)

The geologic setting of a stream channel within its basin can exert subtle but inherent influences on geomorphic processes and stream character. Recognizing these influences is important in understanding channel processes and associated management implications. The Deep Creek system is characterized by four distinct geologic zones that should be considered in development of a management plan:

1. *Upper watershed, above RM 21*: The upper watershed consists primarily of hard and erosion resistant (very old) quartzite, resulting in steep and confined headwater streams that transport virtually all sediment to downstream valley reaches (Figure 2). This is referred to as a source and transport area, because sediment is derived from and transported through, but minimally stored within this area. Consequently, natural and anthropogenic sediment sources, from land use and road networks, are likely to affect water quality and stream processes in downstream reaches.

2. *Deep Creek valley, RM 14.8 to 20.9:* This segment is prone to periodic pulses of sediment derived from the upper watershed or from its own banks. This reach is characterized as a “response reach”, where the transport capacity of the stream is reduced relative to the canyon reach and the stream channel is more likely to move vertically and laterally to fluctuations in sediment supply or channel constraints (Figure 3).

3. Deep Creek valley, RM 3.7 to 14.7: The majority of the Deep Creek alluvial valley flows through mixed alluvial and colluvial terraces that can contribute high sediment loads to the channel where the channel cuts into terraces, and is bounded by conglomerate and sedimentary rocks that are also relatively more erodible. This reach is also characterized as a “response reach”, where the stream is dynamic and responsive. Generally, manipulation of the channel for property protection or infrastructure purposes (stabilization) is less likely to be sustainable in response reaches.

4. Missouri River Valley, Missouri Confluence to RM 3.7: Deep Creek flows across unbounded and low gradient Missouri River alluvial floodplain (Figure 4). Missouri River alluvium is varied but often more coarse than upstream reaches, lending some degree of stability to the stream alignment imposed on it by crossings and land use constraints. Prior to any development of the Missouri River valley, this portion of the creek would have been a dynamic and wandering response reach, but is now largely channelized and constrained. A shift to a flatter valley and channel slope where Deep Creek encounters the Missouri floodplain at the upper portion of this reach likely contributes to overbank flow and flooding between RM3 to RM5.5.

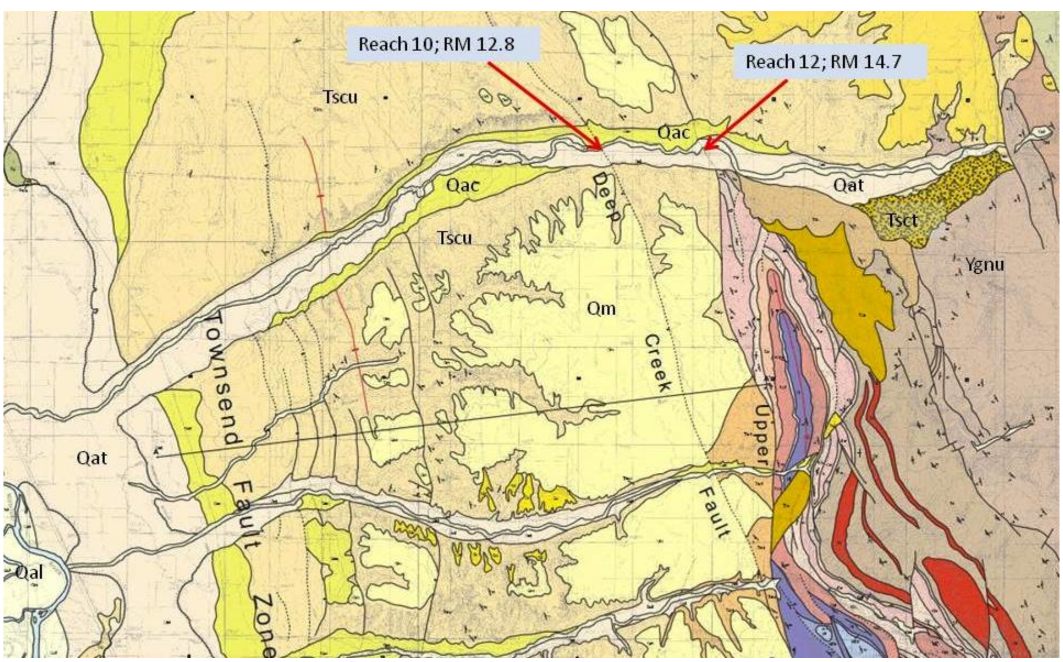
The Deep Creek valley is intersected by two faults (Figure 5). The Upper Sixmile Creek Fault (at RM14.7) has been described as a “significant fault that may be active” (Vuke, 2009). Further downstream, a second Deep Creek Fault crosses the valley at RM12.8. While these faults do not appear to be exerting significant controls on the down-valley slope of Deep Creek, the upper fault line may be subtly influencing the across-valley slope and causing a shift in channel location to the north side of the valley.

Figure 2. Eastward view of confined Deep Creek Canyon and contributing watershed.

Figure 3. Eastward view upstream (from RM 15) showing bluffs of Sixmile Creek Formation, on right.

Figure 4. View upstream along Deep Creek across Missouri River floodplain.

Figure 5. Geologic map of lower Deep Creek. The geologic units within valley bottom and stream corridor include Qal (active stream deposits), Qat (terrace), and Qac (undivided colluvium/alluvium). The mapped extent of the Qat (terrace) unit indicates downcutting in the reach and perching of the historic floodplain. The two arrows identify the faults that influence location and character of valley. (Vuke, 2009).



Land Use Setting (Skidmore and Boyd, 2013)

The natural stream corridor of Deep Creek has been impacted during the past 100 years by loss of riparian vegetation, beaver removal, upland vegetation changes, forestry management, stream channel confinement and manipulation by infrastructure, stream channelization, grazing, and irrigation withdrawals. These alterations have resulted in degradation of stream habitat, water quality, and impacts to late season water supply.

Current land use in lower Deep Creek includes primarily pivot and wheel-line irrigated pasture and cultivated agriculture, grazing, and rural residential development that is gradually encroaching on the Deep Creek valley. There are approximately 14 public and private bridges that cross lower Deep Creek. Irrigation water is taken from the stream through numerous diversions and in-stream pumps. The riparian corridor is highly variable in width and vigor and ranges from wide, thick willow bottoms to narrow cottonwood/willow corridors to segments completely denuded (Figure 6). Additionally, channelization of discontinuous segments has significantly shortened and steepened the creek's channel. The 2011 spring runoff was characterized by long duration and high magnitude flooding throughout lower Deep Creek. Bank erosion was locally severe, with significant channel migration, cutoffs (avulsions), and overbank flooding. The combination of riparian vegetation removal/loss and discontinuous channelization has greatly increased Deep Creek erosion potential.

Figure 6. Aerial view showing discontinuous conversion of riparian floodplain to agricultural land use.

Recent Stream Assessments – Lower Watershed

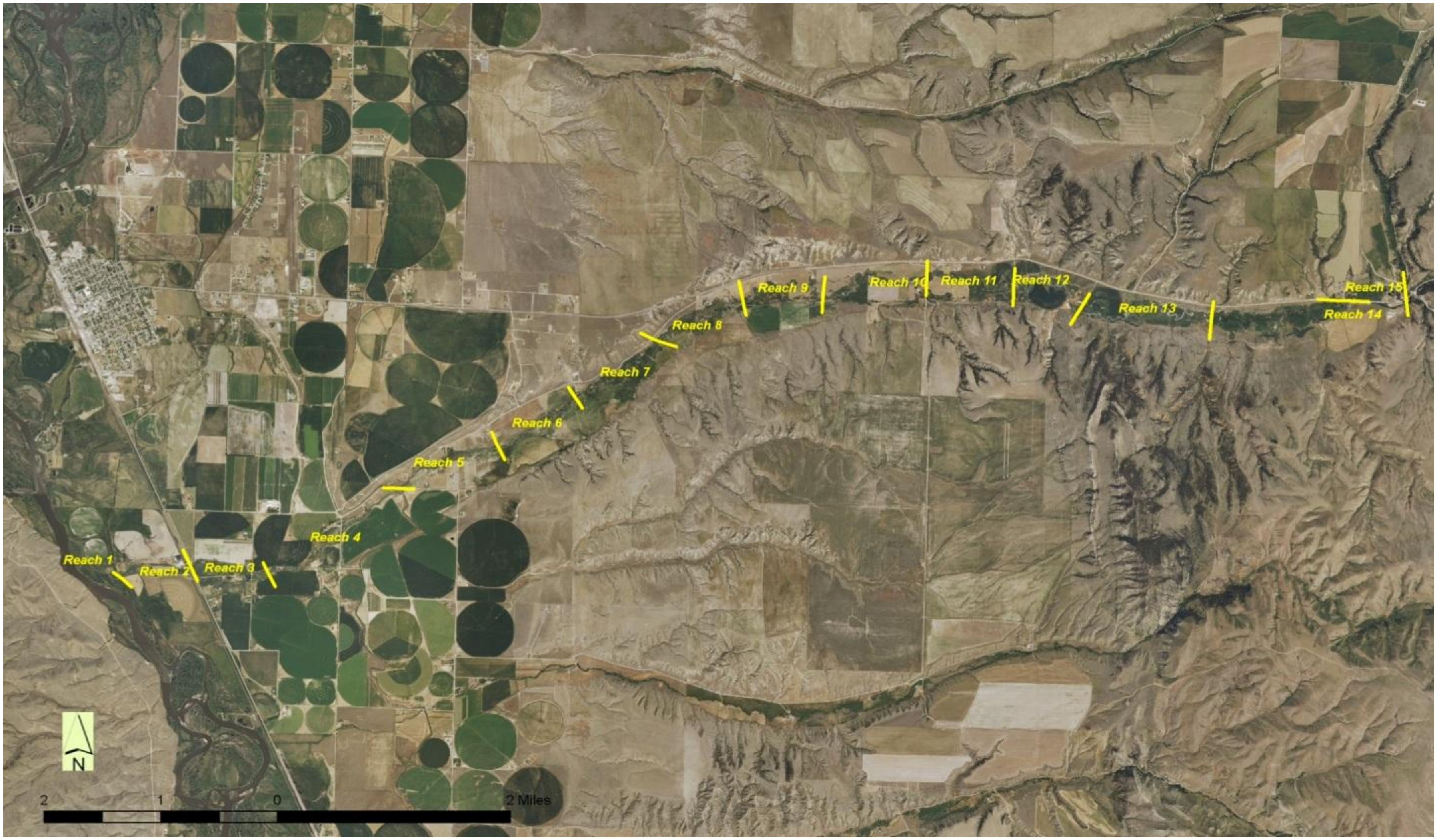
Two detailed stream assessments have recently been conducted in the TMDL study area (lower Deep Creek watershed) extending from the confluence of Deep Creek and North Fork Deep Creek at RM 20.7 to the confluence with the Missouri River at RM (0) (Skidmore and Boyd, 2013, NRCS, 2013). The lower watershed was divided into 15 reaches of similar geomorphic and land use character and were generally defined by permanent infrastructure crossings (Figure 7).

The Skidmore and Boyd (2013) assessment focused on understanding stream channel changes between 1995 and 2012. Field data and observations were integrated and evaluated using GIS. Satellite imagery and oblique air photos were also used to supplement field observations. Field data included: extent and character of bank erosion, extent and type of bank protection treatments, channel width and depth dimensions, pool depth, locations of fences at risk, site photos, and substrate size. Air photos were used to evaluate change in channel length and alignment and included imagery from 1995, 2009, 2011, and 2012. Data summaries and analysis are presented in the following sections. The NRCS (2013) assessment used more thorough riparian techniques than the Skidmore and Boyd study, and provided additional detail about current baseline conditions.

U.S. Forest Service Studies – Upper Watershed

The Helena National Forest has conducted several studies in the past decade in the upper Deep Creek watershed. These studies included hazard tree removal (Cabin Gulch study), timber, vegetation, burning, urban interface and riparian areas (Grassy Mountain Project-previously called Hay Peggy), and weeds along roads and road closures (South Belts Travel Plan). An Allotment Management Plan (decision document) was developed for the region and included 19 improvement projects.

Figure 7. Lower Deep Creek project reaches for assessment and management recommendations.



CHAPTER 2. Nine Elements for the Deep Creek Watershed Restoration Plan

Information and data displayed in Chapter 2 is intended to address the 9 major elements of a long term plan to enhance and restore water quality and the overall health of the Deep Creek Watershed. These elements include:

1. Causes and Sources of Nonpoint Source Pollution
2. Load Reductions Expected for the Management Measures to be Implemented
3. Management Measures to be Implemented to Achieve Load Reductions
4. Technical and Financial Assistance Needs
5. Public Information/Education
6. Schedule for Implementing the NPS Management Measures
7. Measurable Milestones for Implementing NPS Management Measures
8. Criteria to Determine if Pollutant Loading Reductions are Being Achieved
9. Monitoring to Evaluate Effectiveness of the Implementation Efforts

ELEMENT 1: Causes and Sources of Nonpoint Source Pollution

Sediment causes and sources are divided into two sections (1a and 1b) to represent lower and upper Deep Creek, respectively. Causes and sources of flow and temperature issues in lower Deep Creek watershed are addressed in 1c.

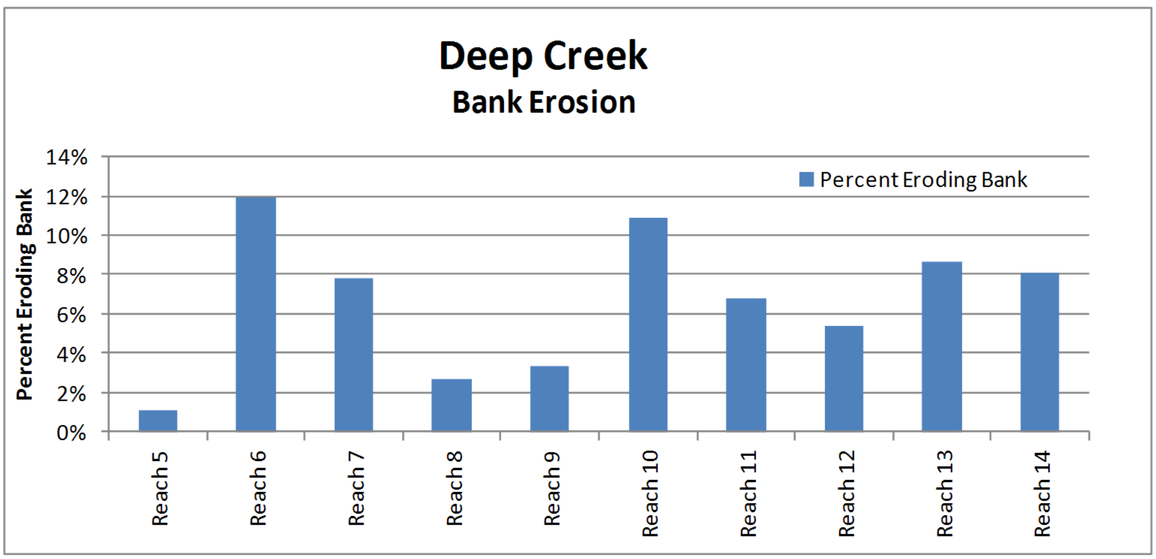
ELEMENT 1a: Sediment Sources – Lower Watershed

The Deep Creek TMDL identified bank erosion as a primary source of fine sediment that was affecting fish habitat. Bank erosion surveys reported in the 1996 TMDL (1991 data) indicated that active eroding banks ranged from 4% to 20% per reach, with a reach average of 13%. (The MT DEQ Deep Creek TMDL Implementation Evaluation report (2011) indicates even higher bank erosion rates from early surveys. Because data reported in previous reports were not reported with sufficient spatial context, it is difficult to effectively compare erosion rates among reports.) The 2012 bank erosion survey completed for the Skidmore and Boyd (2013) assessment indicates that approximately 7% of all banks in Reaches 5 through 14 (RM 4.5 to RM 20) are eroding, with a range of 1% to 12% per reach (Figure 8). This suggests a significant reduction in active bank erosion has occurred since the TMDL was implemented, and that the TMDL target of <6-8% eroding banks (DEQ, 2011) has been achieved in most reaches, even after the 2011 flood event that generated considerable new bank erosion.

Eroding bank area (ft^2) also indicates a significant reduction in active bank erosion since the early 1990s. Prior to TMDL implementation in 1996-97,188,599 ft^2 of eroding bank was measured between RM 5.5 and RM 19.9. The area of eroding bank measured immediately after implementation (1998) was significantly reduced to 62,365 ft^2. Monitoring from 1998-2003 showed a moderate increase in bank erosion to 72,370 ft^2 by 2003 (Hydrotech, 2004). Erosion estimated during the 2012 survey categorized vertical, un-vegetated banks into three classes: high, moderate, and low potential to laterally migrate. When all vertical banks were included (as was done in previous surveys), an estimated 87,320 ft^2 of eroding bank was measured between RM 5.5 and RM 19.9. However, when vertical banks classed as low potential to laterally migrate or deliver sediment were omitted from the analysis, 68,565 ft^2 of bank erosion was estimated. Specific data from before and after the 2011 flood are not available; however it is assumed that the 2011 flood increased the rate of bank erosion.

Although survey methods may have differed between the 1991 and 2012 surveys and the reaches assessed are not identical, the implementation of significant juniper revetment and other bank treatments as part of the TMDL implementation has presumably contributed to a significant reduction in bank erosion. Furthermore, Skidmore and Boyd (2013) concluded that overall bank erosion measured and observed within Deep Creek is within the range of healthy and resilient dynamic stream systems in an entrenched and evolving stream channel system.

Figure 8. Bank erosion expressed as percent of bank eroding by reach, 2012 assessment.



Assessment of Bank Treatments

The 2012 field assessment also mapped the extent of existing bank treatments (Figures 9 and 10). Existing dominant bank protection types were classified as riprap, rootwad, and juniper revetments. Other less common treatment types were also mapped. Riprap has been a dominant bank protection treatment in all reaches. Juniper revetments were implemented extensively in Reaches 9 through 13. A total of approximately 11,300' of bank treatments were mapped in Reaches 5 through 14, or approximately 7% of all banks. Of the 18,500' of bank treatments installed as part of the TMDL implementation from 1999-2003 (Resource and Development Grant Application, 2011), 6,377' of *non-riprap* treatment, including 5,000' of juniper revetment, remain in place (it was assumed that all non-riprap treatments surveyed in 2012 were installed during the TMDL implementation). Because a map of previous treatments was not available, we were not able to effectively determine the fate and condition of all treatments installed in the 1990s as part of the TMDL implementation. Furthermore, many treatments have been completely washed away leaving no trace of their previous location or condition.

Assessment of bank treatments implemented as part of the TMDL is summarized in Table 1. Treatments are characterized as either “Hard” where they are intended to provide permanent constraint on channel migration and bank erosion, or “Soft” where they are intended to provide temporary or long-term protection against erosion but without permanently constraining the channel.

Figure 9. Bank treatment type and length by reach, 2012 assessment.

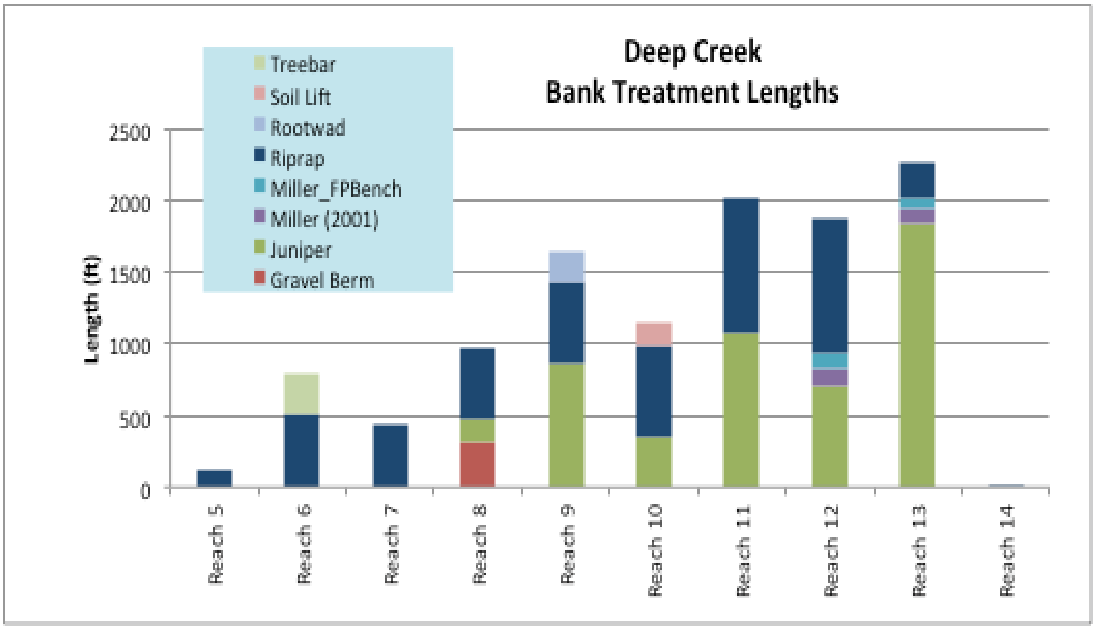


Figure 10. Bank treatment type as percent of total bank length by reach, 2012 assessment.

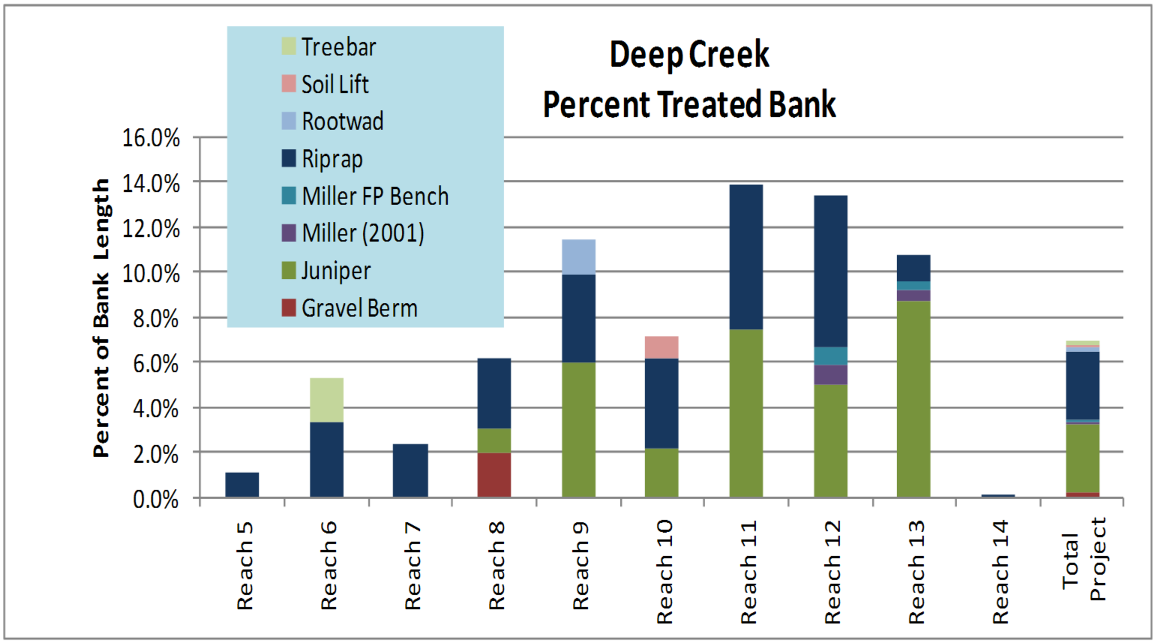


Table 1.Condition and effectiveness of bank treatments. HARD treatments are those that are intended to constrain bank migration permanently, and as a result significantly limit long-term channel health and condition; SOFT treatments are those intended to stabilize banks primarily with vegetation but allow for dynamic stream processes and habitat maintenance over time.

Treatment Type	*Length (ft)*	*Observed conditions summary*	*HARD or SOFT Treatment*	*Effectiveness summary and recommended application*
Soil Lift	161’	Reach 10 only. Poor/fair installation, fair condition, not likely to provide long-term protection as woody vegetation is absent and fabric is degrading.	HARD with rock toe; SOFT without rock toe.	Soil lifts can be very effective at stabilizing banks and can be adapted to varying objectives, but require considerable design and implementation integrity and are ultimately dependent on success of vegetation establishment. Can be installed with or without rock toe. With a rock toe considered.
Rootwad	216’	Reach 9 only. Fair, 50% gone. Fair installation but apparently not adequate to provide long term protection.	HARD	Root wads can be an effective alternative to riprap by providing the same level of protection with some potential habitat benefit. However, root wad protection requires considerable design and implementation integrity. It can be integrated with shrubby vegetation to provide some shade, but otherwise substantially limits and reduces habitat potential and important dynamic stream process.
Riprap	4,921’	Riprap is present in all reaches and in varying	HARD	Riprap can be effective at protecting banks from erosion, but requires considerable design and

		condition from Good to Poor or washed away.		implementation integrity. Riprap does not need to be installed to full bank height, though commonly is. It can be integrated with shrubby vegetation to provide some shade, but otherwise substantially limits and reduces habitat potential and important dynamic stream process.
Miller FP Bench	193’	Reaches 12 and 13. Good installation, good condition, rock remains in place and bench is well vegetated.	HARD	Floodplain benches, as implemented on Deep Creek, are an alternative to riprap that include a rock toe and bench with soil and vegetation on top. This can be an effective method to constrain the channel but provide some floodplain function, but otherwise substantially limits and reduces habitat potential within the channel and important dynamic stream processes. Floodplain benches are commonly used to move channel away from a bank that is otherwise difficult to stabilize. Though not applied as such on Deep Creek, can be an effective means to reduce migration of channel into very high terrace banks.
Miller (2001)	220’	Reaches 12 and 13. Good installation, good condition. Treatments consist of rock toe and re-sloped/re-vegetated banks.	HARD	Rock toe re-sloped streambanks, as implemented on Deep Creek, are an alternative to riprap. This can be an effective method to constrain the channel and provide some vegetation shade, but otherwise substantially limits and reduces habitat potential within the channel and important dynamic stream processes.
Juniper	4,989’	Extensive, Reaches 8-13. Variable condition from good to poor or absent.	SOFT	Juniper revetments are a low cost, low risk, and low-impact mechanism to protect the toe of an eroding bank. They can be very effective when installed with integrity, as protecting a bank toe is typically all that is necessary to stop or slow bank migration. When combined with willow installation, can be effective at stabilizing a degraded bank for long term. When failed, there is low risk to long-term impact, and jams of juniper from failed treatments can, and do, provide excellent pool and cover habitat.
Gravel Berm	314'	Reach 8 only. Fair, apparently fairly recent.	SOFT	Gravel berms are at best a temporary means to keep higher flow from leaving the channel, and only effective during lesser high flows. Gravel berms should be discouraged as they cause significant localized disturbance, typically require annual maintenance, and can contribute sediment to the stream.

Juniper revetment treatments, consisting of junipers anchored to the toe of the bank slope with or without supplemental bank re-sloping and revegetation elements, such as willow cuttings, were the dominant soft bank protection method applied (Figure 11). Revetments were typically accompanied by riparian fencing intended to control grazing impacts on revegetation and bank stabilization efforts. These revetments were variably effective at reducing bank erosion (Figure 12 and 13), though implementation and assessment data were not adequate to determine what percent remained. However, where juniper revetments failed there was typically little or no further consequence to stream habitat or condition, or to adjacent property. In some instances, failed juniper revetments washed into jams (Figure 14) and produced some of the best fish habitat observed in Deep Creek by creating local pool scour and cover (R. Spoon, 2012).

Figure 11. Concept diagram of juniper revetment with bank re-sloping and revegetation (Hydrotech, 2004).

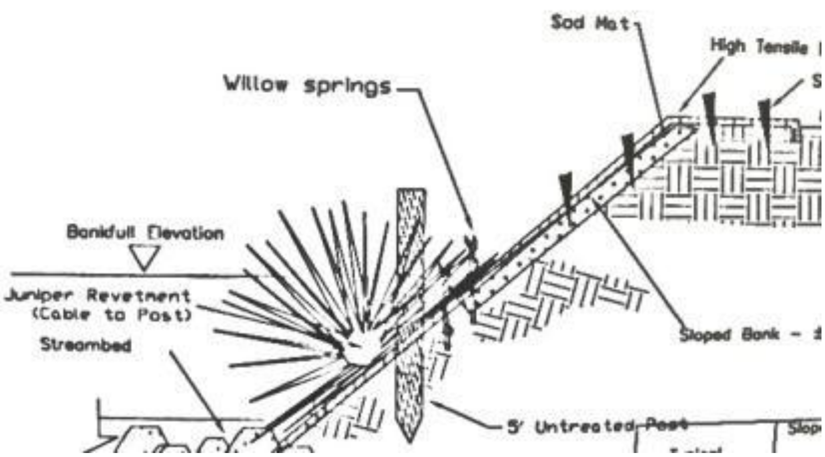


Figure 12. Juniper revetment with effective revegetation, Reach 11. (R. Spoon photo, 2012)

Figure 13. Juniper revetments have partially washed away, though they still provide some protection at the toe of the bank, Reach 13. (R. Spoon photo, 2012)

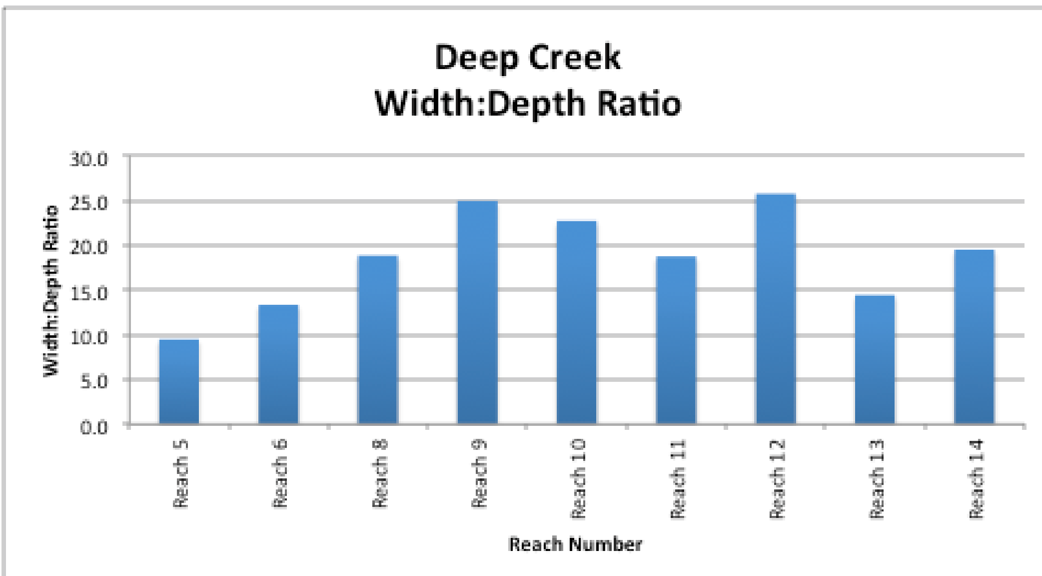
Figure 14. Debris jam of washed out junipers, Reach 13. Such jams can provide fish habitat through pool scour and cover. (R. Spoon photo, 2012)

Riparian fencing was an additional TMDL implementation strategy and was installed through much of Reaches 6-14. In 2012, FWP inventoried "fences at risk" where riparian fencing, intended to exclude or manage grazing within the riparian corridor, was observed to be failing or at risk of failing (Figure 15). Locations of fence at risk points were plotted on reach maps by Skidmore and Boyd (2013) and have been provided to Broadwater Conservation District in GIS format. The overall condition of riparian fencing was poor, and in many cases fences were sited too close to the active channel.

Figure 15. Example of fence at risk, Reach 13. (R. Spoon photo, 2012)

The hydrologic connection between a channel and its floodplain is a key measure of stream health and geomorphic stability. A ratio of channel width to channel depth (W:D) can be used to evaluate this stability. FWP measurements indicated a W:D range between about 10 and 25 (Figure 16). While the low end of this range (10) indicates moderate entrenchment, these values can be considered within the range of normal stream function in that they are typically associated with alluvial river systems with functioning hydrologic connectivity between the channel and its floodplain. Floodplain connectivity is essential for maintaining healthy riparian corridors and associated geomorphic stability and habitat benefits. The reaches with the lowest values are downstream reaches that have been confined and channelized to some extent. Generally, the channel cross-section measured to establish width and depth and W:D ratio was the inset channel cross-section, within the entrenched channel system, and so may not be indicative of a bankfull channel dimension for other analyses. However, all width and depth measures were provided by FWP field crews using a consistent approach to delineate the top of bank at all cross-sections, and so are valuable as relative measurements.

Figure 16. Average width to depth ratios by reach. (No data were collected for Reach 7).



Channel migration into sloping colluvial deposits has created a wide range of bank heights on the active channel, creating a great degree of variability with respect to channel/floodplain hydrologic connectivity. Although entrenchment measures in Reaches 8 through 14 do not indicate *channel* entrenchment within a floodplain, there is fairly consistent evidence of broader entrenchment within the valley bottom. Entrenchment within the valley occurs when the stream cuts down and widens, eventually creating an inset stream channel and floodplain at a lower elevation than historically, leaving the old floodplain surface as a terrace. This creates a narrower floodplain than historically and has considerable bearing on stream dynamics and implications for management. Entrenched stream systems typically exhibit significant reductions in natural resource benefits (Cluer and Thorne, 2013), including:

1. Loss of alluvial aquifer (floodplain) storage, leading to reduced late season flows and increased late season temperature.

2. Increased bank erosion, as an entrenched stream has higher energy than one coupled with its floodplain.

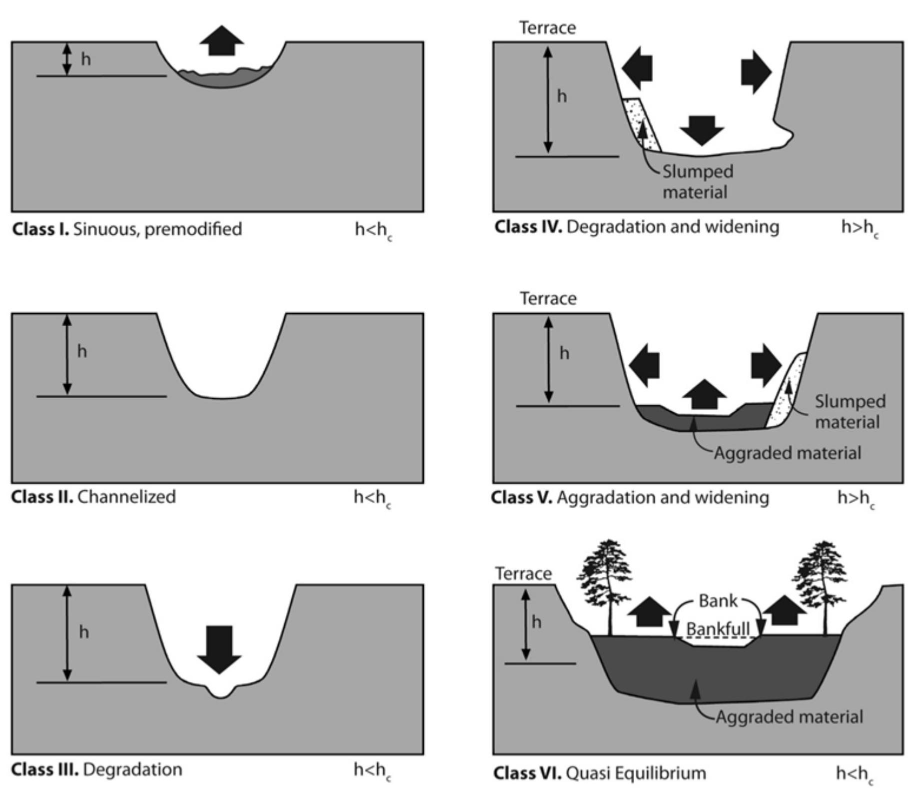
3. Reduced water quality as the natural filtering effects of floodplain have been de-coupled from the channel.

4. Significant loss of riparian habitat for birds and terrestrial wildlife.

5. Increased susceptibility to catastrophic channel migration and property loss, as an entrenched system concentrates stream power within the inset channel.

Historically, Deep Creek was likely a dynamic beaver-dominated system consisting of a series of ponds, wetlands, extensive wet riparian vegetation, and short interconnecting stream channels. Beaver removal in the 1800s and subsequent agricultural development was likely a major factor leading to the current character of Deep Creek as a largely entrenched system. Where beaver dams and wetlands historically provided grade control (maintaining the average stream bed elevation), their removal typically results in channel entrenchment and initiates a common progression of channel form. This loss of grade control has been exacerbated by removal of stabilizing willow vegetation and some channelization of some reaches which steepens a channel and further increases erosive forces and degradation. Figure 17 provides a conceptual model for typical progression of channel entrenchment as a result of loss of grade control (from beavers) or channelization. Observations and surveys indicate that lower Deep Creek is in Classes 3-5, with some reaches showing initial stages of riparian development on new, lowered floodplain surfaces (Class 5).

Figure 17. Channel evolution model following channel entrenchment (figure from Skidmore et al 2011). h = bank height, h_c = critical bank height



Evidence of both historic and ongoing channel evolution is abundant (Figures 18-20). For example, Figure 20 shows the typical widening and aggrading following downcutting (Class 5) with a higher elevation terrace, or historic floodplain, which is no longer hydrologically connected to the channel. Despite this, the terrace is supporting dense riparian vegetation, which suggests that the downcutting has occurred over the last several decades.

Figure 18. Perched headgate in lower end of Reach 8 (RM 8.9) indicating channel bed degradation and associated entrenchment. (R. Spoon photo, 2012)

Figure 19. Exposed bridge pier footer indicating channel bed degradation, Reach 10. (P. Skidmore photo, 2012)

Figure 20. Entrenched stream channel and perched historic floodplain with mature riparian vegetation, Reach 14. (R. Spoon photo, 2012)

Eroding stream banks commonly contribute coarse cobbles and boulders that contribute to inset floodplain formation. Although downcutting has perched the historic floodplain, ongoing bank migration is progressively entraining new coarse and fine sediment to form a new, hydrologically connected inset floodplain on Deep Creek. This surface tends to support predominantly willows, whereas the terrace surfaces have both mature woody riparian species and dense juniper stands. In general, however, low active floodplain margins are very limited, indicating the continued need for channel migration, floodplain development, and natural recovery of the stream corridor. It is important to note a continued input of sediments derived from channel banks to build an inset floodplain will be required for Deep Creek to continue along this channel evolution trajectory.

The upper end of Reach 8 (RM 9.3-10.2) exhibits channel aggradation and appears to be an exception to the condition of downcutting and inset floodplain development. Limited field analysis and data are not sufficient to provide explanation for aggradation in this reach. However, clay lenses which can be resistant to erosion may be providing local grade control in this reach and are observed in streambanks at the downstream end of this reach.

Channel Length Trend

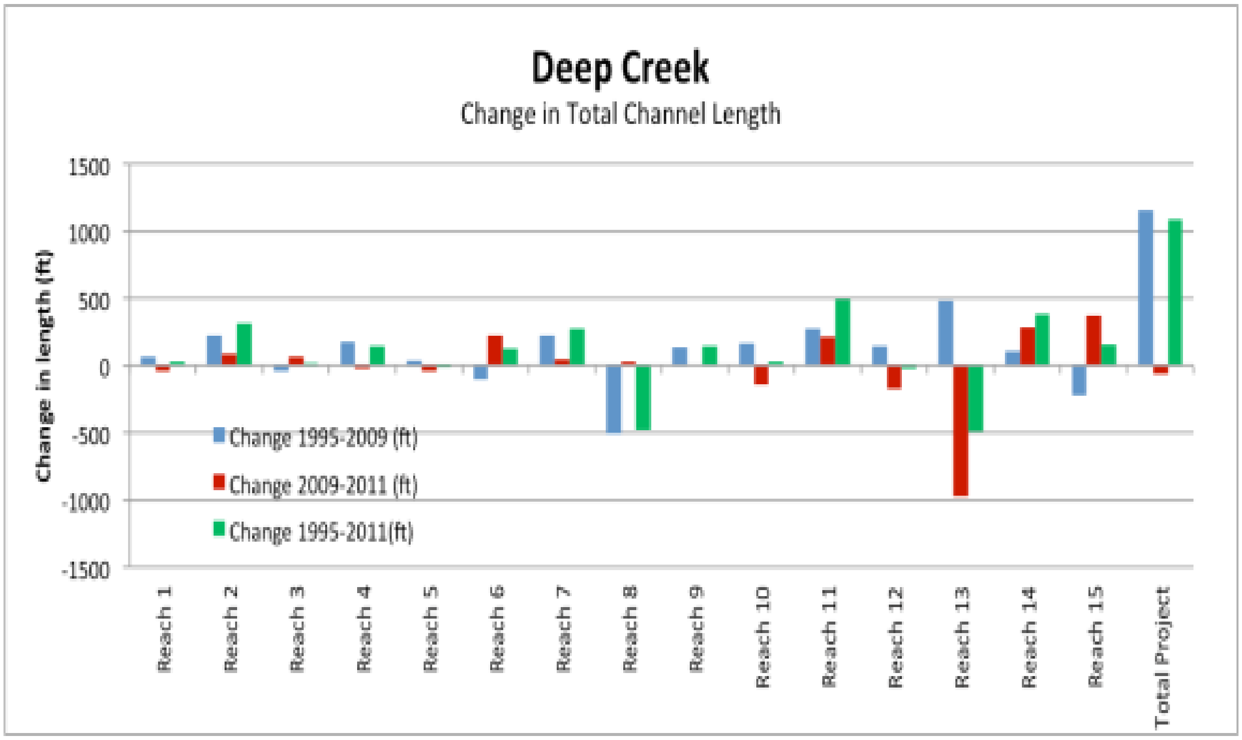
The Deep Creek TMDL states that up to 9,100’ of channel length had been lost between 1955 and 1991. Regaining some of this channel length (2,275’) was a goal of the TMDL to benefit channel condition. This is consistent with general stream dynamics science, in that channelization (straightening or leveeing) steepens a channel and concentrates stream power within the channel, leading to degradation and associated bank erosion and loss of habitat.

Using GIS, Deep Creek channel alignment was mapped from 1995, 2009, and 2011 using air photos and stream length was derived by reach. Table 2 and Figure 21 show the change in reach and overall channel length. Deep Creek has slowly gained approximately 1,100’ of total length since 1995. However, there were dramatic reach-scale losses in channel length that occurred during the 2011 flood when some meander bends were cutoff. This length will likely be restored through natural processes, if not constrained by bank revetments. If the significant loss of length in Reach 13 is regained, the TMDL goal of 2,275' will likely be reached. However, it is important to note that the majority of channelization and shortening has occurred in the lower reaches (1-6), and most gains in channel length have occurred further upstream (Reaches 9-11, 14-15).

Table 2. Changes in channel length (ft) between three sets of aerial photo years (1995, 2009, and 2011).

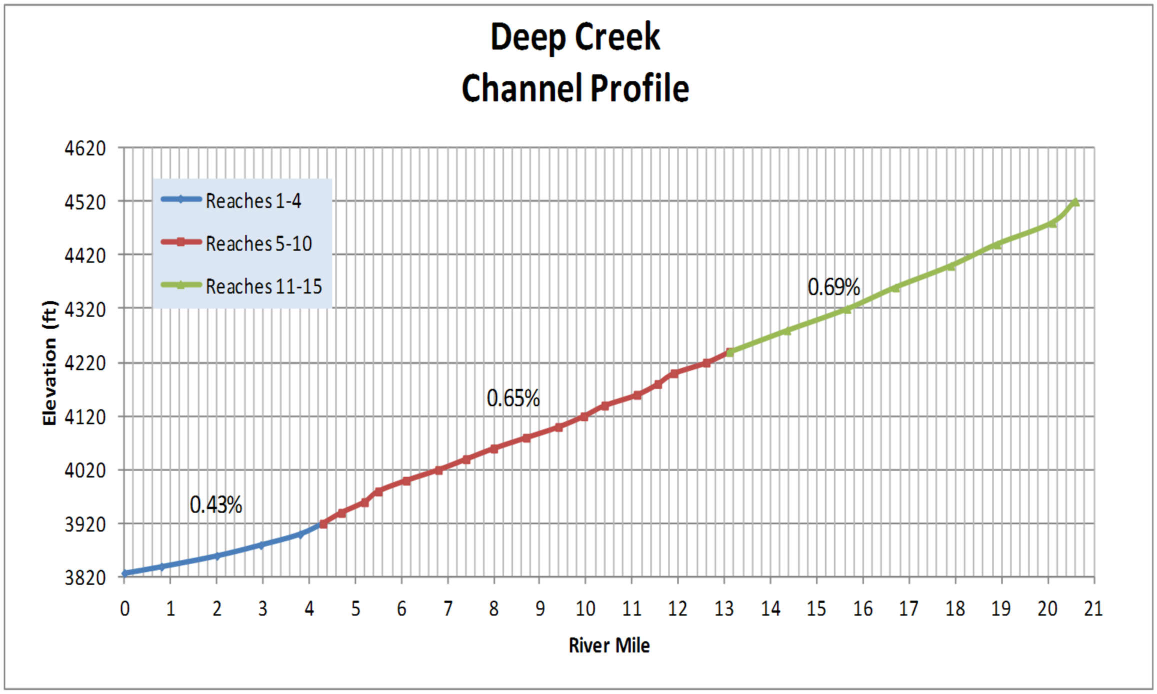
	Change 1995-2009 (ft)	***Change 2009-2011 (ft)***	***Change 1995-2011 (ft)***
Reach 1	68	-43	24.97
Reach 2	220	89	308.71
Reach 3	-42	62	19.65
Reach 4	170	-25	144.90
Reach 5	37	-43	-6.68
Reach 6	-105	227	121.65
Reach 7	219	50	269.36
Reach 8	-504	25	-479.63
Reach 9	138	11	148.15
Reach 10	162	-139	22.96
Reach 11	278	212	490.09
Reach 12	149	-175	-26.10
Reach 13	485	-973	-488.34
Reach 14	104	283	386.64
Reach 15	-222	374	151.64
Total Project	1156	-68	1087.97

Figure 21. Changes in channel length by reach for the periods of 1995-2009, 2009-2011 and overall from 1995-2011.



Channel length and sinuosity are directly related to channel profile, or the slope of the channel. Channel profile is an important indicator of stream energy and stream character, and is influenced by overall valley profile. The Deep Creek valley slope is a fairly consistent 1.2% (1.2 feet of drop per 100' of valley length) from the mouth of the canyon downstream to approximately RM 3.8, where it flattens out to 0.56% as it crosses the Missouri River valley to its confluence with the Missouri River. Streams in alluvial valleys of this character are typically sinuous, meandering across the floodplain. Because the length of the stream is therefore greater than the length of the valley, its slope is reduced. Though there can be considerable variation in slope within a reach, reach-averaged slopes in Deep Creek are consistently 0.43% in Reaches 1-4, 0.65% in reaches 5-10, and 0.69% in Reaches 11-15 (Figure 22).

Figure 22. Channel profile (slope) of lower Deep Creek (Reach 1-15) is consistent with stream types in alluvial valleys characterized by sinuous and meandering streams. Reach-averaged slopes are shown as percent slope.



ELEMENT 1b: Sediment Sources – Upper Watershed

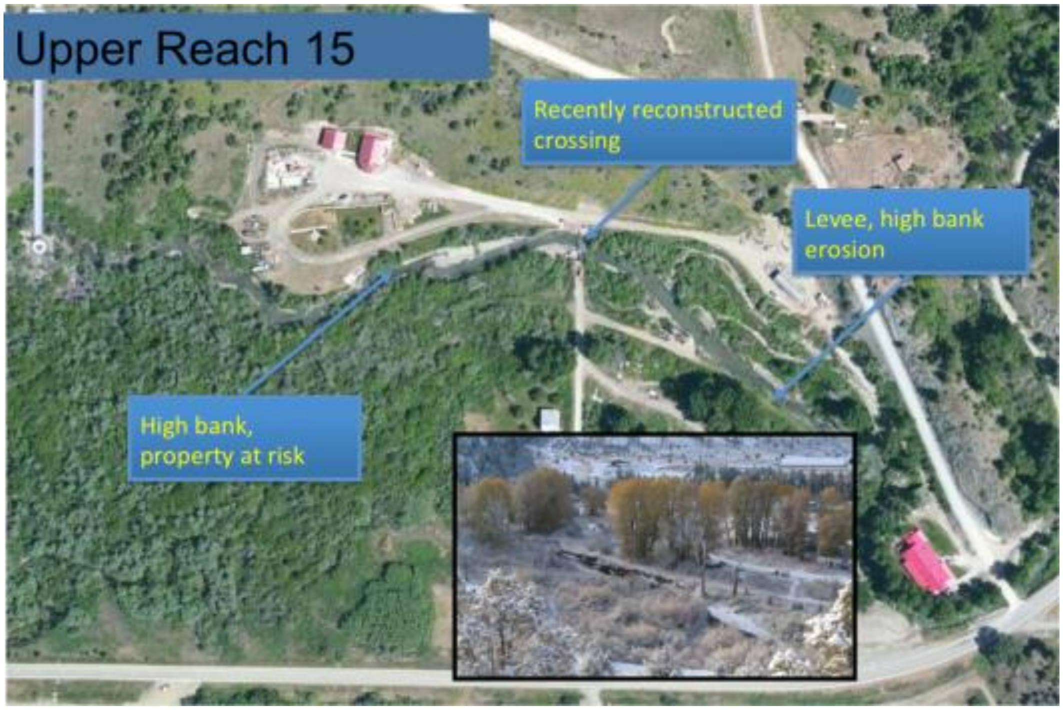
Past monitoring shows that turbidity and TSS in Deep Creek are relatively low when entering private lands (Reach 15), and gradually increase due to bank erosion in the lower watershed (Endicott and McMahon, 1996; Hydrotech, 2004). Bedload transport of coarse sediment, however, appears to be relatively high as the stream enters private lands. Due to the difficulty in quantifying bedload transport, this observation has never been quantified. Channel instability at the mouth of the canyon downstream of North Fork Deep Creek (Reach 15) illustrates the challenge of managing a reach with excessive loading of bedload materials (Figure 23).

Sediment inputs from the contributing (upper) watershed to the lower watershed were not fully assessed for either the Skidmore (2013) or NRCS (2013) assessments. Research on forested watersheds demonstrates that a major source of sediment from managed forests is from road networks (Logan, 2001). Poorly constructed and maintained forest roads can concentrate overland flows and channel these flows down roadways directly into streams. Poorly designed road crossings (e.g., undersized culverts) can also contribute to erosion and sediment issues. Poorly managed livestock grazing in riparian areas can cause significant bank trampling and loss of riparian vegetation, and can substantially reduce wetland vigor and riparian buffering capacity.

Forest fire (Toston-Maudlow Fire in 2000) and beetle kill in the upper Deep Creek watershed have likely impacted hydrologic processes and sediment inputs by reducing canopy cover which can lead to earlier and more rapid snowmelt runoff. Fine sediment from burned areas typically diminishes within a few years as natural understory vegetation becomes re-established. Similarly, fire and beetle kill impacts on hydrology are generally short lived, typically lasting 5 to 10 years following loss of canopy.

The highway corridor (U.S. Highway 12) upstream of Reach 15 results in additional challenges for maintaining natural stream process and managing sediment supply in Deep Creek. The significant encroachment of the road bed on the natural floodplain and the close proximity of the road surface to the stream channel results in increased supply of road sand entering the channel. Incoming material is readily transported to downstream reaches due to the confined channel in the canyon reach.

Figure 23. Example of concentrated infrastructure within an unstable stream reach immediately below the Deep Creek canyon in Reach 15.



ELEMENT 1c: Flow Depletion and Elevated Water Temperature Causes

Extensive irrigation water withdrawals from Deep Creek and loss of riparian cover are the primary causes of low flow and high water temperature concerns on lower Deep Creek. Streamflow and water temperature monitoring was periodically conducted at Clopton Lane, above the Broadwater-Missouri (B-M) Ditch, and at the Hahn Station near the mouth for several years between 1991 and 2013. Although data was not collected every year, low streamflow and high water temperature has been a persistent problem for aquatic life during all but the most abundant water years.

ELEMENT 2. Load Reductions Expected for Management Measures to be Implemented

The Deep Creek TMDL document was completed in 1996 and included TMDL targets for lower Deep Creek (mouth of the canyon to the Missouri River). The Deep Creek TMDL was DEQ's first TMDL completed in the state. At this time, TMDL targets were not expressed as allowable quantities of a given pollutant as they are in more recent TMDL documents (i.e., tons of sediment/yr.), but were rather expressed as quantifiable goals related to the aquatic system. These goal-related TMDL targets included TSS loading, percent of erosive banks, re-establishment of lost channel length, number of trout captured at weir, temperature exceedances, and flow measurements (Endicott and McMahon, 1996).

Sediment

The sediment TMDL goal for lower Deep Creek is to reduce actively eroding banks in Reaches 1-15 by 50%, compared to the assessments conducted prior to 1996 (decreasing average total eroding banks from 13% to 6.5%). As discussed in Element 1, there has been significant progress towards meeting this goal since the TMDL was completed. Further reductions in actively eroding banks, and thus sediment loading, will be achieved by implementing the corridor management approach and reach-specific projects described in Element 3. In the long-term (i.e., a couple decades), a total sediment reduction of at least 50% from 2012 conditions is expected for full implementation of the corridor management and riparian fencing approach. In the nearer term (5-10 years), a total sediment reduction of 5 -10% is expected for the proposed road crossing improvement projects in Reaches 3-4, 11, and 15, and active channel projects in Reaches 7-9 and 15 (see Element 3, Table 4 for project details). Sediment load reductions achieved from specific projects will vary and estimating sediment load reductions are included as a monitoring parameter in Element 9 of this plan.

Expected sediment load reductions in the upper watershed (upstream of Reach 15) will be estimated through a complete sediment source assessment done in coordination with stakeholders in the headwaters (private landowners, U.S. Forest Service, Montana Department of Transportation, and DEQ). Sediment source assessment results will be used to prioritize future management measures to reduce sediment entering Deep Creek from the contributing watershed. These data will also provide a baseline for future progress.

Streamflow and Temperature

The TMDL streamflow target for Deep Creek is to maintain at least 9 cfs at Clopton Lane and 3 cfs near the mouth of Deep Creek. These minimum flow levels are based on requirements for fish (fry) migration and reasonable expectations of water availability. These streamflow targets will be achieved through irrigation improvement projects (e.g., moving diversions off of Deep Creek to alternative water sources or improving irrigation efficiency) and coordination among water users.

The TMDL target for maximum stream temperature is 73˚F for no longer than 10 days in four out of five years. This target is based on the thermal tolerance level for trout. This temperature target will be achieved by improving streamflow and increasing shading through increased riparian vegetation.

ELEMENT 3. Management Measures to be Implemented to Achieve Load Reductions

The following management measures to reduce sediment loading are based on recommendations from two recent stream assessments (Skidmore and Boyd, 2013; NRCS, 2013):

General Management Recommendations (Skidmore and Boyd, 2013)

1. Establish a defined corridor or Channel Migration Zone (CMZ);

2. Address riparian grazing management and fencing;

3. Intensify integrated weed management to improve desirable vegetation in the CMZ as part of a watershed-wide Cooperative Weed Management Area;

4. Plant additional vegetation (primarily wood species) in the riparian zone;

5. Provide additional off-stream watering for livestock;

6. Improve streamflow and reduce water temperature by improving/relocating irrigation withdrawals;

7. Improve or relocate animal feeding operations when possible (refer to "Onsite Guide for Livestock Operators" guidebook);

8. Provide beaver management education and incentive opportunities for landowners to increase beaver tolerance when practical;

9. Consolidate infrastructure and road crossings when possible to address corridor pinch zones;

10. Consider a tempered response to flood damages, by resisting major stream management interventions;

11. Improve understanding of the upper Deep Creek watershed through review and coordination of past studies and initiating sediment source assessment work.

Stream Corridor Recommendations (NRCS, 2013)

The following are NRCS stream corridor recommendations for lower Deep Creek, which generally parallel Skidmore's recommendations:

1. Provide stability to the stream by defining a specific stream corridor setback and limit the overall land management within this corridor, allowing migration for a properly functioning stream. A Channel Migration Zone map addressing woody species regeneration and riparian buffers will increase the overall stream functions. Streambank stabilizations that limit channel movement should only be considered to protect existing infrastructure or to keep the stream from meandering beyond the designated corridor;

2. Consider establishing prescribed grazing plans (i.e. rotational grazing, off stream watering facilities and fencing) for livestock producers, promoting a healthy riparian vegetation zone, while also encouraging proper use along the stream corridor;

3. Limit infrastructure development within the stream corridor, especially within the floodplain and channel migration zone;

4. Combine or move existing infrastructure (i.e. road crossings, irrigation pumps, utility poles) into fewer sites, whenever possible. Consider removing existing fixed irrigation pump sites and installing portable pumps farther from the stream, where feasible;

5. Remove and properly dispose of trash and debris from the stream channel and streambanks to prevent additional debris jams, infrastructure damage, and streamflow issues leading to streambank or streambed scouring and erosion;

6. Implement projects that address elevated water temperature and decreased streamflows. These projects should address irrigation water management, off stream water sources, improved irrigation efficiency and increased riparian woody vegetation;

7. Consider eliminating Animal Feeding Operation (AFO) facilities (i.e. corrals, working areas, holding pens) that have direct contact with the stream by either retrofitting or relocating portions of the facilities;

8. Consider a weed management plan to help control invasive weeds (i.e. Hound's tongue, Spotted knapweed, Common tansy, Canada thistle and Russian olives);

9. Consider establishing fish friendly irrigation diversion structures wherever possible in order to facilitate spawning and migration;

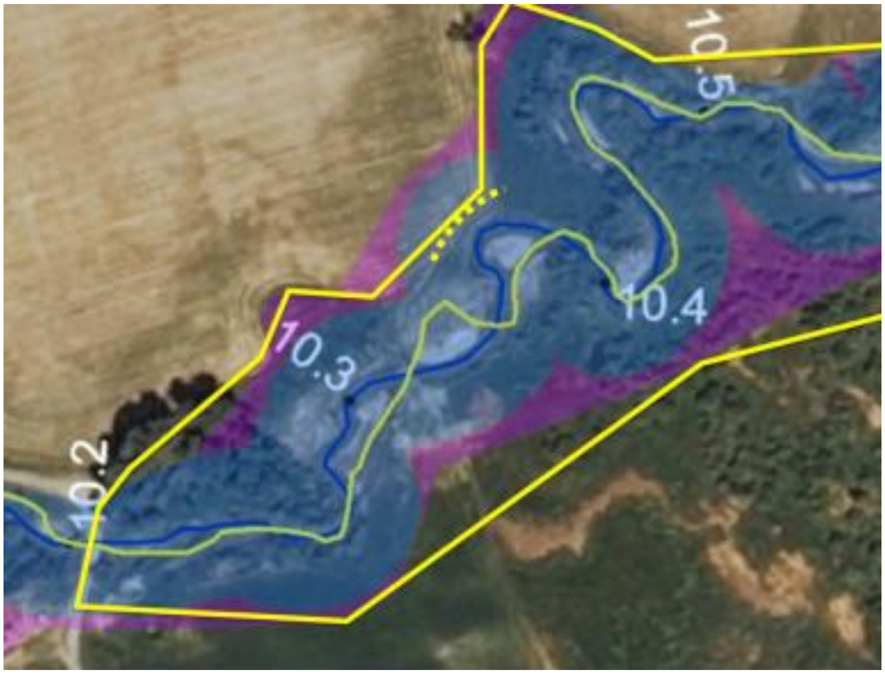
10. Consider screening of irrigation control structures, preventing fish entrainment and population loss. Given this method can be expensive to install and difficult to maintain, screening may only be practical as a possible conservation practice at sites where entrainment has been documented;

11. Consider using a bioengineered approach, such as rock and/or engineered wood treated bank toe combined with a stepped bank bench, when bank stabilization is required and necessary to protect existing infrastructure. This approach is less expensive to build and maintain; it also promotes stream shade, floodplain function, aquatic habitat and energy reduction within the channel.

Corridor Management

Delineation of a management corridor (CMZ) was recommended by both assessments. The basic concept is to provide more room for natural stream process to take place (Figure 24). The health and resilience of a stream ecosystem depends to a large extent on the capacity of that system to evolve through dynamic stream processes, including channel migration and bank erosion. The entrenched channel evolution model aids the understanding of the long term process (Figure 17).

Figure 24. Example of stream management corridor delineation that incorporates roughly 50% of the floodplain. This delineation was derived from a simplistic model of buffering the channel by 2 channel widths on either side of the active channel (blue), and incorporating some potential channel avulsion or flooding areas (pink). A pinch point at RM 10.2 is a private farm access bridge.



The Deep Creek valley is still relatively undeveloped and many agricultural land owners have provided some degree of corridor management already. We suggest a stream corridor delineated to accommodate the following:

Cost Perspectives for Corridor Management Recommendations

Traditional approaches to stream management have focused on stabilization measures to protect property and infrastructure. Stabilization measures often apply hardened treatments, such as riprap, on banks or levees, and these measures typically transfer stream energy and associated erosion problems across a channel or downstream. Stabilization on the margin of a CMZ, however, can often protect property without resulting in significant downstream effects.

To illustrate the relative costs of alternative measures to address dynamic stream systems and associated impacts to property, potential costs for three different approaches are compared in Reach 13 (Table 3). The channel length in Reach 13 is approximately 10,500': 1,800' of which is currently eroding bank and 2,270' of banks have already been stabilized. Approaches are compared assuming a 30-year timeframe.

Traditional stabilization: Stabilization using an installed riprap rock toe with a re-sloped and re-vegetated upper bank for a linear distance of 2,000 feet.

Soft stabilization: Stabilization using a juniper toe revetment with a sloped/revegetated upper bank similar to 1996-97 TMDL implementation at Deep Creek). After 30 years, it is estimated that 30% of this treatment will persist.

Fenced corridor with stabilization and pump relocation: Fencing the delineated stream corridor for all of Reach 13 that encompasses roughly 60% of the floodplain will require 13,000 feet of fence, encompass ~80 acres of riparian floodplain, and may encompass ~3 acres of pivot pasture. Riparian acreage may be seasonally grazed. Riparian fencing is often eligible for some degree of public funding to offset costs.. Over 30 years, approximately 400' of traditional bank stabilization may be necessary at the margins of the fenced corridor to protect property or infrastructure outside of the corridor.

Relative and comparative costs for the three approaches to providing for property protection show that the fenced corridor with 400 ft of targeted bank stabilization is less expensive than traditional approaches of widespread bank protection (Table 3). Soft treatments (e.g., juniper revetments) are often the least expensive alternative, but they may not provide sufficient results over time.

Table 3. Cost comparison of 1) traditional stabilization, 2) soft stabilization, and 3) fenced corridor with limited stabilization alternatives.

Item	**Unit Cost per ft**	**Extent (ft)**	**Alt 1.** **Traditional Stabilization**	**Alt 2.** **Soft Stabilization**	**Alt 3.** **Fenced corridor with stabilization**
Riprap toe w/ vegetated upper bank (Miller Technique)	$25	Alt 1: 2,000' Alt 3: 400'	$50,000		$10,000
Juniper revetment	$5	2,000'		$10,000	
5-wire fence	$2	13,000'			$26,000*
Total Cost Per Alternative			**$50,000**	**$10,000**	**$36,000**

*****Cost share from NRCS or FWP funds generally available.

Reach-Specific Recommendations (Skidmore, 2012)

Simply defining a CMZ does not resolve some of the ongoing stream channel problems in Deep Creek and there are some specific problem areas that require action to assist landowners. The following reach specific management challenges and recommendations were provided by Skidmore and Boyd (2013; Table 4).

Four reaches were designated as priority reaches for immediate consideration and reach-scale planning: Reaches 7, 8, 9, and 15. These reaches were prioritized due to landowner concerns and potential impact to resources. Reaches 1-5 were also identified as a concern, but primarily due to infrastructure crossings. Reaches 10-14 were also identified as opportunities for significant management planning and actions, but were considered less urgent and to some extent represent opportunities for improvement at the multi-reach scale.

Table 4. Reach management recommendations from Skidmore (2012). Priority reaches are indicated in bold font.

Reach	Management Challenges	Corridor Recommendations	Channel Specific Recommendations
Reach 1	None. Deep Creek is essentially a side channel of the Missouri through Reach 1.	Suggest a management corridor that allows dynamic processes, including channel migration and bank erosion, to the west of existing channel alignment.	None
Reach 2	1. Channel migration into agricultural lands and roads.	Suggest a BMP management corridor that extends to limits of current active land use and roads.	1. Consider removal of one private crossing at RM 1.3.
Reach 3	1. Channel migration into agricultural lands and roads. 2. Public road crossing at Carson Lane, water quality and flood capacity.	Suggest a BMP management corridor that extends to limits of current active agricultural use and roads.	1. Reconfiguration of Carson Lane crossing to reduce road contamination and sediment inputs, provide flood capacity, fish passage and long-term bridge stability. 2. Riparian enhancement may be warranted to provide shade and cover.
Reach 4	1. Reach 4 is severely constrained and channelized and offers little room for a stream corridor. 2. Channel migration into agricultural lands and roads. 3. Public road crossing at Litening Barn Road, water quality and flood capacity.	Suggest a BMP management corridor that extends to limits of current active agricultural use and roads. Providing a functional corridor for Reach 4 will require extension laterally into currently irrigated agricultural land.	1. Reconfiguration of Litening Barn Road crossing to reduce road contamination and sediment inputs, provide flood capacity, fish passage and long-term bridge stability. 2. Consider removal of private crossing at RM 3.1 3. Provide wider corridor than currently exists to allow natural adjustment and re-establishment of channel length and planform. 4. Riparian enhancement may be warranted to provide shade and cover.
Reach 5	1. Reach 5 is severely constrained and channelized, devoid of riparian vegetation. 2. Road crossings at Deep Creek Road (2 crossings).	Suggest a BMP management corridor that extends to limits of current active agricultural use and roads. Include flood prone lands (see 2011 photo imagery) within corridor to reduce potential for flood impacts.	1. Provide wider corridor than currently exists to allow natural adjustment and re-establishment of channel length and planform. 2. Consider informal zoning to discourage residential development within flood prone lands.

Reach	Management Challenges	Corridor Recommendations	Channel Specific Recommendations
	Flood capacity and bridge stability. 3. Flooding out of channel throughout reach.		3. Riparian enhancement may be warranted to provide shade and cover.
Reach 6	1. Reach 6 is severely constrained, though less straight/channelized than downstream reaches. 2. Significant number of eroding bends at current riparian corridor boundary, also significant amount of riprap.	Suggest a BMP management corridor that extends to limits of current active agricultural use and roads. Reach 6 may have significant potential for corridor widening and recovery of a riparian corridor.	1. Provide wider corridor than currently exists to allow natural adjustment and re-establishment of channel length and planform. 2. Riparian enhancement may be warranted to provide shade and cover.
Reach 7	1. Reach 7 is unconfined and exhibits an adequate corridor. 2. Bank erosion is frequent at outside bends but does not jeopardize infrastructure, irrigated lands, or property loss. 3. Constructed/ enhanced wetland on south of channel at RM 8.6 is at risk, though would still provide valuable habitat if breached.	Suggest a *broad* BMP management corridor that extends to limits of current active agricultural use and roads. Suggest a beaver management plan within corridor.	1. Allow wetland at RM 8.6 to breach and develop as a natural riparian wetland; broaden BMP corridor RM 8.5 to 8.7. 2. Remove riprap when practical, except where intersects future delineated corridor or protects current infrastructure.
Reach 8	1. Flooding and sedimentation of pasture, levee maintenance and damages, channel dredging. 2. Maintenance of Flynn Ditch	Suggest a *broad* BMP management corridor that extends to limits of current active agricultural use and roads and includes regularly/recently flooded pasture areas. Suggest a beaver management plan within corridor.	1. Allow meander cutoff between RM 9.3 and 9.4 to potentially improve flow through upstream, aggrading reach. 2. Develop alternative point of diversion to current Flynn Ditch point of diversion, consider pump/well alternatives if Flynn water is no longer diverted.

Reach	Management Challenges	Corridor Recommendations	Channel Specific Recommendations
	diversion. 3. Oxbow wetlands on south of channel at RM 8.8-8.9 are at risk of breaching and potentially 'capturing' Deep Creek main channel. 4. Maintenance of pump at RM 9.95.		3. Move pump at RM 9.95 upstream to bridge crossing. 4. Remove levees. Consider corridor easement. 5. Consider channel reconfiguration that provides for sediment transport through this reach, which will require identification of cause of aggradation, though may have only short-term and uncertain value.
Reach 9	1. Private bridge crossing, apparently stable. 2. Maintenance of pump at RM 10.3. 3. Bank erosion threatens pasture (north of channel) and pump infrastructure. 4. Channel responding dynamically to previous stabilization and 2011 flood.	Suggest a BMP management corridor that extends to limits of current active agricultural use and roads. Consolidate infrastructure (pumps) at single road crossing at RM 10.2.	1. Move RM 10.3 pump downstream to bridge crossing at RM 10.2. 2. Consider channel reconfiguration that provides short-term stability and long-term riparian restoration. 3. Provide bank protection at north corridor margin b/w RM 10.3 and 10.4. 4. Provide cattle water gap and crossing.
Reach 10	1. Maintenance of pump at RM 12.9. 2. Maintenance of pipe crossing at 12.8. 3. Public road crossing at Clopton Lane, water quality and flood capacity, bridge stability.	Suggest a BMP management corridor that extends to limits of current active agricultural use and roads. Consolidate infrastructure (pumps) at single road crossing at Clopton Lane. Institute beaver management plan. Maintain broad native corridor from RM 11.7 – 12.3; broaden corridor from RM 12.3 – Clopton Lane.	1. Move RM 12.8 pipe crossing and RM 12.9 pump upstream to bridge crossing at Clopton Lane. 2. Remove riprap throughout, except where intersects future delineated corridor or protects current infrastructure.

Reach	Management Challenges	Corridor Recommendations	Channel Specific Recommendations
Reach 11	1. Bank erosion threatens pasture at RM 13.5.	Suggest a *broad* BMP management corridor that extends to limits of current active agricultural use and roads and includes regularly/recently flooded pasture areas. Suggest a beaver management plan within corridor.	1. Remove riprap throughout, except where intersects future delineated corridor or protects current infrastructure. 2. Provide cattle water gap and crossing.
Reach 12	1. Bank erosion threatens pasture at isolated points between RM 14.7 and 14.9. 2. Maintenance of pump diversion at RM 14.85 (uncertain specific location) 3. Maintenance of ranch bridge crossing, RM15.65.	Suggest a *broad* BMP management corridor that extends to limits of current active agricultural use and roads and includes regularly/recently flooded pasture areas. Suggest a beaver management plan within corridor.	1. Remove riprap throughout, except where intersects future delineated corridor or protects current infrastructure. 2. Consider relocation of pump to consolidate with other infrastructure, possibly at RM 15.65.
Reach 13	1. Bank erosion threatens pasture at isolated points between RM 14.7 and 14.9. 2. Maintenance of pump diversion at RM 16.4.	Suggest a *broad* BMP management corridor that extends to limits of current active agricultural use and roads and includes regularly/recently flooded pasture areas. Suggest a beaver management plan within corridor.	1. Remove riprap throughout, except where intersects future delineated corridor or protects current infrastructure. 2. Consider relocation of pump at RM 16.4 to bridge crossing at RM 15.65.
Reach 14	1. Maintenance of pump and unknown location	Suggest a *broad* BMP management corridor that extends to limits of current active agricultural use and roads and includes regularly/recently flooded pasture areas. Suggest a beaver management plan within corridor.	This reach may potentially serve as a reference for establishing corridor widths appropriate for full natural function.

Reach	Management Challenges	Corridor Recommendations	Channel Specific Recommendations
Reach 15	1. Highway crossing maintenance and associated levee on west side of channel at RM 20. 2. Bank erosion threatens residential property at RM 20.1. 3. Bridge crossing at RM 20.5 constrains channel, maintenance of piers/footers. 4. Erosion threatens property loss on south bank and loss of levee, RM 20.5 to 20.6.	For most of Reach 15, downstream of private bridge at RM 20.5, suggest a *broad* BMP management corridor that extends to limits of current active agricultural use and roads and includes regularly/recently flooded pasture areas. Suggest a beaver management plan within corridor. Corridor for upper third of reach to allow sufficient space for stream to expend energy in inset channel and reduce erosion potential.	1. Consider rock toe with vegetated upper banks to protect property on north stream bank, RM 20 to RM 20.1; Consider rock toe with floodplain bench if needed to protect property on north stream bank, RM 20.4 to 20.5. 2. Levee setback or removal RM 20.5 to RM 20.6 to provide space for stream to distribute energy and reduce erosion potential.

Measures to Improve Streamflow and Water Temperature

Chronic dewatering and elevated water temperature are well documented sources of impairment in lower Deep Creek. Improved efficiency of irrigation withdrawals and development of alternative water sources are the primary management measures proposed to improve streamflow. One example of the positive effects of this approach to restoring streamflow was implemented in 2013. Intensive flow monitoring before and after the project by a volunteer (Jim Beck) demonstrated significant streamflow enhancement in lower Deep Creek (Table 5).

Table 5. Comparison of late August streamflow at three locations on Deep Creek and in one irrigation diversion during 2012 and 2013.

Gauge Location	Discharge (cfs) August 28, 2012	Discharge (cfs) August 29, 2013	Difference in flow (cfs)
Clopton Lane (Above Project)	11.8 cfs	12.8 cfs	+1.0
Stocks Bridge (Below Flynn Div.)	2.5 cfs	9.9 cfs	+7.4
Above B-M Ditch (5 miles below project)	<0.1 cfs	6.4 cfs	+6.3 cfs
Hahn's near mouth	1.9 cfs	11.4 cfs*	+9.5 cfs
Ditch Withdrawal	Approx. 5 cfs**	0.4 cfs**	-4.6 cfs

* Additional flow delivered by B-M Ditch
** Exact ditch measurements not available due to proprietary data collection

This irrigation improvement project serves as an excellent example for future streamflow enhancement projects in Deep Creek where both water users and aquatic life receive benefits. Additional projects intended to consolidate irrigation structures, and when feasible, move irrigation diversions to alternative sources of water (e.g., Broadwater-Missouri Canal) have the potential to significantly improve streamflow and temperature conditions.

ELEMENTS 4 and 6. Technical and Financial Assistance and Schedule of Implementation

The Deep Creek Landowner Advisory Group was appointed by the Broadwater Conservation District in 2012 to help guide and prioritize Deep Creek restoration efforts. The primary sources of technical and/or financial assistance provided to the advisory group and the conservation district are landowners, NRCS, FWP, DNRC, DEQ, USFS, MDT, FEMA, Broadwater County, Peter Skidmore and Karin Boyd.

Additionally, streamflow monitoring is being conducted by a highly qualified volunteer (Jim Beck) since 2012. To date, Mr. Beck has established 6 flow and temperature monitoring locations on Deep Creek and has plans to expand. Jim's work, coupled with the ongoing FWP monitoring program (fish, flow, invertebrates, temperature, and sediment) will provide a reliable evaluation of trends and restoration efforts.

In 2012, a DNRC Planning Grant and FWP funds assisted with the Skidmore Assessment and WRP draft work, and NRCS provided a riparian assessment. In fall 2013 a DEQ 319 Grant was approved to assist with numerous WRP projects from 2014 through 2017. In winter 2014, National Water Quality Initiative (NWQI) funds were awarded to NRCS to be used on the Deep Creek watershed. The NWQI provides technical and financial assistance through NRCS's Environmental Quality Incentives Program (EQIP) to select watershed(s) in each state to address agriculture-related water quality issues. The selection of Deep Creek as a NWQI watershed for 2014 (and potentially 2015-2016) means additional EQIP funding will be available to landowners in the Deep Creek watershed to implement conservation practices to improve water quality. Long-term monitoring of select NWQI watersheds will be provided through a partnership with local stakeholders, DEQ, and NRCS.

Broadwater County is working on a FEMA grant and DNRC RRGL grant to assess public road crossings and residential concerns. MDT is planning major improvements and upgrades to U.S. Highway 12 along the Deep Creek corridor beginning in 2014.

Non-government funding opportunities include Trout Unlimited, PPL Montana, and local sporting associations. An online table provided by the Montana Watershed Coordination Council outlines various sources for funding water quality projects:
www.mtwatersheds.org/Documents/Resources/Natural_Resource_Grant_Program_Spreadsheet_2012_1.pdf

Table 6 lists the estimated costs, partners, schedule of implementation, and potential funding sources for the management activities proposed in this plan.

Table 6. Proposed Deep Creek management activities for 2014-2017: technical and financial needs and schedule of implementation.

Project	Description	Lead Partners	Schedule	Estimated Funding Needed	Potential Funding Sources
Channel Migration Zone (CMZ)	Delineate and map the Deep Creek CMZ	BCD, FWP, consultant, landowners	2014	$15,000	DEQ (319); DNRC, local
Riparian Fencing	Installing 15 miles of riparian fencing	BCD, NRCS, landowners	2014-2017	$180,000	DEQ (319), NRCS, landowners
Offsite watering	Install at least 10 offsite water tanks	BCD, NRCS, landowners	2014-2017	$20,000	DEQ (319),NRCS, landowners
Riparian revegetation	Revegetate select riparian areas with native riparian vegetation	BCD, landowners	2014-2017	$3,000	DEQ (319), landowners
Channel restoration	Channel, riparian, and wetland restoration in reaches 7-9	BCD, landowners	2014-2017	$25,000	DEQ (319), NRCS, FWP (Future Fisheries), landowners
Irrigation improvement projects	Four irrigation improvements to increase streamflows and improve fish passage	BCD, FWP, landowners	2014-2017	$150,000	DEQ (319), NRCS, FWP (Future Fisheries), landowners
Weed management	Develop and implement a cooperative weed management plan	BCD, NRCS, landowners	2014-2017	$85,000 (initially) On-going financial support will vary	DEQ (319 for CMZ), NRCS, landowners, USFS, Noxious Weed Trust Fund, Broadwater County
Education and outreach activities	Numerous E&O activities to support and foster water quality improvement (see Element 5).	BCD, landowners, community members	Ongoing	Varies	DEQ (319), DNRC, MWCC
Volunteer monitoring program	Develop and implement a volunteer monitoring program for area streams	BCD, community members, schools	Ongoing	Varies	DEQ Volunteer Monitoring Program, DNRC, MWCC
FEMA work	Completion of Deep Creek watershed infrastructure improvement projects	Broadwater Co, DES, FEMA	2014-2017	Unknown	FEMA, DNRC, Broadwater Co.
Upper watershed source assessment	Improve Understanding of Contributing Watershed	BCD, USFS, MDT, FEMA	2014-2017	Unknown	USFS, MDT, DEQ

ELEMENT 5. Public Information/Education

The complexity of implementing this WRP will require significant coordination among stakeholders and extensive efforts to inform the public of project activities. Numerous events will be conducted to keep the public informed, involved, and educated. Outreach and education activities that incorporate the local schools (field days, volunteer participation, and classroom activities) will provide exposure for teachers and students, ensuring the next generation has a greater understanding of watershed health and the necessity to be engaged and proactive. Education and outreach activities may include:

- Landowner Advisory Group and Broadwater Conservation District meetings to discuss activities, priorities and potential concerns related to restoration work on Deep Creek.
- Workshops and field tours. Topics may include: controlling flooding and erosion issues in Reach 15; agriculture-related best management practices (BMPs); 310 permit-related BMPs; watershed, riparian and forest health-issues; grazing management; weeds; water quantity and quality monitoring; beaver ecology/ alternative beaver management practices; project “show me” and/or Governor Tour; Missouri River Conservation District Council tour; Kid’s Stream Rendezvous event; Watershed and Forest Appreciation events; fires and their impact on watershed health; multi-agency coordination endeavors; etc.
- A beaver management program that provides interested Deep Creek landowners with protective fencing for riparian trees.
- A Broadwater Conservation District website and regular (quarterly or semi-annual) newsletter.
- Periodic press releases in the local paper.
- Host a Big Sky Watershed Corps Member.
- Host a 6^{th} Grade Conservation Day about watershed issues related to Deep Creek, including its importance as Townsend’s municipal water source.
- Deep Creek Ag Day presentation (grades 1-5).
- Conservation district’s annual meeting.
- Develop a volunteer monitoring program for the Deep Creek watershed with the Broadwater Conservation District, Landowner Advisory Group, community members, schools, and technical partners. Explore incentives, scholarships, and wage options. Use Outdoor Classroom, Service Learning, Summer Bug & Weed Program, Graduation Matters and After School Program to assist.
- A kite photography kit to support education and outreach activities and to assist in volunteer monitoring efforts.
- Work with partners to develop a public information sign about Deep Creek restoration projects.
- Monitor the effectiveness of the education and outreach efforts

ELEMENT 7. Measurable Milestones for Implementing the NPS Management Measures

Milestones are events we will use to ensure that implementation goals are being met over time. Milestones were broken into short-term (3-7 years) and long-term (10+ years) timeframes (Table 7).

Table 7. Milestones to measure progress in implementing the Deep Creek WRP.

Issue	Milestone
Riparian Habitat and Sediment	**By 2017:** • Achieve 20% more riparian cover along Deep Creek reaches 5-14 compared to 2013; this milestone will also help improve temperature issues • Install up to 10 off-site watering tanks • Install 30,000' of fencing along CMZ • Completion of 3 channel restoration projects **By 2025:** • Achieve 30% more native, woody riparian vegetative cover along Deep Creek reaches 5-14 compared to 2013 (based on ground surveys and air photography); this milestone will also help improve temperature issues • Expand weed mapping and implementation of the CWMA within the watershed. • Continue with Cooperative Weed Management Plan and treatment
Sediment	**By 2017:** • Complete 3 road crossing improvement projects in reaches 1-5 • Restore stable stream function associated with levee in reach 15 • Assist reach 7, 8, and 15 landowners with multi-agency process • Determine baseline sediment loading from upper watershed • Establish 10 miles of CMZ with completed maps and riparian protection
Low Flow Alteration and Temperature	**By 2017:** • Implement at least 2 water savings projects on Deep Creek **By 2025:** • Achieve an overall declining trend in maximum water temperatures over a 5 year period • Establish long term streamflow agreements to protect water savings

Issue	Milestone
Aquatic habitat	**By 2020:** • Achieve non-impaired macroinvertebrate community in upper reach • Achieve slightly-impaired macroinvertebrate in mid and lower reaches • Achieve increasing trend in juvenile trout abundance (>3.0 per 100 seconds of electrofishing), number of out-migrant trout (>3,000 per year), number of brown trout redds (>50 per mile in each reach); and a decreasing trend in fish loss to canals.
Upper Watershed	**By 2017:** • Complete a sediment source assessment • Identify 5 road crossing improvements • Flow monitoring at 3 stations • Complete report on hydrology of upper watershed • Work with agencies and landowners to develop a Cooperative Weed Management Plan **By 2020:** • Development of a detailed map of Upper Watershed • Work with agencies, permittees and landowners on grazing improvements • Work with agencies and landowners to address timber resource concerns • Consolidate and evaluate past Forest Service studies within this watershed and use information for the development of an Upper Watershed Restoration Plan
Education and Outreach	**By 2017:** • Hold at least three workshops/tours on issues addressed in WRP • Develop and implement a beaver management incentive/ education program • Develop and distribute a semi-annual BCD newsletter • Develop and maintain a BCD website • Give a Deep Creek presentation at a BCD Annual Meeting/Dinner • Host at least one 6th grade conservation event with Deep Creek as focus

Issue	Milestone
	• Develop a Volunteer Monitoring Program and begin implementation • Develop a Cooperative Weed Management Area to address monitoring, funding, and noxious weed treatment options • Install a project sign within watershed about restoration efforts and projects **By 2025:** • Continue educational events • Continue with the CWMA • Continue Volunteer Monitoring Program

ELEMENT 8. Criteria to Determine if Pollutant Loading Reductions are Being Achieved

Criteria are water quality indicators BCD and partners can use to determine whether progress toward meeting water quality standards is being made in Deep Creek. These criteria can be direct or indirect indicators of pollutant load reductions and serve as benchmarks to measure against through monitoring. For this WRP, criteria include the following:

- Acreage of riparian vegetation restored or protected
- Acreage of noxious weed infestation
- Number of road crossing improvements (culvert upgrades, bridge replacements)
- Decreasing trend in percent of fine surface sediment (< 2mm) in riffles and pool-tails based on pebble counts and grid tosses*
- Improving trend in width/depth ratios*
- Increasing trend in pool frequency and average residual pool depths*
- Decreasing trend in percent and/or area of eroding banks*
- Achieve a minimum flow of 9 cfs at Clopton Lane and 6 cfs at Hahn's Station
- Achieve < 10 days per year of maximum water temperature > 73^{o}F at Clopton Lane, B-M Canal, and Hahn's monitoring locations
- Improving trend in macroinvertebrate communities (species abundance, composition, diversity, richness, etc.)
- Improving trend in fish monitoring (juvenile trout abundance, number of out-migrant trout, number of brown trout redds, and a decreasing trend in fish loss to canals)

* At this time, there is not sufficient data available to define quantifiable sediment-related criteria for the Deep Creek watershed. These criteria will be further refined and quantified through future stream and watershed characterization work, and will be incorporated into this WRP when complete.

ELEMENT 9. Monitoring

Monitoring of stream health and water quantity and quality is key to determining whether restoration goals are being met, and for determining how to adjust management in the future. Extensive monitoring occurred on Deep Creek from 1997-2003 to evaluate the early TMDL implementation work completed (Hydrotech, 2004). Past and proposed monitoring sites are displayed in Figure 25. Some of the parameters have proven useful (e.g., bank erosion assessment, macroinvertebrates, temperature, total suspended sediment (TSS), and streamflow) for assessing effective progress whereas others have not (e.g., total fish counts that didn't take into account other fish population impacts). TSS monitoring data proved difficult to summarize on a year-by-year basis, but it may provide useful information for long-term trend monitoring.

The following selected monitoring parameters and schedule (Table 8) will be maintained to provide short- and long-term evaluation of restoration projects at Deep Creek.

Short-term (0-5 years):

1. Establishment of long-term photopoints and kite photography sites for stream, weed, and agricultural BMP monitoring
2. Summer streamflow and water temperature at least 3 locations in the upper watershed and three locations within Reaches 1-15 on private land
3. Benthic macroinvertebrate surveys at three locations in lower Deep Creek
4. Fisheries monitoring in selected reaches: redd counts, electrofishing, and trapping
5. Beaver dam count in selected reaches
6. Riparian assessment, including short-term survival and establishment of planted woody riparian species
7. Sediment load reduction estimates, specifically for Reaches 7-9
8. CMZ weed monitoring

Medium to long-term (5-10 years, 10+ years):

9. Routine photo monitoring (on the ground and aerial) to visually assess riparian and stream changes over time
10. Bank stability and erosion assessment in Reaches 1 - 15
11. Channel cross-sections in selected reaches
12. Sediment assessment: TSS, bedload, percent fines in riffles and pool-tails using pebble counts and grid tosses, pool structure (pool frequency and residual pool depths), width/depth ratios
13. Sediment load reductions at the project and watershed scales
14. CMZ weed monitoring

Figure 25. Map of selected monitoring stations.

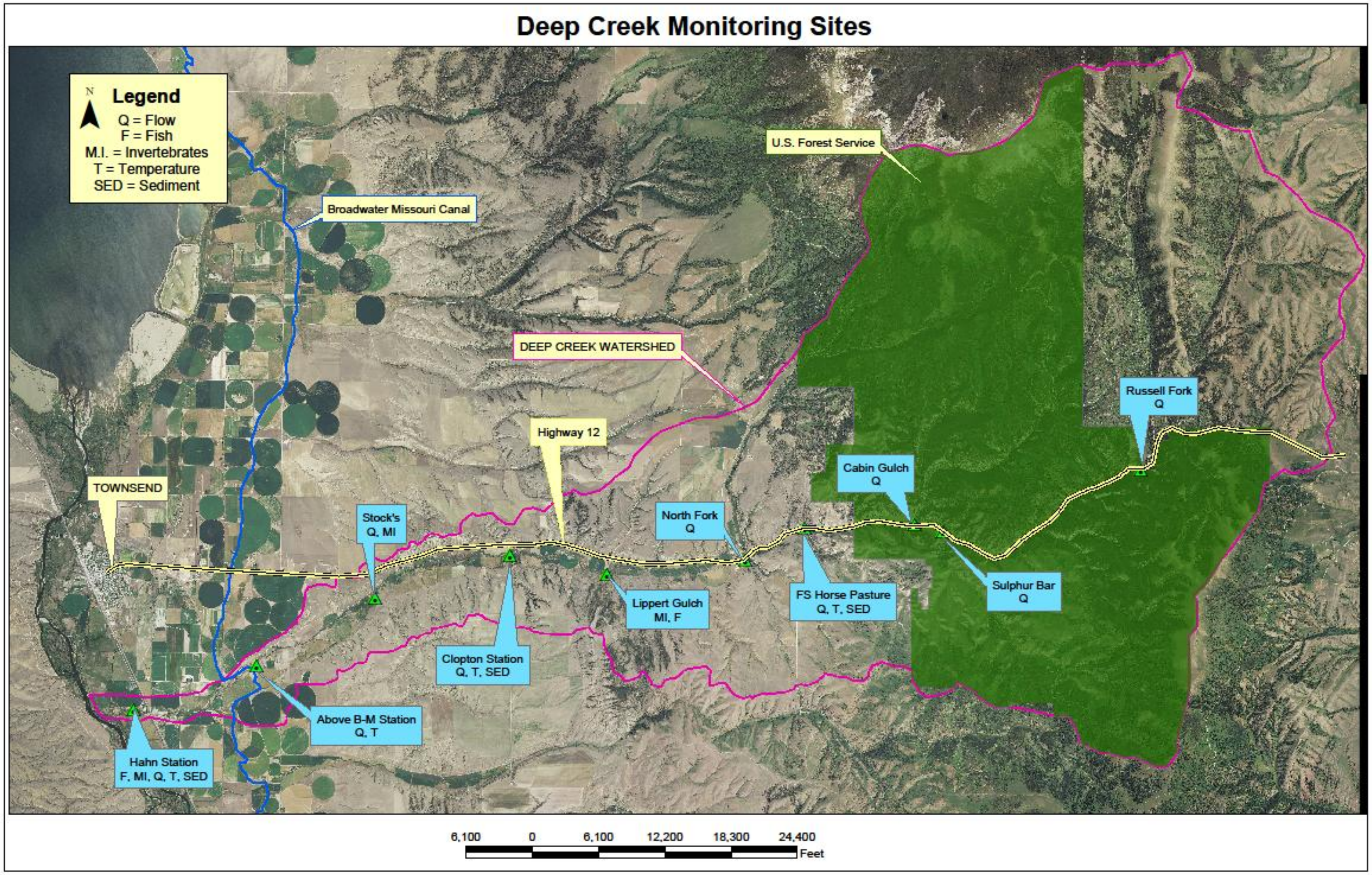


Table 8. Monitoring parameters and schedule.

Monitoring Parameter	Annual	Every 1-5 years	Every 5-10 years
Photo monitoring	X		
Summer streamflow and water temperature	X		
Benthic macroinvertebrate surveys at three locations.			X (planned for 2016)
Fisheries monitoring in selected reaches: redd counts, electrofishing, and trapping	X (spring and fall)		
Beaver dam counts in selected reaches	X (fall)		
Riparian buffer and assessment		Survival and establishment of planted woody species planned for 2017	X
Sediment load reduction estimates at project-specific and watershed scales		X (planned for Reaches 7-9 in 2017)	X
Bank stability and erosion assessment			X
Channel cross-sections in selected reaches			X
Sediment assessment: TSS, bedload, pebble counts, width/depth ratios, pools, etc.			X
Weed monitoring in the CMZ		X	X
Other water quality parameters as needed			X

CHAPTER 3. Landowner Input and Public Involvement

The recommendations and management direction included in the Deep Creek WRP represent over two years of effort to assess historic trends, evaluate past restoration work, and determine priorities for future work to improve the health of Deep Creek. A wide range of priorities were identified in this process, ranging from streamflow enhancement, weed management, sediment control, improving understanding of the upstream water and sediment sources, and mapping a channel migration zone. Landowners, various representatives of the public, the Deep Creek Landowner Advisory Group, and agencies came together with differing priorities, but supported the overall direction of this plan.

Future priorities in the Deep Creek watershed are likely to include more interest by the general public as focus potentially shifts upstream to the contributing watershed. The existing Landowner Advisory Group may need to be modified or expanded in order to make this transition.

This WRP will be reviewed regularly (every 1-3 years as needed) by the BCD, Landowner Advisory Group, and our agency partners (FWP and NRCS). The review will determine if the goals and direction of the WRP remain appropriate and feasible, and changes will be made to the WRP if needed.

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