Watershed Restoration Plan

for

Shields River Watershed

Prepared for:

Shields Valley Watershed Group
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Chapter 1 - Introduction

The Shields Valley Watershed Group (SVWG) consists of landowners coordinating efforts to maintain productive and sustainable ranching lifestyles. A key component to these efforts is protection and management of the limited water resources available for agriculture, drinking water, and recreation. Over the past decade, the SVWG has worked with the Montana Department of Environmental Quality (DEQ) to identify streams and rivers within the watershed that are not meeting water quality standards. Two water bodies, including the Shields River main stem and Potter Creek, are currently listed as "impaired" by DEQ due to physical and ecological impacts derived from sediment. These impairment listings are discussed in detail in the "*Shields River Watershed Water Quality Planning Framework and Sediment TMDLs*" (Shields TMDL), released by DEQ in 2009.

The SVWG is interested in maintaining a high degree of water quality throughout the watershed, and has developed a watershed restoration plan (WRP) to address current water quality issues and prevent streams from becoming impaired in the future. The plan includes nine minimum elements of a watershed-based restoration plan and a list of projects to address sediment and habitat related impairments. The restoration plan is designed to be adaptive as future monitoring efforts indicate trends in water quality and potential projects are added to or removed from the list. The restoration plan will not focus solely on the impaired streams listed in the Shields TMDL; rather, it will be implemented on all tributaries as well as the main stem Shields River (Figure 1).

The Shields TMDL identified three major sources of sediment delivery to the Shields River. These included sediment derived from adjacent roads and road crossings; sediment delivered from stream and river bank erosion; and sediment delivered from uplands. Sampling and modeling efforts conducted in 2004 provided a means of estimating relative sediment loads from smaller sub-watersheds (Figure 2) as well as various landownership categories (private, Forest Service, state lands) in the Shields basin (Figure 3). Land area within each ownership category is a primary determinant in the amount of overall estimated sediment contribution from each category. Private lands account for approximately 81% of the watershed area (Figure 4), and as the dominant land use category, private lands have greater spatial opportunity to contribute sediment than federal or state lands.

This WRP uses estimated sediment loads from various sources to assist in prioritizing restoration and sediment reduction efforts. These estimated loads are derived from various modeling efforts that have an inherent degree of uncertainty, and should not be interpreted literally. Rather, the reported sediment load estimates provide a means of focusing restoration efforts in the watershed where greater proportions of sediment sources exist.

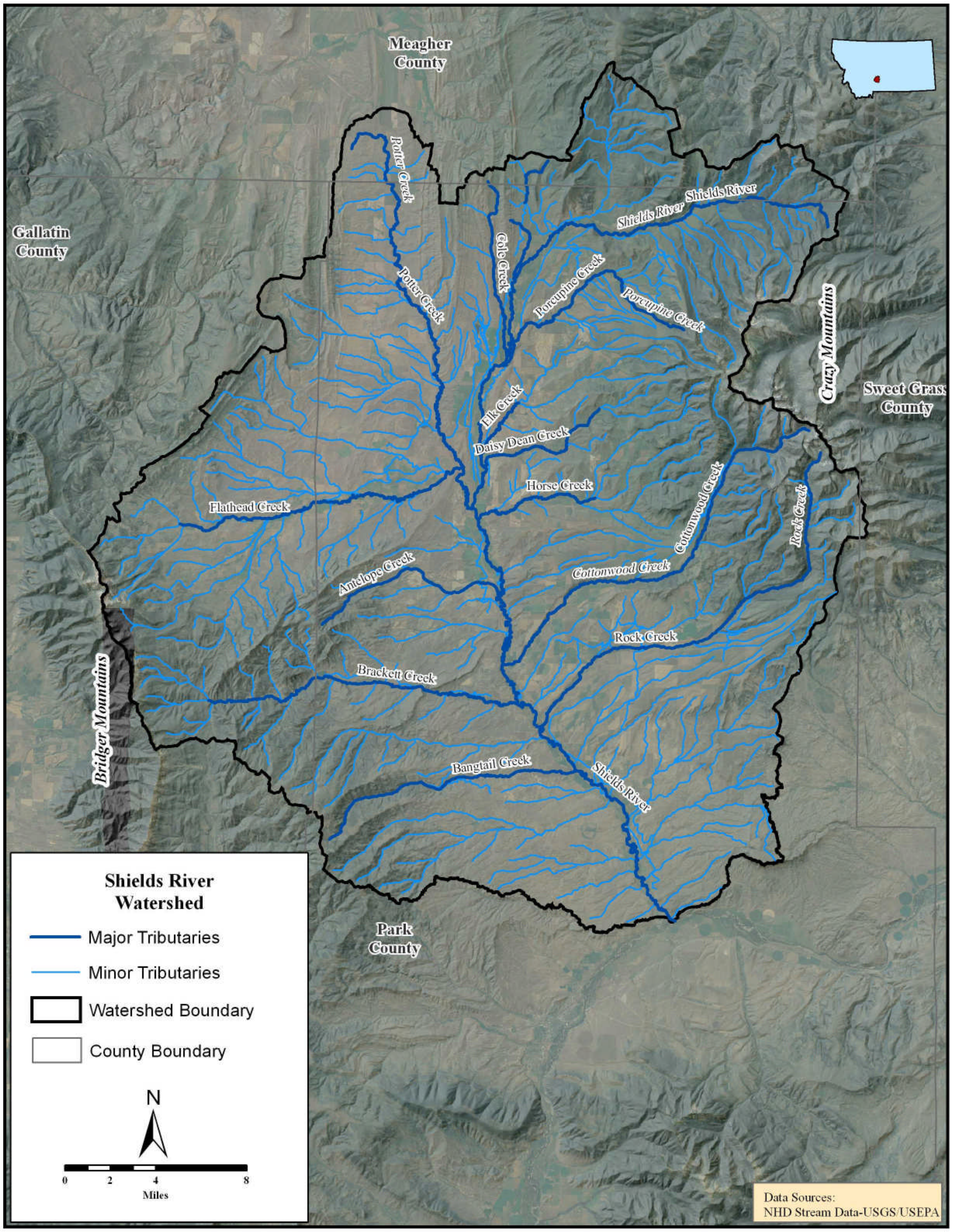

Figure 1. Major and minor tributaries within the Shields River Watershed

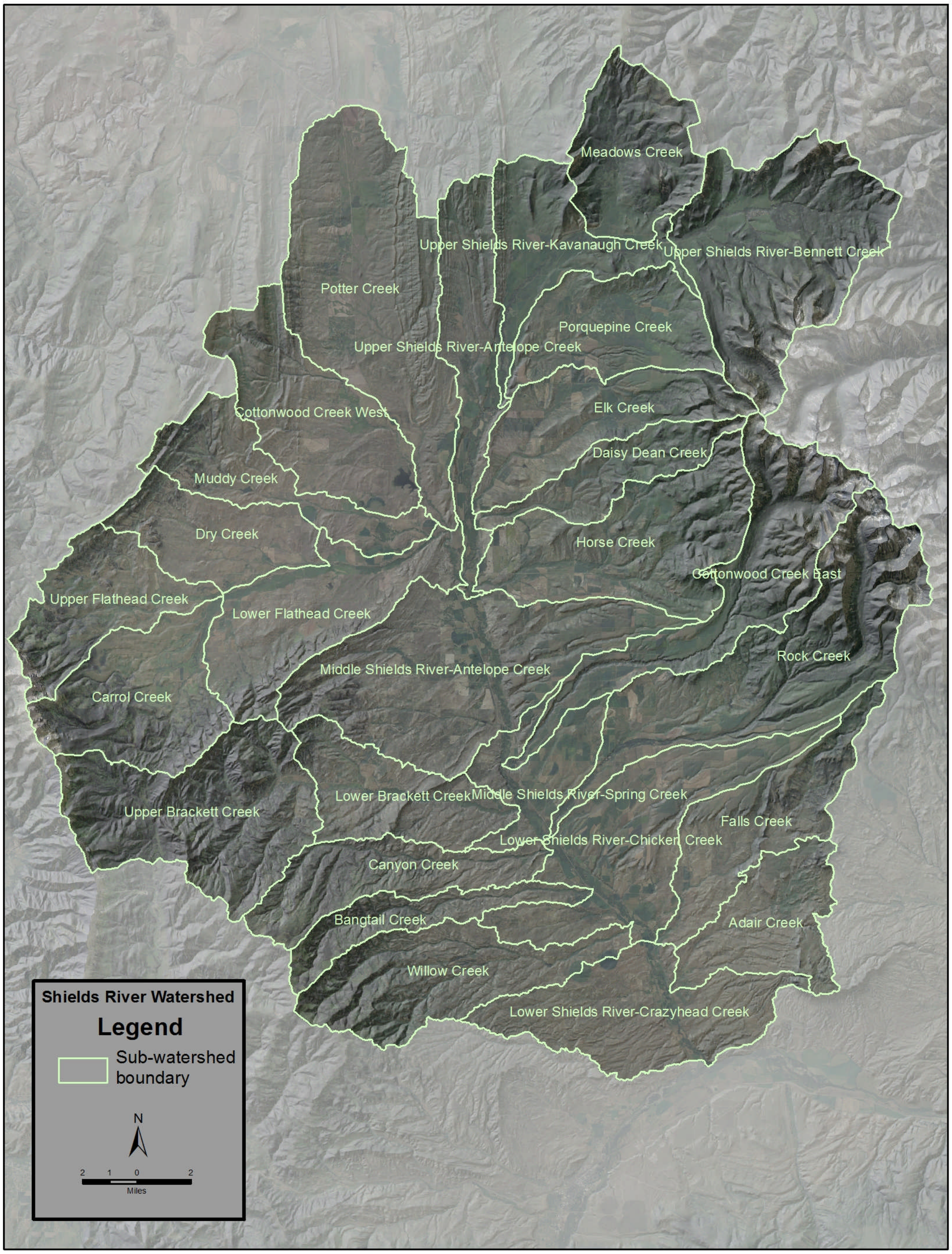

Figure 2. Sub-watershed boundaries in the Shields River.

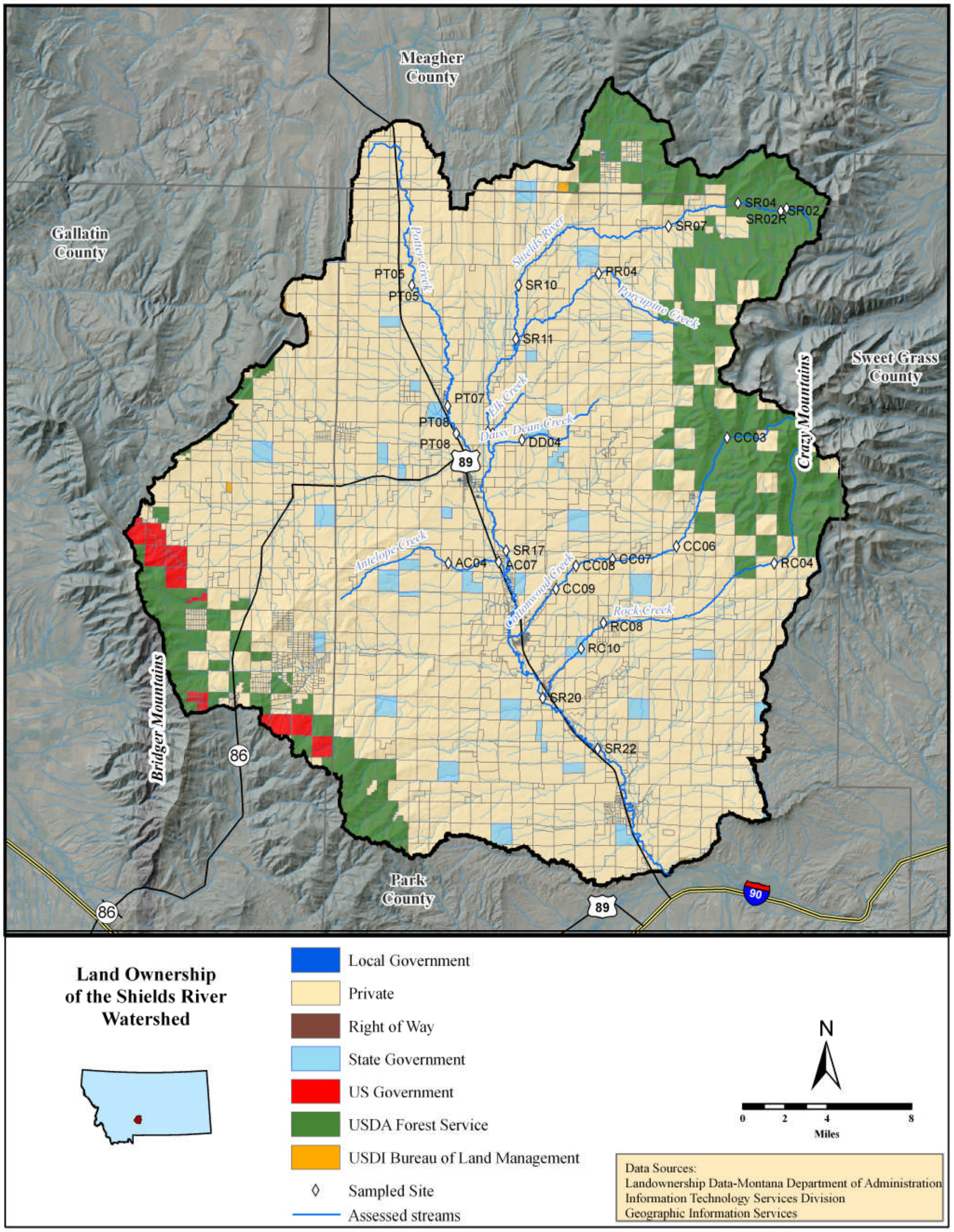

Figure 3. Land ownership categories in Shields Watershed

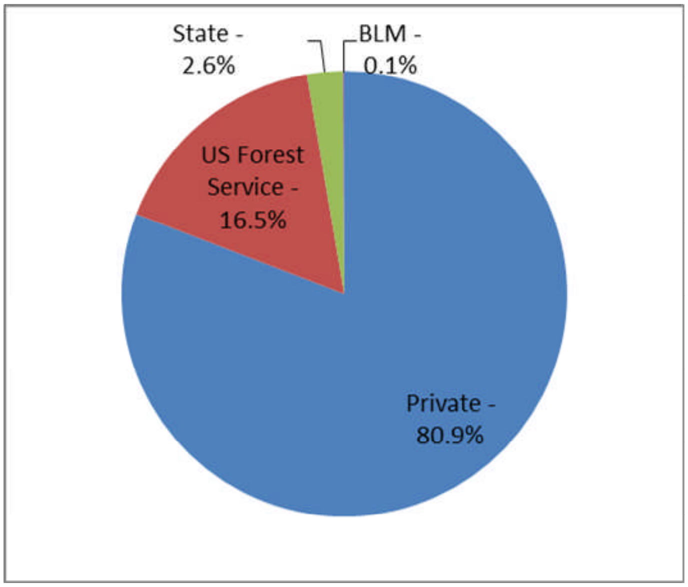

Figure 4. Land ownership percentage by category in Shields River watershed.

Chapter 2 - Nine Major Elements for Shields River Watershed Restoration Plan

1. Causes and Sources of Nonpoint Source Pollution

Primary non-point source categories contributing sediment to the Shields River include unpaved roads, stream bank erosion, and hillslope erosion (MDEQ 2009). As a component of the Shields TMDL investigation, each of these primary sediment sources was modeled to estimate their contribution to the Shields River. Sediment delivery to streams from roadways was estimated using the Washington Road Surface Erosion Model (WARSEM). This model estimates sediment production and delivery based on road surfacing, road use, underlying geology, precipitation, road age, road gradient, road prism geometry, cut slope factors, and other factors. Upland sediment loading due to hillslope erosion was modeled using the Universal Soil Loss Equation (USLE), and a sediment delivery ratio to predict sediment delivery to the stream. This model estimates sediment production and delivery based on soil type, topography, precipitation, land cover and management practices. Sediment loading from streambank erosion was estimated by performing a Bank Erosion Hazard Index (BEHI) assessment, which evaluated bank height, bankfull height, root depth, root density, bank angle, surface protection, and near-bank stress. Results from 39 assessed stream reaches were extrapolated across the watershed to predict an overall sediment load from stream bank erosion.

It is important to note the models used to estimate sediment loading from each of the three sources were not calibrated to existing conditions, nor were they verified against observations to determine the accuracy of their predictions. As such, using these results to inform planning decisions requires making assumptions about the reliability of the estimates. At minimum, one must assume that each of the individual models is internally consistent with respect to its estimates – e.g. that if the road sediment model estimates that road segment A delivers twice the sediment per year that road segment B delivers, observations would reflect that proportion. Using these model results for cross comparison between sources – e.g. for comparing the relative sediment contribution within a watershed from roads vs. that from hillslope erosion– would require the further assumption that each of the models exhibits high accuracy in the absolute terms of the reported units (tons/year). To avoid the necessity of making that further assumption, this restoration plan adopts the approach of estimating the effect of changes in land use and sediment management practices on sediment delivery, on a proportional basis within each of the individual source categories (roads, hillslope, and stream bank erosion) only.

A tool for prioritizing restoration efforts in the Shields watershed includes normalizing the estimated sediment delivery for each source category and developing a ranked list of subwatersheds based on the “intensity” of sediment. The procedure for determining the intensity of sediment for each source includes:

1. Dividing the watershed into the 28 subwatersheds used for the Shields TMDL assessment (as shown in Figure 2),
2. Develop estimates of sediment loading for each source category (roads, hillslope erosion, and stream bank erosion), as performed for the Shields TMDL.
3. Normalize the sediment load data and determine "intensity" for each source category within each subwatershed by:
    a. Dividing sediment load for roads by the miles of road in each subwatershed
    b. Dividing sediment load for hillslope erosion by the acres of land in each subwatershed
    c. Dividing the sediment load for stream bank erosion by the number of miles of stream in each subwatershed
4. Ranking subwatersheds by sediment intensity for each source category.

Developing this intensity rating allows a determination of where in the watershed restoration efforts should be focused to address each sediment source. Results of the normalization of estimated sediment derived from unpaved roads, hillslope sources, and bank erosion are illustrated in ranked order in the following sections. These figures will be used as a tool in developing and prioritizing the restoration plan for addressing sediment related issues within the watershed.

Unpaved Roads

Unpaved roads contribute sediment by disrupting natural drainage patterns, and preventing water infiltration into soil. Improperly built stream crossings and parallel segments may contribute sediment from cut slopes and poor road grading. Nearly 2,500 sediment contributing road segments identified in the watershed lie within a 200 foot buffer of streams. Road crossings contribute approximately 98% of the sediment, whereas parallel road segments contribute approximately 2% of the sediment. Section 3 of this chapter offers guidelines for sediment reduction at road crossings and parallel road segments. For the purposes of prioritization, Figure 5 ranks each subwatershed by the "intensity" of sediment per mile of road.

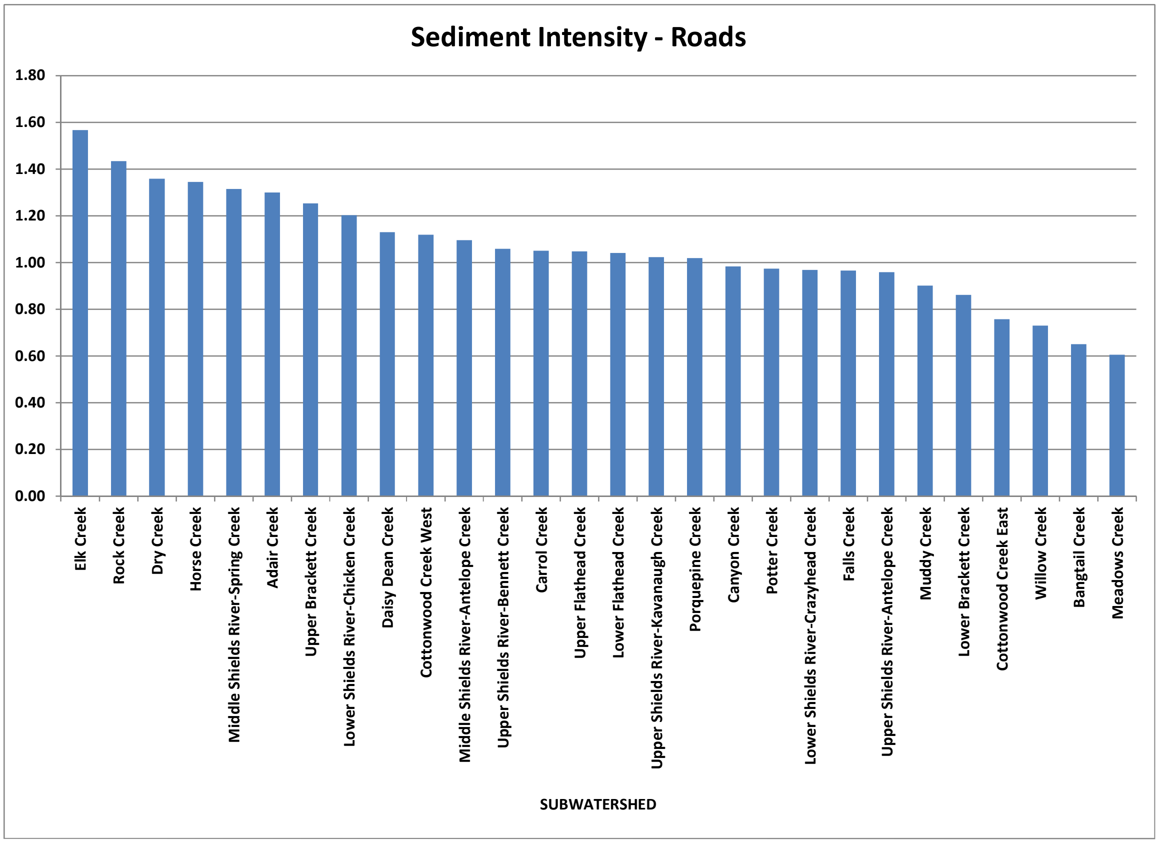

Figure 5. Estimated sediment intensity from roads in the Shields River watershed.

Hillslope Erosion

A certain degree of sediment delivery from upland, or hillslope erosion occurs naturally from gullies and overland runoff.   Hillslope sediment delivery to streams can also be affected by anthropogenic activities including agricultural operations, silviculture, and residential development. Section 3 in this chapter offers best management practices that will aid in reducing sediment delivery from upland sources. For the purposes of prioritization, Figure 6 ranks each subwatershed by the "intensity" of sediment per acre.

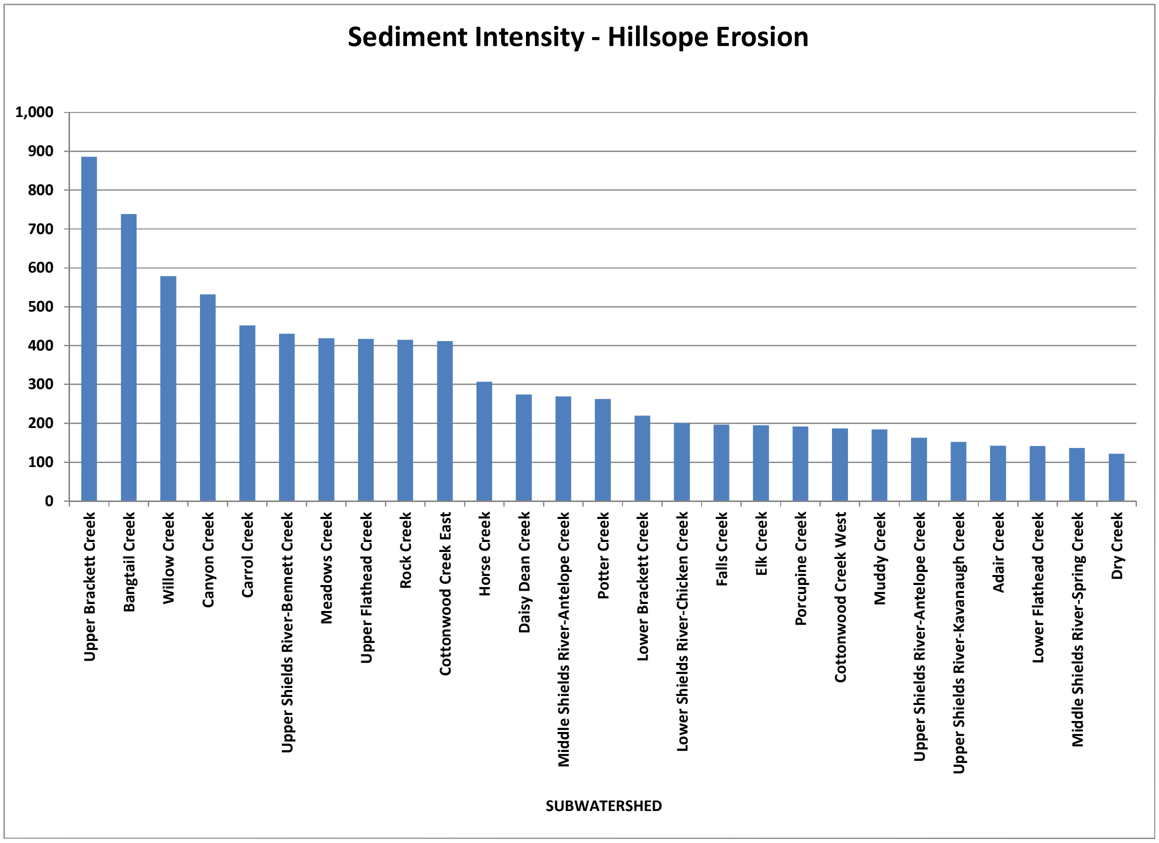

Figure 6. Estimated sediment intensity from hillslope erosion in the Shields River watershed.

Stream Bank Erosion

All streams incur a certain amount of erosion from natural scour and sediment transport processes. Other causes of stream bank erosion along the Shields River include degradation of the riparian zone from heavy grazing and overpopulation of beaver, brush clearing, or regulated hydrology (Inter-Fluve 2001). Section 3 of this chapter offers methods and best management practices for reducing stream bank erosion. For the purposes of prioritization, Figure 7 ranks each subwatershed by the estimated "intensity" of sediment per mile of stream.

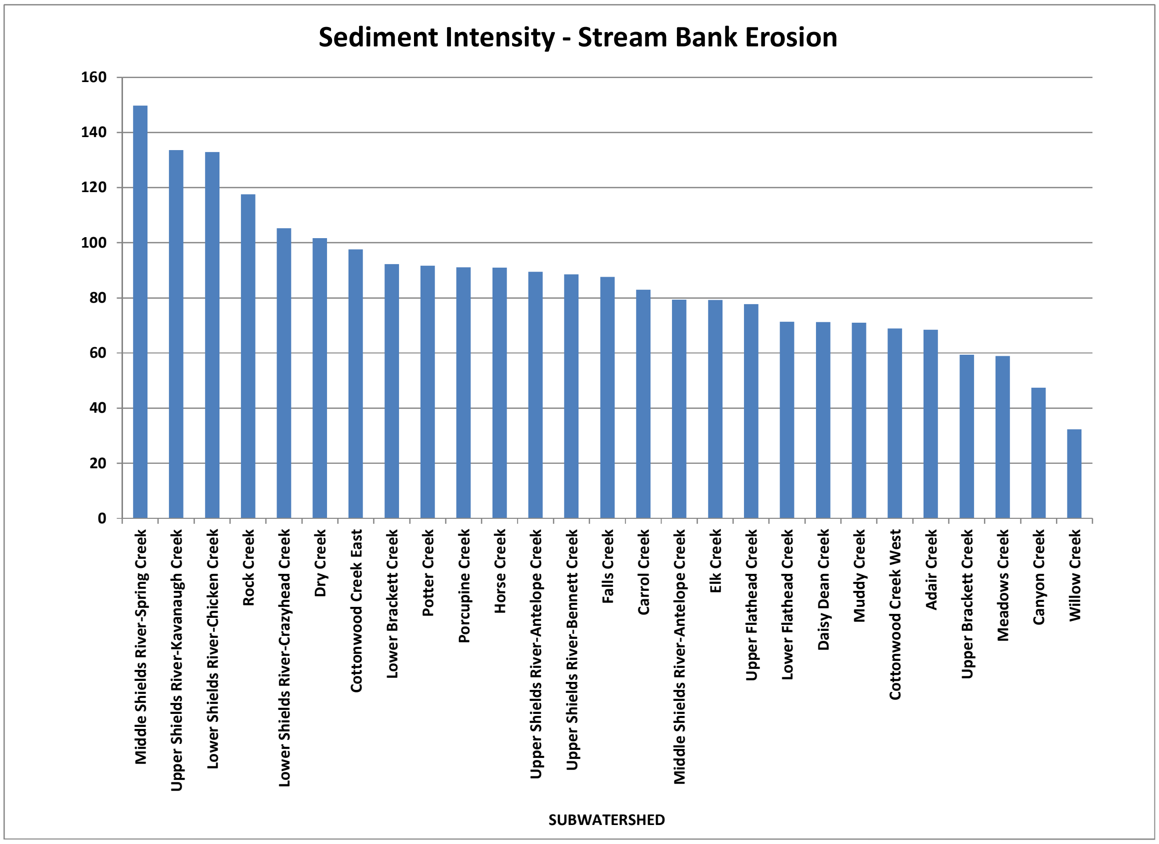

Figure 7. Estimated sediment intensity from streambank erosion in the Shields watershed.

2. TMDL Load Reductions Expected for the Management Measures to be Implemented

The sediment analyses conducted as part of the Shields TMDL included a comparison of existing conditions to estimates of a) natural background levels, and b) levels where reasonable land, soil, and water conservation practices are employed. Sediment load estimates from the reasonable practices scenario provide a means of calculating expected reductions by subtracting them from existing conditions. The Shields TMDL quantifies an anticipated load reduction and resulting, anticipated sediment load if soil and water conservation practices are employed (MDEQ 2009. Section 7.2 and Appendices D, E, and F). A description of best management practices (BMPs), conservation practices, and management actions to achieve these load reductions is included in Element #3.

3. Management Measures to be Implemented to Achieve Load Reductions

A suite of land management techniques and best practices suitable for achieving sediment load reductions throughout the watershed are available. The following section outlines various restorative actions and feasible measures to reduce each sediment source.

Measures to reduce sediment from unpaved roads

Road improvement scenarios used to develop the load reductions in the Shields TMDL included (MDEQ 2009):

- Install settling basins;
- Install silt fences;
- Upgrade all contributing road surfaces to gravel;
- Upgrade all contributing road surfaces one level (i.e. dirt to gravel, gravel to pavement);
- Upgrade all rutted road surfaces to original condition;
- Apply BMPs that reduce the length of road segments contributing sediment;
- Or, incorporate a hybrid of BMPs (i.e. 60% length reduction and 40% upgrade of road surface one level)

Additional road BMP examples include (DEQ 2009):

- Provide adequate ditch relief upgrade of stream crossings;
- Construct waterbars, where appropriate, upgrade of stream crossings;
- Instead of cross pipes, use rolling dips on downhill grades with an embankment on one side to direct flow to the ditch. When installing rolling dips, ensure proper fillslope stability and sediment filtration between the road and nearby streams;
- Inslope roads along steep banks with the use of cross slopes and cross culverts;
- Outslope low traffic roads on gently sloping terrain with the use of a cross slope;
- Use ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches;
- For maintenance, grade materials to the center of the road and avoiding removing the toe of the cutslope;
- Prevent disturbance to vulnerable slopes;
- Use topography to filter sediments; flat, vegetated areas are more effective sediment filters;
- And, where possible, limit road access during wet periods when drainage features could be damaged.

Measures to reduce sediment from bank erosion

Grazing BMPs (DEQ 2009, DNRC 2004):

- Maintain adequate vegetative cover to prevent accelerated soil erosion, protect stream banks and filter sediments. Set target grazing use levels to maintain both herbaceous and woody plants;
- Place salt and minerals in uplands, away from water sources to prevent livestock impacts to stream banks; or
- Create riparian buffers through fencing or develop riparian pastures to be managed as a separate unit through fencing. Water gaps or off-stream watering tanks can be included as part of a riparian fencing plan.

Riparian and stream bank restoration

- Vegetate denuded riparian zones with native species suitable for reducing erosion rates. Rigorous planting of woody plants such as willow and cottonwood using multiple techniques such as pole cuttings, potted containers, bare root stocks, re-located mature plants, as well as re-seeding and weed control are all viable plant material types to use at these sites (Inter-Fluve 2001);
- Bioengineered bank stabilization with vegetative components;
- Hard engineering approaches, such as rip-rap bank stabilization, root wads, and rock weirs/vanes as necessary to protect infrastructure.

Stream Channel Restoration

- Restore channel dimensions, slope, meander pattern, and floodplain to convey anticipated sediment loads and hydrology;
- Improve woody vegetation density to promote bank stabilization;
- Removal or set back artificial dikes and levees in order to reactivate historic floodplain areas, thus reducing the impacts of flood flows currently confined to a narrower corridor. (Inter-Fluve 2001).

Measures to reduce upland sediment

Grazing BMPs

- Design a grazing management plan and determine the intensity, frequency, duration, and season of grazing to promote desirable plant communities and productivity of key forage species;
- Monitor livestock forage use and adjust grazing strategy accordingly;
- Maintain adequate vegetative cover to prevent accelerated soil erosion, protect stream banks and filter sediments. Set target grazing use levels to maintain both herbaceous and woody plants;
- Ensure adequate residual vegetative cover and regrowth and rest periods; Periodically rest or defer riparian pastures during the critical growth period of plant species;
- Alternate season of use from year to year in a given allotment or pasture;
- Time grazing to reduce impacts based on limiting factors for system recovery; For example, early spring use can cause trampling and compaction damage when

soils and stream banks are wet. Fall and early winter grazing can encourage excessive browse on willows; and

- Place salt and minerals in uplands, away from water sources (ideally ¼ mile from water to encourage upland grazing). Periodically rotate feed and mineral sites. Keep salt in troughs and locate salt and minerals in areas where soils are less susceptible to wind or water erosion.

Agricultural and Cropland BMPs

Sediment delivery to streams and rivers can be addressed by minimizing erodible soil (barren or unvegetated), reducing runoff rates, and intercepting eroding soil before it reaches any water body. The most effective measures to achieve these objectives include vegetative filter strips, riparian buffers, and no-till farming techniques. Each of these BMPs is described further below.

Vegetated Filter Strips

The use of filter strips has shown to reduce or remove sediment, nutrients, and pesticides from cropland runoff. Implementation of filter strips in a farm management plan can help keep soils in place, particularly in areas with sloped topography. The filter strip is placed between potential sediment sources such as crops and livestock corrals, and any nearby stream or river (Figure 8). Steeper slopes generally require wider or denser filter strips to achieve the same level of water quality protection.

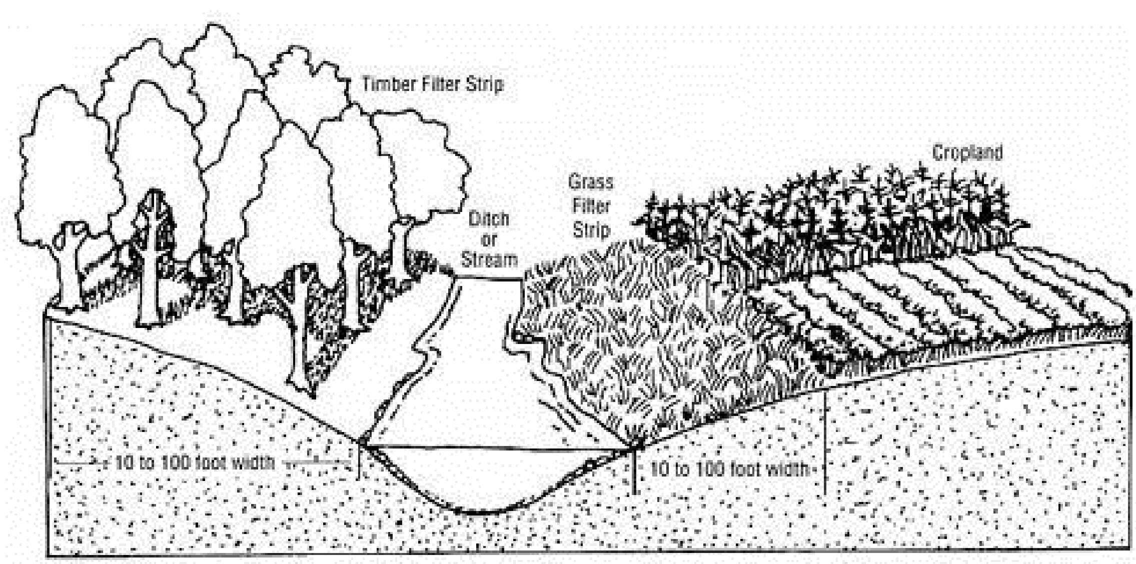

Figure 8. Example filter strip to reduce sediment and other pollutants.

Riparian buffers

The establishment of riparian buffer zones adjacent to streams and rivers is similar to filter strips. A riparian buffer zone is an area where management practices promote stream health by reducing impacts from livestock grazing or vegetation removal. Riparian buffers may be established by fencing while allowing livestock more limited access to the stream at water gaps or creating off-channel water sources.

No-Till farming techniques
This type of farming practice reduces soil erosion by eliminating periodic tillage. Tilling the soil is often used to create rows for improved irrigation and crop maintenance and removing weeds. Nonetheless, it can have unfavorable effects such as soil compaction, loss of organic matter in the soil, and increased topsoil loss from wind and runoff. No-till farming techniques can maintain or improve crop yields while reducing soil loss by carefully managing crop rotations, herbicide use, fertilizer, and irrigation needs.

In addition to adopting agricultural, grazing, and cropland BMPs, the SVWG has identified many projects in the watershed that will reduce sediment delivery to tributaries and the main stem river. These projects include establishing riparian buffers, reducing bank and terrace erosion, and eliminating floodplain barriers. A summary of identified projects is included in Chapter 3.

4. Technical and Financial Assistance

The SVWG has a variety of technical resources available and often works in conjunction with state and federal agencies on natural resource related projects. Examples of these partnerships include:

- Working with Montana Fish, Wildlife and Parks restoration biologists to develop project designs, grant writing, and project implementation;
- Working with the NRCS to assist with design and consulting;
- Working with the MSU Extension service to quickly obtain information and consultation.

Maintaining a supply of funding is critical for continued coordination of the SVWG. Funding sources include grants specific for watershed group coordination and including portions of project grant funding toward administrative services.

SVWG Technical Advisory Committee
A Technical Advisory Committee (TAC) exists to provide technical support and advice for the SVWG regarding numerous natural resource issues within the watershed. In this situation the TAC will help review and provide technical guidance throughout the implementation of the WRP. This group will also be utilized for developing a prioritized list of restoration projects in the watershed. Table 1 includes a list of current members of the TAC.

Technical Workshops and Educational Events
The SVWG often sponsors workshops and educational events focusing on water quality for landowners. In the past, several professionals have given presentations and courses in range management, land stewardship, soils, conservation programs, oil & gas development, noxious weeds, growth trends, sediment monitoring, nutrient testing and natural resource protection.

Available Funding Sources

Financial assistance is available for restoration projects via foundations, grants, and state and federal agencies. Table 2 provides a list of funding sources available for water quality and stream restoration projects.

The SVWG identified three categories of projects within the watershed that will reduce or eliminate sediment delivery to the Shields River (Section 10), including bank restoration, floodplain expansion, and reducing upland erosion. Estimated costs for various treatments under each category are provided in Chapter 4 of this report.

Table 1. Shields Valley Watershed Group Technical Advisory Committee.

Name	Organization	Title	Phone	Email
Adam Sigler	MSU EWQ	Research Associate	406-994-7381	Asigler@montana.edu
Bob Zimmer	Oasis Environmental	Project Manager/Resource Conservation	406-222-7600	B.Zimmer@oasisenviro.com
Brad Shepard	Wildlife Conservation Society	Senior Aquatic Scientist	406-223-3011	shepard.Brad@gmail.com
Carol Endicott	FWP	Yellowstone Cutthroat Trout Restoration Biologist	406-222-3710	Cendicott@mt.gov
Clain Jones	MSU	Soils, Fertilizer		clainj@montana.edu
Clayton Marlow	MSU	Riparian/Livestock Interactions	406-994-2486	cmarlow@montana.edu
Daryl Stutterheim	Park CD	Supervisor	406-686-4411	DDStutterheim@wildsblue.net
Herbert Vasseur	Montana Land & Mineral Owner Assn.	President	406-357-3563	hvasseur@mtintouch.net
James Bauder	MSU	Adjunct Professor, Certified Professional Soil Scientist	406-581-0955	jbauder@montana.edu
Jeff Mosley	MSU	Extension Range Management Specialist	406-994-3415	jmosley@montana.edu
Kenneth Younger	Landowner		406-587-2300	Kyounger@bresnan.net
Kerry Fee	PCEC	Executive Director	406-222-0723	Kerry86303@yahoo.com
Larry Dolan	DNRC	Water Resources Division	406-444-6627	Ldolan@mt.gov
Mark Ockey	DEQ	Water Quality Specialist	406-444-5351	Mockey@mt.gov
Michael Sanctuary	Confluence Consulting	Watershed Restoration Specialist	406-585-9500	Msanctuary@confluenceinc.com
Mike Inman	Park County	Senior Planner	406-222-4102	wminman@parkcounty.org
Pat Byorth	Trout Unlimited	Staff Attorney	406-522-7291	Pbyorth@tu.org
Ron Hoagland	NRCS	District Conservationist	406-222-2899x112	Ronald.Hoagland@mt.usda.gov
Scott Opitz	FWP	Fisheries Biologist	406-222-5105	Sopitz@mt.gov
Tracy Mosley	MSU Extension	Park County Ag Extension Agent	406-222-4156	tmosley@montana.edu

Table 2. Funding sources for projects in the Shields Watershed.

Funding Source	Description	Funding Limits	Submittal Deadlines and Availability	Contact/Website
Private Foundations and Non-Profit Funding Sources				
A) Montana Trout Foundation	The Montana Trout Foundation is a non-political, non-partisan group whose sole purpose is to preserve and enhance wild trout resources.	$2,000 - $7,000, (sometimes larger)	Grants are annual Applications due in fall, press releases typically in September	www.montanatrout.net.
B) Jackson Hole One Fly Foundation	The Jackson Hole One Fly Capital Foundation places an emphasis on watershed planning and an increased focus on native trout conservation. The program reorganization requires that fishery and trout habitat projects be developed in a watershed context. Projects could still have a single-site focus, but they needed to demonstrate a larger watershed perspective.	$10,000 - $60,000	Grants are annual Applications due in February	www.jhonefly.org Cara Rose cara.rose@nfwf.org or 503-417-8700 ext. 6008.
C) Patagonia World Trout Initiative	The World Trout Initiative's mission is to identify the individuals and groups that protect native fish, to tell their story and to support their conservation efforts by placing money into their hands.	$5,000 - $15,000		http://www.patagonia.com/us/patagonia.go?assetid=32942
D) Montana Trout Conserv-ancy	Montana Trout Conservancy is a Montana-based nonprofit that works to keep wild trout around by giving them what they need: great habitat. This organization is not specifically a source of funding, but can assist in procuring funding from available sources	N/A	MT Trout Conservancy will assist with procuring project funding	http://www.montanatrout.org
E) Federation of Fly Fishers	Offers conservation grants to clubs, agencies, organizations and individuals who are working to preserve waters.	$1,500/year is total program funding	Small Conservation Grants are bi-annual Applications due in June and October of each year	www.fedflyfishers.org/Default.aspx?tabid=4389
F) Trout Unlimited	Montana has several local chapters and a Statewide Council. Chapter mini-grants are available to fund habitat restoration projects.	Statewide - $5,000 Local - $2,000	Varies by location	http://www.montanatu.org/issuesandprojects/library%20files/MTU_Chapter_Mini_Grants.pdf

Funding Source	Description	Funding Limits	Submittal Deadlines and Availability	Contact/Website
Private Foundations and Non-Profit Funding Sources (cont)				
G) National Forest Foundation	The NFF Matching Awards Program (MAP), provides matching funds for direct on-the-ground and citizen-based monitoring projects benefiting America's National Forests and Grasslands. MAP funds can be used to support conservation and restoration projects benefiting wildlife habitat, recreation, watershed health, and community-based forestry.	Past awards range from $500 to over $100,000, with a mean of $30,000 and a median of $25,000.	Project funding is for one year, with two award decision cycles per year.	//nationalforests.org/conserve/grantprograms/ontheground/map/application
H) Montana Chapter American Fisheries Society Resource Action Fund	The RAF fund has considers proposals for habitat, management, conservation, fish passage, research, and data management projects.		Requests < $2,000 may be submitted at any time Requests > $2,000 must be submitted by January 15 for review during the committee's annual meeting	www.fisheriessociety.org/AFSmontana/raf.html
I) National Fish and Wildlife Foundation Bring Back the Natives Program	The BBN program seeks projects that initiate partnerships with private landowners, demonstrate successful collaborative efforts, address watershed health issues that would lead to restoring, protecting, and enhancing habitats and are key to restoring, protecting, and enhancing native aquatic species and their migration corridors, promote stewardship on private lands, and that can demonstrate a 2:1 non-federal to federal match.	Average grant award is $60,000	Grants are annual Applications due in January	http://www.nfwf.org/AM/Template.cfm?Section=Charter_Programs_List&CONTENTID=18470&TEMPLATE=/CM/ContentDisplay.cfm Krystyna Wolniakowski Krystyna.Wolniakowski@nfwf.org

Funding Source	Description	Funding Limits	Submittal Deadlines and Availability	Contact/Website
Federal Funding Sources				
J) NRCS Farm Bill Programs	NRCS's natural resources conservation programs help people reduce soil erosion, enhance water supplies, improve water quality, increase wildlife habitat, and reduce damages caused by floods and other natural disasters.	Specific to conservation program. See website for specific NRCS funding information.	Specific to conservation program. See website for specific NRCS funding information	http://www.mt.nrcs.usda.gov/programs/farmbill/index.html
K) EPA Watershed Funding	Tools, databases, and information about funding sources.	See website for specific EPA grant information	See website for specific EPA grant information	epa.gov/owow/funding.html
L) EPA Targeted Watersheds	Capacity building grants to support local watershed efforts.	See website for specific EPA grant information	See website for specific EPA grant information	epa.gov/owow/watershed/initiative
M) DEQ 319 Program	The Montana DEQ provides 319 funding to protect water quality and restore water quality in water bodies whose beneficial uses are impaired by nonpoint source (NPS) pollution and whose water quality does not meet state standards.	Recommended range is $20,000 to $300,000 per application	Grant cycle is annual Proposal applications due in July Final applications due in October	http://deq.mt.gov/wqinfo/nonpoint/319GrantInfo.mcpx Contact Stephanie Crider 406-444-2478 scrider@mt.gov
N) U.S. Fish and Wildlife Service Landowner Incentive Program	Provides financial assistance to States to protect and restore habitats on private lands to benefit Federally listed, proposed or candidate species or other species determined to be at-risk.	Tier 1 Grants up to $200,000/year Tier 2 Grants vary depending on funding	Grants are annual Applications must be submitted 45 days from grant posting at www.grants.gov	http://wsfrprograms.fws.gov/Subpages/GrantPrograms/LIP/LIP.htm

Funding Source	Description	Funding Limits	Submittal Deadlines and Availability	Contact/Website
State of Montana Funding Sources				
O) DNRC Montana Renewable Resource Grant and Loan Program	The Montana Legislature established the Renewable Resource Grant and Loan Program to fund the conservation, management, development and preservation of Montana's renewable resources. Administered by the Montana Department of Natural Resources and Conservation, the program provides both grant and loan funding for public facility and other renewable resource projects.	Funding up to $100,000	Grants are semi-annual Applications due May 15 of even-numbered years	http://dnrc.mt.gov/cardd/ResDevBureau/renewable_grant_program.asp Contacts Bob Fisher - rfischer@mt.gov Pam Smith - pamsmith@mt.gov
P) DNRC HB 223 Funds	Available to Conservation Districts for conservation, education, and natural resource related projects.	Preferential consideration for grants <$15,000; Grants asking >$15,000 must have 1:1 cost match	Grant cycle is quarterly	Laurie Zeller lzeller@mt.gov (406) 444-6667
Q) DNRC Watershed Planning and Assistance Grants	The main purpose of the WPAG has been to provide assistance to help groups meet their resource goals. The three main types of assistance are coordination for specific tasks, assessment, and educational activities.	$10,000 per request	Grant cycle is quarterly	Dave Martin Phone: 406-444-4253 e-mail: damartin@mt.gov www.dnrc.mt.gov/cardd/LoansGrants/WatershedPlanningAssitance.asp
R) DNRC Reclamation and Developme-nt Grant	This grant is meant to fund projects that compensate Montana citizens for the effects of exploration and mining on Montana lands and projects that serve the public interest and the State of Montana.	$300,000	May 15 of even-numbered years	http://www.dnrc.mt.gov/cardd/LoansGrants/Default.asp

Funding Source	Description	Funding Limits	Submittal Deadlines and Availability	Contact/Website
State of Montana Funding Sources (cont)				
S) DNRC Irrigation Developme-nt Grants	Projects that lead toward the development of new irrigation projects, and activities that increase the value of agriculture for existing irrigated lands.	$15,000	Applications may be submitted at any time	Pat Riley Irrigation Development Officer priley@mt.gov Phone: 406.247.4413 http://dnrc.mt.gov/cardd/ResourceDevelopment/IrrigationDevelopment/irrigation_dev_grants.asp
T) DEQ Mini-Grants	Mini-grants provide a mechanism to increase awareness of pollution issues and to improve water quality through educational activities.	Up to $2,000/grant	Grant cycle is annual, 2012 call for applications will be in February, 2012	http://deq.mt.gov/wqinfo/nonpoint/ minigrant.mcpxSWCDMI Jan Fontaine
U) Future Fisheries Program	Montana FWP's Future Fisheries Improvement Program has worked to restore rivers, streams and lakes to improve and restore Montana's wild fish habitats.	Program funding is approx. $750,000/yr. Average project award is $25,000	Grant cycle is bi-annual Applications due in June and December each year	http://fwp.mt.gov/habitat/futureFisheries (406) 444-2432

5. Public Information/Education

Public input is considered a key element to all restoration projects administered by the Park Conservation District (PCD) and the SVWG. The PCD covers the entire Shields watershed including the portion that lies in Gallatin County. The PCD supported the formation of the Upper Shields Watershed Association in 1997 and the Southern Crazy Mountain Watershed Group in 2001. In 2006 both of these groups combined and created what is now known as the Shields Valley Watershed Group.

The SVWG is very active in educating its members on a multitude of local issues including weeds, water quality, wildlife, conservation practices, riparian management, livestock, agriculture, and irrigation. The group consists of local landowners interested in protecting land, water, and natural resources necessary to maintain ranching communities and lifestyles. The group meets several times per year to discuss issues and sponsors several educational workshops and events. Dates and locations for each SVWG meeting are generally posted in the Livingston Enterprise and the Shields Valley "E-News". Meeting announcements are mailed or emailed to stakeholders and landowners who have signed up to receive announcements about a week prior. Members who choose the email method also receive a digital version of the upcoming meeting's agenda and draft minutes from the last meeting. Meeting agendas are posted on the Park County Administrator and Watershed Coordinator's office door and the exterior door of the USDA Building in Livingston. Meeting attendees are asked to sign-in and provide contact information if they wish.

The majority of potential sediment reduction projects in the watershed lie on private lands; therefore, it is crucial for the SVWG to foster new and maintain existing relationships with local landowners in order to pursue these projects. Many landowners do not attend the watershed group meetings or attend tours and workshops; however, the use of county cadastral information and aerial photography provides a means for identifying and contacting these landowners to determine whether they would be interested in conducting a sediment reduction project on their property. In addition to constant communication with local landowners, the SVWG regularly works with land management agencies such as the U.S. Forest Service to maintain awareness of projects on federal lands within the watershed. In the fall of 2010, the SVWG coordinated a tour of restoration project sites targeting all three of the major nonpoint sources of sediment (roads, upland, and stream bank erosion). The goals of the tour were to educate participants how to identify sites that may contribute sediment to streams within the watershed and create a growing list of projects suitable for incorporation into the Watershed Restoration Plan.

The SVWG has coordinated a Technical Advisory Committee (TAC) consisting of professionals and experts of various backgrounds. The TAC developed a prioritized scheme for ranking restoration projects, and will be used to evaluate the feasibility of proposed projects and provide scientific and technical input as needed to address watershed issues.

6. Schedule for Implementing the NPS Management Measures

The Shields TMDL and this WRP provide a framework and prioritization plan for immediate implementation of water quality restoration projects. The SVCD and the PCD are interested in implementing the WRP as soon as funding is secured. Priority will be given to projects with landowner consent, lie within a priority subwatershed, are predicted to effectively reduce sediment delivery, and are along streams known to have native Yellowstone cutthroat trout populations. These projects will be targeted for completion within the next five to ten years. Projects ranking lower in the prioritization scheme will be targeted for completion as funding and landowner permission allow.

7. Measurable Milestones for Implementing NPS Management Measures

Montana's water quality standards for sediment are narrative; therefore, the targets and supplemental indicators developed in the Shields TMDL provide a potential means of measuring trends in water quality parameters. Until specific sediment standards applicable to the Shields watershed are adopted by DEQ, an interim set of measurable milestones will be used to determine progress toward controlling non-point source pollution. A list of projects targeting sediment reduction has been developed as part of this WRP (See Section 10). Completion of projects on this list, accompanied by the reduction in sediment resulting from that project, provides a measurable milestone toward implementing NPS management measures. Additional, specific milestones for the SVWG include:

- Reducing or eliminating an average of one sediment source per year for five years;
- Reducing bank erosion in one high priority (top 10) subwatershed per year on average for five years;
- Increasing riparian buffer areas on average by 10 acres per year for five years.

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

Evaluating the effectiveness of sediment reduction within the watershed involves establishing both technical and nontechnical criteria to determine success. Technical criteria must be evaluated by trained volunteers or professionals; whereas non-technical information can be evaluated by the SVWG, landowners, and interested volunteers.

Non-technical criteria include:

- Photo-documenting vegetation recovery in riparian conservation areas, upland sediment reduction, or stream bank restoration projects.
- Completing specific projects identified in Section 10 of the restoration plan.

The Shields TMDL provides a suite of sediment targets and supplemental indicators to determine whether sediment derived from anthropogenic sources is negatively affecting beneficial uses (Table 3). These technical targets and supplemental indicators will be measured over the long term and compared to baseline conditions to determine if pollutant loading reductions are in fact being realized.

Table 3. Water quality targets and supplemental indicators for Shields River (DEQ 2009)

Water Quality Targets	Proposed Criterion
Percentage of fine surface sediment <6mm based on riffle pebble counts.	Comparable with reference values based on Rosgen Stream type. [a]
Percentage of fine surface sediment <2mm based on riffle pebble counts.	The value must not exceed **10-15%**.
Percentage of fine surface sediment <6mm based on a reach average from 49-point grid toss in pool tails. [b]	The value must not exceed **20%**.
Width/depth ratio, expressed as a reach median from channel cross section measurements. [c]	Comparable with reference values based on Rosgen Stream type. [a]
Macroinvertebrates.	Mountain MMI $\geq$ 63 Low Valley MMI $\geq$ 48 Plains MMI $\geq$ 37 RIVPACS $\geq$ 0.80
Supplemental Indicators	**Proposed Criterion**
Entrenchment ratio, expressed as a reach median from channel cross-section measurements. [c]	Comparable with reference values. [a] This target only applies to B, C, and E stream types. An entrenchment ratio >5.1 will be considered to meet the water quality target for C channels and >3.7 for E channels.
BEHI hazard rating, expressed as a reach average. [b]	Comparable with reference values based on Rosgen Stream type. [a]
Percentage of eroding banks, based on the sum of both left and right bank length per reach.	Eroding banks for less than **15%** of reach for B, C, and E type streams.
Anthropogenic sediment sources.	No significant sources identified based on field and aerial surveys.

[a] Based on the USFS channel morphology dataset

[b] The total number of measurements per reach was dependent on the number of features (i.e. pools and eroding banks).

[c] There were 5 cross section measurements per reach

9. Monitoring to Evaluate Effectiveness of the Implementation Efforts

The SVWG understands the importance of monitoring efforts following restoration projects. The group intends to develop a monitoring strategy specifically designed to determine whether water quality standards for sediment are being met for sediment in the Shields River and its tributaries. Montana DEQ has yet to develop specific criteria for removing formerly-sediment-impaired streams in the Northwestern Great Plains ecoregion from the State's list of impaired waters. When DEQ develops these criteria, the SVWG will adjust their monitoring plan to address the applicable criteria. In the meantime, the SVWG intends to conduct technical and non-technical monitoring to document success toward improving water quality. The SVWG intends to apply for funding to monitor and evaluate the technical targets and supplemental indicators in

Table 3 approximately every 10 years to establish water quality trends in the watershed The first monitoring event is proposed for 2014, or ten years following the initial sampling events establishing baseline conditions and modeling inputs in the TMDL.

Specific project monitoring will include documentation of the efforts made to reduce sediment delivery, and basic calculations of the percentage of eroding banks addressed, area of upland sediment sources addressed, and number of road crossings addressed (Table 4). A more technical list of recommended monitoring methodologies is included in Table 5. These methods require training and should be conducted by agency or professional personnel.

Table 4. Nontechnical monitoring recommendations in Shields River watershed

Technique	Monitoring Recommendation
Develop monitoring list of sediment reduction projects.	Verify and document all sources of sediment that have been addressed within the watershed.
Measure and document length of stabilized eroding banks.	Photo-documentation, calculate % of banks addressed by each project.
Document number of stabilized road crossings.	Photo-documentation, calculate % of roads addressed in watershed.
Measure and document area of upland sediment reduction.	Photo-documentation, collect GPS points around area or estimate acreage visually.

Table 5. Recommended monitoring parameters for Shields Watershed Restoration Plan.

Technical Monitoring Recommendations for Road BMPs		
Restoration Technique	**Monitoring Recommendation**	**Methodology**
Ditch relief culverts or ditch relief at stream crossings	• Place silt trap directly upslope of tributary crossing to determine mass of sediment routed to that point • Rapid inventory to document improvements and condition	• Sediment yield monitoring based on existing literature/USFS methods • Revised Washington Forest Practices Board methodology
Culvert upgrades	• Repeat road crossing inventory after implementation • Fish passage and culvert condition inventory	• Revised Washington Forest Practices Board methodology • Montana DNRC culvert inventory methods
Improved road maintenance	• Repeat road inventory after implementation • Monitor streambed fine sediment (grid or McNeil core) and sediment routing to stream (silt traps) below specific problem areas	• Revised Washington Forest Practices Board methodology • Standard sediment monitoring methods in literature
Technical Monitoring Recommendations for Grazing BMPs		
Recovery Concern	**Monitoring Recommendations**	**Methodology our Source**
Seasonal impacts on riparian area and stream banks	Seasonal monitoring during grazing season using riparian grazing use indicators • Streambank alteration • Riparian browse • Riparian stubble height at bank and "key area"	BDNF/BLM riparian standards (Bengeyfield and Svoboda, 1998)
Long-term riparian area recovery	• Photo points • PFC/NRCS Riparian Assessment • Vegetation Survey (transects perpendicular to stream and spanning immediate floodplain	Harrelson et al, 1994; Bauer and Burton, 1993; NRCS, 2001 Stream Assessment Protocols
Stream bank stability	Greenline (i.e. near bank vegetation) including bare ground, bank stability, woody species regeneration	Modified from Winward, 2000
Channel stability	Cross-sectional area, with % fines/embededness • Channel cross section survey • Wolman pebble count • Grid or McNeil core sample	Rosgen 1996, Harrelson et al., 1994
Aquatic habitat condition	• Aquatic macroinvertebrate sampling • Pool quality • R1/R4 aquatic habitat survey	DEQ biomonitoring protocols; Hankin and Reeves, 1998; USFS 1997 R1R4 protocols
General stream corridor condition	EMAP/Riparian Assessment	NRCS 2001 Stream Assessment Protocols; U.S. EPA 2003

Chapter 3 - Projects to Reduce Sediment Loads to the Shields River

The SVWG has worked with Montana Fish, Wildlife and Parks, restoration consultants, and local landowners to develop a list of projects that aim to reduce sediment delivery and improve water quality in the Shields River. Projects have been derived from aerial and field assessments (2001 Inter-Fluve Assessment; TMDL assessments; various MFWP assessments), and information volunteered by landowners at watershed group meetings. The majority of assessment work has been conducted on the mainstem Shields River upstream of Clyde Park; therefore, the majority of projects lie in the upper extent of the watershed. The majority of projects to date address bank stabilization as a means to reduce sediment, as this source of delivery is relatively easy to observe and identify as compared to upland and road sediment delivery.

Table 6 provides a list of projects with the potential of reducing sediment to the Shields River. This list of projects is intended to be adaptive, whereby projects will be periodically added as they develop or removed as they are completed. Figure 9, Figure 10, and Figure 11 illustrate the location of each project within the watershed. Project numbers in Table 6 correspond to the project numbers on each map.

Project Prioritization

The SVWG has developed a project prioritization plan to rank projects identified for sediment reduction. Priority will be given to project which exhibit the following (in order of importance):

1. Project has landowner consent and involvement;
2. Project lies within a priority subwatershed (top 10 for sediment intensity in each source category)
3. Project illustrates the ability to reduce sediment delivery to the watershed (see criteria in Chapter 1, Section 8)
4. Project is on a stream with known Yellowstone cutthroat trout populations

Table 6. Project list for reducing sediment delivery to Shields River

Project #	Location*	Type of Project	Potential Treatments	Subwatershed	Potential Funding Source (From Table 10)
1	Shields Reach 01; Left floodplain from RM 0.0 to 0.7	Bank restoration	Floodplain and riparian revegetation	Middle Shields River - Spring Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
2	Shields Reach 01; from RM 0.4 to 0.7	Bank restoration and floodplain reactivation	Removal of railroad embankement	Middle Shields River - Spring Creek	A, B, C, E, F, H, I, J, M, N, O, P, R, T, U
3	Shields Reach 01; RM 0.7	Infrastructure removal	Removal of railorad crossing	Middle Shields River - Spring Creek	A, B, C, E, F, H, I, J, M, N, O, P, R, T, U
4	Shields Reach 02; right bank from RM 1.25 to 2.15	Bank restoration	Floodplain and riparian revegetation, crop management	Middle Shields River - Spring Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
5	Shields Reach 02; RM 3.6	Bank restoration	Establish riparian buffer	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
6	Shields Reach 02; RM 4.4	Bank restoration	Establish riparian buffer	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
7	Shields Reach 02; RM 5.5	Bank restoration	Establish riparian buffer	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
8	Shields Reach 03; RM 6.5 to 9.5	Bank restoration	Floodplain revegetation, crop and livestock management	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
9	Shields Reach 03; RM 8.2 to 8.4	Bank restoration	Bioengineered bank stabilization, grazing management, revegetation	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
10	Shields Reach 03; at RM 9.5	Bank restoration	Bioengineered bank stabilization, grazing management, revegetation	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
11	Shields Reach 03; RM 10.1 to 10.5	Bank restoration	Floodplain revegetation, crop and livestock management	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
12	Shields Reach 04; RM 11.2 to 12.8	Bank restoration	Crop management, riparian and floodplain revegetation	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
13	Shields Reach 04; RM 15.4 to 16.5	Bank restoration	Grazing management	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
14	Shields Reach 06; RM 18.8 to 20.7	Bank restoration	Riparian management, revegetation	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
15	Shields Reach 06; RM 19.7; Bright Road bridge	Road crossing	Remove spoils pile from active river corridor	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
16	Shields Reach 07; RM 22.98	Bank restoration	Bioengineered bank stabilization, revegetation, crop management	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
17	Shields Reach 07; RM 23.2 to 24.3	Bank restoration	Riparian revegetation; flow management downstream of Big Canal	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, S, T, U
18	Shields Reach 07; RM 23.35	Bank restoration	Bioengineered bank stabilization, revegetation, crop management	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
19	Shields Reach 08; RM 25.85 to 26.13	Bank restoration	Grazing management, bioengineered bank stabilization	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
20	Shields Reach 08; RM 26.25 to 26.45	Bank restoration	Historic meander reactivation where river avulsed in 1997	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
21	Shields Reach 09; RM 27.6	Bank restoration and floodplain reactivation	Removal of deactivated county road embankement	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, R, T, U
22	Shields Reach 10; RM 30.3 to 31.7	Bank restoration	Riparian and floodplain revegetation	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
23	Shields Reach 10; RM 31.1	Bank restoration	Bioengineered bank stabilization, riparian revegetation, crop management	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
24	Potter Creek from Cottonwood Reservoir to mouth	Bank restoration	Manage dam releases, alternative means of conveyance, bioengineered bank stabilization	Potter Creek	A, B, C, E, F, H, I, J, M, N, O, P, S, T, U
25	Middle Fork Horse Creek	Bank restoration	Bioengineered bank stabilization, willow planting	Horse Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
	*** Reach numbers correspond to 2001 Upper Shields Assessment Report by Inter-Fluve**				

Project #	Location	Type of Project	Potential Treatments		Potential Funding Source (From Table 6)
26	South Fork Horse Creek	Bank restoration	Bioengineered bank stabilizaiton, willow planting	Horse Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
27	Horse Creek	Bank restoration	Bioengineered bank stabilization, willow planting	Horse Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
28	Horse Creek	Bank restoration	Bioengineered bank stabilization, willow planting	Horse Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
29	Horse Creek	Bank restoration	Corral relocation/removal, willow planting	Horse Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
30	Miles Creek	Bank restoration	Bioengineered bank stabilization, willow planting	Upper Brackett Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
31	Nixon Creek	Bank restoration	Revegetation, grazing management	Upper Brackett Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
32	Shields River	Bank restoration on large terrace	Bankfull bench along terrace	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
33	Shields River at Anderson Lane bridge	Bank restoration on large terrace	Bankfull bench along terrace	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
34	Shields River at Indian Creek Road	Bank restoration and floodplain reactivation	Move levees from 1950s - 1970s	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, R, T, U
35	Shields River at Indian Creek Road	Bank restoration	Bioengineered bank stabilization, willow planting	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
36	Shields Reach 2; RM 5.12	Bank restoration	Bioengineered bank stabilization, willow planting	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
37	Shields Reach 2; RM 5.32	Bank restoration	Bioengineered bank stabilization, willow planting	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
38	Shields Reach 2; RM 7.7	Bank restoration	Spoils removal	Middle Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
39	Shields Reach 4; RM 11.7	Floodplain reactivation	Remove floodplain dike, bioengineered bank stabilization	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, R, T, U
40	Shields Reach 4; RM 12.05	Floodplain reactivation	Remove floodplain dike, bioengineered bank stabilization	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, R, T, U
41	Shields Reach 4; RM 12.2	Bank restoration	Bioengineered bank stabilization, willow planting	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
42	Shields Reach 4; RM 14.5	Bank restoration	Bridge resizing to convey flood flows	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
43	Shields Reach 4; RM 15.05	Bank restoration	Bioengineered bank stabilization, willow planting	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
44	Shields Reach 4; RM 15.95	Bank restoration	Revegetation, grazing management	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
45	Shields Reach 5; RM 16.35	Bank restoration	Revegetation, grazing management	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
46	Shields Reach 5; RM 17.13	Bank restoration	Historic meander reactivation	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
47	Shields Reach 5; RM 17.5	Bank restoration	Bioengineered bank stabilization and willow planting	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
48	Shields Reach 5; RM 18	Bank restoration	Historic meander reactivation	Upper Shields River - Antelope Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
49	Shields Reach 7; RM 23.15	Bank restoration	Expand conveyance capacity through bridge	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
50	Shields Reach 7; RM 25	Bank restoration	Bioengineered bank stabilization and willow planting	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
51	Shields Reach 7; RM 25.1	Bank restoration	Removal of dike	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, R, T, U
52	Shields Reach 9; RM 28.1	Bank restoration	Bridge expansion and floodplain reconnection	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
53	Shields Reach 9; RM 28.5	Bank restoration	Bioengineered bank stabilization and willow planting	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
54	Shields Reach 10; RM 31.75	Bank restoration	Floodplain expansion below bridge	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
55	Shields Reach 11; RM 35.6	Bank restoration	Riprap removal, bioengineered bank stabilization, willow planting	Upper Shields River - Kavanaugh Creek	A, B, C, E, F, H, I, J, M, N, O, P, T, U
	*** Reach numbers correspond to 2001 Upper Shields Assessment Report by Inter-Fluve**				

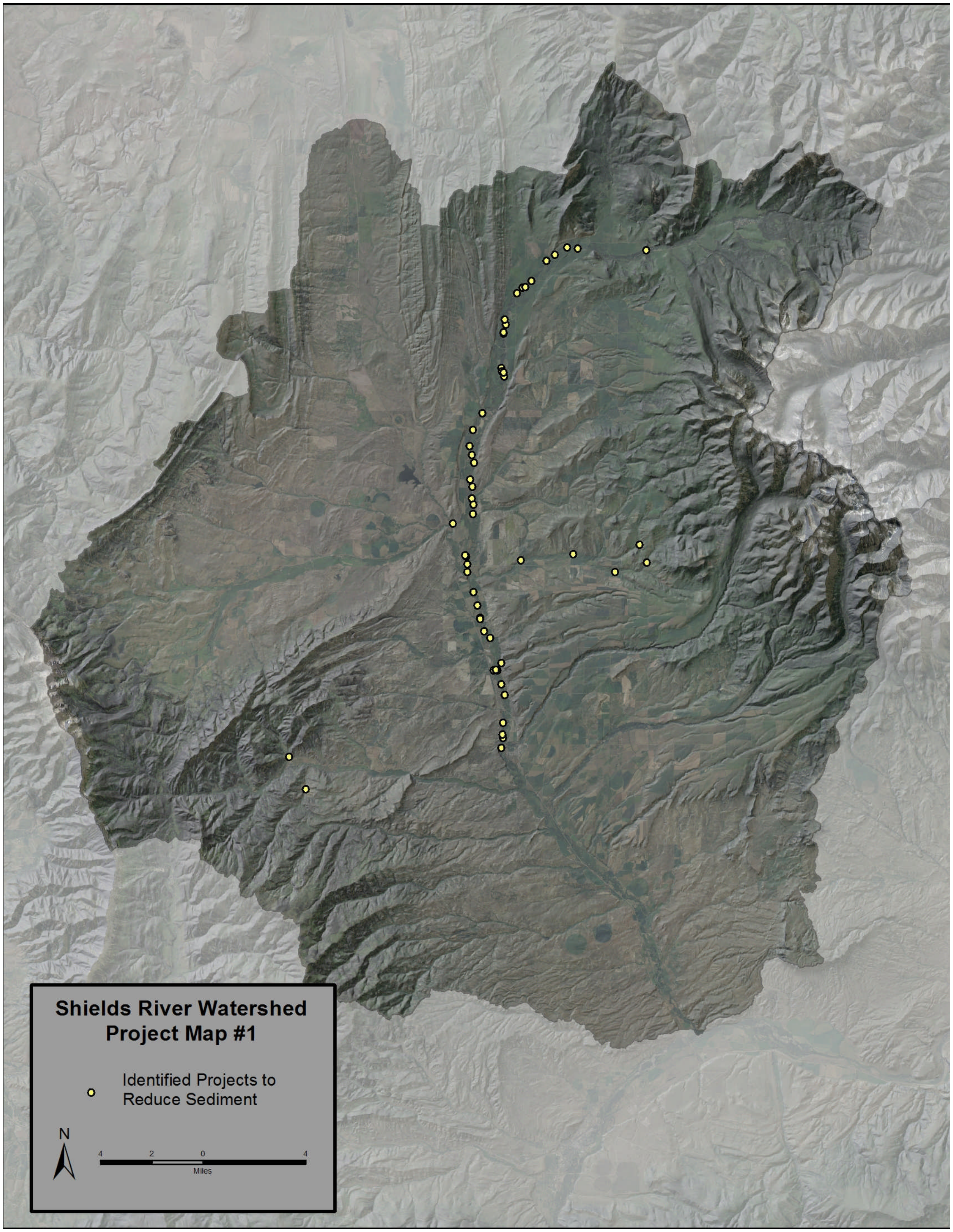

Figure 9. Project Map #1 – Shields River Watershed

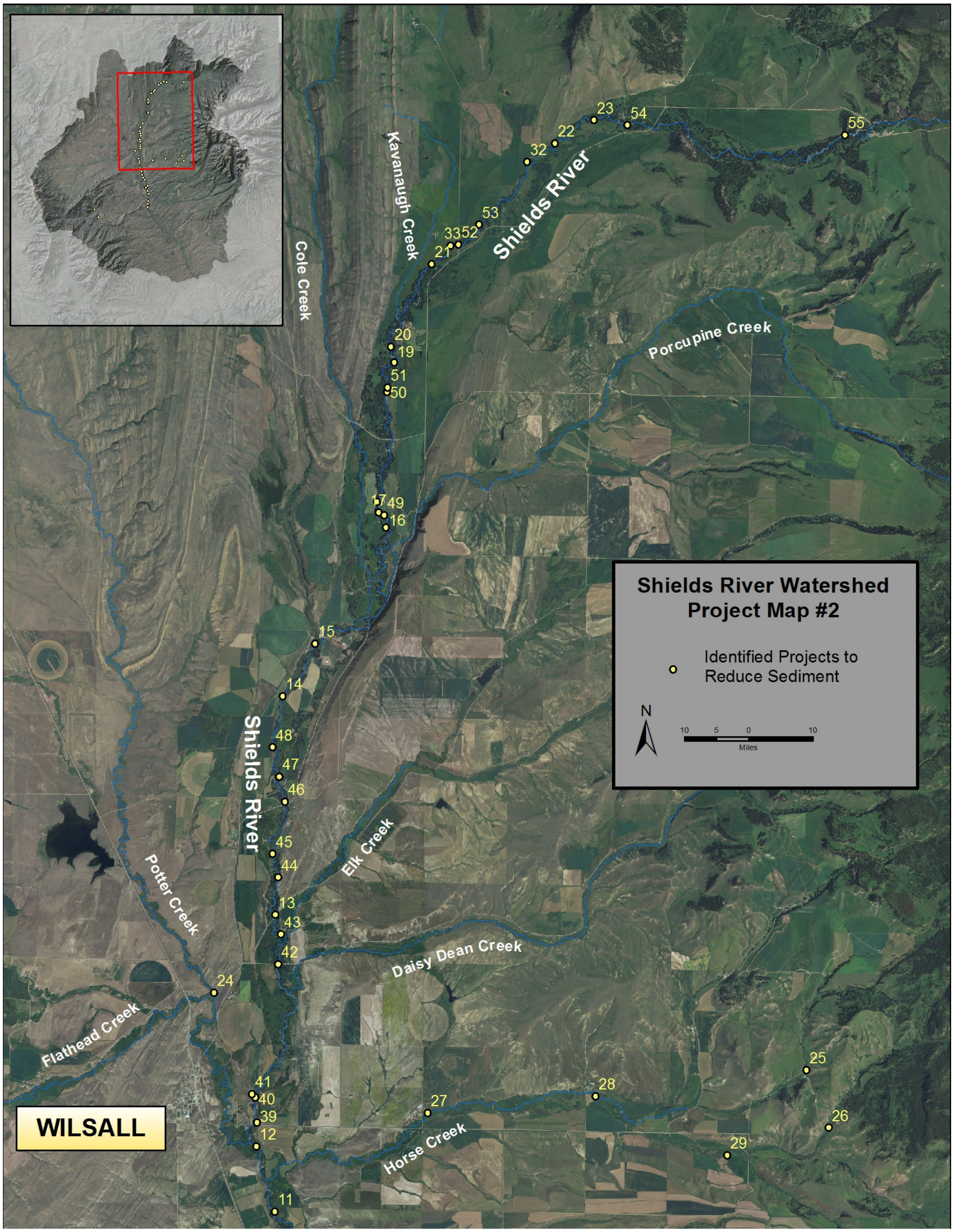

Figure 10. Project Map #2 – Upper Watershed

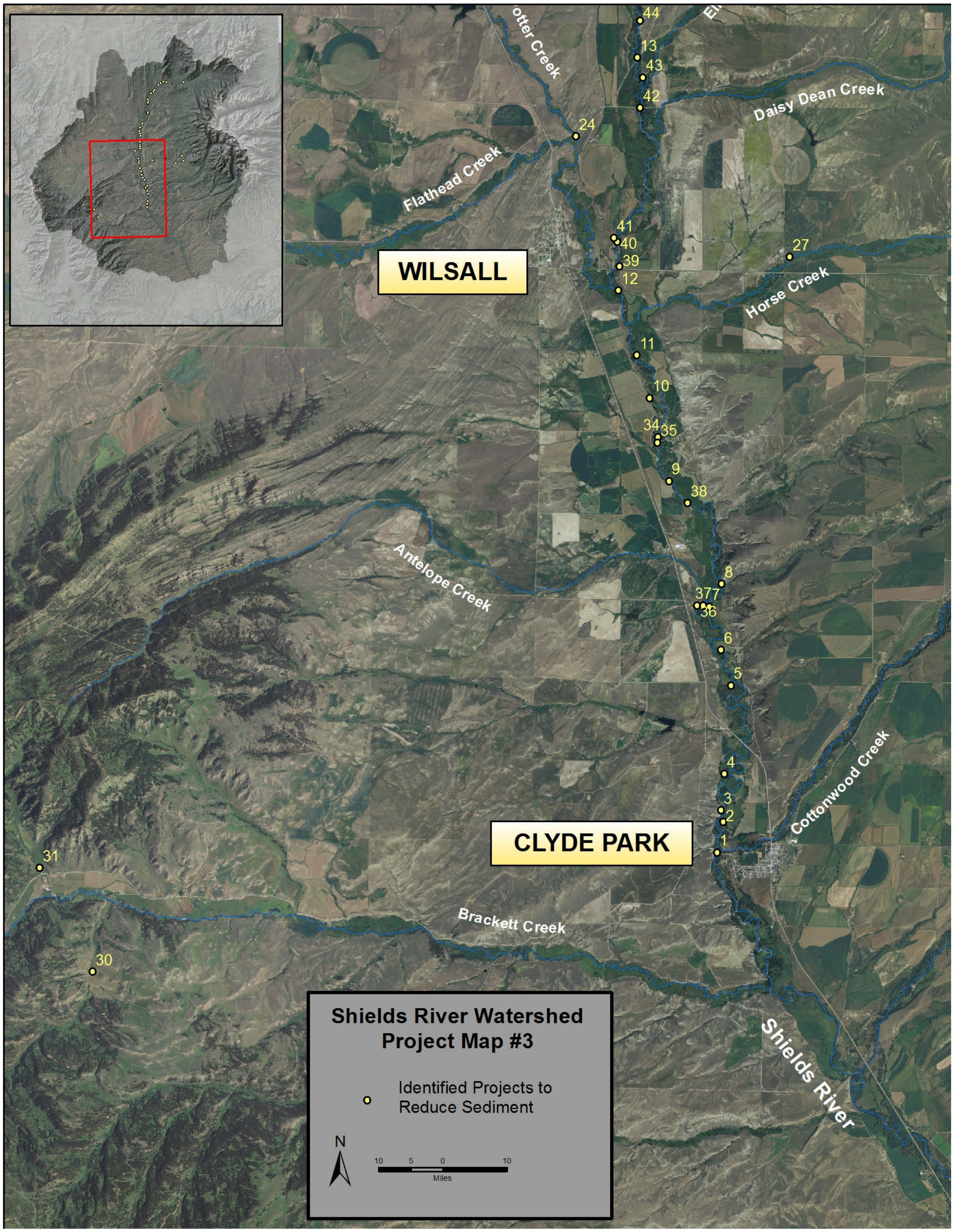

Figure 11. Project Map #3 – Central Watershed

Chapter 4 - Project Costs

Accurately estimating anticipated costs for each of the projects in this WRP is challenging without fully understanding the individual project's goals, scale, design and permitting requirements, and potential constraints. Rather than attempting to estimate each project individually, this section provides a basis for estimating costs by applying a range of costs to a series of restoration concepts. Individual project costs may be generally estimated by applying unit costs for that type of project (i.e. cost/foot for bank stabilization or cost/acre for riparian revegetation).

Table 7 provides a list of various sediment reduction categories and a range of costs for restoration treatments suitable for use in the Shields watershed. This table may not include all potential treatments for reducing sediment in the watershed, but includes a series of commonly implemented methods. Unit costs may vary depending on many factors, including but not limited to the size of stream or river channel, severity of bank erosion, terrain, and accessibility. Figure 12 through Figure 17 provide illustrations of various restoration and sediment reduction techniques listed in this table.

Table 7. Cost/unit categories for sediment reduction treatments.

Category	Treatment	Description	Unit Price
Bank Stabilization	Hard armoring	Blanket riprap	$125-$175/l.f.
	Hard armoring	Rock barbs	$100-$125/l.f.
	Bioengineering	Rock toe with vegetated coir fabric	$80-$140/l.f.
	Bioengineering	Establish bankfull bench along eroding terrace	$100/l.f.
	Riparian revegetation	Plant containerized woody shrubs and herbaceous vegetation	$1,000 – $2000/ac
	Riparian revegetation	Sprig willow stems	$2/stem
	Riparian fencing	Barbed wire	$2-$3/ft.
	Riparian fencing	Electric	$0.50 - $1/ft.
	Riparian fencing	Jackleg	$7/ft.
Floodplain expansion	Removal of floodplain constraint	Eliminate dike/levee/berms adjacent to stream channels	$11/ft.
	Historic meander reactivation	Remove channel plugs to reactivate meanders	$20-$30/l.f.
Upland erosion	Upland revegetation	Plant/broadcast upland vegetation	$75/ac
l.f - lineal foot of stream channel ac – acre ft. - foot			

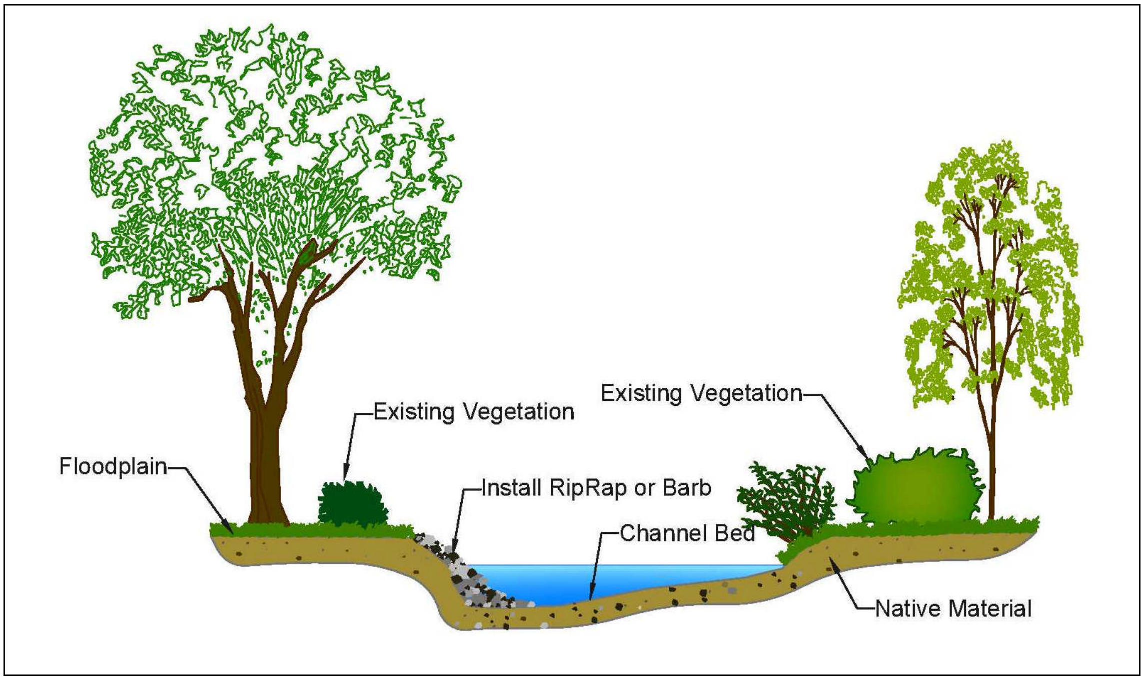

Figure 12. Hard armoring of eroding banks using rock riprap or barbs

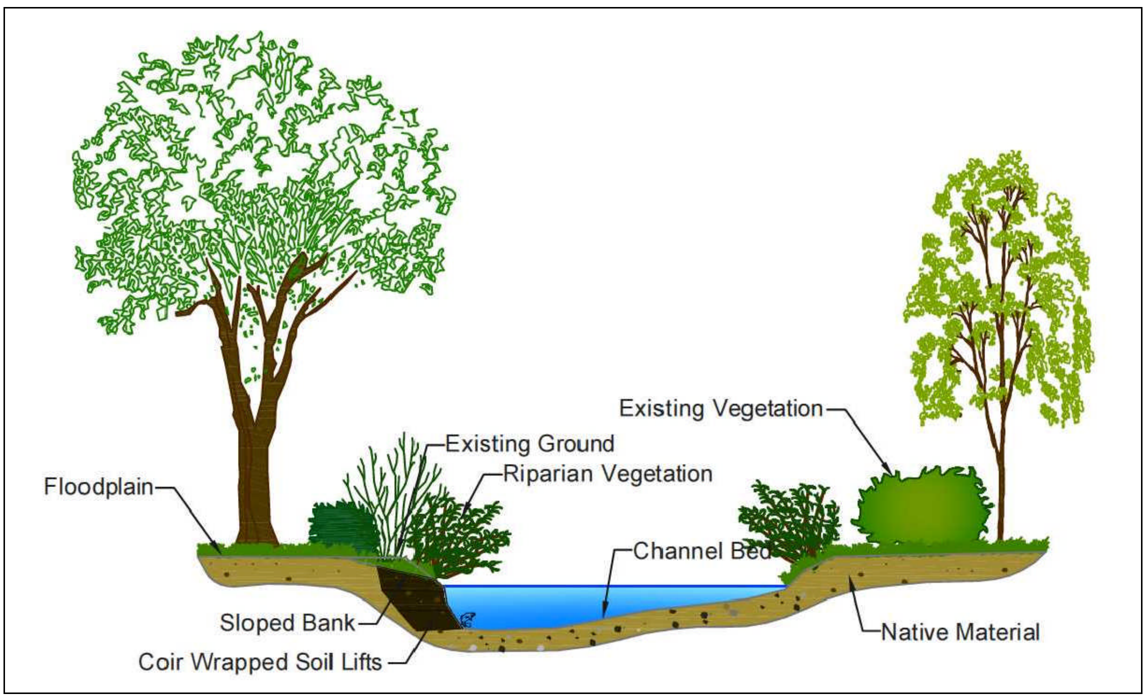

Figure 13. Bioengineered bank stabilization using vegetated coir soil lifts

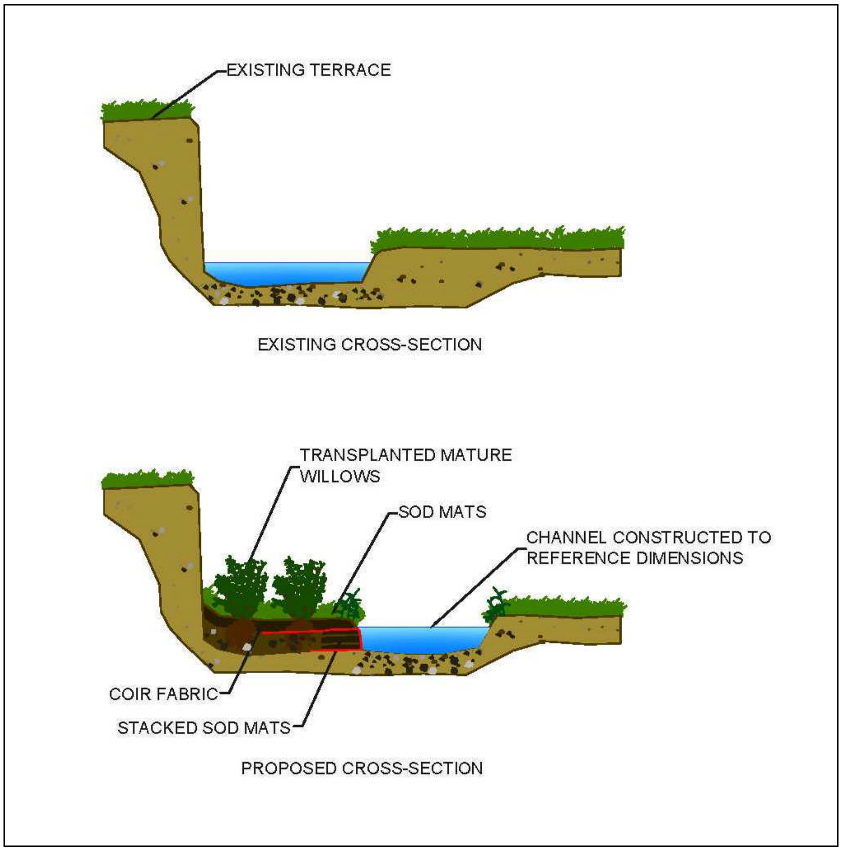

Figure 14. Bioengineered bankfull bench adjacent to eroding terrace

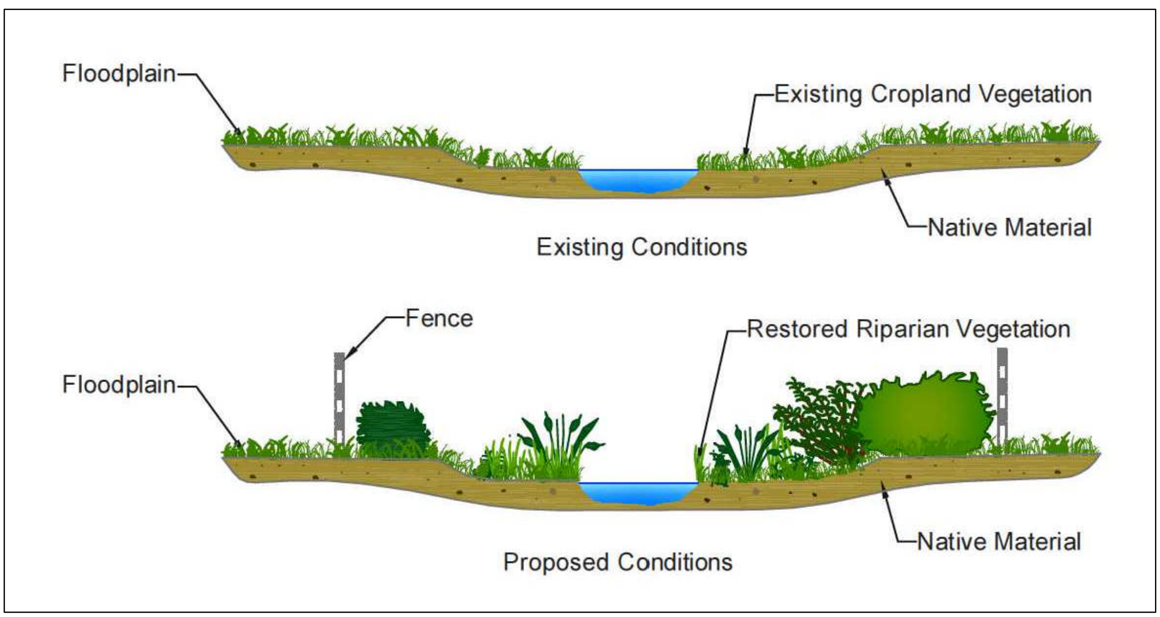

Figure 15. Installation of riparian fencing and revegetated floodplain

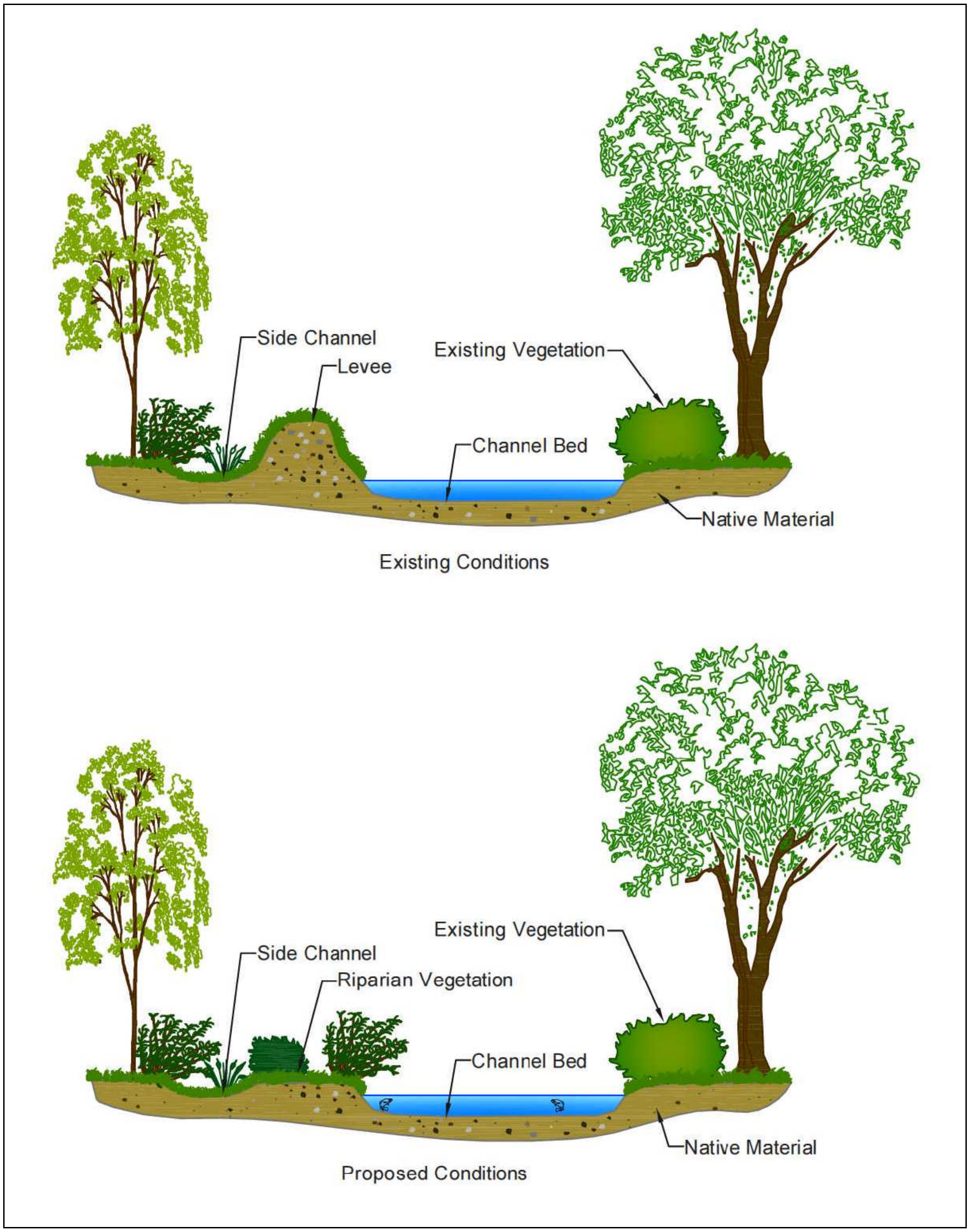

Figure 16. Removal of dike/levee/berm adjacent to stream channel for floodplain reactivation

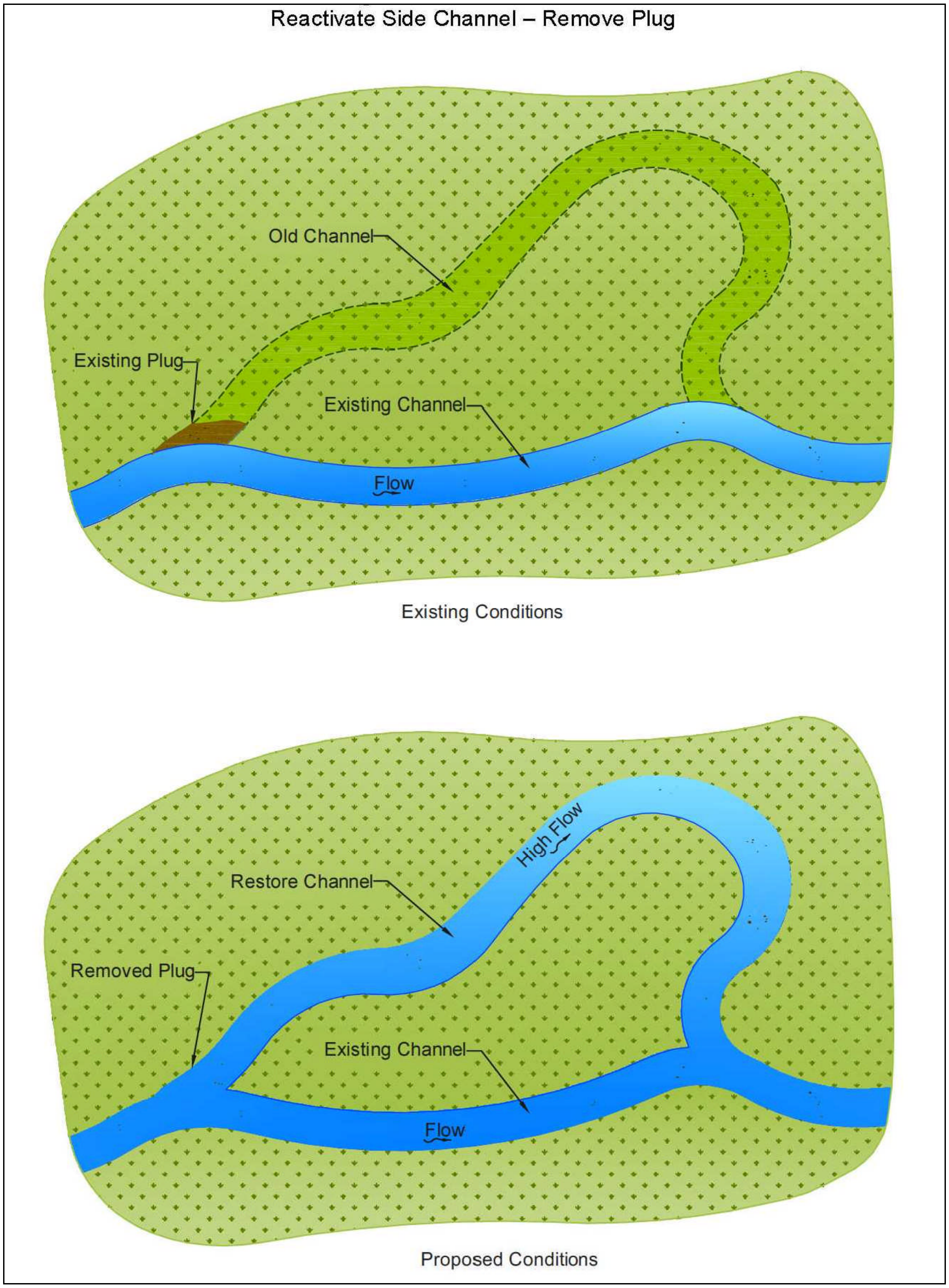

Figure 17. Reactivation of channel and floodplain by removing plugs

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