
MONTANA DEPARTMENT OF TRANSPORTATION STREAM MITIGATION MONITORING REPORT

*Mill Creek
Ravalli County, Montana*

*Project Constructed: 2011
Monitoring Report #2: December, 2014*



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MONTANA DEPARTMENT OF TRANSPORTATION

STREAM MITIGATION MONITORING REPORT #2

YEAR 2014

*Mill Creek
Granite County, Montana*

MDT Project Number: NH7-(114)59
Control Number: 2015004

SPA Number: MDT-R2-15-2010
USACE Number: NOW-1997-90821-MTH

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December 2014

CCI Project No: MDT_.007

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1.0 INTRODUCTION

The following report presents the results of the second year of post stream reconstruction monitoring at the U.S. 93 stream crossing at Mill Creek near Hamilton, Montana. This report includes an evaluation of monitoring results in comparison to project performance standards outlined in the approved U.S. Army Corps of Engineers 404 permit for the project. Mitigation is to be monitored for five years to evaluate compliance toward meeting performance standards. The project was constructed in 2011; therefore, these results provide documentation of the site's condition three years following the project's completion.

As part of the construction of the Bear Creek Road-South segment of U.S. Highway 93, the Montana Department of Transportation (MDT) relocated a segment of Mill Creek to align with a new, permanent bridge. The realignment of Mill Creek included deactivating and filling approximately 630 feet of the channel and constructing approximately 581 feet of new channel through a relic flood swale. Permanent impacts to Mill Creek were authorized by the U.S. Army Corps of Engineers (USACE), as outlined in Corps permit number NWO-1997-90821-MTH and SPA 124 Authorization number MDT-R2-15-2010.

Special conditions specified in this permit included monitoring of the relocated segment of Mill Creek for five years following channel construction to document streambank stability and the success of riparian vegetation establishment. Performance success criteria outlined in the monitoring plan for the Mill Creek site include:

1. Riparian vegetation coverage

- a) Minimum of 80% total vegetative coverage by the end of the third growing season.
- b) Minimum of 50% areal coverage by woody species by the end of the third growing season.

2. Streambank stability – any unstable banks within the relocated channel segment will require corrective actions.

Additional reporting requirements outlined in the monitoring plan include:

3. **As-built survey** - as built drawings of the relocated channel at a 1:50 scale or smaller and planting schematic with a planted species list and number of plants planted.
4. **Monitoring stations** - establishment of 4 monitoring stations 75' apart with surveyed cross sections and bank pins installed as permanent reference points.
5. **Photo points** - color photos at each monitoring station showing both banks and upstream and downstream views.

Results of the second year monitoring of the Mill Creek project are summarized in Section 4 and compared to performance standards in Section 5. Section 6 provides management recommendations to maximize the potential for meeting all performance standards at this and other similar mitigation sites. Additional reporting requirements including a 2013 topographic survey of the project site, repeated survey results at four perpendicular transects, a typical planting plan from the approved design, photo-documentation of the project site, and a map indicating the endpoints of riparian belt transects and perpendicular transect surveys are included as Appendices to this report.

2.0 SITE LOCATION

The relocated segment of Mill Creek flows beneath a newly constructed bridge on U.S. Highway 93 approximately 7 miles north of Hamilton, Montana (Figure 1). The project reach includes approximately 500 feet of Mill Creek upstream of the Highway 93 Bridge and extends approximately 100 feet downstream of the bridge. The project is located in Section 19, Township 7 North, Range 20 West, in Ravalli County, Montana. Note the topographic map in Figure 1 refers to Mill Creek as Fred Burr Creek below the confluence of these streams. The National Hydrography data set indicates the project area is on Fred Burr Creek, although the major contributing stream and larger watershed upstream of the confluence of these streams is Mill Creek.

3.0 MONITORING METHODS

Monitoring field crews visited the project site on July 24, 2014 while topographic survey crews visited the site on July 23, 2014. The following data were collected at the Mill Creek stream mitigation site:

3.1. Riparian Vegetation Inventory - Belt Transects

Two riparian belt transects established during the first monitoring event in 2013 were re-surveyed to document areal percent cover of total vegetation, woody vegetation, and noxious weeds. The belt transect on the right (south) bank is parallel to the downstream extent of the project reach for 140 feet. The left (north) bank belt transect doglegs to maintain a parallel alignment with the channel for 435 feet (Figure 2, Appendix A).

3.2. Bank Erosion Inventory

Both stream banks within the project reach were visually inspected to document eroding banks. Each eroding bank within the project reach was photo-documented. Data collected at each eroding bank included bank length, a qualitative severity rating score, and potential causes of bank erosion.

3.3. Perpendicular Transects

Four perpendicular transects (cross sections) established during the first monitoring event were re-surveyed to document vertical and lateral adjustments at two riffles and at two pools.

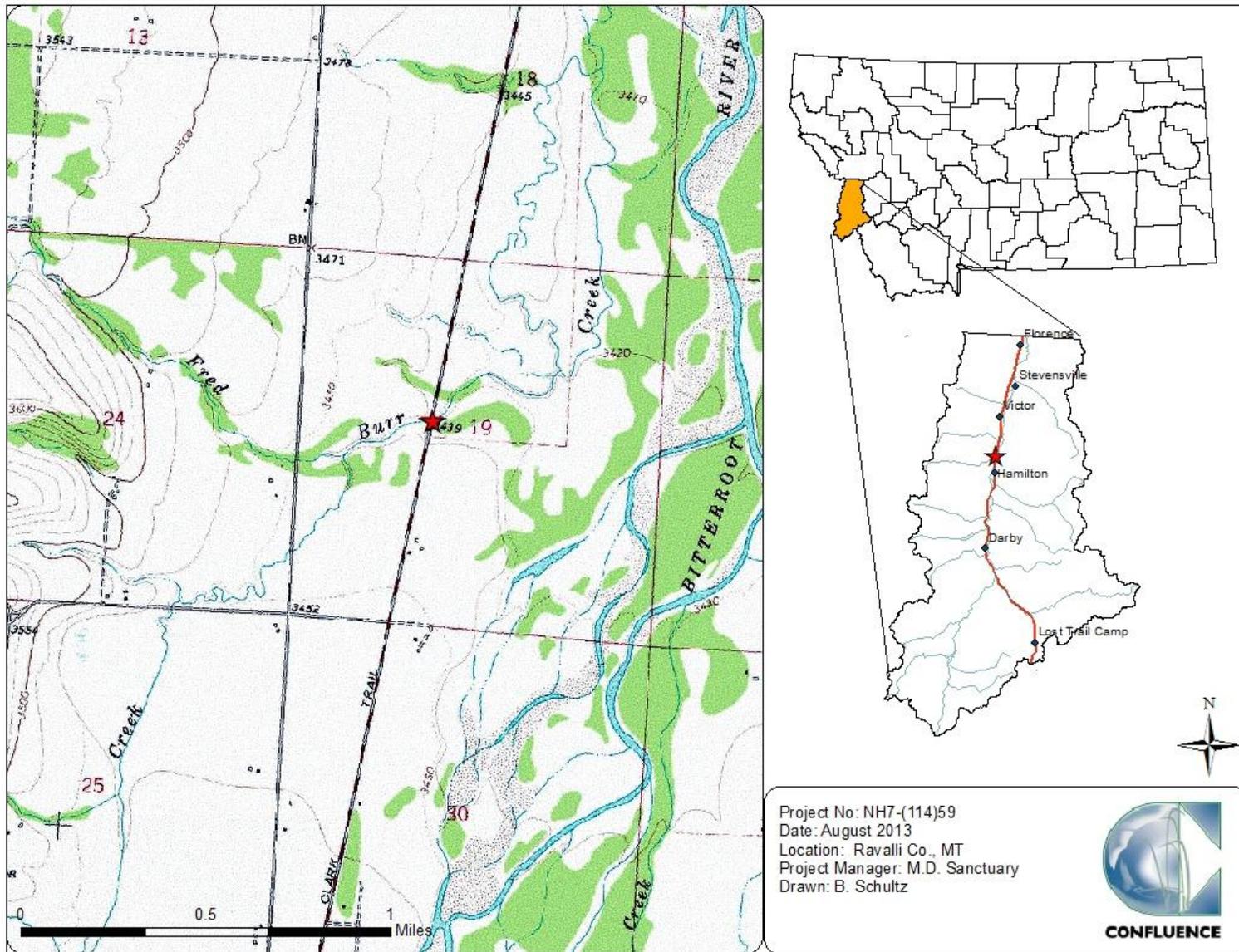


Figure 1. Project location of Mill Creek stream mitigation site.

3.4. Longitudinal Profile

A longitudinal profile of the channel thalweg was surveyed to document bedform complexity and aquatic habitat conditions present within the monitoring reach.

3.5. Photo-Documentation

Photos were taken at all photo points established during the first monitoring event in 2013 to document vegetation establishment and stream bank conditions within the project site. Photos were also taken at each perpendicular cross section in the upstream and downstream direction, as well as toward each stream bank.

4.0 RESULTS

4.1. Riparian Vegetation Inventory-Belt Transects

Table 1 summarizes the vegetative composition of each riparian transect, including areal percent cover of total vegetation, woody vegetation, and noxious weeds. In 2014, the total percent riparian cover was 85%, and included 59% cover by herbaceous species and 26% cover by woody species. Noxious weed coverage increased to 15% in 2014.

Table 1. Riparian vegetation composition of Mill Creek in 2013 and 2014.

Belt Transect	Length (ft)	Total % Riparian Cover		% Woody Cover		% Noxious Weed Cover	
		2013	2014	2013	2014	2013	2014
Right (south bank)	140	100	100	60	60	1	1
Left (north bank)	435	75	80	15	15	15	20
Total	575	81	85	26	26	8	15

Table 2 includes a comprehensive list of plant species observed along the new channel alignment and riparian buffer areas in 2013 and 2014. In 2014, 83 species were observed, representing an increase of 29 species from the previous monitoring event. In 2014, 52% of the species observed were hydrophytic based on the 2014 National Wetland Plant List (NWPL) (Lichvar et al., 2014).

The vegetation inventory along Mill Creek identified six Montana state-listed noxious weeds and one state-regulated species (Table 3). Locations of all noxious weeds observed are shown on Figure 3 in Appendix A.

Table 2. Comprehensive list of plant species identifies at the Mill Creek stream mitigation site in 2013 and 2014.

Scientific Name	Common Name	WMVC Indicator Status*
<i>Achillea millefolium</i>	Common Yarrow	FACU
<i>Agrostis gigantea</i>	Black Bent	FAC
<i>Alnus incana</i>	Speckled Alder	FACW
<i>Alopecurus aequalis</i>	Short-Awn Meadow-Foxtail	OBL
<i>Alyssum alyssoides</i>	Pale Alyssum	NL
<i>Antennaria parvifolia</i>	Nuttall's Pussytoes	NL
<i>Aster sp.</i>	Aster	NL
<i>Bassia scoparia</i>	Mexican-Fireweed	FAC
<i>Betula pumila</i>	Bog Birch	OBL
<i>Bromus arvensis</i>	Field Brome	UPL
<i>Bromus inermis</i>	Smooth Brome	FAC
<i>Bromus japonicus</i>	Japanese Brome	NL
<i>Bromus tectorum</i>	Cheatgrass	NL
<i>Carex aquatilis</i>	Leafy Tussock Sedge	OBL
<i>Carex nebrascensis</i>	Nebraska Sedge	OBL
<i>Carex sp.</i>	Sedge	NL
<i>Carex stipata</i>	Stalk-Grain Sedge	OBL
<i>Carex utriculata</i>	Northwest Territory Sedge	OBL
<i>Centaurea stoebe</i>	Spotted Knapweed	NL
<i>Chamerion angustifolium</i>	Fireweed	NL
<i>Cirsium arvense</i>	Canadian Thistle	FAC
<i>Cornus alba</i>	Red Osier	FACW
<i>Crataegus douglasii</i>	Black Hawthorn	FAC
<i>Dactylis glomerata</i>	Orchard Grass	FACU
<i>Dasiphora fruticosa</i>	Golden-Hardhack	FAC
<i>Deschampsia cespitosa</i>	Tufted Hairgrass	NL
<i>Descurainia sophia</i>	Herb Sophia	NL
<i>Eleocharis palustris</i>	Common Spike-Rush	OBL
<i>Elymus hispidus</i>	Intermediate Wheatgrass	NL
<i>Elymus repens</i>	Creeping Wild Rye	FAC
<i>Epilobium ciliatum</i>	Fringed Willowherb	FACW
<i>Equisetum arvense</i>	Field Horsetail	FAC

*Based on 2014 NWPL (Lichvar *et al.*, 2014)
New species identified in 2014 are **bolded**.

Table 2 (Continued). Comprehensive list of plant species identified at the Mill Creek stream mitigation site in 2013 and 2014.

Scientific Name	Common Name	WMVC Indicator Status*
<i>Equisetum hyemale</i>	Tall Scouring-Rush	FACW
<i>Euphorbia esula</i>	Leafy Spurge	NL
<i>Festuca idahoensis</i>	Bluebunch Fescue	FACU
<i>Fragaria virginiana</i>	Virginia Strawberry	FACU
<i>Geum macrophyllum</i>	Large-Leaf Avens	FAC
<i>Geum sp.</i>	Avens	NL
<i>Juncus balticus</i>	Baltic Rush	FACW
<i>Juncus effusus</i>	Lamp Rush	FACW
<i>Juncus ensifolius</i>	Dagger-Leaf Rush	FACW
<i>Juncus sp.</i>	Rush	NL
<i>Kochia scoparia</i>	Mexican Kochia	NL
<i>Lepidium latifolium</i>	Broad-Leaf Pepperwort	FAC
<i>Leucanthemum vulgare</i>	Ox-Eye Daisy	FACU
<i>Lolium perenne</i>	Perennial Rye Grass	FAC
<i>Lupinus sericeus</i>	Pursh's Silky Lupine	NL
<i>Medicago lupulina</i>	Black Medick	FACU
<i>Melilotus officinalis</i>	Yellow Sweet-Clover	FACU
<i>Mentha arvensis</i>	American Wild Mint	FACW
<i>Mimulus guttatus</i>	Seep Monkey-Flower	OBL
<i>Myosotis laxa</i>	Bay Forget-Me-Not	OBL
<i>Onopordum acanthium</i>	Scotch Thistle	NL
<i>Pascopyrum smithii</i>	Western-Wheat Grass	FACU
<i>Persicaria amphibia</i>	Water Smartweed	OBL
<i>Persicaria sp.</i>	Smartweed	NL
<i>Phalaris arundinacea</i>	Reed Canary Grass	FACW
<i>Phleum pratense</i>	Common Timothy	FAC
<i>Pinus ponderosa</i>	Ponderosa Pine	FACU
<i>Poa palustris</i>	Fowl Blue Grass	FAC
<i>Poa pratensis</i>	Kentucky Blue Grass	FAC
<i>Populus angustifolia</i>	Narrow-Leaf Cottonwood	FACW
<i>Populus balsamifera</i>	Balsam Poplar	FAC

*Based on 2014 NWPL (Lichvar *et al.*, 2014)
New species identified in 2014 are **bolded**.

Table 2 (Continued). Comprehensive list of plant species identifies at the Mill Creek stream mitigation site in 2013 and 2014.

Scientific Name	Common Name	WMVC Indicator Status*
<i>Ribes lacustre</i>	Bristly Black Gooseberry	FAC
<i>Rosa woodsii</i>	Woods' Rose	FACU
<i>Rumex acetosella</i>	Common Sheep Sorrel	FACU
<i>Rumex crispus</i>	Curly Dock	FAC
<i>Salix bebbiana</i>	Gray Willow	FACW
<i>Salix exigua</i>	Narrow-Leaf Willow	FACW
<i>Scirpus microcarpus</i>	Red-Tinge Bulrush	OBL
<i>Silene vulgaris</i>	Maiden's-tears	NL
<i>Sisymbrium altissimum</i>	Tall Hedge-Mustard	FACU
<i>Solanum dulcamara</i>	Climbing Nightshade	FAC
<i>Solidago canadensis</i>	Canadian Goldenrod	FACU
<i>Sonchus arvensis</i>	Field Sow-Thistle	FACU
<i>Symphoricarpos albus</i>	Common Snowberry	FACU
<i>Tanacetum vulgare</i>	Common Tansy	FACU
<i>Taraxacum officinale</i>	Common Dandelion	FACU
<i>Tragopogon pratensis</i>	Meadow Goat's-beard	NL
<i>Trifolium pratense</i>	Red Clover	FACU
<i>Trifolium repens</i>	White Clover	FAC
<i>Verbascum thapsus</i>	Great Mullein	FACU
<i>Veronica americana</i>	American-Brooklime	OBL

*Based on 2014 NWPL (Lichvar *et al.*, 2014)
New species identified in 2014 are **bolded**.

Table 3. Montana State listed noxious weed and regulated species observed in 2014 at the Mill Creek Stream Mitigation Site.

Category*	Scientific Name	Common Name
Priority 2A	<i>Lepidium latifolium</i>	Broad-Leaf Pepperwort
Priority 2B	<i>Centaurea stoebe</i>	Spotted Knapweed
	<i>Cirsium arvense</i>	Canadian Thistle
	<i>Euphorbia esula</i>	Leafy Spurge
	<i>Leucanthemum vulgare</i>	Ox-Eye Daisy
	<i>Tanacetum vulgare</i>	Common Tansy
Priority 3 State Regulated	<i>Bromus tectorum</i>	Cheatgrass

*Based on the MSU Extension Services' Noxious Weed List, 2013

4.2. Bank Erosion Inventory

Four eroding banks were observed within the project reach (EBL3, EBL4, EBR1, EBR2). Two eroding banks (EBL1 and EBL2) that were identified in 2013 occur just upstream of the project reach, and combined into one long eroding bank segment in 2014. Locations of all eroding banks are illustrated on Figure 2 in Appendix A. A qualitative erosion severity rating was generated by observing substrate composition of the bank, vegetation composition, and whether depositional features such as point bars were developing near the erosional area. Descriptions of erosion at each bank are included in the following section.

Two eroding banks, including EBL1 and EBL2, occur on the left (north) side of the channel just upstream of the reconstructed channel segment. These two banks were included in the stream bank erosion inventory due to the potential of these banks affecting the project reach. The initial monitoring event mapped these banks as separate; however subsequent erosion has combined EBL1 and EBL2, into a continuous, 247-foot long eroding bank. Bank erosion at this location is due to point bar formation forcing the channel against an herbaceous vegetated stream bank on a relatively sharp meander. Rootwads and large rocks placed, but not keyed into the toe of the banks is causing increased scour and block failure. The vegetation community along these banks include alder, Kentucky blue-grass, smooth brome, sedges, yarrow, western wheatgrass, goldenrod, and ox-eye daisy. The bank has retreated between 3 and 7 feet since 2013. Based on the combination of eroding factors, severity of erosion along EBL1 and EBL2 is considered high.

Erosion at EBL3 is occurring at the head of the former channel alignment, and extends downstream approximately 90 feet to beyond a newly fallen tree. Erosion is occurring along lower stream bank causing bank failure and retreat. The vegetation community consists of meadow foxtail, white and red clover, Kentucky blue-grass, common tansy, and ox-eye daisy. The bank has retreated approximately 1 to 2 feet since 2013. Based on the combination of erosion factors, severity of erosion along EBL3 is considered low.

At eroding bank EBL4, bank sloughing has continued to occur upstream and downstream of root balls that have fallen into the channel. The 64-foot long eroding bank has several root balls from cut trees along the toe, which may have been used to construct the log revetment just downstream. Bank instability at this location is potentially caused by removal of the trees for use in log revetment construction, or from natural channel adjustments following construction. The dominant vegetation along the bank includes reed canary grass and smooth brome. The bank has retreated approximately 1 to 2 feet since 2013, and is considered low to moderate in severity.

At eroding bank EBR1, several trees have fallen into the channel due to undercutting directly across the channel from EBL4. Trees have also fallen away from the channel, providing evidence of undercutting and block failure, or blow down. The bank appeared more stable during the 2014 monitoring event than in 2013. The vegetation community along this bank consists of cottonwood, alder, smooth brome, and birch. Bank erosion severity along this 58-foot segment is considered low.

Erosion at EBR2 occurs along 65 feet of the channel across from the head of the deactivated stream channel. Erosion at this location is due to channel migration and outside bend scouring. Erosion is occurring along the bank toe with block failure occurring. The vegetation community is dominated by reed canary grass with an alder and birch overstory. This bank has retreated approximately 2 to 3 feet since 2013. These factors contribute to an overall low severity rating.

4.3. Perpendicular Transects

Plots for each surveyed transect are included in Appendix B. Transect #2 and #3 were surveyed at scour pools formed by woody debris jams, while transects #1 and #4 were surveyed at riffles.

The channel at riffle transect #1 appears to be more indicative of a pool, with development of an adjacent point bar and thalweg along the right bank. Bank erosion was noted along this bank during the 2014 monitoring event, although the re-survey does not indicate significant lateral migration toward the south. Upstream of this transect, the channel has migrated northward (Eroding Bank 1-2), and the channel now appears to be creating a shallow pool along the right bank through transect #1. Inspection of the longitudinal profile indicates the bed at this transect occurs at a shallow pool (STA 140+00).

Riffle transect #4 occurs just above the last bend upstream of the U.S. Highway 93 Bridge. The re-survey at this transect indicated some deposition along the left (north) side of the channel with the thalweg along the right (south) bank. The stream bed does not appear to be aggrading, degrading, or laterally moving. Inspection of the longitudinal profile indicates the bed at this transect occurs at the downstream tail end of a pool (STA 500+00).

Pool transect #2 occurs at a woody debris jam, and has only slightly changed since the 2013 monitoring event. The point bar along the right bank has extended approximately 3 feet further north, while the pool has maintained similar depth along the left bank. Inspection of the longitudinal profile indicates this transect occurs within a shallow pool (STA 235+00).

The channel at pool transect #3 appears to have become shallower since the first monitoring event. A woody debris jam in the channel formed a large scour pool on the left (north) side of the channel and a smaller, shallower pool on the right (south) side. Pool depth on both sides of the channel became shallower, while the mid-channel bar also indicated gravel deposition. Inspection of the longitudinal profile indicates this transect also occurs within one of the shallower pools within the project reach (STA 300+00).

Transect surveys conducted at four locations in 2014 indicate relatively minor channel adjustments due to both scour and depositional processes. Within the project reach, the channel bed is a complex development of riffles, and pools forming around woody

debris complexes. The density of woody debris within the project reach is likely to result in stream bed adjustments at both riffles and pools as the channel naturally reacts to erosion and bedload deposition.

4.4. Longitudinal Profile

A longitudinal profile of the stream bed along the thalweg was surveyed to document bedform complexity and aquatic habitat conditions (Appendix B). The bed profile indicates the presence of two deep and multiple shallow pools separated by very short riffles. Shorter, shallower pools exist primarily between meander bends where woody debris is generating localized pool development. Two longer, deeper pools exist (from STA 30+00 to 120+00; and from 320+00 to 420+00) where the channel is scouring against the outside bank of the meander bends. The short riffle features are likely to move as subsequent high flow events continue to deposit and erode the channel, woody debris features migrate, and the channel shifts within its floodplain.

5.0 COMPARISON OF RESULTS TO PERFORMANCE STANDARDS

Monitoring of the Mill Creek Stream Mitigation site is intended to document whether the reconstructed segment of the channel is meeting performance standards outlined in the approved U.S. Army Corps permit for the project. Table 4 summarizes the status of each performance criteria three years following completion of the project. Additional reporting requirements, including results of the perpendicular transects, bed profile survey, photo-documentation, and as-built topographic schematics are included as appendices to this report.

Table 4. Status of performance standards three years following project completion.

Parameter	Success Criteria	Status	Meeting Performance Criteria?
Riparian Cover	80% total vegetative coverage after 3rd year	Total vegetative cover of the project site is 84% following first year of monitoring (100% of south bank and 80% of left bank).	Yes
	50% woody species coverage after 3rd year	Woody cover of the project site is 25% following second year of monitoring (60% of south bank and 15% of north bank).	No
Streambank Stability	Unstable banks identified within the project reach will require corrective action	Five eroding bank segments were observed in 2014 and range in severity from minor to severe.	No

5.1. Riparian Cover

Vegetation along the south bank of Mill Creek was minimally disturbed during construction of the new channel alignment and was limited to a short (approximately 50') reach immediately adjacent to the new highway bridge. This channel segment has been stabilized with rock to protect the bridge infrastructure. As a result, the success of revegetation efforts should focus on the north bank along areas where construction equipment accessed the new channel alignment and filled the former channel configuration.

Total vegetative cover observed along the north bank riparian transect was 80%, which falls right at the success criteria threshold of 80%. Patches of bare ground were observed along the deactivated channel alignment. Bare ground was also observed beneath mature ponderosa pine trees, although the layer of pine needles beneath these trees is a natural cause for barren ground cover. When factoring in the undisturbed south bank, total vegetative cover across the site was 84%.

Woody vegetation cover along the north bank was 15%, which falls well below the success criteria threshold of 50%. No woody vegetation was observed along the backfilled channel segment, and relatively few woody shrubs were observed along the north bank of the newly aligned channel. Several mature ponderosa pine trees remain along the north bank and provide the majority of the woody species composition. When factoring in the undisturbed south bank woody species cover, total woody cover for the site is 25%.

Weed species accounted for 20% of the vegetative cover along the north side of the channel, 1% along the south side of the channel, and 15% of the vegetation within the monitored riparian transects. Based on these results, weed control and the establishment of additional woody vegetation will be necessary along the north bank to meet performance criteria for riparian cover.

5.2. Bank Erosion Inventory

Four eroding streambanks were observed in the project area, while one additional eroding bank (combination of EBL1 and EBL2) occurs immediately upstream of the project reach (Figure 2, Appendix A). The eroding bank upstream of the project area was included in the bank inventory.

The total length of bank erosion observed within the project reach increased following the first monitoring event, with relatively short bank segments ranging from 45-58' in 2013 lengthening to 58-90' in 2014. Although additional erosion was recorded in 2014, the severity of erosion within the project reach is considered low, and is likely due to the newly activated channel segment naturally adjusting. Lateral bank migration rates in the project reach are on the order of 1-2 feet/year. The erosion occurring does not jeopardize infrastructure or threaten to overtake the deactivated channel segment.

The eroding bank immediately upstream of the project area is moving at a more rapid pace than other eroding banks within the project reach. This bank will likely continue to erode until a stable radius of curvature is established, or until this meander bend is cut off. The lateral migration of the bank northward does not currently jeopardize infrastructure, and is not currently threatening the relocated channel segment.

6.0 MANAGEMENT RECOMMENDATIONS

6.1. Woody Vegetation Establishment

Woody vegetation composition is relatively low along the disturbed sections of the north bank, which prevents achievement of the performance criteria for this category. Installation of additional woody vegetation is recommended within 25' of the bank, particularly within backfilled areas of the deactivated channel segment. No woody vegetation was observed within the backfilled channel segment. Installation of willows, alder, chokecherry, or Wood's rose within these areas would improve woody species composition within the riparian zone and assist in meeting this performance target.

6.2. Weed Control

Weed species comprised 20% of the north bank vegetation composition. Weed control efforts are warranted along the north bank to prevent the spread of these species. Weed species necessary to target include broad-leaf pepperwort, spotted knapweed, Canadian thistle, leafy spurge, oxeye daisy, common tansy, and cheat grass.

6.3. Channel Stability

The project reach exhibits a significant amount of recent bedload deposition, gravel point bar formation, and formation of woody debris jams. The result of these processes includes some relatively minor lateral adjustments within the newly activated channel segment. Lateral bank adjustments are typical in streams exhibiting an abundance of bedload material, and should not be mistaken for overall channel instability. The stream banks within the project reach include a gravel/cobble toe overlain by a lens of finer gravel and vegetated topsoil. The banks are relatively steep and susceptible to lateral movements during high flows. Eliminating erosion from occurring within the entire project reach would require armoring each outside meander bend with oversized boulders, or constructing a series of barbs or vanes to deflect energy away from the banks. Neither of these approaches lends to development of a natural channel with supporting habitat components, or would provide appropriate mitigation to offset the project's impacts.

The approved 404 permit for the Mill Creek project states, "If any unstable stream banks are visible within the relocated channel, corrective measures will be required." Four eroding banks occur within the relocated channel segment of the project reach (EBL3, EBL4, EBR1, and EBR2). These banks exhibit bank sloughing, resulting in recruitment of gravel and woody debris to the channel, both of which are beneficial to maintaining trout habitat. In order to maintain a functional, sustainable stream channel, it could be argued these banks should be allowed to naturally adjust until such time as the channel configuration threatens stability of the bridge or highway. However, in order to meet the success criteria outlined in the permit, all of these banks must receive corrective actions.

Two eroding banks identified during the 2013 monitoring event have combined into one long, eroding bank immediately upstream of the project reach (EBL1 and EBL2). Although these banks lie outside of the relocated channel segment, they were noted

and mapped due to the potential that they could affect the reconstructed channel segment. These banks occur on a very sharp bend of Mill Creek, where the channel turns approximately 135 degrees over a length of about 200 feet. This sharp turn in the channel will likely continue to result in lateral movement of the channel to the north until a stable meander radius is established. The landowner has attempted to slow the erosion by cabling a tree and placing large boulders along the bank; however, these efforts are unlikely to successfully reduce the rate of lateral bank movement at this location. Erosion along this bank could be reduced with bioengineering techniques including installing a stone toe, resloping the vertical bank, and installing dense woody riparian vegetation.

6.4. Floodplain Fill

A chunk of asphalt was found in the materials used to fill the deactivated channel segment. It is unknown where the material used to fill the old channel originated, or whether that material came from excavating the new channel alignment. It is possible fragments of asphalt may have been mixed with native gravel and cobbles near the highway project where fill material was generated. It is recommended all fill materials used to fill deactivated channel segments be inspected for foreign materials prior to placement.

6.5. Livestock Access

Evidence of livestock access to the project reach was observed downstream of the Highway 93 Bridge during the first monitoring event in 2013. Although livestock scat and tracks were observed here, the project reach was not harmfully affected by grazing practices. If possible, livestock access should be limited to areas downstream of the bridge to allow time for revegetation efforts upstream of the bridge to colonize. It does not appear livestock grazing currently occurs upstream of the bridge.

6.6. Woody Debris

Several woody debris jams have formed in the channel upstream of the bridge. These woody debris jams include trees that have been cut down, as well some that have naturally fallen into the creek. These debris jams are currently providing good aquatic habitat features, but should be monitored to ensure they do not create a large constriction upstream of the highway bridge. The bridge has been designed to convey a large flood event and will likely be successful at passing woody debris as well; however, periodic inspection of this bridge during and immediately following greater than bankfull flood events is recommended.

7.0 LITERATURE CITED

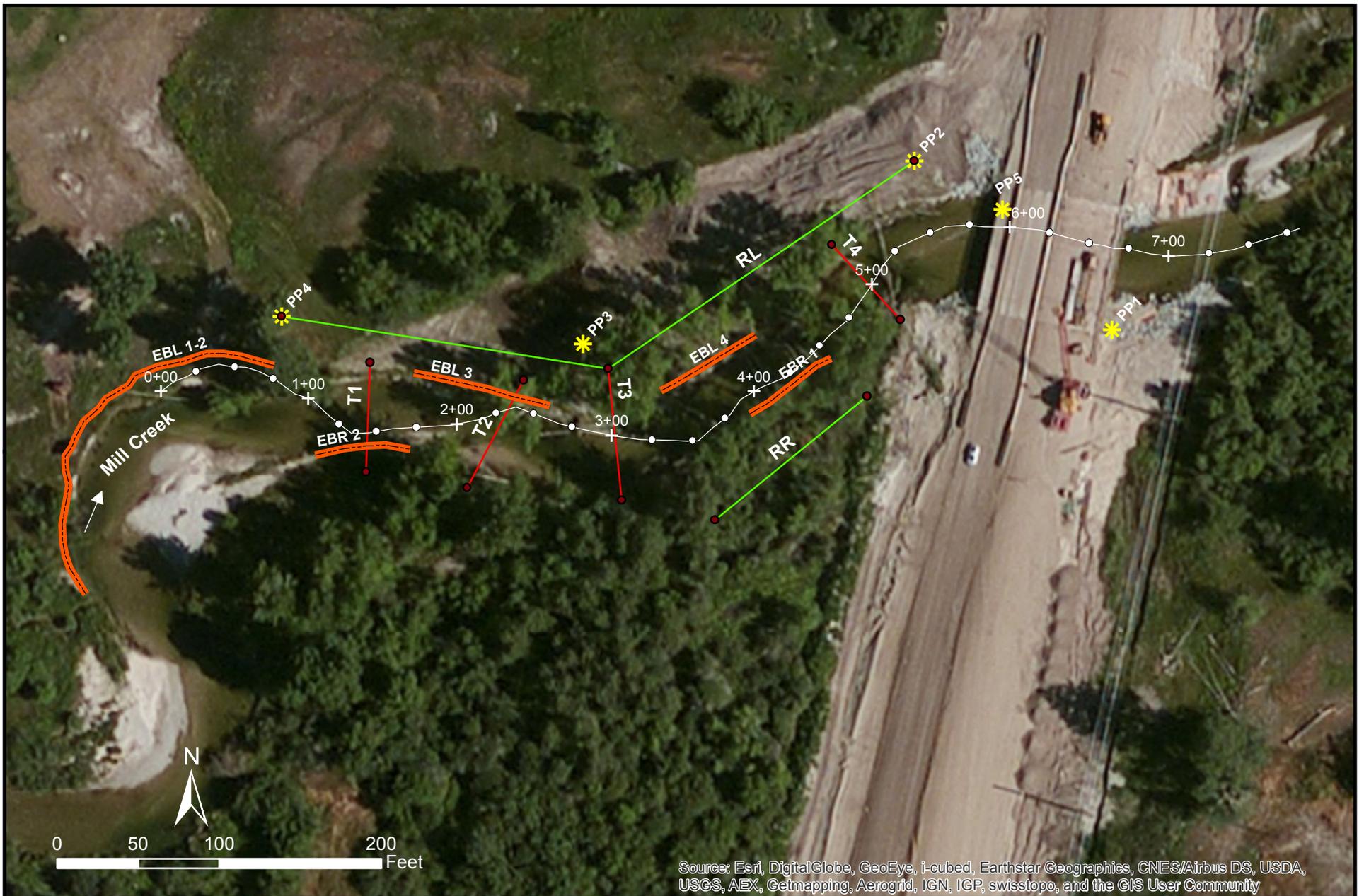
Lichvar, R.W., M. Butterwick, N.C. Melvin, and W.N. Kirchner. 2014. *The National Wetland Plant List. 2014 Update of Wetland Ratings*. Phytoneuron 2014-41:1-42.

Montana State University Extension website. Accessed in September 2014 at <http://www.msuextension.org/invasiveplantsMangold/noxioussub.html>

Appendix A

Project Map

MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana



Legend

- Photo Points
- Riparian and Perpendicular Transect Endpoints
- Channel Thalweg
- Major Station (100')
- Minor Station (25')
- Eroding Banks
- Pool and Riffle Transects
- Riparian Transects

2014 Monitoring Mill Creek

Figure 2

Date: 11/06/2014

X:/MDT_.007/mains



Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Legend

- | | | | |
|-------------------------------------------------------------------------------------|------------------|-------------------------------------------------------------------------------------|----------------------|
|  | Centaurea stoebe |  | Lepidium latifolium |
|  | Cirsium arvense |  | Leucanthemum vulgare |
|  | Euphorbia esula |  | Tanacetum vulgare |



**2014 Monitoring
Mill Creek**

Figure 3

Date: 11/04/2014

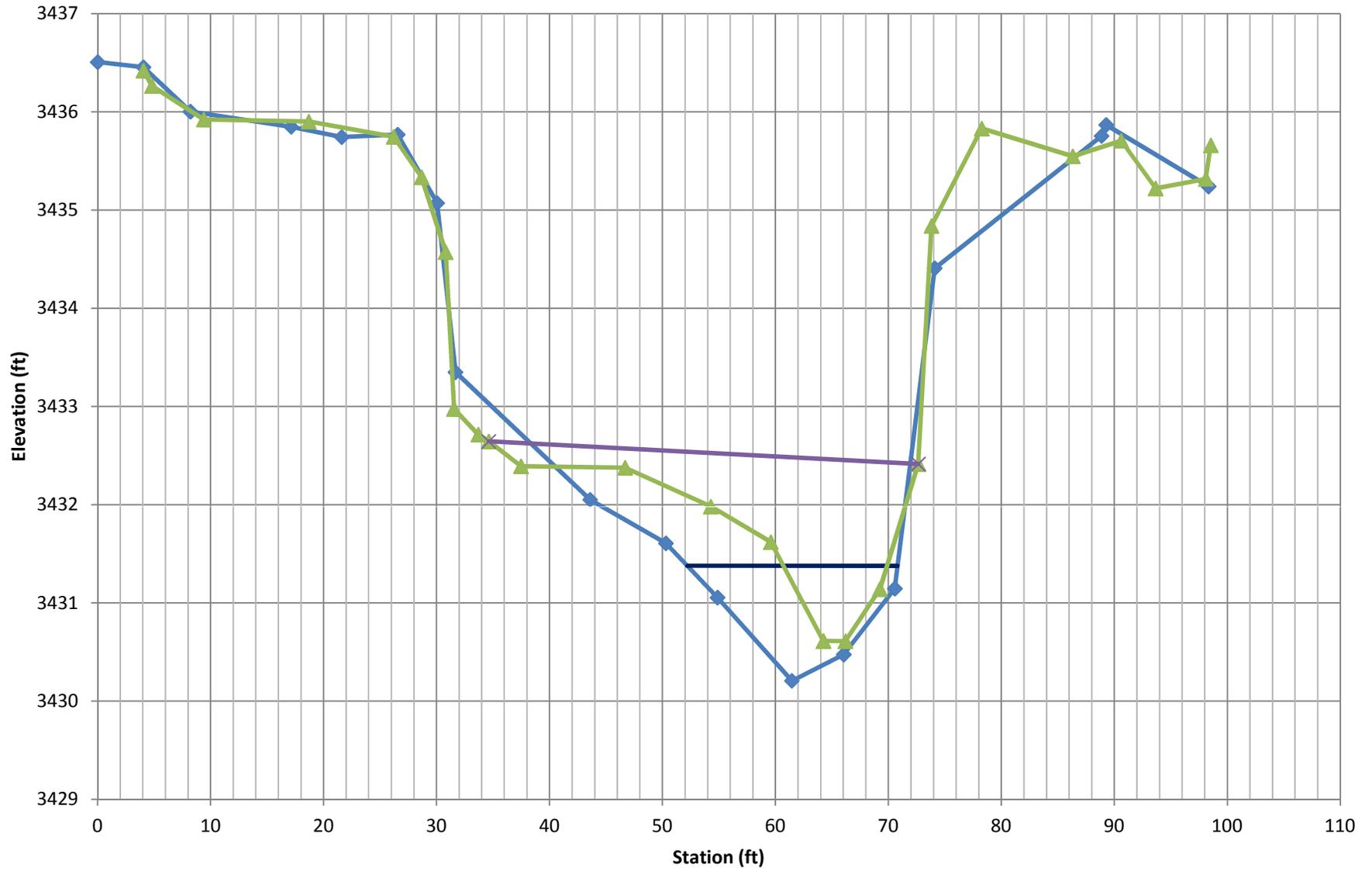
X:/MDT_.007/mains

Appendix B

Perpendicular Transect Plots and Longitudinal Profile

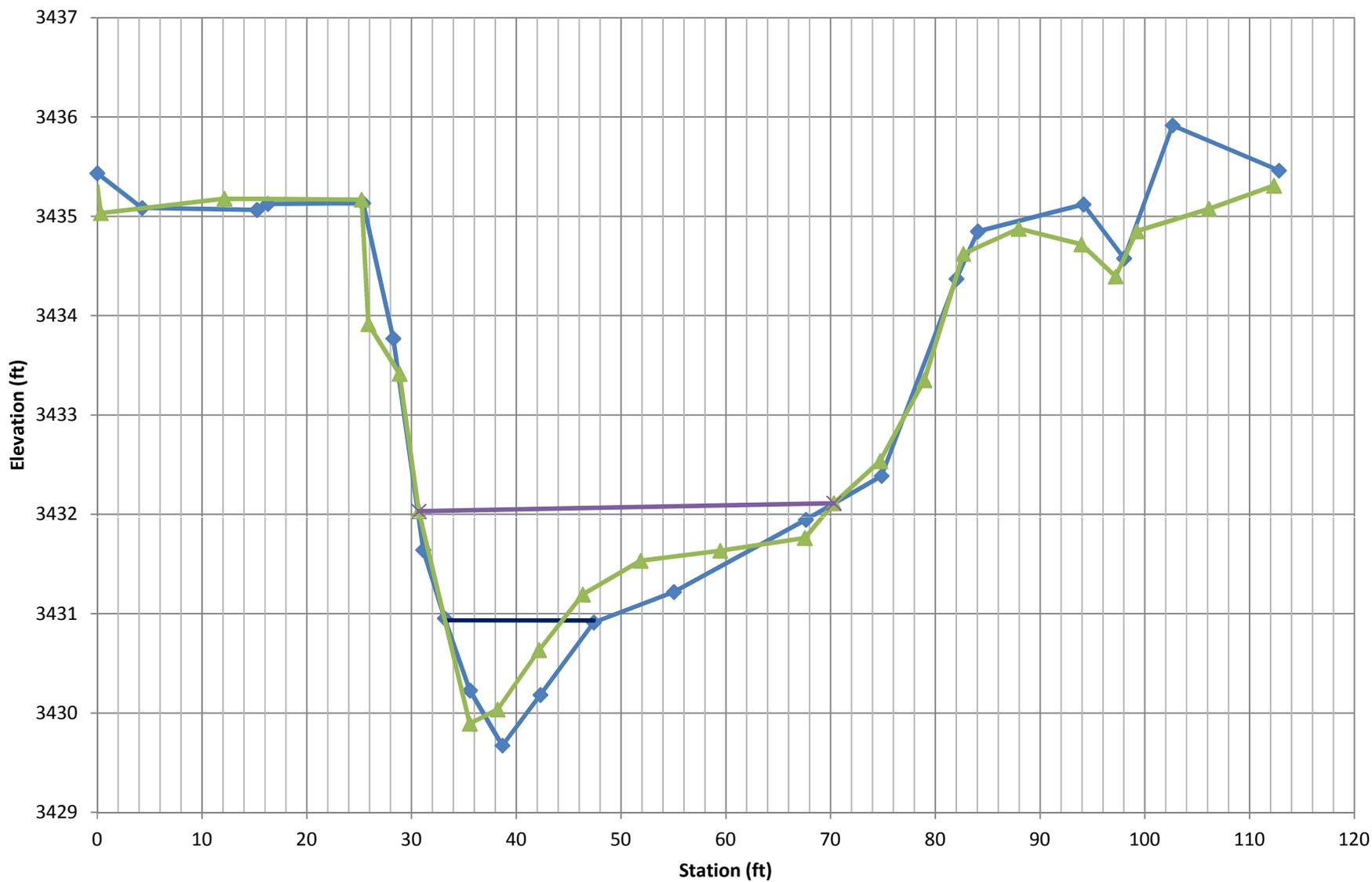
MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana

Mill Creek Transect #1 - Riffle



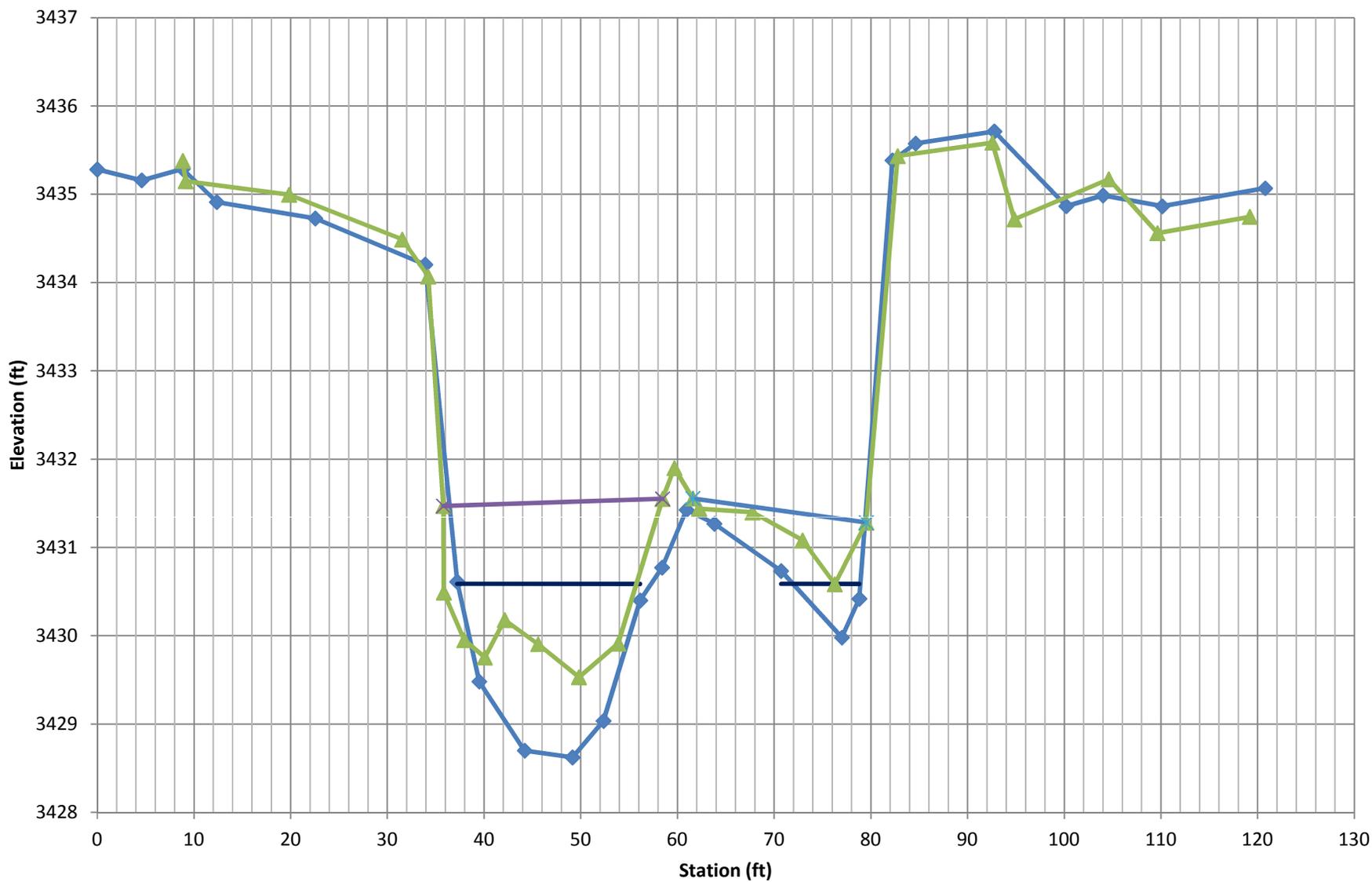
◆ 2013 XS — 2013 WS ▲ 2014 XS × 2014 WS

Mill Creek Transect #2 - Pool



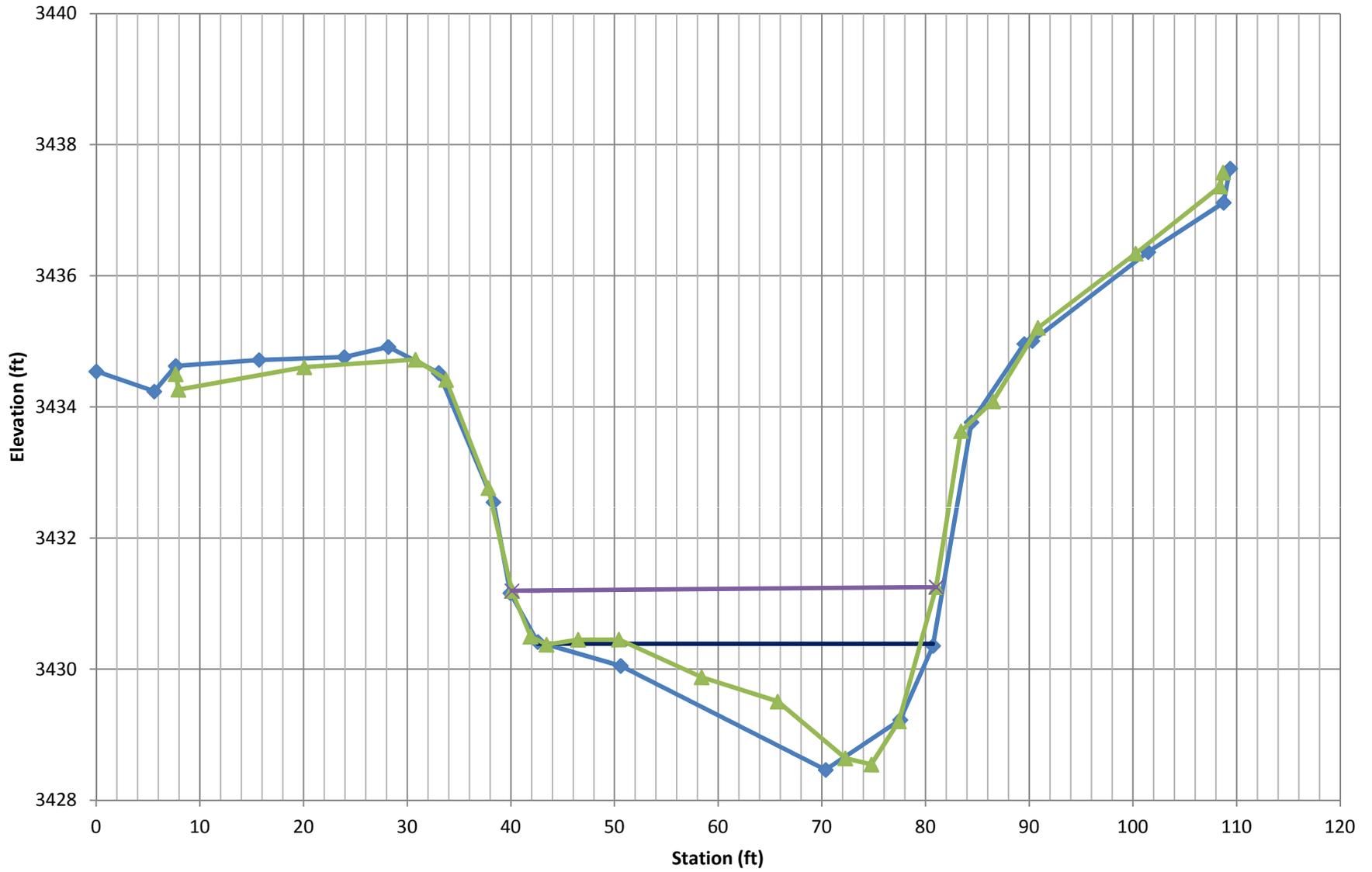
◆ 2013 XS — 2013 WS ▲ 2014 XS × 2014 WS

Mill Creek Transect #3 - Pool



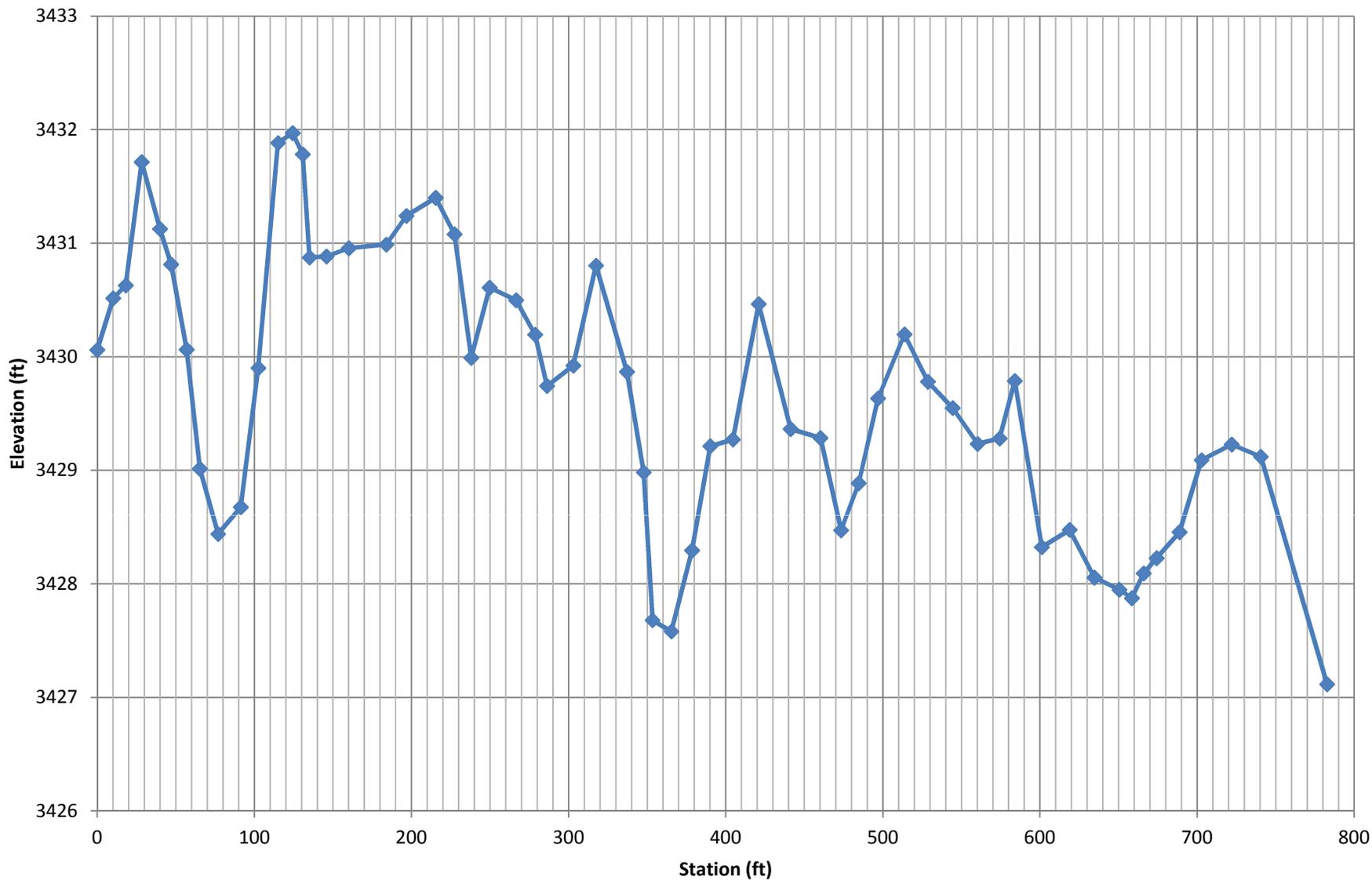
◆ 2013 XS — 2013 WS ▲ 2014 XS × 2014 WS * 2014 WS2

Mill Creek Transect #4 - Riffle



◆ 2013 XS — 2013 WS ▲ 2014 XS × 2014 WS

Mill Creek Longitudinal Profile



—◆— Channel Bed

Appendix C

Project Site Photos

MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Photo Point 1.1—2013
Description: View from south bridge abutment of north bank. **Compass:** 45 (Northeast)



Photo Point 1.1—2014
Description: View from south bridge abutment of north bank. **Compass:** 45 (Northeast)



Photo Point 1.2—2013
Description: View from right bridge abutment downstream. **Compass:** 45 (Northeast)



Photo Point 1.2—2014
Description: View from right bridge abutment downstream. **Compass:** 45 (Northeast)



Photo Point 2.1—2013
Description: View of bridge from Photo Point 2
Compass: 113 (East-Southeast)



Photo Point 2.1—2014
Description: View of bridge from Photo Point 2
Compass: 113 (East-Southeast)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Photo Point 2.2—2013
Description: View from north bank of fence line looking across stream channel. **Compass:** 225 (Southwest)



Photo Point 2.2—2014
Description: View from north bank of fence line looking across stream channel. **Compass:** 225 (Southwest)



Photo Point 2.3—2013
Description: View from Photo Point 2 looking up-stream. **Compass:** 248 (West-Southwest)



Photo Point 2.3—2014
Description: View from Photo Point 2 looking up-stream. **Compass:** 248 (West-Southwest)



Photo Point 2.4—2013
Description: View of deactivated channel alignment. **Compass:** 248 (West-Southwest)



Photo Point 2.4—2014
Description: View of deactivated channel alignment. **Compass:** 248 (West-Southwest)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Photo Point 2.5—2013
Description: View of deactivated channel alignment.
Compass: 248 (West-Southwest)



Photo Point 2.5—2014
Description: View of deactivated channel alignment.
Compass: 248 (West-Southwest)



Photo Point 3.1—2013
Description: View of deactivated channel segment from Photo point 3. **Compass:** 68 (East-Northeast)



Photo Point 3.1—2014
Description: View of deactivated channel segment from Photo point 3. **Compass:** 68 (East-Northeast)



Photo Point 3.2—2013
Description: View of deactivated channel plug from Photo Point 3. **Compass:** 45 (East)



Photo Point 3.2—2014
Description: View of deactivated channel plug from Photo Point 3. **Compass:** 45 (East)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Photo Point 3.3—2013
Description: View of deactivated channel plug from Photo Point 3. **Compass:** 0 (North)



Photo Point 3.3—2014
Description: View of deactivated channel plug from Photo Point 3. **Compass:** 0 (North)



Photo Point 3.4—2013
Description: View of deactivated channel plug from Photo Point 3. **Compass:** 315 (Northwest)



Photo Point 3.4—2014
Description: View of deactivated channel plug from Photo Point 3. **Compass:** 315 (Northwest)



Photo Point 3.5—2013
Description: View of the upstream extent of the deactivated channel segment. **Compass:** 270 (West)



Photo Point 3.5—2014
Description: View of the upstream extent of the deactivated channel segment. **Compass:** 270 (West)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Photo Point 3.6—2013
Description: View of north bank (foreground) and woody debris in the channel. **Compass:** 248



Photo Point 3.6—2014
Description: View of north bank (foreground) and woody debris in the channel. **Compass:** 248



Photo Point 3.7—2013
Description: View of north bank (foreground) and woody debris in the channel. **Compass:** 180 (South)



Photo Point 3.7—2014
Description: View of north bank (foreground) and woody debris in the channel. **Compass:** 180 (South)



Photo Point 4.1—2013
Description: View looking across deactivated channel segment. **Compass:** 90 (East)



Photo Point 4.1—2014
Description: View looking across deactivated channel segment. **Compass:** 90 (East)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Photo Point 4.2—2013

Description: View across stream channel toward south bank. **Compass:** 180 (South)



Photo Point 4.2—2014

Description: View across stream channel toward south bank. **Compass:** 180 (South)



Photo Point 4.3—2013

Description: View of point bar formation from Photo Point 4. **Compass:** 225 (Southwest)



Photo Point 4.3—2014

Description: View of point bar formation from Photo Point 4. **Compass:** 225 (Southwest)



Photo Point 4.4—2013

Description: View of boulders, root wads and logs placed along the north bank. **Compass:** 248



Photo Point 4.4—2014

Description: View of boulders, root wads and logs placed along the north bank. **Compass:** 248

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Photo Point 5.1—2013

Description: View looking upstream of south bank taken from bridge. **Compass:** 248 (West-Southwest)



Photo Point 5.1—2014

Description: View looking upstream of south bank taken from bridge. **Compass:** 248 (West-Southwest)



Photo Point 5.2—2013

Description: View looking upstream from bridge. **Compass:** 203 (South-Southwest)



Photo Point 5.2—2014

Description: View looking upstream from bridge. **Compass:** 203 (South-Southwest)



Photo Point 5.3—2013

Description: View of north bank from bridge. **Compass:** 270 (West)



Photo Point 5.3—2014

Description: View of north bank from bridge. **Compass:** 270 (West)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Description: Upper section of Eroding Streambank L3 in 2014



Description: Lower section of Eroding Streambank L3 in 2014

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Description: Eroding streambank L3 in 2013.



Description: Eroding streambank L4 in 2013.



Description: Eroding streambank R1 in 2013.



Description: Eroding streambank R1 in 2014.

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Description: Eroding Streambank L1 in 2013.



Description: Eroding streambank L1 in 2014.

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2014 Monitoring Events



Description: Eroding Streambank L2 in 2013.

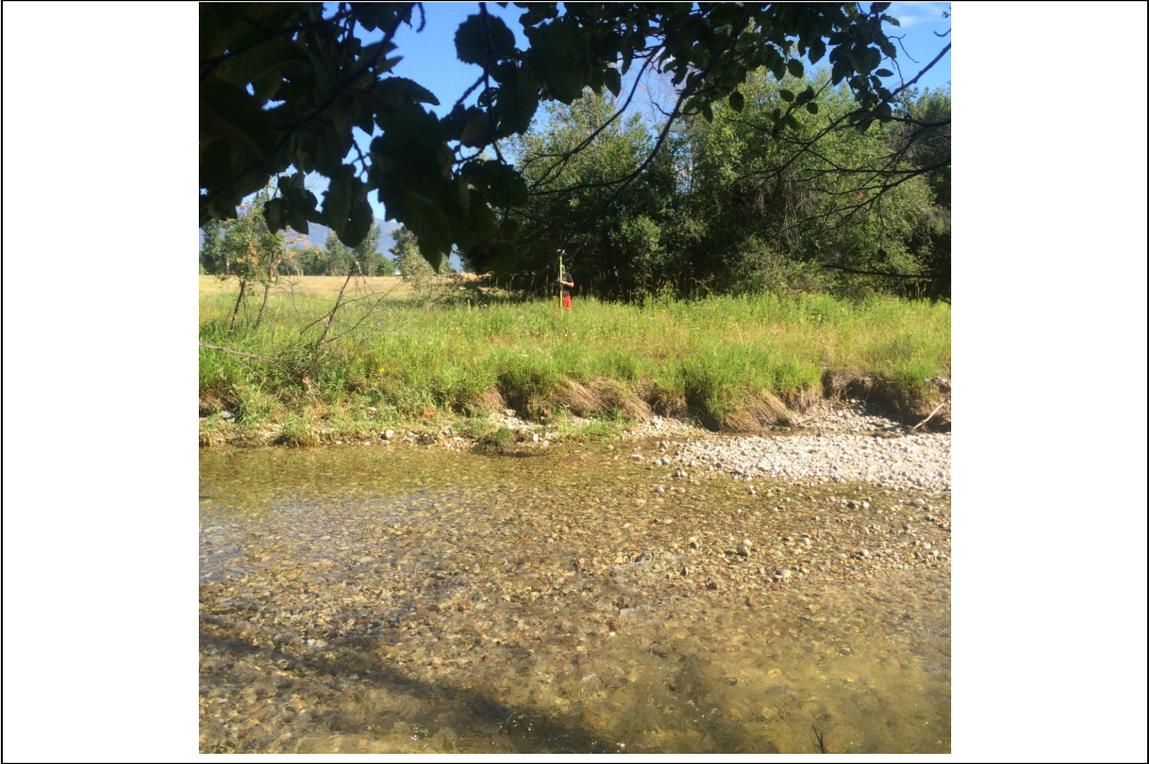


Description: Eroding Streambank L2 in 2014.



PHOTOGRAPHIC INSPECTION INFORMATION Page 1 of 20

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T1 LEFT LOOKING NORTH FROM T1 RIGHT



T1 RIGHT LOOKING SOUTH FROM T1 LEFT



PHOTOGRAPHIC INSPECTION INFORMATION Page 2 of 20

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T1 LOOKING UPSTREAM FROM RIGHT BANK



T1 LOOKING DOWNSTREAM FROM RIGHT BANK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 3 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T1 LOOKING UPSTREAM FROM MIDDLE OF CREEK



T1 LOOKING DOWNSTREAM FROM MIDDLE OF CREEK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 4 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T1 LOOKING NORTH FROM MIDDLE OF CREEK



T1 LOOKING SOUTH FROM MIDDLE OF CREEK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 5 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T1 LOOKING UPSTREAM FROM NORTH BANK



T1 LOOKING DOWNSTREAM FROM NORTH BANK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 6 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T2 LOOKING NORTH FROM T2 RIGHT



T2 LOOKING SOUTH FROM T2 LEFT



PHOTOGRAPHIC INSPECTION INFORMATION *Page 7 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T2 LOOKING UPSTREAM FROM RIGHT BANK



T2 LOOKING DOWNSTREAM FROM RIGHT BANK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 8 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T2 LOOKING UPSTREAM FROM MIDDLE OF CREEK



T2 LOOKING DOWNSTREAM FROM MIDDLE OF CREEK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 9 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-23-14



T2 LOOKING NORTH FROM MIDDLE OF CREEK



T2 LOOKING SOUTH FROM MIDDLE CREEK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 10 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T2 LOOKING UPSTREAM FROM LEFT BANK



T2 LOOKING DOWNSTREAM FROM LEFT BANK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 11 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T3 LOOKING NORTH FROM T3 RIGHT



T3 LOOKING SOUTH FROM T3 LEFT



PHOTOGRAPHIC INSPECTION INFORMATION *Page 12 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-23-14



T3 LOOKING UPSTREAM FROM RIGHT BANK



T3 LOOKING DOWNSTREAM FROM RIGHT BANK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 13 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T3 LOOKING UPSTREAM FROM MIDDLE OF CREEK



T3 LOOKING DOWNSTREAM FROM MIDDLE OF CREEK

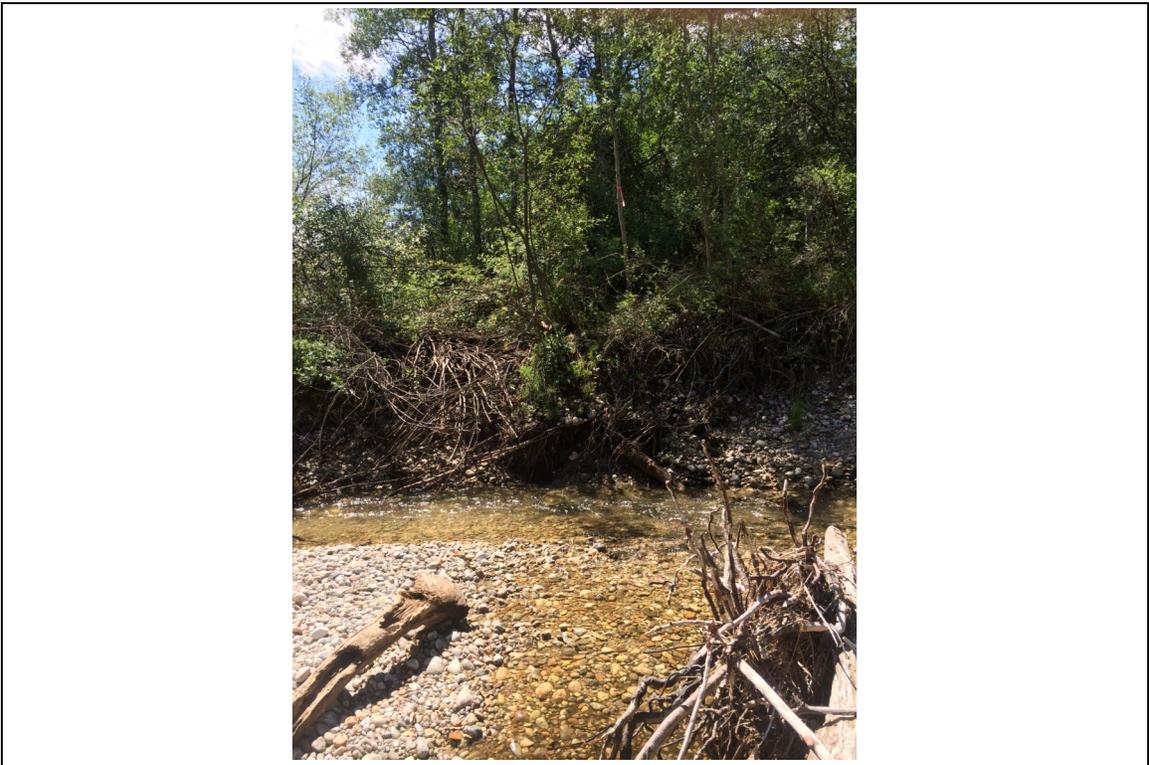


PHOTOGRAPHIC INSPECTION INFORMATION *Page 14 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T3 LOOKING NORTH FROM MIDDLE OF CREEK



T3 LOOKING SOUTH FROM MIDDLE OF CREEK

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-23-14



T3 LOOKING UPSTREAM FROM LEFT BANK



T3 LOOKING DOWNSTREAM FROM LEFT BANK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 16 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T4 LOOKING NORTH FROM T4 RIGHT



T4 LOOKING SOUTH FROM T4 LEFT
C-27



PHOTOGRAPHIC INSPECTION INFORMATION *Page 17 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T4 LOOKING UPSTREAM FROM RIGHT BANK



T4 LOOKING DOWNSTREAM FROM RIGHT BANK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 18 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T4 LOOKING UPSTREAM FROM MIDDLE CREEK



T4 LOOKING DOWNSTREAM FROM MIDDLE CREEK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 19 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK
DATE: 7-23-14



T4 LOOKING NORTH FROM MIDDLE CREEK



T4 LOOKING SOUTH FROM MIDDLE CREEK



PHOTOGRAPHIC INSPECTION INFORMATION *Page 20 of 20*

PROJECT NAME: 2014 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-23-14



T4 LOOKING UPSTREAM FROM LEFT BANK



T4 LOOKING DOWNSTREAM FROM LEFT BANK

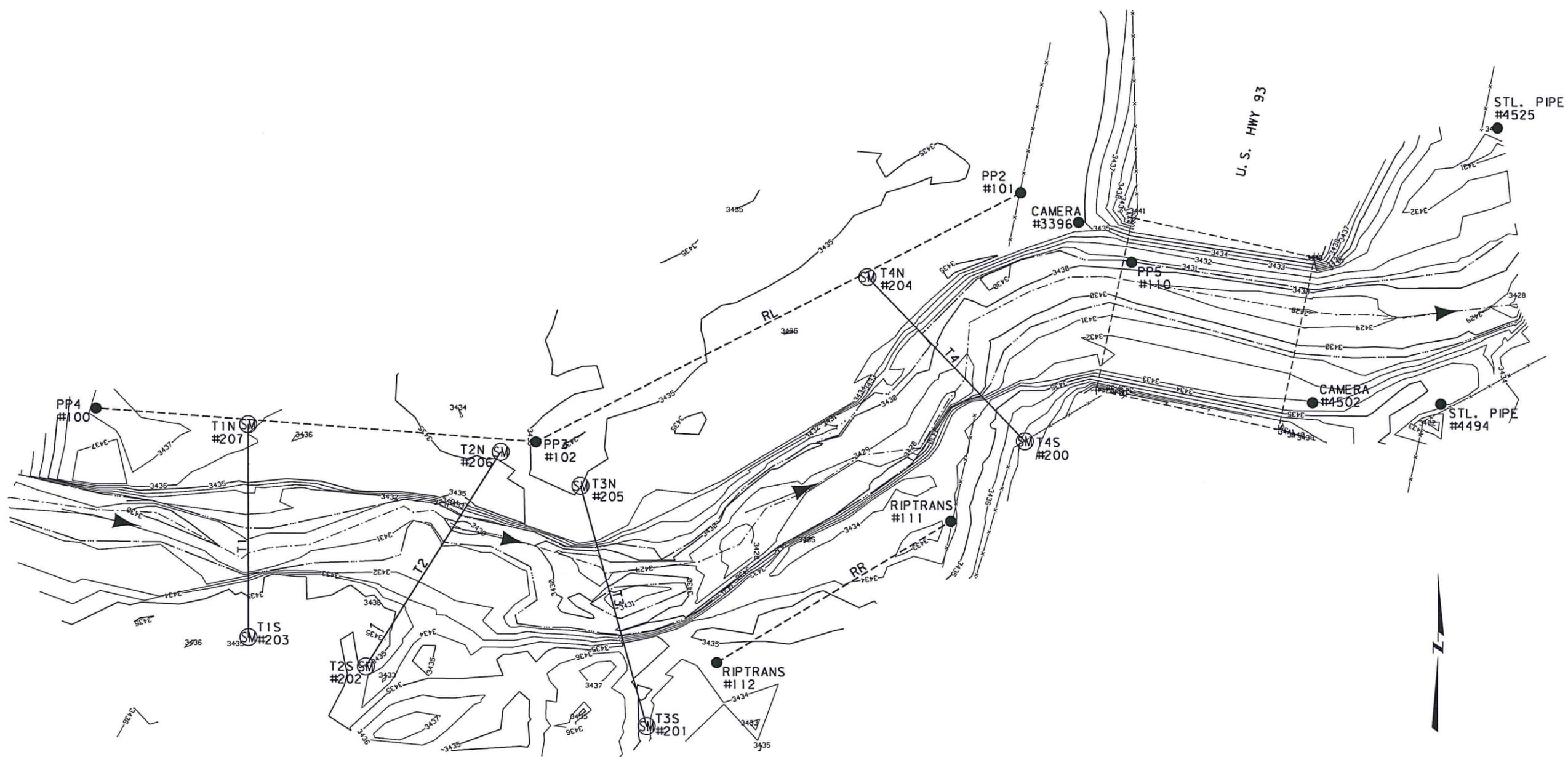
Appendix D

As-Built Surveys & Planting Schematics

MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana

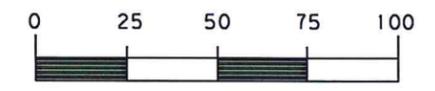
CONTROL TABLE				
PNT#	NORTHING	EASTING	ELEV.	DESCRIPTION
1	800550.322	796062.299	3440.783	CP AC BR2015
2	799324.627	795743.954	3443.762	CP AC BS2015

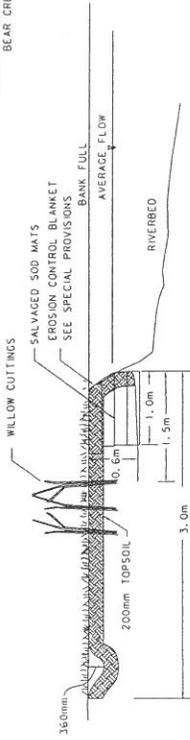
△ CP AC BR2015
#1



SURVEYOR NOTES:

1. THIS SURVEY IS BASED ON FOUND MDT ALUMINUM CAPS STAMPED BR2015 AND BS2015 BUT THEY DO NOT HAVE ESTABLISHED MDT COORDS AND ELEVATIONS. THEREFORE LOCAL CONTROL WAS ESTABLISHED FOR THIS SITE WITH TRIMBLE GPS RTK SURVEY AND THE APPROXIMATE ASSUMED ELEVATION AT MDT ALUM CAP BR2015.
2. THE COORDINATES SHOWN HEREON ARE BASED ON MONTANA STATE PLANE GRID

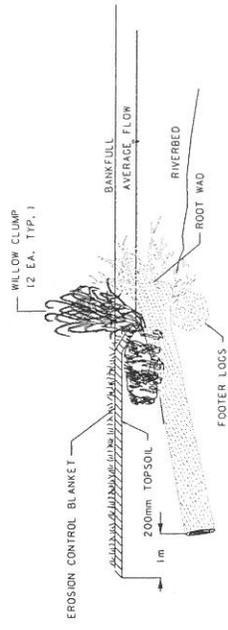




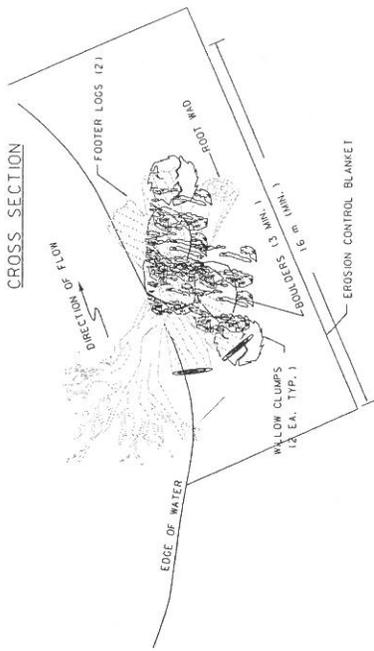
1. SUB EXCAVATE BANKS 0.6 METERS.
2. LAY LOWER BLANKET MINIMUM 1.5 METERS FROM EDGE OF BANK.
3. LAY UPPER BLANKET MINIMUM 1.5 METERS FROM EDGE OF BANK.
4. BACK FILL WITH BANK BACKFILL WITH ONE METRE OF SALVAGED SOD MATS.
5. WRAP BLANKET AND EXTEND 3.0 METERS MIN. FROM BANK EDGE.

EROSION CONTROL BLANKET TYPICAL

MILL CREEK



CROSS SECTION

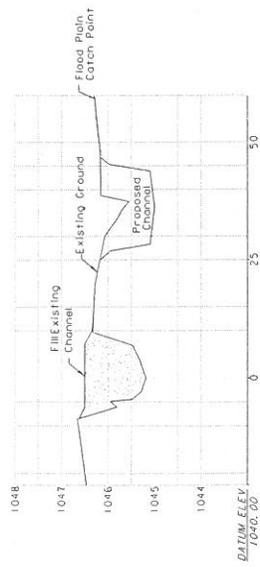


PLAN

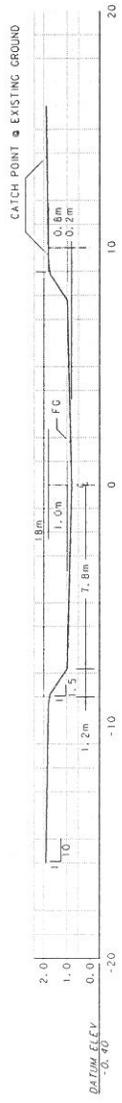
MILL CREEK CHANNEL RESTORATION DETAIL
STA. 97 + 16
SHEET 2 OF 3
NO SCALE

ROOT WAD TYPICAL

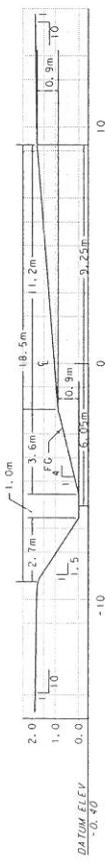
MILL CREEK



CROSS SECTIONS 1+97



TYPICAL RIFFLE CROSS SECTION



TYPICAL POOL LEFT CROSS SECTION

STATION	POOL LEFT	RIFFLE	POOL RIGHT
From To	(INCLUDES 4m TRANSITION)		
0+00 0+53			X
0+53 0+91	X		
0+91 1+10	X		X
1+10 1+34			X
1+34 1+51			X
1+51 2+20	X		
2+20 2+30	X		
2+30 5+00			

- NOTES:
- ① SEE PLANS FOR POOL LOCATION.
 - ② POOL LEFT TEL IS SHOWN, MIRROR POOL RIGHT LOOKING DOWNSTREAM.
 - ③ TRANSITION 4.0m BETWEEN POOL + RIFFLE.
 - ④ ROUND SLOPES FOR NATURAL APPEARANCE.