MONTANA DEPARTMENT OF TRANSPORTATION
STREAM MITIGATION MONITORING REPORT

Mill Creek
Ravalli County, Montana

Project Constructed: 2011
Monitoring Report #4: December, 2016

Prepared for:

MONTANA MDT DEPARTMENT OF TRANSPORTATION

Prepared by:

CONFLUENCE consulting incorporated

MONTANA DEPARTMENT OF TRANSPORTATION

STREAM MITIGATION MONITORING REPORT #4

YEAR 2016

Mill Creek
Ravalli County, Montana

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

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1.0 INTRODUCTION

The following report presents the results of the fourth year of post stream re-construction 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 (USACE) 404 permit for the project. Requirements outlined in this permit require five years of post-construction monitoring to evaluate compliance toward meeting performance standards. The project was constructed in 2011; therefore, these results provide documentation of the site's condition five 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 USACE, as outlined in USACE 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 fourth 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 map indicating the endpoints of riparian belt transects and perpendicular transect surveys, survey results at four perpendicular transects and a longitudinal profile, photo-documentation of the project site, a 2013 topographic survey of the project site, and planting plan from the approved design are included in Appendices as supporting information to document the site's condition.

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 Dataset 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 26, 2016 while topographic survey crews visited the site on July 28, 2016. The following data were collected at the Mill Creek stream mitigation site:

3.1. Riparian Vegetation Inventory - Belt Transects

Performance of riparian vegetation coverage was monitored by establishing two riparian belt transects in 2013. These transects were re-surveyed in 2016 to document areal percent cover of total vegetation, woody vegetation, and noxious weeds. Visual estimates of all vegetation species, woody species, and noxious weeds were recorded within riparian buffer areas extending 25 feet on either side of the active stream channel. Areal percent cover was recorded for each vegetation category based on ocular estimates. 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. The extent of each riparian transect is shown in Figure 3 of Appendix A.

All noxious weed infestations were identified and mapped on aerial photographs, with species, cover class, and infestation extent noted. Observations of isolated noxious weed occurrences were included in the species lists and total areal percent cover estimate of noxious weeds within the project area, but were not mapped. These results provide MDT a tool for developing site specific weed control plans for this mitigation site. Results of the noxious weed inventory are provided on Figure 4 of Appendix A.

3.2. Bank Erosion Inventory

Streambank stability performance was monitored by conducting a visual erosion inventory within and upstream of the project reach. Each eroding bank within the project reach was photo-documented, with eroding bank length and potential causes of bank erosion noted. 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.

3.3. Perpendicular Transects and Longitudinal Profile Surveys

Four perpendicular transects (cross sections) were established in 2013 to document vertical and lateral stability within the project reach. Each of the four transects was re-surveyed from 2014 – 2016 to document vertical and lateral adjustments at two riffles and at two pools.

A longitudinal profile was surveyed down the thalweg of the channel in 2014, 2015, and 2016 to document aggradation, degradation, and habitat complexity along the project reach. All transects and longitudinal profiles were surveyed using a Trimble R8 GPS with rover and base station units, with survey points taken at inflection points along each transect and profile. A total station survey unit was used to shoot longitudinal profile points beneath the Highway 93 Bridge. All surveys tied into benchmark pins established by MDT during construction of the project. Photographs were taken facing upstream, downstream, and across the channel at each transect to further document site conditions and complement permanent photo-documentation points.

3.4. Photo-Documentation

Permanent photo documentation points were established during the first monitoring event in 2013. Photos were re-taken at all photo points to document vegetation establishment and stream bank conditions within the project site. Photos were also taken at each eroding bank to document erosion severity and whether any of the banks began to heal after the initial erosion was noted.

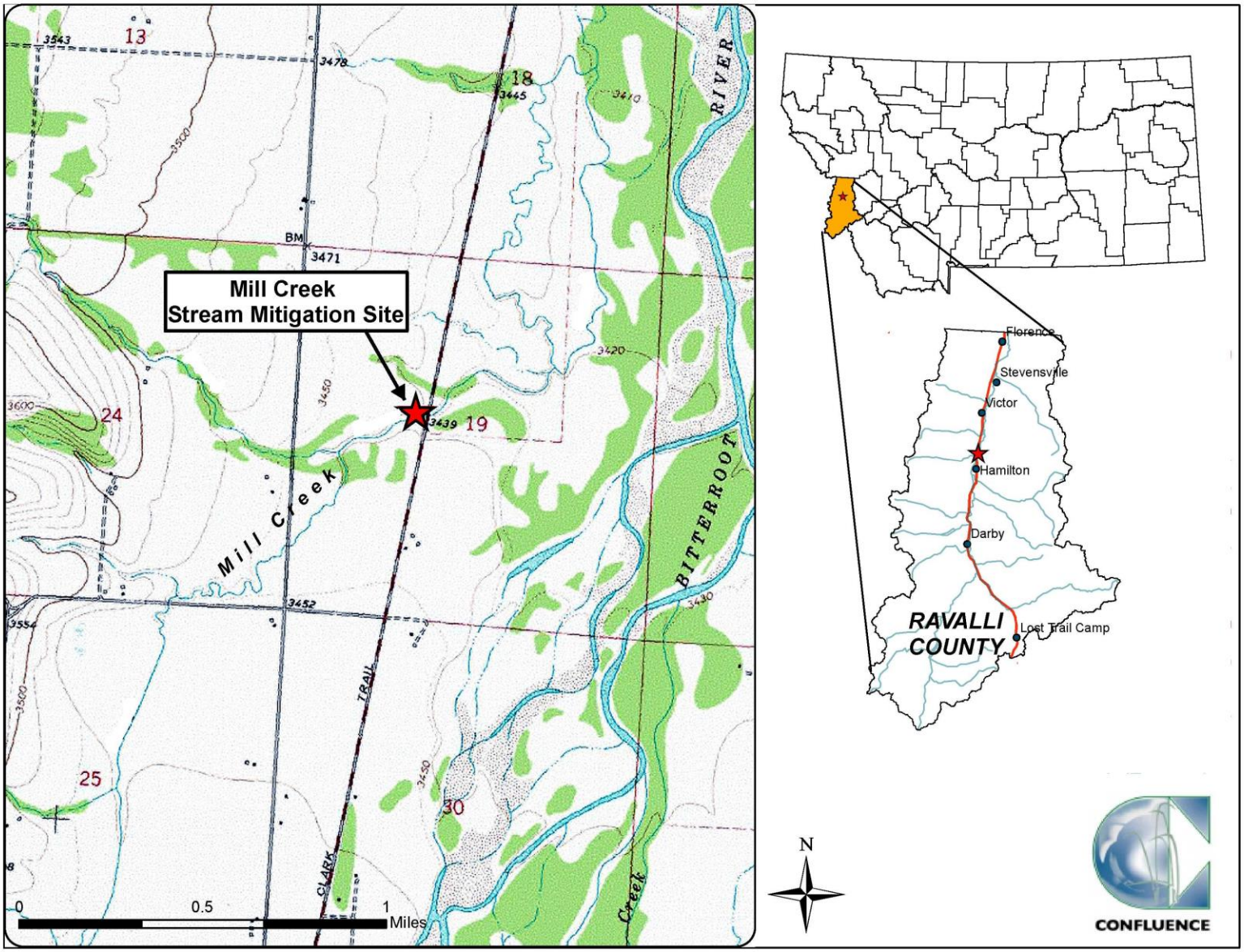


Figure 1. Project location of Mill Creek stream mitigation site.

4.0 RESULTS

4.1. Riparian Vegetation Inventory-Belt Transects

Table 1 summarizes the vegetation composition of each riparian transect, including areal percent cover of total vegetation, woody vegetation, and noxious weeds. In 2016, the total percent riparian cover was 88%, and included 61% cover by herbaceous species and 27% cover by woody species. Percent cover of noxious weeds continued to increase in 2016 and was estimated at 21%. Noxious weeds were particularly high on the left (north) bank of the project reach where construction activities occurred.

Table 1. Riparian vegetation composition of Mill Creek from 2013 through 2016.

Belt Transect	Length (ft)	Total % Riparian Cover				% Woody Cover				% Noxious Weed Cover			
		2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Right (south bank)	140	100	100	96	97	60	60	60	62	1	1	2	3
Left (north bank)	435	75	80	80	85	15	15	15	16	15	20	25	27
Area weighted Total	575	81	85	84	88	26	26	26	27	8	15	19	21

Table 2 includes a comprehensive list of plant species observed along the new channel alignment and riparian buffer areas from 2013 through 2016. In 2016, 109 species were observed, representing an increase of 15 species since the 2015 monitoring event. Seven of the 15 new species observed in 2016 were native and considered beneficial to the restoration efforts within the project area. Fifty-four of the species (50%) observed in 2016 were considered hydrophytic based on the 2016 National Wetland Plant List (NWPL) (Lichvar et al., 2016).

The vegetation inventory along Mill Creek identified six noxious weeds and one state-regulated species (Table 3). In 2013 and 2014, Field Pepper-Grass (*Lepidium campestre*) was incorrectly identified as Broad-Leaf Pepperwort (*Lepidium latifolium*), and has subsequently been removed from the list of noxious weeds present at this site. Each mapped noxious weed infestation was less than 0.1 acre in size. Cover class of noxious weeds within the mapped infestation areas ranged from trace (less than 1 percent) to high (greater than 25 percent). With the exception of isolated weed occurrences, locations of all noxious weed infestations, are shown on Figure 4 of Appendix A.

Table 2. Comprehensive list of plant species identified at the Mill Creek stream mitigation site from 2013 through 2016.

Scientific Name	Common Name	WMVC Indicator Status*
Achillea millefolium	Common Yarrow	FACU
Agrostis gigantea	Black Bent	FAC
Agrostis scabra	Rough Bent	FAC
Agrostis stolonifera	**Spreading Bent**	**FAC**
Algae, brown	Algae, brown	NL
Algae, green	Algae, green	NL
Alnus incana	Speckled Alder	FACW
Alopecurus aequalis	Short-Awn Meadow-Foxtail	OBL
Alyssum alyssoides	Pale Alyssum	NL
Antennaria parvifolia	Nuttall's Pussytoes	NL
Artemisia absinthium	Absinthium	NL
Aster sp.	Aster	NL
Bassia scoparia	Burningbush	FAC
Berteroa incana	Hoary False-Alyssum	NL
Betula pumila	Bog Birch	OBL
Bromus arvensis	Field Brome	UPL
Bromus inermis	Smooth Brome	UPL
Bromus japonicus	Japanese Brome	NL
Bromus tectorum	Cheatgrass	NL
Calamagrostis canadensis	Bluejoint	FACW
Calamagrostis stricta	Slim-Stem Reed Grass	FACW
Camelina microcarpa	**Little-Pod False Flax**	**FACU**
Carduus nutans	Nodding Plumeless-Thistle	UPL
Carex aquatilis	Leafy Tussock Sedge	OBL
Carex nebrascensis	Nebraska Sedge	OBL
Carex sp.	Sedge	NL
Carex stipata	Stalk-Grain Sedge	OBL
Carex utriculata	Northwest Territory Sedge	OBL
Centaurea stoebe	Spotted Knapweed	NL
Chamerion angustifolium	Fireweed	NL
Cirsium arvense	Canadian Thistle	FAC
Cirsium vulgare	Bull Thistle	FACU
Cornus alba	Red Osier	FACW
Crataegus douglasii	Black Hawthorn	FAC
Dactylis glomerata	Orchard Grass	FACU
Dasiphora fruticosa	Golden-Hardhack	FAC
Deschampsia caespitosa	Tufted Hairgrass	FACW
Descurainia sophia	Herb Sophia	NL
Eleocharis palustris	Common Spike-Rush	OBL
Elymus canadensis	Nodding Wild Rye	FAC
Elymus glaucus	**Blue Wild Rye**	**FACU**
Elymus hispidus	Intermediate Wheatgrass	NL
Elymus repens	Creeping Wild Rye	FAC
Epilobium ciliatum	Fringed Willowherb	FACW
Equisetum arvense	Field Horsetail	FAC
Equisetum hyemale	Tall Scouring-Rush	FACW
Erodium cicutarium	Stork's Bill	NL
Euphorbia esula	Leafy Spurge	NL
Festuca idahoensis	Bluebunch Fescue	FACU
Filago arvensis	**Field Fluffweed**	**NL**
Fragaria virginiana	Virginia Strawberry	FACU
Glyceria striata	**Fowl Manna Grass**	**OBL**
Geum macrophyllum	Large-Leaf Avens	FAC
Geum sp.	Avens	NL
Holcus lanatus	**Common Velvet Grass**	**FAC**

Scientific Name	Common Name	WMVC Indicator Status*
Juncus balticus	Baltic Rush	FACW
Juncus effusus	Lamp Rush	FACW
Juncus ensifolius	Dagger-Leaf Rush	FACW
Juncus sp.	Rush	NL
Juncus tenuis	**Lesser Poverty Rush**	**FAC**
Lactuca serriola	**Prickly Lettuce**	**FACU**
Lepidium campestre	Field Pepper-Grass	NL
Leucanthemum vulgare	Ox-Eye Daisy	FACU
Lolium perenne	Perennial Rye Grass	FAC
Lotus corniculatus	**Garden Bird's-Foot-Trefoil**	**FAC**
Lupinus sericeus	Pursh's Silky Lupine	NL
Lycopus asper	**Rough Water-Horehound**	**OBL**
Medicago lupulina	Black Medick	FACU
Melilotus officinalis	Yellow Sweet-Clover	FACU
Mentha arvensis	American Wild Mint	FACW
Mimulus guttatus	Seep Monkey-Flower	OBL
Myosotis laxa	Bay Forget-Me-Not	OBL
Onopordum acanthium	Scotch Thistle	NL
Pascopyrum smithii	Western-Wheat Grass	FACU
Persicaria amphibia	Water Smartweed	OBL
Persicaria sp.	Smartweed	NL
Phalaris arundinacea	Reed Canary Grass	FACW
Phleum pratense	Common Timothy	FAC
Pinus ponderosa	Ponderosa Pine	FACU
Poa compressa	**Flat-Stem Blue Grass**	**FACU**
Poa palustris	Fowl Blue Grass	FAC
Poa pratensis	Kentucky Blue Grass	FAC
Populus angustifolia	Narrow-Leaf Cottonwood	FACW
Populus balsamifera	Balsam Poplar	FAC
Prunella vulgaris	**Common Selfheal**	**FACU**
Ranunculus aquatilis	**White Water-Crowfoot**	**OBL**
Ranunculus sp.	Buttercup	NL
Ribes lacustre	Bristly Black Gooseberry	FAC
Rosa woodsii	Woods' Rose	FACU
Rumex acetosella	Common Sheep Sorrel	FACU
Rumex crispus	Curly Dock	FAC
Salix bebbiana	Gray Willow	FACW
Salix exigua	Narrow-Leaf Willow	FACW
Salix lasiandra	**Pacific Willow**	**FACW**
Scirpus microcarpus	Red-Tinge Bulrush	OBL
Silene vulgaris	Maiden's-tears	NL
Sisymbrium altissimum	Tall Hedge-Mustard	FACU
Solanum dulcamara	Climbing Nightshade	FAC
Solidago canadensis	Canadian Goldenrod	FACU
Sonchus arvensis	Field Sow-Thistle	FACU
Symphoricarpos albus	Common Snowberry	FACU
Tanacetum vulgare	Common Tansy	FACU
Taraxacum officinale	Common Dandelion	FACU
Thlaspi arvense	**Field Pennycress**	**UPL**
Tragopogon pratensis	Meadow Goat's-beard	NL
Trifolium pratense	Red Clover	FACU
Trifolium repens	White Clover	FAC
Verbascum thapsus	Great Mullein	FACU
Veronica americana	American-Brooklime	OBL

*Based on 2016 NWPL (Lichvar *et al*., 2016)
New species identified in 2016 are **bolded**.

Table 3. Montana State listed noxious weed and regulated species observed in 2016 at the Mill Creek Stream Mitigation Site.

Category*	Scientific Name	Common Name
Priority 2B	*Berteroa incana*	Hoary Alyssum
	Centaurea stoebe	Spotted Knapweed
	Cirsium arvense	Canada Thistle
	Euphorbia esula	Leafy Spurge
	Leucanthemum vulgare	Oxeye Daisy
	Tanacetum vulgare	Common Tansy
Priority 3 State Regulated	*Bromus tectorum*	Cheatgrass

*Based on the Montana Dept. of Agriculture's Noxious Weed List, 2015

4.2. Bank Erosion Inventory

Previous monitoring reports documented four eroding banks within and two additional eroding banks immediately upstream of the project reach. Locations of all eroding banks are illustrated on Figure 3 in Appendix A. The following section describes current conditions of each eroding bank segment as observed during the 2016 monitoring event.

Banks EBL1 and EBL2 were originally documented as two separate eroding bank segments that combined into one long, 247-foot eroding bank in 2014 (herein referred to as EBL1-2). This bank occurs on private land upstream of the project reach, but has been documented in previous monitoring reports due to the potential of this bank affecting the project reach. The upper 150 feet of EBL1-2 appears unchanged over the past three monitoring years (see Additional Photo 1 in Appendix C); however, the lower 100 feet of the bank has continued to laterally erode northward. This 100-foot bank segment migrated approximately 2-3 feet during the past year, causing a large ponderosa tree to fall across the channel (see Additional Photo 2 and 8 in Appendix C). The fallen tree may create a debris trap during the next runoff event and result in accelerated erosion along the left bank during the next several years.

Bank erosion at EBL1-2 is due to adjacent point bar formation forcing the channel against a relatively high, herbaceous vegetated stream bank along a relatively sharp meander bend. Root wads and large rocks placed on, but not keyed into, the toe of the banks are causing increased scour against the bank toe. The vegetation community along these banks include speckled alder, Kentucky bluegrass, smooth brome, sedges, common yarrow, western-wheat grass, Canadian goldenrod, and ox-eye daisy, most of which are upland species less capable of withstanding erosive forces. The bank retreated between 3 and 7 feet from 2013 to 2014 an additional 2-5 feet from 2014 to 2015 and approximately 2-3 feet further in 2016. Based on the combination of eroding factors, severity of erosion along EBL1-2 is considered high.

Erosion at EBL3 is occurring at the head of the former channel alignment (now backfilled with gravel, cobble, and soil), and extends downstream approximately 90 feet beyond the root ball of a fallen tree. In 2014, erosion was noted along the toe of the

bank, causing it to retreat. The vegetation community consists of short-awn meadow foxtail, white and red clover, Kentucky bluegrass, common tansy, and ox-eye daisy, all of which are species that are less capable of withstanding erosive forces. Erosion along this bank did not appear to advance in length or retreat further in 2015 or 2016 (see Additional Photo 3 and 4 in Appendix C). Based on the combination of erosion factors, severity of erosion along EBL3 is considered low and no corrective actions are necessary along this bank.

Lateral erosion at bank EBL4 appears to have continued since 2015, as evidenced by the adjacent root balls detaching from the bank (see Additional Photo 5 in Appendix C). The bank has retreated approximately 4-5 feet since 2013, although the eroding bank length of 64 feet has not increased. Bank instability at this location was 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 former of which offers dense roots capable of withstanding erosion more effectively than most species. Erosion severity along this bank is considered low to moderate and does not jeopardize any infrastructure elements or the newly installed bridge downstream. As a result of the erosion occurring likely as a result of natural channel adjustments, no corrective actions are warranted at this location.

Eroding bank EBR1 occurs directly across the channel from EBL4. Previous monitoring efforts documented fallen trees both into the channel and away from the channel along this bank, although it appears no additional erosion has occurred along the bank since 2014 (See Additional Photo 6 in Appendix C). The vegetation community along this bank consists of cottonwood, speckled alder, smooth brome, and bog birch, most of which are generally promote bank stability due to their ability to generate dense root masses. Bank erosion severity along this 58-foot segment is considered low, and the bank has not continued to erode since 2014. These factors combine to indicate no corrective actions are warranted along this bank.

Erosion at EBR2 was noted along 65 feet of the channel across from the head of the deactivated stream channel. Erosion at this location is due to channel adjustments and scour along the outside of a meander. No additional erosion was noted over the past two years along this bank (see Additional Photo 7 in Appendix C). The vegetation community is dominated by reed canary grass with a speckled alder and bog birch overstory. Each of these species are generally capable of withstanding erosive forces. These factors contribute to an overall low erosion severity rating and no corrective actions are warranted along this bank.

4.3. Longitudinal Profile and Perpendicular Transect Surveys

A longitudinal profile of the channel thalweg surveyed from 2014 -2016 is provided in Figure 2, while plots for each surveyed transect are included in Appendix B. Transects #2 and #3 were surveyed at scour pools formed by woody debris jams, while transects #1 and #4 were surveyed at riffles. A discussion of monitoring results at each transect and longitudinal profile is provided in the following section.

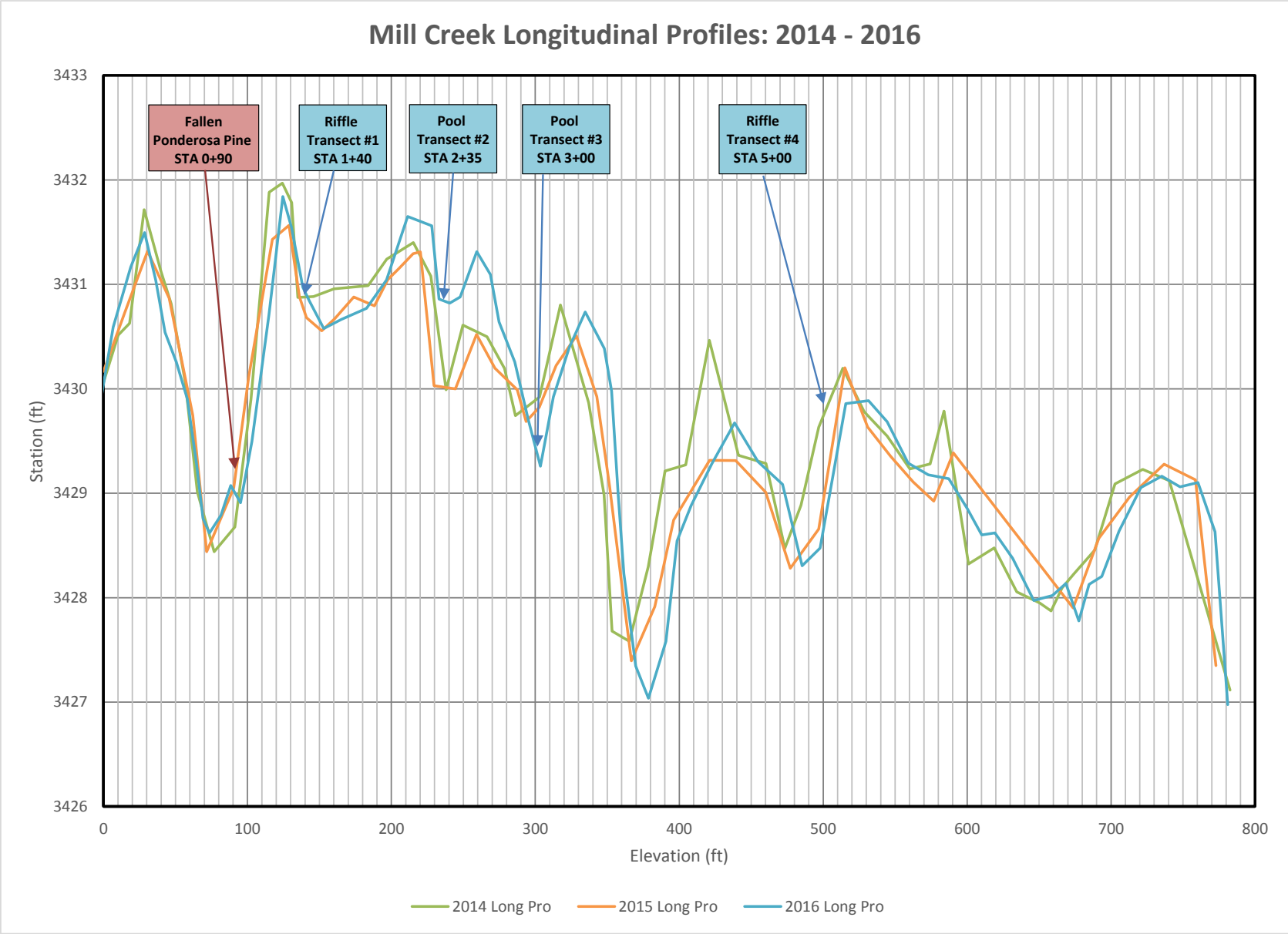


Figure 2. Thalweg longitudinal profile along Mill Creek, 2014 – 2016.

The channel at riffle transect #1 was intended to be positioned at a riffle; however, survey data from 2013-2015 indicated the channel exhibited more pool-type features including a point bar forming on the left side of the channel and thalweg near the right bank. In 2016, a large ponderosa tree fell into the channel just upstream from transect #1, resulting in a mid-channel gravel bar deposit. This deposit has not resulted in lateral migration of the banks to date; however, continued migration of the channel further upstream at EBL1-2 may eventually shift the channel through transect #1. The longitudinal profile surveyed through the Mill Creek project also indicates the bed at this transect occurs in a shallow pool (STA 1+40).

Pool transect #2 was established at a woody debris jam formed along the left (north) bank, which prior to 2016 had maintained its width and depth over the first three monitoring events. In 2016, the survey provides evidence that this pool has partially filled with gravel, with only a shallow thalweg remaining on the left bank where a deeper pool previously existed. The filling of this pool with gravel may partially be attributed to the gravel bar forming immediately upstream as a result of the downed ponderosa pine tree. The longitudinal profile between STA 2+10 and 2+90 reveals a rise in the bed elevation through pool transect #2.

Inspection of the profile and cross sections at transects #1 and #2 reveal stream bed adjustments are occurring along the upper portion of the relocated channel. Adjustments to the bed and banks of a stream channel like Mill Creek are due to natural erosion and depositional processes that can be affected by woody debris recruitment. The large ponderosa tree that has fallen into the channel upstream of transect #1 is likely to generate scour and depositional features in the vicinity of the downed tree, which should be considered a healthy, natural process of forming complex aquatic habitat. Given the tree does not currently jeopardize any infrastructure and provides additional aquatic habitat, its removal from the channel is not warranted at this time.

The channel at transect #3 forms a deep pool along the left bank and a shallower pool on the right bank as a result of a woody debris jam in the middle of the channel. The dimensions of this pool have remained relatively constant over the past three years with only minor adjustments in bed elevations. The mid-channel bar appears to have accumulated some gravels, but is similar in elevation to the original survey performed in 2013. Inspection of the longitudinal profile indicates this transect also occurs within one of the shallower pools within the project reach at Station 3+00.

Riffle transect #4 occurs just above the last meander bend upstream of the U.S. Highway 93 Bridge. Repeated surveys at this transect have thus far revealed very little adjustments to the stream bed and banks over the past four years. To date, this riffle section appears to be stable and efficiently transporting incoming sediment. Inspection of the longitudinal profile indicates the bed at this transect occurs at the downstream extent of a long pool at Station 5+00 and is about 25 feet upstream from the next riffle crest.

A longitudinal profile of the stream bed along the thalweg was repeated in 2015 and again in 2016 to document bedform complexity and aquatic habitat conditions (Appendix B). The profile exhibits a diversity of channel depths, with both shallow and deep pools within the project reach. The most visible difference in the profile occurs between station 2+00 and 3+00, where a gravel deposit has elevated the stream bed downstream of the large, newly fallen ponderosa pine tree. Otherwise, the channel bed has maintained a relatively consistent slope over the past four years.

As indicated in previous monitoring reports, this reach of Mill Creek is actively transporting an abundance of gravel and cobble originating from the upper watershed. The project reach, as well as a lengthy segment of channel observed upstream, exhibits many gravel and cobble point bars and islands, which are indicative of a watershed with a large supply of bedload. Observations of the stream banks along the project reach indicates gravel and cobble material is also generated during lateral bank migrations. As a result of the high bedload composition of Mill Creek, the stream bed forms vary from year to year, with scour and depositional processes influenced by evolving meander patterns and woody debris complexes. Creeks transporting a large supply of cobble and gravel tend to laterally migrate more rapidly as bars develop and bank woody debris is recruited to the channel. The Mill Creek monitoring reach includes several large trees and woody debris complexes, which generate bedform complexity and aquatic habitat variability. As a result of these factors, channel adjustments are likely to continue occurring within the monitoring reach. Adjustments to the channel noted during the monitoring of this project site include the large point bar immediately upstream of the project reach advancing further north each year, deposition of gravels along the stream bed downstream of the newly fallen ponderosa tree, and shifting mid-channel bars observed between STA 2+75 and 3+50. These adjustments and the subsequent erosion/deposition observed do not necessarily equate to channel instability, as these are natural processes that occur within meandering stream channels.

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 following the fourth year of monitoring and five 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 and offer additional documentation of the site’s current condition.

Table 4. Status of performance standards four 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 88**%** following fourth year of monitoring (97% of south bank and 85% of left bank).	Yes
	50% woody species coverage after 3rd year	Woody cover of the project site is 27**%** following fourth year of monitoring (62% of south bank and 16% of north bank).	No
Streambank Stability	Unstable banks identified within the project reach will require corrective action	Four eroding bank segments were observed in 2015 and range in severity from minor to moderate.	Although erosion is occurring within project reach, it occurs as a result of natural channel processes

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 vegetation cover observed along the north bank riparian transect was 85%, which falls just above 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 bare ground cover. When factoring in the undisturbed south bank, total vegetation cover across the site was 88%.

Woody vegetation cover along the north bank was estimated at 16% cover, which falls well below the success criteria threshold of 50%. No woody vegetation was observed along the backfilled channel segment, and 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 was estimated at 27%. Woody vegetation cover along the south bank was estimated at 62%. The performance criterion for woody vegetation cover has been met along the south bank; therefore efforts to increase woody vegetation cover within the project should focus on the north bank.

Noxious weed cover increased to 27% along the north side of the channel, 3% along the south side of the channel, and 21% of the vegetation within the monitored riparian transects. Six noxious weed species were identified within the project reach, and were primarily observed along the north bank. Based on these results, additional weed control and woody vegetation will be necessary along the north bank to meet performance criteria for riparian cover.

5.2. Bank Erosion Inventory

Three of the four eroding bank segments previously identified within the project reach showed no additional lateral migration in 2016. Eroding bank EBL4 appears to have eroded northward approximately 2 feet since 2015, although the eroding bank length did not increase during the past year.

Erosion of the north bank (EBL1-2) immediately upstream of the project reach has advanced northward each year since the inaugural monitoring event in 2013. This bank occurs upstream of the relocated channel segment, and has been continuously observed due to its influence on the reach immediately downstream. This bank migrated an additional 2-3 feet during the past year, causing a large ponderosa pine tree to fall into the river. While recruitment of woody debris is considered a positive effect on the channel due to its ability to help develop pool habitats, this tree is large enough to trap other woody material and result in more accelerated channel migration in its vicinity. Channel migration near this downed tree should be monitored to document whether unintended erosion occurs as a result of its presence.

The severity of bank erosion within the project reach is considered low, and is likely due to the channel naturally adjusting within the new alignment. Bedload deposition and scour created by meander bends and woody debris will continue resulting in minor lateral movement of the stream banks. The erosion occurring within the project reach does not jeopardize any critical infrastructure and is not threatening to overtake the deactivated channel segment.

6.0 MANAGEMENT RECOMMENDATIONS

6.1. Woody Vegetation Establishment

Woody vegetation composition, including volunteer woody species, 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 (*Salix* spp.), speckled alder (*Alnus incana*), chokecherry (*Prunus virginiana*), or Woods' rose (*Rosa woodsii*) 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 25% of the north bank vegetation composition. Weed control efforts are warranted, especially along the north bank, to prevent the spread of these species. Weed species necessary to target include hoary alyssum (*Berteroa incana*), spotted knapweed (*Centaurea stoebe*), Canada thistle (*Cirsium arvense*), leafy spurge (*Euphorbia esula*), oxeye daisy (*Leucanthemum vulgare*), and common tansy (*Tanacetum vulgare*).

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. Corrective actions that would prevent erosion from occurring anywhere within the project reach include 1) installing toe armor along all banks susceptible to erosion, or 2) installing flow deflection structures such as a barb or vane to redirect the thalweg away from all banks susceptible to erosion. While implementation of these techniques may prove successful in meeting the success criteria for bank stability within the project reach, they may result in increased erosion in other reaches of Mill Creek as the energy of the stream is transferred elsewhere. Furthermore, bank armoring or flow deflection techniques may require mitigation depending on their extent, which runs counter to the goal of the Mill Creek project to be self-mitigating.

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. Woody Debris

Several woody debris jams and logs exist between 200 and 400 feet upstream of the Highway 93 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 generating aquatic habitat features, but should be monitored to ensure they do not create a large constriction upstream of the highway bridge. To date, none of the logs have moved more than 20-30 feet downstream since 2013, and their length may preclude them from mobilizing further downstream unless a large flood occurs. 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. Logs that deposit within 100 feet upstream of the bridge should likely be removed to prevent them from causing damage to the bridge. No logs currently exist within 100 feet of the bridge.

7.0 LITERATURE CITED

Lichvar, R.W., D.L. Banks, W.N. Kirchner, and N.C. Melvin. 2016. *The National Wetland Plant List*: *2016 Update of Wetland Ratings.* Phytoneuron 2016-30: 1-17. Published 28 April 2016. ISSN 2153 733X

Montana Department of Agriculture. Montana Noxious Weed List. July 2015. Accessed September 2016 at: http://agr.mt.gov/agr/Programs/Weeds/PDF/2015WeedList.pdf.

Appendix A

Project Maps

MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana

CONFLUENCE
consulting incorporated

Legend

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

2016 Monitoring Features Mill Creek

Figure 3

Date: 9/29/2016

MillCreek_features2016

CONFLUENCE
consulting incorporated

Legend

- *Berteroa incana*
- *Centaurea stoebe*
- *Cirsium arvense*
- *Euphorbia esula*
- *Leucanthemum vulgare*
- *Tanacetum vulgare*

N

0 25 50 100 150 200 Feet

2016 Monitoring Noxious Weeds Mill Creek

Figure 4

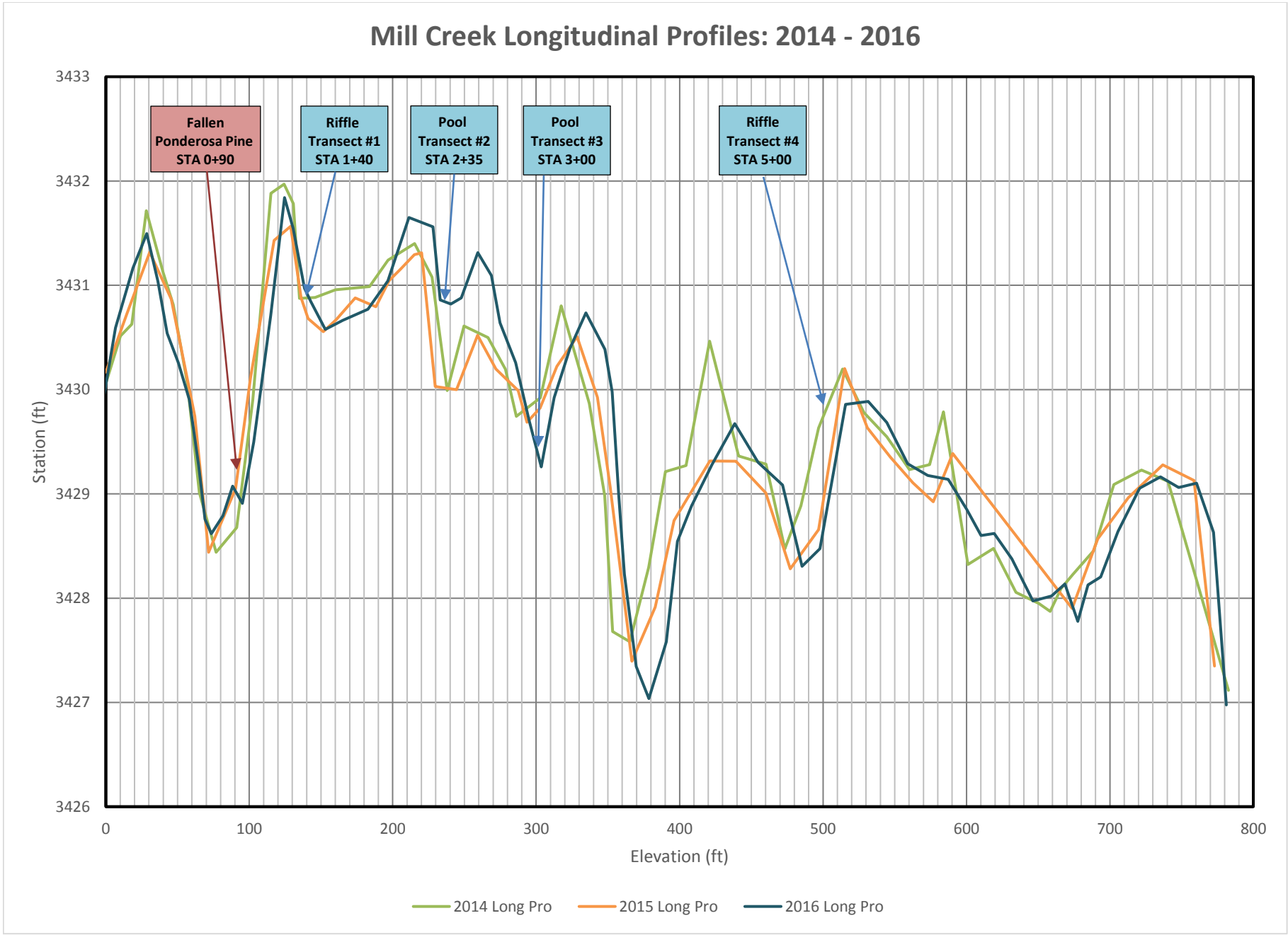
Date: 09/29/2016

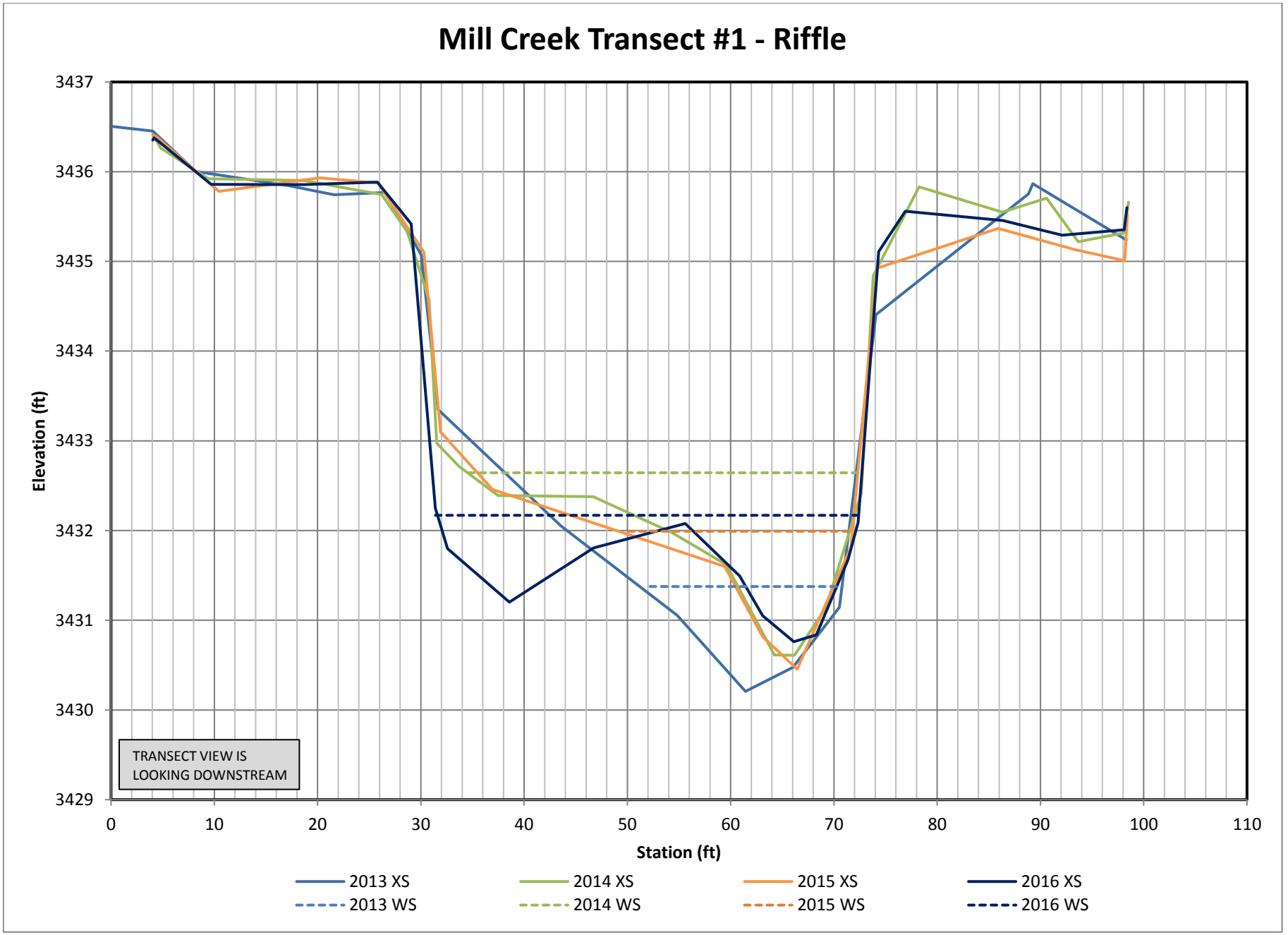
MillCreek_Weeds2016.mxd

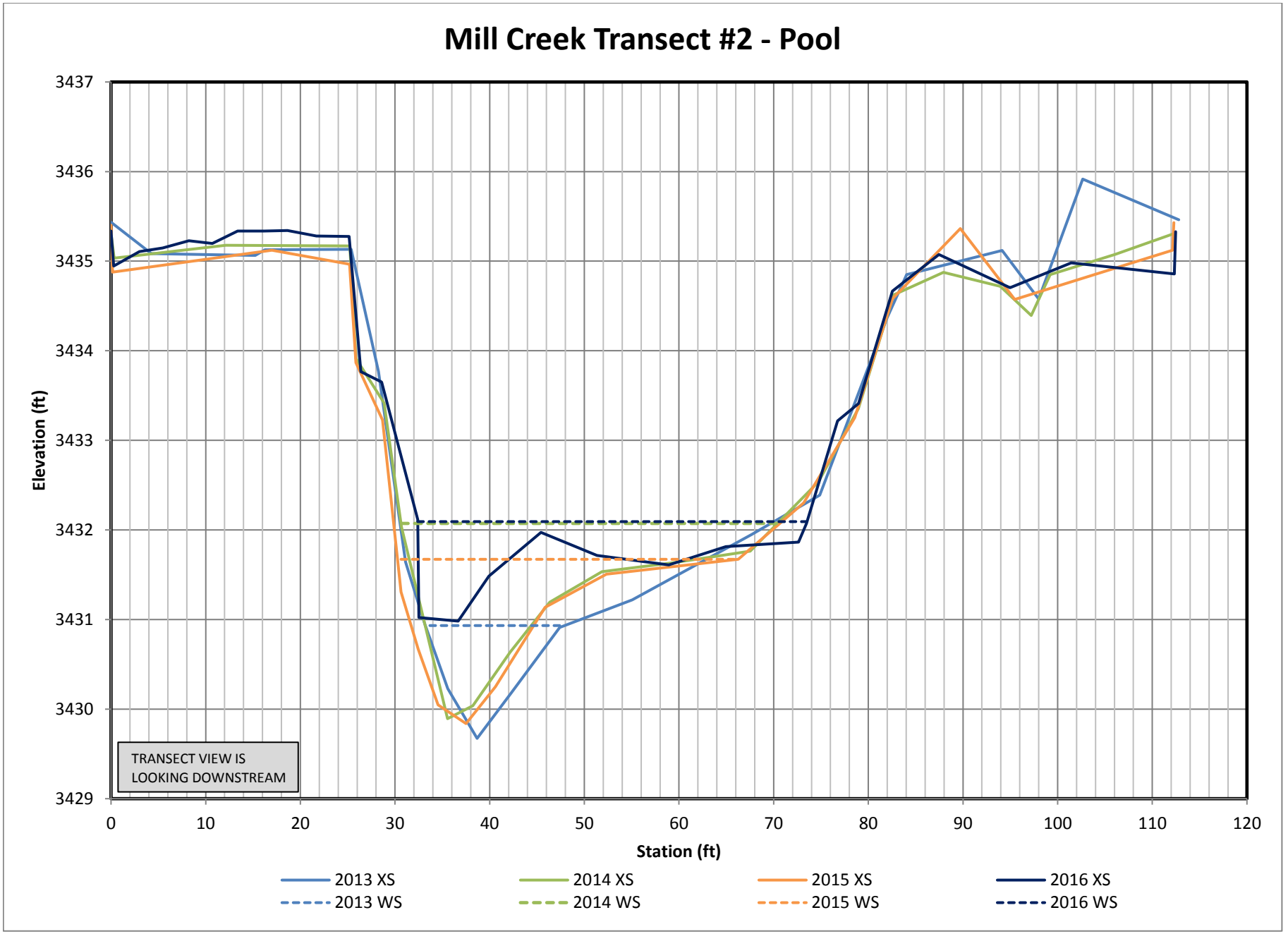
Appendix B

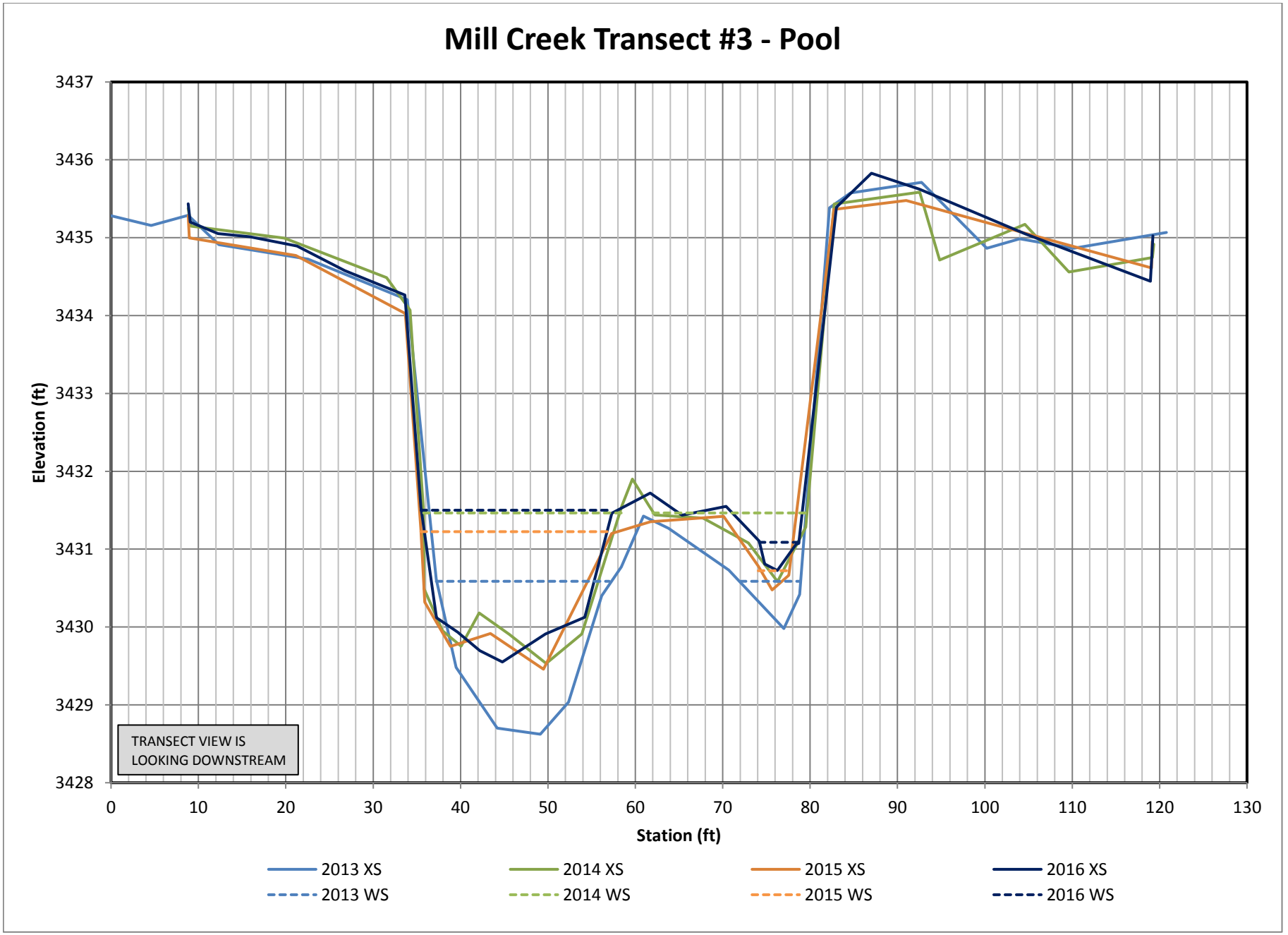
Perpendicular Transect and Longitudinal Profile Plots

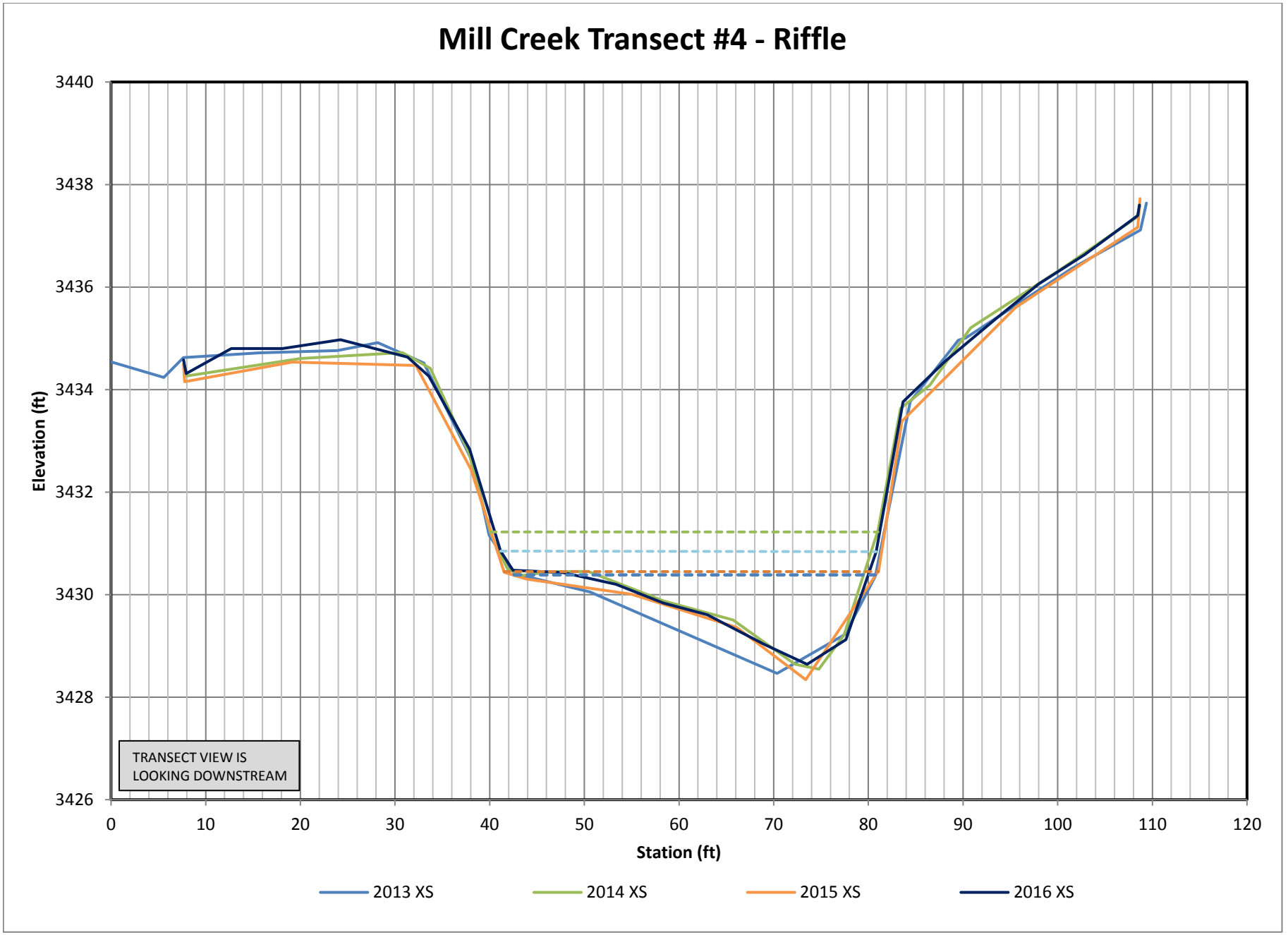
MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana


Mill Creek Longitudinal Profiles: 2014 - 2016
Fallen Ponderosa Pine STA 0+90
Riffle Transect #1 STA 1+40
Pool Transect #2 STA 2+35
Pool Transect #3 STA 3+00
Riffle Transect #4 STA 5+00
Station (ft)
3433
3432
3431
3430
3429
3428
3427
3426
0
100
200
300
400
500
600
700
800
Elevation (ft)
2014 Long Pro
2015 Long Pro
2016 Long Pro


Mill Creek Transect #1 - Riffle
Elevation (ft)
3437
3436
3435
3434
3433
3432
3431
3430
3429
0
10
20
30
40
50
60
70
80
90
100
110
Station (ft)
TRANSECT VIEW IS
LOOKING DOWNSTREAM
2013 XS
2014 XS
2015 XS
2016 XS
2013 WS
2014 WS
2015 WS
2016 WS


Mill Creek Transect #2 - Pool
Elevation (ft)
3437
3436
3435
3434
3433
3432
3431
3430
3429
0
10
20
30
40
50
60
70
80
90
100
110
120
Station (ft)
TRANSECT VIEW IS
LOOKING DOWNSTREAM
2013 XS
2014 XS
2015 XS
2016 XS
2013 WS
2014 WS
2015 WS
2016 WS


Mill Creek Transect #3 - Pool
Elevation (ft)
3437
3436
3435
3434
3433
3432
3431
3430
3429
3428
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Station (ft)
TRANSECT VIEW IS LOOKING DOWNSTREAM
2013 XS
2014 XS
2015 XS
2016 XS
2013 WS
2014 WS
2015 WS
2016 WS


Mill Creek Transect #4 - Riffle
Elevation (ft)
3440
3438
3436
3434
3432
3430
3428
3426
0
10
20
30
40
50
60
70
80
90
100
110
120
Station (ft)
TRANSECT VIEW IS LOOKING DOWNSTREAM
2013 XS
2014 XS
2015 XS
2016 XS

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 2016 Monitoring Events

CONFLUENCE

Photo Point 1.1—2013
Description: East (downstream) side of Hwy 93 Bridge. **Compass**: 45 (Northeast)

Photo Point 1.1—2016
Description: East (downstream) side of Hwy 93 Bridge. **Compass**: 45 (Northeast)

Photo Point 1.2—2013
Description: View from southeast corner of bridge looking downstream. **Compass**: 45 (Northeast)

Photo Point 1.2—2016
Description: View from southeast corner of bridge looking downstream. **Compass**: 45 (Northeast)

Photo Point 2.1—2013
Description: View across channel rom west side of bridge . **Compass:** 113 (East-Southeast)

Photo Point 2.1—2016
Description: View of bridge from Photo Point 2
Compass: 113 (East-Southeast)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2016 Monitoring Events

CONFLUENCE

Photo Point 2.2—2013
Description: View from west side of bridge looking across stream channel. **Compass**: 225 (Southwest)

Photo Point 2.2—2016
Description: View from west side of bridge 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—2016
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: 270 (West)

Photo Point 2.4—2016
Description: View from Photo Point 2 looking up-stream. **Compass**: 270 (West)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2016 Monitoring Events

CONFLUENCE

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

Photo Point 2.5—2016
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—2016
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
Compass: 45 (East)

Photo Point 3.2—2016
Description: View of deactivated channel plug
Compass: 45 (East)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2016 Monitoring Events

CONFLUENCE

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

Photo Point 3.3—2016
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—2016
Description: View of deactivated channel plug from Photo Point 3. **Compass**: 315 (Northwest)

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

Photo Point 3.5—2016
Description: View of upstream extent of deactivated channel segment **Compass**: 270 (West)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2016 Monitoring Events

CONFLUENCE

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

Photo Point 3.6—2016
Description: View of north bank (foreground) and woody debris in the channel. **Compass**: 248 (WSW)

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

Photo Point 3.7—2016
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—2016
Description: View looking across deactivated channel segment. **Compass**: 90 (East)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2016 Monitoring Events

CONFLUENCE

Photo Point 4.2—2013
Description: View across stream channel toward south bank. **Compass**: 180 (South)

Photo Point 4.2—2016
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—2016
Description: View of point bar formation from Photo Point 4. **Compass**: 225 (Southwest)

Photo Point 4.4—2013
Description: View of boulders, logs, and root wads placed on bank. **Compass**: 248 (West-Southwest)

Photo Point 4.3—2016
Description: View of boulders, logs, and root wads placed on bank. **Compass**: 248 (West-Southwest)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2016 Monitoring Events

CONFLUENCE

Photo Point 5.1—2013
Description: View looking upstream of south bank taken from bridge. **Compass**: 248 (West-Southwest)

Photo Point 5.1—2016
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.

Photo Point 5.2—2016
Description: View looking upstream from bridge.

Photo Point 5.3—2013
Description: View looking upstream from bridge.
Compass: 203 (South-Southwest)

Photo 5.3 not available for 2016

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2016 Monitoring Events

Additional Photo 1
Description: Eroding Bank EBL1 - 2013 (panoramic)

Additional Photo 1
Description: Eroding Bank EBL1 - 2016 (panoramic)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2016 Monitoring Events

Additional Photo 2
Description: Eroding Bank EBL2- 2013 (panoramic)

Additional Photo 2
Description: Eroding Bank EBL2 - 2016 (panoramic)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2014 and 2016 Monitoring Events

CONFLUENCE

Additional Photo 3
Description: Upper section of Eroding Streambank EBL3 in 2014

Additional Photo 3
Description: Upper section of Eroding Streambank EBL3 in 2016

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2014 and 2016 Monitoring Events

CONFLUENCE

Additional Photo 4
Description: Lower section of Eroding Streambank L3 in 2014 (panoramic)

Additional Photo 4
Description: Lower section of Eroding Streambank L3 in 2016 (panoramic)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2016 Monitoring Events

CONFLUENCE

Additional Photo 5
Description: Eroding streambank EBL4 in 2013.

Additional Photo 5
Description: Eroding streambank EBL4 in 2016.

Additional Photo 6
Description: Eroding streambank EBR1 in 2013.

Additional Photo 6
Description: Eroding streambank EBR1 in 2016.

Additional Photo 7
Description: Eroding streambank EBR2 in 2014.

Additional Photo 7
Description: Eroding streambank EBR2 in 2016.

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2016 Monitoring Event

Additional Photo 8—2016
Description: Ponderosa pine in channel near downstream end of EBR2

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T1 LOOKING NORTH UPSTREAM FROM T1 SOUTH

T1 LOOKING SOUTH DOWNSTREAM FROM T1 NORTH

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T1 LOOKING WEST UPSTREAM FROM SOUTH BANK

T1 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T1 LOOKING WEST UPSTREAM FROM MIDDLE OF CREEK

T1 LOOKING EAST DOWNSTREAM FROM MIDDLE OF CREEK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T1 LOOKING WEST UPSTREAM FROM NORTH BANK

T1 LOOKING EAST DOWNSTREAM FROM NORTH BANK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T2 LOOKING NORTH UPSTREAM FROM T2 SOUTH

T2 LOOKING SOUTH DOWNSTREAM FROM T2 NORTH

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T2 LOOKING WEST UPSTREAM FROM SOUTH BANK

T2 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T2 LOOKING WEST UPSTREAM FROM MIDDLE OF CREEK

T2 LOOKING EAST DOWNSTREAM FROM MIDDLE OF CREEK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T2 LOOKING WEST UPSTREAM FROM NORTH BANK

T2 LOOKING EAST DOWNSTREAM FROM NORTH BANK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T3 LOOKING NORTH UPSTREAM FROM T3 SOUTH

T3 LOOKING SOUTH DOWNSTREAM FROM T3 NORTH

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T3 LOOKING WEST UPSTREAM FROM SOUTH BANK

T3 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T3 LOOKING WEST UPSTREAM FROM MIDDLE OF CREEK

T3 LOOKING EAST DOWNSTREAM FROM MIDDLE OF CREEK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T3 LOOKING WEST UPSTREAM FROM NORTH BANK

T3 LOOKING EAST DOWNSTREAM FROM NORTH BANK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T4 LOOKING NORTH UPSTREAM FROM T4 SOUTH

T4 LOOKING SOUTH DOWNSTREAM FROM T4 NORTH

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T4 LOOKING WEST UPSTREAM FROM SOUTH BANK

T4 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T4 LOOKING WEST UPSTREAM FROM MIDDLE CREEK

T4 LOOKING EAST DOWNSTREAM FROM MIDDLE CREEK

PROJECT NAME: 2016 MDT STREAM MITIGATION—MILL CREEK

DATE: 7-28-16

T4 LOOKING WEST UPSTREAM FROM NORTH BANK

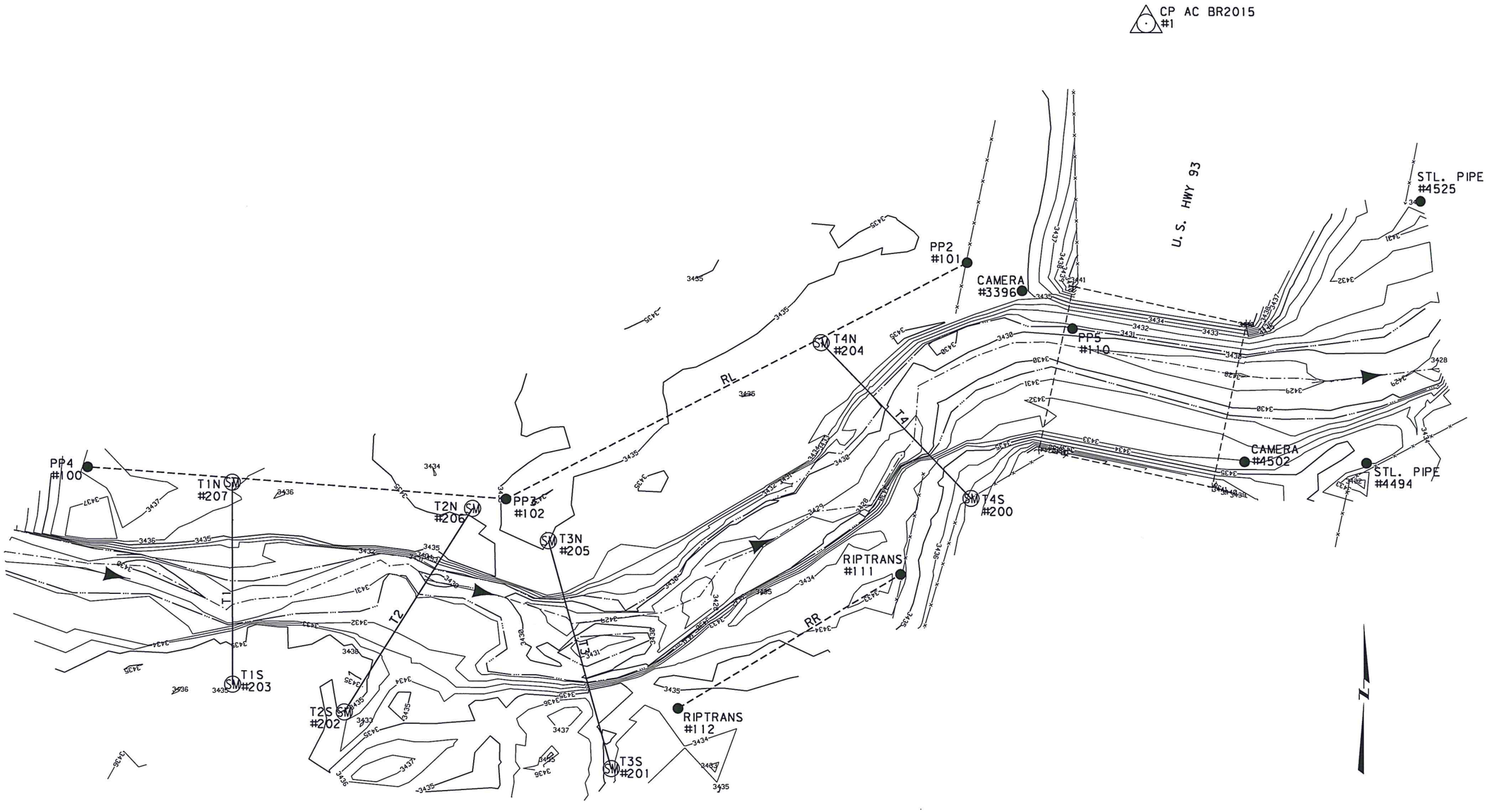
T4 LOOKING EAST DOWNSTREAM FROM NORTH BANK

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



SURVEYOR NOTES:

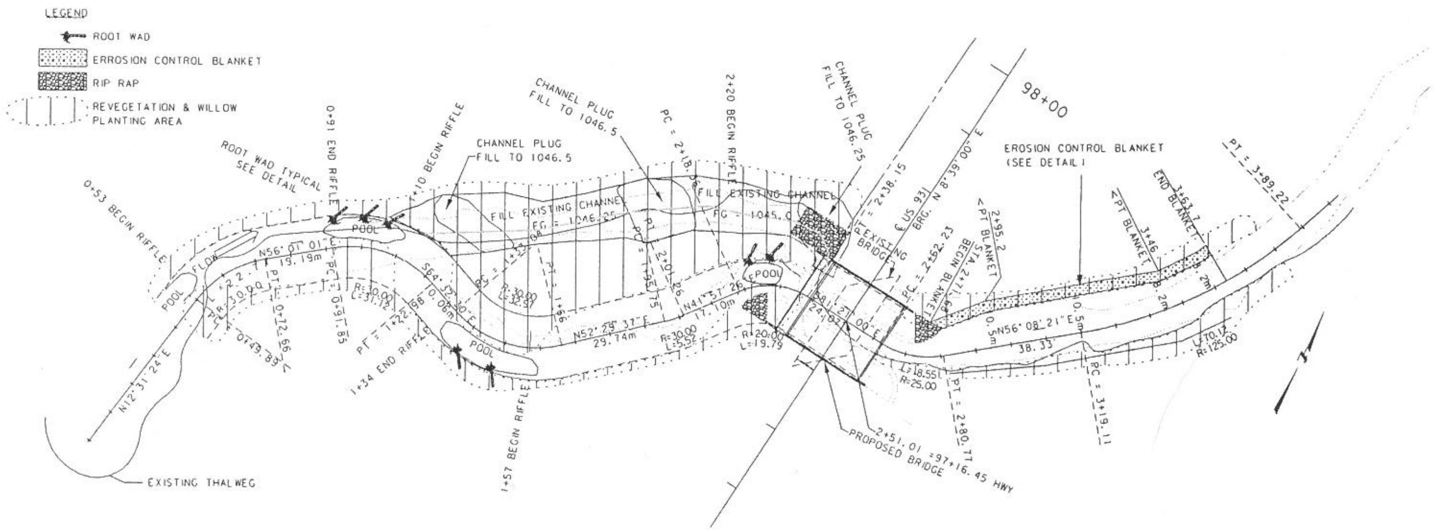
1. THIS SURVEY IS BASED ON FOUND MDT ALUMINUM CAPS STAMPED BR2015 AND BS2015 BUT THEY DO NOT HAVE ESTABLISHED MDT COORDS AND ELEVATIONS. THEREFORE LOCAL CONTROL WAS ESTABLISHED FOR THIS SITE WITH TRIMBLE GPS RTK SURVEY AND THE APPROXIMATE ASSUMED ELEVATION AT MDT ALUM CAP BR2015.
2. THE COORDINATES SHOWN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

0 25 50 75 100

3	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\MILL CREEK\MillcreekPLAN .dgn	DESIGNED BY	ARNE W		MILL CREEK TOPO	MDT STREAM MITIGATION MONITORING SURVEY
2		12/9/2013	REVIEWED BY				
1		11:04:43 AM awiebe	CHECKED BY	LARRY R			

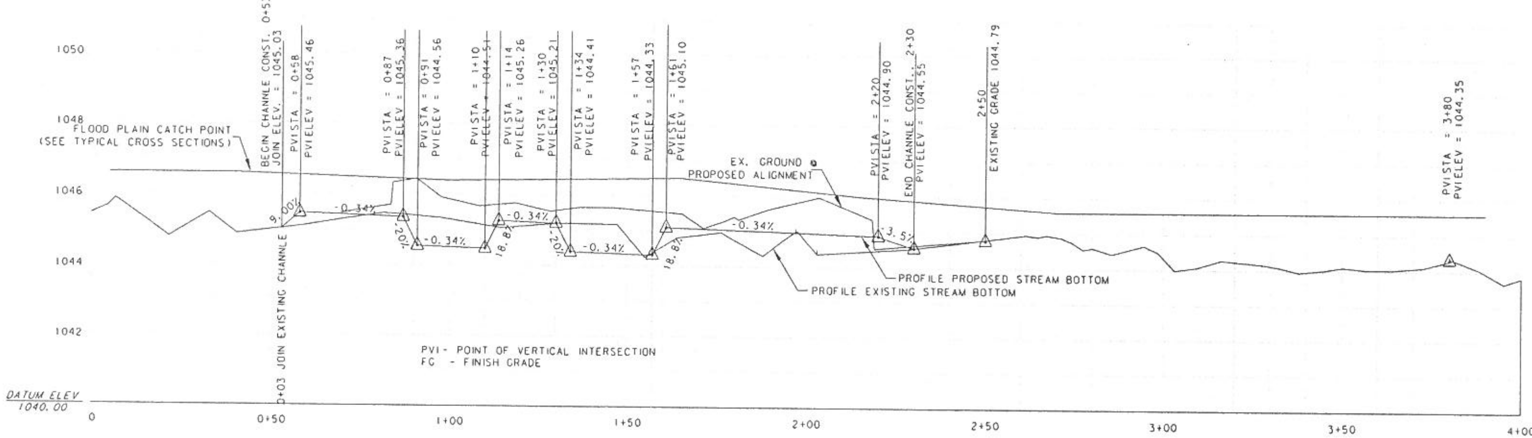
STATE	PROJECT NUMBER	SHEET NO.
MONTANA	NH 7-1(94)54	24

BEAR CREEK ROAD - SOUTH



COORDINATE TABLE			
STATION		NORTHING	EASTING
0+00.00	POT	30 048.8339	55 813.2378
0+49.89	PC	30 097.5369	55 824.0557
0+61.86	PI	30 109.2191	55 826.6506
0+72.66	PT	30 115.9079	55 836.5735
0+91.85	PC	30 126.6342	55 852.4861
1+08.98	PI	30 136.2068	55 866.6871
1+22.98	PT	30 128.8451	55 882.1502
1+33.04	PC	30 124.5211	55 891.2326
1+51.41	PI	30 116.6240	55 907.8201
1+66.00	PT	30 127.8094	55 922.3938
1+95.75	PC	30 145.9183	55 945.9883
1+98.51	PI	30 147.6025	55 948.1827
2+01.26	PT	30 149.6596	55 950.0321
2+18.36	PC	30 162.3748	55 961.4637
2+29.15	PI	30 170.3985	55 968.6774
2+38.15	PT	30 168.7758	55 979.3445
2+62.23	PC	30 165.1551	56 003.1444
2+71.95	PI	30 163.6925	56 012.7585
2+80.77	PT	30 169.1110	56 020.8338
3+19.11	PC	30 190.4690	56 052.6647
3+55.11	PI	30 210.5314	56 082.5648
3+89.22	PT	30 243.4254	56 097.2103
4+03.47	POT	30 256.4436	56 103.0064

PLAN



PROFILE

MILL CREEK CHANNEL RESTORATION DETAIL

STA. 97+16

SHEET 1 OF 3

NO SCALE

MONTANA CADD

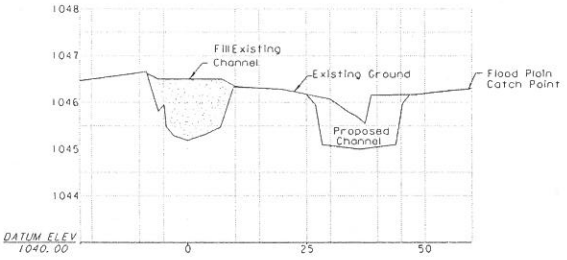
MDT MONTANA DEPARTMENT OF TRANSPORTATION

LAND & WATER CONSULTING, INC.

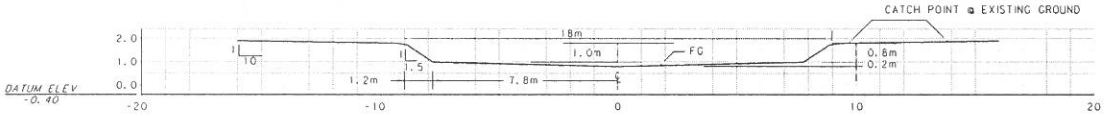
c:\dgn\a015rdet207.dgn
2/17/2011
12:09:18 PM
2 | 3 | EPS - U2160

STATE	PROJECT NUMBER	SHEET NO.
MONTANA	NH 7-1194154	25

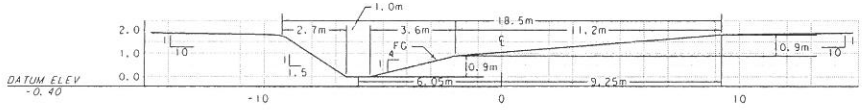
BEAR CREEK ROAD - SOUTH



CROSS SECTIONS 1+97



TYPICAL RIFFLE CROSS SECTION



TYPICAL POOL LEFT CROSS SECTION

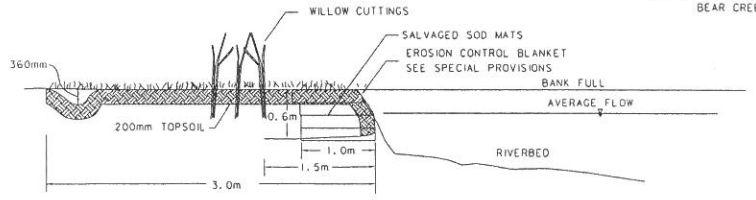
NOTES:

① SEE PLANS FOR POOL LOCATION. POOL LEFT (PL) SHOWN; MIRROR ABOUT CENTERLINE (℄) FOR POOL RIGHT LOOKING DOWNSTREAM.

② TRANSITION 4.0m BETWEEN POOL ↕ RIFFLE.

③ ROUND SLOPES FOR NATURAL APPEARANCE.

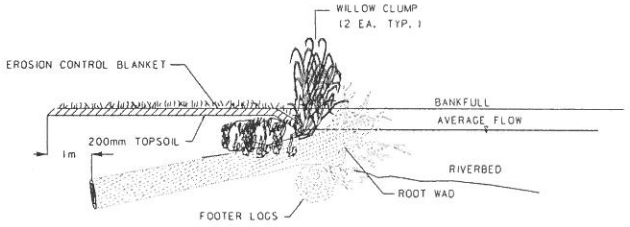
STATION From	STATION To	POOL LEFT	RIFFLE (INCLUDES 4m TRANSITION)	POOL RIGHT
0+00	0+53			
0+53	0+91		X	
0+91	1+10	X		
1+10	1+34		X	
1+34	1+57			X
1+57	2+20		X	
2+20	2+30	X		
2+30	5+00			



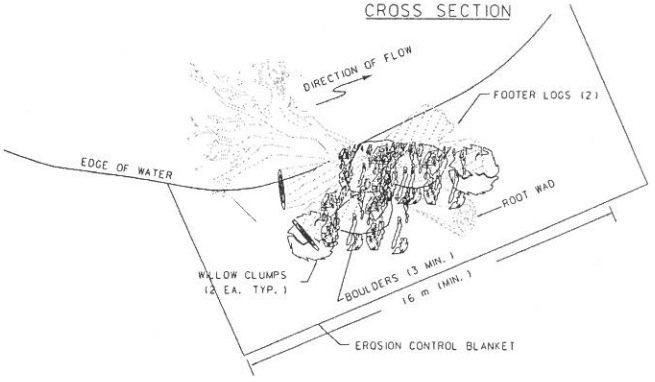
1. SUB EXCAVATE BANKS 0.6 METERS.
2. LAY LOWER BLANKET MINIMUM 1.5 METERS FROM EDGE OF BANK.
3. BACK FILL WITH NATIVE MATERIAL AND 0.2 METERS TOPSOIL.
4. FACE STREAM BANK BACKFILL WITH 1.0 METERS OF SALVAGED SOD MATS.
5. WRAP BLANKET AND EXTEND 3.0 METERS MIN. FROM BANK EDGE.

EROSION CONTROL BLANKET TYPICAL

MILL CREEK



CROSS SECTION



PLAN

ROOT WAD TYPICAL

MILL CREEK

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

MONTANA DEPARTMENT OF TRANSPORTATION
MDT
MONTANA CADD
LAND & WATER CONSULTING, INC.

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