MONTANA DEPARTMENT OF TRANSPORTATION
STREAM MITIGATION MONITORING REPORT

Mill Creek
Ravalli County, Montana

Project Constructed: 2011
Monitoring Report #6: December, 2018

Prepared for:

VISION ZERO
zero deaths · zero serious injuries
MONTANA DEPARTMENT OF TRANSPORTATION

Prepared by:

CONFLUENCE
consulting incorporated

MONTANA DEPARTMENT OF TRANSPORTATION

STREAM MITIGATION MONITORING REPORT #6

YEAR 2018

Mill Creek
Ravalli County, Montana

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

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

Prepared for:

MONTANA DEPARTMENT OF TRANSPORTATION
2701 Prospect Ave
Helena, MT 59620-1001

Prepared by:

Confluence Consulting, Inc.
P.O. Box 1133
Bozeman, MT 59771

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1.0 INTRODUCTION

The following report presents results for the sixth year of annual 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 performance standards outlined in the approved U.S. Army Corps of Engineers (USACE) 404 permit for the project. Requirements outlined in this permit require a minimum of 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 seven 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 at least 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 sixth year monitoring of the Mill Creek project are summarized in Section 4 and compared to performance standards in Section 5. 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 seven 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 August 10, 2018 while topographic survey crews visited the site on August 13th, 2018. Field data collection and surveys followed methodologies as described in the 2013 monitoring reports for the Mill Creek site, which may be accessed at:
https://www.mdt.mt.gov/other/webdata/external/planning/STREAM-MITIGATION/2013_REPORTS/2013_MILL_CREEK_MONITORING_REPORT.PDF.

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 2018, the total percent riparian cover was 86%, and included 57% cover by herbaceous species and 29% cover by woody species. The site exhibited an estimated 14% noxious weed cover, which was similar to that observed during the 2017 monitoring event. Noxious weed infestations were more prevalent on the left (north) bank of the project reach where construction activities occurred. The percent cover estimates recorded for all vegetation categories may have been influenced by a combination of factors, including, but not limited to, adjacent land management, previous herbicide applications, differences in annual precipitation and temperature, calibration training completed by field staff, and other unknown factors that make it difficult to determine the exact cause(s) for increases or decreases in coverage.

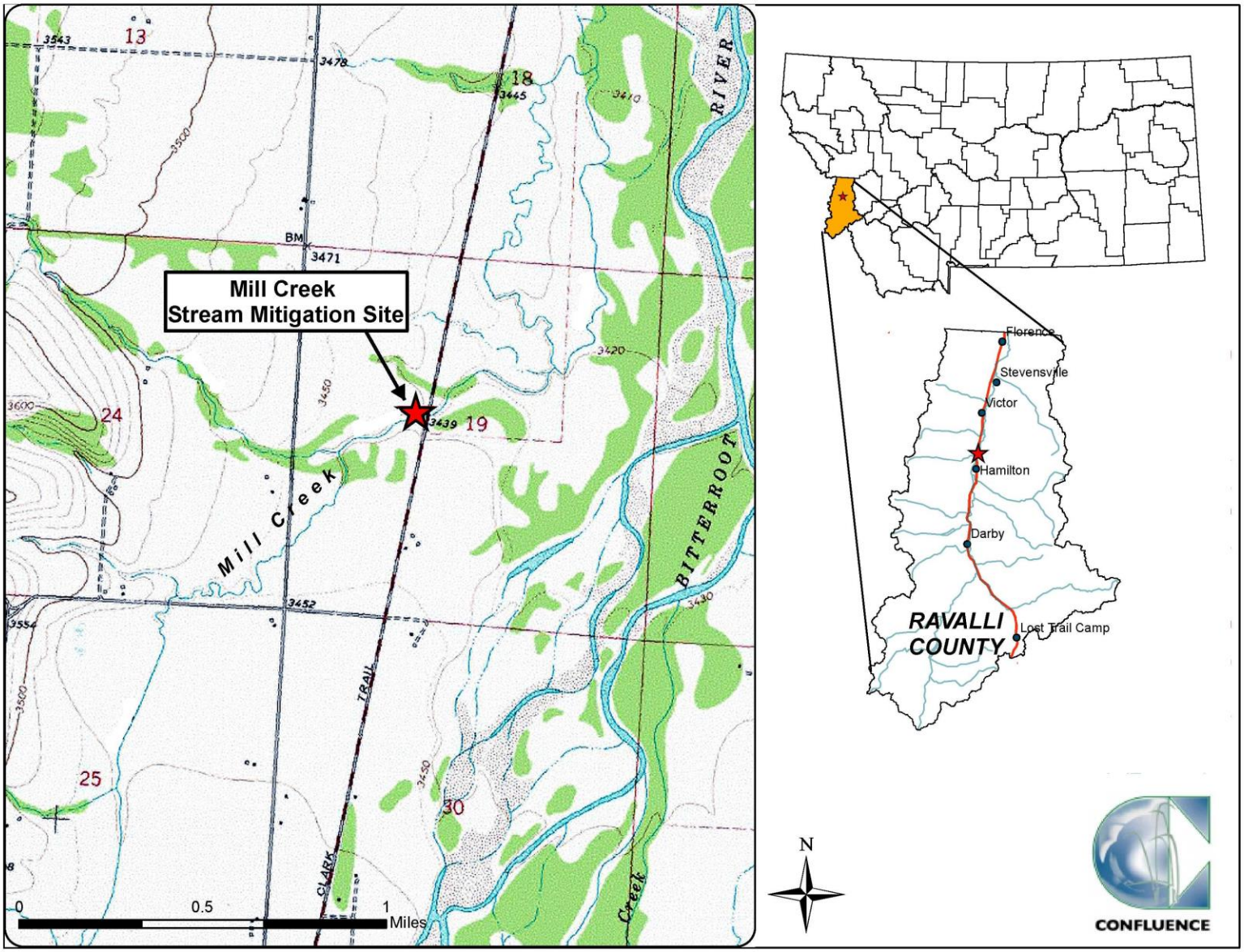


Figure 1. Project location of Mill Creek Stream Mitigation Site.

Table 1. Riparian vegetation composition of Mill Creek from 2013 through 2018.

Belt Transect	Length (ft)	Total % Riparian Cover						% Woody Cover						% Noxious Weed Cover					
		2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Right (south bank)	140	100	100	96	97	97	97	60	60	60	62	62	63	1	1	2	3	3	3
Left (north bank)	435	75	80	80	85	80	82	15	15	15	16	17	18	15	20	25	27	16	17
Area weighted Total	575	81	85	84	88	84	86	26	26	26	27	28	29	11	15	19	21	13	14

The vegetation inventory along Mill Creek identified eight noxious weeds and one state-regulated species (Table 2). Isolated occurrences of houndstongue (*Cynoglossum officinale*), St. Johnswort (*Hypericum perforatum*), and leafy spurge (*Euphorbia esula*) were observed within the project area during the 2017 and 2018 monitoring events, but were not mapped. Noxious weed infestations mapped within the project area ranged from trace (less than 1 percent) to low (1 to 5 percent) cover classes. Locations of all noxious weed infestations, with the exception of isolated weed occurrences, are shown on Figure 4 of Appendix A. Many of these infestations occur on private properties outside of the road right-of-way and are therefore inaccessible to MDT weed contractors.

Table 2. Montana State listed noxious weed and regulated species observed in 2018 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
	Cynoglossum officinale	Houndstongue
	Hypericum perforatum	St. Johnswort
	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, February 2017

Table 3 includes a comprehensive list of plant species observed along the new channel alignment and riparian buffer areas from 2013 through 2018. In 2018, 122 species were observed, representing an increase of 3 species since the 2017 monitoring event. Two of the three new species observed in 2018 were native and considered beneficial to the restoration efforts within the project area, as they increase overall species diversity and enhance riparian habitat complexity. These newly observed plant species included Rocky Mountain juniper (*Juniperus scopulorum*) and smooth blue American-aster (*Symphyotrichum leave*). Creeping buttercup (*Ranunculus repens*), a species native to Europe and Asia, was also observed in 2018 along the streambanks within the project area. Fifty-nine of the species (48%) observed in 2018 were considered hydrophytic based on the 2016 National Wetland Plant List (NWPL) (Lichvar *et al*. 2016).

Table 3. Comprehensive list of plant species identified at the Mill Creek Stream Mitigation Site from 2013 through 2018.

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	N/A
Algae, green	Algae, green	N/A
Alnus incana	Speckled Alder	FACW
Alopecurus aequalis	Short-Awn Meadow-Foxtail	OBL
Alyssum alyssoides	Pale Alyssum	UPL
Amelanchier alnifolia	Saskatoon Service-Berry	FACU
Antennaria parvifolia	Nuttall's Pussytoes	UPL
Artemisia absinthium	Absinthium	UPL
Aster sp.	Aster	N/A
Bassia scoparia	Burningbush	FAC
Berteroa incana	Hoary False-Alyssum	UPL
Betula pumila	Bog Birch	OBL
Bromus arvensis	Field Brome	UPL
Bromus inermis	Smooth Brome	UPL
Bromus japonicus	Japanese Brome	UPL
Bromus tectorum	Cheatgrass	UPL
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 bebbii	Bebb's Sedge	OBL
Carex nebrascensis	Nebraska Sedge	OBL
Carex sp.	Sedge	N/A
Carex stipata	Stalk-Grain Sedge	OBL
Carex utriculata	Northwest Territory Sedge	OBL
Centaurea stoebe	Spotted Knapweed	UPL
Cerastium arvense	Field Mouse-Ear Chickweed	FACU
Chamaenerion angustifolium	Narrow-Leaf Fireweed	FACU
Cirsium arvense	Canadian Thistle	FAC
Cirsium vulgare	Bull Thistle	FACU
Collomia linearis	Narrow-Leaf Mountain-Trumpet	FACU
Cornus alba	Red Osier	FACW
Crataegus douglasii	Black Hawthorn	FAC
Cynoglossum officinale	Gypsy-Flower	FACU
Dactylis glomerata	Orchard Grass	FACU
Dasiphora fruticosa	Golden-Hardhack	FAC
Deschampsia caespitosa	Tufted Hairgrass	FACW
Descurainia sophia	Herb Sophia	UPL
Eleocharis palustris	Common Spike-Rush	OBL
Elymus canadensis	Nodding Wild Rye	FAC
Elymus glaucus	Blue Wild Rye	FACU
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	UPL
Euphorbia esula	Leafy Spurge	UPL
Festuca idahoensis	Bluebunch Fescue	FACU
Filago arvensis	Field Fluffweed	UPL
Fragaria virginiana	Virginia Strawberry	FACU
Glyceria striata	Fowl Manna Grass	OBL
Geum macrophyllum	Large-Leaf Avens	FAC
Geum sp.	Avens	N/A
Holcus lanatus	Common Velvet Grass	FAC
Hypericum perforatum	Common St. John's-Wort	FACU
Juncus balticus	Baltic Rush	FACW
Juncus effusus	Lamp Rush	FACW
Juncus ensifolius	Dagger-Leaf Rush	FACW
Juncus sp.	Rush	N/A
Juncus tenuis	Lesser Poverty Rush	FAC
Juniperus scopulorum	**Rocky Mountain Juniper**	**UPL**
Lactuca serriola	Prickly Lettuce	FACU
Lepidium campestre	Field Pepper-Grass	UPL
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	UPL
Lycopus asper	Rough Water-Horehound	OBL
Maianthemum stellatum	Starry False Solomon's-Seal	FAC
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
Oenothera villosa	Hairy Evening-Primrose	FAC
Onopordum acanthium	Scotch Thistle	UPL
Pascopyrum smithii	Western-Wheat Grass	FACU
Persicaria amphibia	Water Smartweed	OBL
Persicaria sp.	Smartweed	N/A
Phalaris arundinacea	Reed Canary Grass	FACW
Phleum pratense	Common Timothy	FAC
Pinus ponderosa	Ponderosa Pine	FACU
Plantago major	Great Plantain	FAC
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
Pseudoroegneria spicata	Bluebunch Wheatgrass	UPL
Ranunculus aquatilis	White Water-Crowfoot	OBL
Ranunculus repens	**Creeping Buttercup**	**FAC**
Ranunculus sp.	Buttercup	N/A
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	UPL
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
Symphyotrichum laeve	**Smooth Blue American-Aster**	**FACU**
Tanacetum vulgare	Common Tansy	FACU
Taraxacum officinale	Common Dandelion	FACU
Thinopyrum intermedium	Intermediate Wheatgrass	UPL
Thlaspi arvense	Field Pennycress	UPL
Tragopogon pratensis	Meadow Goat's-beard	UPL
Trifolium pratense	Red Clover	FACU
Trifolium repens	White Clover	FAC
Verbascum thapsus	Great Mullein	FACU
Veronica americana	American-Brooklime	OBL

*2016 National Wetland Plant List; *Western Mountains, Valleys, and Coasts* (WMVC) (Lichvar *et al.* 2016)
New species identified in 2018 are **bolded**.
Species identified to genus level have been assigned an indicator status of N/A.

4.2. Bank Erosion Inventory

Over the past six years, erosion has been observed both upstream and within the project reach, with the extent and severity of erosion documented in each monitoring report. Over this monitoring period, erosion has been attributed to adjusting bank lines that occur as a result of natural scour and depositional processes that occur during and following high flows events. In 2018, bank erosion was noted at six locations within the project reach, and continues to occur along a sharp meander bend immediately upstream of the monitoring reach. Descriptions of erosion at these locations is provided in the following section, while the locations of eroding banks are illustrated on Figure 3 in Appendix A.

4.2.1. Erosion Upstream of Monitoring Reach.

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). These eroding bank areas occur on private land upstream of the project reach, but have been documented in previous monitoring reports due to the potential of continued erosion affecting the project reach. The upper 150 feet of EBL1-2 has shown relatively little change over the past four monitoring years, has migrated northward approximately one to three feet since 2014 (see Additional Photo 1 in Appendix C). The lower 100 feet of the bank has migrated northward at a more rapid pace than the upper bank segment since 2014, especially in the vicinity of a large ponderosa pine tree that fell into the channel in 2016. The bank has migrated northward approximately 10 feet in the past two years adjacent to the exposed root ball of this tree (see Additional Photo 10 in Appendix C).

Bank erosion at EBL1-2 is due to an advancing point bar, which places the channel against a relatively high, herbaceously vegetated stream bank that runs 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 downstream end of the bank retreated between 3 and 7 feet from 2013 to 2014, an additional 2-5 feet from 2014 to 2015 and approximately 5-10 feet further since 2016. Based on the combination of eroding factors, severity of erosion along EBL1-2 is considered high. Although this bank has consistently retreated northward over the past six years, its effect on the restored channel segment below it does not appear to be consequential. Rather, the eroding bank has resulted in the recruitment of large woody debris to the channel, which is beneficial toward the development of diverse aquatic habitat.

4.2.2. Previously Eroding Bank Segments

Signs of active erosion at EBL3 were originally observed in 2014 at the head of the former channel alignment which is now largely backfilled with gravel, cobble, and soil. Erosion was originally observed along approximately 90 feet of the bank between the upstream extent of the backfill and the root ball of a fallen tree. While gravel deposition

along this bank reduced the erosion between 2015 and 2017 (see Additional Photo 3), high flows in 2018 eroded approximately 30 feet of the bank toe along the downstream end of this bank (see Additional Photo 4). The vegetation community along this bank consists of short-awn meadow foxtail, white and red clover, Kentucky bluegrass, common tansy, and ox-eye daisy. Erosion along this bank occurred as a riffle developed just upstream, sending water toward the bank during high flows. The erosion is not jeopardizing the backfilled channel alignment, does not jeopardize any infrastructure, and is occurring as part of the channel naturally adjusting. As a result, no corrective actions are warranted at this location.

Lateral erosion at bank EBL4 has continued the past three years, as evidenced by a log jam forming adjacent to the bank causing localized scour (see Additional Photo 5 in Appendix C). The bank has retreated approximately two feet in the past year and 8-10 feet in the past six years, although the eroding bank length has not increased. Bank instability at this location was potentially caused by removal of the trees for use in log revetment construction, or by natural channel adjustments and debris jams forming following construction. These debris jams are considered beneficial to the restored channel alignment, as they improve habitat complexity and generate pool scour features to the benefit of fish. 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, as it does not jeopardize any infrastructure elements or the newly installed bridge downstream. As a result of the erosion occurring from 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. Continued erosion was not observed along the bank between 2015 and 2017, however erosion along the toe of the bank was noted in 2018 (See Additional Photo 6 in Appendix C). As such, it has been added back to the actively eroding bank inventory. This bank's slow erosion rate and protection by numerous rooted trees and shrubs classifies it as low erosion severity.

Erosion at EBR2 was originally noted in 2014 along 65 feet of the channel across from the head of the deactivated stream channel. Erosion at this location was tied to channel adjustments and scour along the outside of a meander. Additional erosion along this bank segment was not observed between 2015 and 2017; however the bank showed signs of erosion again in 2018 including undercutting, slumping sod mats, and root exposure (see Additional Photo 7 in Appendix C). As such, a 40-foot segment of this bank segment returned to the list of actively eroding banks. While this bank began eroding again in 2018, movement of the bank is not jeopardizing any infrastructure and is occurring as part of natural channel adjustments. As such, no corrective actions are warranted along this bank.

Eroding bank EBR3 was observed in 2017 adjacent to a woody debris jam and was characterized by upper bank sloughing and toe scour. Vegetation along the upper bank

includes reed canary grass, oxeye daisy, woods rose, wheatgrass, brome, small cottonwood saplings, and young willows. The bank did not appear to retreat further during 2018 flows, as the adjacent debris jam broke up and a gravel bar has formed adjacent to the bank (Additional Photo 8 in Appendix C).

4.2.3. Newly Observed Bank Erosion

A newly eroding bank segment was observed in 2018 on the left bank near the upstream end of the monitoring reach (EBL5). Erosion along this 20-foot bank segment is due to gravel depositing on the inside of the meander bend and just below the downed ponderosa pine tree. This deposit focuses high flows toward the left bank, which is primarily vegetated with upland species including short-awn meadow foxtail, white and red clover, Kentucky bluegrass, common tansy, and ox-eye daisy. This bank retreated approximately four feet in the past year, as evidenced by bank transect #1.

An updated eroding bank inventory within the Mill Creek project site can be summarized as follows:

Table 4. Eroding bank summary for Mill Creek observed in 2018.

Bank Segment[1]	Length (ft)	Bank actively Eroding	Bank no longer eroding
EBL3	30	X	
EBL4	64	X	
EBR1	58	X	
EBR2	40	X	
EBR3	47		X
EBL5	20	X	
Total active eroding bank length	212 feet		
Total bank length within project reach	1,450 feet		
Percent of banks actively eroding	15%		

[1] Table does not include EBL1-2, as it lies outside of the project boundary.

4.3. Longitudinal Profile and Perpendicular Transect Surveys

A longitudinal profile of the channel thalweg surveyed each year from 2014 to 2018 is provided in Figure 2, while plots for each surveyed transect are included in Appendix B. Transects #2 and #3 were originally installed to document channel dimensions at scour pools formed by woody debris jams, while transects #1 and #4 were surveyed at riffles. While transect #1 was originally positioned at a riffle, survey data from 2013-2015 indicated the channel transitioned to more of a pool feature by forming a point bar 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 forming near this transect. In 2017, the mid channel bar further developed, causing a split flow. In 2018, additional deposition closer to the right bank forced flows against the left bank, which scoured a relatively deep pool feature.

Monitoring across this transect over the past six years depicts an actively adjusting channel due to both depositional and scouring processes.

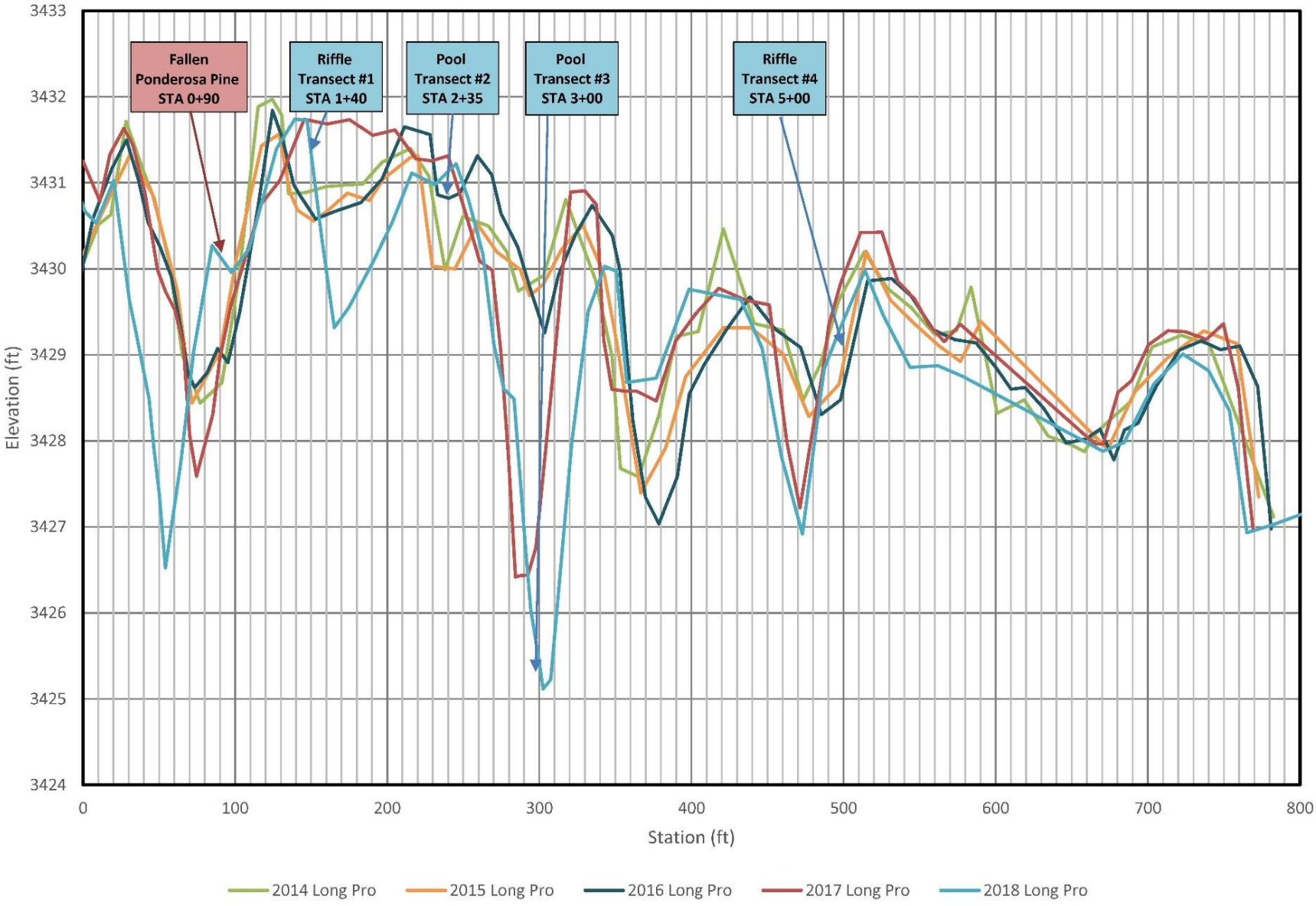
Transect #2 was originally established at a pool adjacent to a woody debris jam formed along the left (north) bank. Between 2015 and 2017, a gravel deposit formed along the left bank which continued to form in 2018 causing the channel thalweg to shift over toward the right bank. The resulting scour against the right bank has developed a shallow pool at transect #2. The shift in thalweg location across the channel over the past six years at this transect provides additional evidence of a dynamic channel that adjusts over time as debris jams form and gravels deposit. The adjustment to the channel transect at this location is considered a natural response to frequent gravel deposits and bar development, which is commonly observed in high bedload streams. These adjustments are considered beneficial to the channel over time, as they provide a diversity in habitat complexity within the active channel.

In 2017, a deep pool developed at transect #3 adjacent to a woody debris jam. In 2018, this debris jam remained a scour feature in the center of the channel, and the deep pool adjacent to it is continuing to provide habitat complexity within the project reach. The pool here is three feet deeper than it was in 2016, and has remained the deepest pool within the project reach for the past two years.

Transect #4 was originally positioned at a riffle just above the last meander bend upstream of the U.S. Highway 93 Bridge. Repeated surveys in 2018 reveal a developing point bar on the left bank and deeper thalweg along the right bank. Although the stream bed at this transect aggraded between 3 and 4 inches between 2016 and 2017; the channel did not continue to aggrade in 2018. Bar development along the left bank may eventually result in erosion along the right bank; however no erosion has been observed in the vicinity of transect #4 to date.

Inspection of the stream bed longitudinal profile and cross sections at each of the four monitoring transects over the past six years reveal a stream bed that is adjusting over time to incoming sediment loads and woody debris complexes. Mill Creek exhibits active bedload transport, as evidenced by the frequency of point bars and a thalweg that shifts from one side of the channel to the other. The adjusting banks and bed within the monitoring reach provide evidence that the channel is naturally adjusting to fluvial processes during and following high flow events. Given the channel is actively moving but does not threaten infrastructure, efforts to stabilize banks or prevent naturally active bed movements are unwarranted. Allowing the channel to freely adjust and migrate has resulted in the development of several high-quality features, including deep scour pools and riffles that provide productive and diverse habitat that benefit aquatic species.

Figure 2. Thalweg longitudinal profile along Mill Creek, 2014 – 2018.



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 5 summarizes the status of each performance criteria following the sixth year of monitoring and seven 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 5. Status of performance standards

Parameter	Success Criteria	Status	Meeting Performance Criteria?
Riparian Cover	80% total vegetative coverage after 3rd year	Total vegetative cover of the project site is **86%** following the sixth year of monitoring (97% of south bank and 82% of north bank).	Yes
	50% woody species coverage after 3rd year	Woody cover of the project site is **29%** following the sixth year of monitoring (63% of south bank and 18% of north bank).	No
Streambank Stability	Unstable banks identified within the project reach will require corrective action	Six eroding bank segments were observed in 2018 totaling 212 feet, or 15% of the total bank length within the project reach.	Although erosion is occurring within project reach, it occurs as a result of natural channel processes and does not threaten infrastructure. Corrective actions do not appear necessary.

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. Woody vegetation establishment along the north bank has yet to develop as planned.

Total vegetation cover observed along the north bank riparian transect was 82%. Patches of bare ground were observed along the deactivated channel alignment and within and adjacent to noxious weed infestations. A mowed, two-track road was observed within the north bank riparian area, running from the private property to the west through the mitigation area to the bridge, which is resulting in a reduction in total percent cover within the riparian transect. Vegetation within the restored channel reach is now dominated by native and non-native grass and forb species, with minimal cover by volunteer woody species. Minimal vegetation cover was observed beneath many of the mature ponderosa pine trees, likely a result of the perpetual shade and dense layer of pine needles beneath the trees. When factoring in the undisturbed south bank, total vegetation cover across the site was 86%, which exceeds the 80% success threshold for riparian cover throughout the site.

Woody vegetation cover along the north bank was estimated at 18% 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.

Woody vegetation cover along the south bank was estimated at 63%. The area weighted average of woody vegetation cover for the north and south bank belt transects was 29%. Woody vegetation cover meets the performance criterion along the south bank but does not along north bank.

5.2. Bank Erosion Inventory

Six eroding banks were observed within the project reach totaling 212 feet, or 15% of the total bank length. Eroding bank length increased by just over 100 feet since 2017, which can be attributed to above average snowpack resulting in a lengthy runoff in the spring of 2018. Woody debris jams have continued to influence bank erosion where large trees have fallen into the channel and generate scour. Although erosion was more prevalent in 2018, none of the erosion threatens highway infrastructure or fences and is occurring due to natural fluvial processes of erosion and scour.

Eroding bank EBL1-2 has continued to advance northward, particularly near the downstream end of the eroding bank. Erosion along this bank has resulted in a large ponderosa pine tree falling into the channel in 2016, which has induced additional scour in the vicinity of the root ball and trunk. The bank has retreated northward approximately ten feet in the past two years near the downed tree, but otherwise has not jeopardized the project reach or any infrastructure. The fallen tree has resulted in more diverse habitat and the development of a deep pool immediately downstream.

The severity of bank erosion within the project reach is considered low due to relatively slow bank migration rates occurring as a result of natural processes that do not currently jeopardize infrastructure. Erosion along the banks within the project reach are due to processes that occur in naturally functioning channels with high bedload and snowmelt driven hydrology. Bedload deposition and scour created by meander bends and woody debris will continue resulting in minor lateral movement of the stream banks. Given the degree of active erosion currently observed, corrective actions do not seem warranted at this time.

6.0 LITERATURE CITED

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. *Measuring and monitoring plant populations*. Bureau of Land Management (BLM) Technical Reference 1730-1. Washington, DC: U.S. Department of the Interior.

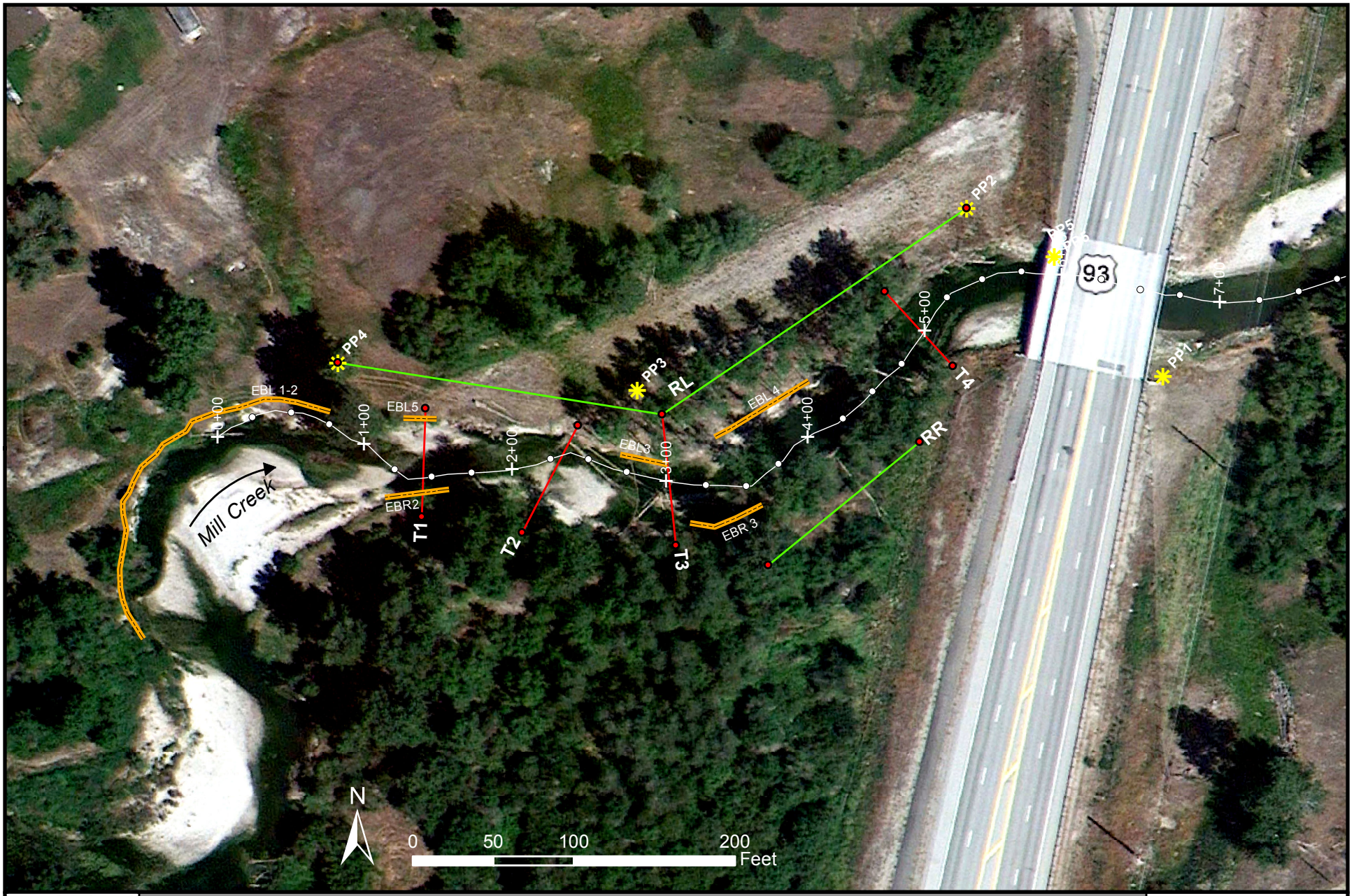
Lichvar, R.W., D.L. Banks, W.N. Kirchner, and N.C. Melvin. 2016. *The National Wetland Plant List*: *2016 Update of Wetland Ratings.* Phytoneuron 2016-30: 1-17. Published 28 April 2016. ISSN 2153 733X

Montana Department of Agriculture. *Montana Noxious Weed List*. February 2017. Accessed October 2018 at: http://agr.mt.gov/Portals/168/Documents/Weeds/2017%20Noxious%20Weed%20List.pdf.

Appendix A

Project Maps

MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana



Legend

- Channel Thalweg
- \+ Major Station (100')
- ○ Minor Station (25')
- ✱ Photo Points
- Eroding Banks
- Pool and Riffle Transects
- Riparian Transects

CONFLUENCE consulting incorporated

2018 Monitoring Features Mill Creek

Figure 3

Date: 10/11/2018

MillCreek_features2018

CONFLUENCE
consulting incorporated

Legend

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

N

0 25 50 100 150 200 Feet

2018 Monitoring Noxious Weeds Mill Creek

Figure 4

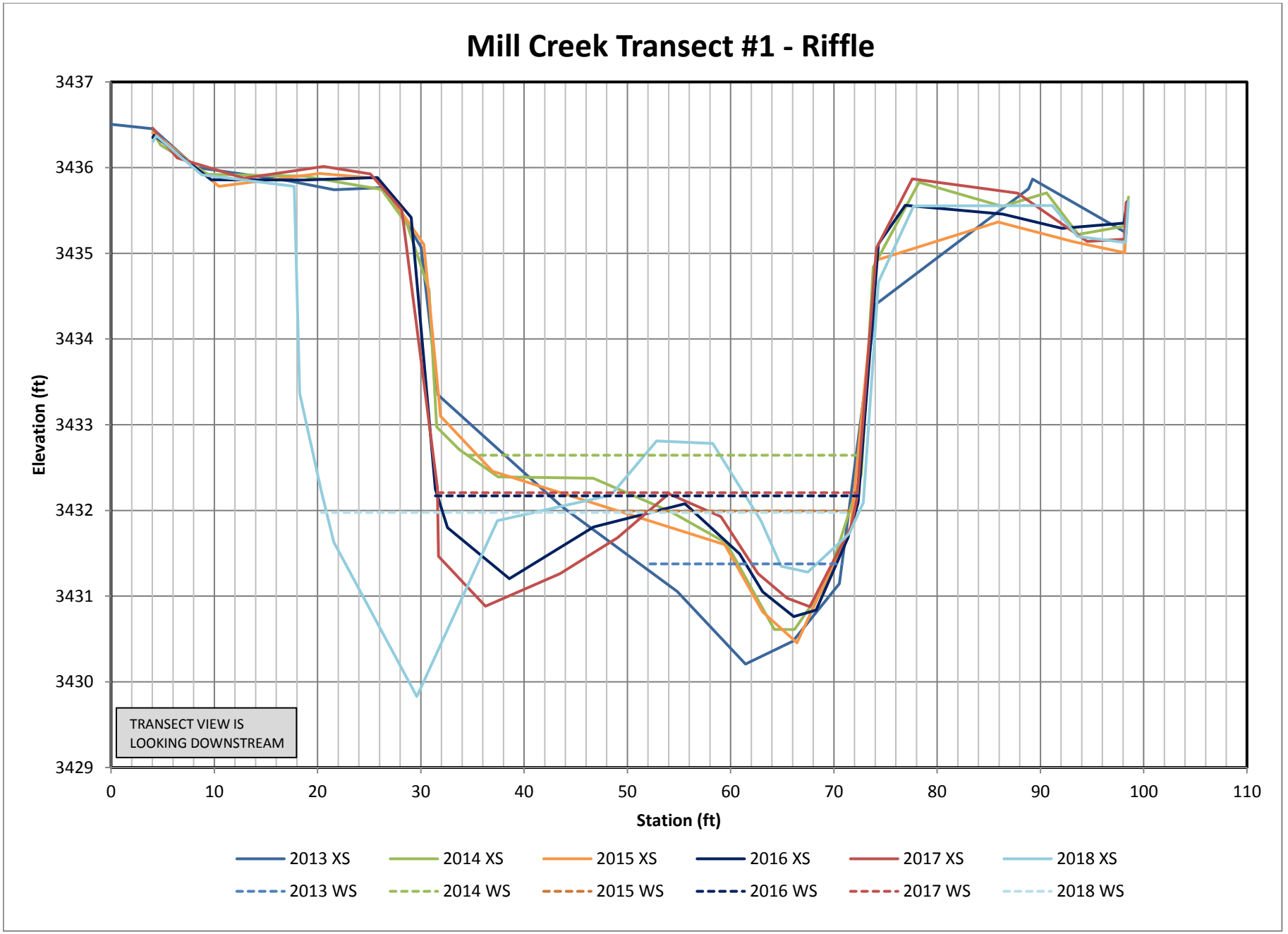
Date: 10/18/2018

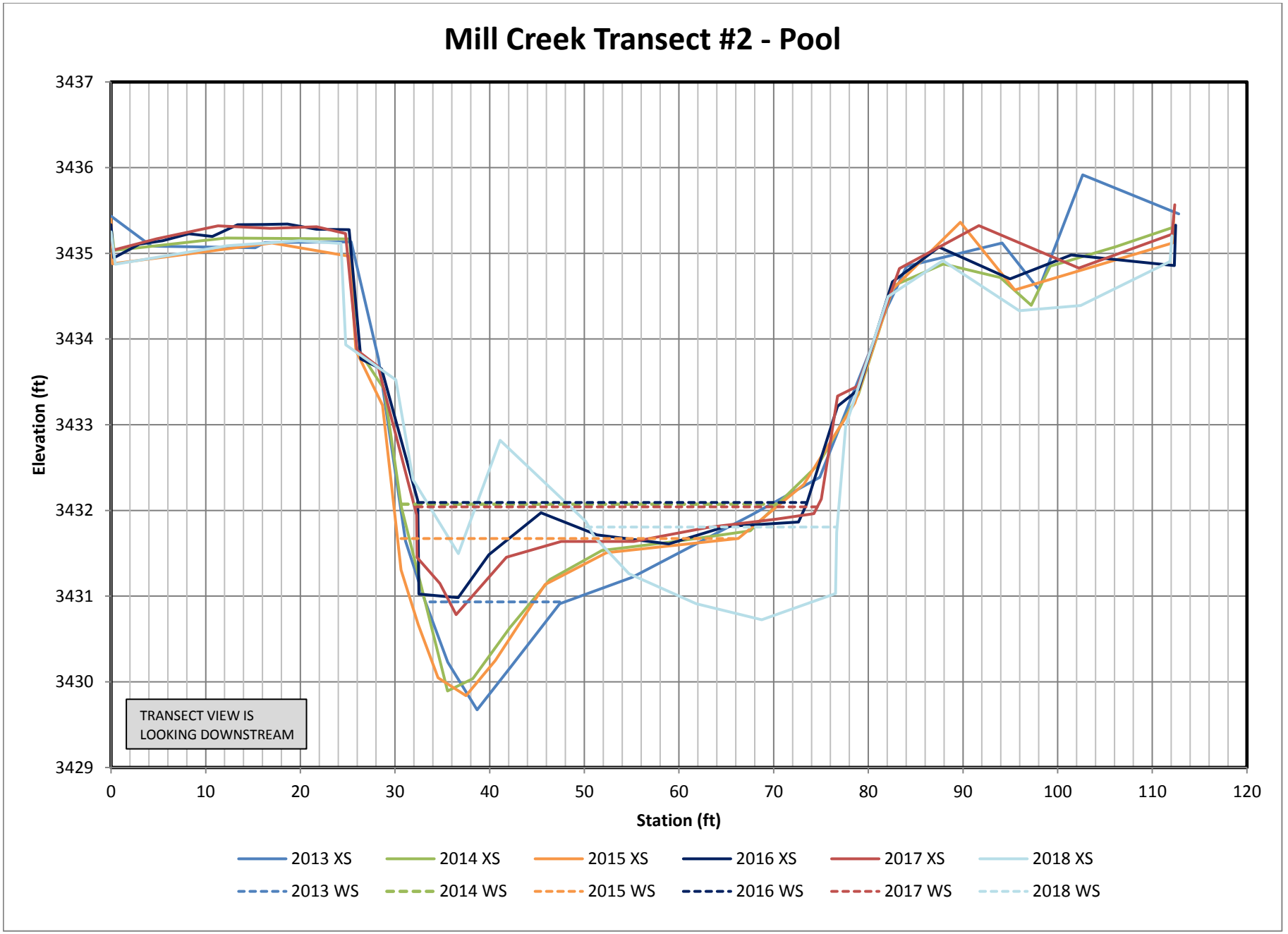
MillCreek_Weeds2018.mxd

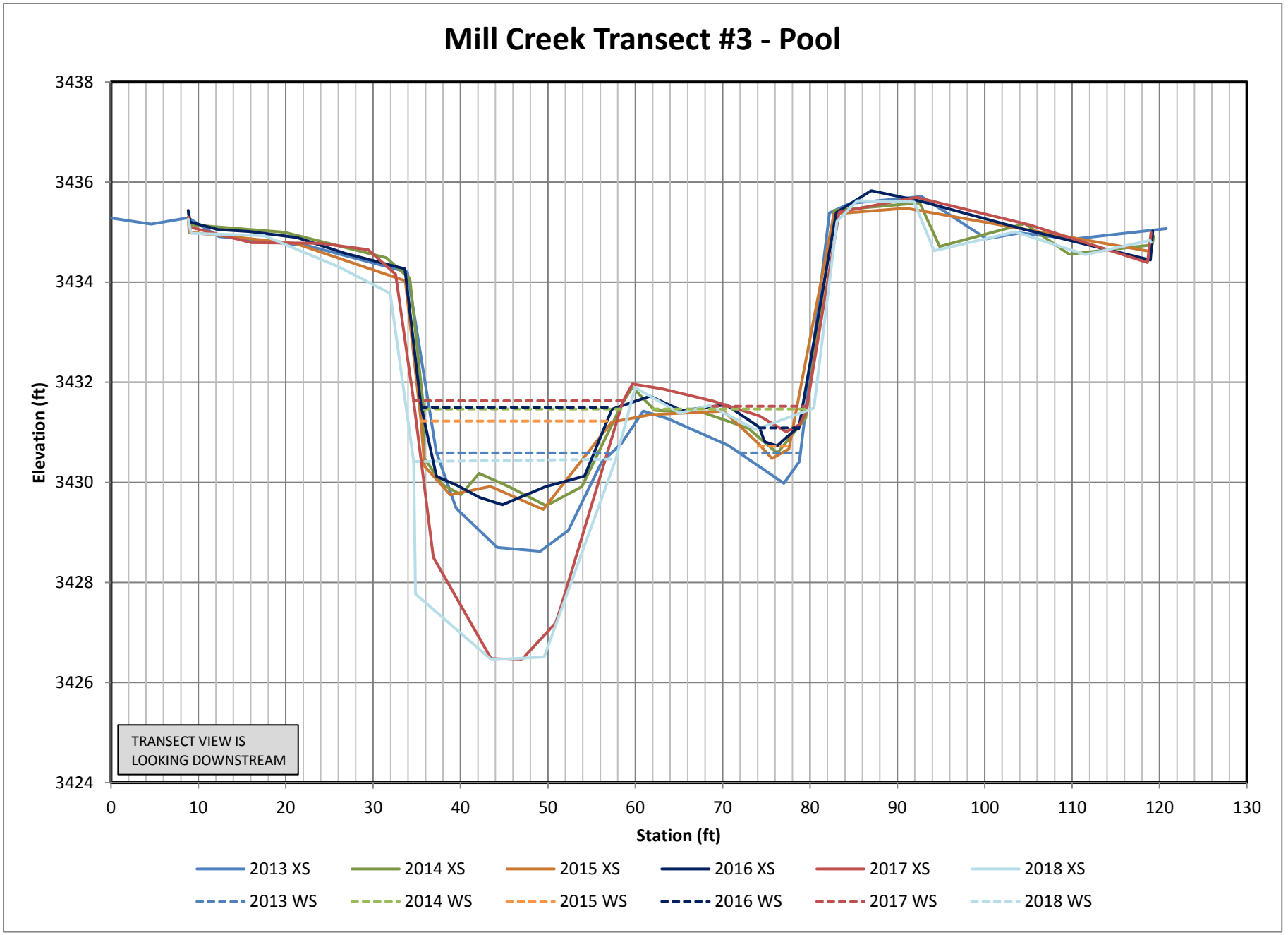
Appendix B

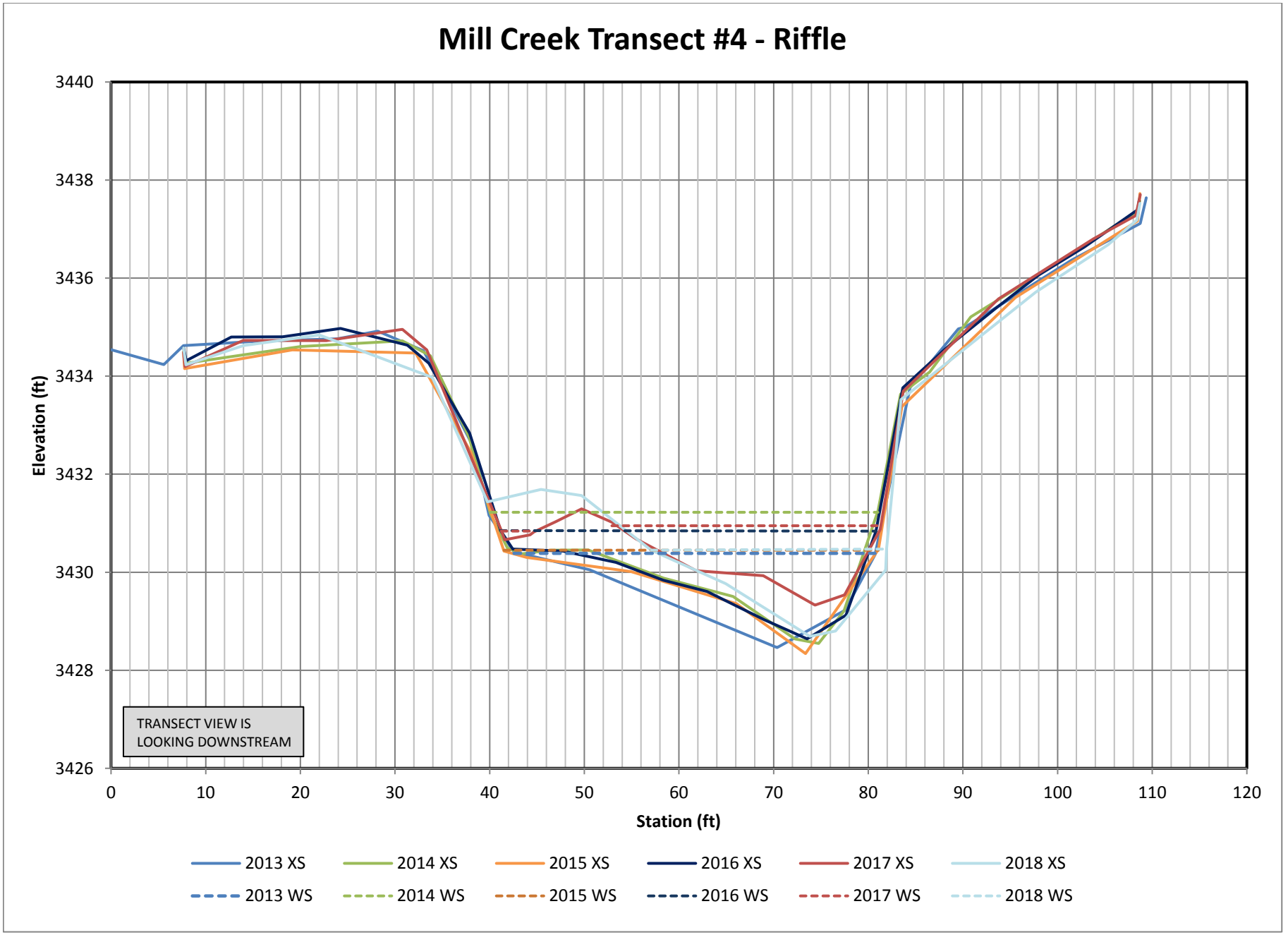
Perpendicular Transect Plots

MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana


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
2017 XS
2018 XS
2013 WS
2014 WS
2015 WS
2016 WS
2017 WS
2018 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
2017 XS
2018 XS
2013 WS
2014 WS
2015 WS
2016 WS
2017 WS
2018 WS


Mill Creek Transect #3 - Pool
Elevation (ft)
3438
3436
3434
3432
3430
3428
3426
3424
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
2017 XS
2018 XS
2013 WS
2014 WS
2015 WS
2016 WS
2017 WS
2018 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
2017 XS
2018 XS
2013 WS
2014 WS
2015 WS
2016 WS
2017 WS
2018 WS

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 2018 Monitoring Events

CONFLUENCE

2013 **2018**

Photo Point 1.1: View east (downstream) of Hwy 93 Bridge. **Compass**: 45 (Northeast)

2013 **2018**

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

2013 **2018**

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

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2018 Monitoring Events

CONFLUENCE

2013 **2018**

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

2013 **2018**

Photo Point 2.3: View from Photo Point 2 looking upstream. **Compass**: 248 (West-Southwest)

2013 **2018**

Photo Point 2.4: View of deactivated channel alignment **Compass**: 270 (West)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2018 Monitoring Events

2013 **2018**

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

2013 **2018**

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

2013 **2018**

Photo Point 3.2: View of deactivated channel plug**. Compass**: 45 (East)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2018 Monitoring Events

2013 **2018**

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

2013 **2018**

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

2013 **2018**

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

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2018 Monitoring Events

CONFLUENCE

2013 **2018**

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

2013 **2018**

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

2013 **2018**

Photo Point 3.8: View looking across deactivated channel segment. **Compass**: 90 (East)

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2018 Monitoring Events

CONFLUENCE

2013 **2018**

Photo Point 4.2: View across stream channel toward south bank. **Compass**: 180 (South)
Note: toppled Ponderosa pine tree obscures view on left side of photo

2013 **2018**

Photo Point 4.3: View of point bar formation from Photo Point 4. **Compass**: 225 (Southwest)

2013 **2018**

Photo Point 4.4: 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 2018 Monitoring Events

CONFLUENCE

2013 **2018**

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

2013 **2018**

Photo Point 5.2: View looking upstream from bridge. **Compass**: 203 (South-Southwest)

2013 **2018**

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

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2018 Monitoring Events

2013

2018

Additional Photo 1:Upper end of eroding Bank EBL1 -2

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2018 Monitoring Events

2013

2018

Additional Photo 2: Lower end of eroding Bank EBL1-2

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2014 and 2018 Monitoring Events

2014

2018

Additional Photo 3: Upper section of Eroding Streambank EBL3

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2014 and 2018 Monitoring Events

CONFLUENCE

2014

2018

Additional Photo 4: Lower section of Eroding Streambank EBL3

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2018 Monitoring Events

CONFLUENCE

2013 **2018**

Additional Photo 5: Eroding streambank EBL4

2013 **2018**

Additional Photo 6: Eroding streambank EBR1

2013 **2018**

Additional Photo 7: Eroding streambank EBR2

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2016 and 2018 Monitoring Events

Additional Photo 8: Eroding Bank EBR3—2018

Additional Photo 9: Eroding bank EBL5—2018

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2016 and 2018 Monitoring Events

2016

2018

Additional Photo 10: Ponderosa pine in channel near downstream end of EBR2

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T1 LOOKING NORTH UPSTREAM FROM T1 SOUTH

T1 LOOKING SOUTH DOWNSTREAM FROM T1 NORTH

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T1 LOOKING WEST UPSTREAM FROM SOUTH BANK

T1 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T1 LOOKING WEST UPSTREAM FROM MIDDLE OF CREEK

T1 LOOKING EAST DOWNSTREAM FROM MIDDLE OF CREEK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T1 LOOKING WEST UPSTREAM FROM NORTH BANK

T1 LOOKING EAST DOWNSTREAM FROM NORTH BANK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T2 LOOKING NORTH UPSTREAM FROM T2 SOUTH

T2 LOOKING SOUTH DOWNSTREAM FROM T2 NORTH

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T2 LOOKING WEST UPSTREAM FROM SOUTH BANK

T2 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T2 LOOKING WEST UPSTREAM FROM MIDDLE OF CREEK

T2 LOOKING EAST DOWNSTREAM FROM MIDDLE OF CREEK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T2 LOOKING WEST UPSTREAM FROM NORTH BANK

T2 LOOKING EAST DOWNSTREAM FROM NORTH BANK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T3 LOOKING NORTH UPSTREAM FROM T3 SOUTH

T3 LOOKING SOUTH DOWNSTREAM FROM T3 NORTH

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T3 LOOKING WEST UPSTREAM FROM SOUTH BANK

T3 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T3 LOOKING WEST UPSTREAM FROM MIDDLE OF CREEK

T3 LOOKING EAST DOWNSTREAM FROM MIDDLE OF CREEK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T3 LOOKING WEST UPSTREAM FROM NORTH BANK

T3 LOOKING EAST DOWNSTREAM FROM NORTH BANK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T4 LOOKING NORTH UPSTREAM FROM T4 SOUTH

T4 LOOKING SOUTH DOWNSTREAM FROM T4 NORTH

T4 LOOKING WEST UPSTREAM FROM SOUTH BANK

T4 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T4 LOOKING WEST UPSTREAM FROM MIDDLE CREEK

T4 LOOKING EAST DOWNSTREAM FROM MIDDLE CREEK

PROJECT NAME: 2018 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-13-18

T4 LOOKING WEST UPSTREAM FROM NORTH BANK

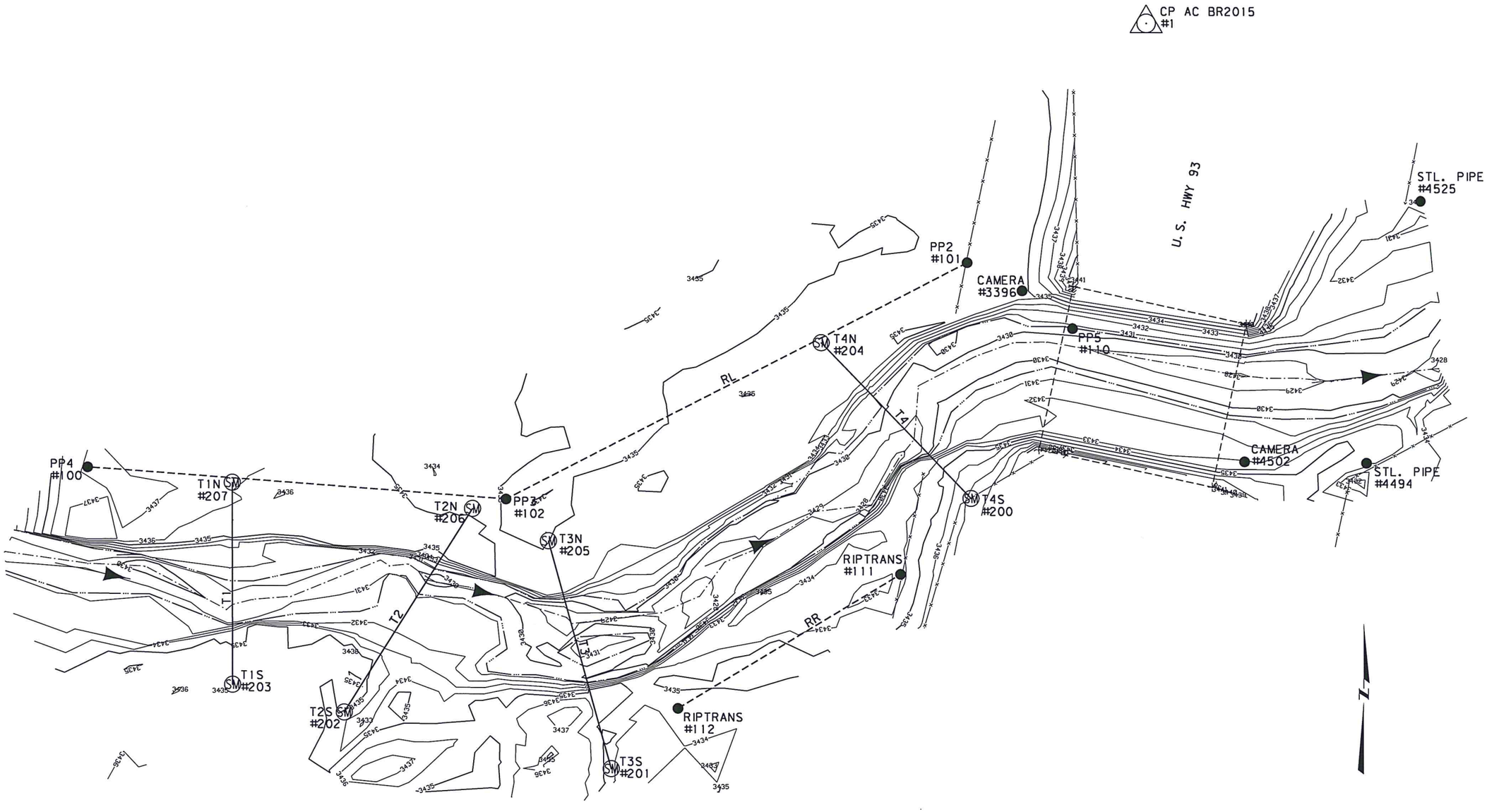
T4 LOOKING EAST DOWNSTREAM FROM NORTH BANK

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:

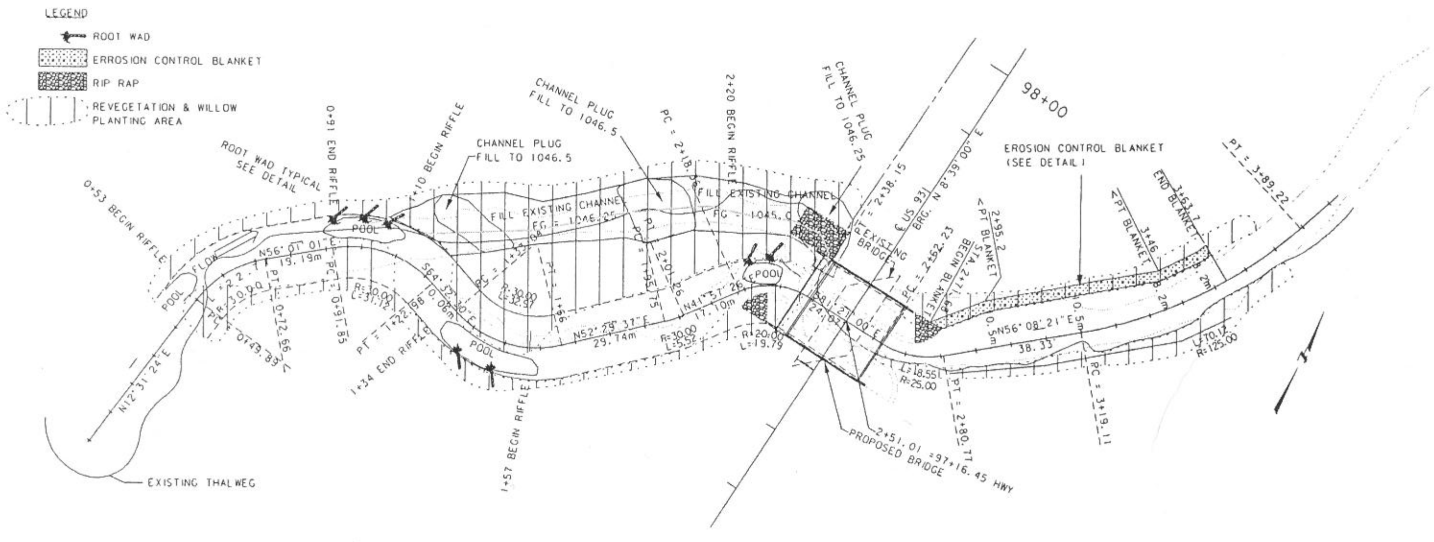
1. THIS SURVEY IS BASED ON FOUND MDT ALUMINUM CAPS STAMPED BR2015 AND BS2015 BUT THEY DO NOT HAVE ESTABLISHED MDT COORDS AND ELEVATIONS. THEREFORE LOCAL CONTROL WAS ESTABLISHED FOR THIS SITE WITH TRIMBLE GPS RTK SURVEY AND THE APPROXIMATE ASSUMED ELEVATION AT MDT ALUM CAP BR2015.
2. THE COORDINATES SHOWN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

0 25 50 75 100

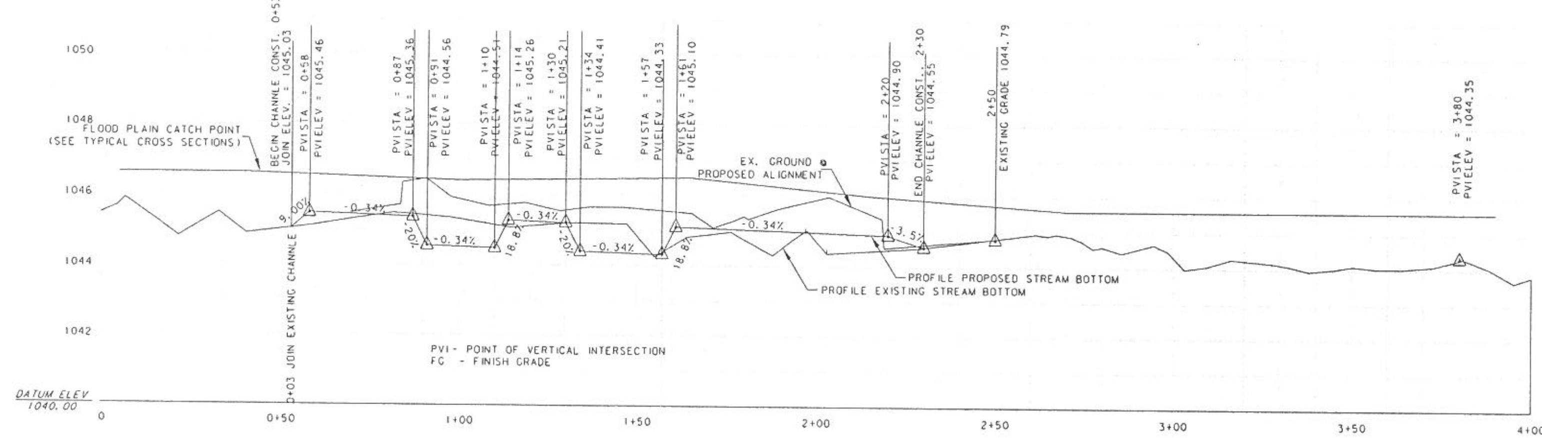
3	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\MILL CREEK\MillcreekPLAN .dgn	DESIGNED BY	ARNE W		MILL CREEK TOPO	MDT STREAM MITIGATION MONITORING SURVEY
2		12/9/2013	REVIEWED BY				
1		11:04:43 AM awiebe	CHECKED BY	LARRY R			

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

BEAR CREEK ROAD - SOUTH



PLAN



PROFILE

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

MILL CREEK
CHANNEL
RESTORATION
DETAIL
STA. 97+16
SHEET 1 OF 3
NO SCALE

LAND & WATER CONSULTING, INC.

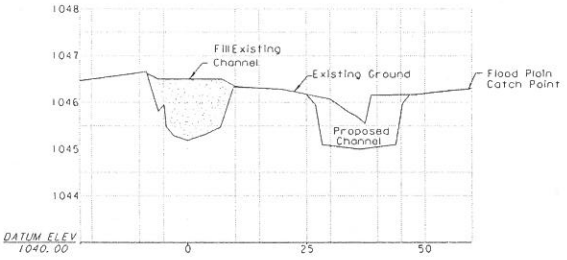
MONTANA CADD

MDT MONTANA DEPARTMENT OF TRANSPORTATION

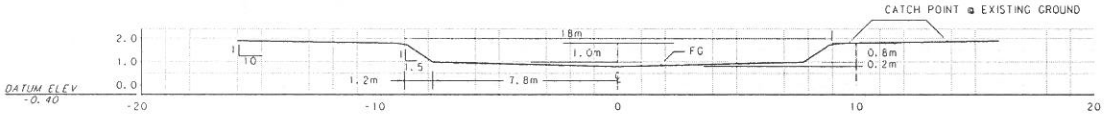
c:\dgn\a015rdet207.dgn
2/7/2011
12:09:18 PM
2 | 3 | EPS - U2160

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

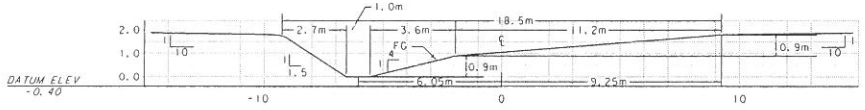
BEAR CREEK ROAD - SOUTH



CROSS SECTIONS 1+97



TYPICAL RIFFLE CROSS SECTION



TYPICAL POOL LEFT CROSS SECTION

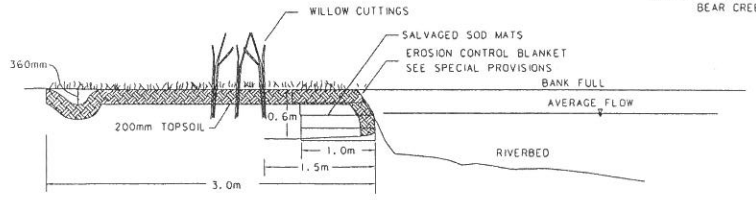
NOTES:

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.

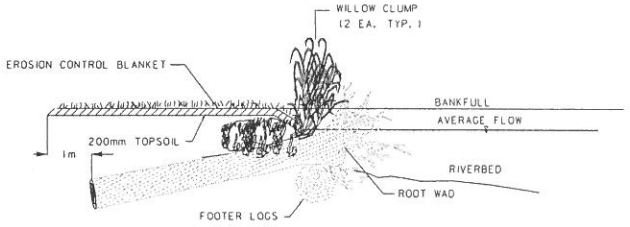
STATION From	STATION To	POOL LEFT	RIFFLE (INCLUDES 4m TRANSITION)	POOL RIGHT
0+00	0+53			
0+53	0+91		X	
0+91	1+10	X		
1+10	1+34		X	
1+34	1+57			X
1+57	2+20		X	
2+20	2+30	X		
2+30	5+00			



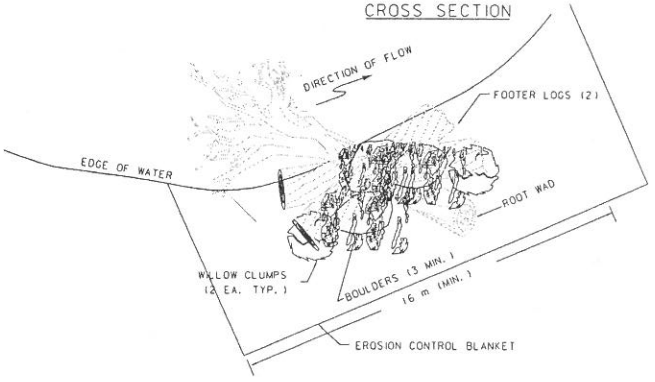
1. SUB EXCAVATE BANKS 0.6 METERS.
2. LAY LOWER BLANKET MINIMUM 1.5 METERS FROM EDGE OF BANK.
3. BACK FILL WITH NATIVE MATERIAL AND 0.2 METERS TOPSOIL.
4. FACE STREAM BANK BACKFILL WITH 1.0 METERS OF SALVAGED SOD MATS.
5. WRAP BLANKET AND EXTEND 3.0 METERS MIN. FROM BANK EDGE.

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.

G:\lgm\0715\dwf\07_dwg
2/17/2017
12:09:20 PM
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