MONTANA DEPARTMENT OF TRANSPORTATION
STREAM MITIGATION MONITORING REPORT

Mill Creek
Ravalli County, Montana

Project Constructed: 2011
Monitoring Report #7: December, 2019

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 #7

YEAR 2019

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:

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December 2019

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1.0 INTRODUCTION

The following report presents results for the seventh 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 eight 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 seventh year monitoring of the Mill Creek project are summarized in Section 4 and compared to performance standards in Section 5. Additional reporting requirements, including project site maps, survey results at four perpendicular transects and a longitudinal profile, project site photographs, 2013 through 2019 comprehensive plant species list, 2019 noxious weed list, 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 13, 2019 while topographic survey crews visited the site on August 19th, 2019. 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 2019, the total percent riparian cover was 88%, and included 58% cover by herbaceous species and 30% cover by woody species. The site exhibited an estimated 14% noxious weed cover, which was similar to that observed during the 2018 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, fluctuations in plant phenological events in response to climate, and other factors that make it difficult to determine the exact cause(s) for increases or decreases in coverage.

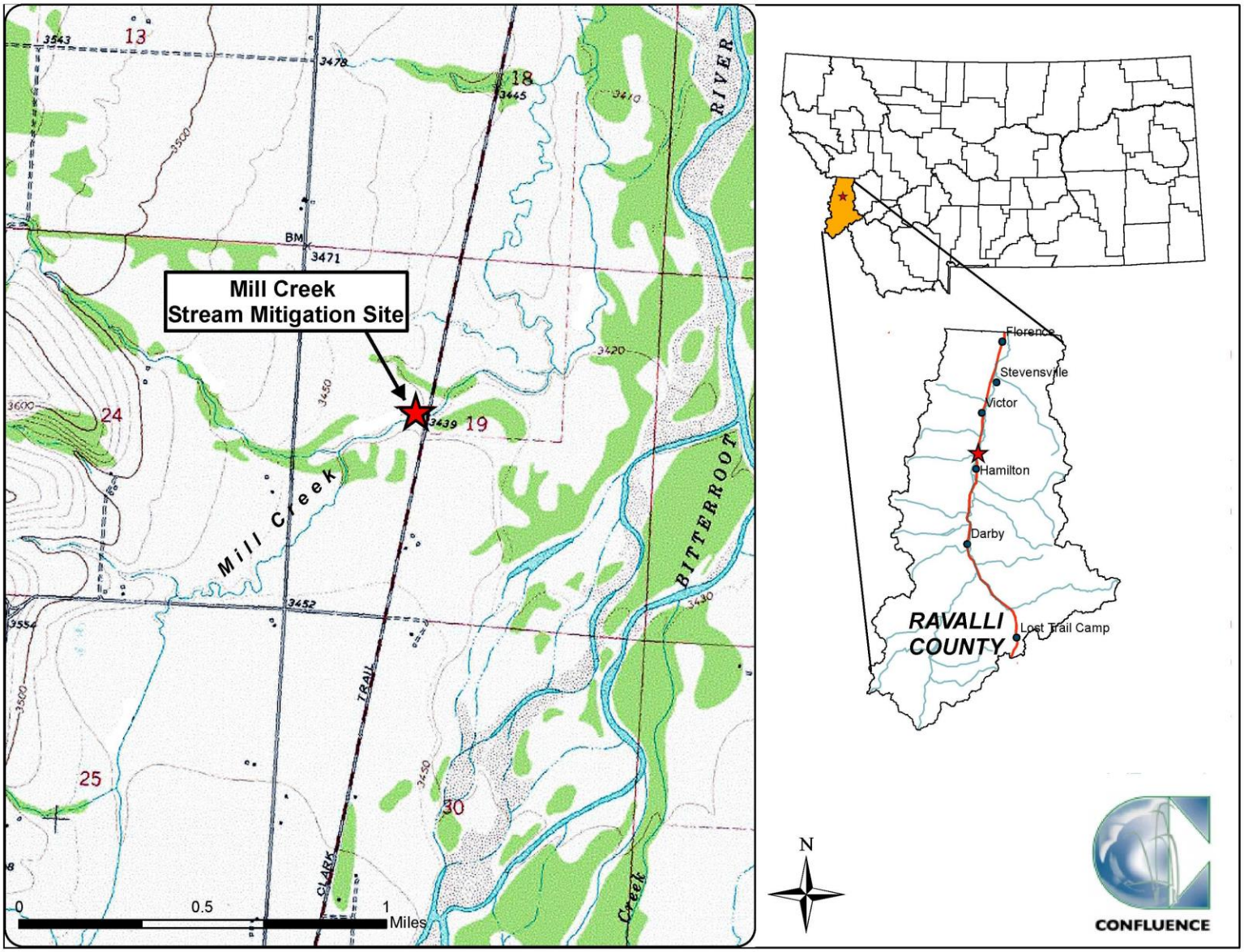

Figure 1. Project location of Mill Creek Stream Mitigation Site.

Table 1. Visual estimate of Mill Creek plant coverage from 2013 through 2019.

Belt Transect	Length (ft)	Total % Riparian Cover							% Woody Cover							% Noxious Weed Cover						
		2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019	2013	2014	2015	2016	2017	2018	2019
Right (south bank)	140	100	100	96	97	97	97	97	60	60	60	62	62	63	63	1	1	2	3	3	3	1
Left (north bank)	435	75	80	80	85	80	82	85	15	15	15	16	17	18	20	15	20	25	27	16	17	18
Area weighted Total	575	81	85	84	88	84	86	88	26	26	26	27	28	29	30	11	15	19	21	13	14	14

The vegetation inventory along Mill Creek identified eight noxious weeds and one state-regulated species (Appendix E). Isolated occurrences of houndstongue (*Cynoglossum officinale*), St. Johnswort (*Hypericum perforatum*), and leafy spurge (*Euphorbia esula*) were observed within the project area during the 2017 through 2019 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 3 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.

Appendix D includes a comprehensive list of plant species observed along the new channel alignment and riparian buffer areas from 2013 through 2019. In 2019, 126 species were observed, representing an increase of 4 species since the 2018 monitoring event. Three of the four new species observed in 2019 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 western water-hemlock (*Cicuta douglasii*), panicled willowherb (*Epilobium brachycarpum*), and common red raspberry (*Rubus idaeus*). Crested wheatgrass (*Agropyron cristatum*), a species native to Russia and Siberia, was also observed in 2019 within the project area. Sixty of the species (48%) observed between 2013 and 2019 are hydrophytic based on the 2016 National Wetland Plant List (NWPL) (Lichvar *et al*. 2016).

4.2. Bank Erosion Inventory

Over the past seven 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 stream bank adjustments resulting from natural scour and depositional processes that occur during and following high flows events. Over the course of the monitoring period (2013-2019), Mill Creek has exhibited mid-channel and point bar depositional features, localized erosion which appears to quickly stabilize, as well as severe erosion just upstream of the project reach. These features are commonly observed in streams that transport large bedload quantities, as is the case for many Bitterroot River tributaries flowing east from the Bitterroot Mountains. In 2019, active bank erosion was noted at four 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 2 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). This eroding bank occurs on private land upstream of the project reach, but has 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, and has shown a bank retreat rate of between 0.2 and 0.6 feet per year (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, especially in the vicinity of a large ponderosa pine tree that fell into the channel in 2016. The bank has migrated at a rate of 6-7 feet/year for the past three 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 at a rate of 1.5 to 3 feet/year from 2013 to 2014, and 3 to 7 feet per year between 2015 and 2018. A 10-foot lateral migration in the past year alone represents the highest rate of erosion noted along this bank since 2013. Based on the combination of eroding factors, severity of erosion along EBL1-2 is considered high, particularly along the lower end of the bank. While erosion rates are high at this location, it 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. As a result, this area is no longer classified as eroding and has been removed from the list of actively eroding banks.

Lateral erosion at bank EBL4 has continued the past four 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 one foot in the past year and 9-11 feet in the past six years, although the eroding bank length has actually reduced since the initial bank erosion inventory in 2013. 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 was observed in 2014 and is 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 minor erosion along the toe of the bank was noted in 2018 (See Additional Photo 6 in Appendix C). No additional erosion was observed in 2019; as such it has been removed from the list of actively eroding banks.

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 and 2019, including undercutting, slumping sod mats, and root exposure (see Additional Photo 7 in Appendix C). The eroding bank length doubled from 40 feet to 81 feet in 2019 due to the development of a gravel bar on the north side of the channel, and subsequent scour against the south bank. The erosion is resulting from the natural dynamics of the channel's fluvial processes, and does not need to be corrected despite the eroding bank length doubling in the past year. 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 appeared to retreat by approximately 1 foot or less during high flows in 2018 or 2019, as the adjacent debris jam broke up and a gravel bar has developed adjacent to the bank (Additional Photo 8 in Appendix C). Given the bank's relatively slow retreat rate and the lack of adjacent infrastructure or fencing, corrective actions are not warranted along this bank at this time.

Erosion 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 2018, and an additional 10 feet in 2019, as evidenced by bank transect #1. Erosion at this location is now connected to the long eroding bank EBL1-2 described above. This bank has been mapped separately, as it lies within the project reach as opposed to EBL1-2,

which lies upstream of the mitigation area. While the creek has begun to erode into the backfilled area that was the former channel alignment at EBL5, it is not threatening to abandon its existing configuration and overtake the former alignment. The former alignment has been completely backfilled to the height of the surrounding floodplain, and does not provide a preferential flow path for Mill Creek to establish. An updated eroding bank inventory within the Mill Creek project site is summarized as follows:

Table 2. Eroding bank summary for Mill Creek observed in 2019.

Bank Segment[1]	Length (ft)	Bank actively Eroding	Bank no longer eroding
EBL3	30		X
EBL4	36	X	
EBR1	58		X
EBR2	81	X	
EBR3	57	X	
EBL5	20	X	
Total active eroding bank length	194 feet		
Total bank length within project reach	1,450 feet		
Percent of banks actively eroding	13%		

[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 2019 and 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. In 2019, the pool partially filled and the left bank eroded northward roughly 10 feet. Monitoring across this transect over the past seven years depicts an actively adjusting channel due to both depositional and scouring processes, and transitions from pool to riffle features at specific locations (see photos of transect #1 on pages C-13 through C18).

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. This gravel bar has enlarged, creating a pool on the right side of

the channel (see photos of transect #2 on pages C-19 through C22). The shift in thalweg location across the channel at this transect provides additional evidence of the dynamic scour and depositional processes occurring in Mill Creek over time. 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. This pool has maintained itself over the past two years due to scour against the adjacent woody debris jam (see photos of transect #2 on pages C-23 through C26). 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 three years.

Transect #4 was originally positioned at a riffle just above the last meander bend upstream of the U.S. Highway 93 Bridge. A point bar has continuously developed on the left bank, with deeper thalweg along the right bank. As a result, this transect has developed into a shallow pool. 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 (see photos of transect #2 on pages C-27 through C30).

Inspection of the stream bed longitudinal profile and cross sections at each of the four monitoring transects over the past seven years reveal a stream bed that is adjusting over time to incoming sediment loads and woody debris complexes and the continued presence of both pool and riffle features. 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.

The longitudinal profile of the channel indicates the presence of several pool and riffle features, which are adjusting spatially as the channel reacts to incoming gravel and woody debris. Two deep pools exist within the project reach, both of which have been observed to hold schools of trout. Five shallower pools exist, and are formed by scour against the stream banks and smaller debris. Overall, the project reach indicates a healthy diversity of aquatic habitat features, and has remained stable since 2014. No signs of aggradation or degradation exist, and the reconstructed channel appears to be maintaining a relatively consistent gradient since monitoring efforts began.

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 3 summarizes the status of each performance criteria following the seventh year of monitoring and eight 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 3. Status of Mill Creek 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 **88%** following the sixth year of monitoring (97% of south bank and 85% of north bank).	YES
	50% woody species coverage after 3rd year	Woody cover of the project site is **30%** following the sixth year of monitoring (63% of south bank and 20% of north bank).	NO
Streambank Stability	Unstable banks identified within the project reach will require corrective action	Four eroding bank segments were observed in 2019 totaling 194 feet, or 13% of the total bank length within the project reach. Given these banks are adjusting due to natural scour and depositional processes and do not threaten infrastructure, corrective actions do not appear warranted.	YES

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 85%. Areas 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. An increase in perennial grass cover (e.g., *Poa compressa*, *Festuca idahoensis*) and volunteer woody cover (e.g., *Pinus ponderosa, Rosa woodsii, Populus balsamifera*) were observed beneath many of the mature ponderosa pine trees, adding to the overall habitat complexity within this area along the north bank. When factoring in the undisturbed south bank, total vegetation cover across the site was 88%, which exceeds the 80% success threshold for riparian cover throughout the site.

Woody vegetation cover along the north bank was estimated at 20% cover, which falls well below the success criteria threshold of 50%. While no woody vegetation was

observed along the backfilled channel segment, there was a minimal increase in woody shrubs and saplings 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 30%. Woody vegetation cover meets the performance criterion along the south bank but does not along north bank.

5.2. Bank Erosion Inventory

Four eroding banks were observed within the project reach totaling 194 feet, or 13% of the total bank length. Locations of eroding bank and eroding bank length over the past seven years have fluctuated due to gravel bar deposition, woody debris, and adjusting riffle locations. Woody debris jams have continued to influence bank erosion where large trees have fallen into the channel and generate scour. None of the erosion threatens highway infrastructure or fences and is occurring due to natural fluvial processes of deposition 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 20 feet in the past three 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. While the erosion is more pronounced along the downstream end of EBL1-2 and at EBL5, the creek is not threatening to overtake the former channel alignment, which has been completely backfilled. The former channel alignment has been filled to match the surrounding floodplain elevations, and is currently functioning as such.

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

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Appendix A

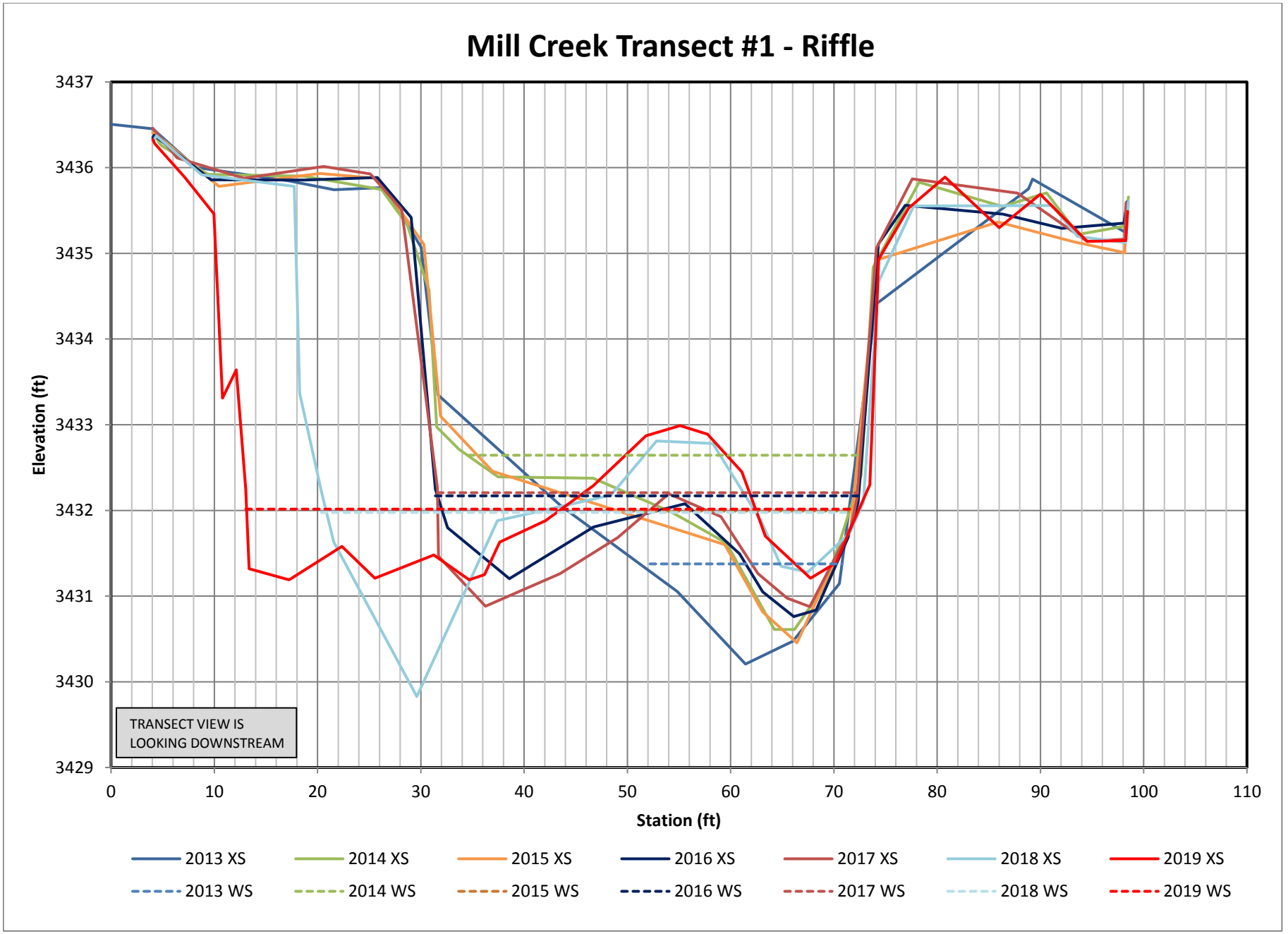
Project Maps

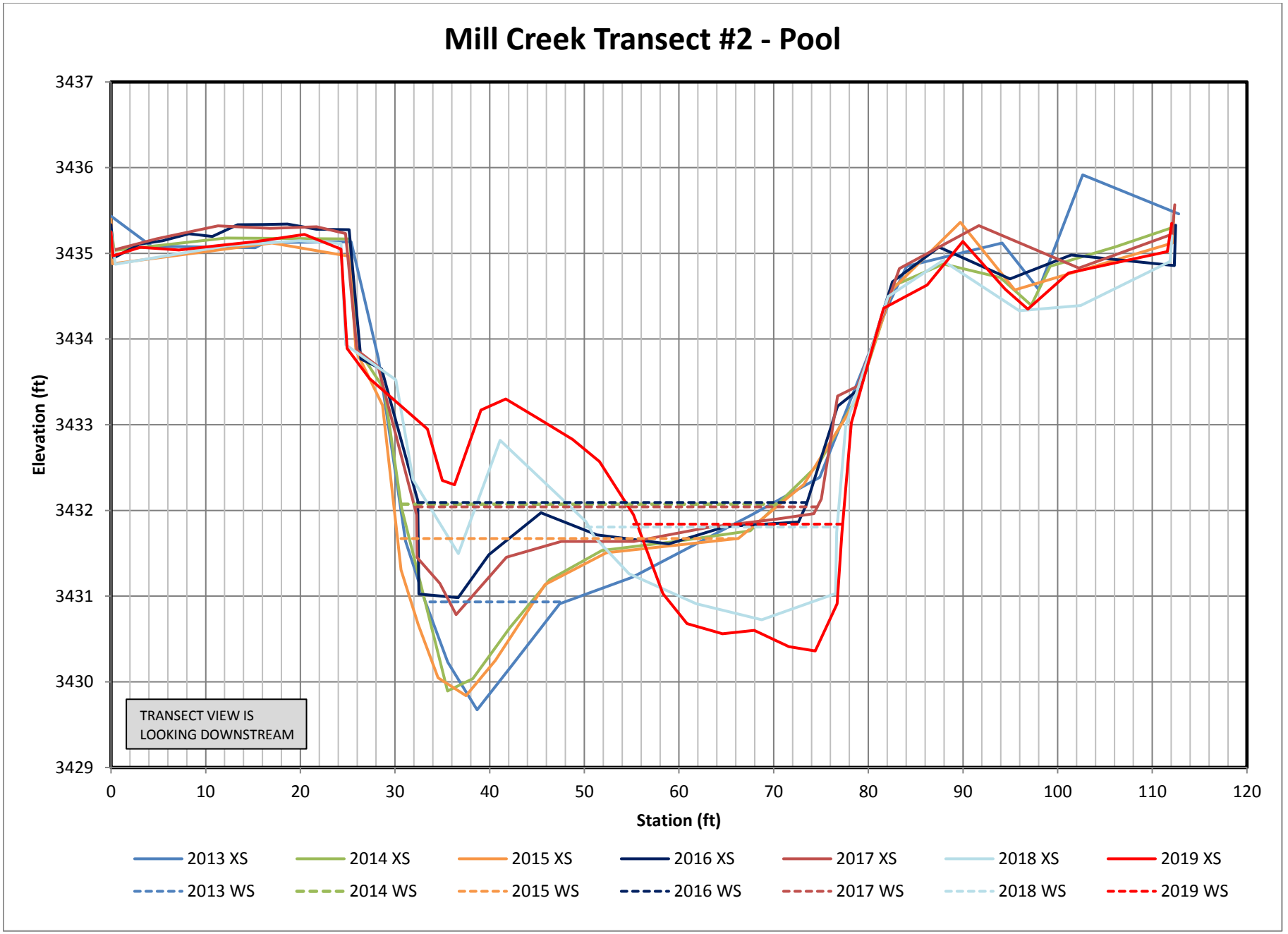
MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana

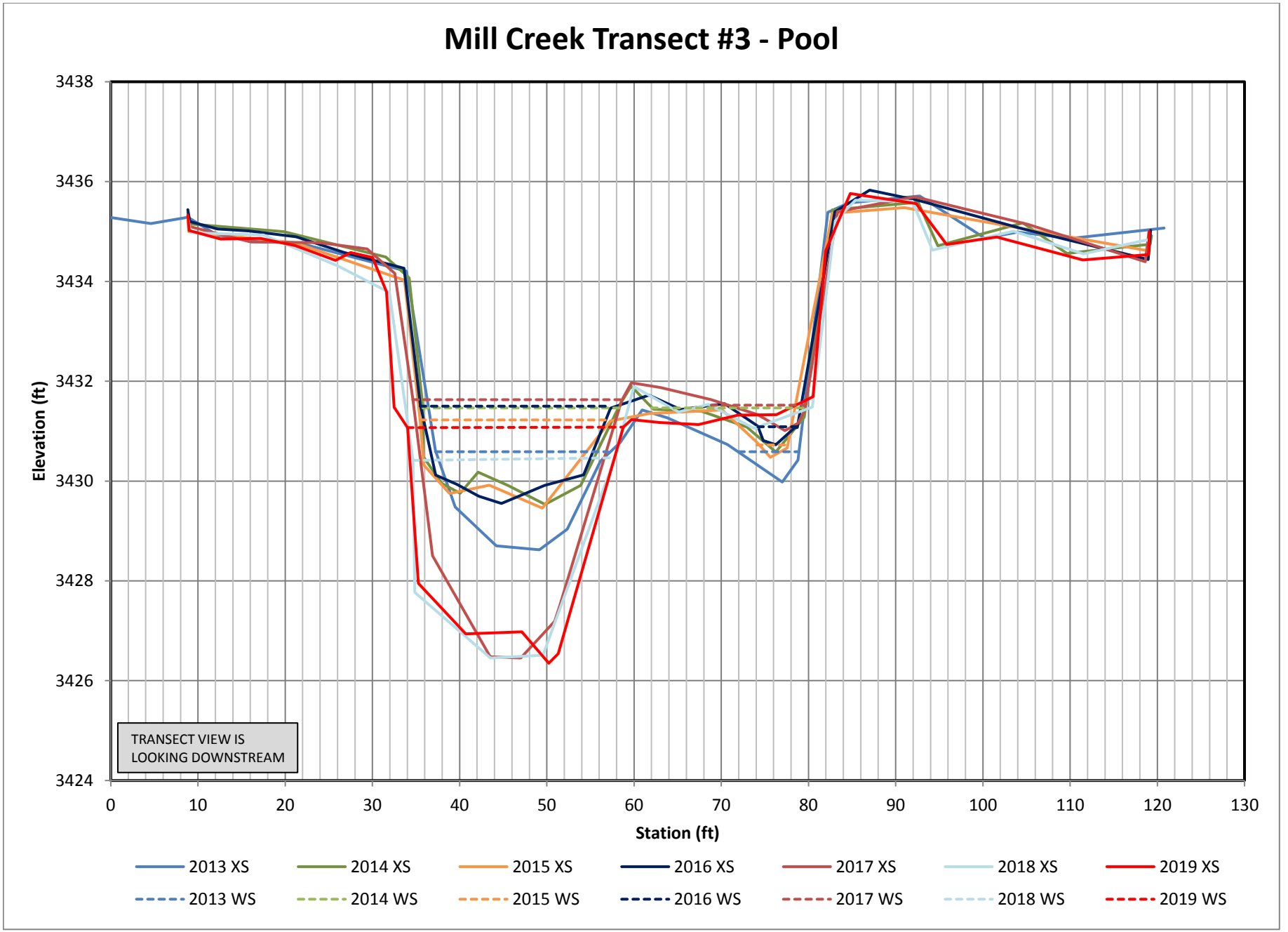
Appendix B

Longitudinal Profile and 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
2019 XS
2013 WS
2014 WS
2015 WS
2016 WS
2017 WS
2018 WS
2019 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
2019 XS
2013 WS
2014 WS
2015 WS
2016 WS
2017 WS
2018 WS
2019 WS


Mill Creek Transect #3 - Pool
Elevation (ft)
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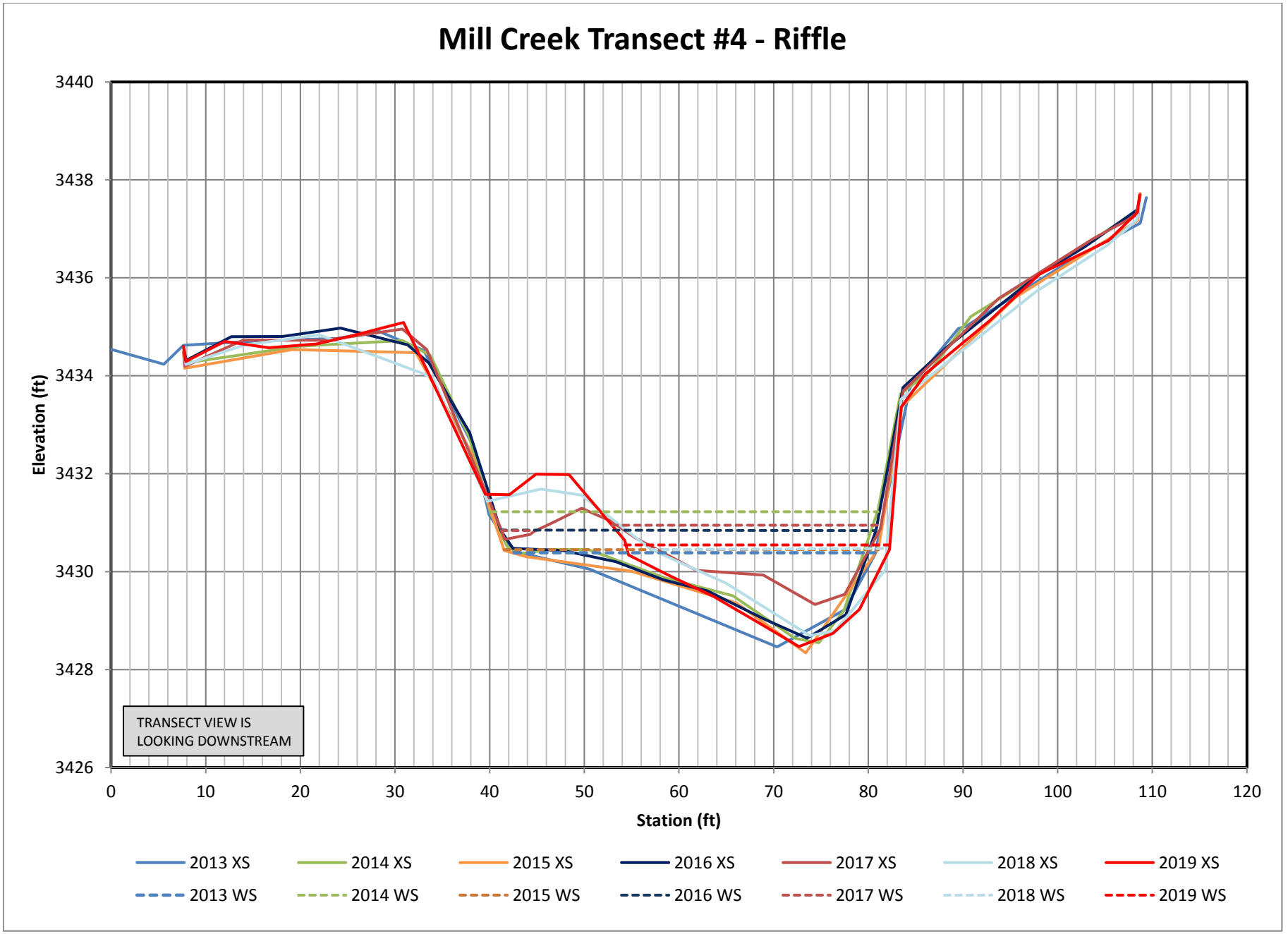
3436
3434
3432
3430
3428
3426
3424
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Station (ft)
TRANSECT VIEW IS LOOKING DOWNSTREAM
2013 XS
2014 XS
2015 XS
2016 XS
2017 XS
2018 XS
2019 XS
2013 WS
2014 WS
2015 WS
2016 WS
2017 WS
2018 WS
2019 WS


Mill Creek Transect #4 - Riffle
Elevation (ft)
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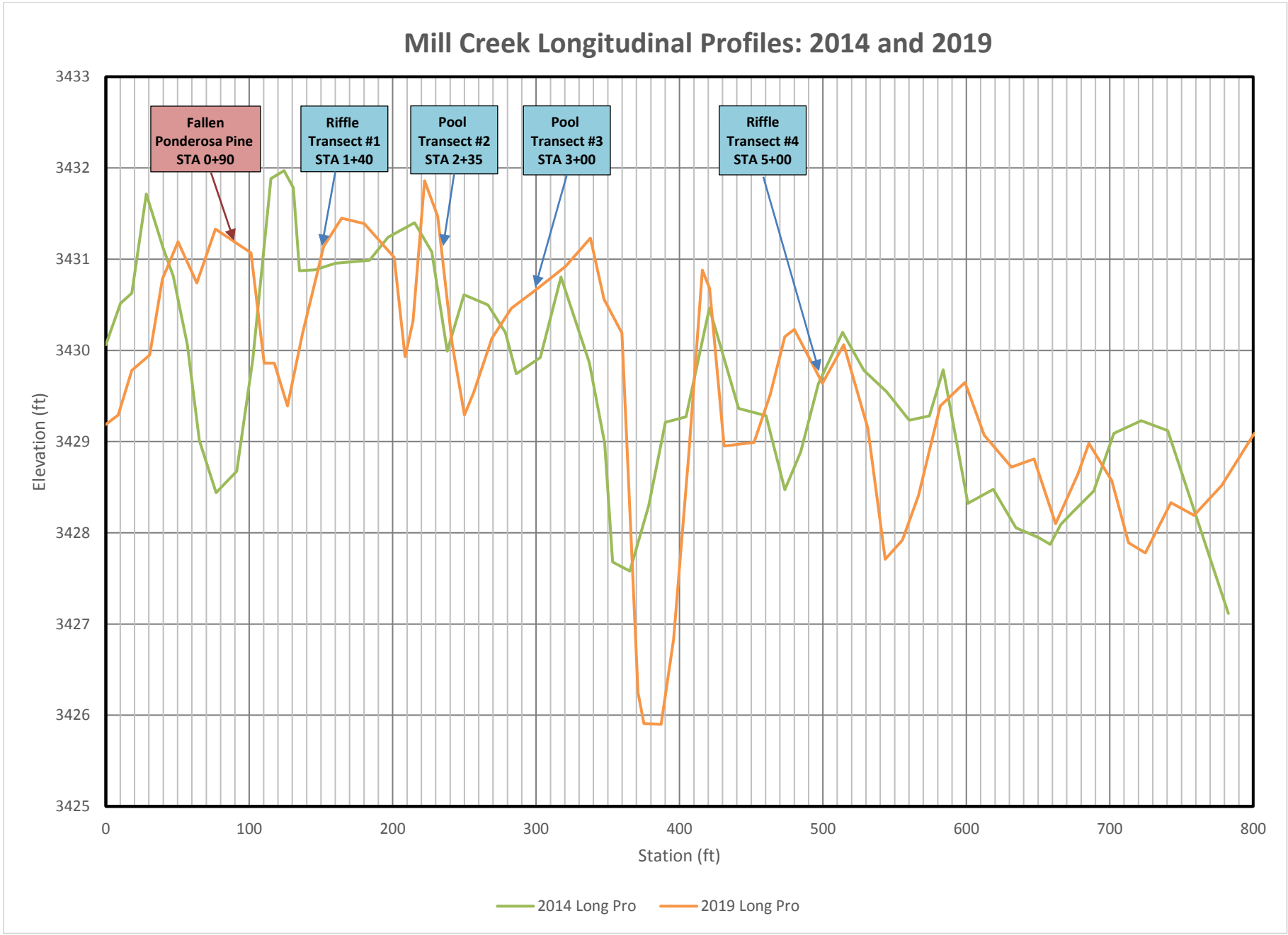
3438
3436
3434
3432
3430
3428
3426
0
10
20
30
40
50
60
70
80
90
100
110
120
Station (ft)
TRANSECT VIEW IS
LOOKING DOWNSTREAM
2013 XS
2014 XS
2015 XS
2016 XS
2017 XS
2018 XS
2019 XS
2013 WS
2014 WS
2015 WS
2016 WS
2017 WS
2018 WS
2019 WS


Mill Creek Longitudinal Profiles: 2014 and 2019
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
Elevation (ft)
3433
3432
3431
3430
3429
3428
3427
3426
3425
0
100
200
300
400
500
600
700
800
Station (ft)
2014 Long Pro
2019 Long Pro

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 2019 Monitoring Events

CONFLUENCE

2013 **2019**

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

2013 **2019**

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

2013 **2019**

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 2019 Monitoring Events

CONFLUENCE

2013 **2019**

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

2013 **2019**

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

2013 **2019**

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

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2019 Monitoring Events

CONFLUENCE

2013 **2019**

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

2013 **2019**

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

2013 **2019**

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

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2019 Monitoring Events

CONFLUENCE

2013 **2019**

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

2013 **2019**

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

2013 **2019**

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 2019 Monitoring Events

CONFLUENCE

2013 **2019**

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

2013 **2019**

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

2013 **2019**

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 2019 Monitoring Events

CONFLUENCE

2013 **2019**

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 **2019**

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

2013 **2019**

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 2019 Monitoring Events

CONFLUENCE

2013 **2019**

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

2013 **2019**

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

2013 **2019**

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 2019 Monitoring Events

2013

2019

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

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2019 Monitoring Events

2013

2019

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

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2014 and 2019 Monitoring Events

2014

2019

Additional Photo 3: Upper section of Eroding Streambank EBL3

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2014 and 2019 Monitoring Events

2014

2019

Additional Photo 4: Lower section of Eroding Streambank EBL3

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2013 and 2019 Monitoring Events

CONFLUENCE

2013 **2019**

Additional Photo 5: Eroding streambank EBL4

2013 **2019**

Additional Photo 6: Eroding streambank EBR1

2013 **2019**

Additional Photo 7: Eroding streambank EBR2

PHOTO INFORMATION

PROJECT NAME: Mill Creek Stream Mitigation Site

DATE: 2016 - 2019 Monitoring Events

CONFLUENCE

2018 **2019**

Additional Photo 8: Eroding Bank EBR3

2018 **2019**

Additional Photo 9: Eroding bank EBL5

2016 **2019**

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

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T1 LOOKING NORTH UPSTREAM FROM T1 SOUTH

T1 LOOKING SOUTH DOWNSTREAM FROM T1 NORTH

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T1 LOOKING WEST UPSTREAM FROM SOUTH BANK

T1 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T1 LOOKING WEST UPSTREAM FROM MIDDLE OF CREEK

T1 LOOKING EAST DOWNSTREAM FROM MIDDLE OF CREEK

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T1 LOOKING WEST UPSTREAM FROM NORTH BANK

T1 LOOKING EAST DOWNSTREAM FROM NORTH BANK

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T2 LOOKING NORTH UPSTREAM FROM T2 SOUTH

T2 LOOKING SOUTH DOWNSTREAM FROM T2 NORTH

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T2 LOOKING WEST UPSTREAM FROM SOUTH BANK

T2 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T2 LOOKING WEST UPSTREAM FROM MIDDLE OF CREEK

T2 LOOKING EAST DOWNSTREAM FROM MIDDLE OF CREEK

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T2 LOOKING WEST UPSTREAM FROM NORTH BANK

T2 LOOKING EAST DOWNSTREAM FROM NORTH BANK

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T3 LOOKING SOUTH UPSTREAM FROM T3 NORTH

T3 LOOKING SOUTH DOWNSTREAM FROM T3 SOUTH

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T3 LOOKING WEST UPSTREAM FROM SOUTH BANK

T3 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T3 LOOKING WEST UPSTREAM FROM MIDDLE OF CREEK

T3 LOOKING EAST DOWNSTREAM FROM MIDDLE OF CREEK

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T3 LOOKING WEST UPSTREAM FROM NORTH BANK

T3 LOOKING EAST DOWNSTREAM FROM NORTH BANK

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T4 LOOKING NORTH UPSTREAM FROM T4 SOUTH

T4 LOOKING SOUTH DOWNSTREAM FROM T4 NORTH

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T4 LOOKING WEST UPSTREAM FROM SOUTH BANK

T4 LOOKING EAST DOWNSTREAM FROM SOUTH BANK

PROJECT NAME: 2019 MDT STREAM MITIGATION—MILL CREEK

DATE: 8-19-19

T4 LOOKING WEST UPSTREAM FROM MIDDLE CREEK

T4 LOOKING EAST DOWNSTREAM FROM MIDDLE CREEK

T4 LOOKING WEST UPSTREAM FROM NORTH BANK

T4 LOOKING EAST DOWNSTREAM FROM NORTH BANK

Appendix D

2013 – 2019 Comprehensive Plant Species List

MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana

Comprehensive list of plant species observed at the Mill Creek Stream Mitigation Site from 2013 through 2019.

Scientific Name	Common Name	WMVC Indicator Status*
Achillea millefolium	Common Yarrow	FACU
Agropyron cristatum	**Crested Wheatgrass**	**UPL**
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
Cicuta douglasii	**Western Water-Hemlock**	**OBL**
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 brachycarpum	**Panicled Willowherb**	**UPL**
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

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	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
Rubus idaeus	**Common Red Raspberry**	**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 Coast Region (WMVC) (Lichvar *et al.* 2016)
New species identified in 2019 are **bolded**
Species identified to genus level have been assigned an indicator status of N/A

Appendix E

2019 Noxious Weed Species List

MDT Stream Mitigation Monitoring
Mill Creek
Ravalli County, Montana

Montana State listed noxious weed and regulated species observed in 2019 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

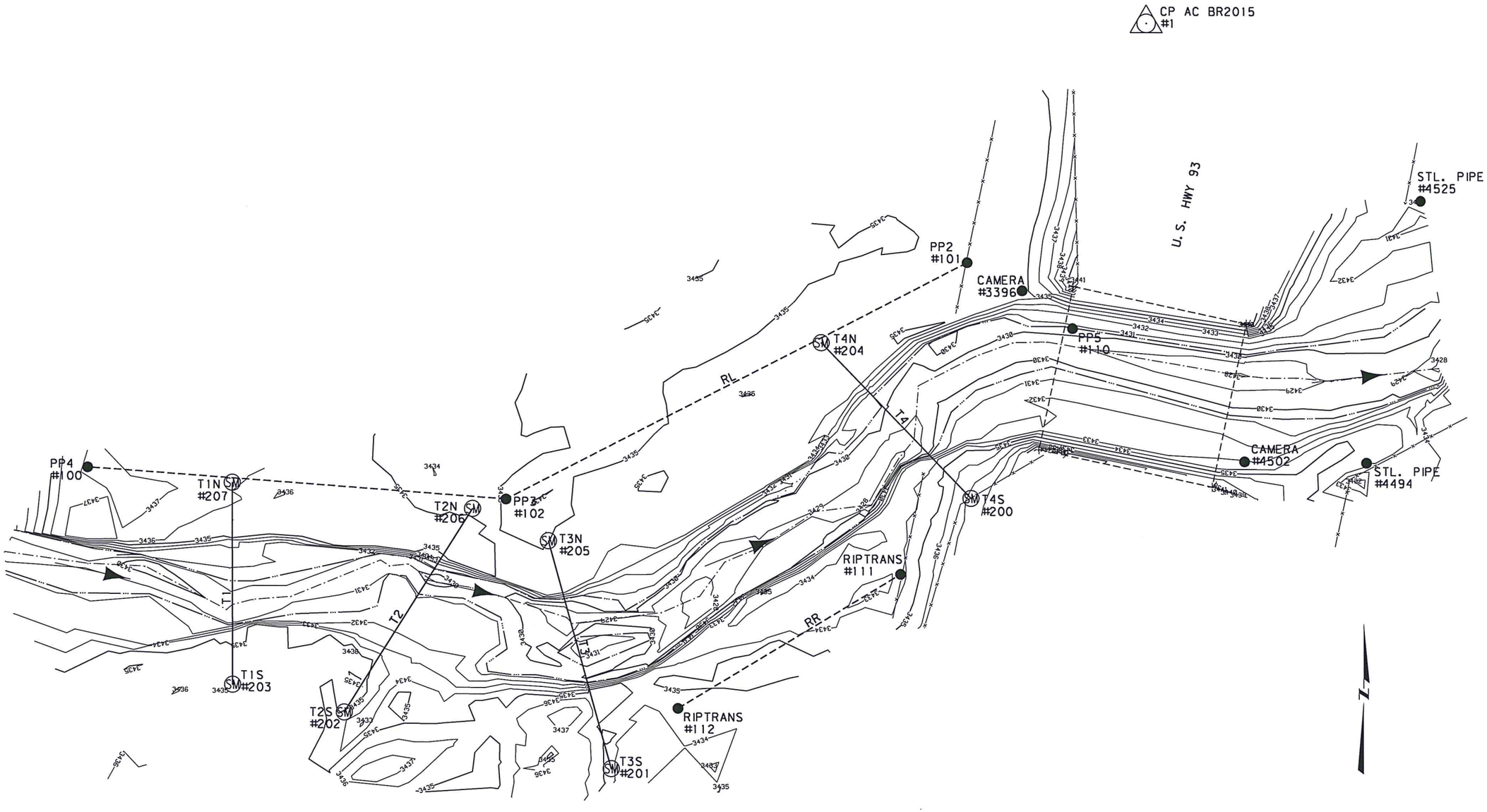
* Based on the MT Department of Agriculture 2019 Noxious Weed List

Appendix F

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:

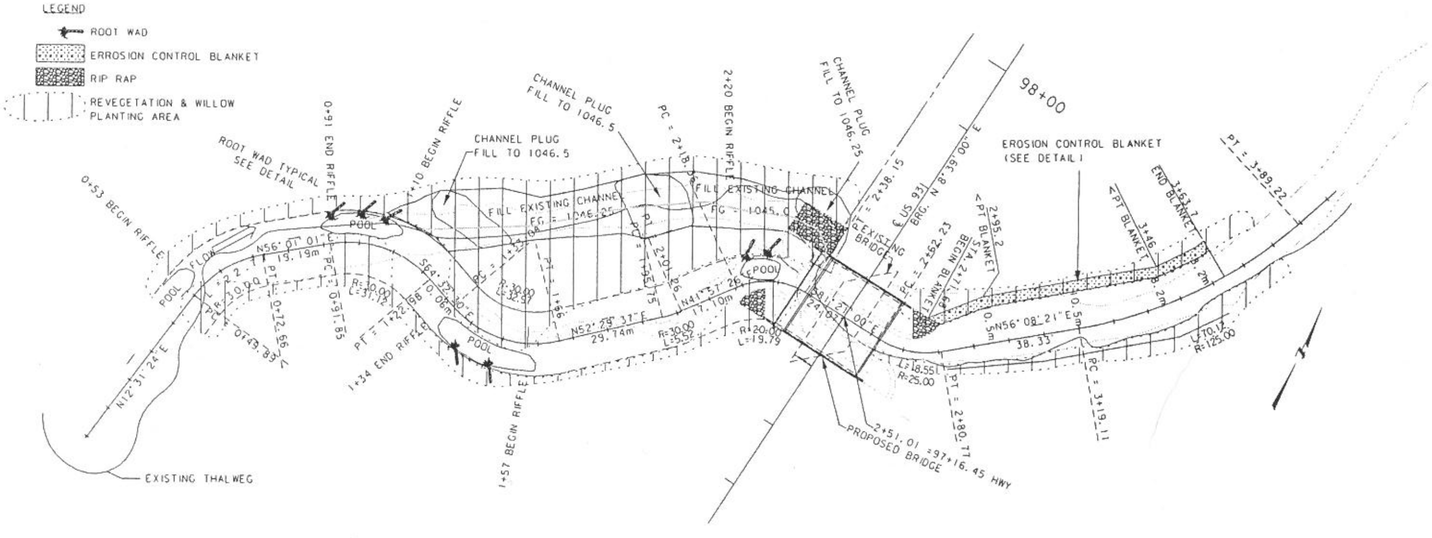
1. THIS SURVEY IS BASED ON FOUND MDT ALUMINUM CAPS STAMPED BR2015 AND BS2015 BUT THEY DO NOT HAVE ESTABLISHED MDT COORDS AND ELEVATIONS. THEREFORE LOCAL CONTROL WAS ESTABLISHED FOR THIS SITE WITH TRIMBLE GPS RTK SURVEY AND THE APPROXIMATE ASSUMED ELEVATION AT MDT ALUM CAP BR2015.
2. THE COORDINATES SHOWN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

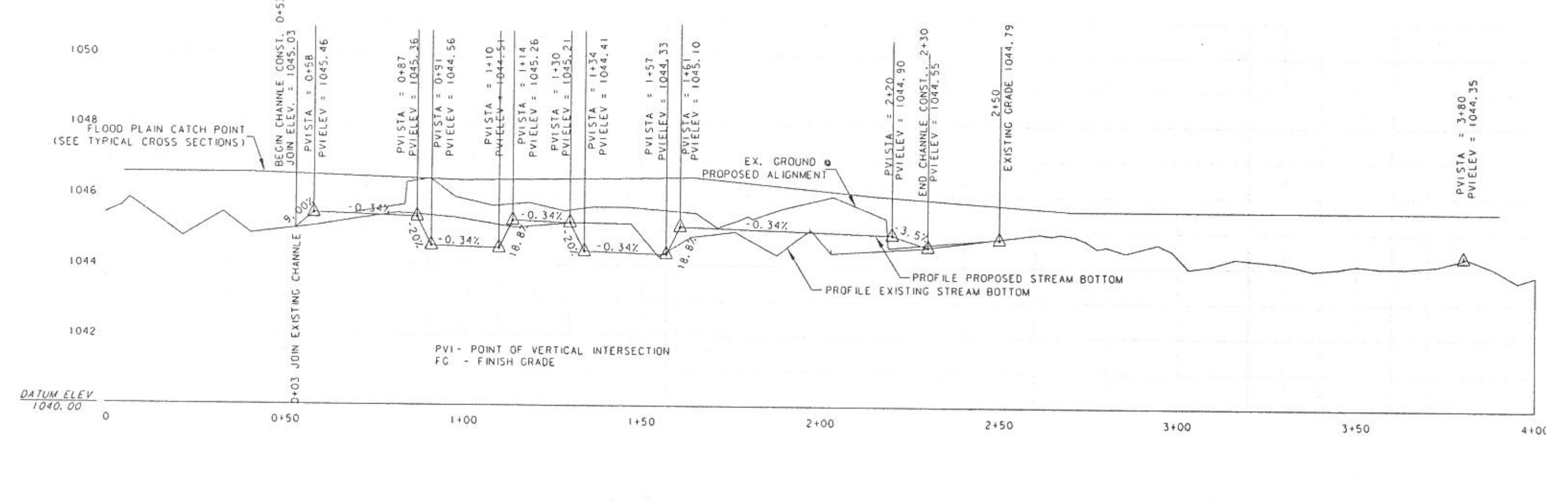
STATE	PROJECT NUMBER	SHEET NO.
MONTANA	NH 7-1(94)54	24

BEAR CREEK ROAD - SOUTH



PLAN

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



PROFILE

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

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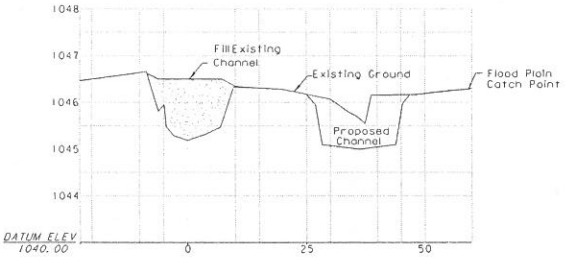
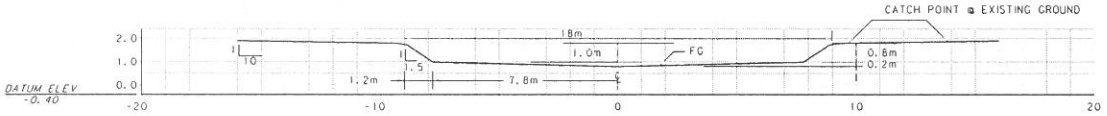
STATE	PROJECT NUMBER	SHEET NO.
MONTANA	NH 7-1194154	25

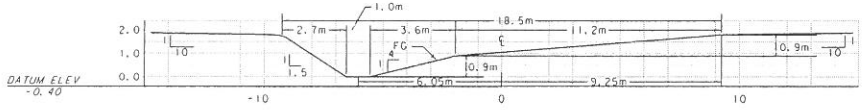
BEAR CREEK ROAD - SOUTH



CROSS SECTIONS 1+97



TYPICAL RIFFLE CROSS SECTION



TYPICAL POOL LEFT CROSS SECTION

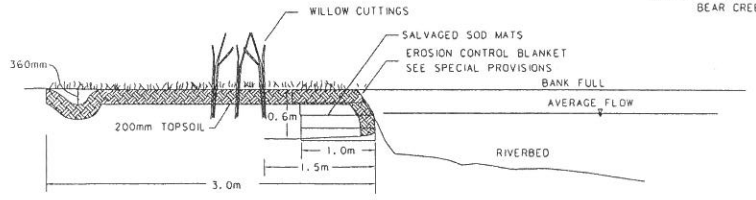
NOTES:

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.

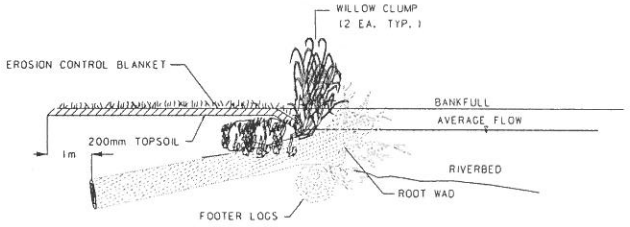
STATION From	STATION To	POOL LEFT	RIFFLE (INCLUDES 4m TRANSITION)	POOL RIGHT
0+00	0+53			
0+53	0+91		X	
0+91	1+10	X		
1+10	1+34		X	
1+34	1+57			X
1+57	2+20		X	
2+20	2+30	X		
2+30	5+00			



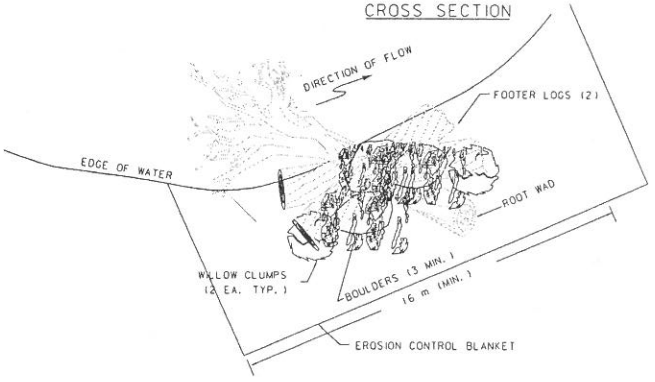
1. SUB EXCAVATE BANKS 0.6 METERS.
2. LAY LOWER BLANKET MINIMUM 1.5 METERS FROM EDGE OF BANK.
3. BACK FILL WITH NATIVE MATERIAL AND 0.2 METERS TOPSOIL.
4. FACE STREAM BANK BACKFILL WITH 1.0 METERS OF SALVAGED SOD MATS.
5. WRAP BLANKET AND EXTEND 3.0 METERS MIN. FROM BANK EDGE.

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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