MONTANA DEPARTMENT OF TRANSPORTATION
STREAM MONITORING REPORT

Little Rock Creek at Judith Slide Repair
Fergus County, Montana

Project Completed: 2013
Monitoring Report #4: December, 2017

Prepared for:

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

Prepared by:

CONFLUENCE
consulting incorporated

MONTANA DEPARTMENT OF TRANSPORTATION

STREAM MONITORING REPORT #4

YEAR 2017

Little Rock Creek at Judith Slide Repair
Fergus County, Montana

MDT Project Number: STPS 426-2(12) 15
Control Number: 7726000

SPA# MDT-R4-55-2012
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Prepared for:

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Cover Photo: Little Rock Creek looking southeast at the Judith Slide Repair site in 2017

1.0 INTRODUCTION

As part of an emergency roadway repair, the Montana Department of Transportation (MDT) realigned a segment of Secondary Highway 426 (also known as S-426 or Hanover Road), around a land slide to provide a stable, paved roadway through the area and reduce annual road maintenance requirements. Due to the new road alignment, modification to a segment of Little Rock Creek was also necessary. This channel modification was approved by the U.S. Army Corps of Engineers (USACE) and does not require compensatory mitigation for stream impacts.

Although compensatory mitigation is not required, MDT requested monitoring of the reconstructed segments of Little Rock Creek to evaluate whether the stream restoration and revegetation techniques were successful in generating a stable, well vegetated channel with variable habitat elements. The following report provides the results of the third year of monitoring along this segment of Little Rock Creek. This project was constructed in 2013, therefore, these results provide documentation of the site's condition four years following the project's completion.

Specific project objectives outlined in the joint permit application for Little Rock Creek included:

- Removal of a 163" x 120" structural steel plate pipe and placement of a 12' x 12' reinforced concrete box culvert approximately 222 feet long to provide fish passage.
- Control spring seepage via interceptor trenches and slope armoring to route water into nearby ditches and culvert.
- Constructing 536 feet of new stream channel within the reclaimed segment of the former highway alignment.

Results of the fourth year of monitoring at the Judith Slide Repair site are provided in Section 4, while Section 5 provides additional site observations that were not captured by the monitoring protocols. Appendices to this monitoring report include maps indicating the endpoints of riparian belt transects, longitudinal profile and perpendicular transect surveys, vegetation communities, noxious weeds, and eroding banks; plots of perpendicular transect and longitudinal profile surveys; photo documentation of the project site; and a topographic survey of the project site (surveyed in 2014).

2.0 SITE LOCATION

The project site is located near Lewistown in the NE ¼ NE ¼ of Section 27, Township 16 North, Range 16 East, and the NW ¼ NW ¼ of Section 26, Township 16 North, Range 16 East, in Fergus County, Montana (Figure 1).

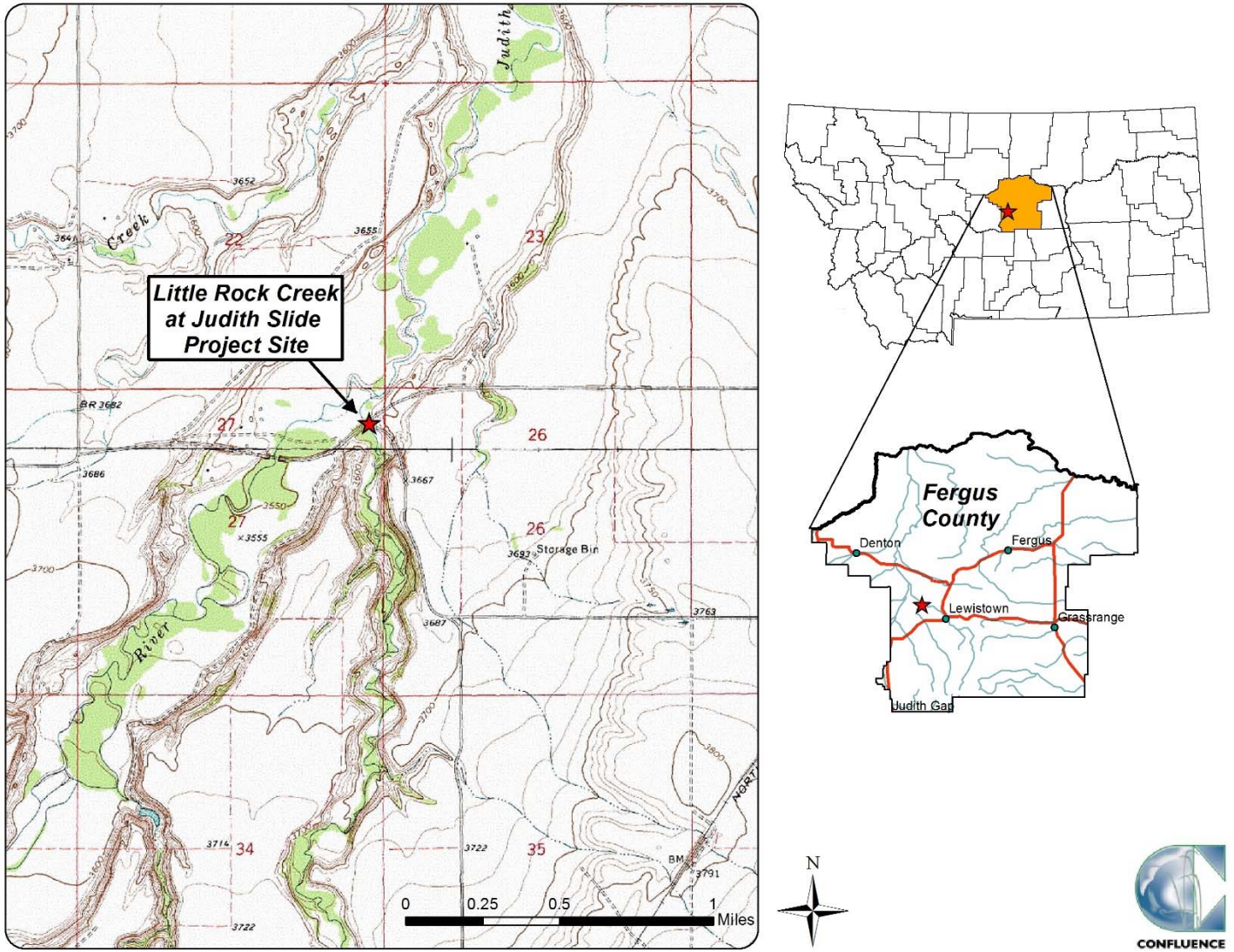

Figure 1. Project location of the Little Rock Creek at Judith Slide Repair site.

3.0 MONITORING METHODS

Monitoring and survey field crews visited the project site on August 2 and August 3, 2017, respectively. The following data were collected at the Little Rock Creek at Judith Slide Repair site:

3.1. Vegetation Inventories and Community Mapping

Two types of transect-based vegetationsurveys were conducted on the Judith Slide site, one of streambank vegetation that exists within three feet of the channel edge, and one of riparian vegetation with a belt transect twenty-five feet further upland.

The streambank vegetation inventory was conducted along both stream banks, and included compiling a list of all plant species and their associated cover classes identified within three feet of the active channel. Percent cover of all species observed along approximately 630 feet of each bank was estimated and recorded using the classification values listed in Table 1.

Table 1. Classification values and associated percent cover classes used for vegetation inventories.

Classification Value	% Cover
0	<1%
1	1-5%
2	6-10%
3	11-20%
4	21-50%
5	>50%

Two riparian belt transects established in 2014 were monitored to document riparian vegetation development and community diversity, as well as areal percent cover of total vegetation, woody vegetation, and noxious weeds within a 25 feet wide buffer upland of the streambank belt transect.. Areal percent cover was recorded for each vegetation category based on ocular estimate methodologies outlined in Elzinga et al. (1998). The riparian transect on the right (east) side of the channel runs parallel to the channel for 203 feet, while the riparian transect on the left (west) side of the channel extends 192 feet. Locations of the riparian transects are shown on Figure 3 in Appendix A.

In addition to the two types of vegetation belt transects, vegetation community boundaries were mapped in the field during the active growing season and subsequently delineated on aerial photographs. Community types were designated based on the predominant vegetation species within each mapped polygon. Bank stability indices were then assigned to the stream bank community types (Winward 2000; Pick *et al*. 2004).

All noxious weed infestations, with the exception of isolated weed occurrences, were identified and mapped on aerial photographs, with species noted. Observations of

isolated noxious weed occurrences were included in the species lists and total areal percent cover estimate of noxious weeds within the project area, but were not mapped. Percent cover of noxious weed species observed along the riparian belt transects were visually estimated and recorded using the classification values listed in Table 2.

Table 2. Classification values and associated percent cover classes used for noxious weed inventory.

Classification Value	% Cover
Trace (T)	<1%
Low (L)	1-5%
Moderate (M)	6-25%
High (H)	25-100%

3.2. Bank Erosion Inventory

Streambank stability performance was monitored by conducting a visual erosion inventory within the project reach. Each eroding bank within the project reach was photo-documented with eroding bank length and potential causes of bank erosion noted. A qualitative erosion severity rating was generated by observing substrate composition of the bank, vegetation composition, and whether depositional features such as point bars were developing near the erosional area.

3.3. Perpendicular Transect and Longitudinal Profile Surveys

Four monitoring cross sections running perpendicular to the channel were established in 2014 to document vertical and lateral stability within the project reach. Each of the four cross sections was re-surveyed annually to document vertical and lateral adjustments at two riffles and at two pools.

A longitudinal profile was surveyed down the thalweg of the channel from 2014 through 2017 to document aggradation, degradation, and habitat complexity along the project reach. All cross sections and longitudinal profiles were surveyed using a Trimble R8 GPS with rover and base station units, with survey points taken at inflection points along each transect and profile. All surveys tied into benchmark pins established by MDT during construction of the project. Cross section alignments and longitudinal profile stationing are presented on Figures 2 and 3 in Appendix A.

3.4. Photo-Documentation

Photos were taken at all photo points established in 2014 to document riparian and stream conditions throughout the project reach. Survey crews documented stream and bank conditions by taking additional photos facing upstream, downstream, left and right from the center of the channel and at the endpoints of each of the four perpendicular transects. Locations of photo points are presented on Figure 2.

3.5. Wildlife Documentation

Wildlife use of the project reach was documented by creating a list of all bird, mammal, and herpetile species observed during the site visit. Wildlife species were identified through visual observation, scat, tracks, nests, burrows, dens, feathers, etc.

4.0 RESULTS

4.1. Riparian and Stream Bank Vegetation Inventory

Table 3 summarizes the areal percent cover of total vegetation, woody vegetation, and noxious weeds observed along each three foot wide streambank transect adjacent to the stream, and each 25 foot wide riparian belt transect further upland, during the 2014 through 2017 monitoring events. In addition to presenting results for the transects individually, Table 3 includes area-weighted, site-wide totals for each of these vegetation cover categories.

Both riparian vegetation transects are located downstream of the box culvert, and are representative of the reconstructed channel and associated riparian zones below the culvert outlet. Total percent cover of vegetation decreased from 88% in 2016 to 85% in 2017. Total percent woody cover decreased from 17% in 2016 to 15% in 2017. Percent cover of Montana State-listed noxious weeds increased from 4% in 2016 to 5% in 2017 (See Section 4.3). Vegetation upstream and downstream of the culvert is establishing well, with a diversity of stream bank and riparian vegetation developing on both sides of the channel (See Photo Point 1 and Additional Photo #1 in Appendix C).

Table 3. Percent cover of Judith Slide Repair site vegetation transects from 2014 through 2017.

Belt Transect	Length (ft)	Total % Vegetation Cover				% Woody Cover				% Noxious Weed Cover			
		2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Right (east) Riparian	203	60	80	85	80	0	0	2	2	0	4	5	6
Left (west) Riparian	192	50	80	85	80	0	0	2	2	0	4	5	6
Riparian Subtotal		55	80	85	80	0	0	2	2	0	4	5	6
Right (east) Stream bank	630	65	90	97	98	47	50	55	50	1	2	2	3
Left (west) Stream bank	630	65	90	97	97	47	50	55	50	1	2	2	3
Streambank Subtotal		65	90	97	98	47	50	55	50	1	2	2	3
Area Weighted Total		**58**	**83**	**88**	**85**	**7**	**14**	**17**	**15**	**0**	**3**	**4**	**5**

Table 4 includes a comprehensive list of plant species observed during the 2014 through 2017 monitoring events. In 2017, 94 plant species were identified within the project area, as compared to 89 species in 2016. Three of the five new species observed were present along the stream banks, while the other two species, field bindweed (*Convolvulus arvensis*) and curly-cup gumweed (*Grindelia squarrosa*), were identified within the riparian area adjacent to the channel. The newly observed species along the stream banks within the project area included biennial wormwood (*Artemisia biennis*), rough water-horehound (*Lycopus asper*), and hard-stem club-rush (*Schoenoplectus acutus*). Of the 94 plants observed, 44 (47%) were considered hydrophytic based on the 2016 National Wetland Plant List (NWPL) (Lichvar *et al*. 2016). The vegetation observed within the riparian and stream bank corridor comprised a mix of native and nonnative annual, biennial, and perennial plant species.

Dominant species recorded along the riparian and stream bank transects were combined with visual observations in other areas to develop a vegetation community map (Figure 3, Appendix A). The dominant plant species observed within the riparian

zone were absinthium (*Artemisia absinthium*), nodding wild rye (*Elymus canadensis*), intermediate wheatgrass (*Elymus hispidus*), slender wild rye (*Elymus trachycaulus*), yellow sweet-clover (*Melilotus officinalis*), and western-wheat grass (*Pascopyrum smithii)*, which primarily occurred above the coir encapsulated soil lifts. The lower banks of the channel were dominated by narrow-leaf willow (*Salix exigua*) and reed canary grass (*Phalaris arundinacea*).

Table 4. Plant species observed at the Judith Slide Repair site from 2014 through 2017.

Scientific Name	Common Name	WMVC Indicator Status*	Scientific Name	Common Name	WMVC Indicator Status*
Achillea millefolium	Common Yarrow	FACU	*Medicago lupulina*	Black Medick	FACU
Agastache urticifolia	Nettle-Leaf Giant-Hyssop	FACU	*Medicago sativa*	Alfalfa	UPL
Agropyron cristatum	Crested Wheatgrass	NL	*Melilotus albus*	White Sweetclover	NL
Agrostis stolonifera	Spreading Bent	FAC	*Melilotus officinalis*	Yellow Sweet-Clover	FACU
Algae, green	Algae, green	NL	*Mentha arvensis*	American Wild Mint	FACW
Alyssum desertorum	Desert Alyssum	NL	*Myriophyllum* sp.	Water-Milfoil	NL
Arctium minus	Lesser Burrdock	UPL	*Nasturtium officinale*	Watercress	OBL
Artemisia absinthium	Absinthium	NL	*Oenothera villosa*	Hairy Evening-Primrose	FAC
Artemisia biennis	**Biennial Wormwood**	**FACW**	*Onopordum acanthium*	Scotch Thistle	NL
Bassia scoparia	Mexican-Fireweed	FAC	*Onosmodium molle*	Soft-hairy False Gromwell	NL
Bromus inermis	Smooth Brome	UPL	*Pascopyrum smithii*	Western-Wheat Grass	FACU
Bromus japonicus	Japanese Brome	NL	*Persicaria amphibia*	Water Smartweed	OBL
Bromus tectorum	Cheatgrass	NL	*Persicaria maculosa*	Spotted Lady's-Thumb	FACW
Calamagrostis canadensis	Reed Grass	FACW	*Persicaria* sp.	Smartweed	NL
Camelina microcarpa	Little-Pod False Flax	FACU	*Phalaris arundinacea*	Reed Canary Grass	FACW
Campanula rotundifolia	Bluebell-of-Scotland	FACU	*Phleum pratense*	Common Timothy	FAC
Carduus nutans	Nodding Plumeless-Thistle	UPL	*Plantago major*	Great Plaintain	FAC
Carex sp.	Sedge	NL	*Poa palustris*	Fowl Blue Grass	FAC
Chamaenerion angustifolium	Narrow-Leaf Fireweed	FACU	*Poa pratensis*	Kentucky Blue Grass	FAC
Chenopodium album	Lamb's-Quarters	FACU	*Polypogon monspeliensis*	Annual Rabbit's-Foot Grass	FACW
Cirsium arvense	Canadian Thistle	FAC	*Populus angustifolia*	Narrow-Leaf Cottonwood	FACW
Cirsium vulgare	Bull Thistle	FACU	*Prunus virginiana*	Choke Cherry	FACU
Convolvulus arvensis	**Field Bindweed**	**NL**	*Ranunculus aquatilis*	White Water-Crowfoot	OBL
Cynoglossum officinale	Gypsy-Flower	FACU	*Ribes* sp.	Currant	NL
Descurainia sophia	Herb Sophia	NL	*Rosa woodsii*	Woods' Rose	FACU
Eleocharis palustris	Common Spike-Rush	OBL	*Rudbeckia laciniata*	Green-Head Coneflower	FAC
Elymus canadensis	Nodding Wild Rye	FAC	*Rumex acetosa*	Garden Sorrel	FAC
Elymus hispidus	Intermediate Wheatgrass	NL	*Rumex crispus*	Curly Dock	FAC
Elymus repens	Creeping Wild Rye	FAC	*Rumex fueginus*	Tierra del Fuego Dock	FACW
Elymus trachycaulus	Slender Wild Rye	FAC	*Salix exigua*	Narrow-Leaf Willow	FACW
Epilobium ciliatum	Fringed Willowherb	FACW	***Schoenoplectus acutus***	**Hard-Stem Club-Rush**	**OBL**
Equisetum arvense	Field Horsetail	FAC	*Scirpus microcarpus*	Red-Tinge Bulrush	OBL
Euphorbia esula	Leafy Spurge	NL	*Silene latifolia*	Bladder Campion	NL
Geum macrophyllum	Large-Leaf Avens	FAC	*Sinapis arvensis*	Corn Mustard	NL
Glyceria grandis	American Manna Grass	OBL	*Sisymbrium altissimum*	Tall Hedge-Mustard	FACU
Glyceria striata	Fowl Manna Grass	OBL	*Solidago canadensis*	Canadian Goldenrod	FACU
Glycyrrhiza lepidota	American Licorice	FAC	*Sonchus arvensis*	Field Sow-Thistle	FACU
Grindelia squarrosa	**Curly-Cup Gumweed**	**FACU**	*Symphoricarpos albus*	Common Snowberry	FACU
Helianthus annuus	Common Sunflower	FACU	*Symphoricarpos occidentalis*	Western Snowberry	FAC
Hordeum jubatum	Fox-Tail Barley	FAC	*Thlaspi arvense*	Field Pennycress	UPL
Juncus ensifolius	Dagger-Leaf Rush	FACW	*Tragopogon dubius*	Meadow Goat's-Beard	NL
Juncus sp.	Rush	NL	*Trifolium pratense*	Red Clover	FACU
Juncus torreyi	Torrey's Rush	FACW	*Trifolium repens*	White Clover	FAC
Lactuca serriola	Prickly Lettuce	FACU	*Typha latifolia*	Broad-Leaf Cat-Tail	OBL
*Lepidium campestre***	Field Pepper-Grass**	NL	*Urtica dioica*	Stinging Nettle	FAC
Lycopus asper	**Rough Water-Horehound**	**OBL**	*Verbascum thapsus*	Great Mullein	UPL
Matricaria discoidea	Pineapple-Weed	FACU	*Veronica americana*	American-Brooklime	OBL

*2016 National Wetland Plant List; *Western Mountains, Valleys, and Coasts* (WMVC) (Lichvar *et al.* 2016)
***Lepidium latifolium* was misidentified in 2014 and was changed to *Lepidium campestre in* 2015
New species identified in 2017 are **bolded**.

Four vegetation community types were observed in 2017 (Figure 4, Appendix A) and are included in Table 5.

Table 5. Vegetation community types observed at Judith Slide Repair site in 2017.

Community Type	Dominant Species
1	*Salix exigua* / *Phalaris arundinacea*
5	*Elymus* spp.
7	*Pascopyrum smithii* / *Elymus* spp.
8	*Artemisia absinthium* / *Pascopyrum smithii*

Vegetation community Type 1 – *Salix exigua* / *Phalaris arundinacea* was identified along both stream banks north of S-426/Hanover Road. Reed canary grass and narrow-leaf willow dominated this community type. American manna grass (*Glyceria grandis*) was also commonly observed at 6 to 10 percent cover.

Vegetation community Type 2 – *Elymus* spp. was identified in 2014 and 2016 north and south of S-426/Hanover Road and was changed in 2017 to community Type 5 – *Elymus* spp*./Melilotus officinalis* to represent the addition of dominant vegetation cover by yellow sweet-clover. Yellow sweet-clover, an early colonizer on recently disturbed landscapes, no longer dominated this vegetation community during the 2016 monitoring event, but was again observed as a dominant species in 2017 and therefore changed back to the community Type 5 classification (Gucker 2009). Nodding wild rye, intermediate wheatgrass, and slender wild rye, also considered early successional species, dominated this community type (Simonin 2000; Sedlvec *et. al* 2011; Howard 1992). Other commonly observed species included western-wheat grass and Japanese brome (*Bromus japonicus*).

Vegetation community Type 7 – *Pascopyrum smithii/Elymus* spp. and community Type 8 – *Artemisia absinthium/Pascopyrum smithii* were identified in 2016 north of S-426/Hanover Road. Absinthium, nodding wild rye, intermediate wheatgrass, slender wild rye, and western-wheat grass dominated these vegetation communities. These species, with the exception of western-wheat grass, are considered early successional species commonly found on recently disturbed landscapes (Carey 1994; Simonin 2000; Sedlvec *et. al* 2011; Howard 1992; Gucker 2009). Western-wheat grass, while it occurs in all seral stages, is commonly described as a late successional species that persists in mature vegetation communities (Tirmenstein 1999). Other commonly observed species in these communities included smooth brome (*Bromus inermis*) and Japanese brome.

4.2. Stream Bank Vegetation Inventory

The stream bank vegetation inventory identified 39 species along the banks of Little Rock Creek (Table 6). Reed canary grass represented greater than 50% of the vegetation cover along both stream banks in 2017, while narrow-leaf willow represented an estimated 50% of the vegetation cover along both stream banks. Narrow-leaf willow was observed less frequently along both streambanks during the 2017 monitoring event as compared to previous monitoring visits, which may have occurred as a result of increased cover and competition from reed canary grass. Vegetation community Type

1 – *Salix exigua/Phalaris arundinacea* was the dominant vegetation community observed along the stream banks, with an associated stability rating of 9 (Winward 2000; Pick et al. 2004).

Table 6. Comprehensive list of plant species and their associated cover classes along the stream banks of Little Rock Creek at the Judith Slide Repair site in 2017.

Streambank Species	Left Bank Upstream	Left Bank Downstream	Right Bank Upstream	Right Bank Downstream	WMVC Indicator Status**	Cover Class
*Phalaris arundinacea**	X	X	X	X	FACW	5
*Salix exigua**	X	X	X	X	FACW	4
Glyceria grandis		X		X	OBL	2
Agastache urticifolia		X	X	X	FACU	1
Artemisia absinthium	X	X	X	X	NL	1
Bare Ground	X	X	X	X	NL	1
Cirsium arvense		X	X	X	FAC	1
Epilobium ciliatum	X	X	X	X	FACW	1
Melilotus officinalis	X	X	X	X	FACU	1
Nasturtium officinale		X		X	OBL	1
Poa palustris		X	X	X	FAC	1
Polypogon monspeliensis		X		X	FACW	0
Scirpus microcarpus		X		X	OBL	1
Sonchus arvensis	X	X		X	FACU	1
Veronica americana		X		X	OBL	1
Agrostis stolonifera				X	FAC	0
Artemisia biennis				**X**	**FACW**	**0**
Bromus inermis		X			UPL	0
Calamagrostis canadensis		X	X		FACW	0
Chamaenerion angustifolium		X		X	FACU	0
Equisetum arvense		X		X	FAC	0
Euphorbia esula		X		X	NL	0
Geum macrophyllum		X		X	FAC	0
Glyceria striata			X		OBL	0
Glycyrrhiza lepidota				X	FAC	0
Juncus ensifolius		X			FACW	0
Juncus torreyi		X			FACW	0
Lactuca serriola			X	X	FACU	0
Lycopus asper				**X**	**OBL**	**0**
Mentha arvensis		X	X	X	FACW	0
Onosmodium molle		X			NL	0
Persicaria amphibia	X	X	X	X	OBL	0
Prunus virginiana		X			FACU	0
Schoenoplectus acutus				**X**	**OBL**	**0**
Solidago canadensis		X		X	FACU	1
Sonchus arvensis		X		X	FACU	0
Symphoricarpos occidentalis		X		X	FAC	0
Thlaspi arvense		X		X	UPL	0
Typha latifolia		X		X	OBL	0
Urtica dioica		X		X	FAC	0

*Dominant species identified along stream banks
**Based on 2016 NWPL (Lichvar *et al*., 2016)
New species identified in 2017 are **bolded**.

4.3. Noxious Weed Inventory

Four Montana State-listed noxious weeds were observed within the reconstructed segment of Little Rock Creek in 2017 (Table 7). Canada thistle (*Cirsium arvense*) and leafy spurge (*Euphorbia esula*) infestations, identified as trace to low cover classes on site, are shown on Figure 4 in Appendix A. Houndstongue (*Cynoglossum officinale)*

and field bindweed were observed as isolated occurrences, and were therefore not mapped on Figure 4. The combined areal cover of all four noxious weed species identified in 2017 was estimated at 5%. The increase in noxious weeds was observed in both riparian and stream bank areas. Infestations of noxious weeds were observed just outside of the project site during the 2013 monitoring event, which may have offered a seed source for establishment of weeds within the site. The percent cover estimates recorded for all vegetation categories, including noxious weeds, 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.

Table 7. Montana State-listed noxious weed species identified at the Judith Slide Repair site in 2017.

Category*	Scientific Name	Common Name
Priority 2B	*Cirsium arvense*	Canada Thistle
	Convolvulus arvensis	**Field Bindweed**
	Cynoglossum officinale	Houndstongue
	Euphorbia esula	Leafy Spurge

*Based on the Montana Dept. of Agriculture's Noxious Weed List, February 2017

4.4. Bank Erosion Inventory

In 2017, two eroding banks totaling 26 feet were observed along Little Rock Creek (See Figure 3 in Appendix A). A 20-foot segment along the left bank between Station 11+60 and 11+80 was originally observed in 2015, and has continued to undercut and erode beneath the coir fabric lifts (see additional photo 2 in Appendix C). The coir logs installed along this bank have slumped and fallen into the void created by this undercutting formation while the lower bank has become established with vegetation. Erosion along this bank segment has been consistently observed for the past three years and does not appear to be lengthening or causing damage to downstream reaches of the reconstructed stream channel. The undercutting beneath the coir lifts is caused by the relatively sharp bend and scour forces acting upon the stream bed. While this bank has exhibited signs of instability for the past three years, it provides good aquatic habitat and cover for fish which are likely utilizing this undercut bank. No corrective actions are warranted along the eroding bank.

A short, 6-foot eroding bank segment was observed in 2017 just downstream from one of the rock plunge pool structures installed at Station 11+20 (see additional photo 3 in Appendix C). Erosion along this bank appears due to the dynamic hydraulics at play in the vicinity of the rock plunge pool structure, which has resulted in a short segment of coir lift separating from the bank. The eroding bank segment remains relatively short and as a result, no corrective actions are necessary at this time.

Of the 1,200 feet of reconstructed bank length along Little Rock Creek, a total of 26 feet (2%) shows signs of active erosion. Given the majority of erosion is occurring along the outside of a relatively sharp meander bend where lateral bank erosion is commonly

observed, lateral stability of the channel appears very successful four years following completion of the project.

4.5. Perpendicular Transects

Plots of two riffle and two pool transects surveyed within the project reach are included in Appendix B. Maximum depth and bankfull width for each transect are provided in Table 8. In 2017, maximum depths ranged from 4.0 to 4.9 feet while bankfull widths ranged from 19.6 to 20.6 feet. Channel depths remain close to the design depth of 4.0 to 4.5 feet (Channel Change Typical Section Detail, Sheet 12).

Repeated surveys indicates some shallowing of the two pool transects over the past four years from an average of 5.3 to 4.5 feet deep. In comparison, average riffle depths have remained relatively consistent since 2014. This trend may be indicative of the new channel adjusting to its incoming sediment loads, scouring forces against meander bends, and both pool and pool tail development over time. Inspection of the longitudinal profile does not indicate widespread aggradation (rise in the channel bed); therefore, the relatively minor decrease in channel depth is not of major concern.

Table 8. Widths and depths at Little Rock Creek stream mitigation site from 2014 to 2017.

Transect	Type	Maximum Depth (ft)				Bankfull Width (ft)			
		2014	2015	2016	2017	2014	2015	2016	2017
1	riffle	4.4	4.2	3.9	4.3	21.9	21.8	21.8	20.6
2	pool	4.8	4.4	4.1	4.1	19.8	20.0	19.7	20.0
3	riffle	4.4	4.0	3.9	4.0	21.0	20.8	20.7	19.6
4	pool	5.7	5.2	5.0	4.9	20.1	20.1	20.1	19.9
Average Riffles		**4.4**	**4.1**	**3.9**	**4.2**	**21.5**	**21.3**	**21.3**	**20.1**
Average Pools		**5.3**	**4.8**	**4.6**	**4.5**	**20.0**	**20.1**	**19.9**	**19.9**

4.6. Longitudinal Profile

Two longitudinal profiles of the channel thalweg are provided in Appendix B, including one that extends 600 feet upstream and 400 feet downstream of the newly constructed channel and a second that only includes the reconstructed channel reach. The profiles reveal the continued presence of at least six pools within the reconstructed channel segment, which offer fish deeper habitat and slower velocities for refuge. Pool habitats are forming from the stream a) scouring against the outside meander bends, b) plunging over rock weirs (grade controls) constructed across the channel width, and c) backwatering upstream of the rock grade control features. The primary adjustment along the channel bed over the past year occurred between Station 11+70 and 13+30. Within this segment of the channel, a much deeper pool has developed along the meander bend, with deposition noted downstream through the majority of the next bend. The plunge pool at Station 12+10 and the deeper run that had established between Station 12+50 and 13+50 have partially filled in with gravels, presumably originating from the deep scour pool that has now developed just upstream. This adjustment to the stream bed is indicative of natural variability along the length of the creek, and is likely to continue as the creek adjusts during high flow years. The longitudinal profile does

not indicate signs of widespread aggradation or degradation, and the channel appears vertically stable four years after its construction.

4.7. Wildlife Documentation

Wildlife observations during the 2017 monitoring event included cedar waxwing, American robin, barn swallow, eastern kingbird, vesper sparrow, wild turkey feather, mink scat, beaver chew, elk scat, and muskrat scat. Ten avian, five mammal, one reptile, and four fish species have either been directly or indirectly observed within the project area since the first monitoring event in 2014 (Table 9). Indirect evidence of a particular species includes scat, tracks, feathers, or other sign. In addition, a spotted frog was observed at the confluence of Little Rock Creek with the Judith River, which is approximately 500 feet downstream of the project area. Livestock, or sign of livestock, have been observed within the project area during each of the four monitoring events.

Table 9. Wildlife species observed at the Judith Slide Repair site from 2014 through 2017.

Common Name	Scientific Name
Birds	
American Robin	*Turdus Migratorius*
Barn Swallow	***Hirundo rustica***
Black-billed Magpie	*Pica hudsonia*
Canada Goose	*Branta canadensis*
Cedar Waxwing	***Bombycilla cedrorum***
Eastern Kingbird	*Tyrannus tyrannus*
Mallard	*Anas platyrhynchos*
Barn Swallow	*Hirundo rustica*
Vesper Sparrow	***Pooecetes gramineus***
Wild Turkey (feather)	***Meleagris gallopavo***
Mammals	
Beaver (chew)	***Castor canadensis***
Elk (scat)	***Cervus canadensis***
Mule deer	*Odocoileus hemionus*
Deer (tracks)	*Odocoileus* sp.
Mink (tracks and scat)	*Neovison vison*
Fish	
Brown Trout	*Salmo trutta*
Fish sp.	
Mountain Whitefish	*Prosopium williamsoni*
Sculpin	*Cottus* sp.
Reptiles	
Garter Snake	*Thamnophis* sp.

New species observed in 2017 are **bolded.**

5.0 SUMMARY OF MONITORING OBSERVATIONS

1. Revegetation efforts along the reconstructed segment of Little Rock Creek have been mostly successful, with 85% overall vegetation cover, 5% cover by noxious weeds, and 15% cover by woody species
2. Percent cover by woody species increased between 2014 and 2016 from 7% to 17%; however woody cover decreased by 2% in 2017. Increased cover and competition by reed canary grass along the lower stream banks is the likely cause for the decrease in woody vegetation cover.
3. Percent cover by noxious weeds within the site has gradually increased from 3% to 5% in the past three years. Canada thistle and leafy spurge (*Euphorbia esula*) infestations, identified as trace to low cover classes, were the primary noxious weeds present on site.
4. Lateral bank stability remains good, with approximately 2% of banks exhibiting signs of erosion.
5. Vertical stability remains good, with no signs of large scale aggradation or degradation.
6. Bed forms are diverse with a variety of riffle, run, and pool habitats available within the project reach
7. The site is being utilized by a variety of wildlife species including birds, mammals, reptiles, and fish.
8. Newly installed fences surrounding the project reach have remained in good condition. No gaps or downed fence strands were observed along the newly installed fences. The barbed wire fence crossing Little Rock Creek at the downstream end and along the northeast corner of the project is in poor condition and allows livestock to cross into/out of the project reach. The segments of fence in poor condition were installed well prior to the 2013 MDT project.
9. Signs of livestock use within the site have been noted each year, particularly on the northern end of the project reach. Although livestock have been provided access within the project area, they have not damaged any constructed features or caused widespread bank instability.
10. Formation of a small gully to the east of the newly constructed channel was noted in 2015. This gully formation appeared to be the result of a seep and surface water runoff flowing across the eastern side of the project reach. Vegetation has matured along the length of the gully, and appears to have stabilized the small gully formation noted during earlier monitoring events.
11. As noted in previous monitoring reports, vegetation establishment along the upper coir fabric lifts remains relatively limited. Much of the coir fabric surfaces remain bare or have been colonized by undesirable and weedy species (See additional Photo 4 in Appendix C). Potential causes include 1) an improper seed mix, or 2) no seeding applied to this area. The design calls for seeding the area above the uppermost lift with a wetland seed mix, which may have been inappropriate for such a dry zone. The design does not call for seeding of native

fill material placed within the second highest coir lift layer. Precipitation data from a nearby weather station indicated lower than average precipitation for the 2017 water year up to the time of the monitoring event, indicating this may also be a limiting factor for vegetation establishment (NRCS 2017).

12. Willows installed along the toe of the stream bank and between the first and second coir wrapped soil lifts have shown good survival; however, they are competing with dense stands of reed canarygrass that have established along both stream banks (see Photo Points 3.1, 3.2, and 4.1, Appendix C).
13. No evidence of a high flow event, such as flood debris or sediment deposits was noted during the past three monitoring events.
14. The design of the "basin pool" immediately downstream of the new culvert incorporated a wider channel width than the rest of the channel, riprapped stream banks, and a weir drop at the culvert outlet. The fringes of this pool have filled with stream bed material and become densely vegetated (See Photo Point 2 and 3.1, Appendix C). Several other pools were observed throughout the reconstructed channel segment; therefore, the lack of pool formation at this location does not significantly reduce the overall habitat complexity. This pool may not have been successful due to:
    a. The invert elevation of the culvert outlet (3551.29') matches that of the elevation of the downstream riffle, providing no gradient through the pool feature.
    b. The channel through this pool is straight, and otherwise has no features against which to generate scouring forces.
    c. Channel width through this pool increases from 12' at the culvert outlet to 44' at the downstream riffle crest. Channel width then transitions back to 19' as it enters the reconstructed channel. The abrupt change in channel width within a straight alignment encourages sediment deposition along the channel fringes, which was observed during the previous three monitoring events.

6.0 LITERATURE CITED

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Appendix A

Project Site Maps

MDT Stream Mitigation Monitoring
Little Rock Creek at Judith Slide
Fergus County, Montana

CONFLUENCE
consulting incorporated

Legend

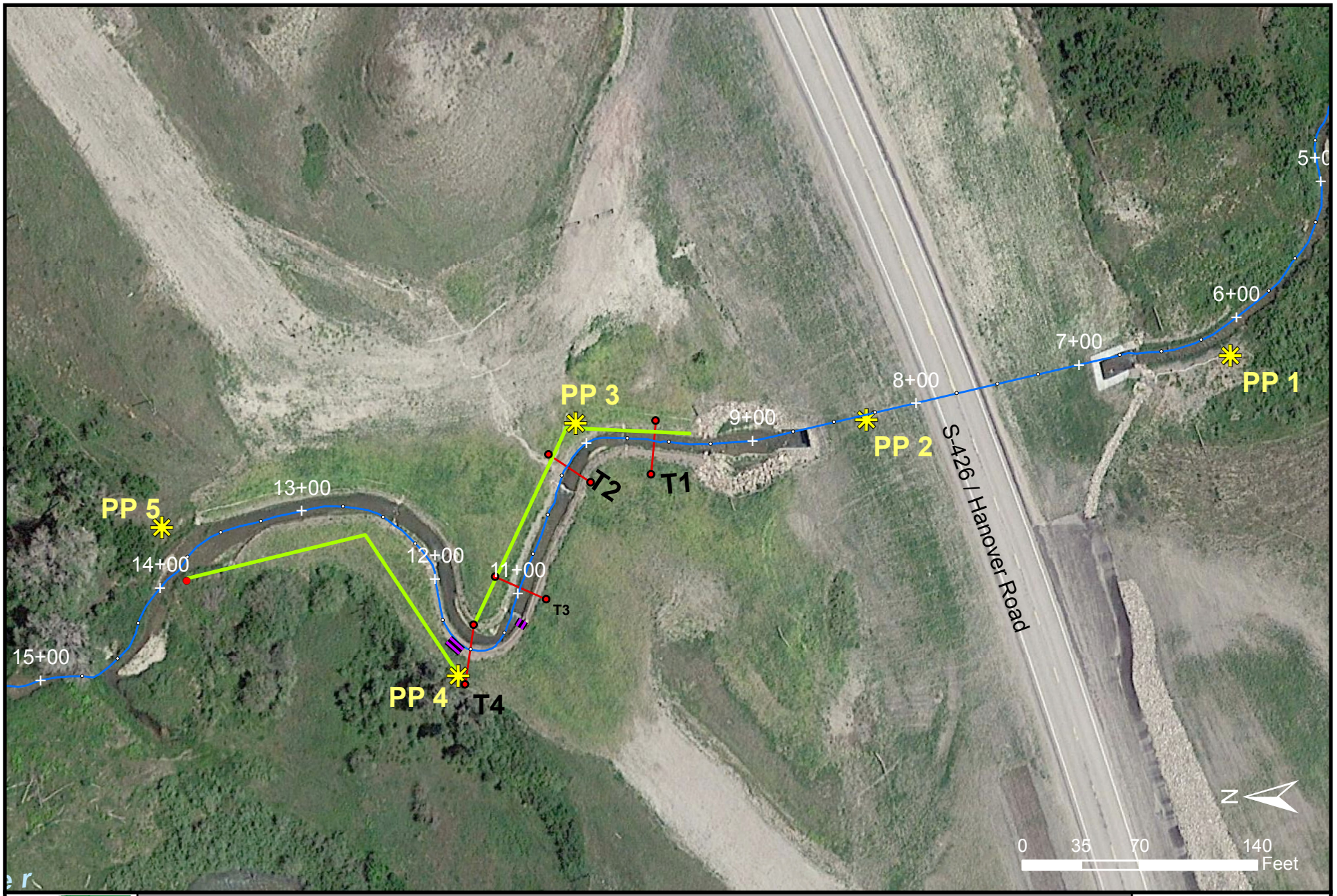
- Channel Thalweg
- \+ Major Station (100')
- ○ Minor Station (25')
- ✳ Photo Points

2017 Monitoring Little Rock Creek at Judith Slide

Figure 2

Date: 10/9/2017

Judith_features2017.mxd



CONFLUENCE
consulting incorporated

Legend

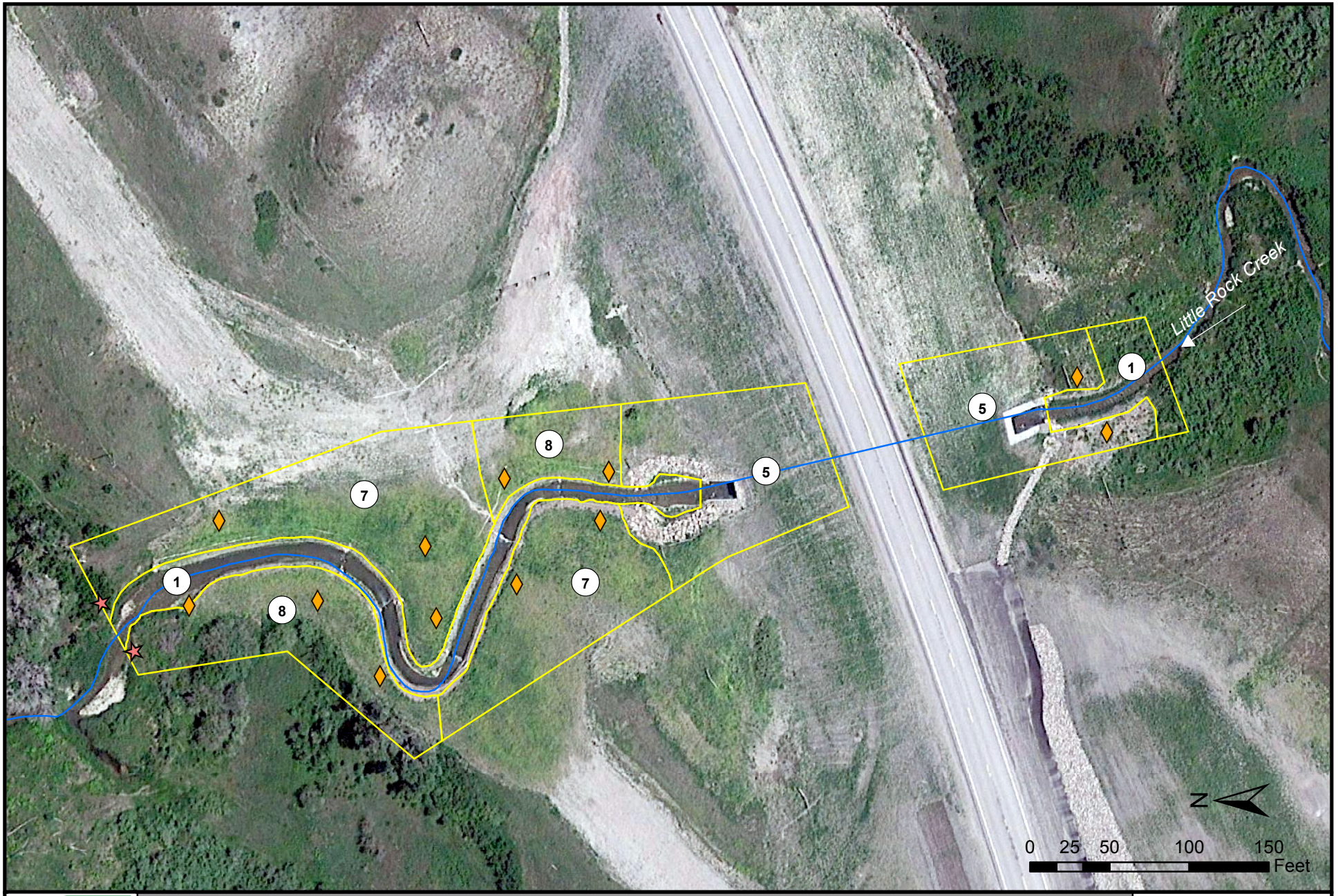
- Photo Points
- Eroding Bank
- Channel Thalweg
- Major Station (100')
- Minor Station (25')
- Pool and Riffle Transects
- Riparian Transects

2017 Monitoring Little Rock Creek at Judith Slide

Figure 3

Date: 10/9/2017

Judith_features2017zoom.mxd



CONFLUENCE
consulting incorporated

Legend

- Cirsium arvense
- Euphorbia esula
- Channel Centerline
- Vegetation Community Boundary

Note: Cynoglossum officinale (Houndstongue) and Convolvulus arvensis (Field bindweed) also observed along project reach as isolated occurrences

1. Salix exigua/Phalaris arundinacea Community
5. Elymus spp./Melilotus officinalis Community
7. Pascopyrum smithii/Elymus spp. Community
8. Artemisia absinthium/Pascopyrum smithii Community

2017 Monitoring
LIttle Rock Creek
at Judith Slide

Figure 4

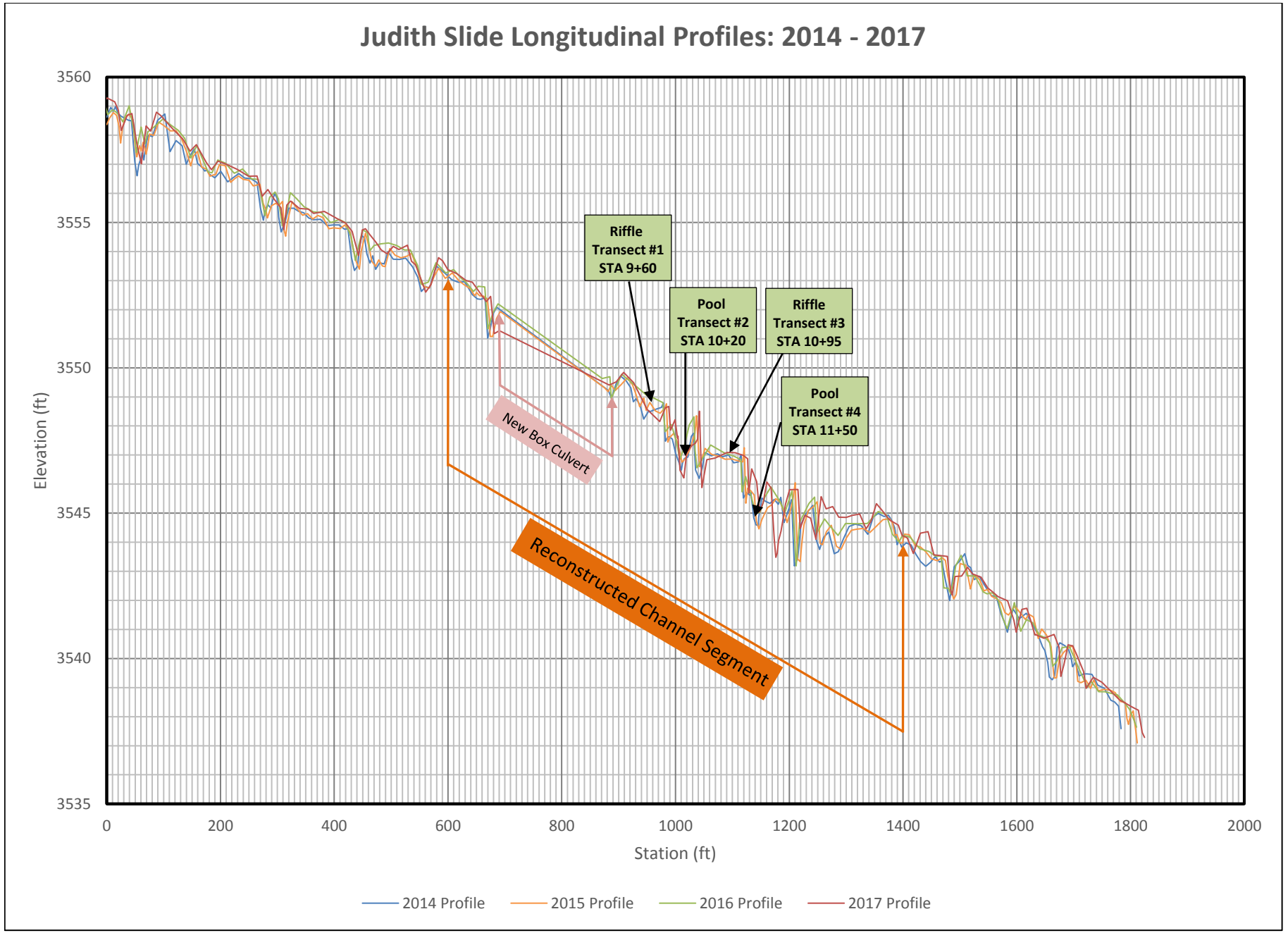
Date: 9/22/2017

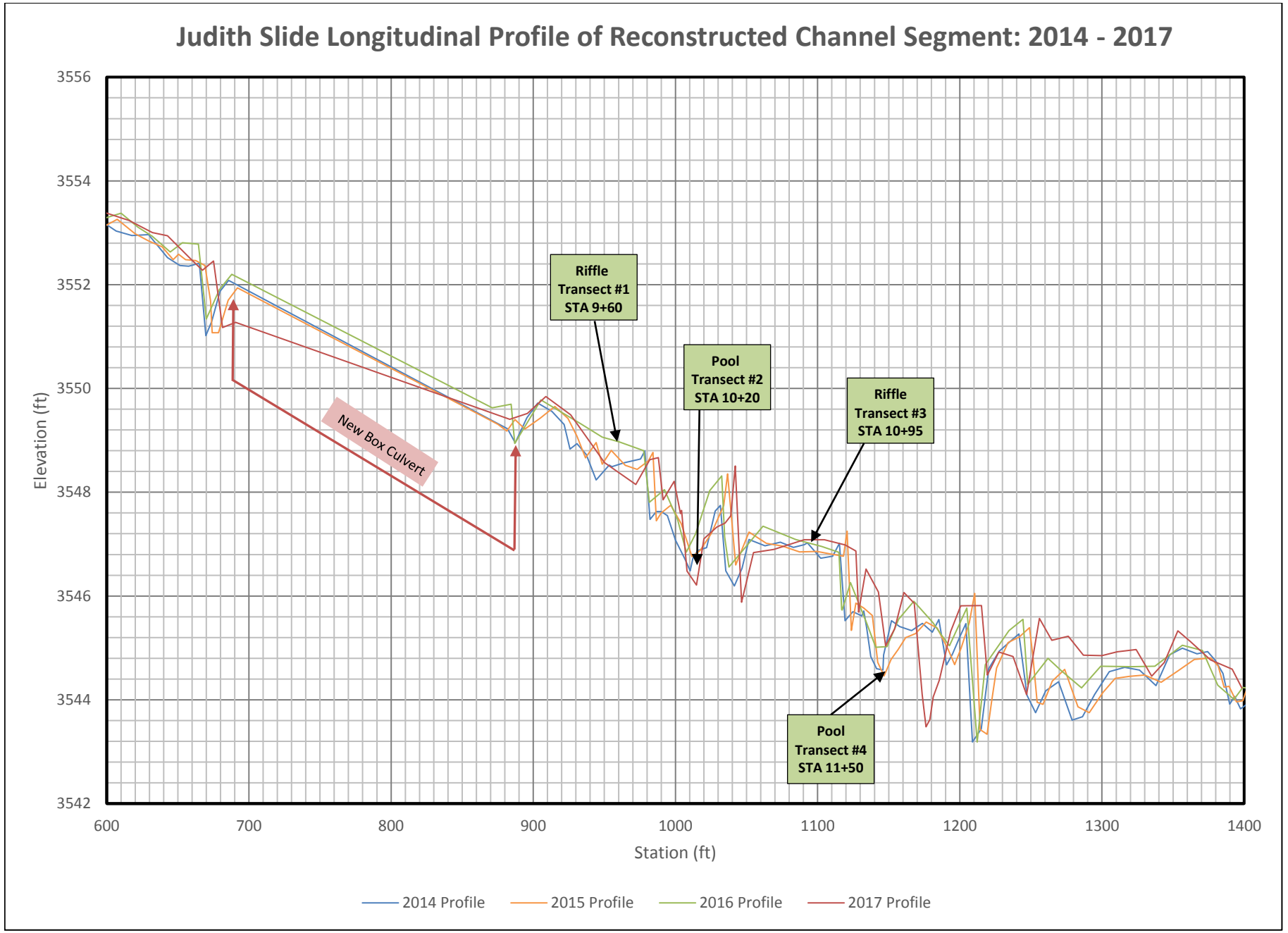
Judith_monitor2017.mxd

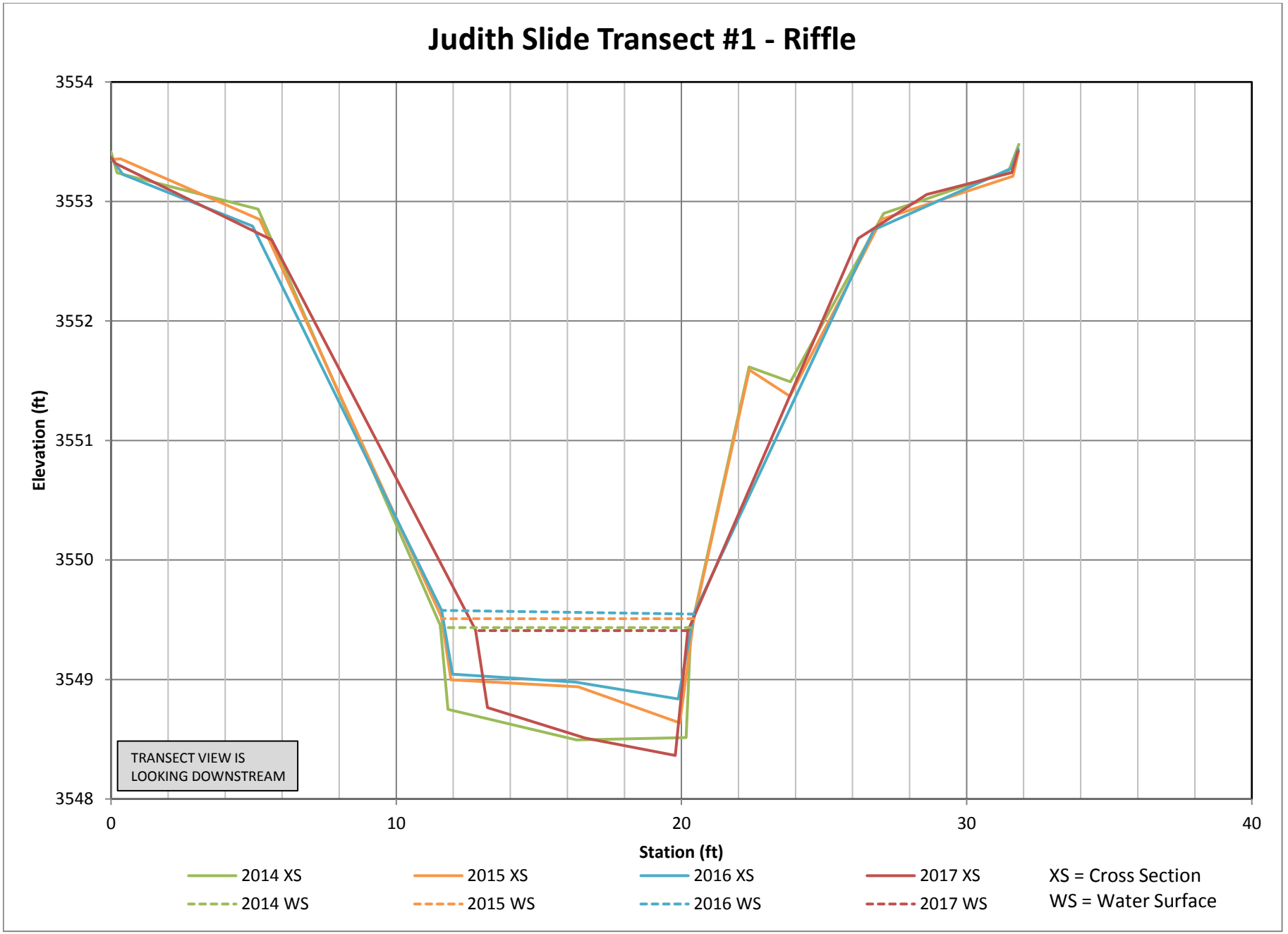
Appendix B

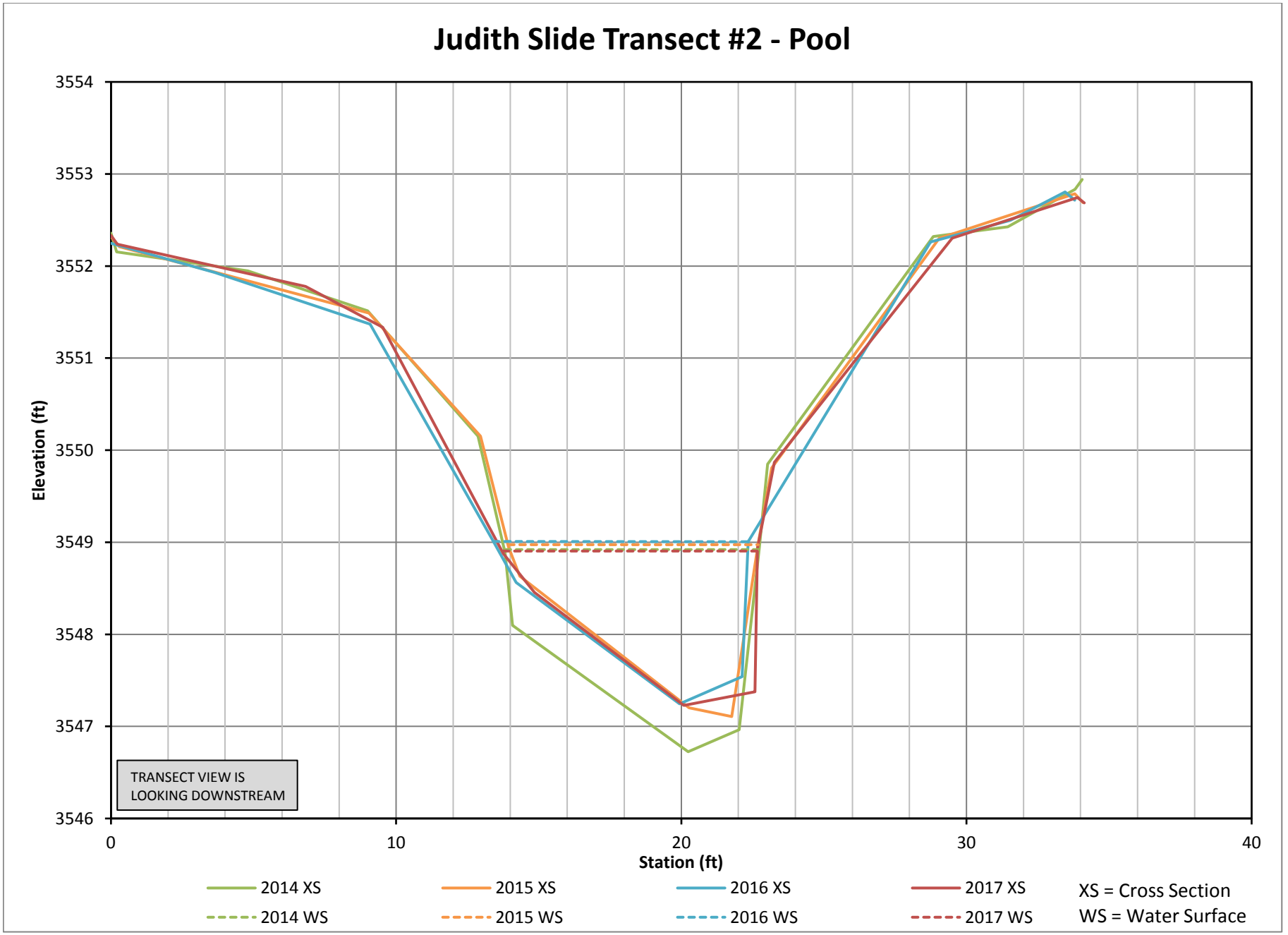
Perpendicular Transect and Longitudinal Profile Plots

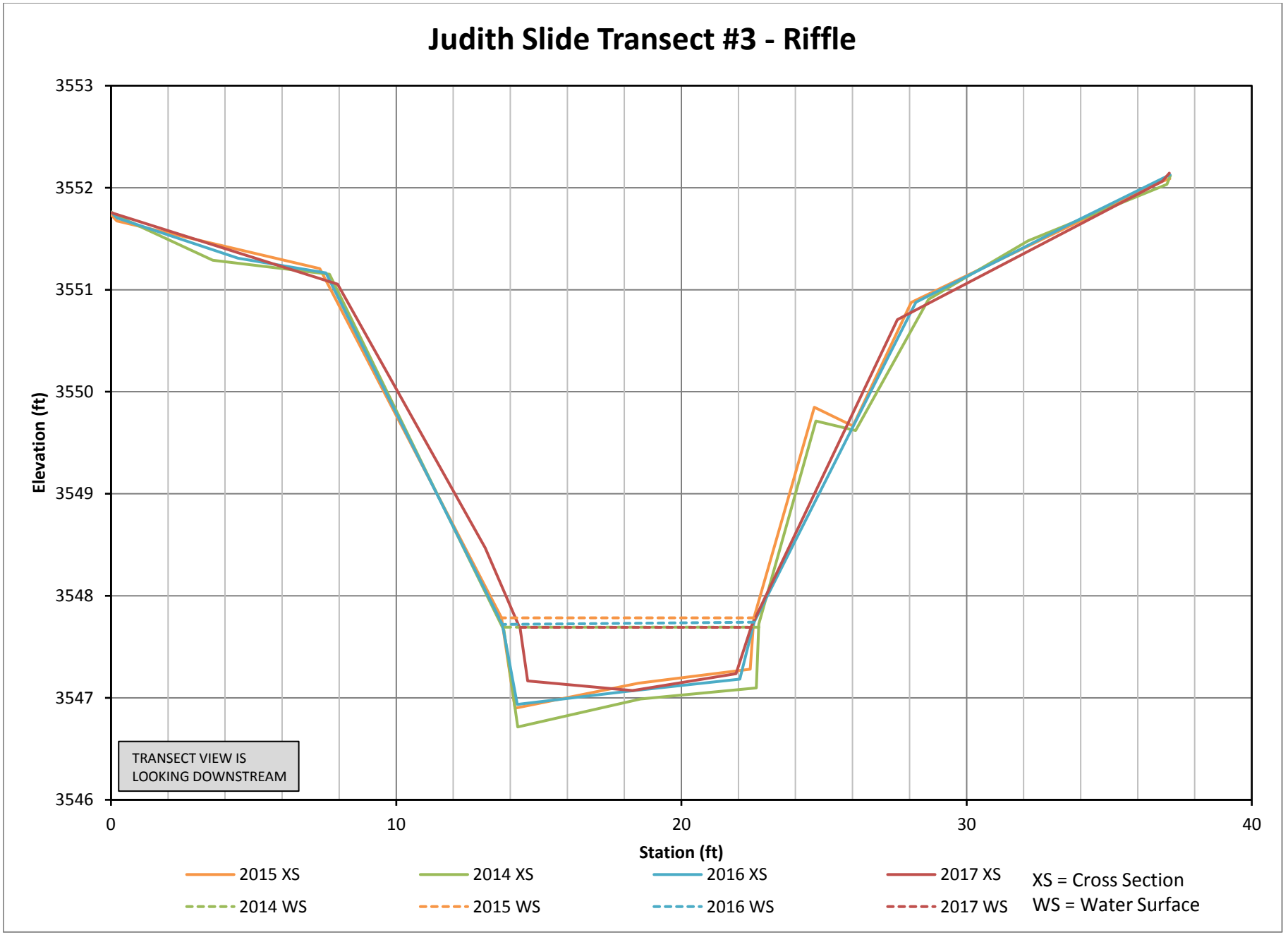
MDT Stream Mitigation Monitoring
Little Rock Creek at Judith Slide
Fergus County, Montana

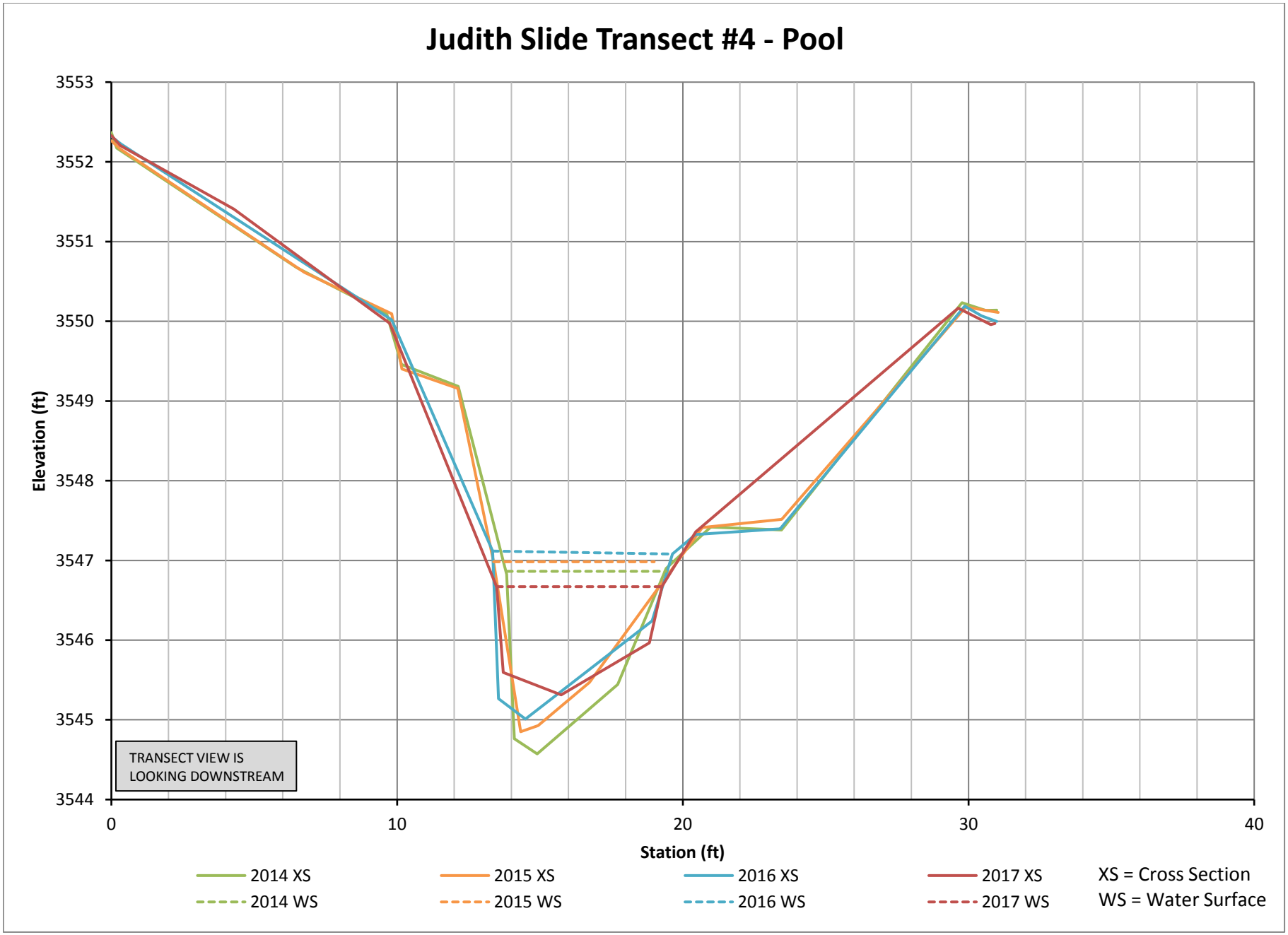

Judith Slide Longitudinal Profiles: 2014 - 2017
Elevation (ft)
3560
3555
3550
3545
3540
3535
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Station (ft)
Riffle Transect #1 STA 9+60
Pool Transect #2 STA 10+20
Riffle Transect #3 STA 10+95
Pool Transect #4 STA 11+50
New Box Culvert
Reconstructed Channel Segment
2014 Profile
2015 Profile
2016 Profile
2017 Profile


Judith Slide Longitudinal Profile of Reconstructed Channel Segment: 2014 - 2017
Elevation (ft)
3556
3554
3552
3550
3548
3546
3544
3542
600
700
800
900
1000
1100
1200
1300
1400
Station (ft)
Riffle Transect #1 STA 9+60
Pool Transect #2 STA 10+20
Riffle Transect #3 STA 10+95
Pool Transect #4 STA 11+50
New Box Culvert
2014 Profile
2015 Profile
2016 Profile
2017 Profile


Judith Slide Transect #1 - Riffle
3554
3553
3552
3551
3550
3549
3548
Elevation (ft)
0
10
20
30
40
Station (ft)
TRANSECT VIEW IS
LOOKING DOWNSTREAM
2014 XS
2015 XS
2016 XS
2017 XS
2014 WS
2015 WS
2016 WS
2017 WS
XS = Cross Section
WS = Water Surface


Judith Slide Transect #2 - Pool
Elevation (ft)
3554
3553
3552
3551
3550
3549
3548
3547
3546
0
10
20
30
40
Station (ft)
TRANSECT VIEW IS
LOOKING DOWNSTREAM
2014 XS
2015 XS
2016 XS
2017 XS
2014 WS
2015 WS
2016 WS
2017 WS
XS = Cross Section
WS = Water Surface


Judith Slide Transect #3 - Riffle
3553
3552
3551
3550
3549
3548
3547
3546
Elevation (ft)
0
10
20
30
40
Station (ft)
TRANSECT VIEW IS LOOKING DOWNSTREAM
2015 XS
2014 XS
2016 XS
2017 XS
2014 WS
2015 WS
2016 WS
2017 WS
XS = Cross Section
WS = Water Surface


Judith Slide Transect #4 - Pool
Elevation (ft)
3553
3552
3551
3550
3549
3548
3547
3546
3545
3544
0
10
20
30
40
Station (ft)
TRANSECT VIEW IS
LOOKING DOWNSTREAM
2014 XS
2015 XS
2016 XS
2017 XS
2014 WS
2015 WS
2016 WS
2017 WS
XS = Cross Section
WS = Water Surface

Appendix C

Project Area Photos

MDT Stream Mitigation Monitoring
Little Rock Creek at Judith Slide
Fergus County, Montana

PHOTO INFORMATION

PROJECT SITE: Little Rock Creek at Judith Slide Repair

DATE: 2014-2017 Monitoring Events

CONFLUENCE

2014 **2017**

Photo Point 1: Upstream end of project looking downstream. **Compass:** 0 (North)

2014 **2017**

Photo Point 2: Above culvert outlet, looking downstream. **Compass:** 0 (North)

2014 **2017**

Photo Point 3.1: First bend in channel, looking upstream. **Compass:** 180 (South)

PHOTO INFORMATION

PROJECT SITE: Little Rock Creek at Judith Slide Repair

DATE: 2014-2017 Monitoring Event

CONFLUENCE

2014 **2017**

Photo Point 3.2: Looking across channel at inside bend. **Compass:** 225 (Southwest)

2014 **2017**

Photo Point 3.3: Looking downstream at left streambank.

2014 **2017**

Photo Point 3.4: Looking downstream at right streambank. **Compass:** 270 (West)

PHOTO INFORMATION

PROJECT NAME: Little Rock Creek at Judith Slide Repair

DATE: 2014-2017 Monitoring Event

CONFLUENCE

2014 **2017**

Photo Point 4.1: Looking upstream. **Compass:** 90 (South)

2014 **2017**

Photo Point 4.2: Looking upstream at right streambank. **Compass:** 135 (Southeast)

2014 **2017**

Photo Point 4.3: Looking downstream. **Compass:** 90 (East)

PHOTO INFORMATION

PROJECT SITE: Little Rock Creek at Judith Slide Repair

DATE: 2014-2017 Monitoring Event

2014 **2017**

Photo Point 4.4: **Looking downstream at left streambank**

2014 **2017**

Photo Point 5.1: Downstream end of project, looking upstream. **Compass:** 180 (South)

2014 **2017**

Photo Point 5.2: Downstream end of project, looking at cattle crossing. **Compass:** 225 (Southwest)

PHOTO INFORMATION

PROJECT SITE: Little Rock Creek at Judith Slide Repair

DATE: 2014-2017 Monitoring Event

CONFLUENCE

2014 **2017**

Photo Point 5.3: Downstream end of project looking downstream. **Compass:** 270 (West)

Additional Photo 1: 2017
Description: **View looking upstream of reconstructed channel immediately upstream of culvert.**

Additional Photo 2: 2017
Description: **Undercut beneath coir fabric stretching along eroding bank.**

Additional Photo 3: 2017
Description: **6' eroding bank immediately downstream of rock plunge pool structure.**

Additional Photo 4: 2017
Description: **Sparse revegetation along upper coir lifts**

PHOTO INFORMATION

PROJECT SITE: Little Rock Creek at Judith Slide Repair

DATE: 2014-2017 Monitoring Event

2015 **2017**

Additional Photo 5: Gully identified along east site of reconstructed channel

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

PHOTO POINT 1 LOOKING DOWNSTREAM NORTH

PHOTO POINT 2 LOOKING DOWNSTREAM NORTH

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

PHOTO POINT 3 LOOKING UPSTREAM SOUTH

PHOTO POINT 3 LOOKING DOWNSTREAM NORTH

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

PHOTO POINT 4 LOOKING UPSTREAM SOUTHEAST

PHOTO POINT 4 LOOKING DOWNSTREAM EAST

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

PHOTO POINT 5 LOOKING UPSTREAM SOUTH

PHOTO POINT 5 LOOKING DOWNSTREAM NORTHWEST

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

RIPARIAN TRANSECT 2 WEST T4 LT LOOKING DOWNSTREAM EAST

RIPARIAN TRANSECT 2 WEST FENCE POST LOOKING UPSTREAM SOUTH

RIPARIAN TRANSECT 1 EAST T4 RT LOOKING UPSTREAM SOUTH

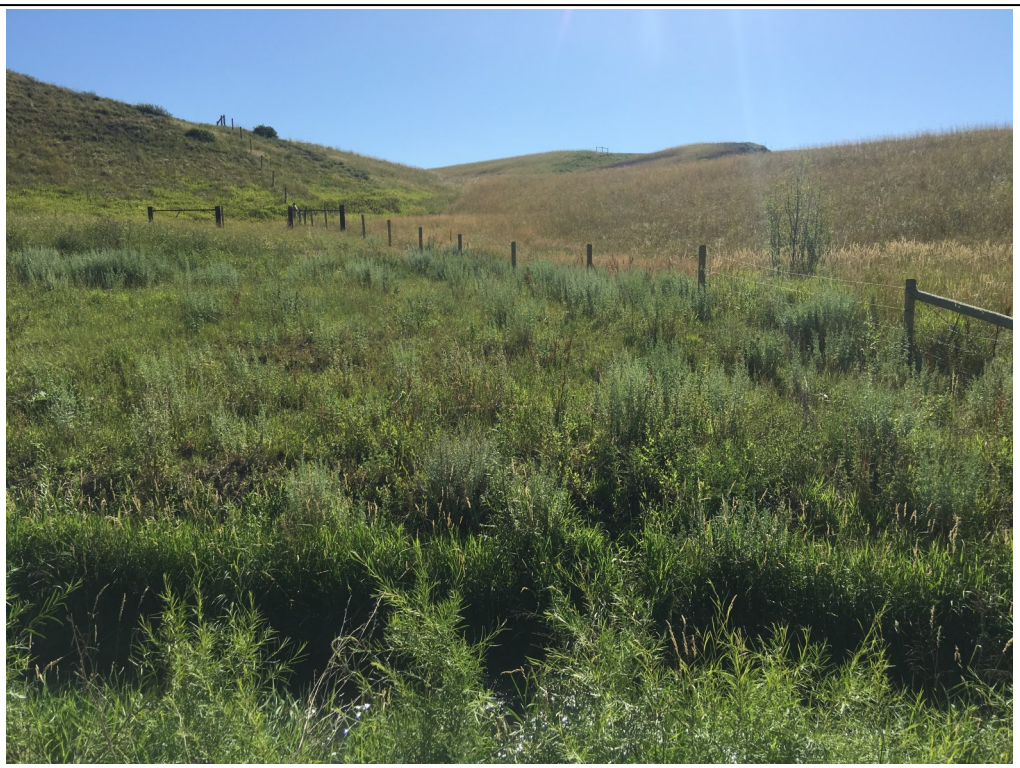
RIPARIAN TRANSECT 1 EAST FENCE POST LOOKING DOWNSTREAM

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

T1 LT: LOOKING UPSTREAM SOUTH

T1 LT: LOOKING DOWNSTREAM NORTH



T1 LT: LOOKING EAST TO T1 RT:

T1 RT: LOOKING WEST TO T1 LT:

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

T1: LOOKING UPSTREAM SOUTH FROM MIDDLE OF CREEK

T1: LOOKING DOWNSTREAM NORTH FROM MIDDLE OF CREEK

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

T1 RT: LOOKING UPSTREAM SOUTHWEST

T1 RT: LOOKING DOWNSTREAM NORTH

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

T2 LT: LOOKING UPSTREAM SOUTH

T2 LT: LOOKING DOWNSTREAM WEST

T2 LT: LOOKING EAST TO T2 RT

T2 RT: LOOKING WEST TO T2 LT

T2: LOOKING UPSTREAM SOUTH FROM MIDDLE OF CREEK

T2: LOOKING DOWNSTREAM NORTHWEST FROM MIDDLE OF CREEK

T2 RT: LOOKING UPSTREAM SOUTHWEST

T2 RT: LOOKING DOWNSTREAM NORTHWEST

T3 LT: LOOKING UPSTREAM SOUTHEAST

T3 LT: LOOKING DOWNSTREAM NORTH

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

T3 LT: LOOKING EAST TO T3 RT

T3 RT: LOOKING WEST TO T3 LT

T3: LOOKING UPSTREAM SOUTHEAST FROM MIDDLE OF CREEK

T3: LOOKING DOWNSTREAM NORTHWEST FROM MIDDLE OF CREEK

T3 RT: LOOKING UPSTREAM SOUTH

T3 RT: LOOKING DOWNSTREAM WEST

T4 LT: LOOKING UPSTREAM SOUTHEAST

T4 LT: LOOKING DOWNSTREAM EAST

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

T4 LT: LOOKING EAST TO T4 RT

T4 RT: LOOKING WEST TO T4 LT

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

T4: LOOKING UPSTREAM SOUTHEAST FROM MIDDLE OF CREEK

T4: LOOKING DOWNSTREAM NORTHEAST FROM MIDDLE OF CREEK

PROJECT NAME: 2017 MDT STREAM MITIGATION—JUDITH SLIDE

DATE: 8-03-17

T4 RT: LOOKING UPSTREAM SOUTH

T4 RT: LOOKING DOWNSTREAM EAST

Appendix D

As-Built Topographic Survey (surveyed in 2014)

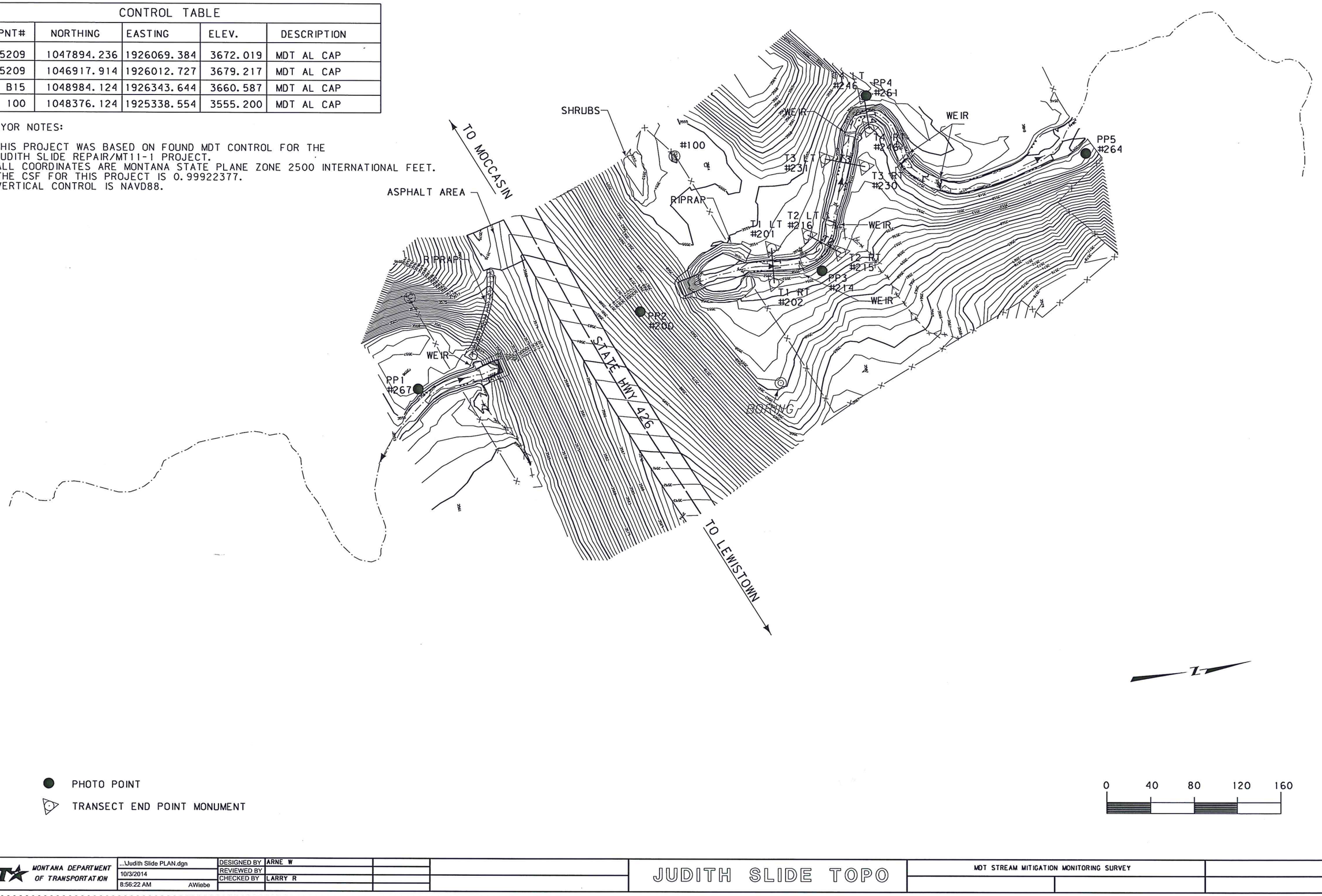
MDT Stream Mitigation Monitoring
Little Rock Creek at Judith Slide
Fergus County, Montana

CONTROL TABLE				
PNT#	NORTHING	EASTING	ELEV.	DESCRIPTION
A5209	1047894.236	1926069.384	3672.019	MDT AL CAP
B5209	1046917.914	1926012.727	3679.217	MDT AL CAP
B15	1048984.124	1926343.644	3660.587	MDT AL CAP
100	1048376.124	1925338.554	3555.200	MDT AL CAP

SURVEYOR NOTES:

1. THIS PROJECT WAS BASED ON FOUND MDT CONTROL FOR THE JUDITH SLIDE REPAIR/MT11-1 PROJECT.
   ALL COORDINATES ARE MONTANA STATE PLANE ZONE 2500 INTERNATIONAL FEET.
   THE CSF FOR THIS PROJECT IS 0.99922377.
   VERTICAL CONTROL IS NAVD88.

STAHLY ENGINEERING & ASSOCIATES
STAHLY
CIVIL ENGINEERS
STAHLY BUILDING
BILLINGS, MONTANA



● PHOTO POINT

TRANSECT END POINT MONUMENT

0 40 80 120 160

3	MDT MONTANA DEPARTMENT OF TRANSPORTATION	...\Judith Slide PLAN.dgn	DESIGNED BY	ARNE W		JUDITH SLIDE TOPO	MDT STREAM MITIGATION MONITORING SURVEY
2		10/3/2014	REVIEWED BY				
1		8:56:22 AM AWiebe	CHECKED BY	LARRY R			