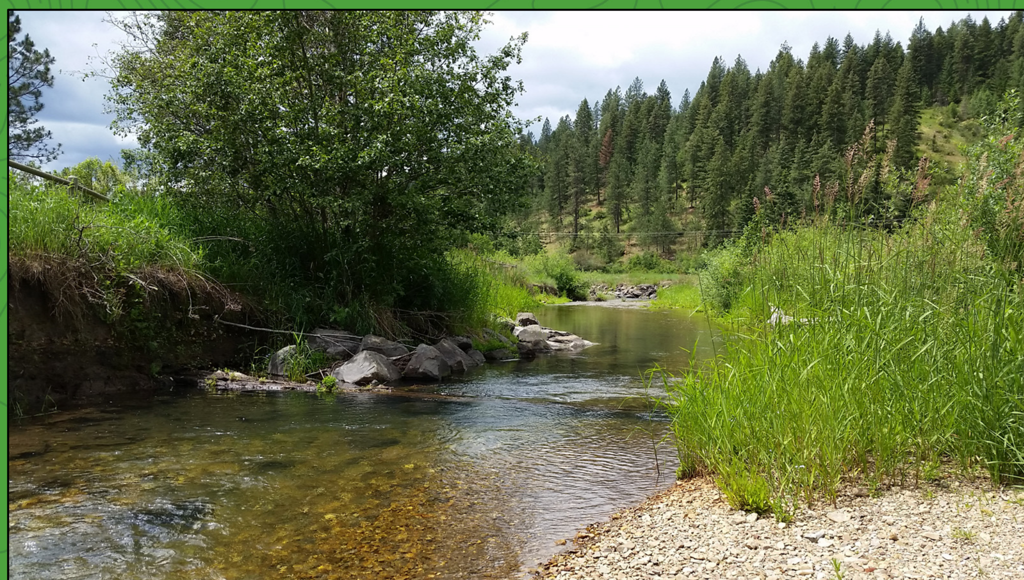
Wolf Lodge Creek
Watershed Assessment and Restoration Prioritization Plan

Near Coeur d'Alene, Idaho



Submitted To:
Idaho Department of Environmental Quality
2110 Ironwood Parkway
Coeur d'Alene, ID 83814

December 2016

RDG
RIVER DESIGN GROUP

www.riverdesigngroup.com

APPENDIX A

WATERSHED MAPS

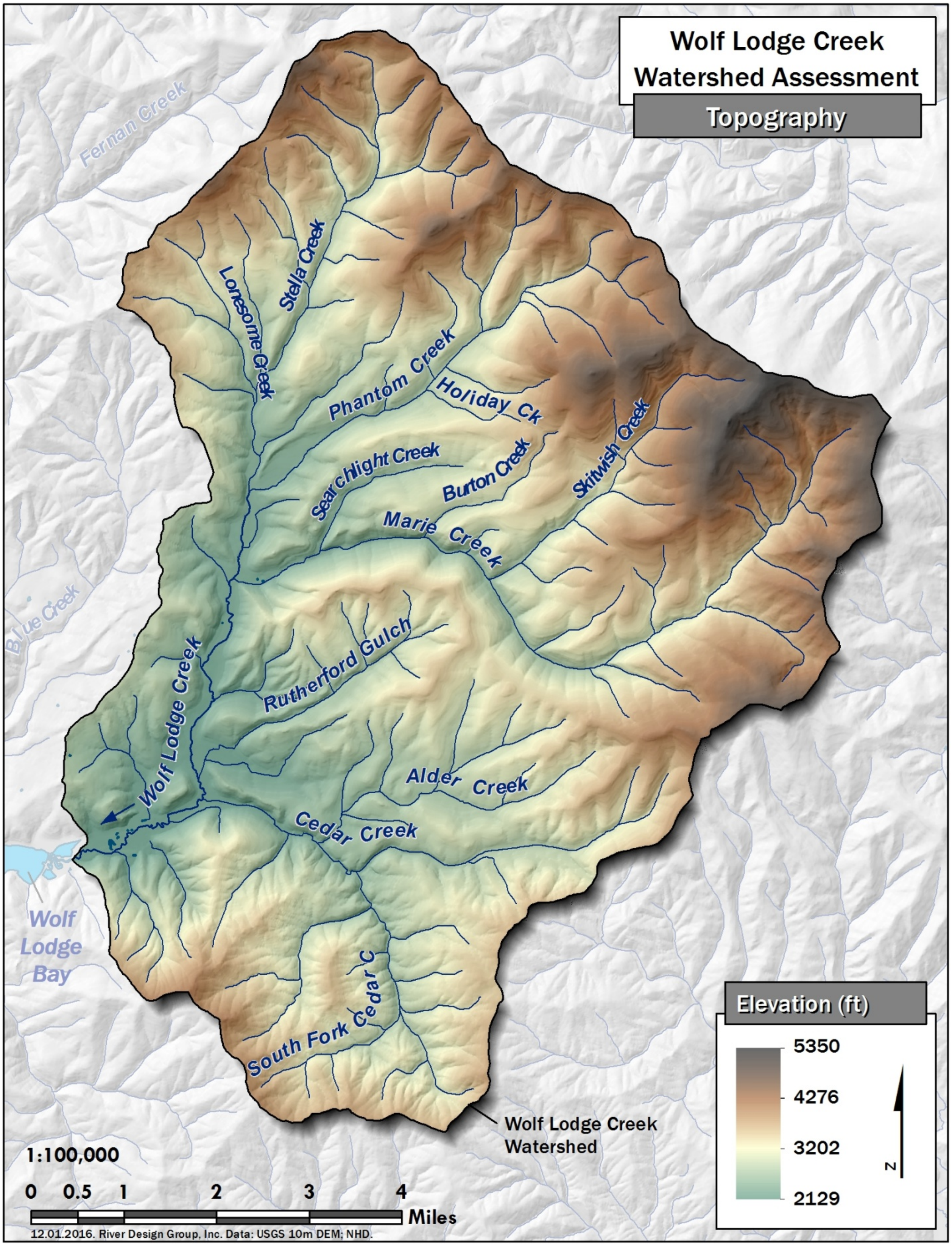


Figure A1. Wolf Lodge Creek watershed topography.

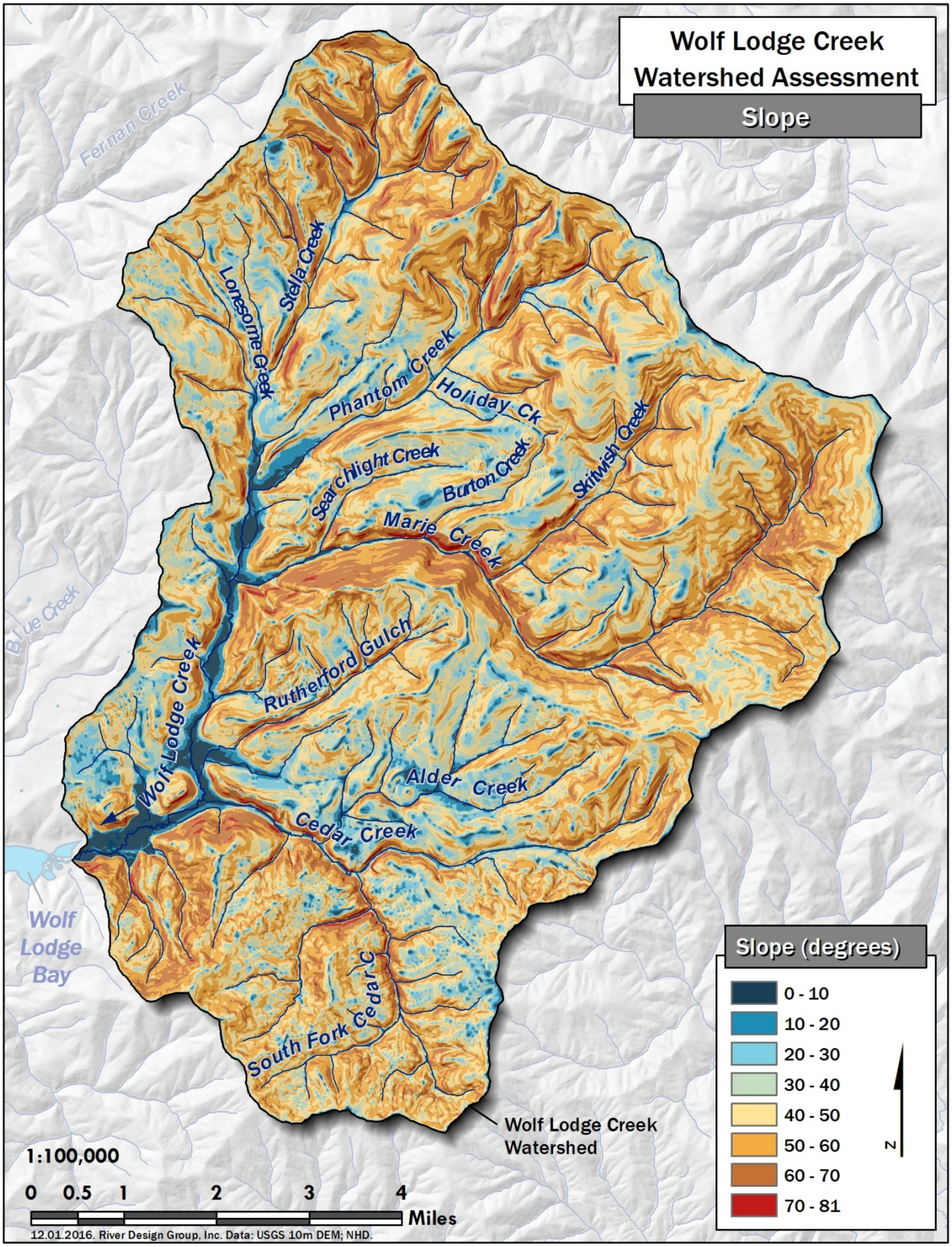


Figure A2. Wolf Lodge Creek watershed slope.

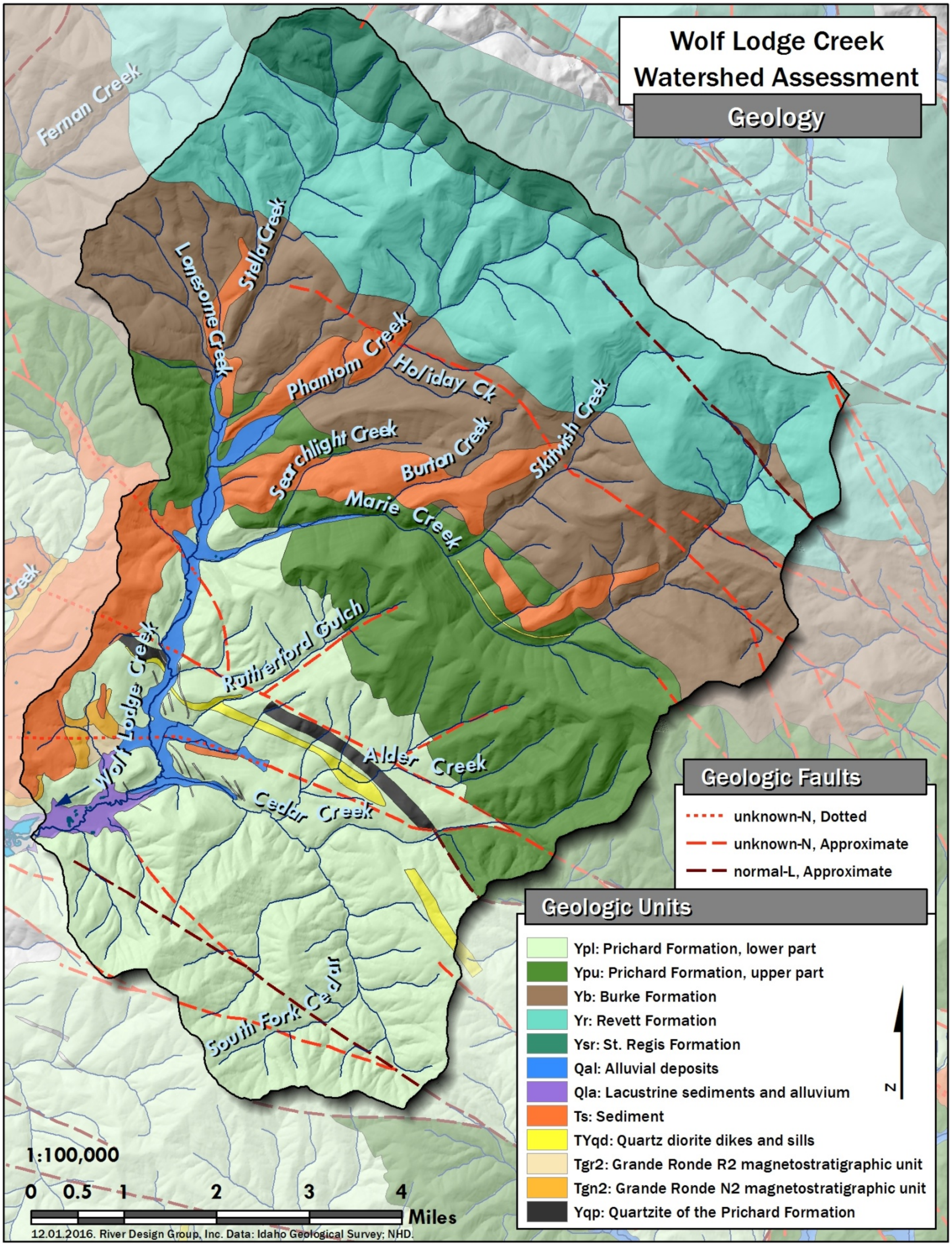


Figure A3. Wolf Lodge Creek watershed geology (Lewis et al. 2002).

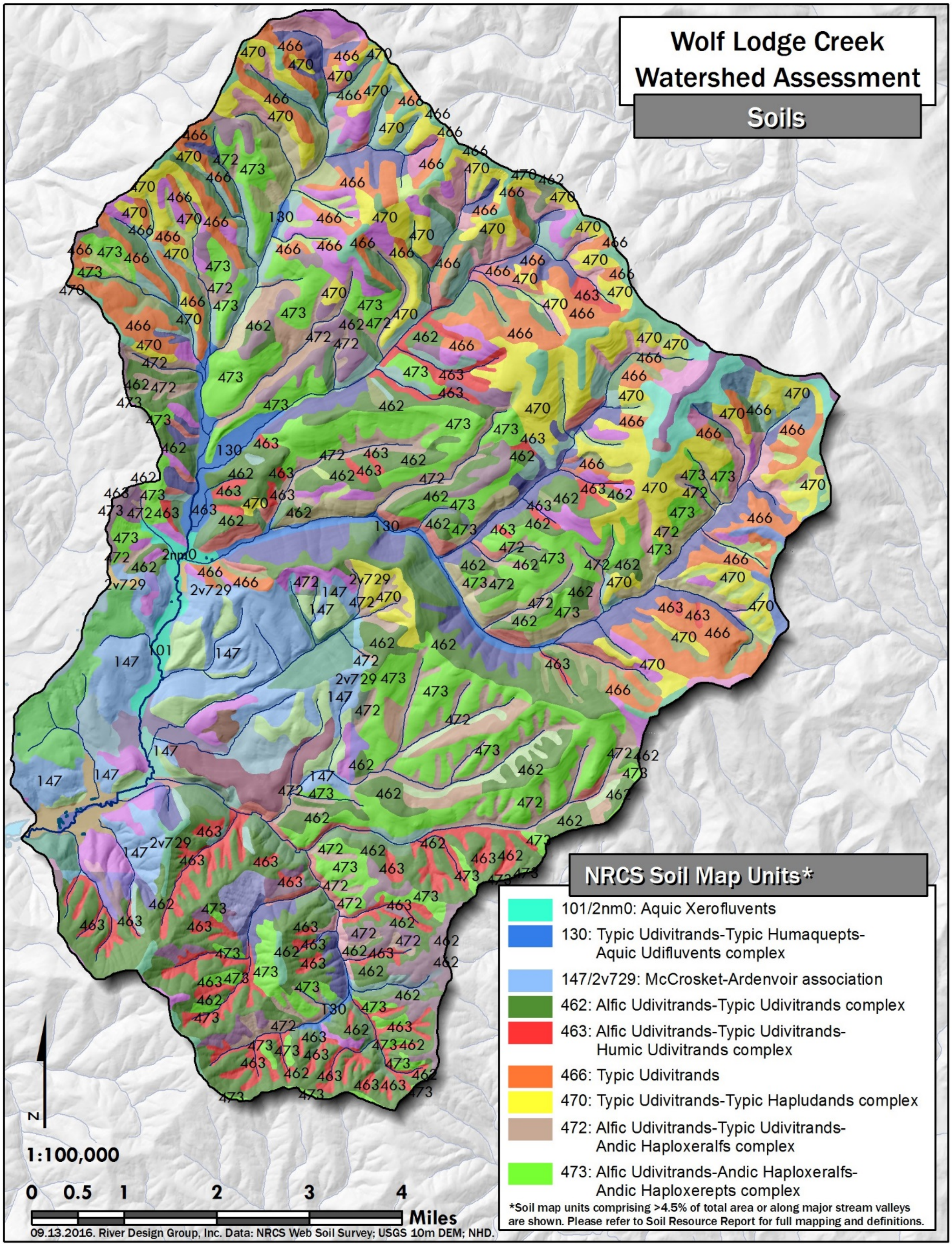


Figure A4. Wolf Lodge Creek watershed soil map units (NRCS 2016).

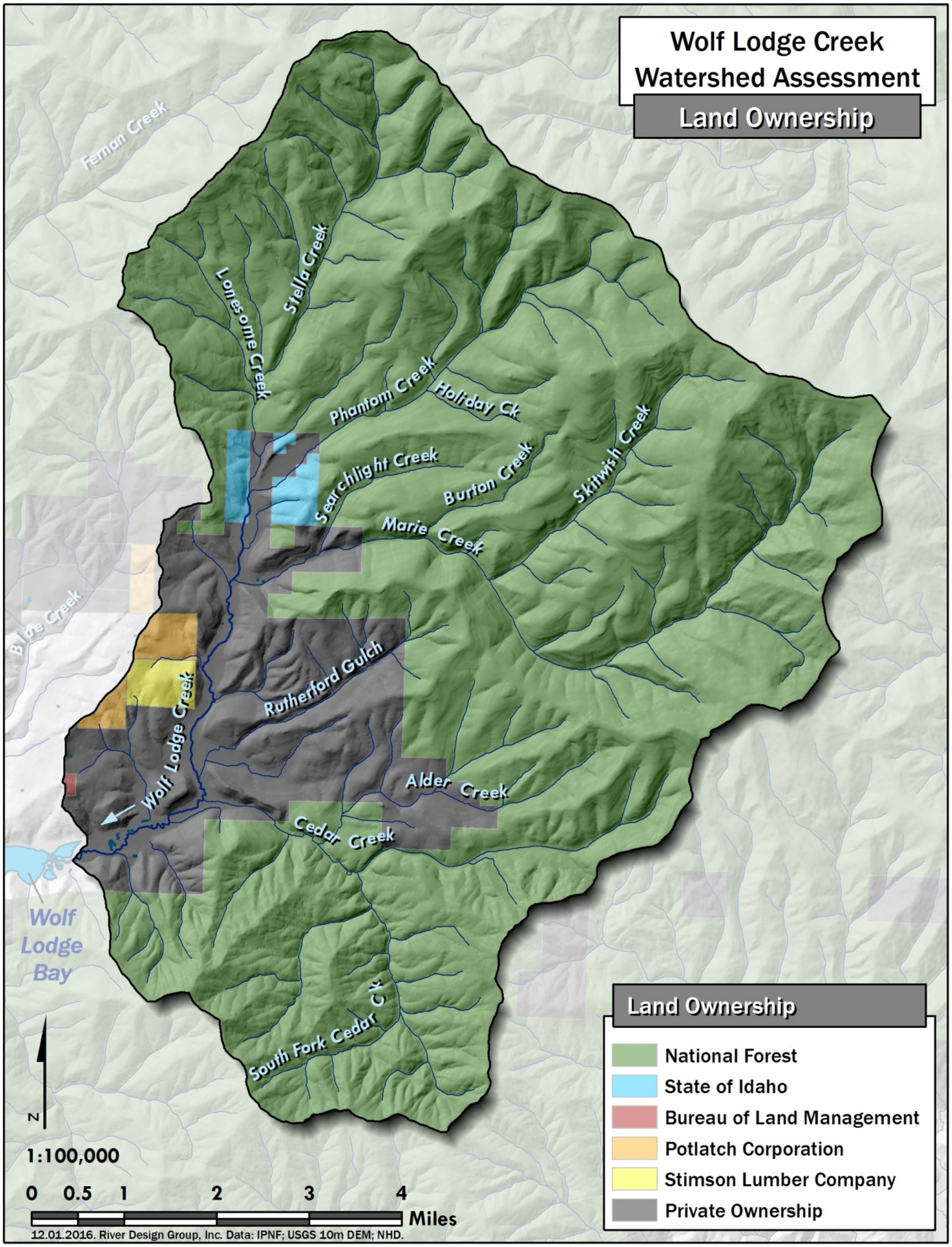


Figure A5. Wolf Lodge Creek watershed land ownership.

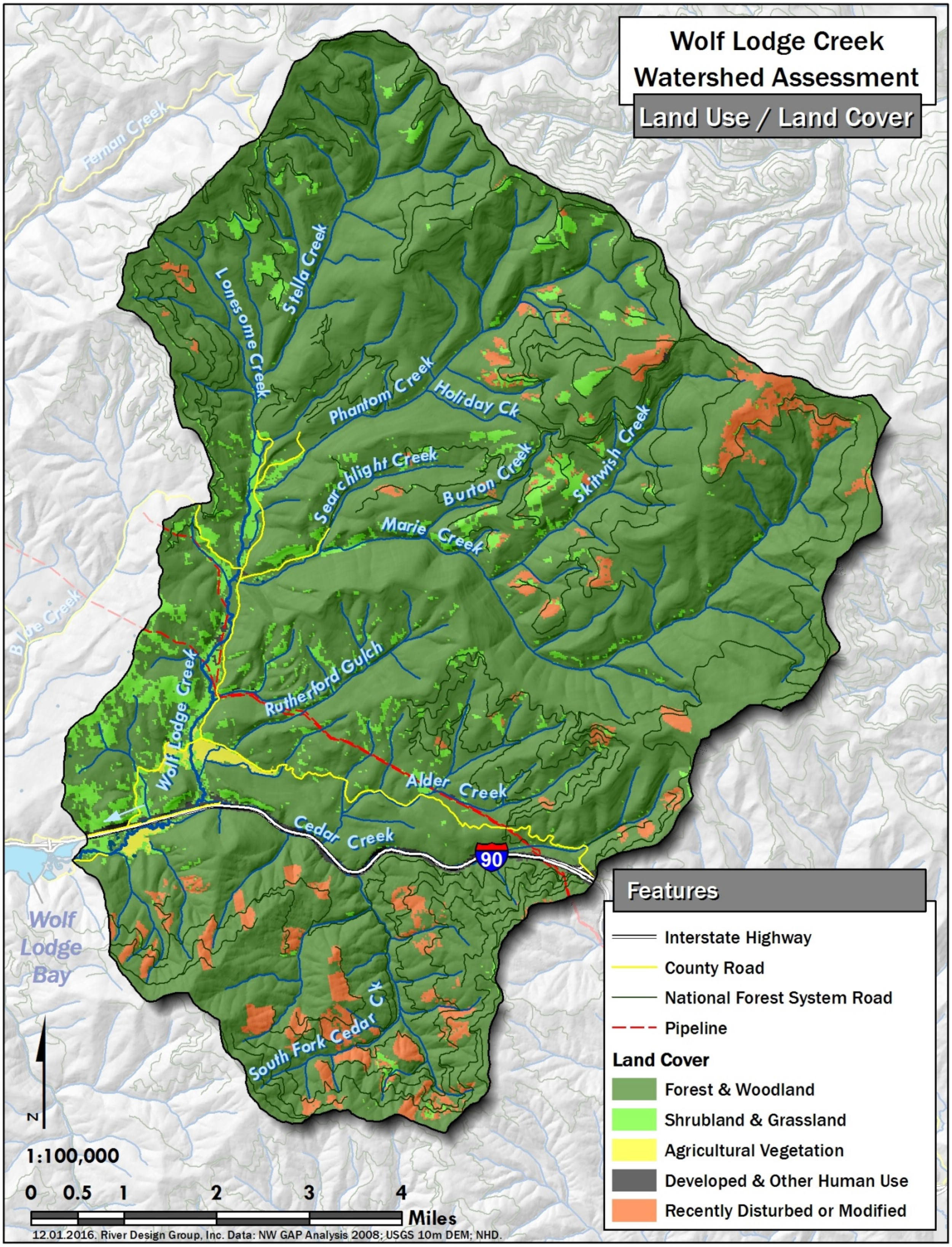


Figure A6. Wolf Lodge Creek watershed land use/land cover.

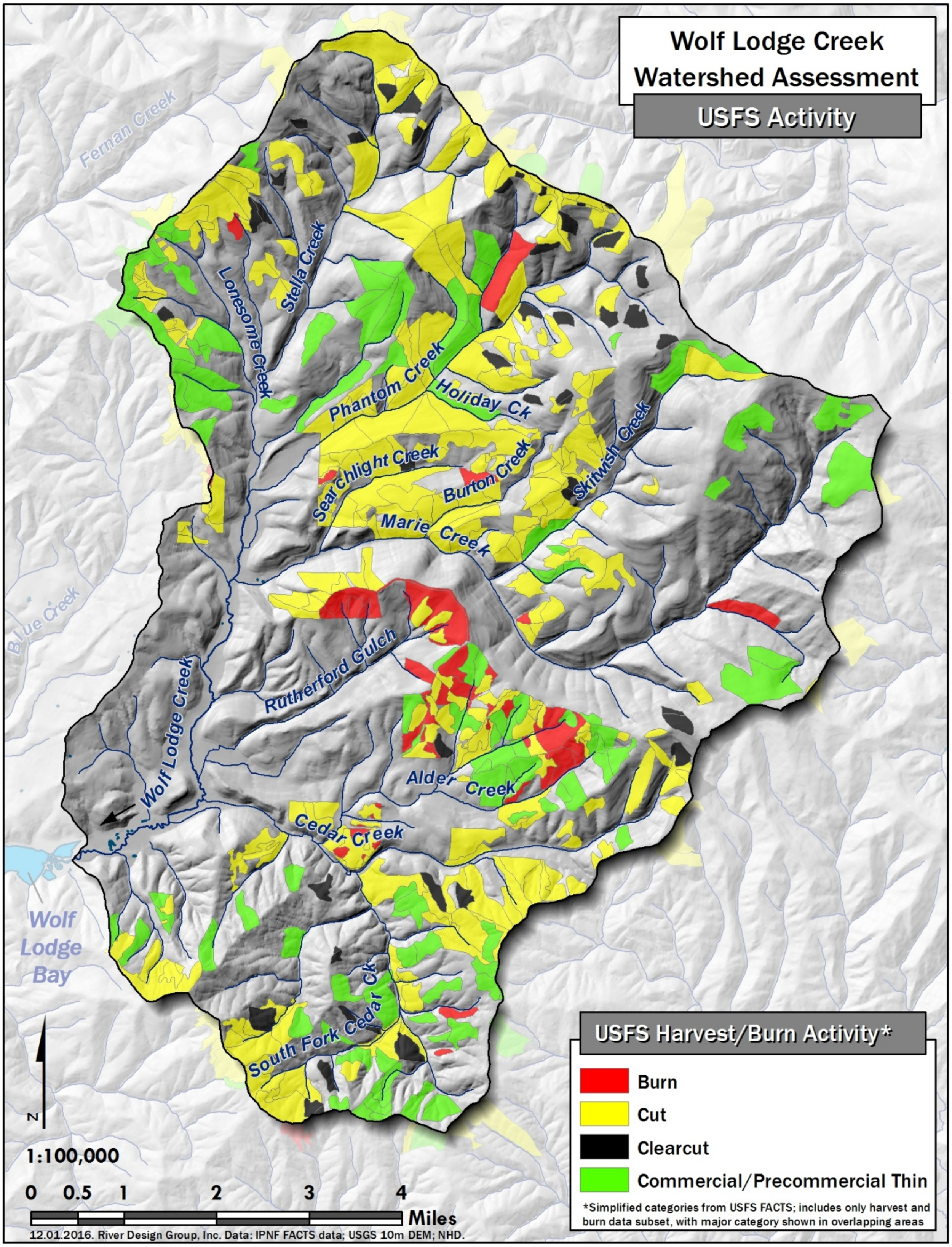


Figure A7. US Forest Service harvest and burn activity within Wolf Lodge Creek watershed.

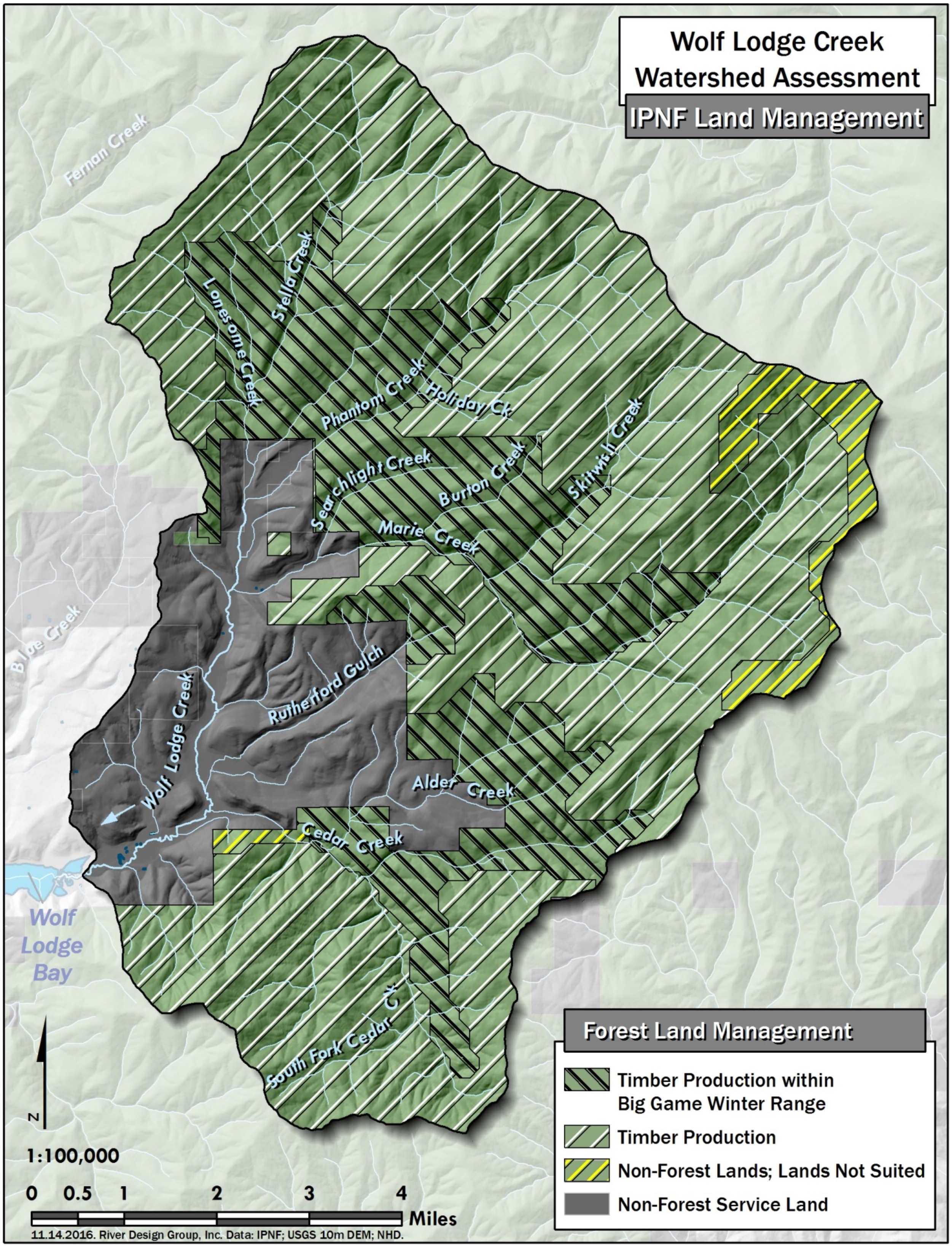


Figure A-8. US Forest Service Land Management in the Wolf Lodge Creek watershed.

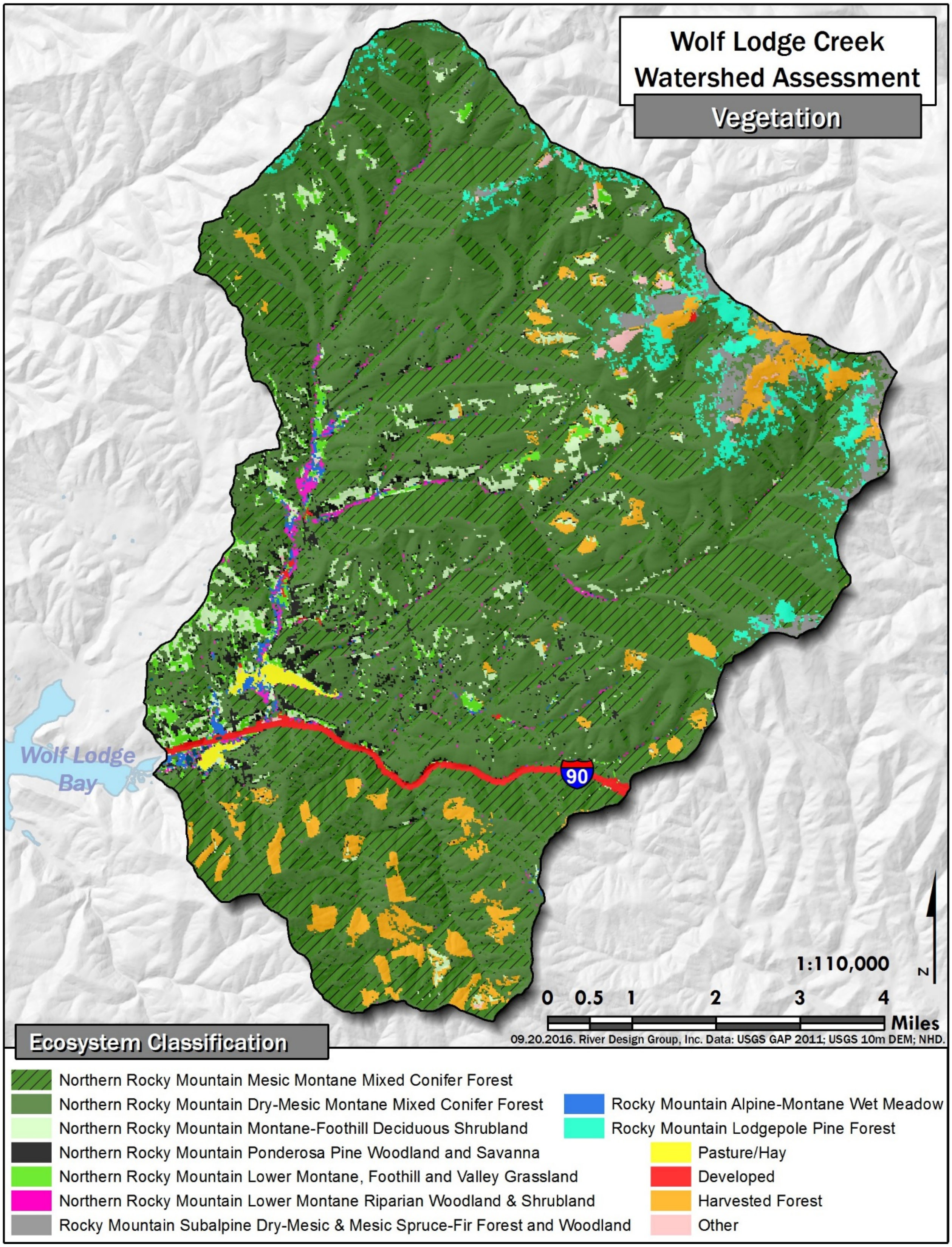


Figure A9. Wolf Lodge Creek watershed vegetation (USGS GAP 2011).

APPENDIX B

GEOMORPHIC DATA SUMMARY

STELLA CREEK

REACH DATA – REACH SC1

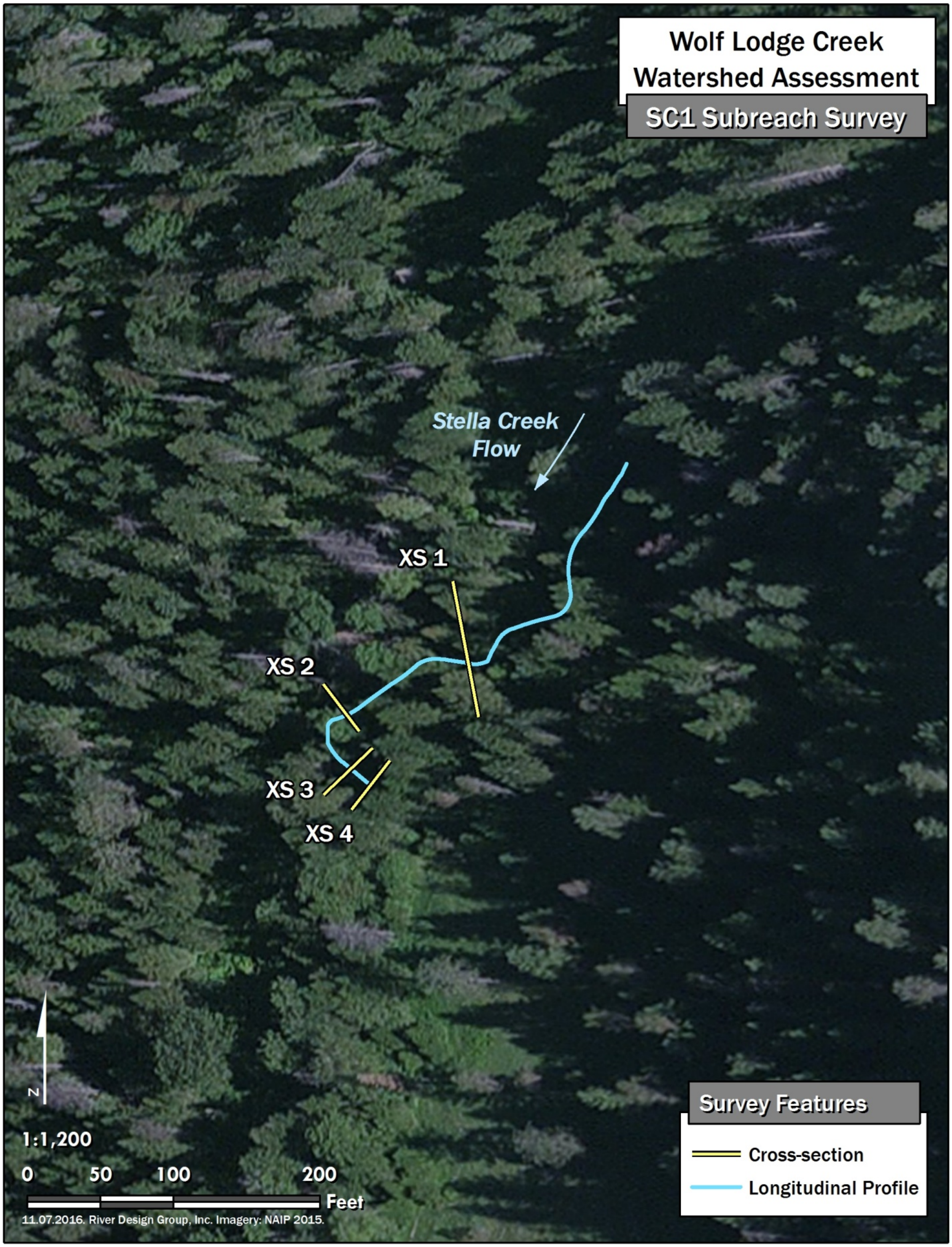


Figure B1-1. SC1 Subreach overview map with survey data from geomorphic assessment.

LONGITUDINAL PROFILE

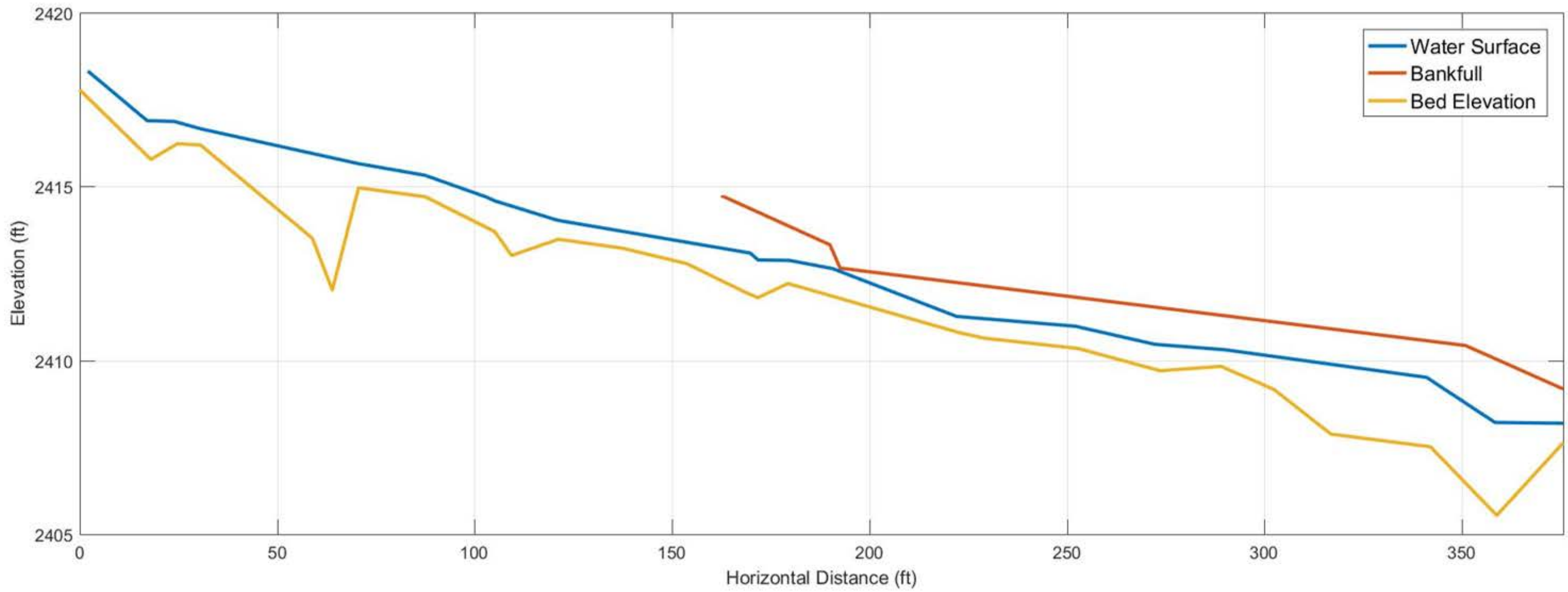


Figure B1-2. Longitudinal profile of SC1.

Table B1-1. Profile dimensions for SC1.	
Bed Slope	-0.026
Water Slope	-0.025
Bankfull Slope	-0.022
Sinuosity	1.28

CROSS SECTION DATA

Figure B1-3. Cross section 4 pool (left) and cross section 2 riffle (right) on SC1.

Table B1-2. Overview of cross section dimensions for SC1.

Metric	Min	Mean	Max
Depth max Riffle (ft)	0.8	1.4	2.0
Depth max Pool (ft)	2.7	3.2	3.6
Riffle Area (ft^2)	8.6	16.4	24.1
Pool Area (ft^2)	37.4	48.9	60.3
Riffle Width (ft)	14.4	22.8	31.1
Pool Width (ft)	24.3	25.5	26.7

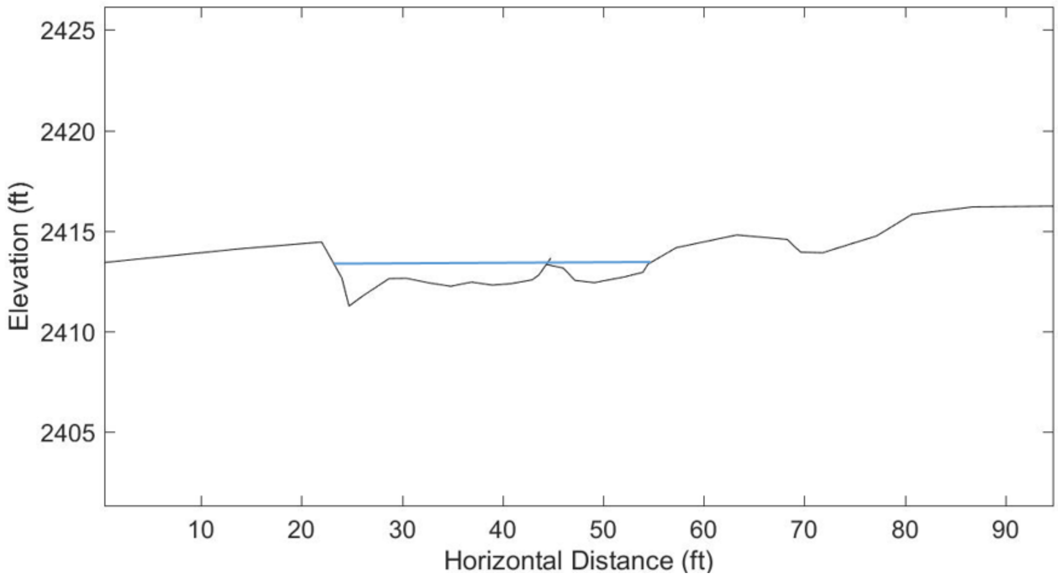


Figure B1-4. Cross section 1 riffle on SC1. The blue line represents bankfull.

Table B1-3. Metrics for cross section 1 on SC1.	
Bankfull Width (ft)	31.1
Mean Depth (ft)	0.8
Max Depth (ft)	2.0
Bankfull Area (ft^2)	24.1
Width/Depth Ratio	37.8
Hydraulic Radius	0.7

Figure B1-5. Cross section 1 downstream (left) & upstream (right) riffle.

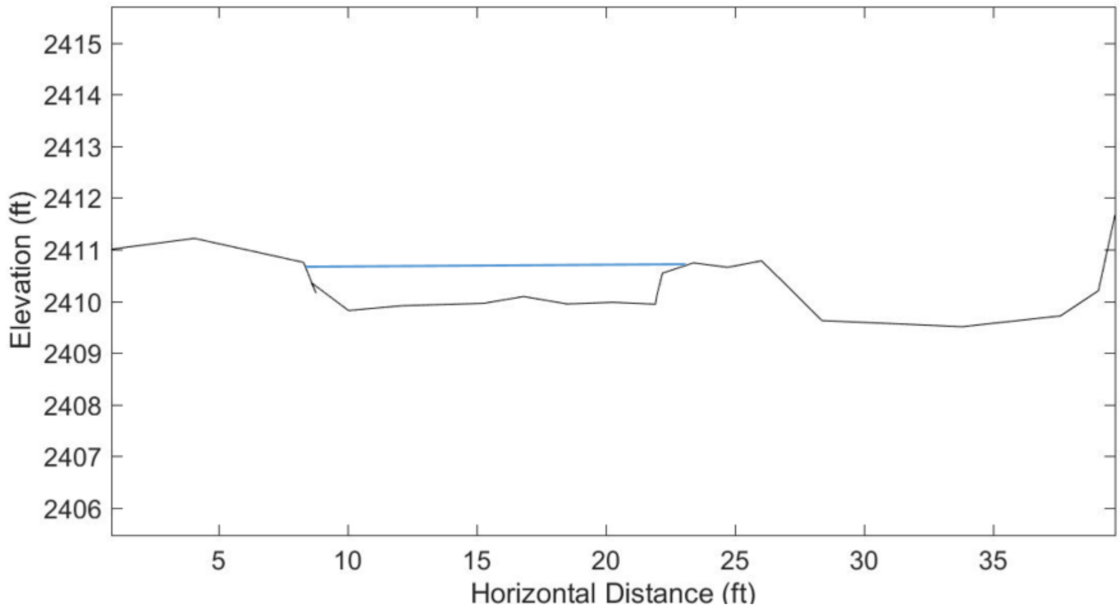


Figure B1-6. Cross section 2 riffle on SC1. The blue line represents bankfull.

Table B1-4. Metrics for cross section 2 on SC1.	
Bankfull Width (ft)	14.4
Mean Depth (ft)	0.6
Max Depth (ft)	0.8
Bankfull Area (ft^2)	8.6
Width/Depth Ratio	23.5
Hydraulic Radius	0.6

Figure B1-7. Cross section 2 downstream riffle.

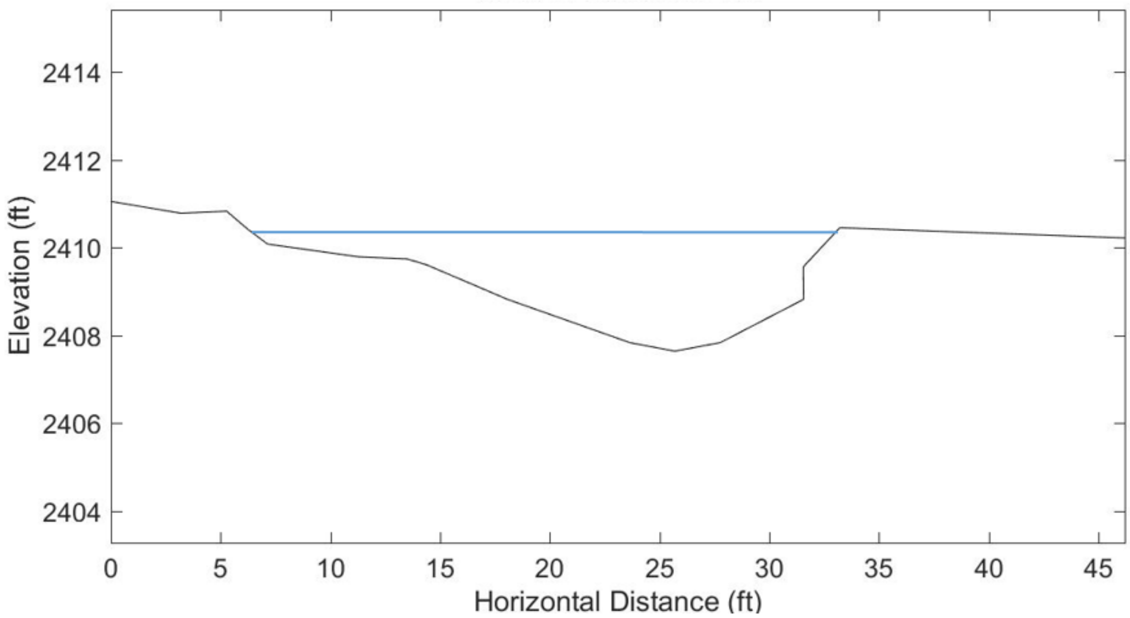


Figure B1-8. Cross section 3 pool on SC1. The blue line represents bankfull.

Table B1-5. Metrics for cross section 3 on SC1.	
Bankfull Width (ft)	26.7
Mean Depth (ft)	1.4
Max Depth (ft)	2.7
Bankfull Area (ft^2)	37.4
Width/Depth Ratio	19.4
Hydraulic Radius	1.3

Figure B1-9. Cross section 3 downstream (left) & upstream (right) pool.

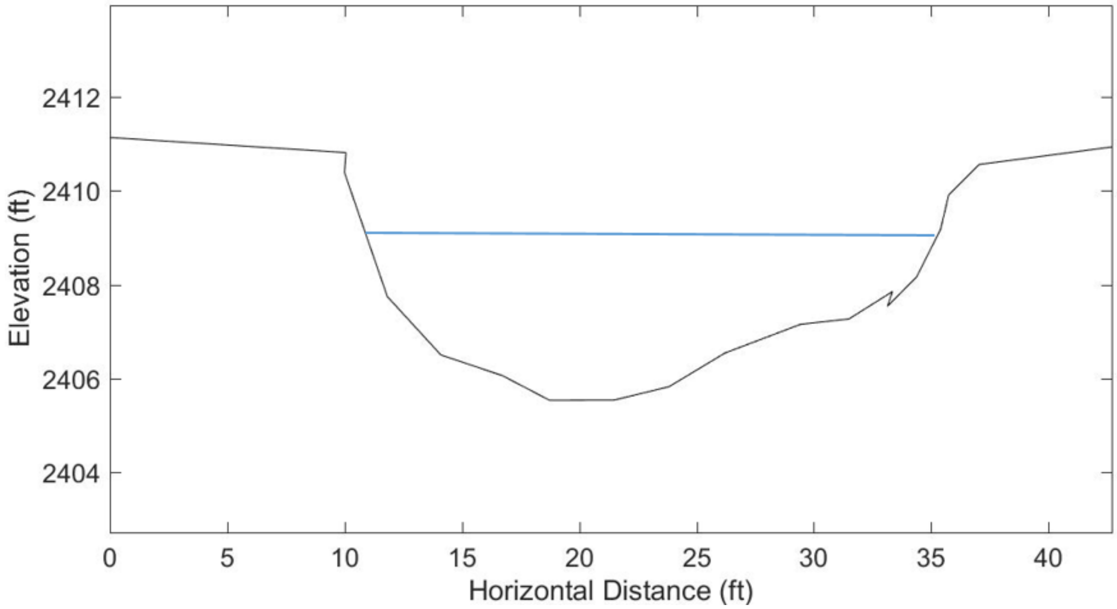


Figure B1-10. Cross section 4 pool on SC1. The blue line represents bankfull.

Table B1-6. Metrics for cross section 4 on SC1.	
Bankfull Width (ft)	24.3
Mean Depth (ft)	2.5
Max Depth (ft)	3.6
Bankfull Area (ft^2)	60.3
Width/Depth Ratio	9.7
Hydraulic Radius	2.3

Figure B1-11. Cross section 4 upstream log-step pool.

GRAIN SIZE DATA

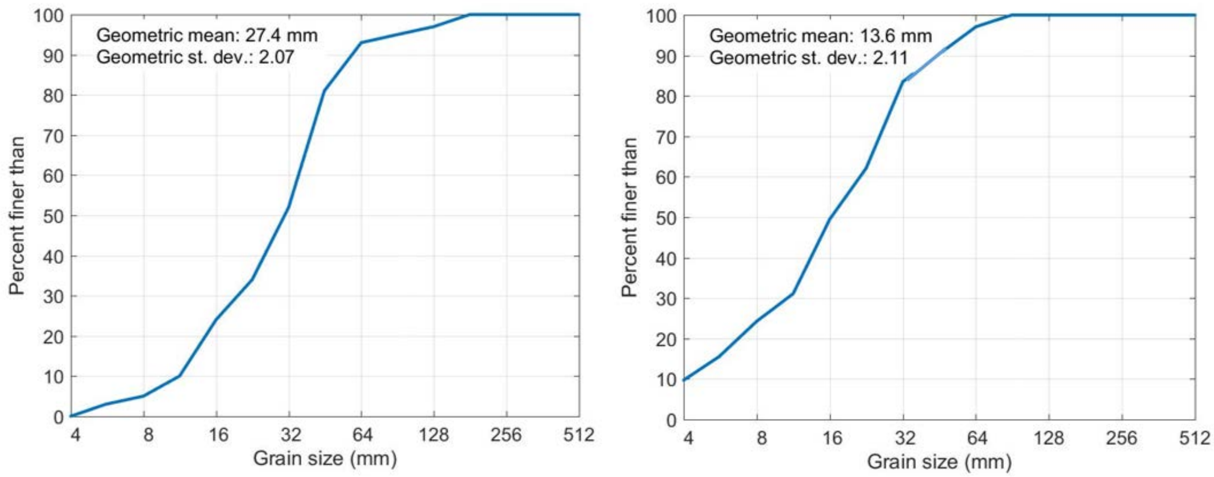


Figure B1-12. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for SC1.

Table B1-7. SC1 pebble count results.		
Percentile	**Riffle (mm)**	**Pool (mm)**
16	13.3	5.7
35	23.1	12.3
50	31.0	16.3
65	37.8	23.9
84	49.7	33.0
95	90.0	58.2

LARGE WOOD SURVEY

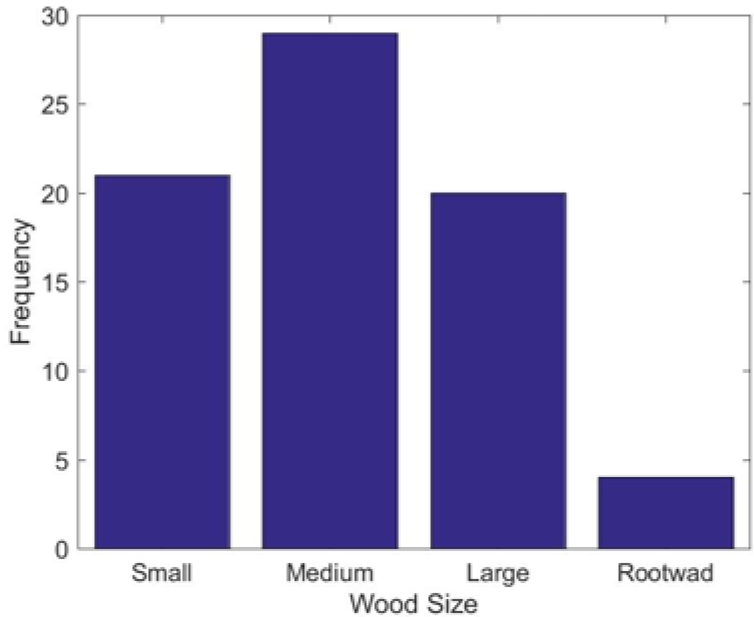


Figure B1-13. Results from large wood survey.

LONESOME CREEK

REACH DATA – REACH LC1

Figure B2-1. Subreach overview map with survey data from geomorphic assessment for LC1.

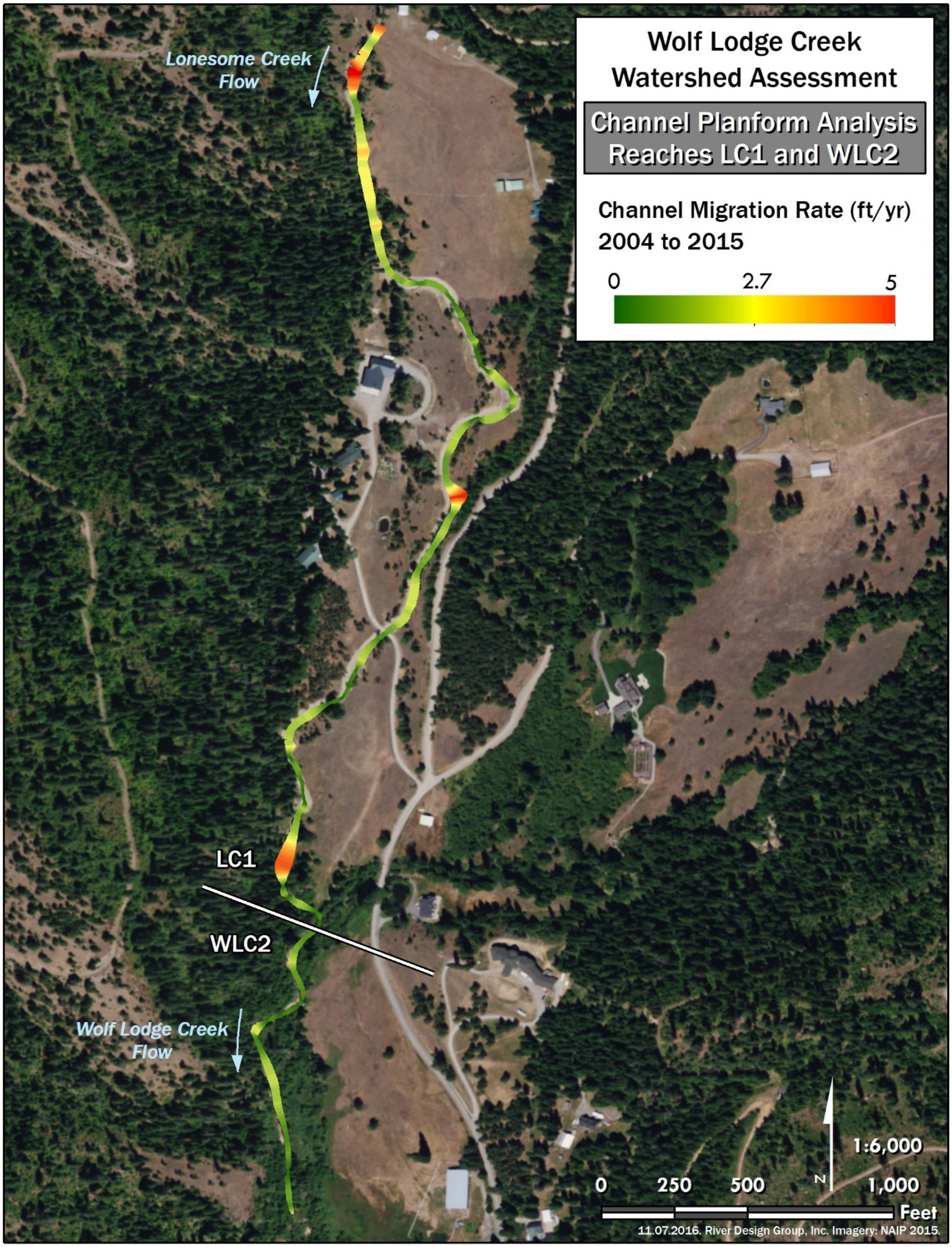


Figure B2-2. Historical channel planform analysis that quantifies migration rates for 2004-2015.

LONGITUDINAL PROFILE

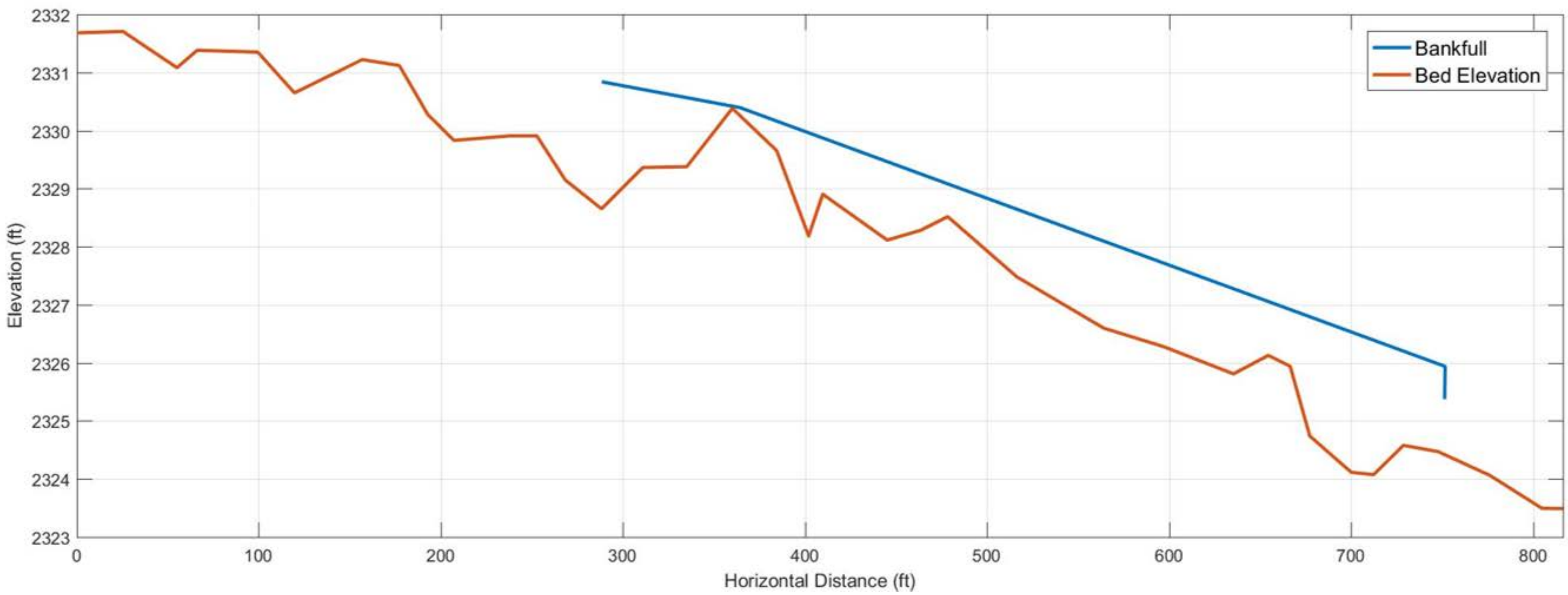


Figure B2-3. Longitudinal profile of LC1.

Table B2-1. Profile dimensions for LC1.	
Bed Slope	-0.01044
Bankfull Slope	-0.01158
Sinuosity	1.459177

CROSS SECTION DATA


Figure B2-4. Mid-reach downstream view (left). Right bank levied by previous owner (right).

Table B2-2. Overview of cross section dimensions for LC1.

Metric	Min	Mean	Max
Depth max Riffle (ft)	1.0	1.1	1.1
Depth max Pool (ft)	2.1	2.3	2.5
Riffle Area (ft^2)	2.7	13.0	23.3
Pool Area (ft^2)	19.5	32.1	44.6
Riffle Width (ft)	8.2	19.3	30.3
Pool Width (ft)	16.4	22.2	28.0

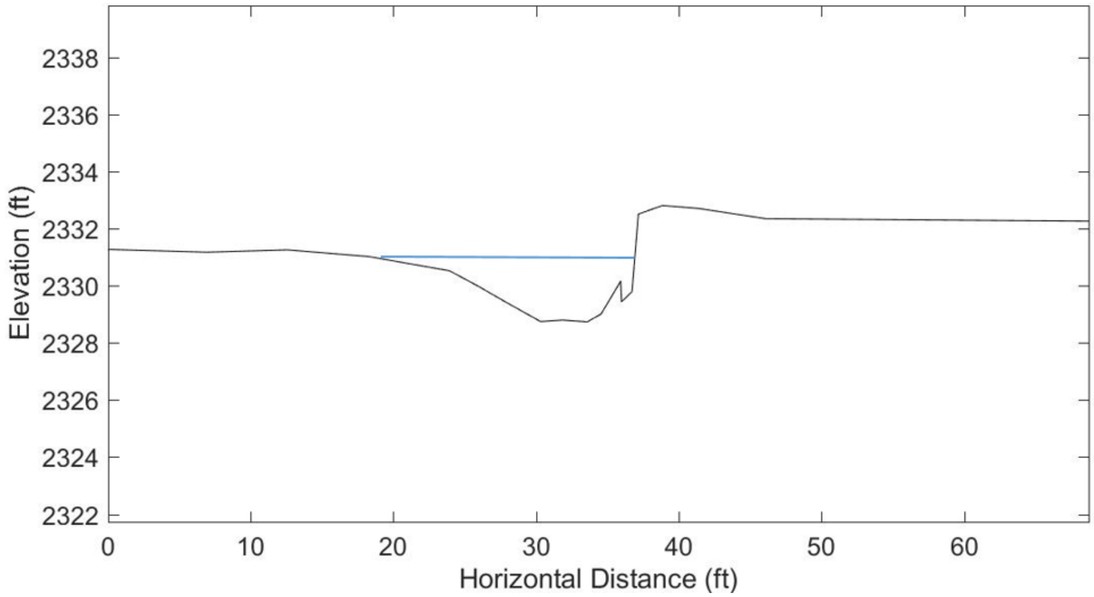


Figure B2-5. Cross section 1 pool on LC1. The blue line represents bankfull.

Table B2-3. Metrics for cross section 1 on LC1.	
Bankfull Width (ft)	16.4
Mean Depth (ft)	1.2
Max Depth (ft)	2.1
Bankfull Area (ft^2)	19.5
Width/Depth Ratio	13.7
Hydraulic Radius	1.1

Figure B2-6. Cross section 1 pool upstream view. Rapidly eroding bank and bank blocks.

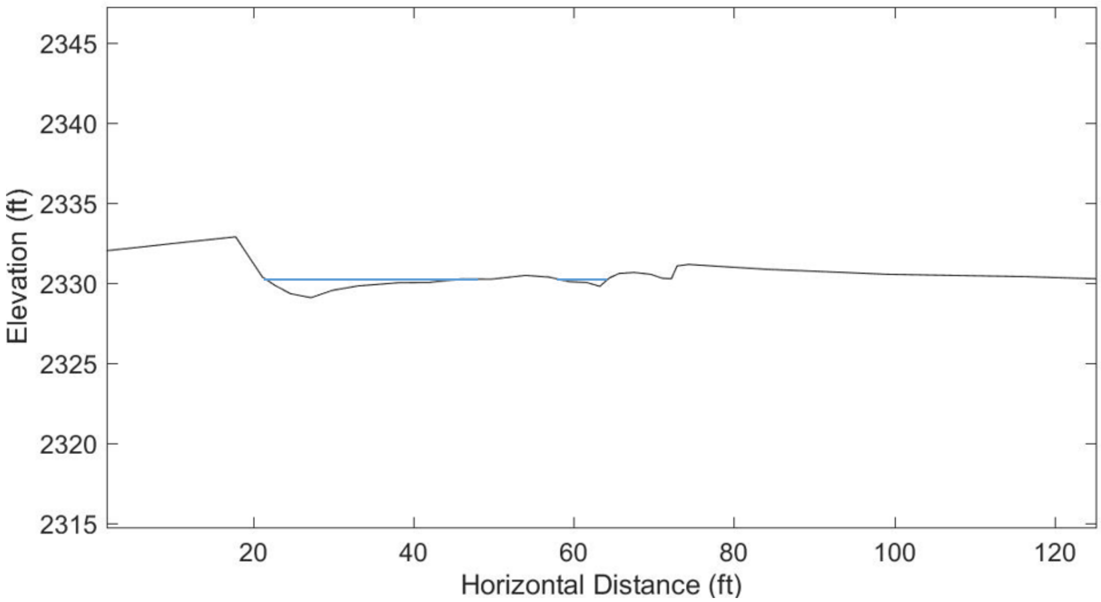


Figure B2-7. Cross section 2 riffle on LC1. The blue line represents bankfull.

Table B2-4. Metrics for cross section 2 on LC1.	
Bankfull Width (ft)	8.2
Mean Depth (ft)	0.4
Max Depth (ft)	1.1
Bankfull Area (ft^2)	2.7
Width/Depth Ratio	20.6
Hydraulic Radius	0.3

Figure B2-8. Cross section 2 riffle downstream. Wide riffle that appears to be a result of vegetation removal and bank instability.

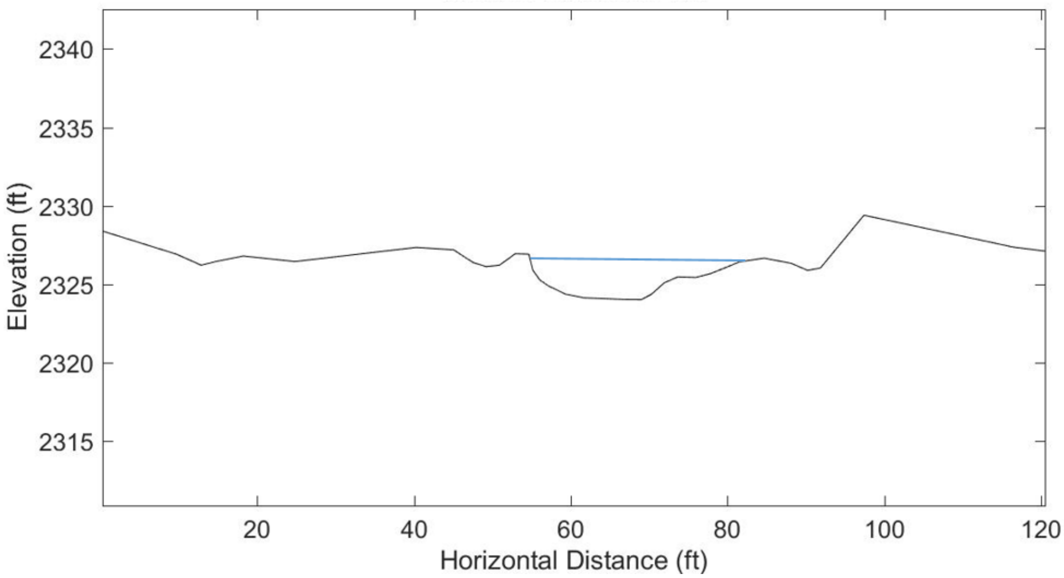


Figure B2-9. Cross section 3 riffle on LC1. The blue line represents bankfull.

1

Table B2-5. Metrics for cross section 3 on LC1.	
Bankfull Width (ft)	28.0
Mean Depth (ft)	1.6
Max Depth (ft)	2.5
Bankfull Area (ft^2)	44.6
Width/Depth Ratio	17.5
Hydraulic Radius	1.5

Figure B2-10. Cross section 3 and 4 downstream view.

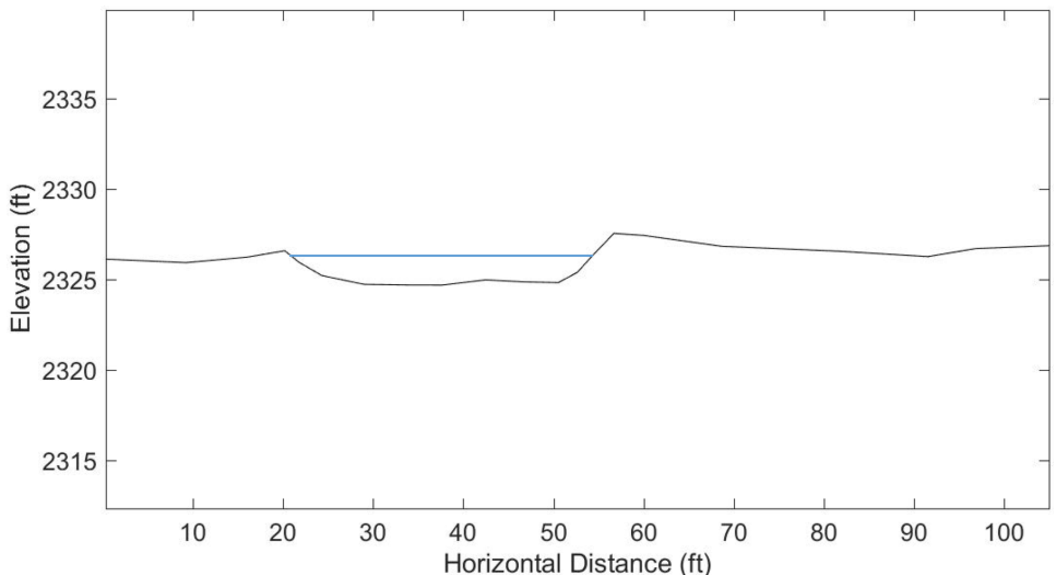


Figure B2-11. Cross section 4 pool on LC1. The blue line represents bankfull.

Table B2-6. Metrics for cross section 4 on LC1.	
Bankfull Width (ft)	30.3
Mean Depth (ft)	0.8
Max Depth (ft)	1.0
Bankfull Area (ft^2)	23.3
Width/Depth Ratio	39.3
Hydraulic Radius	0.8

GRAIN SIZE DATA

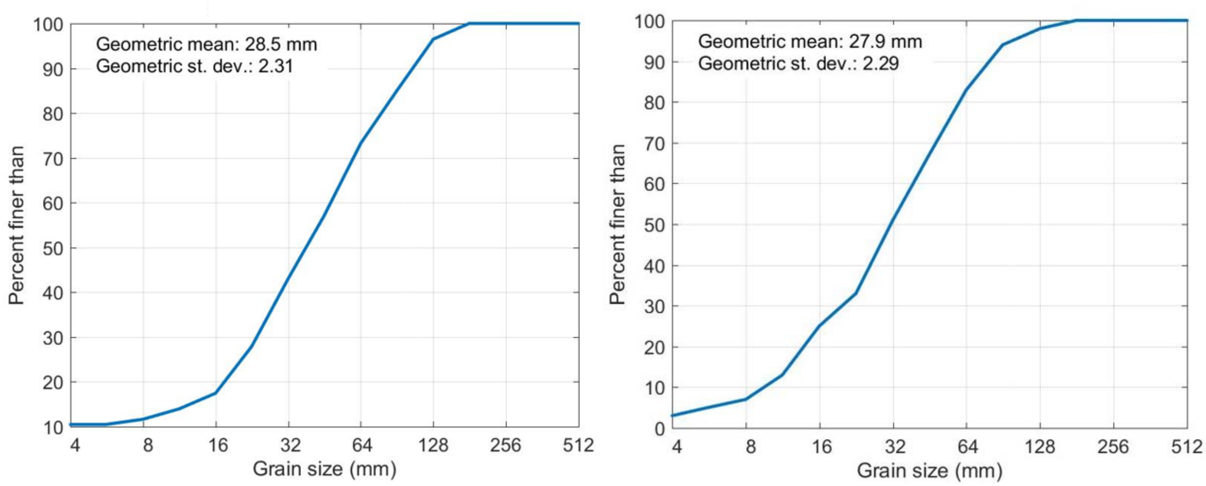


Figure B2-12. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for LC1.

Table B2-7. LC1 pebble count results.

Percentile	Riffle (mm)	Pool (mm)
16	14.1	12.5
35	27.0	23.6
50	38.5	31.5
65	54.4	43.4
84	88.0	66.4
95	123.1	99.5

LARGE WOOD SURVEY

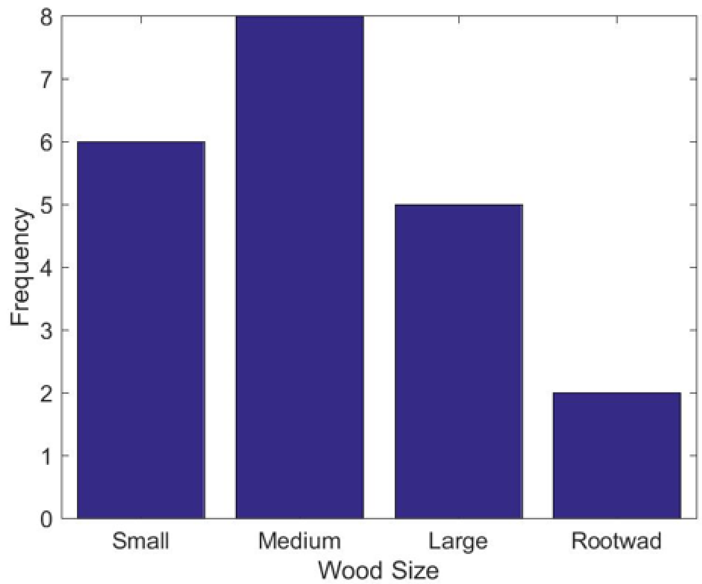


Figure B2-13. Results from large wood survey.

WOLF LODGE CREEK

REACH DATA – REACH WLC1

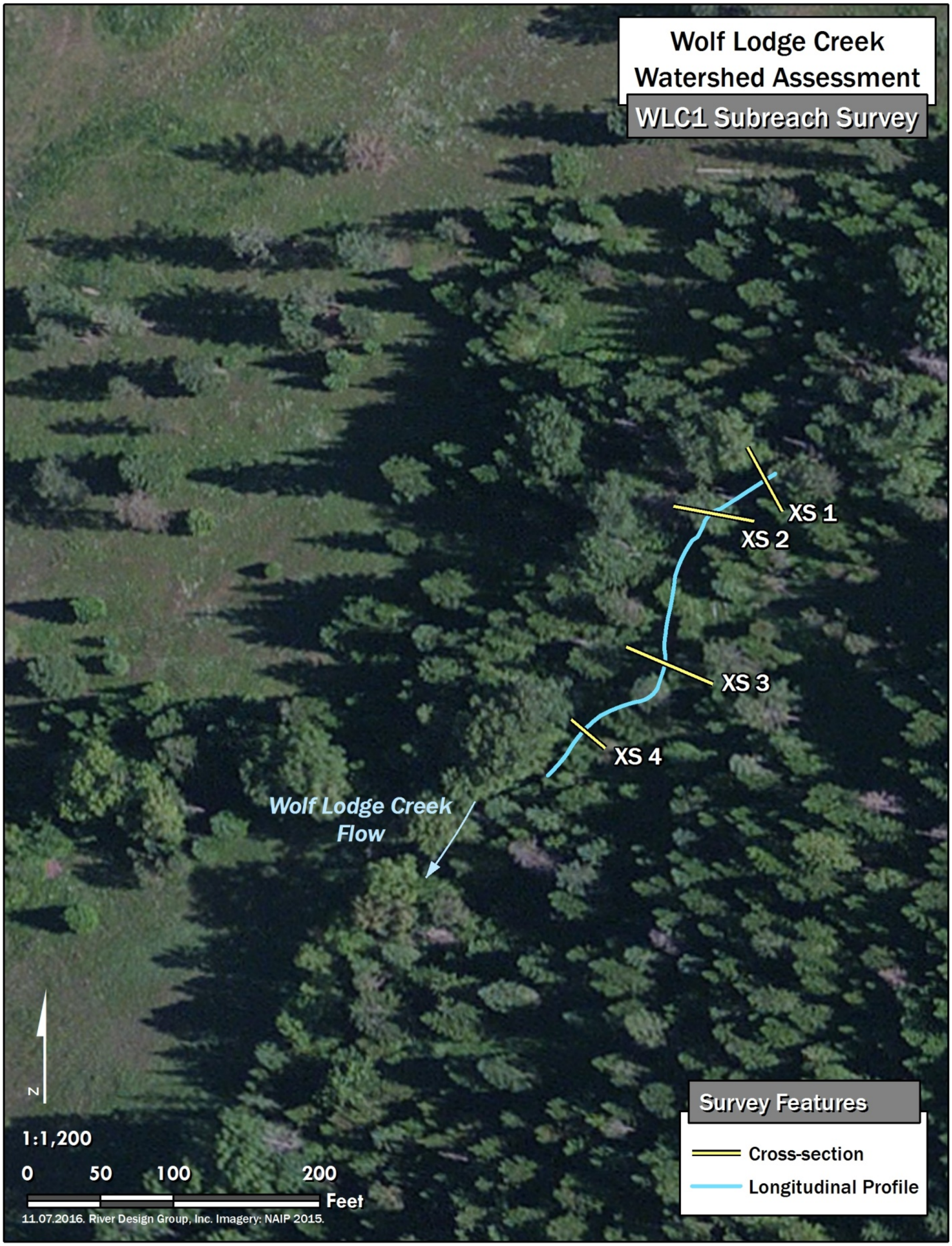


Figure B3-1. Subreach overview map with survey data from geomorphic assessment for WLC1.

LONGITUDINAL PROFILE

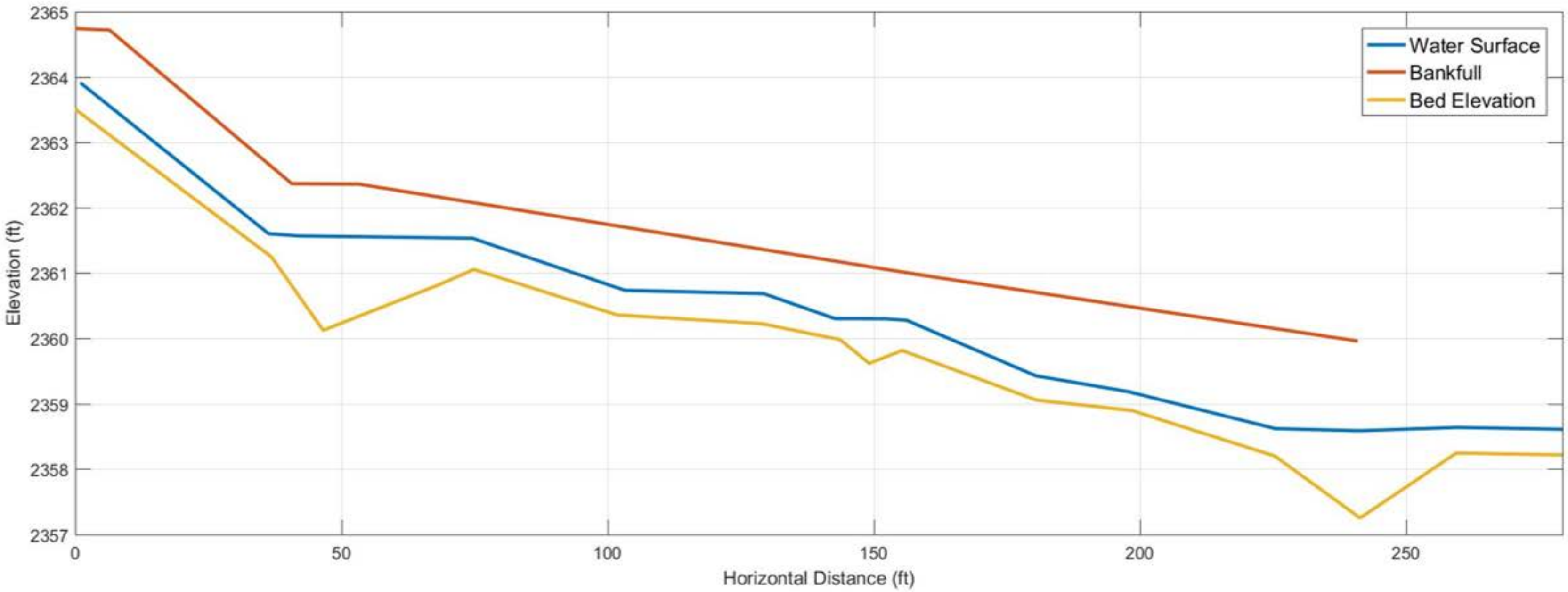


Figure B3-2. Longitudinal profile of WLC1.

Table B3-1. Profile dimensions for WLC1.	
Bed Slope	-0.017
Water Slope	-0.017
Bankfull Slope	-0.019
Sinuosity	1.10

CROSS SECTION DATA


Figure B3-3. Large wood in channel in upstream section (left). Long riffle-run sequence downstream view (right).

Table B3-2. Overview of cross section dimensions for WLC1.			
Metric	**Min**	**Mean**	**Max**
Depth max Riffle (ft)	1.3	1.6	1.8
Depth max Pool (ft)	2.0	2.2	2.4
Riffle Area (ft^2)	18.7	20.2	21.7
Pool Area (ft^2)	20.9	22.3	23.7
Riffle Width (ft)	19.3	20.2	21.0
Pool Width (ft)	15.5	16.2	16.9

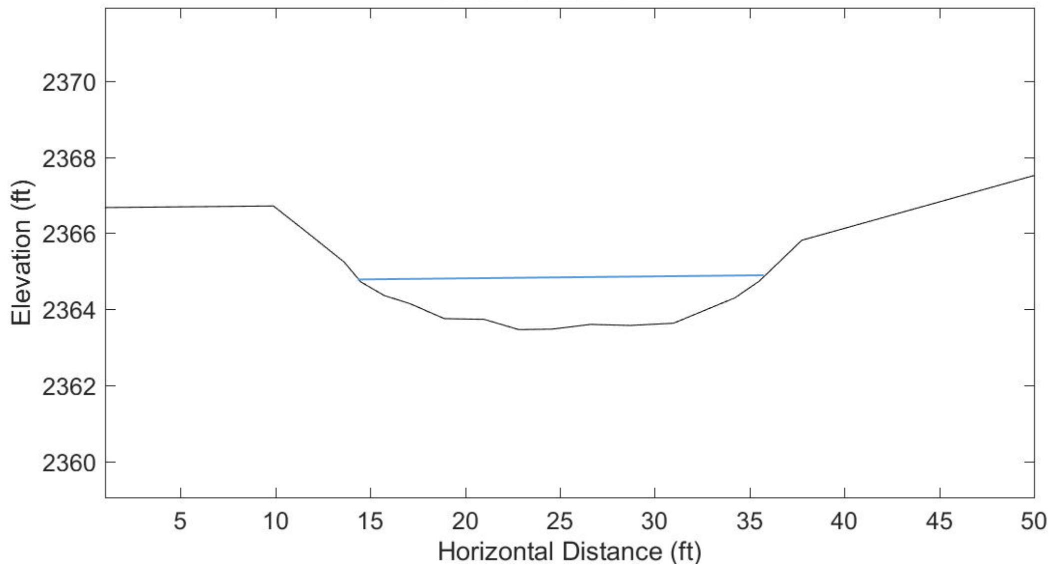


Figure B3-4. Cross section 1 riffle on WLC1. The blue line represents bankfull.

Table B3-3. Metrics for cross section 1 on WLC1.	
Bankfull Width (ft)	21
Mean Depth (ft)	0.9
Max Depth (ft)	1.3
Bankfull Area (ft^2)	18.7
Width/Depth Ratio	23.4
Hydraulic Radius	0.9

Figure B3-5. Right bank of cross section 1 (left) & left bank of cross section 1 (right).

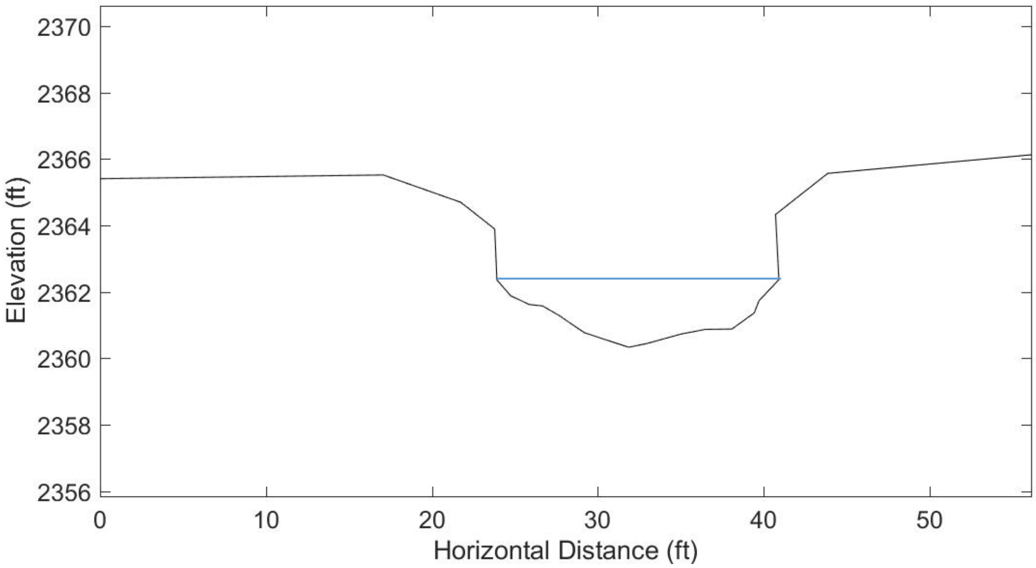


Figure B3-6. Cross section 2 pool on WLC1. The blue line represents bankfull.

Table B3-4. Metrics for cross section 2 on WLC1.	
Bankfull Width (ft)	16.9
Mean Depth (ft)	1.4
Max Depth (ft)	2.0
Bankfull Area (ft^2)	20.9
Width/Depth Ratio	12.3
Hydraulic Radius	1.0

Figure B3-7. Downstream view (left) & upstream view (right) of cross section 2.

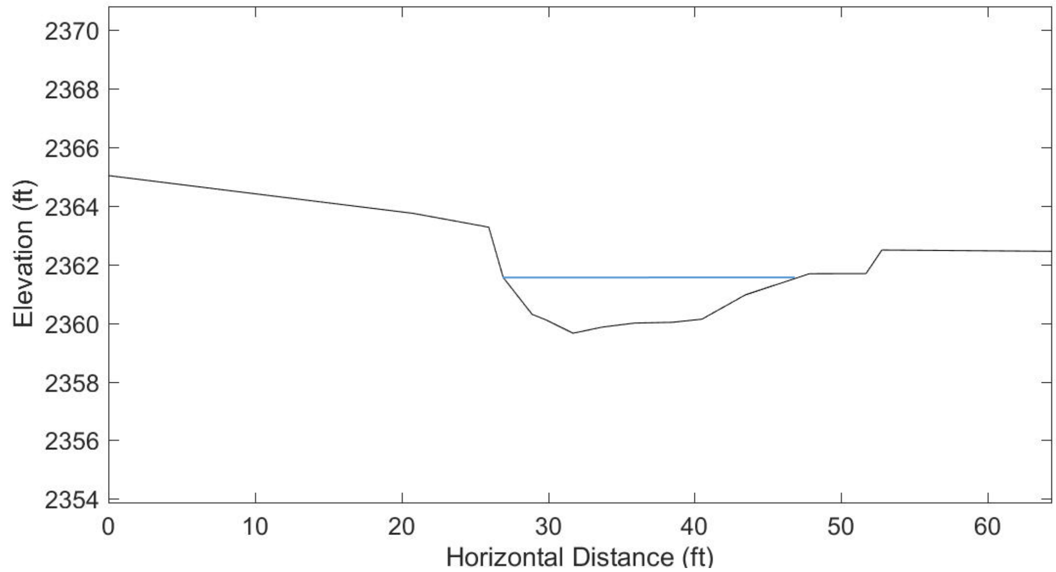


Figure B3-8. Cross section 3 on WLC1. The blue line represents bankfull.

Table B3-5. Metrics for cross section 3 on WLC1.	
Bankfull Width (ft)	19.3
Mean Depth (ft)	1.1
Max Depth (ft)	1.8
Bankfull Area (ft^2)	21.7
Width/Depth Ratio	17.1
Hydraulic Radius	1.1

Figure B3-9. Cross section 3 downstream (left) & upstream (right) riffle.

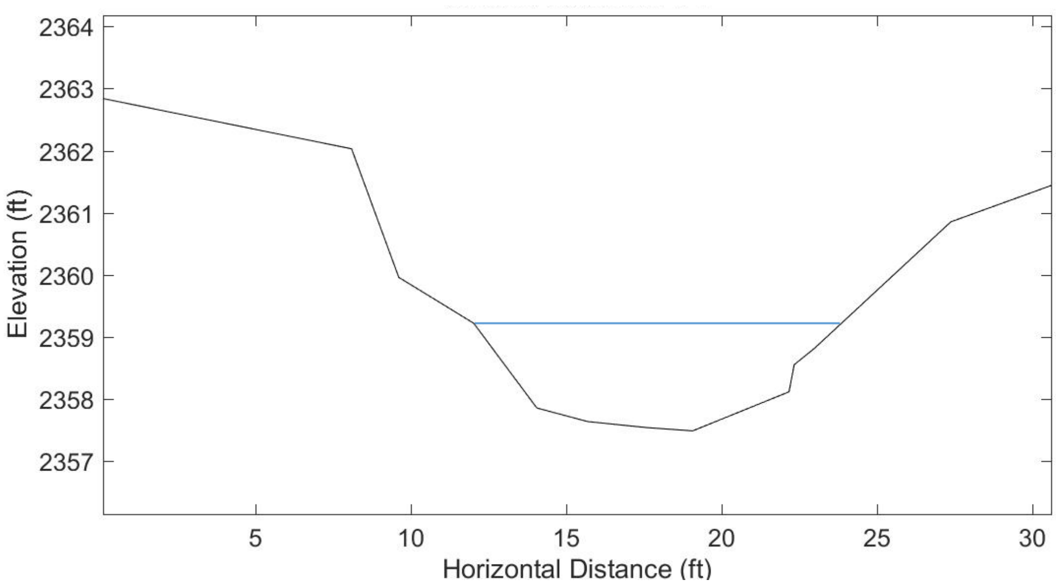


Figure B3-10. Cross section 4 on WLC1. The blue line represents bankfull.

Table B3-6. Metrics for cross section 4 on WLC1.	
Bankfull Width (ft)	15.5
Mean Depth (ft)	1.5
Max Depth (ft)	2.4
Bankfull Area (ft^2)	23.7
Width/Depth Ratio	10.1
Hydraulic Radius	1.4

Figure B3-11. Cross section 4 downstream pool.

GRAIN SIZE DATA

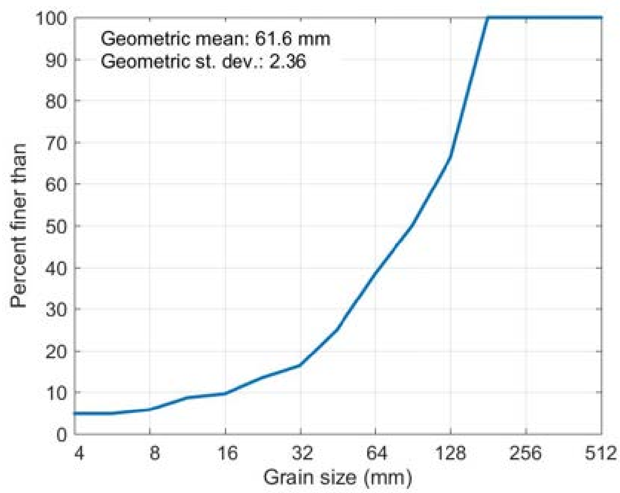


Figure B3-12. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for WLC1.

Table B3-7. WLC1 pebble count results.		
Percentile	**Riffle (mm)**	**Pool (mm)**
16	30.9	10.9
35	59.1	41.2
50	90.0	62.6
65	124.9	85.1
84	155.3	118.3
95	172.3	155.4

LARGE WOOD SURVEY

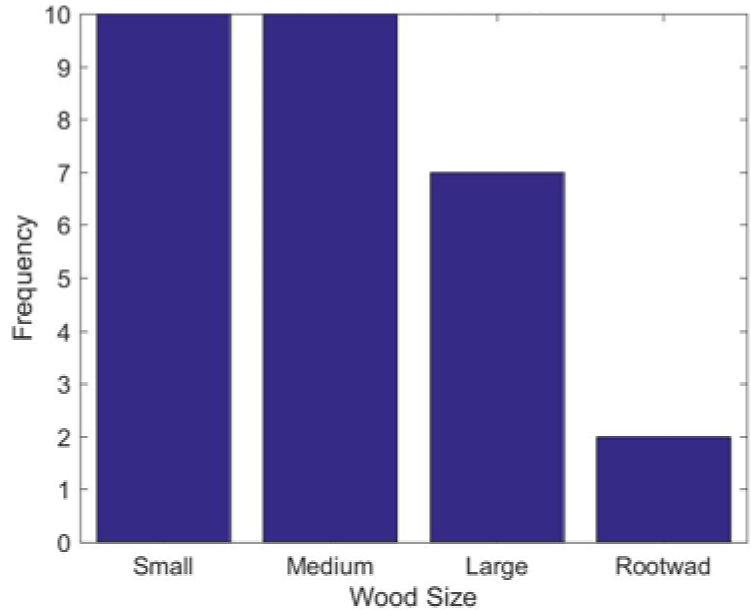


Figure B3-13. Results from large wood survey**.**

WOLF LODGE CREEK

REACH DATA – REACH WLC2

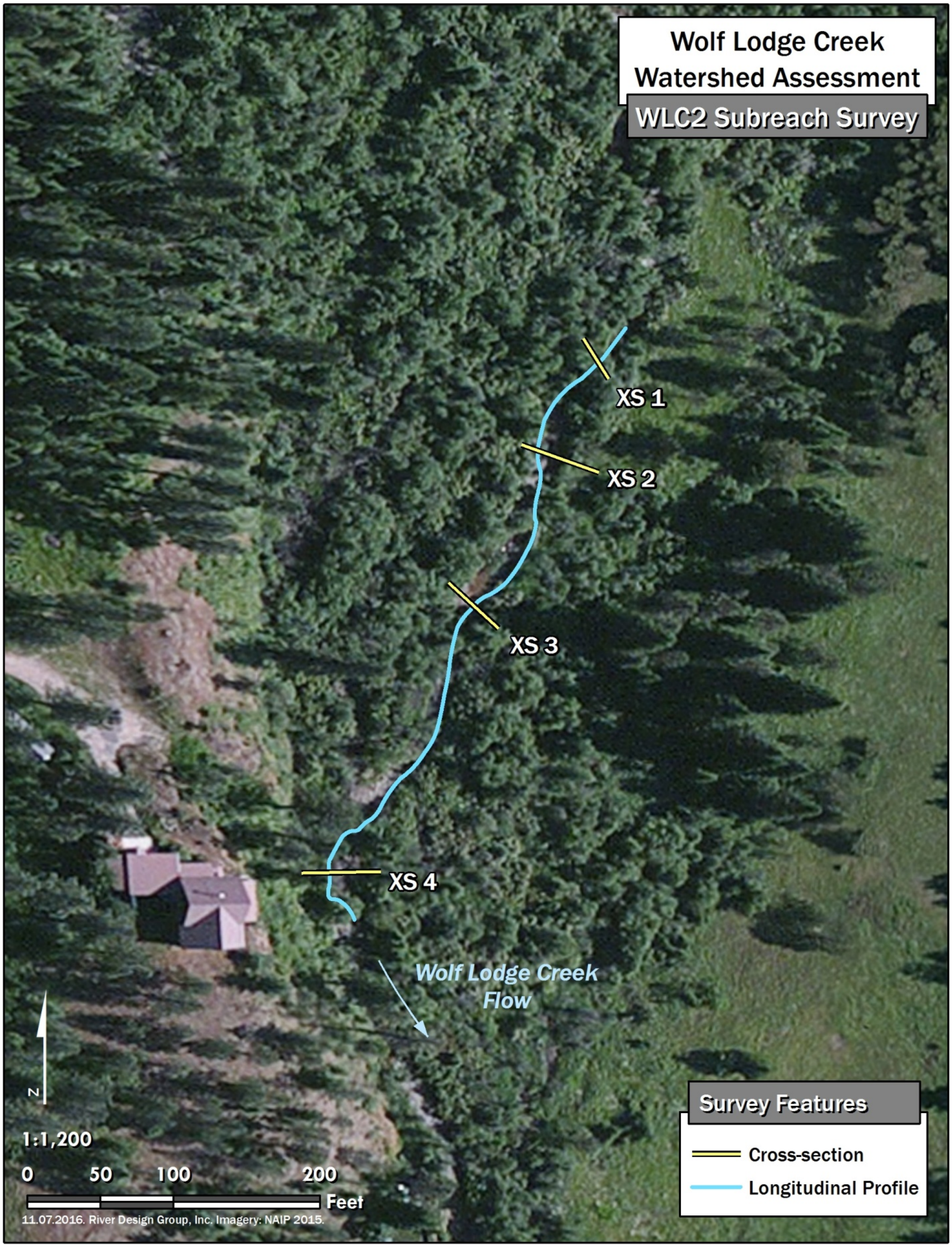


Figure B4-1. Subreach overview map with survey data from geomorphic assessment for WLC2.

LONGITUDINAL PROFILE

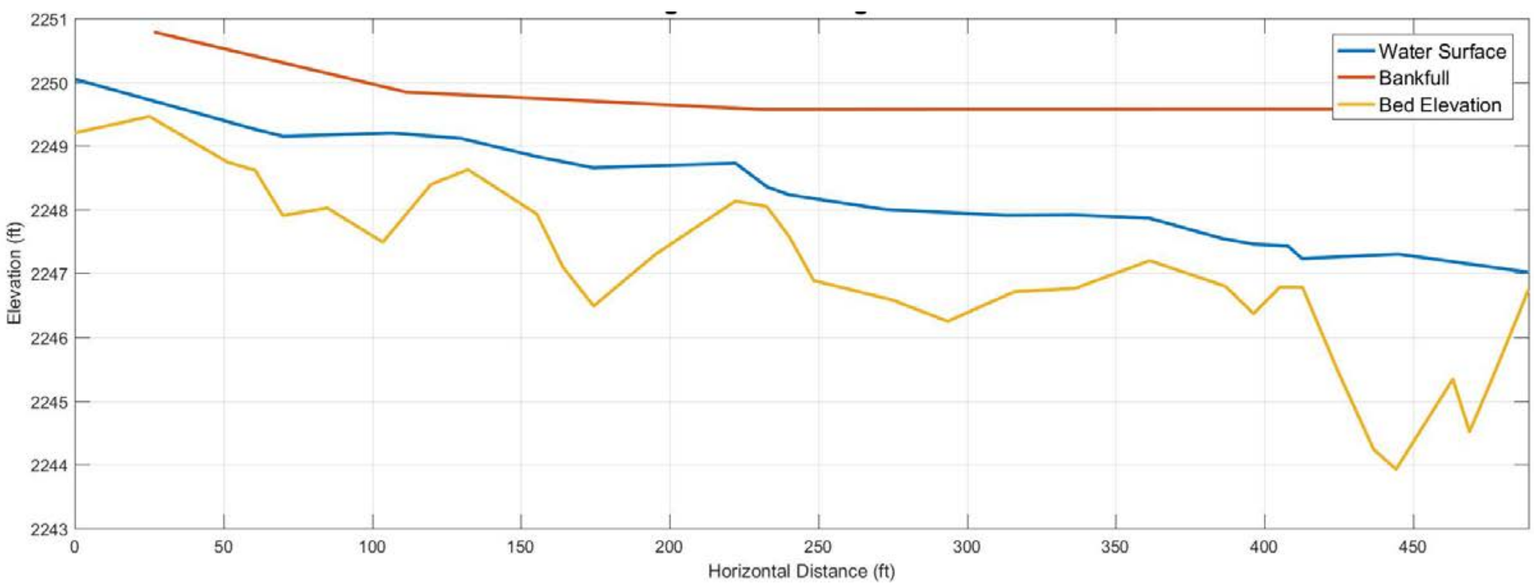


Figure B4-2. Longitudinal profile of WLC2.

Table B4-1. Profile dimensions for WLC2.	
Bed Slope	-0.008
Water Slope	-0.006
Bankfull Slope	-0.003
Sinuosity	1.10

CROSS SECTION DATA

Figure B4-3. Typical riffle in WLC2 (left). Higher bank covered with reed canary grass (right).

Table B4-2. Overview of cross section dimensions for WLC2.

Metric	Min	Mean	Max
Depth max Riffle (ft)	1.4	1.7	1.9
Depth max Pool (ft)	3.1	4.4	5.6
Riffle Area (ft^2)	28.7	29.8	30.9
Pool Area (ft^2)	59.2	85.4	111.6
Riffle Width (ft)	23.5	23.9	24.2
Pool Width (ft)	31.2	36.7	42.2

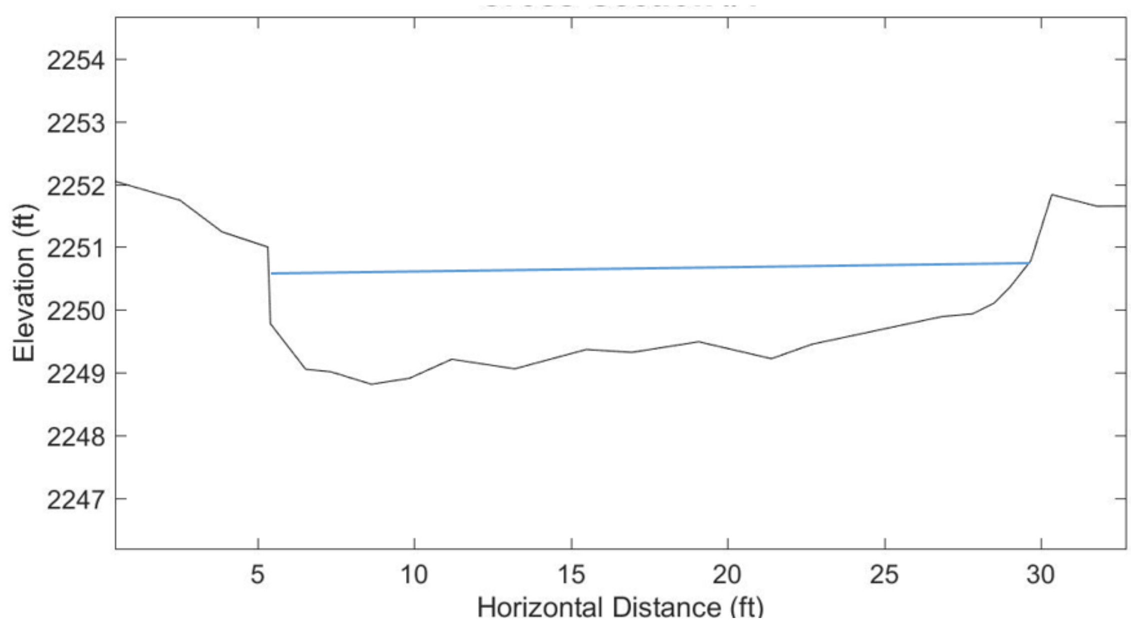


Figure B4-4. Cross section 1 on WLC 2. The blue line represents bankfull.

Table B4-3. Metrics for cross section 1 on WLC2.	
Bankfull Width (ft)	24.2
Mean Depth (ft)	1.3
Max Depth (ft)	1.9
Bankfull Area (ft^2)	30.9
Width/Depth Ratio	18.9
Hydraulic Radius	1.2

Figure B4-5. Cross section 1 riffle with thick alder (left) and upstream (right).

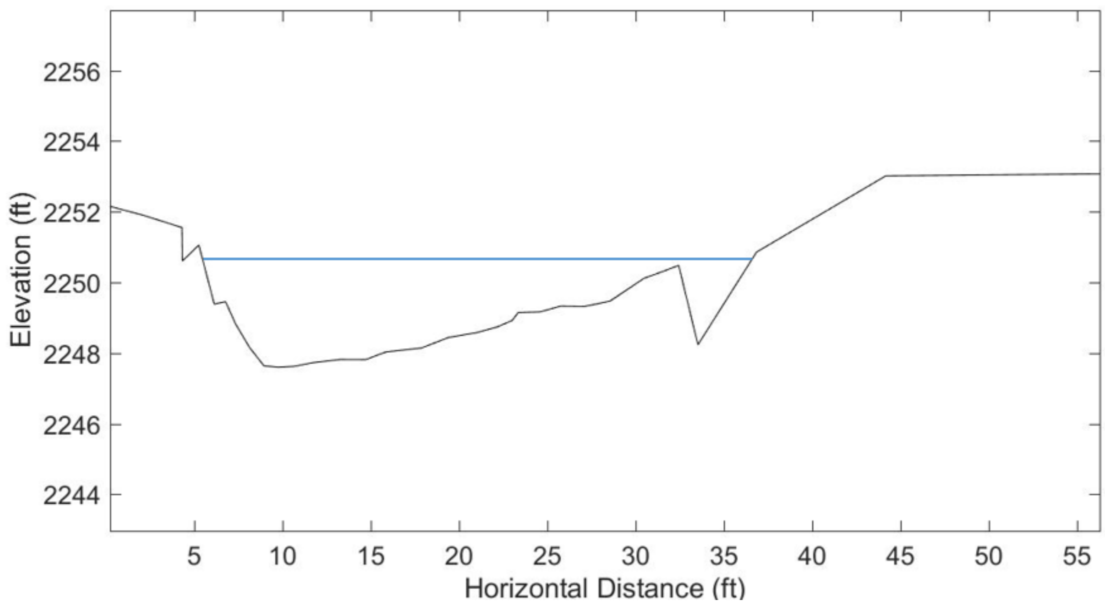


Figure B4-6. Cross section 2 on WLC 2. The blue line represents bankfull.

Table B4-4. Metrics for cross section 2 on WLC 2.	
Bankfull Width (ft)	31.2
Mean Depth (ft)	1.9
Max Depth (ft)	3.1
Bankfull Area (ft^2)	59.2
Width/Depth Ratio	16.4
Hydraulic Radius	1.7

Figure B4-7. Cross section 2 pool upstream view.

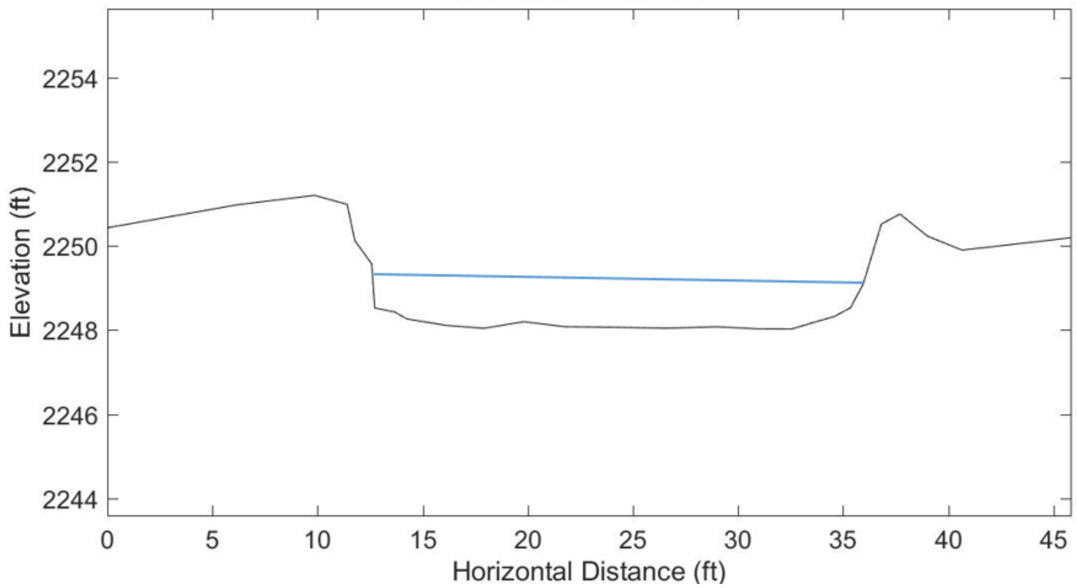


Figure B4-8. Cross section 3 on WLC 2. The blue line represents bankfull.

Table B4-5. Metrics for cross section 3 on WLC 2.	
Bankfull Width (ft)	23.5
Mean Depth (ft)	1.2
Max Depth (ft)	1.4
Bankfull Area (ft^2)	28.7
Width/Depth Ratio	19.2
Hydraulic Radius	1.2

Figure B4-9. Cross section 3 riffle downstream view with overhanging alder.

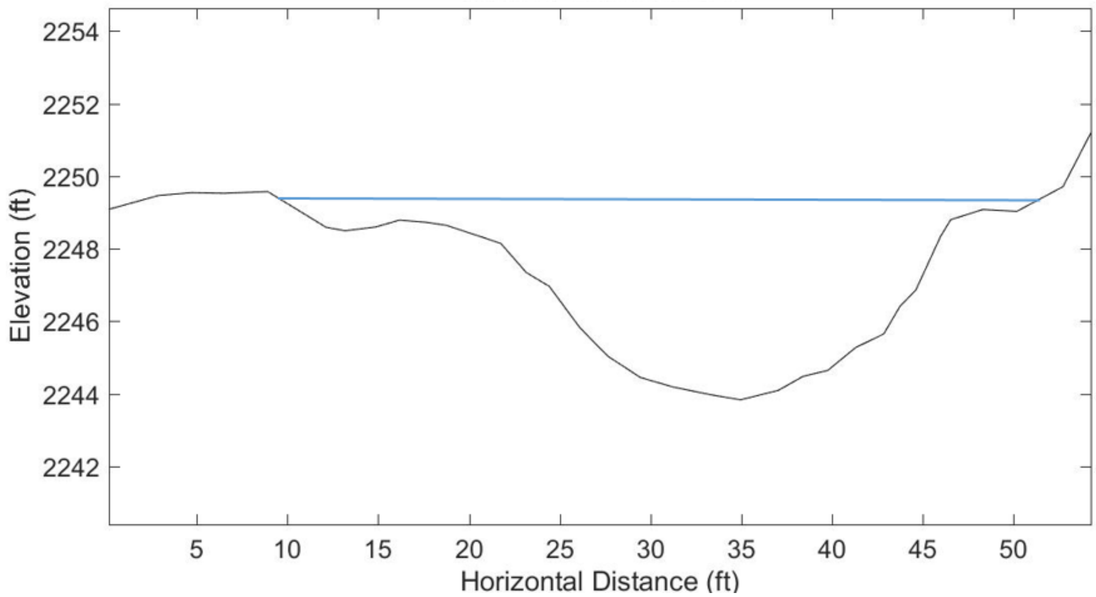


Figure B4-10. Cross section 4 on WLC2. The blue line represents bankfull.

Table B4-6. Metrics for cross section 4 on WLC2.	
Bankfull Width (ft)	42.2
Mean Depth (ft)	2.7
Max Depth (ft)	5.6
Bankfull Area (ft^2)	111.6
Width/Depth Ratio	15.9
Hydraulic Radius	2.5

Figure B4-11. Cross section 4 pool of deepest portion of sub-reach.

GRAIN SIZE DATA

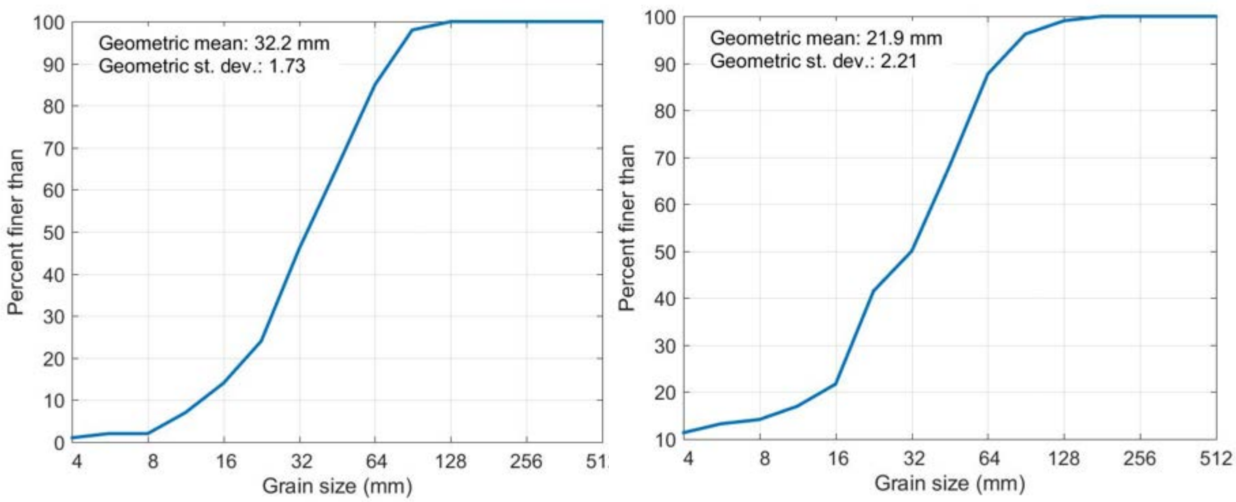


Figure B4-12. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for WLC2.

Table B4-7. WLC2 pebble count results.

Percentile	Riffle (mm)	Pool (mm)
16	17.3	10.2
35	27.3	20.4
50	34.7	32
65	45.0	42.9
84	63.0	60.4
95	84.0	86.2

LARGE WOOD SURVEY

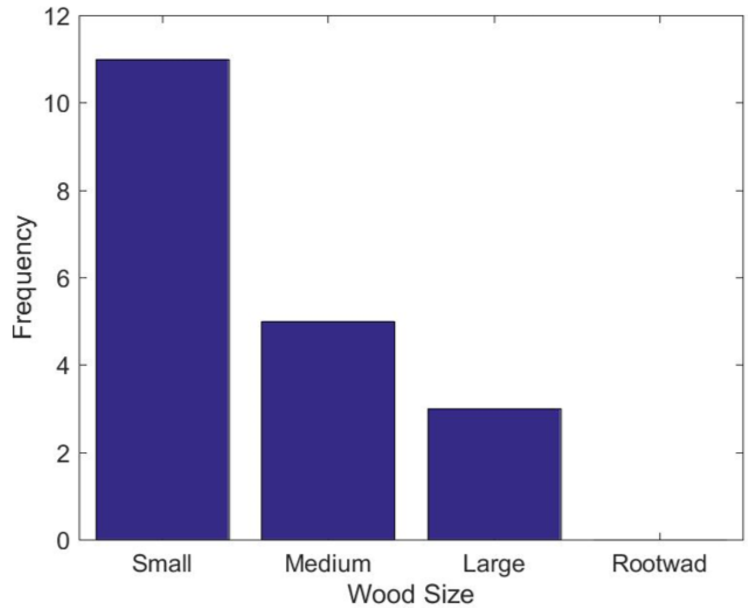


Figure B4-13. Results from large wood survey.

WOLF LODGE CREEK

REACH DATA – REACH WLC3

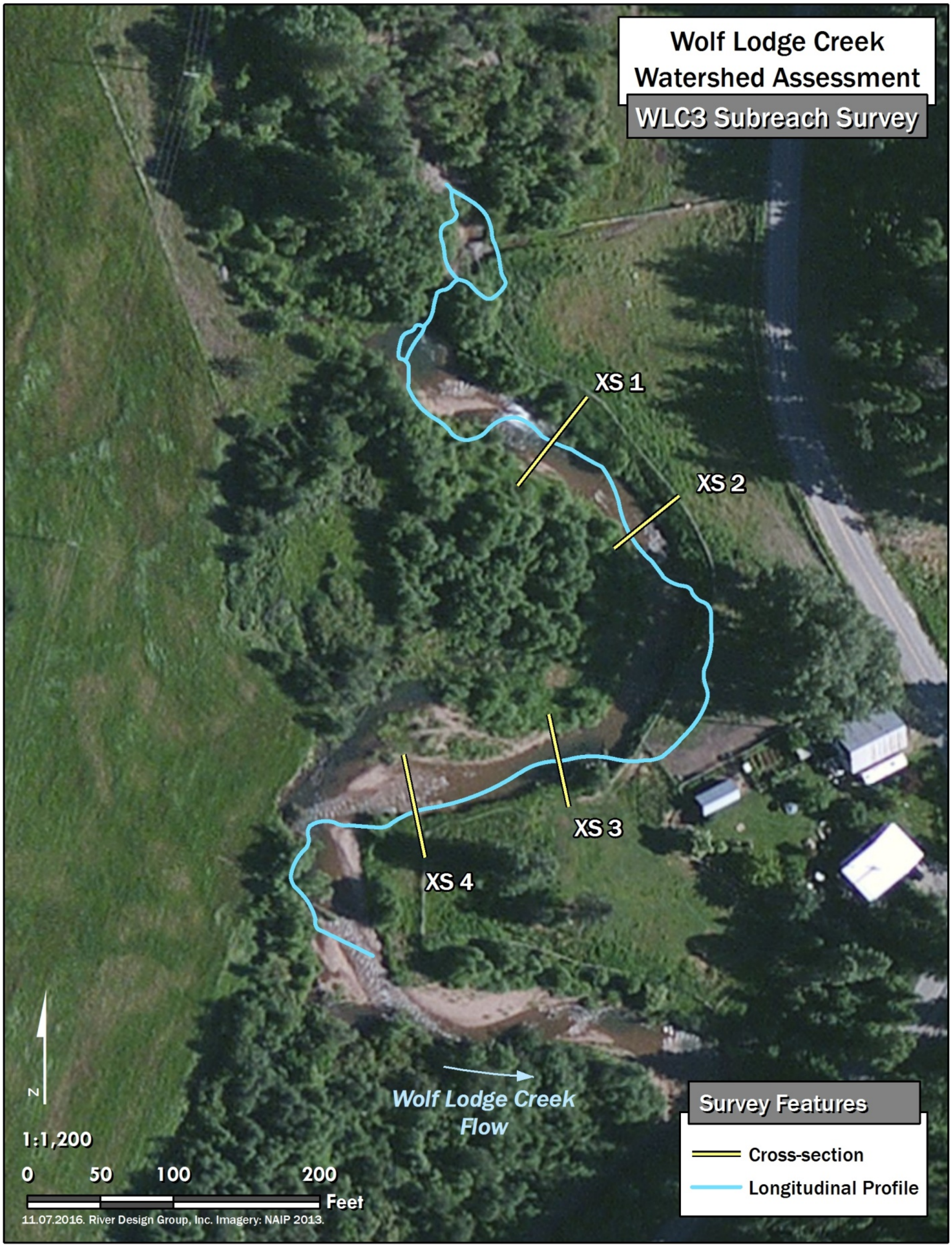


Figure B5-1. Subreach overview map with survey data from geomorphic assessment for WLC3.

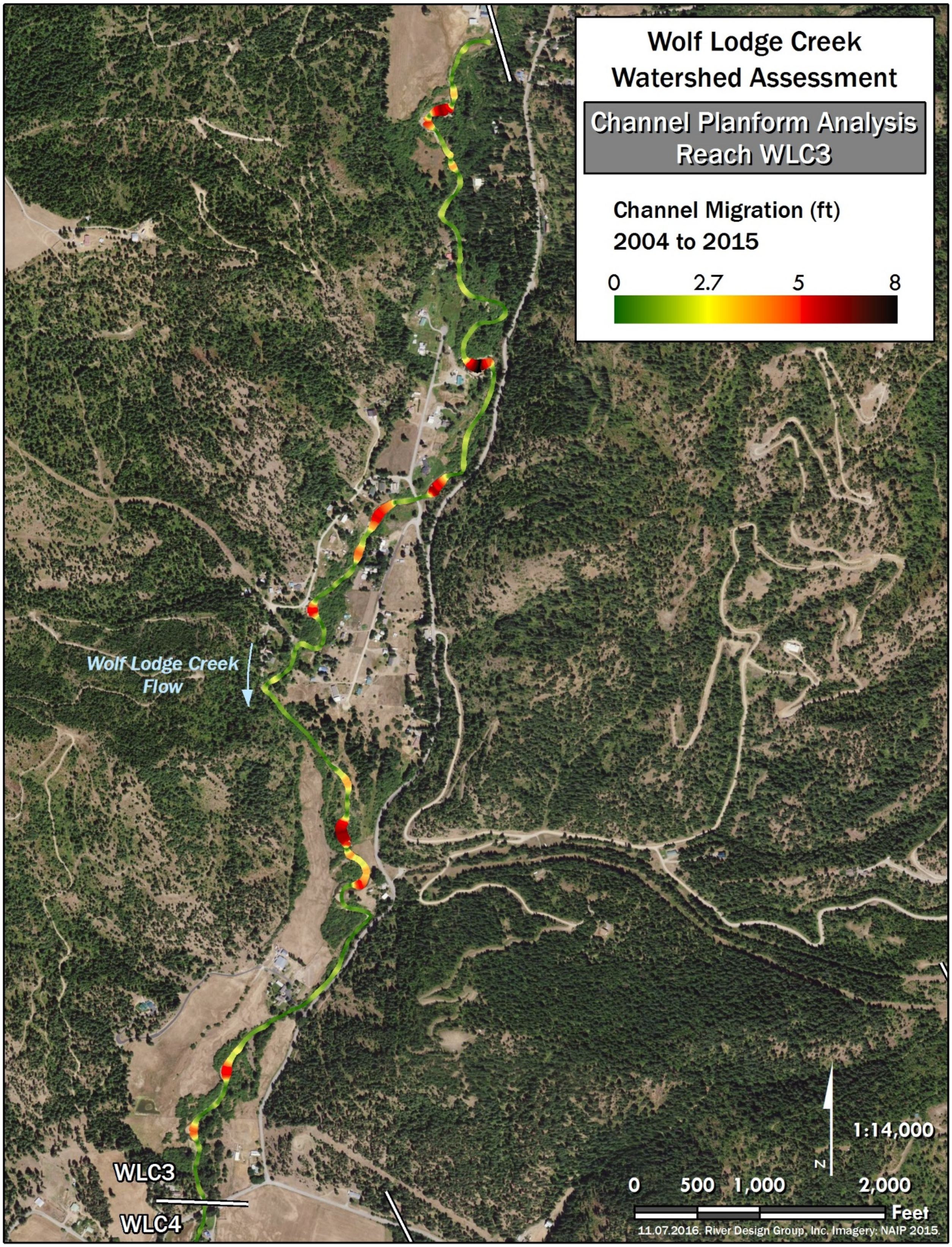


Figure B5-2. Historical channel planform analysis that quantifies migration rates for 2004-2015.

LONGITUDINAL PROFILE

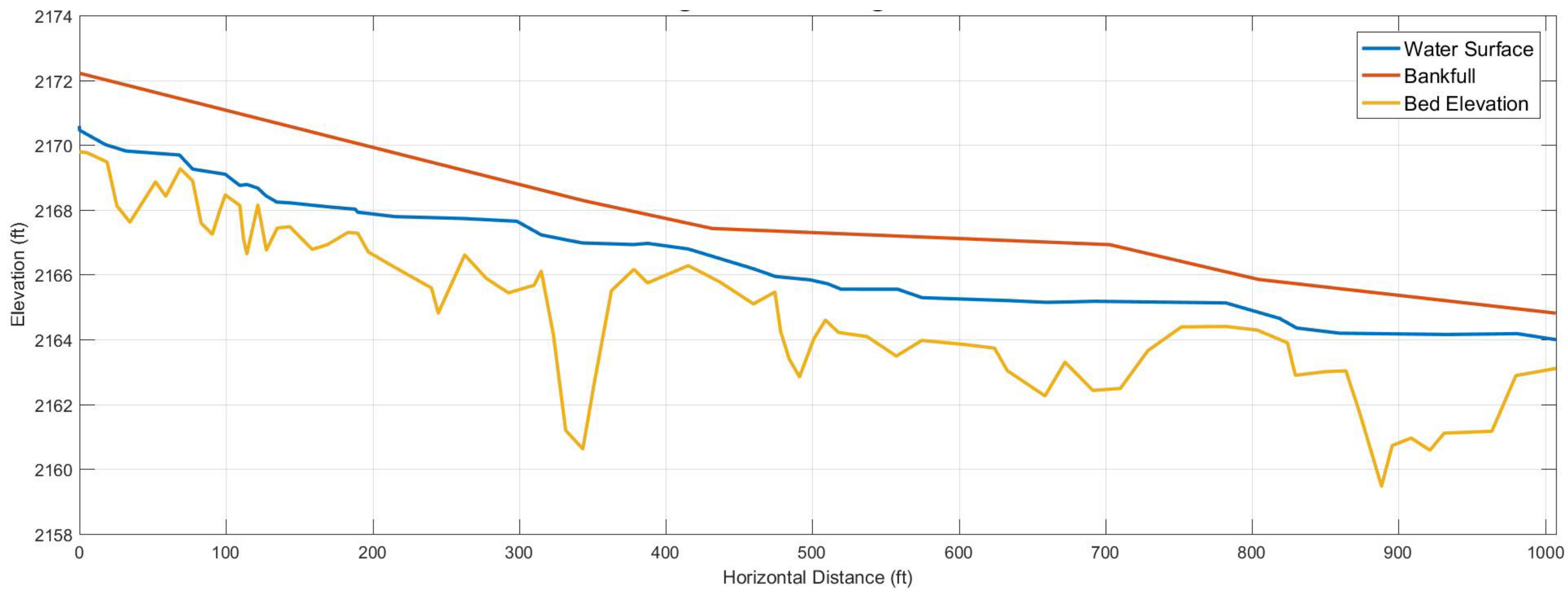


Figure B5-3. Longitudinal profile of WLC3.

Table B5-1. Profile dimensions for WLC3.	
Bed Slope	-0.007
Water Slope	-0.006
Bankfull Slope	-0.007
Sinuosity	1.90

CROSS SECTION DATA

Figure B5-4. Extremely erodible meander bend (left). Upstream end of sub-reach failed beaver dam (right).

Table B5-2. Overview of cross section dimensions for WLC3.			
Metric	**Min**	**Mean**	**Max**
Depth max Riffle (ft)	1.5	1.9	2.2
Depth max Pool (ft)	3.5	4.6	5.7
Riffle Area (ft^2)	34.0	39.3	44.6
Pool Area (ft^2)	64.0	109.4	154.7
Riffle Width (ft)	32.0	35.0	38.0
Pool Width (ft)	33.7	41.1	48.4

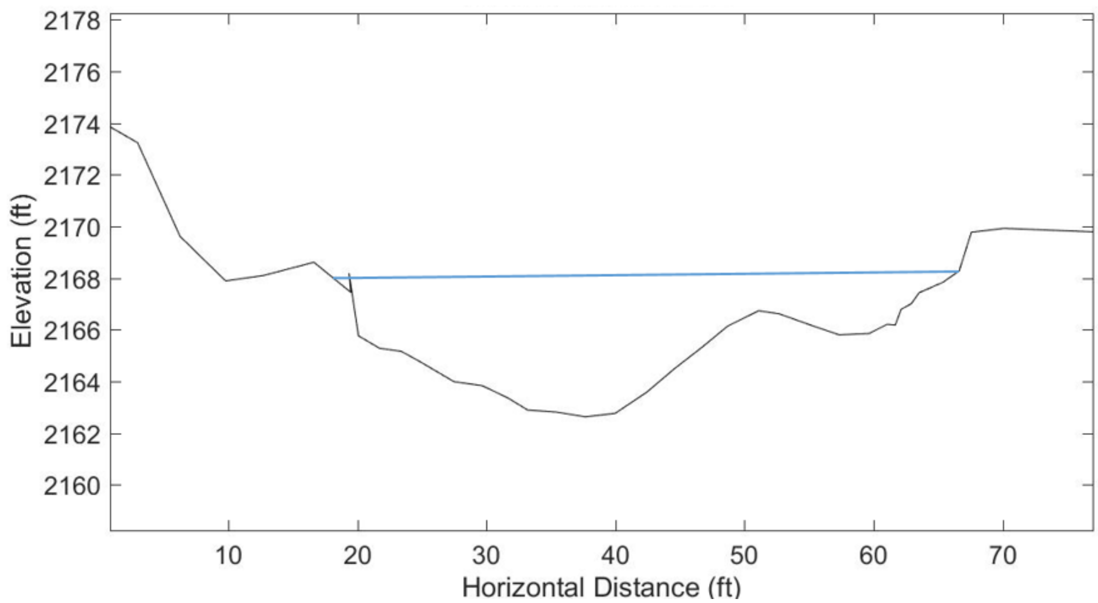


Figure B5-5. Cross section 1 on WLC3. The blue line represents bankfull.

Table B5-3. Metrics for cross section 1 on WLC3.	
Bankfull Width (ft)	48.4
Mean Depth (ft)	3.3
Max Depth (ft)	5.7
Bankfull Area (ft^2)	154.7
Width/Depth Ratio	14.8
Hydraulic Radius	3.0

Figure B5-6. Cross section 1 pool upstream view from rock vein (left). Cross section 1 pool downstream view of rock vein (right).

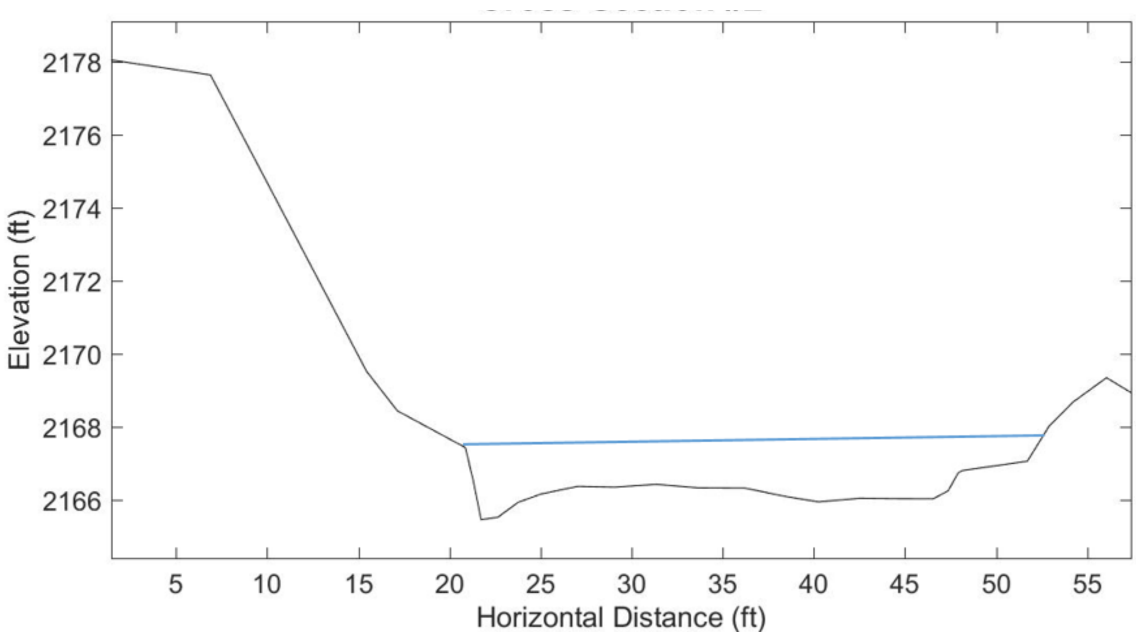


Figure B5-7. Cross section 2 on WLC3. The blue line represents bankfull.

Table B5-4. Metrics for cross section 2 on WLC3.	
Bankfull Width (ft)	32
Mean Depth (ft)	1.4
Max Depth (ft)	2.2
Bankfull Area (ft^2)	44.6
Width/Depth Ratio	22.6
Hydraulic Radius	1.3

Figure B5-8. Cross section 2 riffle downstream view.

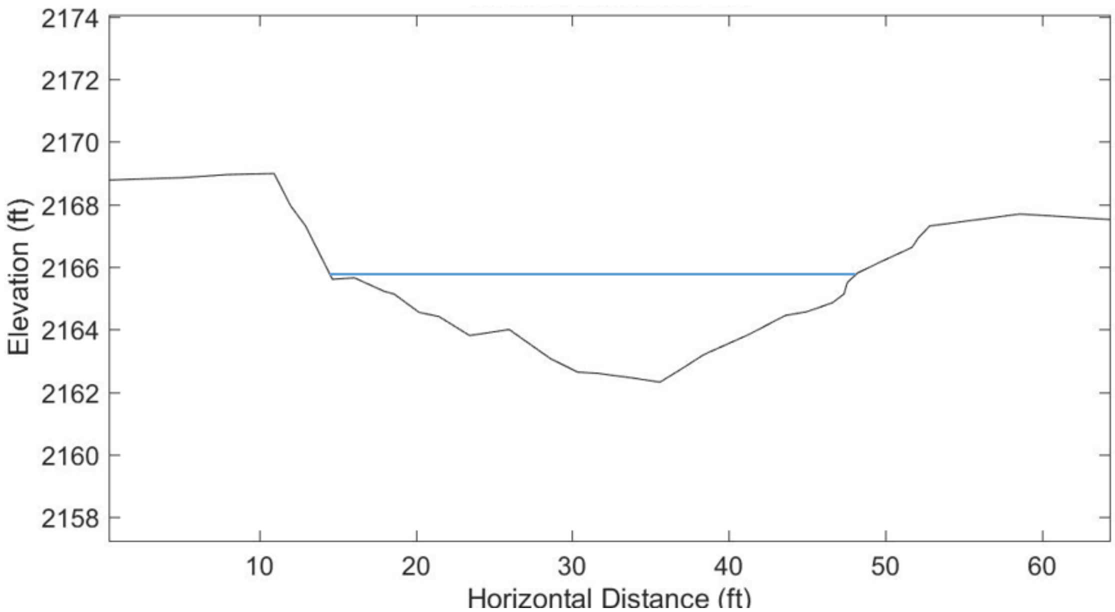


Figure B5-9. Cross section 3 on WLC3. The blue line represents bankfull.

Table B5-5. Metrics for cross section 3 on WLC3.	
Bankfull Width (ft)	33.7
Mean Depth (ft)	1.9
Max Depth (ft)	3.5
Bankfull Area (ft^2)	64.0
Width/Depth Ratio	17.7
Hydraulic Radius	1.8

Figure B5-10. Cross section 3 upstream pool with riprap on left bank.

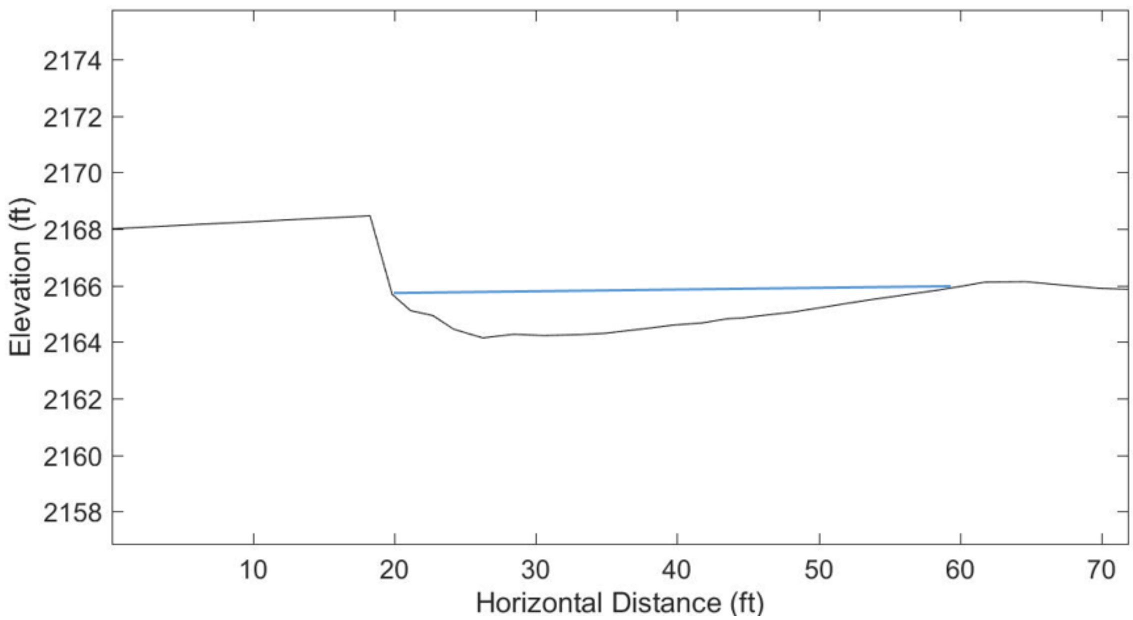


Figure B5-11. Cross section 4 on WLC3. The blue line represents bankfull.

Table B5-6. Metrics for cross section 4 on WLC3.	
Bankfull Width (ft)	38
Mean Depth (ft)	0.9
Max Depth (ft)	1.5
Bankfull Area (sq ft)	34.0
Width/Depth Ratio	40.4
Hydraulic Radius	0.9

Figure B5-12. Cross section 4 riffle view from left bank.

GRAIN SIZE DATA

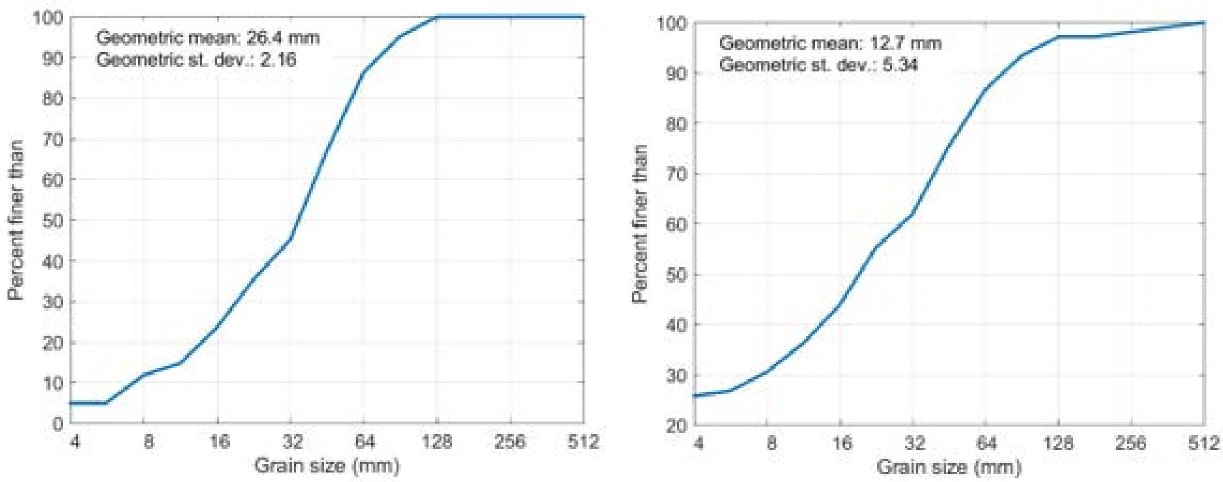


Figure B5-13. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for WLC3.

Table B5-7. WLC3 pebble count results.		
Percentile	**Riffle (mm)**	**Pool (mm)**
16	12.0	NA
35	22.4	10.6
50	35.0	19.6
65	44.0	35
84	61.8	59.6
95	89.7	106.6

LARGE WOOD SURVEY

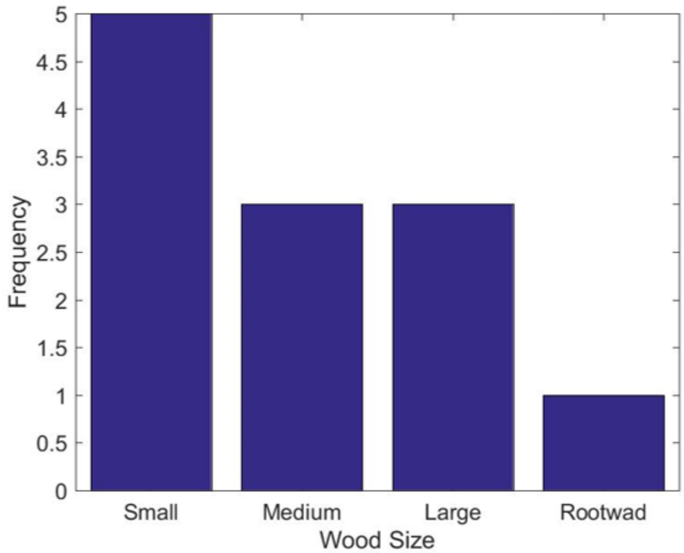


Figure B5-14. Results from large wood survey.

WOLF LODGE CREEK

REACH DATA – REACH WLC4

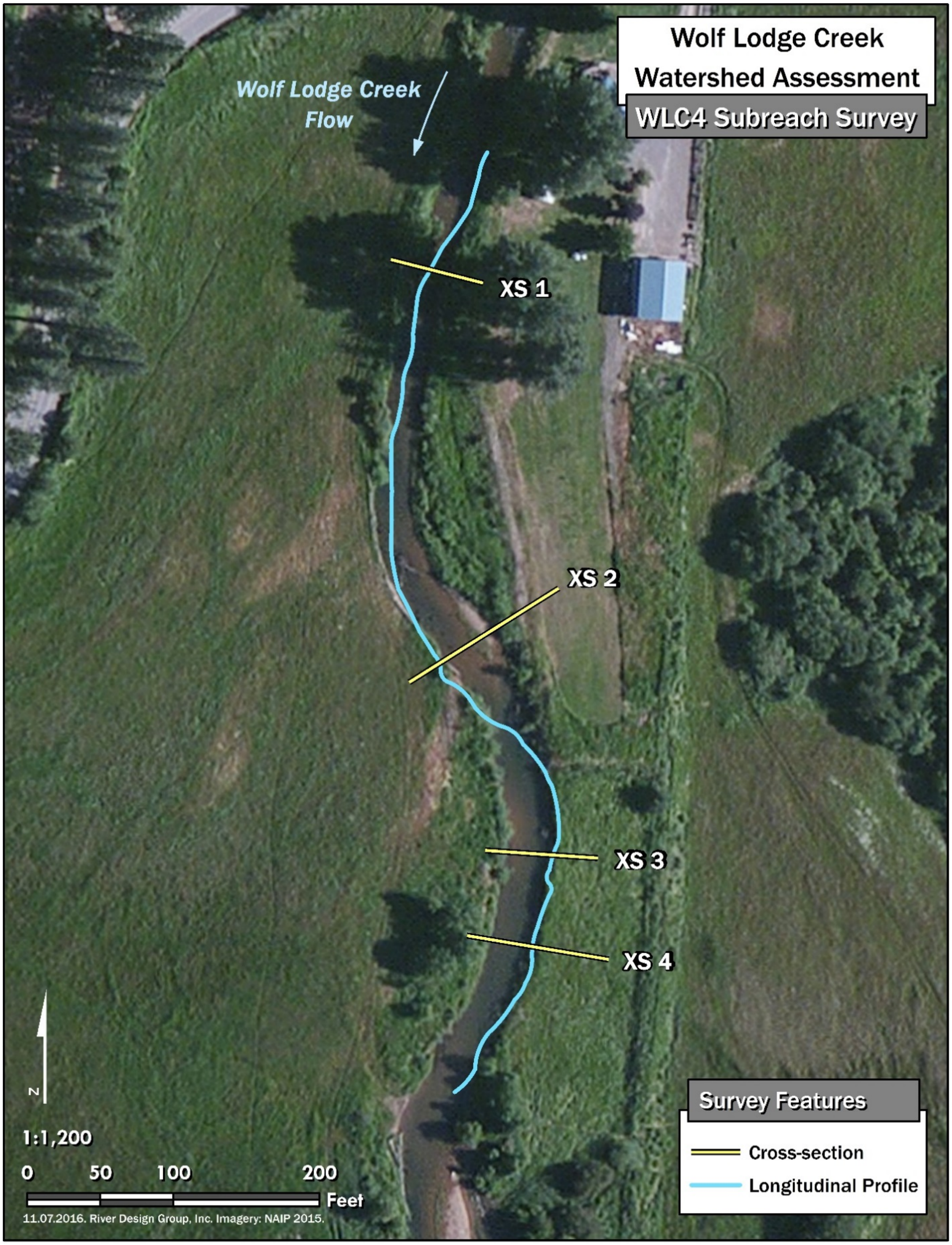


Figure B6-1. Subreach overview map with survey data from geomorphic assessment for WLC4.

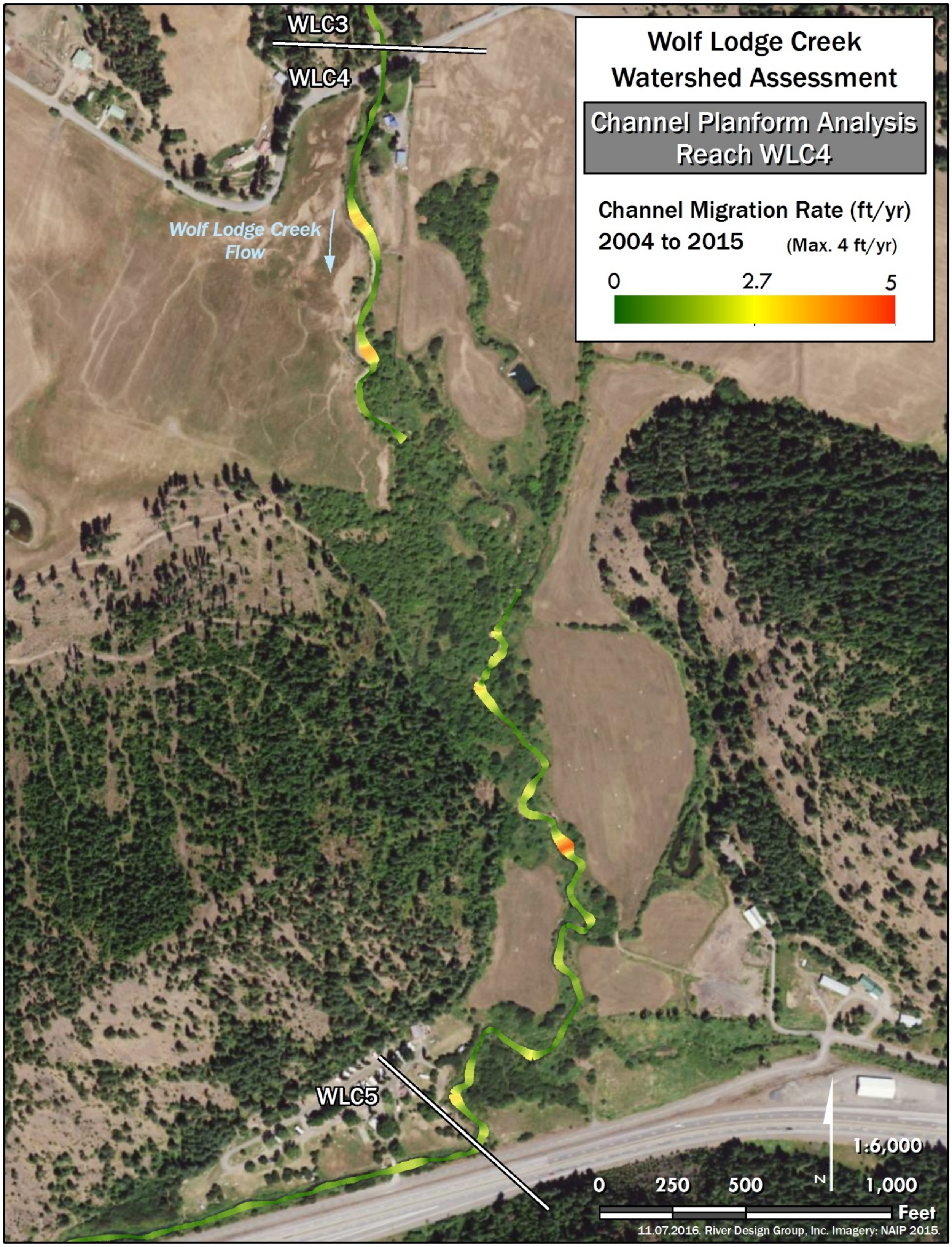


Figure B6-2. Historical channel planform analysis that quantifies migration rates for 2004-2015.

LONGITUDINAL PROFILE

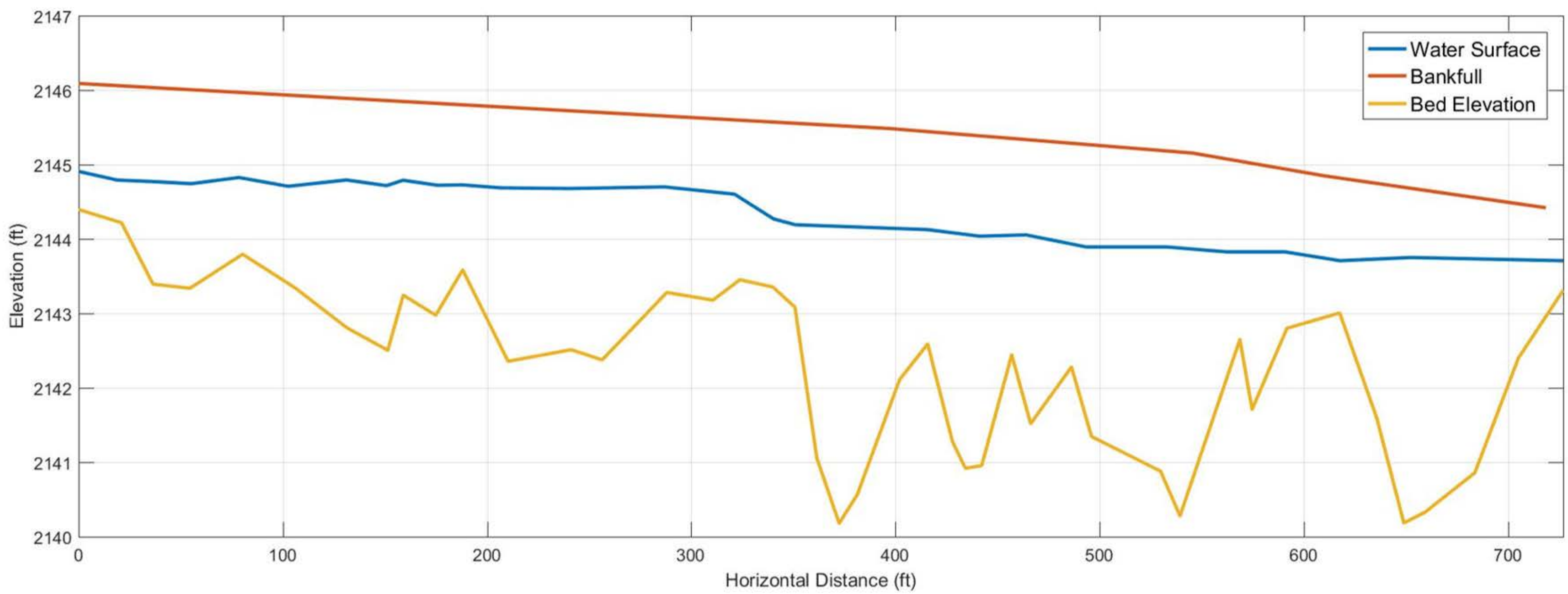


Figure B6-3. Longitudinal profile of WLC4.

Table B6-1. Profile dimensions for WLC4.	
Bed Slope	-0.003
Water Slope	-0.002
Bankfull Slope	-0.002
Sinuosity	1.13

CROSS SECTION DATA


Figure B6-4. Cross section 1 upstream view of sub-reach (left). Large bank blocks indicate large erosion rates (right).

Table B6-2. Overview of cross section dimensions for WLC4.

Metric	Min	Mean	Max
Depth max Riffle (ft)	2.1	2.5	2.9
Depth max Pool (ft)	4.5	5.2	5.9
Riffle Area (ft^2)	44.1	58.1	72.1
Pool Area (ft^2)	67.1	86.3	105.5
Riffle Width (ft)	32.5	33.3	34.1
Pool Width (ft)	29.6	30.6	31.5

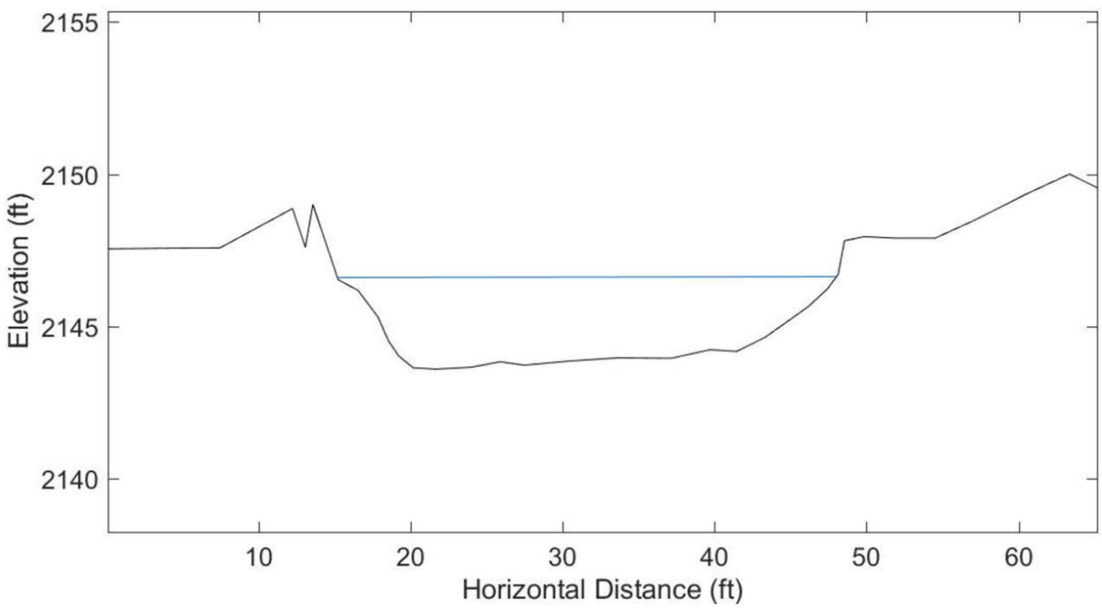


Figure B6-5. Cross section 1 on WLC4. The blue line represents bankfull.

Table B6-3. Metrics for cross section 1 on WLC4.	
Bankfull Width (ft)	32.5
Mean Depth (ft)	2.2
Max Depth (ft)	2.9
Bankfull Area (ft^2)	72.1
Width/Depth Ratio	14.6
Hydraulic Radius	2.1

Figure B6-6. Cross section 1 riffle view from left bank (left) & upstream view (right).

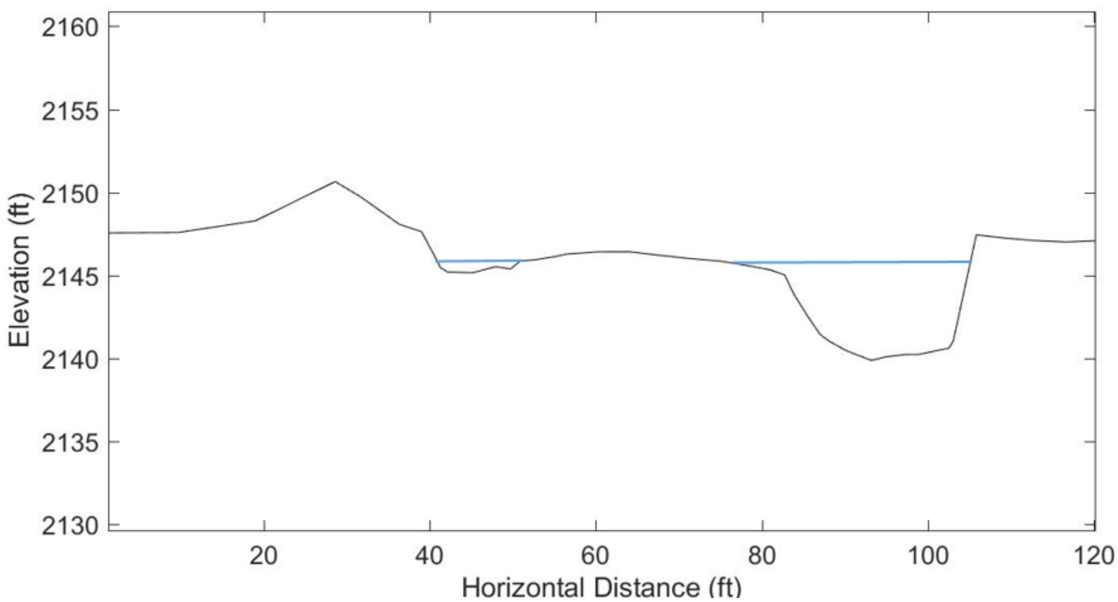


Figure B6-7. Cross section 2 on WLC4. The blue line represents bankfull.

Table B6-4. Metrics for cross section 2 on WLC4.	
Bankfull Width (ft)	31.5
Mean Depth (ft)	2.8
Max Depth (ft)	5.9
Bankfull Area (ft^2)	105.5
Width/Depth Ratio	11.2
Hydraulic Radius	2.9

Figure B6-8. Cross section 2 pool with undercut banks and evidence of dredging.

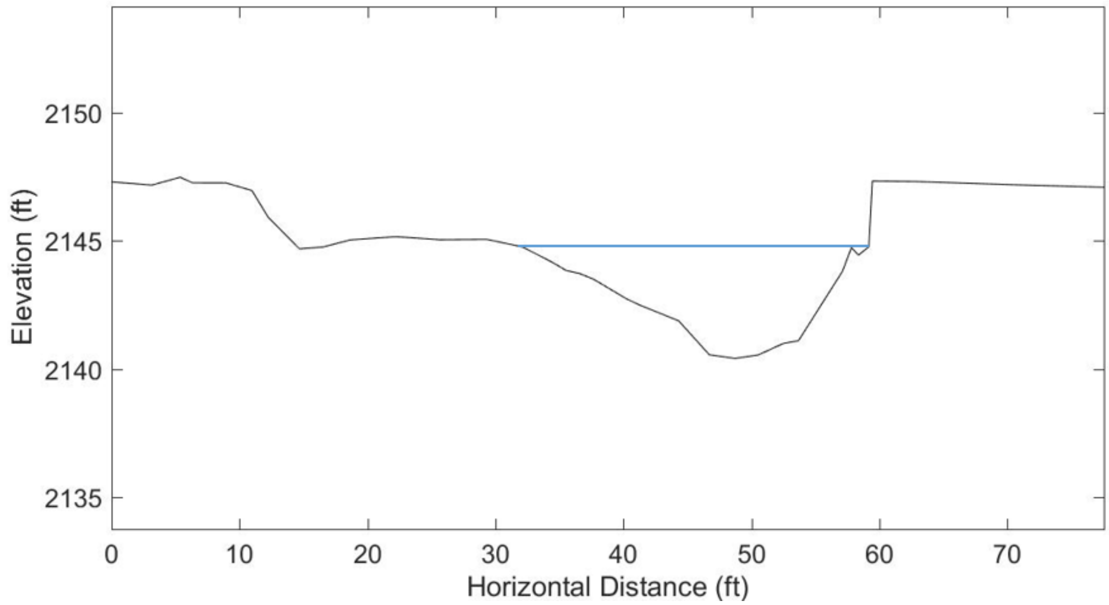


Figure B6-9. Cross section 3 on WLC4. The blue line represents bankfull.

Table B6-5. Metrics for cross section 3 on WLC4.	
Bankfull Width (ft)	29.6
Mean Depth (ft)	2.4
Max Depth (ft)	4.5
Bankfull Area (ft^2)	67.1
Width/Depth Ratio	12.4
Hydraulic Radius	2.1

Figure B6-10. Cross section 3 pool view from left bank (left) and upstream (right).

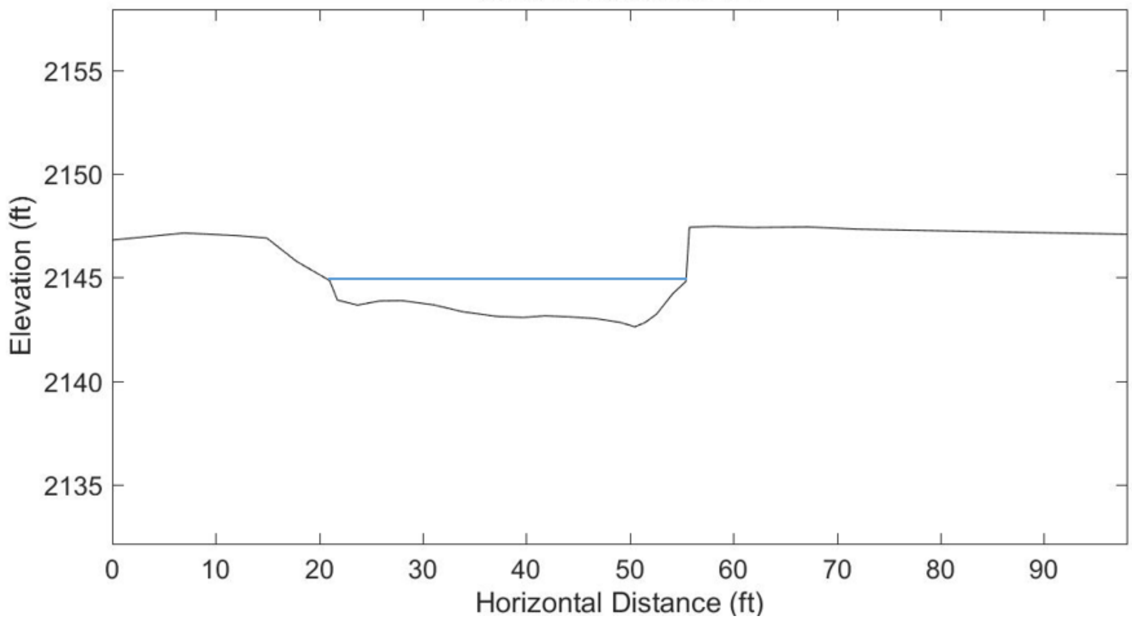


Figure B6-11. Cross section 4 on WLC4. The blue line represents bankfull.

Table B6-6. Metrics for cross section 4 on WLC4.	
Bankfull Width (ft)	34.1
Mean Depth (ft)	1.3
Max Depth (ft)	2.1
Bankfull Area (ft^2)	44.1
Width/Depth Ratio	26.2
Hydraulic Radius	1.3

Figure B6-12. Cross section 4 riffle view from right bank (left) and upstream view (right).

GRAIN SIZE DATA

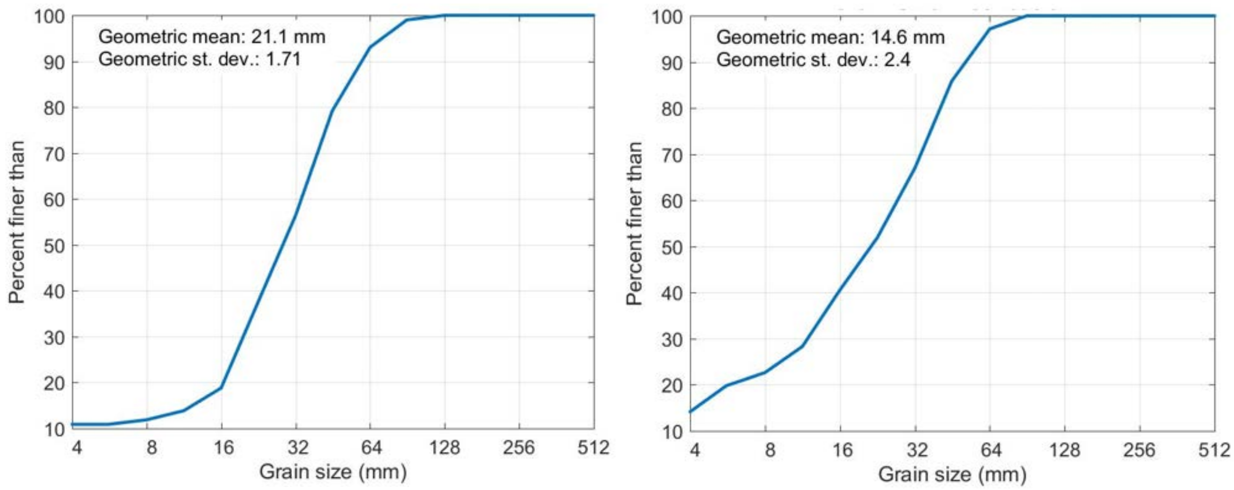


Figure B6-13. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for WLC4.

Table B6-7. WLC4 pebble count results.		
Percentile	**Riffle (mm)**	**Pool (mm)**
16	13.3	4.5
35	21.7	13.9
50	28.8	21.5
65	36.9	30.8
84	51.6	43.7
95	72.4	60.4

LARGE WOOD SURVEY

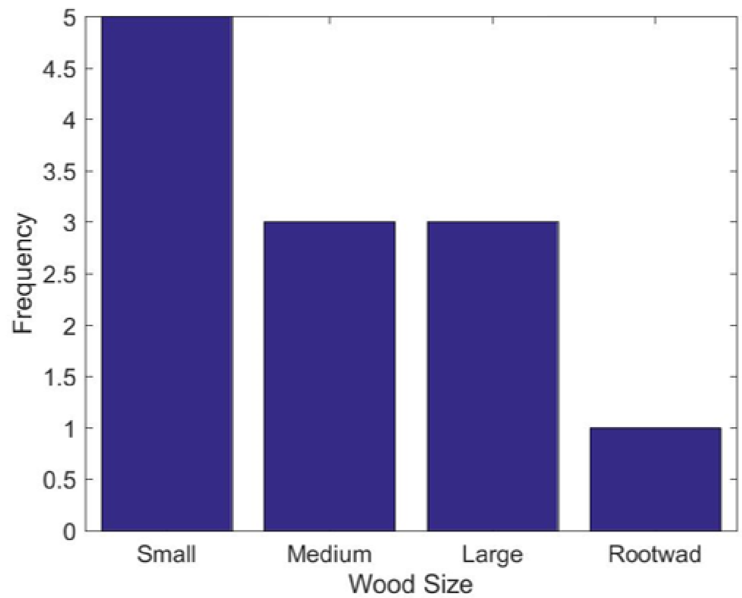


Figure B6-14. Results from large wood survey.

WOLF LODGE CREEK

REACH DATA – REACH WLC5

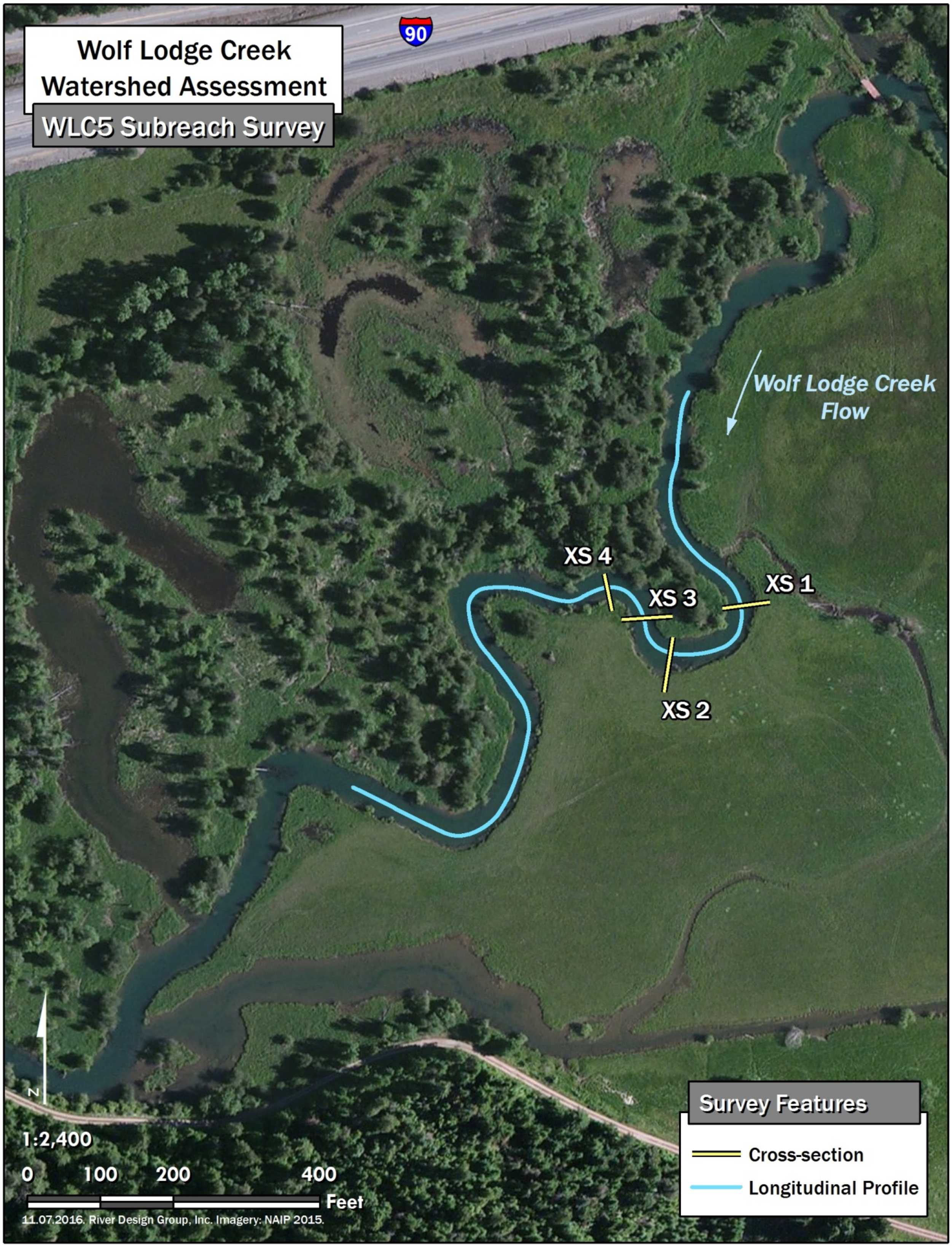


Figure B7-1. Subreach overview map with survey data from geomorphic assessment for WLC5.

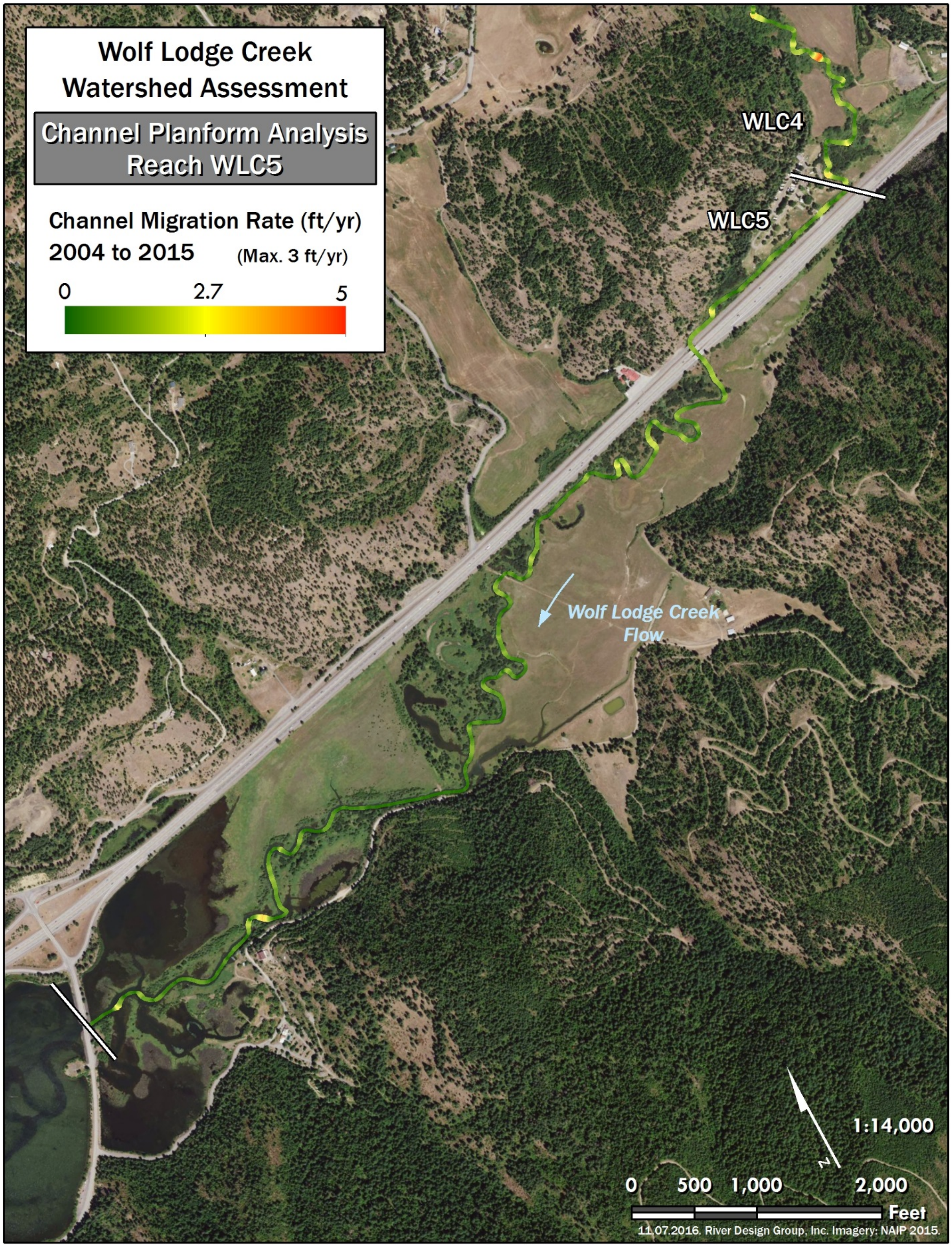


Figure B7-2. Historical channel planform analysis that quantifies migration rates for 2004-2015.

LONGITUDINAL PROFILE

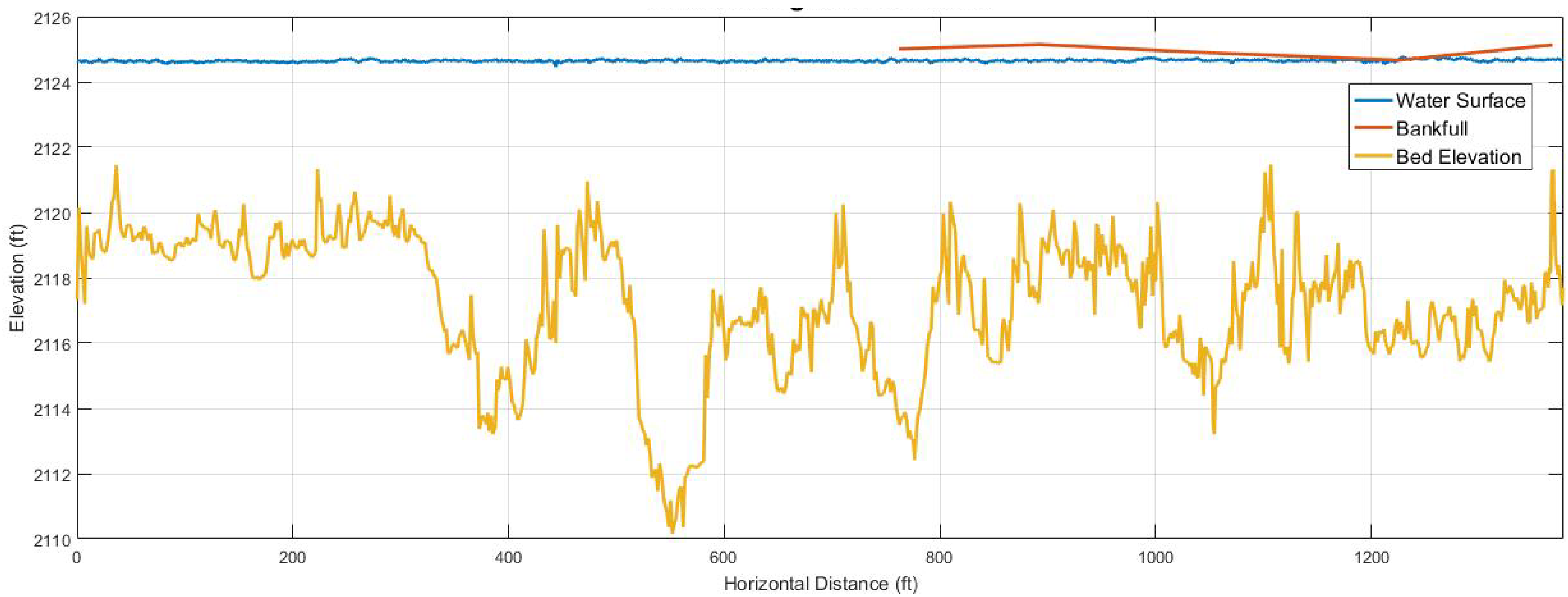


Figure B7-3. Longitudinal profile of WLC5.

Table B7-1. Profile dimensions for WLC5.	
Bed Slope	-0.0003
Water Slope	-0.00004
Bankfull Slope	-0.0002
Sinuosity	1.5

CROSS SECTION DATA

Table B7-2. Overview of cross section dimensions for WLC5.			
Metric	**Min**	**Mean**	**Max**
Max Depth (ft)	5.5	8.2	9.9
Bankfull Width (ft)	42.3	48.6	55.4
Bankfull Area (ft^2)	83.6	195.3	249.7
Width/Depth Ratio	7.2	12.9	21.8

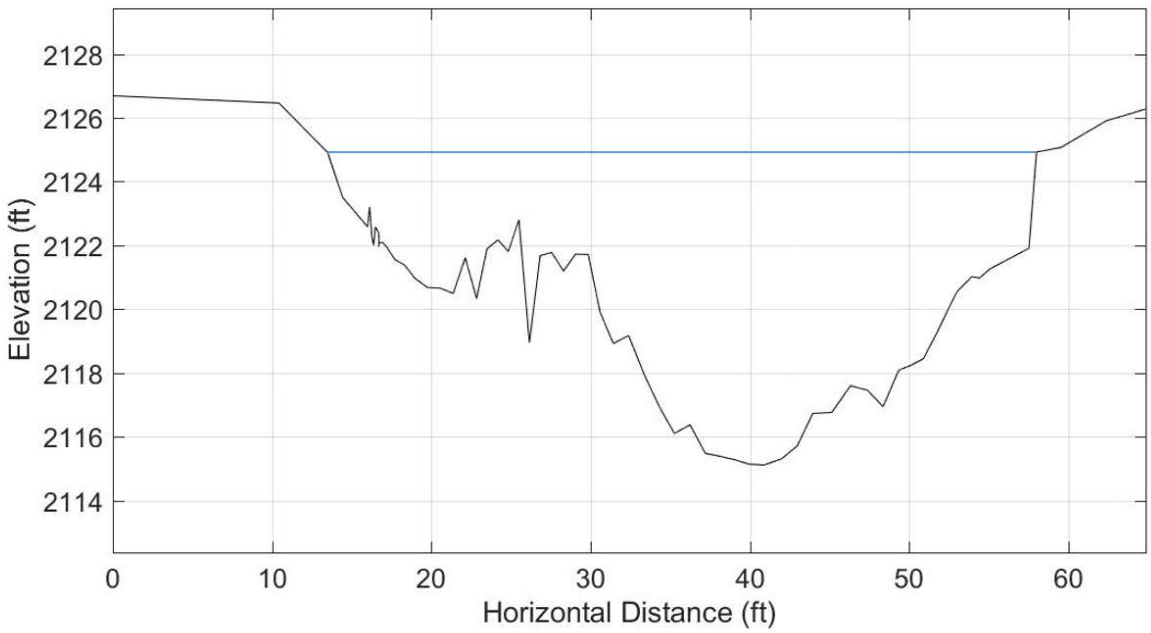


Figure B7-4. Cross section 1 on WLC5. The blue line represents bankfull.

Table B7-3. Metrics for cross section 1 on WLC5.	
Bankfull Width (ft)	44.6
Mean Depth (ft)	5.6
Max Depth (ft)	9.8
Bankfull Area (ft^2)	249.7
Width/Depth Ratio	8
Hydraulic Radius	3.9

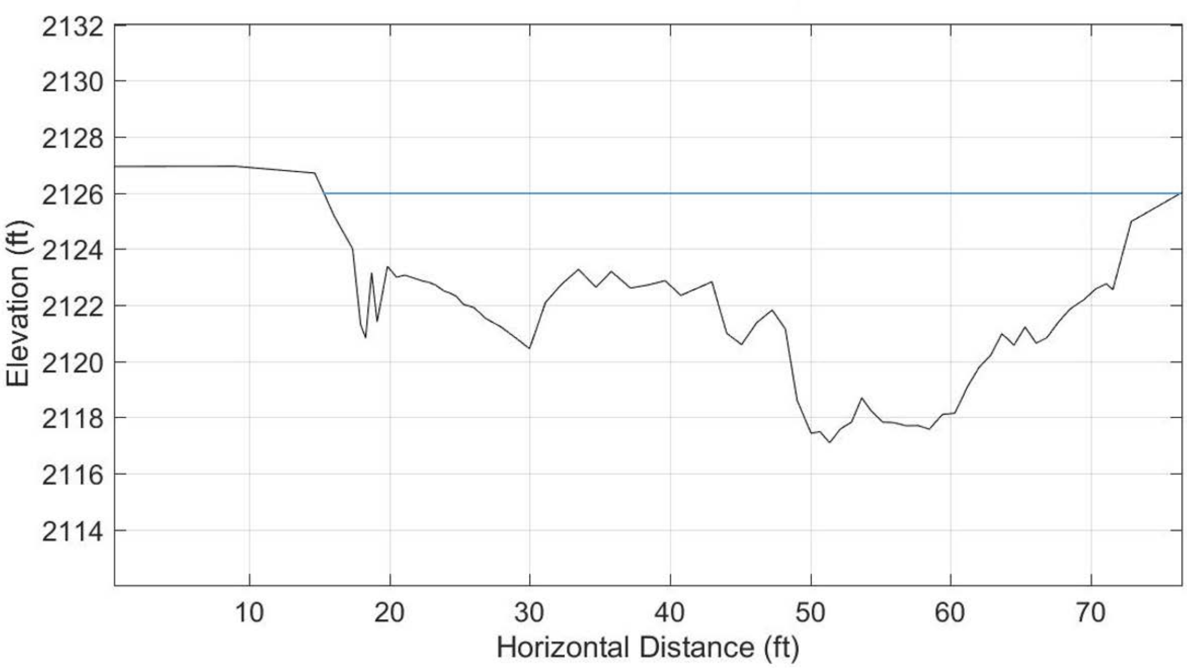


Figure B7-5. Cross section 2 on WLC5. The blue line represents bankfull.

Table B7-4. Metrics for cross section 2 on WLC5.	
Bankfull Width (ft)	52
Mean Depth (ft)	2.4
Max Depth (ft)	5.5
Bankfull Area (ft^2)	83.6
Width/Depth Ratio	21.8
Hydraulic Radius	1.4

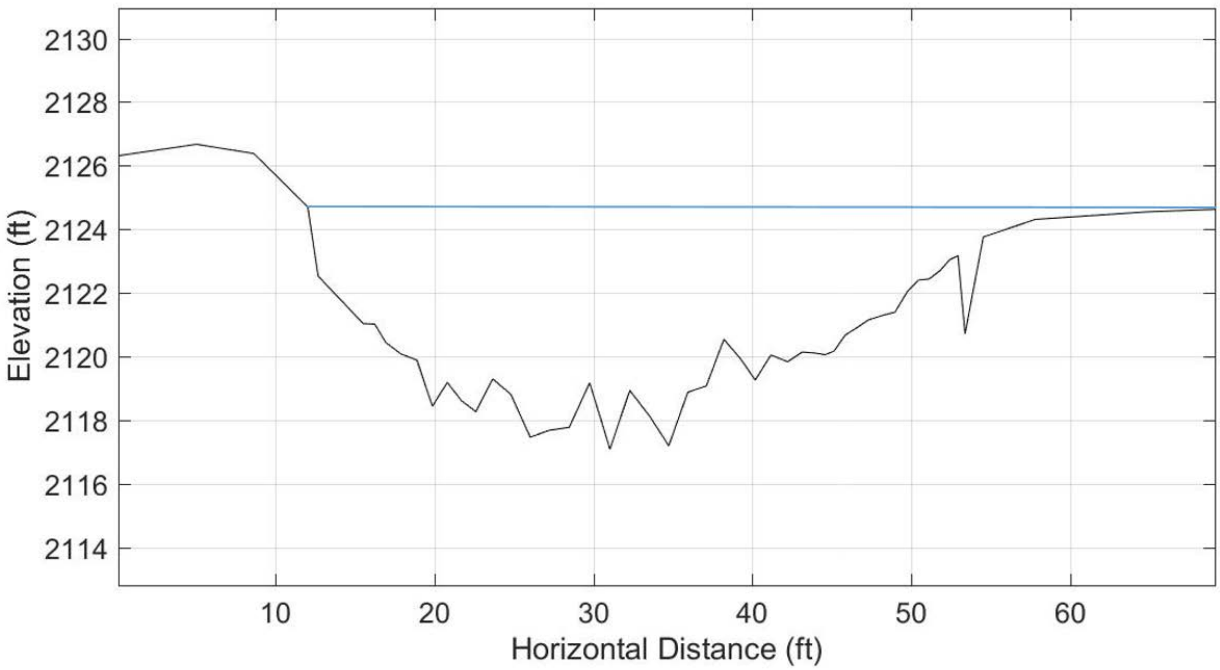


Figure B7-6. Cross section 3 on WLC5. The blue line represents bankfull.

Table B7-5. Metrics for cross section 3 on WLC5.	
Bankfull Width (ft)	55.4
Mean Depth (ft)	3.8
Max Depth (ft)	7.4
Bankfull Area (ft^2)	199.1
Width/Depth Ratio	14.5
Hydraulic Radius	2.8

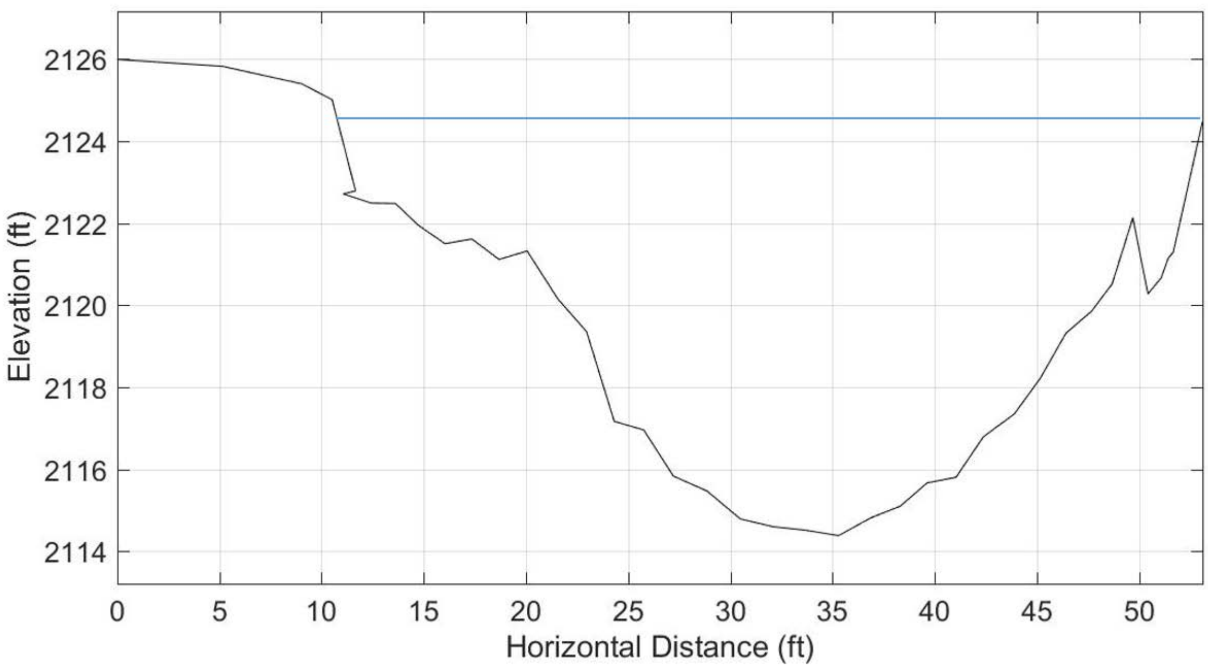


Figure B7-7. Cross section 4 on WLC5. The blue line represents bankfull.

Table B7-6. Metrics for cross section 4 on WLC5.	
Bankfull Width (ft)	42.3
Mean Depth (ft)	5.9
Max Depth (ft)	9.9
Bankfull Area (ft^2)	248.8
Width/Depth Ratio	7.2
Hydraulic Radius	4.8

LARGE WOOD SURVEY

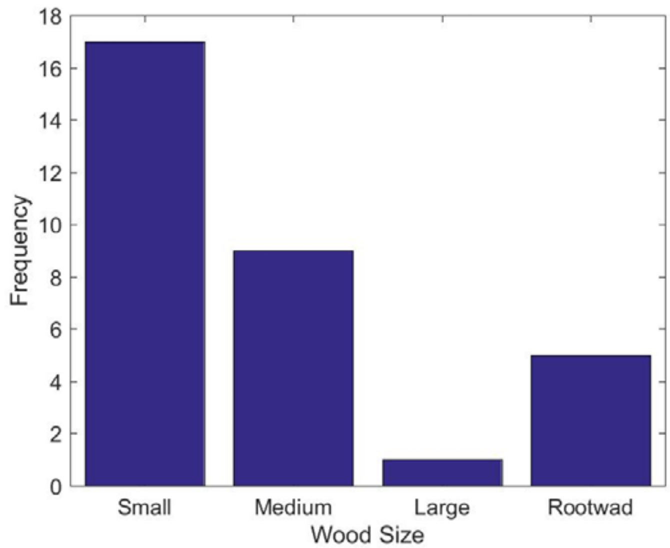


Figure B7-8. Results from large wood survey.

MARIE CREEK

REACH DATA – REACH MC2

Figure B8-1. Subreach overview map with survey data from geomorphic assessment for MC2.

LONGITUDINAL PROFILE

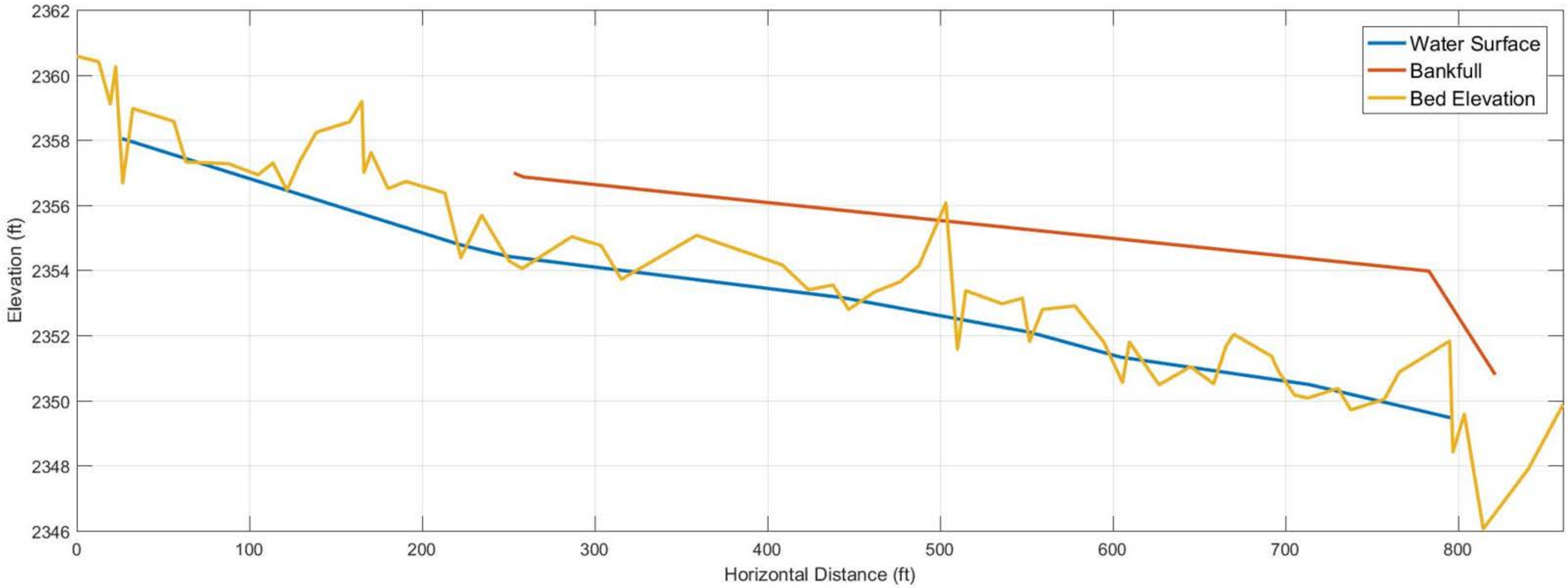


Figure B8-2. Longitudinal profile of MC2.

Table B8-1. Profile dimensions for MC2.	
Bed Slope	-0.012
Water Slope	-0.010
Bankfull Slope	-0.009
Sinuosity	1.23

CROSS SECTION DATA

Table B8-2. Overview of cross section dimensions for MC2.			
Metric	**Min**	**Mean**	**Max**
Depth max Riffle (ft)	1.1	1.3	1.4
Depth max Pool (ft)	2.7	3.5	4.2
Riffle Area (ft^2)	19.6	21.5	23.4
Pool Area (ft^2)	37.0	51.4	65.7
Riffle Width (ft)	25.3	26.2	27.0
Pool Width (ft)	23.4	25.8	28.1

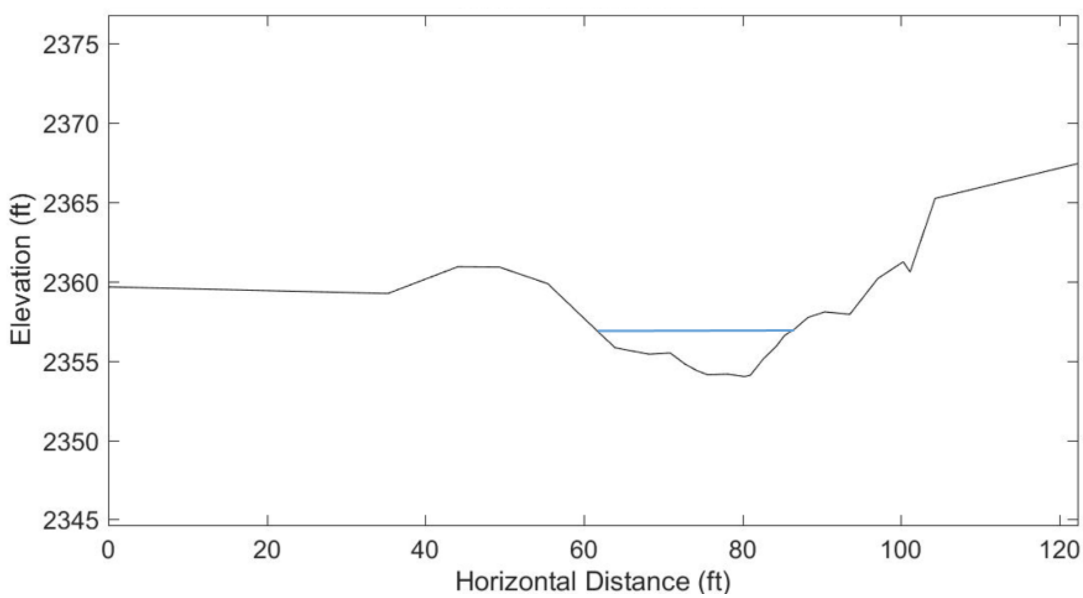


Figure B8-3. Cross section 1 on MC2. The blue line represents bankfull.

Table B8-3. Metrics for cross section 1 on MC2.	
Bankfull Width (ft)	23.4
Mean Depth (ft)	1.6
Max Depth (ft)	2.7
Bankfull Area (ft^2)	37.0
Width/Depth Ratio	14.7
Hydraulic Radius	1.5

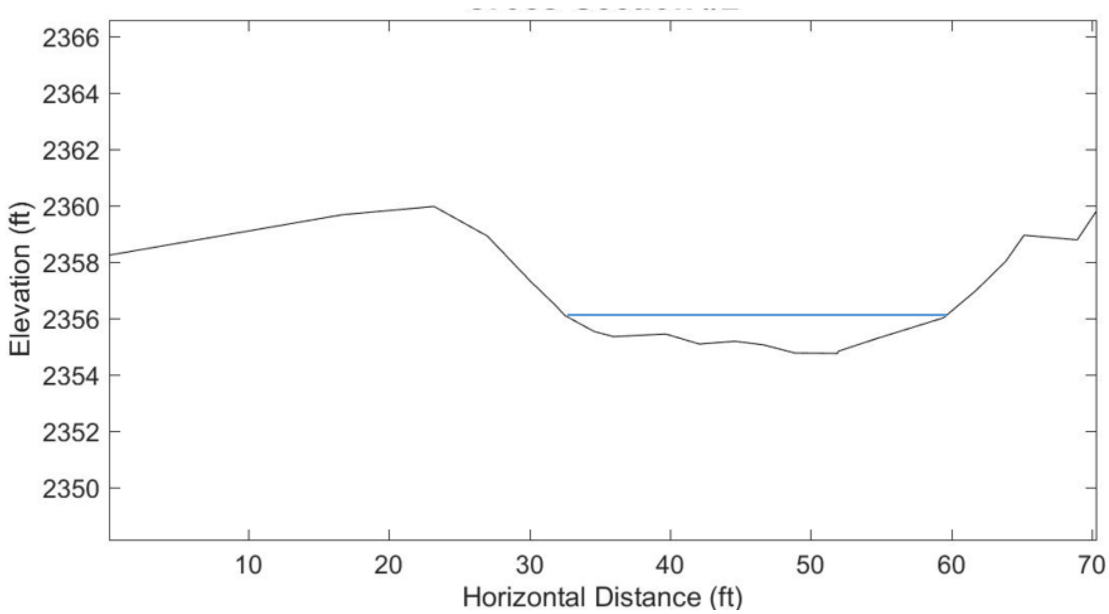


Figure B8-4. Cross section 2 on MC2. The blue line represents bankfull.

Table B8-4. Metrics for cross section 2 on MC2.	
Bankfull Width (ft)	27.0
Mean Depth (ft)	0.9
Max Depth (ft)	1.4
Bankfull Area (ft^2)	23.4
Width/Depth Ratio	30.7
Hydraulic Radius	0.9

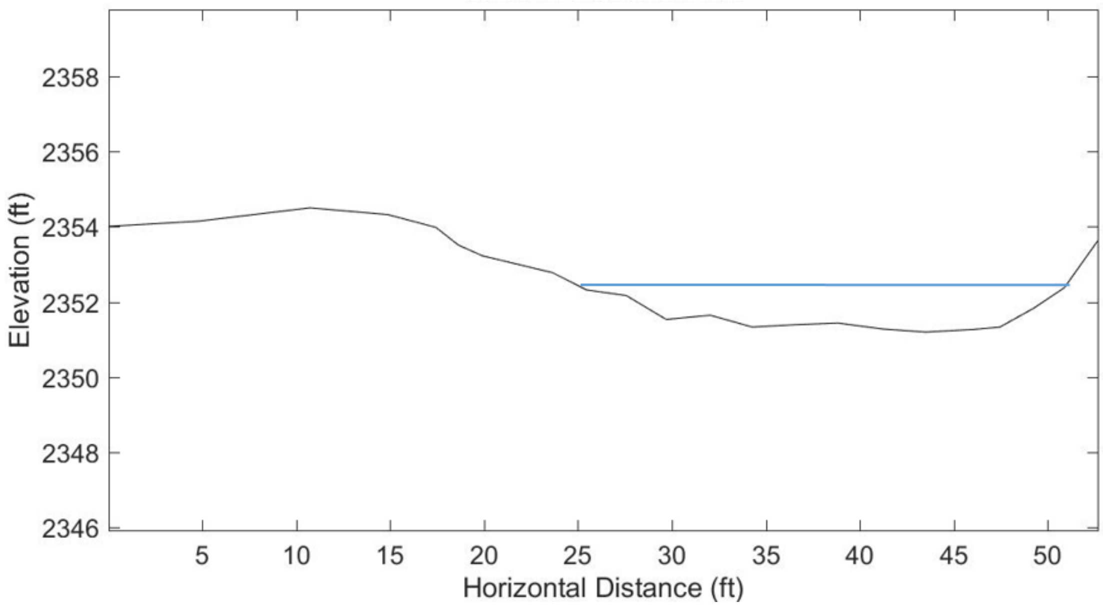


Figure B8-5. Cross section 3 on MC2. The blue line represents bankfull.

Table 8-5. Metrics for cross section 3 on MC2.	
Bankfull Width (ft)	25.3
Mean Depth (ft)	0.8
Max Depth (ft)	1.1
Bankfull Area (ft^2)	19.6
Width/Depth Ratio	32.3
Hydraulic Radius	0.8

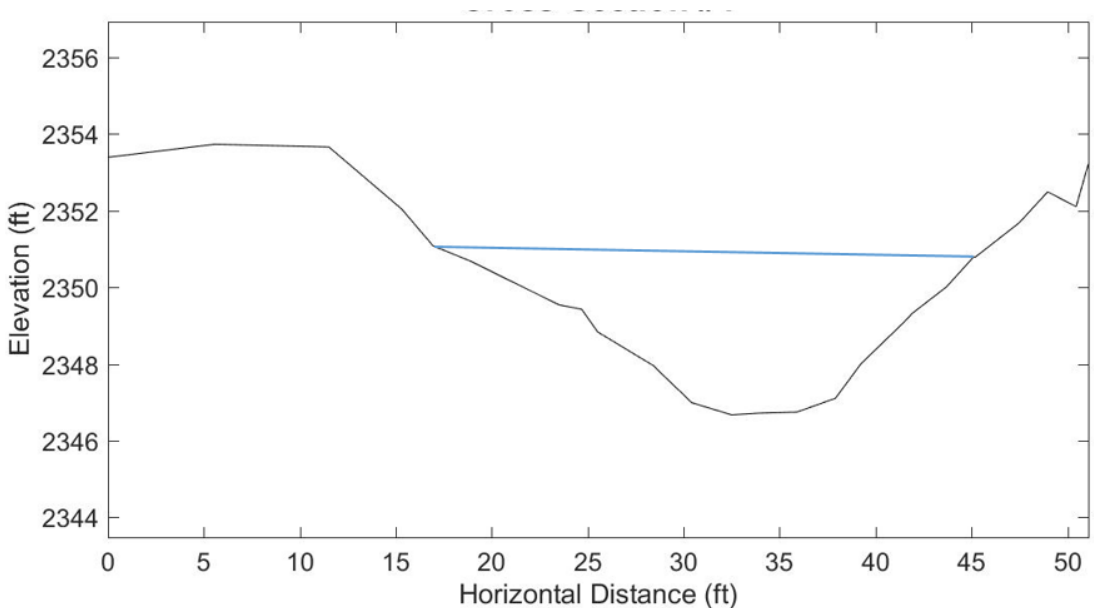


Figure B8-6. Cross section 4 on MC2. The blue line represents bankfull.

Table B8-6. Metrics for cross section 4 on MC2.	
Bankfull Width (ft)	28.1
Mean Depth (ft)	2.4
Max Depth (ft)	4.2
Bankfull Area (ft^2)	65.7
Width/Depth Ratio	11.7
Hydraulic Radius	2.2

GRAIN SIZE DATA

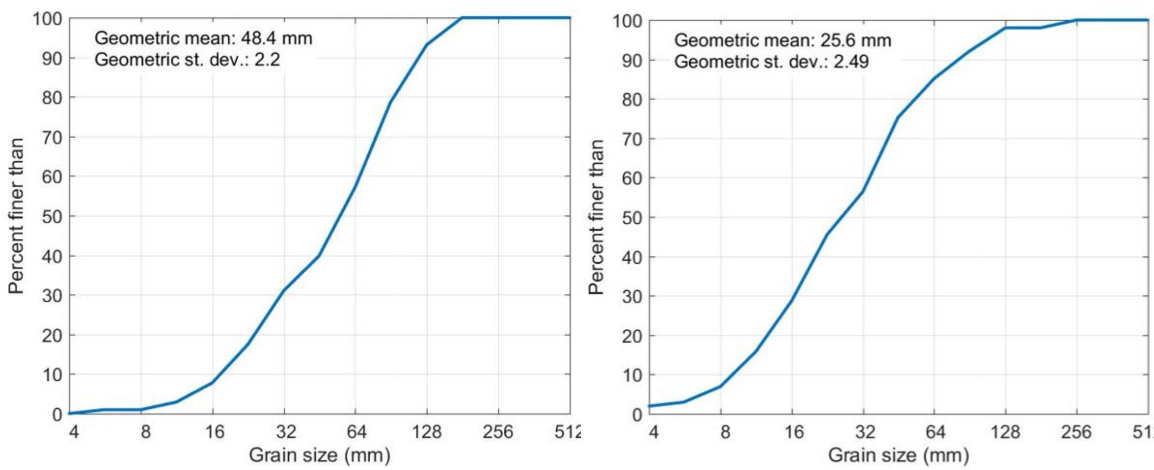


Figure B8-7. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for MC2.

TableB8-7. MC2 pebble count results.		
Percentile	**Riffle (mm)**	**Pool (mm)**
16	21.6	11.4
35	37.8	18.5
50	56.1	26.4
65	73.4	37.9
84	104.0	61.8
95	141.7	108.7

LARGE WOOD SURVEY

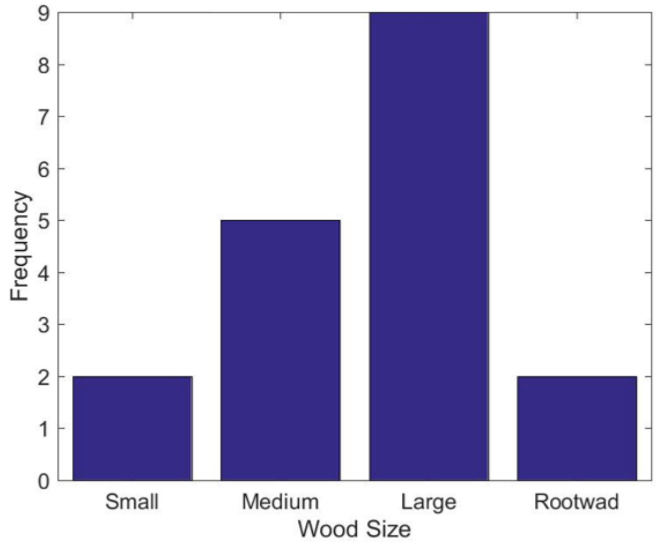


Figure B8-8. Results from large wood survey.

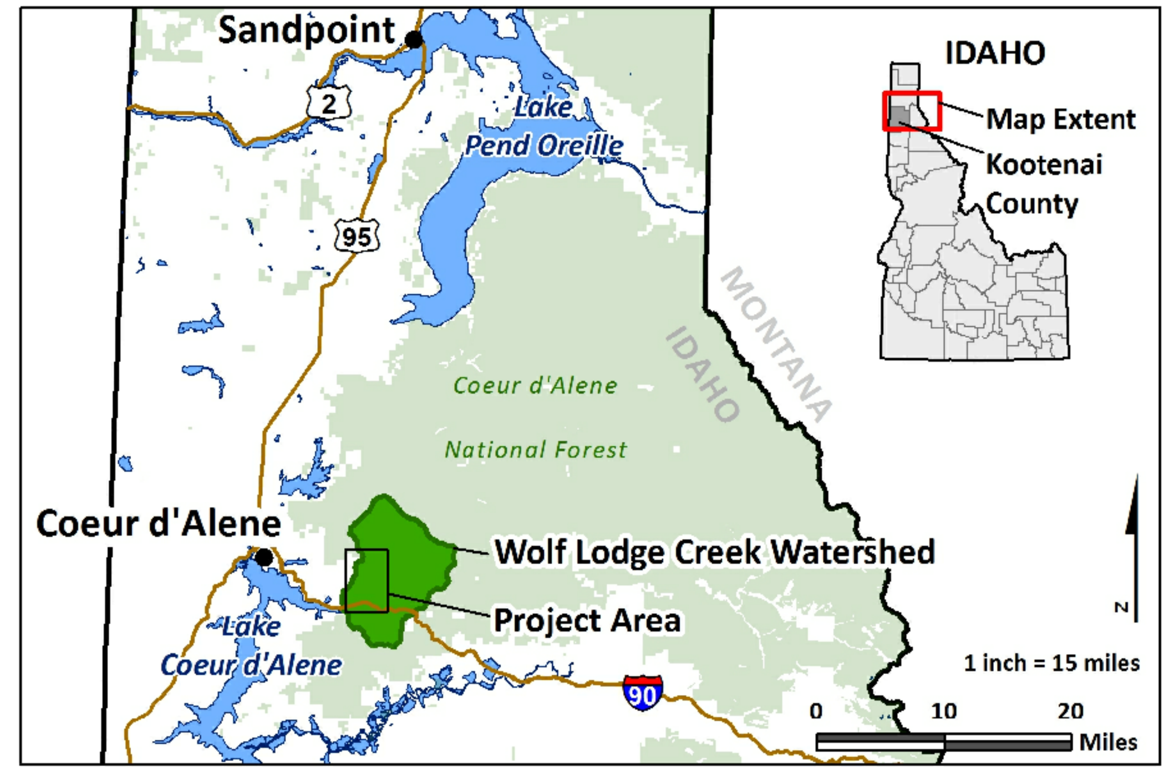
ATTACHMENT A: CONCEPTUAL RESTORATION PLAN

WOLF LODGE CREEK WATERSHED ASSESSMENT AND RESTORATION PRIORITIZATION PLAN

PROJECT SPONSOR

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY
2110 Ironwood Parkway
Coeur d'Alene, ID 83814

PROJECT VICINITY MAP



LEGAL DESCRIPTION: T50N, R02W, SECTIONS 16, 22, 29, 32, AND 33
T49N, R02W, SECTION 5

PROJECT DESCRIPTION

IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY (DEQ) RETAINED RIVER DESIGN GROUP, INC. TO COMPLETE A WATERSHED-SCALE ASSESSMENT AND RESTORATION PRIORITIZATION PLAN FOR WOLF LODGE CREEK, A TRIBUTARY TO LAKE COUER D'ALENE IN NORTHERN IDAHO. GOALS OF THE ASSESSMENT WERE TO PROVIDE A QUANTITATIVE INVENTORY OF STREAM CORRIDOR CONDITIONS IN WOLF LODGE CREEK AND PRIMARY TRIBUTARIES, AND DEVELOP A RESTORATION PRIORITIZATION PLAN TO ADDRESS SEDIMENT AND TEMPERATURE IMPAIRMENTS IN THE WATERSHED. IN 2000, DEQ AND THE ENVIRONMENTAL PROTECTION AGENCY LISTED WOLF LODGE CREEK AS SEDIMENT IMPAIRED, AND IN 2012, WOLF LODGE CREEK, MARIE CREEK, AND CEDAR CREEK WERE ALSO LISTED AS IMPAIRED FOR TEMPERATURE.

THIS ATTACHMENT TO THE WOLF LODGE CREEK WATERSHED ASSESSMENT AND RESTORATION PRIORITIZATION PLAN PRESENTS CONCEPTUAL RESTORATION PLANS FOR SIX PRIORITY SITES. SITE PRIORITIZATION WAS DETERMINED IN CONJUNCTION WITH DEQ. PRIORITY SITES INCLUDE:

- SITE 1: STELLA CREEK SEDIMENT TRAP REMOVAL AND CHANNEL RECONNECTION
- SITE 2: LONESOME CREEK STREAM AND FLOODPLAIN RESTORATION
- SITE 3: MARIE CREEK STREAM AND FLOODPLAIN RESTORATION
- SITE 4: WOLF LODGE CREEK REACH 3 STREAMBANK RESTORATION
- SITE 5: WOLF LODGE CREEK REACH 4 AND RUTHERFORD GULCH STREAM AND FLOODPLAIN RESTORATION
- SITE 6: WOLF LODGE CREEK REACH 5 RIPARIAN AND FLOODPLAIN REVEGETATION

THE DRAWINGS ILLUSTRATE POTENTIAL TREATMENTS AND STRATEGIES TO REDUCE SEDIMENTATION TO WOLF LODGE CREEK, IMPROVE OVERALL STREAM CHANNEL AND FLOODPLAIN FUNCTION, REDUCE PROPERTY LOSS ASSOCIATED WITH ACCELERATED LATERAL CHANNEL MIGRATION, AND IMPROVE AQUATIC HABITAT COMPLEXITY. THE CONCEPTS ARE ILLUSTRATIVE AND ADDITIONAL SURVEYING AND ENGINEERING WILL BE REQUIRED TO DEVELOP PLANS FOR CONSTRUCTION. RESTORATION STRATEGIES ARE FURTHER DESCRIBED IN SECTION 8 OF THE WATERSHED ASSESSMENT REPORT.

DRAWING INDEX

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COVER PAGE AND NOTES

NO.	DATE	BY	DESCRIPTION	CHK
1	12-29-16	RR/NW	CONCEPTUAL DESIGN	JM

-PRELIMINARY-
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
1.0

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PLAN VIEW INDEX AND SITE LAYOUT

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
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PROJECT NUMBER
RDG-16-005

SHEET NUMBER

2.0

EXISTING CONDITIONS

STELLA CREEK IS A THIRD ORDER TRIBUTARY TO LONESOME CREEK. SIMILAR TO OTHER TRIBUTARIES IN THE WATERSHED, RUNOFF IS SNOWMELT DOMINATED WITH PEAK FLOWS OCCURRING IN LATE MARCH AND EARLY APRIL. A MAJORITY OF THE HEADWATERS OF STELLA CREEK ARE MANAGED BY THE PANHANDLE NATIONAL FOREST. DURING THE 1990S, A SEDIMENT TRAP WAS CONSTRUCTED ON STELLA CREEK TO DECREASE THE AMOUNT OF SEDIMENT BEING TRANSPORTED FROM THE HEADWATERS TO THE LOWER REACHES IN THE WATERSHED. INCREASED SEDIMENT FLUX WAS ANTICIPATED FROM TIMBER HARVEST ACTIVITIES. THE SEDIMENT TRAP WAS CONSTRUCTED ON-STREAM, AND WAS STABILIZED WITH HARDENED ROCK SILLS AT THE INLET AND OUTLET. THE SEDIMENT TRAP FRAGMENTED AQUATIC HABITAT IN UPPER STELLA CREEK AND CREATED A COMPLETE BARRIER TO FISH PASSAGE. VISUAL INSPECTION OF THE TRAP INDICATES MINIMAL BEDLOAD HAS ACCUMULATED IN THE TRAP. THE INLET ROCK WEIR HAS CAUSED SEDIMENT TO DEPOSIT AND AGGRADE UPSTREAM OF THE TRAP, CAUSING STREAMBANK EROSION AND LATERAL CHANNEL MIGRATION.

RESTORATION OBJECTIVES

THE CONCEPTUAL DESIGN FOR STELLA CREEK ADDRESSES LIMITING FACTORS IDENTIFIED IN THE WATERSHED ASSESSMENT. THE PRIMARY OBJECTIVE IS TO RECONSTRUCT A NEW CHANNEL THROUGH THE SEDIMENT TRAP TO RESTORE FLUVIAL PROCESSES AND FISH PASSAGE. OBJECTIVES RELATED TO CHANNEL MORPHOLOGY, AQUATIC HABITAT, AND FLOODPLAIN RESOURCES INCLUDE:

- PRODUCE CLEAN WATER CONSISTENT WITH SUPPORTING AQUATIC LIFE AND BENEFICIAL USES.
- REMOVE THE SEDIMENT TRAP AND ROCK WEIRS, AND BACKFILL THE SEDIMENT TRAP TO ORIGINAL GRADE.
- CONSTRUCT A STREAM CHANNEL THAT IS CONNECTED TO A NARROW, SLOPING FLOODPLAIN.
- INCORPORATE COMPLEX AQUATIC HABITAT FEATURES INCLUDING RIFFLES AND POOLS.
- ADDRESS UPSTREAM CHANNEL INSTABILITY BY EXTENDING CHANNEL AND STREAMBANK RESTORATION TREATMENTS APPROXIMATELY 350 FEET UPSTREAM OF THE SEDIMENT TRAP.

RESTORATION TREATMENTS

THE EXISTING SEDIMENT TRAP WILL BE BACKFILLED AND REGRADED TO MATCH THE TOPOGRAPHY OF THE ADJACENT GROUND. AFTER THE TRAP IS BACKFILLED, A MODERATELY ENTRENCHED, RIFFLE-POOL, GRAVEL DOMINATED STREAM TYPE WITH A NARROW, CONNECTED FLOODPLAIN WILL BE CONSTRUCTED TO RE-ESTABLISH CONNECTION WITH UPSTREAM AND DOWNSTREAM REACHES. STREAMBANK TREATMENTS WILL BE COMPOSED OF WOOD, ALLUVIUM, AND VEGETATION, AND WILL INCREASE BANK RESISTANCE TO EROSION. THE CONSTRUCTED STREAMBED WILL CONSIST OF RIFFLE AND POOL HABITAT FEATURES AND INCLUDE WOOD AND ROCK-BASED STEP POOLS. PRELIMINARY CHANNEL DIMENSIONS ARE NOTED ON SHEET 3.1.

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SITE PLAN
STELLA CREEK SEDIMENT TRAP REMOVAL AND CHANNEL RECONNECTION

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PRELIMINARY
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PROJECT NUMBER
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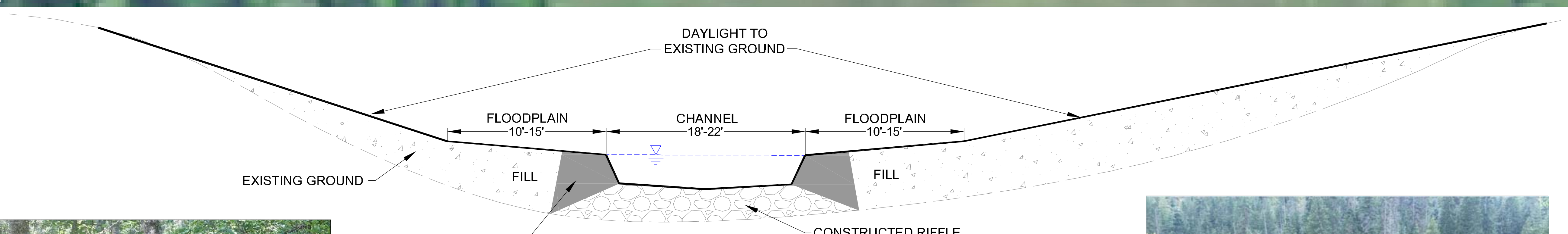
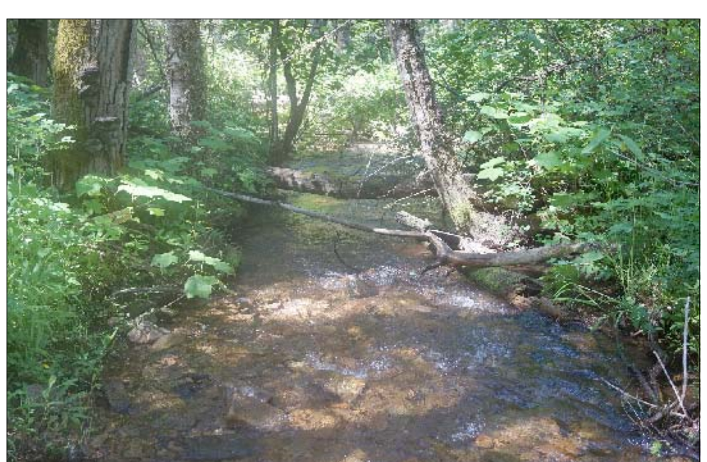
3.0



SECTION VIEW A - A' NTS



DESIRED FUTURE CHANNEL AND FLOODPLAIN CONDITION

STELLA CREEK SEDIMENT TRAP

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CONCEPTUAL RESTORATION PLAN
STELLA CREEK SEDIMENT TRAP REMOVAL AND CHANNEL RECONNECTION

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PRELIMINARY -NOT FOR CONSTRUCTION-

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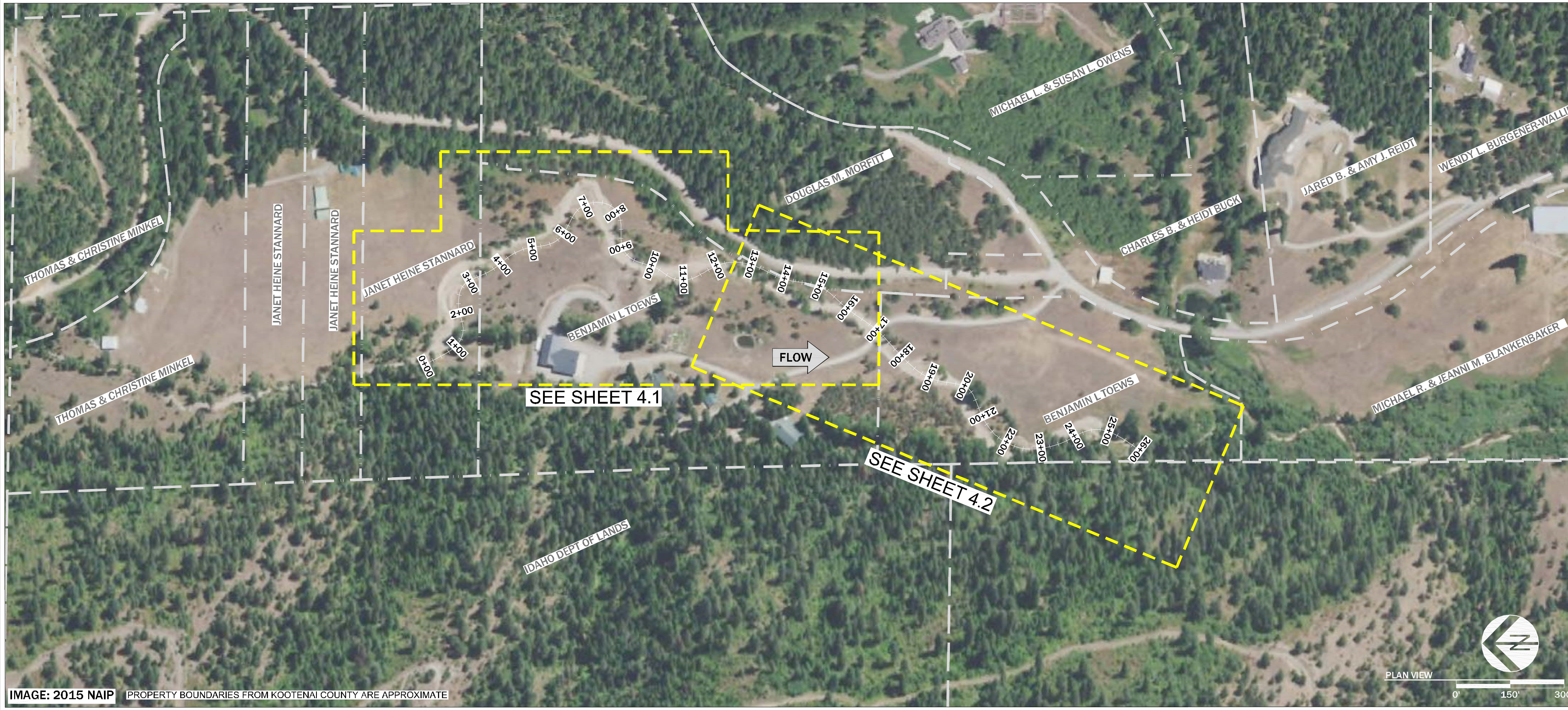

RESTORATION ALTERNATIVES

REACH 1 LONESOME CREEK (LC1) IS A THIRD ORDER TRIBUTARY TO WOLF LODGE CREEK. ORIGINATING FROM THE SOUTHEAST SLOPES OF TREASURE MOUNTAIN, ELEVATIONS RANGE FROM 3,900 FT AMSL AT TREASURE SADDLE TO 2,275 FEET AT THE CONFLUENCE WITH PHANTOM CREEK. THE PROJECT AREA OCCURS IN REACH 1 OF LONESOME CREEK, AND CONSISTS OF A 0.5 MILE (2,600 FEET) REACH THAT HAS BEEN HEAVILY DISTURBED BY LAND CLEARING AND RESIDENTIAL DEVELOPMENT. THE REACH EXPERIENCES INTERMITTENT HYDROLOGY. PAST EFFORTS TO CHANNELIZE THE CREEK HAVE RESULTED IN SEVERE STREAMBANK EROSION, CHANNEL WIDENING, AND REDUCED SEDIMENT TRANPSORT CAPACITY. BANK EROSION RATES ARE HIGH IN LC1 WITH 10% OF THE TOTAL WATERSHED SEDIMENT YIELD DERIVED FROM BANK EROSION ORIGINATING WITHIN THE REACH. LATERAL CHANNEL MIGRATION RATES IN LC1 RANGE FROM 1.5 TO 2 FEET PER YEAR.

SUBSTANTIAL EFFORTS HAVE BEEN UNDERTAKEN TO MITIGATE FLOOD DAMAGE OF PRIVATE PROPERTY AND BANK EROSION IN LC1. THE CHANNEL HAS BEEN BULLDOZED AND LEVEED TO DECREASE FLOODING. THE LEVEES WERE SUBSEQUENTLY REDUCED IN SIZE, AND THE MATERIAL USED TO CONSTRUCT THEM WAS PLACED BACK IN THE CHANNEL. VEGETATION HAS BEEN EXTENSIVELY MODIFIED IN CONJUNCTION WITH FLOOD MITIGATION EFFORTS. STREAMBANKS CURRENTLY LACK WOODY VEGETATION, WHICH EXACERBATES BANK EROSION AND SEDIMENTATION. HERBACEOUS VEGETATION IN THE STREAM CORRIDOR IS CHARACTERIZED BY COMMON INTRODUCED LAWN AND PASTURE PLANT SPECIES INCLUDING SMOOTH BROME, ORCHARD GRASS, KENTUCKY BLUE GRASS, AND WEEDS.

RESTORATION OBJECTIVES

THE CONCEPTUAL DESIGN FOR LONESOME CREK IN REACH 1 ADDRESSES LIMITING FACTORS IDENTIFIED IN THE WATERSHED ASSESSMENT. THE PRIMARY OBJECTIVE IS TO RECONSTRUCT A CHANNEL WITHIN THE CURRENT ALIGNMENT AND CHANNEL BELT WIDTH WITH IMPROVED FUNCTION THAT SUPPORTS NATURAL FLUVIAL PROCESSES AND CURBS ACCELERATED STREAMBANK EROSION. A SECONDARY OBJECTIVE IS TO REDUCE FLOOD HAZARD RISK TO RESIDENTIAL INFRASTRUCTURE. OBJECTIVES RELATED TO CHANNEL MORPHOLOGY, AQUATIC HABITAT, AND FLOODPLAIN RESOURCES INCLUDE:

- PRODUCE CLEAN WATER CONSISTENT WITH SUPPORTING AQUATIC LIFE AND BENEFICIAL USES.
- CREATE COMPLEX AQUATIC HABITAT COMPONENTS SUCH AS DEPTH, VELOCITY, SUBSTRATE, COVER, AND POOLS THAT SUPPORT POPULATIONS OF WILD TROUT AND OTHER AQUATIC ORGANISMS.
- CONSTRUCT A STREAM CHANNEL WITHIN THE CURRENT ALIGNMENT THAT IS CONNECTED TO AN INSET FLOODPLAIN THAT INTERACTS WITH THE CHANNEL IN TERMS OF SURFACE FLOW AND SEDIMENT AND NUTRIENT EXCHANGE.
- REVEGETATE THE FLOODPLAIN CORRIDOR TO INCREASE FLOOD RESILIENCY AND PROMOTE MORE NATURAL RATES OF CHANNEL MIGRATION.
- COORDINATE RESTORATION PLANS WITH THE LANDOWNER TO ENSURE TREATMENTS AND CONCEPTS ARE COMPATIBLE WITH EXISTING AND FUTURE LAND USES.

RESTORATION TREATMENTS

RESTORATION WILL OCCUR ALONG 2,600 FEET OF LONESOME CREEK. THE PROJECT WILL BE IMPLEMENTED IN TWO PHASES. RESTORATION WILL OCCUR WHEN THE CHANNEL IS DEWATERED TO MINIMIZE IMPACTS TO WATER QUALITY.

PHASE ONE INCLUDES SHAPING OF THE CHANNEL STREAMBED, INCLUDING RIFFLES, RUNS, POOLS AND GLIDES, AND INSTALLING THE STREAMBED AND STREAMBANK STRUCTURES. TREATMENTS ARE NATIVE MATERIALS BASED AND DESIGNED TO MIMIC NATURALLY OCCURRING COMPONENTS OF A HEALTHY, FUNCTIONING STREAM CHANNEL AND FLOODPLAIN ECOSYSTEM. STREAMBANK TREATMENTS WILL BE COMPOSED OF WOOD, ALLUVIUM, AND VEGETATION, AND WILL INCREASE BANK RESISTANCE TO EROSION, PROVIDING FOR SHORT-TERM STREAMBED STABILITY REQUIRED TO SUPPORT THE VEGETATION DESIGN WHICH EMPHASIZES CREATING A SELF-SUSTAINING MOSAIC OF RIPARIAN AND WETLAND COMMUNITIES ON A FLOODPLAIN THAT IS HYDROLOGICALLY CONNECTED TO THE CHANNEL.

PHASE 2 INCLUDES IMPLEMENTATION OF THE FLOODPLAIN TREATMENTS WHICH INCLUDES ESTABLISHING VEGETATION COVER TYPES THAT INTEGRATE PLANT SPECIES COMPOSITION WITH GEOMORPHOLOGY AND HYDROLOGY, AND ACCOUNT FOR ECOLOGICAL PROCESSES THAT SUPPORT PLANT COMMUNITY DEVELOPMENT OVER TIME. FLOODPLAIN TREATMENTS WILL INCLUDE MICROTOPOGRAPHY, COARSE WOOD, PLANTINGS, AND SEEDING.

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SITE PLAN
LONESOME CREEK STREAM AND FLOODPLAIN RESTORATION

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
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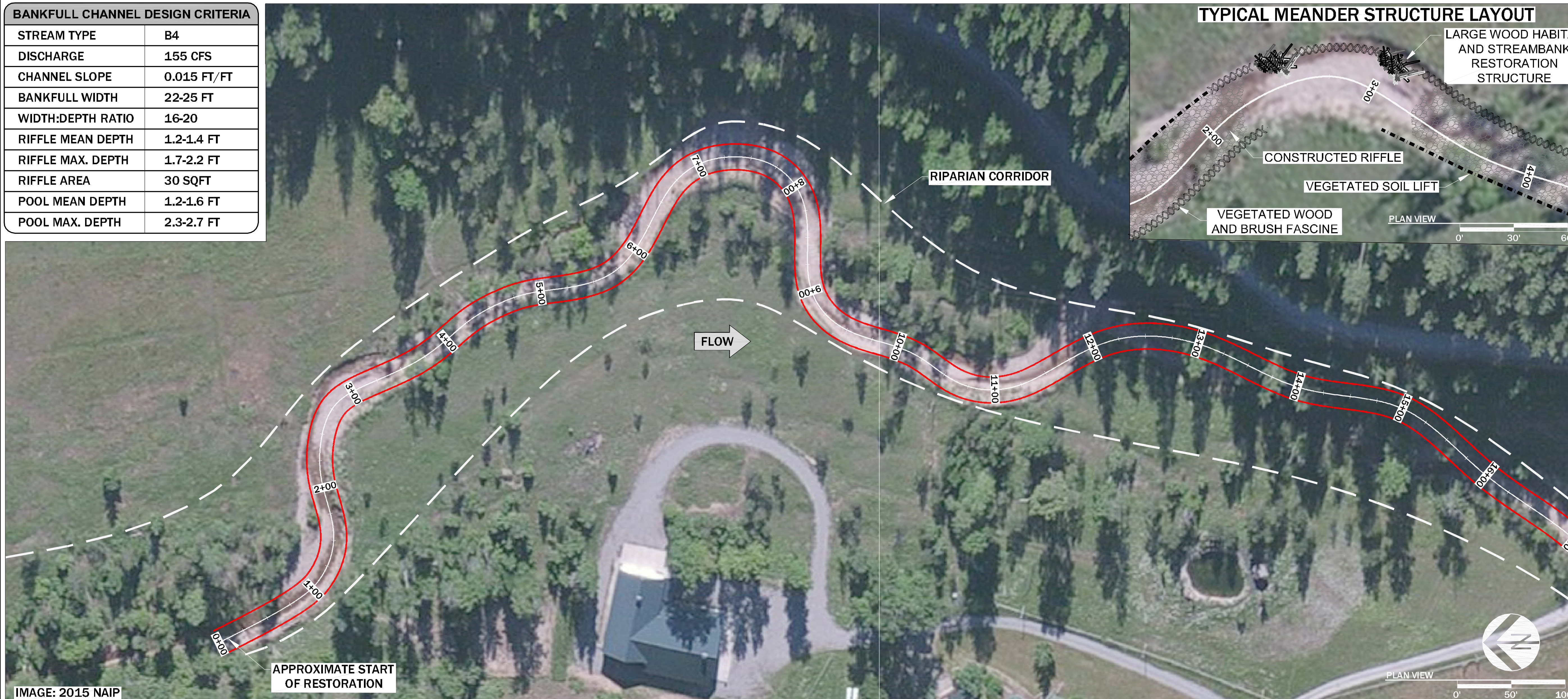
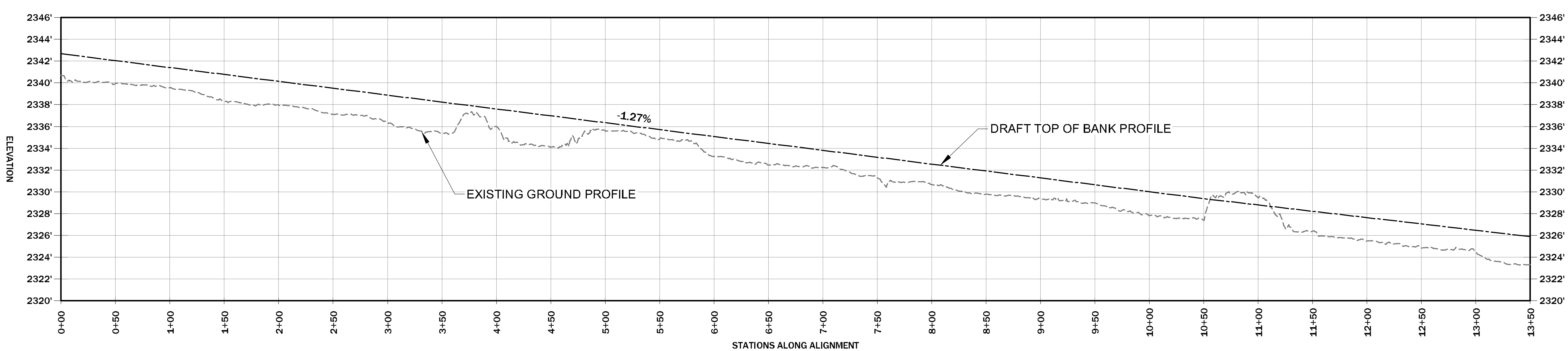
PROJECT NUMBER
RDG-16-005

SHEET NUMBER
4.0

BANKFULL CHANNEL DESIGN CRITERIA	
STREAM TYPE	B4
DISCHARGE	155 CFS
CHANNEL SLOPE	0.015 FT/FT
BANKFULL WIDTH	22-25 FT
WIDTH:DEPTH RATIO	16-20
RIFFLE MEAN DEPTH	1.2-1.4 FT
RIFFLE MAX. DEPTH	1.7-2.2 FT
RIFFLE AREA	30 SQFT
POOL MEAN DEPTH	1.2-1.6 FT
POOL MAX. DEPTH	2.3-2.7 FT





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CONCEPTUAL RESTORATION PLAN
LONESOME CREEK STREAM AND FLOODPLAIN RESTORATION

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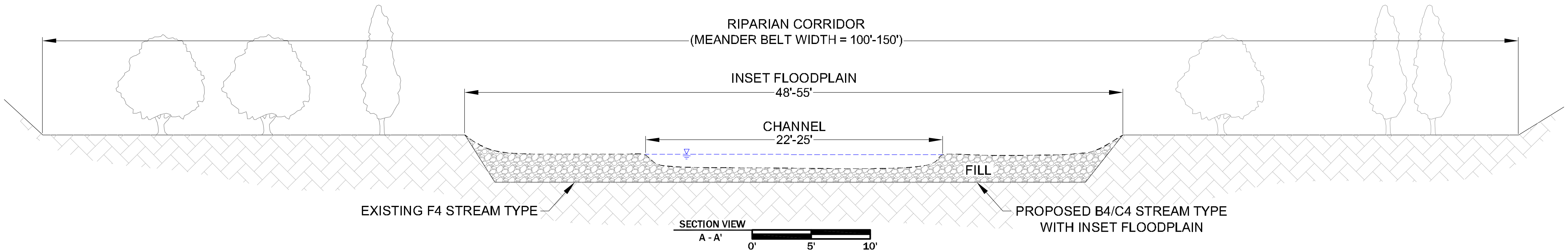

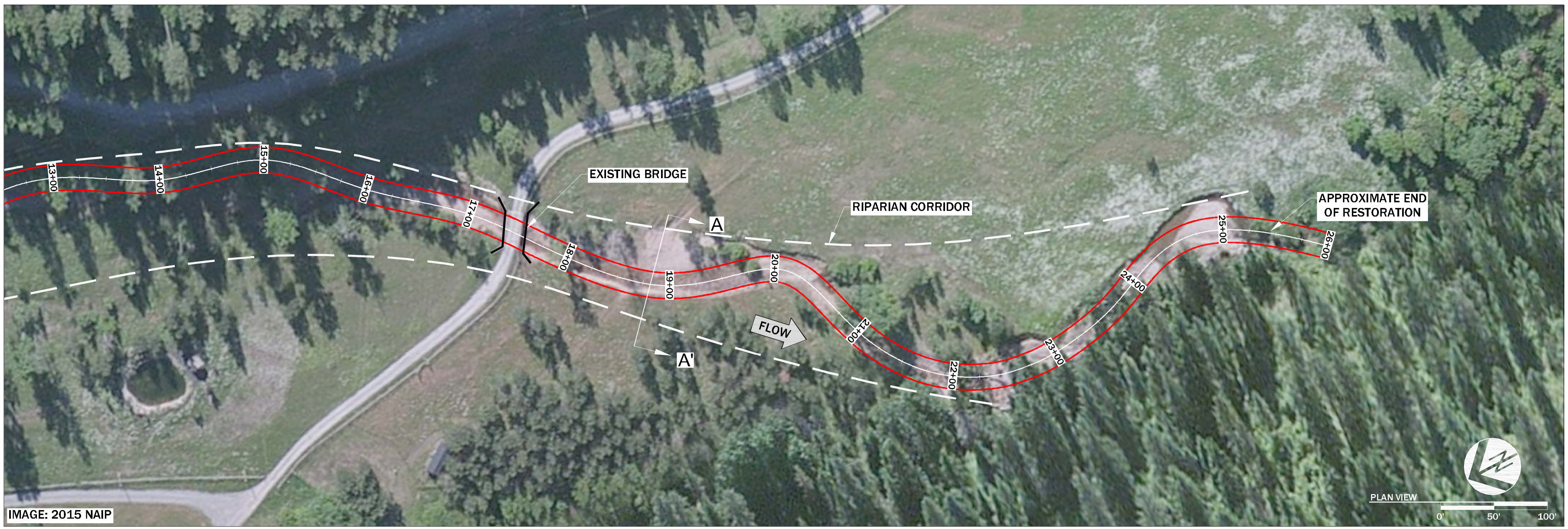

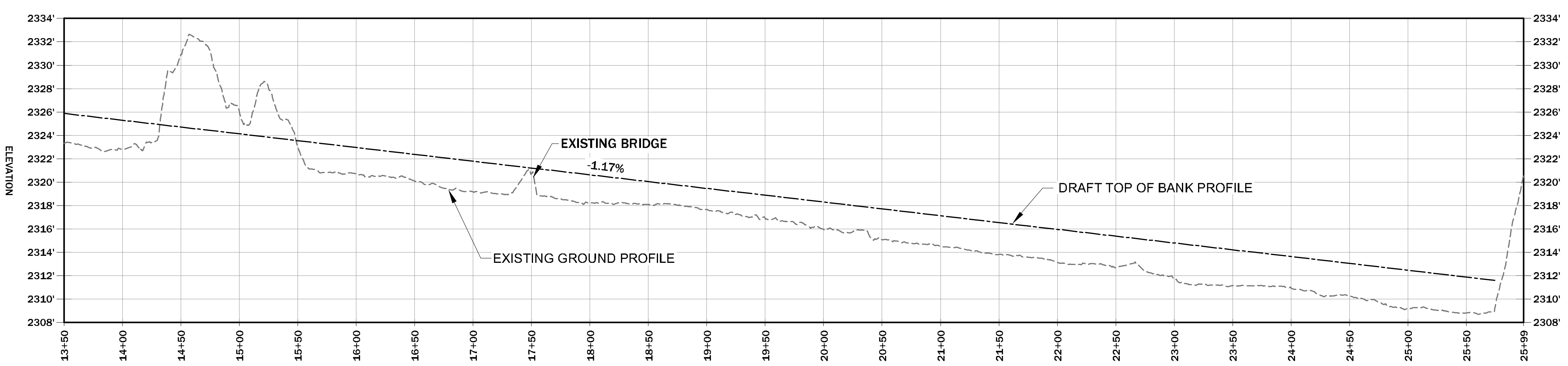

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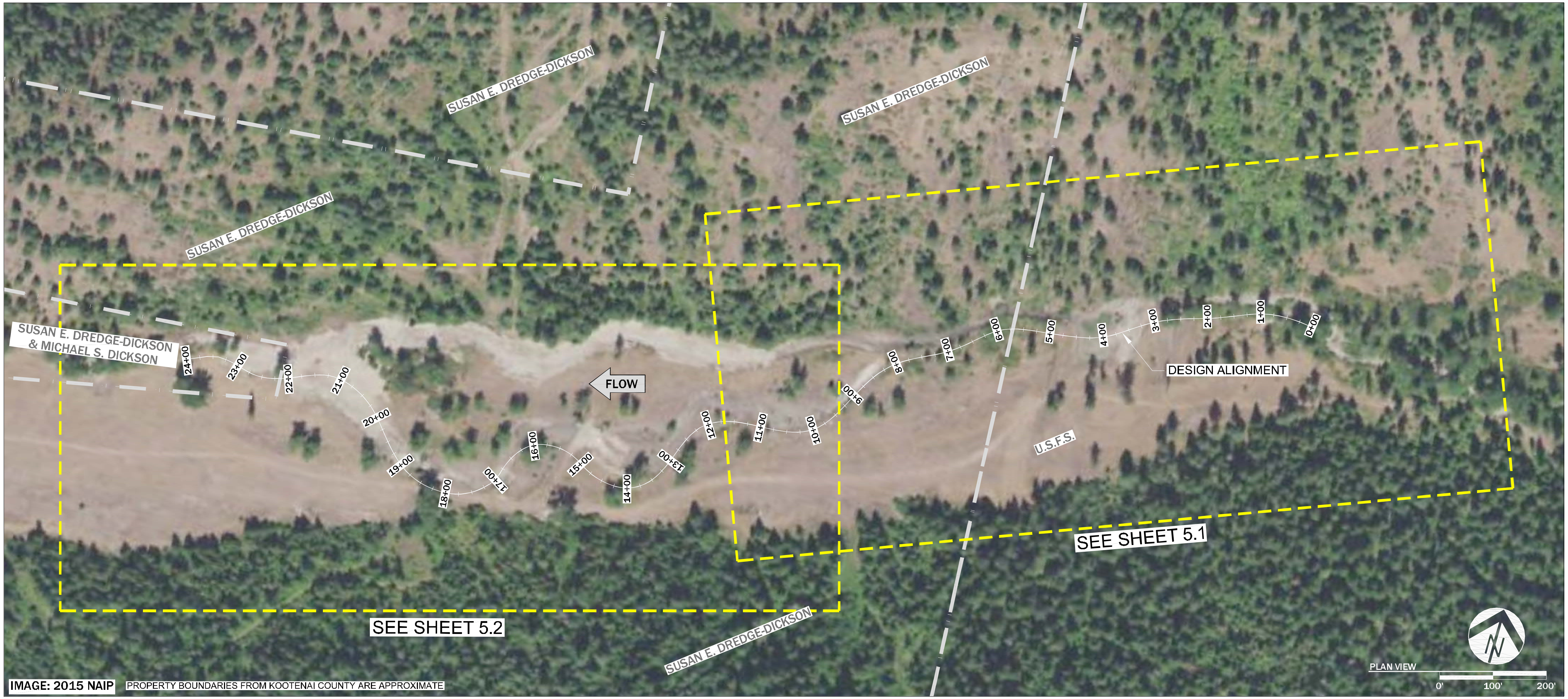
CONCEPTUAL RESTORATION PLAN
LONESOME CREEK STREAM AND FLOODPLAIN RESTORATION

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	GRR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
4.2



EXISTING CONDITIONS

MARIE CREEK IS A THIRD ORDER TRIBUTARY TO WOLF LODGE CREEK AND COMPRISES APPROXIMATELY 29% OF THE WOLF LODGE CREEK WATERSHED AREA. THE PROJECT AREA OCCURS IN REACH 2 OF MARIE CREEK, AND CONSISTS OF A 0.45 MILE (2,400 FEET) REACH THAT WAS SUBJECT TO A CHANNEL AVULSION THAT RESULTED IN FLOODPLAIN DISCONNECTION AND CHANNEL INSTABILITY. EFFORTS TO STABILIZE THE CHANNEL HAVE INCLUDED PLACEMENT OF LARGE WOOD STRUCTURES AND SHAPING/EXCAVATING THE STREAMBED AND STREAMBANKS TO INCREASE CHANNEL CAPACITY. A SEDIMENT TRAP IS LOCATED AT THE TOP OF THE PROJECT AREA AND WAS INSTALLED TO TRAP BEDLOAD ORIGINATING FROM UPSTREAM REACHES. THIS REACH OF MARIE CREEK EXPERIENCES INTERMITTENT HYDROLOGY, AND IN MOST YEARS, THE CHANNEL IS DEWATERED IN THE SUMMER MONTHS. ATTEMPTS TO STABILIZE AND RESTORE MARIE CREEK HAVE RESULTED IN CHANNEL WIDENING AND FLOODPLAIN DISCONNECTION. THE REACH IS UNLIKELY TO REACH EQUILIBRIUM DUE TO THE IMPAIRED CHANNEL GEOMETRY.

RESTORATION OBJECTIVES

THE CONCEPTUAL DESIGN FOR MARIE CREEK IN REACH 2 ADDRESSES LIMITING FACTORS IDENTIFIED IN THE WATERSHED ASSESSMENT. THE PRIMARY OBJECTIVE IS TO RECONSTRUCT A NEW CHANNEL WITH IMPROVED FUNCTION THAT SUPPORTS NATURAL FLUVIAL PROCESSES. OBJECTIVES RELATED TO CHANNEL MORPHOLOGY, AQUATIC HABITAT, AND FLOODPLAIN RESOURCES INCLUDE:

- PRODUCE CLEAN WATER CONSISTENT WITH SUPPORTING AQUATIC LIFE AND BENEFICIAL USES.
- CREATE COMPLEX AQUATIC HABITAT COMPONENTS SUCH AS DEPTH, VELOCITY, SUBSTRATE, COVER, AND POOLS THAT SUPPORT POPULATIONS OF WILD TROUT AND OTHER AQUATIC ORGANISMS.
- CONSTRUCT A STREAM CHANNEL THAT IS CONNECTED TO THE FLOODPLAIN AND INTERACTS WITH THE CHANNEL IN TERMS OF SURFACE FLOW AND SEDIMENT AND NUTRIENT EXCHANGE.
- MAXIMIZE RIPARIAN AND FLOODPLAIN HABITATS, AND UTILIZE EXISTING FLOODPLAIN SURFACES TO THE GREATEST EXTENT PRACTICAL.
- REMOVE THE EXISTING USFS SEDIMENT TRAP AND ON-STREAM POND.
- CONVERT PORTIONS OF THE EXISTING CHANNEL TO OFF-CHANNEL, DISCONNECTED OXBOW WETLANDS.
- COORDINATE RESTORATION PLANS WITH THE LANDOWNER TO ENSURE RESTORATION TREATMENTS ARE COMPATIBLE WITH EXISTING AND FUTURE LAND USES.

RESTORATION TREATMENTS

RESTORATION WORK WILL OCCUR ALONG 2,400 FEET OF CHANNEL BEGINNING APPROXIMATELY 300 FEET UPSTREAM OF THE EXISTING USFS SEDIMENT TRAP AND CONTINUING DOWNSTREAM TO THE EXISTING PRIVATE BRIDGE. THE PROJECT WILL BE IMPLEMENTED IN TWO PHASES. RESTORATION WILL OCCUR DURING LOW FLOW CONDITIONS OR WHEN MARIE CREEK IS DRY TO MINIMIZE IMPACTS TO WATER QUALITY.

PHASE ONE INCLUDES SHAPING OF THE CHANNEL STREAMBED, INCLUDING RIFFLES, RUNS, POOLS AND GLIDES, AND INSTALLING THE STREAMBED AND STREAMBANK STRUCTURES. TREATMENTS ARE NATIVE MATERIALS BASED AND DESIGNED TO MIMIC NATURALLY OCCURRING COMPONENTS OF A HEALTHY, FUNCTIONING STREAM CHANNEL AND FLOODPLAIN ECOSYSTEM. STREAMBANK TREATMENTS WILL BE COMPOSED OF WOOD, ALLUVIUM, AND VEGETATION, AND WILL INCREASE BANK RESISTANCE TO EROSION, PROVIDING FOR SHORT-TERM STREAMBED STABILITY REQUIRED TO SUPPORT THE VEGETATION DESIGN WHICH EMPHASIZES CREATING A SELF-SUSTAINING MOSAIC OF RIPARIAN AND WETLAND COMMUNITIES ON A FLOODPLAIN THAT IS HYDROLOGICALLY CONNECTED TO THE CHANNEL. UNDER PHASE ONE, THE CHANNEL WILL BE SHAPED AND THE HABITAT ENHANCED THROUGH PLACEMENT OF WOOD AND BANK RESTORATION TREATMENTS, AND THE EXISTING SEDIMENT TRAP WILL BE RECLAIMED.

PHASE 2 INCLUDES IMPLEMENTATION OF THE FLOODPLAIN TREATMENTS WHICH INCLUDES SIDE CHANNELS AND A VARIETY OF VEGETATION COVER TYPES THAT INTEGRATE PLANT SPECIES COMPOSITION WITH GEOMORPHOLOGY AND HYDROLOGY, AND ACCOUNT FOR ECOLOGICAL PROCESSES THAT SUPPORT PLANT COMMUNITY DEVELOPMENT OVER TIME. FLOODPLAIN TREATMENTS WILL INCLUDE THE USE OF SWALES, SIDE CHANNELS, OFF-CHANNEL WETLANDS, MICROTOPOGRAPHY, COARSE WOOD, PLANTINGS, AND SEEDING. FOLLOWING INSTALLATION OF FLOODPLAIN, CHANNEL AND STREAMBANK TREATMENTS, STREAMFLOW WILL BE INCREMENTALLY REINTRODUCED INTO THE NEW CHANNEL, AND THE EXISTING CHANNEL BACKFILLED AND RECLAIMED. PHASE 2 ALSO INCLUDES DEVELOPMENT OF OFF-CHANNEL OXBOW WETLANDS THAT WILL CONSIST OF BOTH EMERGENT (HERBACEOUS) AND SHALLOW TO DEEP, OPEN WATER PONDS.

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SITE PLAN
MARIE CREEK STREAM AND FLOODPLAIN RESTORATION

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PROJECT NUMBER
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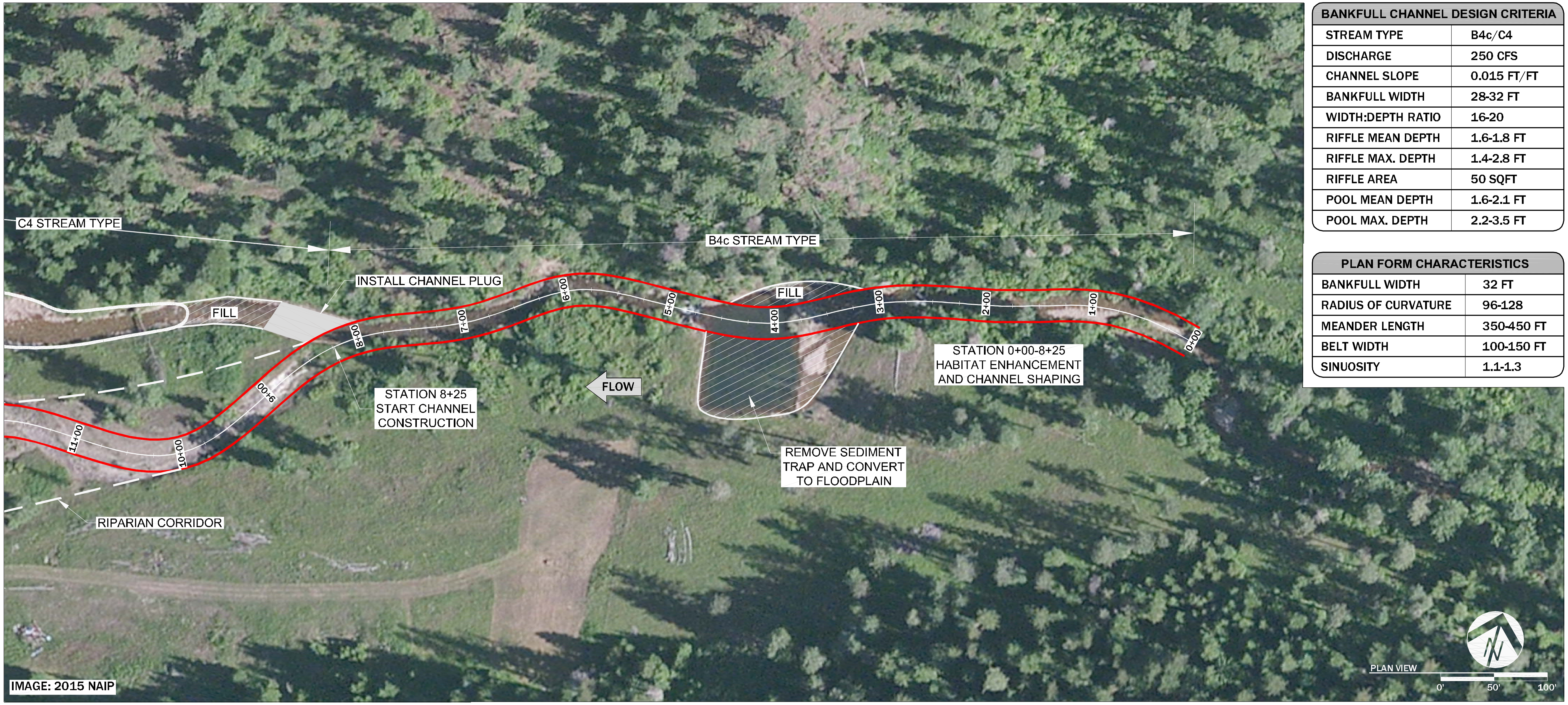
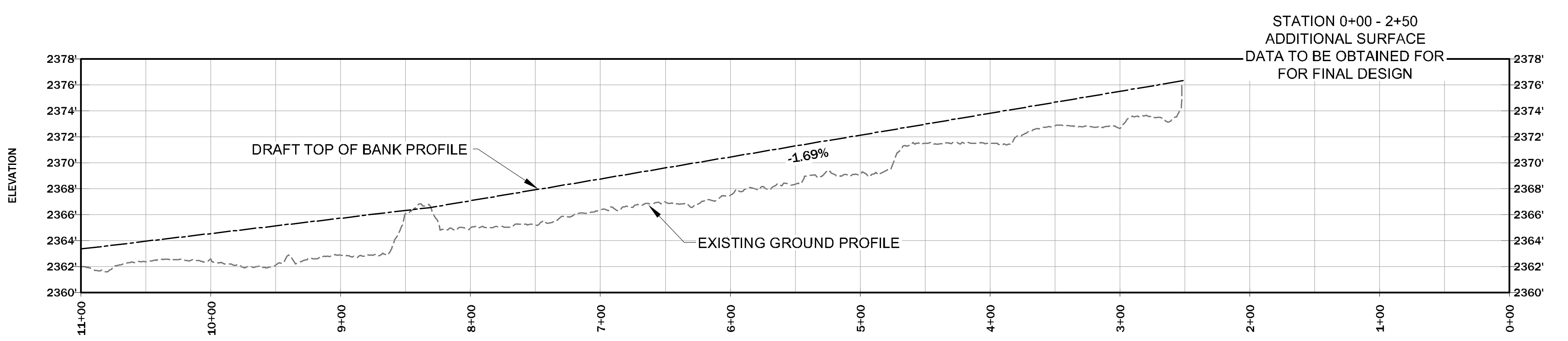


BANKFULL CHANNEL DESIGN CRITERIA	
STREAM TYPE	B4c/C4
DISCHARGE	250 CFS
CHANNEL SLOPE	0.015 FT/FT
BANKFULL WIDTH	28-32 FT
WIDTH:DEPTH RATIO	16-20
RIFFLE MEAN DEPTH	1.6-1.8 FT
RIFFLE MAX. DEPTH	1.4-2.8 FT
RIFFLE AREA	50 SQFT
POOL MEAN DEPTH	1.6-2.1 FT
POOL MAX. DEPTH	2.2-3.5 FT

PLAN FORM CHARACTERISTICS	
BANKFULL WIDTH	32 FT
RADIUS OF CURVATURE	96-128
MEANDER LENGTH	350-450 FT
BELT WIDTH	100-150 FT
SINUOSITY	1.1-1.3



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CONCEPTUAL RESTORATION PLAN
MARIE CREEK STREAM AND FLOODPLAIN RESTORATION

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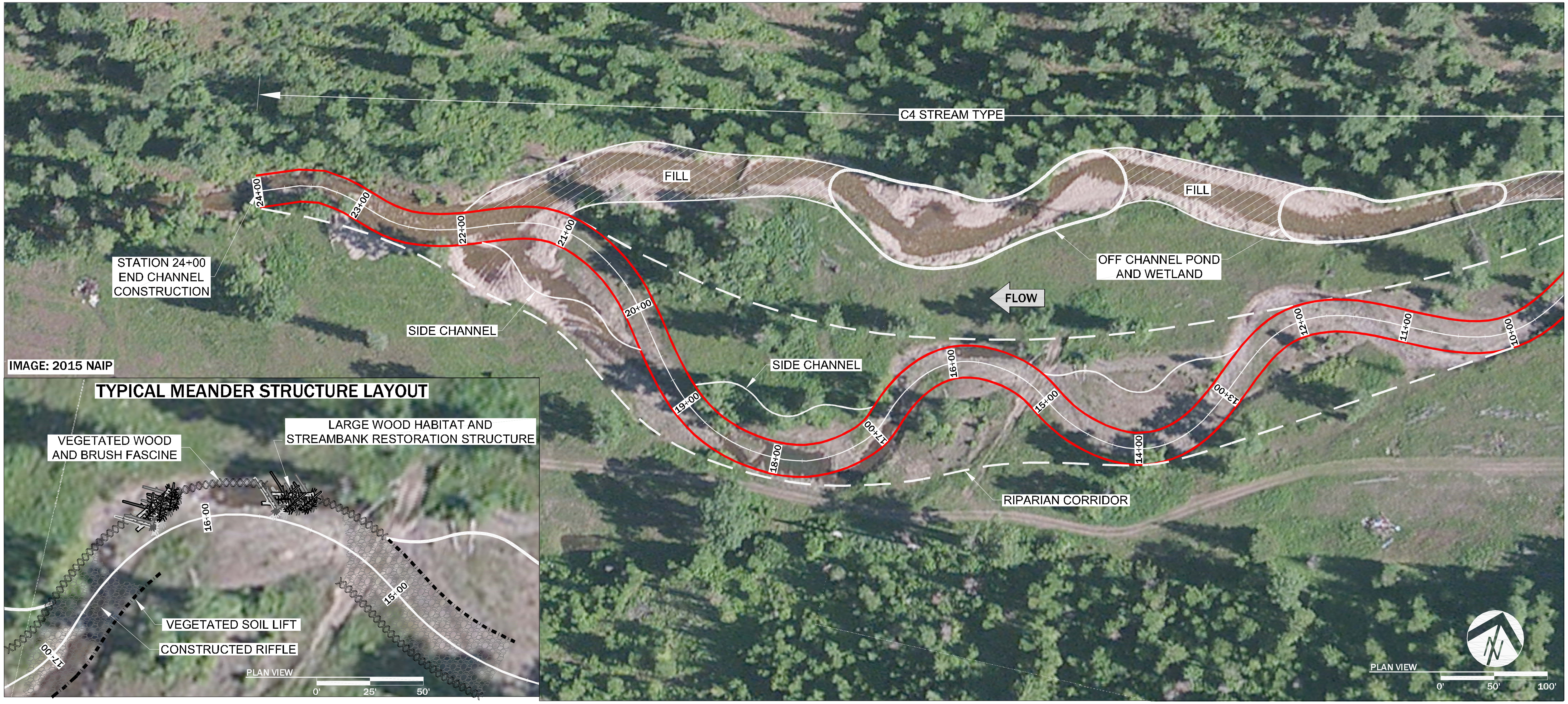

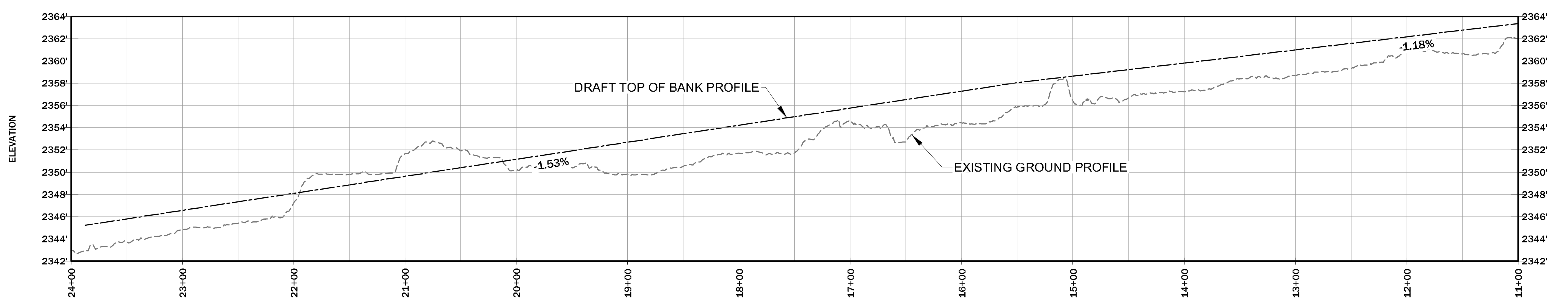

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MARIE CREEK STREAM AND FLOODPLAIN RESTORATION

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SHEET NUMBER
5.2

EXISTING CONDITIONS

WOLF LODGE CREEK REACH 3 (WLC3) BEGINS AT THE CONFLUENCE OF MARIE CREEK AND WOLF LODGE CREEK AND EXTENDS DOWNSTREAM TO THE WOLF LODGE CREEK ROAD BRIDGE. THE REACH ENCOMPASSES THE MAJORITY OF THE RESIDENTIAL DEVELOPMENTS IN THE WATERSHED AND HAS CONTINUED PROBLEMS WITH BANK STABILITY AND PROPERTY LOSS DUE TO STREAMBANK EROSION. IN REACH 3, WOLF LODGE CREEK IS CLASSIFIED AS A MEANDERING, RIFFLE-POOL, C4 STREAM TYPE, WITH INCLUSIONS OF BRAIDED, MULTI-THREADED CHANNEL CONDITIONS. SEDIMENT LOADING DUE TO CHANNEL ALTERATIONS, REMOVAL OF RIPARIAN VEGETATION, AND RAPID BANK EROSION IS A CONCERN THROUGHOUT THE REACH, AND PREVIOUS EFFORTS TO MITIGATE BANK EROSION AND PROPERTY LOSS HAVE INCLUDED HARD BANK STABILIZATION MEASURES INCLUDING PLACEMENT OF ROCK BARBS AND RIP-RAP. APPROXIMATELY 10% OF THE STREAMBANKS IN WLC3 HAVE BEEN STABILIZED WITH HARDENED REVETMENT. BASED ON REACH AVERAGED CONDITIONS, AN ESTIMATED 830 TONS OF SEDIMENT ARE PRODUCED ANNUALLY FROM BANK EROSION RELATED SOURCES OF SEDIMENT IN WLC3.

RESTORATION OBJECTIVES

THIS CONCEPTUAL PLAN ADDRESSES SEVERAL LARGE MEANDERS BENDS THAT ARE MIGRATING AT ACCELERATED RATES. THE PROJECT AREA WAS THE SITE OF A GEOMAX PROJECT DESIGNED TO REDUCE BANK MIGRATION WITH TREE BARBS AND SMALL ROCK CHECK FEATURES. THE PROJECTS FAILED TO REDUCE THE RATES OF BANK MIGRATION AND IN SOME INSTANCES EXACERBATED STREAMBANK INSTABILITY.

THE CONCEPTUAL DESIGN FOR WOLF LODGE CREEK IN REACH 3 ADDRESSES LIMITING FACTORS IDENTIFIED IN THE WATERSHED ASSESSMENT. THE PROJECT OBJECTIVE IS TO RE-ESTABLISH PROPER CHANNEL DIMENSIONS AND STREAMBANK CONDITIONS THAT WILL REDUCE RATES OF LATERAL CHANNEL MIGRATION, PROPERTY LOSS, AND SEDIMENTATION. OBJECTIVES INCLUDE:

- PRODUCE CLEAN WATER CONSISTENT WITH SUPPORTING AQUATIC LIFE AND BENEFICIAL USES.
- INCORPORATE STREAMBANK STABILIZATION TECHNIQUES THAT PROVIDE INTERIM STABILITY AND SUPPORT DEVELOPMENT OF MATURE RIPARIAN VEGETATION.
- REMOVE THE EXISTING SEDIMENT TRAP AND ROCK WEIR.
- CREATE COMPLEX AQUATIC HABITAT COMPONENTS SUCH AS DEPTH, VELOCITY, SUBSTRATE, COVER, AND POOLS THAT SUPPORT POPULATIONS OF WILD TROUT AND OTHER AQUATIC ORGANISMS.
- RESHAPE THE EXISTING CHANNEL TO THE PROPER DIMENSIONS TO INCREASE SEDIMENT TRANSPORT CAPACITY THROUGH THE REACH.
- COORDINATE RESTORATION PLANS WITH THE LANDOWNER TO ENSURE RESTORATION TREATMENTS ARE COMPATIBLE WITH EXISTING AND FUTURE LAND USES.

RESTORATION TREATMENTS

RESTORATION WORK WILL OCCUR ALONG APPROXIMATELY 1,200 FEET OF CHANNEL ON TWO PRIVATE PROPERTIES. THE PROJECT WILL BE IMPLEMENTED IN TWO PHASES. RESTORATION WILL OCCUR DURING LOW FLOW CONDITIONS OR WHEN WOLF LODGE CREEK IS DRY TO MINIMIZE IMPACTS TO WATER QUALITY.

PHASE ONE INCLUDES SITE DEWATERING. TEMPORARY BYPASS CHANNELS WILL BE CONSTRUCTED WHERE NECESSARY TO ISOLATE THE WORK AREA. EXISTING SIDE CHANNELS WILL ALSO BE USED AS TEMPORARY DIVERSIONS WHERE FEASIBLE. FOLLOWING DEWATERING, THE STREAM CHANNEL WILL BE SHAPED TO THE APPROPRIATE DIMENSIONS INCLUDING RIFFLE, RUN, POOL AND GLIDE HABITAT FEATURES. FOLLOWING CHANNEL SHAPING, STREAMBANK TREATMENTS WILL BE INSTALLED AT THE LOCATIONS SHOWN ON THE DRAWINGS. TREAMBANK TREATMENTS WILL BE COMPOSED OF WOOD, ALLUVIUM, AND VEGETATION, AND WILL INCREASE BANK RESISTANCE TO EROSION. UNDER PHASE ONE, THE EXISTING SEDIMENT TRAP AND ROCK WEIR WILL BE REMOVED.

PHASE 2 INCLUDES IMPLEMENTATION OF THE FLOODPLAIN TREATMENTS WHICH INCLUDE FLOODPLAIN MICROTOPOGRAPHY, PLANTINGS, AND SEEDING. IN ADDITION, EXISTING VEGETATION WILL BE SALVAGED AND TRANSPLANTED ON TO CONSTRUCTED STREAMBANK SURFACES. STREAMFLOW WILL BE INCREMENTALLY REINTRODUCED INTO THE NEW CHANNEL, AND SEGMENTS OF THE EXISTING CHANNEL WILL BE BACKFILLED AND RECLAIMED.

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SITE PLAN
WOLF LODGE CREEK REACH 3 STREAMBANK RESTORATION

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

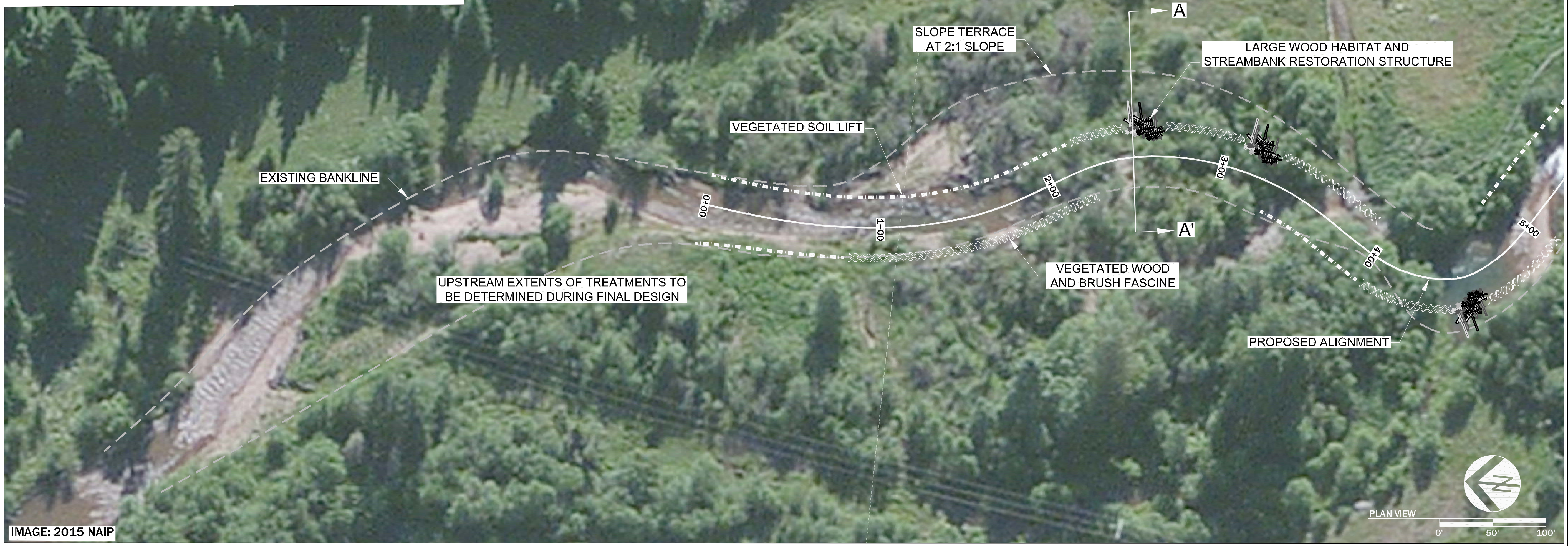
PRELIMINARY -NOT FOR CONSTRUCTION-

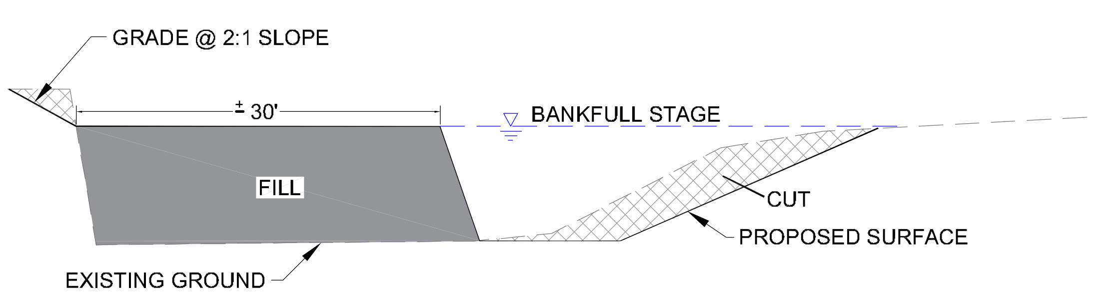
PROJECT NUMBER
RDG-16-005

SHEET NUMBER
6.0

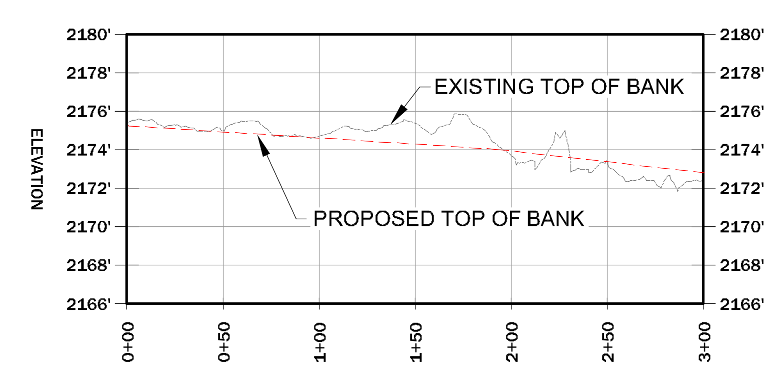
LEGEND

STRUCTURES	DETAIL SHEET #
SINGLE VEGETATED SOIL LIFT	9.0
VEGETATED WOOD AND BRUSH FASCINE	9.2
LARGE WOOD HABITAT AND STREAMBANK RESTORATION STRUCTURE	9.3





PLAN VIEW
A - A' NTS



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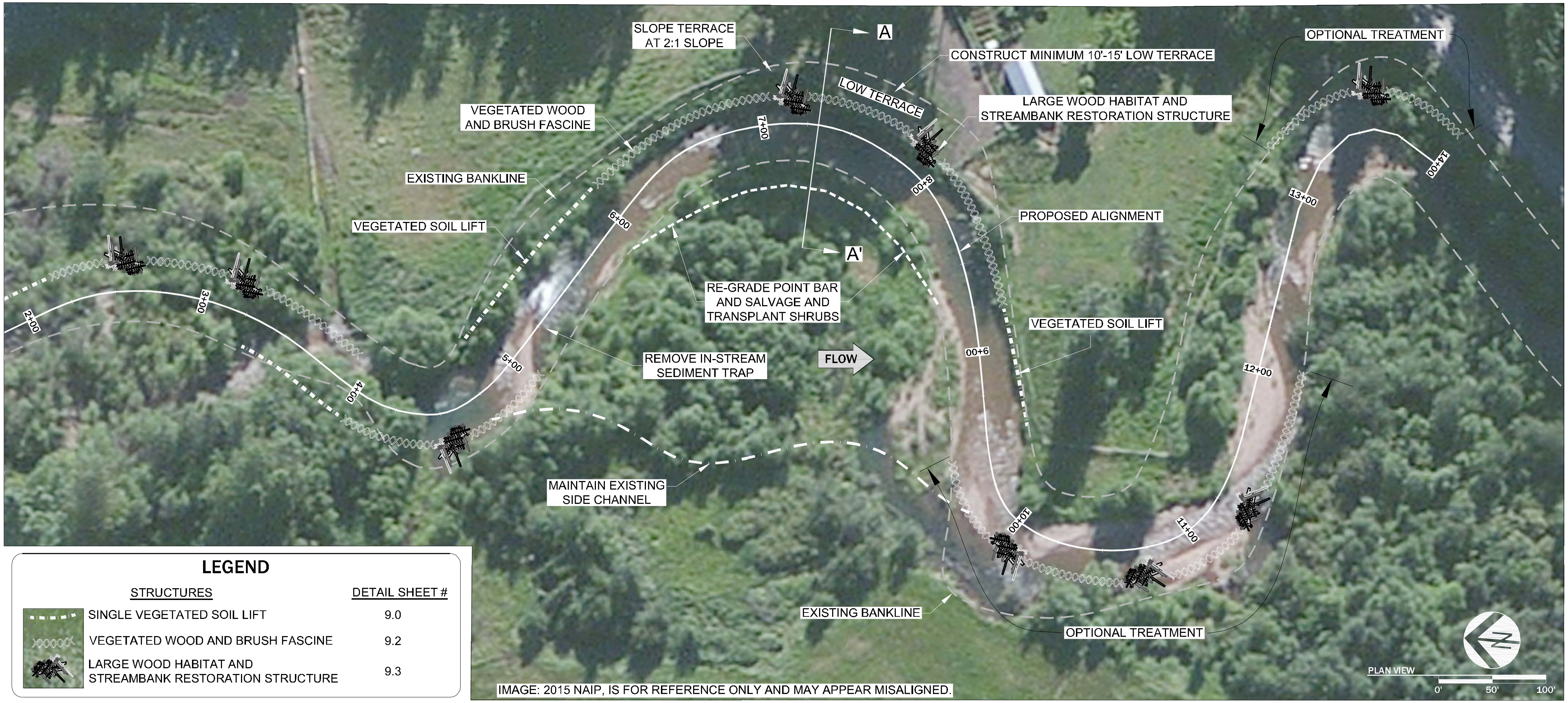
CONCEPTUAL RESTORATION PLAN
WOLF LODGE CREEK REACH 3
STREAMBANK RESTORATION

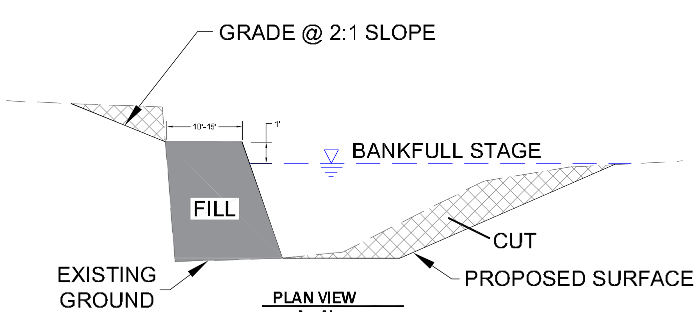
NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

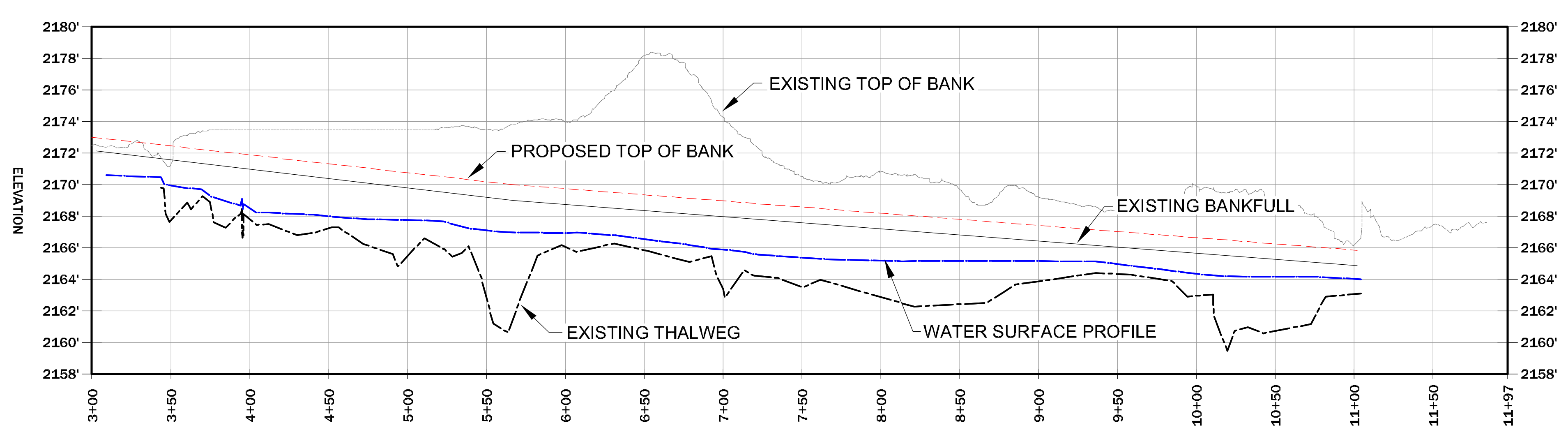
PRELIMINARY
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
6.1







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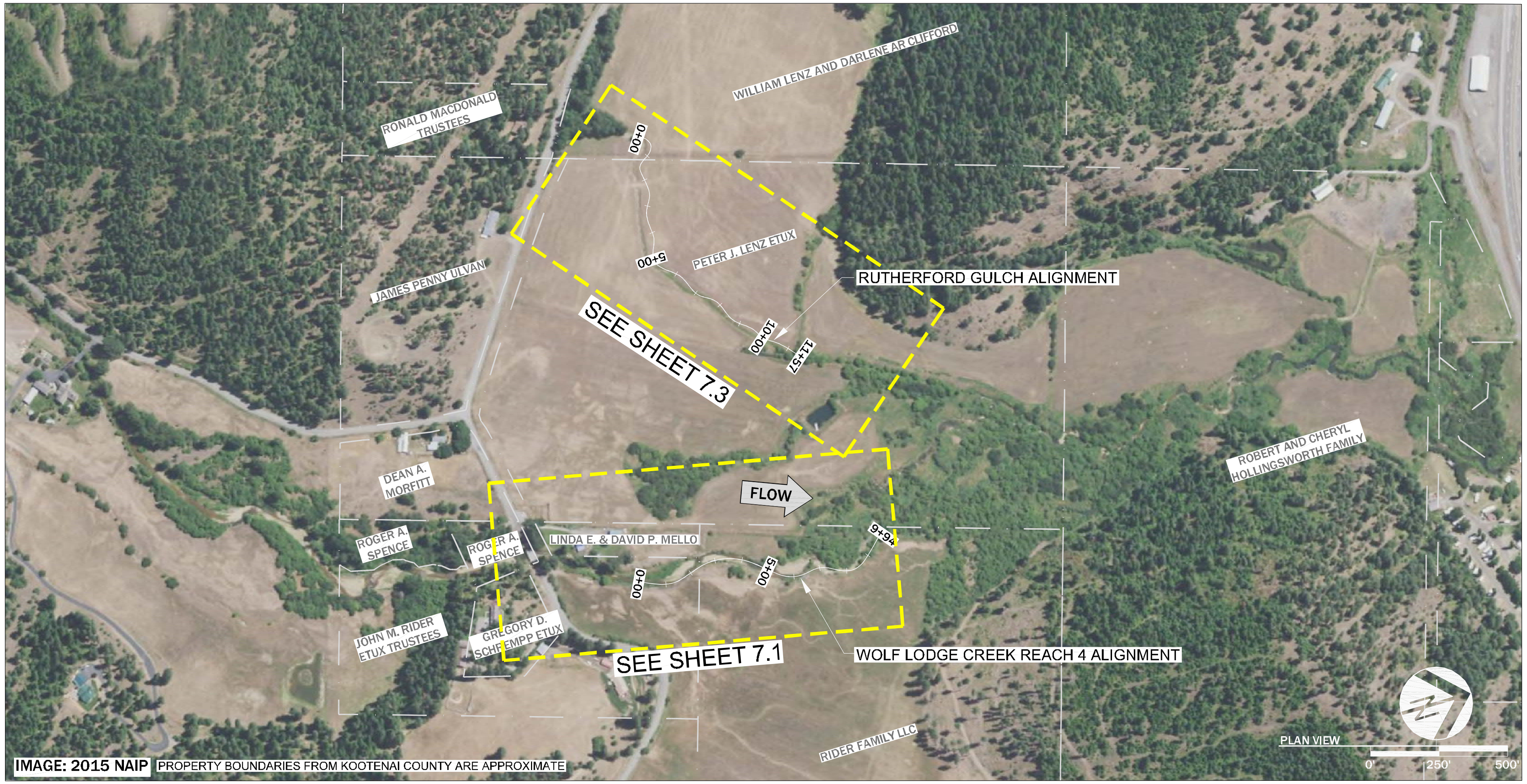
CONCEPTUAL RESTORATION PLAN
WOLF LODGE CREEK REACH 3
STREAMBANK RESTORATION

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
6.2



RESTORATION ALTERNATIVES

WOLF LODGE CREEK REACH 4 (WLC4) BEGINS AT THE WOLF LODGE CREEK ROAD BRIDGE AND EXTENDS DOWNSTREAM TO THE INTERSECTION OF WOLF LODGE CREEK AND INTERSTATE 90. LAND USE IN REACH 4 IS DOMINATED BY AGRICULTURE AND GRAZING. RIPARIAN VEGETATION IN THE UPPER PORTION OF REACH 4 IS LACKING, AND THE CHANNEL IS ENTRENCHED AND SUBJECT TO SEVERE BANK INSTABILITY, LARGELY DRIVEN BY CHANNEL DREDGING EFFORTS TO INCREASE SEDIMENT TRANSORT CAPACITY AND REDUCE FLOODING OF ADJACENT PASTURE AND AGRICULTURAL LAND. WHERE A WOODY RIPARIAN COMPONENT IS PRESENT, OLD AND DECADENT ALDER TREES AND SHRUBS, BEBB'S WILOW, NINEBARK, AND LARGE BLACK COTTONWOOD TREES CHARACTERIZE THE VEGETATION COMMUNITY. IN THE UPPER SEGMENT OF REACH 4, THE NATURAL FUNCTION AND STRUCTURE OF RIPARIAN VEGETATION IS ALTERED, AND RESTORATION ACTIONS INCLUDING CATTLE EXCLUSION, INVASIVE PLANT SPECIES SUPPRESSION, AND ESTABLISHING PROPER CHANNEL DIMENSIONS AND FLOODPLAIN CONNECTIVITY ARE RECOMMENDED.

LANDOWNERS IN WLC4 DREDGE AND REMOVE SEDIMENT FROM THE CHANNEL. THIS PROCESS OF LOWERING THE BED THROUGH SEDIMENT REMOVAL HAS LOWERED THE WATER TABLE, INCREASED BANK HEIGHTS, AND CONCENTRATED FLOW, WHICH HAS RESULTED IN BANK INSTABILITY AND ACCELERATED MEANDER MIGRATION, PARTICULARLY IN THE UPPER PORTION OF THE REACH. REACH-AVERAGED SEDIMENT YIELD FROM BANK EROSION WAS ESTIMATED AT 281 TONS PER YEAR, ACCOUNTING FOR 14% OF THE TOTAL SEDIMENT LOAD DERIVED FROM BANK EROSION IN WOLF LODGE CREEK.

RUTHERFORD GULCH IS A THIRD ORDER TRIBUTARY TO WOLF LODGE CREEK AND JOINS WLC4 IN THE MIDDLE PORTION OF THE REACH. THE MAJORITY OF THE SUB-BASIN IS PRIVATELY OWNED AND CATTLE GRAZING AND AGTICULTURAL ACTIVITIES ARE THE DOMINANT LAND USE PRACTICES. THE LOWER PORTION OF RUTHERFORD GULCH (REACH 3) WAS HISTORICALLY CHANNELIZED AND RELOCATED TO THE BOUNDARY BETWEEN PROPERTIES IN THE LATE 1800S TO EARLY 1900S TO ACCOMMODATE AGRICULTURAL LAND USE PRACTICES. PERIODIC DREDGING HAS OCCURRED IN THE 1900S WHICH HAS LED TO SEVERE CHANNEL INCISION AND LOSS OF FLOODPLAIN CONNECTIVITY. RUTHERFORD GULCH EXPERIENCES INTERMITTENT HYDROLOGY, AND THE CHANNEL IN REACH 3 IS IN A STATE OF DISEQUILIBRIUM.

RESTORATION OBJECTIVES

THE CONCEPTUAL DESIGN FOR WLC4 IS FOCUSED IN THE UPPER PORTION OF WLC4 AND REACH 3 OF RUTHERFORD GULCH, AND ADDRESSES LIMITING FACTORS IDENTIFIED IN THE WATERSHED ASSESSMENT. THE PROJECT OBJECTIVES ARE TO RE-ESTABLISH PROPER CHANNEL DIMENSIONS AND STREAMBANK CONDITIONS THAT WILL REDUCE RATES OF LATERAL CHANNEL MIGRATION, PROPERTY LOSS, AND SEDIMENTATION, WHILE IMPROVING AQUATIC HABITAT CONDITIONS. OBJECTIVES INCLUDE:

- PRODUCE CLEAN WATER CONSISTENT WITH SUPPORTING AQUATIC LIFE AND BENEFICIAL USES.
- INCORPORATE STREAMBANK STABILIZATION TECHNIQUES THAT PROVIDE INTERIM STABILITY AND SUPPORT DEVELOPMENT OF MATURE RIPARIAN VEGETATION.
- ESTABLISH INSET FLOODPLAINS ON WLC4 AND REACH 3 RUTHERFORD GULCH TO REDUCE FLOOD HAZARD TO ADJACENT PASTURE AND AGRICULTURAL LANDS.
- CREATE COMPLEX AQUATIC HABITAT COMPONENTS SUCH AS DEPTH, VELOCITY, SUBSTRATE, COVER, AND POOLS THAT SUPPORT POPULATIONS OF WILD TROUT AND OTHER AQUATIC ORGANISMS.
- RESHAPE THE EXISTING CHANNELS TO THE PROPER DIMENSIONS TO INCREASE SEDIMENT TRANSPORT CAPACITY THROUGH THE REACHES.
- COORDINATE RESTORATION PLANS WITH THE LANDOWNER TO ENSURE RESTORATION TREATMENTS ARE COMPATIBLE WITH EXISTING AND FUTURE LAND USES.

RESTORATION TREATMENTS

RESTORATION WORK WILL OCCUR ALONG APPROXIMATELY 1,070 FEET OF CHANNEL IN WLC4 AND 1,250 FEET IN REACH 3 RUTHERFORD GULCH. RUTHERFORD GULCH WILL BE CONSTRUCTED WHEN THE CHANNEL IS DEWATERED. WATER MANAGEMENT IN WLC4 WILL BE ADDRESSED DURING THE PROJECT DESIGN PHASE. WORK WILL BE COMPLETED IN TWO PHASES.

PHASE ONE INCLUDES SHAPING OF THE CHANNEL STREAMBED, INCLUDING RIFFLES, RUNS, POOLS AND GLIDES, AND INSTALLING THE STREAMBED AND STREAMBANK STRUCTURES. TREATMENTS ARE NATIVE MATERIALS BASED AND DESIGNED TO MIMIC NATURALLY OCCURRING COMPONENTS OF A HEALTHY, FUNCTIONING STREAM CHANNEL AND FLOODPLAIN ECOSYSTEM. INSET FLOODPLAINS ARE PROPOSED FOR BOTH WLC4 AND REACH 3 RUTHERFORD GULCH. THE INTENT OF THE INSET FLOODPLAINS IS TO PROVIDE SUFFICIENT FLOOD CARRYING CAPACITY TO CONVEY FLOODWATER IN ORDER TO MINIMIZE IMPACTS AND FLOODING POTENTIAL OF ADJACENT PASTURE AND AGRICULTURAL LANDS. BANKFULL CHANNELS WILL BE CONSTRUCTED TO ACCOMMODATE THE ESTIMATED BANKFULL DISCHARGE (APPROXIMATE 1.5 YEAR RECURRENCE INTERVAL DISCHARGE) AND INSET FLOODPLAINS WILL CONVEY FLOODS OF GREATER MAGNITUDE. DURING PHASE ONE, THE CHANNELS WILL BE CONSTRUCTED TO THE APPROPRIATE DIMENSIONS, AND STREAMBANK TREATMENTS WILL BE INSTALLED ACCORDING TO THE TYPICAL MEANDER SEQUENCE SHOWN ON THE DRAWINGS. TREATMENTS WILL BE COMPOSED OF WOOD, ALLUVIUM, AND VEGETATION, AND WILL INCREASE BANK RESISTANCE TO EROSION.

PHASE 2 INCLUDES IMPLEMENTATION OF THE FLOODPLAIN TREATMENTS WHICH INCLUDE FLOODPLAIN MICROTOPOGRAPHY, PLANTINGS, AND SEEDING. IN ADDITION, EXISTING VEGETATION WILL BE SALVAGED AND TRANSPLANTED ON TO CONSTRUCTED STREAMBANK SURFACES.

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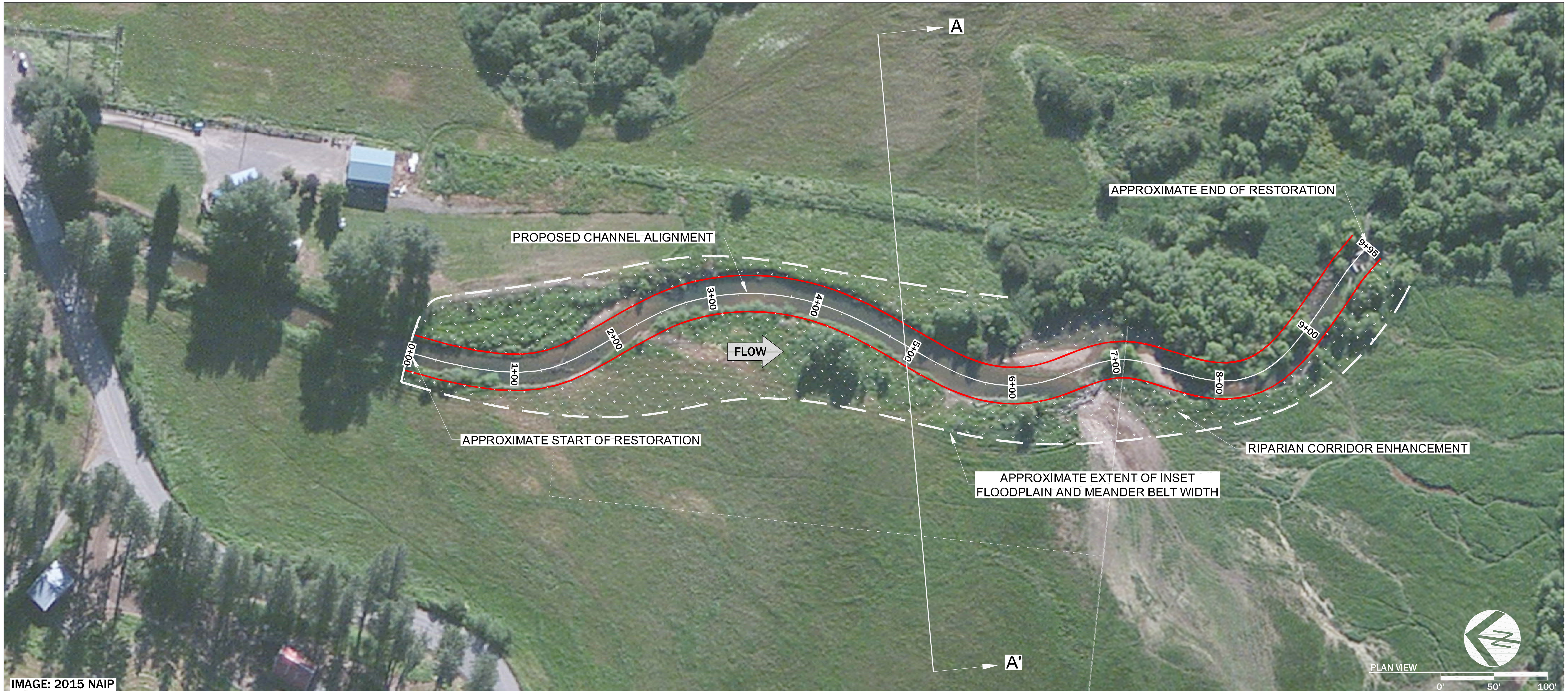
SITE PLAN
WOLF LODGE CREEK REACH 4 AND RUTHERFORD GULCH REACH 2 STREAM AND FLOODPLAIN RESTORATION

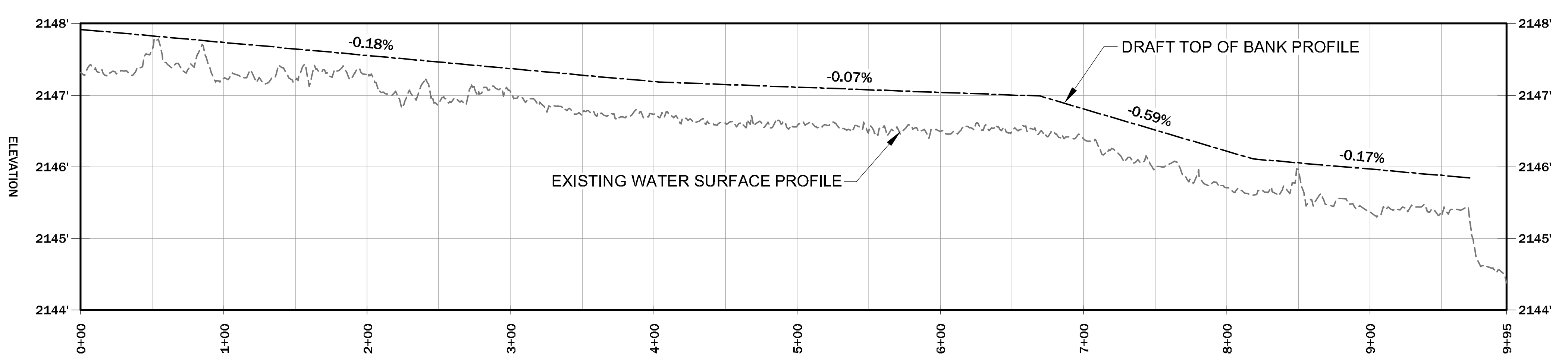
NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
7.0





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CONCEPTUAL RESTORATION PLAN WOLF LODGE CREEK REACH 4 AND RUTHERFORD GULCH REACH 3 STREAM AND FLOODPLAIN RESTORATION

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

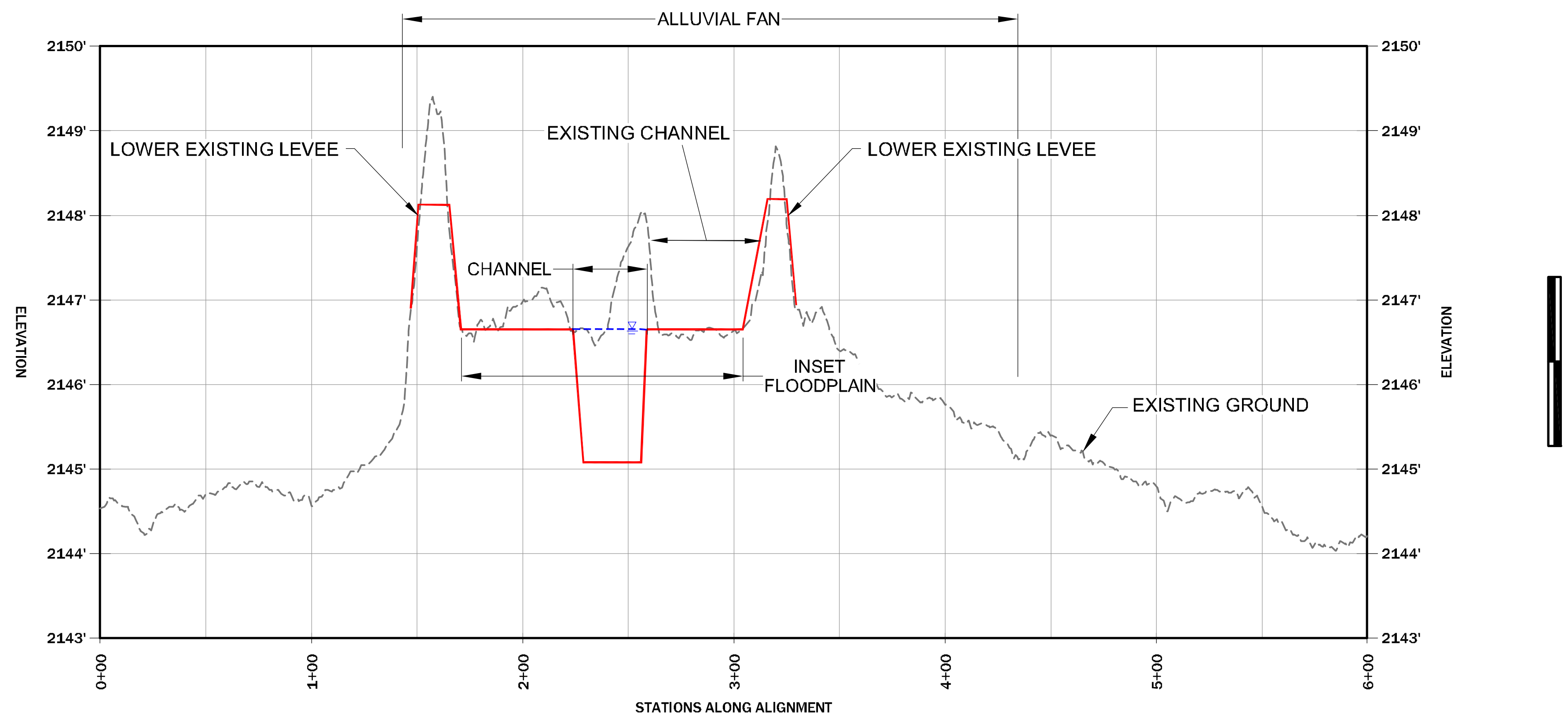
PRELIMINARY
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

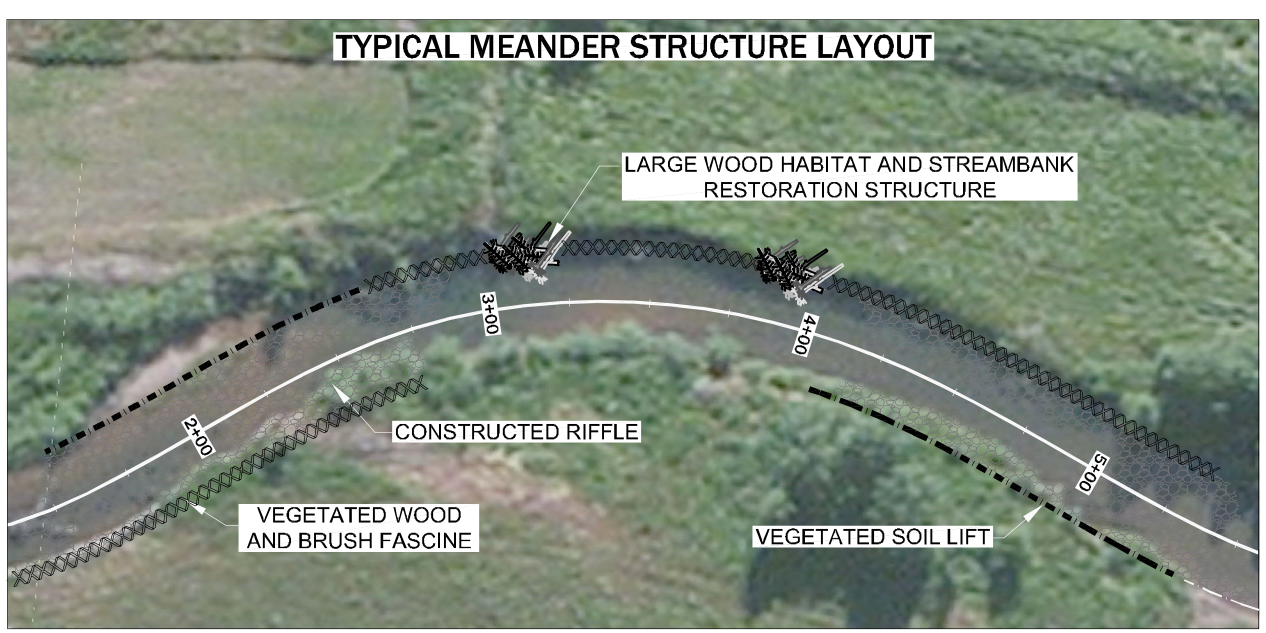
SHEET NUMBER
7.1

BANKFULL CHANNEL DESIGN CRITERIA	
STREAM TYPE	B4c/C4
DISCHARGE	335 CFS
CHANNEL SLOPE	0.06-0.48 FT/FT
BANKFULL WIDTH	32-37 FT
WIDTH:DEPTH RATIO	12-16
RIFFLE MEAN DEPTH	2.3-2.6 FT
RIFFLE MAX. DEPTH	2.2-4.4 FT
RIFFLE AREA	84 SQFT
POOL MEAN DEPTH	2.4-3.2 FT
POOL MAX. DEPTH	3.4-5.4 FT

PLAN FORM CHARACTERISTICS	
BANKFULL WIDTH	32-37 FT
RADIUS OF CURVATURE	100-160
MEANDER LENGTH	350-450 FT
BELT WIDTH	75-140 FT
SINUOSITY	1.1-1.2



SECTION VIEW
A - A'
0' 40' 80'



PLAN VIEW
0' 30' 60'

PHOTO OF EXISTING CONDITIONS IN
WOLF LODGE CREEK REACH 4

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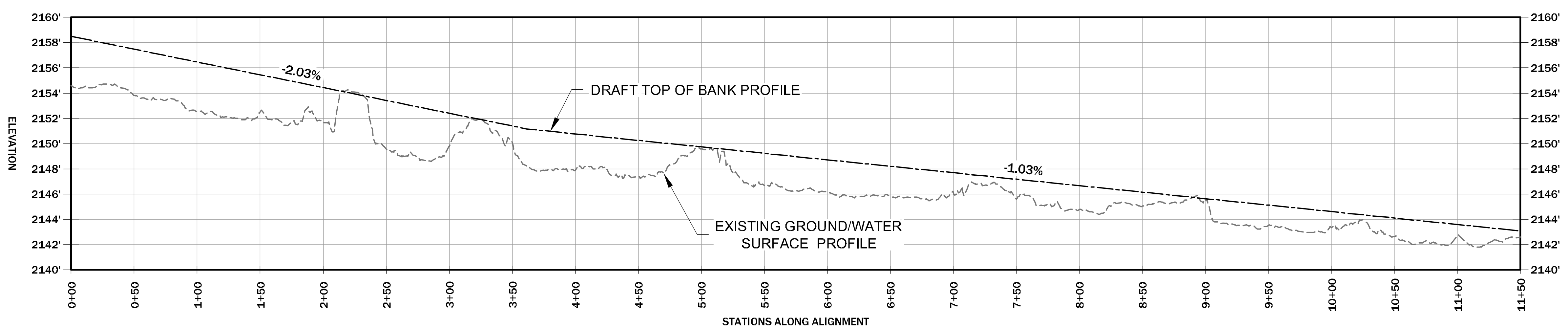
VALLEY CROSS SECTION
WOLF LODGE CREEK REACH 4 AND RUTHERFORD GULCH REACH 3 STREAM AND FLOODPLAIN RESTORATION

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
7.2



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CONCEPTUAL RESTORATION PLAN WOLF LODGE CREEK REACH 4 AND RUTHERFORD GULCH REACH 3 STREAM AND FLOODPLAIN RESTORATION

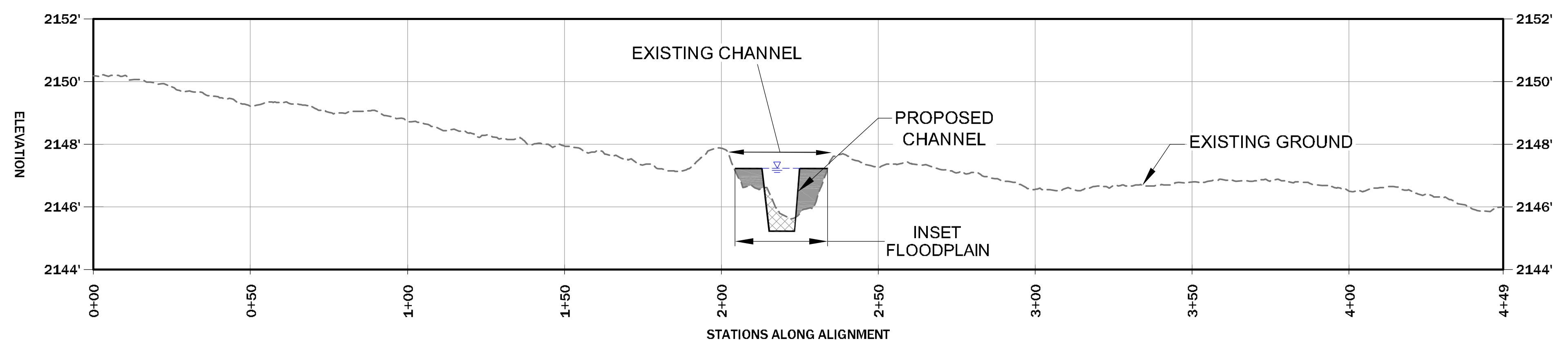
NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	CRR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

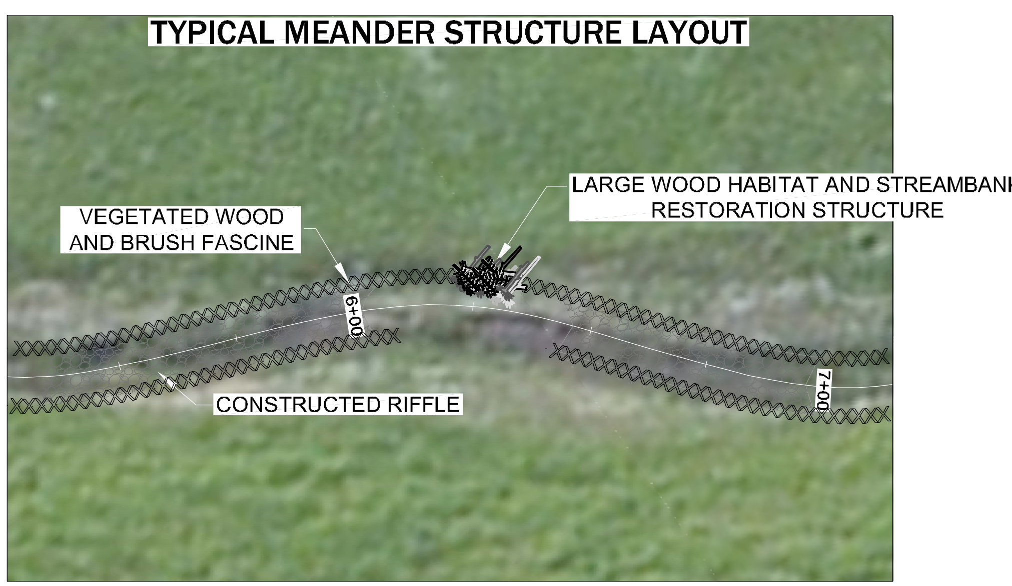
PROJECT NUMBER
RDG-16-005

SHEET NUMBER
7.3

BANKFULL CHANNEL DESIGN CRITERIA	
STREAM TYPE	B4
DISCHARGE	40 CFS
CHANNEL SLOPE	0.01-0.02 FT/FT
BANKFULL WIDTH	9.5-12.2 FT
FLOODPLAIN WIDTH	40-50 FT
WIDTH:DEPTH RATIO	6-10
RIFFLE MEAN DEPTH	1.2-1.6 FT
RIFFLE MAX. DEPTH	1.2-2.5 FT
RIFFLE AREA	15 SQFT
POOL MEAN DEPTH	1.4-1.8 FT
POOL MAX. DEPTH	1.9-3.0 FT



SECTION VIEW
A - A'
0' 25' 50'



PLAN VIEW
0' 20' 40'

PHOTO OF EXISTING CONDITIONS IN RUTHERFORD GULCH

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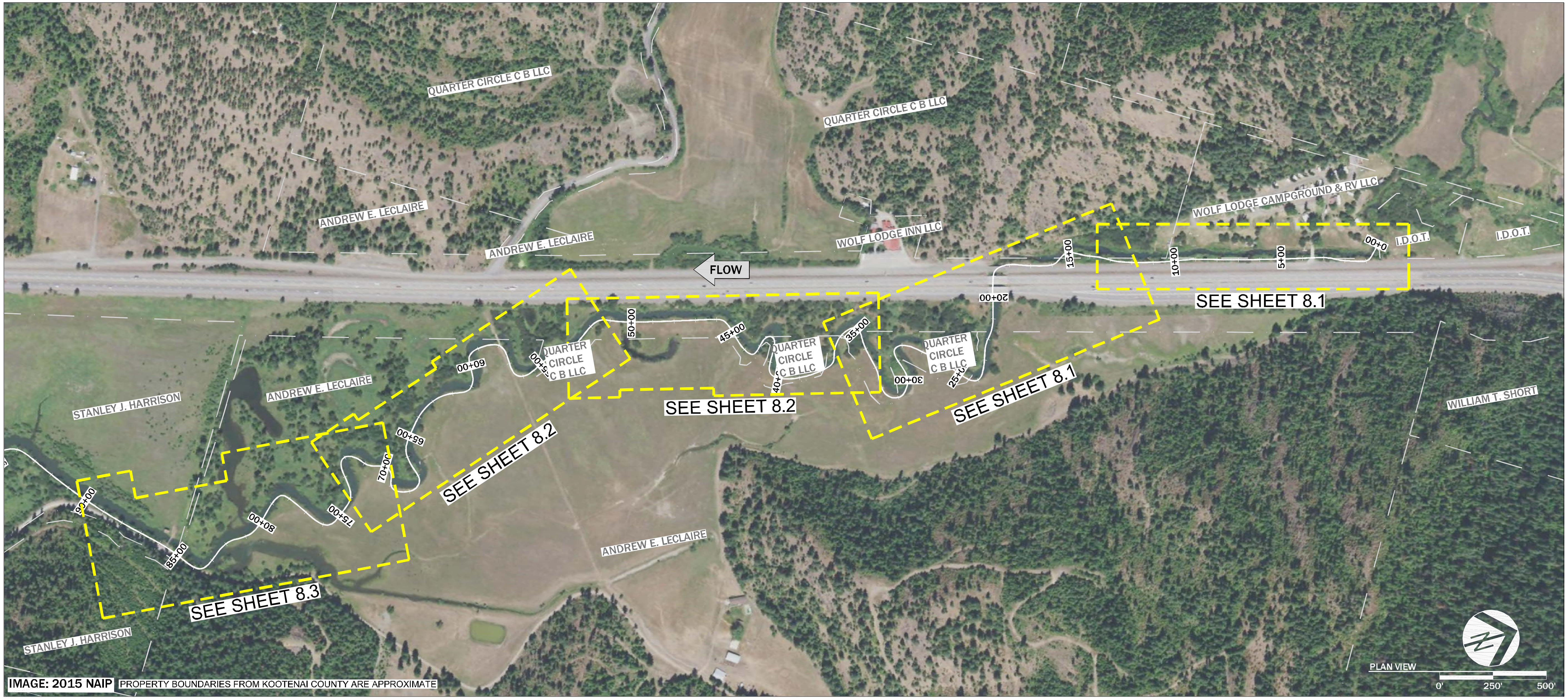
VALLEY CROSS SECTION
WOLF LODGE CREEK REACH 4 AND RUTHERFORD GULCH REACH 3 STREAM AND FLOODPLAIN RESTORATION

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
7.4



RESTORATION ALTERNATIVES

WOLF LODGE CREEK REACH 5 (WLC5) BEGINS AT THE INTERSECTION OF WOLF LODGE CREEK AND INTERSTATE 90. THE REACH TERMINATES AT LAKE COEUR D'ALENE WHERE STATE HIGHWAY 93 CROSSES THE BAY. THE MAJORITY OF WLC5 IS ENCOMPASSED BY AGRICULTURAL LAND USES AND/OR IS CHANNELIZED ADJACENT TO THE INTERSTATE AND INTERSTATE 90 FILLSLOPE. THE CHANNEL IN WLC5 IS SUBJECT TO BACKWATER CONDITIONS RELATED TO LAKE COEUR D'ALENE. THE CHANNEL CLASSIFIED AS A E6 STREAM TYPE, AND STREAMBANK EROSION IS OCCURRING IN AREAS WHERE GRAZING HAS REDUCED THE COVER OF RIPARIAN VEGETATION. SEDIMENT YIELD FROM ERODING STREAMBANKS IN WLC5 IS 219 TONS/YEAR, CONTRIBUTING APPROXIMATELY 11% OF THE TOTAL SEDIMENT LOAD FOR THE WATERSHED.

RESTORATION OBJECTIVES

THE CONCEPTUAL DESIGN FOR WOLF LODGE CREEK IN REACH 5 ADDRESSES LIMITING FACTORS IDENTIFIED IN THE WATERSHED ASSESSMENT. THE PROJECT OBJECTIVES ARE TO ESTABLISH A RIPARIAN BUFFER AND RESTORE ERODING STREAMBANKS TO REDUCE SEDIMENT LOADING TO WLC5 AND LAKE COEUR D'ALENE. EXCLUSION OF CATTLE AND AGRICULTURAL PRACTICES FROM THE RIPARIAN AREA IS RECOMMENDED.

OBJECTIVES INCLUDE:

- PRODUCE CLEAN WATER CONSISTENT WITH SUPPORTING AQUATIC LIFE AND BENEFICIAL USES.
- INCORPORATE STREAMBANK STABILIZATION TECHNIQUES THAT PROVIDE INTERIM STABILITY AND SUPPORT DEVELOPMENT OF MATURE RIPARIAN VEGETATION.
- RE-ACTIVE APPROXIMATELY 500-FEET OF WOLF LODGE CREEK (OXBOW MEANDER) AND CONVERT THE EXISTING CHANNEL TO OFF-CHANNEL, DISCONNECTED OPEN WATER AND EMERGENT WETLANDS.
- INSTALL RIPARIAN EXCLOSURE AND RIPARIAN PROTECTING FENCING TO PROTECT CONTAINERIZED PLANTS FROM BROWSE BY WILDLIFE AND LIVESTOCK.
- PROVIDE OPPORTUNITIES FOR OFF-CHANNEL LIVESTOCK WATERING OR ON-CHANNEL HARDENED WATER GAPS.
- COORDINATE RESTORATION PLANS WITH THE LANDOWNERS TO ENSURE RESTORATION TREATMENTS ARE COMPATIBLE WITH EXISTING AND FUTURE LAND USES.

RESTORATION TREATMENTS

RESTORATION WORK WILL OCCUR ALONG APPROXIMATELY 8,200 FEET OF CHANNEL. AS SHOWN ON THE DRAWINGS, APPROXIMATELY 4,150 LINEAR FEET OF RIPARIAN FENCING IS PROPOSED ALONG THE WEST SIDE OF WOLF LODGE CREEK IN REACH 5. THE FENCING ALIGNMENT AND LOCATION ARE PRELIMINARY AND BALANCE THE NEED TO MINIMIZE THE AMOUNT OF LAND EXCLUDED FROM AGRICULTURAL USE WHILE PROVIDING A RIPARIAN CORRIDOR OF SUFFICIENT WIDTH TO ESTABLISH A FUNCTIONING, FORESTED RIPARIAN COMMUNITY.

AS SHOWN ON THE DRAWINGS, APPROXIMATELY 3,335 FEET OF STREAMBANK RESTORATION AND STABILIZATION IS PROPOSED. THE PRIMARY TECHNIQUE WILL BE THE USE OF VEGETATED WOOD AND BRUSH FASCINES. ALTERNATIVE TECHNIQUES INCLUDE SINGLE AND DOUBLE LAYER VEGETATED SOIL LIFTS. THE INTENT OF THE VEGETATED WOOD AND BRUSH FASCINE STRUCTURE IS TO PROVIDE SITE CONDITIONS ALONG THE CHANNEL BOUNDARIES (STREAMBANKS) THAT ARE SUTIABLE FOR GROWING RIPARAIN VEGETATION. THE VEGETATED WOOD BRUSH MATRIX PROVIDES BANK STRENGTH IN THE SHORT-TERM UNTIL MATURE RIPARIAN VEGETATION ESTABLISHES AND PROVIDES LONG-TERM STREAMBANK STABILITY. THE STRUCTURE ALSO PROVIDES CHANNEL MARGIN ROUGHNESS AND NEAR-BANK AQUATIC HABITAT COMPLEXITY.

THE REVEGETATION PLAN FOR REACH 5 WILL FOCUS ON ESTABLISHING A FORESTED RIPARIAN COMMUNITY, EMULATING THE COVER TYPES AND COMMUNITIES OBSERVED ALONG THE EAST SIDE OF WOLF LODGE CREEK IN REACH 5. CONTAINERIZED WOODY PLANTS AND TREES WILL BE INSTALLED WITHIN THE RIPARAIN BUFFER AND IN HIGH PRIORITY AREAS SUCH AS INSIDE MEANDER TABS. CONTAINERIZED WOODY PLANTS WILL ALSO BE INTEGRATED INTO STREAMBANK RESTORATION/STABILIZATION TREATMENTS. PLANTING SPACING WILL VARY BY LOCATION.

OPPORTUNITIES TO DEVELOP BOTH ON-CHANNEL AND OFF-CHANNEL WATER SOURCES FOR LIVESTOCK WILL BE IDENTIFIED DURING THE DESIGN PHASE IN CLOSE COORDINATION WITH THE LANDOWNER.

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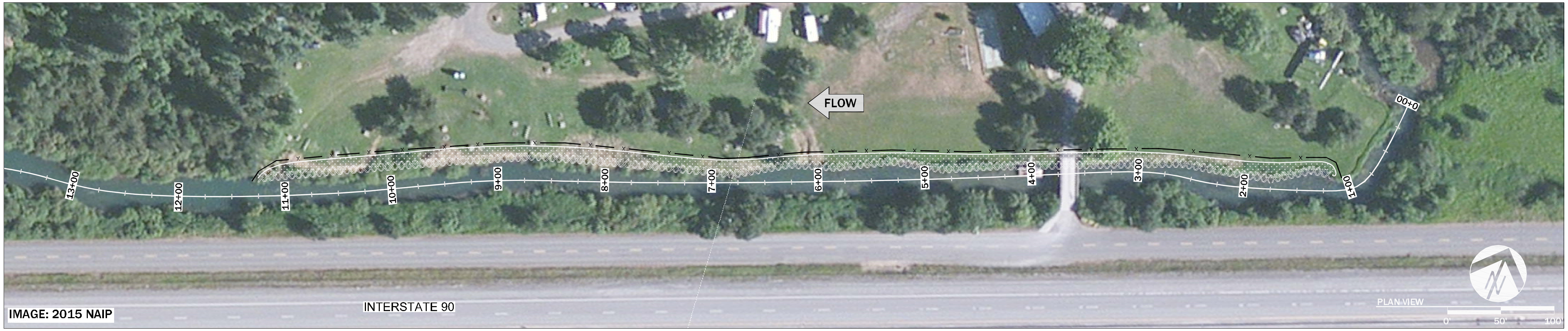
SITE PLAN
WOLF LODGE CREEK REACH 5 RIPARIAN AND FLOODPLAIN REVEGETATION

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
8.0



LEGEND

STRUCTURES	DETAIL SHEET #
VEGETATED WOOD AND BRUSH FASCINE	9.2
RIPARIAN PLANTING	8.3
RIPARIAN FENCING	8.3

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CONCEPTUAL RESTORATION PLAN
WOLF LODGE CREEK REACH 5 RIPARIAN AND FLOODPLAIN REVEGETATION

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
8.1

LEGEND

STRUCTURES	DETAIL SHEET #
VEGETATED WOOD AND BRUSH FASCINE	9.2
RIPARIAN PLANTING	8.3
RIPARIAN FENCING	8.3

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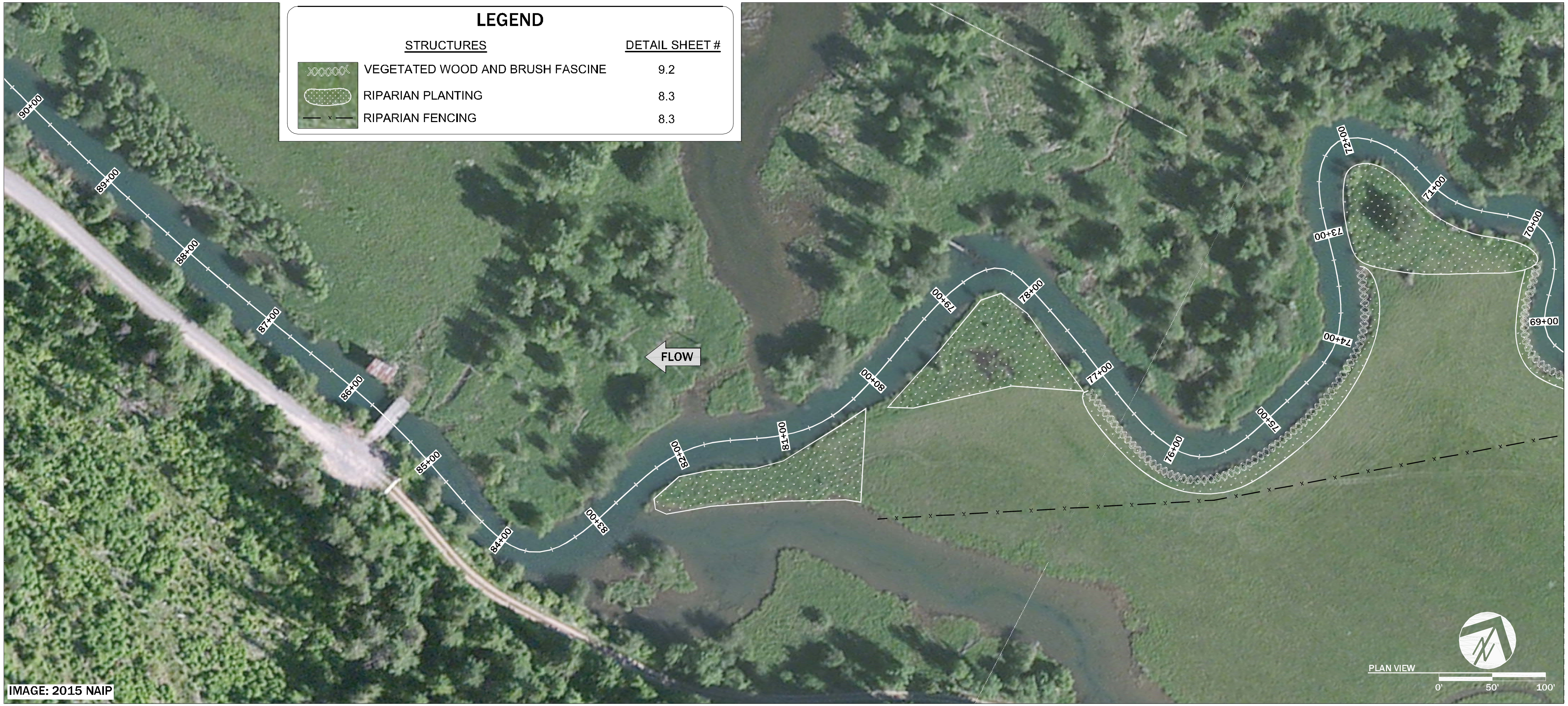
CONCEPTUAL RESTORATION PLAN
WOLF LODGE CREEK REACH 5 RIPARIAN AND FLOODPLAIN REVEGETATION

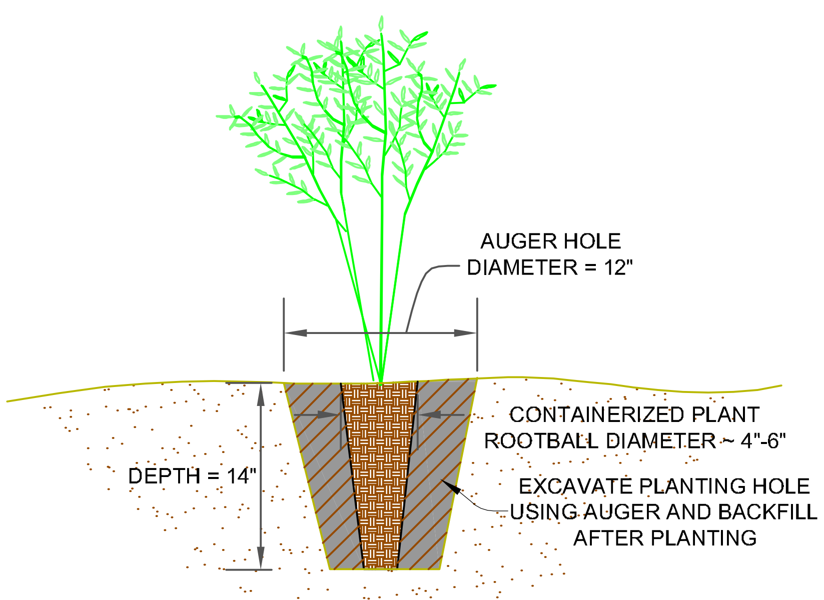
NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

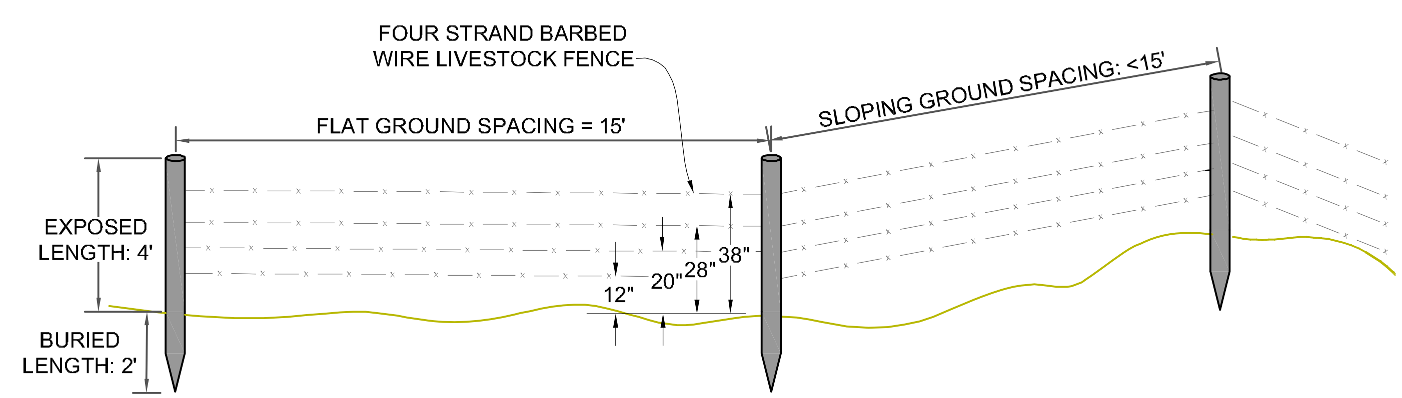
PROJECT NUMBER
RDG-16-005

SHEET NUMBER
8.2





RIPARIAN PLANT INSTALLATION DETAIL
SECTION VIEW



RIPARIAN FENCING
PROFILE VIEW

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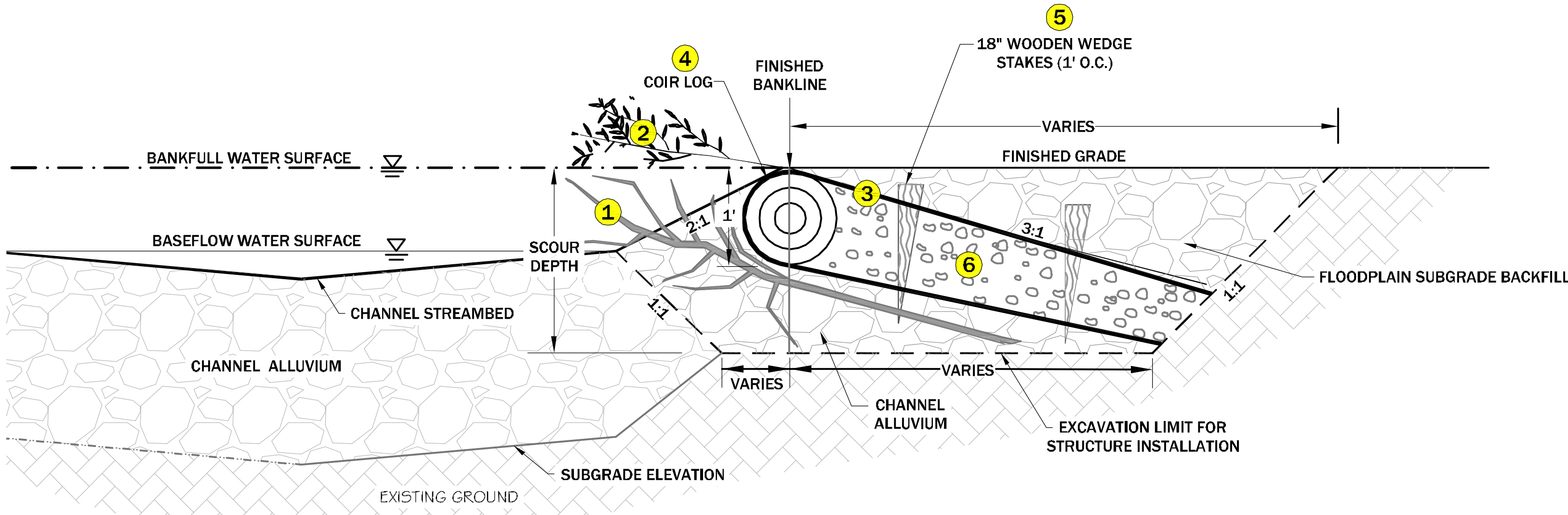
CONCEPTUAL RESTORATION PLAN
WOLF LODGE CREEK REACH 5 RIPARIAN AND FLOODPLAIN REVEGETATION

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	CRR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

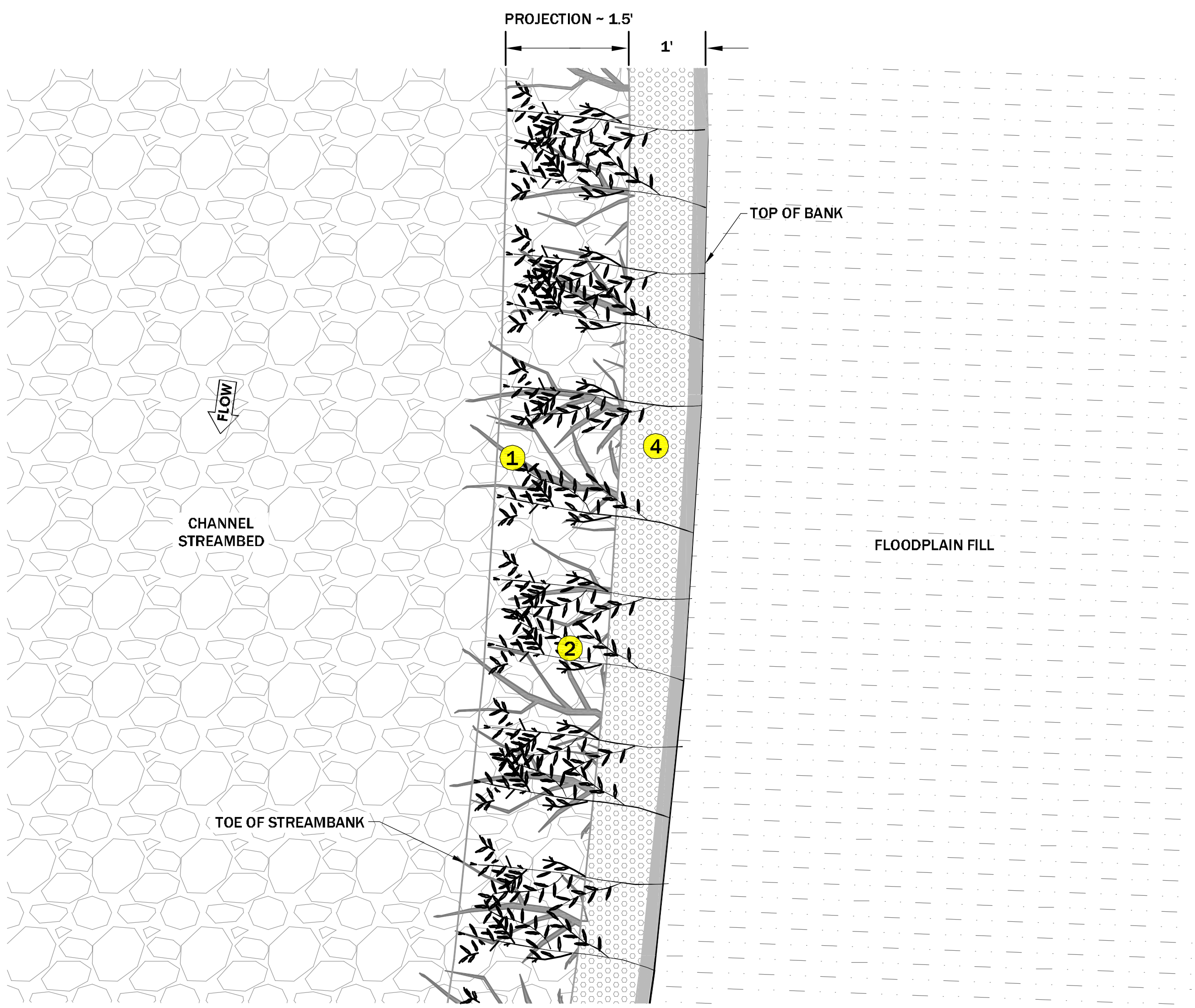
PROJECT NUMBER
RDG-16-005

SHEET NUMBER
8.3



SINGLE VEGETATED SOIL LIFT
SECTION VIEW

0' 1' 2'



SINGLE VEGETATED SOIL LIFT
PLAN VIEW

0' 1' 2'

DESIGN INTENT

PURPOSE: THE PURPOSE OF THE SINGLE VEGETATED SOIL LIFT IS TO PROVIDE A STABLE BANK MARGIN DIRECTLY ALONG THE CHANNEL BOUNDARIES (STREAMBANKS) THAT ARE SUITABLE FOR GROWING RIPARIAN VEGETATION.

PLACEMENT CRITERIA: THE SINGLE VEGETATED SOIL LIFT IS USED IN AREAS OF LOW TO MODERATE SHEAR STRESS ALONG RIFFLE AND RUN FEATURES.

SUPPLEMENTAL INFORMATION: THE SINGLE VEGETATED SOIL LIFT PROVIDES BANK STRENGTH IN THE SHORT-TERM UNTIL MATURE RIPARIAN VEGETATION ESTABLISHES AND PROVIDES LONG-TERM STREAMBANK STABILITY. THE STRUCTURE INCORPORATES A HIGH DENSITY COIR LOG IN ONE LIFT TO SUPPORT THE BANK SHAPE, INCREASE MOISTURE RETENTION, AND EXTEND THE DURATION OF THE GROWING SEASON. THE STRUCTURE INCORPORATES BRUSH TO INCREASE CHANNEL MARGIN ROUGHNESS AND PROVIDE NEAR-BANK AQUATIC HABITAT COMPLEXITY. THE STRUCTURE INCLUDES A CONSTRUCTED TOE TO PROVIDE STREAMBANK STABILITY FOR DESIGN EVENT NEAR-BANK SHEAR STRESS CONDITIONS. THE STRUCTURE IS USED IN A SEQUENCE WITH OTHER STREAMBANK STABILIZATION STRUCTURES AND IS NOT USED AS A STAND-ALONE TREATMENT. OVER A FIVE TO SEVEN YEAR PERIOD, THE FABRIC WILL DECOMPOSE AND THE ROOTING STRENGTH OF ESTABLISHED VEGETATION IS INTENDED TO MAINTAIN LOW BANK EROSION RATES.

MATERIAL SCHEDULE
(PER LINEAR FOOT)

	ITEM
1	SMALL WOOD
2	RIPARIAN CUTTINGS
3	COIR FABRIC
4	12" COIR LOG
5	WOODEN WEDGE STAKES
6	SOIL LIFT FILL

EXAMPLE OF A CONSTRUCTED SINGLE VEGETATED SOIL LIFT

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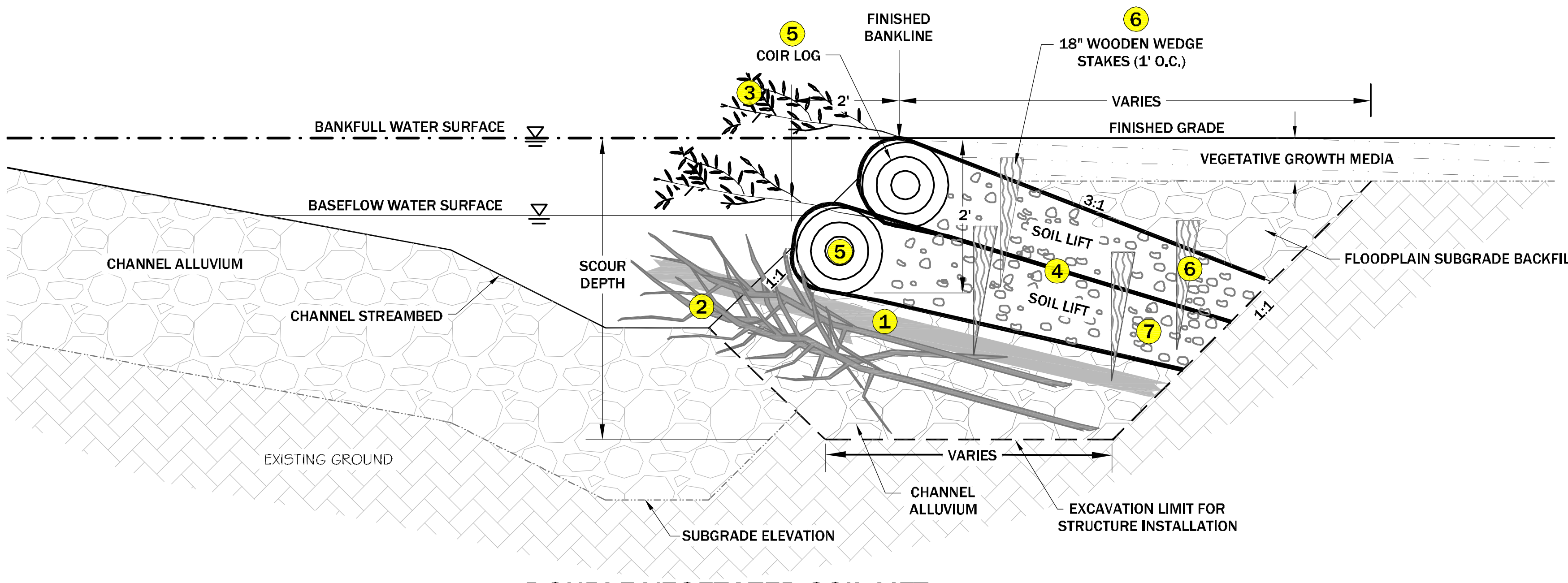
SINGLE VEGETATED SOIL LIFT DETAIL

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY -NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
9.0



DOUBLE VEGETATED SOIL LIFT
SECTION VIEW

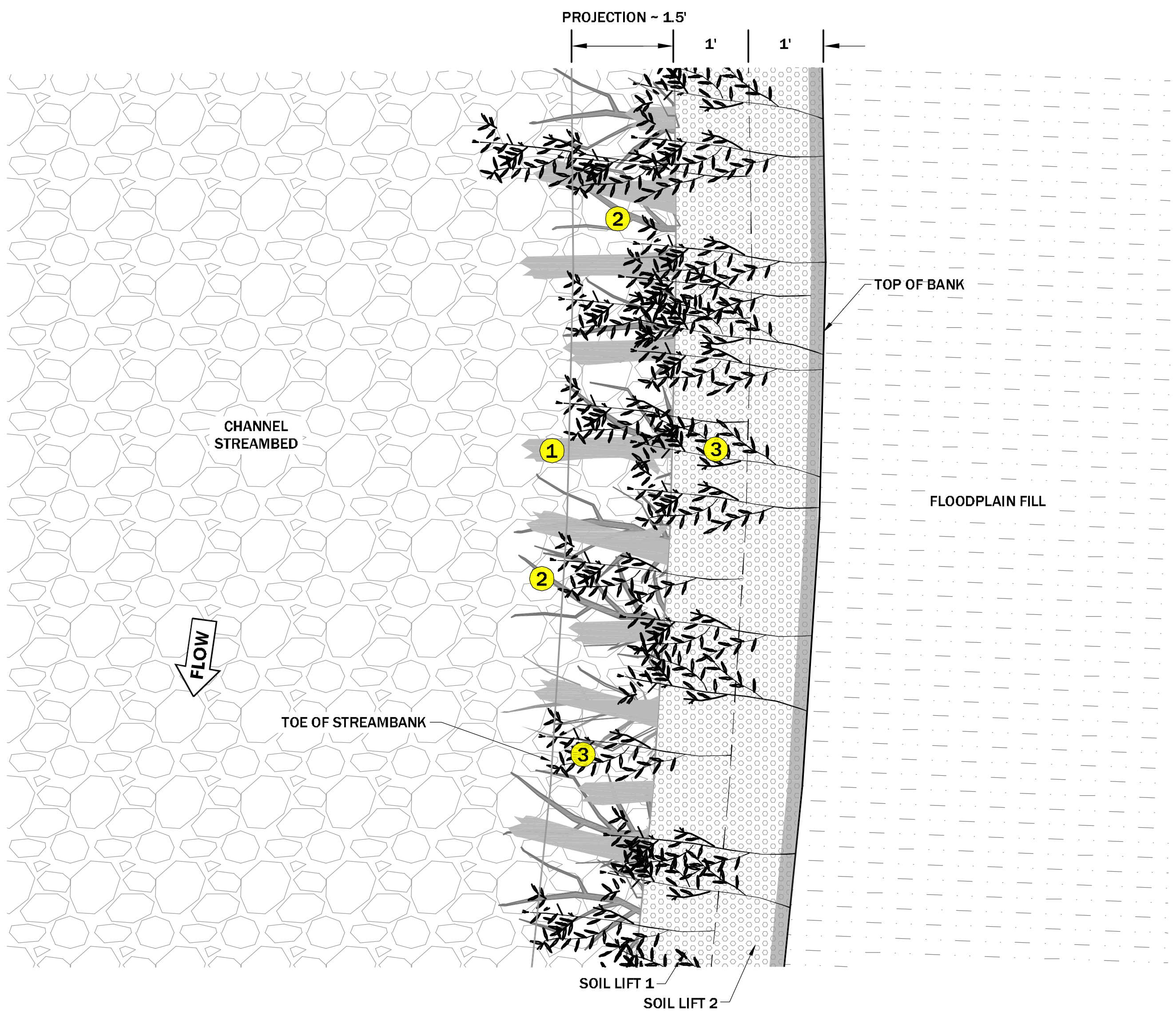
0' 1' 2'

DESIGN INTENT

PURPOSE: THE PURPOSE OF THE DOUBLE VEGETATED SOIL LIFT IS TO PROVIDE A STABLE BANK MARGIN DIRECTLY ALONG THE CHANNEL BOUNDARIES (STREAMBANKS) THAT ARE SUITABLE FOR GROWING RIPARIAN VEGETATION.

PLACEMENT CRITERIA: THE DOUBLE VEGETATED SOIL LIFT IS USED IN AREAS OF MODERATE TO HIGH SHEAR STRESS IN MEANDER BENDS.

SUPPLEMENTAL INFORMATION: THE DOUBLE VEGETATED SOIL LIFT PROVIDES BANK STRENGTH IN THE SHORT-TERM UNTIL MATURE RIPARIAN VEGETATION ESTABLISHES AND PROVIDES LONG-TERM STREAMBANK STABILITY. THE STRUCTURE INCORPORATES A HIGH DENSITY COIR LOGS IN TWO LIFTS TO SUPPORT THE BANK SHAPE, INCREASE MOISTURE RETENTION, AND EXTEND THE DURATION OF THE GROWING SEASON. THE STRUCTURE INCORPORATES WOOD AND BRUSH TO INCREASE CHANNEL MARGIN ROUGHNESS AND PROVIDE NEAR-BANK AQUATIC HABITAT COMPLEXITY. THE STRUCTURE INCLUDES A CONSTRUCTED TOE TO PROVIDE STREAMBANK STABILITY FOR DESIGN EVENT NEAR-BANK SHEAR STRESS CONDITIONS. THE STRUCTURE IS USED IN A SEQUENCE WITH OTHER STREAMBANK STABILIZATION STRUCTURES AND IS NOT USED AS A STAND-ALONE TREATMENT. OVER A FIVE TO SEVEN YEAR PERIOD, THE FABRIC WILL DECOMPOSE AND THE ROOTING STRENGTH OF ESTABLISHED VEGETATION IS INTENDED TO MAINTAIN LOW BANK EROSION RATES.



DOUBLE VEGETATED SOIL LIFT
PLAN VIEW

0' 1' 2'

MATERIAL SCHEDULE
(PER LINEAR FOOT)

	ITEM
1	MEDIUM WOOD
2	SMALL WOOD
3	RIPARIAN CUTTINGS
4	COIR FABRIC
5	12" COIR LOG
6	WOODEN WEDGE STAKES
7	SOIL LIFT FILL

EXAMPLE OF A CONSTRUCTED DOUBLE VEGETATED SOIL LIFT

EXAMPLE OF A CONSTRUCTED DOUBLE VEGETATED SOIL LIFT

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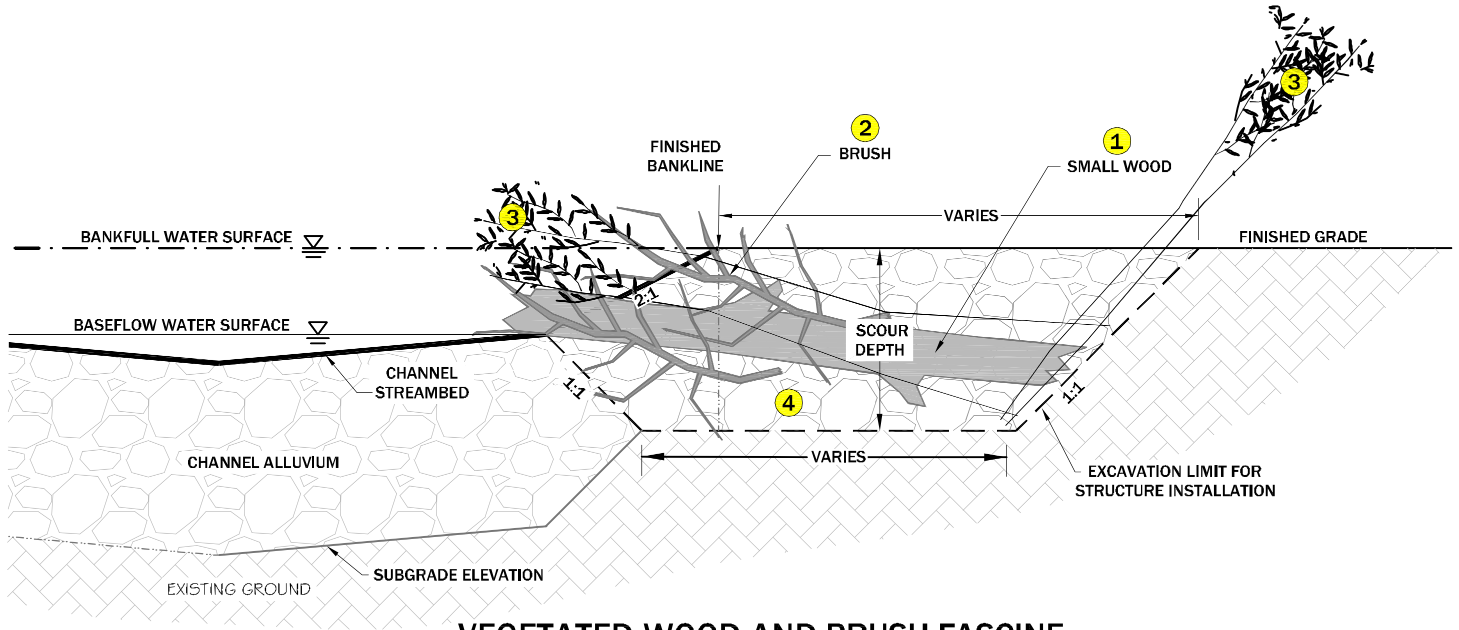
DOUBLE VEGETATED SOIL LIFT DETAIL

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	GRR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

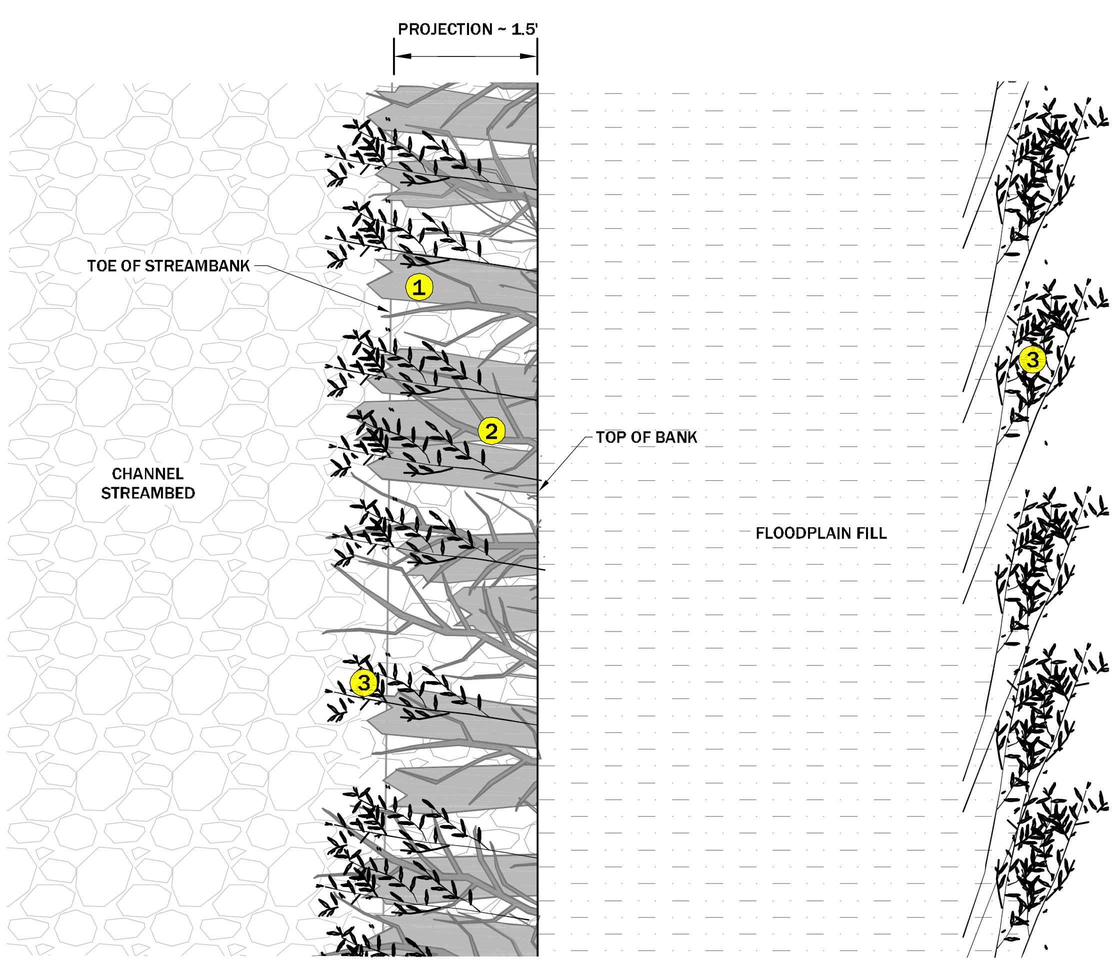
PROJECT NUMBER
RDG-16-005

SHEET NUMBER
9.1



VEGETATED WOOD AND BRUSH FASCINE
SECTION VIEW

0' 1' 2'



VEGETATED WOOD AND BRUSH FASCINE
PLAN VIEW

0' 1' 2'

DESIGN INTENT

PURPOSE: THE PURPOSE OF THIS STRUCTURE IS TO CREATE A COMPLEX, VEGETATED BANK MARGIN THAT SUPPORTS AQUATIC HABITAT, VEGETATION AND GEOMORPHIC OBJECTIVES.

PLACEMENT CRITERIA: THIS STRUCTURE IS DESIGNED TO FUNCTION ON A MODERATE STRESS BANK WITH LOW TO MODERATE CURVATURE.

SUPPLEMENTAL INFORMATION: THE VEGETATIVE WOOD AND BRUSH FASCINE STRUCTURE INCORPORATES NATIVE MATERIALS TO PROVIDE PREFERRED HABITAT CONDITIONS ALONG STREAMBANKS. THE STRUCTURE IS BUILT ON A ROCK AND WOOD TOE. STRUCTURE PERFORMANCE IS DEPENDENT ON TOE STABILITY AS WELL AS SMOOTH TRANSITIONS TO STABLE UPSTREAM AND DOWNSTREAM TIE-IN POINTS. MAINTAINING ADEQUATE BACKFILL BALLAST IS CRITICAL TO COUNTERACT BUOYANCY AND SLIDING/ROTATION OF WOOD. PLACEMENT OF WOOD AT OR BELOW BANKFULL AND PLACEMENT OF HEALTHY WOODY VEGETATION IN CONTACT WITH THE WATER TABLE THROUGHOUT THE GROWING SEASON IS CRITICAL FOR RAPID VEGETATION ESTABLISHMENT.

MATERIAL SCHEDULE (PER LINEAR FOOT)

	ITEM
1	SMALL WOOD
2	BRUSH
3	RIPARIAN CUTTINGS
4	CHANNEL ALLUVIUM

EXAMPLE OF A CONSTRUCTED VEGETATED WOOD AND BRUSH FASCINE

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VEGETATIVE WOOD AND BRUSH FASCINE

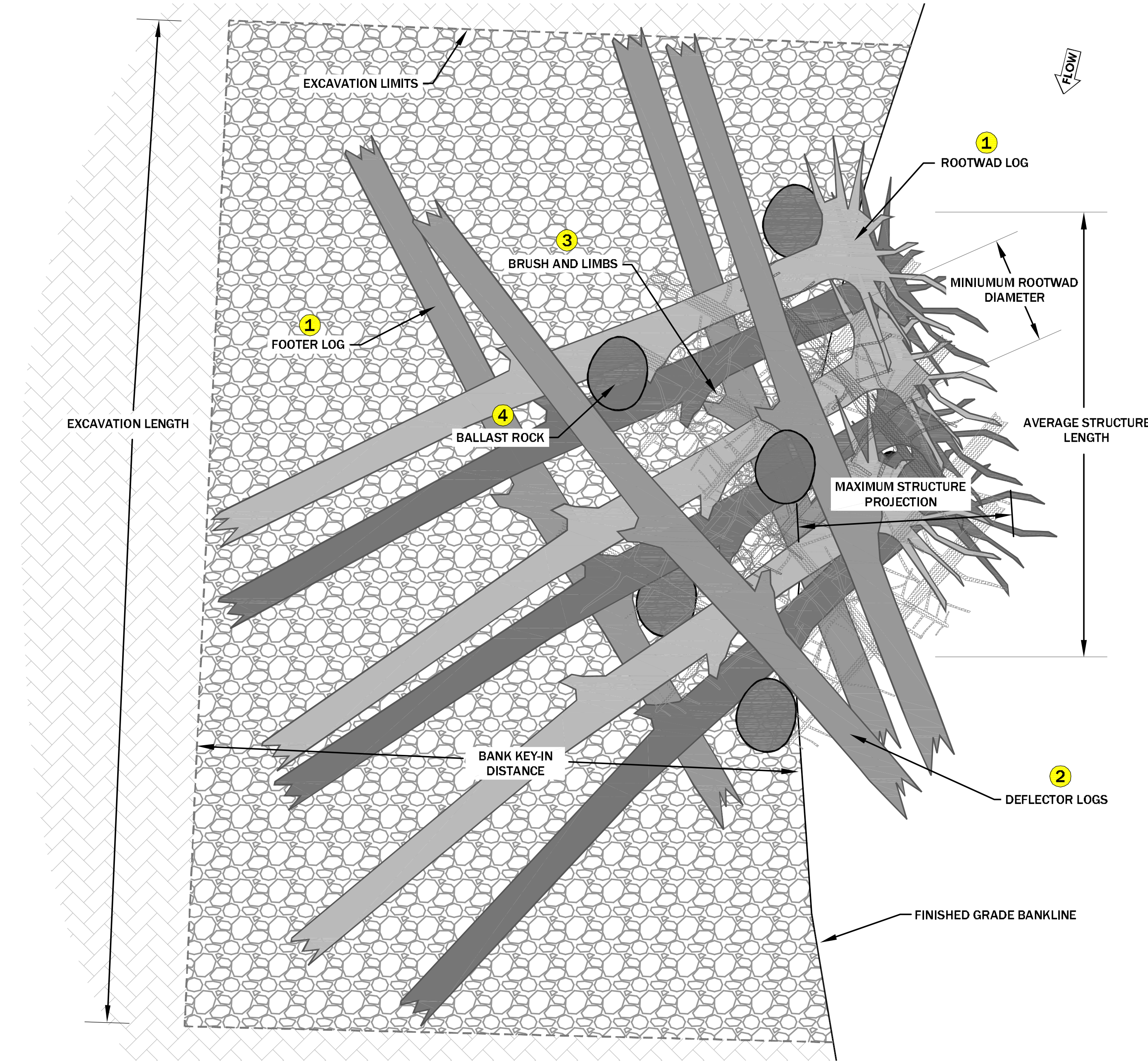
NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY -NOT FOR CONSTRUCTION-

PROJECT NUMBER RDG-16-005

SHEET NUMBER

9.2



LARGE WOOD STRUCTURE
PLAN VIEW

NTS

DESIGN INTENT

PURPOSE: THE PURPOSE OF THIS STRUCTURE IS TO CREATE HYDRAULIC CONDITIONS THAT MAINTAIN A DEEP POOL.

PLACEMENT CRITERIA: THIS STRUCTURE IS DESIGNED TO FUNCTION ON A HIGH STRESS BANK WITH CONCAVE PLANFORM GEOMETRY. THE STRUCTURE IS TYPICALLY PLACED ON THE OUTER BANK OF A MEANDER BEND.

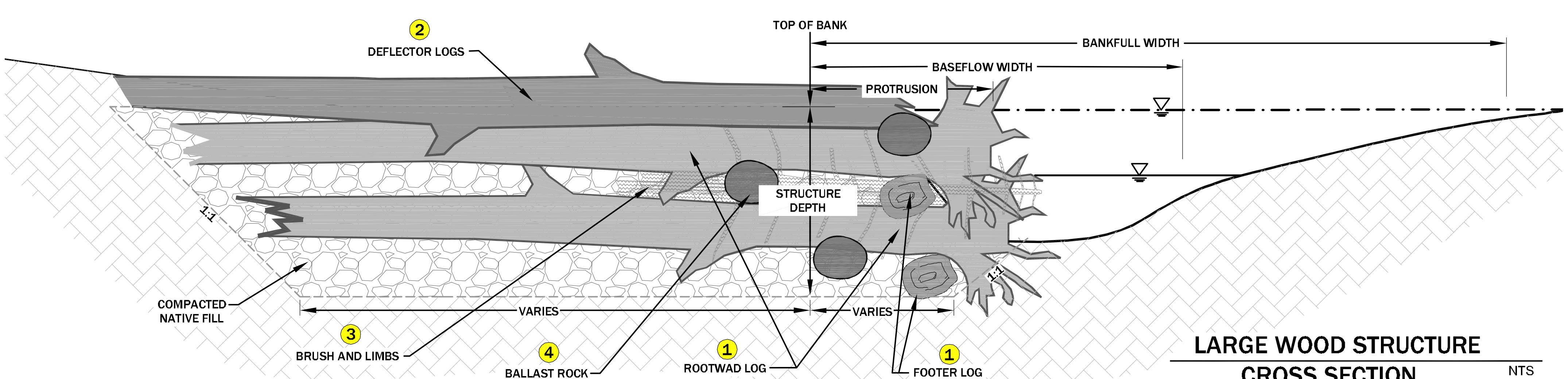
AQUATIC HABITAT OBJECTIVES ADDRESSED: THIS STRUCTURE CREATES COMPLEX HYDRAULICS SUCH AS EDDIES AND SECONDARY FLOW CIRCULATION. LARGE WOOD PROVIDES IN-STREAM COVER AND SHADE FOR TEMPERATURE REDUCTION. DEEP POOLS IMPROVE HYPORHEIC FLOW FOR TEMPERATURE MANAGEMENT. RESIDUAL POOLS PROVIDE LOW-VELOCITY HOLDING HABITAT AND OVER-WINTERING HABITAT.

VEGETATION OBJECTIVES ADDRESSED: CREATES STABLE CONDITIONS TO SUPPORT DEVELOPMENT OF DESIRED VEGETATION COMMUNITY TYPES.

GEOMORPHIC OBJECTIVES ADDRESSED: THIS STRUCTURE SUPPORTS POOL DEVELOPMENT PROCESSES. POOLS PROVIDE PLANFORM VARIABILITY AND FOSTER POINT BAR DEVELOPMENT. THE STRUCTURE IS COMPOSED OF NATIVE MATERIALS.

SUPPLEMENTAL INFORMATION: THE LARGE WOOD HABITAT STRUCTURE PROVIDES TEMPORARY BANK PROTECTION BY RE-DIRECTING FLOW AWAY FROM THE BANK AND DISSIPATING FLOW ENERGY INTO THE RIVERBED. THE STRUCTURE CREATES COMPLEX HYDRAULICS AND TURBULENCE, WHICH REQUIRE ATTENTION TO HOW THE STRUCTURE IS TIED IN TO EXISTING FEATURES OR OTHER BANK STRUCTURES. MAINTAINING ADEQUATE BACKFILL BALLAST IS CRITICAL TO COUNTERACT BUOYANCY AND SLIDING/ROTATION OF WOOD. STRUCTURE PERFORMANCE IS DEPENDENT ON STRUCTURE SIZE AND USE OF ADEQUATELY-SIZED LARGE WOOD WITH INTACT ROOTWADS. EXCAVATION OF THE POOL IN CONJUNCTION WITH THE STRUCTURE IS RECOMMENDED. THE STRUCTURE WILL TEND TO RECRUIT ADDITIONAL WOODY DEBRIS. OVER TIME, THE STRUCTURE WILL DECOMPOSE OR BECOME ABANDONED/ BURIED IN THE FLOODPLAIN AS THE CHANNEL MIGRATES LATERALLY. INTEGRATING MATURE SHRUB TRANSPLANTS OR PLANTINGS ON THE FLOODPLAIN SURFACE BEHIND THIS STRUCTURE CREATES ROOTING STRUCTURE FOR LONG TERM BANK STABILITY.

EXAMPLE OF A LARGE WOOD HABITAT AND STREAMBANK RESTORATION STRUCTURE



LARGE WOOD STRUCTURE
CROSS SECTION

NTS

MATERIAL SCHEDULE (PER STRUCTURE)

	ITEM
1	MEDIUM WOOD
2	SMALL WOOD
3	BRUSH
4	BOULDER

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LARGE WOOD HABITAT AND STREAMBANK RESTORATION STRUCTURE

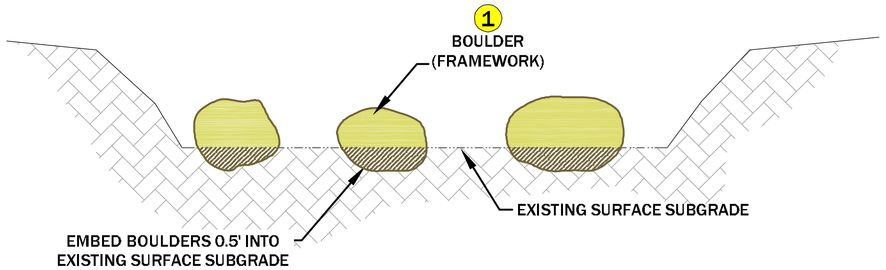
NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY -NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER

9.3

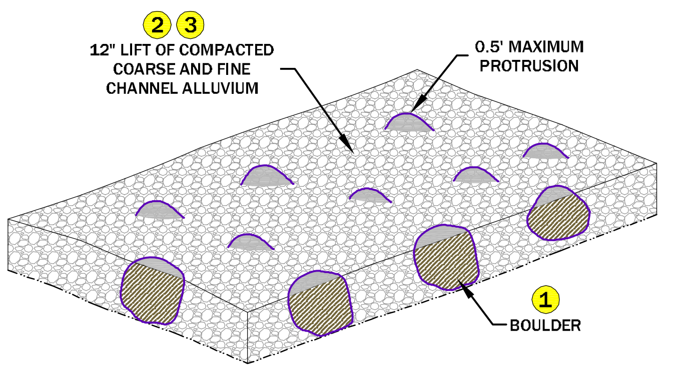


CATEGORY 1 ROCK INSTALLATION
SECTION VIEW
NTS


CHANNEL SUBGRADE

DESIGN INTENT

THE PURPOSE OF THIS STRUCTURE IS TO PROVIDE VERTICAL STABILITY BETWEEN POOLS AND/OR MEANDER BENDS. THE STRUCTURE IS COMPOSED OF A WELL-GRADED MIX OF ALLUVIAL SUBSTRATES THAT REPLICATE NATURAL STREAMBED MATERIALS. A BOULDER FRAMEWORK MAY BE ADDED TO PROVIDE ADDITIONAL STABILITY.

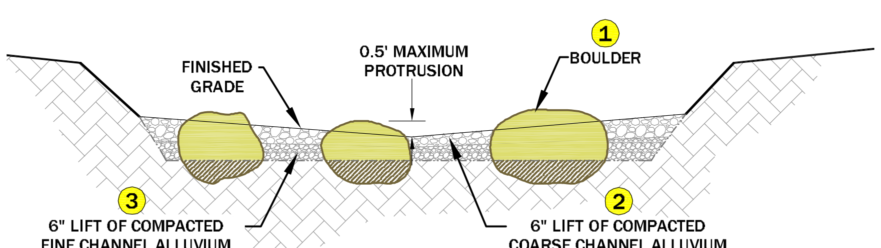


CHANNEL ALLUVIUM LIFT INSTALLATION
3-D VIEW
NTS


CHANNEL ALLUVIUM MATRIX

MATERIAL SCHEDULE (PER LINEAR FOOT)

	ITEM
1	BOULDER
2	COARSE CHANNEL ALLUVIUM
3	FINE CHANNEL ALLUVIUM



CHANNEL ALLUVIUM LIFT INSTALLATION
SECTION VIEW
NTS


CHANNEL ALLUVIUM MATRIX WITH FRAMEWORK


TYPICAL CONSTRUCTED CHANNEL STREAMBED


TYPICAL CONSTRUCTED CHANNEL STREAMBED

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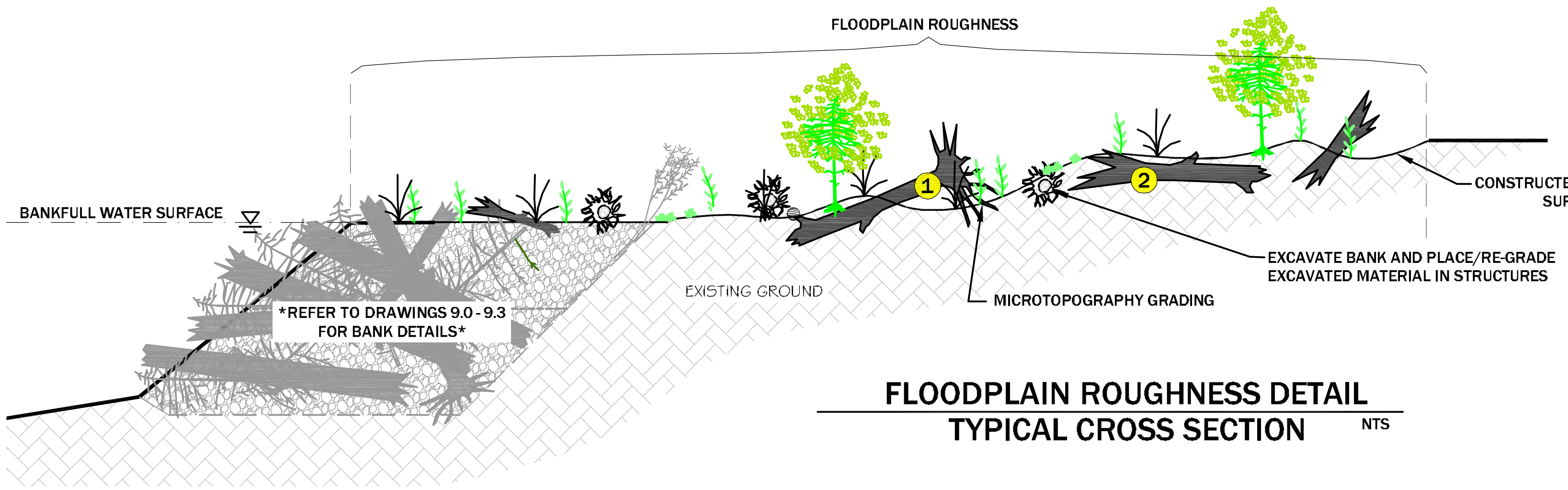
CHANNEL CONSTRUCTION DETAIL

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	RR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY
-NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
9.4



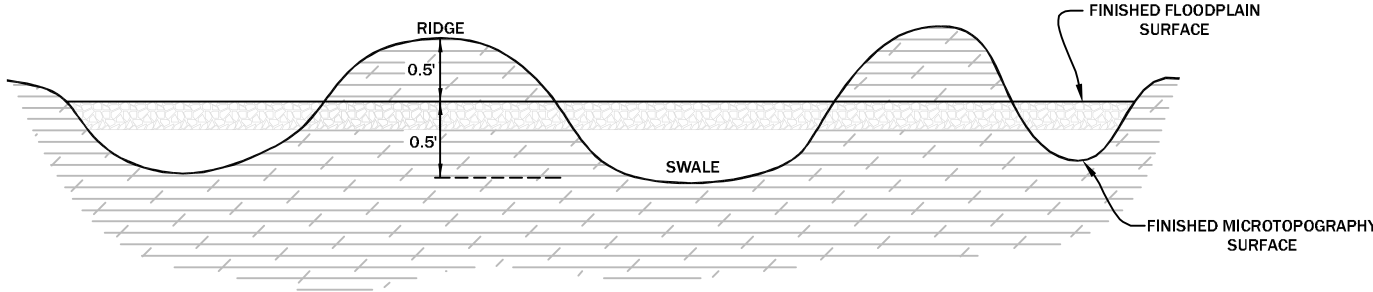
FLOODPLAIN ROUGHNESS DETAIL
TYPICAL CROSS SECTION NTS

DESIGN INTENT

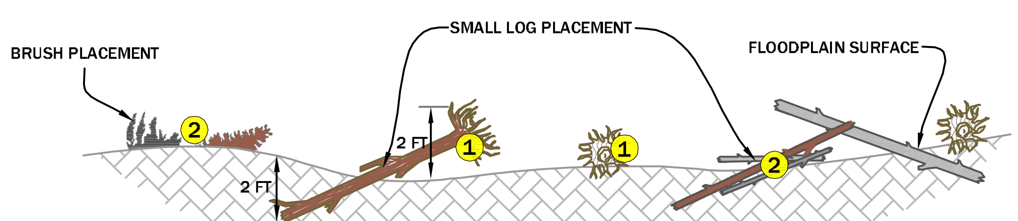
PURPOSE: THE PURPOSE OF THIS TREATMENT IS TO CREATE CHARACTERISTICS ON NEWLY CONSTRUCTED FLOODPLAIN SURFACES THAT ARE SIMILAR TO THE CONDITIONS ON NATURAL, VEGETATED FLOODPLAIN SURFACES.

PLACEMENT CRITERIA: TREATMENTS ARE APPLIED TO FLOODPLAIN SURFACES THAT LACK ROUGHNESS ELEMENTS AND VEGETATION.

SUPPLEMENTAL INFORMATION: FLOODPLAIN ROUGHNESS TREATMENTS REDUCE THE RISK OF SURFACE EROSION AND INCREASE THE RETENTION OF SEDIMENT AND NUTRIENTS FOR THE DEVELOPMENT OF RIPARIAN VEGETATION. FLOODPLAIN ROUGHNESS IS APPLIED USING TWO METHODS: (1) MICROTOPOGRAPHY GRADING AND (2) WOODY DEBRIS PLACEMENT. MICROTOPOGRAPHY GRADING WILL CREATE AN UNEVEN SURFACE OF FURROWS AND RIDGES ON THE FLOODPLAIN. WOODY DEBRIS WILL PROVIDE STABILITY AND CONTRIBUTE ORGANIC MATTER TO FLOODPLAIN SOILS. PROPER ANCHORING OF WOODY DEBRIS IS REQUIRED TO PREVENT MOVEMENT DURING OVERBANK FLOWS.



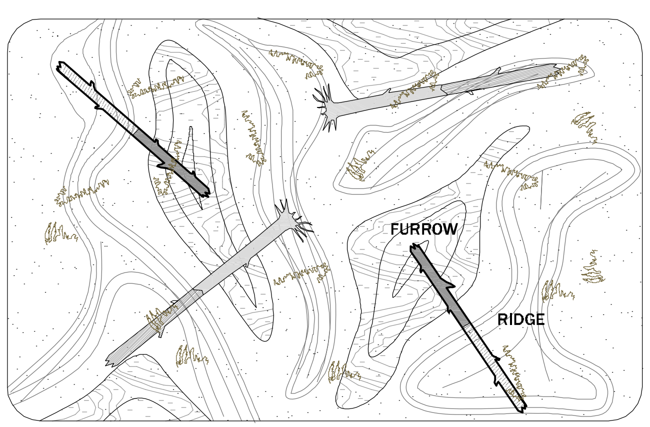
DETAIL 1 - MICROTOPOGRAPHY GRADING
SECTION VIEW NTS



DETAIL 2 - FLOODPLAIN ROUGHNESS WOOD
SECTION VIEW NTS

MATERIAL SCHEDULE (PER ACRE)

	ITEM	QUANTITY
1	MEDIUM WOOD	TBD
2	SMALL WOOD	TBD



DETAIL 3 - MICROTOPOGRAPHY AND FLOODPLAIN WOOD PLACEMENT
PLAN VIEW NTS

EXAMPLE OF CONSTRUCTED FLOODPLAIN SWALE

EXAMPLE OF CONSTRUCTED FLOODPLAIN ROUGHNESS ELEMENT

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FLOODPLAIN ROUGHNESS AND MICROTOPOGRAPHY

NO.	DATE	BY	DESCRIPTION	CHK
1	12-15-16	GR/NW	CONCEPTUAL DESIGN	JM

PRELIMINARY -NOT FOR CONSTRUCTION-

PROJECT NUMBER
RDG-16-005

SHEET NUMBER
9.5

APPENDIX C

BANK EROSION ANALYSIS

Table C1. Overview of Bank Erosion Hazard Index quantification of sediment loading for each reach in the Wolf Lodge Creek watershed. Two densities were used to calculate weight from volumes. The average of these high and low values were used to report the sediment yield for each reach per year.

Reach	Sediment Volume (cubic ft)	Sediment Volume (unit length)	Sediment Yield Tons (low)	Sediment Yield Tons (high)	Sediment Yield Tons (mean)
LC1	3,570	0.9	161	223	192
SC1	1,190	0.2	54	74	64
WLC1	3,200	0.5	144	200	172
WLC2	1,450	0.2	65	90	78
WLC3	15,440	1	695	965	830
WLC4	5,240	1	236	328	282
WLC5	4,070	0.3	183	254	219
MC2	2,170	0.6	98	136	117

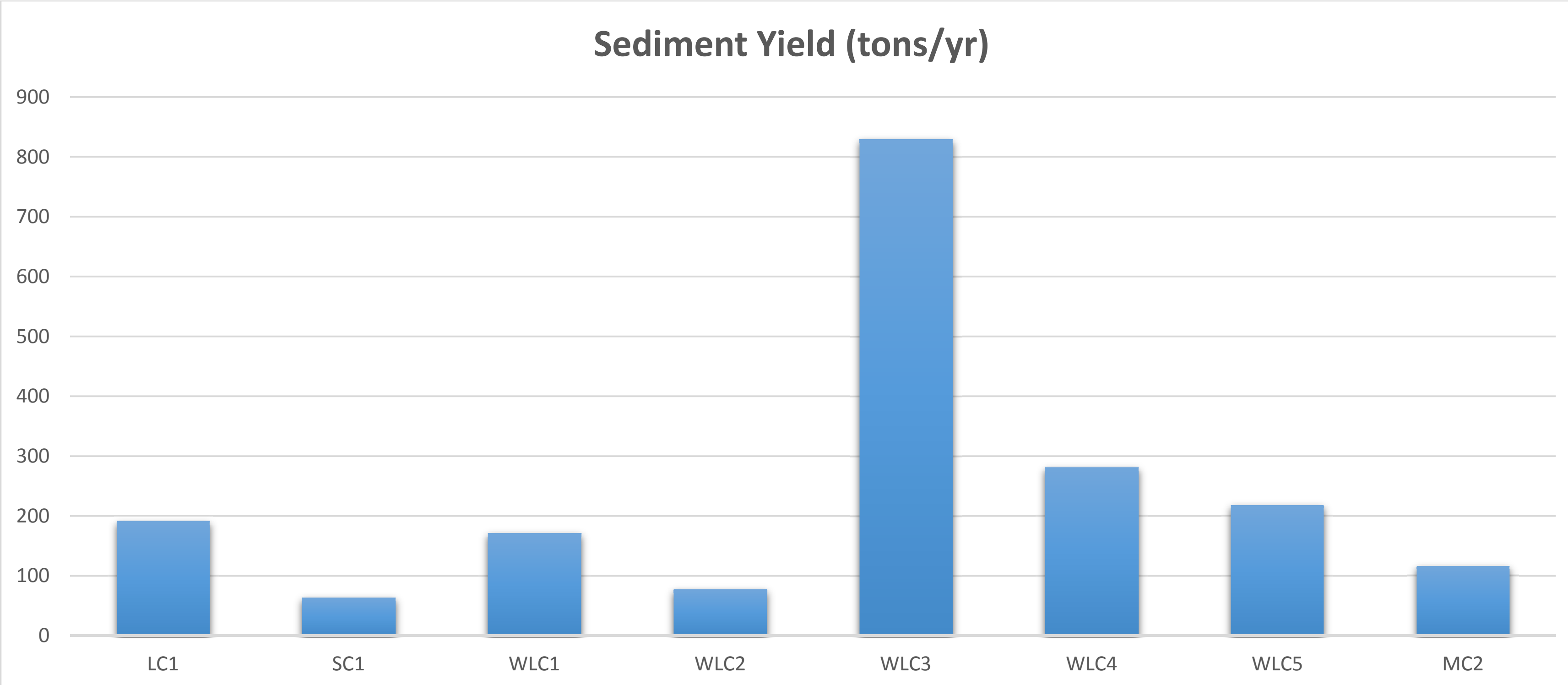


Figure C1. Sediment yield in tons/year for each reach.

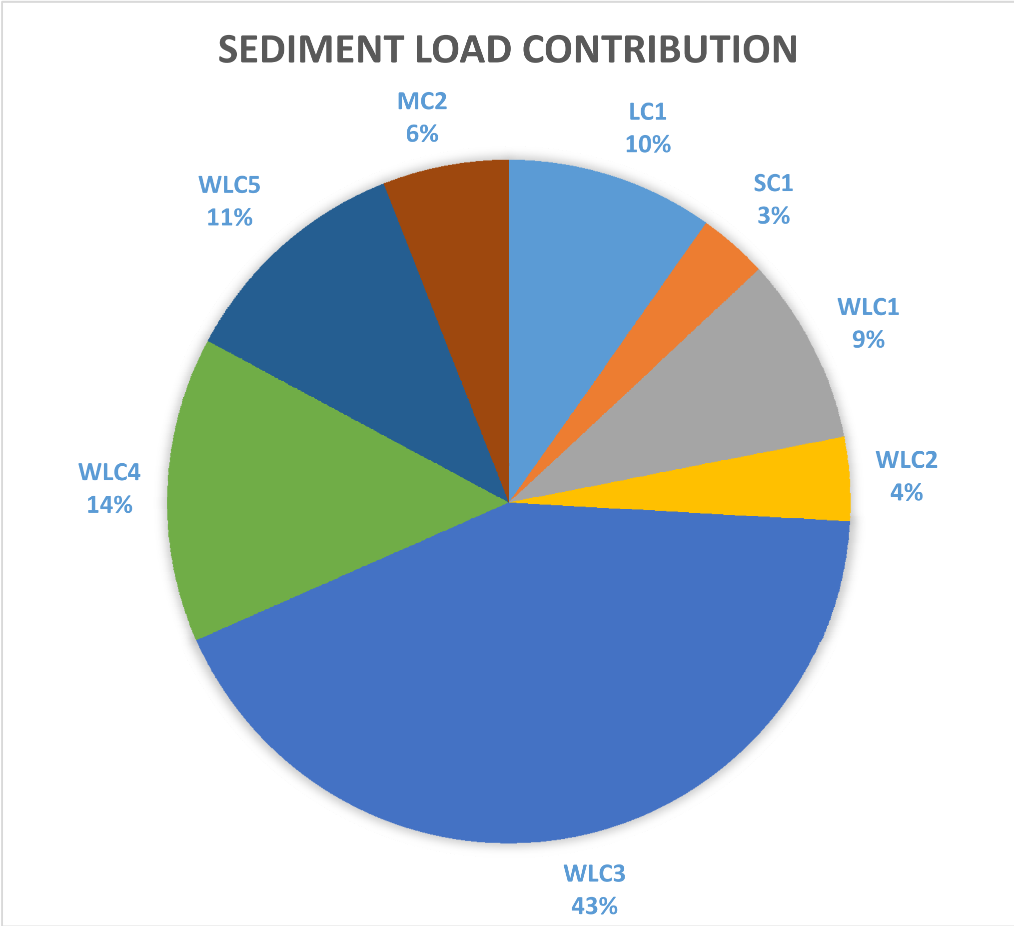


Figure C2. Pie chart of sediment load contribution (percentage) by reach for the Wolf Lodge Creek watershed.

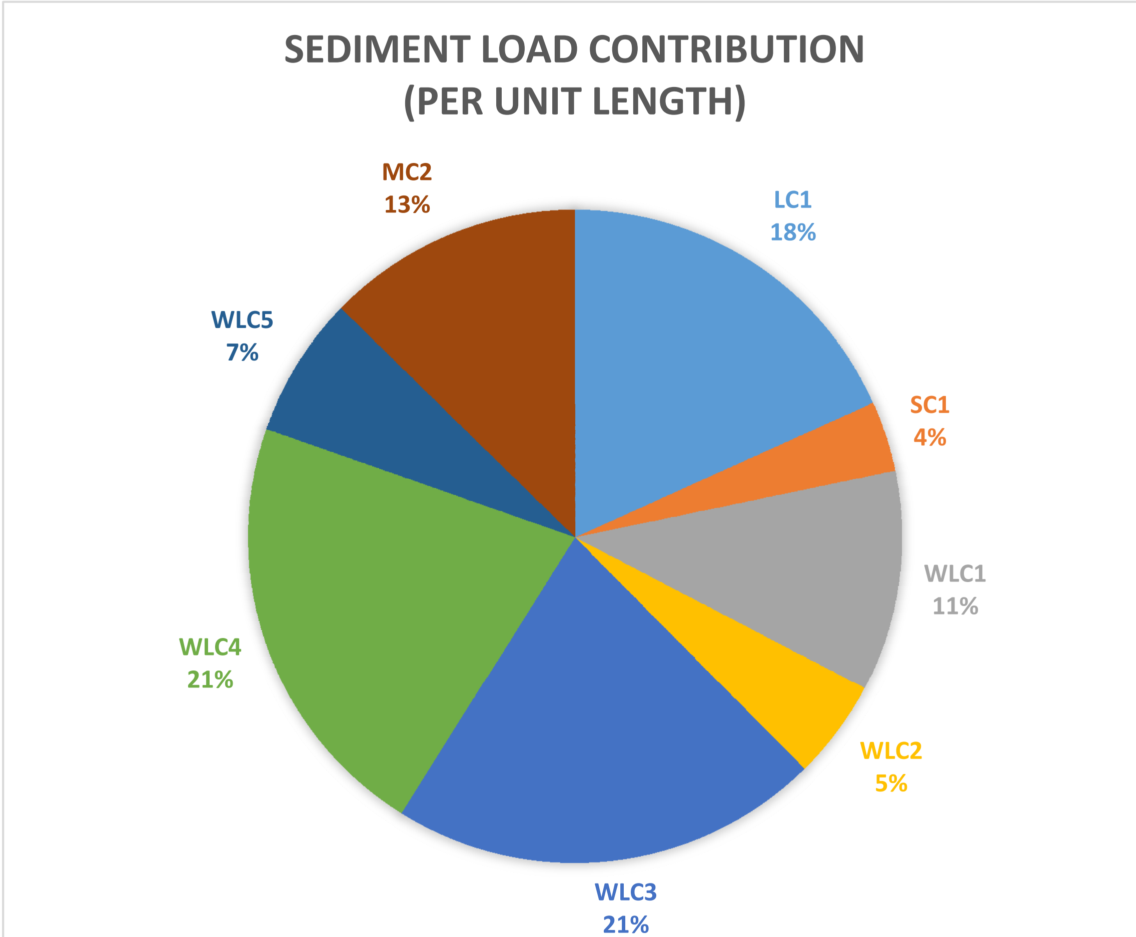


Figure C3. Pie chart of sediment load contribution per unit length for the Wolf Lodge Creek watershed. This analysis allows for more equal comparisons about sediment contribution on the reach scale.

Table C2. Summary of BEHI analysis and sediment yield for WLC1.						
Bank	**Bank Height (ft)**	**Bank Length (Ft)**	**BEHI Score**	**BEHI Rating**	**Predicted Erosion Rate (ft/yr)**	**Sediment Yield (cubic ft/yr)**
1	2.5	3,900	28.3	High	0.31	3,022.5
2	0.5	2,100	13.75	Low	0.17	178.5
Total		6,000				3,200
Per Unit Length	0.5					

Table C3. Summary of BEHI analysis and sediment yield for WLC2.						
Bank	**Bank Height (ft)**	**Bank Length (ft)**	**BEHI Score**	**BEHI Rating**	**Predicted Erosion Rate (ft/yr)**	**Sediment Yield (cubic ft/yr)**
1	1.5	3,600	22.75	Moderate	0.23	1,242
2	0.5	2,400	13.75	Low	0.17	204
Total		6,000				1,450
Per Unit Length	0.2					

Table C4. Summary of BEHI analysis and sediment yield for WLC3.						
Bank	**Bank Height (ft)**	**Bank Length (ft)**	**BEHI Score**	**BEHI Rating**	**Predicted Erosion Rate (ft/yr)**	**Sediment Yield (cubic ft/yr)**
1	4.5	4,725	45.5	Extreme	0.47	9,993
2	3.5	8,775	14.75	Low	0.17	5,221
3	1	1,350	10.25	Low	0.17	230
Total		14,850				15,440
Per Unit Length	1					

Table C5. Summary of BEHI analysis and sediment yield for WLC4.						
Bank	**Bank Height (ft)**	**Bank Length (ft)**	**BEHI Score**	**BEHI Rating**	**Predicted Erosion Rate (ft/yr)**	**Sediment Yield (cubic ft/yr)**
1	3.5	1,750	36.3	Very High	0.39	2,389
2	3	2,750	28.75	High	0.31	2,558
3	3.5	500	13.5	Low	0.17	298
Total		5,000				5,240
Per Unit Length	1					

Table C6. Summary of BEHI analysis and sediment yield for WLC5.						
Bank	**Bank Height (ft)**	**Bank Length (ft)**	**BEHI Score**	**BEHI Rating**	**Predicted Erosion Rate (ft/yr)**	**Sediment Yield (cubic ft/yr)**
1	1.75	6,000	28.75	High	0.31	3,255
2	0.8	6,000	14.75	Low	0.17	816
Total		12,000				4,070
Per Unit Length	0.3					

Table C7. Summary of BEHI analysis and sediment yield for SC1.						
Bank	**Bank Height (ft)**	**Bank Length (ft)**	**BEHI Score**	**BEHI Rating**	**Predicted Erosion Rate (ft/yr)**	**Sediment Yield (cubic ft/yr)**
1	1	7,000	14.25	Low	0.17	1190
Total		7,000				1190
Per Unit Length	0.2					

Table C8. Summary of BEHI analysis and sediment yield for LC1.

Bank	Bank Height (ft)	Bank Length (ft)	BEHI Score	BEHI Rating	Predicted Erosion Rate (ft/yr)	Sediment Yield (cubic ft/yr)
1	3.5	2,400	31.85	High	0.31	2,604
2	0.5	400	14.75	Low	0.17	34
3	2.5	1,200	26.75	High	0.31	930
Total		4,000				3,570
Per Unit Length	0.9					

Table C9. Summary of BEHI analysis and sediment yield for MC2.

Bank	Bank Height (ft)	Bank Length (ft)	BEHI Score	BEHI Rating	Predicted Erosion Rate (ft/yr)	Sediment Yield (cubic ft/yr)
1	2	3,500	32.3	High	0.31	2,170
Total		3,500				2,170
Per Unit Length	0.6					

APPENDIX D

STREAM CROSSING INVENTORY

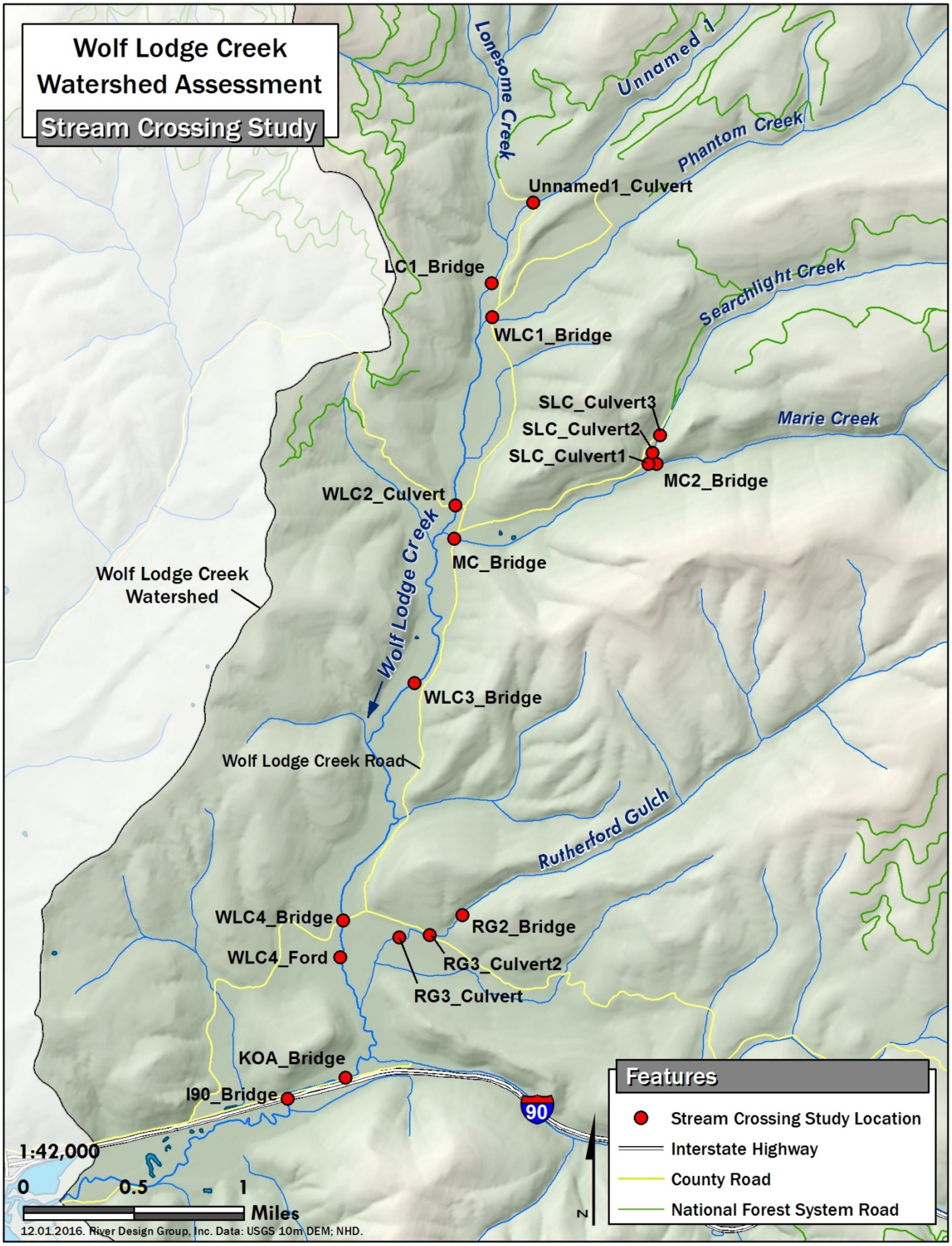


Figure D1. Map of stream crossing inventory sites.

Table D1. Summary of stream crossing inventory locations and associated landownership designations.

Stream Crossing ID	Location	Landownership
UN2_Bridge	47°38'28.19"N, 116°36'19.87"W	Private
UN3_Culvert	47°38'22.50"N, 116°36'41.74"W	Private
UN3_Culvert2	47°38'23.29"N, 116°36'31.05"W	State of Idaho
Unnamed1_Culvert	47°41'17.06"N, 116°36'3.58"W	State of Idaho
WLC2_Culvert	47°40'4.94"N, 116°36'27.06"W	State of Idaho
WLC4_Bridge	47°38'26.02"N, 116°37'1.41"W	State of Idaho
WLC4_Ford	47°38'17.36"N, 116°37'2.17"W	Private
SCL_Culvert1	47°40'16.24"N, 116°35'20.20"W	Private
SCL_Culvert2	47°40'18.93"N, 116°35'18.85"W	Private
SCL_Culvert3	47°40'23.12"N, 116°35'16.35"W	Private
MC2_Bridge	47°40'16.44"N, 116°35'17.22"W	Private
LC1_Bridge	47°40'57.68"N, 116°36'16.99"W	Private
WLC1_Bridge	47°40'49.78"N, 116°36'16.49"W	State of Idaho
MC_Bridge	47°39'57.09"N, 116°36'27.22"W	State of Idaho
WLC3_Bridge	47°39'22.63"N, 116°36'39.39"W	State of Idaho
KOA_Bridge	47°37'48.93"N, 116°36'58.80"W	Private
I90_Bridge	47°37'43.45"N, 116°37'18.85"W	State of Idaho

STREAM CROSSING DATA FORMS

WOLF LODGE CREEK WATERSHED

CROSSING TYPE
Bridge Gravel road/Private

Location: Unnamed 2 Reach 2
Crossing ID: UN2_Bridge

SEDIMENT DELIVERY
Moderate/Intermittent Stream

DRAINED AREA	
Stream Name:	Unnamed 2
Fish Passage:	Yes

BRIDGE DATA	
Construction materials:	Wood deck, steel stringers, native approach grades
Deck condition:	Stable, wood
Stream channel constricted by bridge?	Yes

RISK ASSESSMENT	
Overtopping:	Possible
Mass Failure	Possible, fillslopes eroding at bridge inlet/outlet.
Erosion:	Medium, fillslopes eroding at bridge inlet/outlet.
Significance of problem:	Medium, fill is eroding and bridge is undersized.

COMMENTS	
Scour in channel?	Slight scour downstream of bridge outlet.
Scour at outlet?	Minimal.
Road fill eroding into channel at crossing?	Yes
Fish concerns?	No

RECOMMENDATIONS
Talk with landowner about potential removal/replacement.

Bridge Deck

Stringer

CROSSING TYPE
Culvert Private/Agriculture

Location: Unnamed 2 Reach 3
Crossing ID: UN3_Culvert

SEDIMENT DELIVERY
Moderate/Intermittent Stream

DRAINED AREA	
Stream Name:	Unnamed 2
Fish Passage:	No

CULVERT DATA	
Diameter:	5 ft.
Length:	21 ft.
Alignment with stream:	Culvert is aligned with stream.
Culvert installation:	Stacked rock forms fillslopes. Vertical.
Energy dissipation at outlet:	No, downstream bank erosion is severe.
Armoring:	Not adequate.
Condition:	Both inlet and outlet are degraded and not properly designed.

RISK ASSESSMENT	
Overtopping:	Possible. Plugging risk is high.
Mass Failure	Probable during high flow event, especially if inlet is plugged.
Erosion:	High, extreme bank erosion at outlet.
Significance of problem:	Recommend replacement.

COMMENTS	
Scour in channel?	Yes.
Scour at outlet?	Yes, excessive.
Road fill eroding into channel at crossing?	No
Fish concerns?	Ephemeral, non-fish bearing stream.

RECOMMENDATIONS
Replace culvert and integrate with upstream/downstream channel and streambank restoration treatments.

Inlet

Outlet

RIVER DESIGN GROUP

CROSSING TYPE
Culvert Paved road

Location: Unnamed 2 Reach 3
Crossing ID: UN3_Culvert2

SEDIMENT DELIVERY
Moderate/Intermittent Stream

DRAINED AREA	
Stream Name:	Unnamed 2
Fish Passage:	No

CULVERT DATA	
Diameter:	5 ft.
Length:	25 ft.
Alignment with stream:	No, alignment is causing severe bank erosion.
Culvert installation:	Not installed level with stream bed.
Energy dissipation at outlet:	No, several bank erosion and channel incision downstream of outlet.
Armoring:	Not adequate.
Condition:	Culvert is in relatively good condition, outlet erosion major issue.

RISK ASSESSMENT	
Overtopping:	Probable, would likely overtop if plugged.
Mass Failure	Possible due to lack of hydraulic capacity.
Erosion:	Severe upstream and downstream of culvert.
Significance of problem:	High, significant source of sediment to channel.

COMMENTS	
Scour in channel?	Yes, at outlet due to alignment of culvert.
Scour at outlet?	Yes, at outlet due to alignment of culvert.
Road fill eroding into channel at crossing?	Yes
Fish concerns?	Ephemeral, likely non-fish bearing.

RECOMMENDATIONS
Replace culvert, stabilize fillslopes, and stabilize streambanks at inlet/outlet.

Inlet

Outlet

CROSSING TYPE
Culvert Gravel road

Location: Unnamed 1
Crossing ID: Unnamed1_Culvert

SEDIMENT DELIVERY
Low/Intermittent Stream

DRAINED AREA	
Stream Name:	Unnamed 1
Fish Passage:	No

CULVERT DATA	
Diameter:	2.5 ft x 4 ft
Length:	55 ft
Alignment with stream:	Culvert is aligned with stream.
Culvert installation:	Culvert is installed on grade with stream profile.
Energy dissipation at outlet:	Adequate.
Armoring:	Adequate.
Condition:	Good condition.

RISK ASSESSMENT	
Overtopping:	Unlikely.
Mass Failure	Unlikely.
Erosion:	Medium, road fill eroding downstream on river left.
Significance of problem:	Low.

COMMENTS	
Scour in channel?	No.
Scour at outlet?	Minor scour at culvert outlet.
Road fill eroding into channel at crossing?	Yes, downstream.
Fish concerns?	Fish passage may be compromised. Fish observed upstream.

RECOMMENDATIONS
Further evaluate fish passage conditions and replace as needed. Low priority.

Inlet

Outlet

CROSSING TYPE
Bridge Paved road

Location: Wolf Lodge Creek Reach 1
Crossing ID: WLC1_Bridge

SEDIMENT DELIVERY
Reaches live stream

DRAINED AREA	
Stream Name:	Wolf Lodge Creek
Fish Passage:	Adequate

BRIDGE DATA	
Construction materials:	Concrete abutments, wooden deck.
Deck condition:	Good.
Stream channel constricted by bridge?	Yes.

RISK ASSESSMENT	
Overtopping:	Unlikely.
Mass Failure	Unlikely.
Erosion:	Low.
Significance of problem:	Low.

COMMENTS	
Scour in channel?	No.
Scour at outlet?	No.
Road fill eroding into channel at crossing?	No.
Fish concerns?	No.

RECOMMENDATIONS
Remove USFS stream gage and maintain deck.

Wooden Deck

CROSSING TYPE
Culvert Paved road

Location: WLC Reach 2, Meyer Road
Crossing ID: WLC2_Culvert

SEDIMENT DELIVERY
Moderate/Stream

DRAINED AREA	
Stream Name:	Wolf Lodge Creek
Fish Passage:	Yes

CULVERT DATA	
Diameter:	14.5 ft.
Length:	35 ft.
Alignment with stream:	Adequate.
Culvert installation:	Culvert is countersunk below stream grade.
Energy dissipation at outlet:	Marginal, some erosion.
Armoring:	Yes.
Condition:	Good.

RISK ASSESSMENT	
Overtopping:	Unlikely.
Mass Failure	Unlikely.
Erosion:	Low.
Significance of problem:	No issues to report.

COMMENTS	
Scour in channel?	Channel is slightly scoured through pipe.
Scour at outlet?	Minor scour downstream of outlet.
Road fill eroding into channel at crossing?	No
Fish concerns?	No

RECOMMENDATIONS
None, crossing is functioning.

Inlet

CROSSING TYPE
Bridge Paved road

Location: Wolf Lodge Creek Reach 3
Crossing ID: WLC3_Bridge

SEDIMENT DELIVERY
Moderate/Perennial.

DRAINED AREA	
Stream Name:	Wolf Lodge Creek
Fish Passage:	Adequate.

BRIDGE DATA	
Construction materials:	Concrete abutments, steel stringers.
Deck condition:	Stable, asphalt surface.
Stream channel constricted by bridge?	Yes.

RISK ASSESSMENT	
Overtopping:	Unlikely.
Mass Failure	Unlikely.
Erosion:	Low, abutment erosion minor.
Significance of problem:	Low.

COMMENTS	
Scour in channel?	Yes.
Scour at outlet?	No.
Road fill eroding into channel at crossing?	No.
Fish concerns?	No.

RECOMMENDATIONS
Reinforce right and left abutments.

Upstream Bridge Inlet

CROSSING TYPE
Bridge Paved road

Location: Wolf Lodge Creek Reach 4
Crossing ID: WLC4_Bridge

SEDIMENT DELIVERY
Moderate/Perennial.

DRAINED AREA	
Stream Name:	Wolf Lodge Creek
Fish Passage:	Adequate

BRIDGE DATA	
Construction materials:	Concrete abutments/stringers.
Deck condition:	Stable, paved.
Stream channel constricted by bridge?	Yes.

RISK ASSESSMENT	
Overtopping:	Unlikely.
Mass Failure	Unlikely.
Erosion:	Low.
Significance of problem:	Low.

COMMENTS	
Scour in channel?	No.
Scour at outlet?	No.
Road fill eroding into channel at crossing?	Road fill on river left contributing sediment to channel.
Fish concerns?	No.

RECOMMENDATIONS
None.

Upstream Bridge Inlet

CROSSING TYPE
Unimproved Ford Private/Agriculture

Location: WLC Reach 4
Crossing ID: WLC4_Ford

SEDIMENT DELIVERY
Moderate/Perennial

DRAINED AREA	
Stream Name:	Wolf Lodge Creek
Fish Passage:	Yes

RISK ASSESSMENT	
Erosion:	Medium due to livestock grazing.
Significance of problem:	Low.

COMMENTS	
Scour in channel?	No.
Road fill eroding into channel at crossing?	No.
Fish concerns?	No.

RECOMMENDATIONS
Consider armored ford with improved approach grades to limit sediment delivery.

Ford

CROSSING TYPE
Bridge Private road

Location: Wolf Lodge Creek Reach 5
Crossing ID: KOA_Bridge

SEDIMENT DELIVERY
Moderate/Perennial

DRAINED AREA	
Stream Name:	Wolf Lodge Creek
Fish Passage:	Adequate

BRIDGE DATA	
Construction materials:	Concrete abutments and deck.
Deck condition:	Stable.
Stream channel constricted by bridge?	No.

RISK ASSESSMENT	
Overtopping:	Unlikely.
Mass Failure	Unlikely.
Erosion:	Low.
Significance of problem:	Low.

COMMENTS	
Scour in channel?	No.
Scour at outlet?	No.
Road fill eroding into channel at crossing?	No.
Fish concerns?	No.

RECOMMENDATIONS
None

Upstream Bridge Inlet

CROSSING TYPE
Bridge 3 Bridges Interstate

Location: Wolf Lodge Creek Reach 5
Crossing ID: I90_Bridge

SEDIMENT DELIVERY
Reaches live stream

DRAINED AREA	
Stream Name:	Wolf Lodge Creek
Fish Passage:	Adequate

BRIDGE DATA	
Construction materials:	Concrete abutments w/ metal.
Deck condition:	Asphalt, stable.
Stream channel constricted by bridge?	Yes.

RISK ASSESSMENT	
Overtopping:	Unlikely.
Mass Failure	Unlikely.
Erosion:	Low.
Significance of problem:	Low.

COMMENTS	
Scour in channel?	No.
Scour at outlet?	No.
Road fill eroding into channel at crossing?	Yes.
Fish concerns?	No.

RECOMMENDATIONS
None.

View of Pier Supports and Stringers

CROSSING TYPE
Bridge

Location: Marie Creek
Crossing ID: MC2_Bridge

SEDIMENT DELIVERY
Moderate/Intermittent.

DRAINED AREA	
Stream Name:	Marie Creek
Fish Passage:	Yes

BRIDGE DATA	
Construction materials:	Concrete pier with PVC column.
Deck condition:	Wood.
Stream channel constricted by bridge?	Slightly.

RISK ASSESSMENT	
Overtopping:	Moderate.
Mass Failure	Moderate.
Erosion:	Upstream/downstream channel erosion.
Significance of problem:	Monitor.

COMMENTS	
Scour in channel?	No.
Scour at outlet?	No.
Road fill eroding into channel at crossing?	Minimal.
Fish concerns?	No.

RECOMMENDATIONS
Replace bridge.

Bridge Inlet

CROSSING TYPE
Culvert

Location: Searchlight Creek
Crossing ID: SLC_Culvert1

SEDIMENT DELIVERY
Stream

DRAINED AREA	
Stream Name:	Searchlight Creek
Fish Passage:	No

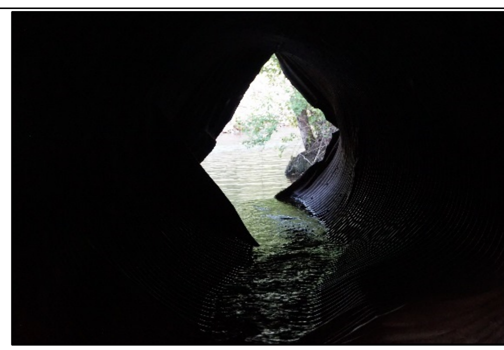
CULVERT DATA	
Diameter:	42 in.
Length:	23 ft.
Alignment with stream:	Not aligned with stream.
Culvert installation:	Damaged/not aligned.
Energy dissipation at outlet:	Inadequate.
Armoring:	Inlet/outlet fillslopes armored.
Condition:	Culvert is partially compromised and crushed.

RISK ASSESSMENT	
Overtopping:	Moderate due to potential for plugging.
Mass Failure	Moderate due to potential for plugging.
Erosion:	Moderate.
Significance of problem:	Moderate.

COMMENTS	
Scour in channel?	Yes.
Scour at outlet?	Yes.
Road fill eroding into channel at crossing?	No.
Fish concerns?	1 foot drop at outlet limits fish passage

RECOMMENDATIONS
Replacement.

Inlet



Inside Culvert

CROSSING TYPE
Culvert

Location: Searchlight Creek
Crossing ID: SLC_Culvert2

SEDIMENT DELIVERY
Stream

DRAINED AREA	
Stream Name:	Searchlight Creek
Fish Passage:	Yes

CULVERT DATA	
Diameter:	30 in
Length:	20 ft
Alignment with stream:	Misaligned.
Culvert installation:	Constricts channel.
Energy dissipation at outlet:	Inadequate.
Armoring:	None.
Condition:	Fair condition.

RISK ASSESSMENT	
Overtopping:	Low.
Mass Failure	Low.
Erosion:	Moderate.
Significance of problem:	Low.

COMMENTS	
Scour in channel?	Deposition at inlet.
Scour at outlet?	Yes.
Road fill eroding into channel at crossing?	No.
Fish concerns?	No.

RECOMMENDATIONS
None

Outlet

CROSSING TYPE
Culvert

Location: Searchlight Creek
Crossing ID: SLC_Culvert3

SEDIMENT DELIVERY
Moderate/Perennial

DRAINED AREA	
Stream Name:	Searchlight Creek
Fish Passage:	Yes

CULVERT DATA	
Diameter:	48 in
Length:	15 ft
Alignment with stream:	Not aligned with stream channel.
Culvert installation:	Culvert is structurally compromised.
Energy dissipation at outlet:	Adequate.
Armoring:	Fillslopes vegetated and armored.
Condition:	Damaged.

RISK ASSESSMENT	
Overtopping:	Low.
Mass Failure	Possible due to existing structural deficiencies.
Erosion:	Yes.
Significance of problem:	Moderate.

COMMENTS	
Scour in channel?	Yes, inlet/outlet.
Scour at outlet?	Yes.
Road fill eroding into channel at crossing?	No.
Fish concerns?	Fish passage is provided.

RECOMMENDATIONS
Replacement/Removal

Damaged Outlet

CROSSING TYPE
Bridge Paved road

Location: Marie Creek Reach 3
Crossing ID: MC_Bridge

SEDIMENT DELIVERY
Moderate/Perennial

DRAINED AREA	
Stream Name:	Marie Creek
Fish Passage:	Adequate

BRIDGE DATA	
Construction materials:	Concrete abutments, asphalt deck.
Deck condition:	Stable, paved.
Stream channel constricted by bridge?	Yes, levees on both side of channel.

RISK ASSESSMENT	
Overtopping:	Unlikely.
Mass Failure	Low risk.
Erosion:	Low.
Significance of problem:	Not significant.

COMMENTS	
Scour in channel?	No.
Scour at outlet?	No.
Road fill eroding into channel at crossing?	Yes.
Fish concerns?	No.

RECOMMENDATIONS
Gravel bar forming at bridge inlet. Recommend monitoring and removal as necessary.

Downstream Bridge

CROSSING TYPE
Bridge Private road

Location: Lonesome Creek Reach 1
Crossing ID: LC1_Bridge

SEDIMENT DELIVERY
Low/Intermittent

DRAINED AREA	
Stream Name:	Lonesome Creek
Fish Passage:	Adequate

BRIDGE DATA	
Construction materials:	Concrete abutments, wooden deck.
Deck condition:	Stable, wooden.
Stream channel constricted by bridge?	Yes.

RISK ASSESSMENT	
Overtopping:	Possible during large flood event.
Mass Failure	Possible during large flood event.
Erosion:	Bank erosion upstream/downstream or crossing.
Significance of problem:	Moderate.

COMMENTS	
Scour in channel?	Channel is aggrading in the vicinity of the bridge inlet/outlet.
Scour at outlet?	No.
Road fill eroding into channel at crossing?	Yes.
Fish concerns?	No.

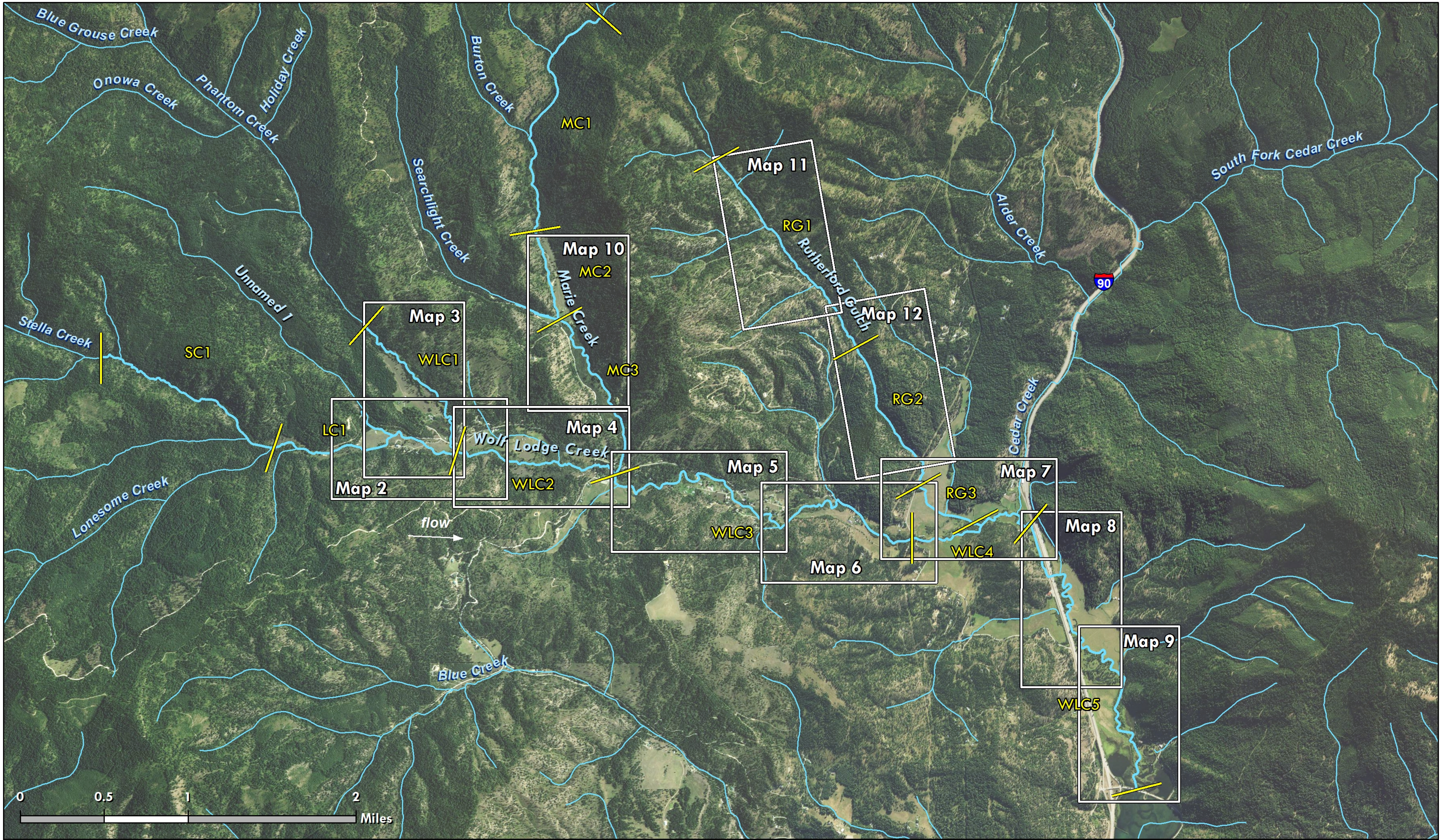
RECOMMENDATIONS
Replace bridge or increase span/freeboard.

Upstream Bridge

Wooden Deck

APPENDIX E

FLOODPLAIN CONNECTIVITY ANALYSIS



Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

Figure E1. Floodplain connectivity index map.

Features

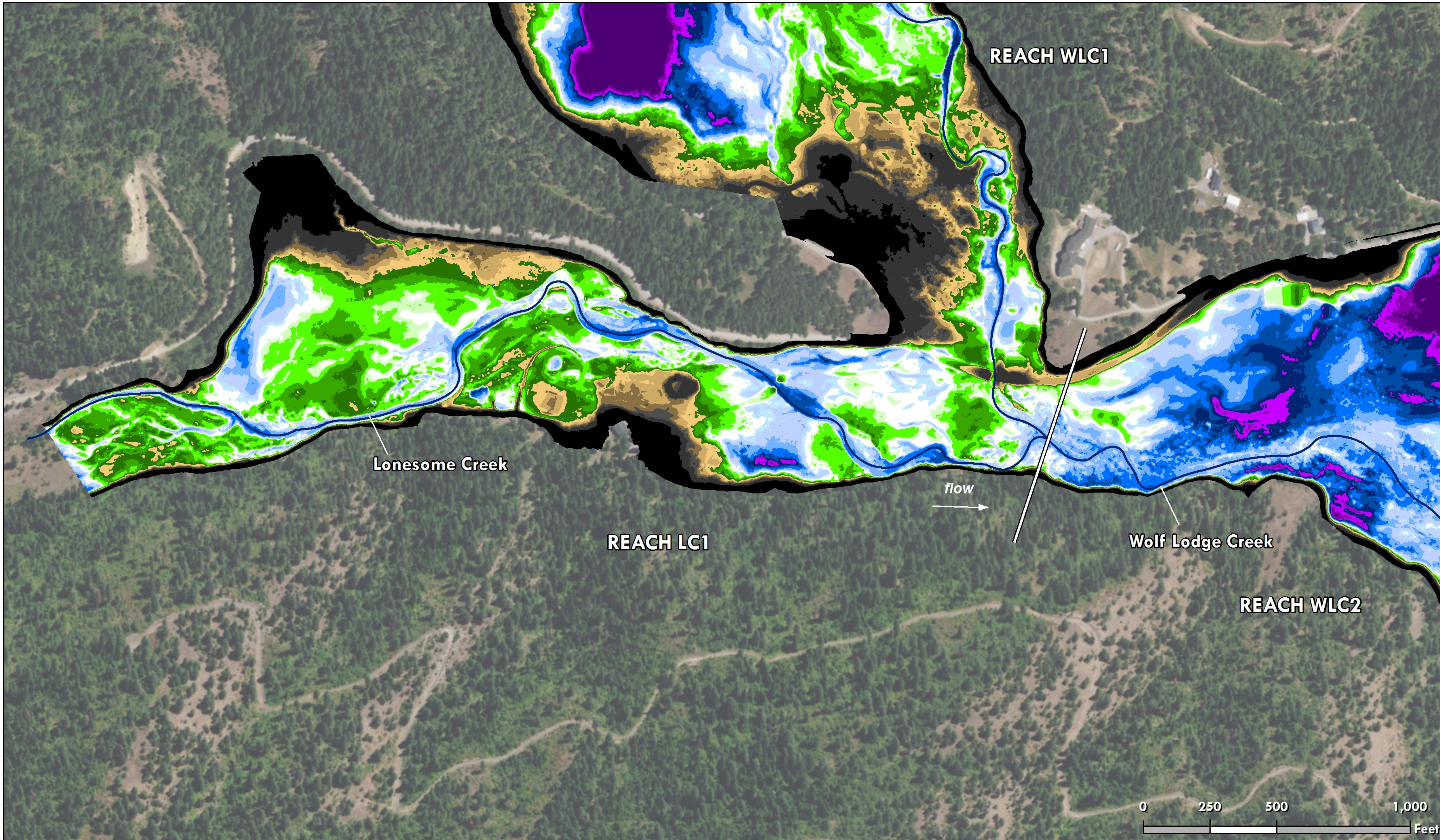
Reach Break

Map Sheet

N

10.31.2016. River Design Group, Inc.
Data: ID DEQ; Imagery: 2015 NAIP

MAP 1 OF 12

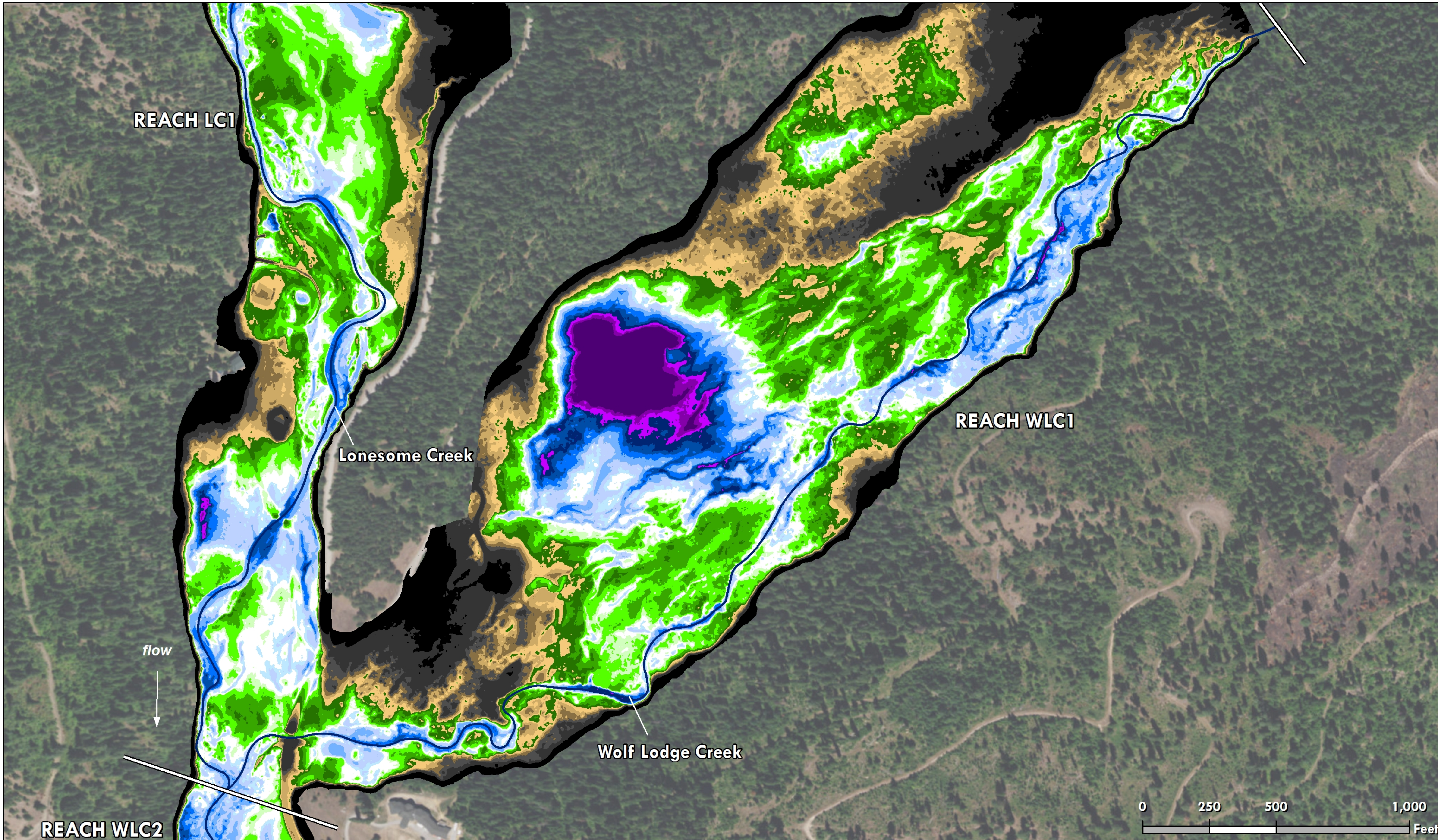


Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

Figure E2. Floodplain connectivity of Reach LC1.

10.31.2016. River Design Group, Inc.
Data: ID DEQ; Imagery: 2015 NAIP

MAP 2 OF 12



Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

Figure E3. Floodplain connectivity of Reach WLC1.

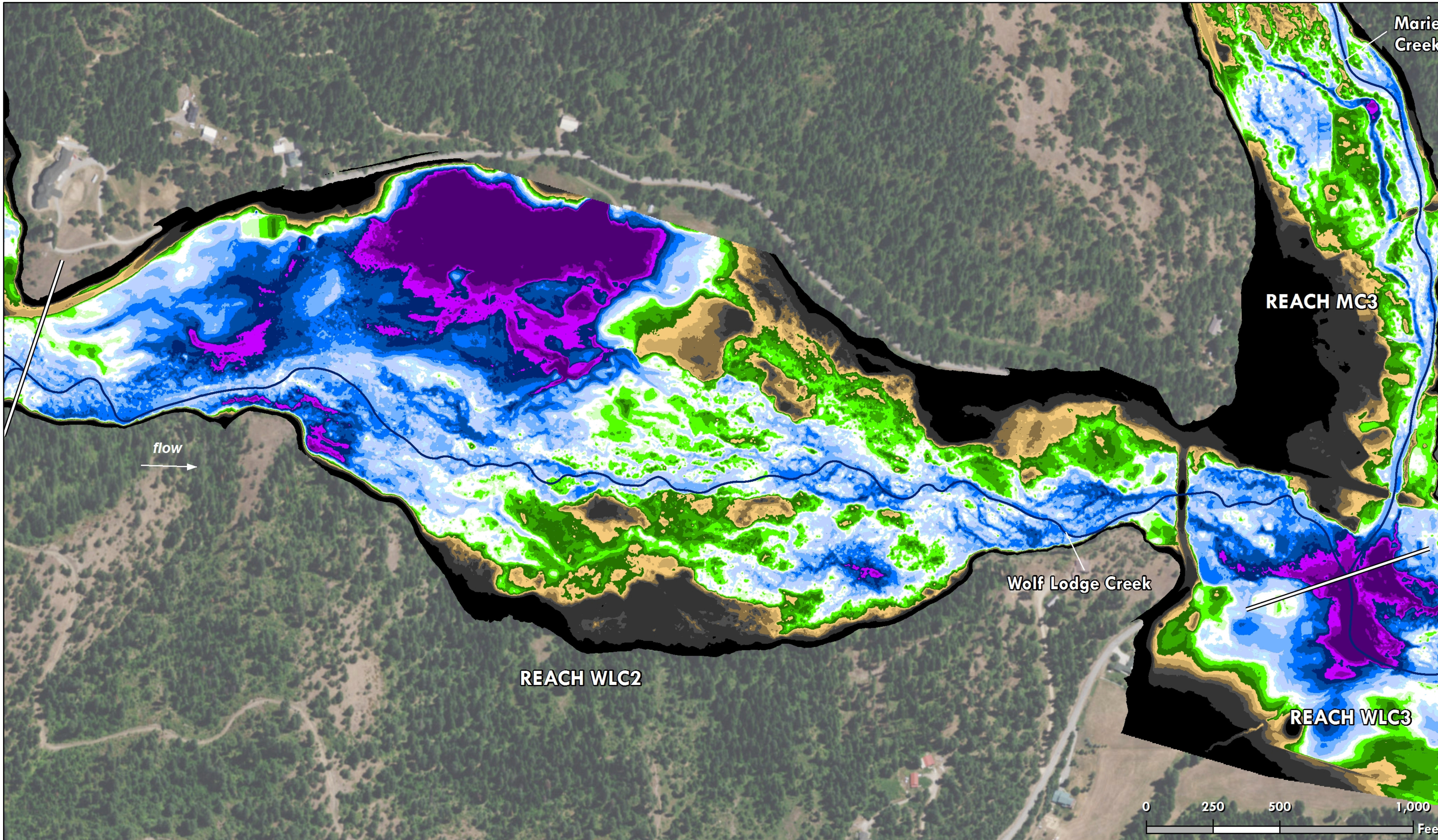
Elevation Relative to Bankfull (ft)

-9 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 -0.25 0.25 0.5 1 1.5 2 2.5 3 3.5 4 6 14

N

10.31.2016. River Design Group, Inc.
Data: ID DEQ; Imagery: 2015 NAIP

MAP
3 OF 12



Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

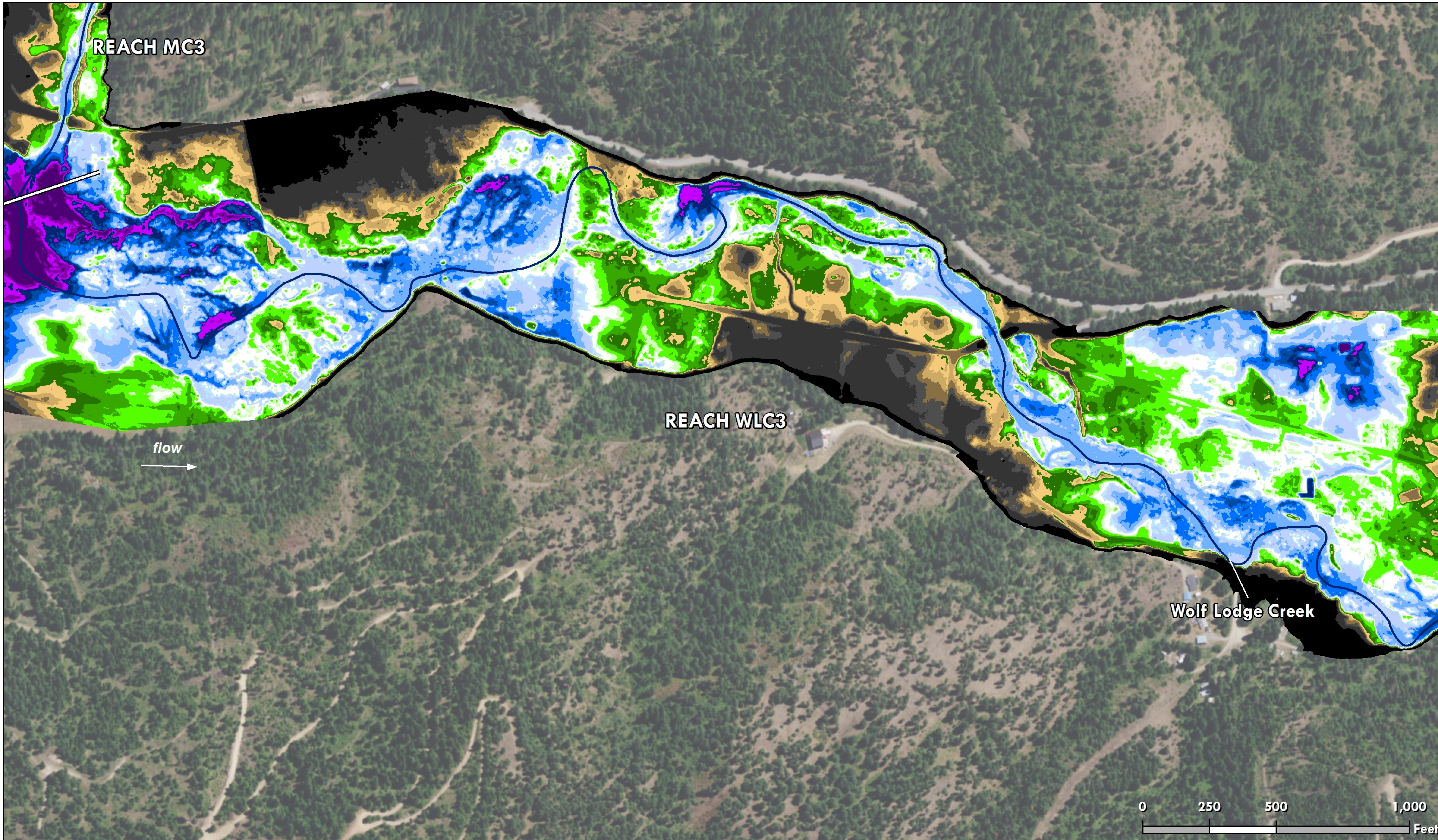
Figure E4. Floodplain connectivity of Reach WLC2.

Elevation Relative to Bankfull (ft)

-8 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 -0.25 0.25 0.5 1 1.5 2 2.5 3 3.5 4 6 14

N

10.31.2016. River Design Group, Inc.
Data: ID DEQ; Imagery: 2015 NAIP



Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

Figure E5. Floodplain connectivity of Reach WLC3 (upstream).

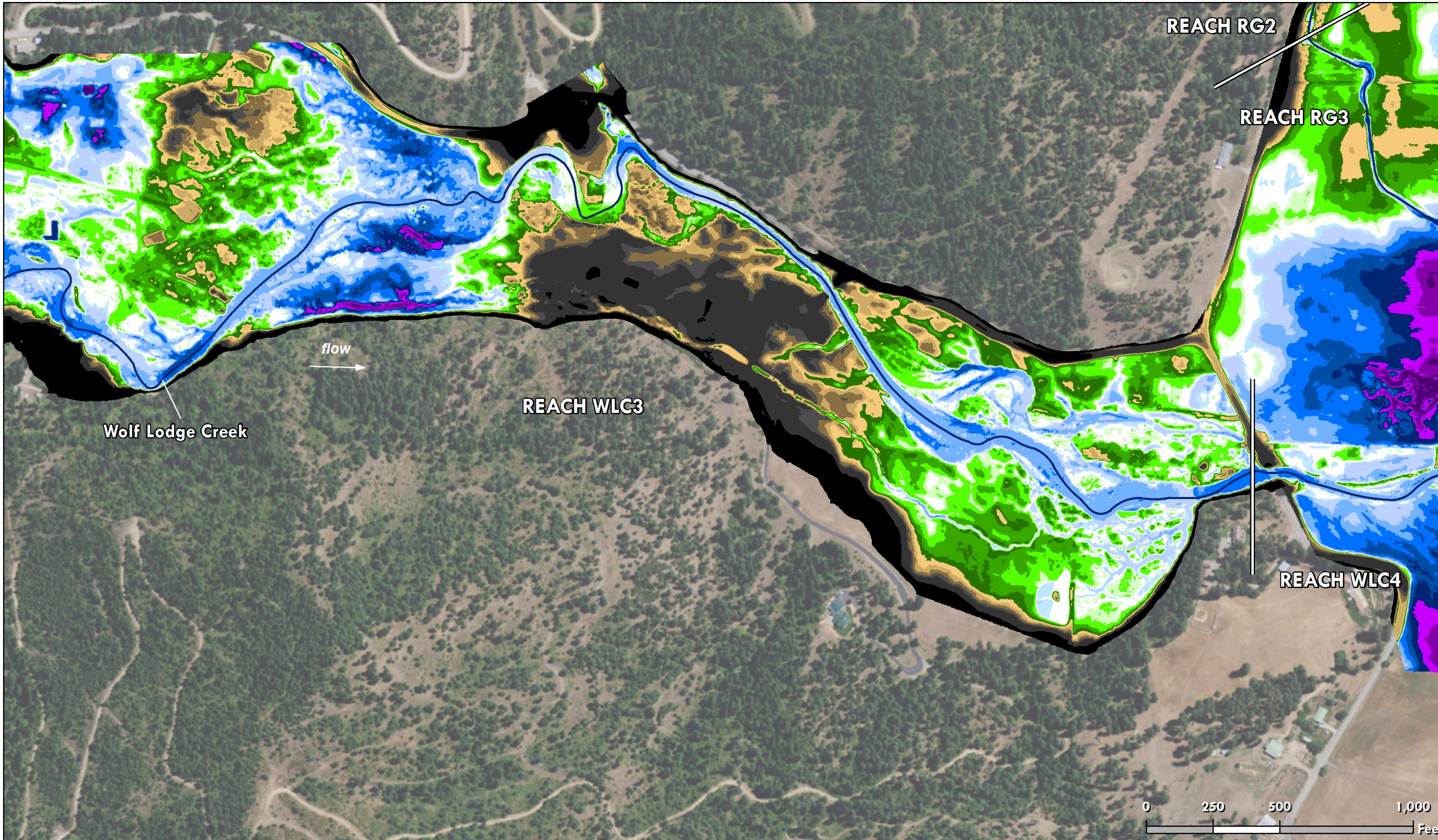
Elevation Relative to Bankfull (ft)

-8 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 -0.25 0.25 0.5 1 1.5 2 2.5 3 3.5 4 6 14

N

10.31.2016. River Design Group, Inc.
Data: ID DEQ; Imagery: 2015 NAIP

MAP 5 OF 12



Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

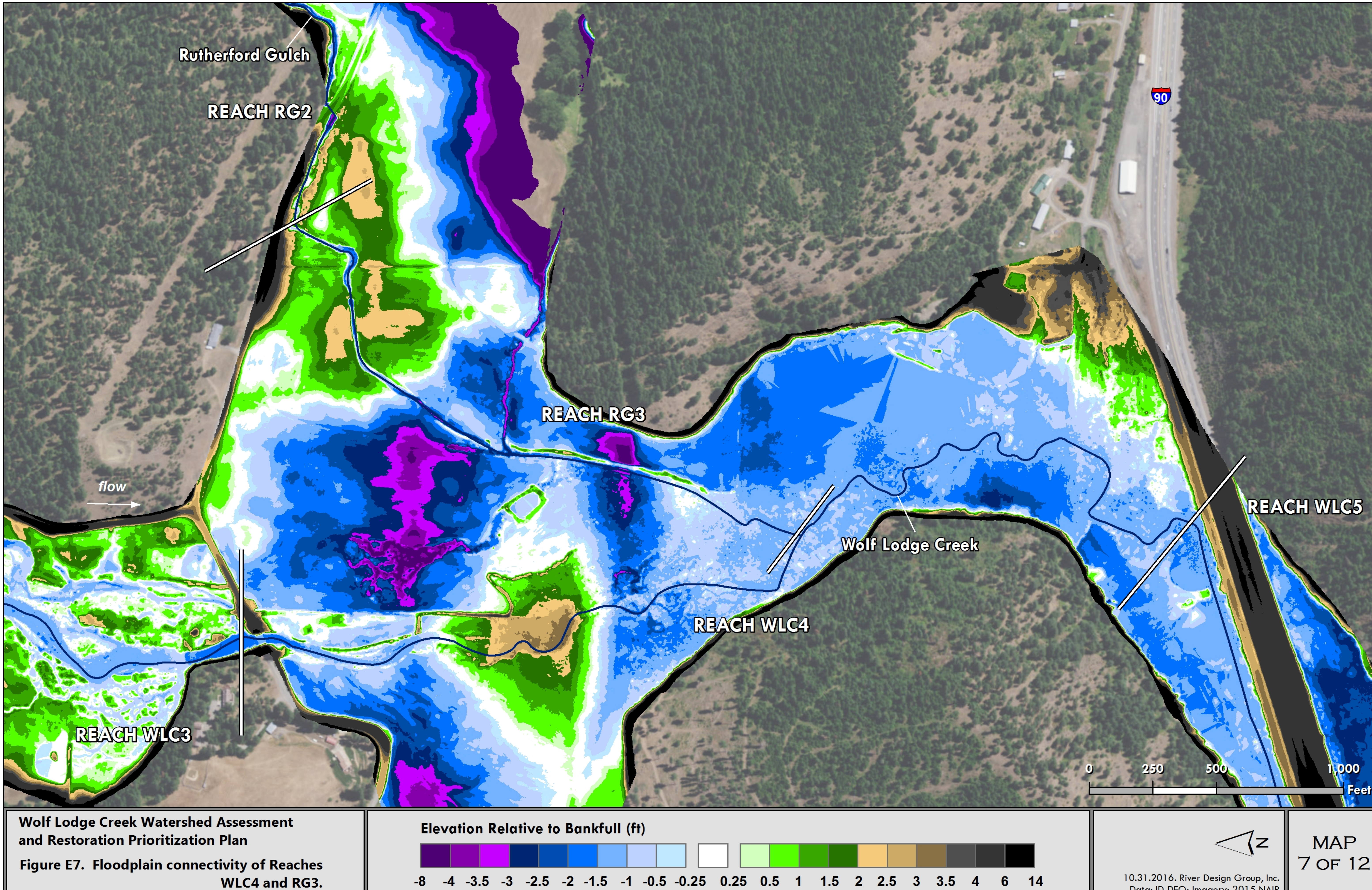
Figure E6. Floodplain connectivity of Reach WLC3 (downstream).

Elevation Relative to Bankfull (ft)

-8 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 -0.25 0.25 0.5 1 1.5 2 2.5 3 3.5 4 6 14

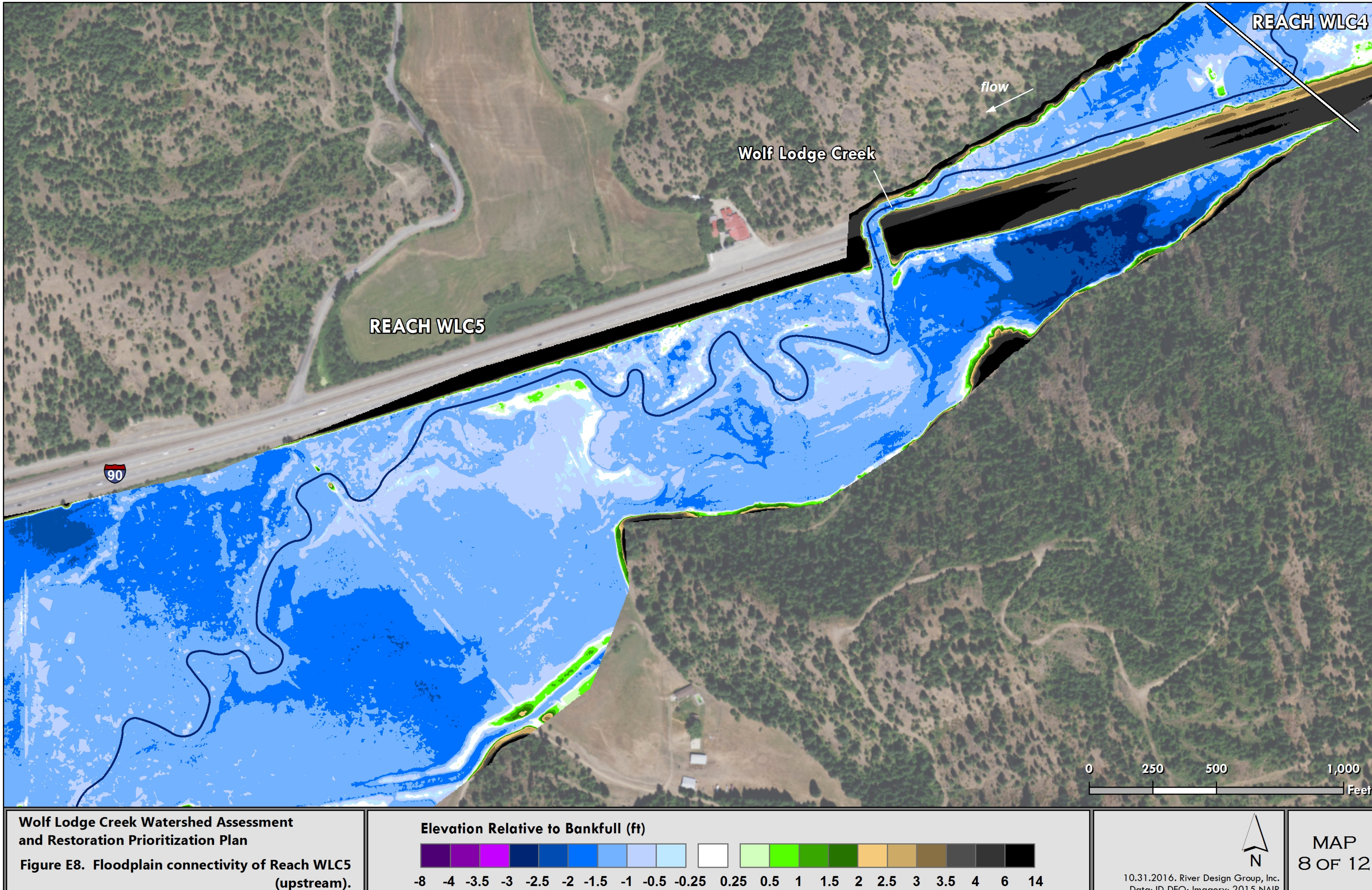
N

10.31.2016. River Design Group, Inc.
Data: ID DEQ; Imagery: 2015 NAIP



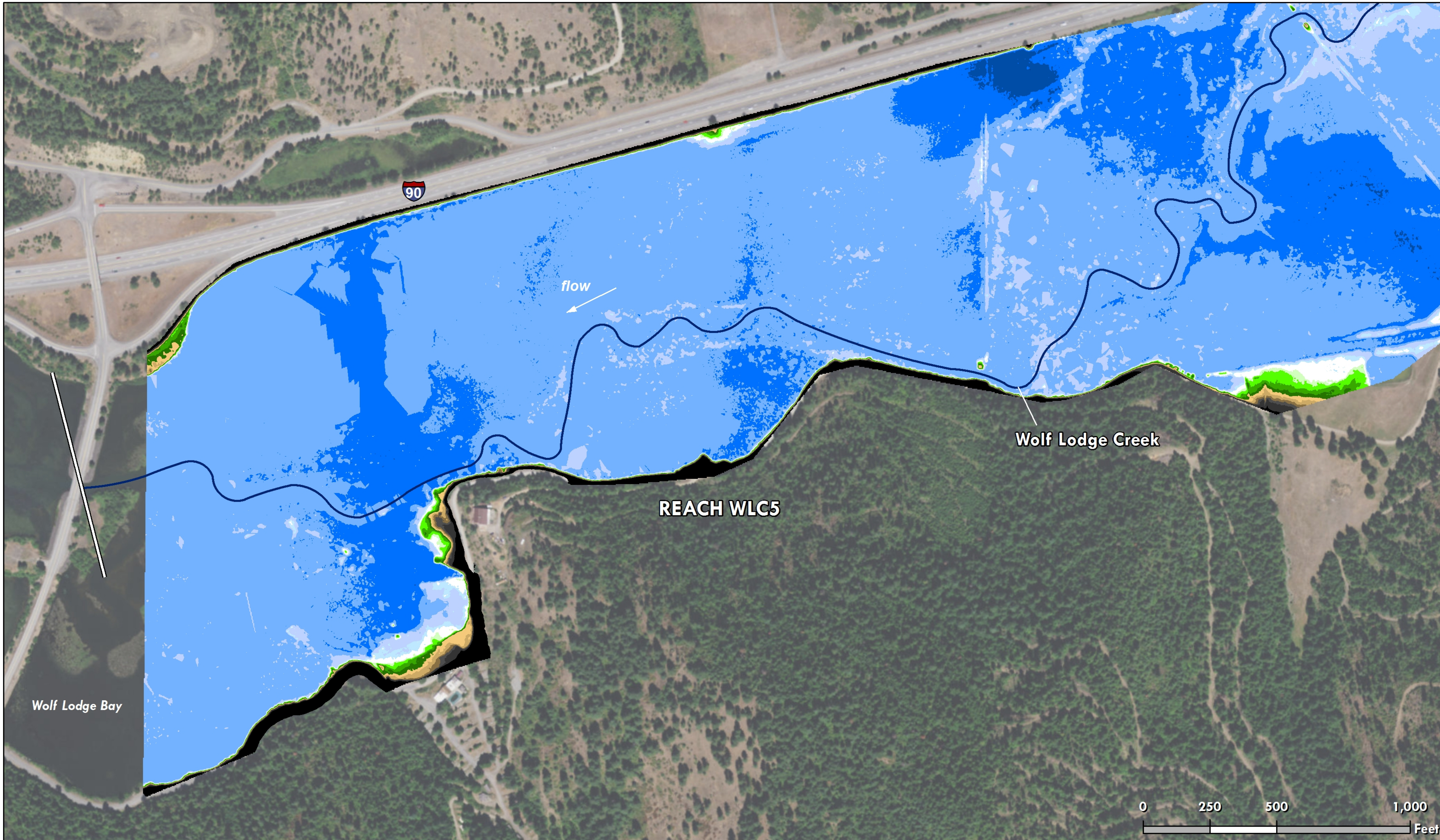
Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

Figure E7. Floodplain connectivity of Reaches WLC4 and RG3.



Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

Figure E8. Floodplain connectivity of Reach WLC5 (upstream).



Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

Figure E9. Floodplain connectivity of Reach WLC5 (downstream).

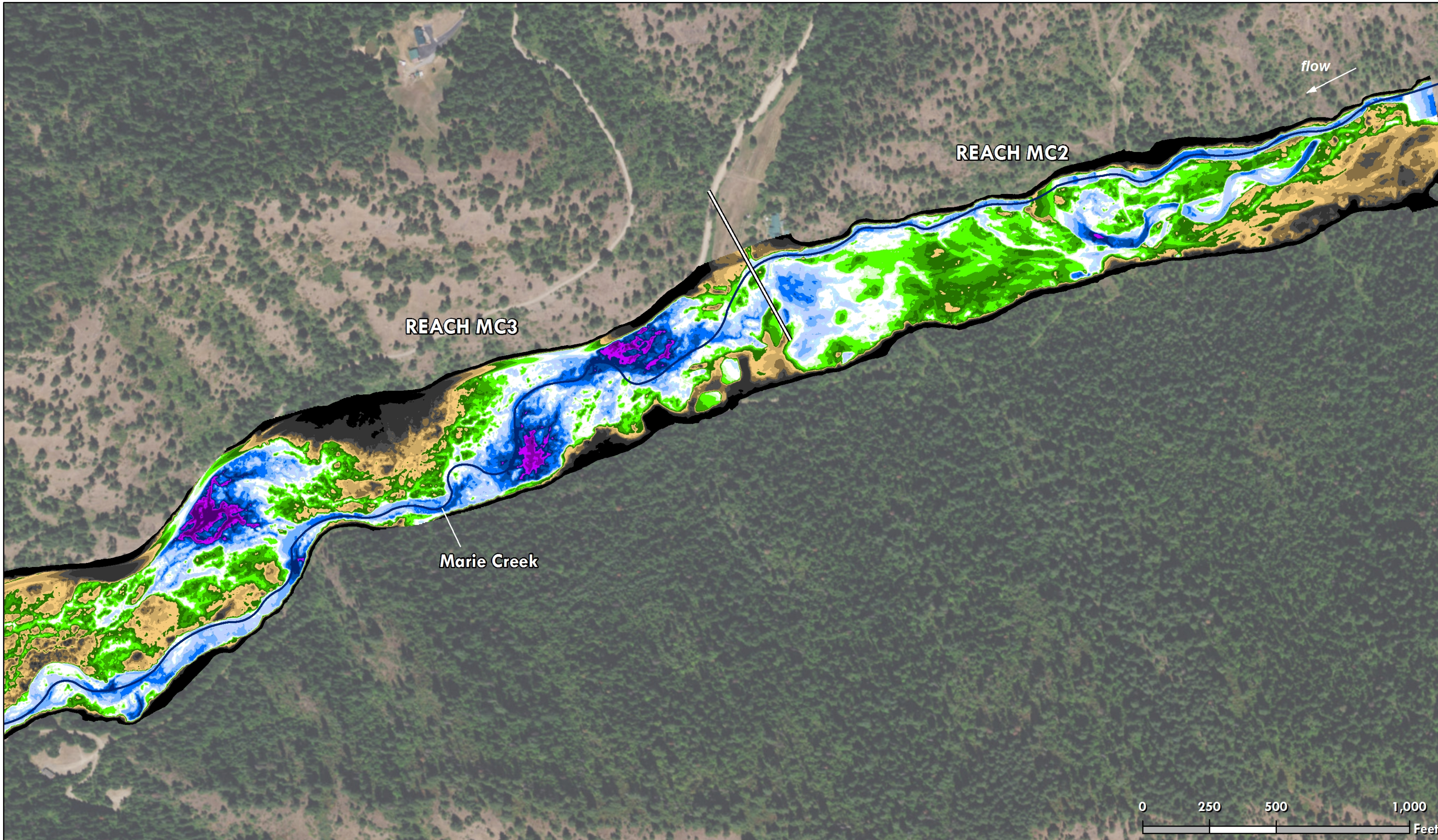
Elevation Relative to Bankfull (ft)

-8 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 -0.25 0.25 0.5 1 1.5 2 2.5 3 3.5 4 6 14

N

10.31.2016. River Design Group, Inc.
Data: ID DEQ; Imagery: 2015 NAIP

MAP
9 OF 12



Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

Figure E10. Floodplain connectivity of Reaches MC2 and MC3.

Elevation Relative to Bankfull (ft)

-8 | -4 | -3.5 | -3 | -2.5 | -2 | -1.5 | -1 | -0.5 | -0.25 | 0.25 | 0.5 | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 | 4 | 6 | 14

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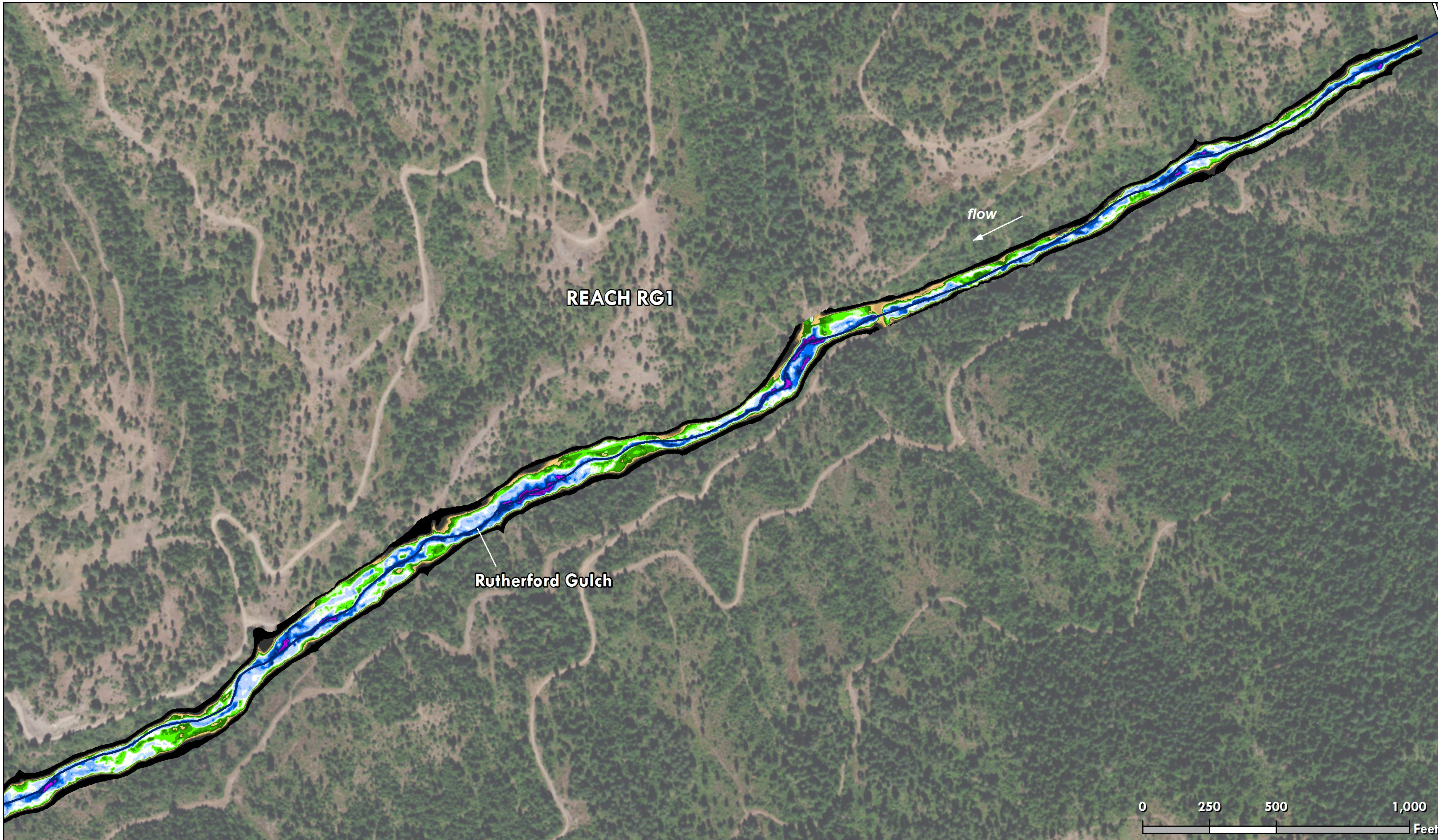

Wolf Lodge Creek Watershed Assessment
and Restoration Prioritization Plan

Figure E11. Floodplain connectivity of Reach RG1.

Elevation Relative to Bankfull (ft)

-8 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 -0.25 0.25 0.5 1 1.5 2 2.5 3 3.5 4 6 14

N

10.31.2016. River Design Group, Inc.
Data: ID DEQ; Imagery: 2015 NAIP

MAP
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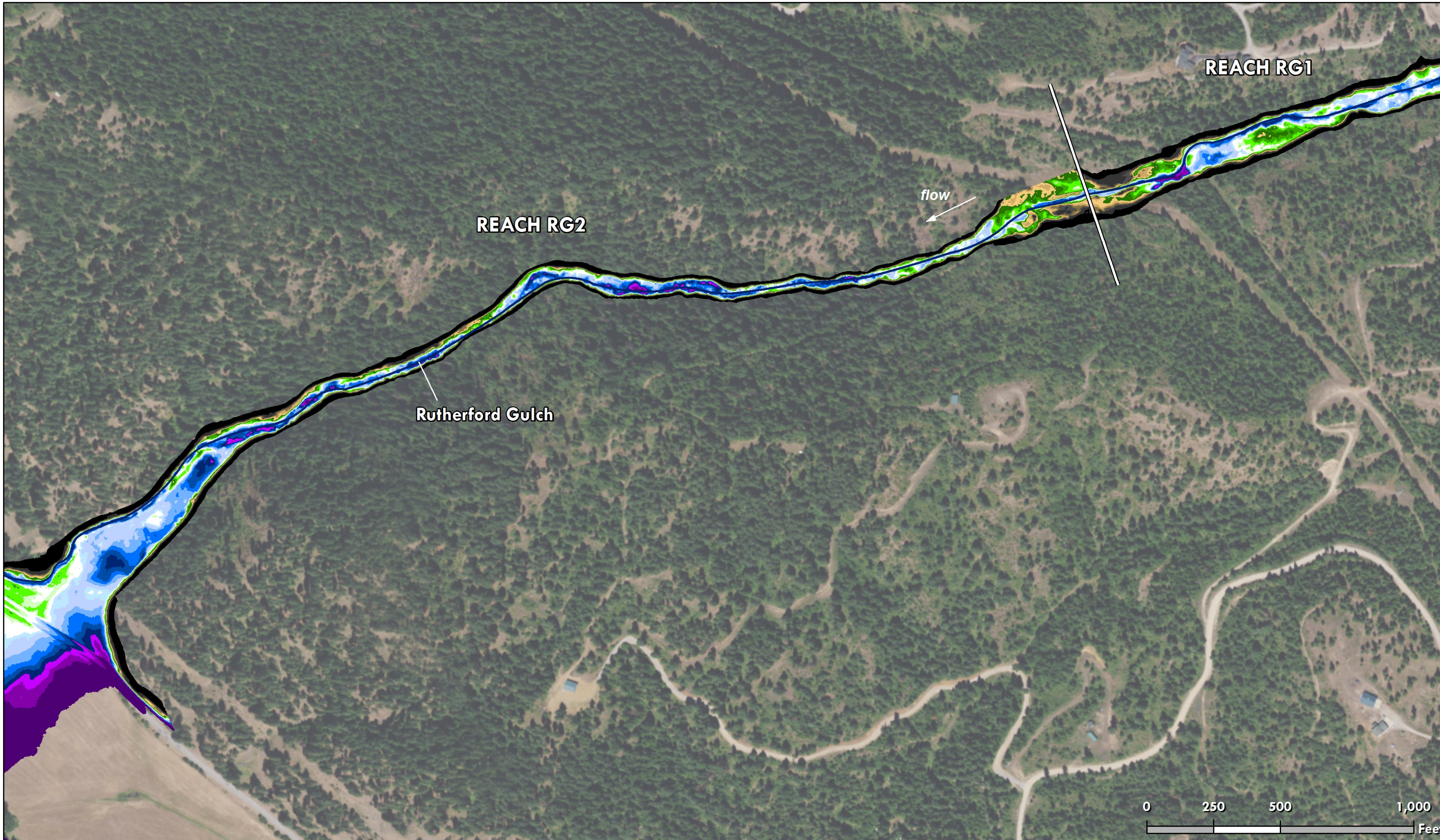

Wolf Lodge Creek Watershed Assessment and Restoration Prioritization Plan

Figure E12. Floodplain connectivity of Reach RG2.

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Executive Summary

Idaho Department of Environmental Quality, in coordination with local, state, and federal agencies and landowners, retained River Design Group, Inc. to complete a watershed-scale assessment and restoration prioritization plan for Wolf Lodge Creek, a tributary to Lake Coeur d'Alene in northern Idaho. Goals of the assessment were to provide a quantitative inventory of stream corridor conditions in Wolf Lodge Creek and tributary streams, and develop a restoration prioritization plan to address sediment and temperature impairments in the watershed. The report and study expand on previous work conducted by Idaho Department of Environmental Quality, US Environmental Protection Agency, US Forest Service, and others, and provides an updated assessment of the existing conditions and limiting factors in watershed.

Remote sensing including analysis of high resolution topographic data and aerial photography, and field investigations were completed from March through November, 2016. Data collection efforts focused on characterizing the conditions of channels and floodplains in the watershed, surveying vegetation, evaluating aquatic habitat features, analyzing and quantifying channel erosion rates for problem areas identified during the field assessment and in previous studies, and identifying opportunities to improve stream crossings including culverts and bridges.

The following major conclusions were derived from the assessment:

1. Removal of native streambank and floodplain vegetation (i.e. trees and shrubs) accelerates rates of bank erosion. Accelerated erosion contributes excess coarse sediment to Wolf Lodge Creek, and affects the ability of the channel to efficiently transport and store sediment. A majority of the sediment produced in the watershed originates locally from rapid bank erosion, rather than the upstream US Forest Service managed reaches.

2. The existing sediment traps on Stella Creek and Marie Creek are not needed. Removal of these structures, and reconstruction of the channels to restore fish passage and fluvial connectivity, is recommended.

3. Channel alterations such as straightening and ditching limit floodplain connection and the amount of area suitable for supporting desired riparian vegetation. Lack of floodplain connection drives channel instability by increasing the amount of energy concentrated in main stream channels. Additionally, lack of floodplain connection reduces the extent of overbank flooding which supports a range of natural processes necessary to create and maintain diverse riparian vegetation, and recharge groundwater tables.

4. Channel alterations simplify channel processes and limit the availability of aquatic habitat for westslope cutthroat trout and other aquatic organisms.

5. Constraints including existing infrastructure and land uses influence opportunities and ability to achieve restoration potential. Major constraints in the project area include:

   Land Use: Private and public lands are adjacent to the project area. Restoration actions must be compatible with adjacent land uses, and actions must be evaluated for potential effects to adjacent property.

   Regulations: Development within the Wolf Lodge Creek and tributary floodplains is regulated by federal, state and county floodplain regulations. Restoration actions must comply with all applicable regulations.

   Non-native fish species: Non-native fish species such as brook trout directly compete with native species and will not be eradicated.

   Beaver activity: Beaver are active throughout the Wolf Lodge Creek watershed and restoration actions may be influenced by continued activity. This needs to be considered when selecting and managing appropriate restoration actions.

Attachment A to this report includes a conceptual restoration plan for six high priority sites in the watershed. The sites were selected based on their potential to address sources of water quality impairment, with the ultimate goal of reducing sediment contributions, improving aquatic habitat, lowering stream temperatures, and increasing community resilience to flooding and erosion. The sites, and recommended actions, include (not in order of priority):

1. Removing the Stella Creek sediment trap and reconstructing a functioning stream channel and floodplain through the former impoundment.

2. Restoring a 0.5-mile reach of Lonesome Creek.

3. Removing the Marie Creek sediment trap and restoring a 0.4-mile reach of Marie Creek.

4. Addressing severe streambank erosion and channel instability in Reach 3 of Wolf Lodge Creek.

5. Restoring a 0.5-mile reach of Wolf Lodge Creek in Reach 4, including Rutherford Gulch.

6. Improving riparian and floodplain conditions in Reach 5 of Wolf Lodge Creek.

In addition to these high priority sites, numerous opportunities have been identified in other areas of the watershed to address bank erosion, property loss, fish passage, and impaired aquatic habitat and stream channel conditions. Restoration projects will be developed and implemented through a phased, adaptive management approach, in close coordination with affected and willing landowners.

1 Introduction

Idaho Department of Environmental Quality (DEQ) retained River Design Group, Inc. to complete a watershed-scale assessment and restoration prioritization plan for Wolf Lodge Creek, a tributary to Lake Coeur d'Alene in northern Idaho. Wolf Lodge Creek has been influenced by a host of natural background and anthropogenic disturbances, and has been identified as water quality impaired for sediment and temperature by Idaho DEQ. In order to investigate causes and sources of water quality impairment, a field data collection plan was developed and implemented in July and August 2016, with a focus on characterizing existing stream channel morphology, aquatic habitat, riparian and floodplain conditions. Remote sensing including analysis of high resolution topographic data and historical and current aerial photography was conducted to supplement field investigations. This report provides a detailed assessment of existing conditions and identifies limiting factors in the Wolf Lodge Creek watershed. Restoration sites were selected based on their potential to help address the sources of water quality impairment with the ultimate goal of reducing sediment contributions and lowering stream temperatures while increasing community resilience to flooding and erosion. Conceptual designs were developed for the highest priority sites based on input from project stakeholders. Implementation of site specific restoration plans will occur through a phased multi-year approach.

1.1 Prior Investigations

The information in this report expands on the previous work conducted by Idaho DEQ, Environmental Protection Agency (EPA), US Forest Service (USFS), and GeoMax. Documents that were reviewed or referenced include the following:

- Coeur d'Alene Lake Tributaries Temperature Total Maximum Daily Loads (Idaho DEQ 2012);
- Coeur d'Alene Lake Subbasin TMDL Five-Year Review (Idaho DEQ 2011);
- Coeur d'Alene Lake and River Sub-basin Assessment and Proposed Total maximum Daily Loads (Idaho DEQ 1999);
- Coeur d'Alene Lake and River TMDL Implementation Plan (Idaho DEQ 2002);
- Stream Stabilization Project: Wolf Lodge Creek, Marie Creek, Stella Creek (GeoMax 1990); and
- Final Environmental Impact Statement: Horizon Forest Resource Area (USDA 1990).

Following the Yellowstone Pipeline rupture and subsequent fish kill on Wolf Lodge Creek in 1985, funding for investigations into stream channel instability became available. GeoMax, an engineering firm formerly out of Bozeman, MT, was contracted to assess stream instability and design projects in 1988 (GeoMax 1990). During this same time period the Idaho Panhandle National Forest was planning and assessing the impacts of planned timber harvest on the Horizon Forest Resource Area in the headwaters of the Wolf Lodge Creek watershed (USDA

1990). In 1992, construction was completed on a number of the proposed projects designed by GeoMax. In 2000, Idaho DEQ and the EPA listed Wolf Lodge Creek as sediment impaired and developed an implementation plan to meet Total Maximum Daily Load (TMDL) goals (Idaho DEQ 1999). Following the listing for sediment impairment, in 2012 Wolf Lodge Creek, Marie Creek, and Cedar Creek were also listed as temperature impaired (Idaho DEQ 2012).

Other miscellaneous documents provided by Idaho DEQ and the Soil and Water Conservation District were also reviewed. Information from these documents was primarily used to provide watershed-level background data presented in *Section 2.0* and provide historical context for the issues facing the Wolf Lodge Creek watershed.

1.2 Goals and Objectives

Goals of the Wolf Lodge Creek Watershed Assessment were to provide a quantitative inventory of stream corridor conditions on Wolf Lodge Creek and its primary tributaries, and develop a restoration prioritization plan. Objectives included:

- Inventory of existing stream channel conditions in Wolf Lodge and its primary tributaries;
- Inventory of road crossings;
- Historical channel migration analysis;
- Stream and floodplain connectivity analysis;
- Bank erosion and sediment loading analysis; and
- Identification of potential restoration/enhancement opportunities intended to reduce sediment loading, improve channel stability, enhance riparian vegetation communities, and/or enhance fish habitat.

Field work was conducted from June through September 2016. Field data collection included a reconnaissance-level watershed review to document stream types, geomorphic survey sites, and location of potential restoration sites. Geomorphic surveys were conducted on all five reaches on the main stem, Marie Creek (two of three reaches), Lonesome Creek (one reach), and Stella Creek (one reach). Rapid assessments were conducted on the remaining reaches to characterize stream type and document concerns related to temperature and sediment impairment. Stream crossing and road inspections were also completed.

Geospatial and remote sensing analysis was conducted using multiple Geographic Information Systems (GIS) programs utilizing ArcGIS tools and functions in addition to proprietary custom functions in MATLAB. AutoCAD was used for the creation of conceptual designs at priority restoration sites.

1.3 Report Structure and Organization

This report is based on existing data from previous studies, remotely sensed data, and data collected during the 2016 field inventory of existing conditions in the Wolf Lodge Creek watershed. The following sections are included:

- ***Section 1.0 Introduction*** provides an overview of the Wolf Lodge Creek Watershed Assessment, and goals, objectives, and organization of this document;
- ***Section 2.0 Study Area*** describes watershed topography, climate, hydrology, geology, soils, land use/ownership, fisheries, and vegetation;
- ***Section 3.0 Methods*** describes the methodology used for field data collection and analysis, and remote sensing analysis;
- ***Section 4.0 Results and Discussion*** presents stream morphology, large wood, sediment, floodplain connectivity, and vegetation analysis results by stream and reach;
- ***Section 5.0 Bank Erosion Analysis*** provides a discussion of bank erosion analysis results and implications;
- ***Section 6.0 Stream Crossing and Culvert Evaluation*** describes stream crossing existing conditions;
- ***Section 7.0 Limiting Factors and Constraints*** includes discussion of limiting factors identified for the Wolf Lodge Creek watershed;
- ***Section 8.0 Restoration Techniques and Strategies*** presents an overview of conceptual restoration designs and describes restoration techniques that would address limiting factors;
- ***Appendix A - Watershed Maps*** includes cartographic products detailing watershed features;
- ***Appendix B - Geomorphic Data Summary*** provides geomorphic data tables and figures;
- ***Appendix C - Bank Erosion Analysis*** includes tables and charts illustrating bank erosion analysis results;
- ***Appendix D - Stream Crossing Study*** contains stream crossing study data forms and description of study locations;
- ***Appendix E - Floodplain Connectivity Analysis*** includes maps illustrating stream and floodplain connectivity; and
- ***Attachment A - Conceptual Restoration Plan*** presents conceptual designs of restoration and enhancement activities for high priority sites.

2 Study Area

2.1 Overview

Located in Kootenai County in northern Idaho, the Wolf Lodge Creek watershed encompasses 40,105 acres (Figure 2-1). Wolf Lodge Creek is a tributary to Lake Coeur d'Alene, a large natural lake that at the outflow becomes the Spokane River. Main tributary drainages to Wolf Lodge Creek include Stella Creek, Lonesome Creek, Phantom Creek, Marie Creek, Rutherford Gulch, and Cedar Creek (Figure 2-2 and Table 2-1). The Cedar Creek sub-basin is not included in this report and is only briefly covered in this section to provide context for watershed scale characterization.

Wolf Lodge Creek contains important spawning and rearing habitat for native westslope cutthroat trout (*Oncorhynchus clarki lewisi*) that migrate up from Lake Coeur d'Alene. Legacy effects from logging, agriculture, and valley floor clearing continue to impact stream corridor conditions. Logging practices including riparian tree harvest, road construction, and the burning of undergrowth and slash have increased historical sediment loading to Wolf Lodge Creek and its tributaries. In addition, removal of riparian buffers has led to unstable channel widening and bank erosion which now threatens residential infrastructure in the valley bottom. Reach level morphology throughout the watershed is driven by two main factors: First, the channel's competence to mobilize sediment, which is controlled by slope; and second, the condition of riparian vegetation communities.

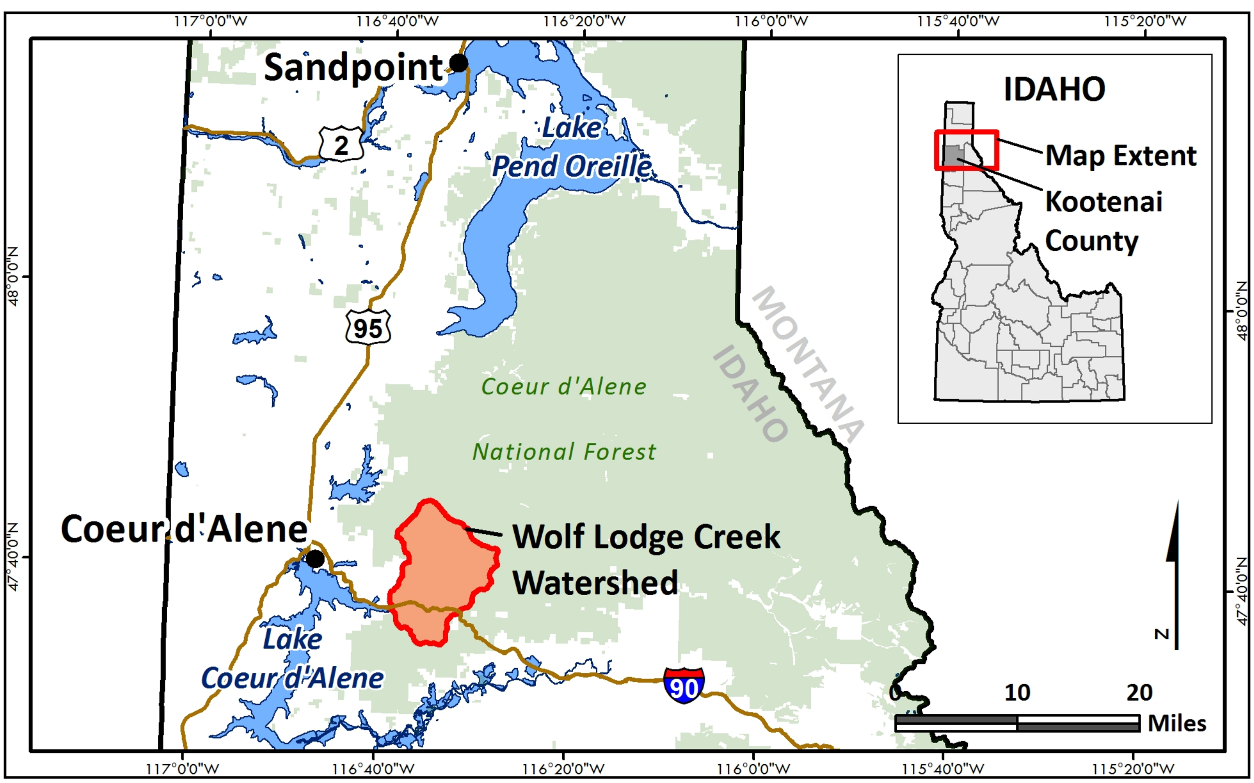

Figure 2-1. Wolf Lodge Creek watershed vicinity map.

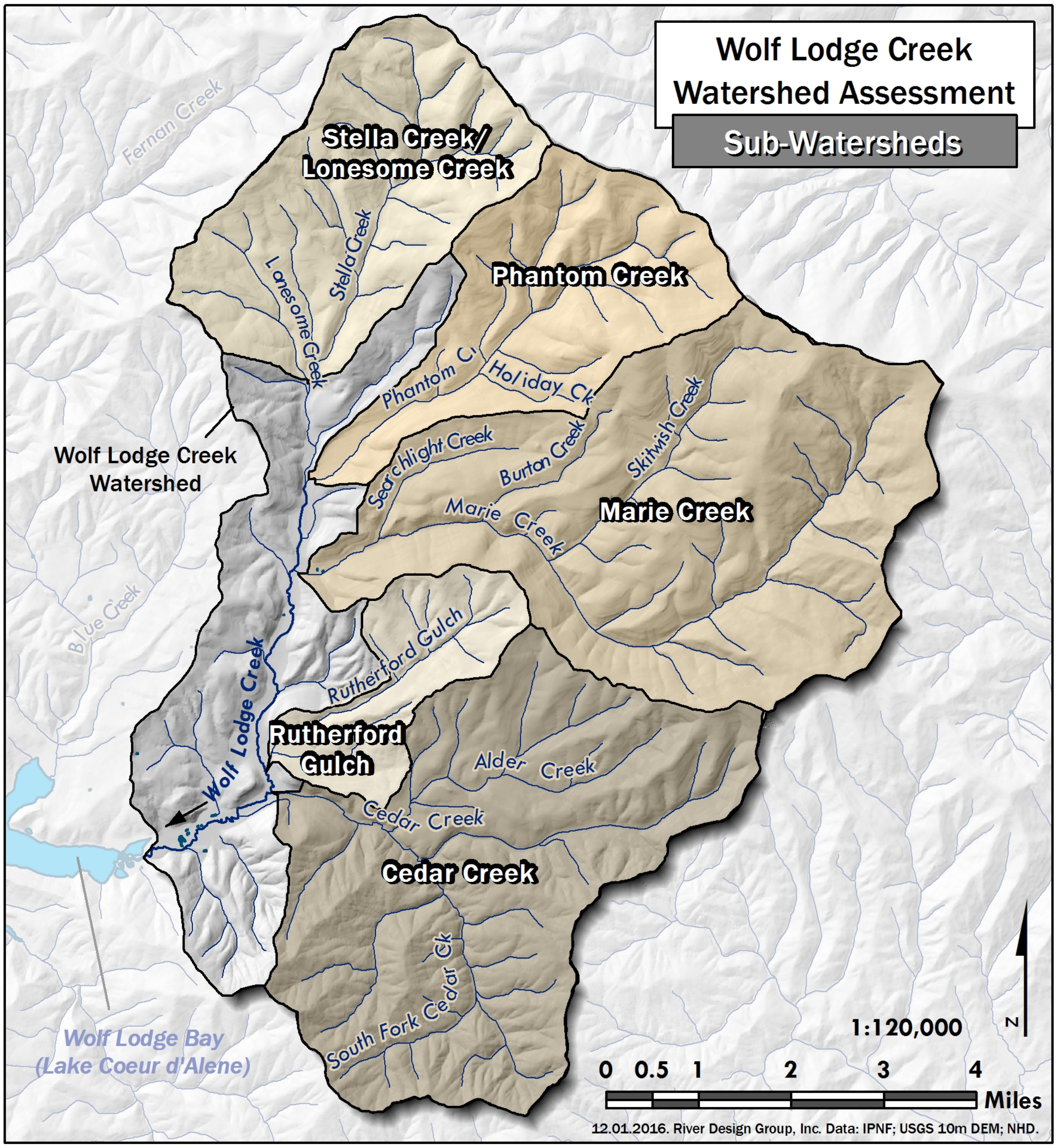

Figure 2-2. Primary sub-watershed delineations for the Wolf Lodge Creek drainage.

Table 2-1. Main tributary drainages to Wolf Lodge Creek.

Sub-Watershed	Acres	% of Wolf Lodge Creek Watershed
Stella Creek and Lonesome Creek	5,527	13.8
Phantom Creek	4,621	11.5
Marie Creek	11,452	28.6
Rutherford Gulch	2,071	5.2
Cedar Creek	10,177	25.4

2.2 Topography

Elevations in the Wolf Lodge Creek drainage range from 5,350 ft above sea level on the Northeast corner in the headwaters of the Marie Creek tributary, to 2,129 ft at Wolf Lodge Bay, where Wolf Lodge Creek empties into Lake Coeur d'Alene (Appendix A, Figure A1). Elevation classes relative to total watershed area are displayed in Table 2-2. As expected, slopes generally increase with an increase in elevation (Appendix A, Figure A2). The steepest portions of the watershed are in the Marie Creek drainage, which has steeper valley walls compared to other tributaries. The valley floor of Wolf Lodge Creek has very low slopes indicative of transitional and depositional stream reaches. Slope continues to decrease to nearly zero as the channel empties into the local base level of Lake Coeur d'Alene.

Table 2-2. Watershed elevation classes relative to watershed area.

Elevation (ft above mean sea level)	Acres	% of Wolf Lodge Creek Watershed
2,129 - 2,130	3	0.01
2,130 - 2,450	3,221	8.0
2,450 - 2,770	5,584	13.9
2,770 - 3,090	7,617	19.0
3,090 - 3,410	7,716	19.2
3,410 - 3,730	5,707	14.2
3,730 - 4,050	3,830	9.6
4,050 - 4,370	2,989	7.5
4,370 - 4,690	1,981	4.9
4,690 - 5,350	1,456	3.6

2.3 Climate

Due to the watershed's proximity to the Pacific Ocean, climate conditions in the Wolf Lodge drainage are often influenced by maritime weather patterns. November through March is punctuated by winter storms, causing a wet winter season. High pressure cells dominate the region during the summer, driving dry conditions from July through September. Winds typically prevail from the west across Lake Coeur d'Alene creating wet conditions from lake effect precipitation, when the high pressure cell dissipates in fall and throughout the winter and early spring. To provide a general representation of the climatic conditions in the Wolf Lodge Creek watershed, data from the Coeur d'Alene weather station (Station #101956) are summarized in Table 2-3 and Figure 2-3. The majority of precipitation in winter months falls as snow, with over 20 inches falling in December and January. Hottest and driest months are July and August. These data support the Köppen-Geiger classification of the majority of the watershed as warm humid continental (Dsb).

Table 2-3. Climate data for Coeur d'Alene weather station 15 miles from project site.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ave Max. Temp (°F)	35.5	40.2	49	56.4	65.2	72.3	81.5	82.5	72.6	58	44	34.3
Ave Mean Temp (°F)	30.5	33.5	40.2	46.5	54.4	61.6	68.9	69	60.1	48.2	37.8	29.8
Ave Min. Temp (°F)	25.4	26.7	31.4	36.7	43.6	50.9	56.3	55.5	47.6	38.4	31.7	25.2
Ave Total Precip (in.)	3.18	2.13	2.34	1.88	2.16	1.98	0.94	0.87	1.01	1.95	3.72	3.52
Ave Total Snowfall (in.)	10.8	3.5	1.1	0.4	0	0	0	0	0	1.2	2.9	10.9

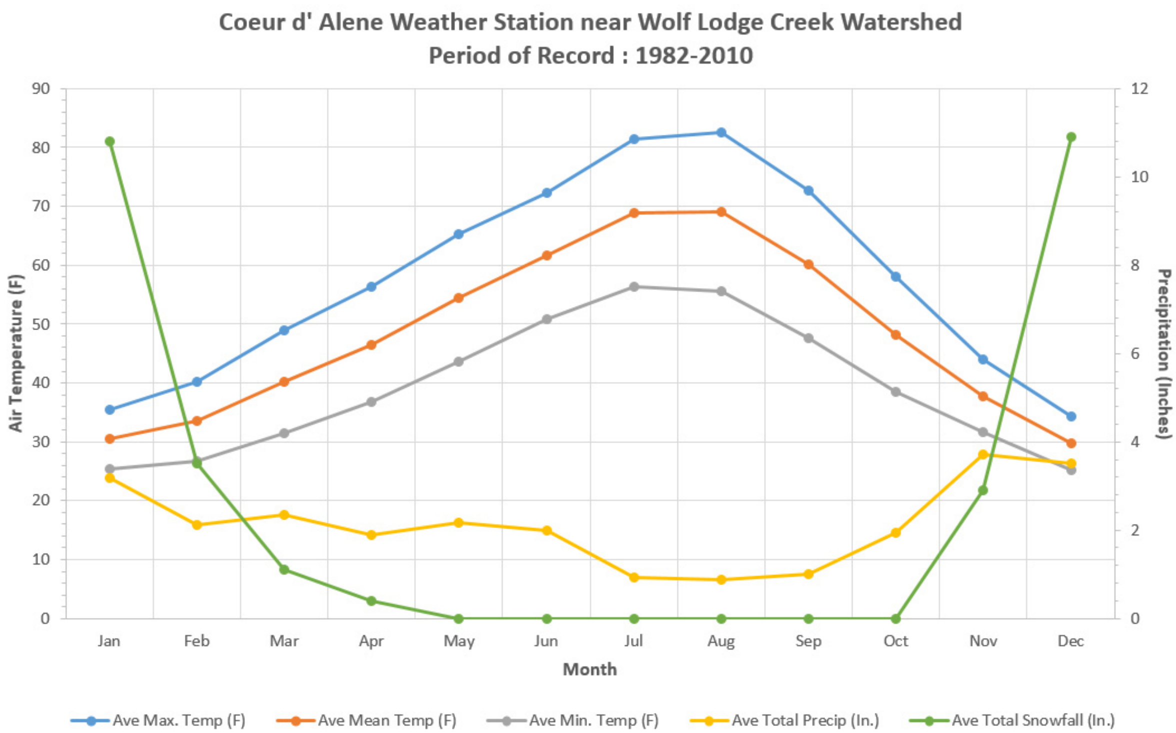

Figure 2-3. Average monthly climate data for Coeur d'Alene weather station 15 miles from Wolf Lodge Creek.

2.4 Hydrology

Wolf Lodge Creek has typical hydrologic characteristics of many western rivers and streams. Highest discharges occur during the spring months March through May, which is driven by the melting snowpack in the headwaters (Figure 2-3). Larger flow events are likely caused by rain-on-snow events typically seen in early spring months (Berris and Harr 1987). Low summer flows persist from June through November until winter rain and snow cause a slight increase in mean daily flows. A United States Geological Survey (USGS) stream gauge on Wolf Lodge Creek was in operation from 1986-1994 at Schoolhouse Bridge, but was discontinued in lieu of two United

States Forest Service (USFS) gauges installed on Marie Creek and Stella Creek. Though gauging data is limited, it provides some insight into the reoccurrence of floods and their magnitude.

USGS stream gauge data were used to conduct a log-Pearson type III flood frequency and recurrence interval analysis for Wolf Lodge Creek (USGS 1982). Results indicate fairly confident predictions for the 2 to 10 year range (Table 2-4). Due to the lack of data, these results provide limited ability to confidently characterize the recurrence interval and magnitude of larger and less frequent events. Additional analysis should be considered to guide design and implementation of future restoration projects.

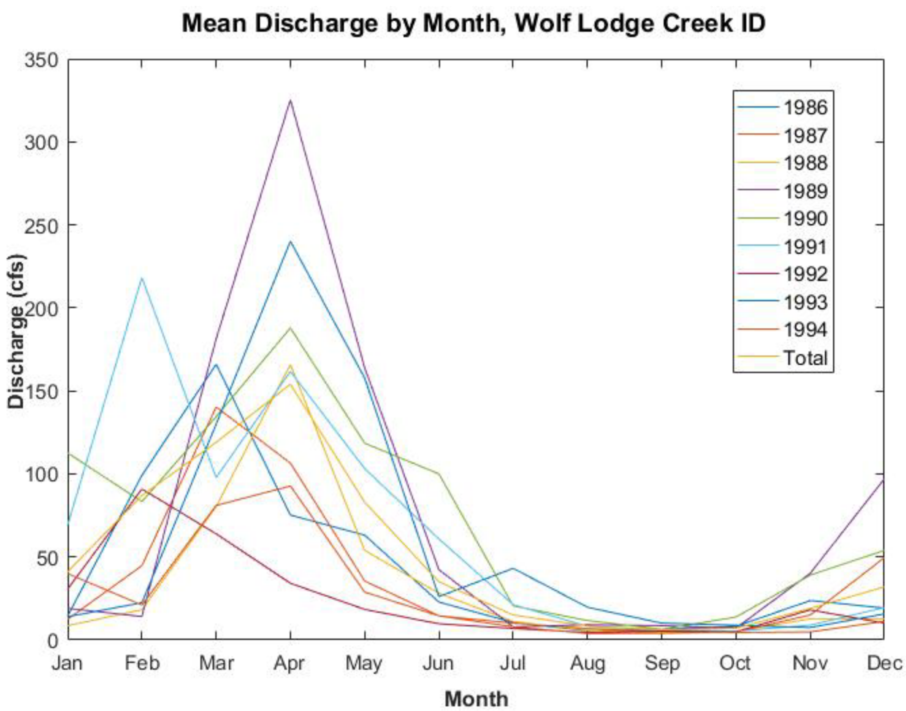

Figure 2-4. Mean monthly discharge for period of record on USGS Wolf Lodge Creek gauge site.

Table 2-4. Flood frequency analysis results from USGS gauge.

Recurrence Interval (Years)	EMA w/Reg Info Estimate	EMA w/o Reg Info Estimate	Variance of Estimate	CI 95% Lower	CI 95% Upper
1	79.2	69.5	0.0451	10.7	149.8
1.25	262.5	265.9	0.0094	132.5	383.5
1.5	335.5	343.2	0.0073	196.5	480
2	427.5	437.6	0.006	275.2	607.5
5	656.8	657.2	0.0057	458.7	1021
10	804.2	785.7	0.0068	570.4	1449
25	981.9	928.1	0.0094	690.7	2230

Table 2-4. Flood frequency analysis results from USGS gauge.					
Recurrence Interval (Years)	**EMA w/Reg Info Estimate**	**EMA w/o Reg Info Estimate**	**Variance of Estimate**	**CI 95% Lower**	**CI 95% Upper**
50	1108	1021	0.0122	761.5	2984
100	1228	1103	0.0155	817.6	3905
200	1342	1177	0.0194	861.5	5069
500	1488	1264	0.0254	906.4	6689

Comparison of the flood frequency analysis conducted for the USGS gage site to regional curves using the USGS StreamStats 4.0 application can be found in Table 2-5. This method is driven largely by basin area and does not produce results with tighter confidence. When comparing these two methods the StreamStats results predict consistently larger flow events. Both methods yield results that overlap when comparing the confidence intervals suggesting that the true values lie in this overlap. Our estimates of bankfull discharge take into account both of these methods in conjunction with the field data collected at each site.

Table 2-5. Stream Stats 4.0 flood frequency based on regional regression analysis.			
Recurrence Interval (Years)	**Estimate (cfs)**	**Prediction Error**	**Comparison to USGS Gage (cfs)**
1.5	535	53.8	199.5
2	675	52.8	247.5
5	1083	52.9	426.2
10	1424	54	619.8
25	1913	56.1	931.1
50	2304	58	1196
100	2751	60	1523
200	3133	62.2	1791
500	3838	65.2	2350

2.5 Geology

The bedrock geology of the watershed consists of meta-sedimentary Belt Series formations (Appendix A, Figure A3) (Lewis et al. 2002). Belt Series rock consists of argillite, siltite, and quartzite lithologies that were deposited in the Precambrian era and slightly metamorphosed. During the deposition of the Belt Series, northern Idaho was covered by a shallow sea that allowed for miles of deposition and burial to create the Belt Series. The lack of terrestrial life in the Precambrian era allowed for extremely high erosion rates. However, the development of large rivers and streams was impeded by hot ground temperatures. As a result, the clasts transported to basins, like the shallow seas encompassing northern Idaho, were dominated by hillslope and aeolian processes. Aeolian, or wind driven transport, is limited in the size of particles that can be carried, leading to sand and silt particles dominating the majority of Belt Series sediments. Formations found in the watershed are members of the Belt Series, including the Prichard Formation, Burke Formation, Revett Formation, and St. Regis Formation (Table 2-6) (Lewis et al. 2002).

Small intrusive dikes and sills cut through the large Belt Series formations and can be found sporadically in the watershed. These intrusions began to form when the North American craton began to rift and form the Atlantic Ocean basin (Lewis et al. 2002). Subsequent orogenies and tectonic uplift created cracks in the Belt Series that were filled with magma and cooled, crystalizing into intrusive diabase formations (Lewis et al. 2002). These formations are more resistant to weathering and erosion causing them to stand out in relief on the landscape. In the Wolf Lodge Creek watershed, Rutherford Gulch cuts through one of these intrusions. This section of channel is much steeper, consisting of a pool-drop channel type for the short area encompassing the intrusion. Bedrock plays a critical role in these situations, limiting the ability of the channel to respond to changes in base level and constricting the channel planform.

In the headwaters, including Stella Creek, Phantom Creek, and Marie Creek, a thin unit of Miocene sediments exists. These sediments were deposited on top of Belt Series formations and represent river and stream networks that were blocked by large basalt flows during the Miocene (Lewis et al. 2002). During this epoch, northern Idaho and Montana were tropical environments with high precipitation and thick tropical vegetation. Additionally, volcanic activity was peaking in the region caused by a subduction zone located to the west. Volcanic eruptions covered the surrounding landscape with hundreds of feet of basalt, which dammed large rivers and streams and caused cobble and gravel deposits (Lewis et al. 2002). Some of these have been preserved in the geologic record, while many were eroded away or buried. Evidence of this formation is in the presence of cobbles and gravels on hillsides that cannot be explained from the current drainage network.

Table 2-6. Summary table of bedrock units present in the Wolf Lodge Creek drainage.

Formation	Unit Name	Era	Major Lithographic Unit	Acres	% of Watershed
Qal	Alluvial deposits	Holocene	Stream deposits	820	2.0
Qla	Lacustrine sediments	Holocene	Silt/sand deposits from Lake Coeur d'Alene and Hayden Lake	246	0.6
Tgn2	Grande Rounde N2	Miocene	Aphyric/plagioclase-phyric basalt	130	0.3
Tgr2	Grande Rounde R2	Miocene	Aphyric/plagioclase-phyric basalt	64	0.2
Ts	Sediment	Miocene	Alluvium from Miocene channels	2,897	7.2
TYqd	Quartz diorite dikes/sills	Cretaceous/Eocene	Hornblende quartz diorite	298	0.7
Yb	Burke Formation	Middle Proterozoic	Siltite and quartzite	7,926	19.8
Ypl	Prichard Formation (lower)	Middle Proterozoic	Thin and evenly bedded siltite	11,126	27.8

Table 2-6. Summary table of bedrock units present in the Wolf Lodge Creek drainage.					
Formation	**Unit Name**	**Era**	**Major Lithographic Unit**	**Acres**	**% of Watershed**
Ypu	Prichard Formation (upper)	Middle Proterozoic	Thinly bedded argillite	6,854	17.1
Yqp	Prichard Formation	Middle Proterozoic	Quartzite	243	0.6
Yr	Revett Formation	Middle Proterozoic	Quartzite with siltite and argilite	7,955	19.8
Ysr	St. Regis Formation	Middle Proterozoic	Siltite, argillite, and quartzite	1,518	3.8

2.6 Soils

Soils in the Wolf Lodge Creek watershed are formed from two different parent material types. The lower subsoil and substratum are formed from glacial till and have a sandy loam texture, moderate amounts of rock fragments, and poor water and nutrient holding capacity. Surface soils are formed from volcanic ash with few rock fragments and high water and nutrient holding capacity. These surface soils make up many of the highly erodible banks found in the reach that are contributing to the high sediment yield. Lower portions of the drainage consist of lacustrine sediments of clay and silt. These soils share many of the same characteristics as the volcanic ash layers found upstream.

Soils were evaluated using the United States Department of Agriculture soil survey units for the Wolf Lodge Creek watershed (Appendix A, Figure A4). Mapped soil units correspond with Idaho Panhandle National Forests Land Types (IPNF 2006), which are used to interpret soil characteristics such as soil erosion hazard, mass erosion potential, sediment delivery potential, and natural sediment load. Table 2-7 includes USDA Soil Map Units and Land Type interpretations for the Wolf Lodge Creek watershed. Sub-watershed data is presented in Table 2-8. Soil Map Unit 462 is the most abundant soil mapped in the Wolf Lodge Creek watershed at 13% of total watershed area. Erosion hazard and sediment delivery potential is low. Soil Map Units 130 and 480 are common along some streams, and both have high sediment delivery potential.

Table 2-7. Summary of Soil Map Units (USDA NRCS 2016) and Land Type Interpretations (IPNF 2006).				
Soil Map Unit	**Unit Name**	**Land Type Interpretations**	**Acres**	**% of Wolf Lodge Creek Watershed**
130	**Typic Udivitrand**s: Typic Humaquepts-Aquic Udifluvents complex, broad stream bottoms	Surface Erosion Hazard: Low Mass Erosion Potential: Low Sediment Delivery Potential: High Natural Sediment Load: 49*	594	1.5
147	**McCrosket-Ardenvoir association**: 35 to 65 percent	N/A	1,795	4.5

Table 2-7. Summary of Soil Map Units (USDA NRCS 2016) and Land Type Interpretations (IPNF 2006).

Soil Map Unit	Unit Name	Land Type Interpretations	Acres	% of Wolf Lodge Creek Watershed
	slopes			
462	**Alfic Udivitrands**: Typic Udivitrands complex, moderately weathered metasedimentary belt geology, mountain slopes, north aspects	Surface Erosion Hazard: Low Mass Erosion Potential: Low Sediment Delivery Potential: Low Natural Sediment Load: 12	5,244	13.1
463	**Alfic Udivitrands**: Typic Udivitrands-Humic Udivitrands complex, moderately weathered belts, lower sideslopes toeslopes and stream bottoms of incised drainages, north aspects	Surface Erosion Hazard: Low Mass Erosion Potential: Moderate Sediment Delivery Potential: Mod. Natural Sediment Load: 22	1,900	4.7
466	**Typic Udivitrands**: weakly weathered metasedimentary belt geology, mountain slopes, north aspects	Surface Erosion Hazard: Low Mass Erosion Potential: Low Sediment Delivery Potential: Low Natural Sediment Load: 12	2,761	6.9
470	**Typic Udivitrand**s: Typic Hapludands complex, weakly weathered metasedimentary belt geology, mountain slopes, south aspects	Surface Erosion Hazard: Low Mass Erosion Potential: Low Sediment Delivery Potential: Low Natural Sediment Load: 17	3,055	7.6
471	**Typic Udivitrands**: Rock outcrop- Typic Udivitrands, moderately acid substratum complex, weakly weathered metasedimentary belt geology, mountain slopes, south aspects, dry	Surface Erosion Hazard: Low Mass Erosion Potential: Low Sediment Delivery Potential: Low Natural Sediment Load: 21	1,266	3.2
472	**Alfic Udivitrand**s: Typic Udivitrands-Andic Haploxeralfs complex, weathered belts, lower sideslopes toeslopes and stream bottoms of drainages in uplands, south aspects	Surface Erosion Hazard: Low Mass Erosion Potential: Moderate Sediment Delivery Potential: Mod. Natural Sediment Load: 35	2,064	5.1

Table 2-7. Summary of Soil Map Units (USDA NRCS 2016) and Land Type Interpretations (IPNF 2006).

Soil Map Unit	Unit Name	Land Type Interpretations	Acres	% of Wolf Lodge Creek Watershed
473	**Alfic Udivitrands**: Andic Haploxeralfs-Andic Haploxerepts complex, weakly to moderately weathered belt geology, dissected rolling uplands, south aspects	Surface Erosion Hazard: Low Mass Erosion Potential: Low Sediment Delivery Potential: Mod. Natural Sediment Load: 22	4,925	12.3
477	**Typic Udivitrands**: weakly weathered metasedimentary belt geology, stream breaklands, north aspects	Surface Erosion Hazard: Low Mass Erosion Potential: Moderate Sediment Delivery Potential: Mod. Natural Sediment Load: 30	1,492	3.7
480	**Typic Udivitrands**: Humic Udivitrands complex, weakly weathered metasedimentary belt geology, dissected stream breaklands, north aspects	Surface Erosion Hazard: Low Mass Erosion Potential: Moderate Sediment Delivery Potential: High Natural Sediment Load: 46	1,922	4.8
483	**Typic Vitrixerands**: Typic Udivitrands complex, weakly weathered metasedimentary belt geology, stream breaklands, south aspects	Surface Erosion Hazard: Low Mass Erosion Potential: Moderate Sediment Delivery Potential: Mod. Natural Sediment Load: 35	1,252	3.1
101/2nm0	**Aquic Xerofluvents**: nearly level	N/A	260	0.6

* Natural Sediment Load is expressed as tons/mi^2/year.

Table 2-8. USDA Soil Map Units by major tributary watershed.

Soil Map Unit	% of Stella Creek/ Lonesome Creek Watershed	% of Phantom Creek Watershed	% of Marie Creek Watershed	% of Rutherford Gulch Watershed	% of Cedar Creek Watershed
130	0.7	2.6	2.0	0.0	0.4
147	0.0	0.0	0.1	22.6	1.0
462	0.3	6.1	12.5	4.9	26.6
463	0.0	6.4	1.6	0.0	12.2
466	20.1	13.0	9.0	0.1	0.0
470	11.6	14.5	13.2	7.3	0.2
471	7.7	4.7	2.7	3.8	0.7
472	1.0	2.4	4.7	5.4	9.5
473	9.1	7.8	12.0	0.0	21.4

Table 2-8. USDA Soil Map Units by major tributary watershed.

Soil Map Unit	% of Stella Creek/ Lonesome Creek Watershed	% of Phantom Creek Watershed	% of Marie Creek Watershed	% of Rutherford Gulch Watershed	% of Cedar Creek Watershed
477	7.4	7.1	2.3	0.0	3.9
480	4.7	5.2	9.6	0.0	2.1
483	10.7	6.7	1.6	0.0	1.3
101/2nm0	0.0	0.0	0.0	0.0	0.0

2.7 Land Ownership and Land Use

Within the Wolf Lodge Creek drainage, most of the land (82%) lies within the Idaho Panhandle National Forest (Appendix A, Figure A5). The remaining land is mostly under private ownership (16%). The State of Idaho, Bureau of Land Management, and two commercial timber operations also have small land holdings within the watershed (Table 2-9). The US Forest Service land consists of the steeper and higher elevations in the watershed, with private land dominating the valley floor on the mainstem of Wolf Lodge Creek. Table 2-10 includes land ownership by major tributary watershed area.

Table 2-9. Land ownership in the Wolf Lodge Creek watershed.

Land Ownership	Acres	% of Wolf Lodge Creek Watershed
US Forest Service	32,716	81.6
State of Idaho	388	1.0
Bureau of Land Management	18	0.04
Potlatch Corporation	294	0.7
Stimson Lumber Co.	242	0.6
Private Land	6,447	16.1

Table 2-10. Land ownership by major tributary watershed.

Land Management	% of Stella Creek/ Lonesome Creek Watershed	% of Phantom Creek Watershed	% of Marie Creek Watershed	% of Rutherford Gulch Watershed	% of Cedar Creek Watershed
Forest Service	100.0	94.9	96.4	27.1	91.0
State of Idaho	0.0	2.3	0.2	0.0	0.0
Private Land	0.0	2.8	3.4	72.9	8.9

Land use is driven by land ownership. Private land in the valley bottom is used for agriculture and residential development. Undisturbed areas in the valley bottom consist of shrubland or grasslands, while US Forest Service land that is undisturbed is made up of dense forest cover (Appendix A, Figure A6). Patches of timber harvest can be seen throughout the watershed as disturbed patches. Forest harvest has been a historically important land use throughout US Forest Service land in the Wolf Lodge Creek watershed, and continues to impact forested environments today. 59% of total watershed area is documented with some degree of harvest or prescribed burn activity since the 1970's (Appendix A, Figure A7). Land management of US Forest Service land is summarized in Table 2-11 for the entire watershed, and in Table 2-12 for major tributary watersheds. Rutherford Gulch watershed is not shown as most of the area is privately owned. The majority of Forest Service land serves timber production. Timber production areas within big game winter range are highlighted along stream valley bottoms and southern aspects (Appendix A, Figure A8).

Table 2-11. Land management of USFS land in the Wolf Lodge Creek watershed.

Land Management	Acres	% of Wolf Lodge Creek Watershed
Timber Production	21,397	53.4
Timber Production within Big Game Winter Range	10,003	24.9
Non-Forest lands, lands non-suited	1,288	3.2

Table 2-12. Land management of USFS land in major tributary watersheds.

Land Management	% of Stella Creek/ Lonesome Creek Watershed	% of Phantom Creek Watershed	% of Marie Creek Watershed	% of Cedar Creek Watershed
Timber Production	74.4	71.2	58.1	60.4
Timber Production within Big Game Winter Range	25.4	23.3	28.2	29.3
Non-Forest lands, lands non-suited	0.0	0.0	10.0	1.3

2.8 Fisheries

Westslope cutthroat trout inhabit the Wolf Lodge Creek watershed and Lake Coeur d'Alene. The Wolf Lodge Creek basin has been identified as a key spawning area for cutthroat in the spring and rearing habitat throughout the year (McIntyre and Rieman 1993). Historically the smaller tributaries in the basin including Searchlight, Clear Cut and Lonesome Creek were critical spawning grounds for westslope cutthroat, while the larger channels including Marie, Wolf Lodge, Cedar, and Stella Creeks were important rearing and migration corridors for the species (Lukens 1978). A number of factors have led to the decline of westslope trout populations throughout the region including this drainage. Logging, agriculture, invasive species, climate change, and hybridization all have contributed loss in abundance of the species (McIntyre and Rieman 1993). Restoration designs described in this report focus on addressing this loss with enhancement of existing habitat as well as projects that will aim to solve systemic issues of rapid bank erosion and sedimentation.

Extensive logging has occurred historically and more recently in the basin (Appendix A, Figure A7). These activities have increased sedimentation by destabilizing hillslopes and allowing for more overland flow rather than infiltration. Increased suspended sediment loads reduce westslope cutthroat trout survival during spawning in the spring, by covering egg surfaces and reducing oxygen to embryos. Increased sediment flux also impacts overwintering westslope cutthroat which bury in interstitial spaces of the channel bed for extended periods during winter. Additionally, the removal of riparian tree and shrub communities increases stream temperatures, decreases the amount of large instream wood, and decreases bank stability furthering sedimentation in the watershed.

Brook trout (*Salvelinus fontinalis*) and Northern Pike (*Esox lucius*) introduced historically to the watershed via Lake Coeur d'Alene have also contributed to the declining westslope cutthroat populations in Wolf Lodge Creek (McIntyre and Rieman 1993). Many of the spawning westslope cutthroat in Wolf Lodge Creek are migrating up channel from the lake during the spring to spawn. These adfluvial cutthroat are likely to encounter spawning pike in the backwater-controlled lower portion of Wolf Lodge Creek, likely increasing rates of predation.

2.9 Vegetation

The Wolf Lodge Creek watershed consists mostly of forested environments (Appendix A, Figure A9). 82% of watershed area is classified as Northern Rocky Mountain Dry-Mesic or Mesic Montane Mixed Conifer Forest according to the Northwest Gap Analysis Project (GAP) (USGS 2011). Species composition of the dry-mesic conifer forest includes an overstory of Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), lodgepole pine (*pinus contorta*) or western larch (*Larix occidentalis*), and an open understory with variable grasses and shrubs. Dry Douglas-fir and grand fir (*Abies grandis*) forests are also components of the dry-mesic montane mixed conifer forest (USGS 2011). The mesic ecosystem is found with moist to wet conditions along valley bottoms and slopes where soil moisture is high, especially on north-facing slopes in the watershed (Appendix A, Figure A9). Common tree species in these productive forests include western hemlock (*Tsuga heterophylla*), western red cedar (*Thuja plicata*), grand fir, and Douglas-fir (USGS 2011).

Other notable ecosystem types include Rocky Mountain Lodgepole Pine Forest, Northern Rocky Mountain Montane-Foothill Deciduous Shrubland, Northern Rocky Mountain Ponderosa Pine Woodland and Savanna, and Northern Rocky Mountain Lower Montane, Foothill, and Valley Grassland. The shrubland is often dominated by mallow-leaf ninebark (*Physocarpus malvaceus*), black hawthorn (*Crataegus douglasii*), Lewis' mock orange (*Philadelphus lewisii*), or serviceberry (*Amelanchier alnifolia*) with grasses in the understory. The Ponderosa Pine Woodland and Savanna ecosystem is characterized by very large ponderosa pine trees and often a grass understory. Shrubs such as sagebrush (*Artemisia spp.*) and common snowberry (*Symphoricarpos albus*) are also fairly common and increase with fire suppression (USGS 2011). Grasslands favor large bunchgrasses such as bluebunch wheatgrass (*Pseudoroegneria spicata*) and Idaho fescue (*Festuca idahoensis*), and may include scattered shrubs (USGS 2011).

Riparian woodland and shrubland is present along most stream corridors, dominated in large part by black cottonwood (*Populus trichocarpa*) and shrubs such as sitka alder (*Alnus viridis ssp. Sinuata*) and mallow-leaf ninebark. Ponderosa pine and grand fir can also be components of these riparian areas, and willow (*Salix spp*.) is a dominant shrub only in lower portions of the Wolf Lodge Creek stream corridor. Pasture grasses and invasive forbs such as common tansy (*Tanacetum vulgare*), Saint John's wort (*Hypericum perforatum*), oxeye daisy (*Leucanthemum vulgare*), and spotted knapweed (*Centaurea maculosa*) are also common in lower elevation riparian areas, and especially prevalent in residential areas, cattle pasture, and agricultural land. In higher elevation locations in the watershed as seen along Stella Creek, species such as cascara buckthorn (*Rhamnus purshiana*), Rocky Mountain maple (*Acer glabrum*), western red cedar, western hemlock, and Douglas-fir can be found in dominant cover in riparian forests. Understory species composition in these wet forests include species such as common snowberry, false huckleberry (Menziesia ferruginea), thimbleberry (Rubus parviflorus), red twinberry (*Lonicera utahensis*), water hemlock (*Cicuta douglasii*), and cow parsnip (*Heracleum maximum*).

Although identified in much smaller proportion in the GAP landcover dataset, a large percentage of the national forest land in the Wolf Lodge Creek watershed has been harvested (Appendix A, Figure A7). Since the 1970's, 59% of total watershed area (23,755 acres) has had some management activity, including various degrees of timber harvest and/or burns (USFS 2016). Clearcut areas total 1,788 acres. Prescribed burn areas range from understory burns to wildlife habitat prescribed fire. Other human modified land in the watershed includes pasture/hay and developed areas. Large agricultural pasture land is mainly located in low elevation areas along Wolf Lodge Creek and toward its outlet into Wolf Lodge Bay in Lake Coeur d'Alene. Other small pasture areas are located on private land in valley bottoms. Developed land is concentrated in the Cedar Creek valley bottom (Interstate 90 Highway area) as well as along the lower portion of Wolf Lodge Creek in residential areas. Terrestrial ecosystem classification is summarized for Wolf Lodge Creek watershed in Table 2-13 and for major tributary watersheds in Table 2-14.

Table 2-13. Terrestrial ecosystem classification in the Wolf Lodge Creek watershed.

Ecosystem Classification	Acres	% of Wolf Lodge Creek Watershed
Cultivated Cropland	1	0.0
Developed, High Intensity	1	0.0
Developed, Low Intensity	98	0.2
Developed, Medium Intensity	98	0.2
Developed, Open Space	139	0.3
Harvested Forest-Shrub Regeneration	90	0.2
Harvested Forest - Grass/Forb Regeneration	4	0.0
Harvested Forest - Northwestern Conifer Regeneration	1,649	4.1
Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	12	0.0
North American Arid West Emergent Marsh	4	0.0
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	19,097	47.6
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	282	0.7
Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	672	1.7
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	13,482	33.6
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	1,353	3.4
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	930	2.3
Northern Rocky Mountain Subalpine-Upper Montane Grassland	55	0.1
Northern Rocky Mountain Subalpine Deciduous Shrubland	66	0.2
Pasture/Hay	149	0.4
Rocky Mountain Alpine-Montane Wet Meadow	228	0.6
Rocky Mountain Lodgepole Pine Forest	1,015	2.5
Rocky Mountain Subalpine-Montane Fen	0	0.0
Rocky Mountain Subalpine-Montane Mesic Meadow	40	0.1
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	234	0.6
Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	402	1.0

Table 2-14. Terrestrial ecosystem classification in major tributary watersheds.

Ecosystem Classification	% of Stella Creek/ Lonesome Creek Watershed	% of Phantom Creek Watershed	% of Marie Creek Watershed	% of Rutherford Gulch Watershed	% of Cedar Creek Watershed
Cultivated Cropland	0.0	0.0	0.0	0.0	0.0
Developed, High Intensity	0.0	0.0	0.0	0.0	0.0
Developed, Low Intensity	0.0	0.0	0.0	0.0	0.7
Developed, Medium Intensity	0.0	0.0	0.0	0.0	0.7
Developed, Open Space	0.0	0.0	0.0	0.0	1.1

Table 2-14. Terrestrial ecosystem classification in major tributary watersheds.

Ecosystem Classification	% of Stella Creek/ Lonesome Creek Watershed	% of Phantom Creek Watershed	% of Marie Creek Watershed	% of Rutherford Gulch Watershed	% of Cedar Creek Watershed
Harvested Forest-Shrub Regeneration	0.0	0.1	0.4	0.0	0.3
Harvested Forest - Grass/Forb Regeneration	0.0	0.0	0.0	0.0	0.0
Harvested Forest - Northwestern Conifer Regeneration	0.7	2.5	4.5	0.0	8.5
Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	0.0	0.0	0.0	0.0	0.0
North American Arid West Emergent Marsh	0.0	0.0	0.0	0.0	0.0
Northern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest	54.5	51.0	45.7	57.3	44.7
Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland	0.4	0.4	0.5	0.8	0.3
Northern Rocky Mountain Lower Montane, Foothill and Valley Grassland	1.3	0.8	0.8	2.1	0.6
Northern Rocky Mountain Mesic Montane Mixed Conifer Forest	37.7	32.5	32.5	27.0	39.7
Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	2.0	2.4	3.7	3.5	1.7
Northern Rocky Mountain Ponderosa Pine Woodland and Savanna	0.4	0.7	1.1	6.4	1.3
Northern Rocky Mountain Subalpine-Upper Montane Grassland	0.0	0.5	0.3	0.0	0.0
Northern Rocky Mountain Subalpine Deciduous Shrubland	0.0	0.6	0.3	0.0	0.0
Pasture/Hay	0.0	0.0	0.0	2.5	0.0
Rocky Mountain Alpine-Montane Wet Meadow	0.1	0.3	0.1	0.4	0.2
Rocky Mountain Lodgepole Pine Forest	2.2	4.3	6.0	0.0	0.0
Rocky Mountain Subalpine-Montane Fen	0.0	0.0	0.0	0.0	0.0
Rocky Mountain Subalpine-Montane Mesic Meadow	0.0	0.0	0.0	0.1	0.0
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	0.1	0.4	1.8	0.0	0.0
Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	0.4	3.1	2.0	0.0	0.0

2.10 Previous Enhancement Activities

Numerous projects have been implemented in the Wolf Lodge Creek watershed since 1992. The projects were designed to improve aquatic habitat and stabilize the channel through a reduction in bank erosion and sediment delivery. The conclusions presented in this section are based largely on the efforts of the Kootenai-Shoshone Soil and Water Conservation District's 2012 investigation that located and assessed all past projects completed by GeoMax on Wolf Lodge Creek in 1992. Site-specific evaluations of past structures are presented throughout *Section 4.0 Results and Discussion* by reach. In 1990, GeoMax designed 11 projects in the Wolf Lodge Creek watershed to help improve channel stability and enhance fish habitat (Figure 2-5). Many of these projects were constructed in 1992, but the exact number has been difficult to verify. A search for the projects confirmed that a majority was constructed; however several projects may not have been built, or were scaled back from original design or have failed completely.

GeoMax designs focused on two primary solutions to channel instability: bank stabilization using rip-rap and sparsely placed tree barbs, and construction of large sediment traps. Two of the largest sediment traps were built at the transition between steeper headwater reaches and the valley floor on Stella Creek and Marie Creek. These traps were designed to trap sediment generated from timber harvest activities conducted in the mid-1990s. Both traps were designed to be maintained indefinitely. Currently, both traps do not have substantial bedload deposition and are largely void of sediment. Smaller sediment traps and rock cross vanes were built throughout the main stem of Wolf Lodge Creek, most notably in the WLC3 sub-reach and School House Bridge. These traps have filled with sediment and are causing channel widening and aggradation upstream, leading to an increase in sediment recruitment and channel instability. Removal of these structures is recommended. Bank stabilization efforts in constructed projects have proven largely ineffective. The best example of this failure is in the WLC3 sub-reach where tree barbs were placed in the bank in addition to rip-rap sections downstream. This site has continued to erode at a rapid rate and is considered a high priority for restoration efforts.

In addition to the projects built in 1992, efforts to stabilize the channel have continued. Several additional projects have been constructed along the main stem that focus on the use of hard stabilization and the use of rip-rap and rock barbs to halt bank erosion. These projects often succeed in locally reducing bank erosion and migration, but do not meet goals of improving fish habitat or treating the underlying cause of rapid bank migration. Near bank stress around meander bends is naturally high, and the placement of large rock barbs or rip-rap on the banks exacerbates near bank stress by concentrating flow closer to the structures and driving rapid bank erosion. The conceptual designs in Attachment A provide new alternatives and structures that can simultaneously reduce bank migration and improve fish habitat without the use of rip-rap or rock barbs.

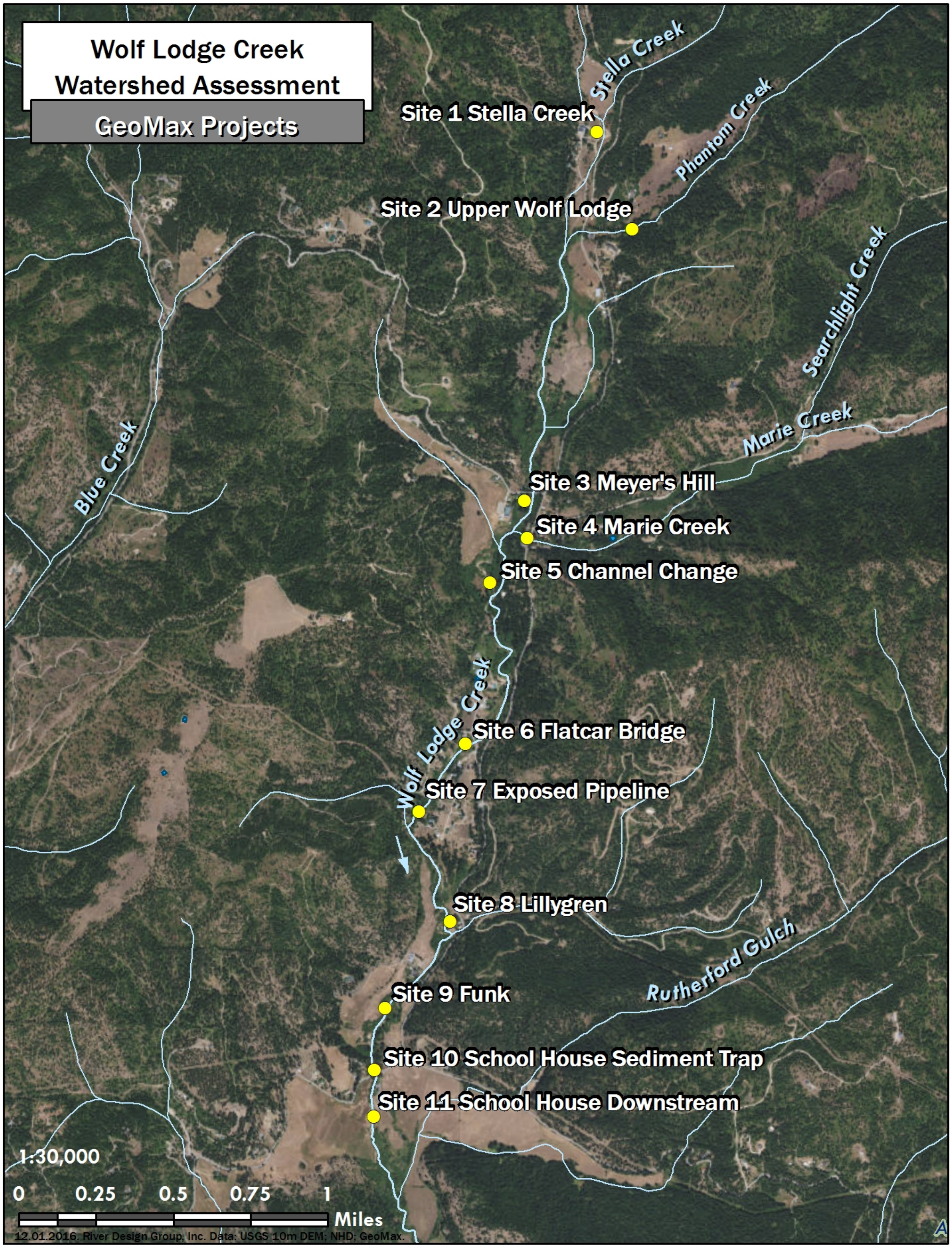

Figure 2-5. Map of proposed GeoMax installations on Wolf Lodge Creek.

3 Methods

3.1 Reach Determinations

Prior to conducting field surveys, Wolf Lodge Creek and its major tributaries were delineated into a total of eight Rosgen Level II reaches and six rapid assessment reaches. Reach breaks were delineated using 2015 National Agriculture Imagery Program (NAIP) imagery and digital elevation models, and field-verified and adjusted as necessary. Reach breaks were determined based on changes in stream type, valley morphology, and tributary confluences. Stream reaches are displayed in Figure 3-1. Classification follows the Rosgen Stream Type Classification System (Rosgen 1994). Stream type determinations were verified using both remote sensing and field data collected during the geomorphic surveys. Stream type was determined by channel sinuosity, slope, entrenchment ratio, width-depth ratio, and dominant sediment particle size.

3.2 Geomorphic Classification

Rosgen Level II surveys (geomorphic surveys) were conducted to characterize typical, impaired, and reference channel conditions. Real Time Kinematic Global Positioning System (RTK GPS) and total-station in areas with dense canopy was used to complete each geomorphic survey. Survey data collection followed USFS procedures (Harrelson et al. 1994) and included channel cross-sections and profiles. Data were collected to characterize terrace, floodplain, bankfull, water surface, and thalweg features. Additional features were also collected if deemed important for characterizing the reach. Channel thalweg measurements were generally collected at changes in the channel bed elevation or habitat features. Water surface measurements were collected at changes in the water surface slope and corresponding habitat features. Grain size was characterized using Wolman pebble counts, in both riffle and pool features (Wolman 1954).

3.3 Vegetation Survey

In most stream reaches, a survey of vegetation was completed to determine species composition and current vegetation condition, as well as document the presence or absence of invasive plant species. Vegetation was surveyed by stratum, using 30 ft radius circular plots for both tree and shrub layers, and nested 25 ft^2 square plots for the herbaceous layer. Absolute percent cover was documented to determine dominant and secondary species at a sampling site. Ground cover of moss or lichen, and bare ground if present was also noted, and photographs of the canopy structure were taken.

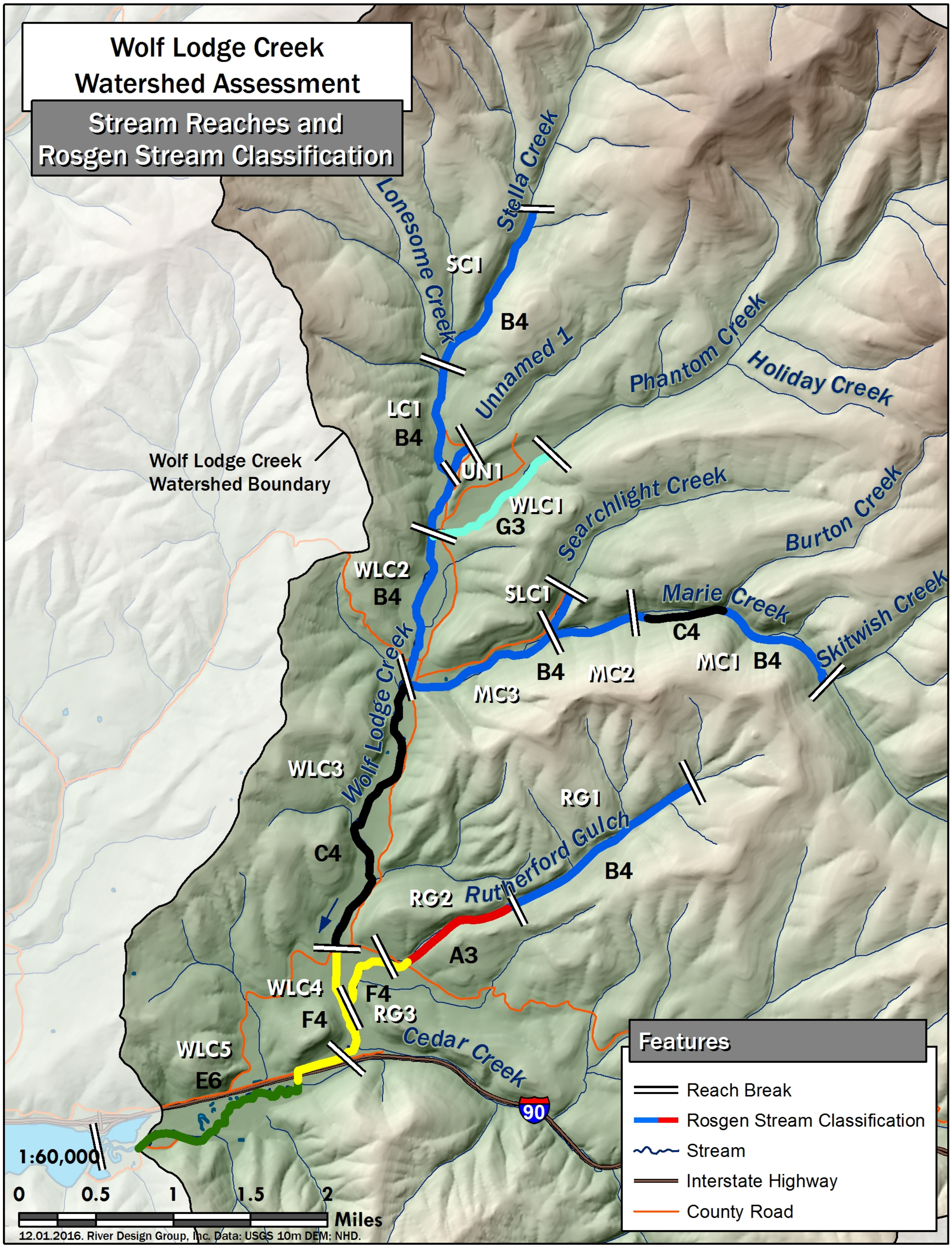

Figure 3-1. Stream reaches and Rosgen Stream Classification of Wolf Lodge Creek and its major tributaries.

3.4 Large Wood Survey

Due to the importance of large wood for creating diverse physical habitat, a basic large wood survey was conducted in all Rosgen Level II reaches. Size categories were determined for specific diameters (Table 3-1). The frequency of each category was tabulated for all pieces at least one meter in length and found within the wetted perimeter of the bankfull channel. Rootwads were included in this survey as well, given their role in creating log jams and maintaining large wood stability (Braudrick and Grant 2000). These data allow for relative, quantitative comparison of wood loading between reaches.

Table 3-1. Summary of large wood categories used in the large wood survey.

Large Wood Category	Diameter (in)
Small	<5
Medium	5-9
Large	>9
Rootwad	N/A

3.5 Channel Migration Analysis

An initial remote sensing effort to analyze the historical channel migration identified key problem areas (excessive bank erosion) and stable portions of the channel. This analysis utilized NAIP imagery from 2004 and 2015 both with one meter pixel resolution. The workflow was based on the National Center for Earth-Surface Dynamics channel planform statistics toolbox v 2.0. The tools perform three primary functions: 1) Interpolation of the centerline of two bank lines that have been digitized from an aerial photograph, with width and local radius of curvature saved in a text file; 2) Estimation of the mean lateral normal distances at even increments between river channel centerlines at two points in time; and 3) Generation of a polygon adjacent to the channel banks that corresponds with a particular centerline point (NCED 2012). The results from this analysis are used to estimate meander migration rates and identify reach bank stability. Maps produced show the rate of migration with a color ramp where red indicates rapid migration and green indicates slow to no migration.

3.6 Instream Sediment Source Evaluation

A modified Bank Erodibility Hazard Index (BEHI) was used to evaluate sediment contributions and associated erosion potential (Rosgen 2001). The BEHI procedure integrates multiple factors which have a direct impact on streambank stability, including the following parameters:

- Ratio of streambank height to bankfull stage;
- Ratio of riparian rooting depth to streambank height;
- Degree of rooting density;
- Composition of streambank materials;

- Bank material stratigraphy; and
- Bank surface protection afforded by large wood and vegetation.

The BEHI index incorporated these six variables into a numerical reach score that was used to rank streambank erosion potential on a scale ranging from very low to extreme. Several bank sites within each reach were evaluated for bank integrity. The number of sites evaluated within each reach was based upon the variability of bank conditions within the reach. Selected sites provided a representative sample of bank conditions throughout the reach.

This analysis was conducted for each Level II sub-reach. Proportions of each bank type found in the sub-reach were extrapolated to the larger reach, from which a rough estimation of instream sediment loading was calculated. These values assist in guiding prioritization of restoration efforts to reduce sediment loading to Wolf Lodge Creek, which has been identified as sediment impaired by IDEQ.

3.7 Floodplain Connectivity Mapping

Floodplain and stream connectivity is vital to the maintenance of stable channels and productive riparian ecosystems. River channels convey one- to two-year flow events (i.e. bankfull), and larger over-bank flows are often dissipated over floodplain surfaces adjacent to channels. When forced to convey large flows within the bankfull channel margin, channels can exhibit an increase in incision, bank erosion, and eventually widening. Floodplains disperse stream energy over a much larger area than what is available within the bankfull channel margin. Benefits of connected floodplains include flood water storage and attenuation, slowing of stream velocities, and reduction of bank erosion. In addition, over-bank flows deliver nutrients and fine sediment to floodplain areas, which helps sustain riparian vegetation communities and provide natural seed recruitment opportunities.

Floodplain connection in the Wolf Lodge Creek watershed was analyzed using available Light Detection and Ranging (LiDAR) data in a Geographic Information System (GIS). The LiDAR data was provided by the Kootenai-Shoshone Soil and Water Conservation District and was flown in January and February of 2014. First, stream centerlines were digitized using a combination of LiDAR data and high resolution aerial imagery. LiDAR elevations were then sampled to the stream centerlines, with the value representing water surface elevations. A mean bankfull height above water surface of 1.2 ft was added to the water surface, and the elevations were written to cross-sections across the floodplain areas, drawn perpendicular to stream flow. A bankfull surface across the floodplain was then created from the cross-sections by interpolation using Delaunay triangulation. Finally, the bankfull surface was compared with the bare earth LiDAR data model, resulting in a continuous surface across floodplain areas which display elevations relative to bankfull. The results from this analysis should not be used in place of, or compared to, Federal Emergency Management Agency flood study results.

3.8 Stream Crossing Evaluation

A basin-wide inventory of all major stream crossings and drainage structures was conducted to supplement the instream sediment source evaluation and identify sites with additional sediment contributions or sources of channel degradation. The Washington Watershed Analysis Methodology (Washington Forest Practices Board 1997) was used to evaluate the effects of stream crossings on sediment delivery to the Wolf Lodge Creek channel network. Field forms for all inventoried crossings are included in Appendix D. Recommendations for improving road crossing conditions are provided in Appendix D.

4 Results and Discussion

Field data were organized by stream, reach, and geomorphic segment. The purpose of this section is to provide an overview of the watershed by stream and reach. Synthesis of the data and discussion of current conditions is presented in this section.

Fifteen reaches were delineated on six streams in the Wolf Lodge Creek watershed (Figure 3-1). Geomorphic surveys were completed in most reaches to characterize the typical channel features, impaired channel conditions, and/or reference conditions. The reaches were grouped as follows:

- Mainstem Wolf Lodge Creek (WLC): Phantom Creek headwaters to Lake Coeur d'Alene (5 reaches);
- Stella Creek (SC): Headwaters to confluence with Lonesome Creek (1 reach);
- Lonesome Creek (LC): Confluence of Stella Creek to confluence with Phantom Creek (1 reach);
- Unnamed 1: Headwaters to confluence with Lonesome Creek (1 reach);
- Marie Creek (MC): Headwaters to confluence of Wolf Lodge Creek (3 reaches);
- Search Light Creek (SLC): Headwaters to confluence with Marie Creek (1 reach); and
- Rutherford Gulch (RG): Headwaters to confluence with Wolf Lodge Creek (3 reaches).

The location of the streams and reaches are included in Figure 3-1. The following sections present an overview of the survey results for each stream.

4.1 Mainstem Wolf Lodge Creek

Five reaches were delineated on mainstem Wolf Lodge Creek. Extending from the headwaters of Phantom Creek to the delta with Lake Coeur d'Alene, Wolf Lodge Creek transitions from a steep confined channel in the upper watershed (WLC1), to a flat low gradient gravel bed channel in the valley floor (WLC2-WLC4), ending in a near zero slope in the backwater connection to the lake (WLC5). The average slope in WLC1 is -0.019 ft/ft compared to an average slope of -0.0002 ft/ft in WLC5 in the delta. The D_{50} sediment particle size reflects this transition. The D_{50} particle size decreases from 90 mm (cobble) in WLC1 to < 2 mm for WLC5. Additional summary channel morphology metrics are included in Table 4-1.

Table 4-1. Summary of reaches on the mainstem of Wolf Lodge Creek.

Reach	Stream Type	Bankfull Slope (ft/ft)	Mean Width (ft)	Max Depth (ft)	Sinuosity	D50 (mm)	D84 (mm)
WLC1	G3	-0.019	20.2	1.8	1.10	90.0	155.3
WLC2	B4	-0.003	23.9	1.9	1.10	34.7	63.0

RDG
RIVER DESIGN GROUP

Table 4-1. Summary of reaches on the mainstem of Wolf Lodge Creek.

Reach	Stream Type	Bankfull Slope (ft/ft)	Mean Width (ft)	Max Depth (ft)	Sinuosity	D50 (mm)	D84 (mm)
WLC3	C4	-0.007	35.0	2.2	1.90	35.0	61.8
WLC4	F4	-0.002	33.3	2.9	1.13	28.8	51.6
WLC5	E6	-0.0002	48.6	9.9	1.5	Clay	Silt

4.1.1 Wolf Lodge Creek Reach 1

Overview

WLC1 begins at the confluence of Lonesome Creek and Phantom Creek. For this report, Phantom Creek is considered an extension of Wolf Lodge Creek. This reach borders grazing lands and residential developments, while the headwaters (not included in the assessment) are on USFS land. Forests in the upper portion of the sub-basin are still recovering from logging including clear cuts and road construction. WLC 1 is classified as a G3 stream type, with substantial incision and steep banks. Stream grade is 0.021 ft/ft, with a local grade of 0.019 ft/ft in the sub-reach. Channel width-to-depth ratios are much lower than in reaches WLC2, WLC3, or LC1. Channel incision generally is caused by increased magnitude and/or frequency of discharge or downcutting from a drop in local base level. Due to the lack of evidence of a shift in base level, the channel incision is likely a result of a change in discharge magnitude and/or frequency. Forest harvest at higher elevations in the headwaters is a potential driver of an increase in water yield and peak flow intensity and duration. Land cover change from forest to bare ground in snowmelt-dominated watersheds has been observed to increase the magnitude and frequency of peak flow events (Kurás et al. 2012; Pomeroy et al. 2012; Sando et al. 2016; Whitaker et al. 2002; Zhang and Wei 2014a; Zhang and Wei 2014b).

Despite channel incision, WLC1 maintains relatively low sediment yield because of large cobbles that protect the bank from erosion. The channel planform appears to be stable due to cobbles and woody vegetation root structures, and instream habitat diversity has been lowered with channel incision. This reach is not a high priority for restoration efforts, but future harvest activities should limit management activities that reduce large wood recruitment to the channel.

Figure 4-1. Typical channel and bank conditions of Reach WLC1.

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Vegetation

A well-developed and diverse vegetation community characterizes the riparian forest environment at WLC1. It is dominated by grand fir, and young to old age classes of conifer are present throughout the stream corridor. Black cottonwood recruitment occurs on stream banks and substantial amounts of mature cottonwood trees occur throughout the riparian environment. Some ponderosa pine is also present, and black hawthorn, cascara buckthorn, and Rocky Mountain maple are secondary components of the overstory environment. Understory species include diverse shrub and forb assemblages with minimal grass cover. Ninebark, serviceberry, cream-bush oceanspray (*Holodiscus discolor*), snowberry, and Rocky Mountain maple are common shrub species found, and trumpet honeysuckle (*Lonicera ciliosa*), a deciduous vine, can be found wrapping around many shrubs and trees. The herbaceous stratum includes species such as stinging nettle (*urtica dioica*), thimbleberry, cow parsnip, wild strawberry (*Fragaria vesca*), columbine (*Aquilegia spp*.), and heart-leaved arnica (*Arnica cordifolia*).

Moss covers up to 20% of the ground surface, while grass species are usually minor components of the herbaceous layer. Invasive forbs were not found in significant amounts, and the native cleavers (*Galium aparine*) was the only weedy species consistently found in vegetation sampling plots. Invasive grass species are not present. Overall, the riparian environment at WLC1 is characterized by a diverse assemblage of native vegetation, minimal unnatural disturbance, and minimal nonnative invasive plant species.

Floodplain Connectivity

A natural channel constriction is present at Reach WLC1. Floodplain connection is adequate above and below the constriction, with floodplain elevations within 1.5 feet of bankfull elevation (Appendix E, Figure E3). The bridge toward the downstream of the reach (WLC1_Bridge) is an unnatural constriction which has resulted in a local reduction in floodplain area. Results from the stream crossing analysis are included in Section 6 of this report.

Sediment Sources

Soils in WLC1 consist of Typic Udivitrands forming in broad stream bottoms, which have low surface erosion and low mass erosion potential, but have high sediment delivery potential (Table 2-7). Streambanks consist of large cobbles and small boulders that provide resistance to planform adjustments. Banks are steep and tall above bankfull, and large amounts of woody vegetation and large grains reduce bank erodibility. Two main bank types exist in this reach, including steep and tall banks armored with cobbles, and low banks that consist of depositional materials. The steep banks are characterized with a High BEHI rating (score of 28.3) and represent 65% of the banks in the reach. The low banks have a Low BEHI rating (score of 13.8) and account for 35% of the reach. Results from the BEHI analysis presented in Table 4-2 suggest a total yield of 172 tons/year, representing 9% of the yield calculated for the Wolf Lodge Creek watershed. Section 5, Table 5-1 includes a description of the calculation of total sediment yield in tons/year.

Table 4-2. Summary of BEHI analysis and sediment yield for WLC1.

Bank	Bank Height (ft)	Bank Length (ft)	BEHI Score	BEHI Rating	Predicted Erosion Rate (ft/yr)	Sediment Yield (ft^3/yr)
1	2.5	3,900	28.3	High	0.31	3,023
2	0.5	2,100	13.75	Low	0.17	179
Total		6,000				3,200

Geomorphic Survey Results

A geomorphic survey was completed in the middle of WLC1 in a forested section on the edge of a pasture used for grazing. A 300 ft longitudinal channel profile, two riffle cross-sections, two pool cross-sections, pebble count for riffle and pool, large wood survey, and BEHI assessment were completed in the reach. The cross-sections were located in representative channel habitat features. The average bankfull slope was 0.019 ft/ft compared to a water surface slope of 0.017 ft/ft. Cross-section and descriptive statistics for one pool are included in Figure 4-2 and Table 4-3. This pool was located in a slight bend in the channel upstream of a large wood jam. The steep banks and bed curvature indicate a G stream type, but the slope is >0.02 ft/ft indicating an F stream type. Ultimately the reach classified as a G3 given the lower width to depth ratios. This level of entrenchment was seen throughout the sub-reach. The stream incision is likely a result of an increase in peak flow magnitude and frequency of large events linked to forest harvest in the headwaters. Banks consist of large cobbles and occasional boulders, which restricts the channels ability to respond laterally to changes in hydrology and forces the channel to respond through downcutting.

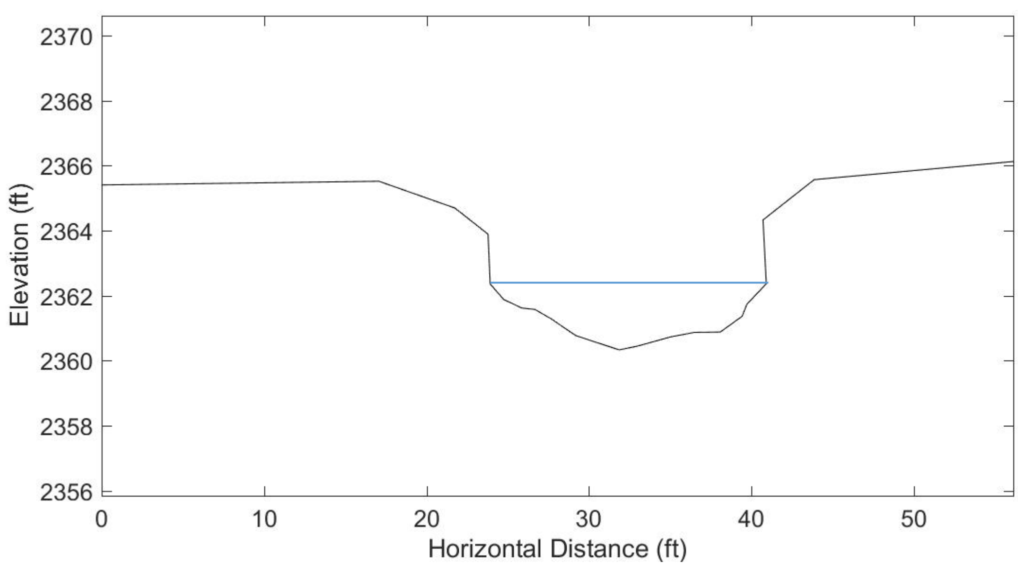

Figure 4-2. Cross-section 2 of typical pool. Blue line represents bankfull stage.

Table 4-3. Metrics for cross section 2 on WLC1.	
Bankfull Width (ft)	16.9
Mean Depth (ft)	1.4
Max Depth (ft)	2.0
Bankfull Area (ft^2)	20.9
Width/Depth Ratio	12.3
Hydraulic Radius	1.0

Channel bed materials ranged from cobbles to silt. The geometric mean particle size ranged from 61.6 mm in riffles to 38.3 mm in pools (Figure 4-3). The bed is highly armored with large particles. Grain size percentiles are listed in Table 4-4.

Table 4-4. WLC1 pebble count results.

Percentile	Riffle (mm)	Pool (mm)
16	30.9	10.9
35	59.1	41.2
50	90.0	62.6
65	124.9	85.1
84	155.3	118.3
95	172.3	155.4

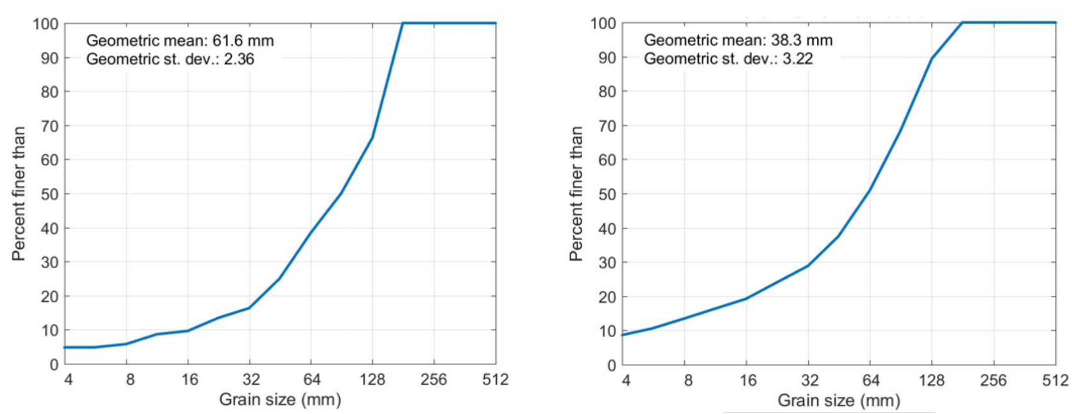

Figure 4-3. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for WLC1.

4.1.2 Wolf Lodge Creek Reach 2

Overview

WLC2 begins at the confluence of WLC1/LC1 and ends at the culvert at Meyers Hill Road. This reach is heavily vegetated and relatively undisturbed by residential development and agriculture in recent history. The surrounding land is owned by a mixture of private owners, who use the land for horses and grazing but have left an adequate riparian corridor. While the stream appears to have relocated to the edge of the valley floor at some time in its history, the reach appears stable and at equilibrium. WLC2 is classified as a B4 stream type for the majority of the reach with small inclusions of C4 stream type where the floodplain width expands. Stream gradient from Light Detection and Ranging (LiDAR) data is 0.01 ft/ft, while the subreach geomorphic survey indicates a bed slope of 0.008 ft/ft. Width-to-depth ratios are lower compared to upstream reach LC1 and downstream reach WLC3. WLC2 appears to be at equilibrium, with a diverse range of habitat and adequate amounts of large wood. Beaver sign is present in the reach, though no active dams were located during the survey. Undercut banks, protected by vegetation, provide habitat for native westslope cutthroat trout. WLC2 banks are much less erodible when compared to WLC3 which has similar geomorphic attributes and the reach contributes 4% of the total sediment load of the watershed. Invasive reed canarygrass (*Phalaris arundinacea*) was found throughout the reach.

WLC2 is a healthy, functioning creek. Recommendations include the addition of large wood for habitat enhancement and removal of reed canarygrass. Overall, this reach can provide a reference for restoration in disturbed reaches. The healthy riparian plant communities and increased access to floodplain reduced both bank erosion and channel migration rates.

Figure 4-4. Typical channel and bank conditions in Reach WLC2.

Vegetation

Reach WLC2 is a riparian shrubland community dominated by ninebark and alder. Many age classes of alder are present throughout the riparian corridor, but mostly older, large-canopied stands of alder characterize the vegetation community. Other woody species found in the reach include mockorange and chokecherry. In the herbaceous stratum, the invasive reed canarygrass dominates. The grass species is an aggressive invader and often outcompetes native herbaceous and woody species for water, nutrients, light, and space. In reach WLC2, reed canarygrass is especially prevalent along the banks of Wolf Lodge Creek and in alder and ninebark canopy openings. Where it is found under thick shrub canopy, ground cover percentage of reed canarygrass is low.

The riparian vegetation community is complex in structure, and even as plant diversity is low, riparian zone function is high. The well-established alder and ninebark stands buffer the stream from excessive pollutant and sediment inputs, and are a source of woody debris and overhanging vegetation, which is important for fish habitat and helps keep stream temperatures low. Other functions of the riparian shrub community include terrestrial wildlife habitat and groundwater recharge. While reed canarygrass is a dominant component of the herbaceous layer, its expansion to monoculture is limited by a structurally diverse shrub canopy, and on streambanks the expansive rhizomatous root system helps curtail erosion and sediment delivery to the stream.

Channel Migration

Channel migration for this reach was unable to be quantified due to inability to define channel banks from imagery. A qualitative assessment indicates that the channel in this reach has been substantially more stable and has had very little lateral migration in comparison with WLC3 and WLC4. This is largely due to the bank stability that the riparian vegetation provides. In addition, this channel has the ability to occupy its floodplain without damaging private property.

Floodplain Connectivity

Reach WLC2 demonstrates high floodplain connectivity. Substantial land area adjacent to Wolf Lodge Creek is at or below bankfull elevation (Appendix E, Figure E4). These floodplains are regularly inundated. The upstream portion of the reach is characterized by low lying depressions on the eastern side of the channel along historical stream locations. These areas allow for flood water storage and groundwater recharge, which increases baseflow during drier summer months. The lower half of the reach exhibits high stream and floodplain connectivity, with surfaces adjacent to the channel at or just below bankfull elevation. The high bank stability and low erosion rates characteristic of Reach WLC2 is attributed in large part to adequate connection between Wolf Lodge Creek and its floodplain. The delivery of water, nutrients, and fine sediment to the floodplain during high flow events benefits riparian plant communities and helps to further increase channel function throughout the reach.

Sediment Sources

Soils in WLC2 consist of Typic Udivitrands forming in broad stream bottoms, which have low surface erosion and low mass erosion potential, but have high sediment delivery potential (Table 2-7). Bank erosion hazard index ratings in WLC2 ranged from low to moderate. The presence of a large, stable riparian vegetation community has increased bank stability significantly. Bank heights for the reach ranged from 0.5 – 1.5 ft, much lower than other reaches. Soil composition is similar to upstream WLC1 and downstream WLC3. Easily erodible topsoil is underlain by alluvial material. Most banks are not tall enough to expose the underlying alluvial material. Moderately erodible banks comprise 60% of the channel margins, while low erodiblity banks comprising 40%. Table 4-5 provides a summary of the BEHI analysis and sediment yield for WLC2. In total, the reach contributes 77 tons/year of sediment from bank erosion, or 4% of the total sediment yield from bank erosion for Wolf Lodge Creek. Section 5, Table 5-1 includes a description of the calculation of total sediment yield in tons/year.

Table 4-5. Summary of BEHI analysis and sediment yield for WLC2.

Bank	Bank Height (ft)	Bank Length (ft)	BEHI Score	BEHI Rating	Predicted Erosion Rate (ft/yr)	Sediment Yield (ft^3/yr)
1	1.5	3,600	22.75	Moderate	0.23	1,242
2	0.5	2,400	13.75	Low	0.17	204
Total		6,000				1,450

Geomorphic Survey Results

A geomorphic survey was completed in the lower portion of WLC2. This site was undisturbed from recent human disturbance and representative of the larger reach. A 500 ft longitudinal channel profile, two riffle cross-sections, two pool cross-sections, pebble count for riffle and pool, large wood survey, and BEHI assessment were completed in the reach. Cross-sections were located at representative channel habitat features. For the entirety of the subreach the channel is classified as a B4 stream type, but upstream sites with vegetation scoured away with recent flood activity have transitioned to C4 stream types. The average water slope is 0.006 ft/ft compared with the bed slope of 0.008 ft/ft. Cross section and descriptive statistics for one pool feature are included in Figure 4-5 and Table 4-6. This pool is a result of a large log jam at the bottom of the reach. Large wood is present throughout the reach, but is often limited to smaller pieces likely due to the lack of large, recruitable trees in the riparian buffer. Addition of large wood in this reach would enhance existing habitat features, but overall, this reach is a low priority for restoration relative to other reaches in the watershed. Width-to-depth ratios are lower in WLC2 and have lower variation between habitat type compared to WLC3 and WLC4.

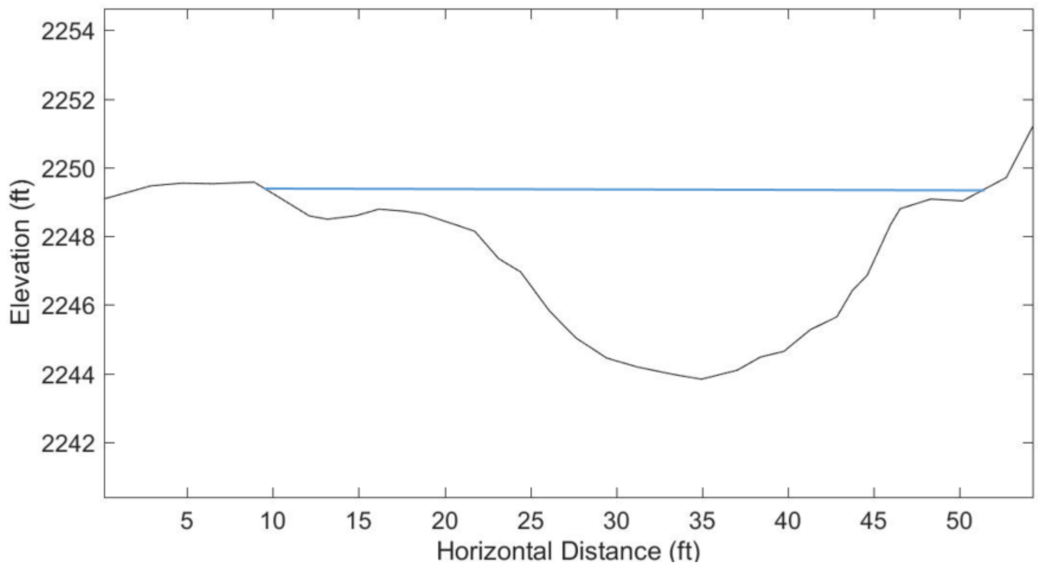

Figure 4-5. Cross section 4 on WLC2, deep pool caused by log jam. Blue line represents bankfull stage.

Table 4-6. Metrics for cross section 4 on WLC2.	
Bankfull Width (ft)	42.2
Mean Depth (ft)	2.7
Max Depth (ft)	5.6
Bankfull Area (ft^2)	111.6
Width/Depth Ratio	15.9
Hydraulic Radius	2.5

Channel bed materials ranged from cobbles to silt. The geometric mean particle size measured ranged from 32.3 mm in riffles to 21.9 mm in pools (Figure 4-6). The bed was highly armored with large particles. Grain size percentiles are listed in Table 4-7.

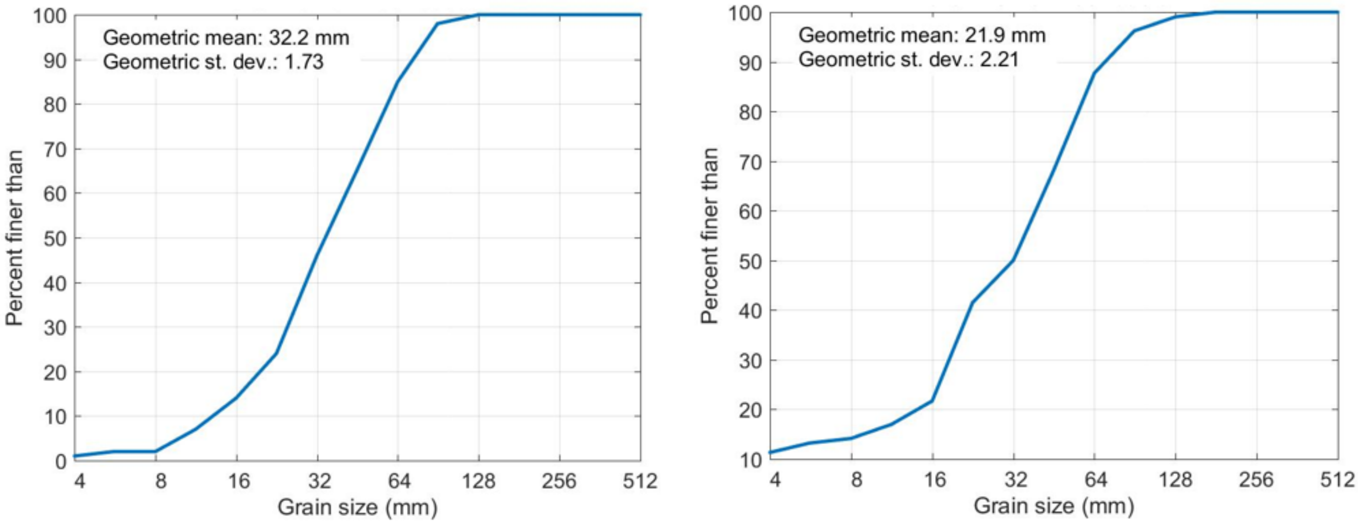

Figure 4-6. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for WLC2.

Table 4-7. WLC2 pebble count results.

Percentile	Riffle (mm)	Pool (mm)
16	17.3	10.2
35	27.3	20.4
50	34.7	32
65	45.0	42.9
84	63.0	60.4
95	84.0	86.2

4.1.3 Wolf Lodge Creek Reach 3

Overview

WLC3 begins at the confluence of Marie Creek and Wolf Lodge Creek and extends downstream to the Wolf Lodge Creek Road Bridge. This reach encompasses the majority of residential development in the watershed and has continued problems with bank stability and property loss. Previous efforts to mitigate bank erosion and property degradation throughout this reach have included hard bank stabilization and installation of rock barb features. Within WLC3, Wolf Lodge Creek is classified as a meandering, riffle-pool dominated, C4 stream type. The stream gradient is 0.006 ft/ft compared to WLC2 slope of 0.003 ft/ft and WLC4 slope of 0.002 ft/ft. Width-to-depth ratios and bank erosion rates are significantly higher than WLC2 throughout the majority of WLC3. This reach is a high priority reach for restoration efforts and the surveyed sub-reach is located at the highest priority site (Figure 4-7). Near-term action is recommended to mitigate additional property damage and high sediment contributions resulting from severe bank and terrace erosion.

Soils in this reach consist of highly erodible glacial till and topsoil in the A horizon, underlain by a compacted ash layer that erodes into blocks that protect the toe of the bank. Beneath this layer, alluvial layers are sporadically present throughout the reach, however the majority of these layers are much smaller in grain size when compared to the existing Wolf Lodge Creek channel. The existence of several single grain width layers in several soil profiles, along with the reduced grain size in larger alluvial layers, suggests that a multi-thread channel may have historically persisted in this valley. This conclusion provides additional insight into drivers of rapid bank erosion in this segment of Wolf Lodge Creek. With flow concentrated into a single thread, the power of the channel to erode the banks increases by orders of magnitude. Additionally, while some portions of the reach are characterized by large willow and alder stands which help bind streambank soil and reduce erosion, some highly erosive outer banks are devoid of woody riparian vegetation and rooting structure.

In summary, WLC3 is a reach that has been substantially altered from its historical condition by human actions including agriculture, riparian shrub and tree clearing, residential development, and timber harvesting. Channelization and hard bank stabilization projects have led to unfavorable channel geometry and increases in bank erosion rates. Efforts to stabilize the banks may prove effective in curbing erosion from a single site, but fails to address underlying causes of the problem. The proximity to home owners and the severity of bank erosion leads to a high restoration prioritization in this reach.

Figure 4-7. High priority restoration site on WLC3.

Previous Mitigation Efforts

Recent efforts to reduce property loss from bank migration in WLC3 have focused on increasing bank stability with large boulders and reducing water velocities on outside bends with rock barbs and large wood. While these efforts will halt the progression of bank erosion locally, they fundamentally fail to address key underlying issues of unfavorable channel geometry. For example, a meander observed migrating 2-3 ft per year before project implementation has stopped migrating; however, the channel is forced to bend nearly 180 degrees up-valley before bending again to flow downstream in a channelized, hard stabilized section adjacent to the road. Flow velocities on the outside of the bend are increased greatly when forced into this channel geometry, which is what caused the initial increase in bank erosion.

Despite halting property damage at the site of bank mitigation projects, upstream and downstream landowners are impacted. At a similar project, just downstream the hard stabilization and rock barb features direct flow into a bank with highly erodible soils, which has been migrating at a rate of 5 ft per year between 2004 and 2015.

The large meander bend in the WLC3 sub-reach was the site of GeoMax a project designed to reduce bank migration with tree barbs and a small rock check feature upstream. Despite full implementation of these projects they have failed to reduce the rate of bank migration and this site is now a high priority for restoration efforts. The goal of the tree barbs were to decrease near bank stress, but they were inadequately spaced leading to secondary flow circulation (i.e. eddies) which have driven further bank erosion. This project has largely failed to address the goals identified in the GeoMax report (GeoMax 1990).

Figure 4-8. Typical channel conditions in Reach WLC3.

Vegetation

Where woody vegetation is present, the riparian stream buffer consists of a multi-layered alder and willow community, with minor occurrences of black cottonwood, ninebark, and very few ponderosa pine in the canopy. Invasive species are present in the understory, including common tansy, Canada thistle (*Cirsium arvense*), spotted knapweed, oxeye daisy, St. John's wort, and reed canarygrass. Other pasture grasses are also present but in small amounts. In contrast, where woody vegetation has been removed in association with residential development, pasture grasses and common tansy are found in dominant cover, and outer banks without shrubs or trees are highly erosive.

Structurally diverse alder and willow communities limit invasive species cover in WLC3, however in canopy openings and along some streambanks, invasive forbs and reed canarygrass occur in patches. Healthy native shrub and tree seed sources are present throughout the reach, and given the right conditions could help to naturally colonize open-canopied streambanks. Vegetation in this reach, while altered due to residential development and lawns, has the potential to recover in impacted areas if high streambanks are lowered to floodplain elevations and some invasive species management occurs.

Channel Migration

WLC3 has the highest frequency of large migration rates of any sites in the watershed. Areas with high erosion rates ranged from 2-7 ft of migration per year between 2004 and 2015 (Figure 4-9). Two sites were the focus of previous mitigation efforts (EP1 and EP2). Bank at these sites stopped migrating following mitigation project implementation, however banks downstream of the projects still have high rates of lateral migration. The geomorphic assessment site focused on the meander bend with the greatest lateral migration rate. The tall, unstable bank has been eroding at a rate of 4-6 ft per year between 2004 and 2015. Upstream of this bend is a second site that has undergone rapid migration in the past 11 years with 3-4 ft of migration per year. Beaver activity appears to have caused a channel avulsion, resulting in accelerated lateral migration. While beaver sign was present throughout WLC3, WLC2, WLC4, WLC5, and MC2, beaver induced erosion was not observed at other sites in the reach.

Floodplain Connectivity

WLC3 lacks floodplain connection in two areas characterized by residential and agricultural development. In the Gateway community, the creek is bracketed between the eastern valley toe and the residential neighborhood (Appendix E, Figure E5). Substantial migration of a meander bend (>6 ft/yr) on the upstream end of the community threatened residential structures, and bank stabilization with rip-rap has halted migration. Increased channel shear stress is exacerbated by the high radius of curvature in the bend. These two factors have resulted in the rapid bank erosion at this site. Options to increase floodplain connection in the Gateway community are limited and high risk. Instead, the construction of a set-back levee on the northern end of the community is recommended to minimize flood hazard along the western valley toe.

Floodplain connection is limited in the downstream portion of Reach WLC3, and at the WLC3 geomorphic survey location (Appendix E, Figure E6). In this area, the channel is pinched between the eastern valley toe and residential and agricultural development. As a result of flow constriction into the channel, a meander bend directly downstream is actively eroding at a high rate. A conceptual restoration design for the upper portion of the site is included in Attachment A.

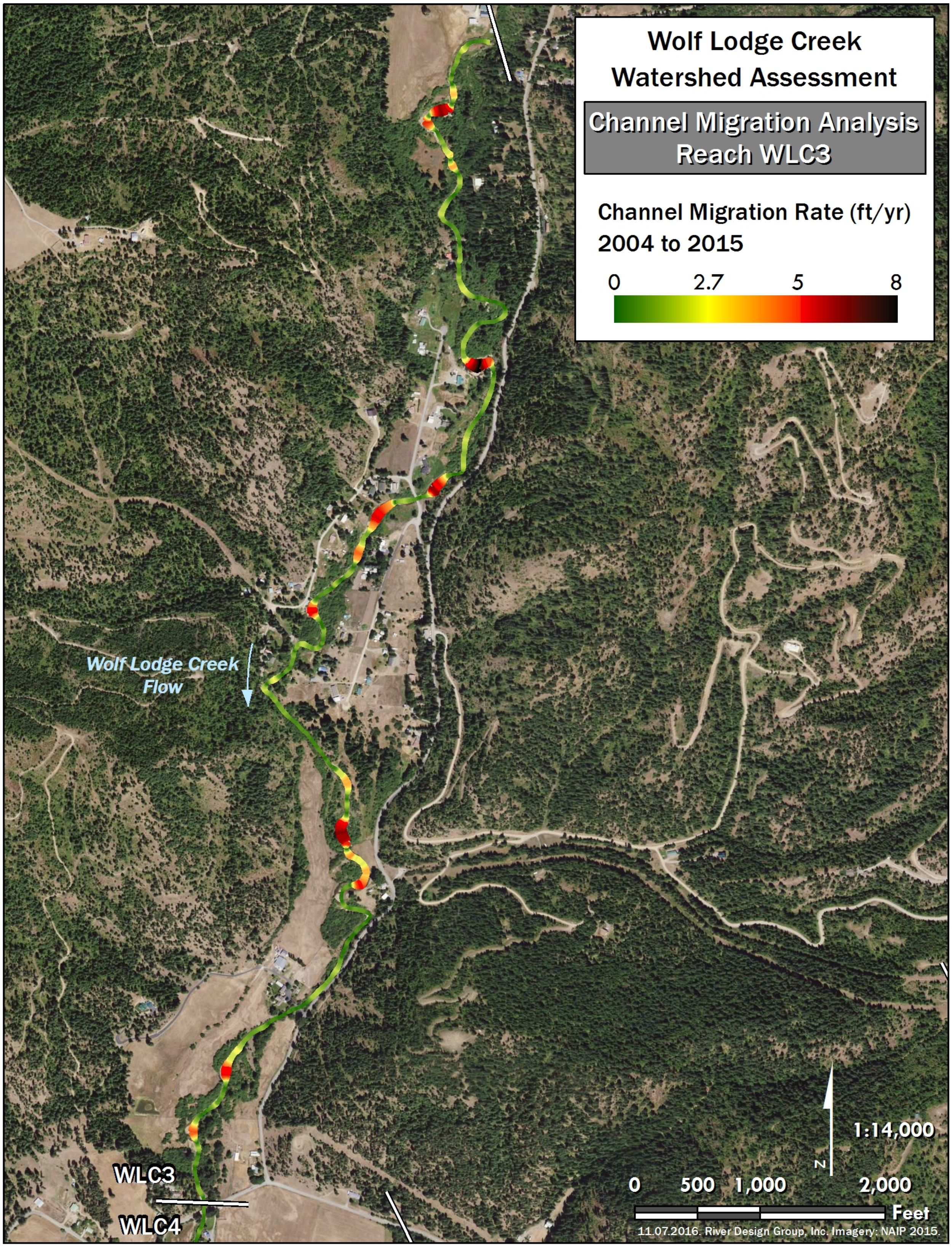

Figure 4-9. Channel migration analysis for Reach WLC3.

Sediment Sources

Streambanks in WLC3 ranged from extreme to low susceptibility to erosion. The increased bank erosion susceptibility is a result of riparian vegetation removal which decreases bank strength, and stream channelization which increases shear stress. Approximately 10% of the streambanks in WLC3 have been stabilized with hardened revetment. Based on reach averaged conditions, an estimated 830 tons of sediment are produced annually from bank erosion related sources of sediment. These findings support the conclusion that sediment is predominately locally sourced from streambank and streambed erosion rather than from upstream sources. Section 5, Table 5-1 includes a description of the calculation of total sediment yield in tons/year.

Table 4-8. Summary of BEHI analysis and sediment yield for WLC3.

Bank	Bank Height (ft)	Bank Length (ft)	BEHI Score	BEHI Rating	Predicted Erosion Rate (ft/yr)	Sediment Yield (ft^3/yr)
1	4.5	4,725	45.5	Extreme	0.47	9,993
2	3.5	8,775	14.75	Low	0.17	5,221
3	1	1,350	10.25	Low	0.17	230
Total		14,850				15,440

Geomorphic Survey Results

A geomorphic survey was completed in the lower portion of WLC3, at a site identified as a high priority for restoration efforts. A 1,000 ft longitudinal channel profile, two riffle cross-sections, two pool cross-sections, pebble count for riffle and pool, large wood survey, and BEHI assessment were completed in the reach. The cross-sections were located at representative channel habitat features. The average bankfull slope is 0.007 ft/ft. One pool cross-section and descriptive statistics are included in Figure 4-10 and Table 4-9. This pool was created from the installation of a rock vane. The pool maintains a 9 ft bankfull maximum depth and was scoured out as evidenced from large depositional features directly downstream. Deposition of this scoured material, and point bar development downstream, has increased the rate of bank erosion through topographic steering (Legleiter et al. 2011), and is further evidence of the majority of sediment loading in Wolf Lodge Creek resulting from local, and not upstream, sources.

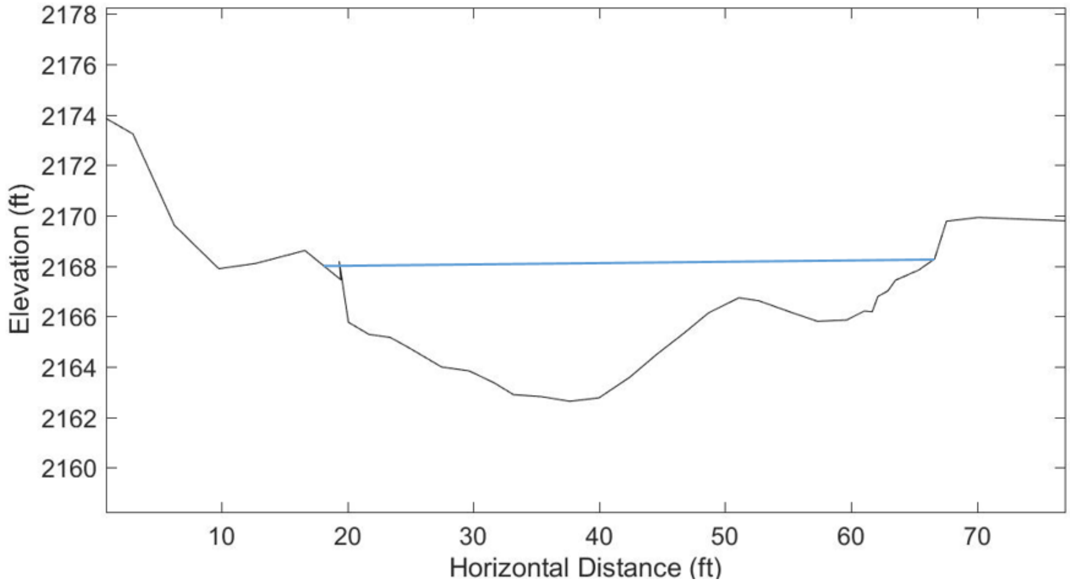

Figure 4-10. Cross section 1 on WLC 3. The blue line represents bankfull stage.

Channel bed materials ranged from boulders (hard stabilization) to silt. The geometric mean particle size measured ranged from 26 mm in riffles to 12.7 mm in pools (Figure 4-11). The prevalence of actively eroding clay blocks from the upstream bank increased the amount of fine sediment in the pool pebble count (Table 4-10).

Table 4-9. Metrics for cross section 1 on WLC3.	
Bankfull Width (ft)	48.4
Mean Depth (ft)	3.3
Max Depth (ft)	5.7
Bankfull Area (ft^2)	154.7
Width/Depth Ratio	14.8
Hydraulic Radius	3.0

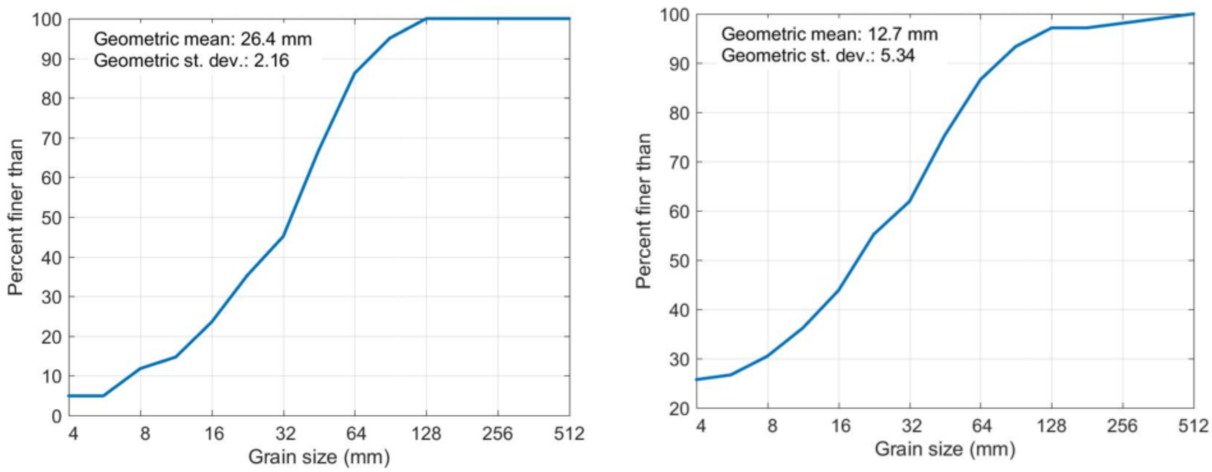

Figure 4-11. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for WLC3.

Table 4-10. WLC3 pebble count results.

Percentile	Riffle (mm)	Pool (mm)
16	12.0	NA
35	22.4	10.6
50	35.0	19.6
65	44.0	35
84	61.8	59.6
95	89.7	106.6

4.1.4 Wolf Lodge Creek Reach 4

Overview

WLC4 begins at the Wolf Lodge Creek Road bridge over Wolf Lodge Creek. A sediment trap is located immediately upstream of the reach. WLC4 is bounded by private property on either side of the channel. Land use is dominated by agriculture and grazing, with only one residential structure in the floodplain. The upper sub-reach is devoid of a riparian corridor with pasture located directly up to the land-water interface of the stream channel. Within the sub-reach of WLC4, the stream type classified as an F4, while downstream it transitioned to a B4 stream type with less entrenchment and increased cover of riparian vegetation. The upper portion of WLC4 is significantly entrenched and has severe bank instability, largely driven by channel dredging efforts to increase bed load transport capacity and reduce flooding of surrounding pasture. The channel is disconnected from the floodplain exacerbating bank erosion. WLC4 is a degraded system that lacks functioning geomorphic process and form. Bank erosion analysis highlighted the large amount of sediment that is being supplied locally to the reach. Previous work and mitigation efforts have focused on limiting the amount of sediment transported into the reach with the construction of an upstream sediment trap, but dredging in the channel at WLC4 has increased bank heights and bank instability causing increased rates of sedimentation from the alluvial banks. A large portion of the sedimentation is coming from the banks within the reach, rather than upstream sources.

The process of lowering the bed through sediment removal lowers the water table, increases bank height, and concentrates flow, leading to greater bank instability and accelerated bank migration. This is evident in WLC4 where vertical banks are actively eroding at a rapid pace. Large bank blocks that have structurally failed are frequent below these over-steepened banks.

Reach-specific recommendations include limiting sediment removal from within the channel except at the upstream bridge sediment trap. WLC4 is a high priority restoration reach. Efforts will focus on creating an adequate inset floodplain for the channel to dissipate energy during high flow events without causing the large amounts of bank erosion observed currently. Restoration efforts will result in downstream landowners having a major reduction in property loss to bank erosion and a reduction to flooding of pasture land, while allowing the channel to support more natural geomorphic processes. The restoration concepts included in this report address the excessive bank erosion and loss of floodplain connection in this section of Wolf Lodge Creek.

Figure 4-12. Typical bank and channel conditions in Reach WLC4.

Vegetation

In WLC4, riparian vegetation is altered due to the agricultural and grazing land use that characterizes the reach. Invasive species such as common tansy, St. John's wort, oxeye daisy, cleavers, field pennycress (*Thlaspi arvense*), and reed canarygrass are common, especially where pasture land directly abuts the stream corridor. In addition, pasture grasses such as redtop (*Agrostis stolonifera*), Kentucky bluegrass (*Poa pratensis*), and various wheat (*Triticum spp.*) varieties are widespread throughout pastures as well as open streambank areas due to proximity of pasture lands to the stream. As detailed in previous sections, above average streambank erosion is due to a combination of anthropogenic alterations to the stream channel, and the lack of woody riparian vegetation through much of the reach exacerbates erosion problems. In many areas shrubs and trees were cleared from streambanks, and in other areas where woody vegetation was recently present, the lowering of water tables following channel dredging resulted in loss of willow and alder from the banks of Wolf Lodge Creek.

Where a woody component is present along the riparian corridor, old and decadent alder trees and shrubs, Bebb willow, ninebark, and large black cottonwood characterize the vegetation community. Often, very young and very old age classes of native shrubs and trees are present, but a middle age class is absent. Cattle browse is evident in many willow and alder thickets, however in areas without recent grazing disturbance, some willow regeneration from seed as well as suckering occurs. In addition, black cottonwood seedling regeneration on small point bar areas is present, however cottonwood saplings are absent. Overall, the natural structure and function of riparian vegetation in the WLC4 reach is highly altered, and restoration actions including cattle exclusion, invasive plant species suppression and continued control, lowering of bank surfaces to floodplain elevations or increasing bed elevations, and native woody species planting are needed to restore riparian vegetation in much of the reach.

Channel Migration

Channel migration analysis results indicate that banks in the impaired sub-reach are migrating at an average rate of three ft per year (Figure 4-13). These rates are rapid, but slower when compared to migration rates in WLC3. A 2009 flood appears to have caused the majority of bank erosion during the 2004-2015 timeframe for the study. Lower rates are observed in the downstream section of the reach where vegetation is present, except for a short section of channel where vegetation density precludes identification of the bank lines. The areas with the most rapid migration rates are located where deep pools have been created from dredging.

Floodplain Connectivity

The upstream portion of Reach WLC4 lacks floodplain connection in an area where the channel cut through a remnant alluvial fan created by a high Lake Coeur d'Alene during the last glacial era. Large depressions on both sides of the channel indicate that the surrounding surfaces would likely have been inundated with flood waters more frequently if not for channelization and diking. The segment of creek flowing through the alluvial fan has high rates of erosion and unstable banks. A conceptual restoration design in Attachment A addresses these problems with the creation of an inset floodplain which allows for decreased channel stress during high flow events. The downstream portion of WLC4 has ample floodplain connectivity, a mature riparian vegetation community, and low bank erosion.

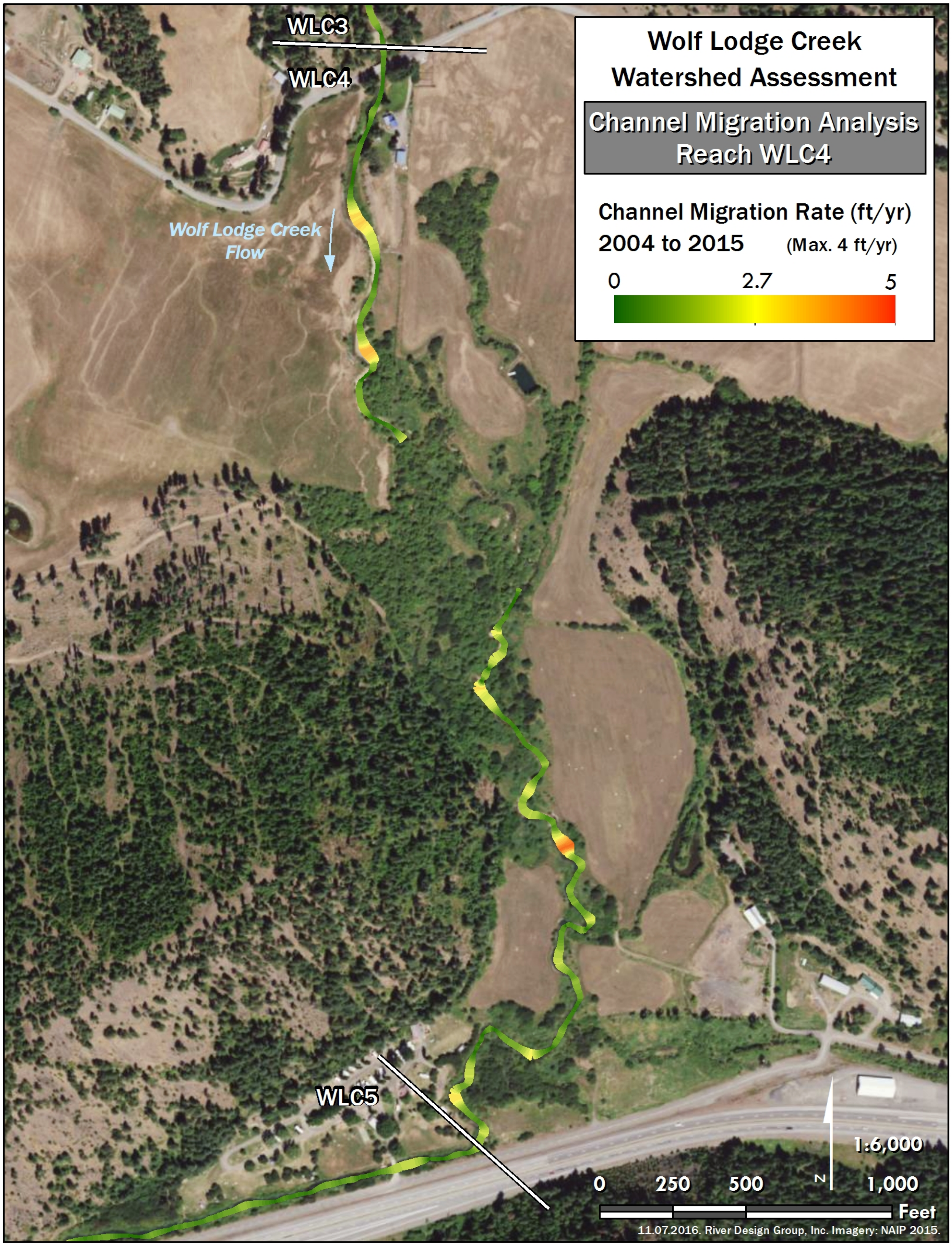

Figure 4-13. Channel migration analysis for Reach WLC4.

Sediment Sources

Banks in WLC4 displayed very high to high BEHI ratings, in addition to 10% of the reach having hard stabilization in place. Table 4-11 provides a summary of bank conditions and sediment yield, and Section 5, Table 5-1 includes a description of the calculation of total sediment yield in tons/year. The total reach-averaged sediment yield from bank erosion was estimated at 281 tons/year, accounting for 14% of the total sediment load from Wolf Lodge Creek. When compared across all reaches, however, WLC4 has an equivalent estimate of sediment yield from bank erosion per unit length as WLC3. The severity of bank erosion, coupled with the existence of a sediment trap just upstream lead to the conclusion that the majority of the sedimentation in WLC4 is a result of locally sourced material from streambank erosion. Restoration efforts at this site could provide substantial reductions in sediment yield to Lake Coeur d'Alene and help achieve TMDL goals for the watershed.

Table 4-11. Summary of BEHI analysis and sediment yield for WLC4.

Bank	Bank Height (ft)	Bank Length (ft)	BEHI Score	BEHI Rating	Predicted Erosion Rate (ft/yr)	Sediment Yield (ft^3/yr)
1	3.5	1,750	36.3	Very High	0.39	2,389
2	3	2,750	28.75	High	0.31	2,558
3	3.5	500	13.5	Low	0.17	298
Total		5,000				5,240

Geomorphic Survey Results

A geomorphic survey was completed at the upstream end of WLC4 just downstream of the Wolf Lodge Creek Road bridge. This reach is highly degraded due to historic dredging and channelization. In the sub-reach the channel is an F4 stream type, with high levels of entrenchment and moderate sinuosity. A 725 ft longitudinal channel profile, two riffle cross-sections, two pool cross-sections, pebble count for riffle and pool, large wood survey, and BEHI assessment were completed in the reach. The cross-sections were located in representative channel habitat features. The average bankfull slope was 0.002 ft/ft compared to a water surface slope of 0.002 ft/ft. Pool cross-section and descriptive statistics are included in Figure 4-14 and Table 4-12. The pool illustrated in the cross section is a location where historic sediment removal likely occurred. Width-to-depth ratios decreased when compared to WLC3. Large wood was not prevalent in the reach with the exception of large trees placed at the top of banks in efforts to increase bank stability. Many of these segments are now undermined by continued bank erosion. Overall, WLC4 is a highly impaired reach and has been identified as a high priority restoration site. Restoration concepts focus on increasing floodplain connectivity by constructing an inset floodplain, which will reduce bank erosion and allow for more natural geomorphic processes.

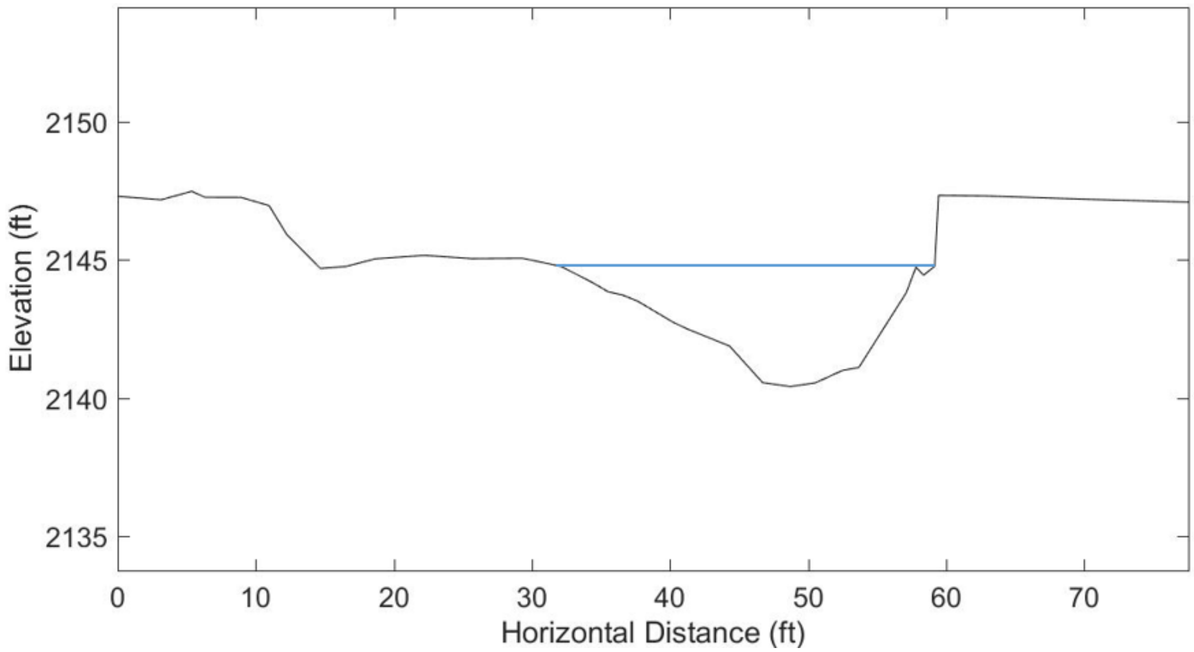

Figure 4-14. Cross section 3 on WLC4. The blue line represents bankfull stage. This cross section shows signs of dredging given the steep, actively eroding overhanging bank on river right.

Table 4-12. Metrics for cross section 2 on WLC4.	
Bankfull Width (ft)	29.6
Mean Depth (ft)	2.4
Max Depth (ft)	4.5
Bankfull Area (ft^2)	67.1
Width/Depth Ratio	12.4
Hydraulic Radius	2.1

Channel bed materials ranged from gravels to silt. The geometric mean particle size measured ranged from 14.6 mm in riffles to 21.1 mm in pools (Figure 4-15). Grain size percentiles are listed in Table 4-13. Channel substrate in the pool was coarser than the riffle, a further indication that this section of Wolf Lodge Creek has been dredged to increase hydraulic capacity.

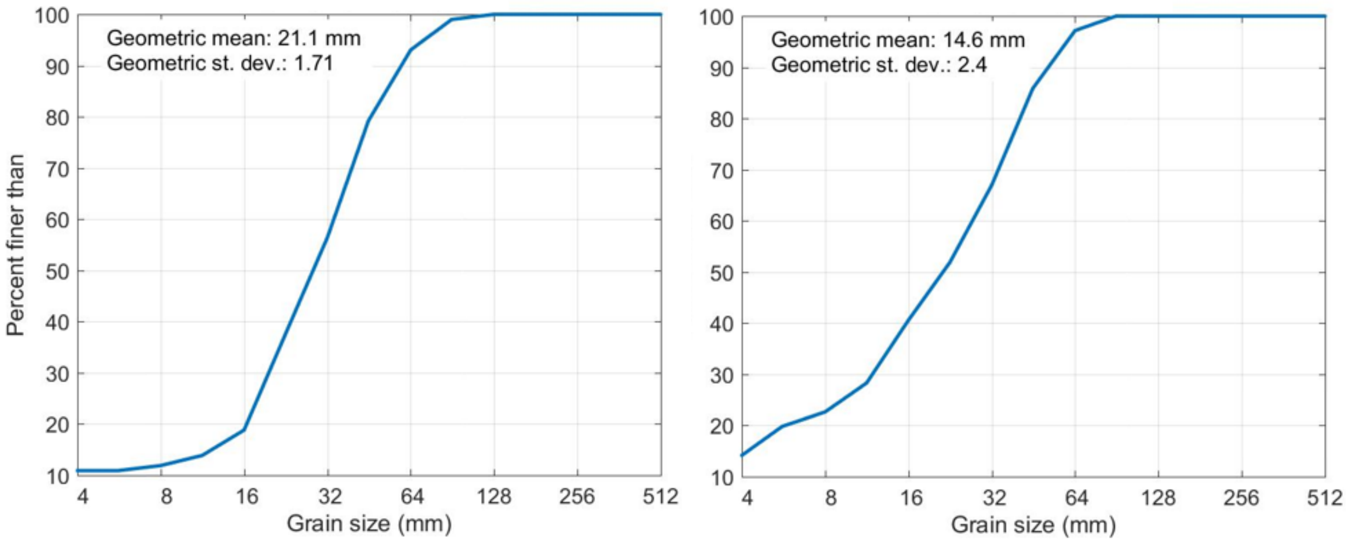

Figure 4-15. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for WLC4.

Table 4-13. WLC4 pebble count results.		
Percentile	Riffle (mm)	Pool (mm)
16	13.3	4.5
35	21.7	13.9
50	28.8	21.5
65	36.9	30.8
84	51.6	43.7
95	72.4	60.4

4.1.5 Wolf Lodge Creek Reach 5

Overview

WLC5 begins at the intersection of Wolf Lodge Creek and Interstate 90 and is bracketed by a private campground and the highway. The reach ends at the juncture with Lake Coeur d'Alene. The majority of this reach is encompassed by grazing land and/or is channelized in place adjacent to the interstate and highway fillslope. It is a deltaic environment where the channel is largely influenced by the backwater effect from Lake Coeur d'Alene. Water surface slope decreases in the downstream direction and channel velocities are very low. Within the sub-reach of WLC5, the stream type classified as an E6 type. Stream bank erosion is occurring in areas where grazing has reduced the cover of riparian vegetation that acted to stabilize the banks. Conversely, areas that are inaccessible to grazing have low BEHI ratings and banks are not actively eroding. Overall, this reach is mildly impaired from grazing activities and hard stabilization near the interstate highway.

Recommendations include constructing exclusion fencing for cattle, establishing a forested riparian corridor, re-activating a 500 ft oxbow meander, and providing the landowner opportunities for off-channel watering. A more detailed illustration of restoration concepts can be found in the restoration plan.

Channel Migration

Aerial analysis of channel migration between 2004 and 2015 shows minimal change in the reach, largely due to the lower energy environment created by the backwater effect from Lake Coeur d'Alene (Figure 4-16). Velocity and shear stress in the channel is very low even during high flows. Translation of the channel in the down valley direction is the most prevalent change to channel planform. This migration is at a natural rate given the geomorphic conditions that exist and is not a cause of concern. However, channel widening that is being driven on the river left bank from grazing, if continued, could compromise aquatic habitat by increasing bank erosion and potential for channel aggradation and pool filling.

Floodplain Connectivity

Reach WLC5 has ample floodplain connectivity (Appendix E, Figures E8 and E9). River stage at this reach, however, is not dependent on Wolf Lodge Creek discharge. Downstream of the Interstate 90 crossing, the Wolf Lodge Creek water level is controlled by management of Lake Coeur d'Alene lake levels.

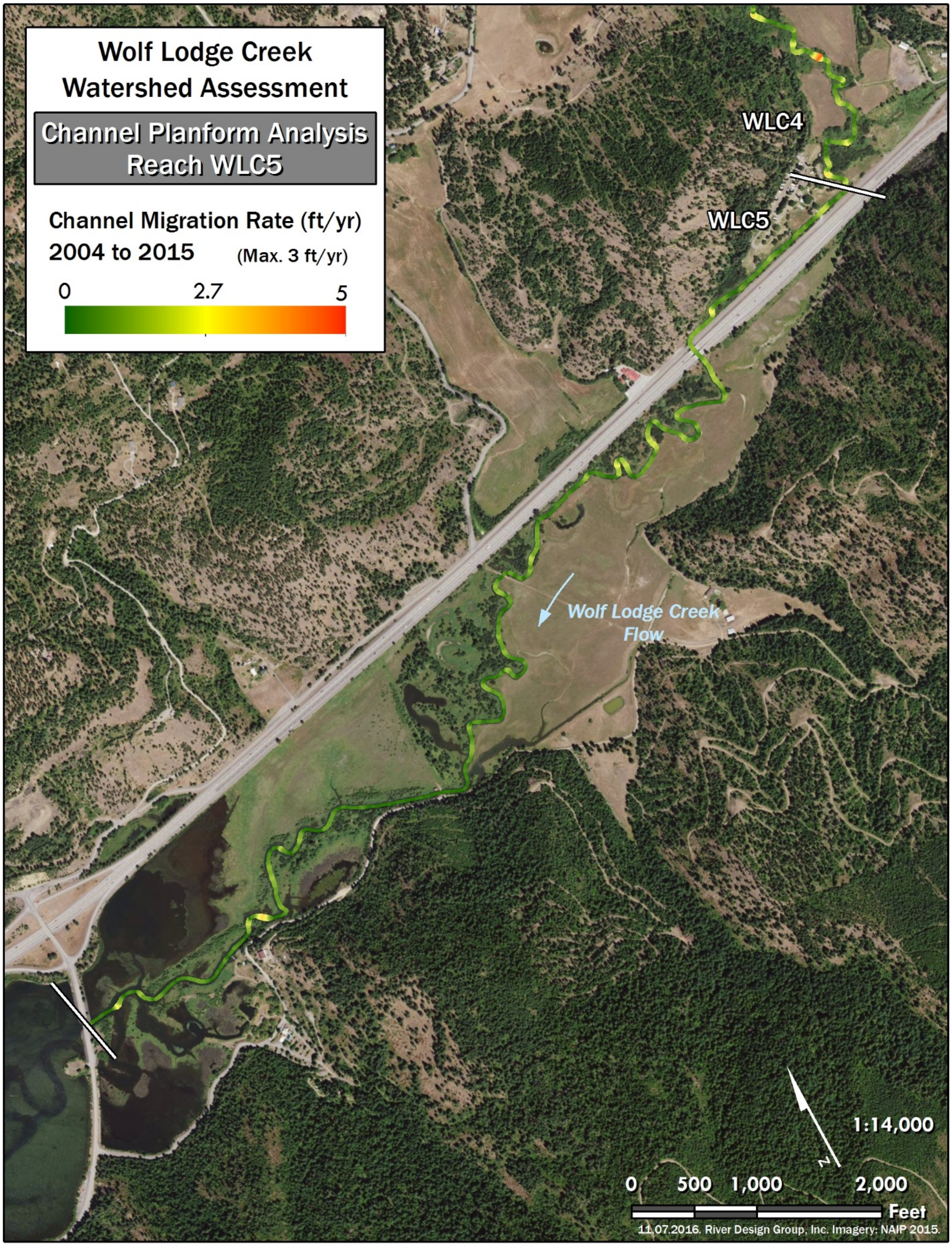

Figure 4-16. Channel migration analysis for Reach WLC5.

Sediment Sources

The streambanks in WLC5 were divided into two categories during the BEHI assessment. A low rating was assigned to the river right bank which was inaccessible to cattle grazing and a high rating was assigned to the river left bank where grazing and occurs (Table 4-14). Hoof shear was present on the grazed bank along with steeper unvegetated banks. Large bank failure blocks at the toe of the bank suggest active erosion on the grazed bank. Alternatively, the river right bank has low bank heights relative to bankfull stage, dense riparian vegetation, and lacks evidence of active erosion. Both banks consist of silty soil that is not stratified. Overall, the BEHI assessment for Reach WLC5 resulted in a total sediment yield of 219 tons/year in the reach, contributing 11% of the total sediment load for the watershed. Section 5, Table 5-1 includes a description of the calculation of total sediment yield in tons/year.

Table 4-14. Summary of BEHI analysis and sediment yield for WLC5.

Bank	Bank Height (ft)	Bank Length (ft)	BEHI Score	BEHI Rating	Predicted Erosion Rate (ft/yr)	Sediment Yield (ft^3/yr)
1	1.75	6,000	28.75	High	0.31	3,255
2	0.8	6,000	14.75	Low	0.17	816
Total		12,000				4,070

Despite the low percentage of sediment yield compared to the other reaches, the proximity of WLC5 to Lake Coeur d'Alene indicates that mobilized sediment is deposited in the lake without the opportunity for local storage. To alleviate some of the bank erosion in this reach, exclusion of cattle from the riparian area is recommended. Cattle trails along the edge of the banks are creating a weak point for large bank blocks to calve off. Establishing a riparian exclosure, and allowing for woody vegetation to reestablish would reduce sediment yield. If fencing is not a viable strategy, placement of large dead trees perpendicular to the bank in the floodplain would discourage cattle from creating trails that undermine bank stability.

Geomorphic Survey Results

A geomorphic survey was completed in the middle of WLC5 where the channel is free of lateral impingement from Interstate 90. This reach has been impacted from grazing and the channelization and hard stabilization associated with the interstate. The reach classified as an E6 stream type. A 1,400 ft longitudinal channel profile, four cross-sections, large wood survey, and BEHI assessment were completed in the reach. The average bankfull slope was 0.0002 ft/ft compared to a water surface slope of 0.00004 ft/ft. Pool cross-section and descriptive statistics are included in Figure 4-17 and Table 4-15. Large wood was abundant throughout the reach, but was not considered a driver on channel form. A pebble count was not conducted on WLC5, as the bed and banks consist of silty-clay particles.

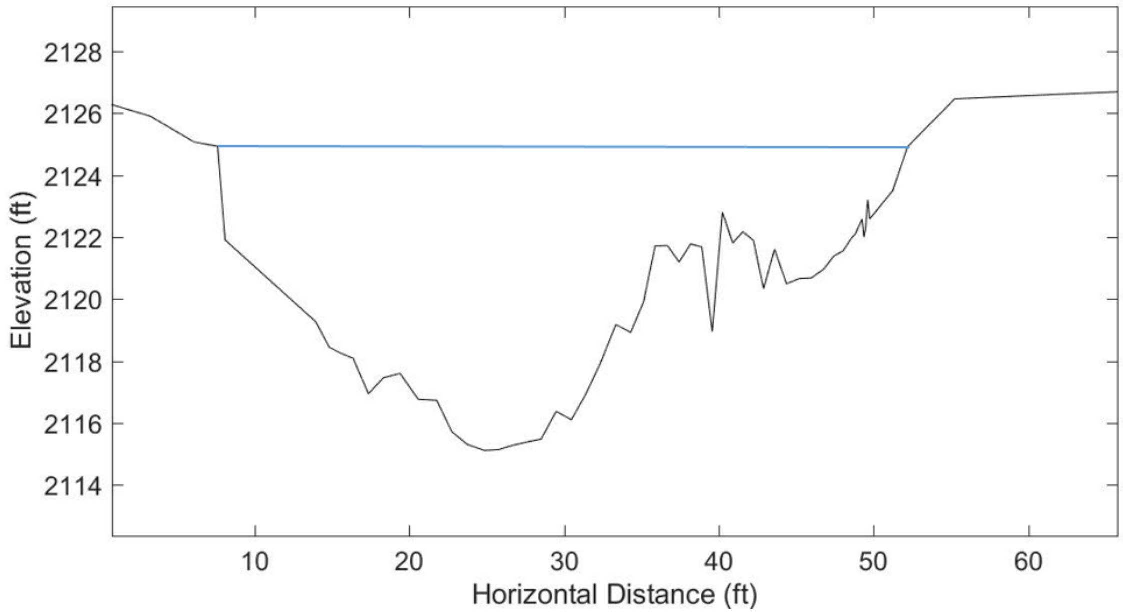

Figure 4-17. Cross section 1 on WLC5. The blue line represents bankfull stage.

Table 4-15. Metrics for cross section 1 on WLC 5.	
Bankfull Width (ft)	44.6
Mean Depth (ft)	5.6
Max Depth (ft)	9.8
Bankfull Area (ft^2)	249.7
Width/Depth Ratio	8
Hydraulic Radius	3.9

4.2 Lonesome Creek

Lonesome Creek is a third order tributary to Wolf Lodge Creek. Originating from the southeast slopes of Treasure Mountain, elevations range from 3,900 ft amsl at Treasure Saddle to 2,275 ft at the confluence with Wolf Lodge Creek. Lonesome Creek is in the middle of the transient snow zone characterized by elevations between 2,500 ft and 4,500 ft (Berris and Harr 1987). Approximately 90% of the sub-basin occurs in this zone where rain-on-snow events are common. In the headwaters of the sub basin, slopes are much lower than that of other headwaters in the northern Wolf Lodge Creek watershed. This is likely driven by lithologic differences, as Marie Creek, Phantom Creek, and Stella Creek headwaters are located in the St. Regis and Revett Formations, while the Lonesome Creek headwaters are within the Burke Formation (Appendix A, Figure A3).

One reach, LC1, was delineated on Lonesome Creek. LC1 is classified as a moderately entrenched, gravel dominated, B4 stream type with a plane bed channel. Summary morphology statistics for Lonesome Creek are included in Table 4-16.

Table 4-16. Summary of reaches on Lonesome Creek.

Reach	Stream Type	Bankfull Slope (ft/ft)	Mean Width (ft)	Max Depth (ft)	Sinuosity	D50 (mm)	D84 (mm)
LC1	B4	-0.01158	19.3	1.1	1.459	38.5	88.0

4.2.1 Lonesome Creek Reach 1

Overview

LC1 begins at the USFS sediment trap and ends at the confluence with Wolf Lodge Creek. This reach is known as Lonesome Creek or a continuation of Stella Creek. The majority of the reach encompasses land cleared for grazing and residential development. The stream is intermittent and streamflow was not observed during field data collection. Previous efforts, both authorized and unauthorized, have attempted to mitigate bank erosion and reduce flooding with construction of bank levees and channel dredging. These efforts have channelized the creek and resulted in high entrenchment, leading to bank erosion and channel widening. LC1 classified as a B4 stream type. High sediment loading, channel widening, and lack of sediment transport capacity has resulted in channel disequilibrium. The channel lacks the habitat diversity and geomorphic features that would be expected for this stream type including defined riffle and pool sequences. The stream gradient is 0.01 ft/ft compared to SC1 slope of 0.02 ft/ft. Width-to-depth ratios are much higher than at WLC2, which is significantly more vegetated and stable. Bank erosion rates are high in LC1 with 10% of the total sediment yield from bank erosion for the watershed originating from this reach. LC1 is identified as a high priority restoration reach that will require channel reconstruction and riparian vegetation community restoration.

Soils in this reach consist of erodible topsoil underlain by alluvial gravels. Levees consist of alluvial material which provides protection from bank erosion. Unprotected banks are subject to greater rates of erosion given the lack of floodplain connectivity and concentration of energy in the main channel. Bank erosion has led to channel widening, a decrease in sediment transport capacity, and sediment deposition.

In summary, LC1 is a reach that has been impacted by stream bank alterations that have resulted in stream and floodplain disconnection, as well as high rates of erosion and sedimentation. The reach lacks aquatic habitat diversity, riparian vegetation, and floodplain connectivity. Conceptual restoration plans are included in Attachment A of this report, and include establishing an inset floodplain, reconstructing the channel to the appropriate dimensions, adding wood and bank restoration structures, and revegetating the floodplain.

History

Substantial efforts have been undertaken to mitigate flood damage of private property and bank erosion in LC1. Previous owners of the property surrounding LC1 bulldozed and leveed the channel in efforts to decrease flooding of their private property. In 2009, the Kootenai County Building and Planning Department filed a code violation on these efforts that required the stream be returned conditions that existed before the unpermitted work was undertaken. Since this request, the levees have been reduced in size, and the material used to construct them was placed back in the channel. This reach continues to contribute sediment to Wolf Lodge Creek and the current conditions do not emulate pre-disturbance conditions.

Vegetation

Vegetation in Reach LC1 has been extensively modified in conjunction with the flood mitigation efforts described above. Streambanks currently lack overhanging woody vegetation, which exacerbates bank erosion and sedimentation, limits local wood inputs to the stream and reduces fish habitat, and results in higher than normal stream temperatures. Herbaceous vegetation in the stream corridor is characterized by common introduced lawn and pasture plant species, including smooth brome (*Bromus inermis*), orchard grass (*Dactylis glomerata*), Kentucky blue grass, and the invasive species yellow hawkweed (*Hieracium caespitosum*), sulfur cinquefoil (*Potentilla recta*), spotted knapweed, oxeye daisy, and common tansy. Native plants in the herbaceous community include stonecrop (*Sedum spp*.), yarrow (*Achillea millefolium*), various sedge species (*Carex spp*.), and ferns.

Adjacent to streambanks where native vegetation communities persist, ponderosa pine woodlands as well as black cottonwood trees or stands are common. Ponderosa pine can be found with 20% or more absolute cover in the tree stratum, while cottonwood, Douglas-fir and grand fir are secondary components. Common shrubs in the understory environment include ninebark, mockorange, and creambush oceanspray, usually with no more than 10 or 20% cover in an area. Along the transition from valley bottoms to slopes, diverse grand fir and ponderosa pine forest environments occur, with western white pine (*Pinus monticola*), serviceberry, ninebark, creambush oceanspray, and black hawthorn often as components of the ecosystem, along with herbaceous species such as thimbleberry, woodland strawberry, snowberry, ferns, woods' rose (*Rosa woodsii*), and arrowleaf groundsel (*Senecio triangularis*). The modified vegetation community present in most of the riparian corridor in Reach LC1 stands out against the backdrop of diverse forested communities in close proximity to the stream. A return to a dominance of woody riparian vegetation is a desired restoration objective throughout the reach.

Channel Migration

Channel migration analysis results indicate that LC1 has experienced minimal lateral migration over the past 11 years (Figure 4-18). This is likely the result of the channelization and leveeing of the reach during the early 2000s. While channel migration has been limited, significant widening has occurred, nearly doubling the width of the channel. Small areas where banks have eroded and migrated include small patches on the left bank where levees were not built and flow is now concentrated on erodible soil and bank materials. Rates of migration range from 1.5-2 ft/year. These rates are influenced by the construction efforts in the channel since extensive work was conducted during the time period examined.

Floodplain Connectivity

LC1 largely lacks floodplain connectivity, especially in the upstream portion of the reach. Approximately 700 feet of the channel is confined against the western valley toe of slope (Appendix E, Figure E2). This segment appears to have been channelized more than 70 years ago, most likely to optimize agricultural production. This constriction limits floodplain connection and causes an increase in water velocities. Limited floodplain connection continues downstream as the channel meanders around residential structures, due in large part to recent stream channelization by previous landowners and set-back levees protecting structures. Floodplain connection is re-established downstream.

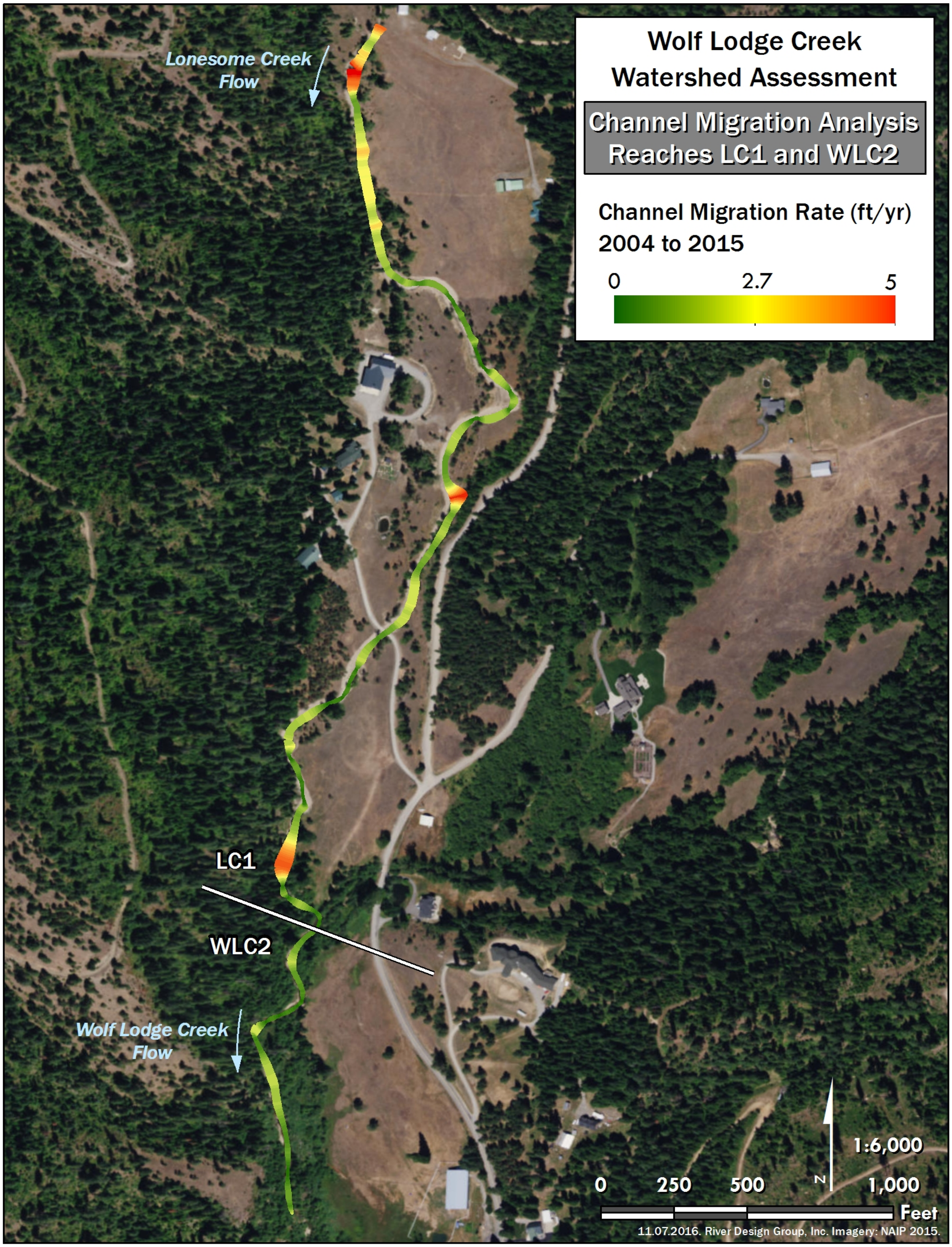

Figure 4-18. Channel migration of Reach LC1 and the upstream portion of Reach WLC2.

Sediment Sources

Soils in LC1 consist of Typic Udivitrands formed in broad stream bottoms, which have low surface erosion and low mass erosion potential, but have high sediment delivery potential (Table 2-7). Banks in this reach are highly erodible and are a large source of sediment downstream. Over-steepened banks with easily erodible topsoil characterize the upper bank, and underlying soils consist of fine to medium size alluvium. Large bank blocks calve off of the undermined banks, causing channel widening (Figure 4-19). BEHI analysis identified three bank conditions in the reach, two of which rated high with BEHI ratings of 31.9 and 26.8 (Table 4-17). These banks characterized a majority of the reach. Depositional bars that demonstrated low BEHI ratings represented 10% of the reach. Overall, LC1 contributes 191 tons/year of sediment through bank erosion, representing approximately 10% of the total contribution to the watershed. Section 5, Table 5-1 includes a description of the calculation of total sediment yield in tons/year.

Figure 4-19. Bank blocks from rapid bank erosion resulting from woody vegetation removal and channel entrenchment.

Table 4-17. Summary of BEHI analysis and sediment yield for LC1.

Bank	Bank Height (ft)	Bank Length (ft)	BEHI Score	BEHI Rating	Predicted Erosion Rate (ft/yr)	Sediment Yield (ft^3/yr)
1	3.5	2,400	31.85	High	0.31	2,604
2	0.5	400	14.75	Low	0.17	34
3	2.5	1,200	26.75	High	0.31	930
Total		4,000				3,570

Geomorphic Survey Results

A geomorphic survey was completed in the middle of LC1 in the section of channel that was disturbed by a previous land owner, and represents the focal point for future restoration efforts in the reach. An 800 ft longitudinal channel profile, two riffle cross-sections, two pool cross-sections, pebble count for riffle and pool, large wood survey, and BEHI assessment were completed in the reach. The average bankfull slope is 0.01 ft/ft which is the same as the bed slope. Riffle cross section and descriptive statistics are included in Figure 4-20 and Table 4-18. The right bank is leveed, as shown in Figure 4-20. The river left floodplain is constricted by the valley wall, limiting the area that could be inundated during flooding. The channel in the reach is geomorphically devoid of complexity. Uniform bed topography limits the development of aquatic habitat and is a result of channel widening and past construction efforts. Additionally, the lack of large wood in the channel exacerbates the lack of habitat diversity.

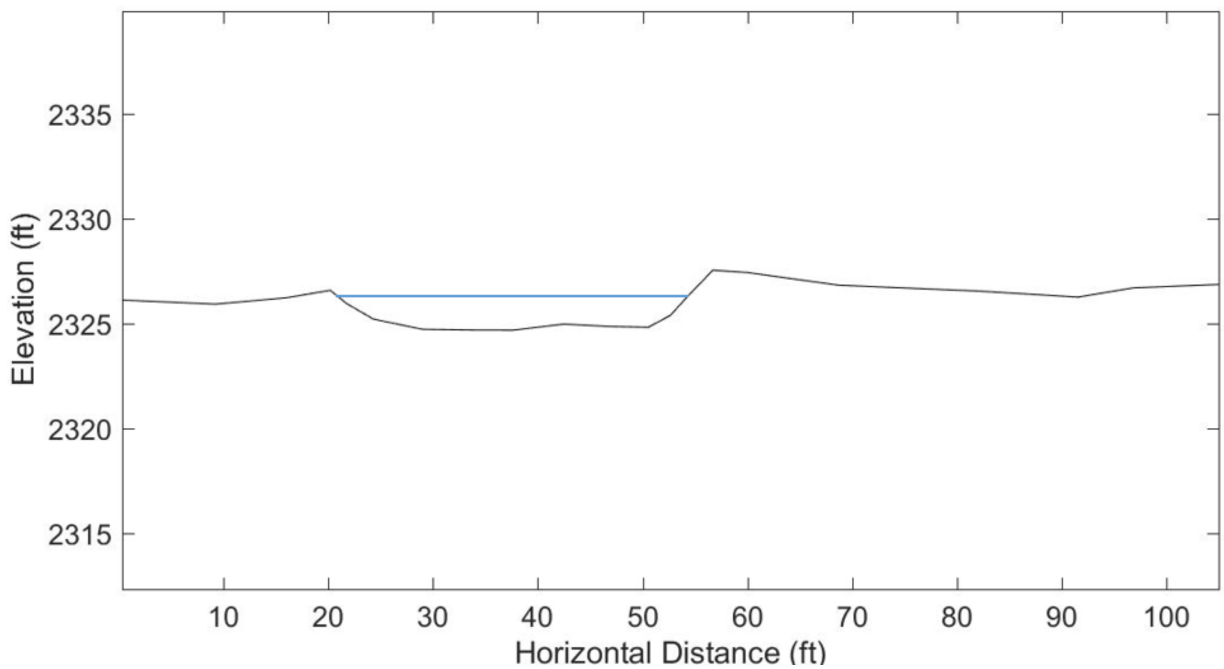

Figure 4-20. Cross section 4 pool on LC 1. The blue line represents bankfull stage. Channel complexity is lacking and the right bank has been leveed.

Table 4-18. Metrics for cross section 4 on LC 1.	
Bankfull Width (ft)	30.3
Mean Depth (ft)	0.8
Max Depth (ft)	1.0
Bankfull Area (sq ft)	23.3
Width/Depth Ratio	39.3
Hydraulic Radius	0.8

Channel bed materials ranged from gravels to silt. The geometric mean particle size measured ranged from 28.5 mm in riffles to 27.9 mm in pools (Figure 4-21). Grain size percentiles are listed in Table 4-19.

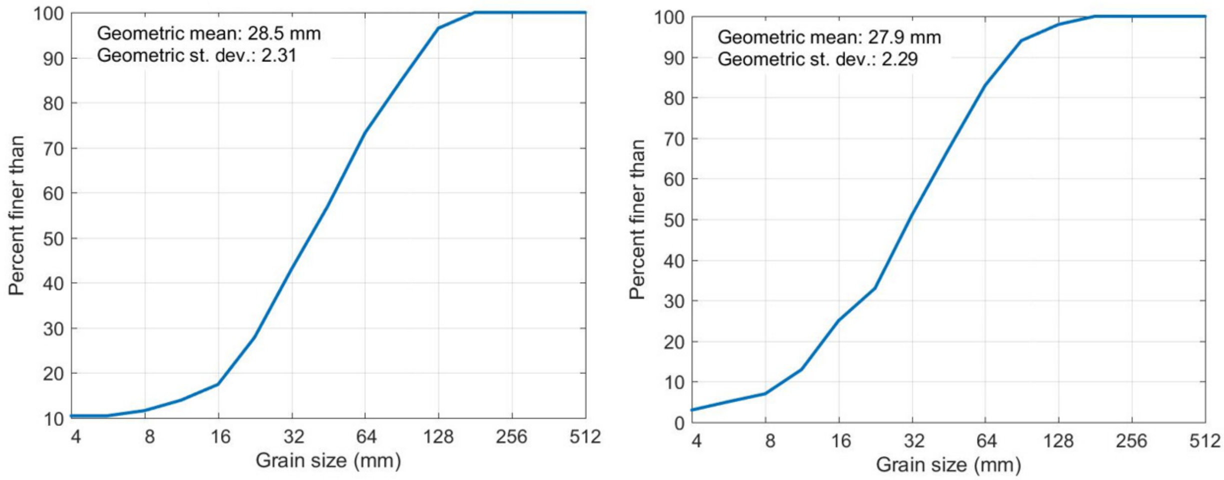

Figure 4-21. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for SC1.

Table 4-19. SC1 pebble count results.

Percentile	Riffle (mm)	Pool (mm)
16	14.1	12.5
35	27.0	23.6
50	38.5	31.5
65	54.4	43.4
84	88.0	66.4
95	123.1	99.5

4.3 Unnamed 1

Unnamed 1 is a second order stream that flows into Lonesome Creek towards the downstream end of reach LC1. This spring fed system flows throughout the summer, but during very dry conditions flows intermittently or subsurface. Land cover throughout the drainage is forested and road density is low. Despite historical logging, the watershed maintains a full forest canopy. One reach, UN1, is delineated on Unnamed 1. UN1 is predominately a B stream type, but has undergone channel incision on the lower section where it shifts to an F stream type (Figure 4-22). This incision is likely driven by anthropogenic changes to Lonesome Creek, including channelization and subsequent incision. In addition to incision, the lower section has begun to widen as banks become more unstable from the increased bank height relative to bankfull stage, and from the removal of shrubs and trees that provided bank stability.

The upper half of UN1 is a healthy, functioning stream with low bank heights, dense riparian vegetation, and ample instream large wood. The channel bed consists of 45-16 mm particles that are angular, suggesting low bed transport rates. Banks in the upper half of the reach are moderately erodible given the high bank surface protection provided by large wood. Stream banks in the lower half are highly erodibile, with high bank height ratios and steep, unvegetated bank slope. The lower segment of the reach has been identified as a high priority site in the adopted Wolf Lodge Creek TMDL.

Westslope cutthroat juveniles were observed in a pool just below a knickpoint separating the upper forested section from the lower gradient reach of UN1. Recommendations for this reach include conservation of forested land and reducing conversion of forest to pasture on private property. This is important for reducing the amount of bank erosion and downstream sedimentation. More broadly, first and second order streams should be managed to reduce the amount of forest cover loss.

Figure 4-22. Incised channel above the knickpoint (left), and widened and incised channel with thinned riparian forest (right).

4.4 Stella Creek

Stella Creek is a third order tributary to Lonesome Creek. Originating from the southern slopes of the Windy Ridge and Huckleberry Mountain, elevations range from 5,350 ft amsl at the watershed divide to nearly 3,000 ft at the confluence with Lonesome Creek. Similar to other tributaries in the watershed, runoff is snowmelt dominated with peak flows occurring in late March and early April. Periodic winter rain-on-snow events typically occur in the transient snow zone characterized by elevations between 2,500 ft and 4,500 ft (Berris and Harr 1987). With approximately 85% of the watershed area occurring in this zone, rain-on-snow events are a common occurrence and can lead to episodic fluxes in sediment, wood and water to the channel network.

One reach, SC1, was delineated and surveyed on Stella Creek. SC1 is classified as a moderately entrenched gravel dominated Rosgen B4 stream type with large log-steps driving channel morphology. Summary channel morphology statistics for Stella Creek are included in Table 4-20.

Table 4-20. Summary of reaches on Stella Creek.

Reach	Stream Type	Bankfull Slope (ft/ft)	Mean Width (ft)	Max Depth (ft)	Sinuosity	D50 (mm)	D84 (mm)
SC1	B4	-0.022	22.8	2	1.28	31.0	49.7

4.4.1 Stella Creek Reach 1

Overview

SC1 begins in the headwaters of Stella Creek and extends downstream to the USFS sediment trap. SC1 is managed by the USFS, Idaho Panhandle National Forest and is a relatively undisturbed reach with approximately 90% forest cover. The SC1 channel classified as a Rosgen B4 stream type with high amounts of instream large wood. Channel morphology is dominated by log formed step pools with interspersed riffles and runs. Channel slope ranges from 0.035 ft/ft to 0.075 ft/ft. The stream is confined by the valley for the majority of the reach. Width-to-depth ratios vary significantly between riffles and pools, due to deep plunge pools formed downstream of log steps. Overall, the stream is a healthy, functioning channel with high quality aquatic habitat.

Sections of the headwaters of SC1 have been disturbed by historical logging operations, which sparked concern over downstream impacts from sediment. Two sediment traps were constructed, including one on SC1 and a second on MC2. These traps were designed as large ponds with grade control structures built at the pond outlet and inlet, intended to capture bedload and to be periodically excavated to maintain capacity. The trap has not been emptied for some time, but very little bedload material is being collected. This suggests that sediment sources from upstream are not significant, or that material being transported from upstream reaches is being stored naturally in localized sinks including log jams, floodplains, and secondary channels.

In conclusion, SC1 is a healthy aquatic ecosystem that has natural geomorphic process and form. The removal of the existing sediment trap and grade control features is recommended, which would be one component of a larger valley and channel restoration effort to help restore floodplain connectivity, sediment transport, and fish passage between the upper and lower reaches of Stella Creek. Conceptual designs are included in Attachment A of this report.

Sediment Trap

During the 1990s the sediment trap was constructed to decrease the amount of sediment being transported from the headwaters to the lower reaches in the watershed (Figure 4-23). Increased sediment flux was anticipated from timber harvest activities upstream. Inspection of the sediment trap reveals that very little bedload is being transported to and deposited in the trap. The majority of bedload is being deposited upstream of the trap and has caused localized adjustments in the channel slope and energy gradient, causing channel braiding. The grade control structure on the upstream end of the trap is the cause of the deposition. The amount of bedload material that has been deposited in this reach is not excessive, suggesting that the original concern of increased bedload from timber harvest activities has not been observed. Local sediment sinks in large wood structures throughout SC1 have likely buffered impacts of coarse sediment increases from logging. Sediment trap removal and restoration of the channel and floodplain in the vicinity of the sediment trap is recommended.

Figure 4-23. Sediment trap on Stella Creek.

Vegetation

Reach SC1 is a highly diverse, wooded headwater stream environment dominated largely by cool and moist grand fir forest. Pockets of western red cedar and western hemlock forest are also present. Grand fir often dominates the overstory with 30 to 50% cover, and black cottonwood, cascara buckthorn, alder, western hemlock, western red cedar, western white pine, and Rocky Mountain maple are secondary but common components in the riparian forest. Shrub species include Woods' rose, fools huckleberry, snowberry, and some streambanks also support tall willow thickets. The diverse forest floor sustains many native herbaceous species including thimbleberry, red twinberry, water hemlock, false hellebore (*Veratrum viride*), heart-leafed arnica, cow parsnip, arrowleaf groundsel, stinging nettle, and various mosses. Climbing nightshade (*Solanum dulcamara*) was the only introduced plant species found at the time and location of sampling. The diverse riparian forest environment at SC1 is characteristic of un-harvested headwater stream ecosystems in the Wolf Lodge Creek drainage.

Channel Migration

Analysis of channel migration was not possible in this reach due to dense canopy coverage. A qualitative assessment indicates that the channel in this reach has frequent avulsions. The prevalence of large wood in the channel is a driver of these avulsions. Multiple side channels are utilized during high flow events, and these side channels allow for the stream to dissipate energy and deposit sediment. Side channels function to decrease lateral migration, bank erosion, and channel incision, while providing important off-channel refugia for fish and aquatic organisms.

Sediment Sources

Soils in SC1 consist of Alfic Udivitrands formed from weathered belt series rock and deposited at the toe of slopes and stream bottoms. These soils have low surface erosion, but have moderate mass erosion potential and moderate sediment delivery potential (Table 2-7). Streambanks in SC1 scored a low BEHI rating (Table 4-21). Banks are characterized by low heights relative to bankfull stage, deep roots from woody vegetation, steep bank angles, and slight stratification between alluvial toe material and topsoil. The entire sub-reach was characterized by low BEHI rating banks and additional reconnaissance of both upstream and downstream areas indicates this trend is persistent throughout SC1. Total sediment yield from stream bank erosion is 64 tons/year, accounting for 3% of the total sediment yield from streambank erosion for the Wolf Lodge Creek Watershed. This analysis suggests that sedimentation problems in the lower reaches are not a result of bedload transport from this reach. Section 5, Table 5-1 includes a description of the calculation of total sediment yield in tons/year.

Table 4-21. Summary of BEHI analysis and sediment yield for SC1.

Bank	Bank Height (ft)	Bank Length (ft)	BEHI Score	BEHI Rating	Predicted Erosion Rate (ft/yr)	Sediment Yield (ft^3/yr)
1	1	7,000	14.25	Low	0.17	1,190
Total		7,000				1,190

In addition, large wood features in this reach provide local sediment sinks that buffer increased sediment load from logging efforts upstream. Figure 4-24 highlights an example of this process. The sub-reach in which the geomorphic assessment was conducted contains four log step features that serve as large, local sinks for sediment. If the frequency of occurrence of log steps is constant throughout the reach, hundreds of local sinks exist to store sediment. These buffers are critical to downstream community resilience to flooding and sedimentation. Recommendations include conservation and maintenance of current land management strategies to protect these riparian forests from logging, fire, and disease.

Figure 4-24. Log step that is storing sediment locally and buffering impacts from upstream timber harvest.

Geomorphic Survey Results

A geomorphic survey was completed at the downstream end of SC1 where the forested channel exits a large meadow. This reach appears undisturbed from direct human impacts for at least the last 70 years, with well-established secondary growth forests making up the riparian environment. The stream is classified as a B4 stream type. A 400 ft longitudinal channel profile, two riffle cross-sections, two pool cross-sections, pebble count for riffle and pool, large wood survey, and BEHI assessment were completed in the reach. The cross-sections were located in representative channel habitat features. The average bankfull slope is 0.022 ft/ft compared to a water surface slope of 0.025 ft/ft. Pool cross-section and descriptive statistics are included in Figure 4-25 and Table 4-22. Large wood is abundant throughout the reach and provides aquatic habitat complexity. Overall, this reach is a stable channel that has reached equilibrium and provides ample, diverse habitat for aquatic species.

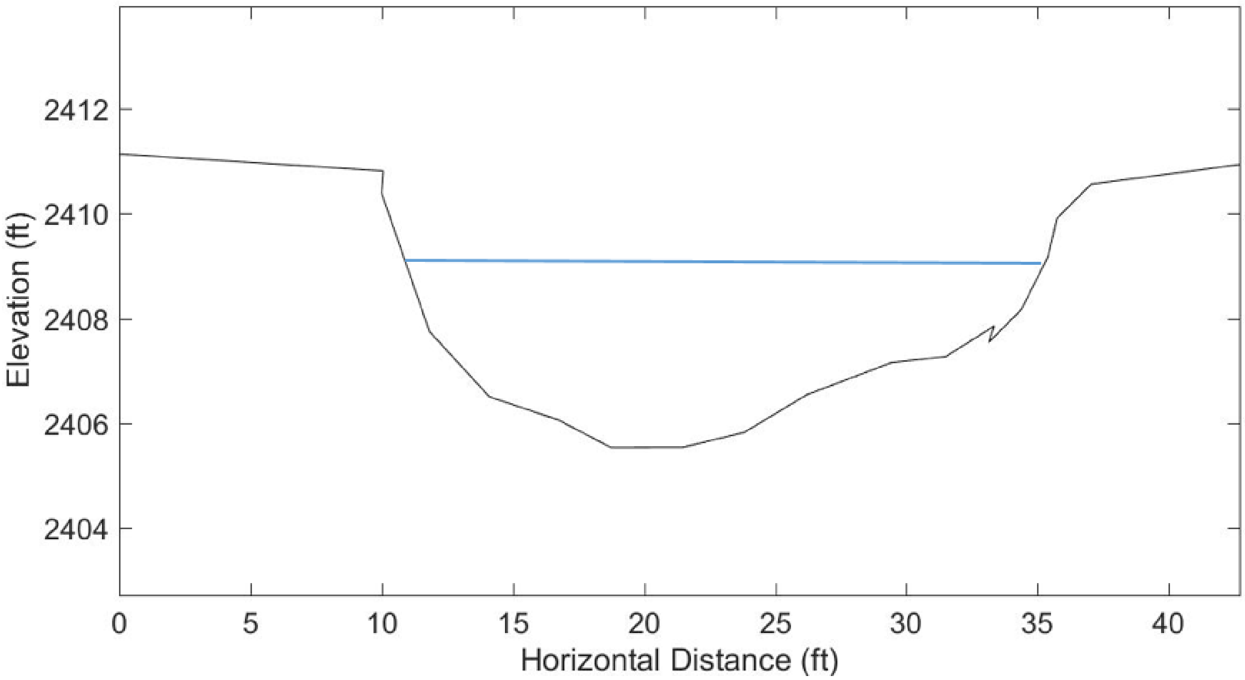

Figure 4-25. Cross section 4 scour pool in SC1, below the log step shown in Figure 5-16. The blue line represents bankfull stage.

Table 4-22. Metrics for cross section 4 on SC 1.	
Bankfull Width (ft)	24.3
Mean Depth (ft)	2.5
Max Depth (ft)	3.6
Bankfull Area (sq ft)	60.3
Width/Depth Ratio	9.7
Hydraulic Radius	2.3

Channel bed materials ranged from gravels to silt. The geometric mean particle size measured ranged from 27.4 mm in riffles to 13.6 mm in pools (Figure 4-26). Grain size percentiles are listed in Table 4-23.

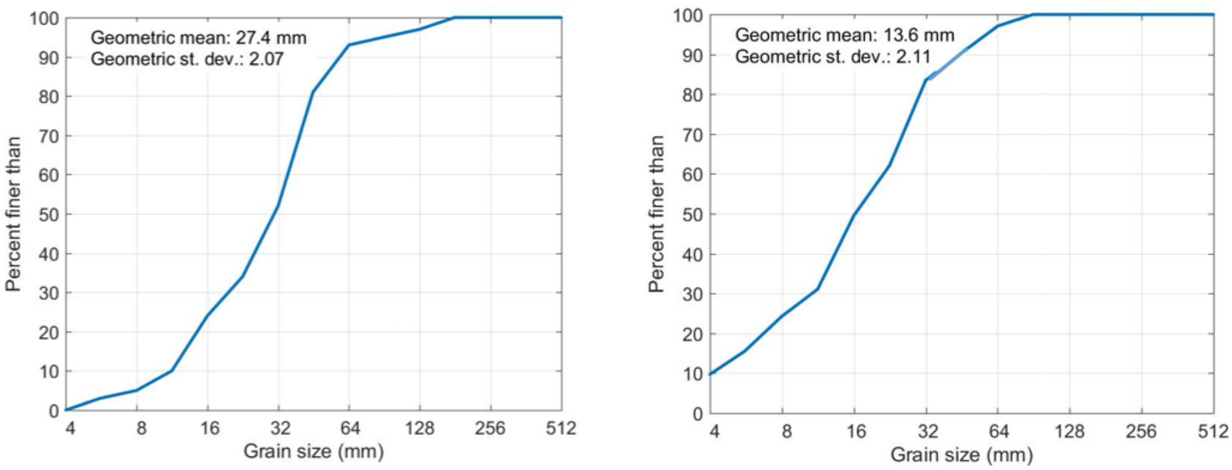

Figure 4-26. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for SC1.

Table 4-23. SC1 pebble count results.		
Percentile	Riffle (mm)	Pool (mm)
16	13.3	5.7
35	23.1	12.3
50	31.0	16.3
65	37.8	23.9
84	49.7	33.0
95	90.0	58.2

4.5 Marie Creek

Marie Creek is a third order tributary to Wolf Lodge Creek. Originating from the eastern portion of the watershed in between Skitwish Peak and Copper Mountain, this tributary comprises 29% of the Wolf Lodge Creek watershed area. Elevations range from 5,350 ft at Skitwish Peak to 2,240 ft at the confluence with Wolf Lodge Creek. Valley slopes encompassing Marie Creek are on average steeper than any other sub-basin. This influences the frequency and of landslide activity in the drainage that provides sediment to both Marie Creek and Wolf Lodge Creek. The headwaters of Marie Creek are owned by the USFS Idaho Panhandle National Forest, similar to Phantom, Lonesome, and Stella Creek.

Three reaches were delineated on Marie Creek. Extending from the headwaters to the Wolf Lodge Creek Confluence, Marie Creek transitions from a steep confined channel in the upper watershed to a moderately sloped, confined valley near the confluence of Searchlight Creek where the valley widens. A Level II classification survey was conducted only on MC2, which is classified as a B4 stream type upstream of the modified reach. The modified reach classified as an entrenched, F4 stream type. Rapid field assessments were conducted for MC1 and MC3, which consisted of aerial photography interpretation and field reconnaissance to generally characterize conditions without survey equipment. Additional summary channel morphology metrics are included in Table 4-24.

Table 4-24. Summary of reaches on Marie Creek.

Reach	Stream Type	Bankfull Slope (ft/ft)	Mean Width (ft)	Max Depth (ft)	Sinuosity	D50 (mm)	D84 (mm)
MC1	B4	NA	NA	NA	Low	Gravel	NA
MC2	B4/F4	-0.009	26.2	1.4	1.23	56.1	104.0
MC3	C4/B4	NA	NA	NA	Moderate	Gravel	NA

4.5.1 Marie Creek Reach 1

MC1 is located on USFS land upstream of the sediment trap on MC2. The entirety of the reach is federally owned and managed by the Panhandle National Forest. Access to the site is restricted to hiking/horseback trails, with no road access. No gauge data is available for this upper portion of the watershed, but the hydrology is likely similar to that of the main stem of Wolf Lodge Creek. Peak flows are dominated by early snowmelt from relatively low elevations in March and April.

This reach has been logged and is recovering from past forest management activities. The forest is a mixture of cedar and pine secondary growth. Riparian vegetation communities are limited to the bankfull width of the stream with pine forest cover dominating the floodplain. Instream large wood is prevalent throughout the reach (Figure 4-27).

MC1 is relatively undisturbed from human activity, with complex aquatic habitat and low bank erosion. The stream is classified as a B4 stream type and transitions to a C4 type toward the downstream end of the reach. Intermittent bedrock intrusions on the left bank and in the channel are present. Grains in the channel are more angular than other reaches, suggesting hillslope activity is contributing the bulk of the sediment supply to the reach. The bed of the channel is armored, indicating low bedload transport rates. Slope of the reach is 0.0195 ft/ft, which is slightly steeper than the downstream MC2. Despite similarities in slope, this reach can be used as a reference reach for MC2 given the significant confinement of MC1. Removal of the downstream sediment trap is supported by the amount of local storage of sediment within the channel. Large wood features create depositional environments where pockets of gravels are being stored, as well as a well-connected floodplain that allows for deposition of fines during flood events. The diversity of habitat in the reach is driven by the interaction with large wood aggregates and single pieces (Figure 4-28).

This reach is functioning with minimal human disturbance occurring in recent history. Recommendations include limiting future logging operations in this drainage to limit the potential for an increase in hillslope activity and sediment loading to MC1.

Figure 4-27. Typical channel conditions in MC1.

Figure 4-28. Channel spanning log jam that forms a deep pool upstream (left) and breached log jam that has retained sediment as a lateral bar on the left bank (right).

4.5.2 Marie Creek Reach 2

Overview

MC2 begins at the USFS sediment trap on Marie Creek and ends just downstream of the confluence with Searchlight Creek. This reach occupies a side valley of the Wolf Lodge Creek drainage basin that supports pasture and agricultural land. MC2 has experienced significant channel avulsions and bank erosion. Landowners have attempted to halt the effects of bank erosion and promote a more stable channel that sustains more diverse habitat for aquatic species. Some concerns remain for reach stability including the potential failure of large wood structures that were installed for stability purposes. This site is identified as a high priority restoration reach and conceptual restoration plans are included in Attachment A of this report.

The stream is classified as a B4 stream type with inclusions of F4 stream type where the channel is entrenched and disconnected from the floodplain. MC2 experiences intermittent hydrology, and in summer months the channel is dewatered. Channel slope averages 0.012 ft/ft. Streambank and floodplain vegetation is sparse, and the channel cross-sectional area is excessive which contributes to channel dewatering and hydrologic entrenchment. The reach is unlikely to reach equilibrium due to the impaired channel geometry, including cross-sectional, longitudinal, and plan form dimensions. Analysis of LiDAR topography indicates the floodplain surface ranges from 1-3 ft in elevation above the existing bankfull floodplain elevation in areas, reflecting the high degree of entrenchment (Appendix E, Figure E10). MC2 is responding to human disturbances and is not meeting its geomorphic or biological potentials.

MC2 is an impaired reach with high restoration potential for both sediment reduction and improved aquatic habitat conditions, including extending or restoring perennial flow. Conceptual plans to restore this reach are presented in Attachment A. Restoration goals focus on increasing floodplain connectivity, re-establishing the appropriate channel dimensions expected for a B4c stream type developed within a terraced valley, establishing a vegetated floodplain corridor, and improving aquatic habitat conditions for westslope cutthroat trout.

Channel Migration

The Marie Creek valley floor in MC2 was cleared for logging, grazing, and other agricultural activities. Native riparian vegetation is limited to relict meander oxbows that were truncated and abandoned in the early 2000s as a result of a major channel avulsion. The avulsion was exacerbated by the lack of vegetation in the valley floor, which decreased channel boundary and floodplain roughness. After this avulsion, efforts were made to restore the channel and provide more diverse habitat, prevent flooding, and minimize bank erosion. Several structures installed are at risk of failure due to scour. A time series of imagery of the site is provided in Figure 4-29.

Figure 4-29. Time series of aerial photography highlighting the channel avulsion on MC2.

Several of the channel spanning wood features are susceptible to failure (Figure 4-30). The channel bed is scoured below the step features, and the structures are at risk of failure. An undersized bridge is located downstream of the restoration site and consists of a narrow span and mid-channel pier. Given the limited hydraulic capacity of the bridge opening, the bridge may be at risk of failure during a large flood event.

Figure 4-30. Example channel spanning log drop structure that is at risk of failure.

Floodplain Connection

Reach MC2 lacks floodplain connectivity (Appendix E, Figure E10). Following the avulsion event, the construction of high banks resulted in a disconnected channel and floodplain environment. The channel currently abuts the steep valley wall which limits floodplain development to the north. This lack of floodplain connectivity confines floodwater within the channel, focusing stream energy and likely leading to channel incision and erosion around constructed structures.

Sediment Sources

Soils in MC2 consist of Typic Udivitrands formed in broad stream bottoms, which have low surface erosion and low mass erosion potential, but have high sediment delivery potential (Table 2-7). Streambanks in MC2 are characterized by steep, sloping alluvium, sparse vegetation, and high bank height ratios. Streambanks are estimated to contribute 117 tons/year of sediment to Marie Creek in Reach 2. This represents 6% of the total sediment load from bank erosion for the Wolf Lodge Creek watershed. A sediment trap was constructed just downstream of this segment which likely captures the majority of the bedload transported out of the sub-reach. Restoration recommendations address the removal of this structure.

Table 4-25. Summary of BEHI analysis and sediment yield for MC2.

Bank	Bank Height (ft)	Bank Length (ft)	BEHI Score	BEHI Rating	Predicted Erosion Rate (ft/yr)	Sediment Yield (ft^3/yr)
1	2	3,500	32.3	High	0.31	2,170
Total		3,500				2,170

Geomorphic Survey Results

A geomorphic survey was completed at the upstream end of MC2 just downstream of the USFS sediment trap. This reach is highly degraded from a recent channel avulsion and mitigation efforts. In the sub-reach, the channel classified as a B4 stream type, with moderate sinuosity and limited floodplain connectivity. A 900 ft longitudinal channel profile, two riffle cross sections, two pool cross-sections, a pebble count, large wood survey, and BEHI assessment were completed in the reach. The cross sections were located in representative channel habitat features. The bed slope is 0.012 ft/ ft and the sinuosity of the channel is 1.23 ft/ft. Riffle cross-section and descriptive statistics are included in Figure 4-31 and Table 4-26. Width-to-depth ratios are outside of the range expected for a B4 stream type which is causing rapid channel widening. Large wood is not present in the reach with the exception of the channel spanning wood structures incorporated as part of the channel stabilization project described above. Uniform bed topography limits the development of aquatic habitat and is a result of channel widening and construction efforts. Additionally, the lack of large wood and riparian vegetation exacerbates the lack of habitat diversity.

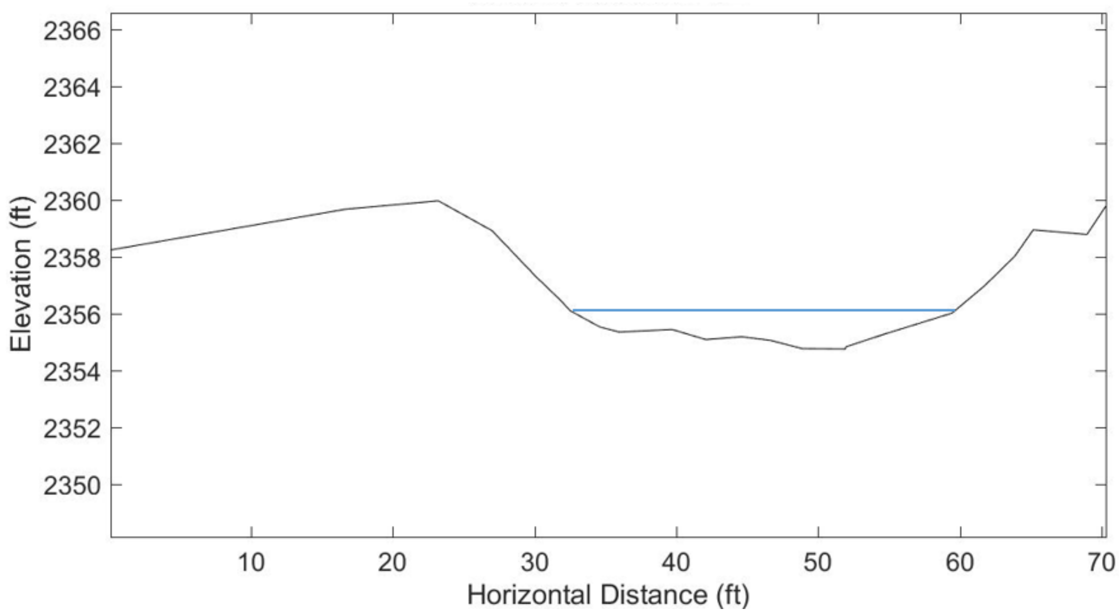

Figure 4-31. Cross section 2 on MC2. The blue line represents bankfull stage. Leveed banks significantly disconnect the floodplain from the channel.

Table 4-26. Metrics for cross section 2 on MC2.	
Bankfull Width (ft)	27.0
Mean Depth (ft)	0.9
Max Depth (ft)	1.4
Bankfull Area (sq ft)	23.4
Width/Depth Ratio	30.7
Hydraulic Radius	0.9

Channel bed materials ranged from boulders to sand. The geometric mean particle size measured ranged from 48.4 mm in riffles to 25.6 mm in pools (Figure 4-32). Grain size percentiles are listed in Table 4-27.

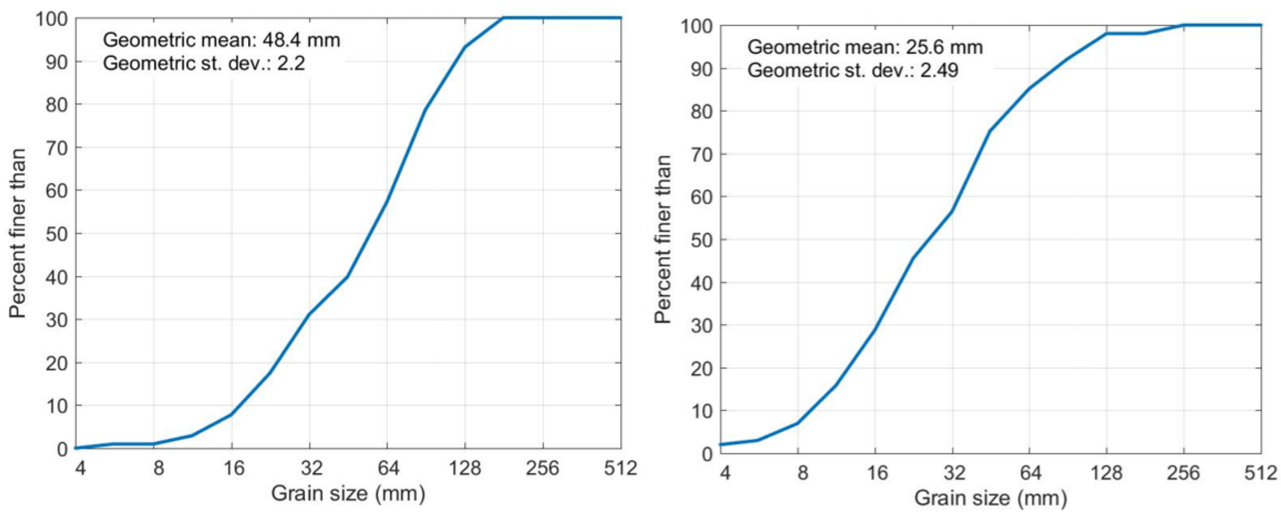

Figure 4-32. Cumulative percent frequency distribution of grain size for riffle (left) and pool (right) for MC2.

Table 4-27. MC2 pebble count results.

Percentile	Riffle (mm)	Pool (mm)
16	21.6	11.4
35	37.8	18.5
50	56.1	26.4
65	73.4	37.9
84	104.0	61.8
95	141.7	108.7

4.5.3 Marie Creek Reach 3

MC3 extends from the confluence of Searchlight Creek, downstream to the confluence with Wolf Lodge Creek. This reach is privately owned and access to the area is limited. Due to these constraints, field collection was focused on the lower portion of the reach. Aerial imagery analysis and field reconnaissance suggest that human activity in the watershed has been limited over the past 30 years. The channel appears to be stable with very little change in planform from 1998 to 2016, due in part to the high degree of bank surface protection provided by woody riparian vegetation.

The reach is characterized by inclusions of C4 and B4 stream types. C4 stream types exist where large gravel bars have formed and the stream has greater sinuosity and a broader, connected floodplain. The reach lacks large trees which in turn limits the amount of large wood interacting with the bankfull channel. The addition of large wood structures would increase habitat complexity, but this site is considered a low priority for restoration relative to other areas in the watershed.

Reach MC3 has sufficient floodplain connectivity in the upper portion of the reach. Depressions below bankfull elevation indicate that during flood events, floodwater storage and groundwater recharge through infiltration can occur (Appendix E, Figure E10). This process decreases flood peaks, increases baseflow conditions and promotes the growth of a healthy riparian community. While the downstream portion of Reach MC3 is more channelized against the southern wall as it approaches Wolf Lodge Creek, the floodplain broadens again after the Wolf Lodge Creek Road bridge (MC_Bridge).

4.6 Searchlight Creek

Searchlight Creek is a second order perennial tributary to Marie Creek. This small basin is comprised of a lower sloped valley characterized by a spring-fed B4 stream type. The total watershed area is small compared to the Marie Creek watershed and is at lower elevations (2,300-3,200 ft). The hydrology is largely driven by rain events and springs rather than snowmelt. The majority of Searchlight Creek is owned by the USFS except for the lower half mile which is on private land. It is forested from the headwaters to the confluence with Marie Creek which likely decreases the overall temperature of the stream throughout the year. Culverts restrict fish passage to Searchlight Creek, but if accessible this stream could provide refugia for juvenile westslope cutthroat trout.

4.6.1 Searchlight Creek Reach 1

One reach, SLC1, was delineated on Searchlight Creek. The confluence with Marie Creek is located at the boundary between MC2 and MC3. The entirety of the reach in the study area is privately owned, but the headwaters of Searchlight Creek are in the Idaho Panhandle National Forest. SLC1 is classified as a B4 stream type. Bank characteristics vary throughout the reach (Figure 4-33) but are generally composed of non-stratified, silty-clay soils. Erosion potential from SLC1 is low due to the presence of woody vegetation, moderate bank angles, and bank surface protection from root systems. Overall, the reach is currently stable.

Three culverts are present in the reach. Removal or modification of two of the structures is recommended to prevent the potential for clogging and failure. Additionally, the most downstream culvert may present a seasonal barrier to fish passage. Results of the stream crossing inventory are included in Appendix D. Recommendations include replacement of two culverts and maintaining adequate riparian buffers in the headwaters of the drainage.

Figure 4-33. Typical streambank conditions in SLC1.

4.7 Rutherford Gulch

Rutherford Gulch (RG) is a third order tributary to Wolf Lodge Creek. The creek originates at much lower elevations than other tributaries, with a maximum elevation of 3,400 ft, to a minimum of 2,145 ft at the confluence with Wolf Lodge Creek. The bulk of the sub-basin is privately owned and cattle grazing and agricultural activities persist. Prescribed burning has been a common management activity on USFS owned land. The longitudinal profile shows a convexity in the RG2 sub-reach where the stream is cutting through a more resistant bedrock unit, quartz diorite. This suggests that on a geologic time scale this basin is still adjusting to changes in base level or climate.

Three reaches were delineated on Rutherford Gulch, extending from the headwaters to the confluence with Wolf Lodge Creek. RG1 transitions from a steep, confined channel in the headwaters to a narrow gorge in RG2 to the flat valley bottom comprised of lacustrine sediments in RG3. Rapid assessments were conducted on all of these reaches, which consisted of a field reconnaissance and visual estimation of channel type and characteristics. Channel morphology metrics are summarized in Table 4-28.

Table 4-28. Summary of reaches on Rutherford Gulch.

Reach	Stream Type	Slope	Sinuosity	Entrenchment	Bed Material
RG1	B4/B4a	0.036-0.064	Low	Moderate	Gravel
RG2	A3	0.085	Low	Entrenched	Cobble/Bedrock
RG3	F4	0.015	Low	Entrenched	Gravel

4.7.1 Rutherford Gulch Reach 1

RG1 is located in the headwaters of Rutherford Gulch. The reach is typified by channel confinement and steep slopes (0.064 ft/ft to 0.036 ft/ft). The stream has adequate access to its available floodplain, which is on average between 50 and 90 feet wide (Appendix E, Figure E11). Removal of riparian vegetation and impacts from grazing cattle were observed and documented during the field assessment. Livestock grazing has resulted in bank trampling throughout the reach, which has introduced fine sediment to the channel. A decrease in riparian vegetation cover as a result of grazing, coupled with hoof shear, has led to channel widening along segments of the reach. A majority of the reach is characterized by moderate entrenchment ratios, low channel sinuosity, and bedrock formed steps (B4 stream type). Bedrock influences the channel by creating force pool morphology. Flow intermittency likely limits the use of RG1 by fish.

RG1 is a source of fine sediment to downstream reaches, including RG2 and RG3. Sediment generated in RG1 deposits in the lower gradient, depositional reaches in RG3, causing channel widening and enlargement. In-channel large wood aggregates and log step structures in RG2 serve as sinks for fine sediment generated in RG1, buffering RG3 from excessive sediment loading.

Recommendations for RG1 include passive restoration approaches including installing exclosures to protect sensitive riparian areas from grazing, and revegetating highly disturbed floodplain surfaces and streambanks. Limiting the number of cattle crossings and developing hardened crossings would also minimize impacts to streambanks from hoof shear. Efforts to restore native riparian shrub communities could substantially improve streambank conditions and reduce fine sediment loading to RG1, and downstream reaches.

4.7.2 Rutherford Gulch Reach 2

RG2 begins downstream of RG1 where a distinct increase in channel slope and valley confinement occurs. RG2 is classified as a predominately A3 stream type with localized inclusions of high gradient, bedrock controlled rock steps (Figure 4-34), and lacks a floodplain. Channel segments connecting steeper bedrock controlled segments exhibit B4 stream type characteristics with decreasing slope. Fine sediments are deposited in pools with dominant substrate comprised of coarse gravel and large cobble.

This area was logged historically (30 or more years ago) and the forest cover has mostly recovered. Shade provided by the forest canopy allows for shade tolerant species to grow in the understory providing shade to the channel. Moderate riparian growth exists, but in areas with larger grains and bedrock, the lack of soil reduces the density of vegetation. Road construction has decreased the width of the stream corridor. Low amounts of stream bank erosion exist, with approximately 25% of the banks comprised of bedrock. Banks are low relative to bankfull with a steep to moderate slope and ample vegetation. The lower portion of the reach that exits the confined valley is disconnected from its floodplain to protect a residential structure (Appendix E, Figure E12). Small dikes have been constructed to prevent property from flooding.

Large wood and log jams are important features in RG2, and create natural storage sites for sediment while increasing aquatic habitat complexity. If recommended restoration efforts outlined in Attachment A are successful in extending the duration of perennial flows in RG3, the potential for increasing the amount of available habitat for juvenile westslope cutthroat trout in RG2 is considered high.


Figure 4-34. Typical step pool and force pool morphology formed by instream large wood (left) and bedrock intrusions (right).

4.7.3 Rutherford Gulch Reach 3

As RG2 transitions from a confined, structurally controlled valley type to an unconfined, low relief valley type in RG3, the stream type changes markedly. The reach is not confined by valley hillslopes and lacks riparian vegetation. Historically, this reach of Rutherford Gulch was channelized and relocated to the boundary between properties in the late 1800s to early 1900s to accommodate agricultural land use practices. Historic dredging has led to severe channel incision, a lower groundwater table, simplified aquatic habitat and loss of floodplain connectivity. Due to these impacts to the system, the stream continues to be in a state of disequilibrium.

Channelization and dredging have led to over-steepened banks that are high and geotechnically unstable. Streambanks exceeding five feet in height relative to the streambank toe are prevalent throughout the reach, representing a significant source of fine grained sediment to lower Wolf Lodge Creek and Lake Coeur d'Alene (Figure 4-35). Removal of riparian vegetation has contributed to bank instability leading to channel widening. The upstream segment of the reach has a marginal riparian corridor that helps limit channel widening (Figure 4-36). Channel widening and incision have created an entrenched F stream type with limited floodplain connectivity and active stream bank erosion.

The main source of the sediment is streambank erosion occurring within the reach. The assessment of RG2 shows a reach that is dominated by bedrock, which does yield significant sediment, and instream large wood jams, which store sediment that is produced or transported into RG2. Dredging has caused a positive feedback loop in RG3 and exacerbates channel and streambank instability. Removal of material from the channel bed has increased bank height ratios. Increasing the bank height decreases bank stability and encourages bank erosion, which supplies more sediment locally at the reach scale. Significant entrenchment is present, especially in the upstream portion of the reach where Rutherford Gulch was channelized through a remnant alluvial fan (Appendix E, Figure E7). Areas adjacent to the stream are used for agricultural production and flood prevention is a goal of the landowners.

Two culverts installed in RG3 also act as local sediment sources through increased bank erosion at the inlets and outlets. One culvert is privately owned and the second is owned and maintained by the State of Idaho. The state owned culvert located at the start of RG3 has caused substantial bank erosion and sediment mobilization in the reach. The RG3_Culvert also causes large amounts of bank erosion at the outlet (Figure 4-35). These culverts should be replaced with structures that provide greater hydraulic capacity, fish passage, and minimize sediment inputs to the channel.

In summary, RG3 is prioritized for restoration actions that reduce sediment loading to the reach and Wolf Lodge Creek. Given the history of channelization and dredging of the channel, RG3 is identified as a reach with significant potential for restoration. Recommendations for short term management include ceasing in-channel dredging, and installing adequate energy dissipation at both culvert outlets. A conceptual restoration plan to address limiting factors in RG3 is presented in Attachment A.

Figure 4-36. Typical streambank conditions in Reach RG3 (left), and undersized culvert (RG3_Culvert) (right).

Figure 4-35. Straightened portion of RG3 and channel aggradation.

5 Bank Erosion Analysis

5.1 Overview

Efforts to characterize streambank erosion related to sources of sediment in the watershed were driven by two underlying questions:

1. Where is the excess sediment in the lower mainstem of Wolf Lodge Creek originating?
2. Which reaches or source areas are generating the highest sediment yield in the watershed?

The results of the bank erosion analysis help drive the restoration plan to address the limiting factors of bank instability and lack of habitat complexity.

5.2 Methods

A comprehensive inventory of instream sediment sources was completed for the primary study reaches in Wolf Lodge Creek. The survey focused on identifying, mapping, and characterizing reach-averaged sediment loading, and mapping discrete major sources of sediment contributions to the primary channel. A modified Bank Erosion Hazard Index (BEHI) (Rogen 2001) was used to evaluate streambank erosion related sources of sediment. The BEHI procedure integrates multiple factors which have a direct impact on streambank stability, including:

- Ratio of streambank height to bankfull stage (i.e. bank height ratio);
- Ratio of riparian vegetation rooting depth to streambank height;
- Degree of rooting density;
- Composition of streambank soils;
- Streambank angle;
- Bank material stratigraphy; and
- Bank surface protection afforded by coarse wood and vegetation.

A BEHI score was then assigned to the major bank types in the reach. These scores were used to estimate bank migration rates from empirically derived curves from the Blackfoot River in Montana, which displays similar parent material and geology to the Wolf Lodge Creek watershed. Bank heights and lengths coupled with migration rates and a high and low estimate of density allowed for sediment yield to be calculated in tons/year (Table 5-1).

5.3 Results

Table 5-1 and Figure 5-1 summarize bank erosion analysis results. The results suggest bank erosion in WLC3 and WLC4 contributes a substantial amount of sediment relative to the other study reaches. Reaches identified in the channel migration analysis as having the most rapid migration rates in WLC3 and WLC4 were the largest contributors of bank-derived sediment. These reaches are the most heavily impacted by human development and riparian vegetation removal.

SC1 and WLC2 have minimal bank erosion and streambanks are stable with intact riparian vegetation. These results suggest that unstable streambanks affected by development and riparian vegetation removal are substantial sediment sources in the study reaches. Since the study reaches have similar geomorphic characteristics in terms of slope and valley type, but dramatic differences in bank erosion and sediment yield, accelerated sediment delivery is related to bank modifications more so than the geomorphic character of the sites.

WLC5 has a low sediment yield which corresponds to the low rates of bank erosion. Despite the reduction in riparian and streambank cover, WLC5 has lower bank erosion rates due to low near bank stress resulting from the backwater influence of Lake Coeur d'Alene.

To account for reach length differences, sediment data were normalized by dividing the total sediment yield by reach length, to derive an estimate of sediment yield per unit stream length (see Appendix C, Figure C3). Reaches WLC3 and WLC4 contribute similar unit sediment loads despite demonstrating large differences in total sediment yield.

Table 5-1. Overview of Bank Erosion Hazard Index quantification of sediment loading for each reach in the Wolf Lodge Creek watershed. Two densities were used to calculate weight from volumes. The average of these high and low values was used to report the sediment yield for each reach per year.

Reach	Sediment Volume (ft^3)	Sediment Volume (ft^3) (unit length)	Sediment Yield Tons/Yr (low)	Sediment Yield Tons/Yr (high)	Sediment Yield Tons/Yr (mean)
LC1	3,570	0.9	161	223	192
SC1	1,190	0.2	54	74.4	64
WLC1	3,200	0.5	144	200	172
WLC2	1,450	0.2	65	90	78
WLC3	15,440	1	695	965	830
WLC4	5,240	1	236	328	282
WLC5	4,070	0.3	183	254	219
MC2	2,170	0.6	98	136	117

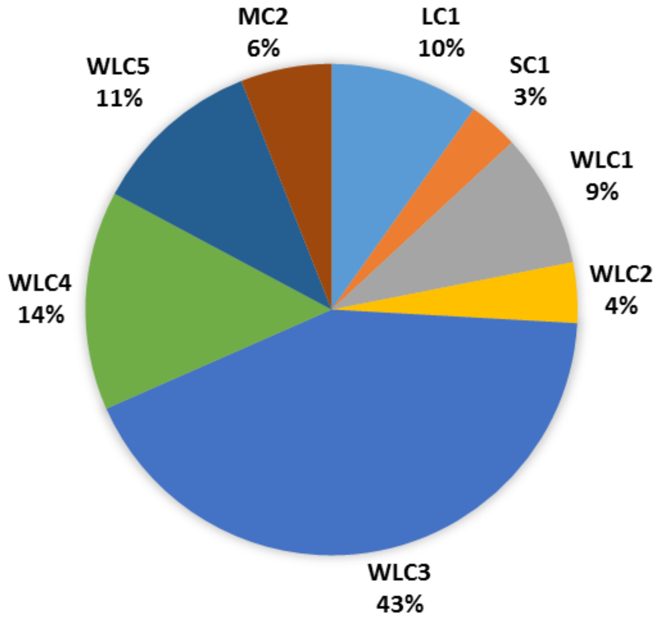

Figure 5-1. Sediment load contribution percentage by reach for the Wolf Lodge Creek watershed.

5.4 Conclusion

The results of the sediment source investigation indicate that a majority of the sediment produced in the watershed originates locally from rapid bank erosion, rather than the upstream forested reaches. However, forest management practices that increase water yield and the frequency, magnitude, and duration of channel forming peak flow events can influence rates of bank erosion in areas where bank stability has been reduced. The field assessment confirmed the absence of bedload in both sediment traps on Stella Creek and Marie Creek. Removal of these structures, and reconstruction of the channels to restore fluvial connectivity, is recommended. Results also demonstrate the significant role of riparian vegetation in moderating sediment loading from streambank related sources of sediment in the Wolf Lodge Creek watershed.

6 Stream Crossing and Culvert Evaluation

6.1 Overview

The Wolf Lodge Creek watershed has a diverse transportation network with a mixture of paved and gravel roads, including county roads, National Forest System roads, private roads, and an interstate highway (I-90). In order to evaluate sediment loading to the channel network and prioritize stream crossing improvements, a review of all accessible stream crossings was conducted (Figure 6-1). Wolf Lodge Creek Road, a county road, provides the main access to the watershed, and mostly follows the mainstem of Wolf Lodge Creek upstream from the interstate highway. Other county roads and private roads provide access to residential properties, and the National Forest System road network covers USFS land.

A total of 238 miles of road exists in the watershed, with a total road density of 3.8 mi/mi^2 (Table 6-1). Most roads are graveled National Forest System roads, with a total of 204.7 miles within the Wolf Lodge Creek watershed. County roads total 16.4 and Interstate 90 stretches for 6.4 miles mostly along the Cedar Creek valley bottom (Appendix A, Figure A6). Road length and road density by sub-watershed is summarized in Table 6-2. High elevation watershed areas are dominated by the National Forest System road network, while lower elevation areas include county roads. This analysis is limited to public roads and does not address private roads. Additional analysis into road density from private roads throughout the watershed can be found in a subsequent report from the Kootenai-Shoshone Soil and Water Conservation District.

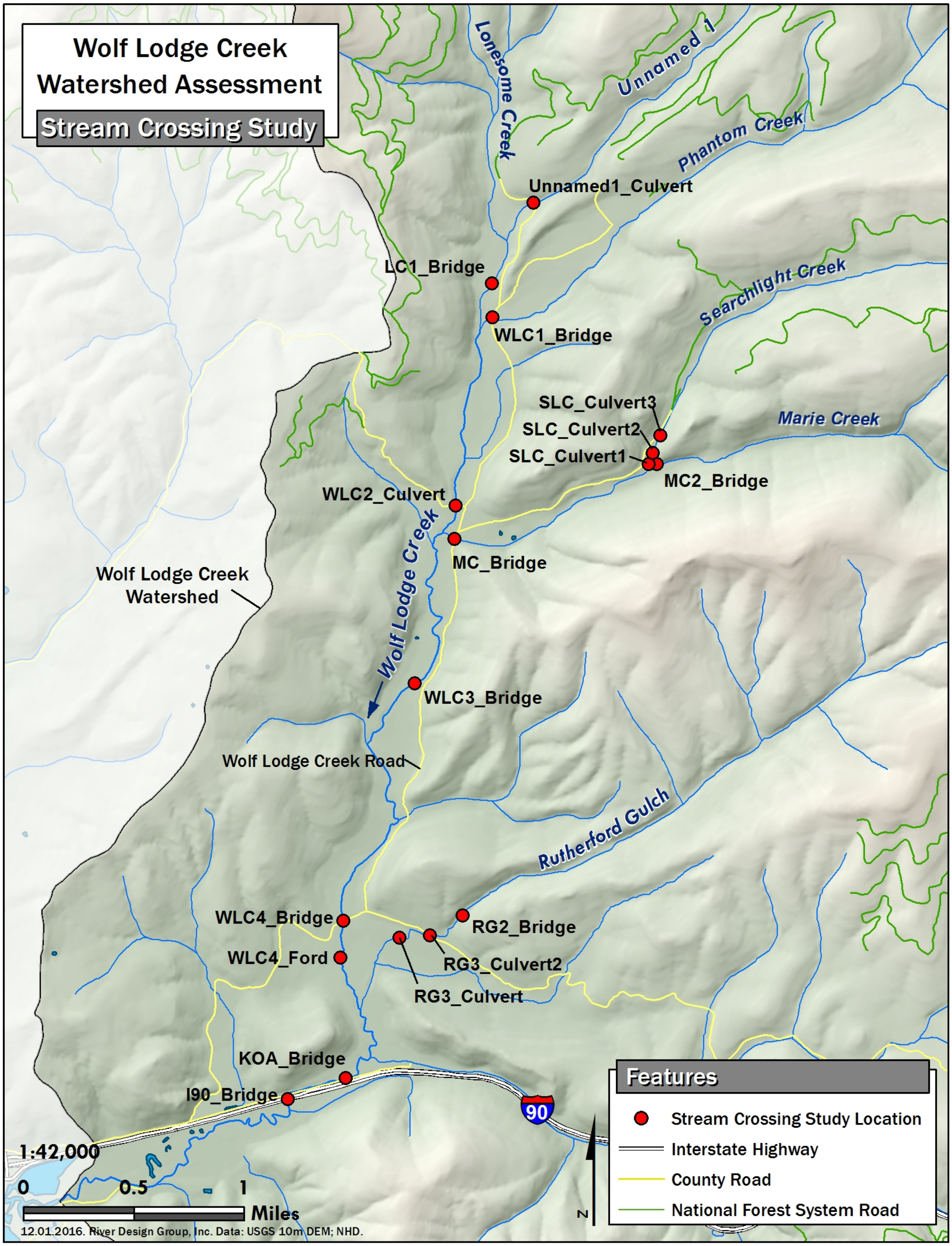

Figure 6-1. Wolf Lodge Creek road network and stream crossing study locations and road network.

Table 6-1. Road length and density within the Wolf Lodge Creek watershed.

Road Type	Road Length (miles)	Road Density (mi/mi^2)
County Road	16.4	0.26
Interstate Highway	6.4	0.10
National Forest System Road	204.7	3.26
Total	227.5	3.63

Table 6-2. Road length and road density in major tributary watersheds.

Road Type	Stella Creek/ Lonesome Creek Watershed	Phantom Creek Watershed	Marie Creek Watershed	Rutherford Gulch Watershed	Cedar Creek Watershed
	Road Length (miles)				
County Road	0.0	1.0	1.1	1.9	4.0
Interstate Highway	0.0	0.0	0.0	0.0	5.1
National Forest System Road	33.1	19.9	51.2	0.0	82.0
Total	33.1	20.9	52.3	1.9	91.1
	Road Density (mi/mi^2)				
County Road	0.0	0.1	0.1	0.5	0.3
Interstate Highway	0.0	0.0	0.0	0.0	0.3
National Forest System Road	3.8	2.7	2.9	0.0	5.3
Total	3.8	2.8	3.0	0.5	5.9

Stream crossing densities for the Wolf Lodge Creek watershed and major tributaries are summarized in Tables 6-3 and 6-4. Total stream crossing density within the Wolf Lodge Creek watershed is 1.93 crossings/mi^2, with the highest density occurring in the Cedar Creek watershed (2.69 crossings/mi^2). Road conditions and use were not evaluated as part of this assessment.

Table 6-3. Stream crossing density within Wolf Lodge Creek watershed (# crossings/mi²).

Road Type	Stream Crossing Density in Wolf Lodge Creek Watershed
County Road	0.37
Interstate Highway	0.10
National Forest System Road	1.34
Total	1.8

Table 6-4. Stream crossing density within major tributary watersheds (# crossings/mi²).

Road Type	Stella Creek/ Lonesome Creek Watershed	Phantom Creek Watershed	Marie Creek Watershed	Rutherford Gulch Watershed	Cedar Creek Watershed
County Road	0.00	0.00	0.00	1.13	0.19
Interstate Highway	0.00	0.00	0.00	0.00	0.32
National Forest System Road	1.51	1.11	1.01	0.00	2.18
Total	1.51	1.11	1.01	1.13	2.69

6.2 Methods

Stream crossings and contributing road segments were evaluated both in the field and with remote sensing. Data forms were completed to characterize road segments contributing to stream crossings, and the condition of stream crossing structures including road prism conditions. Collected data includes risk of failure, erosion, fish passage, alignment, length, diameter, condition, and overtopping risk, all of which could affect stream and crossing stability. Photo points were obtained at each site. In addition, IPNF land type sensitivity ratings were attributed to each stream crossing evaluation location where applicable (IPNF 2006). Land type sensitivity ratings incorporate mass failure, surface erosion, sediment delivery potential, and average slope gradient to determine a rating of low, moderate, or high sensitivity for land types, with high sensitivity indicating high potential for erosion and sediment delivery to streams (G. Rone, IPNF, personal communication). Recommendations for replacement or removal or stream crossings are provioded.

6.3 Results

The condition of culverts and bridges in the Wolf Lodge Creek watershed is largely dependent on ownership. Private bridges and culverts are more likely to be damaged or in need of replacement. A summary table of stream crossing conditions is provided in Table 6-5, and a description of the crossings is provided in the following section.

Table 6-5. Summary of stream crossing conditions for Wolf Lodge Creek watershed.

Site ID	Reach	Type	Erosion	Failure Potential	Landtype Sensitivity	Recommendations
UNNAMED1_ CULVERT	UN1	Culvert	Medium	Not Likely	Moderate	None
LC1_BRIDGE	LC1	Bridge	Medium	Probable	High	Replace
WLC1_BRIDGE	WLC1	Bridge	Low	Not Likely	High	None
WLC2_CULVERT	WLC2	Culvert	Low	Not Likely	High	None
WLC3_BRIDGE	WLC3	Bridge	Low	Not Likely	N/A	Armor abutment
WLC4_BRIDGE	WLC4	Bridge	Low	Not Likely	N/A	None
WLC4_FORD	WLC4	Ford	Medium	N/A	N/A	Replace and implement restoration efforts
KOA_BRIDGE	WLC5	Bridge	Low	Not Likely	N/A	None
I90_BRIDGE	WLC5	Bridge	Medium	Not Likely	N/A	Replace
MC2_BRIDGE	MC2	Bridge	Low	Probable	Moderate	Replace
MC_BRIDGE	MC3	Bridge	Medium	Possible	High	None
SLC_CULVERT1	SLC	Culvert	Medium	Probable	High	Replace
SLC_CULVERT2	SLC	Culvert	Low	Not Likely	High	None
SLC_CULVERT3	SLC	Culvert	Medium	Possible	High	Remove
RG2_BRIDGE	RG2	Bridge	Medium	Possible	N/A	Replace
RG3_CULVERT	RG3	Culvert	High	Probable	N/A	Replace and implement restoration efforts
RG3_CULVERT2	RG3	Culvert	High	Possible	N/A	Replace

Crossing ID: **LC1_Bridge**
Type: **Bridge**
Landowner: **Private**
Priority: **High**

Existing Site Conditions Summary

This bridge provides access to a private residence on Lonesome Creek. The bridge is located directly downstream of sub-reach LC1. The bridge is comprised of concrete abutments and a wooden deck with limited freeboard (Figure 6-2). The channel is constricted by the bridge and bedload is aggrading, reducing channel and bridge hydraulic capacities. Failure risk is considered moderate due to the reduced hydraulic capacity and potential to trap debris/bedload. Both approach grades are contributing sediment to the crossing.

Figure 6-2. LC1_Bridge stream crossing.

Recommendations

The following recommendations are intended to reduce bridge failure risk and improve stream and floodplain function in the vicinity of the crossing:

- Replace bridge and abutments.
- Design bridge to pass the minimum 25-year estimated flood discharge. The design should take into consideration upstream and downstream bankfull channel dimensions and floodplain geometry.

Crossing ID: WLC1_Bridge
Type: Bridge
Landowner: Public
Priority: Low/Medium

Existing Site Conditions Summary

This public bridge provides access to the headwaters of Stella, Lonesome, and Phantom Creek. It spans Phantom Creek (WLC1) and is comprised of concrete abutments and a wooden deck (Figure 6-3). The bridge is in good condition. The channel is constricted by the bridge which has led to bedload aggradation upstream. Overtopping is unlikely. The constriction and subsequent aggradation may lead to further channel adjustment upstream (i.e. bank erosion and widening). A decommissioned USFS gauge structure is attached to the bridge and has been inactive for over 15 years. Channel morphology is stable upstream and downstream of the bridge inlet and outlet, respectively. While a bridge of greater span and hydraulic capacity is warranted, replacement is not considered a priority given the restoration priorities identified in this report.

Figure 6-3. WLC1_Bridge stream crossing.

Crossing ID: **MC2_Bridge**
Type: **Bridge**
Landowner: **Private**
Priority: **High**

Existing Site Conditions Summary

This private bridge provides landowner access to private property and USFS land located in the Marie Creek watershed, including the Marie Creek sediment trap. The bridge deck and stringers are structurally comprised. The abutments consist of cast-in-place concrete and are aligned streamwise with the channel. The wooden deck has deteriorated, and the main center pier support is comprised of a polyvinyl chloride tube filled with concrete (Figure 6-4). The mid-channel pier poses a risk to sediment/debris blockage. The bridge is a constraint to restoration efforts on MC2 and should be replaced concurrent with restoration actions.

Figure 6-4. MC2_Bridge stream crossing.

Crossing ID: **MC_Bridge**
Type: **Bridge**
Landowner: **Public**
Priority: **Medium**

Existing Site Conditions Summary

This public bridge crosses Marie Creek upstream of the confluence with Wolf Lodge Creek. The bridge is in good condition with concrete stringers and abutments, and a paved deck (Figure 6-5). GeoMax conducted a channel enhancement project just downstream consisting of three large wood barbs aimed to increase habitat complexity. Floodplain levees exist on the upstream and downstream approaches limiting floodplain connectivity. The upstream levee is eroding and contributing sediment to the channel. A gravel bar has formed at the bridge inlet, reducing bridge freeboard.

MC_Bridge is functioning and continued monitoring of the bridge and sediment deposition should be performed.

Figure 6-5. MC_Bridge stream crossing.

Crossing ID: **SLC_Culvert1**
Type: **Culvert**
Landowner: **Private**
Priority: **High**

Existing Site Conditions Summary

SLC_Culvert1 measured 23 ft in length and 42 inches in diameter. It is located on a private driveway that spans Searchlight Creek at the confluence with Marie Creek. The culvert is compromised and is in poor condition (Figure 6-6). The culvert is partially collapsed which decreases hydraulic capacity and increases the likelihood of plugging which could result in failure of the road prism. Energy dissipation at the outlet is inadequate and the channel bed is scoured resulting in a 1 ft drop at the outlet. Replacement of the culvert is recommended to lower failure risk, increase hydraulic capacity, and improve fish passage conditions.


Figure 6-6. SLC_Culvert1 stream crossing.

Crossing ID: SLC_Culvert3
Type: Culvert
Landowner: Private
Priority: Medium

Existing Site Conditions Summary

SLC_Culvert3 measured 15 ft in length and is located on Searchlight Creek (Figure 6-1). The crossing appears to support non-motorized use and is in poor condition. The culvert is structurally compromised and the upstream and downstream alignment has resulted in bed scour and streambank erosion. The culvert should be removed, and the approach grades lowered to floodplain elevation to reduce floodplain obstructions.

Figure 6-7. SLC_Culvert 3.

Crossing ID: RG3_Culvert
Type: Culvert
Landowner: Private
Priority: High

Existing Site Conditions Summary

This culvert is located on private property on Rutherford Gulch. The 21 foot long culvert is in poor condition and affecting streambank stability and sediment transport characteristics. The channel upstream of the culvert inlet is aggrading and widening. Severe erosion is occurring at the culvert outlet due to concentrated flow that impinges on unstable, vertical streambanks (Figure 6-8). Mass failure of the crossing is probable in the event of plugging and overtopping.

Replacement of the culvert with a new structure that provides significantly more hydraulic capacity is recommended. Culvert replacement should be coordinated with restoration actions described in Section 8 and Attachment A.

Figure 6-8. RG3_Culvert.

Crossing ID: RG3_Culvert2
Type: Culvert
Landowner: Public
Priority: High

Existing Site Conditions Summary

This culvert is located on Rutherford Gulch and is owned and managed by the State of Idaho. The culvert is structurally sound. The inlet and outlet fillslopes are steep and eroding, resulting in sediment delivery to RG3. The culvert skew and alignment result in streambank erosion downstream of the culvert outlet. Aggradation is occurring upstream of the inlet due to inadequate hydraulic capacity (Figure 6-9). Given the lack of hydraulic capacity and high skew angle, plugging is probable and could result in overtopping of the road prism. Replacement is recommended.

Figure 6-9. RG3_Culvert.

7 Limiting Factors and Constraints

In the context of this watershed assessment, limiting factors are defined as physical, biological, and ecological conditions within the assessment area that: 1) limit the ability of the ecosystem to sustain diverse native plant and animal populations, and to accommodate natural disturbances; 2) limit the quality or availability of habitat that supports all life stages of westslope cutthroat and other focal species; and 3) limit resiliency of local agricultural and residential activities. Limiting factors can be addressed by active restoration or changes in management. In contrast, constraints are components like roads, bridges and other infrastructure that cannot be changed by management or active restoration, but must be considered during the design process.

The four general categories used to organize the limiting factors in this assessment include:

- **Geomorphic limiting factors –** physical conditions that are on a trajectory away from normative habitat conditions or exhibit departure from historical conditions. Although returning the physical environment to the conditions of pre-European settlement is not feasible, addressing the morphological limiting factors is aimed at restoring a trend towards more normative morphological conditions.

- **Riparian vegetation limiting factors** – processes or conditions that prohibit establishment of native plant communities. Riparian vegetation limiting factors are directly influenced by morphological limiting factors.

- **Aquatic habitat limiting factors –** missing components of the ecosystem that support habitat requirements for all life stages of the focal aquatic species. Aquatic habitat limiting factors are directly influenced by morphological and riparian vegetation limiting factors.

- **Restoration constraints** – limitations that cannot be changed by management or active restoration, for example features like roads, bridges and other infrastructure. These constraints must be considered during the design process.

7.1 Aquatic Habitat Limiting Factors

Shallow, infrequent pools: Pools offer important overwintering habitat for resident adult and juvenile fish, and may offer holding habitat during periods of high water temperature or low flow. Although pools exist in the project area, they lack the depth, cover and complexity preferred by native species. Poor pool quality is a result of altered pool forming processes such as large wood recruitment and lateral scour caused by channel sinuosity. Consequently, the straightened channel planform and lack of woody vegetation are contributing to shallow, infrequent pools in the project area.

Lack of habitat diversity: Disturbed riparian conditions and altered stream morphology are influencing the availability of large wood and function of pool-riffle sequences, which offer cover and complexity in the form of variable depth, velocity and substrate. Processes responsible for development of cover and complexity include floodplain interaction, channel migration, and large wood recruitment. In addition, the project area lacks off-channel habitat for juvenile rearing. Suitable juvenile rearing habitat consists of refuge from the main channel in areas of lower velocity, alternate food sources, variable substrate and warmer temperature. Side channels, alcoves and connected wetlands can provide suitable off-channel juvenile rearing habitat. Development of off channel habitat is dependent on floodplain connection and riparian forest establishment.

7.2 Geomorphic Limiting Factors

Channel entrenchment: Channel cross section geometry is affecting floodplain connection and sediment transport characteristics. There are few areas along the channel margins where the water table is accessible from the surface by riparian vegetation. Although a narrow inset floodplain has developed in some areas, not enough floodplain area is present to establish sustainable riparian buffers capable of supporting aquatic habitat development. In addition, the existing floodplain is not providing enough area or energy dissipation to trap and store fine sediments, which are being stored within the interstitial spaces of the gravel on the channel bed. The existing channel entrenchment ratio (ratio of floodplain width to channel width) is below the expected range for historical stream channel conditions.

Straightened channel planform: Channel planform geometry is affecting bedform development and creating simplified habitat conditions. Sinuous planform geometry supports pool development at meander beds and creates hydraulically complex habitat in the form of variable depth, velocity and substrate. Moreover, channelization of Wolf Lodge Creek means there is less available habitat due to decreased channel sinuosity and loss of overall channel length.

Altered pool development processes: Processes responsible for pool development in Wolf Lodge Creek include lateral scour caused by meandering planform and contraction scour caused by flow acceleration or a constriction, and vertical scour caused by bedrock, boulders, wood or beaver dams. Historical pool development processes were likely influenced by channel complexity such as pool-riffle morphology and large woody debris derived from floodplain vegetation. Lateral migration and beaver dams may also have influenced pool development. Despite moderate pool availability in the assessment areas, pool-forming processes such as lateral migration, flow acceleration and woody debris recruitment are affected by altered conditions.

Bank erosion: Wolf Lodge Creek is responding to altered channel morphology and vegetation conditions. Steep, sparsely vegetated banks composed of fine grained soils are susceptible to bank erosion as Wolf Lodge Creek attempts to establish equilibrium in its altered landscape. Bank erosion delivers fine sediment to the channel bed and causes damage to private property along the creek. These fine sediments impact the ability of the watershed to meet TMDL targets for sediment.

7.3 Vegetation Limiting Factors

Insufficient riparian buffers: The current land uses adjacent to Wolf Lodge Creek (residential developments, grazing, and agriculture) require active management and result in the frequent removal of woody riparian vegetation. Frequent clearing reduces the amount of area available for diverse riparian and floodplain vegetation to develop. Vegetation clearing combined with channel straightening has also resulted in bank erosion in some areas which further limits the establishment of riparian vegetation. In many areas, streambank vegetation has been converted from woody vegetation to grasses which provide limited soil stabilization along the land-water interface. Land use also results in localized impacts to existing vegetation through trampling and compaction of frequently accessed areas. A wide, densely vegetated riparian buffer is needed to promote stable geomorphology and maximize aquatic habitat potential through the reduction of fine sediment inputs, filtration of nutrients and other potential contaminants, increase of stream cover and shade, and input of woody material.

Lack of floodplain connection: Due to channel straightening and entrenchment through much of the project area, surfaces adjacent to the creek are relatively high compared to the channel and water table. This lack of floodplain connection limits the area suitable for supporting desired riparian vegetation. The lack of floodplain connection also reduces the extent of overbank flooding which supports a range of natural processes necessary to create and maintain diverse riparian vegetation, such as: deposition of new substrates for natural recruitment of woody species; stability of surfaces to allow vegetation to grow and establish; input of seed and plant propagules; and recharge and maintenance of groundwater tables.

7.4 Restoration Constraints

Project constraints are existing features, infrastructure, or land uses that influence project extents and ability to achieve restoration potential. The following constraints have been identified in the project area:

Land use: Private and public lands are adjacent to the project area. Restoration actions must be compatible with adjacent land uses, and actions must be evaluated for potential effects to adjacent property. Restoration actions must take into consideration potential future land use as well.

Regulatory Floodplain: Flood risk on Wolf Lodge Creek is managed through the National Flood Insurance Program administered by Federal Emergency Management Agency. Development within the Wolf Lodge Creek floodplain is regulated by federal, state and county floodplain regulations. Restoration actions that affect flood elevations must be evaluated using a hydraulic model to demonstrate compliance with applicable regulations. Actions that cause an increase in base flood elevations in Wolf Lodge Creek could be subject to flood insurance rate map revisions.

Non-native fish species: Although restoration actions will improve habitat conditions for native fish species, non-native fish species such as brook trout that directly compete with native species for food and habitat will not be eradicated. Other measures beyond the scope of this project may be required to address species competition.

Effects of beaver activity: Beaver are active throughout Wolf Lodge Creek and would have historically been one of the greatest influences on channel form, aquatic habitat and riparian vegetation community structure and distribution. Proposed restoration actions may be influenced by continued beaver activity in Wolf Lodge Creek. It is likely that beaver will build dams in newly constructed channel reaches and browse on planted vegetation. The effect of continued beaver activity should be considered in selecting and managing restoration actions.

8 Restoration Concepts and Strategies

Section 8.1 introduces the conceptual restoration plan presented in Attachment A to this report. Section 8.2 describes a range of conceptual restoration strategies that can be applied to address limiting factors and problem areas described in Sections 4, 5, 6, and 7 of this report.

8.1 Restoration Concepts

Attachment A Conceptual Restoration Plan presents restoration concepts for the six highest priority sites identified in the watershed assessment. As noted on Sheet 1.0 Cover Page and Notes, site prioritization was determined in conjunction with Idaho DEQ. The sites have a high likelihood of addressing sediment and temperature impairments by correcting altered geomorphic, aquatic habitat, and vegetation conditions. The concepts primarily address anthropogenic disturbances that negatively influence stream corridor habitat conditions and stability. Proposed actions are intended to restore specific sites within the watershed to their properly functioning biological and geomorphic conditions. Restoration and maintenance of water quality and habitat conditions can be achieved with future activities and management strategies that encourage natural processes and limit anthropogenic disturbances to the channel and floodplain environment.

8.2 Restoration Strategies

Restoration actions are described conceptually whereby emphasis is placed on developing specific strategies and treatments that address geomorphic, vegetation and aquatic habitat impairments described in Section 7. Example applications of proposed restoration treatments are provided in this section.

8.2.1 Conservation

Conservation is a restoration strategy applied to protect existing areas that exhibit, or have potential to exhibit, high quality ecological function. Areas proposed for conservation typically display few limiting factors, and those factors that exist usually can be addressed with passive treatments such as changes in land use or weed control. Conservation can be compatible with recreational uses.

8.2.2 Revegetation

Revegetation is a restoration strategy applied to moderately stable areas with few geomorphic limiting factors or in conjunction with other restoration strategies such as wetland construction, streambank reconstruction or floodplain construction. Revegetation is a viable strategy for improving aquatic and terrestrial habitat in the longer term through gradual development of a riparian buffer. Revegetation encompasses a range of treatments including:

- Planting;
- Seeding;
- Plant protection;
- Irrigation; and

- Invasive plant species management.

Revegetation is not suitable for areas prone to high disturbance or areas with incompatible land uses such as grazing or agriculture. Revegetation strategies should only be implemented in areas where adequate site preparation is completed. Site preparation includes a wide range of treatments including weed control, grading to appropriate elevations, incorporating surface roughness, and soil placement or amendments. Most of these treatments are included as part of other restoration strategies such as floodplain construction.

Planting

Planting of nursery grown plant material is a strategy used to promote rapid vegetation establishment along the channel and within newly constructed floodplains. Planting can consist of installation of a wide range of container size plants and for floodplains typically includes both native tree and shrub species and herbaceous wetland species. A diverse mix of trees and shrubs are planted in select areas of the new floodplain, typically along streambanks and within floodplain swales, to develop a range of riparian vegetation communities based on expected floodplain hydrology. Wetland vegetation such as sedges and rushes are also planted in depression features within the floodplain (swales and wetlands) and occasionally along streambanks. The species planted at the site should be determined during the design phase and consist of native riparian species that represent an early successional stage of the desired vegetation communities. Planting should be done in the spring or fall when temperatures are moderate and soil moisture is relatively high.

Planting helps address a range of geomorphic, aquatic and vegetation limiting factors. Planting helps achieve geomorphic objectives by providing bank and floodplain stability via the extensive root system produced by riparian plants and by providing roughness to slow waters during higher flows and minimize erosion along the banks. Planting woody vegetation will also help improve streambank cover. The shade provided by streambank vegetation also addresses aquatic habitat objectives by keeping waters cooler and contributing detritus and nutrient sources to the channel. Planting will also help restore diverse native vegetation communities. Selecting native species for planting provides more self-sustaining and diverse vegetation communities and also prevents weed establishment by colonizing the available space.

Seeding

Seeding is a strategy used to promote rapid vegetation establishment on newly constructed surfaces or disturbed areas. Seeding can provide species diversity to a site for relatively low cost. Multiples seed mixes may be required and should be determined during the design phase. The species included in each seed mix should take into account: desired vegetation community, germination timing and growth period, growth form, rooting depth. In general, seed mixes should include species that have varying rooting depths and will occupy a wide range of habitats. To ensure quick, long-lasting vegetation establishment a two-stage seed mix should be used. The two-stage seed mix includes two components: a mix of quick germinating species (nurse crop or cover crop) that will provide immediate cover to limit colonization by invasive species and a mix of long-term, desired species that may not germinate immediately because they may require a stratification period.

Seeding helps address a range of geomorphic, aquatic and vegetation limiting factors. Establishing native vegetative cover on newly created streambank and floodplain surfaces is essential for maintaining soil stability and preventing weed infestations. Planting will establish native vegetation in portions of the floodplain, but seeding is the primary mechanism for stabilizing soil. Seeding helps achieve geomorphic objectives by providing streambank and floodplain stability through root system development and surface cover. Vegetation established from seed can help prevent weed infestations. The vertical (soil depth) and temporal diversity of the seeded species can prevent weeds from establishing by occupying available habitats that weeds may otherwise occupy.

Plant Protection

Most riparian woody plants are highly palatable and are targeted by a number of wildlife species. Protecting planted vegetation for a minimum of five years after implementation is necessary to allow vegetation to establish without stresses from browse and animal damage. The two primary plant protection treatments for the project area include fencing and individual plant protectors. Individual plant protectors are installed around plants that are most desirable to beavers and wildlife or around plants where fencing is not feasible, such as those located on streambanks. Fencing entire areas for protection is often more affordable, requires less maintenance and is less aesthetically intrusive than individual protectors. Fencing can also protect large seeded areas during the establishment period. The material used to construct plant protection measures should take into consideration the expected degree and type of animal damage expected. For protection against deer and elk, rigid plastic mesh may be sufficient. For protection against beaver, metal fencing is typically more effective.

Irrigation

Successful revegetation typically requires supplemental irrigation for two to three years following planting while the root systems of the plants establish. Supplemental irrigation may only be required in select areas, such as higher surfaces in the floodplain, but in drought years it is likely that all plantings will require at least one round of irrigation. When required, irrigation should consist of a minimum of 5 gallons of water applied slowly to each plant.

Invasive Plant Species Management

Management of invasive plant species is an important strategy to implement in all areas where construction activities are proposed. Invasive species management strategies can be implemented prior to construction, during construction and after construction. Prior to construction, treating existing invasive species infestations will reduce the amount of seed spread during construction. During construction, best management practices (BMPs) should be implemented that prevent the spread of invasive species such as cleaning of equipment prior to arriving on site; ensuring equipment avoids tracking through weedy areas outside of construction limits during construction; and ensuring any imported material is free of invasive species and seeds.

8.2.3 Streambank Structures

Installation of streambank structures is a strategy applied to the channel margins in order to establish vegetation, enhance aquatic habitat and/or improve bank stability. Depending on the application, streambank structures may be localized installations or contiguous reach-scale treatments. Streambank structures used for restoration may be deformable whereby the structures serve a temporary purpose to establish vegetation. Streambank structures used for bank stability may be more permanent in order to manage risk by protecting infrastructure or preventing channel migration. Potential streambank treatments for the Wolf Lodge Creek watershed include:

- Bioengineering;
- Fascines;
- Woody debris jams; and
- Aquatic habitat enhancement.

Bioengineering

Bioengineering is a category of streambank treatments consisting of live plant material and biodegradable coconut fiber fabrics (coir). Bioengineering treatments create bank conditions that support the establishment of woody vegetation. Figure 8-1 shows a conceptual cross section view of a typical bioengineering streambank treatment called a vegetated soil lift. Figure 8-2 shows example photos of bioengineering streambank structures.

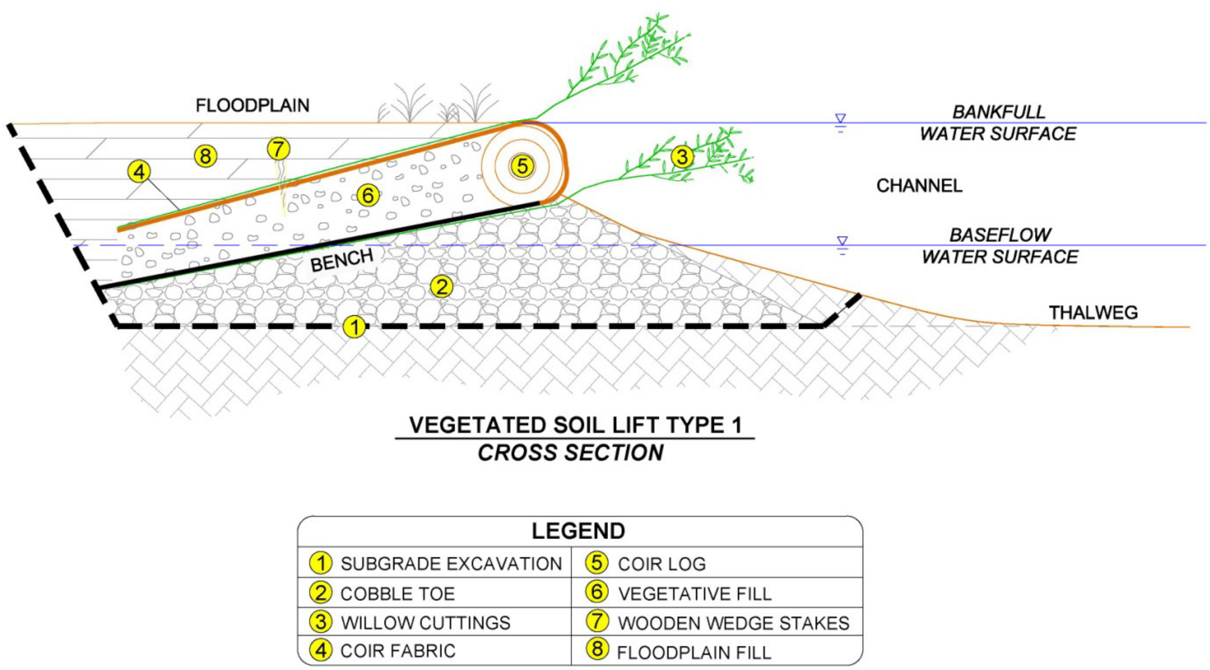

Figure 8-1. Conceptual cross section of a vegetated soil lift bioengineering treatment.

Purpose: The purpose of bioengineering is to provide temporary bank protection in order to allow bank vegetation to become established.

Placement Criteria: Bioengineering is suitable for low to moderate stress banks with low curvature.

Aquatic Habitat Objectives Addressed: Bioengineering promotes the rapid development of woody vegetation on streambanks. Woody vegetation on the streambank provides instream cover, shade for temperature reduction, large wood recruitment over time, refuge during high flows, organic matter inputs, and supports emerging aquatic insects.

Vegetation Objectives Addressed: Bioengineering promotes rapid development of desired woody vegetation. The development of woody vegetation along the streambank provides floodplain stability, and provides a source of seeds and vegetative material to promote the establishment of desired vegetation communities in the floodplain.

Geomorphic Objectives Addressed: Bioengineering structures are composed of biodegradable fabrics and native materials. Short-term streambank stability provided by fabric and long-term stability provided by rooted woody vegetation supports desired disturbance regimes and relatively low erosion rates.

Supplemental Information: Bioengineering provides conditions along the channel banks that are suitable for growing woody riparian vegetation. Bioengineering is built on a gravel or cobble toe. Short term structure performance is dependent on toe stability as well as smooth transitions to stable upstream and downstream tie-in points. Placement of healthy woody vegetative cuttings that are placed to a depth to ensure contact with the water table throughout the growing season is critical, and long term structure performance is dependent on development of dense rootmass.

Figure 8-2. Example of bioengineering streambank structures.

Fascines

Fascines are a category of streambank structures consisting of brush bundles and live plant material. Depending on the application and availability of materials, fascines may also include woody debris and/or wetland sod mats. Figure 8-3 shows a conceptual cross section view of a typical fascine streambank treatment called a sod and brush fascine.

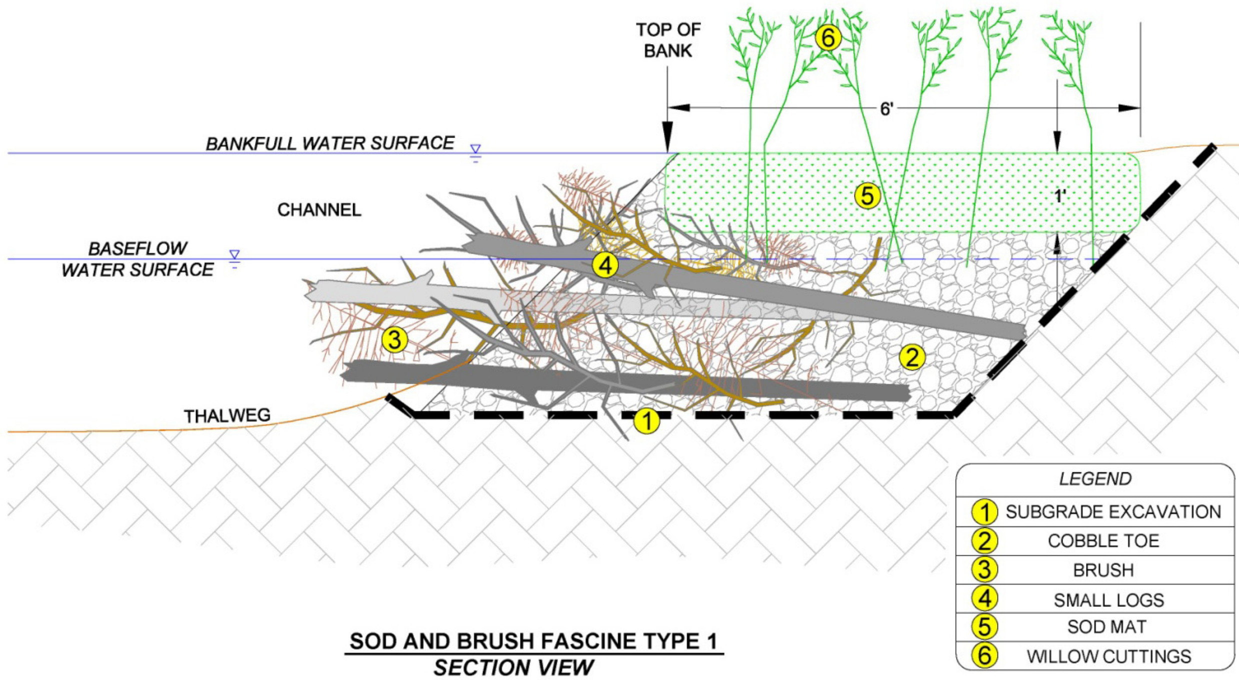

Figure 8-3. Conceptual cross section of a sod and brush fascine.

Purpose: The purpose of fascine treatments is to create a rough, complex and vegetated bank margin.

Placement Criteria: Fascines are designed to function on moderate stress banks with low to moderate curvature.

Aquatic Habitat Objectives Addressed: Brush and vegetation provide cover and hydraulic complexity. Fascines promote the rapid development of woody vegetation on streambanks. Woody vegetation on the streambank provides instream cover, shade for temperature reduction, large wood recruitment over time, refuge during high flows, organic matter inputs, and supports emerging aquatic insects.

Vegetation Objectives Addressed: Fascines promote rapid development of desired vegetation communities. The structure surface provides microsites to support natural recruitment of early successional species of desired vegetation community types. The elevation of the structure allows floodplain connection.

Geomorphic Objectives Addressed: Fascines are composed of native materials. Fascines provide bank margin roughness similar to natural bank conditions. Structure stability supports desired disturbance regimes and relatively low erosion rates.

Supplemental Information: Fascines employ native materials to provide preferred habitat conditions along streambanks. The structure is built on a cobble and wood toe. Structure performance is dependent on toe stability as well as smooth transitions to stable upstream and downstream tie-in points. Maintaining adequate backfill ballast is critical to counteract buoyancy of wood. Placement of wood at or below bankfull and placement of healthy woody vegetation in contact with the water table throughout the growing season is critical for rapid vegetation establishment.

Figure 8-4. Examples of fascine streambank structures.

Large Wood Jams

Large wood jams are a category of streambank structures consisting of logs and brush buried into the streambank and projecting out into the channel. Large wood jams are intended to emulate natural accumulations of large wood along the bank margins. Figure 8-5 shows a conceptual cross section view of a large wood jam structure. Figure 8-6 shows example photos of small wood jams.

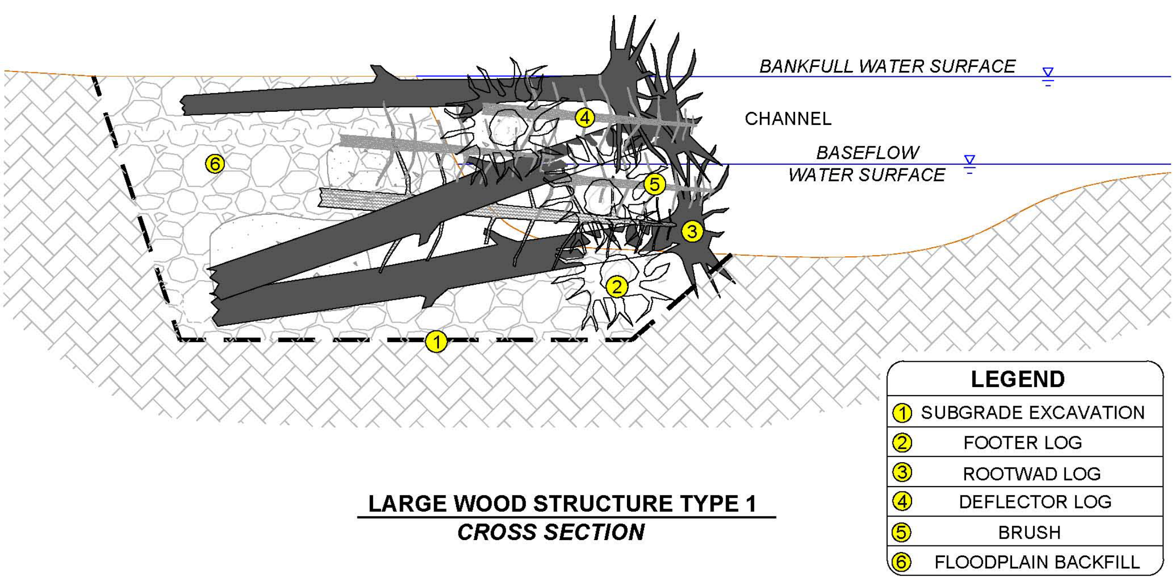

Figure 8-5. Conceptual cross section of a large wood jam.

Purpose: The purpose of this structure is to create hydraulic conditions that maintain a deep pool.

Placement Criteria: This structure is designed to function on a high stress bank with moderate to high curvature.

Aquatic Habitat Objectives Addressed: This structure creates complex hydraulics such as eddies and secondary flow circulation. Wood provides instream cover and shade for temperature reduction. Deep pools improve hyporheic flow for temperature management. Residual pools provide low-velocity holding habitat and over-wintering habitat.

Vegetation Objectives Addressed: Creates stable conditions to support development of desired vegetation community types.

Geomorphic Objectives Addressed: This structure supports pool development processes. Pools provide planform variability and foster point bar development. The structure is composed of native materials.

Supplemental Information: Large wood jams provide temporary bank protection by re-directing flow away from the bank and dissipating flow energy into the riverbed. The structure creates complex hydraulics and turbulence, which require attention to how the structure is tied in to existing features or other bank structures. Maintaining adequate backfill ballast is critical to counteract buoyancy of wood. Structure performance is dependent on structure size and use of adequately-sized wood with intact rootwads. Excavation of the pool in conjunction with the structure is recommended. The structure will tend to recruit additional large wood. Over time, the structure will decompose or become abandoned. Integrating mature shrub transplants or plantings on the floodplain surface behind this structure creates rooting structure for long term bank stability.

Figure 8-6. Examples of large wood jams.

8.2.4 Wetlands

Wetlands are depressional or low-lying features with standing water or saturated soils for a portion of the growing season sufficient to support wetland vegetation such as willows, sedges and rushes. Wetlands provide a wide range of ecological functions such as water quality improvement, flood attenuation and habitat for both terrestrial and aquatic organisms. Including wetlands in the restoration design will help address a number of limiting factors including insufficient riparian buffer and lack of habitat diversity. Floodplain wetlands include existing wetlands to be conserved through restoration actions or wetlands to be constructed in the new, lower floodplain that will provide ecological benefits such as habitat, species diversity and flood attenuation

In wetlands, water quality improvement is achieved by nutrient uptake via plant tissue and also through microbial nutrient cycling including processes like nitrification and denitrification. The dense, rhizomatous root network of wetland plants provides ideal habitat for soil microbes. In wetlands with various water depths both anaerobic and aerobic environments can be present. These various environments support different nutrient cycling processes. In addition to nutrient uptake, plants also provide surface area for particles of sediment to adhere to and the ponded or slow moving waters allows fines to settle out of the water column. The off-channel depressional characteristics of wetlands allow these areas to store excess water during high flows and large rain events. Water is then slowly released into the ground, filtering additional pollutants in the process and recharging groundwater well after the rains or high flows have ceased.

Figure 8-7. Examples of constructed wetlands in floodplains.

8.2.5 Floodplain Excavation

Floodplain excavation is a strategy applied to areas with altered channel morphology in order to improve floodplain connection. Floodplain excavation increases width of the stream corridor thus allowing increased channel sinuosity and riparian vegetation establishment. Floodplain excavation results in a lower floodplain surface relative to the stream channel, allowing flood flows to leave the channel during smaller, more frequent flow events. A lower, more hydrologically connected floodplain can improve channel stability by lowering high banks susceptible to erosion and by dissipating energy from flood flows. Increasing floodplain connection increases community resilience to flooding by lowering the peak flow and allowing for flood waters to infiltrate into groundwater on floodplain surfaces.

Floodplain reconstruction is a viable strategy for improving aquatic and terrestrial habitat in the longer term through gradual development of mature riparian vegetation. Floodplain reconstruction encompasses a range of treatments including:

- Revegetation (including associated treatments described above);
- Construction of floodplain features such as wetlands and floodplain swales;
- Large wood placement and microtopography grading for short term floodplain surface roughness in the absence of vegetation;
- Vegetation salvage and transplant to re-graded surfaces; and
- Soil amendments for improving growth media.

Floodplain Features

Incorporating floodplain features into newly constructed floodplains is a restoration strategy that promotes floodplain diversity. Floodplain features will help address the limiting factor of having an insufficient riparian buffer. There are two main types of floodplain features proposed for new floodplain surfaces in the project area – wetlands and floodplain swales. Wetlands are described above in Section 8.4. Floodplain swales are small depression features incorporated into the floodplain that provide microsites where floodplain vegetation can establish at slightly lower elevations (closer to the water table) than adjacent floodplain surfaces. Floodplain swales also provide storage for flood water and sediment at variable flows, in addition to broadening the range of ecological niches available on the floodplain surface to support different life stages (and behaviors) of plant, bird, amphibian, and terrestrial wildlife species. To maximize diversity, floodplain swales should vary in size and depth but should not extend below the anticipated baseflow elevation.

Floodplain Roughness

Floodplain roughness is a strategy applied to areas within the floodplain where frequent interaction with the channel is anticipated. This treatment creates complexity and microsites on newly constructed floodplain surfaces to trap and protect seed and other plant propagules, and to provide resistance to erosion by limiting rill formation. Floodplain roughness is created using equipment to roughen the floodplain surface with microtopography and partially bury woody debris in the soil. Microtopography creates variation in the constructed floodplain surface ranging from 0.5 feet above to 0.5 feet below the design floodplain surface. The woody debris increases soil moisture retention, creates protective microsites for establishing seed and plants, and promotes soil development by introducing organic material.

Vegetation Salvage and Transplant

Plant salvage and transplant is a technique where healthy plants are harvested from areas inside the construction limits (or from nearby donor locations) and then transplanted back into the re-graded floodplain or along streambanks. This provides rapid establishment of mature vegetation on streambanks and constructed floodplain surfaces. Vegetation salvage and transplant helps address a number of limiting factors including insufficient riparian buffer, altered pool development processes, bank erosion, and lack of habitat diversity. Salvaging native plants and sod can be a relatively inexpensive method for obtaining large, site-adapted plan stock for rapid vegetative reestablishment. Because this vegetation is typically mature it can quickly add natural vegetation function to streambanks and floodplains. Mature plants and high quality sod located within construction and grading areas should be salvaged and relocated to streambanks. Specific opportunities for vegetation salvage and transplant should be identified during the design and construction phase.

Soil Amendments

Soils are one of the most important factors that can influence plant survival and establishment of desired vegetation communities. Some of the more important characteristics of soils that can affect plant health and survival include: soil texture, pH, organic matter, salinity, compaction and the presence of contaminants such as metals or residual herbicides or pesticides. Typically, native soils with no known or suspected contaminants that currently support native riparian vegetation are adequate to support planted, seeded and naturally recruited vegetation on the floodplain over time. Because the soils in most of the project area currently support native riparian vegetation it is assumed that soil texture, pH, and organic matter are sufficient and compaction is not present to a degree that precludes the establishment of desired vegetation and import of suitable growth media will not be required. It is possible that contaminants are present in the soil in some of the project reaches and a soil investigation should be completed during the design phase to verify existing soils are suitable as growth media or whether soil amendments will be required. The type of soil amendment needed will depend on this investigation.

8.2.6 Channel Reconstruction

Channel reconstruction is a strategy applied to areas with altered stream function through modification of channel geometry. Modification of channel geometry changes stream hydraulics, which can have an effect on depth, velocity and substrate components of aquatic habitat. Channel reconstruction is also a viable strategy for improving stream stability and establishing riparian vegetation. Channel reconstruction encompasses a range of treatments including:

- Channel shaping (modifying cross section geometry and width-depth ratio);
- Channel realignment (modifying planform geometry and channel location);
- Pool-riffle sequences (modifying profile geometry and longitudinal bedforms);
- Revegetation (including treatments described previously);
- Streambank structures (including treatments described previously); and
- Floodplain excavation (including treatments described previously).

Channel reconstruction may also include reconstruction of the stream bed, whereby riffles are built from imported streambed material. Riffle construction can provide vertical streambed stability in new channel segments. In addition, riffle construction can introduce appropriate spawning substrate for focal aquatic species.

9 Conclusion

Idaho Department of Environmental Quality, in cooperation with local, state and federal agencies, commissioned a watershed assessment and restoration prioritization plan for Wolf Lodge Creek, a tributary to Lake Coeur d'Alene near Coeur d'Alene, Idaho. The assessment focused on characterizing existing stream corridor and aquatic habitat conditions, and inventorying all major stream crossings. Wolf Lodge Creek is water quality limited and is included on the State of Idaho 303(d) list as impaired for sediment and temperature. The results from this report indicate that the excess sediment loading in the watershed is caused in part by rapid bank erosion and channel migration that are largely driven by the removal of riparian vegetation, dredging, and straightening of the Wolf Lodge Creek.

Results of this assessment were used to develop a comprehensive restoration plan for the watershed, including opportunities to enhance both instream aquatic habitat conditions and reduce sediment loading from bank erosion. The report and restoration prioritization plan are intended to support Idaho DEQ water quality initiatives by providing a framework for developing, prioritizing, and implementing restoration projects that address sediment sources, aquatic habitat, and riparian habitat conditions on Wolf Lodge Creek and primary tributaries.

The recommendations and conceptual designs should be adapted as new information and data regarding watershed conditions and construction constraints are obtained.

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