# APPENDIX D- ROAD SEDIMENT ASSESSMENT, MADISON TMDL PLANNING AREA

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# D1.0 INTRODUCTION

This appendix presents a sediment assessment of the unpaved road network within the Madison River TMDL Planning Area (TPA). Through a combination of GIS analysis, field assessment, and computer modeling, estimated sediment loads were developed for road crossing and parallel road segments in the impaired watersheds within the Madison TPA. Potential future conditions were also estimated after the application of sediment reducing Best Management Practices (BMPs).

# D2.0 DATA COLLECTION

## D2.1 SPATIAL ANALYSIS

Unpaved roads were identified in the impaired watersheds using a combination of aerial imagery and attribute information within the TIGER Roads Layer. Unpaved road crossings were identified as locations where the resulting unpaved roads layer intersected the National Hydrography Dataset (NHD) stream layer. Parallel road segments were identified by placing a 150-foot buffer around the NHD stream layer, and selecting sections of the unpaved roads layer that intersected this buffer. A total of 554 unpaved road crossings and 130 miles of unpaved parallel road segments were identified within the sediment-impaired watersheds of the Madison TPA.

## D2.2 FIELD DATA COLLECTION

A total of 25 unpaved crossings and 16 parallel road segments totaling 4 miles were selected as representative and evaluated in the field in 2015 (**Tables D-1** & **D-2**). In cases where the original crossing or segment could not be sampled due to access issues or was found to be unpaved, a crossing or parallel road segment in the field with the closest spatial proximity was substituted, and identified with an "A" following the name. If a road crossed the stream twice at the same approximate location, then both segments of the crossing were sampled. The following information was collected at road crossings and parallel road segments: soil type, percent rock, road surface, road design, traffic level, and road topographic values (road grade, road length, road width, fill grade, fill length, buffer grade, and buffer length).

**Table D-1. Locations of sampled cross sections in the Madison TPA**

| Watershed | Cross-section | Latitude | Longitude |
|---|---|---|---|
| Red Canyon | X-1A | 44.834 | -111.201 |
| Red Canyon | X-2A | 44.836 | -111.203 |
| Watkins | X-2 | 44.836 | -111.203 |
| Red Canyon | X-3 | 44.831 | -111.200 |
| Watkins | X-4 | 44.799 | -111.286 |
| Watkins | X-5 | 44.806 | -111.279 |
| Red Canyon | X-13 | 45.060 | -111.668 |
| Bear | X-16A | 45.168 | -111.596 |
| North Meadow | X-21 | 45.525 | -111.835 |
| North Meadow | X-25 | 45.514 | -111.822 |
| Bear | X-26A | 45.162 | -111.591 |

**Table D-1. Locations of sampled cross sections in the Madison TPA**

| Watershed | Cross-section | Latitude | Longitude |
|---|---|---|---|
| South Meadow | X-26 | 45.471 | -111.878 |
| South Meadow | X-27A | 45.468 | -111.871 |
| South Meadow | X-28A | 45.449 | -111.854 |
| South Meadow | X-29 | 45.451 | -111.854 |
| North Meadow | X-33A | 45.514 | 111.800 |
| Wigwam | X-35 A | 45.208 | -111.761 |
| North Meadow | X-38 | 45.233 | -111.734 |
| Blaine Spring | X-39A | 45.210 | -111.810 |
| Blaine Spring | X-40 | 45.209 | -111.802 |
| Moore | X-46A | 45.346 | -111.730 |
| Hot Springs | X-51A | 45.565 | -111.754 |
| Hot Springs | X-52 | 45.587 | -111.648 |
| Hot Springs | X-53 | 45.573 | -111.710 |
| Red Canyon | X-RC extra | 44.825 | -111.197 |

**Table D-2. Locations of sampled parallel road segments in the Madison TPA**

| Watershed | Road Name | Site ID | Upstream Latitude | Upstream Longitude | Downstream Latitude | Downstream Longitude |
|---|---|---|---|---|---|---|
| Red Canyon | USFS Rd 681 | P-1A | 44.824 | -111.197 | 44.823 | -111.197 |
| Red Canyon | USFS Rd 681 | P-2A | 44.823 | -111.197 | 44.821 | -111.197 |
| Red Canyon | USFS Rd 681 | P-3A | 44.834 | -111.201 | | |
| Ruby | | P-11 | 45.059 | -111.712 | | |
| Ruby | | P-12 | 45.06 | 111.715 | 45.06 | -111.714 |
| Ruby | | P-13A | 45.06 | -111.716 | 45.06 | -111.717 |
| Bear | Bear Creek Rd E | P-16 | 45.163 | -111.566 | 45.163 | -111.569 |
| Bear | | P-17 | 45.156 | -111.555 | 45.156 | -111.555 |
| South Meadow | Natl Forest Develop Road 1221 Rd | P-39A | 45.45 | -111.852 | 45.449 | -111.849 |
| Hot Springs | Bradley Creek Rd | P-40 | 45.53 | -111.675 | 45.529 | -111.675 |
| North Meadow | N Meadow Creek Rd | P-41 | 45.474 | -111.773 | 45.473 | -111.773 |
| North Meadow | N Meadow Creek Rd | P-42 | 45.469 | 111.773 | 45.468 | 111.773 |
| North Meadow | N Meadow Creek Rd | P-48A | 45.53 | -111.849 | 45.529 | -111.845 |
| Hot Springs | Sterling Rd | P-49 | 45.573 | -111.709 | 45.573 | -111.708 |
| Hot Springs | Bradley Creek Rd | P-55A | | | 45.565 | -111.653 |
| Moore | Moore's Creek Rd | P-MC-extra | | | 45.333 | -111.748 |

# D3.0 SEDIMENT LOADING EXTRAPOLATION

## D3.1 SAMPLED CROSS-SECTION

The WEPP model (Flanagan and Livingston 1995) produced an estimate of sediment leaving the cross-section given the crossing characteristics and resulting contributing length. To estimate the sediment reduction at sampled cross sections if BMP's were implemented, the original field data was used in the WEPP model, but the length of road contributing sediment was shortened to 200 feet (**Table D-5**).

**Table D-5. Estimated sediment leaving each sampled crossings, before and after BMPS**

| Watershed | XS ID | Contributing Length (ft) | Contributing Length-BMP's (ft) | Sediment Leaving Buffer (Tons/Yr) | Sediment Leaving Buffer After BMP's (Tons/Yr) |
|---|---|---|---|---|---|
| Red Canyon | X-1A | 909 | 200 | 0.020 | 0.001 |
| Red Canyon | X-2 | 22 | 200 | 0.004 | 0.004 |
| Red Canyon | X-2A | 243 | 200 | 0.011 | 0.005 |
| Red Canyon | X-2A (2) | 756 | 200 | 0.073 | 0.006 |
| Red Canyon | X-3 | 78 | 200 | 0.025 | 0.025 |
| Red Canyon | X-3 | 694 | 200 | 1.754 | 0.309 |
| Watkins | X-4 | 853 | 200 | 0.059 | 0.007 |
| South Meadow | X-5 | 11 | 200 | 0.001 | 0.001 |
| Ruby | X-13 | 153 | 200 | 0.035 | 0.035 |
| Bear | X-16A | 350 | 200 | 0.611 | 0.349 |
| North Meadow | X-21 | 77 | 200 | 0.000 | 0.000 |
| North Meadow | X-25 | 260 | 200 | 0.332 | 0.226 |
| North Meadow | X-25 (2) | 226 | 200 | 0.270 | 0.226 |
| South Meadow | X-26 | 507 | 200 | 0.074 | 0.014 |
| South Meadow | X 26 (2) | 109 | 200 | 0.016 | 0.016 |
| Bear | x-26A | 362 | 200 | 0.343 | 0.243 |
| South Meadow | X-27A | 235 | 200 | 0.077 | 0.064 |
| South Meadow | X-28A | 203 | 200 | 0.023 | 0.023 |
| South Meadow | X-29 | 730 | 200 | 0.006 | 0.000 |
| South Meadow | X-29 (2) | 1000 | 200 | 0.013 | 0.000 |
| North Meadow | X-33A | 35 | 200 | 0.024 | 0.024 |
| Wigwam | X-35 A | 205 | 200 | 0.030 | 0.029 |
| Wigwam | X-35 A (2) | 277 | 200 | 0.108 | 0.070 |
| North Meadow | X-38 | 35 | 200 | 0.006 | 0.006 |
| Blaine | X-39A | 93 | 200 | 0.007 | 0.007 |
| Blaine | X-40 | 385 | 200 | 0.020 | 0.011 |
| Moore | X-46A | 678 | 200 | 0.012 | 0.004 |
| Hot Springs | X-51A | 635 | 200 | 0.013 | 0.004 |
| Hot Springs | X-52 | 690 | 200 | 0.139 | 0.040 |
| Hot Springs | X-53 | 188 | 200 | 0.028 | 0.028 |
| Red Canyon | X-RC extra | 449 | 200 | 0.497 | 0.151 |

## D3.2 SAMPLED PARALLEL ROAD SEGMENTS

The WEPP model produced an estimate of sediment leaving the parallel road segment given the current length. To estimate the sediment reduction at sampled parallel road segments if BMP's were implemented, the original field data was used in the WEPP model, but the length of the parallel road segment contributing sediment was shortened to 500 feet (**Table D-6**).

**Table D-6. Estimated sediment leaving each sampled parallel road segment, before and after BMPs**

| Watershed | PS ID | Road Length (ft) | Contributing Length-BMP's (ft) | Sediment Leaving Buffer (Tons/Yr) | Sediment Leaving Buffer After BMP's (Tons/Yr) |
|---|---|---|---|---|---|
| Bear | P-16 | 824 | 500 | 0.110 | 0.040 |
| Bear | X 16A | 350 | 500 | 0.611 | 0.611 |
| Bear | P-17 | 381 | 500 | 0.015 | 0.015 |
| Hot Springs | P-40 | 562 | 500 | 1.116 | 1.002 |
| Hot Springs | P-49 | 179 | 500 | 0.097 | 0.097 |
| Hot Springs | P-55A | 1000 | 500 | 0.746 | 0.389 |
| Moore | P-MC Extra | 363 | 500 | 0.013 | 0.013 |
| North Meadow | P-41 | 1000 | 500 | 1.111 | 0.622 |
| North Meadow | P-42 | 160 | 500 | 0.020 | 0.020 |
| North Meadow | P-48A | 154 | 500 | 0.002 | 0.002 |
| Red Canyon | P-1A | 130 | 500 | 0.044 | 0.044 |
| Red Canyon | P-1A (2) | 443 | 500 | 0.203 | 0.203 |
| Red Canyon | P-2A | 914 | 500 | 0.062 | 0.034 |
| Red Canyon | P-3A | 883 | 500 | 0.802 | 0.443 |
| Ruby | P-11 | 75 | 500 | 0.005 | 0.005 |
| Ruby | P-11 (2) | 119 | 500 | 0.008 | 0.008 |
| Ruby | P-12 | 361 | 500 | 0.231 | 0.231 |
| Ruby | P-13A | 188 | 500 | 0.037 | 0.037 |
| South Meadow | P-39 A | 796 | 500 | 0.799 | 0.436 |

## D3.3 WATERSHED LEVEL: CROSS-SECTIONS

For watersheds with > 20% of crossings sampled (Red Canyon, Watkins), the total sediment yield at crossings (sampled + unsampled) was determined by multiplying the total number of crossings estimated using GIS by the average yield per crossing at sampled cross-sections in that watershed (**Table D-7**). For the other watersheds, the sediment yield was estimated by weighing by ownership and elevation category according to the following method. First, the average sediment yield per crossing was determined for the following categories of crossings: Public, high elevation (>6300 feet); public, low elevation (≤ 6300 feet); private, low elevation (≤ 6300 feet) (**Table D-8**). Then the number of crossings in each category was multiplied by the average sediment yield for that type of crossings. For both methods, the private, high elevation crossings were excluded from the analysis due to low prevalence

and a lack of data. Results from all categories were summed to obtain a total estimate of sediment yield in the watershed from crossings. A similar method was used to determine yields once BMP's were implemented (**Table D-9**).

**Table D-7. Summary of estimated sediment loads leaving sampled crossings, by watershed**

| Watershed | No. Gravel Crossings | No. Crossings Evaluated | Total Sediment at Crossings-Field (Tons/Year) | Average Sediment Per Crossing-Field (Tons/ Year) | Total Sediment at Crossings - BMP Field (Tons/Year) | Average Sediment Per Crossing-BMP (Tons/Year) |
|---|---|---|---|---|---|---|
| Bear | 84 | 2 | 0.80 | 0.40 | 0.29 | 0.15 |
| Blaine | 33 | 2 | 0.02 | 0.01 | 0.02 | 0.01 |
| Hot Springs | 96 | 3 | 0.15 | 0.05 | 0.06 | 0.02 |
| Moore | 30 | 1 | 0.01 | 0.01 | 0.00 | 0.00 |
| North Meadow | 87 | 3 | 0.52 | 0.17 | 0.40 | 0.13 |
| Red Canyon | 15 | 6 | 1.99 | 0.33 | 0.42 | 0.07 |
| Ruby | 9 | 1 | 0.03 | 0.03 | 0.03 | 0.03 |
| South Meadow | 39 | 5 | 0.18 | 0.04 | 0.10 | 0.02 |
| Watkins | 3 | 1 | 0.05 | 0.05 | 0.01 | 0.01 |
| Wigwam | 66 | 1 | 0.12 | 0.12 | 0.08 | 0.08 |
| Antelope | 7 | 0 | NA | NA | NA | NA |
| Elk | 19 | 0 | NA | NA | NA | NA |
| Cherry | 66 | 0 | NA | NA | NA | NA |

**Table D-8. Summary of sediment loads leaving sampled crossings by ownership and elevation category**

| Ownership/Elevation Category | No. Crossings | Total Sediment by Category (Tons/Year) | Total Sediment By Category with BMP's (Tons/Year) | Average Sediment Per Crossing (Tons/Year) | Average Sediment Per Crossing-BMP's (Tons/Year) |
|---|---|---|---|---|---|
| Public, high elevation | 8 | 2.18 | 0.50 | 0.272 | 0.063 |
| Public, low elevation | 5 | 0.19 | 0.09 | 0.038 | 0.017 |
| Private, high elevation | 0 | NA | 0.00 | NA | NA |
| Private, low elevation | 11 | 1.49 | 1.02 | 0.136 | 0.093 |

**Table D-9. Estimated sediment loads from crossings in each subwatershed**

| Watershed | No. Gravel Crossings | No. Public, Low | No. Private, Low | No. Public, High | No. Private, High | Method Used | Total Sediment (Tons/Yr) | Total Sediment (Tons/Yr) with BMP's | % Reduction |
|---|---|---|---|---|---|---|---|---|---|
| Antelope | 7 | 0 | 0 | 6 | 1 | own/elev | 1.63 | 0.38 | 77 |
| Bear | 84 | 11 | 71 | 0 | 4 | own/elev | 10.06 | 6.76 | 33 |
| Blaine | 33 | 1 | 31 | 0 | 1 | own/elev | 4.25 | 2.89 | 32 |
| Cherry | 66 | 0 | 59 | 4 | 4 | own/elev | 9.10 | 5.71 | 37 |
| Elk | 19 | 2 | 17 | 0 | 0 | own/elev | 2.39 | 1.61 | 33 |
| Hot Springs | 96 | 43 | 54 | 1 | 0 | own/elev | 9.25 | 5.80 | 37 |
| Moore | 30 | 5 | 17 | 6 | 2 | own/elev | 4.13 | 2.04 | 51 |
| North Meadow | 87 | 3 | 64 | 20 | 1 | own/elev | 14.25 | 7.23 | 49 |
| Red Canyon | 15 | 0 | 0 | 13 | 2 | watershed | 4.30 | 0.90 | 79 |
| Ruby | 9 | 9 | 0 | 0 | 0 | own/elev | 0.34 | 0.15 | 55 |
| South Meadow | 39 | 3 | 18 | 18 | 1 | own/elev | 7.46 | 2.85 | 62 |
| Watkins | 3 | 0 | 0 | 3 | 0 | watershed | 0.15 | 0.02 | 88 |
| Wigwam | 66 | 13 | 37 | 7 | 10 | own/elev | 7.43 | 4.09 | 45 |

## D3.4 WATERSHED LEVEL: PARALLEL ROAD SEGMENTS

The sediment yield at sampled parallel road segments was estimated by weighing by ownership and elevation category according to the following method. First, the average sediment yield (tons/mile/yr) was estimated for each ownership/elevation category based on sampled parallel road segments across the Madison TPA: Public, high elevation (>6300 feet); public, low elevation (< 6300 feet); private, low elevation (< 6300 feet) (**Table D-10**). To estimate the sediment yield per mile from parallel road segments for each watershed, the number of miles in each category was multiplied by the average sediment yield per mile in that category. Results from all categories were summed to obtain a total estimate of sediment yield from parallel road segments in the watershed (**Table D-11**).

**Table D-10. Summary of sediment leaving the buffer at parallel road segments by ownership and elevation category, using results from the WEPP modeling approach**

| | No. Parallel Segments Sampled | Length of Parallel Road Segments Sampled-miles | Total Sediment By Category (Tons/Year) | Total Sediment By Category with BMP's (Tons/Year) | Average Sediment Per Mile (Tons/Year) | Average Sediment Per Mile with BMP's |
|---|---|---|---|---|---|---|
| Public, high elevation | 3 | 1.33 | 1.111 | 0.723 | 0.835 | 0.544 |
| Public, low elevation | 8 | 1.05 | 2.959 | 2.124 | 2.818 | 2.023 |
| Private, high elevation | 0 | 0 | NA | NA | NA | NA |
| Private, low elevation | 5 | 1.45 | 1.352 | 0.792 | 0.932 | 0.546 |

**Table D-11. Estimated sediment entering streams from parallel road segments by subwatershed**

| | Public Low (miles) | Private Low (miles) | Public High (miles) | Private High (miles) | Public Low (Tons) | Private Low (Tons) | Public High (Tons) | Private High (Tons) | Public Low (tons BMP) | Private Low (Tons BMP) | Public High (Tons BMP) | Private High (Tons BMP) | Total(Tons/Yr) | Total (Tons/Yr-BMP's) | % Reduction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Antelope | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.07 | NA | 0.00 | 0.00 | 0.04 | NA | 0.07 | 0.04 | 45.78 |
| Bear | 1.72 | 21.33 | 0.22 | 0.92 | 4.86 | 19.89 | 0.19 | NA | 2.90 | 9.71 | 0.10 | NA | 24.93 | 12.72 | 49.00 |
| Blaine | 0.20 | 7.79 | 0.00 | 0.04 | 0.55 | 7.26 | 0.00 | NA | 0.33 | 3.54 | 0.00 | NA | 7.81 | 3.87 | 50.40 |
| Cherry | 0.00 | 12.26 | 0.60 | 0.38 | 0.00 | 11.43 | 0.50 | NA | 0.00 | 5.58 | 0.27 | NA | 11.93 | 5.85 | 50.95 |
| Elk | 0.86 | 3.98 | 0.00 | 0.00 | 2.42 | 3.71 | 0.00 | NA | 1.45 | 1.81 | 0.00 | NA | 6.14 | 3.26 | 46.84 |
| Hot Springs | 9.28 | 11.81 | 1.32 | 0.00 | 26.16 | 11.01 | 1.10 | NA | 15.65 | 5.38 | 0.60 | NA | 38.27 | 21.62 | 43.51 |
| Moore | 2.16 | 6.72 | 2.01 | 0.86 | 6.07 | 6.27 | 1.68 | NA | 3.63 | 3.06 | 0.91 | NA | 14.02 | 7.60 | 45.77 |
| North Meadow | 1.46 | 13.56 | 3.14 | 0.00 | 4.13 | 12.65 | 2.62 | NA | 2.47 | 6.17 | 1.42 | NA | 19.39 | 10.06 | 48.11 |
| Red Canyon | 0.00 | 0.00 | 3.07 | 1.76 | 0.00 | 0.00 | 2.56 | NA | 0.00 | 0.00 | 1.39 | NA | 2.56 | 1.39 | 45.78 |
| Ruby | 4.36 | 0.71 | 0.92 | 0.00 | 12.27 | 0.66 | 0.77 | NA | 7.34 | 0.32 | 0.42 | NA | 13.70 | 8.08 | 41.03 |
| South Meadow | 1.10 | 4.92 | 2.78 | 0.11 | 3.11 | 4.58 | 2.33 | NA | 1.86 | 2.24 | 1.26 | NA | 10.02 | 5.36 | 46.51 |
| Watkins | 0.00 | 0.00 | 0.27 | 0.01 | 0.00 | 0.00 | 0.22 | NA | 0.00 | 0.00 | 0.12 | NA | 0.22 | 0.12 | 45.78 |
| Wigwam | 1.10 | 4.79 | 1.21 | 1.11 | 3.11 | 4.47 | 1.01 | NA | 1.86 | 2.18 | 0.55 | NA | 8.60 | 4.59 | 46.56 |

# D4.0 REFERENCES

Flanagan, D. C. and S. J. Livingston. 1995. USDA-Water Erosion Prediction Project User Summary. NSERL Report No. 11, National Soil Erosion Research Lab, USDA, West Lafayette IN, 139 pp.