Upper Muddy Creek
Water Quality Investigation 2010

Measurements and reporting by Adam Sigler

Montana State University Extension Water Quality

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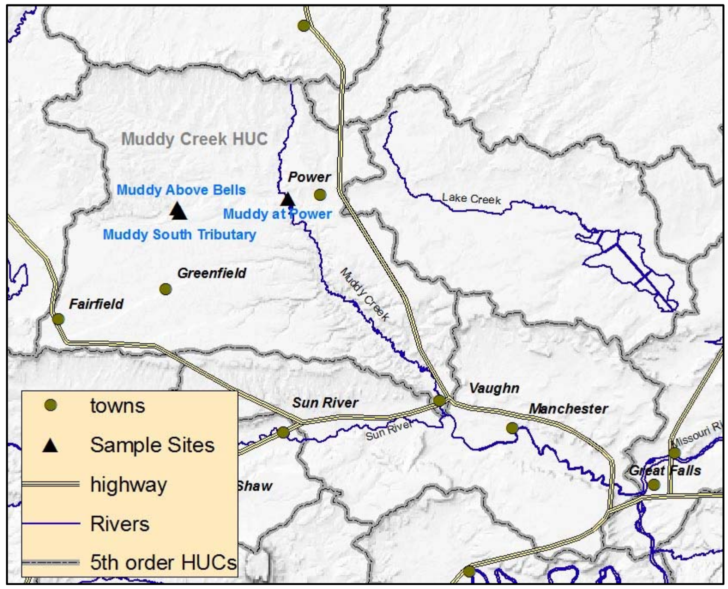
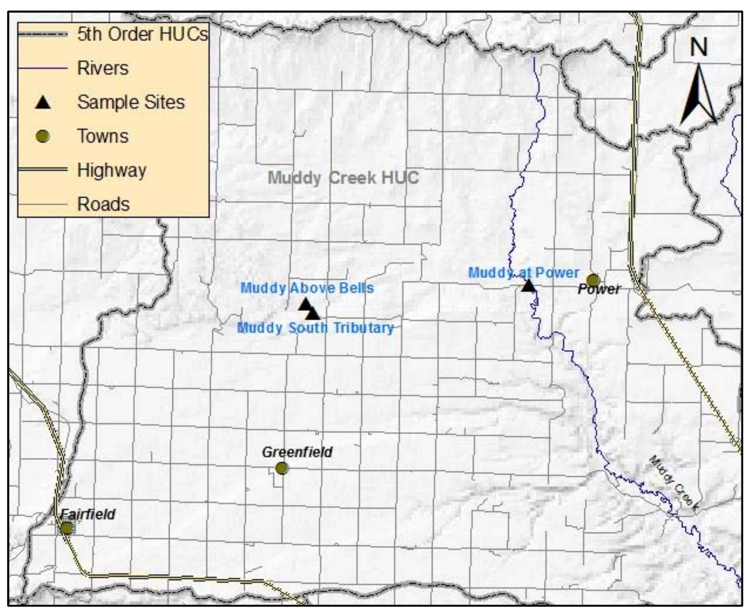
Background



Muddy Creek is located northwest of Great Falls Montana and confluences with the Sun River near Vaughn before the Sun confluences with the Missouri at Great Falls. Muddy Creek drains approximately 256 square miles (2). The Teton Ridge separates Muddy Creek Watershed from the Teton Watershed on the north and the Greenfield bench separates it from the Sun Watershed on the South. Muddy Creek falls within the Northwest Glaciated Plains Level III Ecoregion for the purposes of applying MT DEQ draft nutrient criteria. (1)

Sun River Watershed Group (SRWG) is pursuing nonpoint source pollution mitigation projects on Upper Muddy Creek near Power Montana. Preliminary data collection was initiated in the 2010 season to provide baseline data to inform future data collection efforts and nonpoint source implementation efforts. Funding was made available by the US Bureau of Reclamation for MSU Extension Water Quality (MSUEWQ) to perform discharge measurements, measure field water quality parameters and collect water samples for bacteria and nutrient analysis. SRWG paid for laboratory analysis of water samples.

Methods



MSUEWQ personnel measured discharge, measured field water quality parameters and collected samples for lab analysis at three sample sites on four dates during the 2010 season. Sample events were scheduled in April, May, July and October to targeted different portions of the hydrograph. SRWG coordinator, Alan Rollo identified the sites and acquired access permission. Site names and coordinates are provided in Table 1 and aerials & site images are provided in Figures 1 through 5.

Discharge measurements were taken with a Marsh-McBirney FLO-MATE 2000 and top setting rod. The FLOW-MATE was checked for accuracy against a Doppler velocity meter in a flume at the MSU hydrology laboratory on July 6th 2010 and performed well within expectations. FLO-MATE deviations from the Doppler system were within 2% at a velocity of 2 feet per second. Field water quality parameters (EC, Temperature, and pH) were collected with a YSI 556 multi-parameter meter. The YSI was calibrated within 24 hours of the time measurements were taken for all sample events. Lab analysis was performed by Energy Laboratories and quality control samples were collected during the May and October sample events. Concentrations and loads are presented for assessment of the relative importance of sub-watersheds contributing to the water quality at Power.

Table 1. Site coordinates and descriptions

Site Name	Latitude	Longitude	Description
Muddy Above Bells	47.70274	-111.84881	Smaller North Tributary of Muddy Creek upstream from where it passes under the railroad grade upstream from 7th Lane NE; approximately 0.4 miles northwest of the Michael Konan residence.
Muddy South Tributary	47.69934	-111.84517	Larger South Tributary of Muddy Creek just upstream from a two track crossing, approximately 0.15 miles northwest of the Bremer place; near the intersection of 7th Lane NE and 6th Road NE.
Muddy at Power	47.71253	-111.72282	Muddy Creek just downstream from the check dam at the diversion for the drinking water supply for the town of Power, MT; approximately 1.5 miles west of Power just off 7th Road NE.

Quality Assurance and Quality Control

Duplicate and blank samples were collected for lab analysis at one site in May. Duplicate samples were collected again in October. All blank samples produced none detectable results with the exception of a low detection of nitrate discussed below. Relative percent difference (RPD) for duplicate samples was calculated using the equation below. In the absence of a quality assurance document for this monitoring, professional judgment was used in determining what data to qualify based on quality assurance data.

E. coli duplicates produced RPDs of 5.2 and 22.4% which is acceptable for co-located *E. coli* samples. Total coliform duplicates produced RPDs of 43.6% and 23.4%. This low level of precision is expected due to the high degree of variability of Total Coliform (TC) in surface water and hence all TC data is qualified for the project. Ammonia was not detected in any of the QA samples. Nitrate duplicates were both less than 2% RPD. The nitrate blank collected in May produced a value of 0.02mg/L but no values for this date were less than 10 times this detection level (0.2 mg/L), so no data was qualified. Total nitrogen RPD for May was 0% but was 68.8% for October which resulted in qualification of the TN results for the October sample event. Total phosphorus RPDs were 5.3 and 13.3% which is acceptable.

Detection limits for analysis run at Energy Laboratories were 1 CFU per 100 mL for *E. coli* and Total Coliform (A9223 B); 0.05 mg/L for ammonia (E350.1); 0.04 mg/L for nitrate plus nitrite as N (E353.2); 0.2 mg/L for total nitrogen (A4500 N-C); 0.005 mg/L for total phosphorus (E365.1).

Relative percent difference equation: RPD as % = ((D1-D2)/((D1+D2)/2)x100

Figure 1. Aerial image of Sites 1 and 2, Muddy above Bells and Muddy South Tributary.

Figure 2. Photos taken in April at Site 1, Muddy above Bells.

Figure 3. Photos taken in April at Site 2, Muddy South Tributary.

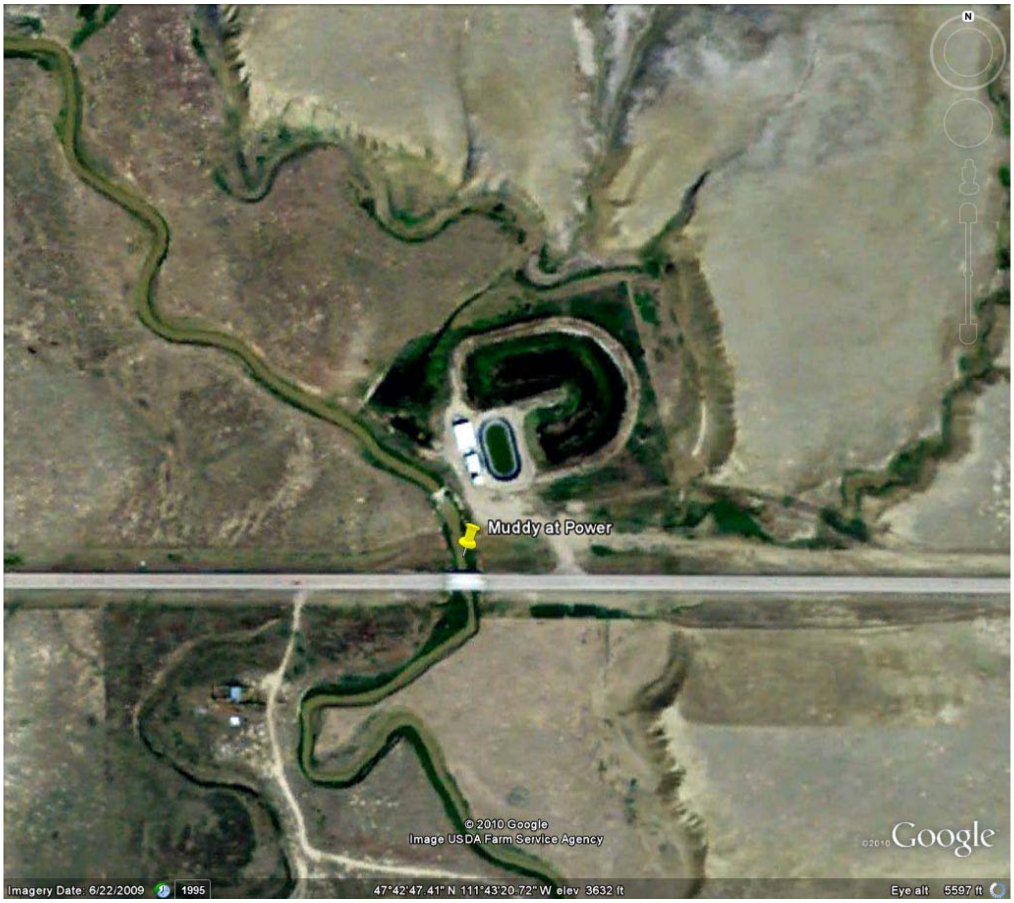


Figure 4. Aerial image of Site 3, Muddy at Power.

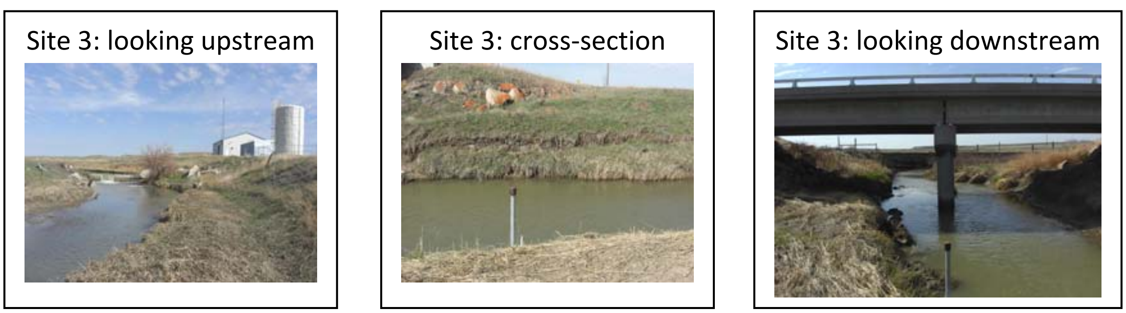


Figure 5. Photos taken in April at Site 3, Muddy at Power.

Results

Discharge for the two tributaries accounted for between 65 and 75 percent of the discharge of Muddy Creek at Power for the four 2010 sample events. The greatest discharge was measured in July for all sample sites. Temperature was warmest in July and coolest in October for all sample sites. pH ranged between 8.0 and 9.0 for all sites for all sample events. Specific conductance (SC) ranged between 400 and 1000 µS/cm. At both tributary sample sites the SC was lower in May and July than in April and October. This classic inverse relationship between discharge and SC suggests a background salt concentration from groundwater exists during baseflow and is diluted by low conductivity water during spring runoff.

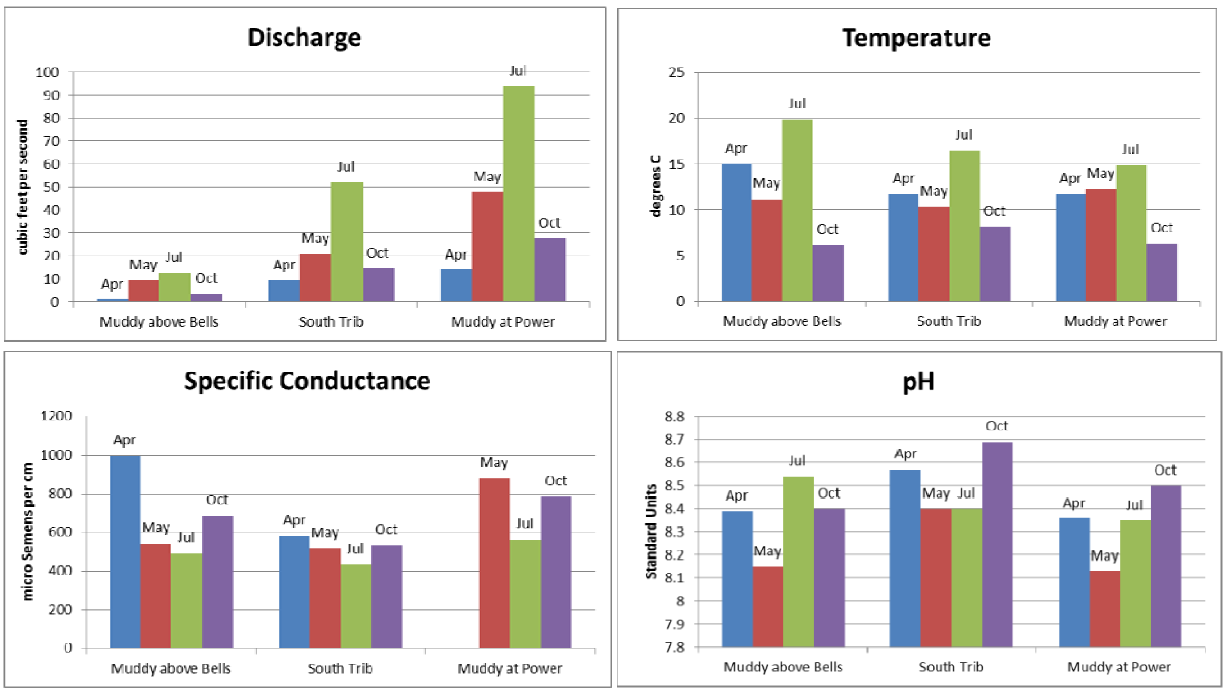


Figure 6. Field measurements: discharge, temperature, specific conductance and pH.

Discharge

Discharge measured on the south tributary of Muddy Creek equaled approximately 45 to 65% of the discharge measured at Power during the 2010 sample events. Discharge measured on the smaller tributary was approximately 9 to 20% of the discharge measured at Power.   A bar graph in Figure 6 depicts this data as well as pie charts in the appendix.

Ammonia

Ammonia was detected only one time during 2010 sampling on Muddy Creek. A concentration of 0.14 mg/L was detected at the Bells Site in March. MT ammonia criteria depend on pH and presence/absence of salmonids. The measured ammonia value is below the criteria for a pH of 8.39

(measured at the time of sampling) regardless of salmonid presence (salmonids present = 2.59 mg/L; salmonids absent = 3.88 mg/L).

E. coli

MT DEQ *E. coli* standards are based on 5 samples collected in a 30 day period. The geometric mean of five samples cannot exceed 126 colony forming units (CFUs) and no more than 10% of samples can exceed 252 CFSs per 100 mL of sample. Sample collection on Upper Muddy Creek was not structured to assess attainment of standards but numbers can be compared to standard threshold values for reference. *E. coli* concentration and load data is depicted in Figure 8. None of the samples collected in April or in October exceeded either of the *E. coli* threshold values. At the Bells Site both May and July samples exceeded the 126 threshold but not the 252 threshold. At the South Tributary site the July concentration exceeded the 126 threshold but not the 252 threshold. At the Power sample site, both the May and July concentrations exceeded both threshold values.

Nitrate-N and Total N

All nitrate-N samples collected at all sites for all events exceeded the MT draft nutrient criteria for the Northwestern Glaciated Plains Ecoregion which Upper Muddy Creek falls within. Nitrate concentration behavior paralleled that of SC with greatest values in April and October and lower values when discharge was greater in May and July. This suggests that the same groundwater/surface water dynamics influencing SC values may also be influencing nitrate concentrations. Following this line of thinking, nitrate concentrations between 2.5 and 4 mg/L may be entering the stream from groundwater as baseflow and are diluted during runoff resulting in concentrations as low as 0.5 to 2.5 mg/L. The concentration of nitrate in the stream is certainly also influenced by uptake by aquatic plants which is greatest during warmer months. However, the relationship between nitrate and discharge is stronger than that between nitrate and temperature (Figure 7). Nitrate makes up between 70 and 90 percent of the concentration of total nitrogen for all 2010 samples collected. This percentage is highest for the South Tributary and lowest for Bells. Dynamics for total nitrogen parallel those of nitrate due to the fact that nitrate is the predominant nitrogen species present.

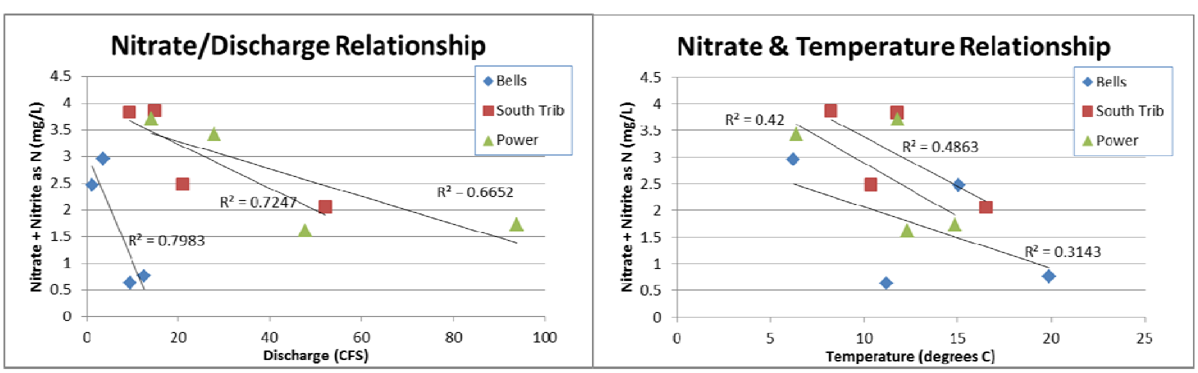


Figure 7. Regression curves depicting the relationship between nitrate/discharge and nitrate/temperature.

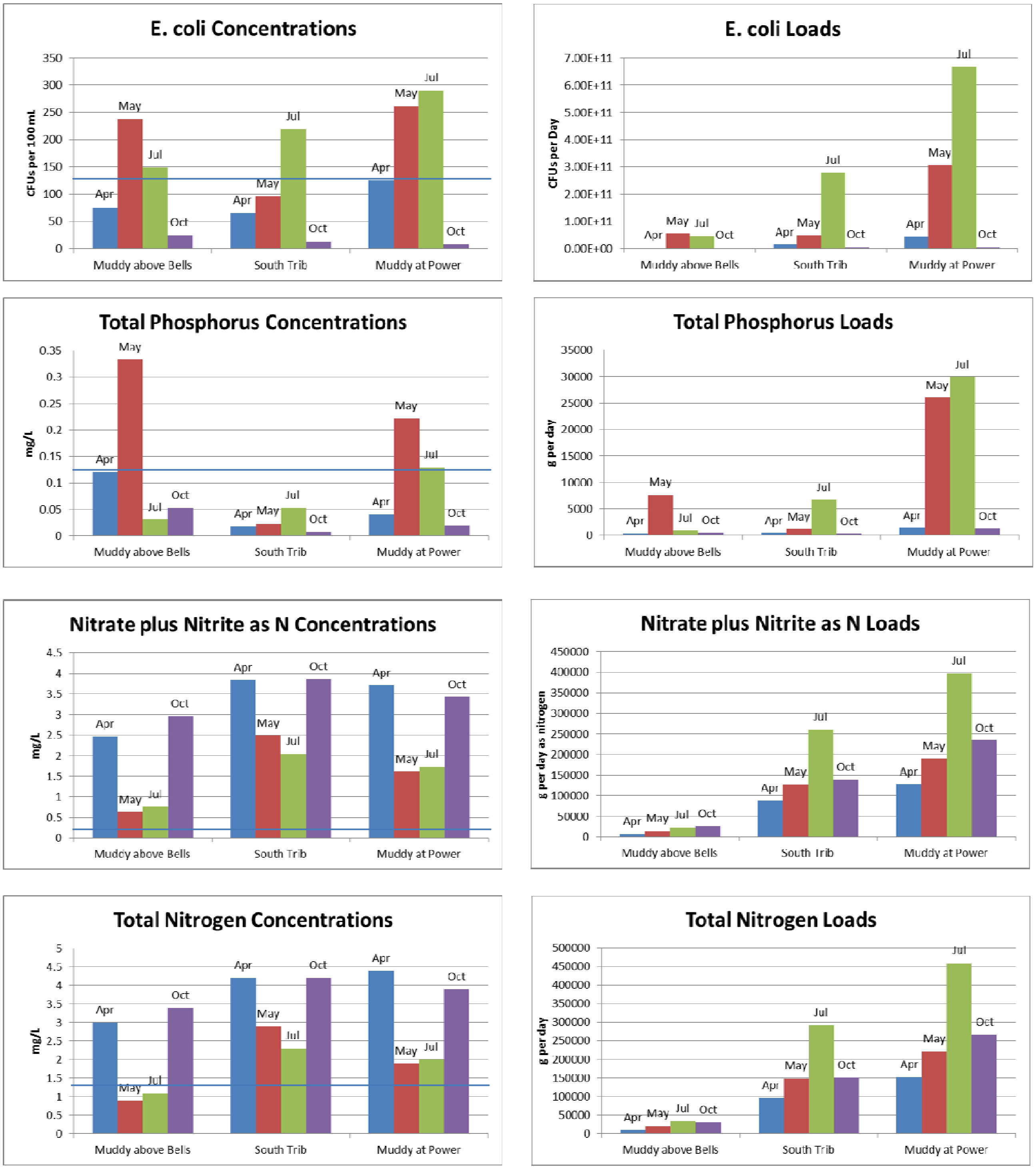


Figure 8. Bar graphs depicting concentrations and loads of *E. coli*, total phosphorus, nitrate plus nitrite as N and total nitrogen by site and date. The blue line on the *E. coli* graph indicates the 126 CFU threshold which is a component of MT DEQ primary contact *E. coli* standards. The blue line on the nutrient graphs are threshold values from the MT draft nutrient standards for the Northwestern Glaciated Plains Ecoregion which Upper Muddy Creek falls within.

Table 5. Water quality/quantity parameters measured in the field.

	Discharge (CFS)	Temperature (degrees C)	Specific Conductance (µS/cm)	pH (standard units)
4/22/2010				
Site 1 (Bells)	1.23	15.05	998	8.39
Site 2 (South)	9.41	11.74	583	8.57
Site 3 (Power)	14.13	11.78	ND	8.36
5/27/2010				
Site 1 (Bells)	9.44	11.22	542	8.15
Site 2 (South)	20.93	10.35	518	8.4
Site 3 (Power)	47.85	12.3	882	8.13
7/28/2010				
Site 1 (Bells)	12.65	19.88	489	8.54
Site 2 (South)	52.08	16.49	432	8.4
Site 3 (Power)	93.94	14.87	564	8.35
10/26/2010				
Site 1 (Bells)	3.6	6.2	687	8.4
Site 2 (South)	14.76	8.23	534	8.69
Site 3 (Power)	27.95	6.36	784	8.5

Table 6. Water quality parameters analyzed at Energy Laboratories. (yellow shaded cells = values that exceed MT *E. coli* standards or MT draft nutrient standards), (grey shaded rows = QC samples), (*= data qualified due to QAQC issues)

	E. coli (CFU/100mL)	Ammonia-N (mg/L)	Nitrate plus Nitrite as N (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
4/22/2010					
Site 1 (Bells)	75.9	0.14	2.47	3	0.121
Site 2 (South)	65.7	ND	3.84	4.2	0.018
Site 3 (Power)	124.6	ND	3.71	4.4	0.041
5/27/2010					
Site 1 (Bells)	238.2	ND	0.63	0.9	0.333
Site 2 (South)	96	ND	2.49	2.9	0.024
Site 3 (Power)	261.3	ND	1.62	1.9	0.222
Site 3 Duplicate	248.1	ND	1.59	1.9	0.234
Site 3 Blank	ND	ND	0.02	ND	ND
7/28/2010					
Site 1 (Bells)	148.3	ND	0.76	1.1	0.031
Site 2 (South)	218.7	ND	2.05	2.3	0.053
Site 3 (Power)	290	ND	1.73	2	0.13
10/26/2010					
Site 1 (Bells)	24.6	ND	2.96	3.4*	0.053
Site 2 (South)	13.4	ND	3.86	4.2*	0.008
Site 2 Duplicate	10.7	ND	3.86	8.6*	0.007
Site 3 (Power)	7.5	ND	3.43	3.9*	0.019

Discussion

The south tributary stands out as an important source of nitrate within the Upper Muddy Creek Watershed. This preliminary work suggests need for further investigation of the source of nitrate in the South Tributary. The seasonality of the data suggests an important groundwater contribution which could either be from natural sources or from anthropogenic sources of elevated nitrate in groundwater. Both tributaries show opportunity for reductions in phosphorus loading but Bells stands out as an important contributor of phosphorus relative to its size. Concentrations of total phosphorus between 0.1 and 0.35 mg/L in the spring result in Bells tributary contributing over a quarter of the load of total phosphorus to the watershed delineated at Power while it accounted for less than a quarter of the discharge (see pie charts in the appendix).

References

1. MT Department of Environmental Quality. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers. Michael Suplee, Ph.D. - Montana Department of Environmental Quality; Vicki Watson, Ph.D. – University of Montana; Arun Varghese and Josh Cleland – ICF International. 2008. Available on the web at: http://deq.mt.gov/wqinfo/standards/PDF/WhitePaper_FNL3_Nov12-08.pdf [verified December 21, 2010].
2. Montana Watershed (5th-code) Hydrologic Unit Boundaries, Bozeman MT, Montana Natural Resource Conservation Service, publication date 2007, downloaded from NRIS

Appendix A

Figure 9. Discharge, nitrate load and total phosphorus load at Bells Tributary and South Tributary expressed as percentage of loads measured at the Power site. "Other" represents the other tributaries not measured and was calculated as the remaining fraction of the loads at Power not accounted for by measurements at Bell Tributary and South Tributary. These graphs are intended to illustrate the relative importance of the loads contributed by the two tributaries to the load at the Power site.