Missouri River Water Quality Report 2016 for the Upper Missouri River, MT

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Collecting water samples upstream of Craig, MT
Photo Taken By David Stagliano

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Acknowledgements

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Executive Summary

In 2016, UMOWA began collecting water quality data at seven sites on the Upper Missouri River between Wolf Creek and Cascade. These sites were chosen to coincide with preexisting sites that were established for the sampling of macroinvertebrates by Montana Biological Survey in 2015. Samples were collected in April, July, and October of 2016. The goals of the water sampling project are: 1) to establish baseline water quality data as it may affect benthic macroinvertebrate and plant communities and 2) collect baseline information about total suspended and dissolved solids, nutrients, and metal concentrations to allow for spatial and temporal comparisons of water quality in the Upper Missouri River. The water quality data collected provided evidence for several major seasonal and spatial trends.

The following materials were not found in any water samples during any of the sampling periods: bromide, ammonia, cadmium, chromium, selenium, silver, and zinc. Concentrations of alkalinity, bicarbonate, calcium, and magnesium were relatively constant at all sites during all sampling periods. These concentrations are constant because they are determined by the underlying geology of the Upper Missouri River basin. Concentrations of total suspended solids were highest during April due to spring runoff but very low during the other sampling periods. At the two sample sites located directly downstream of major tributaries, Little Prickly Pear Creek and the Dearborn River, reduced concentrations of chloride, sulfate, fluoride, arsenic, potassium, and sodium were observed during all sampling periods. This suggests that these two tributaries have a localized effect on Missouri River water quality. The April samples from the site located downstream of Little Prickly Pear Creek yielded the highest observed concentrations of copper, iron, and lead. This suggests that spring runoff temporarily increases the concentrations of heavy metals that Little Prickly Pear Creek contributes to the Missouri River. All of the observed nutrient concentrations showed seasonal trends. Inorganic nitrogen concentrations were low in April and July and highest in October. Total nitrogen and total phosphorus concentrations were highest in April and October and lowest in July. This suggests that aquatic plants are consuming significant amounts of nutrients during the summer growing season. Inorganic nitrogen may be a limiting factor for plant growth during this time. Nutrient levels for all sample sites during all sample periods were below MDEQ's numeric nutrient standards. Concentrations of other pollutants and heavy metals for all sample sites during all sample periods were below MDEQ's aquatic life standards (where applicable).

1.0 Introduction

The 2.84 mile reach of the Missouri River from Holter Dam to Little Pear Creek is listed as impaired for aquatic life due to increased total nitrogen concentrations due to grazing in riparian zones, flow regime alterations from municipal point source discharges, increased total phosphorus concentrations due to natural sources, and sedimentation/siltation caused by on-site treatment systems (septic systems) and upstream impoundments (MDEQ 2016). The 20.93 mile reach of the Missouri River from Little Prickly Pear Creek to Sheep Creek is listed as impaired for aquatic life due to increased arsenic concentrations due to grazing in riparian zones, increased total nitrogen concentrations due to impacts from hydrostructure flow regulation/modification, and sedimentation/siltation caused by irrigated crop production and natural sources (MDEQ 2016).

In 2016, the Aquatic Resources Committee of the upper Missouri Watershed Alliance (UMOWA) determined to fund the collection of water quality data on a periodic and consistent basis to monitor the heath of the Upper Missouri River. Samples would be collected concurrently with macroinvertebrate samples being collected by Montana Biological Survey (Stagliano, 2015) to determine if any correlation exists between water chemistry and aquatic insect community structure. The overall goals of the project were to 1) establish baseline water quality data as it may affect benthic macroinvertebrate and plant communities, and 2) collect baseline information about total suspended/dissolved solids and nutrient and metal concentrations to allow for spatial and temporal comparisons of water quality.

2.0 Methods

2.1 Sample Site Selection

Water quality samples were collected from seven sites between Wolf Creek and the town of Cascade. The sites coincided with the sites that have been sampled for macroinvertebrates by Montana Biological Survey for UMOWA since 2015. The sites were chosen to be spatially representative of the entire upper Missouri River. The sites capture the influence of the three major tributaries (Little Prickly Pear Creek, the Dearborn River, and Sheep Creek) upon water quality.

Station ID	Site Name	Latitude	Longitude
MO_LPPC_US	MISSOURI RIVER U/S LITTLE PRICKLY PEAR	47.02281	-112.01527
MO_LPPC_DS	MISSOURI RIVER D/S LITTLE PRICKLY PEAR	47.02345	-112.01523
MO_CRAIG	MISSOURI RIVER U/S CRAIG	47.05415	-111.96701
MO_DEAR_US	MISSOURI RIVER U/S DEARBORN	47.12819	-111.91174
MO_DEAR_DS	MISSOURI RIVER D/S DEARBORN	47.12791	-111.9109
MO_HARDY	MISSOURI RIVER U/S OF SHEEP CREEK (HARDY BR.)	47.16781	-111.83366
MO_CASCADE	MISSOURI RIVER AT CASCADE FAS	47.28062	-111.69113

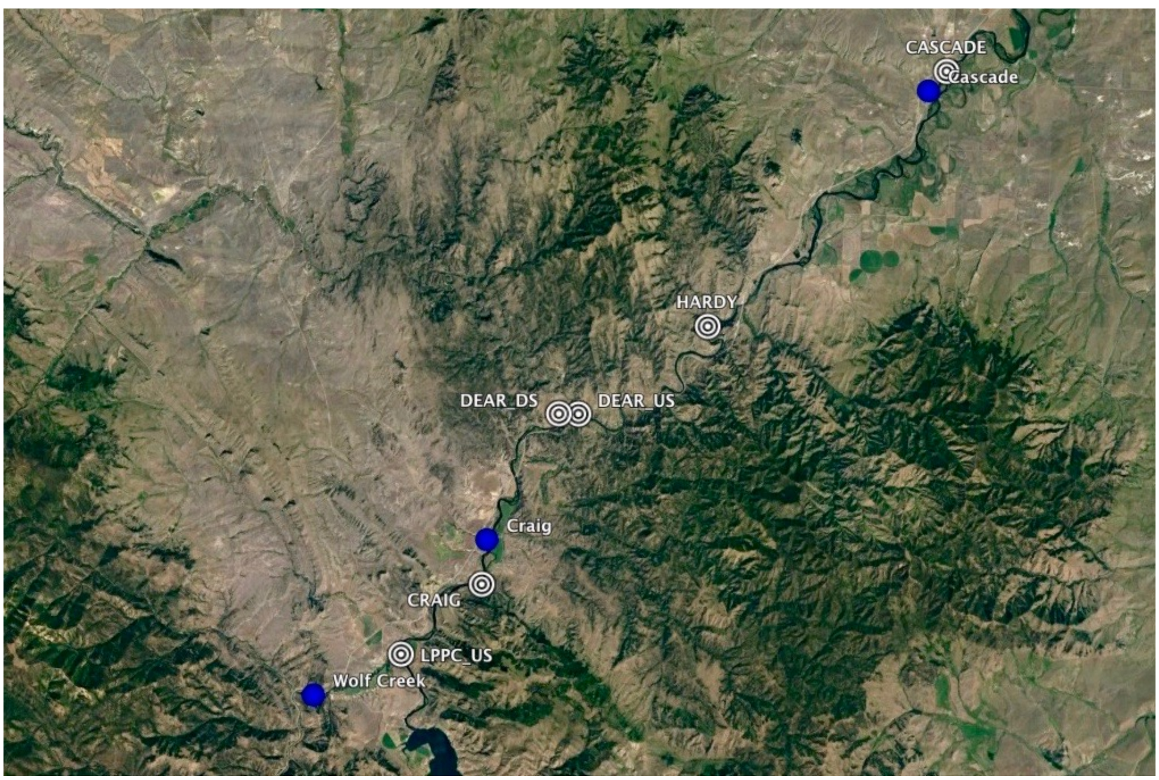


Figure 1 Samples Sites are denoted by bull's-eyes

2.2 Sample Timing

Samples were collected seasonally in the spring, summer, and fall in order to examine temporal changes in water quality throughout the year. Spring samples were collected April 30th. These samples captured water quality before the main runoff period for the main stem of the Missouri River. Summer samples were collected July 11th. These samples captured base-flow water quality during the summer growing season. Fall samples were collected October 22nd. These samples captured base-flow water quality during the post-summer growing season.

The image below shows flows recorded at Holter Dam throughout 2016. The red arrows represent water quality sampling dates.

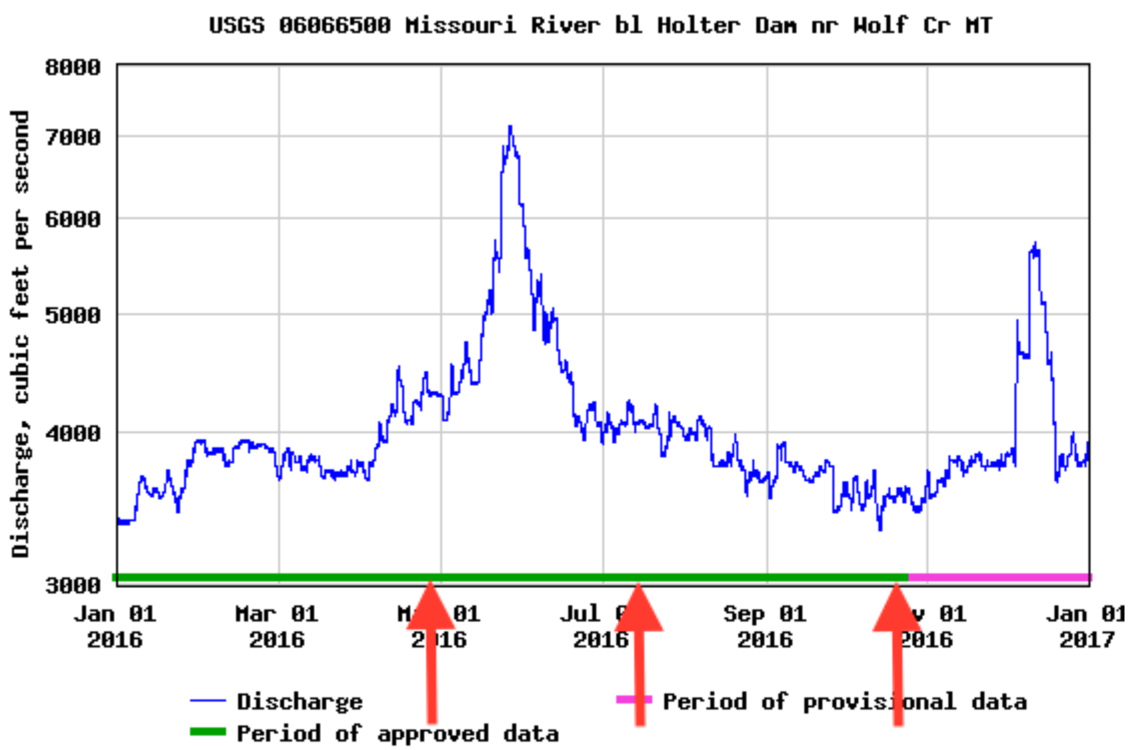


Figure 2 Red arrows represent sampling dates

2.3 Water Sampling Methods

Water quality samples were collected in sterilized bottles provided by Energy Laboratories Inc. At the time of sample collection, each bottle and lid were triple-rinsed with ambient river water prior to collecting the final sample. Total nitrogen samples were collected in 250ml HDPE bottles and kept on ice until analyzed. Total phosphorus and inorganic nitrogen (nitrate and nitrite) samples were collected in 250 ml HDPE bottles, preserved with sulfuric acid, and kept on ice until analyzed. Total suspended solids and total dissolved solids samples were collected in 1000ml HDPE bottles and kept on ice until analyzed. Total recoverable metal samples were collected in 250ml HDPE bottles, preserved with nitric acid, and kept on ice until analyzed. Hardness was calculated from the total recoverable metals bottles. All water samples were submitted to Energy Laboratories Inc. within 48 hours of collection.

2.4 Quality Assurance – Field Blanks and Duplicates

During each seasonal sampling, one field duplicate and one field blank set of samples were collected to ensure the quality of the sampling procedure and the accuracy of the lab analysis.

Field duplicates consist of an extra set of sample bottles filled with the same water from the same sampling site. Field duplicates were collected, handled, and stored in the same way as the routine samples for laboratory shipment. In theory, duplicate samples should yield results identical to the other sample taken at the same site at the same time. Collecting and analyzing duplicate samples ensures that the sampling and analysis process is consistently accurate.

Field blanks consist of an extra set of sample bottles filled with deionized (DI) water and transported with the others samples in the field. Field blanks were prepared in the field at the same time as the routine samples and handled and analyzed in the same way as the routine samples. In theory, field blank samples should be clean of all contaminants. Collecting and analyzing field blank samples ensures that the sampling and analysis processes are free of contaminants.

2.5 Water Quality Analysis

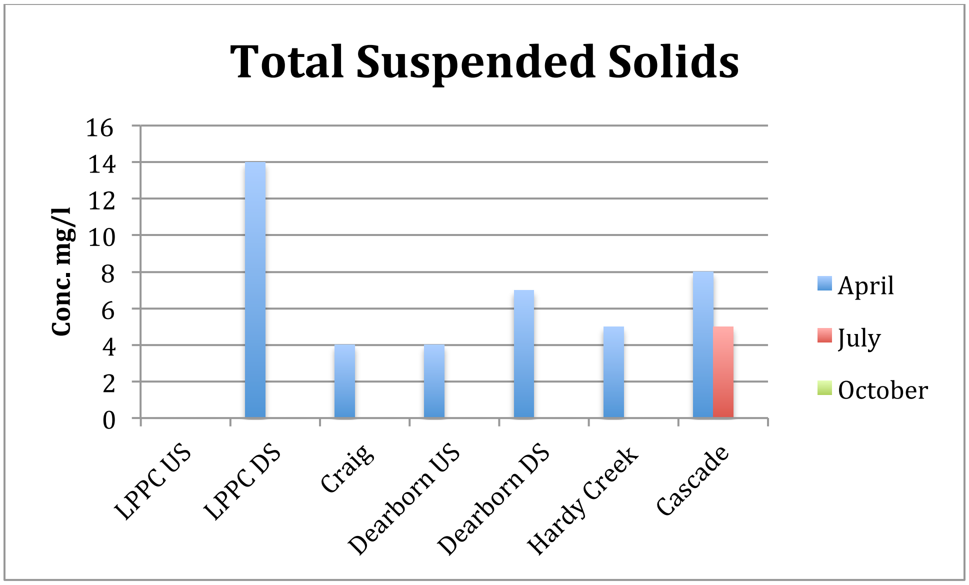
Energy Laboratories Inc. in Helena, MT analyzed all water quality data. Energy Laboratories Inc. routinely processes samples for MDEQ and has been proven to produce data of very high accuracy and consistency.

3.0 Results

Whenever possible, results were interpreted relative to established MDEQ numeric standards. MDEQ has established these numeric water quality criteria in effort to control excessive pollution in Montana’s rivers, lakes, and streams. MDEQ Circular 7 (MDEQ, 2012) provided Montana numeric water quality standards and MDEQ Circular 12A (MDEQ, 2014) provided base numeric nutrient standards. When numeric standards were not available from MDEQ, other applicable standards were applied in order to provide context.

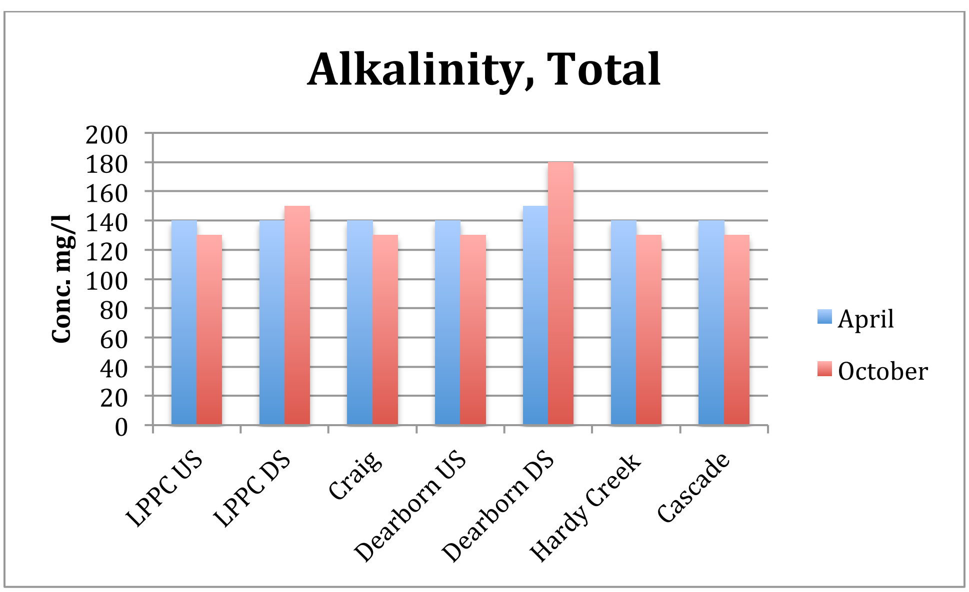
3.1 Total Suspended Solids

Total suspended solids concentrations were elevated in the April samples. This is likely due to spring runoff. In July and October, these concentrations dropped to low or nonexistent levels. This suggests that with the exception of spring runoff, the water clarity in the Missouri River is good.



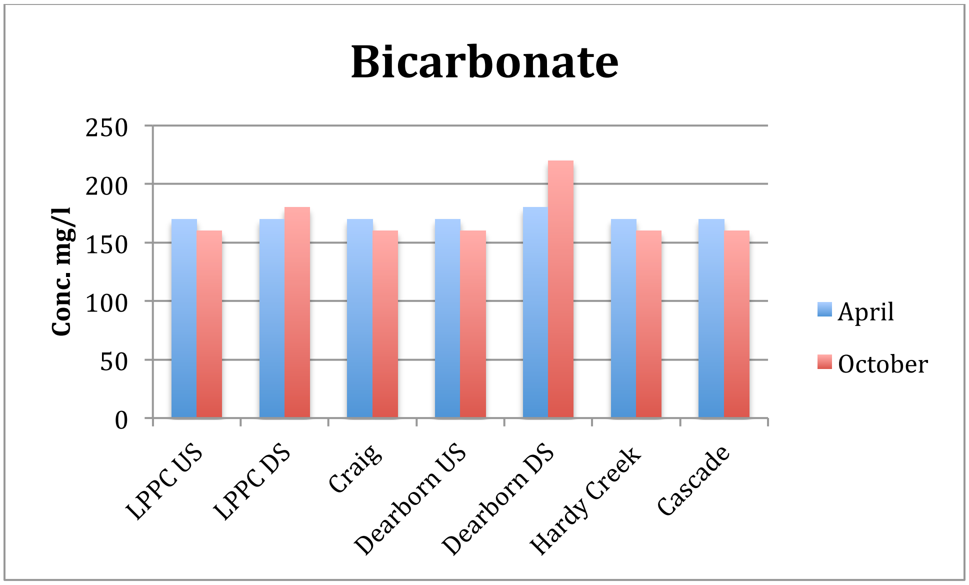
3.2 Alkalinity

Alkalinity concentrations were between 130 and 180 mg/l. Alkalinity was consistently high in all samples. The alkalinity correlates with a year-round pH value of 7.5 – 8.0. The “basic” alkalinity of the Missouri River is largely due to the presence of limestone geology within the upper Missouri River basin.



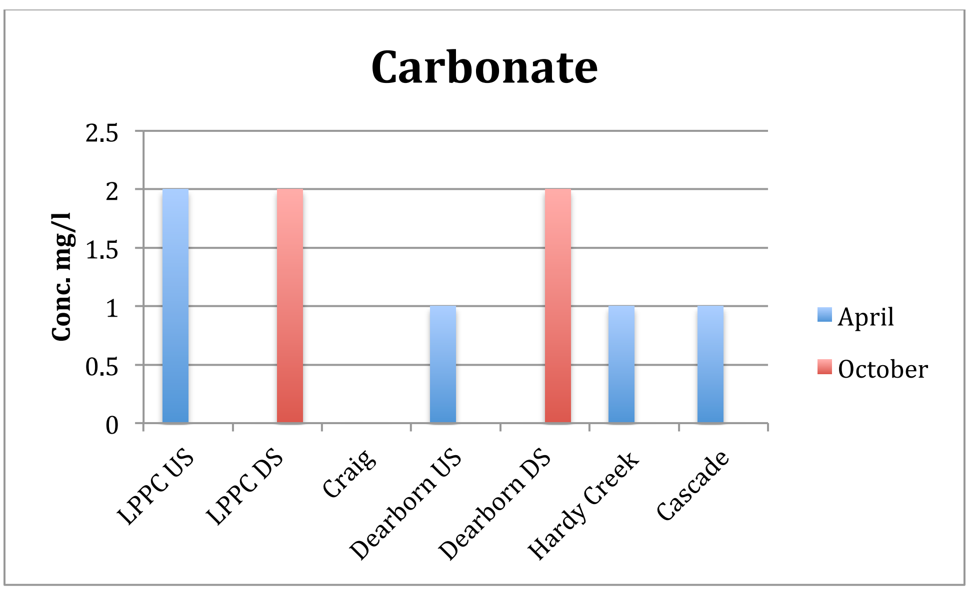
3.3 Bicarbonate

Bicarbonate concentrations were between 160 and 220 mg/l. Bicarbonate concentrations were consistently high throughout the year. The limestone geology in the Upper Missouri River basin contributes high levels of bicarbonates that make the water in the Missouri River "hard."



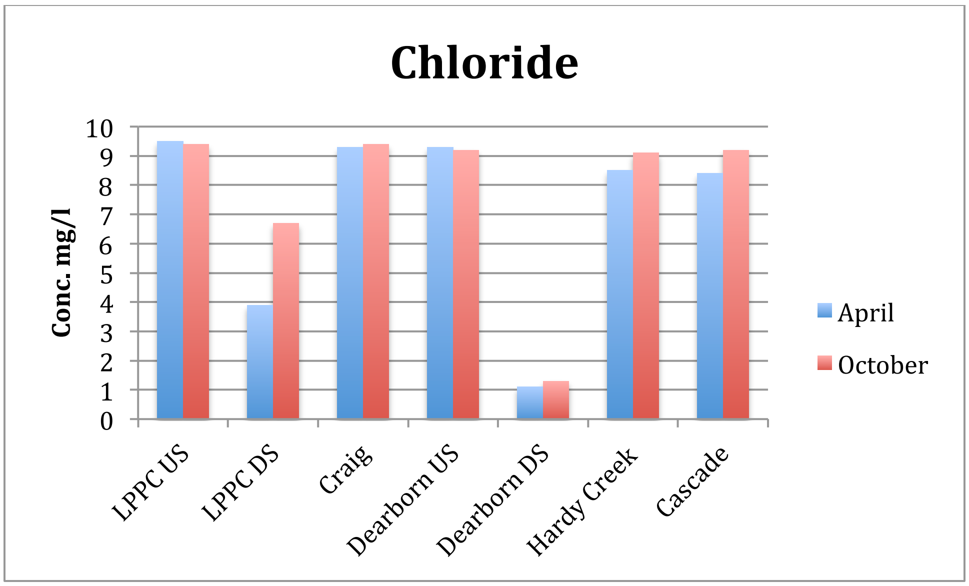
3.4 Carbonate

Carbonate concentrations were between 0 and 2 mg/l. Relative to bicarbonate levels, carbonate levels were low or nonexistent. It is unclear why higher carbonate levels have not been observed.



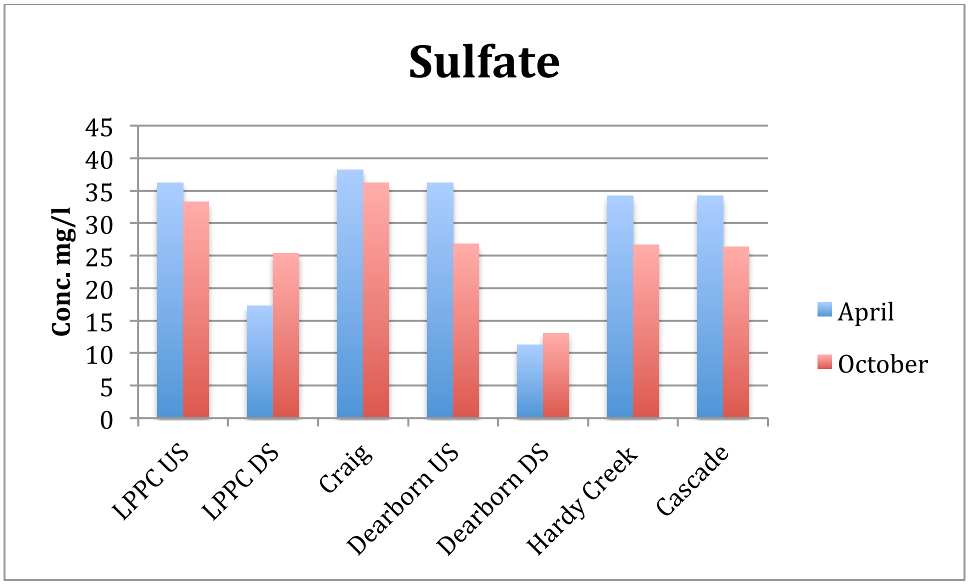
3.5 Chloride

Chloride concentrations were between 1.1 and 9.4 mg/l. Chloride concentrations were much lower at the two sites located below tributaries. No significant seasonal trend in chloride concentrations was detected. MDEQ does not have an aquatic life standard for chloride, but studies performed by the Montana Department of Transportation have suggested that chloride becomes dangerous at concentrations over 230 mg/l (MDT, 2004). All Missouri River water samples were below this threshold.



3.6 Sulfate

Sulfate concentrations were between 11 and 38 mg/l. Sulfate concentrations were much lower at the two sites located below tributaries. Relative to the April samples, sulfate concentrations were slightly lower in October. MDEQ does not have an aquatic life standard for sulfate concentrations but the EPA has set a secondary drinking water standard of 250 mg/l (EPA, 2017). All Missouri River samples were below this threshold.

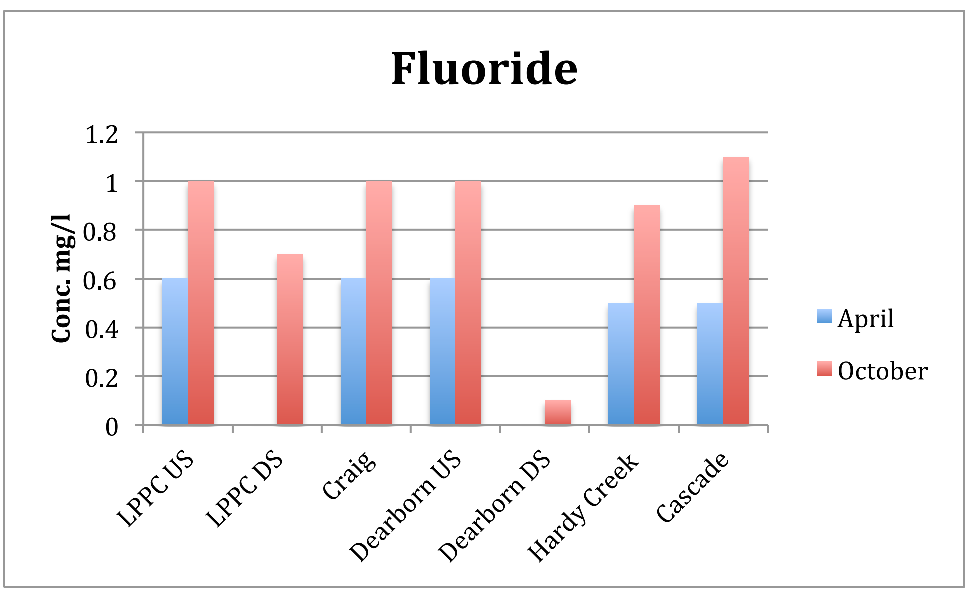


3.7 Bromide

Bromide was not detected in any of the samples analyzed (April and October).

3.8 Fluoride

Fluoride concentrations were between 0 and 1.1 mg/l. Fluoride concentrations were higher in October than they were in April. Fluoride concentrations were much lower at the two sample sites located below tributaries. MDEQ does not have an aquatic life standard for fluoride concentrations, but the EPA has set a standard of 4 mg/l for fluoride concentrations in drinking water. All Missouri River samples were below this threshold.

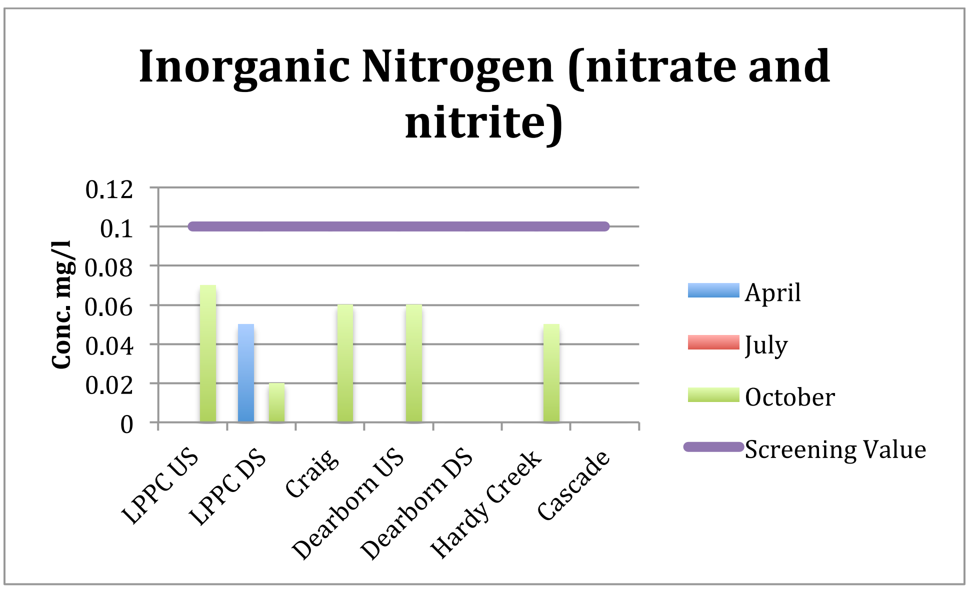


3.9 Ammonia

Ammonia was not detected in any of the Missouri River samples.

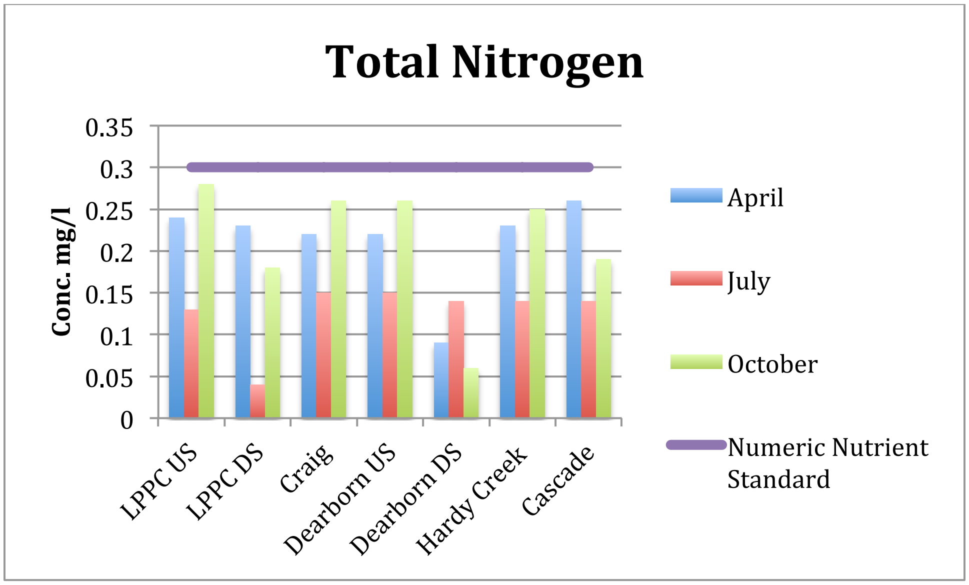
3.10 Inorganic Nitrogen (nitrates and nitrites)

Inorganic Nitrogen concentrations were between 0 and 0.07 mg/l. Inorganic nitrogen concentrations were low or nonexistent in April and July and higher in October. It is likely that aquatic vegetation is using most of the available inorganic nitrogen during the growing season leading to lower concentrations in April and July. MDEQ has set a recommended screening value for inorganic nitrogen levels at 0.1 mg/l. All Missouri River samples were far below this threshold.



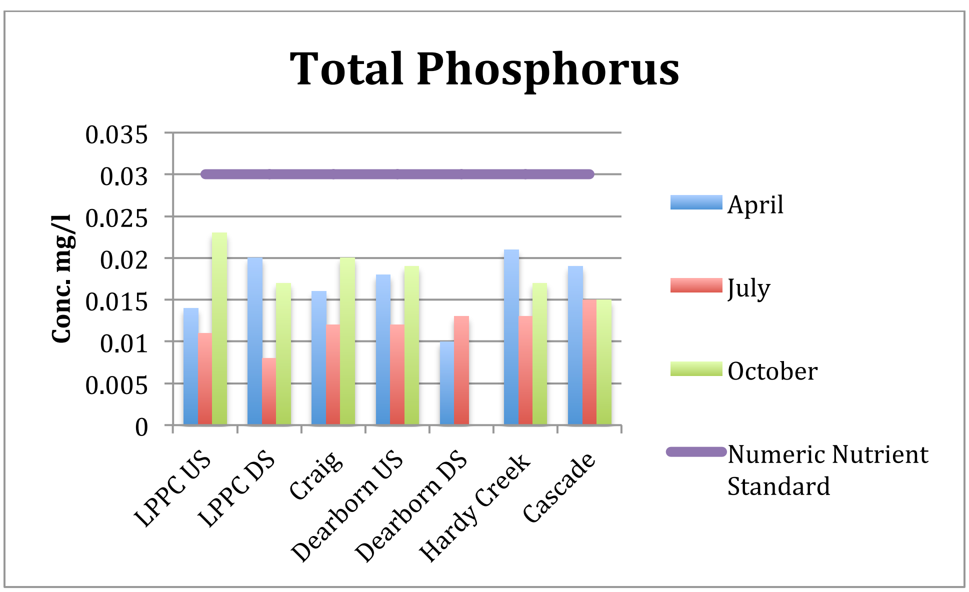
3.11 Total Nitrogen

Total nitrogen concentrations were between 0.04 and 0.28 mg/l. With the exception of the Dearborn DS site, total nitrogen levels were higher in April and October and lower in July. The reduction in July is likely due to uptake by plants during the summer growing season. MDEQ has set a numeric nutrient standard of 0.3 mg/l for total nitrogen concentrations. All Missouri River samples were below this threshold, but many samples were approaching it, especially during April and October.



3.12 Total Phosphorus

Total Phosphorus concentrations were between 0 and 0.023 mg/l. With the exception of the Dearborn DS site, total phosphorus concentrations were higher in April and October and lower in July. The reduction in July is likely due to uptake by plants during the summer growing season. MDEQ has set a numeric nutrient standard of 0.03 mg/l for total phosphorus concentrations. All Missouri River samples were below this threshold.



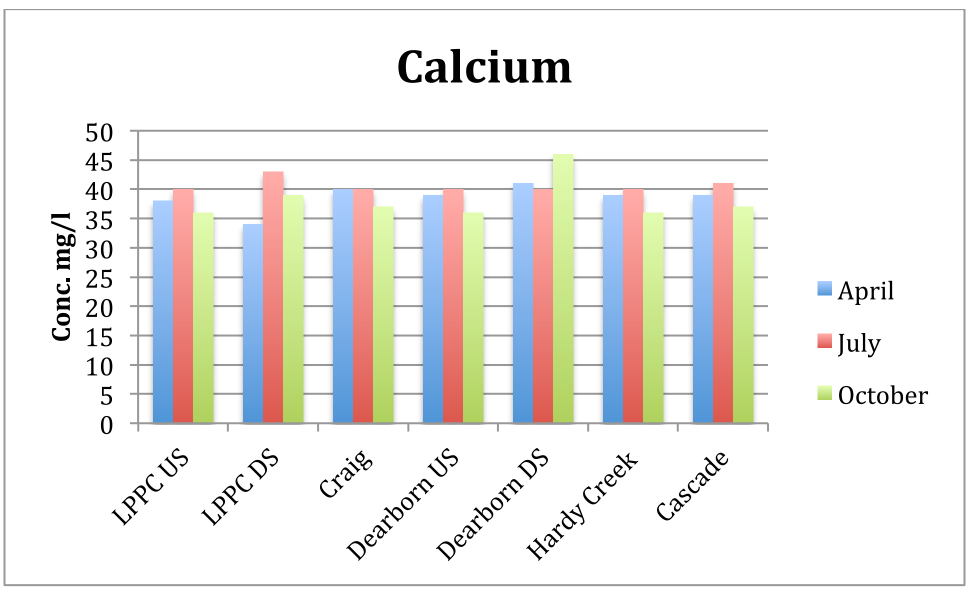
Total Recoverable Metals

The Montana DEQ has set acute and chronic Aquatic Life Criteria for common metal pollutants. Acute levels are dangerous to aquatic organisms even if the duration of exposure is short. Chronic levels are dangerous to aquatic organisms when they endure over a longer period of time.

The aquatic life criteria for some metals are hardness dependent. For the 2016 Missouri River water samples, total hardness was only measured in the July samples. July samples had an average hardness of 153 mg/l. Since compounds containing calcium and magnesium primarily cause hardness, and calcium and magnesium concentrations were very similar (see below) for all sites across all seasons, a hardness value of 153 mg/l was used in all hardness dependent calculations in this analysis.

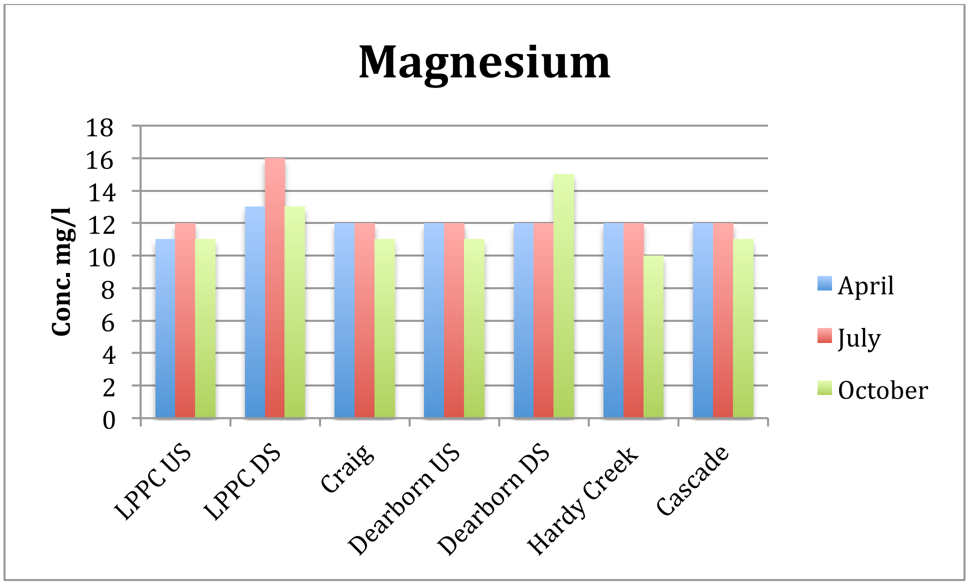
3.13 Calcium

Calcium concentrations were between 34 and 46 mg/l. Calcium concentrations were similar for all sites and seasons. These moderately high levels of calcium are the result of the underlying limestone geology of the upper Missouri River basin.



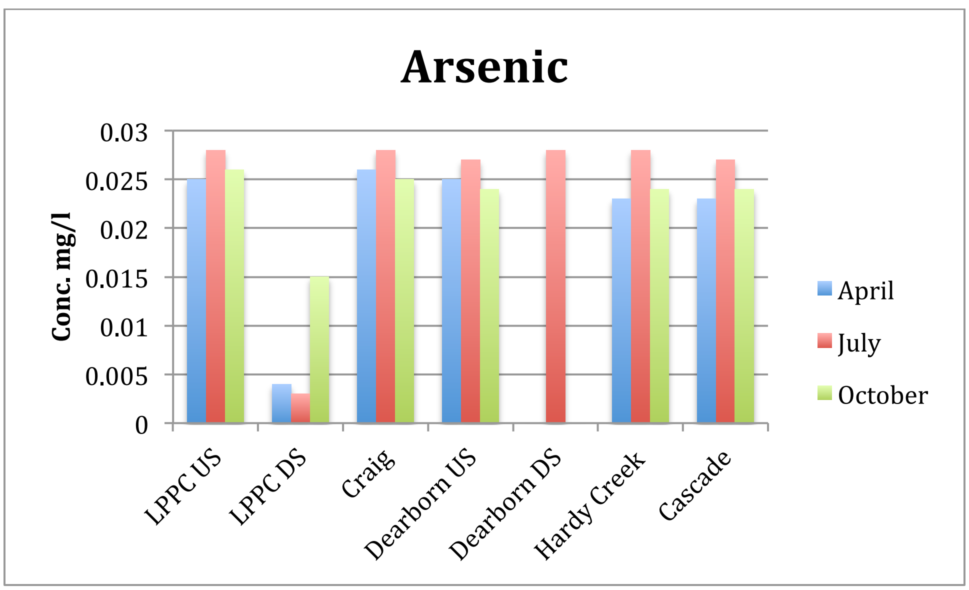
3.14 Magnesium

Magnesium concentrations were between 10 and 16 mg/l. Magnesium concentrations were similar at all sites during all seasons. The primary impact of Magnesium on a body of water is to increase the water's hardness.



3.15 Arsenic

Arsenic concentrations were between 0.003 and 0.026 mg/l. The concentration of arsenic was similar throughout the year at all sites except the two tributary sites. At the LPPC DS site, arsenic concentrations were very low in April and July and elevated in October. At the Dearborn DS site, arsenic concentrations were 0 in April and October and elevated in July. MDEQ has set an acute aquatic life standard of 0.34 mg/l and a chronic aquatic life standard of 0.15 mg/l for arsenic concentrations. All Missouri River samples were below this threshold.



3.16 Cadmium

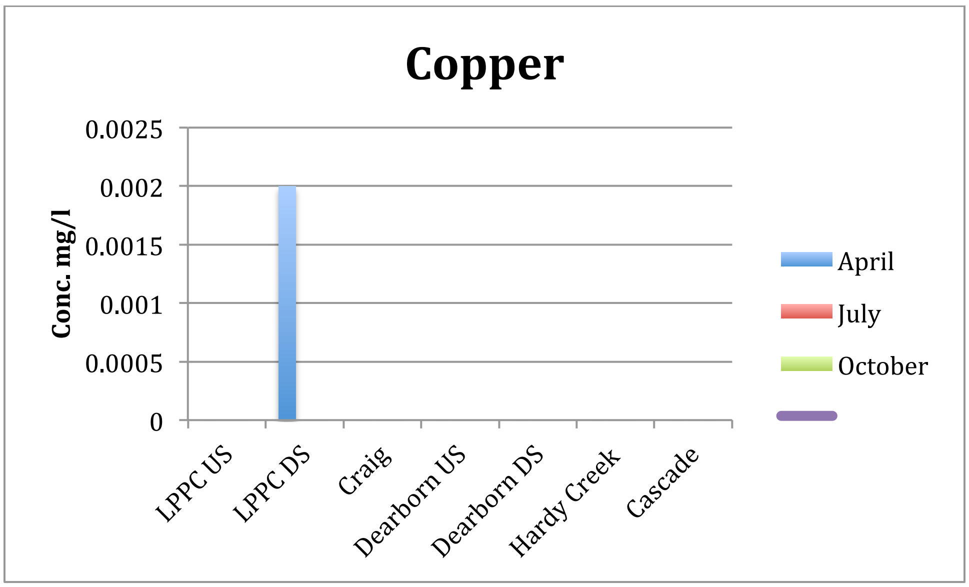
Cadmium was not detected in any of the samples analyzed (April, July, and October).

3.17 Chromium

Chromium was not detected in any of the samples analyzed (April, July, and October).

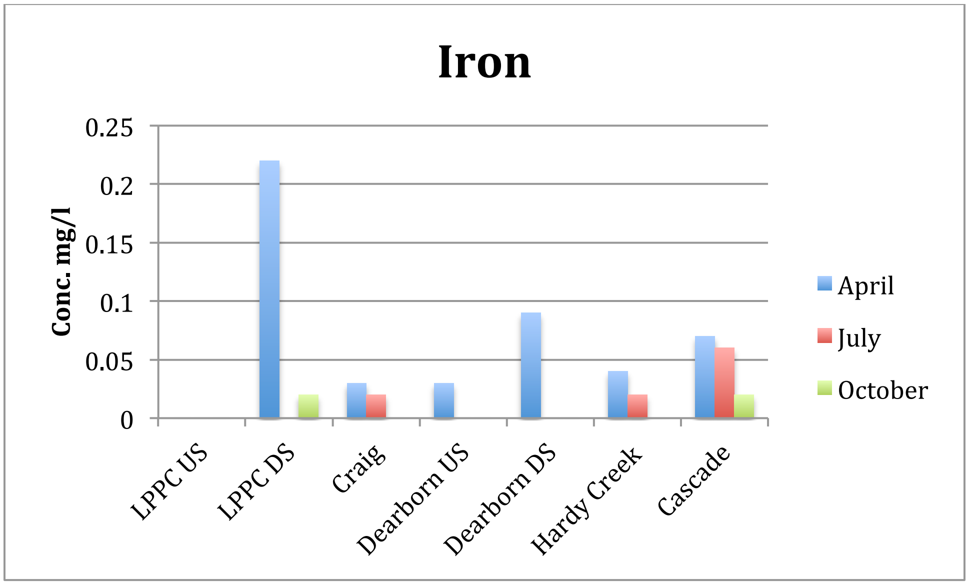
3.18 Copper

Copper was only detected in one sample. In April, the LPPC DS site had a copper concentration of 0.002 mg/l. Relative to the hardness of the Missouri River, MDEQ has set an acute aquatic life standard of 0.021 mg/l and a chronic aquatic life standard of 0.0134 mg/l. All Missouri River samples were below this threshold.



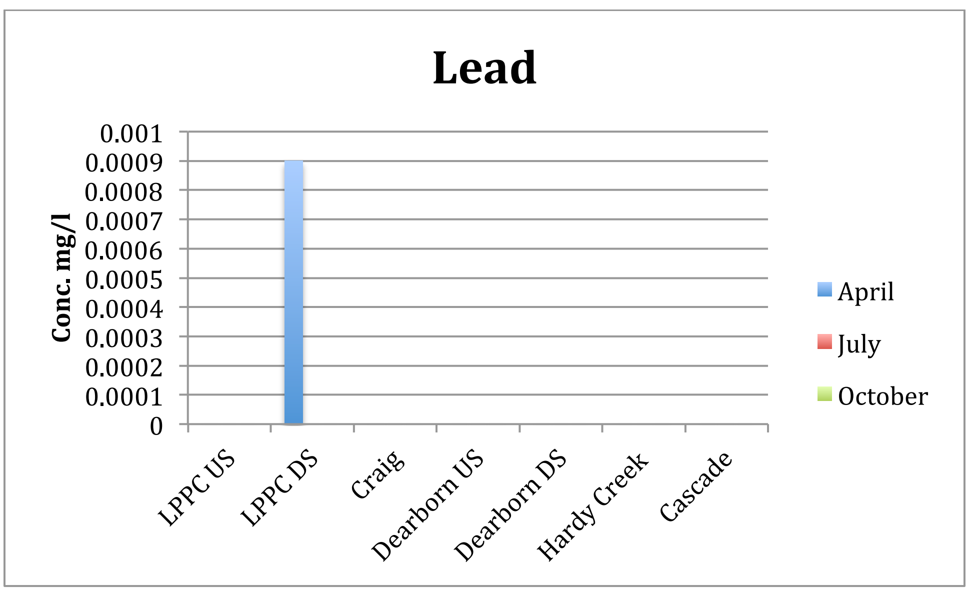
3.19 Iron

Iron concentrations were between 0 and 0.22 mg/l. Iron was highest in the April LPPC DS sample. Iron concentrations were higher in April than they were in July and October at all sites where iron was observed. Runoff in the tributaries is likely responsible for the elevated iron levels observed in April. MDEQ has set a chronic aquatic life standard of 1.0 mg/l for iron concentrations. All the Missouri River samples were below this threshold.



3.20 Lead

Lead was only detected in one sample. In April, the LPPC DS sample had a lead concentration of 0.0009 mg/l. Since lead was not detected in the July or October samples taken at this site, it is likely that runoff from Little Prickly Pear Creek is responsible for this localized lead concentration. Relative to the hardness of the Missouri River, MDEQ has set an acute aquatic life standard of 0.140 mg/l and a chronic aquatic life standard of 0.005 mg/l. All the Missouri River samples were below this threshold.



3.21 Selenium

Selenium was not detected in any of the samples analyzed (April, July, and October).

3.22 Silver

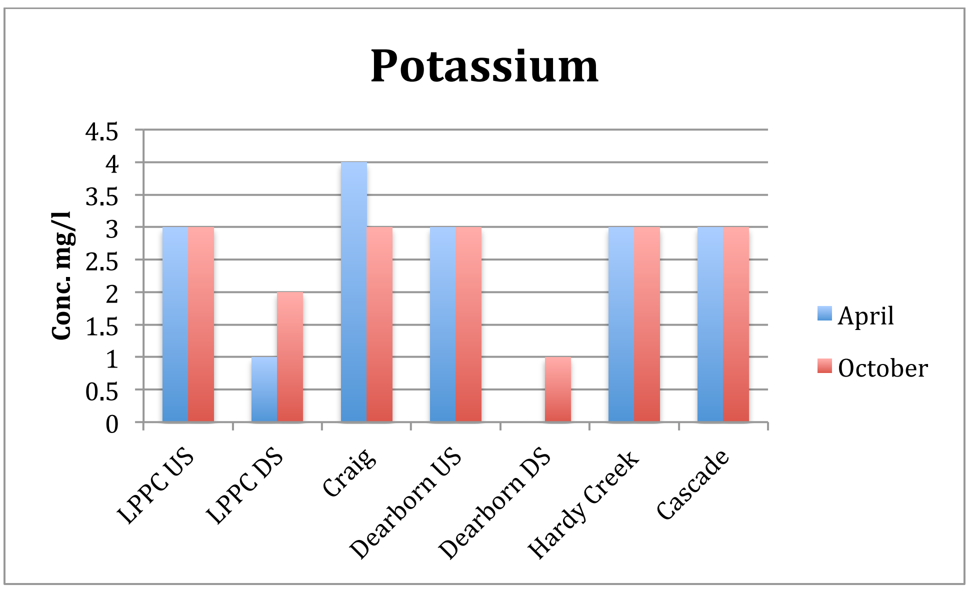
Silver was not detected in any of the samples analyzed (April, July, and October).

3.23 Zinc

Zinc was not detected in any of the samples analyzed (April, July, and October).

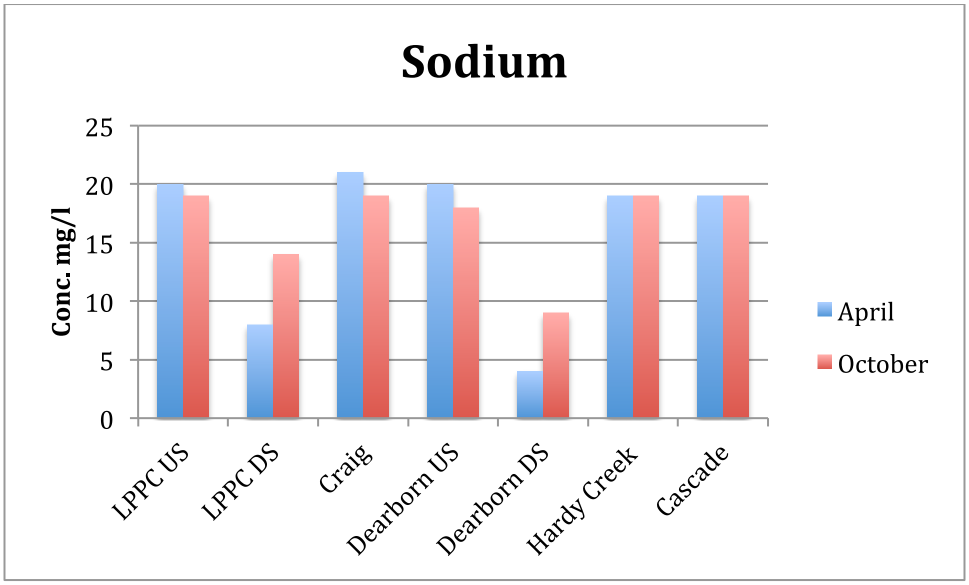
3.24 Potassium

Potassium concentrations were between 0 and 4 mg/l. The concentration of potassium was similar throughout the year at all sites except the two tributary sites. The two tributaries sites had reduced concentrations of potassium during all sampling periods. Potassium is only dangerous at very high concentrations so the EPA and MDEQ have not developed an aquatic life standard.



3.25 Sodium

Sodium concentrations were between 4 and 21 mg/l. The concentration of sodium was similar throughout the year at all sites except the two tributary sites. The two tributary sites had reduced concentrations of sodium. Standards have not been developed for the effect of sodium on aquatic organisms.



4.0 Conclusion

This dataset has established a comprehensive summary of the current water quality of the upper Missouri River and will provide a valuable baseline dataset for future monitoring efforts. This dataset has uncovered several spatial and temporal trends in regard to the water quality of the upper Missouri River. The following materials were not detected in any of the samples collected during any of the sampling periods: bromide, ammonia, cadmium, chromium, selenium, silver, and zinc. The concentrations of alkalinity, bicarbonate, calcium, and magnesium were constant at all sites during all sampling periods. The concentrations of these materials are determined largely by the underlying geology of the Upper Missouri River basin and therefore remain relatively constant year-round. The concentration of total suspended solids was significantly higher in April due to spring runoff, but low or nonexistent at all sites for the rest of the year. Samples collected from the site downstream of Little Prickly Pear Creek and the site downstream of the Dearborn River had reduced levels of chloride, sulfate, fluoride, arsenic, potassium, and sodium during all sampling periods. This suggests that these two tributaries are causing a localized reduction in the concentrations of these materials observed in the upper Missouri River. Nutrient concentrations varied seasonally. Inorganic nitrogen concentrations were very low or nonexistent in April and July and highest in October. This suggests that aquatic vegetation is consuming most of the available inorganic nitrogen during the spring and summer. Inorganic nitrogen availability may be a limiting factor for plant growth in the upper Missouri River. Total nitrogen and phosphorus concentrations were highest during April and October and lowest during July. This suggests that aquatic vegetation growth is causing a decrease in total nitrogen and total phosphorus concentrations during the summer growing season. In April, at the sample site located downstream of Little Prickly Pear Creek, copper, iron, and lead were observed at concentrations much higher than those observed at any other sites during any sampling period. This suggests that spring runoff causes a significant increase in the amount of heavy metals that Little Prickly Pear Creek contributes to the Missouri River. In the future, the continuation of this dataset during years of varied flow will facilitate the examination of how differing flows alter water quality trends in the upper Missouri River.

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