WATER QUALITY STATUS AND TRENDS MONITORING SYSTEM FOR THE CLARK FORK-PEND OREILLE WATERSHED

Summary Monitoring Report 2006

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CLARK FORK-PEND OREILLE WATERSHED MONITORING, 2006

EXECUTIVE SUMMARY

This report summarizes water quality data collected in the Clark Fork-Pend Oreille Basin in 2006 by the Tri-State Water Quality Council. Analyses presented in this study describe the temporal and spatial variability in concentrations of algal nutrients, heavy metals and periphyton (attached algae) in the Clark Fork-Pend Oreille watershed.

The Tri-State Water Quality Council established seven priority water quality monitoring objectives for the Clark Fork-Pend Oreille watershed. These include:

1) Evaluating time trends in nutrient concentrations in the mainstem Clark Fork River and selected tributaries;
2) evaluating time trends for algal standing crops in the Clark Fork River;
3) monitoring compliance with established summer nutrient concentration target levels in the Clark Fork River;
4) estimating nutrient loading rates to Pend Oreille Lake from the Clark Fork River;
5) evaluating time trends for algal standing crops in near-shore areas of Pend Oreille Lake;
6) evaluating time trends for Secchi disc depth in Pend Oreille Lake; and
7) evaluating time trends for nutrient concentrations in the Pend Oreille River.

Nutrient constituents monitored included total phosphorus, total nitrogen (total Kjeldahl nitrogen plus nitrate + nitrite nitrogen), total soluble inorganic nitrogen (nitrate + nitrite plus ammonia nitrogen), and dissolved ortho-phosphorus (soluble reactive phosphorus). Metals constituents included total recoverable and dissolved fractions of copper, zinc, cadmium, lead and arsenic. Attached algae levels were measured in terms of chlorophyll *a* and ash-free dry weight from natural substrate samples. Water quality records from 15 river stations and 9 lake stations in a three-state area were analyzed.

This summary assessment report focuses on water quality status and spatial patterns reflected in instream concentrations of the selected monitoring variables. The report does not provide an in-depth assessment of long-term time trends in the data set, nor does it include an appraisal of nutrient loading to Pend Oreille Lake. Those monitoring objectives are addressed in separate reports, the first representing monitoring during the 1998-2002 time period (Land & Water 2004). The 2006 data described in this report will be analyzed for time trends as part of a planned second assessment report covering the years 2003-2007.

In general, nutrient concentrations in 2006 were lowest in the Pend Oreille River sites, but more varied in the Thompson and Clark Fork Rivers. Generally speaking, nitrogen constituents in the Thompson and Clark Fork Rivers have an increasing spatial trend, while phosphorus constituents exhibit a decreasing spatial trend.

Total recoverable and dissolved metals constituents were generally low during the 2006 calendar year, with median values often at or below the analytical detection limits. Concentrations above the limits of detection did occur, however, and these were usually associated with high flow events during the late-winter or spring periods. The Clark Fork River site below Thompson Falls typically displayed the highest median concentrations of metals, and had the highest number of samples above detection.

Measured summer nutrient concentrations in the Clark Fork River during 2006 generally exceeded the established nutrient target levels. Median total nitrogen concentrations exceeded the instream target of 300 µg/L at five of nine monitoring stations. Median total phosphorus concentrations exceeded the instream target of 20 µg/L at four stations above Missoula. Median total soluble nitrogen concentrations exceeded the instream target of 30 µg/L at four sites, and median soluble reactive phosphate concentrations exceeded the instream target of 6 µg/L at six sites in 2006. Target level compliance was met for total nitrogen in the Clark Fork River above Missoula, at Huson and above Flathead. Target level compliance was not met for any other nutrient constituents during summer 2006. To achieve target level compliance, no more than one of ten samples can exceed the established target value.

Algal standing crops in the Clark Fork River, measured as chlorophyll *a*, were generally low during 2006 when compared to previous sampling years. This trend was evident when all sites were pooled and for individual sample locations. Median chlorophyll *a* values were the lowest ever recorded for the Clark Fork River site below Missoula, and considered quite low at most other stations except Clark Fork River above Little Blackfoot, which had its second highest mean ever recorded. All sample locations had lower mean chlorophyll *a* values during 2006 than in 2005, which was a high year for algae growth throughout the watershed. Four of the sample sites had their highest mean chlorophyll *a* values in August, while three sites peaked in September. When August and September data are combined to create a summer mean chlorophyll *a* value, four stations, including the Clark Fork above Missoula, below Missoula, at Huson and above Flathead, were below the instream summer mean target level.

Mean chlorophyll *a* values for algae samples collected from natural substrates in Pend Oreille Lake in 2006 were among the mid-range when compared to previous sample years (1998-2003). Three of the long-term sampling sites (Bayview, Kootenai and Trestle) exhibited the third lowest yearly mean for the period of record, while sites at Springy Point and Sunnyside had the highest and second highest yearly mean on record, respectively. The site at Springy Point has shown a consistent increase in chlorophyll *a* concentration throughout the period of record. In 2006, mean chlorophyll *a* values were lowest at the Bayview site and highest at the Springy Point site located near the outlet of Pend Oreille Lake.

Mean Secchi depth measurements at the Bayview site during 2006 were among the mid-range when compared to the period of record. Sampling locations at Oden Bay and Sunnyside exhibited the lowest mean Secchi depth readings during 2006, indicating low water clarity. Conversely, sites at PDO North and Telache had the highest mean measurements during 2006.

The 2006 monitoring program is the fourth year of a second five-year data collection cycle. A comprehensive analysis of water quality status, trends and nutrient loads will be performed following the 2007 monitoring year, similar to the recently completed analysis of the 1998-2002 data set.

1.0 INTRODUCTION

1.1 Background

1.1.1 History

The mission of the Tri-State Water Quality Council has been to develop a management strategy to restore and protect designated water uses within the Clark Fork-Pend Oreille Basin. The Tri-State Water Quality Council's Clark Fork-Pend Oreille watershed water quality monitoring program was begun in 1998 and employs a statistically-based sampling design derived from an analysis of previous nutrient and periphyton data collected for the watershed by the state agencies. Through this design approach, sampling frequencies and monitoring locations have been optimized to provide reliable information for watershed management decision-making while minimizing operational costs.

The 2003-2007 monitoring program represents the second five-year monitoring program managed by the Tri-State Water Quality Council. The previous five-year monitoring program, conducted from 1998-2002, provided the basis for a statistical analysis of water quality time trends reflected in the Council's and the state agencies' data (Land & Water, 2004). The 2003 and 2004 sampling years consisted of a limited basic monitoring program, while the 2005 monitoring program was expanded to include previous monitoring stations throughout the watershed. A metals comparability study was also conducted during 2005 to compare different analytical methods. Furthermore, several heavy metal constituents were added to the sampling protocol in 2005, including cadmium, arsenic and lead to provide a baseline of conditions throughout the watershed prior to the planned removal of Milltown Dam upstream of Missoula.

The 2006 monitoring program included the basic monitoring program for the Clark Fork mainstem, and supplemental monitoring on Rock Creek and the Clark Fork River near Noxon, Montana to address citizen concerns about potential cumulative effects of a proposed major metals mine in the Rock Creek drainage. This report presents only the results of the basic monitoring program. Results of the supplemental mine-related monitoring program will be presented in an additional summary report (PBS&J, 2007).

1.1.2 Monitoring Program Goals

The Tri-State Water Quality Council's Water Quality Monitoring Committee has established seven primary monitoring goals for the Clark Fork-Pend Oreille Watershed, which conform to specific watershed management goals articulated in a tri-state management plan (EPA, 1993). These monitoring goals include:

1) Evaluating time trends in nutrient concentrations in the mainstem Clark Fork River and selected tributaries;
2) evaluating time trends for algal standing crops in the Clark Fork River;
3) monitoring compliance with established summer nutrient concentration target levels in the Clark Fork River;
4) estimating nutrient loading rates to Pend Oreille Lake from the Clark Fork River;

5) evaluating time trends for algal standing crops in near-shore areas of Pend Oreille Lake;
6) evaluating time trends for Secchi depth in Pend Oreille Lake; and
7) evaluating time trends for nutrient concentrations in the Pend Oreille River.

1.2 Project Description

The study area includes 24 monitoring locations on the Clark Fork River, selected tributaries, Pend Oreille Lake, and the Pend Oreille River within the Clark Fork-Pend Oreille watershed of western Montana, northern Idaho and northeastern Washington (**Appendix A**). The locations selected for water quality monitoring provide distributed spatial coverage for evaluating the effects of point and non-point pollution sources, and the influences of major population centers and tributary inflows. This design provides for a cost effective and reasonably sensitive assessment of nutrient and metals inputs throughout the basin. A summary of monitoring locations, their rationale, and associated sampling frequencies are provided in **Table 1-1**.

Table 1-1. ***Monitoring Locations and Sampling Frequency.***

Station	STORET ID	Name	Sampling Frequency
2.5	3225SI05	Silver Bow Creek at Opportunity	S10
07	3326CL02	Clark Fork below Warm Springs Creek	S10
09	3526CL01	Clark Fork at Deer Lodge	P10, S10
10	3726CL01	Clark Fork above Little Blackfoot River	P10, S10
12	3919CL01	Clark Fork at Bonita	P10, S10
15.5	4116CL01	Clark Fork above Missoula	P10, S10
18	4115CL01	Clark Fork below Missoula (Shuffields)	P10, S10
22	4313CL01	Clark Fork at Huson	P10, S10
25	4710CL01	Clark Fork above Flathead	P10, S10
27.5	4907TH01	Thompson River near mouth	N12
28*	5005CL01	Clark Fork below Thompson Falls	NM12
29*	5403CL01	Clark Fork at Noxon Bridge	NM12
30*	5538CL01	Clark Fork below Cabinet Gorge Dam	NM18
		Pend Oreille River at Newport, WA	N12
		Pend Oreille River at Metaline Falls, WA	N12
		Pend Oreille Lake: Lakeview	P10, SD
		Pend Oreille Lake: Telache	P10, SD
		Pend Oreille Lake: Midlake	P10, SD
		Pend Oreille Lake: Garfield Bay	P10, SD
		Pend Oreille Lake: Bayview open water	P10, SD
		Pend Oreille Lake: Bayview nearshore	P10, SD
		Pend Oreille Lake: PDO North	P10, SD
		Pend Oreille Lake: Oden Bay	P10, SD
		Pend Oreille Lake: Sunnyside	P10, SD

N12 = Nutrient and field constituents, monthly samples
NM12 = Nutrient, metal and field constituents, monthly samples
NM18 = Nutrient, metal and field constituents, monthly samples and 6 peak flow samples
P10 = Periphyton, 10 replicates per site, August and September
S10 = Summer nutrient and field constituents, 10 samples during 3 months in summer
SD = Secchi Depth (3 readings during 2006)
* These sites sponsored by Avista Corp., pursuant to 401 certification requirement

Currently, the 2003-2007 program includes a basic monitoring component and several annual or periodic rotational add-on elements. The basic program consists of the highest priorities for annual monitoring, while the add-ons represent options for additional monitoring that are contingent on annual funding availability. The 2006 program included each of the tasks described below, which constitute the basic monitoring program:

1. monthly collection of nutrient and heavy metals samples and field constituents at three Clark Fork River sites, monthly collection of nutrient samples and field constituents at one Thompson River site and two Pend Oreille River sites (February – December for Clark Fork and Thompson River sites, January – December for Pend Oreille River sites);
2. summer collection of periphyton standing crop samples at seven Clark Fork River sites (August and September);
3. summer collection of nutrient samples and field constituents at nine Clark Fork River sites (10 samples over 3 months);
4. collection of nutrient and heavy metals samples at the Clark Fork River below Cabinet Gorge Dam during spring peak flow (six samples over a one-month period, May to June);
5. summer collection of periphyton standing crop samples at nine Pend Oreille Lake sites (September); and
6. Secchi depth readings at nine Pend Oreille Lake sites (July, August and September).

Monitored field constituents included: water temperature (˚C), pH (standard units), specific conductance (µs/cm), dissolved oxygen (mg/l) and turbidity (NTU). Stream flow (instantaneous, cubic feet per second (cfs)) and river stage (ft) were also recorded where gauging stations were available. Nutrient constituents included: total phosphorus (TP), total Kjeldahl nitrogen (TKN) or total persulfate nitrogen (TPN, Washington sites only), nitrate + nitrite nitrogen (NO_2+NO_3), total ammonia nitrogen (NH_3+NH_4), and soluble reactive phosphorus (SRP). Heavy metal constituents included dissolved and total recoverable fractions of copper (Cu), zinc (Zn), cadmium (Cd), lead (Pb) and arsenic (As). Samples were also analyzed for hardness (mg/L as $CaCO_3$). Values for total nitrogen (TN) and total soluble inorganic nitrogen (TSIN) were calculated as follows:

$$\text{TN} = \text{TKN plus } NO_2\text{+}NO_3\text{-N} \qquad \text{TSIN} = NO_2\text{+}NO_3\text{-N plus } NH_3\text{+}NH_4\text{-N}$$

Periphyton samples from natural substrates were analyzed for chlorophyll *a* (mg/m^2) and ash-free dry weight (g/m^2). Secchi depth was recorded in meters (m).

This report provides a summary of water quality and algae data collected during the 2006 calendar year. No detailed study was undertaken for analysis of time trends in water quality, nor were statistical comparisons made of water quality between stations. These types of analyses are conducted once every five years on a complete five-year data set. The 2006 calendar year monitoring data will be evaluated for time trends together with 2003-2007 data in 2008.

1.3 Sampling Methods

1.3.1 Field Constituents

Field constituents, including water temperature (˚C), pH (standard units), conductivity (µs/cm), and dissolved oxygen (mg/l) were measured on site using a portable Hach® water quality probe. Turbidity (NTU) levels were measured using a Hach® portable turbidimeter. All field instruments were calibrated each morning and monitored throughout the day to ensure performance. Field constituents were recorded on a field form before leaving the site.

1.3.2 Nutrients and Metals

Water samples for nutrient and metal constituents were collected using a grab sampling technique by wading in a well-mixed portion of the river. Samples were taken in the upstream direction to avoid entrainment of sediment disturbed by wading.

Water samples for total nutrients (TP and TKN) and total recoverable metals (As, Cd, Cu, Pb, and Zn) were collected directly from the stream in separate polyethylene bottles. Bottles were rinsed three times with native water prior to sampling. During sampling, the sample bottle was positioned to face upstream and was drawn through the water column once, carefully avoiding disturbance of bottom sediments. Samples were acidified with concentrated sulfuric acid (H_2SO_4) for nutrient samples and concentrated nitric acid (HNO_3) for metal samples. Nutrient samples were stored on ice and delivered to the analytical laboratory within 48 hours of collection. Metals samples were delivered to the analytical laboratory within their allowable holding time.

Water for soluble nutrients (NO_2+NO_3, NH_4 and SRP) and dissolved metals (dissolved As, Cd, Cu, Pb and Zn) were filtered in the field through a 0.45 µm filter into polyethylene bottles. Bottles were rinsed three times with filtered water, and a small volume of filtrate (30-50 ml) was discarded prior to sample collection to ensure the filter was properly rinsed. Dissolved nutrient samples (NO_2+NO_3, NH_4 and SRP) were frozen or stored on ice and transported to the analytical laboratory within 48 hours of collection. Dissolved metal samples were acidified with concentrated nitric acid (HNO_3) and delivered to the laboratory within their allowable holding time.

Samples were clearly labeled with a waterproof marker or pre-printed labels. Label information included the site identification number, date and time, sample type, preservative, and sampler's initials. Each bottle was recorded on a chain-of-custody form before leaving the site. A summary of sampling protocols is provided in **Table 1-2**.

Table 1-2. ***Nutrient and Metals Sampling Protocol.***

Constituent	Sample Volume	Container	Preservation	Holding Time
TP and TKN	250 ml	Acid-washed polyethylene	H_2SO_4, cool to 4°C	28 days
Total Recoverable Cu, Zn, Cd, Pb, As	250 ml	Acid-washed polyethylene	HNO_3	6 months
Dissolved Cu, Zn, Cd, Pb, As	250 ml	Acid-washed polyethylene	Filter, HNO_3	6 months
NO_2+NO_3 and NH_4	250 ml	Acid-washed polyethylene	Filter, cool to 4°C or freeze	28 days (if frozen)
SRP	250 ml	Acid-washed polyethylene	Filter, cool to 4°C or freeze	48 hours

1.3.3 Periphyton – Clark Fork River and Pend Oreille Lake
Two types of periphyton samples were collected: hoop samples (a bulk sampling method) and template samples (a rock scraping method). Hoop samples were collected for filamentous green algae (*Cladophora)* dominated sites (sites above Missoula) and template samples were collected for diatom dominated sites (sites below Missoula). Periphyton samples on Pend Oreille Lake were taken using the template method. Both chlorophyll *a* and ash-free dry weight (AFDW) were measured from the hoop and template samples. Clark Fork River periphyton samples were collected on two separate sampling events, once in August and again in September, in an attempt to document peak algal standing crops. Pend Oreille Lake periphyton samples were collected in September.

1.3.4 Secchi Depth – Pend Oreille Lake
For Secchi depth monitoring, a standard 20 cm Secchi disc was used. Secchi depth readings were taken on the side of the boat with the least amount of surface roughness. Water transparency was evaluated by lowering the Secchi disc over the side of the boat until the markings were no longer visible. The depth was read after the disc was lowered past the extinction point, and then raised until just visible. Depth was recorded in meters. The sampler also noted time of day, weather, water surface conditions, and any other variables that may have affected the reading.

1.4 Analytical Methods

State-certified laboratories, including the Montana Department of Public Health and Human Services chemistry laboratory, the Missoula wastewater treatment plant laboratory, and the Washington Department of Ecology Manchester laboratory performed all nutrient and metals analyses using standard methods. The University of Montana biology laboratory performed the periphyton sample analyses. The analytical methods and detection limits are listed in **Table 1-3**.

Table 1-3. ***Analytical Methods and Detection Limits.***

Analyte	Method	Detection Limit
Total Phosphorus (TP)	EPA 365.3	4 µg/l
Total Kjeldahl Nitrogen (TKN)	EPA 351.2	100 µg/l
Nitrate + Nitrite-Nitrogen (NO_2NO_3)	EPA 353.2	2 µg/l
Total Ammonia-Nitrogen (NH_4)	EPA 350.1	10 µg/l
Soluble Reactive Phosphorus (SRP)	EPA 365.3	4 µg/l
Total Recoverable and Dissolved Copper (Cu)	EPA 200.7	1 µg/l
Total Recoverable and Dissolved Zinc (Zn)	EPA 200.7	0.5 µg/l
Total Recoverable and Dissolved Cadmium (Cd)	EPA 200.7	0.1 µg/l
Total Recoverable and Dissolved Lead (Pb)	EPA 200.7	1 µg/l
Total Recoverable and Dissolved Arsenic (As)	EPA 200.7	1 µg/l

1.5 Statistical Methods

This report includes summary statistics and boxplots for visual comparisons of water quality. Statistics include median, mean, minimum, maximum and standard deviation. Boxplots compare water quality and algae data from different monitoring locations (i.e. spatial comparison) or at the same station for different sampling years (i.e. temporal comparison). The shapes of the boxplots are based on median, interquartile, and extreme values of the data. The box encloses the interquartile range, which contains the middle 50 percent of the values. The median value is displayed as the centerline of the box. The top and bottom whiskers display the maximum and minimum observed values, excluding outliers and extreme values. Outliers, defined as values that are 1.5 to 3 times greater than or less than values in the interquartile range, are displayed as circles (○). Extreme values, or those more than 3 times the values in the interquartile range, are displayed with an asterisk (*). The boxplot construction is shown graphically in **Figure 1-1**.

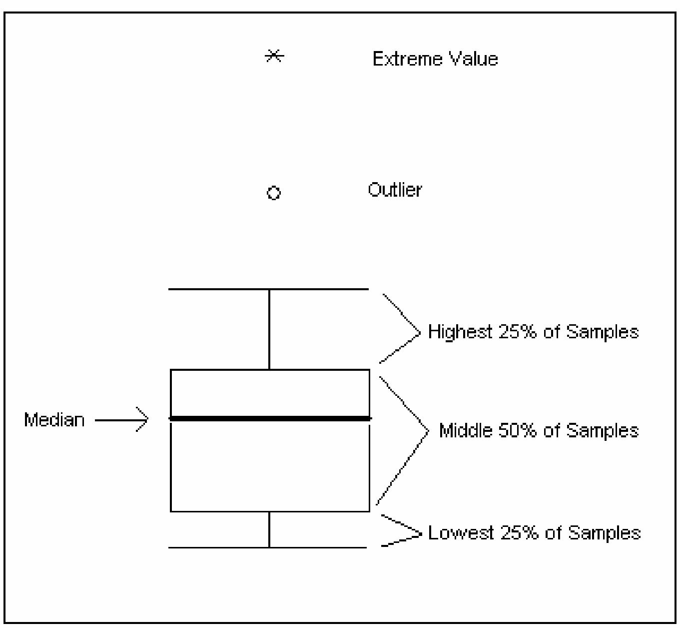

Figure 1-1. ***Boxplot Construction***

2.0 WATER QUALITY STATISTICS

2.1 Algal Nutrients Spatial Comparison

Monthly nutrient samples were collected at six sites throughout the Clark Fork-Pend Oreille watershed in 2006. Samples were analyzed for total nitrogen (comprised of total kjeldahl and nitrate+nitrite nitrogen), total soluble inorganic nitrogen (comprised of nitrate+nitrite and total ammonia nitrogen), total phosphorus, and soluble reactive phosphorus. Boxplots provide a visual comparison of spatial patterns in nutrient concentrations during 2006 (**Appendix B**). Summary statistics including mean, median, minimum, maximum, and standard deviation, as well as the number of samples are provided in **Appendix C**. For boxplot presentations, stations were ordered (left to right) in the upstream to downstream direction.

2.1.1 Total Nitrogen

Median total nitrogen (TN) concentrations were highest in the Clark Fork River below Thompson Falls Dam (0.188 mg/L) and decreased in a downstream direction to Pend Oreille River at Newport (0.055 mg/L). Median TN at the Thompson River site (0.114 mg/L) was lower than at the three Clark Fork River sites, but slightly higher than the Pend Oreille River sites. Of the three Clark Fork River sites, the site below Cabinet Gorge Dam (0.137 mg/L) yielded the lowest median TN concentration during 2006, yet the three Clark Fork River sites differed very little (0.137–0.188 mg/L).

2.1.2 Total Soluble Inorganic Nitrogen

Median total soluble inorganic nitrogen (TSIN) concentrations were lowest in the Thompson River (0.010 mg/L). Median TSIN concentrations increased in the Clark Fork River from below Thompson Falls Dam (0.0390 mg/L) downstream to the Clark Fork River below Cabinet Gorge Dam (0.0436 mg/L). Median TSIN concentrations in the Pend Oreille River at Newport were similar to Thompson River (0.010 mg/L), while median TSIN at the Metaline Falls site was more similar to concentrations in the Clark Fork River (0.0325 mg/L).

2.1.3 Total Phosphorous

Median total phosphorus (TP) concentrations were lowest in the Pend Oreille River sites (0.0049 mg/L at Newport, 0.00465 mg/L at Metaline Falls) and highest at the Clark Fork River at Noxon (0.0105 mg/L). Median TP concentration in the Thompson River (0.00868 mg/L) was lower than values measured for the Clark Fork River.

2.1.4 Soluble Reactive Phosphorus

Median soluble reactive phosphorus (SRP) concentrations fluctuated throughout the lower watershed. The highest median concentration in 2006 occurred in the Thompson River (0.0063 mg/L), while the lowest median TN occurred at the Pend Oreille River sites at Newport and Metaline Falls (0.002 mg/L).

2.2 Heavy Metals Spatial Comparison

2.2.1 Total Recoverable Copper

Median total recoverable copper (Cu) concentrations were below detection (<0.001 mg/L) in the Clark Fork River at sites below Thompson Falls, at Noxon and below Cabinet Gorge Dam. The Clark Fork River site below Thompson Falls had three samples above the analytical detection limit, but all samples collected at the other two Clark Fork sites were below detection.

2.2.2 Total Recoverable Zinc

Median concentrations of total recoverable zinc (Zn) fluctuated throughout the lower watershed. The three lower Clark Fork River sites exhibited varying median concentrations ranging from below detection (<0.0005 mg/L) at Noxon, 0.0006 mg/L below Cabinet Gorge Dam, and 0.0019 mg/L below Thompson Falls.

2.2.3 Total Recoverable Cadmium

Median total recoverable cadmium (Cd) concentrations were below the analytical detection limit (<0.00004 mg/L) at the three sample locations during 2006.

2.2.4 Total Recoverable Lead

Median concentrations of total recoverable lead (Pb) were below the analytical detection limit (<0.0005 mg/L) for all three sample locations during 2006. The Clark Fork River site below Thompson Falls had several samples above detection, but all samples at all other sites were below the analytical detection limit during 2006.

2.2.5 Total Recoverable Arsenic

Median concentrations of total recoverable arsenic (As) were below the analytical detection limit (<0.001 mg/L) for all three sample locations during 2006. The Clark Fork River site below Thompson Falls had three samples above detection, while the Clark Fork river site at Noxon had only one sample above detection. All samples collected from below Cabinet Gorge Dam were below the analytical detection limit.

2.2.6 Dissolved Metals

Dissolved metals samples were collected at three sites in 2006, including the Clark Fork River below Thompson Falls, at Noxon Bridge and below Cabinet Gorge Dam. Samples were analyzed for dissolved copper, dissolved zinc, dissolved cadmium, dissolved lead, and dissolved arsenic at these locations. Median dissolved metal concentrations were below the analytical detection limit at all sites for dissolved copper, dissolved cadmium, dissolved lead, and dissolved arsenic. Very few samples were above the analytical detection limit. Median concentrations of dissolved zinc ranged from 0.0032 mg/L below Thompson Falls to 0.0047 mg/L at Noxon Bridge.

2.2.7 Heavy Metals Standards Comparison

Heavy metals concentrations from Clark Fork River sites below Thompson Falls (Site 28) and at Noxon Bridge (Site 29) were compared to published acute and chronic metals toxicity standards for Montana based on hardness at time of sampling (Montana DEQ, 2007). Metals concentrations from the Clark Fork River site below Cabinet Gorge Dam (Site 30) were compared to acute and chronic metals standards for Idaho (Idaho Administrative Rules Act, 2006). Only one sample from all sites exceeded calculated metals toxicity standards during 2006, including samples collected from below Cabinet Gorge Dam during peak flow sampling. The total recoverable lead sample collected on 5/30/2006 from below Cabinet Gorge Dam (3.30 ug/L) exceeded the calculated chronic standard (1.87 ug/L). This sample was collected during the peak flow sampling period. Otherwise, all samples at all locations were below the calculated acute and chronic standards for metals toxicity during 2006. A comparison of metals concentrations versus calculated standards for Montana and Idaho are provided in **Appendix C**.

2.3 Field Constituents Spatial Comparison

Field constituents were recorded monthly at 6 sample locations throughout the lower Clark-Fork Pend Oreille watershed in 2006. Measured constituents include stream temperature (^oC), pH, specific conductance (µs/cm), dissolved oxygen (mg/L), and turbidity (NTU). Spatial boxplots presenting 2006 field constituent data are provided in **Appendix B**, and summary statistics are provided in **Appendix C**.

2.3.1 Temperature

Median stream temperature varied from 8.3 ^oC in the Thompson River to a high of 11.9 ^oC in the Clark Fork River below Thompson Falls. The Pend Oreille River sites (7.5 ^oC at Newport and 8.2 ^oC at Metaline Falls) were comparable to the Thompson River.

2.3.2 pH

Median pH values were highest in the Clark Fork River below Cabinet Gorge (8.99) and lowest in the Pend Oreille River at Metaline Falls (8.27). pH often increases from morning to evening as plants absorb carbon dioxide during photosynthesis. It is likely that at least some of the between station differences in pH was due to diurnal variations.

2.3.3 Conductivity

Conductivity, an indirect measure of dissolved ion concentrations, was lowest in the Thompson River (133 µs/cm) and highest in the Pend Oreille River at Metaline Falls (165 µs/cm). In general, median specific conductance tends to increase in the downstream direction.

2.3.4 Dissolved Oxygen

Median dissolved oxygen concentrations (DO) in 2006 were highest in the Pend Oreille River at Newport (11.7 mg/L) and lowest in the Clark Fork River below Cabinet Gorge Dam (8.49 mg/L). Median DO concentrations in the Clark Fork River generally decrease in the downstream direction; however, dissolved oxygen concentrations between sampling sites was also likely affected by diurnal fluctuations like was suggested for pH.

2.3.5 Turbidity

Median turbidity was lowest in the Clark Fork River below Cabinet Gorge Dam (1.13 NTU) and highest in the Clark Fork River below Thompson Falls (1.89 NTU), although values were quite low for all sample locations.

2.4 Summer Nutrient Levels

Intensive summer nutrient monitoring was conducted at one station on Silver Bow Creek and eight stations on the Clark Fork River to evaluate compliance with the established instream target concentrations (**Appendix A, Figure 4**). The following stations were each sampled ten times during 2006 by Missoula wastewater treatment plant personnel: Silver Bow Creek at Opportunity, Clark Fork River below Warm Springs Creek, Clark Fork River at Deer Lodge, Clark Fork River above the Little Blackfoot River, Clark Fork River at Bonita, Clark Fork River above Missoula, Clark Fork River below Missoula, Clark Fork River at Huson, and Clark Fork River above the Flathead River.

Samples were collected beginning in June and continuing through September; however, the chlorophyll compliance period is stated as June 21 – September 21, so several samples collected during summer 2006 fall outside the compliance period. Hydrographs depicting summer sample dates are provided for Clark Fork sites at Deer Lodge (**Figure 2-1**) and above Missoula (**Figure 2-2**). Samples collected during the early part of June are on the falling limb of the hydrograph, and may not be representative of summer low-water conditions.

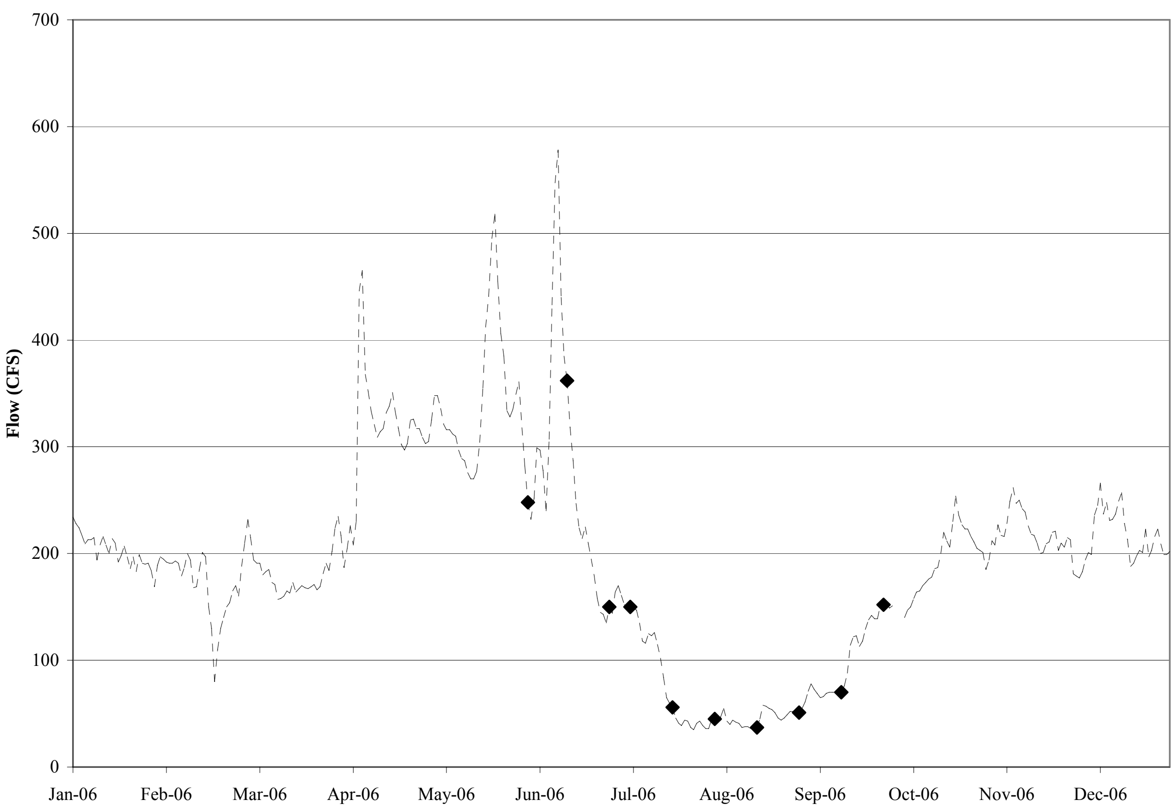

Figure 2-1. ***Clark Fork River above Deer Lodge Summer Sampling Dates.***

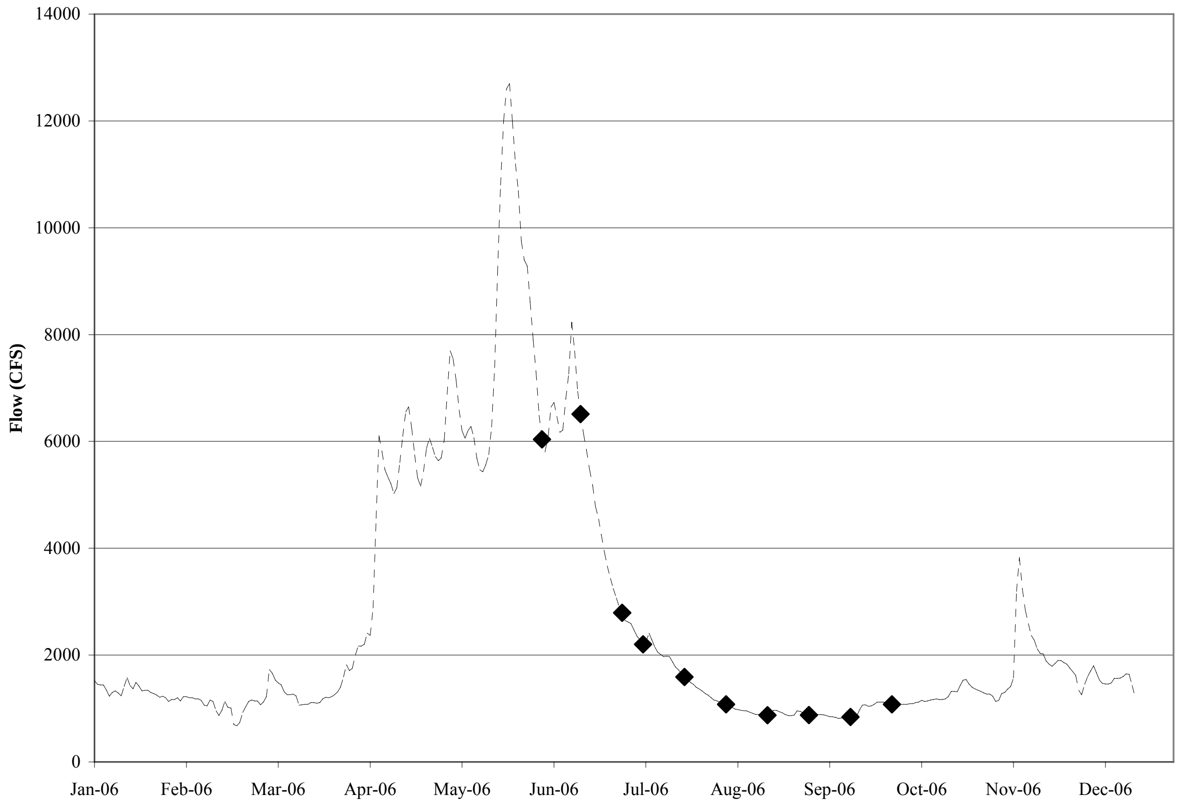

Figure 2-2. ***Clark Fork River above Missoula Summer Sampling Dates.***

The following Clark Fork Basin nutrient targets were developed by the Tri-State Water Quality Council and subsequently adopted as water quality standards by the State of Montana (ARM 17.30.631):

- Total Nitrogen — Clark Fork River (headwaters to Flathead River) — 300 µg/L
- Total Phosphorous — Clark Fork River (headwaters to Missoula) — 20 µg/L
- Total Phosphorous — Clark Fork River (Missoula to Flathead River) — 39 µg/L
- Total Soluble Inorganic Nitrogen — 30 µg/L (secondary target)
- Soluble Reactive Phosphorus — 6 µg/L (secondary target)

2.4.1 Summer Boxplots

Spatial comparisons of summer nutrient concentrations in Silver Bow Creek and the Clark Fork River are presented using statistical boxplots (**Appendix D**). Where appropriate, boxplots are displayed on two scales to better display the data. The relevant target values are shown as horizontal lines, where available. Boxplots were constructed using all samples collected during summer 2006, including samples from early June and late September that fall outside the compliance period.

The total nitrogen (TN) boxplots show that five stations had median values exceeding the target level (300 µg/L) in 2006, including Silver Bow Creek at Opportunity (2426 µg/L) and the Clark Fork River below Warm Springs (321 µg/L), at Deer Lodge (559 µg/L), above the Little

Blackfoot River (320 µg/L), and below Missoula (309 µg/L). Median summer TN was highest at the Silver Bow Creek site, and generally decreased in a downstream direction, although increases were noted at Deer Lodge and below Missoula. The lowest median summer TN concentration was in the Clark Fork River above the Flathead River confluence (146 µg/L).

Median summer total phosphorus (TP) concentrations in the Clark Fork River above Missoula exceeded the 20 µg/L target at four sites in 2006, including Silver Bow Creek at Opportunity (291 µg/L) and the Clark Fork River sites below Warm Springs (36 µg/L), above Deer Lodge (24 µg/L) and above the Little Blackfoot River (25 µg/L). Median summer TP in the Clark Fork River generally decreased from below Warm Springs Creek with a rise occurring below Missoula. As was observed for TN, the lowest median summer TP concentration was observed in the Clark Fork River above the Flathead River confluence (11 µg/L).

Median summer total soluble inorganic nitrogen (TSIN) concentrations in 2006 were above the target value of 30 µg/L at four stations. Silver Bow Creek at Opportunity had the highest median value (1511 µg/L). The Clark Fork stations above Deer Lodge (129 µg/L), below Missoula (66 µg/L), and at Huson (42 µg/L) also exceeded the instream target. The Clark Fork River site above the Little Blackfoot River had the lowest median summer TSIN values at 15 µg/L.

Median summer soluble reactive phosphorus (SRP) concentrations exceeded the target value of 6 µg/L at six of the nine monitoring stations, including Silver Bow Creek at Opportunity (175 µg/L), and the Clark Fork River sites below Warm Springs Creek (14.4 µg/L), above Deer Lodge (9.5µg/L), above the Little Blackfoot River (9.6 µg/L), at Bonita (9.3 µg/L), and below Missoula (7.7 µg/L). The lowest median SRP concentration was found in the Clark Fork River above the Flathead River confluence (2.7 µg/L).

2.4.2 Summer Summary Statistics

Summary statistics, including mean, median, minimum, maximum, and standard deviation, were calculated for 2006 nutrient concentrations at nine summer nutrient target sites (**Appendix E**).

Individual nutrient samples from summer 2006 were compared to the previously stated nutrient target levels. Three samples collected during 2006 fell outside the compliance period, so only the seven samples which fell within the period from June 21 – September 21 were compared to nutrient targets. One sample for total nitrogen was discarded from the summer sampling period, so only six samples were compared to targets for total nitrogen. In summer 2006, four of the nine sites had all total nitrogen samples below the target value (300 µg/L), including Clark Fork River sites at Bonita, above Missoula, at Huson, and above the Flathead River confluence. All sites had at least one sample above the target value for total phosphorus and soluble reactive phosphorus during summer 2006. The Clark Fork River site above the Little Blackfoot River had all total soluble nitrogen samples below the target level (0.03 µg/L) during summer 2006; however, all other sites had at least one sample above the target. The number and percentage of samples exceeding the nutrient target levels during the summer compliance period is shown for each monitoring station below in **Table 2-1**.

Table 2-1. ***Summer Sample Nutrient Target Attainment.***

Station	TN		TP		TSIN		SRP	
	# above target	% above target	# above target	% above target	# above target	% above target	# above target	% above target
SBC at Opportunity	6/6	100	7/7	100	7/7	100	7/7	100
CFR bl Warm Springs	3/6	50	5/7	71	3/7	43	6/7	86
CFR at Deer Lodge	6/6	100	5/7	71	7/7	100	7/7	100
CFR ab Ltl Blackfoot	4/6	75	3/7	43	0/7	0	4/7	57
CFR at Bonita	0/6	0	2/7	29	1/7	14	6/7	86
CFR ab Missoula	0/6	0	2/7	29	1/7	14	1/7	14
CFR bl Missoula	2/6	33	2/7	29	7/7	100	4/7	57
CFR at Huson	0/6	0	1/7	14	6/7	86	2/7	29
CFR ab Flathead	0/6	0	1/7	14	1/7	14	0/7	100

2.5 Cabinet Gorge Peak Flow Sampling

Six additional samples were collected from the Clark Fork River below Cabinet Gorge Dam over a one month period in order to characterize nutrient and metals concentrations during the peak flow period. Samples were collected between May 10 and June 5 around the time of peak flow (**Figure 2-3**).

Median nutrient concentrations were higher during the peak flow period than during the regular monthly sampling. This pattern was evident for all nutrient constituents. Total recoverable metals were also typically higher during the peak flow sampling period. No samples exceeded analytical detection limits for total recoverable copper or lead during regular monthly sampling; however, during peak flow sampling 5 of 6 samples were above the analytical detection limit for copper (0.001 mg/L), and 1 sample was above detection for lead (0.0005 mg/L). Additionally, the highest concentration of cadmium below Cabinet Gorge Dam occurred during the peak flow period. Analytical results and summary statistics for peak flow samples collected below Cabinet Gorge Dam are provided in **Appendix C**.

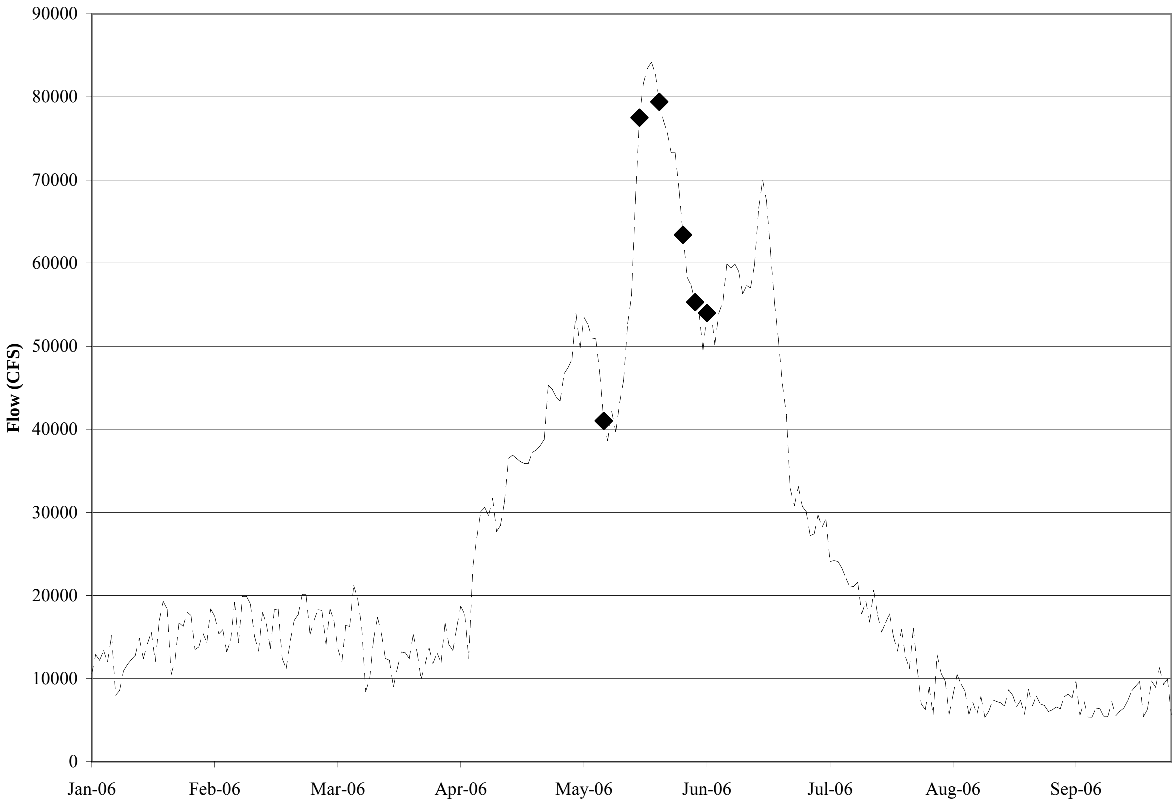

Figure 2-3. ***Clark Fork below Cabinet Gorge Dam Peak Flow Sampling Dates.***

3.0 PERIPHYTON STATISTICS

Seven Clark Fork River stations were sampled for periphyton standing crops during 2006 (**Appendix A, Figure 5**). Clark Fork River stations have been sampled annually in August and September since 1998. Twenty replicate samples were collected at each station during August and September, and replicate samples were analyzed for two variables:

- Chlorophyll *a* (Chl *a*) (mg/m^2)
- Ash-free Dry Weight (AFDW) (g/m^2)

Additionally, nine Pend Oreille Lake stations were sampled for periphyton during 2006. This summary report includes boxplots and summary statistics for 2006 data. Pend Oreille Lake stations will be sampled again in 2007, and a more thorough report including both the 2006 and 2007 data will be completed following the 2007 sampling effort. Pend Oreille Lake stations were previously sampled from 1998-2003 (5 sites only) and during 2006 (9 sites) in the month of September. In addition, Secchi disk depth (m) was measured in Pend Oreille Lake as a component of the periphyton monitoring program.

3.1 Periphyton Temporal Comparison

Temporal boxplots for chlorophyll *a* and ash-free dry weight in periphyton samples from the Clark Fork River (**Appendix F**) and Pend Oreille Lake (**Appendix G**) were developed to show changes over the monitoring period.

3.1.1 Clark Fork River

Mean chlorophyll *a* values for algae samples collected from natural substrates were generally low during 2006 when compared to previous sampling years. This trend was evident when all sites were pooled and for individual sample locations. Median chlorophyll *a* values were the lowest ever recorded for the Clark Fork River site below Missoula, and considered quite low at most other stations except Clark Fork River above Little Blackfoot, which had its second highest mean ever recorded. All sample locations had lower mean chlorophyll *a* values during 2006 than in 2005, which was a high year for algae growth throughout the watershed. Four of the sample sites had their highest mean chlorophyll *a* values in August, while three sites peaked in September. Mean algal biomass values, measured as ash-free dry weight (AFDW), followed a similar pattern to that of chlorophyll *a.*

3.1.2 Pend Oreille Lake

Mean chlorophyll *a* values for algae samples collected from natural substrates in Pend Oreille Lake in 2006 were among the mid-range when compared to previous sample years (1998-2003). Three of the long-term sampling sites (Bayview, Kootenai and Trestle) exhibited the third lowest yearly mean for the period of record, while sites at Springy Point and Sunnyside had the highest and second highest yearly mean on record, respectively. The site at Springy Point has shown a consistent increase in chlorophyll *a* concentration throughout the period of record. Temporal patterns for attached algae measured as mean ash-free dry weight concentrations were similar to those for chlorophyll *a*.

3.2 Periphyton Spatial Comparison

Periphyton data for the Clark Fork River (**Appendix F**) and Pend Oreille Lake (**Appendix G**) are depicted as spatial boxplots for years 1998-2006. Clark Fork River chlorophyll *a* boxplots from 2006 include horizontal lines that show the benthic algae chlorophyll *a* targets levels for both a summer mean (100 mg/m^2) and annual maximum (150 mg/m^2) instream concentration. These targets were developed by the Tri-State Water Quality Council and subsequently adopted as site-specific water quality standards by the State of Montana (ARM 17.30.631).

3.2.1 Clark Fork River

When mean chlorophyll *a* data from all years is pooled (1998-2006), the generally spatial pattern is a downward trend from Clark Fork River at Deer Lodge to the site above the Flathead River confluence. One exception to this trend is a major increase in mean chlorophyll *a* below Missoula.

In August 2006, four of seven Clark Fork River monitoring locations had mean chlorophyll *a* values below the mean target level of 100 mg/m^2. These included sites above Missoula (90.4

mg/m^2), below Missoula (54.1 mg/m^2), at Huson (43.8 mg/m^2), and above the Flathead River (6.4 mg/m^2). In September 2006, four of seven monitoring sites produced mean chlorophyll *a* values less than the mean target level, including the Clark Fork at Bonita (98.4 mg/m^2), above Missoula (61.8 mg/m^2), at Huson (42.0 mg/m^2), and above the Flathead River (19.0 mg/m^2).

When August and September data are combined to create a summer mean chlorophyll *a* value, four stations, including the Clark Fork above Missoula, below Missoula, at Huson and above Flathead, were below the instream summer mean target level of 100 mg/m^2. Additionally, the individual sample replicate data for chlorophyll *a* in the Clark Fork River during 2006 showed that at least one replicate for August and September surpassed the target for maximum growth (150 mg/m^2) at five of the seven sites. Clark Fork River sites at Huson and above Flathead did not have any individual sample replicates above the target maximum (150 mg/m^2) during summer 2006. Summer mean chlorophyll *a* concentrations and the number of samples above the target maximum are depicted below in **Table 3-1**.

Table 3-1. *Chlorophyll a Target Attainment.*

Site	Summer Mean Chlorophyll *a* (mg/m2)	# of Samples Above Target Maximum (150 mg/m2)	% of Samples Above Target Maximum (150 mg/m2)
CF at Deer Lodge	128.4	9/40	22.5 %
CF ab Ltl Blackfoot	267.0	30/39	76.9 %
CF at Bonita	133.7	12/42	28.6 %
CF above Missoula	75.7	6/41	14.6 %
CF below Missoula	85.4	4/40	10.0 %
CF at Huson	42.9	0/40	0.0 %
CF ab Flathead	13.2	0/37	0.0 %

3.2.2 Pend Oreille Lake

In 2006, mean chlorophyll *a* values from algae samples collected from natural substrates in Pend Oreille Lake were lowest at the Bayview site (1.5 mg/m^2), and highest at the Springy Point site (23.6 mg/m^2) located near the outlet of Pend Oreille Lake. The Trestle Creek site had the lowest mean ash-free dry weight in 2006 (g/m^2), while Springy Point had the highest mean (14.4 g/m^2). Among sites sampled for the entire period of record (1998-2003, 2006), the Kootenai site has the highest mean chlorophyll *a* (13.0 mg/m^2) and AFDW (14.1 g/m^2) values. The lowest mean chlorophyll *a* and AFDW for the entire period of record was attributed to the Bayview site (5.3 mg/m^2 and 6.5 g/m^2, respectively).

3.3 Secchi Depth

Secchi transparency measurements were collected at the nine periphyton sampling locations on Pend Oreille Lake during 2006 (**Appendix A, Figure 5**). Measurements were performed at each location during July, August and September. Secchi disc transparency measurements had been collected on Pend Oreille Lake periodically since the 1950s, and the Bayview, Hope and Granite stations all have over 10 years of historical data. Charts and boxplots (**Appendix H**) show measurements collected during 2006, and fluctuations in median Secchi depth throughout the period of record.

Mean Secchi depth measurements at the Bayview site during 2006 were among the mid-range when compared to the period of record. Sampling locations at Oden Bay and Sunnyside exhibited the lowest mean Secchi depth readings during 2006 (2.8 m for both locations), indicating low water clarity. Conversely, sites at PDO North and Telache had the highest mean measurements during 2006 (8.8 and 8.5 m, respectively).

4.0 QA REVIEW

Data collected during 2006 were compared against data quality objectives specifically established for the basic monitoring program (Land & Water, 2003). Data quality objectives include precision, accuracy, representiveness, completeness, and comparability. An analysis of blank sample results was also performed to detect any possible contamination of laboratory samples. An evaluation of each data quality objective for the 2006 data is provided below in **Sections 4.1 – 4.6**.

4.1 Precision

Precision refers to the degree of variability in replicate measurements. Precision for laboratory samples was evaluated by examining relative percent differences (RPDs) of duplicate samples. A duplicate sample was collected from one site each month and analyzed for nutrients and metals. For this project, a precision goal of +/- 15% was established for water chemistry samples. Out of 176 duplicate samples, 19 had RPDs greater than +/- 15%, which is 10.8% of the duplicate samples.

4.2 Accuracy

Accuracy is a measure of confidence that describes how close an analytical measurement is to its "true" value, or the combination of high precision and low bias. Potential bias in the program procedures were minimized through appropriate site selection and strict adherence to the QAPP. Because the “true” value of a field sample cannot be known, the primary tool for assessing accuracy of laboratory analyses is the percent recovery of matrix spikes and control standards run against the field sample.

For this project, an initial accuracy goal of 10 percent was established for water chemistry analyses. Percent recovery of laboratory matrix spikes was outside the acceptable range of accuracy for dissolved zinc during the May sampling event.

4.3 Representiveness

Representativeness is the extent to which the measurements actually represent the true environmental conditions. For this monitoring effort, the sample locations were chosen to best represent the stream or lake segment of interest and minimize site-specific bias. Samplers adhered to all sampling guidelines provided in the QAPP during 2006, and did not deviate from designated sample locations.

4.4 Completeness

Completeness is the comparison between the amount of data that has been planned to be collected versus how much usable data was actually collected. This DQO is evaluated by looking at the each monitoring variable for each station during each sampling event. Four TKN samples were discarded from the dataset from the September 13 sampling event for not passing the laboratory's internal QA procedures; otherwise, all samples intended for laboratory analysis were received, analyzed, and reported by the lab. For field measurements, turbidity was not measured for any sites during the June 13 sampling run due to equipment availability, and dissolved oxygen was not measured during the September 13 sampling run due to poor calibration.

4.5 Comparability

Comparability is the degree to which data can be compared directly to previously collected data. Comparability was achieved for this project through consistent sampling locations, procedures, and analyses as outlined in the QAPP.

4.6 Analysis of Blanks

Field blanks were collected using the same sampling protocol as river samples, but deionized water was submitted as a sample. Field blanks are intended to detect any possible contamination which could occur from sample bottles, storage coolers, sample filters, or from environmental fallout. For nutrient samples, field blanks exceeded analytical detection limits twice for total phosphorus, and twice for total kjeldahl nitrogen. For metals samples, field blanks exceeded analytical detection limits once for total recoverable cadmium, and four times for dissolved zinc.

Zinc contamination from disposable filters has been a recurring problem with this sampling program, and corrective actions have been employed to help alleviate zinc contamination from filters. For future sampling efforts starting in 2007, filters will now be flushed with 100 ml of deionized water and 100 ml of sample water prior to collection.

5.0 REFERENCES

Administrative Rules of Montana. 2002. Numeric Algal Biomass and Nutrient Standards for the Clark Fork River. ARM 17.30.631, Effective August 16, 2002.

Idaho Administrative Procedures Act. 2006. Numeric Criteria for Toxic Substances For Waters Designated For Aquatic Life, Recreation, or Domestic Water Supply Use. IDAPA 58.01.02.210.02, updated April 12, 2006.

Land & Water Consulting, Inc. 1995. Water quality status and trends monitoring system for the Clark Fork-Pend Oreille Watershed. Prepared for the Tri-State Implementation Council. Missoula, MT.

Land & Water Consulting, Inc. 2003. Water Quality Status and Trends Monitoring System for the Clark Fork-Pend Oreille Watershed – Quality Assurance Project Plan. Prepared for Tri-State Water Quality Council. Missoula, MT.

Land & Water Consulting, Inc. 2004. Water Quality Status and Trends Monitoring System for the Clark Fork-Pend Oreille Watershed – Trends Analysis from 1984-2002. Prepared for Tri-State Water Quality Council. Missoula, MT.

Montana DEQ. 2007. Montana Numeric Water Quality Standards, Circular DEQ-7. Helena, MT.

PBS&J. 2007. Clark Fork-Rock Creek Supplemental Monitoring Program, 2006 Monitoring Summary Report. Prepared for Idaho DEQ and the Tri-State Water Quality Council. Helena, MT.

Tri-State Implementation Council (now the Tri-State Water Quality Council). 1998. Clark Fork River Voluntary Nutrient Reduction Program, August 1998. Sandpoint, Idaho.

U.S. Environmental Protection Agency. 1993. Clark Fork-Pend Oreille Basin Water Quality Study – A Summary of Findings and a Management Plan. Conducted under Section 525 of the Clean Water Act of 1987. U.S. Environmental Protection Agency, Regions 8 and 10, State of Montana, State of Idaho, State of Washington. Seattle, WA.

Walker, W.W. 1999. Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. Instruction Report W-96-2, US Army Corps of Engineers Waterways Experiment Station, *updated April 1999.*