Coeur d'Alene Lake Monitoring Program

2009 Report

Coeur d'Alene Tribe
and
Idaho Department of Environmental Quality

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Coeur d'Alene Lake Monitoring Program

2009 Report

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Executive Summary

This report describes a routine monitoring program on Coeur d'Alene Lake conducted by the Idaho Department of Environmental Quality (IDEQ) and the Coeur d'Alene Tribe (Tribe) from April 2009 through December 2009. Limnological data and analysis for this period is presented. A previous report presented monitoring data and analysis for the period of June 2007 through December 2008 (CdA Tribe and IDEQ, 2010).

In June 2007, IDEQ and the Tribe began a routine monitoring program within Coeur d'Alene Lake. This program is a continuation of baseline monitoring and studies conducted by the U.S. Geological Survey (USGS) and the Tribe from October 2003 through August 2006 (WY04-06, Wood and Beckwith, 2008), and an earlier USGS baseline study conducted from January 1991 through December 1992 (CY91-92, Woods and Beckwith, 1997). Under agreement by IDEQ and the Tribe, as part of an ongoing effort to jointly develop and implement a Lake Management Plan (LMP) for the lake, a program of continued monitoring at key USGS sites was initiated. The LMP was finalized in March 2009 (IDEQ and Cd'A Tribe, 2009). The goal of routine monitoring is to provide a long-term, annual trend record of key water quality variables in support of LMP decisions and implementation.

IDEQ and the Tribe jointly prepared a Quality Assurance Project Plan (QAPP) according to EPA guidelines, and submitted the QAPP to EPA for approval. The QAPP was designed to not only address quality assurance/quality control (QA/QC) issues, but to serve as the work plan for the 2009 monitoring season. QA/QC samples prepared by IDEQ and the Tribe entailed equipment and field blanks, sample replicates, replication between IDEQ and Tribe field crews and equipment, and sample replications between the two laboratories for nutrient analysis. QA/QC data is also presented for the metals analysis performed at the EPA Manchester Laboratory.

Five lake stations were sampled during this study period. IDEQ sampled USGS stations C1 (SE of Tubbs Hill), and C4 (NE of University point). The Tribe sampled USGS site C5 (NE of Browns Point, south of Harrison), and C6 (Chatcolet Lake). The Tribe also added a new station (SJ1) on the lower reach of the St. Joe River. For a calendar year, there would be a maximum of 8 sampling events.

The overall average trends of dissolved trace metals in 2009 at the deeper, northern sites were slightly lower compared to CY08 and comparable to WY04-06. The overall average trends of dissolved trace metals in 2009 at the southern pelagic site C5 were slightly higher for zinc and cadmium, but lower for lead compared to CY08 and WY04-06. Trace metals concentrations were examined in relation to the Criterion Continuous Concentration (CCC) limits established in State and Tribal Water Quality Standards (WQS). Dissolved zinc, cadmium and lead during the period of April – December 2009 exceeded the CCC of the WQS at sites C1, C4, and C5.

Total phosphorus (TP) concentrations at northern site C1 were slightly higher in 2009 compared to CY08 and WY04-06. At site C4, the 2009 TP data set was similar to CY08 and higher than WY04-06. The geometric mean (geomean) TP at site C4 for 2009 was 8.0 µg/L, which is the "trigger" concentration established for northern and southern waters in the 2009 LMP. Total phosphorus concentrations were generally higher in southern waters compared to northern waters. At site C5, geomean TP for the 2009 was 13.5 µg/L, slightly higher than CY08 and

higher than WY04-06. At site C6 geomean was 21.7 µg/L, lower than CY08 and WY04-06. Phosphorus dynamics at C6 provide a prime example of the release of phosphorus from sediments during anoxic conditions in the hypolimnion. A TP concentration of 89 µg/L was recorded during August 25, following a period of anoxia in the hypolimnion. In 2009 the geomean TP at C5 and C6 exceed the 2009 LMP trigger concentration.

All sites in 2009 had lower chlorophyll *a* geomean compared to CY08. Except for site 6, chlorophyll *a* was still higher than WY04-06. The 2009 LMP established a trigger geomean concentration of 3.0 µg/L chlorophyll *a* for northern and southern waters. The geomean at site C1 for 2009 was 2.33 µg/L, and at C4 geomean = 2.36 µg/L. For site C5, the 2009 geomean chlorophyll *a* was 1.7 µg/L, and 2.06 µg/L at C6. Even though chlorophyll *a* concentrations decreased in 2009 from 2008, the general trend is an increasing amount of chlorophyll *a* lake-wide since 1991. It is important to follow this chlorophyll *a* trend to determine if increased phytoplankton biomass translates into increased biological oxygen demand in deeper waters during summer stratification.

Samples for phytoplankton identification and enumeration were collected by USGS in the CY91-92 studies, but not in the WY04-06 study. IDEQ and the Tribe have incorporated this sampling into our program, but have not yet done a taxonomic cross-reference with the CY91-92 and 2007-09 data sets. A trend of interest in both northern and southern waters is the presence of the colonial cyanobacteria (blue-green algae*) Microcystis sp*. Certain species of *Microcystis* are known to produce a class of cyanotoxins labeled microcystins, which can be a hepatotoxin (liver damage). While *Microcystis sp.* can dominate phytoplankton samples in cell counts and biovolume during summer months, the cell counts seems well below the guidelines of concern established by the World Health Organization.

In northern waters, the pattern of hypolimnetic oxygen consumption through bacterial decomposition of organic matter progresses from the onset of stratification through early fall where October profiles typically show the lowest levels of dissolved oxygen (DO) mg/L and % saturation in bottom waters. However, DO in northern bottom waters still remain above the trigger condition of 6 mg/L. In southern waters this hypolimnetic oxygen consumption is more dramatic and DO concentration in the southern waters is below the Tribal standard of 8 mg/L at C5, C6 and SJ1. In 2009 the lowest hypolimnetic dissolved oxygen at C5 was 3.4 mg/L on October 7. The hypolimnion of both C6 and SJ1 were anoxic during the summer of 2009. As with previous years these anoxic waters have elevated concentrations of ortho-phosphate and ammonia, and also elevated concentrations of dissolved trace metals including two instances of highly elevated dissolved arsenic. Southern lake-bed sediments of Chatcolet and lower St Joe River are considered to only contain background levels of trace metals. However, regardless of low sediment concentrations, anoxic conditions release trace metals and nutrients into the water column. We believe it is critical that the ongoing processes that drive trace metal and nutrient release from sediments at C6 and SJ1 be avoided in the rest of the lake where trace metal contaminated sediments exhibit much higher concentrations.

Table of Contents

Executive Summary ..... **i**

List of Appendices ..... **iv**

List of Figures ..... **v**

List of Tables ..... **vii**

Acronyms and Abbreviations ..... **viii**

Section 1: Description of Monitoring Program **1**

1.1 Background *1*

1.2 Sampling Locations & Sampling Frequency *2*

1.3 Parameters Sampled and Sampling Methods *5*

Section 2: Quality Assurance/Quality Control **9**

2.1 Method Reporting Limits (MRLs) *9*

2.2 Field and Office Blanks *9*
2.2.1 IDEQ Blank Results 9
2.2.2 Tribe Blank Results 9

2.3 Replicates to Assess Precision *10*

2.4 Matrix Spikes and Lab Control Samples to Assess Accuracy *17*

2.5 Presence of Particulates in Filtered Samples *21*

2.6 Completeness and QA/QC Conclusions *21*

Section 3: Summary of Data Results **23**

3.1 Graphical Presentation of Data *23*
3.1.1 IDEQ Approach for Box Plots 23
3.1.2 CDA Tribe Approach for Box Plots 24

3.2 Riverine Flow: Hydrodynamics and Incoming Metals, Sediments, Nutrients *24*
3.2.1 Lake Results Related to River Flow 25

3.3 Lake Water Quality Results *27*
3.3.1 Trace Metals within the Lake Water Column 31
3.3.1.1 IDEQ Trace Metals 32
3.3.1.2 Tribe Trace Metals 36
3.3.2 Trophic State Classification 38
3.3.3 Nutrients 39
3.3.3.1 IDEQ Phosphorus 39
3.3.3.2 Tribe Phosphorus 41
3.3.3.3 IDEQ Nitrogen 43
3.3.3.4 Tribe Nitrogen 44
3.3.4 Phytoplankton 46
3.3.4.1 IDEQ Chlorophyll a 47

Table of Contents cont.

3.3.4.2 Tribe Chlorophyll a 47
3.3.4.3 Chlorophyll a Maxima 50
3.3.4.4 IDEQ Phytoplankton Identification and Enumeration 50
3.3.4.5 Tribe Phytoplankton Identification and Enumeration 55
3.3.5 Water Clarity 59
3.3.5.1 IDEQ Water Clarity 59
3.3.5.2 Tribe Water Clarity 59
3.3.6 Dissolved Oxygen 61
3.3.6.1 IDEQ Dissolved Oxygen 61
3.3.6.2 Tribe Dissolved Oxygen 61

3.4 Nutrient Loading into Coeur d'Alene Lake 66
3.4.1 USGS Nutrient Load Estimates 66
3.4.2 Tribe and IDEQ Nutrient Load Estimates 68

References 73

Appendices A1 – A10 75
Water Quality Data Collected in the 2009 Coeur d'Alene LakeMonitoring Program - IDEQ and Tribe Sampling Sites

Appendix B 109
Listing of Phytoplankton Genera/Species Identified at Northern and Southern Lake Sampling Sites for the Period August 2007 – December 2009

List of Appendices

Table A1. 2009 Water Quality Data for Site C1 – SE of Tubbs Hill 77
Table A2. 2009 Water Column Profiles at Site C1 - SE of Tubbs Hill 80
Table A3. 2009 Water Quality Data for Site C4 – NE of University Point 84
Table A4. 2009 Water Column Profiles at Site C4 87
Table A5. 2009 Water Quality Data for Site C5- southern pelagic zone S. of Harrison 91
Table A6. 2009 Water Column Profiles at Site C5- southern pelagic zone S. of Harrison 93
Table A7. 2009 Water Quality Data for Site C6- Chatcolet Lake 97
Table A8. 2009 Water Column Profiles at Site C6- Chatcolet Lake 99
Table A9. 2009 Water Quality Data for Site SJ1- Inundated lower St Joe River 102
Table A10. 2009 Water Column Profiles at Site SJ1- Inundated lower St Joe River 104
Table B1. Phytoplankton Genera/species identified at Sites C1, C4, C5, C6, and SJ1 for samples taken by IDEQ and the Tribe, August 2007– December 2009 111

List of Figures

Figure 1. Map of sampling sites for the Coeur d'Alene Lake Monitoring Program (circled); map provided by USGS for WY04-06 sampling program (Wood and Beckwith, 2008).....3
Figure 2. Definitions of box plot statistics used for data presentations within this report.....24
Figure 3. Hydrograph of mean daily flows (cfs) at Coeur d'Alene River @ Harrison and St. Joe River @ Chatcolet for Water Year 2009 (USGS web site); and days of USGS water quality river sampling. 25
Figure 4. USGS samples for total phosphorus at Coeur d'Alene River @ Harrison and St. Joe River @ Chatcolet for WY09 (USGS web site), and IDEQ data for Coeur d'Alene Lake @ station C4.....26
Figure 5. USGS samples for total and dissolved lead at Coeur d'Alene River @ Harrison, WY09 (USGS web site).....26
Figure 6. Dissolved zinc sampling by USGS for WY04-06 and IDEQ for CY08 and CY09, at northern pool sites C1 and C4. Data combined for photic zone composite samples, and discrete samples at 20 m, 30 m, and 1 m off bottom. 33
Figure 7. Dissolved cadmium sampling by USGS for WY04-06 and IDEQ for CY08 and CY09, at northern pool sites C1 and C4. Data combined for photic zone composite samples, and discrete samples at 20 m, 30 m, and 1 m off bottom. 33
Figure 8. Dissolved lead sampling by USGS for WY04-06 and IDEQ for CY08 and CY09, at northern pool sites C1 and C4. Data combined for photic zone composite samples, and discrete samples at 20 m, 30 m, and 1 m off bottom. 34
Figure 9. Sample profiles of total zinc concentrations (µg/L) at site C4 from April 7 to October 8, 2009.....35
Figure 10. Dissolved zinc (A), cadmium (B) and lead (C) sampling by USGS for WY04-06 and Coeur d'Alene Tribe for CY08 and CY09 at southern pelagic site C5. Data combined for photic zone composite samples, Chlorophyll a maximum depth, and 1 m off bottom samples.....37
Figure 11. Dissolved zinc concentration at site C5 in the photic zone and at the one meter above bottom zone from June 26, 2007 through December 2, 2009. 38
Figure 12. Box plot comparisons of total phosphorus for study periods: USGS CY91-92 and WY04-06, and IDEQ CY08 and CY09 at sampling sites C1 and C4. Data combined for photic zone composite samples, and discrete samples at 20 m, 30 m, and 1 m off bottom.....40
Figure 13. Total phosphorus in photic zone composite samples at sites C1 and C4, July 2007 – October 2009.....40
Figure 14. Box plot comparisons of total phosphorus for study periods: USGS CY91-92 and WY04-06, and Coeur d'Alene Tribe CY08 and CY09 at sampling sites C5 and C6.....42
Figure 15. Total phosphorus from photic zone composite samples taken at sites C5, C6 and SJ1 from June 2007 through December 2009.....42
Figure 16. Total phosphorus in samples taken from one meter above lake bottom at sites C5, C6 and SJ1 from June 2007 – December 2009.....43
Figure 17. Dissolved inorganic nitrogen (ammonia + nitrite+nitrate) in photic zone composite samples at sites C1 and C4, July 2007 – October 2009. Note: data point flagged and removed (see A3). 45
Figure 18. Dissolved inorganic nitrogen concentration in photic zone composite samples taken at sites C5, C6 and SJ1, June 2007 – December 2009. 45

List of Figures continued

Figure 19. Dissolved inorganic nitrogen concentration in samples taken at one meter above the lake bottom at sites C5, C6 and SJ1, June 2007 – December 2009. 46
Figure 20. Box plot comparisons of photic zone chlorophyll *a* for study periods: USGS CY91-92 and WY04-06, and IDEQ CY08 and CY09, at sampling sites C1 and C4. 48
Figure 21. Chlorophyll *a* in photic zone composite samples for sites C1 and C4, August 2007 – October 2009. 48
Figure 22. Box plot comparisons of chlorophyll *a* for study periods: USGS CY91-92 and WY04-06, and CDA Tribe CY08 and CY09 at sampling sites C5 and C6. 49
Figure 23. Chlorophyll *a* concentration from photic zone composite samples taken at sites C5, C6 and SJ1 from June 2007 – December 2009. 49
Figure 24. Phytoplankton cell counts/mL at site C4 for July 2007 – October 2009.....54
Figure 25. Phytoplankton biovolume in μm^3/mL at site C4 for July 2007 – October 2009.....54
Figure 26. Total phytoplankton biovolume (μm^3/mL) from photic zone composite samples taken at sites C5, C6 and SJ1 in 2009. 58
Figure 27. Secchi disc transparency (with aid of view tube) and depth of 1% light photic zone at site C1 for the period June 2007 – October 2009. 60
Figure 28. Photic zone depth (1% of surface PAR) at sites C5, C6 and SJ1 for the period June 2007 – December 2009. 60
Figure 29. (a) dissolved oxygen and water temperature profiles at Tubbs Hill sampling station (C1) on July 30, 2009, and (b) October 9, 2009.....63
Figure 30. Temperature and dissolved oxygen profiles from Site C5 (southern pelagic site south of Harrison), 2009. 64
Figure 31. Temperature and dissolved oxygen profiles from Site C6 (Chatcolet Lake), 2009. ..65
Figure 32. Dissolved forms of phosphorus and nitrogen, transition metals (iron and manganese) and arsenic sampled from the photic zone and one-meter above lake-bottom at site C6 and SJ1 on August 25, 2009. Samples were collected following a period of thermal stratification and anoxia. All constituents were 0.45 µm filtered (Y-axis scale is a log base 10). 66
Figure 33. Annual total phosphorus loading (pounds/year) into Coeur d'Alene Lake from the St. Joe River, Coeur d'Alene River, and Other Sources as estimated by USGS for CY91-92 and WY04-06 (Wood and Beckwith, 2008). 68
Figure 34. Total phosphorus load during WY09 for the Coeur d'Alene River.....72

List of Tables

Table 1. Sampling locations of the Coeur d'Alene Lake Monitoring Program. 2
Table 2. Annual sampling visits for the Coeur d'Alene Lake Monitoring Program (selection of 8 sampling events below)..... 4
Table 3. Analytical methods and data quality for analytes of the Coeur d'Alene Lake Monitoring Program (Note: target reporting limits are the values used by the EPA Manchester Lab, Spokane Tribal Lab, and SVL Analytical for the 2009 monitoring years). 6
Table 4. IDEQ and CDA Tribe - QA/QC results: nutrient blanks and replicates for 2009. 11
Table 5. IDEQ - QA/QC results: metals & chlorophyll *a* blanks and replicates for 2009..... 12
Table 6. Coeur d'Alene Tribe - QA/QC results: metals & chlorophyll *a* blanks and replicates for 2009..... 13
Table 7. Results of laboratory splits between SVL Analytical and Spokane Tribal Lab for IDEQ and Tribe samples taken April 7, 2009..... 16
Table 8. Triplicate analysis of chlorophyll *a* samples, corrected for pheophytin a, by SVL, Spokane Tribal lab, and EPA lab. Samples collected by Cd'A Tribe and IDEQ on August 17 and 18, 2009..... 17
Table 9. IDEQ and CDA Tribe - QA/QC results: nutrient Matrix Spikes and Lab Control Samples for 2009. 19
Table 10. EPA Manchester Lab- QA/QC results for IDEQ and CDA Tribe combined: Matrix Spikes and Lab Control Samples for 2009. 20
Table 11. Summary of water quality results for 2009 (variables are presented as µg/L except when noted)[a]. 28
Table 12. Trophic-state classification based on open-boundary values for four limnological variables (Woods and Beckwith, 1997)..... 38
Table 13. 2009 phytoplankton assemblage for site C1 – SE of Tubbs Hill, and C4 – NE of University Point. 52
Table 14. Phytoplankton assemblage for site C5 – south of Harrison, C6 – Chatcolet Lake and SJ1-Inundated St Joe River, April 2009 – December 2009..... 56
Table 15. Summary of nutrient loading budgets and annual river flow volume for Coeur d'Alene Lake as developed by the USGS for calendar years 1991 and 1992 and Water Years 2004 – 2006 (data modified from Table 4, Wood and Beckwith, 2008)..... 67
Table 16. LOADEST regression model statistics. 69
Table 17. IDEQ and Tribe estimates of annual total phosphorus loading into Coeur d'Alene Lake for Water Years 2004 – 2009 from various sampling sites along the Coeur d'Alene River using USGS BEMP data with LOADEST modeling..... 70
Table 18. IDEQ and Tribe estimates of annual total nitrogen loading into Coeur d'Alene Lake for Water Years 2004 – 2009 from various sampling sites along the Coeur d'Alene River using USGS BEMP data with LOADEST modeling. 71
Table 19. Total phosphorus and total nitrogen load budgets for Coeur d'Alene Lake (WY2009) using USGS BEMP data with LOADEST modeling..... 71

Acronyms and Abbreviations

BEIPC	Coeur d'Alene Basin Environmental Improvement Project Commission (formed in 2002)
BEMP	Basin Environmental Monitoring Program
cfs	cubic feet per second
CCC	Criterion Continuous Concentration (chronic criteria)
CMC	Criterion Maximum Concentration (acute criteria)
CWA	Federal Clean Water Act
CY91-92	calendar years 1991-1992, USGS sampling from January 1991 - December 1992
CY07-08	calendar years 2007-2008, IDEQ and Tribe sampling from June 2007 - December 2008
CY08	calendar year 2008, IDEQ and Tribe sampling
CY09	calendar year 2009, IDEQ and Tribe sampling
IDEQ	Idaho Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
IDAPA	Idaho Administrative Procedures Act
kg	kilogram
2009 LMP	2009 Coeur d'Alene Lake Management Plan
m	meter
mg/L	milligrams per liter
ROD	Record of Decision
SSC	suspended sediment concentration
QAPP	Quality Assurance Project Plan
Tribe	Coeur d'Alene Tribe
TSS	total suspended solids
µg/L	micrograms per liter
µm	micron
$\mu m^3/mL$	cubic microns per milliliter
USGS	United States Geological Survey
WQS	water quality standards
WY04-06	water years 2004-2006, USGS sampling from October 2003 – August 2006

Section 1: Description of Monitoring Program

1.1 Background

This report describes a routine monitoring program on Coeur d'Alene Lake conducted by the Idaho Department of Environmental Quality (IDEQ) and the Coeur d'Alene Tribe (Tribe), from April through December 2009. Limnological data and analyses for this period are presented. This is the second annual monitoring report; the initial report covered the period of 2007-08 (Cd'A Tribe and IDEQ, 2010).

In June 2007, IDEQ and the Tribe began a routine monitoring program in Coeur d'Alene Lake. This program is a continuation of baseline monitoring and studies conducted by the U.S. Geological Survey (USGS) and the Tribe from October 2003 through August 2006 (Wood and Beckwith, 2008) and an earlier USGS baseline study conducted from January 1991 through December 1992 (Woods and Beckwith, 1997). The 2003-2006 studies (Water Years 04-06) were funded by an Environmental Protection Agency (EPA) Clean Water Act grant whose funding ended in 2006. Under agreement by IDEQ and the Tribe, as part of an ongoing effort to jointly develop and implement a Lake Management Plan (LMP) for the lake, a program of continued monitoring at key USGS sites was initiated. The goal of routine monitoring is to provide long-term, annual trend records of key water quality parameters in support of LMP decisions and implementation. Under the LMP, Tribal staff shall sample stations in Tribal jurisdiction waters of the southern lake and lower St. Joe River, and IDEQ staff shall sample northern pool waters within State jurisdiction.

Regional EPA staff have participated in the effort for development of an LMP. The EPA staff secured agreements and made arrangements for the EPA Manchester Laboratory (in Port Orchard, WA) to receive and analyze samples for concentrations of trace metals, certain minerals, and chlorophyll *a*. IDEQ and the Tribe secured laboratory facilities and financing for sample analysis of nutrient concentrations and phytoplankton identification/enumeration. The Tribe selected Spokane Tribal Laboratory for their nutrient analysis, IDEQ selected SVL Analytical (Kellogg, ID), and both selected TG EcoLogic (an LLC arm of TerraGraphics) for phytoplankton samples.

IDEQ and the Tribe jointly prepared a Quality Assurance Project Plan (QAPP) according to EPA guidelines, and submitted the QAPP to EPA for approval. The document was approved in June, 2007 (IDEQ and Cd'A Tribe, 2007). The QAPP was designed to not only address quality assurance/quality control (QA/QC) issues but to serve as the initial work plan for the 2007 monitoring season. In preparation for each subsequent monitoring season, EPA has required an amended QAPP. IDEQ and the Tribe have updated the QAPP each year and submitted the updated document to EPA for approval (IDEQ and Cd'A Tribe, 2009a for the 2009 monitoring program). The most current version of the QAPP can be viewed at the IDEQ web site, www.deq.idaho.gov, or the Tribe web site, www.cdatribe-nsn.gov/lake.

The Coeur d'Alene Lake Management Plan was finalized in March of 2009 (IDEQ and Cd'A Tribe, 2009b). Discussion and details of a core routine monitoring program are presented in Appendix B of the 2009 LMP. The 2009 LMP can also be viewed at the above web sites.

Table 1. Sampling locations of the Coeur d'Alene Lake Monitoring Program.

USGS Site #	USGS site number, location, and approximate depth	Latitude[c]	Longitude[c]
C1	473900116453000 Coeur d'Alene Lake – 1.3 miles southeast of Tubbs Hill near Coeur d'Alene, ID Depth: 40 meters[a]	47° 39' 00"	-116° 45' 30"
C4	473054116500600 Coeur d'Alene Lake – 1.7 miles northeast of University Point near Harrison, ID Depth: 40 meters[a]	47° 30' 54"	-116° 50' 06"
C5	472500116450000 Coeur d'Alene Lake – mid-lake between Browns Point and north end of Shingle Bay near Harrison, ID (NE of Blue Point by USGS). Depth: 17 meters[a]	47° 25' 00"	-116° 45' 00"
C6	472120116451000 Chatcolet Lake 0.4 miles northwest of Rocky Point near Plummer, ID Depth: 11 meters[a]	47° 21' 20"	-116° 45' 10"
SJ1[b]	Lower St. Joe River - ~100 m upstream of USGS gauge 12415140 near Chatcolet, ID Depth: 18 meters[a]	47° 21' 27"	-116° 41' 10"

a = At full summer pool, lake surface elevation is 2128 feet
b = New Tribal sampling site within lower St. Joe River
c = North American Datum of 1983

1.2 Sampling Locations & Sampling Frequency

IDEQ selected two of the USGS reference sites in the deep waters of the northern pool for continued monitoring. These were sampling sites C1 – SE of Tubbs Hill, and C4 – NE of University Point (Figure 1, Table 1). The Tribe retained USGS sites C5 – mid-lake between Browns Point and north end of Shingle Bay (NE of Blue Point by USGS), and C6 - Chatcolet Lake. The Tribe added a new station on the lower St. Joe River (SJ1).

The schedule of sampling events was established at a maximum of eight (8) sampling visits per calendar year (Table 2). The timing of sampling visits coincides with specific river flow and lake conditions of interest throughout the year. IDEQ and the Tribe coordinate their respective field sampling events so that they are both conducted during the same week. The lake sampling schedule matches fairly closely the USGS sampling scheme at the mouths of the Coeur d'Alene and St. Joe Rivers under the EPA Coeur d'Alene Basin Environmental Monitoring Plan (BEMP, USEPA, 2004). The BEMP began in October 2003 to evaluate the long-term effects of cleanup actions as part of the remediation process for the Bunker Hill Mining and Metallurgical Complex Superfund facility.

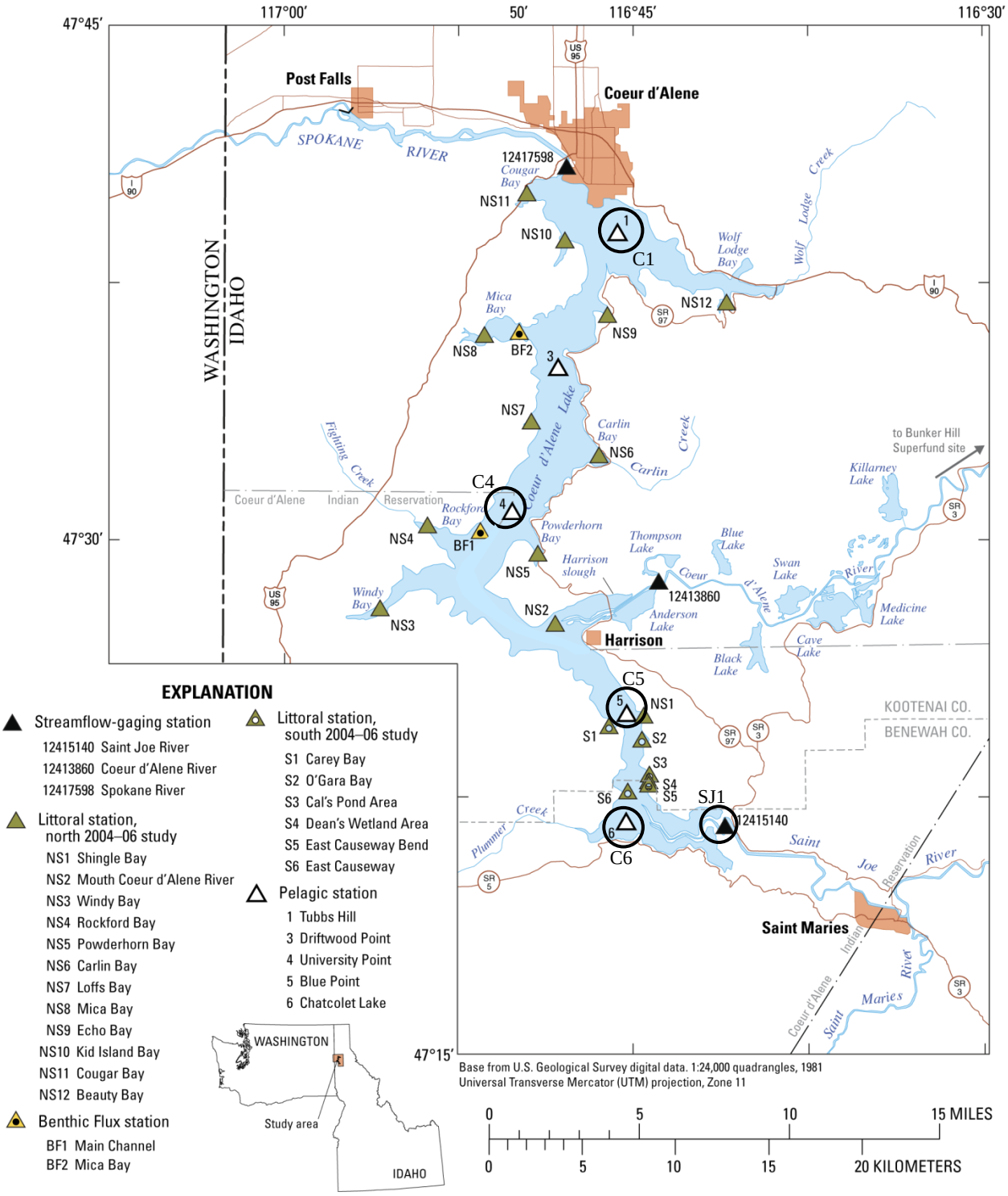

Figure 1. Map of sampling sites for the Coeur d'Alene Lake Monitoring Program (circled); map provided by USGS for WY04-06 sampling program (Wood and Beckwith, 2008).

Table 2. Annual sampling visits for the Coeur d'Alene Lake Monitoring Program (selection of 8 sampling events below).

Sampling visit	Season	Month	Lake condition
1	winter – early spring	December – March	*Variable schedule*: unstratified; prior to spring peak runoff; potential opportunity to sample during major rain-on-snow lake inflow event.
2	winter – early spring	January - March	*Optional schedule*: unstratified; prior to spring peak runoff; second opportunity to sample during major rain-on-snow lake inflow event or early spring peak runoff.
3	spring	late March – early June	*Variable schedule*: during spring peak runoff, opportunity to sample strong riverine influences on the lake; spring pulse of diatom growth develops.
4	late spring	mid-June	*Set schedule*: onset of stratification, spring pulse of diatom growth; before the onset of strong thermal stratification.
5	summer	mid-July	*Set schedule*: strong thermal stratification is established; sample the development of a metalimnetic chlorophyll *a* maximum; for some years, the peak of epilimnetic temperatures and thermocline thickness.
6	summer	mid-August	*Set schedule:* for some years, the peak of epilimnetic temperatures and thermocline thickness; declines in dissolved oxygen near bottom may become evident; phytoplankton peaks might start to develop at stations C5 and C6.
7	late summer	mid-September	*Optional – depending on early season sampling*: phytoplankton growth waning in northern pool, and still-strong thermal stratification in northern pool; DO deficit at C5 may be at maximum for season.
8	fall	early to mid-October	*Set schedule*: within northern pool, thermocline is deep but stratification still persists; DO deficits near bottom are still evident and often exhibit the peak of DO deficit for the season; waters of C5 and C6 have undergone fall turnover, and phytoplankton growth may still be at its peak.
9	early winter	late-November or early December	*Set schedule:* unstratified (northern lake has undergone fall turnover); water quality data fairly uniform from top to bottom, and not yet affected by a rain-on-snow event (usually).

1.3 Parameters Sampled and Sampling Methods

Details of the routine lake sampling are presented in Part B and Appendix B of the QAPP (IDEQ and Cd'A Tribe, 2009a). These details include: 1) variables sampled, 2) instrumentation maintenance and calibration, 3) field measurements taken and methods, 4) sample containers and reagents for water samples, 5) pre-visit cleaning procedures and in-the-field procedures to avoid contamination, 6) methods for water sampling and sample preservation, and 7) quality control samples such as blanks and replicates. The sampling program detailed in the QAPP is summarized below.

Field Measurements Taken

On sampling visits IDEQ and the Tribe measure and record a series of physical parameters. The sampling site is first located using a GPS way-point feature, and then the sampling boats are anchored. Station water depth is recorded using a fathometer.

A Secchi disc transparency measurement is taken. IDEQ records a Secchi disc depth with and without the aid of an aquatic view tube. The Tribe and IDEQ use radiation measurement instruments to determine the depth where Photosynthetically Active Radiation (PAR) is 1% of the light incident on the water surface. This 1% light level is the theoretical compensation point for photosynthetically driven primary productivity and is labeled as the photic zone in this report. Instrumentation includes an on-deck sensor to represent light intensity impinging on the water surface (in $\mu mol/s/m^2$) and an underwater PAR sensor to measure light intensity going down the water column. The photic zone depth is determined and recorded when underwater PAR is 1% of the on-deck light reading.

Lastly, using a Hydrolab® DS5X multiprobe with chlorophyll *a* fluorescence sensor, a water column profile is taken of water temperature, dissolved oxygen (DO) concentration, %DO saturation, pH, specific conductance, chlorophyll *a* fluorescence, and turbidity. As the Hydrolab® reaches the lake bottom, station water depth is confirmed with the depth sensor (the lake bottom is easily felt with the Hydrolab).

Chemical and Biological Constituents

Water quality variables that are sampled and analyzed are shown in Table 3 along with the laboratory methods and target reporting limits from the three laboratories utilized (and the fourth lab, TG Eco-Logic for phytoplankton identification/enumeration). The Tribe and IDEQ sample multiple zones down the water column, as described below. Not all variables are analyzed within every sampling depth zone.

Table 3. Analytical methods and data quality for analytes of the Coeur d'Alene Lake Monitoring Program (Note: target reporting limits are the values used by the EPA Manchester Lab, Spokane Tribal Lab, and SVL Analytical for the 2009 monitoring years).

Analyte	Analytical Method	Target Reporting Limit	Precision & Accuracy/ Completeness
Nutrients	***Spokane Lab / SVL Analytical***	***Spokane / SVL***	
ammonia, dissolved[(a)]	EPA 350.3 / EPA 350.1	10 / 30 µg/L	+/- 25% 95%
nitrite+nitrate, dissolved[(a)]	EPA 353.2	10 / 15 µg/L	
total nitrogen	SVL = SM[b] D-5176	50 µg/L	
total Kjeldahl nitrogen	Spokane = EPA 351.2	50 µg/L	
total phosphorus	EPA 365.3 / SM[b] 4500-P-E	5 µg/L	
total dissolved phosphorus[(a)]	EPA 365.3 / SM[b] 4500-P-E	5 µg/L	
orthophosphate, dissolved[(a)]	EPA 365.5 / SM[b] 4500-P-E	2 / 3 µg/L	
Total recoverable metals, unfiltered, digested		***EPA Manchester Lab***	
cadmium	EPA 200.8 – ICP-MS	0.13 µg/L	+/- 25% 95%
lead	EPA 200.8 – ICP-MS	0.13 µg/L	
zinc	EPA 200.7 – ICP-SAS	5.0 µg/L	
arsenic	EPA 200.8 – ICP-MS	0.63 µg/L	
iron	EPA 200.7 – ICP-SAS	5.0 µg/L	
manganese	EPA 200.8 – ICP-MS	0.13 µg/L	
Dissolved metals, filterable, undigested[(a)]		***EPA Manchester Lab***	
cadmium	EPA 200.8 – ICP-MS	0.10 µg/L	+/- 25% 95%
lead	EPA 200.8 – ICP-MS	0.10 µg/L	
zinc	EPA 200.7 – ICP-SAS	5.0 µg/L	
arsenic	EPA 200.8 – ICP-MS	0.20 µg/L	
iron	EPA 200.7 – ICP-SAS	5.0 µg/L	
manganese	EPA 200.8 – ICP-MS	0.10 µg/L	
Minerals		***EPA Manchester Lab***	
total hardness (as $CaCO_3$)	SM 2340B	0.30 mg/L	
calcium, dissolved	EPA 200.7 – ICP-AES - mod. scan	0.03 mg/L	+/- 25% 95%
magnesium, dissolved	EPA 200.7 – ICP-AES - mod. scan	0.05 mg/L	
Biological		***EPA Manchester Lab***	
chlorophyll *a*	SM 1002G – fluorometric	1.0 µg/L	+/- 25% 95%
Biological	***TG Eco-Logic***		
phytoplankton	SM 1002 C-F – identification /enumeration with sedimentation and 900 magnification	n/a	n/a

a = Samples are field filtered through a 0.45 µm pore size capsule filter for dissolved analysis
b = Standard Methods for the Examination of Water and Wastewater

The four vertical sampling zones are:

1. **Photic zone composite:** five equally spaced samples from 0.75 m below the surface to the depth where underwater PAR is 1% of the light incident on the surface, composited into a churn splitter.

2. **Zone of maximum chlorophyll *a*:** a discrete sample collected at the depth of maximum chlorophyll *a* fluorescence if so determined by the Hydrolab® profile. During summer stratification, on 2 - 3 of the yearly sampling visits, there has been a pronounced peak of chlorophyll *a* fluorescence within the metalimnion or upper hypolimnion observed in both the USGS WY04-06 program and the Tribe/IDEQ program (2007-09).

3. **Discrete sampling at 20 m and 30 m for northern pool stations**: USGS sampled at these depths, and a trend of interest was that zinc concentrations vary considerably from upper waters to bottom waters from about April – October. Beginning in 2009, if IDEQ sampled at a chlorophyll *a* maxima depth in the summer, this sample substituted for the 20 m sample (chlorophyll *a* summer maxima are typically found at 15 – 19 m depths).

4. **1 meter above lake bottom:** a discrete sample, with sampling depth determined from the Hydrolab® profile.

Sampling Methods

In general, the water sampling program is conducted in accordance to the USGS standard procedures for sample collection, as described in the National Field Manual for the Collection of Water-Quality Data: U.S. Geological Survey TWRI, Book 9, chapters A1-A6 (USGS, variously dated). The TWRI manuals describe the procedures for:

- Selection of equipment and supplies for surface water sampling (Chapter A2, Lane *et al*. 2003)
- Preparation for water sampling (Chapter A1, Wilde 2005)
- Cleaning of equipment for water sampling (Chapter A3, Wilde 2004)
- Collection of lake water samples (Chapter A4, Wilde *et al*. 1999)
- Field processing of water samples (Chapter A5, Wilde *et al*. 2004)
- Handling and shipping of samples (Chapter A5)

The specific sampling procedures used by the Tribe and IDEQ are detailed in Appendix B of the QAPP. A summary of some of the sampling features is as follows:

- Sample bottles used for metals samples are PreCleaned Certified™, 500 ml HDPE bottles for dissolved and total metals analysis. Container preparation includes: non-phosphate detergent washing, multiple tap water and ASTM Type I deionized water rinses, and 1:1 HNO_3 rinses.

- Water samples are obtained with a 2.2 L or 6.2 L non-metallic Kemmerer bottle with sample water composited into a 14 L churn splitter.
- Filters for chlorophyll *a* analysis are Advantec MFS GF-75, 0.3 μm pore size. Filters are placed in a Petri dish, covered with aluminum foil, and kept cold on dry ice while on the boat. Filters are shipped to the EPA Manchester lab in dry ice containers.
- Filtration for dissolved metals and nutrients use Millipore groundwater filter capsules: 0.45 μm pore size, 600 cm^2 filter area.

Section 2: Quality Assurance/Quality Control

The QA/QC program and parameters for Coeur d'Alene Lake monitoring are detailed in the QAPP (IDEQ and Cd'A Tribe, 2009a), and were also detailed in the initial annual monitoring report (for 2007-08, Cd'A Tribe and IDEQ, 2010). The following Section of the 2009 annual report presents a summary of QA/QC results collected in 2009 monitoring.

QC samples are controlled samples introduced into the analysis stream whose results are used to review data quality and to calculate the accuracy and precision of the chemical analysis program. Collection and analysis frequency for field QC samples are generally recommended at a rate around 10 percent of the water quality samples taken. For QC results that are unsatisfactory, methods in the field or laboratory need to be examined for modifications that will bring the results within the precision/accuracy guidelines of the QAPP (see right column of Table 3).

2.1 Method Reporting Limits (MRLs)

MRLs for metals, minerals, and chlorophyll *a* are established by the EPA Manchester Lab as shown in Table 3. For nutrient analysis, MRLs were provided by Spokane Tribal Lab (STL) and SVL Analytical.

For analysis of total phosphorus (TP) and dissolved total phosphorus (DTP), SVL has modified their Standard Operating Procedure (SOP) for method SM 4500-P-E to provide for a low level phosphorus analysis to meet the needs of the Coeur d'Alene Lake sampling program. For the modified 2009 SOP, MRLs for TP and DTP are 5 µg/L, and Method Detection Limits (MDL) are 1.9 µg/L.

2.2 Field and Office Blanks

2.2.1 IDEQ Blank Results

Table 4, first data column, shows the results of IDEQ field and office blank data for nutrients (2 to 4 blank samples taken). All office and field blanks were <MRL. Occasionally, SVL laboratory prepared blanks are reported >MDL (method detection limit), but in all but one case blanks were <MRL.

For trace metals, minerals, and chlorophyll *a*, all field and office blanks were <MRL (Table 5, first data column).

2.2.2 Tribe Blank Results

Two types of QAQC blanks were done in 2009. A pre-season equipment blank and a field blank following sampling at site C5. Table 4 provides the results of combined equipment and field blanks. The results from the equipment and field blanks results were different and will be discussed separately. Field blanks are taken in the field at site C5after the equipment was used then acid-washed, and distilled water rinsed. The intent of the field blanks analysis is to measure if the between-site equipment cleaning is effectively reducing the chance of cross-contamination between sites. For the field blanks the constituent orthophosphate exceeded the MRL of

<2 µg/L once from the Churn Splitter blank. The exceedance value was 2.3 µg/L and not considered significant because it was so near the <2 µg/L MRL. For the constituent total phosphorus, two values, both 5 µg/L exceeded the <5 µg/L MRL. These limits were not considered significant because both values were at the MRL.

The exceedance values for orthophosphate and Kjeldahl nitrogen were higher from the equipment blank compared to the field blank. Orthophosphate values of 2.9, 4.7 and 5.3 µg/L from the sample bottle, Van Dorn Bottle and Churn Splitter respectively all exceeded the <2 ug/L MRL. The Kjeldahl values of 80 and 110 ug/L from the sample bottle and churn Splitter respectively were higher than the <50 ug/L MRL. The most likely source of contamination for the equipment blanks is contaminated sample bottles. When equipment blanks are taken the sample bottle cleanliness is tested by pouring certified ASTM type 2 ultrapure water directly into the bottle. The Van Dorn sampler and the churn splitter also receive the ultrapure water and their sample of blank water is poured directly into a sample bottle. The sample bottles used for the equipment blanks were reused sample bottles after they had been washed in Liqui-nox® and then 5% HCL acid washed at the Spokane Tribal Laboratory. We believe the sample bottles were in some way contaminated. This belief is supported by the fact that the laboratory internal blanks were all <MRL for all variables. To remedy this quality issue we purchased new precleaned sample bottles to replace the old bottles. This same equipment blank procedure will be done every year and new bottles will be used at the beginning of each season.

With the exception of calcium, CDA Tribe field blanks and equipment blanks for trace metals were all <MRL (Table 6). The field blank is done after site C5 is sampled because C5 has the highest trace metals concentration than the other southern lake sites we sample. Thus, when the field blanks are <MRL, there is a low likelihood of cross-contamination of samples from sites sampled after C5.

2.3 Replicates to Assess Precision

Precision is defined as the degree of agreement between independent, similar, or repeated measures. Precision is expressed in terms of analytical variability. For this project, analytical variability is measured as the relative percent difference (RPD), or coefficient of variability, between analytical field and laboratory replicates, and between the MSD and LCSD analysis (described later). Field replicates prepared by IDEQ and the Tribe are conducted to identify environmental, monitoring equipment, sample handling, and laboratory environment/ measurement variability. The three laboratories also perform and report duplicate analysis of selected field samples submitted, and these replicates isolate laboratory analytical variability.

For laboratory replicates, the three laboratories have a ± 20% RPD requirement. For SVL nutrient analysis, there is no control limit for the %RPD if the concentration in the samples is less than five (5) times the MRL. For field prepared replicates the level of acceptance is ±25% RPD (Table 3). Replicate data results in Tables 4 - 6 were calculated as absolute differences between pairs, so limit requirements are %RPD.

Table 4. IDEQ and CDA Tribe - QA/QC results: nutrient blanks and replicates for 2009.

Analyte	Field & office blanks: # of <MRL[a]/ # of samples	Lab replicates of selected samples: mean %RPD[b] (n)[c]	Sample replicates: mean %RPD (n)[c]	Absolute mean difference between replicate pairs (µg/L)	Field repli-cates: mean %RPD (n)[cd]	Side-by-side field replicates: mean %RPD for n = 3
Nutrients - SVL Analytical						
ammonia (N), dissolved [e]	4/4	*105 (1)[R3]	24.8 (1)	17.0	29.4 (1)	38.2
nitrite+nitrate (N), dissolved	4/4	10.2 (6)	11.1 (6)	15.5	41.1 (2)	20.2(2)
total nitrogen (N)-analytical	4/4	18.1 (11)	11.6 (6)	18.0	21.6 (3)	45.8
total phosphorus	4/4	4.4 (7)	11.8 (6)	1.6	45.3 (1)	74.9
total phosphorus, dissolved	4/4	8.1 (3)	2.0 (3)	0.1	<MRL (3)	63.5
ortho-phosphate, dissolved	2/2	<MRL (3)	<MRL (2)	<MRL	<MRL (2)	74.6
Nutrients – Spokane Tribal Lab						
ammonia (N), dissolved [e]	5/5	15.6 (14)	<MRL (2)	<MRL	1.1 (1)	Same
nitrate (N), dissolved	6/6	7.2 (9)	<MRL (2)	<MRL	<MRL (2)	as
nitrite (N), dissolved	6/6	<MRL (9)	<MRL (2)	<MRL	<MRL (2)	above
Kjeldahl (N)-analytical	*2/5	15.6 (14)	3.5 (2)	5.0	15.7 (2)	
total phosphorus	*3/5	6.1 (13)	9.9 (2)	1.0	24.2 (2)	
total phosphorus, dissolved	--	13.6 (9)	6.5 (2)	0.1	50.9 (2)	
ortho-phosphate, dissolved	*2/6	8.0 (9)	*27.8 (2)	2.1	36.6 (2)	

a = <MRL - less than Method Reporting Limit.
b = %RPD - relative percent difference.
c = n = sample size. Calculations of mean % RPD and mean absolute difference can be based on fewer replicate pairs when both values of a set were <MRL (not included in the calculations).
d = Field replicates were either photic zone composites or at discrete depths.
e = Samples are field filtered through a 0.45 µm pore size capsule filter for dissolved analysis.
* = QA/QC results that do not meet (exceed) established or required limits (does not apply to field and side-by-side replicates).
R3= For SVL lab replicates, if constituent concentrations are less than 5 times the MRL, %RPD does not apply (as in the case for ammonia).

Table 5. IDEQ - QA/QC results: metals & chlorophyll *a* blanks and replicates for 2009.

Analyte	Field & office blanks: # of <MRL[a]/ # of samples	Lab replicates of selected samples: mean %RPD[b] (n)[c]	Sample replicates: mean %RPD (n)[c]	Absolute mean difference between replicate pairs (µg/L)	Field repli-cates: mean %RPD (n)[cd]	Side-by-side field replicates: mean %RPD for n = 3
Total recoverable metals, unfiltered, digested - EPA Manchester Lab						
cadmium	5/5	3.1 (8)	4.4 (5)	0.01	3.3 (3)	15.5
lead	5/5	1.1 (8)	1.4 (5)	0.01	4.4 (3)	10.5
zinc	5/5	1.6 (8)	0.8 (5)	0.5	2.2 (3)	7.5
arsenic	5/5	21.4 (2)	<MRL (5)	<MRL	<MRL (3)	11.9 (1)
iron	5/5	6.0 (8)	3.3 (5)	2.0	9.8 (3)	13.7
manganese	5/5	0.7 (8)	0.5 (5)	0.06	11.4 (3)	22.7
Dissolved metals, filterable, undigested[e] - EPA Manchester Lab						
cadmium	5/5	6.1 (8)	8.5 (5)	0.03	20.0 (3)	9.3
lead	5/5	2.9 (6)	8.3 (4)	0.05	35.4 (2)	17.8
zinc	5/5	1.8 (8)	1.0 (5)	0.7	1.0 (3)	7.1
arsenic	5/5	3.3 (8)	10.6 (5)	0.04	14.2 (3)	8.5
iron	5/5	7.4 (7)	11.3 (5)	1.0	52.0 (1)	8.5
manganese	5/5	1.5 (8)	4.1 (5)	0.02	54.1 (3)	34.1
Minerals - EPA Manchester Lab						
total hardness (as $CaCO_3$)	5/5	1.2 (8)	1.2 (5)	0.3 mg/L	1.2 (3)	0.5
calcium, dissolved	5/5	1.5 (8)	0.8 (5)	0.04 mg/L	1.5 (3)	2.1
magnesium, dissolved	5/5	0.8 (8)	0.6 (5)	0.01 mg/L	0.9 (3)	1.4
Biological - EPA Manchester Lab						
chlorophyll *a*	2/2	- -	37.2 (1)	0.73	13.7 (2)	30.5 (2)

a = <MRL - less than Method Reporting Limit.
b = %RPD - relative percent difference.
c = n = sample size. Calculations of mean %RPD and mean absolute difference can be based on fewer replicate pairs when both values of a set were <MRL (not included in the calculations).
d= Field replicates were either photic zone composites or at discrete depths.
e= Samples are field filtered through a 0.45 µm pore size capsule filter for dissolved analysis.
* = QA/QC results that do not meet (exceed) established or required limits (does not apply to field and side-by-side replicates).

Table 6. Coeur d'Alene Tribe - QA/QC results: metals & chlorophyll *a* blanks and replicates for 2009.

Analyte	Field & office blanks: # of <MRL[a]/ # of samples	Lab replicates of selected samples: mean %RPD[b] (n)[c]	Sample replicates: mean %RPD (n)[c]	Absolute mean difference between replicate pairs (µg/L)	Field repli-cates: mean %RPD (n)[cd]	Side-by-side field replicates: mean %RPD for n = 3
Total recoverable metals, unfiltered, digested - EPA Manchester Lab						
cadmium	5/5	Same	<MRL (2)	<MRL	<MRL (2)	Same
lead	5/5	as	0.0 (1)	0.00	4.1 (1)	as
zinc	5/5	Table 5	0.6 (1)	0.20	<MRL (2)	Table 5
arsenic	5/5		5.1 (1)	0.04	33.3 (1)	
iron	5/5		4.0 (1)	4.00	21.6 (2)	
manganese	5/5		2.8 (1)	0.29	1.4 (2)	
Dissolved metals, filterable, undigested [e] - EPA Manchester Lab						
cadmium	1/1	Same	18.2 (1)	0.02	<MRL (2)	Same
lead	1/1	as	14.3 (1)	0.02	<MRL (2)	as
zinc	1/1	Table 5	1.4 (1)	0.40	<MRL (2)	Table 5
arsenic	1/1		5.5 (2)	0.02	14.9 (2)	
iron	1/1		7.1 (2)	2.00	27.5 (2)	
manganese	1/1		4.1 (2)	0.12	5.0 (2)	
Minerals - EPA Manchester Lab						
total hardness (as $CaCO_3$)	1/1	Same	1.6 (2)	0.30 mg/L	1.9 (2)	Same
calcium, dissolved	0/1	as	1.5 (2)	0.09 mg/L	0.7 (2)	as
magnesium, dissolved	1/1	Table 5	0.9 (2)	0.02 mg/L	1.2 (2)	Table 5
Biological - EPA Manchester Lab						
chlorophyll *a*	--	--	24.0 (1)	0.55	<MRL (2)	Same as Table 5

a = <MRL - less than Method Reporting Limit.
b = %RPD - relative percent difference.
c = n = sample size. Calculations of mean % RPD and mean absolute difference can be based on fewer replicate pairs when both values of a set were <MRL (not included in the calculations).
d= Field replicates were either photic zone composites or at discrete depths.
e= Samples are field filtered through a 0.45 µm pore size capsule filter for dissolved analysis.
* = QA/QC results that do not meet (exceed) established or required limits (does not apply to field and side-by-side replicates).

For either the laboratory or field replicates, if both results of a replicate set for any variable were <MRL, a %RPD was not calculated, and thus not included in the mean %RPD statistics of Tables 4 - 6 (footnote *c* of the tables).

Laboratory Replicates. Lab replicate results for nutrients and metals are shown in the 2nd data column of Tables 4 and 5. For metals (Table 5), results for IDEQ and Tribe samples submitted to the EPA lab are combined. Often, mean %RPDs are lower than the field prepared replicates. All mean %RDPs for metals and minerals are below the 20% lab requirement except for total arsenic. Only two replicate sets for total arsenic were above MRL, and for one set, %RPD = 31%.

For IDEQ lab replicates of nutrients (Table 4), all results are satisfactory except for dissolved ammonia where the one pair above MRL was 105 %RPD. SVL labeled this result as not applicable for the control limit since concentrations were less than 5 times MRL (code R3 on the footnotes).

For the Tribe, Spokane Tribal Laboratory replicates of nutrients were well below the %RPD QA/QC criteria (Table 4).

Sample Replicates: Replicate sets of samples are withdrawn from the same volume of water in the churn splitter. They are processed and analyzed separately to assess any variability in sample handling, bottles, shipping, or laboratory analytical precision.

For 2009 sampling, IDEQ took six sample replicates at various depth zones for nutrients (3rd data column of Table 4). All results were satisfactory. In the 4th column of Table 4 the mean absolute difference in pairs is presented. For dissolved nitrite+nitrate, a mean difference of 15.5 µg/L is considered to be unrepresentative of most nitrite+nitrate pairs, as one set of the six had a poor replication of 83 µg/L difference and 55 %RPD (mean absolute difference = 2.0 µg/L without the aforementioned high difference).

For the Tribe sample replicates of nutrients (Table 4) all results met QA/QC criteria except for sample replicates of orthophosphate. The mean %RPD of 27.8% for orthophosphate (Table 4) exceeded the 25% QA/QC criteria. However this exceedance was not considered significant because the actual concentrations of the replicate pairs was very low (e.g., 8.8 and 11.0, and 5.0 and 7.0 ug/L). These low concentrations produced very low differences between sample replicates and a mean absolute difference between pairs of 2.1 ug/L.

For metals, IDEQ took five sample replicate sets (3rd column of Table 5.). Mean %RPDs were all under 25%. There was only one sample replicate for chlorophyll *a*, and that pair equaled 37 %RPD.

For the Tribe sample replicates of metals, the tribe took two sets of samples. All metals %RPD for sample replicates were below the 25% QA/QC criteria (Table 6). In some cases the sample size was only one because one or both replicates were below the minimum reporting limit.

Field Replicates. A field replicate is defined as a second sample from the same location and sample depth zone, collected in immediate succession, using identical techniques. A field replicate provides estimates of the total sampling and analytical precision, and potential

heterogeneity in the sampled medium. Unlike sample replicates, IDEQ and the Tribe do not establish a required %RPD limit for field replicates.

IDEQ conducted three field replicates; two from photic zone composite sampling, the sampling zone with the greatest possibility of replicate variability, and one replicate at a discrete depth. Results are shown in the 5th data column of Tables 4 and 5.

For IDEQ nutrient field replicates, all variables with a calculated mean %RPD were greater than sample replicates (sets for DTP and DOP were all <MRL). Except for total nitrogen, all variables with a calculated %RPD had means greater than 25%. For dissolved ammonia and TP there was only one set >MRL. For total metals (Table 5) mean %RPDs were all <12%. For dissolved lead, iron (n=1), and manganese, mean %RPD's were greater than 25%. For two field replicates of chlorophyll *a* within photic zone composites, replication was good at 14 %RPD.

The Tribe sampled for field replicates on two occasions. Similar to IDEQ field replicate results, most of the nutrient %RPD values were greater than 25%. Kjeldahl nitrogen was the only constituent below the 25%, %RPD (Table 4). Variability in the water column is an important factor that produces the high %RPD for nutrients (Table 4). The field replicate results for metals from the Tribe sampling reveals somewhat lower %RPD values compared to nutrients (Table 6).

Field-Staff Replicates and Lab Sample Splits. Once a year, in August, IDEQ and the Tribe have sampled southern station C5 (Figure 1), side-by-side. The two monitoring boats are anchored close together, and then at the same time field staff independently conducts all field measurements and water sample collections for submittal to the laboratories. This sampling incorporates numerous possibilities for sampling error, including environmental heterogeneity from collecting five discrete samples within the photic zone and compositing within a churn splitter. An added level of variability is that IDEQ nutrient samples are analyzed by SVL Analytical, while Tribe samples are analyzed by the Spokane Tribal Laboratory (STL). In 2009 three water zones were sampled by both staff (photic, 9 m, and near bottom). The %RPD results are shown in the 6th data column of Table 4 for nutrients, and the 6th column of Table 5 for metals and chlorophyll *a*. IDEQ and the Tribe do not establish a required %RPD limit for field staff replicates.

The side-by-side results from the EPA Manchester Lab (Table 5) for metals and minerals were good with all mean %RPDs less than 25% except for dissolved manganese (34%). For the two sets of chlorophyll *a* the mean %RPD was satisfactory at 30.5%.

Similar to data from 2007 and 2008, the 2009 side-by-side results for nutrient analysis were poorer than desired (Table 4). The %RPDs for the nitrogen series were satisfactory, but for TP, DTP, and DOP, %RPDs were >60% with IDEQ results consistently lower than Tribe results. For TP, mean concentration for 3 pairs of IDEQ samples = 9.0 µg/L, while mean concentration for Tribe samples = 19.7 µg/L (all concentrations ranged from 8 – 21 µg/L). IDEQ and the Tribe continue to consult with each other on field procedures and consult with personnel from the two laboratories to examine phosphorus lab analysis protocols for the low level of concentrations found in Coeur d'Alene Lake.

Beginning in 2008, IDEQ and the Tribe initiated an annual sampling where IDEQ and the Tribe conduct a nutrient sample replicate test between SVL and STL (lab-sample split). IDEQ

prepares a sample replicate set from one of the depth zones sampled (same churn splitter), and submits one set to SVL and the other to STL. The Tribe does likewise. This provides two %RPD comparisons per analyte. In 2009 the laboratory sample spilt was conducted on April 7.

The lab splits for 2009 provided satisfactory results as shown in Table 7 for n = 2 (TN and DOP were not analyzed in this lab split sampling). Results were far better than described above for field-staff replicates.

Table 7. Results of laboratory splits between SVL Analytical and Spokane Tribal Lab for IDEQ and Tribe samples taken April 7, 2009.

Constituent	SVL results (µg/L)	STL results (µg/L)	Absolute difference (µg/L)	%RPD
Total Phosphorus				
DEQ samples	13	10	3	26.1
Tribe samples	33	32	1	3.1
mean	23	21	2	14.6
Dissolved TP				
DEQ samples	5	6	1	18.2
Tribe samples	11	14	3	24.0
mean	8	10	2	21.1
Dissolved ammonia				
DEQ samples	<30	<10	<MRL	<MRL
Tribe samples	29	24	5	18.9
mean	29	24	5	18.9
Dissolved NO_2+NO_3				
DEQ samples	161	151	10	6.4
Tribe samples	137	130	8	6.0
mean	150	141	9	6.2

<u>Chlorophyll *a* Replicates.</u> In 2009 the Tribe initiated a comprehensive sampling of chlorophyll *a* concentrations to examine more closely the chlorophyll *a* maxima feature observed within the metalimnion during stratification and examine pheophytin *a* concentrations. Results of this sampling will be discussed in Section 3. As part of this study, the Tribe and IDEQ conducted a replicate sampling at stations C3 and C4 on August 17 and 18. For 10 individual samples collected within a churn splitter, triplicate samples were filtered for chlorophyll *a* analysis, and filters were submitted to SVL, STL, and the EPA lab. The former two labs use a spectrophotometer for analysis, and the EPA lab uses a fluorometric method. Results of this replicate sampling are presented in Table 8.

Overall, results from SVL and STL match up fairly well. There were three results from SVL less than the MRL for that lab (<1.00 µg/L), and these results were estimated at 0.50 µg/L for summation comparison. For three pairs the differences between these two labs are greater than 1.0 µg/L (C3 photic, C3–18 m, and C3–19 m). Concentrations for SVL were all higher than

Table 8. Triplicate analysis of chlorophyll *a* samples, corrected for pheophytin a, by SVL, Spokane Tribal lab, and EPA lab. Samples collected by Cd'A Tribe and IDEQ on August 17 and 18, 2009.

Sample station and sample depth	**SVL (µg/L)**	**STL (µg/L)**	**EPA lab (µg/L)**	**Range max – min (µg/L)**
C4 – 1-17.0 m (photic composite)	1.50	0.87	1.12	0.63
C4 – 17.0 m	2.40	1.68	2.01	0.72
C4 – 18.0 m	1.10	1.09	2.98	1.89
C4 – 20.0 m	1.20	1.88	1.89	0.69
C4 – 22-28 m (low light composite)	<1.00	0.41	<1.00	0.09
C3 – 1-17.5 m (photic composite)	1.80	0.57	1.40	1.23
C3 – 18.0 m	3.00	1.95	3.67	1.72
C3 – 19.0 m	3.10	1.85	3.17	1.32
C3 – 22.0 m	<1.00	1.64	3.90	3.40
C3 – 28–40 m (low light composite)	<1.00	0.74	<1.00	0.24
average concentrations[a]	1.56	1.27	2.11	1.19

a = for concentrations <MRL (<1.0 µg for SVL and EPA), one-half the MRL (0.50 µg/L) was used for summary statistics.

STL. On the average, fluorometric results from the EPA lab are higher than spectrophotomic results from SVL and STL. Relatively large differences were at C4-18 m (1.9 µg/L higher than SVL and STL), and at C3–22 m (at least 2.9 µg/L higher than SVL). When tabulating the maximum value minus the minimum value among the 3 lab results for 10 triplicates, the average difference was 1.19 µg/L.

Chlorophyll *a* %RPD calculations of replicate pairs submitted to the EPA lab by IDEQ and the Tribe during routine monitoring are a tighter fit than %RPD calculations of paired sets between EPA and either SVL or STL for the above triplicate set analysis of Table 8. For example, from 6 sets of sample and field replicates prepared by IDEQ for the EPA lab in 2007 – 2009, %RPD averaged 14.6%, where %RPD of EPA values matched with SVL values of Table 8 averaged 43.7% (n=8, eliminating paired sets <MRL).

2.4 Matrix Spikes and Lab Control Samples to Assess Accuracy

Accuracy is the amount of agreement between a measured value and the true value. For the Coeur d'Alene Lake Monitoring Program, accuracy assessments were exclusively prepared and measured in the three laboratories as the percent recovery of Matrix Spikes, Matrix Spike Duplicates, standard Lab Control Samples, and Lab Control Sample Duplicates.

Matrix Spike/Matrix Spike Duplicates (MS/MSDs). MS/MSDs are sample analyses performed to provide information about the effect of the sample matrix on analyte recovery and measurement within the project samples. To create the MS/MSD, known concentrations of analytes are added to the environmental samples prior to digestion or preparation. The samples are then processed through the entire analytical procedure, and the percent recovery of known analytes is calculated (%Rec). The laboratory recovery requirements are 75 – 125 %Rec. The EPA lab analyzes MS duplicates, and the MS %Rec pairs can be matched to calculate a %RPD for precision. For nutrients, SVL and STL do not perform Matrix Spike Duplicates.

IDEQ results for nutrient matrix spikes are shown in Table 9. Mean MS %Rec for all analytes are well within the acceptable limit (1st data column). The range of %Rec (2nd column) depicts whether accuracy was greater or less than 100% recovery, or if the recovery is consistently under, or over, the known spike concentration. For all nutrient analysis the range was on both sides of 100%.

Nutrient matrix spike results from samples collected by the Tribe are presented in Table 9. All % Recovery results were within the range of 75 – 125 % recovery criteria. Orthophosphate had the lowest mean % recovery (93%, but ranged between 80 to 120%). Kjeldahl nitrogen exhibited the broadest % recovery range Table 9.

For analysis from the EPA lab, Table 10 is a composite of IDEQ and Tribe results. The first data column shows the mean %Rec of MS and MSDs combined. All results are well within acceptable limits. For some metals, %Rec is consistently below 100% (total cadmium and dissolved lead for example), and for some the range is consistently above 100% (total iron and dissolved cadmium for example). For mean %RPD of matrix spike duplicate pairs (3rd data column, pairs of MS %Rec), all results are well within acceptable limits.

Laboratory Control Samples (LCS) and LCS Duplicates (LCSD). LCS is a clean matrix spiked with known quantities of analytes. The LCS is processed with field samples through every step of preparation and analysis. Measuring percent recovery of each analyte in the LCS provides a measure of accuracy for the analyte in the project samples. The EPA lab conducts LCS duplicates, and the LCS %Rec pairs can be matched to calculate a %RPD precision. For nutrients, SVL and STL do not perform LCS duplicates.

IDEQ and Tribe nutrient results for LCS are shown in Table 9. For IDEQ, all mean %Rec results are within the acceptable limit, and all ranges of %Rec were on both sides of 100%. For total phosphorus in 2009, SVL utilized a known standard concentration of 10.0 µg/L for LCS, similar to many of the lake concentrations. Given previous discussion on TP precision data of replicates, it is important to note that mean LCS for TP = 100.2 %Rec with a range of 91 – 114 %Rec (n = 7). This demonstrates fairly good laboratory accuracy results at a concentration representative of Coeur d'Alene Lake samples.

For the Tribe lab control sample (LCS) results for nutrients are presented in Table 9. The mean % recovery LCS for dissolved total phosphorus was high at 114%. Only one of the eight LCS samples for dissolved total phosphorus was below 100% recovery, with a range of 96 -123% recovery. This skewed range to the higher recovery rates is being addressed by Spokane Tribal Laboratory. QA/QC analyses in upcoming years will evaluate if progress is being made at reducing the % recovery and potential bias.

Table 9. IDEQ and CDA Tribe - QA/QC results: nutrient Matrix Spikes and Lab Control Samples for 2009.

Analyte	Lab matrix spikes: mean %Rec[a] (n)	Lab matrix spikes: range %Rec	Lab matrix spike duplicate: mean %RPD of %Rec	Lab control samples: mean %Rec (n)	Lab control samples: range of %Rec	Lab control samples duplicate: mean %RPD of %Rec
Nutrients - SVL Analytical						
ammonia (N), dissolved [b]	99 (10)	87-108	- -	100 (7)	92-108	- -
nitrite+nitrate (N), dissolved	106 (14)	95-117	- -	101 (7)	98-107	- -
total nitrogen (N)-analytical	100 (11)	88-110	- -	103 (11)	87-117	- -
total phosphorus	99 (7)	91-107	- -	100 (7)	91-114	- -
total phosphorus, dissolved	98 (7)	93-103	- -	104 (7)	88-116	- -
ortho-phosphate, dissolved	104 (6)	91-113	- -	104 (6)	89-112	- -
Nutrients – Spokane Tribal Lab						
ammonia (N), dissolved[b]	102 (8)	86-110	- -	101 (8)	91-118	- -
nitrite (N), dissolved	94 (8)	91-100	- -	91 (8)	88-95	- -
nitrate (N), dissolved	103 (8)	96-106		96 (8)	85-101	
Kjeldahl (N)-analytical	103 (10)	80-125	- -	98 (8)	81-119	- -
total phosphorus	101 (9)	93-113	- -	106 (8)	92-120	- -
total phosphorus, dissolved	102 (9)	95-110	- -	114 (8)	96-123	- -
ortho-phosphate, dissolved	*93 (8)	80-120	- -	95 (8)	83-120	- -

a = %Rec = percent recovery.
b = Samples are field filtered through a 0.45 µm pore size capsule filter for dissolved analysis.

Table 10. EPA Manchester Lab- QA/QC results for IDEQ and CDA Tribe combined: Matrix Spikes and Lab Control Samples for 2009.

Analyte	Lab matrix spikes: mean %Rec[a] n = 16	Lab matrix spikes: range of %Rec	Lab matrix spike duplicate: mean %RPD of %Rec	Lab control samples: mean %Rec (n)	Lab control samples: range of %Rec	Lab control samples duplicate: mean %RPD of %Rec
Total recoverable metals, unfiltered, digested - EPA Manchester Lab						
cadmium	97	94-99	0.9	99 (14)	97-101	0.6
lead	99	92-103	0.5	98 (14)	95-101	0.7
zinc	99	97-105	1.0	100 (14)	98-102	1.0
arsenic	98	95-100	1.0	97 (14)	95-99	0.6
iron	105	102-108	1.0	105 (14)	103-107	0.4
manganese	96	93-98	1.3	98 (14)	96-101	0.9
Dissolved metals, filterable, undigested [b] - EPA Manchester Lab						
cadmium	105	101-108	0.6	99 (16)	97-101	1.1
lead	95	91-99	0.7	97 (16)	93-100	0.9
zinc	102	97-110	2.8	100 (16)	96-106	1.2
arsenic	103	100-106	0.6	98 (16)	96-100	0.5
iron	105	101-107	1.3	105 (16)	103-107	0.7
manganese	96	91-99	0.7	98 (16)	96-100	1.1
Minerals - EPA Manchester Lab						
total hardness (as $CaCO_3$)	104	102-105	0.7	104 (14)	103-106	0.3
calcium, dissolved [b]	103	99-107	2.8	102 (16)	98-107	1.0
magnesium, dissolved [b]	105	101-108	1.1	104 (16)	102-107	0.7
Biological - EPA Manchester Lab						
chlorophyll *a*	- -	- -	- -	91 (12)	81-96	2.2 (n=3)

a = %Rec = percent recovery.
b = Samples are field filtered through a 0.45 µm pore size capsule filter for dissolved analysis

IDEQ and Tribe LCS/LCSD results from the EPA lab are shown in Table 10. The mean %Rec for metals and chlorophyll *a* is for LCS and LCSDs combined. All results are within the acceptable limit. As with MS %Rec, the range of LCS %Rec (5th data column) can be examined for the distribution pattern around 100%. Note that for chlorophyll *a*, the 12 LCS spike results were all under 100% recovery. For mean %RPD of LCS pairs (6th column, pairs of LCS %Rec), all results are well within acceptable limits.

2.5 Presence of Particulates in Filtered Samples

During periods of high suspended material within the lake, in particular during high river inflows, both IDEQ and the Tribe have experienced fine colloidal materials passing through the 0.45 µm capsule filters and presenting a visual appearance of particulates floating within the filtered samples. This occurred during 2008 sampling (Cd'A Tribe and IDEQ, 2010), and again occurred during sampling on April 7, 2009 (one sample set for IDEQ, and three sample sets for Cd'A Tribe).

When the EPA lab received the four filtered samples from April 7, the water turbidity after being shaken was > 1 NTU. In this case, the EPA lab SOP calls for the sample to be acid digested before going through spectrophotometric analysis. This acid digestion may release metal ions that were adsorbed or incorporated in the fine colloidal material, thereby giving an inaccurate high bias of free dissolved metal ions in the filtered sampled. For site C4 at 20 m, a high bias seemed apparent for dissolved lead, iron, and manganese when compared to concentrations of other filtered samples in the spring period without the acid digestion. The summary statistics in Section 3 do not incorporate these filtered results with high bias.

Dissolved metals samples collected by the Tribe from sites C5 and SJ1 from the early April sampling were flagged for >1 NTU. Like the IDEQ samples, these samples were acid digested. To evaluate if high bias existed from the acid digested samples, the ratio of dissolved, acid-digested samples and their unfiltered metals sample was compared for all samples collected at C5 and SJ1. The acid digested, dissolved sample was divided by the unfiltered, total metals sample providing a ratio. The results of this ratio analysis of the digested samples did not provide evidence of higher concentrations or bias. None of the ratios from the acid-digested, dissolved samples were higher than the range of ratios sampled from the rest of the CY09 season. Thus, all data was included for analyses for this report.

IDEQ and the Tribe have begun testing a procedure of post-filtering 0.45 µm filtered sample water through 0.2 µm polycarbonate membrane filters and comparing the sets of filtered water. This procedure will be used during the next event of high lake turbidity.

2.6 Completeness and QA/QC Conclusions

Completeness is defined as the percentage of usable data obtained from the total amount of data generated. Completeness was not 100% for the sampling data of 2009 (for example, the flagged filtered samples of April 7 discussed above). The category of completeness ties into a summary of the 2009 results where there are some analytical results that cast a level of uncertainty on the data obtained.

As within many lake waters of oxic conditions, ammonia (in filtered samples) has low concentrations in Coeur d'Alene Lake, with maximum values less than 100 μg/L since 2007 (under oxic conditions), and many results are <MRL. With low concentrations and various potentials for field and laboratory ammonia contamination, the QA/QC results have occasionally been well outside the range of acceptance limits.

Within the raw data tables of Appendix A, there is once instance where the nitrogen series results have been flagged. On May 28, the photic zone sample at C4 had substantially less TN (84 μg/L) than the combined concentrations of dissolved ammonia and nitrite+nitrate (194 μg/L). The QA/QC results from SVL for TN in 2009 did show an improvement compared to the 2007-08 results.

Based on the total array of replicate phosphorus samples (sample, field, field-crew, and lab-split replicates), total phosphorus QA/QC results are not as tight as desired. This is in part due to the low concentrations of TP in Coeur d'Alene Lake and the relatively high %RPD with analytes of low concentrations. QA/QC data also suggest a level of non-uniformity among field procedures between IDEQ and the Tribe and/or among analytical procedures between SVL and the Spokane Tribal Lab. In the 2010 sampling season, IDEQ and the Tribe will purchase a series of TP concentration standards and submit these to the two labs as blind tests.

The results for metals analysis are good, with the exception of two questionable total and dissolved manganese results reported by IDEQ (as also questioned for dissolved manganese in the 2007-08 annual report). The near bottom total and dissolved manganese samples at C1 on October 9 and C4 on August 25 (Table A1) and the near bottom dissolved manganese sample at C4 on April 7 were anomalously high. We are unsure whether these values are real and reflect the concentrations of manganese at these locations or if there was a sampling or laboratory error that resulted in these relatively high numbers. If they are indeed representative of the actual manganese concentrations at these locations, it is unclear the mechanisms causing such high values, and further investigation is warranted.

Section 3: Summary of Data Results

A listing of all raw data collected by the Tribe and IDEQ in 2009 is presented in Appendix A (Tables A1 – A10). This Section 3 presents a data analysis summary of the results. The first sampling event was on April 7, and IDEQ conducted a total of 7 sampling events concluding on October 8. The Tribe also conducted a sampling on December 2nd (8 sample events).

This annual report includes comparisons of IDEQ and Tribe monitoring from mid-2007 through 2009 with data collected by USGS in Water Years (WY) 2004 - 2006 (Wood and Beckwith, 2008), and in some cases with data collected by USGS in calendar years 1991 and 1992 (Woods and Beckwith, 1997). The 2009 Lake Management Plan (IDEQ and Tribe, 2009) also includes a rather comprehensive State of Lake Water Quality (Appendix A) which utilized data through 2006 and compared data from the two USGS studies.

3.1 Graphical Presentation of Data

For discussions of lake water quality presented in this Section, box plots are often used for data presentations. A diagram of box plots statistics used in this report as computed by SYSTAT software is shown as Figure 2. Box plot central tendency is shown as the median, and includes calculation of the geometric mean (geomean).

$$geomean = \sqrt[n]{x_1 x_2 x_3 \ldots x_n}$$

The geomean dampens the effect of very high or low values in small sample size data sets compared to calculation of the arithmetic mean. In the CY91-92 data set of limnological variables, USGS used geometric means to assign trophic state to Coeur d'Alene Lake sampling stations (Woods and Beckwith, 1997). The measures and milestone tables of the 2009 LMP (Section 5.1 of the LMP) also assigns geometric means to limnological variables for desired and trigger conditions.

3.1.1 IDEQ Approach for Box Plots

IDEQ box plot data in this Section 3, for the period July 2007 – October 2008, have been restricted to the CY08 data set (December 2007 – October 2008). This CY08 data set includes the December 2007 sampling run because we missed the December 2008 run due to dangerous lake conditions. Sampling data collected in early December are important to include because the late fall season exhibits the most uniformity from top to bottom in chemical concentrations.

The reason for restricting IDEQ box plots to CY08, and including CY09, is because they are compared to earlier USGS studies. An important component of the LMP monitoring program is to establish long-term annual trends in lake water quality. To conduct a comparison with the past USGS data, IDEQ graphic and statistical data should be grouped by either a water year or calendar year. Data comparisons are best made when all seasons are included because of the significant seasonal variability in Coeur d'Alene Lake data. IDEQ has elected to present trends per calendar year.

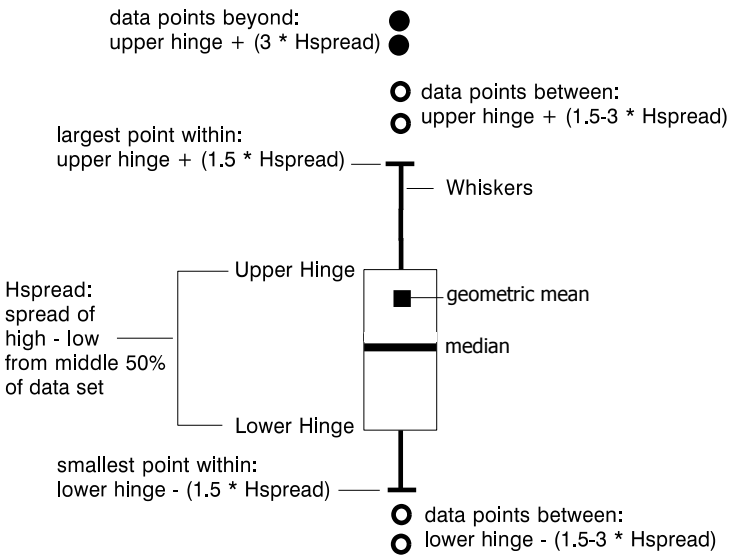

Figure 2. Definitions of box plot statistics used for data presentations within this report.

3.1.2 CDA Tribe Approach for Box Plots

The Coeur d'Alene Tribe included the CY08 data set in the box plots in this report. The CY08 data set is from a complete year of sampling and is more comparable to the CY09 data set. The CY07 data was not used for box plots because it only comprises data from June through December. The lack of a late winter/spring sampling period makes the CY07 data less comparable with the CY08 and CY09 data sets.

3.2 Riverine Flow: Hydrodynamics and Incoming Metals, Sediments, Nutrients

Flow and current patterns within the lake are created by: 1) two major inflow rivers, the Coeur d'Alene and St. Joe, along with tributary streams, and lake outflow via Spokane River regulated by the Post Falls dam, 2) currents generated by wind and cessation of high winds, and 3) thermodynamics. Flow and current patterns are extremely variable and complex in Coeur d'Alene Lake throughout one year and between years. Annually, the Coeur d'Alene River continues to carry elevated concentrations of both dissolved and particulate forms of potentially toxic metals into the lake. The St. Joe River carries low concentrations of trace metal compounds into the southern lake. Both rivers deliver suspended sediment with associated nutrients (phosphorus and nitrogen), along with organic and inorganic nutrient compounds. These sediment/nutrient loads are at their peak during high flow events. Water quality patterns within the lake in part reflect the characteristics of the two inflowing rivers.

Under the EPA Basin Environmental Monitoring Program (BEMP), EPA funds the USGS to monitor flow, sediment, mining-associated contaminants, and nutrient transport at: 1) several sampling sites along the Coeur d'Alene River including the mouth at Harrison, 2) the St. Joe River close to the mouth (near Chatcolet Lake), and 3) at the lake's outlet to the Spokane River (see Figure 1 for sampling sites). This BEMP monitoring began in August 2003 (EPA, 2004).

IDEQ and the Tribe obtain annual BEMP data as an important source of water quality information for concentrations of constituents coming into the lake and as a comparison to concentrations measured within the lake. Annual nutrient loads can be estimated from site data near the mouths of the two rivers. Flow and water quality data from BEMP will continue to be integrated into ELCOM-CAEDYM computer modeling efforts. Selected USGS river data for WY09 (October 1, 2008 – September 30, 2009) is presented in this report.

Total combined flow volume from the two rivers for WY09 was 4.0 million ac-ft (Figure 3). This annual flow is below the 50 year normal based on long-term flow records measured on the Coeur d'Alene River @ Cataldo. There was a very brief rain-on-snow high flow peak in early January (20,000 mean daily cfs on St. Joe River @ Chatcolet, January 9), and then a gradual late-winter through spring runoff rise. The hydrograph peaked twice in spring with high flow peaks around 13,000 mean daily cfs on St. Joe River @ Chatcolet. A high flow event with flooding did not occur in 2009, unlike the May 2008 flood event where Coeur d'Alene River @ Harrison peaked at 27,300 cfs.

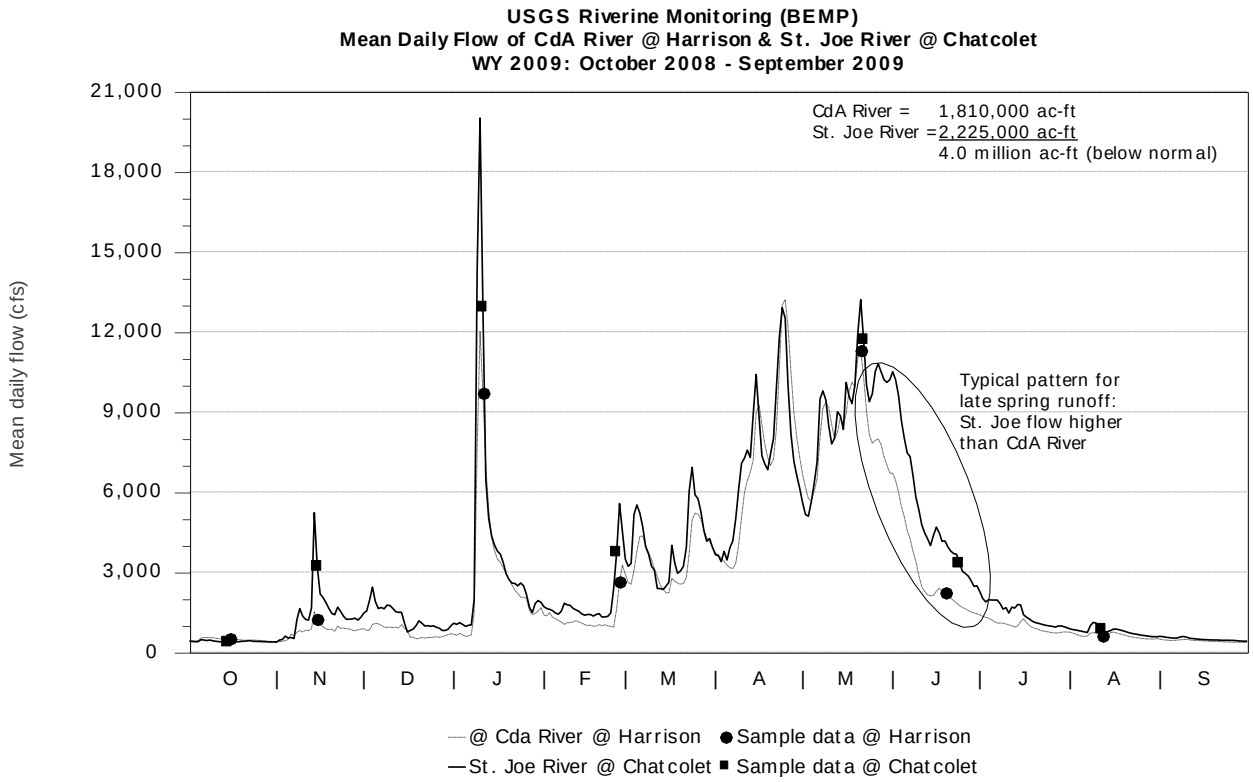

Figure 3. Hydrograph of mean daily flows (cfs) at Coeur d'Alene River @ Harrison and St. Joe River @ Chatcolet for Water Year 2009 (USGS web site); and days of USGS water quality river sampling.

3.2.1 Lake Results Related to River Flow

USGS water quality sampling for WY09 is presented for total phosphorus at the mouth of both rivers (Figure 4). Based on USGS studies, the St. Joe River normally has higher TP concentrations than the Cd'A River, and thus greater annual TP loads in kg/yr. USGS

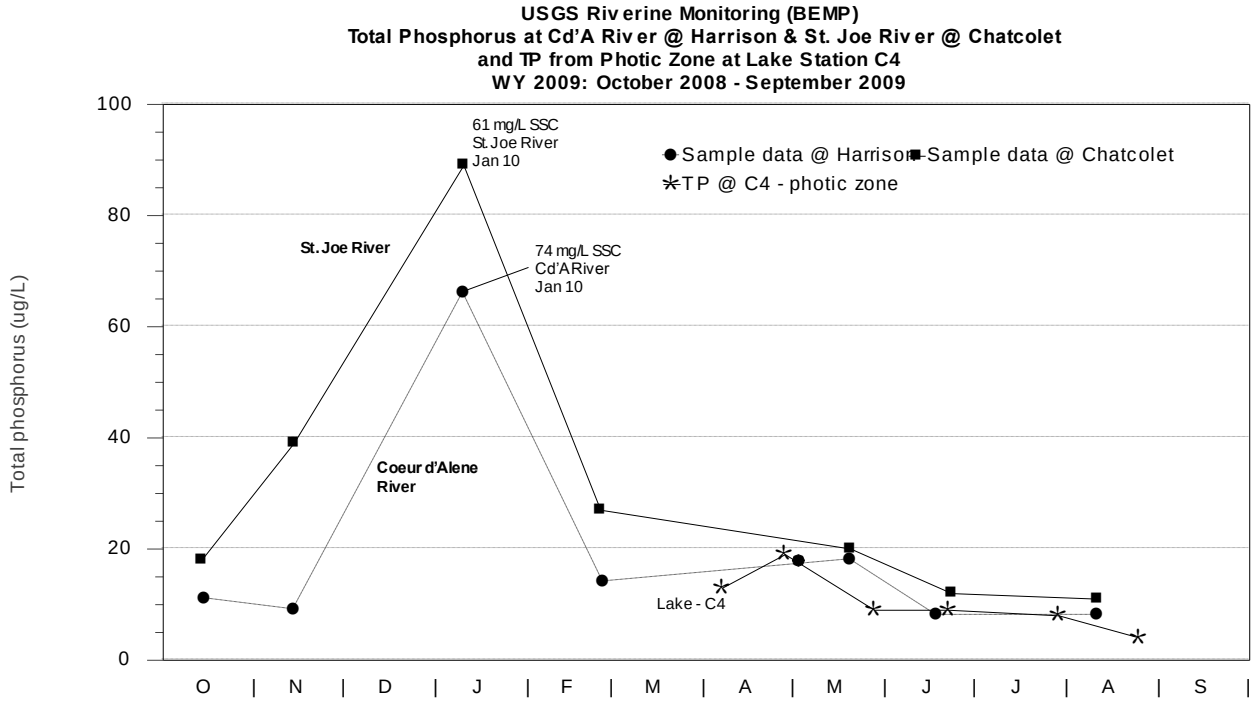

Figure 4. USGS samples for total phosphorus at Coeur d'Alene River @ Harrison and St. Joe River @ Chatcolet for WY09 (USGS web site), and IDEQ data for Coeur d'Alene Lake @ station C4.

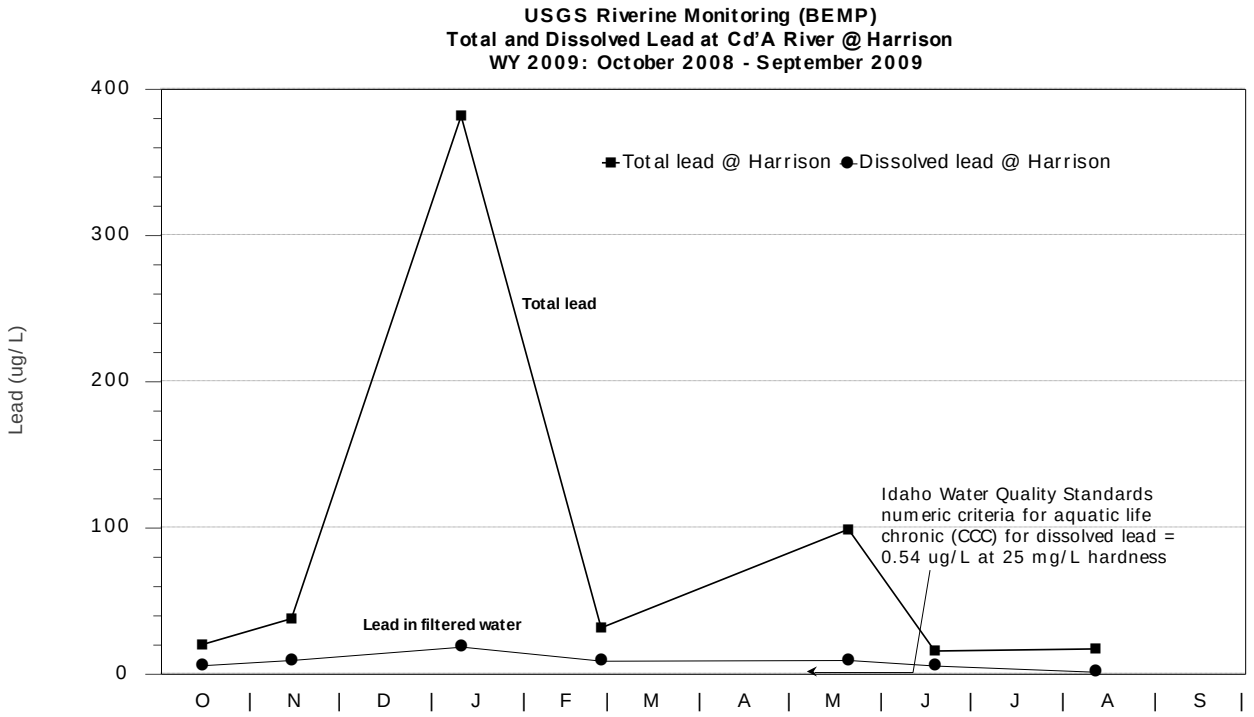

Figure 5. USGS samples for total and dissolved lead at Coeur d'Alene River @ Harrison, WY09 (USGS web site).

obtained samples on the January 9-10 rain-on-snow peak, and both suspended sediment concentrations (SSC) and TP were the highest for the WY on the two rivers (66 µg/L TP @ Harrison and 89 µg/L @ Chatocolet).

IDEQ and Tribe lake sampling began on April 7. The highest in-lake TP for station C4 was recorded on the following lake sampling date of April 28 (Figure 4). During the April 28 sampling event, photic zone TP at C4 was 19 µg/L, and at 20 m, it was 25 µg/L. Highest total phosphorus for southern lake sites during the rising spring hydrograph was 32 µg/L total phosphorus in the photic zone at site C5 during the April 7 sampling event. During the April 7 sampling total phosphorus was also elevated at site C6 and SJ1 at 28 and 23 µg /L respectively.

While TP concentrations at the mouths of the two rivers declined in the spring months following the January peak, mid to late April was the initial spring peak in flow and TP loading. Lake concentrations reflected this. Based on warmer water temperatures of the rivers in comparison with lake waters during spring, and profiles of specific conductance within the lake, river waters will plume as "overflow" as they enter the lake (i.e. a layer of river water flowing over the main body of lake water).

Figure 5 demonstrates that the Cd'A River brings significant concentrations and annual loading of trace metals into the lake, as shown for lead. In the 2007-08 report, river levels of zinc at the mouth was examined (Cd'A Tribe and IDEQ, 2010). As with SSC and TP levels, peak concentration of lead was recorded on January 10, 2009 (381 µg/L total lead and 18.6 µg/L dissolved lead). The Idaho Water Quality Standards aquatic life chronic criterion for dissolved lead is 0.54 µg/L at 25 mg/L hardness (as $CaCO_3$). Similarly to the trend of TP at lake site C4, lead concentrations peaked on the April 28 sampling at 12.3 µg/L total lead and 1.20 µg/L dissolved lead. A similar trend is observed at northern site C1 but with lower concentrations. Again, the trend in lake metal concentrations reflects the highest metal loading period from the Coeur d'Alene River.

3.3 Lake Water Quality Results

Table 11 presents a data summary for water quality variables collected by the Tribe and IDEQ in 2009. In following Sections, separate categories of parameters will be discussed. In Table 11, monitoring data for each variable were combined for all sampling days and all sampling depth zones (see Appendix A, Tables A1 – A10 for all raw data). For data values reported as <MRL, one-half the MRL was assigned for calculation of summary statistics.

As discussed in Section 2, the data results for dissolved lead, iron, and manganese for station C4 on April 7, at 20 m depth, were flagged and eliminated from the data set. These values for iron and lead were the highest dissolved concentrations of the data set, but these values have an inaccurate high bias because of the EPA acid digestion of the filtered samples.

Table 11. Summary of water quality results for 2009 (variables are presented as µg/L except when noted)[a].

Water Quality Variables	Site C1	Site C4	Site C5	Site C6	Site SJ1
Trace metals					
Total zinc					
geometric mean	59.6	63.6	31.3	<5	<5
minimum	40.1	39.7	<5	<5	<5
maximum	77.4	92.4	73.9	<5	<5
sample size	28	28	19	16	16
Dissolved zinc					
geometric mean	56.7	61.0	28.8	<5	<5
minimum	35.2	36.7	<5	<5	<5
maximum	78.8	86.0	75.5	<5	<5
sample size	28	28	19	16	16
Total cadmium					
geometric mean	0.24	0.27	0.13	<0.13	<0.13
minimum	0.18	0.18	<0.13	<0.13	<0.13
maximum	0.37	0.56	0.32	<0.13	<0.13
sample size	28	28	19	16	16
Dissolved cadmium					
geometric mean	0.23	0.26	<0.13	<0.10	<0.10
minimum	0.16	0.18	<0.13	<0.10	<0.10
maximum	q 0.37	0.41	0.27	<0.10	<0.10
sample size	28	28	19	16	16
Total lead					
geometric mean	1.2	2.3	1.3	<0.13	<0.13
minimum	0.3	0.6	0.3	<0.13	<0.13
maximum	4.1	12.3	6.3	0.36	0.24
sample size	28	28	19	16	16
Dissolved lead					
geometric mean	0.17	0.26	0.17	<0.10	<0.10
minimum	<0.10	<0.10	<0.13	<0.10	<0.10
maximum	0.64	1.20	0.95	<0.10	<0.10
sample size	28	27	19	16	16
Total arsenic					
geometric mean	<0.63	<0.63	<0.63	<0.63	<0.63
minimum	<0.63	<0.63	<0.63	<0.63	<0.63
maximum	0.86	<0.63	0.91	2.00	3.60
sample size	28	28	19	16	16
Dissolved arsenic					
geometric mean	0.36	0.34	0.37	0.30	0.29
minimum	0.31	0.29	0.30	<0.20	<0.20
maximum	0.45	0.55	0.80	2.10	3.60
sample size	28	27	19	16	16

Table 11. continued

Water Quality Variables	Site C1	Site C4	Site C5	Site C6	Site SJ1
Metals and Hardness					
Total iron					
geometric mean	48	74	113	256	284
minimum	10	11	23	118	126
maximum	194	370	811	1,420	2,650
sample mean	28	28	19	16	16
Dissolved iron					
geometric mean	8.5	10.2	22.0	52.9	56.2
minimum	<5	<5.0	5.0	21.0	16.0
maximum	25	27	230	1,119	1,690
sample size	28	27	19	16	16
Total manganese					
geometric mean	5.1	8.5	14.4	25.6	14.4
minimum	1.6	3.2	6.4	8.3	7.0
maximum	22.2	32.0	222	755	550
sample size	26	28	19	16	16
Dissolved manganese					
geometric mean	0.7	1.2	8.1	9.7	5.8
minimum	0.2	0.3	0.4	1.0	0.7
maximum	6.4	q 16.1	48.3	775	570
sample size	26	27	19	16	16
Total hardness (mg/L as $CaCO_3$)					
geometric mean	19.8	20.8	20.6	20.4	22.6
minimum	q 12.7	17.6	16.3	15.1	15.7
maximum	22.5	23.2	26.2	27.6	31.5
sample size	28	28	19	16	16
Nutrients, Chlorophyll *a*, Phytoplankton, and Water Clarity					
Total phosphorus					
geometric mean	5.8	8.0	13.5	21.7	17.8
minimum	<5	<5	7	13	5
maximum	16	25	32	89	107
sample size	28	28	19	16	16
Dissolved total phosphorus					
geometric mean	<5	<5	5.3	8.5	8.1
minimum	<5	<5	<5	5	<5
maximum	5	9	21	60	37
sample size	28	28	19	16	16
Dissolved ortho phosphate					
geometric mean	<3	<3	4.8	5.5	6.1
minimum	<3	<3	<2	<2	<2
maximum	<3	<3	10	47	24
sample size	5	8	19	16	16

Table 11. continued

Water Quality Variables	Site C1	Site C4	Site C5	Site C6	Site SJ1
Nutrients, Chlorophyll *a*, Phytoplankton, and Water Clarity; cont.					
Total nitrogen					
geometric mean	141	163	--	--	--
minimum	65	81	--	--	--
maximum	281	269	--	--	--
sample size	25	22	--	--	--
Total Kjeldahl nitrogen					
geometric mean	--	--	151.9	188.7	146.7
minimum	--	--	100	100	90
maximum	--	--	280	300	510
sample size	--	--	19	16	16
Dissolved nitrite+nitrate					
geometric mean	46.2	66.8	26.8	14.8	<20
minimum	<15	<15	<20	<20	<20
maximum	138	167	157	56	41
sample size	28	27	19	16	16
Dissolved ammonia					
geometric mean	<30	<30	<10	11.2	<10
minimum	<30	<30	<10	<10	<10
maximum	78	73	34	185	351
sample size	28	27	19	16	16
Chlorophyll *a*					
geometric mean	2.33	2.36	1.70	2.06	<1.0
minimum	1.01	1.00	<1.0	<1.0	<1.0
maximum	8.42	5.33	5.28	5.68	2.30
sample size	7	7	8	8	8
Phytoplankton (cells/mL)					
geometric mean	4,920	6,808	4,644	7,647	4,110
minimum	1,524	2,512	2,220	1,598	1,281
maximum	28,111	20,842	15,854	21,964	11,098
sample size	7	7	8	8	8
Phytoplankton biovolume (μm^3/mL)					
Geometric mean	269,626	417,479	192,925	203,066	120,122
minimum	42,900	103,400	38,843	14,903	45,185,
maximum	1,019,600	823,400	385,822	1,061,327	246,742
sample size	7	7	8	8	8

Table 11. continued

Water Quality Variables	Site C1	Site C4	Site C5	Site C6	Site SJ1
Nutrients, Chlorophyll *a* & Phytoplankton, Water Clarity; cont.					
Secchi disk (m) – w/o view tube					
geometric mean	5.2	4.6	3.7	2.6	2.6
minimum	1.6	1.7	1.0	0.8	1.2
maximum	11.7	11.8	8.3	4.0	4.5
sample size	7	7	7	8	7
Secchi disk (m) – w/view tube					
geometric mean	5.7	5.0	--	--	--
minimum	2.0	1.8	--	--	--
maximum	11.7	12.1	--	--	--
sample size	7	7	--	--	--
Depth (m) of 1% light photic zone					
geometric mean	12.2	10.7	8.6	6.3	6.8
minimum	6.5	6.0	4.0	4.0	4.0
maximum	17.5	17.0	14.0	8.8	10.0
sample size	7	7	8	8	8

a = Data for sites C1 and C4 are combined data within multiple depth zones: composite photic zone sample, 20 m or chlorophyll *a* maxima, 30 m, and 1 m off bottom. Summary data for chlorophyll *a* and phytoplankton enumeration are from photic zone samples only.

Data for sites C5, C6 and SJ1 are combined for multiple depth zones: composite photic zone sample, depth at chlorophyll *a* maxima when present, and 1 m off bottom.

q = questionable data result

3.3.1 Trace Metals within the Lake Water Column

Initial discussion of trace metals begins with dissolved metals in relation to Idaho Water Quality Standards (WQS) numeric criteria for aquatic life (IDAPA 58.01.02.210) and WQS for approved surface waters of the Coeur d'Alene Tribe (approved by the Cd'A Tribal Council in 2005). Dissolved metals in the WQS are functionally free ions within water samples passed through a 0.45 µm filter. WQS establish Criterion Continuous Concentration (CCC), a 4 day average concentration of a toxic substance which ensures adequate protection of sensitive species of aquatic organisms from chronic toxicity. The CCC is not to be exceeded more than once every 3 years. WQS also establish a Criterion Maximum Concentration (CMC), the maximum instantaneous or 1 hour average concentration to protect aquatic organisms from acute toxicity. The CMC is not to be exceeded more than once every 3 years.

The EPA lab SOP of acid digesting filtered samples if the sample is >1 NTU provides some insight to the Tribe and IDEQ on the presence and nature of amorphous ferric and manganese oxides and/or other ultrafine particles (i.e. colloids) with adsorbed metals within lake samples. For example, at site C4 on April 7, 2009 (with rising lake turbidity), acid digested filtered lead at 20 m was 4.0 µg/L, several times higher than non-acid digested filtered lead in other C4 depth samples of the same day, and non-acidified samples on the next sampling of April 28 (Table A3). On April 7, the total lead:acid digested filtered lead ratio at 20 m was 1.5, considerably lower

than the total lead:non-acid digested filtered lead ratios for all other depths on April 7, and all April 28 samples, where ratios were at least 9.3. The same trend is seen for iron, where at 20 m on April 7 the total iron:acid digested filtered iron ratio was also 1.5, but for all other samples on April 7 and 28, the total iron:non-acid digested filtered iron ratio was at least 10.3.

During periods of high lake turbidity, high concentrations of colloids may be passing through the 0.45 µm filter, and metals that are adsorbed seem to be released by acid digestion and measured. For acid digested dissolved zinc and cadmium, this is not observed in the data. These concentrations are similar to other non-digested filtered samples, and have similar relationships to their total concentration counterparts.

3.3.1.1 IDEQ Trace Metals

IDEQ trace metal results are presented in comparison with the CCC. In the WQS, hardness dependent metals (e.g. zinc, cadmium, lead) are calculated with equations that use total hardness in mg/L as $CaCO_3$. Idaho WQS uses a lower hardness cap of 25 mg/L to calculate CCC for dissolved metals. Hardness in Cd'A Lake is almost always less than 25 mg/L, so CCCs presented for sites C1 and C4 use this lower cap. In Tribal WQS, actual hardness measured is used when below 25 mg/L to calculate CCC for dissolved metals. Total hardness has been recorded as low as 16.1 mg/L in northern waters, and as low as 15.1 mg/L in southern waters. On a sampling day, if one of the trace metal concentrations from the set of depth zone samples exceeded the CCC threshold, this was considered a four day average and an exceedance of the CCC.

Based on the zinc data sets of USGS WY04-06, and IDEQ CY08 and CY09 (Figure 6), concentrations of dissolved zinc within northern pool waters at sites C1 and C4 consistently violate the Idaho CCC of 36 µg/L (CMC is also 36 µg/L at 25 mg/L $CaCO_3$ hardness). For CY09, the geometric mean of dissolved zinc at C1 was 57 µg/L and at C4 the geomean was 61 µg/L (Table 11). While there are differences in the box plot statistics at each site for the data sets since 2006, a consistent trend is not evident. Dissolved zinc values during the high flow and flood year of 2008 are slightly higher at C4 among the years, and zinc concentrations typically, and not unexpectedly, run slightly higher at C4 than C1. This is true for the other sampled metals. In Appendix A of the 2009 LMP (IDEQ and Tribe, 2009), total zinc concentrations in photic zone composite samples collected by the USGS in the northern pool were compared between CY91-92 and WY04-06. There was a pronounced decline in total zinc in the latter study period. Reasons for this apparent zinc decline in photic zone samples between the two USGS baseline studies are subject to further analysis.

For dissolved cadmium in the northern pool (Figure 7), the CCC is occasionally exceeded at site C1 and frequently exceeded at site C4 (Idaho CCC = 0.25 µg/L at 25 mg/L $CaCO_3$ hardness). For CY09, the geomean at C1 was 0.23 µg/L, and at C4, the geomean was 0.26 µg/L.

For dissolved lead in the northern pool (Figure 8), the CCC is occasionally exceeded at site C1 and frequently exceeded at C4 (Idaho CCC = 0.54 µg/L at 25 mg/L $CaCO_3$ hardness). For CY09, the geomean at C1 was 0.17 µg/L, and at C4, the geomean was 0.26 µg/L. As shown in the 2008 box plot data (Figure 8), dissolved lead concentrations (and total lead, not shown) clearly exhibit elevated concentrations during flood events on the Coeur d'Alene River.

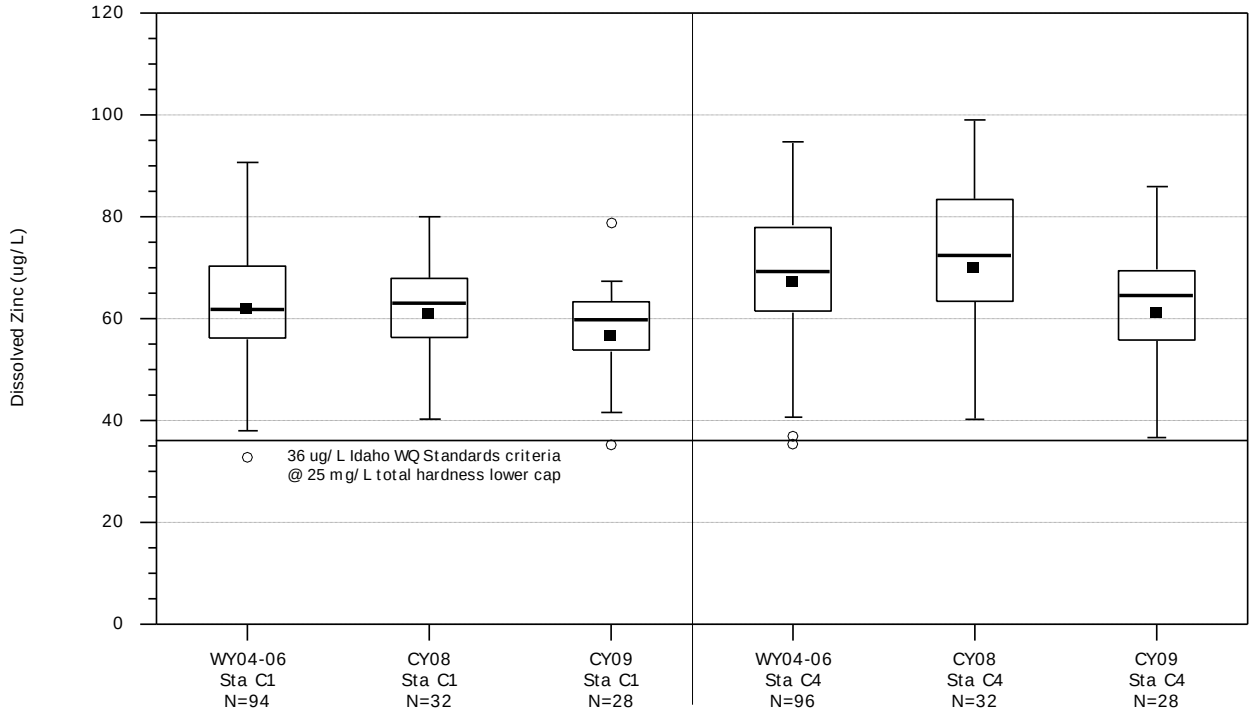

Figure 6. Dissolved zinc sampling by USGS for WY04-06 and IDEQ for CY08 and CY09, at northern pool sites C1 and C4. Data combined for photic zone composite samples, and discrete samples at 20 m, 30 m, and 1 m off bottom.

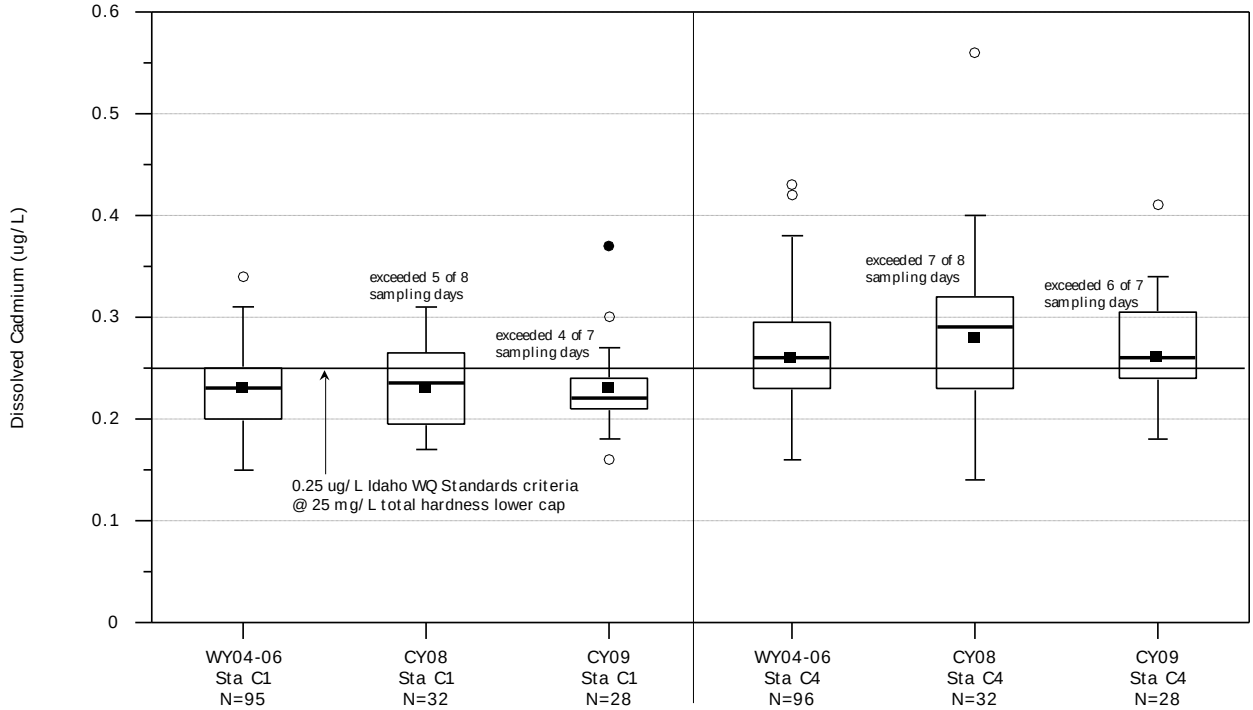

Figure 7. Dissolved cadmium sampling by USGS for WY04-06 and IDEQ for CY08 and CY09, at northern pool sites C1 and C4. Data combined for photic zone composite samples, and discrete samples at 20 m, 30 m, and 1 m off bottom.

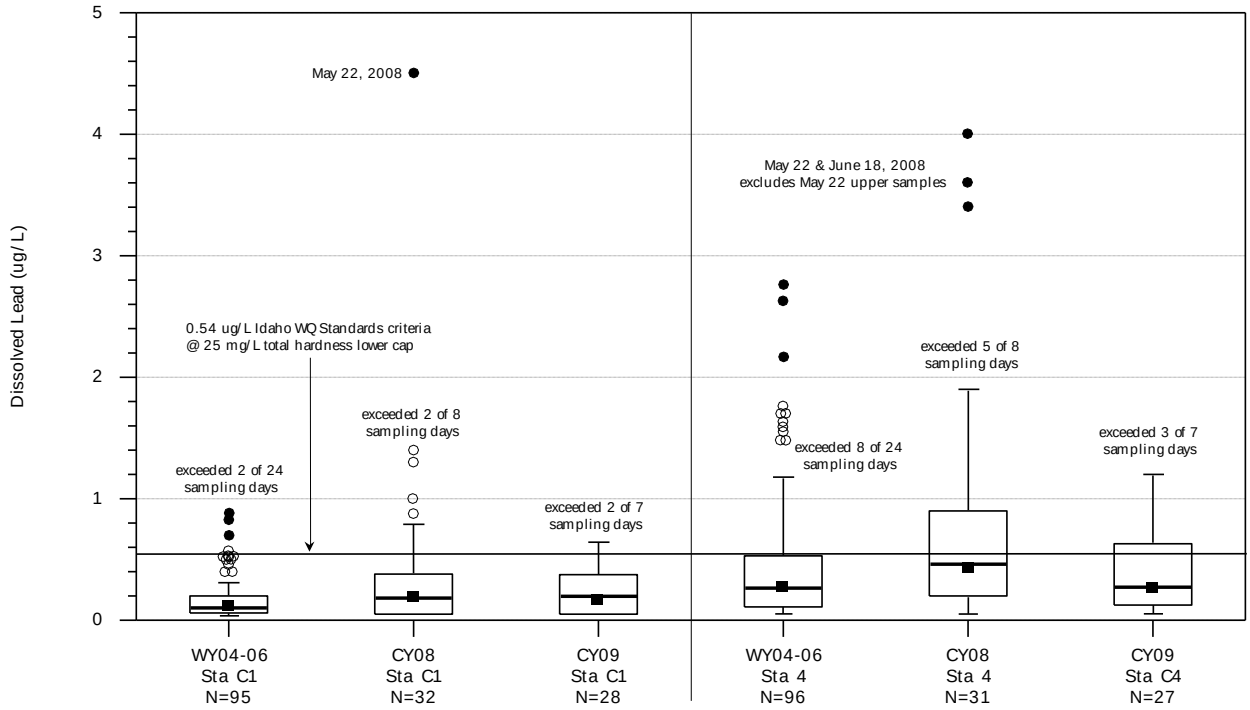

Figure 8. Dissolved lead sampling by USGS for WY04-06 and IDEQ for CY08 and CY09, at northern pool sites C1 and C4. Data combined for photic zone composite samples, and discrete samples at 20 m, 30 m, and 1 m off bottom.

Zinc depth profiles (photic zone, 20 m, 30 m, and 1 m off the bottom) were taken by USGS in 1999 and then routinely sampled in WY04-06. IDEQ has continued this profiling for zinc as well as the other trace metals.

Zinc data in Cd'A Lake exhibit fluctuating trends between seasons and with depth. As documented by USGS and in the Tribe and IDEQ 2007-08 annual report, total and filtered zinc concentrations typically become elevated throughout the water column during late winter and spring months during high river inflow (as shown for total zinc at C4 in Figure 9, April 7 and 28, 2009). In spring, there is a small difference between total and filtered zinc, with the average difference being 6.7 µg/L at C4 for April 7 and 28. Spring total zinc concentrations at C4 since 2004 have ranged from 70 – 115 µg/L. Typically, zinc concentrations decline throughout the water column by early summer (with some exceptions 1 meter off the bottom), ranging from about 50 – 70 µg/L total zinc. Zinc profiles in summer and early fall months exhibit further declining concentrations in the upper water column of 5 – 15 m (Figure 9, ranging around 35 – 50 µg/L zinc). In summer and fall months, total and filtered zinc have nearly the same concentrations.

One reasoning for the summer and fall decline in zinc concentration within upper waters is that this represents a sinking of particulate bound zinc where ionic zinc (filtered) becomes absorbed or adhered to by phytoplankton cells, and the cells sink. However, this mechanism seems contradicted by the nearly identical total and dissolved zinc concentrations. It would seem that the total zinc:filtered zinc ratio should noticeably increase beyond 1.0, but it does not. Lastly,

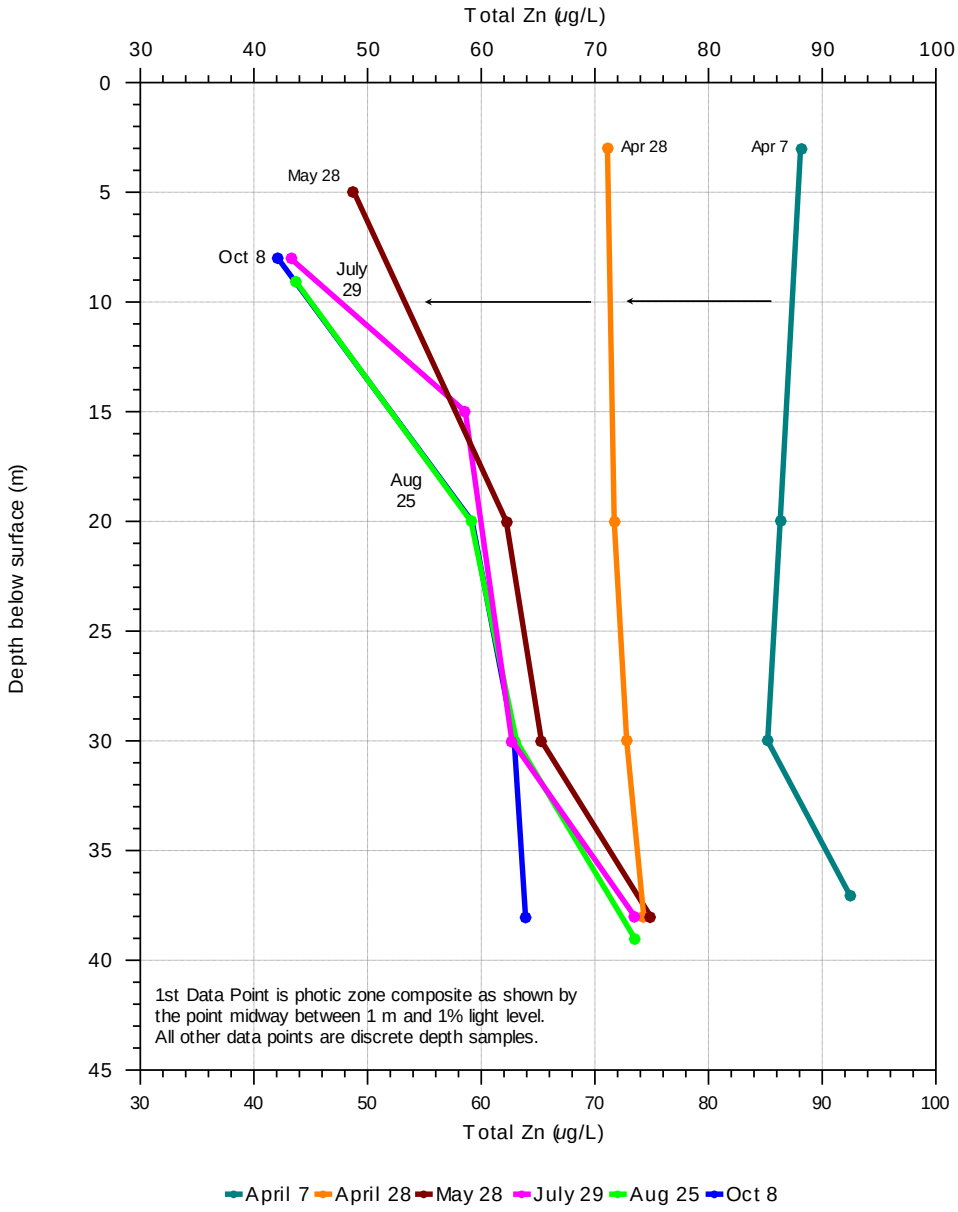

Figure 9. Sample profiles of total zinc concentrations (µg/L) at site C4 from April 7 to October 8, 2009.

some researchers believe that there may also be a positive benthic flux of dissolved zinc from the sediments into the lower-most waters (Kuwabara *et al*., 2003).

Dissolved zinc is of importance because zinc-ion activity can limit, or inhibit phytoplankton productivity within the lake. The mechanism of zinc inhibition to aquatic primary producers is reported as a disruption of phosphate assimilation and phosphate intracellular utilization (Kuwabara *et al*., 2006). Zinc-ion inhibition results in lower chlorophyll *a* concentrations than what might be expected within Cd'A Lake. This would explain the very low values of chlorophyll *a* in the USGS CY91-92 data set (geomeans around 1.0 µg/L in northern waters). It appears that diatoms, a major phytoplankton component of the lake, have a greater tolerance to zinc-ion activity than other phytoplankton forms (Kuwabara *et al*., 2006).

3.3.1.2 Tribe Trace Metals

Trace metals did not violate the Tribal standard at either site C6, or site SJ1 in 2009, with most samples being below minimum reporting limits (Table 11). Zinc CCC criteria at site C5 ranges from 25.4-38.0 µg/L, and was exceeded in 2009 58% of the time. Dissolved zinc was higher in CY09 (geomean 28.8 µg/L) than in CY08 (geomean 21.6 µg/L) and WY04-06 (geomean 26.3µg/L, Figure 10 A). Dissolved zinc concentrations at site C5 were consistently higher at the one meter above bottom sample depth compared to the photic zone for years 2007 through 2009 (Figure 11). The exception being in December of CY07 and CY09 when dissolved zinc concentrations were similar between the photic zone and one meter above bottom (Figure 11). In December of CY08 the photic zone experienced higher dissolved zinc concentrations (Figure 11). Isothermal conditions in December and subsequent water column mixing are likely driving the convergence of dissolved zinc concentrations between the upper and lower waters at C5.

In CY09 cadmium CCC criteria at Tribal site C5 ranged from 0.20 – 0.26 µg/L. Dissolved cadmium at site C5 violated the Tribal CCC standard at the one meter above bottom depth 38% of the time. As with CY07 and CY08, samples from the photic zone in CY09 were consistently lower and did not violate the Tribal CCC standard. Dissolved cadmium concentration in CY09 was slightly higher than in CY08 and WY04-06 (Figure 10B).

Dissolved lead at site C5 violated the Tribal CCC standard in the one meter above bottom zone on April 30 and May 27 sampling dates. Dissolved lead concentration in the photic zone did not violate Tribal standards in 2009. Dissolved lead was slightly lower in CY09 than in CY08, with a geomean in CY09 of 0.17 µg/L compared to a geomean of 0.22 µg/L in WY08 (Figure 10 C).

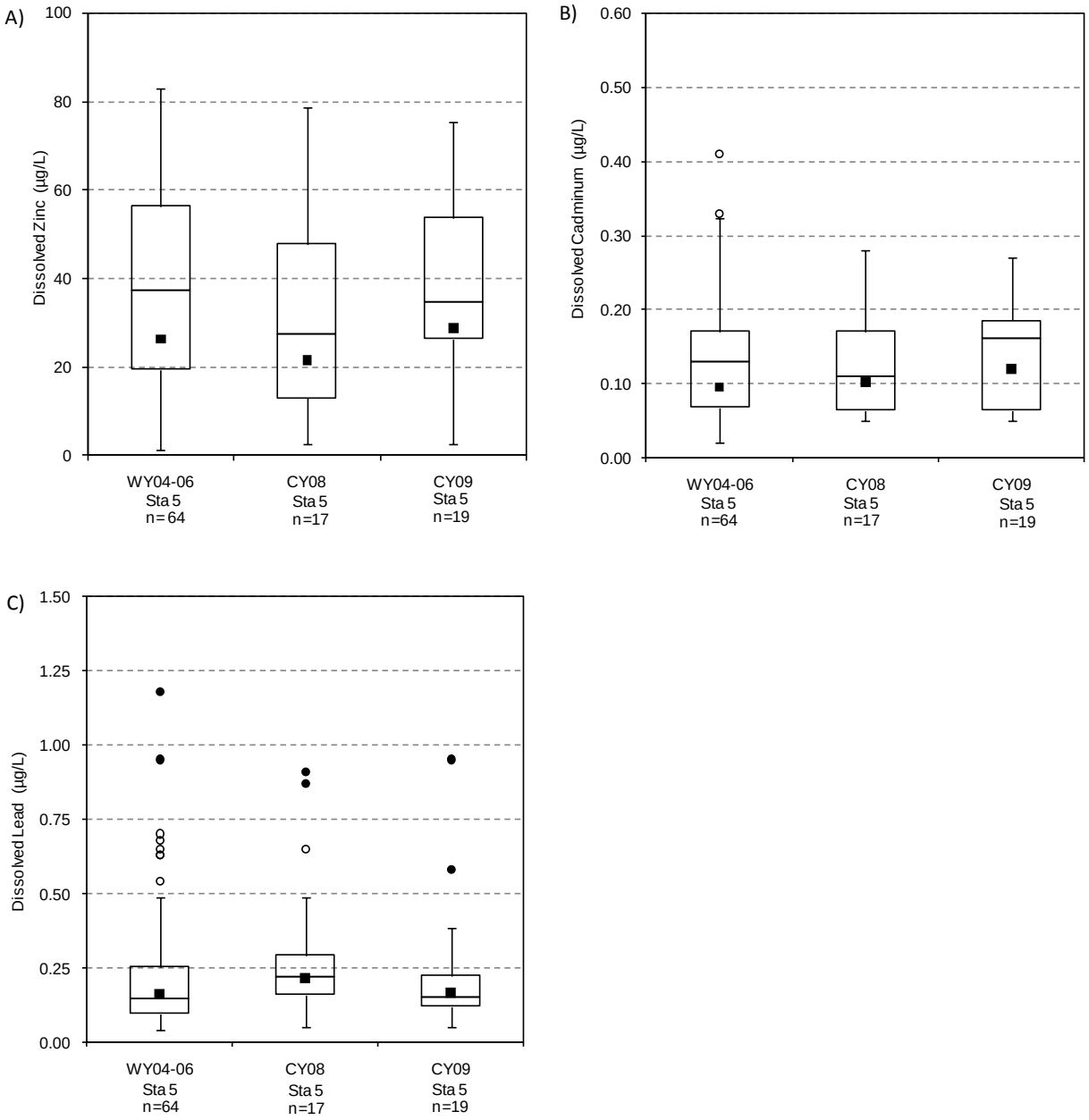

Figure 10. Dissolved zinc (A), cadmium (B) and lead (C) sampling by USGS for WY04-06 and Coeur d'Alene Tribe for CY08 and CY09 at southern pelagic site C5. Data combined for photic zone composite samples, Chlorophyll a maximum depth, and 1 m off bottom samples.

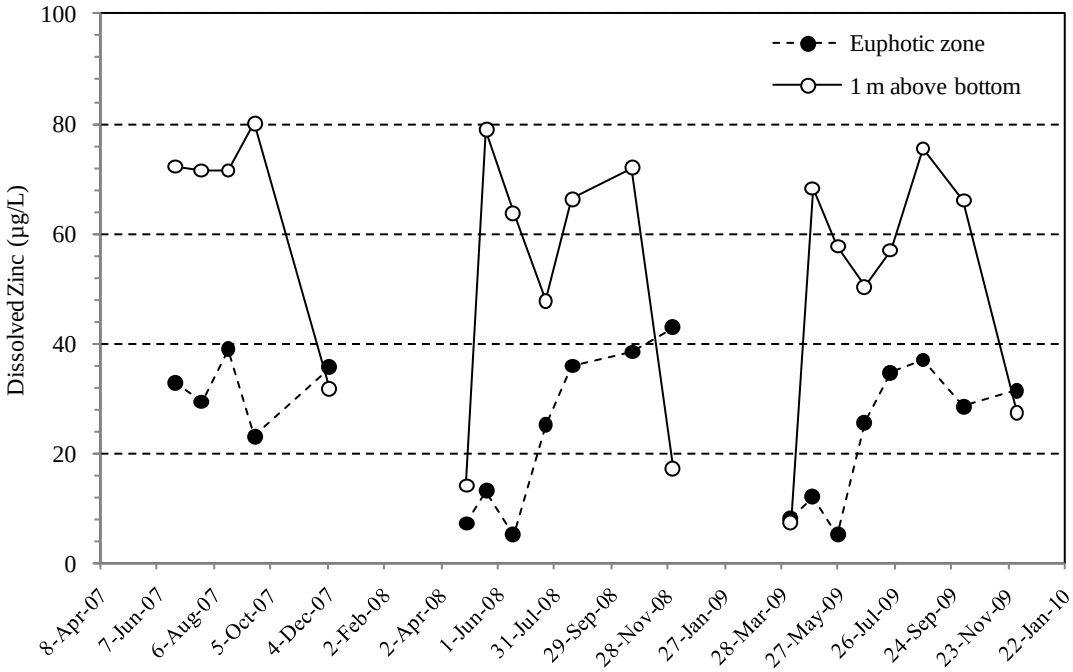

Figure 11. Dissolved zinc concentration at site C5 in the photic zone and at the one meter above bottom zone from June 26, 2007 through December 2, 2009.

3.3.2 Trophic State Classification

Limnological investigations typically categorize a lake with a "trophic state" using in-lake indicator conditions of: total phosphorus, chlorophyll *a* (as a measure of phytoplankton biomass), water clarity, and, at times, nitrogen (Table 12). An "oligotrophic" lake is generally low in nutrient concentrations (phosphorus and nitrogen), low in phytoplankton productivity with minor blue-green algae populations, and high in water clarity during summer through fall months. A "eutrophic lake" is generally high in nutrients, high in phytoplankton productivity, often includes blooms of nuisance blue-green algae, and is low in water clarity.

Table 12. Trophic-state classification based on open-boundary values for four limnological variables (Woods and Beckwith, 1997).

Limnological variable[a]		**Oligotrophic**	**Mesotrophic**	**Eutrophic**
Total phosphorus (µg/L)	geometric mean gm ± 1 SD	8.0 4.8 – 13.3	26.7 14.5 - 49.0	84.4 48.0 – 189.0
Total nitrogen (µg/L)	geometric mean gm ± 1 SD	661 371 – 1,180	753 485 – 1,170	1,875 861 – 4,081
Chlorophyll *a* (µg/L)	geometric mean gm ± 1 SD	1.7 0.8 – 3.4	4.7 3.0 – 7.4	14.3 6.7 – 31.0
Secchi-disc transparency (m)	geometric mean gm ± 1 SD	9.9 5.9 – 16.5	4.2 2.4 – 7.4	2.4 1.5 – 4.0

a = annual geometric mean values and standard deviations

3.3.3 Nutrients

The following discussions present phosphorus and nitrogen data results from IDEQ and Cd'A Tribe sampling. Total phosphorus data in box plots, where data are combined for all sampling depth zones at a station, are compared to USGS study data for CY91-92 and WY04-06.

3.3.3.1 IDEQ Phosphorus

USGS concluded in their WY04-06 final report that when applying TP data to non-parametric statistical analysis, the WY04-06 data are statistically, significantly higher than the CY91-92 data set for all Cd'A Lake pelagic stations (5 sites north to south, Wood and Beckwith, 2008). For the IDEQ CY08 and CY09 data sets (Figure 12), sample site C1 is approximately the same as WY04-06, and at site C4, the CY08 and CY09 data set shows a slight increase. The CY09 geomean for C1 was 5.8 µg/L TP, and at C4, the geomean was 8.0 µg/L TP (Table 11).

Total phosphorus measured in photic zone composite samples for each sample day of the period July 2007 – October 2009 is shown for sites C1 and C4 (Figure 13). In 2008 and 2009, TP concentrations increased in April and May during peak spring runoff. The photic zone peaks in 2009 on the April 29 sampling day (16 and 19 µg/L at C1 and C4 respectively), are not as high as the flood flow TP peak at C4 in May 2008 (31 µg/L within photic zone). Except for periods of high river inflow, TP profiles from top to bottom are fairly uniform.

For dissolved total phosphorus (DTP), the geomeans at C1 and C4 are less than the MRL of 5 µg/L (Table 11). Maximum DTP was 9 µg/L at C4. In 2009, photic zone samples at C1 and C4 were analyzed for dissolved ortho-phosphate. All samples were <MRL (<3 µg/L).

Using water quality data collected by the USGS in WY04-06 for sampling sites C1, C4, C5, and C6, the 2009 LMP established "trigger conditions" for selected variables (LMP Section 5, Tables 3 - 7 , IDEQ and Cd'A Tribe 2009). Trigger conditions are used as an early warning system for water quality deterioration leading to the evaluation of further nutrient management actions within the basin. For sites C1 and C4, an annual geomean exceeding 8.0 µg/L TP is the established trigger. For WY04-06, the annual geomean at C4 was 6.4 µg/L. Geomeans collected by IDEQ at C4 for CY08 and CY09 hover around the trigger (7.7 and 8.0 µg/L respectively, Figure 12). Based on the QA/QC results by IDEQ and the Tribe from 2007 – 2009, the uncertainty around TP for the low concentrations in the northern pool of Coeur d'Alene Lake is a least ± 1 µg/L. This uncertainty will be taken into account when evaluating exceedances of the established trigger.

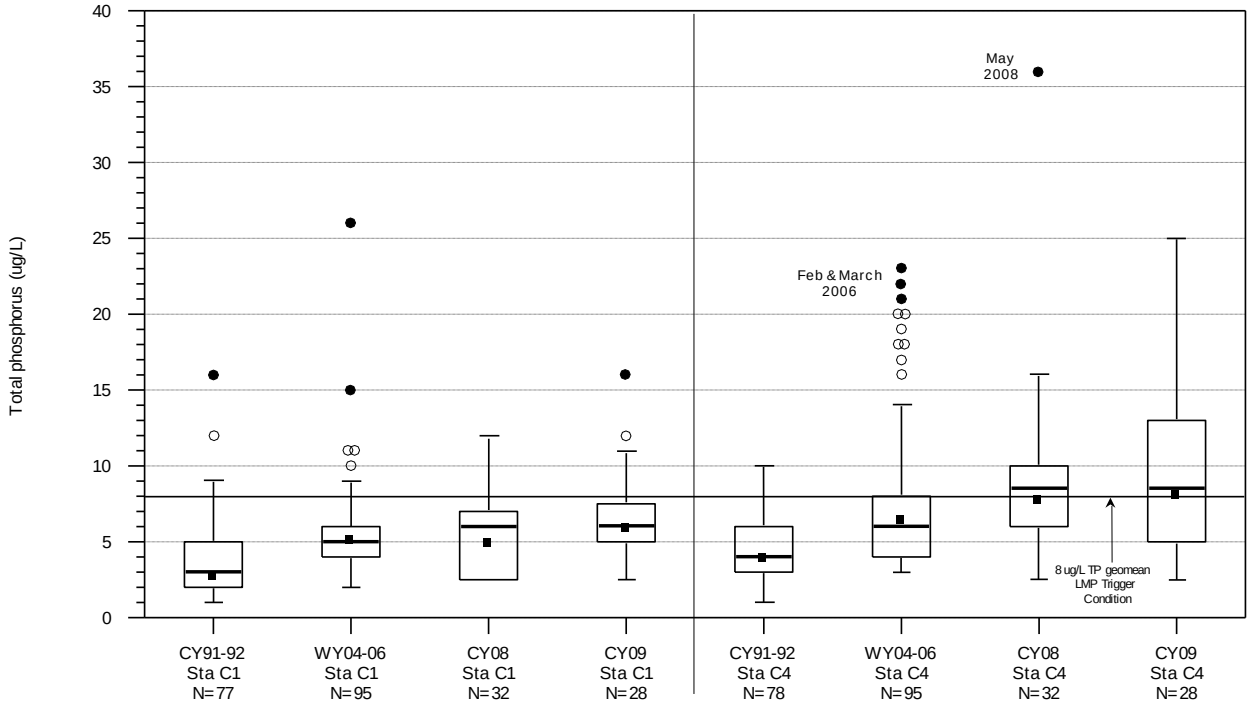

Figure 12. Box plot comparisons of total phosphorus for study periods: USGS CY91-92 and WY04-06, and IDEQ CY08 and CY09 at sampling sites C1 and C4. Data combined for photic zone composite samples, and discrete samples at 20 m, 30 m, and 1 m off bottom.

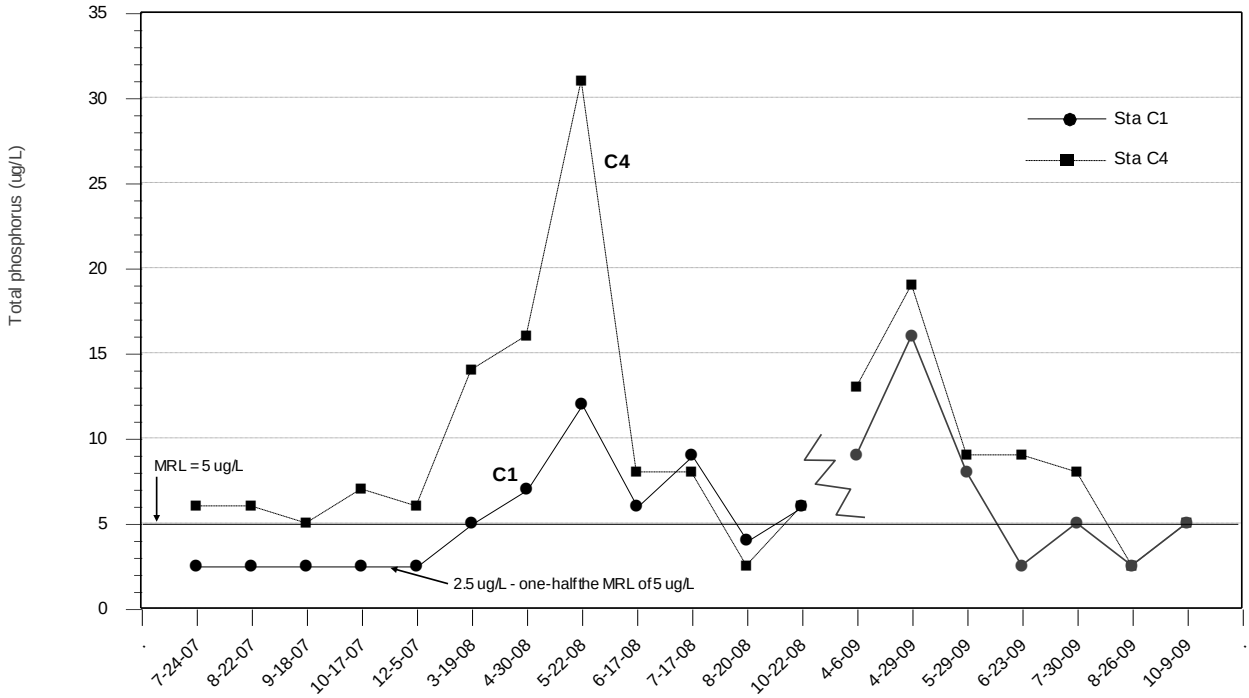

Figure 13. Total phosphorus in photic zone composite samples at sites C1 and C4, July 2007 – October 2009.

3.3.3.2 Tribe Phosphorus

Total phosphorus concentrations are generally higher in the southern waters compared to the northern waters of Coeur d'Alene Lake. The geomean for total phosphorus (all sampled depths combined) at C5 in CY09 was 13.5 (µg/L), slightly lower than the CY08 geomean of 13.2 (µg/ L), (Figure 14).

Total phosphorus concentration in the photic zone at C5 was highest on April 7, 2009 at 32 µg/L (Figure 15). The April 7 sampling was during the rising limb of the St Joe and Coeur d'Alene River hydrographs. Another high flow event from the Coeur d'Alene and St. Joe Rivers peaking on May 20, 2009 did not increase total phosphorus in the photic zone which decreased throughout the season until form the April 7, 2009 maximum until reaching 19 µg/L on August 25, 2009 (Figure 15). Total Phosphorus once again decreased to a season-low of 7µg/L on October 7, 2009 when this part of the lake remained thermally stratified (Figure 30C). Total phosphorus in the photic zone at C5 increased in early winter (December 1, 2009) as this part of the lake was isothermal near 4 °C (Figure 30D), producing a mixed water column.

Total phosphorus concentration at the lake bottom (one meter above lake bottom) at C5 was also highest on April 7, 2009 at 28 µg/L (Figure 16), during the rising limb of the St Joe and Coeur d'Alene River hydrographs. Similar to the photic zone at C5, total phosphorus decreased throughout the season, then increased dramatically reaching 21µg/L on August 25, 2009 (Figure 16). Total Phosphorus remained relatively high at the lake bottom at C5 through the December 1st sample. The total phosphorus increase in August at both photic zone and lake bottom could not be attributed to anoxic conditions because dissolved oxygen saturation in the hypolimnion and above the sediments was 5.2 mg/L (50% saturation). The site was thermally stratified with little wind in the time period preceding the sampling. Thus, wind mixing was unlikely. Whether this is a transient event or a consistent seasonal dynamic at C5 will be answered with continued monitoring in future years.

Total phosphorus concentrations at site C6 (Chatcolet Lake) are higher than at any other site covered in this report. In CY09 the geomean for all sample depths combined at C6 was 21.7 µg/L, lower than the WY04-06 (24.7 µg/L), and CY08 (24.7 µg/L), (Figure 14).

Similar to site C5, C6 total phosphorus concentration in the photic zone was high on April 7, 2009 at 28 µg/L (Figure 15). The higher concentration was likely due to high discharge from the St. Joe River. Total phosphorus concentration declined into the summer months then increased to 28 µg/L on August 25. This is a similar dynamic exhibited at C5, and even though the hypolimnion at C6 was anoxic, strong thermal stratification should have reduced mixing of the high concentrations of total phosphorus from the hypolimnion (Figure 31B).

Total phosphorus concentration at the lake bottom (one meter above lake bottom) on April 7 at C6 was 31 µg/L (Figure 16). Total phosphorus decreased through the early summer until dissolved oxygen levels in the hypolimnion depleted and became anoxic sometime between the July 21 and August 25 sampling dates. A total phosphorus concentration of 89 µg/L was present on August 25 during anoxic conditions in the hypolimnion (Figure 31B).

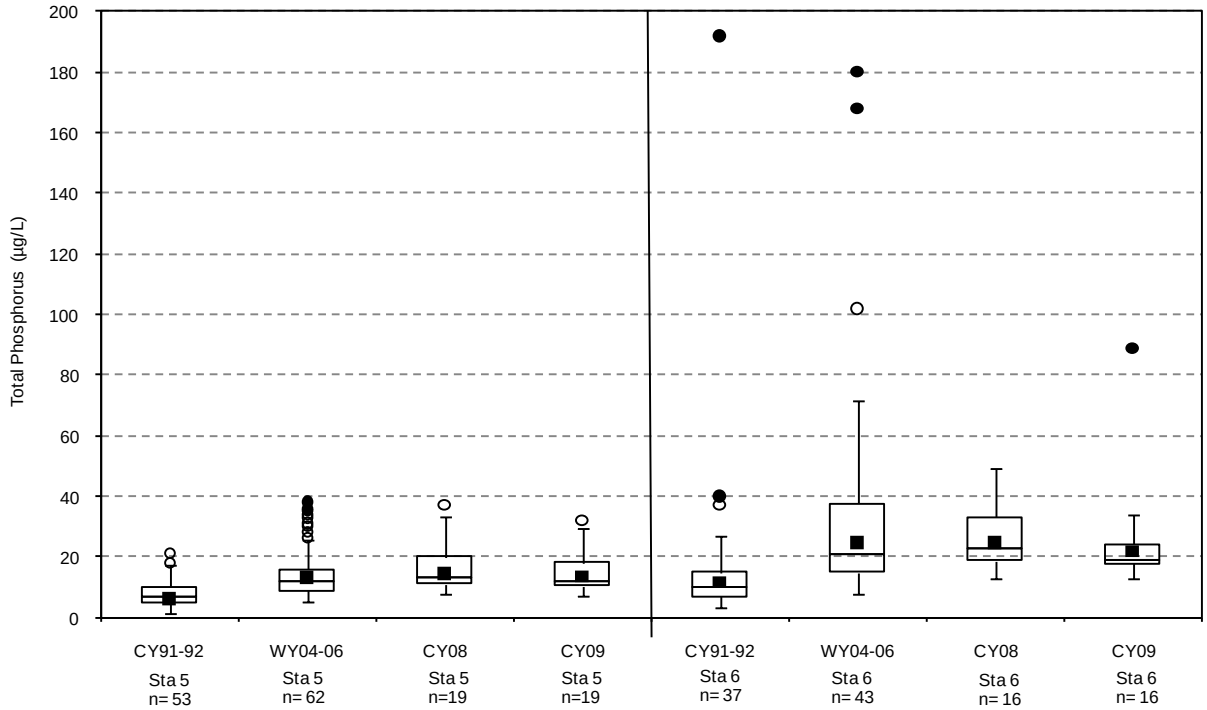

Figure 14. Box plot comparisons of total phosphorus for study periods: USGS CY91-92 and WY04-06, and Coeur d'Alene Tribe CY08 and CY09 at sampling sites C5 and C6.

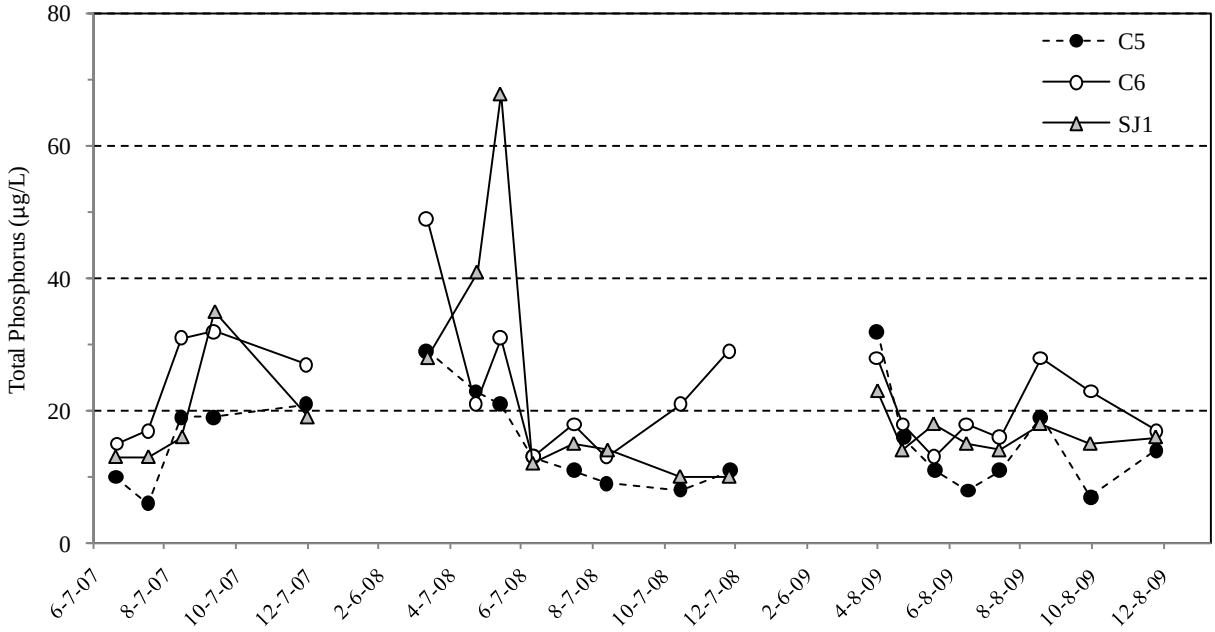

Figure 15. Total phosphorus from photic zone composite samples taken at sites C5, C6 and SJ1 from June 2007 through December 2009.

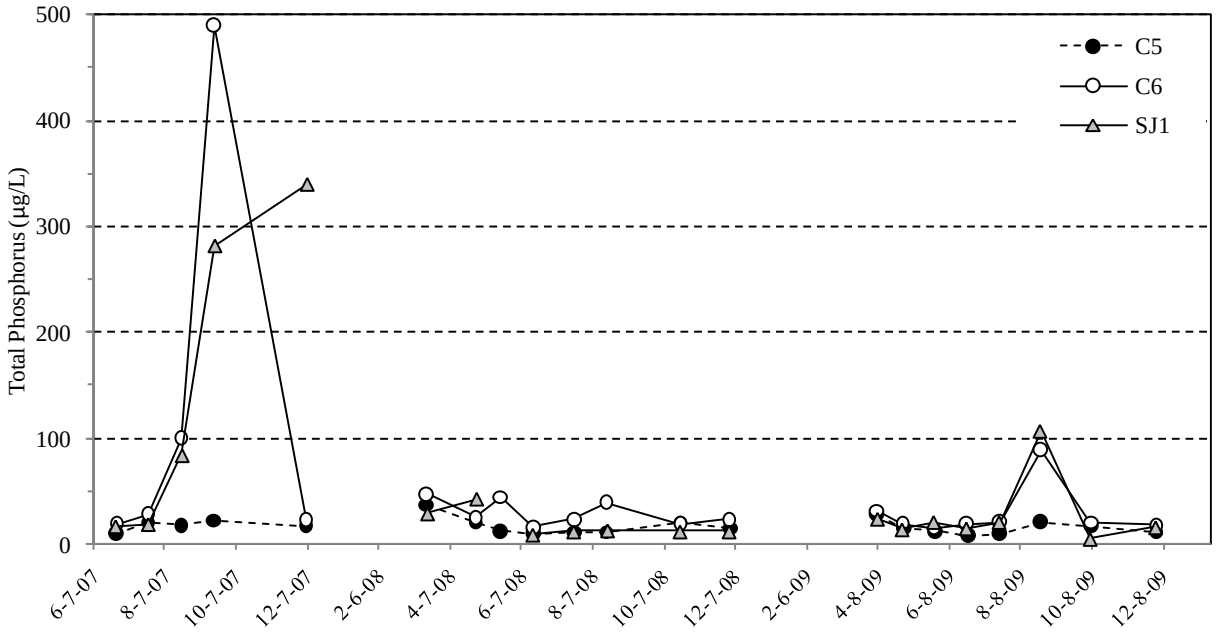

Figure 16. Total phosphorus in samples taken from one meter above lake bottom at sites C5, C6 and SJ1 from June 2007 – December 2009.

3.3.3.3 IDEQ Nitrogen

Total Nitrogen (TN) concentrations within the northern waters of Cd'A Lake are generally quite low; they have seldom been greater than 300 µg/L during the IDEQ 2007-09 study period. For CY09, geomean TN at C1 = 141 µg/L, and at C4 geomean = 163 µg/L (Table 11). The USGS did not conduct a comparison of TN concentrations between the study periods of CY91-92 versus WY04-06 because of a change in the MRL.

The readily bioavialable forms of nitrogen for phytoplankton growth are dissolved ammonia and dissolved nitrite+nitrate. Concentrations of nitrite+nitrate are generally greater than ammonia within northern Cd'A Lake, but they are both low (Table 11). Combining concentrations of these dissolved nitrogen compounds gives dissolved inorganic nitrogen (DIN). USGS was able to perform an analysis of DIN between the CY91-92 and WY04-04 study periods, and the statistical analysis did not show any significant differences in DIN between the study periods at any of the pelagic sampling sites.

DIN concentrations of photic zone composite samples at sites C1 and C4 for the period July 2007 – October 2009 is shown in Figure 17. Peaks of DIN within the photic zone tend to be associated with the spring runoff period. At site C4, a peak of 176 µg/L DIN was recorded on the April 7, 2009 sampling. During spring months of high river inflows, DIN in deeper lake waters also ranges between
100 – 200 µg/L.

In summer months within the photic zone, DIN falls to near or below the combined MRL of 45 µg/L (Figure 17). This is typical of photic zone depletion of DIN by phytoplankton assimilation. In summer months, DIN (mostly nitrate) remains above 100 µg/L in bottom waters (samples at 30 m and 1 m off the bottom). Phytoplankton assimilation has declined, and there is microbial nitrification of sinking organic matter (bottom waters of the northern pool remain oxic during stratification). With lake turnover beginning around mid-October and completed sometime in November, DIN increases in upper waters through upwelling and mixing. This is demonstrated in Figure 17 by the samples taken on October 17 and December 5, 2007. Photic zone DIN concentrations increased from ≈ 25 µg/L summer levels to 40 – 80 µg/L in the fall.

Nitrogen compounds play important roles within the lake. This includes: 1) a subsurface source of dissolved inorganic nitrogen from drainfield wastewater (containing ammonia and nitrate), where flow into nearshore areas can fuel growth of rooted aquatic plants, and 2) the nutrient role for phytoplankton growth and assemblage composition, as algae respond within a seasonal range of bioavailable nitrogen:phosphorus ratios (DIN:DOP). The existing ratio can dictate whether it is phosphorus or nitrogen that is the nutrient limiting phytoplankton growth (or co-limitation).

3.3.3.4 Tribe Nitrogen

Similar to the deeper, northern pool sites (C1 and C4), DIN in the photic zone at C5 remained low throughout the summer, at times below the combined minimum reporting limits of 30 µg/L (Figure 18). The only exception was a small increase captured in the August 25 sampling. Dissolved inorganic nitrogen concentrations near the lake bottom at C5 were higher than photic zone concentrations (Figure 19). Dissolved inorganic nitrogen concentrations near the lake bottom at C5 were highest in the spring, decreasing through mid-summer, then increased in late summer (Figure 19). During late summer, nitrate comprised 78% and 82 % of DIN (August 25 and October 7 respectively). The high percentage of nitrate comprising the DIN at this time is explained by the process of bacterial nitrification which converts the ammonium produced from decomposition of organic into nitrate. This nitrification is an aerobic process and although there is a dissolved oxygen sag in the hypolimnion at site C5 during thermally stratified periods (Figure 30), the hypolimnion at C5 contains enough oxygen for nitrification to proceed. Due to the thermal stratification, mixing of deeper waters into the epilimnion is negligible and DIN in the form of nitrate accumulates in the hypolimnion.

In contrast to C5, sites C6 and SJ1 reveal different DIN dynamics driven by late summer anoxic conditions during thermally stratified periods. Both C6 and SJ1 exhibited similar DIN concentration in the photic zone compared to C5 (Figure 18). However, dissolved inorganic nitrogen concentrations near the lake bottom at C6 and SJ1 were considerably higher than at C5 in August (Figure 19). During this time, 95% of the DIN in the hypolimnion of C6 and SJ1 was ammonium. The high concentration of ammonium was the result of anoxic conditions prohibiting nitrification of ammonium to nitrate and driving ammonium liberation from the sediments.

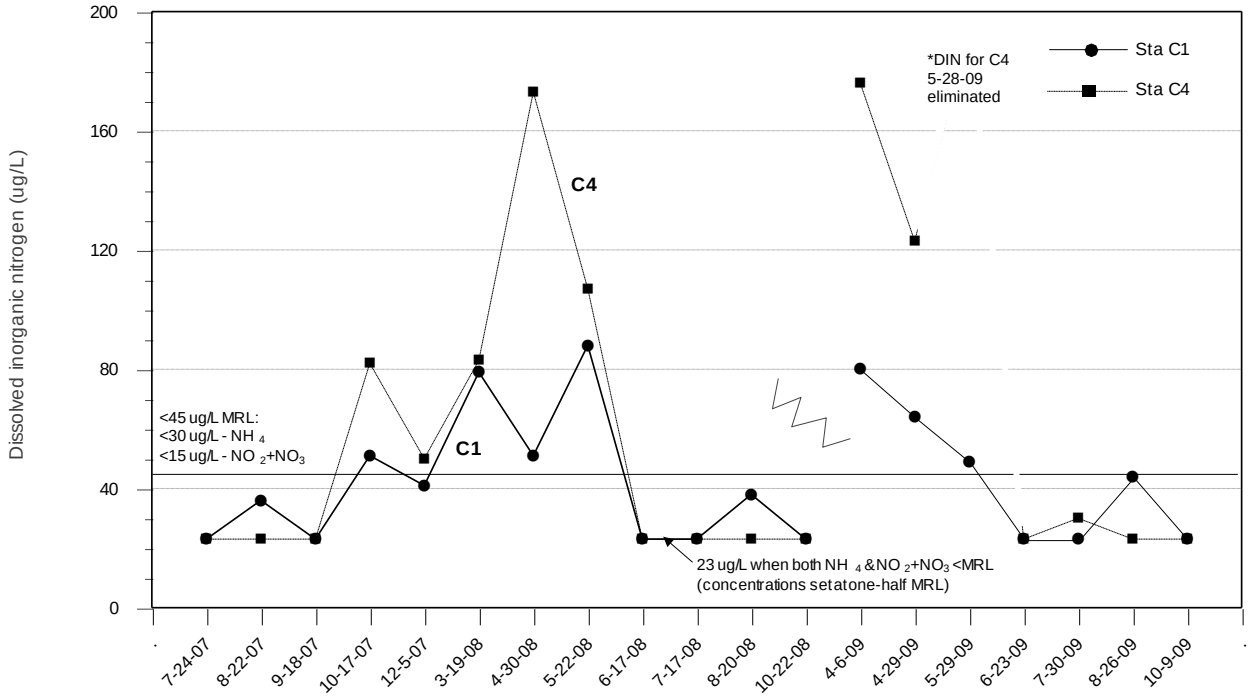

Figure 17. Dissolved inorganic nitrogen (ammonia + nitrite+nitrate) in photic zone composite samples at sites C1 and C4, July 2007 – October 2009. *Note: data point flagged and removed (see Table A3).

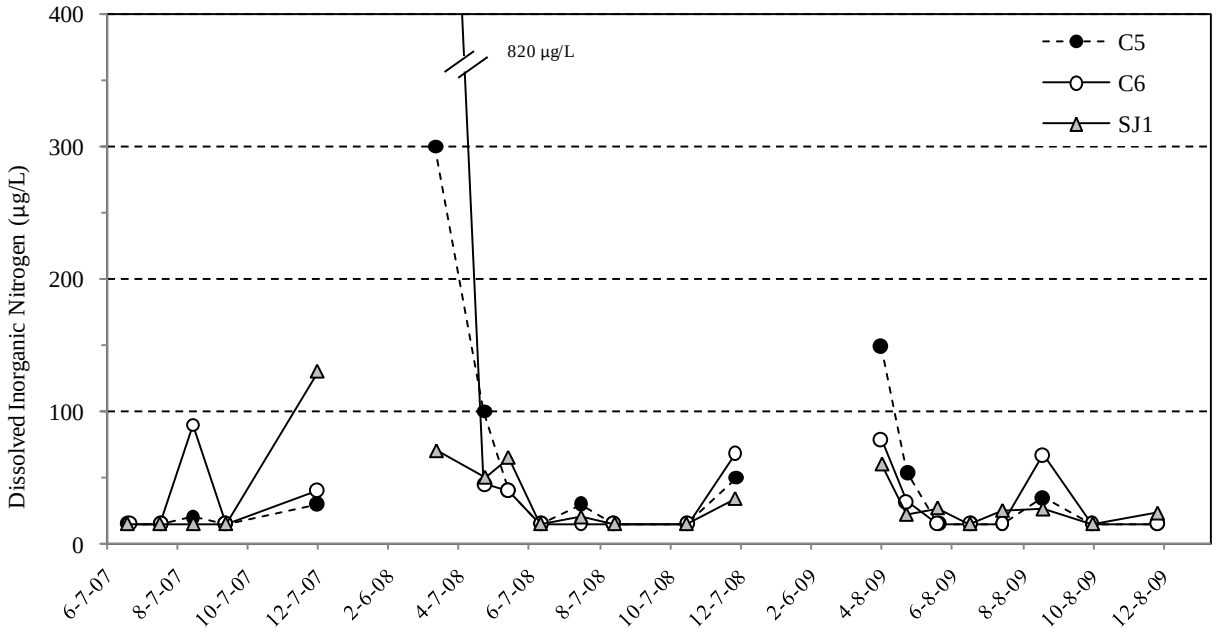

Figure 18. Dissolved inorganic nitrogen concentration in photic zone composite samples taken at sites C5, C6 and SJ1, June 2007 – December 2009.

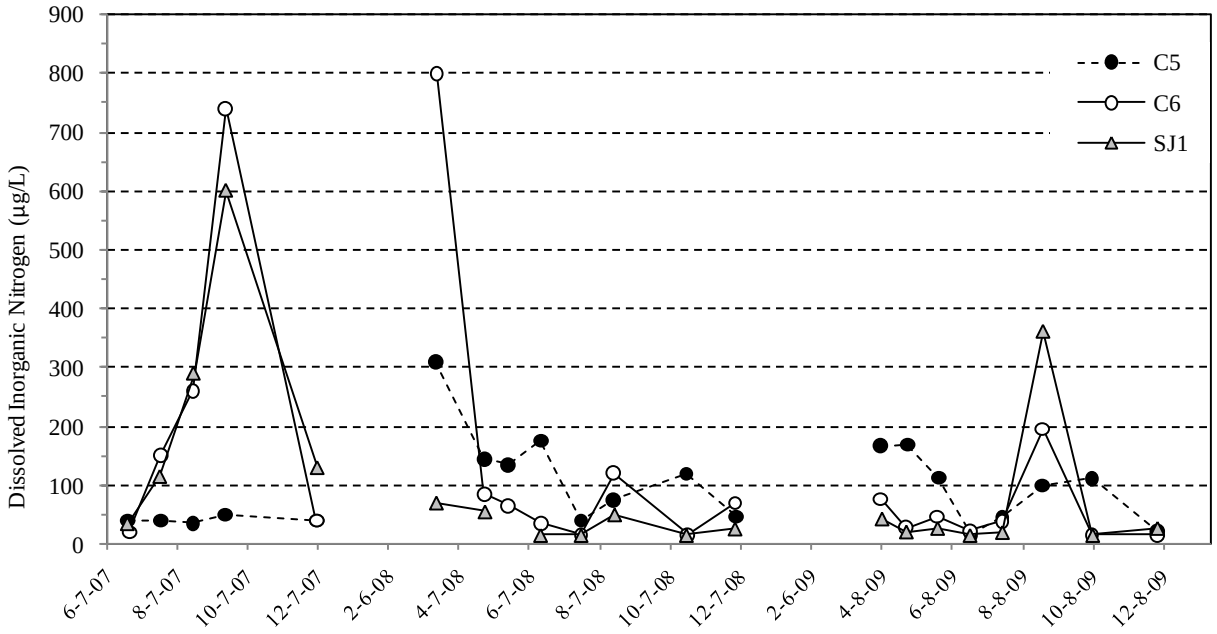

Figure 19. Dissolved inorganic nitrogen concentration in samples taken at one meter above the lake bottom at sites C5, C6 and SJ1, June 2007 – December 2009.

3.3.4 Phytoplankton

Phytoplankton biomass is commonly assessed by measuring chlorophyll *a* concentrations within algae retained on a filter after water filtration. Analytical methods by the USGS national laboratory to determine chlorophyll *a* were different between study periods CY91-92 (high-performance liquid chromatography, HPLC), and WY04-06 (chromatographic-fluorometric, C-F). This change in analytical methods presented some difficulties for comparisons between the two study periods. USGS paired-sampling, with samples analyzed by the two methods, resulted in a regression equation converting CY91-92 HPLC values to C-F values (Wood and Beckwith, 2008). Adjustment to C-F values averaged around 0.4 µg/L higher than the HPLC data set. Data analysis in the following sections utilizes the C-F conversion of CY91-92 data for comparison with the WY04-06 data set, and the IDEQ and Tribe data sets (EPA lab – fluorometric).

In CY91-92, chlorophyll *a* values at all lake sites within the photic zone were very low (Figure 20 for northern pool sites C1 and C4, and Figure 22 for southern lake sites C5 and C6). At all sites the range of values (adjusted) was narrow with the median and geometric mean around 1.0 µg/L. In WY04-06, chlorophyll *a* concentrations at northern and southern sites were greater than CY91-92 (Figures 20 and 22). For northern sites and C5, the WY04-06 geomeans were about 50% greater, and at C6 the geomean was more than double.

USGS concluded in their final 2008 report that when applying chlorophyll *a* data to non-parametric statistical analysis, the WY04-06 data is statistically, significantly higher than the adjusted CY91-92 data set at all pelagic stations (Wood and Beckwith, 2008). Reasons

associated for the increase in chlorophyll *a* between study periods are not clear, and will be the subject of further analysis.

Samples for phytoplankton identification and enumeration were taken during the USGS study period of CY91-92. Diatoms were the predominant algal group throughout the seasons at all sites. The Cyanophyta (blue-green algae, now called cyanobacteria) were incidental or absent at northern pool sites. Phytoplankton ID and enumeration were not part of the routine monitoring during WY04-06. Samples for identification and enumeration have been routinely conducted by IDEQ and the Tribe since July 2007.

3.3.4.1 IDEQ Chlorophyll a

The IDEQ photic zone data set for CY08 showed a substantial increase over WY04-06 for sites C1 and C4 (Figure 20). For site C1 in CY09, the spread of data points was greater than the previous year, but the geomean was less at 2.33 µg/L (n = 7). For site C4 in CY09, the data set is similar to the previous year (geomean = 2.36 µg/L).

For the period of August 2007 – October 2009, the seasonal pattern of photic zone chlorophyll *a* is shown in Figure 21 for each sample day at C1 and C4. Concentrations are typically higher during spring months of peak river inflow and warming temperatures. In CY08 and CY09, spring peak chlorophyll *a* values were higher at C1 than at C4. Concentrations at C1 on April 6 and 29, 2009 were 6.83 and 8.42 µg/L respectively, the highest photic zone chlorophyll *a* values in the northern pool data sets since 1991. Chlorophyll *a* declines and levels out in summer and fall months, ranging from around 3 µg/L down to the MRL of <1.0 µg/L.

3.3.4.2 Tribe Chlorophyll a

At site C5, the USGS data set for WY04-06 had a geomean of 1.6 µg/L, 50% higher than the CY91-92 period (Figure 22). At site C6 the WY04-06 geomean was 2.6 µg/L, two times greater than the CY91-92 period. The geomean chlorophyll *a* concentration from photic zone at site C5 for CY08 was nearly two times higher than during CY09 (Figure 22). The geomean chlorophyll *a* concentration at site C6 for CY08 was over three times higher than during CY09 (Figure 22). For sites C5 and C6 the geomean chlorophyll *a* concentration was similar in CY09 to WY04-06 (Figure 22).

For CY09 the geomean for C5 was 1.7 µg/L with a maximum recorded value of 5.28 µg/L (Table 11). Both values were lower than the CY08 results for site C5 (Figure 23). For CY09 the geomean for C6 was 2.06 µg/L with a maximum recorded value of 5.68 µg/L (Table 11). Both values were lower than the CY08 results for site C6 (Figure 23).

The chlorophyll *a* seasonal trends for sites C5 and C6 in CY09 were different than in CY08 with CY09 lacking a spring chlorophyll a pulse, but having the seasons maximum concentration in December (Figure 23). The season trends at the riverine site, SJ1in CY08 and CY09 were similar with the lowest chlorophyll *a* concentrations during the spring hydrograph and fall drawdown, and increasing concentrations during the summer time period of inundation and thermal stratification from the Post Falls Dam (Figure 23).

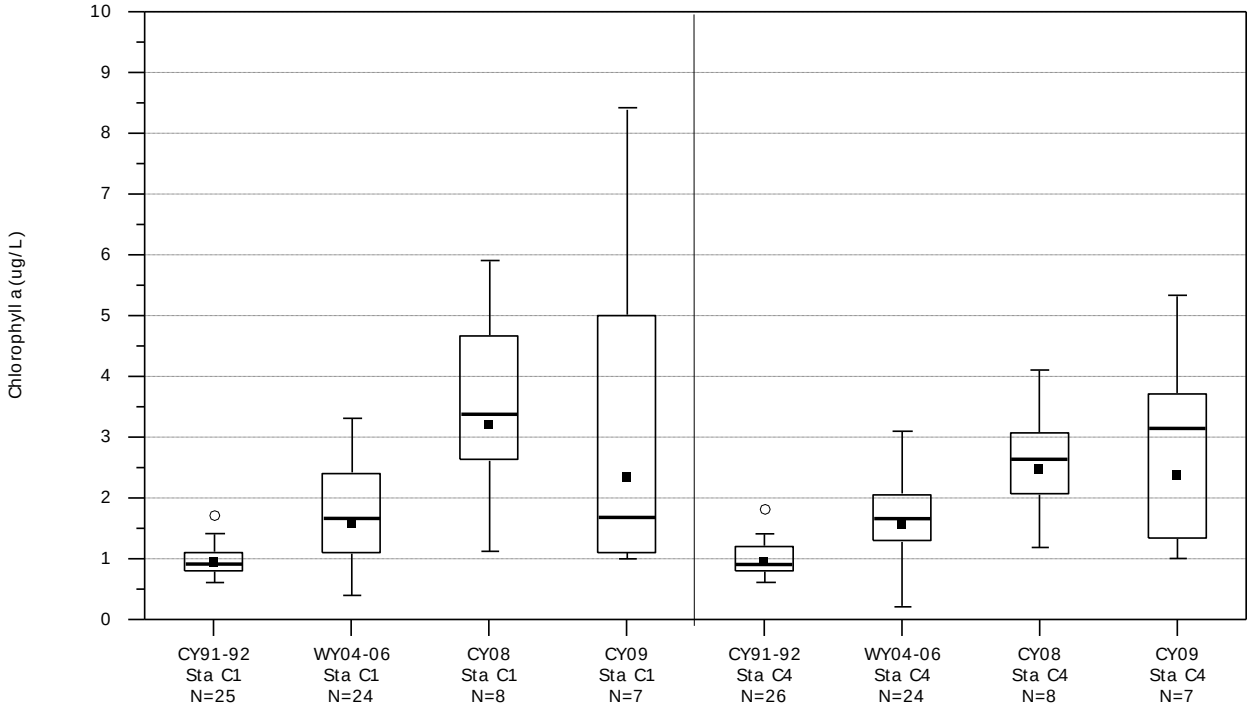

Figure 20. Box plot comparisons of photic zone chlorophyll *a* for study periods: USGS CY91-92 and WY04-06, and IDEQ CY08 and CY09, at sampling sites C1 and C4.

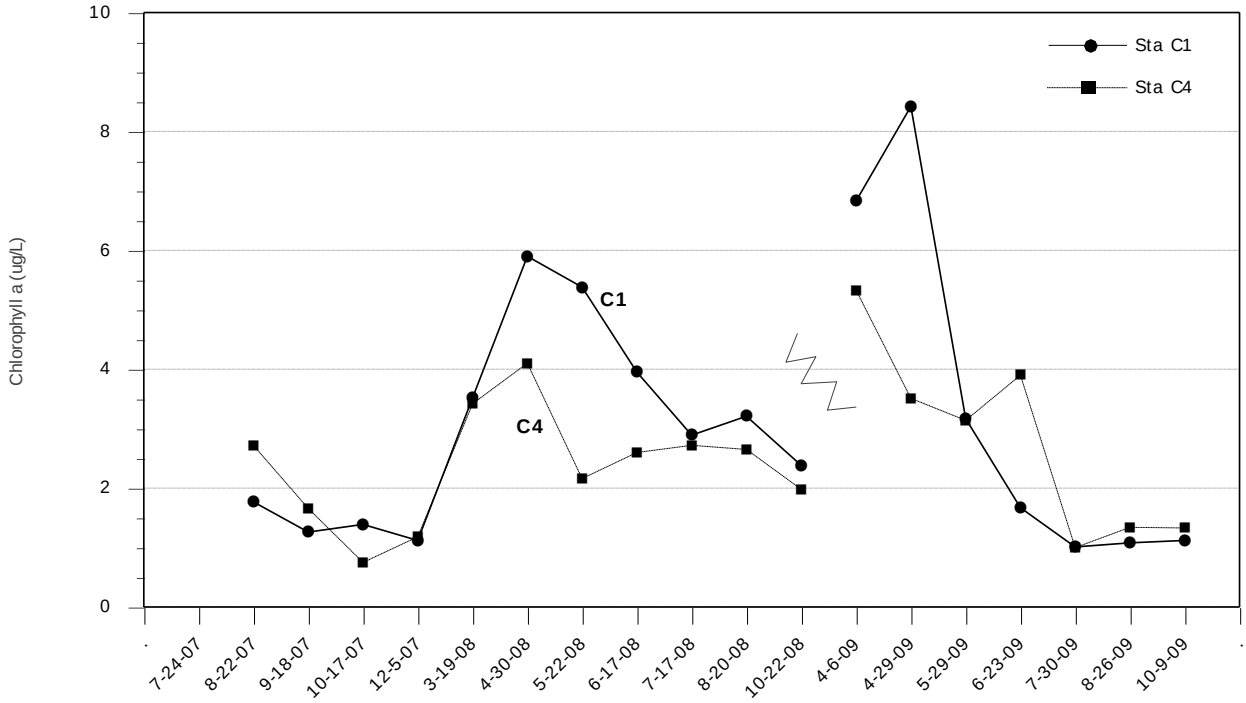

Figure 21. Chlorophyll *a* in photic zone composite samples for sites C1 and C4, August 2007 – October 2009.

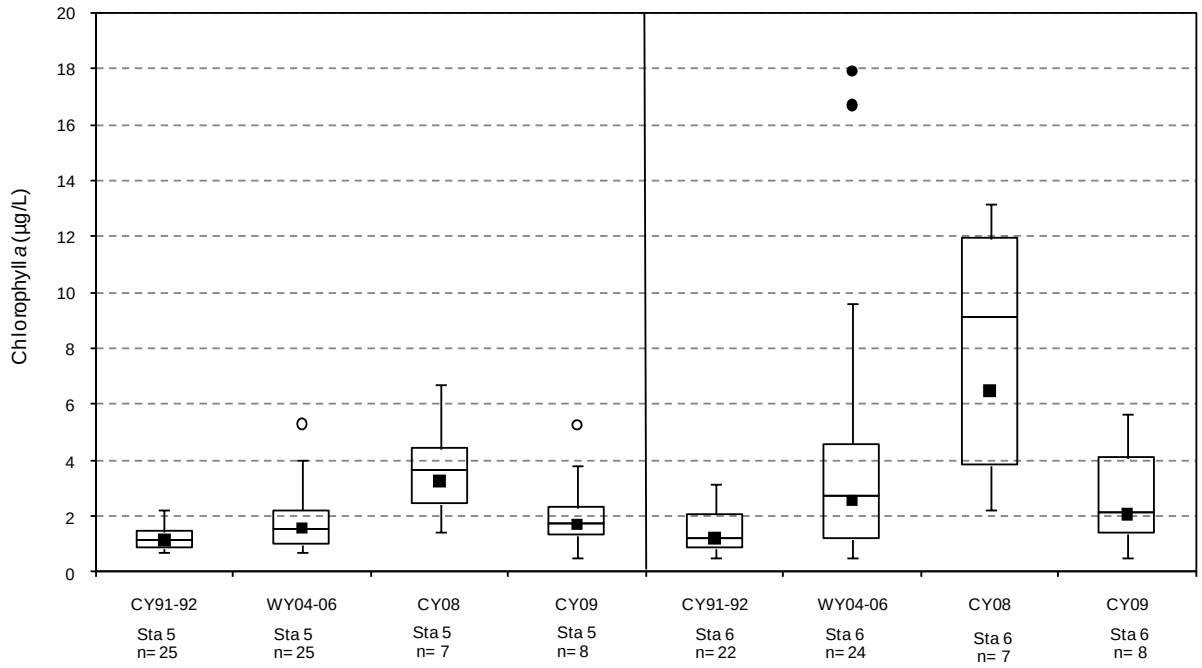

Figure 22. Box plot comparisons of chlorophyll *a* for study periods: USGS CY91-92 and WY04-06, and CDA Tribe CY08 and CY09 at sampling sites C5 and C6.

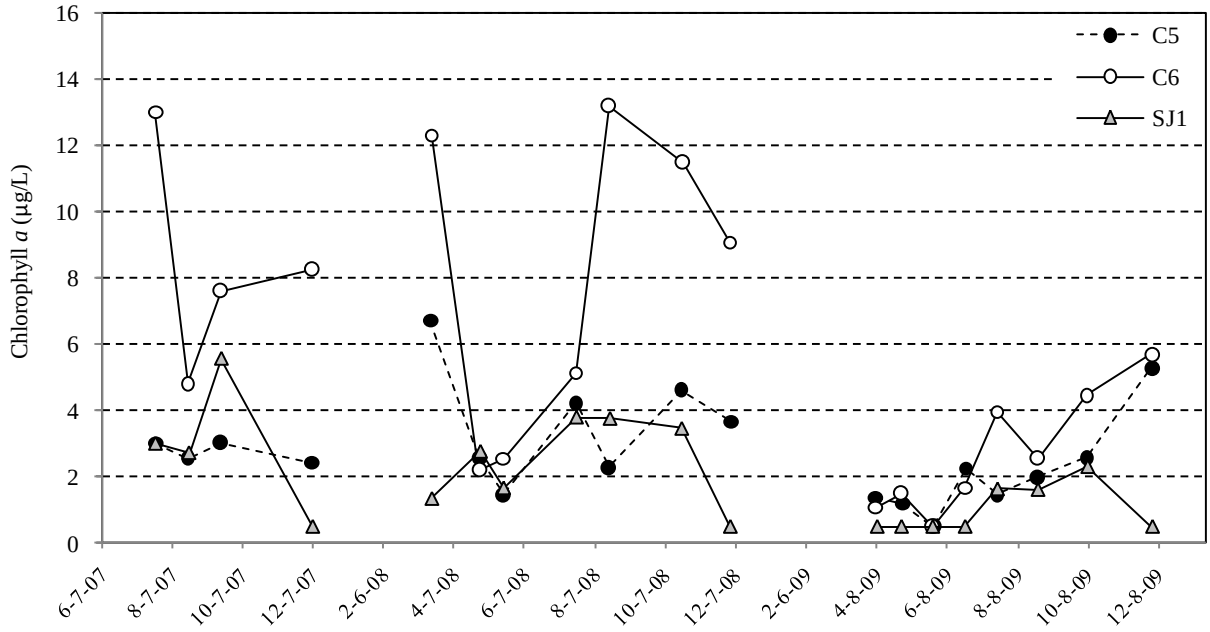

Figure 23. Chlorophyll *a* concentration from photic zone composite samples taken at sites C5, C6 and SJ1 from June 2007 – December 2009.

3.3.4.3 Chlorophyll a Maximum

In oligotrophic lakes there can be a significant subsurface peak of chlorophyll *a* during summer months. The peak is normally found within the cooler waters of the thermocline (metalimnion) or just below the thermocline, as increased water density slows down the sinking rate of non-motile phytoplankton cells, and there may be increased nutrient availability. This peak is called the chlorophyll metalimnetic maximum, and is commonly observed throughout Cd'A Lake in summer months, often at low light levels.

For both IDEQ and Tribe sampling, the presence of a chlorophyll *a* maximum is initially indicated by a significant peak of readings from the chlorophyll *a* fluorescence probe during a Hydrolab® profile. Readings measured in volts can be as much as 10 fold higher or more at a narrow metalimnion depth band compared to epilimnetic values. A discrete sample is taken at the peak fluorescence depth, and both chlorophyll *a* concentrations and phytoplankton numbers (cell counts and biovolume) are compared to the photic zone composite sample. In almost all cases since 2007, the discrete maximum samples produce higher values than photic zone composite samples.

A graphical profile example of chlorophyll *a* maxima was included in the 2007-08 annual report (Cd'A Tribe and IDEQ, 2010). An example for CY09 was at site C1 on June 23, where photic zone composite (0.75 – 13.75 m) chlorophyll *a* was 1.67 µg/L, and at the peak volt readout at 16.5 m, chlorophyll *a* was 5.03 µg/L.

3.3.4.4 IDEQ Phytoplankton Identification and Enumeration

Table 13 lists the genera/species identified in 14 photic zone samples of 2009 at sites C1 and C4 (7 sampling days each) and includes the number of samples where they were identified. Most genera/species were identified at both sites, but some were found at just one of the sites. Appendix B presents the entire array of genera/species identified from 2007 – 2009 at northern and southern lake sampling sites.

Dominant organisms in Table 13 are identified as either the number of samples where their cell count/mL was at least 5% of the total assemblage count, and/or the number of samples where their biovolume (μm^3/mL) was at least 5% of the total assemblage biovolume.

A summary of the dominant organisms in 2009 IDEQ samples is presented below:

Diatoms	The colonial diatoms: *Asterionella formosa*, *Aulacoseira* (formerly *Melosira*) *italica*, and *Tabellaria flocculosa* (cell count & biovolume) The single cell diatom: *Cyclotella comta* (biovolume only)
Green algae	*Nephroselmis sp*. and *Phacus sp.* (biovolume only), and *Pseudosphaerocystis sp.* (cell count & biovolume)
Chrysophytes (yellow-green flagellates)	*Chrysococcus sp.*and *Ochromonas sp*. (biovolume), and small flagellated, taxonomically unidentified, microflagellates (cell count & biovolume)
Cryptophytes	*Cryptomonas sp*. and *Komma sp*. (biovolume only)
Dinoflagellates	*Gymnodinium sp.* (biovolume only)
Blue-green algae (cyanobacteria)	*Chroococcus sp*. (biovolume only); M*icrocystis sp*. and autotrophic picoplankton *Synechococcus sp*. (rod, <2 μm) (cell count and biovolume)

Of particular interest is the appearance of the cyanobacteria *Microcystis sp*. at both C1 and C4. Species of *Microcystis* are known to produce a class of cyanotoxins labeled Microcystins, which can be a hepatotoxin (causes liver damage). Cell count and biovolume of *Microcystis sp.* in Cd'A Lake appear well below the guidelines of concern established by the World Health Organization (>100,000 *Microcystis* cells/mL, Chorus and Bartram 1999). *Microcystis* was identified in all but one of the samples from C1 and C4 (13 samples), and in each sample it was one of the dominant groups of cells/mL with a maximum recorded count of 17,440 cells/mL.

Similar to the pattern for chlorophyll *a*, summer samples taken at the depth of chlorophyll *a* maximum had higher cell counts and biovolume than the corresponding photic zone composite samples. For the complete data set of phytoplankton samples, total cell counts and biovolume were somewhat higher for C4 compared to C1 (Table 11).

Figure 24 presents cell counts on each sample day at site C4 for July 2007 – October 2009, and Figure 25 presents biovolume at C4 for the same period. Cell counts are stacked for the six functional phytoplankton groups, showing group cell count and total assemblage count on each sampling day. Cell counts in general follow a similar pattern as previously described for chlorophyll *a* (Figure 21). During the spring to early-summer peaks of phytoplankton cell counts, three groups tend to dominate: diatoms, flagellated chrysophytes, and blue-green algae. The sample of greatest cell count over the study period was May 29, 2009 at C1 (but highest chlorophyll *a* was on April 29, 2009). Total count was 28,110 cells/mL and was dominated by *Microcystis sp*. at 17,440 cells/ml. Cell counts at C4 on May 28 were also high (Figure 24), just slightly less than C1 and also dominated by *Microcystis sp.* The sample with the highest biovolume over the study period was on May 1, 2008 at C4 (Figure 25) with total biovolume = 2,750,000 μm^3/mL, dominated by the filamentous blue-green algae *Anabaena circinalis*.

Table 13. 2009 phytoplankton assemblage for site C1 – SE of Tubbs Hill, and C4 – NE of University Point.

Genus or species	Presence at site C1 & C4	Number of times genus/species was present in 14 photic zone samples[a]	Number of samples within dominant group in: cells or colonies/mL[b]	Number of samples within dominant group in: biovolume um^3/mL[c]
Bacillariophyceae (diatoms)				
Achnanthidium sp.	C1, C4	3		
Asterionella formosa var1	C1, C4	13	9	12
Aulacoseira granulata	C1	1		1
Aulacoseira italica	C1, C4	8	6	7
Cyclotella comta	C1, C4	6		2(C4)
Cyclotella glomerata	C1, C4	4		
Cyclotella stelligera	C1	1		
Diatoma sp.	C1	1		1
Fragilaria capucina	C1, C4	5		
Fragilaria crotonensis	C1, C4	4	1	1
Fragilaria intermedia	C1, C4	2		
Navicula sp.	C1, C4	2		
Rhizoselenia sp.	C1,C4	2		
Synedra acus var. angustissima	C1	1		
Synedra nana	C1, C4	2		
Tabellaria flocculosa	C1, C4	3	2	3
Chlorophyceae (coccoid greens, desmids, etc.)				
Acanthosphaera sp.	C1	1		
Actinastrum hantschii	C4	1		
Ankistrodesmus sp.	C1, C4	3		
Chlorella	C1, C4	3		
Coelastrum sp.	C1, C4	2		
Dichtyosphaerium	C1	2		2
Elakatothrix sp3	C1,C4	2		
Gloeococcus	C4	1		
Gleotila sp.	C1	1		
Golenkinia sp.	C1, C4	2		
Langerheimia	C1	1		
Monoraphidium	C1, C4	3		
Nephroselmis	C1, C4	11		2
Oocystis sp.	C1, C4	2		1
Pediastrum sp.	C4	1		
Phacus	C1, C4	5		2(C1)
Polytoma sp.	C4	1		
Pseudosphaerocystis sp.	C1, C4	4	3	2
Scourfieldia	C1, C4	7		1
Sphaerocystis sp.	C4	1	1	1
Stichococcus minutissimus	C1	1		

Table 13 - continued

Genus or species	Presence at site C1 & C4	Number of times genus/species was present in 14 photic zone samples[a]	Number of samples within dominant group in: cells or colonies/mL[b]	Number of samples within dominant group in: biovolume um^3/mL[c]
Chrysophyceae (yellow-green flagellates)				
Bitrichia sp.	C4	1		
Chromulina sp1	C1, C4	10		
Chrysochromulina sp.	C1, C4	4		
Chrysococcus	C1, C4	10	1	3
Chrysosphaerella sp.	C1	1		
Dinobryon sp.	C1, C4	6		
Kephyrion sp.	C1, C4	10		
Mallomonas sp2	C4	3		
Ochromonas sp.	C1, C4	12		4
Small microflagellates	C1, C4	13	14	10
Sphaleromantis sp.	C1, C4	4		
Synura	C4	1		1
Trachelomonas sp.	C1, C4	4		
Cryptophyta (flagellates)				
Cryptomonas sp.	C1, C4	13		7
Komma sp. (Boda in 2008)	C1, C4	13		2
Dinophyceae (dinoflagellates)				
Gloeodinium	C1	1		1
Gymnodinium sp1	C1, C4	10		3
Cyanophyta (cyanobacteria or blue-greens)				
Chroococcus sp.	C1, C4	4		3
Coelosphaeria sp.	C1	1		
Merismopedia sp.	C4	1		
Microcystis sp.	C1, C4	13	13	3
Synechococcus sp. (coccoid)	C1, C4	9		
Synechococcus sp. (rod)	C1, C4	14	8	5
Synechocystis	C1	2		

a = 7 sampling events each at C1 and C4; presence combined
b = The group of genus/species where the count of cells (or colonies)/mL, as a percentage of the total assemblage count, was 5% or greater in 14 photic zone samples.
c = The group of genus/species where the biovolume (um^3/mL) of cells (or colonies), as a percentage of the total assemblage biovolume, was 5% or greater in 14 photic zone samples.

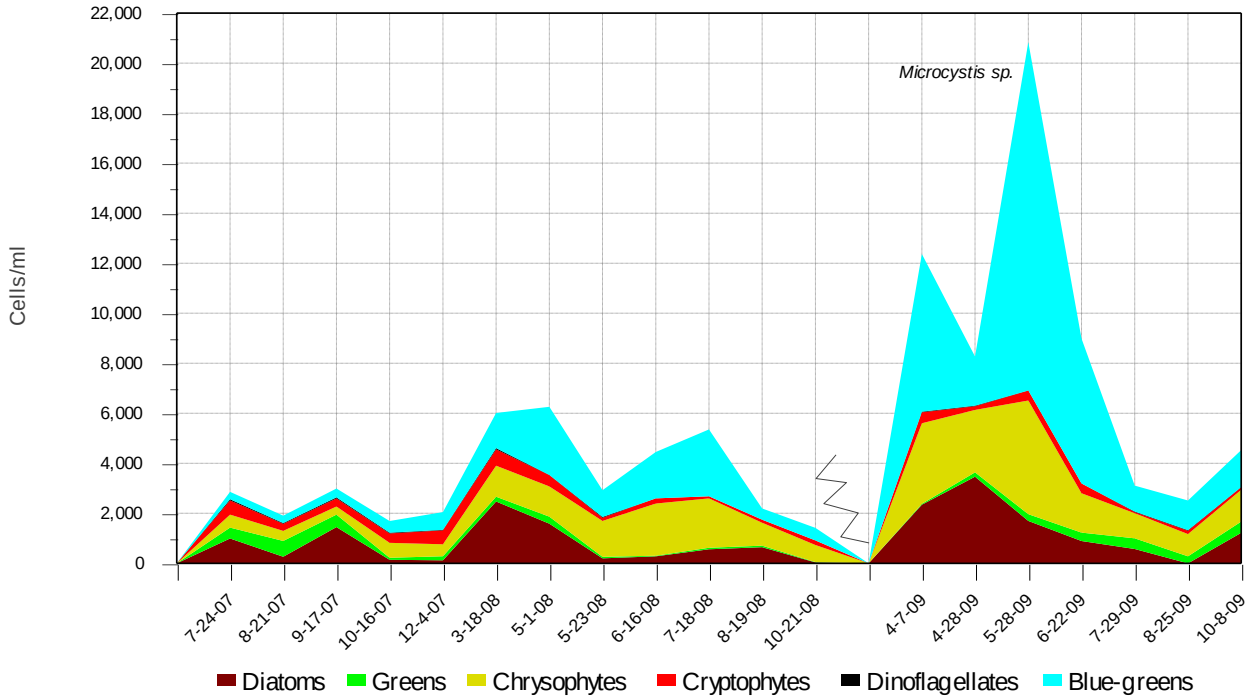

Figure 24. Phytoplankton cell counts/mL at site C4 for July 2007 – October 2009

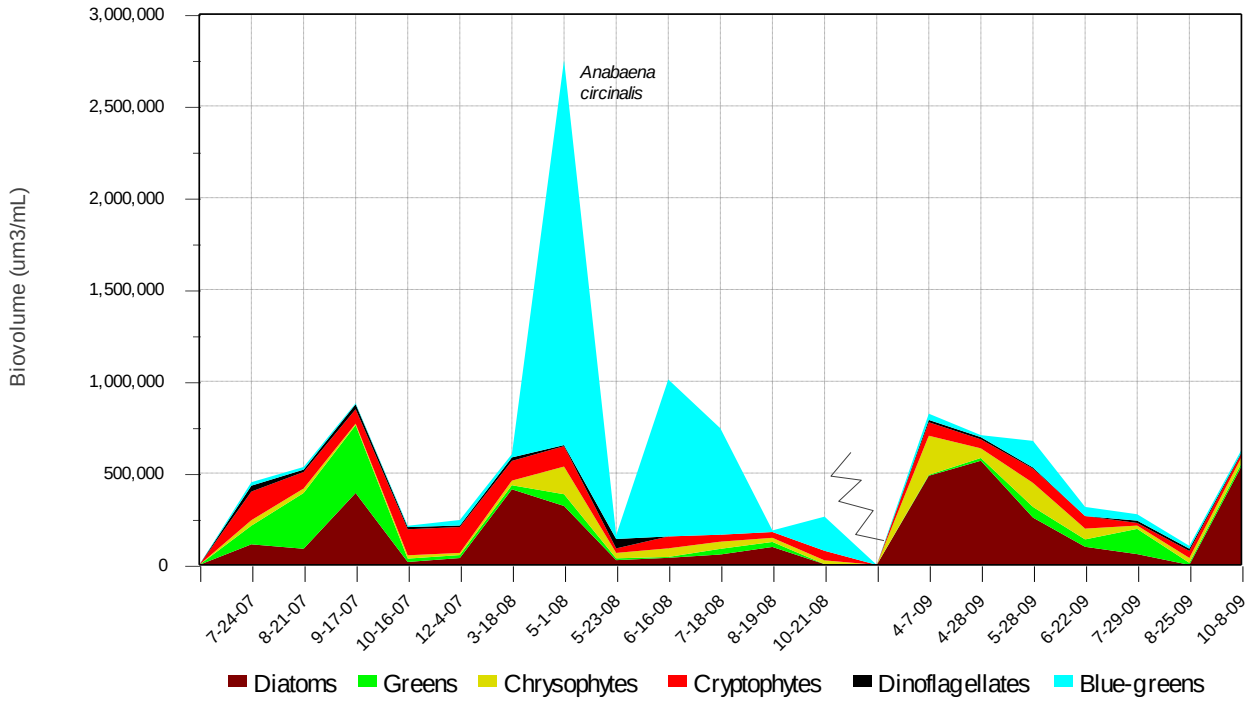

Figure 25. Phytoplankton biovolume in μm^3/mL at site C4 for July 2007 – October 2009

3.3.4.5 Tribe Phytoplankton Identification and Enumeration

Table 14 lists the genera/species identified in 24 photic zone samples at sites C5, C6 and SJ1 from 8 sampling events, and includes the number of samples where they were identified.

As with the northern sites C1 and C4, dominant organisms at C5, C6 and SJ1 are identified in either the number of samples where their cell count/ml was the highest, or cell count was greater than 5% of the total assemblage count; and/or the number of samples where their biovolume (μm^3/ml) was the highest, or biovolume was greater than 5% of the total assemblage biovolume.

A summary of the dominant phytoplankton from C5, C6 and SJ1 is presented below:

Diatoms	The colonial diatoms: *Asterionella formosa, Aulacoseira* (formerly *Melosira*) *italica, Fragilaria crotonensis* and *Tabellaria fenestrata*
Green algae	*Dichtyosphaerium sp., Chlamydocapsa sp.* and *Nephroselmis sp.* (biovolume only)
Chrysophytes (yellow-green flagellates)	*Ochromonas sp., Dinobryon sp.*, and small flagellated, taxonomically unidentified, *microflagellates* (in cells/ml only)
Chryptophytes	*Komma sp.* (formerly *Boda sp.),* and *Cryptomonas sp*.
Dinoflagellates	*Gymnodinium sp.* and *Ceratium sp.* (biovolume only)
Blue-green algae	*Microcystis sp., Anabaena circinalis, Chroococcus sp.* and rod-shaped autotrophic picoplankton (cyanobacteria) *Synechococcus sp*.

During CY09 the inundated lower St. Joe River (SJ1) had the lowest phytoplankton biovolume of the three southern sites throughout 2009. The range of biovolume at SJ1 was 45,185 to 246,742 μm^3/ml. The highest biovolume at SJ1 in 2009 was sampled on October 7 (Figure 26) with the chlorophyte, *Chlamydocapsa sp.* comprising 33% and the cryptophyte, *Komma sp.* 16% of the total biovolume on this date.

During CY09 the pelagic southern site C5 phytoplankton biovolume was higher than SJ1, but lower than site C6 throughout 2009. The range of biovolume at C5 was 38,343 to 385,822 μm^3/ml. The highest biovolume at C5 in 2009 was sampled on December 2 (Figure 26) with three diatoms; *Aulacoseira italica, Tabellaria fenestrata and Aulacoseira granulata* comprising 72% of the total biovolume on this date

During CY09 site C6 produced the lowest and the highest phytoplankton biovolume at the southern lake sites in 2009, with a range of 14,903 to 1,061,327 μm^3/ml. The highest biovolume at C6 in 2009 was sampled on December 1 (Figure 26) and similar to site C5, three diatoms; *Aulacoseira italica, Tabellaria fenestrata and Aulacoseira granulata* comprising 95% of the total biovolume on this date. Site C6 had the highest cell count for the cyanobacteria *Microcyctis* sp. at 13,049.3 cells/mL on August 25, 2009.

Table 14. Phytoplankton assemblage for site C5 – south of Harrison, C6 – Chatcolet Lake and SJ1-Inundated St Joe River, April 2009 – December 2009.

Genus or species	Presence at site C5, C6 & SJ1	Number of times genus/species was present in 24 photic zone samples[a]	Number of samples within dominant group in: cells or colonies/ml[b]	Number of samples within dominant group in: biovolume um^3/ml[c]
Bacillariophyceae (diatoms)				
Achnanthidium sp.	C5, C6, SJ1	8		
Asterionella formosa	C5, C6	12	2	4
Aulacoseira granulata	C5, C6	4		4
Aulacoseira italic	C5, C6, SJ1	9	3	6
Cocconeis sp.	C6	1		
Cyclotella comta	C5, C6	5		2
Cyclotella glomerata	C5, C6, SJ1	5		
Cyclotella stelligera	SJ1	1		
Cymbella sp.	C5, C6, SJ1	12		2
Denticula sp.	SJ1	1		
Diatoma sp.	C6, SJ1	2		
Epithemia sp.	C6	1		
Fragilaria capucina	C5, C6, SJ1	12		1
Fragilaria construens	C5, C6, SJ1	4		1
Fragilaria crotonensis	C5, C6, SJ1	8	2	1
Fragilaria intermedia	SJ1	1		
Gomphonema sp.	C6, SJ1	6		5
Hannea Arcus	C5, C6	2		
Navicula sp.	C5, C6, SJ1	12		3
Nitzschia sp.	C5, C6, SJ1	10		
Pinnularia sp.	SJ1	1		1
Rhizosolenia sp.	C6, SJ1	3		
Stephanodiscus sp.	C5, C6	3		1
Synedra acus	C5, C6	2		
Synedra acus var. angustissima	C6	2		
Synedra nana	C5	2		
Synedra ulna	C6, SJ1	4		2
Tabellaria fenestrata	C5, C6	4	3	3
Tabellaria flocculosa	SJ1	1		1
Chlorophyceae (coccoid greens, desmids, etc.)				
Ankistrodesmus sp.	C5, C6, SJ1	9		1
Botryococcus sp. (colony)	C6	1		
Chlamydocapsa sp.	C5, C6, SJ1	3	1	2
Chlorella sp.	C5, C6, SJ1	14		
Coelastrum sp.	C5, C6	3		1

Table 14 – continued

Genus or species	Presence at site C5, C6 & SJ1	Number of times genus/species was present in 24 photic zone samples[a]	Number of samples within dominant group in: cells or colonies/ml[b]	Number of samples within dominant group in: biovolume um^3/ml[c]
Chlorophyceae cont.				
Cosmarium sp.	C5, SJ1	3		1
Crucigenia sp.	SJ1	1		
Dichtyosphaerium sp.	C6, SJ1	5	2	2
Elakatothrix sp.	C6	1		
Euastrum sp.	SJ1	1		1
Monoraphidium sp.	C5, C6, SJ1	6		1
Nephroselmis sp.	C5, C6, SJ1	16		4
Oocystis sp.	C5, C6, SJ1	6		1
Pediastrum sp.	C5, SJ1	3		2
Phacus sp.	C5, C6, SJ1	5		1
Planctonema sp.	C5	1		
Planctosphaeria sp.	C6	1		
Scenedesmus sp.	C6, SJ1	2		
Scourfieldia sp.	SJ1	1		
Staurastrum sp.	C5, C6	2		
Stichococcus minutissimus	C6	1	1	
Tetraedron sp.	C6	2		
Chrysophyceae (flagellates)				
Chromulina sp.	C5, C6, SJ1	4		
Chrysochromulina sp.	C5, C6, SJ1	8		
Chrysococcus sp.	C5, C6, SJ1	16		
Dinobryon sp.	C5, C6, SJ1	8		1
Isthmochloron sp.	C6	1		1
Kephyrion sp.	C5, C6, SJ1	17		
Mallomonas sp.	C5	1		1
Ochromonas sp.	C5, C6, SJ1	15		4
Small microflagellates	C5, C6, SJ1	24	24	12
Trachelomonas sp.	C6, SJ1	5		

Table 14 – continued

Genus or species	Presence at site C5, C6 & SJ1	Number of times genus/species was present in 24 photic zone samples[a]	Number of samples within dominant group in: cells or colonies/ml[b]	Number of samples within dominant group in: biovolume um^3/ml[c]
Cryptophta (flagellates)				
Cryptomonas sp.	C5, C6, SJ1	21		12
Komma sp. (Boda in 2008)	C5, C6, SJ1	20	4	10
Dinophyceae (dinoflagellates)				
Ceratium sp.	SJ1	1		1
Gymnodinium sp.	C5, C6, SJ1	11		4
Cyanophyta (cyanobacteria or blue-greens)				
Anabaena sp.	C5, C6, SJ1	8	4	6
Chroococcus sp.	C5, C6, SJ1	16		12
Microcystis sp.	C5, C6, SJ1	19	19	6
Synechococcus sp. (coccoid)	C5, C6, SJ1	17		
Synechococcus sp. (rod)	C5, C6, SJ1	19	5	2

a = 8 sampling events each at C5, C6 and SJ1; presence combined.
b = The group of genus/species where the count of cells (or colonies)/ml, as a percentage of the total assemblage count, was 5% or greater.
c = The group of genus/species where the biovolume (um^3/ml) of cells (or colonies), as a percentage of the total assemblage biovolume, was 5% or greater.

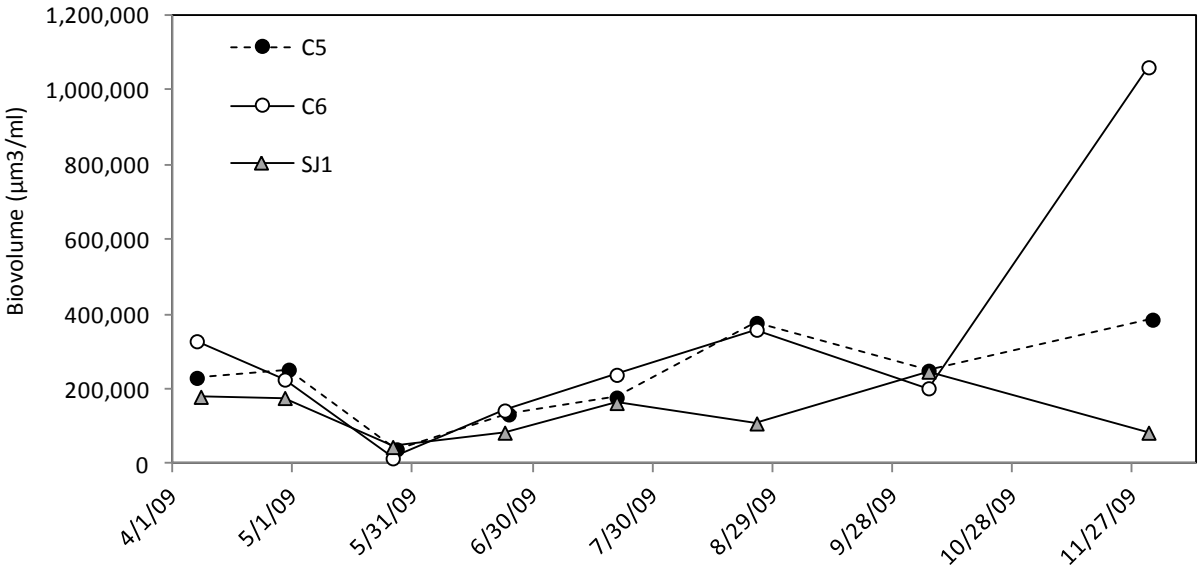

Figure 26. Total phytoplankton biovolume (µm^3/mL) from photic zone composite samples taken at sites C5, C6 and SJ1 in 2009.

3.3.5 Water Clarity

Water clarity, as measured by the semi-quantitative method of Secchi disc transparency, has been measured continuously since 1991 (including July to October, 1995 – 2002 by IDEQ). In the USGS baseline study periods of CY91-92 and WY04-06, photosynthetically active radiation (PAR) through upper waters was measured by solar radiation sensor equipment for light transmission and attenuation. This method determines the depth underwater at which PAR is 1% of the light incident on the water's surface. This depth is the theoretical primary producer photic zone. IDEQ and the Tribe have continued to measure Secchi disc depth and underwater PAR transmission and attenuation.

Water clarity follows a seasonal pattern of being low during significant rain-on-snow events and spring peak flow, and then clearing to reach clarity peaks from July through October. Seasonally combined data did not show a statistical difference between the USGS CY91-92 and WY04-06 study periods at any of the pelagic sampling sites (Wood and Beckwith, 2008).

3.3.5.1 IDEQ Water Clarity

IDEQ has taken Secchi disc measurements with and without the aid of an aqua view-scope. Submersing the view-scope just under the water's surface while lowering the Secchi disc eliminates sun and wave glare, giving more accurate and consistent readings. These aided Secchi disc readings cannot be compared to past data because of a high bias (overall deeper readings than previous values without the aid of the view-scope), but they will be used in the present and future monitoring program.

Figure 27 shows sample day Secchi disc transparency (with view-scope) and 1% light depth at site C1 for June 2007 – October 2009. Secchi disc and 1% light depth from July to October for 2007, 2008, and 2009 show good water clarity with Secchi depths ranging from 8 – 12.5 m, and 1% depths ranging from 13.5 – 19.0 m. During spring high flows and lake turbidity, Secchi depths at C1 declined to a range between 2 – 5 m, and the 1% light level has ranged between 6.5 – 11 m. Overall, water clarity at site C4 is somewhat less than C1 (Table 11). The lowest water clarity recorded during the study period was at C4 on May 23, 2008 where Secchi depth was 0.5 m and the 1% light depth was 2.5 m.

3.3.5.2 Tribe Water Clarity

The 1% PAR depth as a measure of water clarity for C5, C6 and SJ1 is presented in Figure 28. The CY08 and CY09 seasonal trends are similar (Figure 28). The seasonal trend at the three sites is increased water clarity (deeper 1% light depth) in summer and reduced water clarity in the fall through winter and into the spring (Figure 28). The lowest water clarity is produced in the spring period during the St Joe River and Coeur d'Alene River peak hydrographs. In CY09 site C5 had the greatest water clarity of the three southern sites with a maximum 1% PAR depth of 14 meters on July 21 and August 25 (Figure 28). All three sites had a low % PAR depth of 4 meters on April 7 during the first peak discharge of St Joe and Coeur d'Alene rivers (Figure 28). During fall turnover from isothermal water column conditions at C5 and C6 water clarity decreases significantly (Figure 28).

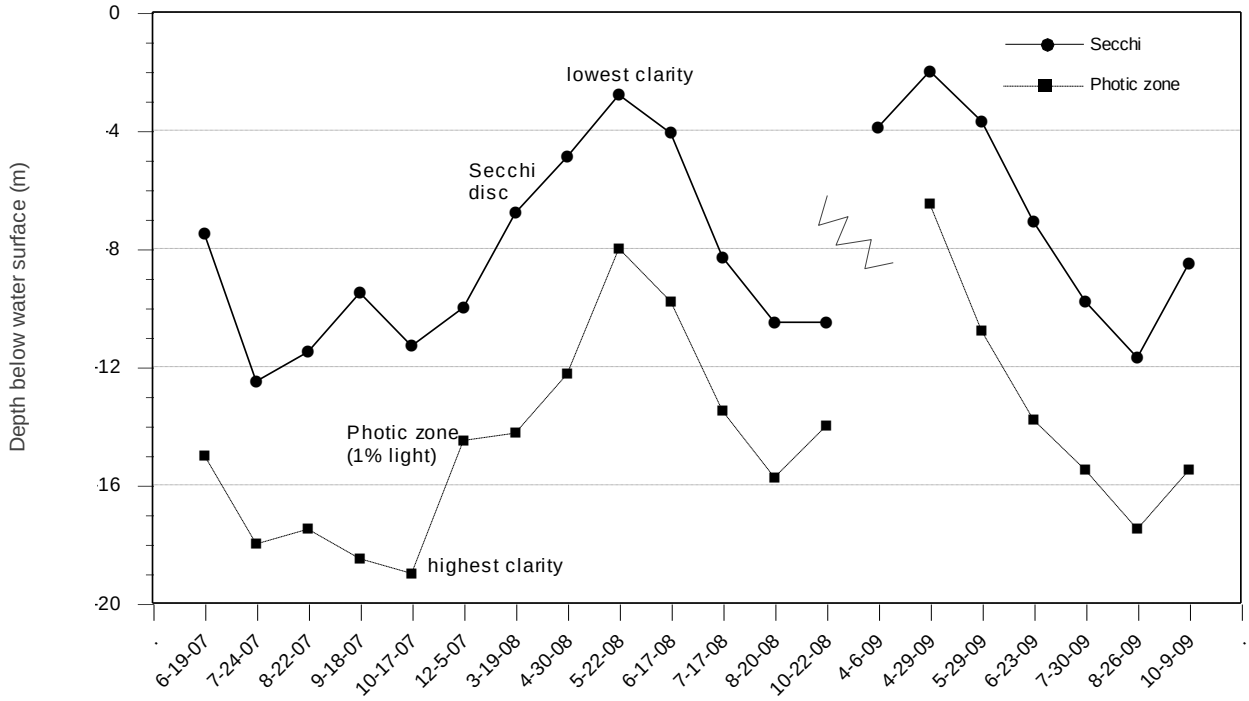

Figure 27. Secchi disc transparency (with aid of view tube) and depth of 1% light photic zone at site C1 for the period June 2007 – October 2009.

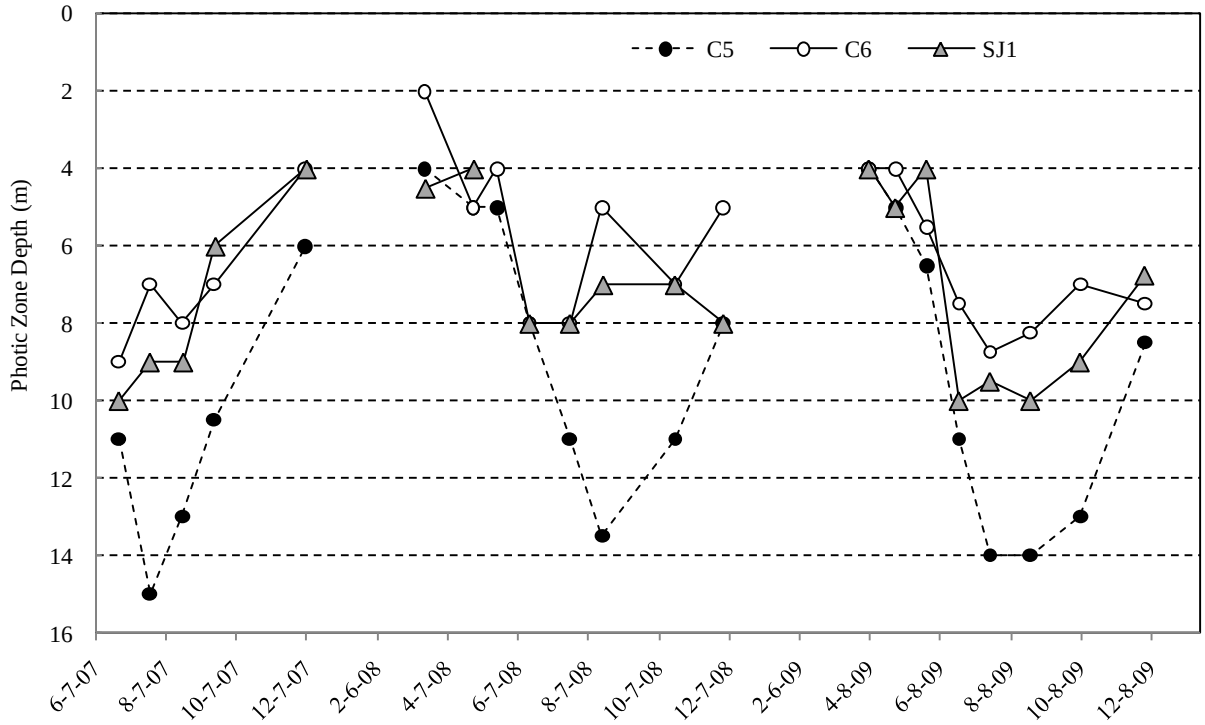

Figure 28. Photic zone depth (1% of surface PAR) at sites C5, C6 and SJ1 for the period June 2007 – December 2009.

3.3.6 Dissolved Oxygen

3.3.6.1 IDEQ Dissolved Oxygen

Dissolved oxygen (DO) profiles at northern pool stations, during early summer through late fall stratification, show a hypolimnetic condition of consumed oxygen primarily through bacterial decomposition of organic material. During stratification there is minimal atmospheric DO replenishment of lower waters until fall turnover. The 2009 LMP has established a lower DO target for the summer – fall hypolimnion of northern waters at 6.0 mg/L DO (IDEQ and Cd'A Tribe, 2009).

Figure 29a shows the C1 profile on July 30, 2009. At 35 m depth, DO = 8.3 mg/L and %DO saturation = 72%. At 40.0 m depth (1 m off the bottom), DO = 7.4 mg/L and %DOsat = 65%. A measurement 20 cm off the bottom equaled 6.2 mg/L DO. Figure 29b is a C1 profile on October 9, 2009. While surface temperatures had cooled to 13.4 ºC, there remains a weak thermocline between 15 – 17 m, and based on the %DOsat profile there is incomplete oxygen mixing (fall turnover has yet occurred). Commonly, northern pool DO profiles taken from early – mid October exhibit further, small declines in DO concentration compared to mid-summer profiles. The October 9 profile shows only slightly less DO concentration at 35 m compared to July 30, and concentration remained the same at 40 m. For the IDEQ study period, minimum recorded DO at 1 m off the bottom was at C1, August 20, 2008 where DO = 6.6 mg/L and %DOsat = 57%.

Based on the northern pool profiles by USGS in CY91-92 and WY04-06, DO near the bottom in late summer and early fall do not drop below 6 mg/L. Comparing DO data between CY91-92 and WY04-06, there were no significant differences at any of the pelagic sampling sites between study periods (Wood and Beckwith, 2008).

3.3.6.2 Tribe Dissolved Oxygen

In CY09, the Tribal dissolved oxygen standard of ≥8 mg/L was violated on 43% of the seven sample dates at C5 and C6. The standard was violated 29% of the seven sample dates at the inundated lower St. Joe River site (SJ1). On all occasions when the standard was violated, the lake (C5 and C6) and St Joe River (SJ1) were thermally stratified. Figure 30 and Figure 31 present examples of temperature and dissolved oxygen profiles from thermally stratified summer periods and isothermal fall and early winter periods at sites C5 and C6.

Similar to the northern lake sites, the southern lake sites (C5 and C6) and the inundated lower St. Joe River (SJ1) exhibit a condition of consumed oxygen in the hypolimnion, primarily through bacterial decomposition of organic material. However, compared to the northern pelagic sites, the southern sites undergo increased oxygen consumption and develop more dramatic dissolved oxygen depletion throughout the season as depicted at site C5 (Figure 30) and a complete dissolved oxygen deficit creating anoxic conditions at C6 (Figure 31). Anoxic conditions have developed in the hypolimnion of C6 for every summer for the sampling time periods CY91-92, WY04-06, CY07-08 and CY09). As described earlier in the report, anoxic conditions produce the high concentrations of phosphorus and nitrogen at C6. Site SJ1 experienced hypolimnetic anoxia in 2009 from July through August and exhibited much higher phosphorus and nitrogen

concentrations compared to the time period of higher dissolved oxygen concentrations in the water column.

In addition to increased nutrients, anoxic conditions also increase the concentration of iron, manganese and arsenic in the lower hypolimnion of C6 and SJ1. Concentrations of arsenic, iron and manganese were 9X, 47X and 57X greater in the anoxic hypolimnion compared to the photic zone (Figure 32). Under conditions of adequate oxygen and high redox potential, arsenic is adsorbed to iron oxyhydroxides (Toevs *et al*. 2008, De Vitre *et al*. 1991). Under anoxic, low redox potential conditions, adsorbed arsenic is released during the dissolution of iron oxyhydroxides. Iron and arsenic are no longer complexed and enter the water column in dissolved form. During the August 2009 sampling, the concentration of arsenic in samples taken from the oxygenated hypolimnion at sites C1, C4 and C5 ranged from 0.35 - 0.44 µg/L, nearly an order of magnitude lower than at C6 and SJ1.

The same dynamics presented above occurred in the summer and fall of 2007. The duration of anoxia in the hypolimnion at C6 and SJ1 was longer in 2007 than in 2009 and higher concentrations of inorganic phosphorus and nitrogen and arsenic were liberated for the sediments. In 2008 the dissolved oxygen concentration in the hypolimnion at SJ1 was higher, and hypolimnetic anoxia did not develop. As a result of adequate oxygen concentrations at SJ1, phosphorus, nitrogen, iron and arsenic concentrations remained low, relative to the high concentrations in the anoxic hypolimnion at C6.

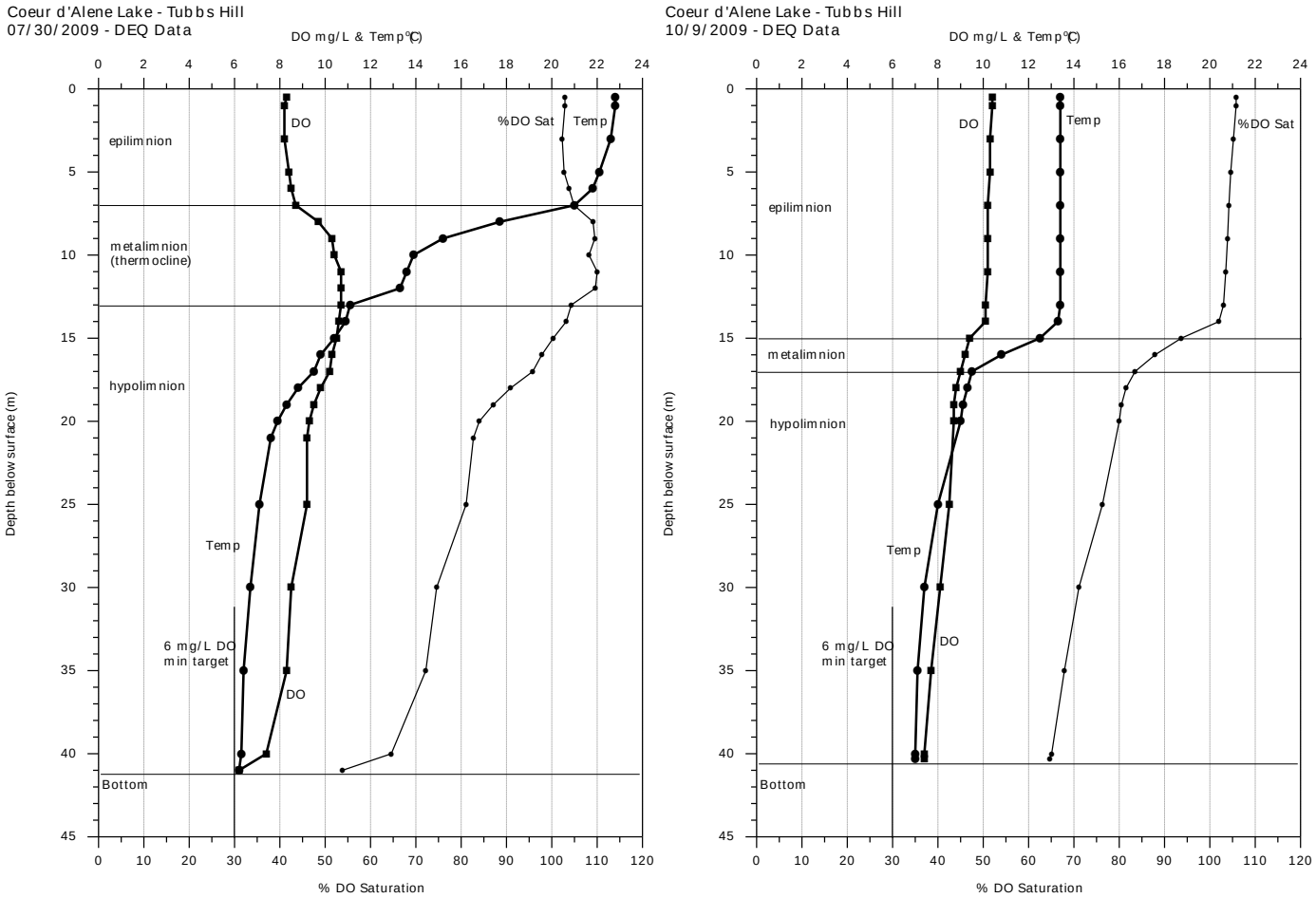

Figure 29. (a) dissolved oxygen and water temperature profiles at Tubbs Hill sampling station (C1) on July 30, 2009, and (b) October 9, 2009.

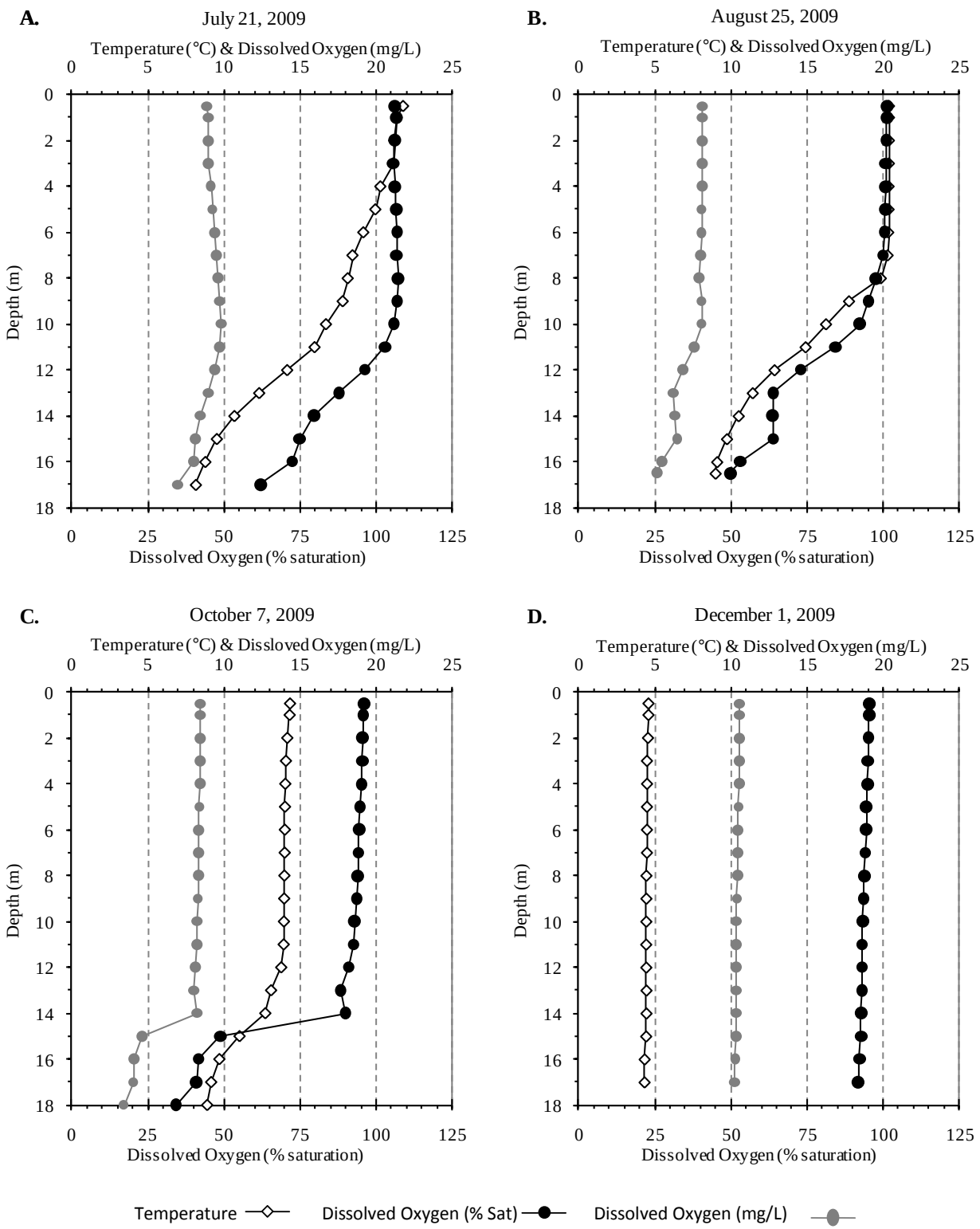

Figure 30. Temperature and dissolved oxygen profiles from Site C5 (southern pelagic site south of Harrison), 2009.

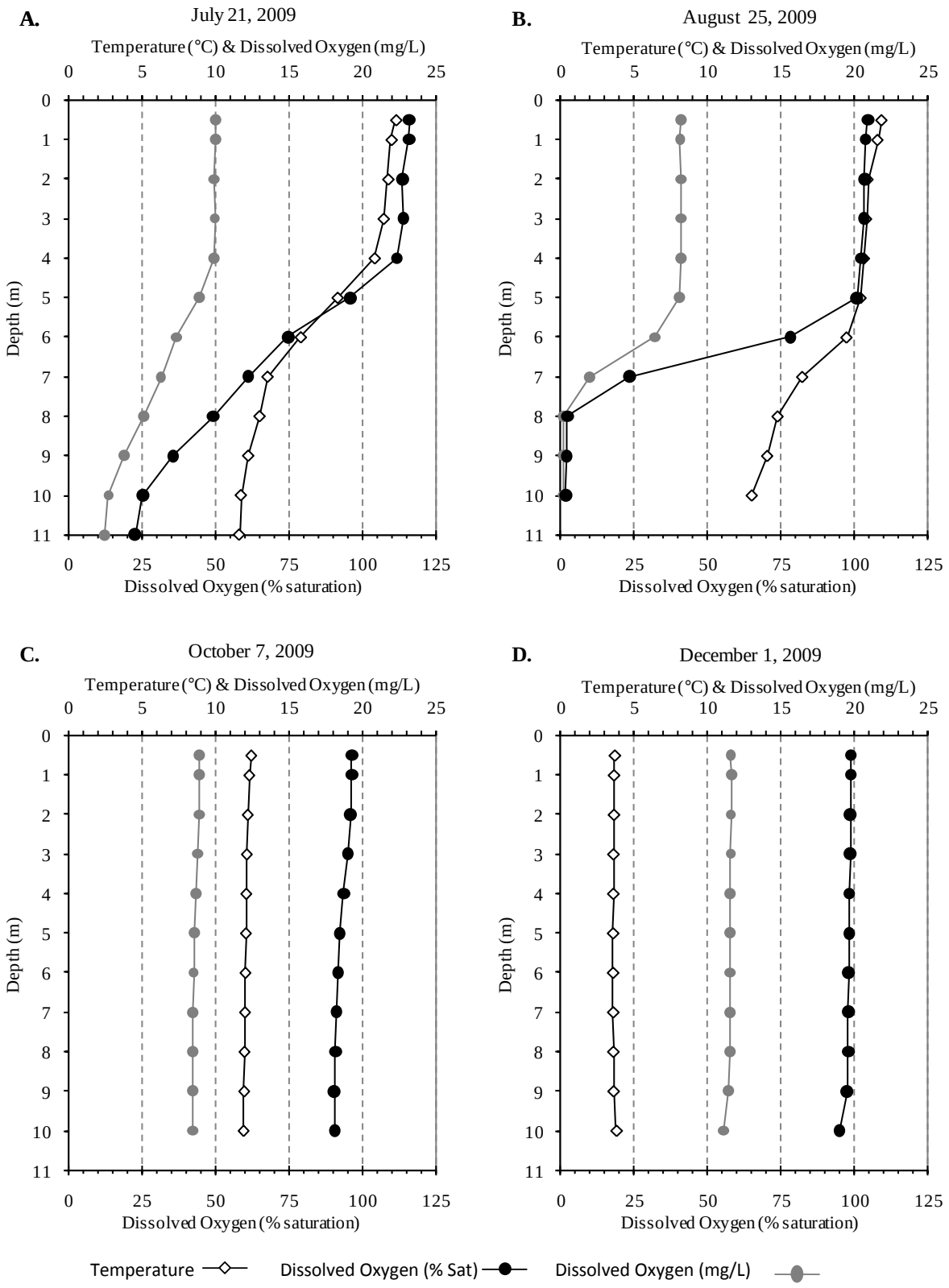

Figure 31. Temperature and dissolved oxygen profiles from Site C6 (Chatcolet Lake), 2009.

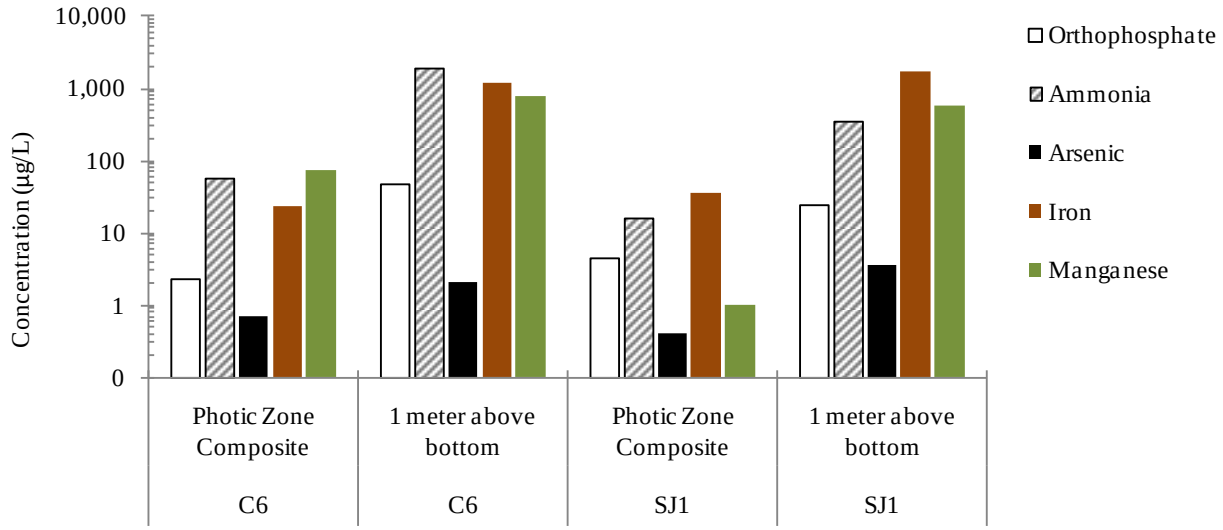

Figure 32. Dissolved forms of phosphorus and nitrogen, transition metals (iron and manganese) and arsenic sampled from the photic zone and one-meter above lake-bottom at site C6 and SJ1 on August 25, 2009. Samples were collected following a period of thermal stratification and anoxia. All constituents were 0.45 µm filtered (Y-axis scale is a log base 10).

3.4 Nutrient Loading into Coeur d'Alene Lake

Lake studies commonly include measurements, estimations, and modeling of phosphorus and nitrogen inflows and outflows to a lake (a nutrient budget). Estimates of annual phosphorus and nitrogen loading are important for nutrient management efforts, where isolated load sources can be identified and cost-effectiveness plans can be made for nutrient-reduction efforts if so warranted. This is one stated goal of the 2009 LMP.

General categories of nutrient sources pertinent to Coeur d'Alene Lake include: 1) input from the two major rivers, Coeur d'Alene and St. Joe, 2) input from streams discharging directly into the lake, 3) point discharges from wastewater treatment plants which mainly are discharges into the rivers and streams, 4) atmospheric deposition, both precipitation and dryfall, 5) groundwater seepage influenced by septic system drainfields around the lake, and 6) stormwater runoff, either from outflow drains or dispersed among properties around the perimeter of the lake.

A great deal of seasonal and annual nutrient loading is related to precipitation patterns and river flows. Nutrient load is a product of water discharge and concentration, thus in general, the higher the flow the higher the loading. Also, high flows with rapid velocity have a scouring and erosive affect, increasing particulate nutrient loading.

3.4.1 USGS Nutrient Load Estimates

For the studies of calendar years 1991 and 1992, USGS preformed a rather comprehensive evaluation of hydrologic budgets, nutrient budgets, and nutrient load/lake response modeling (Woods and Beckwith, 1997). There was considerable monitoring on the lower reaches of the

Coeur d'Alene and St. Joe Rivers, as well as stream flow measurements and water quality sampling on several smaller tributaries to the lake. Samples were also obtained from wastewater treatment plant discharges. Other items of information and computations were gathered for load estimates from atmospheric sources, septic drainfields, and watershed runoff from ungaged streams. USGS also formulated phosphorus and nitrogen annual load estimates for water years 2004 – 2006 (Wood and Beckwith, 2008). While there were considerable field measurements on the lower reaches of the aforementioned two rivers in association with the BEMP program (EPA, 2004), other nutrient sources received less field effort compared to CY91-92. For these sources USGS relied on extrapolation of the CY91-92 estimates. Nutrient loads for WY04-06 were calculated using the computer program LOADEST. The CY91-92 load estimates were recalculated using LOADEST so a proper comparison could be made with the WY04-06 loads (Table 15).

Examination of Table 15 for five years of TP loading points out two factors: 1) total annual inflow TP load is very dependent on annual inflow water volume, and 2) the mouth of the St. Joe River consistently has the highest proportion of TP annual load to the lake (also see Figure 33). Examining the summary data for TN illustrates: 1) that there are years when the Coeur d'Alene River has a higher load than the St. Joe, and 2) that in WY04-06, USGS is making an estimate that TN loads declined compared to CY91-92, and the category of "Other" produces over 50% of the annual nitrogen loading.

Table 15. Summary of nutrient loading budgets and annual river flow volume for Coeur d'Alene Lake as developed by the USGS for calendar years 1991 and 1992 and Water Years 2004 – 2006 (data modified from Table 4, Wood and Beckwith, 2008)

Budget component	CY1991	CY1992	WY2004	WY2005	WY2006
River flow volume (acre-feet/yr)					
Total river inflow	4,831,851	2,383,497	2,950,996	3,283,388	4,272,459
Percent St. Joe River	56%	57%	53%	53%	52%
Percent Coeur d'Alene River	44%	43%	47%	47%	48%
Total phosphorus load (pounds/yr)					
Total inflow load	204,624	86,877	167,139	218,295	317,520
Percent St. Joe River	43%	37%	47%	46%	50%
Percent Coeur d'Alene River	36%	28%	34%	38%	38%
Percent Other	21%	35%	19%	16%	12%
Total nitrogen load (pounds/yr)					
Total inflow load	4,652,550	2,101,365	899,640	879,795	1,027,530
Percent St. Joe River	47%	36%	15%	12%	18%
Percent Cd'A River	39%	42%	29%	27%	19%
Percent other	14%	22%	56%	61%	63%

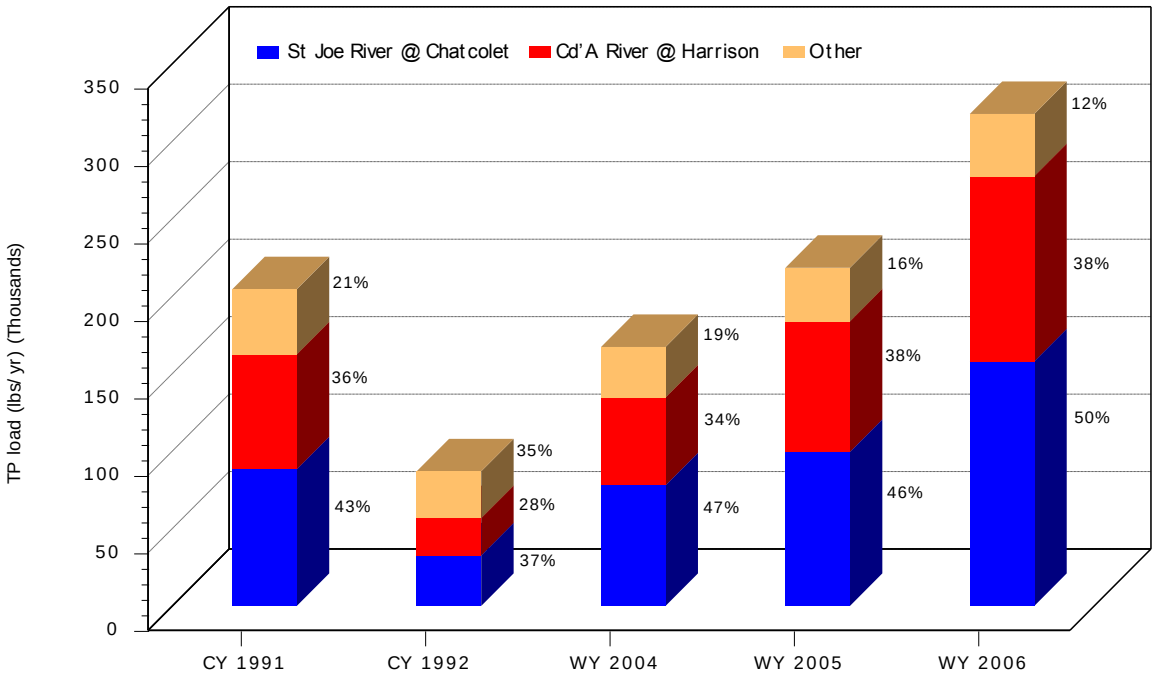

Figure 33. Annual total phosphorus loading (pounds/year) into Coeur d'Alene Lake from the St. Joe River, Coeur d'Alene River, and Other Sources as estimated by USGS for CY91-92 and WY04-06 (Wood and Beckwith, 2008).

3.4.2 Tribe and IDEQ Nutrient Load Estimates

Total phosphorus and total nitrogen loads were calculated for the Spokane, Coeur d'Alene, and St. Joe Rivers using USGS BEMP data and the USGS model, LOADEST (Runkel et al., 2004). LOADEST uses historical discharge and concentration data to develop a regression model. This model is then applied to a time series of stream flow measurements to calculate constituent load. Because the calibration input contains censored data, load estimation was defined under the AMLE method incorporated into LOADEST. Load regression statistics are shown in (Table 16).

The Coeur d'Alene River was analyzed for total phosphorus and total nitrogen load at 5 USGS stations. One station is on the North Fork Coeur d'Alene River at Enaville and one station is at the mouth of the river at Harrison. Three stations are located on the South Fork Coeur d'Alene River at (from upstream to downstream) Elizabeth Park, Smelterville, and Pinehurst. Smelterville discharge data are limited to days when BEMP data were collected. To overcome this limitation, we calculated the correlation between instantaneous discharge at Smelterville and that at Elizabeth Park ($y = 1.0497x + 13.208$; $r^2 = 0.9963$). This calculation was then applied to the time series discharge measurements at Elizabeth Park to derive streamflow at Smelterville. In addition to these stations, contributions from the Page and Smelterville Wastewater Treatment Plants (WWTP) were calculated. Total phosphorus and total nitrogen loads for the Page and Smelterville WWTPs are monthly loads based on discharge monthly reports provided by the treatment plants. Total phosphorus and total nitrogen are once-monthly samples from the WWTP effluent discharge stream. These concentrations are multiplied by the average monthly effluent flow rate to calculate the monthly and total annual loads.

Table 16. LOADEST regression model statistics.

	Calibra-tion points (# of concen-trations)	Days with mean daily flow	Mean load (tons/ day)	95% Confidence Interval		Std. Error prediction	Std. Error	R^2 (%)	Selected model
Total Phosphorus									
Elizabeth Park	32	2192	0.019	0.013	0.027	0.004	0.003	93.30	6
Smelterville	38	2192	0.031	0.023	0.042	0.005	0.005	85.71	6
Pinehurst	64	2192	0.073	0.052	0.099	0.012	0.012	79.80	9
Enaville	50	2192	0.1	0.08	0.13	0.01	0.01	96.62	5
Harrison	54	2040	0.21	0.16	0.28	0.03	0.03	96.39	9
Total Nitrogen									
Elizabeth Park	43	2192	0.18	0.16	0.21	0.01	0.01	94.43	8
Smelterville	43	2192	0.17	0.14	0.2	0.01	0.01	90.93	6
Pinehurst	45	2192	0.35	0.23	0.51	0.07	0.07	64.18	8
Enaville	31	2192	0.49	0.4	0.6	0.05	0.05	96.52	9
Harrison	40	2040	1.03	0.88	1.19	0.08	0.08	96.28	6

TP load calculations for WY09 are represented in a schematic diagram showing the direction of flow from the North and South Forks through Harrison (Figure 34). In the South Fork, 8,790 lbs of TP was added to the stream load between Elizabeth Park and Smelterville. This contrasts to the loss of total nitrogen (34,190 lbs) on this stretch of the river (Table 18). From Smelterville to Pinehurst, the river gained 67,180 lbs of TP and 257,470 lbs of TN. 15% of the increase in TP and 24% of the increase in TN may be accounted for by the effluent from the Page and Smelterville WWTPs. Also, Pine Creek discharges into the South Fork just prior to the Pinehurst sampling site.

For WY09, the South Fork contributed more TP and TN loading to the main stem of the Cd'A River (after the confluence) than the North Fork. This was the only water year of LOADSET calculations from WY04 – WY09 where this was the case (Tables 17 and 18). The North Fork generally has lower concentrations of TP and TN than the South Fork, but on the average since 1991, the North Fork contributes 78% of the water flow at the confluence of the two rivers. This accounts for the normally larger TP and TN load from the North Fork. After adding the Enaville and Pinehurst loads at the confluence, this combined main-stem load accounted for 68% of the TP and 82% of the TN of the calculated load at Harrison.

TP load estimates by IDEQ and the Tribe at the Cd'A River at Harrison compare well to previously published USGS results for WY05 and WY06, however TN load calculations were much higher in this report than USGS estimates (Table 17 and Table 18) (Wood and Beckwith, 2008). This may be due to calibration points collected after WY06 changing the best-fit load regression model. We plan on discussing the causes for these differences with the USGS. TP and TN load estimations vary widely over the time period analyzed in this report (WY04 – WY09). The TP load at Harrison was highest during WY08 and lowest during WY04. WY06 had the highest TN load and WY09 the lowest. In both the TP and TN load estimates, the

nutrient loads at the confluence of the north and south forks (Pinehurst + Enaville) are less than the calculated nutrient loads at Harrison except again, for WY09. This seems to illustrate additional nutrient loading sources along the 33 river miles between the confluence and Harrison.

WY2009 nutrient load calculations for the two rivers flowing into the lake (Coeur d'Alene and St. Joe Rivers) and the Spokane River, which flows out of the lake, give insight into the nutrient budget of Coeur d'Alene Lake (Table 19). Not considering other sources of nutrients such as atmospheric deposition, tributaries, and groundwater, 52% of the total phosphorus entering the lake came from the Coeur d'Alene River, and 48% of the TP came from the St. Joe River (not usually the case, see Figure 33). The much lower amount of TP leaving the lake via the Spokane River shows that Coeur d'Alene Lake is acting as a large total phosphorus sink. The budget for total nitrogen showed that more nitrogen entered from the St. Joe River than the Coeur d'Alene River and a vast majority of this nitrogen is leaving through the Spokane River.

Table 17. IDEQ and Tribe estimates of annual total phosphorus loading into Coeur d'Alene Lake for Water Years 2004 – 2009 from various sampling sites along the Coeur d'Alene River using USGS BEMP data with LOADEST modeling.

Water Year	USGS S. Fork Elizabeth Park 12413210	USGS S. Fork Smelter-ville 12413355	Page+ Smelter-ville WWTP	USGS S. Fork Pinehurst 12413470	USGs N. Fork Enaville 12413000	Add Pinehurst + Enaville	USGS Cd'A River Harrison 12413860
WY2004- TP lbs/yr	4,920	12,140	10,345	20,580	26,410	46,990	ND
USGS estimate	--	--	--	--	--	--	56,660
% of Pinehurst	24%	59%	50%	--	--	--	--
% of Harrison	9%	21%	18%	36%	47%	83%	--
WY2005- TP lbs/yr	5,590	13,110	11,370	23,720	32,200	55,920	70,240
USGS estimate	--	--	--	--	--	--	84,215
% of Pinehurst	24%	55%	48%	--	--	--	--
% of Harrison	3%	19%	16%	34%	46%	80%	--
WY2006- TP lbs/yr	13,350	22,980	13,030	39,550	62,890	114,970	119,630
USGS estimate	--	--	--	--	--	--	119,490
% of Pinehurst	34%	58%	33%	--	--	--	--
% of Harrison	11%	19%	11%	33%	53%	96%	--
WY2007- TP lbs/yr	10,870	19,040	13,900	43,780	66,000	109,780	131,290
% of Pinehurst	25%	43%	32%	--	--	--	--
% of Harrison	8%	15%	11%	33%	50%	84%	--
WY2008- TP lbs/yr	35,480	49,770	13,975	102,920	210,890	313,810	311,480
% of Pinehurst	25%	48%	14%	--	--	--	--
% of Harrison	11%	16%	4%	33%	68%	101%	--
WY2009- TP lbs/yr	11,780	20,570	13,025	87,750	42,330	130,080	191,730
% of Pinehurst	13%	23%	15%	--	--	--	--
% of Harrison	6%	11%	7%	46%	22%	68%	--

Table 18. IDEQ and Tribe estimates of annual total nitrogen loading into Coeur d'Alene Lake for Water Years 2004 – 2009 from various sampling sites along the Coeur d'Alene River using USGS BEMP data with LOADEST modeling.

Water Year	USGS S. Fork Elizabeth Park 12413210	USGS S. Fork Smelter-ville 12413355	Page+ Smelter-ville WWTP	USGS S. Fork Pinehurst 12413470	USGs N. Fork Enaville 12413000	Add Pinehurst + Enaville	USGS Cd'A River Harrison 12413860
WY2004- TN lbs/yr	70,840	80,820	ND	104,430	157,520	261,950	ND
USGS estimate	--	--	--	--	--	--	257,940
% of Pinehurst	68%	77%	ND	--	--	--	--
% of Harrison	27%	31%	ND	48%	61%	102%	--
WY2005- TN lbs/yr	90,300	99,510	ND	149,840	292,870	442,710	666,350
USGS estimate	--	--	--	--	--	--	235,890
% of Pinehurst	60%	66%	ND	--	--	--	--
% of Harrison	14%	15%	ND	22%	44%	66%	--
WY2006- TN lbs/yr	142,680	141,040	92,195	240,370	436,200	676,570	860,770
USGS estimate	--	--	--	--	--	--	193,790
% of Pinehurst	59%	59%	38%	--	--	--	--
% of Harrison	17%	17%	11%	28%	51%	79%	--
WY2007- TN lbs/yr	138,860	126,170	98,245	276,650	422,470	699,120	826,840
% of Pinehurst	50%	46%	36%	--	--	--	--
% of Harrison	17%	15%	12%	33%	51%	85%	--
WY2008- TN lbs/yr	204,520	171,850	98,155	403,710	683,960	1,087,670	855,520
% of Pinehurst	51%	43%	24%	--	--	--	--
% of Harrison	24%	20%	11%	47%	80%	127%	--
WY2009- TN lbs/yr	147,750	113,560	89,595	371,030	173,680	544,710	663,090
% of Pinehurst	40%	31%	24%	--	--	--	--
% of Harrison	22%	17%	14%	56%	26%	82%	--

Table 19. Total phosphorus and total nitrogen load budgets for Coeur d'Alene Lake (WY2009) using USGS BEMP data with LOADEST modeling.

	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)
Coeur d'Alene River at Harrison	191,730	663,090
St. Joe River at Chatcolet	174,710	755,790
Spokane River at Outlet	85,720	1,407,070
(input-output)	280,720	11,810

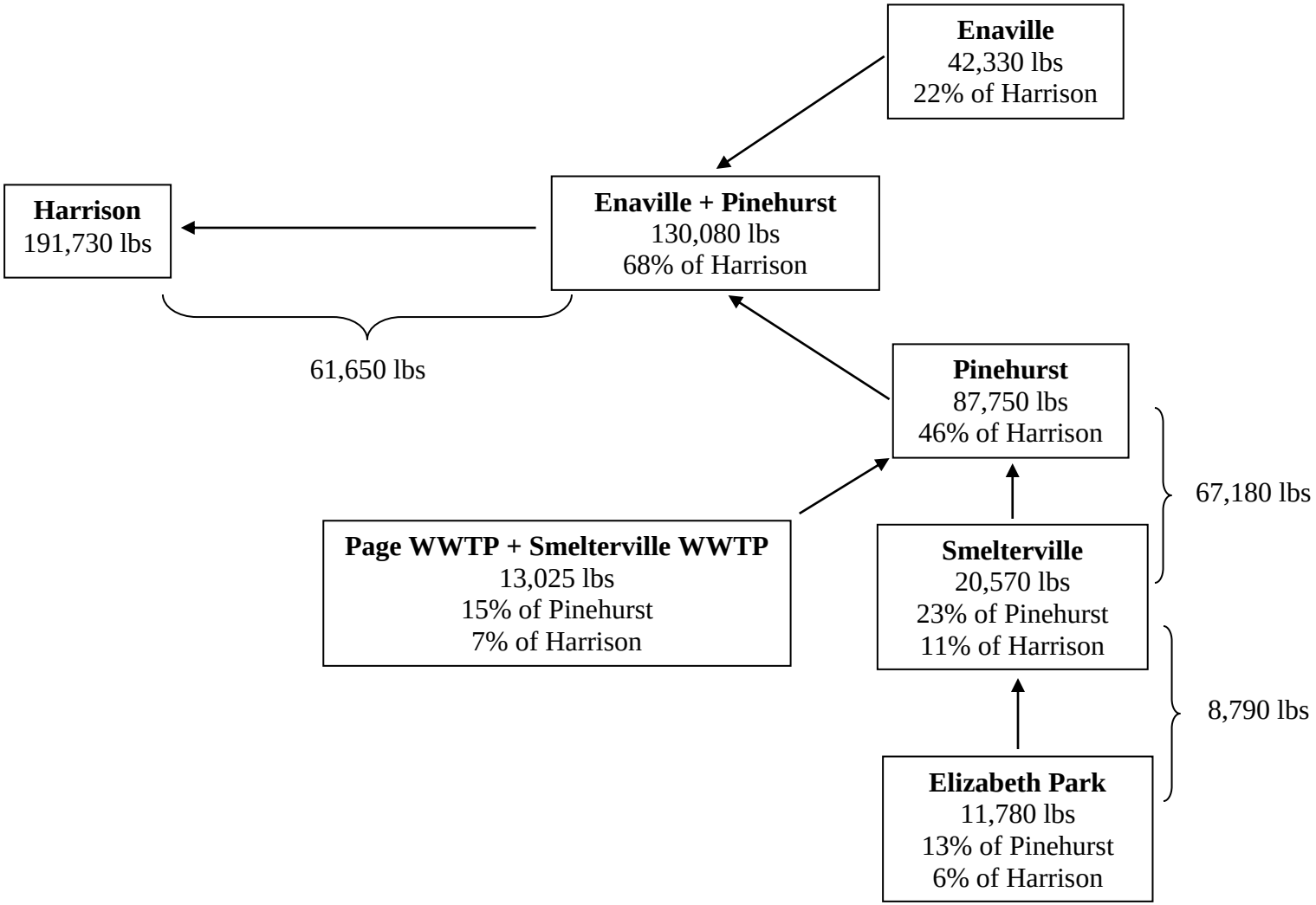

Figure 34. Total phosphorus load during WY09 for the Coeur d'Alene River

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Appendices A1 – A10

Water Quality Data Collected in the 2009 Coeur d'Alene Lake Monitoring Program - IDEQ and Tribe Sampling Sites

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Table A1. 2009 Water Quality Data for Site C1 – SE of Tubbs Hill

Date	Time	Depth to bottom at sampling station (meters)	Temper-ature air (deg C)	Surface light intensity 400 – 700 nm (µmol/s/m^2)	Depth to 1% of surface light (meters)	Secchi disc trans-parency w/view-tube (meters)
Apr 6	10:00	40.3	14.3	--	--	3.9
Apr 29	10:15	41.3	8.3	726	6.5	2.0
May 29	10:00	41.3	16.5	1753	10.8	3.7
June 23	10:15	41.1	16.4	1669	13.8	7.1
July 30	10:30	41.2	20.6	1640	15.5	9.8
Aug 26	9:30	--	--	1098	17.5	11.7
Oct 9	13:15	40.6	14.6	1404	15.5	8.5

April 6: Light meter - data logger broken; no light data

Aug 26: Hydrolab broken; no profile data

Table A1 – 2009 Site C1, continued

Date	Time	Sampling depth meters[a]	Total Hardness mg/L as $CaCO_3$	Calcium fltrd mg/L	Magnesium fltrd mg/L	Iron unfltrd recoverable µg/L	Iron fltrd µg/L	Manganese unfltrd recoverable µg/L	Manganese fltrd µg/L	Zinc unfltrd recoverable µg/L	Zinc fltrd µg/L	Lead unfltrd recoverable µg/L	Lead fltrd µg/L
Apr													
6	11:30	1-10.0	22.0	5.8	1.9	71	10	4.3	0.6	65.1	61.4	1.60	0.24
6	12:45	20.0	22.5	5.9	1.9	68	14	4.0	0.7	67.5	62.7	1.50	0.33
6	13:30	30.0	22.2	5.9	1.9	68	10	4.0	0.3	66.3	63.0	1.50	0.21
6	14:15	39.0	22.2	5.9	1.9	70	10	4.1	0.2	65.7	61.9	1.60	0.20
Apr													
29	11:15	1-6.5	21.1	5.6	1.8	194	19	11.6	1.1	63.8	56.8	4.10	0.50
29	12:00	20.0	21.8	5.6	1.8	171	25	9.9	1.3	64.5	57.9	3.50	0.64
29	13:00	30.0	21.6	5.7	1.8	141	17	8.1	0.6	64.4	58.5	2.90	0.42
29	13:30	40.0	22.4	5.7	1.8	132	24	7.2	1.1	68.3	59.8	2.60	0.59
May													
29	10:45	1-10.8	19.3	5.2	1.6	79	18	6.3	1.8	52.0	41.6	3.10	0.64
29	11:40	20.0	20.6	5.4	1.7	70	19	2.9	0.7	60.5	52.8	2.00	0.61
29	12:15	30.0	21.1	5.6	1.8	76	16	2.5	0.3	64.8	59.7	1.80	0.34
29	13:00	40.0	21.2	5.5	1.7	91	12	3.3	0.6	69.5	61.0	1.90	0.41
June													
23	11:00	1-13.8	17.8	4.8	1.4	42	7	6.9	0.9	40.3	35.2	1.40	0.19
23	11:45	16.5	18.9	5.1	1.6	43	6	4.3	0.2	49.4	46.8	1.50	0.14
23	12:45	30.0	20.1	5.5	1.7	55	11	15.3	3.9	59.1	54.9	1.40	0.21
23	13:15	40.0	21.1	5.5	1.7	90	10	22.2	6.4	71.0	64.2	1.70	0.19
July													
30	11:15	1-15.5	18.9	5.2	1.5	20	7	2.6	1.0	42.7	44.0	1.40	<0.10
30	13:45	19.0	20.5	5.2	1.7	23	7	2.2	0.6	59.0	58.6	0.77	0.24
30	14:45	30.0	20.9	5.4	1.8	39	8	5.7	0.3	63.5	64.5	0.90	0.12
30	15:30	40.0	20.7	5.5	1.7	46	9	14.6	4.9	68.1	66.5	0.93	0.19
Aug													
26	10:20	1-17.5	q 12.7	5.4	1.6	10	<5	2.2	0.5	40.1	43.2	0.30	<0.10
26	12:15	20.0	20.4	5.3	1.7	18	<5	1.6	0.3	57.4	59.2	0.42	<0.10
26	12:45	30.0	20.5	5.7	1.8	22	7	3.3	0.3	60.0	67.3	0.48	<0.10
26	13:20	40.0	21.5	5.6	1.8	42	8	LE	LE	77.4	78.8	0.63	<0.10
Oct													
9	14:00	1-15.5	20.0	5.6	1.6	e 15	<5	3.0	0.7	42.9	43.4	0.52	0.11
9	14:45	20.0	20.2	5.6	1.7	e 15	<5	4.7	0.4	58.0	60.0	0.48	<0.10
9	15:15	30.0	q 13.5	5.7	1.7	24	<5	11.0	0.4	63.8	63.6	0.46	<0.10
9	15:45	39.5	q 14.0	5.8	1.8	29	6	q 46.9	q 8.0	67.1	64.1	0.49	<0.10

Table A1 – 2009 Site C1, continued

Date	Sampling depth meters	Cadmium unfltrd recoverable µg/L	Cadmium fltrd µg/L	Arsenic unfltrd recoverable µg/L	Arsenic fltrd µg/L	Chlorophyll *a* phytoplankton fluoro µg/L	Total Phosphorus unfltrd µg/L	Phosphorus total fltrd µg/L	Orthophosphate fltrd µg/L	Total nitrogen unfltrd µg/L	Ammonia fltrd as N µg/L	Nitrite + Nitrate fltrd as N µg/L
Apr												
6	1-10.0	0.23	0.21	0.86	0.38	6.83	9	<5	<3	200	<30	65
6	20.0	0.21	0.20	<0.63	0.41	--	7	<5	--	158	<30	59
6	30.0	0.21	0.20	<0.63	0.42	--	12	<5	--	137	<30	53
6	39.0	0.20	0.21	<0.63	0.36	--	6	<5	--	140	51	54
Apr												
29	1-6.5	0.29	0.26	<0.63	0.37	8.42	16	5	<3	185	<30	49
29	20.0	0.28	0.25	<0.63	0.36	--	11	5	--	165	<30	48
29	30.0	0.25	0.23	<0.63	0.34	--	12	<5	--	140	<30	49
29	40.0	0.23	0.23	<0.63	0.38	--	10	<5	--	140	<30	50
May												
29	1-10.8	0.26	0.24	<0.63	0.35	3.17	8	<5	--	86	<30	34
29	20.0	0.25	0.22	<0.63	0.33	--	6	<5	--	135	43	41
29	30.0	0.24	0.24	<0.63	0.34	--	6	<5	--	168	43	61
29	40.0	0.26	q 0.37	<0.63	0.45	--	7	<5	--	186	60	111
June												
23	1-13.8	0.20	0.21	<0.63	0.36	1.67	<5	<5	<3	140	<30	<15
23	16.5	0.24	0.21	<0.63	0.32	5.03	5	<5	--	73	<30	<15
23	30.0	0.24	0.21	<0.63	0.37	--	<5	<5	--	--	39	39
23	40.0	0.29	0.27	<0.63	0.36	--	5	<5	--	281	78	66
July												
30	1-15.5	0.22	0.24	<0.63	0.36	1.01	5	<5	<3	65	<30	<15
30	19.0	0.22	0.24	<0.63	0.32	1.98	6	<5	--	111	<30	46
30	30.0	0.23	0.22	<0.63	0.32	--	7	<5	--	141	<30	100
30	40.0	0.27	0.25	<0.63	0.35	--	7	<5	--	150	<30	101
Aug												
26	1-17.5	0.18	0.18	<0.63	0.39	1.08	<5	<5	<3	126	<30	29
26	20.0	0.23	0.22	<0.63	0.31	--	5	<5	--	--	<30	58
26	30.0	0.24	0.23	<0.63	0.33	--	<5	<5	--	--	<30	96
26	40.0	0.37	0.30	<0.63	0.35	--	5	5	--	211	<30	138
Oct												
9	1-15.5	0.19	0.18	<0.63	0.44	1.12	5	<5	--	73	<30	<15
9	20.0	0.23	0.22	<0.63	0.31	--	<5	<5	--	110	<30	50
9	30.0	0.21	0.21	<0.63	0.34	--	6	5	--	155	35	113
9	39.5	0.20	0.16	<0.63	0.34	--	5	<5	--	176	<30	110

a = First row of each sampling date is a photic zone composite sample – five equally spaced samples from 1 meter to 1% of surface light.
e = total phosphorus estimated between the <2 µg/L MDL and <5 µg/L MRL
q = questionable data result
f = flagged data results for October 9, 39.5 m depth, for total and dissolved manganese. Concentrations appear unreasonably high compared to other data. Eliminated from data set.

Table A2. 2009 Water Column Profiles at Site C1 - SE of Tubbs Hill

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)	Turbid-ity (NTU)
April									
6	10:34	0.5	3.1	12.3	100.7	8.4	50	0.040	0.8
6	10:35	1.0	3.0	12.4	100.7	7.6	50	0.037	0.8
6	10:36	3.0	2.8	12.4	100.7	7.3	50	0.068	1.2
6	10:37	5.0	2.8	12.3	100.1	7.2	51	0.144	1.0
6	10:38	7.0	2.8	12.3	99.8	7.4	50	0.136	1.1
6	10:39	9.0	2.9	12.2	99.4	7.3	50	0.162	1.0
6	10:40	11.0	2.9	12.2	99.1	7.2	51	0.175	1.0
6	10:42	13.0	2.9	12.2	98.7	7.2	51	0.167	1.0
6	10:43	15.0	2.8	12.1	98.5	7.3	51	0.161	1.0
6	10:44	17.0	2.9	12.1	98.2	7.5	51	0.175	1.0
6	10:46	20.0	2.9	12.1	97.9	7.6	51	0.147	1.2
6	10:47	25.0	2.8	12.0	97.5	7.6	51	0.154	1.5
6	10:49	30.0	2.9	11.9	96.9	7.5	51	0.154	1.4
6	10:50	35.0	2.8	11.9	96.4	7.3	51	0.148	1.4
6	10:52	40.0	2.9	11.8	95.9	7.3	50	0.149	1.8
April									
29	10:44	0.5	6.5	11.8	102.2	7.8	50	0.067	0.3
29	10:44	1.0	6.5	11.8	102.6	7.8	51	0.069	4.2
29	10:45	3.0	6.5	11.8	101.9	7.8	50	0.145	4.7
29	10:48	5.0	6.5	11.7	101.4	7.9	50	0.157	4.2
29	10:49	7.0	6.5	11.7	100.9	7.9	50	0.150	4.3
29	10:51	9.0	6.4	11.6	100.3	7.9	49	0.151	4.5
29	10:53	10.5	6.3	11.6	99.8	7.8	50	0.150	4.4
29	10:54	13.0	6.2	11.6	99.4	7.8	52	0.145	4.2
29	10:55	15.5	6.1	11.5	99.0	7.8	50	0.142	4.3
29	10:56	17.0	6.1	11.5	98.8	7.8	50	0.151	4.2
29	10:58	19.5	6.0	11.5	98.4	7.8	50	0.151	4.2
29	11:01	25.0	5.8	11.5	97.6	7.7	51	0.153	4.0
29	11:02	30.0	5.4	11.5	96.6	7.7	51	0.170	3.8
29	11:03	35.0	5.2	11.4	95.8	7.6	51	0.159	3.9
29	11:05	39.5	5.1	11.3	94.7	7.6	51	0.162	3.5
29	11:07	40.5	5.1	11.3	94.0	7.5	51	0.208	--

Table A2 – 2009 Site C1, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)	Turbid-ity (NTU
May									
29	9:33	0.5	15.0	10.7	114.1	8.2	47	0.018	0.3
29	9:34	1.0	14.5	10.7	113.1	8.2	47	0.021	0.5
29	9:35	3.0	14.1	10.8	113.0	8.1	47	0.039	0.9
29	9:36	5.0	13.9	10.8	112.2	8.0	46	0.054	1.1
29	9:37	7.0	13.4	10.7	110.8	8.0	45	0.067	1.4
29	9:38	9.0	12.4	10.7	108.1	8.0	45	0.080	1.3
29	9:39	10.0	12.1	10.7	106.8	7.9	46	0.073	1.2
29	9:40	11.0	9.7	10.9	103.1	7.7	48	0.072	1.1
29	9:41	13.0	8.5	10.8	99.6	7.6	50	0.072	0.9
29	9:42	15.0	8.4	10.8	99.0	7.6	49	0.067	0.6
29	9:43	17.0	8.1	10.8	98.3	7.5	50	0.064	0.8
29	9:44	20.0	7.6	10.8	97.0	7.4	51	0.067	0.8
29	9:45	25.0	6.9	10.7	94.4	7.3	52	0.053	0.7
29	9:47	30.0	6.6	10.5	92.2	7.2	52	0.050	0.9
29	9:48	35.0	6.3	10.3	89.3	7.2	52	0.039	1.0
29	9:49	40.0	6.2	9.9	86.1	7.1	53	0.041	1.3
29	9:51	41.0	6.1	9.8	85.1	7.0	53	0.049	1.3
June									
23	9:39	0.5	17.5	9.3	104.4	8.1	50	0.019	0.3
23	9:40	1.0	17.3	9.4	104.6	8.2	41	0.021	0.4
23	9:41	3.0	17.2	9.4	104.1	8.1	42	0.031	0.3
23	9:42	5.0	17.2	9.3	103.6	8.2	42	0.036	0.3
23	9:43	7.0	17.1	9.3	102.8	8.2	42	0.040	0.6
23	9:44	9.0	17.1	9.2	102.3	8.2	42	0.041	0.4
23	9:45	11.0	17.0	9.2	101.8	8.1	42	0.043	0.3
23	9:46	12.0	16.9	9.2	101.8	8.1	42	0.039	0.4
23	9:47	13.0	16.9	9.2	101.5	8.1	42	0.039	0.5
23	9:49	14.0	16.8	9.2	101.4	8.1	42	0.040	0.6
23	9:50	15.0	13.0	10.2	103.6	7.9	44	0.118	0.9
23	9:51	16.0	12.3	10.4	104.3	7.9	44	0.120	1.0
23	9:52	17.0	9.9	10.4	98.9	7.6	47	0.162	0.8
23	9:54	18.0	9.1	10.3	95.3	7.5	47	0.089	0.6
23	9:55	19.0	8.9	10.1	93.8	7.5	47	0.072	0.5
23	9:56	20.0	8.6	10.1	92.9	7.4	48	0.066	0.5
23	9:57	25.0	7.3	10.1	89.6	7.4	50	0.077	0.6
23	9:58	30.0	6.6	9.5	82.6	7.3	52	0.058	0.9
23	10:00	35.0	6.3	9.7	83.9	7.2	52	0.041	0.4
23	10:01	40.0	6.2	9.3	80.0	7.2	52	0.039	0.7
23	10:03	40.5	6.1	8.7	75.5	7.1	53	0.044	1.4

Table A2 – 2009 Site C1, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)	Turbid-ity (NTU
July									
30	9:33	0.5	22.8	8.3	102.9	8.0	44	0.008	0.0
30	9:34	1.0	22.8	8.2	102.9	8.0	46	0.010	0.0
30	9:35	3.0	22.6	8.2	102.3	8.0	44	0.011	0.0
30	9:36	5.0	22.1	8.4	102.7	8.0	47	0.015	0.0
30	9:39	6.0	21.8	8.5	103.8	8.0	44	0.017	0.0
30	9:37	7.0	21.0	8.7	104.9	8.0	44	0.019	0.0
30	9:38	8.0	17.7	9.7	109.1	8.0	44	0.025	0.0
30	9:40	9.0	15.2	10.3	109.5	7.8	43	0.036	0.0
30	9:41	10.0	13.9	10.4	108.2	7.7	43	0.044	0.0
30	9:43	11.0	13.6	10.7	110.0	7.7	44	0.051	0.0
30	9:44	12.1	13.3	10.7	109.6	7.6	44	0.052	0.0
30	9:46	13.0	11.1	10.7	104.3	7.5	45	0.082	0.0
30	9:46	14.0	10.9	10.6	103.2	7.4	45	0.084	0.0
30	9:47	15.0	10.4	10.5	100.3	7.3	46	0.092	0.0
30	9:48	16.0	9.8	10.3	97.8	7.3	46	0.114	0.0
30	9:49	17.0	9.5	10.2	95.8	7.2	46	0.118	0.0
30	9:50	18.0	8.8	9.8	90.9	7.1	47	0.154	0.0
30	10:06	18.50	8.5	9.7	88.7	7.1	48	0.181	0.0
30	10:07	18.75	8.4	9.7	88.6	7.1	47	0.188	0.0
30	10:08	19.00	8.4	9.7	88.3	7.1	48	0.203	0.0
30	10:09	19.25	8.4	9.5	87.1	7.1	48	0.188	0.0
30	10:10	19.50	8.2	9.4	85.8	7.1	47	0.192	0.0
30	10:11	19.75	8.0	9.3	84.7	7.0	48	0.141	0.0
30	10:12	20.00	7.9	9.3	83.9	7.0	49	0.112	0.0
30	9:52	20.0	7.9	9.3	84.0	6.9	49	0.100	0.0
30	9:53	21.0	7.6	9.2	82.7	6.9	49	0.064	0.0
30	9:54	25.0	7.1	9.2	81.1	6.8	49	0.031	0.0
30	9:56	30.0	6.7	8.5	74.6	6.6	51	0.030	0.0
30	9:58	35.0	6.4	8.3	72.2	6.6	51	0.031	0.0
30	10:00	40.0	6.3	7.4	64.6	6.5	52	0.042	0.0
30	10:01	41.0	6.2	6.2	53.8	6.5	54	0.071	0.0

Table A2 – 2009 Site C1, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)	Turbid-ity (NTU
August									
26									

Hydrolab broken - no profile data

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)	Turbid-ity (NTU
October									
9	12:44	0.5	13.4	10.4	105.8	7.6	48	0.035	0.5
9	12:45	1.0	13.4	10.4	105.8	7.6	48	0.035	0.4
9	12:46	3.0	13.4	10.3	105.2	7.5	47	0.036	0.7
9	12:46	5.0	13.4	10.3	104.6	7.5	47	0.039	0.5
9	12:47	7.0	13.4	10.2	104.2	7.5	47	0.043	0.2
9	12:48	9.0	13.4	10.2	103.9	7.5	47	0.046	0.4
9	12:49	11.0	13.4	10.2	103.5	7.5	47	0.045	0.4
9	12:51	13.0	13.4	10.1	103.0	7.5	47	0.047	0.4
9	12:52	14.0	13.3	10.1	102.0	7.4	47	0.050	0.2
9	12:53	15.0	12.5	9.4	93.7	7.2	47	0.047	0.5
9	12:54	16.0	10.8	9.2	87.9	7.1	48	0.045	0.5
9	12:55	17.0	9.5	9.0	83.5	7.0	48	0.042	0.5
9	12:56	18.5	9.3	8.8	81.5	6.9	48	0.042	0.2
9	12:57	19.0	9.1	8.7	80.5	6.9	48	0.041	0.1
9	12:58	20.0	9.0	8.7	80.0	6.9	48	0.042	0.4
9	12:59	25.0	8.0	8.5	76.3	6.9	49	0.039	0.3
9	13:01	30.0	7.4	8.1	71.1	6.8	50	0.036	0.2
9	13:02	35.0	7.1	7.7	67.9	6.8	50	0.035	0.5
9	13:03	40.1	7.0	7.4	65.1	6.7	51	0.034	0.9
9	13:06	40.3	7.0	7.4	64.7	6.7	51	0.034	1.0

Table A3. 2009 Water Quality Data for Site C4 – NE of University Point

Date	Time	Depth to bottom at sampling station (meters)	Temper-ature air (deg C)	Surface light intensity 400 – 700 nm (µmol/s/m^2)	Depth to 1% of surface light (meters)	Secchi disc trans-parency w/view-tube (meters)
Apr 7	10:30	38.5	14.5	--	--	2.4
Apr 28	11:00	39.5	10.8	521	6.0	1.8
May 28	10:45	39.7	18.4	1770	9.0	3.4
June 22	10:30	39.5	14.9	467	10.0	4.9
July 29	10:30	39.1	21.1	1622	15.5	10.7
Aug 25	13:15	--	--	1835	17.0	12.1
Oct 8	10:45	39.4	12.8	1196	16.0	8.9

Apr 7: Light meter - data logger broken; no light data

Aug 25: Hydrolab broken; no profile data

Table A3 – 2009 Site C4, continued

Date	Time	Sampling depth meters[a]	Total Hardness mg/L as $CaCO_3$	Calcium fltrd mg/L	Magnesium fltrd mg/L	Iron unfltrd recoverable µg/L	Iron fltrd µg/L	Manganese unfltrd recoverable µg/L	Manganese fltrd µg/L	Zinc unfltrd recoverable µg/L	Zinc fltrd µg/L	Lead unfltrd recoverable µg/L	Lead fltrd µg/L
Apr													
7	11:00	1-5.8	23.2	6.0	2.0	278	27	17.2	2.9	88.1	77.0	5.70	0.62
7	12:45	20.0	23.2	6.2	2.0	284	f190	18.5	f 12.0	86.3	86.0	5.90	f4.00
7	13:30	30.0	23.1	6.0	2.0	296	24	19.2	3.4	85.2	77.6	6.10	0.64
7	14:00	37.5	22.7	5.9	1.9	370	24	32.1	q 16.1	92.4	83.2	7.97	0.75
Apr													
28	12:45	1-6.5	20.8	5.4	1.8	287	22	19.3	6.7	71.1	63.2	12.30	1.20
28	13:15	20.0	21.0	5.5	1.8	284	22	18.1	5.0	71.7	65.8	11.20	1.20
28	14:15	30.0	21.3	5.6	1.8	290	20	17.6	4.3	72.8	66.7	10.80	0.94
28	14:45	38.0	21.8	5.7	1.8	263	21	14.9	2.2	74.3	68.6	7.85	0.72
May													
28	11:45	1-9.0	17.9	4.8	1.4	121	25	12.5	5.8	48.8	42.5	5.40	1.00
28	12:30	10.0	--	--	--	--	--	--	--	--	--	--	--
28	13:00	20.0	20.3	5.4	1.7	113	14	6.0	0.7	62.2	53.8	3.40	0.48
28	13:30	30.0	20.6	5.4	1.7	108	18	5.2	0.7	65.3	58.0	3.20	0.50
28	14:00	38.5	21.8	5.6	1.8	134	16	5.5	0.7	74.9	64.6	3.30	0.40
June													
22	12:00	1-10.0	17.6	4.9	1.4	72	16	9.8	1.9	39.7	36.7	1.80	0.17
22	14:00	20.0	19.9	5.5	1.7	56	13	3.6	0.4	54.0	54.5	1.70	0.39
22	14:40	30.0	20.4	5.5	1.7	68	13	3.3	0.3	60.8	59.0	1.80	0.34
22	15:15	38.0	21.1	5.7	1.8	87	13	8.0	0.9	71.5	70.1	1.80	0.26
July													
29	11:30	1-15.5	19.6	5.4	1.5	22	<5	5.3	1.3	43.2	42.3	1.20	<0.10
29	12:30	15.5	19.8	5.3	1.6	34	9	7.0	1.1	58.6	57.1	1.80	0.27
29	14:15	30.0	20.7	5.5	1.7	43	8	4.0	0.3	62.7	64.4	1.10	0.15
29	14:45	38.0	21.3	5.5	1.7	57	9	6.7	0.4	73.5	70.6	1.30	0.19
Aug													
25	13:30	1-17.0	20.7	5.7	1.7	11	<5	3.2	0.7	43.6	43.5	0.55	<0.10
25	14:15	20.0	19.9	5.5	1.7	21	<5	4.1	0.4	59.1	63.6	0.93	0.10
25	14:45	30.0	20.9	5.4	1.7	25	9	3.4	0.4	63.1	64.9	0.85	0.15
25	15:15	38.5	21.1	5.6	1.8	34	8	q 20.6	q 4.3	73.5	76.3	0.87	0.10
Oct													
8	13:00	1-16.0	20.9	6.0	1.7	17	<5	4.0	0.6	42.1	43.3	0.62	<0.10
8	13:45	20.0	20.3	5.7	1.7	22	<5	10.0	0.4	59.2	58.4	1.20	<0.10
8	14:15	30.0	20.3	5.6	1.7	23	6	8.6	1.7	62.9	65.7	0.91	0.23
8	15:15	38.3	20.5	5.6	1.7	23	6	8.1	0.4	63.9	66.3	0.76	<0.10

Table A3 – 2009 Site C4, continued

Date	Sampling depth meters	Cadmium unfltrd recoverable µg/L	Cadmium fltrd µg/L	Arsenic unfltrd recoverable µg/L	Arsenic fltrd µg/L	Chlorophyll *a* phytoplankton fluoro µg/L	Total Phosphorus unfltrd µg/L	Phosphorus total fltrd µg/L	Orthophosphate fltrd µg/L	Total nitrogen unfltrd µg/L	Ammonia fltrd as N µg/L	Nitrite + Nitrate fltrd as N µg/L
Apr												
7	1-5.8	0.38	0.32	<0.63	0.29	5.33	13	5	<3	260	<30	161
7	20.0	0.37	0.34	<0.63	f <0.63	--	16	9	--	256	<30	167
7	30.0	0.37	0.32	<0.63	0.32	--	16	7	--	267	<30	165
7	37.5	0.46	0.41	<0.63	0.31	--	15	<5	--	243	<30	157
Apr												
28	1-6.5	0.34	0.31	<0.63	0.38	3.51	19	5	<3	238	<30	108
28	20.0	0.36	0.33	<0.63	0.40	--	25	5	--	187	<30	104
28	30.0	0.33	0.31	<0.63	0.37	--	17	<5	--	189	<30	103
28	38.0	0.33	0.30	<0.63	0.34	--	13	<5	--	224	<30	124
May												
28	1-9.0	0.26	0.27	<0.63	0.32	3.14	9	<5	--	f 84	f 93	f 101
28	10.0	--	--	--	--	4.89	--	--	--	--	--	--
28	20.0	0.26	0.26	<0.63	0.36	--	8	<5	--	153	39	79
28	30.0	0.27	0.26	<0.63	0.34	--	8	<5	--	196	54	94
28	38.5	0.30	0.27	<0.63	0.33	--	13	<5	--	173	73	112
June												
22	1-10.0	0.20	0.19	<0.63	0.32	3.90	9	<5	<3	95	<30	<15
22	20.0	0.24	0.26	<0.63	0.35	--	11	<5	--	--	<30	49
22	30.0	0.26	0.25	<0.63	0.34	--	10	<5	--	--	41	68
22	38.0	0.27	0.27	<0.63	0.33	--	10	<5	--	269	55	82
July												
29	1-15.5	0.21	0.21	<0.63	0.40	1.00	8	6	<3	81	<30	15
29	15.5	0.24	0.23	<0.63	0.36	2.33	7	5	<3	124	<30	31
29	30.0	0.25	0.25	<0.63	0.32	--	5	<5	--	--	<30	98
29	38.0	0.29	0.26	<0.63	0.32	--	6	<5	--	168	<30	125
Aug												
25	1-17.0	0.23	0.21	<0.63	0.46	1.34	<5	<5	<3	113	<30	<15
25	20.0	0.22	0.24	<0.63	0.36	--	<5	<5	--	--	<30	53
25	30.0	0.25	0.25	<0.63	0.33	--	<5	<5	--	--	<30	91
25	38.5	0.32	0.30	<0.63	0.36	--	<5	<5	--	119	<30	133
Oct												
8	1-16.0	0.18	0.18	<0.63	0.55	1.33	5	<5	<3	96	<30	<15
8	20.0	0.21	0.20	<0.63	0.52	--	7	5	--	115	32	41
8	30.0	0.25	0.24	<0.63	0.37	--	5	<5	--	199	<30	101
8	38.3	0.24	0.24	<0.63	0.38	--	5	<5	<3	177	<30	106

a = first row of each sampling date is a photic zone composite sample – five equally spaced samples from 1 meter to 1% of surface light.
e = total phosphorus estimated between the <2 µg/L MDL and <5 µg/L MRL
q = questionable data result
f = flagged data results for April 7, 20 m depth for filtered iron, manganese, and lead were eliminated from data set. EPA Manchester Lab reported substantial fine colloidal sediment within filtered sample. Filtered samples were acid digested giving high bias.
flagged data results for May 28, 1-9.0 m for total nitrogen, ammonia, and nitrite+nitrate were eliminated from data set. Combined concentration of DIN is 194 µm/L, twice the concentration of TN, a result that is not possible.

Table A4. 2009 Water Column Profiles at Site C4

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)	Turbid-ity (NTU)
April									
7	10:53	0.5	3.3	11.9	95.9	7.6	52	0.058	10.0
7	10:55	1.0	3.3	11.9	96.0	7.5	53	0.062	9.8
7	10:57	3.0	3.2	11.9	95.5	7.4	53	0.108	5.2
7	10:58	5.0	3.2	11.8	94.9	7.6	54	0.092	3.4
7	10:59	7.0	3.2	11.7	94.5	7.7	54	0.098	3.1
7	11:00	9.0	3.2	11.7	94.1	7.5	55	0.099	3.5
7	11:01	11.0	3.2	11.7	93.9	7.4	54	0.093	3.8
7	11:02	13.0	3.2	11.6	93.7	7.5	54	0.090	3.8
7	11:03	15.0	3.1	11.6	93.4	7.3	54	0.100	3.5
7	11:04	17.0	3.1	11.6	93.2	7.2	53	0.091	3.8
7	11:05	20.0	3.1	11.6	93.0	7.2	54	0.091	3.8
7	11:07	25.0	3.1	11.5	92.3	7.0	54	0.091	3.8
7	11:08	30.0	3.2	11.4	91.9	7.0	54	0.089	3.6
7	11:09	35.0	3.2	11.3	91.0	7.0	54	0.079	4.3
7	11:12	38.0	3.3	10.9	87.9	6.9	54	0.055	6.7
April									
28	11:32	0.5	5.9	11.3	98.1	7.6	48	0.038	6.9
28	11:34	1.0	5.9	11.3	97.8	7.4	48	0.060	6.8
28	11:35	3.0	5.9	11.3	97.4	7.3	48	0.068	6.5
28	11:35	5.0	5.9	11.3	97.4	7.3	48	0.070	6.7
28	11:36	7.0	5.9	11.2	97.0	7.3	49	0.075	7.2
28	11:37	9.0	5.9	11.2	96.6	7.3	48	0.071	7.2
28	11:39	11.0	5.8	11.1	96.1	7.3	48	0.068	7.1
28	11:40	13.0	5.8	11.1	95.9	7.3	47	0.069	7.1
28	11:41	15.0	5.7	11.1	95.3	7.3	49	0.068	6.8
28	11:42	17.0	5.6	11.1	95.1	7.3	49	0.070	7.1
28	11:44	20.0	5.5	11.1	94.8	7.2	49	0.069	7.1
28	11:46	25.0	5.4	11.0	93.9	7.3	50	0.070	6.7
28	11:47	30.0	5.2	10.9	93.1	7.2	50	0.071	6.5
28	11:48	35.0	5.0	10.9	92.0	7.1	51	0.073	6.1
28	11:52	39.2	4.5	10.9	91.1	7.1	52	0.080	5.3

Table A4 - 2009 Site C4, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)	Turbid-ity (NTU)
May									
28	10:20	0.5	11.6	10.9	107.9	7.8	41	0.017	1.7
28	10:21	1.0	11.3	10.9	107.7	7.7	42	0.020	1.7
28	10:22	3.0	11.0	10.9	106.5	7.6	41	0.039	1.8
28	10:23	5.0	10.7	10.9	105.9	7.5	43	0.047	1.9
28	10:24	7.0	10.2	10.9	104.5	7.6	42	0.062	2.1
28	10:26	8.0	9.6	11.1	105.1	7.7	44	0.095	2.0
28	10:25	9.0	9.3	11.2	104.8	7.6	45	0.104	1.6
28	10:27	10.0	9.1	11.2	104.5	7.7	46	0.111	2.0
28	10:28	11.0	8.7	11.1	103.1	7.6	46	0.111	1.9
28	10:29	13.0	8.2	11.0	100.2	7.6	47	0.098	1.4
28	10:30	15.0	7.8	10.9	98.5	7.5	48	0.090	1.8
28	10:31	17.0	7.6	10.9	97.8	7.4	49	0.066	1.6
28	10:32	20.0	7.4	10.8	96.9	7.4	49	0.064	1.7
28	10:33	25.0	7.1	10.8	96.0	7.3	49	0.073	1.4
28	10:34	30.0	6.8	10.7	94.8	7.2	51	0.075	1.5
28	10:36	35.0	6.1	10.5	91.0	7.1	52	0.053	1.3
28	10:38	39.0	5.8	9.8	84.5	7.0	53	0.073	1.8
June									
22	10:32	0.5	14.7	9.9	105.1	8.0	41	0.027	0.0
22	10:32	1.0	14.6	9.9	105.2	7.9	40	0.031	0.0
22	10:33	3.0	14.6	9.8	104.9	7.9	42	0.042	0.0
22	10:34	5.0	13.5	10.0	104.3	7.8	41	0.071	0.0
22	10:37	6.0	12.0	10.5	105.4	7.7	41	0.116	0.3
22	10:38	7.0	11.4	10.5	104.2	7.6	42	0.102	0.1
22	10:39	8.0	10.9	10.4	102.0	7.6	42	0.114	0.1
22	10:39	9.0	10.0	10.2	98.2	7.6	43	0.098	0.2
22	10:40	10.0	9.5	10.2	97.0	7.4	43	0.078	0.0
22	10:41	11.0	9.3	10.1	95.7	7.4	44	0.069	0.0
22	10:43	13.0	8.7	10.1	93.9	7.3	45	0.046	0.0
22	10:43	15.0	8.0	10.1	92.7	7.3	46	0.036	0.0
22	10:44	17.0	7.6	10.2	92.7	7.3	47	0.033	0.0
22	10:45	20.0	7.3	10.3	92.4	7.3	48	0.041	0.0
22	10:46	25.0	7.0	10.3	91.8	7.2	49	0.048	0.0
22	10:47	30.0	6.6	10.2	90.0	7.1	50	0.041	0.0
22	10:49	35.0	6.1	9.2	80.1	7.0	52	0.042	0.2
22	10:51	38.0	6.1	9.0	78.4	6.9	52	0.047	0.6
22	10:52	39.3	6.1	9.0	78.0	6.9	52	0.048	0.5

Table A4 – 2009 Site C4, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)	Turbid-ity (NTU)
July									
29	9:42	0.5	22.2	8.3	103.5	8.1	45	0.010	0.0
29	9:43	1.0	22.2	8.4	103.6	8.0	47	0.010	0.0
29	9:45	3.0	22.2	8.4	103.6	8.0	47	0.012	0.0
29	9:46	5.0	22.1	8.3	103.1	8.0	44	0.014	0.0
29	9:47	7.0	22.1	8.3	103.0	8.0	46	0.014	0.0
29	9:48	9.0	21.4	8.5	104.2	8.0	46	0.021	0.0
29	9:49	10.0	17.7	9.4	106.7	7.9	44	0.028	0.0
29	9:51	11.0	15.1	9.3	99.8	7.5	43	0.031	0.0
29	9:52	12.0	12.5	9.5	96.5	7.3	43	0.038	0.0
29	9:53	13.0	11.0	9.4	91.6	7.2	44	0.048	0.0
29	9:55	14.0	10.3	8.9	85.2	7.0	45	0.066	0.0
29	9:56	15.0	9.9	8.9	85.2	7.0	45	0.100	0.0
29	9:59	16.0	9.1	8.7	81.6	6.9	46	0.097	0.0
29	10:02	17.0	8.5	8.8	81.4	6.8	46	0.079	0.0
29	10:03	18.0	8.1	8.6	78.7	6.8	47	0.055	0.0
29	10:05	19.0	8.0	8.7	79.0	6.8	47	0.051	0.0
29	10:05	20.0	7.8	8.8	79.2	6.8	47	0.048	0.0
29	10:07	25.0	7.0	9.4	83.4	6.8	49	0.027	0.0
29	10:09	30.0	6.7	9.3	81.9	6.7	50	0.024	0.0
29	10:10	35.0	6.5	8.9	78.1	6.6	50	0.024	0.0
29	10:12	38.4	6.3	8.4	73.6	6.7	51	0.026	0.0

Table A4 – 2009 Site C4, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)	Turbid-ity (NTU)
August									
25									
Hydrolab broken - no profile data									
October									
8	11:00	0.5	14.1	9.1	95.0	7.5	47	0.036	0.0
8	11:03	1.0	14.2	9.0	94.8	7.5	49	0.038	6.1
8	11:07	3.0	14.1	9.0	94.3	7.5	49	0.038	0.0
8	11:08	5.0	14.1	9.0	94.0	7.4	50	0.046	0.0
8	11:10	7.0	14.1	8.9	93.6	7.4	49	0.050	0.0
8	11:11	9.0	14.1	8.9	93.1	7.4	49	0.051	0.0
8	11:12	11.0	14.0	8.9	92.8	7.4	48	0.055	0.0
8	11:13	13.0	14.0	8.9	92.6	7.4	49	0.060	0.0
8	11:13	15.0	14.0	8.8	92.1	7.4	48	0.052	0.0
8	11:14	17.0	14.0	8.8	91.5	7.4	49	0.056	0.0
8	11:17	18.0	13.8	8.6	89.4	7.2	48	0.053	0.1
8	11:18	19.0	11.9	7.3	72.7	6.9	48	0.050	0.2
8	11:20	20.0	10.6	6.9	66.4	6.8	49	0.046	0.2
8	11:21	21.0	9.0	6.7	62.4	6.7	48	0.044	0.3
8	11:22	22.0	8.8	6.7	62.2	6.7	48	0.041	0.3
8	11:24	25.0	8.1	7.3	66.0	6.7	48	0.041	0.0
8	11:25	30.0	7.3	7.2	64.4	6.7	50	0.036	0.2
8	11:28	35.0	7.2	7.2	64.1	6.6	50	0.035	0.2
8	11:32	39.1	7.2	7.1	63.6	6.6	50	0.035	0.6

Table A5. 2009 Water Quality Data for Site C5- southern pelagic zone S. of Harrison

Date	Time	Depth to bottom at sampling station (meters)	Temper-ature air (deg C)	Surface light intensity 400 – 700 nm (µmol/s/m^2)	Depth to 1% of surface light (meters)	Secchi disc trans-parency wo/tube (meters)
April 7	12:20	17.1	15.6	1606.4	4.0	1.0
April 30	12:00	19.2	--	--	5.0[a]	2.5
May 27	12:15	19.0	--	1352.2	6.5	3.25
June 24	13:30	18.1	21.1	1883.0	11.0	--
July 21	14:45	18.1	29.4	1736.4	14.0	6.5
Aug 25	10:30	17.9	--	1251.5	14.0	8.25
Oct 7	14:30	18.8	12.7	1208.4	13.0	7.0
Dec 2	13:25	17.7	-1.1	694.2	8.5	3.6

Date	Time	Samp-ling depth meters[b]	Total Hard-ness mg/L as $CaCO^3$	Calcium fltrd mg/L	Mag-nesium fltrd mg/L	Iron unfltrd recov-erable µg/L	Iron fltrd µg/L	Man-ganese unfltrd recov-erable µg/L	Man-ganese fltrd µg/L	Zinc unfltrd recov-erable µg/L	Zinc fltrd µg/L	Lead unfltrd recov-erable µg/L	Lead fltrd µg/L
April 7	12:40	1–4.0	20.2	5.40	1.50	683	230	20.90	15.00	11.0	8.1	1.20	0.37
7	13:30	15.0	20.4	5.40	1.50	811	200	20.90	14.00	11.0	7.4	1.20	0.29
April 30	10:00	1–5.0	17.5	4.80	1.27	266	25	9.83	4.20	13.0	12.0	1.30	0.16
30	11:00	18.0	22.2	5.72	1.87	274	36	12.80	1.30	73.7	68.2	6.33	0.95
May 27	11:30	1–6.5	16.3	4.60	1.11	120	30	7.38	4.20	<5.0	<5.0	0.25	<0.10
27	13:00	17.75	21.1	5.50	1.72	138	27	9.06	2.40	65.4	57.6	3.10	0.58
June 24	12:00	1–11.0	18.0	5.17	1.37	93	20	9.31	0.87	26.7	25.5	1.00	0.13
24	12:30	6.0	17.7	4.96	1.41	68	11	8.03	0.36	35.0	33.3	1.30	0.13
24	13:00	16.5	19.8	5.39	1.60	90	14	19.50	2.00	52.6	50.2	1.70	0.15
July 21	15:00	1-14.0	20.0	5.36	1.48	41	9.3	6.44	0.49	38.3	34.6	1.30	<0.10
21	15:25	15.0	19.0	5.26	1.53	47	12	8.29	1.30	49.5	50.2	1.10	0.16
21	16:00	17.0	20.3	5.26	1.59	104	10	12.50	1.00	61.3	56.9	1.40	0.11
Aug 25	10:30	1-14.0	21.5	5.91	1.69	26	9.3	11.00	5.60	36.3	36.9	0.71	0.12
25	11:05	9.0	20.7	5.58	1.61	23	5.2	6.35	1.90	44.3	39.2	0.77	0.11
25	11:40	16.5	20.7	5.67	1.70	79	13	60.50	42.80	72.1	75.5	2.10	0.12
Oct 7	13:55	1-13.0	25.5	7.09	1.91	59	15	10.20	2.70	30.8	28.4	0.67	0.15
7	14:30	17.0	21.0	5.84	1.70	209	34	222.00	48.30	73.9	66.0	2.30	0.27
Dec 2	12:40	1-8.5	26.2	7.74	1.88	139	35	16.80	2.80	31.3	31.3	1.00	0.18
2	13:15	16.0	26.2	7.29	2.01	158	37	17.60	3.00	29.9	27.3	1.10	0.15

a= Estimated photic zone by 2X the secchi disk measurement.

Table A5 – 2009 Site C5, continued

Date	Sampling depth meters[a]	Cadmium unfltrd recoverable µg/L	Cadmium fltrd µg/L	Arsenic unfltrd recoverable µg/L	Arsenic fltrd µg/L	Chlorophyll *a* phytoplankton fluoro µg/L	Total Phosphorus unfltrd µg/L	Phosphorus total fltrd µg/L	Orthophosphate fltrd µg/L	Total nitrogen unfltrd µg/L	Ammonia fltrd as N µg/L	Nitrate fltrd as N µg/L	Nitrite fltrd as N µg/L
April													
7	1–4.0	<0.13	<0.13	<0.63	<0.63	1.36	32	14	10	280	24	120	<10
7	15.0	<0.13	<0.13	0.71	<0.63		28	21	10	270	34	128	<10
April													
30	1–5.0	<0.13	<0.10	<0.63	0.25	1.17	16	9	7.8	130	<10	44	<10
30	18.0	0.32	0.27	<0.63	0.35		15	<5	5.9	150	12	152	<10
May													
27	1–6.5	<0.13	<0.10	<0.63	0.21	<1.00	11	<5	10	130	<10	<10	<10
27	17.75	0.24	0.24	<0.63	0.32		12	6.1	10	150	20	88	<10
June													
24	1–11.0	<0.13	0.11	<0.63	0.29	2.24	7.9	<5	10	110	<10	<10	<10
24	6.0	0.17	0.14	<0.63	0.33	2.87	10	<5	4.6	150	<10	<10	<10
24	16.5	0.23	0.18	<0.63	0.37		8.1	<5	7.7	120	<10	<10	<10
July													
21	1-14.0	0.18	0.17	<0.63	0.37	1.45	11	8	<2	170	<10	<10	<10
21	15.0	0.21	0.16	<0.63	0.30	2.87	11	5	2.7	190	11	10	<10
21	17.0	0.22	0.19	<0.63	0.35		10	5	2.9	130	<10	35	<10
Aug													
25	1-14.0	0.16	0.16	<0.63	0.51	1.99	19	8.9	4.7	120	19	11	<10
25	9.0	0.19	0.17	<0.63	0.50	2.02	19	11	5.4	120	20	<10	<10
25	16.5	0.30	0.26	<0.63	0.44		21	8.7	5.5	100	22	72	<10
Oct													
7	1-13.0	<0.13	0.10	0.80	0.68	2.57	7	<5	5	150	<10	<10	<10
7	17.0	0.31	0.21	0.91	0.58		17	6.1	10	280	20	86	<10
Dec													
2	1-8.5	<0.13	<0.10	<0.63	0.42	5.28	14	5	<2	130	<10	<10	<10
2	16.0	<0.13	<0.10	<0.63	0.40		11	<5	<2	150	<10	12	<10

b = First row of each sampling date is a photic zone composite sample – five equally spaced samples from 1 meter to 1% of surface light.

Table A6. 2009 Water Column Profiles at Site C5- southern pelagic zone S. of Harrison

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
April								
7	1208	0.5	5.2			7.9	37	0.009
7		1.0	4.6			7.9	36	0.010
7		2.0	4.5			7.9	36	0.012
7		3.0	4.3			7.9	37	0.013
7		4.0	4.3			7.7	37	0.013
7		5.0	4.2			7.6	37	0.013
7		6.0	4.2			7.6	37	0.013
7		7.0	4.2			7.7	37	0.013
7		8.0	4.2			7.8	37	0.013
7		9.0	4.3			7.8	37	0.013
7		10.0	4.3			7.8	37	0.014
7		11.0	4.3			7.8	37	0.015
7		12.0	4.2			7.8	37	0.013
7		13.0	4.3			7.8	37	0.013
7		14.0	4.3			7.8	37	0.012
7		15.0	4.2			7.9	38	0.011
7	1222	16.0	4.2			7.9	38	0.011
April								
30	10:07	0.5	6.9	11.0	99.8	7.4	40	0.008
30		1.0	6.8	11.0	99.5	7.3	40	0.008
30		2.0	6.6	11.0	99.2	7.3	40	0.012
30		3.0	6.6	11.0	99.0	7.5	40	0.017
30		4.0	6.5	11.0	98.8	7.5	40	0.016
30		5.0	6.5	11.0	98.6	7.4	41	0.016
30		6.0	6.4	11.0	98.3	7.4	41	0.016
30		7.0	6.3	11.0	98.2	7.4	41	0.017
30		8.0	6.1	11.0	97.9	7.4	44	0.025
30		9.0	6.0	11.0	97.8	7.3	47	0.026
30		10.0	5.7	11.1	97.5	7.3	50	0.028
30		11.0	5.4	11.1	97.0	7.3	51	0.032
30		12.0	5.3	11.1	96.9	7.3	52	0.033
30		13.0	5.1	11.1	96.7	7.3	53	0.014
30		14.0	5.0	11.1	96.4	7.2	53	0.032
30		15.0	5.0	11.1	96.0	7.2	53	0.032
30		16.0	5.0	11.0	95.5	7.2	53	0.029
30		17.0	4.9	11.1	95.4	7.2	54	0.032
30	10:25	18.0	4.9	11.1	95.5	7.2	54	0.031

Table A6 – 2009 Site C5, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll a sensor (volts)
May								
27	10:53	0.5	13.0	10.8	111.1	7.6	35	0.008
27		1.0	12.9	10.8	111.3	7.6	35	0.009
27		2.0	12.4	10.7	109.4	7.5	34	0.011
27		3.0	12.2	10.7	108.2	7.6	34	0.014
27		4.0	12.0	10.7	108.1	7.6	34	0.015
27		5.0	11.4	10.7	106.4	7.5	34	0.014
27		6.0	11.0	10.7	105.4	7.5	35	0.014
27		7.0	9.9	10.7	102.8	7.4	36	0.017
27		8.0	8.8	10.9	101.9	7.4	38	0.030
27		9.0	8.8	10.8	101.1	7.3	38	0.027
27		10.0	8.6	10.8	100.8	7.3	38	0.024
27		11.0	7.7	10.9	99.2	7.3	42	0.039
27		12.0	7.4	10.8	97.8	7.2	43	0.037
27		13.0	7.2	10.8	97.4	7.2	44	0.036
27		14.0	6.9	10.9	97.5	7.2	46	0.032
27		15.0	6.6	10.8	96.0	7.2	47	0.043
27		16.0	6.5	10.8	95.4	7.2	47	0.039
27		17.0	6.4	10.8	95.1	7.2	48	0.044
27		18.0	6.1	9.8	86.2	7.1	49	0.047
27	11:13	19.0	6.1	9.8	85.8	7.1	49	0.052
June								
23	11:19	0.5	16.9	9.7	107.0	7.6	34	0.007
23		1.0	15.4	9.8	104.6	7.6	34	0.007
23		2.0	14.5	9.7	102.0	7.5	34	0.009
23		3.0	12.8	9.8	98.7	7.3	33	0.012
23		4.0	11.0	9.8	95.2	7.1	34	0.017
23		5.0	10.1	9.9	94.6	7.2	36	0.018
23		6.0	9.7	9.9	93.6	7.2	37	0.022
23		7.0	8.7	9.9	91.2	7.1	39	0.019
23		8.0	8.5	9.9	91.0	7.1	39	0.017
23		9.0	8.4	9.9	90.5	7.1	39	0.018
23		10.0	8.1	9.9	89.5	7.1	40	0.016
23		11.0	7.8	9.8	88.4	7.1	40	0.017
23		12.0	7.7	9.7	87.1	7.1	41	0.017
23		13.0	7.7	9.7	87.1	7.1	41	0.015
23		14.0	7.7	9.7	87.0	7.1	41	0.017
23		15.0	7.6	9.8	87.6	7.0	41	0.016
23		16.0	7.6	9.7	86.9	7.0	41	0.015
23	11:34	17.0	7.5	9.4	84.4	7.0	41	0.027

Table A6 – 2009 Site C5, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
July								
21	14:22	0.5	21.8	8.9	106.1	8.0	46	0.007
21		1.0	21.4	9.0	106.8	8.2	46	0.007
21		2.0	21.2	9.0	106.2	8.1	46	0.008
21		3.0	21.1	9.0	105.7	8.2	46	0.009
21		4.0	20.3	9.1	106.3	8.2	46	0.013
21		5.0	20.0	9.2	106.6	8.0	46	0.014
21		6.0	19.2	9.4	106.9	8.0	45	0.015
21		7.0	18.5	9.5	106.7	8.0	43	0.016
21		8.0	18.2	9.6	107.2	8.0	43	0.017
21		9.0	17.8	9.7	107.0	8.0	43	0.017
21		10.0	16.7	9.8	105.9	7.8	42	0.020
21		11.0	16.0	9.7	102.9	7.7	41	0.021
21		12.0	14.2	9.4	96.4	7.5	41	0.022
21		13.0	12.3	9.0	87.8	7.3	41	0.023
21		14.0	10.7	8.4	79.5	7.1	42	0.025
21		15.0	9.6	8.2	74.9	7.0	43	0.026
21		16.0	8.8	8.0	72.5	7.0	45	0.026
21	14:37	17.0	8.2	7.0	62.1	6.9	46	0.019
Aug								
25	9:53	0.5	20.4	8.1	101.3	8.1	52	0.007
25		1.0	20.4	8.1	101.3	8.1	52	0.008
25		2.0	20.4	8.1	101.0	8.1	52	0.008
25		3.0	20.4	8.1	100.9	8.0	52	0.010
25		4.0	20.4	8.1	100.9	8.0	52	0.011
25		5.0	20.4	8.1	100.7	8.1	52	0.012
25		6.0	20.4	8.1	100.5	8.0	52	0.012
25		7.0	20.3	8.0	100.0	7.9	52	0.012
25		8.0	19.9	7.9	97.7	7.6	49	0.013
25		9.0	17.8	8.1	95.3	7.3	43	0.014
25		10.0	16.3	8.1	92.5	7.1	43	0.011
25		11.0	14.9	7.6	84.3	7.0	42	0.011
25		12.0	12.9	6.9	72.9	6.8	43	0.011
25		13.0	11.4	6.2	64.0	6.7	44	0.011
25		14.0	10.5	6.3	63.7	6.7	45	0.012
25		15.0	9.7	6.5	63.9	6.6	45	0.014
25		16.0	9.1	5.5	53.1	6.5	46	0.013
25		16.5	9.0	5.2	49.9	6.5	47	0.013
25		17.0	8.9	4.9	47.3	6.5	47	0.013
25	10:13	17.5	8.8	4.4	42.7	6.5	47	0.013

Table A6 – 2008 Site C5, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
Oct								
7	13:27	0.5	14.3	8.4	96.0	7.7	55	0.008
7		1.0	14.3	8.4	95.8	7.7	55	0.008
7		2.0	14.2	8.5	95.7	7.6	55	0.010
7		3.0	14.1	8.5	95.5	7.6	55	0.012
7		4.0	14.0	8.4	95.2	7.7	55	0.016
7		5.0	14.0	8.4	94.7	7.6	55	0.017
7		6.0	14.0	8.4	94.4	7.6	55	0.017
7		7.0	14.0	8.4	94.2	7.6	55	0.017
7		8.0	14.0	8.3	94.0	7.6	55	0.017
7		9.0	14.0	8.3	93.6	7.6	55	0.017
7		10.0	13.9	8.2	93.0	7.6	55	0.018
7		11.0	13.9	8.2	92.6	7.6	55	0.018
7		12.0	13.8	8.1	91.1	7.5	56	0.017
7		13.0	13.1	8.0	88.4	7.5	56	0.017
7		14.0	12.7	8.2	90.0	7.5	57	0.018
7		15.0	11.0	4.6	48.8	6.8	51	0.019
7		16.0	9.7	4.1	41.7	6.6	48	0.011
7		17.0	9.2	4.1	40.9	6.6	48	0.010
7	13:45	18.0	8.9	3.4	34.3	6.5	49	0.011
Dec								
2	12:16	0.5	4.6	10.6	95.5	7.6	58	0.013
2		1.0	4.6	10.6	95.4	7.5	57	0.012
2		2.0	4.6	10.6	95.3	7.5	58	0.016
2		3.0	4.5	10.6	95.0	7.5	58	0.035
2		4.0	4.5	10.5	94.9	7.5	58	0.032
2		5.0	4.5	10.5	94.6	7.5	58	0.034
2		6.0	4.5	10.5	94.5	7.4	58	0.081
2		7.0	4.5	10.5	94.3	7.4	58	0.035
2		8.0	4.4	10.4	93.8	7.4	58	0.033
2		9.0	4.4	10.4	93.6	7.4	58	0.030
2		10.0	4.4	10.4	93.4	7.4	58	0.032
2		11.0	4.4	10.4	93.2	7.4	58	0.032
2		12.0	4.4	10.4	93.2	7.4	58	0.031
2		13.0	4.5	10.3	93.1	7.4	58	0.026
2		14.0	4.5	10.3	92.8	7.4	58	0.033
2		15.0	4.4	10.3	92.8	7.4	58	0.029
2		16.0	4.3	10.3	92.3	7.4	58	0.032
2	12:29	17.0	4.3	10.3	92.0	7.4	58	0.034

Table A7. 2009 Water Quality Data for Site C6- Chatcolet Lake

Date	Time	Depth to bottom at sampling station (meters)	Temper-ature air (deg C)	Surface light intensity 400 – 700 nm (µmol/s/m^2)	Depth to 1% of surface light (meters)	Secchi disc trans-parency wo/tube (meters)
April 7	14:27	10.9	18.3	1625.5	4.0	0.8
April 29	13:00	12.0	10.0	--	4.0	2.5
May 26	13:30	12.0	--	1961.5	5.5	2.75
June 23	13:10	11.1	--	2147.0	7.5	3.7
July 21	12:45	11.2	--	1850.2	8.75	3.8
Aug 25	14:40	10.6	26.7	1556.7	8.25	4.0
Oct 7	12:10	11.0	10.0	1201.5	7.0	2.9
Dec 1	11:00	10.5	--	612.3	7.5	2.6

Date	Time	Samp-ling depth meters[a]	Total Hard-ness mg/L as $CaCO_3$	Calcium fltrd mg/L	Mag-nesium fltrd mg/L	Iron unfltrd recov-erable µg/L	Iron fltrd µg/L	Man-ganese unfltrd recov-erable µg/L	Man-ganese fltrd µg/L	Zinc unfltrd recov-erable µg/L	Zinc fltrd µg/L	Lead unfltrd recov-erable µg/L	Lead fltrd µg/L
April 7	14:15	1-4.0	20.4	5.38	1.51	567	85	16.5	12.80	<5.0	<5.0	0.25	<0.10
7	15:00	9.5	20.1	5.18	1.49	832	146	23.0	17.80	<5.0	<5.0	0.36	<0.10
April 29	12:30	1-4.0	16.4	4.56	1.12	296	22	11.7	6.78	<5.0	<5.0	0.15	<0.10
29	13:00	10.5	17.0	4.66	1.15	293	67	11.8	7.88	<5.0	<5.0	0.15	<0.10
May 26	13:30	1-5.5	15.8	4.66	1.08	118	21	8.3	5.74	<5.0	<5.0	<0.13	<0.10
26	14:00	10.0	15.1	4.36	1.01	174	24	14.3	10.00	<5.0	<5.0	<0.13	<0.10
June 23	12:30	1-7.5	17.3	5.17	1.18	168	33	18.2	5.00	<5.0	<5.0	<0.13	<0.10
2 3	13:10	10.0	16.6	4.88	1.13	163	23	30.8	12.90	<5.0	<5.0	<0.13	<0.10
July 21	12:45	1-8.75	20.3	5.76	1.33	127	31	15.3	0.95	<5.0	<5.0	<0.13	<0.10
21	13:00	9.5	18.9	5.50	1.28	186	24	49.7	8.14	<5.0	<5.0	<0.13	<0.10
Aug 25	14:40	1-8.25	23.1	6.78	1.58	136	23	97.7	74.50	<5.0	<5.0	<0.13	<0.10
25	15:10	9.5	23.8	7.23	1.61	1420	1190	755.0	775.00	<5.0	<5.0	<0.13	<0.10
Oct 7	12:10	1-7.0	26.7	8.01	1.83	293	86	26.2	1.90	<5.0	<5.0	<0.13	<0.10
7	12:35	9.5	26.4	8.09	1.84	302	83	28.4	2.00	<5.0	<5.0	<0.13	<0.10
Dec 1	11:00	1-7.5	27.4	7.86	1.97	188	64	15.2	9.18	<5.0	<5.0	<0.13	<0.10
1	11:20	9.25	27.6	8.18	2.00	195	58	15.1	8.63	<5.0	<5.0	<0.13	<0.10

Table A7 – 2009 Site C6, continued

Date	Sampling depth meters[a]	Cadmium unfltrd recoverable µg/L	Cadmium fltrd µg/L	Arsenic unfltrd recoverable µg/L	Arsenic fltrd µg/L	Chlorophyll *a* phytoplankton fluoro µg/L	Total Phosphorus unfltrd µg/L	Phosphorus total fltrd µg/L	Orthophosphate fltrd µg/L	Total nitrogen unfltrd µg/L	Ammonia fltrd as N µg/L	Nitrate fltrd as N µg/L	Nitrite fltrd as N µg/L
April 7	1-4.0	<0.13	<0.10	<0.63	0.21	1.05	28	12	8.6	300	23	51	<10
7	9.5	<0.13	<0.10	<0.63	<0.20		31	8	7	300	29	42	<10
April 29	1-4.0	<0.13	<0.10	<0.63	0.21	1.49	18	8.6	9.1	120	<10	22	<10
29	10.5	<0.13	<0.10	<0.63	0.24		19	11	11	110	<10	18	<10
May 26	1-5.5	<0.13	<0.10	<0.63	<0.20	<1.00	13	7.3	6.2	110	<10	<10	<10
26	10.0	<0.13	<0.10	<0.63	<0.20		15	10	7.4	140	13	28	<10
June 23	1-7.5	<0.13	<0.10	<0.63	0.26	1.64	18	7.6	7.5	100	<10	<10	<10
23	10.0	<0.13	<0.10	<0.63	0.24		19	7.8	5.7	160	12	<10	<10
July 21	1-8.75	<0.13	<0.10	<0.63	0.34	3.95	16	6	3.1	200	<10	<10	<10
21	9.5	<0.13	<0.10	<0.63	0.25		21	5	3.4	270	29	<10	<10
Aug 25	1-8.25	<0.13	<0.10	0.65	0.69	2.55	28	10	2.3	210	57	<10	<10
25	9.5	<0.13	<0.10	2	2.10		89	60	47	250	185	<10	<10
Oct 7	1-7.0	<0.13	<0.10	0.99	0.72	4.45	23	6.7	7	250	<10	<10	<10
7	9.5	<0.13	<0.10	0.9	0.73		20	6	8	230	<10	<10	<10
Dec 1	1-7.5	<0.13	<0.10	<0.63	0.35	5.68	17	5	<2	200	<10	<10	<10
1	9.25	<0.13	<0.10	<0.63	0.35		18	5	<2	270	<10	<10	<10

a = First row of each sampling date is a photic zone composite sample – five equally spaced samples from 1 meter to 1% of surface light.

Table A8. 2009 Water Column Profiles at Site C6- Chatcolet Lake

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
April								
7	14:16	0.5	7.0			7.7	37	0.008
7		1.0	6.0			7.7	37	0.012
7		2.0	5.7			7.8	37	0.013
7		3.0	5.5			7.8	37	0.011
7		4.0	5.3			7.8	38	0.011
7		5.0	4.8			7.8	38	0.011
7		6.0	4.8			7.8	38	0.012
7		7.0	4.7			7.8	38	0.011
7		8.0	4.3			7.8	37	0.010
7		9.0	3.8			7.8	36	0.010
7	14:29	10.0	3.7			7.8	37	0.011
April								
29	12:12	0.5	6.9	11.1	99.4	7.4	37	0.010
29		1.0	6.9	11.0	99.3	7.4	37	0.011
29		2.0	6.7	11.1	98.8	7.5	37	0.016
29		3.0	6.6	11.0	98.2	7.5	37	0.016
29		4.0	6.6	11.0	98.1	7.5	37	0.016
29		5.0	6.6	11.0	98.1	7.5	37	0.016
29		6.0	6.6	11.0	97.8	7.5	37	0.016
29		7.0	6.6	10.9	97.3	7.5	37	0.016
29		8.0	6.6	10.9	97.6	7.5	37	0.015
29		9.0	6.6	10.9	97.3	7.5	37	0.016
29		10.0	6.5	10.9	97.1	7.5	37	0.015
29		11.0	6.5	10.9	96.9	7.5	37	0.015
29	12:23	12.0	6.5	10.9	96.5	7.5	37	0.015
May								
26	13:08	0.5	12.5	10.3	105.6	7.6	34	0.007
26		1.0	12.5	10.3	105.4	7.6	34	0.007
26		2.0	12.4	10.3	105.4	7.6	34	0.008
26		3.0	12.4	10.3	105.1	7.7	34	0.009
26		4.0	12.3	10.3	105.0	7.7	34	0.010
26		5.0	8.3	10.5	96.5	7.5	32	0.011
26		6.0	8.0	10.4	95.5	7.4	32	0.013
26		7.0	7.6	10.4	94.9	7.3	32	0.010
26		8.0	7.6	10.3	93.5	7.4	32	0.010
26		9.0	7.3	10.3	92.6	7.3	32	0.010
26		10.0	7.1	10.2	91.7	7.3	32	0.010
26	13:16	11.0	7.0	9.9	88.8	7.3	32	0.010

Table A8. 2009 Water Column Profiles at Site C6- Chatcolet Lake, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
June								
23	11:58	0.5	14.2	9.3	102.1	7.5	36	0.008
23		1.0	13.6	9.2	100.2	7.5	36	0.010
23		2.0	13.5	9.2	99.7	7.5	36	0.011
23		3.0	13.3	9.2	99.7	7.5	36	0.013
23		4.0	13.1	9.3	100.2	7.4	36	0.014
23		5.0	12.2	8.8	92.3	7.3	35	0.017
23		6.0	11.8	8.4	87.4	7.1	34	0.018
23		7.0	11.1	8.0	81.9	7.0	34	0.017
23		8.0	10.9	7.8	80.1	7.0	33	0.019
23		9.0	10.8	7.8	79.9	7.0	33	0.018
23		10.0	10.5	6.8	68.6	6.9	33	0.014
23	12:13	11.0	10.2	6.6	66.1	6.8	33	0.014
July								
21	12:10	0.5	22.2	10.0	116.0	8.8	47	0.007
21		1.0	21.9	10.0	115.7	8.8	47	0.007
21		2.0	21.7	9.9	113.6	8.7	46	0.007
21		3.0	21.4	9.9	113.8	8.8	45	0.009
21		4.0	20.8	9.9	111.7	8.5	45	0.012
21		5.0	18.3	8.9	95.8	7.8	41	0.028
21		6.0	15.8	7.3	74.6	7.2	39	0.033
21		7.0	13.5	6.3	61.0	6.9	38	0.027
21		8.0	13.0	5.1	49.2	6.8	38	0.024
21		9.0	12.2	3.7	35.4	6.7	39	0.021
21		10.0	11.7	2.7	25.1	6.6	40	0.018
21	12:23	11.0	11.6	2.4	22.5	6.6	41	0.016
August								
25	14:21	0.5	21.9	8.2	104.6	8.9	52	0.007
25		1.0	21.6	8.1	103.8	9.0	51	0.007
25		2.0	21.0	8.2	103.5	9.0	52	0.011
25		3.0	20.9	8.2	103.4	9.0	52	0.014
25		4.0	20.7	8.2	102.4	8.9	51	0.014
25		5.0	20.5	8.1	100.9	8.9	51	0.012
25		6.0	19.5	6.4	78.2	7.7	49	0.018
25		7.0	16.5	2.0	23.4	6.8	48	0.019
25		8.0	14.8	0.2	2.3	6.6	48	0.013
25		9.0	14.0	0.2	2.0	6.5	51	0.011
25	14:33	10.0	13.0	0.2	1.7	6.6	61	0.010

Table A8. 2009 Water Column Profiles at Site C6- Chatcolet Lake, continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
Oct								
7	11:46	0.5	12.4	8.8	96.3	7.9	56	0.012
7		1.0	12.3	8.9	96.2	7.9	56	0.016
7		2.0	12.2	8.9	95.9	7.9	56	0.029
7		3.0	12.1	8.8	94.9	7.8	56	0.027
7		4.0	12.1	8.7	93.5	7.8	56	0.025
7		5.0	12.0	8.5	92.2	7.7	56	0.024
7		6.0	12.0	8.5	91.6	7.7	56	0.024
7		7.0	12.0	8.5	91.1	7.7	56	0.023
7		8.0	11.9	8.4	90.6	7.6	56	0.021
7		9.0	11.9	8.4	90.4	7.6	56	0.022
7	11:54	10.0	11.9	8.4	90.5	7.6	56	0.056
Dec								
1	10:24	0.5	3.7	11.6	98.8	5.7	59	0.022
1		1.0	3.6	11.6	98.9	7.3	59	0.025
1		2.0	3.6	11.6	98.7	7.4	59	0.036
1		3.0	3.6	11.6	98.6	7.5	59	0.058
1		4.0	3.6	11.6	98.4	7.5	59	0.053
1		5.0	3.6	11.6	98.2	7.5	59	0.049
1		6.0	3.6	11.5	98.0	7.5	59	0.053
1		7.0	3.6	11.5	97.9	7.5	59	0.053
1		8.0	3.6	11.5	97.9	7.6	59	0.052
1		9.0	3.6	11.5	97.5	7.6	59	0.060
1	10:40	10.0	3.8	11.1	95.0	7.5	59	0.093

Table A9. 2009 Water Quality Data for Site SJ1- Inundated lower St Joe River

Date	Time	Depth to bottom at sampling station (meters)	Temper-ature air (deg C)	Surface light intensity 400 – 700 nm (µmol/s/m^2)	Depth to 1% of surface light (meters)	Secchi disc trans-parency wo/tube (meters)
April 8	11:45	20.5	12.8	1423.0	4.0	1.2
April 29	11:00	23.0	--	--	5.0	2.0
May 26	12:00	21.3	18.3	1209.0	4.0	2.0
June 23	10:15	21.3	18.3	1431.0	10.0	4.5
July 21	10:40	21.9	--	1508.0	9.5	2.75
Aug 25	13:00	21.6	--	1662.5	10.0	--
Oct 7	10:10	21.0	4.4	862.8	9.0	3.75
Dec 1	12:50	21.1	--	636.5	6.75	3.3

Date	Time	Samp-ling depth meters[a]	Total Hard-ness mg/L as $CaCO_3$	Calcium fltrd mg/L	Mag-nesium fltrd mg/L	Iron unfltrd recov-erable µg/L	Iron fltrd µg/L	Man-ganese unfltrd recov-erable µg/L	Man-ganese fltrd µg/L	Zinc unfltrd recov-erable µg/L	Zinc fltrd µg/L	Lead unfltrd recov-erable µg/L	Lead fltrd µg/L
April 8	11:45	1-4.0	20.7	5.76	1.51	599	75	12.60	7.87	<5.0	<5.0	0.23	<0.10
8	12:00	19.0	21.1	5.80	1.50	578	250	12.90	8.70	<5.0	<5.0	0.22	<0.10
April 29	11:00	1-5.0	18.9	5.32	1.26	215	30	7.27	4.60	<5.0	<5.0	<0.13	<0.10
29	11:30	20.0	18.7	5.27	1.26	168	29	6.96	4.50	<5.0	<5.0	<0.13	<0.10
May 26	11:20	1-4.0	15.7	4.45	1.02	265	24	8.53	4.10	<5.0	<5.0	0.15	<0.10
26	12:00	20.0	15.7	4.36	1.00	258	16	8.80	3.90	<5.0	<5.0	0.15	<0.10
June 23	10:15	1-10.0	18.2	5.58	1.24	126	37	10.10	8.42	<5.0	<5.0	<0.13	<0.10
23	11:00	17.0	18.2	5.60	1.26	193	36	10.90	8.78	<5.0	<5.0	<0.13	<0.10
July 21	10:40	1-9.5	23.8	6.92	1.57	161	37	12.30	0.95	<5.0	<5.0	<0.13	<0.10
21	11:20	20.0	24.2	7.04	1.58	350	47	23.40	11.40	<5.0	<5.0	0.15	<0.10
Aug 25	13:00	1-10.0	28.3	8.51	1.92	127	36	9.69	1.00	<5.0	<5.0	<0.13	<0.10
25	13:30	19.5	31.5	9.65	2.12	2650	1690	550.00	570.00	<5.0	<5.0	0.24	<0.10
Oct 7	10:10	1-9.0	30.7	9.22	2.06	165	37	9.36	0.74	<5.0	<5.0	<0.13	<0.10
7	10:45	19.5	30.4	9.29	2.05	169	34	9.44	0.71	<5.0	<5.0	<0.13	<0.10
Dec 1	12:50	1-6.75	28.1	8.06	2.04	395	92	18.50	17.50	<5.0	<5.0	<0.13	<0.10
1	13:15	19.0	27.6	8.30	1.86	403	98	19.90	18.20	<5.0	<5.0	<0.13	<0.10

Table A9 – 2009 Site SJ1, continued

Date	Sampling depth meters	Cadmium unfltrd recoverable µg/L	Cadmium fltrd µg/L	Arsenic unfltrd recoverable µg/L	Arsenic fltrd µg/L	Chlorophyll *a* phytoplankton fluoro µg/L	Total Phosphorus unfltrd µg/L	Phosphorus total fltrd µg/L	Orthophosphate fltrd µg/L	Total nitrogen unfltrd µg/L	Ammonia fltrd as N µg/L	Nitrate fltrd as N µg/L	Nitrite fltrd as N µg/L
April 8	1-4.0	<0.13	<0.10	<0.63	<0.20	<1.00	23	14	8.5	210	19	36	<10
8	19.0	<0.13	<0.13	<0.63	<0.63		24	15	12	210	<10	33	<10
April 29	1-5.0	<0.13	<0.10	<0.63	0.22	<1.00	14	6.5	8.4	130	<10	12	<10
29	20.0	<0.13	<0.10	<0.63	0.21		14	8.6	7.3	140	<10	11	<10
May 26	1-4.0	<0.13	<0.10	<0.63	<0.20	<1.00	18	9.6	8.9	130	<10	17	<10
26	20.0	<0.13	<0.10	<0.63	<0.20		21	7.4	8.2	180	<10	17	<10
June 23	1-10.0	<0.13	<0.10	<0.63	0.26	<1.00	15	6.8	8.8	100	<10	<10	<10
23	17.0	<0.13	<0.10	<0.63	0.23		15	6.6	8.7	110	<10	<10	<10
July 21	1-9.5	<0.13	<0.10	<0.63	0.35	1.63	14	5	<2	150	<10	15	<10
21	20.0	<0.13	<0.10	<0.63	0.36		21	7	4.9	180	10	<10	<10
Aug 25	1-10.0	<0.13	<0.10	<0.63	0.41	1.61	18	12	4.5	100	16	<10	<10
25	19.5	<0.13	<0.10	3.60	3.60		107	37	24	510	351	<10	<10
Oct 7	1-9.0	<0.13	<0.10	<0.63	0.39	2.30	15	5.3	6	180	<10	<10	<10
7	19.5	<0.13	<0.10	<0.63	0.38		5	<5	5	100	<10	<10	<10
Dec 1	1-6.75	<0.13	<0.10	<0.63	0.21	<1.00	16	7	2.1	100	<10	13	<10
1	19.0	<0.13	<0.10	<0.63	0.22		16	6	3.2	90	<10	17	<10

a = First row of each sampling date is a photic zone composite sample – five equally spaced samples from 1 meter to 1% of surface light.

Table A10. 2009 Water Column Profiles at Site SJ1- Inundated lower St Joe River

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
April								
7	11:11	0.5	5.4			5.9	39	0.008
7		1.0	5.3			6.3	39	0.009
7		2.0	5.3			6.3	40	0.009
7		3.0	5.3			6.4	39	0.009
7		4.0	5.3			6.5	39	0.010
7		5.0	5.3			6.6	40	0.009
7		6.0	5.3			6.6	40	0.010
7		7.0	5.3			6.5	40	0.009
7		8.0	5.3			6.6	40	0.010
7		9.0	5.3			6.6	40	0.010
7		10.0	5.3			6.7	40	0.010
7		11.0	5.3			6.8	40	0.009
7		12.0	5.3			6.9	40	0.009
7		13.0	5.3			7.0	39	0.009
7		14.0	5.3			7.0	40	0.009
7		15.0	5.3			7.0	40	0.009
7		16.0	5.3			7.0	40	0.010
7		17.0	5.3			7.0	40	0.010
7		18.0	5.3			7.0	40	0.010
7	11:31	19.0	5.3			7.0	39	0.009
April								
29	10:13	0.5	6.2	11.2	98.5	7.3	41	0.009
29		1.0	6.2	11.2	98.4	7.3	41	0.009
29		2.0	6.1	11.2	98.4	7.3	41	0.009
29		3.0	6.1	11.1	97.7	7.5	41	0.011
29		4.0	6.1	11.1	97.6	7.4	41	0.012
29		5.0	6.1	11.1	97.4	7.4	41	0.012
29		6.0	6.1	11.1	97.2	7.5	41	0.013
29		7.0	6.1	11.1	97.3	7.5	41	0.012
29		8.0	6.1	11.0	97.1	7.4	41	0.013
29		9.0	6.1	11.0	96.9	7.4	41	0.012
29		10.0	6.1	11.0	97.0	7.4	41	0.012
29		11.0	6.1	11.1	97.3	7.5	41	0.012
29		12.0	6.1	11.0	96.8	7.5	41	0.012
29		13.0	6.1	11.0	96.4	7.5	41	0.012
29		14.0	6.1	11.0	96.5	7.4	41	0.012
29		15.0	6.1	11.0	96.6	7.5	41	0.012
29		16.0	6.1	11.0	96.7	7.4	41	0.012
29		17.0	6.1	11.0	96.4	7.5	41	0.012
29		18.0	6.1	11.0	96.5	7.5	41	0.012
29		19.0	6.1	10.9	95.9	7.4	41	0.012

Table A10. 2009 Water Column Profiles at Site SJ1- continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
April								
29		20.0	6.1	10.9	96.0	7.4	41	0.012
29		21.0	6.1	10.9	95.9	7.4	41	0.012
29		22.0	6.1	10.9	95.5	7.5	41	0.012
29	10:37	23.0	6.1	10.9	95.5	7.4	41	0.011
May								
26	10:50	0.5	8.9	10.9	102.2	7.3	31	0.007
26		1.0	8.8	10.9	102.3	7.3	31	0.007
26		2.0	8.8	10.9	102.0	7.4	31	0.005
26		3.0	8.9	10.9	101.9	7.5	31	0.007
26		4.0	8.8	10.9	102.0	7.5	31	0.008
26		5.0	8.8	10.9	101.7	7.5	31	0.008
26		6.0	8.8	10.9	101.6	7.4	31	0.007
26		7.0	8.8	10.8	101.4	7.4	31	0.007
26		8.0	8.8	10.9	101.6	7.4	31	0.007
26		9.0	8.8	10.8	101.3	7.4	32	0.010
26		10.0	8.8	10.8	101.2	7.4	31	0.007
26		11.0	8.8	10.8	100.8	7.4	31	0.008
26		12.0	8.9	10.8	101.1	7.4	31	0.008
26		13.0	8.8	10.8	101.1	7.4	31	0.008
26		14.0	8.8	10.8	101.1	7.4	31	0.008
26		15.0	8.8	10.8	100.7	7.4	31	0.008
26		16.0	8.8	10.8	100.7	7.4	31	0.008
26		17.0	8.8	10.7	100.5	7.4	31	0.008
26		18.0	8.8	10.7	100.1	7.4	31	0.008
26		19.0	8.8	10.7	100.0	7.4	31	0.008
26		20.0	8.8	10.7	100.0	7.3	31	0.010
26	11:03	21.0	8.8	10.7	100.1	7.4	31	0.011

Table A10. 2009 Water Column Profiles at Site SJ1- continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
June								
23	9:32	0.5	12.0	9.4	98.6	7.4	37	0.006
23		1.0	11.9	9.4	98.4	7.4	37	0.006
23		2.0	11.9	9.4	98.1	7.4	37	0.006
23		3.0	11.9	9.4	98.2	7.4	37	0.006
23		4.0	11.9	9.3	97.7	7.4	37	0.007
23		5.0	11.9	9.3	97.4	7.4	37	0.007
23		6.0	11.9	9.3	97.2	7.4	37	0.007
23		7.0	11.8	9.3	97.1	7.4	37	0.007
23		8.0	11.9	9.3	97.0	7.4	37	0.007
23		9.0	11.9	9.2	96.7	7.4	37	0.007
23		10.0	11.9	9.2	96.5	7.4	37	0.007
23		11.0	11.9	9.2	96.3	7.4	37	0.007
23		12.0	11.9	9.2	96.2	7.4	37	0.007
23		13.0	11.9	9.2	96.1	7.4	37	0.007
23		14.0	11.9	9.2	96.1	7.4	37	0.007
23		15.0	11.8	9.2	95.8	7.3	37	0.007
23		16.0	11.9	9.2	95.7	7.4	37	0.007
23		17.0	11.9	9.1	95.3	7.3	37	0.007
23	9:47	18.0	11.9	9.1	95.2	7.3	37	0.007
July								
21	10:03	0.5	20.1	8.5	102.4	7.6	50	0.009
21		1.0	20.0	8.5	102.0	7.5	50	0.011
21		2.0	19.9	8.4	101.4	7.5	50	0.013
21		3.0	19.6	8.3	99.5	7.4	50	0.014
21		4.0	19.4	8.2	97.6	7.4	50	0.014
21		5.0	18.5	8.0	93.7	7.4	50	0.013
21		6.0	18.1	7.7	89.4	7.3	50	0.014
21		7.0	17.8	7.6	87.4	7.3	50	0.013
21		8.0	17.8	7.6	87.2	7.2	50	0.012
21		9.0	17.7	7.5	86.8	7.3	50	0.013
21		10.0	17.7	7.5	86.4	7.3	50	0.012
21		11.0	17.7	7.5	86.2	7.3	50	0.013
21		12.0	17.7	7.5	85.9	7.3	50	0.013
21		13.0	17.7	7.5	85.8	7.2	50	0.013
21		14.0	17.7	7.4	85.5	7.2	50	0.012
21		15.0	17.7	7.4	85.1	7.2	50	0.013
21		16.0	17.7	7.3	84.4	7.2	50	0.012
21		17.0	17.7	7.3	83.8	7.2	50	0.012
21		18.0	17.7	7.3	84.0	7.2	50	0.013
21		19.0	17.7	7.3	83.9	7.2	50	0.012
21		20.0	17.7	7.1	81.3	7.1	50	0.013
21	10:32	21.0	17.2	4.0	45.3	6.8	54	0.011

Table A10. 2009 Water Column Profiles at Site SJ1- continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
Aug								
25	12:35	0.5	21.1	8.0	101.0	7.6	60	0.010
25		1.0	20.7	8.0	100.6	7.6	59	0.011
25		2.0	20.3	8.0	99.4	7.6	60	0.011
25		3.0	20.1	7.8	96.4	7.4	60	0.013
25		4.0	19.1	7.2	86.7	7.3	60	0.014
25		5.0	18.8	6.9	83.1	7.2	60	0.014
25		6.0	18.6	6.8	81.3	7.2	60	0.012
25		7.0	18.6	6.8	81.1	7.2	60	0.010
25		8.0	18.5	6.8	81.4	7.2	60	0.010
25		9.0	18.5	6.8	81.4	7.2	60	0.009
25		10.0	18.5	6.8	80.9	7.2	60	0.010
25		11.0	18.5	6.7	80.7	7.1	60	0.009
25		12.0	18.5	6.7	80.2	7.1	60	0.010
25		13.0	18.5	6.7	80.6	7.2	60	0.010
25		14.0	18.5	6.7	80.3	7.1	60	0.009
25		15.0	18.5	6.7	80.1	7.1	60	0.009
25		16.0	18.4	6.5	77.3	7.1	60	0.009
25		17.0	18.1	2.9	34.9	6.8	59	0.008
25		18.0	16.8	0.3	4.0	6.6	64	0.007
25		18.5	16.7	0.2	2.5	6.6	68	0.007
25		19.0	16.6	0.2	2.2	6.5	71	0.007
25		19.5	16.5	0.2	1.9	6.6	74	0.008
25		20.0	16.4	0.2	1.8	6.6	78	0.008
25	12:54	21.0	16.4	0.2	1.7	6.6	79	0.008
Oct								
7	9:45	0.5	13.0	8.2	90.5	7.5	65	0.011
7		1.0	13.0	8.2	90.4	7.5	65	0.012
7		2.0	13.0	8.2	90.4	7.5	65	0.017
7		3.0	13.0	8.2	90.2	7.5	65	0.018
7		4.0	13.0	8.2	90.0	7.5	65	0.019
7		5.0	13.0	8.1	89.7	7.5	65	0.020
7		6.0	12.9	8.1	89.6	7.4	64	0.017
7		7.0	12.9	8.1	89.6	7.4	65	0.018
7		8.0	12.9	8.1	89.6	7.4	65	0.019
7		9.0	12.9	8.1	89.5	7.4	65	0.018
7		10.0	12.9	8.1	89.5	7.4	65	0.020
7		11.0	12.8	8.1	89.2	7.4	65	0.024
7		12.0	12.8	8.1	89.1	7.4	65	0.019
7		13.0	12.8	8.1	89.0	7.4	65	0.020
7		14.0	12.8	8.1	88.9	7.4	65	0.020
7		15.0	12.8	8.1	88.8	7.4	65	0.019
7		16.0	12.8	8.1	88.7	7.4	64	0.019

Table A10. 2009 Water Column Profiles at Site SJ1- continued

Date	Time	Sam-pling depth (meters)	Water temp-erature (deg C)	Diss-olved oxygen (mg/L)	Dissolved oxygen (% of sat-uration)	pH stand-ard units	Specific conduc-tance (µS/cm)	Chloro-phyll *a* sensor (volts)
Oct								
7		17.0	12.8	8.1	88.5	7.4	64	0.023
7		18.0	12.8	8.0	88.4	7.4	64	0.021
7		19.0	12.8	8.0	88.2	7.4	65	0.019
7		20.0	12.7	8.0	88.1	7.4	65	0.022
7	10:03	21.0	12.7	8.0	88.0	7.4	65	0.022
Dec								
1	12:25	0.5	2.2	11.3	92.8	7.3	60	0.006
1		1.0	2.2	11.3	92.8	7.3	60	0.007
1		2.0	2.2	11.3	92.6	7.3	60	0.007
1		3.0	2.2	11.3	92.4	7.2	60	0.008
1		4.0	2.2	11.3	92.4	7.2	60	0.008
1		5.0	2.2	11.3	92.2	7.2	60	0.008
1		6.0	2.2	11.2	91.9	7.2	60	0.009
1		7.0	2.2	11.2	91.7	7.2	60	0.008
1		8.0	2.2	11.2	91.5	7.2	60	0.008
1		9.0	2.2	11.2	91.5	7.2	60	0.008
1		10.0	2.2	11.2	91.5	7.2	60	0.008
1		11.0	2.2	11.1	91.3	7.2	60	0.008
1		12.0	2.3	11.1	91.1	7.2	60	0.008
1		13.0	2.3	11.1	90.9	7.2	60	0.008
1		14.0	2.3	11.1	90.9	7.2	60	0.008
1		15.0	2.3	11.1	90.7	7.2	60	0.008
1		16.0	2.3	11.1	90.7	7.2	60	0.008
1		17.0	2.3	11.0	90.6	7.2	60	0.008
1		18.0	2.3	11.0	90.5	7.2	60	0.008
1	12:38	19.0	2.3	11.0	90.4	7.2	60	0.009

Appendix B

Listing of Phytoplankton Genera/Species Identified at Northern and Southern Lake Sampling Sites for the Period August 2007 – December 2009

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Table B2. Phytoplankton Genera/species identified at Sites C1, C4, C5, C6, and SJ1 for samples taken by IDEQ and the Tribe, August 2007– December 2009

Genus/species	Presence at sites C1, C4, C5, C6, SJ1
Bacillariophyceae (diatoms)	
Achnanthidium sp.	C1, C4, C5, C6, SJ1
Asterionella formosa var1	C1, C4, C5, C6
Aulacoseira distans	C4
Aulacoseira granulata	C1, C4, C5, C6
Aulacoseira italica	C1, C4, C5, C6, SJ1
Ceratoneis sp.	SJ1
Cocconeis sp.	SJ1
Cyclotella bodanica	SJ1
Cyclotella comta	C1, C4, C5, C6, SJ1
Cyclotella glomerata	C1, C4, C5, C6, SJ1
Cyclotella stelligera	C1, C4, C5, C6, SJ1
Cymbella sp.	C5, C6, SJ1
Denticula sp.	SJ1
Diatoma sp.	C1, C6, SJ1
Epithemia sp.	C6
Fragilaria acus	C1, C4, C5, C6, SJ1
Fragilaria angustissima	C5, C6, SJ1
Fragilaria capucina	C1, C4, C5, C6, SJ1
Fragilaria construens	C5, C6, SJ1
Fragilaria crotonensis	C1, C4, C5, C6, SJ1
Fragilaria intermedia	C1, C4, SJ1
Fragilaria ulna	C1, C5, SJ1
Gomphonema sp.	C6, SJ1
Hannea arcus	C5, C6
Navicula sp.	C1, C4, C5, C6, SJ1
Nitzschia sp.	C5, C6, SJ1
Pinnularia sp.	C4, C6, SJ1
Rhizoselenia sp.	C1, C4, C6, SJ1
Stephanodiscus sp.	C1, C5, C6
Synedra acus var. angustissima	C1, C4, C5, C6, SJ1
Synedra nana	C1, C4, C5
Synedra ulna	C6, SJ1
Tabellaria fenestrata	C1, C4, C5, C6
Tabellaria flocculosa	C1, C4, SJ1

Table B1 continued

Genus/species	Presence at sites C1, C4, C5, C6, SJ1
Chlorophyceae (coccoid greens, desmids, etc.)	
Acanthosphaera sp.	C1, C4, C5
Actinastrum hantschii	C4, SJ1
Ankistrodesmus sp.	C1, C4, C5, C6, SJ1
Botryococcus sp.	C4, C6
Bulbochaete sp. (coccoid)	C5
Carteria sp.	C5
Chlorella	C1, C4, C5, C6, SJ1
Clamydocapsa sp.	C1, C4, C5, C6, SJ1
Closterium sp.	SJ1
Coccomyxa sp.	C4, SJ1
Coelastrum sp.	C1, C4, C5, C6, SJ1
Cosmarium sp.	C1, C4, C5, C6, SJ1
Crucigenia sp.	C1, C4, C5, C6, SJ1
Dictyosphaerium sp. (rod)	C1, C6, C5, SJ1
Elakatothrix sp3	C1, C4, C5, C6, SJ1
Euastrum sp. (coccoid)	SJ1
Euglena sp.	C6
Geminella sp	C6
Gleotila sp.	C1, C4, SJ1
Gloeococcus sp.	C4
Golenkinia sp.	C1, C4, C6
Komaredia sp.	SJ1
Langerheimia sp.	C1
Micractinium pusillum	C1
Monoraphidium sp. (rod)	C1, C4, C5, C6, SJ1
Mougeotia sp.	C5, C6, SJ1
Nephroselmis sp.	C1, C4 C5, C6, SJ1
Oocystis sp.	C1, C4, C5, C6, SJ1
Pediastrum sp.	C4, C5, C6, SJ1
Phacus sp. (rod)	C1, C4, C5, C6, SJ1
Planctonema sp.	C1, C4, C5
Planctosphaeria sp. (rod)	C1, C4, C5, C6, SJ1
Polytoma sp.	C1, C4
Pseudosphaerocystis sp.	C1, C4, SJ1
Scenedesmus sp.	C1, C6, SJ1
Scourfieldia sp.	C1, C4, SJ1
Sphaerocystis sp.	C4
Spondylosium sp.	C4
Staurastrum sp.	C1, C4, C5, C6

Table B1 continued

Genus/species	Presence at sites C1, C4, C5, C6, SJ1
Chlorophyceae contin.	
Stichococcus minutissimus	C1, C6
Tetraedron	C1, C4, C5, C6, SJ1
Ulothrix sp.	C5, C6, SJ1
Willea sp.	C1, C4
Chrysophyceae (yellow-green flagellates)	
Bitrichia sp.	C1, C4, C5
Chromulina sp1	C1, C4, C5, C6, SJ1
Chrysochromulina sp.	C1, C4, C5, C6, SJ1
Chrysococcus sp. (coccoid)	C1, C4 C5, C6, SJ1
Chrysosphaerella sp.	C1
Dinobryon sp.	C1, C4, C5, C6, SJ1
Isthmochloron sp.	C6
Kephyrion sp.	C1, C4, C5, C6, SJ1
Mallomonas sp2	C1, C4, C5, C6, SJ1
Ochromonas sp.	C1, C4, C5, C6, SJ1
Pseudokephrion sp.	C1, C4, C5, C6
Small microflagellates	C1, C4, C5, C6, SJ1
Sphaleromantis sp.	C1, C4
Synura sp.	C1, C4, C6
Trachelomonas sp.	C1, C4, C5, C6, SJ1
Uroglena sp.	C1
Cryptophyta (flagellates)	
Cryptomonas sp.	C1, C4, C5, C6, SJ1
Komma sp	C1, C4, C5, C6, SJ1
Dinophyceae (dinoflagellates)	
Ceratium sp.	C6, SJ1
Gloeodinium sp.	C1
Glenodinium sp.	C5
Gymnodinium sp1	C1, C4, C5, C6, SJ1
Gymnodinium sp2	C1, C4, C5, C6, SJ1
Peridinium sp.	C1, C4, C5, C6, SJ1
Cyanophyta (cyanobacteria or blue-greens)	
Anabaena circinalis	C1, C4, C5, C6, SJ1
Anabaenopsis sp.	C5
Aphanazomenon sp.	C6
Aphanothece sp.	C1, SJ1
Chroococcus sp.	C1, C4, C5, C6, SJ1
Coelosphaeria sp.	C1

Table B1 continued

Genus/species	Presence at sites C1, C4, C5, C6, SJ1
Cyanophyta contin.	
Gomphosphaeria sp.	C1, C4, C5, C6, SJ1
Lyngbya sp.	C4, C5, C6, SJ1
Merismopedia sp.	C4
Microcystis sp.	C1, C4, C5, C6, SJ1
Oscillatoria agardhii	C1, C4, C5, C6, SJ1
Synechococcus sp. (coccoid)	C1, C4, C5, C6, SJ1
Synechococcus sp. (rod)	C1, C4, C5, C6, SJ1
Synechocystis sp.	C1