Project Note

Project: Lake L9322 Monitoring and Analysis	**Project No: 115159**
To: Sally A. Rothwell, CPAI	**Project Note No: 115159-MBJ-PN-001**
From: Jeff Baker, P.E.	**Date: March 4, 2009**
Subject: Winter 2009 Lake L9322 Monitoring and Analysis	

Introduction

In support of Alpine Operations, and as authorized by Habitat Permit FG02-III-0103, CPAI withdraws water from Lake L9322 in the Colville River Basin. The basis for this project is to assess possible harm to water quality that may have resulted due to the over-withdrawal of water from Lake L9322, which occurred during the summer of 2008.

The objective of the Winter 2009 Lake L9322 Monitoring and Analysis was the collection of water quality and physical data. Water quality data was collected on February 18, 2009. LCMF provided transportation and assistance to Baker staff.

Methods

Samples were collected at four locations within Lake L9322. In addition to water quality parameters, physical parameters of depth, ice thickness, freeboard, and water surface elevation (WSE) were obtained.

The four sampling locations (identified as SL-1, SL-2, SL-3, and SL-4 on Figure 1) were selected to represent the deepest part of the lake based on existing lake bathymetry. Sample location SL-2 is located approximately 550 feet south of the northern edge of Lake L9322. Sampling location SL-4 is located approximately 350 feet south of SL-2, and is near the center of the lake. SL-1 and SL-3 are located approximately 350 feet west and 600 feet east of SL-4, respectively.

Water quality was measured to depth at each of the sampling points, yielding a profile of parameters from below ice to the lake bottom at intervals of no greater than 2.0 feet.

The water quality parameters included temperature, conductivity, pH, and dissolved oxygen (mg/L and %-saturation). Temperature, conductivity, and pH were measured using a YSI 556 MPS meter, standardized by TTT Environmental 24 hours prior to initial sampling. Dissolved oxygen was measured using a Hach HQ40d LDO, standardized to atmospheric oxygen saturation. Conductivity calibration was checked on the day of sampling. Baker calculated specific conductance (referenced to 25°C) from measured conductivity using standard methods and a standard conversion coefficient of 0.0191.

Water depth and ice thickness were recorded using a weighted rag tape and graduated rod, respectively. Freeboard, the distance from top of ice to water surface, was measured using a weighted rag tape. Water surface elevation was surveyed using standard level loop methods. Local control was used to establish elevation relative to British Petroleum Mean Sea Level (BPMSL).

Water quality measurements were reviewed at the time of collection to identify potential anomalies associated with collection methods or equipment failure. Necessary steps were taken to minimize any adverse effects of the local environmental conditions on the equipment used.

Results

Data collected on February 18, 2009, are presented in Table 1. Water surface elevation (WSE) collected during this event, as well as historic water surface elevation data provided by LCMF, is presented in Table 2. Water surface elevation data will also be presented and compared with the 2009 spring breakup WSE in the final report for this project. On the day of sampling, the ambient temperature was -28°F with winds approaching 15 miles per hour.

Table 1 Lake L9322 Winter Sampling Data (February 18, 2009)

Sampling Location Time	Water Depth (ft)	Ice Thickness (ft)	Free Board (ft)	Sample Depth (ft)	Temp (^{0}C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	DO (mg/L)	DO (Percent Saturation)	pH
L9322-01 N70º20'16.4" W151º01'57.1" 2:56 p.m.	11.6	3.8	0.1	4.0	0.3	162	307	9.6	66.5	7.05
				6.0	1.0	161	297	9.3	65.2	7.22
				8.0	1.5	175	318	8.4	59.6	7.36
				10.0	1.6	194	351	7.6	53.8	7.50

Note: Approximately 1 foot of snow cover. Water column depth = 7.8 feet.

Sampling Location Time	Water Depth (ft)	Ice Thickness (ft)	Free Board (ft)	Sample Depth (ft)	Temp (^{0}C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	DO (mg/L)	DO (Percent Saturation)	pH
L9322-02 N70º20'18.1" W151º01'51.9" 3:31 p.m.	11.6	4.0	0.1	4.0	0.4	156	294	10.8	75.6	7.11
				6.0	1.4	155	282	10.2	72.9	7.15
				8.0	1.7	157	283	9.1	66.1	7.30
				10.0	1.8	161	289	6.4	47.3	7.57

Note: Approximately 1 foot of snow cover. Water column depth = 7.6 feet.

Sampling Location Time	Water Depth (ft)	Ice Thickness (ft)	Free Board (ft)	Sample Depth (ft)	Temp (^{0}C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	DO (mg/L)	DO (Percent Saturation)	pH
L9322-03 N70º20'16.1" W151º01'43.1" 3:47 p.m.	12.0	5.0	0.4	5.0	0.7	158	295	9.3	64.8	6.85
				7.0	1.3	158	289	8.3	58.6	6.86
				9.0	1.6	158	285	6.8	48.4	7.00
				11.0	1.8	159	285	4.0	28.8	7.10

Note: No snow cover on this side of lake. Water column depth = 7.0 feet.

Sampling Location Time	Water Depth (ft)	Ice Thickness (ft)	Free Board (ft)	Sample Depth (ft)	Temp (^{0}C)	Conductivity (µS/cm)	Specific Conductance (µS/cm)	DO (mg/L)	DO (Percent Saturation)	pH
L9322-04 N70º20'16.4" W151º01'52.0" 4:06 p.m.	11.3	4.7	0.2	6.0	0.8	154	287	11.3	79.3	6.95
				8.0	1.7	158	285	7.3	52.9	6.95
				10.0	2.2	155	275	7.2	52.9	7.25

Note: Thin snow cover at this location. Water column depth = 6.6 feet.

Notes:

(1) All sample location coordinates referenced to NAD83 datum.

(2) Freeboard is the distance from the top of ice to the water surface.

(3) Sample depth is measured from the water surface.

(4) Conductivity, pH, and temperature were measured using a YSI-556 meter.

(5) Specific conductance (referenced to 25^{0}C) was obtained using a standard conversion coefficient of 0.0191.

(6) Dissolved oxygen measurements were obtained using a Hach HQ40d meter.

Table 2 Lake L9322 Lake Water Surface Elevation Data

Date	Elevation (ft, BPMSL)
6/11/2008	7.10
6/30/2008	6.91
7/28/2008	6.65
8/29/2008	6.62
9/28/2008	6.59
11/4/2008	6.68
11/28/2008	6.53
2/1/2009	6.55
2/18/2009	6.84

Physical Parameters

Ice thickness ranged from 3.8 feet to 5.0 feet. Ice thickness was 3.8 feet at SL-1 and 4.0 feet at SL-2. At both locations, the snow depth was approximately 1 foot. Ice thickness increased to 5.0 feet at SL-3, where no snow cover was on the ice. The ice thickness was 4.7 feet at SL-4 with a thin snow cover.

Freeboard ranged from 0.1 foot to 0.4 feet. Freeboard at SL-1 and SL-2 was measured at 0.1 foot. Freeboard was 0.4 feet at SL-3 and 0.2 feet at SL-4. Observed water depths ranged from 11.3 feet to 12.0 feet. Water column depth, from bottom-of-ice to bottom-of-lake, ranged from 7.8 feet at SL-1 and 7.6 feet at SL-2, to 7.0 feet at SL-3 and 6.6 feet at SL-4.

Temperature

Temperature profiles were relatively linear, increasing with depth before moderating at approximately 8.0 feet of depth. Minimum temperatures ranged from 0.3°C to 0.8°C at the shallowest sampling depths (4.0 to 6.0 feet—generally just below ice surface). The lowest temperatures were associated with the sampling locations with the least ice thickness at SL-1 and SL-2. Temperatures ranged from 1.6°C to 2.2°C at the deepest sampling depths (10.0 to 11.0 feet). Temperatures were fairly constant below the 8.0 foot depth, except for SL-4. At SL-4, temperature continued to increase from 1.7°C at 8.0 feet to the maximum temperature of 2.2°C at 10.0 feet of depth. All observed temperatures, and the trend in overall temperatures, are consistent with observed winter values at other area lakes.

Specific Conductance

Conductivity and specific conductance were relatively consistent at three of the four sampling locations. The average specific conductance across all four sampling locations was 295 µS/cm. Omitting SL-1, the average specific conductance at SL-2, SL-3 and SL-4 was 286 µS/cm. Values did not vary significantly with depth at SL-2, SL-3, and SL-4. The average specific conductance value at SL-2 was 287 µS/cm, compared to an average value of 289 µS/cm at SL-3, and 282 µS/cm at SL-4. The maximum difference at equal depth was 12 µS/cm. Values ranged from a maximum of 295 µS/cm to a minimum of 275 µS/cm.

The average specific conductance at SL-1 was 318 µS/cm, 11% higher than the average of the other three sampling locations. The values at SL-1 ranged from a high of 351 µS/cm at 10.0 feet of depth (near lake bottom) to a low value of 297 µS/cm at 6.0 feet of depth. Generally, specific conductance increased with depth at location SL-1.

pH

Observed pH generally increased with depth in the water column, though the magnitude of this rise in pH was relatively small. The average pH was 7.2 across all sampling locations and depths. The average pH observed at shallow depths (less than or equal to 7.0 feet) was 7.02. The average pH observed at the greater depths (greater than 7 feet) was 7.25. Values were relatively similar between sample locations at each location, with slightly lower pH values at SL-3 and SL-4, compared to observed pH values at SL-1 and SL-2. The reported accuracy of the meter for recording pH values is +/- 0.2 pH units.

Dissolved Oxygen (DO)

Sampling locations SL-1, SL-2, and SL-3 exhibited similar trends in dissolved oxygen concentration profiles. Dissolved oxygen dropped off at a higher rate with increased depth at sampling location SL-3, with a dissolved oxygen value of 4.0 mg/L at a depth of 11.0 feet. This reading was the lowest dissolved oxygen value recorded at any of the four sampling locations, but was also the closest to the bottom of the lake (approximately 1 foot above the bottom of the lake).

Dissolved oxygen concentrations at sampling location SL-4 exhibited a different profile with nearly identical dissolved oxygen readings of 7.3 mg/L at 8.0 feet and 7.2 mg/L at 10.0 feet of depth and a maximum concentration of 11.3 mg/L at 6.0 feet.

Dissolved oxygen values varied between locations and depths. The maximum difference at equal depth was 2.0 mg/L. Dissolved oxygen values ranged from 4.0 mg/L near the bottom of the lake at SL-3 to 11.3 mg/L at a depth of 6.0 feet at SL-4. All of these values are consistent with values observed at other lakes in the region.

Discussion

Lake bathymetry was utilized to obtain sampling locations in the deepest portions of the lake. Based on the bathymetry and observed ice thickness, water in the sampling locations is not isolated from the main body of the lake. Predominant wind direction in the area is from the east-northeast, and this corresponds with observed snow cover. Lake snow cover ranged from approximately 1 foot at both SL-1 and SL-2, to no snow at SL-3 (located the farthest east on the lake). Ice thickness was greatest at SL-3 (5.0 feet), where no snow cover was observed. Ice thickness decreased as snow cover increased, to a minimum observed thickness of 3.8 feet at SL-1.

Temperatures at each of the sampling locations showed a similar trend, with temperatures linearly increasing with increased depth. Temperature increase slowed noticeably at approximately 8.0 feet of depth in three of the four sampling locations. In all four locations, the temperature trend indicates stratification and likely minimal, if any, mixing in the water column.

Dissolved oxygen decreased with increasing depth (and a corresponding increase in temperature) at all four locations. The overall observed DO stratification suggests a lack of vertical mixing of the water column. Variations between dissolved oxygen readings at the four sampling locations were not significant. The lowest DO concentration, 4.0 mg/L at 11.0 feet of depth (SL-3), is consistent with respiration and decomposition at the benthic boundary layer at or near the lake bottom.

Observed pH was relatively consistent across all four sampling locations. The pH generally increased with depth, but the magnitude of increase was relatively small.

Specific conductance was fairly consistent at sampling locations SL-2, SL-3, and SL-4, and did not vary significantly with depth at those locations. Specific conductance values were consistently higher at SL-1.

Conclusions

The total estimated volume under 7 feet of ice serves as a basis for the permitted withdrawal volume (L. Moulton L9322 Volume Curve spreadsheet 07/10/08) and is estimated at 11.8 million gallons. Permitted withdrawal volume for Lake L9322 is 1.63 million gallons per year under Habitat Permit FG02-III-0103. This represents 13.8 % of the estimated water volume beneath 7 feet of ice. The total summer 2008 withdrawal volume of 2.49 million gallons represents a withdrawn volume equal to approximately 1.5 times the permitted volume.

Based on 2009 current observed ice thicknesses of 5 feet, the estimated volume of Lake L9322 under ice is 23.3 million gallons. The 2008 withdrawal volume of 2.49 million gallons represents 10.7% of the estimated under ice volume in the lake at this time.

No major anomalies in water quality parameters were observed at Lake L9322 during the winter water quality monitoring event. While the total permitted volume was exceeded, the actual volume is still under the guidelines used to set the withdrawal amounts.

Additional Distribution: **Julie Shewman, P.E., Baker**

Attachments: **Figure 1**

ConocoPhillips Alaska, Inc.

DATE:	2/25/09	PROJECT:	115159
DRAWN:	JMS/REH	FILE:	WINTER_NOTES_FIGURE_1.DWG
CHECKED:	MDM	SCALE:	1" = 250'

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LAKE L9322
WATER QUALITY
SAMPLING LOCATIONS

FIGURE 1
(SHEET 1 OF 1)