Project Note

Project: Lake L9322 Monitoring and Analysis	**Project No: 115159**
To: Sally A. Rothwell, CPAI	**Project Note No: 115159-MBJ-PN-002**
From: Jeff Baker, P.E.	**Date: July 27, 2009**
Subject: Spring Breakup 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. During the summer of 2008, an over-withdrawal of water from Lake L9322 occurred. The 2009 Lake L9322 monitoring and analysis study was conducted to assess possible harm to water quality that may have resulted due to the over-withdrawal. The assessment included collection of winter water quality and physical data, as well as evaluation and documentation of recharge during spring breakup.

Winter water quality monitoring was conducted in February 2009, with results presented in a project note dated March 4, 2009. Recharge of Lake L9322 was monitored in conjunction with the Colville River Delta Spring Breakup. Springtime water quality data were collected on May 18, 2009. Results of the recharge monitoring are presented here.

Methods

Recharge

Water surface elevations were collected throughout the winter, as well as pre- and post-breakup. In February, a standard level loop survey was used to tie the observed water surface elevation to a local temporary benchmark (TBM 9322 A). In May, prior to breakup, a standard level loop survey was used to tie the observed water surface elevation to a local permanent direct read staff gage, Gage #6. Both TBM 9322A and Gage #6 were tied to the British Petroleum Mean Sea Level (BPMSL) datum by Kuukpik/LCMF. Kuukpik/LCMF provided survey assistance and basis of elevations for the local benchmarks.

When ice was present on the water surface, water surface elevations were calculated by subtracting the measured freeboard from the elevation of the ice surface. Freeboard is defined as the distance from the top of ice to the observed water surface in the sample hole. An electric drill was used to

auger a 2-inch (minimum) sample hole through the ice. Freeboard was measured using a graduated pocket tape.

During open water conditions, water surface elevations were monitored using a graduated staff gage tied to the local permanent staff Gage #6. The lake staff gage, identified as Gage @ L9322 on Figure 1, is located at the northeast end of Lake L9322 approximately 250 feet from permanent staff Gage #6. Figure 1 illustrates the sampling and gage locations.

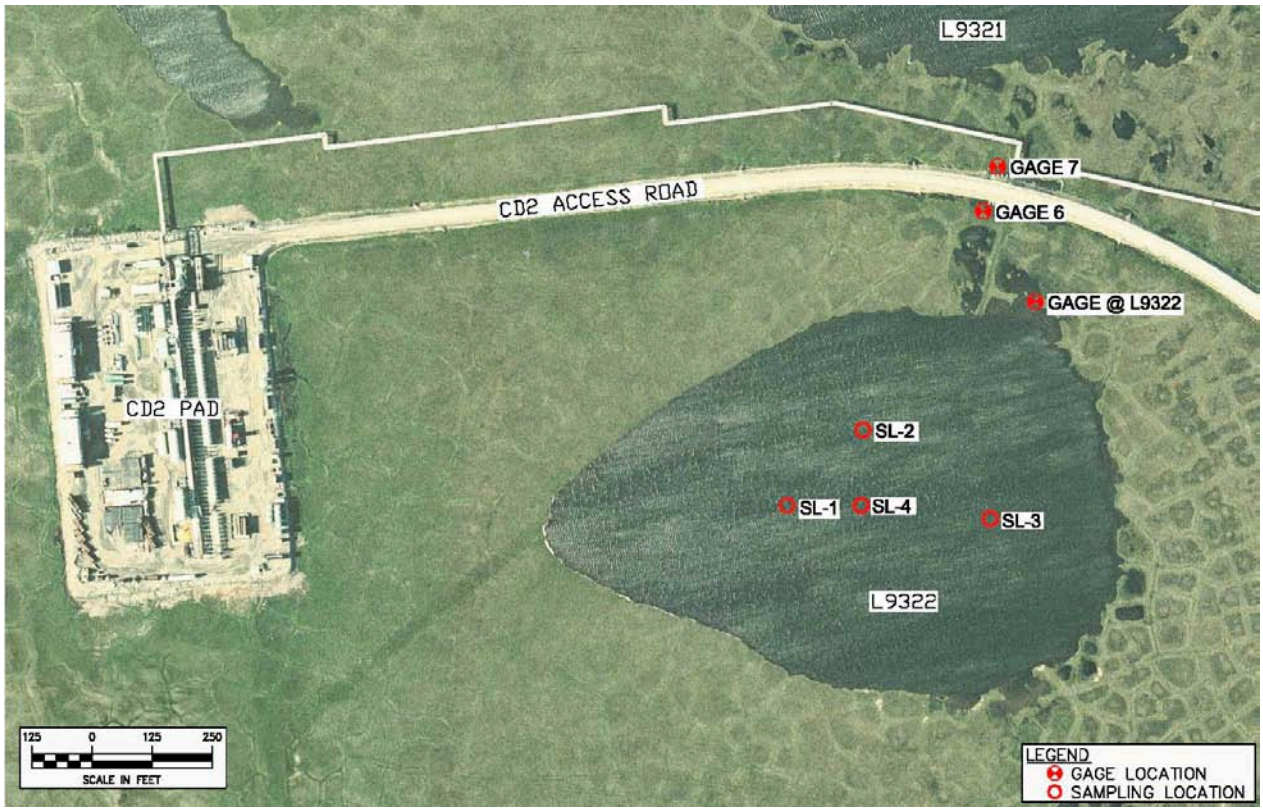


Figure 1: Lake L9322 with staff gage and sampling locations. Aerial image provided by Aero-Metric, Anchorage, from photography flown in 2006.

As shown on Figure 1, additional gages are located on either side of the CD2 road, adjacent to the CD2-4 through CD2-7 culvert battery. Gage #6 (south side) and Gage #7 (north side) are permanent direct read staff gages and were monitored during breakup to further evaluate recharge of the lake basin. The culvert battery along the CD2 road in this area is designed to convey water from the L9322 area on the south side of the CD-2 road to the north side of the road and Lake L9321.

Aerial observations of lake water recharge were conducted with the support of AirLogistics Helicopters. Ground observations were performed to identify recharge flows and hydraulic connectivity to local floodwaters.

Water Quality

Water samples were collected at four locations (identified as SL-1, SL-2, SL-3, and SL-4 on Figure 1) within Lake L9322. These locations were sampled both in February and again in May 2009.

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. In addition to water quality parameters, physical parameters of depth, ice thickness, freeboard, and water surface elevation (WSE) were obtained.

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 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

Recharge

A full suite of water surface elevation data is presented in Table 1.

Table 1
Observed Water Surface Elevations

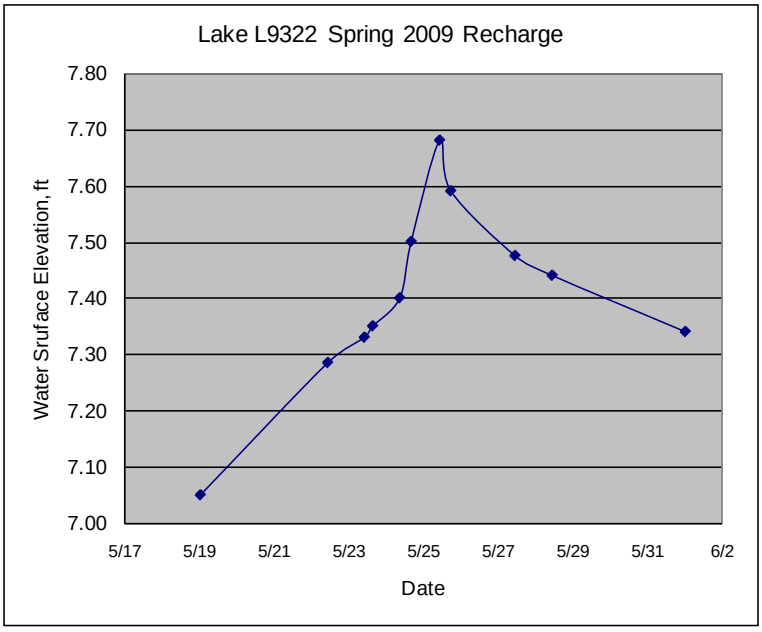
Date	Elevation (ft, BPMSL)	Date	Elevation (ft, BPMSL)
6/11/2008*	7.10	5/3/2009*	6.70
6/30/2008*	6.91	5/19/2009	7.05
7/28/2008*	6.65	5/22/09 9:55 AM	7.29
8/29/2008*	6.62	5/23/09 9:30 AM	7.33
9/28/2008*	6.59	5/23/09 2:50 PM	7.35
11/4/2008*	6.68	5/24/09 8:15 AM	7.40
11/28/2008*	6.53	5/24/09 3:35 PM	7.50
1/8/2009*	6.53	5/25/09 9:55 AM	7.68
2/1/2009*	6.55	5/25/09 5:05 PM	7.59
2/18/2009	6.84	5/27/09 10:25 AM	7.48
3/8/2009*	6.64	5/28/09 10:20 AM	7.44
4/1/2009*	6.66	6/1/2009*	7.34

Dates denoted with * indicate data provided by LCMF. All other WSE data by Baker.

Table 2 provides a summary of field observations related to the water surface elevations observed during the spring breakup period, as well as field observations. Graph 1 illustrates the observed water surface elevations during spring breakup.

Table 2
Spring Breakup Observations

Date	Elevation (ft)	Notes
2/18/2009	6.84	Snow cover varied on lake. One foot of snow at two sampling locations, thin snow cover, and exposed ice in other locations.
5/19/2009	7.05	Ice thickness greater than 5 feet at all sampling locations.
5/23/09	7.33	Foggy, 26 ºF, 5-10 mph wind.
5/24/09	7.50	Snow, overcast, 26 ºF
5/25/09	7.68	9:55 a.m. Peak recorded water surface elevation
5/25/09	7.59	5:05 p.m. Water elevation dropping. High water mark on gage noted at 7.66 feet.
5/27/09	7.48	Lake is no longer being recharged.



Graph 1: Lake L9322 Spring 2009 Water Surface Elevations

An initial WSE of 6.84 feet was surveyed by Baker in February 2009. At that time, local snow depth on lake ice ranged from no snow cover to approximately one foot of snow at the sampling locations. On May 19, a pre-breakup WSE was measured at 7.05 feet. During spring breakup monitoring, water levels rose to a peak measured water surface elevation of 7.68 feet on May 25, and then began to drop as lake recharge ended. Lake water surface returned to an estimated bankfull condition with a water surface elevation of approximately 7.3 ft BPMSL, as measured on June 1, 2009. Lake ice was intact throughout the monitoring event with recharge water surrounding the entire lake periphery, but concentrated on the eastern side.

Recharge waters from the Nigliq Channel via Nanuq Lake overbank flooding reached Lake L9322 on May 24. Prior to overbank flooding, local melt and recent snows increased water surface elevations nearly 0.3 feet. Figure 2 illustrates overbank recharge flow in the vicinity of Lake L9322, concentrated on the east side of Lake L9322. Figure 3 (May 28) and Figure 4 (May 31) also show the extent of floodwater recharge defined by saturated polygons and peripheral lake water as floodwater receded and local water surface elevations dropped.

Figure 2: View looking southwest taken May 24, 2009.

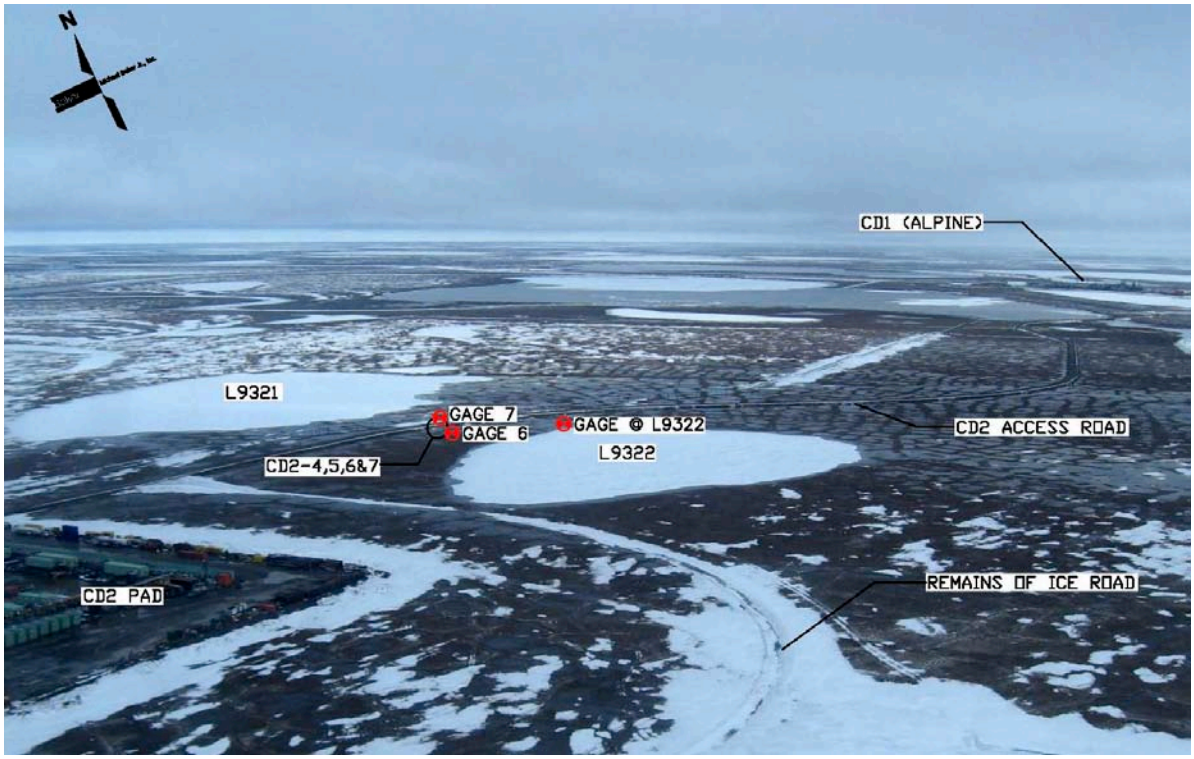


Figure 3: View looking northeast taken May 28, 2009.

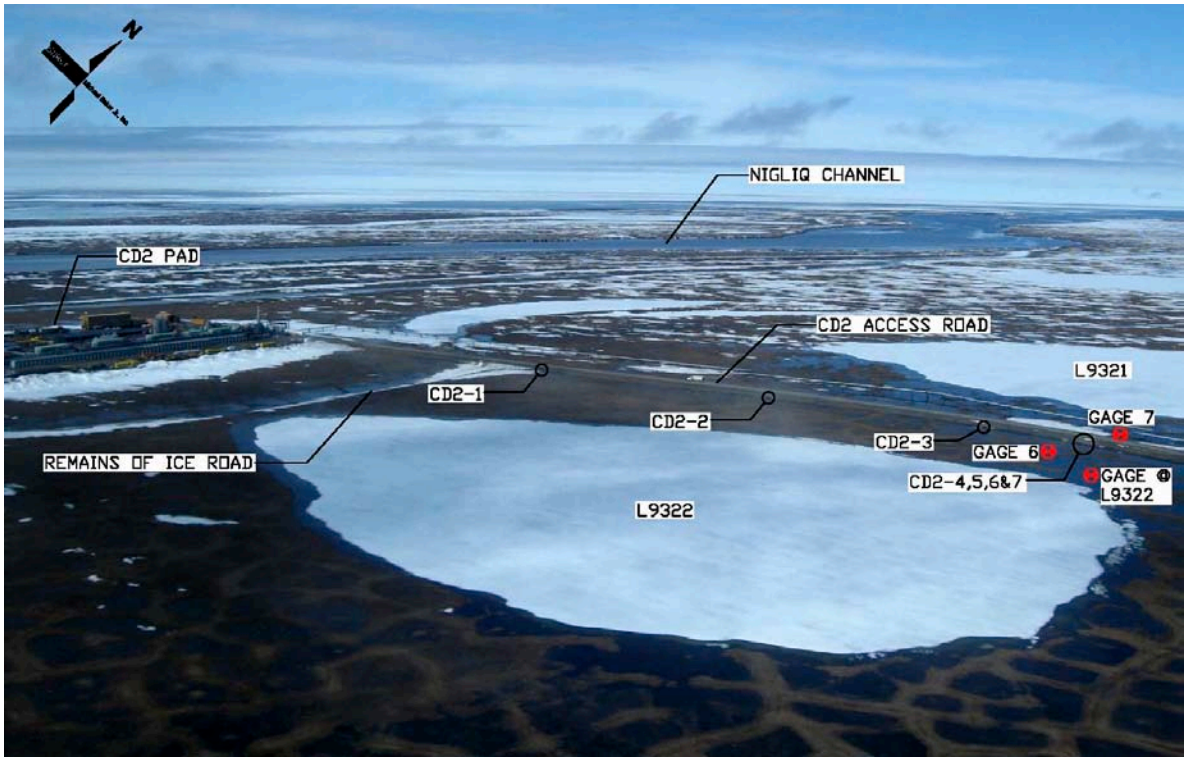


Figure 4: View looking northwest taken May 31, 2009.

Water Quality

Water quality data, collected on May 18, 2009, are presented in Table 3. On the day of sampling, the ambient temperature was 30°F to 35°F with winds 10 to 15 miles per hour.

Physical Parameters

On the day of sampling, ice thickness ranged from 5.2 feet to 5.8 feet. There was no observed snow cover on the ice at any of the four sampling locations. Ice thickness was 5.2 feet at SL-1 and 5.3 feet at SL-2. Ice thickness increased to 5.8 feet at SL-3. The ice thickness was 5.5 feet at SL-4.

Freeboard was relatively consistent at all locations, ranging from 0.4 to 0.5 foot. Freeboard at SL-1, SL-3, and SL-4 was measured at 0.4 foot. Freeboard was 0.5 foot at SL-2. Observed water depths ranged from 10.7 to 11.5 feet. Water column depth, from bottom-of-ice to bottom-of-lake, ranged from 5.2 feet at SL-4 and 5.7 feet at SL-3, to 6.0 feet at SL-2 and 6.1 feet at SL-1.

Temperature

Temperature profiles were fairly consistent, increasing with depth before moderating at approximately 8 to 9 feet of depth. The minimum temperature was 1.2°C just below the ice at SL-4. Observed temperatures were between 2.0°C and 2.2°C at the other three sampling locations at the first sampling interval below the ice. At greater depths, temperatures ranged from 2.4°C near lake bottom at SL-2, to temperatures in the 2.7°C to 2.9°C range at all other sampling locations and depths. The lowest temperatures were associated with the sampling depths nearest the ice-water interface. Temperatures were fairly constant below the 8.0 foot depth.

Specific Conductance

Conductivity and specific conductance were relatively consistent at all four sampling locations. The average specific conductance across all four sampling locations was 382 µS/cm. Specific conductance ranged from 369 µS/cm at SL-4 to an upper value of 391 µS/cm at SL-3. Overall, values for specific conductance did not vary much between sampling locations or with depth.

Baker

Lake L9322 Water Quality

18-May-09

Table 3

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 N70°20'16.4" W151°01'57.1" 8:35 a.m.	11.3	5.2	0.4	7.0	2.0	214	381	2.3	16.9	6.48
				9.0	2.9	221	382	1.5	11.1	6.48
				11.0	2.8	220	383	1.3	9.8	6.57

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 N70°20'18.1" W151°01'51.9" 8:45 a.m.	11.3	5.3	0.5	7.0	2.0	214	382	2.4	17.7	6.49
				9.0	2.8	220	382	*0.6*	4.7	6.47
				11.0	2.4	214	376	1.3	9.3	6.47

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 N70°20'16.1" W151°01'43.1" 8:50 a.m.	11.5	5.8	0.4	7.0	2.2	219	388	3.7	27.0	6.53
				9.0	2.8	225	391	5.3	39.1	6.57
				11.0	2.9	225	389	6.2	45.5	6.58

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 N70°20'16.4" W151°01'52.0" 9:05 a.m.	10.7	5.5	0.4	6.0	1.2	201	369	3.3	23.8	6.53
				8.0	2.7	220	383	3.2	23.7	6.55
				10.0	2.9	221	382	3.7	27.5	6.53

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.

(7) No snow cover on lake.

pH

Observed pH remained relatively consistent with depth. The average pH was 6.5 across all sampling locations and depths. Values for pH ranged from a minimum of 6.47 at SL-2 to a maximum value of 6.58 at SL-3. The reported accuracy of the meter for recording pH values is +/- 0.2 pH units.

Dissolved Oxygen (DO)

Sampling locations SL-1 and SL-2 exhibited similar trends in dissolved oxygen concentration profiles, with dissolved oxygen generally decreasing with increased depth. Dissolved oxygen was 2.3 mg/L and 2.4 mg/L at 7.0 feet of depth for SL-1 and Sl-2, respectively. In both cases, dissolved oxygen decreased to 1.3 mg/L at 11.0 feet.

The lowest dissolved oxygen level recorded was a value of 0.6 mg/L at 9.0 feet of depth at SL-2. This value was checked twice during the fieldwork to verify, but seems to be a deviation from the other sampling values. Figure 5 shows the sampling locations overlaid on lake bathymetry. Given the location of SL-2 compared to the other sampling locations, it is possible that this area is very close to a more shallow area in the lake.

Dissolved oxygen values at SL-3 were generally higher than all other sampling locations, and increased with increasing depth. Values at SL-3 were 3.7 mg/L at 7.0 feet, 5.3 mg/L at 9.0 feet, and 6.2 mg/L at 11.0 feet.

Dissolved oxygen values at SL-4 remained relatively consistent with depth, increasing slightly with depth. Dissolved oxygen values at SL-4 ranged from 3.3 mg/L and 3.4 mg/L at 6.0 and 8.0 feet of depth, to a value of 3.7 mg/L at 10.0 feet of depth.

Dissolved oxygen concentrations were generally lower than values observed in February at all four sampling locations.

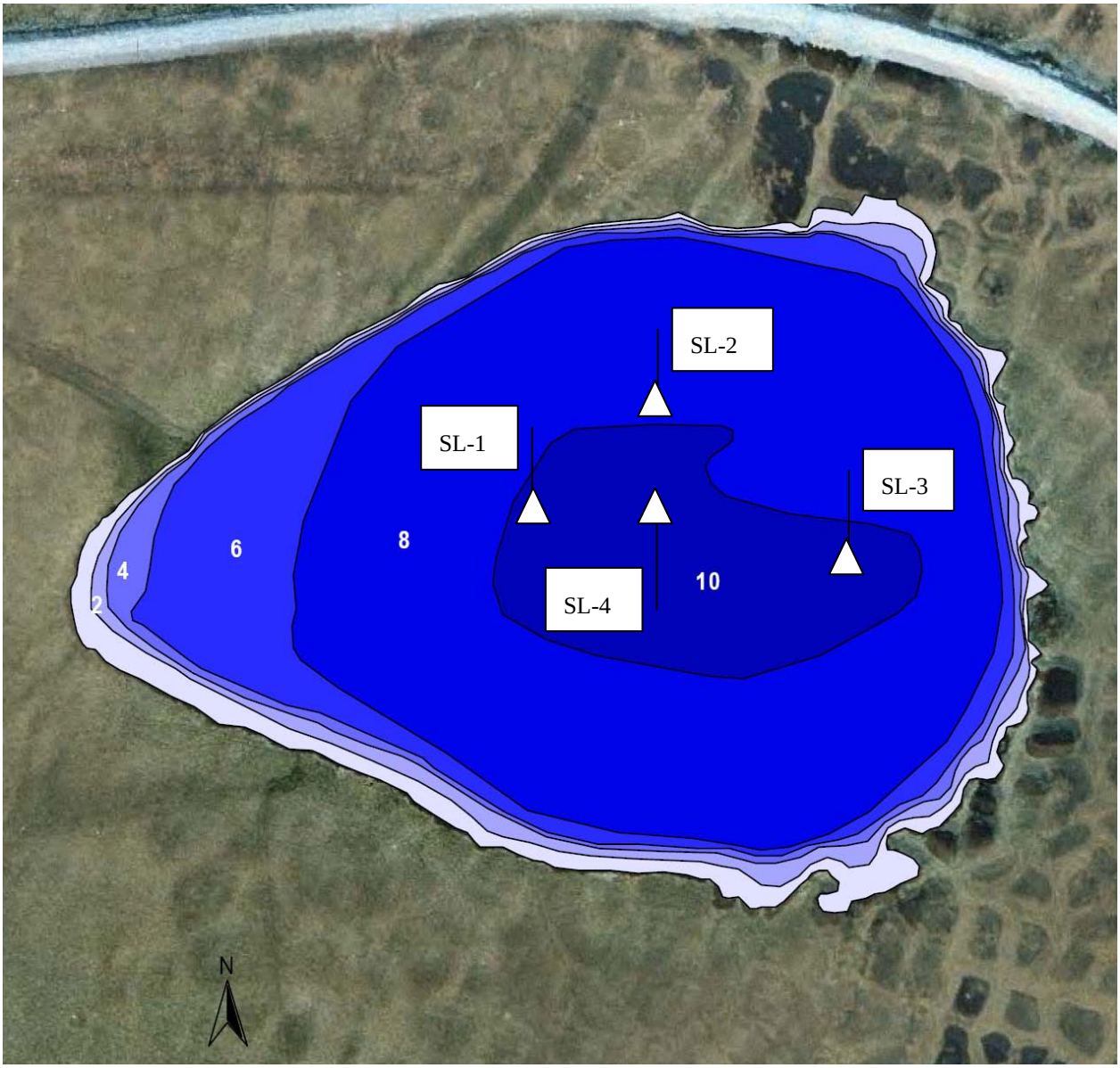


Figure 5: Lake Bathymetry with sample locations. Bathymetry courtesy of Moulton, 2002.

Summary

Lake L9322 was fully recharged via spring breakup floodwaters. This determination is based on visual observations and the rapid rise and fall in water surface elevation observed during breakup, as illustrated in Graph 1. Recharge of the lake occurred over a period of approximately 72 hours beginning on May 22. Floodwaters from the Nigliq Channel recharged Lake L9322 above the bankfull elevation. An estimated peak water surface elevation of 7.68 feet (BPMSL) was measured on May 25. Water continued to drain from L9322 as of June 1 to an elevation of 7.34 feet (BPMSL).

No major anomalies in water quality parameters were observed at Lake L9322 during the spring breakup water quality monitoring event.

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