Lake Survey Data for the Coastal Plain from the Sagavanirktok River to Bullen Point: Spring 2006

Drilling a sampling hole in lake ice, D. White

by

Daniel White, Michael Lilly, Molly Chambers,

Kristie Hilton, and Peter Prokein

July 2006

Sagavanirktok River/Bullen Point Hydrology Project

Report No. INE/WERC 06.02

Lake Survey Data for the Coastal Plain from the Sagavanirktok River to Bullen Point: Spring 2006

by

Daniel White[1], Michael Lilly[2], Molly Chambers[1],
Kristie Hilton[2], and Peter Prokein[1]

A report on research sponsored by the

Alaska Department of Transportation and Public Facilities

July 2006

Sagavanirktok River/Bullen Point Hydrology Project

Report Number INE/WERC 06.02

[1]University of Alaska Fairbanks, Water and Environmental Research Center
[2]Geo-Watersheds Scientific, Fairbanks, Alaska

Recommended Citation:

White, D.M., Lilly, M.R., Chambers, M., Hilton, K.M., and Prokein, P., 2006. Lake survey data for the coastal plain from the Sagavanirktok River to Bullen Point: Spring 2006. July 2006, University of Alaska Fairbanks, Water and Environmental Research Center, Report INE/WERC 06-02, Fairbanks, Alaska, 14 pp.

Fairbanks, Alaska
July 2006

For additional information write to:

Publications,
Water and Environmental Research Center
University of Alaska Fairbanks
Fairbanks, Alaska 99775
www.uaf.edu/water/

TABLE OF CONTENTS

TABLE OF CONTENTS i
LIST OF FIGURES i
LIST OF TABLES ii
DISCLAIMER iii
CONVERSION FACTORS, UNITS, WATER QUALITY UNITS, VERTICAL AND HORIZONTAL DATUM, ABBREVIATIONS AND SYMBOLS iv
ABSTRACT viii
ACKNOWLEDGEMENTS viii
INTRODUCTION 1
OBJECTIVES 3
PROCEDURE 3
RESULTS 4
SUMMARY 13
REFERENCES 14
APPENDIX A. WATER QUALITY ASSURANCE DATA 15

LIST OF FIGURES

Figure 1. Study area and lake location map for the Sagavanirktok River/Bullen Point Region, North Slope, Alaska. 2
Figure 2. Badami gravel pit chemistry profiles. 7
Figure 3. Shaviovik gravel pit chemistry profiles. 9

Figure 4. Satellite imagery of lakes (a) W0609, (b) W0610, (c) W0611, and (d) W0612 (MDA Federal 2004, ESA 1994-1999). 12

LIST OF TABLES

Table 1. Sampling locations and physical measurements. 5

Table 2. Badami gravel pit chemistry data. 6

Table 3. Shaviovik gravel pit chemistry data 8

Table 4. Lake W0609 chemistry data 10

DISCLAIMER

CONVERSION FACTORS, UNITS, WATER QUALITY UNITS, VERTICAL AND HORIZONTAL DATUM, ABBREVIATIONS AND SYMBOLS

Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (mm)
mile (mi)	1.609	kilometer (km)
	Area	
Acre	43559.826	square feet (ft^2)
Acre	0.407	hectare (ha)
square foot (ft^2)	2.590	square mile (mi^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	3785	milliliter (mL)
cubic foot (ft^3)	23.317	liter (L)
Acre-ft	1233	cubic meter (m^3)
	Velocity and Discharge	
foot per day (ft/d)	0.3048	meter per day (m/d)
Square foot per day (ft^2/d)	.0929	square meter per day (m^2/d)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/sec)
	Hydraulic Conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per day (ft/d)	0.00035	centimeter per second (cm/sec)
meter per day (m/d)	0.00115	centimeter per second (cm/sec)
	Hydraulic Gradient	
foot per foot (ft/ft)	5280	foot per mile (ft/mi)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Pressure	
pound per square inch (lb/in^2)	6.895	kilopascal (kPa)

Units

For the purposes of this report, both English and Metric (SI) units were employed. The choice of "primary" units employed depended on common reporting standards for a particular property or parameter measured. Whenever possible, the approximate value in the "secondary" units was also provided in parentheses. Thus, for instance, stream flow was reported in cubic feet per second (cfs) followed by the approximate value in cubic meters per second (m^3/s) in parentheses.

Physical and Chemical Water-Quality Units:

Temperature:

Water and air temperature is given in degrees Celsius (°C) and in degrees Fahrenheit (°F).

Degrees Celsius can be converted to degrees Fahrenheit by use of the following equation:

$$°F = 1.8(°C) + 32$$

Specific electrical conductance (conductivity):

Conductivity of water is expressed in microsiemens per centimeter at 25°C (μS/cm). This unit is equivalent to micromhos per centimeter at 25°C.

Milligrams per liter (mg/L) or micrograms per liter (μg/L):

Milligrams per liter is a unit of measurement indicating the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million.

Millivolt (mV):

A unit of electromotive force equal to one thousandth of a volt.

Vertical Datum:

In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929), a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called *Sea Level Datum of 1929*.

Horizontal Datum:

The horizontal datum for all locations in this report is the North American Datum of 1983.

Abbreviations, Acronyms, and Symbols

AC	Actual conductivity
ADOT&PF	Alaska Department of Transportation and Public Facilities
ASTM	American Society for Testing and Materials
atm	atmospheres
C	Celsius
DO	Dissolved oxygen
DVM	digital voltage multi-meter
e-tape	electric tape
F	Fahrenheit (^{o}F).
ft	feet
GWS	Geo-Watersheds Scientific
GWSI	USGS Ground-Water Site Inventory
km^2	square kilometers
kPa	kilopascal
lb/in^2	pounds per square inch
m	meters
mg/L	milligrams per liter
μg/L	micrograms per liter
mi^2	square miles
mm	millimeters
μS/cm	microsiemens per centimeter
mV	Millivolt
NGVD	National Geodetic Vertical Datum
NWIS	National Water Information System
ORP	oxygen-reduction potential
ppm	parts per million
QA	quality assurance
QC	quality control
SC25	specific conductance at 25^{o}C
UAF	University of Alaska Fairbanks
USACE	U.S. Army Corps of Engineers, Alaska District
USGS	U.S. Geological Survey
WERC	Water and Environmental Research Center
WWW	World Wide Web
YSI	Yellow Springs Instruments

ABSTRACT

Water resources are limited in many areas of the North Slope, Alaska, particularly during mid-winter operations. Water is used both for ice road construction and maintenance, drilling and facility operations, and potable water supplies. The coastal plain area between the Sagavanirktok River and Bullen Point has numerous shallow lakes. Identifying potential water sources for this region will help both industry and resource-management agencies. Sampling conducted in the spring of 2006 served as a preliminary study of lakes. Field chemistry measurement, lake depth, ice thickness, and snow measurements were collected at each site. Lakes with a potential for unfrozen water in mid-winter were pre-selected for field sampling. Two former gravel mine sites (also referred to as lakes) were also sampled to help identify mid-winter water availability and water chemistry characteristics. The natural lakes sampled were generally found to have little under-ice water available. The two gravel mine sites had the greatest available water volumes and also had the highest dissolved oxygen in all, or most of the water column. Data from this project will also be used for analysis in the North Slope Lakes project, sponsored by the US Department of Energy.

ACKNOWLEDGEMENTS

This project was funded by grant ADN #2562122, Alaska Department of Transportation and Public Facilities. Field coordination was provided by BP Exploration (Alaska) Inc. and the Department of Natural Resources provided background data for lakes in the study area.

Lake Survey Data for the Coastal Plain from the Sagavanirktok River to Bullen Point: Spring 2006

INTRODUCTION

Water resources are essential to gravel road and ice road / pad construction on the North Slope, yet many natural lakes are too shallow to provide significant freshwater resources through the winter operations period. The coastal plain between the Sagavanirktok River and Bullen Point, east of the Canning River, has had numerous oil and gas exploration activities conducted over the last 25 years. Future development in this region will need a network of water sources, including natural lakes and gravel-mine sites. Available water sources in this region provide an opportunity for concurrent gravel procurement and water-resource development. Existing gravel pits as well as selected lakes between Prudhoe Bay and Bullen Point were visited at the end of winter, 2006. Chemical profiles of gravel pits showed the potential of deep lakes and gravel pits to provide significant water resources as well as fish over-wintering habitat. Physical and chemical measurements show that many natural lakes are insufficient for use as winter water resources. Although not monitored, the larger rivers in the area (Sagavanirktok, Kadleroshilik, Shaviovik, and Kavik Rivers) have low winter baseflows and are not generally considered potential sites for obtaining water in the winter months.

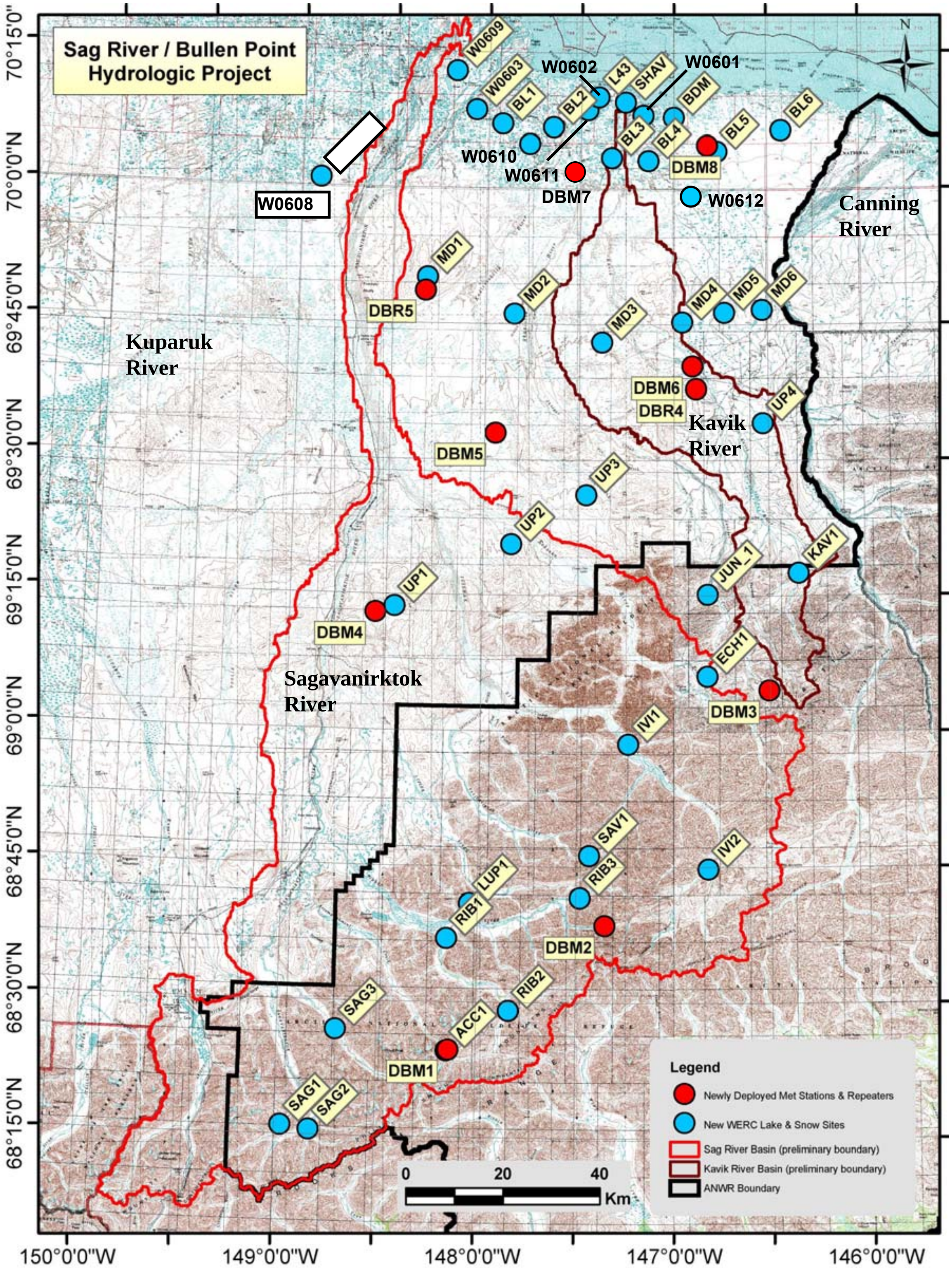

Figure 1. Study area and lake location map for the Sagavanirktok River/Bullen Point Region, North Slope, Alaska.

PROCEDURE

Lakes selected for the study fell within 15 miles of the arctic coast, from the Sagavanirktok River to Bullen Point, which is approximately 40 miles east (Figure 1). There is no current road access to the lakes and all lakes were accessed by helicopter. At each lake the ice was drilled with a 2-inch ice auger powered by a cordless drill. Physical measurements of depth (lake bottom to water surface), freeboard (water surface to top of ice), ice thickness (bottom of ice to top of ice), and snow depth (top of ice to top of snow, measured at the hole where snow was cleared to drill) were taken with a folding measure with a hook for feeling the bottom of ice or a weighted flexible measuring tape. The precision with which physical measurements are reported takes into account field conditions. Temperature, pH, oxidation-reduction potential (ORP), dissolved oxygen (DO), and electrical conductivity were measured with a Yellow Springs Instruments (YSI) 556 multi-parameter meter. The calibration of each parameter was checked before and after each day of sampling. To pass the calibration check, pH had to be within 0.2 pH units and ORP, DO, and conductivity had to be within 10% of the calibration standard value. All parameters passed each check and DO and conductivity checks had error less than 5% (Appendix A). Actual conductivity (AC) was temperature compensated to specific conductivity at 25°C (SC_{25}) by 2% per degree Celsius (Hem 1985).

OBJECTIVES

The objectives of this report are to provide lake data collected in the early spring of 2006. Spring snowmelt had not started and lake ice conditions were at a winter maximum. Snow depth measurements on and adjacent to lakes were also collected to help with regional hydrologic analysis. This data will help resource developers and management agencies evaluate potential water sources in the region, and areas where future water sources are needed.

RESULTS

Nine lakes and reservoirs were visited along the potential Bullen Point road corridor (Table 1). Of these, Badami and Shaviovik gravel pits and lake W0609 had enough sub-ice water for chemistry measurements. An additional lake (W0601, latitude N 70.1275590, longitude W 147.1577966, NAD 83) was visited, but no ice was found, only sediments and vegetation.

The Badami and Shaviovik gravel pits, which now serve as reservoirs, are deep relative to the natural lakes in the area. Age and sediment conditions likely account for the differences in profiles observed. Badami (Table 2, Figure 2) had high oxygen levels throughout the depth of the reservoir. On the other hand, Shaviovik Pit (Table 3, Figure 3) had a dissolved oxygen curve expected of a lake with significant oxygen consumption within the sediments. Temperature and pH varied little through the vertical profile of the gravel pits, though a slight increase in temperature with depth in Shaviovik is consistent with the stratification expected of lakes in winter due to the maximum density of water near 4°C. Conductivity, indicative of dissolved salts, also increased in the lower parts of the reservoirs. ORP remained relatively high near the bottom of the deep lakes.

Table 1. Sampling locations and physical measurements.

Location[a]	North Latitude (NAD83)	West Longitude (NAD83)	Date	Ice thickness (ft)	Water depth (ft)[b]	Freeboard (ft)	Snow depth (ft)
Badami chemistry	70.13026	146.99872	4/30/2006	~ 6.5[c]	28.1	0.6	0.1
Badami hole 2	70.12975	146.99802	4/30/2006	7.0	22.3	0.5	0.2
Shaviovik chemistry	70.15843	147.25415	5/3/2006	5.1	32.9	0.22	0.3
W0609 chemistry	70.21412	148.17752	5/2/2006	4.46	5.9	0.08	1.0
W0609 hole 2	70.21363	148.17821	5/2/2006	4.50	5.4	-0.13	- -
W0610 hole 1	70.08219	147.78024	5/2/2006	3.85	dry	- -	0.9
W0610 hole 2	70.08396	147.78462	5/2/2006	5.38	5.87[d]	0.33	- -
W0611 hole 1	70.14442	147.46007	5/2/2006	4.65	dry	- -	- -
W0611 hole 2	70.14433	147.45700	5/2/2006	5.5	5.6[d]	0.3	0.5
W0612 hole 1	70.01359	146.89888	5/3/2006	4.83	3.78[d]	1.42	0.5
W0612 hole 2	70.01408	146.89569	5/3/2006	4.9	dry	- -	- -
W0602[e] hole 1	70.16447	147.39891	4/30/2006	1.6	dry	- -	- -
W0602[e] hole 2	70.16396	147.39722	4/30/2006	1.75	dry	- -	- -
W0602[e] hole 3	70.16225	147.39473	4/30/2006	0.85	dry	- -	- -
W0602[e] hole 4	70.16294	147.39134	4/30/2006	1.55	dry	- -	- -
W0602[e] hole 5	70.16408	147.39330	4/30/2006	1.42	dry	- -	- -
W0602[e] hole 6	70.16542	147.39912	4/30/2006	1.7	dry	- -	- -
W0603 hole 1	70.14255	148.07011	4/30/2006	0.75	dry	- -	1.2
W0603 hole 2	70.14073	148.07478	4/30/2006	2.65	dry	- -	1.2
W0603 hole 3	70.14108	148.07956	4/30/2006	2.6	dry	- -	0.8
W0603 hole 4	70.14303	148.08151	4/30/2006	- -	dry	- -	- -
W0608 hole 1	70.15462	148.47794	5/1/2006	3	dry	- -	1.3
W0608 hole 2	70.15402	148.48233	5/1/2006	3	dry	- -	1.4
W0608 hole 3	70.15339	148.47832	5/1/2006	3.3	dry	- -	1.2
W0608 hole 4	70.15321	148.47598	5/1/2006	2.2	dry	- -	0.9
W0608 hole 5	70.15415	148.47659	5/1/2006	2.6	dry	- -	1.1
W0608 hole 6	70.15495	148.47633	5/1/2006	3.25	dry	- -	1.0
W0608 hole 7	70.15543	148.47592	5/1/2006	2.65	dry	- -	1.2

[a]Locations in italics had enough sub-ice water for water chemistry measurements.

[b]Bottom of lake to water surface

[c]Too deep for folding measure, used almost all of 2 meter auger length plus auger bit

[d]Too muddy for water chemistry

[e]W0602 is the same site as snow measurement site L43, shown in Figure 1

Table 2. Badami gravel pit chemistry data.

Location	Badami Pit			
Date	4/30/2006	**Depth BWS (ft)**	28.1	
Latitude	N 70.13023	**Freeboard (ft)**	0.6	
Longitude	W 146.99872	**Ice thickness (ft)**	~ 6.5	(too thick for folding tape)
Datum	NAD 83	**Snow depth (ft)**	~ 0.1	

Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**ORP (mV)**	**DO (mg/L)**	**Conductivity AC (µS/cm)**	**Conductivity SC_{25} (µS/cm)***
	5	0.3	7.59	109.1	17.94	135	267
12:21	6	0.2	7.54	114.5	16.38	136	270
	7	0.2	7.52	116.0	16.60	137	272
	8	0.05	7.49	119.3	16.76	137	273
	10	0.02	7.52	116.2	16.75	142	284
	12	0.03	7.56	117.9	17.03	144	288
	14	0.04	7.48	118.3	16.60	161	321
12:28	16	0.11	7.46	121.2	16.66	169	337
	18	0.21	7.44	122.9	16.24	188	373
	20	0.22	7.43	122.8	15.97	189	375
	22	0.22	7.39	124.4	16.10	191	379
	24	0.23	7.39	126.3	15.94	193	382
	25	0.23	7.45	123.8	15.28	194	384
	26	0.23	7.43	125.2	15.62	194	384
	27	0.24	7.42	125.5	15.67	195	386
	28	0.24	7.43	126.5	15.72	197	390
	28.1**	0.24	7.37	127.8	15.44	199	394

*Temperature corrected by 2% per degree Celsius.
**29 feet of cable down hole, probe on lake bottom

Sampled by: Chambers, White
Instrument: YSI 556 SN#04G127880AA
Pre-sampling calibration check: pass 4/29/06
Post-sampling calibration check: pass 4/30/06

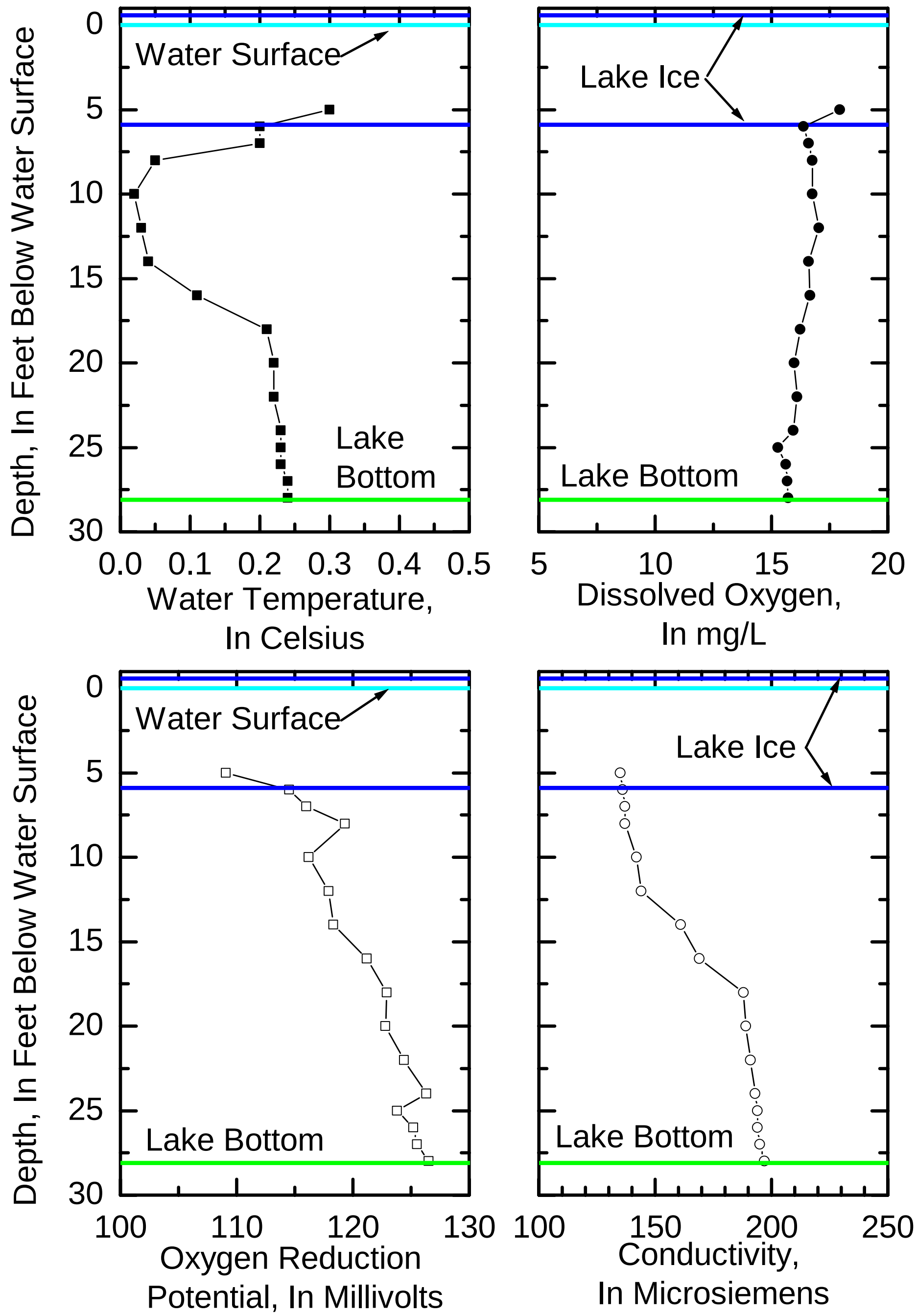

Figure 2. Badami gravel pit chemistry profiles.

Table 3. Shaviovik gravel pit chemistry data.

Location	Shaviovik Pit		
Date	5/3/2006	**Depth BWS (ft)**	32.9
Latitude	N 70.15843	**Freeboard (ft)**	0.22
Longitude	W 147.25415	**Ice thickness (ft)**	5.1
Datum	NAD 83	**Snow depth**	~ 0.25 ft

Time	Depth (ft BWS)	Temp. °C	pH	ORP (mV)	DO (mg/L)	Conductivity AC (µS/cm)	Conductivity SC_{25} (µS/cm)*
17.21	5	0.14	6.67	80.8	17.74	181	360
17.22	6	0.08	6.72	80.9	17.46	180	359
17.23	7	0.09	6.72	82.6	17.17	180	359
17.24	9	0.15	6.80	86.0	16.96	179	356
17.25	11	0.17	6.81	87.4	16.85	179	356
17.26	13	0.18	6.83	85.8	16.86	179	355
17.27	15	0.18	6.85	86.5	16.80	179	355
17.28	20	0.27	6.92	84.5	16.61	179	354
17.30	25	0.45	6.95	84.2	14.35	178	350
17.32	26	0.47	6.96	88.4	14.23	179	351
17.33	27	0.47	6.94	89.0	13.26	179	351
17.40	28	0.49	6.98	94.8	7.41	179	351
17.42	30	0.48	6.78	101.2	3.66	186	365
17.45	31	0.47	6.80	102.7	0.76	208	408
17.50	32	0.46	6.74	- -	0.44	248	487

*Temperature corrected by 2% per degree Celsius.

Sampled by: Chambers, Lilly
Instrument: YSI 556 SN#04G127880AA
Pre-sampling calibration check: pass 5/2/06
Post-sampling calibration check: pass 5/3/06

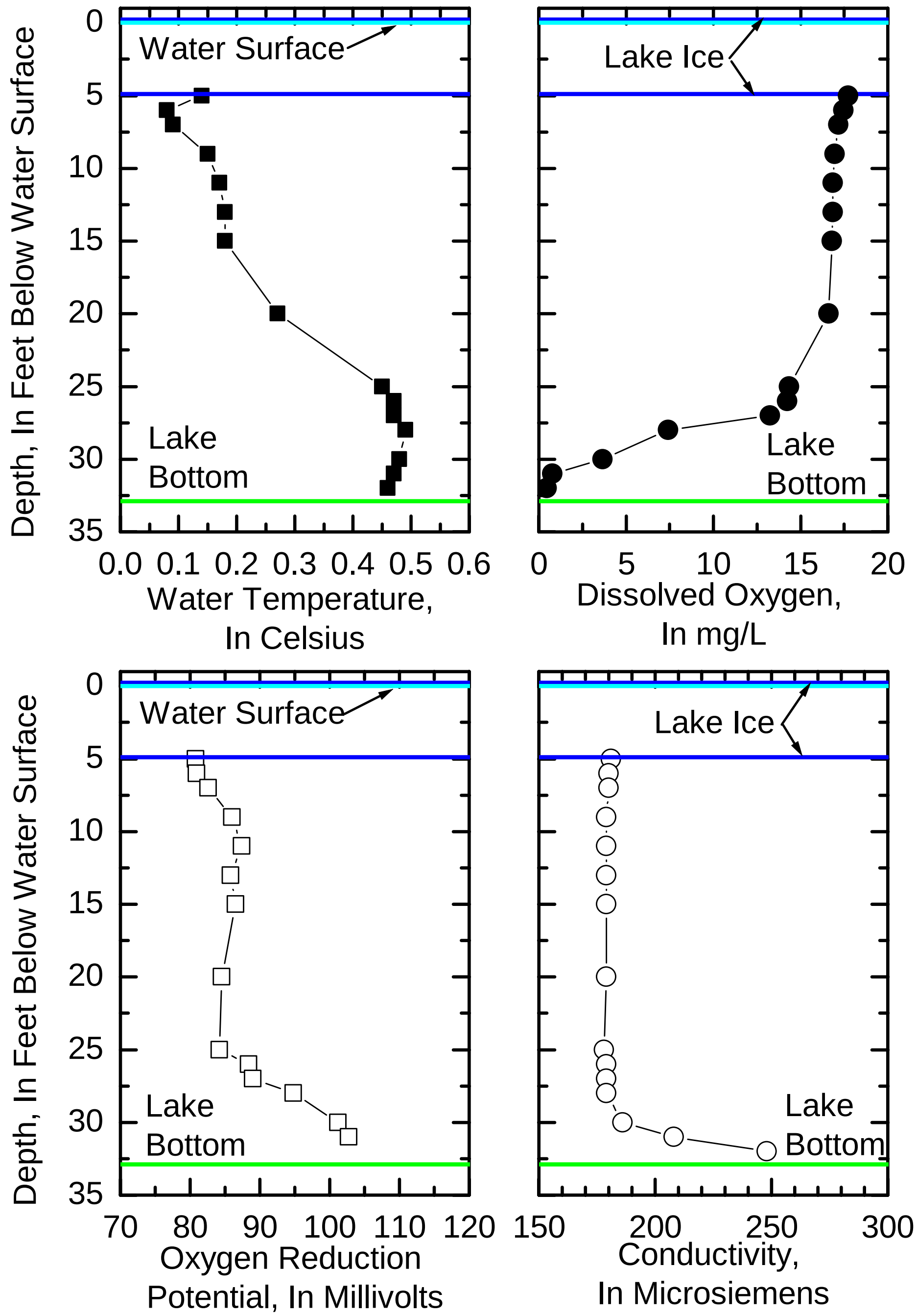

Figure 3. Shaviovik gravel pit chemistry profiles.

Lake W0609 was the only natural lake sampled in the Sagavanirktok River to Bullen Point region where there was enough sub-ice water to measure chemical parameters. Water was found in W0612, W0611, and W0610, but was so shallow that the auger stirred up sediment and prevented chemical profiling.

As seen in table 4, there was still little sub-ice water in W0609. This short water column had low dissolved oxygen and high conductivity. Exclusion of dissolved salts during the formation of ice likely increased the conductivity from unfrozen levels. While oxygen is also excluded from freezing ice, consumption by sediments had depleted the small store of oxygen in the lake to levels unsuitable for most fish.

Table 4. Lake W0609 chemistry data

Location	W0609		
Date	5/2/2006	**Depth BWS (ft)**	5.9
Latitude	N 70.21412	**Freeboard (ft)**	0.08
Longitude	W 148.17752	**Ice thickness (ft)**	4.46
Datum	NAD 83	**Snow depth (ft)**	1.0

						Conductivity	
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**ORP (mV)**	**DO (mg/L)**	**AC (µS/cm)**	**SC_{25} (µS/cm)***
16.00	4.5	0.03	6.88	87.0	1.87	1095	2187
16.02	5.0	-0.02	6.90	79.7	1.68	1091	2184
16.04	5.5	-0.02	6.92	72.5	1.55	1090	2182

*Temperature corrected by 2% per degree Celsius.

Sampled by: Chambers, Lilly
Instrument: YSI 556 SN#04G127880AA
Pre-sampling calibration check: pass 4/30/06 and 5/1/06 (DO)
Post-sampling calibration check: pass 5/2/06

Hole locations (Table 1) are plotted on Landsat images of lakes W0609, W0610, W0611 and W0612 in figure 4. Synthetic aperture radar (SAR) images adjacent to the Landsat images give some indication of the likelihood of finding liquid water (Duguay and Lefleur, 2003; Jeffries and others, 1995). The Landsat images (left, color) show the locations of sampling sites. The SAR images (right, grayscale) are from January or February of low snow years (a, c: January 22, 1999; b: January 26, 1994; d: February 24, 1999). Dark areas on the SAR image during this stage of the winter indicate grounded ice. Bright or white areas indicate liquid water under the ice at the time of the image. While some sample locations are very close to the shore, deepest (brightest) parts of the lake are not always near the center (Figure 4). Access issues affected site selection at a lake as the helicopter pilot, for safety reasons, often preferred landing on the shore to landing on the lake. While we had coordinates for the centers of the lakes, the lakes were often indistinguishable from the surrounding tundra, so locating a specific portion of the lake proved difficult.

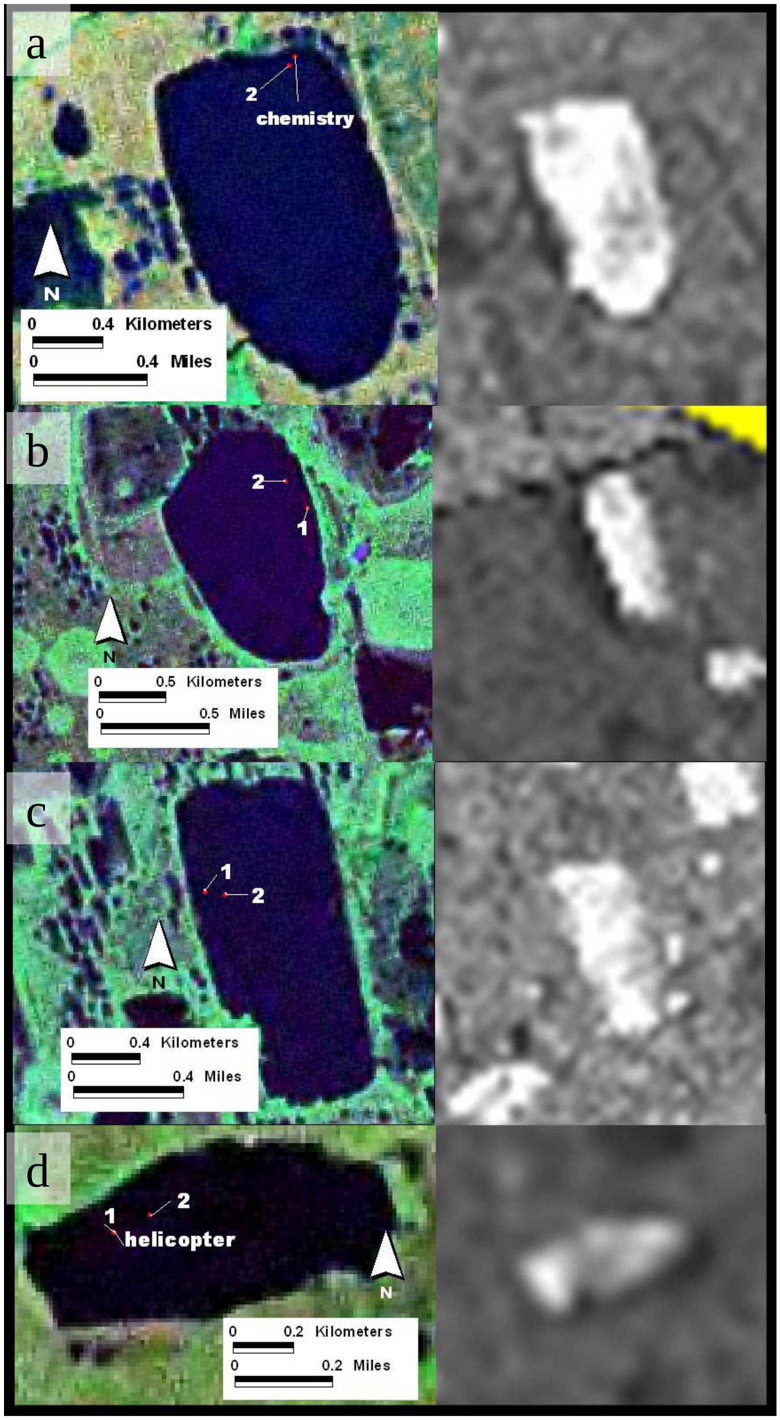

Figure 4. Satellite imagery of lakes (a) W0609, (b) W0610, (c) W0611, and (d) W0612 (MDA Federal 2004, ESA 1994-1999).

SUMMARY

The collected data indicate that little mid- to late-winter water is available in the natural lakes sampled in the coastal plain between Prudhoe Bay and Bullen Point. The two gravel mines, now serving as water sources, both had high dissolved oxygen levels through all, or most, of the water column. Neither mine site indicated high salinity levels. These sites help serve as a good example of converting gravel mines to winter water-use reservoirs. The use of SAR satellite data helped indicate lakes with potential water under ice. Additional investigation of water availability in late winter through SAR imagery would help better characterize regional water availability. The location of gravel mine sites in areas with adequate recharge characteristics will help improve the distribution and volume of winter water availability.

REFERENCES

Duguay, C.R. and Lafleur, P.M., 2003. Determining depth and ice thickness of shallow sub-Arctic lakes using space-borne optical and SAR data. *Int. J. Remote Sensing* **24**(3): 475-489.

Hem, J.D., 1985. Study and interpretation of the chemical characteristics of natural water 3rd ed. USGS Report 2254.

ESA 1994-1999. ERS-1/ERS-2 Standard Beam Full Resolution. Fairbanks, Alaska: Alaska SAR Facility

Jeffries, M.O., Morris, K., and Liston, G.E., 1995. A method to determine lake depth and water availability on the North Slope of Alaska with Spaceborne Imaging Radar and Numerical Ice Growth Modeling. Arctic vol. 48, no.4, p.367-374.

MDA Federal 2004. Landcover 2000/ETM+ Edition Mosaics. Tile N-06-65, N-06-70. Sioux Falls, Dakota: USGS

APPENDIX A. WATER QUALITY ASSURANCE DATA

The following table reports the pre- and post-calibration checks for water quality meters used during field sampling.

Instrument: YSI 556 SN# 04G127880AA **Rented from TTT, Anchorage**

Date		Conductivity			pH			DO			ORP		
pass/fail	**By**	standard*	reading	error (%)	standard*	reading	difference	standard*	reading	error (%)	standard*	reading	error (%)
4/19/2006	TT	1.413 mS	1.413 mS	0	7.000	7.02	0.02	100	99.4	-0.6	220	228	3.6
pass					4.01	4.00	-0.01						
					10.000	10.04	0.04						
4/21/2006	MC	338	346	2.4	4.01	3.95	-0.06	100	99.2	-0.8	251	236.3	-5.9
pass					7.00	7.02	0.02						
					10.00	10.03	0.03						
4/29/2006	MC	252	264	4.8	4.01	4.11	0.10	100	104.6	4.6	246	232.9	-5.3
pass					7.00	7.09	0.09						
					10.00	10.08	0.08						
4/30/2006	MC	285	296	3.9	4.01	4.07	0.06	100	103.9	3.9	238	217.6	-8.6
pass					7.00	7.11	0.11						
					10.00	10.16	0.16						
5/1/2006	MC							100	102.5	2.5			
pass													
5/2/2006	MC	315	326	3.5	4.01	4.06	0.05	100	102.1	2.1	233	212.2	-8.9
pass					7.00	7.07	0.07	0	1.8	n/a			
					10.00	10.05	0.05						
5/3/2006	MC	319	328	2.8	4.01	4.09	0.08	100	104.1	4.1	232	211.0	-9.1
pass					7.00	7.08	0.08	0	0.15	n/a			
					10.00	10.07	0.07						
5/4/2006	MC	316	330	4.4	4.01	4.07	0.06	100	101.7	1.7	231	213.5	-7.6
pass					7.00	7.09	0.09	0	0.20	n/a			
					10.00	10.05	0.05						
				max error: 4.8%		**max. difference:**	**0.16**		**max error:**	**4.6%**		**max error:**	**-9.1%**

*Standard values were temperature compensated. Saturated DO standard was chilled, bubbled nanopure water. The conductivity standard was also chilled. Conductivity was measured as actual conductance, and results must be temperature compensated to specific conductance. A 2% per degree to 25°C compensation is recommended.

Units--conductivity: µS/cm unless otherwise noted; pH: pH units; DO: % of saturation for temperature, barometric pressure; ORP: mV

Error/recalibration cut-offs: recalibration was deemed necessary when error exceeded 10% or 0.2 pH units.