Lake Survey Data for the Kuparuk Foothills Region: Spring 2008

Jeff Derry helps William Schnabel prepare for helicopter work, by Greta Myerchin.

by

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July 2008

Kuparuk Foothills Hydrology Project

Report No. INE/WERC 08.05

Water and Environmental Research Center

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by

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A report on research sponsored by the

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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 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

Electrical Conductance (Actual Conductivity and Specific Conductance):

In this report conductivity of water is expressed as Actual Conductivity [AC] in microSiemens per centimeter (µS/cm). This unit is equivalent to micromhos per centimeter. Elsewhere, conductivity is commonly expressed as Specific Conductance at 25°C [SC25] in µS/cm which is temperature corrected. To convert AC to SC25 the following equation can be used:

$$SC25 = \frac{AC}{1 + r(T - 25)}$$

where:

SC25 = Specific Conductance at 25°C, in µS/cm

AC = Actual Conductivity, in µS/cm

R = temperature correction coefficient for the sample, in °C

T = temperature of the sample, in °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 (ppm).

Millivolt (mV):

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

Vertical Datum:

"Sea level" in the following report 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 or North American Datum of 1927.

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
INE	Institute of Northern Engineering
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

The abundance of natural lakes is limited in the Kuparuk Foothills region of the North Slope, Alaska. As a consequence, the water resources required for oil and gas activities are often limited during mid-winter operational periods. Such water resources are needed for ice road construction and maintenance, drilling and facility operations, and potable water supplies. The Foothills region area between the Sagavanirktok River and the Kuparuk River has numerous shallow lakes on the north side of the White Hills. Identifying potential water sources for this region will help both industry and resource-management agencies. Sampling conducted in spring 2008 served as part of an ongoing study of lakes. Field chemistry measurements, lake depth, ice thickness, and snow measurements were collected at each site visited. Lakes with a potential for unfrozen water in mid-winter were pre-selected for field sampling. Due to poor weather conditions, four of five potential lake sites were visited and sampled, including two lakes previously sampled in the 2007 survey. The natural lakes sampled were generally found to have little or no under-ice water available. The greatest depth of sub-ice water observed was just over three feet. 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 #2562123, Alaska Department of Transportation and Public Facilities. Alaska Department of Natural Resources provided background data for lakes in the study area. Information was also provided by Kuparuk Watershed projects funded by the National Science Foundation.

Lake Survey Data for the Kuparuk Foothills Region: Spring 2008

INTRODUCTION

Water resources are essential for construction and maintenance of gravel roads, and ice road / pad construction on the North Slope of Alaska, yet many natural lakes are too shallow to provide significant freshwater throughout the winter operations period. The area between the Sagavanirktok River and the Kuparuk River has numerous, but shallow, lakes in the White Hills region. Future development in this area will need a network of natural lakes, or gravel-mine sites to provide water. In planning transportation networks, an opportunity for concurrent gravel procurement and water resource development exists. Physical and chemical measurements show that many natural lakes are insufficient for use as winter water resources or overwintering fish habitats. Although not monitored, the larger rivers in the area (Kuparuk and Toolik) have low winter baseflows and are not generally considered potential sites for obtaining water in the winter months.

OBJECTIVES

The objective of this report is to make available the lake data which were collected in the early spring of 2008. At the time of sampling, 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. These data will help resource developers and management agencies evaluate potential water sources in the region, and areas where future water sources are needed.

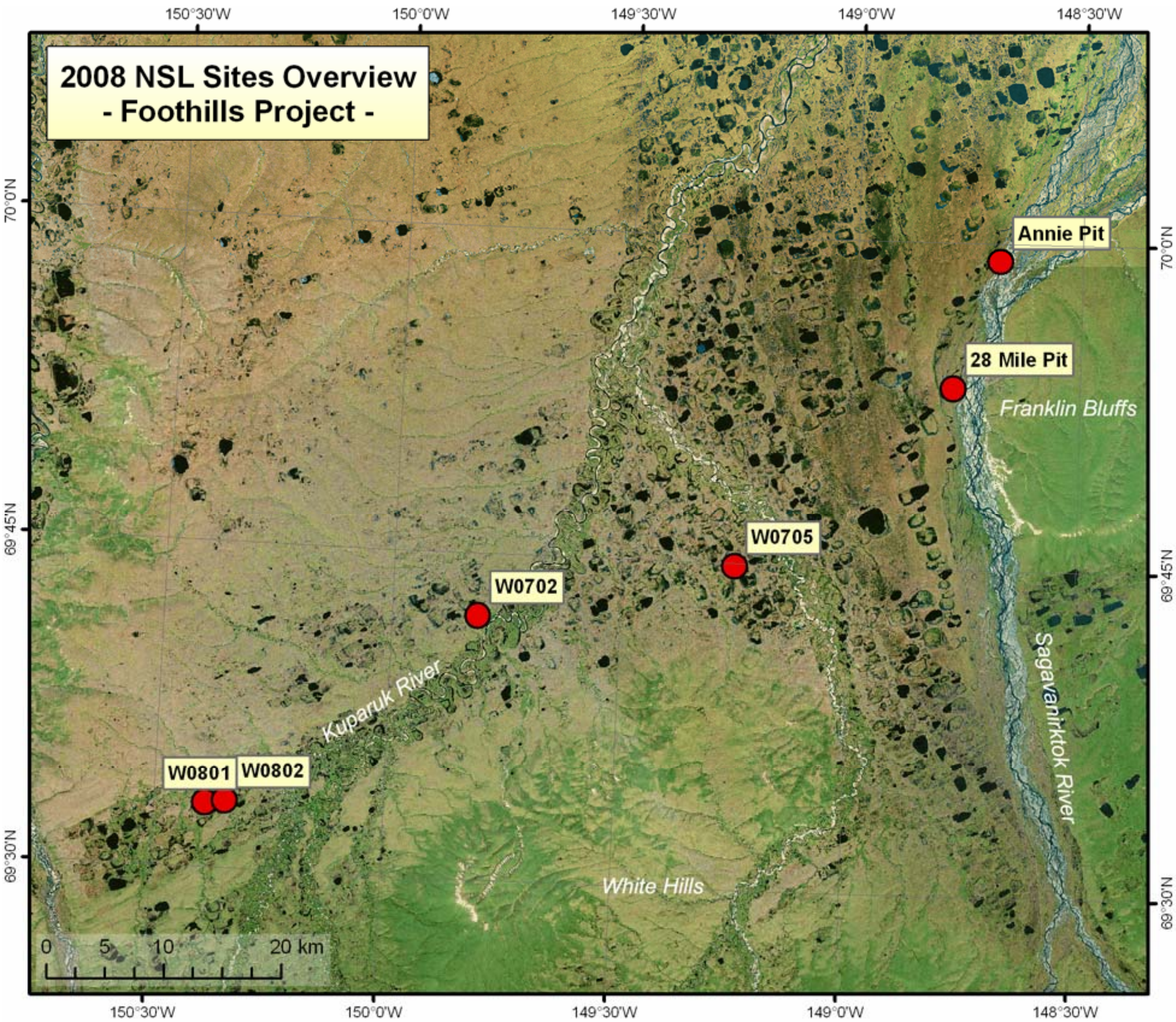


Figure 1. Study area and lake location map for Kuparuk foothills region, North Slope, Alaska.

PROCEDURE

Lakes selected for the study fell between 50 and 60 miles south of the arctic coast, and within 30 miles to the west of the Dalton Highway (Figure 1). As seen in Figure 1, few lakes are present in the foothills relative to the coastal plain. 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 hole where snow was cleared to drill) were taken with 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. DO, ORP and pH parameters passed each check (Appendix A). Conductivity failed post-calibration for all sites and results are not included in this report.

RESULTS

Four lakes were visited in the Kuparuk foothills region (Table 1). Of these, two had enough sub-ice water for chemical measurements. The water column depths in the sampled lakes varied from about 1.5 to 3.5 feet. In the two natural lakes sampled for water chemistry, dissolved oxygen and oxidation-reduction potential were relatively low, indicating an environment which may be unable to provide sufficient end of winter oxygen for fish if water was withdrawn throughout the winter (Tables 2 and 3).

Table 1. Sampling locations and physical measurements.

Location	North Latitude (NAD 83)	West Longitude (NAD 83)	Date	Ice thickness (ft)	Water depth (ft)	Freeboard (ft)	Snow depth (ft)
W0801	69 32.99	150 23.24	5/7/2008	4.67	6.26	0.17	0.96
W0802: hole 2	69 33.16	150 20.70	5/7/2008	4.17	dry	---	0.75
W0802: hole 3	69 33.14	150 20.68	5/7/2008	3.17	dry	---	0.77
W0702	69 42.16	149 48.53	5/7/2008	4.46	7.88	0.25	0.88
W0705: hole 1	69 44.90	149 15.11	5/7/2008	5.67	dry	---	0.83
W0705: hole 2	69 44.900	149 15.119	5/7/2008	5.83	dry	---	0.33

Table 2. Lake W0801 chemistry data.

Location	W0801		
Date	5/7/2008	**Depth BWS (ft)**	6176
Latitude	N 69 32.99	**Freeboard (ft)**	0.45
Longitude	W 150 23.24	**Ice thickness (ft)**	4.67
Datum	NAD 83	**Snow depth (ft)**	0.96

Time	Depth (ft BWS)	Temp. °C	pH	ORP (mV)	DO (mg/L)	DO (%)
15:00	5	0.67	5.44	109.1	6.5	46
	6	0.79	5.28	65.1	5.70	39
	6.25	0.85	5.23	30.0	4.85	34

Sampled by: Myerchin, Schnabel
Instrument: YSI 556 SN#04D5945AC
Pre-sampling calibration check: pass 5/5/08
Post-sampling calibration check: pass 5/8/08

Figure 2. WO801 chemistry profiles.

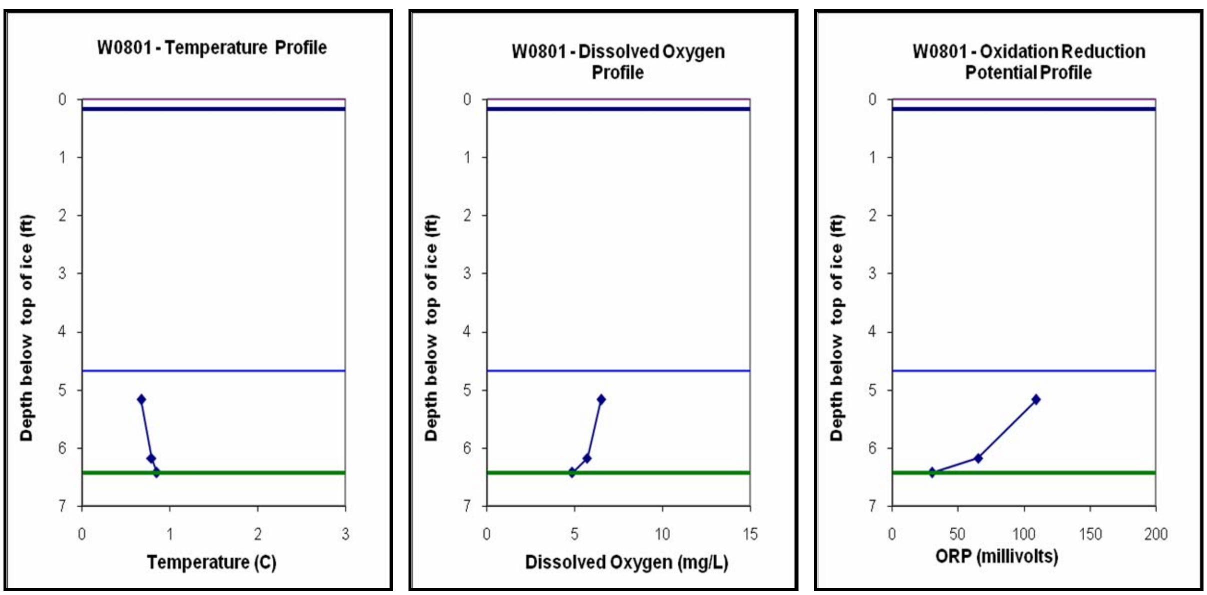
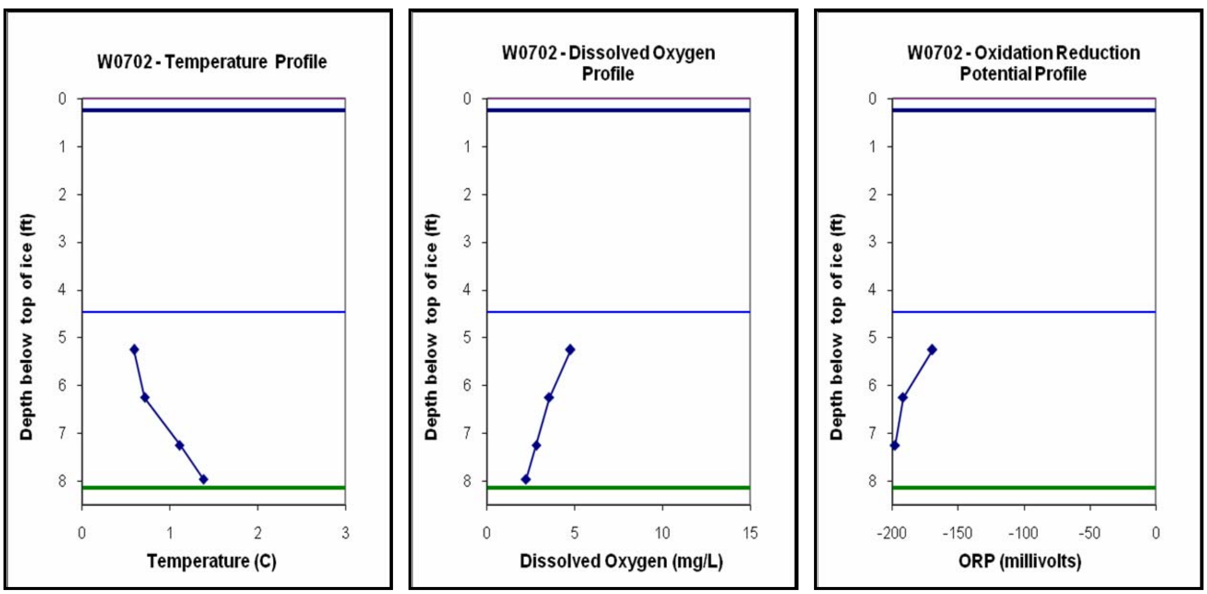


Table 3. Lake W0702 chemistry data.

Location	W0702					
Date	5/7/2008	**Depth BWS (ft)**	7.88			
Latitude	N 69 42.16	**Freeboard (ft)**	0.25			
Longitude	W 149 48.53	**Ice thickness (ft)**	4.46			
Datum	NAD 83	**Snow depth (ft)**	0.88			
Time	**Depth (ft BWS)**	**Temp. °C**	**pH**	**ORP (mV)**	**DO (mg/L)**	**DO (%)**
18:15	5	0.59	7.04	-169.6	4.76	33.6
	6	0.71	7.08	-192.0	3.53	24.9
	7	1.11	7.11	-198.0	2.80	20.0
	7.7	1.38	7.22	-214.0	2.23	16.1

Sampled by: Myerchin, Schnabel
Instrument: YSI 556 SN#04D5945AC
Pre-sampling calibration check: pass 5/5/08
Post-sampling calibration check: pass 5/8/08

Figure 3. WO702 chemistry profiles.



Dissolved oxygen concentrations have been a consistent concern when evaluating potential winter water sources. Although many references disagree with what constitutes an acceptable level of dissolved oxygen, for this project we are referencing requirements cited by Cott, et al. for Canadian and Alaskan fish. On average, these cold water freshwater fish require between 4 and 6 mg/l of DO, and mortality can occur when oxygen concentrations become 2.0 mg/l or less

(Cott, et al, 2008). Biota in small, isolated water bodies are particularly sensitive to winter water level reductions since these withdrawals can limit the oxygen available to overwintering fish and the decreasing water levels can reduce the available fish habitat or cause freezing of essential littoral zones (Cott, et al., 2008). Table 4 outlines the oxygen concentration thresholds for select species which occur in Northern Canada and Alaska. When considering that these lakes are at or below the average requirements, it's plausible to assume that water usage from these sources could potentially reduce oxygen concentrations and water levels below acceptable limits and should therefore not be considered viable water resources.

Table 4. Oxygen Concentration Thresholds for Select Fish Species Occurring in Northern Canada and Alaska (from Cott, et al. 2008, based on Doudoroff and Shumway, 1970).

Species	Age or Size	Lethal O_2 (mg/l)	Deaths	Exposure	Water (°C)	Methods/Thresholds
Broad whitefish: *Coregonus nasus*	1 day	1.9	–	Declining O_2	12	Cessation of opercular movements
	120 days	1.9	–	Declining O_2	12	Cessation of opercular movements
	209 days	1.1	–	Declining O_2	10	Cessation of opercular movements
Chum salmon: *Oncorhynchus keta*	Fingerling	2	–	–	–	Methods unknown
Yellow perch: *Perca flavescens*	78 g	<2.0	1	Declining O_2	19-24	CO_2 tensions 0-40 mmHg
	89-99 g	0.5-0.8	0.5	Declining O_2	12-21	Loss of equilibrium
	–	3.1	1	Constant O_2 48 h	15	Fish held in cage submerged in a lake in summer
	–	1.5	0.5	Constant O_2 48 h	4 or less	Fish held in cage submerged in a lake in winter
	7.6 cm	0.9-1.1	0.5	Declining O_2	18-27	Loss of equilibrium, graph interpolation
Burbot: *Lota lota*	830 g	<2.0	1	Declining O_2	12-18	CO_2 tensions 0-40 mmHg
	–	1.4-3.2	First	–	0	Methods unknown
Brook stickleback: *Culaea inconstans*	0.6 g	<2.0	1	Declining O_2	20-23	CO_2 tensions 0-40 mmHg
White sucker: *Catostomus commersonii*	265 g	<2.0	1	Declining O_2	17-18	CO_2 tensions 0-40 mmHg
Pearl dace: *Semotilus margarita*	5.3 cm	<2.0	1	Declining O_2	18-19	CO_2 tensions 0-40 mmHg
Inconnu: *Stenodus leucichthys*	–	4.0-4.5	First	–	0	Methods unknown
Northern pike: *Esox lucius*	–	3.1	100%	Constant O_2 24 h	15	Fish held in cage submerged in a lake in summer
	–	2.3	100%	Constant O_2 48 h	4 or less	Fish held in cage submerged in a lake in winter
	–	0.2-0.5	100%	Declining O_2	0-20	Methods unknown
	–	0.3-0.6	First		0	Methods unknown
	–	0.5-1.6	About 50%	Declining O_2	15-25	Water gradually replaced with low O_2 water
	1-2 year	0.7-1.4	–	..	15-29	Methods unknown

Hole locations (Table 1) are plotted on a Landsat image of lake W0801, W0802, W0702, and W0705 in Figure 2. Images were generated in April, 2006. Viewing synthetic aperture radar (SAR) images adjacent to the Landsat images provides 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 spring images near to the date of maximum ice thickness. 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. Sampling locations were selected based on the brightest spots indicated by the SAR imagery.

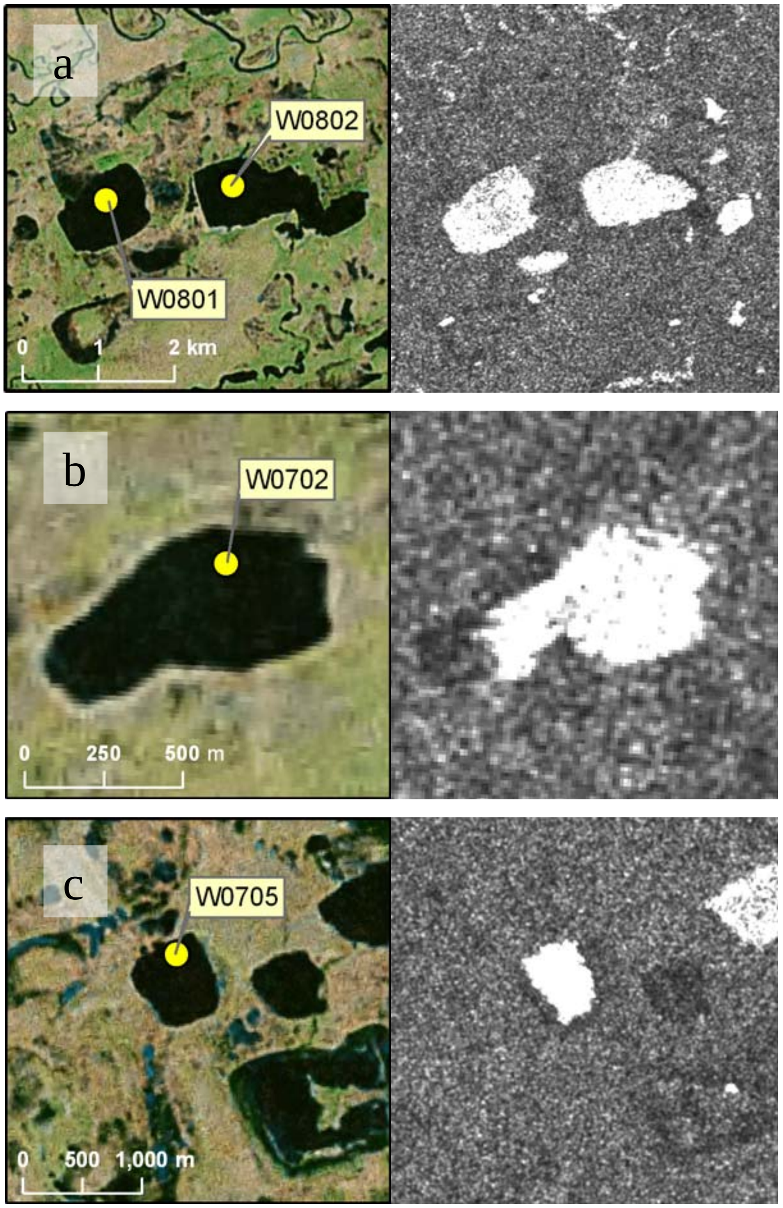


Figure 4. Satelline imagery of lakes (a) W0801 and W0802, (b) W0702, and (c) W0705 (MDA Federal 2006, ESA 1994-1999).

SUMMARY

The four natural lakes sampled in the Foothills region between the Sagavanirktok and Kuparuk Rivers contained little mid- to late-winter water, with maximum depths of sub-ice water up to 4 feet. The use of SAR satellite data was essential in identifying which lakes in the region had potential water under ice and helpful for characterizing regional water availability. As gravel mine sites could potentially serve as more effective reservoirs than naturally-occurring lakes, with fewer environmental impact risks, locating gravel mine sites in areas with adequate recharge characteristics could help improve the distribution and volume of winter water availability. Areas along streams or older drained lakes would serve as promising sites for gravel mines. These gravel mine sites should be able to provide abundant water for industry usage while protecting the shallow natural lakes in the area from potential environmental impacts associated with winter water withdrawal.

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APPENDIX A. WATER QUALITY ASSURANCE DATA

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

Calibration and Quality Assurance Information

Meter: YSI 556 MPS, S/N 04D55945 AC

Parameter	Date	Time	Standard	Lot No.	Exp.	Reading	Pass/ Fail
PRE-SAMPLING QA							
pH 4.01	5/5/08	0930	Oakton	2801177	Dec-09	4.03 @ 6.07 C	Pass
pH 7.00	5/5/08	0930	Oakton	2803372	Mar-10	7.08 @ 5.62C	Pass
pH 10.00	5/5/08	0930	Oakton	2803401	Sep-09	10.00 @ 5.62 C	Pass
Conductivity (µS/cm)	5/5/08	0930	Oakton 447 µS/cm	2709363	Sep-08	277 @ 5.05 C	Pass
ORP (mV)	5/5/08	0930	Zobells	1802303	Nov-08	228 @ 5.06 C	Pass
DO 100 (%)	5/5/08	0930	Nanopure Water	----	----	92.3 @ 7.13 C	Pass
DO 0 (%)	5/5/08	0930	Oakton	2706384	Jun-08	3.0 @ 4.69 C	Pass
POST-SAMPLING QA							
pH 4.01	5/8/08	0840	Oakton	2801177	Dec-09	3.90 @ 10.50 C	Pass
pH 7.00	5/8/08	0840	Oakton	2803372	Mar-10	6.90 @ 9.54 C	Pass
pH 10.00	5/8/08	0840	Oakton	2803401	Sep-09	10.08 @ 9.85 C	Pass
Conductivity (µS/cm)	5/8/08	0840	Oakton 447 µS/cm	2709363	Sep-08	149 @ 9.72 C	Fail
ORP (mV)	5/8/08	0840	Zobells	1802303	Nov-08	221.7 @ 9.80 C	Pass
DO 100 (%)	5/8/08	0840	Nanopure Water	----	----	105.6 @ 9.91 C	Pass
DO 0 (%)	5/8/08	0840	Oakton	2706384	Jun-08	3.0 @ 9.90 C	Pass