Lake Survey Data for the Kuparuk Foothills Region: Spring 2007

Helicopter pilot observes Greta Myerchin preparing for lake chemistry sampling, by Jeff Derry.

by

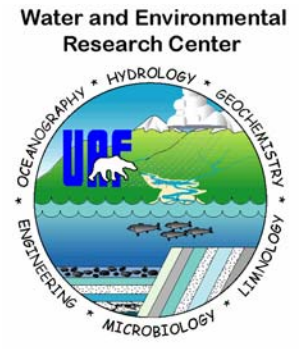
Greta Myerchin, Daniel White, Michael Lilly,

Kristie Holland, and Peter Prokein

September 2007

Kuparuk Foothills Hydrology Project

Report No. INE/WERC 07.15



Lake Survey Data for the Kuparuk Foothills Region: Spring 2007

by

Greta Myerchin[1],Daniel White [1], Michael Lilly[2],
Kristie Holland[2], and Peter Prokein[1]

A report on research sponsored by the

Alaska Department of Transportation and Public Facilities

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

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Fairbanks, Alaska
September 2007

For additional information write to:

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

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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°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 foothills region of the North Slope, Alaska, which affects the available water resources needed during mid-winter operations periods. Water is 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 2007 served as part of an ongoing study of lakes. Field chemistry measurements, 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. The natural lakes sampled were generally found to have little under-ice water available. The greatest depth of sub-ice water found 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 2007

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 habitat. 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 collected in the early spring of 2007. 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.

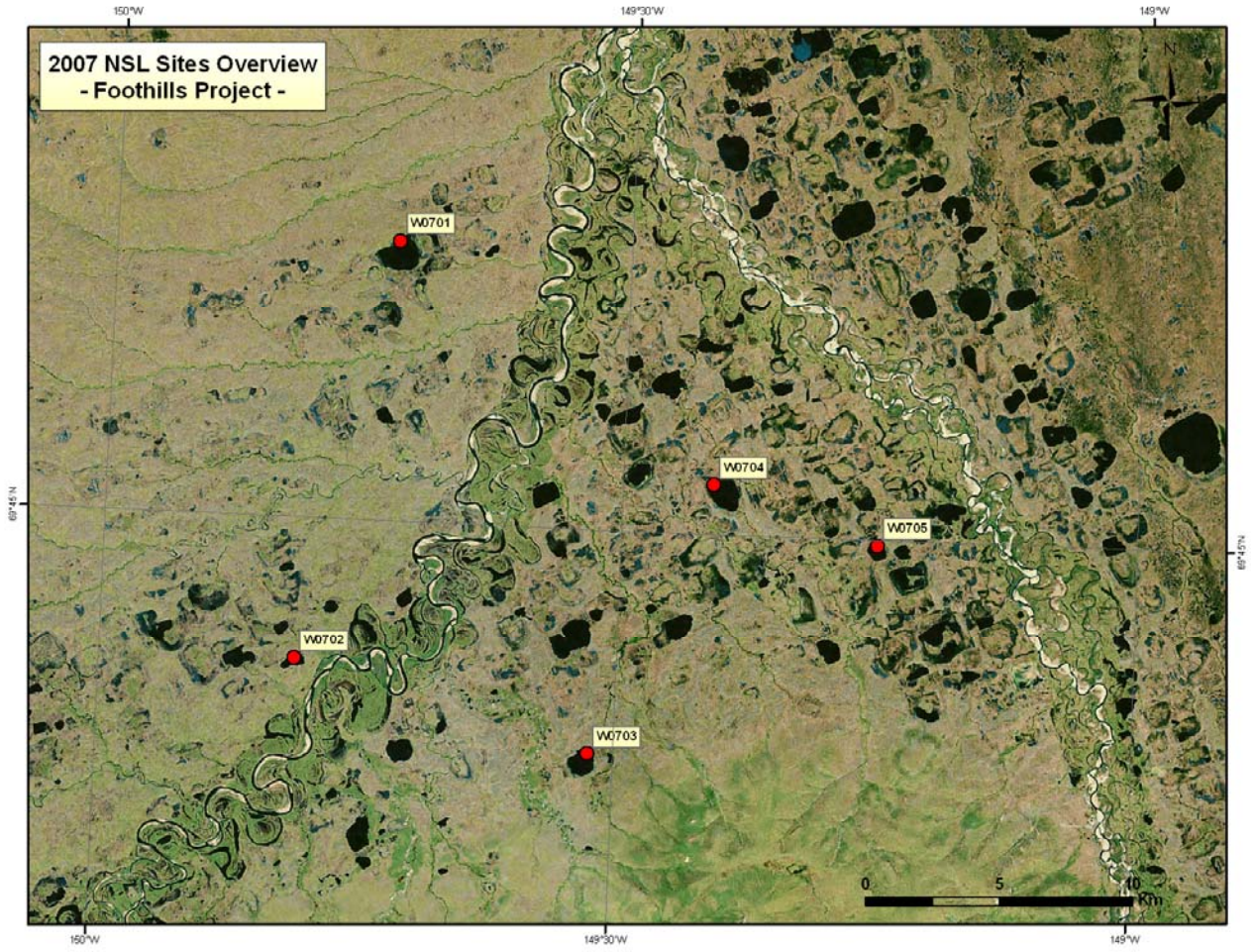


Figure 1. Study area and lake location map for Kuparuk foothills region, North Slope, Alaska.

PROCEDURE

Lakes selected for the study fell between 50 and 60 miles south of the arctic coast, and within 25 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 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. ORP and pH parameters passed each check. Conductivity checks passed for lake W0705. Actual conductivity (AC) was temperature compensated to specific conductivity at 25°C (SC_{25}) by 2% per degree Celsius (Hem 1985). DO checks failed post-calibration for lakes W0701-W0704 and was not verified for lake W0705 (Appendix A).

RESULTS

Five lakes were visited in the Kuparuk foothills region (Table 1). Of these, four had enough sub-ice water for chemistry measurements. Water was found in lake W0703 but was shallow enough that the auger stirred up sediment and prevented chemical profiling.

DO checks failed post-calibration for lakes W0701-W0704. An experiment was performed that demonstrates the DO measurements from this instrument are significant for the purpose of this report. The experiment included DO measurements of the two YSI instruments, one which passed all calibration checks and one that failed. DO measurements were obtained for both YSI instruments from the same lake, hole and time. A summary of results follows:

<u>YSI 556 SN#04D5945AB:</u>
DO measured in field (5.5’ depth): 3.33 mg/L/23%; DO Sat. calcheck: 106.2% (PASS);

<u>YSI 556 SN#04D5945AD:</u>
DO measured in field (5.5’): 3.61 mg/l/ 25.3%; DO Sat. calcheck: 124.0% (FAIL).

These results indicate the YSI that failed post-calibration check measured a DO value within 0.3 mg/L of the YSI that passed both calibration checks. The DO values measured by the YSI that failed are reportable since the margin of error is significantly small.

In all four of the natural lakes that were sampled for water chemistry, dissolved oxygen and oxidation-reduction potential were low, indicating a reducing environment with insufficient end of winter oxygen for fish (Tables 2, 3, 4, and 5). The water column depths in lakes varied from 2-inches to under 4 feet. Specific conductivities were high and ranged from 420 – 1120 µS/cm. Higher conductivities indicate exclusion of dissolved salts during the formation of ice. While oxygen is also excluded from freezing ice, it is consumed by sediments and depleted the small store of oxygen in the lake to levels unsuitable for most fish.

Table 1. Sampling locations and physical measurements.

Location [a]	North Latitude (NAD 83)	West Longitude (NAD 83)	Date	Ice thickness (ft)	Water depth (ft)[c]	Freeboard (ft)	Snow depth (ft)
W0701	69 50.66	149 43.54	5/4/2007	4.56	5.61	0.23	0.66
W0702	69 42.16	149 48.65	5/4/2007	3.94	7.81	0.10	1.15
W0703 hole 2	69 40.48	149 31.48	5/4/2007	5.05	5.38[c]	0.16	0.82
W0703 hole 3	69 40.48	149 31.48	5/4/2007	5.02	4.99[c]	0.59	0.66
W0703 hole 4	69 40.48	149 31.48	5/4/2007	5.41	4.83[c]	0.33	0.46
W0704	69 46.00	149 24.75	5/4/2007	4.72	4.9	0.2	0.75
W0705[a]	69 44.900	149 15.122	5/9/2007	4.33	6.33	0.13	0.98

[a]Coordinates datum WGS 84.
[b]Bottom of lake to water surface.
[c]Too muddy for water chemistry.

Table 2. Lake WO701 chemistry data.

Location	W0701		
Date	5/4/2007	**Depth BWS (ft)**	5.61
Latitude	N 69 50.66	**Freeboard (ft)**	0.23
Longitude	W 149 43.54	**Ice thickness (ft)**	4.56
Datum	NAD 83	**Snow depth (ft)**	0.66

Time	Depth (ft BWS)	Temp. °C	pH	ORP (mV)	*DO (mg/L)	Conductivity *AC (µS/cm)	Conductivity *SC_{25} (µS/cm)**
13:50	5	0.00	7.08	35.6	1.30	218	417
	5.5	0.01	7.03	34.0	0.95	222	425
	Bottom	0.00	7.03	-6.4	0.68	220	421

**Temperature corrected by 2% per degree Celsius.

Sampled by: Myerchin, White
Instrument: YSI 556 SN#04D5945AD
Pre-sampling calibration check: pass 5/1/07
*Post-sampling calibration check: pass 5/4/07 for pH, and ORP/ fail for DO and conductivity

Table 3. Lake WO702 chemistry data.

Location	W0702		
Date	5/4/2007	**Depth BWS (ft)**	7.81
Latitude	N 69 42.16	**Freeboard (ft)**	0.10
Longitude	W 149 48.65	**Ice thickness (ft)**	3.94
Datum	NAD 83	**Snow depth (ft)**	1.15

Time	Depth (ft BWS)	Temp. °C	pH	ORP (mV)	*DO (mg/L)	Conductivity *AC (µS/cm)	Conductivity *SC_{25} (µS/cm)**
12:30	4	0.48	7.27	-27.1	1.05	601	1129
	5	0.22	7.22	-28.7	0.80	595	1131
	6	0.35	7.16	-34.6	0.65	597	1129
	7	0.61	7.07	-42.4	0.60	603	1128
	7.5	0.82	7.10	-67.0	0.60	612	1136

**Temperature corrected by 2% per degree Celsius.

Sampled by: Myerchin, White
Instrument: YSI 556 SN#04D5945AD
Pre-sampling calibration check: pass 5/1/07
*Post-sampling calibration check: pass 5/4/07 for pH, and ORP/ fail for DO and conductivity

Table 4. Lake WO704 chemistry data.

Location	W0704		
Date	5/4/2007	**Depth BWS (ft)**	4.9
Latitude	N 69 46.00	**Freeboard (ft)**	0.2
Longitude	W 149 24.75	**Ice thickness (ft)**	4.72
Datum	NAD 83	**Snow depth (ft)**	0.75

Time	Depth (ft BWS)	Temp. °C	pH	ORP (mV)	*DO (mg/L)	Conductivity *AC (µS/cm)	Conductivity *SC_{25} (µS/cm)**
14;45	4.5	-0.03	7.22	-116.9	1.85	524	1004

**Temperature corrected by 2% per degree Celsius.

Sampled by: Myerchin, White
Instrument: YSI 556 SN#04D5945AD
Pre-sampling calibration check: pass 5/1/07
*Post-sampling calibration check: pass 5/4/07 for pH, and ORP/ fail for DO and conductivity

Table 5. Lake WO705 chemistry data.

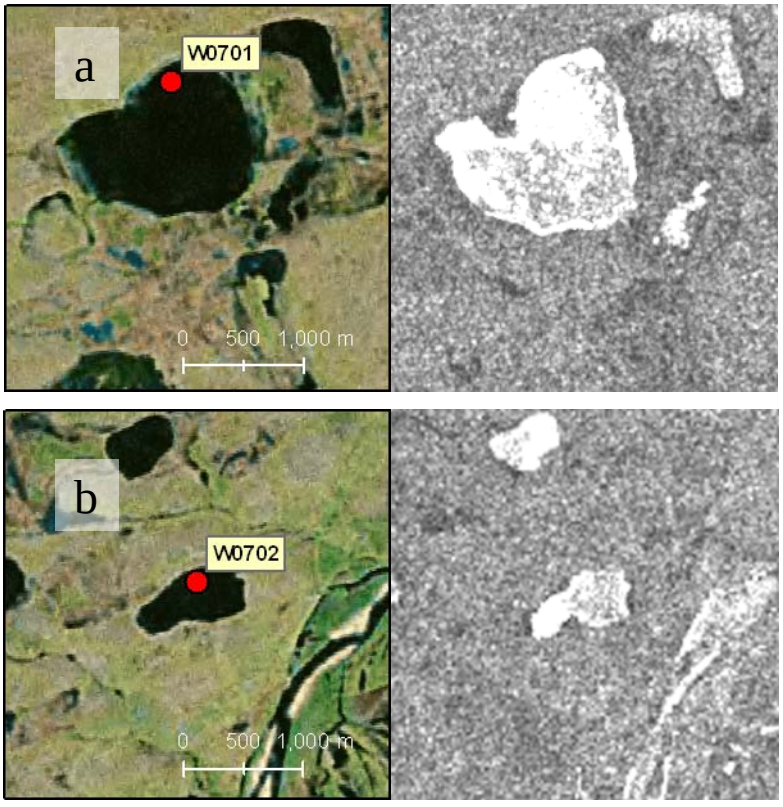
Location	W0705		
Date	5/9/2007	**Depth BWS (ft)**	6.33
Latitude	N 69 44.900	**Freeboard (ft)**	0.13
Longitude	W 149 15.122	**Ice thickness (ft)**	4.33
Datum	WGS 84	**Snow depth (ft)**	0.98

Time	Depth (ft BWS)	Temp. °C	pH	ORP (mV)	*DO (mg/L)	Conductivity AC (µS/cm)	Conductivity SC_{25} (µS/cm)**
13:05	5.5	0.08	7.14	-113.0	2.00	532	1016
13:08	6	0.6	7.11	-124.2	1.70	543	1018
13:11	6.5	0.67	7.13	-128.6	1.56	546	1020

**Temperature corrected by 2% per degree Celsius.

Sampled by: Myerchin, Derry
Instrument: YSI 556 SN#04D5945AB
Pre-sampling calibration check: pass 5/8/07
*Post-sampling calibration check: pass 5/9/07 for pH, ORP and conductivity/ unverified for DO

Hole locations (Table 1) are plotted on a Landsat image of lake W0701, W0702, W0703, W0704, and W0705 in Figure 2. 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 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.



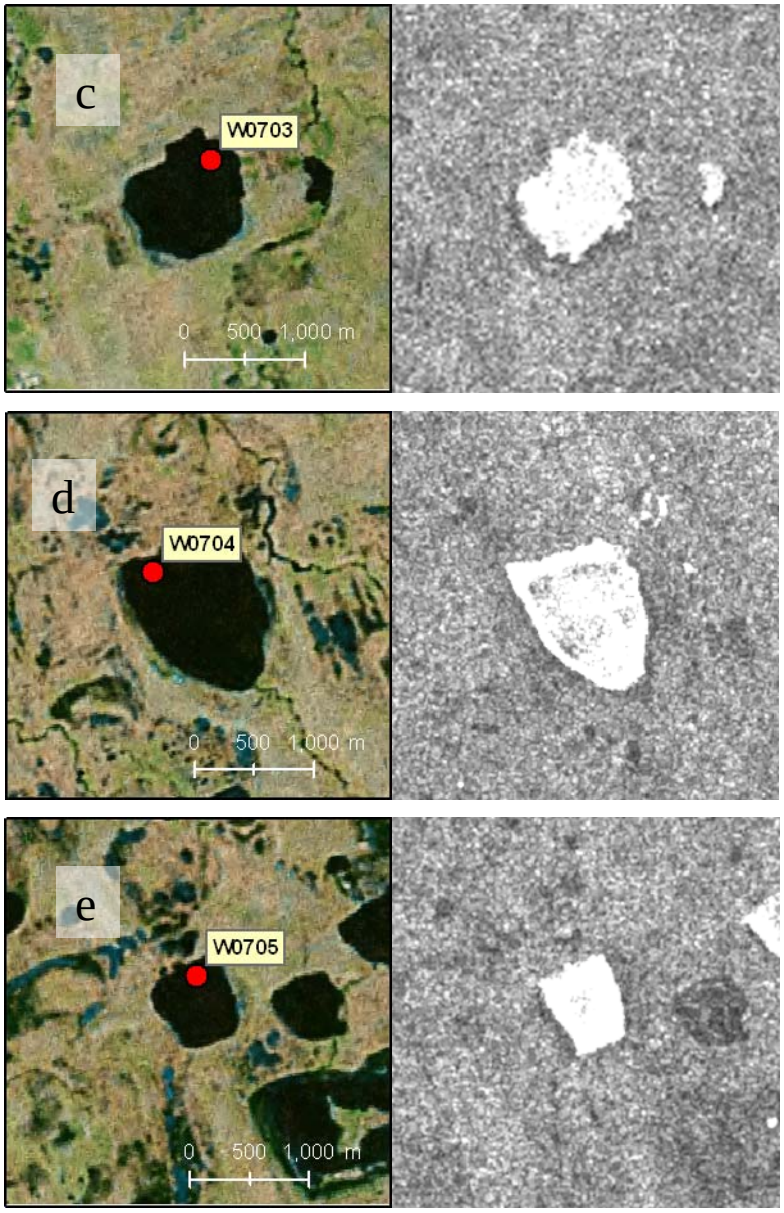


Figure 2. Satellite imagery of lakes (a) W0701, (b) W0702 , (c) W0703, (d) W0704 and (e) W0705 (MDA Federal 2004, ESA 1994-1999).

SUMMARY

The data collected indicate that several lakes contain little mid- to late-winter water in the foothills region area between the Sagavanirktok and Kuparuk Rivers 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. The location of gravel mine sites in areas with adequate recharge characteristics will help improve the distribution and volume of winter water availability. Areas along streams or older drained lakes with adequate recharge would both serve as potential areas for long-term water sources.

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.

University of Alaska Fairbanks, Water and Environmental Research Center

Form F-004e: Water Quality Meter Calibration Form

Project ID: **North Slope Lakes** Site Location/Lake ID: W0703, W0702,
Sample Purpose: **Lake Water Quality** W0701, W0704

WATER QUALITY METER INFORMATION

Meter Make: YSI Make: 556 MPS
Owner: TTT Environmental S/N: 04D55945 AD (yellow)

CALIBRATION AND QUALITY ASSURANCE INFORMATION

Pre-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH 4.01	5/1/07	1600	Oakton	2610086	Oct-08	3.99 @ 15.9	Pass
pH 7.00	5/1/07	1600	Oakton	2610087	Oct-08	7.04 @ 15.01	Pass
pH 10.00	5/1/07	1600	Oakton	2612532	Jun-08	10.12 @ 14.10	Pass
Conductivity	5/1/07	1600	Oakton 447us/cm	2701471	Jan-08	448 @ 24.85	Pass
DO 100	5/1/07	1600	Bubbled Nanopure	---	---	103.5 @ 10.98	Pass
ORP	5/1/07	1600	Quickcal	33240	Apr-07	237.3 @ 16.46	Pass

Post-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH 4.01	5/4/07	2032	Oakton	2610086	Oct-08	4.07 @ 17.10	Pass
pH 7.00	5/4/07	2032	Oakton	2610087	Oct-08	7.15 @ 17.95	Pass
pH 10.00	5/4/07	2032	Oakton	2612532	Jun-08	10.17 @ 17.97	Pass
Conductivity	5/4/07	2032	Oakton 447us/cm	2701471	Jan-08	447 @ 25.03	FAIL
DO 100	5/4/07	2032	Bubbled Nanopure	---	---	84.9 @ 18.22	FAIL
ORP	5/4/07	2032	Quickcal	33240	Apr-07	227 @ 19.30	Pass

Remarks:

Field-Form Filled Out By: Greta Myerchin Date: 6/12/2007
QAQC Check By: K. Holland Date: 6/30/2007

University of Alaska Fairbanks, Water and Environmental Research Center

Form F-004e: Water Quality Meter Calibration Form

Project ID: **North Slope Lakes** Site Location/Lake ID: W0705

Sample Purpose: **Lake Water Quality**

WATER QUALITY METER INFORMATION

Meter Make: YSI Make: 556 MPS

Owner: TTT Environmental S/N: 04D55945 AB (red)

CALIBRATION AND QUALITY ASSURANCE INFORMATION

Pre-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH 4.01	5/8/07	2100	Oakton	2610086	Oct-08	4.03 @ 17.99	Pass
pH 7.00	5/8/07	2100	Oakton	2610087	Oct-08	7.01 @ 19.28	Pass
pH 10.00	5/8/07	2100	Oakton	2612532	Jun-08	10.0 @ 19.86	Pass
Conductivity	5/8/07	2100	Oakton 447us/cm	2701471	Apr-08	388 @ 18.08	Pass
DO 100	5/8/07	2100	Bubbled Nanopure	---	---	106.2 @ 19.85	Pass
DO 0	5/8/07	2100	Hanna H17040	G1012	Feb-11	0.35 @16.84	Pass
ORP	5/8/07	2100	Quickcal	33240	May-07	227.7 @ 19.30	Pass

Post-Sampling QA

Parameter	Date	Time	Standard	Lot No.	Exp.	Meter Reading	Pass/Fail
pH 4.01	5/9/07	2222	Oakton	2612530	Dec-08	4.01 @ 21.56	Pass
pH 7.00	5/9/07	2225	Oakton	2612531	Dec-08	7.06 @ 21.42	Pass
pH 10.00	5/9/07	2228	Oakton	2612532	Jun-08	10.02 @ 20.13	Pass
Conductivity	5/9/07	2215	Oakton 447us/cm	2701471	Jan-08	412 @ 21.38	Pass
DO 100	5/9/07		Bubbled Nanopure	---	---		
DO 0	5/9/07		Hanna H17040	G1012	Feb-11		
ORP	5/9/07	2100	Quickcal	33240	May-07	224.7 @ 21.27	Pass

Remarks: DO 100 and 0 not recorded into field notebook

Field-Form Filled Out By: Greta Myerchin Date: 6/12/2007

QAQC Check By: K. Holland Date: 6/30/2007