Snow Management to Augment Fresh Water Supplies in the Arctic

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Acknowledgements

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- Alaska Department of Transportation and Public Facilities

Team Members

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Douglas Kane - *Co-PI*

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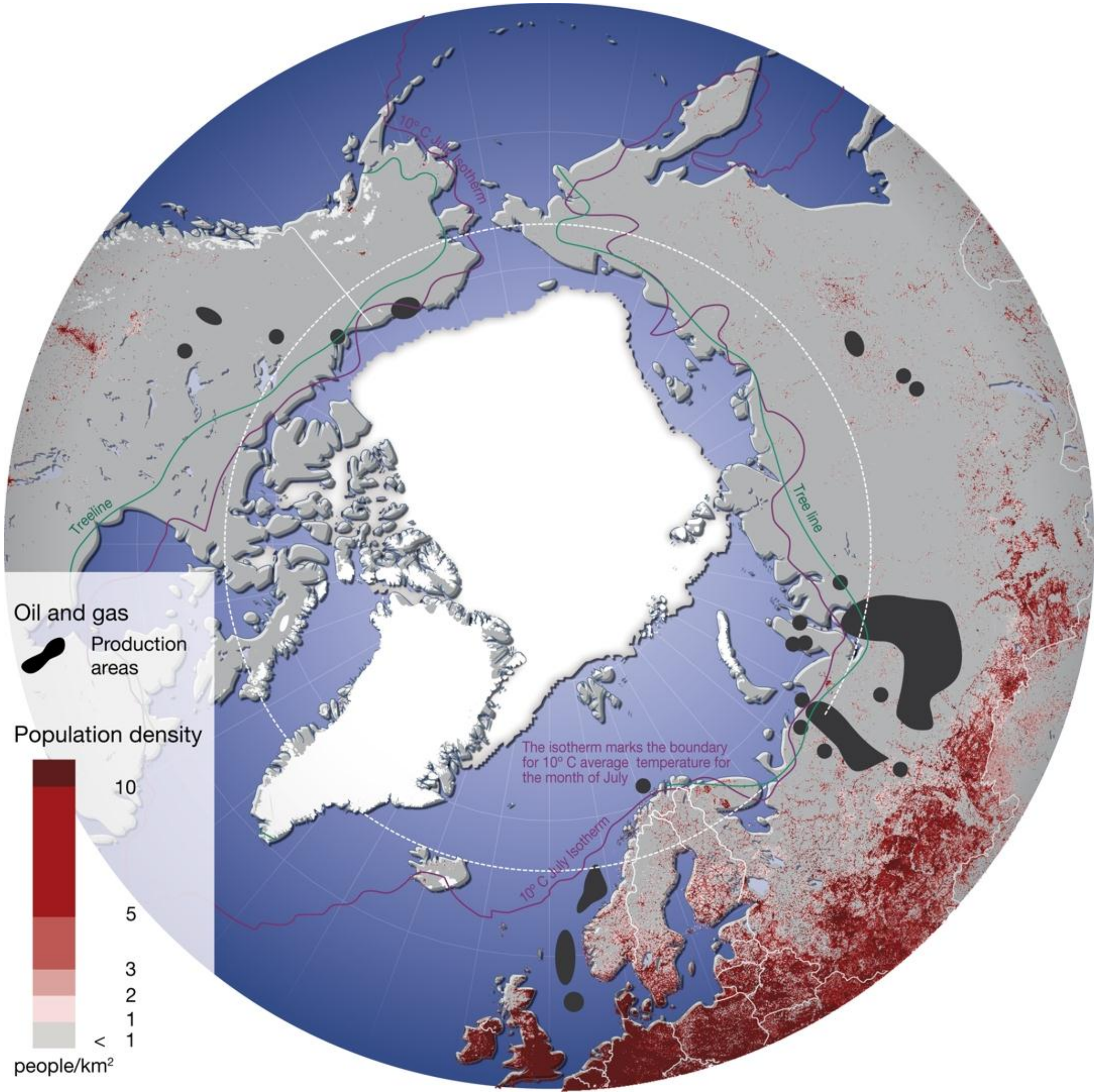
Matthew Sturm - *Collaborator*

Chris Hiemstra - *Collaborator*

Background:
Arctic Population and Production



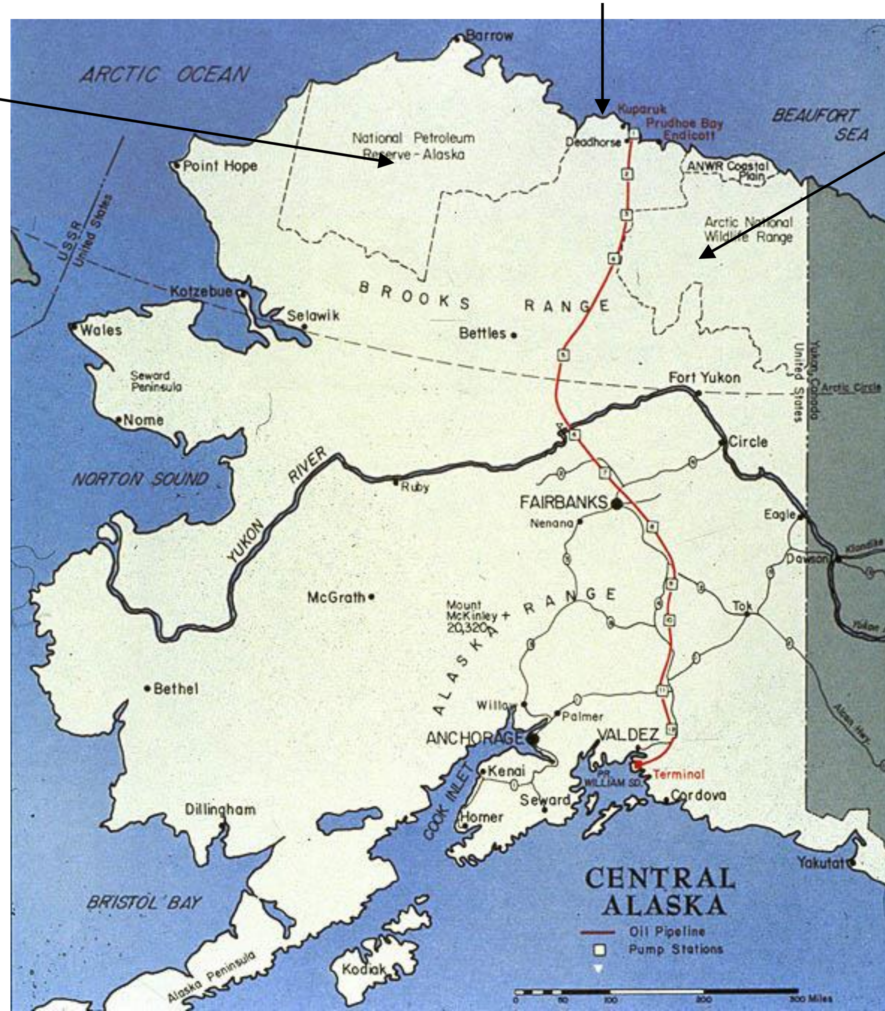
Source:
ORNL. 2005. LandScan 2004.
http://www.ornl.gov/sci/landscan

Background: Alaska's North Slope

National Petroleum Reserve - Alaska

Petroleum-rich North Slope

Arctic National Wildlife Refuge



Background: Permits

- Many exploration activities require permits (ice road construction).
- BLM estimates

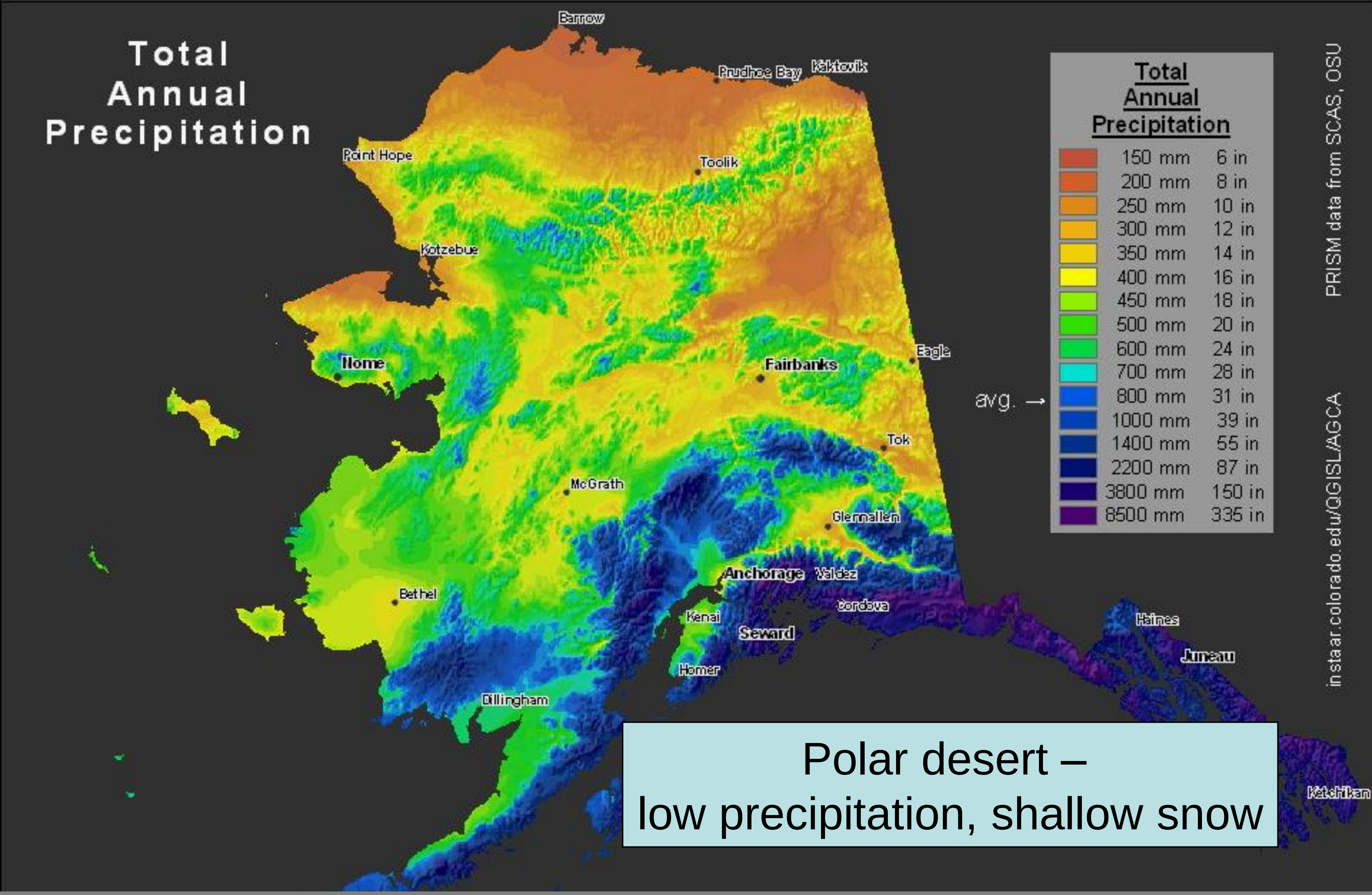
3.8 to 5.7 million liters (1 to 1.5 million gallons) of water is needed per 1 mile to construct an ice road 15 cm or 6 inches thick and 9-11 meters or 30-35 feet wide.

Source: Cumulative environmental effects of oil and gas activities on Alaska's North Slope, 2003.

Background: Water Resources

- Difficulties in domestic water supplies are associated with
  - Short open-water seasons
  - Engineering problems encountered with water storage and distribution systems in permafrost terrain
  - Severe winter climates
  - High operational costs

Slaughter,C. W. ; Mellor,M. ; Sellmann,P. V. ; Brown,J. ; Brown,L., 1975. CRREL, Hannover, Special report.



Polar desert –
low precipitation, shallow snow

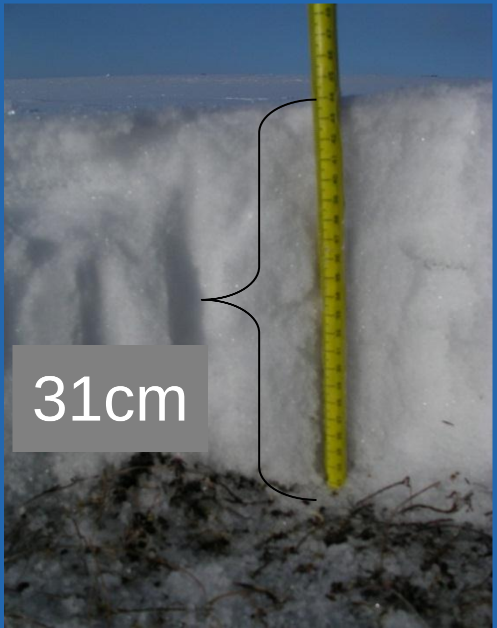
Manley, W.F., and Daly, C., 2005, Alaska Geospatial Climate Animations of Monthly Temperature and Precipitation: INSTAAR, University of Colorado, http://instaar.colorado.edu/QGISL/AGCA.

TUNDRA SNOWPACK

- on average shallow
- host to steep temperature gradients
- hard, high-density, wind-packed layers
- low density depth hoar layer

(Benson and Sturm 1993)



Snow is central to activities in Arctic Alaska

Insulation

- Host to steep temperature gradients

Transportation

- Snow machines, Dog sledge, Ice roads, ice pads

Water Supply

- Wildlife, industry, humans

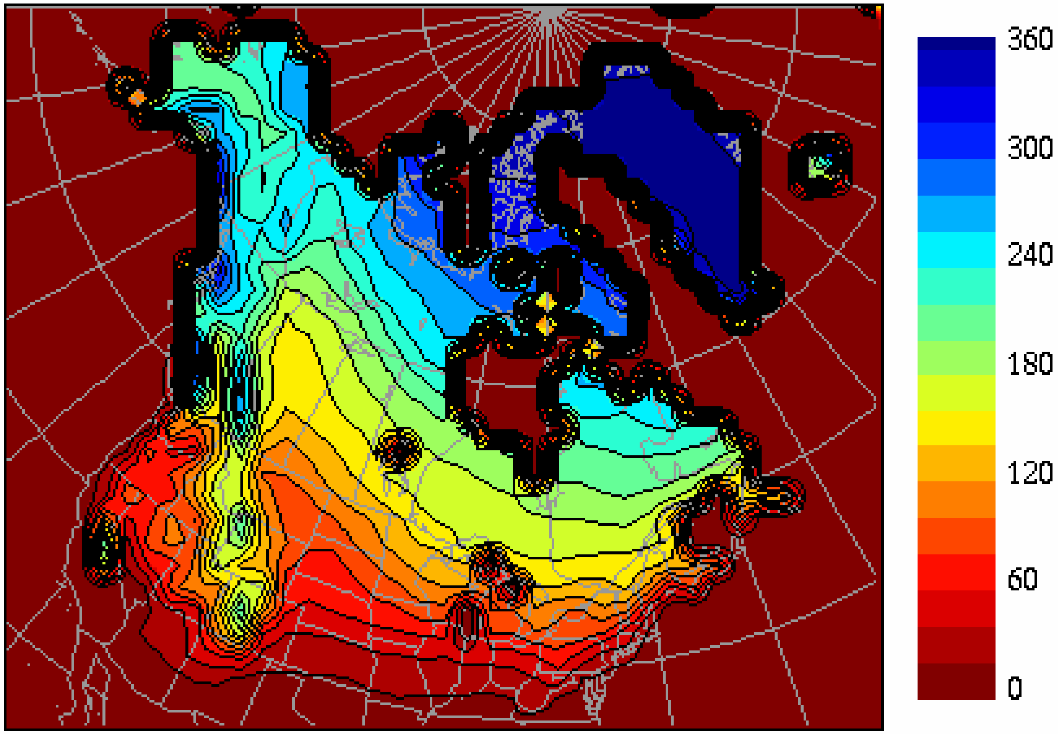
Source:
Slaughter,C. W. ; Mellor,M. ; Sellmann,P. V. ; Brown,J. ; Brown,L., 1975. CRREL, Hannover, Special report.

Image courtesy: U.S. Department of Energy's Atmospheric Radiation Measurement Program

image courtesy of www.morooka.com

Mean duration of snow cover (days) over the 1972-94 period

as computed from satellite-derived maps of weekly snow cover extent



Source: R. Brown, Environment Canada (data supplied by D. Robinson, Rutgers University). Published on http://www.msc.ec.gc.ca/crysys/education/snow/snow_edu_e.cfm

Snow is there to harvest during these 9 months!

Alaska Miners Store Snow.
Seward Weekly Gateway, April 10, **1909**

RD GATEWAY

LISHED WEEKLY BY

Y PUBLISHING CO.

Second Class matter August 24th,
postoffice at Seward, Alaska, un-
of Congress of March 8, 1879.

BSCRIPTION RATES

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" - - - -	$1.50

ffice 212 Alworth Building, Duluth,
Chas. B. Aske, authorized agent.

URDAY, APRIL 10, 1909

ALASKA MINERS STORE SNOW

They Gather the Precipitation to a Depth of twenty Feet Over 2000 Acres.

In certain parts of Alaska the water question is almost as serious as in the desert regions of the west. Without water, it is impossible to operate the

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1908

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Accumulating Snow to Augment Water Supply in Barrow, 1973

- The ability to accomplish increased snow deposition by fencing was clearly demonstrated
- There remains a question of optimal snow fence location and number of fences
- Recommendation to concentrate a drift adjacent to stream channel

by Slaughter,C. W. ; Mellor,M. ; Sellmann,P. V. ; Brown,J. ; Brown,L., 1975. CRREL, Hannover, Special report.

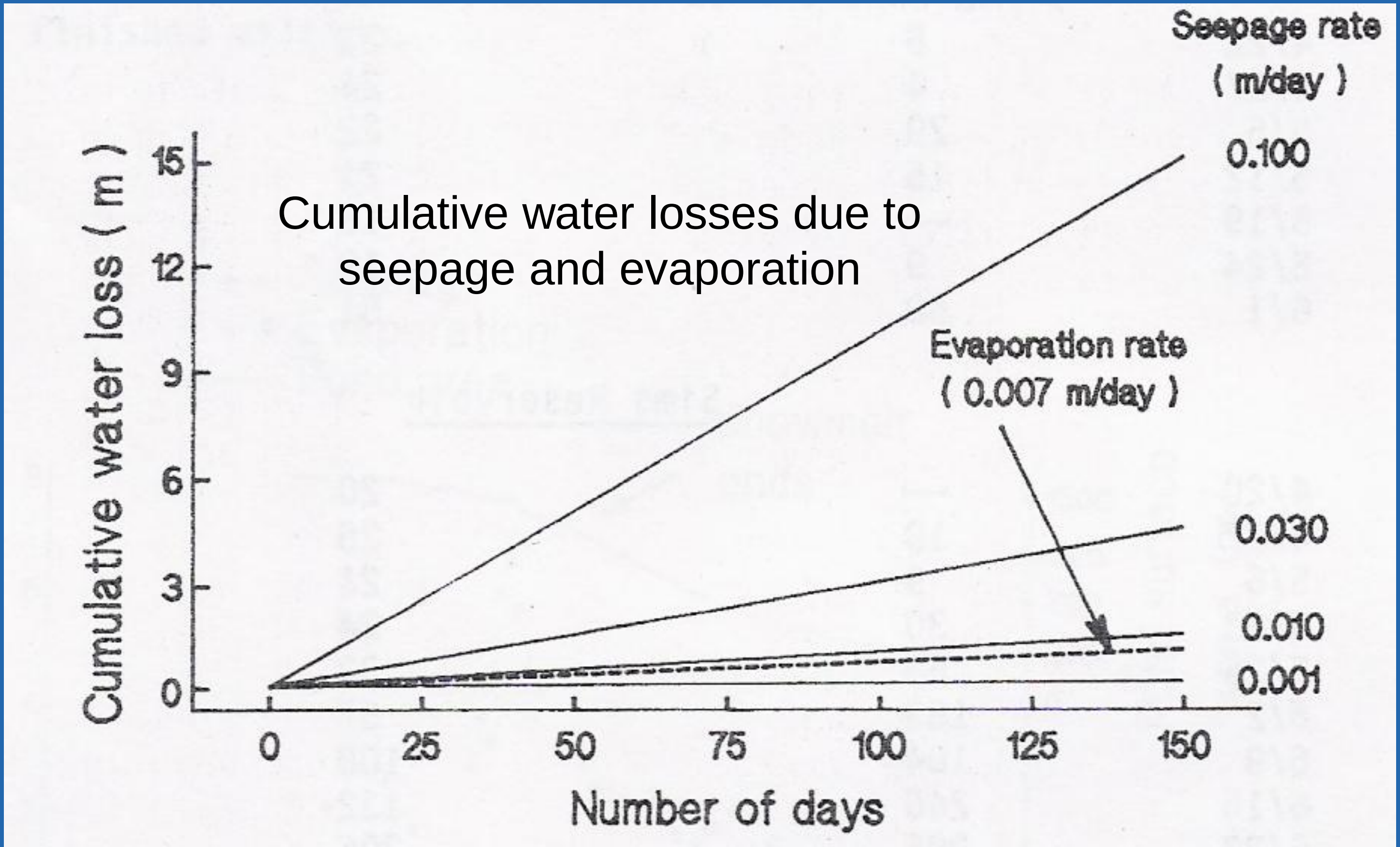
Summary for Alaska

Fence Height (m)	Water Equivalent (liter per meter of fence)	Location in Alaska	Source
1.5	15,650	Barrow	Slaughter et al, 1975
2.7	32,950	Barrow	Slaughter et al, 1975
1.5	10,900	Point Hope	McFadden and Collins (1978)

Fresh Water Supply for a Village Surrounded by Salt Water, Point Hope, Alaska, 1978 by McFadden and Collins, CRREL, Hannover, Special report.

“Snow fence may deposit a large quantities of snow, but the reservoir is often dry by the time water is needed.”

By David Sturges, 57th Western Snow Conference, 1989



What are the recognized obstacles for delivering snow drift water to the reservoir on the coastal plain?

- Low gradient terrain - water ponds during snowmelts
- Water losses due to evaporation from the reservoir surface and evapotranspiration from the tundra
- Seepage loss – water moves through permafrost (i.e. talik zone)

Objective

- Evaluate the use of snow management and snow fences to augment water supplies in shallow arctic lakes.
- This topic is qualified as “research leading to more efficient use or allocation of water resources for ice road and ice pad construction”.

Research sites: Experimental Lake and Control Lake

Research sites are located 30 miles south of Prudhoe Bay in the vicinity of Franklin Bluffs.

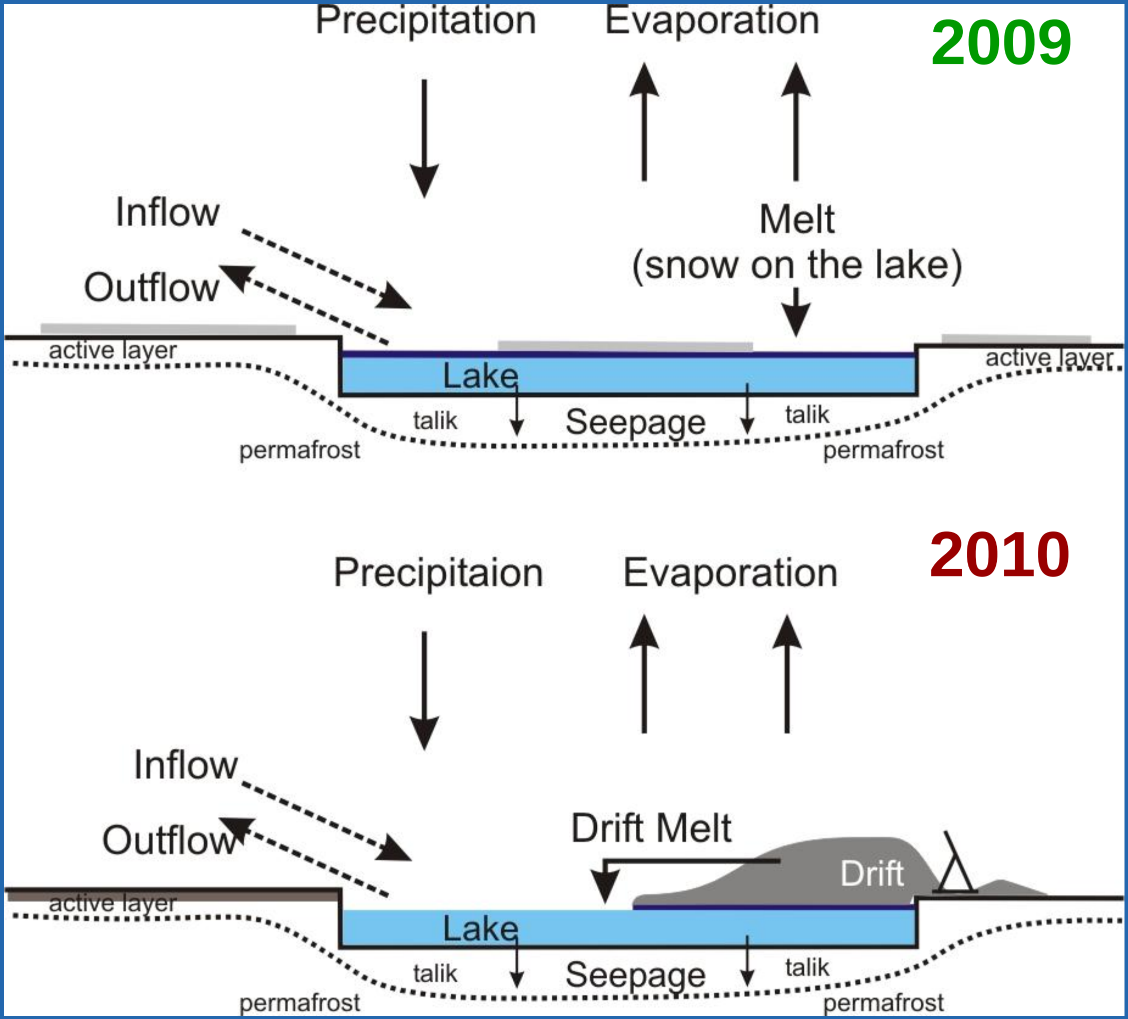
Methods: pre-treatment study

2009

$V_{exp} = f\,(V_{nat})$

2010, 2011

$V_{without\_drift} = f\,(V_{nat})$

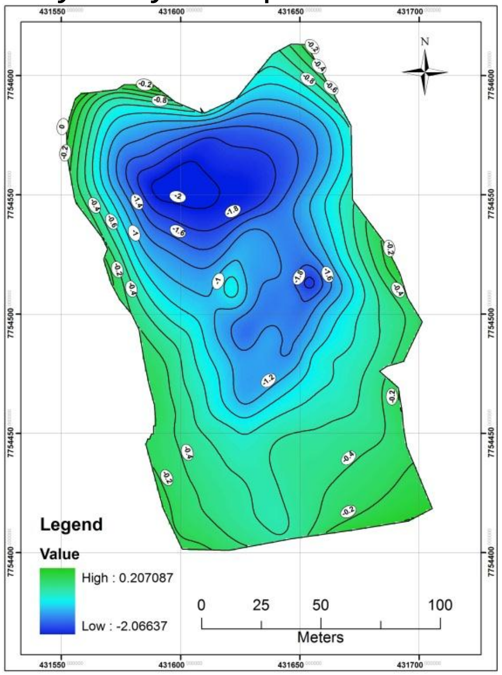


$V_{net\_increase} = V_{with\_drift} - V_{without\_drift}$

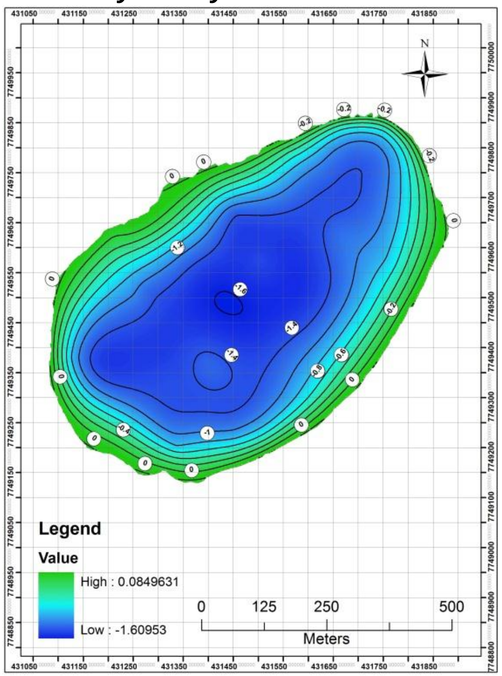
Data collection: climate and hydrology

Weather data (precipitation, wind, air temperature, relative humidity), bathymetry, water levels, snow data, DGPS surveys, Digital Elevation Model.

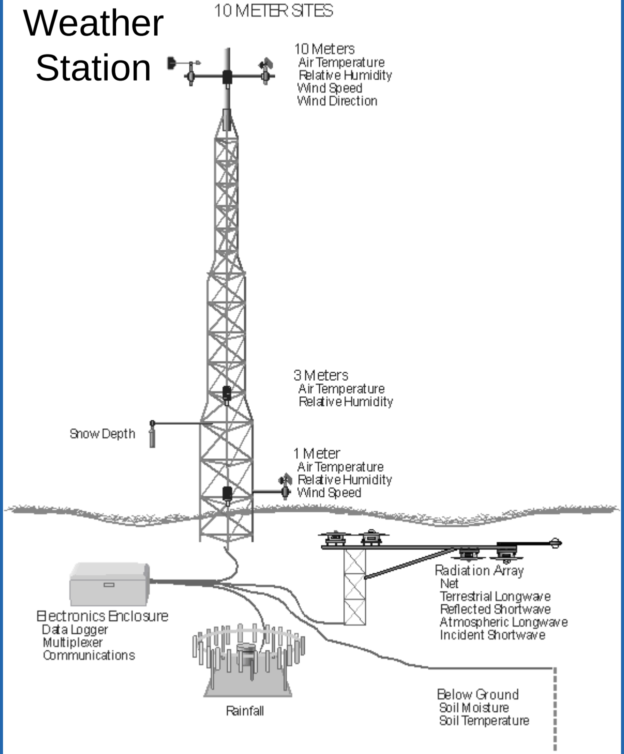
Bathymetry of Experimental Lake



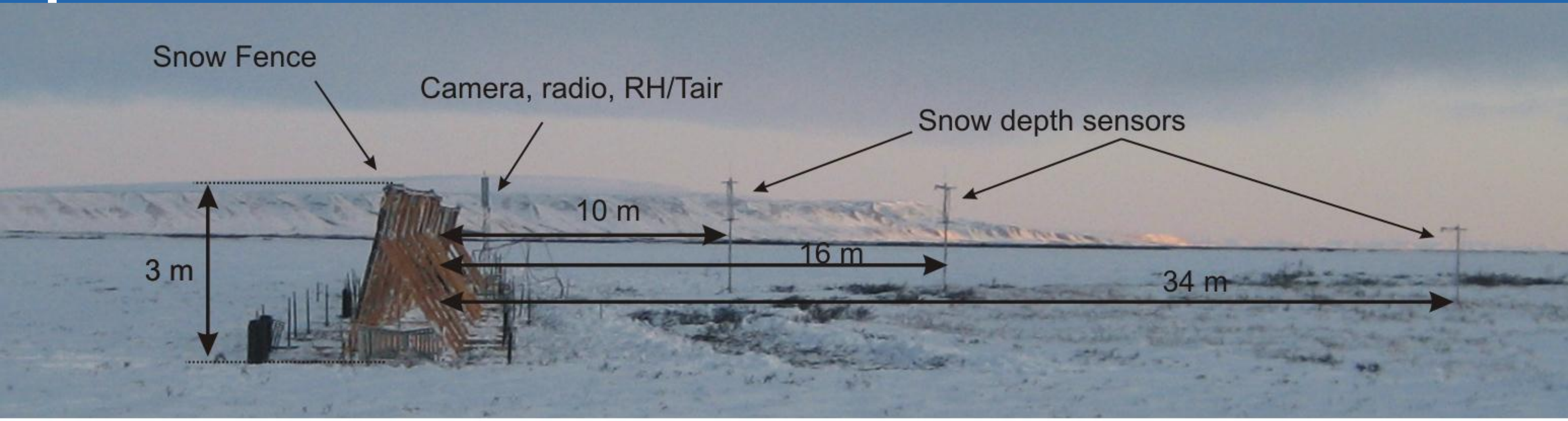
Bathymetry of Control Lake

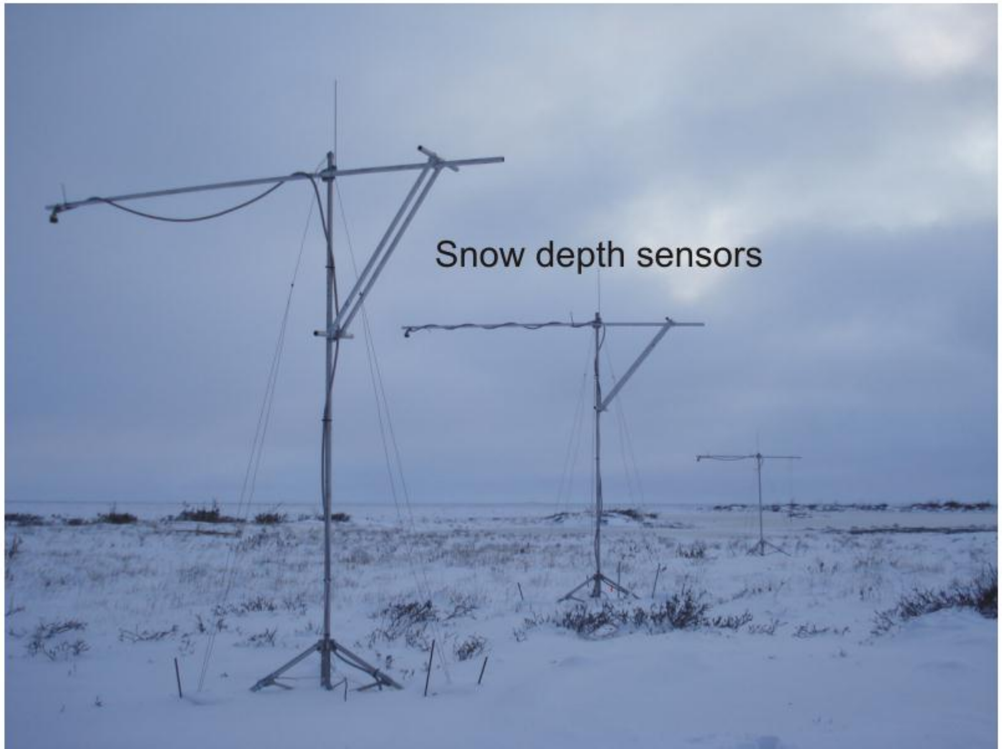


Weather Station

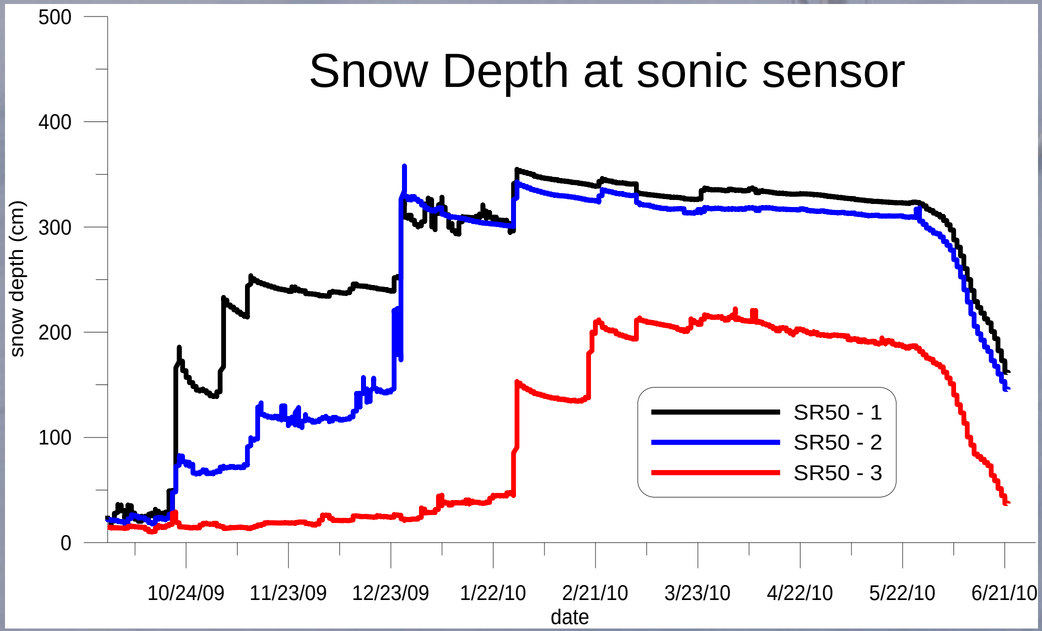


Experimental Site



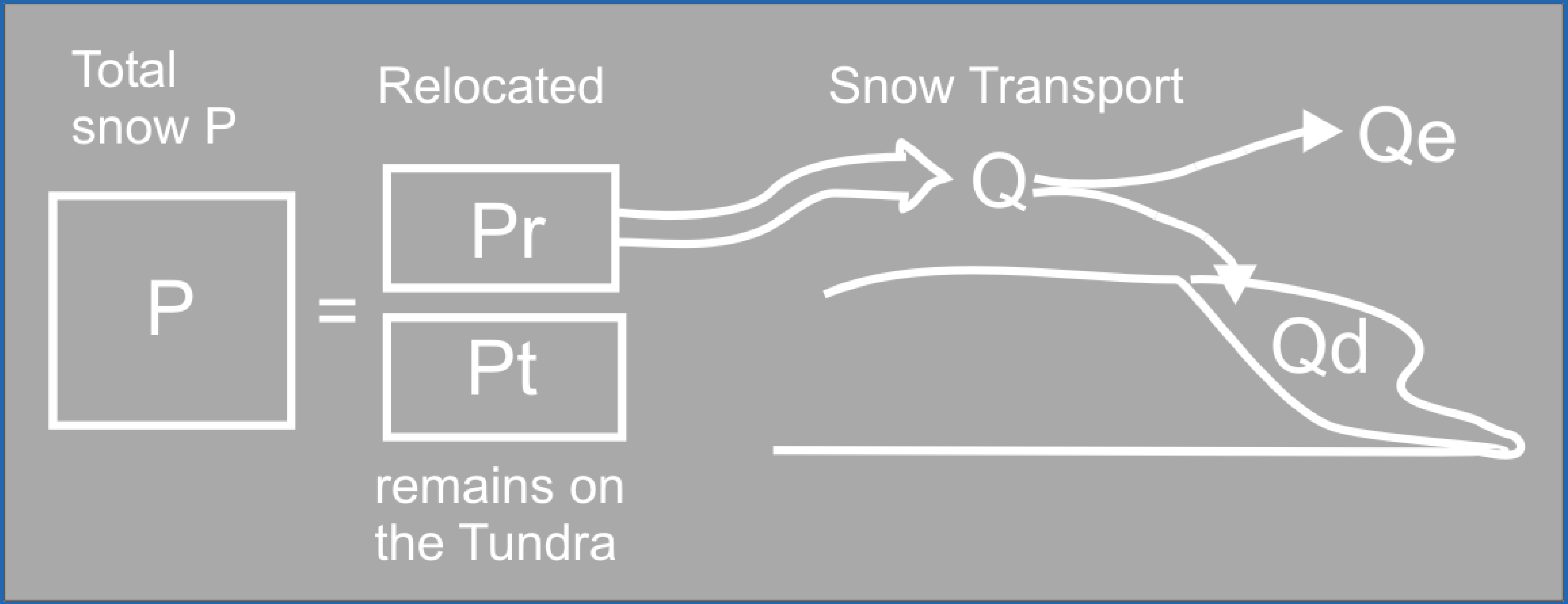


March 5th, 2010



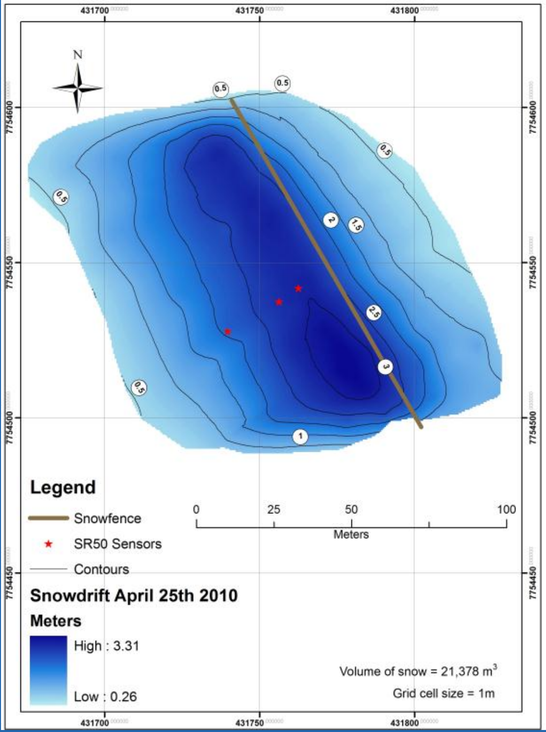
Creating 'new' water

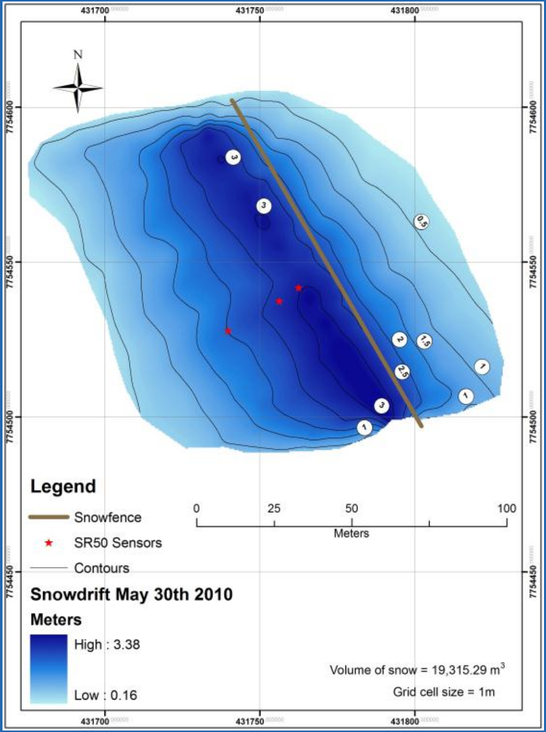
Snow fence reduces sublimation losses from blowing particles.

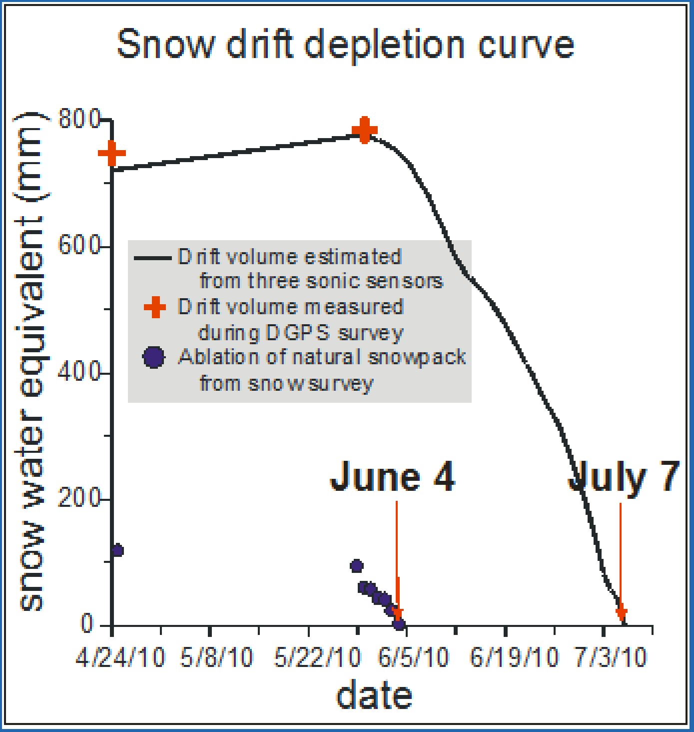


"Reassessment of winter precipitation on Alaska's Arctic" by Carl Benson, 1982
SnowModel by G.Liston and K.Elder, 2006

Results: Snow Drift Melt

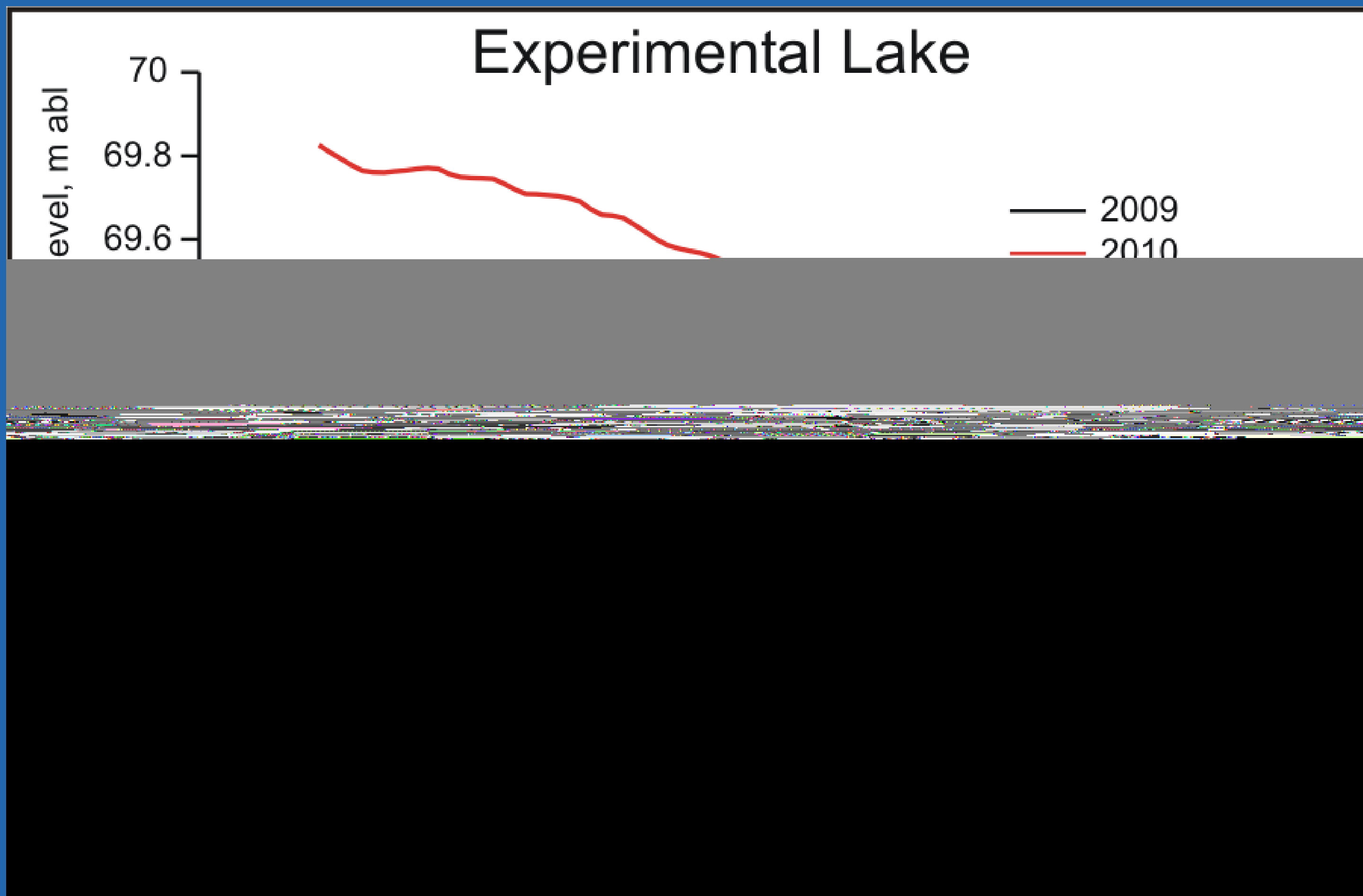






Additional 32 days of melt water supply

Results: Water Levels Before and After Experiment



Upcoming Results

Assessment of the reservoir-volume net increase and the cost of additional water.

Cost of installation /
Reservoir-volume net increase
=
Cost of additional water

Summary

- Snow fence creates ‘new' water due to reduced sublimation losses from blowing snow;
- Snow drift creates additional month of water supply to the lake;
- Elevated water levels in experimental lake were observed during entire open water season;
- Complete assessment of costs awaits collection of additional data in 2011.

Water Pumping