Cassin Lakes Recharge Study

2013

ConocoPhillips Alaska

Submitted by

Baker

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ACRONYMS AND ABBREVIATIONS

Baker	Michael Baker Jr., Inc.
CPAI	ConocoPhillips Alaska, Inc.
GPS	Global Positioning System
NAD83	North American Datum of 1983
SWE	Snow Water Equivalent
TBM	Temporary Benchmark
WGS84	World Geodetic System 1984
WSE	Water Surface Elevation

1.0 INTRODUCTION

ConocoPhillips Alaska Inc., (CPAI) builds and maintains ice roads and ice pads for access and transportation of people and equipment during the winter months. Each season, millions of gallons of fresh water are withdrawn to meet winter construction and operation requirements. Additional fresh water is used for potable water supplies at temporary rig camps and make-up water for drilling operations. Water withdrawal for construction and operations may begin as early as December and will continue into May.

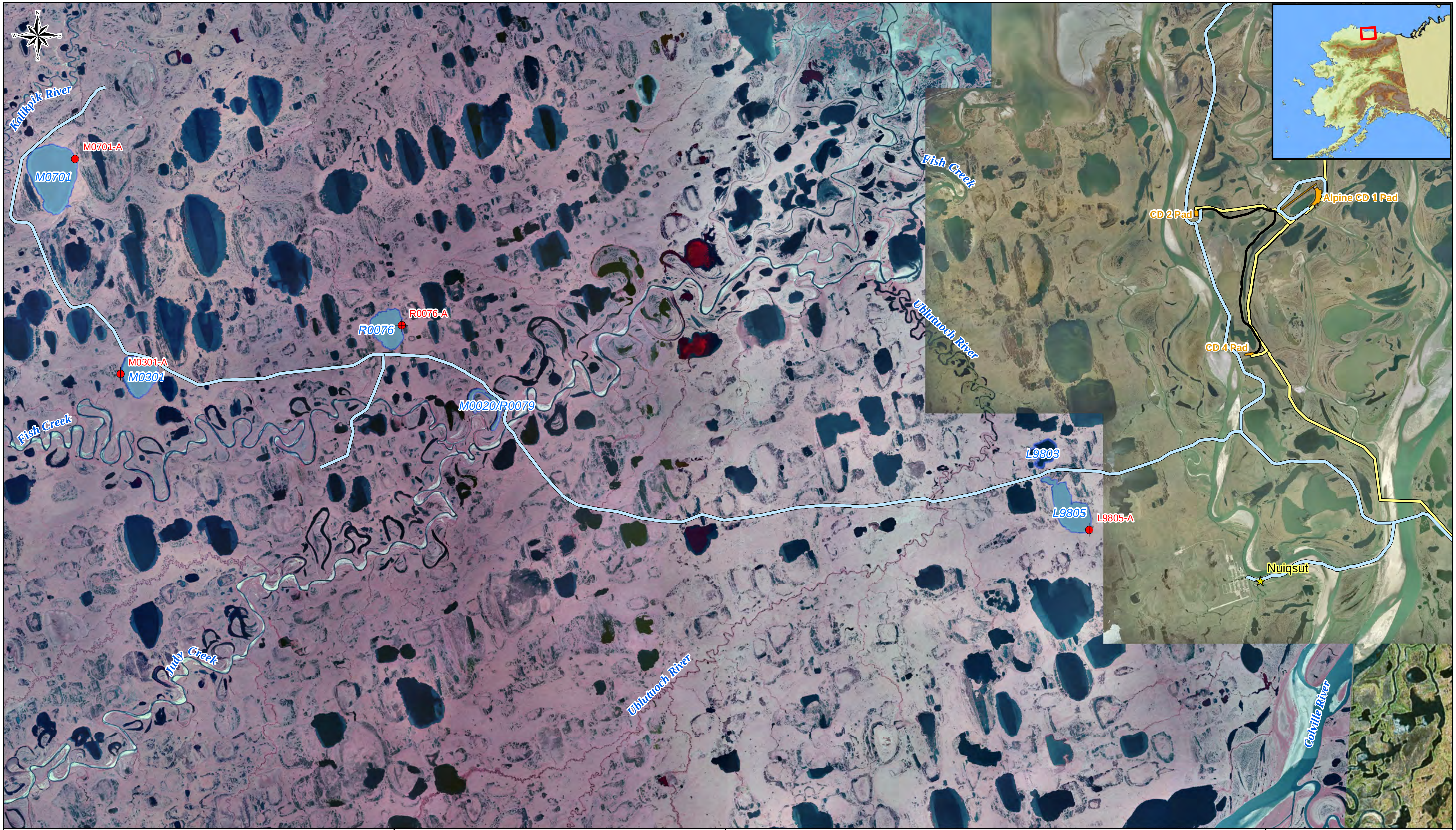
This report summarizes hydrologic observations, measurements, and analysis made during the 2013 Cassin Lakes Monitoring Program. The study was performed at the request of CPAI by Michael Baker Jr., Inc. (Baker). Tasks consisted of breakup and post breakup monitoring during springtime when water surface elevations (WSE) were collected and observations were made to document lake recharge. Five lakes, identified by CPAI, were included in this study.

Throughout the monitoring program, Baker was supported by Bristow Helicopters, Umiaq/LCMF, LLC, and the CPAI Alpine Environmental Coordinators. Baker and support crews are recognized for contributing to a field effort free of incident.

1.1 STUDY OVERVIEW

The objectives of the 2013 Cassin Lakes Recharge Studies included the observation and analysis of lake recharge at five water withdrawal lakes. The study lakes for the 2013 Cassin Lakes Monitoring Program include lakes L9805, M0020/R0079, M0301, M0701, and R0076.

Field investigations include breakup monitoring, collection of WSE, and photographic evidence of hydrologic connections. Lake M0020/R0079 only required photographic evidence of recharge. WSEs were not collected at Lake M0020/R0079. Lake recharge was determined using hydrographs, visual observations, and analysis of photos focusing on key hydrologic features including peak water levels, hydraulic connectivity, and inflow/outflow locations. The location of each lake in relation to other relevant features within the study area is shown in Figure 1.



ConocoPhillips Alaska	Miles 0 1 2 4		
Date: 07/15/2013	Project: 134783		
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Legend

- Place Names
- Monument Location
- Pipeline
- 2012-2013 Ice Road
- Existing Road
- Monitoring Lake
- Lake
- Existing Facility

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2013 CASSIN LAKES RECHARGE STUDY

MONITORING LOCATIONS

FIGURE: 1

(SHEET 1 of 1)

1.2 Lake Recharge Background

Annual recharge of the Cassin Lakes occurs as a result of three primary mechanisms: spring breakup flooding in the Fish Creek Basin, snow melt, and precipitation. Of these, spring breakup flooding and snow melt were investigated for this report and are considered overland flow. Lakes located within annually inundated stream floodplains or otherwise hydraulically connected areas recharge primarily from spring breakup flood flows. Lakes not inundated by flood flow because of distance or topographical limitations, depend solely on snowmelt runoff and precipitation for recharge. Lake recharge fluctuates year to year due to changes in the three recharge mechanisms.

The hydrologic cycle on the North Slope is typical of extreme northern latitudes. The Alaska Climate Research Center estimates that 75% of the mean annual total water equivalent precipitation is in the form of rain between June and September with the remaining 25% from snow fall in the winter months (Baker 2007). Evaporative loss is also a significant driver of the hydrologic cycle.

Lake recharge by floodwater is dependent on the magnitude and distribution of floodwaters during spring breakup and the topography of the tundra surrounding each lake. Local ice jamming during spring breakup influences the floodwater extents and can increase the uncertainty of recharge from year to year due to the unpredictable establishment and release of ice during breakup.

The amount of snowmelt runoff a lake receives depends on terrain, topography, and the properties of the snow in the catchment basin. Snow cover on lake ice is generally thinner and denser than snow cover on the surrounding tundra. All snowmelt located within the lake area is assumed to directly contribute to lake recharge. However, tundra snowmelt will not directly contribute to lake recharge because of variations in vegetation and topography relative to the lake. Lower wetland areas, for example, may retain a portion of snowmelt making recharge contribution dependent on snowmelt quantities and wetland elevations relative to the lake. The quantity of snowmelt retained in tundra areas differs for each lake catchment basin.

2.0 PERMITS AND WATER USE

CPAI requires water sources for use in building ice roads and ice pads, drilling, obtaining drinking water, and for performing general operations. The Alaska Department of Natural Resources, Alaska Department of Fish and Game, or both agencies will grant permits on the condition of CPAI compliance with temporary water use requirements to regulate water withdrawal and maintain conditions supportive of fish habitat. To maintain fish habitat, lakes must seasonally recharge water volumes borrowed during the winter season and lost naturally through evaporation. Fish Habitat and Temporary Water Use permits stipulate the quantities of water that may be withdrawn each water year. A water year is defined as one year beginning and ending with spring breakup (June through May). Additionally, these permits specify the form of water that may be borrowed from each lake, which varies as either liquid only, specific quantities of liquid and ice, or a total of both without designation of individual quantities. Actual withdrawal quantities are reported by CPAI each water year and these numbers are compared to the maximum water withdrawal allowed. If two permits are issued for one lake, the maximum water withdrawal by CPAI is less than or equal to the lesser allowable quantity.

Lakes M0701, M0301 and M0020/R0079 were permitted for specific borrow quantities of liquid only. Lakes L9805 and R0076 were permitted for liquid and ice use with specific designation of individual quantities. Ice aggregate removal is permitted only over naturally grounded ice.

Liquid or ice was withdrawn from each of the lakes during the 2012/2013 season. Lakes M0701, M0301, and M0020/R0079 were used as liquid sources only per the stipulations. Liquid and ice withdrawal occurred at Lake R0076 while Lake L9805 only had ice withdrawn.

Table 2.1 summarizes the permitted and withdrawn volumes of water at the five study lakes during the 2012/2013 water season. The permitted versus actual withdrawal volumes by form are included in Table 2.1 and are based on fourth quarter 2012 and first and second quarter 2013 water use reports (CPAI 2012, 2013a, and 2013b).

Table 2.1: Summary of Permitted and Actual Withdrawal Volumes

Lake	Permit		Permit Expiration	Water Use Purpose	Permitted Volume [1]			Withdrawal Volume [3]		
	ADF&G	ADNR			Liquid	Ice	Total Water [2]	Liquid	Ice	Total Water
					(million gallons)					
L9805	FH12-III-0264	TWUP A2012-173	12/20/2017	Ice Road/Pad	0.01	99.82	99.83	0	2.19	2.19
M0020/R0079	FH12-III-0259	TWUP A2012-176	12/10/2017	Ice Road/Pad & Camp Supply			14.98	12.16	0	12.16
M0301	FH12-III-0266	TWUP A2012-173	12/20/2017	Ice Road/Pad & Drilling Make-up	20.69		20.69	12.7	0	12.7
M0701	FH12-III-0260	TWUP A2012-176	12/10/2017	Ice Road/Pad	7.39		7.39	7.23	0	7.23
R0076	FH12-III-0271	TWUP A2012-175	12/9/2017	Ice Road/Pad	17.67	29.7	47.37	12.09	8.39	20.48

Notes:
1. Per water year
2. Total permitted withdrawal may be either ice, water, or a combination
3. Total withdrawal volume between June 1, 2012 and May 31, 2013

3.0 Study Methods

3.1 Water Surface Elevation Surveys

To estimate lake water recharge, staff gages were installed and changes in WSE were measured at lakes L9805, M0301, M0701 and R0076.

A gage assembly consists of a metal gage faceplate mounted on a two-by-four timber. The timber is attached with U-bolts to a 1.5-inch wide angle iron driven approximately 2 feet into the ground. Chalk was applied to the angle iron to capture high water marks. All gages installed are indirect-read staff gages; meaning, the values read on the gage faceplate do not directly correspond to a known elevation. Photo 3.1 shows the gage setup at Lake R0076. A tabulated list of gage and temporary benchmarks (TBM) locations is included in Appendix A.

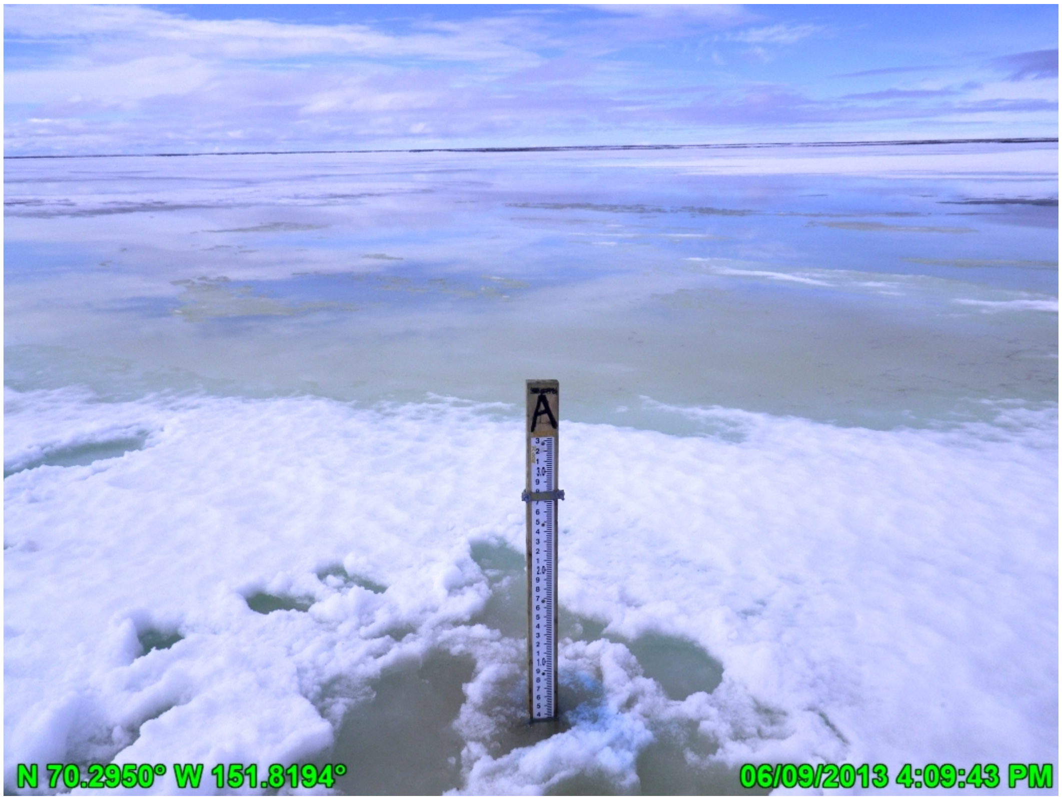


Photo 3.1: Staff gages at Lake R0076, pre-breakup; June 9, 2013

Standard differential leveling techniques were used to establish staff gage elevations with local TBMs. Two new TBMs were installed when a preexisting TBM was farther than ¼ mile from the study lake; three TBMs were installed at Lake L9805. New TBMs were all given an assumed elevation of 100.00 feet; therefore, WSE records at these gages are relative. A staff gage tied to an assumed elevation is used to illustrate a change in WSE for a specific lake, and does not provide British Petroleum Mean Sea Level elevations.

WSE monitoring was conducted during the breakup and post-breakup periods. When water levels were not sufficiently high to be recorded on the staff gage face plates, a pocket rod was used to measure from the top of the angle iron to the water surface. The horizontal position of each staff gage and TBM was recorded using a handheld global positioning system (GPS) in North American Datum of 1983 (NAD83).

3.2 Lake Recharge Observations

Aerial photographs were taken from a helicopter using a GPS camera. Photos were taken from various perspectives to capture the extent of snow melt, flow pattern, potential lake water recharge sources, and hydraulic connectivity with other water bodies. Written documentation of visual observations combined with time-stamped GPS photos support identification of each lake's recharge mechanism(s), extent, and timeline.

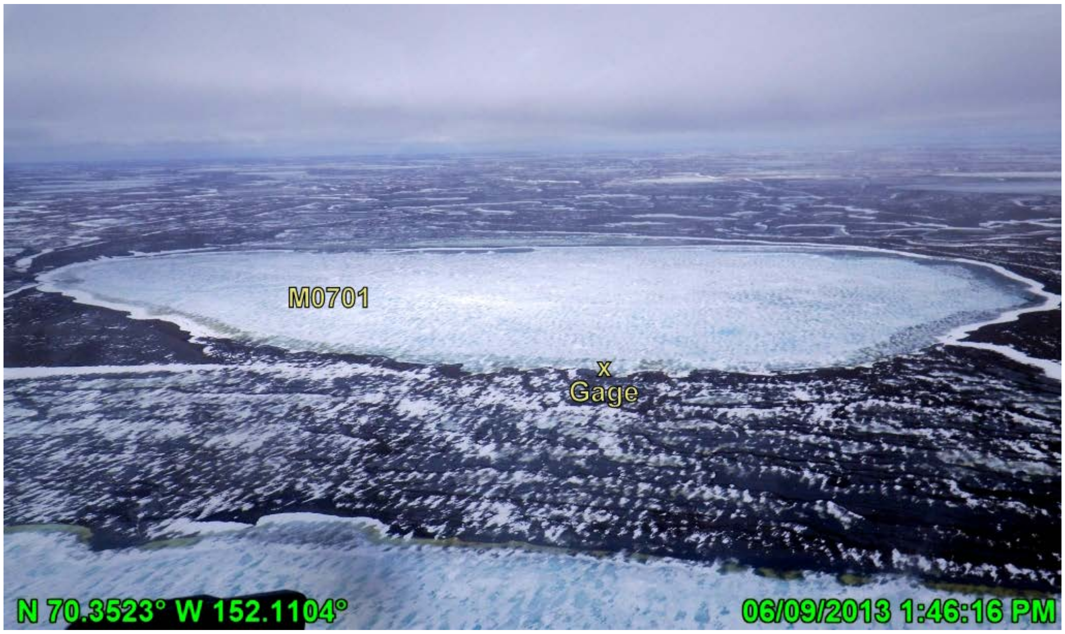


Photo 3.2: Aerial view of Lake M0701, looking southwest; June 9, 2013

Hydrographs are typically used to show changes in WSE over time in order to determine estimated lake recharge. A negative slope after peak stage, signifying recession of floodwaters, indicates a lake has recharged over bankfull conditions and is discharging excess water by means of overbank flow. Due to ice cover remaining on the lakes at the cessation of concurrent breakup activities (Photo 3.2), WSE was not monitored for a sufficient amount of time after the initial visit. Upon returning to the lakes, observable outflow was used as evidence of bankfull recharge.

4.0 STUDY RESULTS

4.1 CASSIN STUDY LAKES

The WSE and lake recharge observations for Cassin lakes L9805, M0020/R0079, M0301, M0701 and R0076 are presented in this section.

4.1.1 WATER SURFACE ELEVATION

The WSE was measured during and after spring breakup at lakes L9805, M0301, M0701 and R0076. No gage was installed at Lake M0020/R0079; recharge was determined by visual observation and aerial photographs. Photographs during and after spring breakup of each lake are included in Appendix B.

Although substantial ice covered the lakes at the time of gage installation, significant snow melt in the basins had already occurred. Initial WSE measurements at all gages reflect the snow melt contribution and are likely higher than the actual pre-breakup WSE.

WSE at lakes L9805 and R0076 decreased during the monitoring period. During post-breakup observations, Lake L9805 was completely clear of snow and ice and Lake R0076 had minimal lake ice present. The WSE at lakes M0301 and M0701 increased during the monitoring period. During post-breakup observations, both lakes had significant lake ice present.

The WSE data and hydrographs are presented in Table 4.1 through Table 4.4.

Table 4.1: WSE Data for Lake L9805

Date and Time	WSE (feet)	Observations
6/10/13 2:00 PM	93.56	Channelized inflow from wetlands (south); connected to Lake L9803 and wetlands (north)
6/28/13 10:06 AM	93.10	No inflow or outflow

Notes:

1. Elevations are assumed based on TBM N193AL at 100.00 feet, installed by Baker in May 2013.
2. Dashed line indicates a substantial time interval between observations and that the change in WSE is not likely direct.

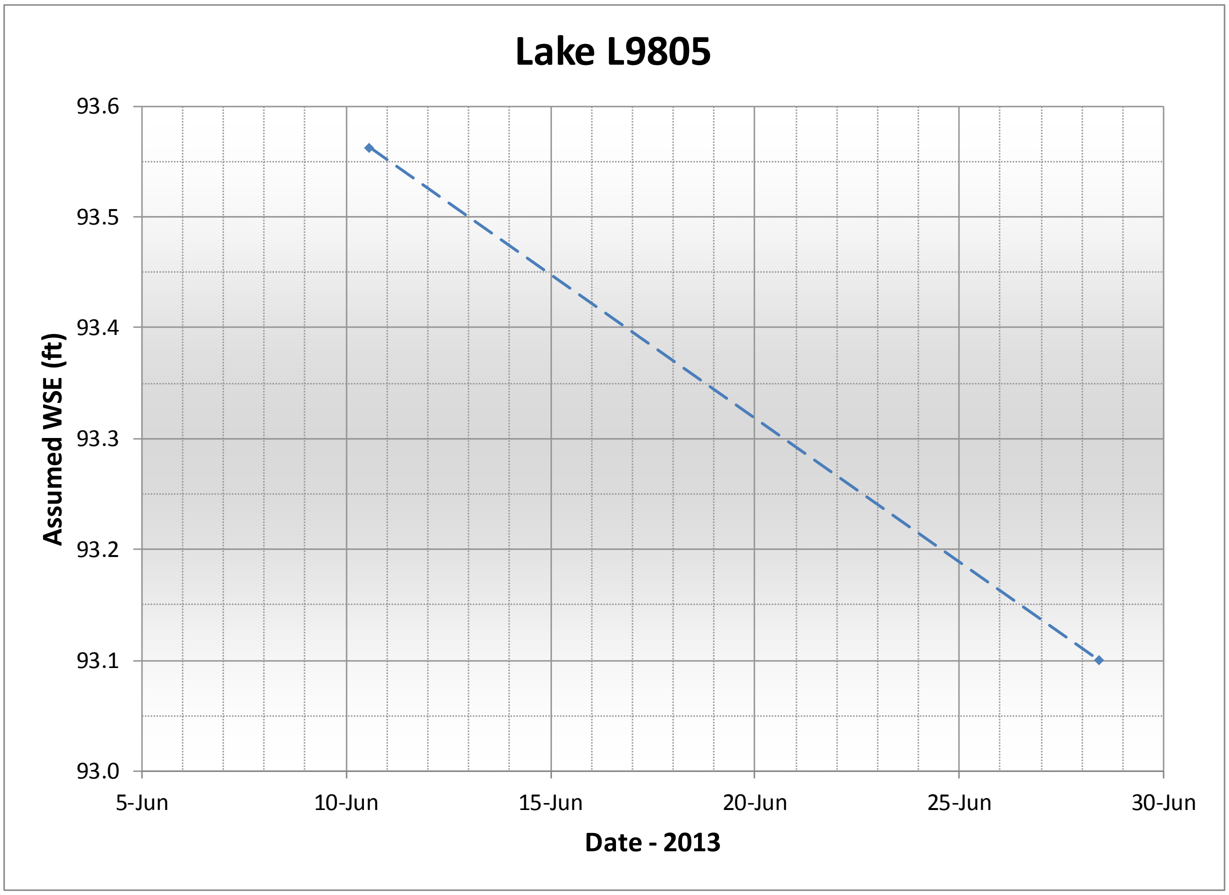


Table 4.2: WSE Data for Lake M0301

Date and Time	WSE (feet)	Observations
6/9/13 2:52 PM	97.59	Inflow from the east
6/28/13 3:49 PM	97.60	Inflow from lake to the southeast; outflow to the west

Notes:

1. Elevations are assumed based on TBM LIAM at 100.00 feet, installed by Baker in May 2013.

2. Dashed line indicates a substantial time interval between observations and that the change in WSE is not likely direct.

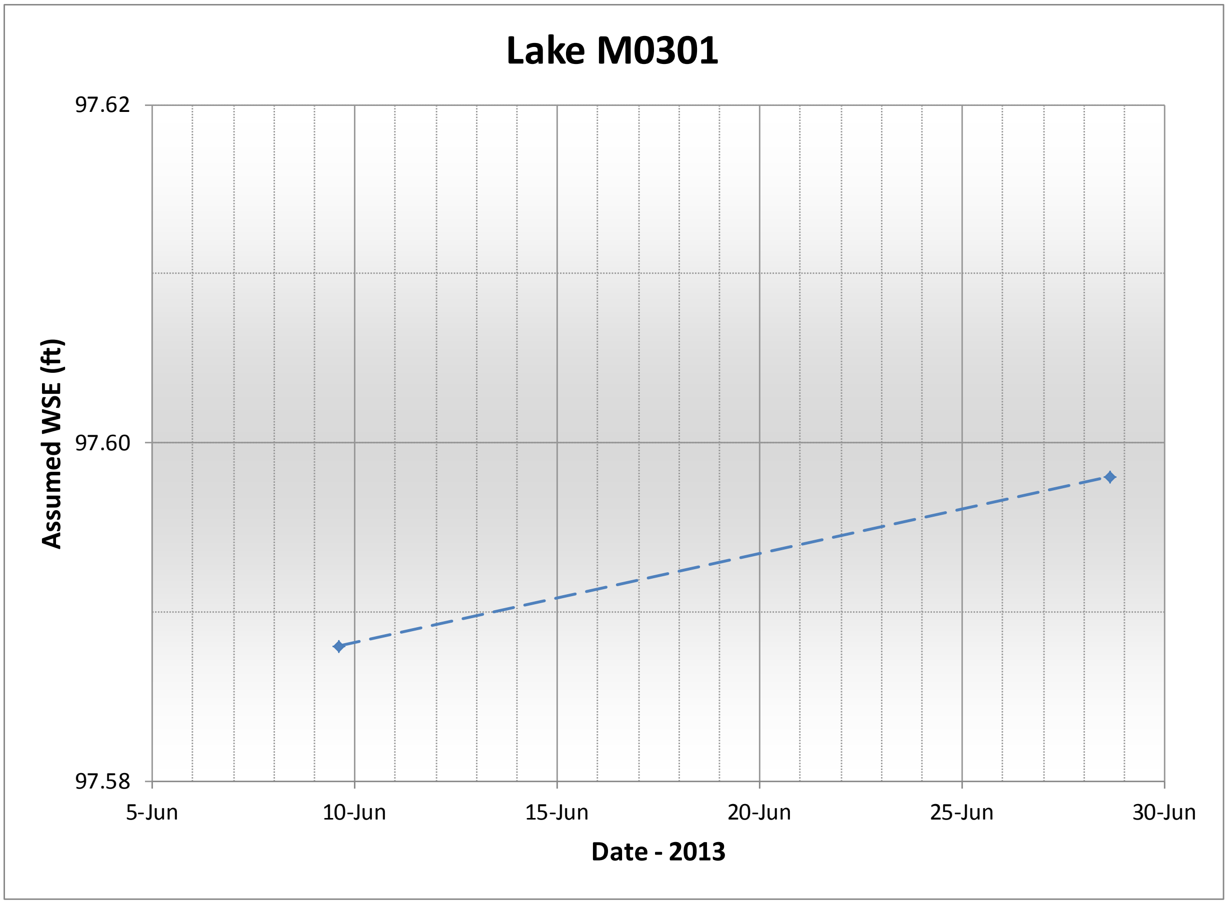


Table 4.3: WSE Data for Lake M0701

Date and Time	WSE (feet)	Observations
6/9/13 1:16 PM	97.59	Channelized inflow from the south
6/28/13 3:30 PM	97.91	Channelized inflow from the south; outflow to the east

Notes:

1. Elevations are assumed based on TBM KB1 at 100.00 feet, installed by Baker in May 2013.

2. Dashed line indicates a substantial time interval between observations and that the change in WSE is not likely direct.

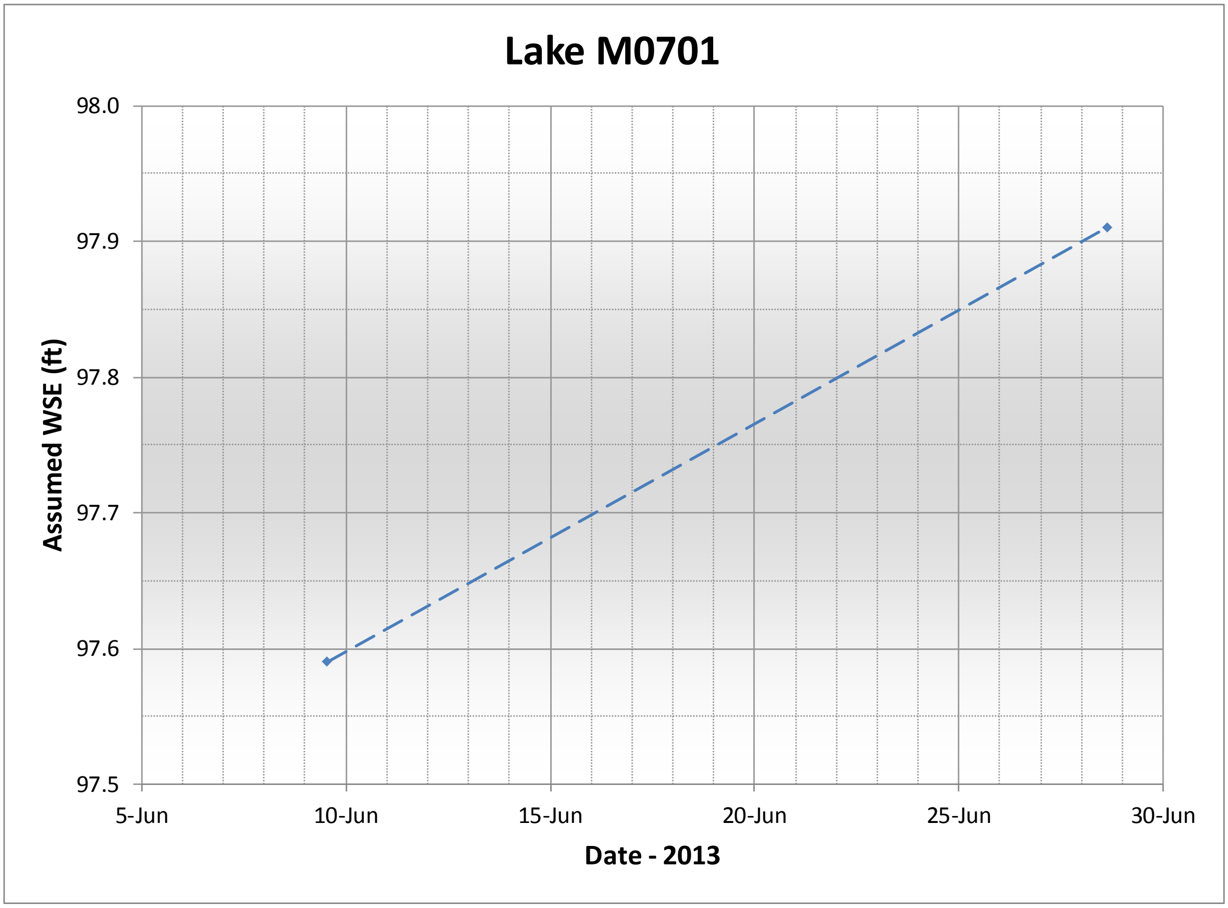


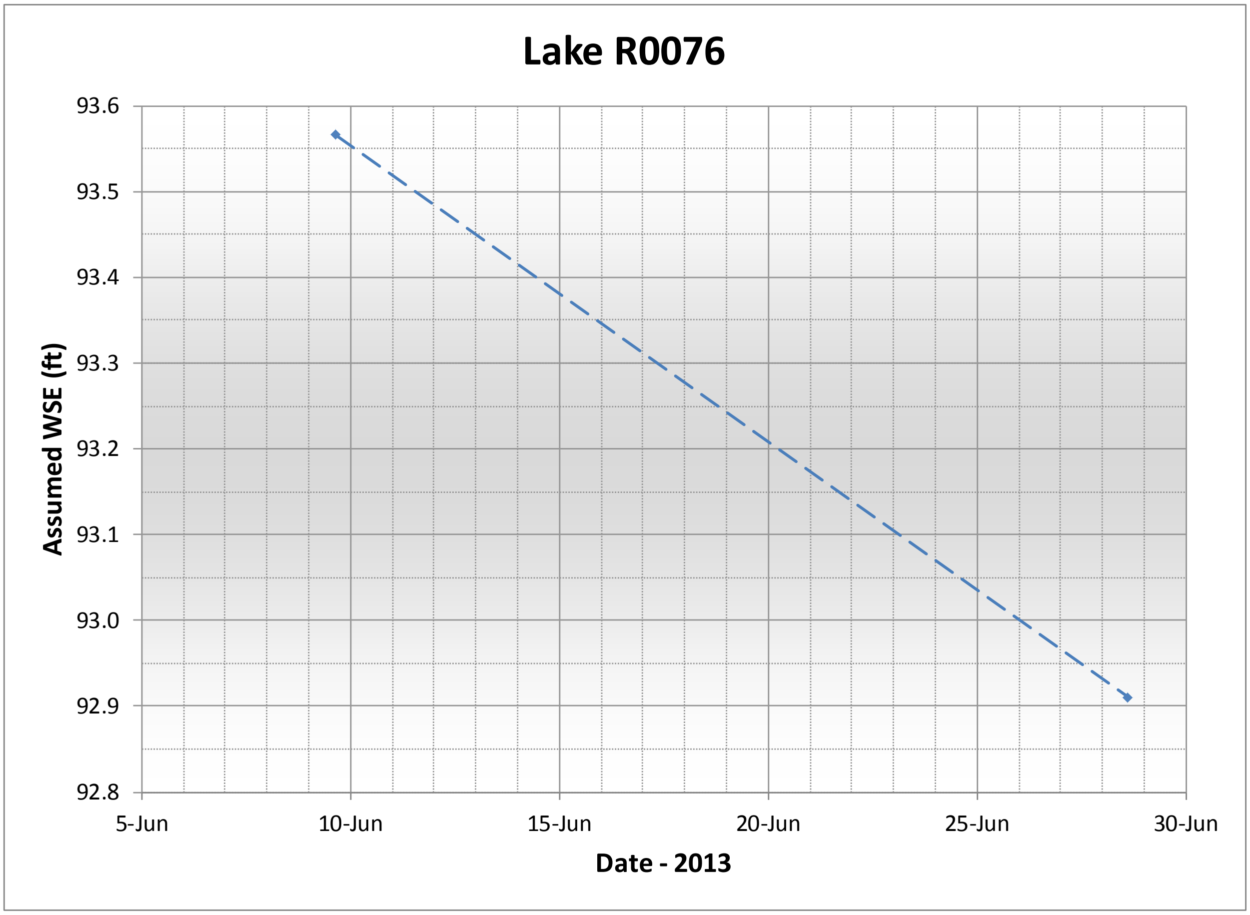
Table 4.4: WSE Data for Lake R0076

Date and Time	WSE (feet)	Observations
6/9/13 4:09 PM	93.57	Local melt; no inflow of outflow
6/28/13 3:12 PM	92.91	No inflow or outflow

Notes:

1. Elevations are assumed based on TBM KAUAI at 100.00 feet, installed by Baker in May 2013.

2. Dashed line indicates a substantial time interval between observations and that the change in WSE is not likely direct.



4.1.2 Lake Recharge

All Cassin Study Lakes were observed to fully recharge over bankfull during the 2013 monitoring season. Bankfull recharge was determined through visual observations of outflow. The recession of WSE at lakes L9805 and R0076 further supports the documented recharge. The rise in WSE at lakes M0301 and M0701 suggests the hydrograph had not yet peaked and the observed inflow was greater than the observed outflow.

Lakes L9805, M0301, M0701, and R0076 recharged primarily from local melt and were observed draining into nearby water bodies. Lake M0020/R0079, an oxbow lake, was hydraulically connected to Fish Creek during breakup monitoring. Lake M0020/R0079 is expected to recharge from Fish Creek during flood stage and recharge from local melt when Fish Creek water levels are below flood stage.

The observed hydraulic connections are likely seasonal and limited to an increase in stage conditions during spring breakup. The lakes should be considered hydraulically isolated during the remainder of the year.

4.2 Summary of Lake Recharge Observations

At the time of the study, all lakes appeared to recharge to or above bankfull elevations via either channelized spring breakup flood flow or local melt. A compilation of hydrologic observations is provided in Table 4.5.

Table 4.5: Summary of 2013 Hydrologic Recharge Observations

Study Lake	Recharge to Bankfull	Primary Recharge Mechanism	Additional Hydraulic Connection[1]	
			Flow In	Flow Out
L9805	√	Local melt	Channelized inflow from wetlands to the south.	Connected to Lake L9803 to the north and wetlands to the northeast
M0020/R0079	√	Fish Creek	Inflow from small northwest channel in oxbow bend	Outflow through small northeast channel in oxbow bend
M0301	√	Local melt	Channelized inflow from lake to the southeast	Channelized outflow to the west into Fish Creek
M0701	√	Local melt	Inflow from beaded stream connecting drained lake basin to the south	Channelized outflow to the east
R0076	√	Local melt	South drainage visible but no observed inflow	Outflow through small northwest channel into adjacent unnamed lake
Notes:	1. Observations between June 9 and June 28, 2013. Unless specified, hydraulic connections are likely seasonal only.			

5.0 REFERENCES

ConocoPhillips AK, Inc. (CPAI). 2012. Alaska Department of Natural Resources Alpine 4th Quarter 2012 Water Use Report.

—— 2013a. Alaska Department of Natural Resources Alpine 1st Quarter 2013 Water Use Report.

—— 2013b. Alaska Department of Natural Resources Alpine 2nd Quarter 2013 Water Use Report.

Michael Baker Jr., Inc. (Baker). 2007. Colville River Delta Lakes Recharge Monitoring and Analysis. Prepared for ConocoPhillips Alaska, Inc. 110919-MBJ-RPT-001. October 26, 2007.

Appendix A Gage and TBM Locations

Monitoring Location	Site Name	Type	Latitude (WGS84)	Longitude (WGS84)
L9805	L9805-A	Gage	N70° 13.995'	W151° 8.636'
	N193AL	TBM	N70° 13.973'	W151° 8.622'
	TOAL	TBM	N70° 13.975'	W151° 8.617'
	PNUT	TBM	N70° 13.976'	W151° 8.613'
M0020/R0079	M0020/R0079 - Lake Center	Aerial Photos	N70° 16.308'	W151° 43.732'
M0301	M0301-A	Gage	N70° 16.573'	W152° 5.586'
	ISAAC	TBM	N70° 16.603'	W152° 5.624'
	LIAM	TBM	N70° 16.605'	W152° 5.632'
M0701	M0701-A	Gage	N70° 20.795'	W152° 8.689'
	KB1	TBM	N70° 20.800'	W152° 8.611'
	KB2	TBM	N70° 20.801'	W152° 8.608'
R0076	R0076-A	Gage	N70° 17.714'	W151° 49.199'
	KAUAI	TBM	N70° 17.739'	W151° 49.108'
	JOSHUA	TBM	N70° 17.738'	W151° 49.104'

Note 1: Locations are referenced to World Geodetic System 1984 (WGS84) datum.

Appendix B Cassin Lake Photos

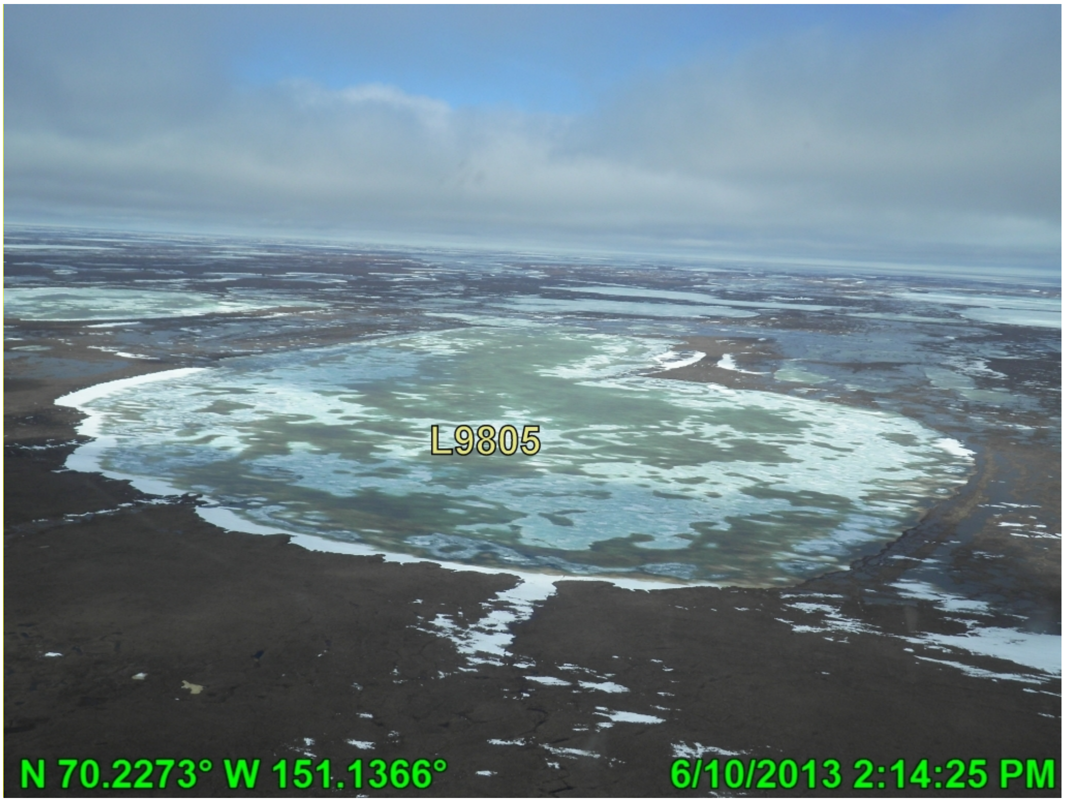


Photo D. 1: Lake L9805 during breakup, looking northwest; June 10, 2013

Photo D. 2: Lake L9805 post breakup, looking northwest; June 28, 2013

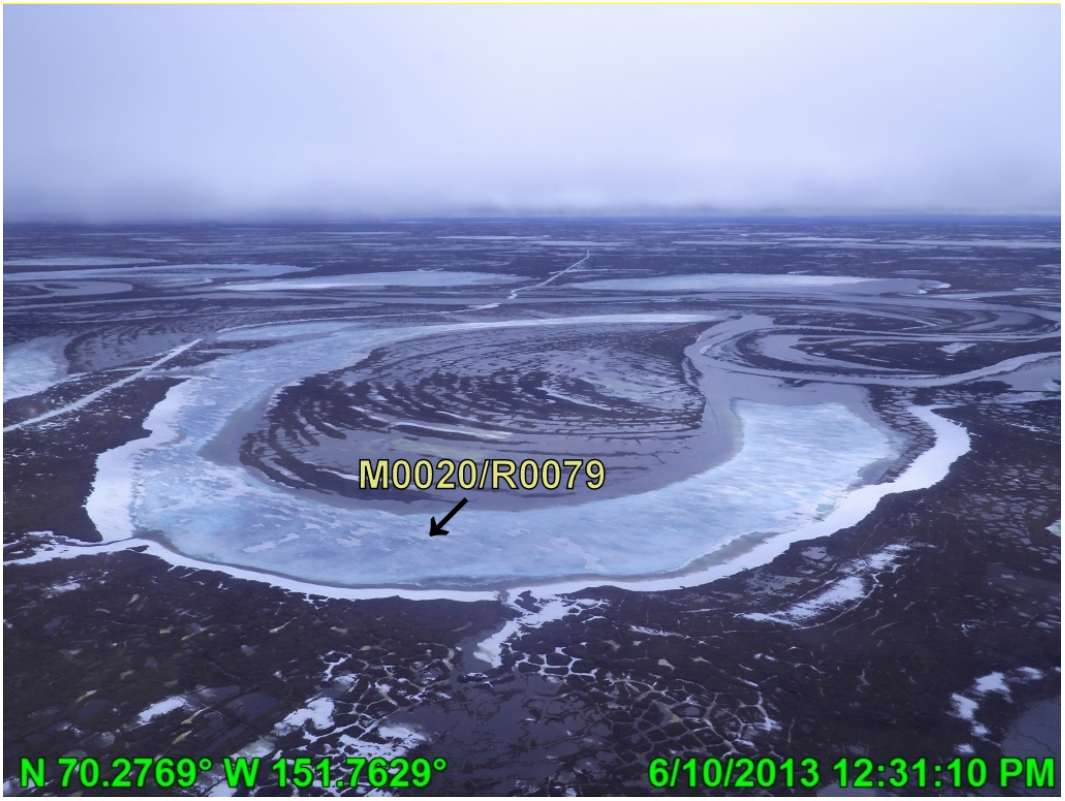


Photo D. 3: **Lake M0020/R0079 during breakup, looking southeast; June 10, 2013**

Photo D. 4: **Lake M0020/R0079 post breakup, looking east; June 28, 2013**

Photo D. 5: **Lake M0301 during breakup, looking south; June 9, 2013**

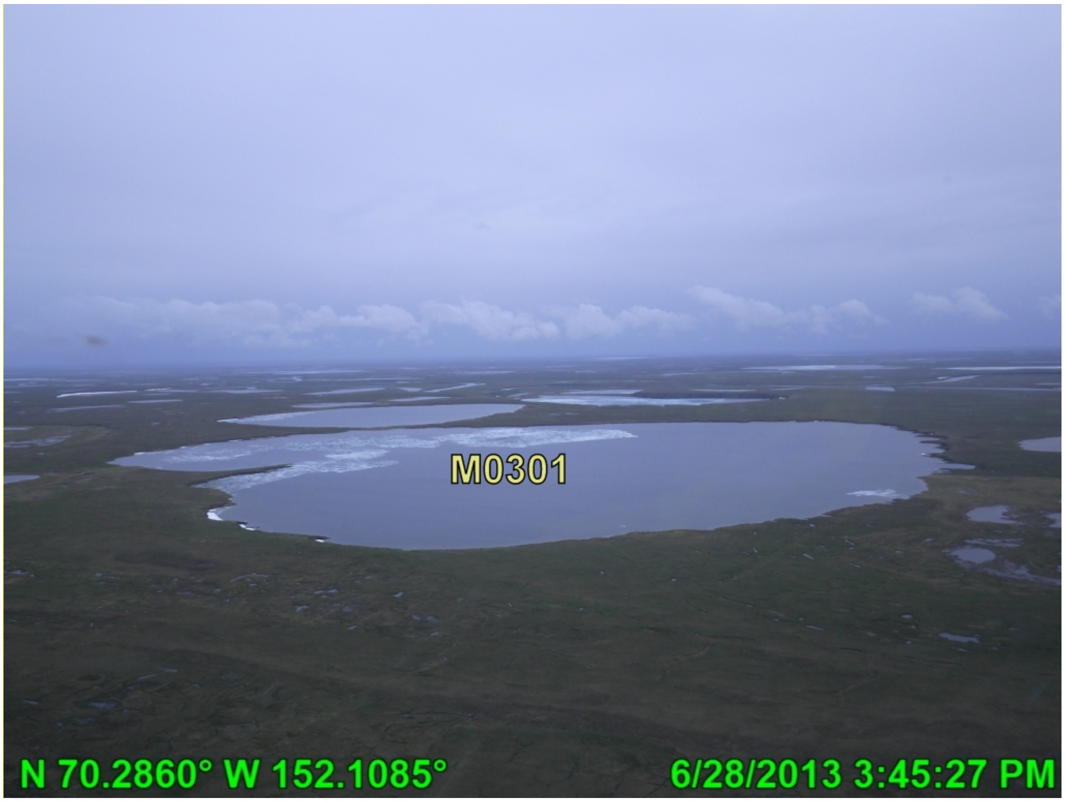


Photo D. 6: **Lake M0301 post breakup, looking southeast; June 28, 2013**

Photo D. 7: Lake M0701 during breakup, looking southwest; June 9, 2013

Photo D. 8: Lake M0701 post breakup, looking southeast; June 28, 2013

Photo D. 9: **Lake R0076 during breakup, looking southeast; June 9, 2013**

Photo D. 10: **Lake R0076 post breakup, looking northwest; June 28, 2013**

2013 Cassin Lakes

Recharge Study