2010

Fish Creek Basin (FCB) 2010 Spring Breakup Hydrologic Assessment

Submitted to

ConocoPhillips Alaska

Submitted by

Baker

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December 2010
120172-MBJ-RPT-001

Executive Summary

This report presents observations and findings of the 2010 Fish Creek Basin (FCB) Alpine Satellite Project Spring Breakup and Hydrologic Assessment conducted by Michael Baker Jr., Inc. (Baker) at the request of ConocoPhillips Alaska. The assessment supports the Alpine Development Project and Alpine Satellite Development Plan, and is Baker's sixth year of study in the Fish Creek Basin.

Observations and measurements of water surface elevation were recorded at seven locations associated with the proposed Greater Moose's Tooth 1 (GMT1) and GMT2 access road corridor, as well as the proposed Clover Material Source (CMS) area. All the monitored locations lie within the Fish Creek Drainage Basin (FCB) of the National Petroleum Reserve, Alaska (NPR-A). The seven monitoring locations included four CMS area locations, one small drainage near the proposed GMT2 pad, a small stream crossing along the GMT1 access road corridor, and the Ublutuoch River at the proposed GMT1 road crossing.

The 2010 FCB breakup was characterized by relatively low water surface elevations throughout the monitoring area, with small stream flooding conditions primarily due to local melt. The timing of the 2010 breakup of the Ublutuoch River, based on the limited eight-year period of record, was later than the historical average by four to five days. The 2010 Ublutuoch River peak water surface elevation was slightly below average and estimated peak discharge was above average compared to those on record since observations began in 2001.

The peak water surface elevation at the Ublutuoch River crossing occurred on June 8 and was measured at 10.38 feet British Petroleum Mean Sea Level (BPMSL) at river mile (RM) 6.8. The 2010 peak water surface elevation was approximately 0.12 feet lower than the maximum peak observed over the historic record. The elevated water surface elevation was likely due to nearby ice jamming. The peak water surface elevation recurrence interval is 4.5 years, based on stage frequency analysis calculations.

The Ublutuoch peak discharge occurred shortly after peak stage, estimated to be on June 8. Peak discharge was estimated to be 5,360 cfs with a WSE of 10.38 feet BPMSL. The 2010 peak discharge has a recurrence interval of 5.1 years, based on the Ublutuoch River flood frequency analysis.

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Acronyms and Abbreviations

ADP	Alpine Development Project
ASDP	Alpine Satellite Development Plan
BPMSL	British Petroleum Mean Sea Level
CMS	Clover Material Source
CPAI	ConocoPhillips, Alaska, Inc.
CRD	Colville River Delta
EOW	Edge of Water
FCB	Fish Creek Basin
FEMA	Federal Emergency Management Agency
GMT1	Greater Moose's Tooth 1
GMT2	Greater Moose's Tooth 2
GPS	Global Positioning System
NAD83	North American Datum of 1983
NPR-A	National Petroleum Reserve, Alaska
OSW	Office of Surface Water
PT	Pressure Transducer
RM	River Mile
TBM	Temporary Benchmark
UB	Ublutuoch River
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WSE	Water Surface Elevations

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Section 1 Introduction

This report presents the results of the 2010 spring breakup monitoring activities conducted in the eastern portion of the Fish Creek Drainage Basin (FCB) of the National Petroleum Reserve, Alaska (NPR-A). Monitoring was conducted along the Greater Moose's Tooth 1 (GMT1) access road corridor, near the proposed GMT2 pad, and in the proposed Clover Material Source (CMS) area. Figure 1.1 shows the location of the proposed GMT1 and GMT2 pads and access road corridor in relation to the Colville River Delta (CRD) and other proposed and existing Alpine facilities. Figure 1.2 illustrates the Colville River basin and Harrison Bay sub-basin drainage delineations.

The Alpine facilities are owned by ConocoPhillips, Alaska (CPAI), in conjunction with Anadarko Petroleum Company, and are operated by CPAI. "Alpine facilities" refers to the existing facilities, including the CD1 processing facility (Alpine); CD2, CD3, and CD4 drilling pads; access roads; and associated pipelines.

The proposed GMT1 and GMT2 drilling pads will be accessed by a gravel road. The proposed road begins at the west end of the proposed CD5 access road and extends approximately 7.8 miles west to GMT1, and an additional 8.3 miles southwest to GMT2. The proposed road alignment crosses the Ublutuoch River as well as several small drainages.

The CMS lies approximately 4.2 miles south of CD5 and 5.9 miles east of GMT1. The proposed facilities are part of the Alpine Satellite Development Plan (ASDP).

Many areas on the North Slope of Alaska, including the CRD and the FCB, share similar hydrologic and hydraulic characteristics common to the arctic climate and to the continuous presence of regional permafrost. Shallow groundwater is generally restricted to isolated zones beneath deep lakes and river channels. Groundwater influx is largely nonexistent. For much of the year, many small streams and tributaries in the FCB are completely frozen.

Spring breakup flooding is the largest annual flooding event in the North Slope region and monitoring of this event is integral to understanding regional hydrology and maintaining the continued safety of the environment, oilfield personnel, and facilities during the annual flooding event. Flow generally declines over the summer months, with occasional temporary minor flow increases resulting from rainfall events.

Spring breakup monitoring activities have been conducted specifically for the Alpine Development Project (ADP) since 1992, making the 2010 hydrologic field program the 19th consecutive year of CRD breakup investigations. Preliminary hydrologic and hydraulic assessments were conducted in the FCB between 2001 and 2003. Spring breakup monitoring in the FCB was conducted in 2003, 2004, 2005, and 2006, and then resumed in 2009. During

the 2010 spring breakup, a limited monitoring field program was conducted at key locations along the proposed road corridor.

Observations and measurements for the 2010 FCB Spring Breakup hydrologic assessment were recorded at two locations along the proposed access road between CD5 and the proposed GMT1 pad; at a single drainage near the GMT2 pad; and at four drainages in the vicinity of the CMS area. This included monitoring and discharge measurements at the Ublutuoch River and at one well-defined small stream near the Ublutuoch between CD5 and GMT1, denoted S5. Fieldwork began on June 4 and was completed on June 14, except bi-weekly monitoring of the GMT2 gage and CMS gage locations continued until July 29 where flow was observed. Figure 1.3 illustrates the 2010 monitoring locations.

This report presents the results of the 2010 FCB spring breakup monitoring program.

- **Section 1, Introduction:** discusses the objectives of the monitoring program as well as an historical overview of the Ublutuoch breakup.
- **Section 2, 2010 Monitoring Locations**: outlines and discusses the 2010 monitoring sites**.**
- **Section 3, Methods: desc**ribes the methods used to collect and analyze the data.
- Section 4, 2010 FCB Spring Breakup Hydrologic Observations, WSE, and Discharge: presents summaries of observations, stage, and discharge results for the assessment.
- **Section 5, Flood and Stage Frequency Analysis**: presents the results of the flood frequency analysis for the Ublutuoch and S5 locations and the stage frequency analysis for the Ublutuoch River.
- **Section 6, 2011 Monitoring Plan**: is a brief summary of the proposed 2011 monitoring for the CMS, and the GMT road corridor, including GMT2 drainage and selected drainage crossings along the proposed GMT1 road.
- **Section 7, References**: contains the references used in the development of this report.

We would like to thank Alaska Kuukpik/LCMF, Inc., and Bristow Helicopters for their assistance with the water resources fieldwork. Their support and diligence contributed to a safe and productive breakup monitoring season and is greatly appreciated. We would also to express our appreciation to CPAI for their continued trust in Baker to perform this work.

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2010 EXISTING AND PROPOSED FACILITIES CRD & FCB

FIGURE 1.1
(SHEET 1 OF 1)

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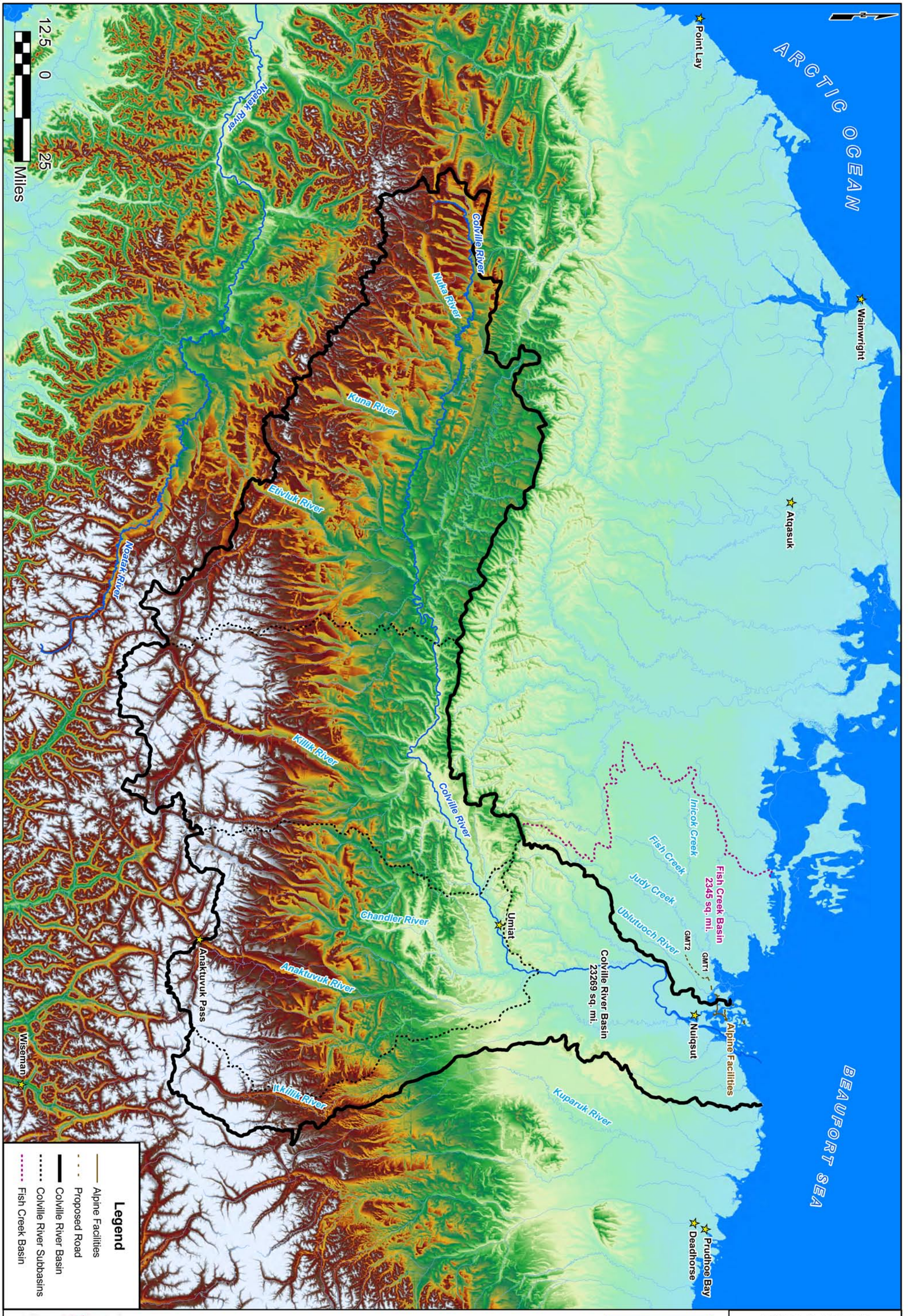

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COVILLE RIVER & FISH CREEK BASIN DELINEATION

FIGURE 1.2

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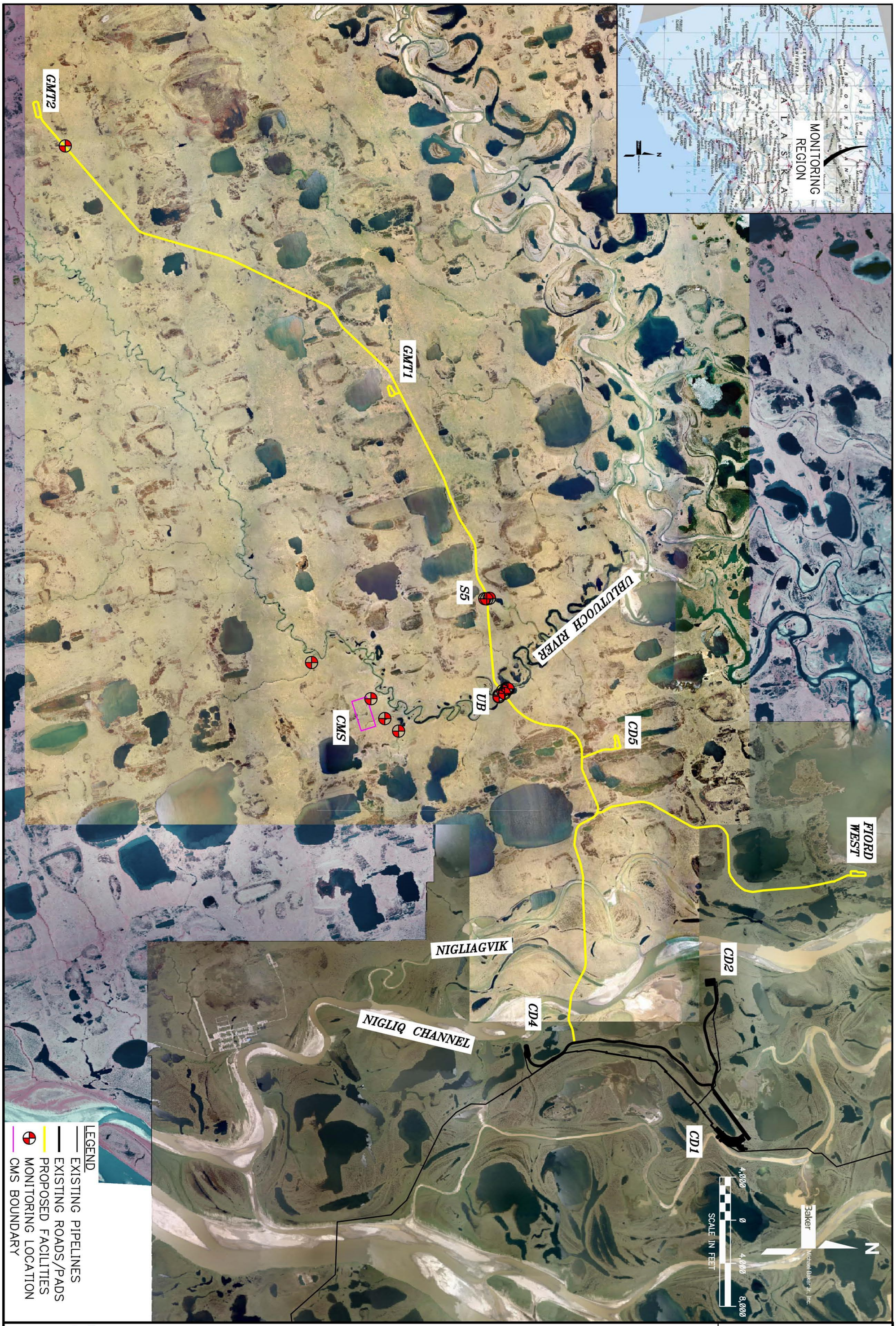

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2010 FCB BREAKUP

GAGE LOCATIONS

FIGURE 1.3

(SHEET 1 OF 1)

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1.1 2010 Monitoring Objectives

The primary objective of the 2010 FCB spring breakup program was to monitor and estimate the magnitude of breakup flooding at select locations in the eastern portion of the FCB. This was completed by observation of breakup events; documentation of the distribution of floodwater; measurement of water levels at select drainages crossed by the proposed GMT road corridor as well as at several drainages in the vicinity of the CMS area; and direct measurement of discharge at the Ublutuoch River, S5, the GMT2 drainage, and the four CMS gage sites. Additionally, indirect discharge calculations were performed at those locations where direct measurements were taken.

1.2 Ublutuoch Historical Breakup Overview

Since 2001, sporadic breakup monitoring data for the FCB has been collected at various locations. The most consistent historical record of breakup peak stage and discharge observations available is from the Ublutuoch River, the largest contributing stream within the area of interest. Table 1.1 presents the annual peak discharge, peak stage, and their respective dates for the eight years data is available.

Based on this limited eight-year data record, the average date of peak discharge is June 4. Peak discharge was estimated to have occurred on June 8 in 2010, which is four days later than average. The average date of peak stage is June 3; in 2010, peak stage occurred on June 8, five days later than average.

Table 1.1: Ublutuoch River Historical Peak Discharge, Stage & Date

Year	Location (RM)	Discharge		Stage		Reference
		Peak Discharge (cfs)	Date	Peak Stage (feet BPMSL)	Date	
2010	6.8	5,360	8-Jun	10.38	8-Jun	This Report
2009	6.8	1,990	30-May	8.45	29-May	Baker 2009
2006	6.8	1,290	6-Jun	6.19	7-Jun	Baker 2007
2005	6.8	1,680	9-Jun	10.01	7-Jun	Baker 2005b
2004	6.8 Up	2,800	5-Jun	10.50	6-Jun	Baker 2005a
2003	6.8 Up	1,300	9-Jun	10.14	6-Jun	Baker 2003
2002	13.7	1,900	22-May	18.22	22-May	URS 2003
2001	13.7	1,440	10-Jun	18.09	10-Jun	URS 2001

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Section 2 2010 Monitoring Locations

Monitoring locations were selected based on aerial imagery and topography in relation to historic hydrologic and hydraulic observations in the region and proximity of proposed facilities to relevant terrain features.

The 2010 FCB monitoring locations listed in Table 2.1 were selected in areas of surface flow or surface water concentration in the vicinity of the proposed CMS area, at two locations along the proposed GMT1 access road (as provided by PND Engineers, Inc.), and at a small drainage near the proposed GMT2 pad location. Coordinates for each monitoring site are located in Appendix A. For those sites monitored in 2009, specifically the Ublutuoch River and small stream crossing S5, the naming convention from 2009 was retained.

Table 2.1: 2010 FCB Monitoring Program

Location Type	Location	Number of Gages
CMS	CMS1-A	1
	CMS2-A	1
	CMS2-B	1
	CMS2-C	1
GMT2 Drainage	GMT2	1
Ublutuoch River	RM 6.7	4
	RM 6.8	4
	RM 6.9	3
Small Streams	S5	3
Total		**19**

2.1 Clover Material Source (CMS)

Four locations were identified as monitoring sites in 2010, representative of the general CMS area. Site location was based on a preliminary map of the CMS area showing a "Clover Site 1" and "Clover Site 2" boundary. Figure 1.3 shows the FCB breakup gage locations. The four monitoring locations were established based on topography and aerial imagery. A single gage was established at each site. Photo 2.1 shows an aerial view of the CMS2-B location.

Photo 2.1: Aerial Photo near CMS2-B Monitoring Location, June 8, 2010

2.1.1 CMS1-A

Gage CMS1-A is located approximately 1 mile southwest of the proposed CMS excavation boundary, and approximately 0.2 miles east-northeast from the nearest reach of the Ublutuoch River. Tussocks dominated both overbanks, with dwarf willows and native grass in the channel. The channel is well-defined. The confluence with the Ublutuoch River lies approximately 0.2 miles downstream from the gage location. Figure 2.1 shows the location of the CMS1-A gage.

2.1.2 CMS2-A

Gage CMS2-A is located approximately 0.4 mile north-northeast of the northeast corner of the CMS excavation boundary, and 0.3 miles southeast of the Ublutuoch River. The channel is well-defined, and is located along a series of beaded ponds. Tussocks dominated both overbanks, with dwarf willows and native grass in the channel. Lake L9826 lies approximately 0.1 mile downstream of the gage location between the gage and the Ublutuoch River. Figure 2.2 shows the location of the CMS2-A gage.

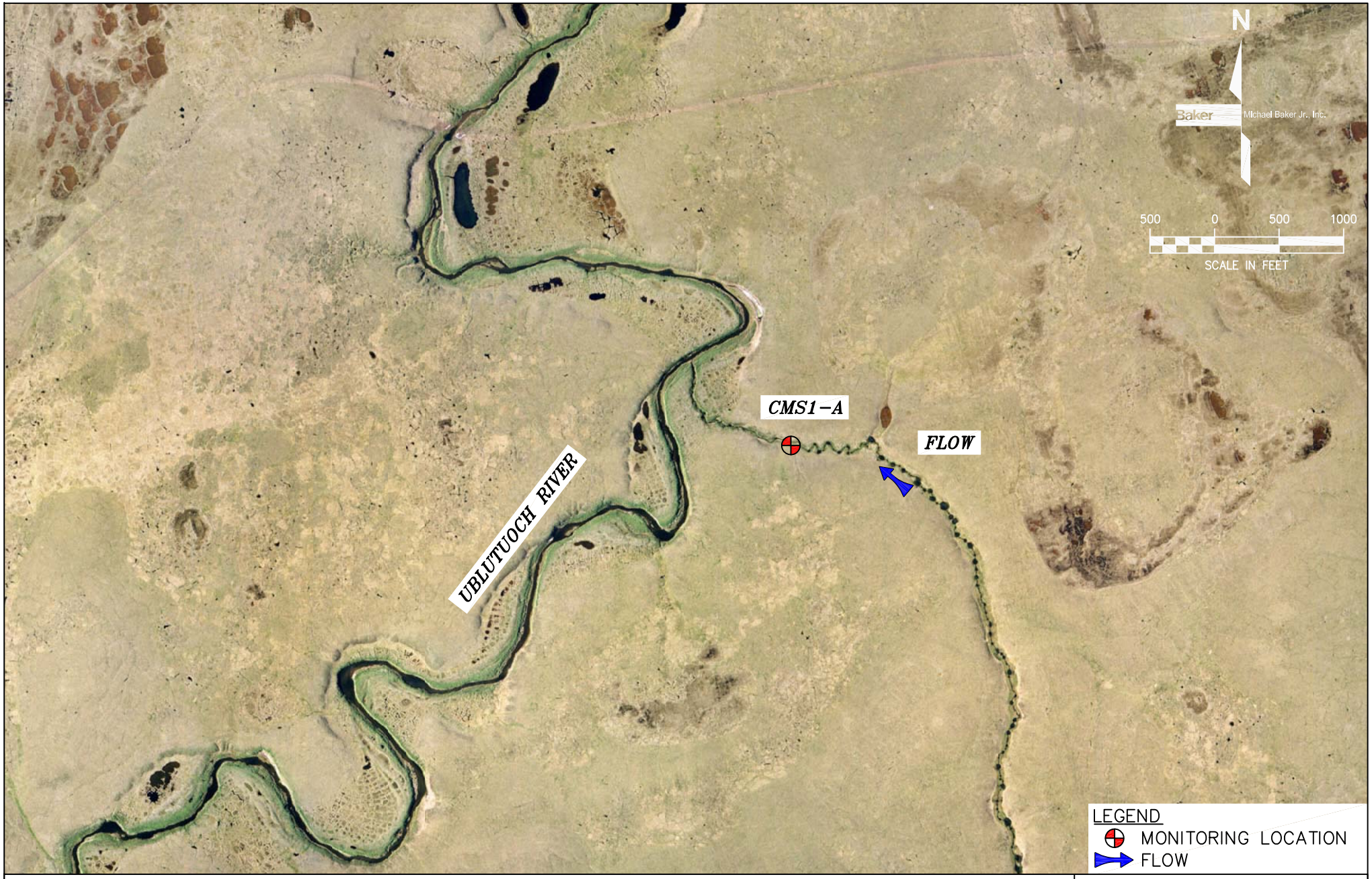
2.1.3 CMS2-B

Gage CMS2-B is located approximately 900 feet north-northwest and downstream of the proposed CMS excavation boundary. This drainage lies approximately 0.25 miles upstream of Lake L9826, and approximately 0.25 miles east-southeast from the nearest reach of the

Ublutuoch River. The channel is well-defined, and later in the season is located along a series of beaded ponds. Generally this drainage empties into Lake L9826, although during periods of higher flow, overland flow to the Ublutuoch through a secondary drainage is likely. Tussocks and native grasses covered both overbanks, with dwarf willows and native grass in the channel. The confluence with the Ublutuoch River lies approximately 0.2 miles downstream from the gage location. Figure 2.3 shows the location of the CMS2-B gage.

2.1.4 CMS2-C

Gage CMS2-C is located approximately 250 feet north-northwest (350 feet downstream) from the northern CMS boundary. This drainage lies approximately 0.17 miles upstream of the Ublutuoch River. The drainage is defined during breakup flow; later in the season flow ceased, and water depth was approximately 0.35 feet in the depression that remained of the channel. Tussocks and native grasses covered both overbanks, with native grass in the channel. Figure 2.4 shows the location of the CMS2-C gage.



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2010 FCB BREAKUP

CMS1-A

GAGE LOCATION

FIGURE 2.1

(SHEET 1 OF 1)

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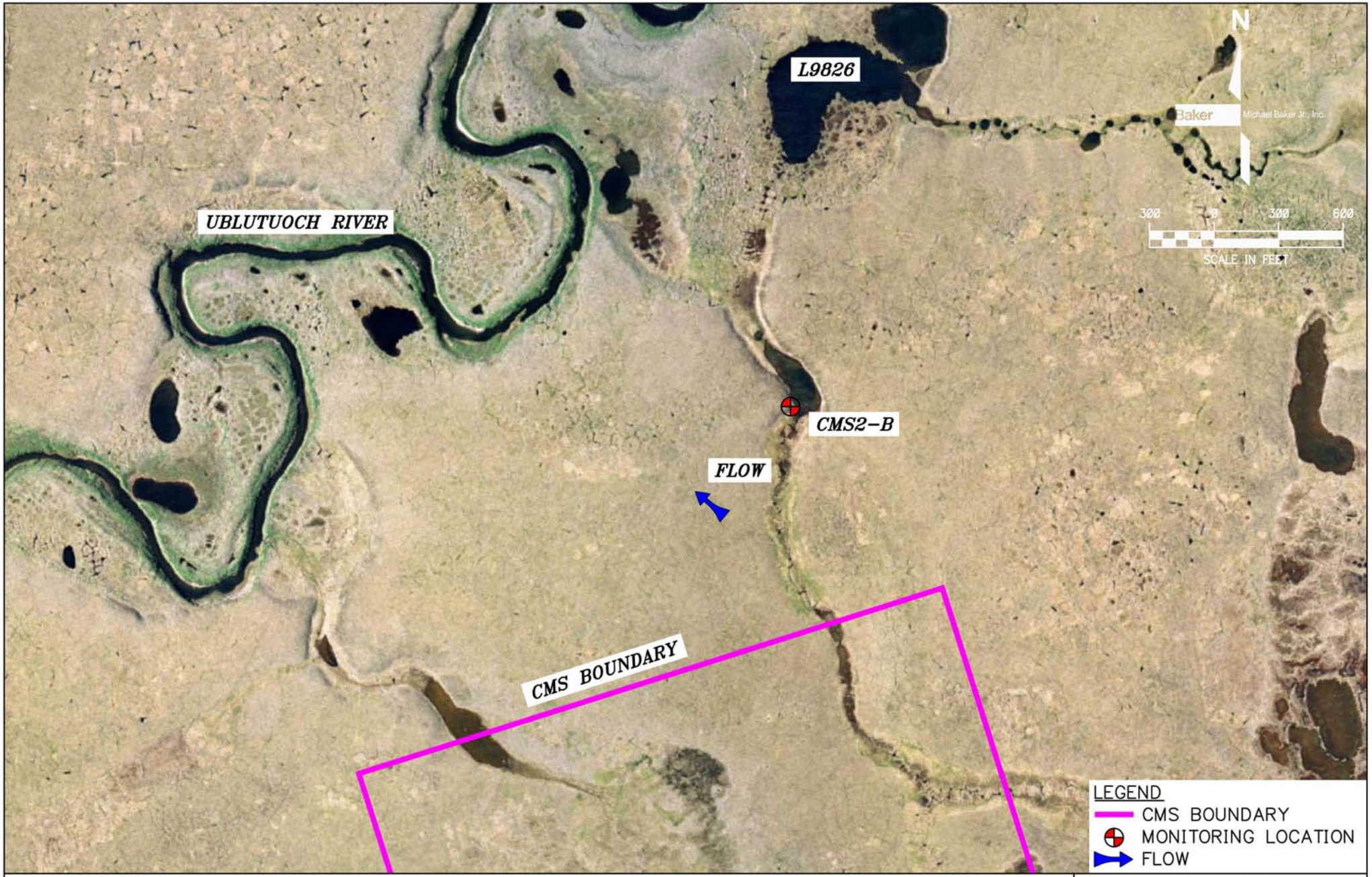
2010 FCB BREAKUP

CMS2-A

GAGE LOCATION

FIGURE 2.2

(SHEET 1 OF 1)



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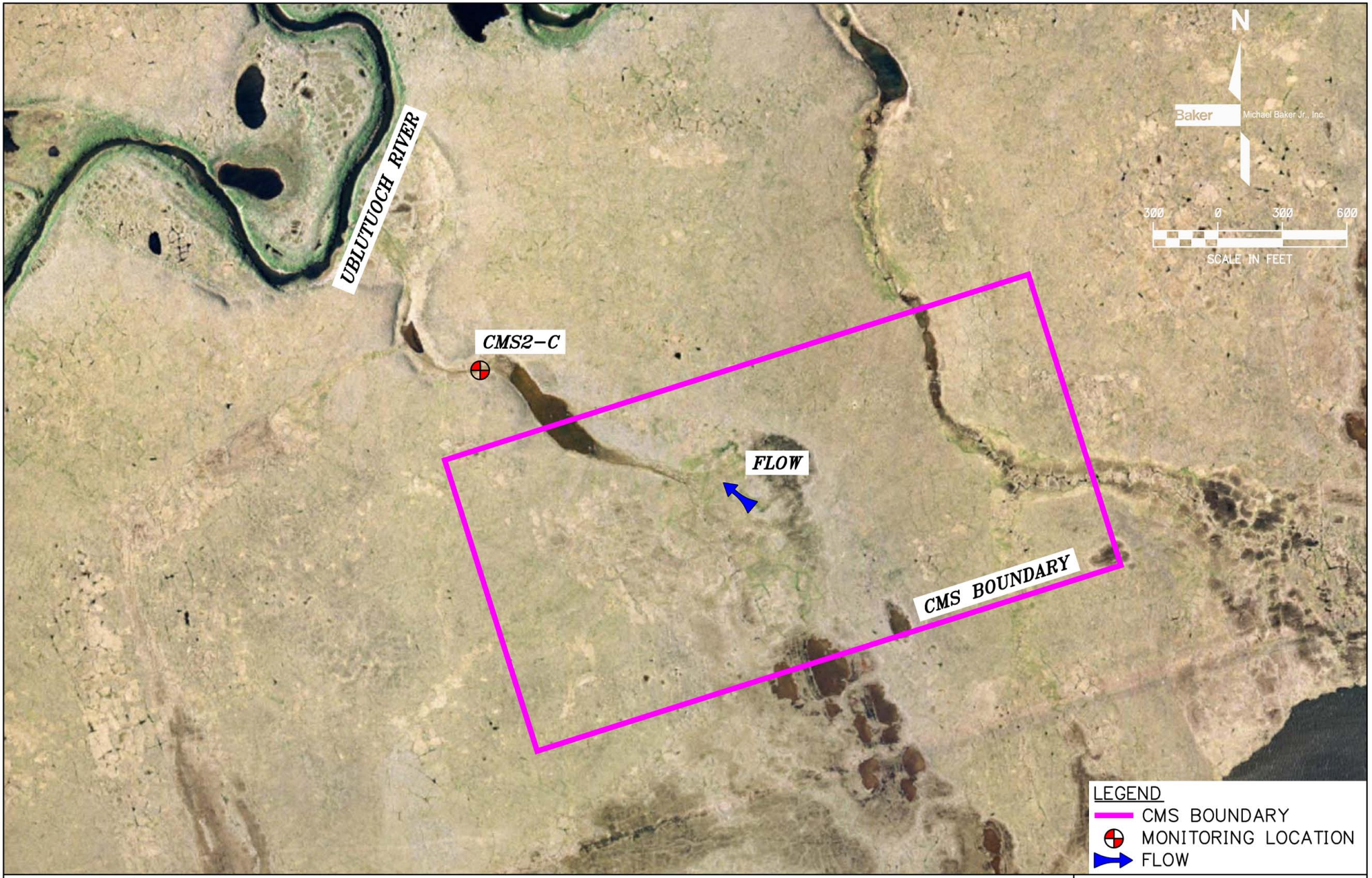
2010 FCB BREAKUP

CMS2-B

GAGE LOCATION

FIGURE 2.3

(SHEET 1 OF 1)



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2010 FCB BREAKUP

CMS2-C

GAGE LOCATION

FIGURE 2.4

(SHEET 1 OF 1)

2.2 GMT1 Road

The 2010 monitoring locations focused on two proposed bridge sites along the GMT1 road corridor, the Ublutuoch River and a small stream crossing designated "S5." The proposed GMT1 access road alignment was provided by PND Engineers, Inc.

2.2.1 Ublutuoch River

The Ublutuoch River lies in the southeast portion of the FCB. The river is sinuous with a low gradient, flowing north into Fish Creek at a location approximately 10 river miles (RM) upstream of Harrison Bay. The channel is characterized by numerous meander bends, often with undercut banks and associated bank sloughing along the outer edges.

The Ublutuoch River monitoring sites were comprised of sets of three to four gages installed on the west bank of the Ublutuoch River at RM 6.7, 6.8, and 6.9, as shown in Figure 2.5. The RM location designations, UB 6.7, UB 6.8, and UB 6.9, refer to the distance in river miles from the confluence of the Ublutuoch River and Fish Creek. The gage locations were selected to monitor and document local breakup conditions at the proposed bridge location as well as upstream and downstream from the proposed crossing. The proposed Ublutuoch bridge location at UB 6.8 remains the same as it was in 2005 and 2006. An aerial view of the proposed bridge location is provided in Photo 2.2. At the proposed bridge site, the Ublutuoch River has a drainage area of approximately 228 square miles.

Photo 2.2: Ublutuoch River near Proposed GMT1 Road Crossing Site, UB 6.8, June 8, 2010

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2010 FCB BREAKUP

UBLUTUOCH RIVER

GAGE LOCATIONS

FIGURE 2.5

(SHEET 1 OF 1)

2.2.2 Small Stream Crossing S5

In 2009, eight locations were identified as monitoring sites along the GMT1 road corridor. In 2010, monitoring was limited to a single small steam crossing, S5, where a bridge is proposed. The gage location was initially based on topography and aerial imagery, as a location where a drainage structure would potentially be required to preserve the integrity of the proposed road. Three gages were installed and monitored at S5.

The 3.6 square mile drainage basin of S5 flows into the Ublutuoch River via connected pools, small ponds, and lakes. The drainage at S5 connects two smaller lakes and is uniform in cross-section, having a firm channel bed with underlying sedge and banks dominated by willows. The S5 gage locations are identified in Figure 2.6.

2.3 Greater Moose's Tooth 2 (GMT2)

A single location was identified as a monitoring site near the proposed GMT2 pad in 2010. Site location was based on a map showing the drainage located near the proposed GMT2 pad, near the proposed road crossing location. The GMT2 monitoring location was established based on topography and aerial imagery.

Gage GMT2 is located approximately 0.7 miles northwest of the proposed pad. This drainage lies approximately 1.3 miles northeast of a tributary to the Ublutuoch River. The drainage is defined during breakup flow; later in the season flow ceased, and water depth was approximately 0.2 feet in the depression that remained of the channel. Tussocks and native grasses covered both overbanks and the channel. Figure 2.7 shows the location of the GMT2 gage. Photo 2.3 shows an aerial view of the GMT2 drainage area.

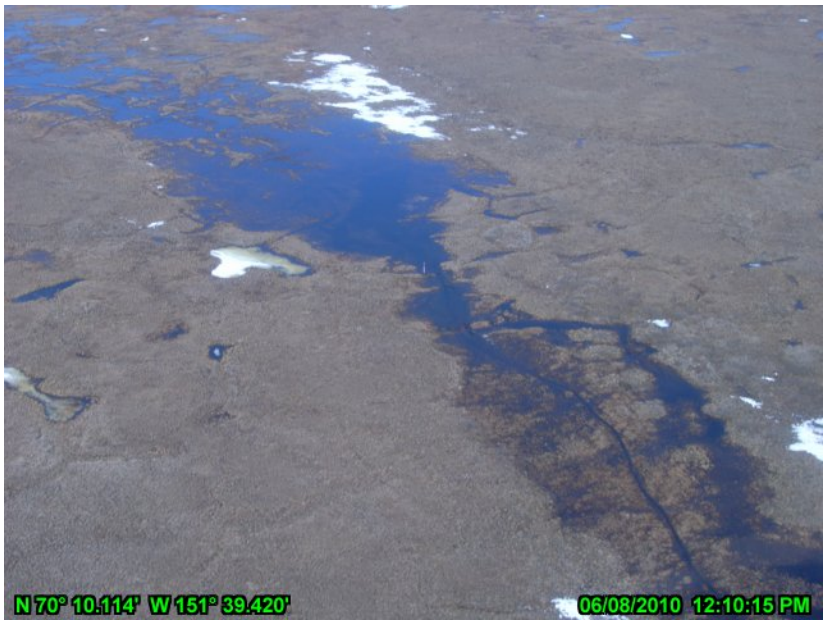
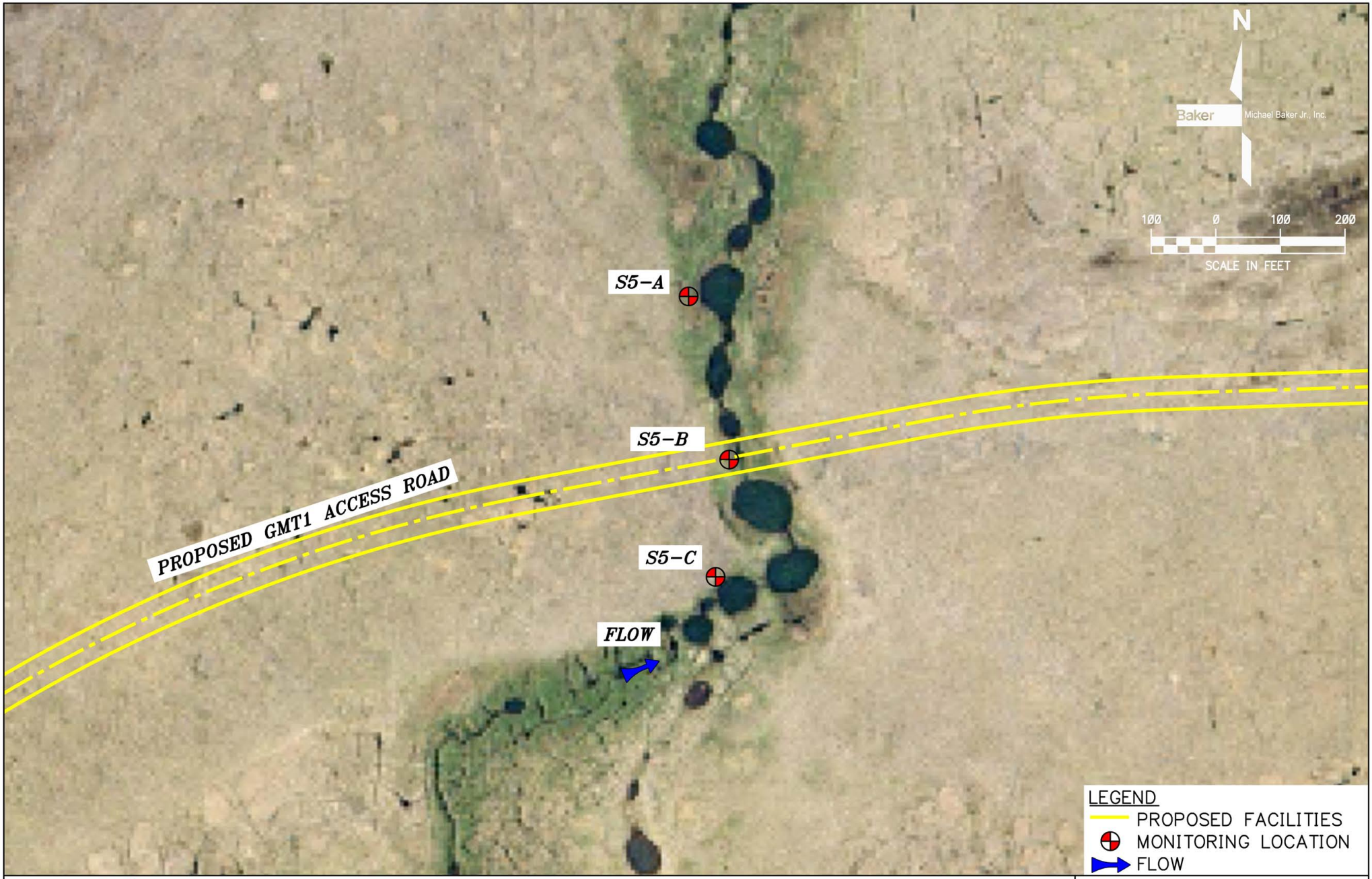


Photo 2.3: Aerial View GMT2 Drainage, June 8, 2010



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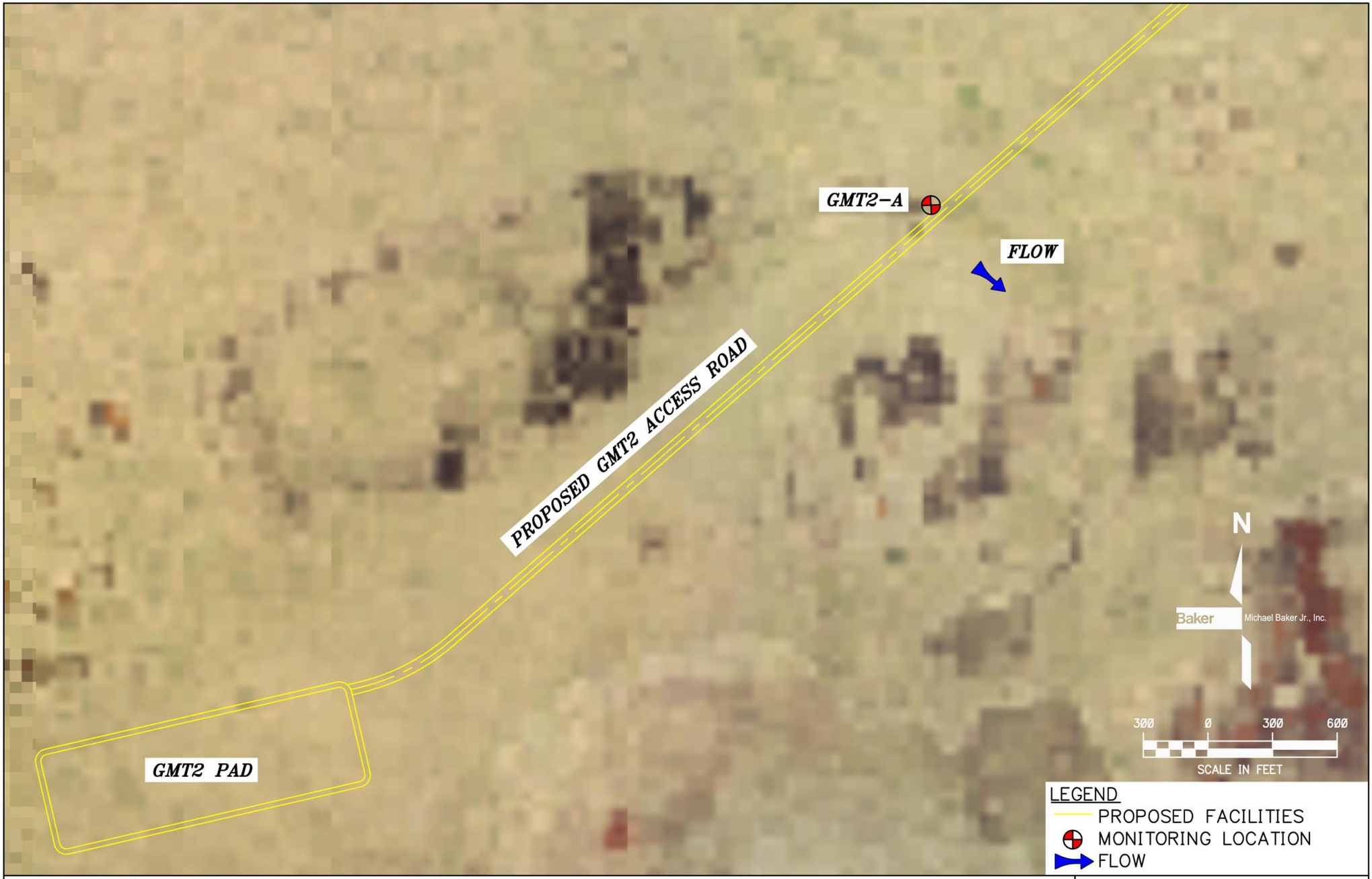
2010 FCB BREAKUP

S5

GAGE LOCATIONS

FIGURE 2.6

(SHEET 1 OF 1)



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2010 FCB BREAKUP

GMT2 DRAINAGE

GAGE LOCATION

FIGURE 2.7

(SHEET 1 OF 1)

Section 3 Methods

The primary methods used during the 2010 FCB spring breakup assessment were visual observations of the distribution of flow, measurement of water surface elevation, and measurement of discharge. Field methods were based on standard techniques proven safe, reliable, efficient, and accurate for the conditions found in the FCB during spring breakup.

3.1 Visual Observations

An initial reconnaissance flight was conducted on June 4, during which it was determined spring breakup was slightly behind the CRD area. At the time of the flight, attention focused on pre-breakup conditions in the Ublutuoch River area, and only local melt was observed in the area and the Ublutuoch River at RM 6.8. Previously monitored GMT1 road corridor gage sites (including small stream crossing S5) were visited on June 4.

Visual observations were recorded in field books. Additionally, digital photographs were collected to document the progression of spring breakup during and after peak flooding events. The geographic position of the camera, date, and time were automatically imprinted onto each photo. Additional photographs were taken and manually geographically referenced to document the location of each image.

3.2 Water Surface Elevation

Water surface elevation (WSE) was measured by visual observation of staff gages at each site, or by survey level loop techniques when the WSE was too low to be read directly from the gages. It was not possible to deploy pressure transducers (PT) at any of the monitoring locations, as it was impossible to retrieve them from the CRD due to high water and remaining stranded ice.

Photo 3.1: Staff Gage Installed at UB6.9-A, June 6, 2010

3.2.1 Staff Gages

Temporary staff gages consisted of one to four gage assemblies per site. Each gage assembly contained a metal gage faceplate mounted on a two-by-four timber attached with U-bolts to a 6-foot long 1.5-inch angle iron post driven 2 feet into the ground. The horizontal position of each gage was recorded using a handheld Garmin GPSMAP 60CS in North American Datum of 1983 (NAD83). Photo 3.1 shows an example of a staff gage after installation.

Where survey control is established, the elevation of each gage was surveyed from a local benchmark tied to British Petroleum Mean Sea Level (BPMSL) using standard level loop techniques. Where survey control has not been established (particularly the CMS and GMT2 monitoring sites), local control was established based on handheld GPS elevations. These local control monuments can be tied to survey control in the future. The basis of elevation for each gage and the horizontal position of respective benchmarks and gages are presented in Appendix A. The most recent (as of spring 2009) basis of elevation of vertical control was used. Gage surveys were conducted during field observations.

Gages were named based on the site location identification. In locations where terrain elevation varied more than three feet, more than one gage was installed. This occurred at S5 and at each site along the Ublutuoch River. These gages were further identified with alphabetical designations A, B, C, or D, with A being closest to the water's edge (e.g., S5-A, S5-B, and S5-C).

3.3 Discharge Measurements

Discharge was both directly measured and indirectly calculated at all seven locations on either June 7 or June 8, 2010. Standard United States Geological Survey (USGS) midsection methods were used to directly measure discharge. When possible, velocity and discharge measurements should be taken as close to the observed peak stage as possible to determine the peak direct discharge. Indirect discharge was calculated based on observed data.

3.3.1 USGS Midsection Techniques

Photo 3.2: Ublutuoch River Boat Discharge Measurement, June 8, 2010

Standard USGS midsection techniques (Rantz 1982) were used to determine discharge at the Ublutuoch River (UB 6.8) as well as at Site S5.

A Price AA velocity meter was used to measure velocities and discharge at UB 6.8. Measurements were taken using a sounding reel connected to a boat-mounted boom with a 30-pound Columbus-type lead sounding weight. A tag line was used to define the cross section and to delineate measurement subsections within the channel. The velocity meter was calibrated by the USGS at the Office of Surface Water (OSW) Hydraulic Laboratory in 2006. To ensure accurate performance of meters, procedures outlined in OSW Technical Memorandum No. 99.06 were followed. Photo 3.2 shows the

Photo 3.3: Small Stream Wading Discharge Measurement at CMS2-B, June 7, 2010

velocity meter and sounding weight used for the Ublutuoch River UB 6.8 discharge measurement.

A Marsh-McBirney Flo-Mate 2000 portable velocity meter and USGS wading rod were used to determine discharge at all other gage locations. A tag line was used to define the cross section and delineate measurement subsections within the channel. Photo 3.3 shows the small stream discharge measurement at CMS2-B.

3.3.2 Indirect Discharge Calculations

The indirect discharge calculations used physical characteristics, such as WSE slope, as input variables. Indirect discharge calculations were performed for all seven locations.

Indirect calculations of peak discharge for the Ublutuoch River were performed by correlating hydraulic depths observed during the direct discharge measurement and during peak discharge conditions. This indirect method assumes that the average measured velocity varies little between the time of direct measurements and actual peak discharge. The assumption is valid if the observed increase in stage, as well as the differential stage between upstream and downstream, is relatively low. For this reason, direct discharge measurements are collected as near to peak discharge as possible.

Indirect calculations of peak discharge for the Ublutuoch River and S5 were also performed using the slope-area method for a uniform channel (Benson and Dalrymple 1967). Water surface elevation and slope data were obtained from observations made at gages. Cross-section geometry for S5 and the Ublutuoch River were based on cross sections surveyed by Kuukpik/LCMF in 2005 on the Ublutuoch River.

The remaining locations utilized the velocity-area method for indirect discharge.

3.4 Flood and Stage Frequency Analysis Method

Flood and stage frequency analyses were performed on select locations in the monitoring area in 2009 (Baker 2009a). Of those locations, S5 and the Ublutuoch River were also monitored in 2010. The 2010 discharge data for S5 and UB6.8, as well as stage data at UB6.8, was compared to the 2009 flood and stage frequency analysis results for these locations.

The 2009 flood frequency analysis was performed on small stream site S5 using a delineated drainage basin and USGS regional regression equations for Region 7 (Curran, Meyer, and Tasker 2003).

A flood frequency analysis was performed on the Ublutuoch River using three methods: 1) USGS regional regression equations, 2) a station-specific frequency analysis using historic peak discharge, and 3) weighted estimates based on results from the station-specific and regional regression analyses. USGS regression equations and weighted estimates were calculated using methods presented in Curran, Meyer, and Tasker (2003). The program PeakFQ Version 5.2 (USGS 2007) was used to perform the station-specific flood frequency analysis.

Section 4 2010 FCB Spring Breakup Hydrologic Observations, WSE, and Discharge

This section presents the images, data, observations, and analyses results for the FCB Alpine Satellite Project 2010 Hydrologic Assessment. Hydrologic data and observations were documented between June 4 and June 14, 2010, and are described in the following sections.

The initial reconnaissance flight was conducted on June 4. Only local melt was observed in the area of the Ublutuoch River at RM 6.8. The Ublutuoch did not appear to be hydraulically connected in the vicinity of the proposed road crossing. Previously monitored GMT1 road corridor gage sites (including small stream crossing S5) were also visited on June 4.

4.1 Clover Mine Source (CMS)

The proposed CMS area is located approximately 2.3 miles south of the UB 6.8 gage location. The area is generally bounded on the north by the Ublutuoch River and on the west, east, and south by drainage channels that are both perennial and ephemeral channels.

On June 6, each of the proposed CMS monitoring sites were visited and a gage and steel were left onsite. Installation of gages was not accomplished due to helicopter scheduling issues. All channels were noted to be flowing well, with snow and ice remaining on the banks and in the channels. Compared to the June 4 reconnaissance flight, when only local melt was observed, on the June 6 flight, snow cover was estimated to be approximately 20 percent coverage, most channels were flowing, and most lakes were translucent blue and appeared to be softening due to melt.

Due to weather and helicopter logistics, gages were established at the CMS sites on June 7. On June 7, an initial gage reading at each of the four CMS monitoring sites, CMS1-A, CMS2-A, CMS2-B and CMS2-C, was obtained.

Water surface elevations were obtained at each of the four CMS gage locations either daily or every other day (depending on weather conditions and helicopter availability) from June 7 through June 10, then again June 14, June 28, July 13 (final visit to CMS 2-C) and July 29. Flow was determined to have ceased at CMS2-C by July 13, although water remained in the low-lying portions of the channel.

High water surface elevations were recorded at CMS1-A (June 8, 25.29 feet BPMSL), CMS 2-A (June 8, 19.34 feet BPMSL), and CMS2-B (based on drift line on snow bank, prior to June 7, 41.82 feet BPMSL). Water surface elevation at CMS2-C drainage continued to decline from the initial readings throughout the monitoring period; therefore, a high water surface elevation was not obtained at CMS2-C. The initial high reading at CMS2-C on June 7 was 31.27 feet BPMSL.

4.1.1 CMS1-A Hydrologic Observations and WSE

Water surface elevation measurements at CMS1-A began on June 7 (Photo 4.1). Daily monitoring during breakup was not possible in 2010 because of inaccessibility due to weather conditions. After breakup, monitoring continued at this location every two weeks through July. Flow was still present in this channel on July 29, after which observations were discontinued.

Photo 4.1: View near CMS1-A Gage Location, June 7, 2010

Measured WSE increased from initial observations on June 7 to June 8, when peak stage is estimated to have occurred. Peak WSE at CMS1-A was 25.29 feet BPMSL. WSE are based on temporary benchmark TBM elevations set by handheld GPS, and are not tied to nearby monitoring locations or verified by survey to local control. WSE data for CMS1-A is provided in Table 4.1. Photo 4.2, Photo 4.3, and Photo 4.4 show the CMS1-A area at different times after breakup.

Photo 4.2: Aerial View, CMS1-A, June 14, 2010

Photo 4.3: Aerial View CMS1-A, July 13, 2010

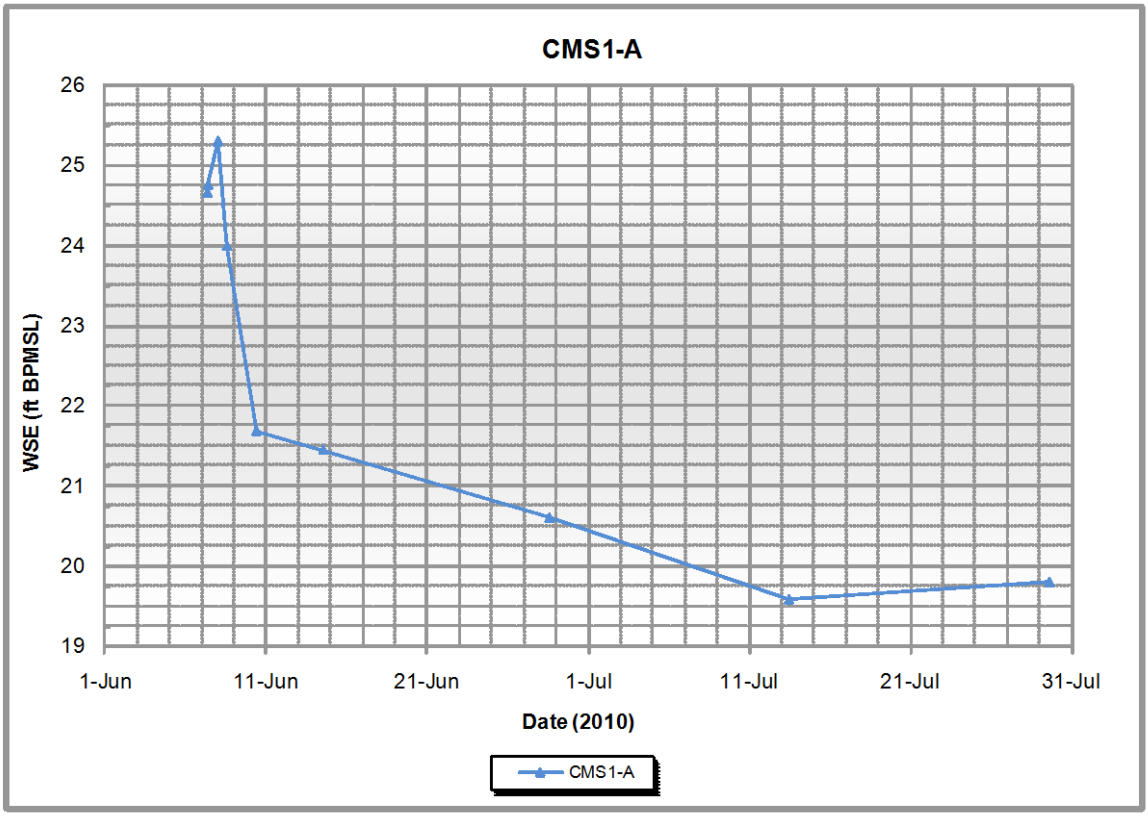
Photo 4.4: CMS1-A Channel View, July 13, 2010

Table 4.1: CMS1-A WSE

Date and Time	WSE (feet BPMSL) CMS1-A	Observations
6/7/10 9:14 AM	24.65	Installed gage, chalked to water; channel has a lot of slush and ice on bottom.
6/7/10 10:05 AM	24.75	WSE measurement following discharge measurement.
6/8/10 1:00 AM	25.29	**PEAK STAGE**, HWM - time estimated
6/8/10 2:08 PM	23.99	
6/10/10 10:00 AM	21.68	
6/14/10 1:40 PM	21.44	measured using peep sight
6/28/10 2:05 PM	20.59	
7/13/10 10:50 AM	19.58	
7/29/10 2:30 PM	19.79	stream still has evident flow

Notes:

1. WSE are based on TBMs TUNDRA and CHICKEN, established by Baker in 2010. The elevations for these TBMs are set by handheld GPS, and are not tied to nearby monitoring locations or verified by survey to local control.
2. One discharge measurement of 51 cfs was taken on 6/7/2010 at 9:47 AM.



4.1.2 CMS1-A Discharge

4.1.2.1 Direct Discharge

A direct discharge measurement at CMS1-A was conducted on June 7 beginning at 9:47 a.m., as close to peak flow as possible (approximately 13 hours before peak) (Photo 4.5). Discharge was measured to be 51 cfs. The measurement was rated "poor" based on channel conditions; the channel cross section was irregular due to ice and it was partially constricted by snow.

Photo 4.5: CMSA-1 Direct Discharge Measurement, June 7, 2010

A summary of the 2010 direct discharge measurement is presented in Table 4.2, and complete notes are included in Appendix A.

Table 4.2: CMS1-A Direct Discharge

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
CMS1-A	6/7/10 9:47 AM	24.65	72	71	0.72	**51**	P	Marsh McBirney	16	Wading

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.
[2] Measurement Rating
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.1.2.2 INDIRECT DISCHARGE

The 2010 peak discharge at CMS1-A likely occurred at the time of peak stage. Peak stage is estimated to have occurred at 1:00 a.m. on June 8.

Peak discharge at the CMS1-A drainage was estimated using a velocity-area analysis and based on the assumption the measured average adjusted velocity was representative of the average velocity at peak stage. This assumption is made due to the relative timing of peak stage to the time velocity data was collected during the direct discharge measurement. This calculation is performed assuming open-channel conditions, and should be considered a conservative estimate.

Peak discharge was estimated to have been 84 cfs at CMS1-A. Table 4.3 summarizes the indirect discharge results.

Table 4.3: CMS1-A Indirect Discharge

Location	Date & Time	Peak WSE[1] (ft BPMSL)	Peak Discharge (cfs)	Indirect Discharge Analysis Type
CMS1-A	6/8/2010 1:00 AM*	25.29	**84**	Velocity-Area

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.
* WSE value is a high water mark; time is estimated

4.1.3 CMS2-A HYDROLOGIC OBSERVATIONS AND WSE

Water surface elevation measurements at CMS2-A began on June 7. Daily monitoring during breakup was not possible in 2010 because of inaccessibility due to weather conditions. After breakup, monitoring continued at this location every two weeks through July. Flow was still present in this channel on July 29, after which observations were discontinued. Photo 4.6 shows the CMS2-A location on June 7.

Photo 4.6: CMS2-A Location, June 7, 2010

Measured WSE increased from initial observations on June 7 to June 8, when peak stage is estimated to have occurred. Peak WSE at CMS2-A was 19.34 feet BPMSL. WSEs are based on TBM elevations set by handheld GPS, and are not tied to nearby monitoring locations or verified by

survey to local control. WSE data for CMS2-A is provided in Table 4.4. Photo 4.7, Photo 4.8, and Photo 4.9 show CMS2-A at various times following breakup. As shown in Photo 4.8, CMS2-A is a defined channel along a series of deep beaded ponds.

Photo 4.7: CMS2-A Aerial View, June 14, 2010

Photo 4.8: Aerial View CMS2-A, July 13, 2010

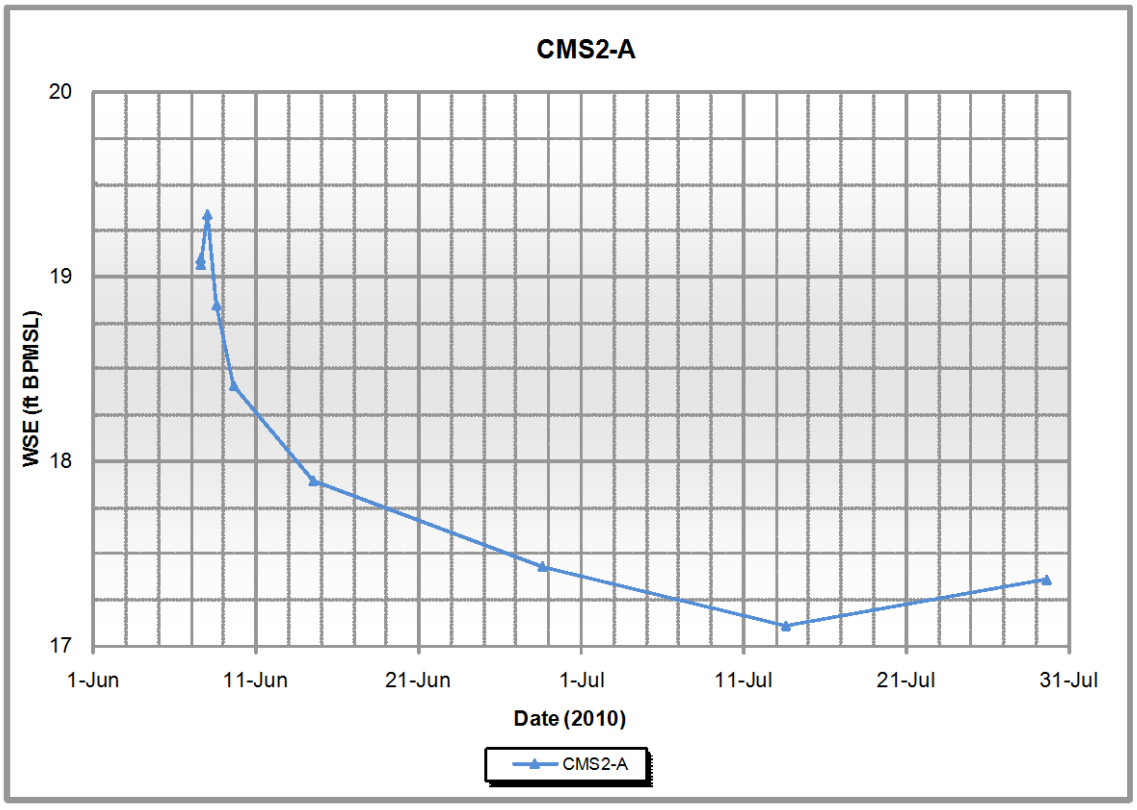
Photo 4.9: Gage CMS2-A, June 9, 2010

Table 4.4: CMS2-A WSE

Date and Time	WSE (feet BPMSL) CMS2-A	Observations
6/7/10 2:58 PM	19.10	
6/7/10 3:19 PM	19.07	
6/8/10 1:00 AM	19.34	**PEAK STAGE**, HWM- time estimated
6/8/10 2:26 PM	18.85	
6/9/10 4:15 PM	18.41	
6/14/10 1:40 PM	17.90	measured using peep sight
6/28/10 3:30 PM	17.43	
7/13/10 2:40 PM	17.11	
7/29/10 3:40 PM	17.36	observable flow in stream

Notes:

1. WSE are based on TBMs PENELOPE and RUST, established by Baker in 2010. The elevations for these TBMs are set by handheld GPS, and are not tied to nearby monitoring locations or verified by survey to local control.
2. One discharge measurement of 41 cfs was taken on 6/7/2010 at 3:00 PM.



4.1.4 CMS2-A Discharge

4.1.4.1 Direct Discharge

A direct discharge measurement at CMS2-A was conducted on June 7 beginning at 3:00 p.m., as close to peak flow as possible (approximately 10 hours before peak) (Photo 4.10). At that time, discharge was measured to be 41 cfs. The measurement was rated "poor" based on channel conditions; the channel was partially constricted by snow.

Photo 4.10: Discharge Measurement at CMS2-A, June 7, 2010

A summary of the 2010 direct discharge measurement is presented in Table 4.5, and complete notes are in Appendix A.

Table 4.5: CMS2-A Direct Discharge

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
CMS2-A	6/7/10 3:00 PM	19.1	48	65	0.62	**41**	P	Marsh McBirney	12	Wading

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.
[2] Measurement Rating
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.1.4.2 INDIRECT DISCHARGE

The 2010 peak discharge at CMS2-A likely occurred at the time of peak stage. Peak stage is estimated to have occurred at 1:00 a.m. on June 8.

Peak discharge at the CMS2-A drainage was estimated using a velocity-area analysis and based on the assumption that the measured average adjusted velocity was representative of the average velocity at peak stage. This calculation is performed assuming open-channel conditions, and should be considered a conservative estimate.

Peak discharge was estimated to have been 47 cfs at CMS2-A. Table 4.6 summarizes the indirect discharge results.

Table 4.6: CMS2-A Indirect Discharge

Location	Date & Time	Peak WSE[1] (ft BPMSL)	Peak Discharge (cfs)	Indirect Discharge Analysis Type
CMS2-A	6/8/2010 1:00 AM*	19.34	**47**	Velocity-Area

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.
* WSE value is a high water mark; time is estimated

4.1.5 CMS2-B HYDROLOGIC OBSERVATIONS AND WSE

Water surface elevation measurements at CMS2-B began on June 7. Daily monitoring during breakup was not possible in 2010 because of inaccessibility due to weather conditions. After breakup, monitoring continued at this location every two weeks through July. Slight flow was still present in this channel on July 29, after which observations were discontinued.

Photo 4.11: Gage at CMS2-B, June 10, 2010

Measured WSE decreased from initial observations on June 7, when the peak WSE was documented based on a drift line in the adjacent snow, measuring 41.82 feet BPMSL. WSE are based on TBM elevations set by handheld GPS, and are not tied to nearby monitoring locations or verified by survey to local control. WSE data for CMS2-B is provided in Table 4.7. Photo 4.12,

Photo 4.13, and Photo 4.14 show the CMS2-B area at various times during and following breakup.

Photo 4.12: Aerial View CMS2-B Area, June 8, 2010

Photo 4.13: Aerial View CMS2-B Area, June 14, 2010

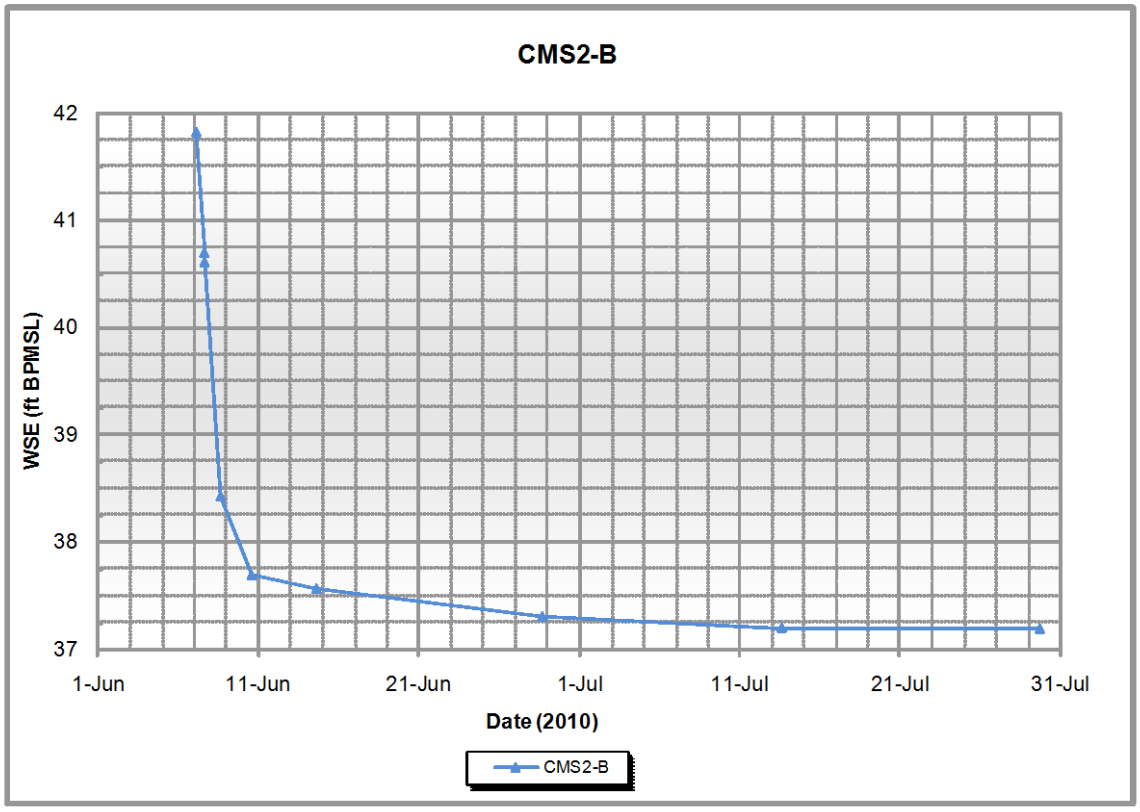
Photo 4.14: Aerial View CMS2-B Area, July 13, 2010

Table 4.7: CMS2-B WSE

Date and Time	WSE (feet BPMSL) CMS2-B	Observations
6/7/10 1:50 AM	41.82	**PEAK STAGE**, HWM on bank - time estimated; measured with peep sight
6/7/10 1:50 PM	40.70	
6/7/10 2:07 PM	40.61	WSE measured following completion of discharge measurement
6/8/10 2:19 PM	38.43	
6/10/10 12:35 PM	37.70	
6/14/10 1:40 PM	37.57	measured using peep sight
6/28/10 3:05 PM	37.31	
7/13/10 1:30 PM	37.21	
7/29/10 3:10 PM	37.20	slight flow still present in stream

Notes:

1. WSE are based on TBMs Baker CP3 and MEG, established by Baker in 2010. The elevations for these TBMs are set by handheld GPS, and are not tied to nearby monitoring locations or verified by survey to local control.
2. One discharge measurement of 59 cfs was taken on 6/7/2010 at 1:40 PM.



4.1.6 CMS2-B Discharge

4.1.6.1 Direct Discharge

A direct discharge measurement at CMS2-B was conducted on June 7 beginning at 1:38 p.m., as close to peak flow as possible (although the timing of peak flow at this location is estimated). Discharge was measured to be 59 cfs. The measurement was rated "poor" based on channel conditions; snow and slush were present in the channel bed and the right edge of water was in a snow bank. Photo 4.15 shows the discharge June 7 measurement at CMS2-B .

Photo 4.15: Discharge Measurement at CMS2-B, June 7, 2010

A summary of the 2010 direct discharge measurement is presented in Table 4.8, and complete notes are in Appendix A.

Table 4.8: CMS2-B Direct Discharge

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
CMS2-B	6/7/10 1:38 PM	40.7	36	37	1.61	**59**	P	Marsh McBirney	13	Wading

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.
[2] Measurement Rating
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.1.6.2 INDIRECT DISCHARGE

The 2010 peak discharge at CMS2-B likely occurred at the time of peak stage. For the purpose of this analysis, peak stage is estimated to have occurred at 1:50 a.m. on June 7.

Peak discharge at the CMS2-B drainage was estimated using a velocity-area analysis and based on the assumption that the measured average adjusted velocity was representative of the average velocity at peak stage. This calculation is performed assuming open-channel conditions, and should be considered a conservative estimate.

Peak discharge was estimated to have been 124 cfs at CMS2-B. Table 4.9 summarizes the indirect discharge results.

Table 4.9: CMS2-B Indirect Discharge

Location	Date & Time	Peak WSE[1] (ft BPMSL)	Peak Discharge (cfs)	Indirect Discharge Analysis Type
CMS2-B	6/7/2010 1:50 AM*	41.82	**124**	Velocity-Area

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.
* WSE value is a high water mark; time is estimated

4.1.7 CMS2-C HYDROLOGIC OBSERVATIONS AND WSE

Water surface elevation measurements at CMS2-C began on June 7. Daily monitoring during breakup was not possible in 2010 because of inaccessibility due to weather conditions. After breakup, monitoring continued at this location every two weeks through mid-July. While some water was observed, seasonal flow was no longer present in this channel on July 13, after which observations were discontinued. Photo 4.16 shows the gage installed at CMS2-C on June 7.

Photo 4.16: Gage Location CMS2-C, June 7, 2010

Measured WSE decreased from initial observations on June 7, making the initial gage reading the highest WSE noted at the CMS2-C drainage during spring breakup. Peak stage was not captured at this location. The highest documented WSE at CMS2-C was 31.27 feet BPMSL. WSE are based on TBM elevations set by handheld GPS, and are not tied to nearby monitoring locations or verified by

survey to local control. WSE data for CMS2-C is provided in Table 4.10. Photo 4.17, Photo 4.18, Photo 4.19 show aerial and ground views of the CMS2-C vicinity.

Photo 4.17: Aerial View CMS2-C, June 8, 2010

Photo 4.18: Aerial View CMS2-C, July 13, 2010

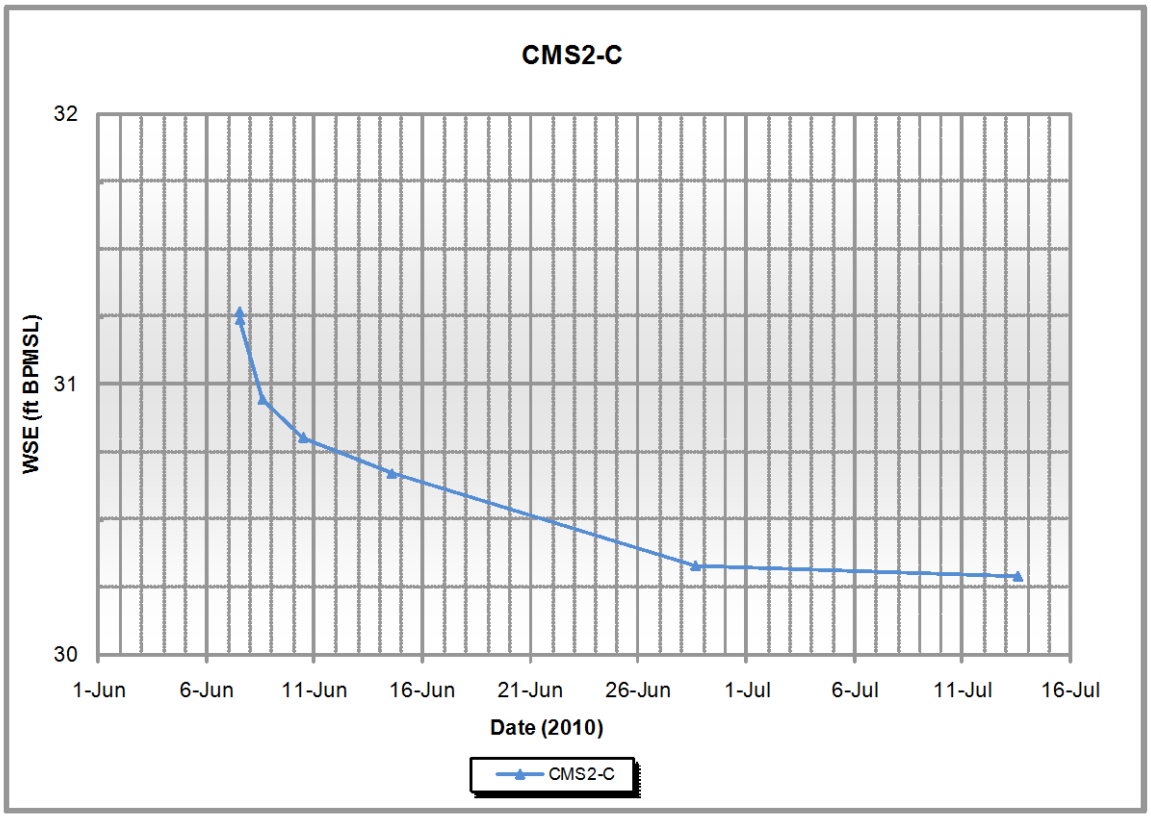
Photo 4.19: CMS2-C Vicinity, July 13, 2010

Table 4.10: CMS2-C WSE

Date and Time	WSE (feet BPMSL) CMS2-C	Observations
6/7/10 12:36 PM	31.27	**Highest WSE**; did not capture peak
6/7/10 12:58 PM	31.24	
6/8/10 2:13 PM	30.95	
6/10/10 11:25 AM	30.81	
6/14/10 1:40 PM	30.67	measure with peep sight
6/28/10 3:05 PM	30.33	
7/13/10 1:30 PM	30.29	water present, but no flow observed
07/29/10	-	no site visit

Notes:

1. WSE are based on TBMs Baker CP2 and EICKELMAN, established by Baker in 2010. The elevations for these TBMs are set by handheld GPS, and are not tied to nearby monitoring locations or verified by survey to local control.
2. One discharge measurement of 25 cfs was taken on 6/7/2010 at 12:40 PM.



4.1.8 CMS2-C Discharge

4.1.8.1 Direct Discharge

A direct discharge measurement at CMS2-C was conducted on June 7 beginning at 12:43 p.m., as close to peak flow as possible (as peak flow receded). At that time, discharge was measured to be 25 cfs. The measurement was rated "fair" based on channel conditions; the channel was fairly uniform, vertical snow banks were present along the right and left edges. Photo 4.20 shows the CMS2-C channel on June 7 prior to discharge measurement.

Photo 4.20: Discharge Measurement Preparations at CMS2-C, June 7, 2010

A summary of the 2010 direct discharge measurement is presented in Table 4.11, and complete notes are in Appendix A.

Table 4.11: CMS2-C Direct Discharge

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
CMS2-C	6/7/10 12:43 PM	31.27	21	15	1.71	**25**	F	Marsh McBirney	11	Wading

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.
[2] Measurement Rating
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.1.8.2 INDIRECT DISCHARGE

The 2010 peak discharge at CMS2-C likely occurred at the time of peak stage. Peak stage is estimated to have occurred prior to 12:36 p.m. on June 7.

Peak discharge at the CMS2-C drainage was estimated using a velocity-area analysis and based on the assumption that the measured average adjusted velocity was representative of the average velocity at peak stage. This calculation is performed assuming open-channel conditions, and should be considered a conservative estimate.

Peak discharge was estimated to have been 27 cfs at CMS2-C. Table 4.12 summarizes the indirect discharge results.

Table 4.12: CMS2-C Indirect Discharge

Location	Date & Time	Peak WSE[1] (ft BPMSL)	Peak Discharge (cfs)	Indirect Discharge Analysis Type
CMS2-C	6/7/10 12:36 PM	31.27	**27**	Velocity-Area

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.
* WSE value is a high water mark; time is estimated

4.2 GMT Road Corridor

A gravel road is proposed to access the GMT1 and GMT2 drilling pads. The proposed road begins at the west end of the proposed CD5 access road and extends approximately 7.8 miles west to GMT1, and an additional 8.3 miles southwest to GMT2. The proposed road alignment crosses the Ublutuoch River as well as several small drainages. The GMT2 pad represents the westernmost extent of the study area.

4.2.1 GMT2 Drainage Hydrologic Observations and WSE

Due to poor weather and helicopter logistics, the first opportunity to reach GMT2 occurred on June 7. On June 7, a single gage was installed at the GMT2 drainage and a gage reading was made. The channel was flowing well. Photo 4.21 shows the vicinity at gage GMT2 on June 7.

Photo 4.21: GMT2 Gage Vicinity, June 7, 2010

Water surface elevations were recorded at the GMT2 drainage gage location daily June 7 through June 9, June 14, June 28, and July 13. Flow was determined to have ceased at the GMT2 drainage by July 13, although water remained in the low-lying portions of the channel.

Peak WSE at GMT2 was 88.74 feet BPMSL on June 8. WSE are based on TBM elevations set by handheld GPS, and are not tied to nearby monitoring locations or verified by survey to local control. WSE data for GMT2 is provided in Table 4.13. Photo 4.22, Photo 4.23, and Photo 4.24 show the GMT2 vicinity at various times following breakup.

Photo 4.22: Aerial View GMT2 Gage Vicinity, June 8, 2010

Photo 4.23: Aerial View GMT2 Gage Vicinity, July 13, 2010

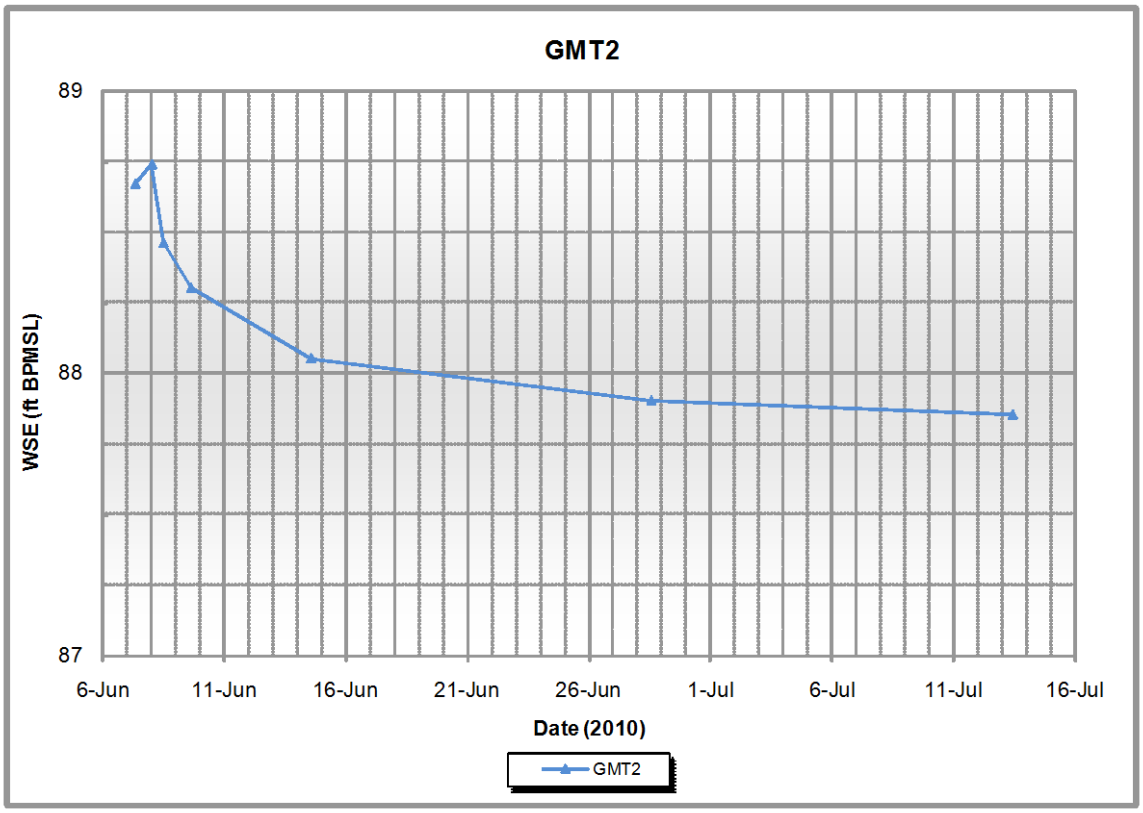
Photo 4.24: Ground Level View GMT2 Vicinity, July 13, 2010

Table 4.13: GMT2 WSE

Date and Time	WSE (feet BPMSL) GMT2	Observations
6/7/10 8:43 AM	88.67	Initial reading
6/8/10 1:00 AM	88.74	**PEAK STAGE**, HWM - time estimated
6/8/10 12:17 PM	88.46	Gage reading prior to discharege measurement
6/9/10 3:35 PM	88.30	Survey to WSE
6/14/10 1:50 PM	88.05	Little flow, survey to WSE
6/28/10 1:15 PM	87.90	Ponded water present, but no flow
7/13/10 9:30 AM	87.85	Survey to WSE
07/29/10	-	No site visit.

Notes:

1. WSE are based on TBMs MADISON, BRYNN and LOGAN, established by Baker in 2010. The elevations for these TBMs are set by handheld GPS, and are not tied to nearby monitoring locations or verified by survey to local control.
2. One discharge measurement of 4 cfs was taken on 6/8/2010 at 12:25 PM.



4.2.2 GMT2 Discharge

4.2.2.1 Direct Discharge

A direct discharge measurement at GMT2 was conducted on June 8 beginning at 12:25 p.m., approximately 11 hours after peak flow. Discharge was measured to be 4 cfs. The measurement was rated "fair" based on channel conditions; the channel was fairly uniform. Photo 4.25 shows the discharge measurement at GMT2.

Photo 4.25: GMT2 Discharge Measurement, June 8, 2010

A summary of the 2010 direct discharge measurement is presented in Table 4.14, and complete notes are in Appendix A.

Table 4.14: GMT2 Direct Discharge

Location	Date & Time	WSE[1] (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[2]	Meter Type	Number of Sections	Measurement Type
GMT2	6/8/10 12:25 PM	88.46	13	8	0.53	**4**	F	Marsh McBirney	14	Wading

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.

[2] Measurement Rating:

E - Excellent: Point plots nearly on the rating curve; within 2% of true value

G - Good: Within 5% of true value

F - Fair: Within 7-10% of true value

P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.2.2.2 INDIRECT DISCHARGE

The 2010 peak discharge at GMT2 likely occurred at the time of peak stage. Peak stage is estimated to have occurred at 10:43 a.m. on June 7.

Peak discharge at the GMT2 drainage was estimated using a velocity-area analysis and based on the assumption that the measured average adjusted velocity was representative of the average velocity at peak stage. This calculation is performed assuming open-channel conditions, and should be considered a conservative estimate.

Peak discharge was estimated to have been 6 cfs at GMT2. Table 4.15 summarizes the indirect discharge results.

Table 4.15: GMT2 Indirect Discharge

Location	Date & Time	Peak WSE[1] (ft BPMSL)	Peak Discharge (cfs)	Indirect Discharge Analysis Type
GMT2-A	6/7/10 10:43 AM	88.67	**6**	Velocity-Area

[1] WSE values are based on GPS data; elevations are not relative or tied to local control.

4.2.3 UBLUTUOCH RIVER HYDROLOGIC OBSERVATIONS AND WSE

The Ublutuoch River is a perennial stream along the proposed GMT1 right-of-way. The 2010 peak stage in the Ublutuoch River is estimated to have occurred on June 8, approximately five days later than the historic average based on an eight-year data record (Table 1.1). Peak discharge was estimated to have occurred shortly after peak stage. Some ice jamming was present in the area during peak flow.

During the June 4, 2010, reconnaissance flight, the Ublutuoch River in the vicinity of the proposed road crossing showed signs of local melt only, and did not appear to be hydraulically connected. The leading edge on the Ublutuoch was identified near UB14.8, approximately 8 miles upstream from the proposed GMT1 road crossing location. Due to deteriorating weather conditions, it was not possible to reach the UB6.7, UB6.8, or UB6.9 gages to chalk.

The UB6.7, UB6.8, and UB6.9 gages were dug out and chalked on June 6, and gages at UB6.8 were surveyed. UB6.9-C was also surveyed and tied to control on June 6. Photo 4.26 and Photo 4.27 show aerial views of the UB6.8 area surrounding peak stage.

Photo 4.26: UB6.8 Aerial View, June 6, 2010

Photo 4.27: Aerial View Ublutuoch River 0.7 MI Upstream of UB6.8 , June 9, 2010

Photo 4.28: Stranded Ice at UB6.8, June 8, 2010

Photo 4.29: Gages at UB6.8, June 14, 2010

Water surface elevation measurements at Ublutuoch River gages began on June 6 and continued until June 14. Daily monitoring was not possible in 2010 because of inaccessibility due to weather conditions. Pressure transducers installed in the CRD were irretrievable during FCB breakup and therefore not installed at the Ublutuoch in 2010.

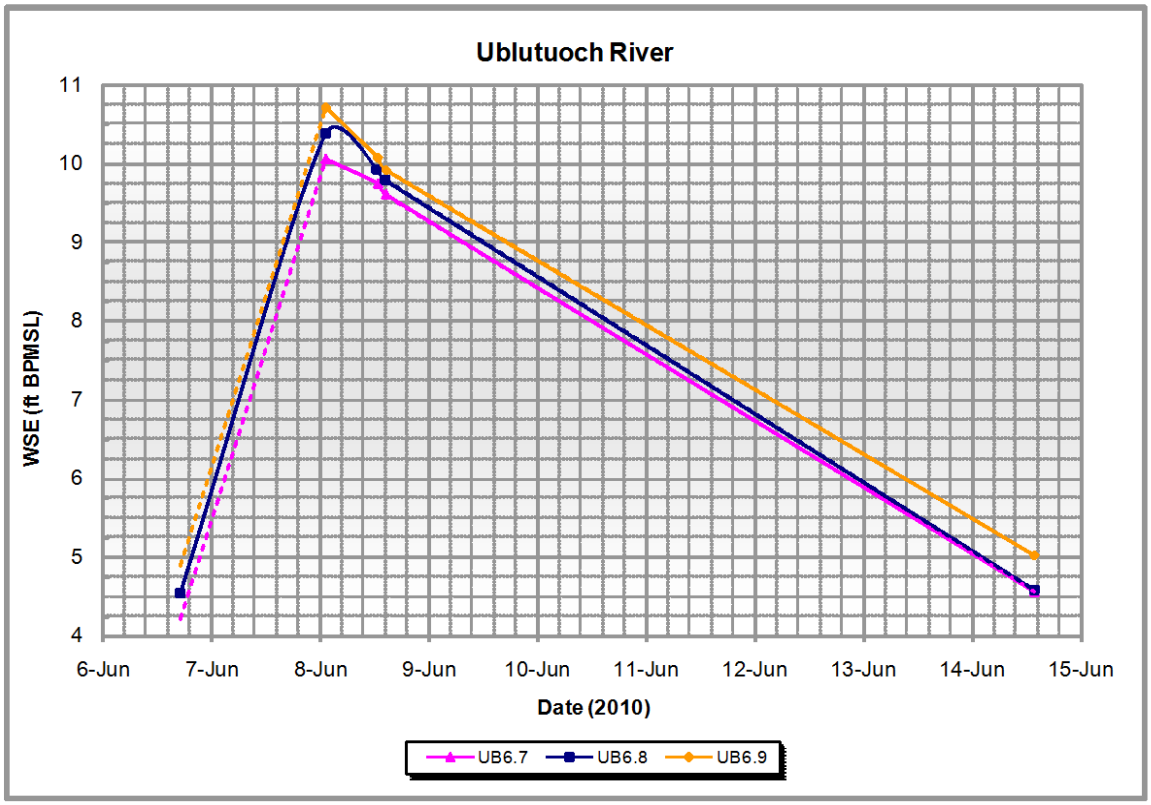
Measured WSE increased from initial observations on June 6 to June 8, when peak stage is estimated to have occurred. Peak WSE at UB 6.8 was 10.38 feet BPMSL. Ublutuoch WSE in 2010 was affected by an ice jam that formed just downstream of the monitoring location (approximately 1000 feet downstream of UB6.7). Values are likely inflated due to flow backing up in the channel. WSE data for the Ublutuoch River is provided in Table 4.16. Photo 4.28 and Photo 4.29 show the UB6.8 vicinity on June 8 and 9.

Table 4.16: Ublutuoch WSE

Date and Time	WSE (feet BPMSL)			Observations
	UB6.7	UB6.8	UB6.9	
6/6/10 5:00 PM	4.21	4.54	4.88	open water in area, WSE estimated at UB6.7 and UB6.9 based on UB6.8.
6/8/10 1:00 AM	10.05	10.38	10.72	**PEAK STAGE**, HWM- time estimated, ice jam present just downstream.
6/8/10 12:30 PM	9.74	9.92	10.08	Ice jam in vicinity.
6/8/10 2:20 PM	9.60	9.79	9.92	
6/14/10 1:30 PM	4.56	4.58	5.02	measured using peep sight

Notes:

1. Elevations are based on CP09-11-09B, established by LCMF in 2009.
2. One discharge measurement was taken at UB6.8 of 3,217 cfs on 6/8/2010 at 12:55 PM.
3. Dashed lines indicate estimated WSE.



4.2.4 Ublutuoch Discharge

4.2.4.1 Direct Discharge

A direct discharge measurement in the Ublutuoch was conducted at UB6.8 on June 8 beginning at 12:55 p.m., approximately 12 hours after estimated time of peak flow. Discharge was measured to be 3,217 cfs. The measurement was rated "poor" based on channel conditions. The channel was not uniform; the left bank side was much shallower than the right bank side. Grounded ice was present in the channel upstream and downstream of the tagline during the discharge measurement, and an ice jam had formed approximately 1,000 feet downstream of the tagline, near the UB6.7 gages. This ice jam was causing flow to divert over the left bank into a swale west of and downstream from the measurement location. This ice jam also caused flow to back up, resulting in likely inflated WSE readings. Photo 4.30 and Photo 4.31 show the boat discharge measurements and aerial view on June 8, 2010.

Photo 4.30: Preparing for Boat Discharge Measurement at UB6.8, June 8, 2010

Photo 4.31: Aerial View UB6.8 Boat Discharge Measurement, June 8, 2010

A summary of the 2010 direct discharge measurement is presented in Table 4.17, and complete notes are in Appendix A.

Table 4.17: Ublutuoch Direct Discharge

Location	Date & Time	WSE (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[1]	Meter Type	Number of Sections	Measurement Type
UB6.8	6/8/10 12:55 PM	9.92	740	2472	1.30	**3217**	P	Price AA	29	Boat

[1] Measurement Rating:
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.2.4.2 INDIRECT DISCHARGE

The 2010 peak discharge in the Ublutuoch at UB6.8 likely occurred at the time of peak stage. Peak stage is estimated to have occurred at 1:00 a.m. on June 8.

Peak discharge at UB6.8 was estimated using a slope-area method. Discharge is calculated using the energy grade-line slope (as approximated by the water surface slope between UB6.8 and UB6.9), the peak WSE at UB6.8, and the 2010 cross-sectional data collected during the direct discharge measurement at UB6.8. Indirect discharge calculations are performed assuming an ice-free channel and are considered a conservative estimate. The ice jam just downstream of the discharge location elevated the WSE values, resulting in an artificially inflated peak discharge value, as calculations are based on WSE data.

Peak discharge in the Ublutuoch was estimated to have been 5,360 cfs at UB6.8. Table 4.18 summarizes the indirect discharge results. A historical record of peak discharge in the Ublutuoch is presented in Table 1.1.

Table 4.18: Ublutuoch Indirect Discharge

Location	Date & Time	Peak WSE (ft BPMSL)	Peak Discharge (cfs)	Indirect Discharge Analysis
UB6.8	6/8/10 1:00 AM	10.38	**5,360**	Slope-Area

4.2.5 SMALL STREAM CROSSING S5 HYDROLOGIC OBSERVATIONS AND WSE

Small stream crossing site S5 was selected at a well-defined channel where moderate flow velocity was expected, and where a proposed bridge crossing will be located.

During the preliminary reconnaissance flight on June 4, 2010, gages at small stream crossing S5 were chalked. Photo 4.32 shows the extent of snow in the area on June 4. Daily monitoring was not possible in 2010 because of inaccessibility due to weather conditions. On June 8, the S5 gages were surveyed. Photo 4.33 and Photo 4.34 show the S5 area on the day of the survey.

A high water mark was identified at the GMT1 bridge site (S5) during a site visit on June 8. Due to significantly reduced water surface elevation at S5 at that time, and decreased water surface elevation noted during the survey on June 8, monitoring was not conducted again at S5 until a site visit on June 14.

Measured WSE increased from initial observations on June 4 to June 8, when peak stage is estimated to have occurred. Peak WSE at S5-C was 19.63 feet BPMSL. WSE data for S5 is provided in Table 4.19. Photo 4.35 shows an aerial view of the S5 area on June 14.

Photo 4.32: Snow in Vicinity of S5, June 4, 2010

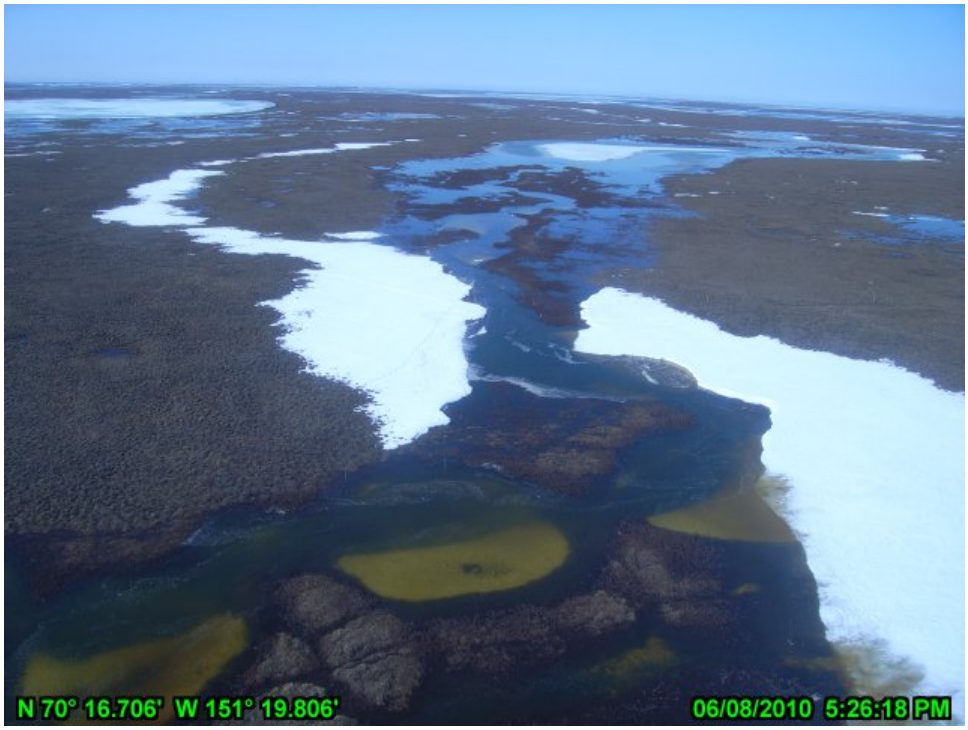


Photo 4.33: S5 Aerial View, June 8, 2010

Photo 4.34: S5 Area, June 8, 2010

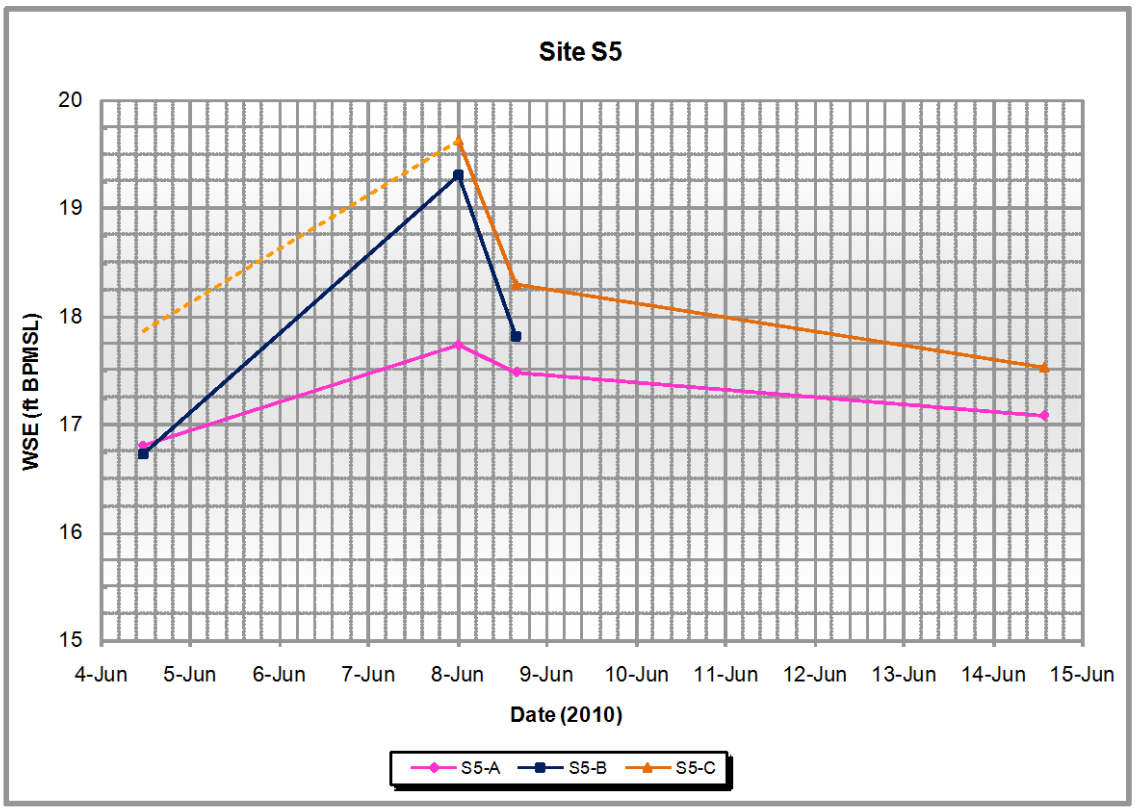
Photo 4.35: Aerial View S5, June 14, 2010

Table 4.19: S5 WSE

Date and Time	WSE (feet BPMSL)			Observations
	S5-A	S5-B	S5-C	
6/4/10 11:00 AM	16.80	16.73	17.87	Local melt on gages, gages chalked
6/8/10 12:00 AM	17.73	19.30	19.63	**PEAK STAGE**, HWM - time estimated
6/8/10 3:34 PM	17.48	17.82	18.29	
6/14/10 1:45 PM	17.08	-	17.52	

Notes:

1. Elevations are based on TBMs Alma and Clara, both updated by LCMF in 2009.
2. One discharge measurement of 103 cfs was taken at S5 on 6/8/2010 at 2:50 PM.
3. Dashed lines indicate estimated WSE.



4.2.6 S5 Discharge

4.2.6.1 Direct Discharge

A direct discharge measurement at S5 was conducted on June 8 beginning at 2:50 p.m., as peak flow began to recede. Discharge was measured to be 103 cfs. The measurement was rated "poor" based on channel conditions; snow was present along the left bank and immeasurable flow was likely passing under the drift. The discharge measurement on June 8 is shown in Photo 4.36.

Photo 4.36: S5 Discharge Measurement, June 8, 2010

A summary of the 2010 direct discharge measurement is presented in Table 4.20, and complete notes are in Appendix A.

Table 4.20: S5 Direct Discharge

Location	Date & Time	WSE (ft BPMSL)	Width (ft)	Area (ft^2)	Mean Velocity (ft/s)	Discharge (cfs)	Measurement Rated[1]	Meter Type	Number of Sections	Measurement Type
S5	6/8/10 2:50 PM	18.29	46.5	59	1.74	**103**	P	Marsh McBirney	18	Wading

[1] Measurement Rating:
E - Excellent: Point plots nearly on the rating curve; within 2% of true value
G - Good: Within 5% of true value
F - Fair: Within 7-10% of true value
P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; less than 15% of true value

4.2.6.2 INDIRECT DISCHARGE

The 2010 peak discharge at S5 likely occurred at the time of peak stage. Peak stage is estimated to have occurred at 2:45 p.m. on June 8.

Peak discharge at the S5 drainage was estimated using a slope-area method. Discharge is calculated using the energy grade-line slope (as approximated by the water surface slope between upstream and downstream gages at S5), WSE, and the 2010 cross-sectional data collected during the direct discharge measurement. Indirect discharge calculations are performed assuming an ice-free channel and are considered a conservative estimate. The resulting value supports the assumption that flow was passing under the left bank snow drift and therefore unable to be accessed during the direct discharge measurement.

Peak discharge at S5 was estimated to have been 202 cfs. Table 4.21 summarizes the indirect discharge results.

Table 4.21: S5 Indirect Discharge

Location	Date & Time	Peak WSE (ft BPMSL)	Peak Discharge (cfs)	Indirect Discharge Analysis Type
S5	6/8/10 2:45 PM	18.29	**202**	Slope-Area

Section 5 Flood and Stage Frequency Analysis

Flood and stage frequency analyses were performed by Baker in 2009 for select locations in the GMT1/CD5 monitoring area. Of those, two locations were again monitored in 2010: the Ublutuoch River at RM 6.8 and small stream site S5. Presented below are the results of the 2009 flood frequency analysis for UB6.8 and S5, and the stage frequency analysis for UB6.8, compared with 2010 values.

5.1 Ublutuoch River

The proposed GMT1 access road bridge crossing at the Ublutuoch River will be the largest drainage structure between the CD5 and GMT2 facilities. The Ublutuoch River flood frequency and stage frequency analyses aid in the development of design criteria for the proposed bridge. For discussion on 2009 analysis criteria, see the report, Greater Moose's Tooth 1 (GMT1) Alpine Satellite Project 2009 Spring Breakup Hydrologic Assessment (Baker 2009a).

5.1.1 Ublutuoch Flood Frequency

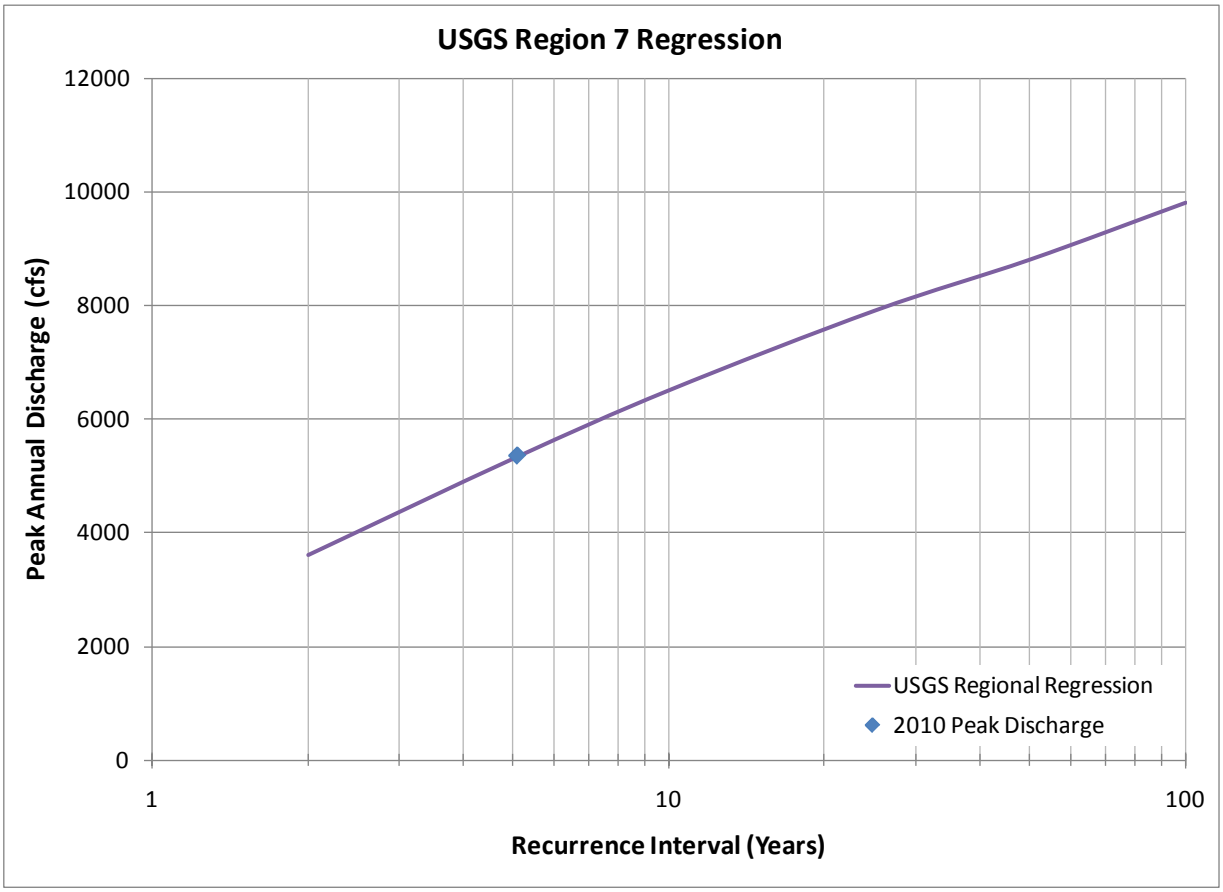
In 2009, a flood frequency analysis was performed for UB6.8. This analysis, using the USGS Region 7 regression equations, assumes open channel conditions and should be considered a conservative estimate, since breakup in the Ublutuoch is typically affected by snow and ice.

The 2010 peak discharge in the Ublutuoch (UB6.8) of 5,360 cfs corresponds to a 5.1-year recurrence interval flood. This value is considered conservative; discharge was considered artificially inflated in 2010 because of the downstream ice jam. The 2009 design values are presented in Table 5.1. The 2010 peak discharge is compared with 2009 analysis results in Graph 5.1.

Table 5.1: Ublutuoch River Flood Frequency Analysis Results (2009)

Recurrence Interval (Years)	Discharge (cfs) USGS Region 7 Regression Equations RM 6.8[1]
2	3,600
5	5,300
10	6,500
25	7,900
50	8,800
100	9,800
[1]Baker 2009	

Graph 5.1: Ublutuoch River Flood Frequency Estimates (2009)



5.1.2 UBLUTUOCH STAGE FREQUENCY

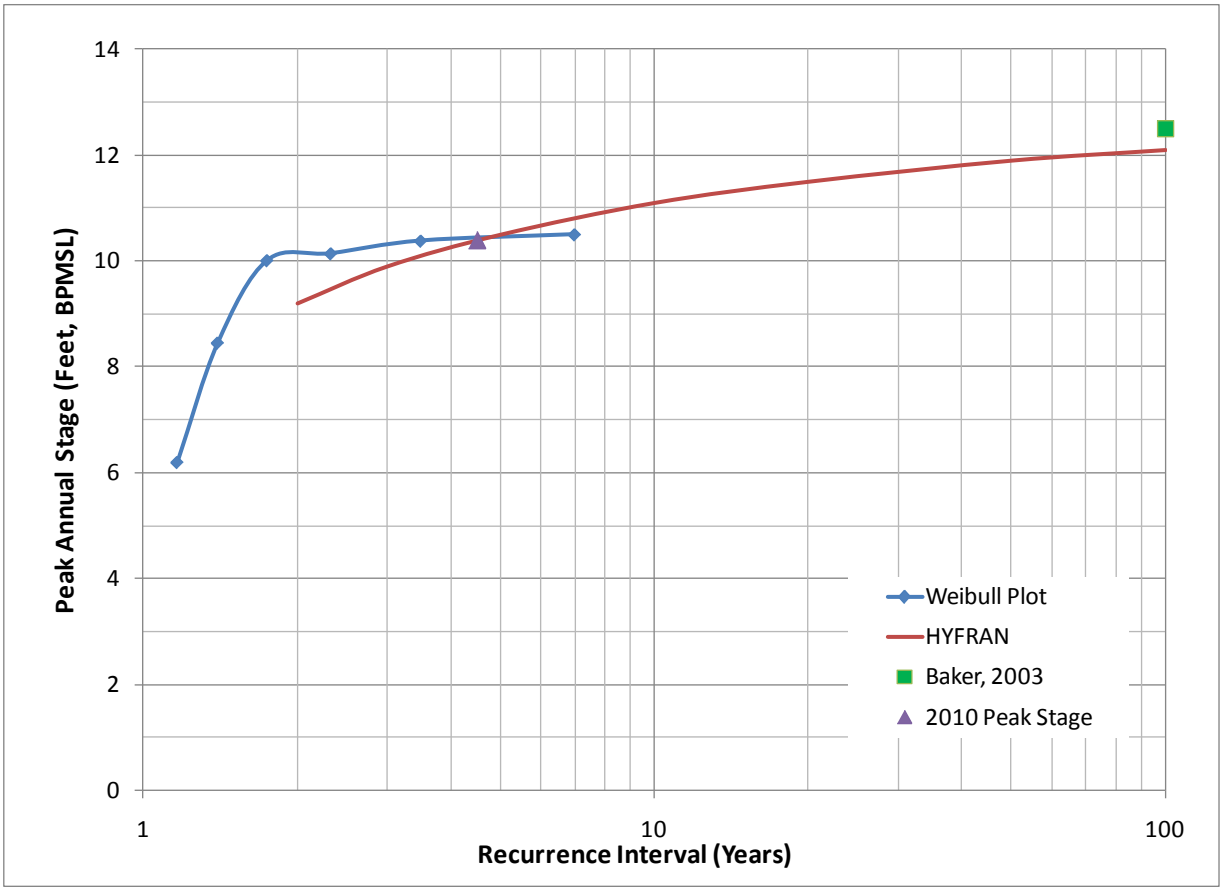
In 2009, a stage frequency analysis (using HYFRAN - log Pearson type III) was performed at UB6.8 based on 5 years of breakup data. This analysis assumes open channel conditions and should be considered a conservative estimate, since breakup in the Ublutuoch is typically impacted by snow and ice. Additionally, a HEC-RAS model was designed by Baker in 2003 to estimate 100-year flood stage. Given the current stage frequency analysis and the 2003 HEC-RAS estimate, peak stage for a 100-year event is estimated to be 12.5 feet at RM 6.8.

The 2010 peak stage in the Ublutuoch (UB6.8) of 10.38 ft BPMSL corresponds to a 4.5-year recurrence interval flood. This value is considered conservative, since stage was elevated in 2010 because of an ice jam just downstream of the monitoring location. The 2009 design values are presented in Table 5.2. The 2010 peak stage is compared with 2009 analysis results in Graph 5.2.

Table 5.2: Ublutuoch Peak Annual Stage Estimates (2009)

Recurrence Interval (years)	Peak Annual Stage (feet, BPMSL)
	log Pearson type III[1]
2	9.2
5	10.5
10	11.1
50	11.9
100	12.1
[1]Baker 2009	

Graph 5.2: Ublutuoch Stage Frequency Estimates (2009)



5.2 Small Stream Crossing S5

Small stream crossing S5 was the only GMT1 road small stream crossing selected for monitoring in 2010. The flood frequency and stage frequency analyses aid in the development of design criteria for proposed drainage structures. Due to lack of data, a stage frequency analysis cannot be performed with any level of confidence. For discussion on the 2009 analysis criteria, see the report, Greater Moose's Tooth 1 (GMT1) Alpine Satellite Project 2009 Spring Breakup Hydrologic Assessment (Baker 2009a).

5.2.1 S5 Flood Frequency

In 2009, a flood frequency analysis was performed at small stream crossing S5. This analysis, using the USGS Region 7 regression equations, assumes open channel conditions and should be considered a conservative estimate, since typically breakup in the FCB is affected by snow and ice.

The 2010 peak discharge at S5 of 202 cfs corresponds to a 14.1-year recurrence interval flood. This value is considered conservative, due to ice and snow effects. The 2009 design values are presented in Table 5.3.

Table 5.3: S5 Flood Frequency Analysis Results (2009)

Recurrence Interval (Years)	Discharge (cfs)
	USGS Region 7 Regression Equation S5[1]
2	87
5	144
10	182
25	231
50	267
100	303
[1]Baker 2009	

Section 6 2011 Monitoring Plan

The following provides a brief summary of the proposed 2011 monitoring for the CMS and the GMT road corridor, including GMT2 drainage, and selected drainage crossings along the proposed GMT1 road.

6.1 CMS

Figure 6.1 shows the proposed CMS area monitoring locations for 2011.

- Monitor temporary staff gages at the following locations on two minor drainages (CMS B and CMS C) identified in the greater CMS area and as shown in the attached figure:
  - Clover B stream: Monitoring will be conducted at 3 or 4 locations including:
    - Clover B1 (formerly CMS2-B) located approximately 900 feet NNW (also 900 feet downstream) from the N CMS boundary;
    - Clover B2 (located at the downstream intersection B stream and CMS N boundary;
    - Clover B3 (located at the upstream intersection B stream and the CMS E boundary);
    - and possibly, Clover B4 (located at the upstream intersection B stream and the CMS S boundary—not very defined channel in this location).
  - Clover C stream: Monitoring will be conducted at 2 or 3 locations including:
    - Clover C1 (formerly CMS2-C, located approximately 250 feet NNW or 350 feet downstream from the N CMS boundary);
    - Clover C2 (located at the upstream defined channel of C stream inside the CMS boundary;
    - and possibly, Clover C3 (located downstream of the S CMS boundary, within the CMS boundary).
- Utilize local control for reporting based on rebar and caps set June 2010.
- Conduct discharge measurements at Clover B1, Clover B2, Clover B3, Clover C1, Clover C2. Discharge measurements may be made at Clover B4 and Clover C3 if measurable flow is present.
- Depending on topographic data available, delineate drainage basins for Clover B and C streams at farthest downstream monitoring location.
- Install and monitor two or three sets of staff gages on the Ublutuoch River where it is close to the CMS (approximate RM 11.4-11.6) to collect water surface elevations; develop the base (100-year recurrence interval) flood magnitude and associated inundation limits of the Ublutuoch River near the proposed CMS depending on data availability.
- Install one pressure transducer each at Clover B2 and Clover C2 (or other location as determined in the field).
- Continued to monitor the CMS sites biweekly until cessation of flow, for a maximum of three post-breakup bi-weekly monitoring events.

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UB 11.6

UB-11.45

CLOVER B1

UBLUTUOCH RIVER

CLOVER C1

CLOVER B2

CLOVER C2

CLOVER B3

CLOVER C3

CLOVER B4

CMS BOUNDARY

N

Baker Michael Baker Jr., Inc.

500 0 500 1,000

SCALE IN FEET

LEGEND

MONITORING LOCATION

CMS BOUNDARY

2011 CMS PROPOSED GAGE LOCATIONS

FIGURE 6.1

(SHEET 1 OF 1)

Michael Baker Jr., Inc.
A Unit of Michael Baker Corporation
1400 West Benson Blvd., Suite 200
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

ConocoPhillips Alaska, Inc.

DATE:	11/11/10	PROJECT:	120172
DRAWN:	REH	FILE:	FIGURE 6.1
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6.2 GMT Road Corridor

Figure 6.2 shows the proposed monitoring gage sites for 2011 including gaging sites focusing on the GMT1 road proposed bridge and culvert locations, as outlined below.

Road Corridor (GMT1 road and GMT2 drainage):

- Monitor temporary staff gages at the Ublutuoch (UB6.7, UB6.8, and UB6.9) gage locations as well as the GMT1 road proposed bridge location (S5).
- Monitor at the two proposed GMT1 road proposed culvert locations S3 and S4 (locations as identified in 2009).
- Monitor temporary staff gage at the drainage identified near GMT2 if directed by CPAI.
- Install pressure transducers at UB6.7 and UB6.9
- Utilize local control for reporting based on rebar and caps set June 2010.
- Conduct discharge measurements at the UB6.8 and at S5.
- Conduct discharge measurements at S3 and S4, if directed by CPAI.
- Conduct a discharge measurement at the drainage identified near GMT2 if directed by CPAI.

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ConocoPhillips Alaska, Inc.

DATE:	11/11/10	PROJECT:	120172
DRAWN:	REH	FILE:	FIGURE 6.2
CHECKED:	HLR	SCALE:	AS SHOWN

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2011 GMT
ROAD CORRIDOR
PROPOSED GAGE LOCATIONS
FIGURE 6.2
(SHEET 1 OF 1)

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Appendix A SURVEY CONTROL AND GAGE SUMMARY

Gage Site	Gage	Latitude (NAD 83)	Longitude (NAD83)	Basis of Elevation
CMS1-A	CMS1-A	N 70° 14' 08.3"	W 151° 16' 46.3"	TUNDRA CHICKEN BAKER CP1
CMS2-A	CMS2-A	N 70° 15' 29.1"	W 151° 13' 46.0"	PENELOPE RUST LCMF CP
CMS2-B	CMS2-B	N 70° 15' 16.3"	W 151° 14' 19.1"	CLARK MEG BAKER CP2
CMS2-C	CMS2-C	N 70° 15' 03.2"	W 151° 15' 11.9"	EICKELMAN SHOCKER BAKER CP3
Ublutuoch 6.7	UB6.7-A	N 70° 17' 08.2"	W 151° 15' 45.7"	CP09-11-09B
	UB6.7-B	N 70° 17' 08.1"	W 151° 15' 46.1"	
	UB6.7-C	N 70° 17' 07.4"	W 151° 15' 47.4"	
	UB6.7-D	N 70° 17' 06.9"	W 151° 15' 47.4"	
Ublutuoch 6.8	UB6.8-A	N 70° 17' 05.0"	W 151° 15' 33.8"	
	UB6.8-B	N 70° 17' 04.4"	W 151° 15' 36.5"	
	UB6.8-C	N 70° 17' 04.1"	W 151° 15' 37.8"	
	UB6.8-D	N 70° 17' 03.4"	W 151° 15' 40.9"	
Ublutuoch 6.9	UB6.9-A	N 70° 17' 00.0"	W 151° 15' 23.9"	
	UB6.9-B	N 70° 17' 00.1"	W 151° 15' 25.4"	
	UB6.9-C	N 70° 17' 00.1"	W 151° 15' 28.8"	
S5	S5-A	N 70° 16' 49.4"	W 151° 19' 50.1"	ALMA CLARA
	S5-B	N 70° 16' 47.0"	W 151° 19' 48.2"	
	S5-C	N 70° 16' 45.2"	W 151° 19' 48.7"	
GMT2	GMT2-A	N 70° 10' 12.2"	W 151° 39' 41.3"	MADISON BRYNN LOGAN

Control	Elevation (BPMSL - feet)	Latitude (NAD 83)	Longitude (NAD83)	Control Type	Reference
ALMA	25.263	N 70° 16' 45.7"	W 151° 19' 53.2"	Alcap	LCMF 2009
BAKER CP1	**30.757**	**N 70° 14' 06.9"**	**W 151° 16' 49.1"**	**Alcap**	**BAKER 2010**
BAKER CP2	**35.001**	**N 70° 15' 01.8"**	**W 151° 15' 13.5"**	**Alcap**	**BAKER 2010**
BAKER CP3	**48.022**	**N 70° 15' 16.3"**	**W 151° 14' 22.6"**	**Alcap**	**BAKER 2010**
BRYNN	**89.272**	**N 70° 10' 11.1"**	**W 151° 39' 41.3"**	**Alcap**	**BAKER 2010**
CHICKEN	**32.050**	**N 70° 14' 06.6"**	**W 151° 16' 45.0"**	**Alcap**	**BAKER 2010**
CLARA	23.228	N 70° 16' 49.3"	W 151° 19' 59.0"	Alcap	LCMF 2009
CLARK	**47.293**	**N 70° 15' 16.5"**	**W 151° 14' 28.1"**	**Alcap**	**BAKER 2010**
CP09-11-09B	9.638	N 70° 17' 02.9"	W 151° 15' 36.4"	Alcap	LCMF 2009
EICKELMAN	**36.542**	**N 70° 15' 02.0"**	**W 151° 15' 11.5"**	**Alcap**	**BAKER 2010**
LCMF CP	**25.628**	**N 70° 15' 27.5"**	**W 151° 13' 42.4"**	**Alcap**	**BAKER 2010**
LOGAN	**90.005**	**N 70° 10' 11.1"**	**W 151° 39' 44.8"**	**Alcap**	**BAKER 2010**
MADISON	**90.137**	**N 70° 10' 10.3"**	**W 151° 39' 43.6"**	**Alcap**	**BAKER 2010**
MEG	**46.984**	**N 70° 15' 16.4"**	**W 151° 14' 21.1"**	**Alcap**	**BAKER 2010**
PENELOPE	**23.998**	**N 70° 15' 27.6"**	**W 151° 13' 45.7"**	**Alcap**	**BAKER 2010**
RUST	**23.456**	**N 70° 15' 27.6"**	**W 151° 13' 48.7"**	**Alcap**	**BAKER 2010**
SHOCKER	**36.216**	**N 70° 15' 01.8"**	**W 151° 15' 09.3"**	**Alcap**	**BAKER 2010**
TUNDRA	**31.997**	**N 70° 14' 06.7"**	**W 151° 16' 46.9"**	**Alcap**	**BAKER 2010**

Note: Elevations for control in **bold** were set by handheld GPS and are not verified by survey to local control.

Appendix B DIRECT DISCHARGE MEASUREMENTS

B.1 Site CMS1-A

Baker

Discharge Measurement Notes

Date: June 7, 2010
Computed By: JPM
Checked By:

Location Name: CMS1-A

Party: JWW, JPM, JMS Start: 9:47 Finish: 10:05

Temp: 40 °F Weather: Sunny and clear

Channel Characteristics:

Width: 72 ft Area: 71 sq ft Velocity: 0.72 fps Discharge: 51 cfs

Method: 0.6 Number of Sections: 16 Count:

Spin Test: ____ revolutions after ____ seconds Meter: Marsh McBirney

Meter: ____ ft above bottom of weight

Weight: ____ lbs

Wading | Cable | Ice | Boat

Upstream or Downstream

GAGE READINGS			
Gage	Start	Finish	Change
CMS1-A	0.57	0.67	0.10

GPS Data: BAKER 5

Left Edge of Water:	N	70 °	14 '	7.7 "	
	E	151 °	16 '	37.3 "	
Right Edge of Water:	N	°	'	"	
	E	°	'	"	

LE Floodplain: ° ' "

RE Floodplain: ° ' "

Measurement Rated: Excellent Good Fair **Poor** based on "Descriptions"

Descriptions:

Cross Section: Irregular, snow and ice. Some willows in water.

Flow: Rising stage

Remarks: Channel partially constricted by snow

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Discharge Measurement Data

Angle Coeff.	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY			Area (s.f.)	Discharge (cfs)
							At Point (fps)	Mean in Vertical (fps)	Adjusted for Angle Coeff (fps)		
	34	9.5	0							0.0	
	53	13	0.7	0.4				0.33		9.1	3.0
	60	6.5	0.9	0.5				0.33		5.9	1.9
	66	3.5	2.1	1.3				0.40		7.4	2.9
	67	3	1.6	1.0				0.95		4.8	4.6
	72	4	2.5	1.5				1.60		10.0	16.0
	75	3.5	2.6	1.6				1.70		9.1	15.5
	79	2	1.7	1.0				0.80		3.4	2.7
	89	2	1.8	1.1				0.00		3.6	0.0
	93	4	0.9	0.5				0.00		3.6	0.0
	97	3.5	0.7	0.4				0.00		2.5	0.0
	100	4	0.9	0.5				0.87		3.6	3.1
	105	4.5	0.8	0.5				0.34		3.6	1.2
	109	3.5	0.5	0.3				0.10		1.8	0.2
	112	3.5	0.8	0.5				0.10		2.8	0.3
	116	2						0.00		0.0	0.0
									Totals:	71.0	51.4

B.2 CMS2-A

Baker

Discharge Measurement Notes

Date: June 7, 2010
Computed By: JPM
Checked By:

Location Name: CMS2-A

Party: JWW, JPM, JMS Start: 14:58 Finish: 15:19

Temp: 45 °F Weather: Sunny, clear, slight breeze

Channel Characteristics:

Width: 48 ft Area: 65 sq ft Velocity: 0.62 fps Discharge: 41 cfs

Method: 0.6 Number of Sections: 12 Count:

Spin Test: ____ revolutions after ____ seconds Meter: Marsh McBirney

Meter: ____ ft above bottom of weight

Weight: ____ lbs

[Wading] Cable Ice Boat

Upstream or Downstream

GAGE READINGS			
Gage	Start	Finish	Change
CMS2-A	0.33	0.30	-0.03

GPS Data: BAKER 5

Left Edge of Water:	N	70 °	15 '	28.8 "	LE Floodplain: ° ' . "
	E	151 °	13 '	46.4 "	
Right Edge of Water:	N	°	'	"	RE Floodplain: ° ' . "
	E	°	'	"	

Measurement Rated: Excellent Good Fair [Poor] based on "Descriptions"

Descriptions:

Cross Section: Beaded stream channel; frozen (grass) on bottom; both banks clear. Ponds up and downstream.

Flow: Stage falling

Remarks: Channel partially constricted by snow

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Discharge Measurement Data

Angle Coeff.	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY			Area (s.f.)	Discharge (cfs)
							At Point (fps)	Mean in Vertical (fps)	Adjusted for Angle Coeff (fps)		
	32	1.5	0.0					0.00		0.0	0.0
	35	4.0	0.4	0.24				0.02		1.6	0.0
0.85	40	5.0	0.7	0.42				0.29	0.25	3.5	0.9
0.7	45	5.0	0.8	0.48				0.22	0.15	4.0	0.6
0.5	50	5.0	1.0	0.60				0.01	0.01	5.0	0.0
0.8	55	5.0	1.1	0.66				0.01	0.01	5.5	0.0
0.85	60	5.0	2.8	1.68				1.51	1.28	14.0	18.0
0.9	65	3.5	3.9	2.34				1.22	1.10	13.7	15.0
0.92	67	2.0	3.4	2.04				0.50	0.46	6.8	3.1
0.94	69	3.5	2.0	1.20				0.48	0.45	7.0	3.2
1	74	5.5	0.8	0.48				0.08		4.4	0.0
	80	3.0	0.0	0.00				0.00		0.0	0.0
									Totals:	65.5	40.8

B.3 CMS2-B

Baker

Discharge Measurement Notes

Date: June 7, 2010
Computed By: JPM
Checked By:

Location Name: CMS2-B

Party: JWW, JPM, JMS Start: 13:38 Finish: 14:18

Temp: 45 °F Weather: Sunny, clear, slight breeze

Channel Characteristics:

Width: 36 ft Area: 37 sq ft Velocity: 1.61 fps Discharge: 59 cfs

Method: 0.6 Number of Sections: 13 Count:

Spin Test: ____ revolutions after ____ seconds Meter: Marsh McBirney

Meter: ____ ft above bottom of weight

Weight: ____ lbs

Wading | Cable | Ice | Boat

Upstream or Downstream

GAGE READINGS			
Gage	Start	Finish	Change
CMS2-B	0.26	0.17	-0.09

GPS Data: BAKER 5

Left Edge of Water:	N	70 °	15 '	16.3 "	LE Floodplain: ° ' "
	E	151 °	14 '	19.0 "	
Right Edge of Water:	N	°	'	"	RE Floodplain: ° ' "
	E	°	'	"	

Measurement Rated: Excellent Good Fair [Poor] based on "Descriptions"

Descriptions:

Cross Section: Non-uniform, snow and slush on bottom - REW in snowbank

Flow: Stage falling

Remarks:

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Discharge Measurement Data

Angle Coeff.	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY			Area (s.f.)	Discharge (cfs)
							At Point (fps)	Mean in Vertical (fps)	Adjusted for Angle Coeff (fps)		
	13	1.5	0.0					0.00		0.0	
	16	3.0	1.5	0.9				0.80		3.3	2.6
	19	3.0	1.9	1.1				1.87		5.7	10.7
	22	3.0	1.5	0.9				2.20		4.5	9.9
	25	3.0	1.3	0.8				2.21		3.9	8.6
	28	3.0	1.1	0.7				1.60		3.3	5.3
	31	3.0	1.0	0.6				0.87		3.0	2.6
	34	3.0	1.0	0.6				1.73		3.0	5.2
	37	3.0	0.8	0.5				1.76		2.4	4.2
	40	3.0	1.0	0.6				1.75		3.0	5.3
	43	3.0	1.1	0.7				1.50		3.3	5.0
	46	3.0	0.5	0.3				0.08		1.5	0.1
	49	1.5						0.00			
									Totals:	36.9	59.4

B.4 CMS2-C

Baker

Discharge Measurement Notes

Date: June 7, 2010
Computed By: JPM
Checked By:

Location Name: CMS2-C

Party: JWW, JPM, JMS Start: 12:43 Finish: 12:52

Temp: 45 °F Weather: Sunny, clear, slight breeze

Channel Characteristics:

Width: 21 ft Area: 15 sq ft Velocity: 1.71 fps Discharge: 25 cfs

Method: 0.6 Number of Sections: 11 Count:

Spin Test: ____ revolutions after ____ seconds Meter: Marsh McBirney

Meter: ____ ft above bottom of weight

Weight: ____ lbs

[Wading] Cable Ice Boat

Upstream or Downstream

GAGE READINGS			
Gage	Start	Finish	Change
CMS2-C	0.03	0.00	-0.03

GPS Data: BAKER 5

Left Edge of Water:	N	70 °	15 '	3.2 "
	E	151 °	15 '	11.8 "
Right Edge of Water:	N	°	'	"
	E	°	'	"

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

Measurement Rated: Excellent Good [Fair] Poor based on "Descriptions"

Descriptions:

Cross Section: Fairly uniform; firm; bottom sedge; R & L banks vertical snow edge

Flow: Stage falling

Remarks: There is a pond located upstream and just downstream of the section

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Discharge Measurement Data

Angle Coeff.	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY			Area (s.f.)	Discharge (cfs)
							At Point (fps)	Mean in Vertical (fps)	Adjusted for Angle Coeff (fps)		
	23	1.0	0.3	0.18				1.54		0.3	0.5
	25	2.0	0.7	0.42				2.56		1.4	3.6
	27	2.0	0.9	0.54				2.1		1.8	3.8
	29	2.0	0.9	0.54				1.82		1.8	3.3
	31	2.0	0.8	0.48				2.61		1.6	4.2
	33	2.0	0.8	0.48				2.05		1.6	3.3
	35	2.0	0.8	0.48				0.5		1.6	0.8
	37	2.0	0.8	0.48				0.54		1.6	0.9
	39	2.0	0.2	0.12				0.32		0.4	0.1
	41	2.5	0.8	0.48				2.36		2	4.7
	44	1.5	0.4	0.24				0.05		0.6	0.0
									Totals:	14.7	25.1

B.5 GMT2 Drainage

Baker

Discharge Measurement Notes

Date: June 8, 2010
Computed By: JMS
Checked By: JPM

Location Name: GMT2-A

Party: JWW, JMS, SMC Start: 12:25 Finish: 12:32

Temp: 55 °F Weather: Sunny, clear, amazing

Channel Characteristics:

Width: 13 ft Area: 8 sq ft Velocity: 0.53 fps Discharge: 4 cfs

Method: 0.6 Number of Sections: 14 Count:

Spin Test: revolutions after seconds Meter: Marsh McBirney

Meter: ft above bottom of weight

Weight: lbs

[Wading] Cable Ice Boat

Upstream or Downstream

GAGE READINGS			
Gage	Start	Finish	Change
GMT2-A	0.52	0.52	0.00

GPS Data: BAKER 5

Left Edge of Water:	N	70 °	10 '	12.2 "
	E	151 °	39 '	41.8 "
Right Edge of Water:	N	70 °	10 '	12.0 "
	E	151 °	39 '	41.8 "

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

Measurement Rated: Excellent Good [Fair] Poor based on "Descriptions"

Descriptions:

Cross Section: Good cross section, pretty uniform

Flow: Stage static

Remarks: Bed is entirely covered in grass, not frozen

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Discharge Measurement Data

Angle Coeff.	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY			Area (s.f.)	Discharge (cfs)
							At Point (fps)	Mean in Vertical (fps)	Adjusted for Angle Coeff (fps)		
	2	0.5	0					0.00		0.0	
	3	1	0.3	0.18				0.48		0.3	0.14
	4	1	0.4	0.24				0.34		0.4	0.14
	5	1	0.6	0.36				0.00		0.6	0.00
	6	1	0.7	0.42				0.31		0.7	0.22
	7	1	0.7	0.42				0.66		0.7	0.46
	8	1	0.7	0.42				0.03		0.7	0.02
	9	1	0.7	0.42				0.01		0.7	0.01
	10	1	0.7	0.42				0.54		0.7	0.38
	11	1	0.6	0.36				0.66		0.6	0.40
	12	1	0.7	0.42				0.61		0.7	0.43
	13	1	0.7	0.42				1.07		0.7	0.75
	14	1	0.6	0.36				1.67		0.6	1.00
	15	0.5	0.4	0.24				0.31		0.2	0.06
									Totals:	7.6	4.0

B.6 Ublutuoch

Baker

Discharge Measurement Notes

Date: June 8, 2010
Computed By: HLR
Checked By: JPM

Location Name: UBLUTUOCH 6.8

Party: JPM, EJK, HLR Start: 12:55 Finish: 14:00

Temp: 45 °F Weather: Beautiful sunny day! light breeze

Channel Characteristics:

Width: 740 ft Area: 2472 sq ft Velocity: 1.30 fps Discharge: 3217 cfs

Method: 0.6/0.2-0.8,5 Number of Sections: 29 Count:

Spin Test: 3+mins revolutions after 3+mins seconds Meter: PRICE AA No.501016

Meter: 0.5 ft above bottom of weight

Weight: 30 lbs

Wading Cable Ice [Boat]

[Upstream] or Downstream of CL (6.8)

GAGE READINGS

Gage	Start	Finish	Change
UB 6.9-C	1.96	1.8	-0.16
UB 6.8-C	1.48	1.25	-0.23

GPS Data: BAKER 5

Left Edge of Water:	N	70 °	16 '	58.7 "
	E	151 °	15 '	38.7 "
Right Edge of Water:	N	70 °	17 '	0.3 "
	E	151 °	15 '	22.0 "

LE Floodplain: ° ' "

RE Floodplain: ° ' "

Measurement Rated: Excellent Good Fair [Poor] based on "Descriptions"

Descriptions:

Cross Section: Sta 250-280: Ice floes 80'-20' upstream; Sta 250-320: Ice floes 20'-30' downstream of tagline. Much shallower on LB side from ~400'. Willows between right bank and Sta 105, between left bank and Sta 395.

Flow: Stage falling

Remarks: Ice jam in vicinity of downstream gages ~1000ft (+/- 100ft) downstream of tagline; water is diverting over LB into swale west of and downstream from discharge location. Inflated WSE and discharge quantity due to jam.

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Discharge Measurement Data

Angle Coeff.	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
	60	5	0							0.0	
1	70	12.5	1.1	0.7	3	43	0.17			13.8	2.4
1	85	17.5	1.3	0.8	5	40	0.29			22.8	6.7
1	105	17.5	2.7	0.5 2.2	10 3	42 47	0.54 0.16	0.35		47.3	16.6
1	120	17.5	6.5	1.3 5.2	60 40	45 40	2.96 2.22	2.59		113.8	294.6
1	140	20	6.7	1.3 5.4	80 50	52 41	3.41 2.71	3.06		134.0	409.8
1	160	20	6.1	1.2 4.9	60 60	40 42	3.33 3.17	3.25		122.0	396.0
1	180	20	7.7	1.5 6.2	60 80	42 53	3.17 3.35	3.26		154.0	501.5
1	200	20	7.6	1.5 6.1	40 40	40 43	2.22 2.07	2.15		152.0	326.1
1	220	25	6.9	1.4 5.5	20 20	42 41	1.07 1.09	1.08		172.5	186.4
1	250	30	7	1.4 5.6	5 5	49 51	0.24 0.23	0.24		210.0	50.1
1	280	25	4.9	1.0 3.9	15 7	42 55	0.81 0.30	0.55		122.5	67.6
1	300	20	6	1.2 4.8	30 25	40 45	1.67 1.24	1.46		120.0	174.8
1	320	20	6.2	1.2 5.0	30 30	40 42	1.67 1.59	1.63		124.0	202.4
1	340	20	6.2	1.2 5.0	25 20	46 44	1.22 1.02	1.12		124.0	138.6
1	360	20	6.2	1.2 5.0	30 25	41 47	1.63 1.19	1.41		124.0	174.9
1	380	17.5	6.1	1.2 4.9	25 20	47 44	1.19 1.02	1.11		106.8	118.0
1	395	15	4.2	0.8 3.4	10 3	49 46	0.47 0.16	0.31		63.0	19.8
	410	17.5	0.6					0		10.5	
	430	20	1.4					0		28.0	
	450	25	1.6					0		40.0	
	480	30	1.4					0		42.0	
	510	30	0.8					0		24.0	
1	540	45	1.3	S	10	51	0.45	0.41		58.5	23.7
1	600	60	1	S	7	54	0.30	0.27		60.0	16.4
1	660	60	2.5	1.5	5	53	0.23			150.0	33.9
1	720	55	1.4	0.8	10	54	0.43			77.0	32.8
1	770	40	1.4	0.8	10	55	0.42			56.0	23.4
	800	15	0								
									Totals:	2472.3	3216.6

B.7 S5

Baker

Discharge Measurement Notes

Date: June 8, 2010
Computed By: JMS
Checked By: JPM

Location Name: S5

Party: JMS, JWW, SMC Start: 14:53 Finish: 15:30

Temp: 55 °F Weather: Sunny, clear

Channel Characteristics:

Width: 46.5 ft Area: 59 sq ft Velocity: 1.74 fps Discharge: 103 cfs

Method: 0.6 Number of Sections: 18 Count:

Spin Test: revolutions after seconds Meter: March McBirney

Meter: ft above bottom of weight

Weight: lbs

Wading Cable Ice Boat

Upstream or Downstream

GAGE READINGS			
Gage	Start	Finish	Change
S5TBM B	1.21	1.21	0
S5 TBM C	1.15	1.16	0.01
S5 TBM A	1.785	1.79	0.005

GPS Data: BAKER 6

Left Edge of Water:	N	70 °	16 '	46.8 "
	E	151 °	19 '	48.1 "
Right Edge of Water:	N	70 °	16 '	46.9 "
	E	151 °	19 '	46.6 "

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

Measurement Rated: Excellent Good Fair Poor based on "Descriptions"

Descriptions:

Cross Section: Willows Sta 6 to Sta 27 above the water, willows under water Sta 27 to 33; remainder is all grass-covered channel, not frozen.

Flow: Snow on LEW down to the water. There may be 1' active flow under the ice but it cannot be measured.

Remarks:

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Discharge Measurement Data

Angle Coeff.	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY			Area (s.f.)	Discharge (cfs)
							At Point (fps)	Mean in Vertical (fps)	Adjusted for Angle Coeff (fps)		
	6	2	0.6	0.4				1.05		1.2	1.3
	10	4	0.6	0.4				0.68		2.4	1.6
	14	4	0.4	0.2				0.43		1.6	0.7
	18	4	0.6	0.4				0.70		2.4	1.7
	22	4	1.0	0.6				0.75		4.0	3.0
	26	4	1.1	0.7				0.86		4.4	3.8
	30	3	1.3	0.8				1.42		3.9	5.5
	32	2	1.5	0.9				1.88		3.0	5.6
	34	2	1.9	1.1				2.45		3.8	9.3
	36	2	2.1	1.3				2.85		4.2	12.0
	38	2	2.8	1.7				2.25		5.6	12.6
	40	2	2.2	1.3				2.50		4.4	11.0
	42	2	1.7	1.0				3.01		3.4	10.2
	44	2	1.7	1.0				2.10		3.4	7.1
	46	2	1.4	0.8				2.74		2.8	7.7
	48	2	1.6	1.0				0.97		3.2	3.1
	50	2.25	1.5	0.9				1.85		3.4	6.3
	52.5	1.25	1.6	1.0				0.30		2.0	0.6
									Totals:	59.1	103.1

Fish Creek Basin (FCB) Alpine Satellite Project 2010 Spring Breakup Hydrologic Assessment

Fish Creek Basin (FCB) Alpine Satellite Project 2010 Spring Breakup Hydrologic Assessment