2016 COLVILLE RIVER DELTA

SPRING BREAKUP MONITORING & HYDROLOGICAL ASSESSMENT

SUBMITTED BY:

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EXECUTIVE SUMMARY

This report presents the observations and results from the 2016 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment conducted by Michael Baker International for ConocoPhillips Alaska. In the Colville River Delta, the breakup and downstream movement of river ice typically occurs during a three-week period in May and June. The spring breakup event historically produces flooding, and rapid rise and fall of stage can occur as the result of ice jam formation and release. Annual study and reporting of spring breakup supports the Alpine Development Project, the Alpine Satellite Development Plan, and the CD5 Monitoring Plan with an Adaptive Management Strategy by assessing the relative magnitude of flooding in the delta and documenting the interaction between floodwater and infrastructure. The analyses provide data to support design, permitting, and operation of oilfield development and satisfies permit requirements that include evaluating the effectiveness of road cross-drainage structures during flood events.

The 2016 hydrologic study is the 25th consecutive year of spring breakup investigations. Water surface elevations were monitored throughout the delta at locations of hydrologic importance and near infrastructure. Discharge was measured and peak discharge was calculated at key locations. The entire breakup event was documented with visual observations and photography from a helicopter and from roadways. Following breakup, roads, pads, and drainage structures were assessed for erosion and damage.

This year's spring breakup flood was characterized as a low magnitude, prolonged event, drawn out over two weeks. Initial floodwater arrived in the delta on May 15. Over the next two days all distributary channels were conveying floodwater though channel ice remained intact. A large ice jam formed approximately 22 river miles upstream of MON1 with moderate backwater. As temperatures in the region cooled, water levels receded. A second rise of floodwater, in response to rising temperatures, arrived in the delta on May 21. As channel ice deteriorated, and ice floes progressed downstream, ice jams were observed in the Nigliq Channel, and in the East Channel near the Tamayayak Channel bifurcation and between the Kachemach and Miluveach River confluences. Backwater and overbank flooding were minimal. All channels were ice free by May 29.

Peak conditions throughout the delta occurred between May 23 and May 26. Peak stage at MON1C occurred on May 23 and was 17.16 feet British Petroleum Mean Sea Level having an estimated 2.1-year recurrence interval. Peak discharge at MON1C occurred on May 23 and was 348,000 cubic feet per second having an estimated 4.5-year recurrence interval.

During peak conditions, floodwater in the delta was generally confined within channels, lakes, and swales. Measured pier scour at all bridges was minimal. Post-breakup visual inspections of all roads and pads found no evidence of erosion or damage.

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ACRONYMS & ABBREVIATIONS

°F	degrees Fahrenheit
2D	Two-dimensional
ADF&G	Alaska Department of Fish and Game
ADCP	Acoustic Doppler Current Profiler
ABR	Alaska Biological Research
Michael Baker	Michael Baker International
BPMSL	British Petroleum Mean Sea Level
CPAI	ConocoPhillips Alaska, Inc.
CD	Colville Delta
CFDD	Cumulative Freezing Degree Days
cfs	cubic feet per second
CRD	Colville River Delta
fps	feet per second
DGPS	Differential global positioning system
FEMA	Federal Emergency Management Agency
GPS	Global positioning system
HDD	Horizontal directional drill
HWM	High water mark
LCMF	UMIAQ LLC (LCMF)
MON	Monument
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
OSW	USGS Office of Surface Water
PT	pressure transducer
RM	river mile
RTFM	Real-Time Flood Monitoring
SAK	Sakoonang
TAM	Tamayayak
ULAM	Ulamnigiaq
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VSM	Vertical support member
WSE	Water surface elevation

1. INTRODUCTION

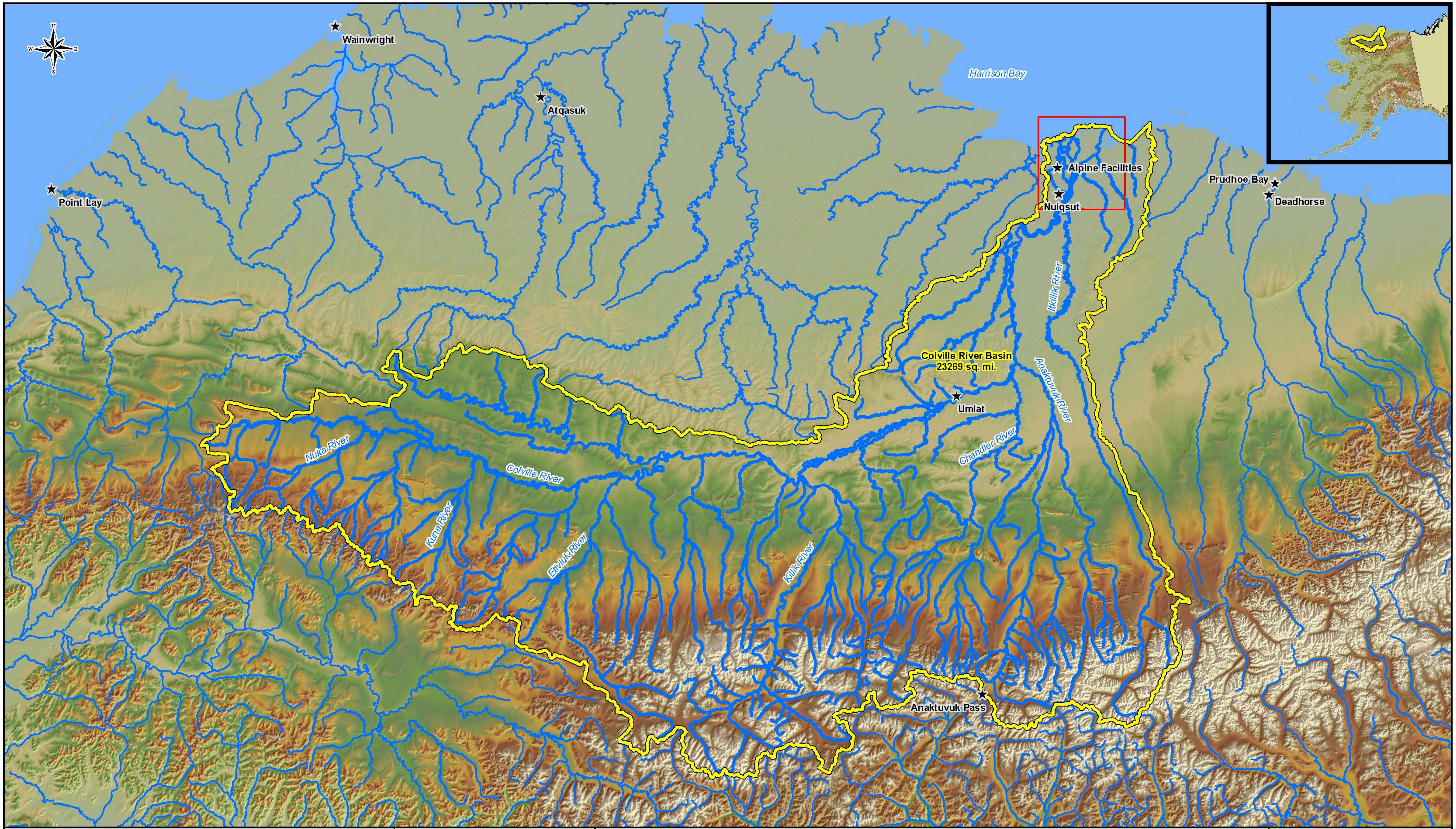
The Colville River is the largest river on the North Slope, initiating in the DeLong Mountains on the northern side of the Brooks Range, running north and east through the Arctic Coastal Plain, and forms the Colville River Delta (CRD) where the river empties into the Beaufort Sea. The Colville River drainage basin is approximately 23,269 square miles and includes a large portion of the western and central areas north of the Brooks Range (Figure 1.1). Spring breakup flooding commences with the arrival of meltwater in the delta and progresses with a rapid rise in stage which facilitates the breakup and downstream movement of river ice. CRD spring breakup is generally considered to be the largest annual flooding event in the region and typically occurs during a three-week period in May and June. Spring breakup monitoring is integral to understanding regional hydrology and ice effects, establishing appropriate design criteria for proposed facilities, and maintaining the continued safety of the environment, oilfield personnel, and existing facilities during the flooding event.

The CRD Spring Breakup Hydrologic Assessment supports the ConocoPhillips Alaska, Inc. (CPAI) Alpine Development Project and the Alpine Satellite Development Plan. The Alpine facilities are operated by CPAI and owned by CPAI and Anadarko Petroleum Company. Alpine facilities include the Colville Delta (CD) 1 processing facility (Alpine) and the CD2, CD3, CD4, and CD5 pads, access roads, and pipelines.

Spring breakup monitoring activities have been conducted in the CRD since 1992. The program was expanded to include additional Alpine facilities in 2004 and the CD5 development area in 2009. The 2016 hydrologic field program is the 25th consecutive year of CRD spring breakup investigations.

The 2016 field program took place from April 26 to May 29. Field personnel setup and rehabilitated the monitoring gages between April 26 and May 11. Monitoring began on May 12 and concluded on May 29. Primary field tasks included documenting the distribution of floodwater and measuring water levels and discharge at select locations. Observations of lake recharge, ice jams, ice road crossing degradation, and post-breakup floodwater effects on infrastructure were also recorded. Hydrologic observations were documented at all Alpine facilities, roads, and drainage structures, and relevant waterbodies within the CRD.

UMIAQ, LLC (LCMF), CPAI Alpine Field Environmental Coordinators, Alpine Helicopter Coordinators, and Pathfinder Aviation provided support during the field program and contributed to a safe and productive monitoring season.



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1.1 MONITORING OBJECTIVES

The primary objective of the CRD spring breakup monitoring and hydrologic assessment is to monitor and estimate the magnitude of breakup flooding within the CRD in relation to the Alpine facilities. Flood stage, discharge data, and observations are used to validate design parameters of existing infrastructure and for planning and design of proposed infrastructure. Flood data collection supports refinement of the CRD flood frequency, two-dimensional (2D) surface water model, and stage frequency analyses.

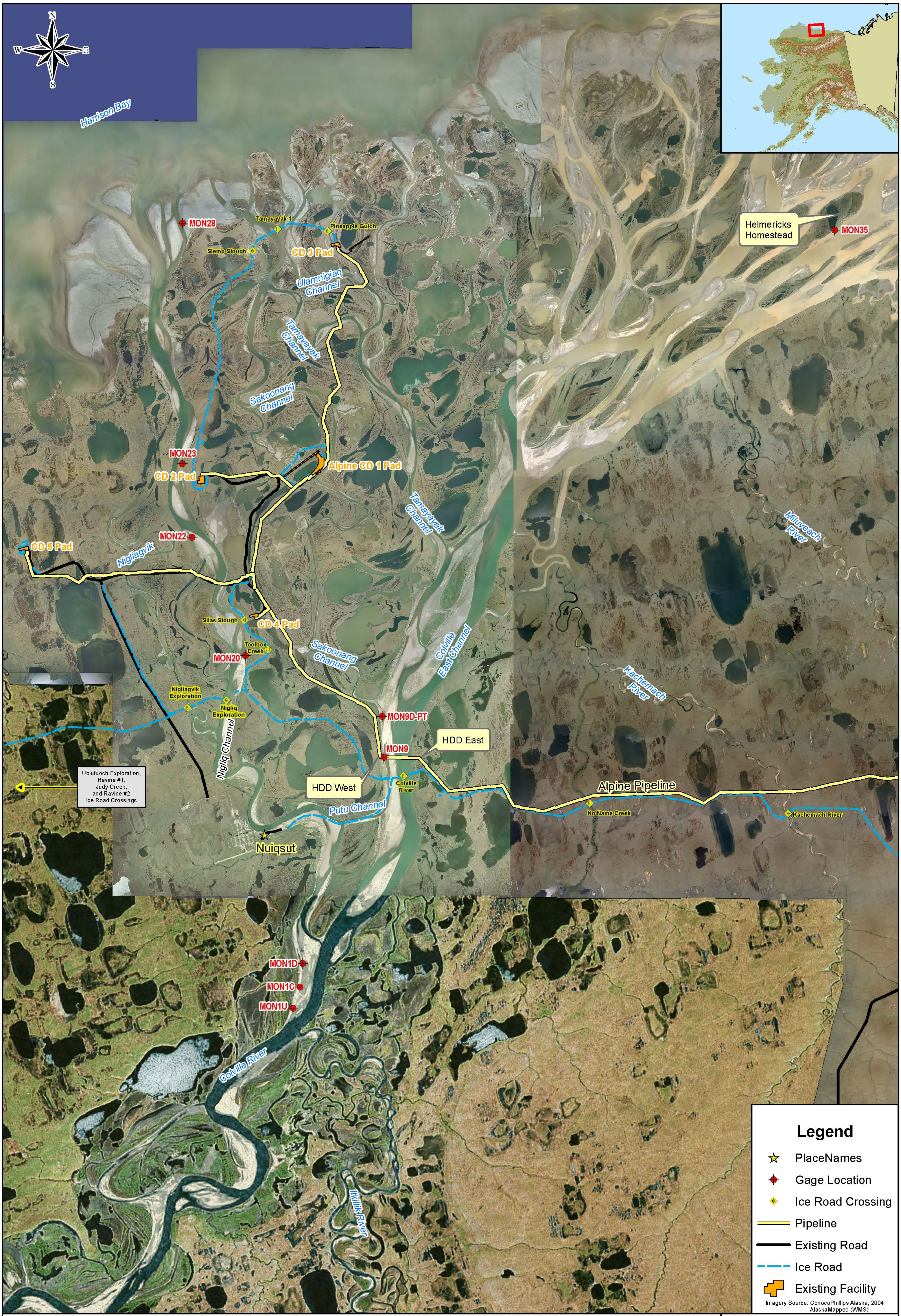
CRD spring breakup monitoring is also conducted to satisfy permit requirements. Permit stipulations of the U.S. Army Corps of Engineers (USACE) Permit No. POA-2004-253-2 and the State of Alaska, Department of Natural Resources, Office of Habitat Management and Permitting, Fish Habitat Permit FH04-III-0238 require monitoring the Alpine facilities during spring breakup. Permit requirements include direct measurements and indirect calculations of discharge through drainage structures and documentation of pad and access road erosion caused by spring breakup flooding. USACE Permit No. POA-2005-1576 has similar requirements for breakup monitoring along the CD5 road and bridges. It also required submittal of a *Monitoring Plan with an Adaptive Management Strategy* (Michael Baker and Alaska Biological Research [ABR] 2013). This monitoring plan includes documentation of annual hydrologic conditions, monitoring channel sedimentation and erosion, and assessing the performance of culverts and bridges for the CD5 development.

Culvert inlets and outlets are surveyed annually by LCMF to compare structure elevations on either side of the road to satisfy Alaska Department of Fish and Game (ADF&G) permit FH04-III-0238. Observations on functionality and flooding effects to the swale bridges are recorded to satisfy ADF&G permit FG97-III-0260.

Observations of the hydraulic effects of winter ice roads across the Colville East Channel near the Alpine horizontal directionally drilled (HDD) buried pipeline crossing, Nigliq Channel, Nigliagvik Channel, and the Kachemach River were documented. Additional ice road crossings also observed during breakup included:

- Judy Creek
- No Name Creek
- Pineapple Gulch
- Ravine #1
- Ravine #2
- Silas Slough
- Slemp Slough
- Tamayayak Channel
- Toolbox Creek
- Ublutuoch Exploration Crossing

ADF&G permits FG99-III-0051-Amendment #8 and FG97-III-0190-Amendment #5 require monitoring of recharge to lakes L9312 and L9313, respectively. The Alpine facilities rely on water withdrawal from these lakes for daily operations; the volume of which is dictated in part by annual spring recharge. The information presented in this report encompasses the data required by the permits.



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2016 SPRING BREAKUP
COLVILLE RIVER DELTA

Monitoring Locations

FIGURE: 1.2

(SHEET 1 of 1)

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2016 SPRING BREAKUP
ALPINE AREA FACILITIES

Monitoring Locations

FIGURE: 1.3

(SHEET 1 of 1)

1.2 MONITORING LOCATIONS

A network of hydrologic staff gages are used to monitor flood stage (Figure 1.2 and Figure 1.3). Most monitoring locations are adjacent to major hydrologic features and are selected based on topography, importance to the historical record, and proximity and hydraulic significance to existing or proposed facilities or temporary infrastructure.

The 2016 monitoring locations are similar to those studied in 2015 (Michael Baker 2015). Figure 1.2 shows the historical CRD monitoring locations denoted with a MON prefix. Monitoring locations specific to the Alpine facilities are shown in Figure 1.3. The specific type of data collected and location descriptions for each monitoring location are listed in Table 1.1. Gage geographic coordinates and vertical control names are provided in Appendix A.

Table 1.1: 2016 Monitoring Locations

Monitoring Location	Data Collected	Location
Colville River Upstream of Bifurcation		
MON1U	Staff Gage/PT	West bank, flow confined to a single channel
MON1C	Staff Gage/RTFM PT/RTFM Camera/Direct Discharge	West bank, flow confined to a single channel
MON1D	Staff Gage/PT	West bank, flow confined to a single channel
Colville River East Channel		
MON9	Staff Gage/PT/Baro PT	HDD crossing
MON9D	Staff Gage/PT	Downstream of the HDD crossing
MON35	Staff Gage	Helmericks Homestead
Nigliq Channel		
MON20	Staff Gage/PT	East bank south of CD4 pad
G28/G29	Staff Gage/PT	West bank north of CD4 pad
G26/G27	Staff Gage/PT	East bank adjacent to Nigliq Bridge (2009-2011 known as G21)
MON22	Staff Gage/PT	West bank south of CD2 pad
MON23	Staff Gage/PT	East bank north of CD2 pad
MON28	Staff Gage/PT	At Harrison Bay
Alpine Facilities and Roads		
CD1 Pad		
G1	Staff Gage/PT	CD1 between pad and Sakoonang Channel
G9	Staff Gage/PT/Remote Camera	Drinking water Lake L9312, northwest side
G10	Staff Gage/PT	Drinking water Lake L9313, west side adjacent to CD1 pad
CD2 Road and Pad		
G3/G4	Staff Gage/RTFM PT	CD2 access road, swale bridge vicinity
G12/G13	Staff Gage/PT	CD2 access road
G6/G7	Staff Gage/PT	CD2 access road
G8	Staff Gage	CD2 between pad and Nigliq Channel
CD3 Pad		
G11	Staff Gage	CD3 between pad and bifurcation of Ulamnigiaq Channel
CD4 Road and Pad		
M9525	Staff Gage	CD4 access road
G42/G43	Staff Gage	CD4 access road
G40/G41	Staff Gage	CD4 access road
G15/G16	Staff Gage/PT	CD4 access road
G17/G18	Staff Gage/RTFM PT	CD4 access road
G19	Staff Gage/Baro PT	CD4 between south side of pad and Lake L9324
G20	Staff Gage	CD4 between west end of pad and Nigliq Channel
CD5 Road		
G24/G25	Staff Gage/PT	Northeast side of Lake L9323, adjacent to bridge
G30/G31	Staff Gage/PT	CD5 access road
G32/G33	Staff Gage/PT	West side of Lake L9341, adjacent to bridge (2009-2011 known as G22)
G34/G35	Staff Gage/PT	CD5 access road

Monitoring Location	Data Collected	Location
CD5 Road - continued		
G36/G37	Staff Gage/PT	CD5 access road
G38/G39	Staff Gage/PT	West bank of Nigliagvik Channel, adjacent to Nigliagvik Bridge (2009-2011 known as G23)
S1/S1D	Staff Gage	CD5 access road south of Lake MB0301
CD3 Pipeline Stream Crossings		
SAK	Staff Gage/PT	Sakoonang Channel (Pipe Bridge #2)
TAM	Staff Gage/PT	Tamayayak Channel (Pipe Bridge #4)
ULAM	Staff Gage/PT	Ulamnigiaq Channel (Pipe Bridge #5)
CD2 Road Swale Bridges		
62-foot bridge	Direct Discharge	Along CD2 access road
452-foot bridge	Direct Discharge	Along CD2 access road
CD5 Road Bridges		
L9323 Bridge	Visual Survey/PT	Along CD5 access road
L9341 Bridge	Visual Survey/PT	Along CD5 access road
Nigliq Bridge	Direct Discharge/RTFM PT/RTFM Pier Scour	Along CD5 access road
Nigliagvik Bridge	Direct Discharge/RTFM PT/RTFM Pier Scour	Along CD5 access road
Road Culverts		
CD2 Road	Direct Discharge/Visual Survey	26 culverts
CD4 Road	Direct Discharge/Visual Survey	38 culverts
CD5 Road	Direct Discharge/Visual Survey	43 culverts
Post Breakup Conditions Assessment		
CD2 Access Road	Visual Erosion Survey	Access road from CD1 to CD2
CD4 Access Road		Access road from CD1 to CD4
CD5 Access Road		Access road from CD4 to CD5
Ice Road Crossing Degradation		
Colville River East Channel	Visual Survey	North of HDD
Judy Creek		Approximate location - N70.15523 W152.06932
Kachemach River		South of pipeline crossing to 2L Pad - Kuparuk
Nigliagvik Channel		West of Nigliq Exploration Crossing
Nigliq Channel		West of B8531/L9326
No Name Creek		East of HDD between lakes M9602 and M9605
Pineapple Gulch		North of CD3 along bifurcation of Ulamnigiaq Channel
Ravine #1		Approximate location - N70.14482 W151.95580
Ravine #2		Approximate location - N70.18463 W152.11723
Silas Slough		Silas Slough
Slemp Slough		Slemp Slough
Tamayayak Channel		West of CD3 and Tamayayak Bridge
Toolbox Creek		Swale connecting Nigliq Channel and M9934, south of CD4
Ublutuoch Exploration Crossing		Approximate location - N70.24211 W151.30089

Note:
PT - Pressure Transducer, Baro PT – Barometric Pressure Transducer
RTFM – Real Time Flood Monitoring network

2. METHODS

2.1 OBSERVATIONS

The U.S. Geological Survey (USGS) operates a hydrologic gaging station on the Colville River at Umiat, approximately 90 river miles (RM) upstream of the CRD. Real-time stage data and photos from this site were used during the breakup study to help forecast the initial arrival of meltwater and timing of peak conditions in the CRD study area. Helicopter and fixed wing overflights were also conducted upstream of MON1 to Ocean Point and the Anaktuvuk River to track the progression of the floodwaters.

Field data collection and observations of breakup progression, flow distribution, bank erosion, ice events, scour, lake recharge, and interactions between floodwaters and infrastructure were recorded in field notebooks (Photo 2.1). Photographic documentation of breakup conditions was collected using digital cameras with integrated global positioning systems (GPS). The latitude and longitude, date, and time are imprinted onto each photo. The photo location is referenced to the World Geodetic System of 1984 horizontal datum.

Pathfinder Aviation provided helicopter support to access remote sites. LCMF provided Hägglund track vehicle support to access gage locations during setup.

Photo 2.1: Field crew recording observations at MON9; May 23, 2016

2.2 WATER SURFACE ELEVATIONS

STAFF GAGES

For the purposes of this report, stage and water surface elevation (WSE) are used interchangeably. Stage or WSE data was collected using staff gages (designed to measure floodwater levels) and pressure transducers (PT). Site visits were performed daily as conditions allowed. The field methodologies used to collect hydrologic data on the North Slope of Alaska during spring breakup are proven safe, efficient, and accurate for the conditions encountered.

Gages were re-installed or rehabilitated as needed in the previous fall and re-surveyed in the early spring before breakup using standard differential leveling techniques.

Two types of gages were used:

1) Direct-read gages directly correspond to a British Petroleum Mean Sea Level (BPMSL) elevation and were surveyed prior to breakup in May by LCMF. The pre-breakup survey is used to determine if correction factors must be applied to adjust elevations during flooding conditions. Adjustments are made annually by LCMF during ice-free conditions to correct for jacking or settlement induced by the freeze-thaw cycle. The gages consist of metal gage faceplates attached to drill stems permanently driven into the ground or attached to pipeline vertical support members (VSM).
2) Indirect-read gages do not directly correspond to a BPMSL elevation (Photo 2.2). The gage elevations were surveyed relative to a known benchmark elevation to determine a correction factor. The correction factor is applied to the gage reading to obtain the elevation in feet BPMSL.

Photo 2.2: Temporary staff gages at MON9D; April 27, 2016

Gage sets consist of one or more gage assemblies positioned perpendicular to stream channels and lakes at monitoring locations. Each gage assembly in a set includes a standard USGS metal faceplate mounted on a wooden two-by-four. The two-by-four is attached with U-bolts to a 1.5-inch-wide angle iron post driven into the ground. The faceplate is graduated and indicates water levels every 100th of a foot between 0.00 to 3.33 feet.

Photo 2.3: Field crew chalking gage G1; May 22, 2016

The number of gage assemblies per set depends on site specific conditions: primarily slope of the channel, bank, and overbank. In locations where terrain elevation varied by more than three feet, multiple gages were installed linearly from the edge of the low water channel up to the overbank. The gages were installed at elevations overlapping by approximately one foot. Individual gage assemblies were identified with alphabetical designations beginning with 'A' representing the location nearest to the stream centerline. High water marks (HWMs) were measured by applying chalk on the angle iron gage supports or VSMs (Photo 2.3) and measuring the wash line.

PRESSURE TRANSDUCERS

PTs were used at monitoring locations to supplement gage measurements and provide a continuous record of WSEs. PTs are designed to collect and store pressure and temperature data at discrete pre-set intervals. PTs were programmed to collect data at 15-minute intervals from May 1 to August 30. Each PT was housed in a small perforated galvanized steel pipe and secured to the base of the gage assembly nearest to the bed of the active channel (Photo 2.4). By sensing the absolute pressure of the atmosphere and water column above the PT, the depth of water above the sensor was calculated. Absolute pressure was accounted for using barometric pressure sensors (Baro PT) at two locations in the CRD. During data processing, the PT measurements were adjusted to WSEs recorded at the staff gages.

Photo 2.4: PT at gage G1; May 12, 2016

Secondary PTs were installed at some monitoring locations to validate and backup the primary PT data. During data processing, the secondary PT data was used for QA/QC of the primary PT data. The redundancy ensures data is available for sites where discharge is calculated. Appendix A contains details regarding PT setup and testing (A.3). Table 1.1 indicates monitoring locations with PT installations.

2.3 DISCHARGE

MEASURED DISCHARGE

Discharge was measured as close to the observed peak stage as possible at the following locations:

- Colville River at MON1 (Photo 2.5)
- Culverts along the CD2, CD4, and CD5 roads
- Long and Short Swale Bridges along the CD2 road (Photo 2.6)
- Nigliq Bridge
- Nigliagvik Bridge

Direct discharge at MON1 was measured using an Acoustic Doppler Current Profiler (ADCP) mounted on a boat. Direct discharge measurements have been collected at MON1 on the Colville River using an ADCP each year since 2005, with the exception of 2010 and 2012. Measurements were conducted as outlined in the USGS *Quality-Assurance Plan for Discharge Measurements Using Acoustic Doppler Current Profilers* (USGS 2005). Discharge was measured at the Long and Short Swale Bridges, and at the Nigliq and Nigliagvik Bridges using conventional current meters and the USGS midsection technique. Culvert discharge was calculated using measured velocity, flow depth, and culvert geometry.

Photo 2.5: Discharge measurements at MON1; May 25, 2016

Photo 2.6: Discharge measurements at the Nigliq Bridge; May 25, 2016

PEAK DISCHARGE

Peak discharge was calculated indirectly and, if necessary, calibrated with the direct discharge measurements and observed WSEs. Under open channel conditions, peak discharge typically occurs at the same time as peak stage. However, this is not the case in the Colville River Delta where peak discharge is often affected by ice and snow. Ice-affected channels produce backwater effects and can temporarily increase stage and reduce velocity yielding a lower discharge than an equivalent stage under open water conditions.

Peak discharge was indirectly calculated at the following locations:

- Colville River (MON1)
- Colville East Channel (MON9)
- Nigliq Bridge
- Nigliagvik Bridge
- CD2, CD4, and CD5 road culverts (where flow was present)
- Long and Short Swale Bridges

Peak discharge at MON1 was calculated indirectly using both the Slope-Area and Normal Depth methods. The Normal Depth method applies similar theories as the Slope-Area method by using upstream and downstream stage data and surveyed channel bathymetry. The Normal Depth method, however, requires a single cross section rather than multiple cross sections required by the Slope-Area method. Peak discharge at MON9 was determined using the Normal Depth method.

Flow was contracted by a large snow drift at the Nigliagvik Bridge. Flow contractions at bridges result in energy losses not accounted for in the Normal Depth or Slope-Area methods. The USGS width contraction method (USGS 1976) was used to estimate peak discharge through the Nigliagvik Bridge. Flow was not contracted at any other CD5 bridges.

Bentley CulvertMaster® software was used to calculate discharge through the CD2, CD4, and CD5 road culverts. Timing and magnitude of peak discharge through the culverts was determined based on recorded stage on both sides of the road prism.

Average velocity and discharge through the culverts assumes ice-free open-water conditions and were estimated based on several variables, including:

- Headwater and tailwater elevations at each culvert (hydraulic gradient)
- Culvert diameter and length from LCMF as-built surveys (LCMF 2002, 2016)
- Culvert upstream and downstream invert elevations (LCMF 2016)
- Culvert Manning's roughness coefficients (0.012 for smooth steel and 0.024 for corrugated metal pipe)

Culvert peak discharge results were evaluated against visual assessment of performance. The peak discharge estimates for the Long and Short Swale Bridges were calculated using the velocities measured during the discharge measurements and adjusting the hydraulic depth for peak conditions.

Indirect discharge results are estimates based on conditions at the time of data collection. These conditions often include ice and snow effects, which are highly dynamic and challenging to quantify. Ice and snow conditions can affect channel geometry, roughness, energy gradient, and stage, all of which are used to calculate discharge indirectly. In consideration of these conditions, indirect calculations of peak discharge are presented with quality ratings, as described in Table 2.1.

Table 2.1: Indirect Discharge Peak Calculation Quality Ratings

Quality Rating	Description
Good	Open channel/drainage structure free of ice and snow, no backwater effects from downstream ice jamming, uniform channel/drainage structure through reach
Fair	Some ice floes and/or snow in the channel/drainage structure, some backwater effects, fairly uniform conditions through reach
Poor	Significant quantities of ice and snow in the channel/drainage structure, significant backwater effects from downstream ice jamming, non-uniform conditions through channel/drainage structure reach

Direct discharge measurement techniques and peak discharge calculation methods are detailed in Appendix B.1.

2.4 POST-BREAKUP CONDITIONS ASSESSMENT

The Alpine facilities roads, pads, and drainage structures were assessed immediately following the breakup flood. A systematic inventory was completed to document the effects of flooding on infrastructure with a focus on erosion. Both sides of the roads were photographed from the ground and the condition of the fill material was described.

2.5 CD5 PIER SCOUR, BANK EROSION, & BATHYMETRY

Monitoring described in this section supports additional requirements specific to CD5 per the *Monitoring Plan with an Adaptive Management Strategy* (Michael Baker and ABR 2013).

PIER SCOUR

The objective of measuring pier scour is to determine maximum pier scour depths during flood conditions using a real-time pier scour monitoring system and to determine final pier scour depths via a post-breakup survey. Real-time pier scour measurements supports the requirement for annual pier scour measurements during spring breakup and other large flood events at the Nigliq and Nigliagvik Bridges (Michael Baker and ABR 2013). Maximum scour occurring under the influence of peak velocities is often greater than the final scour measured after flood recession due to sediment deposition in the scour hole associated with lower flow velocities. For this reason, it is imperative that real-time soundings are collected during peak flood conditions.

The Nigliq Bridge is supported by two bridge abutments, abutment 1 and 9, and seven bridge piers, piers 2 through 8. Each bridge pier contains five piles labeled A through E, with pile A being the most upstream pile. Piles A and B support the ice breaker, while piles C, D, and E support the bridge. Bridge piers 2 through 5 are located within the main portion of the Nigliq Channel. The Nigliagvik Bridge is supported by two bridge abutments, abutment 1 and 5, and three bridge piers, piers 2 through 4. Each bridge pier contains two piles labeled A and B, with pile A being the upstream pile. Bridge piers 3 and 4 are located within the main portion of the Nigliagvik Channel. Drawings with the Nigliq and Nigliagvik Bridge pier and pile layouts are available in Appendix G.1.

A real-time pier scour monitoring system was installed on bridge piers that are the most susceptible to scour. These include pier 3 of the Nigliagvik Bridge, installed in the spring of 2015, and piers 2 through 5 of the Nigliq Bridge, installed in the spring of 2016. Scour depths were measured using a single beam sonar installed inside a steel pipe casing welded to the downstream side of pile E on the Nigliq Bridge and pile B on the Nigliagvik Bridge. Sonar measurements were recorded with an on-site datalogger. The sonar system was programmed to measure depths and record data at 30 minute intervals. A telemetry system, using cellular communication, provided remote access to the sonar measurements. A post-breakup survey of the scour holes at the base of bridge piers within the main channel at the Nigliq and

Nigliagvik Bridges was completed to ensure maximum scour depth had been documented (LCMF 2016d). The maximum pier scour depths measured during breakup and final post-breakup surveyed scour depths were determined at each bridge. Post-breakup contour plots around the piers within the main channel of the Nigliq and Nigliagvik Bridges are provided in Appendix G.1.

BANK EROSION

The objective of the bank erosion study is to monitor bank migration near the Nigliq and Nigliagvik Bridges. This work supports the requirements for visual inspection and documentation of tundra as well as bank erosion monitoring upstream and downstream of the bridges. A detailed edge-of-bank delineation was surveyed near the proposed Nigliq and Nigliagvik Bridge crossing locations in 2013 to establish pre-construction baseline data. This survey was performed again this year, post-construction (LCMF 2016c). Bank erosion survey data is provided in Appendix G.1. The maximum erosion and the average rate of erosion between 2013 and 2016 were determined for each bank.

BATHYMETRY

The objective of the channel bathymetry survey is to monitor channel geometry at, as well as upstream and downstream, of the bridges crossing the Nigliq Channel, the Nigliagvik Channel, and Lake L9341. This work supports the requirements for channel bathymetry at bridges to adequately document seasonal scour and deposition, and to monitor bathymetry and bank erosion in the vicinity of the bridges. In August 2013, prior to construction of the CD5 bridges, topographic and bathymetric baseline surveys were performed by LCMF in the Nigliq Channel, Nigliagvik Channel, and Lake L9341. Transect profiles and bathymetric cross-sections are provided in Appendix G.3. Four transects at each bridge location are re-surveyed every year and all transects are re-surveyed every three years (LCMF 2016b). The maximum incremental change between 2015 and 2016 was documented for the bridge transects. The maximum cumulative change since 2013 was documented for all transects.

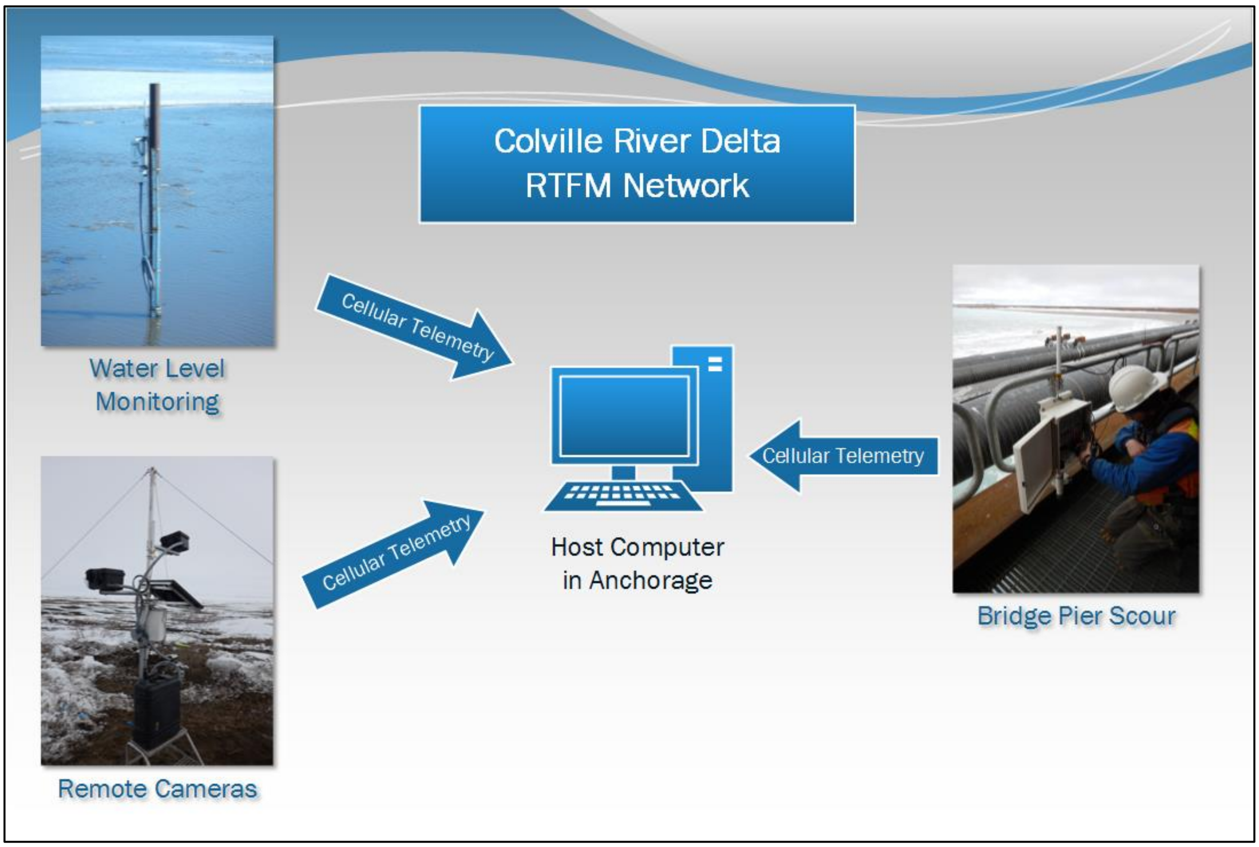
2.6 REAL-TIME FLOOD MONITORING NETWORK

The objective of the Real-Time Flood Monitoring (RTFM) Network is to remotely monitor stage and pier scour at select monitoring locations during spring breakup flood events (Table 2.2). Real-time pier scour monitoring discussed in Section 2.5 above, is a component of the RTFM Network. The RTFM Network has the following components: remote cameras to monitor stage and river conditions; sensors to monitor stage, barometric pressure and bridge pier scour; dataloggers and telemetry systems to collect and transmit data; and a host computer to receive the transmitted data (Figure 2.1). The ability to remotely monitor stage and scour helps reduce helicopter traffic in the CRD, allows for round-the-clock monitoring of conditions, and provides an interactive tool for the hydrologic data when helicopter travel is restricted. In addition, a network of real-time monitoring stations at critical locations around the Alpine infrastructure helps guide facilities operations preparedness, and helps hydrologists deploy resources during peak conditions when critical measurements are required.

Table 2.2: RTFM Network Stations

Monitoring Location	Real-Time Data
MON1C	• Stage • River conditions via camera images
G3 (CD2 Road)	• Stage
G18 (CD4 Road)	• Stage • Barometric pressure sensor
Nigliq Bridge	• Stage • Pier scour (piers 2-5)
Nigliagvik Bridge	• Stage • Pier scour (pier 3)

Figure 2.1: RTFM Network Schematic



REMOTE CAMERAS

A remote camera system was installed at the MON1C monitoring location. High resolution digital cameras were programmed to take pictures on 15-minute intervals. One camera collected photographs of the Colville River to document conditions and monitor ice jam formation and releases in the MON1 reach (Photo 2.7). A second camera focused on individual staff gages to allow hydrologists to remotely collect stage measurements for validating PT data.

SENSORS

PTs were programmed to read and record water levels and barometric pressure at 15 minute intervals (Photo 2.8). Real-time pier scour was measured using single beam sonars at 30-minute intervals (Photo 2.9).

Photo 2.7: Remote camera installation at MON1C; May 4, 2016

Photo 2.8: Pressure transducer connected to datalogger at gage G3; May 18, 2016

Photo 2.9: Single beam sonar and pressure transducer at Nigliagvik Bridge; May 6, 2016

DATALOGGERS & TELEMETRY

Onsite dataloggers were programmed to interface with the PTs and sonars (Photo 2.10). Data was uploaded to the datalogger via a data cable and stored internally. The dataloggers were programmed to interact with telemetry equipment to transmit data. Data was transmitted using an onsite cellular modem and TCP/IP communication where each cellular modem has a unique static IP address. To conserve power, cellular modems were programmed to power-on every 15 minutes for data transmission. At MON1C, a separate onsite computer with mobile broadband internet access was used to upload camera images to cloud storage. Dataloggers and onsite computers were powered with 12v DC batteries. A solar panel was used to charge the battery of the remote station at MON1C. Batteries for the other dataloggers on the road system were periodically changed with charged batteries.

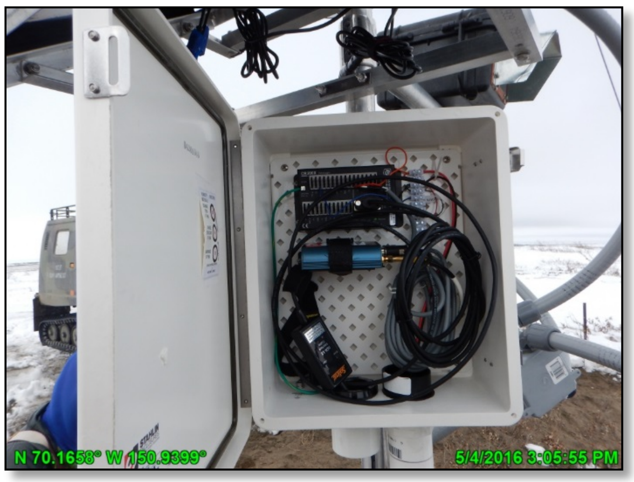


Photo 2.10: Datalogger at MON1C; May 4, 2016

HOST COMPUTER, DATA ACCESS, & NOTIFICATIONS

A host computer listened for the cellular modem IP addresses and communicated with the dataloggers once the connection was established. The host computer received the data as an ASCII file and Campbell Scientific Loggernet software was used for data processing. Real-time stage was processed using downloaded stage and barometric pressure data. Real-time stage was periodically compared with field-observed stage data for quality assurance. Real-time stage and pier scour were plotted on graphs and updated in tables as data was received. Alarms were set to notify Alpine operations personnel if stage or pier scour reached the 50- or 200-year predicted values at any of the monitoring locations. If alarms were triggered, notifications would automatically be sent by email and text message.

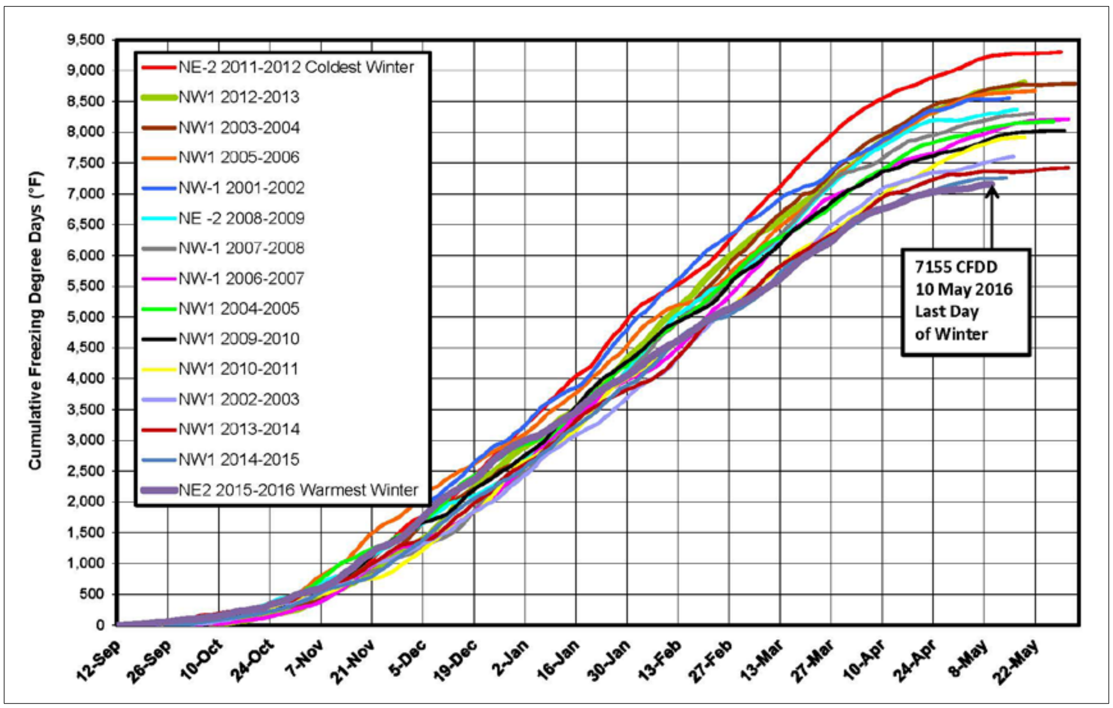
2.7 FLOOD & STAGE FREQUENCY ANALYSES

Peak discharge at MON1 is annually assigned a flood recurrence interval based on current design criteria. The flood recurrence interval provides an estimate of the magnitude of annual breakup flooding entering the CRD. A flood recurrence interval was assigned to the peak discharge at MON1 based on the results from the 2015 flood frequency analysis (Michael Baker 2015). Peak stage at select monitoring locations was compared with historical stage data and results from the 2D model and assigned a stage recurrence interval.

3. OBSERVATIONS & WATER SURFACE ELEVATIONS

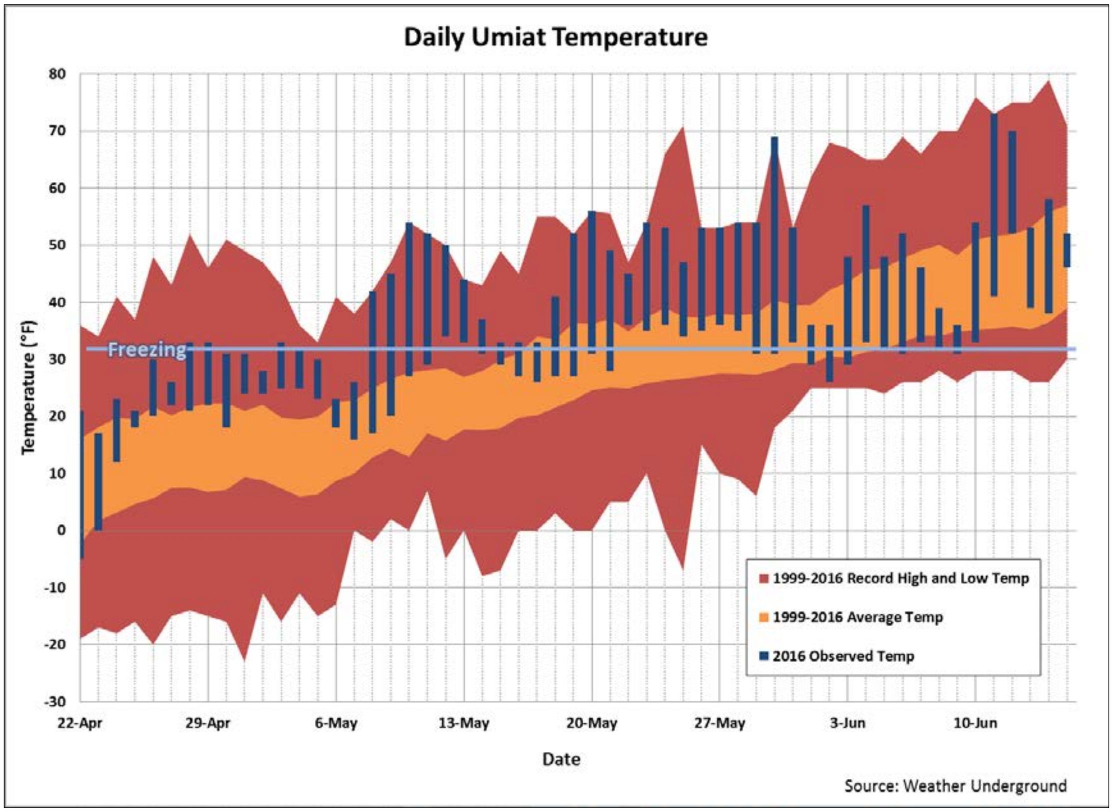
3.1 TEMPERATURE

The winter of 2015-2016 was the warmest on record for the past 15 years; the coldest was 2011-2012, as shown in Graph 3.1 (ICE 2016). Cumulative freezing degree days (CFDD) are a measurement in degrees of the daily mean air temperature below freezing accumulated over the total number of days the temperature remained below freezing. This year, snowpack north of the Brooks Range was slightly below average and spring temperatures were above average (NRCS 2016).



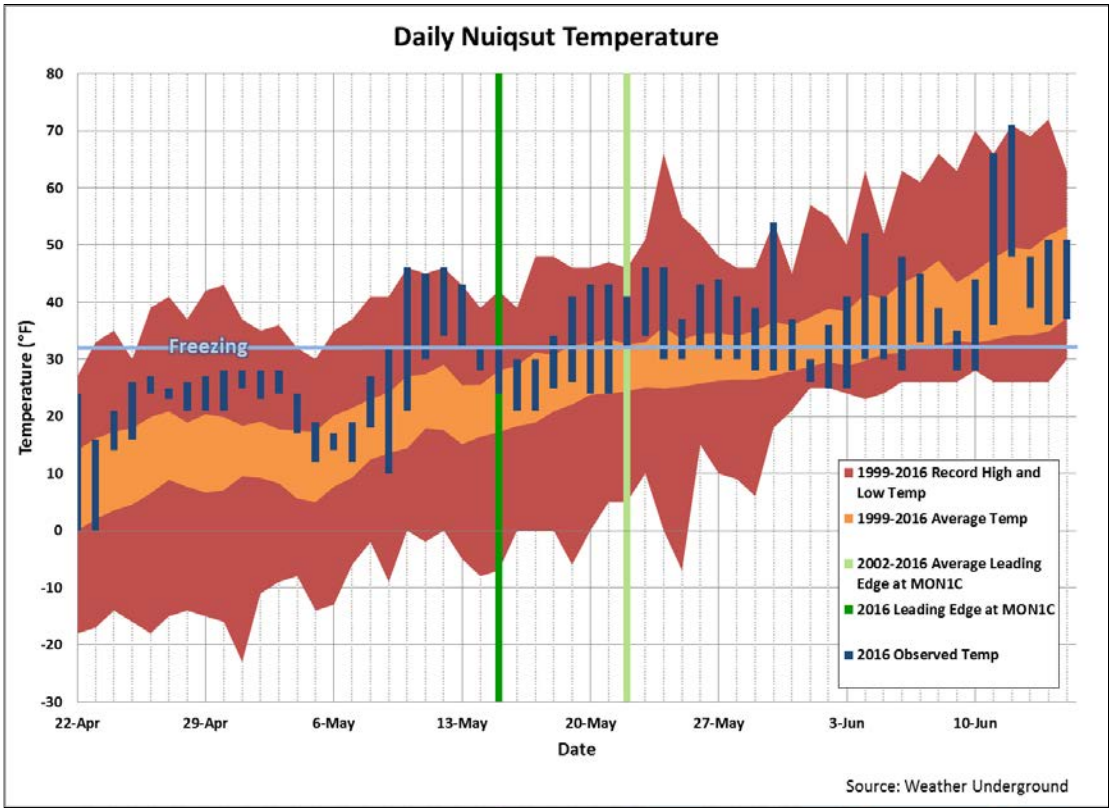
Graph 3.1: NPRA N. Tundra Monitoring Station, Cumulative Freezing Degree Days, Winters 2002-2016 (ICE 2016)

Breakup in the CRD typically begins when daily low air temperatures consistently exceed freezing in the northern foothills of the Brooks Range. Climate data at the northern extent of the Brooks Range foothills is available from the Umiat weather station, located approximately 60 air miles south (upstream) of the head of the CRD. Ambient air temperatures in Umiat were generally above historical averages. Nighttime ambient air temperatures in Umiat fluctuated above and below freezing during spring breakup. Record temperature days from May 8 through May 13 accelerated melting of the snowpack and initiating floodwater in the delta earlier than normal. A period of cooling followed, which slowed regional breakup processes and contributed to a protracted breakup event. Graph 3.2 illustrates daily high and low ambient air temperatures recorded at Umiat superimposed on the average and record daily highs and lows during the breakup monitoring period (Weather Underground 2016).



Graph 3.2: Umiat Daily High and Low Ambient Air Temperatures

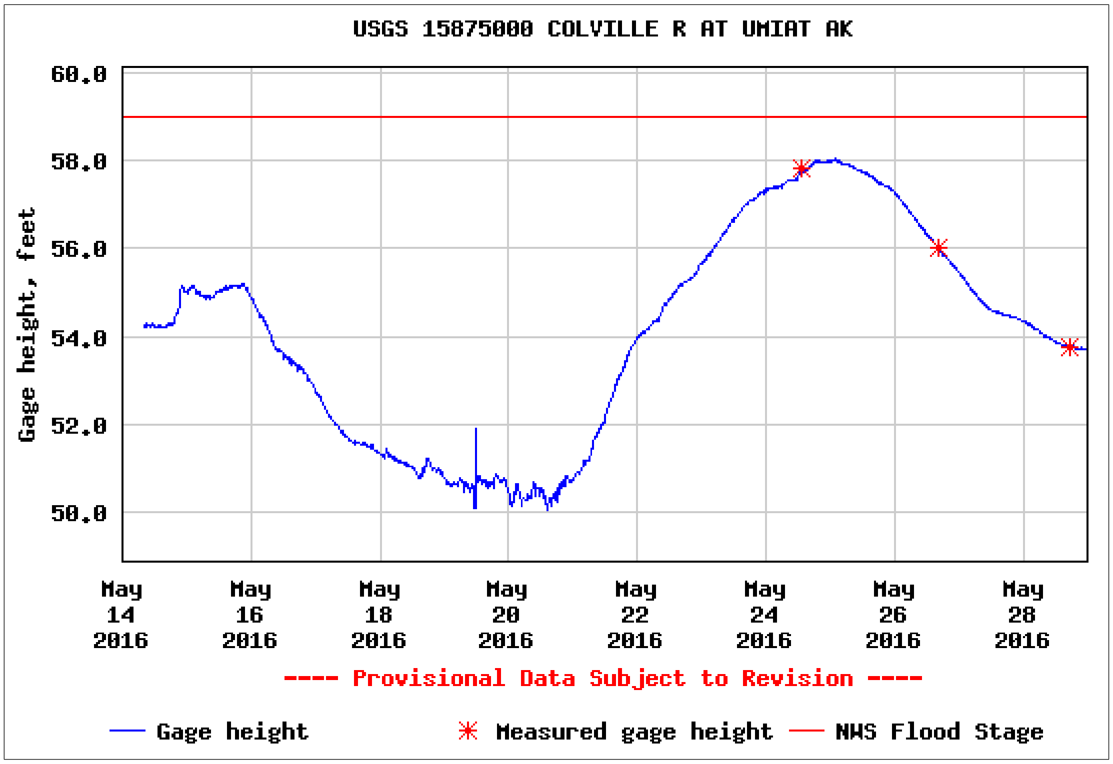
Temperatures for the Alpine area were obtained from the Nuiqsut weather station. Nuiqsut is located on the west bank of the Nigliq Channel approximately 9 air miles south of the Alpine facilities, as shown in Figure 1.1. With the exception of a period of record high temperatures experienced at Nuiqsut early in the season, between May 10 and May 13, daily low ambient air temperatures in the CRD remained near or below freezing during breakup. Graph 3.3 illustrates daily high and low ambient air temperatures superimposed on daily average and record highs and lows recorded at Nuiqsut during the breakup monitoring period (Weather Underground 2016). The arrival the leading edge at MON1 this year and the average arrival of the leading edge at MON1 from 2002 to 2016 are included for comparison.



Graph 3.3: Nuiqsut Daily High and Low Ambient Air Temperatures and MON1 Leading Edge

3.2 CONDITIONS SUMMARY

The USGS Umiat gage station is monitored prior to and during breakup to help predict the timing of floodwater and flood crests in the CRD; there is typically a 24-hour lag time between flood crests at Umiat and the CRD. The Umiat gage station is upstream of the Chandler and Anaktuvuk River confluences and the gage data does not account for the contribution from these two major tributaries. The National Weather Service (NWS) established flood stage at Umiat indicates the magnitude of flooding upstream of the CRD; however, because of local ice effects, it does not necessarily correlate with the magnitude of flooding in the CRD (Graph 3.4).



Graph 3.4: Colville River at Umiat Stage Data (USGS 2016)

On May 12, the leading edge of floodwater was observed in the Colville River on the Umiat webcam. An aerial reconnaissance flight was conducted on May 13 and the leading edge of floodwater was observed in the Colville River just downstream of the confluence with the Anaktuvuk River, approximately 65 RMs upstream of MON1 (Photo 3.1). The Anaktuvuk River had a continuous open lead at the confluence with the Colville River. Air temperatures in the foothills and throughout the CRD began to drop around May 14.

On the morning of May 15, the leading edge passed MON1 and reached the Tamayayak Channel bifurcation in the East Channel and stage began to rise throughout the delta. A 7.4-mile long ice jam was observed at Ocean Point, approximately 22 RMs upstream of MON1, with minimal backwater upstream of the ice jam (Photo 3.2). Stage at Umiat crested in response to cooler air temperatures.

On May 16, the leading edge continued to move through the CRD and reached the ocean as stage continued to rise in most distributary channels. The ice jam at Ocean Point continued to develop causing moderate inundation of adjacent high-water channels and low-lying areas. Flow over bottom-fast ice in the Kachemach River and local ponded water in the Miluveach River were observed at the Alpine Sales Pipeline crossings.

By May 17, the ice jam near Ocean Point had grown to approximately 13.4-miles long, causing backwater to fill the low level, meander channels with some overbank flooding. Stage at most monitoring locations throughout the delta crested in response to the cooler air temperatures. Channel ice was floating intact and stationary in most distributary channels. Over the next few days, the ice jam at Ocean Point decreased in size and water levels behind the jam receded. Stage throughout the delta continued to recede and daily low air temperatures in the foothills and throughout the delta began to rise again.

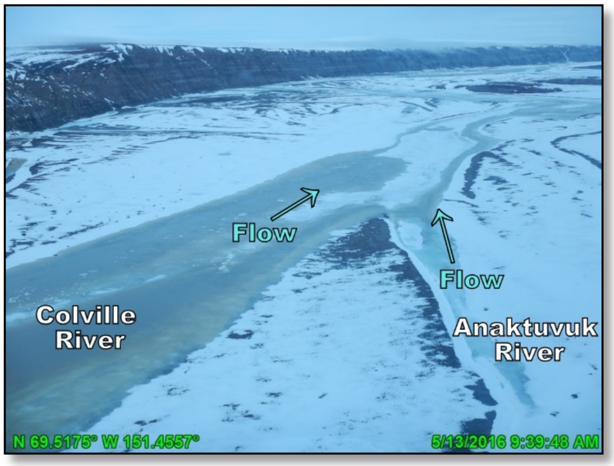


Photo 3.1: Leading edge of floodwater downstream of the Anaktuvuk River confluence, looking northwest; May 13, 2016

Photo 3.2: Downstream extent of the Colville River ice jam at Ocean Point, looking southwest; May 15, 2016

On May 21, stage at Umiat and throughout the CRD began to rise again due to rising air temperatures. Ice floes began backing up behind the intact channel ice upstream of MON1 downstream of Ocean Point (Photo 3.3). On May 22, portions of the ice jam at Ocean Point began moving downstream forming a second 2.4-mile long ice jam, approximately 5 miles upstream of MON1 (Photo 3.4). High water channels near the ice jams were observed conveying flow. Rising water levels began breaking up ice in the smaller distributary channels in the delta.

Photo 3.3: Intact channel ice holding back ice floes on the Colville River upstream of MON1, looking northeast; May 21, 2016

Photo 3.4: Ice jam on the Colville River upstream of MON1, looking southwest; May 22, 2016

On the morning of May 23, the ice jams upstream of MON1 released. Stage peaked at the head of the delta as the surge of backwater and ice floes progressed downstream. Ice floes re-formed as ice jams at the Tamayayak Channel bifurcation (Photo 3.5) and Nigliq Channel bifurcation upstream of Nuiqsut. Channel ice remained intact in the East Channel downstream of the Sakoonang Channel bifurcation and in the Nigliq Channel downstream of Nuiqsut. Backwater from the ice jam in the Nigliq Channel began diverting flow into the East Channel through the Putu Channel.

On May 24, channel ice remained intact in the East Channel between the Kachemach and Miluveach River confluences. The ice jam at the Tamayayak Channel bifurcation moved downstream and re-formed upstream of the intact channel ice (Photo 3.6) causing moderate flooding at the mouth of the Kachemach River (northern distributary) confluence and in eastern distributary channels. The ice jam in the Nigliq Channel had advanced downstream of Nuiqsut and no significant overbank flooding was observed.

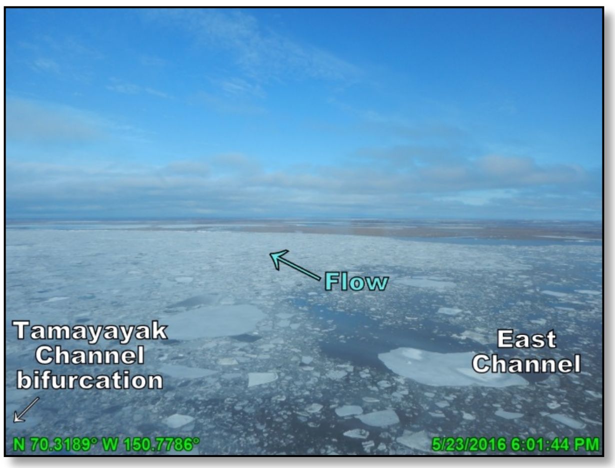


Photo 3.5: Ice jam at the Tamayayak Channel bifurcation, looking northeast; May 23, 2016

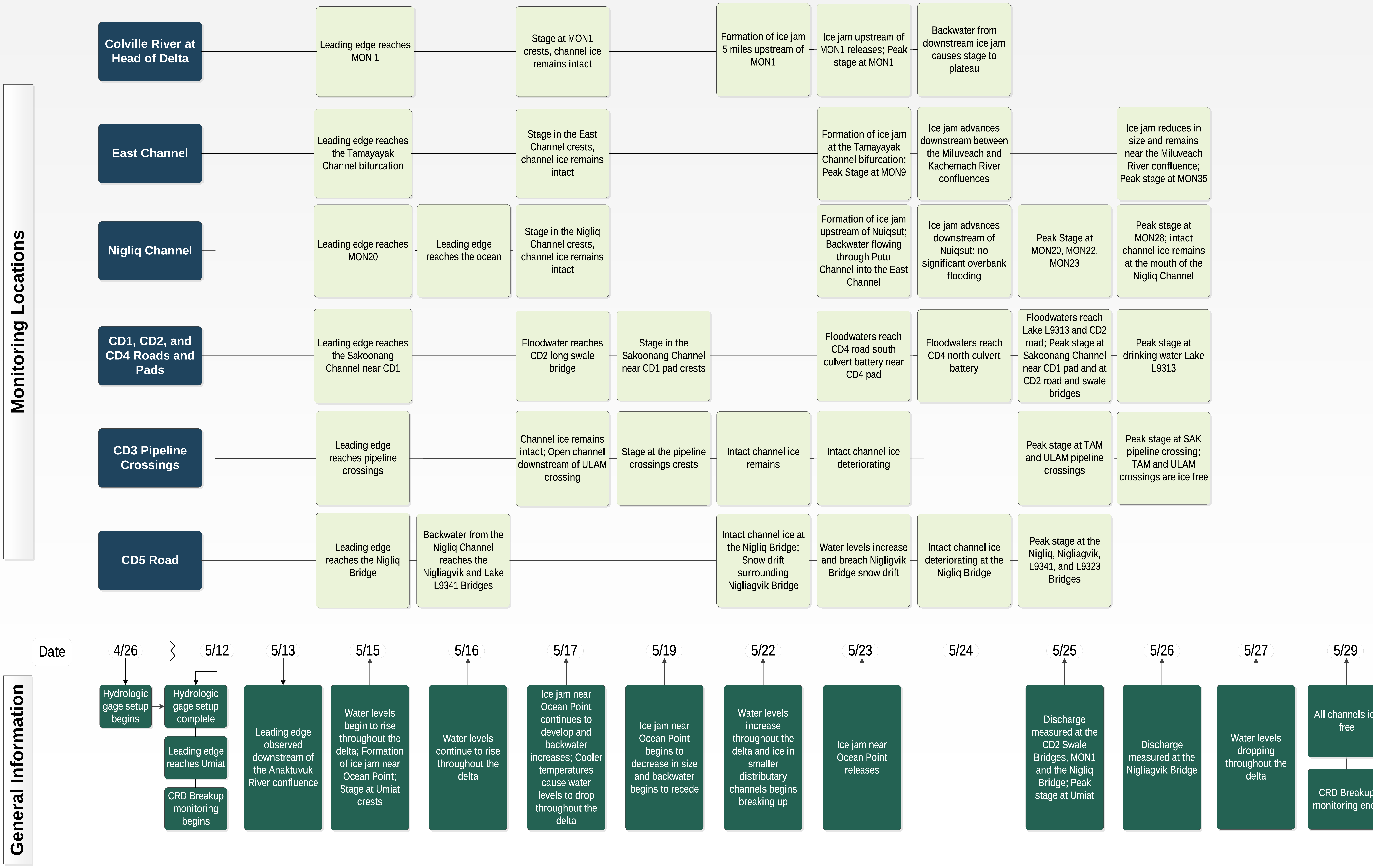
Photo 3.6: Ice jam moving toward the Kachemach and Miluveach River confluences, looking northeast; May 24, 2016

On May 25, stage at Umiat peaked approximately one foot below the NWS flood stage for the site (Graph 3.4). Stage around Alpine facilities peaked on May 25 and May 26 and fluctuated as water levels responded to ice jam movements in the East Channel and Nigliq Channel. By the evening of May 26, stage was receding throughout the CRD. Channel ice remained intact at the mouth of the Nigliq Channel causing inundation of the mud flats along the coast (Photo 3.7). Floodwater upstream of the intact channel ice was confined within the channel banks. The ice jam in the East Channel decreased in size and remained near the Miluveach River confluence. Ice floes continued moving downstream toward the ocean (Photo 3.8). At the Kachemach River and Miluveach River Alpine Sales Pipeline crossings, bottom-fast ice and saturated snow were present in the channel. Over the next two days, the ice jam in the East Channel continued to decrease in size and stage continued to drop throughout the CRD. By May 29, all channels were ice free.

Photo 3.7: Intact channel ice at the mouth of the Nigliq Channel, looking northwest; May 26, 2016

Photo 3.8: Ice floes at MON35 moving down the East Channel toward the ocean, looking east; May 26, 2016

Figure 3.1 provides a visual timeline summarizing the major breakup events. Detailed WSEs and observations at specific monitoring locations are presented in the following sections.



Monitoring Locations
Colville River at Head of Delta
Leading edge reaches MON 1
Stage at MON1 crests, channel ice remains intact
Formation of ice jam 5 miles upstream of MON1
Ice jam upstream of MON1 releases; Peak stage at MON1
Backwater from downstream ice jam causes stage to plateau
East Channel
Leading edge reaches the Tamayayak Channel bifurcation
Stage in the East Channel crests, channel ice remains intact
Formation of ice jam at the Tamayayak Channel bifurcation; Peak Stage at MON9
Ice jam advances downstream between the Miluveach and Kachemach River confluences
Ice jam reduces in size and remains near the Miluveach River confluence; Peak stage at MON35
Nigliq Channel
Leading edge reaches MON20
Leading edge reaches the ocean
Stage in the Nigliq Channel crests, channel ice remains intact
Formation of ice jam upstream of Nuiqsut; Backwater flowing through Putu Channel into the East Channel
Ice jam advances downstream of Nuiqsut; no significant overbank flooding
Peak Stage at MON20, MON22, MON23
Peak stage at MON28; intact channel ice remains at the mouth of the Nigliq Channel
CD1, CD2, and CD4 Roads and Pads
Leading edge reaches the Sakoonang Channel near CD1
Floodwater reaches CD2 long swale bridge
Stage in the Sakoonang Channel near CD1 pad crests
Floodwaters reach CD4 road south culvert battery near CD4 pad
Floodwaters reach CD4 north culvert battery
Floodwaters reach Lake L9313 and CD2 road; Peak stage at Sakoonang Channel near CD1 pad and at CD2 road and swale bridges
Peak stage at drinking water Lake L9313
CD3 Pipeline Crossings
Leading edge reaches pipeline crossings
Channel ice remains intact; Open channel downstream of ULAM crossing
Stage at the pipeline crossings crests
Intact channel ice remains
Intact channel ice deteriorating
Peak stage at TAM and ULAM pipeline crossings
Peak stage at SAK pipeline crossing; TAM and ULAM crossings are ice free
CD5 Road
Leading edge reaches the Nigliq Bridge
Backwater from the Nigliq Channel reaches the Nigliagvik and Lake L9341 Bridges
Intact channel ice at the Nigliq Bridge; Snow drift surrounding Nigliagvik Bridge
Water levels increase and breach Nigligvik Bridge snow drift
Intact channel ice deteriorating at the Nigliq Bridge
Peak stage at the Nigliq, Nigliagvik, L9341, and L9323 Bridges
Date
4/26
5/12
5/13
5/15
5/16
5/17
5/19
5/22
5/23
5/24
5/25
5/26
5/27
5/29
General Information
Hydrologic gage setup begins
Hydrologic gage setup complete
Leading edge reaches Umiat
CRD Breakup monitoring begins
Leading edge observed downstream of the Anaktuvuk River confluence
Water levels begin to rise throughout the delta; Formation of ice jam near Ocean Point; Stage at Umiat crests
Water levels continue to rise throughout the delta
Ice jam near Ocean Point continues to develop and backwater increases; Cooler temperatures cause water levels to drop throughout the delta
Ice jam near Ocean Point begins to decrease in size and backwater begins to recede
Water levels increase throughout the delta and ice in smaller distributary channels begins breaking up
Ice jam near Ocean Point releases
Discharge measured at the CD2 Swale Bridges, MON1 and the Nigliq Bridge; Peak stage at Umiat
Discharge measured at the Nigliagvik Bridge
Water levels dropping throughout the delta
All channels ice free
CRD Breakup monitoring ends

3.3 COLVILLE RIVER – MON1

Located at the head of the CRD, MON1 is on the farthest downstream confined reach of the Colville River, conveying approximately 22,500 square miles of runoff in a single channel. MON1 is the only monitoring location upstream of the East Channel and Nigliq Channel bifurcations. Stage and discharge have been monitored at MON1 annually since 1992 and periodically since 1962. It is considered the primary spring breakup monitoring site because of its location at the head of the CRD and long historical record.

Three gaging stations are installed along the west bank. MON1U is located farthest upstream, about 1.8 miles upstream of the Nigliq Channel bifurcation. MON1C and MON1D are located approximately 0.5 mile and 1 mile downstream of MON1U, respectively. The WSEs at MON1U, MON1C, and MON1D are used to approximate the energy grade line for indirectly computing peak discharge at MON1.

The leading edge of breakup floodwater passed MON1 the morning of May 15. Over the next two days stage steadily rose until cooler air temperatures caused stage to crest on May 17 and recede for the next four days. On May 21, stage began to steadily rise again in response to warmer air temperatures. On the morning of May 23, the ice jams upstream of MON1 released and peak stage was observed at the MON1 gages at approximately 3:30pm (Photo 3.9) as the ice jam and resulting backwater moved downstream. Peak stage at MON1C was 17.16 feet BPMSL (Table 3.1). Stage remained high until the afternoon of May 24 when the ice jam at the Tamayayak Channel bifurcation in the East Channel moved downstream (Graph 3.5).

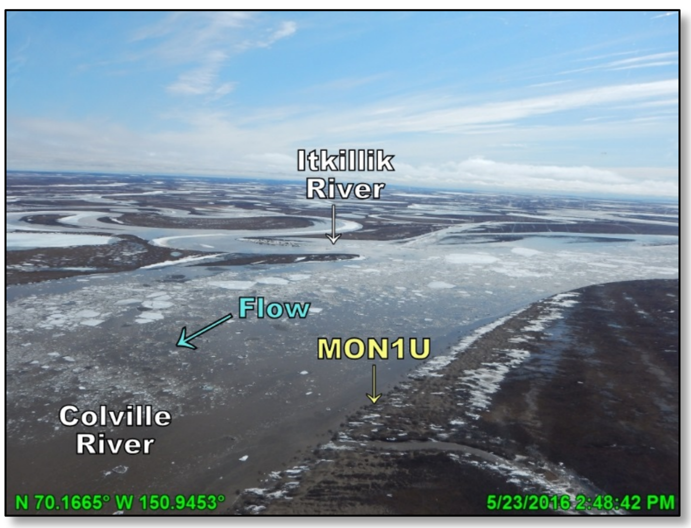
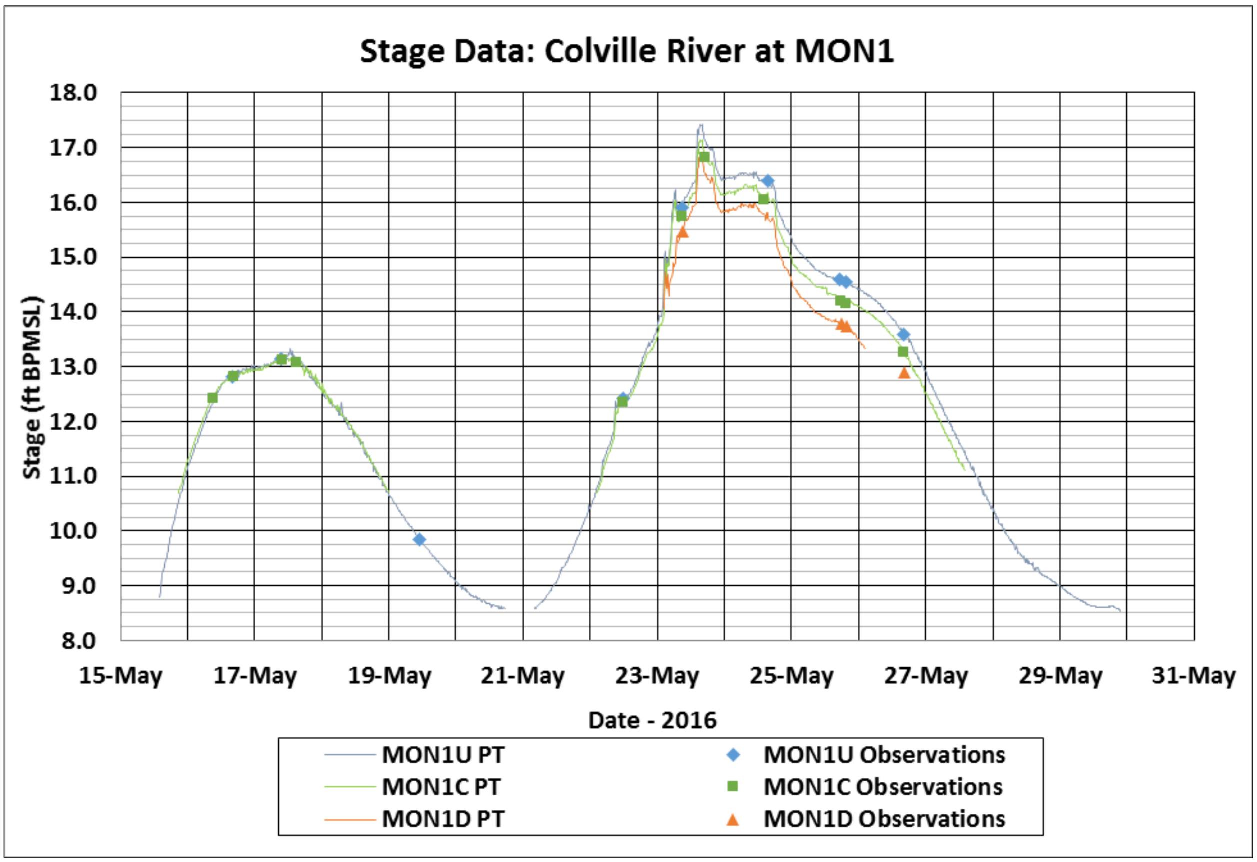


Photo 3.9: Conditions during the approximate time of peak stage at MON1, looking southeast; May 23, 2016

Table 3.1: Colville River at MON1 Stage Data and Observations

Date	Stage (feet BPMSL)			Observations
	MON1U	MON1C	MON1D	
16-May	12.81	12.82	-	A large ice jam forming upstream at Ocean Point
17-May	13.14	13.12	-	Stage crests at MON1
19-May	9.84	-	-	Dropping stage in response to cooler air temperatures
22-May	12.42	12.35	-	Channel ice remains intact, stage rising
23-May	15.90	15.75	15.47	Stage continues to rise
23-May	*17.42*	*17.16*	*16.90*	MON1 peak stage at 3:30pm
24-May	16.40	16.05	-	MON1D gage dry
25-May	14.59	14.19	13.75	Direct discharge measured at MON1
26-May	13.60	13.26	12.89	Ice free conditions

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected



Graph 3.5: Colville River at MON1 Stage Data

3.4 COLVILLE RIVER EAST CHANNEL – MON9, MON9D, & MON35

The East Channel is monitored at three gaging stations: MON9, MON9D, and MON35. The gaging station located farthest upstream is MON9, situated on the west bank, downstream of the resupply ice road and the Alpine Sales Pipeline HDD crossing. This location has been monitored annually since 2005 and the data contributes to estimating the distribution of flow between the East Channel and Nigliq Channel bifurcations. MON9D is located about one mile downstream of MON9, also on the west bank, immediately upstream of the Sakoonang Channel bifurcation. The WSEs at MON9 and MON9D are used to determine the energy grade line for computing peak discharge using indirect methods at MON9. MON35 is located at the Helmericks Homestead and is the farthest downstream gage station on the East Channel. MON35 has been monitored since 1999 and provides WSEs at the outer extents of the CRD.

Stage at MON9 trended similar to MON1. The leading edge of floodwater passed MON9 the morning of May 15 and was observed at the Tamayayak Channel bifurcation at approximately 10:00am. Similar to MON1, stage crested on May 17 and began to rise again on May 21. On May 23, the ice jams upstream of MON1 released and peak stage was observed at the MON9 gages at approximately 7:00pm as the ice jam and resulting backwater moved downstream (Photo 3.10), cresting at MON9 at 14.48 feet BPMSL (Table 3.2). A second, slightly lower crest in stage occurred in the afternoon on May 24 as backwater accumulated behind the ice jam at the Tamayayak Channel bifurcation (Graph 3.6). Ice floes continued moving downstream over the next two days and peak stage was observed at MON35 in the evening of May 26, cresting at 3.58 feet BPMSL (Photo 3.11).

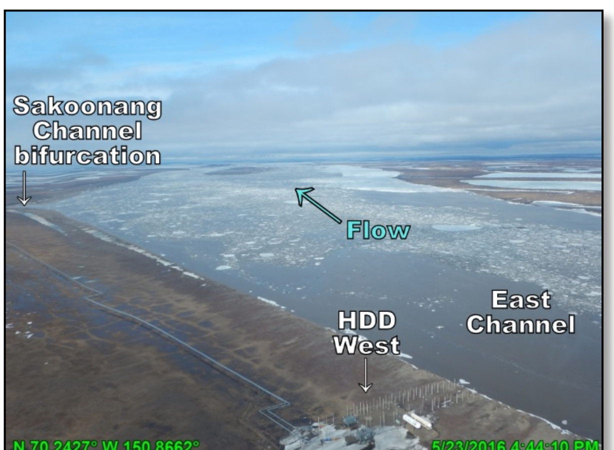
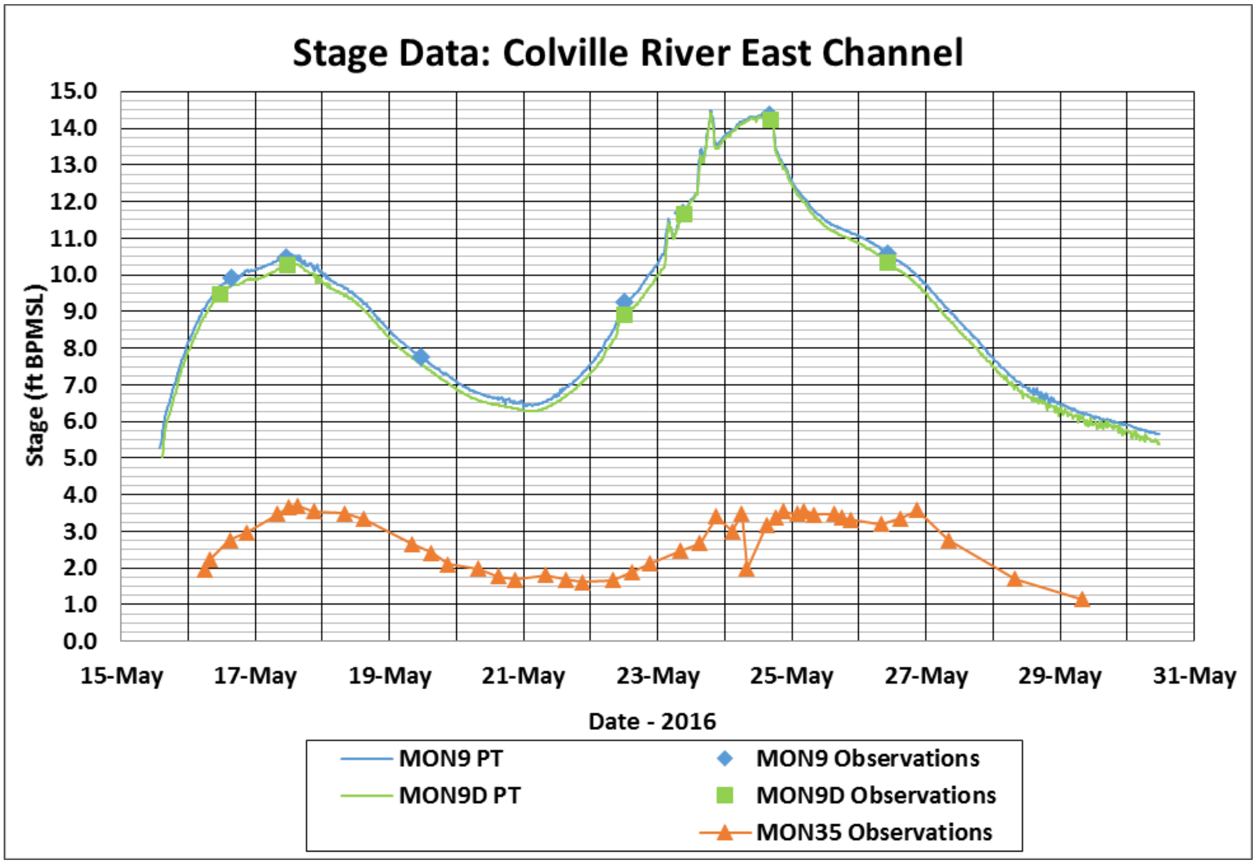


Photo 3.10: Conditions prior to the time of peak stage at MON9, looking northeast; May 23, 2016

Photo 3.11: Conditions during the approximate time of peak stage at MON35, looking east; May 26, 2016

Table 3.2: Colville River East Channel Stage Data and Observations

Date	Stage (feet BPMSL)			Observations
	MON9	MON9D	MON35	
16-May	9.92	9.48	2.76	Leading edge passes the Tamayayak bifurcation
17-May	10.49	10.27	3.70	Stage crests in east channel; Intact channel ice throughout the East Channel
19-May	7.74	-	2.42	Floodwater recedes
22-May	9.24	8.91	1.90	
23-May	*14.48*	*14.41*	3.40	MON9 and MON9D peak stage at 7:00pm; formation of ice jam at the Tamayayak Channel bifurcation
24-May	14.35	14.17	3.54	Ice jam causing moderate flooding at the mouth of the Kachemach River
26-May	10.58	10.35	*3.58*	MON35 peak stage at 9:00pm
27-May	-	-	2.76	Ice free conditions in the East Channel
Note: 1. *Italicized* values are pressure transducer data indicating peak WSE 2. Dash (-) indicates no gage reading collected				



Graph 3.6: Colville River East Channel Stage Data

3.5 NIGLIQ CHANNEL

The Nigliq Channel has historically been monitored at four gaging stations: MON20, MON22, MON23, and MON28. Four additional gage stations, G29, G28, G27, and G26, provide local site specific data upstream and downstream of the CD5 Nigliq Bridge and are discussed in the Nigliq Bridge section of the report. MON20 is the most upstream gage station and is located on the east bank approximately two miles upstream of the bridge and downstream of the Nigliagvik Channel bifurcation. MON22 is located on the west bank approximately one mile downstream of the bridge. MON23 is located on the east bank adjacent to the CD2 pad and downstream of the Nigliagvik Channel confluence, and MON28 is located farthest downstream at the outer extents of the CRD near Harrison Bay. MON20, MON22, and MON23 have been monitored intermittently since 1998 and MON28 has been monitored since 1999.

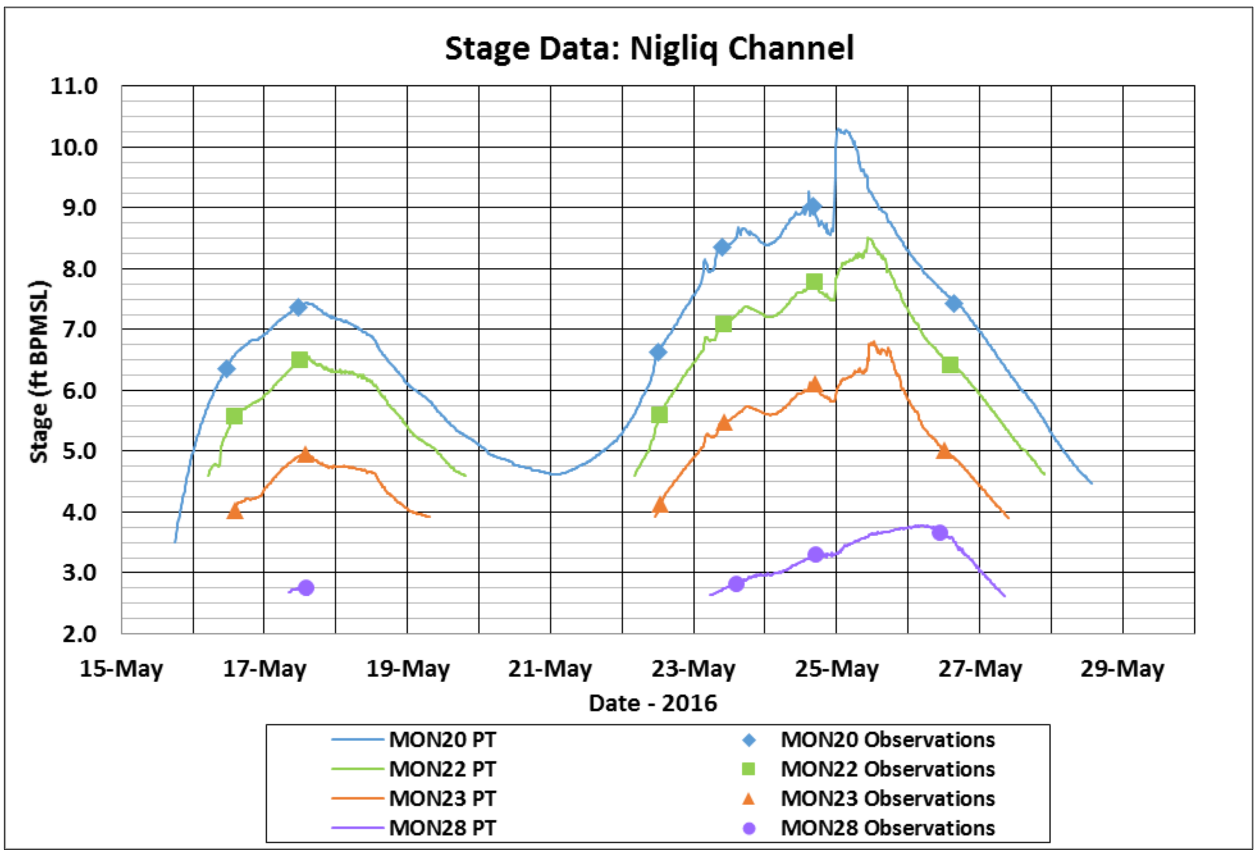
The leading edge of floodwater passed MON20 on May 15 and reached the ocean on May 16. Similar to the East Channel, stage crested at all Nigliq Channel monitoring locations on May 17 and began to rise again on May 21. On May 24, the ice jam upstream of Nuiqsut moved downstream. PT data suggests the ice jam reformed upstream of the deteriorating intact channel ice between MON20 and the Nigliq Bridge (Photo 3.12) causing water to backup and stage to peak at MON20 at approximately 12:45am on May 25, cresting at 10.31 feet BPMSL. On the morning of May 25, the intact channel ice broke up and the upstream ice jam and resulting backwater released and peak stage was observed at MON22 at approximately 10:30am and MON23 at approximately 12:45pm, cresting at 8.52 feet BPMSL and 6.80 feet BPMSL, respectively. Stage subsequently peaked at MON28 at 3:30am on May 26, cresting at 3.79 feet BPMSL (Table 3.3 and Graph 3.7).

Photo 3.12: Deteriorating channel ice downstream of MON20, looking southeast; May 24, 2016

Table 3.3: Nigliq Channel Stage Data and Observations

Date	Stage (feet BPMSL)				Observations
	MON20	MON22	MON23	MON28	
16-May	6.37	5.57	4.04	-	Leading edge reaches Harrison Bay
17-May	7.37	6.51	4.95	2.76	Stage crests
22-May	6.63	5.60	4.13	2.29	
23-May	8.37	7.10	5.48	3.03	Ice jam upstream of Nuiqsut diverting flow to the East Channel through the Putu Channel
24-May	9.02	7.78	6.11	3.28	Ice jam moves downstream of Nuiqsut
25-May	***10.31***	***8.52***	***6.80***	-	**MON20 peak stage at 12:45am; MON22 peak stage at 10:30am; MON23 peak stage at 12:45pm**
26-May	7.43	6.41	5.03	***3.79***	**MON28 peak stage at 3:30am; inundation of coastal mudflats**

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected



Graph 3.7: Nigliq Channel Stage Data

3.6 ALPINE FACILITIES & ROADS

Monitoring locations are established at pads and along roads adjacent to major water features and at drinking water source Lakes L9313 and L9312. Paired gages along the access roads capture water levels on the upstream and downstream side of drainage structures to determine stage differential.

Drainage structures are kept free of ice, snow accumulation, and blockages during winter months through regular maintenance by CPAI. Techniques include covering the culvert inlets and outlets during the winter and removing prior to breakup and mechanically removing snow from the immediate upstream and downstream areas of all culverts and swale bridges prior to breakup flooding. Drainage structures are monitored for conveyance performance during spring breakup flooding.

Conditions in active channels surrounding facilities, including the Sakoonang, Tamayayak, and Ulamnigiaq Channels to the east and the Nigliq Channel to the west, dictate the progression of the floodwater around Alpine facilities. Floodwaters in the Nigliq and Sakoonang Channels typically overtop the banks and facilitate the annual recharge of many lakes and paleolake areas through overbank inundation and established drainages. The extent of inundation is dependent on WSEs and local ice jam activity.

CD1 PAD & LAKES L9312 & L9313

Gage G1 is located on the west bank of the Sakoonang Channel on the southeast side of the CD1 pad. Gages G9 and G10 are located in Alpine drinking water source Lakes L9312 and L9313, respectively. Recharge at Lakes L9312 and L9313 has been monitored annually since 1988. Historical observations indicate the Sakoonang Channel floodwater is the primary recharge mechanism for both lakes (Michael Baker 2013a)

The leading edge of floodwater reached the Sakoonang Channel on May 15 and stage at gage G1 began to rise until May 19 when cooler air temperatures caused stage to crest. Stage receded over the next day and a half and began to rise again on May 21. Stage continued rising steadily (Photo 3.13) until 11:00pm on May 25 when peak stage was observed, cresting at 7.17 feet BPMSL (Table 3.4 and Graph 3.8). Floodwaters receded over the next four days.

Sakoonang Channel floodwater reached Lake L9313 (gage G10) on the afternoon of May 25 when conditions were nearing peak stage at gage G1. Peak stage was observed in Lake L9313 (gage G10), approximately 8 hours after stage peaked at gage G1, at approximately 7:00am on May 26, cresting at 8.38 feet BPMSL (Table 3.5). Lake L9312 (gage G9) remained hydraulically isolated from Sakoonang Channel floodwater; however, gage G9 PT recorded a slow steady rise in stage attributed to local snowmelt in the lake basin and peaked at 7.48 feet BPMSL at approximately 3:15pm on May 26 (Photo 3.15, Table 3.5, and Graph 3.9).

Photo 3.13: Sakoonang Channel, looking southwest; May 23, 2016

Photo 3.14: Sakoonang Channel floodwater via Lake M9525 recharge at Lake L9313 (Gage G10), looking southwest; May 27, 2016

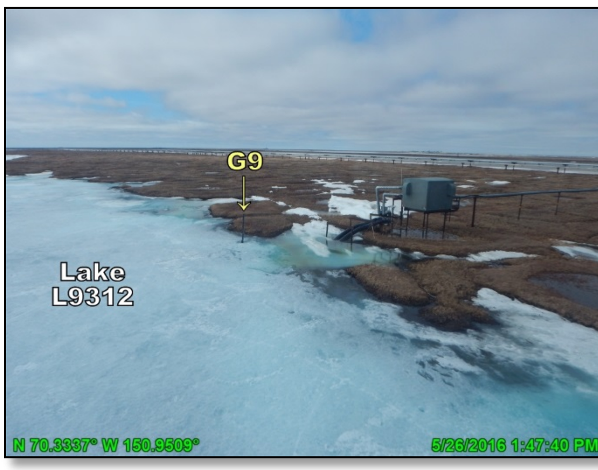
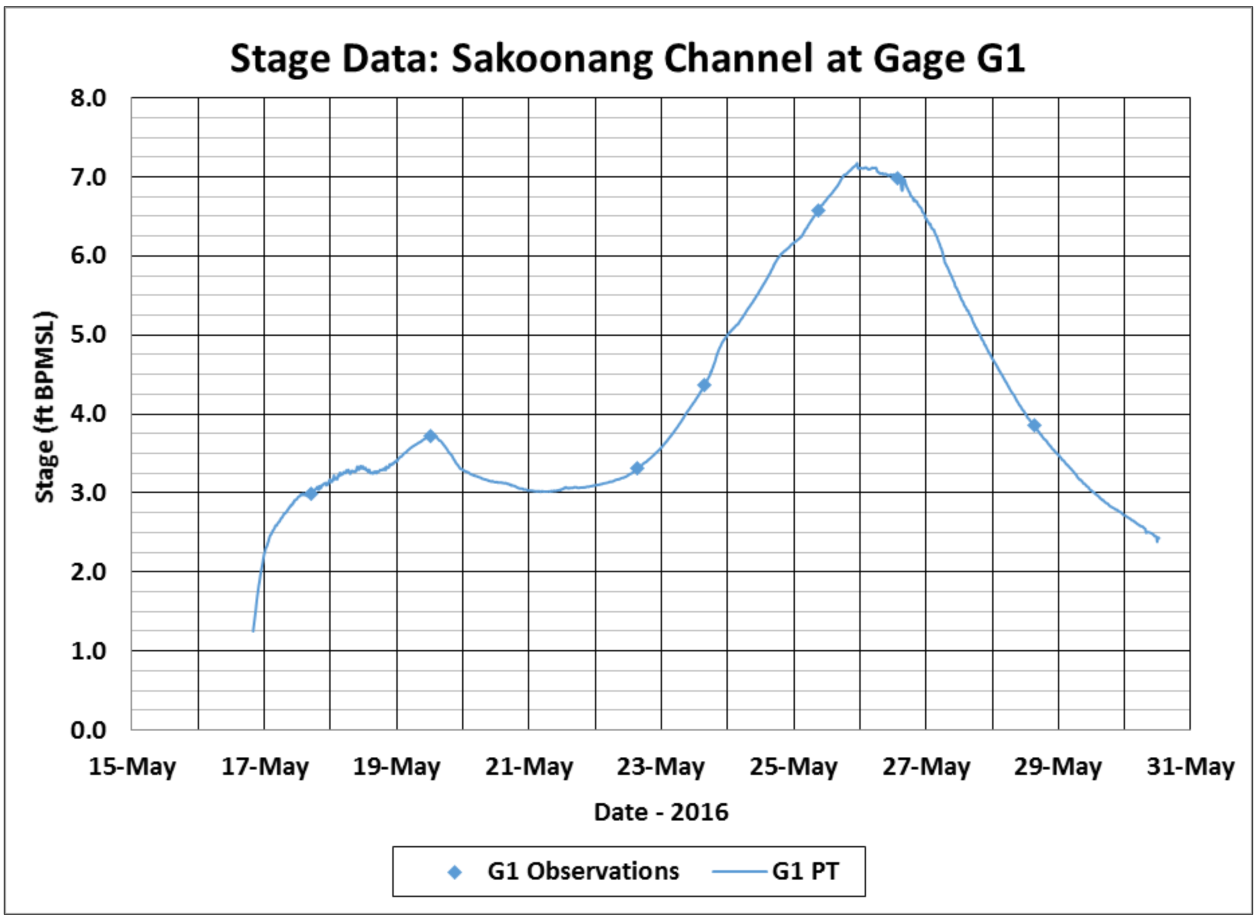


Photo 3.15: Local melt at Lake L9312 (Gage G9), looking southwest; May 26, 2016

Table 3.4 Sakoonang Channel (Gage G1) Stage Data and Observations

Date	Stage (feet BPMSL)	Observations
	G1	
17-May	2.99	Intact channel ice
19-May	3.72	Open water conditions at the gage; stage crests
22-May	3.31	Stage rising
23-May	4.37	
25-May	***7.17***	**Peak stage at 11:00pm**
26-May	6.99	Stage gradually receding
28-May	3.85	

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE

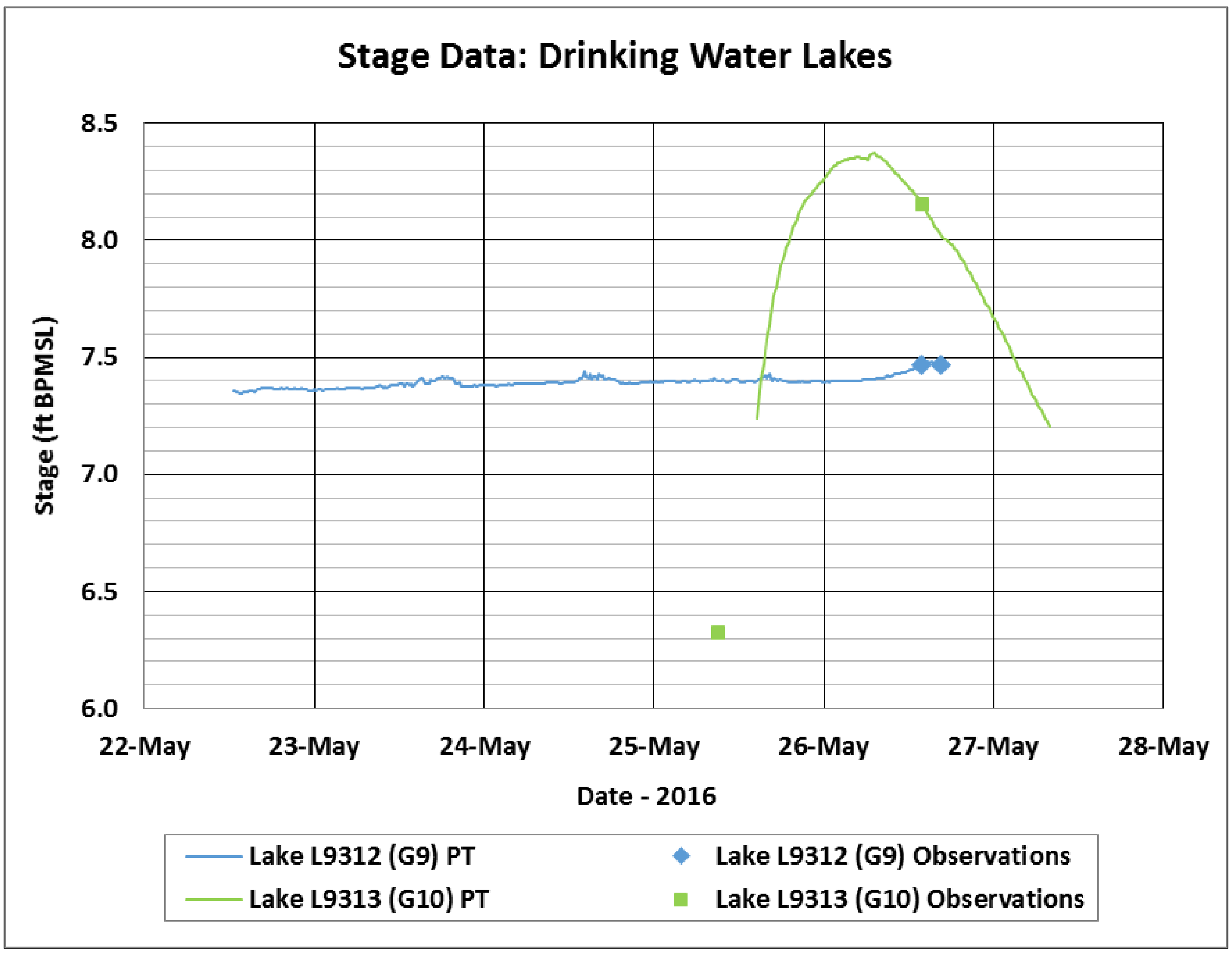


Graph 3.8: Sakoonang Channel (Gage G1) Stage Data

Table 3.5: Alpine Drinking Water Source Lakes L9312 (Gage G9) and L9313 (Gage G10) Stage Data and Observations

Date	Stage (feet BPMSL)		Observations
	Lake L9312 (G9)	Lake L9313 (G10)	
3-May	7.24	5.83	Both lakes frozen
25-May	-	6.32	Overflow from Sakoonang Channel causing steady rise in WSE in Lake L9313
26-May	***7.48***	***8.38***	**Lake L9312 mostly frozen with local melt around the fringe; Lake L9313 hydraulically connected to Sakoonang Channel overflow; G9 peak stage at 3:15pm; G10 peak stage at 7:00am**

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected



Graph 3.9 Alpine Drinking Water Source Lakes L9312 (Gage G9) and L9313 (Gage G10) Stage Data

CD2 ROAD & PAD

Three sets of paired gages are located near drainage structures along the CD2 road and one gage station is located at the CD2 pad. From east to west the gages are G3/G4 between the Long and Short Swale Bridges, G6/G7 adjacent to the culvert battery near the west end of the road connecting Lakes L9321 and L9322, G12/G13 in the vicinity of several individual culverts west of the Short Swale Bridge, and G8 at the northwest corner of the CD2 pad. Stage data and observations of breakup processes have been collected at these locations intermittently since 1998.

On the afternoon of May 17, as stage was cresting in the Nigliq Channel, low velocity floodwater from the Nigliq Channel overflowed into Nanuq Lake and reached the Long Swale Bridge via Lake M9524. Over the next few days, floodwater in the Nigliq Channel receded and flow through the Long Swale Bridge ceased. On May 23, as water levels rose again in the Nigliq Channel, floodwater returned to both swale bridges (Photo 3.16). Stage continued to increase until 5:00pm on May 25 when peak stage was observed (Photo 3.17), cresting at gages G3 and G4 at 7.49 feet BPMSL and 7.10 feet BPMSL, respectively (Table 3.6 and Graph 3.10). The maximum WSE differential between gages G3 and G4 was 0.46 feet and occurred at approximately 6:30am on May 25. Stage gradually decreased and equalized within 24 hours of peak.

The PTs on gages G6/G7 and G12/G13 recorded a brief rise and fall in stage on May 25 attributed to overbank flow from the Nigliq Channel via Nanuq Lake. No floodwater was observed at gage G8. Peak stage was recorded at gage G6 at 7.90 feet BPMSL at 9:15am and at gage G7 at 7.85 feet BPMSL at 10:00am (Table 3.7 and Graph 3.11). The maximum WSE differential between gages G6 and G7 was 0.08 feet and occurred at approximately 7:30am on May 25. Peak stage was recorded at gage G12 at 7.89 feet BPMSL at 8:00am and at gage G13 at 7.71 feet BPMSL at 11:00am (Table 3.8 and Graph 3.12). The maximum WSE differential between gages G12 and G13 was 0.38 feet at approximately 4:00am on May 25.

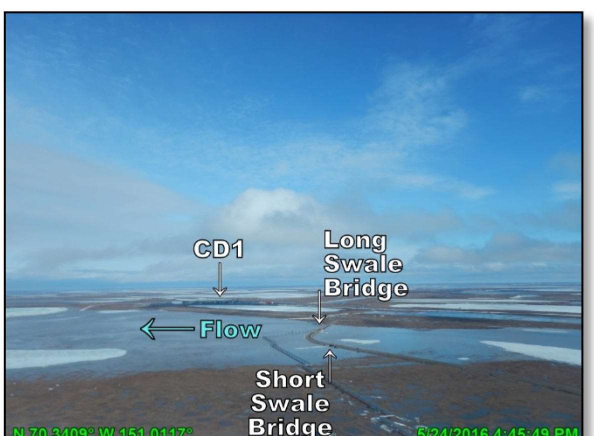


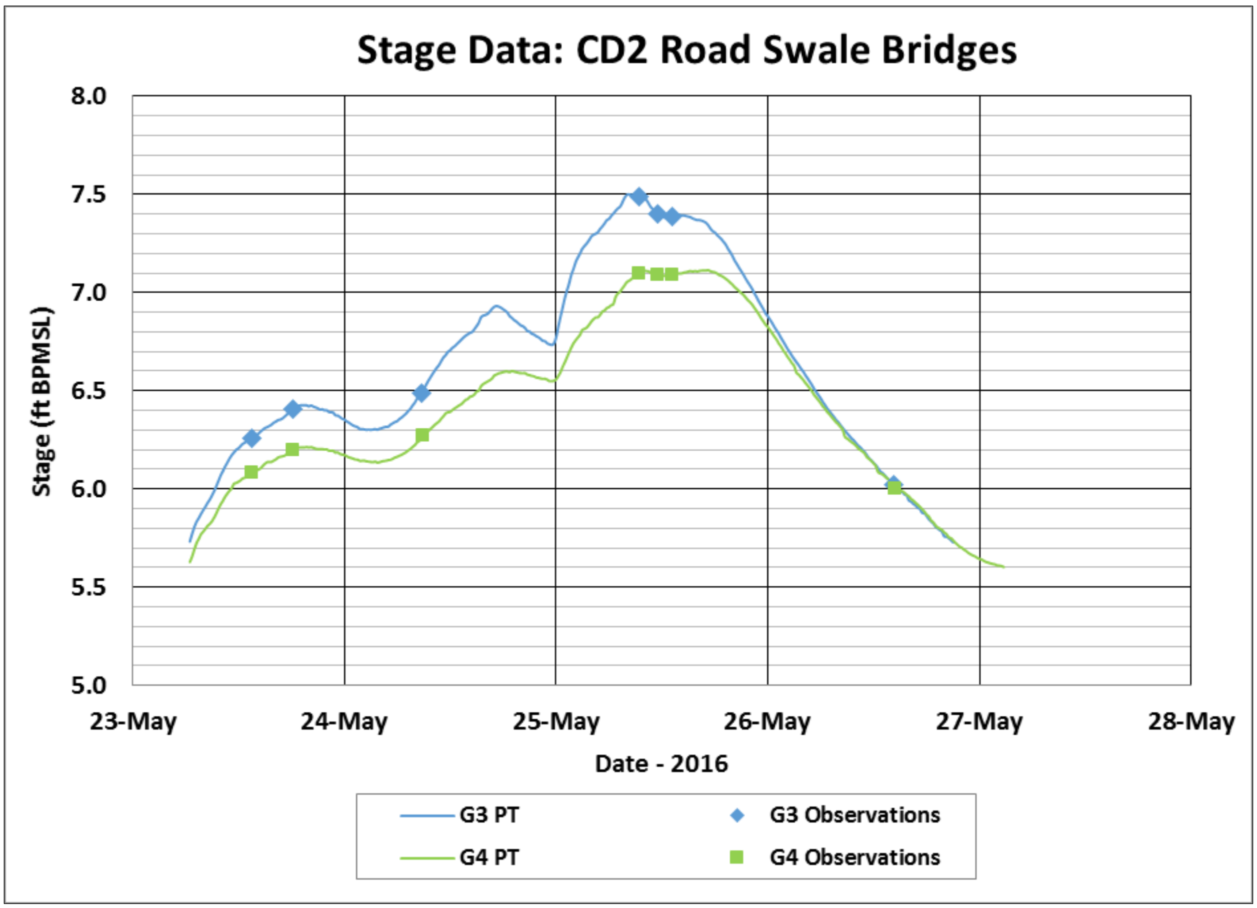
Photo 3.16: Floodwater at the CD2 road swale bridges prior to peak stage, looking west; May 24, 2016

Photo 3.17: Floodwater at the Short Swale Bridge just prior to peak stage, looking northeast; May 25, 2016

Table 3.6: CD2 Road Swale Bridges (Gages G3 and G4) Stage Data and Observations

Date	WSE (feet BPMSL)		Observations
	G3	G4	
23-May	6.26	6.08	Swale Bridges conveying flow
24-May	6.49	6.27	
25-May	*7.49*	*7.10*	G3 peak stage at 8:00am; G4 peak stage at 5:00pm
26-May	6.02	6.00	
28-May	-	-	WSEs continue to drop; Flow ceases at swale bridges

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected

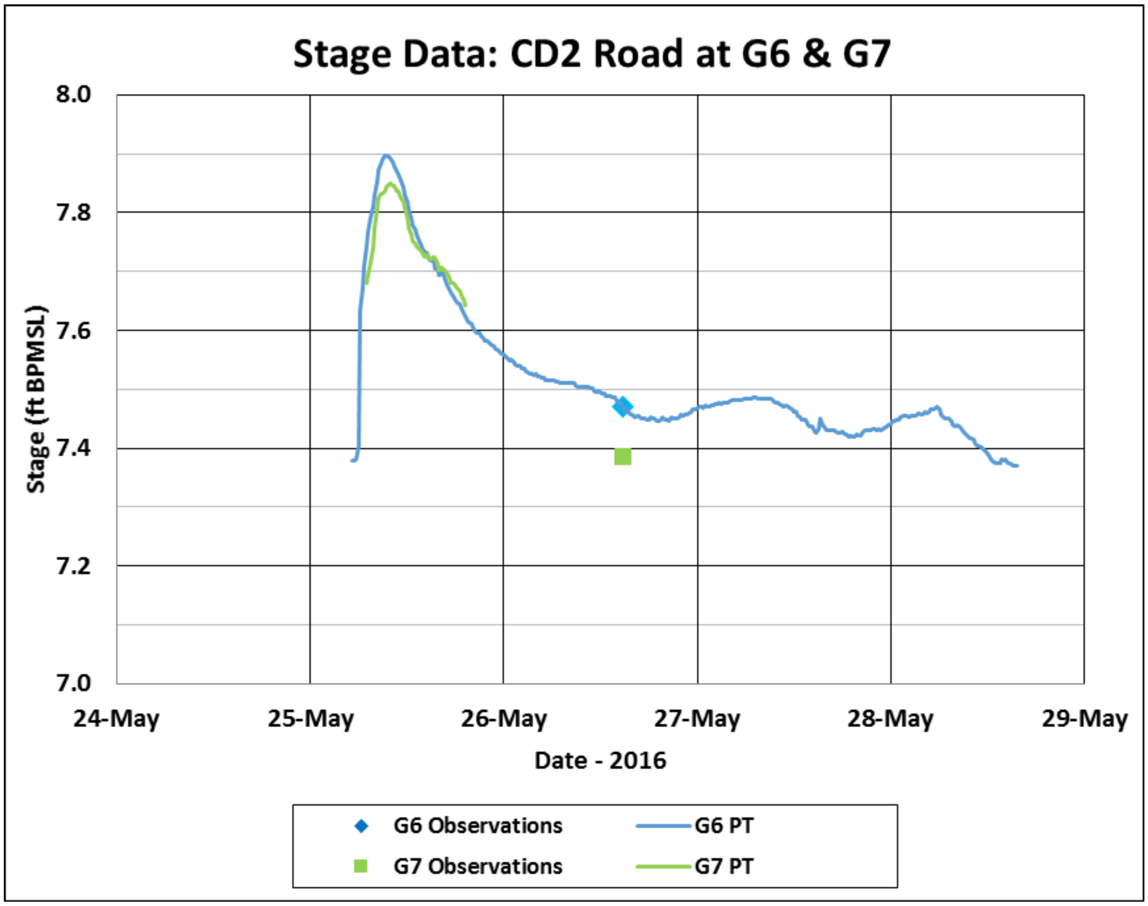


Graph 3.10: CD2 Road Swale Bridges (Gages G3 and G4) Stage Data

Table 3.7: CD2 Road Culverts (Gages G6 and G7) Stage Data and Observations

Date	Stage (feet BPMSL)		Observations
	G6	G7	
25-May	*7.90*	*7.85*	G6 peak stage at 9:15am; G7 peak stage at 10:00am
26-May	7.47	7.39	Floodwater receding

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE

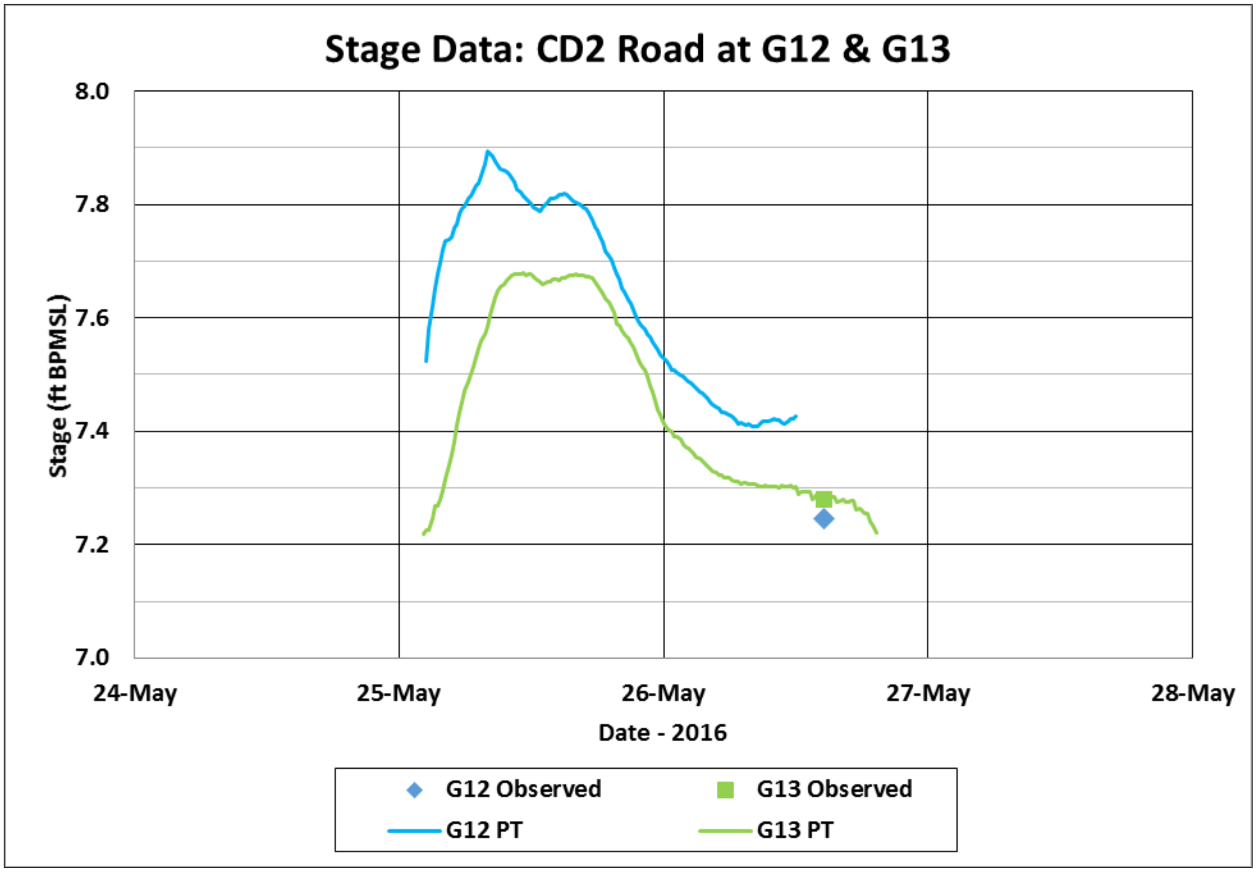


Graph 3.11: CD2 Road Culverts (Gages G6 and G7) Stage Data

Table 3.8: CD2 Road Culverts (Gages G12 and G13) Stage Data and Observations

Date	Stage (feet BPMSL)		Observations
	G12	G13	
25-May	*7.89*	*7.68*	G12 peak stage at 8:00am; G13 peak stage at 11:00am
26-May	7.25	7.28	Floodwater receding, not hydraulically connected

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE



Graph 3.12: CD2 Road Culverts (Gages G12 and G13) Stage Data

CD3 PAD & PIPELINE

The CD3 pad is monitored at one gage station, G11, located near the southwest corner of the CD3 pad adjacent to a distributary of the Ulamnigiaq Channel. Gage G11 monitors stage south of the CD3 pad and west of the airstrip. The CD3 pipeline is monitored at three gage stations: SAK, TAM, and ULAM. Stage data and observations of breakup processes have been collected at these locations intermittently since 2000.

The Sakoonang (SAK) Channel, Tamayayak (TAM) Channel, and the Ulamnigiaq (ULAM) Channel are three major distributary channels of the Colville River East Channel. All three channels converge just prior to draining into the Beaufort Sea. The SAK and TAM gage stations are located on the left bank of the Sakoonang Channel and Tamayayak Channel, respectively. The ULAM gage station is located on the right bank of the Ulamnigiaq Channel. All three gage stations are located downstream of the pipeline.

On May 15, the leading edge of floodwater reached all three pipeline crossings. On May 17, stage crested at the TAM and ULAM gages and began receding. Intact channel ice with saturated snow was observed at all three crossings. PT data shows the trends at the TAM and ULAM gages were nearly identical (Graph 3.13). Stage crested at the SAK gages on May 19 before receding. By May 22, stage began rising again at all three crossings. On May 24, channel ice remained intact in all three channels but was deteriorating (Photo 3.18). Stage peaked at all three crossings on May 25. Peak stage at the TAM gages crested at 8.11 feet BPMSL at 8:30am, peak stage at the ULAM gages crested at 6.92 feet BPMSL at 9:45am, and peak stage at the SAK gages crested at 6.68 feet BPMSL at 10:15pm (Table 3.9). By May 26, floodwater was steadily receding at all three crossings. The Tamayayak and Ulamnigiaq Channel pipeline crossings were ice free while channel ice was still moderately intact downstream of the Sakoonang Channel pipeline crossing. Floodwater was contained within the channel banks at all three crossings throughout breakup (Photo 3.19 and Photo 3.20). No floodwater was observed at gage G11.

Photo 3.18: Deteriorating channel ice at the ULAM CD3 pipeline crossing, looking southwest; May 24, 2016

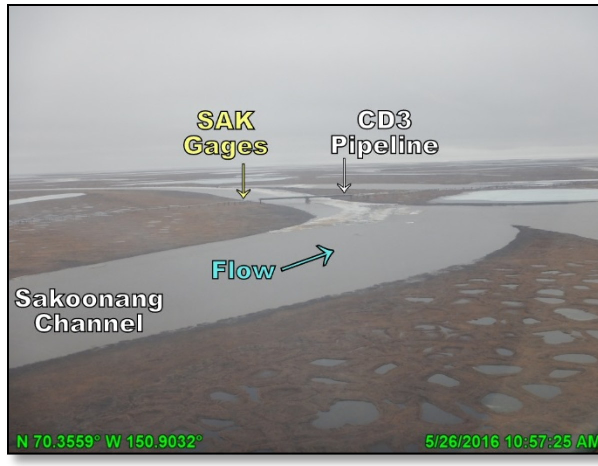


Photo 3.19: Sakoonang Channel at the CD3 pipeline crossing, looking northwest; May 26, 2016

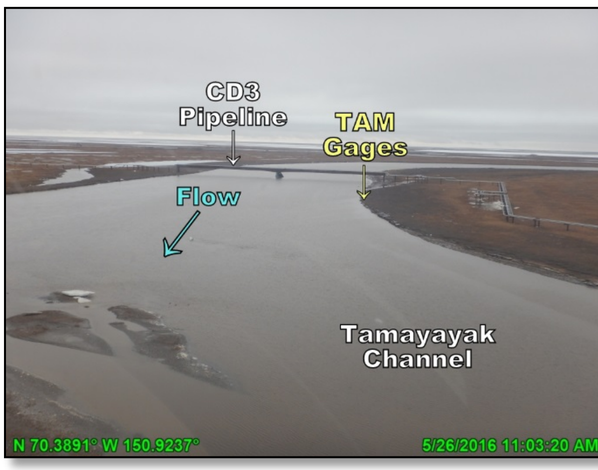
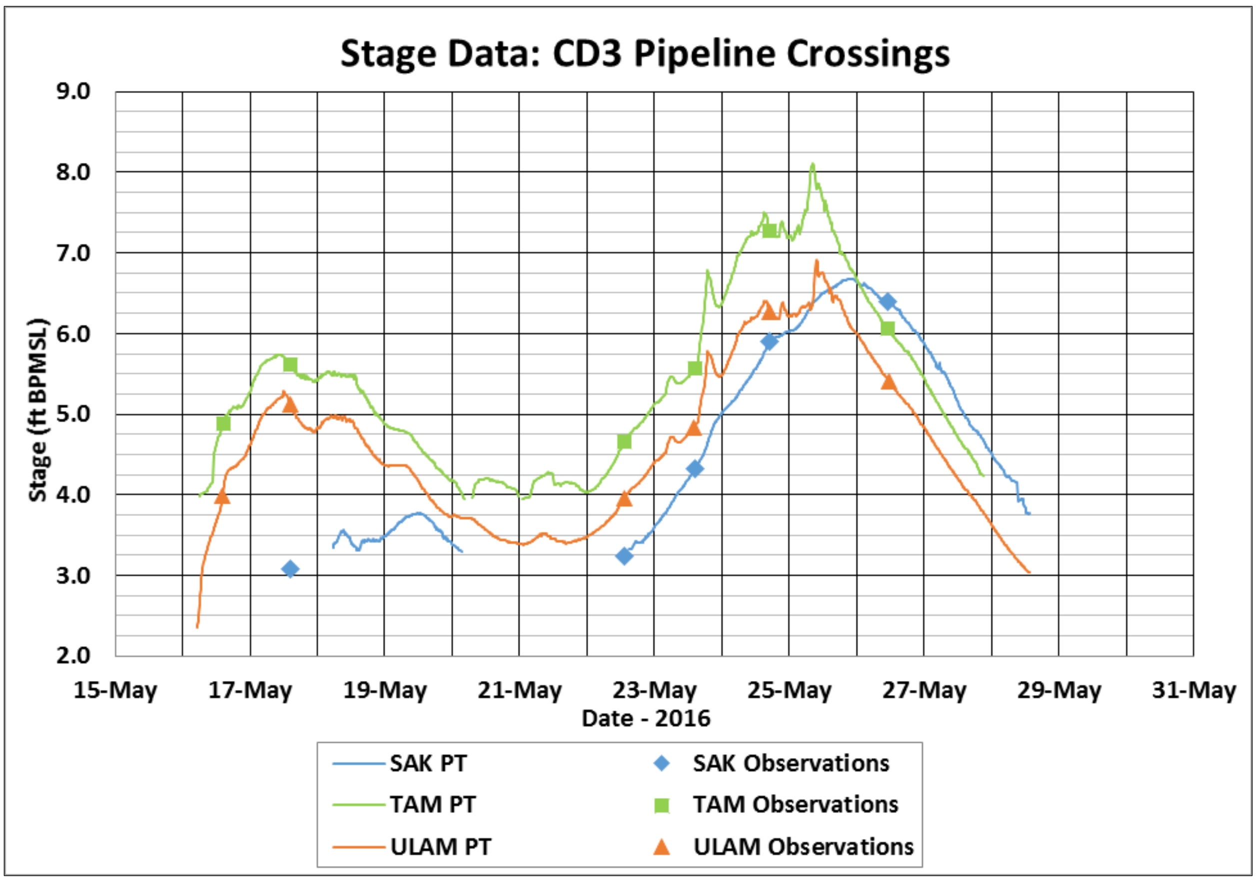


Photo 3.20: Tamayayak Channel at CD3 pipeline crossing, looking northeast; May 26, 2016

Table 3.9 CD3 Pipeline Crossings Stage Data and Observations

Date	Stage (feet BPMSL)			Observations
	SAK	TAM	ULAM	
16-May	-	4.88	3.99	Leading edge passes the pipeline crossings
17-May	3.08	5.61	5.11	Stage crests at TAM and ULAM crossings; Intact channel ice and saturated snow at the pipeline crossings; Mostly open channel downstream of the ULAM crossing
22-May	3.24	4.65	3.95	Stage rising again
23-May	*4.33*	*5.55*	*4.83*	Channel ice is deteriorating at the pipeline crossings
24-May	5.90	7.25	6.27	Channel ice continues to deteriorate
25-May	***6.68***	***8.11***	***6.92***	**TAM peak stage at 8:30am, ULAM peak stage at 9:45am, SAK peak stage at 10:15pm**
26-May	6.40	6.07	5.41	The TAM and ULAM crossings are clear of ice; Partially intact channel ice at the SAK crossing

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE



Graph 3.13: CD3 Pipeline Crossings Stage Data

CD4 ROAD & PAD

Four sets of paired gages are located near drainage structures along the CD4 road and two gage stations are located adjacent to the CD4 pad. From north to south the gages are G40/G41 and G42/G43 located north of the CD5 road junction, G15/G16 just south of the CD5 road junction at the north culvert battery, G17/G18 at the south culvert battery near the CD4 pad, gage G19 on the south side of the CD4 pad, and gage G20 between Tapped Lake and the southwest corner of the CD4 pad. Stage data and observations of breakup processes have been collected at these locations intermittently since 2005.

On May 16, stage at gage G20 began to rise as floodwater in the Nigliq Channel overflowed into Tapped Lake. On May 17, local melt began accumulating in polygon depressions and low-lying areas adjacent to the CD4 road and pad and stage at gage G20 crested. On May 23, stage in the Nigliq Channel and Sakoonang Channel was rising again causing stage at G20 to rise again and low velocity floodwater from the Sakoonang Channel to overflow into low-lying paleo lakes and channels east and south of the CD4 road. Some Sakoonang Channel floodwater was conveyed through Lake L9324 and into the Nigliq Channel (Photo 3.21). Floodwaters reached the south culvert battery (G18 and G17) the evening of May 23 (Photo 3.22) and reached the north culvert battery (G15 and G16) via Lake L9323 the morning of May 24.

Peak stage was observed at gages G18 and G17 at 8:45pm, cresting at 10.84 feet BPMSL and 10.53 feet BPMSL, respectively (Table 3.10 and Graph 3.14). Peak stage at gage G20 was determined from a HWM of 9.31 feet BPMSL and likely coincided with peak stage on the Nigliq Channel on May 25. Peak stage was observed at gages G15 and G16 at 6:15am on May 26, cresting at 8.37 feet BPMSL and 8.41 feet BPMSL, respectively (Table 3.11 and Graph 3.15).

The maximum WSE differential between gages G17 and G18 was 0.39 feet on May 23 at 6:00pm. The maximum WSE differential between gages G15 and G16 was 0.11 feet on May 25 at 5:30pm. By May 26, the WSE between gages G17/G18 and G16/G15 had equalized and floodwater began to recede. No floodwater was observed at gages G19 and G40 through G43.

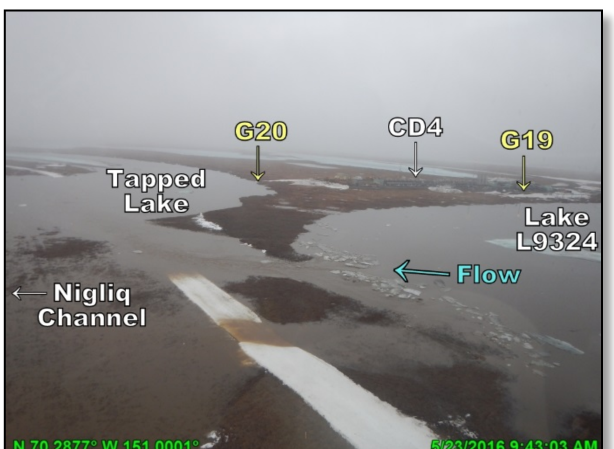


Photo 3.21: Floodwater from Lake L9324 flowing into the Nigliq Channel, looking northeast; May 23, 2016

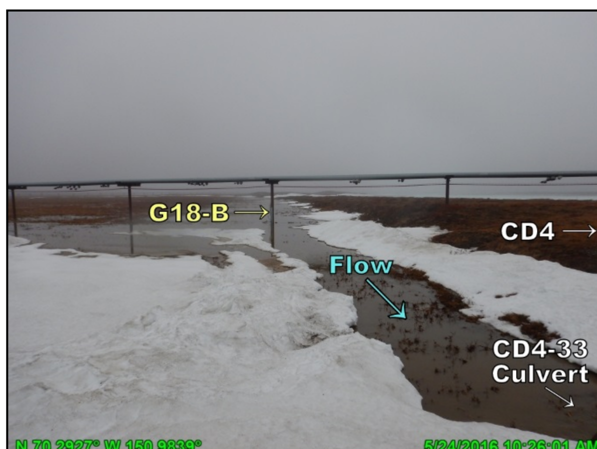
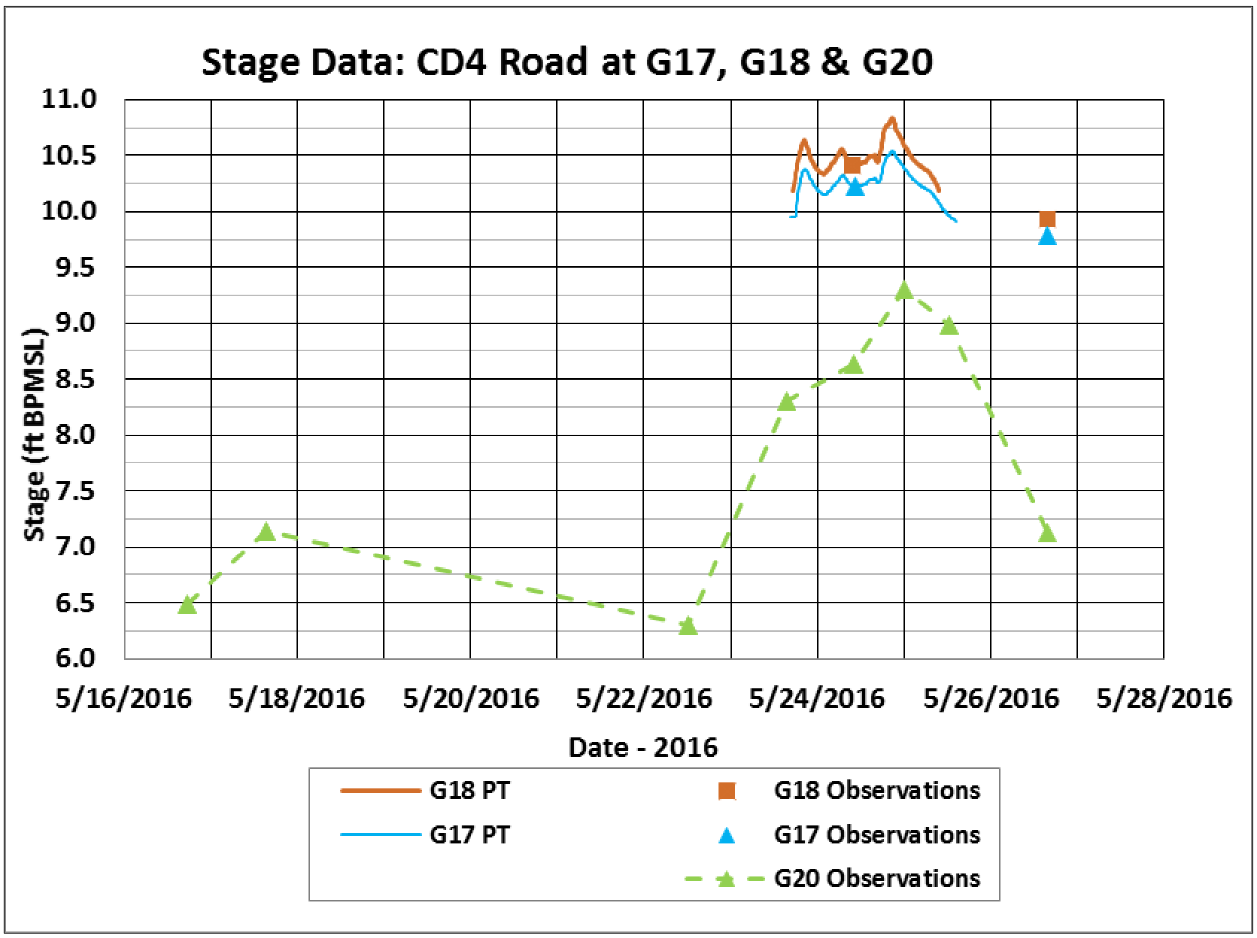


Photo 3.22: Overland flow southeast of the CD4 pad, looking south; May 24, 2016

Table 3.10: CD4 Road Culverts (Gages G17 and G18) and CD4 Pad (Gage G20) Stage Data

Date	Stage (feet BPMSL)			Observations
	G17	G18	G20	
16-May	-	-	6.49	
17-May	-	-	7.14	Stage crests in Nigliq Channel and Sakoonang Channel
22-May			6.30	Rising stage in the Nigliq Channel and Sakoonang Channel
23-May	-	-	8.31	Flow from Sakoonang Channel filling paleo lakes south and east of CD4 road
24-May	***10.53***	***10.84***	8.61	**G17 and G18 peak stage at 8:45pm**
25-May	-	-	***9.31**	**Peak stage at gage G20 coinciding with peak stage in the Nigliq Channel**
26-May	9.78	9.93	7.11	Floodwater receding

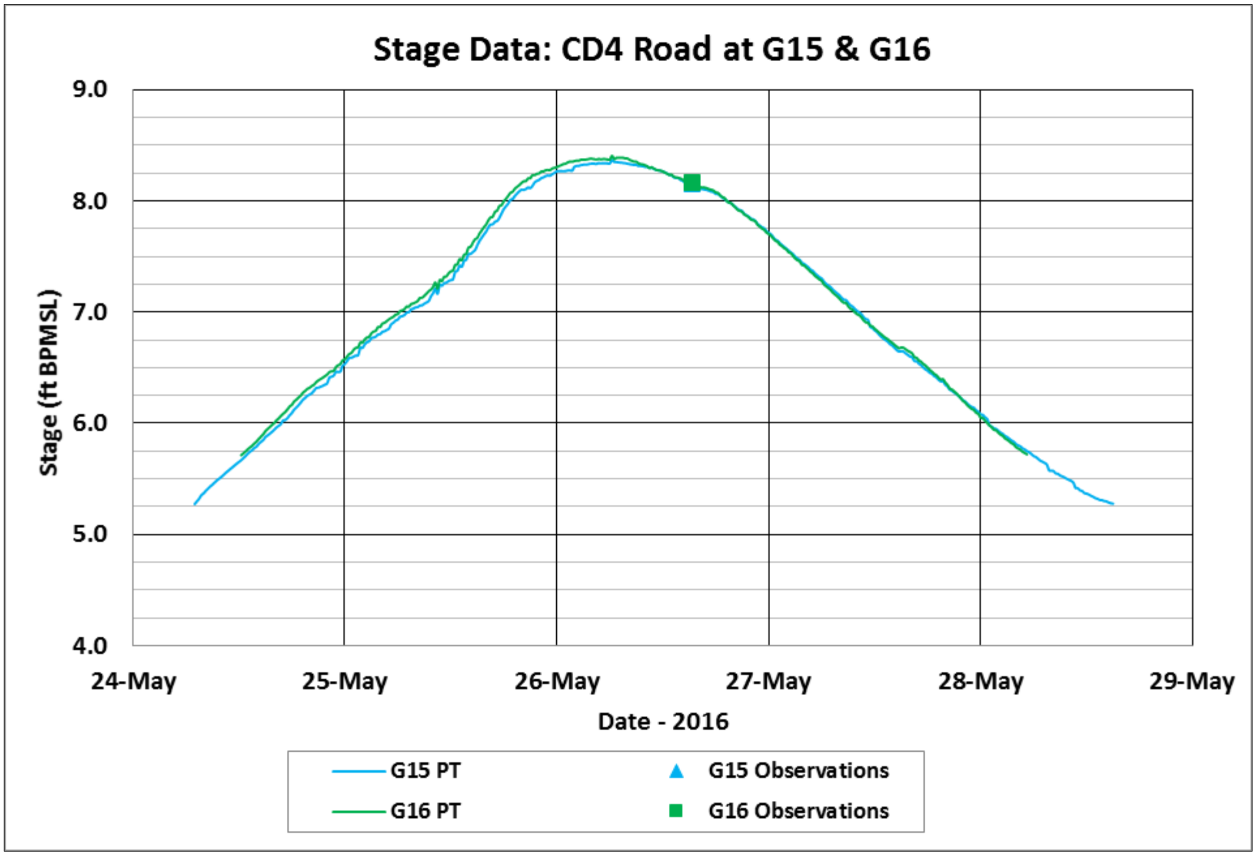
Note:
1. Dash (-) indicates no gage reading
2. *Value from high water mark observed when flooding receded
3. Italicized values are pressure transducer data indicating peak WSE



Graph 3.14: CD4 Road Culverts (Gages G17 and G18) and CD4 Pad (Gage G20) Stage Data

Table 3.11: CD4 Road Culverts (Gages G15 and G16) Stage Data and Observations

Date	Stage (feet BPMSL)		Observations
	G15	G16	
26-May	*8.37*	*8.41*	G15 and G16 peak stage at 6:15am; north culvert battery equalizes by the afternoon
Note: 1. Italicized values are pressure transducer data indicating peak WSE			



Graph 3.15: CD4 Road Culverts (Gages G15 and G16) Stage Data

CD5 ROAD & PAD

Nine sets of paired gages are located along the CD5 road to monitor WSEs at drainage structures. From east to west the gages are G24/G25 located at Lake L9323 Bridge, G26/G27 and G28/G29 at the Nigliq Bridge, G30/G31 at culverts just west of the Nigliq Channel, G32/G33 at Lake L9341 Bridge, G34/G35 and G36/G37 at culverts east of the Nigliagvik Channel, G38/G39 at the Nigliagvik Bridge, and S1/S1D at a small drainage west of the Nigliagvik Channel near the CD5 pad. Stage data and observations of breakup processes have been collected at these locations since 2009.

As discussed previously, the leading edge of floodwater reached the Nigliq Channel on May 15. Stage at three of the four CD5 road bridge crossings responded similarly to the cooler temperatures and crested on May 17. Stage began rising again on May 21. During breakup, Colville River floodwater was contained within channel banks, resulting in many monitoring locations being dry.

A. Nigliq Bridge

Gages G26 and G27 are located immediately upstream and downstream of the Nigliq Bridge, respectively, and monitor WSE differential at the bridge opening. Gages G28 and G29 are located approximately 0.5 miles upstream and downstream of the bridge, respectively. The WSE differential between these two gages provide the energy grade line for estimating peak discharge and flow distribution in the Nigliq channel.

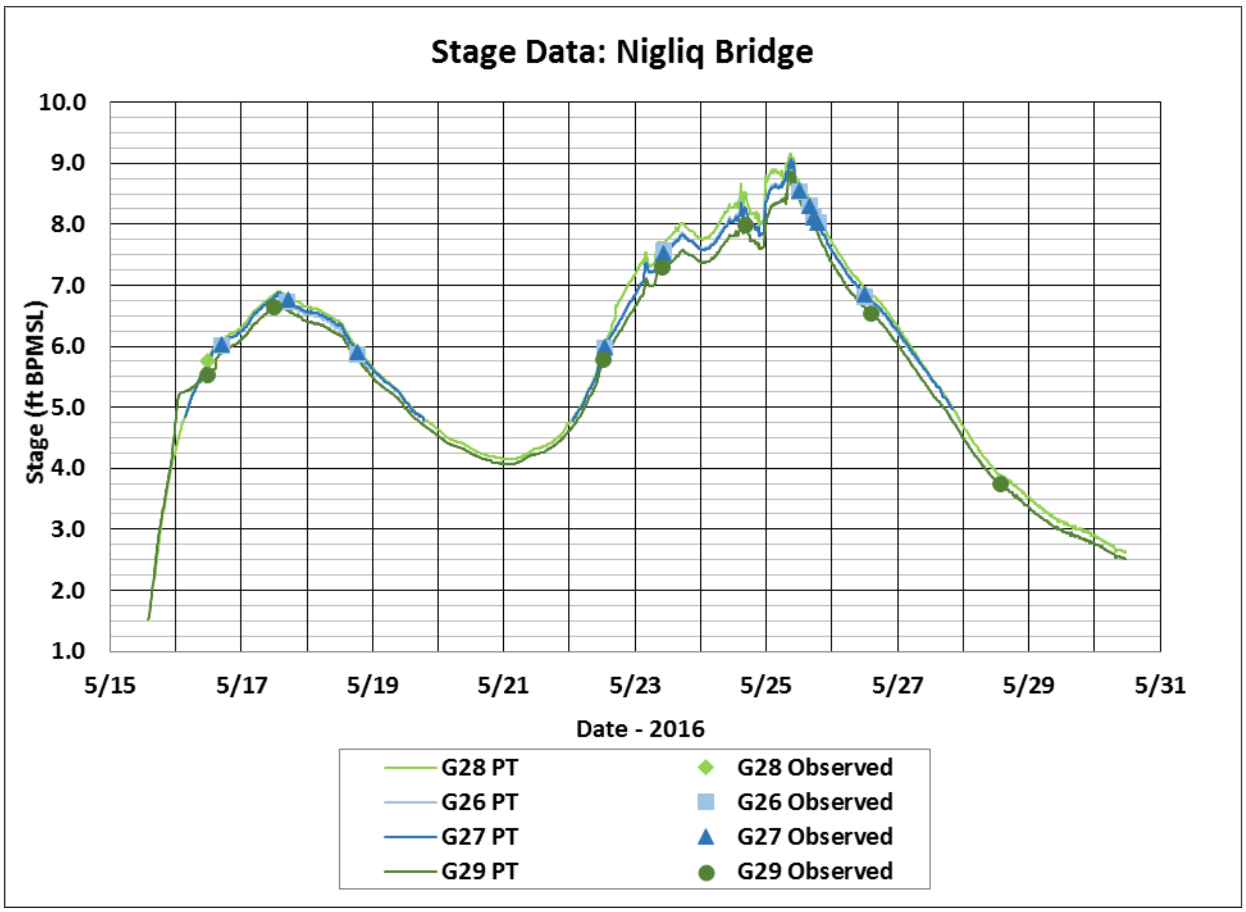
Prior to peak stage on the Nigliq Channel, channel ice was progressively deteriorating. By May 24, longitudinal and transverse cracks in conjunction with local ponding and shrinking ice cover were observed at the Nigliq Bridge (Photo 3.23). On the morning of May 25, the intact channel ice broke up releasing the upstream ice jam and resulting backwater. Peak stage was observed at 9:00am, cresting at gages G28, G26, G27, and G29 at 9.16 feet BPMSL, 9.05 feet BPMSL, 9.06 feet BPMSL, and 8.86 feet BPMSL, respectively (Table 3.12 and Graph 3.16).

Photo 3.23: Deteriorating intact channel ice at the Nigliq Bridge, looking southeast; May 24, 2016

Table 3.12: Nigliq Bridge Stage Data and Observations

Date	Stage (feet BPMSL)				Observations
	G26	G27	G28	G29	
16-May	6.02	6.03	5.77	5.53	Leading edge reaches Harrison Bay
17-May	6.72	6.76	6.84	6.64	Stage crests; channel ice floating and intact
18-May	5.85	5.92	-	-	Stage recedes
22-May	5.94	5.99	5.99	5.79	Stage rising
23-May	7.56	7.53	7.69	7.29	Ice jam upstream of Nuiqsut diverting flow to the East Channel through the Putu Channel
25-May	***9.05***	***9.06***	***9.16***	***8.86***	**Upstream ice jam releases, intact channel ice breaks up, peak stage at 9:00am**
26-May	6.81	6.85	6.83	6.53	Stage receding, channel is ice free at the bridge
28-May	-	-	3.87	3.75	Stage continues to drop

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected
3. Value from a high water mark surveyed after flooding receded



Graph 3.16: Nigliq Bridge Stage Data

B. Lake L9323 & Lake L9341 Bridges

Lake L9323 is located west of the CD4 Road and east of the Nigliq Channel. Gages G24 and G25 are located on the east side of Lake L9323 immediately upstream and downstream of the Lake L9323 Bridge, respectively. Sakoonang Channel floodwaters reached Lake L9323 Bridge via the CD4 road south culvert battery on the evening of May 24. On May 25, stage peaked at gages G24 and G25 at 7:45am, cresting at 8.85 feet BPMSL and 8.82 feet BPMSL, respectively (Photo 3.24, Table 3.13, and Graph 3.17). Nigliq Channel floodwaters did not hydraulically connect to Lake L9323 (Photo 3.25). Ice cover on the lake south of the bridge remained throughout the duration of breakup.

Photo 3.24: Lake L9323 Bridge approximately 4.5 hours after peak stage, looking northwest; May 25, 2016

Photo 3.25: Nigliq Channel upstream of Lake L9323, looking northwest; May 26, 2016

Lake L9341 is located west of the Nigliq Channel and east of the Nigliagvik Channel. Gages G32 and G33 are located on the west side of Lake L9341 immediately upstream and downstream of the Lake L9341 Bridge, respectively. Nigliq Channel backwater reached the Lake L9341 Bridge on May 16 and stage crested on May 17 in response to receding stage in the Nigliq Channel. Flow was conveyed on the west side of the lake due to intact ice and a large snow drift on the east side of the lake (Photo 3.26). Nigliq Channel backwater returned on May 22 in response to rising stage in the Nigliq Channel. On May 25, stage peaked at gages G32 and G33 at 10:00am, cresting at 8.65 feet BPMSL and 8.69 feet BPMSL, respectively (Table 3.13 and Graph 3.17). Stage equalized later that afternoon. Intact ice and the snow drift remained after peak stage (Photo 3.27). Stage data and observations suggest Lake L9341 never hydraulically connected to the Nigliq Channel upstream of the Lake L9341 Bridge and received only backwater from the Nigliq Channel downstream of the Lake L9341 Bridge.

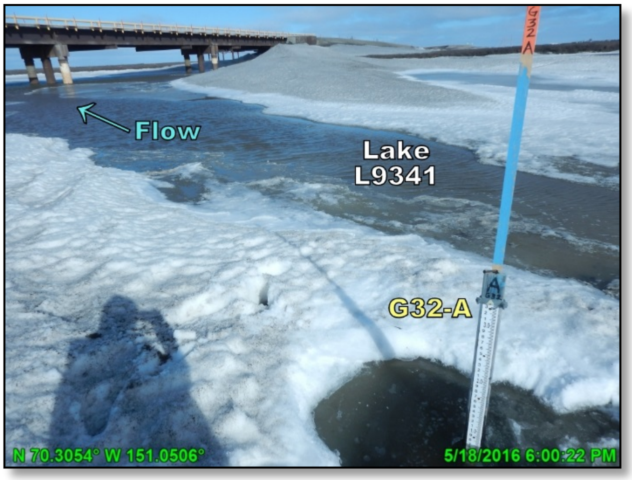


Photo 3.26: Intact ice and snow drift at Lake L9341 Bridge, looking northeast; May 18, 2016

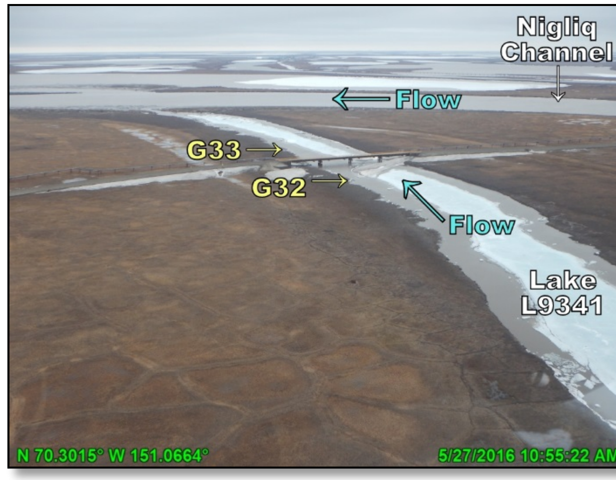
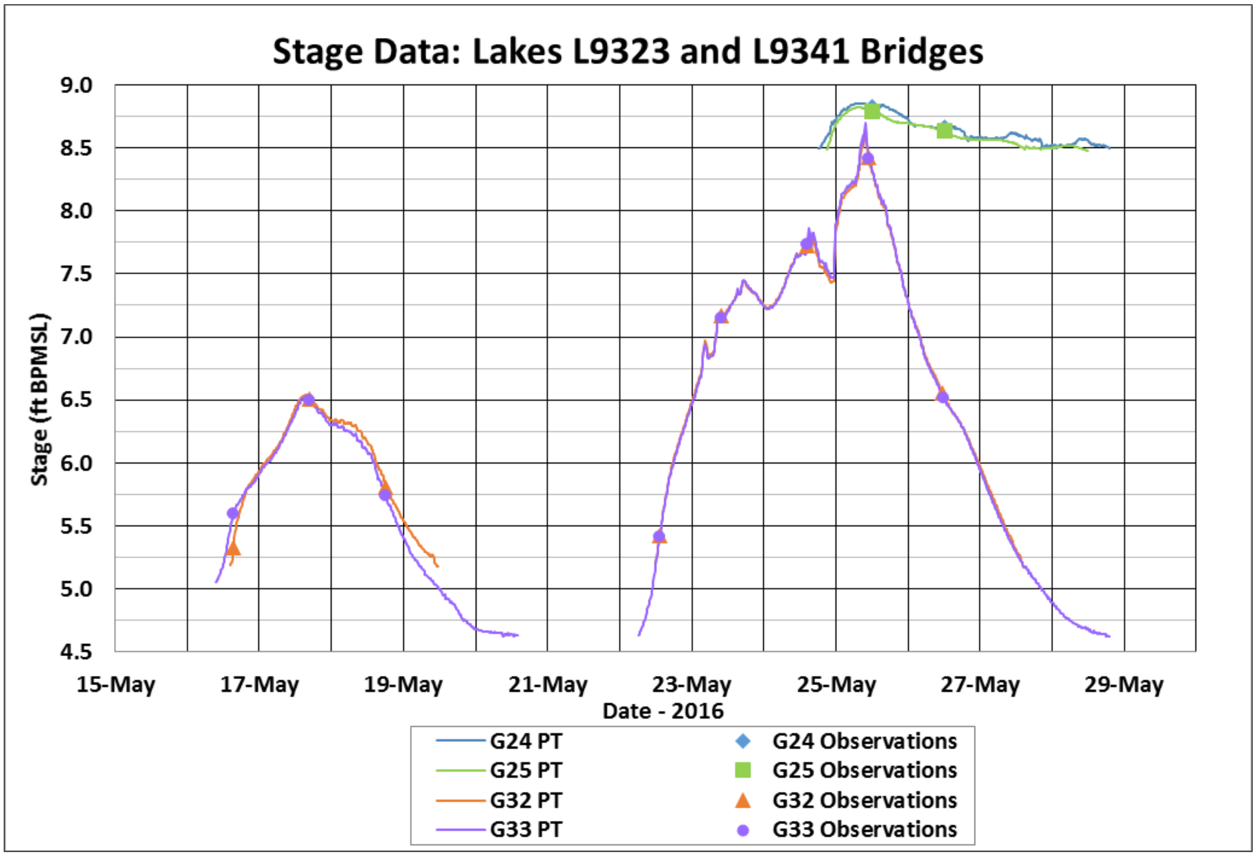


Photo 3.27: Deteriorating intact ice and snow drift at Lake L9341 Bridge, looking northeast; May 27, 2016

Table 3.13: Lake L9323 (Gage G24 & G25) and Lake L9341 (Gage G32 & G33) Bridges Stage Data and Observations

Date	Stage (feet BPMSL)				Observations
	G24	G25	G32	G33	
16-May	-	-	5.33	5.60	Backwater from the Nigliq Channel reaches Lake L9341, stage begins to rise
17-May	-	-	6.51	6.50	Stage crests at Lake L9341 bridge
18-May	-	-	5.81	5.74	Stage begins to recede at Lake L9341 bridge; Intact ice and snow remain along the west side of Lake L9341
22-May	-	-	5.42	5.41	Backwater from the Nigliq Channel at Lake L9341
23-May	-	-	7.17	7.15	
24-May	-	-	7.72	7.73	Sakoonang Channel floodwaters reach Lake L9323 Bridge
25-May	***8.85***	***8.82***	***8.65***	***8.69***	**Lake L9323 (G24 and G25) peak stage at 7:45am; Lake L9341 (G32 and G33) peak stage at 10:00am; Stage at Lake L9341 Bridge equalizes**
26-May	8.65	8.63	6.55	6.52	Floodwaters receding

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected



Graph 3.17: Lake L9323 (Gages G24 & G25) and Lake L9341 (Gages G32 & G33) Bridges Stage Data

C. NIGLIAGVIK BRIDGE

The Nigliagvik Channel is an anabranch of the Nigliq Channel. The Nigliagvik Channel branches off from the Nigliq Channel approximately 4 RMs and 5.5 RMs upstream of the Nigliq and Nigliagvik Bridges, respectively, and reconverges with the Nigliq Channel approximately 2 RMs downstream of the Nigliq and Nigliagvik Bridges. Gages G38 and G39 are located on the east bank of the Nigliagvik Channel immediately upstream and downstream of the Nigliagvik Bridge, respectively.

Nigliq Channel backwater reached the downstream side of the Nigliagvik Bridge on May 16 and stage crested on May 17 in response to receding stage in the Nigliq Channel. A snow drift spanning the width of the Nigliagvik Channel under the bridge restricted backwater from flowing under the bridge and reaching gage G38. Stage at gage G39 began to rise from backwater while stage at gage G38 began to gradually rise due to localized snow melt.

By May 22, stage in the Nigliq Channel was on the rise and Nigliq Channel floodwater and backwater reached the Nigliagvik Bridge (Photo 3.28). Stage at gage G38 began to rise from the rising floodwater and stage at gage G39 began to rise again from the rising backwater. On the morning of May 23, the snow drift breached and the Nigliagvik Channel began flowing downstream at the bridge. On May 25, stage peaked at gages G38 and G39 at 12:00pm, cresting at 8.35 feet BPMSL and 8.14 feet BPMSL, respectively (Table 3.14 and Graph 3.18).

At peak stage, the snow drift partially remained in the channel causing contracted flow through the bridge opening (Photo 3.29). By May 29, the presence of the snow drift was only limited to the east bank and was no longer causing contracted flow within the channel (Photo 3.30).

The highest WSE differential between gages G38 and G39 was 0.80 feet and occurred at 5:00pm on May 24. At this time, the elevated stage at the gage G38 compared to gage G39 suggests the snow drift or an ice jam was impeding flow at the bridge opening.

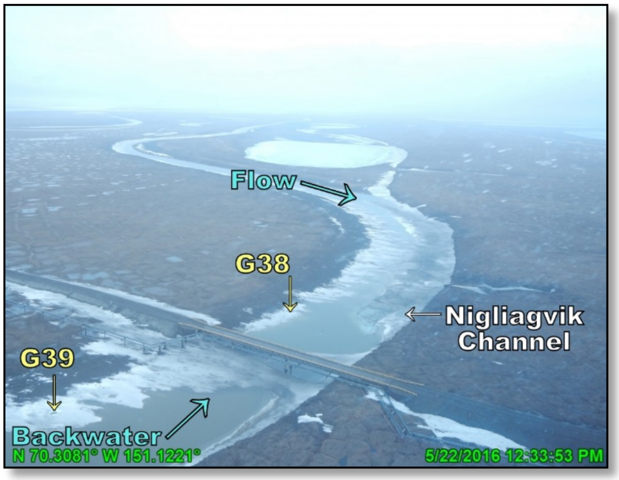


Photo 3.28: Floodwater and backwater from the Nigliq Channel at the Nigliagvik Bridge, looking southeast; May 22, 2016

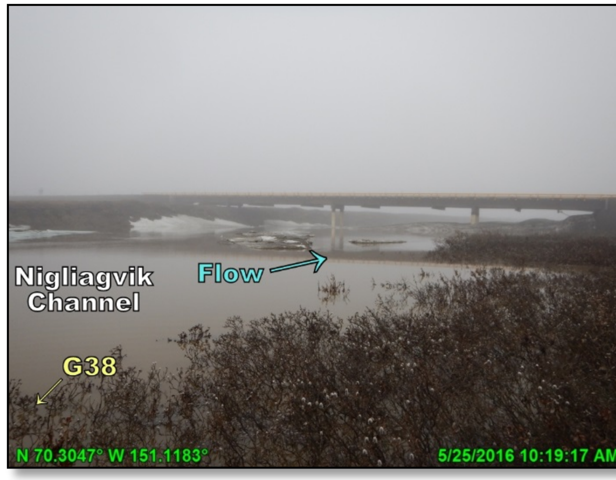


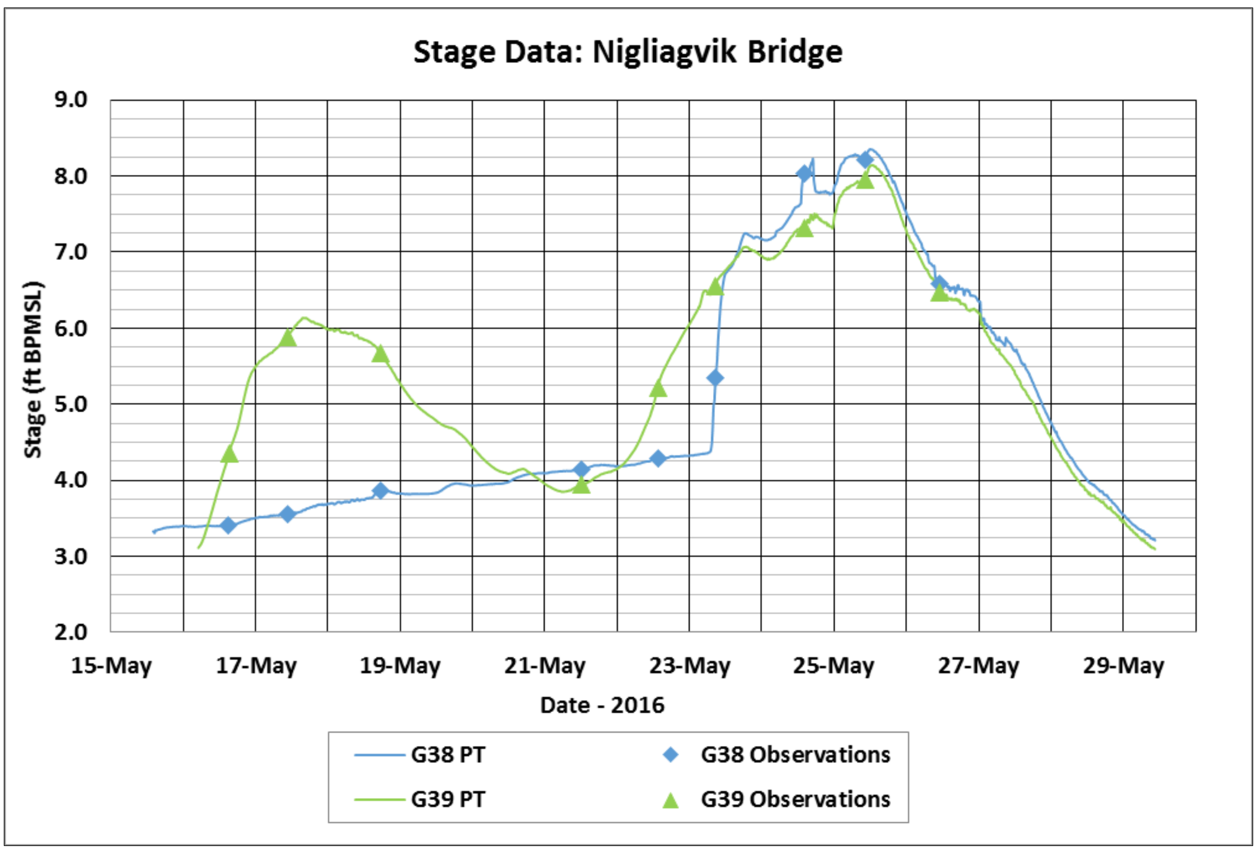
Photo 3.29: Nigliagvik Bridge just prior to peak stage, looking west; May 25, 2016

Photo 3.30: Remaining snow drift at the Nigliagvik Bridge, looking northwest; May 29, 2016

Table 3.14: Nigliagvik Bridge Stage Data and Observations

Date	Stage (feet BPMSL)		Observations
	G38	G39	
16-May	3.41	4.35	Backwater from the Nigliq Channel reaches the downstream side of the Nigliagvik Bridge; Large snow drift under bridge
17-May	3.55	5.89	Stage crests at G39
18-May	3.86	5.67	Stage receding at G39
21-May	4.14	3.94	Stage steadily increasing at G38
22-May	4.28	5.19	Nigliq Channel floodwater reaches G38, Nigliq Channel backwater returns to G39
23-May	5.34	6.55	Breach of snow drift and equalization of upstream and downstream WSEs; Downstream flow through bridge
24-May	8.03	7.31	Peak WSE differential
25-May	***8.35***	***8.14***	**G38 and G39 peak stage at 12:00pm; Snow drift remains in the channel contracting flow at bridge**
26-May	6.58	6.47	Stage receding
29-May	-	3.02	Snow drift no longer causing contracted flow at bridge

Note:
1. *Italicized* values are pressure transducer data indicating peak WSE
2. Dash (-) indicates no gage reading collected



Graph 3.18: Nigliagvik Bridge Stage Data

D. West of the Nigliagvik Channel

Spring breakup flooding west of the Nigliagvik Channel is isolated from Colville River flooding and is limited to the accumulation of local melt in surrounding lake basins and flow in small channels and swales forming hydraulic connections between lake basins. On May 23, culverts CD5-05, CD5-08, and CD5-09 began conveying low velocity flow (Photo 3.31 and Photo 3.32) from surrounding lakes. Peak stage was observed on May 23 at gages S1 and S1D, located upstream and downstream of culverts CD5-08 and CD5-09, respectively (Table 3.15). No flooding was observed around the CD5 pad. Ice cover on Lake MB0301 remained throughout the duration of breakup (Photo 3.33).

Photo 3.31: Culvert CD5-05, looking northwest; May 23, 2016

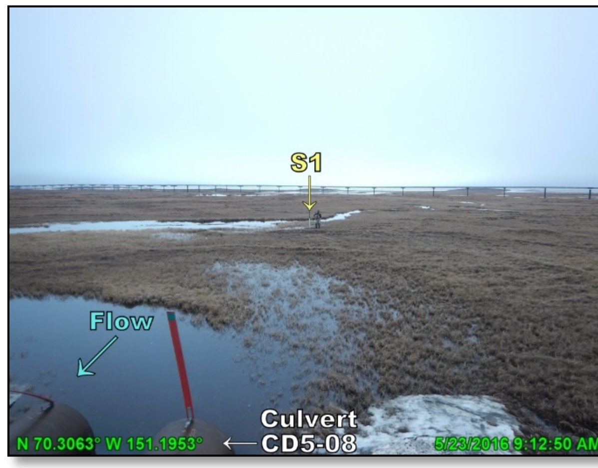


Photo 3.32: Culverts CD5-08 and CD5-09, looking southeast; May 23, 2016

Photo 3.33: Ice cover on Lake MB0301, looking northeast; May 27, 2016

Table 3.15: West of the Nigliagvik Channel Stage Data and Observations

Date	Stage (feet BPMSL)		Observations
	S1	S1D	
23-May	19.28	19.21	Flow through culverts CD5-08 and CD5-09

4. DISCHARGE

4.1 COLVILLE RIVER

MON1C

A. Measured Discharge

On May 25, discharge was measured on the Colville River adjacent to MON1C using an ADCP mounted on an inflatable boat (Appendix B). At the time of the measurement the channel was clear of snow and ice (Photo 4.1). Four transects and one loop test were completed during the discharge measurement. The loop test revealed a moving bed. Measured discharge, accounting for moving bed conditions, was approximately 253,000 cubic feet per second (cfs) with a corresponding stage of 14.17 feet BPMSL at MON1C. The average velocity was 5.29 feet per second (fps) and the maximum measured velocity was 10.0 fps. The measurement quality was rated fair because of intermittent data gaps in the loop test. A summary of the discharge measurement and the WinRiver II output for each transect are presented in Appendix D.1.

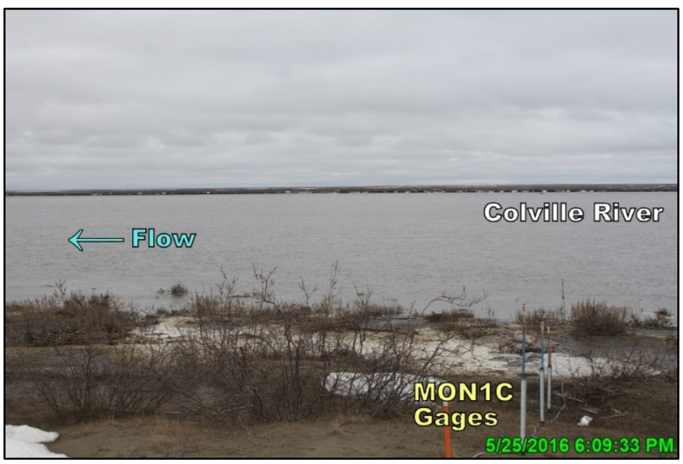


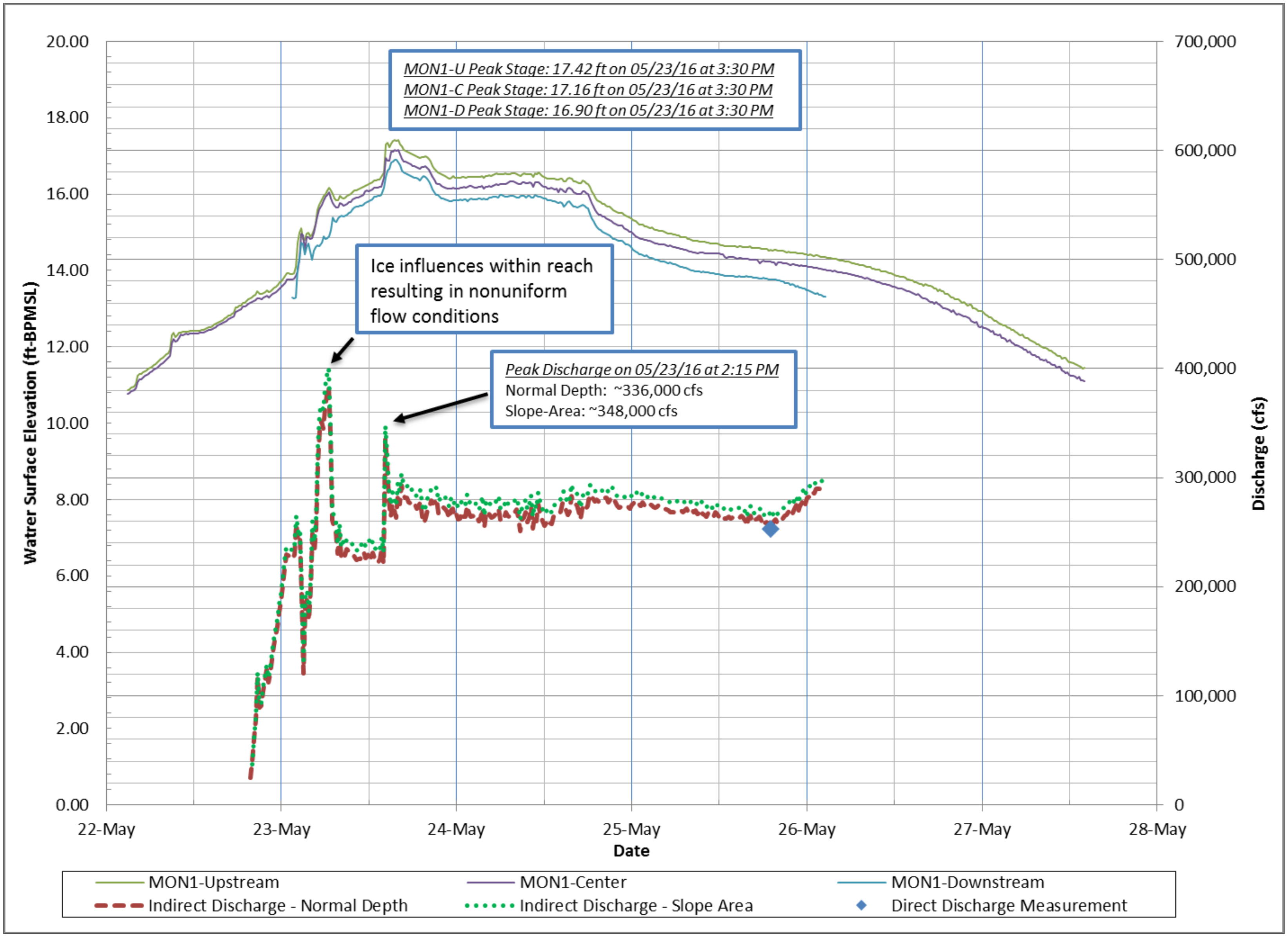
Photo 4.1: Colville River at MON1 during discharge measurement, looking east; May 25, 2016

B. Peak Discharge

Peak discharge was calculated indirectly using the Normal Depth and Slope-Area methods (Appendix B.1.3). The Normal Depth calculation was based on a topographic survey of channel geometry at MON1C (LCMF 2004). The Slope-Area method used cross-section data at MON1U, MON1C, and MON1D (LCMF 2004). The energy grade-line was approximated by the average water surface slope between MON1U, MON1C, and MON1D. The channel roughness was validated with the measured discharge and corresponding WSEs. The plan and cross-section profiles are located in Appendix B.2.1.

Peak discharge occurred at 2:15pm on May 23, approximately 1 hour and 15 minutes before peak stage. Peak discharge followed the release of the ice jam upstream of MON1 and passage of the accompanying flood wave and ice floes and was estimated to be 348,000 cfs with a corresponding WSE of 16.95 feet BPMSL. This value was determined using the Slope-Area method because it uses multiple cross-sections (i.e. uses more information about the MON1 reach geometry) as opposed to the single cross-section in the Normal Depth calculation. The difference in results between the two methods is less than 3%. Ice floes were present in the channel at the time of peak discharge but were flowing and expected to have minimal impact on the computed values, therefore the quality rating was fair (Photo 4.2). Graph 4.1 shows the results from the discharge calculations and the WSEs versus time.

Photo 4.2: Colville River at MON1C at time of calculated peak discharge, looking east; May 23, 2016



Graph 4.1 MON1 WSE and Calculated Discharge versus Time

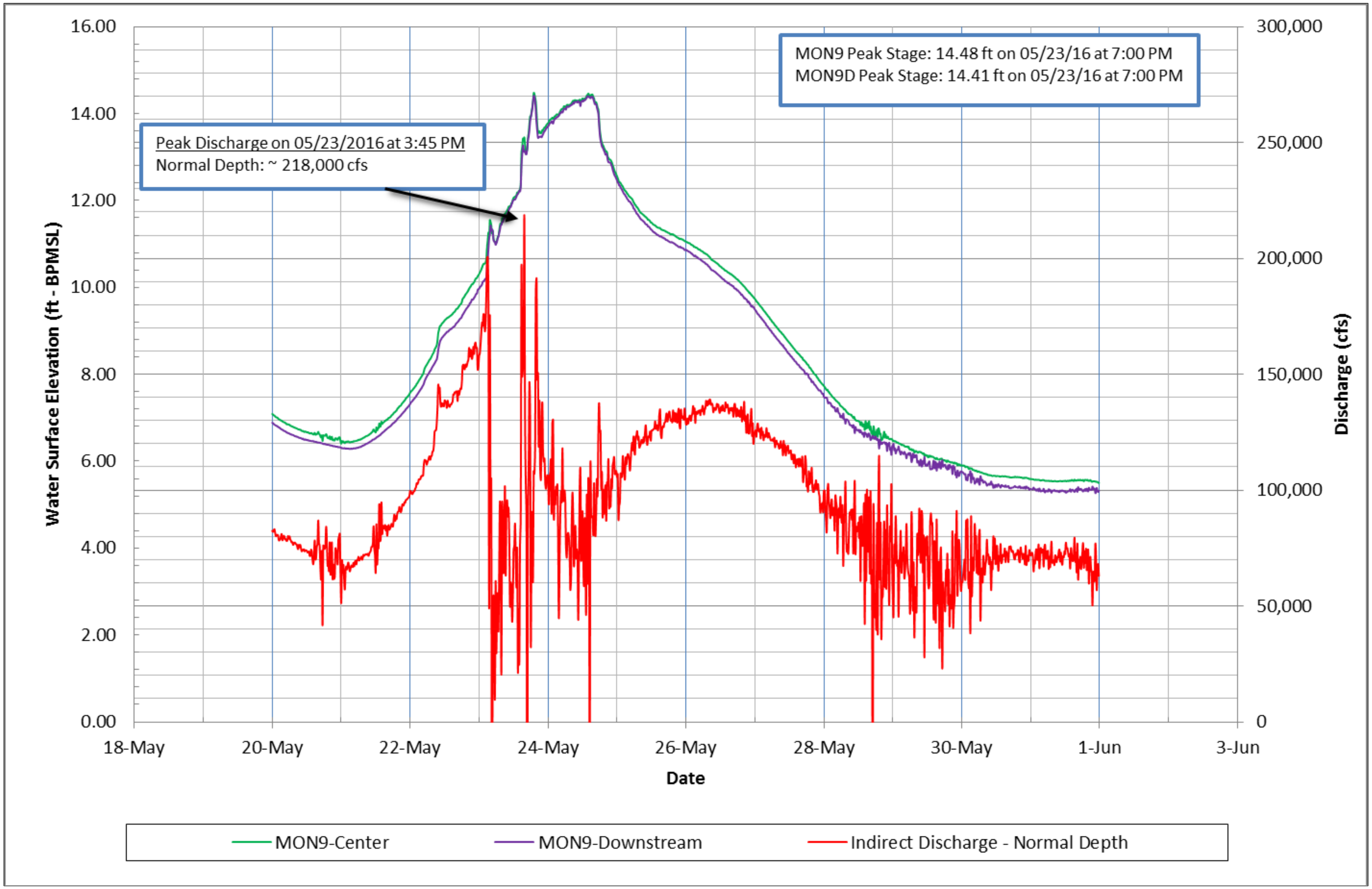
EAST CHANNEL - MON9

A. PEAK DISCHARGE

Peak discharge in the East Channel at MON9 was calculated indirectly using the Normal Depth method. The Normal Depth calculation was based on a topographic survey of the channel geometry at MON9 (LCMF 2009). The energy grade-line was approximated by the water surface slope between MON9 and MON9D. The plan and cross-section profile are located in Appendix B.2.2.

Peak discharge occurred at 3:45pm on May 23, 3 hours and 15 minutes before peak stage. Peak discharge followed the release of the ice jam upstream of MON1 and the passage of accompanying flood wave and ice floes and was approximately 218,000 cfs with a corresponding WSE of 13.45 feet BPMSL. Peak discharge was likely influenced by backwater and ice floes in the channel and therefore was assigned a fair-poor quality rating (Table 2.1) (Photo 4.3). Graph 4.2 shows the results from the discharge calculations and the WSEs versus time.

Photo 4.3: East Channel at MON9 at the time of peak discharge, looking east; May 23, 2016



Graph 4.2: MON9 WSE and Calculated Discharge versus Time

4.2 CD5 ROAD BRIDGES

LAKE L9323 BRIDGE

A. Peak Discharge

Lake L9323 received limited overflow from the Sakoonang Channel and was not hydraulically connected to the Nigliq Channel on the north end of the lake. As a result, there was no discernable flow through Lake L9323 Bridge and discharge was not measured or calculated. The plan and cross-section profile are located in Appendix B.2.2.1 (LCMF 2016b).

LAKE L9341 BRIDGE

A. Peak Discharge

Lake L9341 received backwater from the Nigliq Channel at the north end of the lake. WSEs and observations suggest Lake L9341 was not hydraulically connected to the Nigliq Channel on the south end of the lake. As a result, there was no discernable flow through the Lake L9341 Bridge and discharge was not measured or calculated. The plan and cross-section profile are located in Appendix B.2.2.2 (LCMF 2016b).

NIGLIQ BRIDGE

A. Measured Discharge

On the evening of May 25, Nigliq Channel discharge was measured at the upstream side of the Nigliq Bridge using a USGS Type AA Current Meter and the USGS midsection technique (Appendix B.1.1). At the time of the measurement, the channel was mostly clear of snow and ice and conditions were considered steady and uniform (Photo 4.4). Measured discharge was approximately 46,300 cfs with a corresponding stage of 8.08 feet BPMSL at gage G26. The average velocity was 2.4 fps and the highest depth-averaged velocity within a particular section was 3.9 fps. The quality of the measurement was classified as good-fair based on the remaining snow drifts and grounded ice along the mud bar on the east side of the channel. The plan and cross-section profile at gage G26 is presented in Appendix B.2.2.3. A summary of the discharge measurement is presented in Appendix D.2.

Photo 4.4: Conditions at the Nigliq Bridge during discharge measurement, looking southwest; May 25, 2016

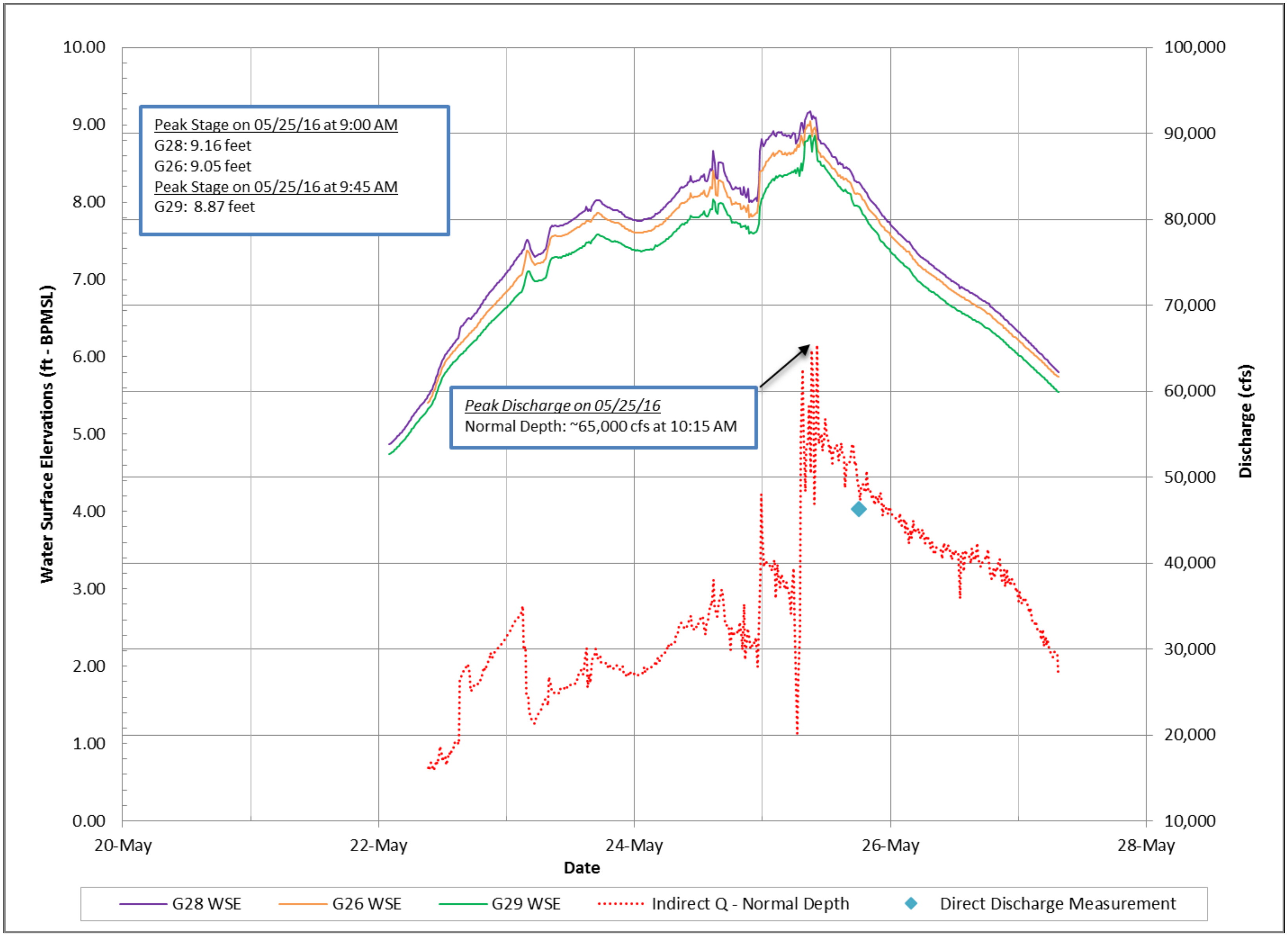
B. Peak Discharge

Peak discharge was calculated using the Normal Depth method. The channel geometry applied in the Normal Depth calculation was from Transect 10 surveyed for the *Monitoring Plan with an Adaptive Management Strategy* in July 2016 (LCMF 2016b). The friction slope used in the

Normal Depth calculation was based on WSEs at gages G28 and G26. The channel roughness was calibrated from the measured discharge and corresponding WSEs.

Peak discharge occurred at 10:15am on May 25, 1 hour and 15 minutes before peak stage. Peak discharge followed the release of an upstream ice jam and the passage of the accompanying flood wave and ice floes and was 65,000 cfs with a corresponding WSE of 8.69 feet BPMSL. Minor ice floes were present at the time of peak discharge and no backwater effects were observed, therefore the computation was assigned a quality rating of fair (Photo 4.5). In addition, the computed peak discharge was within 8 hours of the measured discharge, adding to the confidence in the computation. Graph 4.3 shows the results from the discharge calculations and the WSEs versus time.

Photo 4.5: Conditions at the Nigliq Bridge at the time of peak discharge, upstream looking east May 25, 2016



Graph 4.3: Nigliq Bridge WSE and Calculated Discharge versus Time

NIGLIAGVIK BRIDGE

A. Measured Discharge

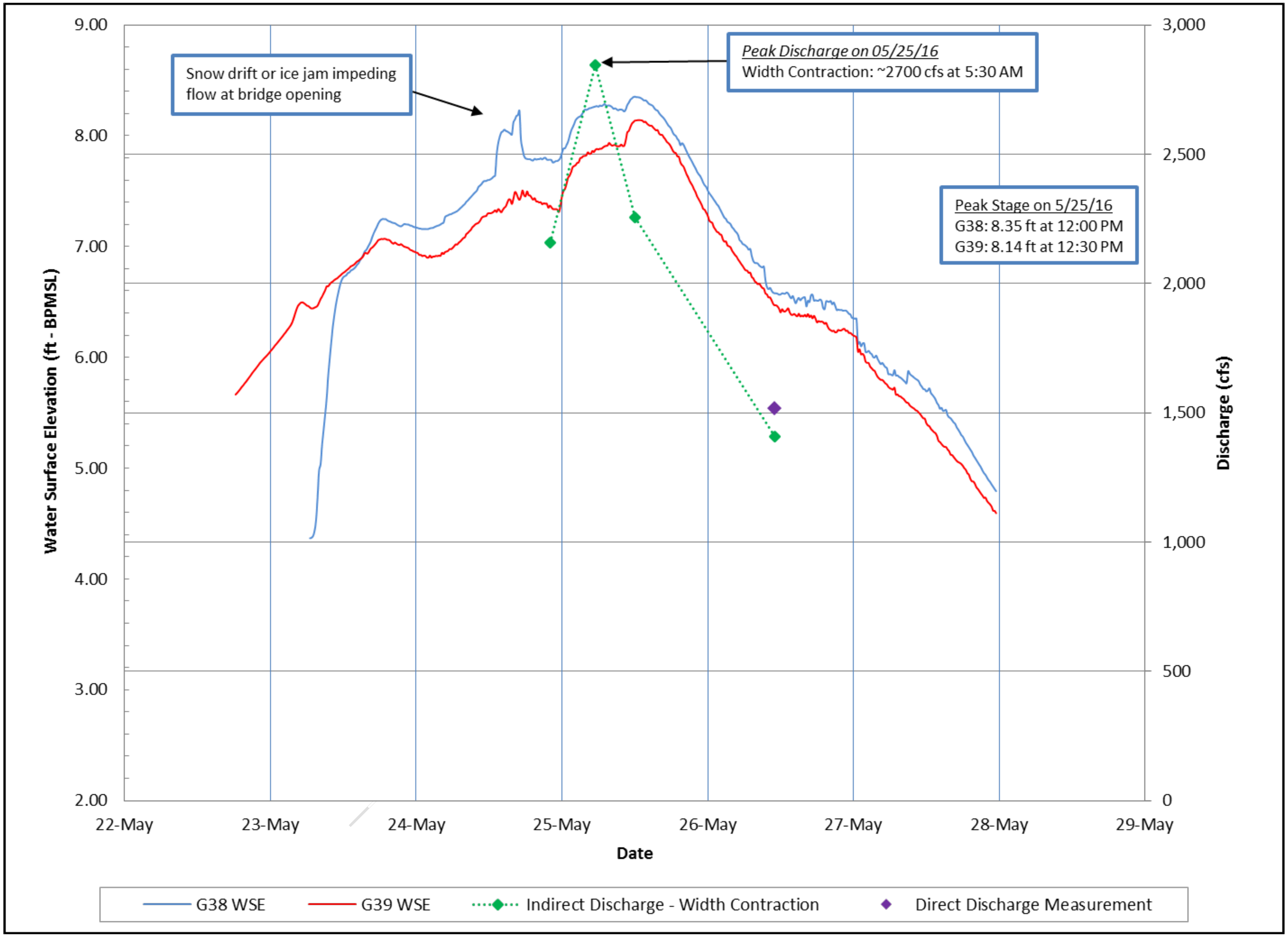
On the afternoon of May 26, discharge was measured in the Nigliagvik Channel at the upstream side of the Nigliagvik Bridge using an USGS Type AA Current Meter and the USGS midsection technique (Appendix B.1.1). At the time of measurement, there was a snow drift along the right (east) bank immediately upstream of the bridge contracting flow along the left (west) bank and creating eddies on the downstream side of the snow drift (Photo 4.6). The measured discharge was approximately 1,500 cfs with a corresponding stage of 6.58 feet BPMSL at gage G38.

Photo 4.6: Nigliagvik Bridge conditions during direct discharge measurement, looking west; May 26, 2016

B. Peak Discharge

The large snow drift under the east side of the bridge was present during peak conditions and was observed contracting flow through the bridge opening. To account for the energy losses through the contracted section, the USGS width contraction method was used to estimate peak discharge (Appendix B.1.3). The approach section channel geometry was from Transect 28 surveyed for the *Monitoring Plan with an Adaptive Management Strategy* in July 2016 (LCMF 2016b). The bridge section channel geometry was from the direct discharge measurement on May 26. WSEs at Transect 28 were from gage G38 and WSEs at the bridge section were interpolated between gages G38 and G39. The channel roughness was calibrated from the measured discharge and corresponding WSEs.

Peak discharge occurred at approximately 5:30am on May 25, approximately 7 hours before peak stage. Peak discharge was in response to rising water levels in the Nigliq Channel and was 2,700 cfs with a corresponding WSE of 8.26 feet BPMSL at gage G38. Observations and pier scour measurements suggest the channel was clear of bottomfast ice at the time of peak discharge; however, due to the uncertainty and the effects from the snow drift, the quality of the computation was considered poor. Graph 4.4 presents the discharge calculations and the WSEs versus time.



Graph 4.4: Nigliagvik Bridge WSE and Calculated Discharge versus Time

4.3 CD2 ROAD SWALE BRIDGES

MEASURED DISCHARGE

Discharge was measured at the CD2 road swale bridges on May 25 using an USGS Type AA Current Meter and the USGS midsection technique. Discharge measurements occurred approximately 2 to 3 hours after peak stage at gage G3. Measured discharge at the Long Swale Bridge was 4,800 cfs with a corresponding stage of 7.44 feet BPMSL at gage G3. The average velocity was 2.25 fps and the highest depth-averaged velocity within a particular section was 3.39 fps. Measured discharge at the Short Swale Bridge was 700 cfs with a corresponding stage of 7.39 feet BPMSL at gage G3. The average velocity was 2.11 fps and the highest depth-averaged velocity within a particular section was 2.69 fps.

At the time of the measurements, the bridges were ice free with small ice floes periodically passing under the bridges (Photo 4.7). At the downstream side of the Short Swale Bridge, a long snow drift (approximately 13 feet) was protruding from the left bank (Photo 4.8). The quality of the measurements at the Long Swale Bridge and Short Swale Bridge were rated good/fair and fair, respectively.

Photo 4.7: Long Swale Bridge during direct discharge measurement, looking east; May 25, 2016

Photo 4.8: Snow drift on the downstream side of the Short Swale Bridge during discharge measurement, looking east; May 25, 2016

PEAK DISCHARGE

Peak discharge was estimated using the measured velocity and adjusting the hydraulic depth for peak conditions. Peak discharge was estimated to have occurred during peak stage, which occurred about 1.5 hours after the peak WSE differential was observed between gages G3 and G4. At 8:15am on May 25, the peak observed stage was 7.49 feet BPMSL at gage G3, and the corresponding peak discharge for the Long and Short Swale Bridges equaled the measured discharge when rounding to the nearest 100 cfs; 4,800 cfs and 700 cfs for the Long Swale Bridge and Short Swale Bridge, respectively.

4.4 ROAD CULVERTS

CD2, CD4, and CD5 road culverts were monitored to assess flow conditions and culvert performance. All culvert covers were removed prior to the arrival of floodwater. Snow and ice was cleared at all culvert inlets and no flow restrictions were observed. Peak discharge was calculated using the WSE differential between the headwater and tailwater elevation at the culverts and survey data provided by LCMF (LCMF 2016a). During peak stage, culvert flow was limited to four CD2 culverts located in the vicinity of the swale bridges, nine CD4 culverts at the north and south batteries, and three CD5 culverts near the CD5 pad. Direct discharge measurements of culverts conveying flow were collected as close to peak conditions as possible. Drainage structure locations and proximity to gages are shown in Appendix F.1. Appendix F.2 contains road culvert discharge data including estimated peak discharge and corresponding average velocities.

CD2 ROAD CULVERTS

Visual observations of flow conditions at each CD2 road culvert are summarized in Table 4.1 and Table 4.2. Photo 4.9 and Photo 4.10 show culverts along the CD2 road conveying flow near peak conditions. The WSE differential at the CD2 road gages is presented in Graph 4.5.

Photo 4.9: Culvert CD2-23 direct discharge measurement, looking northwest; May 23, 2016

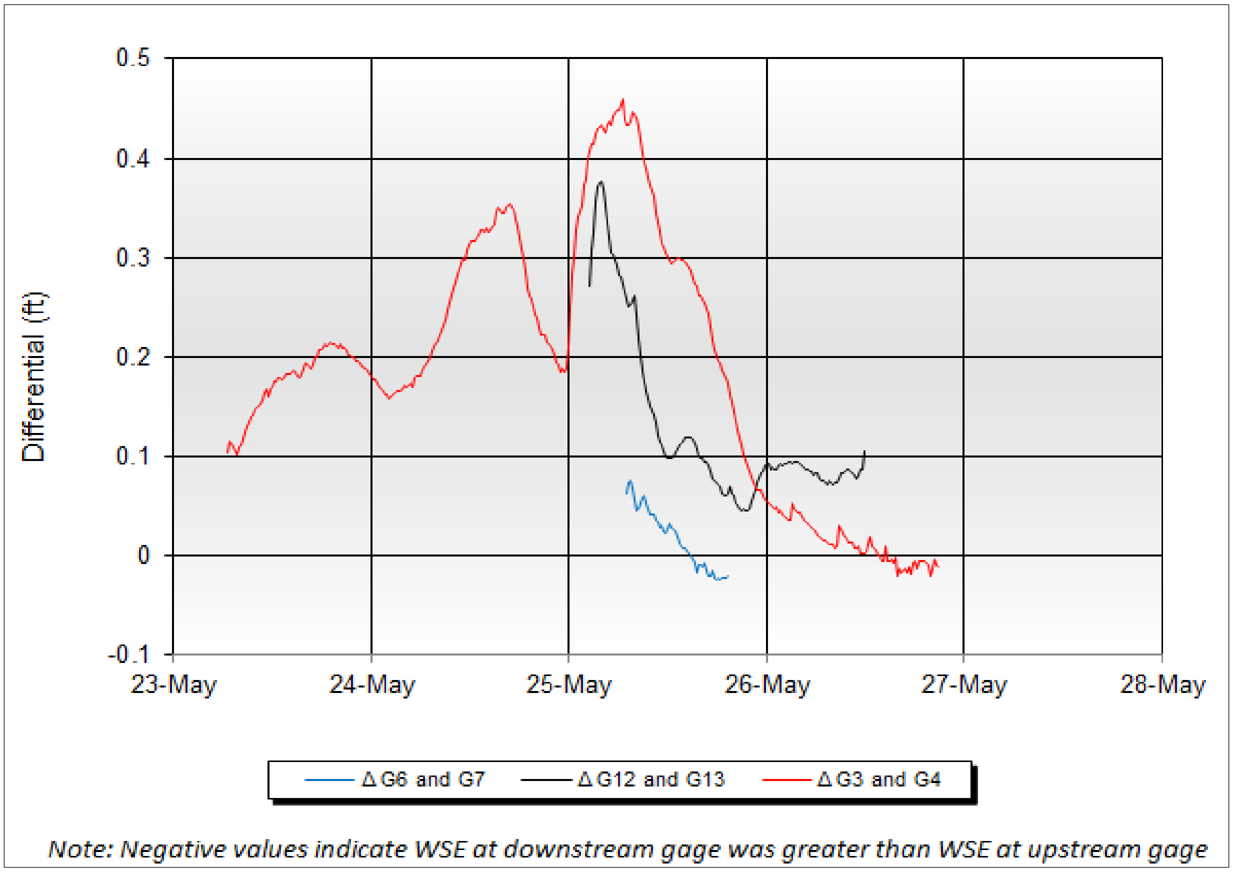
Photo 4.10: Culvert CD2-21 within 24 hours of peak conditions, looking southwest; May 24, 2016

Table 4.1: CD2 Road Culvert Visual Observation Summary on May 23, 2016

Culvert	Associated Gages	Observation	Date & Time
CD2-01	G6/G7	Isolated meltwater/No flow	5/23/2016 14:02
CD2-02		Isolated meltwater/No flow	5/23/2016 14:02
CD2-03		Isolated meltwater/No flow	5/23/2016 14:01
CD2-04		Isolated meltwater/No flow	5/23/2016 14:01
CD2-05		Isolated meltwater/No flow	5/23/2016 14:00
CD2-06		Isolated meltwater/No flow	5/23/2016 14:00
CD2-07		Isolated meltwater/No flow	5/23/2016 13:59
CD2-08		Isolated meltwater/No flow	5/23/2016 13:58
CD2-09	G12/G13	Isolated meltwater/No flow	5/23/2016 13:58
CD2-10		Isolated meltwater/No flow	5/23/2016 13:57
CD2-11		Isolated meltwater/No flow	5/23/2016 13:56
CD2-12		Isolated meltwater/No flow	5/23/2016 13:55
CD2-13		Isolated meltwater/No flow	5/23/2016 13:53
CD2-14		Isolated meltwater/No flow	5/23/2016 13:51
CD2-15		Isolated meltwater/No flow	5/23/2016 13:50
CD2-16		Isolated meltwater/No flow	5/23/2016 13:49
CD2-17		Isolated meltwater/No flow	5/23/2016 13:48
CD2-18		Isolated meltwater/No flow	5/23/2016 13:48
CD2-19	G3/G4	Dry	5/23/2016 13:47
CD2-20		Isolated meltwater/No flow	5/23/2016 13:46
CD2-21		Flowing (South to North)	5/23/2016 13:44
CD2-22		Flowing (South to North)	5/23/2016 13:30
CD2-23		Flowing (South to North)	5/23/2016 13:22
CD2-24		Flowing (South to North)	5/23/2016 13:10
CD2-25		Dry	5/23/2016 14:18
CD2-25		Dry	5/23/2016 14:18
CD2-26		Dry	5/23/2016 14:18

Table 4.2 CD2 Road Culvert Visual Observation Summary on May 24, 2016

Culvert	Associated Gages	Observation	Date & Time
CD2-01	G6/G7	Isolated meltwater/No flow	5/24/2016 11:02
CD2-02		Isolated meltwater/No flow	5/24/2016 11:02
CD2-03		Isolated meltwater/No flow	5/24/2016 11:02
CD2-04		Isolated meltwater/No flow	5/24/2016 11:02
CD2-05		Isolated meltwater/No flow	5/24/2016 11:02
CD2-06		Isolated meltwater/No flow	5/24/2016 11:02
CD2-07		Isolated meltwater/No flow	5/24/2016 11:02
CD2-08		Isolated meltwater/No flow	5/24/2016 11:02
CD2-09	G12/G13	Isolated meltwater/No flow	5/24/2016 11:02
CD2-10		Isolated meltwater/No flow	5/24/2016 11:02
CD2-11		Isolated meltwater/No flow	5/24/2016 11:02
CD2-12		Isolated meltwater/No flow	5/24/2016 11:02
CD2-13		Isolated meltwater/No flow	5/24/2016 11:02
CD2-14		Isolated meltwater/No flow	5/24/2016 11:02
CD2-15		Isolated meltwater/No flow	5/24/2016 11:02
CD2-16		Isolated meltwater/No flow	5/24/2016 11:02
CD2-17		Isolated meltwater/No flow	5/24/2016 11:02
CD2-18		Isolated meltwater/No flow	5/24/2016 11:02
CD2-19	G3/G4	Isolated meltwater/No flow	5/24/2016 11:02
CD2-20		Isolated meltwater/No flow	5/24/2016 11:02
CD2-21		Unimpeded Flow (South to North)	5/24/2016 11:22
CD2-22		Unimpeded Flow (South to North)	5/24/2016 11:10
CD2-23		Unimpeded Flow (South to North)	5/24/2016 11:05
CD2-24		Unimpeded Flow (South to North)	5/24/2016 11:40
CD2-25		Dry	5/24/2016 11:46
CD2-25		Dry	5/24/2016 11:46
CD2-26		Dry	5/24/2016 11:47



Graph 4.5: CD2 Road WSE Differential

Total peak discharge at the CD2 road culverts was approximately 278 cfs on May 25. At the time of peak discharge, culverts CD2-1 through CD2-8, CD2-9 through CD2-18, and CD2-19 through CD2-26 were conveying 37%, 21%, and 42%, respectively, of the total discharge. Culverts CD2-19 through CD2-26 had the highest average velocity of 2.3 fps.

Discharge measurements were collected at CD2-21 through CD2-24 on the afternoon of May 23 and in the afternoon of May 24. The total measured discharge through these culverts was 35.1 cfs on May 23 and 60.7 cfs on May 24. The average measured velocity was approximately 3.8 fps. Table 4.3 compares the measured velocity and discharge to the calculated velocity and discharge at the time of measurements.

Table 4.3: CD2 Road Culverts near G3/G4, Direct Measurement/Calculated Discharge Comparison

Culvert	Direct (Measured)			Indirect (Calculated)			Percent Variance	
	Date/Time of Measurement	Velocity (V) (ft/s)	Discharge (Q) (cfs)	Date/Time of Calculation	Velocity (V) (ft/s)	Discharge (Q) (cfs)	Velocity (V) (ft/s)	Discharge (Q) (cfs)
CD2-21	5/23/16 1:44 PM	1.2	2.6	5/23/16 1:35 PM	1.9	3.7	56%	42%
CD2-21	5/24/16 11:22 AM	2.5	8.9	5/24/16 8:53 AM	2.3	5.8	-11%	-35%
CD2-22	5/23/16 1:30 PM	2.8	5.0	5/23/16 1:35 PM	2.3	4.7	-17%	-7%
CD2-22	5/24/16 11:10 AM	3.6	11.5	5/24/16 8:53 AM	2.6	6.9	-28%	-40%
CD2-23	5/23/16 1:22 PM	5.9	12.5	5/23/16 1:35 PM	2.5	11.1	-58%	-11%
CD2-23	5/24/16 11:05 AM	4.1	17.7	5/24/16 8:53 AM	2.7	14.3	-33%	-19%
CD2-24	5/23/16 1:10 PM	6.1	15.0	5/23/16 1:35 PM	2.4	13.0	-61%	-13%
CD2-24	5/24/16 11:40 AM	4.1	22.7	5/24/16 8:53 AM	2.7	16.4	-36%	-28%
5/23 Total Measured Q (cfs)			**35.1**	**5/23 Total Calculated Q (cfs)**		**32.5**	**5/23 Total Q**	**-8%**
5/24 Total Measured Q (cfs)			**60.7**	**5/24 Total Calculated Q (cfs)**		**43.4**	**5/24 Total Q**	**-29%**
Average Measured Q (cfs)			**10.5**	**Average Calculated Q (cfs)**		**9.5**	**Average Q**	**-9%**
Average Measured V (ft/s)			**3.8**	**Average Calculated V (ft/s)**		**2.4**	**Average V**	**-35%**

CD4 ROAD CULVERTS

Visual observations of flow conditions at each CD4 road culvert are summarized in Table 4.4 and Table 4.5. Photo 4.11 and Photo 4.12 show culverts along the CD4 road conveying flow near peak conditions. The WSE differential for the CD4 road gages is presented in Graph 4.6.

Peak discharge for culverts CD4-19 through CD4-23D was approximately 244 cfs at approximately 5:30pm on May 25. Peak discharge for culverts CD4-24 through CD4-33 was approximately 168 cfs at approximately 8:45pm on May 24. Culverts CD2-24 through CD2-33 had the highest average velocity of 3.1 fps.

Discharge measurements were collected at nine culverts along the CD4 road on the morning of May 24. The total measured discharge through culverts CD4-25 through CD4-33 was 11.4 cfs. The average measured velocity was approximately 0.4 fps. Table 4.6 presents the measured velocity and discharge. Saturated snow between gage G18 and the inlets of culverts CD4-25 through CD4-33 at the time of measurement had an influence on stage which likely overestimated calculated velocities and calculated discharge at the time. These values are not presented for comparison.

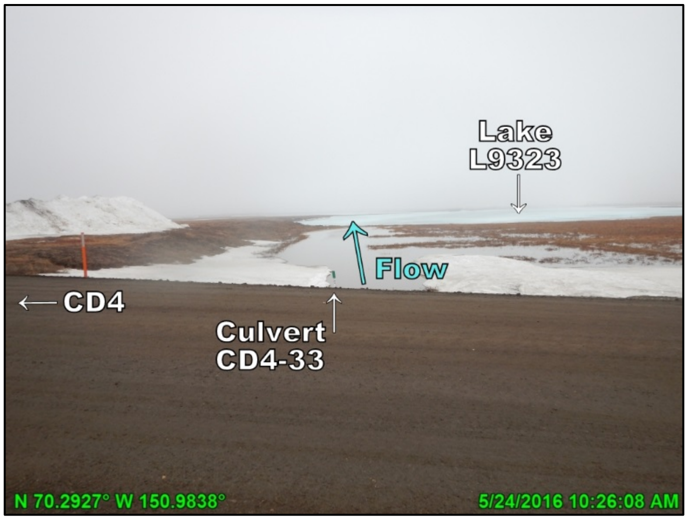


Photo 4.11: Flow conveyed through culvert CD4-33 into Lake L9323, looking north; May 24, 2016

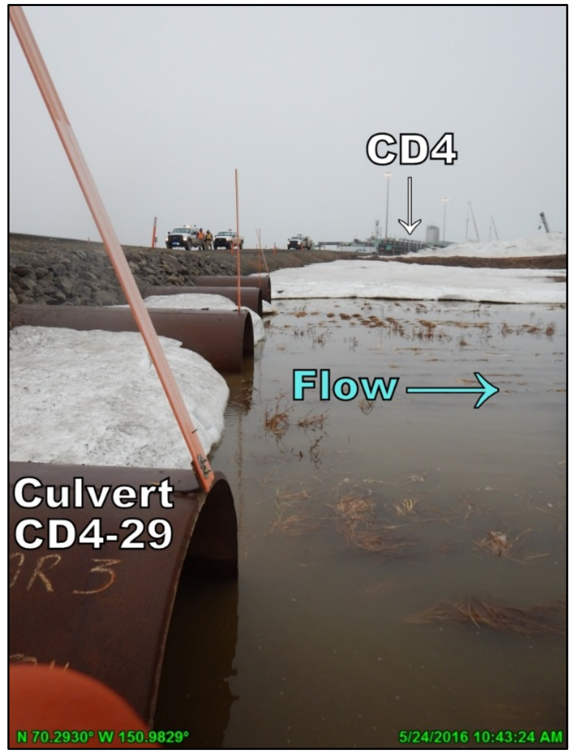


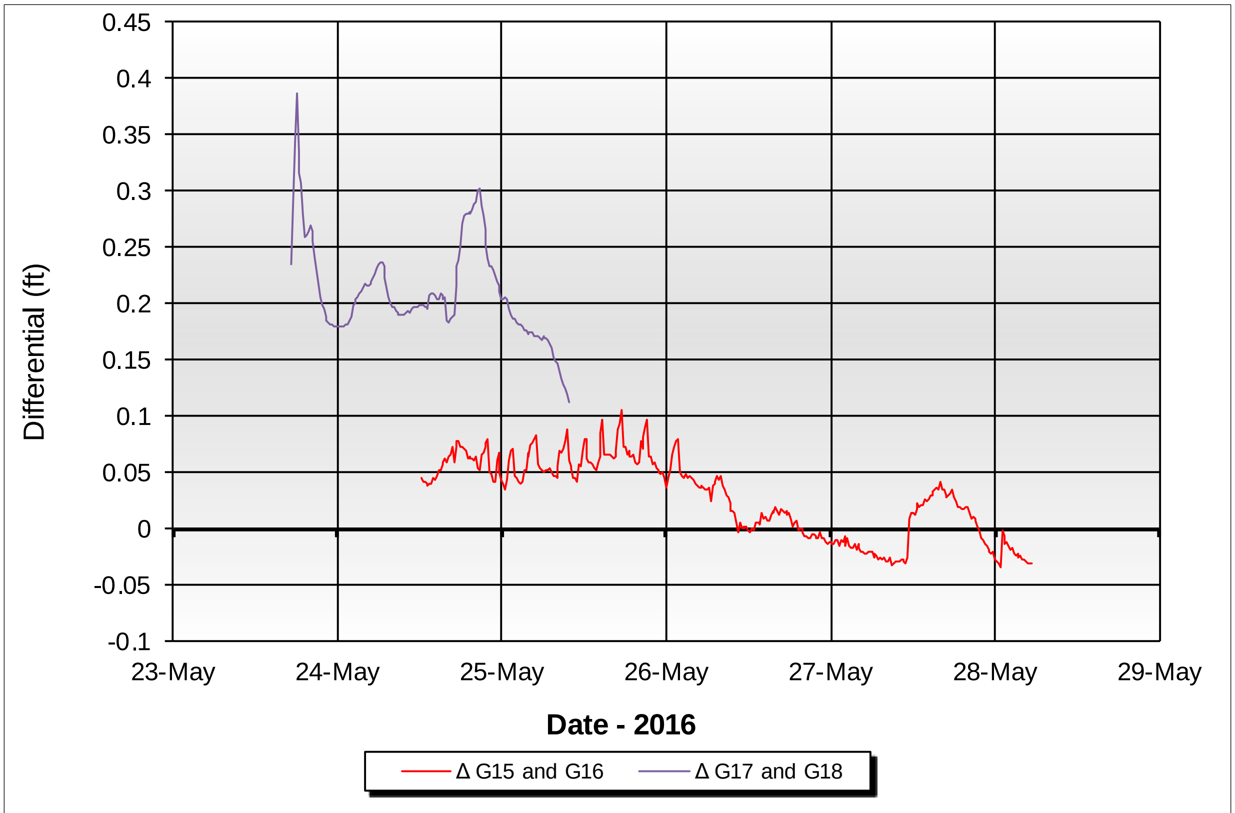
Photo 4.12: Culverts CD4-29 through CD4-32 within 24 hours of peak conditions, looking southwest; May 24, 2016

Table 4.4: CD4 Road Culvert Visual Observation Summary on May 23, 2016

Culvert	Associated Gages	Observation	Date & Time
CD4-01	G42/G43	Isolated meltwater/No flow	5/23/2016 15:45
CD4-02		Dry	5/23/2016 14:18
CD4-03		Isolated meltwater/No flow	5/23/2016 14:19
CD4-04		Isolated meltwater/No flow	5/23/2016 14:21
CD4-05		Isolated meltwater/No flow	5/23/2016 14:23
CD4-06		Isolated meltwater/No flow	5/23/2016 14:24
CD4-07		Isolated meltwater/No flow	5/23/2016 14:25
CD4-08		Dry	5/23/2016 14:26
CD4-09		Dry	5/23/2016 14:27
CD4-10		Dry	5/23/2016 14:30
CD4-11	G40/G41	Dry	5/23/2016 14:30
CD4-12		Dry	5/23/2016 14:30
CD4-13		Dry	5/23/2016 14:30
CD4-14		Dry	5/23/2016 14:30
CD4-15		Dry	5/23/2016 14:30
CD4-16		Dry	5/23/2016 14:30
CD4-17		Dry	5/23/2016 14:30
CD4-18		Dry	5/23/2016 14:30
CD4-19	G15/G16	Isolated meltwater/No flow	5/23/2016 14:30
CD4-20		Dry	5/23/2016 15:00
CD4-20A		Isolated meltwater/No flow	5/23/2016 14:57
CD4-21		Dry	5/23/2016 15:00
CD4-22		Dry	5/23/2016 15:00
CD4-23		Dry	5/23/2016 15:00
CD4-23A		Dry	5/23/2016 15:00
CD4-23B		Dry	5/23/2016 15:00
CD4-23C		Dry	5/23/2016 15:00
CD4-23D		Dry	5/23/2016 15:00
CD4-24	G17/G18	Isolated meltwater/No flow	5/23/2016 15:00
CD4-25		Isolated meltwater/No flow	5/23/2016 15:00
CD4-26		Isolated meltwater/No flow	5/23/2016 15:00
CD4-27		Isolated meltwater/No flow	5/23/2016 15:00
CD4-28		Isolated meltwater/No flow	5/23/2016 15:05
CD4-29		Isolated meltwater/No flow	5/23/2016 15:05
CD4-30		Isolated meltwater/No flow	5/23/2016 15:05
CD4-31		Isolated meltwater/No flow	5/23/2016 15:05
CD4-32		Isolated meltwater/No flow	5/23/2016 15:05
CD4-33		Isolated meltwater/No flow	5/23/2016 15:05

Table 4.5: CD4 Road Culvert Visual Observation Summary on May 24, 2016

Culvert	Associated Gages	Observation	Date & Time
CD4-01	G42/G43	Isolated meltwater/No flow	5/24/2016 8:50
CD4-02		Dry	5/24/2016 8:50
CD4-03		Dry	5/24/2016 8:50
CD4-04		Dry	5/24/2016 8:50
CD4-05		Dry	5/24/2016 8:50
CD4-06		Dry	5/24/2016 8:50
CD4-07		Dry	5/24/2016 8:50
CD4-08		Dry	5/24/2016 8:50
CD4-09		Dry	5/24/2016 8:50
CD4-10		Dry	5/24/2016 8:50
CD4-11	G40/G41	Dry	5/24/2016 8:50
CD4-12		Dry	5/24/2016 8:50
CD4-13		Dry	5/24/2016 8:50
CD4-14		Dry	5/24/2016 8:50
CD4-15		Dry	5/24/2016 8:50
CD4-16		Dry	5/24/2016 8:50
CD4-17		Dry	5/24/2016 8:50
CD4-18		Dry	5/24/2016 8:50
CD4-19	G15/G16	Dry	5/24/2016 8:50
CD4-20		Isolated meltwater/No flow	5/24/2016 9:28
CD4-20A		Isolated meltwater/No flow	5/24/2016 9:28
CD4-21		Dry	5/24/2016 9:29
CD4-22		Dry	5/24/2016 9:29
CD4-23		Dry	5/24/2016 9:29
CD4-23A		Dry	5/24/2016 9:29
CD4-23B		Dry	5/24/2016 9:29
CD4-23C		Dry	5/24/2016 9:29
CD4-23D		Dry	5/24/2016 9:29
CD4-24	G17/G18	Isolated meltwater/No flow	5/24/2016 10:13
CD4-25		Unimpeded Flow (South to North)	5/24/2016 10:51
CD4-26		Unimpeded Flow (South to North)	5/24/2016 10:50
CD4-27		Unimpeded Flow (South to North)	5/24/2016 10:47
CD4-28		Unimpeded Flow (South to North)	5/24/2016 10:45
CD4-29		Unimpeded Flow (South to North)	5/24/2016 10:08
CD4-30		Unimpeded Flow (South to North)	5/24/2016 10:25
CD4-31		Unimpeded Flow (South to North)	5/24/2016 10:20
CD4-32		Unimpeded Flow (South to North)	5/24/2016 10:15
CD4-33		Unimpeded Flow (South to North)	5/24/2016 10:10



Graph 4.6: CD4 Road WSE Differential

Table 4.6: CD4 Road Culverts near G17/G18, Direct Measurement

Culvert	Direct (Measured)		
	Time of Measurement May 24	Measured Velocity (ft/s)	Discharge (cfs)
CD4-25	10:51 AM	0.19	0.5
CD4-26	10:50 AM	0.17	0.5
CD4-27	10:47 AM	0.22	0.7
CD4-28	10:45 AM	0.32	0.9
CD4-29	10:08 AM	0.44	1.7
CD4-30	10:25 AM	0.66	1.8
CD4-31	10:20 AM	0.50	1.4
CD4-32	10:15 AM	0.59	1.6
CD4-33	10:10 AM	0.86	2.1
Total Measured Discharge (cfs)			11.4
Average Measured Velocity (ft/s)			0.4
Average Measured Discharge (cfs)			1.3

CD5 ROAD CULVERTS

Floodwater did not contact the portion of the CD5 road within in the CRD and all culverts remained dry. Three culverts along drainages west of the Nigliagvik Channel, outside of the CRD, were observed flowing. Visual observations of flow conditions at each CD5 road culvert are summarized in Table 4.7. Photo 3.31 and Photo 3.32 in Section 3.6.D of this report show culverts CD5-5, CD5-8, and CD5-9 conveying flow during peak conditions.

CD5 road culvert peak discharge for culverts CD5-07 through CD5-09 was approximately 11 cfs at approximately 9:00am on May 23. Culverts CD5-07 through CD5-09 had an average velocity of 0.8 fps.

Discharge measurements were collected at three culverts along the CD5 road in the morning of May 23. The total measured discharge through culverts CD5-5, CD5-08, and CD5-09 was 6.5 cfs on May 23 and the average measured velocity was approximately 1.1 fps. Table 4.8 presents the measured velocity and discharge. Gages S1 and S1D were dry at the time of measurement, therefore, a comparison with calculated discharge is not presented.

Table 4.7: CD5 Road Culvert Visual Observation Summary on May 23, 2016

Culvert	Associated Gages	Observation	Date & Time
CD5-01	S1/S1D	Dry	5/23/2016 9:35
CD5-02		Dry	5/23/2016 9:35
CD5-03		Dry	5/23/2016 9:35
CD5-04		Dry	5/23/2016 9:25
CD5-05		Unimpeded Flow (North to South)	5/23/2016 9:22
CD5-06		Dry	5/23/2016 9:21
CD5-07		Dry	5/23/2016 9:20
CD5-08		Unimpeded Flow (South to North)	5/23/2016 9:20
CD5-09		Unimpeded Flow (South to North)	5/23/2016 9:06
CD5-10		Dry	5/23/2016 9:04
CD5-11		Dry	5/23/2016 9:03
CD5-12		Dry	5/23/2016 9:03
CD5-13		Dry	5/23/2016 9:03
CD5-14		Dry	5/23/2016 9:02
CD5-15		Dry	5/23/2016 9:01
CD5-16		Dry	5/23/2016 9:01
CD5-17		Dry	5/23/2016 9:01
CD5-18		Dry	5/23/2016 9:00
CD5-19		Dry	5/23/2016 9:00
CD5-20	G38/G39	Dry	5/23/2016 8:59
CD5-21		Dry	5/23/2016 8:58
CD5-22		Dry	5/23/2016 8:58
CD5-23		Dry	5/23/2016 8:57
CD5-24		Dry	5/23/2016 8:55
CD5-25		Dry	5/23/2016 8:55
CD5-26		Dry	5/23/2016 9:47
CD5-27	G36/G37	Dry	5/23/2016 9:47
CD5-28		Dry	5/23/2016 9:50
CD5-29		Dry	5/23/2016 9:51
CD5-30		Dry	5/23/2016 9:52
CD5-31		Dry	5/23/2016 9:52
CD5-32	G34/G35	Dry	5/23/2016 9:53
CD5-33		Dry	5/23/2016 9:53
CD5-34		Dry	5/23/2016 9:53
CD5-35		Dry	5/23/2016 9:53
CD5-36		Dry	5/23/2016 9:54
CD5-37	G32/G33	Dry	5/23/2016 9:55
CD5-38		Dry	5/23/2016 9:56
CD5-39		Dry	5/23/2016 9:57
CD5-40	G30/G31	Dry	5/23/2016 9:57
CD5-41		Dry	5/23/2016 10:11
CD5-42		Dry	5/23/2016 10:12
CD5-43	G24/G25	Dry	5/23/2016 10:13

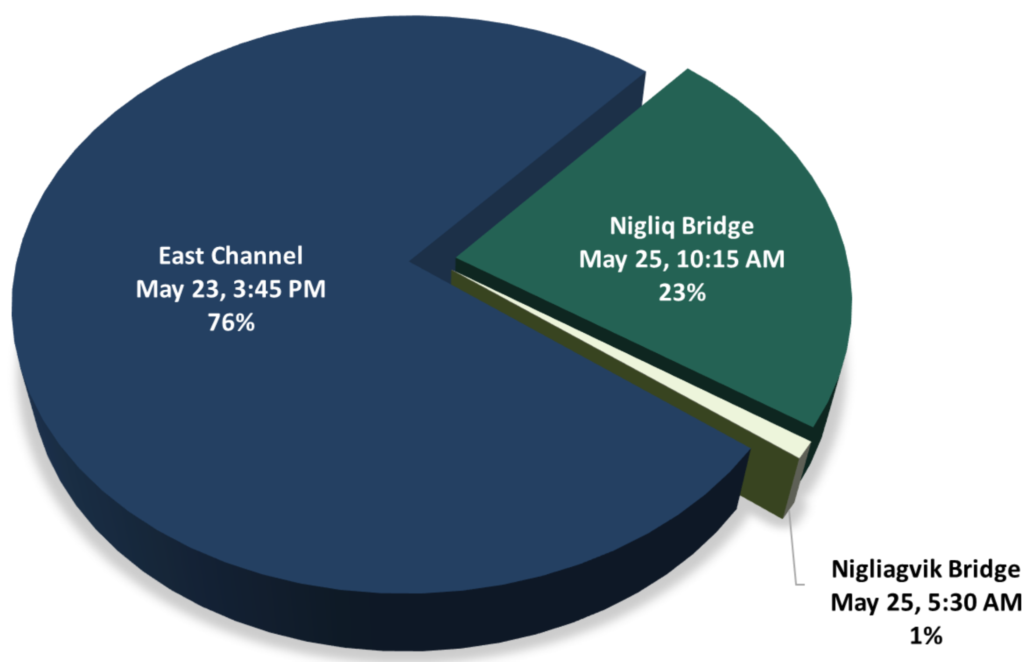
Table 4.8: CD5 Road Culverts near S1/S1D, Direct Measurement

Culvert	Direct (Measured)		
	Time of Measurement	Measured Velocity (ft/s)	Discharge (cfs)
CD5-05	5/23/16 9:25 AM	2.59	4.07
CD5-08	5/23/16 9:20 AM	0.38	1.20
CD5-09	5/23/16 9:20 AM	0.38	1.20
Total Measured Discharge (cfs)			6.5
Average Measured Discharge (cfs)			2.16
Average Measured Velocity (ft/s)			1.1

4.5 FLOW DISTRIBUTION

During the period of peak discharge, the Colville River East Channel accounted for 76% of the total discharge in the delta. The remaining flow passed through the CD5 road drainage structures; the Nigliq Bridge is estimated to have conveyed 23% of the total discharge through the delta and the Nigliagvik Bridge is estimated to have conveyed 1% of the total discharge through the delta. This is shown graphically in Figure 4.1. Each section of the pie graph is represented by the location's peak discharge; however, peak discharge did not occur at the same time and date for each location. Total peak discharge in the delta was under estimated by 18% when compared to the peak discharge calculated for the Colville River at MON1. Storage and attenuation during a low flow year are likely to have contributed to the under estimate, as are the possible errors associated with indirect methods.

Figure 4.1: Peak Flow Distribution



5. POST-BREAKUP CONDITIONS ASSESSMENT

Alpine gravel pads and access roads were inspected for erosion on May 28 and May 29. Other than washlines, no discernable erosion was observed during aerial and ground reconnaissance of the CD2 (Photo 5.1), CD4 (Photo 5.2), and CD5 (Photo 5.3) roads. Floodwaters did not reach the CD5 bridge abutments or road within the CRD. A prominent washline from 2015 spring breakup was evident along portions of the CD2, CD4, and CD5 roads. There were no signs of sloughing or undermining at drainage structures. Additional photo documentation of erosion surveys and breakup conditions along the Alpine facilities roads and pads are shown in Appendix C.1.

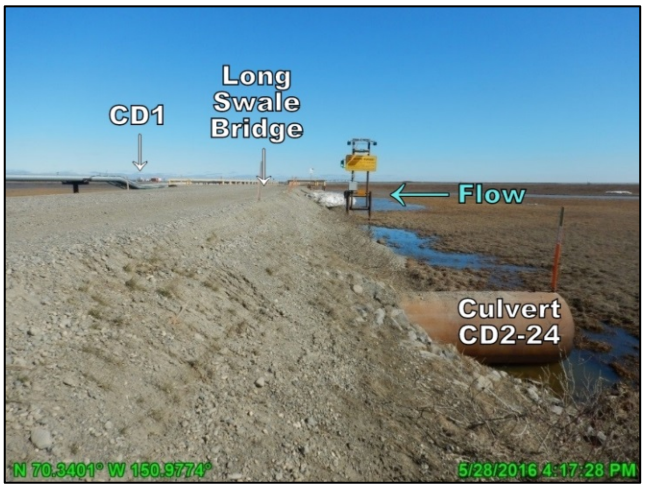


Photo 5.1: CD2 road at culvert CD2-24, looking east; May 28, 2016

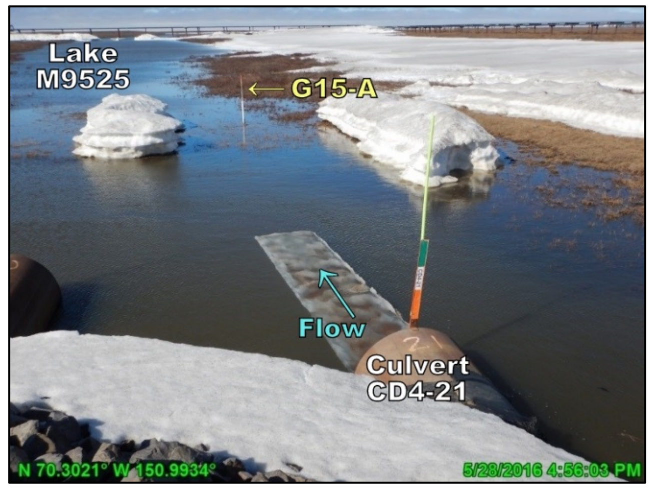


Photo 5.2: CD4 road at culvert CD4-21; looking north, May 28, 2016

Photo 5.3: CD5 road near CD5 pad, looking west; May 29, 2016

6. CD5 PIER SCOUR, BANK EROSION, & BATHYMETRY

6.1 PIER SCOUR

NIGLIQ BRIDGE

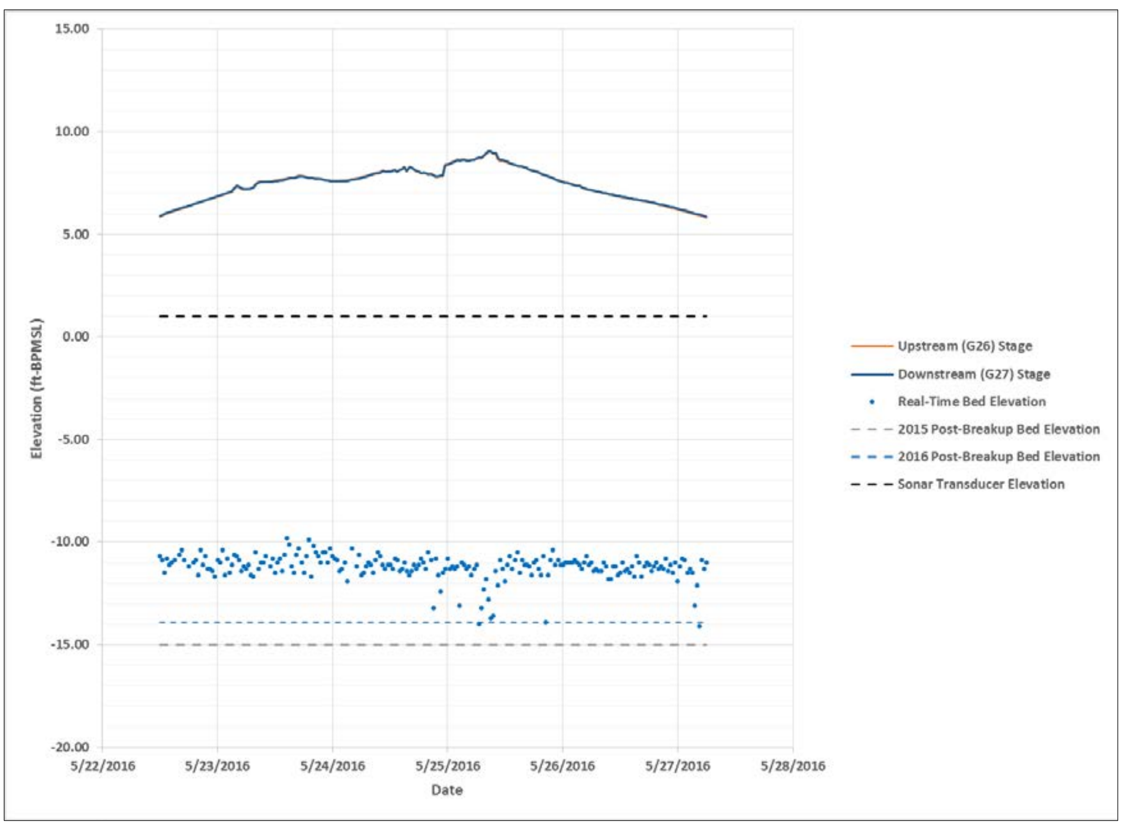
All real-time pier scour measurements were located at the downstream side of pile E. The minimum pier scour elevation, recorded by the real-time scour monitoring system during spring breakup, was -29.5 feet BPMSL at pier 4. The minimum post-breakup pier scour elevation around bridge support piles (C-E), surveyed by LCMF, was -30.0 feet BMPSL at pier 4 (LCMF 2016d). The post-breakup pier scour elevation is 1.1 feet below the 50-year design scour elevation and 3.0 feet above the 200-year design scour elevation. A comparison of design and observed scour elevations are presented in Table 6.1.

Real-time pier scour at piers 2 through 5 and corresponding WSEs during spring breakup monitoring are presented in Graph 6.1 through Graph 6.5. Real-time pier scour measurements indicated little to no active scour during peak conditions. The scatter in sonar measurements during real-time monitoring at some locations may be attributed to a high concentration of near-bed sediments suspended in turbulence associated with eddies converging on the downstream side of the pier. In these cases, the lower readings are interpreted as the true bed elevations. Based on the post-breakup surveyed contours, the real-time scour measurements at the downstream side of pile E are considered representative of the scour conditions at each pile of the respective pier. Post-breakup contour plots around the piers are available in Appendix G.1.1. Visual observations of piers 6, 7, and 8 after breakup floodwaters receded showed no signs of excessive scour (Photo 6.1 and Photo 6.2). Photo 6.3 indicates a small scour hole has developed around pier 6. The estimated depth of the scour depression is approximately 4 feet. Based on the upstream and downstream elevations of the bounding transects 9 and 10, the estimated elevation of the scour hole is 0 feet BPMSL.

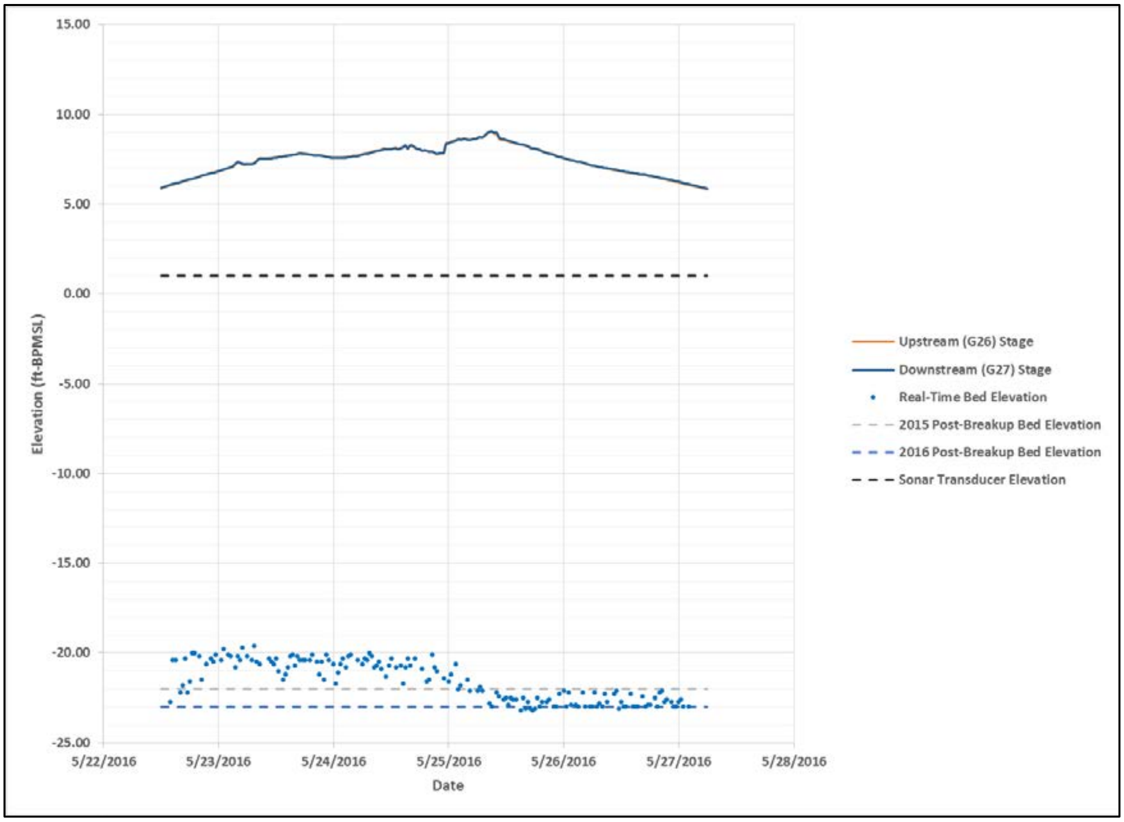
Table 6.1: Nigliq Bridge Comparison of Design and Observed Pier Scour Elevations

Nigliq Bridge Pier Scour		
During Breakup		**Elevation (ft-BPMSL)[1,2]**
Pier 2	Pile E	-12.8
Pier 3	Pile E	-23.1
Pier 4	Pile E	-29.5
Pier 5	Pile E	-23.7
Post-Breakup		**Elevation (ft-BPMSL)[3]**
Pier 2	Pile C	-18.0
Pier 3	Pile C, D, E	-24.0
Pier 4	Pile C, D, E	-30.0
Pier 5	Pile C, D	-22.0
Design 2013		**Elevation (ft-BPMSL)[4,5]**
50-year	**Pier 2-6**	-28.9
	Pier 7-8	-7.1
200-year	**Pier 2-6**	-33.0
	Pier 7-8	-16.4

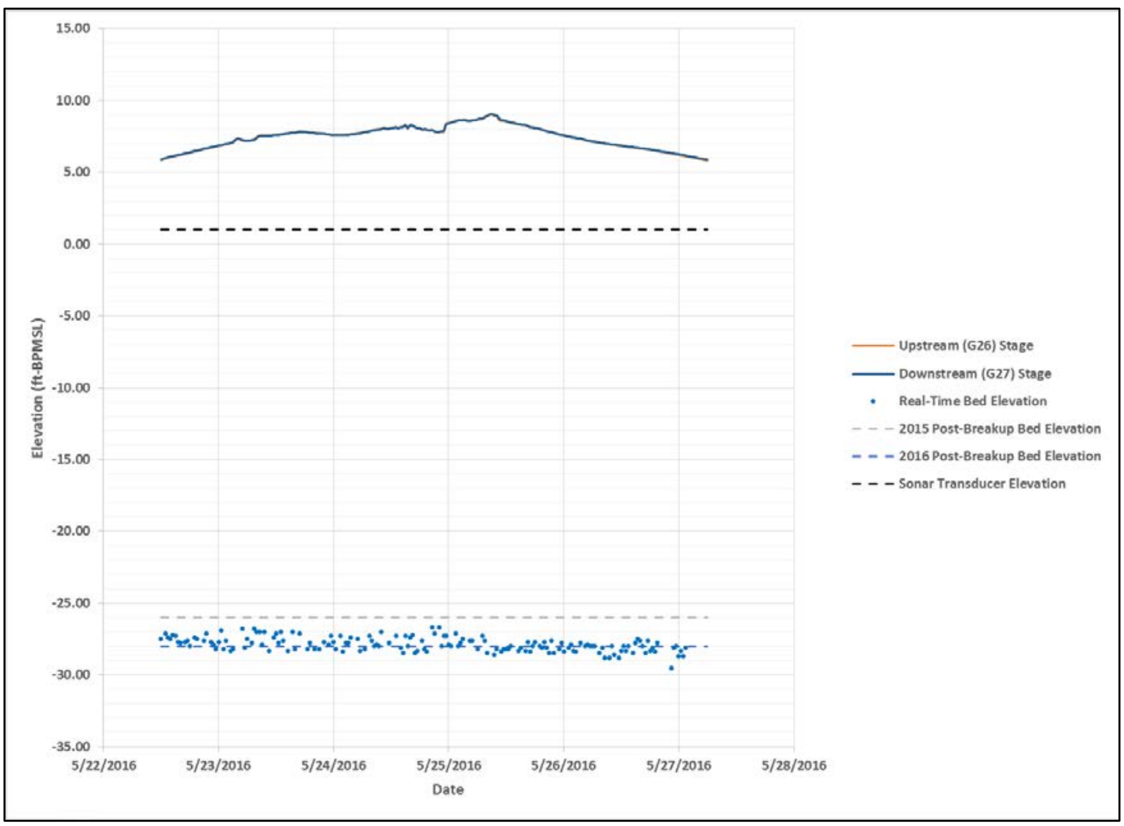
Notes:
1. Minimum channel bed elevations recorded by real-time pier scour monitoring system in May 2016
2. Real-time scour measurements at downstream side of pile E
3. Minimum channel bed elevations surveyed by LCMF in August 2016
4. Design values presented in PND 2013
5. Elevations based on LCMF 2008 survey



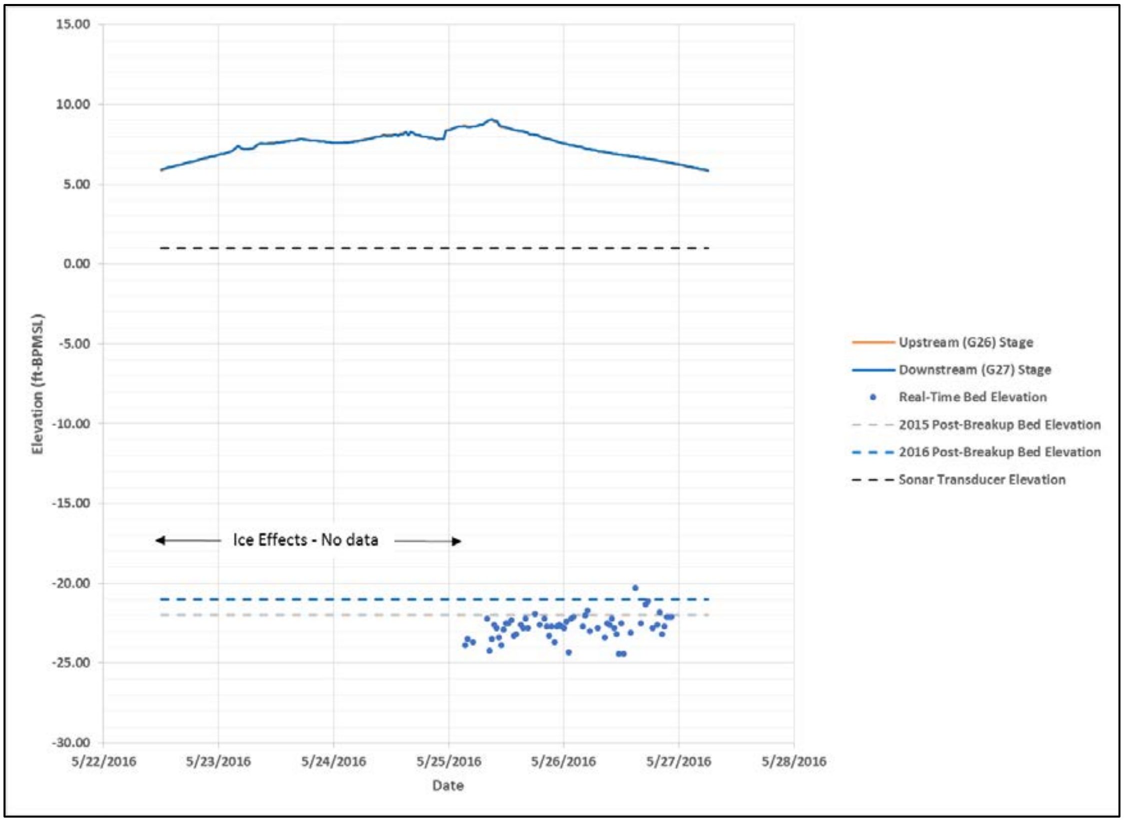
Graph 6.1: Nigliq Bridge Pier 2 (Pile E) Real-Time Scour Elevations



Graph 6.2: Nigliq Bridge Pier 3 (Pile E) Real-Time Scour Elevations



Graph 6.3: Nigliq Bridge Pier 4 (Pile E) Real-Time Scour Elevations



Graph 6.4: Nigliq Bridge Pier 5 (Pile E) Real-Time Scour Elevations

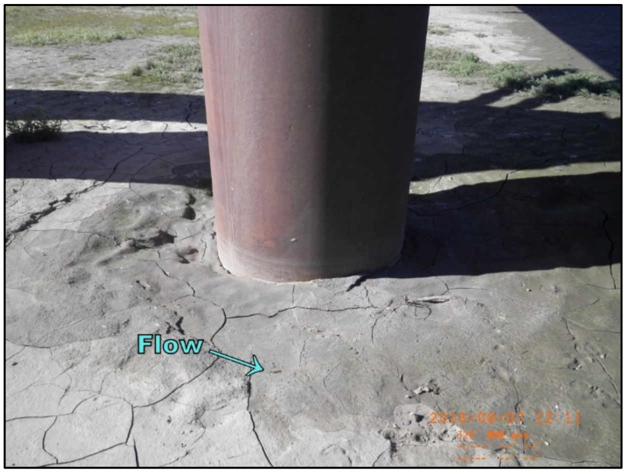


Photo 6.1: Nigliq Bridge pier 7, pile D post-breakup; August 7, 2016

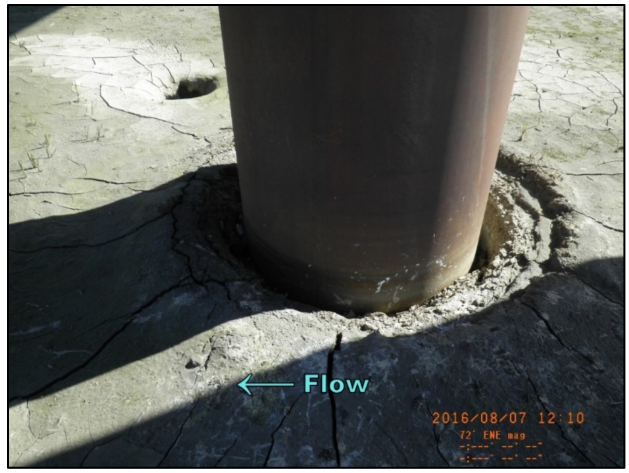


Photo 6.2: Nigliq Bridge pier 8, pile D post-breakup; August 7, 2016

Photo 6.3: Small scour hole around Nigliq Bridge pier 6, piles C, D, & E post-breakup; August 7, 2016

NIGLIAGVIK BRIDGE

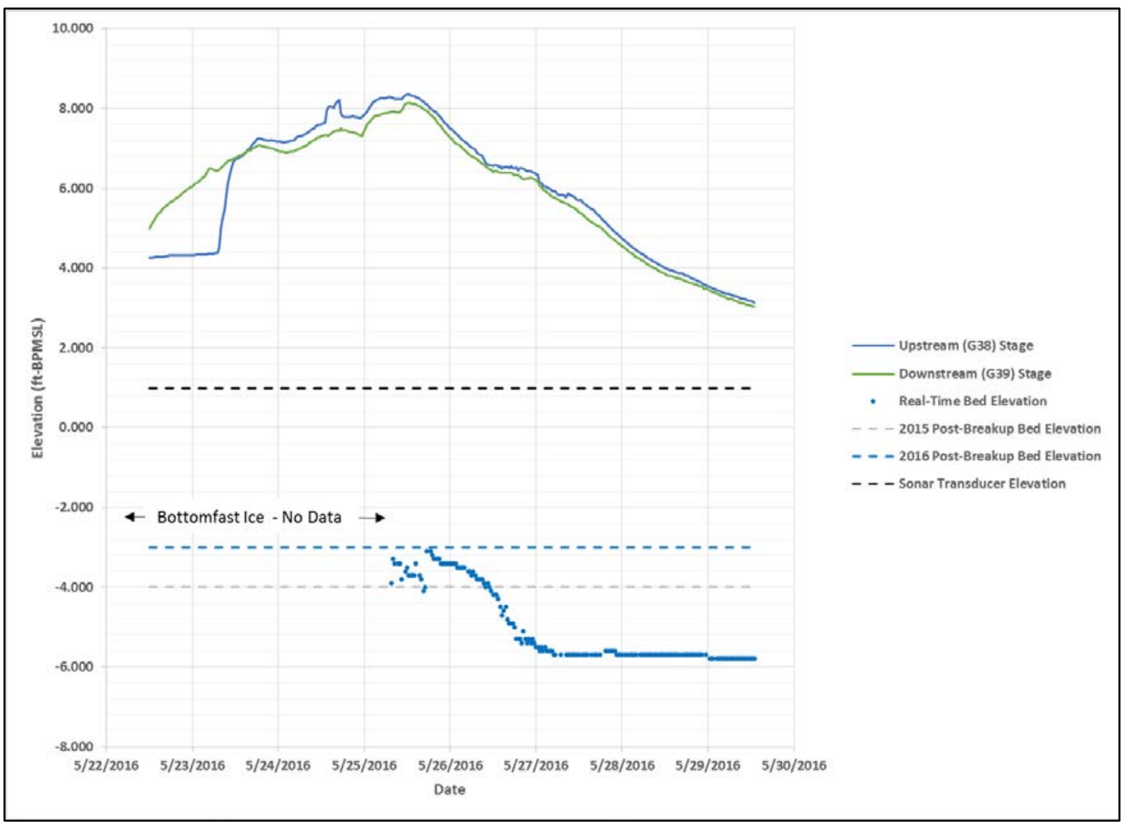
The minimum pier scour elevation, recorded by the real-time scour monitoring system during spring breakup, was -5.8 feet BPMSL at pier 3. The minimum pier scour elevation, surveyed by LCMF post-breakup, was -5.5 feet BMPSL at pier 4 (LCMF 2016d). The post-breakup pier scour elevation is 8.4 feet above the 50-year design scour elevation and 16.0 feet above the 200-year design scour elevation. A comparison of design and observed scour elevations are presented in Table 6.2.

Scour at pier 3 and corresponding WSEs during spring breakup monitoring are presented in Graph 6.5. The maximum scour elevation was recorded just after peak stage. Noisy data prior to May 25 are attributed to the degradation of bottomfast ice at the base of pier 3. A scour hole developed at the base of pier 3 after the bottomfast ice eroded. The post-breakup bed elevation measured in August 2016 indicates infilling of the scour hole to an elevation comparable to post-breakup elevations measured in August 2015. Post-breakup contour plots around the piers are available in Appendix G.1.2.

Table 6.2: Nigliagvik Bridge Comparison of Design and Observed Pier Scour Elevations

Nigliagvik Bridge Pier Scour		
During Breakup		Elevation (ft-BPMSL)[1,2]
Pier 3	Pile B	-5.8
Pier 4	-	-
Post-Breakup		Elevation (ft-BPMSL)[3]
Pier 3	Pile A	-4.5
Pier 4	Pile A	-5.5
Design 2013		Elevation (ft-BPMSL)[4,5]
50-year	**Pier 3-4**	-14.2
200-year	**Pier 3-4**	-21.8

Notes:
1. Minimum channel bed elevations recorded by real-time scour monitoring system in May 2016
2. Real-time pier scour measurements at downstream side of pile B
3. Minimum channel bed elevations recorded by LCMF in August 2016
4. Design values presented in PND 2013
5. Elevations based on LCMF 2008 survey



Graph 6.5: Nigliagvik Bridge Pier 3 (Pile B) Real-Time Scour Elevations

6.2 BANK EROSION

NIGLIQ CHANNEL

A. West Bank

The greatest bank erosion observed between 2013 and 2016 along the west bank was 26.6 feet occurring at station 0+00, approximately 1,200 feet upstream (south) of the Nigliq Bridge. The average rate of erosion at station 0+00 is 8.9 feet per year (ft/yr). The average rate of change for all stations between 2013 and 2016 is approximately 5.4 ft/yr (erosion). This value averages both erosion and deposition. Survey data is presented in Appendix G.1.

Photo 6.4: West bank upstream of the Nigliq Bridge, looking north; July 6, 2016

B. East Bank

The greatest bank erosion observed between 2013 and 2016 along the east bank was 0.2 feet occurring at station 10+00, approximately 400 feet upstream (south) of the Nigliq Bridge. The average rate of erosion at station 10+00 is 0.05 ft/yr. The average rate of change for all stations between 2013 and 2016 is approximately -0.46 ft/yr (deposition). This value averages both erosion and deposition. Survey data is presented in Appendix G.1.

Photo 6.5: East bank at Nigliq Bridge, looking west; July 7, 2016

NIGLIAGVIK CHANNEL

A. West Bank

The greatest bank erosion observed between 2013 and 2016 along the west bank was 9.3 feet occurring at station 0+00, approximately 480 feet upstream (south) of the Nigliagvik Bridge. The average rate of erosion at station 0+00 is 3.1 ft/yr. The average rate of change for all stations between 2013 and 2016 is approximately 3.2 ft/yr (erosion). This value averages both erosion and deposition. Survey data is presented in Appendix G.1.

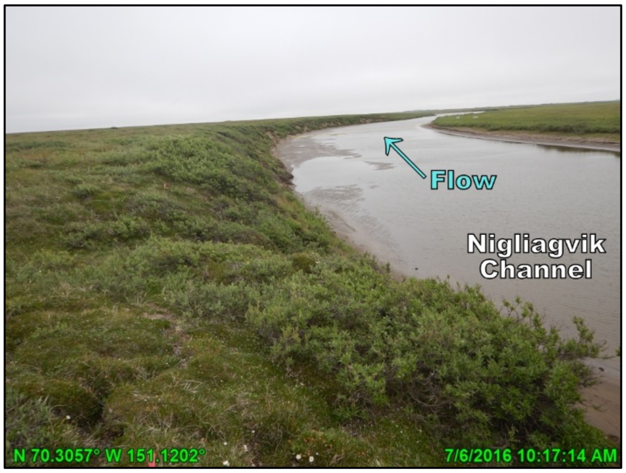


Photo 6.6: West bank downstream of the Nigliagvik Bridge, looking north; July 6, 2016

Photo 6.7: West bank downstream of the Nigliagvik Bridge, looking south; July 6, 2016

B. East Bank

The greatest bank erosion observed between 2013 and 2016 along the east bank was 7.3 feet occurring at station 4+00, approximately 100 feet upstream (south) of the Nigliagvik Bridge (Photo 6.8). The average rate of erosion at station 4+00 is 2.4 ft/yr. The average rate of change for all stations between 2013 and 2016 is approximately 0.8 ft/yr (erosion). This value averages both erosion and deposition. Survey data is presented in Appendix G.2.

Photo 6.8: East bank upstream of the Nigliagvik Bridge, looking west; July 6, 2016

6.3 BATHYMETRY

BATHYMETRY AT BRIDGES

The 2016 survey results at each CD5 bridge location were compared with the 2013, 2014, and 2015 survey results to obtain maximum incremental scour and deposition between 2016 and 2015, and maximum cumulative scour and deposition between 2016 and 2013 (

Table 6.3). Transect locations, profile plots, and data tables are located in Appendix G.3.

Table 6.3: Nigliq Bridge Comparison of Observed Scour Elevations

	Nigliq Bridge			Lake L9341 Bridge			Nigliagvik Bridge		
	Depth (ft)	Station (STA)	Transect	Depth (ft)	Station (STA)	Transect	Depth (ft)	Station (STA)	Transect
Maximum Incremental Scour (2015-2016)	3.0	6+30	9	1.5	4+22	38	2.8	1+45	24
Maximum Cumulative Scour (2013-2016)	11.7	2+67	10	1.4	3+96	36	3.5	1+00	25
Maximum Incremental Deposition (2015-2016)	4.6	8+33	9	1.0	2+01	37	1.9	2+53	26
Maximum Cumulative Deposition (2013-2016)	3.6	8+79	8	0.9	2+20	36	3.5	1+03	26

CHANNEL BATHYMETRY

Every 3 years, all transects of the Nigliq Channel (Transect 01-15) and Nigliagvik Channel (Transect 16-35) are surveyed by LCMF as part of the *Monitoring Plan with an Adaptive Management Strategy* (LCMF 2016b). This plan was put in place to monitor changes related to the hydrologic functions of the CRD. The pre-construction baseline survey was completed in 2013. The maximum scour and deposition are presented in Table 6.4.

Table 6.4: Maximum Channel Scour and Deposition in the Nigliq and Nigliagvik Channels

	Nigliq Channel			Nigliagvik Channel		
	Depth (ft)	Station (STA)	Transect	Depth (ft)	Station (STA)	Transect
Maximum Cumulative Scour (2013-2016)	22.9	1+89	11	3.5	1+00	25
Maximum Cumulative Deposition (2013-2016)	8.8	37+59	13	3.5	1+03	26

7. ICE ROAD CROSSINGS DEGRADATION

Ice roads are constructed annually for ground transportation of supplies and equipment to the Alpine facilities. During the spring, major ice road waterway crossings in the Alpine area were observed to document the degradation process.

Aerial surveys were conducted to observe and photo-document the progression of melting and degradation of the ice road crossings. Observations were conducted at the following ice road crossings (Figure 1.2):

- Colville River East Channel
- Judy Creek
- Kachemach River
- Nigliagvik Channel (Exploration Crossing)
- Nigliq Channel (Exploration Crossing)
- No Name Creek
- Pineapple Gulch
- Ravine #1
- Ravine #2
- Silas Slough
- Slemp Slough
- Tamayayak Channel
- Toolbox Creek
- Ublutuoch (Exploration Crossing)

To facilitate melt and the progression of breakup flooding, ice road crossings are mechanically slotted at the conclusion of the winter season. In general, ice road crossings melted at a similar rate as channel ice. Aerial surveys showed that slotting was completed and the initial floodwaters were passing freely through the ice road crossings. The majority of the crossings were submerged during the peak of flooding. When flooding receded, the ice road crossings and channel ice, had cleared at most locations. Photos of all monitored ice road crossings are presented in Appendix C.2

8. BREAKUP TIMING & MAGNITUDE

Colville River breakup monitoring has been ongoing, intermittently, since 1962. The timing and magnitude of breakup flooding has been determined consistently since 1992 by measuring WSEs and discharge at established locations throughout the delta.

8.1 COLVILLE RIVER – MON1

The most consistent historical record of peak stage and discharge for the CRD is at MON1C, at the head of the delta. Annual peak stage and peak discharge at MON1C has been recorded intermittently from 1962 to 1992 and consistently from 1992 to 2016 (Table 8.1 and Graph 8.1).

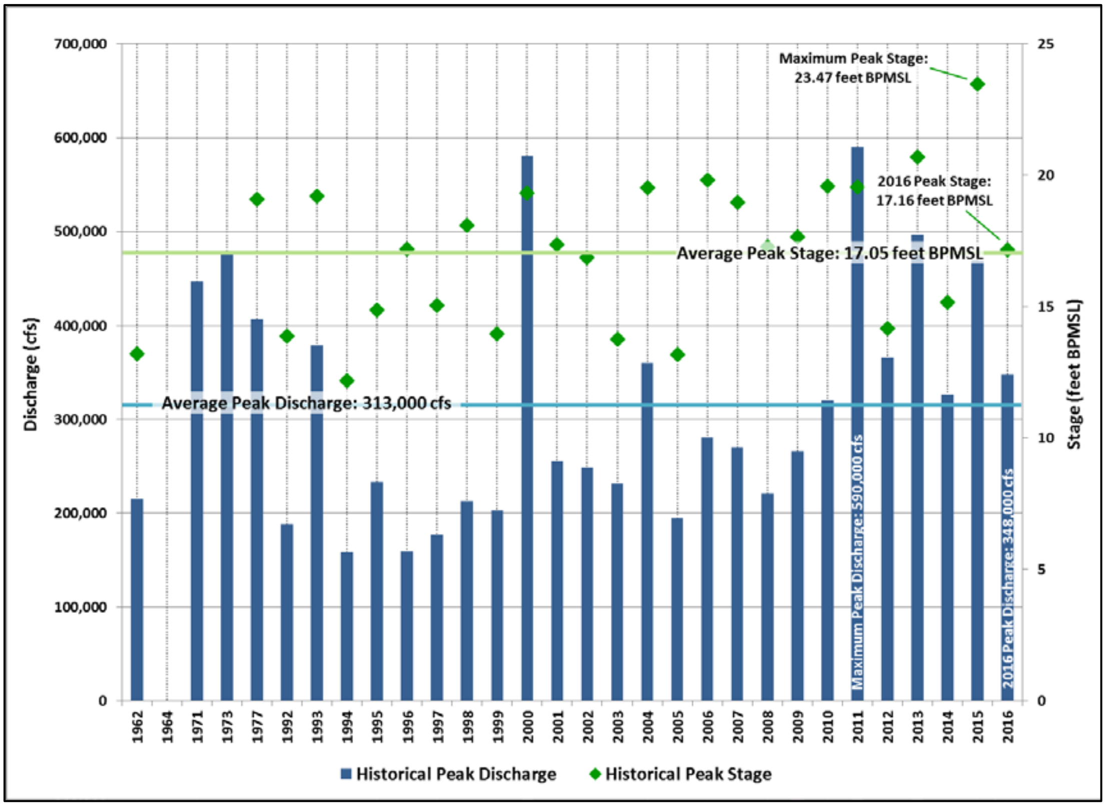
Peak stage at MON1C was 17.16 feet BPMSL and occurred on May 23. The average historical peak stage is 17.05 feet BPMSL and the average date is May 30. The maximum historical peak stage is 23.47 feet BPMSL occurring in 2015.

Peak discharge at MON1C was 348,000 cfs and occurred on May 23. The average historical peak discharge is 313,000 cfs and the average date is May 31. The maximum historical peak discharge is 590,000 cfs occurring in 2011.

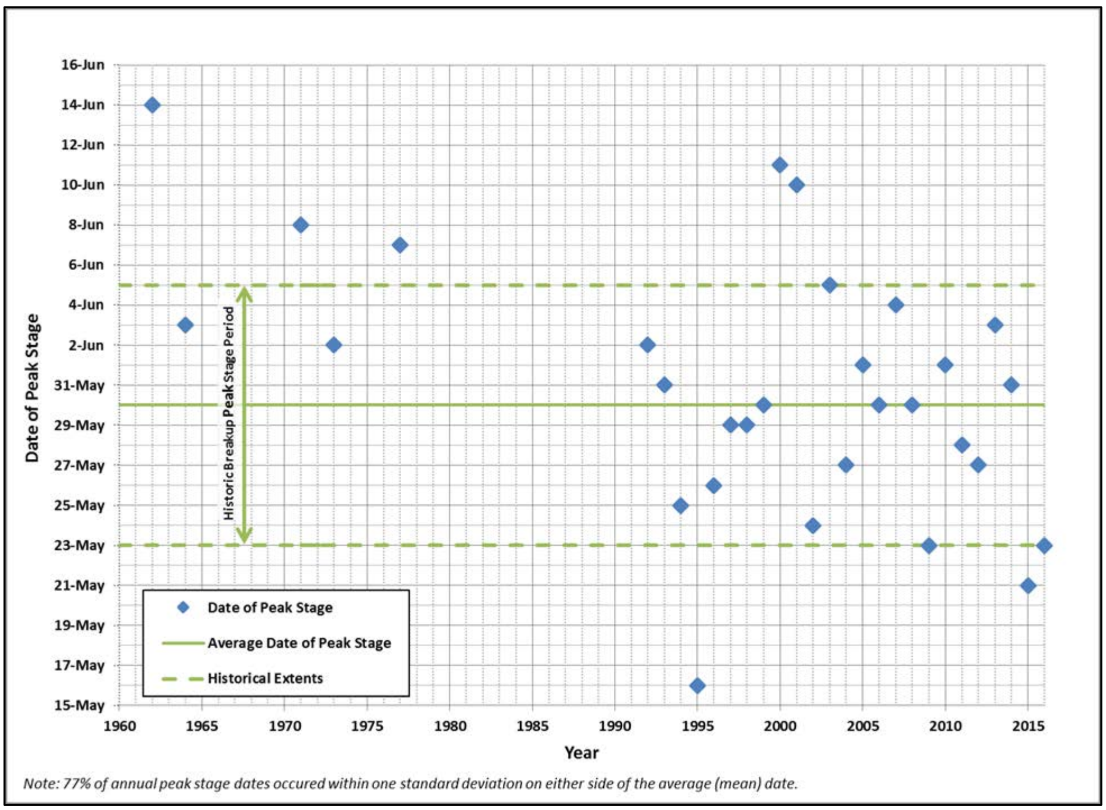
Statistical analysis of historical peak stage dates show 77% of the peaks at MON1C occur during a 14-day period from May 23 to June 5. This represents one standard deviation of 6.5 days on either side of the average (mean) peak stage date of May 30, based on a normal distribution, as illustrated in Graph 8.2. Peak stage at MON1C this year was 7 days prior to the historical average.

Table 8.1: Colville River at MON1C Peak Discharge and Peak Stage Historical Summary

Year	Discharge		Stage (WSE)		Reference
	Peak Discharge (cfs)	Date	Peak Stage (ft BPMSL)	Date	
2016	348,000	23-May	17.16	23-May	This Report
2015	469,000	22-May	23.47	21-May	Michael Baker 2015
2014	327,000	1-Jun	15.18	31-May	Michael Baker 2014
2013	497,000	3-Jun	20.69	3-Jun	Michael Baker 2013
2012	366,000	1-Jun	14.18	27-May	Michael Baker 2012b
2011	590,000	28-May	19.56	28-May	Michael Baker 2012a
2010	320,000	31-May	19.59	1-Jun	Michael Baker 2010
2009	266,000	23-May	17.65	23-May	Michael Baker 2009b
2008	221,000	28-May	17.29	30-May	Michael Baker 2008
2007	270,000	3-Jun	18.97	4-Jun	Michael Baker 2007b
2006	281,000	30-May	19.83	30-May	Michael Baker 2007a
2005	195,000	9-Jun	13.18	1-Jun	Michael Baker 2005b
2004	360,000	26-May	19.54	27-May	Michael Baker 2005a
2003	232,000	11-Jun	13.76	5-Jun	Michael Baker 2006a
2002	249,000	27-May	16.87	24-May	Michael Baker 2006a
2001	255,000	11-Jun	17.37	10-Jun	Michael Baker 2006a
2000	580,000	11-Jun	19.33	11-Jun	Michael Baker 2000
1999	203,000	30-May	13.97	30-May	Michael Baker 1999
1998	213,000	3-Jun	18.11	29-May	Michael Baker 1998b
1997	177,000	-	15.05	29-May	Michael Baker 2002b
1996	160,000	26-May	17.19	26-May	Shannon & Wilson 1996
1995	233,000	-	14.88	16-May	ABR 1996
1994	159,000	25-May	12.20	25-May	ABR 1996
1993	379,000	31-May	19.20	31-May	ABR 1996
1992	188,000	-	13.90	2-Jun	ABR 1996
1977	407,000	-	19.10	7-Jun	ABR 1996
1973	478,000	-	-	2-Jun	ABR 1996
1971	447,000	8-Jun	-	8-Jun	ABR 1996
1964	-	-	-	3-Jun	ABR 1996
1962	215,000	-	13.20	14-Jun	ABR 1996

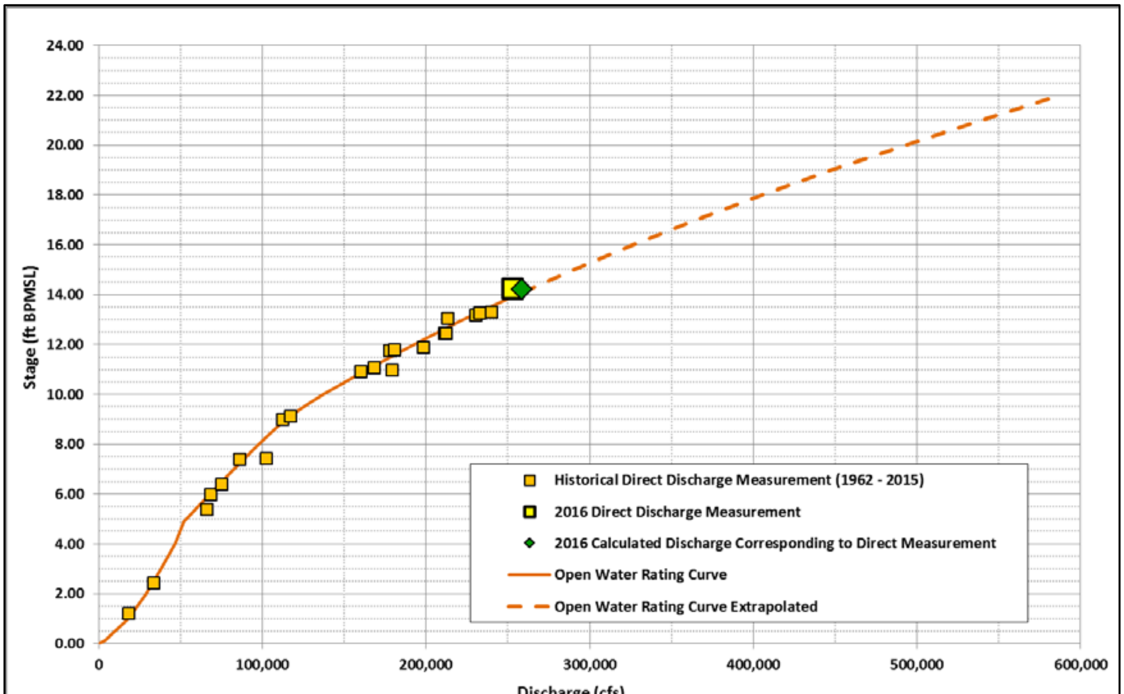


Graph 8.1: MON1C Historical Peak Discharge and Peak Stage



Graph 8.2: MON1C Annual Peak Stage and Timing

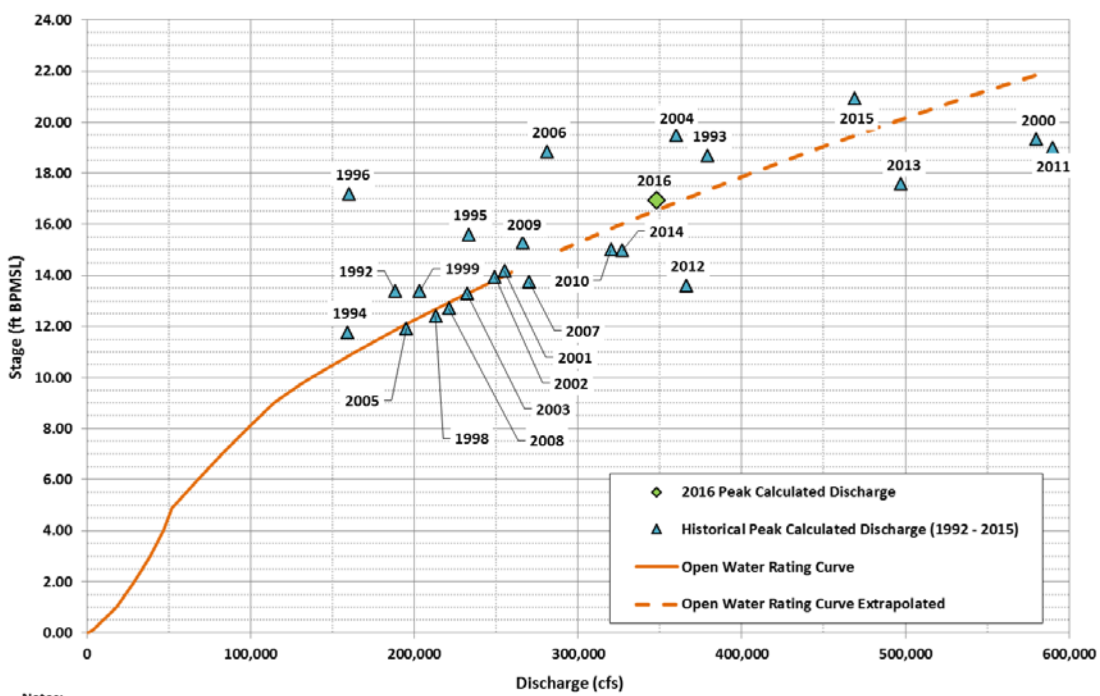
The MON1C stage-discharge rating curve, shown in Graph 8.3, represents a relationship between known stage and corresponding discharge measurements collected between 1992 and 2016. The rating curve was calculated from direct discharge measurements during ice-free conditions. The rating curve more accurately represents the relationship between stage and discharge at lower stage values when ice-free discharge measurements are possible. The 2016 direct discharge measurement of 253,000 cfs and the calculated discharge at the time of measurement of 259,000 cfs, both with corresponding stage of 14.21 feet BPMSL, are plotted for comparison. The 2016 direct discharge measurement and the calculated discharge vary from the rating curve by –3.9% and -1.5%, respectively. The shift is likely due to changes in channel geometry, affecting the calculated discharge.



Notes:
1. Rating curve calculated from direct discharge measurements made during open water (ice free) conditions between 1962 and 2005.
2. Extrapolated portion is extension of slope of curve between highest known stage/discharge values, to be used for reference only.
3. Stage corresponds to direct measurement/indirect calculation
4. Historical direct discharge measurements are those collected during open water conditions; direct measurements from 2006, 2007, 2008, and 2009 were ice-affected and are not included.

Graph 8.3: MON1C Stage-Discharge Rating Curve with Direct Discharge

Calculated (indirect) peak discharge between 1992 and 2016 are plotted against the open water rating curve in Graph 8.4. Open water conditions rarely occur at or near peak stage during breakup. Differences between the indirect discharge and the open water rating curve are attributed to ice effects on stage and discharge. Values that fall to the right of the rating curve tend to be the result of an upstream ice jam release. Conversely, values that fall to the left of the rating curve tend to be the result of downstream ice jam backwater effects. The 2016 calculated peak discharge of 348,000 cfs, with corresponding stage of 16.95 feet BPMSL, falls to the left of the rating curve by -4.2%.



Notes:
1. Rating curve calculated from direct discharge measurements made during open water (ice free) conditions between 1962 and 2005
2. Extrapolated portion is extension of slope of curve between highest known stage/discharge values; to be used for reference only
3. Stage corresponds to direct measurement/indirect calculation
4. Calculated peak discharge in 1997 was 177,000 cfs; corresponding stage data is not available

Graph 8.4: MON1C Stage-Discharge Rating Curve with Peak Discharge

8.2 CD2 ROAD SWALE BRIDGES

Discharge has been measured at the CD2 road swale bridges since 2000, and overall the measurements are estimated to be within 5-10% of the true discharge value based on the quality rating assigned to measurements. A summary of discharge measurements at the Alpine swale bridges is presented with historical data in Table 8.2.

Table 8.2: Alpine Swale Bridges Direct Discharge Historical Summary

Date	Stage[1] (ft)	Stage Differential[2] (ft)	Width (ft)	Area (ft²)	Mean Velocity[3] (ft/s)	Discharge (cfs)	Measurement Rating[4]	Number of Sections	Measurement Type	Reference
Short Swale Bridge (62 ft)										
05/25/16	**7.39**	**0.32**	**53**	**322**	**2.11**	**700**	**G**	**27**	**Cable**	**This Report**
05/23/15	7.85	0.05	54	373	0.81	302	F	19	Cable	Michael Baker 2015
06/02/14	7.90	0.12	54	365	1.31	479	F	28	Cable	Michael Baker 2014
06/05/13	9.75	0.46	54	446	3.60	1,608	G	36	Cable	Michael Baker 2013
06/03/12	7.04	0.17	52	306	1.26	386	F	19	Cable	Michael Baker 2012b
05/28/11	8.15	0.43	52	336	2.51	840	F	27	Cable	Michael Baker 2012a
06/03/10	7.58	0.16	55	316	1.79	570	F	28	Cable	Michael Baker 2010
–[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2009b
05/29/08	6.35	0.18	55	211	0.58	120	P	14	Cable	Michael Baker 2008
06/05/07	7.83	0.09	55	292	1.18	350	F	20	Cable	Michael Baker 2007b
05/31/06	8.49	0.26	55	615	1.59	980	F	20	Cable	Michael Baker 2007a
–[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2005b
05/29/04	8.34	0.14	55	451	1.60	720	F	17	Cable	Michael Baker 2005a
–[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2003
05/25/02	6.74	0.22	56	283	1.52	430	G	17	Cable	Michael Baker 2002b
06/11/01	7.64	0.56	56	336	1.79	600	G	15	Cable	Michael Baker 2001
06/10/00	7.87	0.61	47	175	3.30	580	F	13	Cable	Michael Baker 2000
Long Swale Bridge (452 ft)										
05/25/16	**7.48**	**0.40**	**445**	**2,025**	**2.25**	**4,800**	**G/F**	**28**	**Cable**	**This Report**
05/22/15	9.93	0.55	447	3,024	3.12	9,440	G	24	Cable	Michael Baker 2015
06/02/14	8.00	0.13	445	2,183	1.30	2,842	G	38	Cable	Michael Baker 2014
06/05/13	9.87	0.42	448	2,947	2.47	7,286	G	36	Cable	Michael Baker 2013
06/03/12	7.10	0.17	445	1,686	1.53	2,582	-	26	Cable	Michael Baker 2012b
05/29/11	8.16	0.38	447	2,027	2.22	4,500	F	26	Cable	Michael Baker 2012a
06/01/10	7.97	0.47	441	1,699	2.66	4,500	G	25	Cable	Michael Baker 2010
05/26/09	5.89	0.09	445	1,592	0.82	730	F	27	Wading	Michael Baker 2009b
05/29/08	6.35	0.18	445	949	2.03	1,930	F	21	Wading	Michael Baker 2008
06/05/07	7.76	0.08	447	1,670	0.74	1,240	F	20	Cable	Michael Baker 2007b
05/31/06	8.42	0.18	409	1,730	1.89	3,260	F	29	Cable	Michael Baker 2007a
06/02/05	6.13	0.08	445	841	1.37	1,100	G	20	Wading	Michael Baker 2005b
05/29/04	8.34	0.14	446	1,700	1.40	2,400	F	18	Cable	Michael Baker 2005a
06/08/03	5.48	-0.05	444	478	0.88	420	G	16	Wading	Michael Baker 2003
05/25/02	6.74	0.22	445	930	3.47	3,200	G	17	Cable	Michael Baker 2002b
06/11/01	7.64	0.56	460	1,538	2.40	3,700	G	16	Cable	Michael Baker 2001
06/09/00	7.34	0.78	437	1,220	3.27	4,000	F	15	Cable	Michael Baker 2000

Notes:
1. Source of stage is G3
2. Stage differential between G3/G4 at time of discharge measurement
3. Mean velocities adjusted with angle of flow coefficient
4. Measurement Rating -
   - E - Excellent: 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
5. Bridge obstructed with snow or ice, no measurement made

The calculated peak discharge of 5,500 cfs through both bridges is the same as the average peak historical discharge of 5,500 cfs.

Table 8.3 summarizes the calculated peak annual discharge data at the Alpine swale bridges between 2000 and 2016.

Table 8.3: Alpine Swale Bridges Calculated Peak Discharge Historical Summary (2000-2016)

Date [1]	Peak Stage[2] (ft)	Stage Differential[3] (ft)	Long Swale Bridge (452 ft)		Short Swale Bridge (62 ft)		References
			Discharge[4] (cfs)	Mean Velocity (ft/s)	Discharge[4] (cfs)	Mean Velocity (ft/s)	
05/25/16	7.50	0.44	4,800	2.35	680	2.06	This Report
05/22/15	11.93	1.54	12,350	3.12	484	0.81	Michael Baker 2015
06/02/14	8.18	0.19	2,971	1.30	501	1.31	Michael Baker 2014
06/04/13	10.27	1.17	7,723	2.47	1,706	3.60	Michael Baker 2013
06/03/12	7.60	0.41	2,940	1.53	425	1.26	Michael Baker 2012b
05/29/11	8.89	0.30	5,200	2.22	940	2.51	Michael Baker 2012a
06/02/10	8.64	0.59	5,300	2.66	670	1.79	Michael Baker 2010
05/25/09	7.63	0.45	1,400	0.82	– [5]	– [5]	Michael Baker 2009b
05/30/08	6.49	0.26	2,100	0.49	100	0.58	Michael Baker 2008
06/05/07	8.60	0.43	1,500	1.35	400	1.18	Michael Baker 2007b
05/31/06	9.72	0.87	4,400	1.77	1,100	1.59	Michael Baker 2007a
05/31/05	6.48	0.20	1,400	1.37	– [5]	– [5]	Michael Baker 2005b
05/27/04	9.97	0.50	3,400	1.38	900	1.59	Michael Baker 2005a
06/07/03	6.31	0.12	700	0.88	– [5]	– [5]	Michael Baker 2003
05/26/02	7.59	0.69	4,000	3.47	500	1.52	Michael Baker 2002b
06/11/01	7.95	0.73	3,900	2.40	600	1.79	Michael Baker 2001
06/12/00	9.48	0.73	7,100	3.60	1,000	4.30	Michael Baker 2000

Notes:
1. Based on gage HWM readings
2. Source of stage is Gage 3
3. Stage differential between G3/G4 at time of peak discharge
4. Estimated peak discharge
5. Bridge obstructed with snow or ice, no velocity measurements

8.3 CD5 ROAD BRIDGES

Peak annual discharge has been calculated at the Nigliq Bridge since 2009 and at the Nigliagvik, Lake L9341, and Lake L9323 Bridges since 2012. A summary of the peak stage and peak discharge during breakup flood events for the CD5 road bridge crossings is shown in Table 8.4.

Table 8.4: CD5 Road Bridge Crossings Peak Discharge and Peak Stage Historical Summary

Year	Lake L9323 Bridge		Nigliq Bridge		Lake L9341 Bridge		Nigliagvik Bridge	
	Peak Indirect Discharge (cfs)	Peak Stage [G24] (ft-BPMSL)	Peak Indirect Discharge (cfs)	Peak Stage [G26] (ft-BPMSL)	Peak Indirect Discharge (cfs)	Peak Stage [G32] (ft-BPMSL)	Peak Indirect Discharge (cfs)	Peak Stage [G38] (ft-BPMSL)
Post-Bridge Construction								
2016	- [1]	8.85	65,000	9.05	- [1]	8.65	2,800	8.35
2015[2]	9,100	15.39	112,000	14.50	22,500	14.51	17,300	13.57
2014	- [1]	8.58	66,000	9.38	- [3]	8.48	7,800	8.64
Prior to Bridge Construction								
2013	- [1]	12.40	110,000 [4]	12.42 [5]	5,000 [4]	11.07	7,800 [4]	11.41
2012	- [1]	8.55	94,000 [6]	8.82	6,000 [6]	8.58	11,000 [6]	8.51
2011	- [3]	- [3]	141,000 [6]	9.89 [7]	- [3]	9.5 [8]	- [3]	8.78 [9]
2010	- [3]	- [3]	134,000 [6]	9.65 [7]	- [3]	5.85 [8]	- [3]	8.69 [9]
2009	- [3]	- [3]	57,000 [6]	7.91 [7]	- [3]	7.98 [8]	- [3]	7.71 [9]

Notes:
1. No discharge reported because of a lack of hydraulic connection through bridge, backwater flow, and/or ice conditions return unreasonable calculation results
2. Discharge influenced by flow contraction through bridges
3. Data not available
4. Indirect discharge computed with consideration of intact channel ice present at time of peak discharge
5. Inferred from G25 at Lake L9323 Crossing
6. Indirect discharge computed as open water conditions, even though channel ice was present at time of peak discharge
7. Stage data from decommissioned gage G21 at proposed bridge centerline
8. Stage data from decommissioned gage G22 at proposed bridge centerline
9. Stage data from decommissioned gage G23 at proposed bridge centerline

8.4 ALPINE DRINKING WATER LAKES RECHARGE

Recharge of Alpine drinking water lakes, Lakes L9312 and L9313, has been documented annually since 1998. Primary recharge mechanisms for these lakes are overland flood flow and local melt. Lakes are determined to be fully recharged if bankfull conditions are met; either overland floodwater was observed flowing into the lake, or there was evidence of a stage rise and fall on the breakup hydrograph.

In most years, Lake L9313 is recharged by overland flow from the Sakoonang Channel via the North Paleo Lake and Lake M9525. The historical record of observed flooding and stage monitoring indicate bankfull elevation of Lake L9313 is approximately 6.5 feet BPMSL (Michael Baker 2006a, 2007b) at gage G10.

Lake L9312 is surrounded by higher tundra than Lake L9313 and is less frequently recharged by floodwater from the Sakoonang Channel. Recharge at this lake relies more on local melt of snow and ice and precipitation. Bankfull elevation of Lake L9312 is 7.8 feet BPMSL per the Fish Habitat Permit FG99-III-0051-Amendment #8.

Table 8.5 provides a historical summary of Alpine drinking water lakes stage and bankfull recharge record. Lake L9313 has recharged to bankfull 17 of the last 19 years, and Lake L9312 has recharged to bankfull 14 of the last 19 years. This year, Lake L9312 did not recharge to bankfull elevation.

Table 8.5: Alpine Drinking Water Lakes Historical Summary of Recharge

Year	Lake L9312		Lake L9313	
	Peak Stage (ft BPMSL)	Bankfull Recharge to 7.8 ft BPMSL[1]	Peak Stage (ft BPMSL)	Bankfull Recharge to 6.5 ft BPMSL[2]
2016	7.47	No[3]	8.15	Yes
2015	13.32	Yes	12.71	Yes
2014	7.94	Yes	8.59	Yes
2013	8.79	Yes	10.44	Yes
2012	8.23	Yes	8.20	Yes
2011	10.72	Yes	10.67	Yes
2010	7.63	No[3]	7.52	Yes
2009	7.65	No[3]	7.12	Yes
2008	7.45	No[3]	6.95	Yes
2007	9.35	Yes	9.47	Yes
2006	9.55	Yes	9.95	Yes
2005	8.00	Yes	6.12	No[3]
2004	8.37	Yes	9.40	Yes
2003	8.01	Yes	7.12	Yes
2002	8.05	Yes	7.98	Yes
2001	7.55	No[3]	8.31	Yes
2000	-	Yes	-	Yes
1999	7.93	Yes	6.14	No[3]
1998	8.35	Yes	7.35	Yes

Notes:
1. Bankfull recharge is based on peak stage exceeding 7.8 ft BPMSL per Fish Habitat Permit FG99-III-0051, Amendment #8.
2. Bankfull recharge elevation is based on visual observations of hydraulic connectivity of lake to breakup floodwater.
3. Lake recharged from snow meltwater.

9. FLOOD & STAGE FREQUENCY ANALYSES

9.1 FLOOD FREQUENCY

A flood frequency analysis is performed every three years for the head of the CRD at MON1 to estimate flood magnitudes for standard recurrence intervals. The current basis of design flood magnitudes were compared with the flood frequency analysis results to ensure the basis of design values are relevant as the body of data grows. The most recent flood frequency analysis was performed in 2015. These values are presented in Table 9.1 along with the current basis of design.

Table 9.1: Colville River Flood Frequency Analysis Results

Return Period	Basis for Current Design Criteria[1]	2015 Analysis Values[2]
	Flood Discharge (cfs)	Flood Discharge (cfs)
2-year	240,000	261,000
5-year	370,000	394,000
10-year	470,000	491,000
25-year	610,000	623,000
50-year	730,000	727,000
100-year	860,000	837,000
200-year	1,000,000	953,000

Note:
1. (Baker and Hydroconsult 2002)
2. (Baker 2015)

This year's peak discharge of 348,000 cfs has a recurrence interval of 4.5 years. The flood recurrence interval should be considered with respect to conditions at the time of peak discharge. Peak discharge was the result of an upstream ice jam release, sending a surge of ice floes and floodwater through the MON1 reach, and was not a sustained event. The ranking of the 2016 peak discharge relative to the historical record (evaluated using current basis of design flood magnitudes) is shown in Table 9.2.

Table 9.2: Colville River at MON1 Peak Flood Historical Record

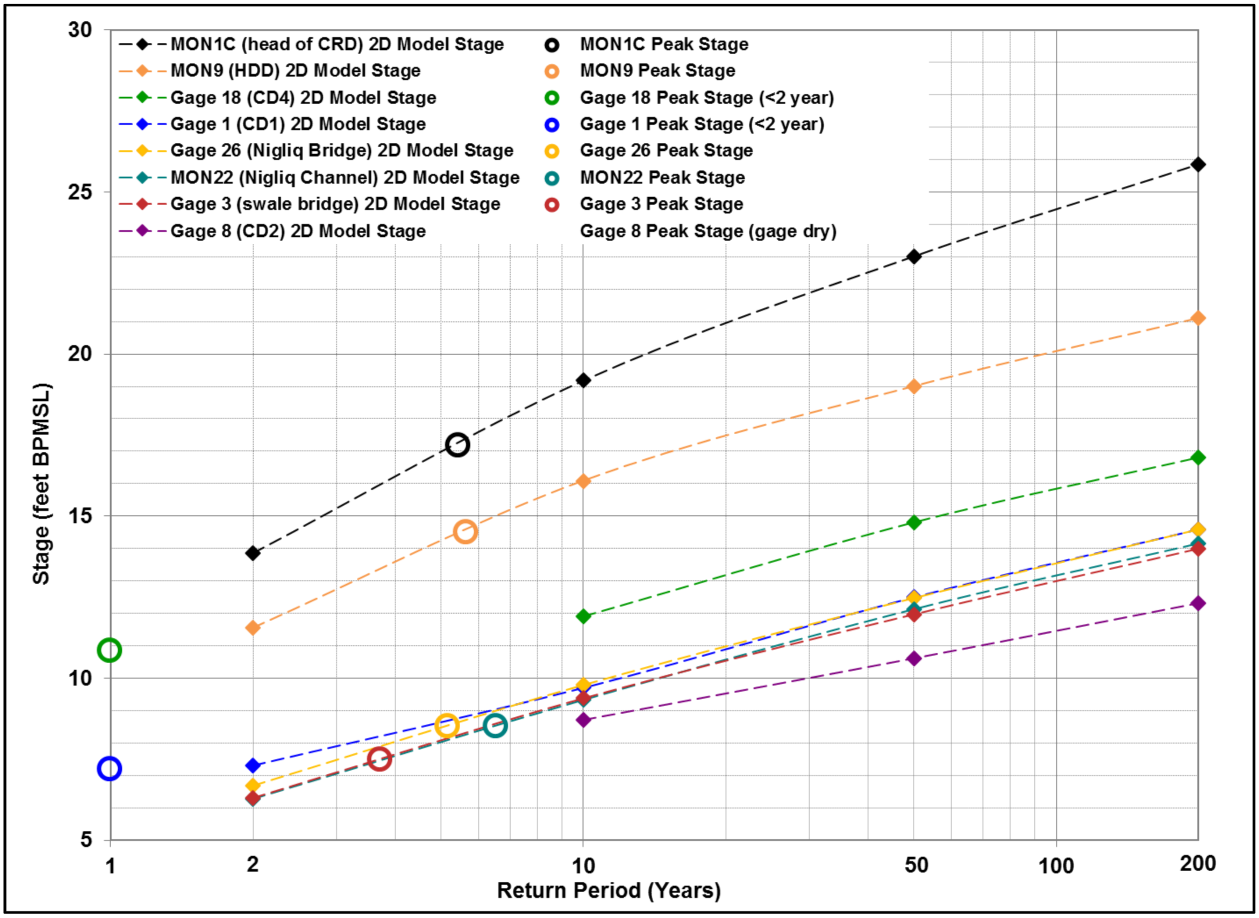
Year	Peak Discharge (cfs)	Flood Recurrence Interval (years)
2011	590,000	22.9
2000	580,000	21.8
2013	497,000	12.9
2015	469,000	10.0
1993	379,000	5.5
2012	366,000	4.9
2004	360,000	4.8
2016	**348,000**	**4.5**
2014	327,000	4.0
2010	320,000	3.8
2006	281,000	2.9
2007	270,000	2.7
2009	266,000	2.6
2001	255,000	2.3
2002	249,000	2.2
1995	233,000	<2
2003	232,000	<2
2008	221,000	<2
1998	213,000	<2
1999	203,000	<2
2005	195,000	<2
1997	177,000	<2
1994	165,000	<2
1992	164,000	<2
1996	160,000	<2

9.2 TWO-DIMENSIONAL SURFACE WATER MODEL

The CRD 2D surface water model was first created in 1997 to estimate stage and velocities at the proposed Alpine facility locations (Baker 1998a). The model has undergone numerous revisions to include improved topographic and bathymetric data and the CD3, CD4, and CD5 facilities (Baker 2002a, Baker 2006b, Baker 2009a and Baker 2012b).

The 2D model was developed to predict open water flood conditions during low-frequency, high-magnitude events, i.e. design events having 50- and 200-year recurrence intervals. To estimate the relationship between discharge and stage during more frequent, lower magnitude floods, 2- and 10-year recurrence intervals have also been modeled. Peak stage at select monitoring locations was assigned a recurrence interval relative to the 2D model predictions (Graph 9.1 and Table 9.3). The 2D model assumes open water steady-state conditions and does not account for snow, channel ice, or ice jams. Elevated stage resulting from snow and ice effects is typically localized and more pronounced during lower magnitude flood events. As a result, the 2D model generally under-predicts stage for lower recurrence intervals of approximately 10-years and less.

Based on the 2D model predictions, flood stage recurrence intervals throughout the CRD ranged from less than 2-years to 39-years. All but one monitoring location fell below the 10-year recurrence interval. The 39-year recurrence interval at MON28 is attributed to its location at the northern edge of the delta and its close proximity to the downstream boundary of the 2D model. The range of predicted stage at MON28 is very small (1.2 feet) so assigned recurrence intervals can vary widely with small changes in stage. Additionally, influences such as coastal ice and tidal and wind events affect this location.



Graph 9.1: 2D Model and Observed Peak Stage

Table 9.3: 2D Model Stage and Observed Peak Stage

Monitoring Location	2D Model Predicted Stage Recurrence Intervals (feet BPMSL)				Observed Peak Stage (feet BPMSL)	Approximate Recurrence Interval of Peak Stage Based on 2D Model (years)
	2-year	10-year	50-year	200-year		
Colville River						
MON1C (head of CRD)	13.9	19.2	23.0	25.9	17.2	5
Colville River East Channel						
MON9 (HDD)	11.5	16.1	19.0	21.1	14.5	6
MON35 (Helmericks)	4.3	5.4	6.1	6.5	3.6	<2
Nigliq Channel						
MON20	7.8	11.4	14.6	16.8	10.3	6
MON22	6.3	9.3	12.1	14.2	8.5	7
MON23	5.1	7.4	10.2	12.0	6.8	6
MON28	3.1	3.4	3.9	4.3	3.8	39
CD1 Pad						
Gage G1	7.3	9.7	12.5	14.6	7.2	<2
Gage G9 (Lake L9312)	8.3	10.8	13.4	15.7	7.5	<2
Gage G10 (Lake L9313)	8.3	10.8	13.4	15.7	8.4	2
CD2 Pad						
Gage G8	\	8.7	10.6	12.3	Dry	-
CD2 Road						
Gage G3 (swale bridges)	6.3	9.4	12.0	14.0	7.5	4
Gage G4 (swale bridges)	6.2	8.5	10.1	11.6	7.1	4
Gage G6	\	9.5	12.2	14.2	7.9	<10
Gage G7	\	8.4	10.0	11.6	7.9	<10
Gage G12	\	9.5	12.1	14.1	7.9	<10
Gage G13	\	8.4	10.0	11.6	7.7	<10
CD3 Pad						
Gage G11	5.2	6.4	6.9	8.0	Dry	-
CD4 Pad						
Gage G19	\	\	14.7	16.8	Dry	-
Gage G20	\	11.1	14.3	16.4	9.3	<10
CD4 Road						
Gage G15	8.4	10.8	13.5	15.9	8.4	2
Gage G16	8.4	11.1	14.2	16.3	8.4	2
Gage G17	\	11.1	14.2	16.3	10.5	<10
Gage G18	\	11.9	14.8	16.8	10.8	<10
CD3 Pipeline Crossings						
SAK Gage (Crossing #2)	6.4	8.9	11.2	12.9	6.7	2
TAM Gage (Crossing #4)	6.7	8.5	9.0	9.8	8.1	7
ULAM Gage (Crossing #5)	5.5	7.1	7.8	8.7	6.9	8
CD5 Road						
Gage G24 (Lake L9323)	\	11.1	14.1	16.0	8.8	<10
Gage G26 (Nigliq Channel)	6.7	9.8	12.5	14.6	8.5	5
Gage G27 (Nigliq Channel)	6.7	9.8	12.5	14.5	8.6	5
Gage G30	\	\	13.3	15.5	Dry	-
Gage G32 (Lake L9341)	\	\	13.3	15.1	8.4	<50
Gage G34	\	\	13.3	15.7	Dry	-
Gage G36	\	\	13.3	15.7	Dry	-
Gage G38 (Nigliagvik Channel)	6.9	10.0	12.8	14.9	8.4	4

Notes:
1. Sites having dry ground in 2D model are denoted with a backward slash "\"
2. 2D water surface elevations based on post-CD5 model results
3. Sites that remained dry during 2016 spring breakup are denoted with a dash "-"

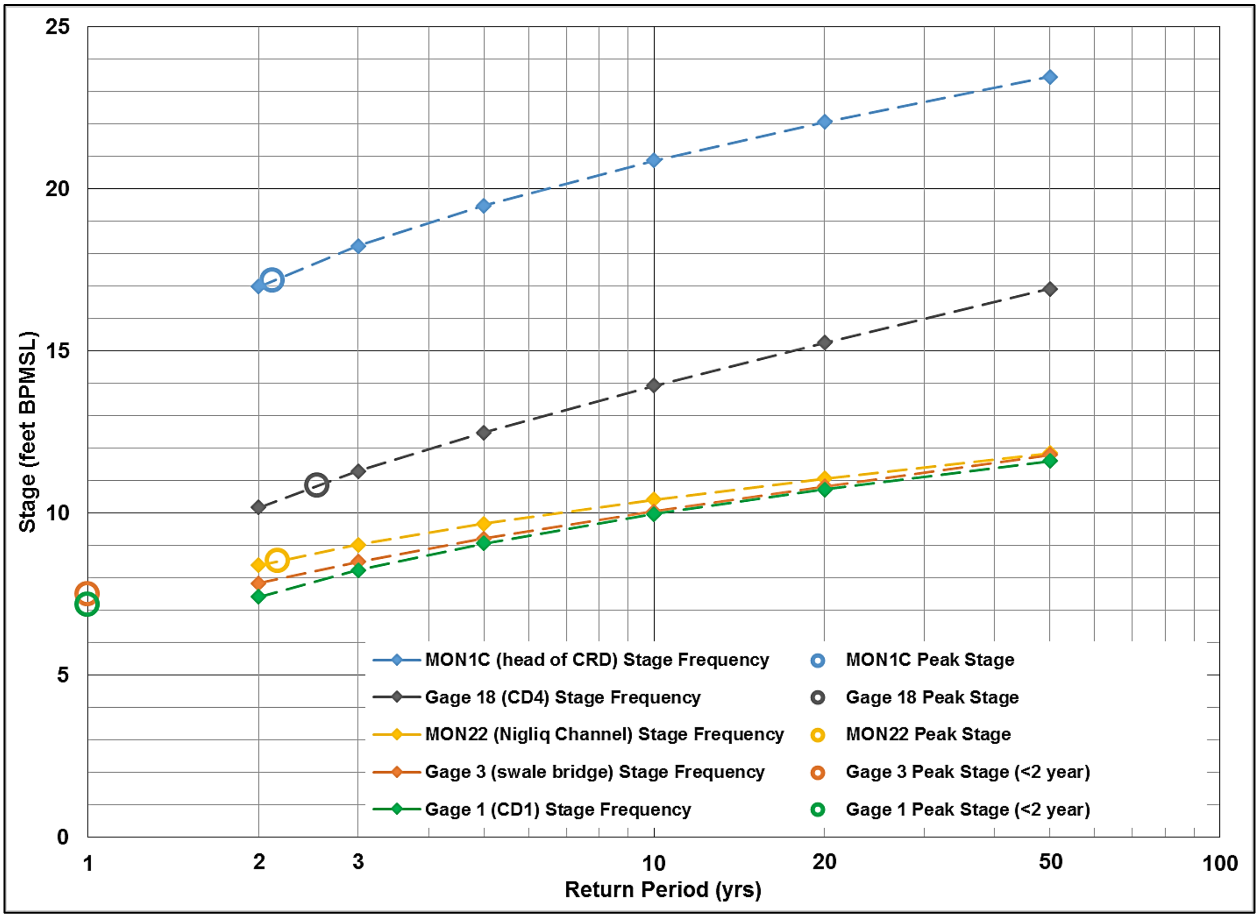
9.3 STAGE FREQUENCY

A site-specific stage frequency analysis can provide a better estimate of low magnitude recurrence intervals. MON1C, MON22, gage G1, gage G3, and gage G18 have the longest periods of continuous record and are distributed throughout the project area. Analyses have been performed every three years as the body of data grows (Baker 2007a, Baker 2009a, and Baker 2012b), the most recent being in 2015 (Baker 2015). The maximum period of continuous record is 24 years at MON1C.

It is considered risky to extrapolate stage data for a river impacted by ice and ice jamming beyond the continuous record (USACE 2002; FEMA 2003). This is because of the inherent unpredictability of ice jams, the greater impact ice effects have on lower magnitude events, and the upper limit of stage considering available floodplain storage for overbank flow (i.e. water height can only increase so much once it has crested the banks and spilled into the floodplain). Stage frequency was extrapolated to the 50-year recurrence interval, almost twice the continuous record at MON1C, for comparison to the 2D model because this is where the 2D model results and stage frequency analysis results tend to converge. Unlike the 2D model, the observed data upon which the stage frequency analyses are based reflect ice-affected flooding conditions. Therefore the stage frequency analysis results can be used to supplement design criteria for low-magnitude, ice impacted flood events. Results from the most recent stage frequency analysis are compared to this year's observed peak stage in Table 9.4 and Graph 9.2. Based on the stage frequency analysis, flood stage recurrence ranged from less than 2-years to 2.5-years.

Table 9.4: Stage Frequency Analysis Results and Observed Peak Stage

Monitoring Location	Stage Frequency Recurrence Interval (feet BPMSL)						Observed Peak Stage (feet BPMSL)	Approximate Recurrence Interval of Peak Stage Based on Frequency Analysis (years)
	2-year	3-year	5-year	10-year	20-year	50-year		
MON1C (head of CRD)	16.99	18.24	19.49	20.88	22.08	23.46	17.16	2.1
MON22 (Nigliq Channel)	8.40	9.03	9.68	10.42	11.07	11.85	8.52	2.2
Gage G1 (CD1 pad)	7.41	8.24	9.06	9.97	10.73	11.60	7.17	<2
Gage G3 (CD2 road)	7.84	8.50	9.21	10.05	10.83	11.80	7.49	<2
Gage G18 (CD4 road)	10.17	11.30	12.49	13.93	15.26	16.92	10.84	2.5



Graph 9.2: Stage Frequency Analysis Results and Observed Peak Stage

10. REFERENCES

Alaska Biological Research (ABR). 1996. Geomorphology and Hydrology of the Colville River Delta, Alaska, 1995. Prepared for ARCO Alaska, Inc.

Benson, M. A. and Tate Dalrymple. 1967. General Field and Office Procedures for Indirect Discharge Measurements: Techniques of Water-Resources Investigations of the United States Geological Survey. USGS-TWRI Book 3, Chapter A1. United States Government Printing Office, Washington, DC. USGS. 1967.

Chow, V.T., 1959, Open-Channel Hydraulics, New York, McGraw-Hill, p. 138.

Federal Emergency Management Agency (FEMA). 2003. Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix F: Guidance for Ice-Jam Analysis and Mapping. April 2003.

ICE Consult and Design (ICE). 2015 NPR-A North Tundra Monitoring Station. Cumulative Freezing Degree Days. Winters 2002-2015 Coldest to Warmest Year. October 1, 2015.

Michael Baker International (Michael Baker). 1998a. Colville River Delta Two-Dimensional Surface Water Model Project Update. September 1998. Prepared for ARCO Alaska, Inc.

-------- 1998b. 1998 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska. October 1998. Prepared for ARCO Alaska, Inc.

-------- 1999. 1999 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska. November 1999. Prepared for ARCO Alaska, Inc.

-------- 2000. Alpine Facilities Spring 2000 Breakup Monitoring Alpine Development Project. November 2000. Prepared for Phillips Alaska, Inc.

-------- 2001. Alpine Facilities 2001 Spring Breakup and Hydrologic Assessment. August 2001. Prepared for Phillips Alaska, Inc.

-------- 2002a. Colville River Delta Two-Dimensional Surface Water Model, CD-Satellite Project Update. May 2002. Prepared for ConocoPhillips Alaska, Inc.

-------- 2002b. Alpine Facilities 2002 Spring Breakup and Hydrologic Assessment. October 2002. Prepared for ConocoPhillips Alaska, Inc.

-------- 2003. Alpine Facilities 2003 Spring Breakup and Hydrologic Assessment. September 2003. Prepared for ConocoPhillips Alaska, Inc.

-------- 2005a. Alpine Facilities 2004 Spring Breakup and Hydrologic Assessment. March 2005. Prepared for ConocoPhillips Alaska, Inc.

-------- 2005b. 2005 Colville River Delta and Fish Creek Basin Spring Breakup and Hydrologic Assessment. December 2005. Prepared for ConocoPhillips Alaska, Inc.

-------- 2006a. 1992-2005 Annual Peak Discharge Colville River Monument 1 Estimate, Calculation, and Method Review. Prepared for ConocoPhillips Alaska, Inc.

-------- 2006b. Colville River Delta Two-Dimensional Surface Water Model CD5 Update. February 2006. Prepared for ConocoPhillips Alaska, Inc.

-------- 2007a. 2006 Colville River Delta and Fish Creek Basin Spring Breakup and Hydrological Assessment. January 2007. Prepared for ConocoPhillips Alaska, Inc.

-------- 2007b. 2007 Colville River Delta Spring Breakup and Hydrologic Assessment. November 2007. Prepared for ConocoPhillips Alaska, Inc.

-------- 2008. 2008 Colville River Delta Spring Breakup and Hydrologic Assessment. December 2008. Prepared for ConocoPhillips Alaska, Inc.

-------- 2009a. Colville River Delta, Two-Dimensional Surface Water Model Update. CD5 Alpine Satellite Development Project. September 2009. Prepared for ConocoPhillips Alaska, Inc.

-------- 2009b. Colville River Delta Spring Breakup 2009 Hydrologic Assessment. December 2009. Prepared for ConocoPhillips Alaska, Inc.

-------- 2009c. Alpine Pipeline River Crossings 2009 Monitoring Report. September 2009. Prepared for ConocoPhillips Alaska, Inc.

-------- 2010. 2010 Colville River Delta Spring Breakup 2010 Hydrologic Assessment. November 2010. Prepared for ConocoPhillips Alaska, Inc.

-------- 2012a. Colville River Delta Spring Breakup 2011 Hydrologic Assessment. January 2012. Prepared for ConocoPhillips Alaska, Inc.

-------- 2012b. 2012 Colville River Delta Spring Breakup Monitoring and Hydrologic Assessment. December 2012. Prepared for ConocoPhillips Alaska, Inc.

-------- 2013a. 2013 Colville River Delta Spring Breakup Monitoring and Hydrologic Assessment. November 2013. Prepared for ConocoPhillips Alaska, Inc.

-------- 2013b. 2012 Colville River Delta Two-Dimensional Surface Water Model Update & CD5 Bridge Scour Analysis. 127873-MBJ-2D-2012. January 28, 2013.

------- 2014. 2014 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment. November 2014. Prepared for ConocoPhillips Alaska, Inc.

------- 2015. 2015 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment. November 2015. Prepared for ConocoPhillips Alaska, Inc.

Michael Baker International (Michael Baker) and Alaska Biological Research (ABR), 2013 Monitoring Plan with an Adaptive Management Strategy CD5 Development Project for ConocoPhillips, Alaska. March 2013.

Michael Baker International (Michael Baker) and Hydroconsult EN3 Services, Ltd. 2002. Colville River Flood Frequency Analysis, Update. September 2002. Prepared for ConocoPhillips Alaska, Inc.

Natural Resource Conservation Service (NRCS). 2016. Alaska Snow Survey Report. April 2016. United States Department of Agriculture (USDA).

Office of Surface Water (OSW). 1999a. Development of New Standard Rating Tables for the Price Type AA and Pygmy Current Meters. Technical Memorandum No. 99.05. Website access 2009. (http://water.usgs.gov/admin/memo/SW/sw99.05.html). U.S. Geological Survey (USGS).

-------- 1999b. Care and Maintenance of Vertical-Axis Current Meters. Technical Memorandum No. 99.06. Website access 2009. (http://water.usgs.gov/admin/memo/SW/sw99.06.html). USGS.

PND Engineers (PND). 2013. Proposed CD5 Access Road Bridges Scour Estimates Summary. May 2013.

Shannon & Wilson, Inc. 1996. 1996 Colville River Delta Spring Breakup and Hydrologic Assessment, North Slope, Alaska. November 1996. Prepared for Michael Baker Jr., Inc.

UMIAQ/LCMF LLC, Inc. (LCMF) 2002. As-built survey. CD2 and CD4 culverts. Prepared for ConocoPhillips Alaska, Inc. (Submitted as Kuukpik/LCMF LLC, Inc. [LCMF]).

-------- 2004. Cross-section survey, Colville River at Monument 01. Prepared for Michael Baker Jr., Inc. (Submitted as Kuukpik/LCMF LLC, Inc. [LCMF]).

-------- 2005. Cross-section survey, Colville River at Monument 23. Prepared for Michael Baker Jr., Inc. (Submitted as Kuukpik/LCMF LLC, Inc. [LCMF]).

-------- 2008. Cross-section survey, proposed 2008 CD-5 road Nechelik [Nigliq] Channel crossing. Prepared for Conoco Phillips Alaska, Inc. (Submitted as Kuukpik/LCMF LLC, Inc. [LCMF]).

-------- 2009. Cross-section survey, Colville East Channel at Monument 09. Prepared for Conoco Phillips Alaska, Inc. (Submitted as Kuukpik/LCMF LLC, Inc. [LCMF]).

-------- 2012. As-built survey, CD2 and CD4 culvert invert elevations. Prepared for ConocoPhillips Alaska, Inc. May 2012.

-------- 2013. As-built survey, CD2 and CD4 culvert invert elevations. Prepared for ConocoPhillips Alaska, Inc. May 2013.

-------- 2014a. As-built survey, CD5 culvert invert elevations. Prepared for ConocoPhillips Alaska, Inc. May 2014.

-------- 2014b. Cross-section survey of the Nigliq Channel crossing. Prepared for ConocoPhillips Alaska, Inc. 2014.

-------- 2014c. Cross-section survey of the Nigliagvik Channel crossing. Prepared for ConocoPhillips Alaska, Inc. 2014.

-------- 2015a. As-built survey, CD2 and CD4 culvert invert elevations. Prepared for ConocoPhillips Alaska, Inc. June 2015.

-------- 2015b. As-built survey, CD5 culvert invert elevations. Prepared for ConocoPhillips Alaska, Inc. August 2015.

-------- 2016a. As-built survey, CD2, CD4, and CD5 access road culverts. Prepared for ConocoPhillips Alaska, Inc. July 2016.

-------- 2016b. Cross-section survey of the Nigliq & Nigliagvik Channel crossings. Prepared for ConocoPhillips Alaska, Inc. July 2014.

-------- 2016c. Top of bank survey of the Nigliq & Nigliagvik Channel crossings. Prepared for ConocoPhillips Alaska, Inc. July 2016.

-------- 2016d. CD5 access road Nigliq & Nigliagvik Bridge scour monitoring. Prepared for ConocoPhillips Alaska, Inc. July 2016.

U.S. Army Corps of Engineers (USACE). 2002. U.S. Army Corps of Engineers Ice Engineering Manual EM 1110-2-1612. Washington D.C. 30 October 2002.

-------- 2010. User's Manual for HEC-SSP Statistical Software Program Version 2.0, Annual Flood-Frequency Analysis Using Bulletin 17B Guidelines. Brunner, G.W. and Fleming, M.J.

U.S. Geological Survey (USGS). 1976. Matthai, H.F. 1967. Measurement of Peak Discharge at Width Contractions by Indirect Methods: Techniques of Water-Resources Investigations of the U.S. Geological Survey. USGS-TWRI Book 3, Chapter A4. United States Government Printing Office, Washington, DC. 1967.

-------- 1982. Measurement and Computation of Streamflow, Vols. 1 and 2. S.E. Rantz and others. Water Supply Paper 2175.

-------- 1991. U.S. Army Corps of Engineers Ice-Influenced Flood Stage Frequency Analysis TL 110-2-325. Washington D.C. July 2002.

-------- 2005. Quality-Assurance Plan for Discharge Measurements Using Acoustic Doppler Current Profilers. Lipscomb, Steven W., Scientific Investigations Report 2005-5183.

-------- 2006. Application of the Loop Method for Correcting Acoustic Doppler Current Profiler Discharge Measurements Biased by Sediment Transport. Scientific Investigations Report 2006-5079.

-------- 2016. Gage height data, May 10 through June 15, 2016. Website access September 2, 2016. (http://nwis.waterdata.usgs.gov/ak/nwis/uv?cb_00065=on&format=gif_default&site_no=15875000&period=&begin_date=2016-05-10&end_date=2016-06-15).

Weather Underground. Website access August 2016. (http://www.wunderground.com).

Appendix A GAGE LOCATIONS, VERTICAL CONTROL, & PT METHODS

A.1 GAGE LOCATIONS

Monitoring Location	Gage	Latitude (NAD83)	Longitude (NAD83)	Basis of Elevation
Colville River Upstream of Bifurcation				
Monument 1 U	MON1U-A[1]	N 70.1585°	W 150.9450°	MONUMENT 1
	MON1U-A1	N 70.1585°	W 150.9451°	
	MON1U-B[1]	N 70.1585°	W 150.9455°	
	MON1U-C	N 70.1585°	W 150.9461°	
	MON1U-D	N 70.1585°	W 150.9462°	
	MON1U-E	N 70.1585°	W 150.9464°	
	MON1U-F	N 70.1585°	W 150.9465°	
Monument 1 C	MON1C-A[1]	N 70.1657°	W 150.9383°	MONUMENT 1
	MON1C-B[1]	N 70.1658°	W 150.9386°	
	MON1C-C	N 70.1658°	W 150.9392°	
	MON1C-D	N 70.1658°	W 150.9393°	
	MON1C-E	N 70.1658°	W 150.9395°	
	MON1C-F	N 70.1659°	W 150.9397°	
Monument 1 D	MON1D-A[1]	N 70.1738°	W 150.9359°	MONUMENT 1
	MON1D-B[1]	N 70.1738°	W 150.9371°	
	MON1D-C	N 70.1738°	W 150.9372°	
	MON1D-D	N 70.1738°	W 150.9373°	
	MON1D-Z	N 70.1737°	W150.9376°	
Colville River East Channel				
Monument 9	MON9-A[1]	N 70.2447°	W 150.8573°	MONUMENT 9
	MON9-B[1]	N 70.2447°	W 150.8575°	
	MON9-B1	N 70.2446°	W 150.8576°	
	MON9-C	N 70.2447°	W 150.8578°	
	MON9-D	N 70.2446°	W 150.8580°	
	MON9-E	N 70.2446°	W 150.8580°	
	MON9-F	N 70.2446°	W 150.8580°	
	MON9-G	N 70.2446°	W 150.8581°	
	MON9-BARO[2]	N 70.2442°	W 150.8605°	
Monument 9 D	MON9D-A[1]	N 70.2586°	W 150.8593°	MONUMENT 9
	MON9D-B[1]	N 70.2586°	W 150.8597°	
	MON9D-C	N 70.2586°	W 150.8598°	
	MON9D-D	N 70.2586°	W 150.8600°	
	MON9D-E	N 70.2586°	W 150.8600°	
Monument 35 (Helmericks)	MON35-A	N 70.4260°	W 150.4058°	MONUMENT 35
	MON35-B	N 70.4260°	W 150.4058°	
	MON35-C	N 70.4261°	W 150.4058°	
	MON35-D	N 70.4261°	W 150.4058°	
	MON35-E	N 70.4261°	W 150.4058°	

Notes:
1. Pressure Transducer
2. BaroTROLL or Barologger barometer
3. Staff gage surveyed and adjusted for elevation annually by LCMF

Monitoring Location	Gage	Latitude (NAD83)	Longitude (NAD83)	Basis of Elevation
Nigliq Channel				
Monument 20	MON20-A[1]	N 70.2786°	W 150.9986°	PBM-P
	MON20-B	N 70.2786°	W 150.9985°	
	MON20-C	N 70.2786°	W 150.9983°	
	MON20-D	N 70.2785°	W150.9982°	
Nigliq Channel Gages	G26-A[1]	N 70.3024°	W 151.0227°	MONUMENT 26
	G26-B[1]	N 70.3022°	W 151.0206°	
	G26-C	N 70.3022°	W 151.0190°	
	G26-D	N 70.3022°	W 151.0190°	
	G26-E	N 70.3023°	W 151.0185°	
	G27-A[1]	N 70.3033°	W 151.0224°	
	G27-B[1]	N 70.3033°	W 151.0207°	
	G27-C	N 70.3033°	W 151.0194°	
	G27-D	N 70.3032°	W 151.0185°	
	G27-E	N 70.3032°	W 151.0179°	
	G28-A[1]	N 70.2961°	W 151.0328°	
	G28-B	N 70.2961°	W 151.0331°	
	G28-C	N 70.2961°	W 151.0331°	
	G28-D	N 70.2961°	W 151.0332°	
	G28-E	N 70.2961°	W 151.0335°	
	G29-A[1]	N 70.3095°	W 151.0332°	
	G29-B	N 70.3095°	W 151.0334°	
	G29-C	N 70.3095°	W 151.0337°	
	G29-D	N 70.3094°	W 151.0343°	
	G29-E	N 70.3093°	W 151.0350°	
	G45[1]	N 70.3028°	W 151.0226°	
Monument 22	MON22-A[1]	N 70.3186°	W 151.0546°	MONUMENT 22
	MON22-B	N 70.3185°	W 151.0549°	
	MON22-C	N 70.3185°	W 151.0550°	
	MON22-D	N 70.3183°	W 151.0555°	
Monument 23	MON23-A[1]	N 70.3436°	W 151.0659°	MONUMENT 23
	MON23-B	N 70.3436°	W 151.0657°	
	MON23-C	N 70.3436°	W 151.0652°	
	MON23-D	N 70.3436°	W 151.0649°	
	MON23-E	N 70.3436°	W 151.0648°	
Monument 28	MON28-A[1]	N 70.4258°	W 151.0697°	MONUMENT 28
	MON28-B	N 70.4257°	W 151.0692°	
	MON28-C	N 70.4256°	W 151.0672°	

Notes:
1. Pressure Transducer
2. BaroTROLL or Barologger barometer
3. Staff gage surveyed and adjusted for elevation annually by LCMF

Monitoring Location	Gage	Latitude (NAD83)	Longitude (NAD83)	Basis of Elevation
Alpine Facilities and Roads				
CD1 Gage	G1[1]	N 70.3428°	W 150.9208°	[3]
Lake L9312	G9[1]	N 70.3336°	W 150.9519°	[3]
Lake L9313	G10[1]	N 70.3425°	W 150.9328°	[3]
CD2 Gages	G3[1]	N 70.3400°	W 150.9831°	[3]
	G4[1]	N 70.3403°	W 150.9833°	[3]
	G6[1]	N 70.3397°	W 151.0292°	[3]
	G7[1]	N 70.3400°	W 151.0289°	[3]
	G8	N 70.3393°	W 151.0491°	PBM-F
	G12[1]	N 70.3367°	W 151.0117°	CD2-14N
	G13[1]	N 70.3373°	W 151.0118°	
CD3 Gage	G11	N 70.4175°	W 150.9105°	Pile 08
CD4 Gages	G15-A[1]	N 70.3023°	W 150.9929°	CD4-20AE
	G15-B	N 70.3024°	W 150.9939°	
	G16-A[1]	N 70.3017°	W 150.9933°	
	G16-B	N 70.3018°	W 150.9943°	
	G17-A[1]	N 70.2933°	W 150.9827°	NANUQ-5
	G18-A	N 70.2930°	W 150.9818°	
	G18-B[1]	N 70.2925°	W 150.9828°	
	G18-Baro[2]	N 70.2925°	W 150.9828°	
	G19-A	N 70.2915°	W 150.9883°	PBM-P
	G19-Baro[2]	N 70.2915°	W 150.9883°	
	G20-A	N 70.2917°	W 150.9968°	
	G20-B	N 70.2917°	W 150.9968°	
	G40	N 70.3234°	W 150.9968°	CD4-12W
	G41	N 70.3235°	W 150.9949°	CD4-12E
	G42	N 70.3276°	W 150.9939°	CD4-10W
	G43	N 70.3274°	W 150.9924°	CD4-10E
CD5 Gages				
Lake L9323	G24-A[1]	N 70.3030°	W 151.0065°	MONUMENT 25
	G24-B	N 70.3034°	W 151.0041°	
	G25-A[1]	N 70.3044°	W 151.0066°	
	G25-B	N 70.3046°	W 151.0049°	
	G44[1]	N 70.3034°	W 151.0089°	
Lake L9341	G32-A[1]	N 70.3054°	W 151.0507°	MONUMENT 27
	G32-B	N 70.3055°	W 151.0513°	
	G33-A[1]	N 70.3065°	W 151.0484°	
	G33-B	N 70.3065°	W 151.0487°	
	G33-C	N 70.3068°	W 151.0500°	
	G46[1]	N 70.3060°	W 151.0504°	

Notes:
1. Pressure Transducer
2. BaroTROLL or Barologger barometer
3. Staff gage surveyed and adjusted for elevation annually by LCMF

Monitoring Location	Gage	Latitude (NAD83)	Longitude (NAD83)	Basis of Elevation
CD5 Gages - Continued				
Small Drainages	G30[1]	N 70.3046°	W 151.0443°	CD5-40S (C141S)
	G31[1]	N 70.3051°	W 151.0437°	
	G34[1]	N 70.3060°	W 151.0710°	CD5-35S (C136S)
	G35[1]	N 70.3067°	W 151.0711°	CD5-35N (C136N)
	G36[1]	N 70.3055°	W 151.0968°	MONUMENT 28
	G37[1]	N 70.3063°	W 151.0971°	
	S1-A[1]	N 70.3058°	W 151.1944°	MONUMENT 31
	S1-D[1]	N 70.3066°	W 151.1957°	
Nigliagvik Channel Gages	G38-A[1]	N 70.3046°	W 151.1187°	MONUMENT 29, TBM 15-12-52
	G38-B[1]	N 70.3046°	W 151.1185°	
	G38-C	N 70.3046°	W 151.1183°	
	G38-D	N 70.3047°	W 151.1172°	
	G39-A[1]	N 70.3064°	W 151.1177°	
	G39-B[1]	N 70.3063°	W 151.1175°	
	G39-C	N 70.3063°	W 151.1172°	
	G47[1]	N 70.3056°	W151.1183°	
Pipeline River Crossings				
Sakoonang Channel Pipe Bridge	SAK-A[1]	N 70.3646°	W 150.9217°	Pile 568 cap SW bolt, CP-08-11-12
	SAK-B	N 70.3645°	W 150.9220°	
	SAK-C	N 70.3645°	W 150.9220°	
Tamayayak Channel Pipe Bridge	TAM-A[1]	N 70.3917°	W 150.9115°	CP08-11-23
	TAM-B	N 70.3915°	W 150.9113°	
	TAM-C	N 70.3914°	W 150.9113°	
	TAM-Z	N 70.3912°	W 150.9109°	
Ulamnigiaq Channel Pipe Bridge	ULAM-A[1]	N 70.4068°	W 150.8835°	CP08-11-35
	ULAM-B	N 70.4069°	W 150.8833°	
	ULAM-C	N 70.4070°	W 150.8831°	
	ULAM-Z	N 70.4070°	W 150.8831°	

Notes:
1. Pressure Transducer
2. BaroTROLL or Barologger barometer
3. Staff gage surveyed and adjusted for elevation annually by LCMF

A.2 VERTICAL CONTROL

Control	Elevation (ft-BPMSL)	Latitude (NAD83)[1]	Longitude (NAD83)	Control Type	Reference
CD2-14N	10.862	N 70.3371°	W 151.0110°	Culvert top	LCMF 2016
CD4-10W	12.248	N 70.3275°	W 150.9934°	Culvert top	LCMF 2016
CD4-10E	11.809	N 70.3274°	W 150.9930°	Culvert top	LCMF 2016
CD4-12W	12.517	N 70.3401°	W 150.9962°	Culvert top	LCMF 2016
CD4-12E	11.463	N 70.3235°	W 150.9954°	Culvert top	LCMF 2016
CD4-20AE	7.024	N 70.3022°	W 150.9937°	Culvert top	LCMF 2016
CD5-35N (C136N)	13.167	N 70.3063°	W 151.0522°	Culvert top	LCMF 2015
CD5-35S (C136S)	13.366	N 70.3061°	W 151.0526°	Culvert top	LCMF 2015
CD5-40S (C141S)	11.130	N 70.3048°	W 151.0443°	Culvert top	LCMF 2015
CP08-11-12	7.365	N 70.3640°	W 150.9205°	Alcap	BAKER 2012
CP08-11-23	8.524	N 70.3916°	W 150.9079°	Alcap	LCMF 2008
CP08-11-35	8.880	N 70.4066°	W 150.8822°	Alcap	BAKER 2015 (LCMF 2010)
MONUMENT 1	27.930	N 70.1659°	W 150.9400°	Alcap	LCMF 2006
MONUMENT 9	25.060	N 70.2446°	W 150.8583°	Alcap	LCMF 2008
MONUMENT 22	10.030	N 70.3181°	W 151.0560°	Alcap	BAKER 2010
MONUMENT 23	9.546	N 70.3444°	W 151.0613°	Alcap	BAKER 2009c
MONUMENT 25	17.939	N 70.3024°	W 151.0130°	Capped drill stem	LCMF 2016
MONUMENT 26	11.522	N 70.3025°	W 151.0322°	Capped drill stem	LCMF 2016
MONUMENT 27	13.848	N 70.3060°	W 151.0533°	Capped drill stem	LCMF 2016
MONUMENT 28 (CD5)	11.372	N 70.4256°	W 151.0670°	Capped drill stem	LCMF 2016
MONUMENT 28 (Colville @ Coast)	3.650	N 70.4256°	W 151.0670°	Alcap	LCMF GPS 2002
MOUNMENT 29	28.629	N 70.3052°	W 151.1229°	Capped drill stem	LCMF 2016
MONUMENT 31	26.898	N 70.3051°	W 151.1992°	Capped drill stem	LCMF 2016
MONUMENT 35	5.570	N 70.4325°	W 150.3834°	Alcap	Lounsbury 1996
NANUQ-5	17.415	N 70.2917°	W 150.9806°	Alcap	LCMF 2016
PBM-F	17.831	N 70.3393°	W 151.0468°	PBM in Casing	LCMF 2016
PBM-P	20.937	N 70.2914°	W 150.9889°	PBM in Casing	LCMF 2016
Pile 08	16.740	-	-	SW Bolt	LCMF 2010
Pile 568	23.719	N 70.3639°	W 150.9206°	HSM cap SW bolt	LCMF 2010
TBM 15-12-52	18.023	N 70.3055°	W 151.1174°	Sheet Pile SE Abutm.	LCMF 2015
TBM 99-32-59-A	14.630	N 70.3338°	W 150.9522°	-	LCMF 2016
TBM 99-32-60	15.871	N 70.3420°	W 150.9321°	Top NW lifting lug	LCMF 2016

1. North American Datum of 1983 (NAD83)

A.3 PT SETUP, TESTING, & PROCESSING METHODS

PTs measure the absolute pressure of the atmosphere and water, allowing the depth of water above the sensor to be calculated. Resulting data yield a comprehensive record of the fluctuations in stage. The reported pressure is the sum of the forces imparted by the water column and atmospheric conditions. Variations in local barometric pressure are taken into account, using two independent barometric pressure loggers: In-Situ BaroTROLL® and Solinst Barologger®. A correction of barometric pressure was obtained from the BaroTROLL sensor installed at CD4 and the Barologger installed at MON9.

The PTs were tested before field mobilization. The PTs were configured using Win-Situ® LT 5.6.21.0 (for the Level TROLL 500s) or Solinst Levelogger® v4.0.3 (for the Solinst Leveloggers) software prior to placement in the field. Absolute pressure was set to zero. The PT sensor was surveyed during setup to establish a vertical datum using local control.

PT-based stage values were determined by adding the calculated water depth and the surveyed sensor elevation. PTs have the potential to drift and can be affected by ice and sediment. Staff gage WSE readings were used to validate and adjust the data collected by the PTs. A standard conversion using the density of water at 0°C was used to calculate all water depths from adjusted gage pressures. Fluctuations in water temperature during the sampling period did not affect WSE calculations because of the limited range in temperature and observed water depths.

Appendix B DISCHARGE METHODS, DISCHARGE LOCATIONS, & CROSS-SECTIONS

B.1 DISCHARGE METHODS

B.1.1 STANDARD USGS MIDSECTION TECHNIQUES

Standard USGS midsection techniques (USGS 1982) were used to measure velocities and determine discharge at the Long and Short Swale Bridges on the CD2 road and at the Nigliq and Nigliagvik Bridges on the CD5 road.

Bridge depth and velocity measurements were taken from the upstream side of each bridge deck using a sounding reel mounted on a wooden boom. A Price AA velocity meter was attached to the sounding reel and stabilized with a 30-pound Columbus-type lead sounding weight. A tag line was placed along the bridge rail to define the cross section and to delineate measurement subsections within the channel. The standard rating table No.2 for Price AA velocity meters, developed by the USGS Office of Surface Water (OSW) Hydraulic Laboratory as announced in the OSW Technical Memorandum No. 99.05 (OSW 1999a) was used to convert revolutions to stream velocity. The Price AA velocity meter was serviced in March 2014 in accordance to USGS precise standards. A spin test of the meter was successfully completed before and after the measurements. Procedures outlined in OSW Technical Memorandum No. 99.06 (OSW 1999b) were followed to confirm accurate meter performance.

Velocity at the outlets of the CD2, CD4, and CD5 road culverts experiencing flow was measured using a USGS wading rod and Hach FH950 electromagnetic velocity meter at the downstream side of the culvert. Discharge was determined based on velocity, flow depth, and culvert geometry.

B.1.2 ADCP METHODS

Direct discharge measurements were collected at MON1 using an Acoustic Doppler Current Profiler (ADCP).

1) HARDWARE & SOFTWARE

A Teledyne RD Instruments 600-kilohertz Workhorse Sentinel broadband ADCP was used. The unit has a phased array, Janus four-beam transducer with a 20-degree beam angle. The ADCP unit and supporting laptop (Panasonic Toughbook® CF-19) were self-powered via internal batteries.

BBTalk® v3.06, a DOS-based communication program, was used to perform pre-deployment tests. WinRiverII® v2.07 was used to configure, initiate, and communicate with the ADCP while on the river. WinRiverII® was also used to review and evaluate collected discharge data after returning from the field.

2) PRE-DEPLOYMENT TESTING

Prior to deployment of the ADCP unit, a full suite of tests were run in accordance with the manufacturer's instructions using BBTalk.® The tests confirmed the signal path and all major signal processing subsystems were functioning properly. Tests also confirmed accurate tilt and pitch readings. A beam continuity test was performed to verify the transducer beams were connected and operational. Additional diagnostic tests were performed using WinRiverII.® Pre-deployment tasks also included compass calibration and verification. Internal compass error was within the specified 5-degree limit.

3) ADCP DEPLOYMENT & DATA COLLECTION

The Workhorse Sentinel ADCP was mounted to an Achilles SGX-132 inflatable raft powered by a Tohatsu 9.8 horsepower outboard motor. A fabricated aluminum tube framework spanning the boat's gunwales provided a rigid and secure placement of the ADCP unit, and allowed necessary navigation adjustments as river conditions required.

Cross sections were identified at established monitoring sites MON1C. A minimum of four transects were completed, so the measured discharges varied by less than five percent of their mean. Cross section end points were dependent on a minimum water depth of approximately eight feet to provide acceptable data.

Cross section end points were marked with handheld GPS units having wide area augmentation system enabled accuracy. The position of the boat was determined by tracking the bottom of the channel with the ADCP. Distances to the right and left edge of water from respective end points were estimated from GPS coordinates.

4) ADCP BACKGROUND & DATA PROCESSING

An ADCP measures the velocity of particles in the water. Particles, on average, move at the same horizontal velocity of the water relative to the ADCP unit. The velocity of flow is then calculated relative to the earth, based on the simultaneous velocity and position of the boat. The velocity and position of the boat were recorded by tracking the bottom of the channel with the ADCP unit.

The Colville River channel is composed of fine-grained sediment, and water velocities are sufficient to entrain the materials resulting in a moving river bed condition. When using bottom tracking, a moving bed will tend to affect the accuracy of the results by biasing the velocity and discharge lower than actual values. This phenomenon can be eliminated with the use of either a differential global positioning system (DGPS) or the loop method (USGS 2006). To account for the bias introduced by a moving bed, the loop method was employed.

The loop method is a technique to determine whether a moving bed is present and, if present, to provide an approximate correction to the final discharge value. The USGS established guidance for the loop method by outlining procedures for mean correction and distributed correction (USGS 2006). Both procedures yield results within 2 percent of the actual discharge, as measured using DGPS. The mean correction procedure was applied to the Colville River discharge calculations because of the simple geometry of the channel cross section. The results of the loop test, performed immediately following discharge measurements, was used to estimate the mean velocity of the moving bed. The mean velocity was multiplied by the cross-sectional area perpendicular to the mean observed flow to yield a discharge correction. The resulting correction was applied to each transect, and the daily direct discharge measurement was determined by averaging the corrected discharge measurements.

B.1.3 INDIRECT CALCULATION METHODS

1) NORMAL DEPTH & SLOPE-AREA

The Normal Depth method (Chow 1959) and Slope-Area method (Benson and Dalrymple 1967) were used to develop the estimates of peak discharge at MON1. Both methods use channel cross section geometry and stage differential between gage sites as an estimate for the energy grade line. The methods differ by the number of cross sections used in the calculations. At MON1, the Normal Depth method uses the cross section at MON1C where the Slope-Area Method uses the cross sections from MON1U, MON1C, and MON1D. Accuracy of each method depends on conditions at the time of calculation, particularly the presence of ribbon and bottom fast ice, ice jam activity, and backwater effects. The average of the Normal Depth and Slope-Area results were used to compute the peak indirect discharge at MON1.

Lacking additional cross sections, the Normal Depth method was used to estimate peak discharge at all other locations (MON9, the Nigliq Bridge crossing, and the Nigliagvik Bridge crossing). Cross sectional geometry for MON9 is the result of data from the 2009 survey by LCMF for the Alpine Pipelines Monitoring report (Baker 2009c). Cross sectional geometry at the Nigliagvik Bridge, Nigliq Bridge, and Lake L9341 Bridge crossings is current as of 2014 (LCMF 2014). The Lake L9323 crossing was surveyed by LCMF in 2012. Because of channel bed morphology, cross sectional geometry becomes less accurate with time, particularly for those CRD channels that are predominantly comprised of fine grained soils or have bottom-fast ice. Stage and energy gradient data were obtained from observations made at nearby gages and PT results.

2) USGS WIDTH CONTRACTION

The USGS Width Contraction method was used to indirectly calculate peak discharge through the CD5 bridges. The constriction formed by the bridge can be used to estimate flow by measuring the drop in water-surface elevation (WSE) between the upstream (approach) and contraction section at the bridge which are related to the corresponding change in velocity. The width contraction method assumes unobstructed open-channel flow.

B.2 INDIRECT DISCHARGE PLAN & CROSS-SECTIONS

B.2.1 MON1

ConocoPhillips Alaska

Miles
0 0.25 0.5

Date:	09/16/2016	Project:	153210
Drawn:	BTG	File:	2016_CRD_8x11L_Mon1.mxd
Checked:	GCY	Scale:	1 in = .5 miles

Legend

Gage Location

2004 Cross Section Alignment

Imagery Source: AlaskaMapped (WMS)

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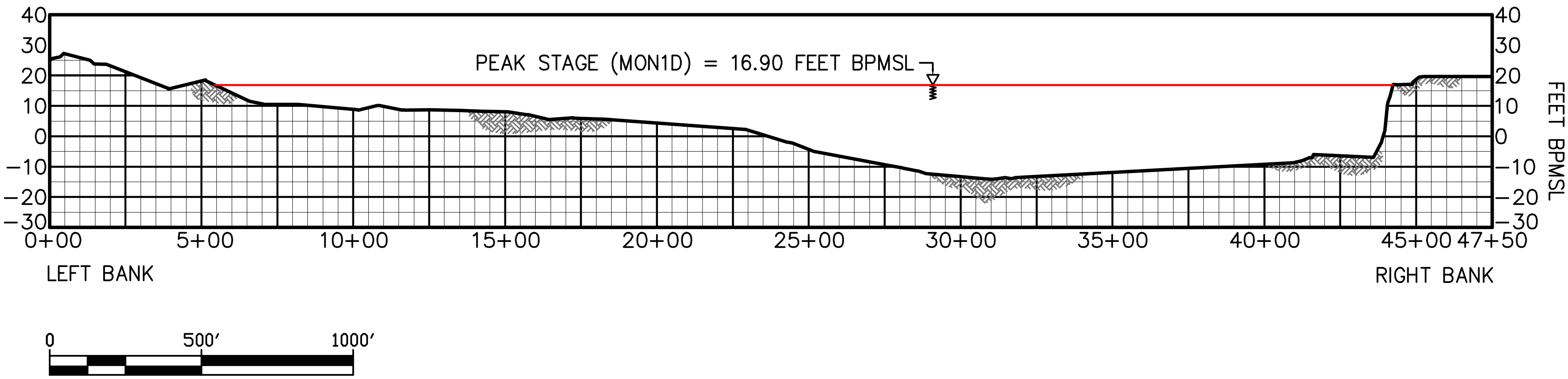
2016 SPRING BREAKUP
MONUMENT 1
PLAN

FIGURE:

(SHEET 1 of 4)

NOTES
1. BASIS OF ELEVATION, MONUMENT 1.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED AUGUST 2004 BY UMIAQ (KUUKPIK/LCMF INC.)



1D COLVILLE RIVER AT MON1 DOWNSTREAM CROSS−SECTION

ConocoPhillips Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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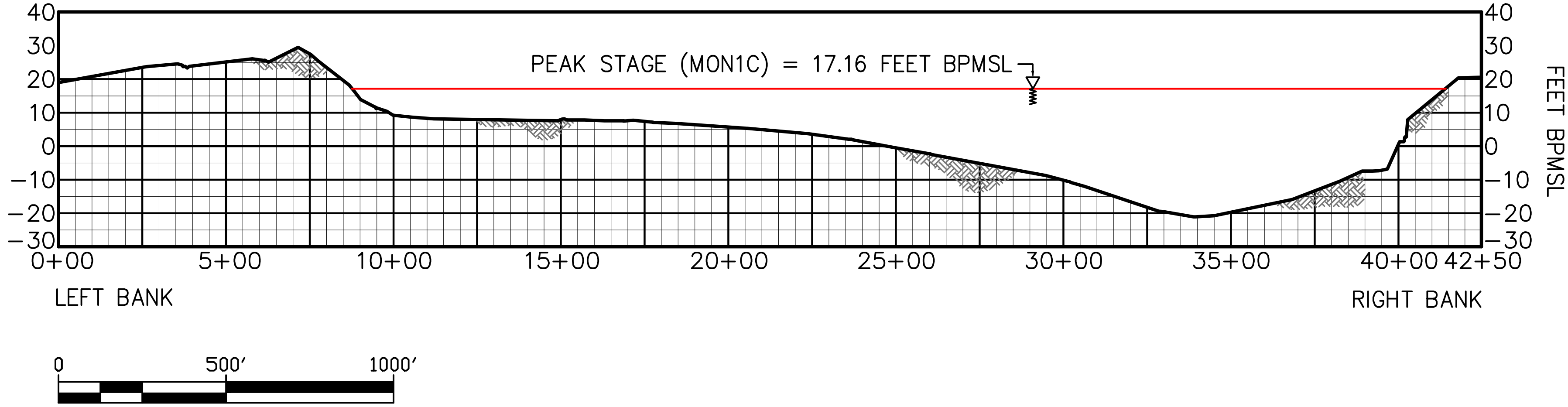
2016 SPRING BREAKUP
MONUMENT 1 DOWNSTREAM PROFILE

NOTES
1. BASIS OF ELEVATION, MONUMENT 1.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED AUGUST 2004 BY UMIAQ (KUUKPIK/LCMF INC.)



1C COLVILLE RIVER AT MON1 CENTERLINE CROSS−SECTION

ConocoPhillips Alaska, Inc.

DATE: 09/14/2016	PROJECT: 153210
DRAWN: DTR	FILE: MON1 X-SECTIONS.DWG
CHECKED: GCY	SCALE: AS SHOWN

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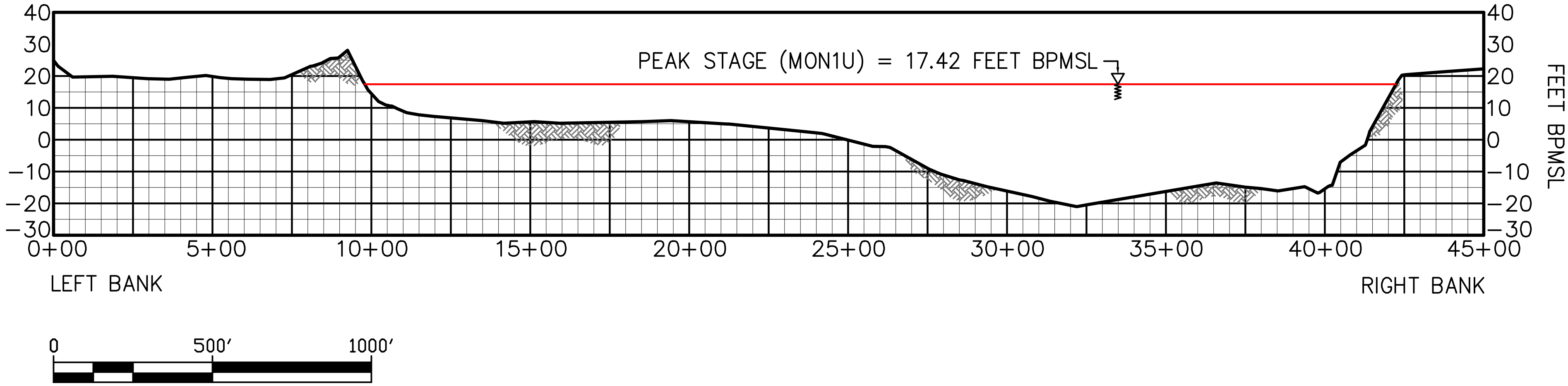
2016 SPRING BREAKUP
MONUMENT 1 CENTERLINE
PROFILE

(SHEET 3 OF 4)

NOTES

1. BASIS OF ELEVATION, MONUMENT 1.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED AUGUST 2004 BY UMIAQ (KUUKPIK/LCMF INC.)



1U COLVILLE RIVER AT MON1 UPSTREAM CROSS-SECTION

ConocoPhillips Alaska, Inc.

DATE: 09/14/2016		PROJECT: 153210	
DRAWN: DTR		FILE: MON1 X-SECTIONS.DWG	
CHECKED: GCY		SCALE: AS SHOWN	

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2016 SPRING BREAKUP
MONUMENT 1 UPSTREAM
PROFILE

NUMBER
(SHEET 4 OF 4)

B.2.2 MON9

ConocoPhillips Alaska

Feet
0 500 1,000

Date:	09/20/2016	Project:	153210
Drawn:	BTG	File:	2016_CRD_8x11L_Mon9.mxd
Checked:	GCY	Scale:	1 in = 1000 feet

Legend

- Gage Location
- 2009 Cross Section Alignment
- Pipeline

Imagery Source: ConocoPhillips Alaska, 2004

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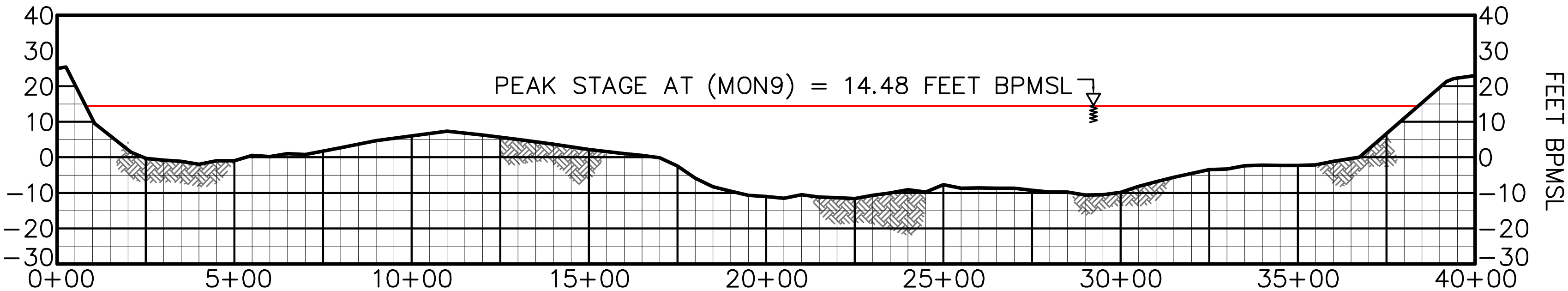
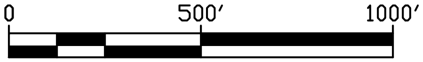
2016 SPRING BREAKUP
Monument 9 / HDD
PLAN

FIGURE:
(SHEET 1 of 2)

NOTES
1. BASIS OF ELEVATION, MONUMENT 9.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED NOVEMBER 2009 BY UMIAQ (KUUKPIK/LCMF INC.)





1 COLVILLE EAST CHANNEL AT MON9 CROSS-SECTION

ConocoPhillips Alaska, Inc.

DATE: 09/14/2016	PROJECT: 153210
DRAWN: DTR	FILE: MON9 X-SECTION.DWG
CHECKED: GCY	SCALE: AS SHOWN

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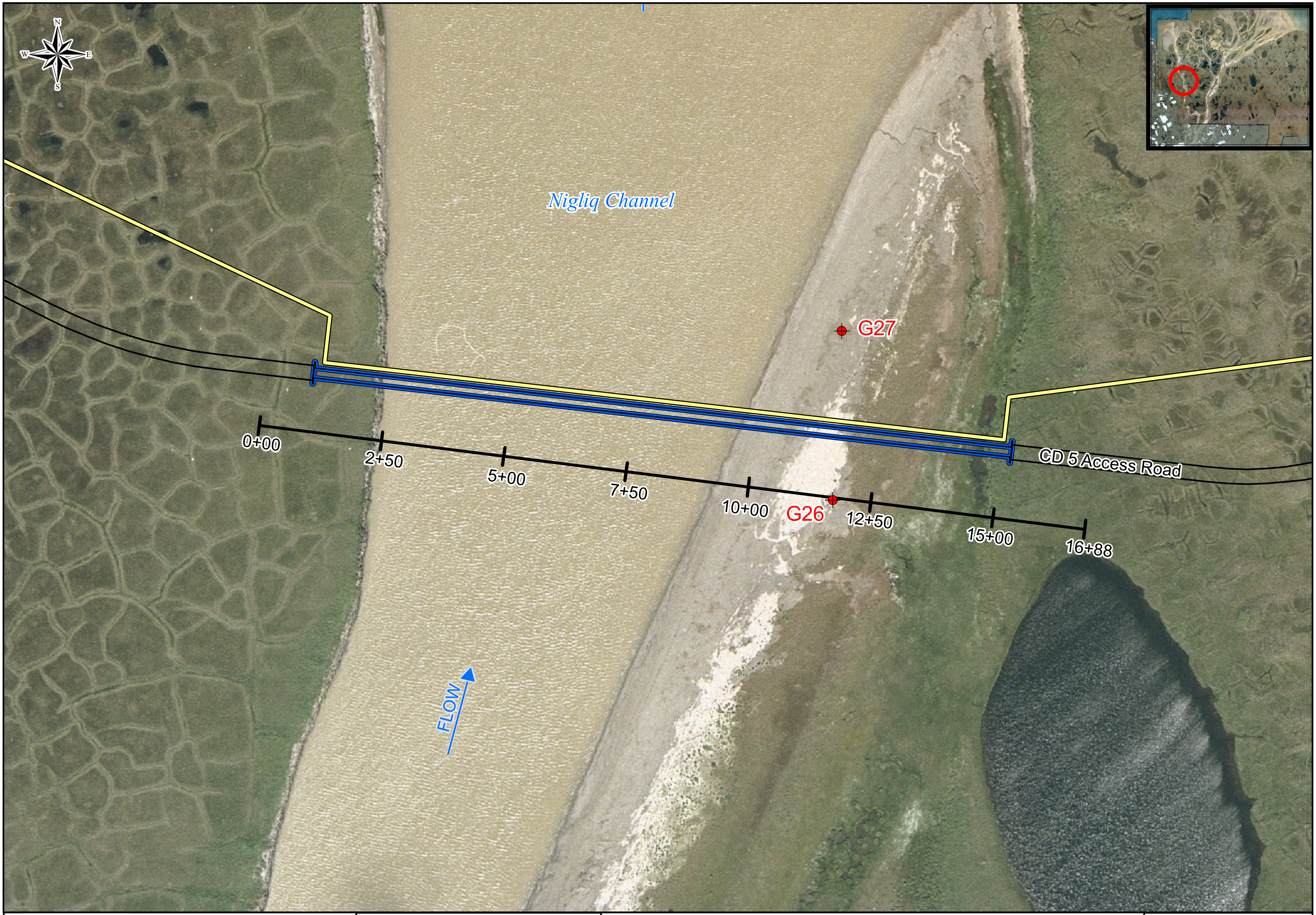
2016 SPRING BREAKUP
MONUMENT 9 / HDD
PROFILE

(SHEET 2 OF 2)

B.2.3 NIGLIQ BRIDGE



ConocoPhillips
Alaska

Feet
0 125 250

Date:	10/19/2016	Project:	153210
Drawn:	BTG	File:	2016_CRD_8x11L_Nigliq.mxd
Checked:	GCY	Scale:	1 in = 250 feet

Legend

- Gage Location
- 2016 Cross Section Alignment
- Road
- Bridge
- Pipeline

Imagery Source: ConocoPhillips Alaska, 2004

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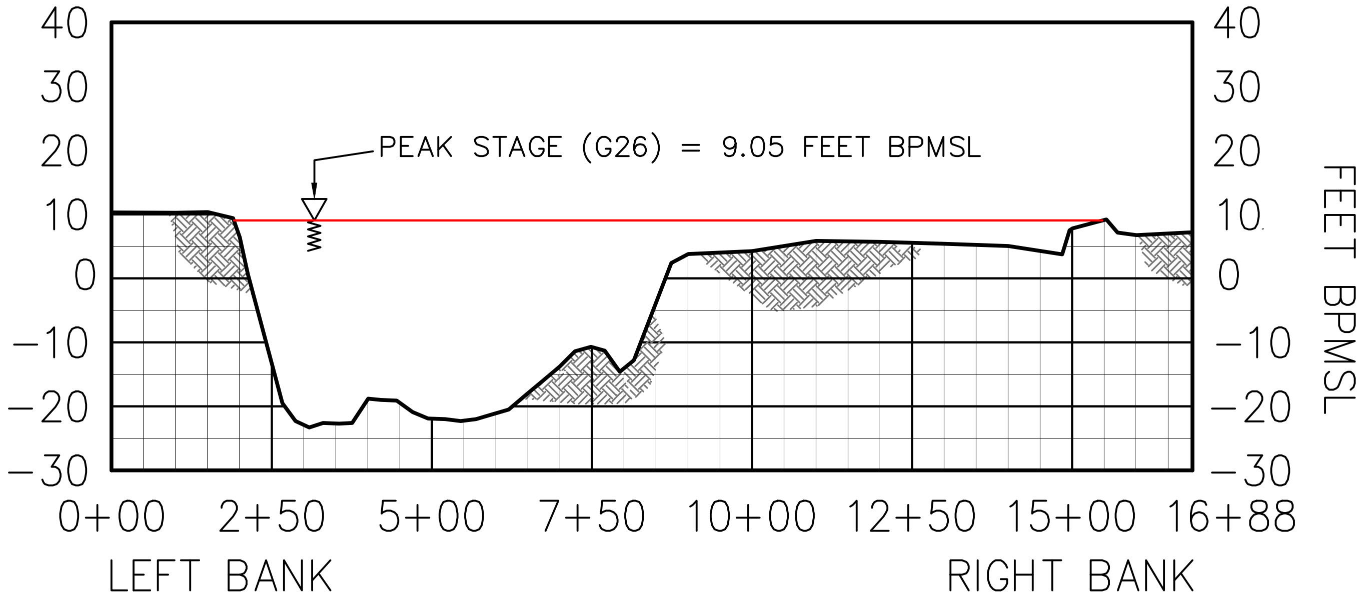
2016 SPRING BREAKUP
NIGLIQ CHANNEL
TRANSECT 10 PLAN

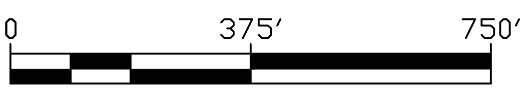
DOC LCMF-156 REV4

(SHEET 1 of 2)

NOTES

1. BASIS OF ELEVATION, MONUMENT 26.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 2016 BY UMIAQ (KUUKPIK/LCMF INC.)





(1) CD5 CROSSING – NIGLIQ CHANNEL CENTERLINE CROSS-SECTION
TRANSECT 10 (DOC LCMF-156 CD5 BRIDGE TRANSECTS REV4)

ConocoPhillips Alaska, Inc.

DATE: 09/14/2016	PROJECT: 153210
DRAWN: DTR	FILE: NIGLIQ X-SECTION.DWG
CHECKED: GCY	SCALE: AS SHOWN

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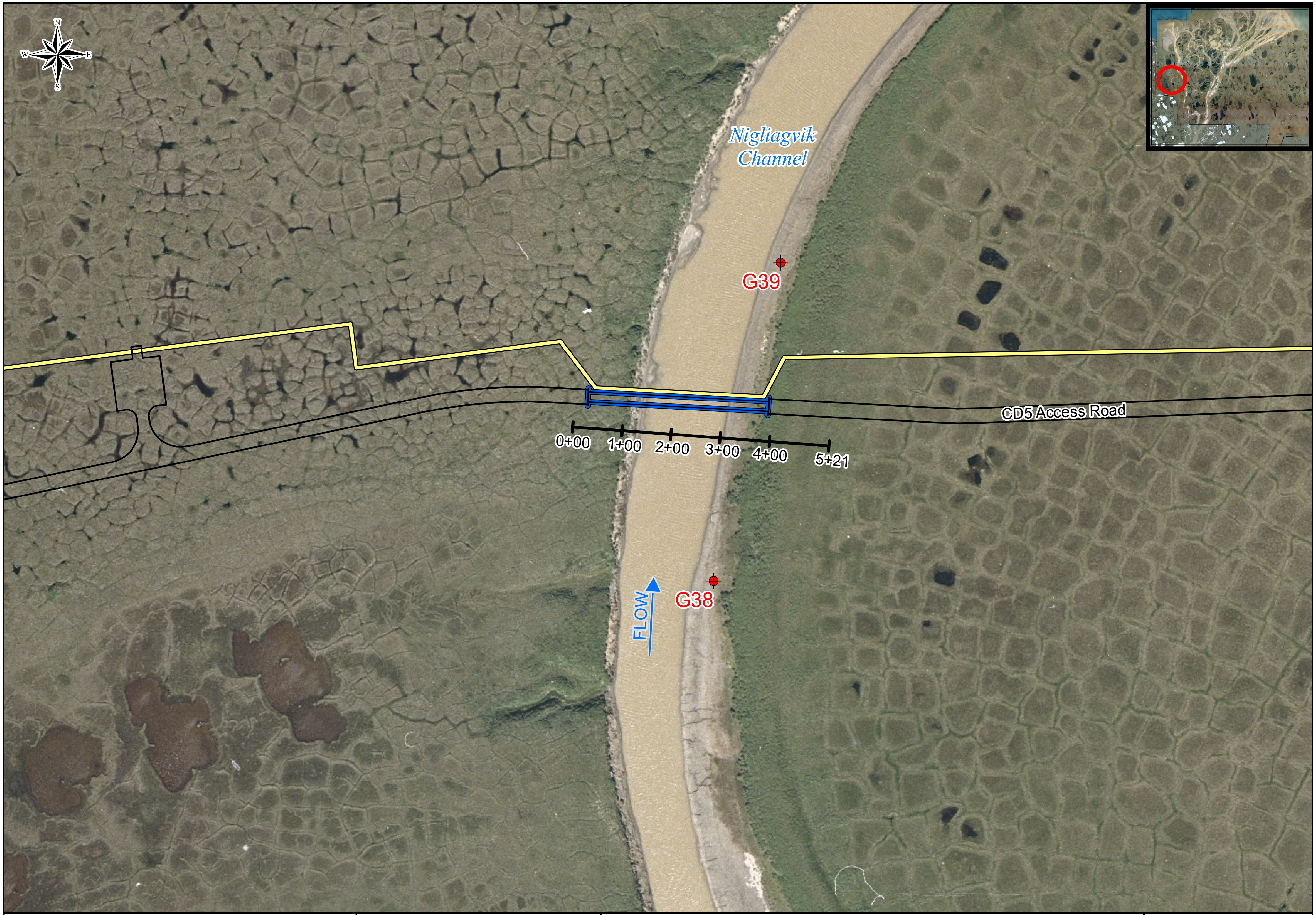
2016 SPRING BREAKUP
NIGLIQ CHANNEL
TRANSECT 10 PROFILE

(SHEET 2 OF 2)

B.2.4 NIGLIAGVIK BRIDGE



ConocoPhillips Alaska

Feet		
0	125	250

Date:	10/19/2016	Project:	153210
Drawn:	BTG	File:	2016_CRD_8x11L_Nigliagvik.mxd
Checked:	GCY	Scale:	1 in = 250 feet

Legend

- Gage Location
- 2016 Cross Section Alignment
- Road
- Bridge
- Pipeline

Imagery Source: ConocoPhillips Alaska, 2004

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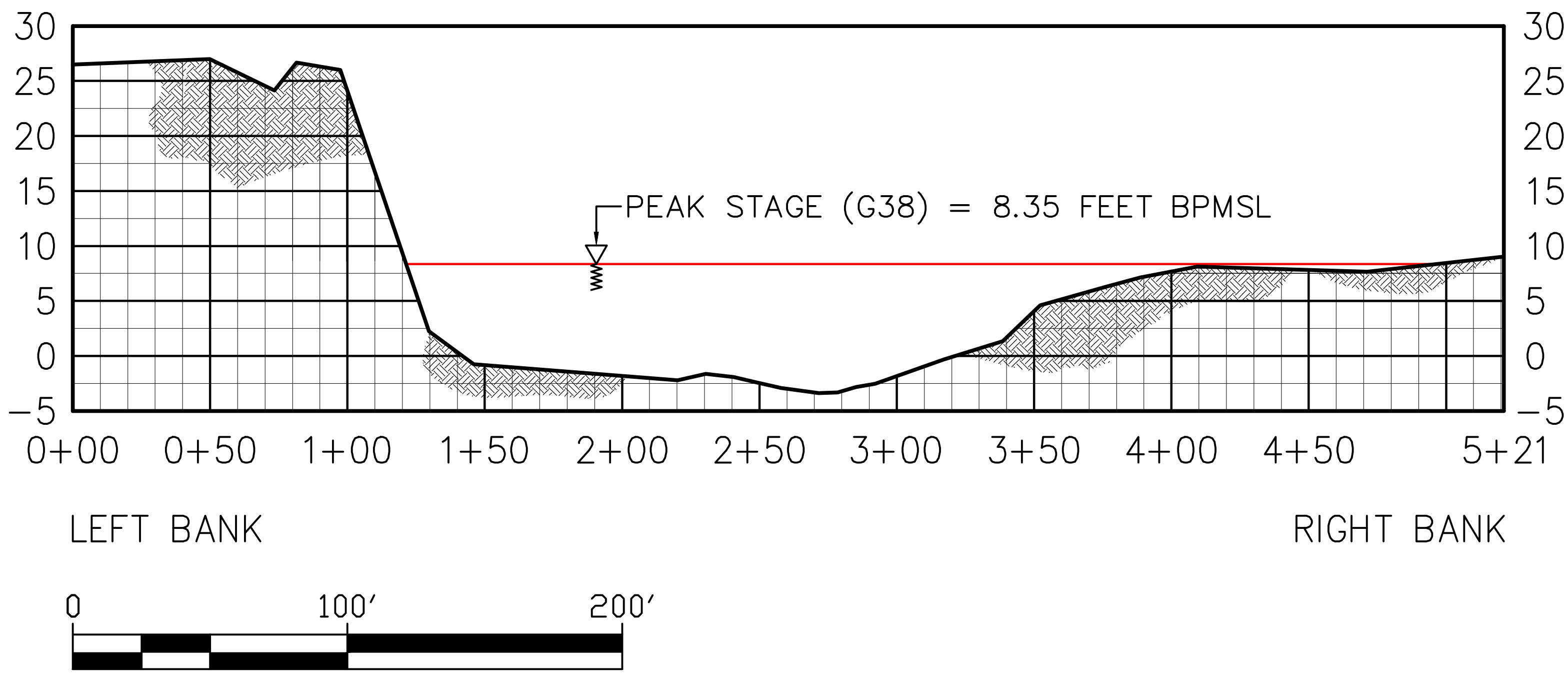
2016 SPRING BREAKUP
NIGLIAGVIK CHANNEL
TRANSECT 27 PLAN

DOC LCMF-156 REV4

(SHEET 1 of 2)

NOTES
1. BASIS OF ELEVATION, MONUMENT 29.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 2016 BY UMIAQ (KUUKPIK/LCMF INC.)



1 CD5 CROSSING – NIGLIAGVIK CENTERLINE CROSS-SECTION
TRANSECT 27 (DOC LCMF-156 CD5 BRIDGE TRANSECTS REV4)

ConocoPhillips Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	NIGLIAGVIK X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2016 SPRING BREAKUP
NIGLIAGVIK CHANNEL
TRANSECT 27 PROFILE

(SHEET 2 OF 2)

B.2.5 LAKE L9323 BRIDGE

ConocoPhillips Alaska

Feet 0 250 500

Date:	10/19/2016	Project:	153210
Drawn:	BTG	File:	2016_CRD_8x11L_L9323.mxd
Checked:	GCY	Scale:	1 in = 500 feet

Legend

- Gage Location
- 2012 Cross Section Alignment
- Road
- Bridge
- Pipeline

Imagery Source: ConocoPhillips Alaska, 2004

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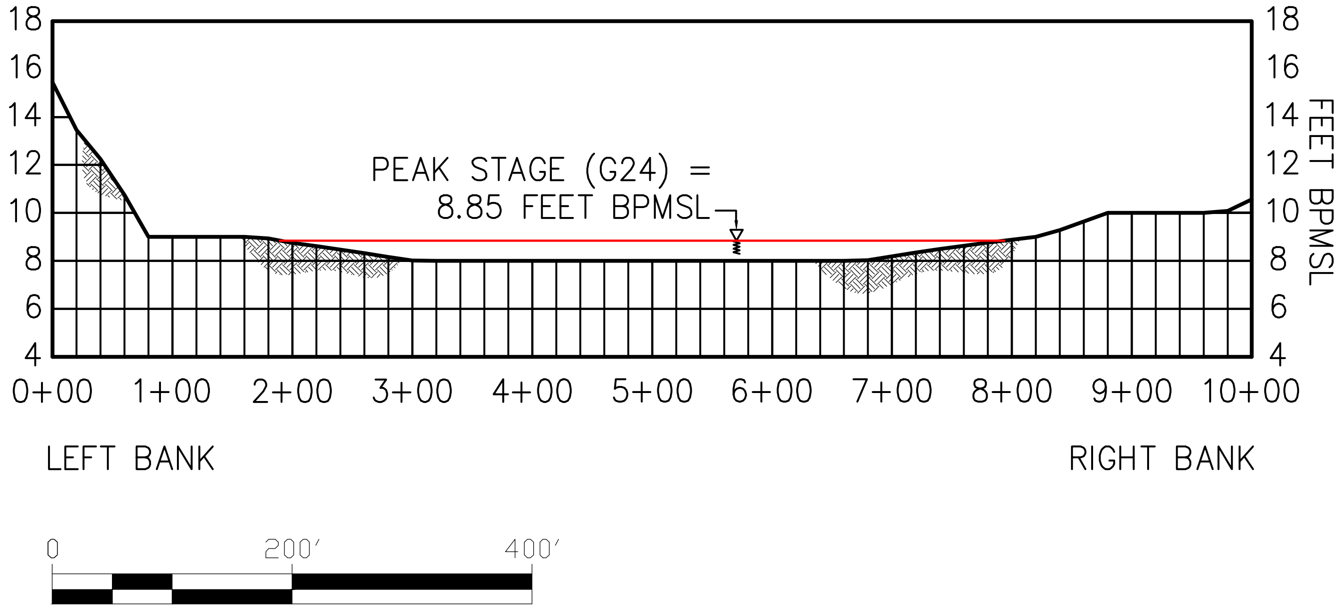
2016 SPRING BREAKUP
LAKE L9323
PLAN

(SHEET 1 of 2)

NOTES
1. BASIS OF ELEVATION, MONUMENT 25.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED SEPTEMBER 2012 BY UMIAQ (KUUKPIK/LCMF INC.)



1 CD5 CROSSING – LAKE L9323 CENTERLINE CROSS-SECTION

ConocoPhillips Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	L9323 X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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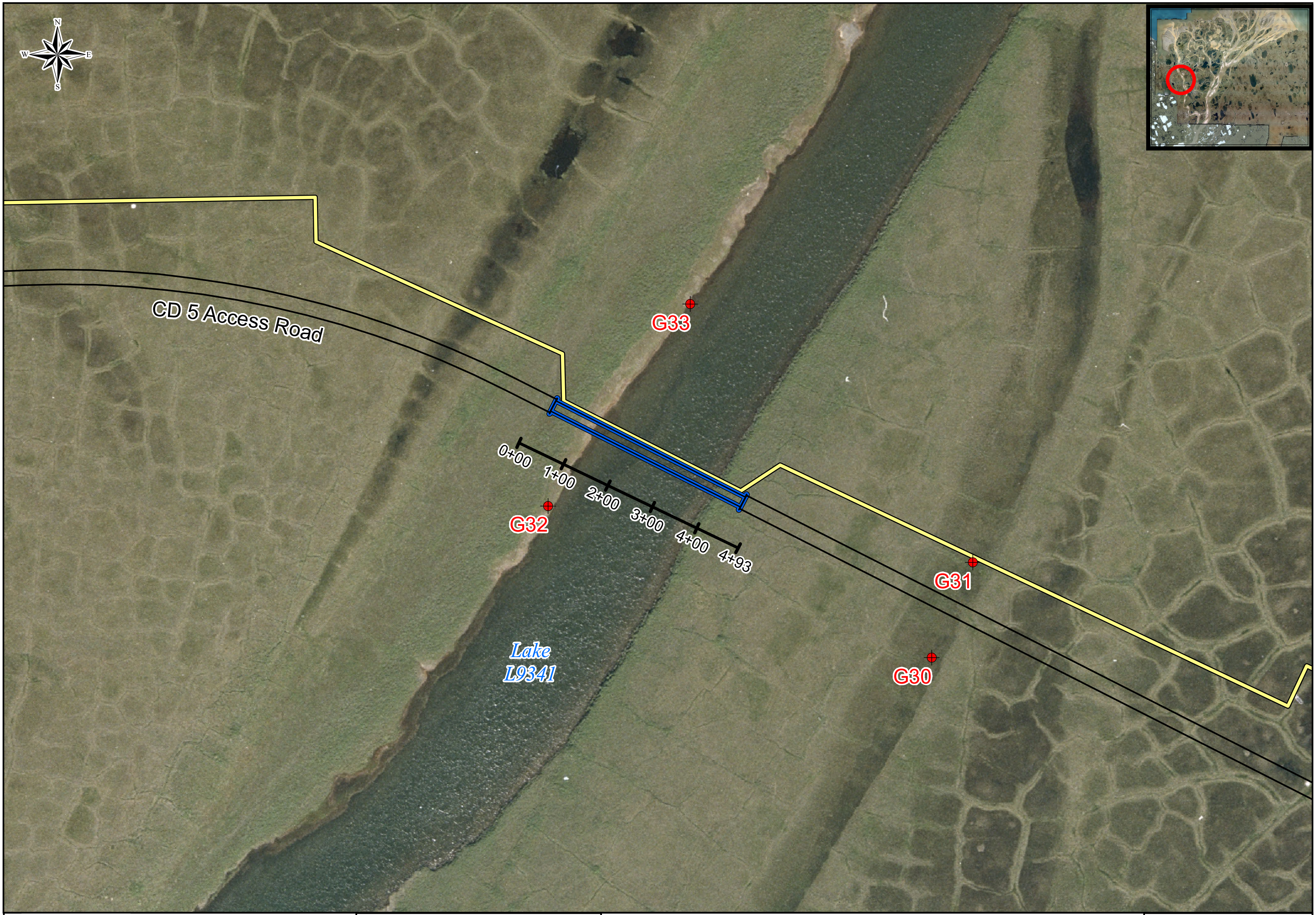
2016 SPRING BREAKUP
LAKE L9323
PROFILE

(SHEET 2 OF 2)

B.2.6 LAKE L9341 BRIDGE



ConocoPhillips Alaska

Feet
0 125 250

Date: 10/19/2016	Project: 153210
Drawn: BTG	File: 2016_CRD_8x11L_L9341.mxd
Checked: GCY	Scale: 1 in = 250 feet

Legend

- Gage Location
- 2016 Cross Section Alignment
- Road
- Bridge
- Pipeline

Imagery Source: ConocoPhillips Alaska, 2004

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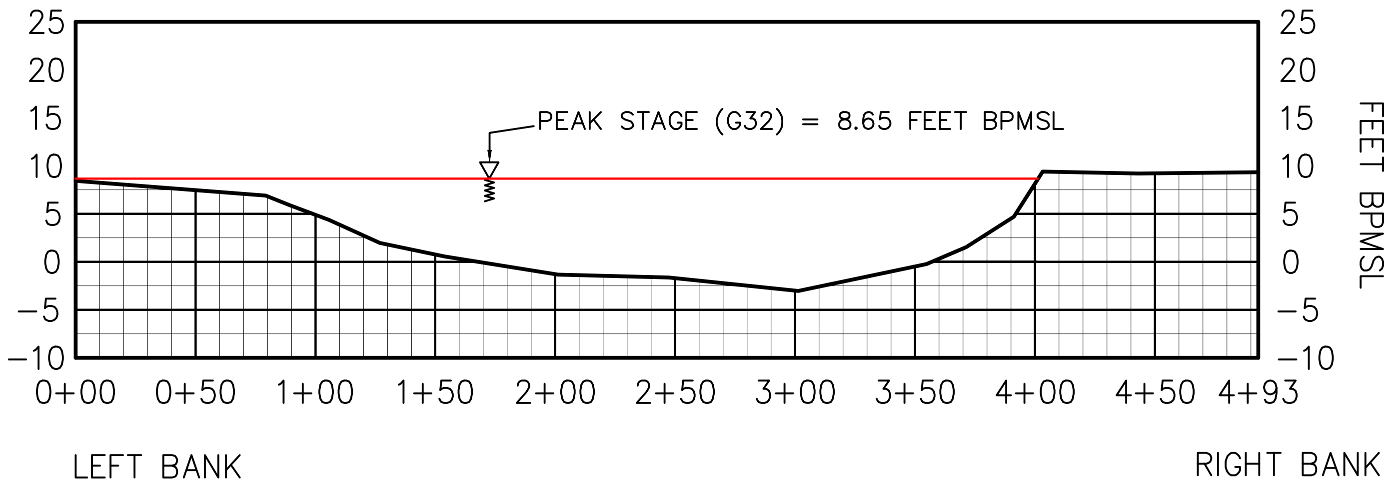
2016 SPRING BREAKUP
LAKE L9341
TRANSECT 39 PLAN

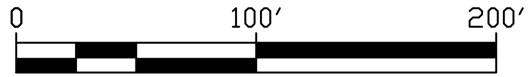
DOC LCMF-156 REV4

(SHEET 1 of 2)

NOTES
1. BASIS OF ELEVATION, MONUMENT 25.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 2016 BY UMIAQ (KUUKPIK/LCMF INC.)



(1) CD5 CROSSING – LAKE L9341 CENTERLINE CROSS–SECTION
TRANSECT 39 (DOC LCMF–156 CD5 BRIDGE TRANSECTS REV4)



ConocoPhillips Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	L9341 X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2016 SPRING BREAKUP
LAKE L9341
PROFILE

(SHEET 2 OF 2)

Appendix C ADDITIONAL PHOTOGRAPHS

C.1 EROSION SURVEY

C.1.1 CD2 ROAD & PAD

Photo C.1: South side of CD2 road east of CD2 pad, looking west; May 28, 2016

Photo C.2: North side of CD2 road east of CD2 pad, looking east; May 28, 2016

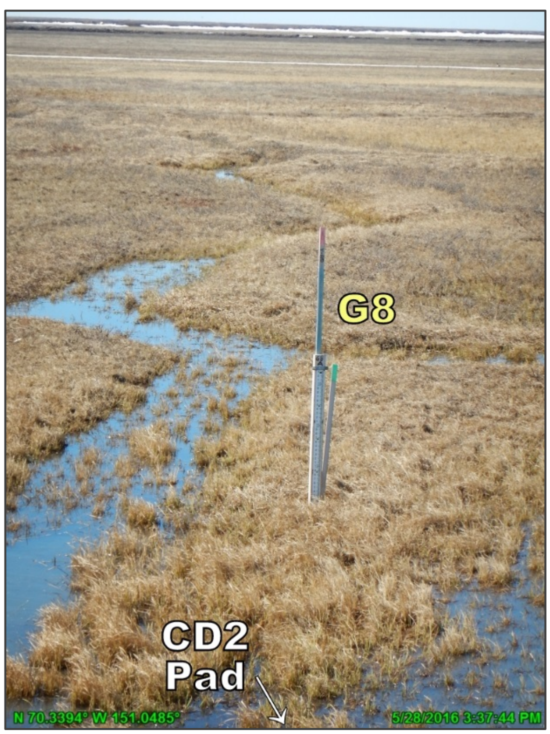


Photo C.3: Northwest side of CD2 pad, looking north; May 28, 2016

Photo C.4: South side of CD2 road west of CD2 pad, looking east; May 28, 2016

Photo C.5: South side of CD2 road west of the Short Swale Bridge, looking west; May 28, 2016

Photo C.6: South side of CD2 road west of the Short Swale Bridge, looking northeast; May 28, 2016

Photo C.7: North side of CD2 road east of the Short Swale Bridge, looking southwest; May 28, 2016

Photo C.8: South side of CD2 road west of the Long Swale Bridge, looking southwest; May 28, 2016

Photo C.9: North side of CD2 road east of the Long Swale Bridge, looking west; May 28, 2016

C.1.2 CD4 ROAD & PAD

Photo C.10: North side of CD4 road east of CD4 pad, looking northeast; May 28, 2016

Photo C.11: North side of CD4 road east of CD4 pad, looking southwest; May 28, 2016

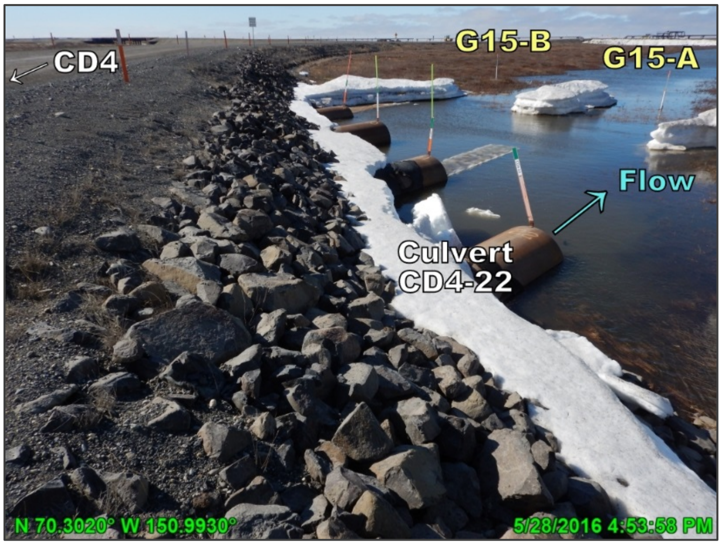


Photo C.12: East side of CD4 road south of CD5 road, looking northwest; May 28, 2016

C.1.3 CD5 ROAD & PAD

Photo C.13: East side of CD5 road south of CD5 pad, looking southeast; May 29, 2016

Photo C.14: West side of CD5 road south of CD5 pad, looking northwest; May 29, 2016

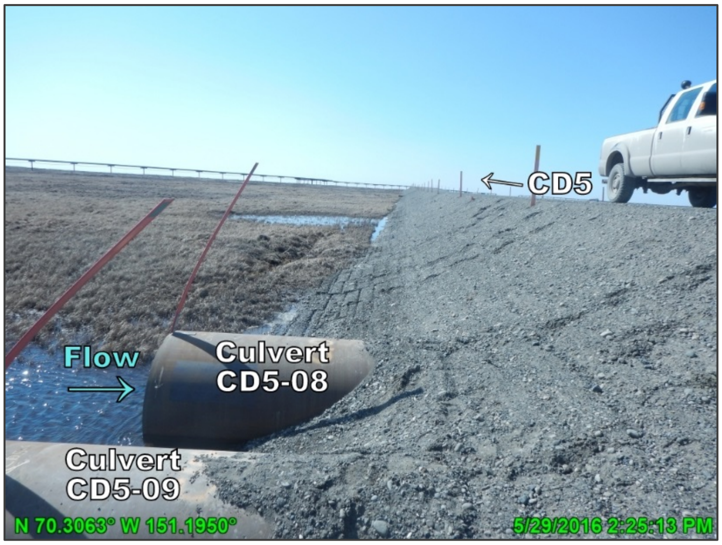


Photo C.15: South side of CD5 road south of Lake MB0301, looking southwest; May 29, 2016

Photo C.16: South side of CD5 road at the Nigliagvik Bridge, looking east; May 29, 2016

Photo C.17: North side of CD5 road at the Lake L9341 Bridge, looking north; May 29, 2016

Photo C.18: Under the Lake L9341 Bridge, looking east; May 29, 2016

Photo C.19: South side of CD5 road at the Nigliq Bridge, looking north; May 29, 2016

Photo C.20: South side of CD5 road east of Lake L9323 Bridge, looking north; May 29, 2016

C.2 ICE ROADS

Photo C.21: Colville River pre-breakup, looking northeast.; May 14, 2016

Photo C.22: Colville River during breakup, looking west; May 21, 2016

Photo C.23: Colville River post breakup, looking southwest; May 26, 2016

Photo C.24: Judy Creek post breakup, looking southwest; May 27, 2016

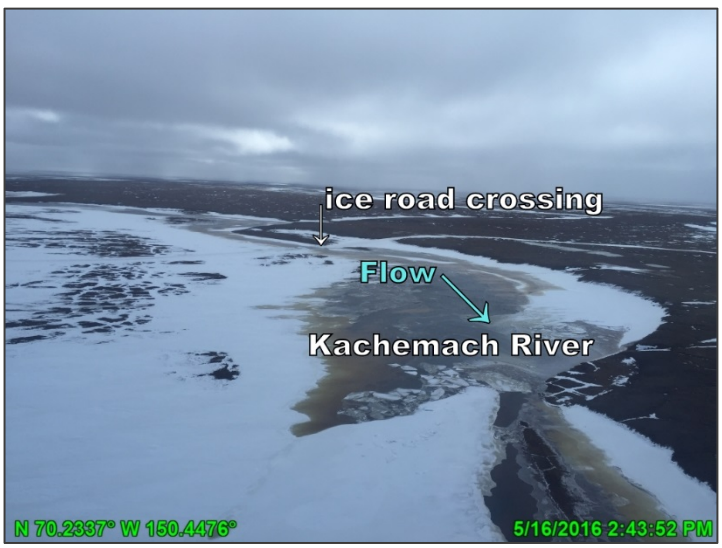


Photo C.25: Kachemach River pre-breakup, looking south; May 16, 2016

Photo C.26: Kachemach River during breakup, looking south-southeast; May 21, 2016

Photo C.27: Kachemach River post breakup, looking north; May 26, 2016

Photo C.28: Nigliagvik Exploration Crossing pre-breakup, looking southeast; May 14, 2016

Photo C.29: Nigliagvik Exploration Crossing during breakup, looking west; May 20, 2016

Photo C.30: Nigliagvik Exploration Crossing during breakup, looking southeast; May 26, 2016

Photo C.31: Nigliq Exploration Crossing pre-breakup, looking south; May 14, 2016

Photo C.32: Nigliq Exploration Crossing during breakup, looking south; May 22, 2016

Photo C.33: Nigliq Exploration Crossing post breakup, looking south; May 26, 2016

Photo C.34: No Name Creek pre-breakup, looking southwest; May 14, 2016

Photo C.35: No Name Creek post breakup, looking south; May 26, 2016

Photo C.36: Pineapple Gulch pre-breakup, looking east; May 14, 2016

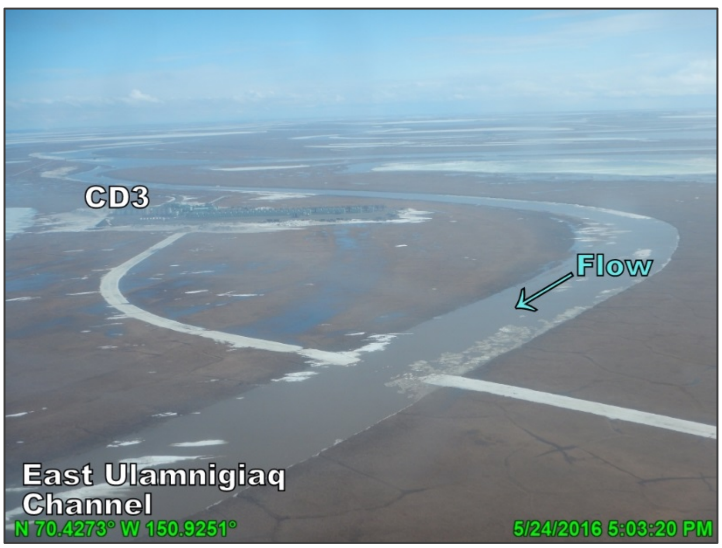


Photo C.37: Pineapple Gulch during breakup, looking south; May 24, 2016

Photo C.38: Pineapple Gulch post breakup, looking west; May 26, 2016

Photo C.39: Ravine 1 post breakup, looking southeast; May 27, 2016

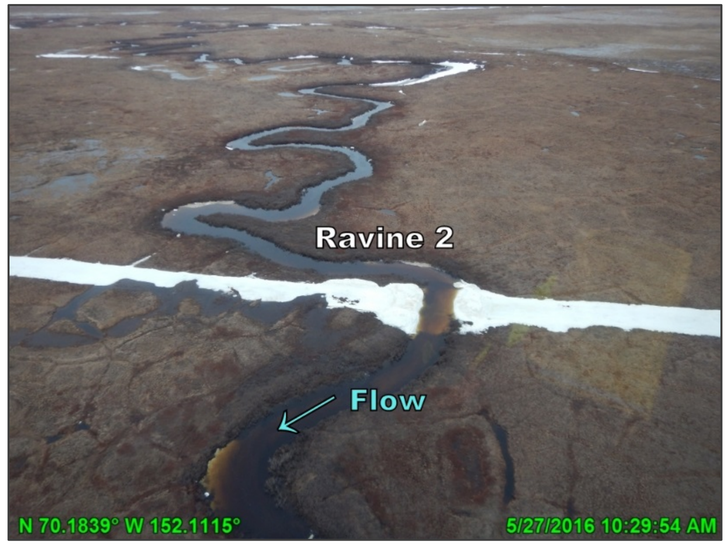


Photo C.40: Ravine 2 post breakup, looking west; May 27, 2016

Photo C.41: Silas Slough pre-breakup, looking northeast; May 14, 2016

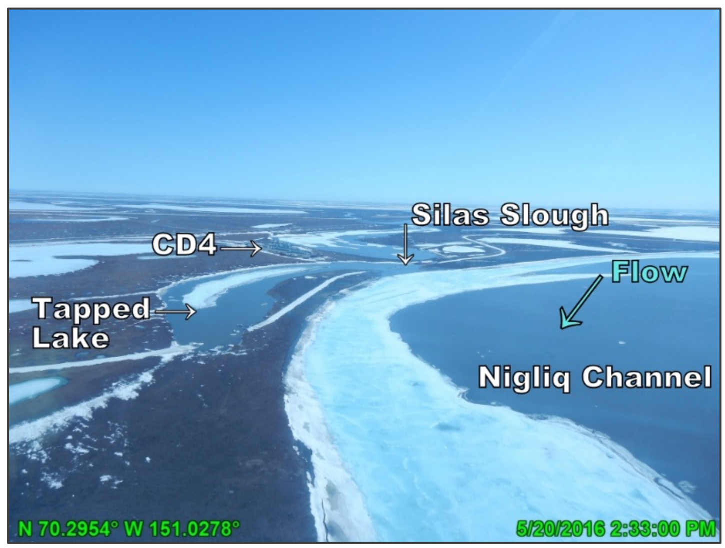


Photo C.42: Silas Slough during breakup, looking south; May 20, 2016

Photo C.43: Silas Slough post breakup, looking north-northwest; May 26, 2016

Photo C.44: Slemp Slough pre-breakup, looking southeast; May 14, 2016

Photo C.45: Slemp Slough post breakup, looking southeast; May 27, 2016

Photo C.46: Tamayayak Channel pre-breakup, looking northwest; May 14, 2016

Photo C.47: Tamayayak Channel during breakup, looking south; May 24, 2016

Photo C.48: Tamayayak post breakup, looking north-northwest; May 26, 2016

Photo C.49: Toolbox Creek pre-breakup, looking north; May 14, 2016

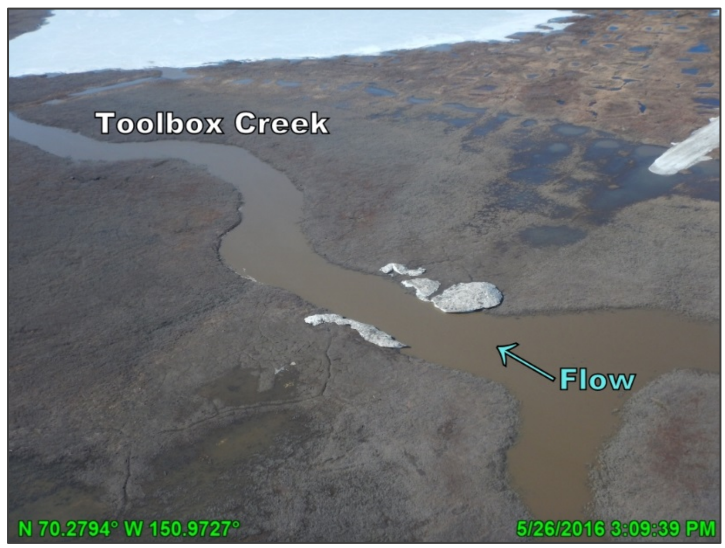


Photo C.50: Toolbox Creek post breakup, looking northwest; May 26, 2016

Photo C.51: Ublutuoch River post breakup, looking southwest; May 27, 2016

Appendix D ADCP DIRECT DISCHARGE DATA

D.1 COLVILLE RIVER AT MON1C

D.1.1 MEASUREMENT SUMMARY

Station Number:
Meas. No:
Station Name:
Date: 05/25/2016

Party:
Boat/Motor:
Gage Height: 0.00 ft

Width: 3,040 ft
Area: 48,200 ft²
G.H.Change: 0.000 ft

Processed by:
Mean Velocity: 4.70 ft/s
Discharge: 227,000 ft³/s

Area Method: Avg. Course
Nav. Method: Bottom Track
MagVar Method: None (17.9°)
Depth: Composite (BT)
Discharge Method: None
% Correction: 0.00

ADCP Depth: 1.350 ft
Shore Ens.:10
Bottom Est: Power (0.1667)
Top Est: Power (0.1667)

Index Vel.: 0.00 ft/s
Adj.Mean Vel: 0.00 ft/s
Rated Area: 0.000 ft²
Control1: Unspecified
Control2: Unspecified
Control3: Unspecified

Rating No.: 1
Qm Rating: U
Diff.: 0.000%

Screening Thresholds:
BT 3-Beam Solution: YES
WT 3-Beam Solution: YES
BT Error Vel.: 0.33 ft/s
WT Error Vel.: 3.50 ft/s
BT Up Vel.: 1.00 ft/s
WT Up Vel.: 16.00 ft/s
Use Weighted Mean Depth: YES

Max. Vel.: 10.0 ft/s
Max. Depth: 37.3 ft
Mean Depth: 15.9 ft
% Meas.: 66.80
Water Temp.: None
ADCP Temp.: 38.4 °F

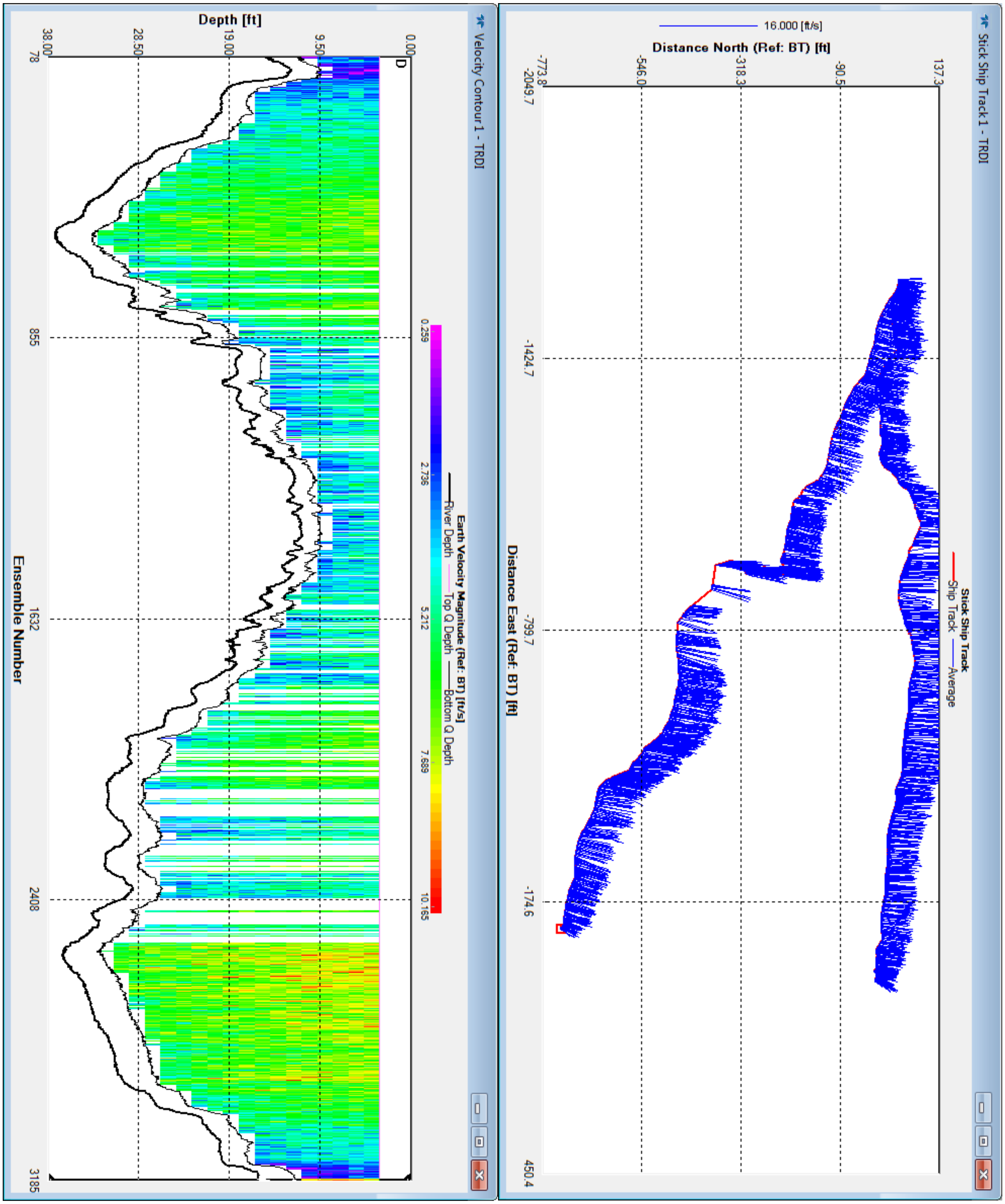
ADCP:
Type/Freq.: Workhorse / 600 kHz
Serial #: 18178
Firmware: 51.40
Bin Size: 50 cm
Blank: 25 cm
BT Mode: 5
BT Pings: 1
WT Mode: 1
WT Pings: 1
WV : 335

Performed Diag. Test: NO
Performed Moving Bed Test: YES
Performed Compass Calibration: NO Evaluation: NO
Meas. Location:

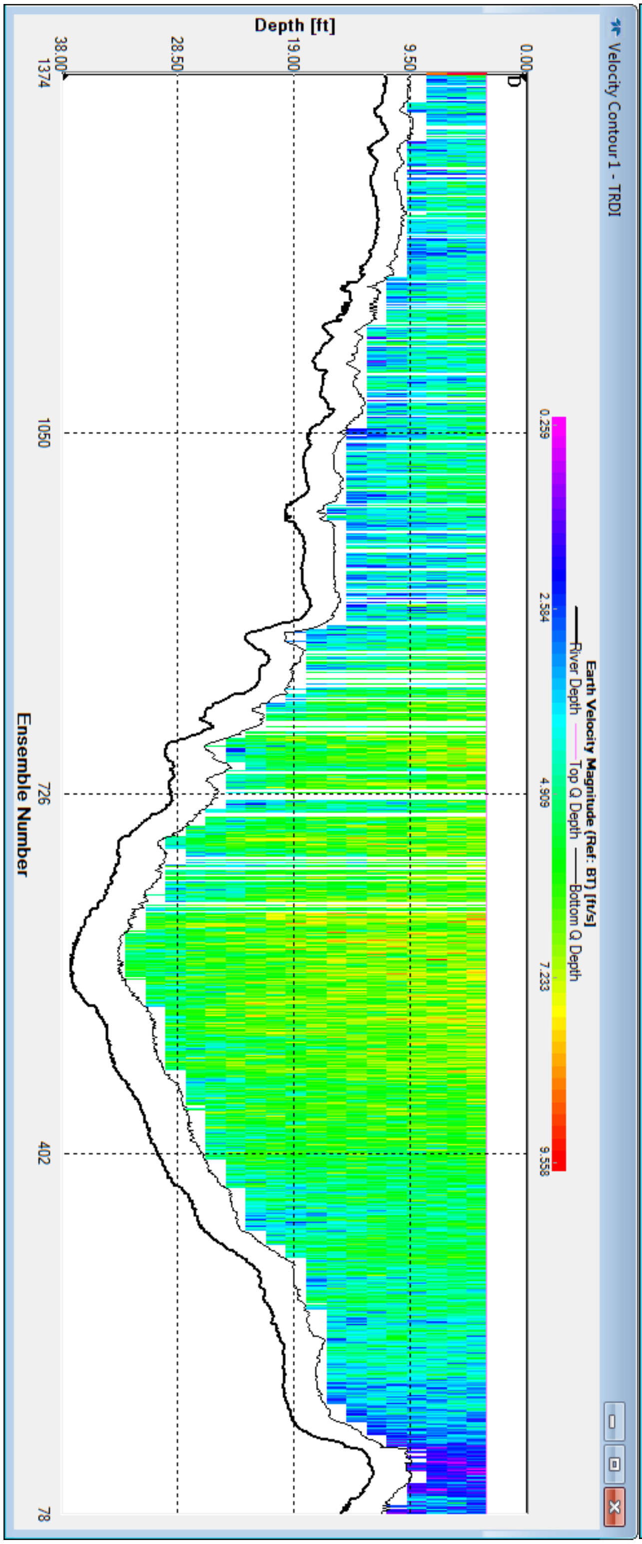
Project Name: mon1c_final_corrected.mmt
Software: 2.17

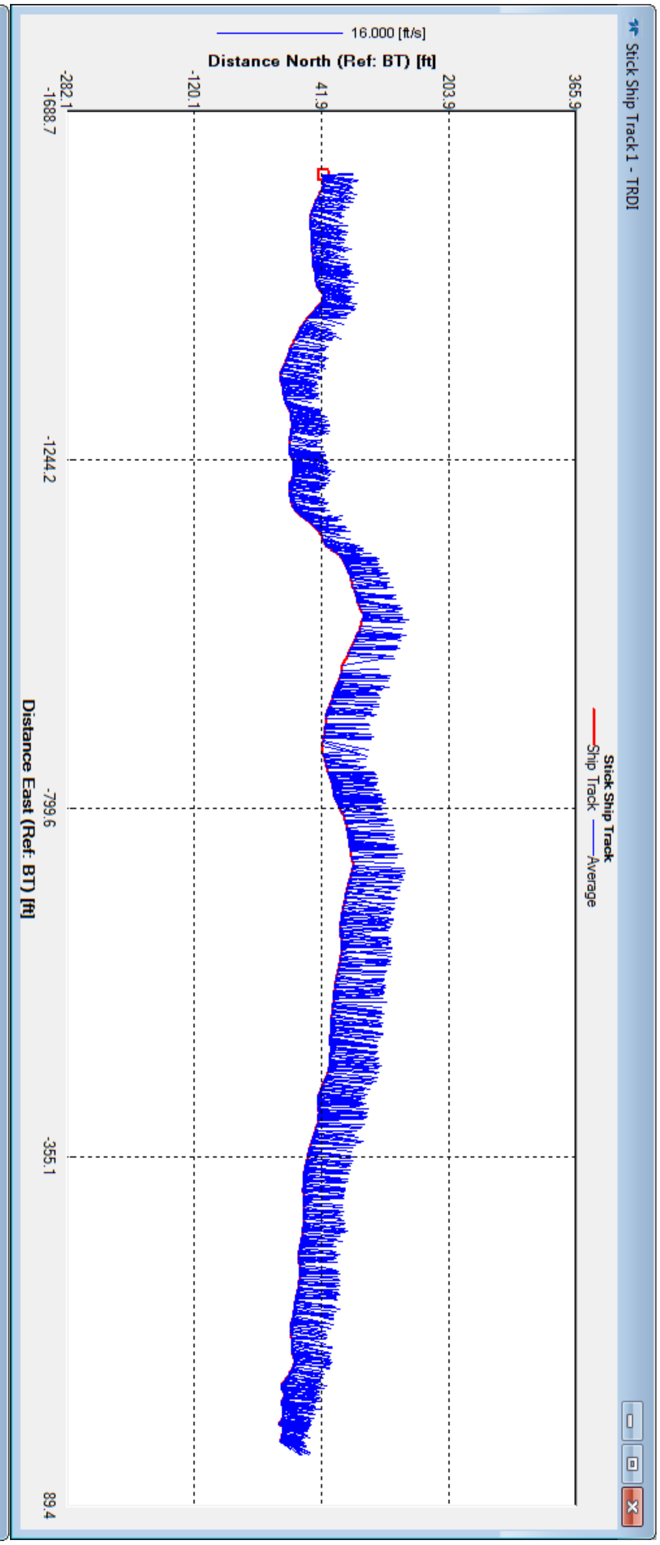
Tr.#		Edge Distance		#Ens.	Discharge						Width	Area	Time		Mean Vel.		% Bad	
		L	R		Top	Middle	Bottom	Left	Right	Total			Start	End	Boat	Water	Ens.	Bins
003	R	1360	14	1297	29695	152395	24084	21193	488	227857	2983	48165	17:51	18:00	3.07	4.73	10	0 #
006	R	1360	14	1286	30433	153840	23863	20260	357	228752	3041	48439	19:09	19:18	3.16	4.72	8	0
007	R	1360	14	1605	30311	149079	24153	20890	157	224590	3064	48006	19:28	19:39	2.57	4.68	10	0
008	R	1360	14	1404	30675	150592	23678	20628	269	225842	3072	48174	19:49	19:59	2.97	4.69	8	0
Mean		1360	14	1398	30278	151477	23944	20743	318	226760	3040	48196	Total	02:08	2.94	4.70	9	0
SDev		0	0	148	417	2078	216	396	140	1891	40.6	179.7			0.26	0.03		
SD/M		0.00	0.00	0.11	0.01	0.01	0.01	0.02	0.44	0.01	0.01	0.00			0.09	0.01		

D.1.2 LOOP TEST VELOCITY PROFILE & TRACK

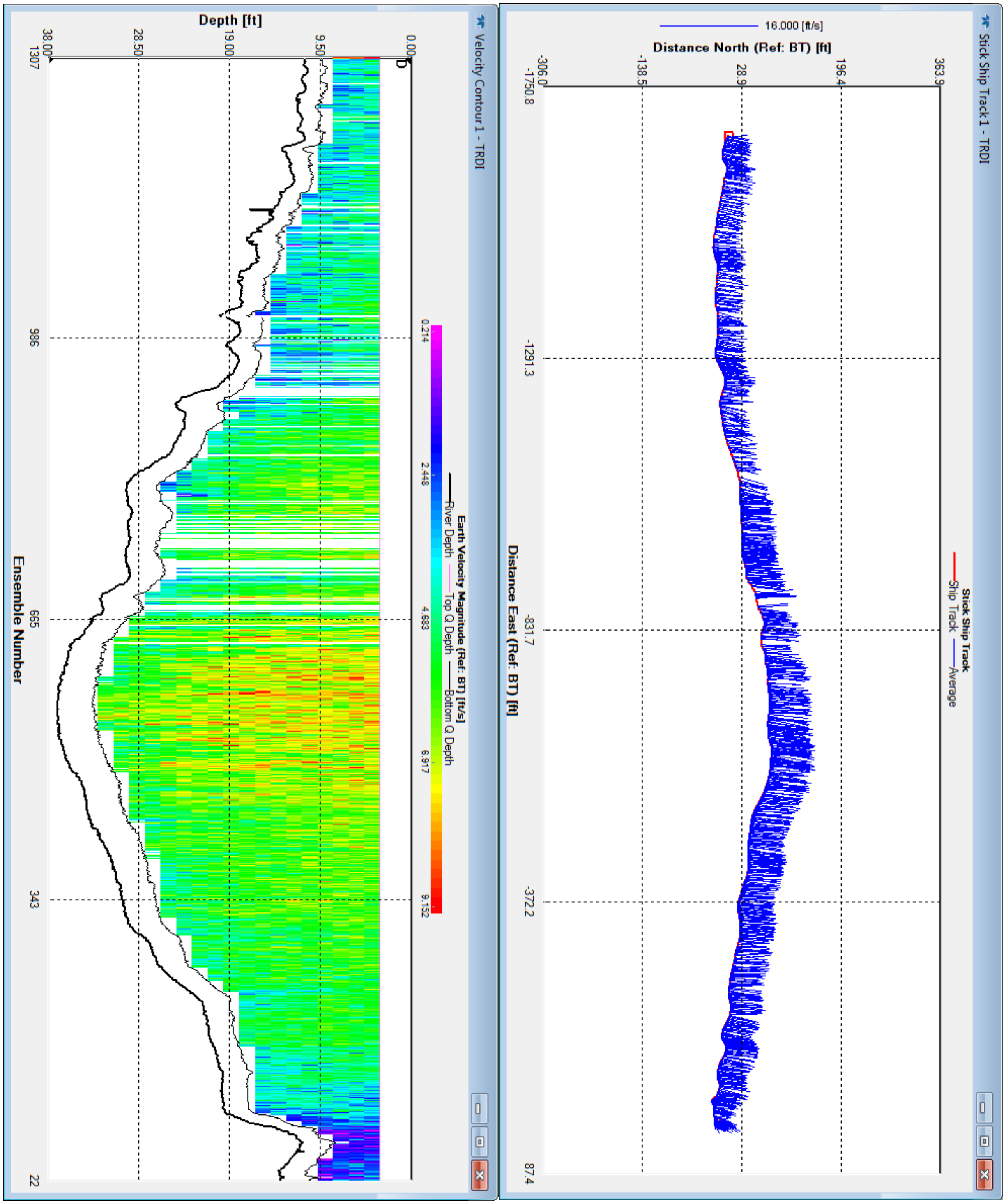


D.1.3 TRANSECT 3 VELOCITY PROFILE & TRACK

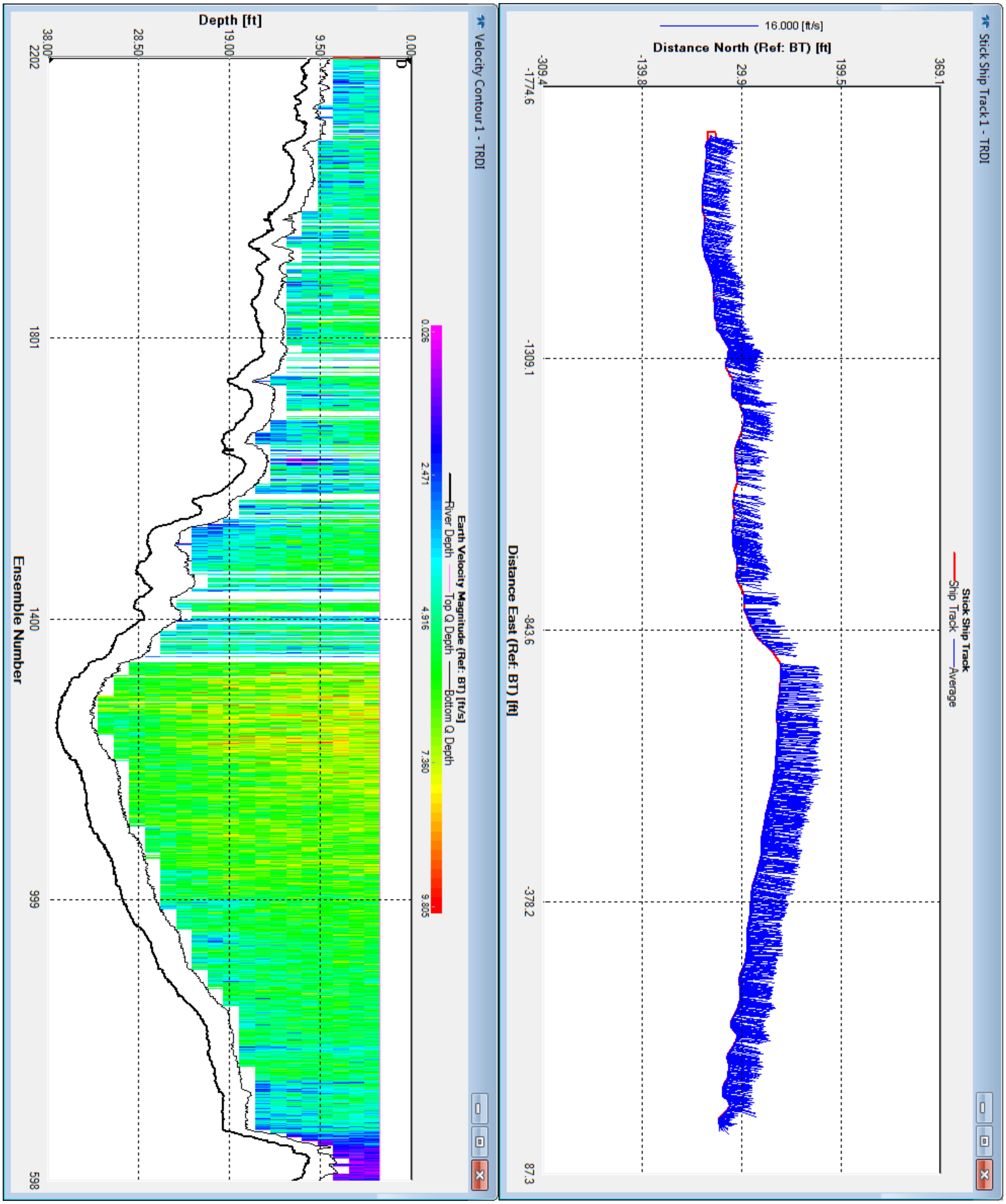




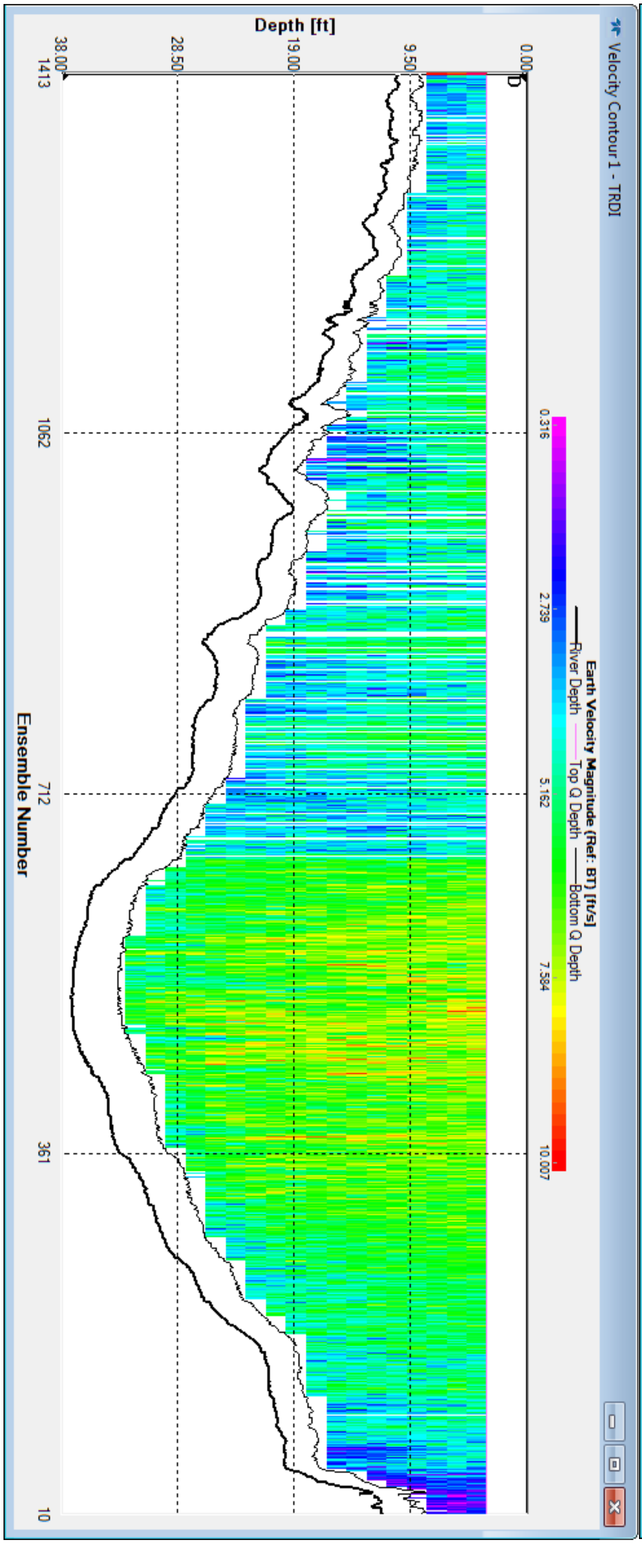
D.1.4 TRANSECT 6 VELOCITY PROFILE & TRACK

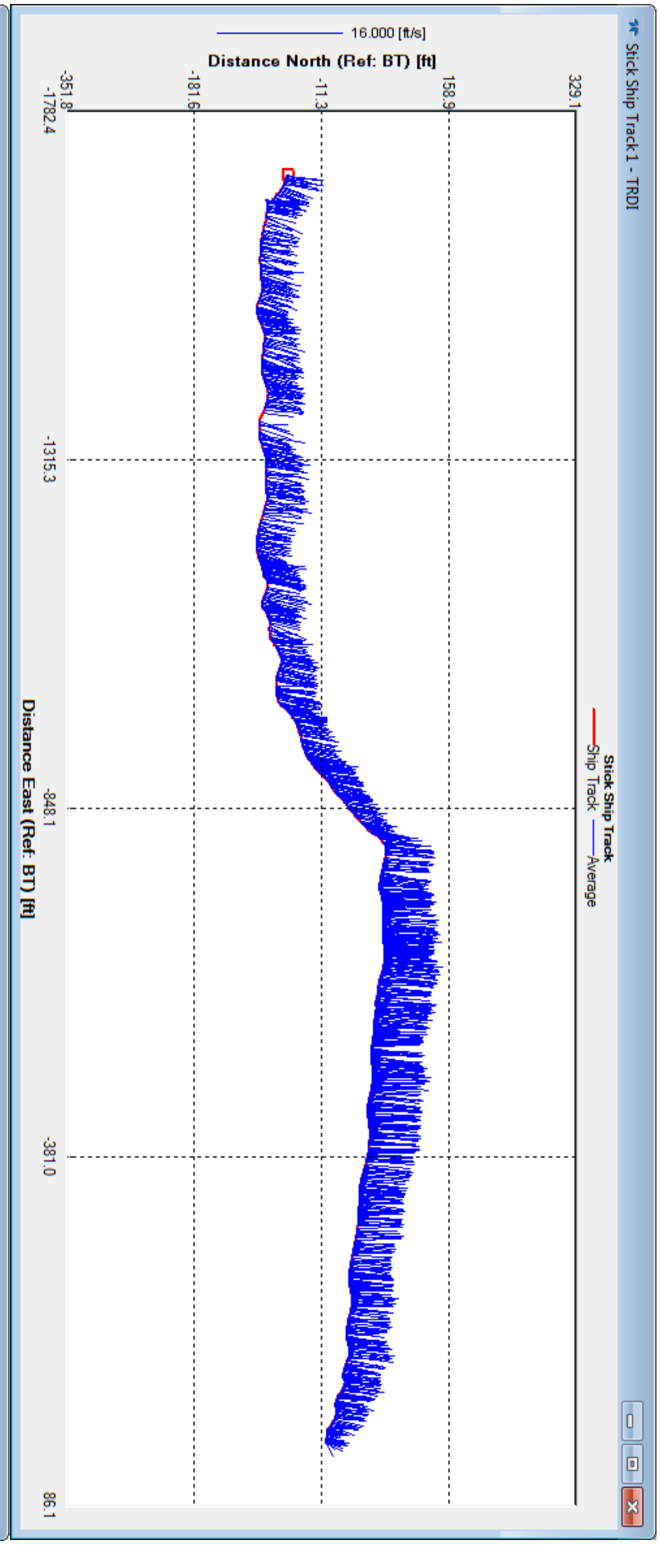


D.1.5 TRANSECT 7 VELOCITY PROFILE & TRACK



D.1.6 TRANSECT 8 VELOCITY PROFILE & TRACK





Appendix E CONVENTIONAL DISCHARGE MEASUREMENT DATA

E.1 CD5 ROAD BRIDGES

E.1.1 NIGLIQ BRIDGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 25, 2016
Computed By: AquaCalc/MNU
Checked By: ALS

Location Name: Nigliq Bridge

Party: ALS, JGM, JPM Start: 17:19 Finish: 18:59

Temp: 38 °F Weather: Overcast, slight breeze

Channel Characteristics:

Width: 1103.5 ft Area: 18376.6 sq ft Velocity: 2.38 fps Discharge: 46,280 cfs

Method: 0.6, 0.2/0.8 Number of Sections: 21 Count: N/A

Spin Test: 3.5 minutes after Good Meter: Price AA

GAGE READINGS			
Gage	Start	Finish	Change
G27-D	0.99	0.9	-0.09
G26-D	0.02	M.D. TOS -3.68	-0.11
G26-C	1.82	1.7	-0.12

Meter: 0.9 ft above bottom of weight

Weight: 50 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data:

Left Edge of Water: W Bridge Abutment

Right Edge of Water: E Bridge Abutment

LE Floodplain: º ' . "

RE Floodplain: º ' . "

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

Descriptions:

Cross Section: Within banks, some ice floes in main portion of channel.

Flow: Mainly perpendicular to the cross section, some skew near edges, right 1/3 of channel is shallow flow with very slow velocity and some remaining snow drifts and grounded ice.

Remarks: Measurement recorded with AquaCalc Pro +

Nigliq Bridge
May 25, 2016

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 Adjusted for Angle Coeff (fps)	VELOCITY Mean in Vertical (fps)	Area (s.f.)	Discharge (cfs)
LEW @ 17:19											
	113	0	0.00				0	0	0	0	0
1	120	3.5	6.30	0.2	3	23.2	0.34	0.34			
1	120	10	6.30	0.8	4	23.0	0.45	0.45	0.39	85.05	33.4
1	140	10	7.40	0.2	4	23.7	0.43	0.43			
1	140	15	7.40	0.8	6	21.2	0.72	0.72	0.58	185.00	106.4
1	170	15	27.00	0.2	16	20.2	1.97	1.97			
1	170	15	27.00	0.8	6	21.9	0.69	0.69	1.33	810.00	1077.2
1	200	15	29.90	0.2	14	21.1	1.65	1.65			
1	200	15	29.90	0.8	22	20.1	2.71	2.71	2.18	897.00	1955.6
1	230	15	32.20	0.2	31	20.3	3.77	3.77			
1	230	15	32.20	0.8	23	20.1	2.83	2.83	3.30	966.00	3190.5
1	260	15	32.20	0.2	30	20.2	3.66	3.66			
1	260	15	32.20	0.8	25	20.3	3.04	3.04	3.35	966.00	3236.5
1	290	15	32.00	0.2	34	20.3	4.14	4.14			
1	290	15	32.00	0.8	18	20.3	2.20	2.20	3.17	960.00	3043.4
1	320	15	29.30	0.2	18	10.0	4.43	4.43			
1	320	15	29.30	0.8	23	21.4	2.66	2.66	3.55	879.00	3116.2
1	350	15	30.00	0.2	34	20.1	4.17	4.17			
1	350	15	30.00	0.8	30	20.2	3.67	3.67	3.92	900.00	3526.8
1	380	15	29.00	0.2	35	20.4	4.23	4.23			
1	380	15	29.00	0.8	20	20.8	2.39	2.39	3.31	870.00	2877.8
1	410	15	28.80	0.2	35	20.0	4.31	4.31			
1	410	15	28.80	0.8	26	20.7	3.10	3.10	3.71	864.00	3202.6
1	440	15	28.40	0.2	32	20.1	3.94	3.94			
1	440	15	28.40	0.8	25	20.0	3.09	3.09	3.51	852.00	2991.9
1	470	15	29.00	0.2	30	20.5	3.62	3.62			
1	470	15	29.00	0.8	22	20.8	2.61	2.61	3.12	870.00	2710.2
1	500	15	29.10	0.2	31	20.4	3.76	3.76			
1	500	15	29.10	0.8	26	20.7	3.11	3.11	3.43	873.00	2998.4
1	530	15	22.10	0.2	24	20.7	2.87	2.87			
1	530	50	22.10	0.8	25	20.6	3.00	3.00	2.94	1436.50	4218.8
1	630	50	22.10	0.2	7	5.9	2.93	2.93			
1	630	25	22.10	0.8	26	20.6	3.13	3.13	3.03	1657.50	5023.3
1	680	25	25.30	0.2	2	2.0	2.49	2.49			
1	680	40	25.30	0.8	2	17.7	0.30	0.30	1.39	1644.50	2290.8
1	760	40	14.90	0.2	0	20.0	0.00	0.00			
1	760	50	14.90	0.8	1	9.3	0.29	0.29	0.14	1341.00	191.2
1	860	100	4.10	0.6	1	4.3	0.59	0.59	0.59	410.00	241.3
1	960	100	3.30	0.6	3	10.1	0.75	0.75	0.75	330.00	247.6
0	1060	210	2.00	0.6	0	20.0	0	0	0	420.00	0
	1380	0	1.00				0	0	0	160.00	0
REW @ 18:59											
								Total Discharge (cfs):			46279.8

E.1.2 NIGLIAGVIK BRIDGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 26, 2016
Computed By: ALS
Checked By: MNU/HLR

Location Name: Nigliagvik Bridge

Party: ALS, GCY Start: 11:20 Finish: 15:00

Temp: 35 °F Weather: Overcast, with eventual clearing

Channel Characteristics:

Width: 117.5 ft Area: 763 sq ft Velocity: 1.99 fps Discharge: 1519 cfs

Method: 0.6, 0.2/0.8 Number of Sections: 24 Count: N/A

Spin Test: 3.5 minutes after Good Meter: Price AA

GAGE READINGS			
Gage	Start	Finish	Change
G38-B	2.02	1.99	-0.03
G39-B	1.52	1.41 (@3:10pm)	-0.11

Meter: 0.5 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data:

Left Edge of Water: W Bridge Abutment

Right Edge of Water: E Bridge Abutment

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

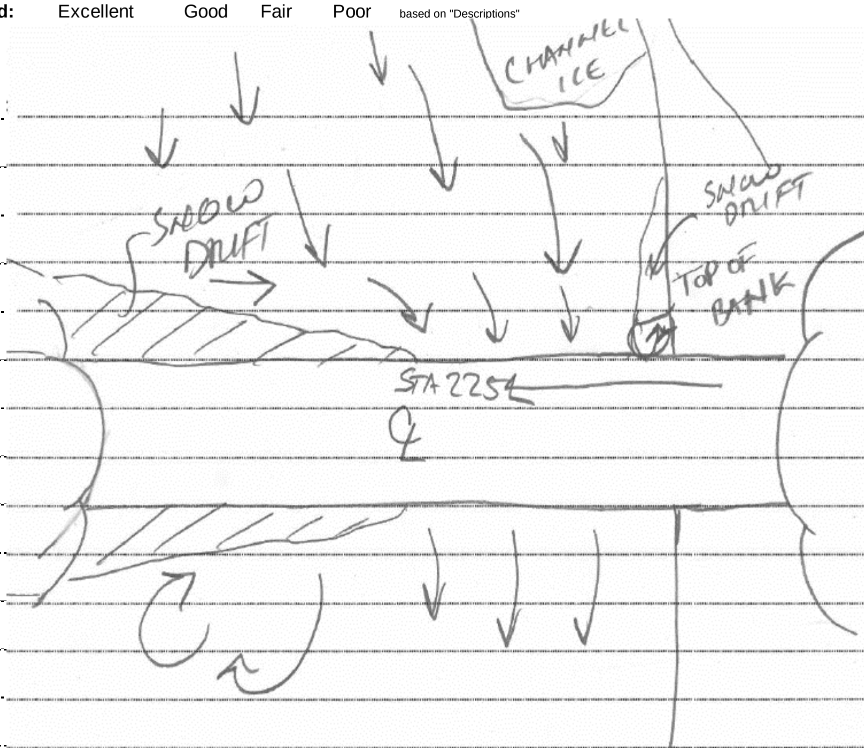
Measurement Rated: Excellent Good Fair Poor based on "Descriptions"

Descriptions:

Cross Section:

Flow:

Remarks:



* First measurement taken with AquaCalc Pro, then connection was broken, all other measurements taken by counting clicks with headphones.

Nigliagvik Bridge
May 26, 2016

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)
			LEW @ 11:20								
	97.0	0.0	0.0								
1.00	105.0	6.5	2.4		*			-1.60	-1.60	15.6	-25.0
0.95	110.0	5.0	3.7	0.8 0.2	15 20	43 52	0.787 0.866	0.83	0.79	18.5	14.5
1.00	115.0	5.0	4.8	0.8 0.2	30 20	42 44	1.59 1.02	1.31	1.31	24.0	31.4
1.00	120.0	5.0	5.7	0.8 0.2	50 40	50 47	2.22 1.89	2.06	2.06	28.5	58.7
1.00	125.0	5.0	6.3	0.8 0.2	40 40	42 43	2.12 2.07	2.09	2.09	31.5	65.9
1.00	130.0	5.0	7.0	0.8 0.2	40 50	42 45	2.12 2.47	2.29	2.29	35.0	80.2
1.00	135.0	5.0	7.3	0.8 0.2	50 50	48 44	2.31 2.52	2.42	2.42	36.5	88.3
1.00	140.0	5.0	7.9	0.8 0.2	40 50	40 44	2.22 2.52	2.37	2.37	39.5	93.7
1.00	145.0	5.0	8.0	0.8 0.2	50 50	49 45	2.27 2.47	2.37	2.37	40.0	94.7
1.00	150.0	5.0	8.0	0.8 0.2	50 50	49 44	2.27 2.52	2.40	2.40	40.0	95.8
1.00	155.0	5.0	8.0	0.8 0.2	40 50	42 46	2.12 2.41	2.27	2.27	40.0	90.6
1.00	160.0	5.0	7.9	0.8 0.2	40 50	44 47	2.02 2.36	2.19	2.19	39.5	86.6
1.00	165.0	5.0	7.5	0.8 0.2	40 50	45 49	1.98 2.27	2.12	2.12	37.5	79.6
1.00	170.0	5.0	7.4	0.8 0.2	40 50	44 49	2.02 2.27	2.14	2.14	37.0	79.4
1.00	175.0	5.0	8.7	0.8 0.2	40 40	51 43	1.75 2.07	1.91	1.91	43.5	83.0
1.00	180.0	5.0	9.2	0.8 0.2	30 40	43 42	1.56 2.12	1.84	1.84	46.0	84.5
0.97	185.0	5.0	7.1	0.8 0.2	40 50	40 46	2.22 2.41	2.32	2.25	35.5	79.8
0.97	190.0	5.0	6.9	0.8 0.2	40 50	43 48	2.07 2.31	2.19	2.13	34.5	73.3
0.97	195.0	5.0	6.4	0.8 0.2	40 40	46 40	1.94 2.22	2.08	2.02	32.0	64.5
0.97	200.0	5.0	6.1	0.8 0.2	50 40	52 42	2.14 2.12	2.13	2.06	30.5	62.9
0.97	205.0	5.0	5.4	0.8 0.2	40 40	43 43	2.07 2.07	2.07	2.01	27.0	54.2
0.97	210.0	5.0	5.1	0.8 0.2	40 40	44 42	2.02 2.12	2.07	2.01	25.5	51.2
0.94	215.0	3.5	4.6	0.8 0.2	30 40	46 48	1.46 1.86	1.66	1.56	16.1	25.1
0.91	217.0	2.5	3.8	0.8 0.2	20 15	66 45	0.69 0.75	0.72	0.65	9.5	6.2
	220.0										
			REW @ 15:00								
									Total Discharge (cfs):		1519.3

* First measurement taken with AquaCalc Pro, then connection was broken, all other measurements taken by counting clicks with headphones.

E.2 CD2 ROAD SWALE BRIDGES

E.2.1 LONG SWALE BRIDGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 25, 2016
Computed By: J. Gillenwater
Checked By: D. Roe

Location Name: Long Swale Bridge

Party: Alaina, Jim, Jen, Michael l Start: 9:32 Finish: 11:04

Temp: 35 °F Weather: Overcast, light rain

Channel Characteristics:

Width: 445 ft Area: 2,025 sq ft Velocity: 2.25 fps Discharge: 4,765 cfs

Method: .2 - .8, .6 Number of Sections: 28 Count: N/A

Spin Test: Minutes after Minutes Meter: Price AA Poly

GAGE READINGS			
Gage	Start	Finish	Change
G3	7.48	7.39	0.09
G4	7.08	7.07	0.01

Meter: 0.9 ft above bottom of weight

Weight: 50 lbs

Wading [Cable] Ice Boat

[Upstream] or Downstream side of bridge

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

Descriptions:

Cross Section: Open channel with some floating ice
Section uniform and firm

Flow: Steady flow, steady stage

Remarks: Left edge water at abutment
Right edge water at abutment
Downstream control is ponded water clear of ice
Measurements taken with AquaCalc Pro Plus

Long Swale Bridge
May 25, 2016

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)
LEW @ 9:32											
	0	0	0				0	0	0	0	0
0.71	1	2.5	3.6	0.6	78	40.3	4.77	3.39	3.39	9.00	30.50
0.71	5	4.5	3.4	0.6	73	40.2	4.48	3.18	3.18	15.30	48.65
0.77	10	7.5	3.3	0.6	64	40.6	3.89	3.00	3.00	24.75	74.18
0.77	20	15	3.4	0.6	69	40.1	4.25	3.27	3.27	51.00	166.87
0.71	40	20	3.8	0.6	64	40.5	3.90	2.77	2.77	76.00	210.71
0.71	60	20	3.9	0.6	53	40.4	3.25	2.30	2.30	78.00	179.72
0.87	80	20	3.8	0.6	54	40.3	3.31	2.88	2.88	76.00	218.81
0.91	100	20	3.8	0.6	45	40.7	2.74	2.49	2.49	76.00	189.19
0.91	120	20	4.1	0.6	42	40.4	2.58	2.34	2.34	82.00	192.21
0.94	140	20	3.8	0.6	44	40.8	2.67	2.51	2.51	76.00	190.65
0.94	160	20	3.7	0.6	42	40.5	2.57	2.41	2.41	74.00	178.65
0.94	180	20	4.2	0.6	39	40.9	2.36	2.22	2.22	84.00	186.63
0.94	200	20	4.2	0.6	43	40.7	2.61	2.46	2.46	84.00	206.26
0.94	220	20	4.5	0.6	38	40.4	2.33	2.19	2.19	90.00	197.08
0.94	240	10	5.6	0.2	51	40.4	3.12	2.93			
0.94	240	10	5.6	0.8	29	40.2	1.79	1.69	2.31	112.00	258.77
0.94	260	10	6.6	0.2	55	40.4	3.36	3.16			
0.94	260	10	6.6	0.8	29	40.0	1.80	1.69	2.43	132.00	320.35
0.94	280	10	6.5	0.2	63	40.6	3.83	3.60			
0.94	280	10	6.5	0.8	42	40.6	2.56	2.41	3.01	130.00	390.73
0.91	300	10	5.9	0.2	47	40.4	2.88	2.62			
0.91	300	10	5.9	0.8	35	40.2	2.16	1.96	2.29	118.00	270.17
0.91	320	20	4.7	0.6	48	40.8	2.91	2.65	2.65	94.00	249.05
0.97	340	20	4.4	0.6	40	40.7	2.43	2.36	2.36	88.00	207.75
0.97	360	20	5.3	0.6	35	40.3	2.15	2.09	2.09	106.00	221.15
0.94	380	20	4.6	0.6	31	40.0	1.92	1.81	1.81	92.00	166.17
0.87	400	10	5.4	0.2	34	40.1	2.10	1.83			
0.87	400	10	5.4	0.8	23	40.1	1.43	1.24	1.54	108.00	165.86
0.93	420	20	4.4	0.6	28	41.3	1.68	1.57	1.57	88.00	137.81
1	440	11.5	4.1	0.6	30	40.2	1.85	1.85	1.85	47.15	87.34
0.97	443	2.5	4.4	0.6	30	40.9	1.82	1.77	1.77	11.00	19.43
	445	0	2.9				0	0	0	2.90	0
REW @ 11:04											

*Estimated value

Total Discharge: **4764.7** cfs

E.2.2 SHORT SWALE BRIDGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 25, 2016
Computed By: J. Gillenwater
Checked By: D. Roe

Location Name: Short Swale Bridge

Party: Alaina, Jim, Jen, Michael U Start: 11:27 Finish: 13:16

Temp: 35 °F Weather: Overcast, light rain

Channel Characteristics:

Width: 53 ft Area: 322 sq ft Velocity: 2.11 fps Discharge: 700 cfs

Method: .2 - .8, .6 Number of Sections: 27 Count: N/A

Spin Test: Minutes after Minutes Meter: Price AA Poly

GAGE READINGS			
Gage	Start (ft)	Finish (ft)	Change (ft)
G3	7.39	7.38	-0.01
G4	7.07	7.07	0.00

Meter: 0.55 ft above bottom of weight

Weight: 50 lbs

Wading **[Cable]** Ice Boat

[Upstream] or Downstream side of bridge

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

Descriptions:

Cross Section: Open channel no floating ice, section uniform and firm, skewed flow

Flow: Steady flow, steady stage

Remarks: Left edge water at abutment

Right edge water at abutment

Downstream side of bridge has 12.5' of snow on left bridge abutment

Measured with AquaCalc Pro + Section 4

Short Swale Bridge
May 25, 2016

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 Adjusted for Angle Coeff (fps)	VELOCITY Mean in Vertical (fps)	Area (s.f.)	Discharge (cfs)
			LEW @ 11:39								
	0	0	0						0	0	0
	0.1	1	3.55						0	3.55	0
0.77	2	0.95	2.35	0.2	22	41.08	1.34	1.03			
0.77	2	0	2.35	0.6	27	40.23	1.67	1.28			
0.77	2	1	2.35	0.8	26	40.67	1.59	1.22	1.21	4.58	5.52
0.82	4	1	2.95	0.2	24	40.6	1.47	1.21			
0.82	4	0	2.95	0.6	31	40.87	1.88	1.54			
0.82	4	1	2.95	0.8	31	40.26	1.91	1.57	1.47	5.90	8.65
0.91	6	1	3.45	0.2	28	40.2	1.73	1.57			
0.91	6	1	3.45	0.8	25	40.52	1.54	1.40	1.49	6.90	10.25
0.87	8	1	5.05	0.2	33	40.82	2.01	1.74			
0.87	8	1	5.05	0.8	19	40.48	1.17	1.02	1.38	10.10	13.96
0.82	10	1	5.45	0.2	32	40.53	1.96	1.61			
0.82	10	1	5.45	0.8	31	40.43	1.90	1.56	1.58	10.90	17.26
0.82	12	1	5.75	0.2	31	40.11	1.92	1.57			
0.82	12	0	5.75	0.6	40	40.2	2.46	2.02			
0.82	12	1	5.75	0.8	48	40.65	2.92	2.39	2.00	11.50	23.02
0.82	14	1	6.25	0.2	33	40.94	2.00	1.64			
0.82	14	1	6.25	0.8	50	40.12	3.08	2.53	2.08	12.50	26.04
0.91	16	1	6.05	0.2	38	40.9	2.30	2.09			
0.91	16	1	6.05	0.8	50	40.23	3.07	2.80	2.45	12.10	29.59
0.9	18	1	6.05	0.2	46	40.77	2.79	2.51			
0.9	18	1	6.05	0.8	49	40.68	2.98	2.68	2.60	12.10	31.41
0.94	20	1	6.15	0.2	41	40.3	2.52	2.37			
0.94	20	1	6.15	0.8	46	40.28	2.82	2.66	2.51	12.30	30.89
0.97	22	1	6.55	0.2	41	40.68	2.50	2.42			
0.97	22	1	6.55	0.8	46	40.11	2.84	2.75	2.59	13.10	33.88
0.98	24	1	6.35	0.2	37	40.96	2.24	2.19			
0.98	24	1	6.35	0.8	42	40.57	2.56	2.51	2.35	12.70	29.88
0.99	26	1	6.45	0.2	37	40.66	2.25	2.23			
0.99	26	1	6.45	0.8	38	40.55	2.32	2.30	2.27	12.90	29.22
1	28	1	6.35	0.2	40	40.48	2.45	2.45			
1	28	1	6.35	0.8	33	40.35	2.03	2.03	2.24	12.70	28.45
1	30	1	6.85	0.2	37	40.51	2.26	2.26			
1	30	1	6.85	0.8	33	41.06	1.99	1.99	2.13	13.70	29.16
1	32	1	6.75	0.2	32	40.06	1.98	1.98			
1	32	1	6.75	0.8	38	40.56	2.32	2.32	2.15	13.50	29.04
0.98	34	1	7.65	0.2	37	40.84	2.25	2.20			
0.98	34	1	7.65	0.8	37	40.15	2.28	2.24	2.22	15.30	33.95
0.98	36	1	7.75	0.2	41	40.47	2.51	2.46			
0.98	36	1	7.75	0.8	38	41.15	2.29	2.24	2.35	15.50	36.43
0.98	38	1	8.05	0.2	43	40.56	2.62	2.57			
0.98	38	1	8.05	0.8	36	40.05	2.23	2.18	2.38	16.10	38.27
0.94	40	1	7.35	0.2	50	40.57	3.05	2.86			
0.94	40	1	7.35	0.8	29	40.55	1.78	1.67	2.27	14.70	33.32
0.96	42	1	7.35	0.2	50	40.07	3.08	2.96			
0.96	42	1	7.35	0.8	27	40.42	1.66	1.59	2.28	14.70	33.48
0.95	44	1	7.25	0.2	55	40.57	3.35	3.18			
0.95	44	1	7.25	0.8	35	40.39	2.15	2.04	2.61	14.50	37.87
0.94	46	1	7.35	0.2	59	40.71	3.58	3.36			
0.94	46	1	7.35	0.8	33	40.32	2.03	1.91	2.64	14.70	38.76
0.92	48	1	7.35	0.2	59	40.11	3.63	3.34			
0.92	48	1	7.35	0.8	36	40.28	2.22	2.04	2.69	14.70	39.54

E.3 CD2, CD4, & CD5 ROAD CULVERTS

Culvert ID	Date Time	Depth (ft)	Area (ft^2)	Measured Velocity (ft/s)	Direct Discharge (cfs)
CD2-21	5/23/16 13:44	0.90	2.12	1.24	2.6
CD2-21	5/24/16 11:22	1.30	3.54	2.52	8.9
CD2-22	5/23/16 13:30	0.80	1.79	2.80	5.0
CD2-22	5/24/16 11:10	1.20	3.17	3.62	11.5
CD2-23	5/23/16 13:22	0.90	2.12	5.89	12.5
CD2-23	5/24/16 11:05	1.50	4.30	4.10	17.7
CD2-24	5/23/16 13:10	1.00	2.46	6.12	15.0
CD2-24	5/24/16 11:40	1.80	5.48	4.13	22.7
Average Measured Velocity (ft/s) on 05/23/16				4.01	
Average Measured Velocity (ft/s) on 05/24/16				3.60	
Average Measured Discharge (cfs) on 05/23/16				35.12	
Average Measured Discharge (cfs) on 05/24/16				60.75	

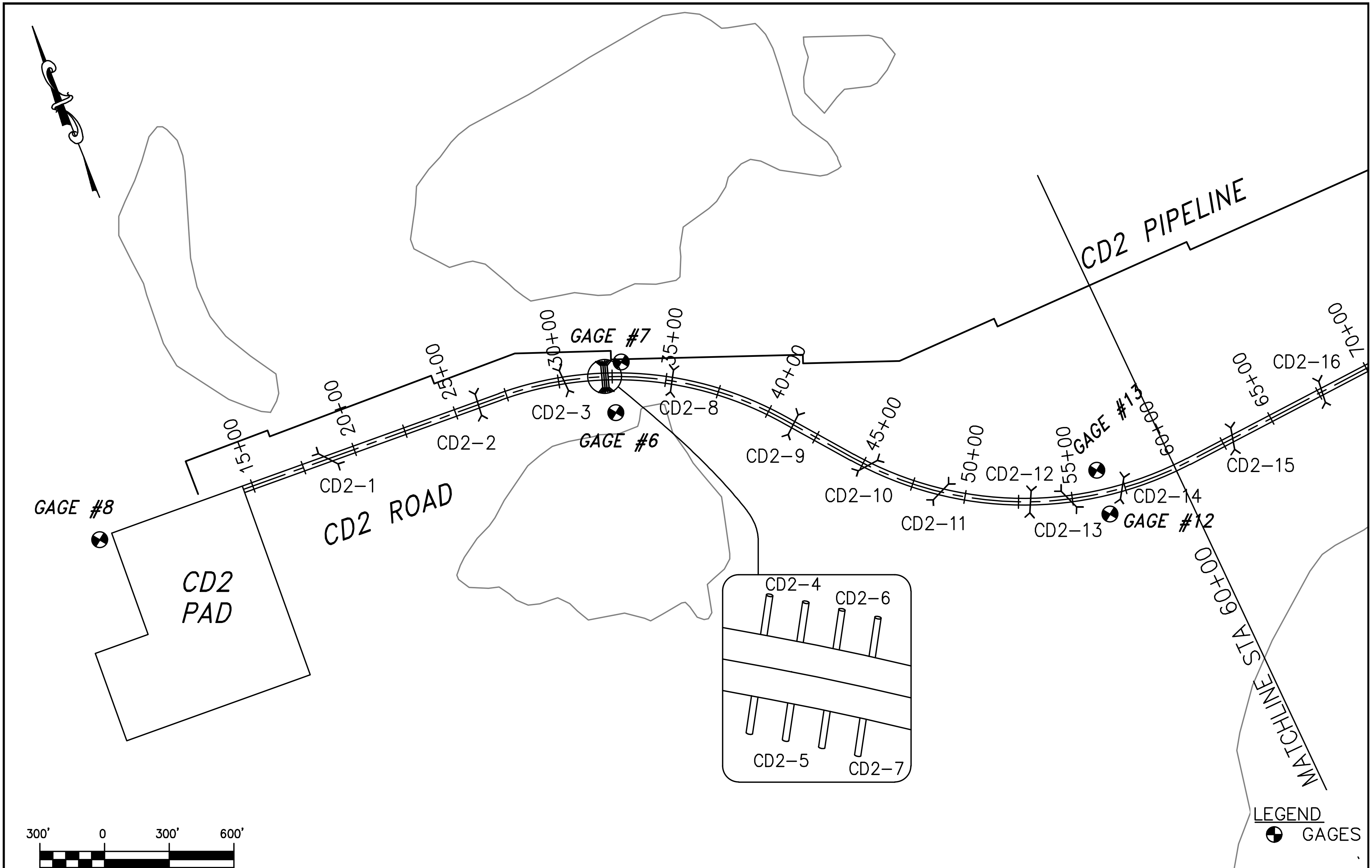
Culvert ID	Date Time	Depth (ft)	Area (ft^2)	Measured Velocity (ft/s)	Direct Discharge (cfs)
CD4-25	5/24/16 10:51	1.1	2.81	0.19	0.52
CD4-26	5/24/16 10:50	1.1	2.81	0.17	0.49
CD4-27	5/24/16 10:47	1.2	3.17	0.22	0.71
CD4-28	5/24/16 10:45	1.1	2.81	0.32	0.90
CD4-29	5/24/16 10:08	1.4	3.92	0.44	1.71
CD4-30	5/24/16 10:25	1.1	2.81	0.66	1.84
CD4-31	5/24/16 10:20	1.1	2.81	0.50	1.41
CD4-32	5/24/16 10:15	1.1	2.81	0.59	1.65
CD4-33	5/24/16 10:10	1.0	2.46	0.86	2.12
Average Measured Velocity (ft/s)				0.44	
Total Measured Discharge (cfs)				11.36	

Culvert ID	Date Time	Depth (ft)	Area (ft^2)	Measured Velocity (ft/s)	Direct Discharge (cfs)
CD5-05	5/23/15 9:25	1.0	1.57	2.59	4.07
CD5-08	5/23/16 9:20	1.2	3.17	0.38	1.20
CD5-09	5/23/16 9:20	1.2	3.17	0.38	1.20
Average Measured Velocity (ft/s)				1.12	
Total Measured Discharge (cfs)				6.48	

Appendix F CULVERT LOCATIONS & PEAK DISCHARGE

F.1 CULVERT LOCATIONS

F.1.1 CD2 ROAD



ConocoPhillips
Alaska, Inc.

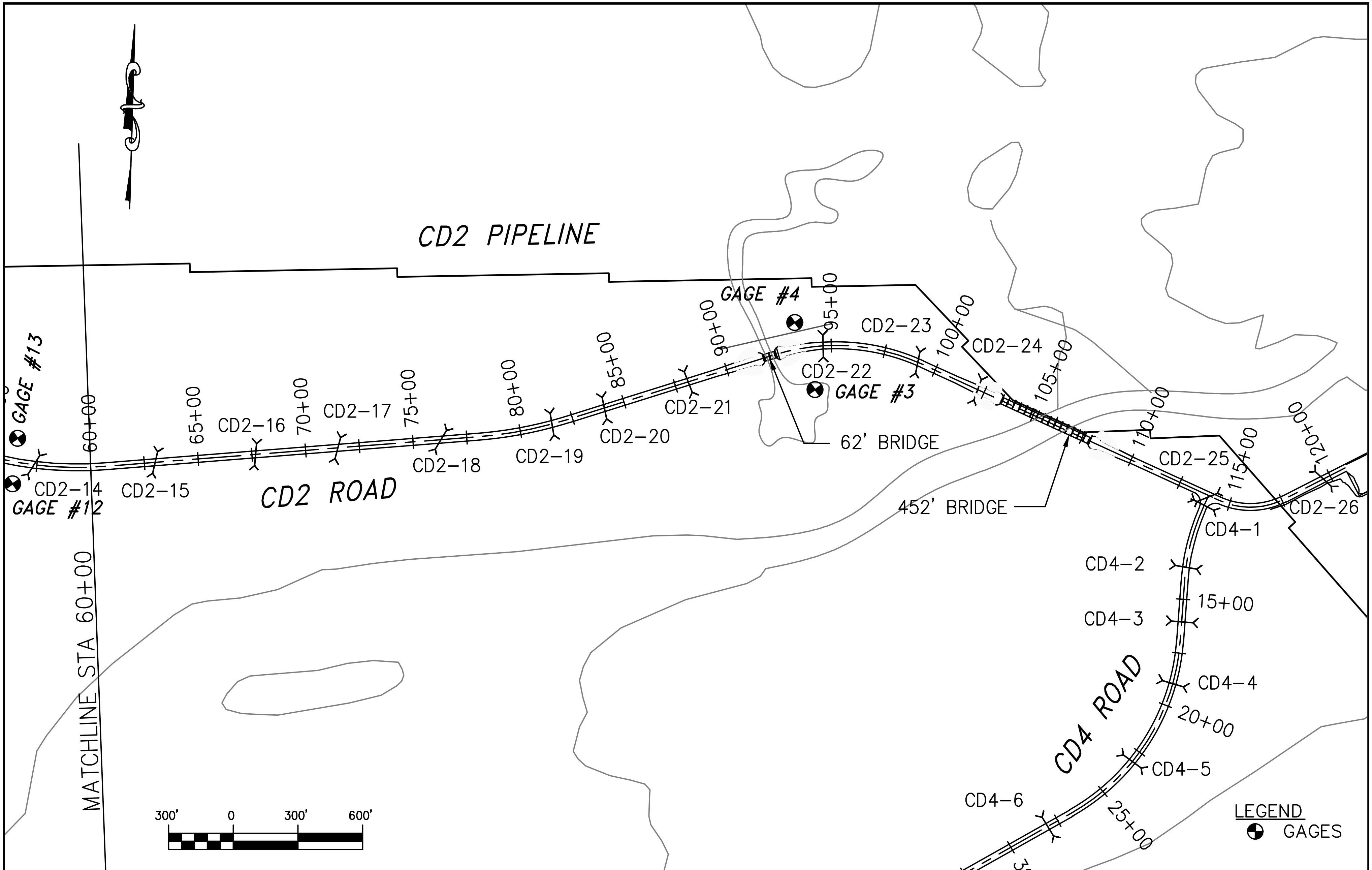
DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL

Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2016 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 1 OF 13)



ConocoPhillips
Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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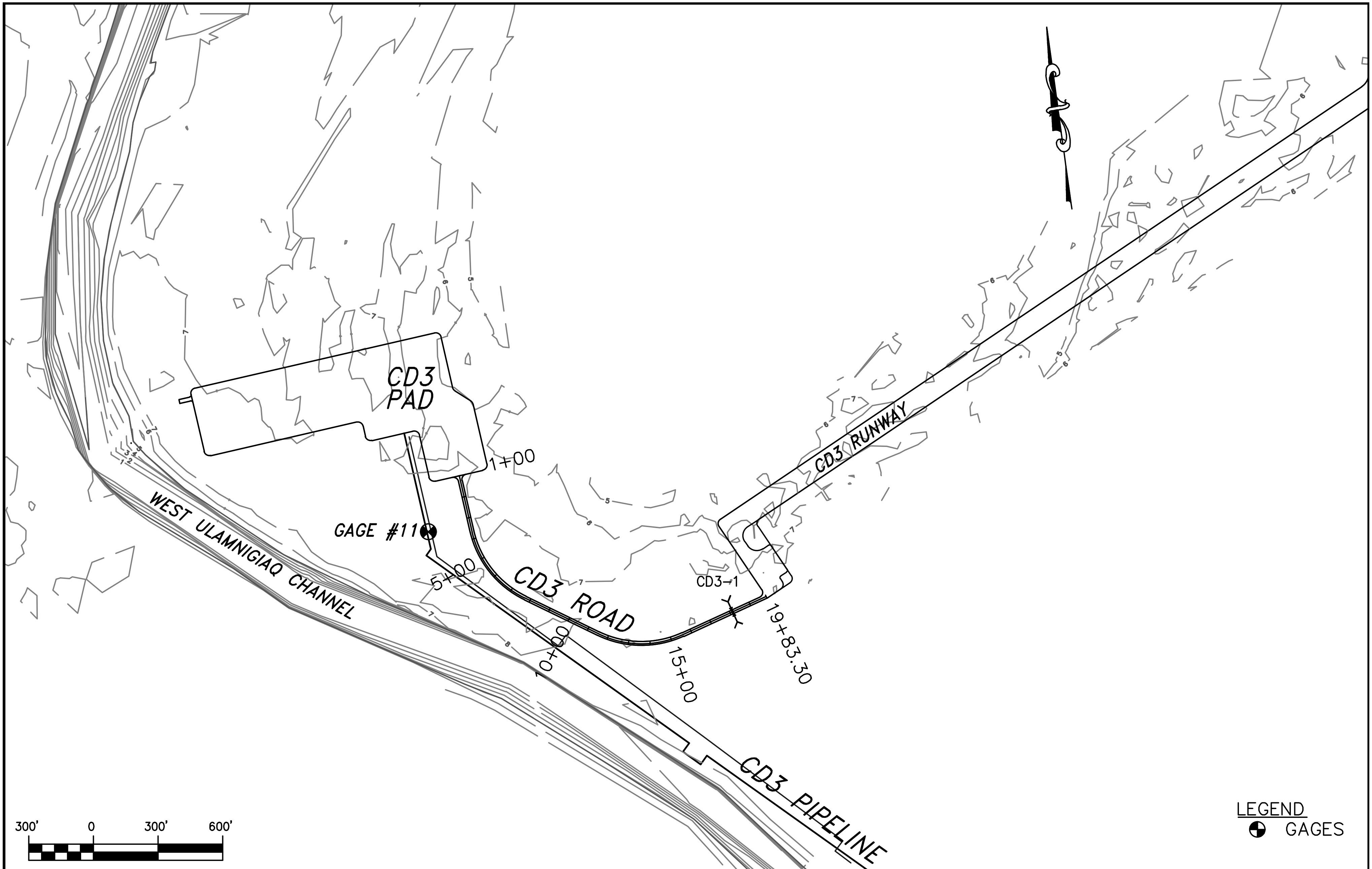
2016 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 2 OF 13)

F.1.2 CD3 PAD



ConocoPhillips
Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL
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Phone: (907) 273-1600
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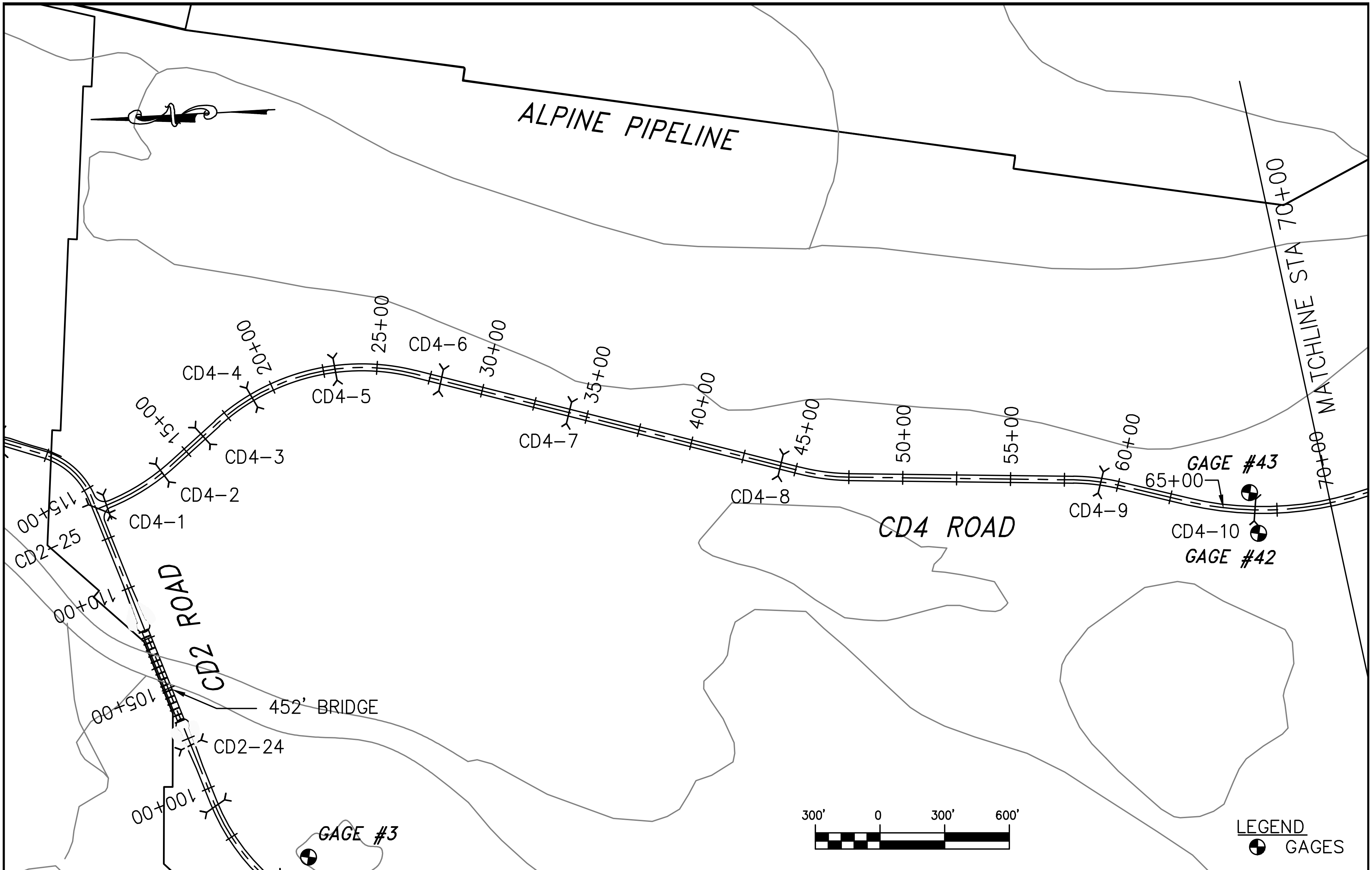
2016 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET13 OF 13)

F.1.3 CD4 ROAD



ConocoPhillips Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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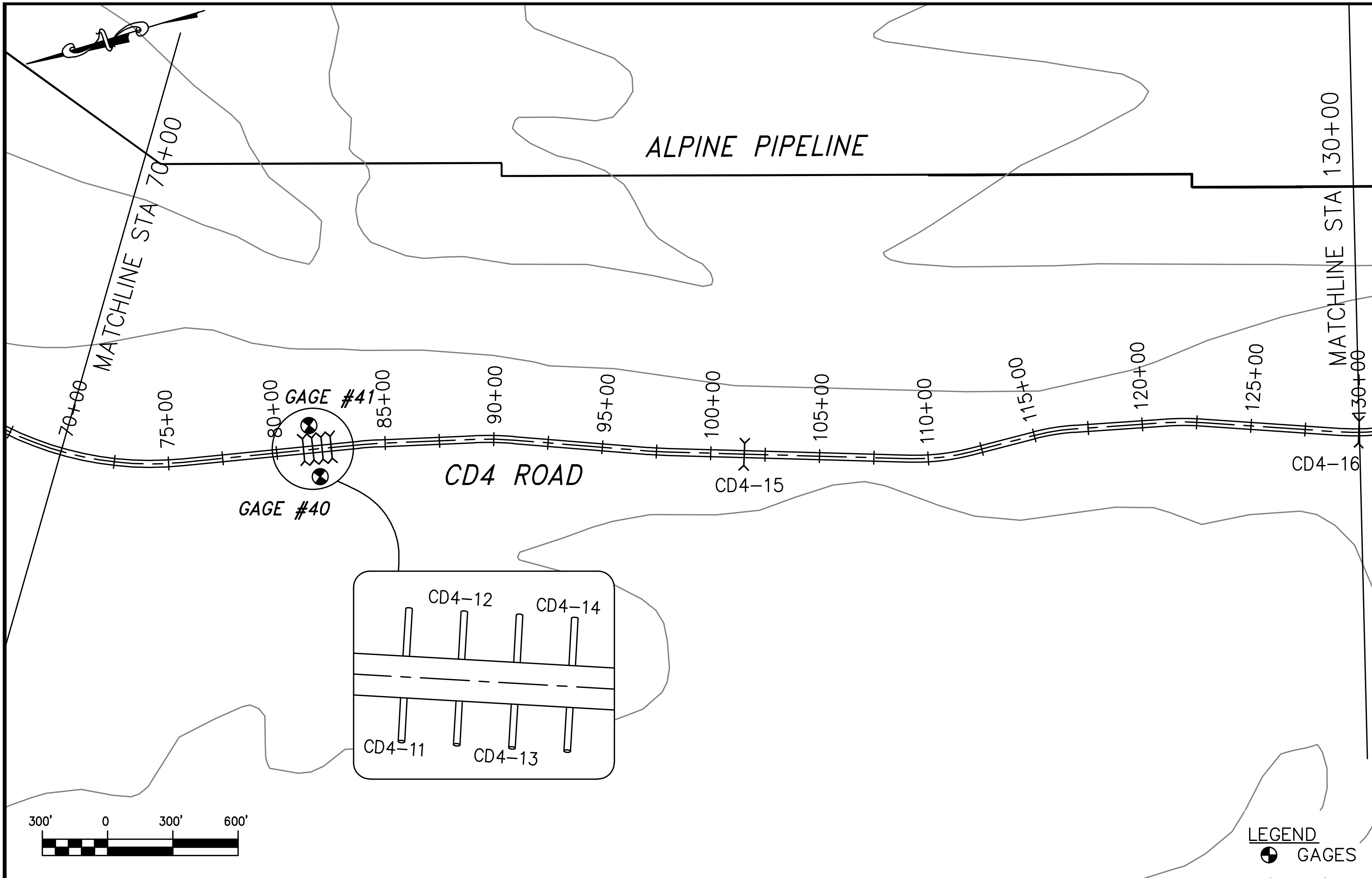
2016 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION



ConocoPhillips
Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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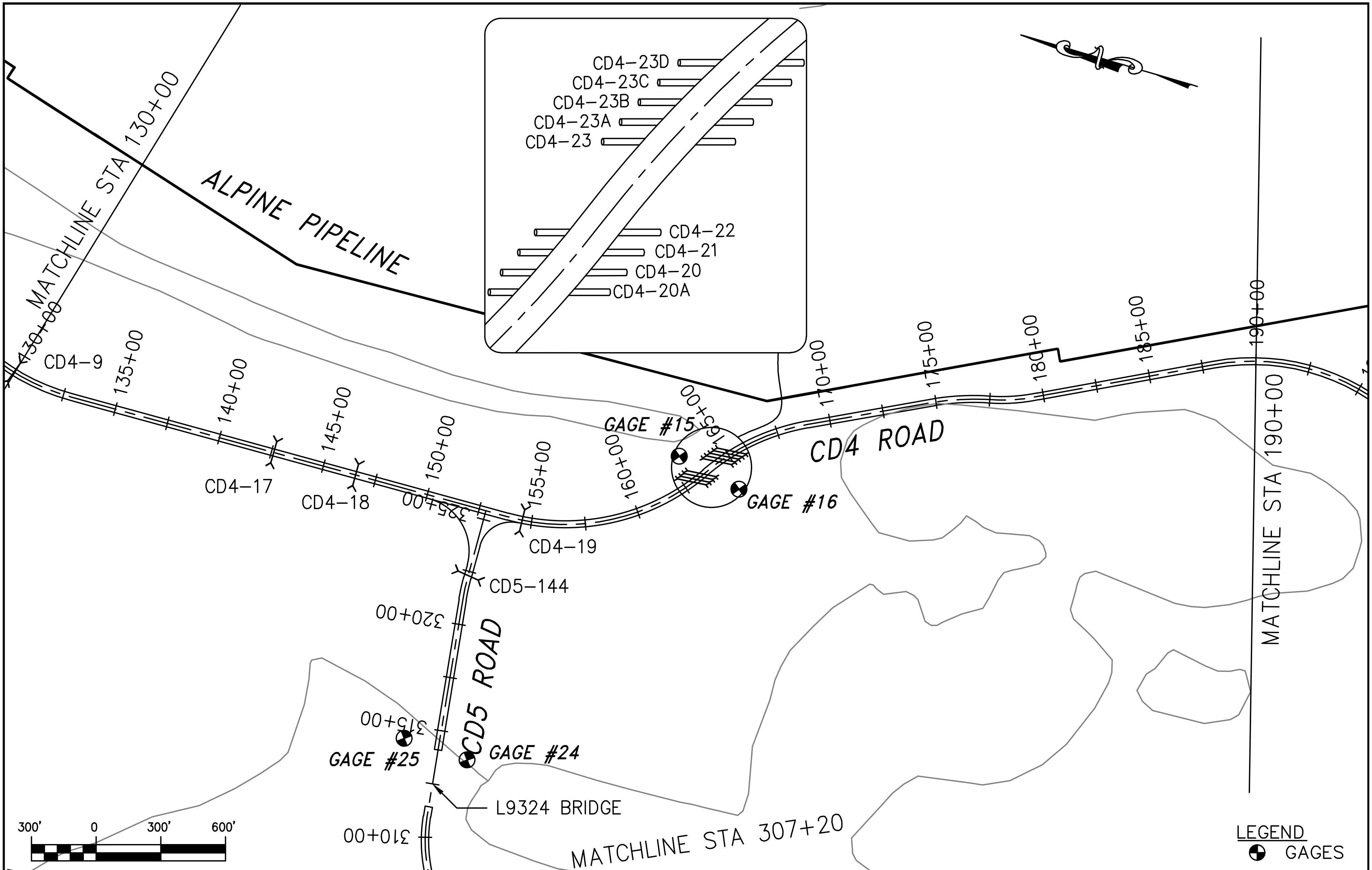
2016 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 4 OF 13)



ConocoPhillips
Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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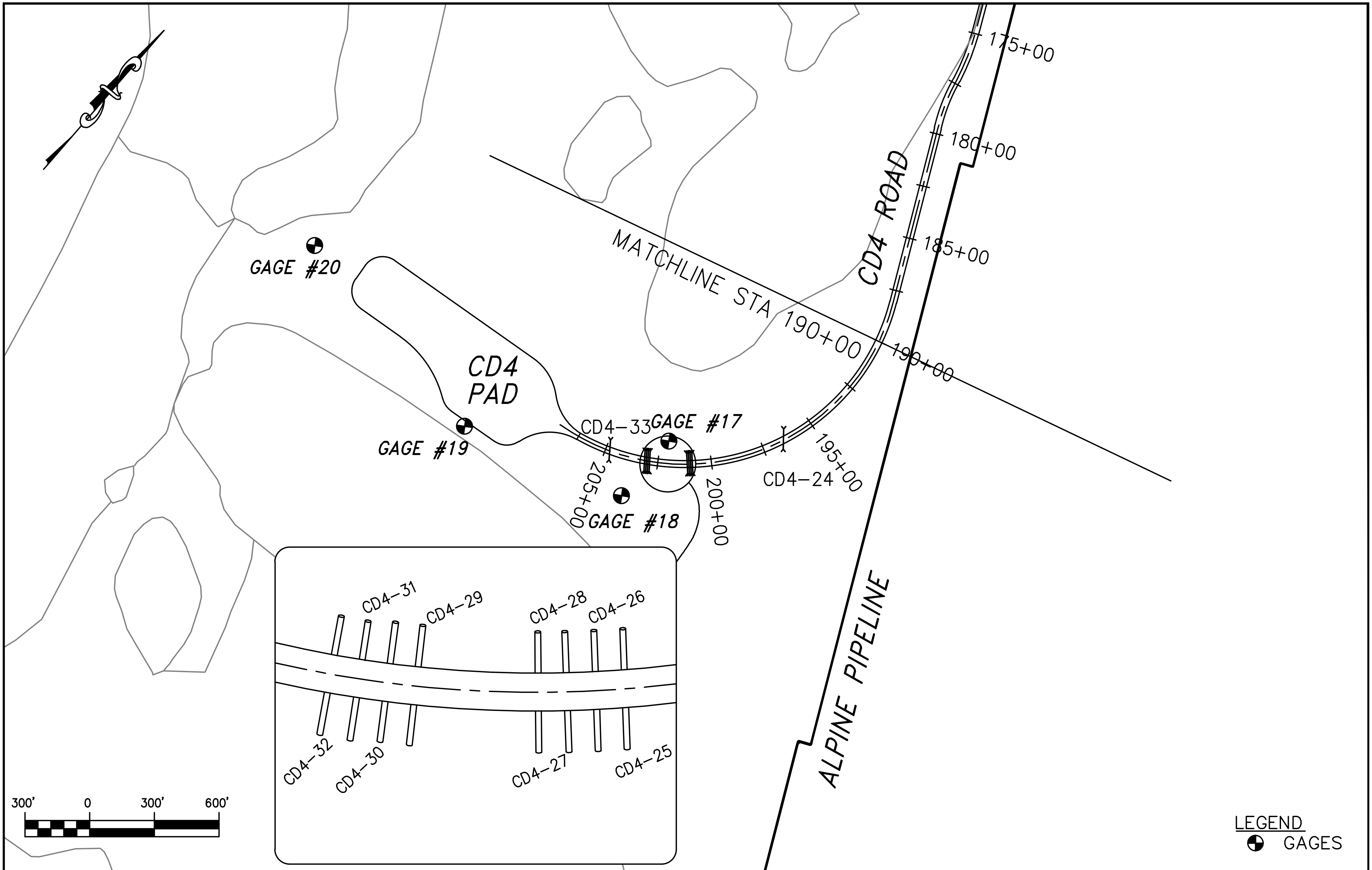
2016 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 5 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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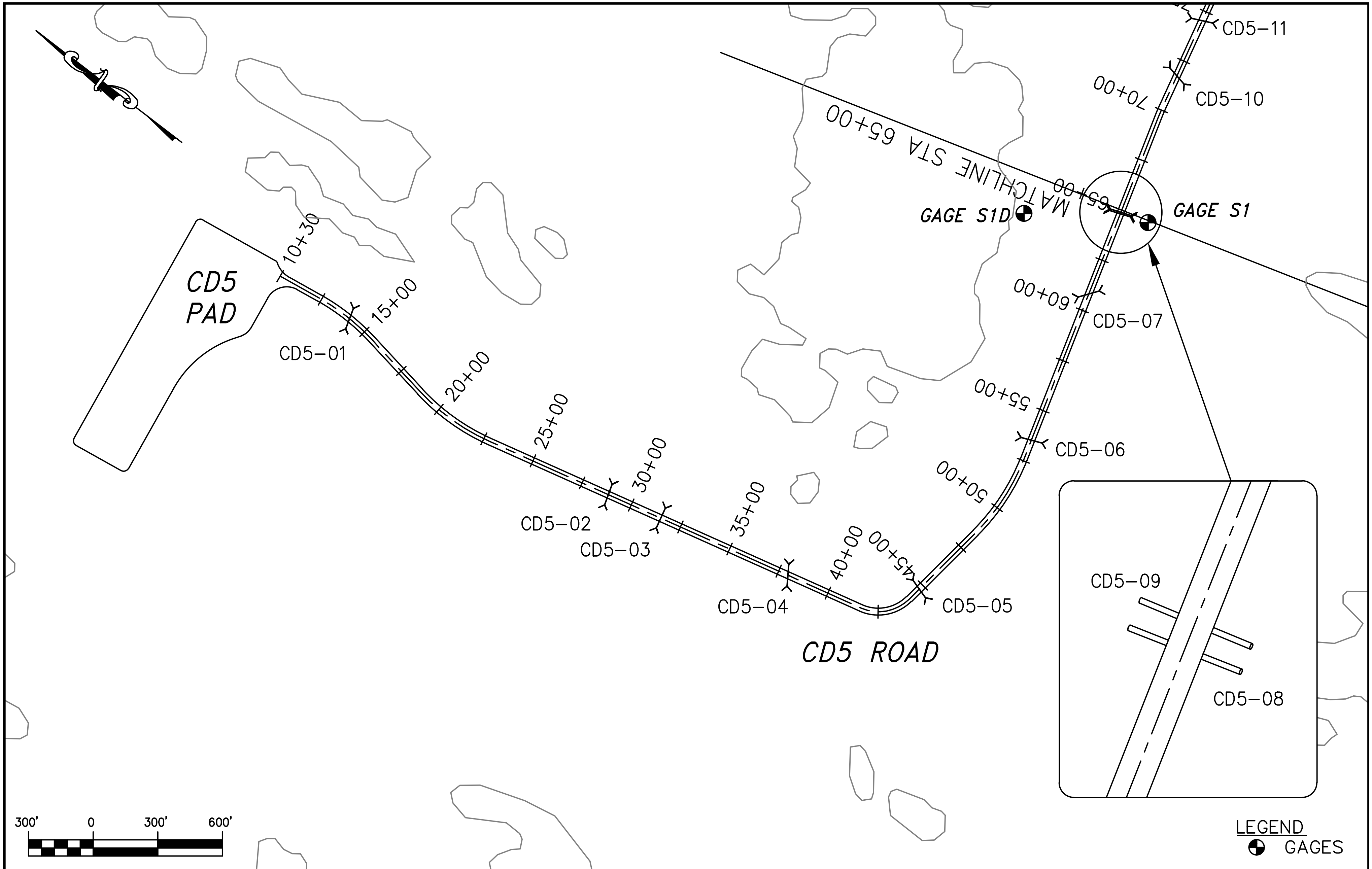
2016 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 6 OF 13)

F.1.4 CD5 ROAD



ConocoPhillips Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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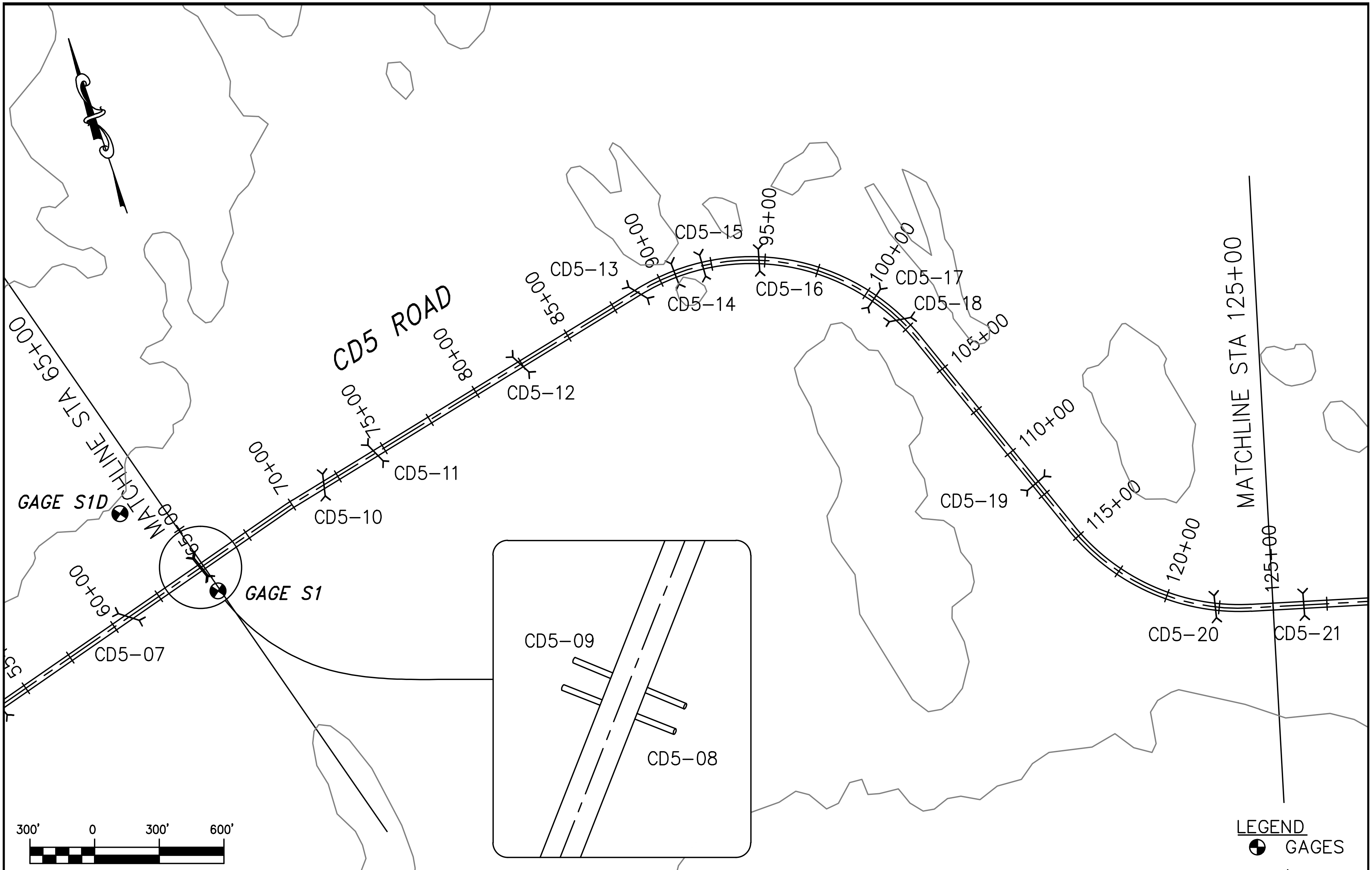
2016 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 7 OF 13)



ConocoPhillips
Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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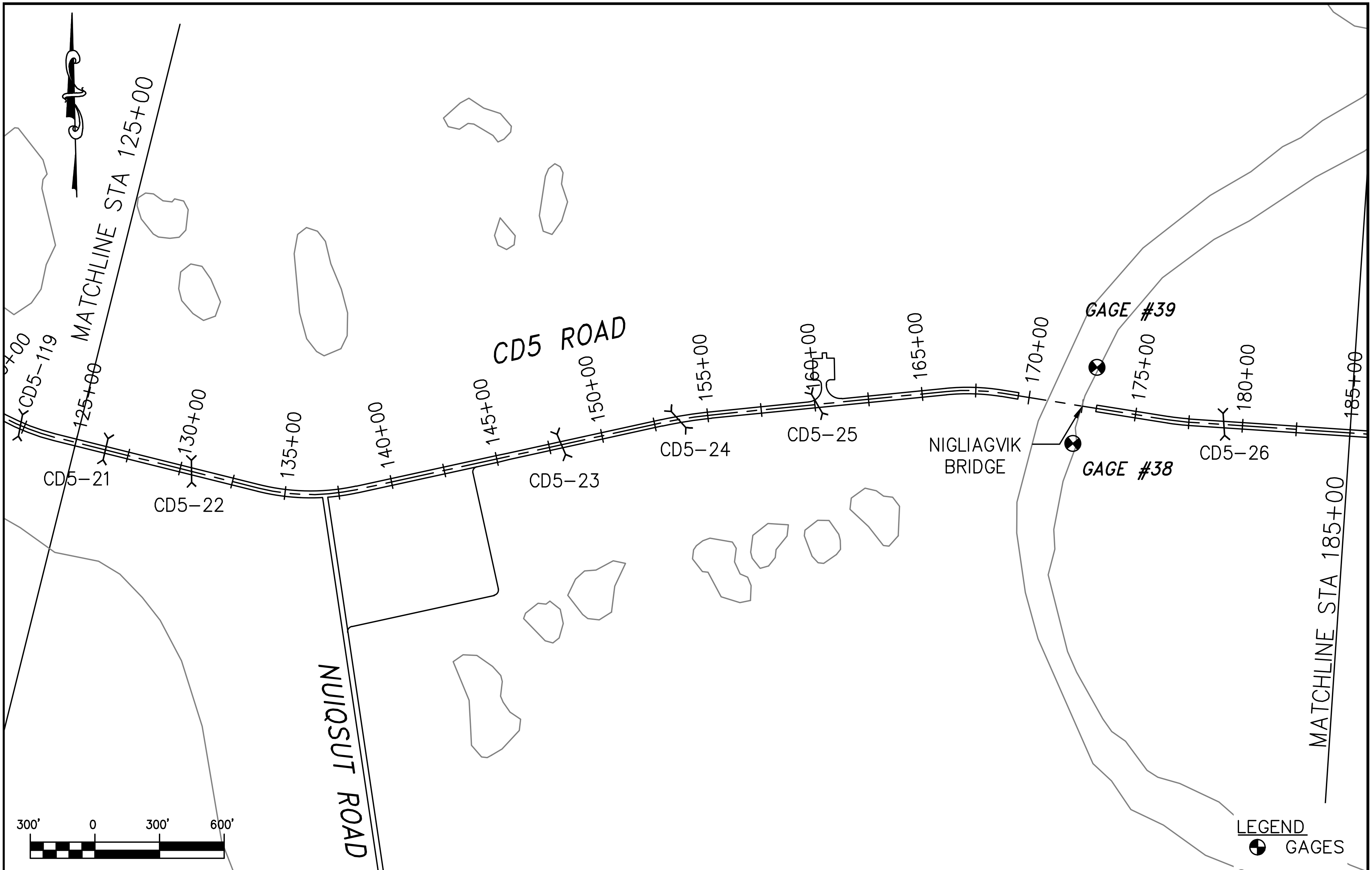
Fax: (907) 273–1699

2016 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 8 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL
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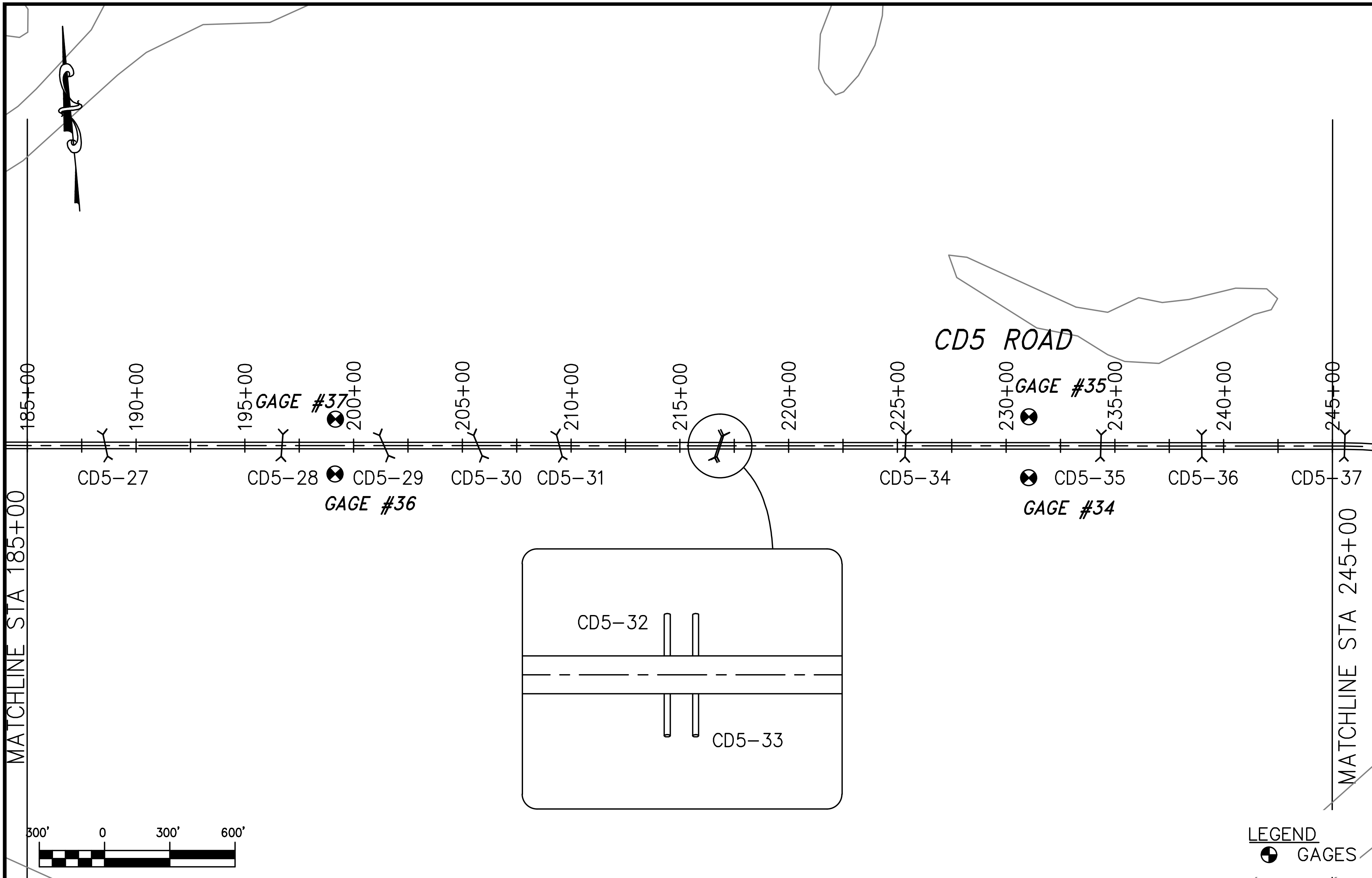
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2016 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION



ConocoPhillips Alaska, Inc.

DATE: 09/14/2016	PROJECT: 153210
DRAWN: DTR	FILE: ALPINE_FACILITES.DWG
CHECKED: GCY	SCALE: AS SHOWN

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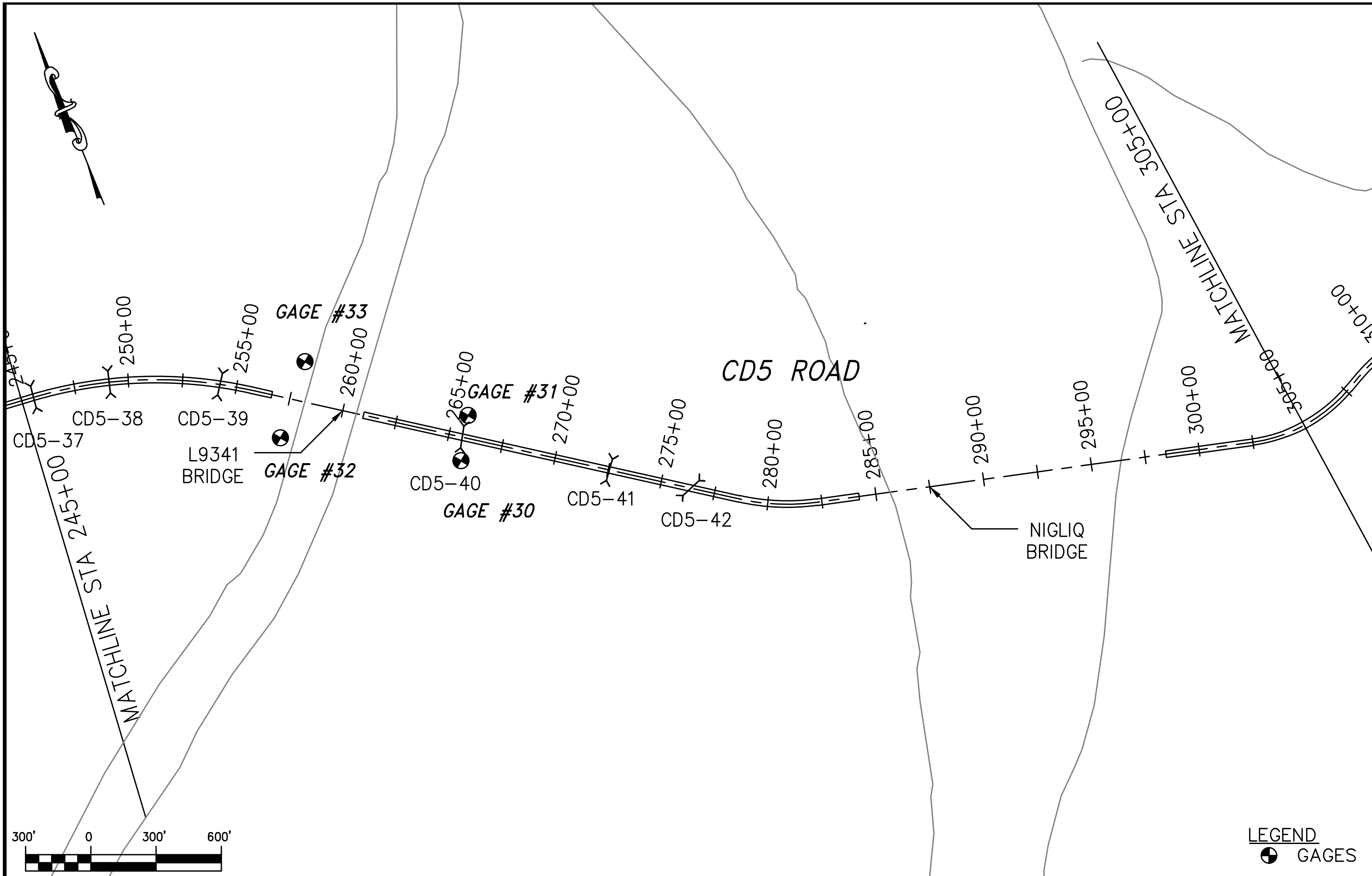
Fax: (907) 273-1699

2016 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION



ConocoPhillips
Alaska, Inc.

DATE: 09/14/2016	PROJECT: 153210
DRAWN: DTR	FILE: ALPINE_FACILITES.DWG
CHECKED: GCY	SCALE: AS SHOWN

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Anchorage, Alaska 99503
Phone: (907) 273-1600
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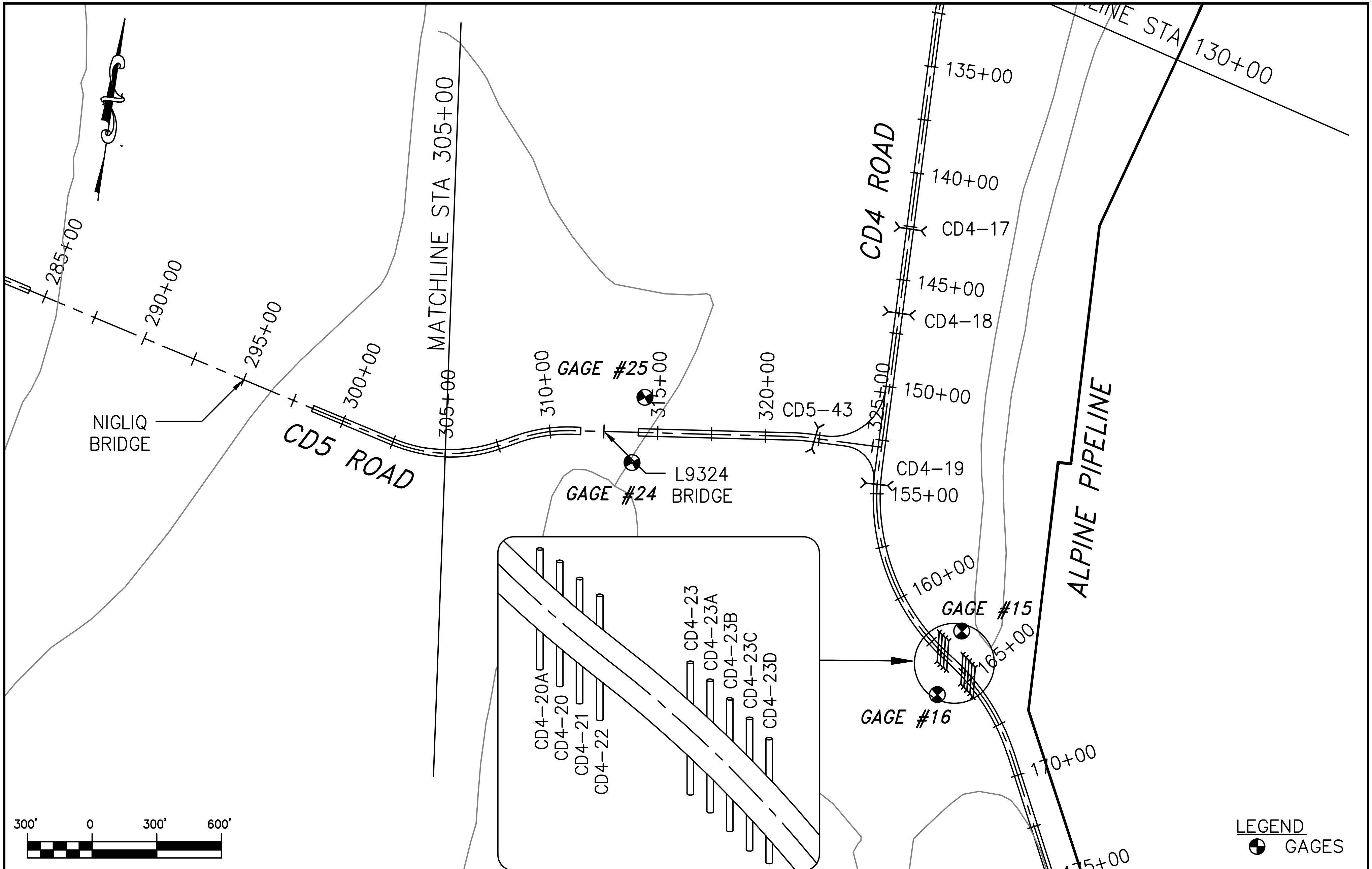
2016 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET11 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	09/14/2016	PROJECT:	153210
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

Michael Baker INTERNATIONAL
Michael Baker International
3900 C Street, Suite 900
Anchorage, Alaska 99503
Phone: (907) 273-1600
Fax: (907) 273-1699

2016 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET12 OF 13)

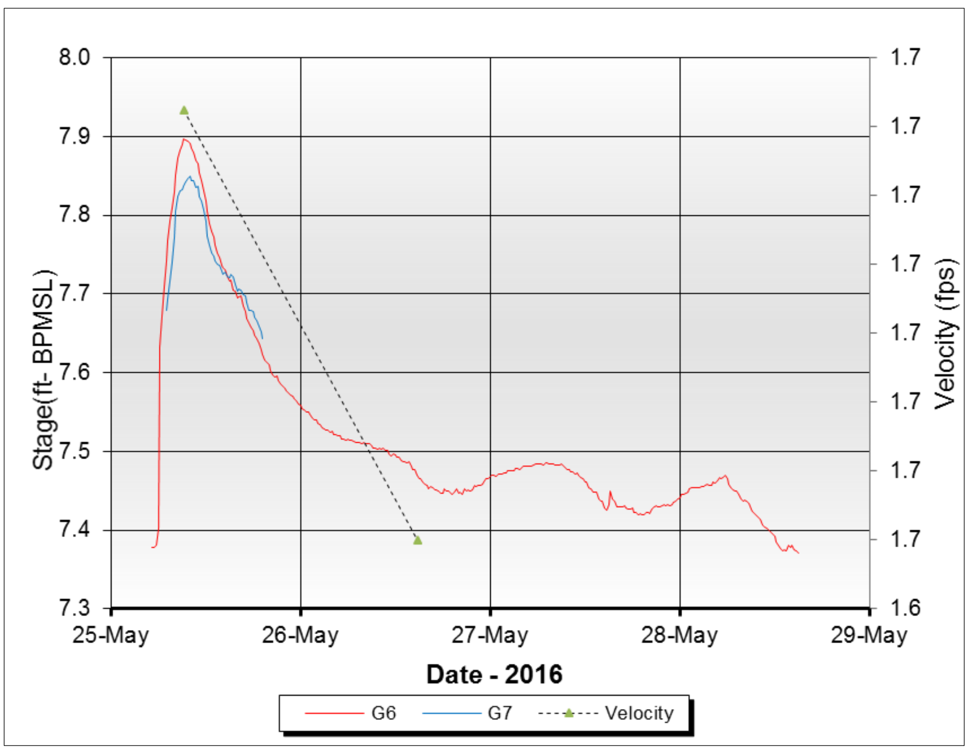
F.2 PEAK VELOCITY & DISCHARGE

F.2.1 CD2 ROAD CULVERTS

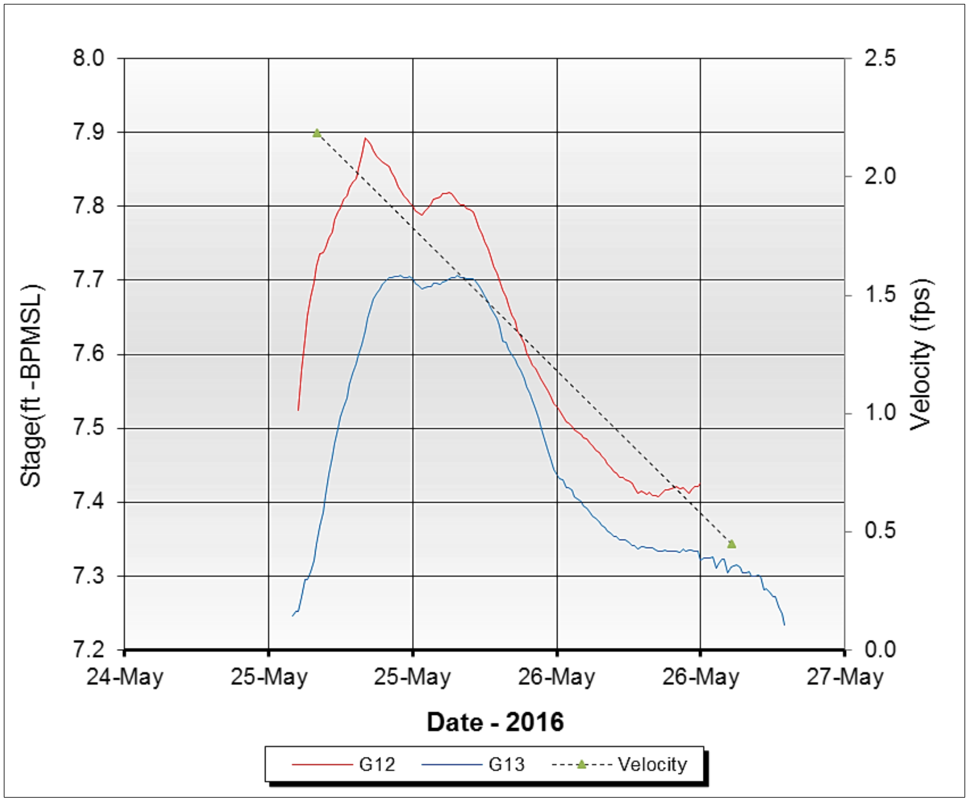
1) INDIRECT VELOCITY

Table F.1: CD2 Road Culvert Indirect Velocity Summary

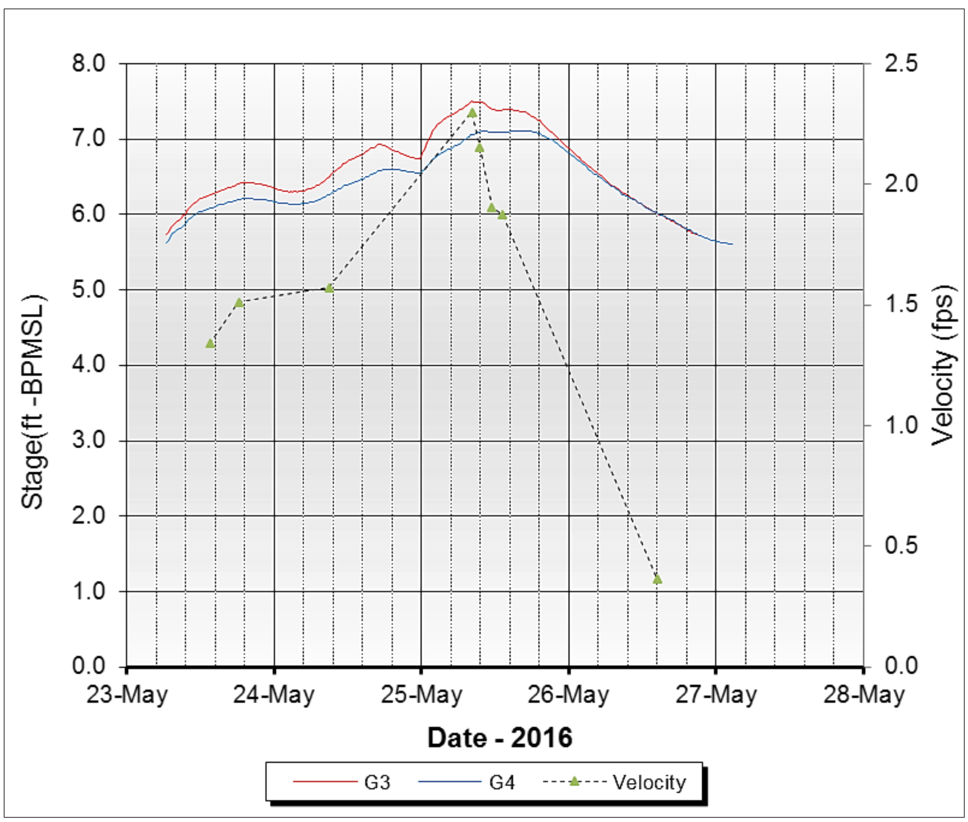
Culverts near G6/G7		Culverts near G12/G13		Culverts near G3/G4	
Culvert	May 25 9:15 AM	Culvert	May 25 4:00 AM	Culvert	May 25 8:15 AM
CD2-1	1.9	CD2-9	2.8	CD2-19	0.0
CD2-2	1.7	CD2-10	3.0	CD2-20	3.5
CD2-3	1.5	CD2-11	3.2	CD2-21	3.5
CD2-4	1.8	CD2-12	2.8	CD2-22	3.8
CD2-5	1.7	CD2-13	2.0	CD2-23	3.9
CD2-6	1.7	CD2-14	2.8	CD2-24	3.8
CD2-7	1.7	CD2-15	4.0	CD2-25	0.0
CD2-8	1.8	CD2-16	0.0	CD2-26	0.0
		CD2-17	0.0		
		CD2-18	1.3		
Average Velocity (ft/s)	1.7		2.2		2.3



Graph F.1: Indirect Velocity vs. Observed Stage, CD2 Road Culverts CD2-1 through CD2-8 near G6/G7



Graph F.2: Indirect Velocity vs. Observed Stage, CD2 Road Culverts CD2-9 through CD2-18 near G12/G13

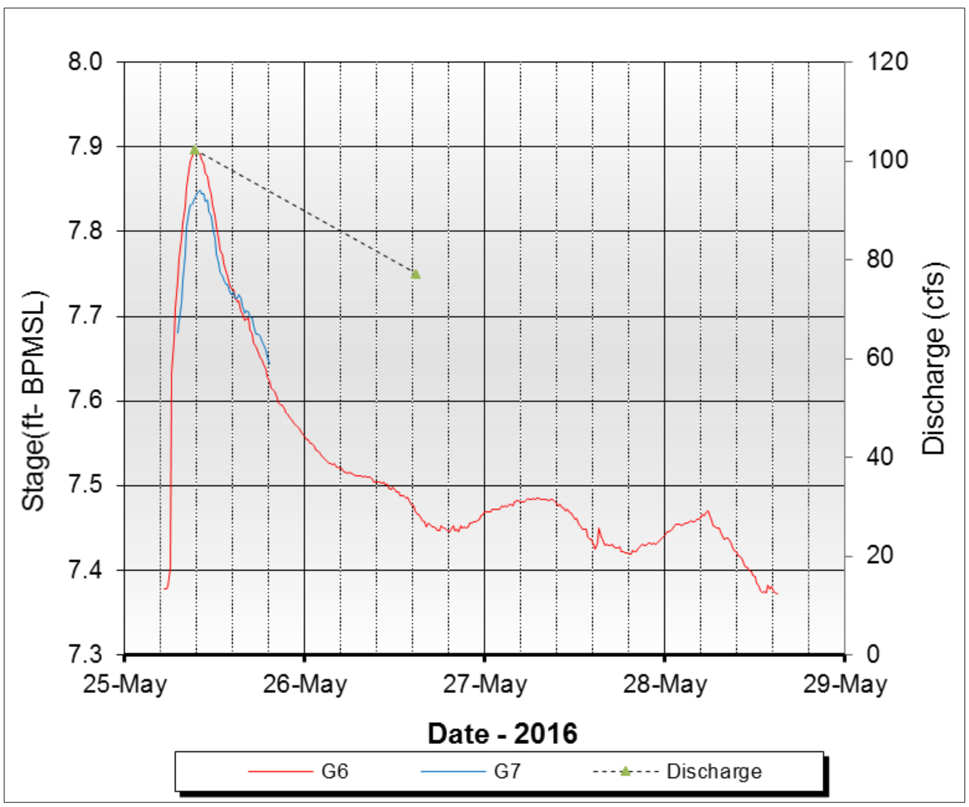


Graph F.3: Indirect Velocity vs. Observed Stage, CD2 Road Culverts CD2-19 through CD2-26 near G3/G4

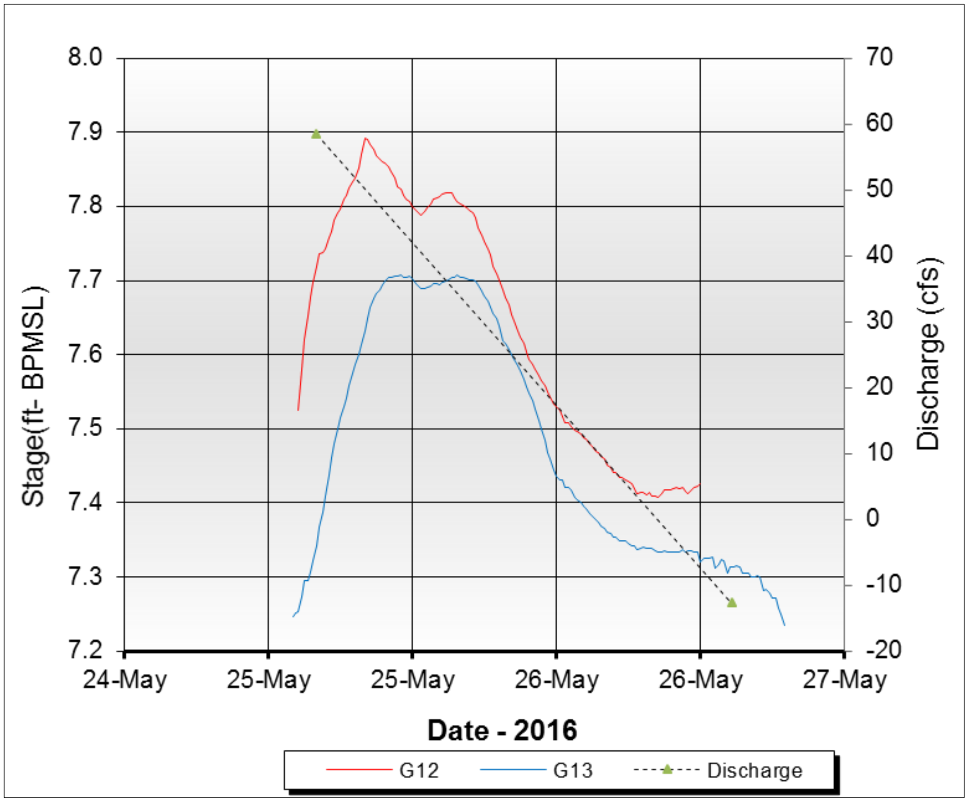
2) INDIRECT DISCHARGE

Table F.2: CD2 Road Culvert Indirect Discharge Summary

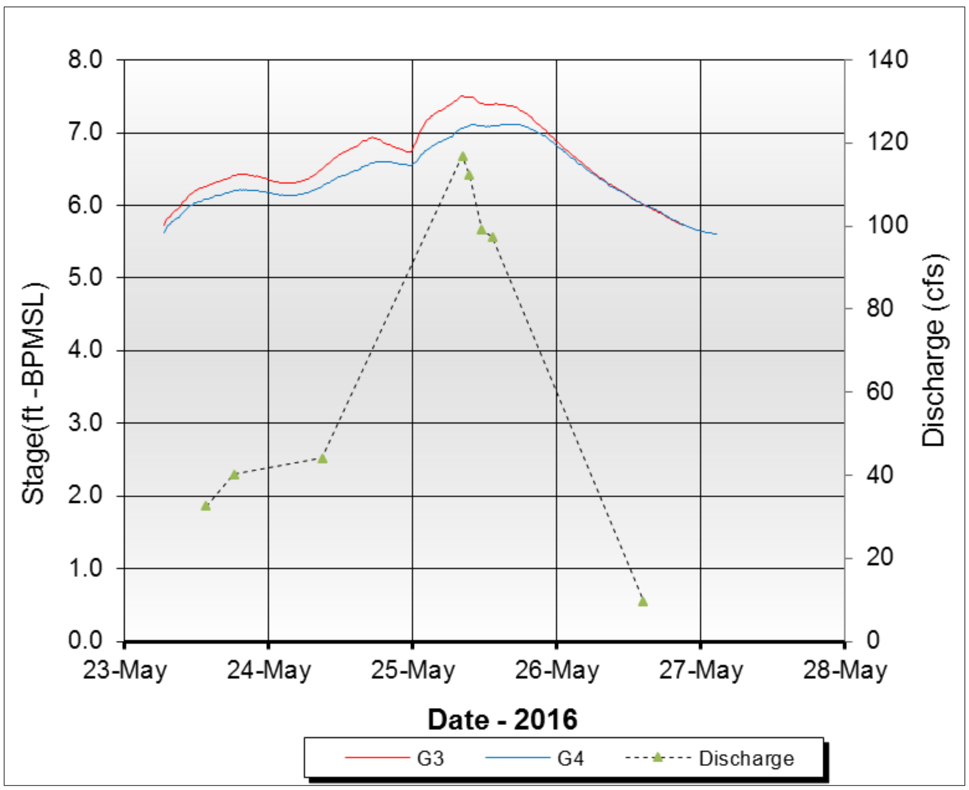
Culverts near G6/G7		Culverts near G12/G13		Culverts near G3/G4	
Culvert	**May 25 8:15 AM**	**Culvert**	**May 25 8:15 AM**	**Culvert**	**May 25 8:15 AM**
CD2-1	8.6	CD2-9	3.9	CD2-19	0
CD2-2	8.1	CD2-10	6.2	CD2-20	9
CD2-3	11.3	CD2-11	7.3	CD2-21	19
CD2-4	16.5	CD2-12	12.6	CD2-22	21
CD2-5	14.9	CD2-13	7.8	CD2-23	32
CD2-6	15.8	CD2-14	13.6	CD2-24	35
CD2-7	16.7	CD2-15	7.0	CD2-25	0
CD2-8	10.4	CD2-16	0.0	CD2-26	0
		CD2-17	0.0		
		CD2-18	0.1		
Total Discharge (cfs)	**102**		**58**		**117**



Graph F.4: Indirect Discharge vs. Observed Stage, CD2 Road Culverts CD2-1 through CD2-8 near G6/G7



Graph F.5: Indirect Discharge vs. Observed Stage, CD2 Road Culverts CD2-9 through CD2-18 near G12/G13



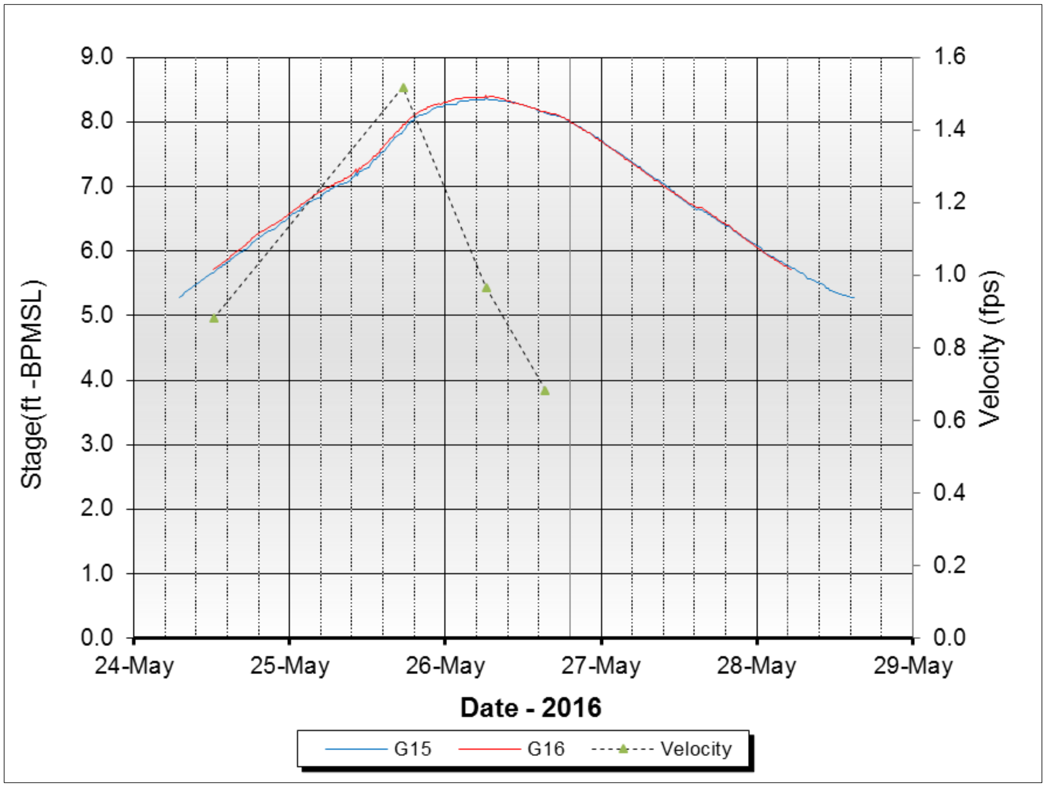
Graph F.6: Indirect Discharge vs. Observed Stage, CD2 Road Culverts CD2-19 through CD2-26 near G3/G4

F.2.2 CD4 ROAD CULVERTS

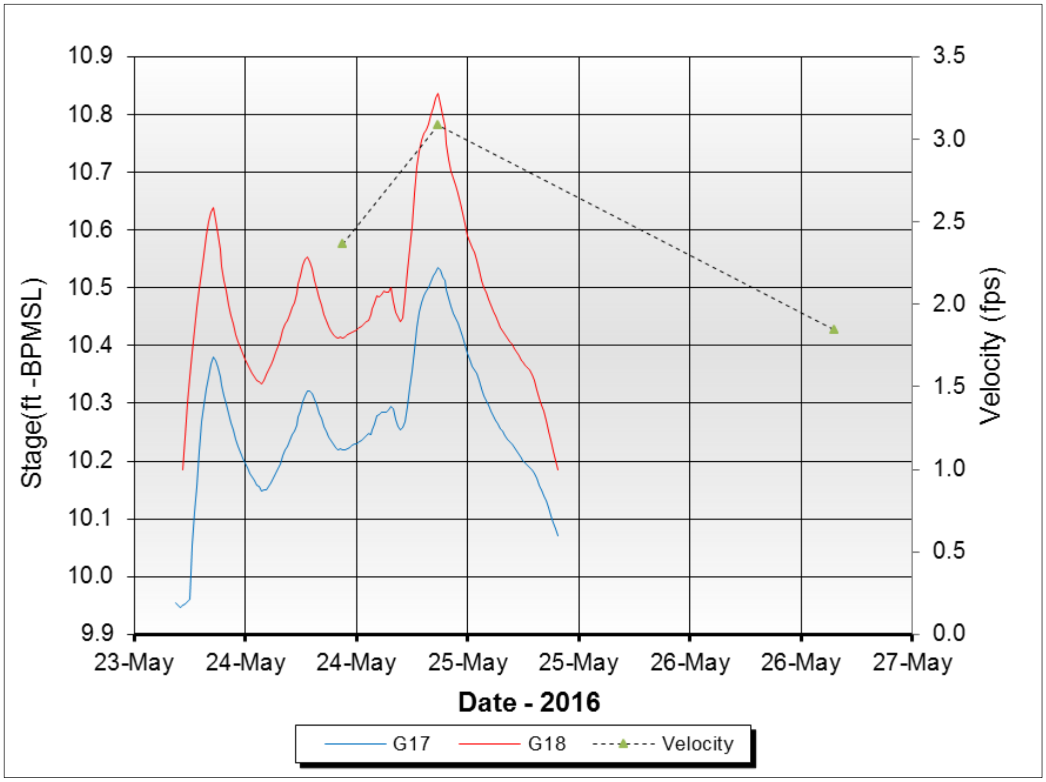
1) INDIRECT VELOCITY

Table F.3: CD4 Road Culvert Indirect Velocity Summary

Culverts near G16/G15		Culverts near G18/G17	
Culvert	May 25 5:30 PM	Culvert	May 24 8:45 PM
CD4-19	0.0	CD4-24	3.1
CD4-20A	1.7	CD4-25	3.4
CD4-20	1.7	CD4-26	3.2
CD4-21	1.7	CD4-27	3.4
CD4-22	1.7	CD4-28	3.2
CD4-23	1.8	CD4-29	3.1
CD4-23A	1.8	CD4-30	3.1
CD4-23B	1.6	CD4-31	3.1
CD4-23C	1.5	CD4-32	3.6
CD4-23D	1.7	CD4-33	1.8
Average Velocity (ft/s)	**1.5**		**3.1**



Graph F.7: Indirect Velocity vs. Observed Stage, CD4 Road Culverts CD4-19 through CD4-23D near G16/G15

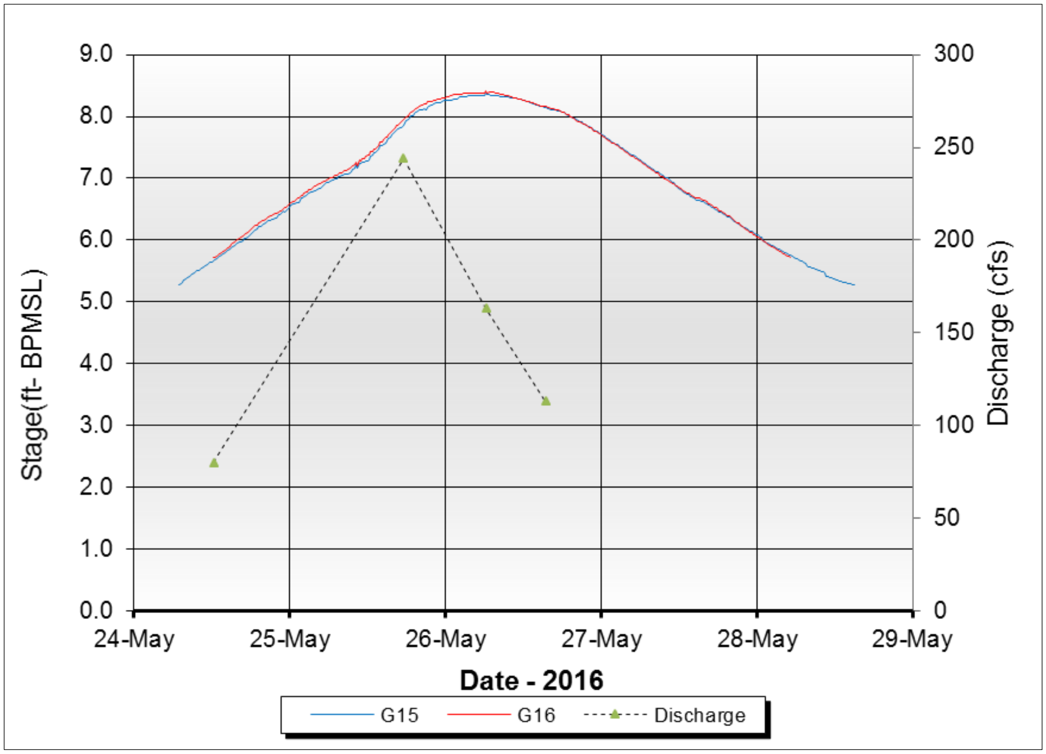


Graph F.8: Indirect Velocity vs. Observed Stage, CD4 Road Culverts CD4-24 through CD4-33 near G18/G17

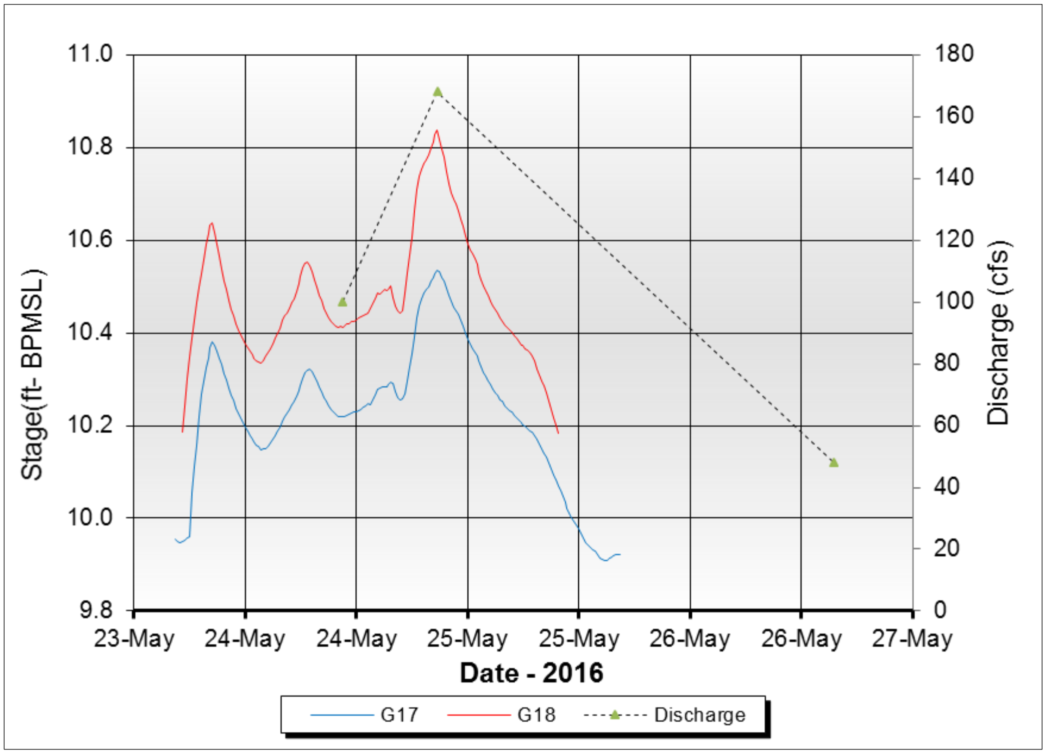
2) INDIRECT DISCHARGE

Table F.4: CD4 Road Culvert Indirect Discharge Summary

Culverts near G16/G15		Culverts near G18/G17	
Culvert	**May 25 5:30 PM**	**Culvert**	**May 24 8:45 PM**
CD4-19	0	CD4-24	16.7
CD4-20A	33	CD4-25	13.6
CD4-20	33	CD4-26	13.5
CD4-21	33	CD4-27	15.6
CD4-22	33	CD4-28	14.5
CD4-23	18	CD4-29	20.0
CD4-23A	25	CD4-30	20.0
CD4-23B	30	CD4-31	18.3
CD4-23C	19	CD4-32	16.4
CD4-23D	20	CD4-33	19.6
Total Discharge (cfs)	**244**		**168**



Graph F.9: Indirect Discharge vs. Observed Stage, CD4 Road Culverts CD4-19 through CD4-23D near G16/G15



Graph F.10: Indirect Discharge vs. Observed Stage, CD4 Road Culverts CD4-24 through CD4-33 near G18/G17

F.2.3 CD5 ROAD CULVERTS

1) INDIRECT VELOCITY

Table F.5: CD5 Road Culvert Indirect Velocity Summary

Culverts near S1/S1D	
Culvert	**May 23 9:07 AM**
CD5-07	0.0
CD5-08	1.2
CD5-09	1.2
Average Velocity (ft/s)	**0.8**

2) INDIRECT DISCHARGE

Table F.6: CD5 Road Culvert Indirect Discharge Summary

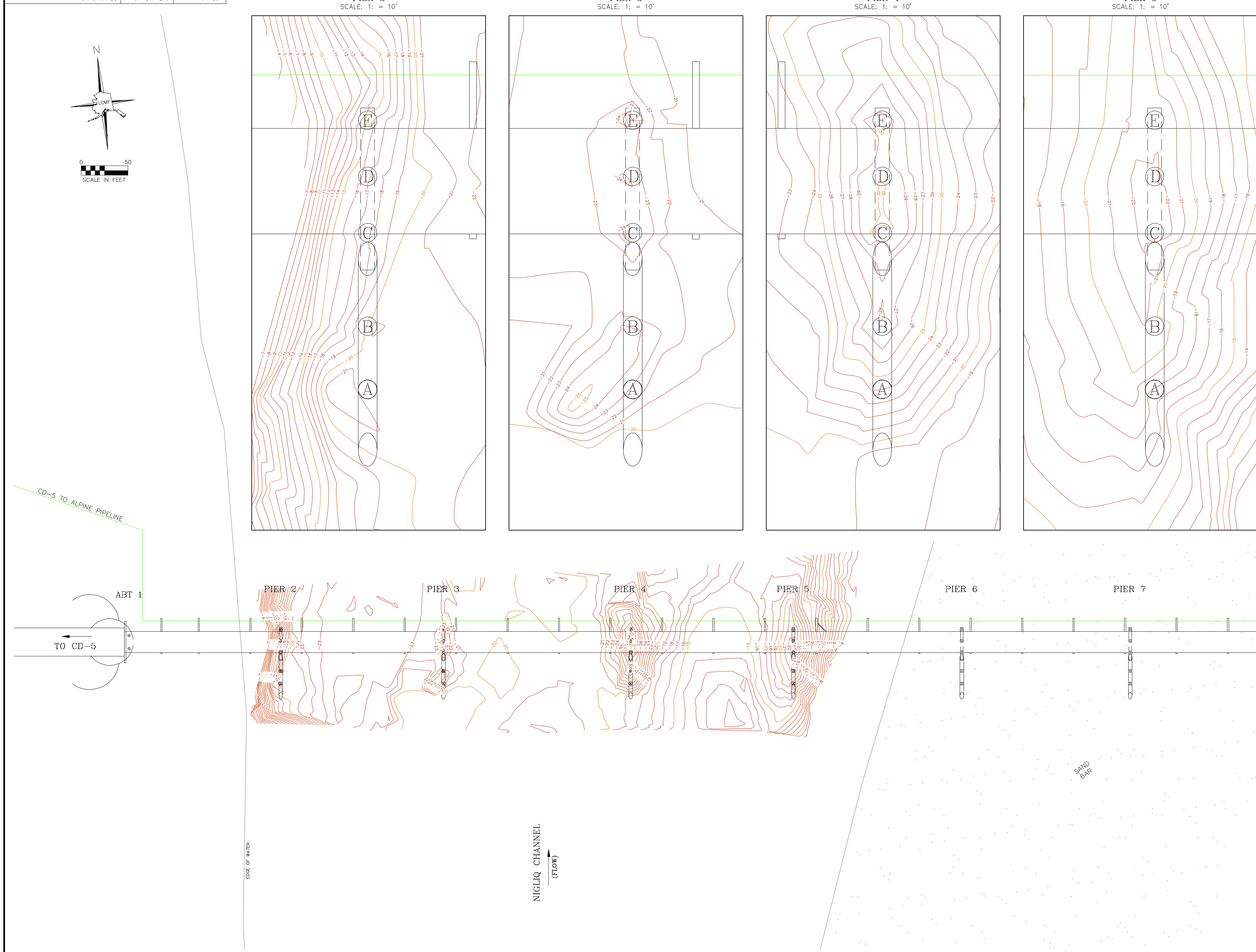
Culverts near S1/S1D	
Culvert	**May 23 9:07 AM**
CD5-07	0.0
CD5-08	5.3
CD5-09	5.4
Total Discharge (cfs)	**11**

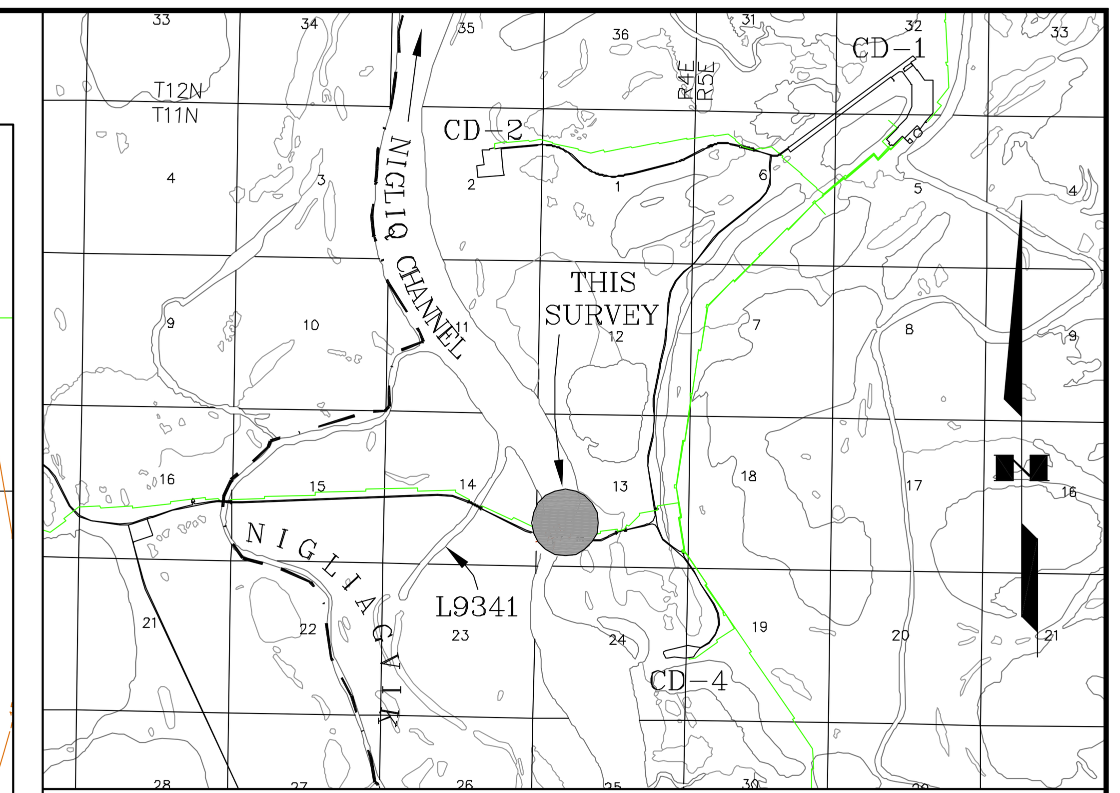
Appendix G CD5 PIER SCOUR, BANK EROSION, & BATHYMETRY

G.1 PIER SCOUR

G.1.1 NIGLIQ BRIDGE

JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE-CD50-1022





VICINITY MAP

NOTES:
1. DATES OF SURVEY: AUGUST 7,8, 2016.
2. REFERENCE FIELD BOOK: 2016–14, PGS. 1–9.
3. ELEVATIONS ARE BRITISH PETROLEUM MEAN SEAL LEVEL (B.P.M.S.L.)
4. AVERAGE WATER SURFACE ELEVATION DURING SURVEY IS 0.7'.
5. HORIZONTAL DATUM IS NAD 83 ALASKA STATE PLANE ZONE 4.

LEGEND:
–18– 1' CONTOUR
–20– 5' CONTOUR

KUUKPIK LCMF LLC
Alpine Survey Office

ConocoPhillips
Alaska, Inc.

ALPINE MODULE: CD50 UNIT: CD

CD–5 ACCESS ROAD
NIGLIQ BRIDGE
SCOUR MONITORING

REDRAWN FROM: CONSTRUCTION SHEET OF

DO NOT SCALE ABOVE SCALE FOR REFERENCE ONLY

DATE:	DRAWN:	DESIGN:	ECM NO:
08/23/14	CZ	GD	K140003ACS
	CHECKED: –		CC NO: –
SCALE: 1" = 50'	APPROVAL: –		CADD FILE NO. 14–08–12–1AW
JOB NO: –	SUB JOB NO: –	DRAWING NO: CE–CD50–1022	PART: 1 OF 1 REV: 3

FORM: DSIZE

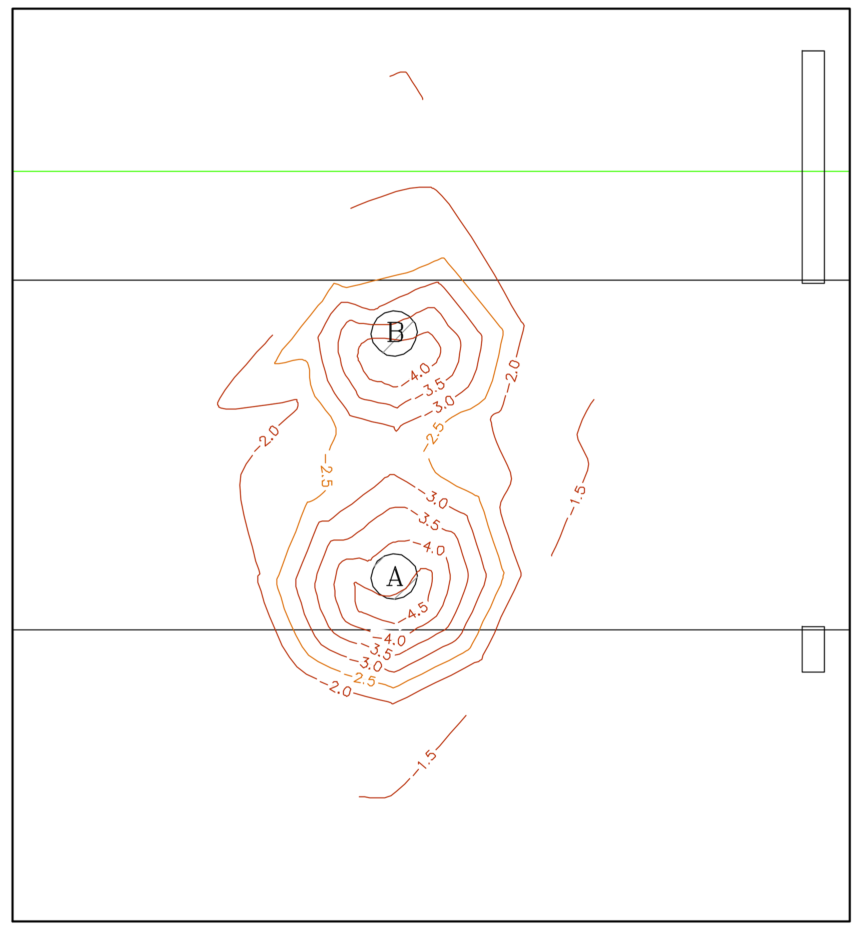
REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
3	8/10/16	UPDATED PER K160003ACS	TRB	DB			
2	8/30/15	UPDATED PER 20968257ACS	TB	DB			
1	08/25/14	ISSUED PER K140003ACS	CZ	GD			

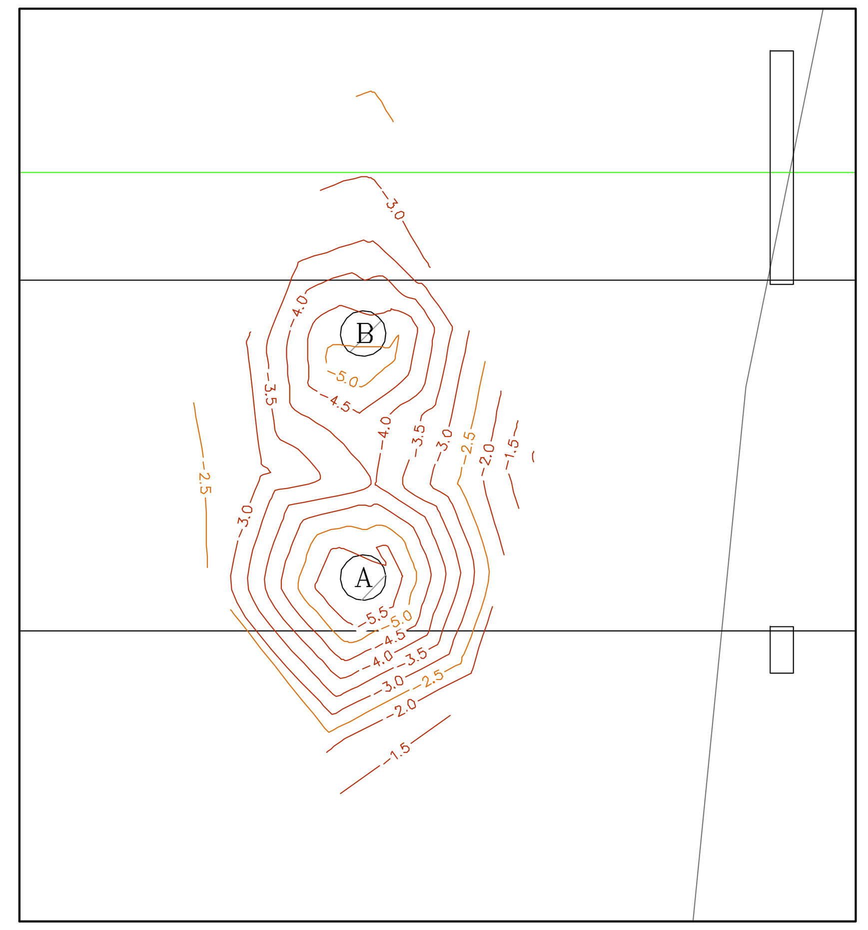
G.1.2 NIGLIAGVIK BRIDGE

JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE–CD50–1023

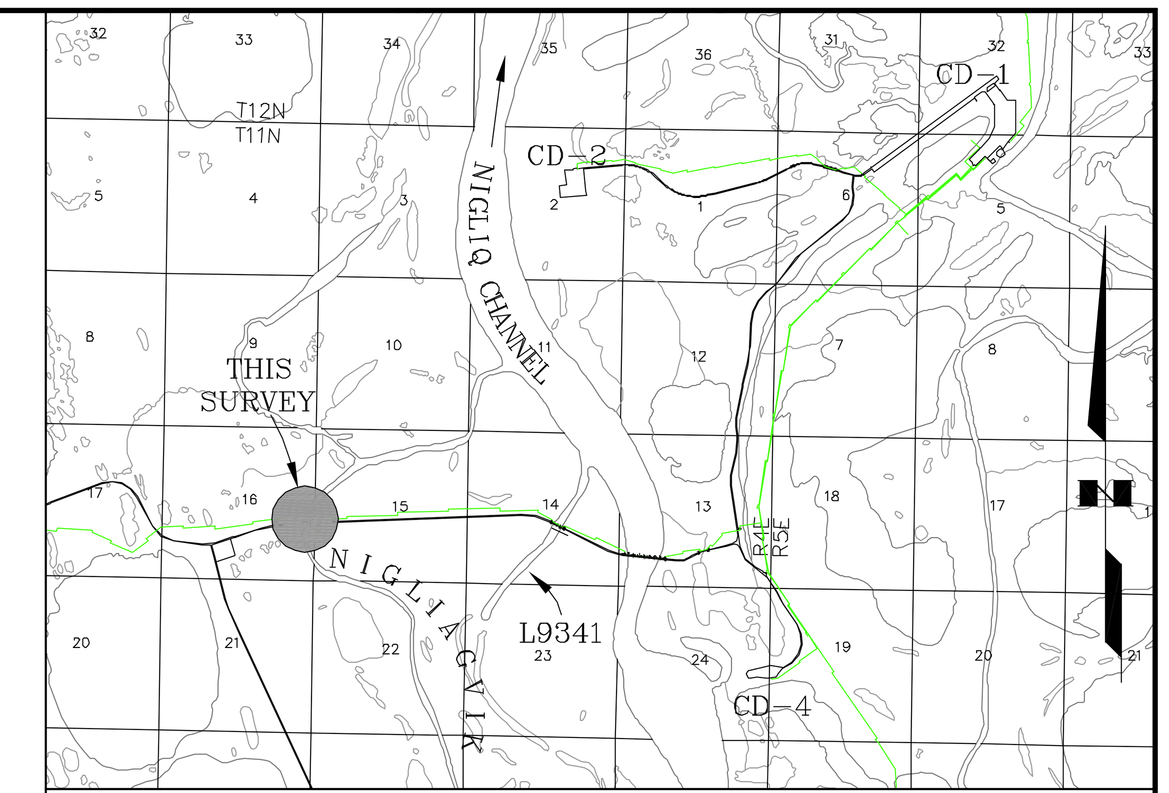
PIER 3
SCALE: 1" = 10'



PIER 4
SCALE: 1" = 10'



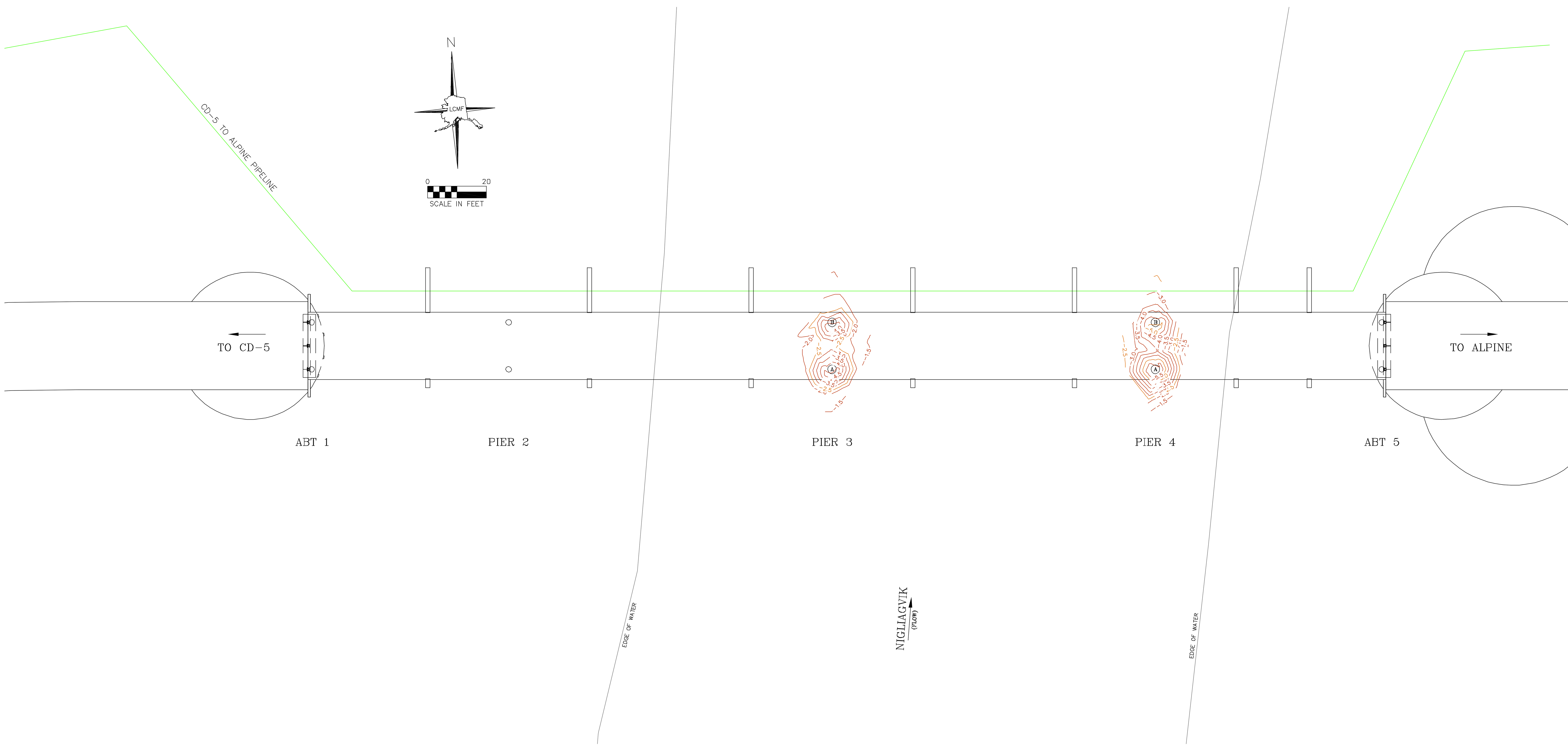
LEGEND:
- 0.5' CONTOUR
- 2.5' CONTOUR



VICINITY MAP

NOTES

1. DATE OF SURVEY: 8/21/14; 9/3/15; 7/30/16;
2. REFERENCE FIELD BOOKS: 2014–21, PG. 37; 2015–19, PG. 14; 2016–12, PG. 62.
3. ELEVATIONS ARE BRITISH PETROLEUM MEAN SEAL LEVEL (B.P.M.S.L.)
4. HORIZONTAL DATUM IS NAD 83 ALASKA STATE PLANE ZONE 4,.



REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
4	11/28/16	UPDATED PER K160003ACS	TB	DB			
3	7/31/16	UPDATED PER K160003ACS	CZ	DB			
2	9/8/15	UPDATED PER 20968257ACS	CZ	DB			
1	08/25/14	ISSUED PER K140003ACS	CZ	GD			

FORM: DSIZE

KUUKPIK
LCMF LLC
Alpine Survey Office

ConocoPhillips
Alaska, Inc.

ALPINE | MODULE: CD50 | UNIT: CD

CD–5 ACCESS ROAD
NIGLIAGVIK BRIDGE
SCOUR MONITORING

REDRAWN FROM: | CONSTRUCTION SHEET OF

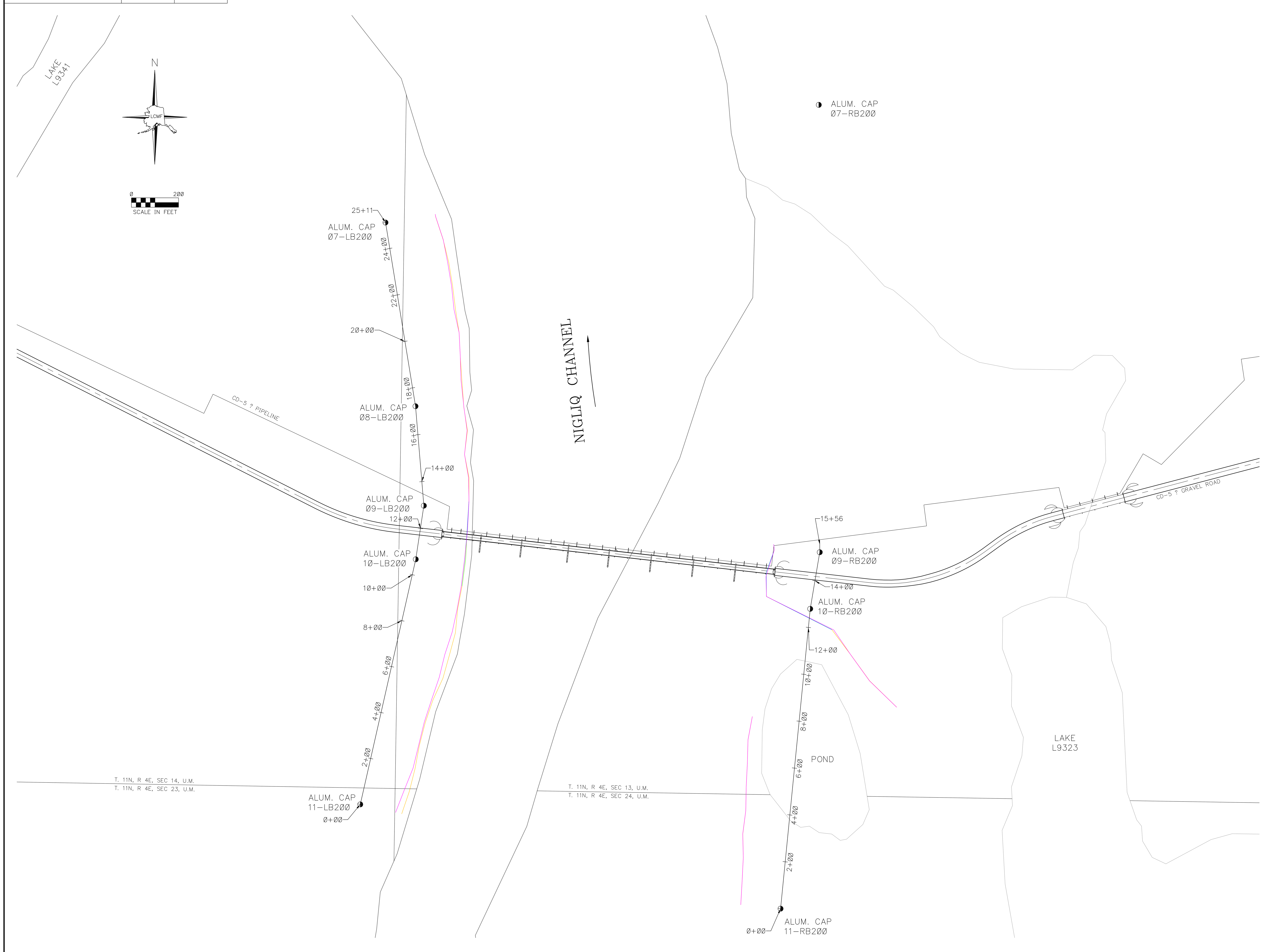
DO NOT SCALE — ABOVE SCALE FOR REFERENCE ONLY

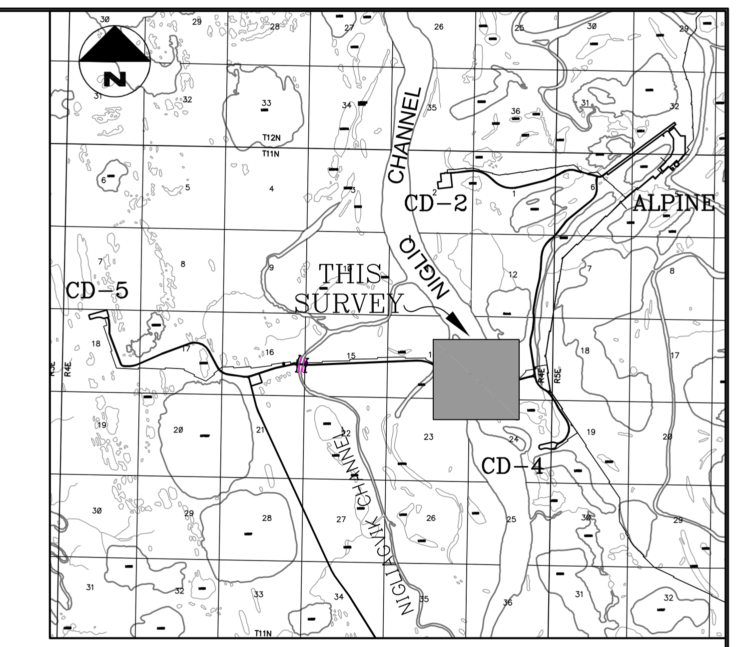
DATE: 8/25/14	DRAWN: CZ	DESIGN: –	ECM NO: K140003ACS
	CHECKED: GD		CC NO: –
SCALE: 1" = 20'	APPROVAL: –		CADD FILE NO. 14–08–12–1CW
JOB NO: –	SUB JOB NO: –	DRAWING NO: CE–CD50–1023	PART: 1 OF 1 — REV: 4

G.2 BANK EROSION

G.2.1 NIGLIQ & NIGLIAGVIK CHANNEL PLAN VIEW

JOB NO: 02-204 | SUB JOB NO: – | DRAWING NO: CE-AP00-1126





VICINITY MAP

NOTES

1. DATE OF SURVEY: 8/22/13; 8/24/14; 8/27/15, 9/3/15; 7/7/16.
2. REFERENCE FIELD BOOK: LCMF 2013-19, PG. 24; LCMF 2014-21, PG. 44; LCMF 2015-17, PG. 75 & LCMF 2015-19, PG. 13; LCMF 2016-12 PGS. 23-25.
3. TOP OF BANK DEFINED BY: MICHAEL BAKER JR.
4. SEE DOCUMENT RPT-CE-CD-112 FOR BANK EROSION BASELINE SURVEY DATA.

LEGEND:

◑ 5/8" REBAR SET WITH 2" ALUMINUM CAP

TOP OF BANK 8/21/13
TOP OF BANK 8/24/14
TOP OF BANK 8/28/15
TOP OF BANK 7/07/16

KUUKPIK LCMF LLC Alpine Survey Office

ConocoPhillips Alaska, Inc.

ALPINE | MODULE: AP00 | UNIT: AP

CD-5 MONITORING
TOP OF BANK SURVEY
NIGLIQ CHANNEL

REDRAWN FROM: | CONSTRUCTION SHEET OF

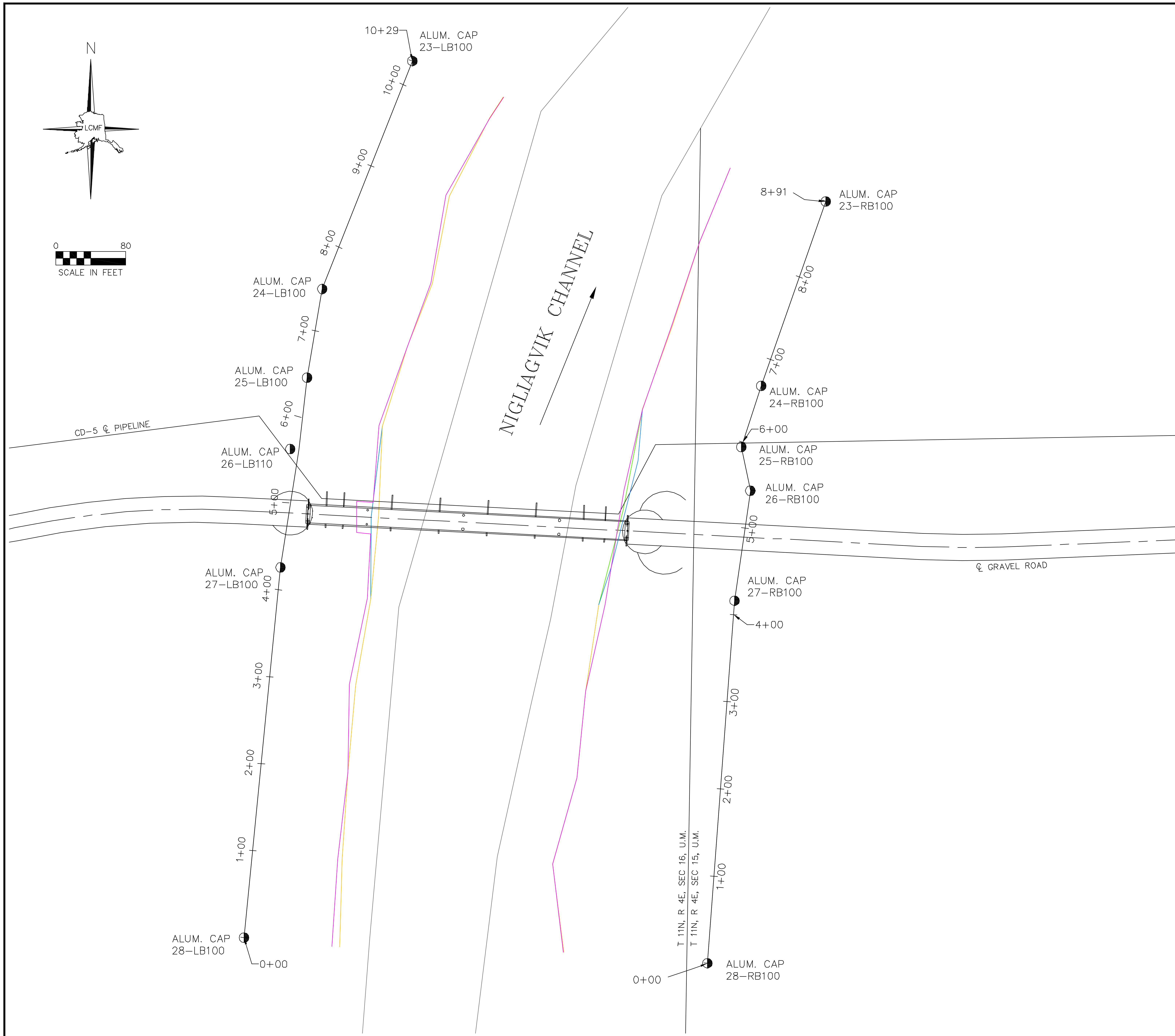
FORM: DSIZE

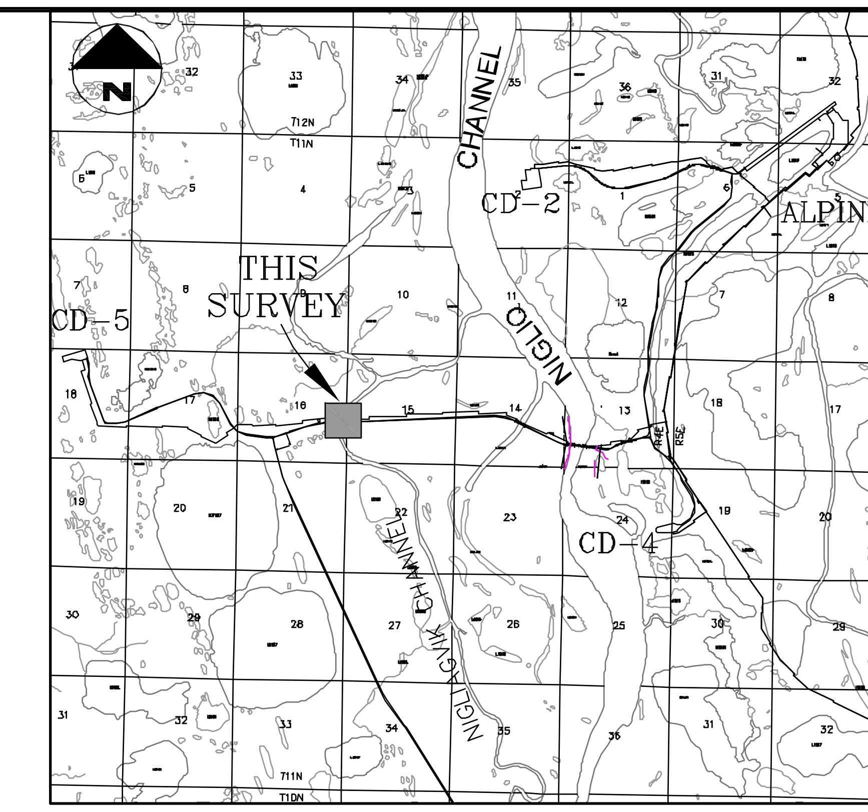
DO NOT SCALE — ABOVE SCALE FOR REFERENCE ONLY

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
4	7/9/16	UPDATED PER K160003ACS	TRB	DB			
3	9/6/15	UPDATED PER 20968257ACS	CZ	DB			
2	8/26/14	UPDATED PER K140003ACS	CZ	DB			
1	8/29/13	ISSUED PER K130003ACS	AG	GD			

DATE: 8/29/13	DRAWN: AG	DESIGN: –	ECM NO: K130003ACS
SCALE: 1" = 200'	CHECKED: GD		CC NO: K130003ACS
	APPROVAL: –		CADD FILE NO: 13-08-07-1 8/29/13
JOB NO: 02-204	SUB JOB NO: –	DRAWING NO: CE-AP00-1126	PART: 2 OF 2 / REV: 4





VICINITY MAP

NOTES

1. DATE OF SURVEY: 8/21/13; 8/24/14; 8/28/15; 7/6/16.
2. REFERENCE FIELD BOOK: LCMF 2013–19, PG. 22; LCMF 2014–21, PG. 43; LCMF 2015–17, PG. 7; LCMF 2016–12, PG.22.
3. TOP OF BANK DEFINED BY: MICHAEL BAKER JR.
4. SEE DOCUMENT RPT–CE–CD–111 FOR BANK EROSION BASELINE SURVEY DATA.
5. BASED ON FIELD EVALUATIONS AND REVIEW OF AERIAL IMAGERY, THE 2013 TOP OF BANK POINT AT STATION 3+00 ALONG THE EAST BANK IS CONSIDERED A MISREPRESENTATION OF THE BANK AT THE TIME OF SURVEY. THERE IS NO VISIBLE EROSION AT THIS LOCATION AND THE 2013 TOP OF BANK WAS REPOSITIONED TO ALIGN WITH THE 2016 TOP OF BANK.

LEGEND:

◑ 5/8" REBAR SET WTH 2"ALUMINUM CAP

TOP OF BANK 8/21/13
TOP OF BANK 8/24/14
TOP OF BANK 8/28/15
TOP OF BANK 7/06/16

KUUKPIK LCMF LLC
Alpine Survey Office

FORM: CSIZE

REFERENCE DWG NO:	REV	DATE	REVISION	BY	CHK	JOB	PROJ
	5	11/30/16	UPDATED PER K160003ACS	TRB	DB		
	4	7/9/16	UPDATED PER K160003ACS	TRB	DB		
	3	9/6/15	UPDATED PER 20968257ACS	CZ	DB		
	2	8/26/14	UPDATED PER K140003ACS	CZ	DB		

DRAWN: AG	DESIGN: –	ECM NO: K130003ACS
CHECKED: GD	APPROVAL: –	CC NO: K130003ACS
SCALE: 1" = 80'	DATE: 8/29/13	CADD FILENAME: 13-08-07-1 8/29/2013

ConocoPhillips Alaska, Inc.

ALPINE | MODULE: AP00 | UNIT: AP

CD–5 MONITORING
TOP OF BANK SURVEY
NIGLIAGVIK CHANNEL

JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
02-204	02-204	CE–AP00–1126	1 OF 2	5

G.2.2 NIGLIQ CHANNEL WEST & EAST BANK TABULATED DATA

Calc/d By: TRB
Date: 07/09/2016
RPT-CE-CD-112 REV4

Alpine AP00
West Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV4

Baseline	**West Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 4 for Survey Baseline Location											
	8/21/2013	**8/24/2014**	**8/27/2015**	**7/6/2016**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
0+00	180.2			153.6								Baseline Offset (In Feet)
				-26.6								Incremental Change
				-26.6								Cumulative Change
1+00	191.0			168.5								Baseline Offset (In Feet)
				-22.5								Incremental Change
				-22.5								Cumulative Change
2+00	193.1			184.4								Baseline Offset (In Feet)
				-8.7								Incremental Change
				-8.7								Cumulative Change
3+00	189.2			186.1								Baseline Offset (In Feet)
				-3.1								Incremental Change
				-3.1								Cumulative Change
4+00	192.2			187.7								Baseline Offset (In Feet)
				-4.5								Incremental Change
				-4.5								Cumulative Change
5+00	202.9			197.1								Baseline Offset (In Feet)
				-5.8								Incremental Change
				-5.8								Cumulative Change
6+00	224.0			207.8								Baseline Offset (In Feet)
				-16.2								Incremental Change
				-16.2								Cumulative Change

Doc LCMF-155 Nigliq Streambank Monitor Rev4.xlsx   1 of 4   2013 - Current W Bank Monitor

Calc'd By: TRB
Date: 07/09/2016
RPT-CE-CD-112 REV4

Alpine AP00
West Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV4

Baseline	**West Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 4 for Survey Baseline Location											
	8/21/2013	**8/24/2014**	**8/27/2015**	**7/6/2016**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
7+00	228.9			209.3								Baseline Offset (In Feet)
				-19.6								Incremental Change
				-19.6								Cumulative Change
8+00	232.9			219.1								Baseline Offset (In Feet)
				-13.8								Incremental Change
				-13.8								Cumulative Change
9+00	220.0			217.9								Baseline Offset (In Feet)
				-2.1								Incremental Change
				-2.1								Cumulative Change
10+00	216.8	216.8	213.5	213.5								Baseline Offset (In Feet)
		0.0	-3.3	0.0								Incremental Change
		0.0	-3.3	-3.3								Cumulative Change
11+00	209.1	209.1	204.9	204.8								Baseline Offset (In Feet)
		0.0	-4.2	-0.1								Incremental Change
		0.0	-4.2	-4.3								Cumulative Change
12+00	199.0	199.0	199.0	* Unable to Survey - Under Bridge								Baseline Offset (In Feet)
		0.0	0.0									Incremental Change
		0.0	0.0									Cumulative Change
12+21.5				198.8								Baseline Offset (In Feet)
												Incremental Change
												Cumulative Change

Doc LCMF-155 Nigliq Streambank Monitor Rev4.xlsx 2 of 4 2013 - Current W Bank Monitor

Calc/d By: TRB
Date: 07/09/2016
RPT-CE-CD-112 REV4

Alpine AP00
West Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV4

Baseline	West Bank Monitor - Top of Bank Locations											Description
Station	See Drawing CE-AP00-1126 Rev 4 for Survey Baseline Location											
	8/21/2013	8/24/2014	8/27/2015	7/6/2016	Future	Future	Future	Future	Future	Future	Future	Date
13+00	192.1	192.1	192.1	192.1								Baseline Offset (In Feet)
		0.0	0.0	0.0								Incremental Change
		0.0	0.0	0.0								Cumulative Change
14+00	200.9			198.8								Baseline Offset (In Feet)
				-2.1								Incremental Change
				-2.1								Cumulative Change
15+00	190.0			190.0								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
16+00	211.0			209.5								Baseline Offset (In Feet)
				-1.5								Incremental Change
				-1.5								Cumulative Change
17+00	204.0			204.0								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
18+00	212.0			208.3								Baseline Offset (In Feet)
				-3.7								Incremental Change
				-3.7								Cumulative Change
19+00	221.9			221.9								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change

Doc LCMF-155 Nigliq Streambank Monitor Rev4.xlsx 3 of 4 2013 - Current W Bank Monitor

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Alpine AP00
West Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
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Baseline	**West Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 4 for Survey Baseline Location											
	8/21/2013	**8/24/2014**	**8/27/2015**	**7/6/2016**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
20+00	232.9			232.9								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
21+00	233.9			227.5								Baseline Offset (In Feet)
				-6.4								Incremental Change
				-6.4								Cumulative Change
22+00	237.8			233.3								Baseline Offset (In Feet)
				-4.5								Incremental Change
				-4.5								Cumulative Change
23+00	237.9			233.0								Baseline Offset (In Feet)
				-4.9								Incremental Change
				-4.9								Cumulative Change
24+00	229.9			229.9								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
25+00	214.1			214.1								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
25+11	213.9			213.9								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change

***__Note:__ Survey completed on 8/22/13 was used for baseline data to compute Incremental/Cumulative Change. Negative numbers indicate erosion.

Doc LCMF-155 Nigliq Streambank Monitor Rev4.xlsx 4 of 4 2013 - Current W Bank Monitor

Calc/d By: TRB
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Alpine AP00
East Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
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Baseline	East Bank Monitor - Top of Bank Locations											Description
Station	See Drawing CE-AP00-1126 Rev 4 for Survey Baseline Location											
	8/22/2013	8/24/2014	8/27/2015	7/6/2016	Future	Future	Future	Future	Future	Future	Future	Date
0+00	169.9			169.9								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
1+00	174.0			174.0								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
2+00	178.9			178.9								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
3+00	191.0			191.0								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
4+00	188.0			188.0								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
5+00	196.1			196.1								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
6+00	201.1			201.1								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change

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Alpine AP00
East Bank Nigliq
Streambank Monitor

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Alpine Survey Office
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Baseline	**East Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 4 for Survey Baseline Location											
	8/22/2013	**8/24/2014**	**8/27/2015**	**7/6/2016**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
7+00	208.1			208.1								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
8+00	199.8			199.8								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
9+00	406.2			406.2								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
10+00	280.9			280.7								Baseline Offset (In Feet)
				-0.2								Incremental Change
				-0.2								Cumulative Change
11+00	192.2			192.0								Baseline Offset (In Feet)
				-0.2								Incremental Change
				-0.2								Cumulative Change
12+00	100.1			107.9								Baseline Offset (In Feet)
				7.8								Incremental Change
				7.8								Cumulative Change
13+00	192.0	192.0	192.0	192.0								Baseline Offset (In Feet)
		0.0	0.0	0.0								Incremental Change
		0.0	0.0	0.0								Cumulative Change

Doc LCMF-155 Nigliq Streambank Monitor Rev4.xlsx 2 of 3 2013 - Current E Bank Monitor

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East Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
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Baseline	**East Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 4 for Survey Baseline Location											
	8/22/2013	**8/24/2014**	**8/27/2015**	**7/6/2016**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
13+83.8				208.0								Baseline Offset (In Feet)
												Incremental Change
												Cumulative Change
14+00	210.0	210.0	210.0	*Unable to Survey - Under Bridge								Baseline Offset (In Feet)
		0.0	0.0									Incremental Change
		0.0	0.0									Cumulative Change
15+00	192.0	192.0	192.0	192.0								Baseline Offset (In Feet)
		0.0	0.0	0.0								Incremental Change
		0.0	0.0	0.0								Cumulative Change
15+56	195.4			195.4								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change

***Note:** Survey completed on 8/22/13 was used for baseline data to compute Incremental/Cumulative Change. Negative numbers indicate erosion. Positive numbers indicate erosion Sta 9+00 to 12+00.

Doc LCMF-155 Nigliq Streambank Monitor Rev4.xlsx 3 of 3 2013 - Current E Bank Monitor

G.2.3 NIGLIAGVIK CHANNEL WEST & EAST BANK TABULATED DATA

Calc'd By: TRB
Date: 07/08/2016
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Alpine AP00
West Bank Nigliagvik
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Baseline	West Bank Monitor - Top of Bank Locations											Description
Station	See Drawing CE-AP00-1126 Rev 4 for Survey Baseline Location											
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	Future	Future	Future	Future	Future	Future	Future	Date
0+00.0	110.0			100.7								Baseline Offset (In Feet)
				-9.3								Incremental Change
				-9.3								Cumulative Change
1+00.0	103.0			97.9								Baseline Offset (In Feet)
				-5.1								Incremental Change
				-5.1								Cumulative Change
2+00.0	99.6			99.6								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
3+00.0	98.8			91.3								Baseline Offset (In Feet)
				-7.5								Incremental Change
				-7.5								Cumulative Change
4+00.0	106.0	106.0	106.0	102.4								Baseline Offset (In Feet)
		0.0	0.0	-3.6								Incremental Change
		0.0	0.0	-3.6								Cumulative Change
4+78.5				79.9								Baseline Offset (In Feet)
												Incremental Change
												Cumulative Change
4+79.7				96.1								Baseline Offset (In Feet)
												Incremental Change
												Cumulative Change

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Calc'd By: TRB
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Alpine AP00
West Bank Nigliagvik
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-154 REV4

Baseline	**West Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 4 for Survey Baseline Location											
	8/21/2013	**8/21/2014**	**8/28/2015**	**7/6/2016**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
5+00.0	102.0	93.5	93.5	**Unable to Survey - Under Bridge								Baseline Offset (In Feet)
		-8.4	0.0									Incremental Change
		-8.4	-8.4									Cumulative Change
5+13.7				74.1								Baseline Offset (In Feet)
												Incremental Change
												Cumulative Change
5+15.7				93.0								Baseline Offset (In Feet)
												Incremental Change
												Cumulative Change
6+00.0	92.0	90.4	90.4	87.9								Baseline Offset (In Feet)
		-1.6	0.0	-2.5								Incremental Change
		-1.6	-1.6	-4.1								Cumulative Change
7+00.0	107.1			107.1								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
8+00.0	115.0			112.8								Baseline Offset (In Feet)
				-2.2								Incremental Change
				-2.2								Cumulative Change
9+00.0	96.1			91.8								Baseline Offset (In Feet)
				-4.3								Incremental Change
				-4.3								Cumulative Change

Doc LCMF-154 Nigliagvik Streambank Monitor Rev4.xlsx 2 of 3 2013 - Current W Bank Monitor

Calc'd By: TRB
Date: 07/08/2016
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Alpine AP00
West Bank Nigliagvik
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
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Baseline	**West Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 4 for Survey Baseline Location											
	8/21/2013	**8/21/2014**	**8/28/2015**	**7/6/2016**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
10+00.0	106.1			106.1								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
10+28	112.0			112.0								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
***Note: Survey completed on 8/21/13 was used for baseline data to compute Incremental/Cumulative Change. Negative numbers indicate erosion.												

Doc LCMF-154 Nigliagvik Streambank Monitor Rev4.xlsx 3 of 3 2013 - Current W Bank Monitor

Calc'd By: TRB
Date: 11/30/2016
RPT-CE-CD-111 REV5

Alpine AP00
East Bank Nigliagvik
Streambank Monitor

Umiaq LLC
Alpine Survey Office
Doc.LCMF-154 REV5

Baseline Station	East Bank Monitor - Top of Bank Locations (See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location)											Description
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	Future	Future	Future	Future	Future	Future	Future	Date
0+00.0	165.1			165.1								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
1+00.0	185.0			185.0								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
2+00.0	165.0			165.0								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
3+00.0	162.3			162.3								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
4+00.0	154.9	154.9	154.9	147.6								Baseline Offset (In Feet)
		0.0	0.0	-7.3								Incremental Change
		0.0	0.0	-7.3								Cumulative Change
5+00.0	141.0	141.0	138.4	*Unable to Survey - Under Bridge								Baseline Offset (In Feet)
		0.0	-2.7									Incremental Change
		0.0	-2.7									Cumulative Change
5+23.2				143.2								Baseline Offset (In Feet)
												Incremental Change
												Cumulative Change

Doc LCMF-154 Nigliagvik Streambank Monitor Rev5.xlsx 1 of 2 2013 - Current E Bank Monitor

Calc'd By: TRB
Date: 11/30/2016
RPT-CE-CD-111 REV5

Alpine AP00
East Bank Nigliagvik
Streambank Monitor

Umiaq LLC
Alpine Survey Office
Doc.LCMF-154 REV5

Baseline	**East Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											
	8/21/2013	**8/21/2014**	**8/28/2015**	**7/6/2016**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
6+00.0	120.9	120.9	120.9	120.9								Baseline Offset (In Feet)
		0.0	0.0	0.0								Incremental Change
		0.0	0.0	0.0								Cumulative Change
7+00.0	119.0			119.0								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
8+00.0	120.9			120.9								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change
8+91.0	115.7			115.7								Baseline Offset (In Feet)
				0.0								Incremental Change
				0.0								Cumulative Change

***Note: Survey completed on 8/21/13 was used for baseline data to compute Incremental/Cumulative Change. Negative numbers indicate erosion.

***Note: Based on field evaluations and review of aerial imagery, the 2013 top of bank point at station 3+00 along the east bank is considered a misrepresentation of the bank at the time of survey. There is no visible erosion at this location and the 2013 top of bank was repositioned to align with the 2016 top of bank.

Doc LCMF-154 Nigliagvik Streambank Monitor Rev5.xlsx 2 of 2 2013 - Current E Bank Monitor

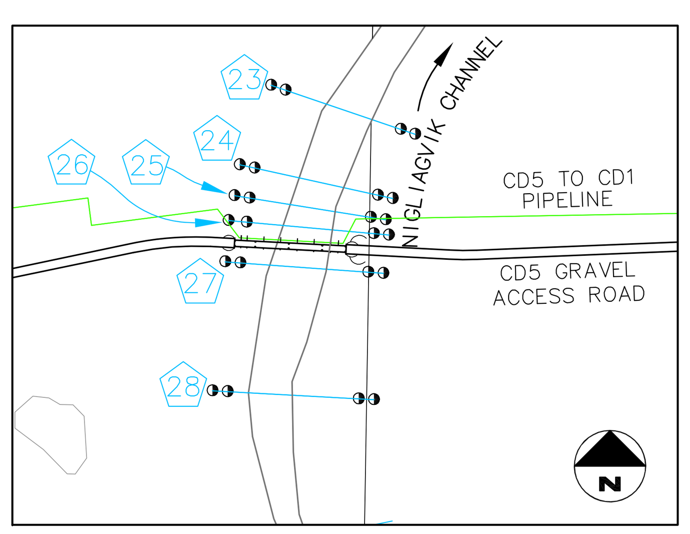
G.3 BATHYMETRY

G.3.1 TRANSECT PROFILES

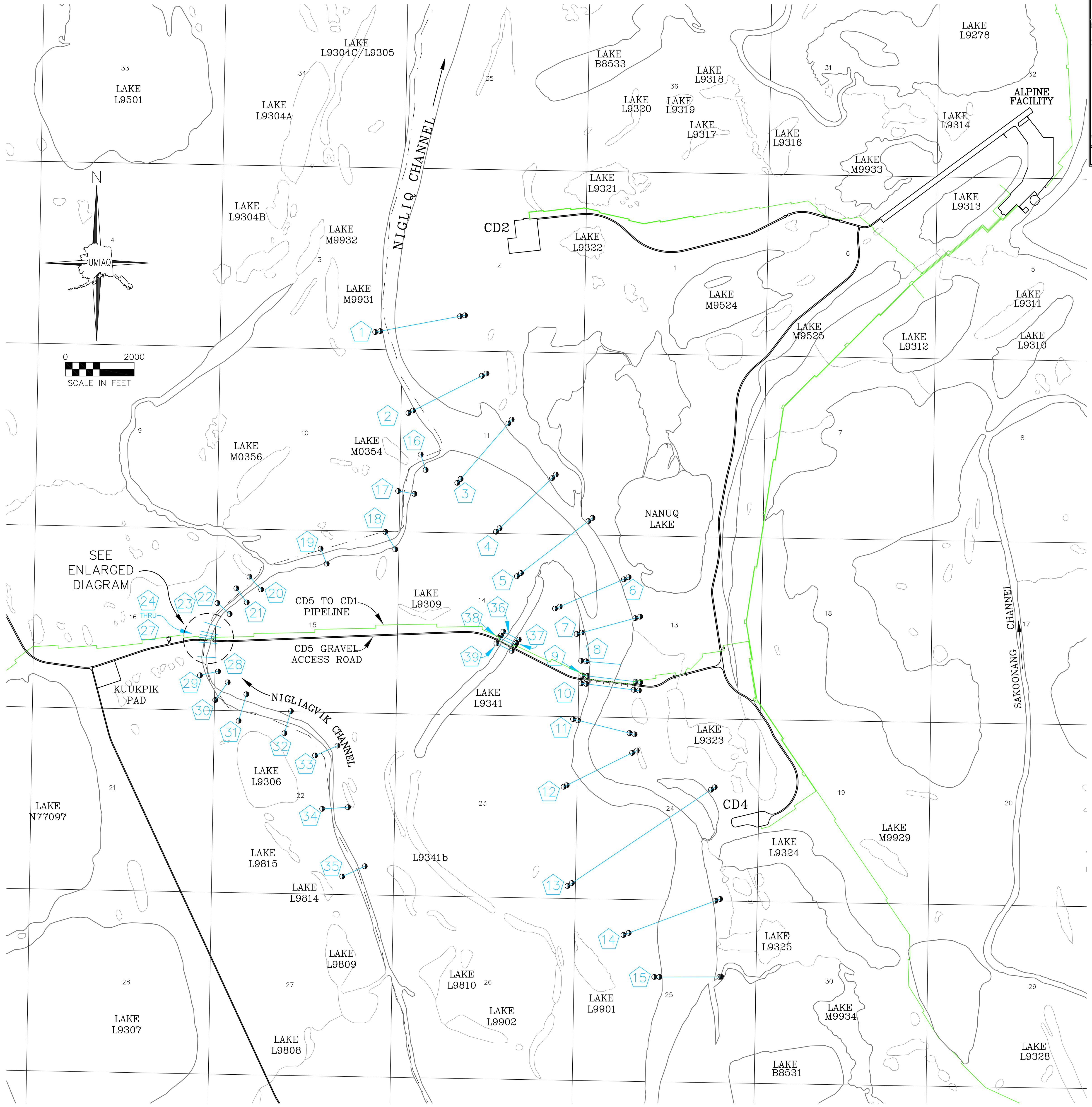
JOB NO:	SUB JOB NO:	DRAWING NO:
02-204	–	CE-CD50-1004

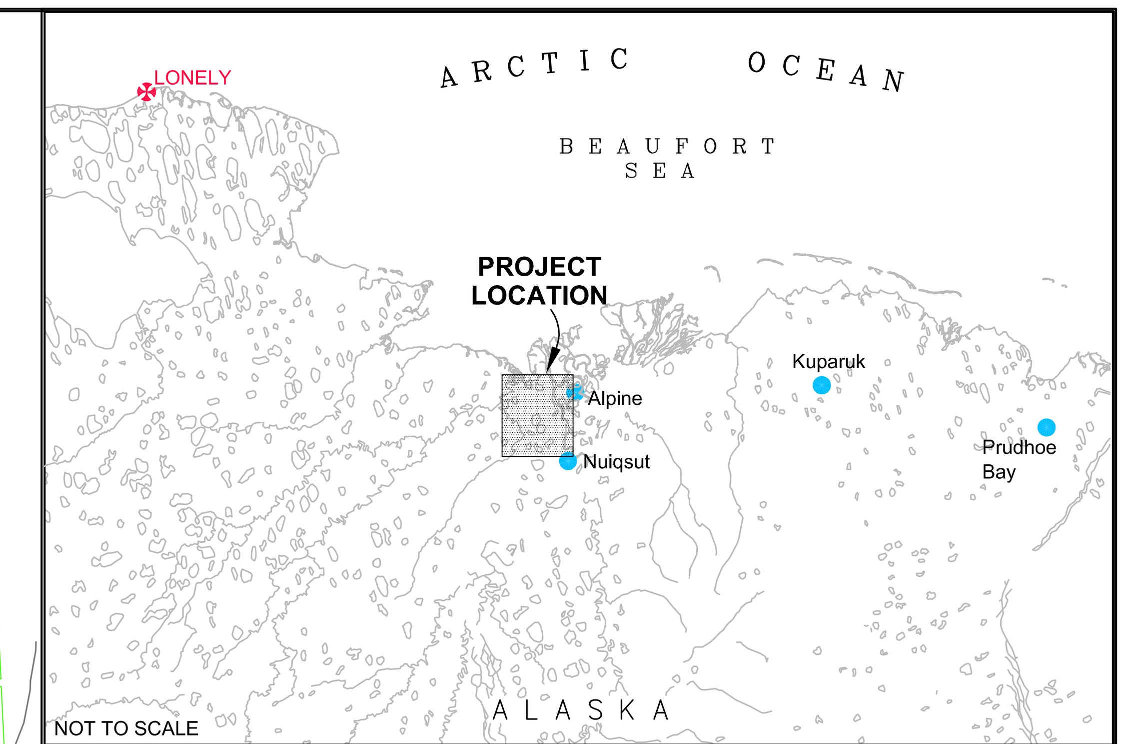
CD5 TRANSECT CONTROL

NORTHING	EASTING	ELEV	DESCRIPTION	NORTHING	EASTING	ELEV	DESCRIPTION
5,971,410.111	1,507,156.507	8.375	01–LB200 Al Cap Flush	5,963,972.491	1,503,814.186	7.459	20–RB50 Al Cap Flush
5,971,437.592	1,507,304.119	8.350	01–LB50 Al Cap Flush	5,963,970.152	1,503,127.897	24.547	21–LB100 Al Cap Flush
5,971,895.731	1,509,763.438	9.198	01–RB200 Al Cap Flush	5,963,929.998	1,503,157.768	20.695	21–RB50 Al Cap Flush
5,971,868.403	1,509,615.800	9.390	01–RB50 Al Cap Flush	5,963,562.371	1,503,430.552	8.692	21–RB100 Al Cap Flush
5,969,060.145	1,508,119.651	8.725	02–LB200 Al Cap Flush	5,963,602.540	1,503,400.642	9.043	21–RB50 Al Cap Flush
5,969,127.942	1,508,253.631	7.632	02–LB50 Al Cap Flush	5,963,540.689	1,502,578.194	26.011	22–LB110 Al Cap Flush
5,970,205.991	1,510,386.384	9.134	02–RB200 Al Cap Flush	5,963,501.047	1,502,623.030	24.045	22–RB50 Al Cap Flush
5,970,138.250	1,510,252.496	9.022	02–RB50 Al Cap Flush	5,963,224.481	1,502,935.978	8.581	22–RB100 Al Cap Flush
5,967,032.197	1,509,538.707	9.654	03–LB200 Al Cap Flush	5,963,257.660	1,502,898.513	9.107	22–RB50 Al Cap Flush
5,967,145.939	1,509,636.534	10.141	03–LB50 Al Cap Flush	5,962,989.574	1,502,198.804	25.198	23–LB100 Al Cap Flsh
5,968,868.924	1,511,117.917	9.525	03–RB200 Al Cap Flush	5,962,973.528	1,502,246.029	25.135	23–LB50 Al Cap Flush
5,968,755.161	1,511,019.891	9.295	03–RB50 Al Cap Flush	5,962,828.910	1,502,671.893	10.148	23–RB100 Al Cap Flush
5,965,610.328	1,510,661.005	12.550	04–LB200 Al Cap Flush	5,962,845.113	1,502,624.595	7.819	23–RB50 Al Cap Flush
5,965,716.664	1,510,772.038	13.795	04–LB50 Al Cap Flush	5,962,728.683	1,502,095.487	26.389	24–LB100 Al Cap Flush
5,967,272.801	1,512,396.888	10.370	04–RB200 Al Cap Flush	5,962,717.773	1,502,144.346	26.947	25–LB100 Al Cap Flush
5,967,169.080	1,512,288.542	10.235	04–RB50Al Cap Flush	5,962,617.951	1,502,598.131	9.023	24–RB100 Al Cap Flush
5,964,322.007	1,511,269.860	12.003	05–LB200 Al Cap Flush	5,962,628.787	1,502,549.419	8.330	24–RB50 Al Cap Flush
5,964,413.661	1,511,388.515	13.230	05–LB50 Al Cap Flush	5,962,627.114	1,502,078.244	27.304	25–LB100 Al Cap Flush
5,966,013.955	1,513,463.366	8.727	05–RB200 Al Cap Flush	5,962,619.300	1,502,127.761	26.154	25–LB50 Al Cap Flush
5,965,922.255	1,513,344.562	8.681	05–RB50 Al Cap Flush	5,962,547.963	1,502,575.158	8.370	25–RB100 Al Cap Flush
5,963,381.291	1,512,373.941	11.577	06–LB200 Al Cap Flush	5,962,555.723	1,502,525.896	8.163	25–RB50 Al Cap Flush
5,963,439.993	1,512,511.985	13.134	06–LB50 Al Cap Flush	5,962,545.624	1,502,059.077	27.246	26–LB110 Al Cap Flush
5,964,292.026	1,514,511.969	9.856	06–RB250 Al Cap Flush	5,962,539.991	1,502,118.574	27.468	26–LB50 Al Cap Flush
5,964,233.795	1,514,375.455	10.312	06–RB50 Al Cap Flush	5,962,498.348	1,502,585.627	9.497	26–RB100 Al Cap Flush
5,962,644.653	1,513,005.195	10.747	07–LB200 Al Cap Flush	5,962,502.417	1,502,535.991	8.293	26–RB50 Al Cap Flush
5,962,684.027	1,513,149.924	12.409	07–LB50 Al Cap Flush	5,962,409.987	1,502,047.856	26.725	27–LB100 Al Cap Flush
5,963,144.339	1,514,845.076	10.611	07–RB200 Al Cap Flush	5,962,406.441	1,502,097.738	26.979	27–LB50 Al Cap Flush
5,963,105.174	1,514,700.440	9.926	07–RB50 Al Cap Flush	5,962,371.846	1,502,567.474	9.160	27–RB100 Al Cap Flush
5,961,864.650	1,513,132.791	10.365	08–LB200 Al Cap Flush	5,962,375.566	1,502,517.756	7.642	27–RB50 Al Cap Flush
5,961,851.343	1,513,282.150	10.510	08–LB50 Al Cap Flush	5,961,986.460	1,502,006.057	21.004	28–LB100 Al Cap Flush
5,961,442.294	1,513,168.278	10.582	09–LB200 Al Cap Flush	5,961,983.610	1,502,055.932	21.167	28–LB50 Al Cap Flush
5,961,424.826	1,513,317.461	10.271	09–LB50 Al Cap Flush	5,961,959.915	1,502,486.609	8.456	28–RB50 Al Cap Flush
5,961,244.691	1,514,849.205	9.330	09–RB200 Al Cap Flush	5,961,957.294	1,502,536.444	9.109	28–RB100 Al Cap Flush
5,961,261.026	1,514,710.012	8.041	09–RB60 Al Cap Flush	5,961,446.941	1,502,073.294	24.264	29–LB100 Al Cap Flush
5,961,214.615	1,513,133.921	10.311	10–LB200 Al Cap Flush	5,961,457.453	1,502,122.142	23.680	29–LB50 Al Cap Flush
5,961,195.939	1,513,282.753	10.347	10–LB50 Al Cap Flush	5,961,559.139	1,502,596.959	9.792	29–RB100 Al Cap Flush
5,961,004.280	1,514,808.558	7.205	10–RB200 Al Cap Flush	5,961,548.601	1,502,547.922	8.632	29–RB50 Al Cap Flush
5,961,023.156	1,514,659.846	8.340	10–RB50 Al Cap Flush	5,960,727.264	1,502,515.812	23.695	30–LB100 Al Cap Flush
5,960,173.851	1,512,898.219	10.949	11–LB200 Al Cap Flush	5,960,768.335	1,502,544.687	23.252	30–LB50 Al Cap Flush
5,960,137.665	1,513,043.875	8.842	11–LB50 Al Cap Flush	5,961,239.607	1,502,877.125	10.025	30–RB100 Al Cap Flush
5,959,731.080	1,514,682.771	10.217	11–RB200 Al Cap Flush	5,961,198.828	1,502,848.333	9.530	30–RB50 Al Cap Flush
5,959,767.257	1,514,537.190	9.110	11–RB50 Al Cap Flush	5,960,124.308	1,503,193.296	8.597	31–LB100 Al Cap Flush
5,958,209.520	1,512,625.560	11.014	12–LB200 Al Cap Flush	5,960,172.272	1,503,207.278	9.583	31–LB50 Al Cap Flush
5,958,254.063	1,512,715.203	11.209	12–LB100 Al Cap Flush	5,960,896.073	1,503,418.975	10.685	31–RB100 Al Cap Flush
5,959,260.208	1,514,746.153	10.018	12–RB200 Al Cap Flush	5,960,848.117	1,503,404.867	11.226	31–RB50 Al Cap Flush
5,959,193.540	1,514,611.484	8.779	12–RB50 Al Cap Flush	5,959,762.528	1,504,523.237	8.354	32–LB100 Al Cap Flush
5,955,329.174	1,512,738.215	11.599	13–LB200 Al Cap Flush	5,959,810.484	1,504,537.164	7.832	32–LB50 Al Cap Flush
5,955,412.736	1,512,862.693	12.103	13–LB50 Al Cap Flush	5,960,406.305	1,504,711.493	10.826	32–RB100 Al Cap Flush
5,958,196.004	1,517,009.823	10.240	13–RB200 Al Cap Flush	5,960,358.134	1,504,697.314	11.512	32–RB50 Al Cap Flush
5,958,123.575	1,516,901.881	11.599	13–RB70 Al Cap Flush	5,959,119.009	1,505,412.923	9.969	33–LB100 Al Cap Flush
5,953,908.388	1,514,359.152	13.345	14–LB215 Al Cap Flush	5,959,138.922	1,505,458.830	8.627	33–LB50 Al Cap Flush
5,953,965.679	1,514,513.889	15.721	14–LB50 Al Cap Flush	5,959,403.853	1,506,064.781	10.609	33–RB120 Al Cap Flush
5,954,950.430	1,517,166.278	9.530	14–RB200 Al Cap Flush	5,959,375.835	1,506,000.620	10.542	33–RB50 Al Cap Flush
5,954,898.275	1,517,025.644	9.730	14–RB50 Al Cap Flush	5,957,568.029	1,505,617.425	12.571	34–LB100 Al Cap Flush
5,952,688.585	1,515,253.994	13.802	15–LB200 Al Cap Flush	5,957,571.319	1,505,667.199	12.720	34–LB50 Al Cap Flush
5,952,688.769	1,515,404.109	16.615	15–LB50 Al Cap Flush	5,957,615.330	1,506,366.067	10.148	34–RB100 Al Cap Flush
5,952,691.496	1,517,145.180	12.506	15–RB50 Al Cap Flush	5,957,612.262	1,506,316.239	10.634	34–RB50 Al Cap Flush
5,952,691.566	1,517,195.136	12.497	15–RB100 Al Cap Flush	5,955,603.321	1,506,200.605	12.510	35–LB100 Al Cap Flush
5,967,852.343	1,508,476.556	9.896	16–LB100 Al Cap Flush	5,955,624.160	1,506,246.167	12.950	35–LB50 Al Cap Flush
5,967,804.926	1,508,492.070	9.109	16–LB50 Al Cap Flush	5,955,901.752	1,506,854.805	10.213	35–RB100 Al Cap Flush
5,967,407.564	1,508,622.128	9.258	16–RB100 Al Cap Flush	5,955,880.852	1,506,809.436	9.269	35–RB50 Al Cap Flush
5,967,455.159	1,508,606.562	8.783	16–RB50 Al Cap Flush	5,962,713.554	1,510,877.336	7.958	36–LB100 Al Cap Flush
5,966,795.120	1,507,822.720	8.368	17–LB100 Al Cap Flush	5,962,690.413	1,510,921.652	7.979	36–LB50 Al Cap Flush
5,966,786.390	1,507,871.946	8.233	17–LB50 Al Cap Flush	5,962,479.528	1,511,322.851	9.414	36–RB100 Al Cap Flush
5,966,712.387	1,508,294.836	8.445	17–RB100 Al Cap Flush	5,962,502.792	1,511,278.653	8.739	36–RB50 Al Cap Flush
5,966,720.847	1,508,245.565	8.534	17–RB50 Al Cap Flush	5,962,603.125	1,510,806.707	8.362	37–LB100 Al Cap Flush
5,965,609.712	1,507,451.150	8.608	18–LB100 Al Cap Flush	5,962,580.929	1,510,851.631	8.260	37–LB50 Al Cap Flush
5,965,566.194	1,507,475.858	8.579	18–LB50 Al Cap Flush	5,962,383.015	1,511,254.358	9.460	37–RB100 Al Cap Flush
5,965,103.307	1,507,739.338	7.838	18–RB100 Al Cap Flush	5,962,405.148	1,511,209.407	8.831	37–RB50 Al Cap Flush
5,965,146.858	1,507,714.592	7.597	18–RB50 Al Cap Flush	5,962,540.221	1,510,738.151	7.654	38–LB100 Al Cap Flush
5,965,119.481	1,505,573.320	8.671	19–LB100 Al Cap Flush	5,962,518.496	1,510,783.374	7.826	38–LB50 Al Cap Flush
5,965,073.080	1,505,592.237	8.699	19–LB50 Al Cap Flush	5,962,311.249	1,511,215.131	9.129	38–RB100 Al Cap Flush
5,964,684.621	1,505,750.628	8.163	19––RB100 Al Cap Flush	5,962,332.743	1,511,169.926	8.892	38–RB50 Al Cap Flush
5,964,730.879	1,505,731.755	8.547	19–RB50 Al Cap Flush	5,962,367.918	1,510,674.682	8.413	39–LB100 Al Cap Flush
5,964,307.514	1,503,508.716	13.781	20–LB100 Al Cap Flush	5,962,346.125	1,510,719.731	7.533	39–LB50 Al Cap Flush
5,964,270.652	1,503,542.404	15.560	20–LB50 Al Cap Flush	5,962,154.473	1,511,119.180	9.345	39–RB100 Al Cap Flush
5,963,935.646	1,503,847.816	7.594	20–RB100 Al Cap Flush	5,962,176.206	1,511,074.048	9.248	39–RB50 Al Cap Flush



ENLARGED DIAGRAM





VICINITY MAP

NOTES:

1. DATE OF SURVEY: AUGUST 29 TO SEPTEMBER 18, 2013; OCTOBER 21, 2013; JUNE 29 TO JULY 26, 2016.
2. COORDINATES SHOWN ARE ALASKA STATE PLANE, ZONE 4 N.A.D. 83, IN FEET. BASED ON THE 2013 CD-5 CONTROL SURVEY.
3. ELEVATIONS SHOWN ARE BRITISH PETROLEUM MEAN SEA LEVEL (B.P.M.S.L.) DATUM.
4. REFERENCE FIELD BOOK LCMF2013-18, PGS. 57-59, 67, 70-72. LCMF2013-20 PGS. 4-14; LCMF2013-21, PG. 29; LCMF2016-11, PG. 76, LCMF2016-12, PGS. 17-20, 26-28, 36-37 & 59.

LEGEND:

◑ 2" ALUMINUM CAP ON 5/8" x 30" REBAR (TYPICAL 4 REBAR ON EACH TRANSECT)

KUUKPIK LCMF LLC
Alpine Survey Office

ConocoPhillips
Alaska, Inc.

ALPINE — MODULE: CD50 — UNIT: CD

CD-5 ROAD
MONITORING PLAN BASELINES
ALPINE, ALASKA

REDRAWN FROM: — CONSTRUCTION SHEET OF

DO NOT SCALE — ABOVE SCALE FOR REFERENCE ONLY

DATE: 8/26/13	DRAWN: CZ	DESIGN: –	ECM NO: –
SCALE: 1" = 2000'	CHECKED: DB		CC NO: –
	APPROVAL: –		CADD FILE NO. 13-08-07-1 –
JOB NO: 02-204	SUB JOB NO: –	DRAWING NO: CE-CD50-1004	PART: 1 OF 6 — REV: 2

REFERENCE DWG NO/SHT NO:

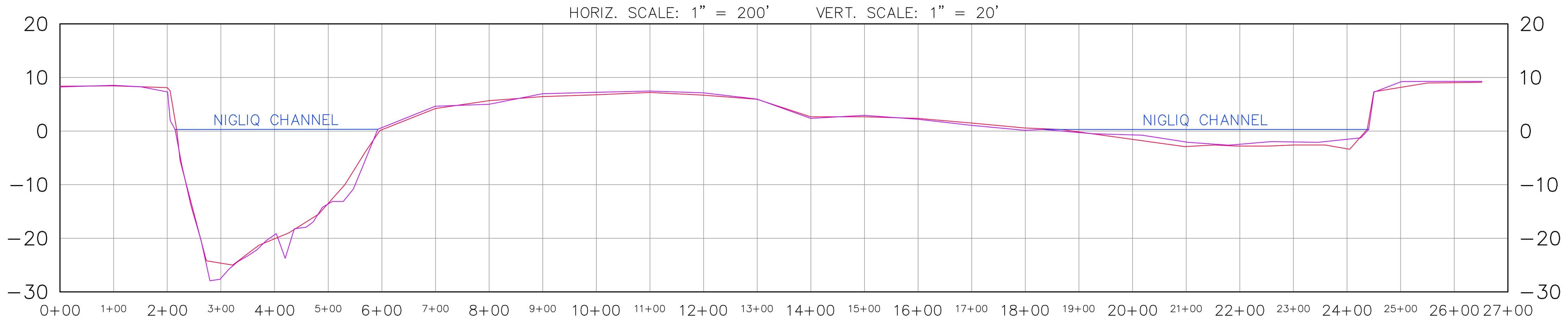
REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
2	7/29/16	UPDATED PER K160003ACS	CZ	DB			
1	10/22/13	ISSUED PER K130003ACS	AG	DB			

FORM: DSIZE

DRAWING NO:	SUB JOB NO:	JOB NO:
CE-CD50-1004	–	–

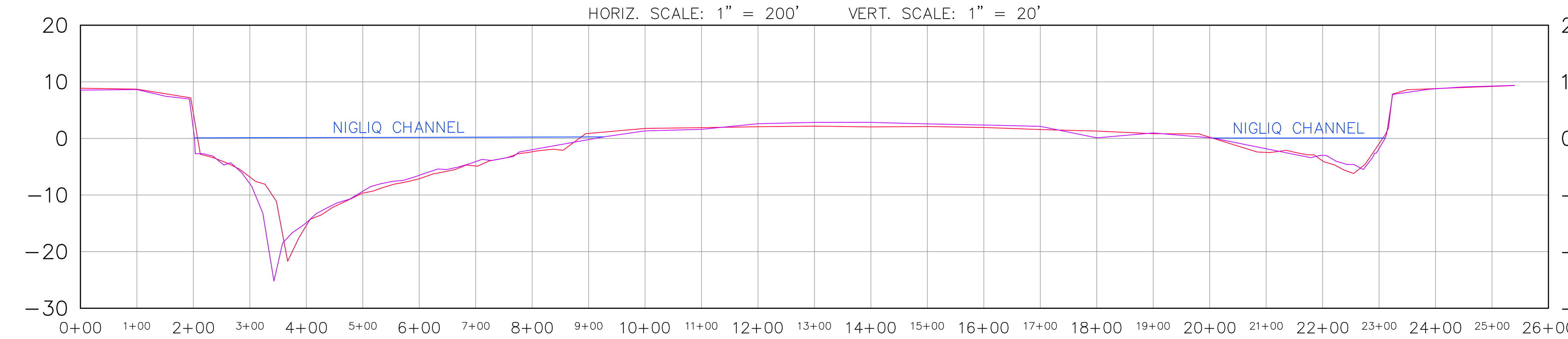
Profile View of Transect-1

HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



Profile View of Transect-2

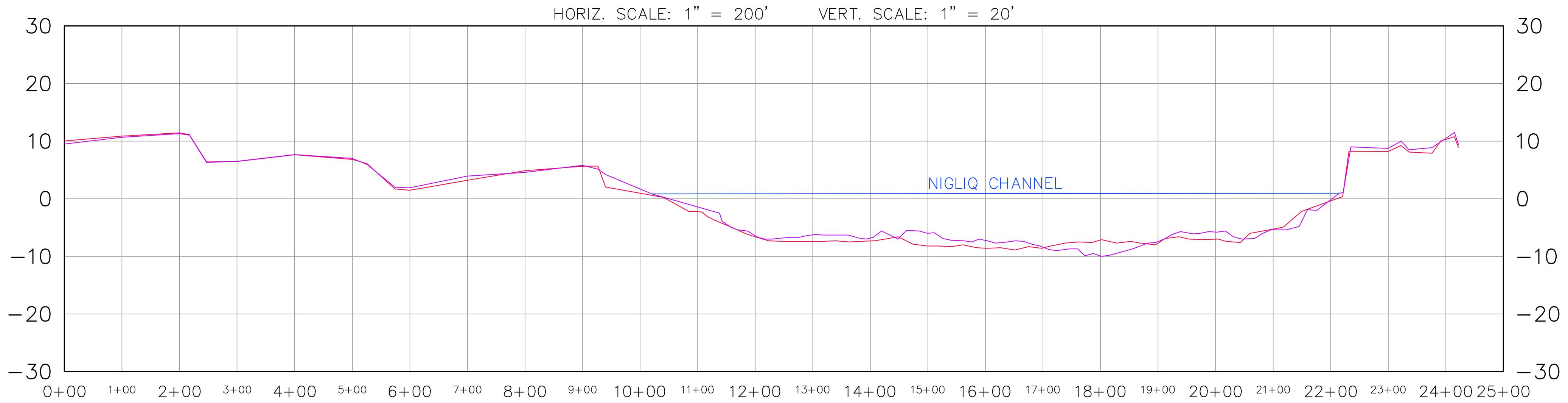
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



LEGEND:
VIEW LOOKING DOWNSTREAM
- 2013 TRANSECT PROFLIE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE

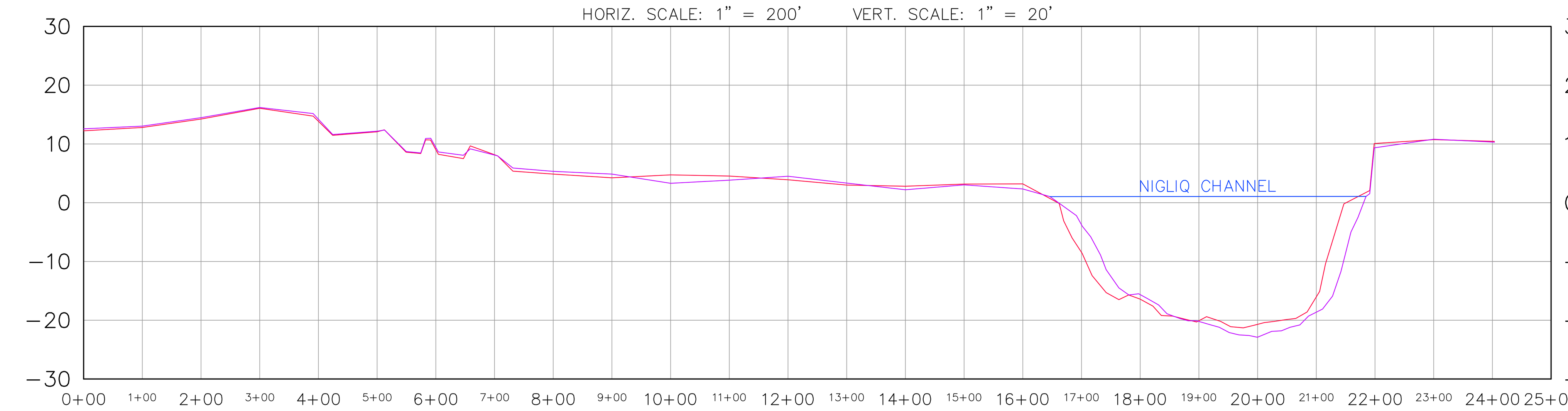
Profile View of Transect-3

HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



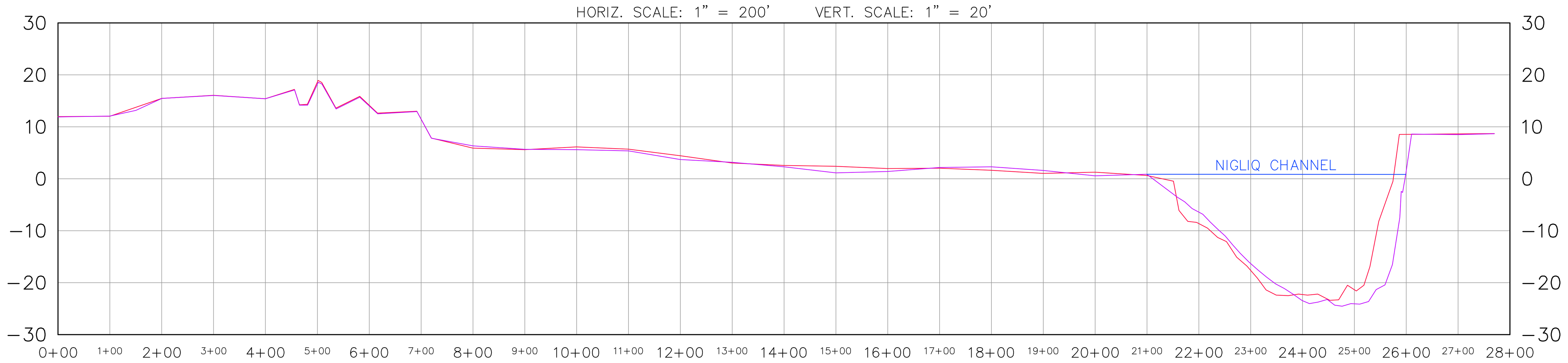
Profile View of Transect-4

HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



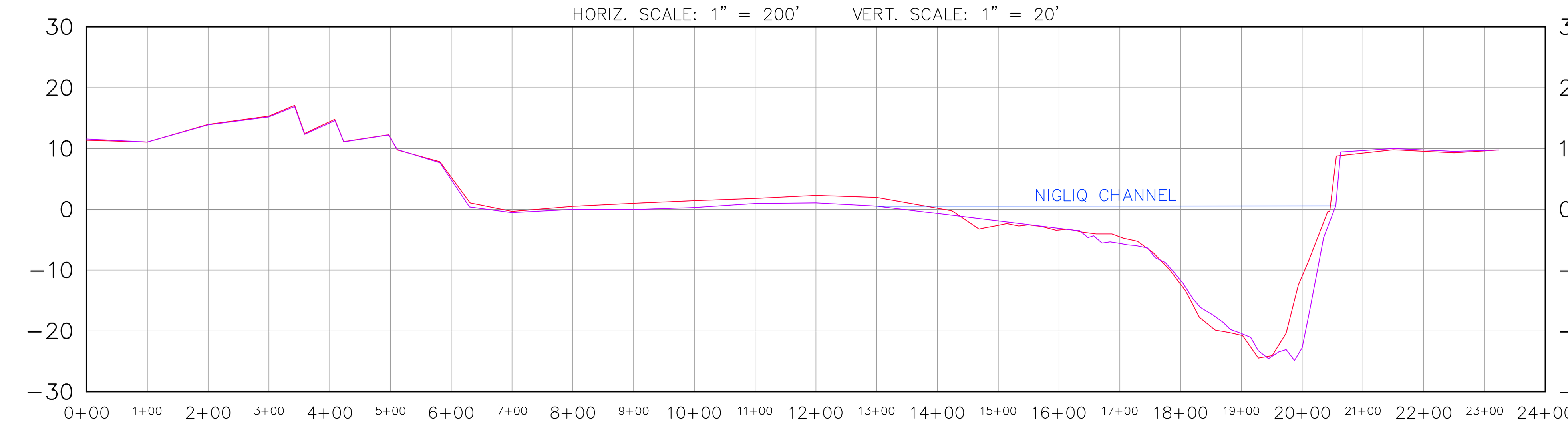
Profile View of Transect-5

HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



Profile View of Transect-6

HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE: 907-670-4739

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

ECM NO: K160003ACS
CC NO: –
CADD FILE NO. 13-08-07-1 –
SCALE: 1" = 200'
DATE: 7/01/2016

ConocoPhillips Alaska, Inc.

DRAWN: CZ
DESIGN: –
CHECKED: DB
REDRAWN FROM: –
APPROVAL: –

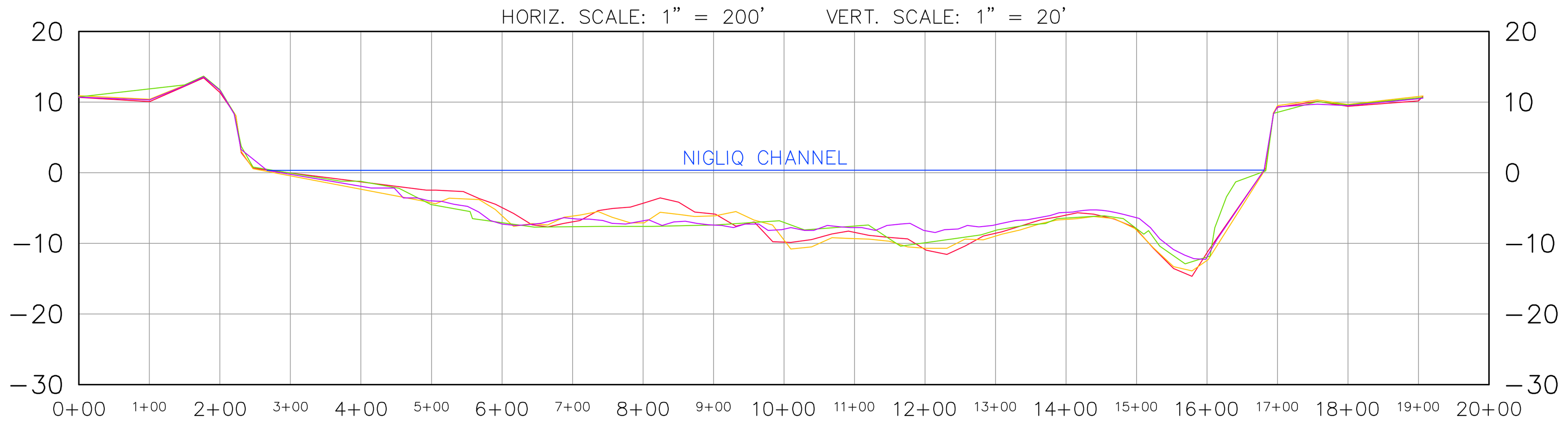
ALPINE
MODULE: CD50
UNIT: CD

CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

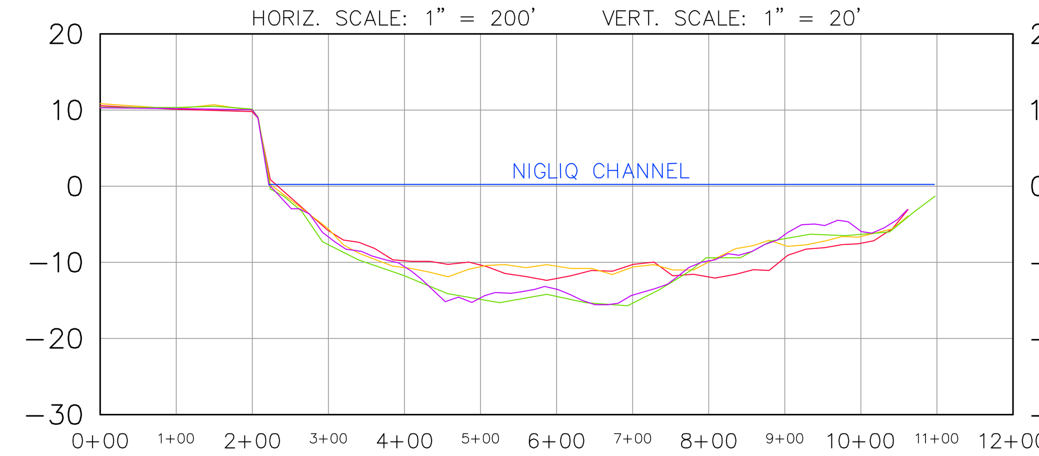
JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	2 of 6	1

JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE–CD50–1004

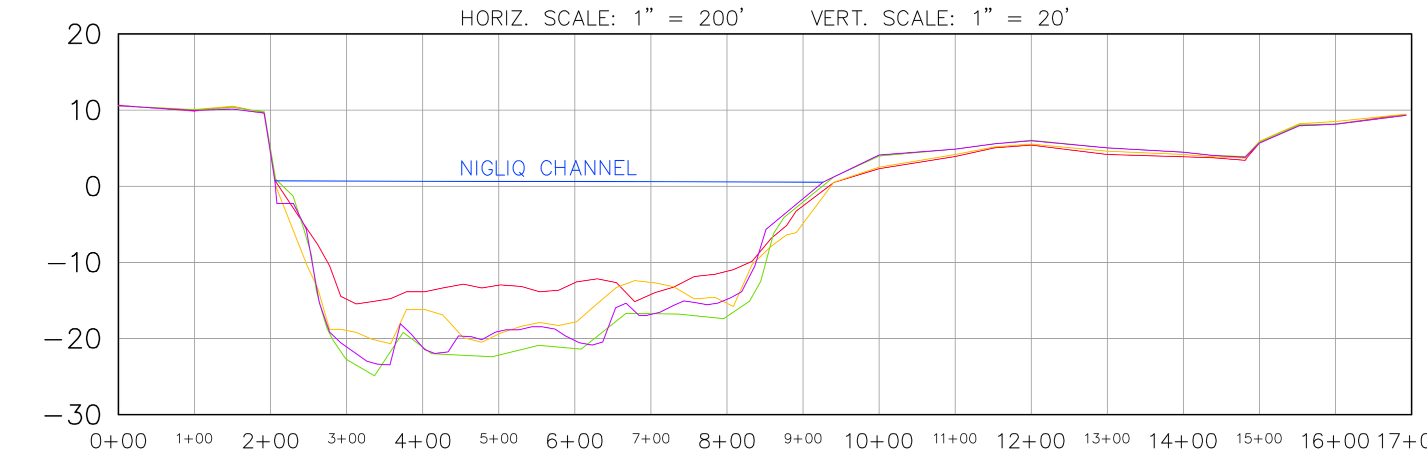
Profile View of Transect–7
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



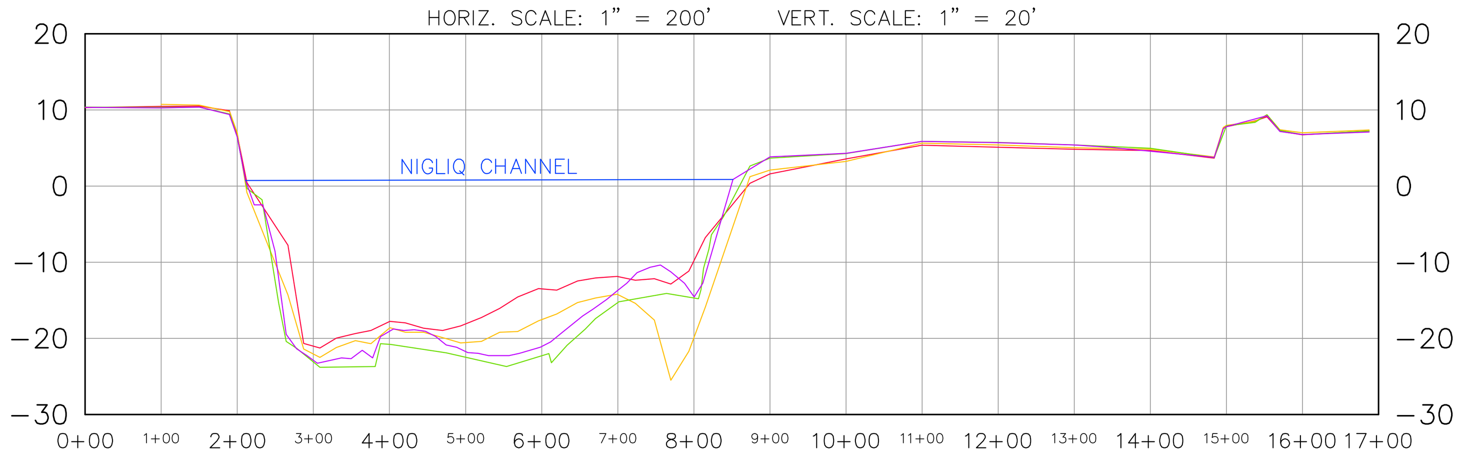
Profile View of Transect–8
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



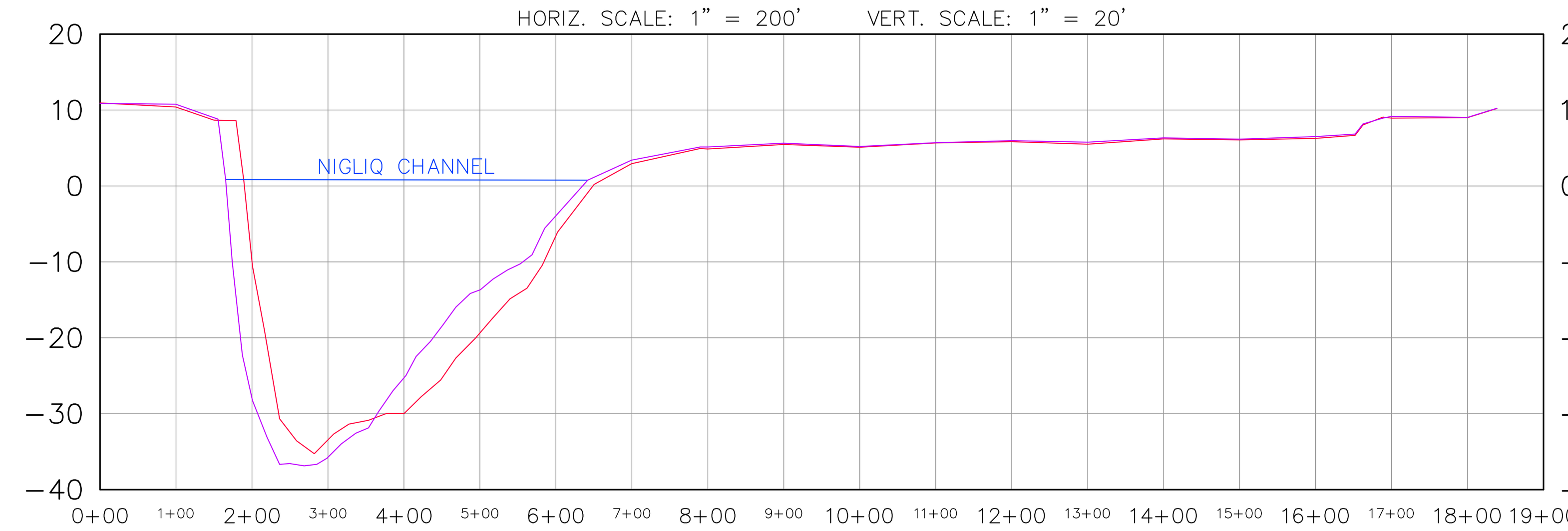
Profile View of Transect–9
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



Profile View of Transect–10
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



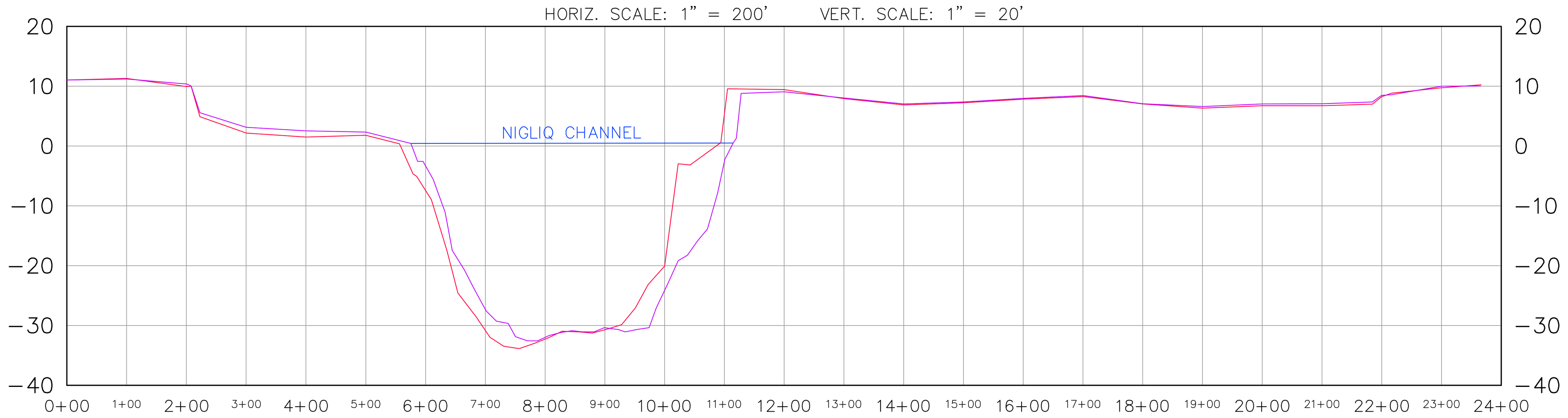
Profile View of Transect–11
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



LEGEND:
VIEW LOOKING DOWNSTREAM

- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE

Profile View of Transect–12
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE : 907-670-4739

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

ECM NO: K160003ACS
CC NO: –
CADD FILE NO. 13–08–07–1 –
SCALE: 1" = 200'
DATE: 7/01/2016

ConocoPhillips Alaska, Inc.

DRAWN: CZ
DESIGN: –
CHECKED: DB
REDRAWN FROM: –
APPROVAL: –

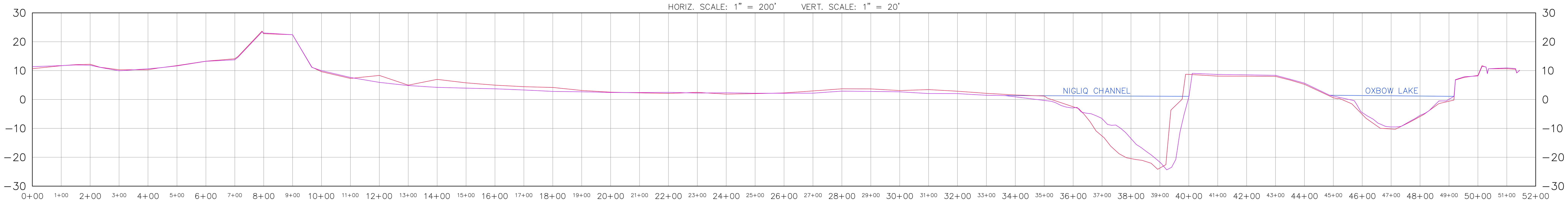
ALPINE
MODULE: CD50
UNIT: CD

CD–5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE–CD50–1004	3 of 6	1

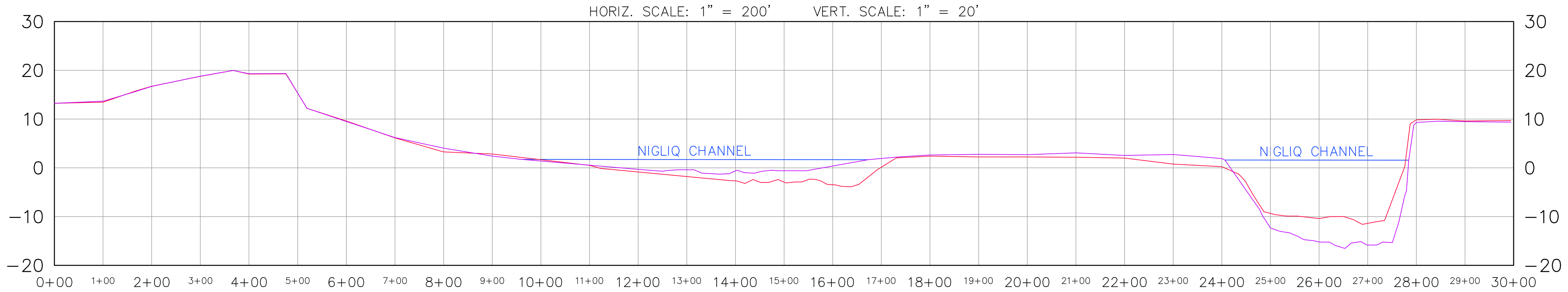
JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE-CD50-1004

Profile View of Transect-13
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'

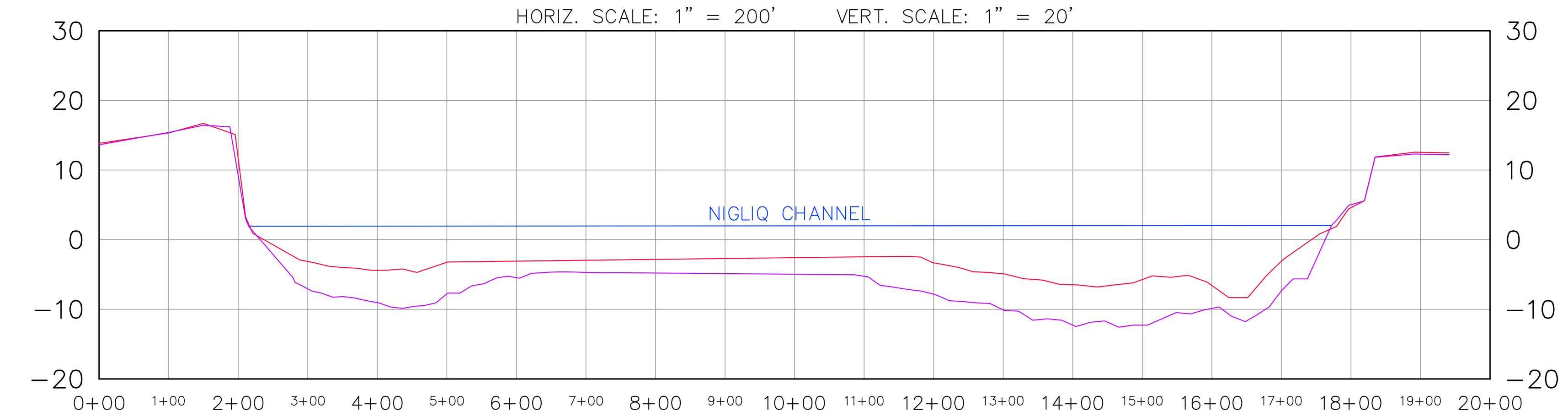


LEGEND:
VIEW LOOKING DOWNSTREAM
2013 TRANSECT PROFILE
2014 TRANSECT PROFILE
2015 TRANSECT PROFILE
2016 TRANSECT PROFILE

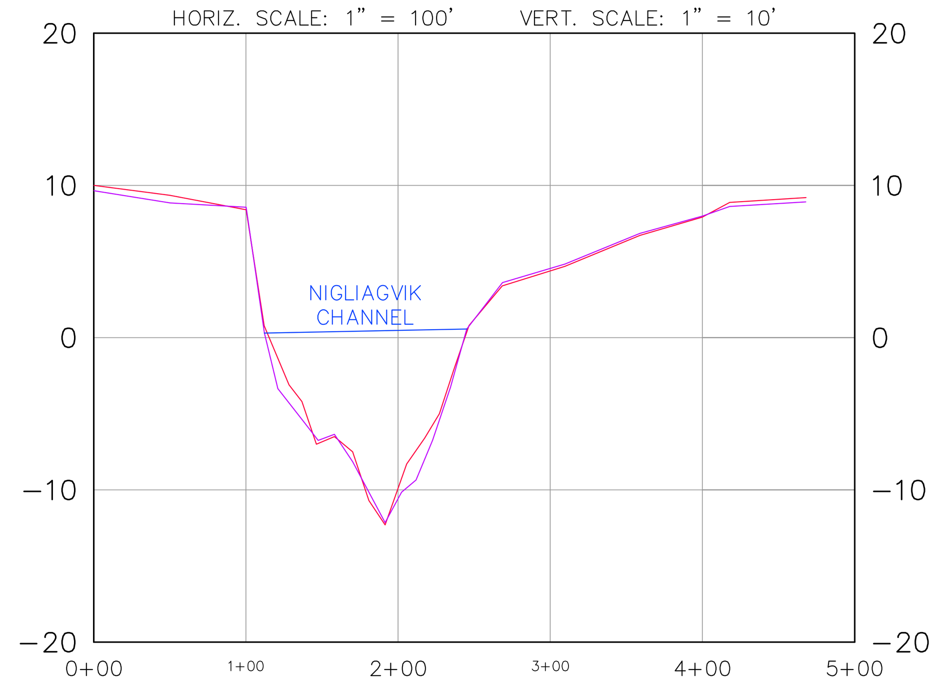
Profile View of Transect-14
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



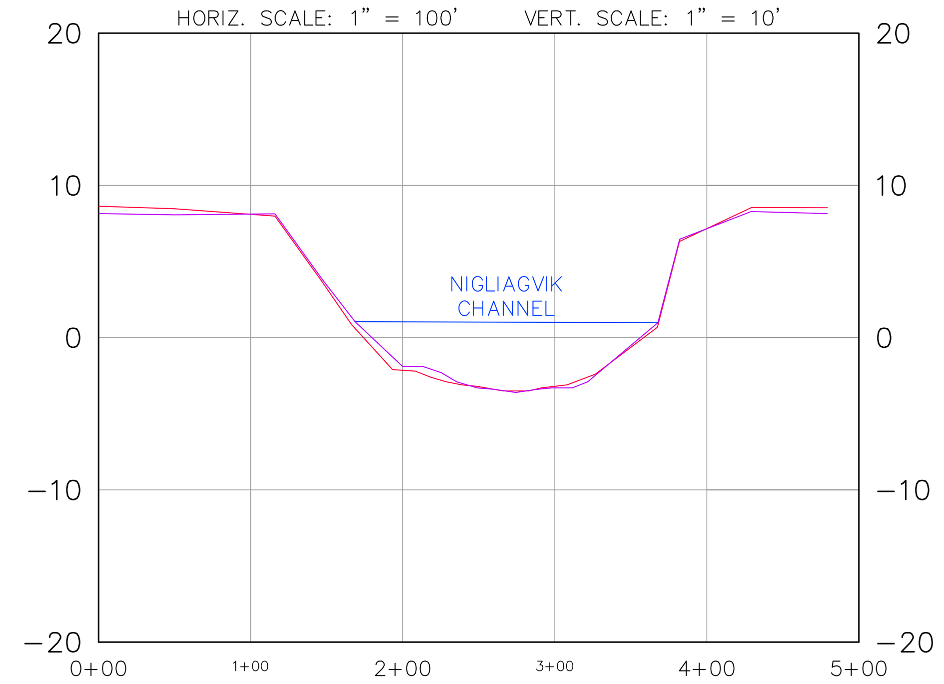
Profile View of Transect-15
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



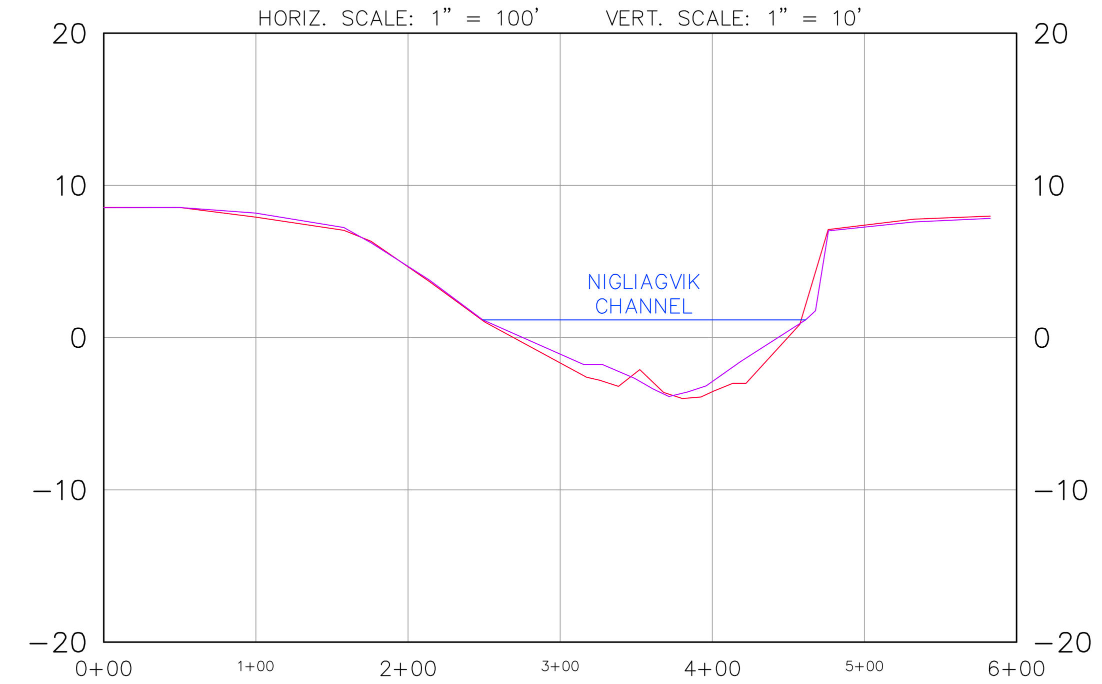
Profile View of Transect-16
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



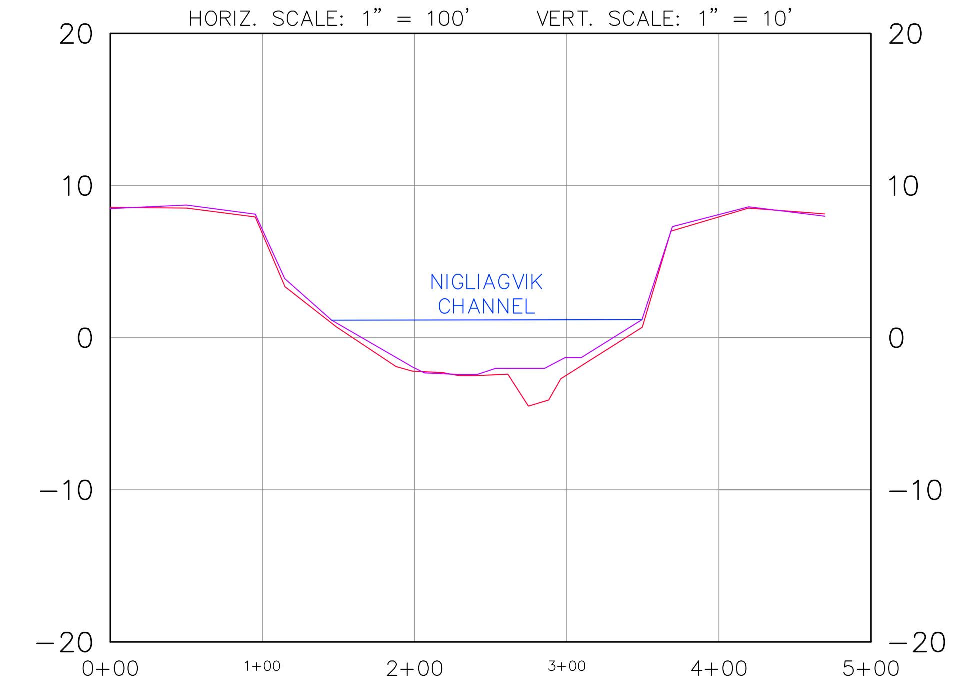
Profile View of Transect-17
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



Profile View of Transect-18
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



Profile View of Transect-19
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE: 907-670-4739
FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

ECM NO: K160003ACS
CC NO: –
CADD FILE NO. 13-08-07-1 –
SCALE: VARIES
DATE: 7/01/2016

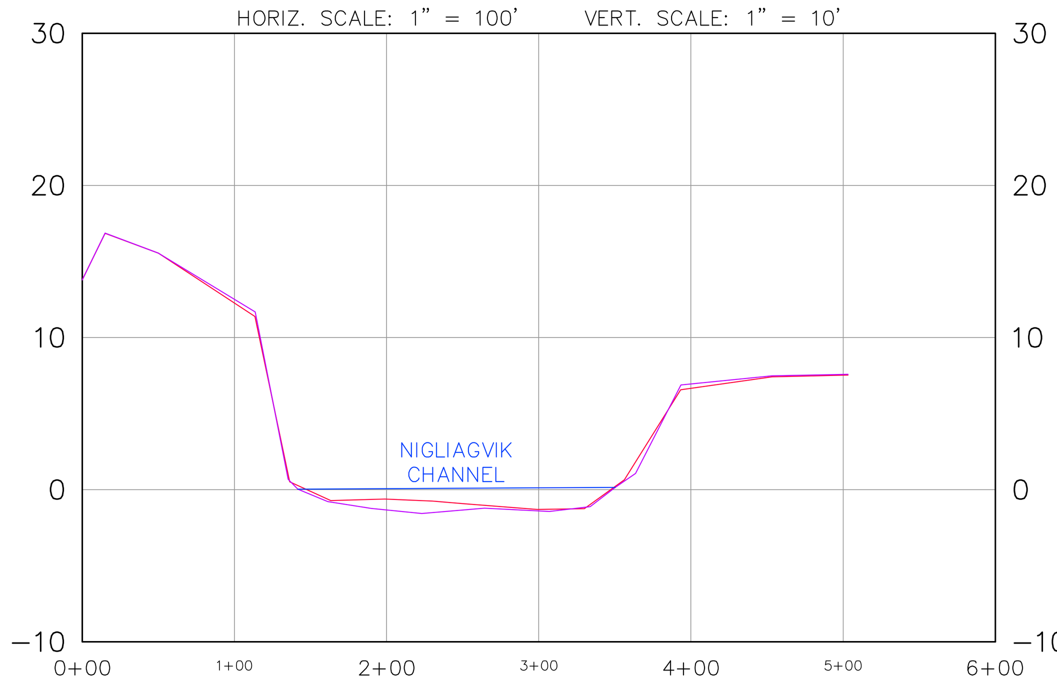
ConocoPhillips Alaska, Inc.

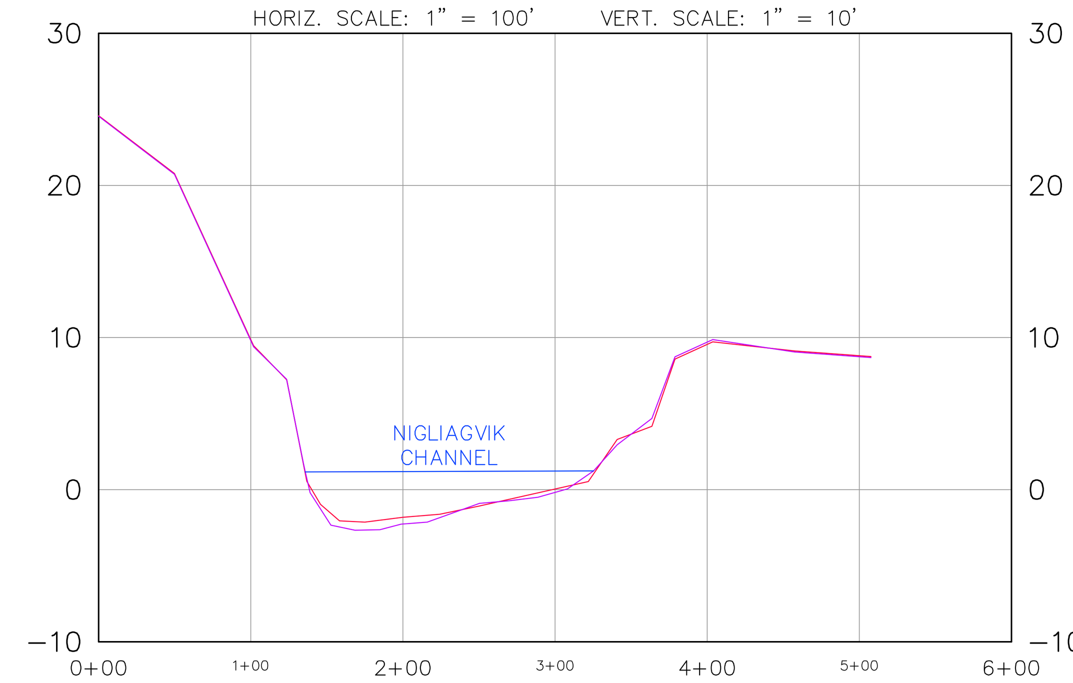
DRAWN: CZ
DESIGN: –
CHECKED: DB
REDRAWN FROM: –
APPROVAL: –

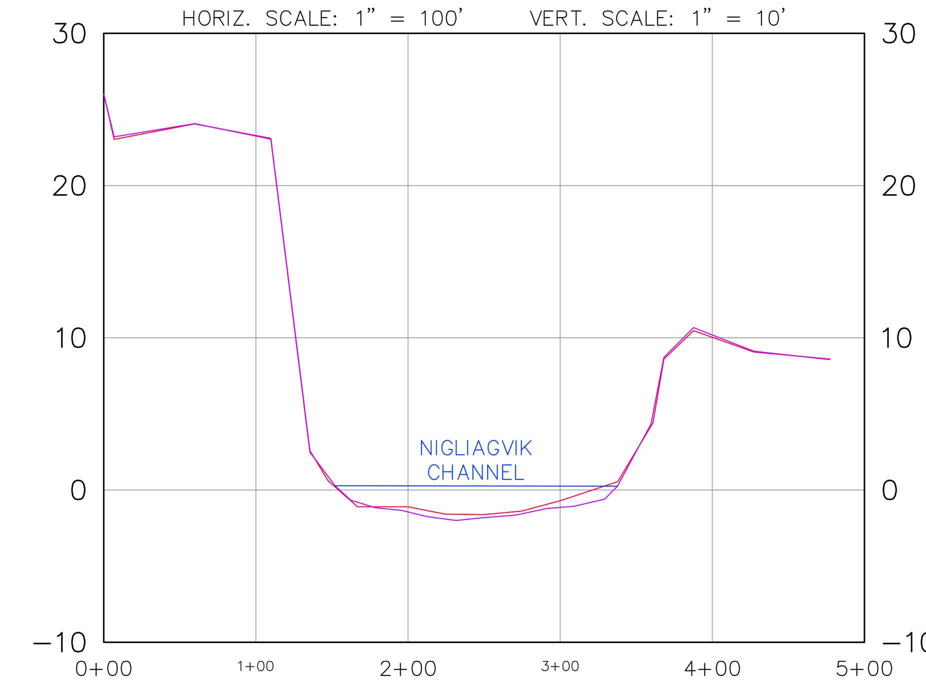
ALPINE
MODULE: CD50
UNIT: CD
CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

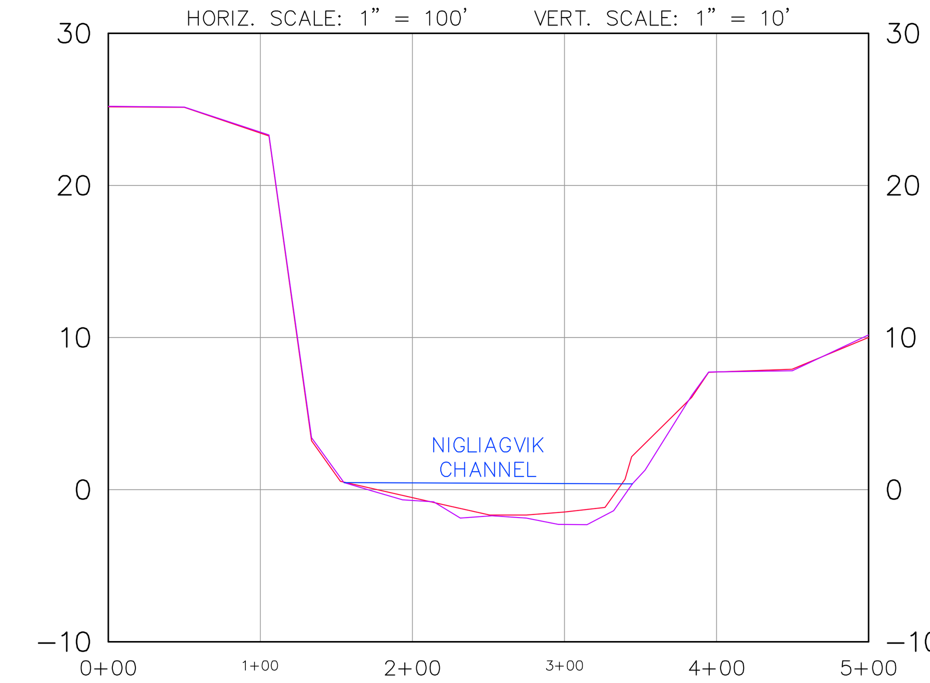
JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	4 of 6	1

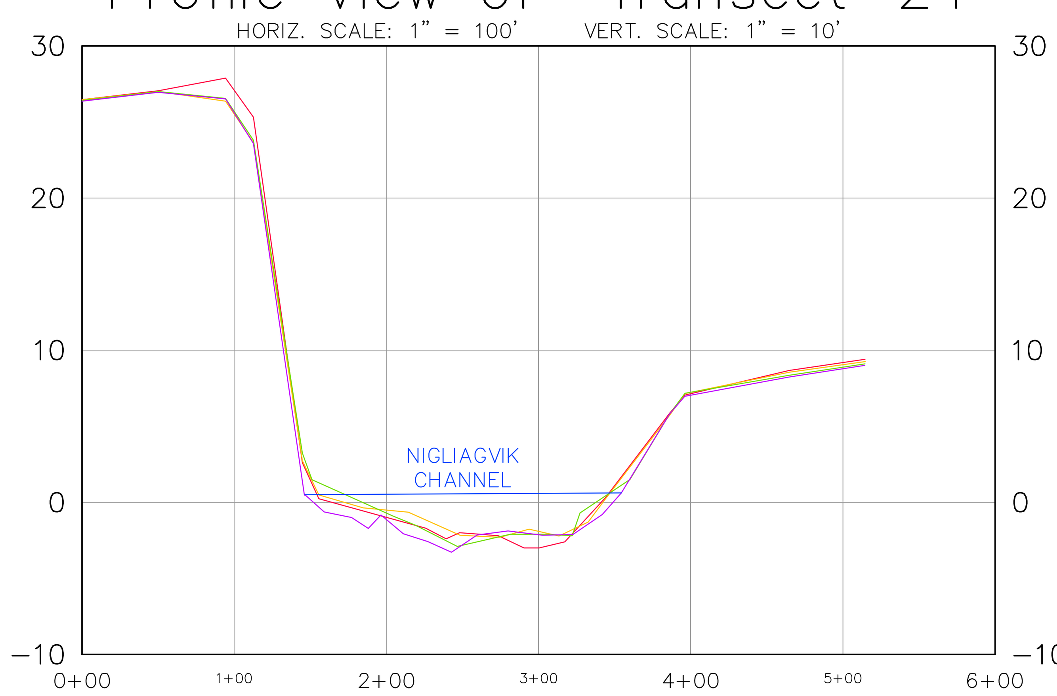
DRAWING NO:	SUB JOB NO:	JOB NO:
CE-CD50-1004	–	–

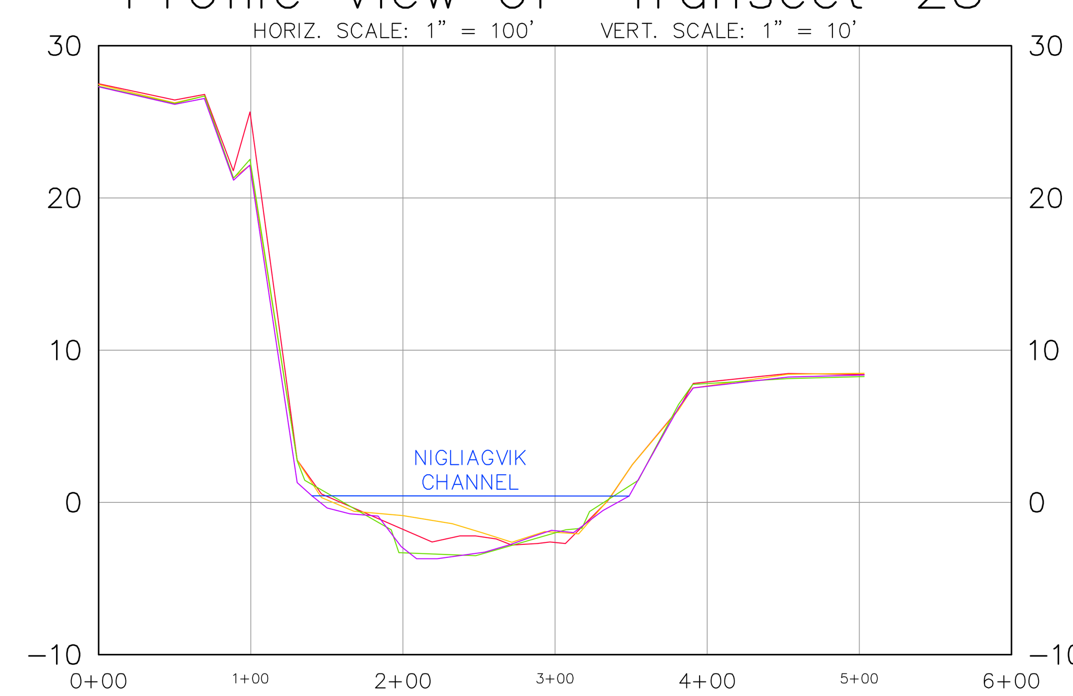
Profile View of Transect-20


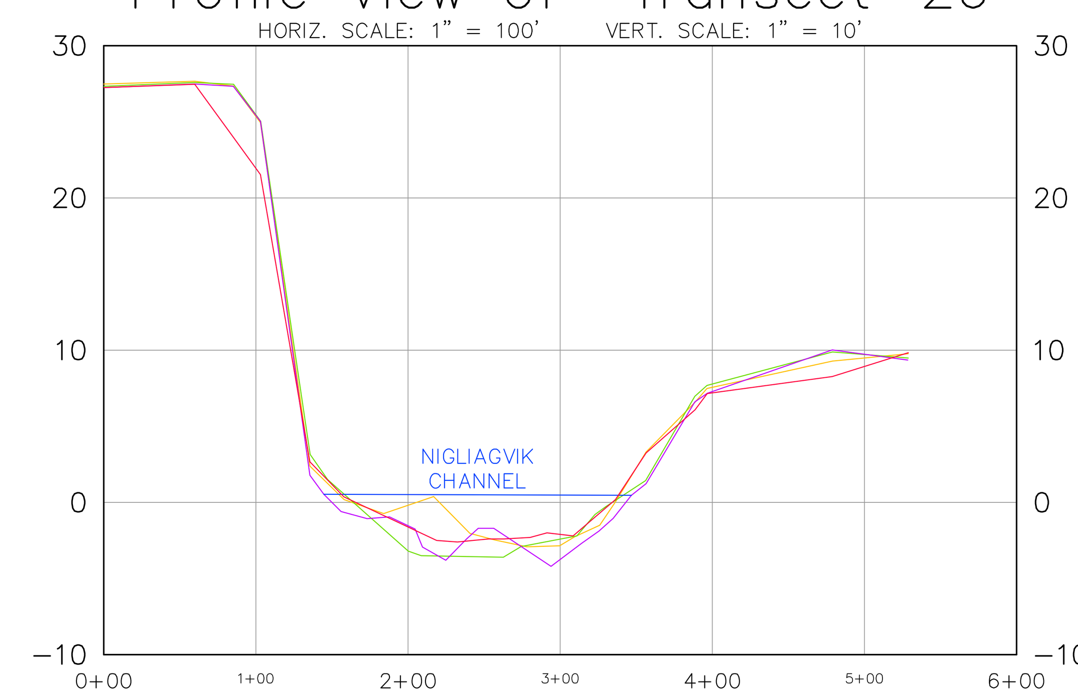
Profile View of Transect-21


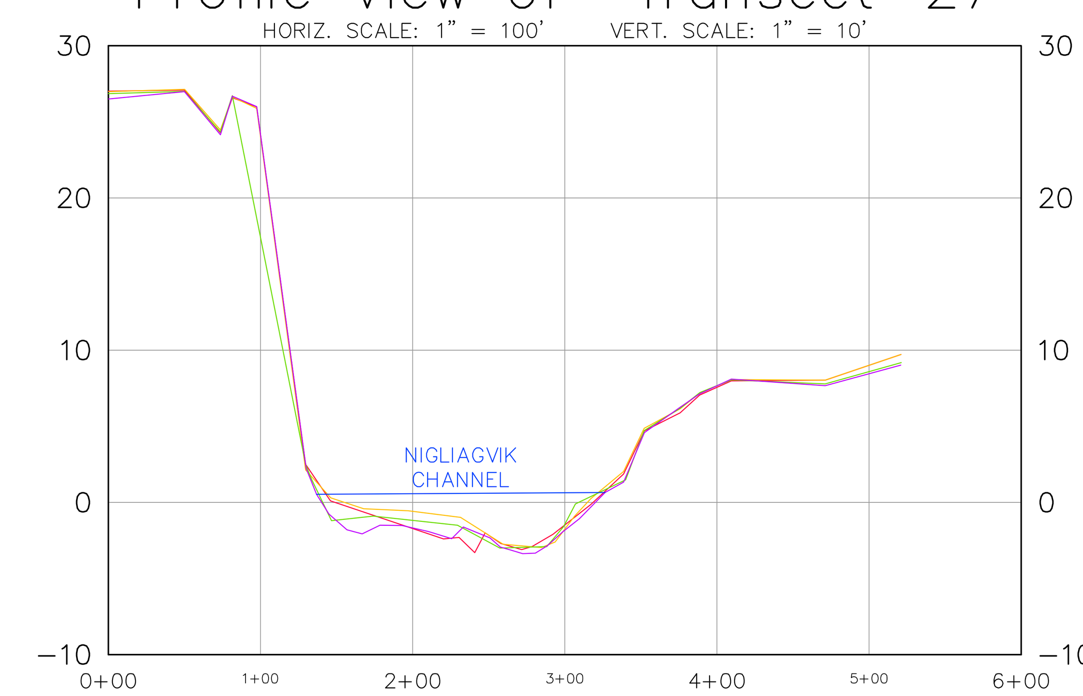
Profile View of Transect-22


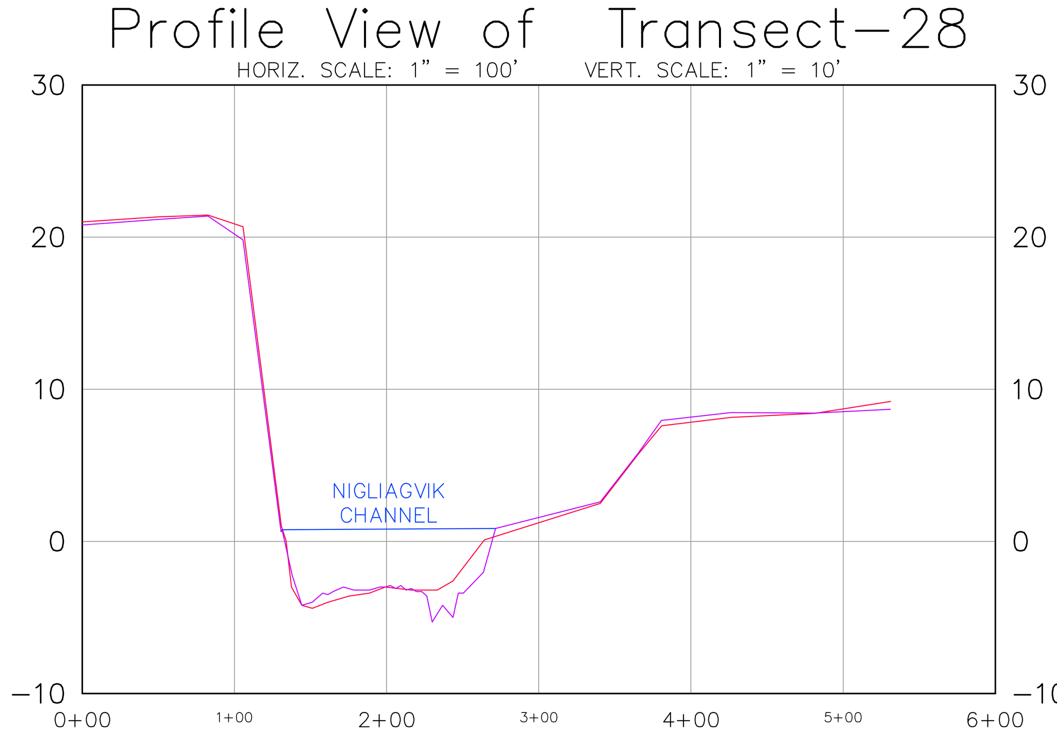
Profile View of Transect-23


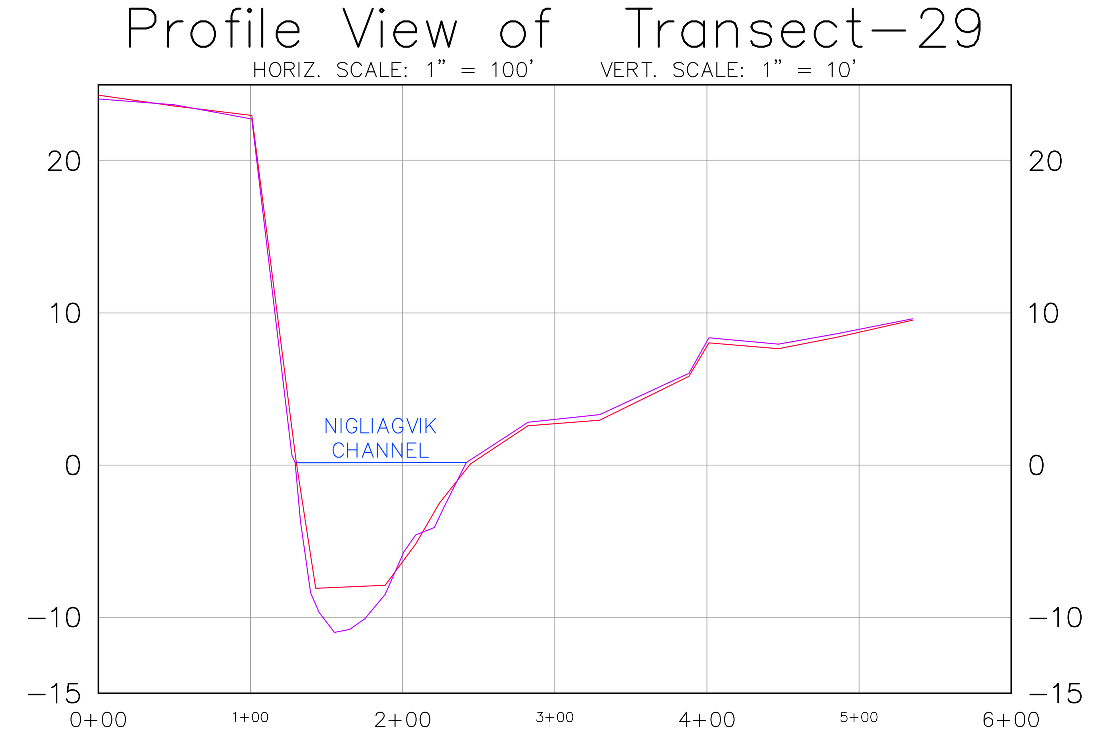
Profile View of Transect-24


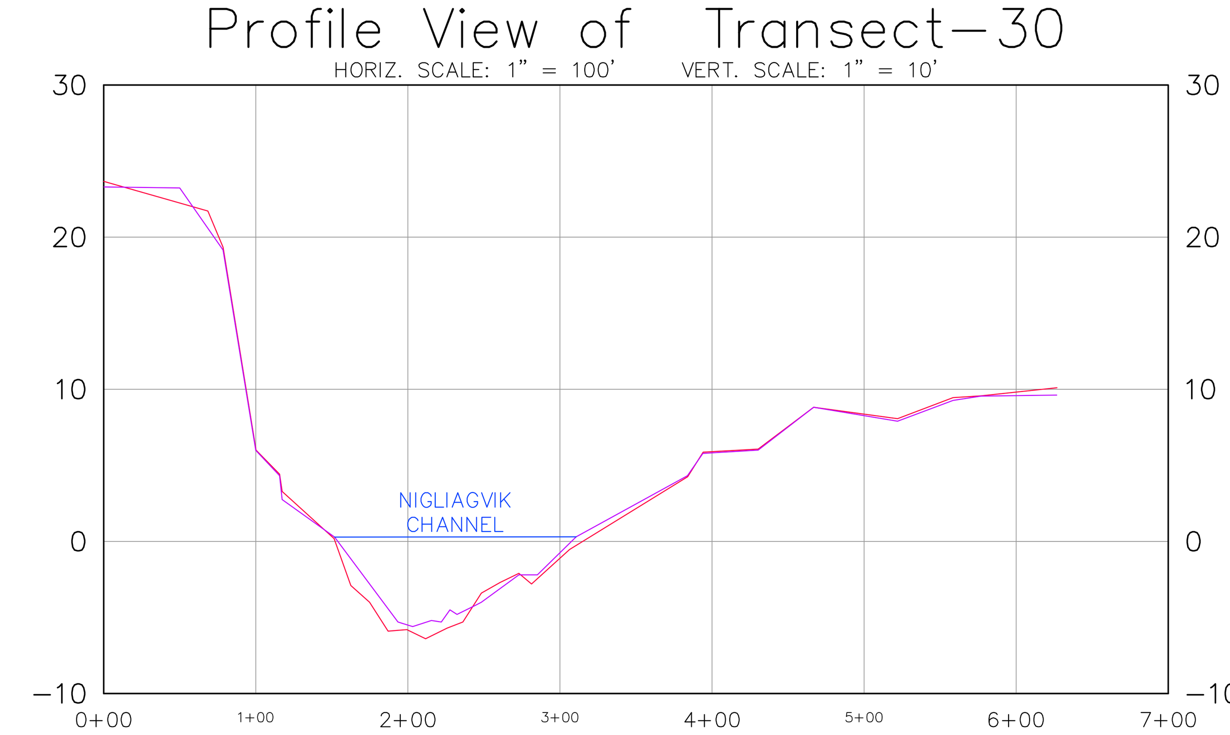
Profile View of Transect-25


Profile View of Transect-26


Profile View of Transect-27


Profile View of Transect-28


Profile View of Transect-29


Profile View of Transect-30


LEGEND:
VIEW LOOKING DOWNSTREAM

- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE: 907-670-4739

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

ECM NO: K160003ACS
CC NO: –
CADD FILE NO: 13-08-07-1 –
SCALE: 1" = 200'
DATE: 7/01/2016

ConocoPhillips Alaska, Inc.

DRAWN: CZ | DESIGN: – | CHECKED: DB
REDRAWN FROM: – | APPROVAL: –

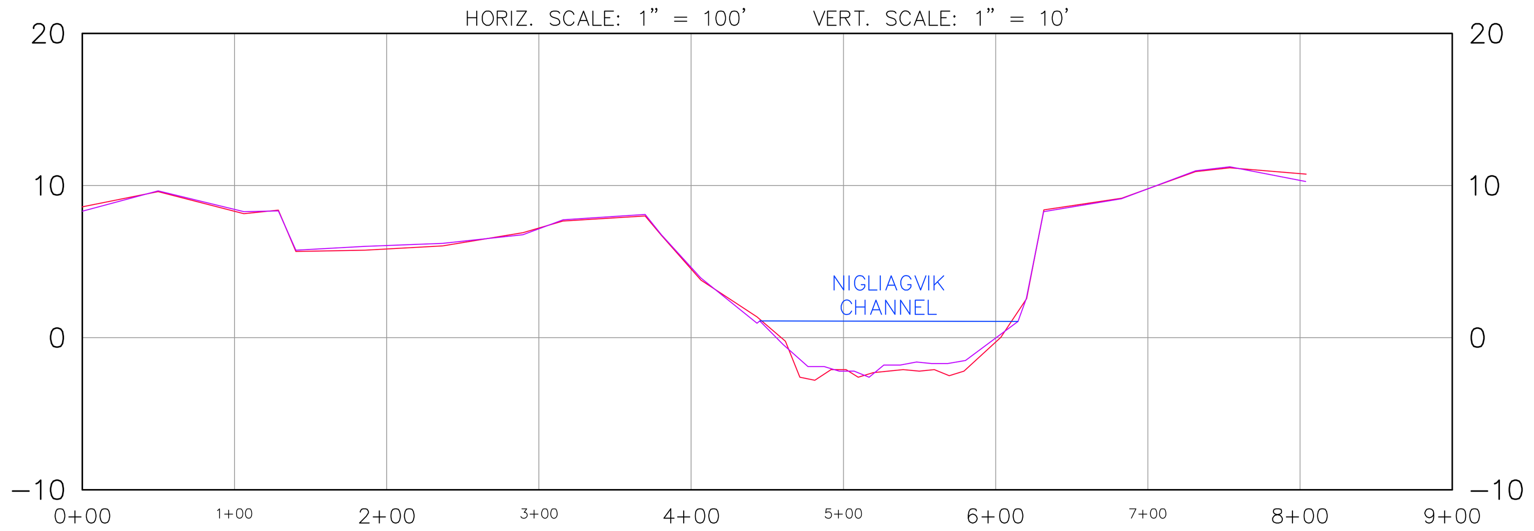
ALPINE | MODULE: CD50 | UNIT: CD

CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

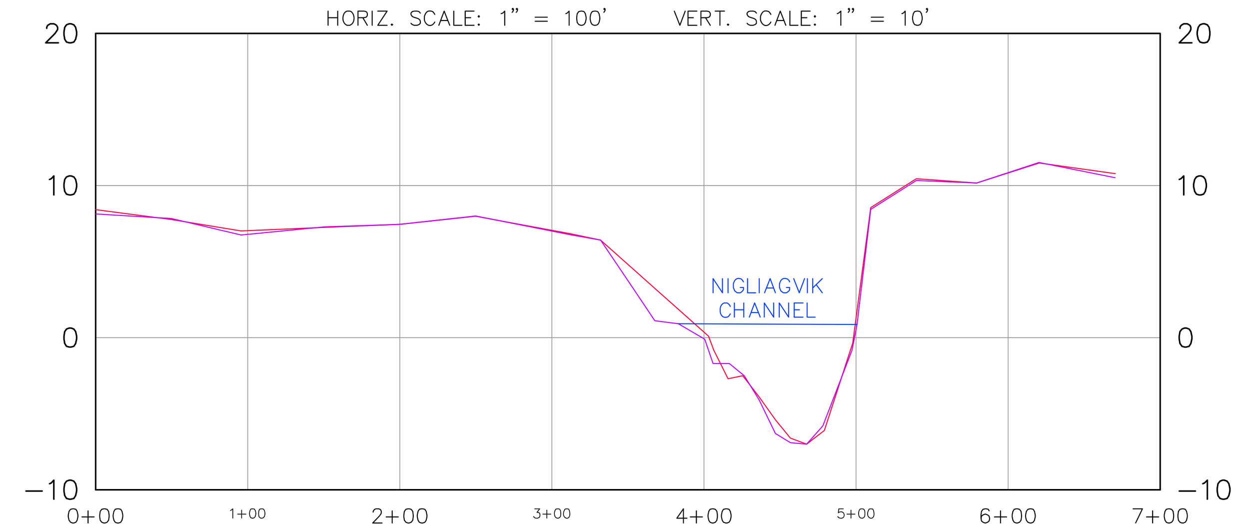
JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	5 of 6	1

JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE-CD50-1004

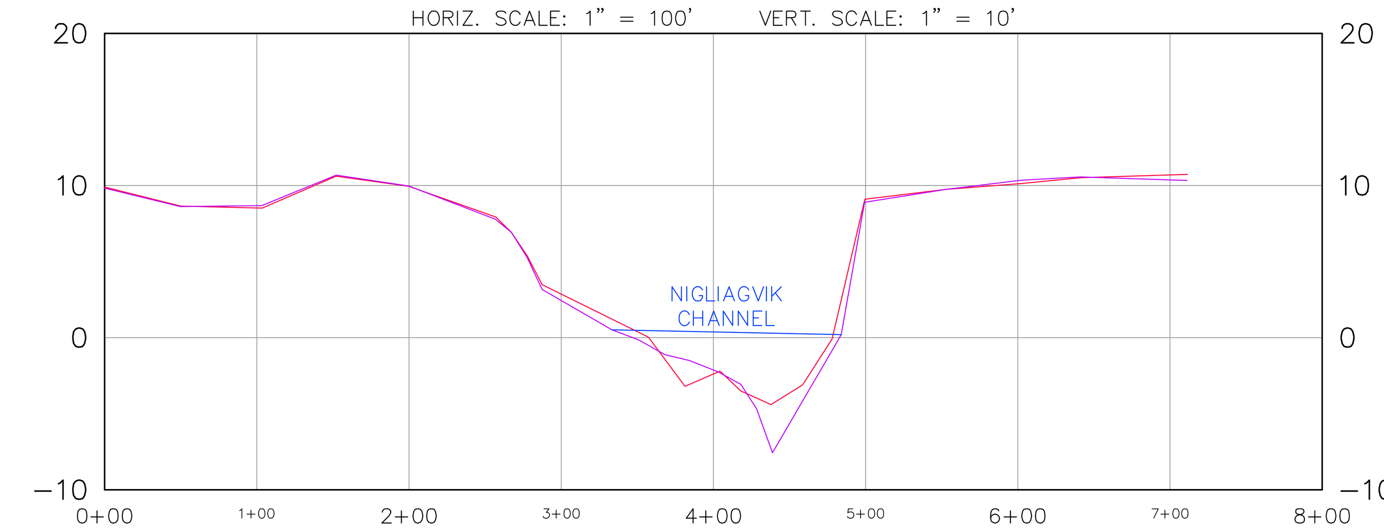
Profile View of Transect-31
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



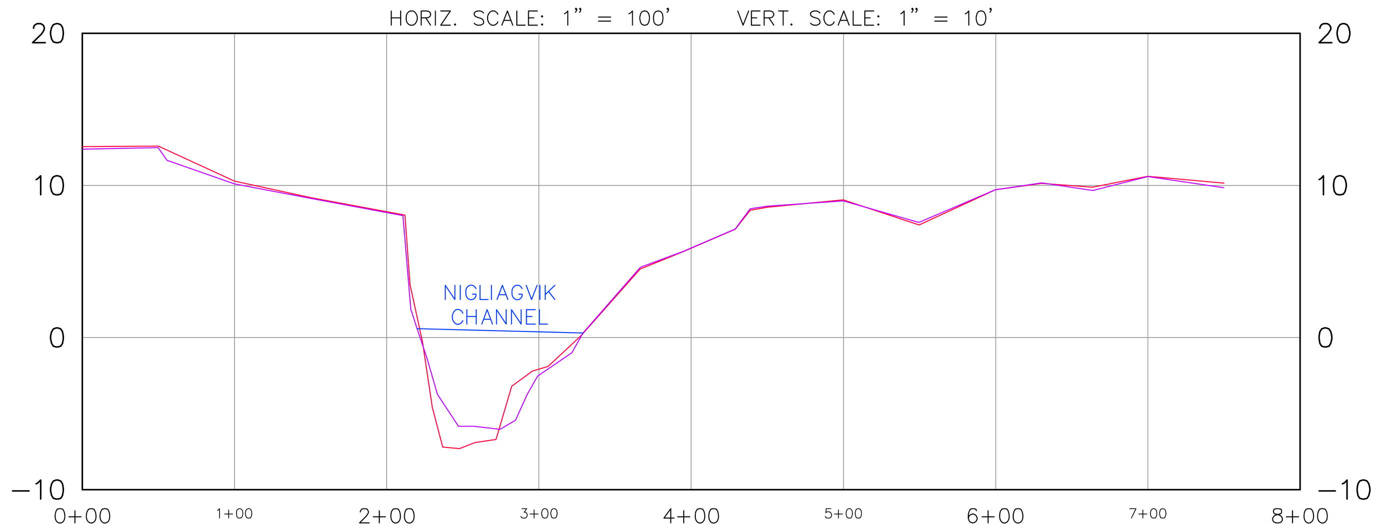
Profile View of Transect-32
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



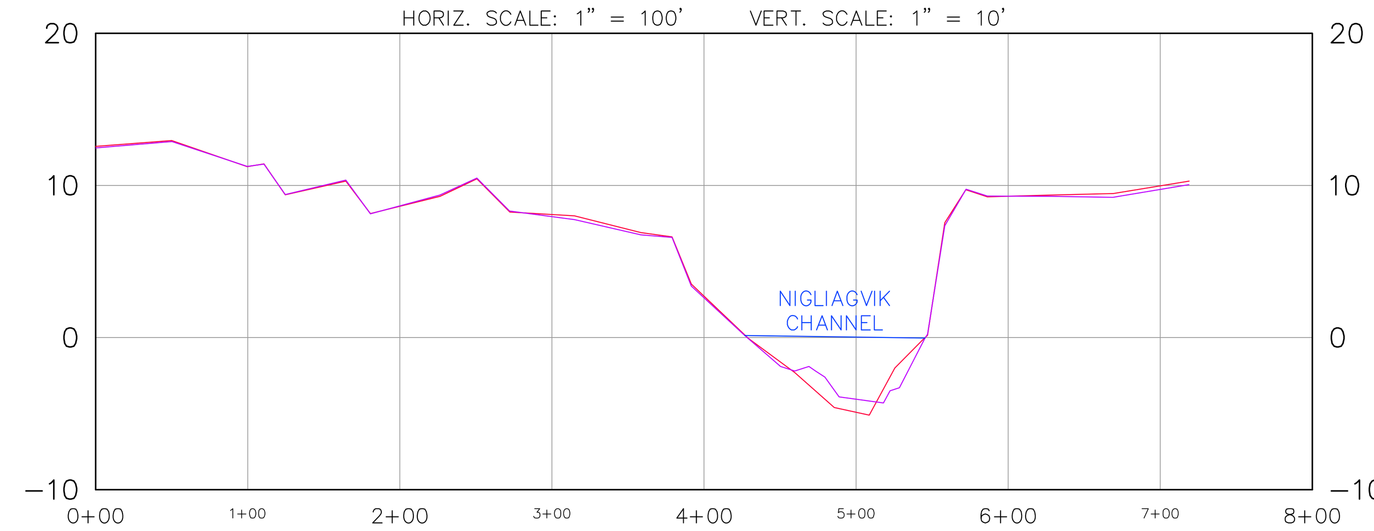
Profile View of Transect-33
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



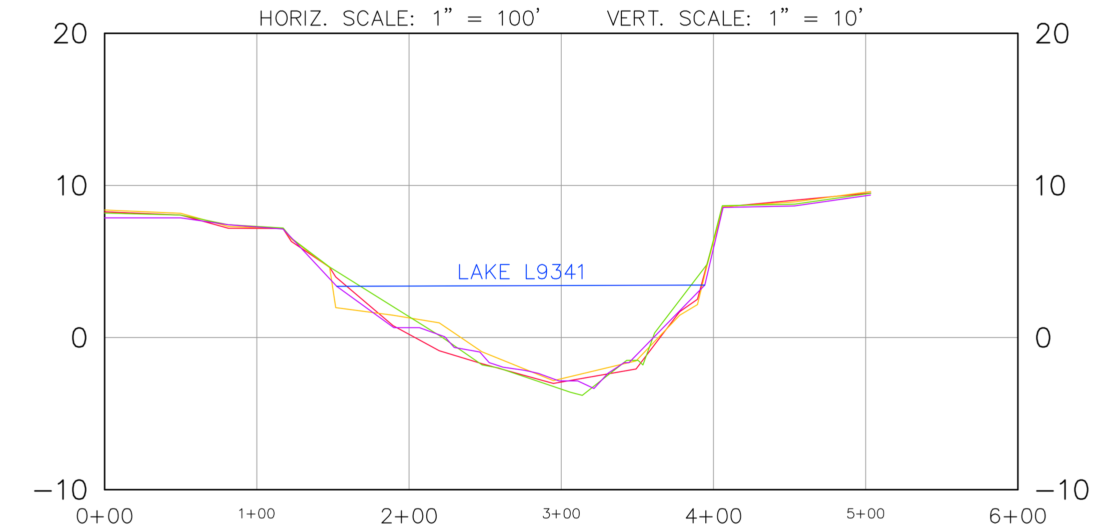
Profile View of Transect-34
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



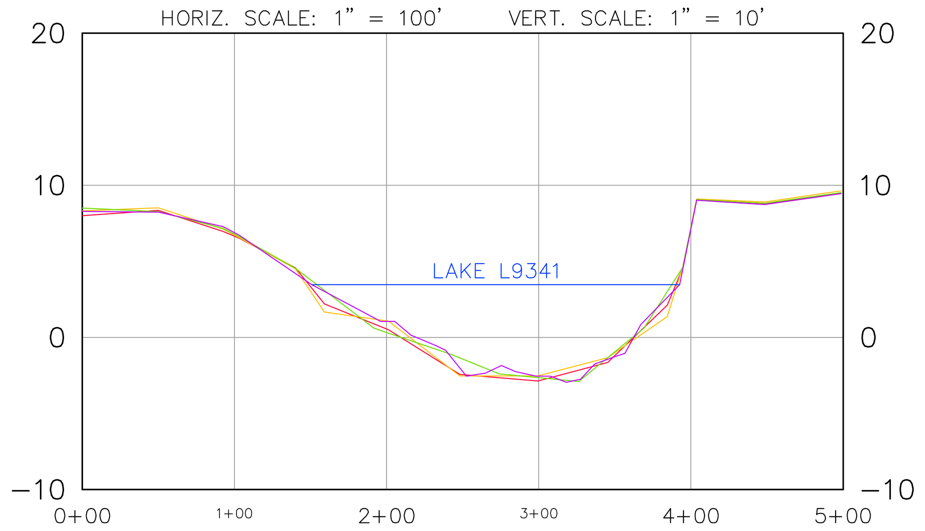
Profile View of Transect-35
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



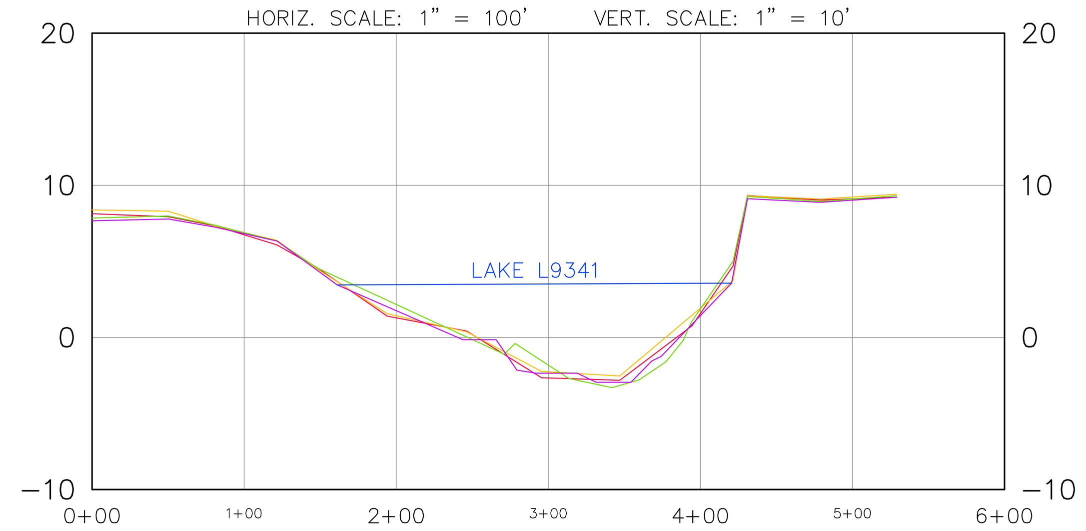
Profile View of Transect-36
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



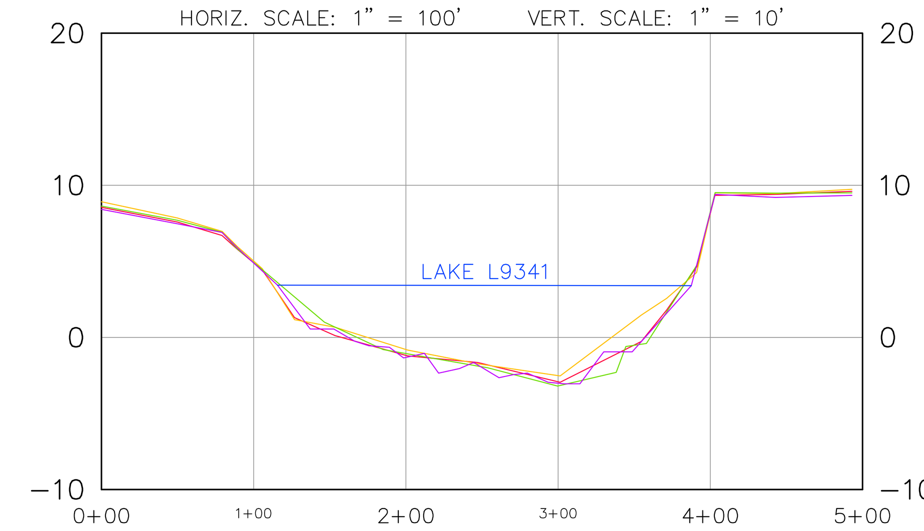
Profile View of Transect-37
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



Profile View of Transect-38
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



Profile View of Transect-39
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



LEGEND:
VIEW LOOKING DOWNSTREAM
- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
PHONE : 907-670-4739

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

ECM NO: K160003ACS
CC NO: –
CADD FILE NO. 13-08-07-1 –
SCALE: 1" = 200'
DATE: 7/01/2016

ConocoPhillips Alaska, Inc.

DRAWN: CZ
DESIGN: –
CHECKED: DB
REDRAWN FROM: –
APPROVAL: –

ALPINE MODULE: CD50 UNIT: CD

CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

JOB NO:	SUB JOB NO:	DRAWING NO.	PART:	REV:
–	–	CE-CD50-1004	6 of 6	1

G.3.2 NIGLIQ CHANNEL TABULATED DATA (TRANSECTS 1 – 15)

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	8.4	8.2	Ground Shot
1+00	8.4	8.5	Ground Shot
2+00	8.1	7.3	Ground Shot
2+05	7.5	1.9	Top of Bank
2+18	0.0	0.3	Toe of Bank/Edge of Water
2+24	-5.5	-6.4	River Bottom
2+73	-24.2	-27.9	River Bottom
3+22	-25.0	-23.2	River Bottom
3+71	-21.3	-22.1	River Bottom
4+27	-19.0	-23.7	River Bottom
4+82	-15.5	-14.2	River Bottom
5+31	-10.0	-13.1	River Bottom
5+70	-3.7	-6.8	River Bottom
5+96	0.1	0.3	Edge of Water
7+00	4.2	4.6	Sand Bar
8+00	5.6	5.0	Sand Bar
9+00	6.4	7.0	Sand Bar
10+00	6.8	7.2	Sand Bar
11+00	7.2	7.5	Sand Bar
12+00	6.7	7.1	Sand Bar
13+00	5.9	5.9	Sand Bar
14+00	2.7	2.3	Sand Bar
15+00	2.7	2.9	Sand Bar
16+00	2.4	2.2	Sand Bar
17+00	1.5	1.0	Sand Bar
18+00	0.6	0.1	Sand Bar
18+67	0.3	-0.5	Edge of Water
20+98	-2.9	-2.1	River Bottom
21+53	-2.6	-2.6	River Bottom
21+96	-2.8	-2.3	River Bottom
22+55	-2.8	-2.0	River Bottom
23+00	-2.6	-2.0	River Bottom
23+59	-2.6	-2.1	River Bottom
24+05	-3.4	-1.3	River Bottom
24+38	0.3	0.3	Edge of Water
24+50	7.3	7.3	Top of Bank
25+50	8.9	9.2	Ground Shot
26+51	9.1	9.3	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_01

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	8.9	8.5	Ground Shot
1+00	8.7	8.6	Ground Shot
1+95	7.2	6.9	Top of Bank
2+06	0.7	-2.7	Edge of Water
2+12	-2.8	-2.7	River Bottom
2+35	-3.4	-3.1	River Bottom
2+58	-4.3	-4.7	River Bottom
2+81	-5.4	-6.1	River Bottom
3+10	-7.6	-8.4	River Bottom
3+27	-8.1	-13.2	River Bottom
3+47	-11.1	-25.2	River Bottom
3+67	-21.7	-18.5	River Bottom
3+87	-17.6	-16.7	River Bottom
4+07	-14.3	-15.1	River Bottom
4+27	-13.5	-13.3	River Bottom
4+46	-12.2	-11.4	River Bottom
4+78	-10.7	-10.7	River Bottom
4+98	-9.7	-9.7	River Bottom
5+18	-9.3	-8.5	River Bottom
5+35	-8.7	-8.0	River Bottom
5+55	-8.1	-7.6	River Bottom
5+81	-7.6	-7.4	River Bottom
6+01	-7.1	-6.8	River Bottom
6+24	-6.3	-6.1	River Bottom
6+44	-5.9	-5.5	River Bottom
6+64	-5.5	-5.0	River Bottom
6+83	-4.7	-4.4	River Bottom
7+03	-4.9	-3.7	River Bottom
7+23	-4.0	-3.9	River Bottom
7+55	-3.4	-3.5	River Bottom
7+75	-2.7	-2.4	River Bottom
7+92	-2.5	-2.1	River Bottom
8+09	-2.2	-1.8	River Bottom
8+38	-1.9	-1.3	River Bottom
8+55	-2.1	-1.0	River Bottom
8+95	0.8	0.2	Edge of Water
10+00	1.8	1.3	Sand Bar
11+00	1.9	1.6	Sand Bar
12+00	2.0	2.6	Sand Bar
13+00	2.2	2.8	Sand Bar
14+00	2.0	2.8	Sand Bar
15+00	2.1	2.6	Sand Bar
16+00	1.9	2.3	Sand Bar
17+00	1.6	2.1	Sand Bar
18+00	1.3	0.1	Sand Bar
19+00	0.8	0.9	Sand Bar
19+81	0.8	0.3	Edge of Water
20+84	-2.4	-1.6	River Bottom
21+07	-2.5	-2.0	River Bottom
21+36	-2.1	-2.6	River Bottom
21+53	-2.5	-2.9	River Bottom
21+72	-2.9	-3.4	River Bottom
21+85	-2.9	-3.3	River Bottom

Analysis of Changes to Bathymetry.xlsx 1 of 2 Transect_02

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
22+01	-4.1	-3.0	River Bottom
22+21	-4.7	-4.0	River Bottom
22+38	-5.6	-4.6	River Bottom
22+55	-6.2	-4.6	River Bottom
22+75	-4.6	-5.5	River Bottom
23+11	0.7	0.0	Edge of Water
23+16	1.8	0.8	Toe of Bank
23+24	7.8	7.8	Top of Bank
23+50	8.6	8.7	Ground Shot
24+50	9.0	9.1	Ground Shot
25+40	9.3	9.4	Ground Shot

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	10.0	9.5	Ground Shot
1+00	10.8	10.7	Ground Shot
2+00	11.4	11.3	Ground Shot
2+17	11.1	11.0	Top of Bank
2+47	6.4	6.3	Toe of Bank
3+00	6.4	6.5	Ground Shot
4+00	7.6	7.7	Ground Shot
5+00	6.8	7.0	Ground Shot
5+25	6.1	6.0	Top of Bank
5+74	1.7	2.0	Toe of Bank
6+00	1.5	1.9	Sand Bar
7+00	3.2	3.9	Sand Bar
8+00	4.8	4.6	Sand Bar
9+00	5.6	5.8	Sand Bar
9+27	5.7	5.1	Top of Bank
9+40	2.0	4.2	Toe of Bank
10+41	0.2	0.8	Edge of Water
10+85	-2.2	-1.0	River Bottom
10+95	-2.2	-1.3	River Bottom
11+07	-2.3	-1.6	River Bottom
11+17	-3.1	-1.9	River Bottom
11+31	-3.8	-2.3	River Bottom
11+44	-4.3	-3.9	River Bottom
11+60	-5.0	-4.9	River Bottom
11+85	-6.1	-5.6	River Bottom
12+07	-6.8	-6.7	River Bottom
12+23	-7.3	-7.0	River Bottom
12+48	-7.4	-6.8	River Bottom
12+72	-7.4	-6.7	River Bottom
12+89	-7.4	-6.4	River Bottom
13+15	-7.4	-6.3	River Bottom
13+40	-7.3	-6.3	River Bottom
13+64	-7.5	-6.3	River Bottom
13+81	-7.4	-6.8	River Bottom
14+07	-7.3	-6.7	River Bottom
14+32	-6.9	-6.3	River Bottom
14+48	-6.6	-7.0	River Bottom
14+75	-7.9	-5.6	River Bottom
14+99	-8.2	-6.0	River Bottom
15+16	-8.2	-5.9	River Bottom
15+42	-8.3	-7.2	River Bottom
15+61	-8.0	-7.3	River Bottom
15+86	-8.5	-7.0	River Bottom
16+02	-8.6	-7.3	River Bottom
16+27	-8.5	-7.6	River Bottom
16+51	-8.9	-7.3	River Bottom
16+75	-8.3	-7.9	River Bottom
16+98	-8.6	-8.2	River Bottom
17+14	-8.2	-8.8	River Bottom
17+39	-7.7	-8.7	River Bottom
17+63	-7.5	-8.7	River Bottom
17+85	-7.6	-9.5	River Bottom
18+02	-7.1	-10.0	River Bottom

Analysis of Changes to Bathymetry.xlsx 1 of 2 Transect_03

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
18+28	-7.7	-9.8	River Bottom
18+53	-7.4	-8.8	River Bottom
18+69	-7.7	-8.3	River Bottom
18+96	-8.0	-7.6	River Bottom
19+12	-6.9	-7.0	River Bottom
19+37	-6.6	-5.7	River Bottom
19+53	-7.0	-6.1	River Bottom
19+80	-7.1	-6.0	River Bottom
20+04	-7.0	-5.8	River Bottom
20+19	-7.4	-5.6	River Bottom
20+43	-7.6	-7.0	River Bottom
20+60	-6.0	-6.9	River Bottom
20+82	-5.6	-6.0	River Bottom
21+04	-5.2	-5.4	River Bottom
21+19	-4.9	-5.4	River Bottom
21+31	-3.8	-4.8	River Bottom
21+50	-2.2	-1.9	River Bottom
22+00	-0.4	-0.2	Edge fo Water
22+21	0.4	1.0	Toe of Bank
22+32	8.2	9.0	Top of Bank
23+00	8.2	8.7	Ground Shot
23+22	9.2	10.0	Top of Bank
23+36	8.1	8.5	Toe of Bank
23+76	7.9	8.9	Toe of Bank
23+91	10.0	10.0	Grade Break
24+15	10.7	11.5	Top of Bank
24+22	8.9	9.4	Toe of Bank

Analysis of Changes to Bathymetry.xlsx 2 of 2 Transect_03

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	12.2	12.6	Ground Shot
1+00	12.8	13.0	Ground Shot
2+00	14.2	14.4	Ground Shot
3+00	16.1	16.2	Ground Shot
3+91	14.7	15.2	Top of Bank
4+24	11.5	11.6	Toe of Bank
5+00	12.1	12.1	Ground Shot
5+12	12.4	12.4	Top of Bank
5+49	8.6	8.7	Toe of Bank
5+74	8.3	8.4	Toe of Bank
5+83	10.7	10.9	Top of Bank
5+91	10.7	11.0	Top of Bank
6+04	8.2	8.6	Toe of Bank
6+47	7.5	8.0	Toe of Bank
6+59	9.7	9.2	Top of Bank
7+05	8.0	7.9	Top of Bank
7+31	5.3	5.9	Toe of Bank
8+00	4.9	5.3	Sand Bar
9+00	4.2	4.9	Sand Bar
10+00	4.7	3.3	Sand Bar
11+00	4.5	3.8	Sand Bar
12+00	3.9	4.5	Sand Bar
13+00	3.0	3.3	Sand Bar
14+00	2.8	2.2	Sand Bar
15+00	3.1	3.0	Sand Bar
16+00	3.2	2.3	Sand Bar
16+62	-0.1	-0.1	Edge of Water
16+70	-3.1	-0.7	River Bottom
16+84	-6.0	-1.7	River Bottom
17+01	-8.6	-4.0	River Bottom
17+18	-12.4	-5.8	River Bottom
17+42	-15.3	-11.4	River Bottom
17+63	-16.5	-14.5	River Bottom
17+80	-15.7	-15.7	River Bottom
18+00	-16.4	-15.5	River Bottom
18+21	-17.6	-16.3	River Bottom
18+36	-19.2	-17.4	River Bottom
18+55	-19.3	-18.9	River Bottom
18+79	-19.9	-19.7	River Bottom
18+96	-20.3	-20.1	River Bottom
19+13	-19.4	-20.8	River Bottom
19+37	-20.2	-21.2	River Bottom
19+54	-21.1	-22.1	River Bottom
19+75	-21.3	-22.6	River Bottom
19+92	-20.9	-22.9	River Bottom
20+12	-20.4	-22.4	River Bottom
20+29	-20.2	-21.9	River Bottom
20+48	-19.9	-21.8	River Bottom
20+65	-19.7	-20.8	River Bottom
20+84	-18.6	-19.3	River Bottom
21+06	-15.1	-18.1	River Bottom
21+15	-10.4	-15.9	River Bottom
21+47	-0.2	-11.7	Edge of Water

Analysis of Changes to Bathymetry.xlsx 1 of 2 Transect_04

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
21+91	2.1	1.5	Toe of Bank
21+98	10.1	9.3	Top of Bank
23+00	10.7	10.8	Ground Shot
24+03	10.4	10.3	

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	11.9	11.9	Ground Shot
1+00	12.0	12.1	Ground Shot
2+00	15.5	15.5	Ground Shot
3+00	16.1	16.0	Ground Shot
4+00	15.4	15.4	Ground Shot
4+56	17.2	17.1	Top of Bank
4+65	14.2	14.2	Toe of Bank
4+81	14.3	14.1	Toe of Bank
5+01	18.9	18.6	Top of Bank
5+08	18.5	18.2	Top of Bank
5+36	13.6	13.4	Toe of Bank
5+82	15.9	15.7	Top of Bank
6+16	12.6	12.5	Toe of Bank
6+92	13.0	12.9	Top of Bank
7+20	7.8	7.8	Toe of Bank
8+00	5.9	6.3	Sand Bar
9+00	5.6	5.7	Sand Bar
10+00	6.1	5.6	Sand Bar
11+00	5.7	5.3	Sand Bar
12+00	4.4	3.7	Sand Bar
13+00	3.0	3.1	Sand Bar
14+00	2.5	2.3	Sand Bar
15+00	2.4	1.1	Sand Bar
16+00	1.9	1.4	Sand Bar
17+00	2.0	2.1	Sand Bar
18+00	1.6	2.3	Sand Bar
19+00	1.0	1.6	Sand Bar
20+00	1.2	0.5	Sand Bar
21+00	0.6	0.8	Sand Bar
21+51	-0.5	-3.0	Edge of Water
21+62	-6.1	-3.5	River Bottom
21+79	-8.2	-4.4	River Bottom
21+96	-8.4	-6.8	River Bottom
22+17	-9.5	-8.3	River Bottom
22+36	-11.3	-9.7	River Bottom
22+53	-12.1	-11.0	River Bottom
22+73	-15.1	-14.3	River Bottom
22+93	-16.8	-16.0	River Bottom
23+13	-19.1	-17.5	River Bottom
23+30	-21.4	-18.9	River Bottom
23+49	-22.4	-20.2	River Bottom
23+73	-22.5	-21.1	River Bottom
23+93	-22.2	-23.4	River Bottom
24+10	-22.4	-24.0	River Bottom
24+29	-22.2	-23.7	River Bottom
24+53	-23.4	-23.2	River Bottom
24+70	-23.3	-24.3	River Bottom
24+87	-20.5	-24.5	River Bottom
25+04	-21.6	-24.0	River Bottom
25+18	-20.5	-24.1	River Bottom
25+30	-16.9	-23.6	River Bottom
25+47	-8.2	-21.3	River Bottom
25+74	-0.5	-16.5	Edge of Water/Toe of Bank

Analysis of Changes to Bathymetry.xlsx 1 of 2 Transect_05

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
25+87	8.5	8.6	Top of Bank
27+00	8.6	8.5	Ground Shot
27+70	8.7	8.7	Ground Shot

Analysis of Changes to Bathymetry.xlsx 2 of 2 Transect_05

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	11.4	11.6	Ground Shot
1+00	11.0	11.1	Ground Shot
2+00	14.0	13.9	Ground Shot
3+00	15.3	15.2	Ground Shot
3+42	17.1	16.9	Top of Bank
3+59	12.5	12.3	Toe of Bank
4+08	14.8	14.6	Top of Bank
4+23	11.1	11.1	Toe of Bank
4+96	12.3	12.2	Top of Bank
5+11	9.8	9.8	Toe of Bank
5+81	7.8	7.7	Top of Bank
6+31	1.1	0.4	Toe of Bank
7+00	-0.3	-0.5	Sand Bar
8+00	0.5	0.0	Sand Bar
9+00	1.0	0.0	Sand Bar
10+00	1.4	0.3	Sand Bar
11+00	1.8	1.0	Sand Bar
12+00	2.3	1.1	Sand Bar
13+00	2.0	0.5	Sand Bar
14+24	-0.2	-1.0	Edge of Water
14+68	-3.3	-1.5	River Bottom
14+78	-3.1	-1.7	River Bottom
14+94	-2.8	-1.9	River Bottom
15+14	-2.4	-2.1	River Bottom
15+34	-2.8	-2.3	River Bottom
15+49	-2.6	-2.5	River Bottom
15+72	-2.9	-2.8	River Bottom
15+95	-3.5	-3.1	River Bottom
16+15	-3.3	-3.5	River Bottom
16+38	-3.8	-3.5	River Bottom
16+61	-4.1	-4.4	River Bottom
16+87	-4.1	-5.4	River Bottom
17+06	-4.8	-5.6	River Bottom
17+29	-5.3	-5.6	River Bottom
17+55	-7.2	-8.0	River Bottom
17+82	-10.0	-10.2	River Bottom
18+08	-13.4	-12.2	River Bottom
18+31	-17.8	-16.2	River Bottom
18+57	-19.9	-17.4	River Bottom
18+80	-20.3	-19.8	River Bottom
19+02	-20.8	-20.4	River Bottom
19+28	-24.5	-23.3	River Bottom
19+51	-24.1	-23.5	River Bottom
19+74	-20.4	-23.1	River Bottom
19+93	-12.5	-16.2	River Bottom
20+10	-8.6	-4.1	River Bottom
20+42	-0.3	-2.2	Edge of Water
20+45	-0.4	0.6	Toe of Bank
20+56	8.8	9.4	Top of Bank
21+50	9.8	10.0	Ground Shot
22+50	9.3	9.5	Ground Shot
23+24	9.8	9.8	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_06

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RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2014	2015	2016	Description
0+00	10.6	10.9	10.7	10.7	Ground Shot
1+00	10.1	10.4	10.4	10.3	Ground Shot
1+50	12.2	12.4	12.4	12.3	Ground Shot
1+77	13.4	13.7	13.7	13.5	Grade Break
2+00	11.3	11.6	11.7	11.6	Ground Shot
2+23	8.1	8.1	8.4	8.3	Top of Bank
2+30	2.8	3.0	3.7	3.3	Toe of Bank
2+47	0.6	0.5	0.8	1.9	Edge of Water
4+93	-2.5	-4.1	-4.2	-4.0	River Bottom
5+06	-2.5	-4.4	-4.6	-4.0	River Bottom
5+25	-2.6	-3.6	-5.0	-4.3	River Bottom
5+45	-2.7	-3.7	-5.3	-4.7	River Bottom
5+68	-3.7	-3.8	-6.6	-5.6	River Bottom
5+91	-4.5	-5.2	-7.0	-7.0	River Bottom
6+17	-5.8	-7.6	-7.3	-7.5	River Bottom
6+42	-7.4	-7.2	-7.7	-7.3	River Bottom
6+65	-7.7	-7.4	-7.7	-7.2	River Bottom
6+88	-7.2	-6.3	-7.7	-6.4	River Bottom
7+11	-6.8	-6.0	-7.6	-6.6	River Bottom
7+37	-5.4	-5.5	-7.6	-6.8	River Bottom
7+56	-5.1	-6.3	-7.6	-7.2	River Bottom
7+82	-4.9	-7.1	-7.6	-7.3	River Bottom
8+02	-4.3	-7.1	-7.6	-6.7	River Bottom
8+25	-3.6	-5.6	-7.6	-7.5	River Bottom
8+50	-4.2	-5.9	-7.5	-7.0	River Bottom
8+74	-5.6	-6.2	-7.5	-7.2	River Bottom
9+03	-5.9	-6.1	-7.4	-7.5	River Bottom
9+32	-7.6	-5.5	-7.2	-7.8	River Bottom
9+58	-7.0	-6.7	-7.0	-7.3	River Bottom
9+84	-9.8	-7.4	-6.9	-8.2	River Bottom
10+10	-9.9	-10.8	-7.4	-7.8	River Bottom
10+39	-9.5	-10.5	-8.0	-8.2	River Bottom
10+68	-8.7	-9.2	-7.8	-7.5	River Bottom
10+91	-8.3	-9.3	-7.6	-7.8	River Bottom
11+21	-8.9	-9.4	-7.4	-7.8	River Bottom
11+50	-9.2	-9.7	-9.4	-7.5	River Bottom
11+76	-9.4	-10.5	-10.3	-7.2	River Bottom
12+02	-11.0	-10.7	-9.9	-8.4	River Bottom
12+31	-11.6	-10.7	-9.5	-8.1	River Bottom
12+57	-10.4	-9.4	-9.1	-7.5	River Bottom
12+83	-9.0	-9.5	-8.8	-7.7	River Bottom
13+09	-8.4	-8.7	-8.0	-7.2	River Bottom
13+35	-7.6	-8.1	-7.6	-6.8	River Bottom
13+64	-6.7	-7.2	-7.2	-6.4	River Bottom
13+87	-6.3	-6.7	-6.5	-6.1	River Bottom
14+17	-5.7	-6.5	-6.3	-5.6	River Bottom
14+40	-5.9	-6.2	-6.2	-5.4	River Bottom
14+69	-6.6	-6.5	-6.3	-5.7	River Bottom
14+98	-7.8	-7.9	-7.8	-6.5	River Bottom
15+24	-10.7	-10.6	-9.2	-7.8	River Bottom
15+53	-13.6	-13.3	-11.8	-10.9	River Bottom
15+79	-14.7	-13.9	-12.6	-12.2	River Bottom
16+02	-11.1	-12.3	-12.3	-12.3	River Bottom

Analysis of Changes to Bathymetry.xlsx   1 of 2   Transect_07

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CD-5 Michael Baker
Bridge Transects

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Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2014	2015	2016	Description
16+84	0.7	0.5	0.2	0.3	Edge of Water
16+95	8.5	8.4	8.4	8.3	Top of Bank
17+00	9.2	9.5	9.4	9.3	Ground Shot
17+57	10.1	10.3	10.0	9.7	Ground Shot
18+00	9.4	9.6	9.6	9.5	Ground Shot
19+00	10.2	10.5	10.6	10.4	Ground Shot
19+07	10.8	10.9	10.7	10.5	Ground Shot

Analysis of Changes to Bathymetry.xlsx 2 of 2 Transect_07

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Bridge Transects

Kuukpik/LCMF
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STA	2013	2014	2015	2016	Description
0+00	10.6	10.8	10.35	10.29	Ground Shot
1+00	10.1	10.2	10.33	10.19	Ground Shot
2+00	9.8	10.0	10.12	10.03	Ground Shot
2+08	8.9	9.0	9.02	9.00	Top of Bank
2+24	0.9	0.2	-0.40	0.22	Edge of Water
2+99	-5.8	-5.5	-7.30	-6.57	River Bottom
3+20	-7.1	-7.7	-8.74	-8.28	River Bottom
3+40	-7.4	-8.8	-9.70	-8.58	River Bottom
3+61	-8.2	-9.6	-10.42	-9.18	River Bottom
3+85	-9.7	-10.5	-11.25	-9.89	River Bottom
4+09	-9.9	-10.8	-12.14	-11.18	River Bottom
4+33	-9.9	-11.3	-13.14	-13.58	River Bottom
4+57	-10.3	-11.9	-14.10	-15.18	River Bottom
4+85	-10.0	-10.9	-14.26	-15.28	River Bottom
5+09	-10.6	-10.4	-15.02	-14.38	River Bottom
5+33	-11.5	-10.3	-15.16	-14.04	River Bottom
5+60	-11.9	-10.7	-14.67	-13.77	River Bottom
5+87	-12.4	-10.3	-14.20	-13.18	River Bottom
6+19	-11.8	-10.8	-14.90	-14.28	River Bottom
6+46	-11.1	-10.8	-15.36	-15.58	River Bottom
6+73	-11.2	-11.6	-15.55	-15.51	River Bottom
7+01	-10.3	-10.6	-15.30	-14.38	River Bottom
7+28	-10.0	-10.3	-13.94	-13.48	River Bottom
7+53	-11.8	-11.0	-12.47	-12.38	River Bottom
7+80	-11.6	-11.0	-11.10	-10.45	River Bottom
8+08	-12.1	-9.5	-9.40	-9.68	River Bottom
8+36	-11.6	-8.2	-9.40	-9.08	River Bottom
8+59	-11.0	-7.8	-8.46	-8.58	River Bottom
8+79	-11.1	-7.1	-7.20	-7.49	River Bottom
9+04	-9.1	-7.9	-6.82	-7.08	River Bottom
9+28	-8.3	-7.7	-6.30	-5.05	River Bottom
9+53	-8.1	-7.2	-6.38	-5.18	River Bottom
9+76	-7.7	-6.6	-6.50	-4.57	River Bottom
9+96	-7.6	-6.7	-6.36	-5.61	River Bottom
10+17	-7.2	-6.2	-6.18	-6.18	River Bottom
10+42	-5.6	-5.6	-6.00	-4.80	River Bottom
10+62	-3.1	-3.9	-3.40	-3.08	River Bottom

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_08

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CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
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STA	2013	2014	2015	2016	Description
0+00	10.6	10.6	10.6	10.6	Ground Shot
1+00	9.9	10.0	10.0	9.9	Ground Shot
1+50	10.5	10.5	10.3	10.1	Ground Shot
1+92	9.6	9.6	9.7	9.6	Top of Bank
2+07	0.6	0.0	0.9	0.7	Edge of Water
2+48	-5.7	-10.5	-7.1	-5.7	River Bottom
2+62	-7.7	-13.4	-13.8	-15.3	River Bottom
2+78	-10.5	-18.8	-18.7	-19.2	River Bottom
2+92	-14.5	-18.8	-21.6	-20.6	River Bottom
3+13	-15.5	-19.2	-23.5	-21.8	River Bottom
3+33	-15.2	-20.1	-24.9	-23.0	River Bottom
3+58	-14.8	-20.7	-21.4	-23.5	River Bottom
3+79	-13.9	-16.2	-19.2	-19.4	River Bottom
4+03	-13.9	-16.2	-21.4	-21.5	River Bottom
4+26	-13.4	-16.9	-22.1	-22.0	River Bottom
4+54	-12.9	-19.9	-22.2	-19.8	River Bottom
4+78	-13.4	-20.5	-22.3	-20.2	River Bottom
5+02	-13.0	-19.3	-22.4	-19.0	River Bottom
5+30	-13.2	-18.4	-21.5	-19.0	River Bottom
5+54	-13.9	-17.9	-20.9	-18.5	River Bottom
5+79	-13.7	-18.3	-21.3	-18.8	River Bottom
6+02	-12.6	-17.8	-19.7	-20.6	River Bottom
6+30	-12.2	-15.4	-17.7	-20.7	River Bottom
6+55	-12.7	-13.3	-16.7	-16.0	River Bottom
6+79	-15.2	-12.4	-16.8	-16.5	River Bottom
7+06	-14.0	-12.7	-17.0	-16.7	River Bottom
7+30	-13.3	-13.2	-16.8	-15.7	River Bottom
7+57	-11.9	-14.8	-17.0	-15.3	River Bottom
7+84	-11.6	-14.6	-17.3	-15.4	River Bottom
8+08	-11.0	-15.8	-16.6	-14.5	River Bottom
8+33	-9.9	-10.3	-15.1	-10.5	River Bottom
8+58	-6.9	-7.9	-6.2	-5.1	River Bottom
8+78	-5.2	-6.4	-4.1	-3.5	River Bottom
8+91	-3.3	-6.1	-2.8	-2.4	River Bottom
9+41	0.5	0.5	1.2	1.2	Edge of Water
10+00	2.3	2.5	4.0	4.1	Sand Bar
11+00	3.9	4.1	4.9	4.9	Sand Bar
11+52	5.0	5.2	5.5	5.6	Edge of Vegetation
12+00	5.4	5.5	6.0	6.0	Ground Shot
13+00	4.2	4.6	5.0	5.0	Ground Shot
14+00	3.9	4.1	4.5	4.5	Ground Shot
14+39	3.7	3.9	4.0	4.0	Edge of Water
14+81	3.4	3.7	3.9	3.8	Edge of Water
14+84	3.8	4.1	4.2	4.0	Toe of Bank
15+00	5.7	5.9	5.7	5.7	Top of Bank
15+52	8.0	8.2	8.0	7.9	Ground Shot
16+00	8.2	8.5	8.1	8.1	Ground Shot
16+92	9.4	9.4	9.3	9.3	Ground Shot

Analysis of Changes to Bathymetry.xlsx　　1 of 1　　Transect_09

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CD-5 Michael Baker
Bridge Transects

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STA	2013	2014	2015	2016	Description
0+00	10.3	10.4	10.3	10.3	Ground Shot
1+00	10.4	10.7	10.3	10.3	Ground Shot
1+50	10.5	10.6	10.4	10.3	Ground Shot
1+90	9.9	9.7	9.5	9.4	Top of Bank
2+00	6.7	7.0	6.5	6.4	Ground Shot
2+12	0.5	-0.8	-0.3	0.7	Edge of Water
2+67	-7.8	-14.3	-20.4	-19.5	River Bottom
2+87	-20.7	-21.4	-21.3	-22.3	River Bottom
3+09	-21.3	-22.5	-23.8	-23.3	River Bottom
3+30	-20.0	-21.2	-23.8	-22.6	River Bottom
3+55	-19.4	-20.3	-23.7	-22.7	River Bottom
3+76	-19.0	-20.7	-23.7	-22.6	River Bottom
4+00	-17.8	-18.6	-20.8	-18.8	River Bottom
4+21	-18.0	-19.2	-21.1	-19.0	River Bottom
4+45	-18.7	-19.2	-21.5	-19.1	River Bottom
4+70	-19.0	-19.9	-21.9	-20.9	River Bottom
4+94	-18.4	-20.6	-22.3	-21.9	River Bottom
5+21	-17.3	-20.4	-23.0	-22.0	River Bottom
5+45	-16.1	-19.2	-23.7	-22.3	River Bottom
5+69	-14.6	-19.1	-23.2	-22.0	River Bottom
5+96	-13.5	-17.7	-22.4	-21.2	River Bottom
6+20	-13.7	-16.8	-21.5	-20.5	River Bottom
6+47	-12.5	-15.3	-19.7	-18.2	River Bottom
6+71	-12.1	-14.7	-17.4	-16.2	River Bottom
6+99	-11.9	-14.2	-15.2	-13.8	River Bottom
7+23	-12.4	-15.4	-14.8	-11.4	River Bottom
7+48	-12.2	-17.6	-14.4	-10.7	River Bottom
7+70	-12.9	-25.5	-14.1	-11.3	River Bottom
7+94	-11.2	-21.7	-14.8	-14.6	River Bottom
8+15	-6.8	-15.9	-10.8	-12.8	River Bottom
8+74	0.4	1.2	2.6	2.4	Edge of Water
9+00	1.6	2.1	3.7	3.8	Sand Bar
10+00	3.6	3.2	4.3	4.3	Sand Bar
11+00	5.4	5.6	5.8	5.9	Edge of Vegetation
12+00	5.1	5.4	5.7	5.7	Ground Shot
13+00	4.8	5.0	5.4	5.4	Ground Shot
14+00	4.6	4.8	5.0	5.1	Ground Shot
14+84	3.7	3.8	3.7	3.7	Toe of Bank
14+96	7.7	7.7	6.8	7.5	Top of Bank
15+00	7.8	8.0	7.9	7.8	Ground Shot
15+38	8.6	8.5	8.4	8.8	Ground Shot
15+53	9.1	9.4	9.4	9.2	Grade Break
15+71	7.2	7.4	7.3	7.2	Grade Break
16+00	6.7	7.0	6.8	6.7	Ground Shot
16+88	7.2	7.4	7.2	7.2	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_10

Calc'd By: TAB
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RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	10.9	10.9	Ground Shot
1+00	10.4	10.7	Ground Shot
1+50	8.7	8.8	Ground Shot
1+79	8.6	-10.0	Top of Bank
1+89	0.6	-22.3	Edge of Water
2+01	-10.6	-28.3	River Bottom
2+16	-19.0	-33.1	River Bottom
2+36	-30.7	-36.7	River Bottom
2+59	-33.6	-36.6	River Bottom
2+82	-35.3	-36.7	River Bottom
3+08	-32.7	-35.9	River Bottom
3+28	-31.4	-34.0	River Bottom
3+54	-30.9	-31.8	River Bottom
3+77	-30.0	-29.7	River Bottom
4+00	-30.0	-25.0	River Bottom
4+23	-27.8	-22.5	River Bottom
4+48	-25.6	-18.3	River Bottom
4+68	-22.7	-16.0	River Bottom
4+94	-20.1	-13.7	River Bottom
5+16	-17.5	-12.3	River Bottom
5+40	-14.9	-11.1	River Bottom
5+62	-13.5	-9.1	River Bottom
5+82	-10.5	-5.6	River Bottom
6+02	-6.1	-3.6	River Bottom
6+50	0.2	0.8	Edge of Water
7+00	2.9	3.4	Sand Bar
7+90	4.9	5.1	Edge of Vegetation
8+00	4.9	5.1	Ground Shot
9+00	5.5	5.6	Ground Shot
10+00	5.1	5.2	Ground Shot
11+00	5.6	5.7	Ground Shot
12+00	5.8	5.9	Ground Shot
13+00	5.5	5.8	Ground Shot
14+00	6.2	6.3	Ground Shot
15+00	6.1	6.2	Ground Shot
16+00	6.3	6.5	Edge of Vegetation
16+52	6.7	6.8	Grade Break
16+62	8.0	8.2	Grade Break
16+89	9.1	8.9	Ground Shot
17+00	8.9	9.1	Ground Shot
18+00	9.0	9.0	Ground Shot
18+39	10.2	10.2	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_11

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	11.0	11.0	Ground Shot
1+00	11.3	11.2	Ground Shot
2+00	9.9	10.4	Ground Shot
2+08	10.0	10.0	Top of Bank
2+22	4.9	5.6	Toe of Bank
3+00	2.2	3.1	Sand Bar
4+00	1.5	2.5	Sand Bar
5+00	1.8	2.3	Sand Bar
5+56	0.4	0.9	Edge of Water
5+79	-4.7	0.4	River Bottom
5+85	-5.1	-2.6	River Bottom
6+10	-9.0	-5.6	River Bottom
6+36	-17.5	-11.1	River Bottom
6+54	-24.6	-20.7	River Bottom
6+85	-28.6	-24.0	River Bottom
7+08	-32.0	-29.3	River Bottom
7+31	-33.5	-29.7	River Bottom
7+57	-33.9	-31.9	River Bottom
7+83	-33.0	-32.6	River Bottom
8+06	-32.1	-31.7	River Bottom
8+29	-31.0	-31.2	River Bottom
8+56	-31.1	-31.1	River Bottom
8+79	-31.3	-31.1	River Bottom
9+02	-30.7	-30.4	River Bottom
9+28	-29.9	-30.7	River Bottom
9+51	-27.1	-30.7	River Bottom
9+72	-23.2	-30.4	River Bottom
10+00	-20.1	-22.9	River Bottom
10+23	-3.0	-19.2	River Bottom
10+43	-3.2	-18.3	River Bottom
10+94	0.6	-2.3	Edge of Water
11+05	9.5	0.5	Top of Bank
12+00	9.4	9.1	Ground Shot
13+00	7.9	8.0	Edge of Vegetation
14+01	6.9	7.0	Ground Shot
15+01	7.2	7.3	Ground Shot
16+00	7.8	8.0	Ground Shot
17+01	8.3	8.4	Ground Shot
18+00	7.0	7.1	Ground Shot
19+00	6.3	6.6	Ground Shot
20+00	6.7	7.0	Ground Shot
21+00	6.7	7.1	Ground Shot
21+85	7.0	7.4	Toe of Bank
22+00	8.2	8.5	Top of Bank
22+16	8.8	8.6	Ground Shot
23+00	9.7	10.0	Ground Shot
23+67	10.2	10.0	Ground Shot

Analysis of Changes to Bathymetry.xlsx   1 of 1   Transect_12

Calc'd By: TAB
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CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	7.5	11.4	Ground Shot
1+00	8.5	11.7	Ground Shot
1+50	8.9	11.9	Ground Shot
2+00	9.0	11.8	Ground Shot
2+34	8.0	11.1	Edge of Vegetation
3+00	7.2	9.9	Ground Shot
4+00	7.2	10.6	Ground Shot
4+36	7.7	10.9	Edge of Vegetation
5+00	8.6	11.6	Ground Shot
6+00	10.1	13.2	Ground Shot
7+00	10.9	13.7	Ground Shot
7+11	11.7	14.6	Grade Break
7+95	20.5	23.4	Grade Break
8+00	19.6	23.0	Ground Shot
9+00	19.3	22.4	Top of Bank
9+67	8.1	11.1	Toe of Bank
10+00	6.5	10.0	Sand Bar
11+00	4.2	7.6	Sand Bar
12+00	5.2	5.9	Sand Bar
13+00	1.8	4.8	Sand Bar
14+00	3.8	4.2	Sand Bar
15+00	2.6	3.9	Sand Bar
16+00	1.8	3.7	Sand Bar
17+00	1.3	3.3	Sand Bar
18+01	1.0	2.8	Sand Bar
19+00	0.0	2.6	Sand Bar
20+00	-0.6	2.4	Sand Bar
21+00	-0.8	2.4	Sand Bar
22+00	-1.0	2.5	Sand Bar
23+00	-0.7	2.2	Sand Bar
24+00	-1.3	2.3	Sand Bar
25+00	-1.1	2.2	Sand Bar
26+00	-0.9	2.1	Sand Bar
27+00	-0.2	2.2	Sand Bar
28+00	0.6	2.9	Sand Bar
29+00	0.5	2.8	Sand Bar
30+00	0.0	2.7	Sand Bar
31+00	0.3	2.1	Sand Bar
32+00	-0.3	2.0	Sand Bar
33+00	-1.0	1.5	Sand Bar
34+00	-1.6	0.9	Sand Bar
35+00	-1.9	-0.3	Sand Bar
35+11	-2.7	-0.5	Edge of Water
36+19	-3.2	-2.8	River Bottom
36+39	-5.3	-4.4	River Bottom
36+59	-7.8	-5.0	River Bottom
36+79	-10.9	-5.8	River Bottom
37+07	-13.3	-8.7	River Bottom
37+30	-16.2	-9.0	River Bottom
37+59	-18.8	-10.0	River Bottom
37+84	-20.2	-11.5	River Bottom
38+16	-20.8	-15.6	River Bottom
38+38	-21.1	-16.7	River Bottom

Analysis of Changes to Bathymetry.xlsx 1 of 2 Transect_13

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CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
38+70	-22.1	-19.2	River Bottom
38+92	-24.2	-22.1	River Bottom
39+21	-22.6	-24.4	River Bottom
39+38	-3.7	-23.5	River Bottom
39+77	-3.0	-11.4	Edge of Water
39+89	5.6	-5.4	Top of Bank
40+00	5.6	1.1	Ground Shot
41+00	5.0	8.6	Ground Shot
42+00	4.9	8.5	Ground Shot
43+00	4.9	8.4	Ground Shot
43+53	3.5	7.0	Edge of Vegetation
44+00	2.1	5.6	Top of Bank
45+00	-2.5	1.4	Sand Bar
45+15	-2.9	0.8	Edge of Water
45+19	0.4	0.8	River Bottom
45+64	-1.5	-0.4	River Bottom
46+13	-6.5	-5.7	River Bottom
46+62	-10.0	-8.8	River Bottom
47+14	-10.3	-9.5	River Bottom
47+65	-7.8	-7.5	River Bottom
48+13	-5.2	-4.8	River Bottom
48+65	-1.5	-0.5	River Bottom
49+17	-3.3	1.1	Edge of Water
49+22	3.6	6.9	Top of Bank
49+53	4.5	7.8	Grade Break
50+00	5.2	8.2	Ground Shot
50+14	8.57	11.5	Ground Shot
50+28	8.09	11.3	Grade Break
50+33	5.84	8.9	Grade Break
50+36	7.50	10.6	Grade Break
51+00	7.55	10.9	Ground Shot
51+30	7.35	10.7	Grade Break
51+34	6.05	9.3	Grade Break
51+44	7.01	10.0	Ground Shot

Analysis of Changes to Bathymetry.xlsx 2 of 2 Transect_13

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CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	10.1	13.2	Ground Shot
1+00	10.4	13.7	Ground Shot
1+65	12.6	15.6	Ground Shot
2+00	13.6	16.7	Ground Shot
3+00	15.6	18.8	Ground Shot
3+67	16.9	20.0	Ground Shot
4+00	16.1	19.3	Ground Shot
4+76	16.1	19.3	Top of Bank
5+19	9.1	12.2	Toe of Bank
6+00	6.5	9.5	Edge of Vegetation
7+00	3.0	6.2	Edge of Vegetation
8+00	0.1	4.0	Sand Bar
9+00	-0.3	2.4	Sand Bar
10+00	-1.5	1.4	Sand Bar
11+00	-2.6	0.5	Sand Bar
11+24	-3.3	0.3	Edge of Water
13+87	-2.6	-1.2	River Bottom
14+03	-2.7	-0.5	River Bottom
14+20	-3.2	-1.0	River Bottom
14+36	-2.4	-1.1	River Bottom
14+52	-3.0	-0.7	River Bottom
14+68	-3.0	-0.5	River Bottom
14+88	-2.4	-0.6	River Bottom
15+04	-3.1	-0.6	River Bottom
15+24	-2.9	-0.6	River Bottom
15+36	-2.9	-0.6	River Bottom
15+53	-2.3	-0.5	River Bottom
15+66	-2.4	-0.3	River Bottom
15+76	-2.7	-0.1	River Bottom
15+89	-3.4	0.2	River Bottom
16+05	-3.5	0.5	River Bottom
16+18	-3.8	0.7	River Bottom
16+38	-3.9	1.0	River Bottom
16+54	-3.4	1.7	River Bottom
16+92	-3.5	1.9	Edge of Water
17+31	-1.1	2.2	Sand Bar
18+00	-0.7	2.6	Sand Bar
19+00	-0.9	2.8	Sand Bar
20+00	-0.9	2.7	Sand Bar
21+01	-1.0	3.1	Sand Bar
22+00	-1.1	2.5	Sand Bar
23+00	-2.4	2.8	Sand Bar
24+00	-2.9	1.9	Sand Bar
24+35	-4.4	-2.5	Edge of Water
24+48	-2.7	-4.3	River Bottom
24+64	-5.5	-6.5	River Bottom
24+87	-9.0	-9.8	River Bottom
25+10	-9.6	-12.3	River Bottom
25+33	-9.9	-13.0	River Bottom
25+56	-9.9	-14.0	River Bottom
25+82	-10.2	-14.7	River Bottom
26+01	-10.4	-15.2	River Bottom
26+24	-10.0	-15.2	River Bottom

Analysis of Changes to Bathymetry.xlsx 1 of 2 Transect_14

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RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
26+50	-10.0	-16.5	River Bottom
26+70	-10.6	-15.4	River Bottom
26+89	-11.6	-15.1	River Bottom
27+15	-11.1	-15.8	River Bottom
27+35	-10.8	-15.2	River Bottom
27+76	-2.8	-5.6	Edge of Water
27+87	5.9	1.6	Top of Bank
28+00	6.7	9.3	Ground Shot
28+44	6.9	9.6	Ground Shot
29+00	6.5	9.5	Ground Shot
29+94	6.6	9.4	Ground Shot

Analysis of Changes to Bathymetry.xlsx 2 of 2 Transect_14

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	13.8	13.6	Ground Shot
1+00	15.3	15.4	Ground Shot
1+50	16.7	16.4	Ground Shot
1+95	15.1	15.1	Top of Bank
2+11	3.3	3.0	Toe of Bank
2+21	0.9	1.2	Edge of Water
2+88	-2.9	-5.4	River Bottom
3+09	-3.3	-7.3	River Bottom
3+30	-3.8	-7.6	River Bottom
3+50	-4.0	-8.1	River Bottom
3+71	-4.1	-8.3	River Bottom
3+91	-4.4	-8.7	River Bottom
4+12	-4.4	-9.0	River Bottom
4+36	-4.2	-9.8	River Bottom
4+57	-4.7	-9.5	River Bottom
4+81	-3.9	-9.0	River Bottom
5+01	-3.2	-7.6	River Bottom
11+47	-2.4	-6.8	River Bottom
11+64	-2.4	-7.1	River Bottom
11+81	-2.5	-7.3	River Bottom
11+98	-3.3	-7.8	River Bottom
12+16	-3.6	-8.7	River Bottom
12+36	-4.0	-8.8	River Bottom
12+57	-4.6	-9.0	River Bottom
12+77	-4.7	-9.1	River Bottom
13+01	-4.9	-10.1	River Bottom
13+29	-5.6	-10.2	River Bottom
13+56	-5.8	-11.3	River Bottom
13+80	-6.4	-11.5	River Bottom
14+08	-6.5	-12.4	River Bottom
14+35	-6.8	-11.8	River Bottom
14+59	-6.5	-11.6	River Bottom
14+87	-6.2	-12.2	River Bottom
15+14	-5.2	-11.3	River Bottom
15+42	-5.4	-10.4	River Bottom
15+66	-5.1	-10.6	River Bottom
15+93	-6.1	-10.0	River Bottom
16+24	-8.3	-10.9	River Bottom
16+52	-8.3	-11.7	River Bottom
16+79	-5.1	-9.6	River Bottom
17+03	-2.8	-7.3	River Bottom
17+55	0.8	-1.7	Edge of Water
17+79	1.9	2.8	Sand Bar
17+97	4.4	4.9	Sand Bar
18+19	5.6	5.6	Toe of Bank
18+35	11.9	11.8	Top of Bank
18+91	12.6	12.3	Ground Shot
19+41	12.5	12.2	Ground Shot

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G.3.3 NIGLIAGVIK CHANNEL TABULATED DATA (TRANSECTS 16 – 35)

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Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
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STA	2013	2016	Description
0+00	10.0	9.7	Ground Shot
0+50	9.4	8.9	Ground Shot
1+00	8.4	8.6	Top of Bank
1+12	0.8	0.3	Edge of Water
1+28	-3.1	-3.4	River Bottom
1+37	-4.2	-5.7	River Bottom
1+46	-7.0	-6.8	River Bottom
1+58	-6.5	-6.4	River Bottom
1+70	-7.5	-8.2	River Bottom
1+81	-10.7	-10.2	River Bottom
1+91	-12.3	-12.2	River Bottom
2+06	-8.3	-9.8	River Bottom
2+17	-6.6	-8.1	River Bottom
2+27	-5.0	-6.8	River Bottom
2+37	-2.1	-3.3	River Bottom
2+47	0.8	0.6	Edge of Water
2+68	3.4	3.6	Sand Bar
3+10	4.7	4.8	Edge of Vegetation
3+59	6.7	6.9	Edge of Vegetation
4+00	7.9	8.0	Ground Shot
4+18	8.9	8.6	Ground Shot
4+68	9.2	8.9	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_16

Calc'd By: TAB
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RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	8.6	8.2	Ground Shot
0+50	8.5	8.1	Ground Shot
1+16	8.0	8.1	Top of Bank
1+47	3.7	3.9	Edge of Vegetation
1+66	0.9	1.0	Edge of Water
1+93	-2.1	-1.9	River Bottom
2+08	-2.2	-1.9	River Bottom
2+19	-2.6	-2.3	River Bottom
2+29	-2.9	-2.9	River Bottom
2+39	-3.1	-3.3	River Bottom
2+49	-3.2	-3.4	River Bottom
2+66	-3.5	-3.6	River Bottom
2+83	-3.5	-3.4	River Bottom
2+91	-3.3	-3.3	River Bottom
3+08	-3.1	-3.3	River Bottom
3+27	-2.4	-2.9	River Bottom
3+68	0.7	1.0	Edge of Water
3+82	6.3	6.5	Top of Bank
4+29	8.6	8.3	Ground Shot
4+79	8.5	8.2	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_17

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV2

STA	2013	2016	Description
0+00	8.6	8.5	Ground Shot
0+50	8.6	8.6	Ground Shot
1+00	7.9	8.2	Ground Shot
1+58	7.1	7.2	Top of Bank
1+76	6.3	6.2	Edge of Vegetation
2+14	3.7	3.8	Edge of Vegetation
2+50	1.0	1.2	Edge of Water
3+17	-2.6	-1.8	River Bottom
3+26	-2.8	-1.8	River Bottom
3+38	-3.2	-2.7	River Bottom
3+52	-2.1	-3.4	River Bottom
3+68	-3.6	-3.9	River Bottom
3+80	-4.0	-3.6	River Bottom
3+93	-3.9	-3.2	River Bottom
4+01	-3.5	-2.8	River Bottom
4+14	-3.0	-1.9	River Bottom
4+22	-3.0	-1.6	River Bottom
4+57	0.9	0.9	Edge of Water
4+76	7.1	7.0	Top of Bank
5+33	7.8	7.6	Ground Shot
5+83	8.0	7.8	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_18

Calc'd By: TAB
Date: 8/22/2016
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CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	8.6	8.5	Ground Shot
0+50	8.5	8.7	Ground Shot
0+95	7.9	8.1	Top of Bank
1+15	3.3	3.9	Edge of Vegetation
1+49	0.7	1.2	Edge of Water
1+88	-1.9	-1.3	River Bottom
1+99	-2.2	-1.9	Edge of Water
2+19	-2.3	-2.4	River Bottom
2+29	-2.5	-2.4	Edge of Water
2+40	-2.5	-2.4	River Bottom
2+61	-2.4	-2.0	Edge of Water
2+75	-4.5	-2.0	River Bottom
2+88	-4.1	-2.0	Edge of Water
2+96	-2.7	-1.3	River Bottom
3+50	0.7	1.2	Edge of Water
3+69	7.0	7.3	Top of Bank
4+20	8.5	8.6	Ground Shot
4+70	8.1	8.0	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_19

Calc'd By: TAB
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RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	13.8	13.8	Ground Shot
0+15	16.8	16.9	Ground Shot
0+50	15.5	15.5	Ground Shot
1+13	11.4	11.7	Top of Bank
1+36	0.5	0.7	Edge of Water
1+63	-0.7	-0.8	River Bottom
1+99	-0.6	-1.3	River Bottom
2+30	-0.8	-1.5	River Bottom
2+50	-0.9	-1.3	River Bottom
2+99	-1.3	-1.4	River Bottom
3+30	-1.3	-1.1	River Bottom
3+56	0.6	0.5	Edge of Water
3+93	6.6	6.9	Top of Bank
4+53	7.4	7.5	Ground Shot
5+03	7.5	7.6	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_20

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	24.6	24.5	Ground Shot
0+50	20.8	20.7	Ground Shot
1+02	9.5	9.4	Ground Shot
1+24	7.2	7.3	Top of Bank
1+37	0.5	1.2	Edge of Water
1+46	-1.0	-1.3	River Bottom
1+58	-2.1	-2.4	River Bottom
1+75	-2.1	-2.7	River Bottom
2+00	-1.8	-2.3	River Bottom
2+24	-1.6	-2.0	River Bottom
2+50	-1.1	-1.1	River Bottom
3+22	0.5	1.2	Edge of Water
3+41	3.3	2.9	Grade Break
3+64	4.2	4.7	Toe of Bank
3+79	8.6	8.7	Top of Bank
4+04	9.7	9.9	Grade Break
4+58	9.1	9.0	Ground Shot
5+08	8.7	8.7	Ground Shot

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Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	26.0	26.0	Ground Shot
0+07	23.0	23.2	Ground Shot
0+60	24.0	24.1	Ground Shot
1+10	23.1	23.1	Top of Bank
1+36	2.6	2.5	Toe of Bank
1+48	0.6	0.3	Edge of Water
1+67	-1.1	-0.8	River Bottom
2+00	-1.1	-1.5	River Bottom
2+24	-1.6	-1.9	River Bottom
2+50	-1.6	-1.8	River Bottom
2+75	-1.4	-1.6	River Bottom
3+01	-0.7	-1.2	River Bottom
3+38	0.6	0.2	Edge of Water
3+61	4.4	4.3	Toe of Bank
3+68	8.6	8.7	Top of Bank
3+88	10.5	10.7	Ground Shot
4+27	9.1	9.1	Ground Shot
4+77	8.6	8.6	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_22

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	25.2	25.2	Ground Shot
0+50	25.1	25.1	Ground Shot
1+06	23.2	23.3	Top of Bank
1+34	3.2	3.4	Toe of Bank
1+53	0.5	0.5	Edge of Water
2+25	-1.1	-1.5	River Bottom
2+51	-1.7	-1.7	River Bottom
2+75	-1.7	-1.9	River Bottom
3+00	-1.5	-2.3	River Bottom
3+27	-1.2	-1.7	River Bottom
3+40	0.7	-0.3	Edge of Water
3+44	2.2	0.4	Grade Break
3+84	6.1	6.2	Edge of Vegetation
3+95	7.7	7.7	Top of Bank
4+50	7.9	7.8	Ground Shot
5+00	10.0	10.2	Ground Shot

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Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2014	2015	2016	Description
0+00	26.5	26.5	26.4	26.4	Ground Shot
0+50	27.0	27.0	27.0	26.9	Ground Shot
0+94	27.9	26.4	26.5	26.5	Ground Shot
1+13	25.3	23.6	23.8	23.6	Top of Bank
1+45	2.6	2.7	3.2	0.5	Toe of Bank
1+56	0.2	0.5	1.2	-0.6	Edge of Water
2+26	-1.7	-1.2	-1.9	-2.6	River Bottom
2+39	-2.4	-1.8	-2.6	-3.3	River Bottom
2+48	-2.0	-2.2	-2.9	-2.9	River Bottom
2+61	-2.1	-2.2	-2.6	-2.2	River Bottom
2+74	-2.2	-2.3	-2.3	-2.1	River Bottom
2+90	-3.0	-1.9	-2.1	-2.0	River Bottom
3+00	-3.0	-1.9	-2.1	-2.2	River Bottom
3+17	-2.6	-2.0	-2.2	-2.1	River Bottom
3+44	0.3	0.2	0.4	-0.8	Edge of Water
3+86	5.9	5.7	5.8	5.8	Edge of Vegetation
3+96	7.1	7.2	7.2	7.0	Top of Bank
4+65	8.7	8.5	8.3	8.2	Ground Shot
5+15	9.4	9.2	9.1	9.0	Ground Shot

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2014	2015	2016	Description
0+00	27.5	27.4	27.3	27.3	Ground Shot
0+50	26.4	26.2	26.2	26.1	Ground Shot
0+70	26.8	26.7	26.7	26.5	Ground Shot
0+89	21.8	21.3	21.3	21.2	Grade Break
1+00	25.7	22.2	22.5	22.1	Top of Bank
1+31	2.8	2.8	2.7	1.3	Toe of Bank
1+47	0.6	0.3	0.9	-0.4	Edge of Water
2+19	-2.6	-1.2	-3.4	-3.7	River Bottom
2+38	-2.2	-1.6	-3.5	-3.5	River Bottom
2+48	-2.2	-1.9	-3.5	-3.4	River Bottom
2+61	-2.4	-2.9	-3.2	-3.1	River Bottom
2+72	-2.8	-2.6	-2.8	-2.8	River Bottom
2+89	-2.7	-2.1	-2.3	-2.1	River Bottom
2+97	-2.6	-1.9	-2.1	-1.8	River Bottom
3+07	-2.7	-2.0	-1.8	-1.9	River Bottom
3+35	0.1	0.1	0.2	-0.3	Edge of Water
3+51	2.5	2.5	1.5	0.4	Ground Shot
3+81	6.1	6.1	6.4	6.2	Edge of Vegetation
3+91	7.8	7.5	7.7	7.5	Top of Bank
4+53	8.5	8.3	8.1	8.2	Ground Shot
5+03	8.4	8.4	8.3	8.4	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_25

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2014	2015	2016	Description
0+00	24.0	27.5	27.3	27.3	Ground Shot
0+60	24.1	27.7	27.6	27.5	Ground Shot
0+85	24.0	27.3	27.5	27.3	Ground Shot
1+03	21.5	24.9	25.0	25.0	Grade Break
1+36	2.7	2.4	3.1	1.8	Top of Bank
1+58	0.4	0.2	0.5	-0.6	Toe of Bank
2+19	-2.5	0.2	-3.5	-3.5	Edge of Water
2+32	-2.6	-1.2	-3.5	-3.0	River Bottom
2+43	-2.5	-2.1	-3.6	-1.7	River Bottom
2+53	-2.4	-2.4	-3.6	-1.7	River Bottom
2+63	-2.4	-2.6	-3.6	-2.1	River Bottom
2+80	-2.3	-2.9	-2.8	-3.3	River Bottom
2+91	-2.0	-2.9	-2.6	-4.0	River Bottom
3+08	-2.2	-2.3	-2.2	-3.2	River Bottom
3+36	0.2	0.0	0.1	-1.1	River Bottom
3+57	3.2	3.3	1.4	1.2	Edge of Water
3+89	6.1	6.6	7.0	6.6	Ground Shot
3+97	7.1	7.5	7.7	7.2	Edge of Vegetation
4+79	8.3	9.3	9.9	10.0	Top of Bank
5+29	9.8	9.8	9.5	9.4	Ground Shot

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Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2014	2015	2016	Description
0+00	27.0	27.0	26.8	26.5	Ground Shot
0+50	27.1	27.1	27.0	27.0	Ground Shot
0+74	24.3	24.5	24.3	24.1	Grade Break
0+82	26.6	26.6	26.7	26.7	Grade Break
0+98	26.0	25.9	25.9	26.0	Top of Bank
1+30	2.5	2.1	2.5	2.2	Toe of Bank
1+46	0.1	0.3	-1.2	-0.8	Edge of Water
2+20	-2.4	-0.8	-1.4	-2.2	River Bottom
2+31	-2.3	-1.0	-1.5	-1.6	River Bottom
2+41	-3.3	-1.6	-2.1	-1.9	River Bottom
2+48	-2.0	-1.7	-2.5	-2.3	River Bottom
2+58	-2.7	-2.7	-3.0	-2.9	River Bottom
2+65	-2.9	-2.7	-3.0	-3.2	River Bottom
2+72	-3.1	-2.8	-3.0	-3.4	River Bottom
2+78	-2.9	-2.8	-2.9	-3.3	River Bottom
2+85	-2.5	-3.0	-2.9	-2.8	River Bottom
2+92	-2.1	-2.6	-2.4	-2.5	River Bottom
3+17	-0.1	0.2	0.4	-0.3	Edge of Water
3+39	1.9	2.0	1.5	1.3	Ground Shot
3+52	4.7	4.9	4.7	4.6	Ground Shot
3+76	5.9	6.1	6.2	6.3	Edge of Vegetation
3+89	7.0	7.2	7.2	7.1	Top of Bank
4+10	8.0	8.1	8.0	8.1	Ground Shot
4+71	8.0	8.0	7.8	7.7	Ground Shot
5+21	9.7	9.7	9.2	9.0	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_27

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	21.0	20.8	Ground Shot
0+50	21.3	21.2	Ground Shot
0+83	21.5	21.4	Ground Shot
1+06	20.7	19.8	Top of Bank
1+31	1.0	0.8	Toe of Bank
1+34	0.0	-0.5	Edge of Water
1+37	-3.0	-2.2	River Bottom
1+44	-4.2	-4.2	River Bottom
1+51	-4.4	-4.0	River Bottom
1+61	-4.0	-3.5	River Bottom
1+75	-3.6	-3.1	River Bottom
1+89	-3.4	-3.2	River Bottom
1+99	-3.0	-3.0	River Bottom
2+16	-3.2	-3.1	River Bottom
2+33	-3.2	-4.8	River Bottom
2+44	-2.6	-5.0	River Bottom
2+64	0.1	-2.0	Edge of Water
3+40	2.5	2.6	Ground Shot
3+65	5.7	5.8	Edge of Vegetation
3+81	7.6	8.0	Top of Bank
4+26	8.2	8.5	Ground Shot
4+81	8.4	8.4	Ground Shot
5+31	9.2	8.7	Ground Shot

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Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	24.3	24.1	Ground Shot
0+50	23.6	23.7	Ground Shot
1+01	23.0	22.7	Top of Bank
1+30	0.2	0.1	Edge of Water
1+43	-8.1	-9.7	River Bottom
1+89	-7.9	-8.5	River Bottom
2+09	-5.2	-4.6	River Bottom
2+24	-2.5	-2.7	River Bottom
2+45	0.1	0.2	Edge of Water
2+82	2.6	2.8	Ground Shot
3+30	2.9	3.3	Ground Shot
3+88	5.8	6.0	Edge of Vegetation
4+01	8.0	8.4	Top of Bank
4+47	7.7	7.9	Ground Shot
4+85	8.4	8.6	Ground Shot
5+36	9.5	9.6	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_29

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	23.7	23.3	Ground Shot
0+69	21.7	20.5	Top of Bank
0+79	19.3	19.1	Grade Break
1+00	6.0	6.0	Toe of Bank
1+16	4.4	4.3	Top of Bank
1+17	3.3	2.7	Toe of Bank
1+52	0.2	0.3	Edge of Water
1+63	-2.9	-1.2	River Bottom
1+75	-4.0	-2.8	River Bottom
1+87	-5.9	-4.3	River Bottom
1+99	-5.8	-5.5	River Bottom
2+12	-6.4	-5.2	River Bottom
2+26	-5.7	-4.5	River Bottom
2+36	-5.3	-4.6	River Bottom
2+48	-3.4	-4.0	River Bottom
2+61	-2.7	-3.1	River Bottom
2+73	-2.1	-2.2	River Bottom
2+81	-2.8	-2.2	River Bottom
3+06	-0.5	-0.2	Edge of Water
3+84	4.3	4.3	Sand Bar
3+94	5.9	5.8	Grade Break
4+30	6.1	6.0	Edge of Vegetation
4+67	8.8	8.8	Grade Break
5+22	8.1	7.9	Grade Break
5+58	9.4	9.3	Grade Break/Edge of Veg
5+77	9.6	9.5	Ground Shot
6+27	10.1	9.6	Ground Shot

Analysis of Changes to Bathymetry.xlsx   1 of 1   Transect_30

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	8.6	8.3	Ground Shot
0+50	9.6	9.6	Ground Shot
1+06	8.1	8.3	Edge of Vegetation
1+29	8.4	8.3	Top of Bank
1+40	5.7	5.7	Toe of Bank
1+85	5.7	6.0	Ground Shot
2+37	6.0	6.2	Ground Shot
2+89	6.9	6.8	Ground Shot
3+16	7.7	7.8	Ground Shot
3+70	8.0	8.1	Top of Bank
3+80	6.7	6.8	Grade Break/Edge of Veg
4+06	3.8	3.9	Sand Bar
4+43	1.4	0.9	Grade Break
4+62	-0.2	-0.4	Edge of Water
4+71	-2.6	-1.3	River Bottom
4+81	-2.8	-1.9	River Bottom
4+92	-2.1	-2.0	River Bottom
5+02	-2.1	-2.2	River Bottom
5+10	-2.6	-2.3	River Bottom
5+20	-2.3	-2.4	River Bottom
5+29	-2.2	-1.8	River Bottom
5+39	-2.1	-1.8	River Bottom
5+50	-2.2	-1.6	River Bottom
5+60	-2.1	-1.7	River Bottom
5+70	-2.5	-1.7	River Bottom
5+79	-2.2	-1.5	River Bottom
6+03	0.0	0.1	Edge of Water
6+20	2.6	2.6	Toe of Bank
6+32	8.4	8.3	Top of Bank
6+83	9.2	9.1	Grade Break
7+31	10.9	11.0	Edge of Vegetation
7+54	11.2	11.2	Ground Shot
8+04	10.7	10.3	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_31

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	8.4	8.1	Ground Shot
0+50	7.8	7.8	Ground Shot
0+96	7.0	6.7	Ground Shot
1+50	7.2	7.3	Ground Shot
2+00	7.4	7.4	Ground Shot
2+50	8.0	8.0	Ground Shot
3+12	6.8	6.8	Edge of Vegetation
3+32	6.4	6.4	Top of Bank
4+03	0.1	-0.1	Edge of Water
4+07	-0.8	-1.7	River Bottom
4+16	-2.7	-1.7	River Bottom
4+26	-2.5	-2.5	River Bottom
4+36	-3.9	-4.1	River Bottom
4+47	-5.4	-6.3	River Bottom
4+57	-6.6	-6.9	River Bottom
4+68	-7.0	-7.0	River Bottom
4+79	-6.1	-5.8	River Bottom
4+98	-0.4	-0.8	Edge of Water
5+10	8.5	8.4	Top of Bank
5+40	10.4	10.3	Ground Shot
5+79	10.2	10.2	Ground Shot
6+21	11.5	11.5	Ground Shot
6+71	10.8	10.5	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_32

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	9.9	9.8	Ground Shot
0+50	8.6	8.6	Ground Shot
1+03	8.5	8.7	Edge of Vegetation
1+52	10.6	10.7	Grade Break
2+00	9.9	10.0	Ground Shot
2+57	7.9	7.8	Top of Bank
2+67	6.9	6.9	Edge of Vegetation
2+78	5.4	5.3	Sand Bar
2+87	3.5	3.2	Grade Break
3+57	0.0	-0.5	Edge of Water
3+81	-3.2	-1.5	River Bottom
4+04	-2.2	-2.3	River Bottom
4+18	-3.5	-3.1	River Bottom
4+38	-4.4	-7.5	River Bottom
4+59	-3.1	-4.2	River Bottom
4+78	-0.1	0.9	Edge of Water
4+99	9.1	8.9	Top of Bank
5+53	9.7	9.8	Edge of Vegetation
6+02	10.1	10.3	Ground Shot
6+41	10.5	10.6	Ground Shot
7+11	10.7	10.3	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_33

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	12.6	12.4	Ground Shot
0+50	12.6	12.5	Ground Shot
1+00	10.3	10.1	Ground Shot
1+50	9.2	9.2	Ground Shot
2+12	8.1	8.0	Top of Bank
2+15	3.5	1.9	Toe of Bank
2+23	-0.3	0.6	Edge of Water
2+30	-4.6	-3.7	River Bottom
2+37	-7.2	-4.3	River Bottom
2+48	-7.3	-5.8	River Bottom
2+58	-6.9	-5.8	River Bottom
2+72	-6.7	-6.0	River Bottom
2+82	-3.2	-5.4	River Bottom
2+96	-2.2	-3.1	River Bottom
3+06	-1.9	-2.1	River Bottom
3+27	0.1	0.3	Edge of Water
3+66	4.5	4.6	Grade Break
3+94	5.6	5.6	Sand Bar
4+29	7.1	7.1	Edge of Vegetation
4+39	8.4	8.5	Top of Bank
4+50	8.6	8.6	Ground Shot
5+00	9.0	9.0	Ground Shot
5+50	7.4	7.6	Ground Shot
6+00	9.7	9.7	Ground Shot
6+30	10.1	10.2	Edge of Vegetation
6+64	9.9	9.7	Ground Shot
7+00	10.6	10.6	Ground Shot
7+50	10.1	9.9	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_34

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2016	Description
0+00	12.6	12.5	Ground Shot
0+50	13.0	12.9	Ground Shot
1+00	11.2	11.3	Ground Shot
1+11	11.4	11.4	Grade Break
1+25	9.4	9.4	Grade Break
1+65	10.3	10.4	Grade Break
1+81	8.1	8.1	Grade Break
2+27	9.3	9.4	Grade Break
2+51	10.4	10.5	Grade Break
2+72	8.2	8.3	Grade Break
3+15	8.0	7.7	Grade Break
3+59	6.9	6.8	Edge of Vegetation
3+79	6.6	6.6	Top of Bank
3+92	3.5	3.4	Sand Bar
4+29	-0.1	0.1	Edge of Water
4+60	-2.3	-2.2	River Bottom
4+86	-4.6	-3.9	River Bottom
5+09	-5.1	-4.2	River Bottom
5+26	-2.0	-3.3	River Bottom
5+44	-0.2	0.0	Edge of Water
5+47	0.2	0.2	Toe of Bank
5+58	7.6	7.4	Top of Bank
5+72	9.7	9.7	Grade Break
5+86	9.2	9.3	Edge of Vegetation
6+28	9.4	9.3	Ground Shot
6+69	9.5	9.2	Ground Shot
7+19	10.3	10.1	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_35

G.3.4 LAKE L9341 TABULATED DATA (TRANSECTS 36 – 39)

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Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2014	2015	2016	Description
0+00	8.3	8.4	8.2	7.9	Ground Shot
0+50	8.0	8.2	8.0	7.9	Ground Shot
0+81	7.2	7.3	7.4	7.4	Ground Shot
1+17	7.2	7.2	7.2	7.1	Top of Bank
1+23	6.3	6.5	6.5	6.6	Edge of Vegetation
1+48	4.6	4.6	4.6	3.8	Edge of Water
1+52	4.0	2.0	4.4	3.4	River Bottom
1+89	0.8	1.5	2.1	0.7	River Bottom
2+20	-0.9	1.0	0.0	0.1	River Bottom
2+48	-1.7	-0.9	-1.8	-1.0	River Bottom
2+95	-3.0	-2.8	-3.2	-2.9	River Bottom
3+49	-2.1	-1.5	-1.5	-1.2	River Bottom
3+78	1.7	1.5	2.5	1.7	River Bottom
3+90	2.5	2.2	4.1	3.0	River Bottom
3+96	4.8	4.7	4.8	3.5	Edge of Water
4+06	8.6	8.6	8.7	8.5	Top of Bank
5+03	9.5	9.6	9.5	9.4	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_36

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2014	2015	2016	Description
0+00	8.0	8.1	8.5	8.3	Ground Shot
0+50	8.3	8.5	8.3	8.2	Ground Shot
0+92	7.0	7.1	7.2	7.3	Top of Bank
1+03	6.5	6.6	6.6	6.7	Edge of Vegetation
1+40	4.6	4.5	4.6	4.2	Edge of Water
1+59	2.2	1.7	3.1	3.0	River Bottom
2+01	0.5	1.1	0.0	1.1	River Bottom
2+48	-2.4	-2.5	-1.4	-2.0	River Bottom
2+99	-2.9	-2.5	-2.6	-2.6	River Bottom
3+45	-1.6	-1.3	-1.3	-1.3	River Bottom
3+84	2.1	1.4	3.0	2.5	River Bottom
3+95	4.6	4.7	4.7	3.5	Edge of Water
4+04	9.1	9.1	9.1	9.0	Top of Bank
4+49	8.8	8.9	8.8	8.7	Ground Shot
4+99	9.5	9.6	9.5	9.4	Ground Shot

Analysis of Changes to Bathymetry.xlsx 1 of 1 Transect_37

Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2014	2015	2016	Description
0+00	8.1	8.4	7.8	7.7	Ground Shot
0+50	7.9	8.3	8.0	7.8	Ground Shot
0+81	7.3	7.3	7.4	7.2	Top of Bank
1+22	6.1	6.4	6.3	6.3	Edge of Vegetation
1+48	4.6	4.5	4.6	4.4	Edge of Water
1+94	1.4	1.6	2.4	2.1	River Bottom
2+46	0.4	0.4	0.0	-0.2	River Bottom
2+96	-2.6	-2.2	-1.6	-2.4	River Bottom
3+47	-2.8	-2.5	-3.2	-3.0	River Bottom
3+95	0.8	1.5	1.0	0.8	River Bottom
4+22	4.7	3.7	5.0	3.6	Edge of Water
4+31	9.3	9.3	9.3	9.1	Top of Bank
4+79	9.0	9.1	9.0	8.9	Ground Shot
5+29	9.2	9.3	9.3	9.2	Ground Shot

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Calc'd By: TAB
Date: 8/22/2016
RPT-CE-CD-114 REV4

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STA	2013	2014	2015	2016	Description
0+00	8.5	8.8	8.6	8.4	Ground Shot
0+50	7.6	7.8	7.7	7.5	Ground Shot
0+79	6.7	7.0	6.9	6.9	Top of Bank
0+89	5.8	6.0	5.8	5.9	Edge of Vegetation
1+06	4.4	4.5	4.5	4.3	Edge of Water
1+27	1.3	1.2	2.6	1.9	River Bottom
1+54	0.1	0.7	0.6	0.6	River Bottom
2+01	-1.2	-0.8	-1.1	-1.4	River Bottom
2+47	-1.7	-1.7	-2.0	-1.7	River Bottom
3+01	-3.0	-2.5	-3.2	-3.1	River Bottom
3+55	-0.3	1.5	-0.4	-0.3	River Bottom
3+71	1.8	2.6	1.7	1.5	River Bottom
3+91	4.6	4.3	4.8	4.7	Edge of Water
4+03	9.3	9.5	9.5	9.4	Top of Bank
4+43	9.4	9.5	9.5	9.2	Ground Shot
4+93	9.6	9.7	9.5	9.3	Ground Shot

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2016 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment