2020 Colville River Delta Spring Breakup Monitoring & Hydrological Assessment - Final

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Prepared for:

ConocoPhillips Alaska

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EXECUTIVE SUMMARY

This report presents the observations and results from the 2020 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 resulting from the rapid rise and fall of stage often attributed to ice jam formations and releases. Annual study and reporting of spring breakup is required by U.S. Army Corps of Engineers Permits 2-960874 Special Condition #6, POA-2004-253 Special Condition #17, and POA-2005-1576 Special Conditions #1 and #17 and Alaska Department of Fish and Game Permits FH04-III-0238, FG97-III-0260, FG99-III-0051, and FG97-III-0190. The analyses provide data to support design, permitting, and operation of oilfield development.

The 2020 monitoring and hydrological assessment is the 29th consecutive year of spring breakup investigations and the 34th year of historical breakup monitoring in the Colville River Delta. Water surface elevations were monitored throughout the delta at locations of hydrologic importance, including 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 dynamic, short duration, historically high magnitude event. Initial floodwater arrived in the delta on May 18 and reached the coast by May 21. On May 26, an ice jam was observed approximately 10 river miles upstream of MON1. On May 27, the ice jam moved downstream of the HDD crossing in the East Channel and another ice jam formed in the Nigliq channel upstream of Nuiqsut. The ice jams remained in place until May 29 coinciding with peak water surface elevations and overbank flooding throughout the delta. On May 30, water levels began to drop and continued to drop the following days.

Peak conditions throughout the delta occurred between May 28 and May 29. Peak stage at MON1C occurred on May 28 and was 21.4 ft British Petroleum Mean Sea Level (BPMSL) having an estimated recurrence interval of 25.5 years. Peak discharge at MON1C occurred on May 28 and was estimated at 341,000 cubic ft per second having an estimated 4.3-year recurrence interval. Recurrence intervals are relative to design basis values.

During peak conditions, overbank flooding and floodplain inundation were widely observed around Alpine. Many typical hydraulic connections between lakes and channels were established, including the recharge of both Alpine Drinking Water Lakes L9312 and L9313. Overall, ice jamming effects in the CRD were pronounced, as was the associated backwater and flooding.

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ACRONYMS & ABBREVIATIONS

2D	Two-dimensional
ABR	Alaska Biological Research
ADF&G	Alaska Department of Fish and Game
Baro PT	barometric pressure transducer
BPMSL	British Petroleum Mean Sea Level
CD	Colville Delta
CFDD	cumulative freezing degree days
cfs	cubic feet per second
CPAI	ConocoPhillips Alaska, Inc.
CRD	Colville River Delta
FEMA	Federal Emergency Management Agency
fps	feet per second
ft	feet
gage	hydrologic staff gage
GPS	Global positioning system
HDD	Horizontal directional drill
HWM	High water mark
Michael Baker	Michael Baker International
MON	Monument
MP-AMS	Monitoring Plan with an Adaptive Management Strategy
NOAA	National Atmospheric and Oceanic Administration
NRCS	Natural Resources Conservation Service
NPR-A	National Petroleum Reserve of Alaska
PT	pressure transducer
RM	river mile
RTFM	Real-Time Flood Monitoring
SAK	Sakoonang
TAM	Tamayayak
ULAM	Ulamnigiaq
UMIAQ	Umiaq, LLC (UMIAQ)
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, originating in the DeLong Mountains on the north 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 23,455 square miles and includes a large portion of the western and central areas north of the Brooks Range (Figure 1-1). Spring breakup starts 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. The 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 Monitoring and Hydrological 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, CD5, and Greater Moose's Tooth 1 (GMT1/MT6) pads, access roads, and pipelines.

Colville River breakup monitoring has been ongoing since 1962. The timing and magnitude of breakup flooding has been determined annually since 1992 by measuring stage and discharge at established locations throughout the delta. The program was expanded to include additional Alpine facilities in 2004 and the CD5 development area in 2009. The 2020 monitoring and hydrological assessment is the 29th consecutive year of CRD spring breakup investigations.

The 2020 field program took place from May 4 to June 9. Spring breakup setup began on May 4 and concluded on May 22. Spring breakup monitoring began on May 22 and concluded on June 9. 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 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 (UMIAQ), CPAI Alpine Field Environmental Coordinators, Alpine Helicopter Coordinators, and Soloy Helicopters, LLC provided support during the field program and contributed to a safe and productive field season.

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★ Place Name
Stream
Colville River Basin Stream
Waterbody
Colville River Basin
NPRA Boundary

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2020 COLVILLE RIVER DELTA SPRING BREAKUP

Colville River Drainage Basin

FIGURE 1.1

1.1 Monitoring Objectives

The primary objective of CRD spring breakup monitoring and hydrological assessment is to monitor and estimate the magnitude of breakup flooding within the CRD in relation to Alpine facilities. Water surface elevations (WSE, or stage, used interchangeably in this report), discharge, and observations are used to validate design parameters of existing infrastructure, for planning and design of proposed infrastructure, and to satisfy permit requirements. Data collection supports refinement of the CRD flood frequency, two-dimensional (2D) surface water model, and stage frequency analyses.

The CRD spring breakup monitoring satisfies permit stipulations by the U.S. Army Corps of Engineers (USACE) and the Alaska Department of Fish and Game (ADF&G).

Permit stipulations for USACE Permits 2-960874 Special Condition #6, POA-2004-253-2 Special Condition #17, ADF&G Fish Habitat Permit FH04-III-0238, and USACE Permit POA-2005-1576 Special Conditions #1 and #17 require monitoring Alpine facilities during spring breakup. Permit stipulations include documentation of annual hydrologic conditions, direct measurements and indirect calculations of discharge through drainage structures, and documentation of pad and road erosion caused by spring breakup flooding. USACE Permit POA-2005-1576 Special Condition #1 requires the *Monitoring Plan with an Adaptive Management Strategy* (MP-AMS) (Michael Baker and Alaska Biological Research [ABR] 2013) which includes monitoring channel sedimentation and erosion specific to the CD5 development. Observations of functionality and flooding effects to the CD2 road bridges are recorded to satisfy ADF&G permit FG97-III-0260-Amendment #3. The ADF&G permits FG99-III-0051-Amendment #8 and FG97-III-0190-Amendment #1 require monitoring of recharge to lakes L9312 and L9313, respectively. 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.

1.2 Monitoring Locations

The 2020 monitoring locations and gage stations are the same as those studied in 2019 (Michael Baker 2019). In addition, MBI monitored the Tinimiaqsugvik Bridge and associated gage stations on the GMT1/MT6 road. Spring breakup at the Tinmiaqsiugvik Bridge has been reported in the GMT1/MT6 spring breakup reports. Most gage stations are adjacent to major hydrologic features and were selected based on topography, importance to the historical record, and proximity and hydraulic significance to existing or proposed facilities or temporary infrastructure. Figure 1-2 shows the CRD monitoring locations and gage stations denoted with a MON prefix. Monitoring locations and gage stations specific to Alpine facilities are shown in Figure 1-3. The location descriptions for each gage station are listed in Table 1.1. Gage and culvert geographic coordinates and associated vertical control are provided in Appendix A.

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- ☆ Place Name
- Gage Location
- Ice Road Crossing
- Pipeline
- Gravel Road
- Ice Road
- Facility
- Ice Pad

Imagery from CPAI 2019 and Maxar 2019

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2020 SPRING BREAKUP COLVILLE RIVER DELTA

Monitoring Locations

FIGURE 1.2

ConocoPhillips Alaska

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File:	2020_CRD_Monitoring.mxd

Gage Location
Place Name
Pipeline
Gravel Road
Ice Road
Ice Pad
Facility

Imagery from CPAI, 2019

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2020 COLVILLE RIVER DELTA SPRING BREAKUP

Alpine Facilities Monitoring Locations

FIGURE 1.3

Table 1.1: Monitoring & Gage Station Locations

Monitoring Location	Monitoring Location Description	Gage Station	Gage Station Description
CRD Monitoring Locations			
Colville River	Head of the CRD	MON1U	West bank, farthest downstream confined reach of the Colville River, conveying approximately 23,455 square miles of runoff in a single channel. Stations are located upstream (U), center (C), and downstream (D) and are offset be a distance of approximately 1 mile.
		MON1C	
		MON1D	
Colville River East Channel	East Channel Bifurcation	MON9	West bank, adjacent to horizontal directional drill (HDD) West, downstream of Nigliq Channel bifurcation
		MON9D	West bank, downstream (north) of HDD West, upstream of Sakoonang Channel bifurcation
		MON35	East side of Helmericks Homestead, Kupigruak Channel just upstream of the coastline, farthest downstream gage station
Nigliq Channel	Nigliq Channel Bifurcations	MON20	East bank, upstream (south) of CD4 pad, upstream of Toolbox Creek
		MON22	West bank, upstream of Nigliagvik Channel tributary
		MON23	East bank, downstream of Nigliagvik Channel tributary, downstream (northwest) of CD2 pad
		MON28	Eastern tributary channel at Harrison Bay, farthest downstream gage station
Alpine Facilities Monitoring Locations			
CD1 Pad & Drinking Water Lakes	Lake L9312	G9	Northwest side of lake, southwest of CD1 pad
	Lake L9313	G10	East side of lake, adjacent to CD1 pad
	CD1 Pad	G1	West bank of Sakoonang Channel, east side of CD1 pad
CD2 Pad & Road	Long Swale Bridge	G3	South side of road, downstream of Lake M9524
		G4	North side of road, downstream of Lake M9524
	Short Swale Bridge	G3	South side of road, downstream of Lake M9524
		G4	North side of road, downstream of Lake M9524
	Culverts	G3	South side of road, downstream of Lake M9524
		G4	North side of road, downstream of Lake M9524
		G6	South side of road, between Lake L9322 and Lake L9321
		G7	North side of road, between Lake L9322 and Lake L9321
		G12	South side of road, downstream of Nanuq Lake
		G13	North side of road, downstream of Nanuq Lake
	CD2 Pad	G8	Northwest side of CD2 pad, adjacent to Nigliq Channel
CD3 Pad & Pipeline	Pipeline Crossings	SAK	South side of Sakoonang Channel, downstream of pipeline bridge #2
		TAM	South side of Tamayayak Channel, downstream of pipeline bridge #4, downstream of Ulamnigiaq Channel bifurcation
		ULAM	North side of Ulamnigiaq Channel, downstream of pipeline bridge #5, upstream of East and West Ulamnigiaq Channel bifurcation
	CD3 Pad	G11	South side of CD3 pad, adjacent to north side of East Ulamnigiaq Channel
CD4 Pad & Road	Culverts	G15	East side of road, between Lake L9323 and Lake M9525
		G16	West side of road, between Lake L9323 and Lake M9525
		G17	North side of road, between Sakoonang Channel and Lake L9323
		G18	South side of road, between Sakoonang Channel and Lake L9323
		G40	West side of road, between Lake M9525 and Nanuq Lake
		G41	East side of road, between Lake M9525 and Nanuq Lake
		G42	West side of road, between Lake M9525 and Nanuq Lake
		G43	East side of road, between Lake M9525 and Nanuq Lake
	CD4 Pad	G19	South side of CD4 pad, north side of Lake L9324
		G20	West side of CD4 pad, east side of Tapped Lake
CD5 Road	Culverts	G30	South side of road, east of Lake L9341
		G31	North side of road, east of Lake L9341
		G34	South side of road, west of Lake L9341
		G35	North side of road, west of Lake L9341
		G36	South side of road, east of Nigliagvik Channel
		G37	North side of road, east of Nigliagvik Channel
		S1	South side of road, between Oil Lake and Lake MB0301, outside of the CRD
		S1D	North side of road, between Oil Lake and Lake MB0301, outside of the CRD
	Lake L9323 Bridge/ CD5 Bridge #1	G24	Northeast side of Lake L9323, 200-ft upstream of bridge centerline
		G25	Northeast side of Lake L9323, 310-ft downstream of bridge centerline
	Nigliq Bridge/ CD5 Bridge #2	G28	West side of Nigliq Channel, 2,600-ft upstream of bridge centerline
		G26	East side of Nigliq Channel, 200-ft upstream of bridge centerline
		G27	East side of Nigliq Channel, 160-ft downstream of bridge centerline
		G29	West side of Nigliq Channel, 2,300-ft downstream of bridge centerline
	Lake L9341 Bridge/ CD5 Bridge #3	G32	West side of Lake L9341, 180-ft upstream of bridge centerline
		G33	West side of Lake L9341, 300-ft downstream of bridge centerline
	Nigliagvik Bridge/ CD5 Bridge #4	G38	East side of Nigliagvik Channel, 350-ft upstream of bridge centerline
		G39	East side of Nigliagvik Channel, 300-ft downstream of bridge centerline
GMT1/MT6 Road	Tinmiaqsiugvik Bridge	UB6.7	West side of the Tinmiqsiugvik channel 500-ft downstream of bridge centerline
		UB6.9	West side of the Tinmiaqsiugvik channel 600-ft upstream of bridge centerline

2. METHODS

2.1 Observations

The U.S. Geological Survey (USGS) operates a hydrologic gage station on the Colville River at Umiat, approximately 90 river miles (RM) upstream of the head of the CRD at MON1. Real-time stage data and photos from this site were used during spring breakup monitoring to help forecast the arrival of floodwater and timing of peak conditions in the CRD study area. Reconnaissance flights to Ocean Point and the confluences of the Anaktuvuk River and the Chandler River assisted in tracking the progression of floodwater as breakup progressed.

Field data and observations of breakup progression, floodwater 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). Each photo was geotagged with the latitude and longitude, date, and time. The photo location is referenced to the World Geodetic System of 1984 horizontal datum. Additional photos were collected in 15-minute intervals via game cameras installed at MON9/HDD West and on the west bank of the Nigliq Bridge, which provided time-lapse observations of the East Channel and the Nigliq Channel respectively.

UMIAQ provided Hägglund track vehicle support to access gage stations during setup and before a helicopter was onsite at Alpine (Photo 2-2). Soloy Helicopters, LLC provided helicopter support to access CRD gage stations, and Alpine Environmental Coordinators provided a pickup truck to access Alpine facilities monitoring locations.

Photo 2-1: Field crew recording observations during site visit; May 31, 2020

Photo 2-2: Hägglund track vehicle transporting crew to Nigliagvik channel; May 14, 2020

2.2 Water Surface Elevations

HYDROLOGIC STAFF GAGES

Water surface elevation (WSE) data was collected using hydrologic staff gages (gages) and pressure transducers (PTs) installed at monitoring locations. Gages are read during site visits and are used to verify the data collected on fixed intervals by the pressure transducers. Site visits were performed as needed and 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 installed or rehabilitated as needed in the previous fall and re-surveyed prior to spring 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 by UMIAQ. The survey is used to determine if correction factors must be applied to adjust elevations during flooding conditions. Physical adjustments are made annually by UMIAQ 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 (Photo 2-3) or attached to pipeline vertical support members (VSMs).
2) **Indirect-read gages** do not directly correspond to a BPMSL elevation. The gage elevations were surveyed relative to a known benchmark elevation to determine a correction. The correction is applied to the gage reading to obtain the elevation in feet (ft) BPMSL.

Indirect-read gage stations consist of one or more gage assemblies positioned perpendicular to the waterbody or road. Each indirect-read gage assembly 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 0.01 feet between 0.00 to 3.33-ft (Photo 2-4).

Photo 2-3: Direct-read gage G3 along the CD2 road; May 13, 2020

Photo 2-4: Indirect-read gages at G38; May 27, 2020

Alpine facilities gage stations were established at pads, along roads, and at drinking water source Lakes L9313 and L9312. Paired gages along the access roads captured water levels on the upstream and downstream side of drainage structures to determine stage differential.

The CRD gage stations were established throughout the delta at locations of hydrologic importance. The number of gage assemblies per station is dependent upon site specific conditions, primarily slope of the channel bank and overbank. In locations where terrain elevation varied by more than 3 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 1 foot. Individual gage assemblies were identified with alphabetical designations beginning with "A" representing the location nearest to the stream. High water marks (HWMs) were measured by applying chalk on the angle iron gage supports or VSMs and measuring the wash line (Photo 2-5).

Photo 2-5: Observing and recording a high water mark on gage G38-C; May 30, 2020

PRESSURE TRANSDUCERS

Pressure transducers were used at select gage stations to supplement gage measurements and provide a continuous record of WSE when the water column is above the PT sensor (Photo 2-6). The PTs are designed to collect and store pressure and temperature data at discrete pre-set intervals. The PTs were programmed to collect data at 15-minute intervals beginning mid-May. Each PT was housed in a small perforated galvanized steel pipe and secured to the base of the gage assembly nearest to the channel via hose clamps. The PTs record the absolute pressure of the atmosphere and water column above the PT. Atmospheric pressure was accounted for using barometric (Baro) PTs, installed at two locations in the CRD (Photo 2-7). The depth of water above the PT sensor was calculated by subtracting the atmospheric pressure from the measured absolute pressure. During data processing, the PT measurements were adjusted to WSE readings recorded at the staff gages.

Secondary PTs were installed to validate and backup the primary PT data at locations where discharge is calculated. The PT setup and testing methods are detailed in Appendix B.

Photo 2-6: Installation of PT on staff gage MON9D-A; May 8, 2020

Photo 2-7: Baro at MON9/East Channel HDD; May 14, 2020

2.3 Discharge

MEASURED DISCHARGE

Discharge was measured as close to observed peak stage at the following drainage structures conveying flow:

- Nigliq Bridge/CD5 Bridge #2
- Nigliagvik Bridge/CD5 Bridge #4
- Tinmiaqsiugvik Bridge
- CD2 Road Short Swale Bridge
- CD2 Road Long Swale Bridge
- CD2, CD4, and CD5 Road Culverts

A discharge measurement at MON1 was planned for May 29, after the downstream ice jams released and backwater at MON1 was relieved. However, due to dense fog on the morning of May 29 grounding the helicopter and preventing access to the site, the measurement was not attempted. Water levels had dropped considerably the following days and a discharge measurement was determined to be of little value at the lower flows. Discharge was not measured at the Lake L9323 Bridge/CD5 Bridge #1 or the Lake L9341 Bridge/CD5 Bridge #3 because either ice was present at the crossing, or the channel was only hydraulically connected for a brief period.

Flow depth and velocity were measured at the Nigliq, Tinmiaqsiugvik, CD2 Road Long Swale, and CD2 Road Short Swale bridges using a Price AA current meter suspended by cable with a sounding weight following USGS midsection procedures for measuring discharge (USGS 1982 [Photo 2-8]). Culvert flow depth and velocity were measured using a Hach flow meter attached to a wading rod following USGS velocity/area procedures for measuring discharge (USGS 1968 [Photo 2-9]). Discharge at the Nigliagvik Bridge was measured using a tethered acoustic doppler current profiler (ADCP) following USGS ADCP measurement procedures (USGS 2005). Measured discharge methods are further detailed in Appendix C.

Photo 2-8: Measuring discharge at the CD2 Road Short Swale Bridge; May 29, 2020

Photo 2-9: Measuring discharge at a culvert along the CD2 road; May 28, 2020

PEAK DISCHARGE

Discharge was calculated using indirect methods and observed WSEs to determine the timing and magnitude of peak discharge. When possible, these results were calibrated with a direct discharge measurement by adjusting the channel roughness factor (manning's n). Under open channel conditions, peak discharge typically occurs at the same time as peak stage; however, discharge in the CRD is typically affected by ice and snow during peak conditions. This often yields a lower discharge than an equivalent stage under open water conditions.

Discharge was calculated and peak discharge was determined at the following locations:

- Colville River (MON1)
- Colville River East Channel (MON9)
- L9323 Bridge/CD5 Bridge #1
- Nigliq Bridge/CD5 Bridge #2
- Nigliagvik Bridge/CD5 Bridge #4
- CD2 Road Long Swale Bridge
- CD2 Road Short Swale Bridge
- CD2 road culverts associated with gages G3/G4
- CD2 road culverts associated with gages G6/G7
- CD2 road culverts associated with gages G12/G13
- CD4 road culverts associated with gages G15/G16
- CD4 road culverts associated with gages G17/G18

The quality of the peak discharge results is rated either good, fair, or poor based conditions at the time. 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, calculations of discharge are presented with the quality ratings described in Table 2.1. Detailed discharge calculation methods are presented in Appendix C.

Table 2.1: Discharge 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

2.4 Post-Breakup Conditions Assessment

Alpine facilities roads, pads, and drainage structures were assessed immediately following breakup flooding. 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 the CD5 development per USACE Permit POA-2005-1576 Special Condition #1 which requires the MP-AMS (Michael Baker and ABR 2013).

PIER SCOUR

The objective of measuring pier scour is to monitor the progression of pier scour at bridge piers during and after breakup flooding. Pier scour measurements satisfy the requirement for annual pier scour measurements during spring breakup and other large flood events at the Nigliq Bridge and Nigliagvik Bridge (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, real-time soundings are collected during peak flood conditions.

Photo 2-10: Installation of real-time pier scour equipment on the Nigliagvik Bridge; May 26, 2020

The Nigliq Bridge is supported by two bridge abutments (abutments 1 and 9) and seven bridge piers (piers 2 through 8) with numbers increasing west to east. 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 superstructure. Nigliq Bridge piers 2 through 5 are located within the main portion of the Nigliq Channel.

The Nigliagvik Bridge is supported by two bridge abutments (abutments 1 and 5) and three bridge piers (piers 2 through 4) with numbers increasing west to east. 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. Appendix E presents a plan view of each bridge (UMIAQ 2020a).

A real-time pier scour monitoring system was installed on the bridge piers most susceptible to scour (Photo 2-10). The systems were installed on piers 2 through 5 of the Nigliq Bridge in spring of 2016, and pier 3 of the Nigliagvik bridge in spring of 2015. Scour depths were measured using a single beam sonar installed inside a steel pipe casing welded to the downstream pile of the selected piers. 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 cellular based telemetry system provided remote access to the sonar measurements. A comprehensive post-breakup survey of the scour holes around the bridge piers within the main channel of the Nigliq Bridge and Nigliagvik Bridge was also conducted. Contour plots around the piers are provided in Appendix E.

BANK EROSION

The objective of the bank erosion study is to monitor bank migration upstream and downstream of the Nigliq Bridge and Nigliagvik Bridge. This work supports the requirements for visual inspection and documentation of tundra as well as bank erosion monitoring. A detailed edge-of-bank delineation was surveyed in 2013 to establish pre-construction baseline data. Bank surveys were performed annually between 2016 and 2019 (UMIAQ 2016, 2017c, 2018, and 2019). After 2019, the bank surveys are performed every five years or following large flood events having a recurrence interval of 10-years of more (Michael Baker and ABR 2013). The 2020 flood had a stage recurrence interval that was greater than 10-years around the CD5 infrastructure, therefore the bank erosion surveys were completed. Maximum and average rates of erosion between 2013 and 2020 were determined for each bank.

BATHYMETRY

A. Bathymetry at Bridges

Topographic and bathymetric baseline surveys upstream and downstream of the Nigliq Bridge, Nigliagvik Bridge, and Lake L9341 Bridge were performed by UMIAQ in August 2013, prior to construction of the bridges. The pre-construction survey included two transects surveyed upstream and two transects surveyed downstream of the Nigliq Bridge (Transects 8-11), the Nigliagvik Bridge (Transects 25-28), and the Lake L9341 Bridge (Transects 36-39). These transects have been surveyed annually since 2013 (Michael Baker and ABR 2013).

B. Channel Bathymetry

Topographic and bathymetric baseline post-breakup surveys of the Nigliq Channel and Nigliagvik Channel were performed by UMIAQ in August 2013, prior to construction of the bridges. The pre-construction survey included 15 transects surveyed along the Nigliq Channel upstream and downstream of the Nigliq Bridge (Transects 1-15) and 20 transects surveyed at the Nigliagvik Channel upstream and downstream of the Nigliagvik Bridge (Transects 16-35). These transects were surveyed post-construction in 2016 and annually through 2019. After 2019, the transects will be surveyed every five years (Michael Baker and ABR 2013). The next channel bathymetry survey is scheduled for 2024.

2.6 Ice Road Crossings Breakup

Aerial observations of the hydraulic effects of winter ice road crossings during breakup were documented at locations outlined in Figure 2-1.

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Date:	12/01/2020	Scale:	1 Inch = 2 Miles
Drawn:	JEM	Project:	178181
Checked:	GCY	File:	2020_Ice_Monitoring.mxd

Monitoring Location
Gravel Road
Existing Gravel Structure
Ice Road
Stream
Ice Pad

Imagery from CPAI & Maxar 2019

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2020 SPRING BREAKUP COLVILLE RIVER DELTA

Ice Structure Monitoring Locations

FIGURE 2.1

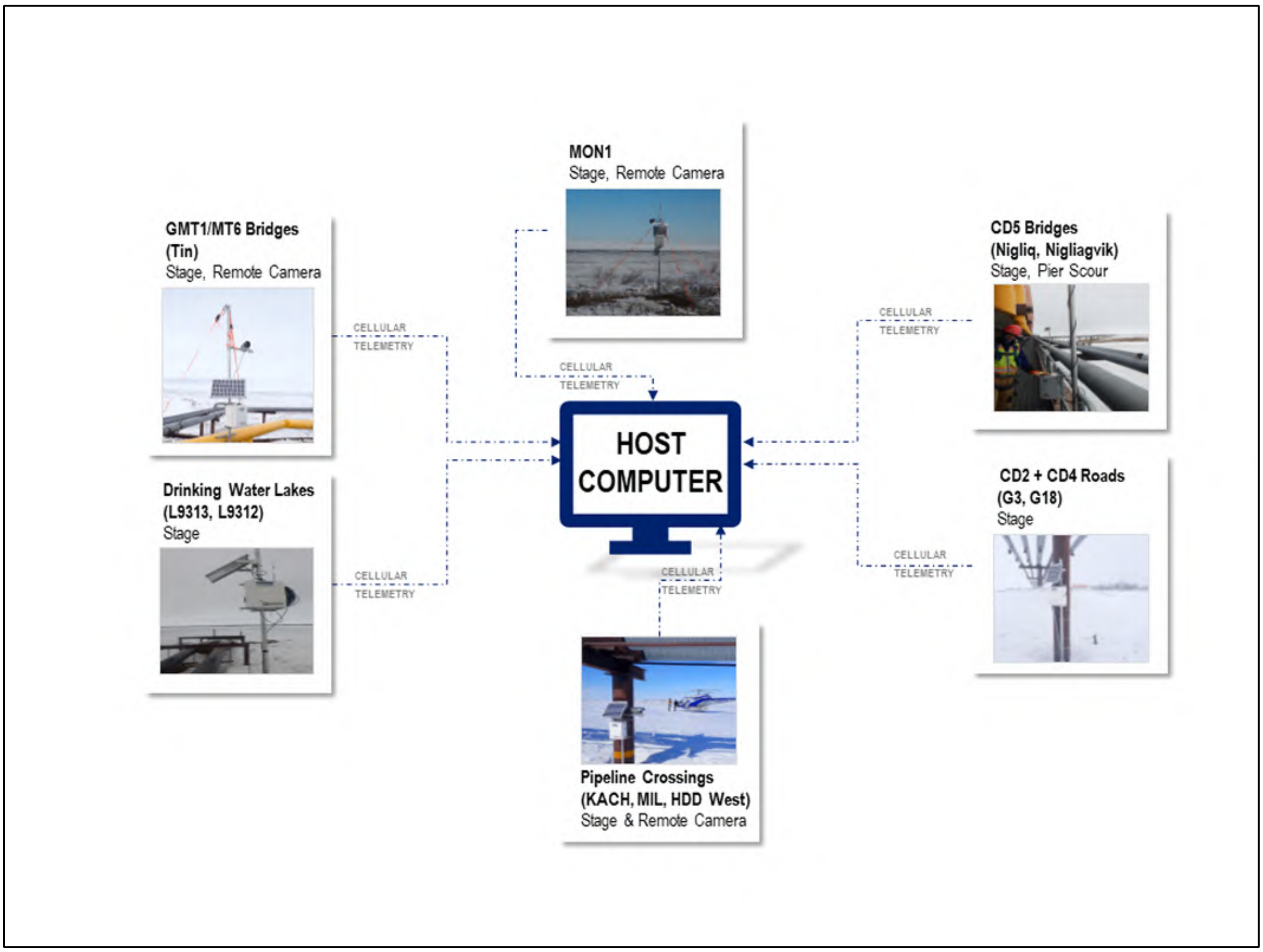
2.7 Real-Time Flood Monitoring Network

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 flooding (Table 2.2). The RTFM Network has the following components: remote cameras to monitor stage and river conditions, sensors to monitor stage, barometric pressure and real-time bridge pier scour discussed in Section 2.5, dataloggers and telemetry systems to collect and transmit data, and a host computer to receive the transmitted data (Figure 2-2). The ability to remotely monitor stage and scour helps reduce helicopter traffic, allows for round-the-clock monitoring of conditions, and provides an interactive tool for collecting hydrologic data when helicopter travel is restricted because of weather, maintenance, or other issues. In addition, a network of real-time monitoring stations at critical locations around 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	Gage Station	Real-Time Data
Colville River	• MON1U • MON1C • MON1D	Stage River conditions and staff gage measurements via remote camera images
Alpine Drinking Water Lakes	• L9312 (G9) • L9313 (G10)	Stage
CD2 Road Swale Bridges	• G3	Stage
CD4 Road/CD4 Pad	• G18	Stage Barometric pressure
CD5 Road	• Nigliq Bridge • Nigliagvik Bridge	Stage Pier scour
GMT1/MT6 Road	• Tinmiaqsiugvik Bridge	Stage River conditions via remote camera images
Alpine Pipeline Crossings	• Miluveach River • Kachemach River • HDD West Bank	Stage River conditions via remote camera images

Figure 2-2: RTFM Network Schematic



REMOTE CAMERAS

Remote camera systems were installed at the MON1 monitoring locations (Photo 2-11). A high-resolution digital camera was programmed to take pictures at 15-minute intervals. The camera collected wide-angle photographs of the Colville River to document conditions and monitor ice jam formation and releases in the MON1 reach. Additionally, the cameras' zoom capabilities allowed hydrologists to remotely read staff gages for validating PT data. This proved extremely valuable during peak stage when hydrologists were unable to land at the MON1 monitoring locations due to helicopter weather delays. Remote cameras were also installed to observed conditions at the Tinmiaqsiugvik Bridge and at the Alpine Pipeline crossings (HDD West Bank, Miluveach River, and Kachemach River).

Photo 2-11: Remote camera setup at HDD West bank; May 16, 2020

SENSORS

Pressure transducers were programmed to read and record water levels and barometric pressure at 15-minute intervals. The RTFM PTs were installed at the head of the CRD (MON1), at MON9, along the CD2 and CD4 road (G3 and G18), at the Nigliq and Nigliagvik Bridges (G45 and G46), at the Alpine drinking water lakes (G9 and G10 [Photo 2-12]), at the Tinmiaqsiugvik Bridge, and at the Alpine Pipeline crossings (HDD West bank, Miluveach River, and Kachemach River). Real-time pier scour sensors were also installed on the Nigliq and Nigliagvik Bridges. Pier scour was measured using single beam sonars (Photo 2-13) at 30-minute intervals.

Photo 2-12: Remote stage monitoring equipment at Lake L9313 (G10); May 15, 2020

Photo 2-13: Pier scour sonar equipment on the Nigliagvik; May 26, 2020

DATALOGGERS & TELEMETRY

Onsite dataloggers were programmed to interface with the PTs and sonars. 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 at set intervals for data transmission. Systems were powered with 12v DC batteries and charged with solar panels (Photo 2-14).

Photo 2-14: Installation of telemetry and solar/battery RTFM equipment at the Tinmiaqsiugvik Bridge; May 13, 2020

HOST COMPUTER, DATA ACCESS, & NOTIFICATIONS

A host computer monitored the cellular modem IP addresses offsite and received data from the dataloggers once the connection was established. 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 to the Michael Baker project manager and Alpine Operations personnel for immediate assessment.

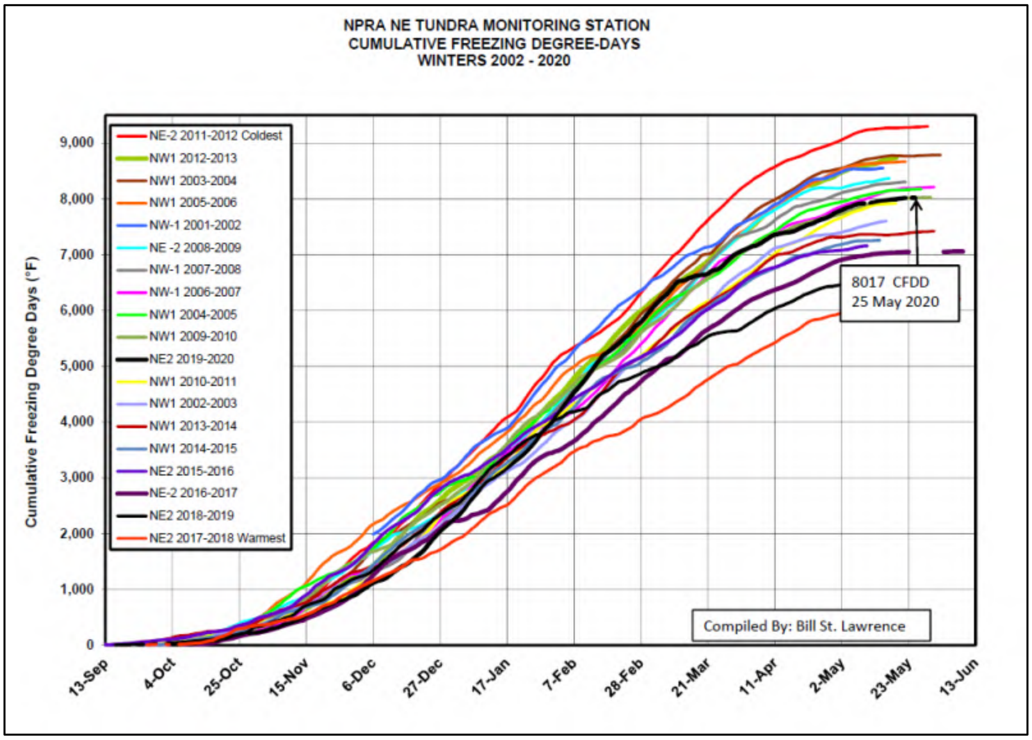
2.8 Flood & Stage Frequency Analyses

Peak discharge at MON1 is assigned a flood recurrence interval annually 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 using the basis of design flood frequency analysis (Michael Baker 2018). Peak stage at select monitoring locations was compared to historical stage data and results from the 2D model. A stage recurrence interval was assigned to this year's peak stage.

3. OBSERVATIONS

3.1 General Climatic Summary

According to cumulative freezing degree-days (CFDD) measured at the National Petroleum Reserve Alaska (NPR-A) tundra monitoring station, the 2019-2020 (September – May) winter temperatures were within the normal range of the historical record for the past 18 years (Graph 3.1, ICE 2020).



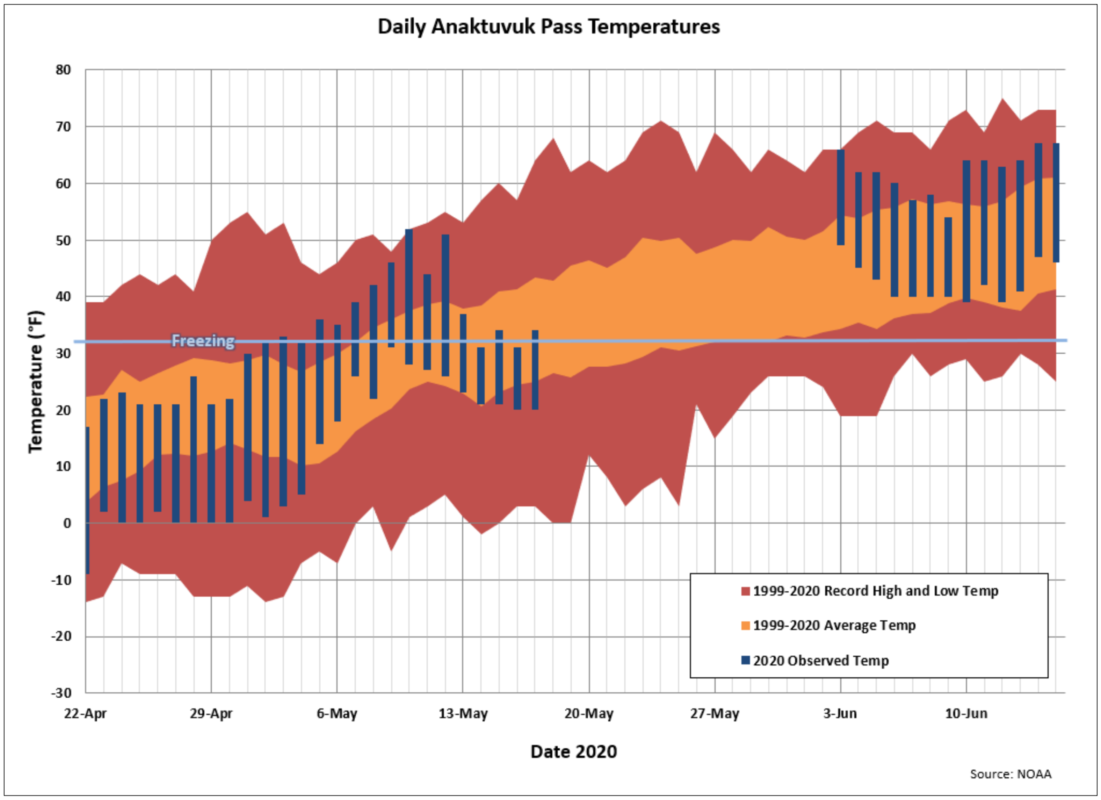
Graph 3-1: NPR-A N. Tundra Monitoring Station, CFDD, Winters 2002-2020 (ICE 2020)

Snowpack data for the North Slope was not available for the 2019-2020 winter season through the Natural Resource Conservation Service, but general observations indicate snowpack was at or above normal levels in the lower Colville River drainage basin.

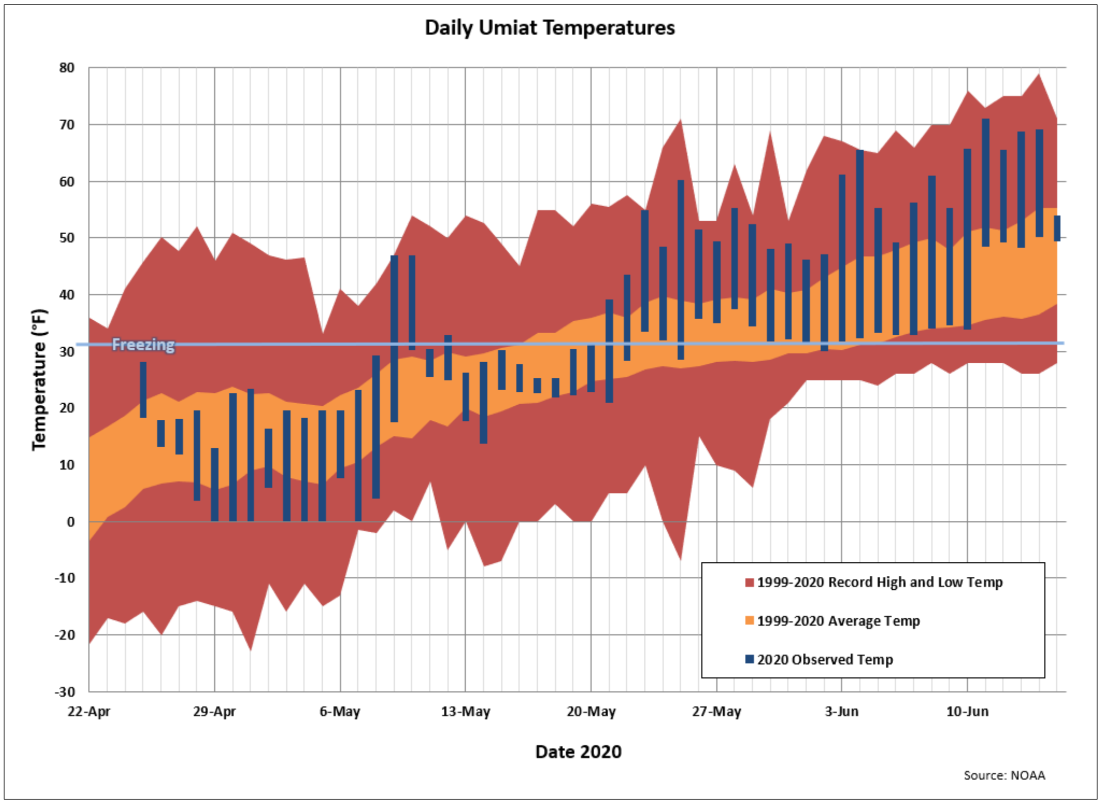
Air temperatures were generally average to lower than average throughout the Colville River drainage prior to the start of the spring breakup season. At the southern-most extent of the drainage (at Anaktuvuk Pass in the Brooks Range), a brief warm period in early to mid-May saw temperatures reach 50 degrees which initiated runoff in the upper reaches of the watershed. A similar brief warm period was observed in the foothills at Umiat. This warming event was followed by a 10-day period where the daily highs at Umiat did not exceed freezing. Temperatures at Umiat started to consistently exceed freezing around May 21 and daily minimum temperatures began to consistently exceed freezing after May 25.

Temperatures measured in Nuiqsut followed a similar trend to temperature upriver but were slightly cooler, experiencing a brief period above freezing in early May. Daily high temperatures above freezing began on May 22 and lasted throughout breakup monitoring, with daily minimum temperatures remaining below freezing throughout the monitoring period.

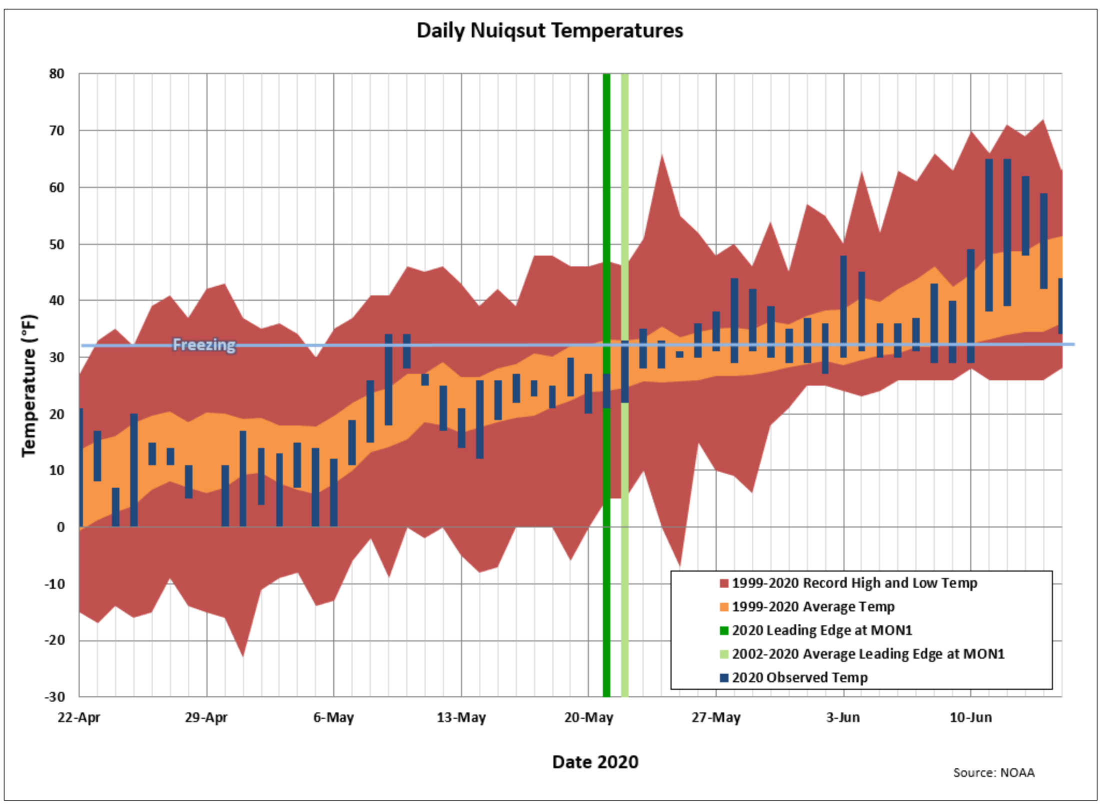
Graph 3.2, Graph 3.3, and Graph 3.4 illustrate daily high and low ambient air temperatures recorded in Anaktuvuk Pass, Umiat, and Nuiqsut, respectively, superimposed on the average and record daily highs and lows during the breakup monitoring period (National Oceanic and Atmospheric Administration [NOAA] 2020).



Graph 3-2: Anaktuvuk Pass Daily High and Low Ambient Air Temperatures



Graph 3-3: Umiat Daily High and Low Ambient Air Temperatures



Graph 3-4: Nuiqsut Daily High and Low Ambient Air Temperatures and MON1 Leading Edge

3.2 General Breakup Summary

On May 18, clear, non-turbid water with no visible flow was first observed in the CRD. A distinct leading edge was not apparent, rather discontinuous stretches of local melt on top of channel ice and overflow along the banks was observed in the distributary channels. These conditions were consistent in the CRD through May 20. Inclement weather prevented aerial observations to identify any leading edge upstream of the CRD. On May 21, a distinct leading edge of floodwater was observed near the Sakoonang Channel bifurcation (Photo 3-1), but visible flow wasn't observed until 2 RM upstream of Ocean Point.

On May 22, stage was rising in the CRD and the leading edge of floodwater in the East Channel had progressed to the Tamayayak Channel bifurcation. The leading edge of floodwater in the Nigliq Channel was observed near the Putu Channel bifurcation. Channel ice was intact throughout the CRD and upstream of MON1 through Horseshoe Bend. Conditions were similar through May 23, as stage continued to rise as floodwater entered distributary channels, lifting the channel ice from the banks (Photo 3-2).

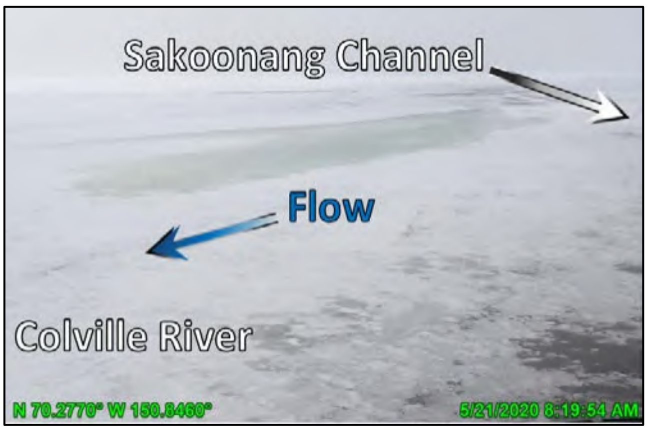


Photo 3-1: Approximate leading edge near the Sakoonang Channel bifurcation, looking south (upstream); May 21, 2020

Photo 3-2: Lifted channel ice near the Horseshoe Bend upstream of MON1, looking south (upstream); May 23, 2020

On May 26, a large ice jam approximately 10-miles long was observed beginning at the Horseshoe Bend (Photo 3-3). Upstream of this jam, stage approached bankfull and overbank flooding was present in low-lying areas (Photo 3-4). In the afternoon, stage began to recede at MON1, indicating backwater was developing behind the ice jam upstream of MON1. In the morning on May 27, this ice jam progressed into the delta and re-formed in the East Channel downstream of the HDD crossing, near the Tamayayak Channel bifurcation (Photo 3-5). Additional ice jams were observed in the Nigliq Channel upstream of Nuiqsut (Photo 3-6) and in the Sakoonang Channel near the East Channel bifurcation. Backwater rapidly accumulated behind the East Channel ice jam. Ice jams in the Nigliq and Sakoonang Channels obstructed flow into their respective channels, forcing backwater into the eastern floodplain of the CRD (Photo 3-7).

On May 28, backwater and ice continued to accumulate behind the East Channel ice jam causing further inundation of the eastern floodplain (Photo 3-8). Stage peaked at MON1 at midday on May 28. Peak stage in 2020 was the second highest stage recorded at MON1 and was only exceeded during the 2015 flood event.

Photo 3-3: Colville River ice jam downstream extent at the Horseshoe Bend, looking north; May 26, 2020

Photo 3-4: Colville River ice jam upstream extent, 14 RM upstream from MON1, looking north (downstream); May 26, 2020

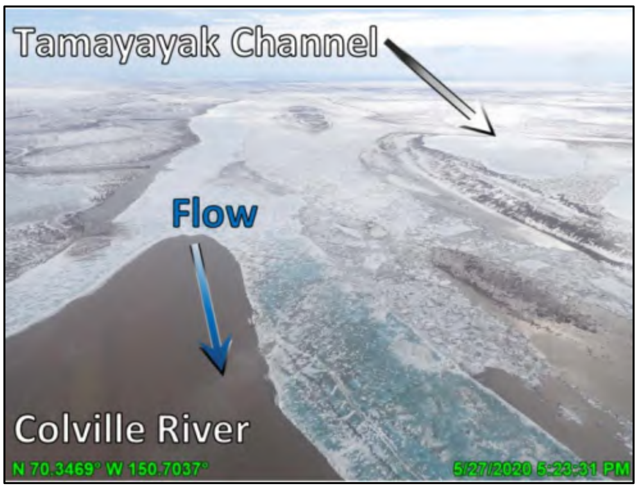


Photo 3-5: East Channel ice jam downstream extent near the Tamayayak Channel bifurcation, looking south (upstream); May 27, 2020

Photo 3-6: Ice jam in the Nigliq Channel and Putu Channel bifurcations, looking west (downstream - Nigliq); May 27, 2020

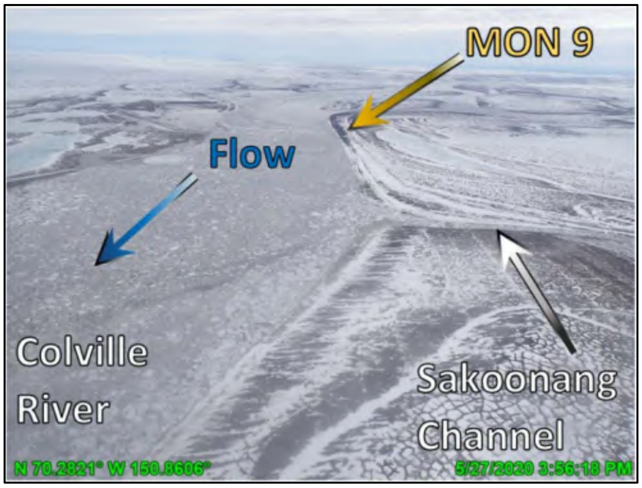


Photo 3-7: Ice jamming into Sakoonang and Putu Channels, looking south (upstream); May 27, 2020

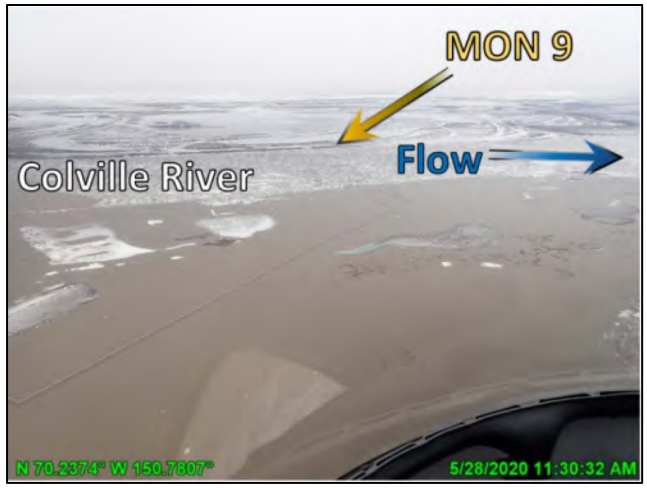


Photo 3-8: Backwater near the east HDD crossing in the East Channel, looking west (downstream); May 28, 2020

On the morning of May 29, the ice jam in the Nigliq Channel released resulting in a rapid rise in water levels in the Nigliq Channel and around Alpine facilities (Photo 3-9). A concurrent steady drop in water levels was observed in the East Channel as backwater was relieved through the Nigliq Channel. Water levels peaked around facilities on May 29 and remained below the top of all roads and pads. The East Channel ice jam at the Tamayayak Channel bifurcation released at approximately 5:00 PM on May 29. By May 30, water levels in the East Channel and around Alpine facilities were steadily receding (Photo 3-10).

Discharge was measured at bridge and culvert crossing locations around Alpine facilities between May 29 and June 1. Stage continued to decrease across the CRD through the rest of the monitoring period (Photo 3.11). Open water extending to the coast in all distributary channels was confirmed on June 2 (Photo 3.12).

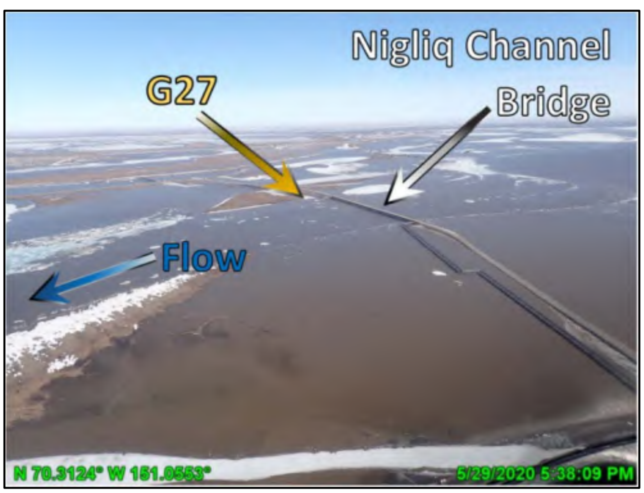


Photo 3-9: Flooding at the Nigliq Channel Bridge near peak stage, looking east (upstream); May 27, 2020

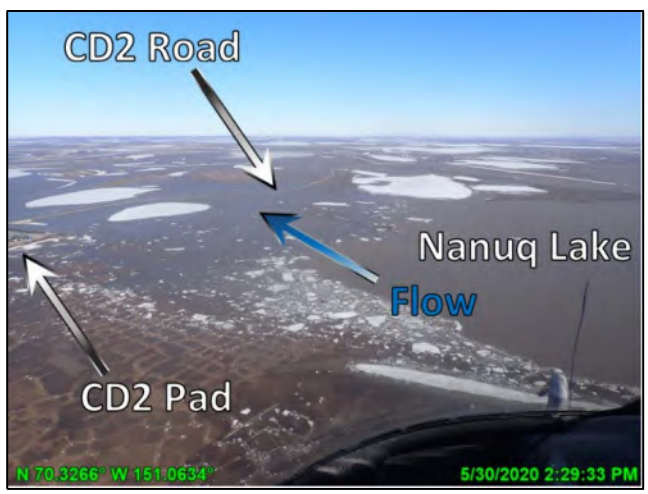


Photo 3-10: Stranded ice along the banks of the Niqliq channel as water levels recede, looking northeast; May 30, 2020

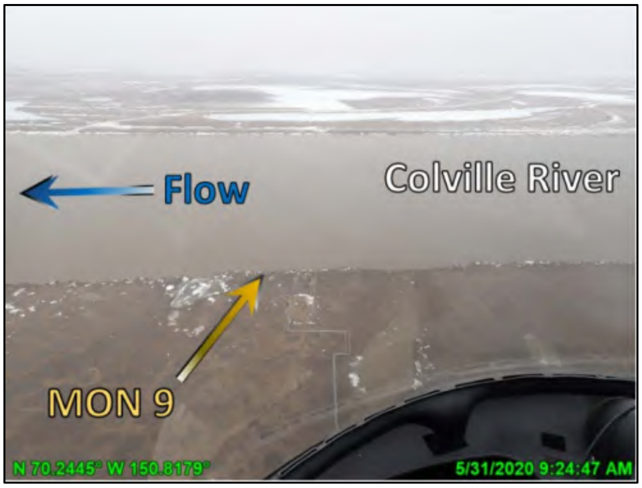


Photo 3-11: Receding stage near the east HDD crossing in the East Channel, looking west; May 31, 2020

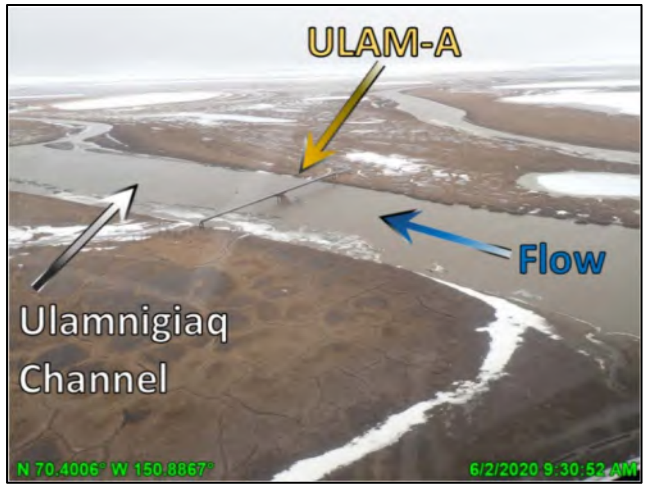
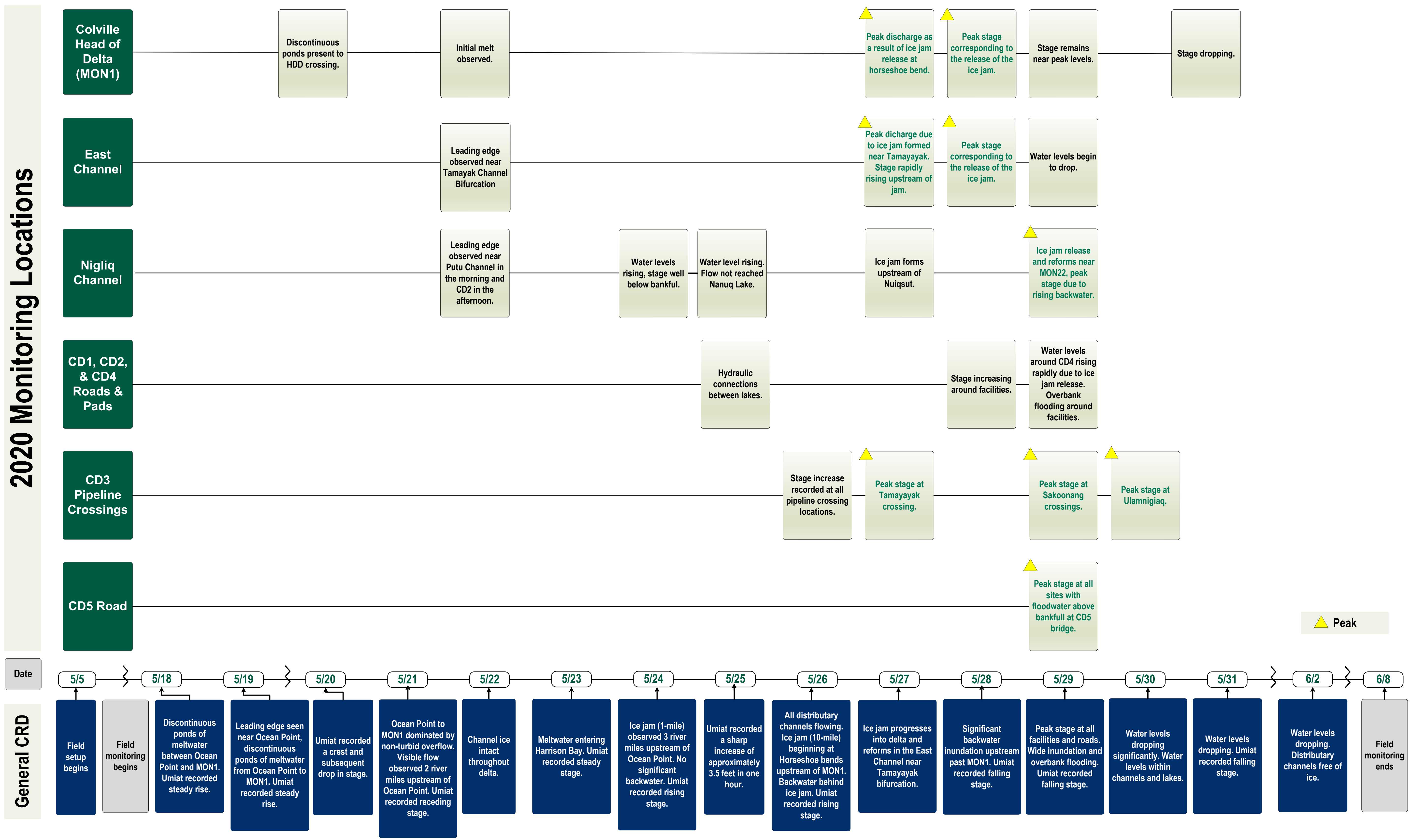


Photo 3-12: Ice-free channel near the Ulamnigiaq Bridge, looking north (downstream); June 2, 2020

In general, peak stage was observed around the CRD and Alpine facilities from May 28 to May 29. During peak conditions, overbank flooding and floodplain inundation were widely observed around Alpine. Most hydraulic connections between lakes and channels were fully established, including the recharge of both Alpine Drinking Water Lakes L9312 and L9313. Overall, ice jamming effects in the CRD were pronounced and widely distributed, as was the associated backwater and flooding. The 2020 spring breakup in the CRD was characterized as a short-term, dynamic flood event. The general breakup timeline is presented in Figure 3.1.

Figure 3.1: Spring Breakup Hydrologic Timeline



4. STAGE & DISCHARGE

Table 4.1 contains a summary of peak stage, measured discharge (in cubic ft per second [cfs]), and peak discharge at each gage station.

Table 4.1: Peak Stage, Measured Discharge, and Peak Discharge Summary

Monitoring Location	Monitoring Location Description	Gage Station	Peak Stage		Measured Discharge			Peak Discharge		
			Stage ft BPMSL	Date & Time	Discharge cfs	Stage[1] ft BPMSL	Date & Time	Discharge cfs	Stage ft BPMSL	Date & Time
Colville River	Upstream of Anaktuvuk & Chandler River Confluences	Umiat[3]	56.76	5/27, 3:15pm	91,000	54.13	5/30, 2:30pm	147,000	56.73	5/27, 3:00pm
CRD Monitoring Locations										
Colville River	Head of the CRD	MON1U	21.30	5/28, 12:00pm	Not measured because of access restrictions			341,000	17.77	5/27, 11:45am
		MON1C	21.41	5/28, 11:45am					17.53	
		MON1D	21.21	5/28, 11:45am					16.97	
Colville River East Channel	East Channel Distributary	MON9	20.34	5/28, 1:30pm				238,000	14.36	5/27, 12:15pm
		MON9D	19.10	5/28, 10:45pm					14.07	
		MON35	5.02	5/30, 8:30am						
Nigliq Channel	Nigliq Channel Distributary	MON20	14.55	5/29, 11:15am	See Nigliq Bridge Below			See Nigliq Bridge Below		
		MON22	11.61	5/29, 4:15pm						
		MON23	9.13	5/29, 4:15pm						
		MON28	3.80	5/29, 6:00pm						
Alpine Facilities Monitoring Locations										
CD1 Pad & Drinking Water Lakes	Lake L9312	G9	10.08	5/29, 9:00pm						
	Lake L9313	G10	10.37	5/29, 7:15pm						
	CD1 Pad	G1	8.88	5/29, 8:30pm						
CD2 Pad & Road	Short Swale Bridge	G3	10.91	5/29, 6:30pm	2,460	9.92	5/29, 3:10pm	2,765	10.73	5/29, 6:30pm
		G4	9.47	5/29, 8:15pm		7.86			9.34	
	Long Swale Bridge	G3	10.91	5/29, 6:30pm	2,100	7.89	5/30, 12:40pm	2,868	10.73	5/29, 6:30pm
		G4	9.47	5/29, 8:15pm		7.69			9.34	
	Culverts	G3	10.91	5/29, 6:30pm	170	8.43	5/28 12:15pm	488	10.91	5/29 6:30pm
		G4	9.47	5/29, 8:15pm		8.10			9.30	
		G6	11.18	5/29, 6:45pm	297	8.95	5/28 10:15pm	691	11.18	5/29 6:45pm
		G7	9.51	5/29, 7:15pm		8.55			9.46	
		G12	11.13	5/29, 6:45pm	260	8.97	5/28 11:45am	756	11.20	5/29 6:45pm
		G13	9.31	5/29, 7:45pm		8.50			9.93	
	CD2 Pad	G8[4]	8.58	5/29, 4:45pm						
CD3 Pad & Pipeline	Pipeline Crossings	SAK	8.99	5/29, 9:00pm						
		TAM	8.47	5/27, 2:15pm						
		ULAM	7.37	5/30, 6:45am						
	CD3 Pad	G11[4]	8.02	5/28, 6:00pm						
CD4 Pad & Road	Culverts	G15	10.64	5/29, 7:15pm				1,180	10.04	5/29 11:00am
		G16	12.90	5/29, 12:30pm					12.74	
		G17	12.76	5/29, 12:30pm	340	10.38	5/29, 9:45am	750	12.73	5/29, 12:00pm
		G18	14.00	5/29, 12:45pm		10.93			13.99	
		G40	Unk	--						
		G41	Unk	--						
		G42	Unk	--						
		G43	Unk	--						
	CD4 Pad	G19[2]	14.15	5/29, 5:30pm						
		G20	13.55	5/29, 11:30am						
CD5 Road	Culverts	G30[2]	12.04	5/29 5:45pm						
		G31[2]	12.24	5/29 5:45pm						
		G34[2]	10.06	5/29, 3:15pm						
		G35[2]	10.34	5/29, 3:15pm						
		G36	Unk	--						
		G37	Unk	--						
	Lake L9323 Bridge (CD5 Bridge #1)	G24	12.43	5/29, 12:30pm				1,620	12.22	5/29 10:45am
		G25	12.24	5/29, 12:45pm					11.98	
	Nigliq Bridge (CD5 Bridge #2)	G28	12.51	5/29, 5:00pm	55,500	8.61	5/30, 1:30pm	100,500	12.15	5/29, 4:00pm
		G26	12.23	5/29, 5:00pm		8.10			11.83	
		G27	12.26	5/29, 4:45pm		8.13			11.90	
		G29	11.97	5/29, 5:15pm		8.00			11.72	
	Lake L9341 Bridge (CD5 Bridge #3)	G32	11.89	5/29, 5:45pm						
		G33[2]	12.36	5/29 5:45pm						
	Nigliagvik Bridge (CD5 Bridge #4)	G38	11.24	5/29, 7:00pm	1,700	7.00	5/31, 2:00pm	6,800	11.12	5/29 7:30pm
		G39	11.17	5/29, 4:30pm		7.04				
GMT-1 Road	Tinmiaqsiugvik Bridge	UB6.7	8.55	5/31 11:45pm	1,700	8.26	6/1 12:00pm	2,070	8.05	6/1 2:45pm
		UB6.9	8.59	5/31 11:30pm		8.34			8.17	

Notes:
1. Stage prior to discharge measurement
2. Peak stage date estimated. Peak stage based on HWM reading.
3. Data obtained from USGS Umiat gage station 15875000 and referenced to NAVD88 vertical datum
4. Reported value is a gage observation and not representative of peak stage

Gray cells indicate that discharge was not measured or calculated. Reasons for this vary but include that discharge data was not included in program scope, ice influence at discharge cross section during and after peak, or PT malfunction.

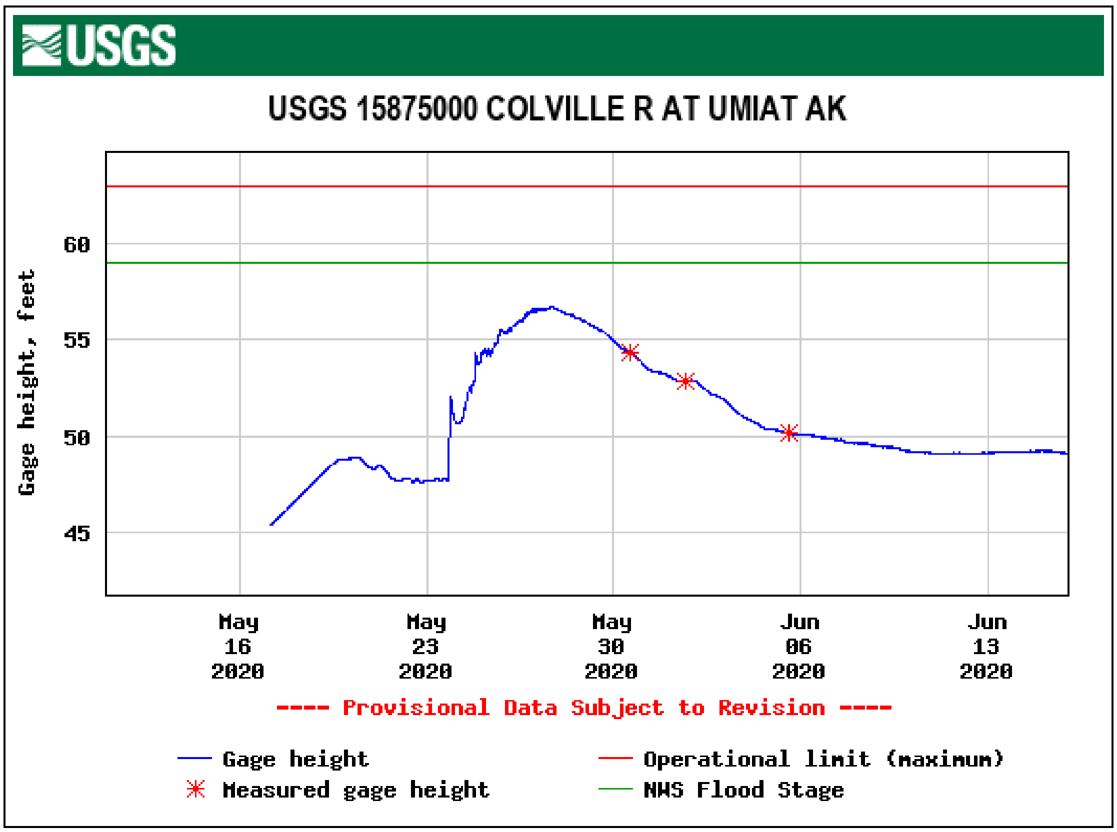
4.1 Colville River

UMIAT

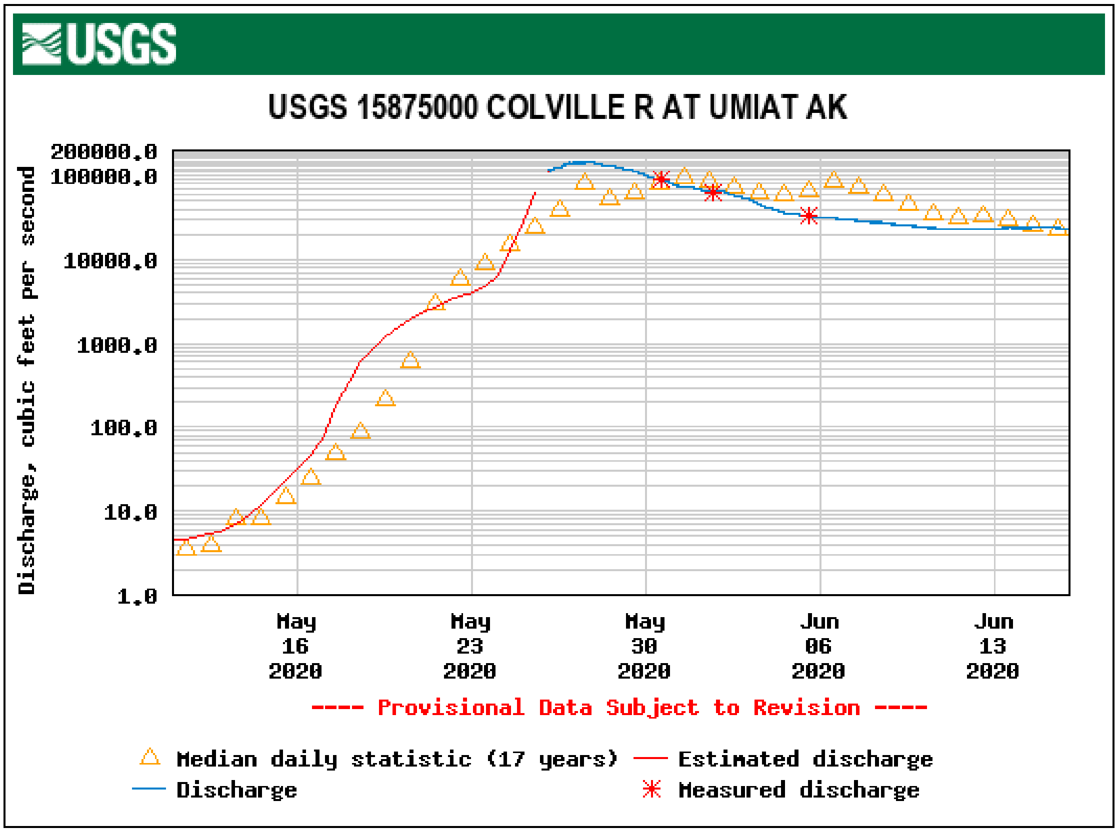
The USGS Umiat gage station 15875000 is located approximately 90 RM upstream of the CRD and is monitored throughout breakup. This real time data helps predict the timing of floodwater in the CRD. Umiat is upstream of the Chandler and Anaktuvuk River confluences and Umiat gage data does not account for the contribution from these two major tributaries. Due to local ice effects, distance, and tributaries between Umiat and the CRD, the magnitude of flooding at Umiat and in the CRD do not necessarily correlate.

The Umiat gage began measuring water levels on May 17. Observations from an overflight to Umiat on May 21 showed stage well below bankfull, with saturated snow and ice still present in the channel. Stage peaked on May 27 at 56.8 ft NAVD88. This is below the National Weather Service established flood stage of 59.0 ft NAVD88. Stage steadily receded to base summer conditions after peak stage was recorded.

The peak discharge of 147,000 cfs occurred near peak stage on May 27. Peak annual discharges at this location, with the exception of the lowest year of the 2002 to 2020 reporting period (2017), occur during spring breakup. Peak annual discharge values range from 82,000 cfs, recorded in August 2017, to 268,000 cfs, recorded in May 2015. USGS stage and discharge data, presented in Graph 4.1 and Graph 4.2, respectively, is provisional and subject to revision.



Graph 4-1: Colville River at Umiat Stage (USGS 2020)



Graph 4-2: Colville River at Umiat Discharge (USGS 2020)

HEAD OF THE DELTA

MON1 is located at the head of the Colville River Delta, where all flow is confined to a single channel, upstream of the Nigliq Channel bifurcation. Stage and discharge have been monitored at MON1 annually since 1992 and periodically since 1962. This location has the longest historical record of all CRD monitoring locations.

Spring breakup floodwater was initially observed at MON1 through aerial observations on May 22. On this day, the leading edge of floodwater in the East Channel was observed near the Tamayayak Channel bifurcation. Channel ice remained intact through the MON1 reach until May 27. On May 27, the upstream ice jam at the Horseshoe Bend released and the ice and accompanying backwater progressed through the MON1 reach, flushing out the intact channel ice (Photo 4-1). Peak discharge at MON1 occurred on May 27 and was the result of this upstream ice jam release (Photo 4-2). Ice jams then reformed downstream in the Colville River at the Nigliq bifurcation, and in the East Channel at the Tamayayak Channel bifurcation. Peak stage occurred on May 28 as backwater behind the East Channel and Nigliq Channel ice jams extended into the MON1 reach (Photo 4-3 through Photo 4-6). Stage remained elevated near peak levels until the morning of May 29 when it started steadily receding. This was likely attributed to the ice jam release at the Nigliq Channel bifurcation and the associated backwater relief. Stage continued to steadily recede until around 5:00 PM on May 29 when a sharp drop in stage occurred, likely corresponding with the East Channel jam releasing. Stage continued to recede until the end of spring breakup monitoring.

Discharge was not measured at MON1 because of inclement weather during peak conditions. Stage and discharge results at MON1 are presented in Graph 4.3. Site specific discharge data and plan and profile drawings are provided in Appendix C.

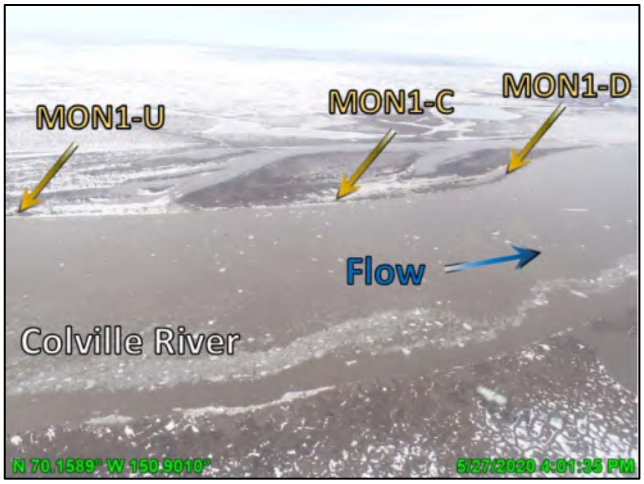


Photo 4-1: MON1 reach after channel ice flushed, looking northwest (downstream); May 27, 2020

Photo 4-2: RTFM photo of MON1C near peak discharge, looking east; May 27, 2020

Photo 4-3: RTFM photo of MON1C near peak stage, looking east; May 28, 2020

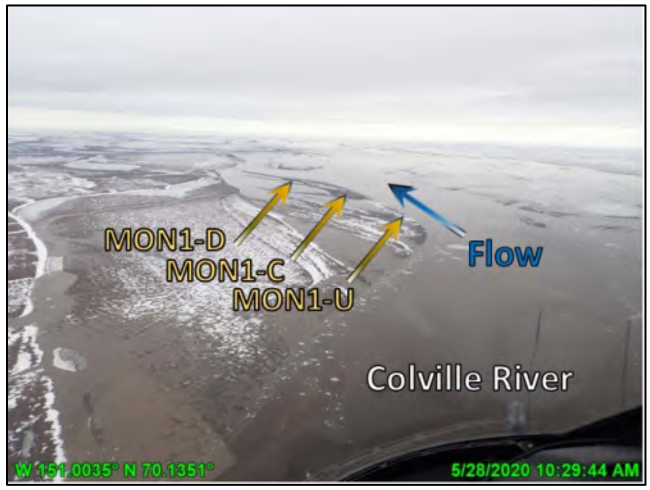


Photo 4-4: Peak Stage at the MON1 reach, looking north (downstream); May 28, 2020

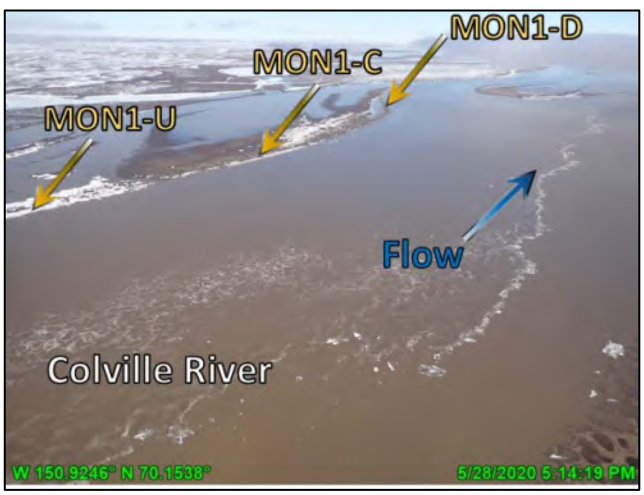


Photo 4-5: Overbank flooding near MON1, looking northwest (downstream); May 28, 2020

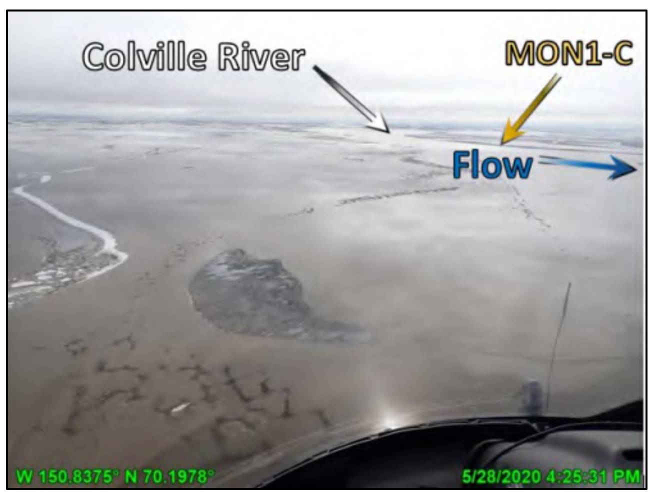
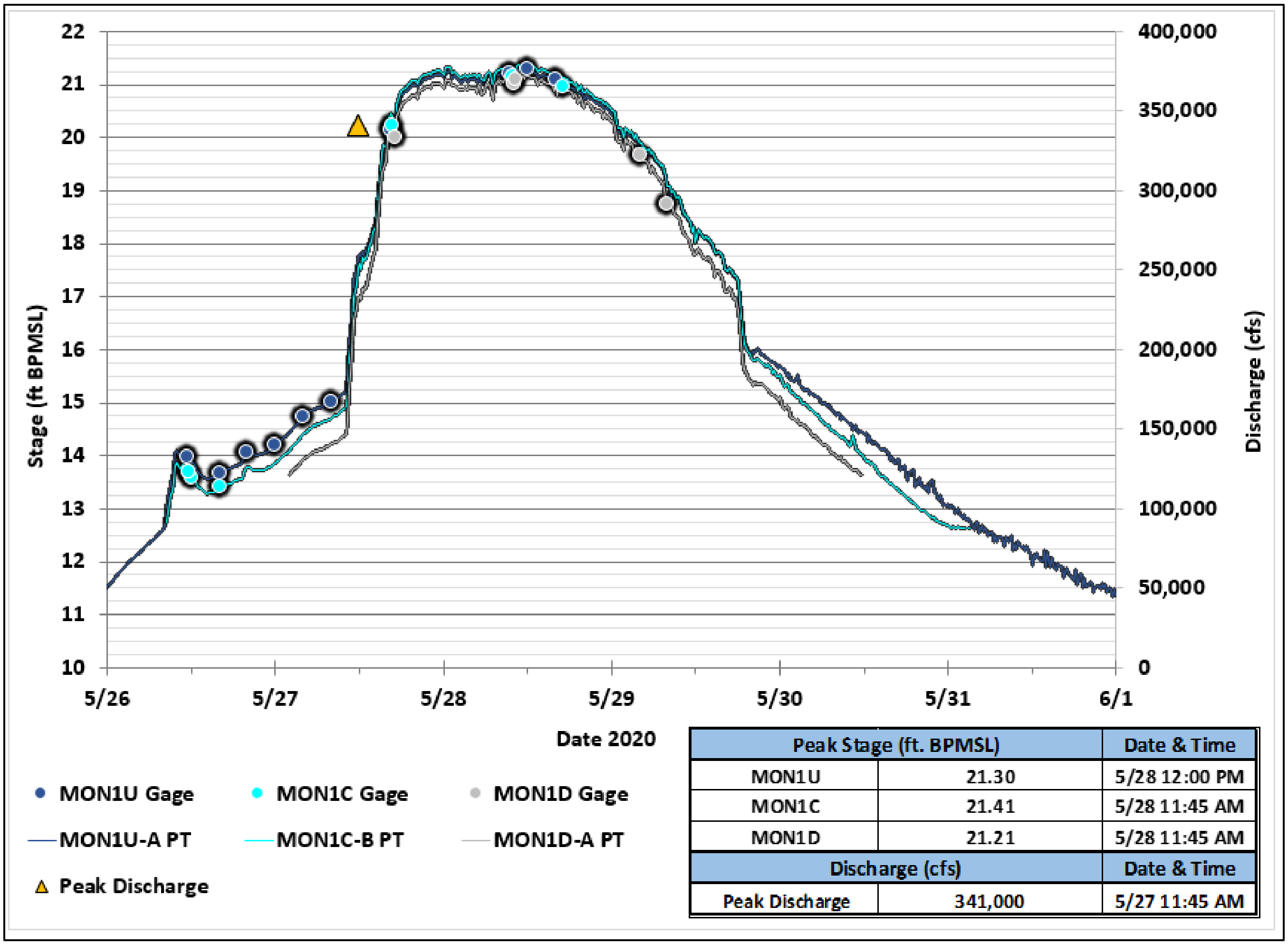


Photo 4-6: Widespread floodwater inundation in the eastern floodplain, looking south (upstream); May 28, 2020



Peak Stage (ft. BPMSL)		Date & Time
MON1U	21.30	5/28 12:00 PM
MON1C	21.41	5/28 11:45 AM
MON1D	21.21	5/28 11:45 AM
Discharge (cfs)		**Date & Time**
Peak Discharge	341,000	5/27 11:45 AM

Graph 4-3: Colville River at the Head of the Delta Stage & Discharge

4.2 Colville River East Channel

MON9 is located at the Colville HDD pipeline crossing. It has been monitored annually since 2005. Data is collected to estimate the distribution of discharge between the East Channel and Nigliq Channel and to monitor stage and ice affects at the HDD pipeline crossing. MON35 is located at the Helmericks Homestead and has been monitored for stage at the outer extents of the CRD since 1999.

The leading edge of floodwater in the East Channel was observed near the Tamayayak Channel bifurcation on May 22. PT data at MON9 and MON9D shows stage in the East Channel gradually rising on May 25 as floodwater from the Colville River continued to enter the lower delta. On May 27, stage rose sharply at MON9 and MON9D as the ice jam near the Tamayayak Channel formed and backwater began to develop. Ice accumulation from this jam extended upstream past MON9 soon after the jam formed (Photo 4-7). PT data shows an increased stage differential between MON9 and MON9D after the ice jam extended into the reach. This stage differential, measured while MON9 and MON9D stations were within the jam, was approximately 4X higher than the stage differential observed under open water conditions. This high stage differential sustained until the morning of May 29. when the ice jam in the Nigliq Channel cleared, and MON9 water levels started receding. Observations around 1:40 PM show that the trailing end of the ice jam had moved downstream of the MON9 and MON9D reach further minimizing the differential (Photo 4-8).

As backwater was relieved through the Nigliq Channel stage decreased steadily, until a sharp drop was recorded corresponding to the East Channel jam releasing at approximately 5:00 PM on May 29. Aerial observations from May 31 show stranded ice indicating receding stage (Photo 4-9).

Peak stage at MON9 and MON9D occurred on May 28 and was the result of backwater accumulation from the ice jam at the Tamayayak Channel bifurcation in the East Channel (Photo 4-10, Photo 4-11 and Photo 4-12). Peak stage at MON35 occurred on May 30. Peak discharge at MON9 occurred on May 27 at approximately 12:15 PM, corresponding to the release of the Horseshoe Bend ice jam. Peak discharge at MON9 occurred at a stage lower than peak stage.

Stage and discharge at MON9 and MON9D and stage at MON35 are presented in Graph 4-4. Plan and profile drawings are provided in Appendix C.

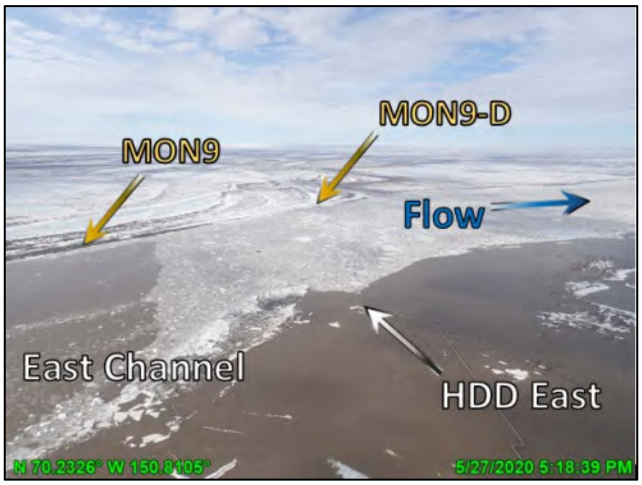


Photo 4-7: Ice accumulation near MON9, looking northwest (downstream); May 27, 2020

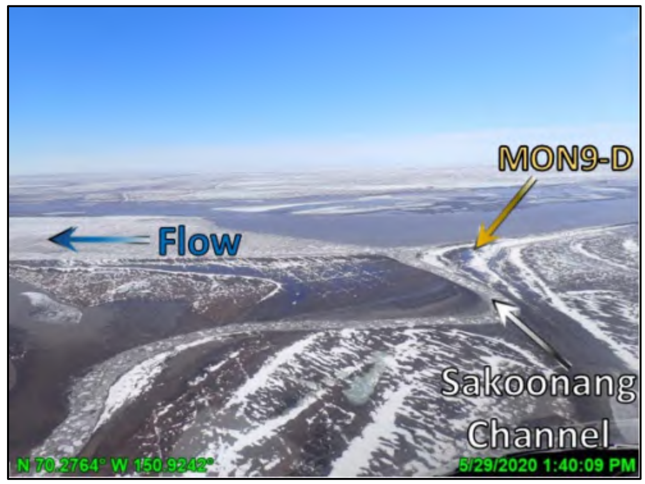


Photo 4-8: MON9 reach after Nigliq Channel ice jam release, looking east; May 29, 2020

Photo 4-9: Stranded ice near the Tamayayak Channel bifurcation, looking north (downstream); May 31, 2020

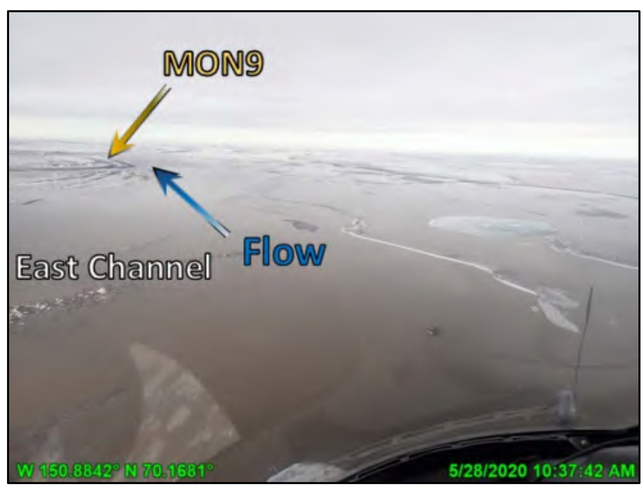


Photo 4-10: Widespread overbank flooding in the East Channel, looking north (downstream); May 28, 2020

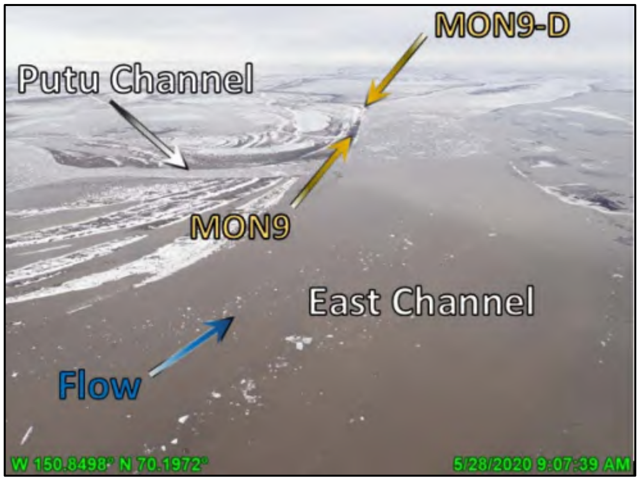


Photo 4-11: Stage near peak in the East Channel at MON9, looking north (downstream); May 28, 2020

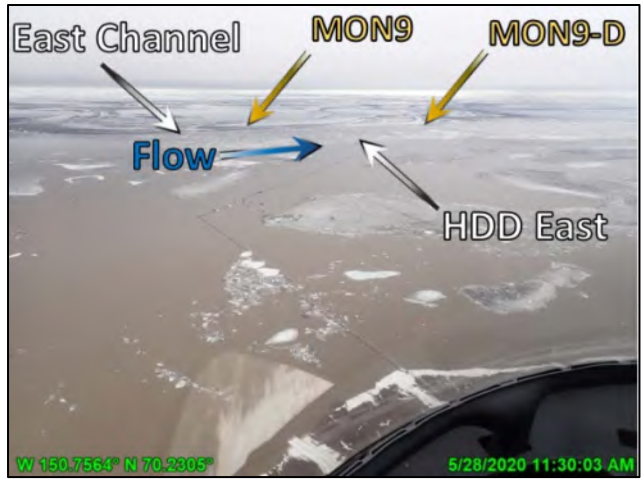
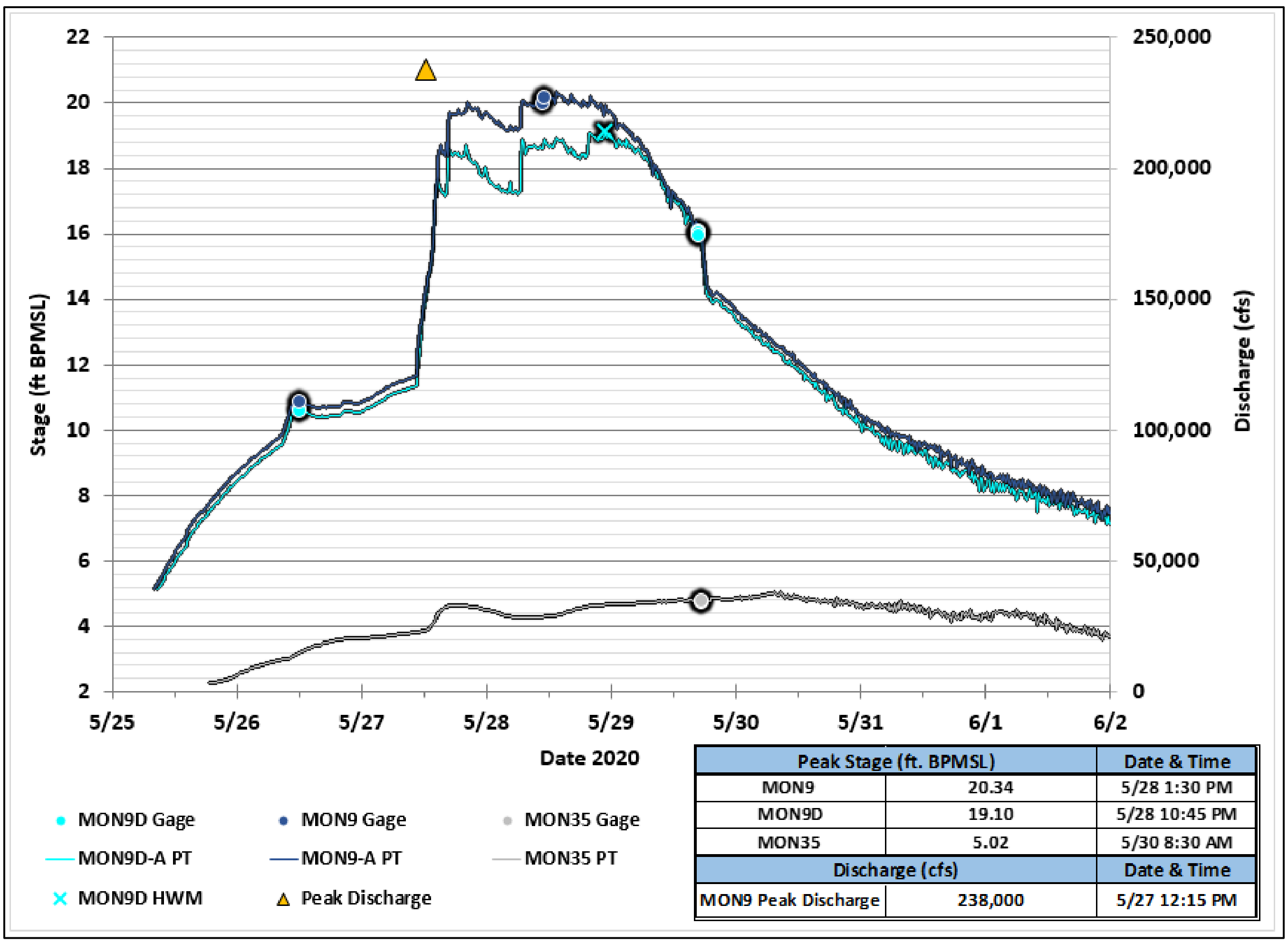


Photo 4-12: Widespread meltwater in the eastern floodplain, looking west; May 28, 2020



Peak Stage (ft. BPMSL)		Date & Time
MON9	20.34	5/28 1:30 PM
MON9D	19.10	5/28 10:45 PM
MON35	5.02	5/30 8:30 AM
Discharge (cfs)		Date & Time
MON9 Peak Discharge	238,000	5/27 12:15 PM

Graph 4-4: Colville River East Channel Stage & Discharge

4.3 Nigliq Channel

MON20, MON22, and MON23 have been monitored intermittently since 1998 and MON28 has been monitored since 1999. Four additional gage stations, G29, G28, G27, and G26, provide site specific data upstream and downstream of the Nigliq Bridge and are discussed in Section 4.4, Nigliq Bridge. Discharge associated with Nigliq Channel flooding is measured and/or calculated at the Nigliq, Nigliagvik, and Lake L9323 bridge crossings.

Stage was rising at all Nigliq Channel monitoring stations on May 26. Aerial observations from this day show stage well below bankfull and intact channel ice near MON20 (Photo 4-13). Flow had entered Nanuq Lake but had not yet reached the CD2 road swale bridges. On May 27, stage continued to increase gradually, and an ice jam formed in the Nigliq Channel upstream of Nuiqsut (Photo 4-14). This ice jam remained in place until releasing at approximately 1:00 AM on May 29. At this point a surge of floodwater and ice entered the Nigliq Channel, flushing out the channel ice downstream to MON22 and rapidly increasing water levels around Alpine facilities. The ice jam reformed near MON22 and the Nigliagvik Channel confluence at approximately 7:00 AM (Photo 4-15). The stage hydrograph at MON20 and MON23 record a sharp rise and fall corresponding to the surge of floodwater through the Nigliq Channel. Peak stage occurred on May 29 at all Nigliq Channel gages.

During peak stage, widespread overbank flooding was observed around the CD4 pad, along the CD5 road, and along the CD2 road and pad (Photo 4-16, Photo 4-17, and Photo 4-18). The ice jam near MON22 was observed to still be in place at approximately 5:30 PM on May 29. By May 31, aerial observations confirmed the ice jam near MON22 had cleared, and stage had receded below bankfull (Photo 4-19 and Photo 4-20). Widespread stranded ice was observed near CD2.

Stage at MON20, MON22, MON23, and MON28 is presented in Graph 4.5.

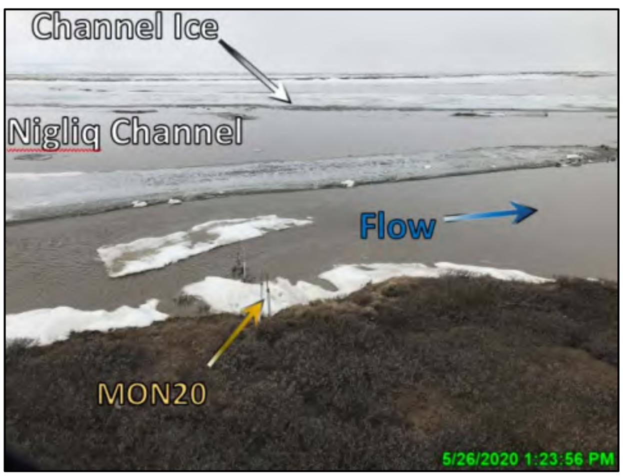


Photo 4-13: Intact channel ice near MON20, looking west; May 26, 2020

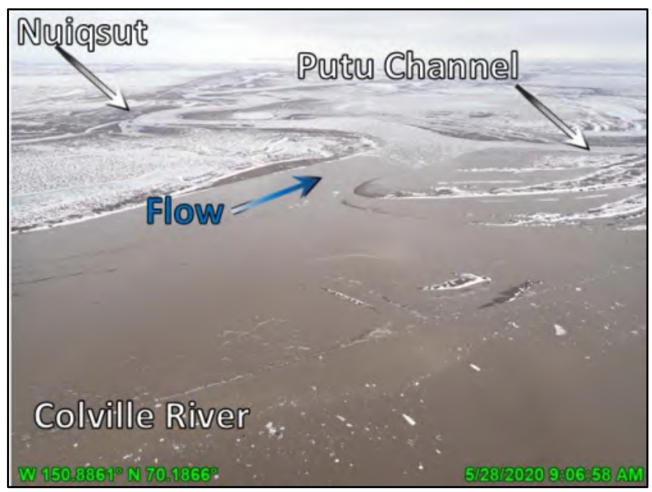


Photo 4-14: Ice jam in the Nigliq Channel, looking northwest (downstream); May 27, 2020

Photo 4-15 Ice jam near the Nigliagvik Channel confluence, looking southeast (upstream); May 29, 2020

Photo 4-16: Widespread overbank flooding in the Nigliq Channel near CD2, looking south (upstream); May 29, 2020

Photo 4-17 Widespread overbank flooding in the Nigliq Channel near CD4, looking southeast (upstream); May 29, 2020

Photo 4-18: Peak Stage along the CD5 road, looking southeast (upstream); May 29, 2020

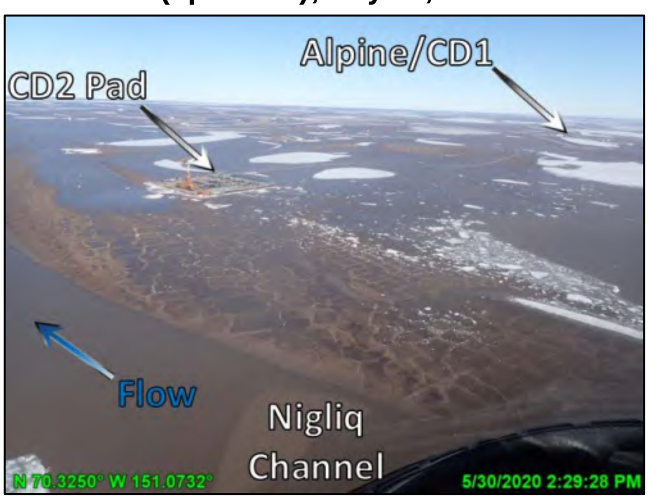
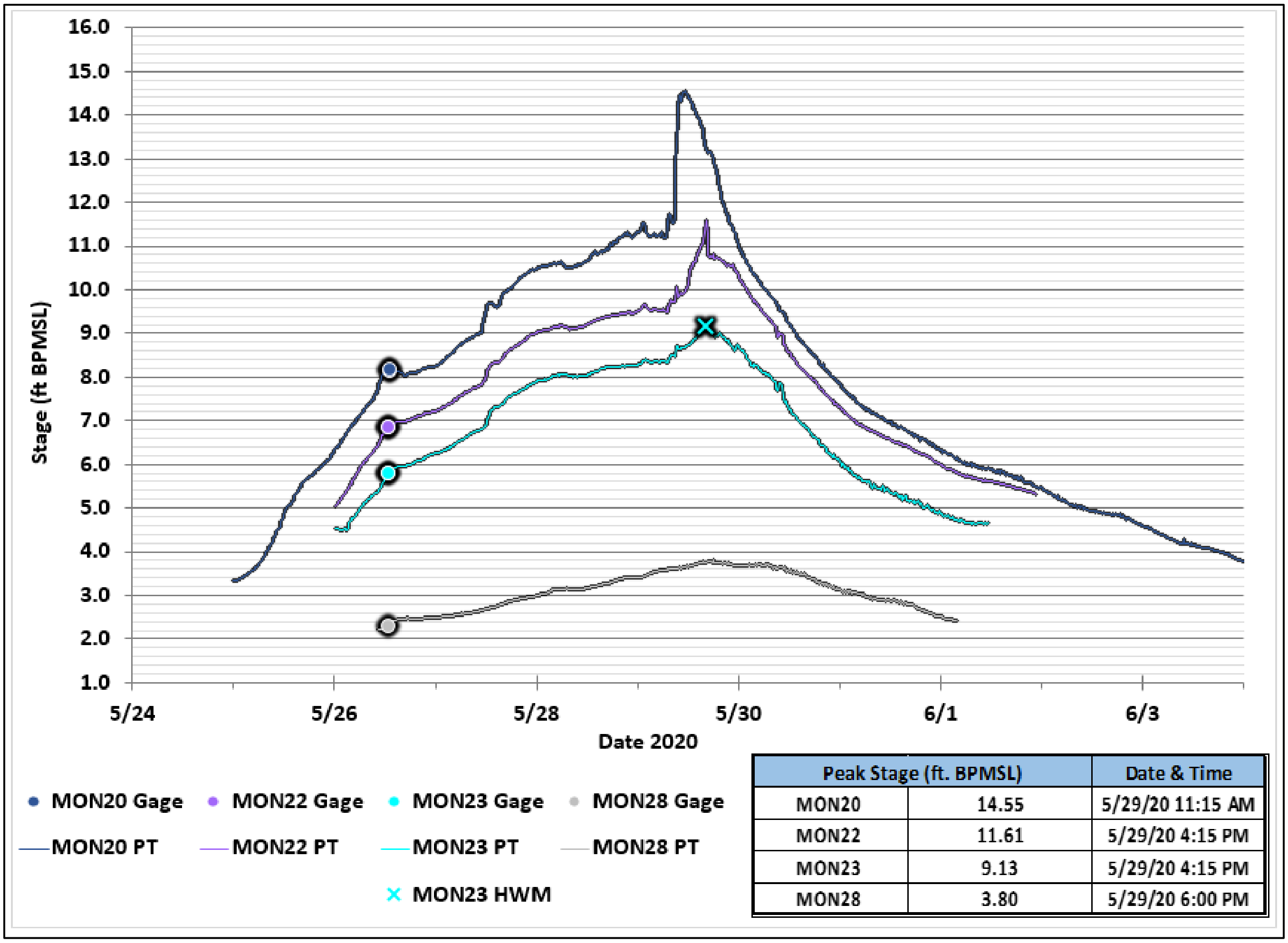


Photo 4-19: Stranded ice near CD2, looking north (downstream); May 30, 2020

Photo 4-20: Receding stage in Nigliq Channel, looking north (downstream); June 1, 2020



Peak Stage (ft. BPMSL)		Date & Time
MON20	14.55	5/29/20 11:15 AM
MON22	11.61	5/29/20 4:15 PM
MON23	9.13	5/29/20 4:15 PM
MON28	3.80	5/29/20 6:00 PM

Graph 4-5: Nigliq Channel Stage

4.4 Alpine Facilities

Conditions in active channels surrounding Alpine facilities, including the Sakoonang, Tamayayak, and Ulamnigiaq channels to the east/northeast and the Nigliq Channel to the west, dictate the progression of the floodwater around facilities. Floodwaters in the Nigliq and Sakoonang channels typically overtop the banks and facilitate the annual recharge of many lakes and paleochannels through overbank inundation. The extent of inundation is dependent on topography, vegetation, WSE, and local ice and ice jam influences.

Drainage structures are kept free of ice, snow accumulation, and blockages through regular maintenance by CPAI. Plywood covers are installed at the culvert inlets and outlets during the winter and removed prior to breakup. Snow is also mechanically removed from the immediate upstream and downstream areas of all culverts and the CD2 swale bridges prior to breakup flooding. Snow was cleared from the entrances and exits of CD2 swale bridges in the spring, though some drifted snow did accumulate prior to the arrival of floodwater (Photo 4-21).

Culverts were monitored to assess flow conditions and culvert performance. Most culvert covers were removed prior to the arrival of floodwater. Snow and ice were cleared at all culvert inlets prior to breakup. Limited flow restrictions were observed related to piles of removed snow and ice in and around culvert ends. Culvert locations and proximity to gages are shown in Appendix A. Detailed culvert discharge measurements, calculations, and performance summary field notes are provided in Appendix C.

Photo 4-21: Snow cleared from the south side of the short swale bridge. Note drifted snow still present directly underneath bridge deck

CD1 PAD & LAKES L9312 & L9313

Gage station G1 is situated along the east end of the CD1 pad to monitor stage in the adjacent Sakoonang Channel. Spring breakup stage data and observations have been collected at gage G1 since 2000. Peak stage at G1 occurred after the ice jam on the East Channel at the Tamayayak Channel confluence cleared on May 29. (Photo 4-22), Aerial observations from May 29 prior to peak showed stage below bankfull, and minimal ice remaining in the channel. Stage at gage G1 is presented in Graph 4.6.

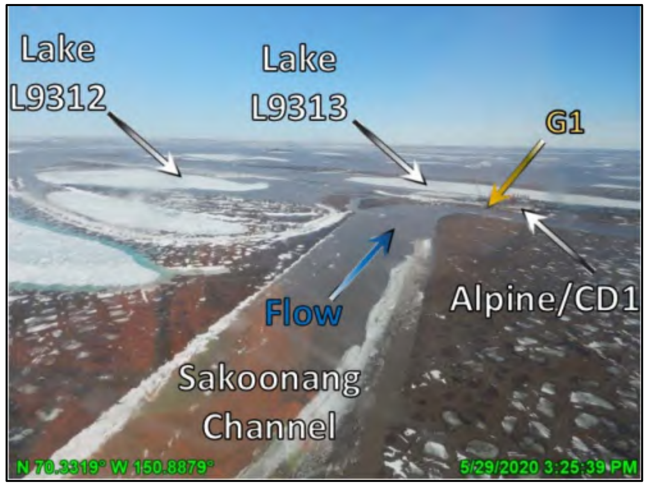
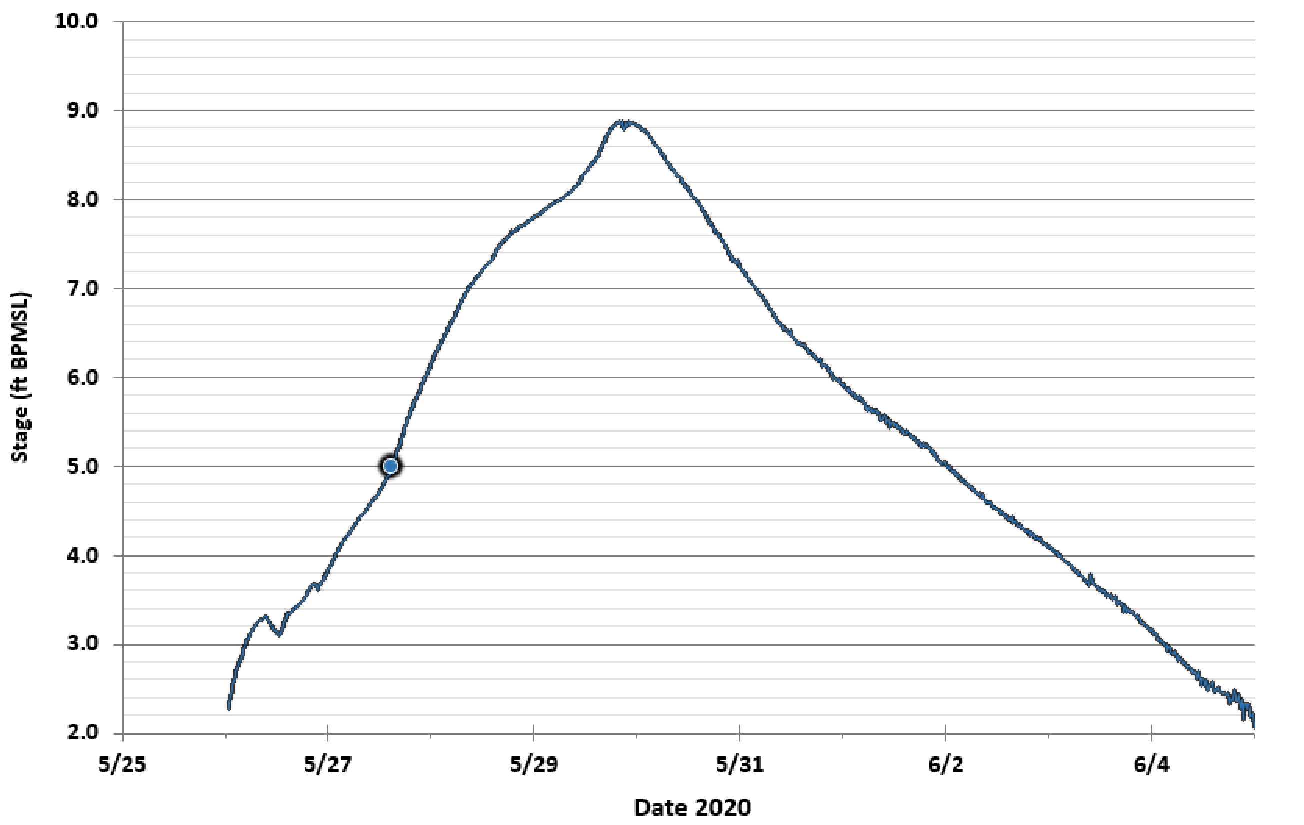


Photo 4-22: Peak stage at G1 under the influence of channel ice in the Sakoonang, looking east; May 29, 2020

Recharge at drinking water source Lake L9312 (gage G9) and Lake L9313 (gage G10) has been monitored annually since 1998. Overbank flooding from the Sakoonang Channel is the primary recharge mechanism for both lakes. Snowmelt from within each drainage basin, however, also contributes to recharge. Both Lake L9312 and Lake L9313 recharged from overbank flow this spring (Photo 4-23, Photo 4-24, and Photo 4-25). Peak stage at each site occurred on May 29 and correlated to peak stage in the Sakoonang Channel. Stage at gage G9 (L9312) and gage G10 (L9313) is presented in Graph 4.7.



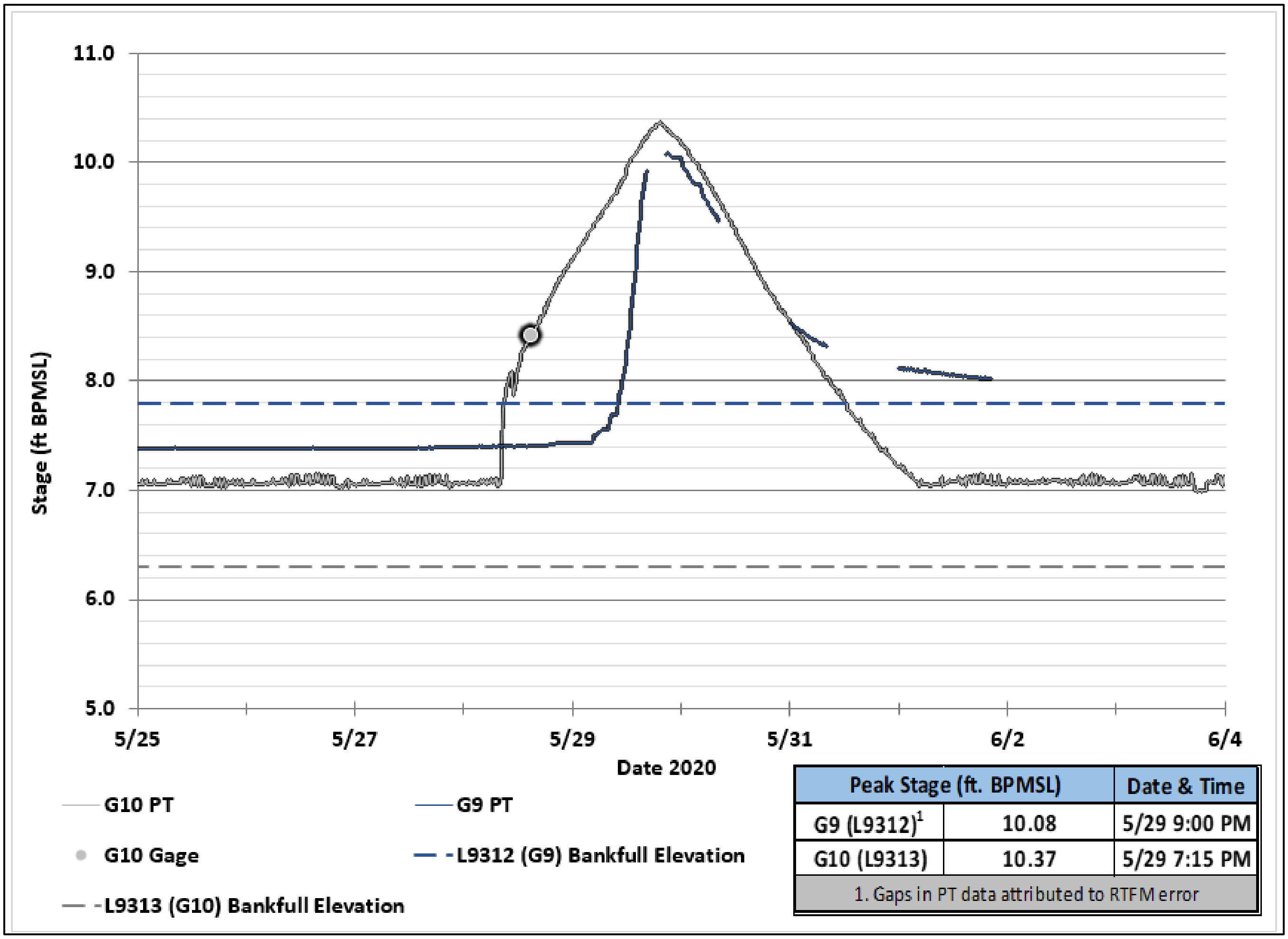
Peak Stage (ft. BPMSL)		Date & Time
G1	8.88	5/29 8:30 PM

Graph 4-6: CD1 Pad (Gage G1) Stage

Photo 4-23: Overland recharge of both Lakes L9312 and L9313 near peak stage, looking east; May 29 2020

Photo 4-24: Lake L9312 after recharge from overland flow, looking east; June 1, 2020

Photo 4-25: Lake L9313 hydraulically connected to Lake M9525 after peak stage; June 4, 2020



Peak Stage (ft. BPMSL)		Date & Time
G9 (L9312)[1]	10.08	5/29 9:00 PM
G10 (L9313)	10.37	5/29 7:15 PM
1. Gaps in PT data attributed to RTFM error		

Graph 4-7: Lakes L9312 (Gage G9) and L9313 (Gage G10) Stage

CD2 ROAD & PAD

Stage data and observations of breakup processes have been collected along the CD2 road and pad intermittently since 1998.

Floodwater along the CD2 road was present at all monitoring locations by May 27 (Photo 4-26). As stage rose, the long swale bridge, the short swale bridge, and most culverts along the road conveyed flow from the Niqliq Channel (via Nanuq Lake then Lake M9524) across the CD2 road north towards Lake L9316 and M9933 (Photo 4-27). Peak stage at all monitoring locations along CD2 road occurred on the evening of May 29 (Photo 4-28 and Photo 4-29). Discharge was measured at all culverts conveying flow along the CD2 road on May 28 (Photo 4-30). On May 28, all culverts were conveying flow, except culverts CD2-16, CD2-17, and CD2-19, which were observed to be dry at this time. Discharge was measured at the short swale bridge on May 29 and at the long swale bridge on the morning of May 30.

The average velocity measured at the long swale bridge on May 30 was 0.59 ft per second (fps) and the highest depth averaged velocity within a single section was 1.4 fps. The bridge was clear of snow and ice and there were no snow berms. Ice floes were minimal during the measurement and flow was unobstructed. Surface water was affected by approximately a 20-mph wind from the east. The measurement was classified as fair.

The average velocity measured through the short swale bridge on May 29 was 5.17 fps and the highest depth average velocity within a single section was 6.43 fps. Ice was present south of the bridge but did not obstruct flow through the discharge cross section (Photo 4-31). The overall quality rating of the discharge measurement was classified as fair based on conditions at the time of the measurement.

All culverts along CD2 performed as designed during this year's breakup event. Peak discharge through this drainage area occurred on May 29 during peak stage differential across the CD2 road measured at G3 and G4.

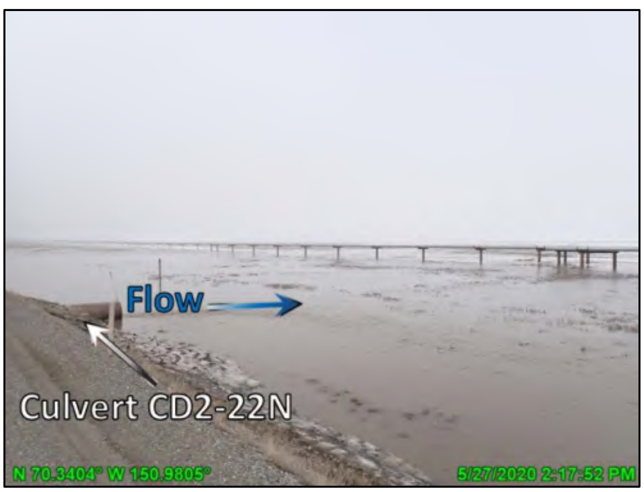


Photo 4-26: Floodwater along the CD2 road, looking northwest; May 27, 2020

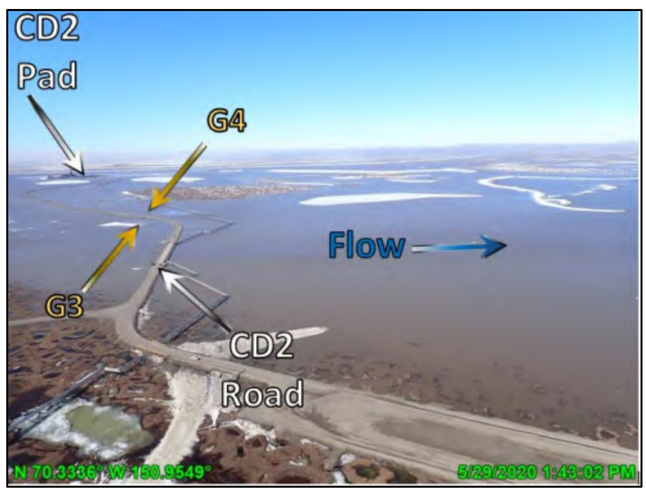


Photo 4-27: Floodwater along the CD2 road near peak stage, looking west; May 29, 2020

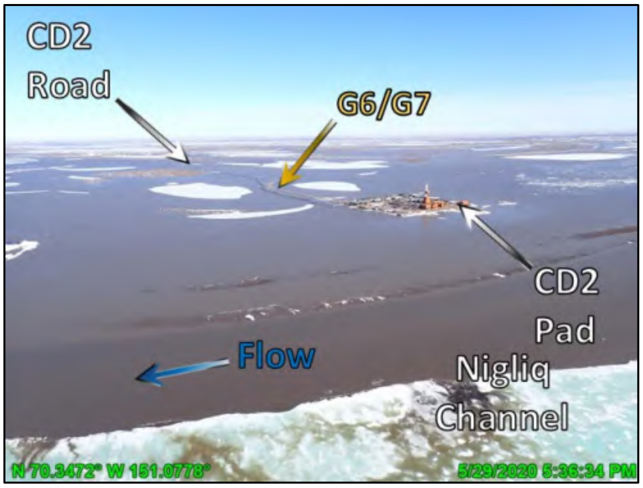


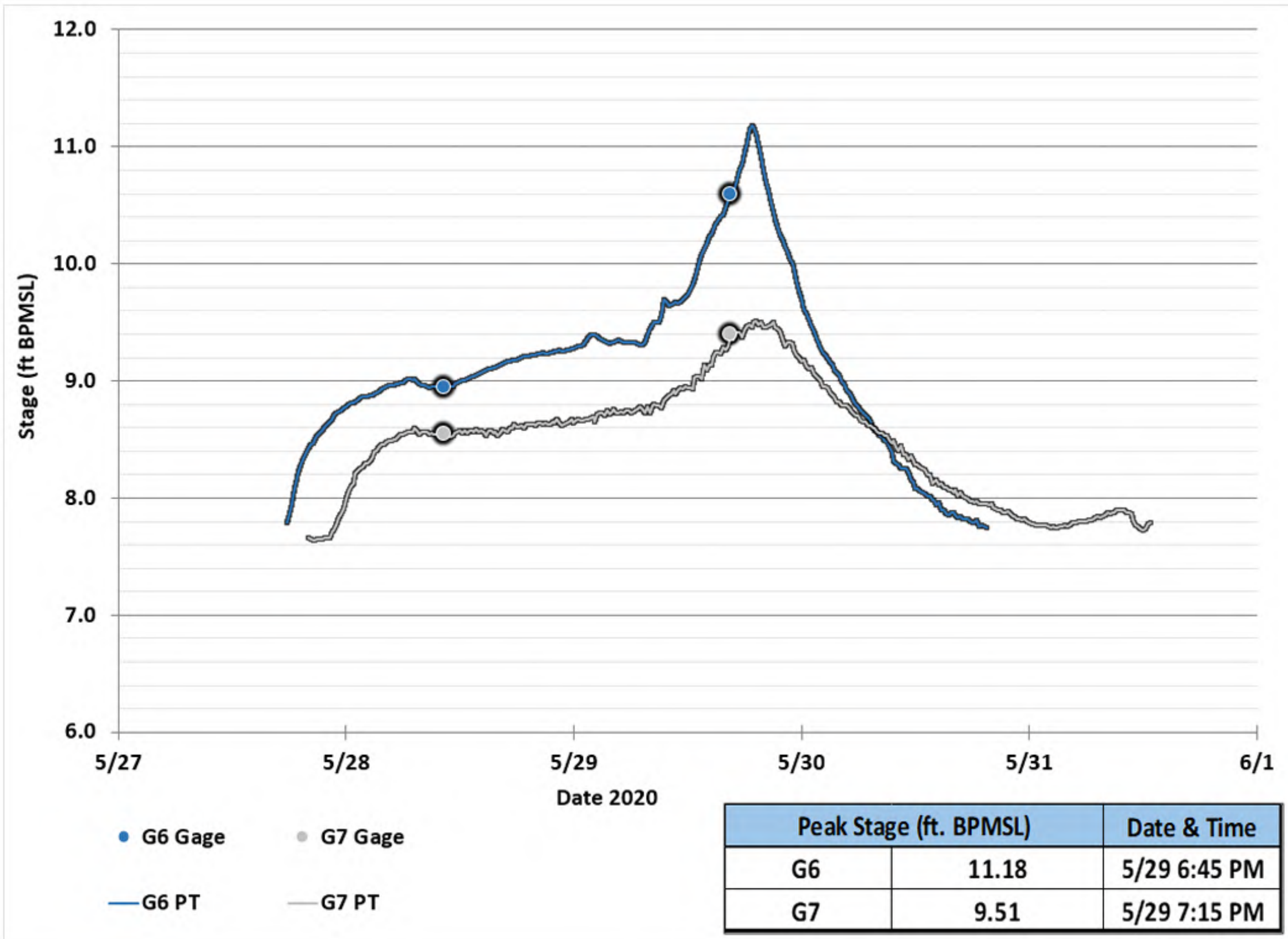
Photo 4-28: Floodwater near the CD2 pad, looking southeast; May 29, 2020

Photo 4-29: Floodwater passing through the swale bridges near peak stage; looking north (downstream) May 29, 2020

Photo 4-30: Crew measuring discharge through culvert CD2-02, looking northwest; May 28, 2020

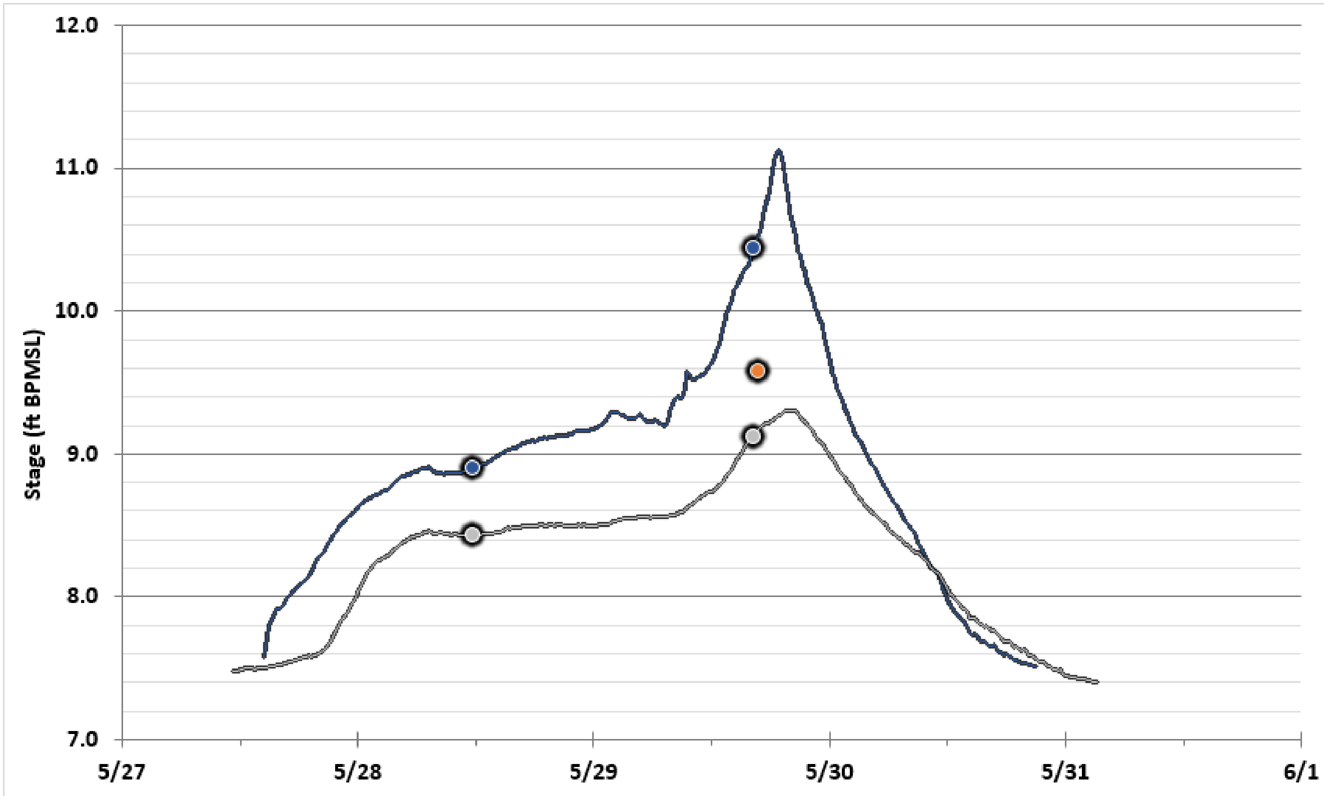
Photo 4-31: Ice present south of Short Swale Bridge during discharge measurement, looking south (upstream); May 29, 2020

Stage and total discharge at CD2 bridges and culverts are provided in Graph 4-8, Graph 4-9, and Graph 4-10. Measured discharge and peak discharge at culverts conveying flow is summarized in Table 4.2 and Table 4.3, respectively. Historical discharge measurements and peak discharge at the long and short swale bridges are summarized in Section 8. A summary of discharge measurements for the CD2 road swale bridges and culverts are presented in Appendix C.



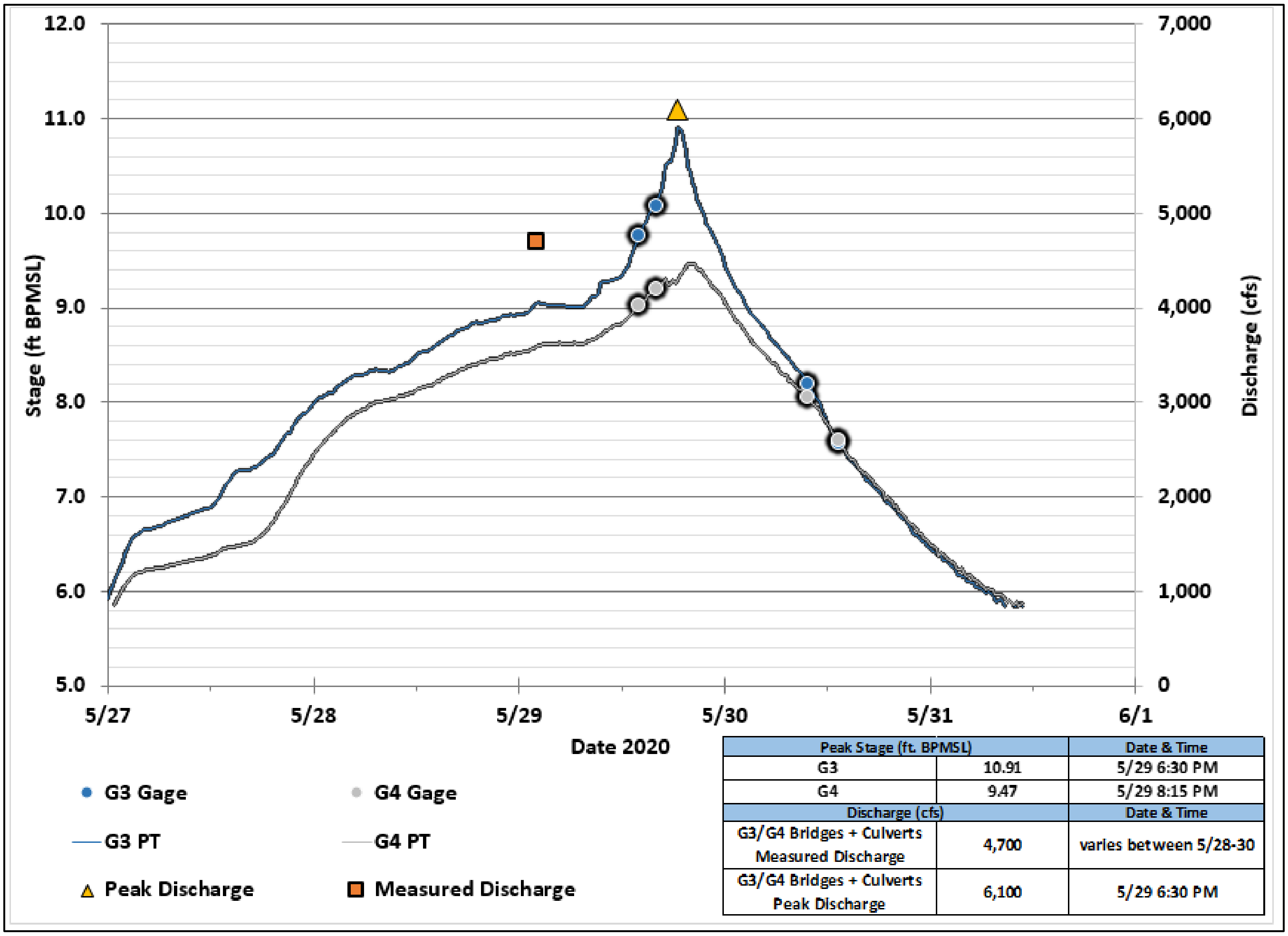
Peak Stage (ft. BPMSL)		Date & Time
G6	11.18	5/29 6:45 PM
G7	9.51	5/29 7:15 PM

Graph 4-8: CD2 Road Bridges and Culverts (Gages G6 & G7) Stage



Peak Stage (ft. BPMSL)		Date & Time
G12	11.13	5/29 6:45 PM
G13	9.31	5/29 7:45 PM

Graph 4-9: CD2 Road Bridges and Culverts (Gages G8, G12, & G13) Stage



Peak Stage (ft. BPMSL)		Date & Time
G3	10.91	5/29 6:30 PM
G4	9.47	5/29 8:15 PM
Discharge (cfs)		**Date & Time**
G3/G4 Bridges + Culverts Measured Discharge	4,700	varies between 5/28-30
G3/G4 Bridges + Culverts Peak Discharge	6,100	5/29 6:30 PM

Graph 4-10: CD2 Road Bridges and Culverts (Gages G3 & G4) Stage & Discharge

Table 4.2: CD2 Road Culverts Measured Discharge

Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measurement Depth [1] (ft)	Flow Direction	Measured Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD2-01	5/28 10:00 AM	2.20	0.88	South to North	5.14	36.4	730
CD2-02	5/28 10:05 AM	2.30	0.92	South to North	5.02	37.5	
CD2-03	5/28 10:11 AM	2.70	1.08	South to North	4.34	39.2	
CD2-04	5/28 10:22 AM	1.90	0.76	South to North	3.20	18.8	
CD2-05	5/28 10:25 AM	3.00	1.20	South to North	3.90	39.5	
CD2-06	5/28 10:28 AM	3.00	1.20	South to North	4.02	40.7	
CD2-07	5/28 10:32 AM	3.10	1.24	South to North	3.95	41.2	
CD2-08	5/28 10:40 AM	2.60	1.04	South to North	5.03	43.5	
CD2-09	5/28 10:50 AM	1.70	0.68	South to North	4.78	28.1	
CD2-10	5/28 11:07 AM	2.40	0.96	South to North	4.68	43.6	
CD2-11	5/28 11:18 AM	2.30	0.92	South to North	4.35	38.4	
CD2-12	5/28 11:30 AM	2.40	0.96	South to North	4.15	43.9	
CD2-13	5/28 11:38 AM	2.60	1.04	South to North	3.50	36.1	
CD2-14	5/28 11:48 AM	2.60	1.04	South to North	3.89	40.2	
CD2-15	5/28 11:57 AM	2.00	0.80	South to North	4.53	28.5	
CD2-18	5/28 12:01 PM	1.00	0.40	South to North	1.73	4.2	
CD2-20	5/28 12:08 PM	2.20	0.88	South to North	4.27	30.2	
CD2-21	5/28 12:15 PM	3.00	1.20	South to North	3.15	31.9	
CD2-22	5/28 12:20 PM	3.10	1.24	South to North	3.69	38.6	
CD2-23	5/28 12:25 PM	3.60	1.44	South to North	3.05	36.4	
CD2-24	5/28 12:30 PM	3.90	1.56	South to North	2.65	33.1	

Notes:
1. Measurement taken at 0.6 of total depth of flow.
2. Flow direction at time of measurement.

Table 4.3: CD2 Road Culverts Peak Discharge

Culvert [1]	Calculated Date & Time	WSE Differential (ft)[2]	Total Depth of Flow (ft)	Flow Depth	Calculated Velocity (ft/s)	Calculated Discharge[3] (cfs)	Total Discharge (cfs)
CD2-01	5/29 6:45 PM	1.72	4.1	More than Half Full	6.6	83	691
CD2-02	5/29 6:45 PM		3.5	More than Half Full	7.1	83	
CD2-03	5/29 6:45 PM		3.9	More than Half Full	7.0	87	
CD2-04	5/29 6:45 PM		5.0	More than Half Full	7.0	88	
CD2-05	5/29 6:45 PM		4.6	More than Half Full	7.0	88	
CD2-06	5/29 6:45 PM		5.6	More than Half Full	7.0	88	
CD2-07	5/29 6:45 PM		4.8	More than Half Full	7.0	88	
CD2-08	5/29 6:45 PM		3.9	More than Half Full	7.0	88	
CD2-09	5/29 6:45 PM	0.44	3.3	More than Half Full	5.7	79	756
CD2-10	5/29 6:45 PM		3.9	More than Half Full	5.4	89	
CD2-11	5/29 6:45 PM		3.9	More than Half Full	5.5	91	
CD2-12	5/29 6:45 PM		3.9	More than Half Full	6.1	117	
CD2-13	5/29 6:45 PM		3.5	More than Half Full	6.0	89	
CD2-14	5/29 6:45 PM		4.1	More than Half Full	5.8	98	
CD2-15	5/29 6:45 PM		3.7	More than Half Full	6.0	73	
CD2-16	5/29 6:45 PM		1.7	Less than Half Full	6.4	32	
CD2-17	5/29 6:45 PM		1.9	More than Half Full	5.8	33	
CD2-18	5/29 6:45 PM		2.5	More than Half Full	6.6	55	
CD2-19	5/29 6:30 PM	1.61	1.8	Less than Half Full	6.7	37	488
CD2-20	5/29 6:30 PM		3.3	More than Half Full	7.2	79	
CD2-22	5/29 6:30 PM		4.0	More than Half Full	6.8	85	
CD2-23	5/29 6:30 PM		4.2	More than Half Full	6.8	85	
CD2-24	5/29 6:30 PM		5.0	More than Half Full	6.8	85	
CD2-25	5/29 6:30 PM		5.2	More than Half Full	1.8	14	
CD2-26	5/29 6:30 PM		2.3	Less than Half Full	5.4	18	

Notes:
1. Culverts 01-08 associated with gages G6/G7, culverts 09-18 associated with gages G12/G13, culverts 19-26 associated with gages G3/G4.
2. Calculated during peak stage differential between upstream and downstream gages most proximal to culverts.
3. Positive values indicate flow was south to north

CD3 PAD & PIPELINE

Stage data and observations of breakup processes have been collected at the CD3 pad and along the pipeline intermittently since 2000. Gage stations SAK, TAM, and ULAM are situated at each respective pipeline crossing of each channel (Sakoonang, Tamayayak, and Ulamnigiaq), and G11 is situated on a VSM on the CD3 pipeline near the south end of the CD3 pad.

PTs first recorded water levels at all pipeline crossing locations on May 26. Peak stage in the Tamayayak Channel (CD3 Pipe Bridge #4) occurred on May 27 as the East Channel ice jam formed near the Tamayayak Channel bifurcation. As this occurred, corresponding stage spikes were recorded at both TAM and ULAM monitoring stations. This is likely attributed to floodwater flowing into the Tamayayak Channel before the ice jam at the bifurcation impeded flow and as backwater developed behind the ice jam, subsequently reducing water levels in Tamayayak and Ulamnigiaq Channels. On May 28, channel ice was still present at the Sakoonang and Tamayayak Channel pipeline crossing locations (Photo 4-32 and Photo 4-33). Peak stage at the SAK and ULAM monitoring stations occurred on May 29 and May 30, respectively, after the ice jam at the Tamayayak Channel bifurcation released, and the associated backwater moved into the Sakoonang, Tamayayak, and Ulamnigiaq Channels. An overflight on June 2 revealed no channel ice, however some remaining isolated ice was observed at all CD3 monitoring locations (Photo 4-34). Stage at the SAK, TAM, and ULAM gages is presented in Graph 4-11.

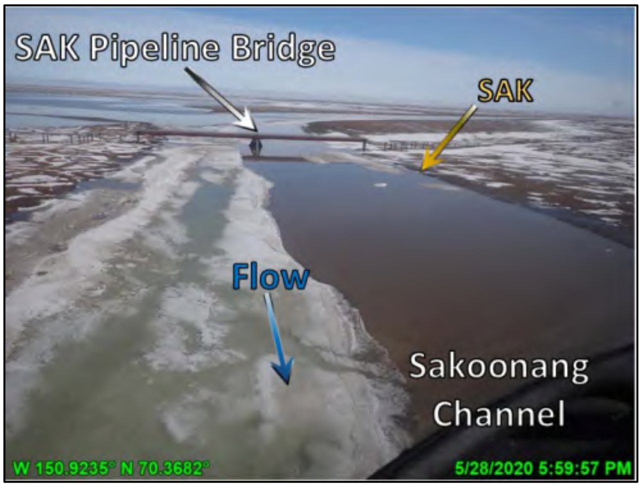


Photo 4-32: Channel ice in the Sakoonang Channel prior to peak stage at SAK, looking south; May 28, 2020

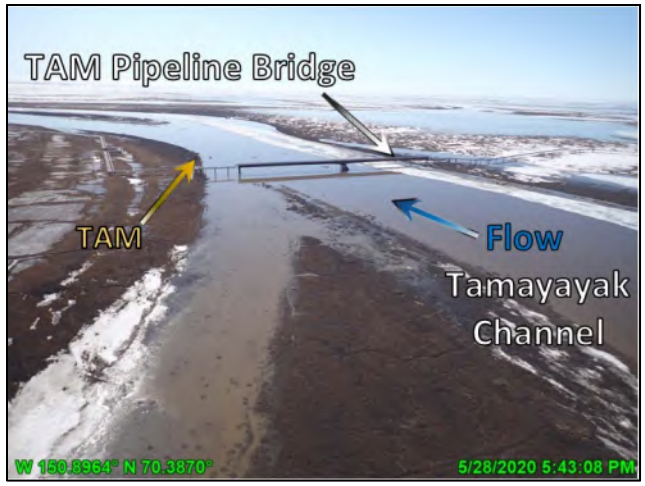


Photo 4-33: Channel ice in the Tamayayak Channel after peak stage at TAM, looking east; May 28, 2020

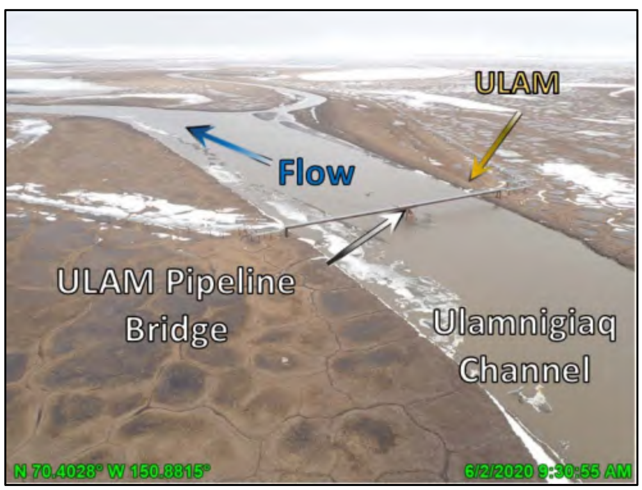
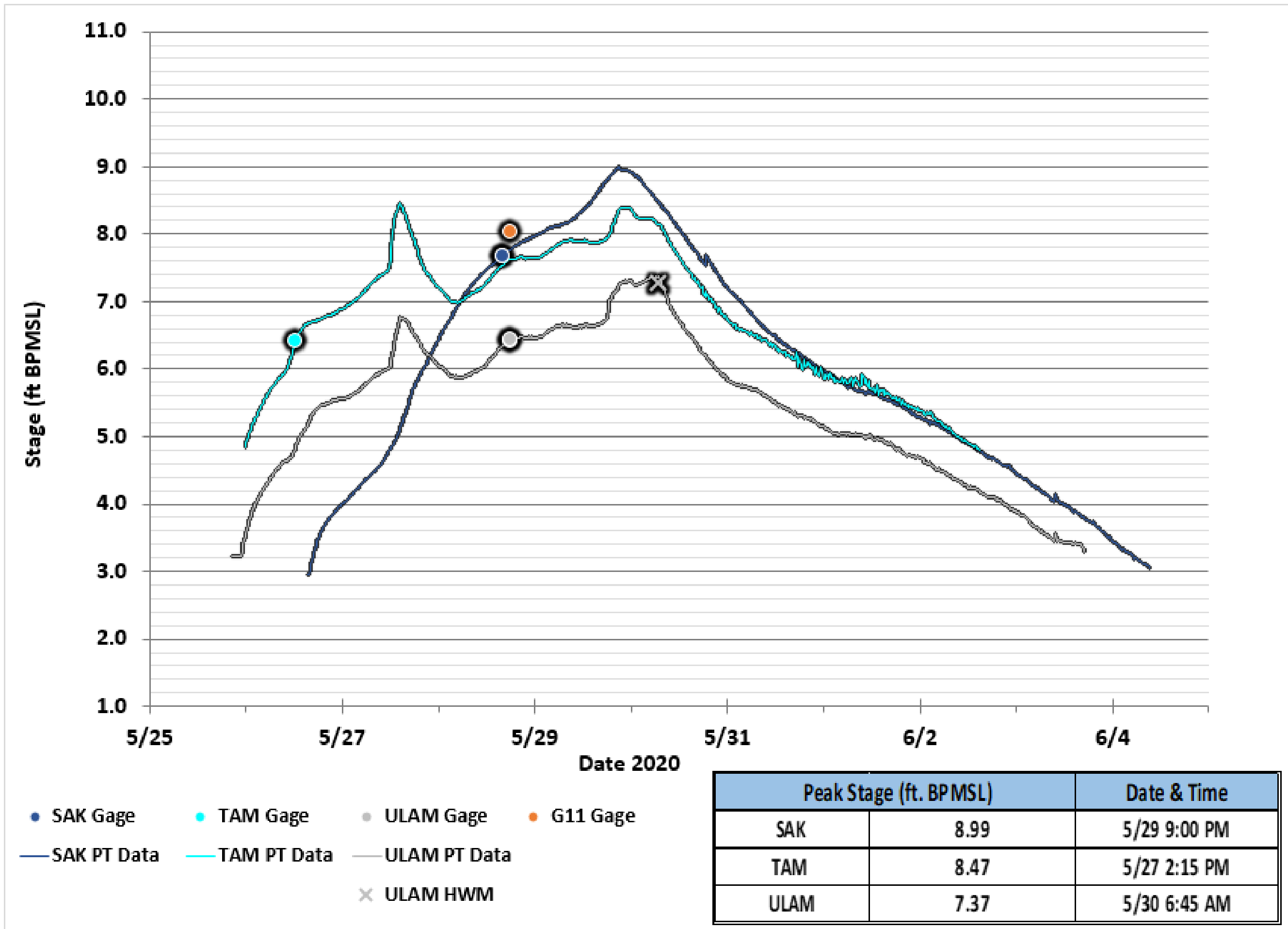


Photo 4-34: Isolated ice in the Ulamnigiaq Channel after peak stage, looking northwest; June 2, 2020



	Peak Stage (ft. BPMSL)	Date & Time
SAK	8.99	5/29 9:00 PM
TAM	8.47	5/27 2:15 PM
ULAM	7.37	5/30 6:45 AM

Graph 4-11: CD3 Pipelines Stage

CD4 ROAD & PAD

Stage data and observations of breakup processes have been collected at the CD4 road and pad intermittently since 2005. Gage stations G15/G16 are located at the north culvert battery near the CD5 road turnoff, G17/G18 at the south culvert battery before the CD4 pad, and G19 and G20 along the south and west side of the CD4 pad, respectively.

Initial localized melt was observed at road gages G15/G16 on May 28. The stage hydrographs indicate additional floodwater was accumulating by late day May 28 as water levels in Lake M9525 increased from the Sakoonang Channel (Photo 4-35). Stage at G15 and G16 rose approximately 4-feet from the evening of May 28 to the morning of May 29 and water levels equalized across the CD4 road through the north culvert battery. On the morning of May 29, the ice jam in the Nigliq Channel at Nuiqsut released and the surge of floodwater inundated Lake L9323 and surrounding floodplain, resulting in a rapid stage increase at G16. Stage peaked at G16 around mid-day on May 29 and coincided with peak stage at adjacent Nigliq Channel gages. G16 peak stage was approximately 2 feet higher than at G15, and the culverts were flowing at full capacity from south to north. Stage peaked at G15 on the evening of May 29 and stage at G16 dropped rapidly. Minimal stage differential between G15 and G16 was noted by May 30 indicating water levels had once again equalized. During peak conditions, the culvert battery was completely submerged, and turbulent flow was observed at the outlets (Photo 4-36). Discharge was not measured at this site due to safety concerns associated with culvert access during the high discharge and stage conditions.

Initial meltwater was observed at road gages G17 and G18 on May 28. On the morning of May 29, the release of the ice jam in the Nigliq channel caused a rapid surge of water at G17 and G18 (Photo 4-37 and Photo 4-38). Ice floes were observed impeding the culvert battery inlets and were removed via excavator to facilitate flow through the culverts (Photo 4-39). Discharge was measured at culverts CD4-25 through CD4-33 on May 29.

At the CD4 pad, G19 and G20 experienced similar stage trends as the Nigliq channel. Peak stage at G20 occurred in the afternoon on May 29 (Photo 4-40). Gage readings and the highwater mark from G19 suggest similar stage trends as the nearby G20 gage.

Stage and discharge, as applicable, at CD4 road gages G15/G16, G17/G18, and CD4 pad gages G19/G20 are provided in Graph 4-12, Graph 4-13, and Graph 4-14. Measured and peak discharge at G15/G16 & G17/G18 culverts conveying flow is summarized in Table 4.4 and Table 4.5, respectively. Additional culvert discharge data is provided in Appendix C.

Photo 4-35: Floodwater in Lake M9525 reaching CD4 road north culvert battery, looking north; May 28, 2020

Photo 4-36: Turbulent flow through north culvert battery at G15/G16 near peak stage, looking north (downstream); May 29, 2020

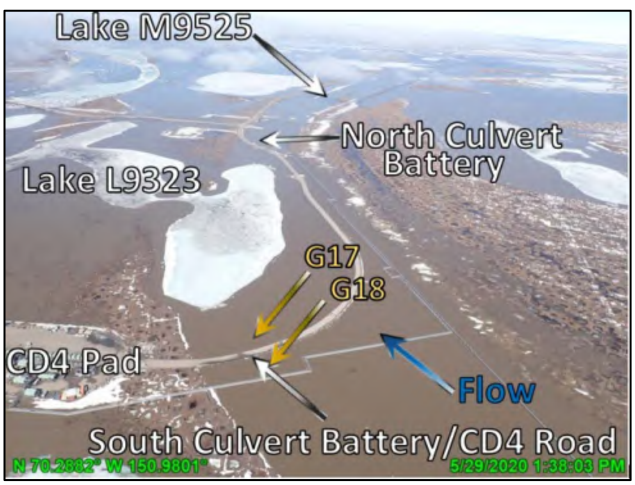


Photo 4-37: Peak conditions on CD4 road near Gage G17/G18, looking north (downstream); May 29, 2020

Photo 4-38: Peak conditions on CD4 road near Gage G17 & G18, looking southeast; May 29, 2020

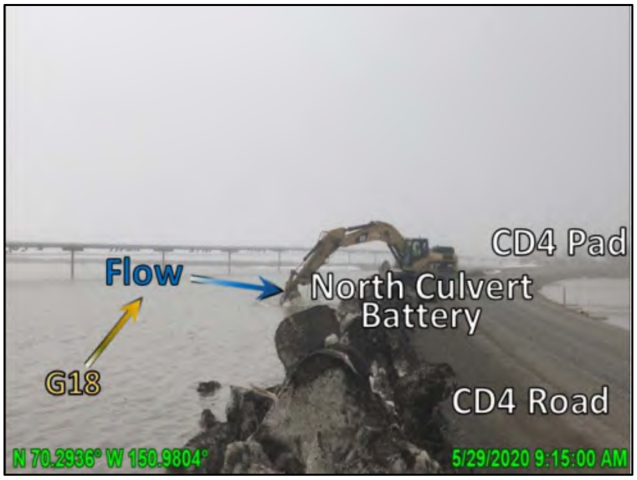


Photo 4-39: Excavator clearing ice from G17/G18 culverts battery, looking southwest; May 29, 2020

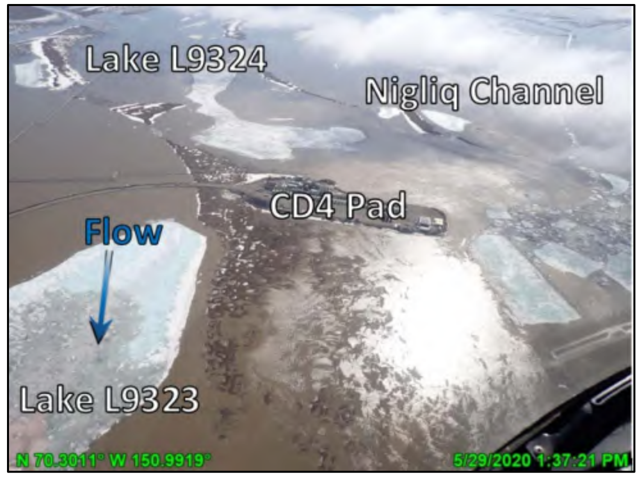
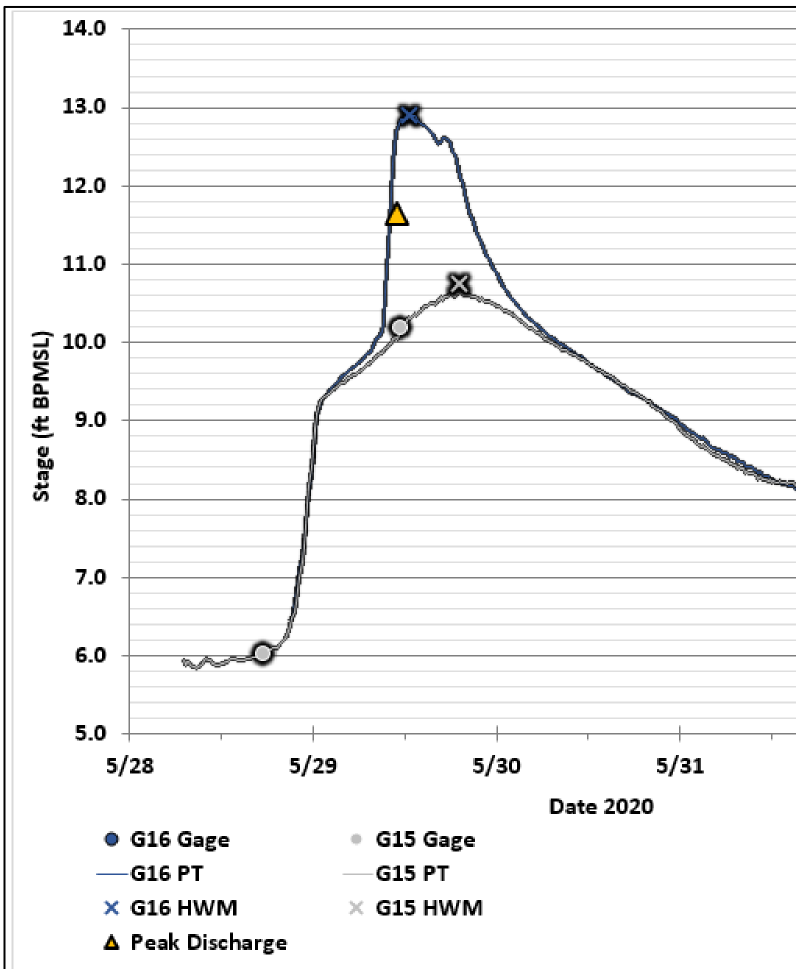
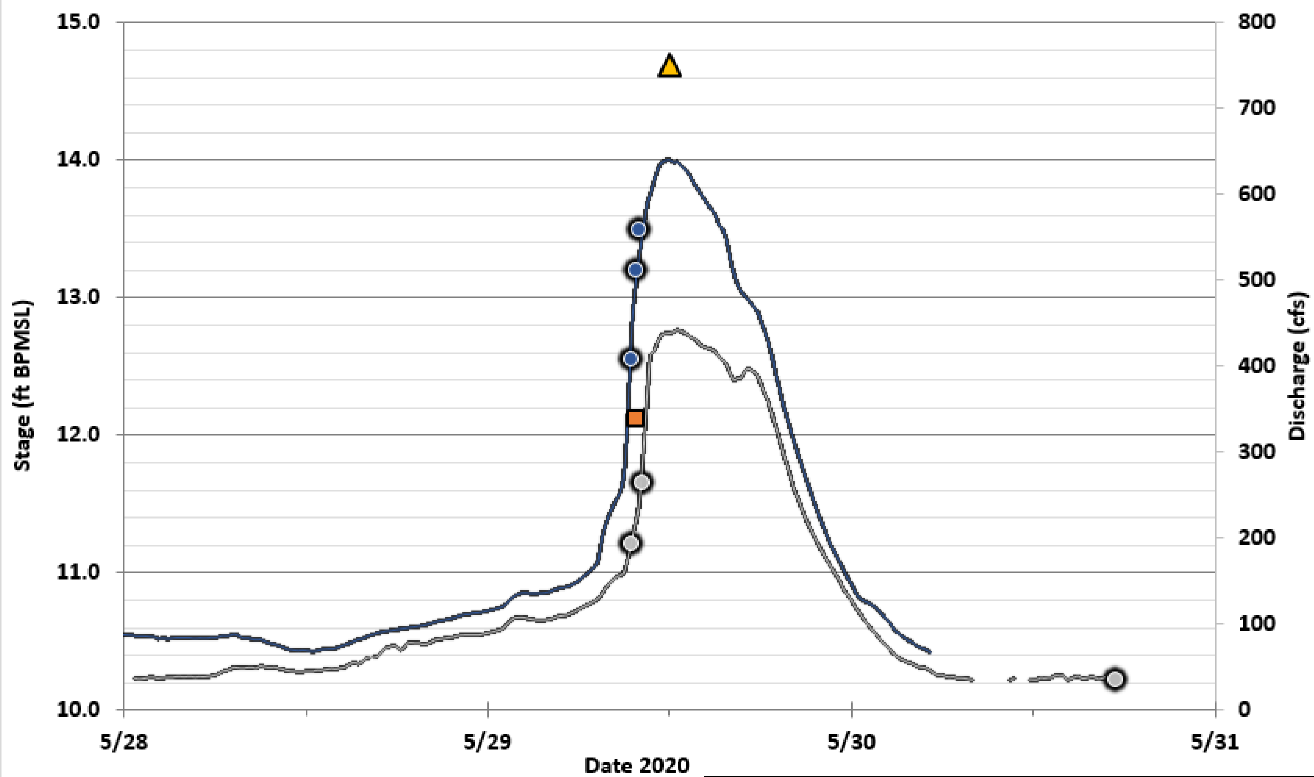


Photo 4-40: CD4 pad near peak stage conditions, looking southeast; May 29, 2020



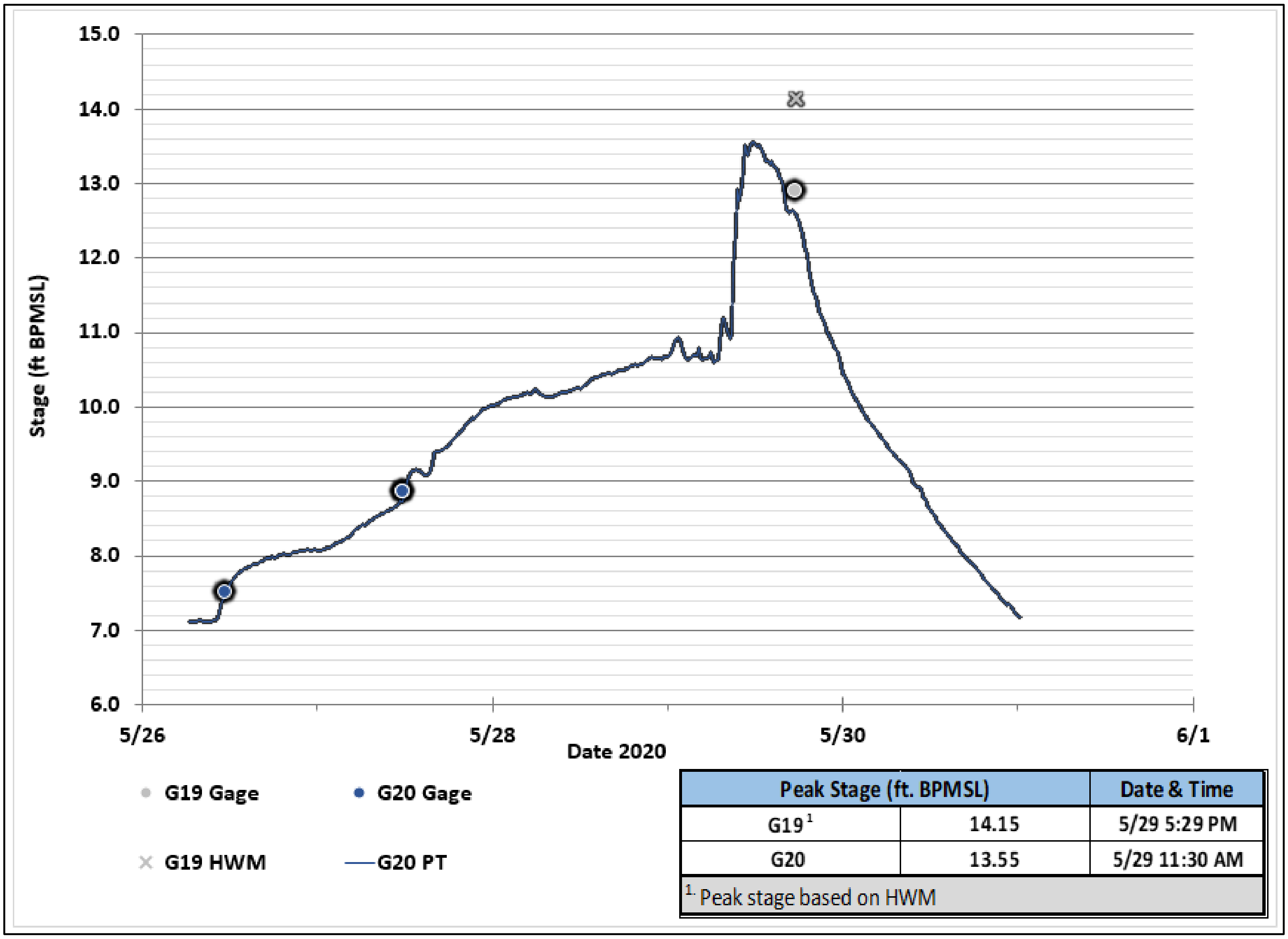
Peak Stage (ft. BPMSL)		Date & Time
G15	10.64	5/29 7:15 PM
G16	12.90	5/29 12:30 PM
Discharge (cfs)		**Date & Time**
Peak Discharge	1,180	5/29 11:00 AM

Graph 4-12: CD4 Road Culverts (Gages G15 & G16) Stage & Discharge



Peak Stage (ft. BPMSL)		Date & Time
G17	12.76	5/29 12:30 PM
G18	14.00	5/29 12:00 PM
Discharge (cfs)		**Date & Time**
Measured Discharge	340	5/29 9:45 AM
Peak Discharge	750	5/29 12:00 PM

Graph 4-13: CD4 Road Culverts (Gages G17 & G18) Stage & Discharge



Graph 4-14: CD4 Pad (Gages G19 & G20) Stage

Table 4.4: CD4 Road Culverts (Gages G17 & G18) Measured Discharge

Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measurement Depth[1] (ft)	Flow Direction[2]	Measured Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD4-25	5/29 10:05 AM	1.50	0.6	South to North	8.29	35.7	337
CD4-26	5/29 10:01 AM	2.80	1.12	South to North	6.60	62.0	
CD4-27	5/29 9:59 AM	2.60	1.04	South to North	3.62	31.3	
CD4-28	5/29 9:57 AM	2.50	1.00	South to North	1.90	15.7	
CD4-29	5/29 9:53 AM	2.80	1.12	South to North	3.22	30.3	
CD4-30	5/29 9:48 AM	2.80	1.12	South to North	6.10	57.3	
CD4-31	5/29 9:42 AM	3.10	1.24	South to North	5.43	56.7	
CD4-32	5/29 9:37 AM	2.50	1.00	South to North	5.84	48.3	

Notes:
1. Measurement taken at 0.6 of total depth of flow.
2. Direction of flow at time of measurement.

Table 4.5: CD4 Road Culverts (Gages G15/G16 & G17/G18) Peak Discharge

Culvert[1]	Calculated Date & Time	WSE Differential (ft)[2]	Total Depth of Flow (ft)	Flow Depth	Calculated Velocity (ft/s)	Calculated Discharge (cfs)[3]	Total Discharge (cfs)
CD4-19	5/29 11:00 AM	2.70	0.4	Less than Half Full	3.1	2	1180
CD4-20A	5/29 11:00 AM		8.0	More than Half Full	7.3	143	
CD4-20B	5/29 11:00 AM		7.2	More than Half Full	7.3	143	
CD4-21	5/29 11:00 AM		7.7	More than Half Full	7.3	143	
CD4-22	5/29 11:00 AM		8.2	More than Half Full	7.3	143	
CD4-23	5/29 11:00 AM		4.9	More than Half Full	7.4	144	
CD4-23A	5/29 11:00 AM		5.6	More than Half Full	7.4	145	
CD4-23B	5/29 11:00 AM		6.7	More than Half Full	7.4	145	
CD4-23C	5/29 11:00 AM		6.8	More than Half Full	6.8	86	
CD4-23D	5/29 11:00 AM		5.8	More than Half Full	6.9	86	
CD4-24	5/29 12:00 PM	1.26	4.1	More than Half Full	5.8	73	746
CD4-25	5/29 12:00 PM		3.7	More than Half Full	6.1	74	
CD4-26	5/29 12:00 PM		3.9	More than Half Full	6.0	75	
CD4-27	5/29 12:00 PM		4.2	More than Half Full	6.0	75	
CD4-28	5/29 12:00 PM		4.0	More than Half Full	6.0	75	
CD4-29	5/29 12:00 PM		4.4	More than Half Full	6.0	75	
CD4-30	5/29 12:00 PM		4.4	More than Half Full	6.0	75	
CD4-31	5/29 12:00 PM		4.2	More than Half Full	6.0	75	
CD4-32	5/29 12:00 PM		4.5	More than Half Full	6.0	75	
CD4-33	5/29 12:00 PM		5.5	More than Half Full	6.0	75	

Notes:
1. Culverts 19-23D associated with gages G15/G16, culverts 24-33 associated with G17/G18.
2. Calculated during peak stage differential between upstream and downstream gages.
3. Positive values indicate flow was south to north

CD5 ROAD

Stage data and observations of breakup processes have been collected along the CD5 road since 2009. Gage sets upstream and downstream of the road are used to evaluate stage a drainage structures and to determine the flood extents along the CD5 road as required per the MP-AMS. The 2020 flood event produced widespread overbank flooding along the CD5 road within the CRD floodplain.

Lake L9323 Bridge

The CD5 Road Bridge #1 crosses a swale at the north/downstream end of the western lobe of Lake L9323. Lake L9323 can become hydraulically connected to the Nigliq Channel (via Tapped Lake and north of the Lake L9323 Bridge) during periods of high water. Lake L9323 also becomes hydraulically connected to the Sakoonang Channel through the CD4 road culvert batteries at the northern/downstream and southern/upstream ends of the eastern lobe. Gage G24 is south/upstream and gage G25 is north/downstream of the bridge.

Isolated localized meltwater was observed near Lake L9323 Bridge on May 28 (Photo 4-41). PT data indicates floodwater reached the G24/G25 gages during early morning on May 29, shortly after the ice jam in the Nigliq Channel at Nuiqsut released. Peak stage occurred around noon on May 29. Aerial observations around peak stage showed widespread overbank flooding, with Lake L9323 hydraulically connected to the Nigliq Channel and the

Sakoonang Channel (Photo 4-42). Stage rapidly receded after peaking and observations from June 1 revealed floodwater was confined to low-lying polygons and Lake L9323 (Photo 4-43 and Photo 4-44).

The Lake L9323 Bridge adequately conveyed flow throughout this year's flood event. Aerial observations show natural flow patterns maintained in the area during peak stage, and the stage hydrographs do not show a large stage differential between G24 and G25, indicating flow passed through the drainage structure unimpeded. Discharge was not measured at the Lake L9323 Bridge due to the limited duration (approximately 1 day) flow was observed through the bridge. Peak discharge occurred on May 29 and was calculated from the G24/G25 stage data.

Lake L9323 Bridge stage and calculated discharge data is provided in Graph 4-15. A summary of peak discharge calculation methods, and plan and profile drawings are presented in Appendix C.

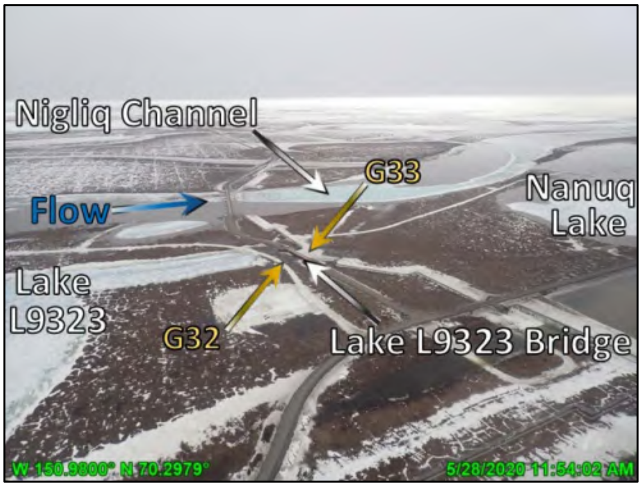


Photo 4-41: Lake L9323 bridge and vicinity prior to peak stage, looking west; May 28, 2020

Photo 4-42: Lake L9323 bridge near peak stage, looking east; May 29, 2020

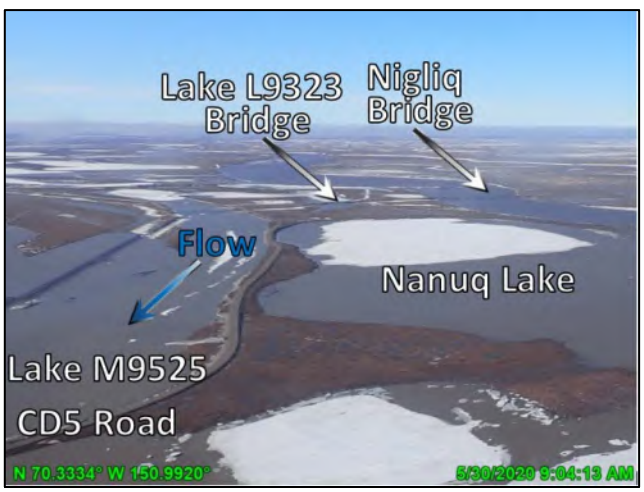


Photo 4-43: Lake L9323 hydraulically disconnected from Nigliq Channel north of bridge crossing, looking south (upstream); May 30, 2020

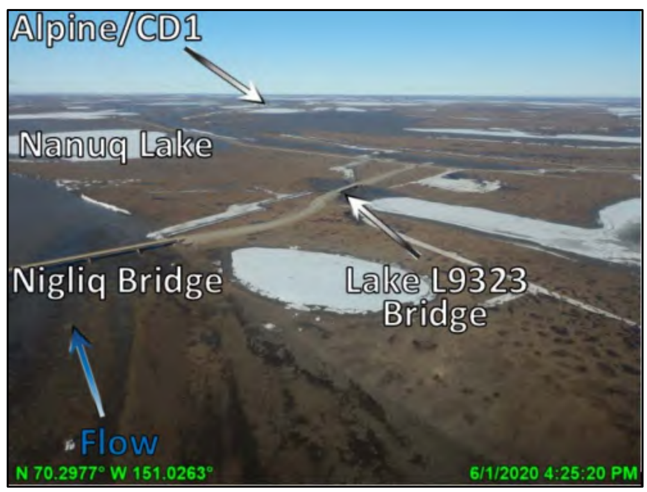
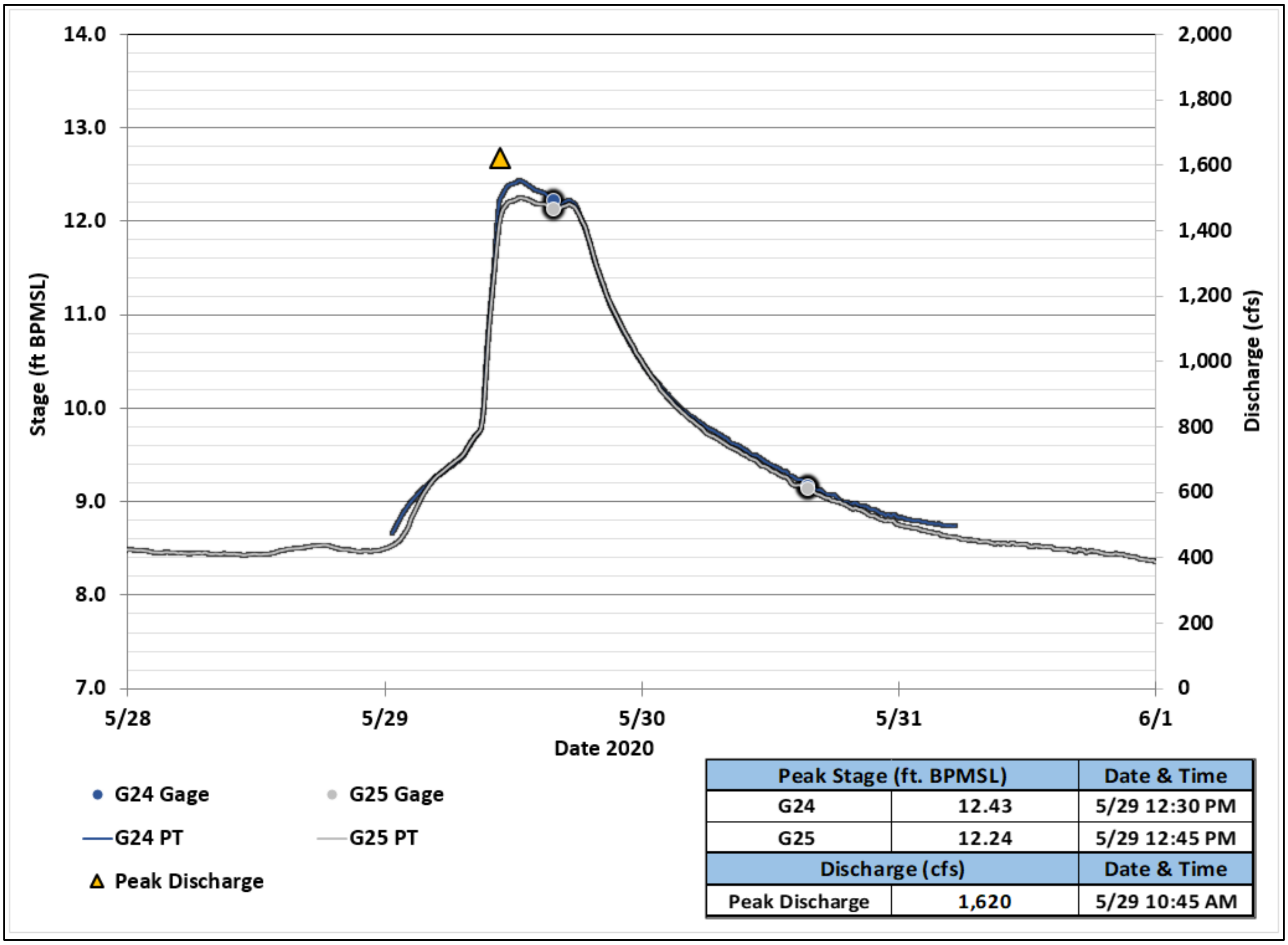


Photo 4-44: Lake L9323 bridge 3 days after peak stage, looking north; June 1, 2020



Peak Stage (ft. BPMSL)		Date & Time
G24	12.43	5/29 12:30 PM
G25	12.24	5/29 12:45 PM
Discharge (cfs)		Date & Time
Peak Discharge	1,620	5/29 10:45 AM

Graph 4-15: Lake L9323 Bridge (Gages G24 & G25) Stage

Nigliq Bridge

The leading edge of floodwater in the Nigliq Channel passed under the bridge on May 22. PT data indicates stage began to rise on May 25. On May 26, aerial observations showed channel ice lifted from the banks, and stage near bankfull (Photo 4-45). Stage continued to gradually increase (Photo 4-46) until May 29 when the ice jam in the Nigliq Channel at Nuiqsut released. Stage and discharge peaked as the surge of floodwater passed through the bridge (Photo 4-47 and Photo 4-48). Observations from the evening on May 29 indicate an ice jam had formed directly downstream from the Nigliq Bridge (Photo 4-49). After peaking, stage rapidly receded as the surge of floodwater progressed down the Nigliq Channel and through Nanuq Lake (Photo 4-50 and Photo 4-51). Stage continued to recede, and stranded ice was observed on the banks near the Nigliq Bridge on May 30 (Photo 4-52).

Discharge was measured on May 30 on the upstream side of the Nigliq Bridge. At the time of the measurement, the channel was free of ice and minimal saturated snow remained along the west bank. Conditions were considered steady and uniform, with minimal effects from ice and snow. The quality of the measurement was classified as fair due to these conditions. Indirect discharge calculated at the time of direct measurement was 6.07 percent higher than the measured discharge.

Nigliq Bridge stage and discharge data is provided in Graph 4-16. A summary of the discharge measurement, peak discharge calculation methods, and plan and profile drawings are presented in Appendix C.

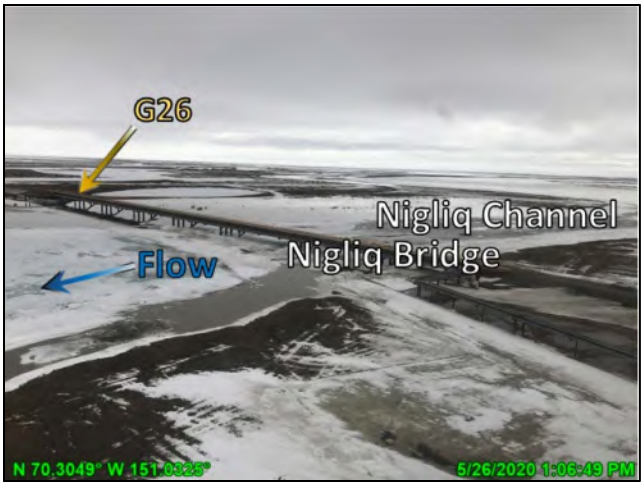


Photo 4-45: Channel ice at the Nigliq Bridge, looking southeast (upstream); May 26, 2020

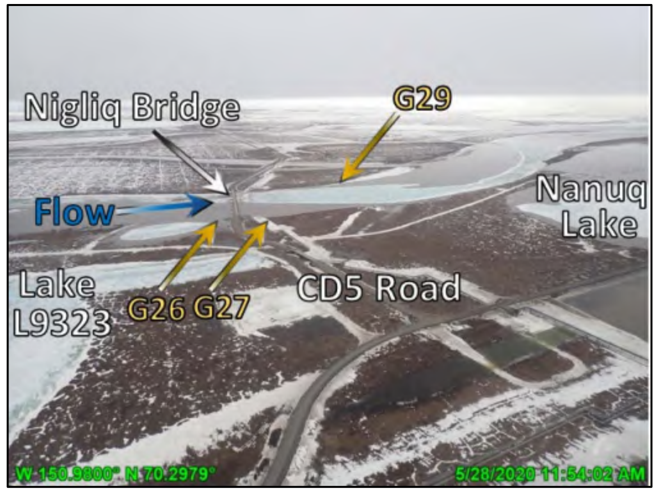


Photo 4-46: Increasing Floodwater at the Nigliq Channel Bridge looking west; May 28 2020

Photo 4-47: Peak stage at the Nigliq Bridge, looking east; May 29 2020

Photo 4-48: Overbank flooding at the Nigliq Bridge, looking southeast (upstream); May 29, 2020

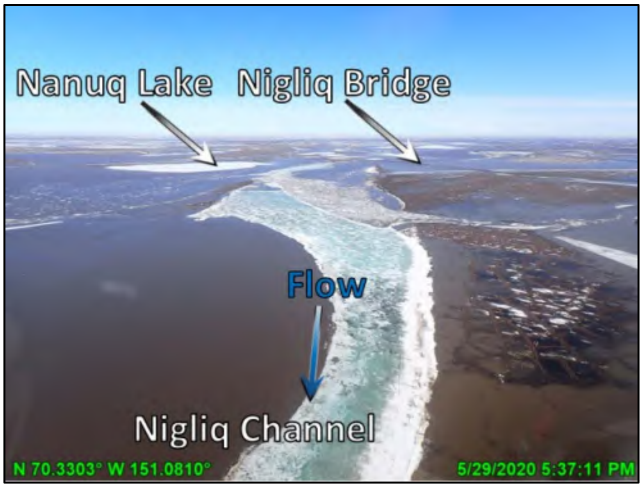


Photo 4-49: Widespread floodwater inundation downstream of Nigliq Bridge crossing, looking south (upstream); May 29, 2020

Photo 4-50: Stranded ice on the east bank of the Nigliq channel, looking northeast; May 30, 2020

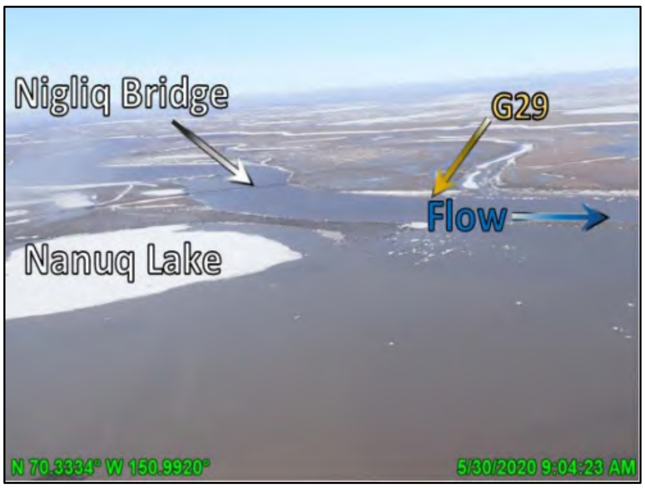


Photo 4-51: Nigliq Bridge the day after peak stage, looking south (upstream); May 30, 2020

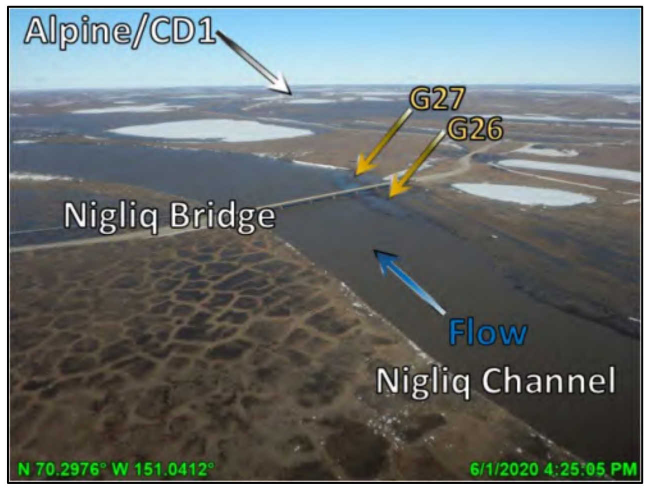
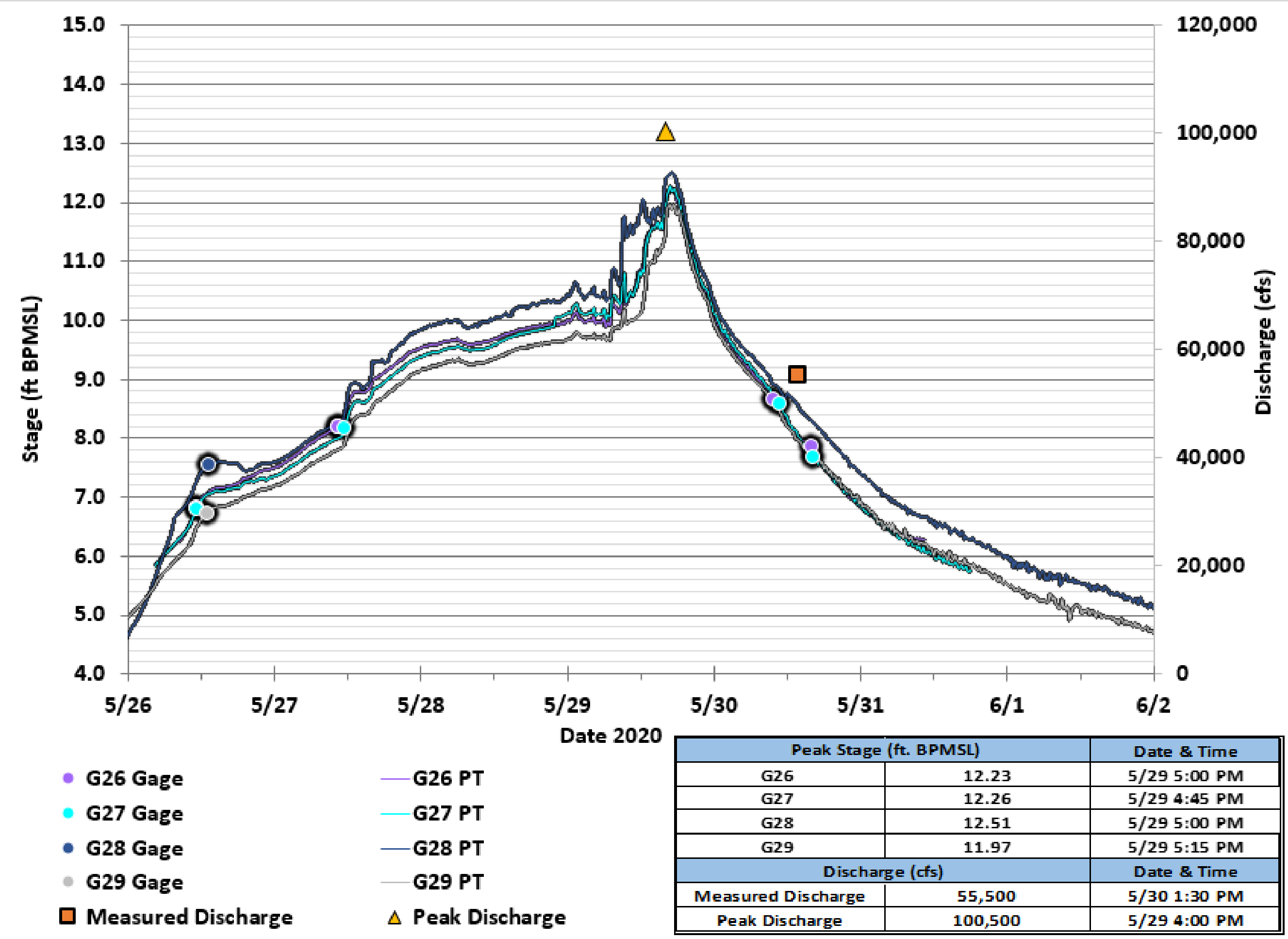


Photo 4-52: Stranded ice on the west bank of the Nigliq channel, looking northeast; May 30, 2020



Peak Stage (ft. BPMSL)		Date & Time
G26	12.23	5/29 5:00 PM
G27	12.26	5/29 4:45 PM
G28	12.51	5/29 5:00 PM
G29	11.97	5/29 5:15 PM
Discharge (cfs)		**Date & Time**
Measured Discharge	55,500	5/30 1:30 PM
Peak Discharge	100,500	5/29 4:00 PM

Graph 4-16: Nigliq Bridge (Gages G26, G27, G28, and G29) Stage & Discharge

Lake L9341 Bridge

The CD5 Road Bridge #3 crosses Lake L9341, which is the downstream-most water body in a series of lakes formed through a paleochannel of the Nigliq Channel. This paleochannel can become an active channel during periods of high water. During lower stage breakup events, only backwater from the Nigliq Channel is present and typically enters Lake L9341 from the northern end. Gage G32 is south (upstream) and gage G33 is north (downstream) of the bridge. G30(south) and G31 (north) are situated on the overbank between Lake L9341 and the Nigliq Channel.

PT data indicates stage began to rise at G32 on May 26. The initial rise in stage was concurrent with stage rise at gage G29 in the Nigliq Channel downstream of the CD5 road, suggesting backwater from the Nigliq Channel had reached the Lake L9341 crossing. A site visit on May 27 revealed minor overbank flooding on the east bank (Photo 4-53). An ice road adjacent to the bridge on the north side persisted through May 28 (Photo 4-54). Stage continued to gradually rise until May 29 when the surge of floodwater in the Nigliq Channel caused stage to rapidly rise (Photo 4-55, Photo 4-56, and Photo 4-57). During peak stage, flow was observed from north to south through the bridge crossing. PT data shows stage quickly receding after peak. The G33 PT malfunctioned but highwater marks and staff gage measurements near peak stage indicate there was a small differential upstream and downstream of the bridge suggesting flow through the bridge opening. Spring

Aerial photographs confirm that intact ice persisted in Lake L9341 throughout breakup and after peak stage. An overflight on June 1 showed ice present in Lake L9341 from the northern confluence with the Nigliq extending south past the bridge crossing (Photo 4-58). The intact ice under the bridge prevented discharge from being measured. Discharge calculations were not performed due to the uncertainties in channel geometry associated with the intact ice.

Lake L9341 Bridge stage data is provided in Graph 4-17. Plan and profile drawings are presented in Appendix C.

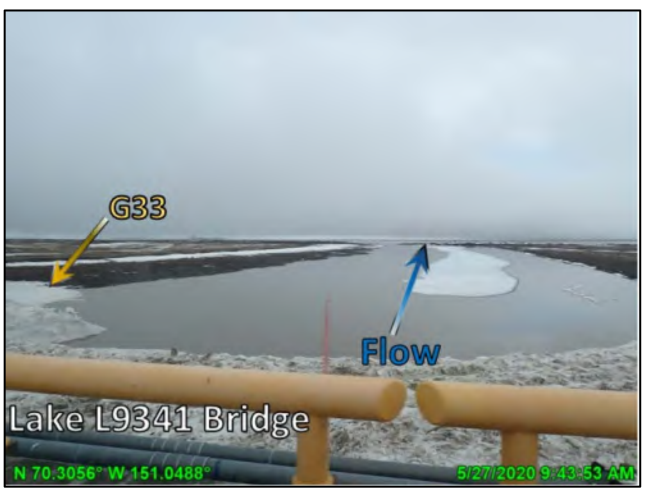


Photo 4-53: Channel ice in Lake L9341 as breakup initiates, looking north (downstream); May 27, 2020

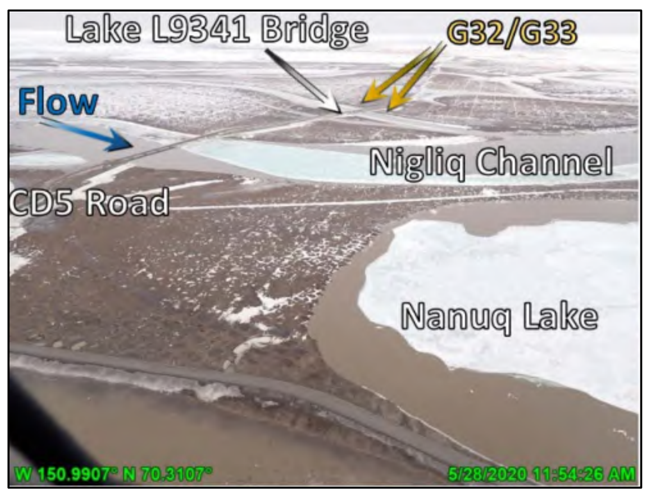


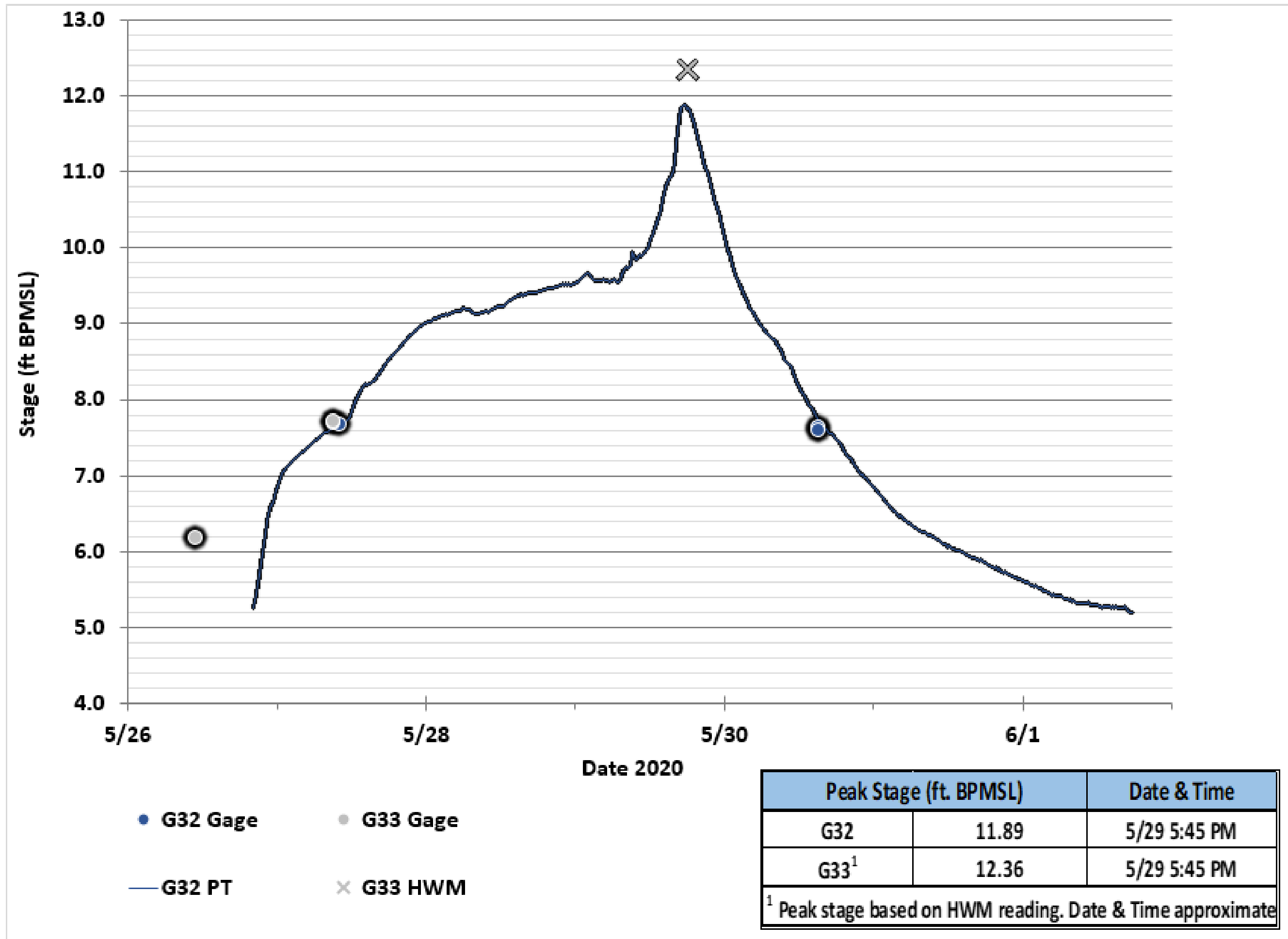
Photo 4-54: Lake L9341 hydraulically connected to Nigliq Channel on north end, looking southwest; May 28, 2020

Photo 4-55: L9341 and vicinity near peak stage, looking southeast (upstream); May 29, 2020

Photo 4-56: Overbank flooding near the Lake L9341 bridge crossing, looking southeast (upstream); May 29, 2020

Photo 4-57: Lake L9341 hydraulically connected to Nigliq Channel on north end, looking north (upstream); May 30, 2020

Photo 4-58: Chanel ice persisting in Lake L9341 after peak, looking north; June 1, 2020



Peak Stage (ft. BPMSL)		Date & Time
G32	11.89	5/29 5:45 PM
G33[1]	12.36	5/29 5:45 PM

[1] Peak stage based on HWM reading. Date & Time approximate

Graph 4-17: Lake L9341 Bridge (Gages G32 and G33) Stage

Nigliagvik Bridge

The CD5 Road Bridge #4 crosses the Nigliagvik Channel, which is a branch of the Nigliq Channel on the western extent of the CRD. The Nigliagvik Channel diverges from the Nigliq Channel approximately 4 RM upstream of the Nigliq Bridge and 5.5 RM upstream of the Nigliagvik Bridge; it converges with the Nigliq Channel approximately 2 RM downstream of each bridge. The Nigliagvik Channel is typically hydraulically connected throughout its length with the Nigliq Channel during the open water season. Gage G38 is south (upstream) and gage G39 is north (downstream) of the bridge.

PT data shows an increase in stage at G38 and G39 starting on May 25. On May 26, south to north flow was observed through the bridge crossing. Saturated snow was observed along each bank, and channel ice was observed south of the bridge crossing (Photo 4-59). PT data shows stage rising until peak stage occurred on May 29, corresponding to the surge of floodwater in the Nigliq Channel. A site visit on May 29 revealed minor overbank flooding along the east bank, saturated snow along the west bank, and channel ice still present south of the bridge crossing (Photo 4-60). Ice floes were observed actively breaking from the channel ice near the bridge crossing. After peak stage, PT data shows stage receded until falling below the PT elevation on June 5. Observations from May 30 show the channel clear of ice (Photo 4-61). By June 1, stage throughout the Nigliagvik Channel was below bankfull (Photo 4-62).

Peak Stage at the Nigliagvik Bridge was concurrent with peak stage in the Nigliq Channel. Peak discharge occurred on the falling limb of the stage hydrograph, immediately after peak stage. Aerial observations show snow along the banks and ice in the channel approximately 3 hours prior to peak stage. Calculated peak discharge was assigned a fair quality rating based on the high potential of ice and snow during peak conditions. Discharge was measured on the upstream side of the Nigliagvik Bridge on May 31. At the time of the measurement, the Nigliagvik Channel at the discharge location was clear of ice and snow. The quality of the measurement was classified as good due to the ice-free channel conditions.

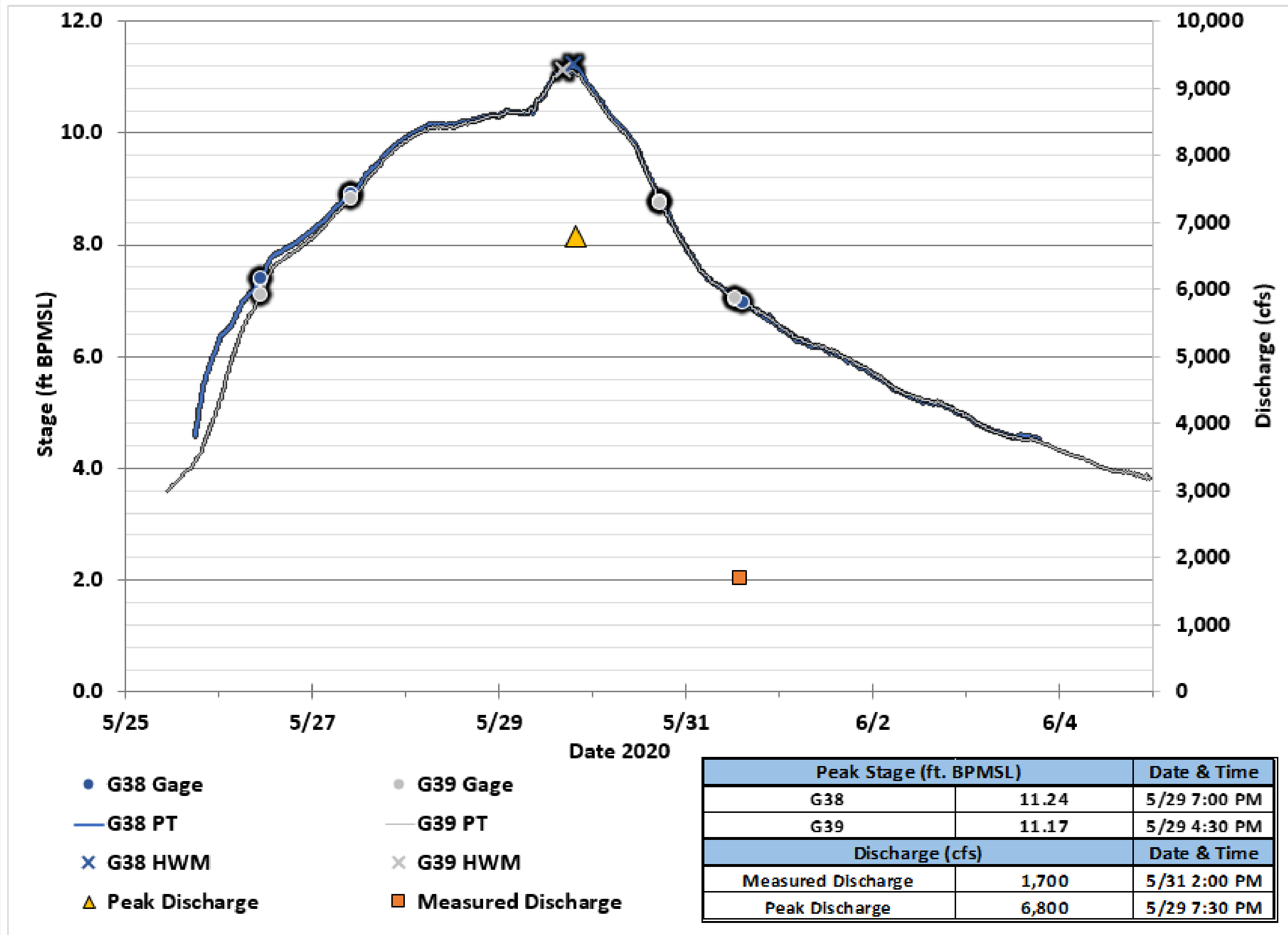
Nigliagvik Bridge stage data is provided in Graph 4-18. A summary of the discharge measurement, peak discharge calculation methods, and plan and profile drawings are presented in Appendix C.

Photo 4-59: Floodwater and channel ice in the Nigliagvik Channel, looking south; May 26, 2020

Photo 4-60: Nigliagvik Bridge near peak stage, looking southeast; May 29, 2020

Photo 4-61: Conditions at the Nigliagvik Bridge one day after peak stage, looking southwest (upstream); May 30,2020

Photo 4-62: Stage below bankfull in the Nigliagvik Channel, looking northeast (downstream); June 1, 2020



Peak Stage (ft. BPMSL)		Date & Time
G38	11.24	5/29 7:00 PM
G39	11.17	5/29 4:30 PM
Discharge (cfs)		**Date & Time**
Measured Discharge	1,700	5/31 2:00 PM
Peak Discharge	6,800	5/29 7:30 PM

Graph 4-18: Nigliagvik Bridge (Gages G38 & G39) Stage

Culverts

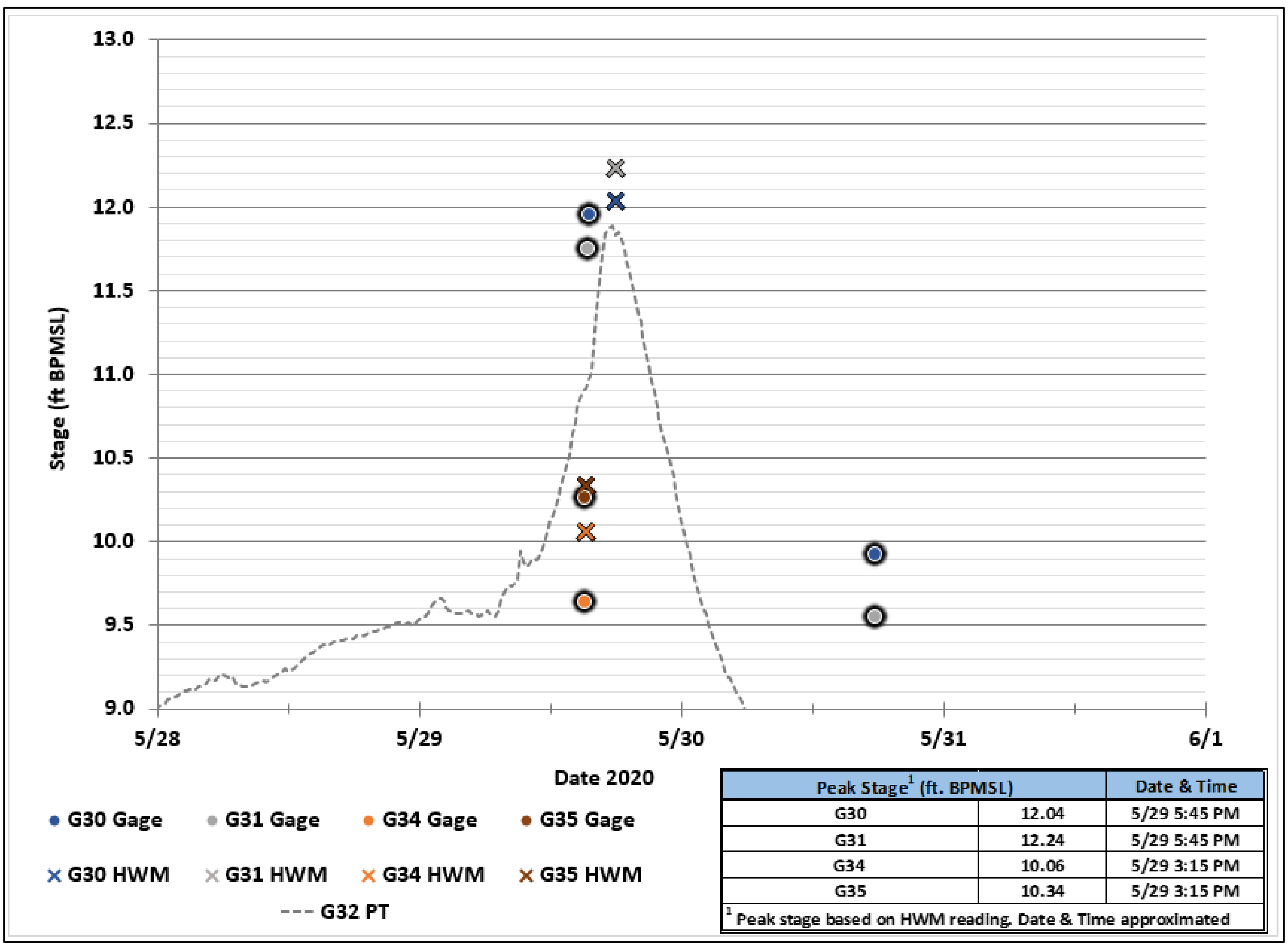
The CD5 culverts east of the Nigliagvik Channel convey overbank floodwater from the Nigliq and Nigliagvik Channels during large flood events and equalize local meltwater across the CD5 road during low flood events. The CD5 culverts west of the Nigliagvik Channel are topographically isolated from CRD flooding. Lacking major channels in the vicinity, culverts in this region allow hydraulic equalization of meltwater between lakes, swales, and/or paleochannels.

During a site visit on May 29 prior to peak stage, flow through CD5 road culverts east of the Nigliagvik was limited to the equalization of local melt water, and most culverts were not flowing. Culverts CD5-35 and CD5-42, immediately west of Lake L9341, were observed flowing North to South at this time (Photo 4-63 and Photo 4-64).

PT data suggests that as stage along the CD5 road increased and local drainages became hydraulically connected, south to north flow was established through most CD5 culverts. Stage data from gage readings is presented in Graph 4-19. Measured discharge at CD5 road culverts conveying flow is summarized in Table 4.6. Additional culvert discharge data is provided in Appendix C.

Photo 4-63: Widespread inundation west of the Nigliq channel due to overbank flooding, looking north; May 29, 2020

Photo 4-64: North to south flow through culvert CD5-35, looking south; May 29, 2020



Peak Stage[1] (ft. BPMSL)		Date & Time
G30	12.04	5/29 5:45 PM
G31	12.24	5/29 5:45 PM
G34	10.06	5/29 3:15 PM
G35	10.34	5/29 3:15 PM

[1] Peak stage based on HWM reading. Date & Time approximated

Graph 4-19: CD5 Road Culverts (Gages G30, G31, G34, & G35) Stage

Table 4.6: CD5 Road Culverts Measured Discharge

Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measurement Depth[1] (ft)	Flow Direction[2]	Measured Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD5-35	5/29 3:11 PM	4.0	1.6	North to South	2.49	31	44
CD5-42	5/29 3:34 PM	3.0	1.2	North to South	1.29	13	

Notes:
1. Measurement taken at 0.6 of total depth of flow.
2. Direction of flow at time of measurement.

GMT1/MT6 ROAD

The UB6.7 and UB6.9 gage stations are located in the Tinmiaqsiugvik River at RM 6.7 (downstream of the Tinmiaqsiugvik Bridge) and at RM 6.9 (upstream of the Tinmiaqsiugvik Bridge), measured upstream from the confluence with Fish Creek. The drainage basin area is approximately 231 square miles upstream of the Tinmiaqsiugvik Bridge. The Tinmiaqsiugvik River drains northwest into Fish Creek 6.7 RM downstream of the bridge. The UB gage stations have been monitored intermittently since 2003.

Meltwater was initially observed as discontinuous pools in the channel during an overflight on May 24. Snow cover was estimated at 85% along the GMT1/MT6 road. On May 28, meltwater was hydraulically connected through the bridge crossing. Stage began steadily rising on May 29 as recorded on both upstream and downstream gages. On May 30, aerial observations revealed stage below bankfull and channel ice intact near the crossing (Photo 4-65). A small ice jam was observed upstream of the bridge on May 31. This jam appeared to hold minimal backwater as overbank flow paths developed around the jam (Photo 4-66). Stage continued to rise until peak stage on May 31. Observations near peak stage revealed minor overbank flooding in low-lying areas near the gages (Photo 4-67). After peaking, stage gradually receded to summer flow levels. An overflight on June 4 showed the ice jam still in place as water levels receded (Photo 4-68).

Discharge was measured on the morning of June 1 from the upstream side of the bridge. At the time of the measurement, the channel was mostly free of ice and snow with minor ice floes releasing from the jam upstream of the bridge (Photo 4-69 and Photo 4-70). Peak discharge occurred on June 1 about 2 hours after discharge was measured. The discharge quality rating was classified as fair due to minor ice effects at the time of the measurement.

Tinmiaqsiugvik Bridge stage and discharge data is provided in Graph 4-20. A summary of the discharge measurement and peak discharge calculation methods are provided in Appendix C.

Photo 4-65: Tinmiaqsiugvik Bridge prior to peak stage, looking south (upstream); May 30, 2020

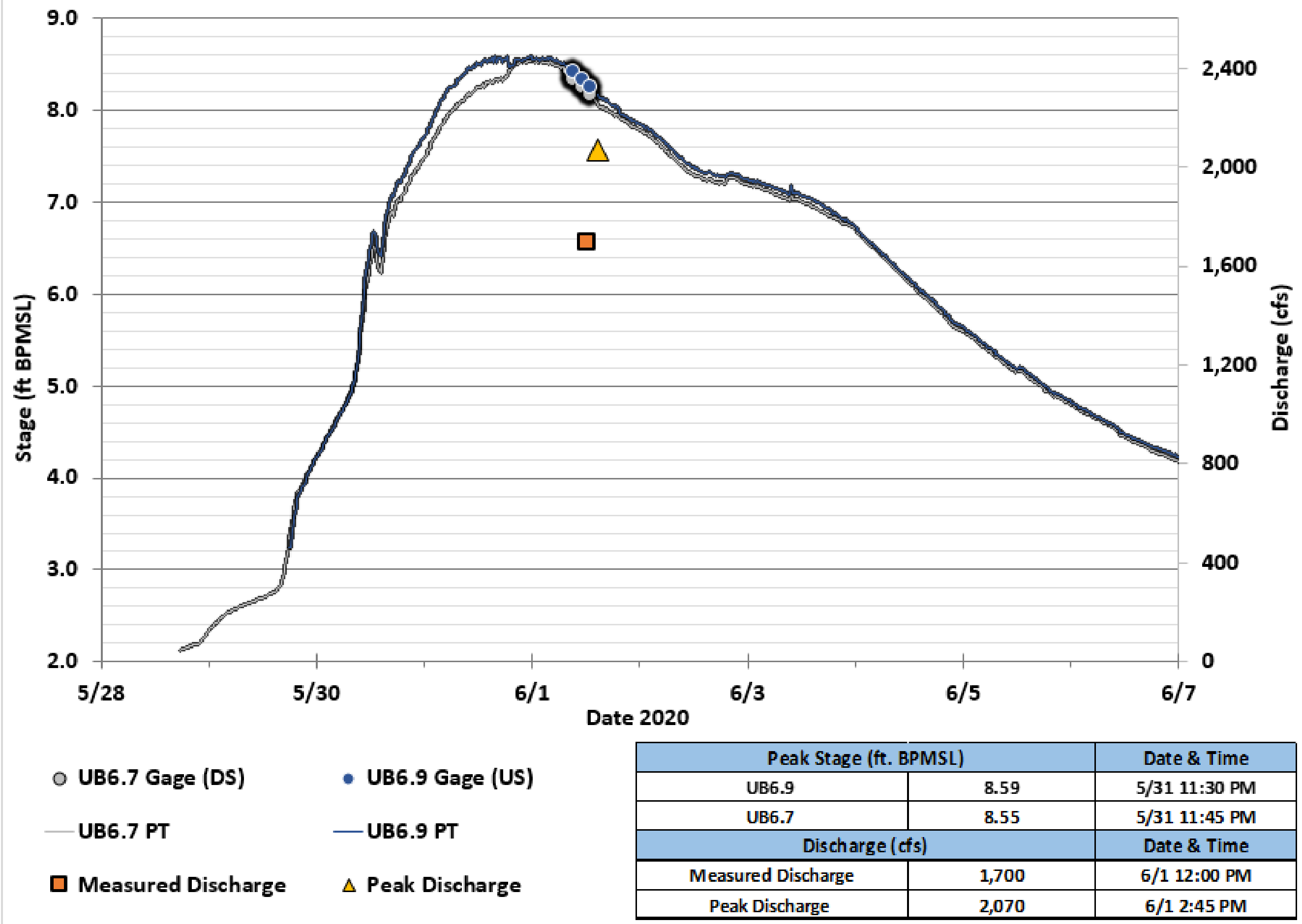
Photo 4-66: Ice jam upstream of the Tinmiaqsiugvik Bridge, looking southeast (upstream); May 31, 2020

Photo 4-67: RTFM photo from directly downstream of Tinmiaqsiugvik Bridge at peak stage, looking north (downstream); May 31, 2020

Photo 4-68 Ice jam still in place upstream from the bridge crossing, looking northeast (downstream); June 4, 2020

Photo 4-69: Ice jam upstream of Tinmiaqsiugvik Bridge in place after peak stage, looking north (downstream); June 1, 2020

Photo 4-70: Tinmiaqsiugvik Bridge during discharge measurement looking east; June 1, 2020



Peak Stage (ft. BPMSL)		Date & Time
UB6.9	8.59	5/31 11:30 PM
UB6.7	8.55	5/31 11:45 PM
Discharge (cfs)		**Date & Time**
Measured Discharge	1,700	6/1 12:00 PM
Peak Discharge	2,070	6/1 2:45 PM

Graph 4-20: Tinmiaqsiugvik Bridge (UB6.7 & UB6.9) Stage

4.5 Peak Discharge Distribution

In general, flow distribution between the East Channel and Nigliq Channel bifurcations is about 80/20% respectively. Historically, this value is determined at the general time of peak discharge common to both channels. However, during years with large ice jams in the Colville River Delta, the timing of peak discharge between the two channels can vary greatly due to the storage and release of floodwater behind the jams. The 2020 spring flood event produced peak discharge in each channel nearly two days apart. Peak discharge at MON1 and in the East Channel was the result of an upstream ice jam release on May 27, before the ice jam reformed in the delta and accumulated backwater. Peak discharge in the Nigliq Channel was the result of an ice jam release near Nuiqsut two days later on May 29. Since peak discharge in each channel occurred on different days and was the result of separate ice jamming events, determining a common time with which to compare the discharge distribution was not feasible for the 2020 spring flood event.

5. POST-BREAKUP CONDITIONS ASSESSMENT

Alpine roads and pads were inspected for erosion on June 1. Washlines were noted on the north side of the CD2 road between the long and short swale bridge, however vegetation under the washlines suggest this was from a flood event prior to 2020, likely 2015. Photo 5-1 through Photo 5-4 shows the CD2 and CD4 road, after stage had receded. No discernable erosion directly attributable to 2020 breakup flooding was observed during aerial and ground reconnaissance of the CD2, CD4, and CD5 roads. Floodwaters did reach most CD5 bridge abutments, but no discernable erosion was observed along the abutments. Washlines from 2015 spring breakup, which was the largest historical flood event to impact Alpine facilities, remain evident along portions of the CD2, CD4, and CD5 roads. There were no signs of sloughing or undermining at drainage structures.

Soundings collected during the discharge measurement at the long swale bridge indicate the scour hole between piers E9 and E10 continues to get deeper. This was confirmed by comparing the 2019 and 2020 bathymetric surveys which indicate an additional 3.5 ft of scour. At this location, ponded water is not freezing to the bed in the winter, leading to a thaw bulb developing under the bridge. Since bed material is not frozen during spring breakup flooding, it continues to be prone to scour.

Additional photo documentation of erosion surveys and breakup conditions along the Alpine facilities roads and pads are shown in Appendix D.

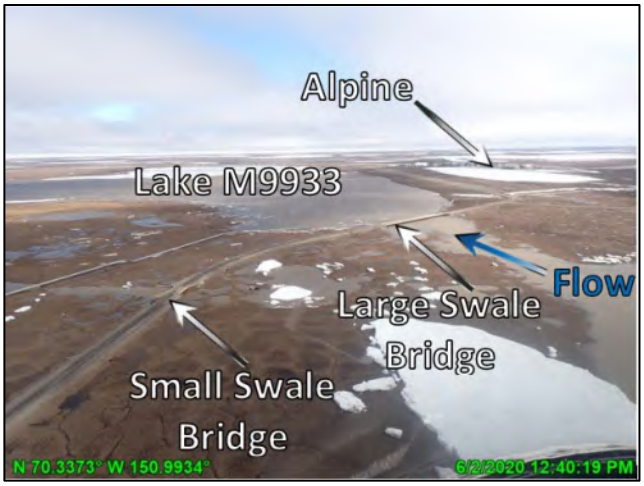


Photo 5-1: CD2 road Long and Short Swale Bridges post-breakup, looking northeast; June 2, 2020

Photo 5-2: CD2 road post-breakup, looking northwest; June 1, 2020

Photo 5-3: CD2 road near Short Swale Bridge post-breakup, looking west; June 1, 2020

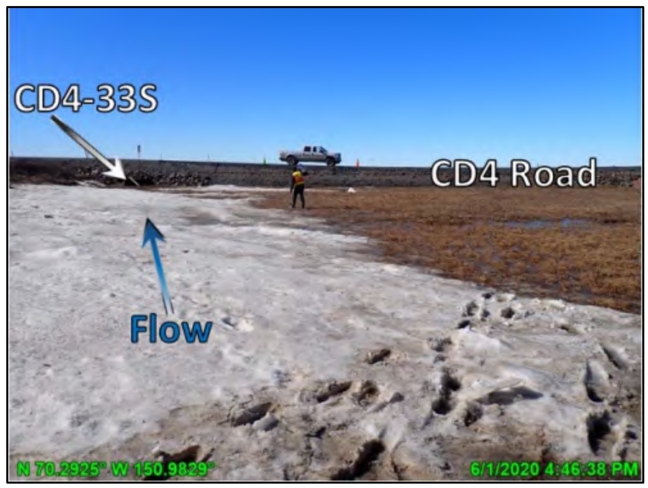


Photo 5-4: CD4 road post breakup near Gage G18, looking northwest; June 1, 2020

6. CD5 PIER SCOUR, BANK EROSION, & BATHYMETRY

6.1 Pier Scour

Real-time pier scour was measured during spring break up at the downstream pile at each scour-susceptible pier group. Post-breakup pier scour elevations that encompass all piles in each pier group were measured by UMIAQ in August 2020. Photo 6-1 and Photo 6-2 show pier numbers for the Nigliq and Nigliagvik bridges, respectfully. Post-breakup contour plots around the piers and within the main channel of the Nigliq Bridge and Nigliagvik Bridge are provided in Appendix E (UMIAQ 2020a).

Photo 6-1: Pier numbers on the Niglig Bridge, looking northeast; June 1, 2020

Photo 6-2: Pier numbers on the Nigliagvik Bridge, looking north; May 30, 2020

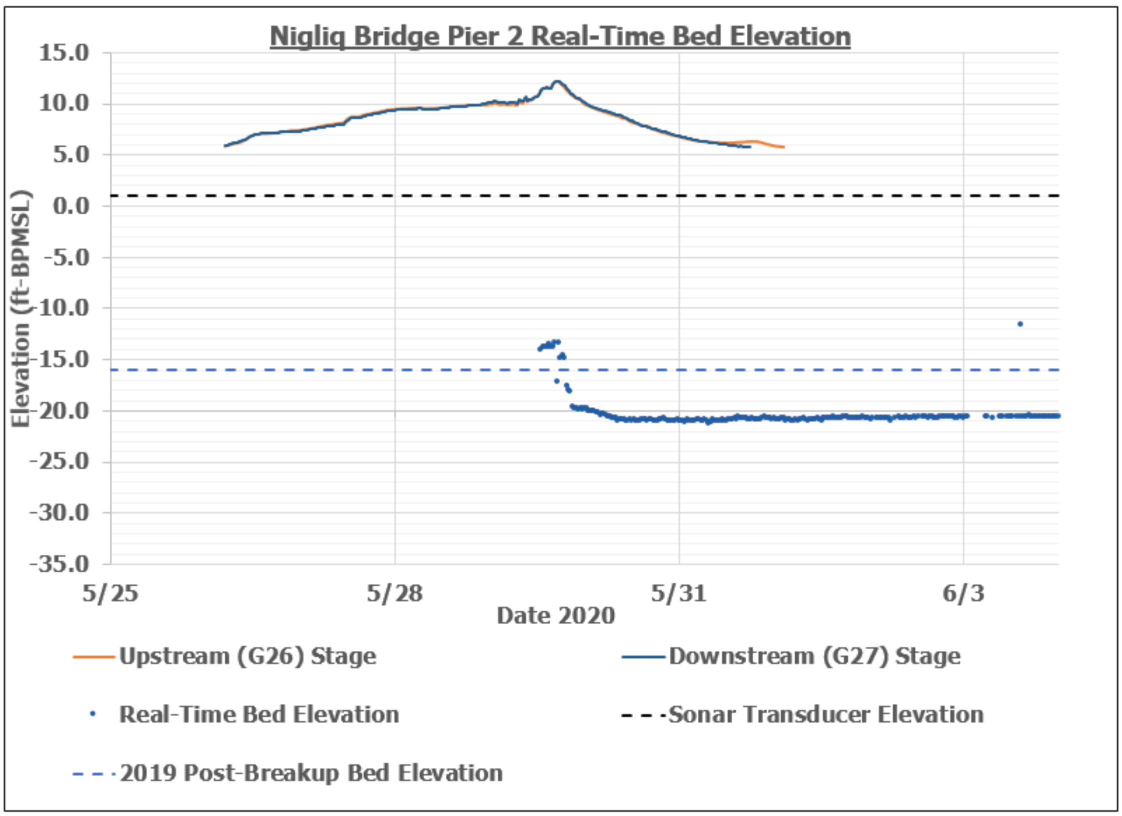
NIGLIQ BRIDGE

The minimum post-breakup scour elevation (-30.2 ft BPMSL at pier 4, pile D) is 1.3 ft below the 50-year design scour elevation and 2.8 ft above the 200-year 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 6-4. Real-time pier scour measurements at pier 2 and pier 3 recorded approximately 5 and 4 ft of scour below the 2019 post-breakup survey elevation, respectively. At piers 4 and 5, real-time scour measurements recorded approximately 1 ft of scour followed by infilling to the 2019 post breakup survey elevation.

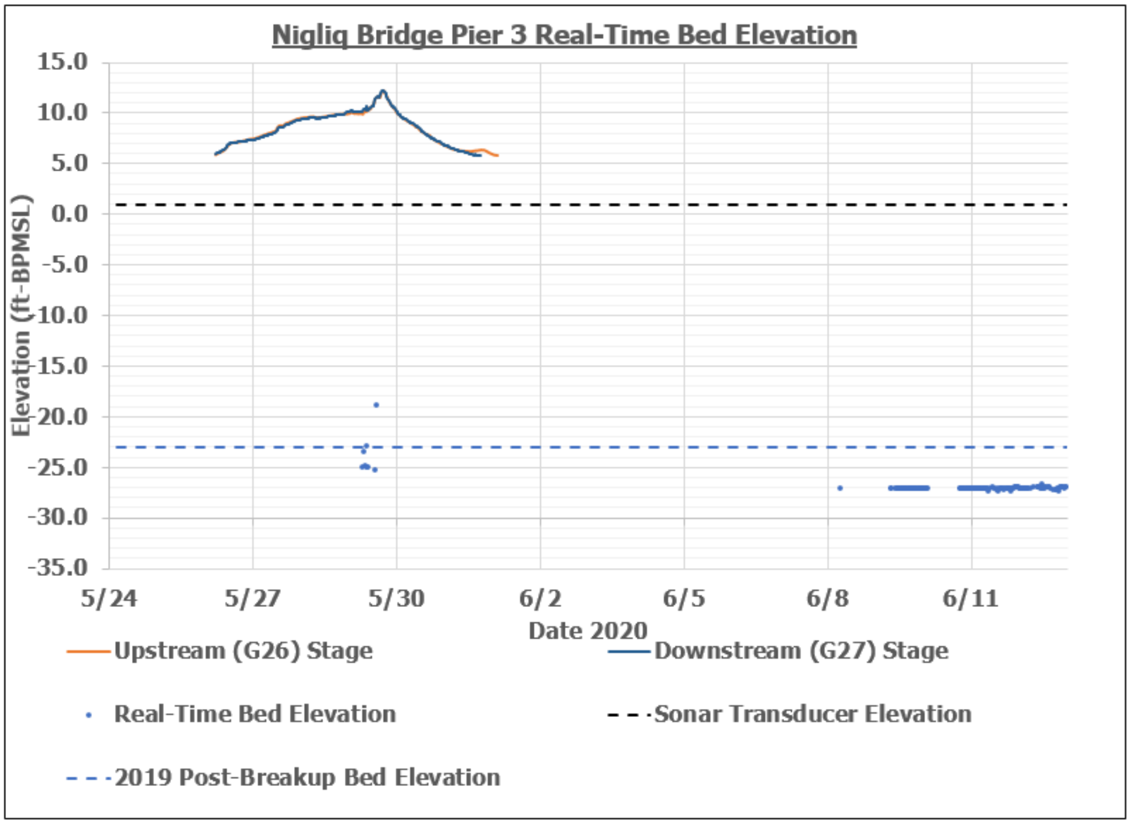
Table 6.1: Nigliq Bridge Comparison of Design and Observed Pier Scour Elevations

Nigliq Bridge Pier Scour		
During Breakup 2020		Elevation (ft-BPMSL)[1,2]
Pier 2	Pile E	-21.2
Pier 3	Pile E	-25.3
Pier 4	Pile E	-31.1
Pier 5	Pile E	-20.5
Post-Breakup 2020		Elevation (ft-BPMSL)[3]
Pier 2	Pile B on southeast side	-24.3
Pier 3	Pile E on southwest side	-28.1
Pier 4	Pile E on south side	-30.2
Pier 5	Pile E on north side	-18.2
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

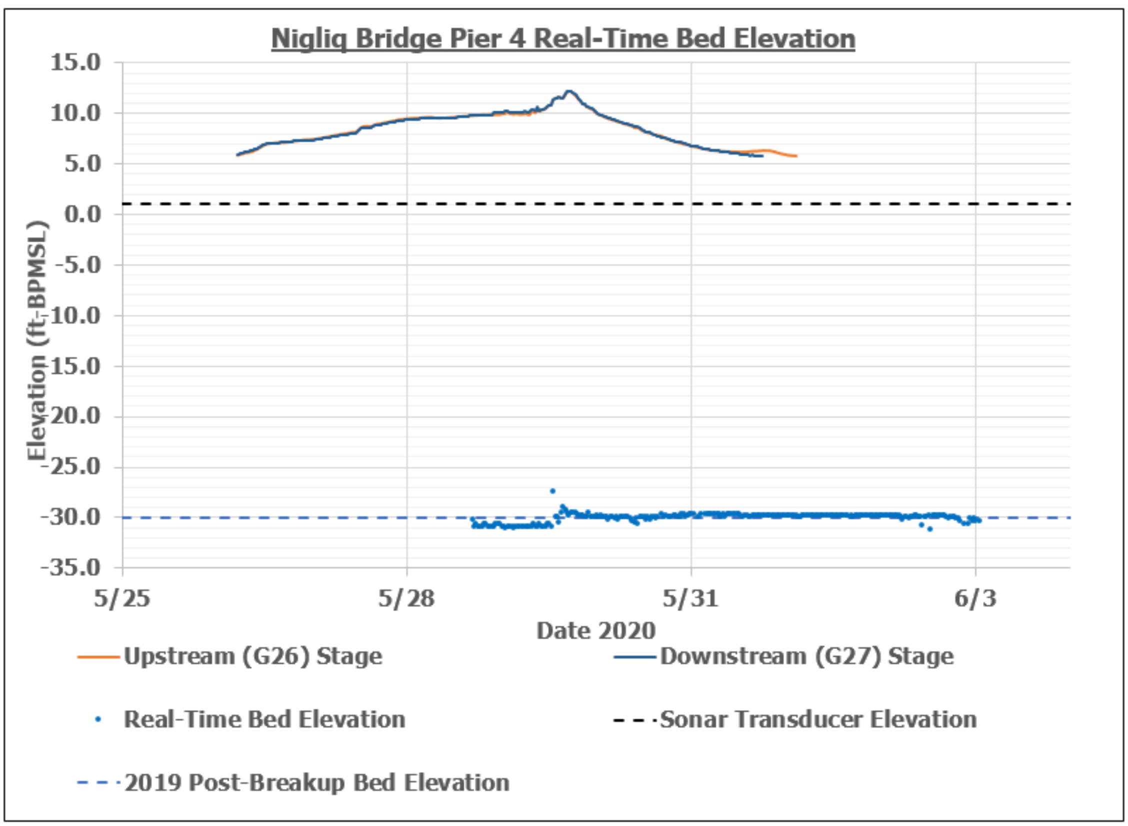
Notes:
[1]Minimum channel bed elevations recorded by real-time scour system in May and June 2020.
[2]Real-time scour measurements at downstream side of downstream pile.
[3]Minimum channel bed elevations recorded by LCMF in August 2020.
[4]Design values presented in PND 2013.
[5]Elevations based on LCMF 2008 survey.



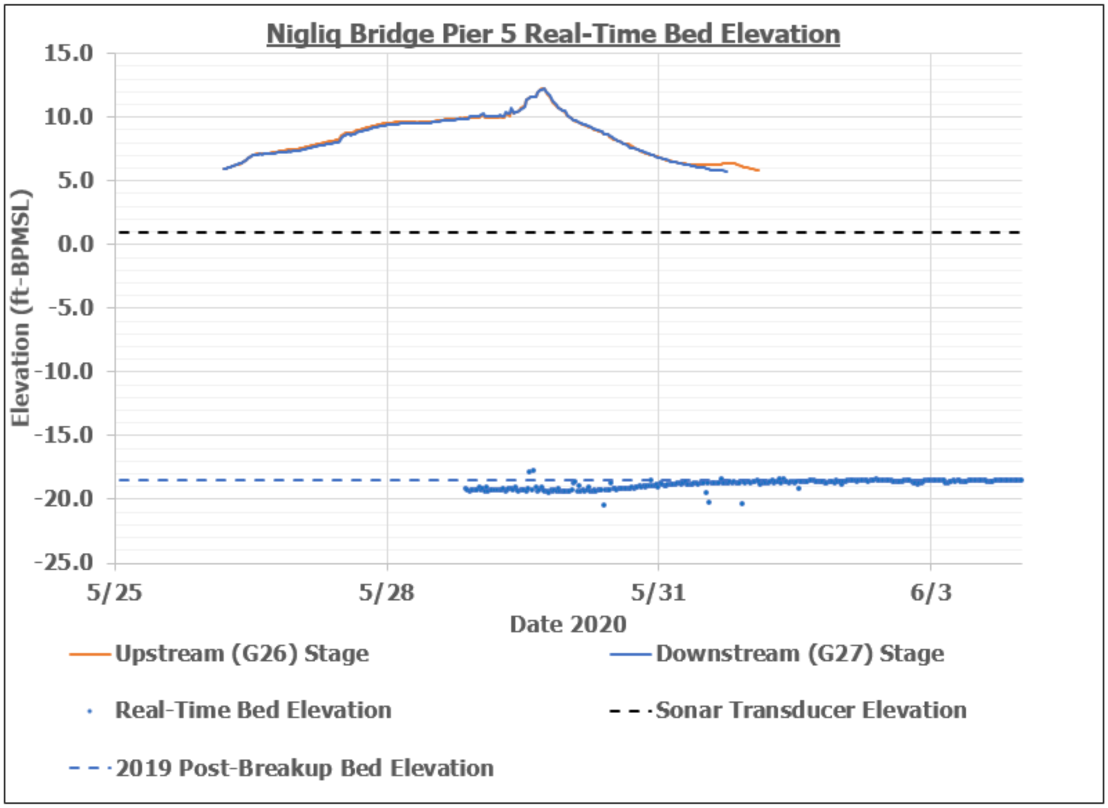
Graph 6-1: Nigliq Bridge Pier 2 (Pile E) Real-Time Scour Elevations



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

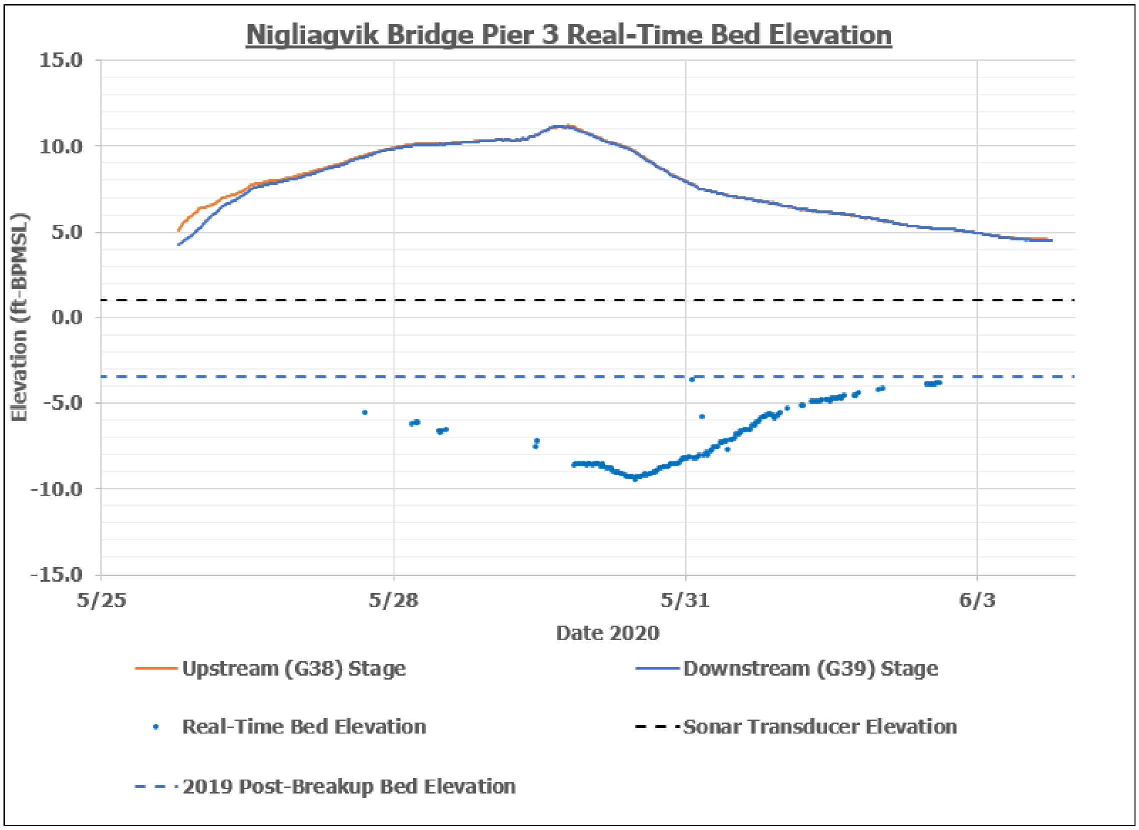
NIGLIAGVIK BRIDGE

The minimum post-breakup scour elevation (-5.0 ft BPMSL at pier 4, pile B) is 9.2 ft above the 50-year design scour elevation and 16.8 ft above the 200-year scour elevation. A comparison of design and observed scour elevations are presented in Table 6.2. Real-time pier scour at pier 3 and corresponding WSEs during spring breakup monitoring is presented in Graph 6-5. Real-time pier scour measurements indicated approximately 6 ft of active scour during peak conditions that filled back in with sediment as stage decreased.

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

Nigliagvik Bridge Pier Scour		
During Breakup 2020		**Elevation (ft-BPMSL)[1]**
Pier 3	Pile B on north side	-9.4
Post-Breakup 2020		**Elevation (ft-BPMSL)[1]**
Pier 3	Pile A on north side	-4.5
Pier 4	Pile B on North side	-5.0
Design 2013		**Elevation (ft-BPMSL)[2,3]**
50-year	Pier 3-4	-14.2
200-year	Pier 3-4	-21.8

Notes:
[1]Minimum channel bed elevations recorded by LCMF in August 2020
[2]Design values presented in PND 2013
[3]Elevations based on LCMF 2008 survey



Graph 6-5: Nigliagvik Bridge Pier 3 (Pile B) Real-Time Scour Elevations

6.2 Bank Erosion

Aerial photos taken post breakup showing no apparent channel migration of the Nigliq and Nigliagvik Channels are presented in Photo 6-3 and Photo 6-4, respectively. A bank erosion survey upstream and downstream of the Nigliq and Nigliagvik Bridges was performed on August 29 and August 24, respectively. Site conditions during the bank erosion survey at the Nigliq Bridge are presented in Photo 6-5 and Photo 6-6. Maximum incremental and cumulative erosion at the Nigliq Bridge and Nigliagvik Bridge and maximum incremental, maximum cumulative, and average erosion along the top of bank, upstream and downstream of the bridges, is presented in Table 6.3. Bank erosion tabulated data form the bank erosion survey is presented in Appendix E (UMIAQ 2020).

Photo 6-3: Nigliq channel post breakup showing no channel migration, looking northeast; June 1, 2020

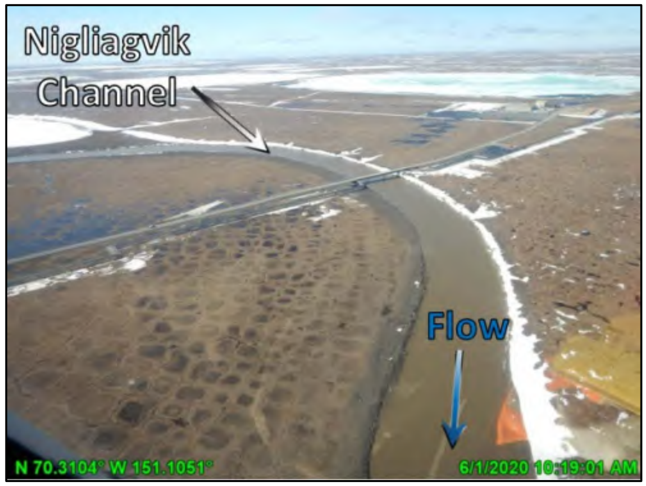


Photo 6-4: Nigliagvik channel post breakup showing no channel migration, looking southwest; June 1, 2020

Photo 6-5: West bank of the Nigliq Channel near the Nigliq Bridge, looking north; September 7, 2020

Photo 6-6: West bank of the Nigliq Channel south of the Nigliq Bridge, looking north; September 7, 2020

Table 6.3: Nigliq Channel and Nigliagvik Channel Bank Erosion

		Nigliq Channel						Nigliagvik Channel					
		West Bank			East Bank			West Bank			East Bank		
		Station[1] (STA)	Distance (ft)	Rate (ft/yr)	Station[1] (STA)	Distance (ft)	Rate (ft/yr)	Station[1] (STA)	Distance (ft)	Rate (ft/yr)	Station[1] (STA)	Distance (ft)	Rate (ft/yr)
Bridge Stations[2]	Maximum Incremental Erosion (2019-2020)	12+00	4.2	--	None	None	--	None	None	--	6+00	0.1	--
Bridge Stations[2]	Maximum Cumulative Erosion (2013-2020)	12+00	12.0	1.7	14+00	4.2	0.6	5+00	20.9	3.0	None	None	--
All Stations	Maximum Incremental Erosion (2019-2020)	2+00	14.9	--	Varies	0.2	--	0+00	0.4	--	Varies	0.1	--
All Stations	Maximum Cumulative Erosion (2013-2020)	0+00	45.1	6.4	Varies	0.2	0.0	0+00	9.3	1.3	4+00	7.3	1.0
All Stations	Average Cumulative Erosion (2013-2020)	All	--	1.6	All	--	0.0	All	--	0.9	All	--	0.0

Notes:
1. Stationing begins upstream of bridge
2. Nigliq Bridge Stations 10+00 through 13+00 on West Bank and 13+00 through 15+00 on East Bank. Nigliagvik Bridge Stations 5+00 through 6+00 on both banks

6.3 Bathymetry

BATHYMETRY AT BRIDGES

The 2020 survey results at each CD5 bridge location were compared with the survey results from 2013-2019 to obtain maximum incremental scour and deposition between 2020 and 2019, and maximum cumulative scour and deposition between 2020 and 2013 (Table 6.4). Transect profiles, bathymetric cross-sections, and tabulated data are provided in Appendix E (UMIAQ 2020).

Table 6.4: Nigliq Bridge, Lake L9341 Bridge, and Nigliagvik Bridge Scour and Deposition

	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 (2019-2020)	5.6	6+55	9	0.9	3+78	36	1.7	Varies	25
Maximum Cumulative Scour (2013-2020)	11.3	2+67	10	1.1	Varies	36	3.0	1+00	25
Maximum Incremental Deposition (2019-2020)	2.7	8+15	9	1.8	3+45	37	1.5	2+48	27
Maximum Cumulative Deposition (2013-2020)	6.0	15+53	7	1.2	3+45	37	3.3	0+00	26

7. ICE ROAD CROSSINGS BREAKUP

Ice roads are constructed annually for ground transportation of supplies and equipment and maintenance of Alpine facilities. Aerial surveys were conducted before, during, and after spring breakup at most locations to observe and document the ice deterioration at stream and dragline crossings. To expedite melt and facilitate flow through the crossings during breakup flooding, ice road crossings are mechanically slotted at the conclusion of the winter season.

In general, ice road crossings deteriorated at a similar rate as surrounding channel ice. Aerial surveys showed that slotting was completed, and floodwaters were passing through all ice road crossings. The majority of the crossings were submerged during the peak flood conditions. 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 D.

8. HISTORICAL BREAKUP TIMING & MAGNITUDE

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

8.1 Colville River – Head of the Delta

The historical record of peak stage and peak 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 annually from 1992 to 2020 (Table 8.1 and Graph 8-1).

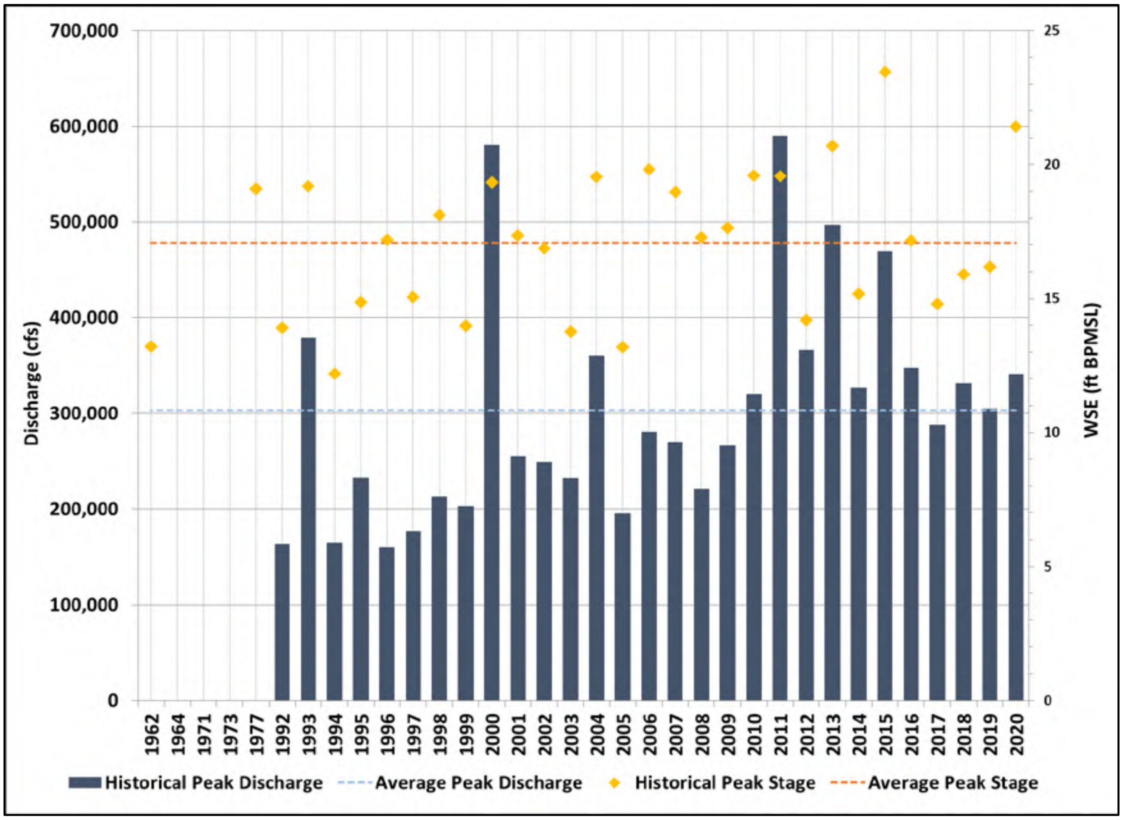
Peak stage at MON1C was 21.41 ft BPMSL and occurred on May 28. The average historical peak stage is 17.06 ft BPMSL and the average date is May 30. The maximum historical peak stage is 23.47 ft BPMSL occurring in 2015 on May 21.

Peak discharge at MON1C was 341,000 cfs and occurred on May 27. The average historical peak discharge is 303,000 cfs and the average date is May 30. The maximum historical peak discharge is 590,000 cfs occurring in 2011 May 28.

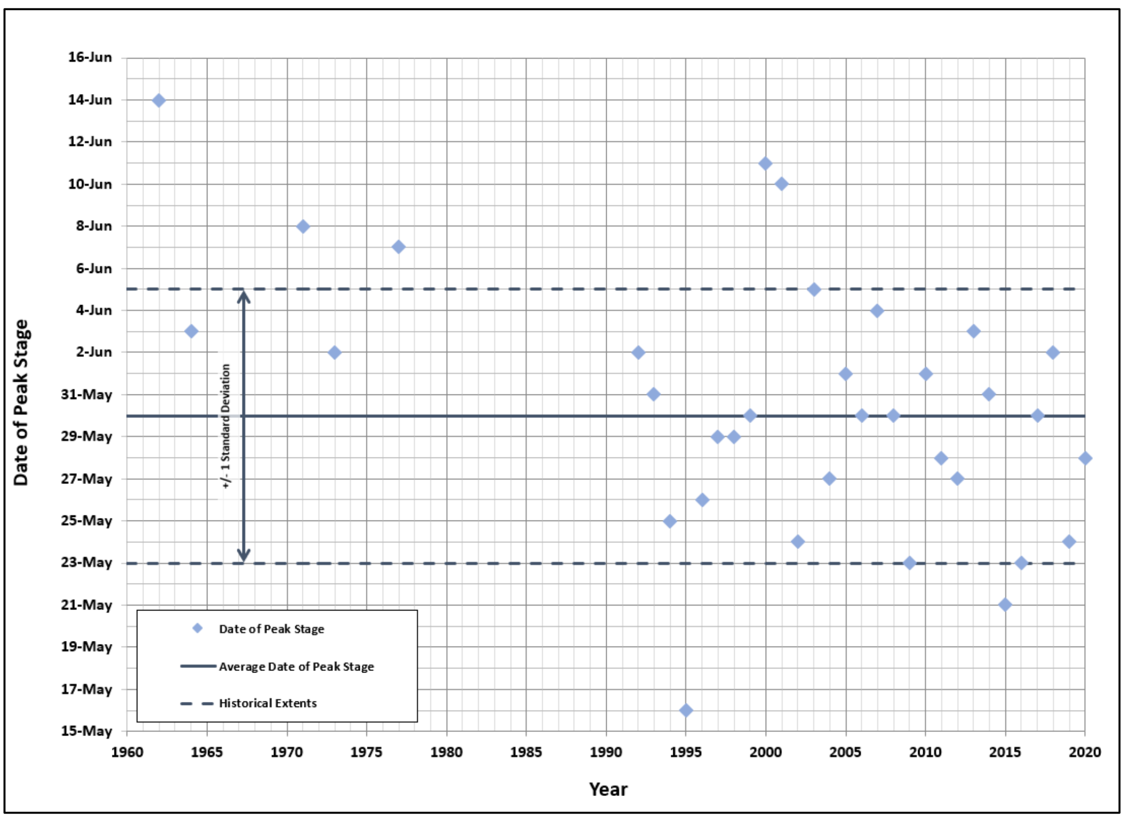
Statistical analysis of historical peak stage dates shows 79 percent of the peaks at MON1C occur during a 13-day period from May 23 to June 5. This represents one standard deviation of 6.3 days on either side of the average (mean) peak stage date of May 30, based on a normal distribution, as illustrated in Graph 8-2. Peak stage at MON1C this year was two days prior to the historical average.

Table 8.1: Colville River at the Head of the Delta Peak Discharge and Peak Stage Historical Summary

Year	Discharge		Stage (WSE)		Reference
	Peak Discharge (cfs)	Date	Peak Stage (ft BPMSL)	Date	
2020	**341,000**	**27-May**	**21.41**	**28-May**	**This Report**
2019	305,000	24-May	16.19	24-May	Michael Baker 2019
2018	331,000	1-Jun	15.90	2-Jun	Michael Baker 2018
2017	288,000	30-May	14.79	30-May	Michael Baker 2017
2016	348,000	23-May	17.16	23-May	Michael Baker 2016
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

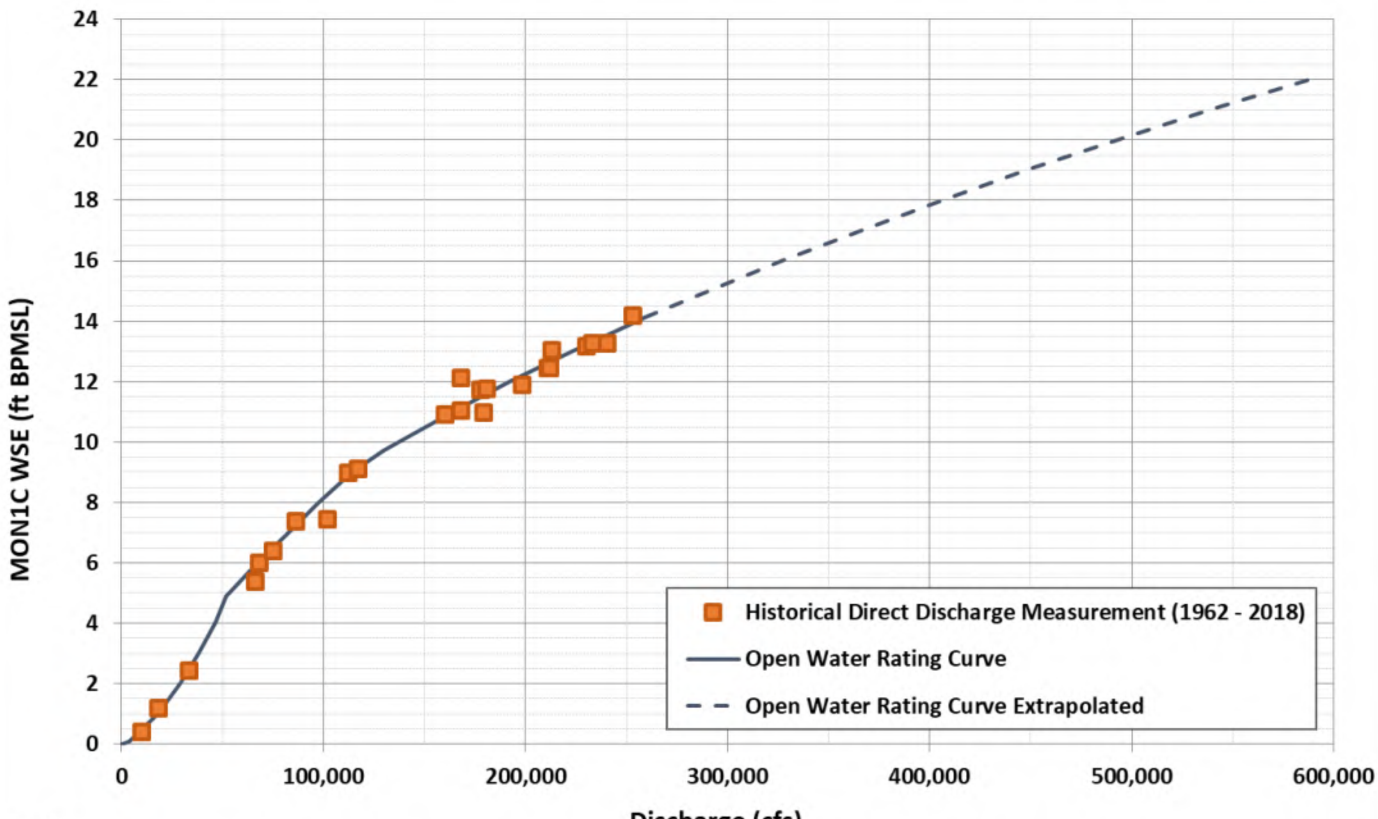


Graph 8-1: Colville River at the Head of the Delta Historical Peak Stage and Peak Discharge



Graph 8-2: Colville River at the Head of the Delta Historical Timing of Peak Stage

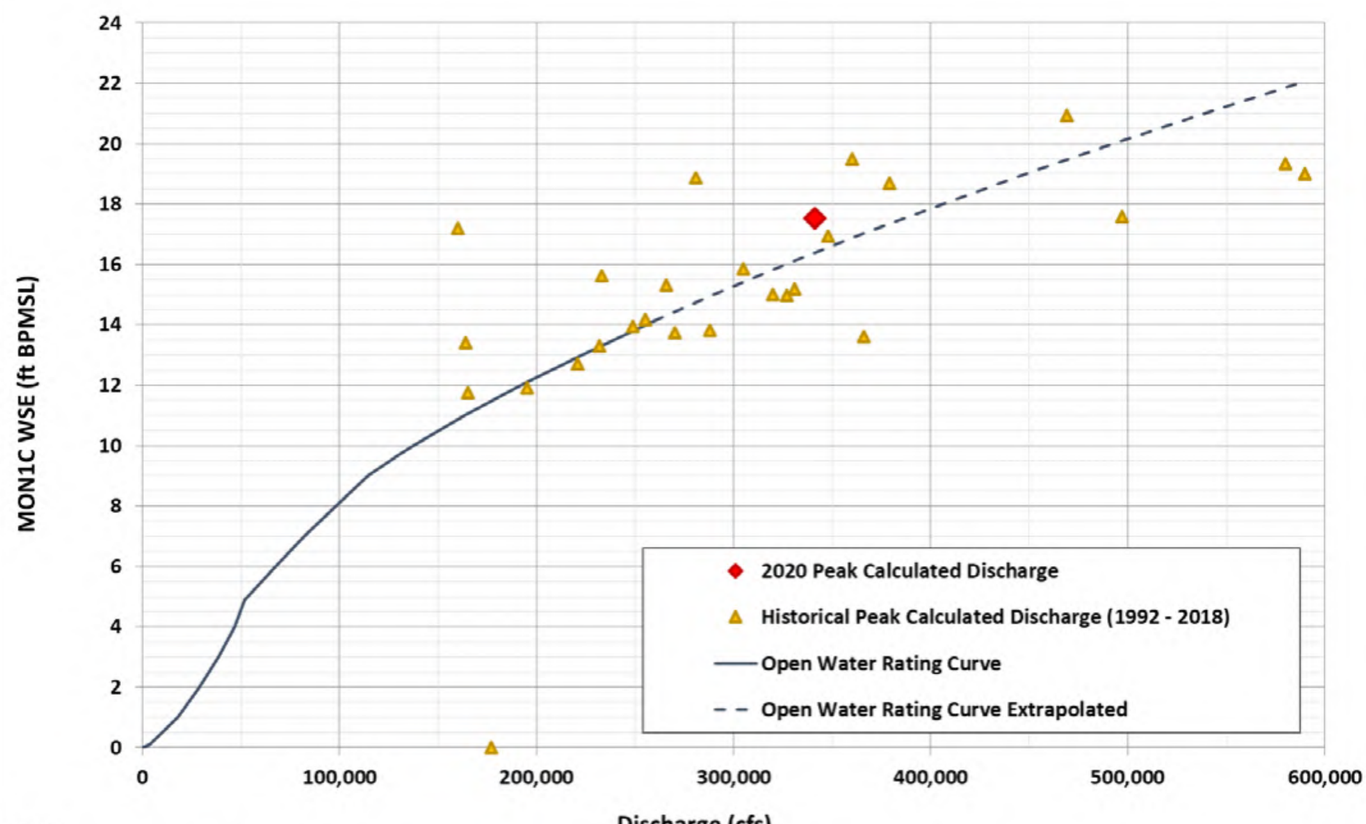
The MON1C stage-discharge rating curve, shown in Graph 8-3, represents a relationship between stage and discharge. The rating curve was calculated from direct discharge measurements taken during ice-free conditions between 1992 and 2005. Colville River discharge can be greatly influenced by channel ice; the rating curve more accurately represents the relationship between stage and discharge at lower stage values when ice-free discharge measurements are possible. A direct measurement was not collected in 2020 because of adverse weather conditions during peak conditions.



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 value; physical geometery of the banks and floodplain would cause the curve to asymptote at an unknown stage - 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: Colville River at the Head of the Delta Stage-Discharge Rating Curve with Measured Discharge

Peak discharge between 1992 and 2020 are plotted against the open water rating curve in Graph 8-4. Open water conditions rarely occur (ice influences are typically present) at or near peak discharge during breakup. Differences between peak discharge and the open water rating curve are attributed to ice effects on stage and discharge. Values that fall to the right and below the rating curve tend to be the result of an upstream ice jam release. Conversely, values that fall to the left and above the rating curve tend to be the result of downstream ice jam backwater effects. Peak discharge in 2020 falls to the left of the rating curve.



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; physical geometery of the banks and floodplain would cause the curve to asymptote at an unknown stage - 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: Colville River at the Head of the Delta Stage-Discharge Rating Curve with Peak Discharge

8.2 CD2 Road Bridges

Discharge has been measured at the CD2 road 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. Measured flow in 2020 through both the Long Swale Bridge and Short Swale Bridge was 122.6% of the average annual measured flow through both bridges (3,746 cfs). A summary of historical discharge measurements at the CD2 road bridges is presented in Table 8.2.

Table 8.2: CD2 Road Bridges Measured 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)										
05/29/20	**9.92**	**0.81**	**55**	**476**	**5.17**	**2,460**	**F**	**22**	**Cable**	**This report**
05/26/19	7.27	0.02	53	349	0.7	244	G	11	Cable	Michael Baker 2019
06/03/18	6.63	0.08	36	32	0.22	5.40	P	22	Cable	Michael Baker 2018
2017[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2017
05/25/16	7.39	0.32	53	322	2.11	700	G	27	Cable	Michael Baker 2016
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
2009[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
2005[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2005b
05/29/04	8.34	0.14	55	451	1.60	720	F	17	Cable	Michael Baker 2005a
2003[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)										
05/30/20	**7.89**	**0.06**	**445**	**3,602**	**0.59**	**2,131**	**F**	**32**	**Cable**	**This report**
05/25/19	6.84	0.29	440	2,046	1.37	2,795	F	21	Cable	Michael Baker 2019
06/03/18	7.05	0.16	431	2,090	1.50	3,140	P	-	Cable	Michael Baker 2018
06/01/17	5.92	0.04	445	1,505	0.86	1,290	F	27	Cable	Michael Baker 2017
05/25/16	7.48	0.40	445	2,025	2.25	4,800	G/F	28	Cable	Michael Baker 2016
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 8% of true value
   - P - Poor: Velocity < 0.70 ft/s; shallow depth for measurement; greater than 8% error
5. Bridge obstructed with snow or ice and/or lack of flow; no measurement made

Calculated peak flow through both bridges was 124.7% of the average annual peak flow through both bridges (4,508 cfs). Table 8.3 summarizes peak stage and peak calculated discharge at the CD2 Long and Short Swale Bridges between 2000 and 2020.

Table 8.3: CD2 Road Bridges Peak Stage and Discharge Historical Summary

Date[1]	Peak Stage[2] (ft BPMSL)	Stage Differential[3] (ft)	Long Swale Bridge (452 ft)		Short Swale Bridge (62 ft)		References
			Peak Discharge (cfs)	Mean Velocity (ft/s)	Peak Discharge (cfs)	Mean Velocity (ft/s)	
05/29/20	**10.91**	**1.61**	**2,868**	**0.59**	**2,765**	**5.17**	**This report**
05/25/19	7.32	0.35	3,000	1.37	250	0.71	Michael Baker 2019
06/02/18	7.12	0.25	3,240	1.50	12	0.22	Michael Baker 2018
05/31/17	6.04	0.04	1,350	0.86	– [4]	– [4]	Michael Baker 2017
05/25/16	7.50	0.44	4,800	2.35	680	2.06	Michael Baker 2016
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	– [4]	– [4]	Michael Baker 2009b
05/30/08	6.49	0.26	2,100	0.49	130	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	– [4]	– [4]	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	– [4]	– [4]	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]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 peak stage and peak discharge during breakup flood events for the CD5 road bridges is shown in Table 8.4.

Table 8.4: CD5 Road Bridges Peak Discharge and Peak Stage Historical Summary

Year	Lake L9323 Bridge		Nigliq Bridge		Lake L9341 Bridge		Nigliagvik Bridge	
	Peak Discharge (cfs)	Peak Stage [G24] (ft BPMSL)	Peak Discharge (cfs)	Peak Stage [G26] (ft BPMSL)	Peak Discharge (cfs)	Peak Stage [G32] (ft BPMSL)	Peak Discharge (cfs)	Peak Stage [G38] (ft BPMSL)
Post-Bridge Construction								
2020	**1,620**	**12.43**	**100,500**	**12.23**	**- [1]**	**11.89**	**6,800**	**11.24**
2019	- [1]	8.49	95,000	9.16	- [1]	8.63	- [3]	9.30
2018	- [1]	9.67	42,200	8.43	- [1]	8.77	10,400	7.43
2017	- [1]	9.54	47,400	8.60	- [1]	7.10	2,550	6.86
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
Pre-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 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 indicates bankfull elevation of Lake L9313 is approximately 6.5 ft BPMSL at gage G10 (Michael Baker 2006a, 2007b). Observations on July 10 and July 18, 2018 indicated a hydraulic connection was established between Lakes L9313 and M9525, implying WSE at Lake L9313 was at or above bankfull elevation. The measured WSE on July 10 was 6.29 ft BPMSL, suggesting actual bankfull elevation at L9313 is lower than 6.5 ft BPMSL. Based on the 2018 observations, the bankfull recharge elevation at Lake L9313 was revised to 6.29 ft BPMSL in 2018.

Lake L9312 is surrounded by higher tundra than Lake L9313 and is less frequently recharged by floodwater from the Sakoonang Channel. During most years, recharge at this lake is limited to local melt of snow and ice and precipitation; however, Lake L9312 did recharge from floodwater in 2020. Bankfull elevation of Lake L9312 is 7.8 ft BPMSL at gage G9 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 L9312 has recharged to bankfull 17 of the last 23 years, and Lake L9313 has recharged to bankfull 20 of the last 23 years.

Table 8.5: Alpine Drinking Water Lakes Historical Recharge Summary

Year	Lake L9312		Lake L9313	
	Peak Stage (ft BPMSL)	Bankfull Recharge to 7.8 ft BPMSL[1]	Peak Stage (ft BPMSL)	Bankfull Recharge to 6.29 ft BPMSL[2]
2020	**10.08**	**Yes**	**10.37**	**Yes**
2019	8.09	Yes[3]	8.72	Yes
2018	8.10	Yes[3]	6.29	Yes[3]
2017	-	No[3]	7.40	Yes
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 typically performed every three years for the head of the CRD at MON1 to estimate and update flood magnitudes for standard recurrence intervals. The basis of design flood magnitudes are compared with the flood frequency analysis results to ensure the basis of design values are relevant as the body of data grows. The basis of design was computed in 2002 using a mix of observed flooding and extrapolated data. The extrapolated data used the Kuparuk and Sagavanirktok Rivers to estimate flooding discharge on the Colville River. With 29 consecutive years of flood record on the Colville River, the Kuparuk and Sagavanirktok Rivers do not correlate as well to the Colville River as anticipated and were omitted from the 2020 flood frequency analysis in favor of using only the extend historical record. The 2020 flood frequency analysis was computed using the updated USGS Bulletin 17C guidelines. The 2020 flood frequency results are presented in Table 9.1 and compared to the original 2002 basis of design. In general, the 2020 results show the high frequency/low magnitude discharge values have increased and the low frequency/high magnitude discharge values have decreased.

Table 9.1: Colville River Flood Frequency Analysis Comparison

Annual Exceedance Probability (%)	Return Period (years)	Discharge (cfs)			
			2020 Results		
		2002 Basis of Design Criteria	Average	Lower Confidence Limit (0.95)	Upper Confidence Limit (0.05)
50	2	240,000	**276,000**	244,000	314,000
20	5	370,000	**381,000**	332,000	453,000
10	10	470,000	**455,000**	391,000	580,000
4	25	610,000	**557,000**	464,000	812,000
2	50	730,000	**637,000**	517,000	1,062,000
1	100	860,000	**722,000**	568,000	1,404,000
0.5	200	1,000,000	**812,000**	618,000	1,844,000

This year's peak discharge of 341,000 cfs has a recurrence interval of 4.3 years or a 23% chance of occurrence in any given year based on the 2002 basis of design values. The ranking of the 2020 peak discharge relative to the historical record (evaluated using the basis of design flood magnitudes) is shown in Table 9.2.

Table 9.2: Colville River Peak Annual Discharge Historical Summary

Year	Peak Discharge (cfs)	Recurrence Interval (years)	Percent Chance Exceedance (%)
2011	590,000	22.9	4.4
2000	580,000	21.8	4.6
2013	497,000	12.9	7.8
2015	469,000	10.0	10.1
1993	379,000	5.5	18.3
2018	331,000	4.1	24.4
2012	366,000	4.9	20.4
2004	360,000	4.8	21.0
2016	348,000	4.5	22.3
2020	**341,000**	**4.3**	**23.1**
2014	327,000	4.3	25.0
2010	320,000	3.8	26.0
2019	305,000	3.5	28.6
2017	288,000	3.1	32.2
2006	281,000	2.9	33.9
2007	270,000	2.7	37.1
2009	266,000	2.6	38.5
2001	255,000	2.3	42.6
2002	249,000	2.2	45.3
1995	233,000	<2	>50
2003	232,000	<2	>50
2008	221,000	<2	>50
1998	213,000	<2	>50
1999	203,000	<2	>50
2005	195,000	<2	>50
1997	177,000	<2	>50
1994	165,000	<2	>50
1992	164,000	<2	>50
1996	160,000	<2	>50

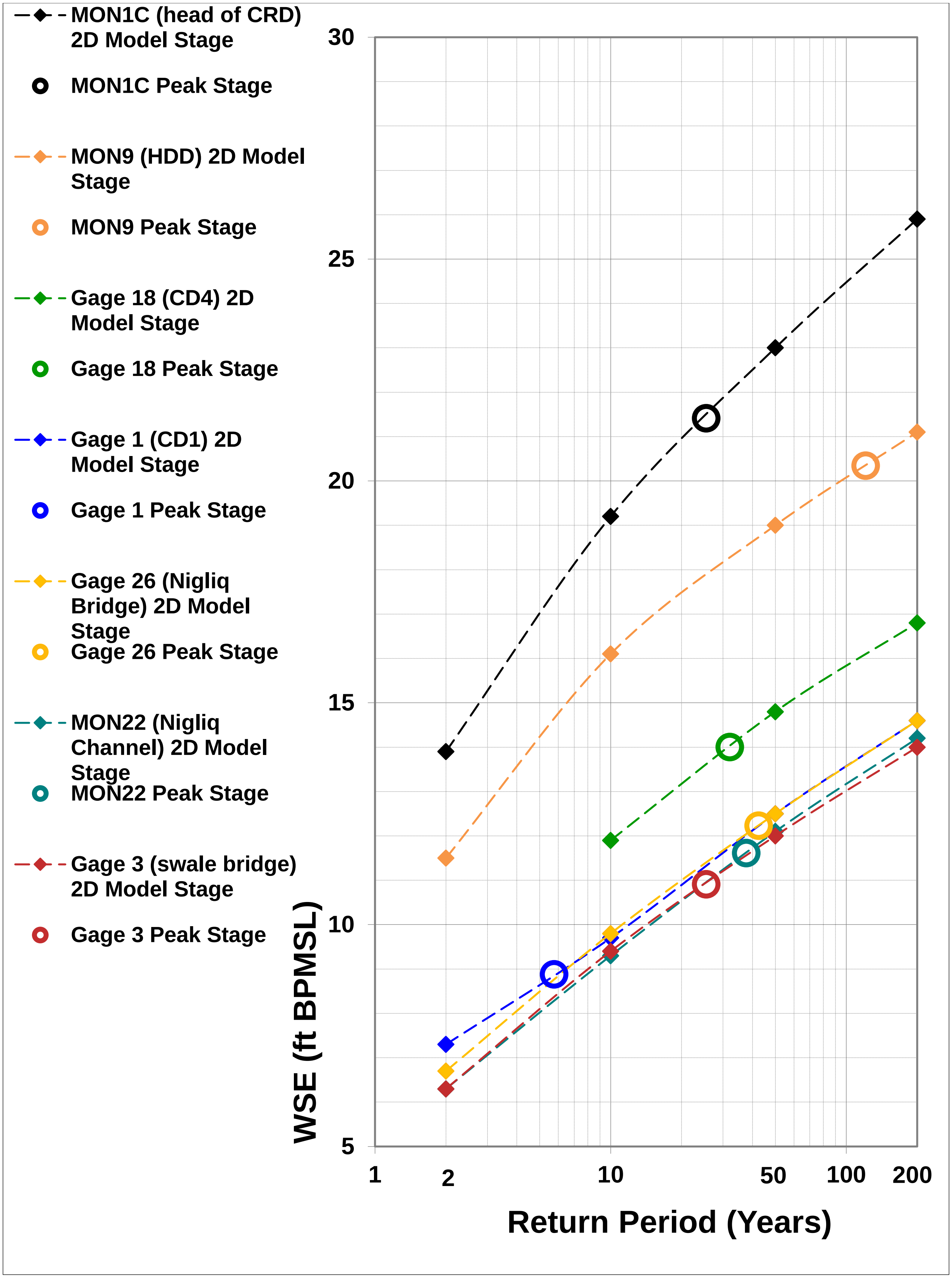
9.2 Stage Frequency

HIGH MAGNITUDE, LOW FREQUENCY

The CRD 2D surface water model was first developed in 1997 to estimate stage and velocities at the proposed Alpine facility locations (Michael Baker 1998a). The model has undergone numerous revisions to include improved topographic and bathymetric data and the addition of CD3, CD4, and CD5 facilities (Michael Baker 2002a, 2006b, 2009a, and 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. The 2020 peak stage at select gage stations were 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 below model results of area inundation (i.e. site-specific areas can be dry during lower magnitude flood-recurrence events) to a maximum of 121 years. Peak spring breakup flood stage is highly variable throughout the CRD. Local ice and snow processes influence specific sites, and the effect is more pronounced during lower-magnitude, higher-frequency spring breakup flood events.



Graph 9-1: 2D Model Stage and Peak Stage Recurrence Intervals

Table 9.3: Peak Stage Frequency Relative to 2D Model Stage Frequency Analysis

Gage Station	2D Model Stage Recurrence Intervals[1,2] (ft BPMSL)				Peak Stage (ft BPMSL)	Peak Stage Recurrence Interval (years)
	2-year	10-year	50-year	200-year		
Colville River						
MON1C (head of CRD)	13.9	19.2	23	25.9	21.41	25.5
Colville River East Channel						
MON9 (HDD)	11.5	16.1	19	21.1	20.34	121.1
MON35 (Helmericks)	4.3	5.4	6.1	6.5	5.02	5.7
Nigliq Channel						
MON20	7.8	11.4	14.6	16.8	14.55	48.8
MON22	6.3	9.3	12.1	14.2	11.61	37.7
MON23	5.1	7.4	10.2	12	9.13	27.0
MON28	3.1	3.4	3.9	4.3	3.8	36.2
CD1 Pad & Drinking Water Lakes						
Gage G1 (Sakoonang)	7.3	9.7	12.5	14.6	8.88	5.8
Gage G9 (Lake L9312)	8.3	10.8	13.4	15.7	8.58	2.4
Gage G10 (Lake L9313)	8.3	10.8	13.4	15.7	10.37	7.6
CD2 Pad & Road						
Gage G8 (CD2 pad)	-[1]	8.7	10.6	12.3	-[4]	-[4]
Gage G3 (swale bridges)	6.3	9.4	12	14	10.91	25.5
Gage G4 (swale bridges)	6.2	8.5	10.1	11.6	9.47	26.5
Gage G6	-[1]	9.5	12.2	14.2	11.18	27.2
Gage G7	-[1]	8.4	10	11.6	9.51	30.5
Gage G12	-[1]	9.5	12.1	14.1	11.2	28.6
Gage G13	-[1]	8.4	10	11.6	9.38	26.8
CD3 Pad & Pipeline						
Gage G11 (CD3 pad)	5.2	6.4	6.9	8	-[4]	-[4]
SAK Gage (Pipeline Crossing #2)	6.4	8.9	11.2	12.9	8.99	10.7
TAM Gage (Pipeline Crossing #4)	6.7	8.5	9	9.8	8.47	9.7
ULAM Gage (Pipeline Crossing #5)	5.5	7.1	7.8	8.7	7.37	18.6
CD4 Pad & Road						
Gage G15	8.4	10.8	13.5	15.9	10.64	9.0
Gage G16	8.4	11.1	14.2	16.3	12.9	25.5
Gage G17	-[1]	11.1	14.2	16.3	12.76	23.7
Gage G18	-[1]	11.9	14.8	16.8	14	32.1
Gage G19 (CD4 pad)	-[1]	-[1]	14.7	16.8	14.15	<50
Gage G20 (CD4 pad)	-[1]	11.1	14.3	16.4	13.56	34.5
CD5 Road						
Gage G24 (Lake L9323/CD5 Bridge #1)	-[1]	11.1	14.1	16	12.43	20.4
Gage G26 (Nigliq/CD5 Bridge #2)	6.7	9.8	12.5	14.6	12.23	42.6
Gage G27 (Nigliq/CD5 Bridge #2)	6.7	9.8	12.5	14.5	12.26	43.3
Gage G30	-[1]	-[1]	13.3	15.5	12.04	<50
Gage G32 (Lake L9341/CD5 Bridge #3)	-[1]	-[1]	13.3	15.1	11.89	<50
Gage G34	-[1]	-[1]	13.3	15.7	9.89	<50
Gage G36	-[1]	-[1]	13.3	15.7	-[4]	-[4]
Gage G38 (Nigliagvik/CD5 Bridge #4)	6.9	10	12.8	14.9	11.24	20.4

Notes:
1. Sites having dry ground in 2D model during lower recurrence intervals
2. 2D WSEs based on results modeled incorporating the CD5 development
3. Stage attributed to ponded local melt
4. Not monitored this year.

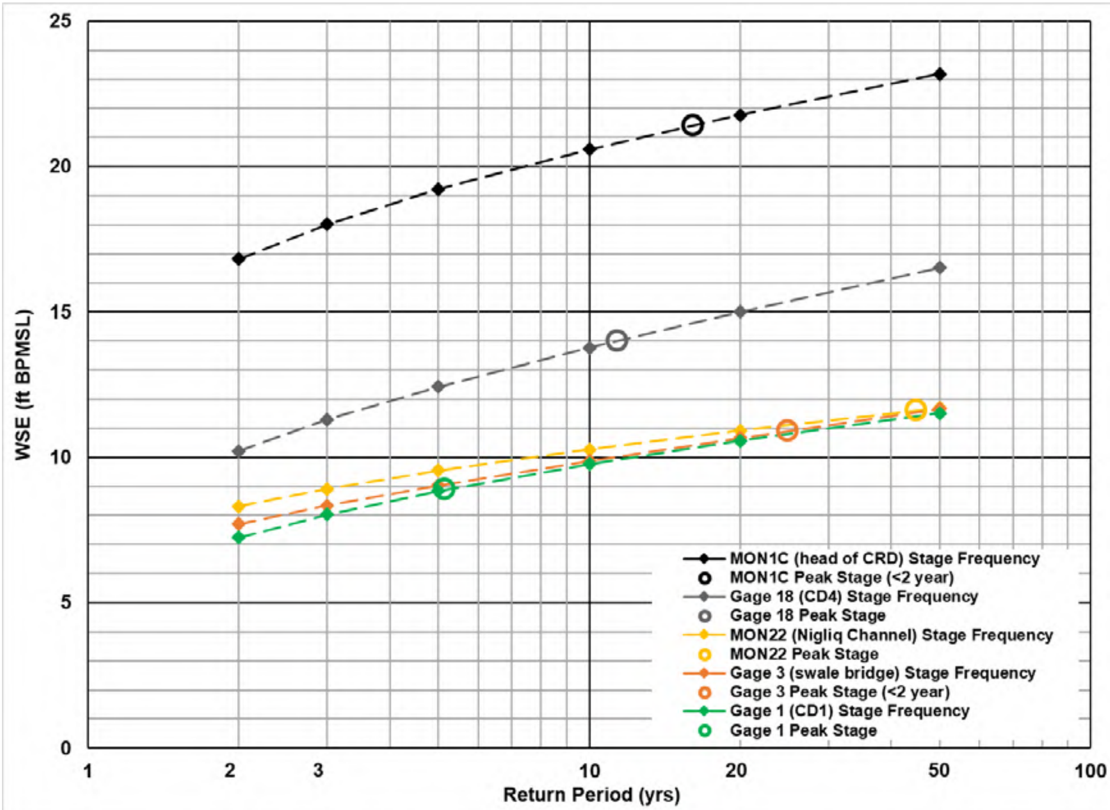
LOW MAGNITUDE, HIGH FREQUENCY

A site-specific stage frequency analysis using the historical record can provide a better estimate of low magnitude, high frequency 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. The maximum period of continuous record is 29 years at MON1C. Analyses have been performed every three years as the body of data grows (Michael Baker 2007a, 2009a, and 2012b), the most recent being in 2018 (Michael Baker 2018).

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, variability in available floodplain storage and influence on stage above bankfull conditions, and potential for ice jam release at higher stage. Stage frequency was extrapolated to the 50-year recurrence interval, almost twice the continuous record at MON1C, for comparison to the 2D model. 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 stages in Table 9.4 and Graph 9-2.

Table 9.4: Peak Stage Frequency Relative to Stage Frequency Analysis

Monitoring Location	Stage Frequency Recurrence Intervals (ft BPMSL)						Peak Stage (ft BPMSL)	Peak Stage Recurrence Interval (years)	Percent Chance Exceedance (%)
	2-year	3-year	5-year	10-year	20-year	50-year			
MON1C (head of CRD)	16.82	18.02	19.23	20.59	21.78	23.18	21.41	16.1	6.2
MON22 (Nigliq Channel)	8.31	8.92	9.55	10.27	10.92	11.70	11.61	45.0	2.2
Gage G1 (CD1 Pad)	7.24	8.03	8.84	9.77	10.57	11.52	8.88	5.2	19.4
Gage G3 (CD2 Road)	7.70	8.35	9.04	9.88	10.67	11.67	10.91	24.9	4.0
Gage G18 (CD4 Road)	10.22	11.30	12.43	13.77	15.00	16.52	14.00	11.4	8.8



Graph 9-2: Stage Frequency and Peak Stage Recurrence Intervals

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APPENDIX A VERTICAL CONTROL, GAGE LOCATIONS, & CULVERT LOCATIONS

A.1 VERTICAL CONTROL

Control	Elevation (ft BPMSL)	Latitude (NAD83) [1]	Longitude (NAD83)	Control Type	Reference
CD2-4N	8.89	N 70.3399°	W 151.0292°	Culvert top	UMIAQ 2020
CD2-14N	10.89	N 70.3371°	W 151.0110°	Culvert top	UMIAQ 2020
CD2-14S	10.85	N 70.3369°	W 151.0111°	Culvert top	UMIAQ 2020
CD2-22N	9.15	N 70.3404°	W 150.9829°	Culvert top	UMIAQ 2020
CD2-22S	9.10	N 70.3402°	W 150.9827°	Culvert top	UMIAQ 2020
CD2-6N	8.89	N 70.3399°	W 151.0290°	Culvert top	UMIAQ 2020
CD2-6S	8.68	N 70.3397°	W 151.0291°	Culvert top	UMIAQ 2020
CD4-10E	11.57	N 70.3274°	W 150.9929°	Culvert top	UMIAQ 2020
CD4-10W	11.98	N 70.3275°	W 150.9934°	Culvert top	UMIAQ 2020
CD4-12E	11.33	N 70.3235°	W 150.9954°	Culvert top	UMIAQ 2020
CD4-12W	12.12	N 70.3401°	W 150.9962°	Culvert top	UMIAQ 2020
CD4-22E	6.73	N 70.3021°	W 150.9932°	Culvert top	UMIAQ 2017
CD4-22W	7.45	N 70.3018°	W 150.9930°	Culvert top	UMIAQ 2017
CD4-6E	14.28	N 70.3348°	W 150.9707°	Culvert top	UMIAQ 2020
CD5-29N	12.28	N 70.3060°	W 151.0951°	Culvert top	UMIAQ 2016
CD5-29S	12.38	N 70.3058°	W 151.0948°	Culvert top	UMIAQ 2016
CD5-35N	13.09	N 70.3065°	W 151.0683°	Culvert top	UMIAQ 2016
CD5-35S	13.26	N 70.3063°	W 151.0683°	Culvert top	UMIAQ 2016
CD5-40N	10.65	N 70.3050°	W 151.0439°	Culvert top	UMIAQ 2016
CD5-40S	10.93	N 70.3048°	W 151.0442°	Culvert top	UMIAQ 2016
CP01-13-09A	12.94	N 70.3401°	W 150.9843°	Top rail support	UMIAQ 2016
CP08-11-12	7.36	N 70.3639°	W 150.9204°	Alcap	BAKER 2012
CP08-11-23	8.52	N 70.3916°	W 150.9078°	Alcap	LCMF 2008
CP08-11-35	8.88	N 70.4066°	W 150.8822°	Alcap	BAKER 2015 (UMIAQ 2010)
CP08-12-61	11.95	N 70.2777°	W 150.9935°	Alcap	LCMF 2017
MONUMENT 1	27.93	N 70.1659°	W 150.9400°	Alcap	LCMF 2005
MONUMENT 9	25.06	N 70.2446°	W 150.8583°	Alcap	UMIAQ 2016
MONUMENT 20	18.97	N 70.2800°	W 151.0115°	Alcap	BAKER 2017
MONUMENT 21	13.28	N 70.3424°	W 150.9236°	Top of bolt	UMIAQ 2020
MONUMENT 22 (BAKER)	10.03	N 70.3181°	W 151.0560°	Alcap	UMIAQ 2020
MONUMENT 22	11.21	N 70.3422°	W 150.9321°	Alpine drill stem	UMIAQ 2020
MONUMENT 23	9.55	N 70.3444°	W 151.0613°	Alcap	BAKER 2009
MONUMENT 25	17.89	N 70.3024°	W 151.0130°	Capped drill stem	UMIAQ 2016
MONUMENT 27	13.86	N 70.3060°	W 151.0533°	Capped drill stem	UMIAQ 2016
MONUMENT 28 (Colville @ Coast)	3.65	N 70.4256°	W 151.0670°	Alcap	UMIAQ GPS 2002
MOUNMENT 29	28.63	N 70.3052°	W 151.1228°	Capped drill stem	UMIAQ 2016
NANUQ 4	12.64	N 70.2954°	W 150.9813°	Alcap	UMIAQ 2016

Control	Elevation (ft BPMSL)	Latitude (NAD83) [1]	Longitude (NAD83)	Control Type	Reference
NANUQ-5	17.39	N 70.2917°	W 150.9805°	Alcap	UMIAQ 2020
PBM-F	17.88	N 70.3393°	W 151.0467°	Top of rod	UMIAQ 2020
PBM-P	20.88	N 70.2915°	W 150.9889°	South side of CD4 pad	UMIAQ 2020
Pile 08	16.74	N 70.4175°	W 150.9105	SW Bolt	UMIAQ 2020
Pile 568	23.72	N 70.3639°	W 150.9206°	HSM cap SW bolt	LCMF 2010
TBM A	5.89	N 70.4264°	W 150.4053°	Corner of entryway	BAKER 2017
TBM B	8.46	N 70.4264°	W 150.4056°	East corner of structure	BAKER 2017
TBM C	8.15	N 70.3338°	W 150.4057°	West corner of structure	BAKER 2017
TBM 02-01-39 O	11.72	N 70.3338°	W 150.9522°	Top SW corner 2nd HSM	UMIAQ 2020
TBM 02-01-39 P	11.92	N 70.3337°	W 150.9521°	Top SW corner 1st HSM	UMIAQ 2020
TBM 05-05-06 B	21.01	N 70.3427°	W 150.9250°	NW corner F1 Product	UMIAQ 2016
TBM 99-32-60	15.86	N 70.3420°	W 150.9321°	Top lifting lug	LCMF 2015
TBM L99-32-59	14.60	N 70.3338°	W 150.9522°	Pile Cap SE VSM	UMIAQ 2015
TBM M9603-X	-	N 70.2213°	W 150.7896°	Angle iron	BAKER 2011
TBM M9605-X	-	N 70.2290°	W 150.5127°	Angle iron	BAKER 2011

1. North American Datum of 1983 (NAD83)

A.2 CRD GAGE LOCATIONS

Location	Gage Station	Gage Type	Gage Assembly	Latitude (NAD83)	Longitude (NAD83)	Control
Head of the Colville River Delta	MON1U	Indirect-Read	MON1U-A[1]	N 70.1585°	W 150.9450°	MONUMENT 1
			MON1U-B[2]	N 70.1585°	W 150.9451°	
			MON1U-C	N 70.1585°	W 150.9455°	
			MON1U-D	N 70.1585°	W 150.9461°	
			MON1U-E	N 70.1585°	W 150.9462°	
			MON1U-F	N 70.1585°	W 150.9464°	
			MON1U-G	N 70.1585°	W 150.9465°	
	MON1C		MON1C-A[1]	N 70.1657°	W 150.9383°	
			MON1C-B[2]	N 70.1656°	W 150.9385°	
			MON1C-C	N 70.1658°	W 150.9386°	
			MON1C-D	N 70.1658°	W 150.9392°	
			MON1C-E	N 70.1658°	W 150.9393°	
			MON1C-F	N 70.1658°	W 150.9395°	
			MON1C-G	N 70.1659°	W 150.9397°	
	MON1D		MON1D-A[1]	N 70.1738°	W 150.9359°	
			MON1D-B[2]	N 70.1738°	W 150.9371°	
			MON1D-C	N 70.1738°	W 150.9372°	
			MON1D-D	N 70.1738°	W 150.9373°	
Colville River East Channel	MON9	Indirect-Read	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-F1	N 70.2446°	W 150.8580°	
			MON9-F2	N 70.2446°	W 150.8580°	
			MON9-G	N 70.2446°	W 150.8581°	
			MON9-BARO[3]	N 70.2442°	W 150.8605°	
	MON9D		MON9D-A[1]	N 70.2586°	W 150.8593°	
			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°	
			MON9-D1	N 70.2586°	W 150.8600°	
			MON9D-E	N 70.2586°	W 150.8600°	
	MON35		MON35-A	N 70.4260°	W 150.4058°	TBM B
			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°	
Nigliq Channel	MON20	Indirect-Read	MON20-A[1]	N 70.2786°	W 150.9986°	MONUMENT 20
			MON20-B	N 70.2786°	W 150.9985°	
			MON20-C	N 70.2786°	W 150.9983°	
			MON20-D	N 70.2785°	W150.9982°	
			MON20-E	N 70.2785°	W 150.9982°	
	MON22		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°	
	MON23		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°	
	MON28		MON28-A[1]	N 70.4258°	W 151.0697°	MONUMENT 28 (Colville @ Coast)
			MON28-B	N 70.4257°	W 151.0692°	
			MON28-C	N 70.4256°	W 151.0672°	
	Notes: 1. PT, 2. RTFM PT, 3. Baro PT					

A.3 ALPINE FACILITIES GAGE LOCATIONS

Location	Gage Station	Gage Type	Gage Assembly	Latitude (NAD83)	Longitude (NAD83)	Control
CD1 Pad & Lakes L9312 & L9313	G1	Direct-Read	G1[1]	N 70.3428°	W 150.9208°	TBM 05-05-06 B
	G9		G9[1]	N 70.3336°	W 150.9519°	TBM 02-01-39 O
	G10		G10[1]	N 70.3425°	W 150.9328°	MONUMENT 22
CD2 Road and Pad	G3	Direct-Read	G3[1,2]	N 70.3400°	W 150.9831°	CD2-22S
	G4		G4[1]	N 70.3403°	W 150.9833°	
	G6	Direct-Read	G6[1]	N 70.3396°	W 151.0293°	CD2-6N
	G7		G7[1]	N 70.3400°	W 151.0289°	
	G12	Indirect-Read	G12[1]	N 70.3367°	W 151.0117°	CD2-14S
	G13		G13[1]	N 70.3373°	W 151.0118°	CD2-14N
	G8	Indirect-Read	G8	N 70.3393°	W 151.0491°	PBM-F
CD3 Pad & Pipeline	SAK	Indirect-Read	SAK-A[1]	N 70.3646°	W 150.9217°	Pile 568 cap SW bolt
			SAK-B	N 70.3645°	W 150.9220°	
			SAK-C	N 70.3645°	W 150.9220°	
	TAM		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°	
	ULAM		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°	
	G11	Direct-Read	G11	N 70.4175°	W 150.9105°	Pile 08
CD4 Road & Pad	G15	Indirect-Read	G15-A[1]	N 70.3023°	W 150.9929°	CD4-22W
			G15-B	N 70.3023°	W 150.9929°	
	G16		G16-A[1]	N 70.3017°	W 150.9933°	CD4-22E
			G16-B	N 70.3017°	W 150.9933°	
	G17		G17-A[1]	N 70.2933°	W 150.9827°	NANUQ-5
	G18		G18-A	N 70.2930°	W 150.9818°	
		Direct-Read	G18-B[1,2,3,4]	N 70.2925°	W 150.9828°	
	G19	Direct-Read	G19	N 70.2915°	W 150.9882°	PBM-P
	G20	Indirect-Read	G20-A	N 70.2917°	W 150.9968°	
			G20-B	N 70.2917°	W 150.9968°	
CD5 Road	G40		G40	N 70.3234°	W 150.9968°	CD4-12E
	G41		G41	N 70.3235°	W 150.9949°	
	G42		G42	N 70.3276°	W 150.9939°	CD4-10E
	G43		G43	N 70.3274°	W 150.9924°	
	G24	Indirect-Read	G24-A[1]	N 70.3030°	W 151.0065°	MONUMENT 25
			G24-B	N 70.3034°	W 151.0041°	
	G25		G25-A[1]	N 70.3044°	W 151.0066°	
			G25-B	N 70.3046°	W 151.0049°	
	G26		G26-A[1]	N 70.3023°	W 151.0217°	MONUMENT 25
			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°	
	Notes: 1. PT, 2. RTFM PT, 3. Baro PT					

Location	Gage Station	Gage Type	Gage Assembly	Latitude (NAD83)	Longitude (NAD83)	Control
CD5 Road	G27	Indirect-Read	G27-A[1]	N 70.3033°	W 151.0216°	PBM-24
			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		G28-A[1]	N 70.2959°	W 151.0329°	
			G28-B	N 70.2959°	W 151.0331°	
			G28-C	N 70.2959°	W 151.0331°	
			G28-D	N 70.2959°	W 151.0332°	
			G28-E	N 70.2959°	W 151.0335°	
	G29		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°	
	G32		G32-A[1]	N 70.3054°	W 151.0507°	MONUMENT 27
			G32-B	N 70.3055°	W 151.0513°	
	G33		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°	
	G38		G38-A[1]	N 70.3046°	W 151.1187°	MONUMENT 29
			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		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°	
			G39-D	N 70.3063°	W 151.1170°	
	G30		G30[1]	N 70.3046°	W 151.0443°	CD5-40S
	G31		G31[1]	N 70.3051°	W 151.0437°	CD5-40N
	G34		G34[1]	N 70.3060°	W 151.0710°	CD5-35S
	G35		G35[1]	N 70.3067°	W 151.0711°	CD5-35N
	G36		G36[1]	N 70.3056°	W 151.0968°	CD5-29S
	G37		G37[1]	N 70.3063°	W 151.0971°	CD5-29N
GMT1/MT6 Road	UB6.7	Indirect-Read	UB6.7-A	70.2856	-151.2626	PBM-35
			UB6.7-B	70.2855	-151.2627	
			UB6.7-C	70.2852	-151.2632	
	UB6.9		UB6.9-A	70.2834	-151.2578	
			UB6.9-B	70.2830	-151.2571	
	Notes: 1. PT, 2. RTFM PT, 3. Baro PT					

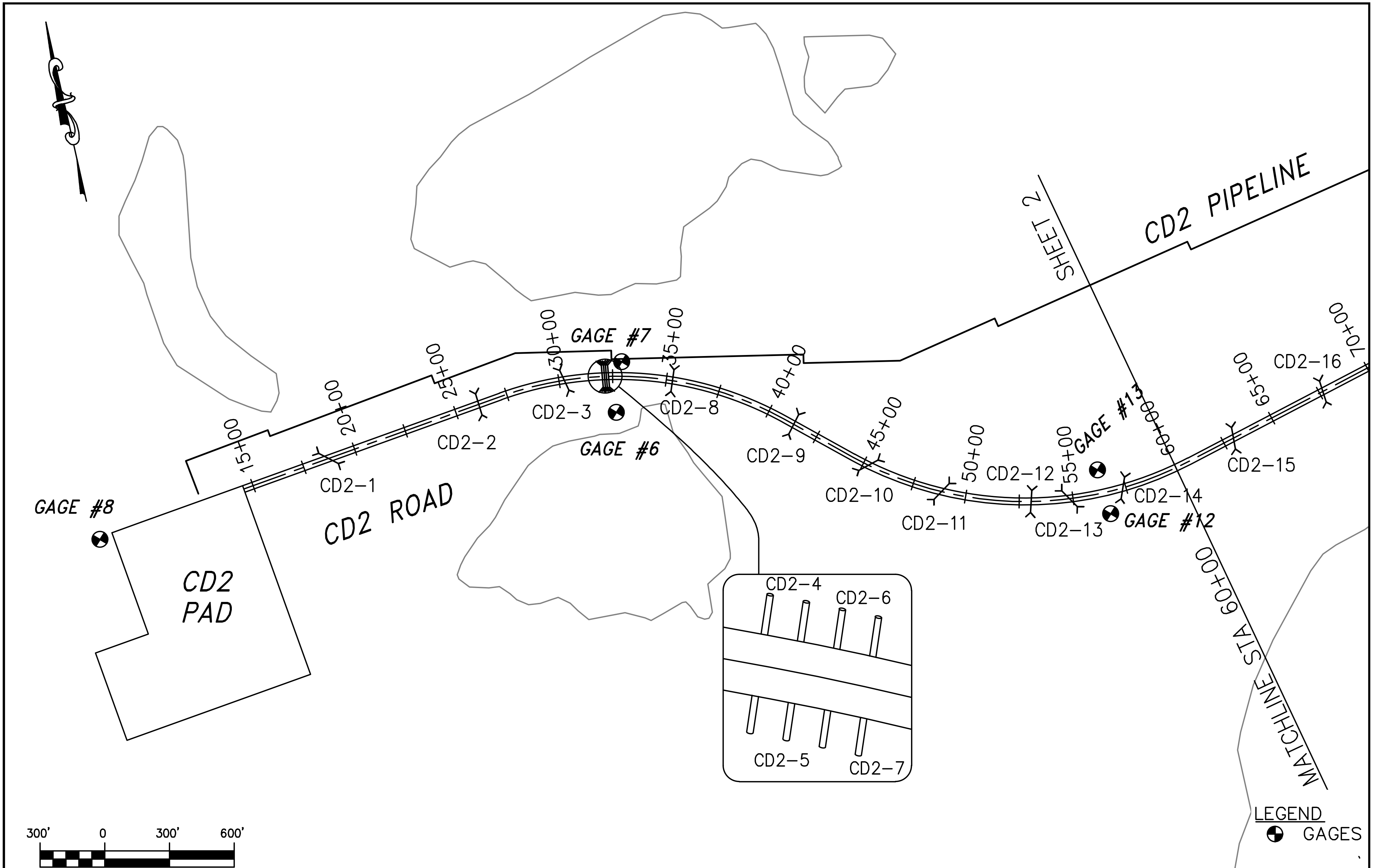
A.4 CULVERT LOCATIONS

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
CD2-01N	18+71	N 70.3396°	W 151.0403°
CD2-01S		N 70.3395°	W 151.0396°
CD2-02N	26+12	N 70.3399°	W 151.0340°
CD2-02S		N 70.3397°	W 151.0340°
CD2-03N	30+24	N 70.3399°	W 151.0308°
CD2-03S		N 70.3397°	W 151.0306°
CD2-04N	32+01	N 70.3399°	W 151.0292°
CD2-04S		N 70.3397°	W 151.0292°
CD2-05N	32+10	N 70.3399°	W 151.0291°
CD2-05S		N 70.3397°	W 151.0292°
CD2-06N	32+21	N 70.3399°	W 151.0290°
CD2-06S		N 70.3397°	W 151.0291°
CD2-07N	32+30	N 70.3399°	W 151.0290°
CD2-07S		N 70.3397°	W 151.0291°
CD2-08N	35+29	N 70.3397°	W 151.0265°
CD2-08S		N 70.3394°	W 151.0268°
CD2-09N	41+30	N 70.3388°	W 151.0224°
CD2-09S		N 70.3386°	W 151.0227°
CD2-10N	45+25	N 70.3381°	W 151.0198°
CD2-10S		N 70.3379°	W 151.0206°
CD2-11N	48+85	N 70.3375°	W 151.0174°
CD2-11S		N 70.3374°	W 151.0180°
CD2-12N	53+08	N 70.3372°	W 151.0144°
CD2-12S		N 70.3370°	W 151.0145°
CD2-13N	54+84	N 70.3371°	W 151.0133°
CD2-13S		N 70.3369°	W 151.0129°
CD2-14N	57+38	N 70.3371°	W 151.0110°
CD2-14S		N 70.3369°	W 151.0111°
CD2-15N	63+01	N 70.3373°	W 151.0065°
CD2-15S		N 70.3372°	W 151.0066°
CD2-16N	67+69	N 70.3377°	W 151.0029°
CD2-16S		N 70.3375°	W 151.0029°
CD2-17N	71+51	N 70.3380°	W 150.9999°
CD2-17S		N 70.3378°	W 150.9999°
CD2-18N	76+29	N 70.3383°	W 150.9960°
CD2-18S		N 70.3381°	W 150.9963°
CD2-19N	81+56	N 70.3387°	W 150.9922°
CD2-19S		N 70.3386°	W 150.9921°
CD2-20N	84+06	N 70.3391°	W 150.9905°
CD2-20S		N 70.3389°	W 150.9901°
CD2-21N	88+50	N 70.3396°	W 150.9873°
CD2-21S		N 70.3394°	W 150.9869°
CD2-22N	94+42	N 70.3403°	W 150.9829°
CD2-22S		N 70.3401°	W 150.9827°
CD2-23N	98+66	N 70.3403°	W 150.9793°
CD2-23S		N 70.3402°	W 150.9795°
CD2-24N	101+43	N 70.3402°	W 150.9771°
CD2-24S		N 70.3400°	W 150.9772°
CD2-25N	113+94	N 70.3393°	W 150.9670°
CD2-25S		N 70.3391°	W 150.9679°
CD2-26N	119+33	N 70.3397°	W 150.9638°
CD2-26S		N 70.3396°	W 150.9632°
CD4-01E	10+50	N 70.3391°	W 150.9670°
CD4-01W		N 70.3392°	W 150.9678°
CD4-02E	13+51	N 70.3383°	W 150.9675°
CD4-02W		N 70.3383°	W 150.9680°
CD4-03E	16+02	N 70.3377°	W 150.9672°
CD4-03W		N 70.3376°	W 150.9677°
CD4-04E	18+95	N 70.3368°	W 150.9672°
CD4-04W		N 70.3369°	W 150.9676°

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
CD4-05E	23+08	N 70.3358°	W 150.9682°
CD4-05W		N 70.3358°	W 150.9686°
CD4-06E	28+03	N 70.3347°	W 150.9709°
CD4-06W		N 70.3349°	W 150.9712°
CD4-07E	34+16	N 70.3337°	W 150.9748°
CD4-07W		N 70.3338°	W 150.9751°
CD4-08E	44+28	N 70.3319°	W 150.9811°
CD4-08W		N 70.3320°	W 150.9814°
CD4-09E	59+20	N 70.3287°	W 150.9886°
CD4-09W		N 70.3289°	W 150.9890°
CD4-10E	66+48	N 70.3274°	W 150.9929°
CD4-10W		N 70.3275°	W 150.9933°
CD4-11E	81+24	N 70.3236°	W 150.9954°
CD4-11W		N 70.3236°	W 150.9961°
CD4-12E	81+66	N 70.3235°	W 150.9954°
CD4-12W		N 70.3235°	W 150.9961°
CD4-13E	82+09	N 70.3233°	W 150.9955°
CD4-13W		N 70.3233°	W 150.9961°
CD4-14E	82+51	N 70.3232°	W 150.9955°
CD4-14W		N 70.3232°	W 150.9961°
CD4-15E	102+00	N 70.3180°	W 150.9980°
CD4-15W		N 70.3180°	W 150.9985°
CD4-16E	129+97	N 70.3104°	W 151.0003°
CD4-16W		N 70.3104°	W 151.0009°
CD4-17E	143+00	N 70.3070°	W 150.9990°
CD4-17W		N 70.3069°	W 150.9994°
CD4-18E	146+55	N 70.3060°	W 150.9985°
CD4-18W		N 70.3059°	W 150.9989°
CD4-19E	154+57	N 70.3038°	W 150.9973°
CD4-19W		N 70.3038°	W 150.9978°
CD4-20A E	162+95	N 70.3022°	W 150.9937°
CD4-20A W		N 70.3019°	W 150.9936°
CD4-20B E	163+15	N 70.3021°	W 150.9934°
CD4-20B W		N 70.3018°	W 150.9933°
CD4-21E	163+35	N 70.3021°	W 150.9933°
CD4-21W		N 70.3018°	W 150.9932°
CD4-22E	163+55	N 70.3021°	W 150.9932°
CD4-22W		N 70.3018°	W 150.9930°
CD4-23E	164+40	N 70.3020°	W 150.9926°
CD4-23W		N 70.3017°	W 150.9925°
CD4-23A E	164+60	N 70.3080°	W 150.9924°
CD4-23A W		N 70.3017°	W 150.9923°
CD4-23B E	164+80	N 70.3019°	W 150.9923°
CD4-23B W		N 70.3016°	W 150.9922°
CD4-23C E	165+00	N 70.3019°	W 150.9921°
CD4-23C W		N 70.3016°	W 150.9920°
CD4-23D E	165+20	N 70.3019°	W 150.9920°
CD4-23D W		N 70.3016°	W 150.9919°
CD4-24E	197+02	N 70.2942°	W 150.9798°
CD4-24W		N 70.2944°	W 150.9803°
CD4-25E	200+89	N 70.2933°	W 150.9812°
CD4-25W		N 70.2934°	W 150.9818°
CD4-26E	201+05	N 70.2932°	W 150.9813°
CD4-26W		N 70.2934°	W 150.9818°
CD4-27E	201+05	N 70.2932°	W 150.9815°
CD4-27W		N 70.2934°	W 150.9820°
CD4-28E	201+21	N 70.2932°	W 150.9816°
CD4-28W		N 70.2933°	W 150.9821°
CD4-29E	201+21	N 70.2929°	W 150.9825°
CD4-29W		N 70.2931°	W 150.9828°

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
CD4-30E	201+37	N 70.2929°	W 150.9826°
CD4-30W		N 70.2930°	W 150.9829°
CD4-31E	201+37	N 70.2928°	W 150.9827°
CD4-31W		N 70.2930°	W 150.9830°
CD4-32E	202+88	N 70.2928°	W 150.9828°
CD4-32W		N 70.2930°	W 150.9832°
CD4-33E	202+88	N 70.2926°	W 150.9838°
CD4-33W		N 70.2928°	W 150.9841°
CD5-01E	14+08	N 70.3122°	W 151.2186°
CD5-01W		N 70.3121°	W 151.2190°
CD5-02E	28+83	N 70.3083°	W 151.2161°
CD5-02W		N 70.3082°	W 151.2166°
CD5-03E	31+50	N 70.3076°	W 151.2153°
CD5-03W		N 70.3075°	W 151.2158°
CD5-04N	37+97	N 70.3060°	W 151.2134°
CD5-04S		N 70.3059°	W 151.2138°
CD5-05N	44+77	N 70.3047°	W 151.2103°
CD5-05S		N 70.3045°	W 151.2104°
CD5-06N	53+53	N 70.3051°	W 151.2036°
CD5-06S		N 70.3049°	W 151.2033°
CD5-07N	60+82	N 70.3059°	W 151.1984°
CD5-07S		N 70.3058°	W 151.1978°
CD5-08N	64+82	N 70.3064°	W 151.1953°
CD5-08S		N 70.3062°	W 151.1950°
CD5-09N	64+89	N 70.3064°	W 151.1952°
CD5-09S		N 70.3062°	W 151.1950°
CD5-10N	71+74	N 70.3072°	W 151.1900°
CD5-10S		N 70.3070°	W 151.1901°
CD5-11N	74+56	N 70.3074°	W 151.1881°
CD5-11S		N 70.3073°	W 151.1878°
CD5-12N	82+45	N 70.3082°	W 151.1821°
CD5-12S		N 70.3081°	W 151.1818°
CD5-13N	88+82	N 70.3089°	W 151.1774°
CD5-13S		N 70.3087°	W 151.1769°
CD5-14N	90+76	N 70.3090°	W 151.1757°
CD5-14S		N 70.3088°	W 151.1756°
CD5-15N	92+09	N 70.3091°	W 151.1746°
CD5-15S		N 70.3089°	W 151.1746°
CD5-16N	94+73	N 70.3090°	W 151.1724°
CD5-16S		N 70.3088°	W 151.1725°
CD5-17N	100+44	N 70.3083°	W 151.1683°
CD5-17S		N 70.3081°	W 151.1686°
CD5-18N	101+99	N 70.3079°	W 151.1673°
CD5-18S		N 70.3079°	W 151.1679°
CD5-19N	111+86	N 70.3056°	W 151.1634°
CD5-19S		N 70.3055°	W 151.1639°
CD5-20N	122+31	N 70.3037°	W 151.1578°
CD5-20S		N 70.3035°	W 151.1578°
CD5-21N	126+42	N 70.3035°	W 151.1545°

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
CD5-21S	126+42	N 70.3033°	W 151.1546°
CD5-22N	130+54	N 70.3034°	W 151.1513°
CD5-22S		N 70.3032°	W 151.1512°
CD5-23N	148+07	N 70.3043°	W 151.1377°
CD5-23S		N 70.3041°	W 151.1374°
CD5-24N	153+63	N 70.3048°	W 151.1336°
CD5-24S		N 70.3046°	W 151.1331°
CD5-25N	160+11	N 70.3052°	W 151.1284°
CD5-25S		N 70.3050°	W 151.1280°
CD5-26N	179+13	N 70.3056°	W 151.1130°
CD5-26S		N 70.3054°	W 151.1129°
CD5-27N	188+59	N 70.3058°	W 151.1054°
CD5-27S		N 70.3056°	W 151.1052°
CD5-28N	196+71	N 70.3059°	W 151.0987°
CD5-28S		N 70.3057°	W 151.0987°
CD5-29N	201+40	N 70.3060°	W 151.0951°
CD5-29S		N 70.3058°	W 151.0948°
CD5-30N	205+72	N 70.3060°	W 151.0916°
CD5-30S		N 70.3058°	W 151.0913°
CD5-31N	209+46	N 70.3061°	W 151.0885°
CD5-31S		N 70.3059°	W 151.0883°
CD5-32N	216+78	N 70.3062°	W 151.0824°
CD5-32S		N 70.3060°	W 151.0826°
CD5-33N	216+86	N 70.3062°	W 151.0823°
CD5-33S		N 70.3060°	W 151.0825°
CD5-34N	225+38	N 70.3063°	W 151.0755°
CD5-34S		N 70.3061°	W 151.0755°
CD5-35N	234+35	N 70.3065°	W 151.0683°
CD5-35S		N 70.3063°	W 151.0683°
CD5-36N	239+00	N 70.3065°	W 151.0645°
CD5-36S		N 70.3064°	W 151.0645°
CD5-37N	245+56	N 70.3066°	W 151.0592°
CD5-37S		N 70.3065°	W 151.0592°
CD5-38N	249+12	N 70.3066°	W 151.0563°
CD5-38S		N 70.3064°	W 151.0564°
CD5-39N	254+23	N 70.3063°	W 151.0522°
CD5-39S		N 70.3060°	W 151.0525°
CD5-40N	265+63	N 70.3049°	W 151.0439°
CD5-40S		N 70.3047°	W 151.0441°
CD5-41N	272+56	N 70.3041°	W 151.0388°
CD5-41S		N 70.3039°	W 151.0391°
CD5-42N	276+40	N 70.3036°	W 151.0359°
CD5-42S		N 70.3035°	W 151.0365°
CD5-43N	322+30	N 70.3042°	W 151.0003°
CD5-43S		N 70.3040°	W 151.0003°



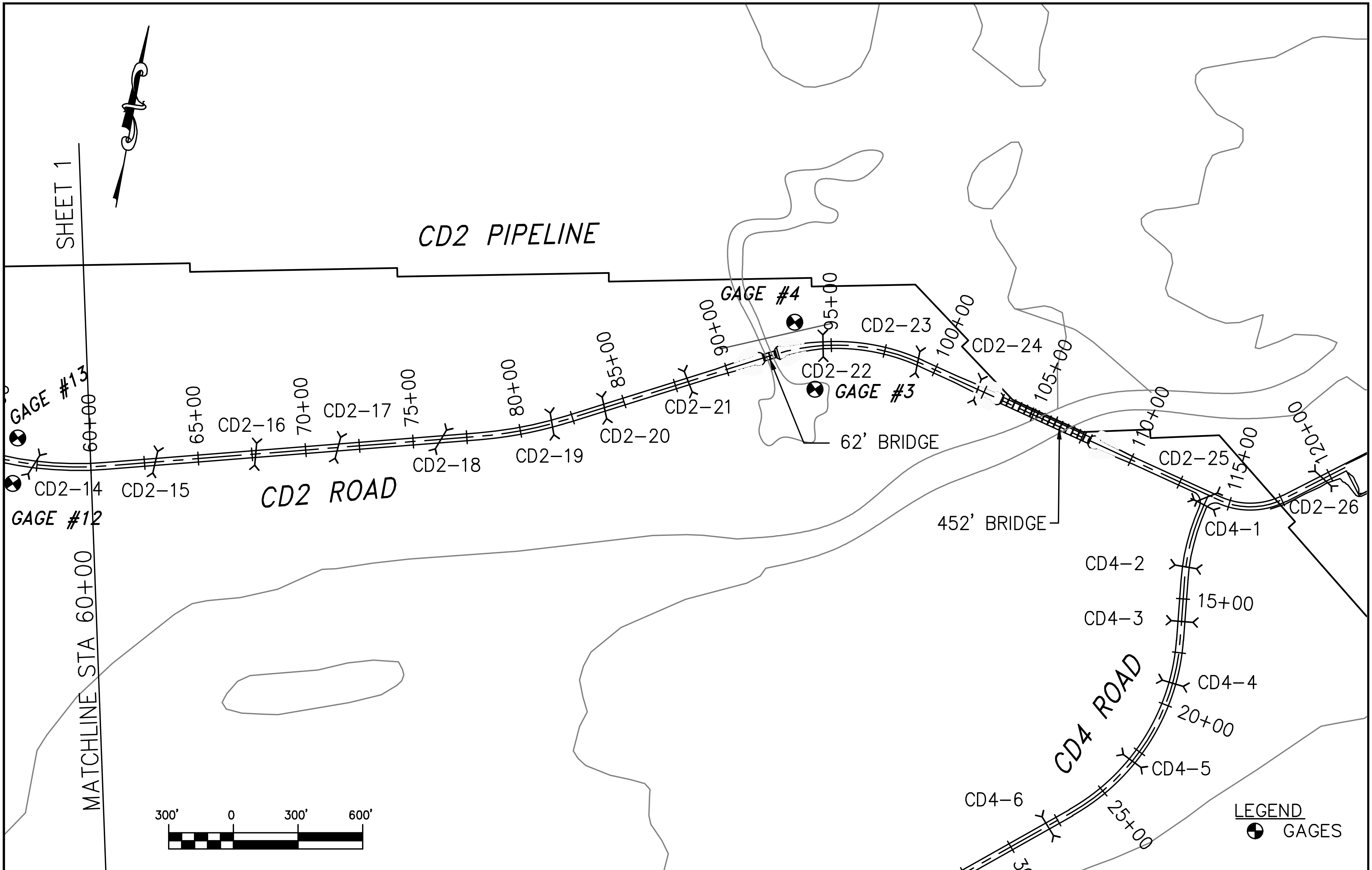
ConocoPhillips
Alaska, Inc.

DATE:	10/14/2020	PROJECT:	178181
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

2020 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 1 OF 13)



ConocoPhillips
Alaska, Inc.

DATE: 10/14/2020	PROJECT: 178181
DRAWN: DTR	FILE: ALPINE_FACILITES.DWG
CHECKED: GCY	SCALE: AS SHOWN

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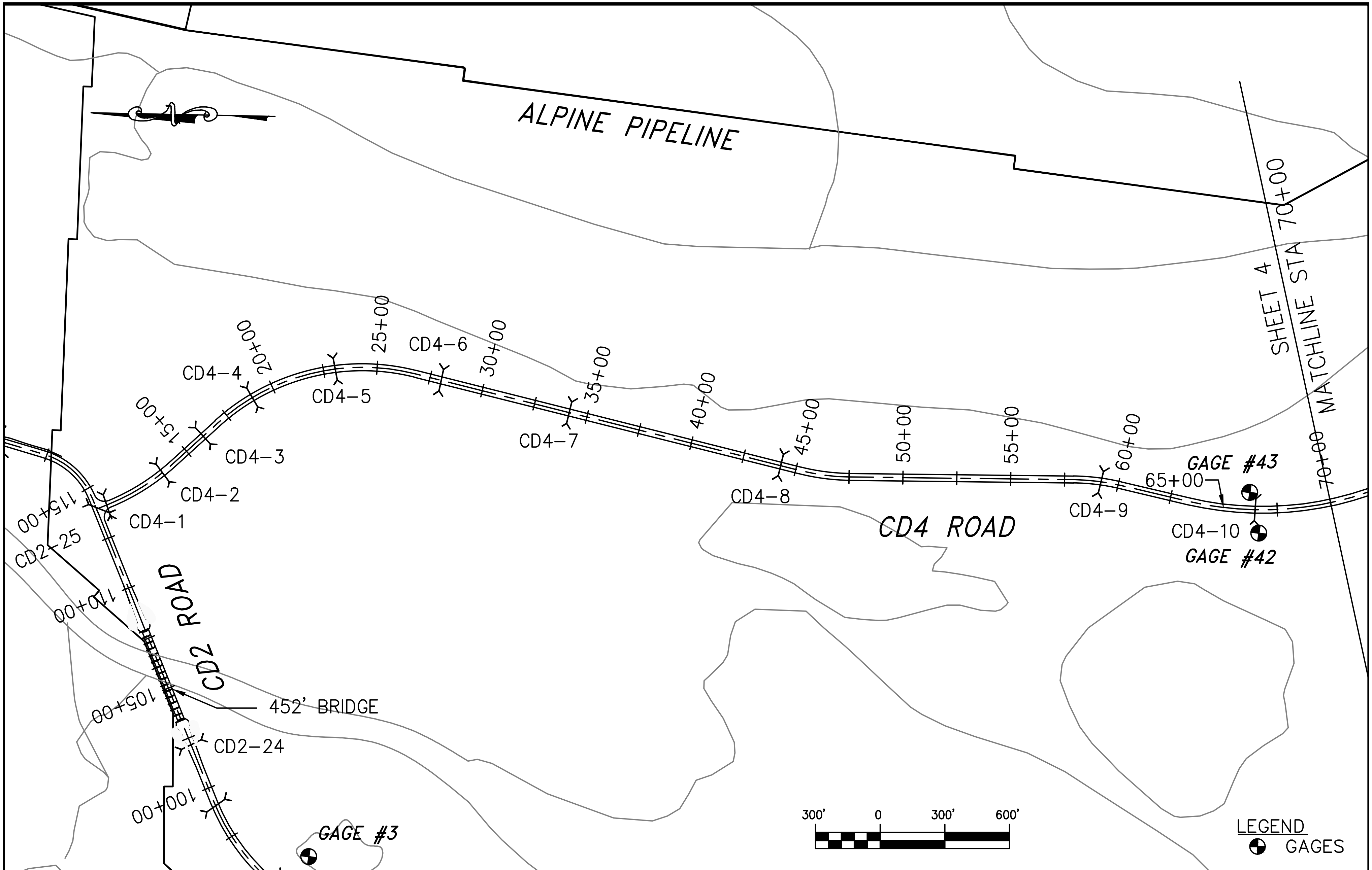
2020 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 2 OF 13)



ConocoPhillips
Alaska, Inc.

DATE:	10/14/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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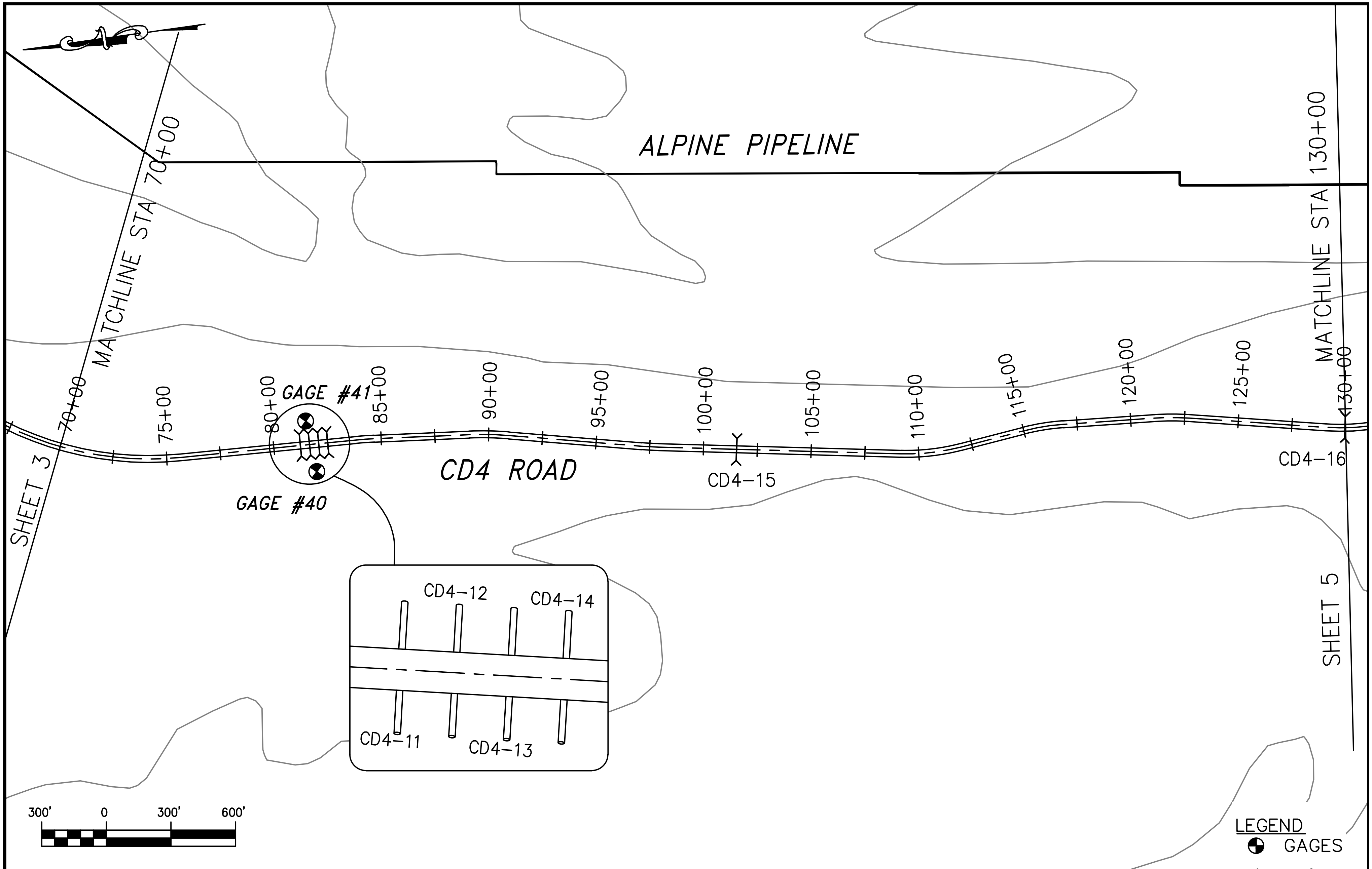
2020 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 3 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	10/14/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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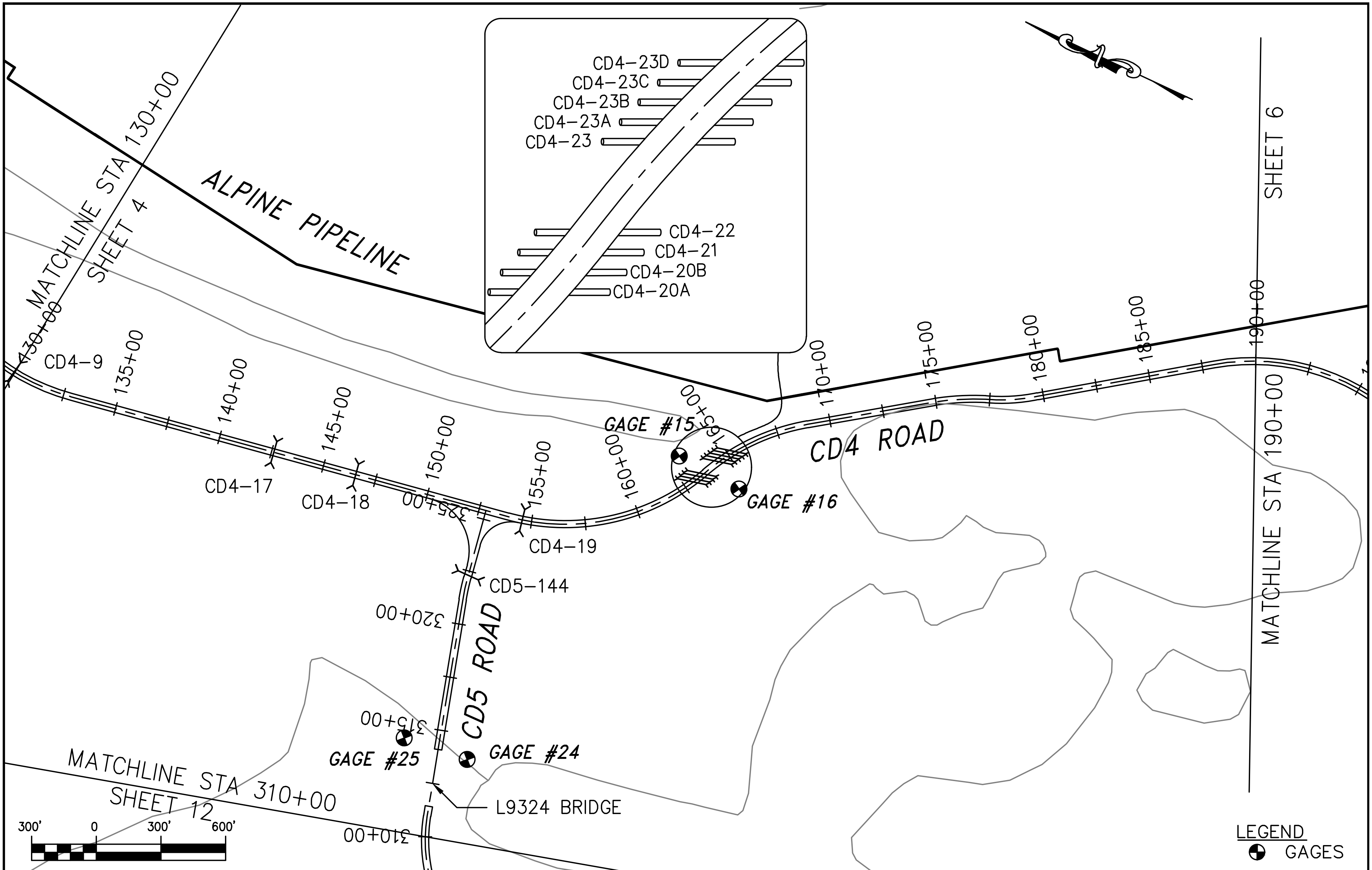
2020 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 4 OF 13)



ConocoPhillips
Alaska, Inc.

DATE: 10/14/2020	PROJECT: 178181
DRAWN: DTR	FILE: ALPINE_FACILITES.DWG
CHECKED: GCY	SCALE: AS SHOWN

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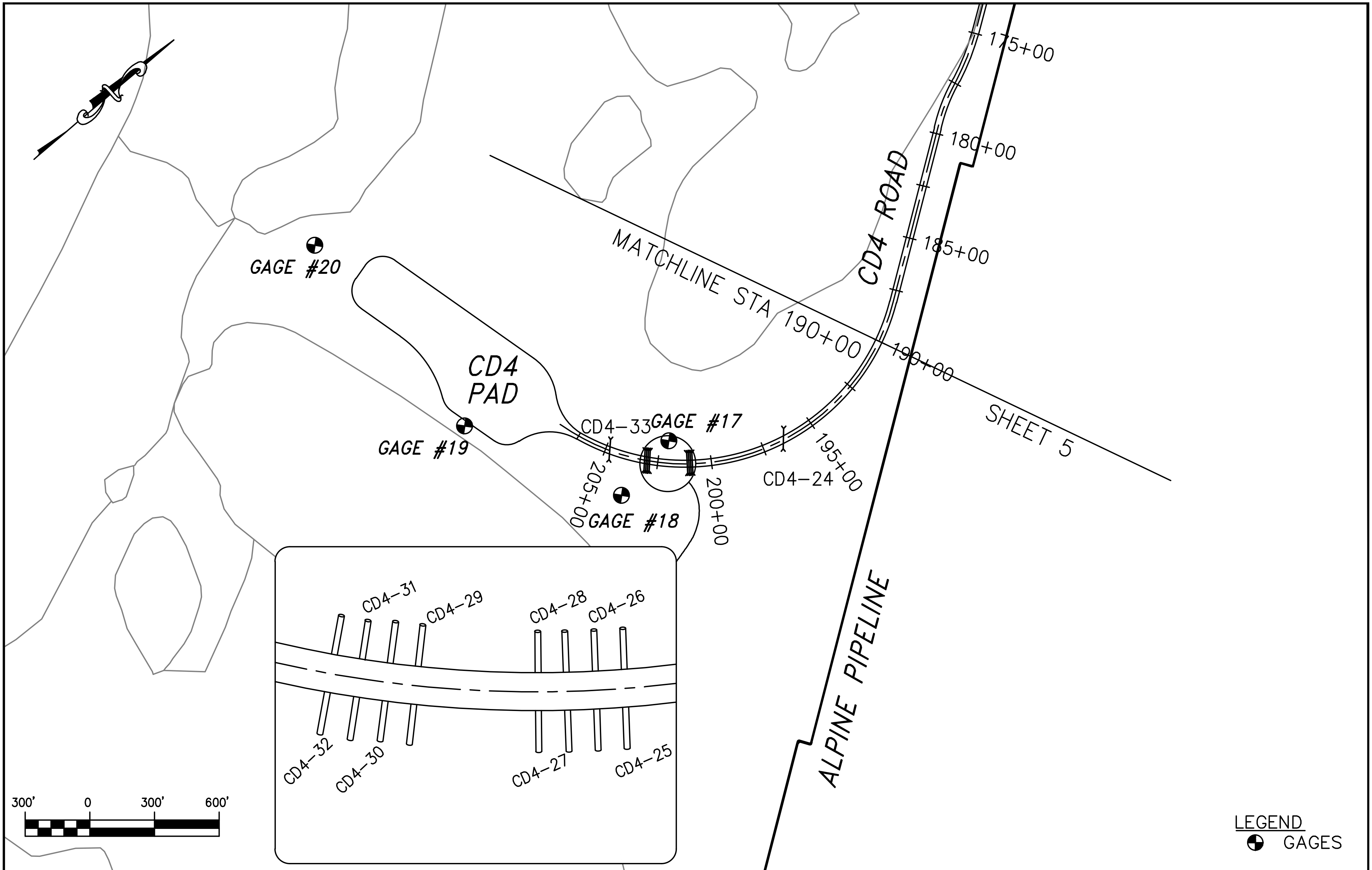
2020 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 5 OF 13)



ConocoPhillips
Alaska, Inc.

DATE:	10/15/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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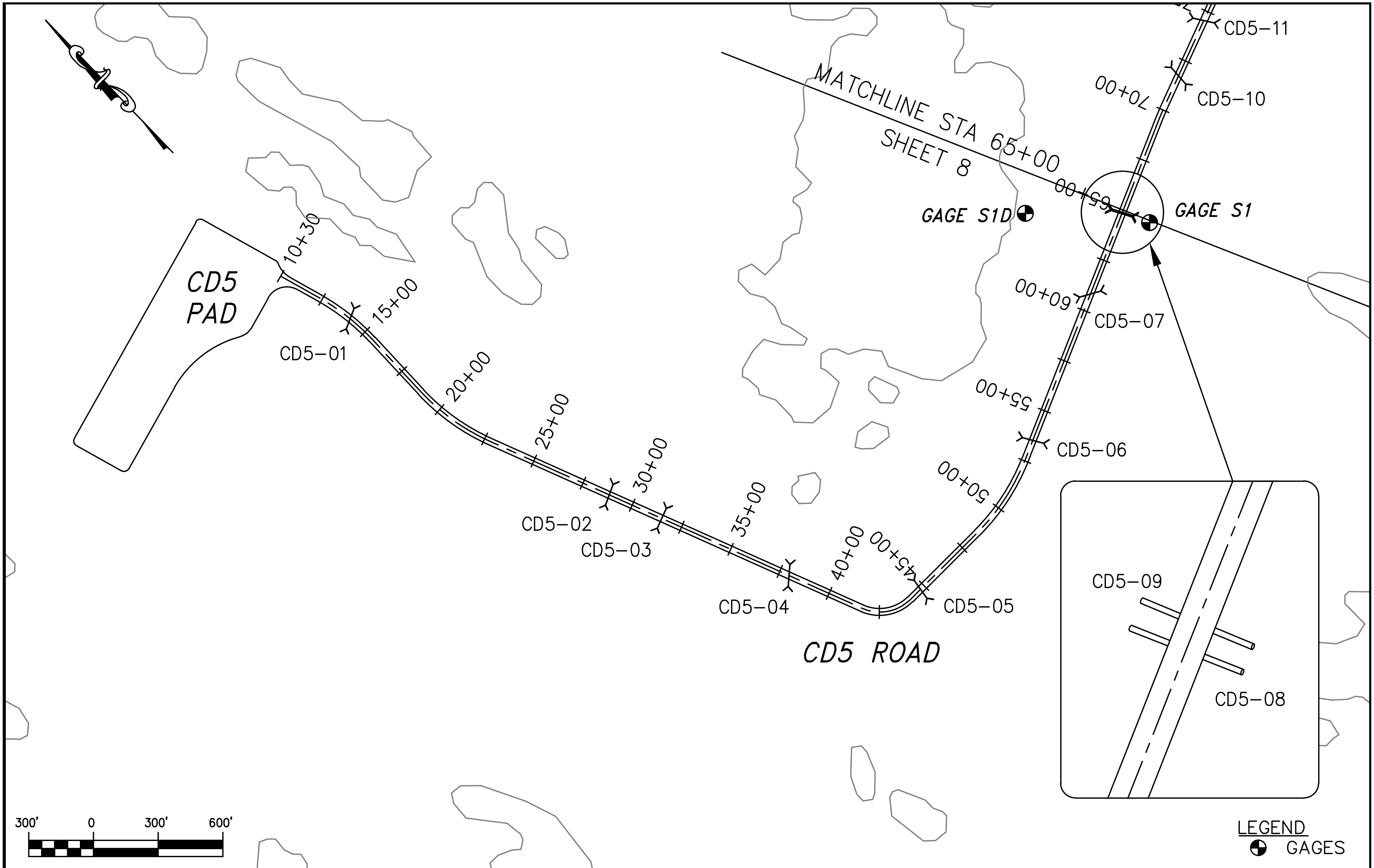
2020 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION



ConocoPhillips
Alaska, Inc.

DATE:	10/15/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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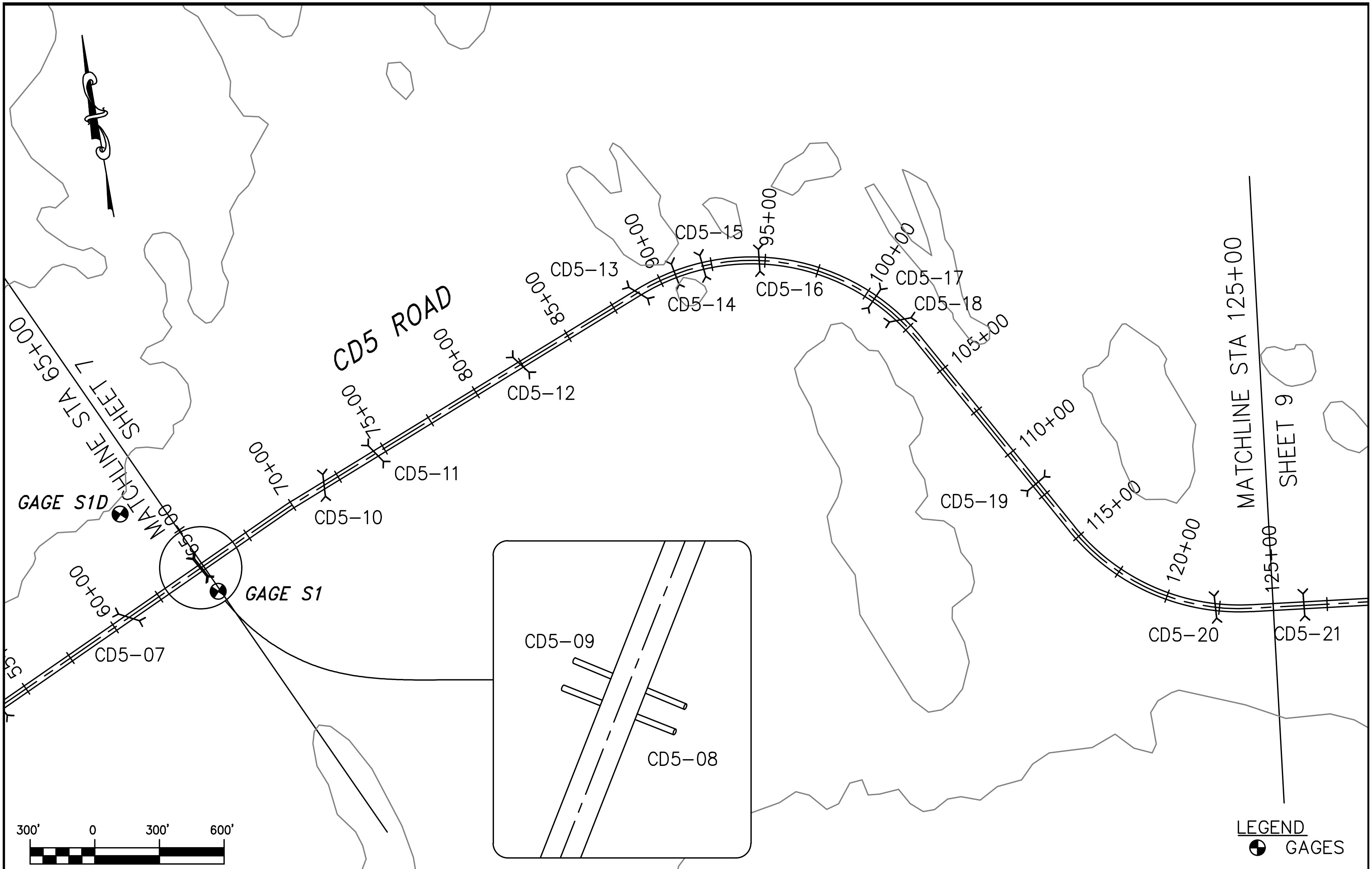
2020 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 7 OF 13)



ConocoPhillips
Alaska, Inc.

DATE:	10/15/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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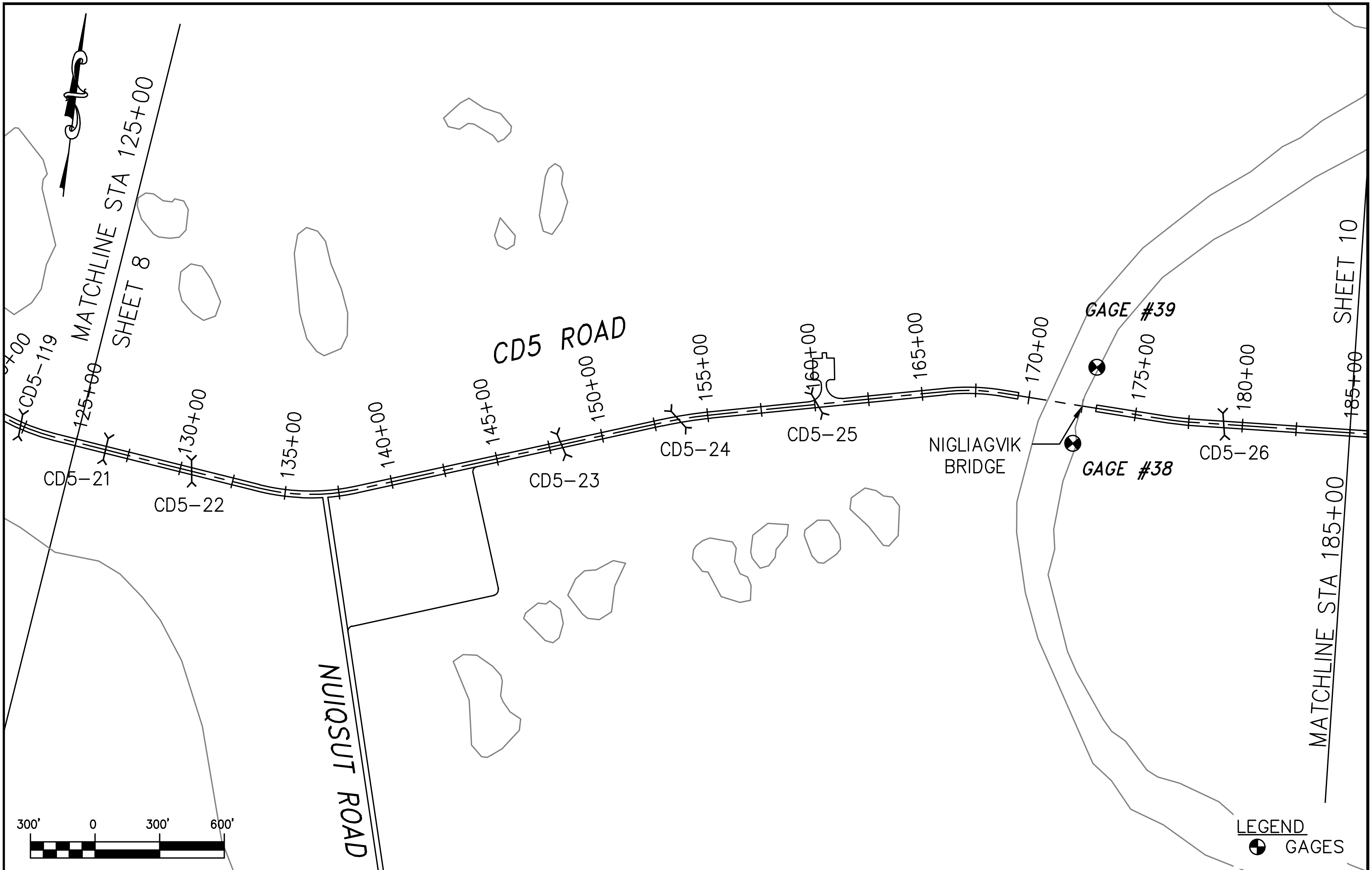
Fax: (907) 273–1699

2020 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 8 OF 13)



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DATE:	10/15/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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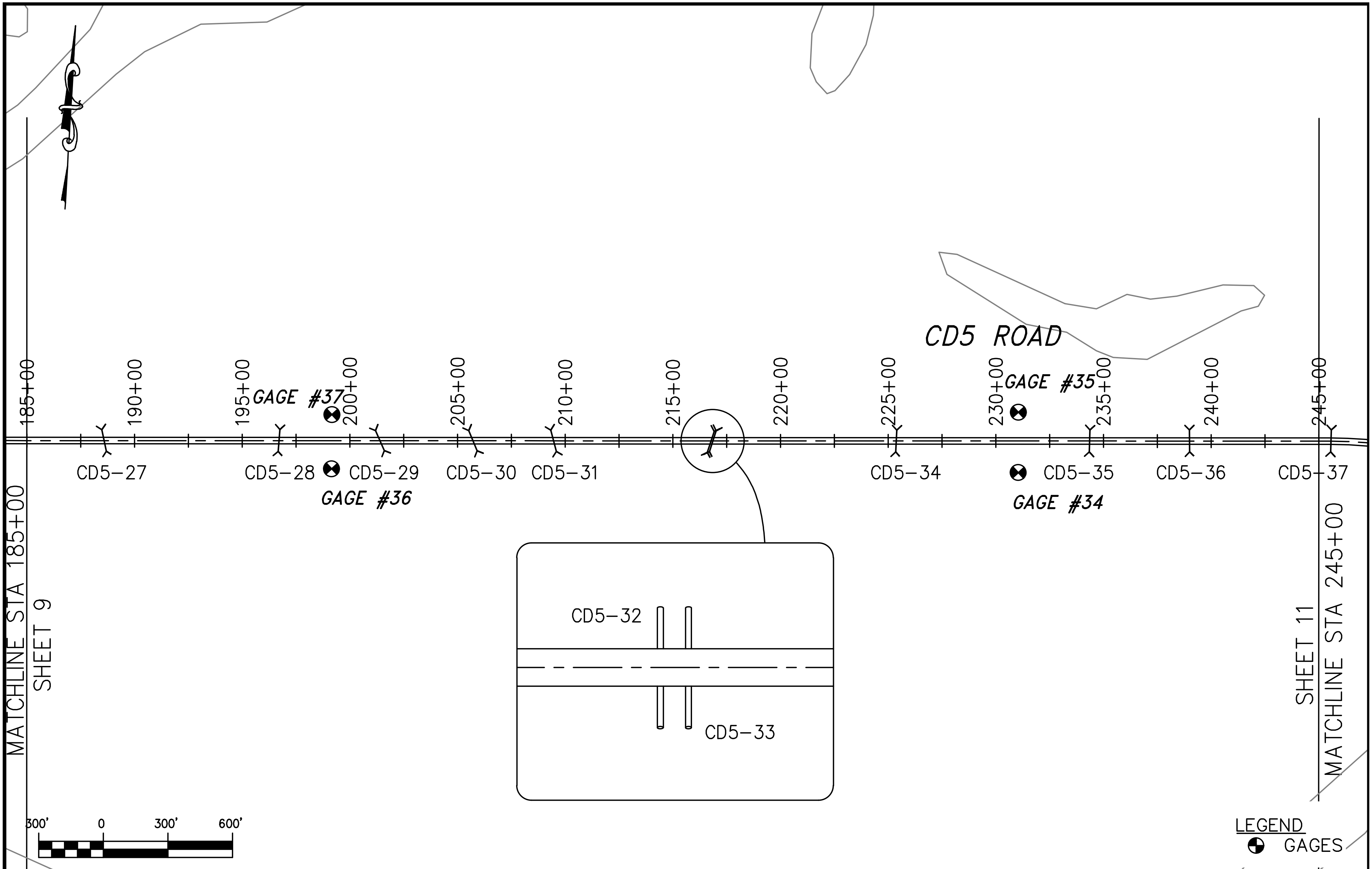
2020 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION



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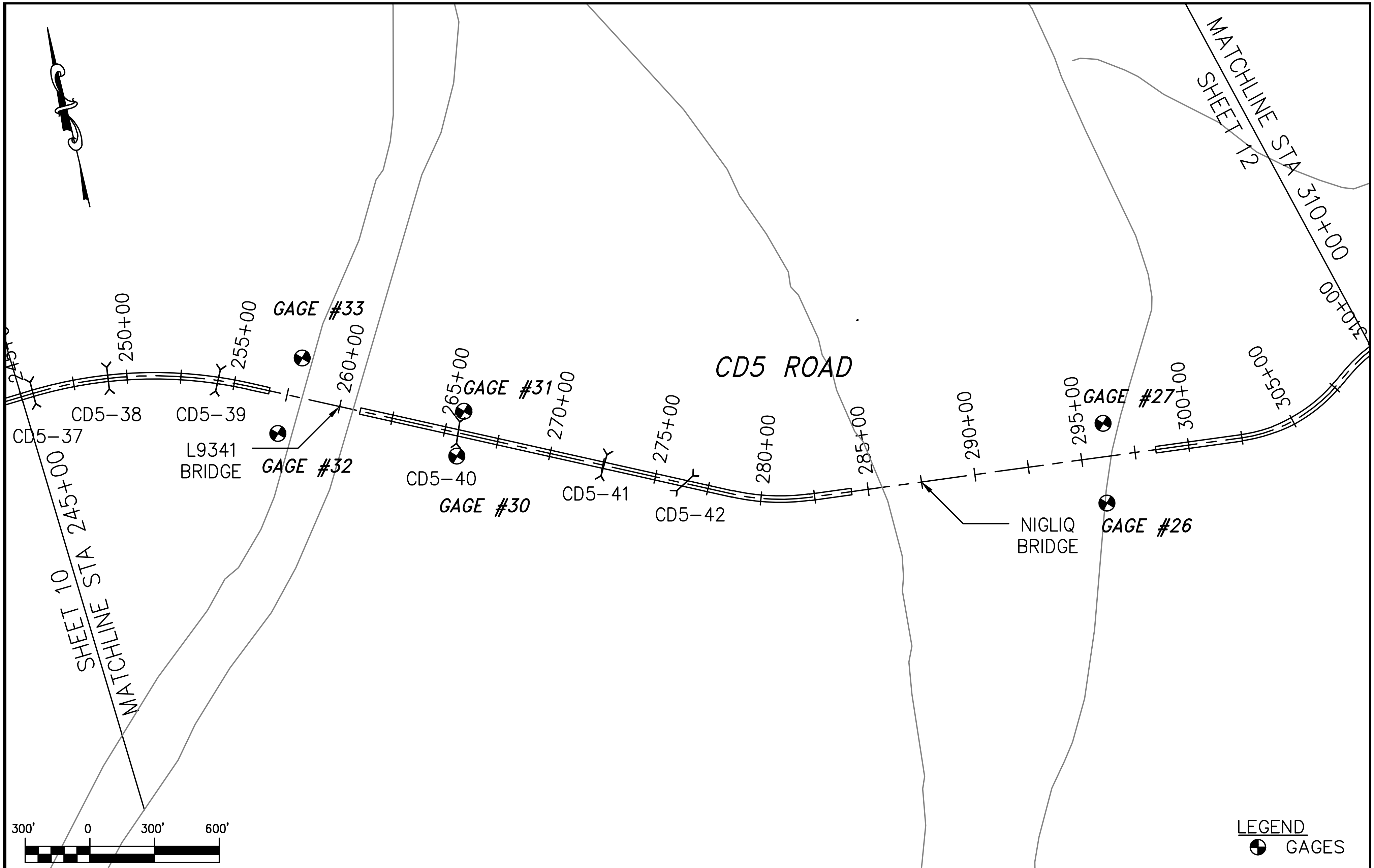
2020 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET10 OF 13)



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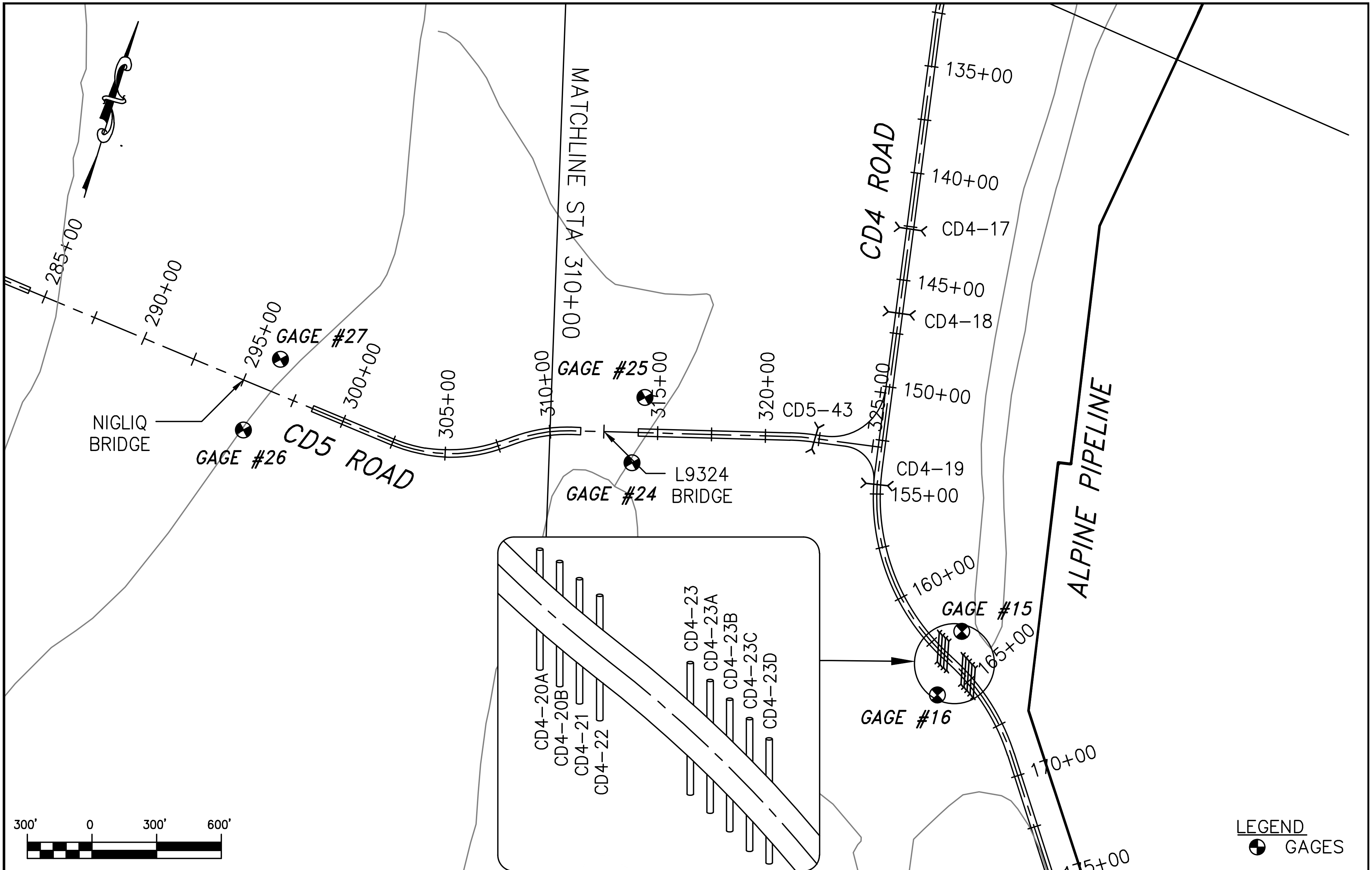
2020 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION



ConocoPhillips
Alaska, Inc.

DATE:	10/30/2018	PROJECT:	166417
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
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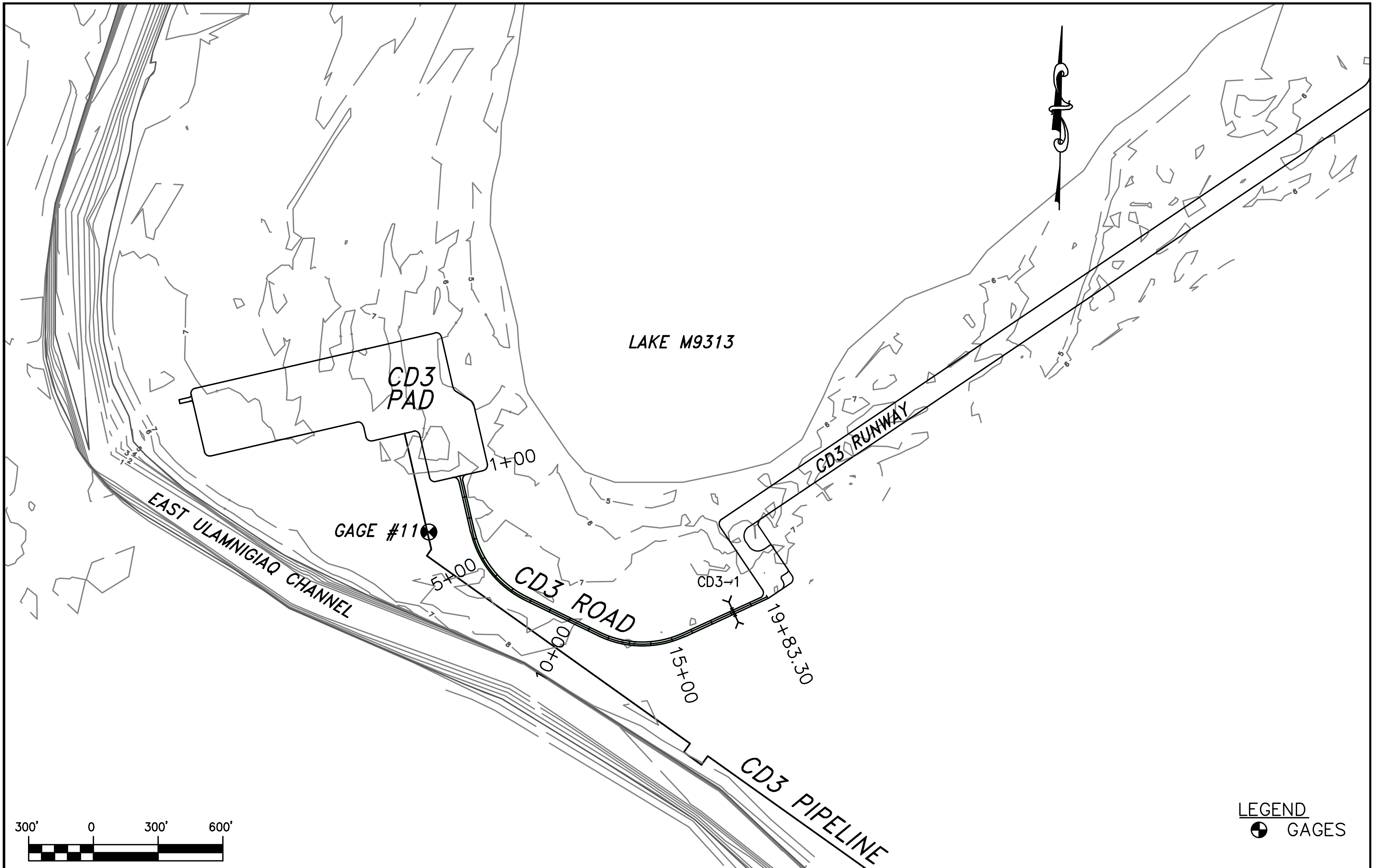
2018 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET12 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	10/15/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2020 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET13 OF 13)

APPENDIX B PT SETUP & TESTING 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 were taken into account using a Solinst Barologger® barometric pressure logger. A correction of barometric pressure was obtained from the Solinst Levelogger installed at the Tinmiaqsiugvik Bridge.

The PTs were tested before field mobilization. The PTs were configured using Solinst Levelogger® v4.0.3 (for both the Solinst Leveloggers and Barologgers) 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. 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 C DISCHARGE METHODS, SITE SPECIFIC INFORMATION, & PLAN & PROFILE DRAWINGS

C.1 METHODS

C.1.1 MEASURED DISCHARGE

1) USGS Midsection Technique

Bridge flow depth and velocity measurements were taken from the upstream side of bridge decks using a sounding reel mounted on a USGS Type A crane with 4-wheel truck. A Price AA velocity meter was attached to the sounding reel and stabilized with a counterweight. 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 prior to spring breakup monitoring in accordance with USGS precise standards. A spin test of the meter was completed prior to and after each measurement. Procedures outlined in OSW Technical Memorandum No. 99.06 (OSW 1999b) were followed to confirm accurate meter performance. Discharge was calculated based on velocity and flow depth.

2) USGS Velocity/Area Technique

Standard USGS velocity/area techniques (USGS 1968) were used to measure depth of flow and velocity to determine discharge at each culvert experiencing flow. Depth of flow and velocity were measured on the downstream end of the culvert using a HACH FH950 electromagnetic velocity meter attached to a wading rod. The accuracy of the HACH meter is ± 2% of the reading, ± 0.05 ft/s between 0 ft/s and 10 ft/s, and ± 4% of the reading from between 10 ft/s and 16 ft/s. Discharge was calculated based on velocity, flow depth, and culvert geometry.

3) ADCP METHODS

Direct discharge was measured using an Acoustic Doppler Current Profiler (ADCP). Information regarding ADCP discharge measurements are included in the following sections.

A. 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 v2.18 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.

B. 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 and a moving bed test. The internal compass was calibrated to an error of 1.9°, which is within the specified 5° limit. A loop test was performed to detect and estimate compensation for a moving bed, which was identified at a velcoity of 0.073 ft/s.

C. 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.

The discharge measurements were performed at bridge crossings and areas of hydraulic importance in the CRD. 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.

The four most agreeing of a total of six transects were used. The measured discharges varied by 0.00%, which is less than the standard 5% of their mean. Cross section end points were dependent on a depth associated with a minimum of two good bins to provide acceptable data.

D. 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.

Some channels in the CRD are 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 can 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), 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. Since a moving bed was identified, the mean correction procedure was applied to the because of the simple geometry of the channel cross section. The results of the loop test, performed during 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 resulting direct discharge measurement was determined by averaging the corrected discharge measurements.

C.1.2 PEAK DISCHARGE

1) Culverts

Bentley CulvertMaster® software was used to calculate peak discharge through the CRD road culverts associated with gage stations that experienced flow. Timing and magnitude of peak discharge through the culverts was determined based on recorded stage on both sides of the road prism. Peak discharge results were evaluated against visual assessment of performance. Average velocity and discharge through the culverts assume 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 UMIAQ as-built surveys (UMIAQ 2002, 2017)
- Culvert upstream and downstream invert elevations (UMIAQ 2017, 2019d)
- Culvert Manning's roughness coefficients (0.013 for smooth steel and 0.024 for corrugated metal pipe)

2) Streams

Peak discharge in streams was calculated indirectly using either the Slope Area (Benson and Dalrymple 1967) or the Normal Depth method (Chow 1959). Both methods use channel roughness, cross sectional 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. The Slope Area method is considered the standard for indirect discharge calculations and is generally used if sufficient stage data is available for multiple cross-sections through a reach. The accuracy of each method, however, depends on conditions at the time of calculation, particularly the presence of channel ice and bottom-fast ice, ice jam activity, and backwater effects. Direct discharge measurements at or near the time of peak can support calibration and accuracy of indirect calculations.

Cross sectional geometry for MON1 is current as of 2004 (UMIAQ 2004), MON9 is current as of 2014 (UMIAQ 2014), Nigliq Bridge (CD5 Bridge #2) is current as of 2019 (UMIAQ 2019a). Cross-sectional geometry data was collected in the summer and does not account for bank-fast or bottom-fast ice or snow. Additionally, 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. Stage and energy gradient data were obtained from observations, gage data, and PT data.

3) CD5 Bridges

During large flood events like 2020, overbank flooding along the CD5 road can result in contracted flow through the bridge openings. Under contracted flow conditions, the width contraction method for calculating discharge can provide a better estimate than the normal depth method by accounting for energy losses through the constricted bridge opening.

Lake L9341 bridge (CD5 bridge #3) was under the influence of competent lake ice. Peak discharge could not be estimated with a sufficient degree of confidence.

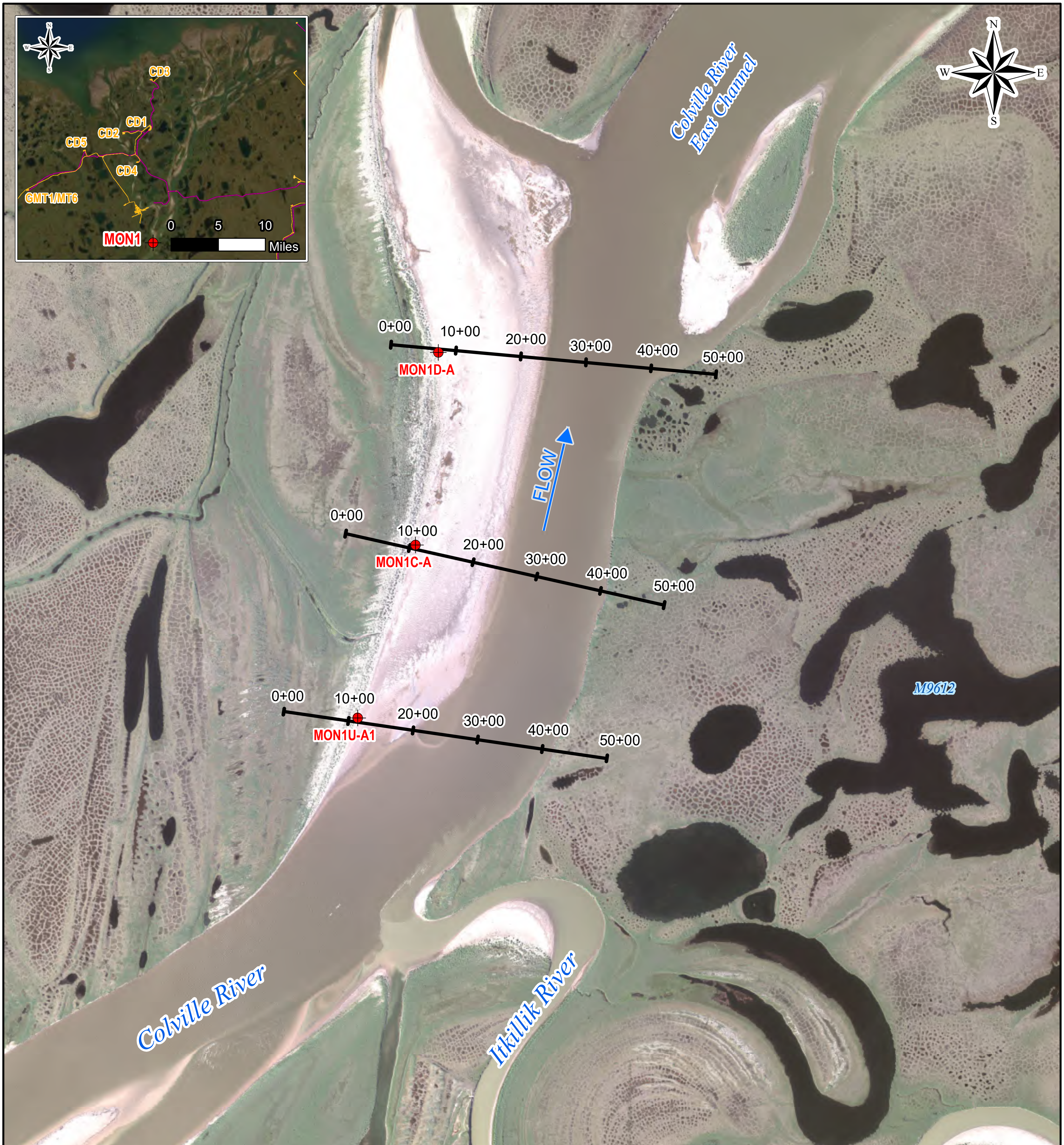
C.2 Site Specific Data & Plan & Profile Drawings

C.2.1 MON1

1) PEAK DISCHARGE DATA

Peak discharge at MON1 was calculated indirectly using the Normal Depth method. The energy grade-line was approximated by the average water surface slope between MON1U, MON1C, and MON1D. Manning's n roughness values used were 0.0256 for the main channel and 0.06 for the overbanks, based on historical calibration of measured discharge and corresponding stage.

2) PLAN & PROFILES



Feet
0 2,000 4,000

Gage Location	Pipeline
Flow Direction	Facility
Cross Section Alignment	

Imagery from CPAI 2019

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Date:	10/27/2020	Scale:	1 Inch = 2,000 feet
Drawn:	JEM	Project:	178181
Checked:	GCY	File:	Mon1.mxd

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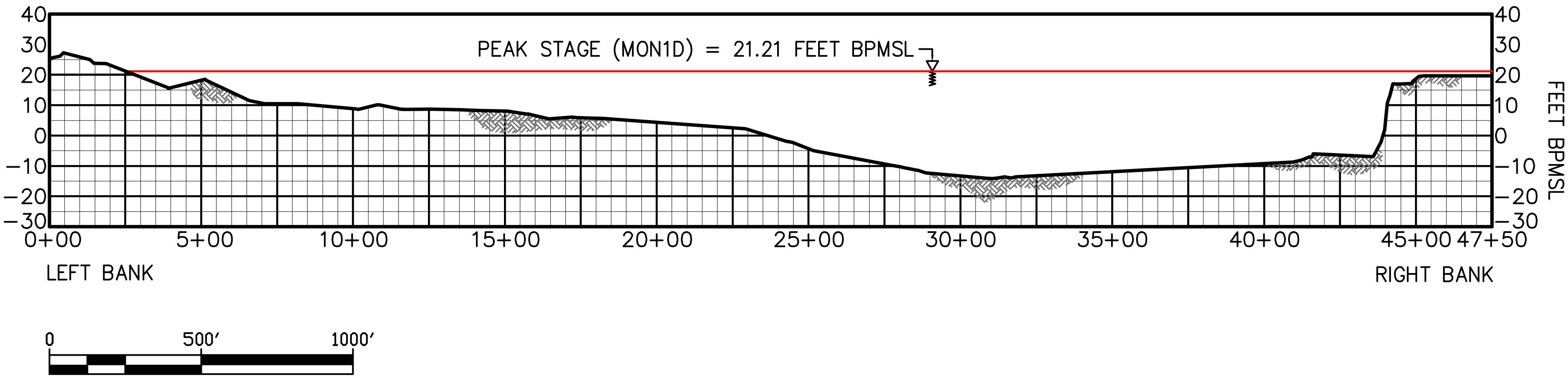
Alaska

2020 SPRING BREAKUP
COLVILLE RIVER DELTA

Monitoring Locations

FIGURE C.2.1 | 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

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DATE:	10/16/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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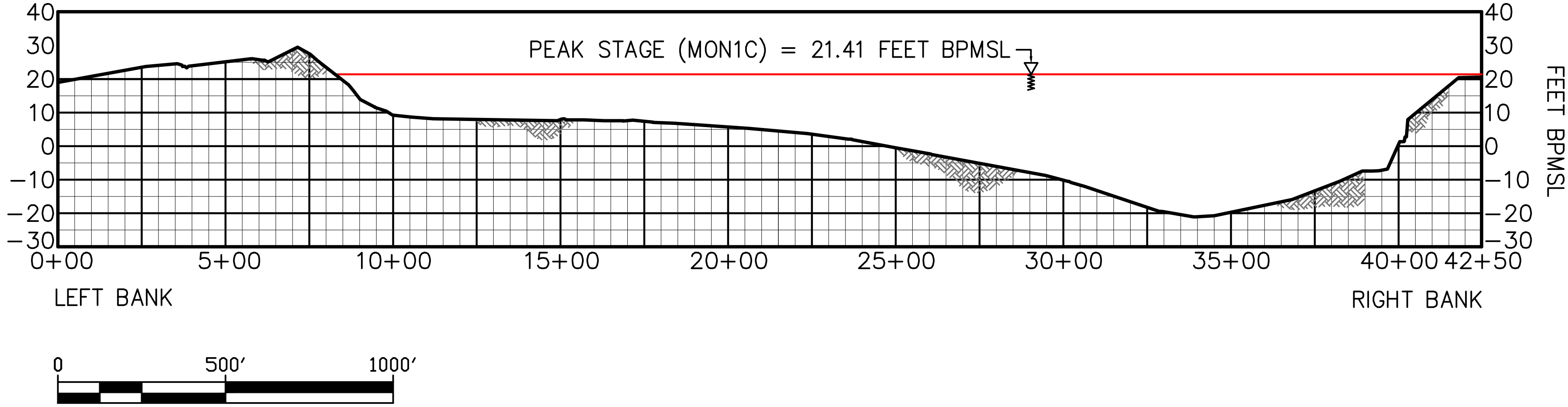
2020 SPRING BREAKUP
MONUMENT 1 DOWNSTREAM
PROFILE

(SHEET 2 OF 4)

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

DATE:	10/16/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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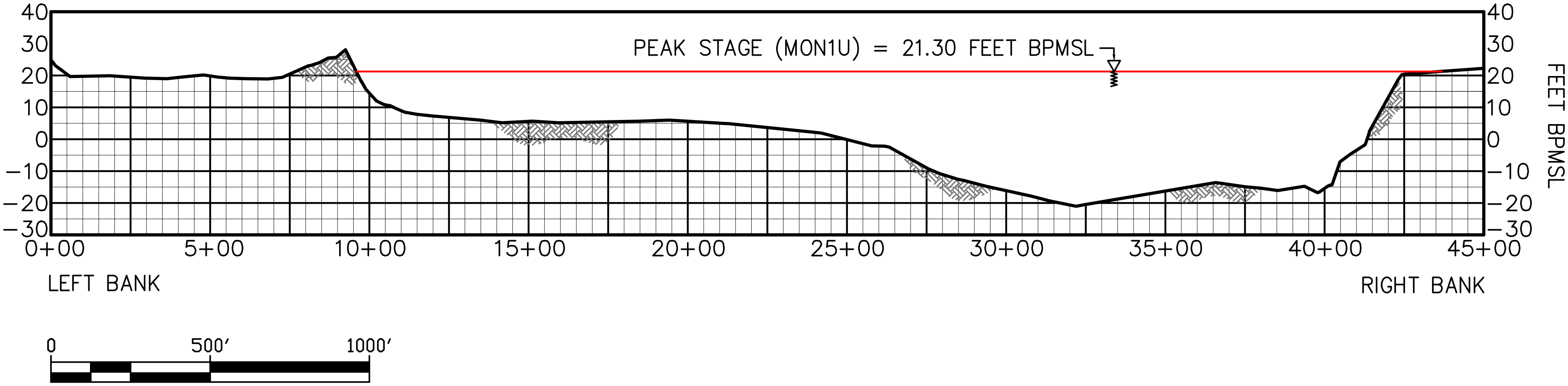
2020 SPRING BREAKUP
MONUMENT 1 CENTERLINE PROFILE

(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: 10/16/2020		PROJECT: 178181	
DRAWN: DTR		FILE: MON1 X-SECTIONS.DWG	
CHECKED: GCY		SCALE: AS SHOWN	

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2020 SPRING BREAKUP
MONUMENT 1 UPSTREAM
PROFILE

NUMBER
(SHEET 4 OF 4)

C.2.2 MON9

1) PEAK DISCHARGE DATA

Peak discharge at MON9 was calculated using the Normal Depth method. The energy grade-line was approximated by the water surface slope between MON9 and MON9D. Manning's n roughness values used were 0.021 for the low flow channel and 0.023 for the main channel.

2) PLAN & PROFILE

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Date: 10/27/2020	Scale: 1 Inch = 1,000 feet
Drawn: JEM	Project: 178181
Checked: GCY	File: Mon9.mxd

Feet
0 1,000 2,000

- Gage Location
- Flow Direction
- Cross Section Alignment
- Pipeline
- Facility

Imagery from CPAI 2019

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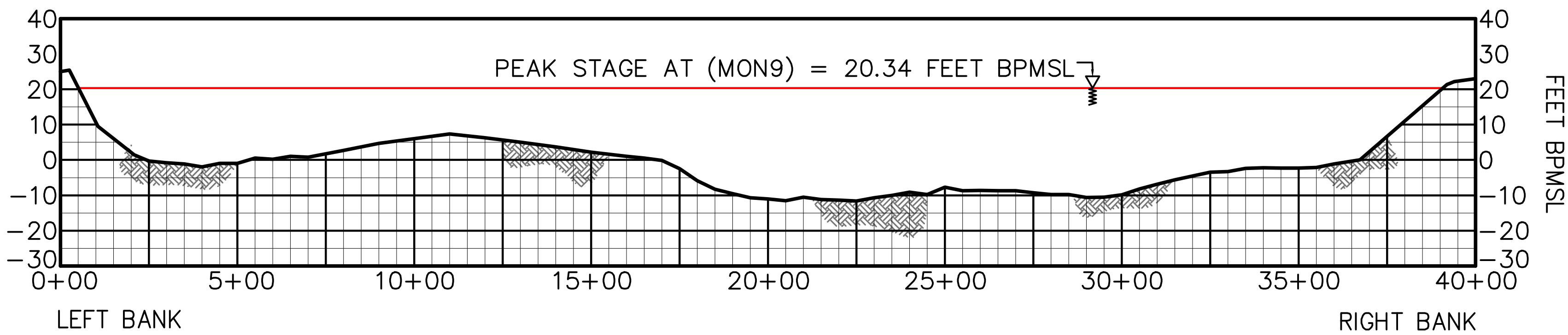
2020 SPRING BREAKUP
COLVILLE RIVER DELTA

MON9 & HDD Plan View

FIGURE C.2.2 | 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

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Alaska, Inc.

DATE:	10/16/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	MON9 X-SECTION.DWG
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2020 SPRING BREAKUP
MONUMENT 9 / HDD
PROFILE

(SHEET 2 OF 2)

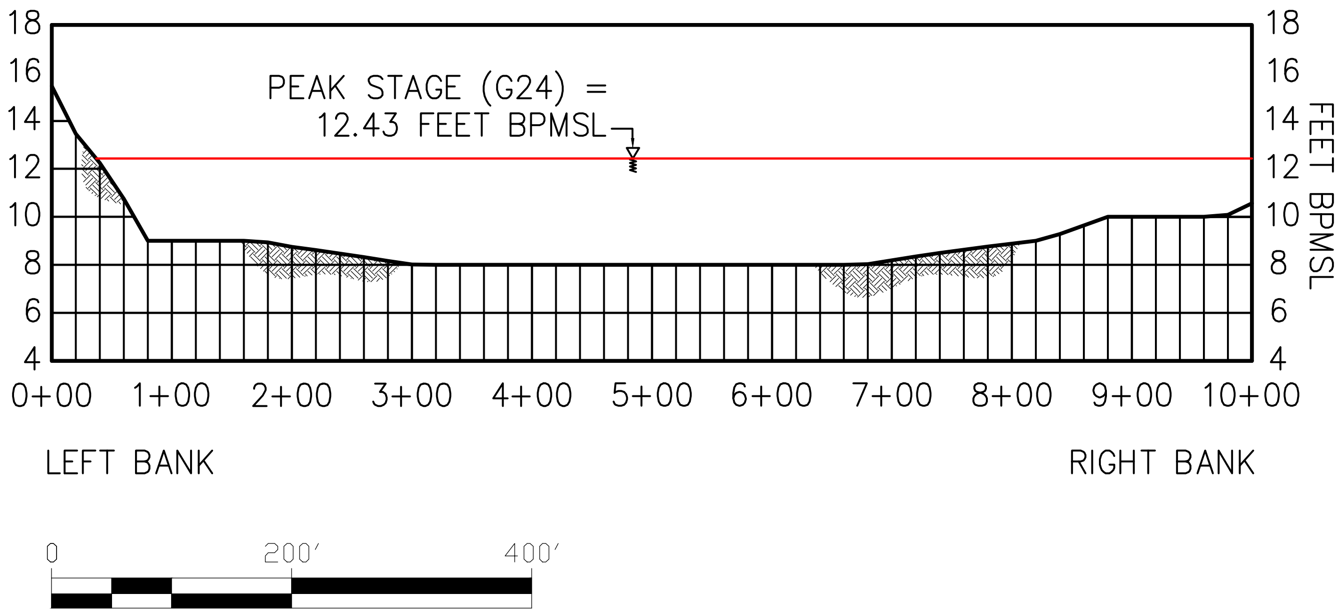
C.2.3 LAKE L9323 BRIDGE

1) PEAK DISCHARGE DATA

Peak Discharge was calculated using the width contraction method. Channel slope was used from G24 and G25 PT's. Manning's n roughness value used was 0.06.

2) PROFILE

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:	10/16/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	L9323 X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2020 SPRING BREAKUP
LAKE L9323
PROFILE

(SHEET 2 OF 2)

C.2.4 NIGLIQ BRIDGE

1) MEASURED DISCHARGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 30, 2020
Computed By: SAO
Checked By: HLR

Location Name: Nigliq Bridge

Party: EKB, WAB **Start:** 10:49 AM **Finish:** 4:20 PM

Temp: 35 °F **Weather:** Sunny, East/NE wind 20-25 mph

Channel Characteristics:

Width: 1120 ft **Area:** 17226 sq ft **Velocity:** 3.2 fps **Discharge:** 55504 cfs

Method: Mid-section technique **Number of Sections:** 25 **Count:** varies

Spin Test: OK minutes after OK minutes **Meter:** Price AA

Meter: 0.8 ft above bottom of weight

Weight: 50 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GAGE READINGS			
Gage	Start	Finish	Change
G26-D	0.58		0.58
VSM 584 MD	2.03	2.94	-0.91
G26-C		1.6	
G26 (BPMSL)	8.65	7.86	-0.79

GPS Data:

Left Edge of Water: West bridge abutment

Right Edge of Water: East bridge abutment

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

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

Descriptions:

Cross Section: Shallow beach along right bank

Flow: Ineffective/upstream flow between LEW to Station 112 ft and also between Station 810 ft and REW

Remarks: Strong east wind

Discharge measurement performed then additional measurements were added at intermediate stations. High velocities - Price AA meter set to reco click after every 5 rotations. G27 gages were all unusable because of impacts from ice floes, VSM 584 was used instead (not tied to BPMSL datum)

Rating of "Poor" due to amount of time it took to collect measurement and having to go back for intermediate stations.

Nigliq Bridge
May 30, 2020

Angle Coeff	Distance from Initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	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)
-	0	-	Ineffective flow between 0 and 112 ft									
-	112	126.0										
1	140	39.0	9.6	7.7 1.9	11 12	55 60	73 51	1.7 2.6	2.1	2.1	374	803
1	190	37.5	30.0	24.0 6.0	15 17	75 85	47 45	3.5 4.2	3.9	3.9	1125	4342
0.99	215	25.0	29.0	23.2 5.8	13 14	65 70	48 42	3.0 3.7	3.3	3.3	725	2403
1	240	25.0	31.4	25.1 6.3	12 16	60 80	46 42	2.9 4.2	3.6	3.6	785	2791
0.99	265	25.0	29.0	23.2 5.8	12 15	60 75	47 42	2.8 4.0	3.4	3.4	725	2436
1	290	25.0	30.0	24.0 6.0	13 19	65 95	49 46	2.9 4.6	3.8	3.8	750	2818
0.99	315	35.0	30.8	24.6 6.2	11 15	55 75	46 43.5	2.7 3.8	3.2	3.2	1078	3454
1	360	25.0	31.7	25.4 6.3	14 17	70 85	45 43	3.4 4.4	3.9	3.9	793	3100
1	365	17.5	30.0	24.0 6.0	13 15	65 75	48 43	3.0 3.9	3.4	3.4	525	1803
1	395	32.5	27.8	22.2 5.6	14 14	70 70	44.7 43	3.5 3.6	3.5	3.5	904	3197
1	430	35.0	28.2	22.6 5.6	15 16	75 80	47 43.5	3.5 4.1	3.8	3.8	987	3755
1	465	35.0	28.4	22.7 5.7	13 15	65 75	53.5 44	2.7 3.8	3.2	3.2	994	3217
1	500	25.0	30.8	24.6 6.2	13 15	65 75	44.7 44	3.2 3.8	3.5	3.5	770	2695
1	515	35.0	33.0	26.4 6.6	10 15	50 75	44 46.4	2.5 3.6	3.1	3.1	1155	3526
1	570	45.0	33.8	27.0 6.8	13 13	65 65	47 43	3.1 3.4	3.2	3.2	1521	4881
1	605	35.0	24.6	19.7 4.9	10 10	50 50	51 61	2.2 1.8	2.0	2.0	861	1724
0.99	640	42.5	18.0	14.4 3.6	10 10	50 50	45 43	2.5 2.6	2.5	2.5	765	1912
0.8	690	50.0	19.8	15.8 4.0	65 5	325 25	49.5 43.5	14.5 1.3	7.9	6.3	990	6248
0.7	740	60.0	17.0	13.6 3.4	4 2	20 10	91 79	0.5 0.3	0.4	0.3	1020	285
0.85	810	82.5	4.6	3.7 0.9	1 3	5 15	81 61	0.2 0.6	0.4	0.3	380	115
1	905	97.5	2.0	upstream/ineffective flow between 810 ft and 1120 ft								
1	1005	105.0	1.4									
1	1115	60.0	2.3									
-	1120											

Highest depth averaged velocity 7.9
Average Velocity: 3.2 Total Discharge: 55504

2) PEAK DISCHARGE DATA

Although floodwater spanned the entire Nigliq Bridge (CD5 Bridge #2) opening, calculations suggested that flow was not constricted, and the Normal Depth method was used to estimate peak discharge.

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 2019. The friction slope used in the Normal Depth calculation was based on WSEs at gages G26 and G28. The channel roughness values used were calibrated from the measured discharge. Manning's n values used were 0.095 for the left overbank, 0.06 for the right overbank, and 0.034 for the main channel. Main channel roughness is relatively high to account for minor obstructions from the bridge piers and scour holes.

3) PLAN & PROFILE

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Date: 10/27/2020	Scale: 1 Inch = 333.3 feet
Drawn: JEM	Project: 178181
Checked: GCY	File: Nigliq.mxd

Feet
0 740

Gage Location
Flow Direction
Cross Section Alignment
Pipeline
Road Shoulder
Bridge Deck
Facility

Imagery from CPAI 2019

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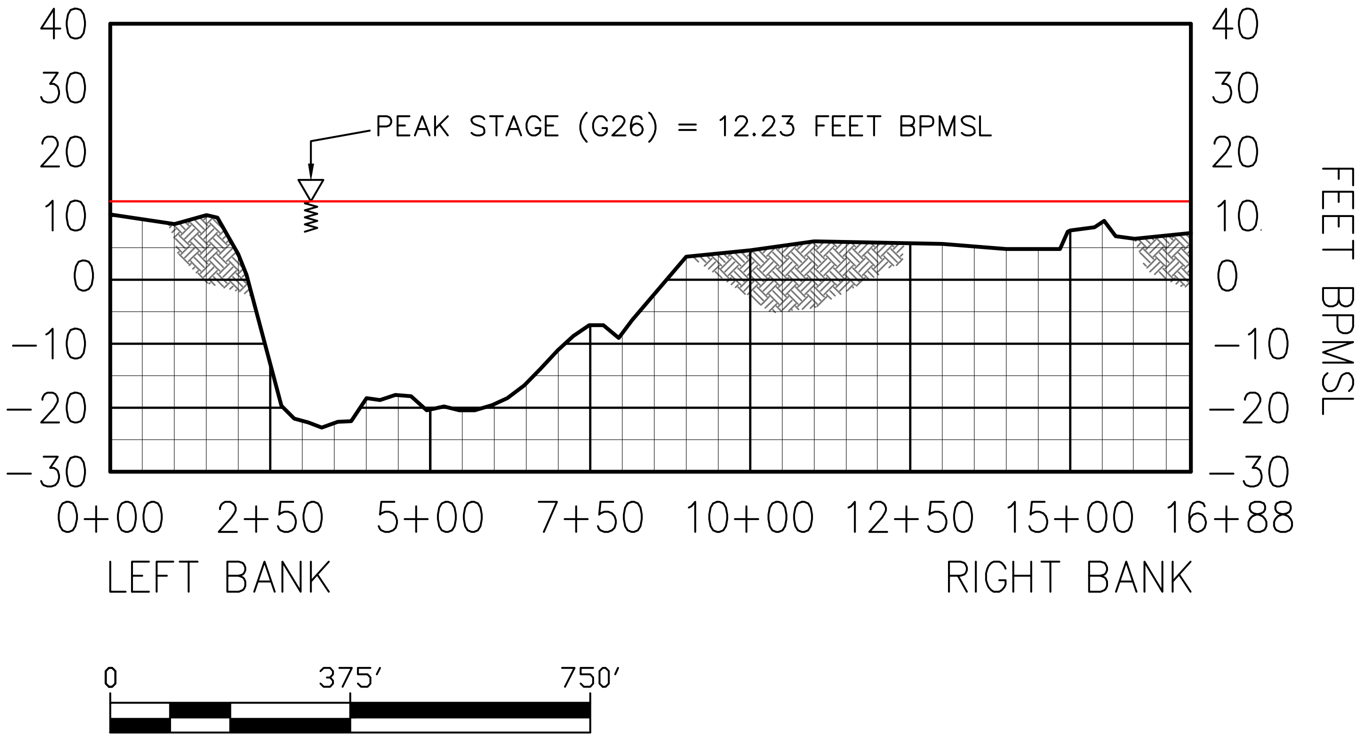
2020 SPRING BREAKUP
COLVILLE RIVER DELTA

Nigliq Channel Plan View

FIGURE C.2.3 | Sheet 1 of 2

NOTES
1. BASIS OF ELEVATION, MONUMENT 26.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 2019 BY UMIAQ (KUUKPIK/LCMF INC.)



1 CD5 CROSSING – NIGLIQ CHANNEL CENTERLINE CROSS–SECTION
TRANSECT 10 (DOC LCMF–156 CD5 BRIDGE TRANSECTS REV9)

ConocoPhillips Alaska, Inc.

DATE:	10/16/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	NIGLIQ X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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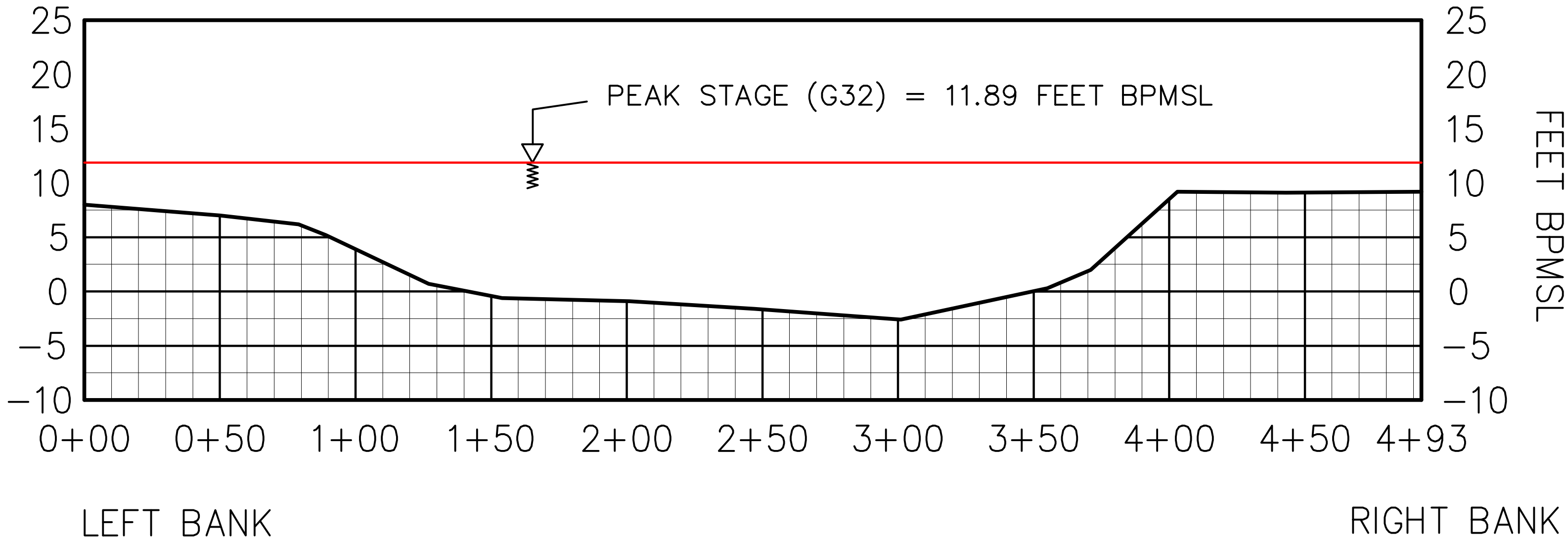
2020 SPRING BREAKUP
NIGLIQ CHANNEL
TRANSECT 10 PROFILE

(SHEET 2 OF 2)

C.2.5 LAKE L9341 BRIDGE

1) PROFILE

NOTES
1. BASIS OF ELEVATION, MONUMENT 25.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 2019 BY UMIAQ (KUUKPIK/LCMF INC.)



1 CD5 CROSSING – LAKE L9341 CENTERLINE CROSS–SECTION
TRANSECT 39 (DOC LCMF–156 CD5 BRIDGE TRANSECTS REV9)

0 100′ 200′

ConocoPhillips Alaska, Inc.

DATE:	10/16/2020	PROJECT:	178181
DRAWN:	DTR	FILE:	L9341 X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2020 SPRING BREAKUP
LAKE L9341
PROFILE

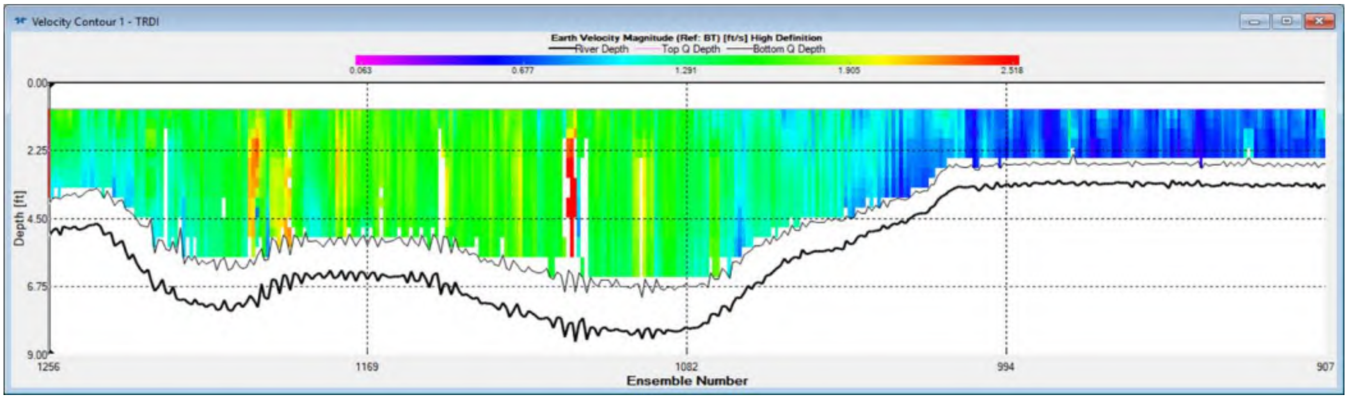
(SHEET 2 OF 2)

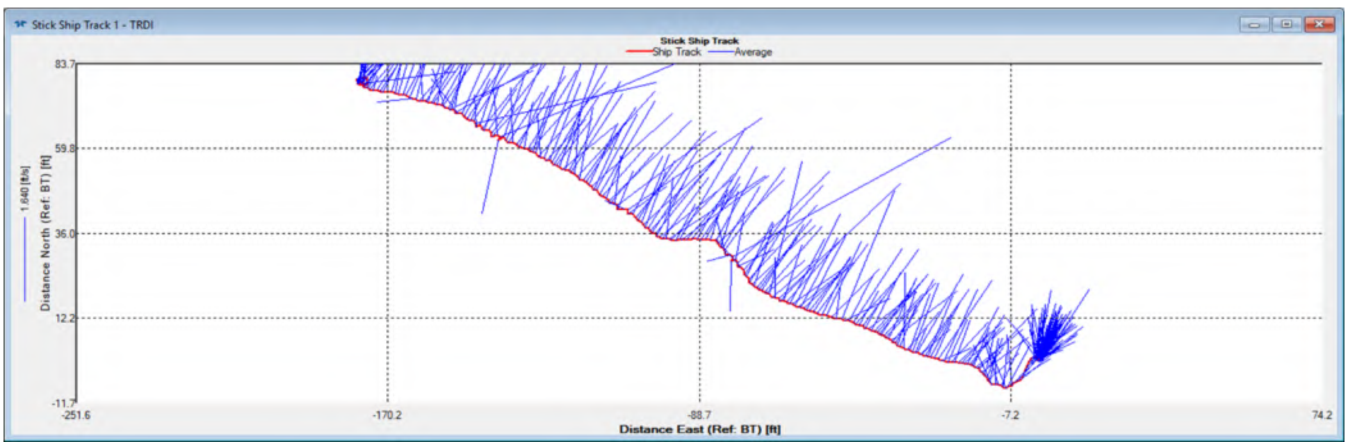
C.2.6 NIGLIAGVIK BRIDGE

1) MEASURED DISCHARGE

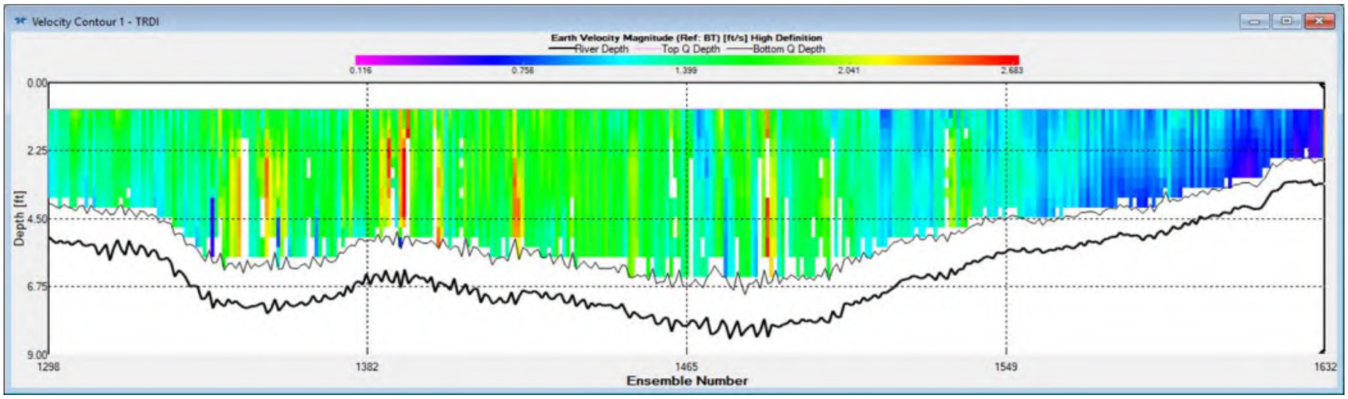
Transect	Area (ft^2)	Unadjusted Measured Discharge (cfs)	Discharge Correction Attributed to Moving Bed (cfs)	Adjusted Measured Discharge (cfs)	Error	Average Velocity (ft/s)
Downstream000 at 13:44	1385	1,718	N/A	N/A	0.00%	1.24
Downstream001 at 13:49	841	1,695	N/A	N/A	-1.37%	2.02
Downstream002 at 13:53	1365	1,753	N/A	N/A	2.02%	1.28
Downstream003 at 13:56	1154	1,707	N/A	N/A	-0.65%	1.48
Average	**1,186**	**1,718**	**--**	**--**	**--**	**1.51**

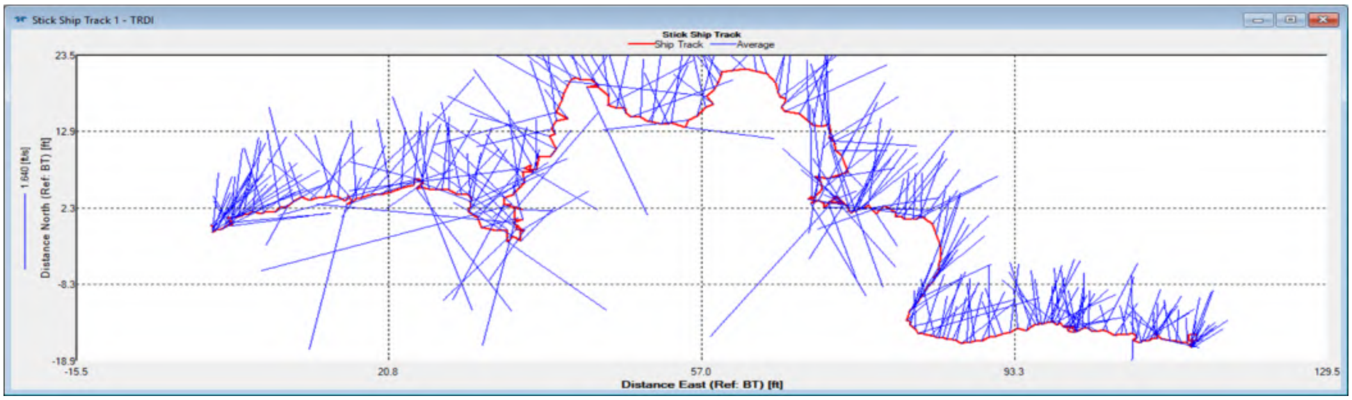
E. TRANSECT 000 RAW DATA OUTPUT



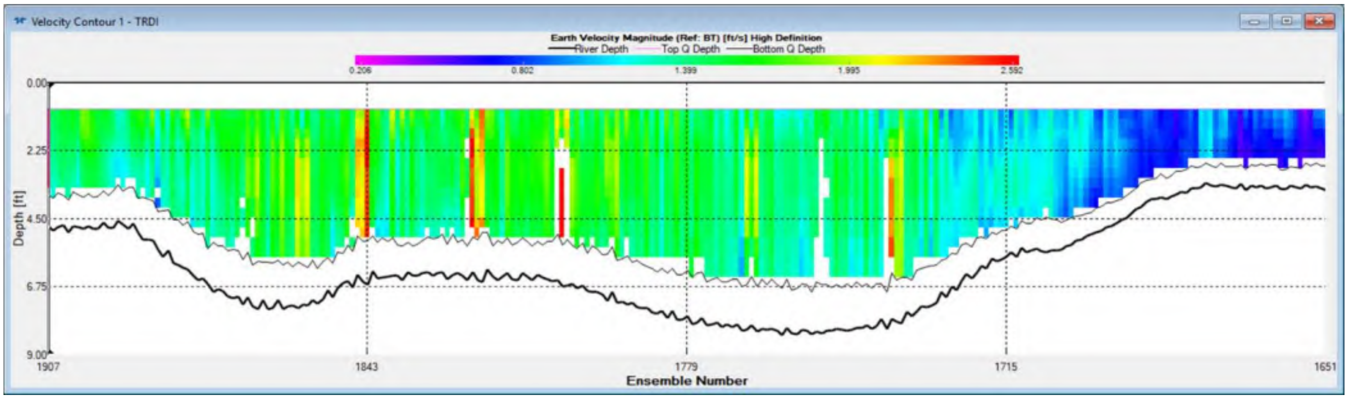


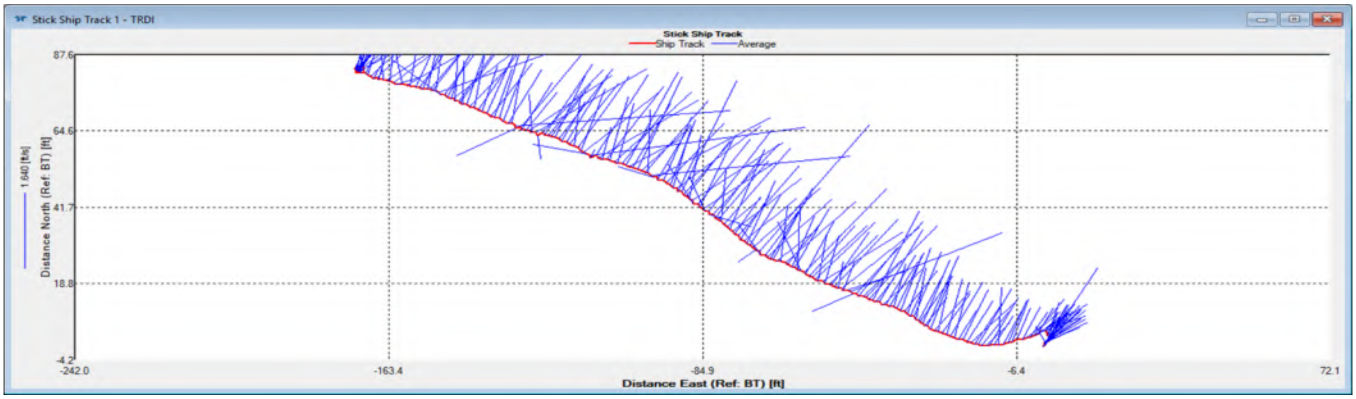
F. TRANSECT 001 RAW DATA OUTPUT



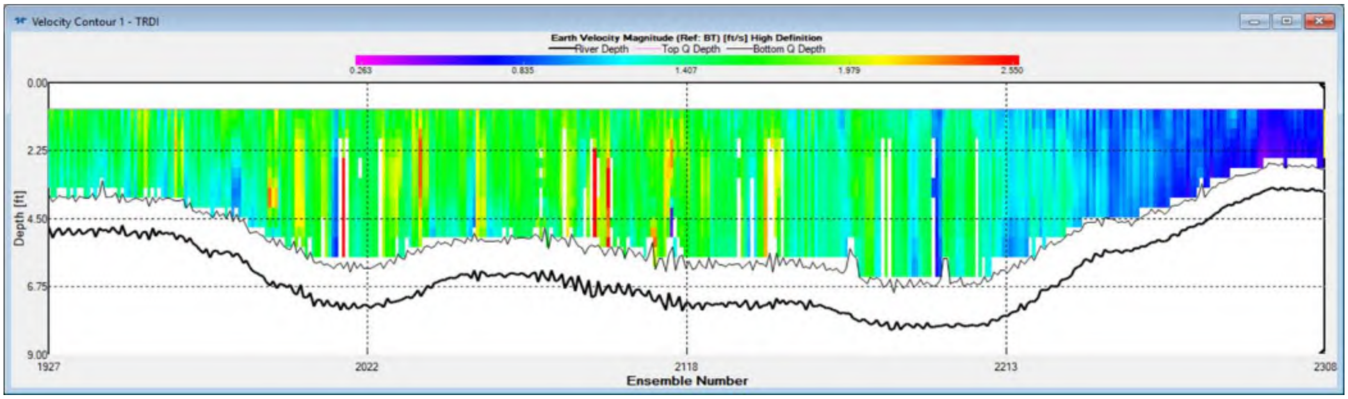


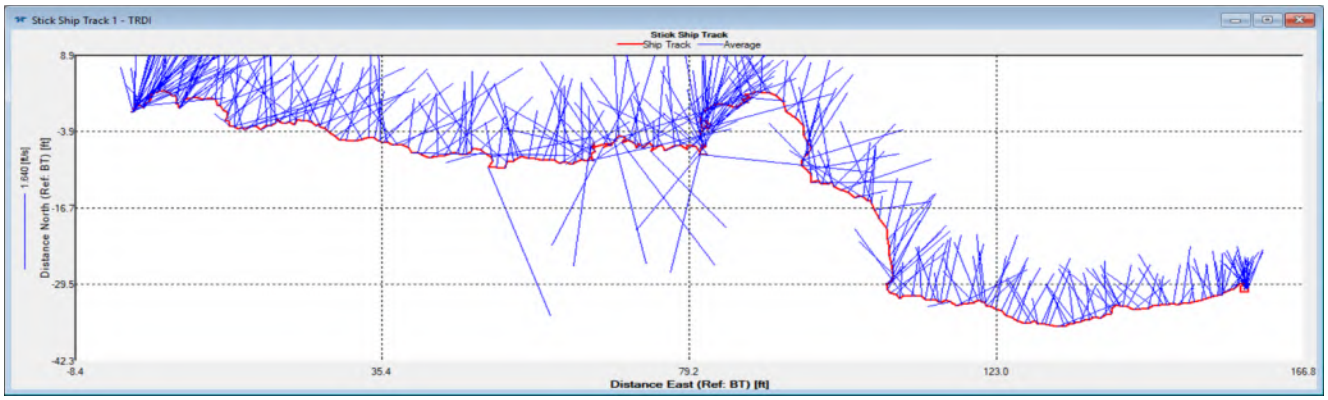
G. TRANSECT 002 RAW DATA OUTPUT





H. TRANSECT 003 RAW DATA OUTPUT

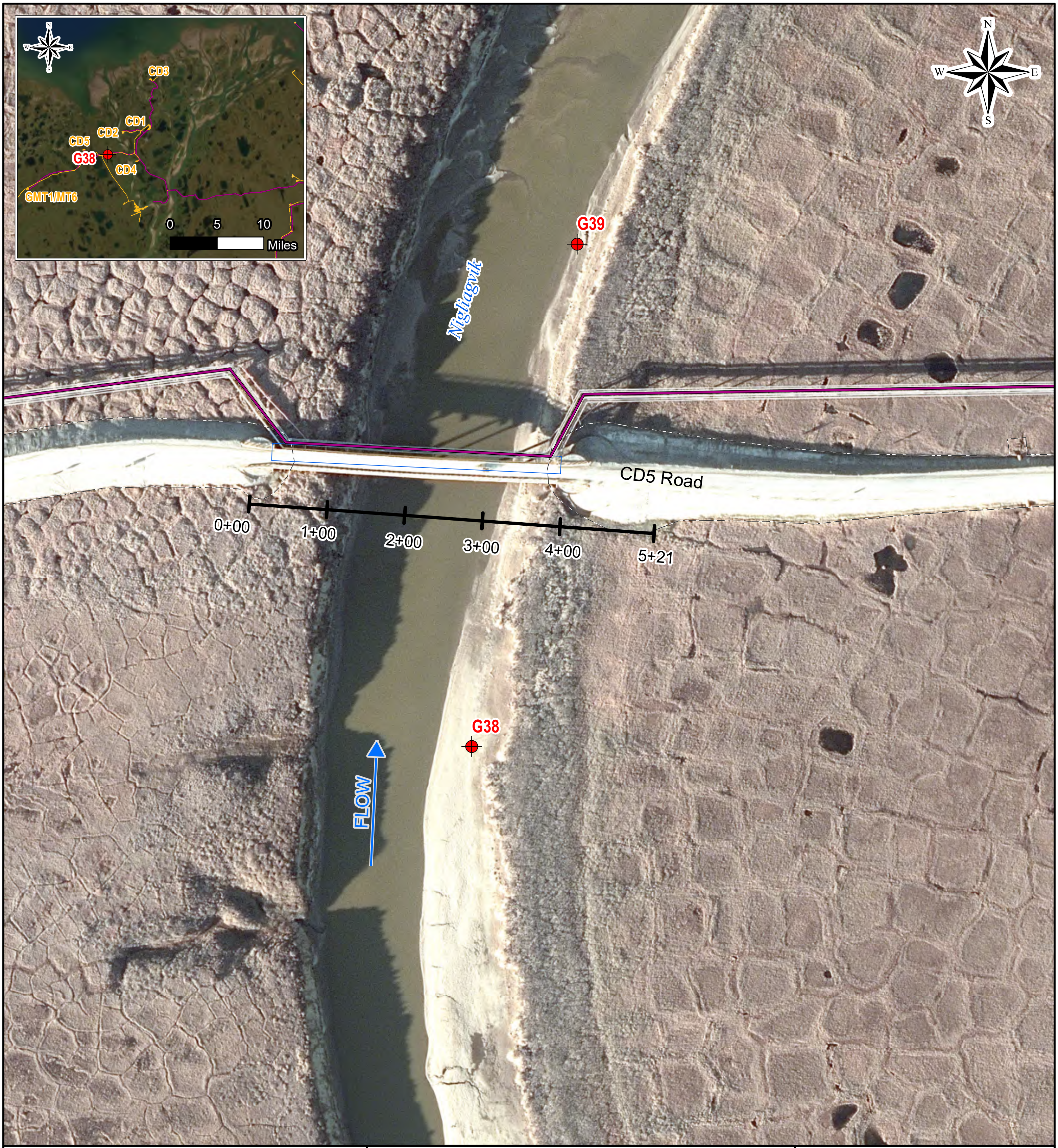




1) PEAK DISCHARGE DATA

Peak discharge was calculated using the width contraction method. The channel geometry applied in the Width Contraction calculation was from Transect 27 surveyed for the *Monitoring Plan with an Adaptive Management Strategy* July 2019. The slope used in the width contraction calculation was based on WSE's at G38 and G39 PT. Manning's n roughness value used was 0.025.

2) PLAN & PROFILE



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Date:	10/27/2020	Scale:	1 Inch = 166.7 feet
Drawn:	JEM	Project:	178181
Checked:	GCY	File:	Nigliagvik.mxd

Feet
0 100 200 300

Gage Location
Flow Direction
Cross Section Alignment
Pipeline
Road Shoulder
Bridge Deck
Facility

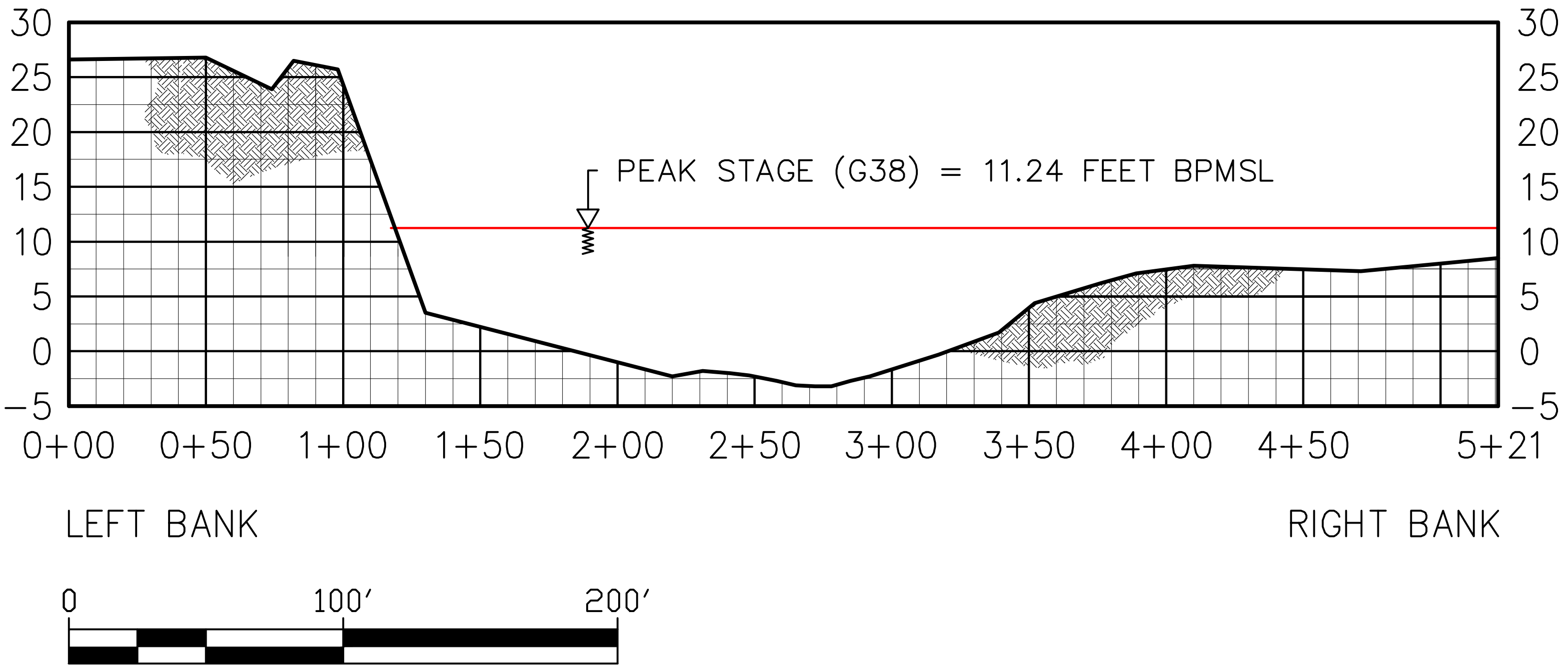
Imagery from CPAI 2019

ConocoPhillips
Alaska

2020 SPRING BREAKUP
COLVILLE RIVER DELTA
Nigliagvik Channel
Plan View

FIGURE C.2.4 | Sheet 1 of 2

NOTES
1. BASIS OF ELEVATION, MONUMENT 29.
2. CHANNEL PROFILE MEASUREMENTS COMPLETED JULY 2019 BY UMIAQ (KUUKPIK/LCMF INC.)



1 CD5 CROSSING – NIGLIAGVIK CENTERLINE CROSS-SECTION
TRANSECT 27 (DOC LCMF-156 CD5 BRIDGE TRANSECTS REV9)

ConocoPhillips Alaska, Inc.

DATE: 10/16/2020	PROJECT: 178181
DRAWN: DTR	FILE: NIGLIAGVIK X-SECTION.DWG
CHECKED: GCY	SCALE: AS SHOWN

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2020 SPRING BREAKUP
NIGLIAGVIK CHANNEL
TRANSECT 27 PROFILE

(SHEET 2 OF 2)

C.2.7 LONG SWALE BRIDGE

1) MEASURED DISCHARGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 30, 2020
Computed By: SAO
Checked By: HLR

Location Name: Long Swale Bridge

Party: GCY, SAO   Start: 11:10 AM   Finish: 2:10 PM

Temp: 32 °F   Weather: Sunny, 20 mph wind (East)

Channel Characteristics:

Width: 445 ft   Area: 3602 sq ft   Velocity: 0.59 fps   Discharge: 2131 cfs

Method: Mid-section technique   Number of Sections: 32   Count: varies

Spin Test: Spin Stopped @ 1:50 minutes after seconds   Meter: Price AA

GAGE READINGS			
Gage	Start	Finish	Change
G3	8.20	7.57	-0.63
G4	8.05	7.60	-0.45

Meter: 0.94 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data:

Left Edge of Water: West bridge abutment   LE Floodplain: ° ' . "

Right Edge of Water: Right bridge abutment   RE Floodplain: ° ' . "

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

Descriptions:

Cross Section: Bridge opening

Flow: Unobstructed, wind affected on surface

Remarks: Clear of snow and ice, no snow berms

Long Swale Bridge
May 30, 2020

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)
-	0	-	-	-	-	-	-	-	-	-	-
0.9	3	4.0	5.0	4 1	15 10	45 48	0.76 0.47	0.61	0.55	20.0	11.0
0.92	5	3.5	4.5	2.7	25	50	1.12	1.12	1.03	15.8	16.2
0.94	10	7.5	4.8	2.8	25	48	1.17	1.17	1.10	36.0	39.6
0.96	20	10.0	4.5	2.7	30	48	1.40	1.40	1.34	45.0	60.3
0.97	30	10.0	5.1	4.1 1	20 25	43 42	1.04 1.33	1.19	1.15	51.0	58.7
0.98	40	15.0	4.6	2.8	25	50	1.12	1.12	1.10	69.0	75.7
0.98	60	20.0	5.8	4.6 1.2	15 20	51 41	0.67 1.09	0.88	0.86	116.0	100.0
0.98	80	20.0	5.0	4 1	15 20	42 41	0.81 1.09	0.95	0.93	100.0	93.0
0.99	100	20.0	4.8	2.8	15	45	0.76	0.76	0.75	96.0	71.6
0.99	120	20.0	6.3	5 1.3	15 20	55 46	0.62 0.98	0.80	0.79	126.0	99.5
1	140	20.0	6.2	5 1.2	15 15	62 41	0.55 0.82	0.69	0.69	124.0	85.3
1	160	20.0	6.3	5 1.3	10 15	44 45	0.52 0.76	0.64	0.64	126.0	80.1
1	180	20.0	7.0	5.6 1.4	10 15	60 44	0.38 0.77	0.58	0.58	140.0	80.8
1	200	15.0	6.7	5.4 1.3	10 15	53 45	0.43 0.76	0.59	0.59	100.5	59.6
1	210	10.0	7.6	6.1 1.5	10 15	61 48	0.38 0.74	0.56	0.56	76.0	42.4
1	220	10.0	12.8	10.2 2.6	3 15	203 54	0.06 0.63	0.34	0.34	128.0	43.6
1	230	10.0	18.2	14.6 3.6	0 10	- 43	 0.53	0.53	0.53	182.0	96.6
1	240	15.0	20.1	16.1 4	2 10	360 44	0.03 0.52	0.27	0.27	301.5	82.8
1	260	20.0	22.0	17.6 4.4	2 15	277 43	0.03 0.79	0.41	0.41	440.0	180.5
1	280	20.0	15.4	12.3 3.1	10 20	68 44	0.34 1.02	0.68	0.68	308.0	209.6
1	300	20.0	8.2	6.6 1.6	15 20	49 52	0.69 0.87	0.78	0.78	164.0	127.8
1	320	20.0	7.1	5.7 1.4	15 15	55 41	0.62 0.82	0.72	0.72	142.0	102.5
0.99	340	20.0	6.3	5 1.3	15 15	53 48	0.64 0.71	0.67	0.67	126.0	84.1
0.99	360	20.0	7.4	5.9 1.5	15 15	58 57	0.61 0.60	0.60	0.60	148.0	88.4
0.98	380	20.0	6.4	5.1 1.3	10 10	48 48	0.50 0.50	0.50	0.49	128.0	62.4
0.98	400	20.0	6.5	5.2 1.3	10 10	54 54	0.43 0.43	0.43	0.42	130.0	54.3
0.98	420	15.0	5.7	4.6 1.1	3 5	74 58	0.11 0.21	0.16	0.16	85.5	13.2
0.98	430	10.0	4.5	2.7	5	64	0.19	0.19	0.19	45.0	8.4
0.98	440	6.5	5.1	4.1 1	2 3	210 50	0.04 0.16	0.09	0.09	33.2	3.1
0.96	443	3.5	5.6	4.5 1.1	0 0	- -	-	-	-	-	-
-	445	-	-	-	-	-	-	-	-	-	-

Total Discharge: 2131 cfs

C.2.8 SHORT SWALE BRIDGE

1) MEASURED DISCHARGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: May 29, 2020
Computed By: SAO
Checked By: HLR

Location Name: Short Swale Bridge

Party: KDB, WAB   Start: 2:20 PM   Finish: 3:55 PM

Temp: 35 °F   Weather: Sunny/clear, light wind

Channel Characteristics:

Width: 55 ft   Area: 476 sq ft   Velocity: 5.17 fps   Discharge: 2460 cfs

Method: Mid-section technique   Number of Sections: 22   Count: varies

Spin Test: minutes after seconds   Meter: Price AA

GAGE READINGS			
Gage	Start	Finish	Change
G3	9.77	10.07	0.30
G4	9.03	9.20	0.17

Meter: 0.8 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data:
Left Edge of Water: West bridge abutment
Right Edge of Water: Right bridge abutment

LE Floodplain: ° ' . "
RE Floodplain: ° ' . "

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

Descriptions:

Cross Section: Edges of flow extend far beyond bridge abutments, area completely inudated

Flow: Grounded ice at two locations upstream of bridge in vicinity of west abutment

Remarks: True revolution count = written x5 (velocity too fast for 1 rev = 1 click setting)

Short Swale Bridge
May 29, 2020

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)
-	0	-	-	-	-	-	-	-	-	-	-
0.75	2.5	3.8	6.4	5.1 1.3	80 85	44 43	4.03 4.38	4.20	3.15	24.0	75.6
0.94	5	2.5	6.8	5.4 1.4	120 95	42 43	6.32 4.89	5.60	5.27	17.0	89.6
0.98	7.5	2.5	7.2	5.8 1.4	115 115	40 40	6.38 6.38	6.38	6.23	18.0	112.1
0.99	10	2.5	7.4	5.9 1.5	125 120	43 43	6.43 6.17	6.30	6.24	18.5	115.4
0.99	12.5	2.5	8.1	6.5 1.6	115 120	45 44	5.65 6.03	5.84	5.78	20.3	117.1
1	15	2.5	8.3	6.6 1.7	120 110	45 41	5.90 5.93	5.92	5.92	20.8	122.7
1	17.5	2.5	8.3	6.6 1.7	100 115	42 43	5.27 5.91	5.59	5.59	20.8	116.0
1	20	2.5	8.2	6.6 1.6	90 110	42 41	4.74 5.93	5.34	5.34	20.5	109.4
1	22.5	2.5	8.9	7.1 1.8	100 115	44 43	5.03 5.91	5.47	5.47	22.3	121.7
1	25	2.5	9.2	7.4 1.8	100 100	44 43	5.03 5.16	5.09	5.09	23.0	117.0
1	27.5	2.5	9.0	7.2 1.8	85 90	41 41	4.59 4.86	4.72	4.72	22.5	106.3
1	30	2.5	9.1	7.3 1.8	95 90	45 41	4.67 4.86	4.76	4.76	22.8	108.4
1	32.5	2.5	10.2	8.2 2	100 100	42 46	5.27 4.81	5.04	5.04	25.5	128.6
1	35	2.5	10.5	8.4 2.1	110 95	46 41	5.29 5.13	5.21	5.21	26.3	136.7
1	37.5	2.5	10.5	8.4 2.1	95 90	41 40	5.13 4.98	5.06	5.06	26.3	132.8
1	40	2.5	10.4	8.3 2.1	100 100	45 44	4.92 5.03	4.97	4.97	26.0	129.3
1	42.5	2.5	10.0	8 2	90 100	41 43	4.86 5.16	5.00	5.00	25.0	125.0
1	45	2.5	9.9	7.9 2	100 95	44 43	5.03 4.89	4.96	4.96	24.8	122.7
0.99	47.5	2.5	9.8	7.8 2	95 100	40 40	5.25 5.53	5.39	5.34	24.5	130.8
0.98	50	2.5	9.3	7.4 1.9	75 110	42 45	3.96 5.41	4.68	4.59	23.3	106.7
0.97	52.5	2.0	6.6	5.3 1.3	105 105	41 40	5.65 5.81	5.73	5.56	13.2	73.4
0.95	54	1.8	6.4	5.1 1.3	110 110	41 42	5.93 5.79	5.86	5.57	11.2	62.4
-	56	-	-	-	-	-	-	-	-	-	-

Total Discharge: 2460 cfs

C.2.9 TINMIAQSIUGVIK BRIDGE

1) MEASURED DISCHARGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: June 1, 2020
Computed By: SAO
Checked By: HLR

Location Name: Tinmiaqsiugvik Bridge

Party: SAO, KDB   Start: 11:20 AM   Finish: 12:50 PM

Temp: 35 °F   Weather: Sunny 20-30 mph wind

Channel Characteristics:

Width: 252 ft   Area: 1140 sq ft   Velocity: 1.5 fps   Discharge: 1737 cfs

Method: Mid-section technique   Number of Sections: 25   Count: varies

Spin Test: 1 minutes and 50 seconds   Meter: Price AA

GAGE READINGS			
Gage	Start	Finish	Change
UB6.7-C	1.53	1.45	-0.08
UB6.9-B	3.10	3.02	-0.08
UB6.9-C	0.41	0.33	-0.08

Meter: 0.94 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data:
Left Edge of Water: West bridge abutment
Right Edge of Water: East bridge abutment

LE Floodplain: ° ' . "
RE Floodplain: ° ' . "

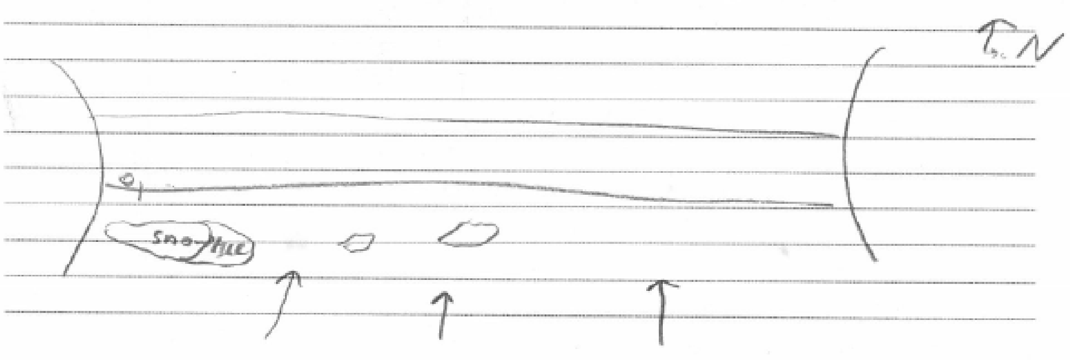
Measurement Rated: Excellent **Good** Fair Poor based on "Descriptions"

Descriptions:

Cross Section: Bridge opening

Flow:

Remarks: Snow and ice berm on LEW



Tin Bridge
June 1, 2020

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)
1	0	saturated snow berm at LEW									
1	20										
1	40										
1	60	ineffective flow influenced by saturated snow berm on LEW									
1	65	15.0	2.8	1.7	3	51	0.1	0.1	0.1	42.0	6.2
1	75	22.5	1.7	1.0	7	52	0.3	0.3	0.3	38.3	12.0
1	100	22.5	1.8	1.1	3	177	0.1	0.1	0.1	40.5	2.2
1	120	20.0	2.4	stagnant, weeds						48.0	0
1	140	25.0	2.7	stagnant, weeds						67.5	0
1	170	25.0	2.8	stagnant, weeds						70.0	0
1	180	15.0	4.3	2.6	7	48	0.3	0.3	0.3	64.5	21.5
1	200	10.0	5.8	4.6 1.2	25 35	48 43	1.1 1.8	1.5	1.5	58.0	86.7
1	210	10.0	6.8	5.4 1.4	25 35	43 41	1.3 1.9	1.6	1.6	68.0	108.8
1	220	10.0	7.2	5.8 1.4	35 45	41 41	1.9 2.4	2.2	2.2	72.0	158.2
1	230	7.5	7.4	5.9 1.5	40 55	47 48	1.9 2.7	2.3	2.3	55.5	128.2
1	235	5.0	7.4	5.9 1.5	40 55	45 43	2.0 2.8	2.4	2.4	37.0	89.1
1	240	5.0	7.4	5.9 1.5	45 55	44 43	2.3 2.8	2.6	2.6	37.0	94.5
1	245	5.0	7.5	6.0 1.5	40 60	48 48	1.9 2.8	2.4	2.4	37.5	88.3
1	250	5.0	7.3	5.8 1.5	45 60	45 45	2.2 3.0	2.6	2.6	36.5	94.5
1	255	5.0	7.7	6.2 1.5	50 60	48 47	2.4 2.8	2.6	2.6	38.5	101.0
1	260	5.0	7.7	6.2 1.5	45 60	40 44	2.5 3.0	2.8	2.8	38.5	106.3
1	265	5.0	7.8	6.2 1.6	40 60	43 43	2.1 3.1	2.6	2.6	39.0	100.7
1	270	5.0	7.7	6.2 1.5	50 60	48 42	2.4 3.2	2.8	2.8	38.5	107.5
1	275	5.0	7.3	5.8 1.5	45 60	41 44	2.4 3.0	2.7	2.7	36.5	99.7
1	280	5.0	6.9	5.5 1.4	50 65	44 30	2.5 4.8	3.7	3.7	34.5	128.2
0.99	285	5.0	6.7	5.4 1.3	50 55	47 45	2.4 2.7	2.5	2.5	33.5	84.2
0.94	290	5.0	7.8	6.2 1.6	25 45	43 41	1.3 2.4	1.9	1.8	39.0	68.5
0.9	295	5.0	7.6	6.1 1.5	25 25	50 47	1.1 1.2	1.2	1.0	38.0	39.6
0.85	300	4.5	7.1	5.7 1.4	15 15	44 56	0.8 0.6	0.7	0.6	32.0	18.7
-	302	-	-	-	-	-	-	-	-	-	-

Total Discharge: 1737 cfs

C.2.10 CULVERTS

1) **MEASURED DISCHARGE**

Date	Time	Culvert ID	Flow Conditions	Flow Direction	Total Depth (ft)	Measured Depth (ft)	v1 (ft/s)	v2 (ft/s)	v3 (ft/s)	Upstream Gage	Upstream WSE (ft BPMSL)	Downstream Gage	Downstream WSE (ft BPMSL)	Notes
5/28/2020	10:00	CD2-01	Free Flowing	South to North	2.20	0.88	5.23	5.05	5.15	G6	8.95	G7	3.36	Inlet 85 – 95%, Outlet 40% full
5/28/2020	10:05	CD2-02	Free Flowing	South to North	2.30	0.92	4.77	5.13	5.16	G6	8.95	G7	3.36	Inlet 90%, outlet 60% full
5/28/2020	10:11	CD2-03	Free Flowing	South to North	2.70	1.08	4.33	4.29	4.41	G6	8.95	G7	3.36	Inlet 90%, Outlet 60% full
5/28/2020	10:22	CD2-04	Free Flowing	South to North	1.90	0.76	3.36	3.06	3.19	G6	8.95	G7	3.36	Submerged inlets, possible ice, outlets 90% full
5/28/2020	10:25	CD2-05	Free Flowing	South to North	3.00	1.20	4.03	3.85	3.83	G6	8.95	G7	3.36	Submerged inlets, outlets 90% full
5/28/2020	10:28	CD2-06	Free Flowing	South to North	3.00	1.20	4.09	4.02	3.96	G6	8.95	G7	3.36	Submerged inlets, outlets 90% full
5/28/2020	10:32	CD2-07	Free Flowing	South to North	3.10	1.24	4.03	3.92	3.89	G6	8.95	G7	3.36	Submerged inlets, outlets 90% full
5/28/2020	10:40	CD2-08	Free Flowing	South to North	2.60	1.04	5.05	5.04	5.00	G6	8.95	G7	3.36	Inlet 90%, Outlet 50%
5/28/2020	10:50	CD2-09	Free Flowing	South to North	1.70	0.68	4.76	4.67	4.90	G12	1.61	G13	2.36	Inlet 40%, Outlet 20%
5/28/2020	11:07	CD2-10	Free Flowing	South to North	2.40	0.96	4.72	4.70	4.63	G12	1.61	G13	2.36	Inlet 45%, Outlet 60%
5/28/2020	11:18	CD2-11	Free Flowing	South to North	2.30	0.92	4.43	4.39	4.24	G12	1.61	G13	2.36	Inlet 40%, Outlet 40%
5/28/2020	11:30	CD2-12	Free Flowing	South to North	2.40	0.96	4.13	4.17	4.16	G12	1.61	G13	2.36	Inlet 60%, Outlet 50%
5/28/2020	11:38	CD2-13	Free Flowing	South to North	2.60	1.04	3.53	3.49	3.48	G12	1.61	G13	2.36	Inlet 60%, Outlet 50%
5/28/2020	11:48	CD2-14	Free Flowing	South to North	2.60	1.04	3.95	3.88	3.85	G12	1.61	G13	2.36	Inlet 30%, Outlet 30%
5/28/2020	11:57	CD2-15	Free Flowing	South to North	2.00	0.80	4.51	4.50	4.59	G12	1.61	G13	2.36	Inlet 60%. Outlet 50%
5/28/2020	12:01	CD2-18	Free Flowing	South to North	1.00	0.40	1.73	1.73	1.72	G12	1.61	G13	2.36	Inlet 85%. Outlet 60%
5/28/2020	12:08	CD2-20	Free Flowing	South to North	2.20	0.88	4.29	4.28	4.24	G3	8.52	G4	8.14	Inlet 90%. Outlet 90%
5/28/2020	12:15	CD2-21	Free Flowing	South to North	3.00	1.20	3.18	3.11	3.17	G3	8.52	G4	8.14	Inlet submerged. Outlet 90%
5/28/2020	12:20	CD2-22	Free Flowing	South to North	3.10	1.24	3.70	3.67	3.71	G3	8.52	G4	8.14	Inlet submerged. Outlet 90%
5/28/2020	12:25	CD2-23	Free Flowing	South to North	3.60	1.44	3.09	3.03	3.04	G3	8.52	G4	8.14	Inlet 60%. Outlet 50%
5/28/2020	12:30	CD2-24	Free Flowing	South to North	3.90	1.56	2.68	2.65	2.63	G3	8.52	G4	8.14	Inlet 85%. Outlet 60%
5/29/2020	10:05	CD4-25	Overtopped	South to North	1.50	0.60	8.30	8.29	8.27	G18	13.32	G17	10.60	Ice @ bottom
5/29/2020	10:01	CD4-26	Overtopped	South to North	2.80	1.12	6.55	6.65	6.60	G18	13.32	G17	10.60	
5/29/2020	9:59	CD4-27	Overtopped	South to North	2.60	1.04	3.75	3.55	3.55	G18	13.32	G17	10.60	Ice @ bottom
5/29/2020	9:57	CD4-28	Overtopped	South to North	2.50	1.00	1.87	1.90	1.94	G18	13.32	G17	10.60	Inlet 5/5 full, outlet 3/5 full
5/29/2020	9:53	CD4-29	Overtopped	South to North	2.80	1.12	3.32	3.24	3.10	G18	13.32	G17	10.60	Ice potential at bottom, ice flowing through
5/29/2020	9:48	CD4-30	Overtopped	South to North	2.80	1.12	6.19	6.10	6.00	G18	13.32	G17	10.60	Ice potential at bottom, ice flowing through
5/29/2020	9:42	CD4-31	Overtopped	South to North	3.10	1.24	5.35	5.48	5.46	G18	13.32	G17	10.60	Ice potential at bottom, ice flowing through
5/29/2020	9:37	CD4-32	Overtopped	South to North	2.50	1.00	5.77	5.83	5.93	G18	13.32	G17	10.60	Inlet 5/5 full outlet 1/2 full
5/29/2020	15:11	CD5-35	Overtopped	North to South	4.00	1.60	2.47	2.48	2.52	G34		G35		
5/29/2020	15:34	CD5-42	Overtopped	North to South	3.00	1.20	1.27	1.27	1.32	G30		G31		

Note: Any culvert not listed was observed to either be stagnant or dry at the time of the discharge measurements

APPENDIX D ADDITIONAL PHOTOGRAPHS

D.1 EROSION SURVEY

D.1.1 CD2 ROADS

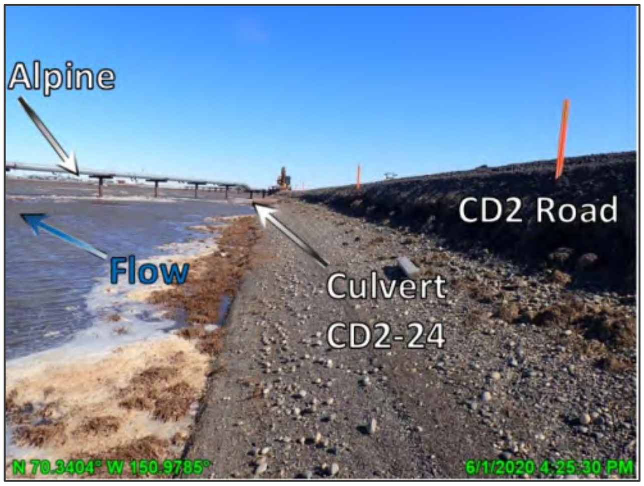


Photo D.1: CD2 road embankment near long swale bridge NE abutment, looking east; June 1, 2020

Photo D.2: CD2 road between long swale and short swale bridges, looking northeast; June 1, 2020

Photo D.3: CD2 road between long swale and short swale bridges, looking southeast; June 1, 2020

Photo D.4: CD2 road short swale bridge SW abutment, looking east; June 1, 2020

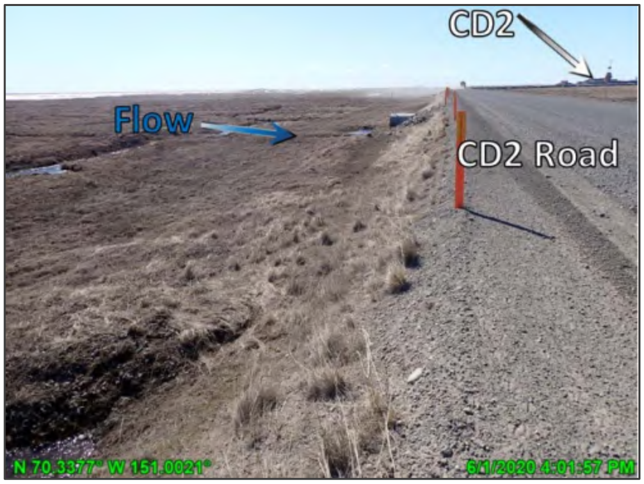


Photo D.5: Road in vicinity of culvert CD2-16S post-breakup, looking east; June 1, 2020

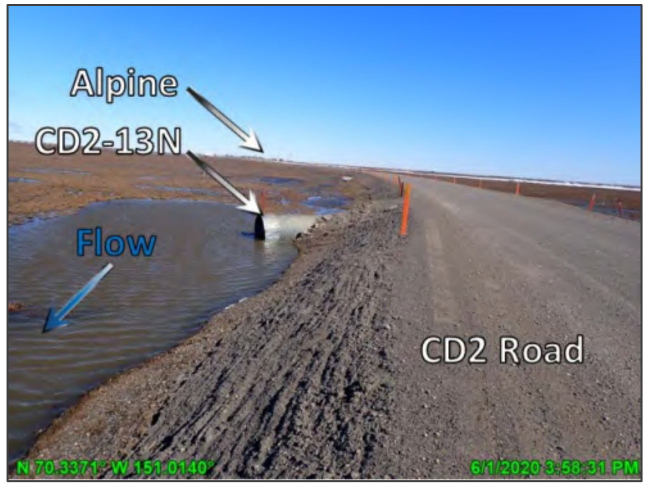


Photo D.6: Road in vicinity of culvert CD2-13N post-breakup, looking east; June 1, 2020

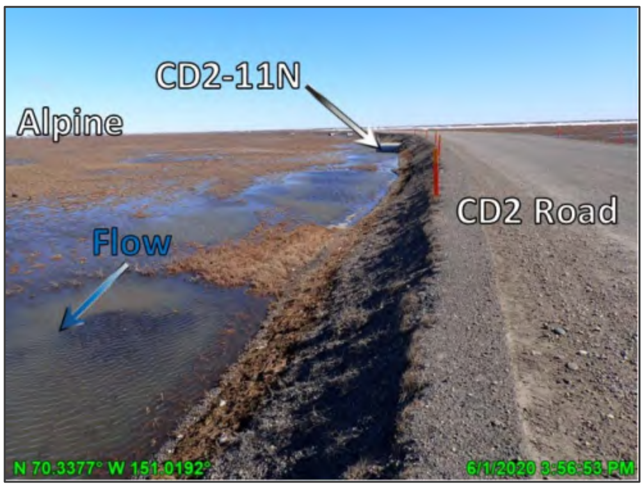


Photo D.7: Road in vicinity of culvert CD2-11N post-breakup, looking west; June 1, 2020

Photo D.8: Road in vicinity of culvert CD2-8S post-breakup, looking southwest; June 1, 2020

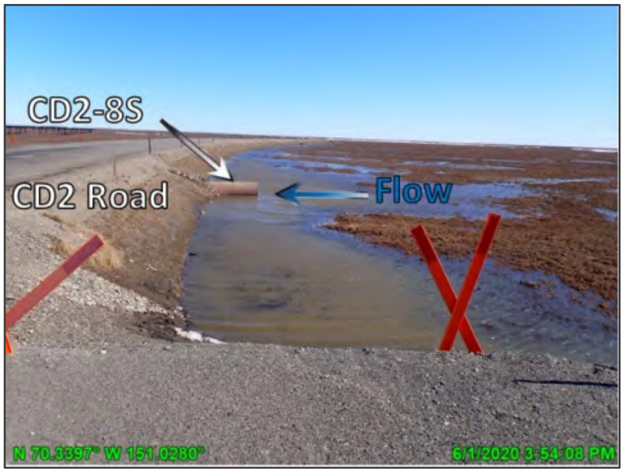


Photo D.9: Road in vicinity of culvert CD2-8S post-breakup, looking east; June 1, 2020

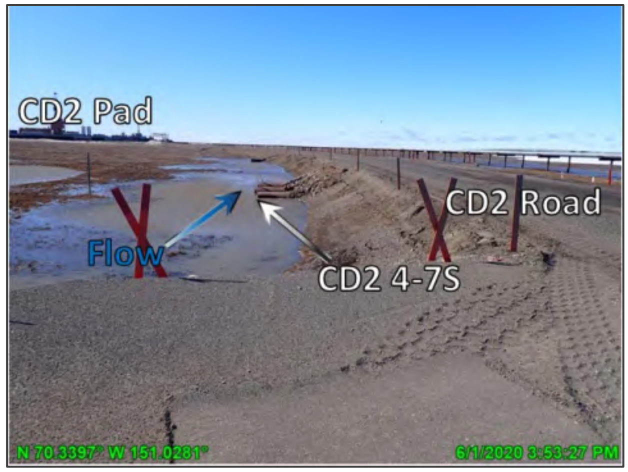


Photo D.10: Road in vicinity of culvert battery CD2-4-7S post-breakup, looking west; June 1, 2020

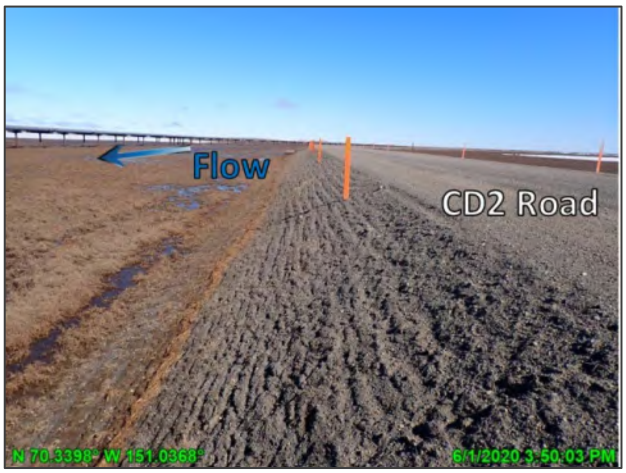


Photo D.11: Road in vicinity of culvert CD2-2N post-breakup, looking west; June 1, 2020

Photo D.12: Road in vicinity of culvert CD2-1S post-breakup, looking east; June 1, 2020

D.1.2 CD4 ROADS

Photo D.13: CD4 pad post-breakup, looking north; June 3, 2020

Photo D.14: CD4 road in vicinity of G18 culverts post-breakup, looking northeast; June 3, 2020

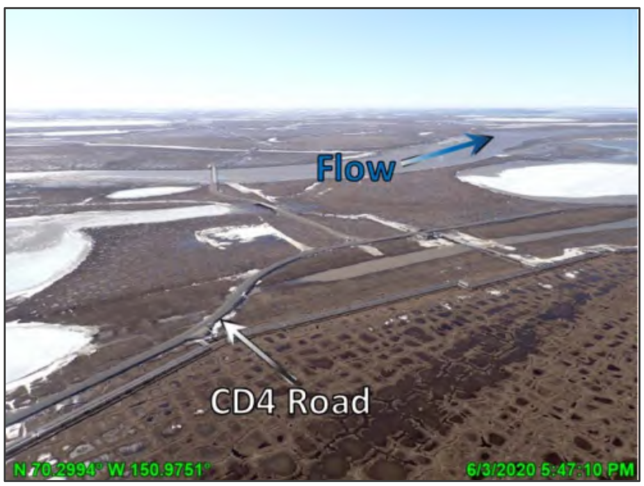


Photo D.15: CD4 road in vicinity of G15 culverts post-breakup, looking north; June 3, 2020

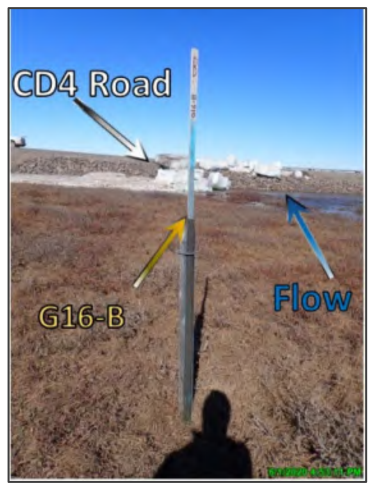


Photo D.16: CD4 road with stranded ice in vicinity of north CD4 culvert battery post-breakup, looking north; June 1, 2020

D.1.3 CD5 ROAD

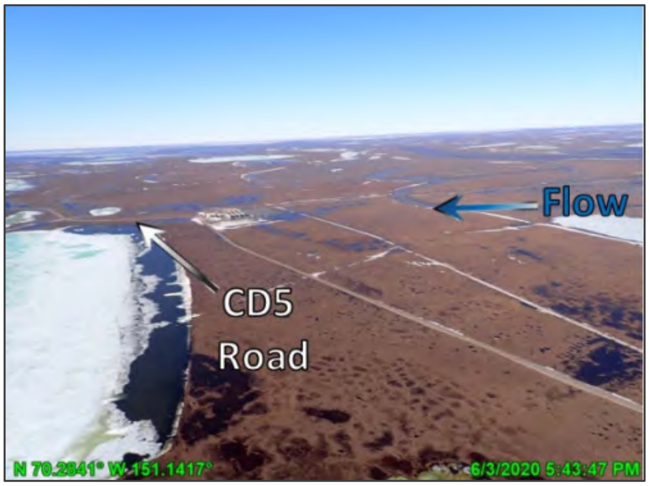


Photo D.17: CD5 road in the vicinity of K-Pad as breakup subsides, looking south; June 3, 2020

Photo D.18: CD5 road Lake L9341 Bridge as breakup subsides, looking North; June 3, 2020

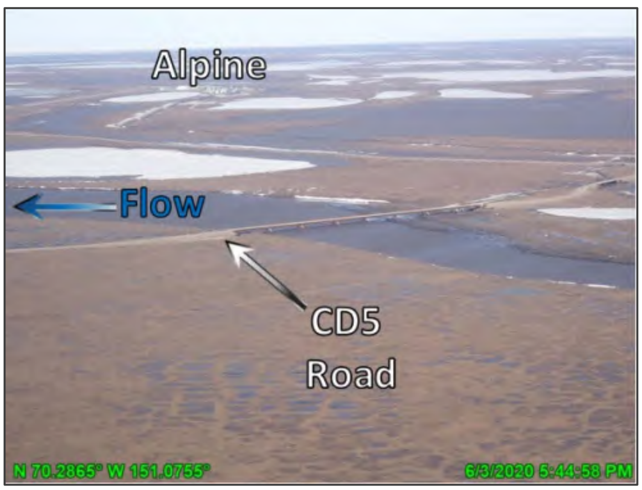


Photo D.19: CD5 road Nigliq Bridge #2 as breakup subsides, looking northeast; June 3, 2020

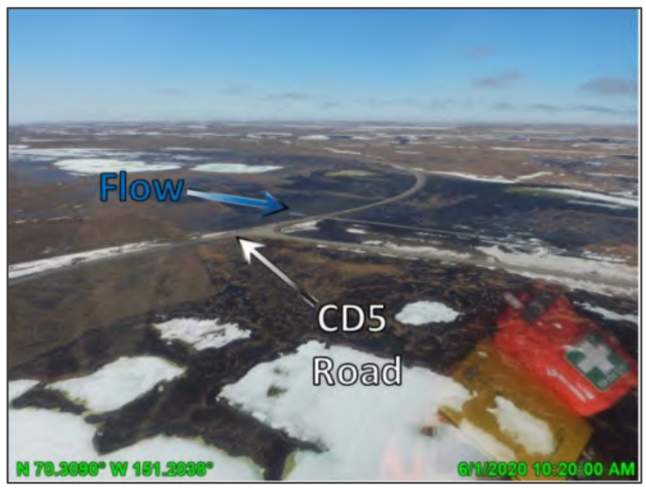


Photo D.20: CD5 road near conjunction with GMT1/MT6 road, looking east; June 1, 2020

Photo D.21: CD5 road near Nigliagvik Bridge post-breakup, looking north; June 1, 2020

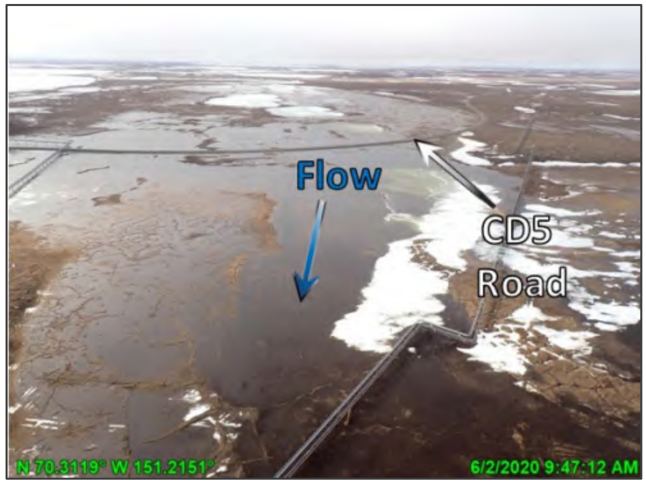


Photo D.22: CD5 road in vicinity conjunction with GMT-1 road, looking south; June 2, 2020

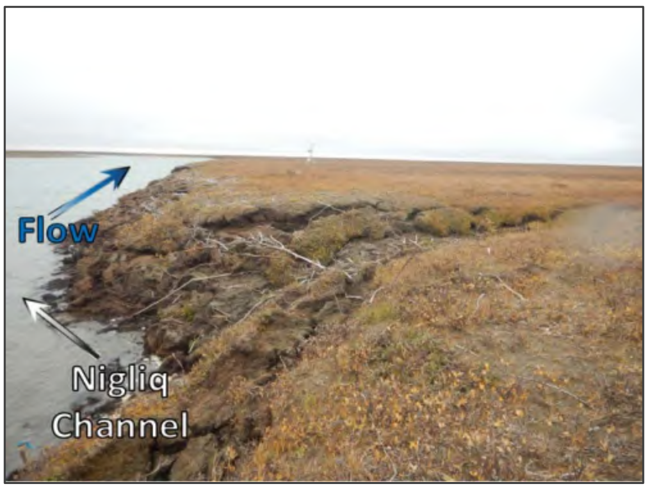


Photo D.23: East bank of Nigliq channel south of CD5 road during fall setup, looking south; September 7, 2020

Photo D.24: East bank of Nigliq channel north of CD5 road during fall setup, looking north; September 7, 2020

D.2 ICE ROAD CROSSINGS BREAKUP

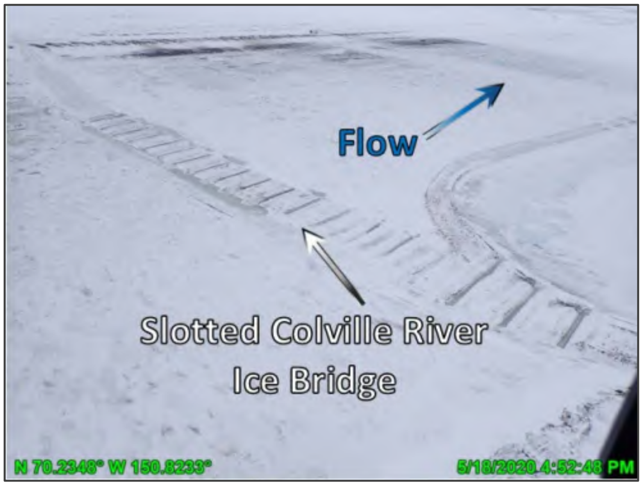


Photo D.25: Slotting through the Colville River Ice Bridge, looking northwest (downstream); May 18, 2020

Photo D.26: Initial flow through the slotted Colville River Ice Bridge, looking east; May 23, 2020

Photo D.27: Meltwater progression through the slotted Colville River Ice Bridge, looking north (downstream); May 26, 2020

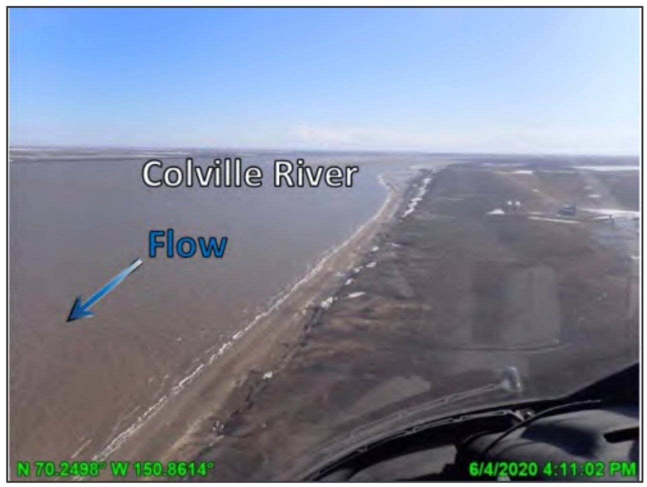


Photo D.28: Open channel at Colville River Ice Bridge, looking south (upstream); June 4, 2020

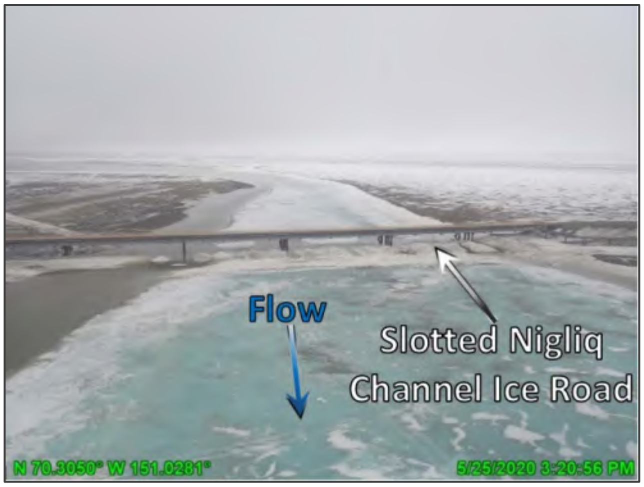


Photo D.29: Initial flow in slotted Nigliq Channel ice road, looking south; May 25, 2020

Photo D.30: Peak stage near the Nigliq Channel ice road, looking east; May 29, 2020

Photo D.31: Pre-breakup near the L9323 ice road crossing-south, looking northwest, May 16, 2020

Photo D.32: Pre-breakup near the L9323 ice road crossing-north, looking northwest; May 16, 2020

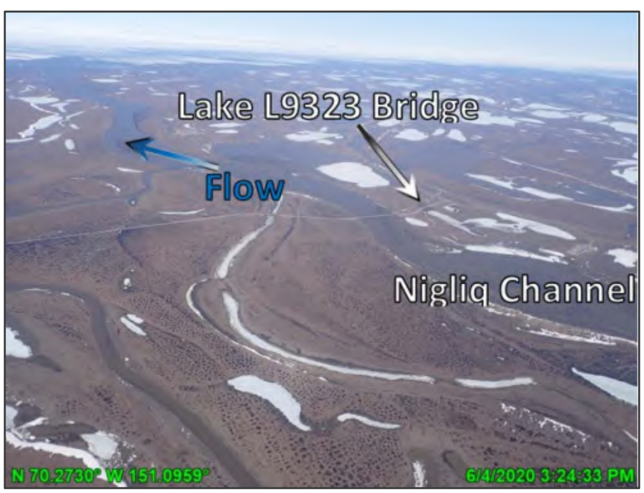


Photo D.33: Post-breakup conditions at Nigliq and Lake L9323 ice road crossings; June 4, 2020

Photo D.34: Pre-breakup conditions at the Nigliagvik ice road crossing, looking south (upstream); May 17, 2020

Photo D.35: Meltwater progression at the Nigliagvik ice road crossing, looking east; May 27, 2020

Photo D.36: Post-breakup conditions at the Nigliagvik ice road crossing, looking southwest (upstream); June 1, 2020

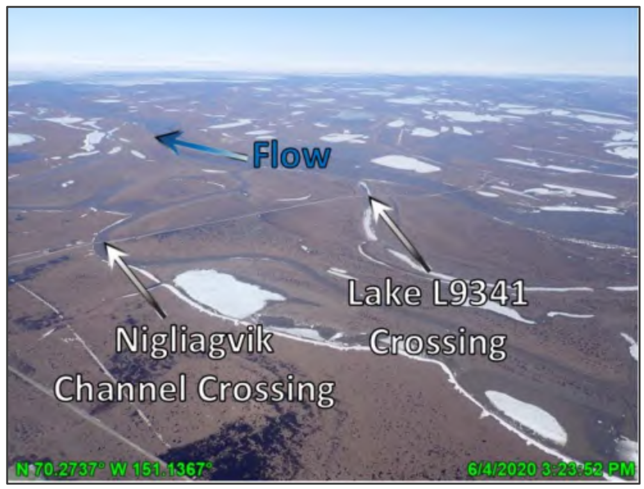


Photo D.37: Post-breakup conditions at the Nigliagvik and Lake L9341 ice road crossings, looking north (downstream); June 4, 2020

Photo D.38: Pre-breakup conditions at the multi-season ice pad north of K-pad, looking southwest; May 17, 2020

Photo D.39: Post-breakup conditions at the multi-season ice pad north of K-pad, looking west; June 1, 2020

Photo D.40: Pre-breakup conditions at the slotted Kachemach ice road crossing, looking east; May 14, 2020

Photo D.41: Peak stage near the slotted Kachemach ice road crossing, looking south (upstream); May 31, 2020

Photo D.42: Pre-breakup conditions at the slotted Silas Slough ice road crosing, looking west; May 16, 2020

Photo D.43: Peak stage near the slotted Silas Slough ice road crossing, looking southwest; May 28, 2020

Photo D.44: Post-breakup conditions at the Silas Slough ice road crossing, looking west; May 29, 2020

Photo D.45: Pre-breakup conditions at the slotted Toolbox Creek ice road crossing, looking west (downstream); May 16, 2020

Photo D.46: Peak stage near the Toolbox Creek ice road crossing, looking south (upstream); May 31, 2020

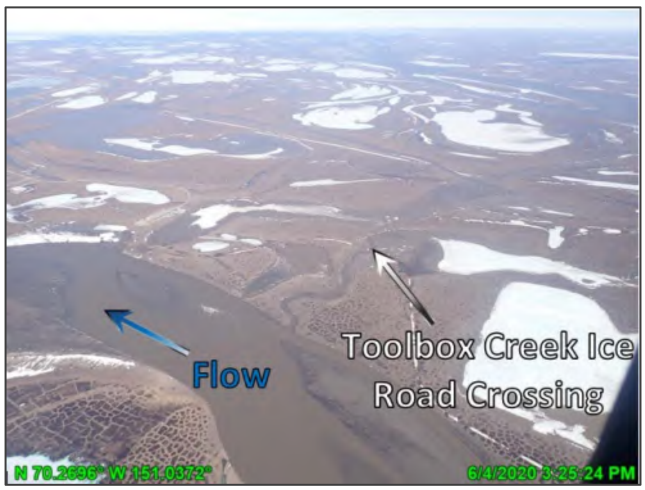


Photo D.47: Post-breakup conditions at the Toolbox Creek and Silas Slough ice road crossings, looking northeast; June 4, 2020

Photo D.48: Pre-breakup conditions at the slotted Slemp Slough ice road crossing, looking north; May 20, 2020

Photo D.49: Peak stage near the Slemp Slough ice road crossing, looking south; May 29, 2020

Photo D.50: Pre-breakup conditions at the slotted Tamayayak ice road crossing, looking east; May 20, 2020

Photo D.51: Peak stage near the slotted Tamayayak ice road crossing, looking southwest (upstream); May 29, 2020

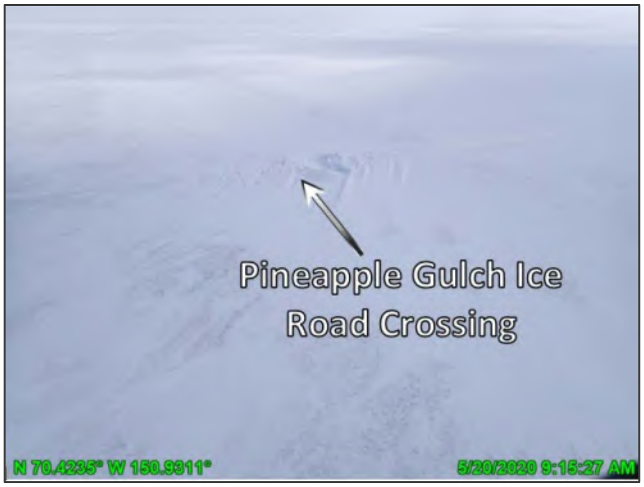


Photo D.52: Pre-breakup conditions at the slotted Pineapple Gulch (West Ulamnigiaq Channel) ice road crossing, looking east; May 20, 2020

Photo D.53: Peak stage near the Pineapple Gulch (West Ulamnigiaq Channel) ice road crossing, looking south (upstream); May 29, 2020

Photo D.54: Pre-breakup conditions at the slotted Crea Creek ice road crossing, looking south; May 17, 2020

Photo D.55: Pre-breakup conditions at the slotted Tinmiaqsiugvik Bypass ice road crossing, looking northwest; May 17, 2020

Photo D.56: Peak stage near the Tinmiaqsiugvik Bypass ice road crossing, looking east; May 31, 2020

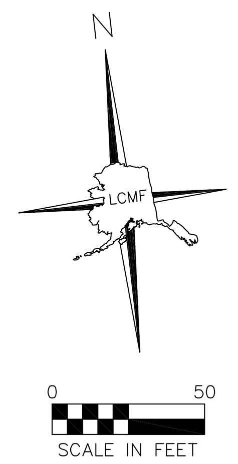
Photo D.57: Post-breakup conditions at the Tinmiaqsiugvik Bypass ice road crossing, looking northeast; May 20, 2020

APPENDIX E CD5 PIER SCOUR, BANK EROSION, & BATHYMETRY

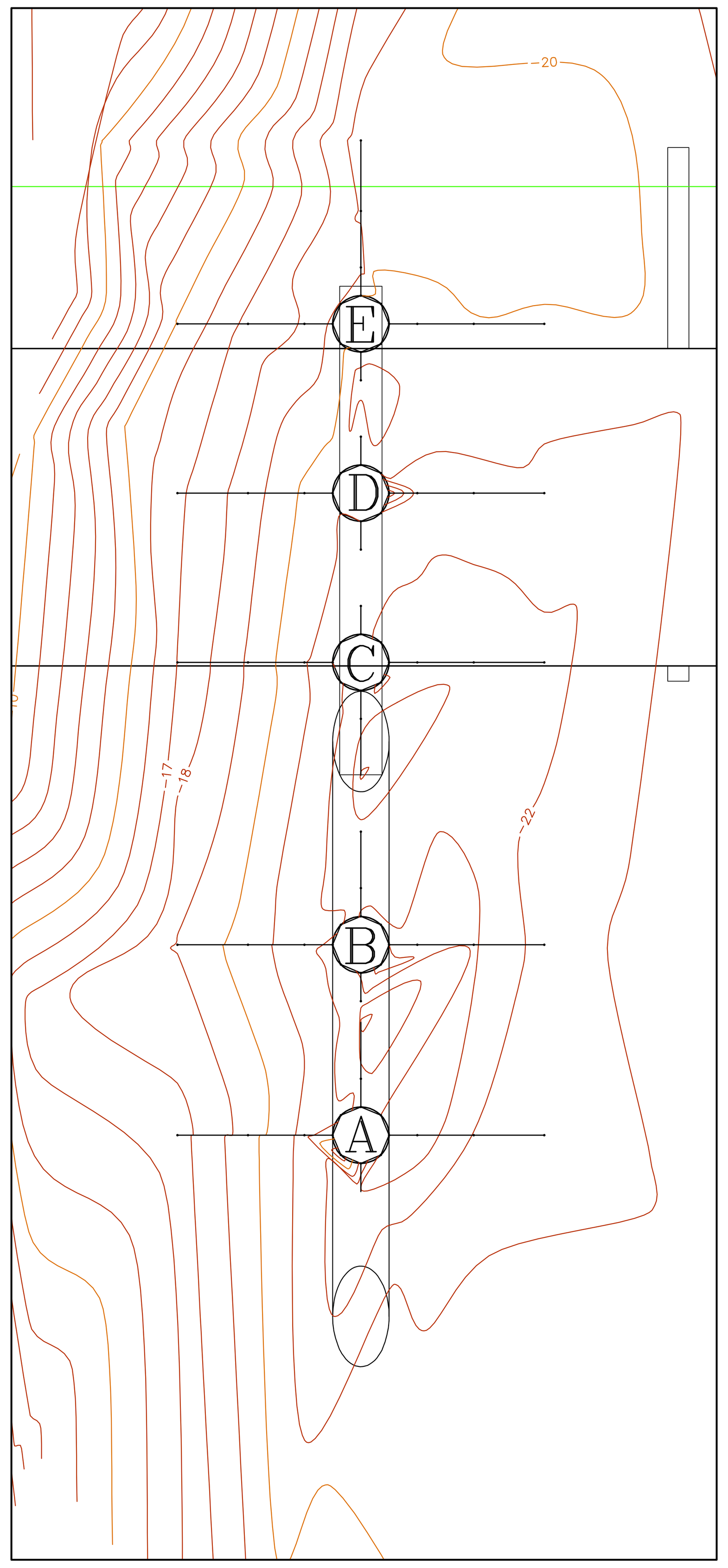
E.1 PIER SCOUR

E.1.1 NIGLIQ BRIDGE

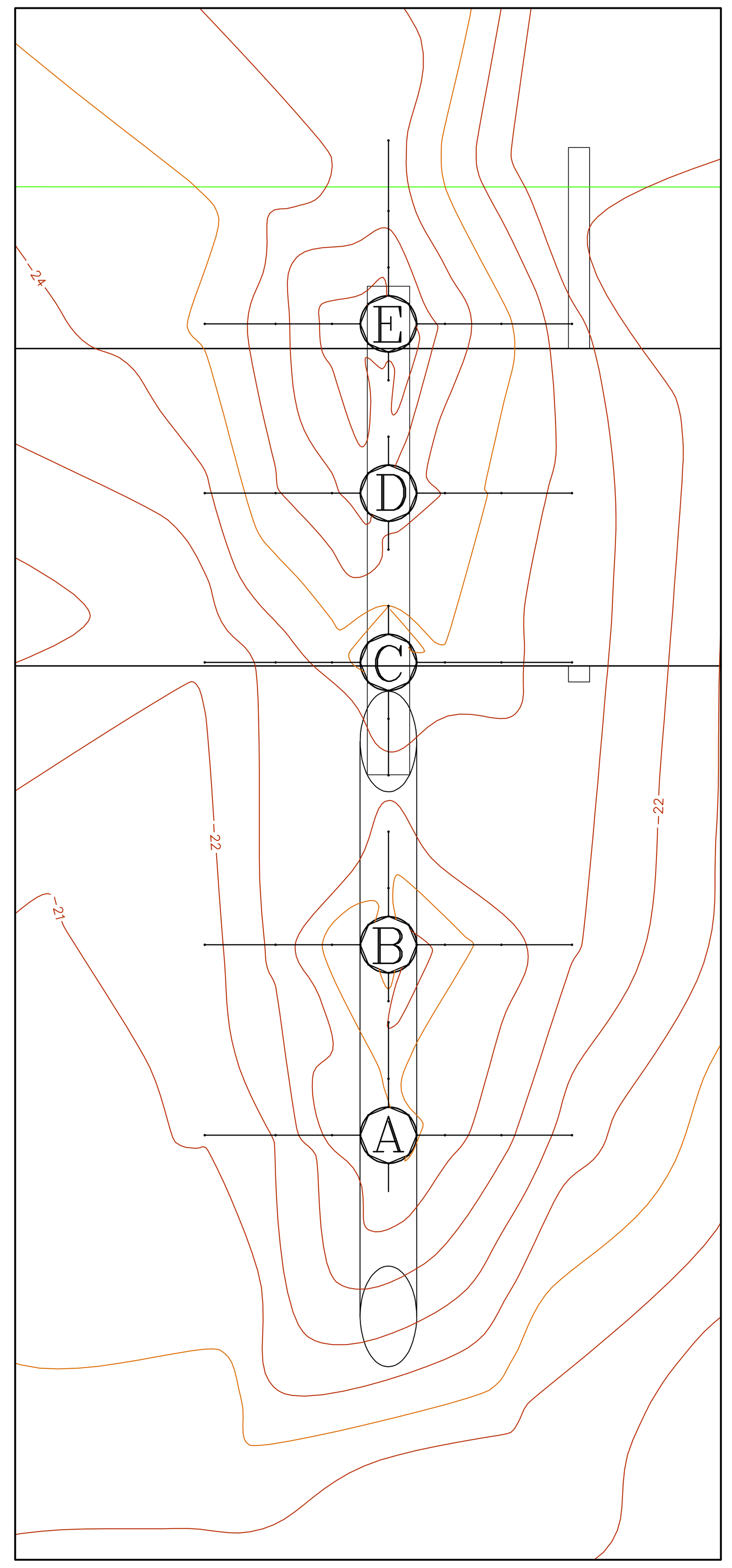
JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE-CD50-1022



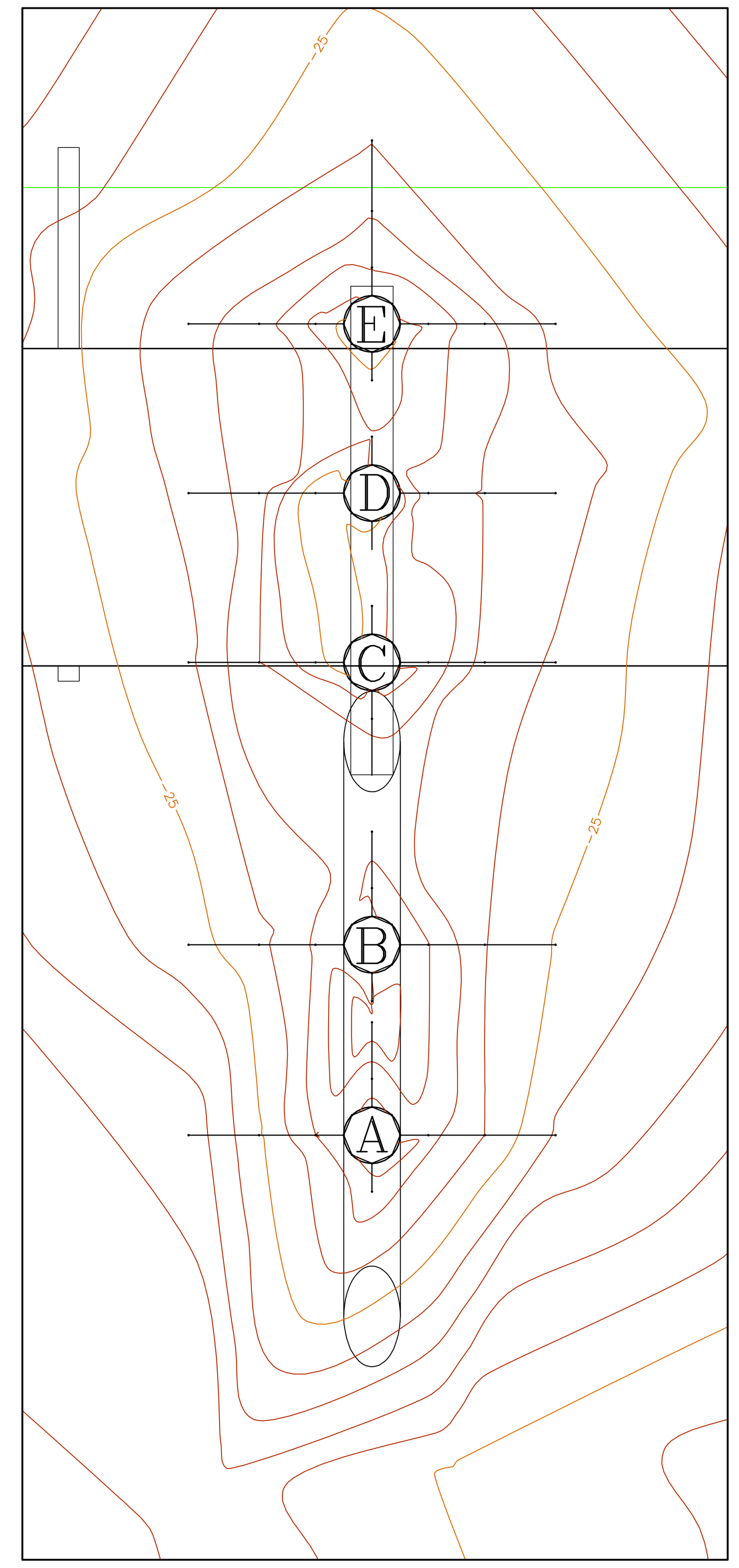
PIER 2
SCALE: 1: = 10'



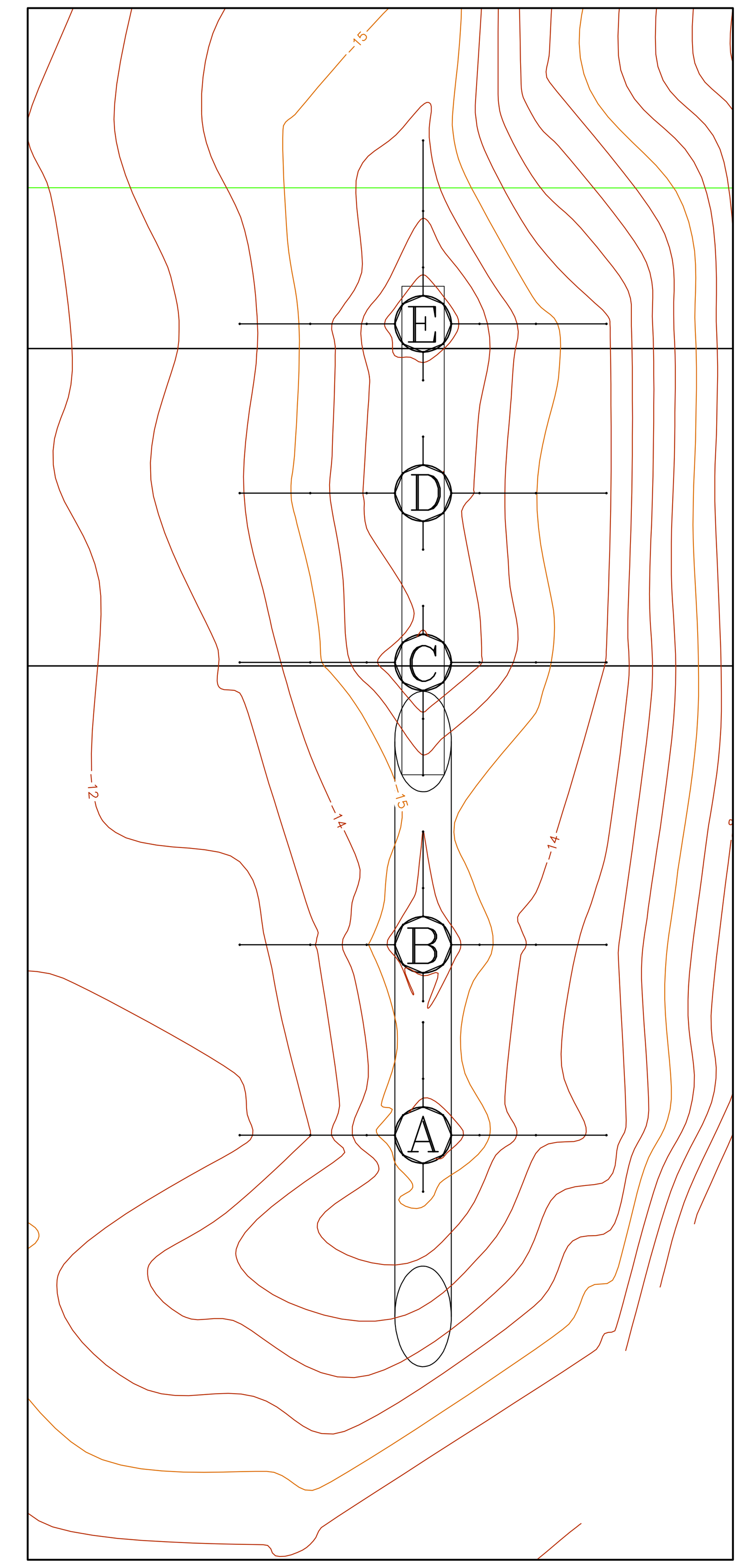
PIER 3
SCALE: 1: = 10'

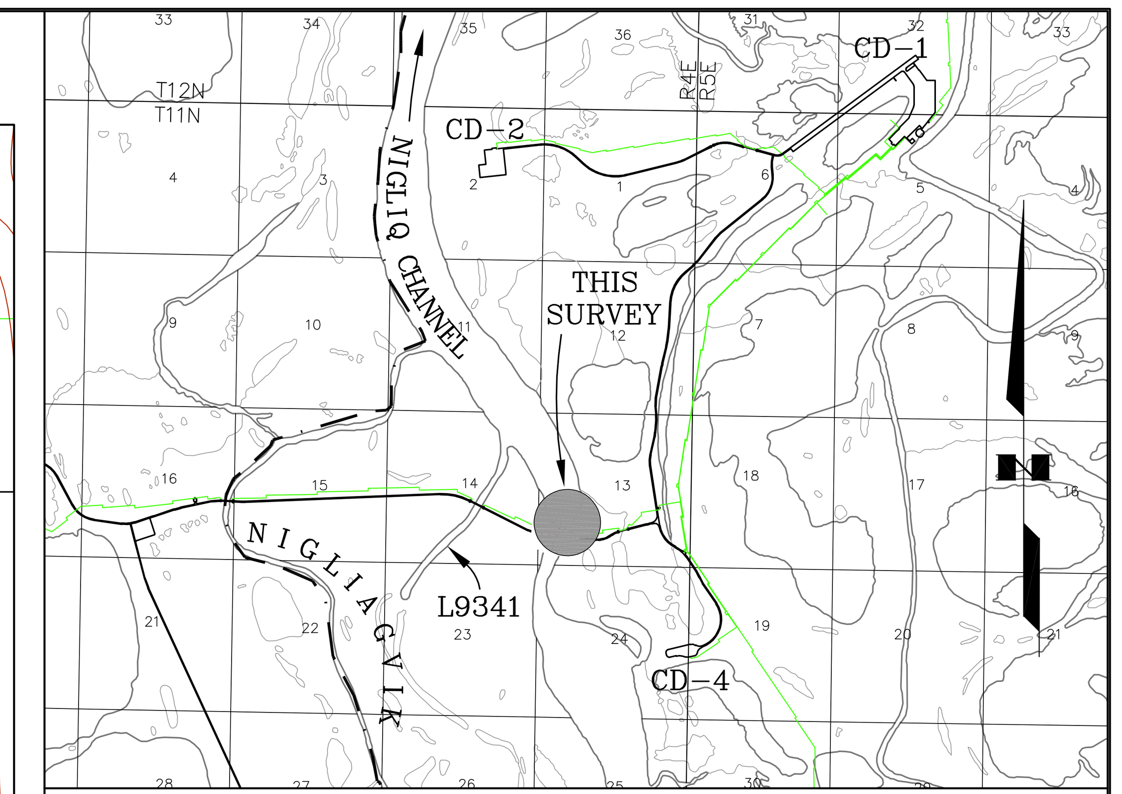


PIER 4
SCALE: 1: = 10'



PIER 5
SCALE: 1: = 10'





VICINITY MAP 1" = 1 MILE

NOTES:

1. DATES OF SURVEY: AUGUST 23, 2020
2. REFERENCE FIELD BOOK: 2020-26, PGS. 22-25.
3. ELEVATIONS ARE BRITISH PETROLEUM MEAN SEAL LEVEL (B.P.M.S.L.)
4. AVERAGE WATER SURFACE ELEVATION DURING SURVEY IS -0.632'.
5. HORIZONTAL DATUM IS NAD 83 ALASKA STATE PLANE ZONE 4.

LEGEND:
1' CONTOUR
5' CONTOUR

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

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

FORM: DSIZE

DATE:	DRAWN:	DESIGN:	ECM NO:
08/23/14	CZ	GD	K140003ACS
SCALE:	CHECKED:		CC NO:
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: 7

REFERENCE DWG NO/SHT NO:

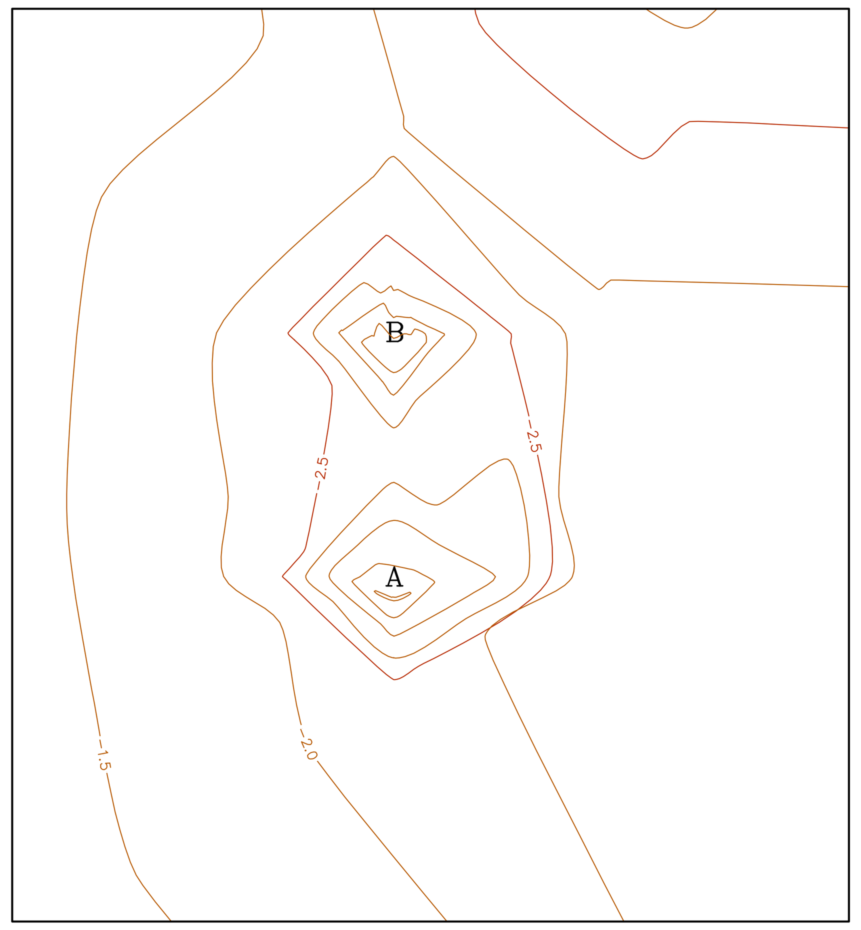
REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
7	8/31/2020	UPDATED PER K20000ACS	KR	CZ			

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
6	08/31/19	UPDATED PER K190003ACS	SZ	CZ			
5	8/21/18	UPDATED PER K180003ACS	SZ	DB			
4	8/4/17	UPDATED PER K170003ACS	CZ	GD			
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			

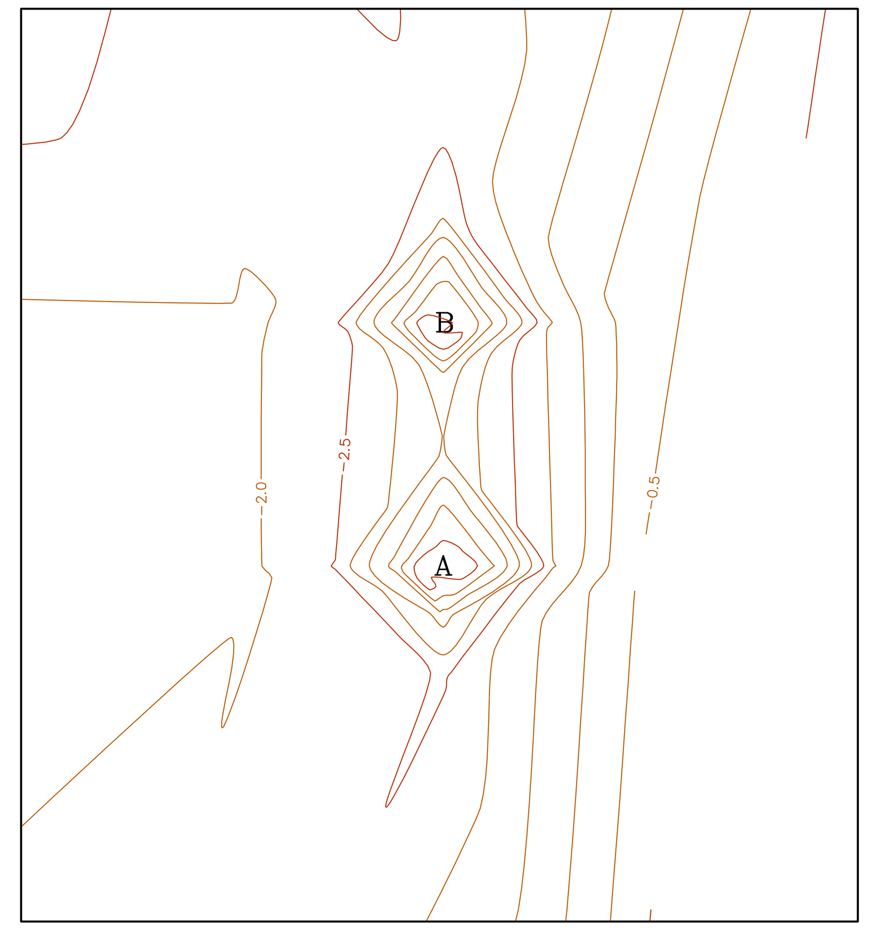
E.1.2 NIGLIAGVIK BRIDGE

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

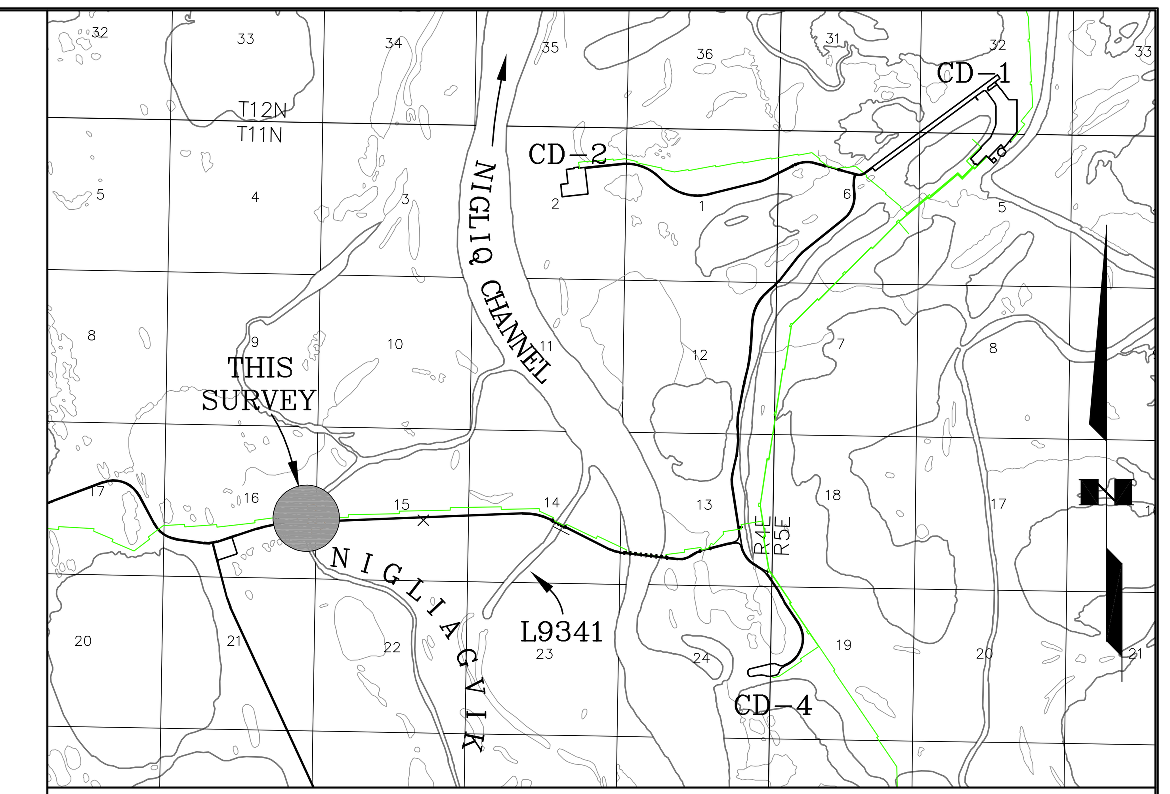
PIER 3
SCALE: 1" = 10'



PIER 4
SCALE: 1" = 10'



LEGEND:
- 0.5' CONTOUR
- 2.5' CONTOUR



VICINITY MAP

NOTES

1. DATE OF SURVEY: August 25, 2020.
2. REFERENCE FIELD BOOKS: 2020–26 PGS. 29–32
3. ELEVATIONS ARE BRITISH PETROLEUM MEAN SEAL LEVEL (B.P.M.S.L.)
4. HORIZONTAL DATUM IS NAD 83 ALASKA STATE PLANE ZONE 4.

KUUKPIK UMIAQ
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

FORM: DSIZE

DATE:	8/25/14
SCALE:	1" = 20'
DRAWN:	CZ
DESIGN:	–
CHECKED:	GD
APPROVAL:	–
ECM NO:	K140003ACS
CC NO:	–
CADD FILE NO.	14–08–12–1CW
JOB NO:	–
SUB JOB NO:	–
DRAWING NO:	CE–CD50–1023
PART:	1 OF 1
REV:	7

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
7	8/26/20	UPDATED PER K200003ACS	KR	CZ			
6	09/03/19	UPDATED PER K190003ACS	SZ	CZ			
5	08/12/18	UPDATED PER K180003ACS	RR	CZ			
4	9/21/17	UPDATER PER K170003ACS	RR	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			

E.2 BANK EROSION

E.2.1 NIGLIQ CHANNEL WEST & EAST BANK TABULATED DATA

Calc'd By: CSS
Date: 08/29/20
Chk'd: RTD
RPT-CE-CD-112 REV10

Alpine AP00
West Bank Nigliq
Streambank Monitor

KUUKPIK UMIAQ

Doc.LCMF-155 REV10

Baseline	West Bank Monitor - Top of Bank Locations								
	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
Station	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	8/29/2020	Description
0+00	180.2			153.6	147.0	147.0	144.6	135.1	Baseline Offset (In Feet)
				-26.6	-6.6	0.0	-2.4	-9.5	Incremental Change
				-26.6	-33.2	-33.2	-35.6	-45.1	Cumulative Change
1+00	191.0			168.5	168.5	164.8	155.8	148.2	Baseline Offset (In Feet)
				-22.5	0.0	-3.7	-9.0	-7.6	Incremental Change
				-22.5	-22.5	-26.2	-35.2	-42.7	Cumulative Change
2+00	193.1			184.4	181.6	177.7	173.1	158.2	Baseline Offset (In Feet)
				-8.7	-2.8	-3.9	-4.6	-14.9	Incremental Change
				-8.7	-11.5	-15.4	-20.0	-34.9	Cumulative Change
3+00	189.2			186.1	186.1	183.4	178.6	165.1	Baseline Offset (In Feet)
				-3.1	0.0	-2.7	-4.8	-13.5	Incremental Change
				-3.1	-3.1	-5.8	-10.6	-24.1	Cumulative Change
4+00	192.2			187.7	187.7	185.7	182.4	174.8	Baseline Offset (In Feet)
				-4.5	0.0	-2.0	-3.3	-7.6	Incremental Change
				-4.5	-4.5	-6.5	-9.8	-17.4	Cumulative Change
4+55								174.3	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
4+65								168.5	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
4+75								174.8	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
5+00	202.9			197.1	194.8	191.3	188.0	181.8	Baseline Offset (In Feet)
				-5.8	-2.3	-3.5	-3.3	-6.2	Incremental Change
				-5.8	-8.1	-11.6	-14.9	-21.1	Cumulative Change
6+00	224.0			207.8	203.8	203.8	203.8	196.4	Baseline Offset (In Feet)
				-16.2	-4.0	0.0	0.0	-7.4	Incremental Change
				-16.2	-20.2	-20.2	-20.2	-27.6	Cumulative Change

Doc LCMF-155 Nigliq Streambank Monitor Rev10.xlsx1 of 7 West Bank Monitor

Calc'd By: CSS
Date: 08/29/20
Chk'd: RTD
RPT-CE-CD-112 REV10

Alpine AP00
West Bank Nigliq
Streambank Monitor

KUUKPIK UMIAQ
Doc.LCMF-155 REV10

	West Bank Monitor - Top of Bank Locations								
Baseline	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
Station	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	8/29/2020	Description
7+00	228.9			209.3	206.0	202.7	202.7	198.7	Baseline Offset (In Feet)
				-19.6	-3.3	-3.3	0.0	-4.0	Incremental Change
				-19.6	-22.9	-26.2	-26.2	-30.2	Cumulative Change
8+00	232.9			219.1	215.1	212.3	212.3	208.1	Baseline Offset (In Feet)
				-13.8	-4.0	-2.8	0.0	-4.2	Incremental Change
				-13.8	-17.8	-20.6	-20.6	-24.8	Cumulative Change

Doc LCMF-155 Nigliq Streambank Monitor Rev10.xlsx2 of 7 West Bank Monitor

Calc'd By: CSS
Date: 08/29/20
Chk'd: RTD
RPT-CE-CD-112 REV10

Alpine AP00
West Bank Nigliq
Streambank Monitor

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

Doc.LCMF-155 REV10

	West Bank Monitor - Top of Bank Locations								
Baseline	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
Station	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	8/29/2020	Description
9+00	220.0			217.9	217.9	217.9	219.4	211.7	Baseline Offset (In Feet)
				-2.1	0.0	0.0	1.5	-7.7	Incremental Change
				-2.1	-2.1	-2.1	-0.6	-8.2	Cumulative Change
10+00	216.8	216.8	213.5	213.5	213.5	210.9	209.5	209.5	Baseline Offset (In Feet)
		0.0	-3.3	0.0	0.0	-2.6	-1.4	0.0	Incremental Change
		0.0	-3.3	-3.3	-3.3	-5.9	-7.3	-7.3	Cumulative Change
10+67A								195.5	Baseline Offset (In Feet)
									Incremental Change
	1.2								Cumulative Change
10+67B								158.9	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
	9.2								
10+67C								158.1	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
10+80								189.5	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
11+00	209.1	209.1	204.9	204.8	204.8	204.8	204.8	202.6	Baseline Offset (In Feet)
		0.0	-4.2	-0.1	0.0	0.0	0.0	-2.2	Incremental Change
		0.0	-4.2	-4.3	-4.3	-4.3	-4.3	-6.5	Cumulative Change
11+30					206.1	206.1	206.1	203.7	Baseline Offset (In Feet)
						0.0	0.0	-2.4	Incremental Change
						0.0	0.0	-2.4	Cumulative Change
11+50					206.9	206.9	206.9	204.5	Baseline Offset (In Feet)
						0.0	0.0	-2.4	Incremental Change
						0.0	0.0	-2.4	Cumulative Change
11+70					203.8	203.8	202.6	200.7	Baseline Offset (In Feet)
						0.0	-1.2	-1.9	Incremental Change
						0.0	-1.2	-3.1	Cumulative Change
11+90					195.7	195.7	193.2	192.8	Baseline Offset (In Feet)

Calc'd By: CSS
Date: 08/29/20
Chk'd: RTD
RPT-CE-CD-112 REV10

Alpine AP00
West Bank Nigliq
Streambank Monitor

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ALPINE SURVEY OFFICE

Doc.LCMF-155 REV10

	West Bank Monitor - Top of Bank Locations								
Baseline	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
Station	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	8/29/2020	Description
						0.0	-2.5	-0.4	Incremental Change
						0.0	-2.5	-2.9	Cumulative Change

Calc'd By: CSS
Date: 08/29/20
Chk'd: RTD
RPT-CE-CD-112 REV10

Alpine AP00
West Bank Nigliq
Streambank Monitor

KUUKPIK UMIAQ
Doc.LCMF-155 REV10

	West Bank Monitor - Top of Bank Locations								
Baseline	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
Station	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	8/29/2020	Description
12+00	199.0	199.0	199.0	199.8	189.8	189.7	187.0	187.0	Baseline Offset (In Feet)
		0.0	0.0	0.8	-10.0	-0.1	-2.7	0.0	Incremental Change
		0.0	0.0	0.8	-9.2	-9.3	-12.0	-12.0	Cumulative Change
12+10					182.2	181.5	180.0	180.0	Baseline Offset (In Feet)
						-0.7	-1.5	0.0	Incremental Change
						-0.7	-0.8	-2.2	Cumulative Change
12+15								180.5	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
12+20					187.1	183.3	183.3	183.3	Baseline Offset (In Feet)
						-3.8	0.0	0.0	Incremental Change
						-3.8	-3.8	-3.8	
12+30					193.8	192.2	188.0	188.0	Baseline Offset (In Feet)
						-1.6	-4.2	0.0	Incremental Change
						-1.6	-5.8	-5.8	Cumulative Change
12+50					194.5	192.1	192.1	190.2	Baseline Offset (In Feet)
						-2.4	0.0	-1.9	Incremental Change
						-2.4	-2.4	-4.3	Cumulative Change
12+70								191.5	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
13+00	192.1	192.1	192.1	192.1	188.3	188.3	188.6	184.4	Baseline Offset (In Feet)
		0.0	0.0	0.0	-3.8	0.0	0.3	-4.2	Incremental Change
		0.0	0.0	0.0	-3.8	-3.8	-3.5	-7.7	Cumulative Change
13+35								180.0	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
13+45								167.8	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
14+00	200.9			198.8	193.7	193.7	194.4	191.5	Baseline Offset (In Feet)
				-2.1	-5.1	0.0	0.7	-2.9	Incremental Change

Doc LCMF-155 Nigliq Streambank Monitor Rev10.xlsx5 of 7 West Bank Monitor

Calc'd By: CSS
Date: 08/29/20
Chk'd: RTD
RPT-CE-CD-112 REV10

Alpine AP00
West Bank Nigliq
Streambank Monitor

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Doc.LCMF-155 REV10

	West Bank Monitor - Top of Bank Locations								
Baseline	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
Station	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	8/29/2020	Description
				-2.1	-7.2	-7.2	-6.5	-9.3	Cumulative Change
14+80								176.1	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
15+00	190.0			190.0	186.2	186.2	184.8	184.8	Baseline Offset (In Feet)
				0.0	-3.8	0.0	-1.4	0.0	Incremental Change
				0.0	-3.8	-3.8	-5.2	-5.2	Cumulative Change
15+50								200.1	Baseline Offset (In Feet)
									Incremental Change
									Cumulative Change
16+00	211.0			209.5	203.3	203.3	202.3	202.3	Baseline Offset (In Feet)
				-1.5	-6.2	0.0	-1.0	0.0	Incremental Change
				-1.5	-7.7	-7.7	-8.7	-8.7	Cumulative Change
17+00	204.0			204.0	202.9	200.6	200.8	198.7	Baseline Offset (In Feet)
				0.0	-1.1	-2.3	0.2	-2.1	Incremental Change
				0.0	-1.1	-3.4	-3.2	-5.3	Cumulative Change
18+00	212.0			208.3	208.3	208.3	208.6	207.3	Baseline Offset (In Feet)
				-3.7	0.0	0.0	0.3	-1.3	Incremental Change
				-3.7	-3.7	-3.7	-3.4	-4.6	Cumulative Change
19+00	221.9			221.9	221.9	221.9	222.0	222.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.1	0.0	Incremental Change
				0.0	0.0	0.0	0.1	0.1	Cumulative Change
20+00	232.9			232.9	232.9	232.9	230.1	225.7	Baseline Offset (In Feet)
				0.0	0.0	0.0	-2.8	-4.4	Incremental Change
				0.0	0.0	0.0	-2.8	-7.2	Cumulative Change

Calc'd By: CSS
Date: 08/29/20
Chk'd: RTD
RPT-CE-CD-112 REV10

Alpine AP00
West Bank Nigliq
Streambank Monitor

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ALPINE SURVEY OFFICE

Doc.LCMF-155 REV10

	West Bank Monitor - Top of Bank Locations								
Baseline	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
Station	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	8/29/2020	Description
21+00	233.9			227.5	227.5	227.5	227.7	227.7	Baseline Offset (In Feet)
				-6.4	0.0	0.0	0.2	0.0	Incremental Change
				-6.4	-6.4	-6.4	-6.2	-6.2	Cumulative Change
22+00	237.8			233.3	233.3	233.3	233.4	233.4	Baseline Offset (In Feet)
				-4.5	0.0	0.0	0.1	0.0	Incremental Change
				-4.5	-4.5	-4.5	-4.4	-4.4	Cumulative Change
23+00	237.9			233.0	233.0	233.0	233.4	233.4	Baseline Offset (In Feet)
				-4.9	0.0	0.0	0.4	0.0	Incremental Change
				-4.9	-4.9	-4.9	-4.5	-4.5	Cumulative Change
24+00	229.9			229.9	229.9	229.9	230.5	230.5	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.6	0.0	Incremental Change
				0.0	0.0	0.0	0.6	0.6	Cumulative Change
25+00	214.1			214.1	214.1	214.1	214.4	214.4	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.3	0.0	Incremental Change
				0.0	0.0	0.0	0.3	0.3	Cumulative Change
25+11	213.9			213.9	213.9	213.9	214.1	212.6	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.2	-1.5	Incremental Change
				0.0	0.0	0.0	0.2	-1.3	Cumulative Change

***Note: Survey completed on 8/22/13 was used for baseline data to compute Incremental /Cumulative Change. Negative numbers indicate erosion.
Staitons 10+67A, B, and C are on an angle point on the baseline. Which distorts the stationing.
10+67B is 1.2' from A and 10+67C is 9.1' from B

Calc'd By: CSS
Date: 08/29/20
Chk'd: RTD
RPT-CE-CD-112 REV10

Alpine AP00
East Bank Nigliq
Streambank Monitor

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

Doc.LCMF-155 REV10

Baseline	East Bank Monitor - Top of Bank Locations								
	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
Station	8/22/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/25/2018	8/13/2019	8/28/2020	Description
0+00	169.9			169.9	169.9	169.9	169.8	169.9	Baseline Offset (In Feet)
				0.0	0.0	0.0	-0.1	0.1	Incremental Change
				0.0	0.0	0.0	-0.1	0.0	Cumulative Change
1+00	174.0			174.0	174.0	174.0	173.9	174.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	-0.1	0.1	Incremental Change
				0.0	0.0	0.0	-0.1	0.0	Cumulative Change
2+00	178.9			178.9	178.9	178.9	179.0	178.9	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.1	-0.1	Incremental Change
				0.0	0.0	0.0	0.1	0.0	Cumulative Change
3+00	191.0			191.0	191.0	191.0	191.0	191.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	0.0	0.0	Cumulative Change
4+00	188.0			188.0	188.0	188.0	188.0	188.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	0.0	0.0	Cumulative Change
5+00	196.1			196.1	196.1	196.1	196.3	196.1	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.2	-0.2	Incremental Change
				0.0	0.0	0.0	0.2	0.0	Cumulative Change
6+00	201.1			201.1	201.1	201.1	201.1	201.1	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	0.0	0.0	Cumulative Change
7+00	208.1			208.1	208.2	208.2	208.3	208.1	Baseline Offset (In Feet)
				0.0	0.1	0.0	0.1	-0.2	Incremental Change
				0.0	0.1	0.1	0.2	0.0	Cumulative Change
8+00	199.8			199.8	199.9	199.9	199.8	199.8	Baseline Offset (In Feet)
				0.0	0.1	0.0	-0.1	0.0	Incremental Change
				0.0	0.1	0.1	0.0	0.0	Cumulative Change
9+00	406.2			406.2	406.0	406.0	406.0	406.2	Baseline Offset (In Feet)
				0.0	-0.2	0.0	0.0	0.2	Incremental Change
				0.0	-0.2	-0.2	-0.2	0.0	Cumulative Change

Doc LCMF-155 Nigliq Streambank Monitor Rev10.xlsx1 of 2 East Bank Monitor

Calc'd By: CSS
Date: 08/29/20
Chk'd: RTD
RPT-CE-CD-112 REV10

Alpine AP00
East Bank Nigliq
Streambank Monitor

KUUKPIK UMIAQ

Doc.LCMF-155 REV10

	East Bank Monitor - Top of Bank Locations								
Baseline	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
Station	8/22/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/25/2018	8/13/2019	8/28/2020	**Description**
10+00	280.9			280.7	280.6	280.6	280.7	280.7	Baseline Offset (In Feet)
				-0.2	-0.1	0.0	0.1	0.0	Incremental Change
				-0.2	-0.3	-0.3	-0.2	-0.2	Cumulative Change
11+00	192.2			192.0	192.0	192.0	192.1	192.0	Baseline Offset (In Feet)
				-0.2	0.0	0.0	0.1	-0.1	Incremental Change
				-0.2	-0.2	-0.2	-0.1	-0.2	Cumulative Change
12+00	100.1			107.9	107.6	107.6	108.1	108.1	Baseline Offset (In Feet)
				7.8	-0.3	0.0	0.5	0.0	Incremental Change
				7.8	7.5	7.5	8.0	8.0	Cumulative Change
13+00	192.0	192.0	192.0	192.0	191.8	191.8	191.9	192.0	Baseline Offset (In Feet)
		0.0	0.0	0.0	-0.2	0.0	0.1	0.1	Incremental Change
		0.0	0.0	0.0	-0.2	-0.2	-0.1	0.0	Cumulative Change
13+84				208.0	208.0	208.0	207.7	208.1	Baseline Offset (In Feet)
					0.0	0.0	-0.3	0.4	Incremental Change
					0.0	0.0	-0.3	0.1	Cumulative Change
14+00	210.0	210.0	210.0	*Unable to	205.8	205.8	205.8	205.8	Baseline Offset (In Feet)
		0.0	0.0		-4.2	0.0	0.0	0.0	Incremental Change
		0.0	0.0		-4.2	-4.2	-4.2	-4.2	Cumulative Change
15+00	192.0	192.0	192.0	192.0	192.0	192.0	191.9	192.0	Baseline Offset (In Feet)
		0.0	0.0	0.0	0.0	0.0	-0.1	0.1	Incremental Change
		0.0	0.0	0.0	0.0	0.0	-0.1	0.0	Cumulative Change
15+56	195.4			195.4	195.4	195.4	195.4	195.4	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	0.0	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 Rev10.xlsx2 of 2 East Bank Monitor

E.2.2 NIGLIAGVIK CHANNEL WEST & EAST BANK TABULATED DATA

Calc/d By: CSS
Date: 08/28/2020
Chk'd: KR
RPT-CE-CD-111 REV8

Alpine AP00
West Bank Nigliagvik
Streambank Monitor

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

Doc.LCMF-154 REV8

Baseline Station	West Bank Monitor - Top of Bank Locations								Description
	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/25/2018	8/13/2019	8/26/2020	Date
0+00	110.0			100.7	100.7	100.7	101.1	100.7	Baseline Offset (In Feet)
				-9.3	0.0	0.0	0.4	-0.4	Incremental Change
				-9.3	-9.3	-9.3	-8.9	-9.3	Cumulative Change
1+00	103.0			97.9	97.9	97.9	98.2	97.9	Baseline Offset (In Feet)
				-5.1	0.0	0.0	0.3	-0.3	Incremental Change
				-5.1	-5.1	-5.1	-4.8	-5.1	Cumulative Change
2+00	99.6			99.6	97.5	97.5	97.5	97.5	Baseline Offset (In Feet)
				0.0	-2.1	0.0	0.0	0.0	Incremental Change
				0.0	-2.1	-2.1	-2.1	-2.1	Cumulative Change
3+00	98.8			91.3	91.3	91.3	91.4	91.3	Baseline Offset (In Feet)
				-7.5	0.0	0.0	0.1	-0.1	Incremental Change
				-7.5	-7.5	-7.5	-7.4	-7.5	Cumulative Change
4+00	106.0	106.0	106.0	102.4	102.4	102.4	99.7	99.7	Baseline Offset (In Feet)
		0.0	0.0	-3.6	0.0	0.0	-2.7	0.0	Incremental Change
		0.0	0.0	-3.6	-3.6	-3.6	-6.3	-6.3	Cumulative Change
5+00	102.0	93.5	93.5	81.1	81.1	81.1	81.1	81.1	Baseline Offset (In Feet)
		-8.4	0.0	-12.4	0.0	0.0	0.0	0.0	Incremental Change
		-8.4	-8.4	-20.9	-20.9	-20.9	-20.9	-20.9	Cumulative Change
6+00	94.4	90.4	90.4	87.9	87.9	87.9	98.2	98.2	Baseline Offset (In Feet)
		-4.0	0.0	-2.5	0.0	0.0	10.3	0.0	Incremental Change
		-4.0	-4.0	-6.5	-6.5	-6.5	3.8	3.8	Cumulative Change

Doc LCMF-154 Nigliagvik Streambank Monitor Rev8.xlsx 1 of 4 West Bank Monitor

Calc'd By: CSS
Date: 08/28/2020
Chk'd: KR
RPT-CE-CD-111 REV8

Alpine AP00
West Bank Nigliagvik
Streambank Monitor

KUUKPIK UMIAQ
Doc.LCMF-154 REV8

Baseline	West Bank Monitor - Top of Bank Locations								Description
Station	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/25/2018	8/13/2019	8/26/2020	Date
7+00	107.1			107.1	107.1	107.1	101.5	101.5	Baseline Offset (In Feet)
				0.0	0.0	0.0	-5.6	0.0	Incremental Change
				0.0	0.0	0.0	-5.6	-5.6	Cumulative Change
8+00	115.0			112.8	112.8	112.8	112.9	112.8	Baseline Offset (In Feet)
				-2.2	0.0	0.0	0.1	-0.1	Incremental Change
				-2.2	-2.2	-2.2	-2.1	-2.2	Cumulative Change
9+00	96.1			91.8	91.8	91.8	92.0	91.8	Baseline Offset (In Feet)
				-4.3	0.0	0.0	0.2	-0.2	Incremental Change
				-4.3	-4.3	-4.3	-4.1	-4.3	Cumulative Change
10+00	106.1			106.1	106.1	105.2	106.4	106.1	Baseline Offset (In Feet)
				0.0	0.0	-0.9	1.2	-0.3	Incremental Change
				0.0	0.0	-0.9	0.3	0.0	Cumulative Change

Notes:
1. Survey completed on 8/21/13 was used for baseline data to compute Incremental/Cumulative Change.
2. Negative numbers indicate erosion.
3. Station 6+00 information corrected from 2014 to 2020.

Calc/d By: CSS
Date: 08/28/2020
Chk'd: KR
RPT-CE-CD-111 REV8

Alpine AP00
East Bank Nigliagvik
Streambank Monitor

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

Doc.LCMF-154 REV8

Baseline	East Bank Monitor - Top of Bank Locations								Description
Station	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	8/26/2020	Date
0+00	165.1			165.1	165.3	165.3	165.4	165.3	Baseline Offset (In Feet)
				0.0	0.2	0.0	0.1	-0.1	Incremental Change
				0.0	0.2	0.2	0.3	0.2	Cumulative Change
1+00	185.0			185.0	185.0	185.0	185.0	185.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	0.0	0.0	Cumulative Change
2+00	165.0			165.0	165.1	165.1	165.0	165.0	Baseline Offset (In Feet)
				0.0	0.1	0.0	-0.1	0.0	Incremental Change
				0.0	0.1	0.1	0.0	0.0	Cumulative Change
3+00	162.3			162.3	162.2	162.2	162.4	162.3	Baseline Offset (In Feet)
				0.0	-0.1	0.0	0.2	-0.1	Incremental Change
				0.0	-0.1	-0.1	0.1	0.0	Cumulative Change
4+00	154.9	154.9	154.9	147.6	147.6	147.6	147.7	147.6	Baseline Offset (In Feet)
		0.0	0.0	-7.3	0.0	0.0	0.1	-0.1	Incremental Change
		0.0	0.0	-7.3	-7.3	-7.3	-7.2	-7.3	Cumulative Change
5+00	141.0	141.0	138.4	Under	143.7	143.7	143.7	143.7	Baseline Offset (In Feet)
		0.0	-2.7	Bridge	5.3	0.0	0.0	0.0	Incremental Change
		0.0	-2.7		2.7	2.7	2.7	2.7	Cumulative Change
6+00	120.9	120.9	120.9	120.9	121.1	121.1	121.0	120.9	Baseline Offset (In Feet)
		0.0	0.0	0.0	0.2	0.0	-0.1	-0.1	Incremental Change
		0.0	0.0	0.0	0.2	0.2	0.1	0.0	Cumulative Change

Calc'd By: CSS
Date: 08/28/2020
Chk'd: KR
RPT-CE-CD-111 REV8

Alpine AP00
East Bank Nigliagvik
Streambank Monitor

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

Doc.LCMF-154 REV8

Baseline	East Bank Monitor - Top of Bank Locations								Description
Station	See Drawing CE-AP00-1126 Rev 8 for Survey Baseline Location								
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/24/2018	8/13/2019	8/26/2020	Date
7+00	119.0			119.0	119.5	119.5	119.3	119.5	Baseline Offset (In Feet)
				0.0	0.5	0.0	-0.2	0.2	Incremental Change
				0.0	0.5	0.5	0.3	0.5	Cumulative Change
8+00	120.9			120.9	121.3	121.3	121.2	121.3	Baseline Offset (In Feet)
				0.0	0.4	0.0	-0.1	0.1	Incremental Change
				0.0	0.4	0.4	0.3	0.4	Cumulative Change

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

***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.

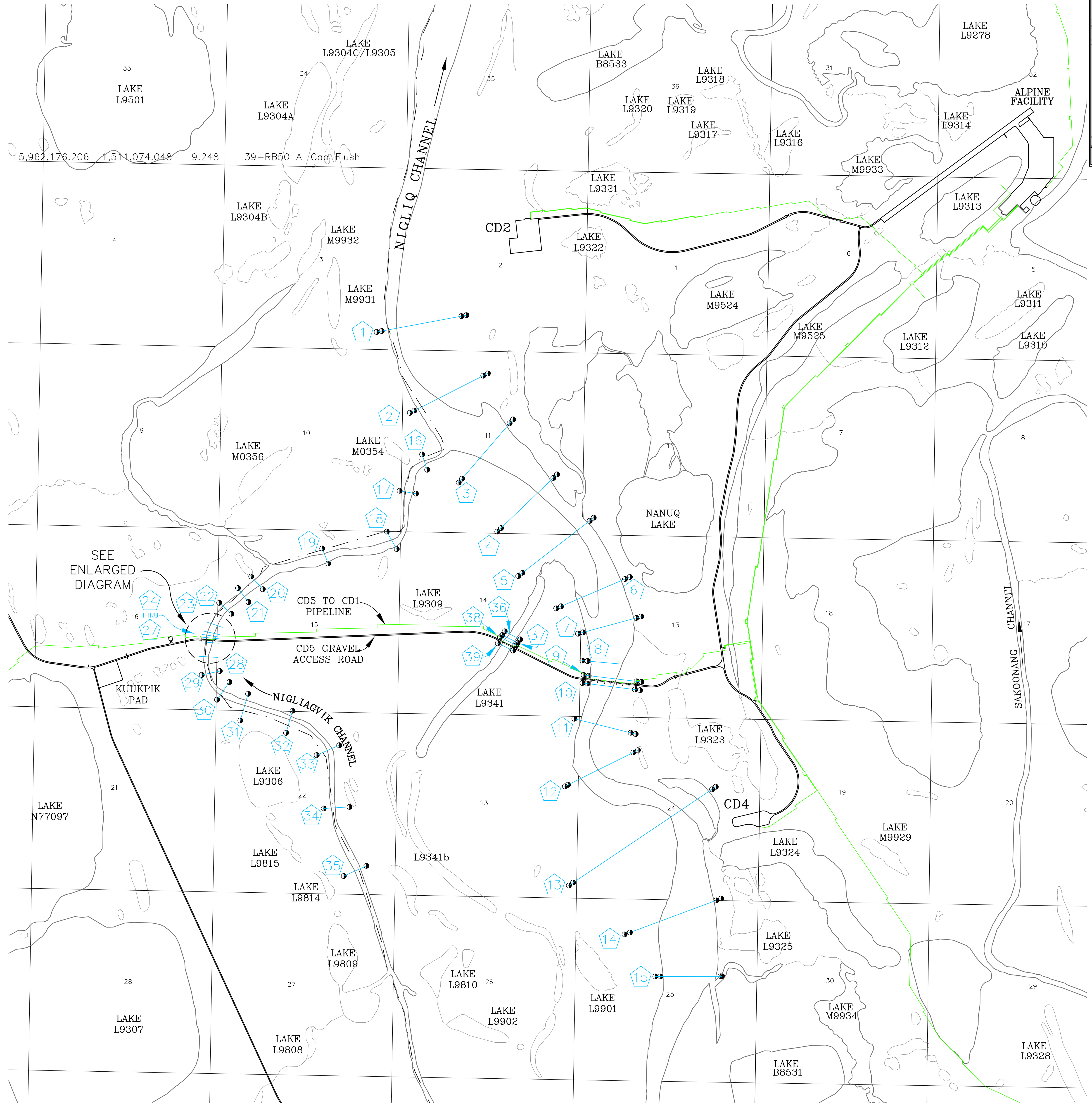
E.3 BATHYMETRY

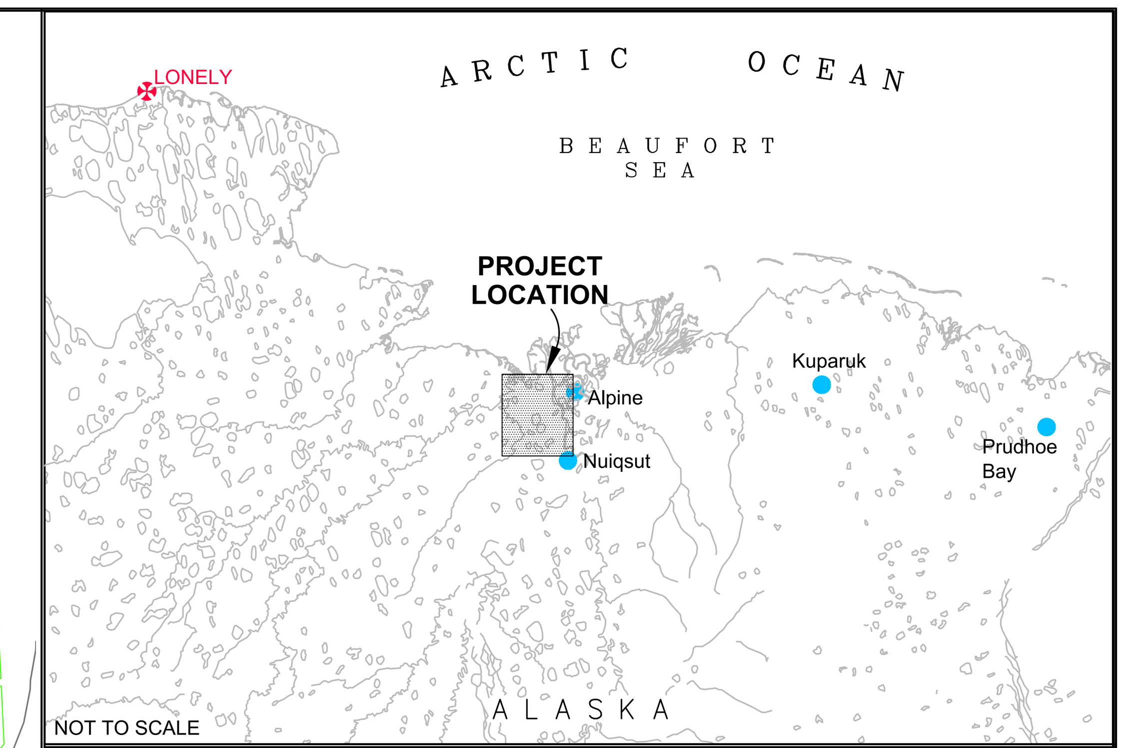
E.3.1 TRANSECT PROFILES

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

CD5 2017 TRANSECT CONTROL

NORTHING	EASTING	ELEV	DESCRIPTION	NORTHING	EASTING	ELEV	DESCRIPTION
5,971,410.079	1,507,156.531	8.39	01–LB200 Al Cap Flush	5,963,972.572	1,503,814.158	7.59	20–RB50 Al Cap Flush
5,971,437.609	1,507,304.061	8.37	01–LB50 Al Cap Flush	5,963,970.131	1,503,127.991	24.55	21–LB100 Al Cap Flush
5,971,895.666	1,509,763.389	9.13	01–RB200 Al Cap Flush	5,963,929.997	1,503,157.807	20.75	21–LB50 Al Cap Flush
5,971,868.384	1,509,615.796	9.28	01–RB50 Al Cap Flush	5,963,562.385	1,503,430.606	8.83	21–RB100 Al Cap Flush
5,969,060.212	1,508,119.663	8.87	02–LB200 Al Cap Flush	5,963,602.552	1,503,400.707	9.12	21–RB50 Al Cap Flush
5,969,127.986	1,508,253.629	7.65	02–LB50 Al Cap Flush	5,963,540.635	1,502,578.236	26.09	22–LB110 Al Cap Flush
5,970,206.007	1,510,386.350	9.26	02–RB200 Al Cap Flush	5,963,500.929	1,502,623.041	24.05	22–LB50 Al Cap Flush
5,970,138.188	1,510,252.432	8.96	02–RB50 Al Cap Flush	5,963,224.550	1,502,936.061	8.70	22–RB100 Al Cap Flush
5,967,032.227	1,509,538.697	9.67	03–LB200 Al Cap Flush	5,963,257.784	1,502,898.581	9.16	22–RB50 Al Cap Flush
5,967,145.969	1,509,636.499	10.13	03–LB50 Al Cap Flush	5,962,989.540	1,502,198.702	25.27	23–LB100 Al Cap Flsh
5,968,868.865	1,511,117.892	9.41	03–RB200 Al Cap Flush	5,962,973.551	1,502,246.078	25.13	23–LB50 Al Cap Flush
5,968,755.138	1,511,019.833	9.05	03–RB50 Al Cap Flush	5,962,828.919	1,502,671.911	10.17	23–RB100 Al Cap Flush
5,965,610.351	1,510,661.003	12.54	04–LB200 Al Cap Flush	5,962,844.993	1,502,624.671	7.92	23–RB50 Al Cap Flush
5,965,716.677	1,510,772.064	13.71	04–LB50 Al Cap Flush	5,962,728.640	1,502,095.594	26.44	24–LB100 Al Cap Flush
5,967,272.750	1,512,396.862	10.36	04–RB200 Al Cap Flush	5,962,717.858	1,502,144.429	26.95	24–LB50 Al Cap Flush
5,967,169.020	1,512,288.517	10.23	04–RB50 Al Cap Flush	5,962,617.871	1,502,598.118	9.07	24–RB100 Al Cap Flush
5,964,321.998	1,511,269.867	11.98	05–LB200 Al Cap Flush	5,962,628.701	1,502,549.442	8.42	24–RB50 Al Cap Flush
5,964,413.665	1,511,388.462	13.14	05–LB50 Al Cap Flush	5,962,627.134	1,502,078.374	27.30	25–LB100 Al Cap Flush
5,966,013.940	1,513,463.318	8.66	05–RB200 Al Cap Flush	5,962,619.297	1,502,127.805	26.17	25–LB50 Al Cap Flush
5,965,922.233	1,513,344.473	8.66	05–RB50 Al Cap Flush	5,962,548.009	1,502,575.213	8.35	25–RB100 Al Cap Flush
5,963,381.239	1,512,373.965	11.39	06–LB200 Al Cap Flush	5,962,555.885	1,502,525.978	8.2	25–RB50 Al Cap Flush
5,963,439.930	1,512,511.976	13.14	06–LB50 Al Cap Flush	5,962,545.552	1,502,059.146	27.26	26–LB110 Al Cap Flush
5,964,291.972	1,514,511.882	9.79	06–RB250 Al Cap Flush	5,962,540.029	1,502,118.494	27.46	26–LB50 Al Cap Flush
5,964,233.822	1,514,375.381	10.19	06–RB50 Al Cap Flush	BURRIED UNDER GRAVEL			26–RB100 Al Cap Flush
5,962,644.628	1,513,005.197	10.58	07–LB200 Al Cap Flush	5,962,502.417	1,502,535.991	8.29	26–RB50 Al Cap Flush
5,962,683.997	1,513,149.917	12.40	07–LB50 Al Cap Flush	5,962,409.840	1,502,047.832	26.75	27–LB100 Al Cap Flush
5,963,144.351	1,514,844.945	10.50	07–RB200 Al Cap Flush	5,962,406.393	1,502,097.689	27.08	27–LB50 Al Cap Flush
5,963,105.246	1,514,700.397	9.82	07–RB50 Al Cap Flush	5,962,371.836	1,502,567.565	9.06	27–RB100 Al Cap Flush
5,961,864.665	1,513,132.738	10.2	08–LB200 Al Cap Flush	5,962,375.576	1,502,517.753	7.45	27–RB50 Al Cap Flush
5,961,851.284	1,513,282.157	10.33	08–LB50 Al Cap Flush	5,961,986.379	1,502,006.081	20.98	28–LB100 Al Cap Flush
5,961,442.295	1,513,168.264	10.42	09–LB200 Al Cap Flush	5,961,983.603	1,502,055.994	21.16	28–LB50 Al Cap Flush
5,961,424.719	1,513,317.431	10.13	09–LB50 Al Cap Flush	5,961,957.194	1,502,536.500	9.11	28–RB100 Al Cap Flush
5,961,244.647	1,514,849.158	9.12	09–RB200 Al Cap Flush	5,961,959.887	1,502,486.585	8.59	28–RB50 Al Cap Flush
5,961,260.962	1,514,709.975	8.00	09–RB60 Al Cap Flush	5,961,446.898	1,502,073.299	24.32	29–LB100 Al Cap Flush
5,961,214.551	1,513,133.956	10.14	10–LB200 Al Cap Flush	5,961,457.481	1,502,122.198	23.74	29–LB50 Al Cap Flush
5,961,195.621	1,513,282.771	10.03	10–LB50 Al Cap Flush	5,961,559.094	1,502,596.981	9.95	29–RB100 Al Cap Flush
5,961,004.269	1,514,808.574	7.14	10–RB200 Al Cap Flush	5,961,548.539	1,502,547.942	8.74	29–RB50 Al Cap Flush
5,961,023.112	1,514,659.873	8.32	10–RB50 Al Cap Flush	5,960,727.323	1,502,515.764	23.70	30–LB100 Al Cap Flush
5,960,173.813	1,512,898.140	10.87	11–LB200 Al Cap Flush	5,960,768.246	1,502,544.713	23.31	30–LB50 Al Cap Flush
	DESTROYED		11–LB50 Al Cap Flush	5,961,239.638	1,502,877.149	10.09	30–RB100 Al Cap Flush
5,959,731.052	1,514,682.745	9.82	11–RB200 Al Cap Flush	5,961,198.817	1,502,848.288	9.62	30–RB50 Al Cap Flush
5,959,767.242	1,514,537.080	9.00	11–RB50 Al Cap Flush	5,960,124.411	1,503,193.299	8.62	31–LB100 Al Cap Flush
5,958,209.440	1,512,625.576	11.02	12–LB200 Al Cap Flush	5,960,172.274	1,503,207.266	9.61	31–LB50 Al Cap Flush
5,958,254.040	1,512,715.127	10.92	12–LB100 Al Cap Flush	5,960,896.074	1,503,418.951	10.76	31–RB100 Al Cap Flush
5,959,260.219	1,514,746.099	9.87	12–RB200 Al Cap Flush	5,960,848.125	1,503,404.834	11.27	31–RB50 Al Cap Flush
5,959,193.533	1,514,611.494	8.71	12–RB50 Al Cap Flush	5,959,762.546	1,504,523.242	8.41	32–LB100 Al Cap Flush
5,955,329.125	1,512,738.208	11.43	13–LB200 Al Cap Flush	5,959,810.524	1,504,537.152	7.89	32–LB50 Al Cap Flush
5,955,412.750	1,512,862.609	12.06	13–LB50 Al Cap Flush	5,960,406.267	1,504,711.424	10.85	32–RB100 Al Cap Flush
5,958,195.963	1,517,009.777	10.14	13–RB200 Al Cap Flush	5,960,358.129	1,504,697.371	11.51	32–RB50 Al Cap Flush
5,958,123.467	1,516,901.811	11.55	13–RB70 Al Cap Flush	5,959,118.940	1,505,412.996	10.03	33–LB100 Al Cap Flush
5,953,908.305	1,514,359.013	13.31	14–LB215 Al Cap Flush	5,959,138.921	1,505,458.863	8.59	33–LB50 Al Cap Flush
5,953,965.587	1,514,513.819	15.69	14–LB50 Al Cap Flush	5,959,403.885	1,506,064.808	10.64	33–RB120 Al Cap Flush
5,954,950.427	1,517,166.196	9.37	14–RB200 Al Cap Flush	5,959,375.851	1,506,000.615	10.61	33–RB50 Al Cap Flush
5,954,898.227	1,517,025.567	9.62	14–RB50 Al Cap Flush	5,957,567.999	1,505,617.468	12.62	34–LB100 Al Cap Flush
5,952,688.560	1,515,253.984	13.81	15–LB200 Al Cap Flush	5,957,571.228	1,505,667.234	12.76	34–LB50 Al Cap Flush
5,952,688.785	1,515,404.124	16.65	15–LB50 Al Cap Flush	5,957,615.360	1,506,366.139	10.14	34–RB100 Al Cap Flush
5,952,691.528	1,517,195.155	12.55	15–RB100 Al Cap Flush	5,957,612.187	1,506,316.238	10.73	34–RB50 Al Cap Flush
5,952,691.504	1,517,145.172	12.62	15–RB50 Al Cap Flush	5,955,603.337	1,506,200.646	12.56	35–LB100 Al Cap Flush
5,967,852.411	1,508,476.570	9.97	16–LB100 Al Cap Flush	5,955,624.160	1,506,246.181	13.00	35–LB50 Al Cap Flush
5,967,804.830	1,508,492.228	9.22	16–LB50 Al Cap Flush	5,955,901.753	1,506,854.754	10.25	35–RB100 Al Cap Flush
5,967,407.583	1,508,622.098	9.35	16–RB100 Al Cap Flush	5,955,880.833	1,506,809.440	9.42	35–RB50 Al Cap Flush
5,967,455.156	1,508,606.495	8.81	16–RB50 Al Cap Flush	5,962,713.562	1,510,877.357	8.07	36–LB100 Al Cap Flush
5,966,795.092	1,507,822.806	8.49	17–LB100 Al Cap Flush	5,962,690.396	1,510,921.695	8.07	36–LB50 Al Cap Flush
5,966,786.414	1,507,872.068	8.36	17–LB50 Al Cap Flush	5,962,479.473	1,511,322.888	9.50	36–RB100 Al Cap Flush
5,966,712.932	1,508,294.932	8.55	17–RB100 Al Cap Flush	5,962,502.709	1,511,278.659	8.95	36–RB50 Al Cap Flush
5,966,720.904	1,508,245.574	8.57	17–RB50 Al Cap Flush	5,962,603.138	1,510,806.681	8.54	37–LB100 Al Cap Flush
5,965,609.736	1,507,451.191	8.67	18–LB100 Al Cap Flush	5,962,580.899	1,510,851.601	8.30	37–LB50 Al Cap Flush
5,965,566.246	1,507,475.943	8.64	18–LB50 Al Cap Flush	5,962,382.914	1,511,254.351	9.43	37–RB100 Al Cap Flush
5,965,103.321	1,507,739.424	7.92	18–RB100 Al Cap Flush	5,962,405.072	1,511,209.390	8.82	37–RB50 Al Cap Flush
5,965,146.872	1,507,714.623	7.65	18–RB50 Al Cap Flush	5,962,540.247	1,510,738.266	7.55	38–LB100 Al Cap Flush
5,965,119.506	1,505,573.364	8.71	19–LB100 Al Cap Flush	5,962,518.495	1,510,783.408	7.94	38–LB50 Al Cap Flush
5,965,073.146	1,505,592.274	8.72	19–LB50 Al Cap Flush	5,962,311.243	1,511,215.086	8.87	38–RB100 Al Cap Flush
5,964,684.662	1,505,750.583	8.18	19–RB100 Al Cap Flush	5,962,332.728	1,511,169.935	8.96	38–RB50 Al Cap Flush
5,964,730.844	1,505,731.763	8.59	19–RB50 Al Cap Flush	5,962,367.922	1,510,674.689	8.40	39–LB100 Al Cap Flush
5,964,307.555	1,503,508.766	13.76	20–LB100 Al Cap Flush	5,962,346.127	1,510,719.731	7.44	39–LB50 Al Cap Flush
5,964,270.636	1,503,542.458	15.57	20–LB50 Al Cap Flush	5,962,154.431	1,511,119.189	9.32	39–RB100 Al Cap Flush
5,963,935.619	1,503,847.844	7.68	20–RB100 Al Cap Flush	5,962,176.176	1,511,074.056	9.20	39–RB50 Al Cap Flush





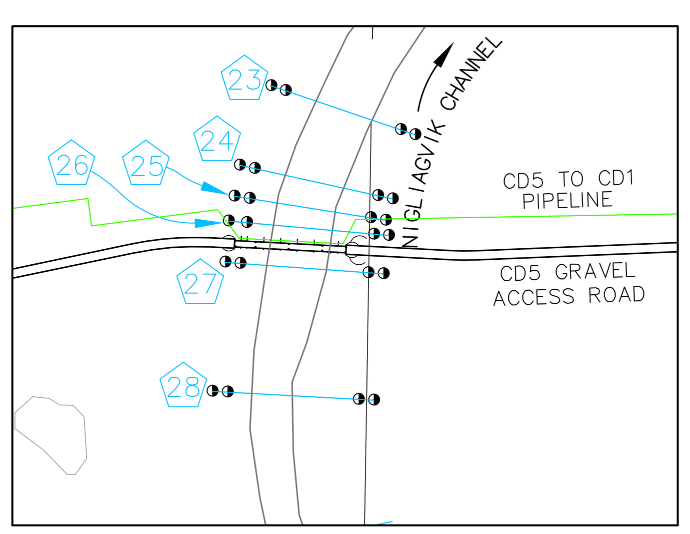
VICINITY MAP

NOTES:

1. DATE OF SURVEY: AUGUST 29 TO SEPTEMBER 18, 2013; OCTOBER 21, 2013; JUNE 29 TO JULY 26, 2016; JULY 26, 2017 TO AUGUST 24, 2017; AUGUST 12 TO AUGUST 19, 2018; AUGUST 19 TO AUGUST 31, 2019; AUGUST 27 TO AUGUST 30, 2020.
2. COORDINATES SHOWN ARE ALASKA STATE PLANE, ZONE 4 N.A.D. 83, IN FEET.
3. ELEVATIONS SHOWN ARE BRITISH PETROLEUM MEAN SEA LEVEL (B.P.M.S.L.) DATUM.
4. REFERENCE FIELD BOOK 2013–18, PGS. 57–59, 67, 70–72. 2013–20 PGS. 4–14; 2013–21, PG. 29; 2016–11, PG. 76, 2016–12, PGS. 17–20, 26–28, 36–37 & 59; 2017–13, PGS. 70–73, 2017–14, PGS. 15–17; 2017–15, PGS. 3–27; 2018–18, PG. 2–4; 2018–13, PG. 35–38; 2018–17, PG. 19–20; 2019–28, PGS. 56–67; 2019–29, PG. 43–44; 2019–34, PG.4; 2020–26, PGS 27–39.

LEGEND:

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



ENLARGED DIAGRAM

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

FORM: DSIZE

REFERENCE DWG NO/SHT NO:

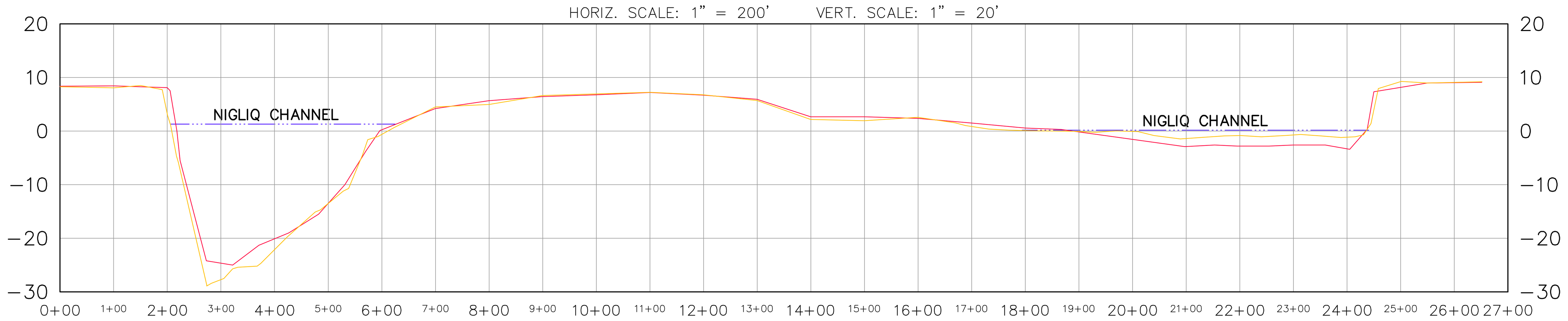
REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
6	08/31/20	UPDATED PER K200003ACS	CSS	CZ			
5	09/02/19	UPDATED PER K190003ACS	SZ	CZ			
4	08/20/18	UPDATED PER K180003ACS	SZ	CZ			
3	10/9/17	UPDATED PER K170003ACS	KD	CZ			
2	7/29/16	UPDATED PER K160003ACS	CZ	DB			
1	10/22/13	ISSUED PER K130003ACS	AG	DB			

DATE: 8/26/13 | DRAWN: CZ | DESIGN: – | ECM NO: –
CHECKED: DB | CC NO: –
SCALE: 1" = 2000' | 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: 6

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

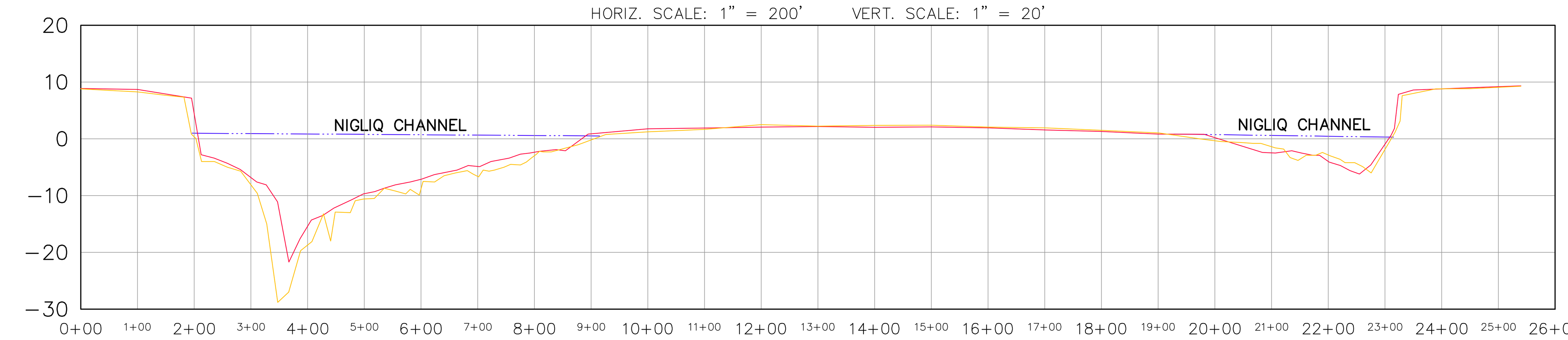
Profile View of Transect-1

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



Profile View of Transect-2

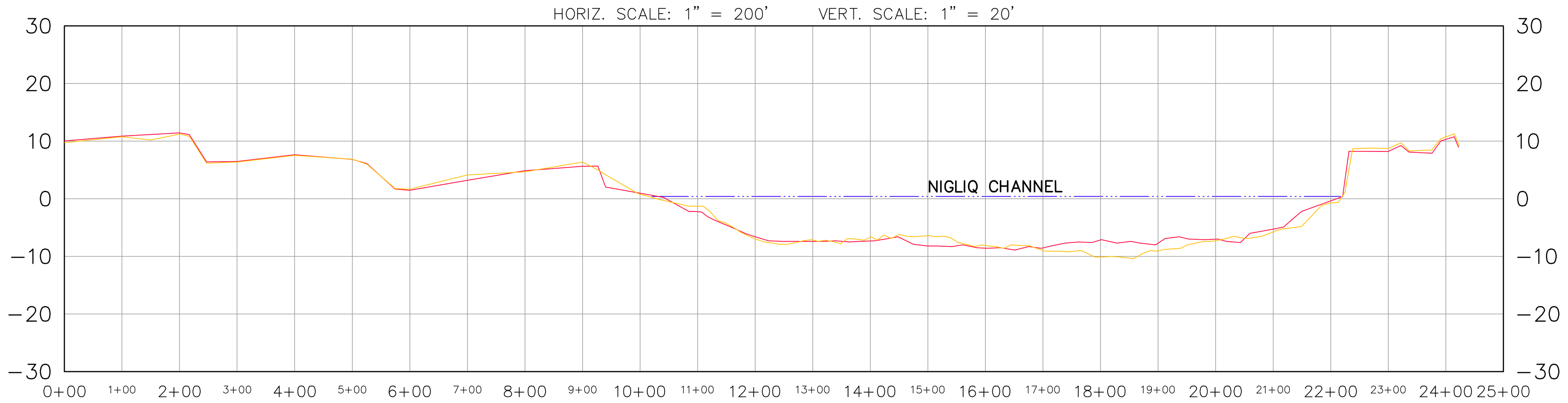
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



LEGEND:
VIEW LOOKING DOWNSTREAM
2013 TRANSECT PROFILE
2019 TRANSECT PROFILE

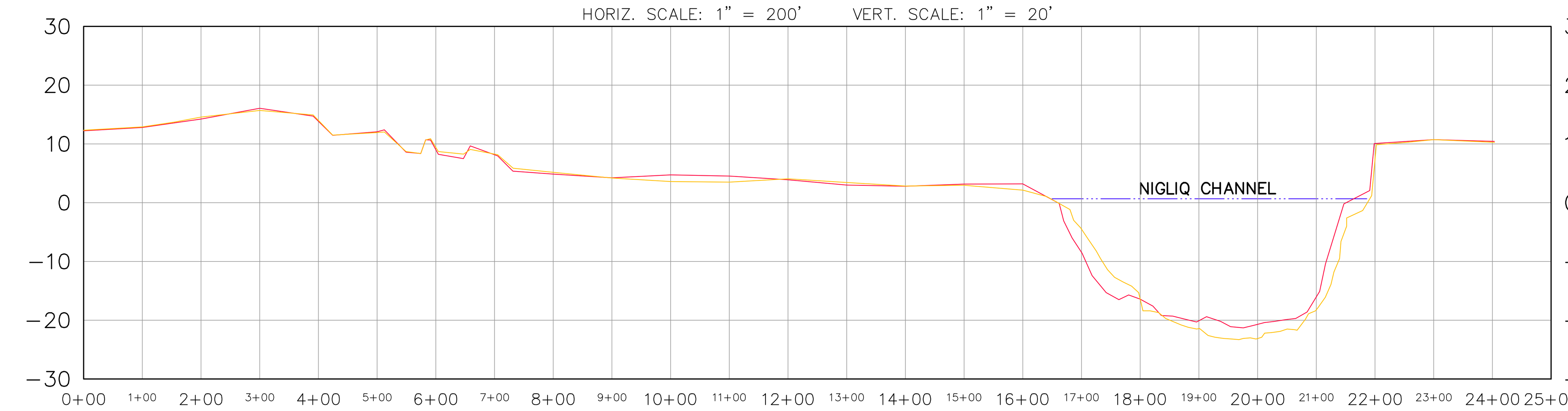
Profile View of Transect-3

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



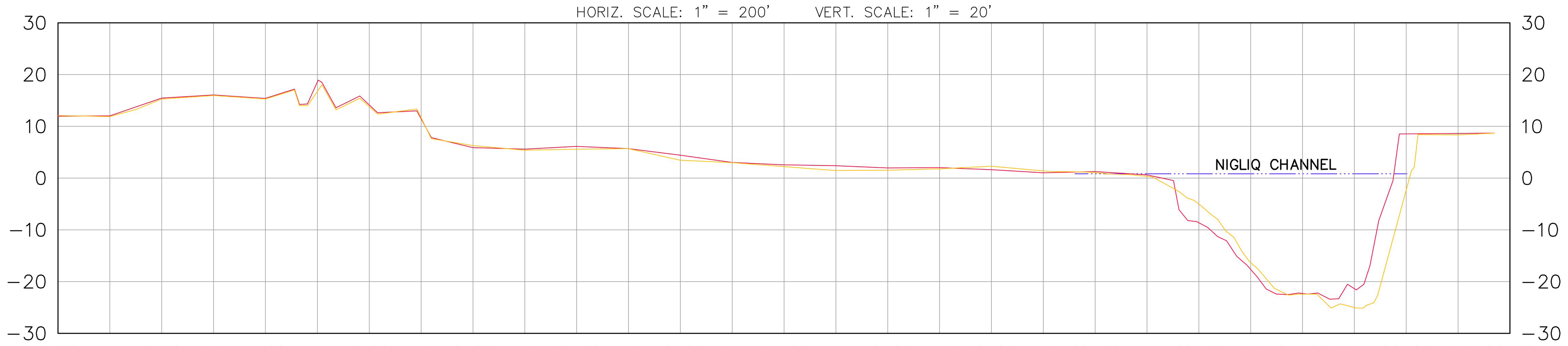
Profile View of Transect-4

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



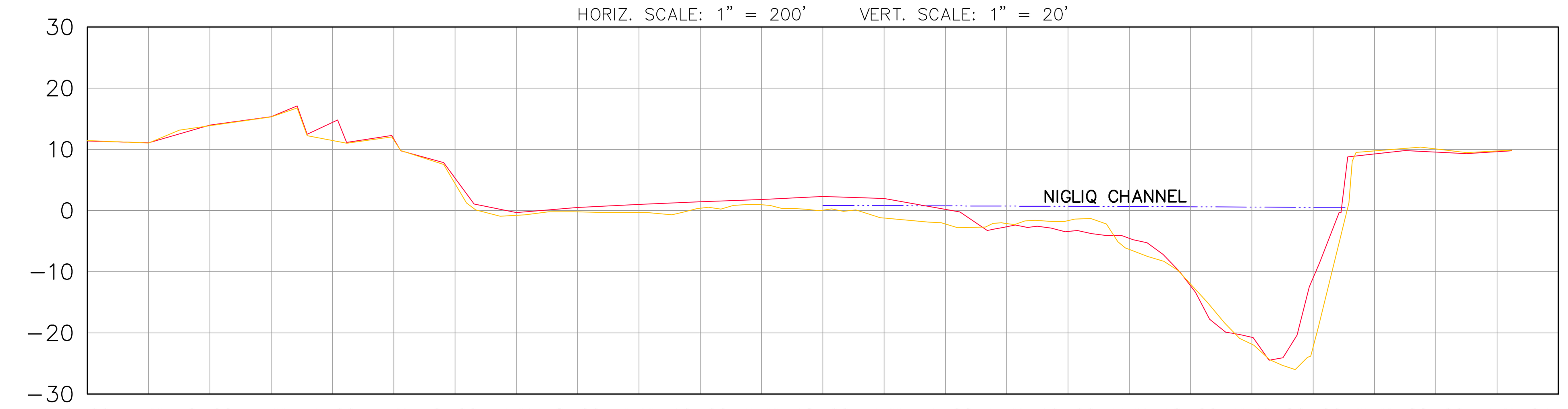
Profile View of Transect-5

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
4	09/02/2019	UPDATED PER K190003ACS	SZ	CZ			
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
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.

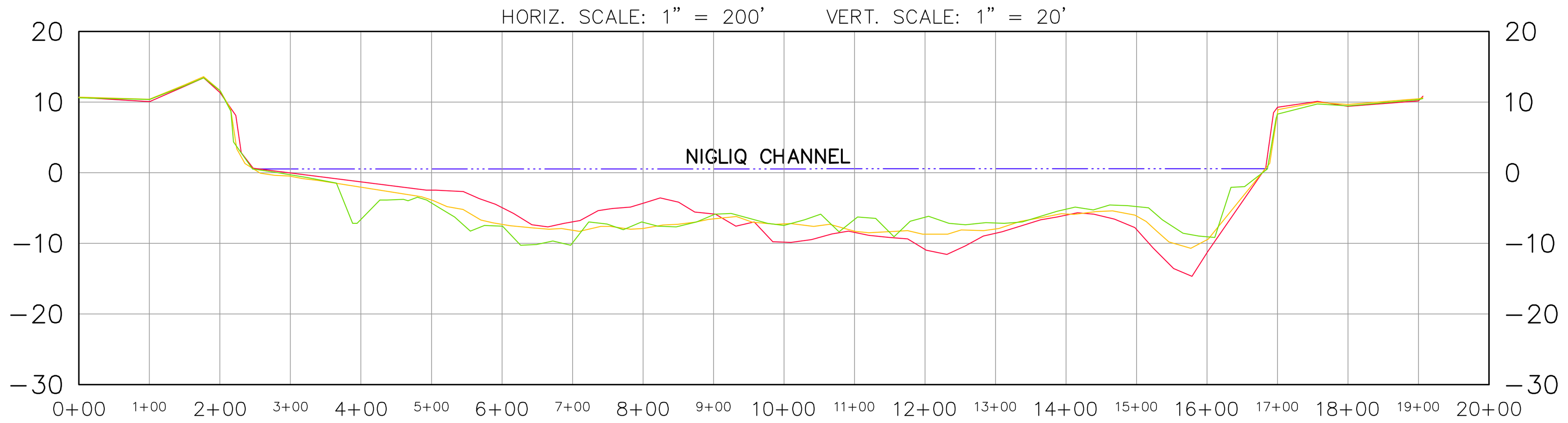
DRAWN: CZ
DESIGN: –
CHECKED: DB
REDRAWN FROM: –
APPROVAL: –

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

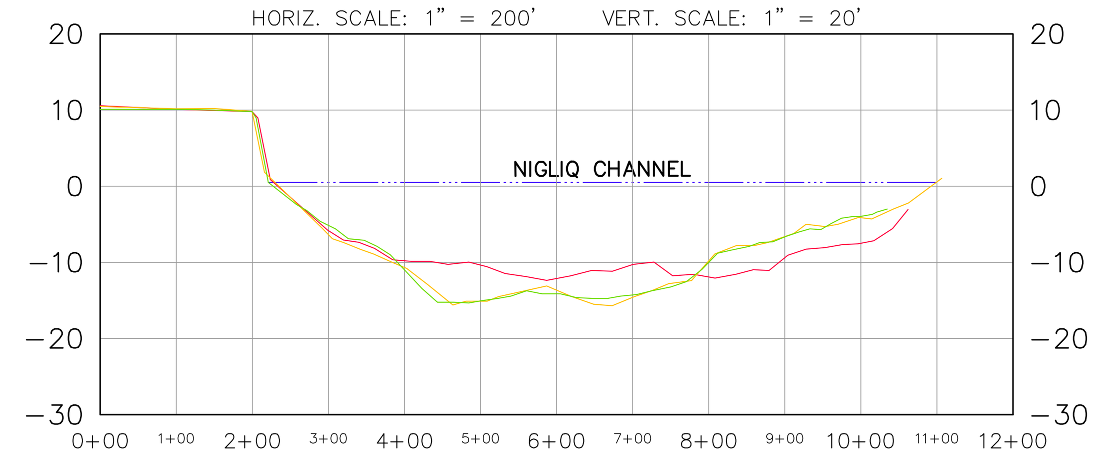
JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	2 of 6	4

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

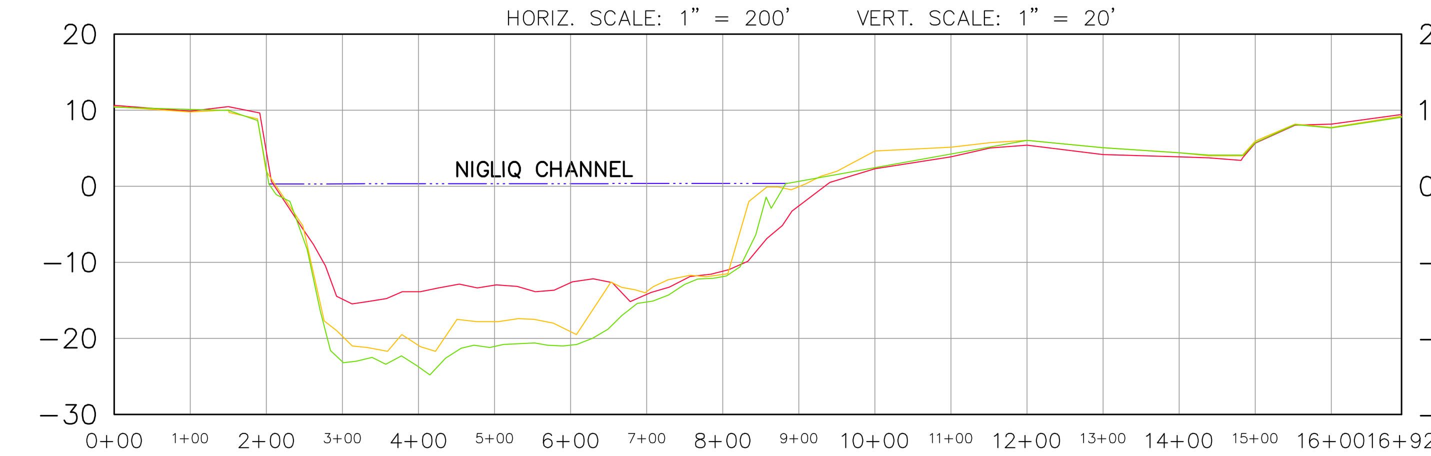
Profile View of Transect-7
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



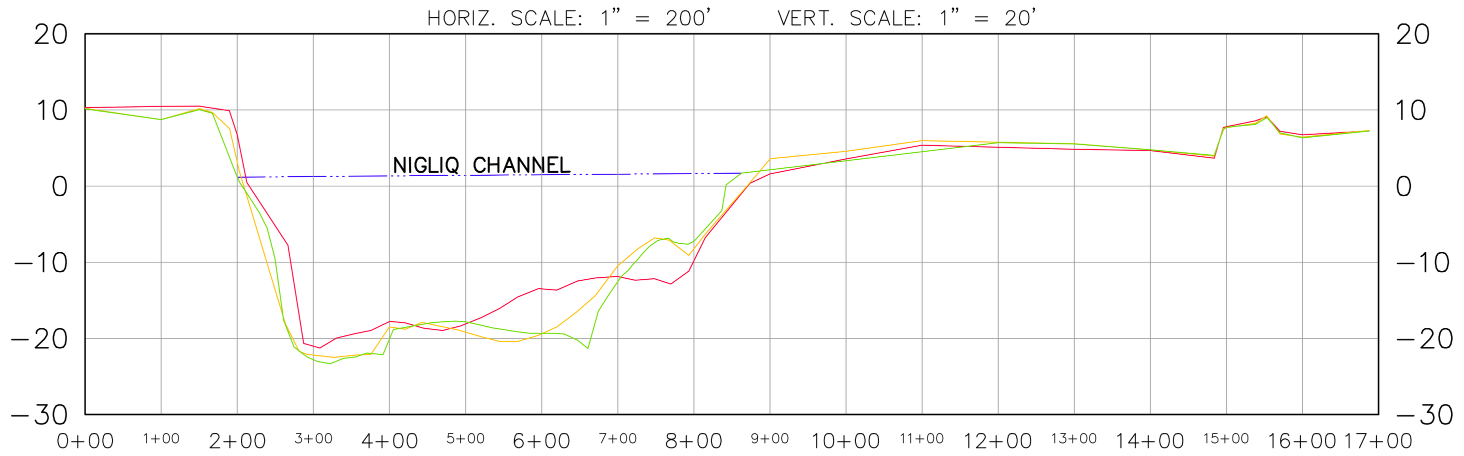
Profile View of Transect-8
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



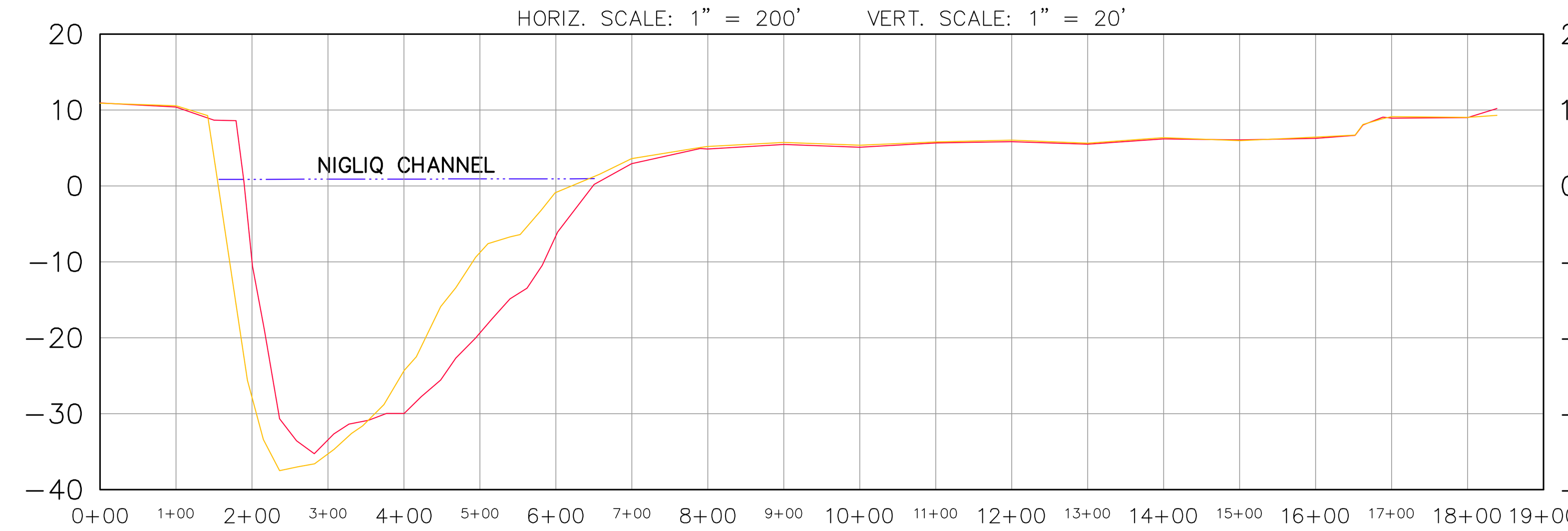
Profile View of Transect-9
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



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

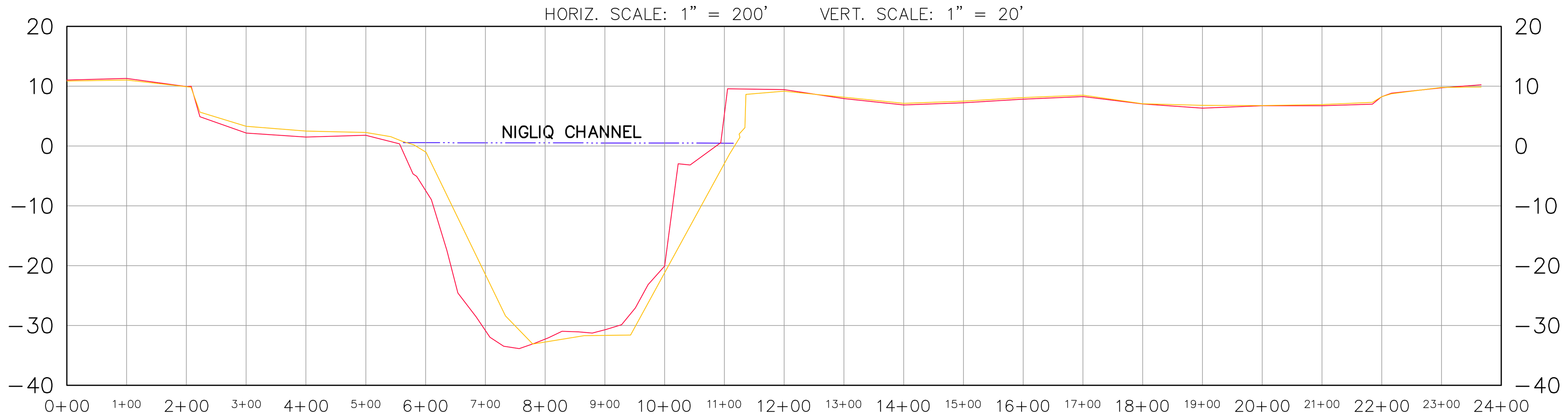


Profile View of Transect-11
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



LEGEND:
VIEW LOOKING DOWNSTREAM
2013 TRANSECT PROFILE
2019 TRANSECT PROFILE
2020 TRANSECT PROFILE

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



REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
6	08/31/20	UPDATED PER K200003ACS	CSS	CZ			
5	08/30/20	UPDATED PER K200003ACS	WJ	CZ			
4	09/02/19	UPDATED PER K190003ACS	SZ	CZ			
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
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: –

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

FORM: DSIZEPID

ALPINE MODULE: CD50 UNIT: CD

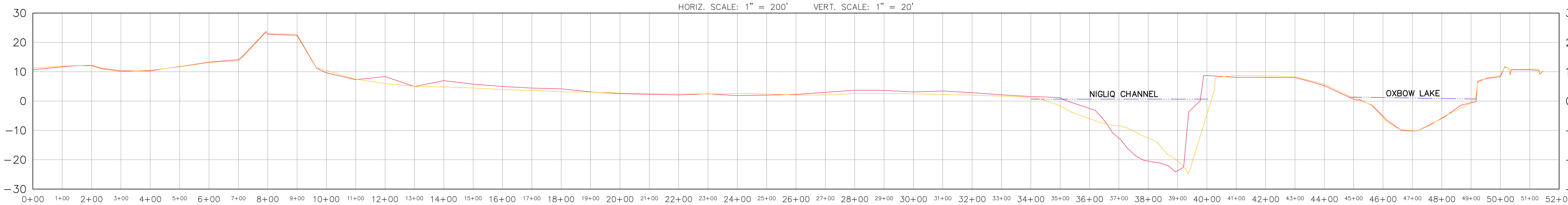
CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

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

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

Profile View of Transect–13

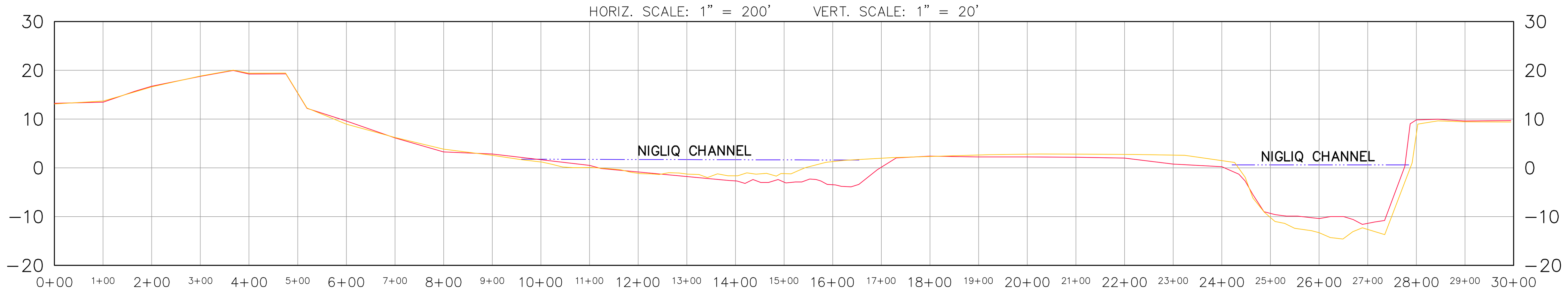
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



LEGEND:
VIEW LOOKING DOWNSTREAM
2013 TRANSECT PROFILE
2019 TRANSECT PROFILE

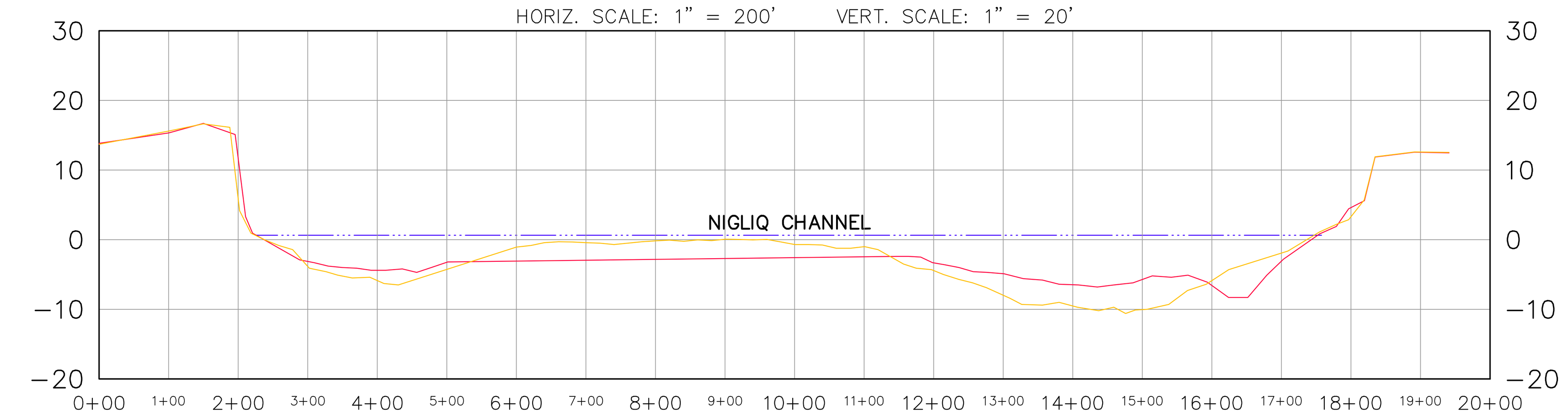
Profile View of Transect–14

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



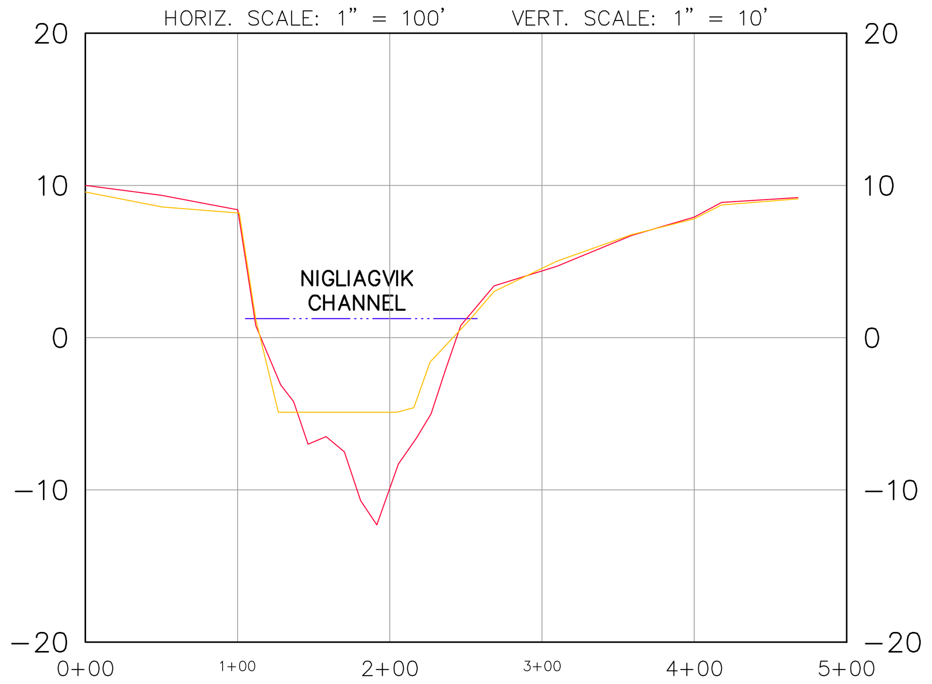
Profile View of Transect–15

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



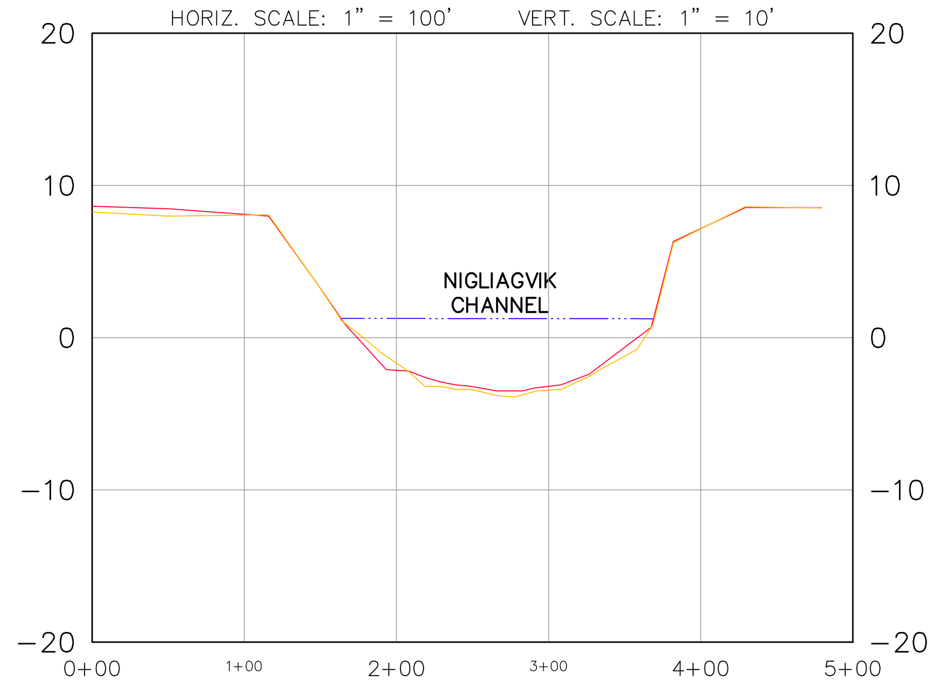
Profile View of Transect–16

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



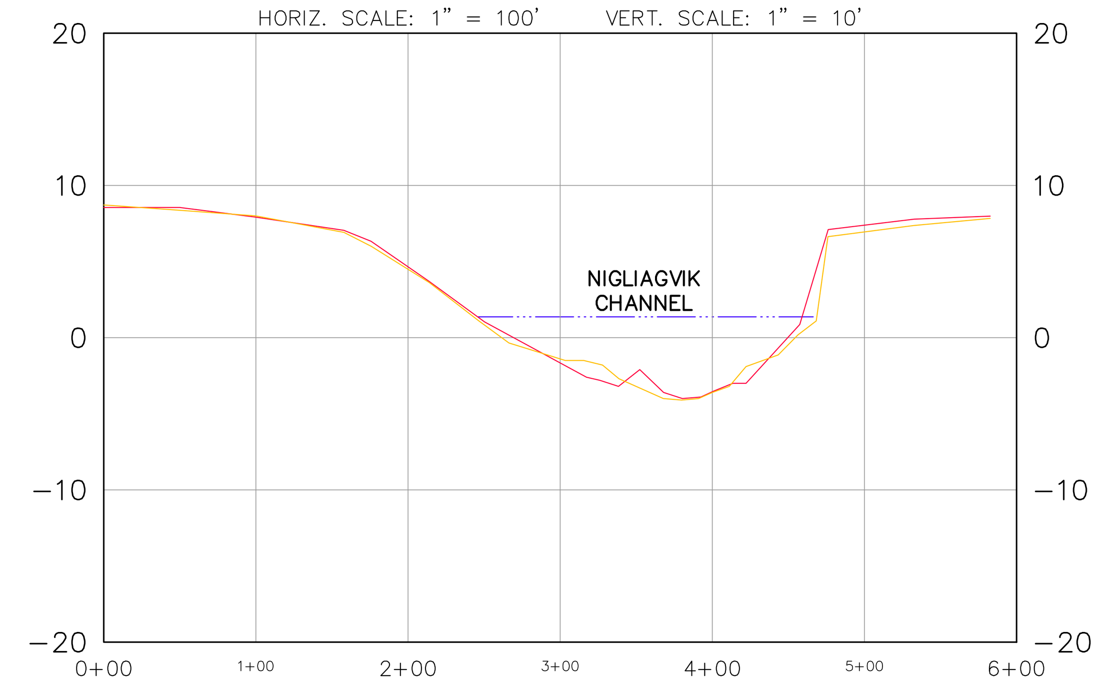
Profile View of Transect–17

HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



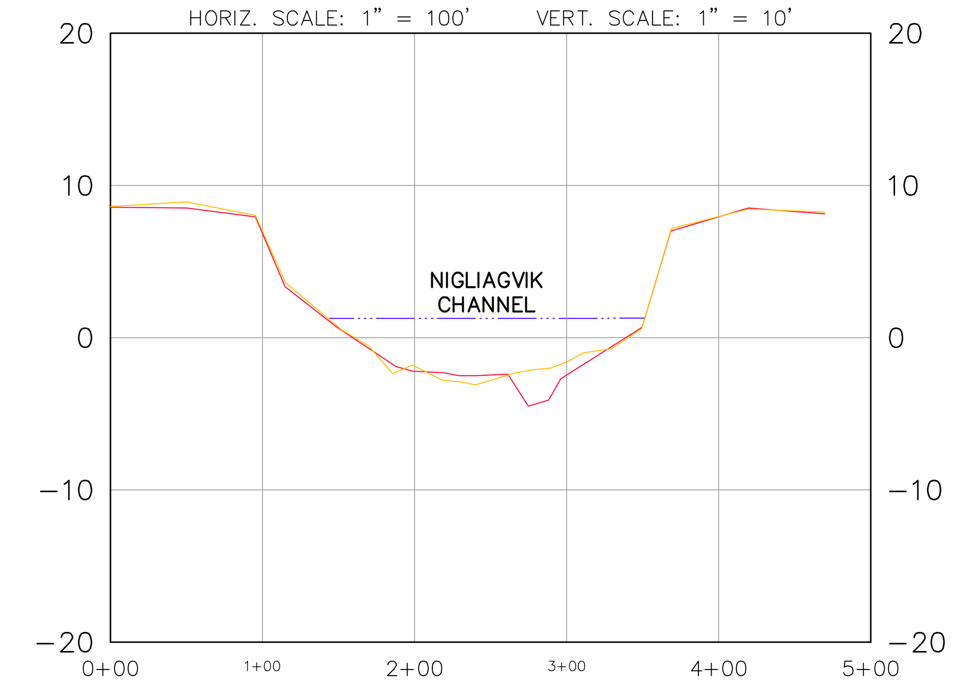
Profile View of Transect–18

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
4	09/02/19	UPDATED PER K190003ACS	SZ	CZ			
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
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: –

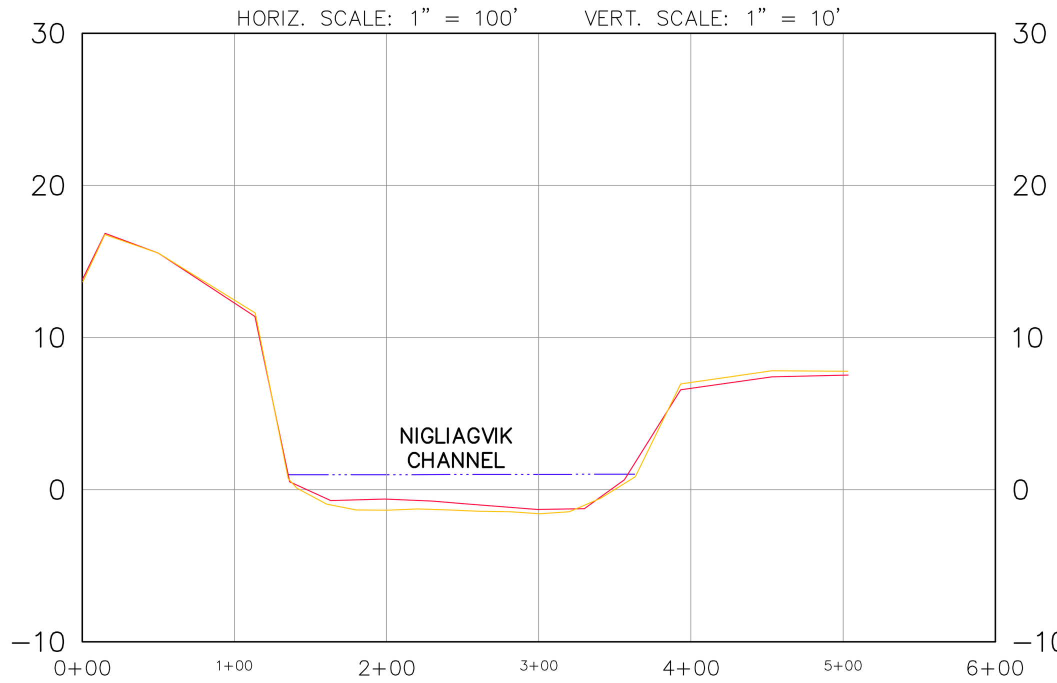
ALPINE
MODULE: CD50
UNIT: CD

CD–5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

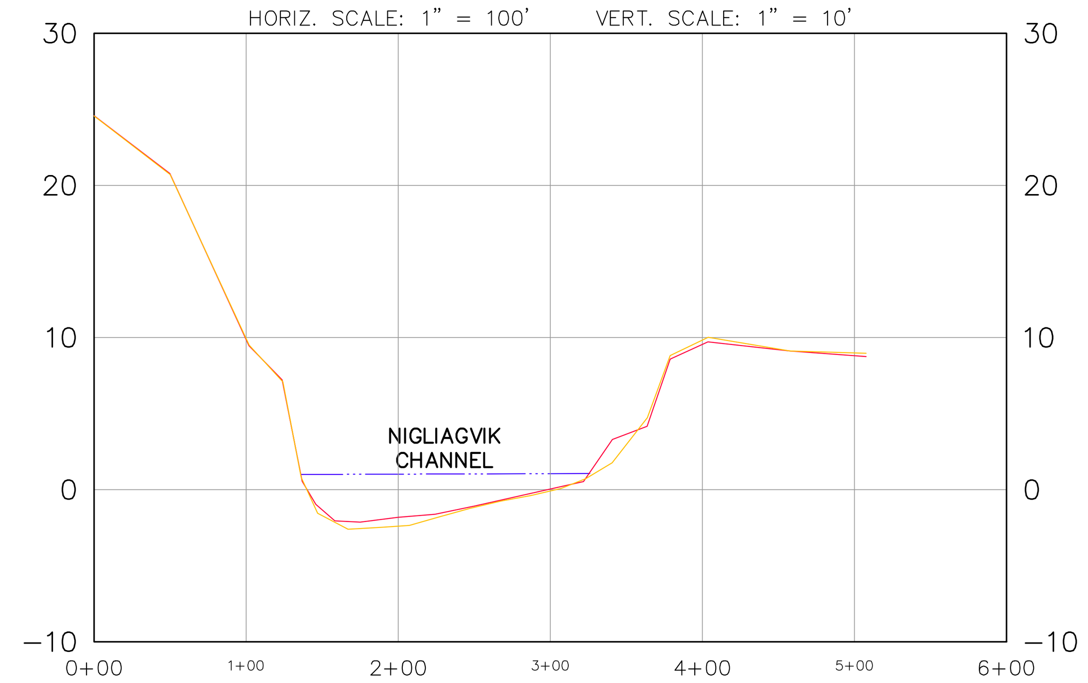
JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	4 of 6	4

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

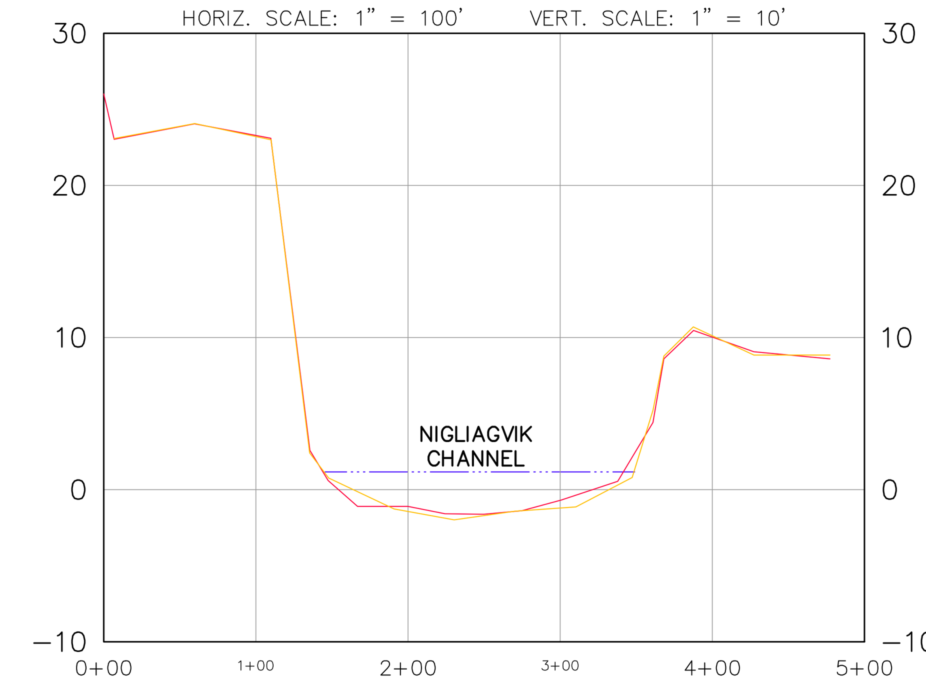
Profile View of Transect-20
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



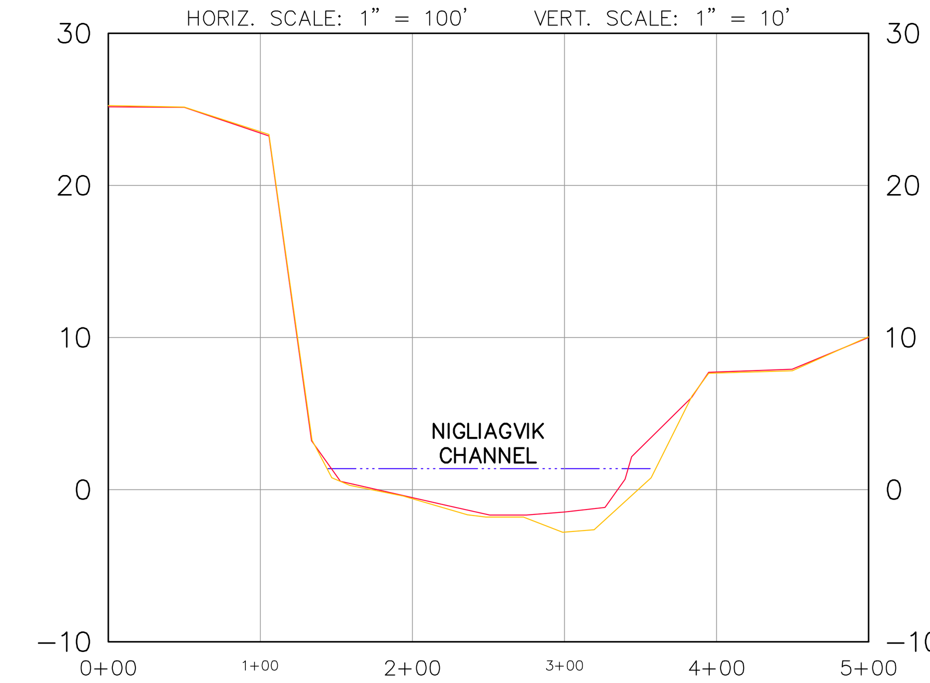
Profile View of Transect-21
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



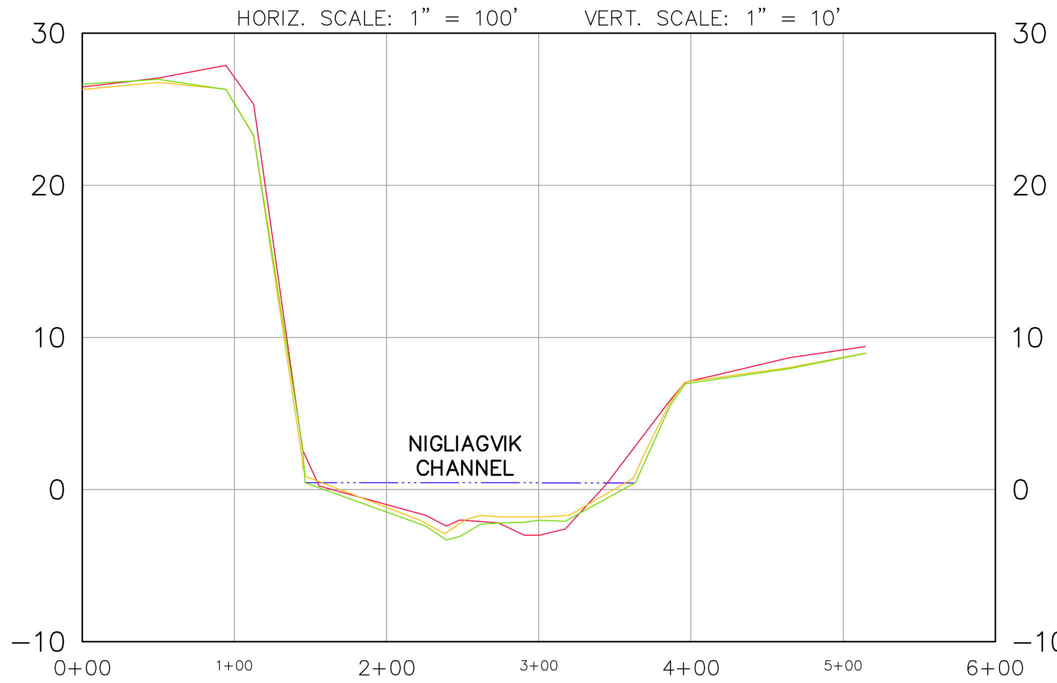
Profile View of Transect-22
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



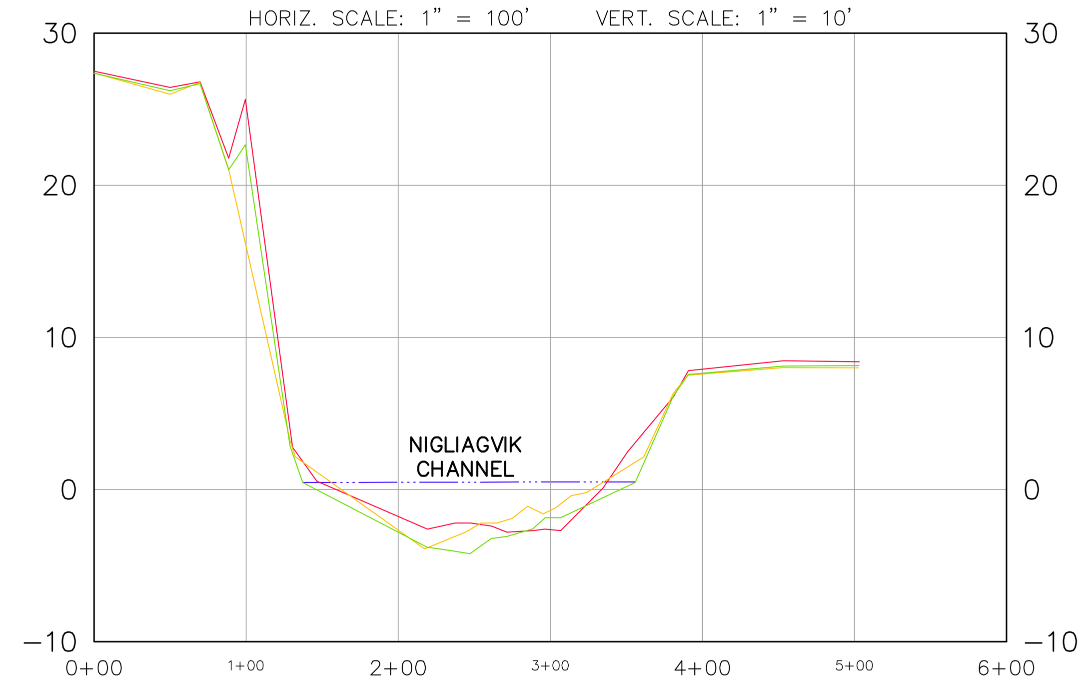
Profile View of Transect-23
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



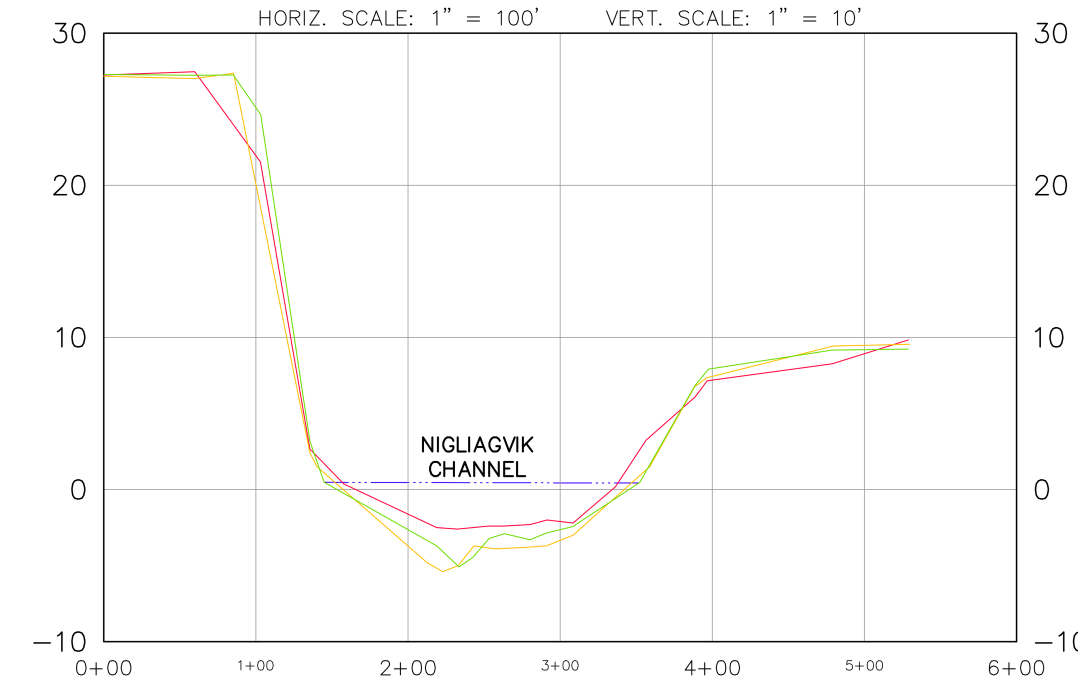
Profile View of Transect-24
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



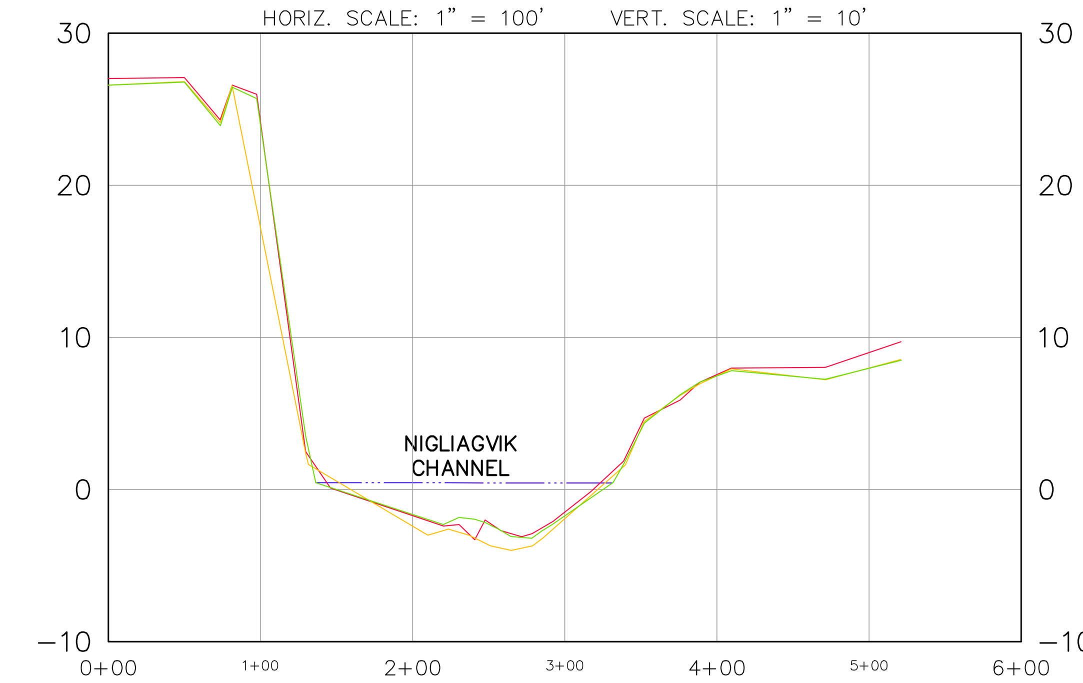
Profile View of Transect-25
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



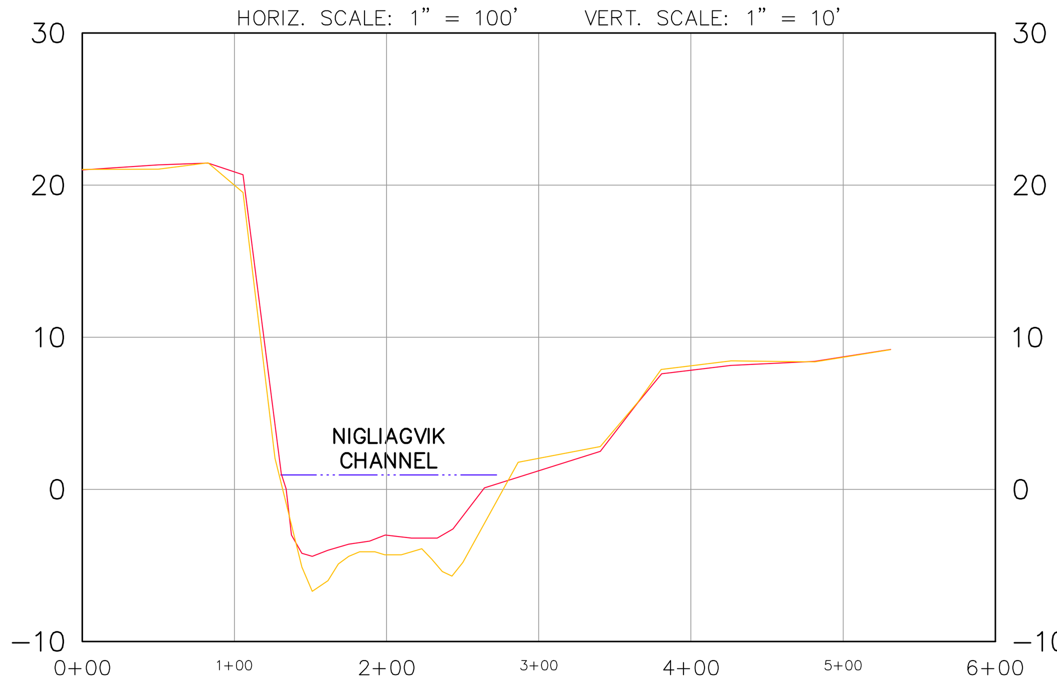
Profile View of Transect-26
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



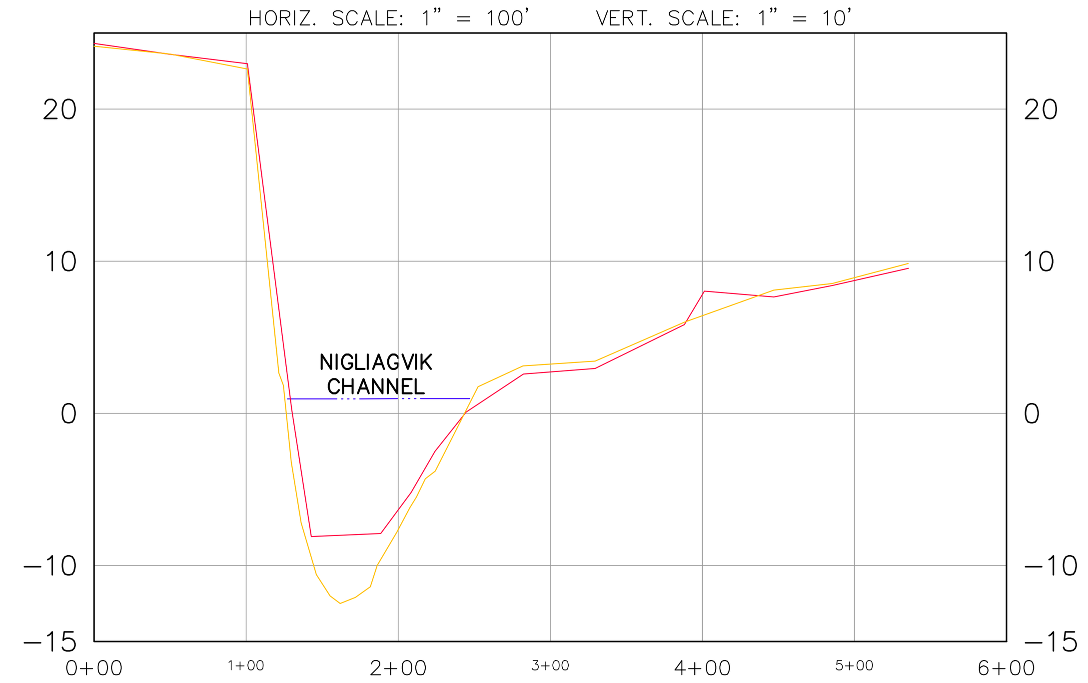
Profile View of Transect-27
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



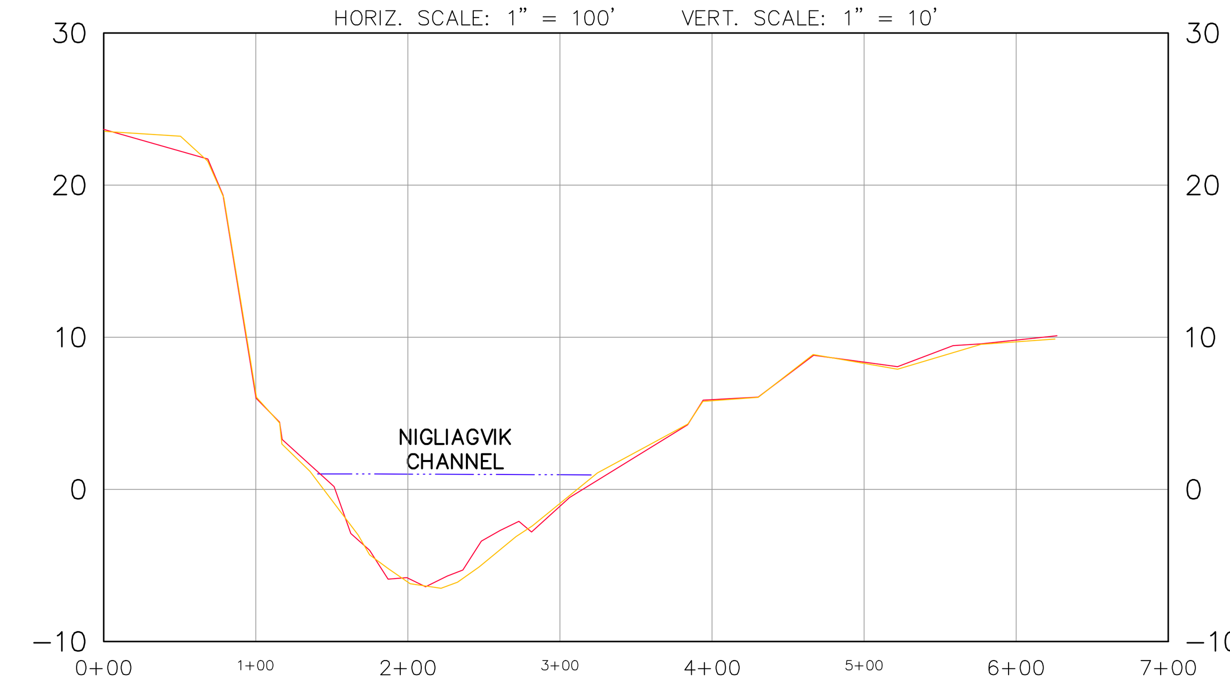
Profile View of Transect-28
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



Profile View of Transect-29
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



Profile View of Transect-30
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



LEGEND:
VIEW LOOKING DOWNSTREAM
2013 TRANSECT PROFILE
2019 TRANSECT PROFILE
2020 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
5	08/31/20	UPDATED PER K200003ACS	CSS	CZ			
4	09/02/19	UPDATED PER K190003ACS	SZ	CZ			
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
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.

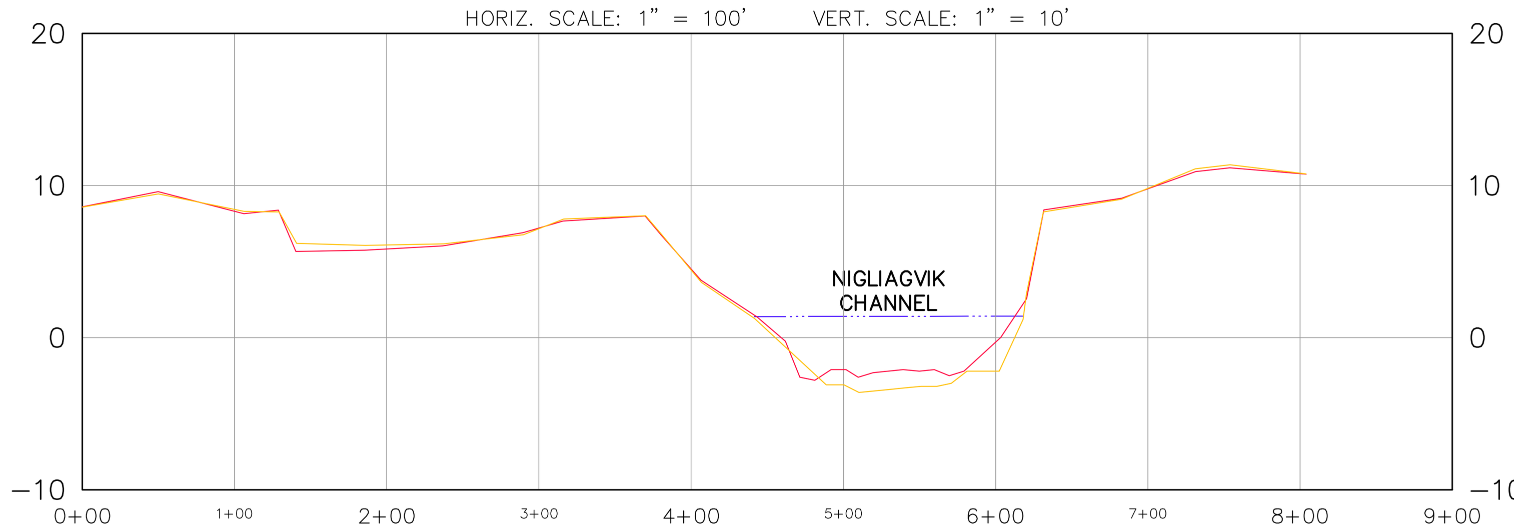
DRAWN: CZ DESIGN: – CHECKED: DB
REDRAWN FROM: – APPROVAL: –

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

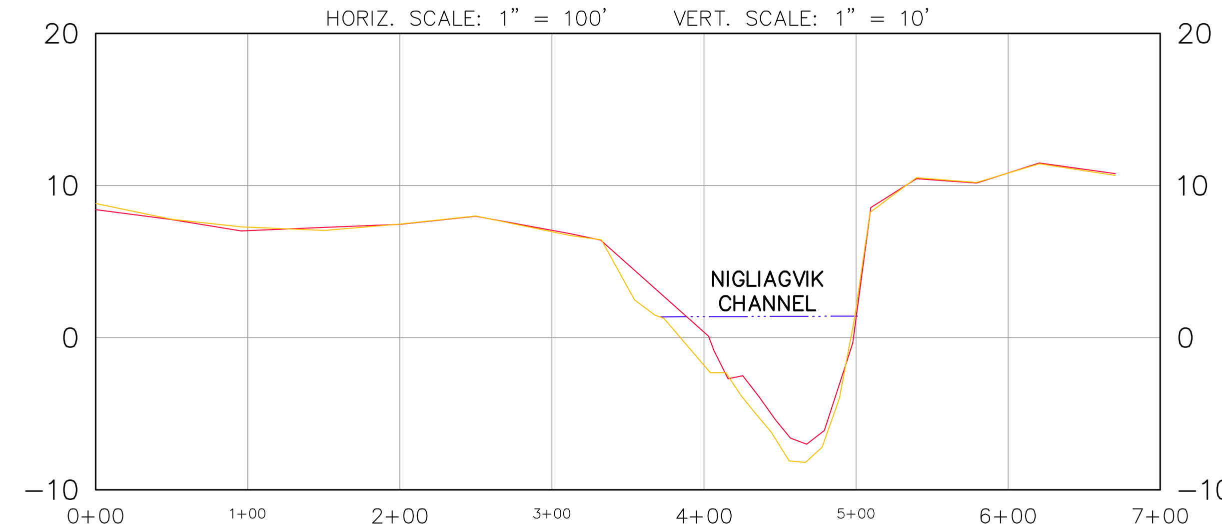
JOB NO:	SUB JOB NO:	DRAWING NO.	PART:	REV:
–	–	CE-CD50-1004	5 of 6	5

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

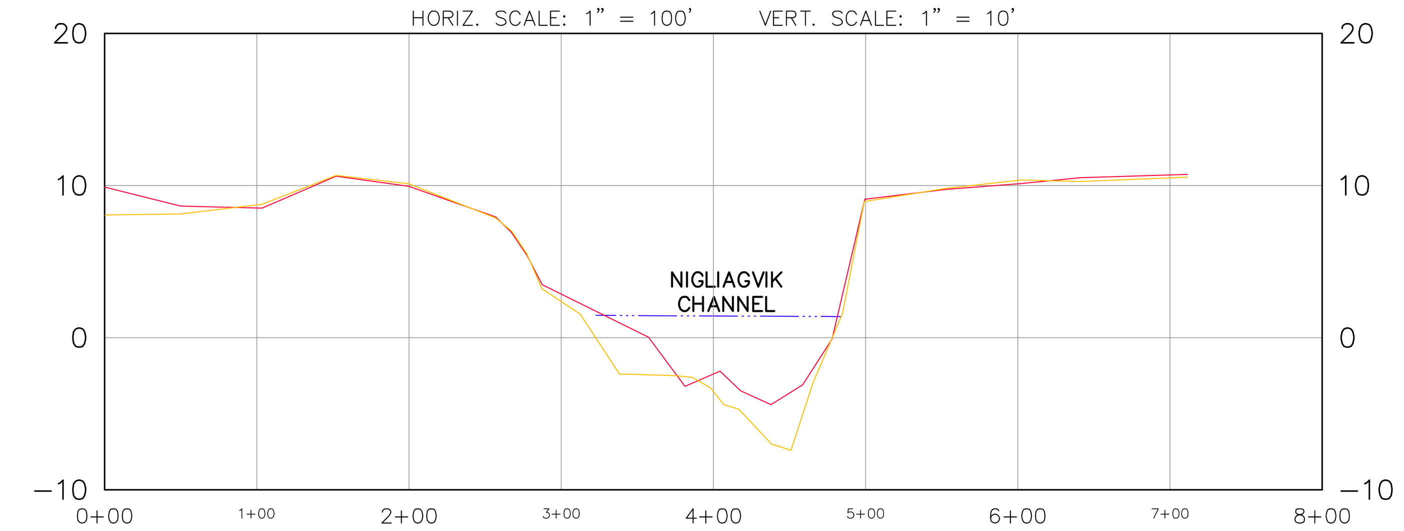
Profile View of Transect-31
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



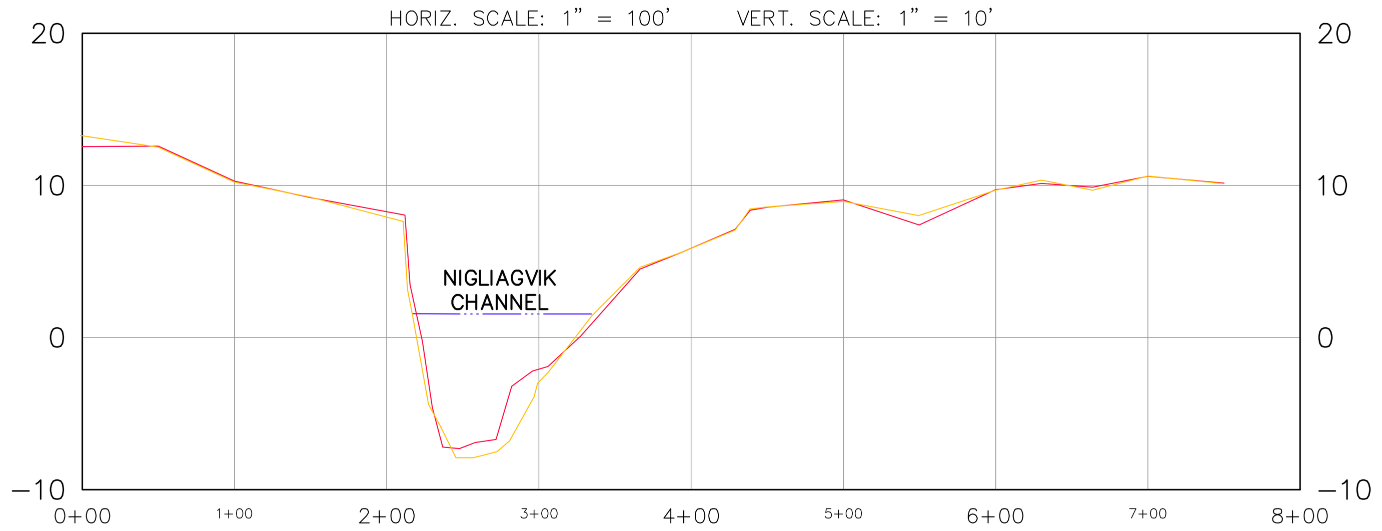
Profile View of Transect-32
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



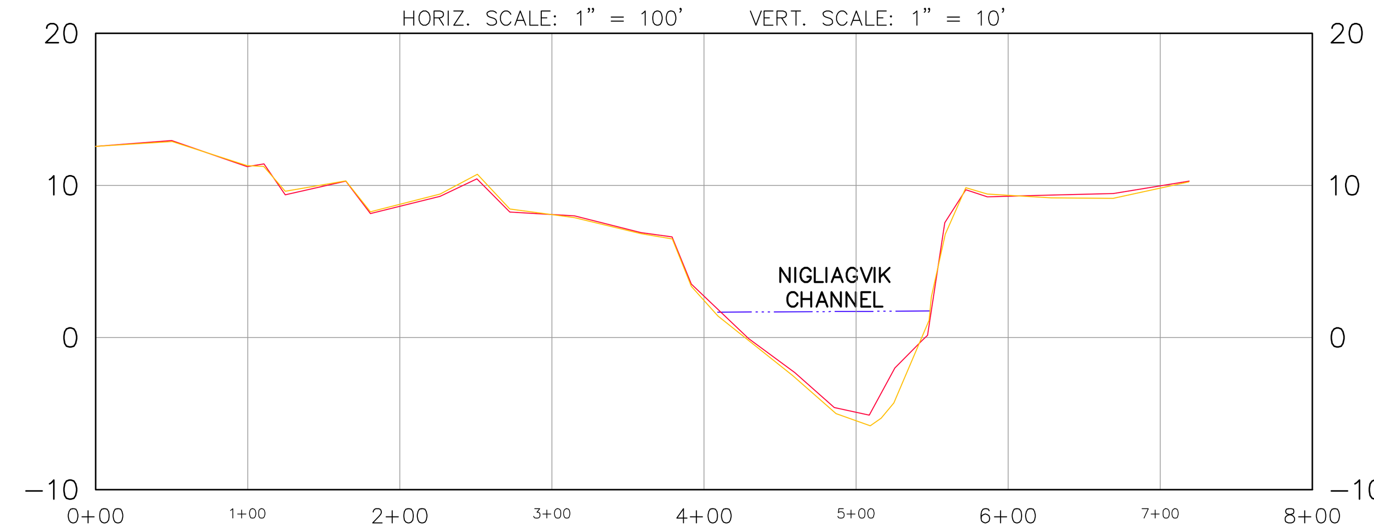
Profile View of Transect-33
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



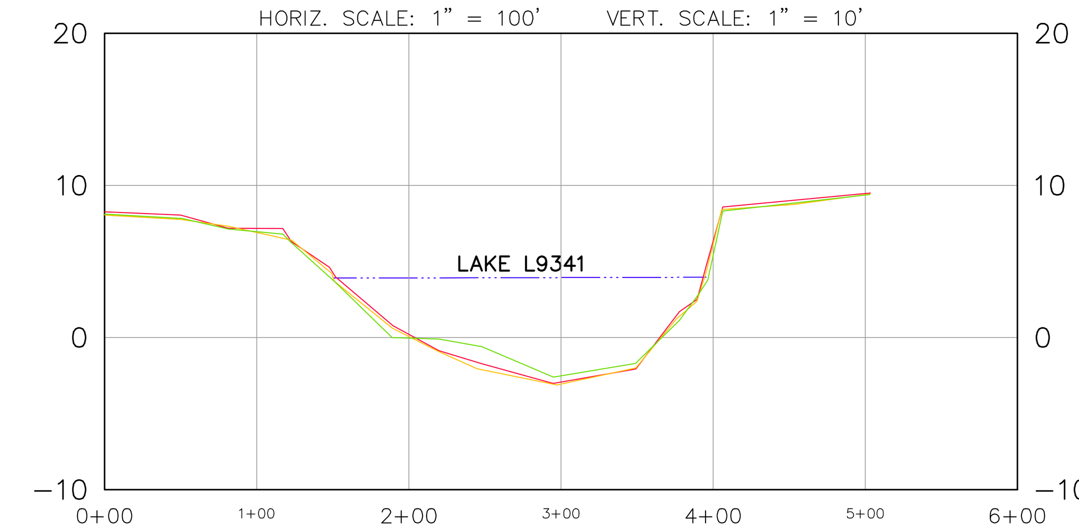
Profile View of Transect-34
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



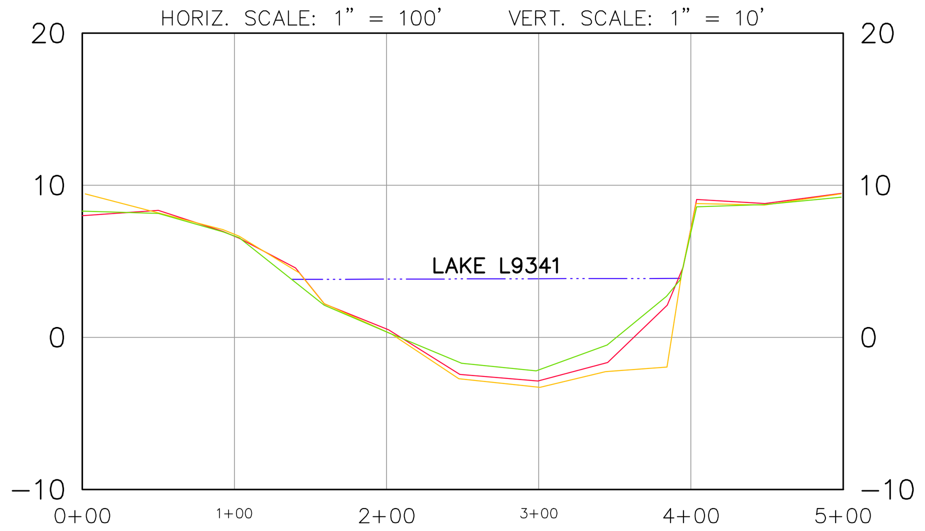
Profile View of Transect-35
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



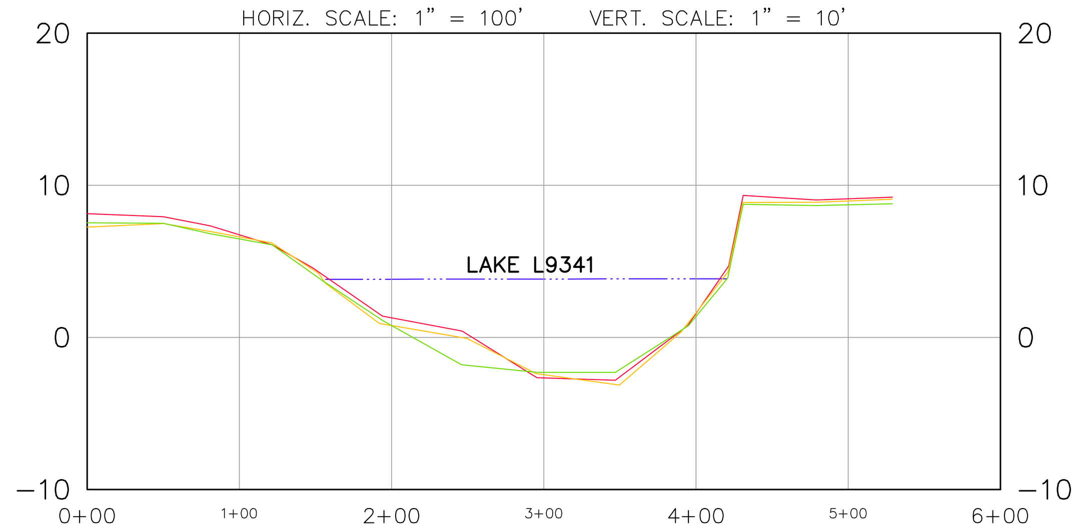
Profile View of Transect-36
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



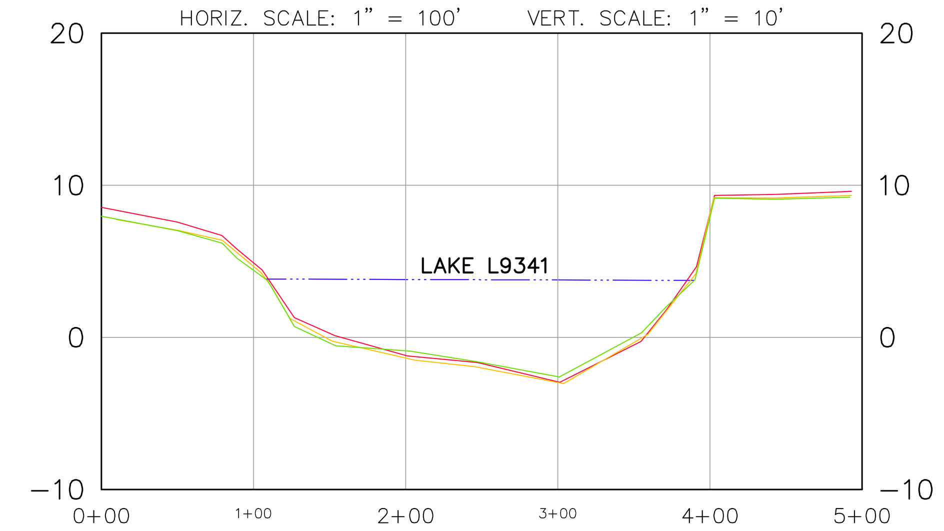
Profile View of Transect-37
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



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

2019 TRANSECT PROFILE

2020 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
5	9/02/20	UPDATED PER K200003ACS	CS	KR			
4	09/02/19	UPDATED PER K190003ACS	SZ	CZ			
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
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	5

E.3.2 NIGLIQ CHANNEL & BRIDGE TABULATED DATA (TRANSECTS 7 – 10)

Calc'd By: CZ
Date: 08/26/20
RPT-CE-CD-114 REV8

CD-5 Michael Baker
Bridge Transects
Transect 7

KUUKPIK UMIAQ

DOC LCMF-156 REV9

STA	2013	2014	2015	2016	2017	2018	2019	2020	Description
0+00	10.6	10.9	10.7	10.7	10.5	10.6	10.7	10.6	Ground Shot
1+00	10.1	10.4	10.4	10.3	10.3	10.3	10.4	10.4	Ground Shot
1+50	12.2	12.4	12.4	12.3	12.3	12.4	12.4	12.3	Ground Shot
1+77	13.4	13.7	13.7	13.5	13.5	13.5	13.6	13.4	Grade Break
2+00	11.3	11.6	11.7	11.6	11.6	11.6	11.6	11.6	Ground Shot
2+15							9.0	8.7	Top of Bank
2+19								4.4	Toe of Bank (2019)
2+20			8.4	8.3	8.0	8.1	-	-	Top of Bank (2018)
2+23	8.1	8.1	-	-	-	-	-	-	Top of Bank (2014)
2+24							3.4	-	Toe of Bank
2+30	2.8	3.0	3.7	3.3	2.9	3.1	-	-	Toe of Bank (2018)
Varies	0.6	0.5	0.8	0.3	1.0	-0.3	1.3	0.5	Edge of Water
4+93	-2.5	-4.1	-4.2	-4.0	-4.0	-3.9	-3.7	-3.9	River Bottom
5+06	-2.5	-4.4	-4.6	-4.0	-4.5	-4.4	-4.1	-4.5	River Bottom
5+25	-2.6	-3.6	-5.0	-4.3	-5.0	-5.0	-4.9	-5.7	River Bottom
5+45	-2.7	-3.7	-5.3	-4.7	-5.0	-5.2	-5.2	-7.3	River Bottom
5+68	-3.7	-3.8	-6.6	-5.6	-6.2	-6.8	-6.5	-7.9	River Bottom
5+91	-4.5	-5.2	-7.0	-7.0	-7.0	-7.1	-7.1	-7.5	River Bottom
6+17	-5.8	-7.6	-7.3	-7.5	-7.6	-7.6	-7.5	-9.0	River Bottom
6+42	-7.4	-7.2	-7.7	-7.3	-7.7	-7.7	-7.8	-10.2	River Bottom
6+65	-7.7	-7.4	-7.7	-7.2	-7.2	-8.0	-8.0	-10.0	River Bottom
6+88	-7.2	-6.3	-7.7	-6.4	-6.7	-7.6	-8.2	-10.0	River Bottom
7+11	-6.8	-6.0	-7.6	-6.6	-6.7	-8.2	-8.3	-8.6	River Bottom
7+37	-5.4	-5.5	-7.6	-6.8	-6.9	-7.8	-7.7	-7.1	River Bottom
7+56	-5.1	-6.3	-7.6	-7.2	-7.3	-7.9	-7.5	-7.5	River Bottom
7+82	-4.9	-7.1	-7.6	-7.3	-7.7	-7.7	-8.0	-7.7	River Bottom
8+02	-4.3	-7.1	-7.6	-6.7	-7.3	-7.8	-7.8	-7.1	River Bottom
8+25	-3.6	-5.6	-7.6	-7.5	-6.9	-7.9	-7.5	-7.6	River Bottom
8+50	-4.2	-5.9	-7.5	-7.0	-6.8	-7.1	-7.3	-7.7	River Bottom
8+74	-5.6	-6.2	-7.5	-7.2	-7.5	-7.0	-7.0	-7.0	River Bottom
9+03	-5.9	-6.1	-7.4	-7.5	-7.9	-8.0	-0.6	-5.9	River Bottom
9+32	-7.6	-5.5	-7.2	-7.8	-7.6	-7.8	-6.2	-6.0	River Bottom
9+58	-7.0	-6.7	-7.0	-7.3	-7.6	-6.6	-7.0	-6.7	River Bottom
9+84	-9.8	-7.4	-6.9	-8.2	-7.9	-6.2	-7.1	-7.3	River Bottom
10+10	-9.9	-10.8	-7.4	-7.8	-8.0	-6.2	-7.2	-7.2	River Bottom
10+39	-9.5	-10.5	-8.0	-8.2	-8.5	-6.7	-7.6	-6.7	River Bottom
10+68	-8.7	-9.2	-7.8	-7.5	-7.9	-7.9	-7.3	-7.2	River Bottom
10+91	-8.3	-9.3	-7.6	-7.8	-7.9	-9.6	-8.2	-7.5	River Bottom
11+21	-8.9	-9.4	-7.4	-7.8	-8.4	-9.3	-8.5	-6.4	River Bottom
11+50	-9.2	-9.7	-9.4	-7.5	-8.4	-8.6	-8.3	-8.4	River Bottom
11+76	-9.4	-10.5	-10.3	-7.2	-7.7	-9.0	-8.2	-7.1	River Bottom
12+02	-11.0	-10.7	-9.9	-8.4	-8.6	-8.6	-8.7	-6.2	River Bottom
12+31	-11.6	-10.7	-9.5	-8.1	-8.4	-8.6	-8.7	-7.2	River Bottom
12+57	-10.4	-9.4	-9.1	-7.5	-8.0	-8.6	-8.2	-7.4	River Bottom
12+83	-9.0	-9.5	-8.8	-7.7	-7.9	-8.4	-8.2	-7.1	River Bottom
13+09	-8.4	-8.7	-8.0	-7.2	-7.4	-7.9	-7.8	-7.2	River Bottom
13+35	-7.6	-8.1	-7.6	-6.8	-6.8	-7.0	-6.9	-7.0	River Bottom
13+64	-6.7	-7.2	-7.2	-6.4	-6.5	-6.5	-6.4	-6.2	River Bottom
13+87	-6.3	-6.7	-6.5	-6.1	-6.3	-6.4	-6.0	-5.5	River Bottom
14+17	-5.7	-6.5	-6.3	-5.6	-5.7	-5.7	-5.8	-4.9	River Bottom
14+40	-5.9	-6.2	-6.2	-5.4	-5.5	-5.6	-5.5	-5.3	River Bottom
14+69	-6.6	-6.5	-6.3	-5.7	-5.7	-5.4	-5.4	-4.6	River Bottom

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Bridge Transects
Transect 7

KUUKPIK UMIAQ
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STA	2013	2014	2015	2016	2017	2018	2019	2020	Description
14+98	-7.8	-7.9	-7.8	-6.5	-6.4	-6.1	-6.0	-4.7	River Bottom
15+24	-10.7	-10.6	-9.2	-7.8	-8.6	-7.9	-7.6	-5.6	River Bottom
15+53	-13.6	-13.3	-11.8	-10.9	-10.9	-10.5	-10.0	-7.6	River Bottom
15+79	-14.7	-13.9	-12.6	-12.2	-11.9	-11.5	-10.7	-8.8	River Bottom
16+02	-11.1	-12.3	-12.3	-12.3	-12.2	-11.8	-9.4	-9.1	River Bottom
Varies	0.7	0.5	0.2	0.3	1.0	-0.2	1.3	0.5	Edge of Water
16+95	8.5	8.4	8.4	8.3	-	-	-	-	Top of Bank (2016)
16+97					8.7	7.9	-		Top of Bank (2018)
17+00							8.9	7.7	Top of Bank
17+00	9.2	9.5	9.4	9.3	9.2	8.9	8.9	8.3	Ground Shot
17+57	10.1	10.3	10.0	9.7	9.6	9.8	9.9	9.7	Ground Shot
18+00	9.4	9.6	9.6	9.5	9.4	9.5	9.7	9.5	Ground Shot
19+00	10.2	10.5	10.6	10.4	10.2	10.3	10.4	10.3	Ground Shot
19+07	10.8	10.9	10.7	10.5	10.3	10.5	10.6	10.5	Ground Shot

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CD-5 Michael Baker
Bridge Transects
Transect 8

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV9

STA	2013	2014	2015	2016	2017	2018	2019	2020	Description
0+00	10.6	10.8	10.3	10.3	10.1	10.1	10.1	10.1	Ground Shot
1+00	10.1	10.2	10.3	10.2	10.1	10.1	10.2	10.1	Ground Shot
2+00	9.8	10.0	10.1	10.0	9.9	10.0	9.8	9.8	Ground Shot
2+00							9.8	8.9	Top of Bank
2+08	8.9	9.0	9.0	9.0	8.9	8.7	-	-	Top of Bank (2018)
Varies	0.9	0.2	-0.4	0.2	1.3	-0.2	1.8	0.5	Edge of Water
2+99	-5.8	-5.5	-7.3	-6.6	-6.6	-3.7	-6.6	-5.0	River Bottom
3+20	-7.1	-7.7	-8.7	-8.3	-8.3	-7.8	-7.4	-6.2	River Bottom
3+40	-7.4	-8.8	-9.7	-8.6	-8.8	-8.4	-8.1	-7.0	River Bottom
3+61	-8.2	-9.6	-10.4	-9.2	-9.8	-9.1	-8.9	-7.7	River Bottom
3+85	-9.7	-10.5	-11.2	-9.9	-10.6	-10.4	-10.0	-9.3	River Bottom
4+09	-9.9	-10.8	-12.1	-11.2	-11.6	-11.5	-11.3	-11.6	River Bottom
4+33	-9.9	-11.3	-13.1	-13.6	-13.5	-12.9	-12.9	-14.3	River Bottom
4+57	-10.3	-11.9	-14.1	-15.2	-15.6	-16.5	-15.8	-15.2	River Bottom
4+85	-10.0	-10.9	-14.3	-15.3	-15.2	-15.3	-15.2	-15.3	River Bottom
5+09	-10.6	-10.4	-15.0	-14.4	-14.6	-14.9	-15.1	-14.9	River Bottom
5+33	-11.5	-10.3	-15.2	-14.0	-14.4	-14.5	-14.4	-14.6	River Bottom
5+60	-11.9	-10.7	-14.7	-13.8	-14.0	-13.6	-13.7	-13.7	River Bottom
5+87	-12.4	-10.3	-14.2	-13.2	-13.5	-13.2	-13.1	-14.0	River Bottom
6+19	-11.8	-10.8	-14.9	-14.3	-14.6	-14.6	-14.5	-14.4	River Bottom
6+46	-11.1	-10.8	-15.4	-15.6	-15.6	-15.4	-15.3	-14.7	River Bottom
6+73	-11.2	-11.6	-15.6	-15.5	-15.6	-15.3	-15.7	-14.5	River Bottom
7+01	-10.3	-10.6	-15.3	-14.4	-14.7	-14.5	-14.5	-14.1	River Bottom
7+28	-10.0	-10.3	-13.9	-13.5	-13.5	-13.6	-13.3	-13.7	River Bottom
7+53	-11.8	-11.0	-12.5	-12.4	-12.2	-12.4	-12.8	-13.2	River Bottom
7+80	-11.6	-11.0	-11.1	-10.5	-10.7	-11.3	-12.0	-11.7	River Bottom
8+08	-12.1	-9.5	-9.4	-9.7	-9.8	-9.1	-8.9	-9.1	River Bottom
8+36	-11.6	-8.2	-9.4	-9.1	-9.0	-8.2	-8.0	-8.2	River Bottom
8+59	-11.0	-7.8	-8.5	-8.6	-8.4	-8.3	-7.8	-7.7	River Bottom
8+79	-11.1	-7.1	-7.2	-7.5	-7.6	-7.2	-7.4	-7.3	River Bottom
9+04	-9.1	-7.9	-6.8	-7.1	-6.5	-5.6	-6.4	-6.6	River Bottom
9+28	-8.3	-7.7	-6.3	-5.0	-5.5	-4.8	-5.0	-5.8	River Bottom
9+53	-8.1	-7.2	-6.4	-5.2	-5.5	-5.4	-5.3	-5.4	River Bottom
9+76	-7.7	-6.6	-6.5	-4.6	-4.9	-4.1	-4.5	-4.2	River Bottom
9+96	-7.6	-6.7	-6.4	-5.6	-5.0	-5.1	-4.1	-4.0	River Bottom
10+17	-7.2	-6.2	-6.2	-6.2	-5.8	-5.2	-4.3	-3.6	River Bottom
10+42	-5.6	-5.6	-6.0	-4.8	-4.3	-3.3	-3.5	-3.0	River Bottom
10+62	-3.1	-3.9	-3.4	-3.1	-3.1	-2.5	-2.2	-2.2	River Bottom

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CD-5 Michael Baker
Bridge Transects
Transect 9

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

DOC LCMF-156 REV9

STA	2013	2014	2015	2016	2017	2018	2019	2020	Description
0+00	10.6	10.6	10.6	10.6	10.3	10.4	10.5	10.4	Ground Shot
1+00	9.9	10.0	10.0	9.9	10.0	9.8	9.8	10.1	Ground Shot
1+50	10.5	10.5	10.3	10.1	10.0	10.1	10.0	10.0	Ground Shot
1+89							8.9	8.6	Top of Bank
1+92	9.6	9.6	9.7	9.6	9.4	9.2	-	-	Top of Bank (2018)
Varies	0.6	0.0	0.9	0.7	0.8	-0.2	2.0	0.3	Edge of Water
2+48	-5.7	-10.5	-7.1	-5.7	-7.0	-5.5	-5.2	-6.6	River Bottom
2+62	-7.7	-13.4	-13.8	-15.3	-14.6	-14.3	-14.0	-12.3	River Bottom
2+78	-10.5	-18.8	-18.7	-19.2	-17.4	-19.1	-17.7	-19.0	River Bottom
2+92	-14.5	-18.8	-21.6	-20.6	-20.2	-20.1	-19.5	-22.5	River Bottom
3+13	-15.5	-19.2	-23.5	-21.8	-21.9	-22.0	-21.0	-23.1	River Bottom
3+33	-15.2	-20.1	-24.9	-23.0	-23.2	-23.0	-21.2	-22.7	River Bottom
3+58	-14.8	-20.7	-21.4	-23.5	-23.5	-23.3	-21.7	-23.4	River Bottom
3+79	-13.9	-16.2	-19.2	-19.4	-21.7	-19.8	-19.5	-22.3	River Bottom
4+03	-13.9	-16.2	-21.4	-21.5	-20.8	-21.4	-21.1	-23.7	River Bottom
4+26	-13.4	-16.9	-22.1	-22.0	-20.0	-22.0	-21.0	-23.7	River Bottom
4+54	-12.9	-19.9	-22.2	-19.8	-19.5	-18.4	-17.5	-21.4	River Bottom
4+78	-13.4	-20.5	-22.3	-20.2	-19.4	-18.8	-17.8	-20.9	River Bottom
5+02	-13.0	-19.3	-22.4	-19.0	-19.0	-18.8	-17.9	-21.0	River Bottom
5+30	-13.2	-18.4	-21.5	-19.0	-18.6	18.1	-17.5	-20.7	River Bottom
5+54	-13.9	-17.9	-20.9	-18.5	-18.5	-17.9	-17.5	-20.6	River Bottom
5+79	-13.7	-18.3	-21.3	-18.8	-19.4	-18.6	-18.0	-20.9	River Bottom
6+02	-12.6	-17.8	-19.7	-20.6	-20.3	-19.7	-19.0	-20.9	River Bottom
6+30	-12.2	-15.4	-17.7	-20.7	-21.0	-20.2	-18.8	-20.0	River Bottom
6+55	-12.7	-13.3	-16.7	-16.0	-15.5	-14.0	-12.6	-18.2	River Bottom
6+79	-15.2	-12.4	-16.8	-16.5	-16.3	-14.5	-16.5	-16.2	River Bottom
7+06	-14.0	-12.7	-17.0	-16.7	-16.6	-15.3	-13.6	-15.1	River Bottom
7+30	-13.3	-13.2	-16.8	-15.7	-15.6	-14.6	-12.3	-14.3	River Bottom
7+57	-11.9	-14.8	-17.0	-15.3	-14.8	-13.2	-11.7	-12.7	River Bottom
7+84	-11.6	-14.6	-17.3	-15.4	-14.9	-14.0	-12.1	-12.1	River Bottom
8+08	-11.0	-15.8	-16.6	-14.5	-13.9	-13.5	-10.8	-11.8	River Bottom
8+33	-9.9	-10.3	-15.1	-10.5	-15.9	-11.0	-6.1	-8.6	River Bottom
8+58	-6.9	-7.9	-6.2	-5.1	-5.1	-4.2	-0.1	-2.9	River Bottom
8+78	-5.2	-6.4	-4.1	-3.5	-2.3	-2.6	-0.3	0.0	River Bottom
8+91	-3.3	-6.1	-2.8	-2.4	-2.0	-1.5	-0.5	0.2	River Bottom
Varies	0.5	0.5	1.2	0.5	0.9	-0.3	2.0	0.3	Edge of Water
10+00	2.3	2.5	4.0	4.1	4.0	4.4	4.6	5.0	Sand Bar
11+00	3.9	4.1	4.9	4.9	4.2	5.1	5.1	5.3	Sand Bar
11+52	5.0	5.2	5.5	5.6	5.4	5.8	5.7	5.8	Edge of Vegetation
12+00	5.4	5.5	6.0	6.0	5.7	5.9	6.0	6.0	Ground Shot
13+00	4.2	4.6	5.0	5.0	5.8	5.2	5.1	5.1	Ground Shot
14+00	3.9	4.1	4.5	4.5	4.9	4.5	4.4	4.4	Ground Shot
14+39	3.7	3.9	4.0	4.0	4.0	4.1	4.0	4.1	Edge of Water
14+82	3.4	3.7	3.9	3.8	3.8	4.2	4.0	4.1	Edge of Water
14+84	3.8	4.1	4.2	4.0	4.0	4.2	4.1	4.0	Toe of Bank
15+00	5.7	5.9	5.7	5.7	5.7	5.8	5.9	5.7	Top of Bank
15+52	8.0	8.2	8.0	7.9	7.8	8.0	8.2	8.1	Ground Shot
16+00	8.2	8.5	8.1	8.1	8.0	7.9	7.7	7.7	Ground Shot
16+92	9.4	9.4	9.3	9.3	9.0	7.8	9.2	9.1	Ground Shot

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Bridge Transects
Transect 10

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STA	2013	2014	2015	2016	2017	2018	2019	2020	Description
0+00	10.3	10.4	10.3	10.3	10.2	10.1	10.2	10.1	Ground Shot
1+00	10.4	10.7	10.3	10.3	9.6	9.3	8.7	8.7	Ground Shot
1+50	10.5	10.6	10.4	10.3	10.1	10.1	10.1	10.0	Ground Shot
1+67							9.7	9.6	Top of Bank
1+90	9.9	9.7	9.5	9.4	8.9	8.2	-		Top of Bank (2018)
2+00	6.7	7.0	6.5	6.4	5.3	5.1	4.0	1.2	Ground Shot
Varies	0.5	-0.8	-0.3	0.7	1.2	-0.2	2.0	-0.5	Edge of Water
2+67	-7.8	-14.3	-20.4	-19.5	-19.9	-20.2	-19.7	-19.1	River Bottom
2+87	-20.7	-21.4	-21.3	-22.3	-21.6	-22.6	-21.7	-21.7	River Bottom
3+09	-21.3	-22.5	-23.8	-23.3	-23.2	-24.0	-22.3	-23.1	River Bottom
3+30	-20.0	-21.2	-23.8	-22.6	-23.1	-22.8	-23.1	-22.9	River Bottom
3+55	-19.4	-20.3	-23.7	-22.7	-22.4	-22.3	-22.2	-22.4	River Bottom
3+76	-19.0	-20.7	-23.7	-22.6	-21.1	-22.3	-22.1	-22.0	River Bottom
4+00	-17.8	-18.6	-20.8	-18.8	-18.3	-18.9	-18.5	-20.5	River Bottom
4+21	-18.0	-19.2	-21.1	-19.0	-18.9	-18.8	-18.8	-18.5	River Bottom
4+45	-18.7	-19.2	-21.5	-19.1	-19.1	-18.6	-18.0	-18.2	River Bottom
4+70	-19.0	-19.9	-21.9	-20.9	-20.3	-19.3	-18.2	-17.8	River Bottom
4+94	-18.4	-20.6	-22.3	-21.9	-21.2	-20.3	-20.4	-17.8	River Bottom
5+21	-17.3	-20.4	-23.0	-22.0	-22.0	-21.3	-19.8	-18.2	River Bottom
5+45	-16.1	-19.2	-23.7	-22.3	-22.2	-21.3	-20.4	-18.7	River Bottom
5+69	-14.6	-19.1	-23.2	-22.0	-21.5	-21.3	-20.4	-19.1	River Bottom
5+96	-13.5	-17.7	-22.4	-21.2	-20.1	-20.4	-19.6	-19.3	River Bottom
6+20	-13.7	-16.8	-21.5	-20.5	-19.8	-19.1	-18.5	-19.3	River Bottom
6+47	-12.5	-15.3	-19.7	-18.2	-17.9	-17.4	-16.5	-20.2	River Bottom
6+71	-12.1	-14.7	-17.4	-16.2	-16.2	-15.4	-14.0	-16.9	River Bottom
6+99	-11.9	-14.2	-15.2	-13.8	-13.2	-11.8	-11.0	-12.7	River Bottom
7+23	-12.4	-15.4	-14.8	-11.4	-10.8	-9.5	-8.8	-9.9	River Bottom
7+48	-12.2	-17.6	-14.4	-10.7	-9.7	-8.3	-7.1	-7.5	River Bottom
7+70	-12.9	-25.5	-14.1	-11.3	-10.5	-9.1	-7.1	-7.0	River Bottom
7+94	-11.2	-21.7	-14.8	-14.6	-12.7	-10.6	-9.1	-7.6	River Bottom
8+15	-6.8	-15.9	-10.8	-12.8	-7.9	-6.5	-6.3	-5.6	River Bottom
Varies	0.4	1.2	2.6	0.8	1.1	-0.3	1.9	0.1	Edge of Water
9+00	1.6	2.1	3.7	3.8	3.5	3.6	3.6	3.8	Sand Bar
10+00	3.6	3.2	4.3	4.3	4.4	4.6	4.6	4.9	Sand Bar
11+00	5.4	5.6	5.8	5.9	5.9	6.1	6.0	6.2	Edge of Vegetation
12+00	5.1	5.4	5.7	5.7	5.7	5.9	5.8	5.7	Ground Shot
13+00	4.8	5.0	5.4	5.4	5.3	5.5	5.6	5.5	Ground Shot
14+00	4.6	4.8	5.0	5.1	5.0	4.7	4.8	4.8	Ground Shot
14+84	3.7	3.8	3.7	3.7	3.8	3.9	4.0	4.0	Toe of Bank
14+96	7.7	7.7	6.8	7.5	7.4	7.5	7.5	7.4	Top of Bank
15+00	7.8	8.0	7.9	7.8	7.7	7.8	7.7	7.7	Ground Shot
15+38	8.6	8.5	8.4	8.8	8.4	8.2	8.2	8.0	Ground Shot
15+53	9.1	9.4	9.4	9.2	9.1	9.2	9.2	9.0	Grade Break
15+71	7.2	7.4	7.3	7.2	7.2	7.1	6.8	7.0	Grade Break
16+00	6.7	7.0	6.8	6.7	6.4	6.6	6.4	6.3	Ground Shot
16+88	7.2	7.4	7.2	7.2	6.9	7.1	7.3	7.2	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev9.xlsx 16 of 47 Transect_10

E.3.3 NIGLIAGVIK CHANNEL & BRIDGE TABULATED DATA (TRANSECTS 24 – 27)

Calc'd By: CZ
Date: 08/29/20
RPT-CE-CD-114 REV9

CD-5 Michael Baker
Bridge Transects
Transect 24

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV9

STA	2013	2014	2015	2016	2017	2018	2019	2020	Description
0+00	26.5	26.5	26.4	26.4	26.4	26.5	26.3	26.65	Ground Shot
0+50	27.0	27.0	27.0	26.9	27.0	27.0	26.8	26.96	Ground Shot
0+94	27.9	26.4	26.5	26.5	26.4	26.3	26.3	26.30	Ground Shot
1+13	25.3	23.6	23.8	23.6	23.5	23.3	23.3	23.24	Top of Bank
1+45	2.6	2.7	3.2	0.5	0.8	1.4	1.5	2.73	Toe of Bank
Varies	0.2	0.5	1.5	0.5	1.4	1.2	0.8	0.45	Edge of Water
2+26	-1.7	-1.2	-1.9	-2.6	-2.7	-2.6	-2.5	-2.41	River Bottom
2+39	-2.4	-1.8	-2.6	-3.3	-2.8	-2.7	-2.9	-3.32	River Bottom
2+48	-2.0	-2.2	-2.9	-2.9	-1.9	-3.2	-2.2	-3.08	River Bottom
2+61	-2.1	-2.2	-2.6	-2.2	-1.8	-2.5	-1.7	-2.28	River Bottom
2+74	-2.2	-2.3	-2.3	-2.1	-1.7	-2.5	-1.8	-2.20	River Bottom
2+90	-3.0	-1.9	-2.1	-2.0	-2.0	-2.8	-1.8	-2.16	River Bottom
3+00	-3.0	-1.9	-2.1	-2.2	-1.9	-2.4	-1.8	-2.02	River Bottom
3+17	-2.6	-2.0	-2.2	-2.1	-2.3	-2.2	-1.7	-2.09	River Bottom
Varies	0.3	0.2	1.5	0.6	1.4	1.3	0.7	0.46	Edge of Water
3+86	5.9	5.7	5.8	5.8	5.7	5.6	5.7	5.55	Edge of Vegetation
3+96	7.1	7.2	7.2	7.0	6.9	6.9	6.9	6.94	Top of Bank
4+65	8.7	8.5	8.3	8.2	8.4	8.2	8.0	7.95	Ground Shot
5+15	9.4	9.2	9.1	9.0	9.1	8.9	9.0	8.95	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev9.xlsx 32 of 47 Transect_24

Calc'd By: CZ
Date: 08/29/20
RPT-CE-CD-114 REV9

CD-5 Michael Baker
Bridge Transects
Transect 25

KUUKPIK UMIAQ

DOC LCMF-156 REV9

STA	2013	2014	2015	2016	2017	2018	2019	2020	Description
0+00	27.5	27.4	27.3	27.3	27.3	27.3	27.2	27.4	Ground Shot
0+50	26.4	26.2	26.2	26.1	26.0	26.1	26.0	26.2	Ground Shot
0+70	26.8	26.7	26.7	26.5	26.6	26.7	26.8	26.7	Grade Break
0+89	21.8	21.3	21.3	21.2	21.2	21.1	21.1	21.0	Grade Break
1+00	25.7	22.2	22.5	22.1	22.2	22.3	22.3	22.7	Top of Bank
1+29					1.8	1.7	3.3	2.9	Toe of Bank
1+31	2.8	2.8	2.7	1.3	-	-	-	-	Toe of Bank (2016)
Varies	0.6	0.3	1.4	0.4	1.0	1.3	2.2	0.5	Edge of Water
2+19	-2.6	-1.2	-3.4	-3.7	-3.0	-5.2	-3.9	-3.8	River Bottom
2+38	-2.2	-1.6	-3.5	-3.5	-3.6	-4.0	-3.2	-4.1	River Bottom
2+48	-2.2	-1.9	-3.5	-3.4	-3.2	-4.2	-2.8	-4.2	River Bottom
2+61	-2.4	-2.9	-3.2	-3.1	-2.6	-3.3	-2.2	-3.2	River Bottom
2+72	-2.8	-2.6	-2.8	-2.8	-2.1	-3.2	-2.0	-3.1	River Bottom
2+89	-2.7	-2.1	-2.3	-2.1	-1.7	-2.8	-1.2	-2.6	River Bottom
2+97	-2.6	-1.9	-2.1	-1.8	-1.7	-2.6	-1.6	-1.9	River Bottom
3+07	-2.7	-2.0	-1.8	-1.9	-1.3	-2.2	-1.2	-1.9	River Bottom
Varies	0.1	0.1	1.5	0.4	1.0	1.3	2.1	0.5	Edge of Water
3+51	2.5	2.5	-	-	-	-	-	-	Ground Shot (2014)
3+81	6.1	6.1	6.4	6.2	6.3	6.2	6.3	6.2	Edge of Vegetation
3+91	7.8	7.5	7.7	7.5	7.4	7.4	7.5	7.6	Top of Bank
4+53	8.5	8.3	8.1	8.2	8.2	8.3	8.0	8.1	Ground Shot
5+03	8.4	8.4	8.3	8.4	8.5	8.4	8.5	8.2	Ground Shot

Calc'd By: CZ
Date: 08/29/20
RPT-CE-CD-114 REV9

CD-5 Michael Baker
Bridge Transects
Transect 26

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE

DOC LCMF-156 REV9

STA	2013	2014	2015	2016	2017	2018	2019	2020	Description
0+00	24.0	27.5	27.3	27.3	27.3	27.3	27.2	27.3	Ground Shot
0+60	24.1	27.7	27.6	27.5	27.4	27.2	27.2	27.2	Ground Shot
0+85	24.0	27.3	27.5	27.3	27.2	27.2	27.4	27.2	Ground Shot
1+03	21.5	24.9	25.0	25.0	25.0	24.9	24.9	24.7	Top of Bank
1+36	2.7	2.4	3.1	1.8	1.9	1.9	2.4	3.2	Toe of Bank
Varies	0.4	0.2	1.5	0.5	1.0	1.4	1.5	0.5	Edge of Water
2+19	-2.5	0.2	-3.5	-3.5	-4.0	-3.0	-5.1	-3.7	River Bottom
2+32	-2.6	-1.2	-3.5	-3.0	-4.4	-5.4	-5.0	-5.1	River Bottom
2+43	-2.5	-2.1	-3.6	-1.7	-3.0	-4.0	-3.7	-4.5	River Bottom
2+53	-2.4	-2.4	-3.6	-1.7	-2.6	-3.9	-3.8	-3.2	River Bottom
2+63	-2.4	-2.6	-3.6	-2.1	-3.0	-4.2	-3.9	-2.9	River Bottom
2+80	-2.3	-2.9	-2.8	-3.3	-2.6	-4.1	-3.8	-3.3	River Bottom
2+91	-2.0	-2.9	-2.6	-4.0	-2.8	-3.9	-3.7	-2.9	River Bottom
3+08	-2.2	-2.3	-2.2	-3.2	-1.7	-2.5	-3.0	-2.4	River Bottom
Varies	0.2	0.0	1.4	0.5	0.9	1.4	1.5	0.5	Edge of Water
3+57	3.2	3.3		1.2	1.0	-	-	1.2	Ground Shot
3+89	6.1	6.6	7.0	6.6	6.6	6.5	6.7	6.8	Edge of Vegetation
3+97	7.1	7.5	7.7	7.2	7.6	7.5	7.3	7.9	Top of Bank
4+79	8.3	9.3	9.9	10.0	9.9	8.1	9.4	9.2	Ground Shot
5+29	9.8	9.8	9.5	9.4	9.4	9.4	9.5	9.2	Ground Shot
Station 4+79 falls in Slope of Gravel Road									

Calc'd By: CZ
Date: 08/29/20
RPT-CE-CD-114 REV9

CD-5 Michael Baker
Bridge Transects
Transect 27

KUUKPIK UMIAQ ALPINE SURVEY OFFICE

DOC LCMF-156 REV9

STA	2013	2014	2015	2016	2017	2018	2019	2020	Description
0+00	27.0	27.0	26.8	26.5	26.8	26.6	26.5	26.6	Ground Shot
0+50	27.1	27.1	27.0	27.0	27.1	26.7	26.8	26.8	Ground Shot
0+74	24.3	24.5	24.3	24.1	24.0	24.1	24.1	23.9	Grade Break
0+82	26.6	26.6	26.7	26.7	26.5	26.5	26.6	26.5	Grade Break
0+98	26.0	25.9	25.9	26.0	26.0	25.9	25.9	25.7	Top of Bank
1+30	2.5	2.1	2.5	2.2	2.3	2.3	2.3	3.5	Toe of Bank
Varies	0.1	0.3	1.5	0.5	1.0	1.3	1.7	0.5	Edge of Water
2+20	-2.4	-0.8	-1.4	-2.2	-1.6	-3.1	-2.8	-2.3	River Bottom
2+31	-2.3	-1.0	-1.5	-1.6	-1.6	-3.3	-2.8	-1.8	River Bottom
2+41	-3.3	-1.6	-2.1	-1.9	-1.8	-3.3	-3.0	-2.0	River Bottom
2+48	-2.0	-1.7	-2.5	-2.3	-2.2	-3.3	-3.7	-2.2	River Bottom
2+58	-2.7	-2.7	-3.0	-2.9	-2.7	-3.3	-3.8	-2.7	River Bottom
2+65	-2.9	-2.7	-3.0	-3.2	-2.9	-3.0	-4.0	-3.1	River Bottom
2+72	-3.1	-2.8	-3.0	-3.4	-2.8	-3.0	-4.0	-3.2	River Bottom
2+78	-2.9	-2.8	-2.9	-3.3	-2.6	-3.0	-3.7	-3.2	River Bottom
2+85	-2.5	-3.0	-2.9	-2.8	-2.3	-3.0	-3.2	-2.7	River Bottom
2+92	-2.1	-2.6	-2.4	-2.5	-2.0	-3.0	-	-2.3	River Bottom
Varies	-0.1	0.2	1.5	0.6	0.9	1.5	1.6	0.5	Edge of Water
3+39	1.9	2.0	-	1.3	1.4	-	-	1.7	Ground Shot
3+52	4.7	4.9	4.7	4.6	4.4	4.5	4.5	4.4	Ground Shot
3+76	5.9	6.1	6.2	6.3	6.2	6.2	6.2	6.2	Edge of Vegetation
3+89	7.0	7.2	7.2	7.1	7.0	7.2	6.9	7.1	Top of Bank
4+10	8.0	8.1	8.0	8.1	8.0	8.0	7.9	7.8	Ground Shot
4+71	8.0	8.0	7.8	7.7	7.4	7.3	7.2	7.3	Ground Shot
5+21	9.7	9.7	9.2	9.0	9.1	8.8	8.5	8.5	Ground Shot

2020 Colville River Delta Spring Breakup Monitoring & Hydrological Assessment