ConocoPhillips
Alaska

2017

COLVILLE RIVER DELTA

SPRING BREAKUP MONITORING & HYDROLOGICAL ASSESSMENT

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EXECUTIVE SUMMARY

This report presents the observations and results from the 2017 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment conducted by Michael Baker International for ConocoPhillips Alaska. In the Colville River Delta, the breakup and downstream movement of river ice typically occurs during a three-week period in May and June. The spring breakup event historically produces flooding, and rapid rise and fall of stage can occur as the result of ice jam formation and release. Annual study and reporting of spring breakup 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 2017 monitoring and hydrological assessment is the 26th consecutive year of spring breakup investigations. 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 low magnitude, prolonged event, drawn out over three weeks. Initial floodwater arrived in the delta on May 22. Over the next two days all distributary channels were conveying floodwater and floodwater reached facilities. Two small ice jams formed approximately 8 and 12 river miles upstream of MON1 with very little backwater. As channel ice deteriorated and ice floes progressed downstream, ice jams were observed at the head of the CRD in multiple locations throughout the Nigliq Channel, and in the East Channel at the Sakoonang Channel bifurcation. Backwater was minimal and no overbank flooding was observed. All channels were ice free by June 4.

Peak conditions throughout the delta occurred between May 27 and June 1. Peak stage at MON1C occurred on May 30 and was 14.79 feet British Petroleum Mean Sea Level having an estimated recurrence interval of less than 2.0-years. Peak discharge at MON1C occurred on May 30 and was 288,000 cubic feet per second having an estimated 3.1-year recurrence interval.

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

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ACRONYMS & ABBREVIATIONS

2D	Two-dimensional
ABR	Alaska Biological Research
ADF&G	Alaska Department of Fish and Game
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
DNR	Department of Natural Resources
FEMA	Federal Emergency Management Agency
fps	feet per second
ft	feet
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
NRCS	Natural Resources Conservation Service
NPR-A	National Petroleum Reserve of Alaska
OSW	USGS Office of Surface Water
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

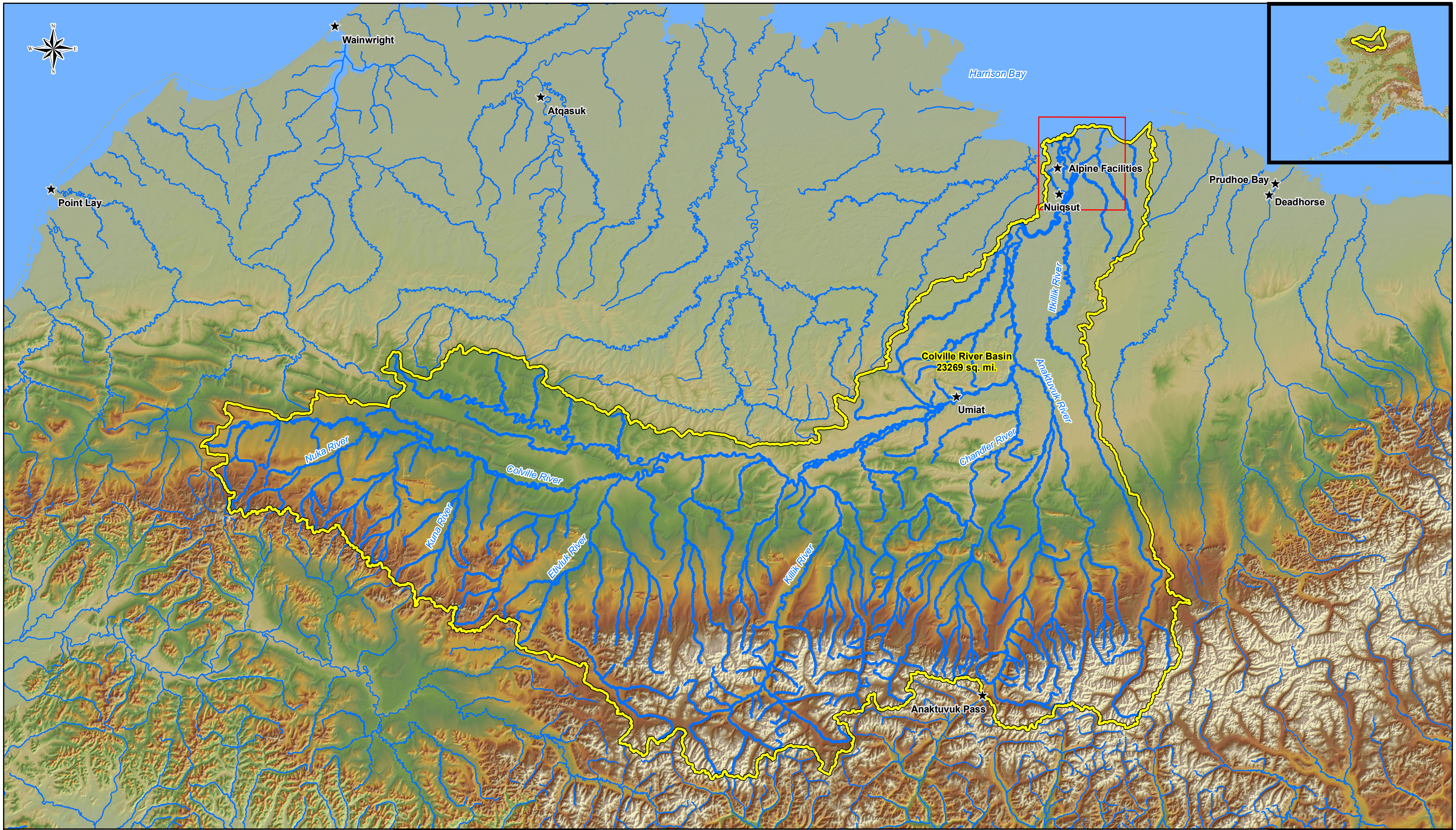
The Colville River is the largest river on the North Slope, initiating in the DeLong Mountains on the northern side of the Brooks Range, running north and east through the Arctic Coastal Plain, and forms the Colville River Delta (CRD) where the river empties into the Beaufort Sea. The Colville River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

The CRD Spring Breakup 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, and CD5 pads, access roads, and pipelines. A new drillsite, Greater Moose's Tooth 1 (GMT1) is under construction.

Colville River breakup monitoring has been ongoing since 1962. The timing and magnitude of breakup flooding has been determined consistently 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 2017 monitoring and hydrological assessment is the 26th consecutive year of CRD spring breakup investigations.

The 2017 field program took place from April 20 to June 8. Spring breakup setup began on April 20 and concluded on May 6. Spring breakup monitoring began on May 13 and concluded on June 8. 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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Legend
- ★ Place Name
- Stream
- Study Area
- Colville River Basin

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2017 SPRING BREAKUP
COLVILLE RIVER DELTA

Drainage Basin

FIGURE: 1.1

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1.1 MONITORING OBJECTIVES

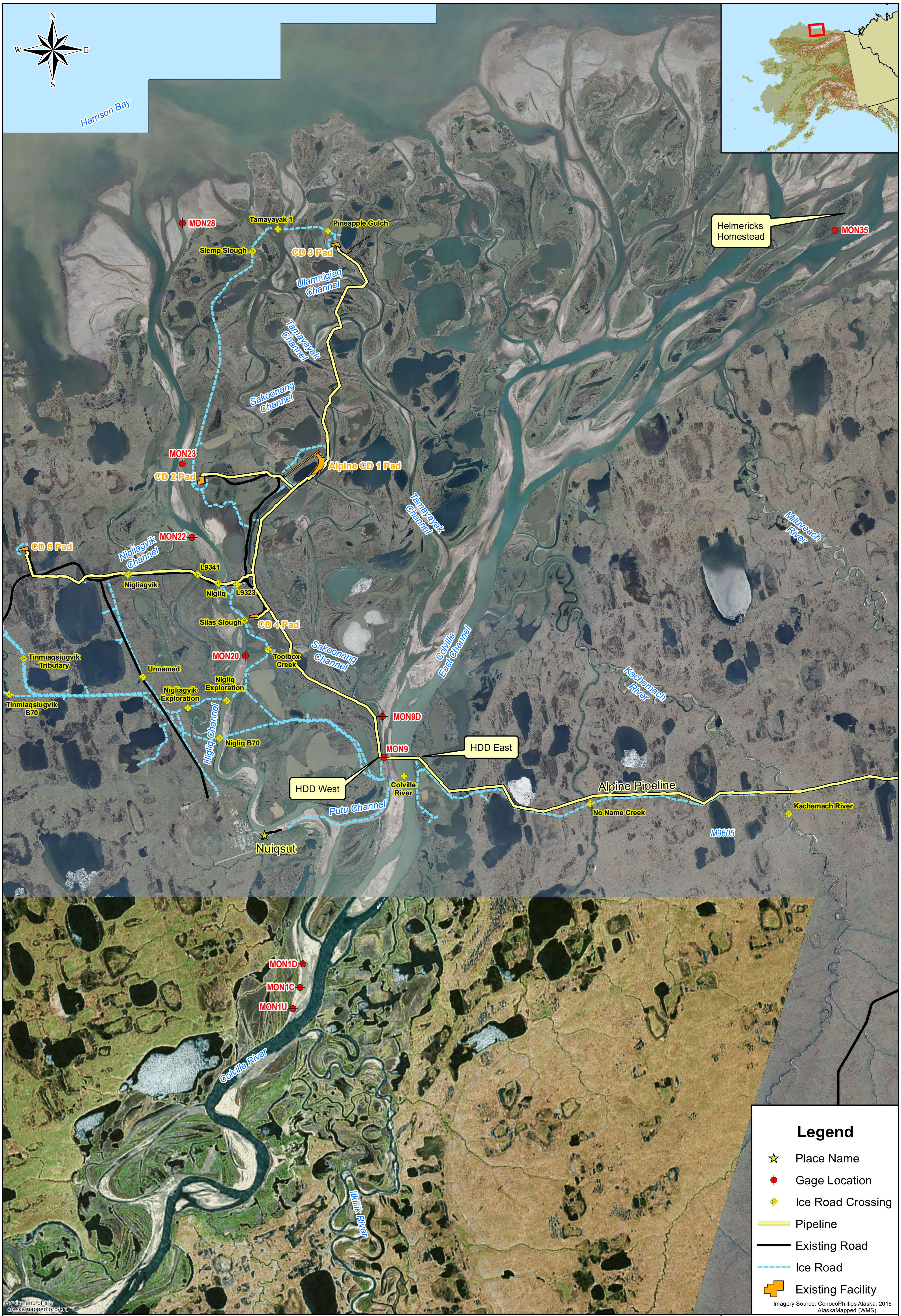
The primary objective of CRD spring breakup monitoring and hydrological assessment is to monitor and estimate the magnitude of breakup flooding within the CRD in relation to Alpine facilities. Water surface elevations (WSE, or stage, used interchangeably in this report), discharge, and observations are 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.

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

Permit stipulations for U.S. Army Corps of Engineers (USACE) Permits 2-960874 Special Condition #6, POA-2004-253-2 Special Condition #17, DNR 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 Alaska Department of Fish and Game (ADF&G) permit FG97-III-0260-Amendment #3. 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 2017 monitoring locations and gage stations are similar to those studied in 2016 (Michael Baker 2016). 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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2017 SPRING BREAKUP
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Monitoring Locations

FIGURE: 1.2

(SHEET 1 of 1)

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2017 SPRING BREAKUP
ALPINE AREA FACILITIES

Monitoring Locations

FIGURE: 1.3

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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 22,500 square miles of runoff in a single channel
		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 coast line, 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 (north) 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, south 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	G24	Northeast side of Lake L9323, 200 feet upstream of bridge centerline
		G25	Northeast side of Lake L9323, 310 feet downstream of bridge centerline
	Nigliq Bridge	G28	West side of Nigliq Channel, 2,600 feet upstream of bridge centerline
		G26	East side of Nigliq Channel, 200 feet upstream of bridge centerline
		G27	East side of Nigliq Channel, 160 feet downstream of bridge centerline
		G29	West side of Nigliq Channel, 2,300 feet downstream of bridge centerline
	Lake L9341 Bridge	G32	West side of Lake L9341, 180 feet upstream of bridge centerline
		G33	West side of Lake L9341, 300 feet downstream of bridge centerline
	Nigliagvik Bridge	G38	East side of Nigliagvik Channel, 350 feet upstream of bridge centerline
		G39	East side of Nigliagvik Channel, 300 feet downstream 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 CRD. 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. Helicopter reconnaissance flights were also conducted to Ocean Point, the Anaktuvuk River, and the Chandler River to track the progression of the floodwaters.

Field data collection and observations of breakup progression, discharge 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.

UMIAQ provided Hägglund track vehicle support to access gage stations during setup and before a helicopter was onsite at Alpine. 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 during spring breakup monitoring.

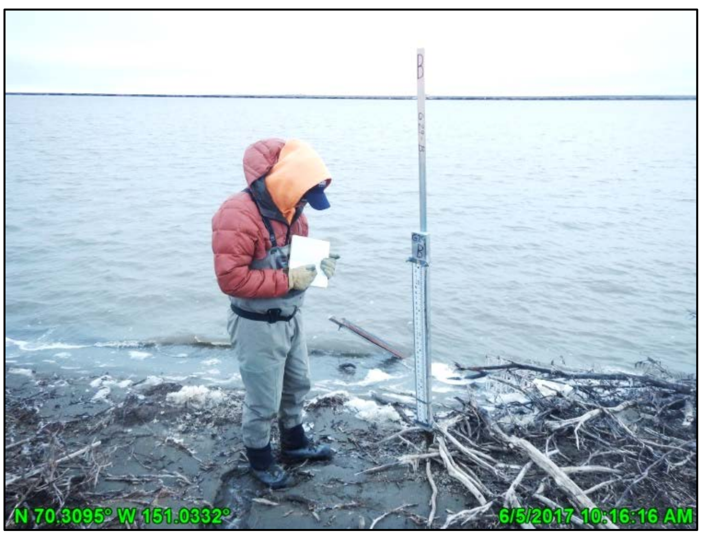


Photo 2.1: Field crew recording observations at gage G29; June 5, 2017

2.2 STAGE

HYDROLOGIC STAFF GAGES

Stage data was collected using hydrologic staff gages (gages) and pressure transducers (PTs). 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. 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 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.

Photo 2.2: Indirect-read gages at MON9D; April 28, 2017

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 100^{th} of a foot between 0.00 to 3.33 feet (Photo 2.2).

Alpine facilities gage stations were established at pads and along roads adjacent to infrastructure 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.

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 three feet, multiple gages were installed linearly from the edge of the low water channel up to the overbank. The gages were installed at elevations overlapping by approximately one foot. Individual gage assemblies were identified with alphabetical designations beginning with

'A' representing the location nearest to the stream. High water marks (HWMs) were measured by applying chalk on the angle iron gage supports or VSMs and measuring the wash line (Photo 2.3).

Photo 2.3: Field crew chalking gage G38-B; May 27, 2017

PRESSURE TRANSDUCERS

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

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

Photo 2.4: PT on direct-read gage G18-B on a VSM; May 21, 2017

2.3 DISCHARGE

MEASURED DISCHARGE

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

- Nigliq Bridge
- Nigliagvik Bridge
- Long Swale Bridge
- CD2, CD4, and CD5 road culverts observed conveying flow

Drainage structures not listed above were either dry or did not have discernable flow. Bridge flow depth and velocity were measured at the Nigliq Bridge, Nigliagvik Bridge, and Long Swale Bridge using a Price AA current meter suspended by cable with a sounding weight and the USGS midsection technique (USGS 1982) (Photo 2.5). Culvert flow depth and velocity were measured using a flow meter attached to a wading rod and the USGS velocity/area technique (USGS 1968). Measured discharge methods are further detailed in Appendix C.1.1.

Photo 2.5: Measuring discharge at the Nigliagvik Bridge; June 1, 2017

PEAK DISCHARGE

Peak discharge was calculated indirectly and, when possible, calibrated with the respective direct discharge measurement and observed WSEs. Under open channel conditions, peak discharge typically occurs at the same time as peak stage; however, in the delta, discharge is often affected by ice and snow which can temporarily increase stage and reduce velocity. This in turn yields a lower discharge than an equivalent stage under open water conditions.

Culvert peak discharge was calculated using the WSE differential between the headwater and tailwater elevation, approximated by WSEs at corresponding gages, and annual culvert survey data provided by UMIAQ (UMIAQ 2017a).

Peak discharge was calculated at the following locations:

- Colville River (MON1)
- Colville River East Channel (MON9)
- Nigliq Bridge
- Nigliagvik Bridge
- Long Swale Bridge
- CD2 road culverts associated with gages G3/G4

Drainage structures not listed above were either dry or did not have discernable flow. Peak discharge results are estimates based on conditions at the time of data collection. These conditions often include ice and snow effects, which are highly dynamic and challenging to quantify. Ice and snow conditions can affect channel geometry, roughness, energy gradient, and stage, all of which are used to calculate discharge indirectly. In consideration of these conditions, calculations of peak discharge are presented with quality ratings, as described in Table 2.1. Detailed peak discharge methods are presented in Appendix C.1.2.

Table 2.1: Peak 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 was to determine maximum pier scour depths during flood conditions and to determine post-breakup pier scour depths. Pier scour measurements support 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, it is imperative that real-time soundings are collected during peak flood conditions.

The Nigliq Bridge is supported by two bridge abutments, abutment 1 and 9, and seven bridge piers, piers 2 through 8. Each bridge pier contains five piles labeled A through E, with pile A being the most upstream pile. Piles A and B support the ice breaker, while piles C, D, and E support the bridge. Bridge piers 2 through 5 are located within the main portion of the Nigliq Channel. The Nigliagvik Bridge is supported by two bridge abutments, abutment 1 and 5, and three bridge piers, piers 2 through 4. Each bridge pier contains two piles labeled A and B, with pile A being the upstream pile. Bridge piers 3 and 4 are located within the main portion of the Nigliagvik Channel. Appendix E.1 presents a plan view of each bridge (UMIAQ 2017).

A real-time pier scour monitoring system was installed on bridge piers that are the most susceptible to scour. These include pier 3 of the Nigliagvik Bridge, installed in the spring of 2015, and piers 2 through 5 of the Nigliq Bridge, installed in the spring of 2016. Scour depths were measured using a single beam sonar installed inside a steel pipe casing welded to the downstream side of pile E on the Nigliq Bridge and pile B on the Nigliagvik Bridge. Sonar measurements were recorded with an on-site datalogger. The sonar system was programmed to measure depths and record data at 30-minute intervals. A telemetry system, using cellular communication, provided remote access to the sonar measurements. A post-breakup survey of the scour holes at the base of bridge piers within the main channel of the Nigliq Bridge and Nigliagvik Bridge was completed to ensure maximum scour depth had been documented (UMIAQ 2017b). The maximum pier scour depths measured during breakup and final post-breakup surveyed scour depths were determined at each bridge.

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. These surveys were performed last year, post-construction, and again this year (UMIAQ 2017c). Maximum and average rates of erosion between 2013 and 2017 and between 2016 and 2017 were determined for each bank.

BATHYMETRY

A. Bathymetry at Bridges

Topographic and bathymetric baseline post-breakup 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 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 again this year and will be surveyed annually through 2019. After 2019, the transects will be surveyed every five years (Michael Baker and ABR 2013).

2.6 ICE ROAD CROSSINGS BREAKUP

Aerial observations of the hydraulic effects of winter ice road crossings during breakup included:

- Colville River East Channel at HDD
- Kachemach River
- Lake L9323 at bridge
- Lake L9341 at bridge
- Nigliq Channel at bridge
- Nigliq Channel Exploration
- Nigliq Channel B70
- Nigliagvik Channel at bridge

- Nigliagvik Channel Exploration
- No Name Creek
- Pineapple Gulch
- Silas Slough
- Slemp Slough
- Tamayayak Channel 1 near coast
- Toolbox Creek
- Unnamed Stream northwest of Nigliagvik Channel Exploration

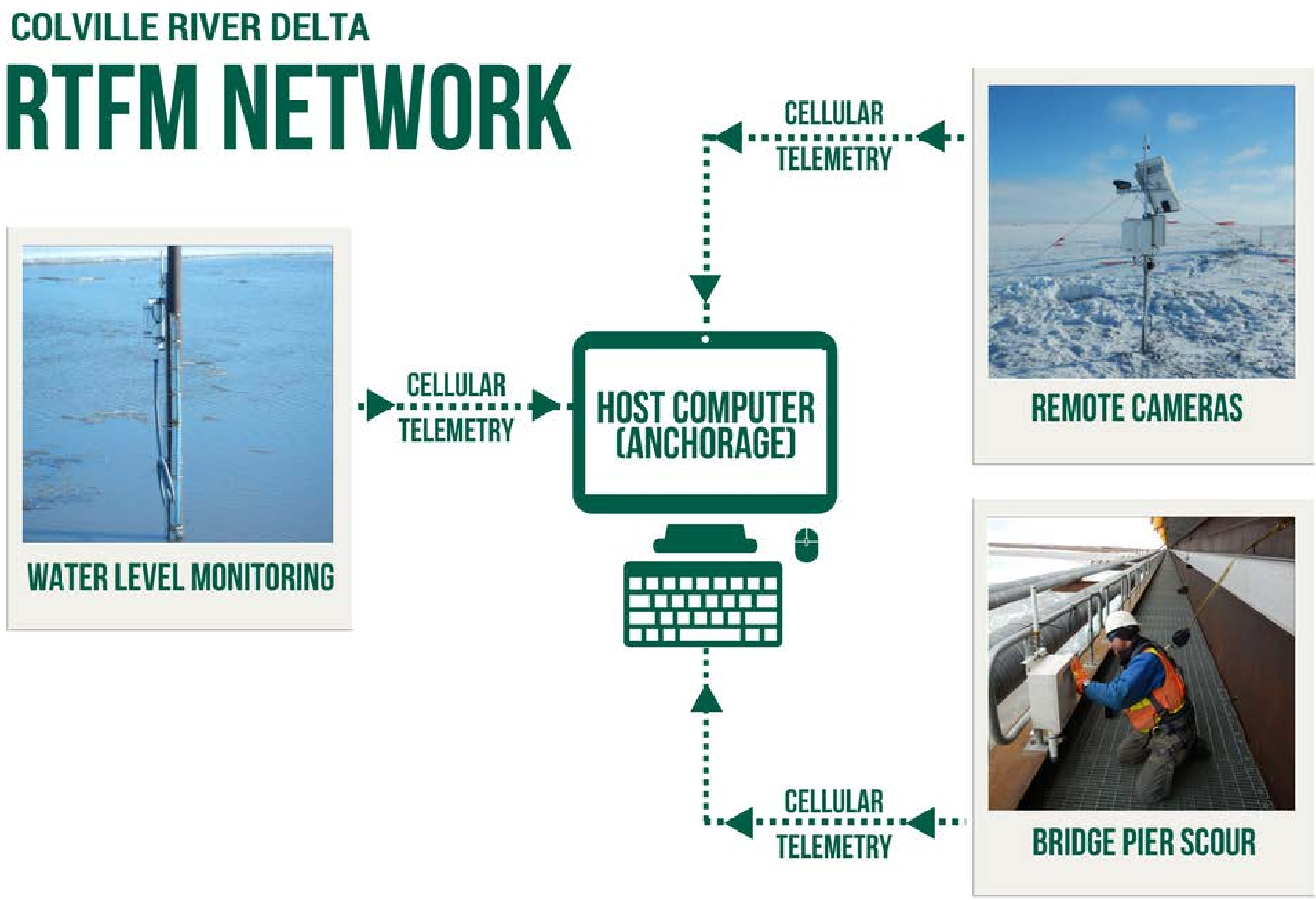
2.7 REAL-TIME FLOOD MONITORING NETWORK

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 above; dataloggers and telemetry systems to collect and transmit data; and a host computer to receive the transmitted data (Figure 2.1). The ability to remotely monitor stage and scour helps reduce helicopter traffic in the CRD, allows for round-the-clock monitoring of conditions, and provides an interactive tool for the hydrologic data when helicopter travel is restricted. In addition, a network of real-time monitoring stations at critical locations around 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 via remote camera images
CD2 Road (Gage G3)	• Stage
CD4 Road (Gage G18)	• Stage • Barometric pressure
CD5 Road (Nigliq & Nigliagvik Bridges)	• Stage • Pier scour

Figure 2.1: RTFM Network Schematic



REMOTE CAMERAS

Remote camera systems were installed at MON1U, MON1C, and MON1D (Photo 2.6). High resolution digital cameras were programmed to take pictures at 15-minute intervals. Cameras collected zoomed out photographs of the Colville River to document conditions and monitor ice jam formation and releases in the MON1 reach. Additionally, cameras were programmed to take pictures that were zoomed-in and focused on gages to allow hydrologists to remotely collect stage measurements for validating PT data.

Photo 2.6: Remote camera setup at MON1C overlooking gages; May 4, 2017

SENSORS

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

DATALOGGERS & TELEMETRY

Onsite dataloggers were programmed to interface with the PTs and sonars (Photo 2.7). Data was uploaded to the datalogger via a data cable and stored internally. The dataloggers were programmed to interact with telemetry equipment to transmit data. Data was transmitted using an onsite cellular modem and TCP/IP communication where each cellular modem has a unique static IP address. To conserve power, cellular modems were programmed to power-on every 15 minutes for data transmission. At MON1C, a separate onsite computer with mobile broadband internet access was used to upload camera images to cloud storage. Systems were powered with 12v DC batteries and charged with onsite solar panels.

Photo 2.7: Datalogger and camera at MON1U; May 5, 2017

HOST COMPUTER, DATA ACCESS, & NOTIFICATIONS

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

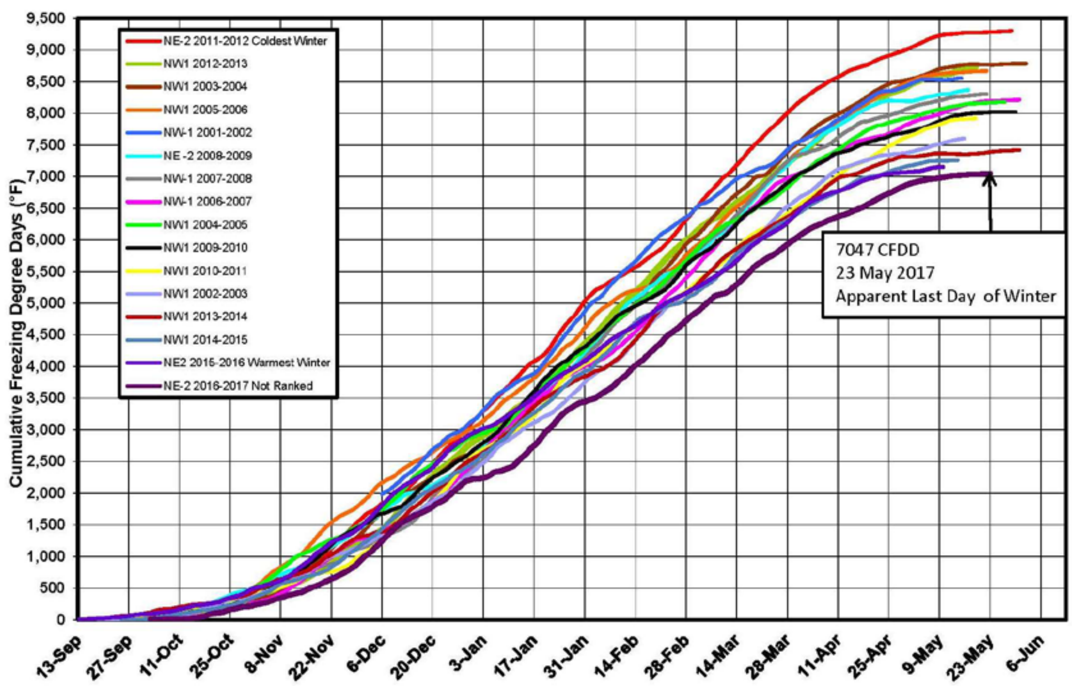
2.8 FLOOD & STAGE FREQUENCY ANALYSES

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

3. OBSERVATIONS

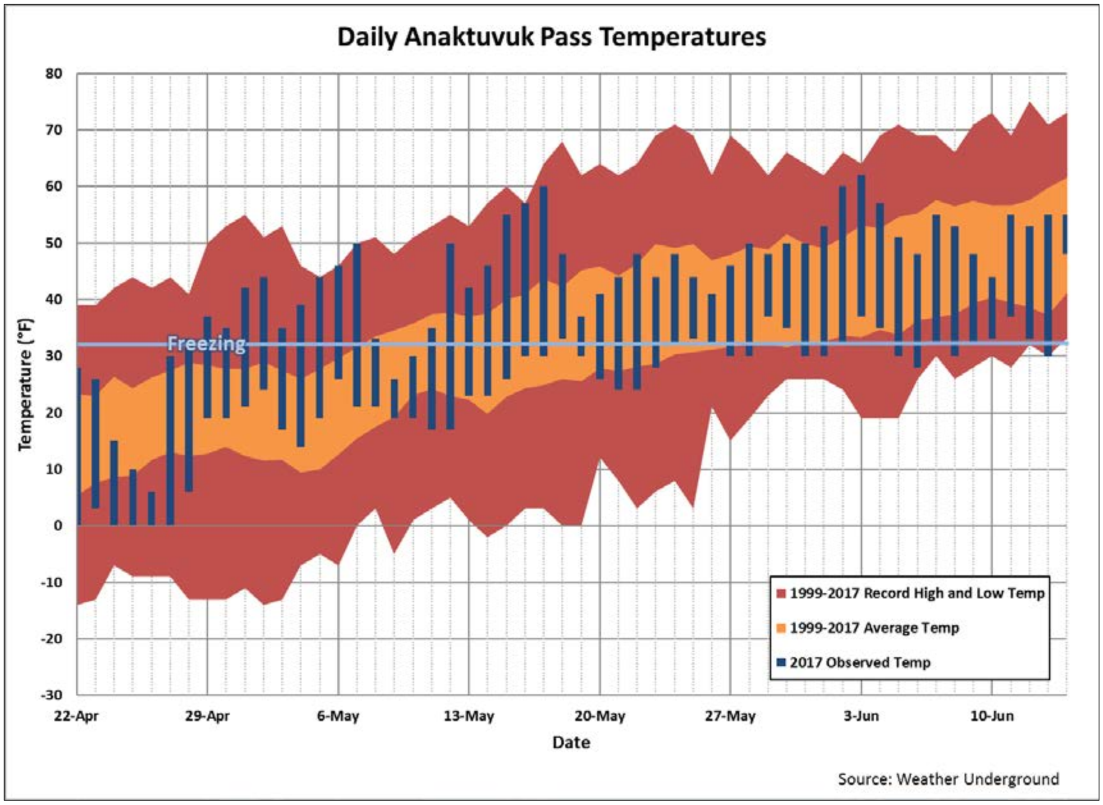
3.1 GENERAL CLIMATIC SUMMARY

According to cumulative freezing degree days (CFDD) measured at the National Petroleum Reserve Alaska (NPR-A) tundra monitoring station, the 2016-2017 (September – May) winter was the warmest on record for the past 16 years, as shown in Graph 3.1 (ICE 2017). As of March 1, 2017, snowpack east of the Colville River was reported as 90-109% of the 1981-2010 median. In April and May 2017, all North Slope snowpack was reported as 90-109% of the 1981-2010 median (Natural Resources Conservation Service 2017).

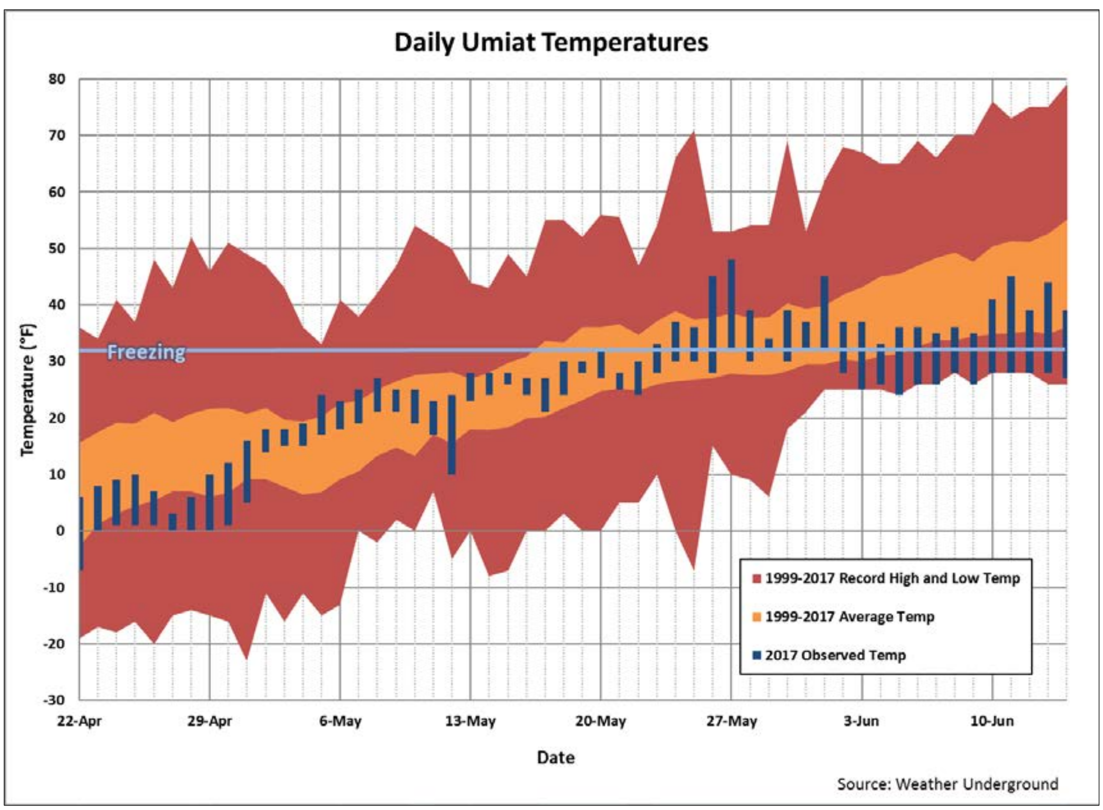


Graph 3.1: NPR-A N. Tundra Monitoring Station, CFDD, Winters 2002-2017 (ICE 2017)

Breakup in the CRD typically begins when daily low air temperatures consistently exceed freezing in the northern foothills of the Brooks Range. Climate data at the northern extent of the Brooks Range foothills is available from the Anaktuvuk Pass weather station and the Umiat weather station, located approximately 140 air miles and 60 air miles south (upstream) of the head of the CRD, respectively. Daily low air temperatures in Anaktuvuk Pass and Umiat remained near or below freezing throughout the majority of breakup which slowed regional breakup processes and contributed to a protracted breakup event. Daily high air temperatures in Anaktuvuk Pass from May 8 through May 13 accelerated melting of the snowpack in the foothills. Graph 3.2 and Graph 3.3 illustrate daily high and low ambient air temperatures recorded in Anaktuvuk Pass and Umiat, respectively, superimposed on the average and record daily highs and lows during the breakup monitoring period (Weather Underground 2017).

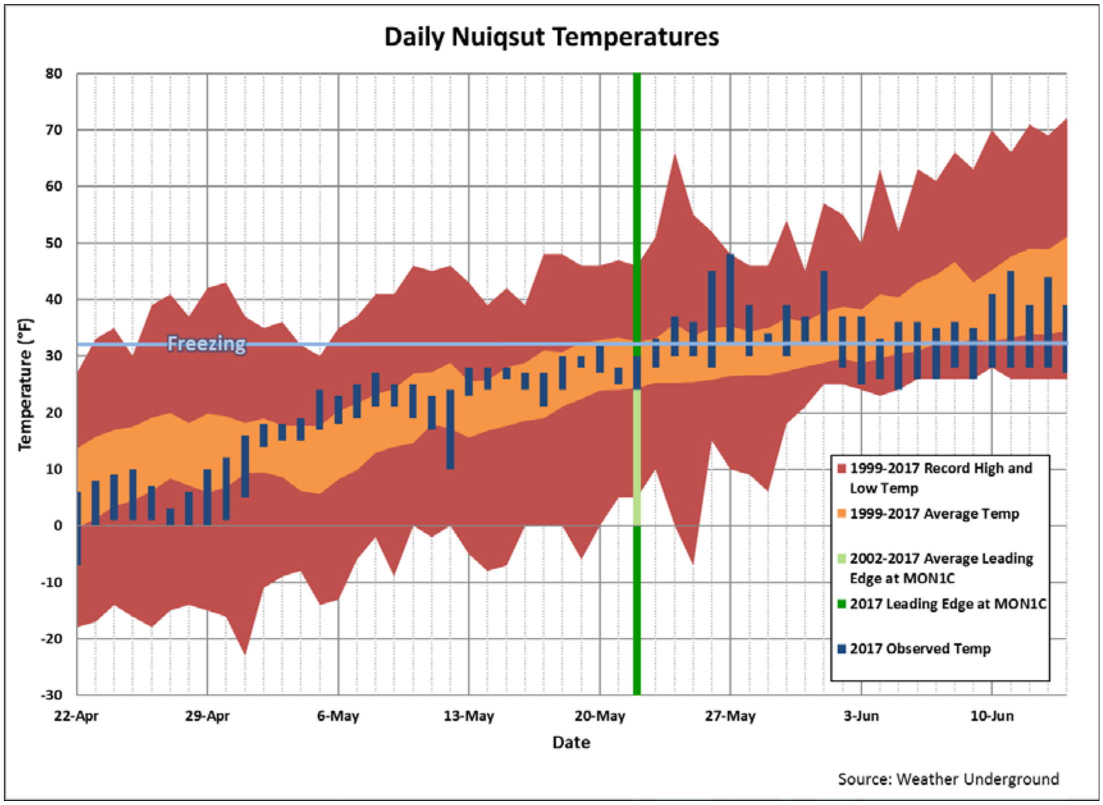


Graph 3.2: Anaktuvuk Pass Daily High and Low Ambient Air Temperatures



Graph 3.3: Umiat Daily High and Low Ambient Air Temperatures

Temperatures for the Alpine area are available from the Nuiqsut weather station, located approximately 9 air miles south (upstream) of Alpine facilities. Daily low ambient air temperatures in the CRD remained at or below freezing throughout breakup. Graph 3.4 illustrates daily high and low ambient air temperatures recorded in Nuiqsut superimposed on the average and record daily highs and lows during the breakup monitoring period (Weather Underground 2017). The arrival of the leading edge at MON1 this year and the average arrival of the leading edge at MON1 from 2002 to 2017 occurred on the same day and are included on the graph for comparison.



Graph 3.4: Nuiqsut Daily High and Low Ambient Air Temperatures and MON1 Leading Edge

3.2 GENERAL BREAKUP SUMMARY

Field crew members began regular reconnaissance flights towards the headwaters of the Colville River drainage on May 16. On May 19, initial floodwater was observed in the lower reaches of the Anaktuvuk River extending into the Colville River. The leading edge was observed in the Colville River approximately 3 RMs downstream of the confluence (Photo 3.1). No flow was observed in the Colville River upstream of the Anaktuvuk River confluence. It is common for Anaktuvuk River floodwater to enter the Colville River prior to water flowing in the Colville River upstream of the confluence. By May 20, the leading edge had advanced 25 RMs downstream and substantial snow cover (approximately 95%) remained in the drainage basin. On the morning of May 22, the leading edge was intermixed with local melt upstream of the Itkillik River confluence. Downstream, the Itkillik River was discharging into the Colville River (Photo 3.2). This condition has not been observed in the past 19 years. The arrival of Itkillik

River floodwater into the CRD prior to that from upstream in the Colville River suggests snow melt in the eastern portion of the watershed occurred before that in the western part. The leading edge likely passed MON1 in the afternoon on May 22.

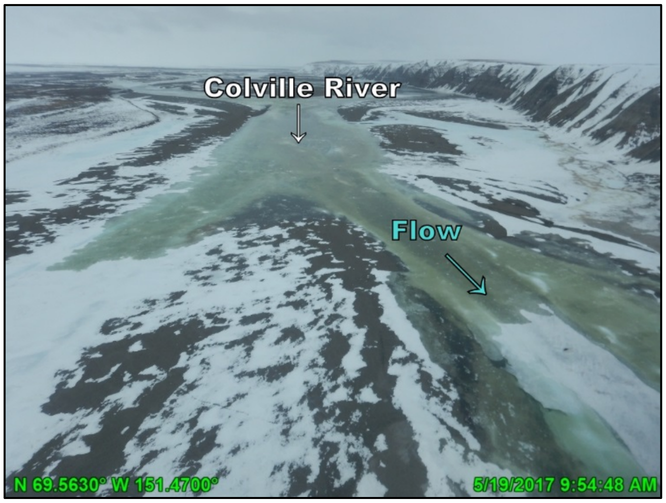


Photo 3.1: Leading edge in the Colville River from the Anaktuvuk River, looking south (upstream); May 19, 2017

Photo 3.2: Floodwater entering the Colville River from the Itkillik River, looking north (downstream); May 22, 2017

On May 24, floodwater and intact channel ice was observed throughout the CRD distributary channels (Photo 3.3) and air temperatures recorded in Nuiqsut began increasing. On May 26, floodwater reached the CD3 pipeline crossings (Photo 3.4) and channel ice lifted throughout the CRD and began slowly degrading (Photo 3.5). By May 27, stage was rising in all main distributary channels of the CRD. On May 28, two small ice jams formed upstream approximately 8 and 12 RMs upstream of MON1 (Photo 3.6); however, floodwater remained well within the channel banks, indicating minimal backwater upstream of the ice jams. Degrading channel ice remained throughout the CRD distributary channels (Photo 3.7 and Photo 3.8) and snow cover around Alpine facilities was approximately 20% (Photo 3.9). Floodwater reached Alpine facilities on May 29 and flow was observed through the CD2 access road Long Swale Bridge. Overflow was also observed entering Lake M9525 from the Sakoonang Channel.

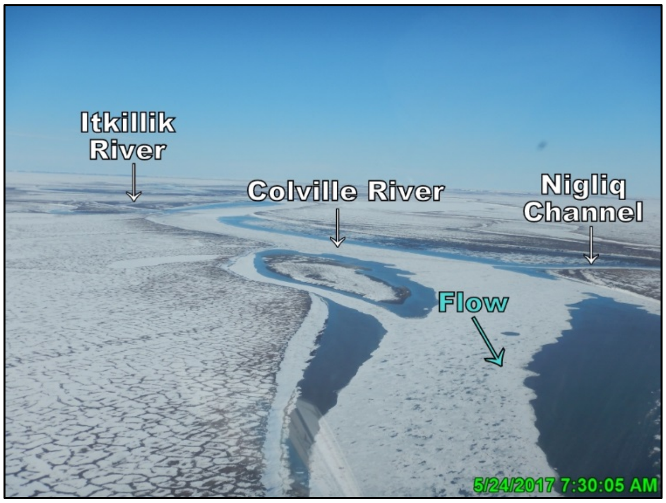


Photo 3.3: Colville River at Nigliq Channel and East Channel bifurcation, looking south (upstream); May 24, 2017

Photo 3.4: Floodwater at the Ulamnigiaq Pipeline Crossing, looking southeast (upstream); May 26, 2017

Photo 3.5: Degrading channel ice in the Nigliq Channel, looking southeast (upstream); May 26, 2017

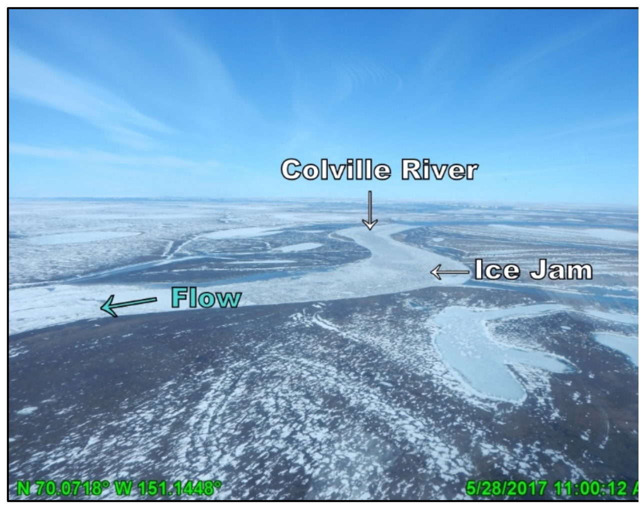


Photo 3.6: Ice jam upstream of MON1, looking south (upstream); May 28, 2017

Photo 3.7: Degrading channel ice in the East Channel, looking south (upstream); May 28, 2017

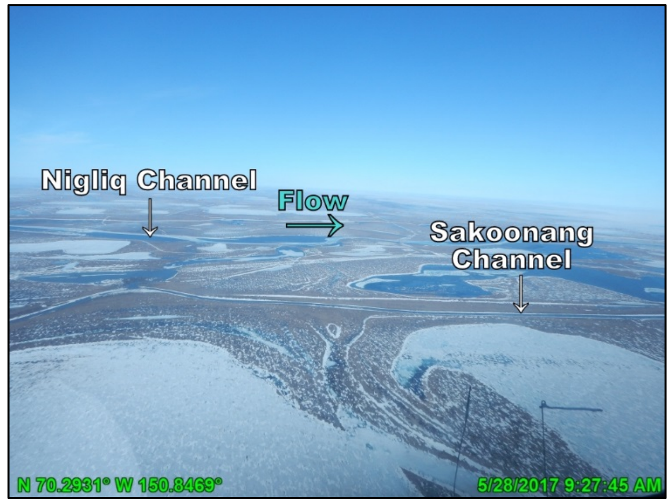


Photo 3.8: Degrading channel ice in the Nigliq Channel, looking west; May 28, 2017

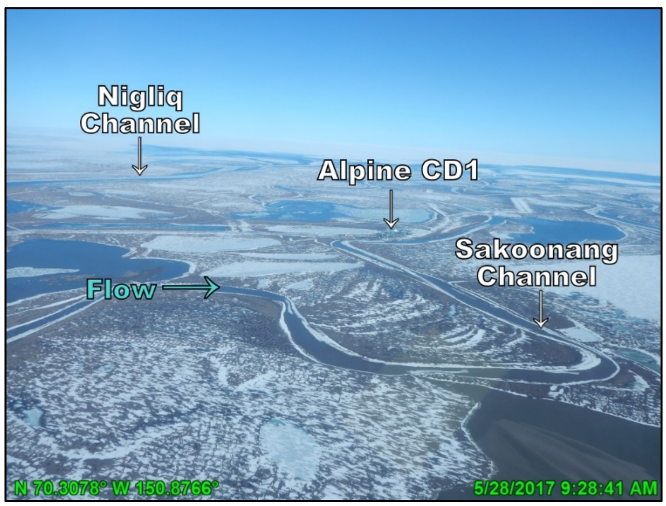


Photo 3.9: Snow cover around Alpine facilities, looking northwest; May 28, 2017

On the morning of May 30, an ice jam formed behind channel ice immediately upstream of the MON1 reach. Remote camera images at MON1 indicated the upstream ice jam released the afternoon of May 30. The ice jam temporarily reformed within the MON1 reach and released again the evening of May 30, producing a small, short-lived rise in water levels amounting to peak stage at MON1. A small ice jam was also observed in the Nigliq Channel just upstream of Nuiqsut (Photo 3.10). On May 31, the East Channel and Nigliq Channel bifurcations were free of channel ice (Photo 3.11) and the ice jam at MON1 moved downstream and reformed in the East Channel at the Sakoonang Channel bifurcation upstream of channel ice. The ice jam in the Nigliq Channel moved downstream and reformed adjacent to Nuiqsut. By June 1, channel ice broke up in the main distributary channels in the CRD. Peak stage was observed around Alpine facilities between May 31 and June 1. All flow in the CRD remained well within the channel banks.

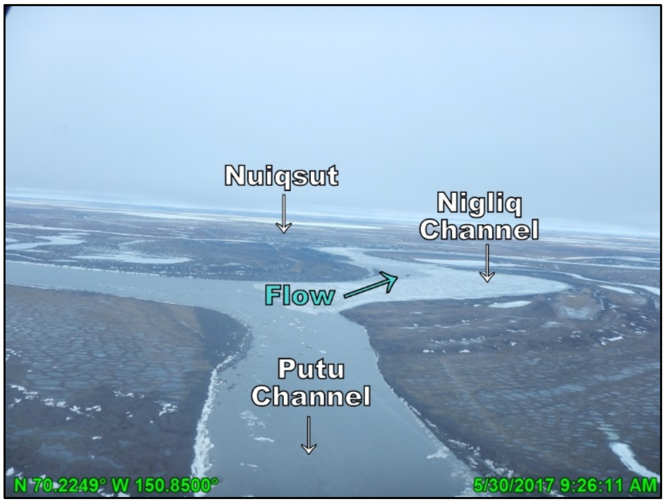
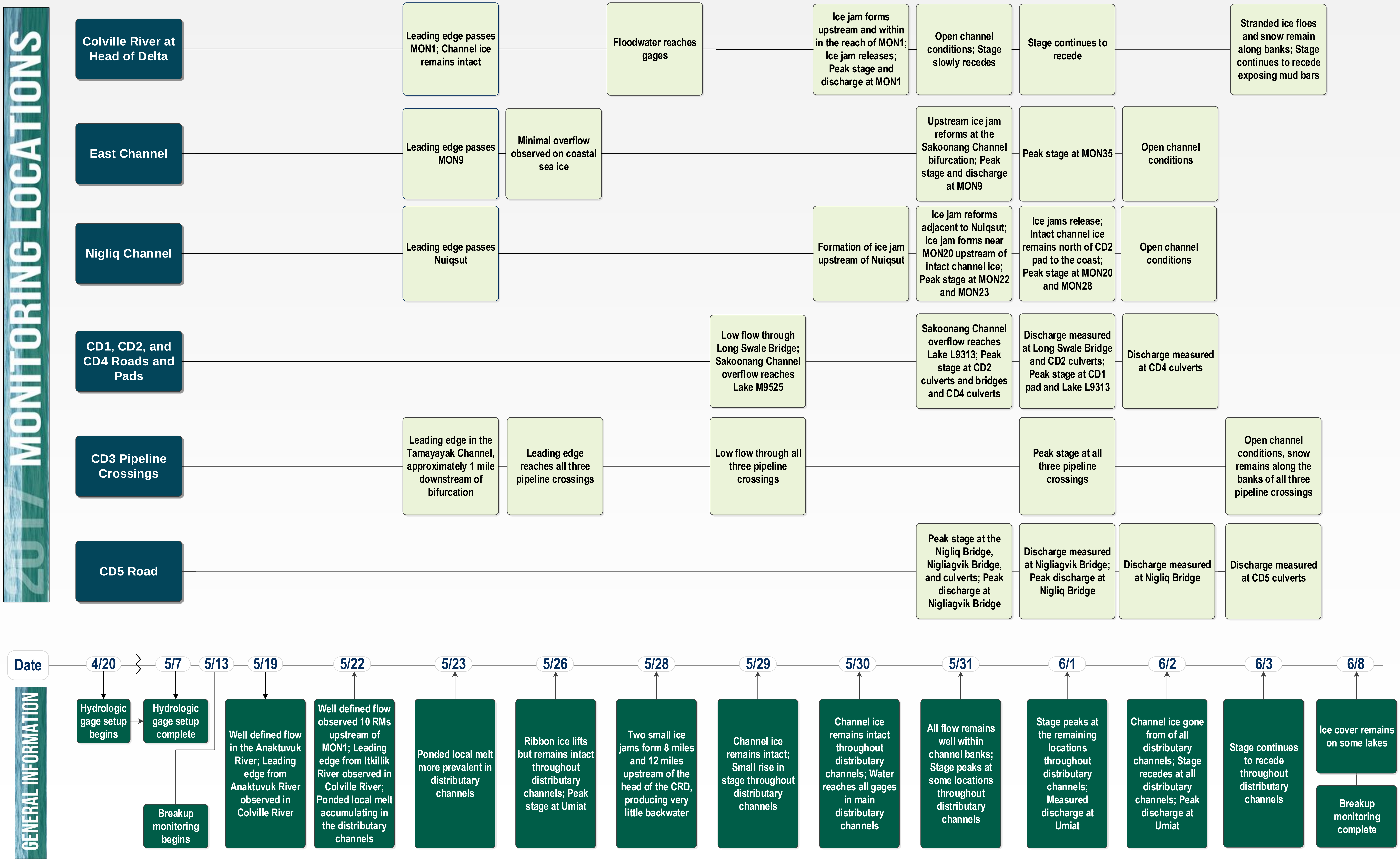


Photo 3.10: Nigliq Channel ice jam upstream of Nuiqsut, looking southwest (upstream); May 30, 2017

Photo 3.11: Open channel conditions in the East Channel at the bifurcation, looking south (upstream); May 31, 2017

By June 2, water levels throughout the CRD were slowly receding and channel ice was slowly flushed out of the CRD with minimal ice jamming. By June 4, most distributary channels were ice free. Figure 3.1 provides a visual timeline summarizing major breakup events.

Figure 3.1: Spring Breakup Hydrologic Timeline



4. STAGE & DISCHARGE

Table 4.1 contains a summary of peak stage, measured discharge (in cubic feet 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[4]	51.01	5/26, 11:30am	66,700	49.96	6/1, 1:30pm	75,100	50.21	6/2, 2:15am
CRD Monitoring Locations										
Colville River	Head of the CRD	MON1U	15.48	5/30, 5:15pm	not measured			288,000	14.35	5/30, 8:15pm
		MON1C	14.79	5/30, 7:00pm					13.83	
		MON1D	14.14	5/30, 1:15pm					13.71	
Colville River East Channel	East Channel Distributary	MON9	12.24	5/31, 4:30am	--			207,000	11.75	5/31, 4:15pm
		MON9D	11.77	5/31, 12:00pm					11.37	
		MON35	4.11	6/1, 3:00pm	--			--		
Nigliq Channel	Nigliq Channel Distributary	MON20	8.41	6/1, 7:30am	--			--		
		MON22	7.27	5/31, 9:30pm						
		MON23	6.26	5/31, 9:45pm						
		MON28	3.42	6/1, 12:30pm						
Alpine Facilities Monitoring Locations										
CD1 Pad & Drinking Water Lakes	Lake L9312	G9	dry	--	--			--		
	Lake L9313	G10	7.40	6/1, 5:45am	--			--		
	CD1 Pad	G1	6.17	6/1, 5:30pm	--			--		
CD2 Pad & Road	Short Swale Bridge	G3	6.04	5/31, 10:30pm	no observable flow			not calculated		
		G4	5.96	5/31, 10:30pm						
	Long Swale Bridge	G3	6.04	5/31, 10:30pm	1,290	5.91	6/1, 3:45pm	1,350	6.04	5/31, 10:30pm
		G4	5.96	5/31, 10:30pm		5.87			5.96	
	Culverts	G3	6.04	5/31, 10:30pm	17	5.91	6/1, 4:50pm	18	6.03	5/31, 11:30pm
		G4	5.96	5/31, 10:30pm		5.87			5.94	
		G6	dry	--	no observable flow			not calculated		
		G7	dry	--						
		G12	dry	--	no observable flow			not calculated		
		G13	dry	--						
	CD2 Pad	G8	dry	--	--			--		
CD3 Pad & Pipeline	Pipeline Crossings	SAK	6.15	6/1, 5:30pm	--			--		
		TAM	6.57	6/1, 5:45pm	--			--		
		ULAM	6.13	6/1, 5:15pm	--			--		
	CD3 Pad	G11	dry	--	--			--		
CD4 Pad & Road	Culverts	G15	7.45	5/31, 7:15pm	no observable flow			not calculated		
		G16	7.44	5/31, 11:30pm						
		G17	dry	--	0.4	dry	6/2, 4:12pm	not calculated		
		G18[2]	10.33	5/27, 6:30pm		dry				
		G40	dry	--	no observable flow			not calculated		
		G41	dry	--						
		G42	dry	--	no observable flow			not calculated		
		G43	dry	--						
	CD4 Pad	G19	dry	--	--			--		
		G20[3]	7.50	5/31	--			--		
CD5 Road	Culverts	G30[3]	9.80	5/31	1	8.69	6/3, 5:55pm	not calculated		
		G31[3]	9.70	5/31		8.59				
		G34	dry	--	no observable flow			not calculated		
		G35	dry	--						
		G36	dry	--	no observable flow			not calculated		
		G37	dry	--						
		S1[3]	19.75	5/31	1	19.35	6/3, 17:20	not calculated		
		S1D[3]	19.33	5/31		19.33				
	Lake L9323 Bridge	G24[2]	9.54	5/29, 8:00am	no observable flow			not calculated		
		G25[2]	9.76	5/27, 6:15pm						
	Nigliq Bridge	G28	8.73	5/31, 9:90pm	24,600	--	6/2, 1:50pm	46,800	8.42	6/1, 2:00pm
		G26	8.60	5/31, 9:15pm		6.863			8.21	
		G27	8.58	5/31, 9:15pm		6.876			8.17	
		G29	8.42	5/31, 9:30pm		--			8.06	
	Lake L9341 Bridge	G32	7.10	5/31, 9:45pm	no observable flow			not calculated		
		G33	7.13	5/31, 9:45pm						
	Nigliagvik Bridge	G38	6.86	5/31, 10:00pm	1,200	6.66	6/1, 1:45pm	2,600	6.70	5/31, 2:15pm
		G39	6.82	5/31, 10:00pm		6.64			6.64	

Notes:

1. Stage prior to discharge measurement
2. Peak stage from ponded local melt
3. Peak stage date estimated
4. Data obtained from USGS Umiat gage station 15875000 and converted from NAVD88 to BPMSL using an adjustment factor of -3.51 ft (Lounsbury 2013)

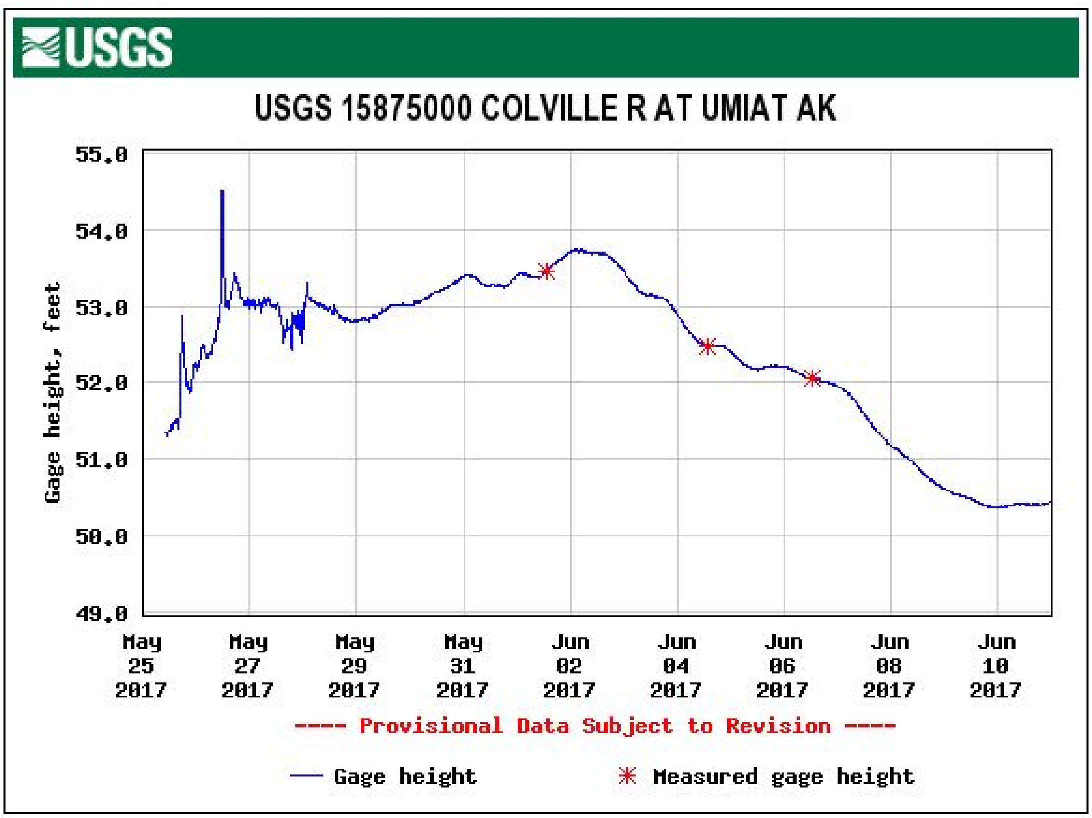
4.1 COLVILLE RIVER

UMIAT

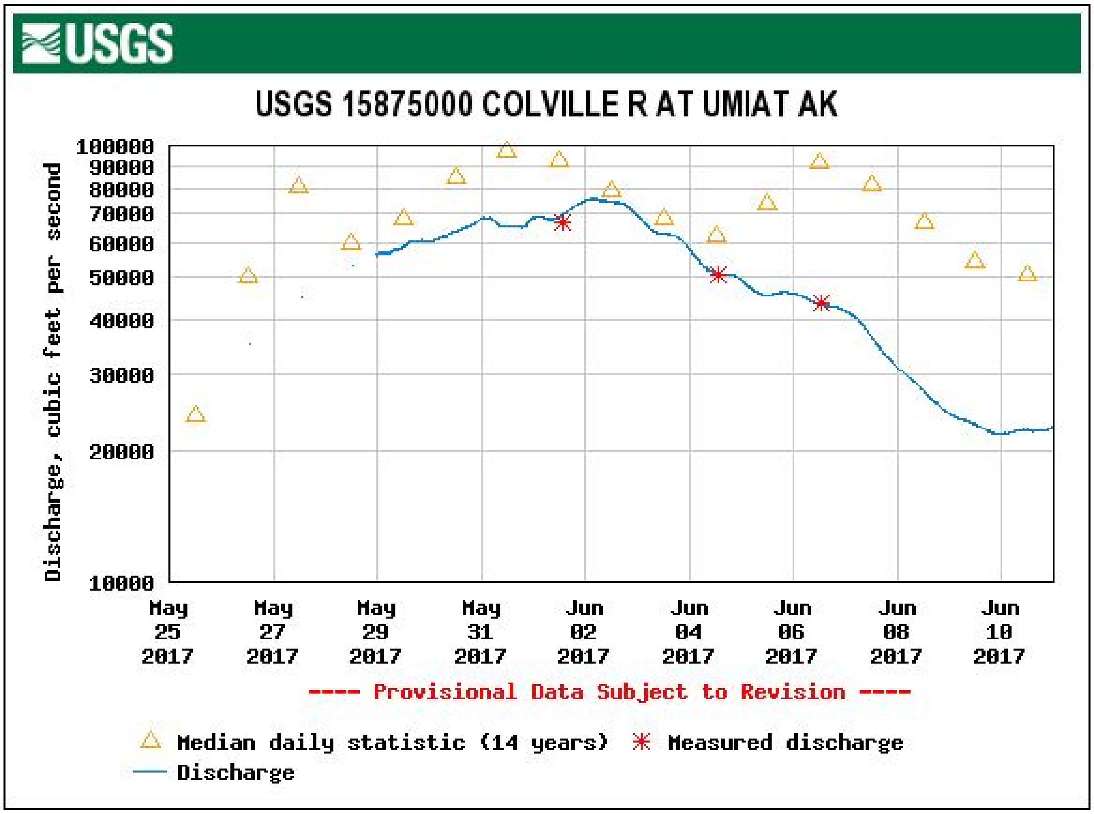
USGS Umiat gage station 15875000 is located approximately 90 RM upstream of the CRD and is monitored throughout breakup to help predict the timing of floodwater and flood crests in the CRD. Umiat is upstream of the Chandler and Anaktuvuk River confluences and Umiat gage data does not account for the contribution from these two major tributaries. Because of local ice effects, distance, and streamflow additions between Umiat and the CRD, the magnitude of flooding at Umiat and in the CRD do not necessarily correlate. There is typically a 24-hour lag time between flood crests at Umiat and the CRD.

The Umiat gage was offline this year until May 26. It is unknown when the leading edge of floodwater reached Umiat. USGS stage (Graph 4.1) and discharge (Graph 4.2) data is provisional and subject to revision.

Colville River at Umiat stage peaked at 11:30 AM on May 26 at 54.5 ft NAVD88 (51.0 ft BPMSL), 4.5 feet below National Weather Service established flood stage of 59.0 ft NAVD88 (55.5 ft BPMSL). A lower crest of 53.7 ft NAVD88 (50.2 ft BPMSL) was recorded at 2:15 AM on June 2. Peak discharge of 75,100 cfs coincided with the June 2 crest (USGS 2017).



Graph 4.1: Colville River at Umiat Stage (USGS 2017)



Graph 4.2: Colville River at Umiat Discharge (USGS 2017)

HEAD OF THE DELTA

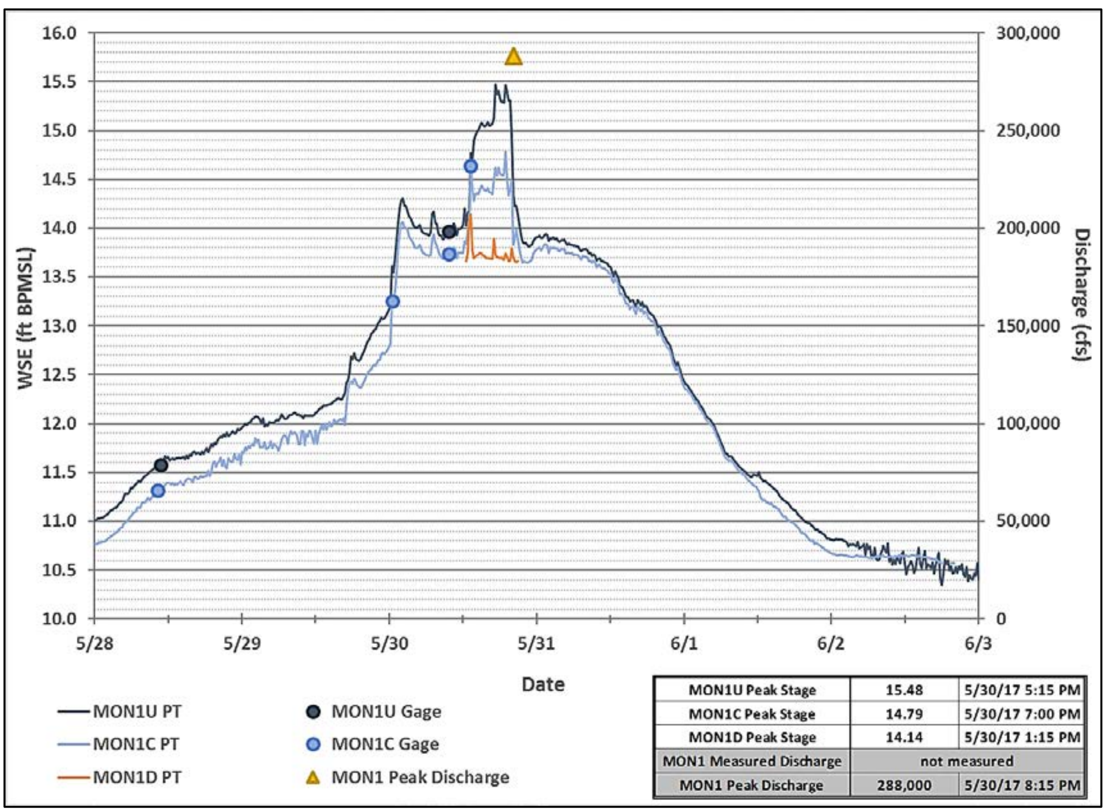
Stage and discharge have been monitored at MON1 annually since 1992 and periodically since 1962. It is considered the primary spring breakup monitoring location for the Colville River Delta because of its location at the head of the CRD and long historical record.

Peak stage and peak discharge at MON1 were the results of backwater from the ice jam within the MON1 reach (Photo 4.1 and Photo 4.2). The ice jam formed between MON1C and MON1D resulting in backwater at MONC and MON1U, just prior to release. Additionally, ice floes were moving through the reach when the ice jam released, impacting stage. The estimated peak discharge was assigned a fair quality rating (Table 2.1) because of these influences.

Discharge was not measured in the Colville River because of wind induced high wave conditions. Direct discharge measurements require a relatively smooth water surface for accuracy and safety. 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.2.1.

Photo 4.1: Conditions the day of peak stage and peak discharge at MON1, looking northeast (downstream); May 30, 2017

Photo 4.2: Conditions the day after peak stage and peak discharge at MON1, looking south (upstream); May 31, 2017



Graph 4.3: Colville River at the Head of the Delta Stage & Discharge

4.2 COLVILLE RIVER EAST CHANNEL

MON9 has been monitored annually since 2005 and the data contributes to estimating the distribution of discharge between the East Channel and Nigliq Channel. MON35 has been monitored since 1999 and provides WSEs at the outer extents of the CRD.

Peak stage at MON9 and MON9D were the result of backwater from the downstream ice jam at the Sakoonang Channel bifurcation. Prior to peak discharge, channel ice remained intact throughout the reach (Photo 4.3). At the time of peak discharge, the ice jam release at MON1 flushed the intact channel ice and ice floes were observed moving through the reach (Photo 4.4). After peak discharge, ice floes backed up behind the downstream intact channel ice at the Sakoonang Channel bifurcation (Photo 4.5). The estimated discharge was assigned a fair to poor quality rating (Table 2.1) due to these influences. Site specific discharge data and plan and profile drawings are provided in Appendix C.2.2.

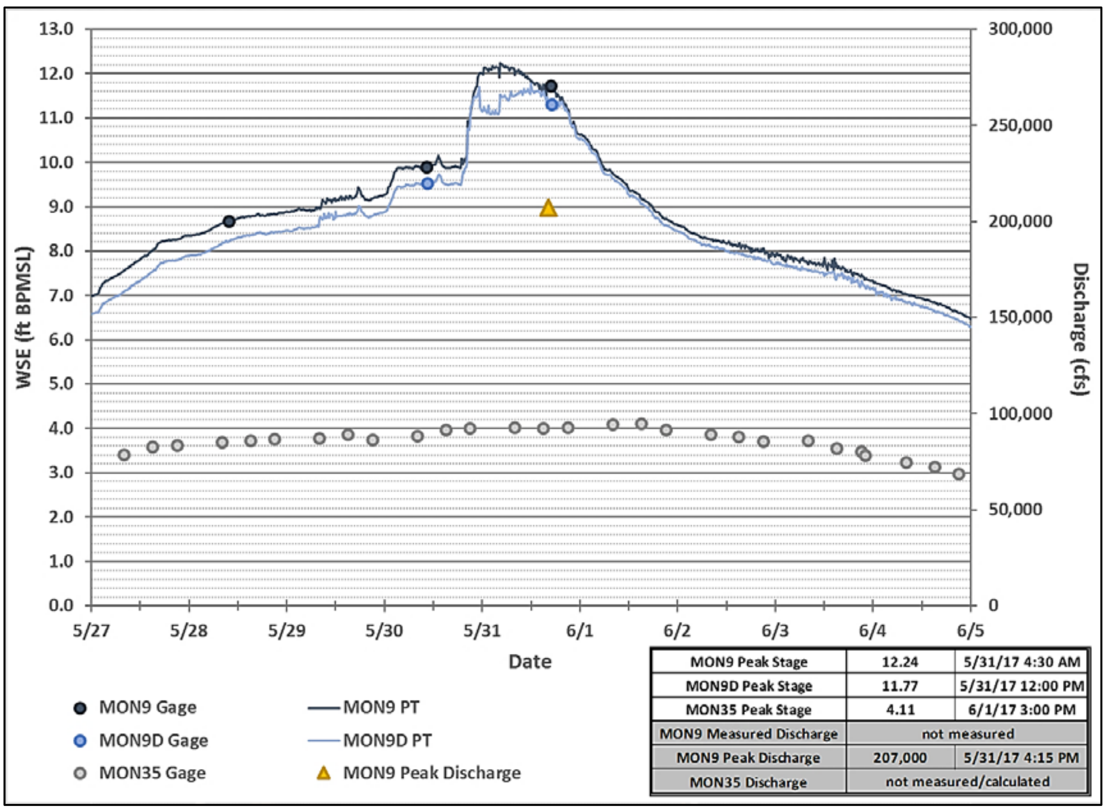
Stage at MON35 was manually recorded, on average, three times per day, supplemented by a time-lapse camera. Discharge was not measured or calculated at this location. Peak stage at MON35 occurred when intact channel ice was still in place.

Stage and discharge at MON9 and MON9D and stage at MON35 are presented in Graph 4.4.

Photo 4.3: Conditions the day prior to peak stage and peak discharge at MON9, looking southwest (upstream); May 30, 2017

Photo 4.4: Conditions during peak discharge at MON9, looking east; May 31, 2017

Photo 4.5: Conditions the day of peak stage and peak discharge at MON9, looking north (downstream); May 31, 2017



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 in the Nigliq Channel is measured and calculated at the bridge.

Peak stage in the Nigliq Channel occurred while channel ice was still present at all locations except at MON20. On May 31, stage increased in the MON20-MON23 reach after the ice jam at MON1 released the evening prior. Increasing stage at MON20 on June 1 was likely the result of floes jamming on intact channel ice upstream of the Nigliq Bridge (Photo 4.6). Backwater diminished by the evening though floes and channel ice remained in place. Channel ice remained intact at and downstream of MON22 that evening (Photo 4.7). Open channel conditions were observed throughout the MON20 to MON22 reach by June 2. Channel ice was still observed in the MON28 vicinity on June 5.

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

Photo 4.6: Ice jam downstream of MON20 twelve hours after peak stage, looking southeast (upstream); June 1, 2017

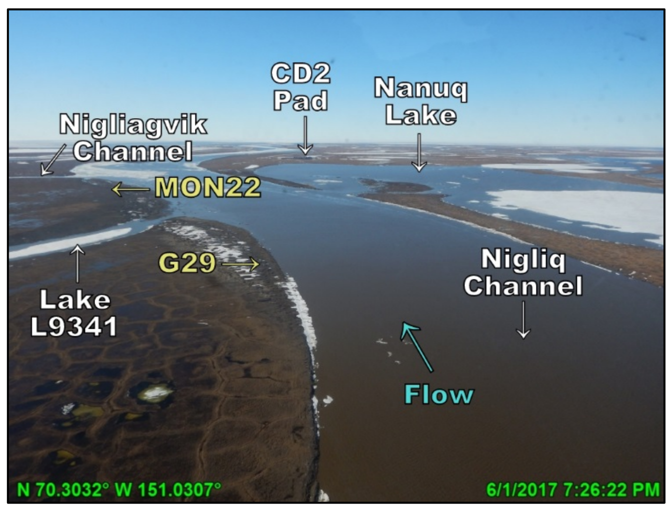
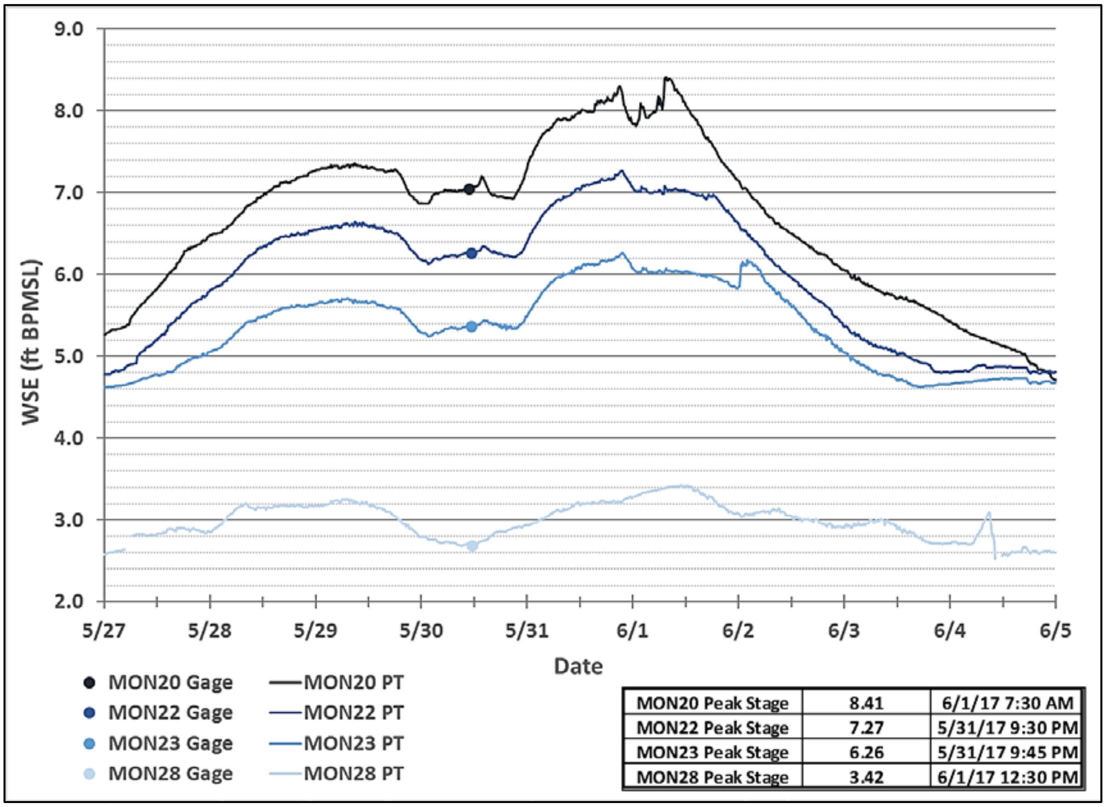


Photo 4.7: Channel ice at MON22 the day after peak stage, looking northwest (downstream); June 1, 2107



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 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 WSEs and local ice jam activity.

Drainage structures are kept free of ice, snow accumulation, and blockages through regular maintenance by CPAI. Techniques include inserting and inflating pillows in the culvert inlets and outlets during the winter and removing prior to breakup. Snow is also mechanically removed from the immediate upstream and downstream areas of all culverts and swale bridges prior to breakup flooding.

Culverts were monitored to assess flow conditions and culvert performance. All culvert pillows were removed prior to the arrival of floodwater. Snow and ice were cleared at all culvert inlets and no flow restrictions were observed. Culvert locations and proximity to gages are shown in Appendix A.3. Detailed culvert discharge measurements, calculations, and performance summary field notes are provided in Appendix C.2.6.

CD1 PAD & LAKES L9312 & L9313

Recharge at drinking water source Lake L9312 (gage G9) and Lake L9313 (gage G10) has been monitored annually since 1998. Historical observations indicate the Sakoonang Channel floodwater is the primary recharge mechanism for both lakes (Michael Baker 2013a). Stage data and observations of breakup processes have been collected at gage G1 since 2000.

Spring breakup overbank flow did not reach Lake L9312 this year and snowmelt recharge from within the lake basin did not reach bankfull elevation. Water levels remained below the gage G9 PT throughout the duration of breakup. Floodwater from the Sakoonang Channel reached Lake L9313 on May 31 (Photo 4.8) and the lake recharged above bankfull elevation. Stage at gage G1 is presented in Graph 4.6. Stage at gage G9 (L9313) and gage G10 (L9313) is presented in Graph 4.7.

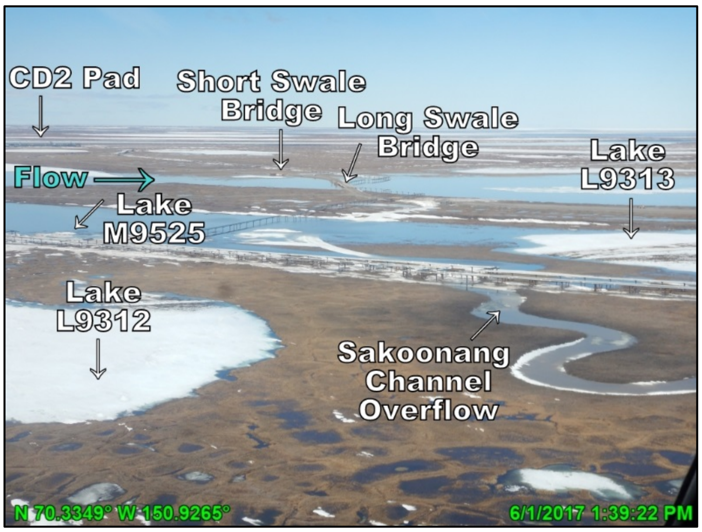
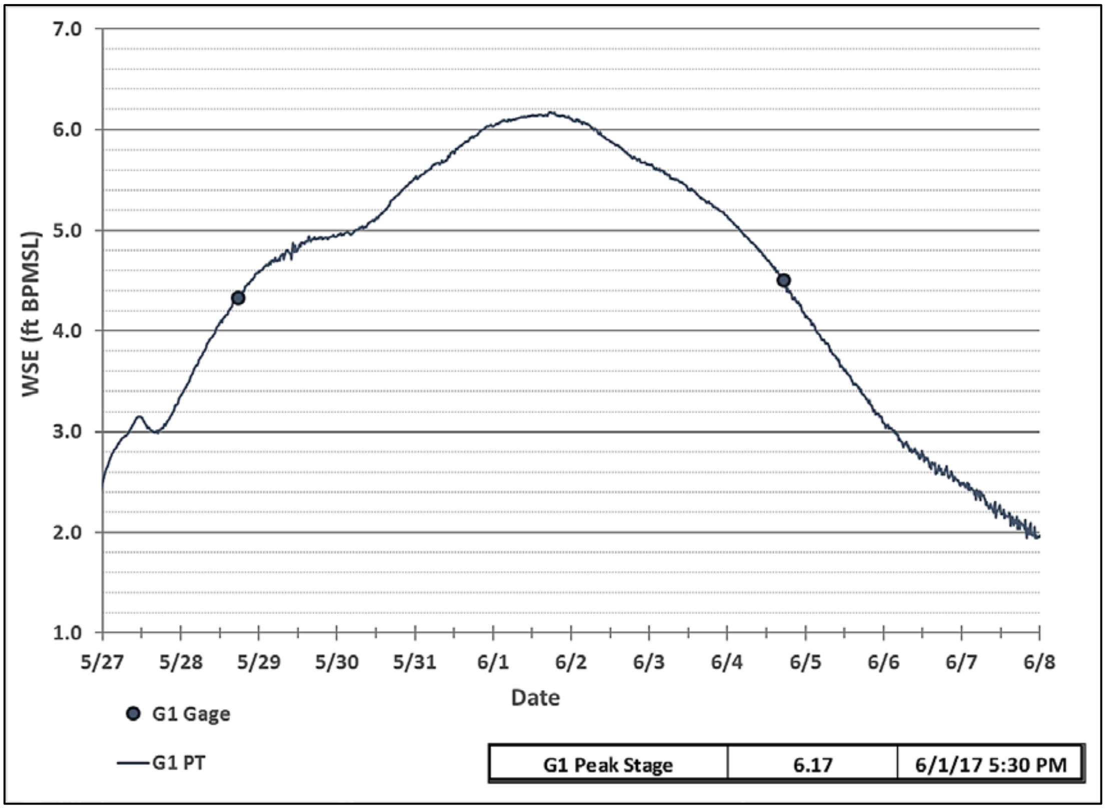
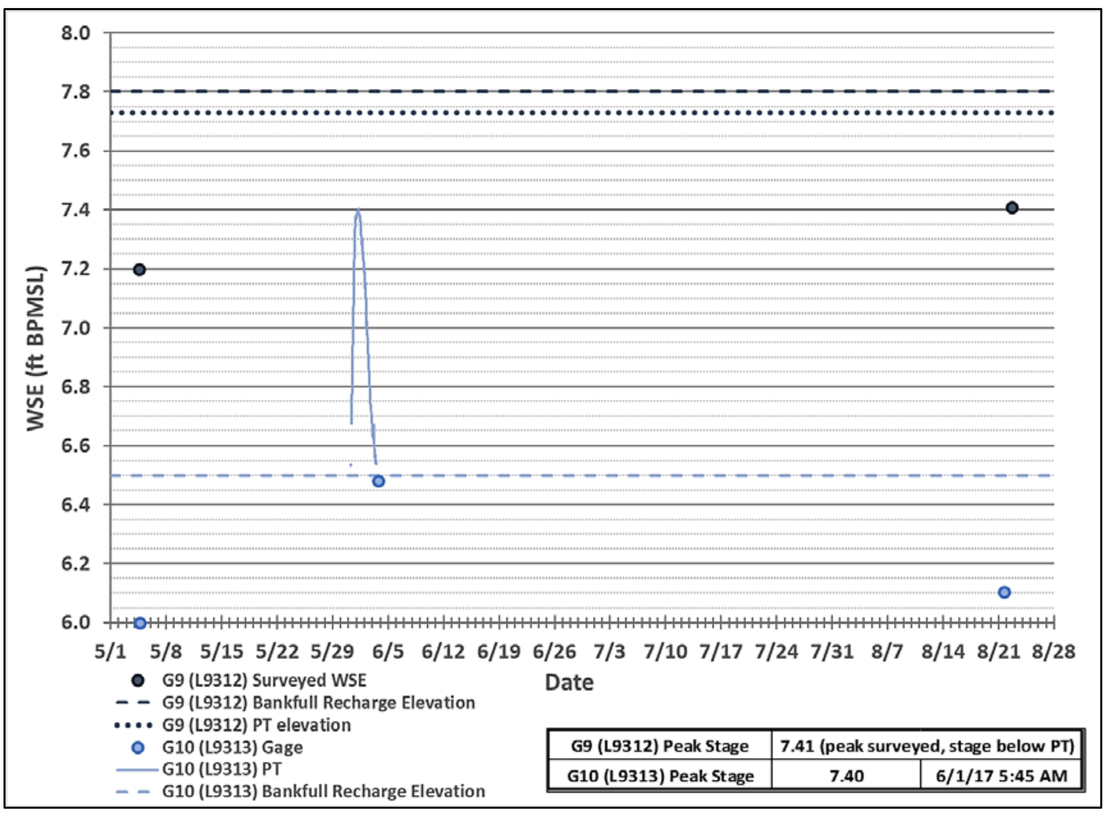


Photo 4.8: Lake L9313 recharge and hydraulically isolated Lake L9312 the day of peak stage, looking west; June 1, 2017



Graph 4.6: CD1 Pad (Gage G1) Stage



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 only present in the vicinity of gages G3/G4. The Long Swale Bridge and three adjacent culverts conveyed flow from the Nigliq Channel into Lake M9524 via Nanuq Lake (Photo 4.9). Minimal floodwater reached the Short Swale Bridge and was not hydraulically connected at the downstream side, therefore, discharge was not measured or calculated (Photo 4.10).

Measured average velocity at the Long Swale Bridge was 0.89 feet per second (fps) and the highest depth-averaged velocity within a single section was 1.80 fps. At the time of the measurement, the bridge opening was ice and snow free, though some backwater effects were observed from the lake downstream. The quality of the measurement was rated fair. Peak discharge was calculated using the measured velocity and adjusting the hydraulic depth for peak conditions. Peak discharge was estimated to have occurred during peak stage.

Discharge was measured through the Long Swale Bridge and gage G3/G4 culverts approximately 17 hours after peak stage at gage G3. Peak discharge through gage G3/G4 culverts was estimated to have occurred approximately one hour after peak stage. Stage and total discharge at CD2 bridges and culverts are provided in Graph 4.8. The graph shows stage above the PT only; gaps in data indicate stage dropped below the PT. Measured discharge and peak discharge at culverts conveying flow is summarized in Table 4.2 and Table 4.3, respectively. Historical measured and peak discharge at the Long and Short Swale Bridges are summarized in Section 8.0, Historical Breakup Timing & Magnitude. A summary of the Long Swale Bridge discharge measurement is presented in Appendix C.2.5.

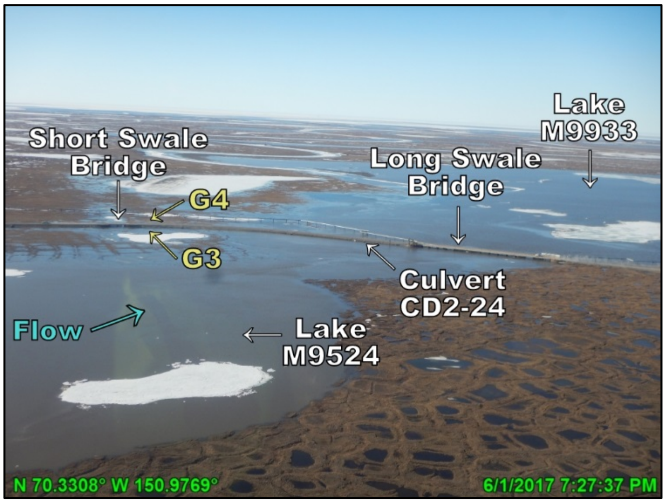
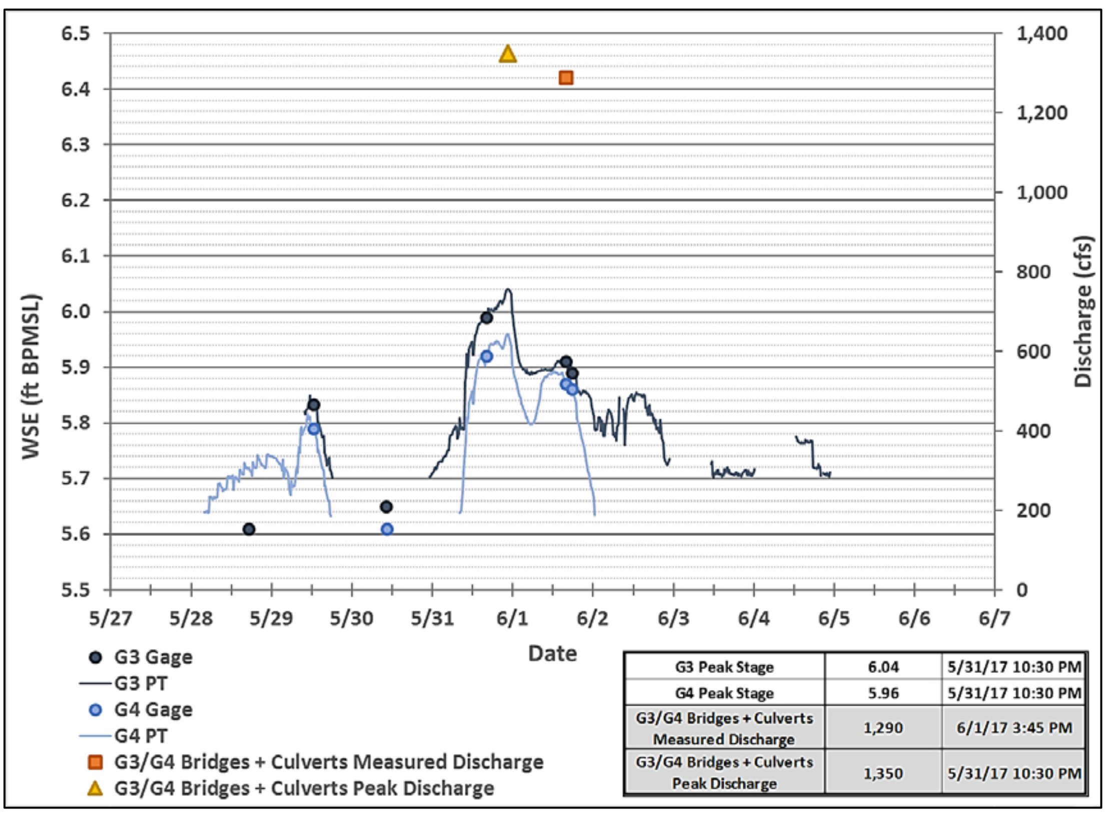


Photo 4.9: Conditions at CD2 road drainage structures the day after peak stage and the day of measured discharge, looking north (downstream); June 1, 2017

Photo 4.10: Conditions at the CD2 road Short Swale Bridge the day after peak stage, looking northwest (downstream); June 1, 2017



G3 Peak Stage	6.04	5/31/17 10:30 PM
G4 Peak Stage	5.96	5/31/17 10:30 PM
G3/G4 Bridges + Culverts Measured Discharge	1,290	6/1/17 3:45 PM
G3/G4 Bridges + Culverts Peak Discharge	1,350	5/31/17 10:30 PM

Graph 4.8: CD2 Road Bridges and Culverts (Gages G3 & G4) Stage & Discharge

Table 4.2: CD2 Road Culverts (Gages G3 & G4) Measured Discharge

Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measured Depth of Flow[1] (ft)	Flow Depth[2]	Measured Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD2-22	6/1/17 5:00 PM	0.60	0.24	Less than Half Full	2.02	2	
CD2-23	6/1/17 4:50 PM	1.30	0.52	Less than Half Full	2.44	9	17
CD2-24	6/1/17 4:40 PM	1.50	0.60	Less than Half Full	1.38	6	

Note:
[1] Measurement taken at 0.6 of total depth of flow
[2] Culverts are 48” in diameter

Table 4.3: CD2 Road Culverts (Gages G3 & G4) Peak Discharge

Culvert	Calculated Date & Time	WSE Differential (ft)	Total Depth of Flow (ft)	Flow Depth[1]	Calculated Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD2-22	5/31/17 11:30 PM		0.74	Less than Half Full	1.57	2	
CD2-23	5/31/17 11:30 PM	0.09	1.42	Less than Half Full	1.75	7	18
CD2-24	5/31/17 11:30 PM		1.68	Less than Half Full	1.69	8	

Note:
[1] Culverts are 48” in diameter

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 G11 remained dry throughout breakup. Peak stage in the Sakoonang Channel, Tamayayak Channel, and Ulamnigiaq Channel occurred after channel ice broke up and moved downstream (Photo 4.11, Photo 4.12, and Photo 4.13). Open channel conditions were observed in channel by June 2.

Stage at the SAK, TAM, and ULAM gages is presented in Graph 4.9.

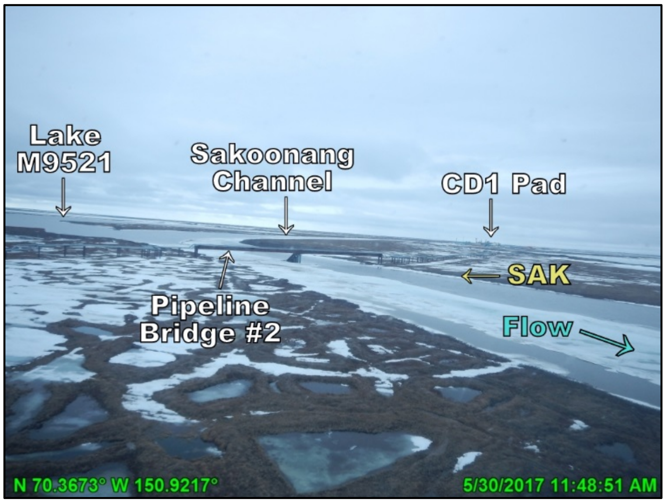


Photo 4.11: Conditions in the Sakoonang Channel two days prior to peak stage at SAK, looking southeast; May 30, 2017

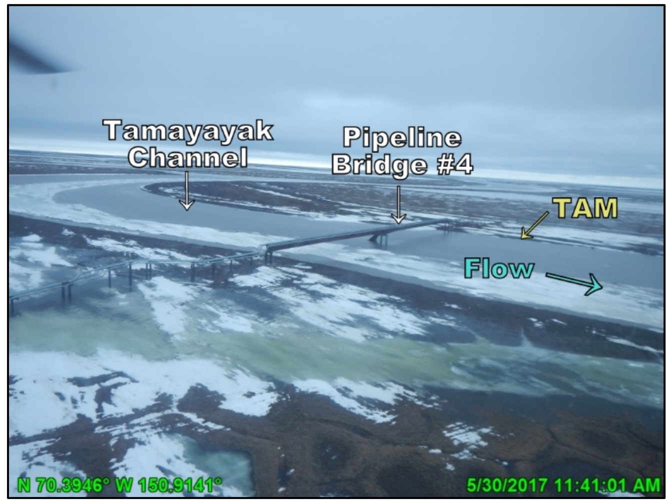


Photo 4.12: Conditions in the Tamayayak Channel two days prior to peak stage at TAM, looking southeast; May 30, 2017

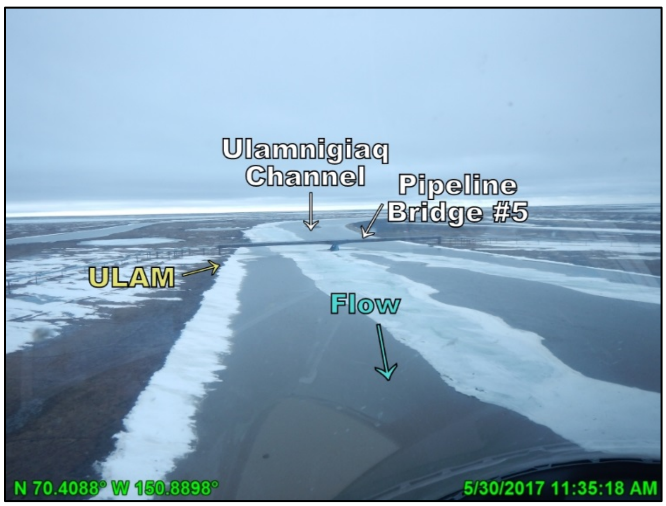
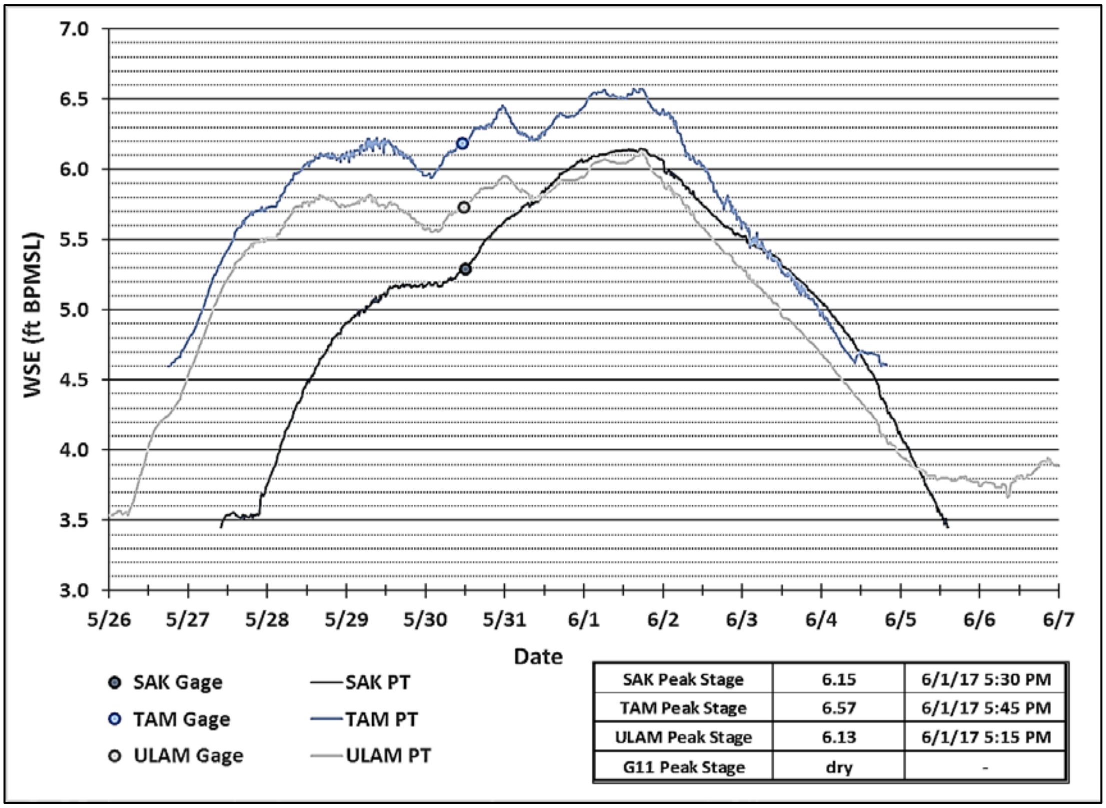


Photo 4.13: Conditions in the Ulamnigiaq Channel two days prior to peak stage at ULAM, looking southeast; May 30, 2017



SAK Peak Stage	6.15	6/1/17 5:30 PM
TAM Peak Stage	6.57	6/1/17 5:45 PM
ULAM Peak Stage	6.13	6/1/17 5:15 PM
G11 Peak Stage	dry	-

Graph 4.9: 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.

Gages G40/G41 and G42/G43 remained dry throughout monitoring (Photo 4.14). Culvert equalization was observed at gages G15/G16 (Photo 4.15). No discernable flow was observed and discharge was not measured or calculated.

Gage G17 remained dry throughout monitoring (Photo 4.16). A slight rise in stage at gage G18 was due to ponded local melt. Flow was observed and measured at one culvert associated with gages G17/G18. Peak discharge was not calculated due to gage G17 remaining dry.

At the CD4 pad, gage G19 remained dry. Stage at G20 was affected by ice conditions in the Nigliq Channel and is estimated to have peaked at the same time as stage peaked at MON20 on June 1 (Photo 4.17).

Stage at gages G15/G16, G17/G18, and G19/G20 is provided in Graph 4.10, Graph 4.11, and Graph 4.12. The graphs show stage above the PT only; gaps in data indicate stage dropped below the PT. Culvert direct discharge data is summarized in Table 4.4.

Photo 4.14: North end of CD4 road one day after peak stage, looking south; June 1, 2017

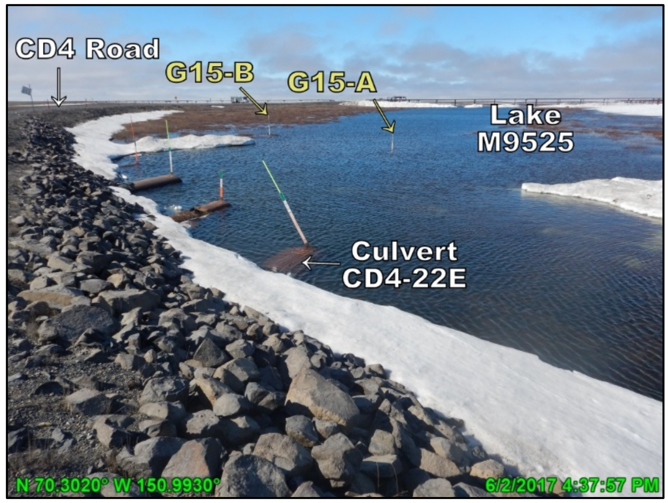


Photo 4.15: Equalization at CD4 road culverts at gage G15/G16 two days after peak stage, looking northeast; June 2, 2017

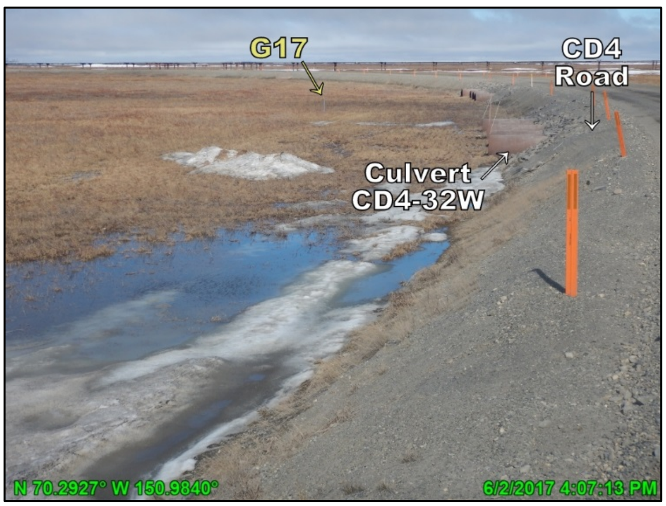
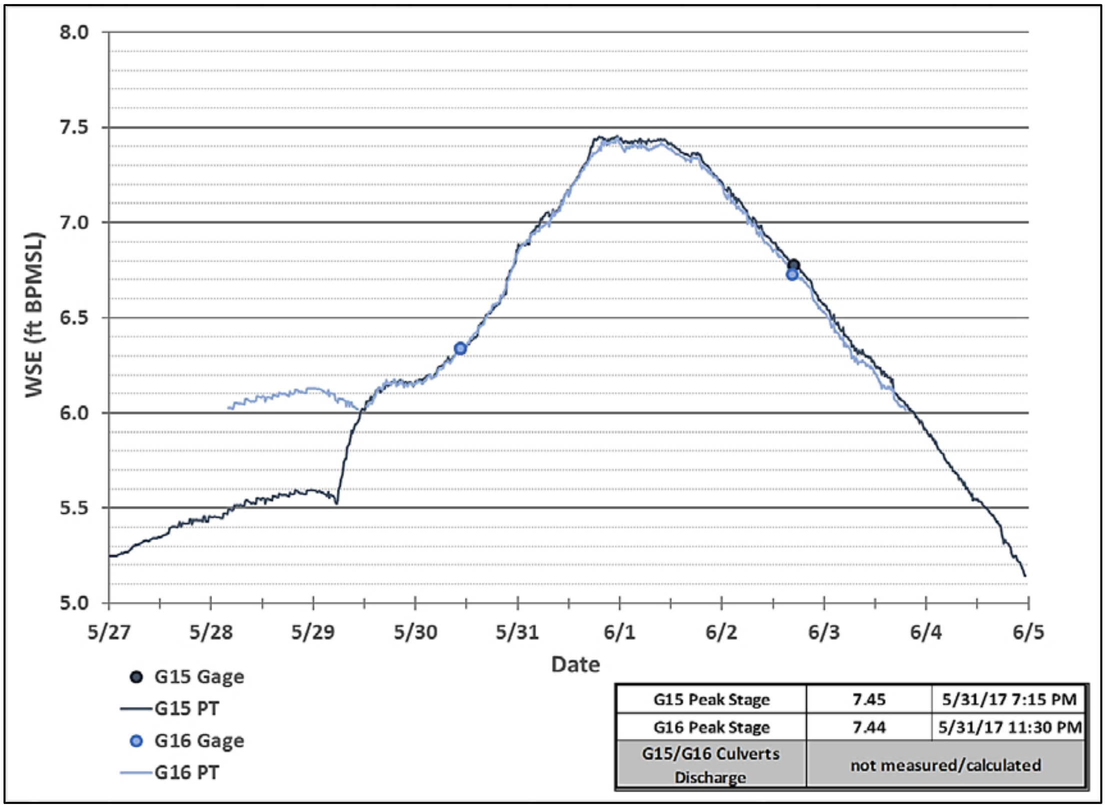


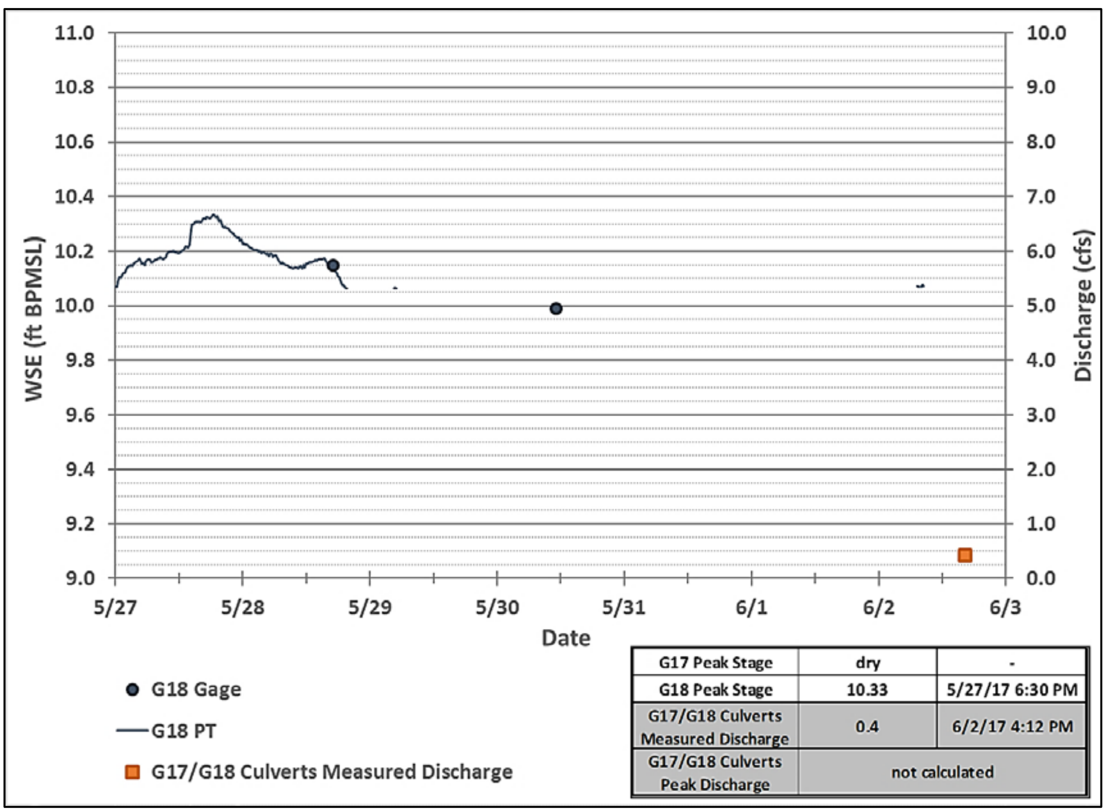
Photo 4.16: CD4 road at gage G17 and associated culverts the day of measured discharge, looking east; June 2, 2017

Photo 4.17: CD4 pad and road one day after estimated peak at gage G20, looking northeast; June 2, 2107



G15 Peak Stage	7.45	5/31/17 7:15 PM
G16 Peak Stage	7.44	5/31/17 11:30 PM
G15/G16 Culverts Discharge	not measured/calculated	

Graph 4.10: CD4 Road Culverts (Gages G15 & G16) Stage



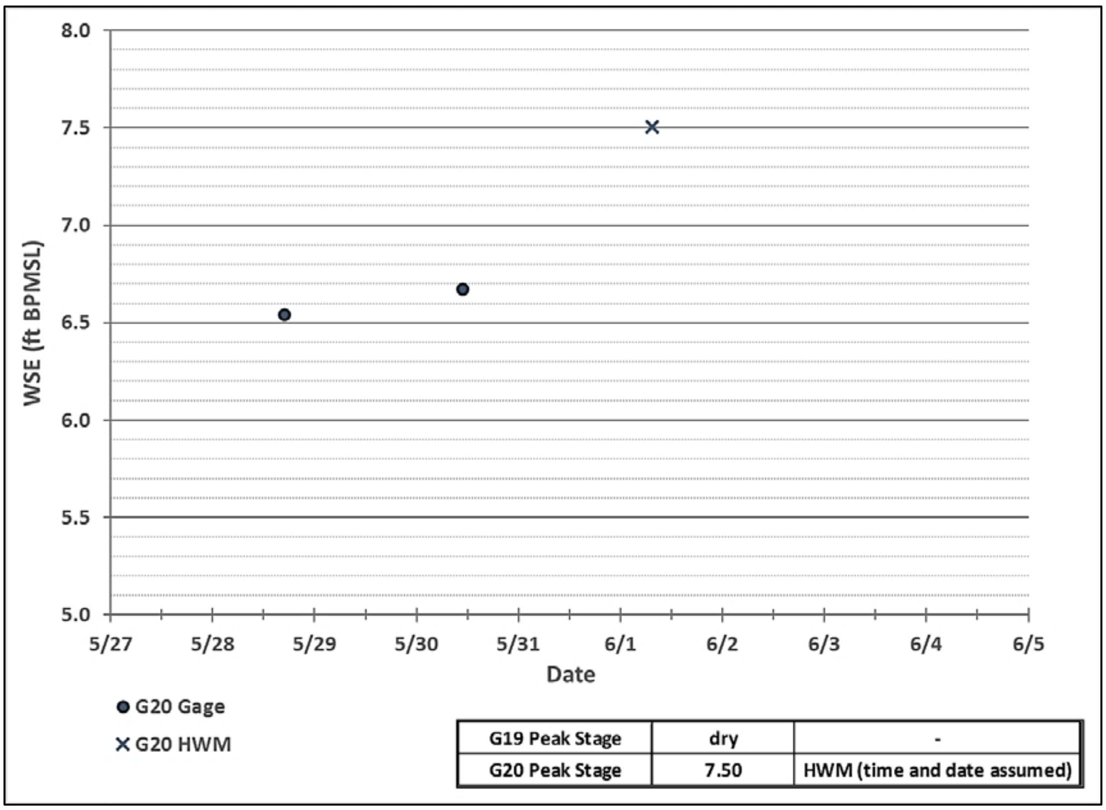
G17 Peak Stage	dry	-
G18 Peak Stage	10.33	5/27/17 6:30 PM
G17/G18 Culverts Measured Discharge	0.4	6/2/17 4:12 PM
G17/G18 Culverts Peak Discharge	not calculated	

Graph 4.11: CD4 Road Culverts (Gages G17 & G18) Stage & Discharge

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

Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measured Depth of Flow[1] (ft)	Flow Depth[2]	Measured Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD4-24	6/2/17 4:12 PM	0.50	0.20	Less than Half Full	0.48	0.4	0.4

Notes:
[1.] Measurement taken at 0.6 of total depth of flow
[2.] Culvert is 48" in diameter



Graph 4.12: CD4 Pad (Gages G19 & G20) Stage

CD5 ROAD

Stage data and observations of breakup processes have been collected along the CD5 road since 2009. CRD floodwater remained within channels and no overbank flooding was observed along the CD5 road.

C. Lake L9323 Bridge

Nigliq Channel floodwaters did not hydraulically connect to Lake L9323 (Photo 4.16). Recorded water levels were the result of local melt from within the lake basin and no flow through the bridge was observed. Ice cover on the lake remained throughout the duration of monitoring. Lake L9323 Bridge stage data is provided in Graph 4.13. The graph shows stage above the PT only; gaps in data indicate stage dropped below the PT.

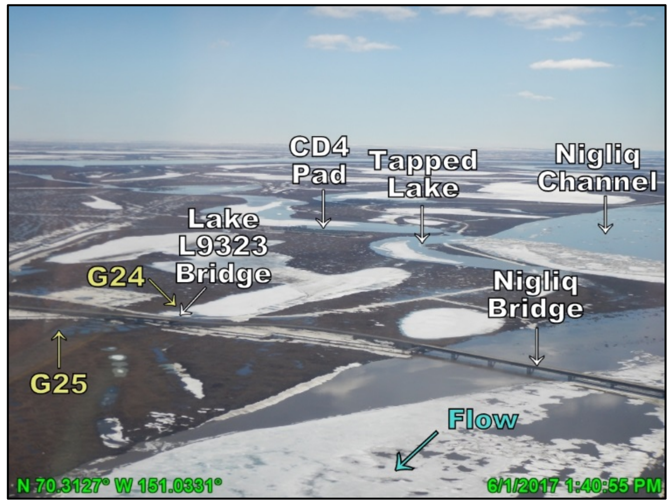
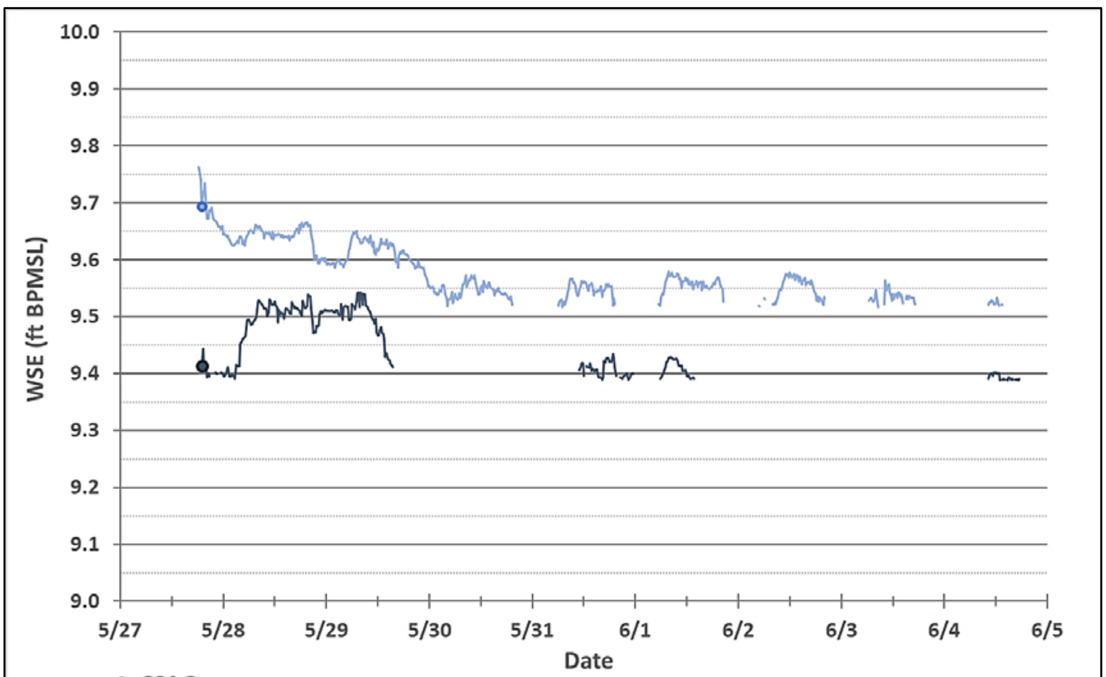


Photo 4.18: Lake L9323 hydraulically isolated from the Nigliq Channel, looking south; June 1, 2107



G24 Peak Stage	9.54	5/29/17 8:00 AM
G25 Peak Stage	9.76	5/27/17 6:15 PM
L9323 Bridge Discharge	no flow	

Graph 4.13: Lake L9323 Bridge (Gages G24 & G25) Stage

D. Nigliq Bridge

Peak stage at the Nigliq Bridge occurred as floodwater from the May 30 ice jam release at MON1 was conveyed downstream. In the process, the ice jam adjacent to Nuiqsut released and channel ice between Nuiqsut and MON20 broke up and jammed upstream of the Nigliq Bridge reach. Channel ice and floes were present throughout the Nigliq Bridge reach during peak stage and through the following day (Photo 4.19).

Discharge was measured from the upstream side of the Nigliq Bridge on June 2. At the time of the measurement, the channel was mostly clear of snow and ice and conditions were considered fairly steady and uniform (Photo 4.20). The average velocity was 1.57 fps and the highest depth-averaged velocity was 2.06 fps. The quality of the measurement was classified as fair based on the remaining snow on the left bank and grounded ice along the mud bar on the east side of the channel approximately 600 to 800 feet downstream. Peak discharge occurred on the falling limb of the hydrograph; it was correlated with the estimated release of an ice jam that formed upstream of intact channel ice upstream of the bridge. Channel ice was still present in the reach during this event. Peak discharge was assigned a poor quality rating (Table 2.1) because of these influences. Indirect discharge calculated at the time of direct measurement was 8.6% greater than the measured discharge.

Nigliq Bridge stage and discharge data is provided in Graph 4.13. A summary of the discharge measurement, peak discharge calculation methods, and plan and profile drawings are presented in Appendix C.2.3.

Photo 4.19: Nigliq Bridge the day of peak discharge and the day after peak stage, looking south (upstream); June 1, 2017

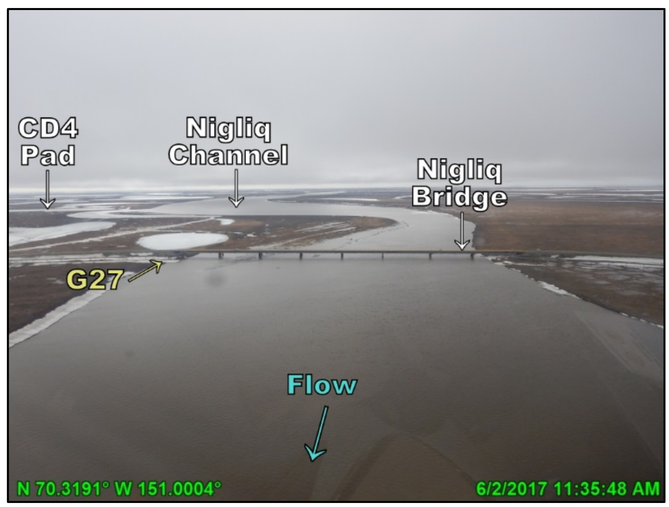
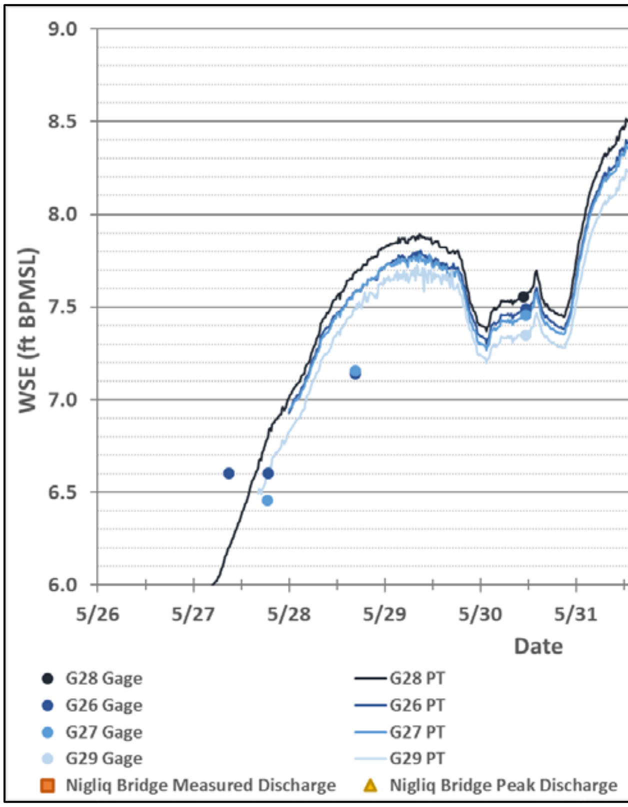


Photo 4.20: Conditions at the Nigliq Bridge the day of discharge measurement, looking south (upstream); June 2, 2017



G28 Peak Stage	8.73	5/31/17 9:30 PM
G26 Peak Stage	8.60	5/31/17 9:15 PM
G27 Peak Stage	8.58	5/31/17 9:15 PM
G29 Peak Stage	8.42	5/31/17 9:30 PM
Nigliq Bridge Measured Discharge	24,600	6/2/17 1:50 PM
Nigliq Bridge Peak Discharge	46,800	6/1/17 2:00 PM

Graph 4.14: Nigliq Bridge (Gages G26, G27, G28, & G29) Stage & Discharge

E. Lake L9341 Bridge

Lake L9341 received backwater from the Nigliq Channel at the north end of the lake, the influence of which drove peak stage (Photo 4.19). Lake L9341 was not hydraulically connected to the Nigliq Channel on the south end of the lake. As a result, there was no discernable flow through the Lake L9341 Bridge and discharge was not measured or calculated. Lake L9341 Bridge stage data is provided in Graph 4.15.

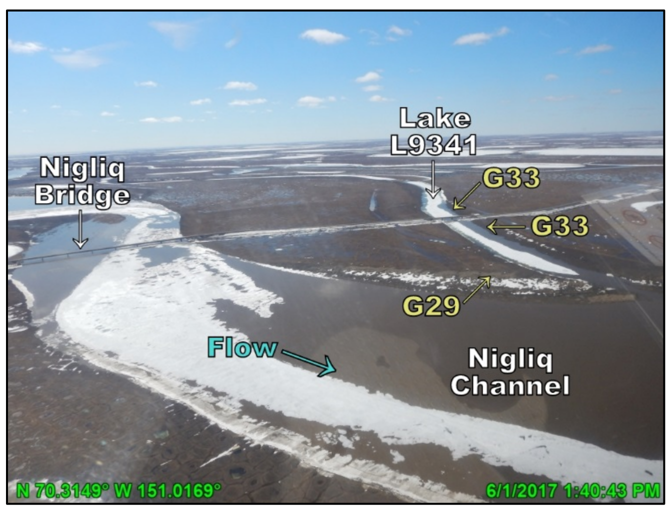
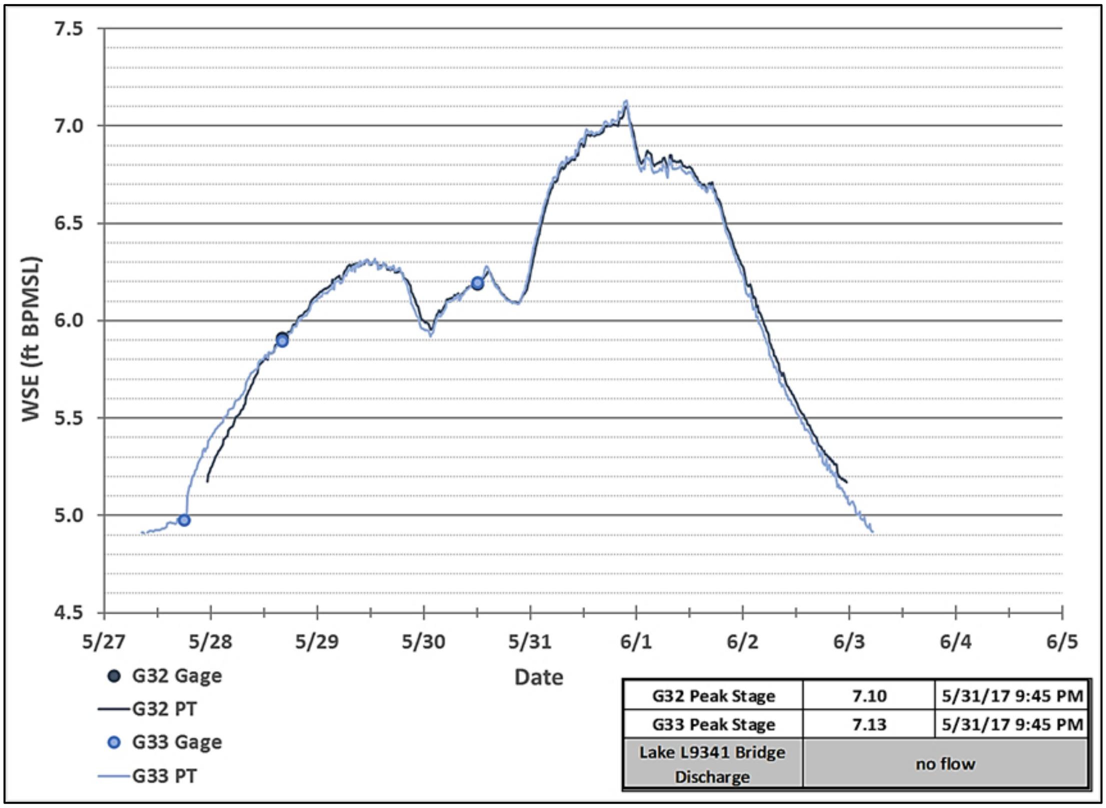


Photo 4.21: North end of Lake L9341 hydraulically connected to the Nigliq Channel the day after peak stage, looking southwest; June 1, 2017



Graph 4.15: Lake L9341 Bridge (Gages G32 & G33) Stage

F. Nigliagvik Bridge

The Nigliagvik Channel is an anabranch of the Nigliq Channel. The Nigliagvik Channel branches off from the Nigliq Channel approximately 4 RMs and 5.5 RMs upstream of the Nigliq and Nigliagvik Bridges, respectively, and converges with the Nigliq Channel approximately 2 RMs downstream of the Nigliq and Nigliagvik Bridges. Water from the Nigliq Channel diverges into the upstream connection of the Nigliagvik Channel during low-magnitude, high-recurrence flood events; however, backwater from the Nigliq Channel often reaches the Nigliagvik Bridge prior to downstream flow. This can be seen in the stage hydrograph as water levels at the downstream gage are initially higher than water levels at the upstream gage (Graph 4.16). This trend generally ceases as a larger slope in WSEs develops in the Nigliq Channel reducing the backwater influence and allowing flow to move in a downstream direction.

Peak stage at the Nigliagvik Bridge occurred approximately concurrent with peak stage in the Nigliq Channel. Peak discharge timing occurred on the rising limb of the stage hydrograph. Aerial observations suggest that the influences of ice and snow in the Nigliagvik channel during peak discharge were minimal (Photo 4.22) and as a result, peak discharge was assigned a good quality rating (Table 2.1).

Discharge was measured from the upstream side of the Nigliagvik Bridge on June 1. At the time of the measurement, the Nigliagvik channel was clear of snow and ice (Photo 4.23). The average velocity was 1.28 fps and the highest depth-averaged velocity was 1.62 fps. The quality of the measurement was assigned fair based on variable flow angles. Indirect discharge calculated at the time of direct measurement was 3.2% less than the measured discharge.

Nigliagvik Bridge stage and discharge data is provided in Graph 4.16. A summary of the discharge measurement, peak discharge calculation, and plan and profile drawings are presented in Appendix C.2.4.

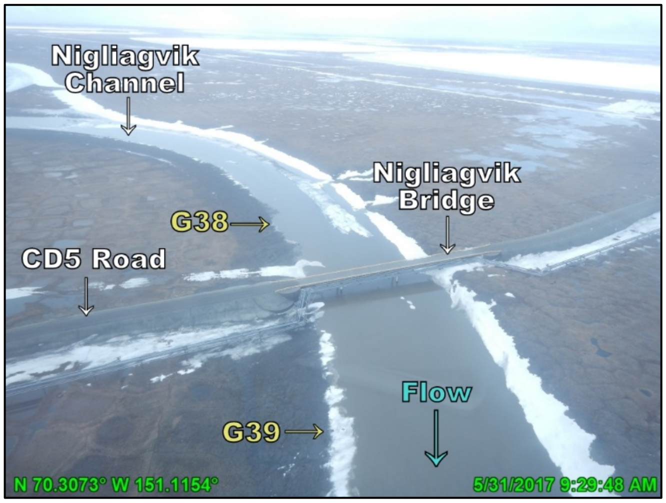
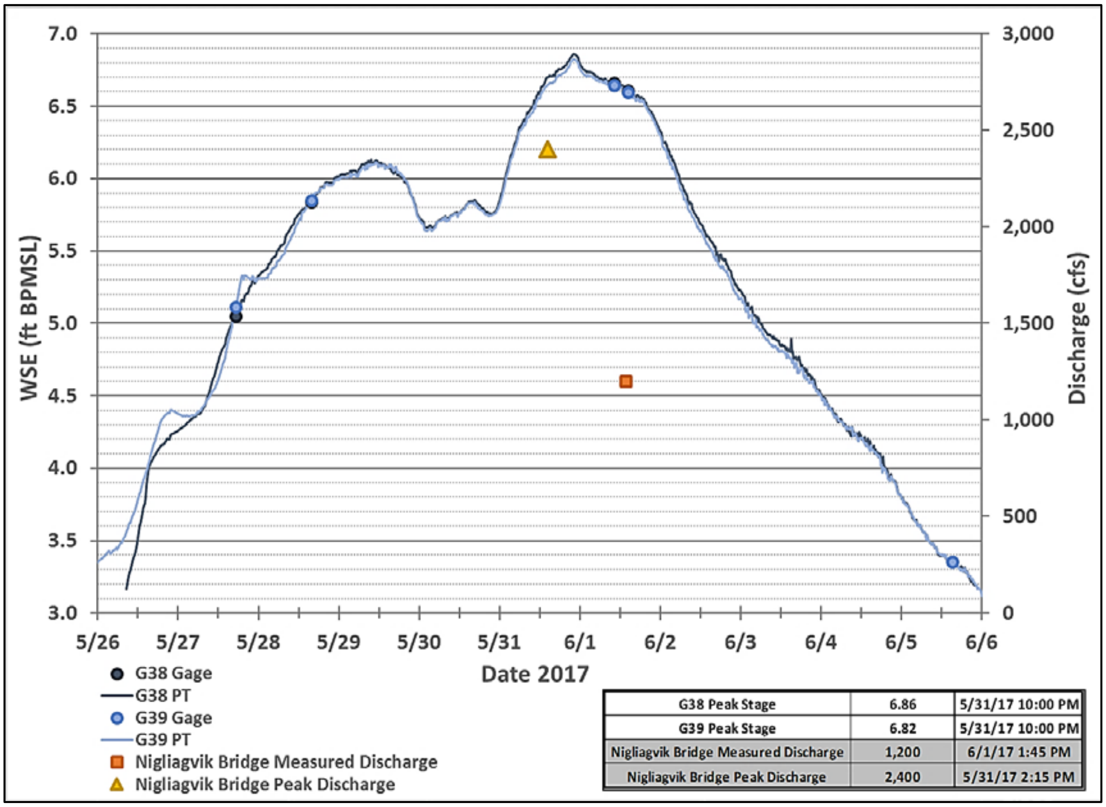


Photo 4.22: Nigliagvik Bridge conditions the day of peak stage and peak discharge, looking southeast (upstream); May 31, 2017

Photo 4.23: Nigliagvik Bridge conditions the day of discharge measurement, looking east; June 1, 2017



Graph 4.16: Nigliagvik Bridge (Gages G38 & G39) Stage & Discharge

G. Culverts

CD5 culverts east of the Nigliagvik Channel can be influenced by CRD flooding during high-magnitude, low-frequency events. CD5 culverts west of the Nigliagvik Channel are topographically isolated from CRD flooding and are limited to equalizing local melt in surrounding lake basins and flow in small channels and swales forming hydraulic connections between lake basins. Culverts in this region allow hydraulic equalization of meltwater between lakes, swales, and/or paleochannels.

Gages G34/G35 (Photo 4.24) and gages G36/G37 were dry throughout monitoring. Peak stage at gages G30/G31 was recorded as a HWM. Low flow through the paleochannel at gages G30/G31, attributed to the equalization of local melt, (Photo 4.25) was measured at one associated culvert. Peak discharge through this culvert was not determined because the HWMs were of low confidence. Gages G30/G31 stage and discharge data is provided in Graph 4.17 and the direct discharge measurement is summarized in Table 4.5.

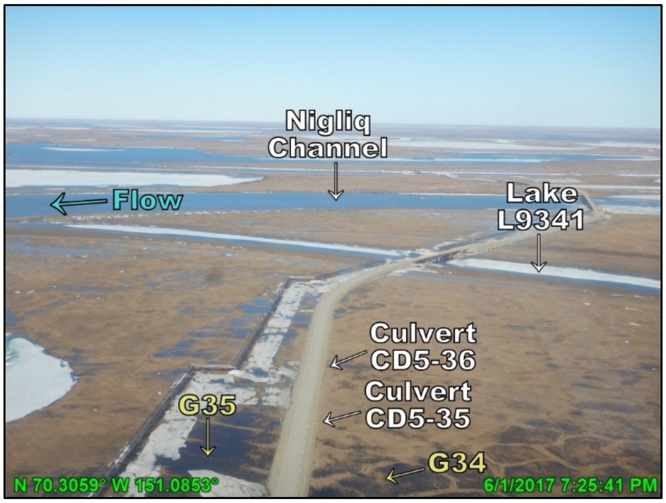
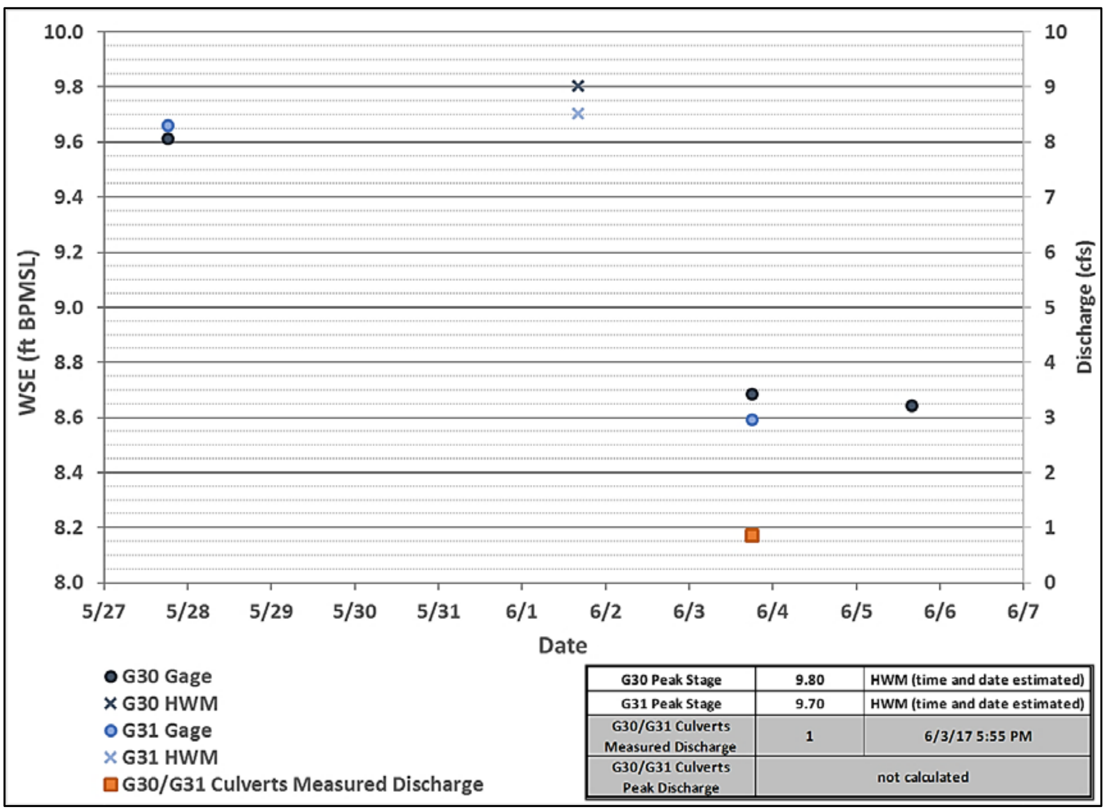


Photo 4.24: Local melt near culverts associated with gages G34/G35, looking west; June 1, 2017

Photo 4.25: Low flow through a culvert associated with gages G30/31, looking west; June 1, 2017



G30 Peak Stage	9.80	HWM (time and date estimated)
G31 Peak Stage	9.70	HWM (time and date estimated)
G30/G31 Culverts Measured Discharge	1	6/3/17 5:55 PM
G30/G31 Culverts Peak Discharge	not calculated	

Graph 4.17: CD5 Road Culverts (Gages G30 & G31) Stage and Discharge

Table 4.5: CD5 Road Culverts (Gages G30 & G31) Measured Discharge

Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measured Depth of Flow[1] (ft)	Flow Depth[2]	Measured Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD5-40	6/3/17 5:55 PM	1.80	0.72	Less than Half Full	0.16	1	1

Notes:
[1] Measurement taken at 0.6 of total depth of flow
[2] Culvert is 48" in diameter

Discharge was measured at other culverts along the CD5 road to the west of the Nigliagvik Channel, provided below in Table 4.6. Stage remained below the PT elevation at gages S1/S1D throughout breakup. Peak stage at gage S1 was recorded as a HWM and channelized downstream (south to north) flow between lakes was measured at two associated culverts. Photo 4.26 shows hydraulic connections through culverts CD5-03 and CD5-04. Peak discharge through these culverts was not determined because gage S1D did not have a HWM. Gages S1/S1D stage and discharge data is provided in Graph 4.18 and the direct discharge measurements are summarized in Table 4.7.

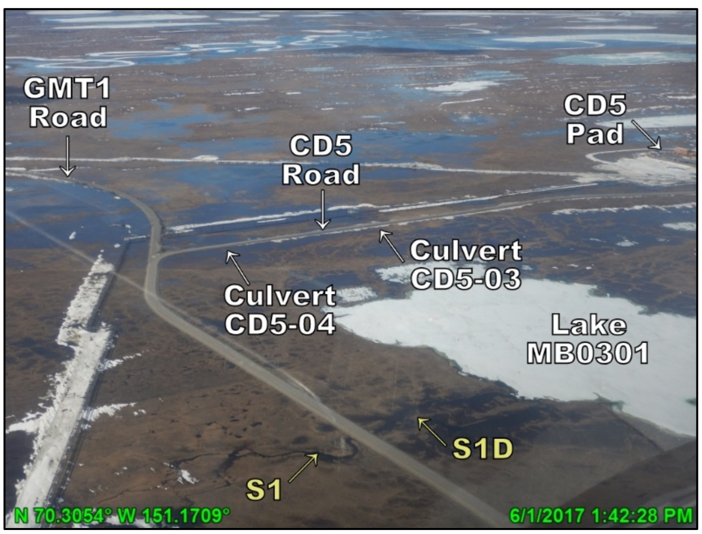
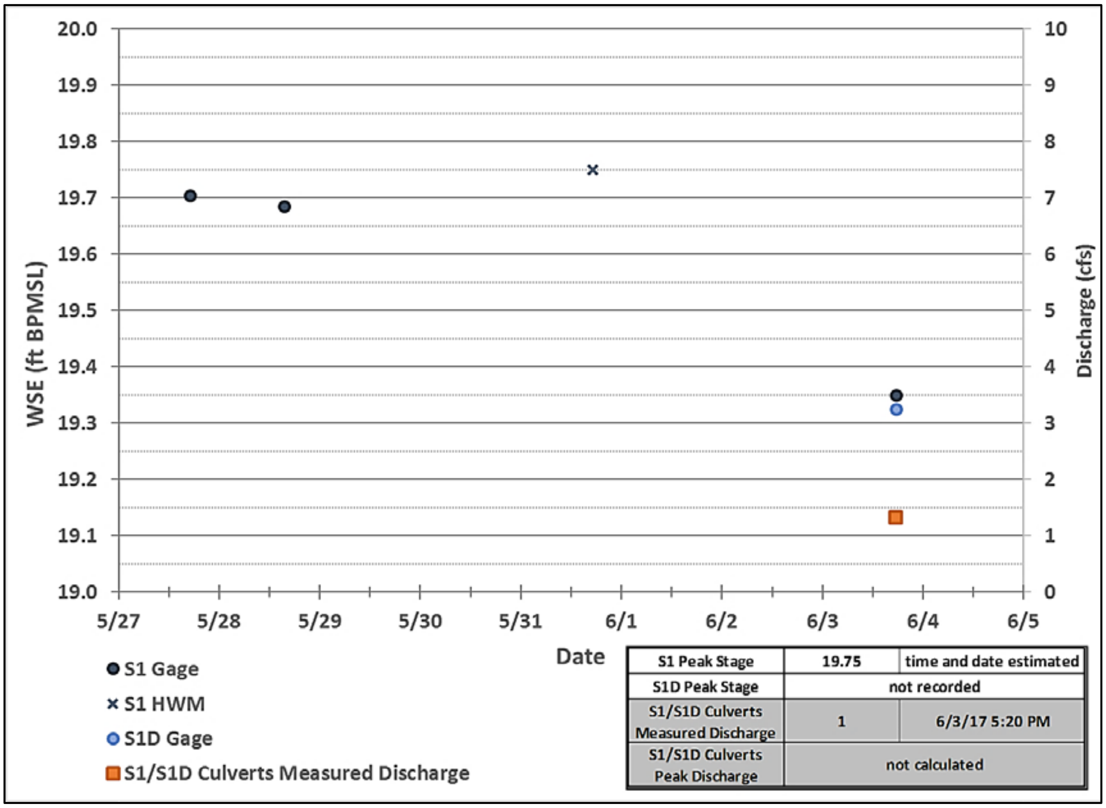


Photo 4.26: Hydraulic connections through CD5 culverts CD5-03 and CD5-04 and culverts at S1/S1D gages, looking northwest; June 1, 2017

Table 4.6: CD5 Road Culverts (no associated gages) Measured Discharge

Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measured Depth of Flow[1] (ft)	Flow Depth[2]	Measured Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD5-03	6/3/17 5:07 PM	1.80	0.72	Less than Half Full	1.29	6	10
CD5-04	6/3/17 4:57 PM	0.85	0.34	Less than Half Full	2.14	4	

Notes:
[1] Measurement taken at 0.6 of total depth of flow
[2] Culvert CD5-03 is 36' in diameter, culvert CD5-04 is 48" in diameter



Graph 4.18: CD5 Road Culverts (Gages S1 & S1D) Stage and Discharge

Table 4.7: CD5 Road Culverts (Gages S1 & S1D) Measured Discharge

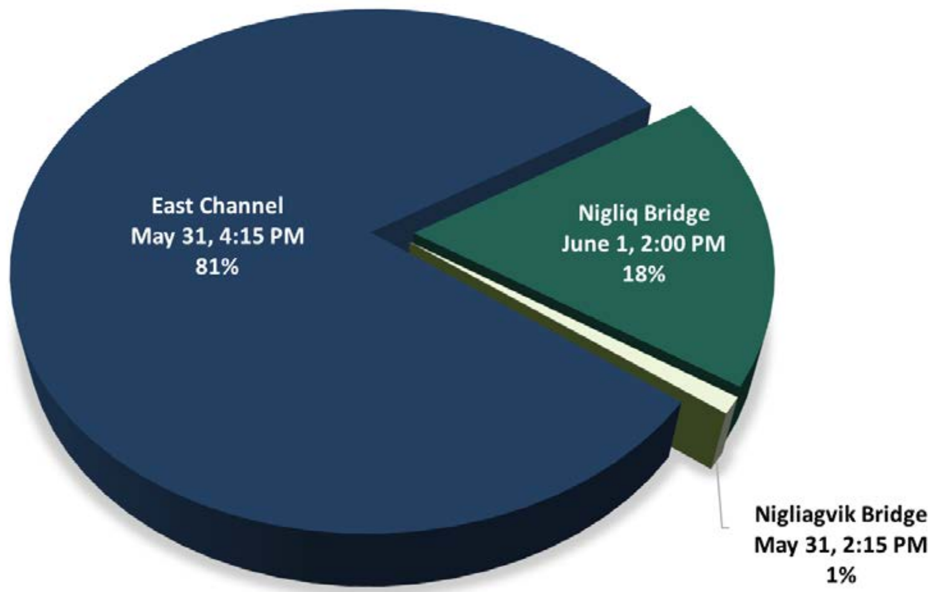
Culvert	Measurement Date & Time	Total Depth of Flow (ft)	Measured Depth of Flow[1] (ft)	Flow Depth[2]	Measured Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD5-08	6/3/17 5:20 PM	1.30	0.52	Less than Half Full	0.02	0.1	1
CD5-09	6/3/17 5:25 PM	1.40	0.56	Less than Half Full	0.32	1	

Notes:
[1] Measurement taken at 0.6 of total depth of flow
[2] Culverts are 48" in diameter

4.5 PEAK DISCHARGE DISTRIBUTION

The distribution of peak discharge between the East Channel and Nigliq Channel bifurcations is presented in Figure 4.1. Each section of the pie graph is represented by the location's peak discharge; however, peak discharge did not occur at the same time and date for each location. Total peak discharge was underestimated by 11% when compared to peak discharge calculated for the Colville River at MON1. Storage and attenuation are likely to have contributed to the under estimate, as are the possible errors associated with indirect methods.

Figure 4.1: Peak Discharge Distribution



5. POST-BREAKUP CONDITIONS ASSESSMENT

Alpine road and pads were inspected for erosion between June 5 and 7. Other than minor washlines, no discernable erosion was observed during aerial and ground reconnaissance of the CD2 (Photo 5.1), CD4 (Photo 5.2), and CD5 (Photo 5.3) roads. Floodwaters did not reach CD5 bridge abutments or the majority of the CD5 road within the CRD. A prominent washline from 2015 spring breakup was evident along portions of the CD2, CD4, and CD5 roads. There were no signs of sloughing or undermining at drainage structures. Additional photo documentation of erosion surveys and breakup conditions along the Alpine facilities roads and pads are shown in Appendix D.1.

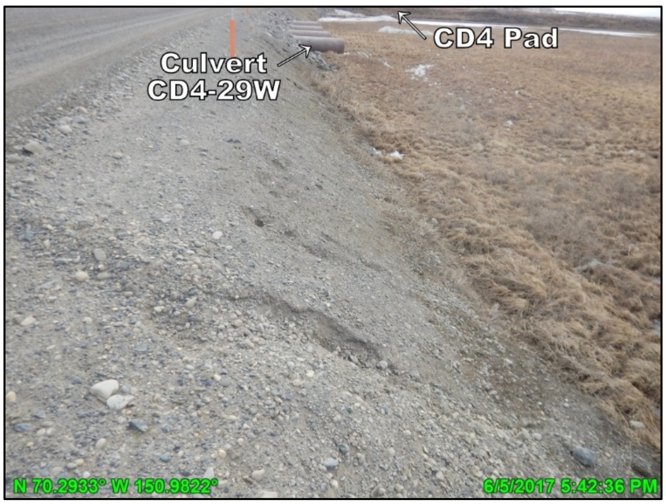


Photo 5.1: South side of CD4 road near CD4 pad, looking west; June 5, 2017

Photo 5.2: East side of CD4 road near CD5 intersection, looking southeast; June 5, 2017

Photo 5.3: South side of CD2 road, looking west; June 6, 2017

Photo 5.4: South side of CD2 road near the Long Swale Bridge looking west; June 6, 2017

6. CD5 PIER SCOUR, BANK EROSION, & BATHYMETRY

6.1 PIER SCOUR

Post-breakup pier scour elevations that encompass all piles in each pier group were measured by UMIAQ in August 2017. Post-breakup contour plots around the piers and within the main channel of the Nigliq Bridge and Nigliagvik Bridge are provided in Appendix E.1 (UMIAQ 2017b).

NIGLIQ BRIDGE

Field crews cleared ice and snow from the pier scour housing during spring setup; however, the freeze/thaw cycle prior to breakup filled the housing with ice before the sonars could be installed. The housing was not clear of ice until after peak stage. During peak conditions, field crews took manual measurements with a sounding reel and 50-lb sounding weight on the downstream side of pile E of piers 2 through 5.

The minimum post-breakup scour elevation (-30.6 ft BPMSL at pier 4, piles C-E) is 1.7 ft below the 50-year design scour elevation and 2.4 ft above the 200-year scour elevation. A comparison of design and observed scour elevations are presented in Table 6.1.

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

Nigliq Bridge Pier Scour		
During Breakup		**Elevation (ft BPMSL)[1]**
Pier 2	Pile E	-14.4
Pier 3[5]	Pile E	-21.8
Pier 4	Pile E	-27.9
Pier 5	Pile E	-20.9
Post-Breakup		**Elevation (ft BPMSL)[2]**
Pier 2	Pile B	-21.4
Pier 3[5]	Pile A, B, D	-24.6
Pier 4	Pile C, D, E	-30.6
Pier 5	Pile C, E	-22.0
Design 2013		**Elevation (ft BPMSL)[3,4]**
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] Scour measurement at downstream side of pile E
[2] Minimum channel bed elevations surveyed by UMIAQ in August 2017
[3] Design values presented in PND 2013
[4.] Elevations based on LCMF 2008 Survey
[5] Pier 3, piles A and B are ice breakers and piles C through E are bridge support

NIGLIAGVIK BRIDGE

Similar freeze/thaw conditions prevented real-time sonar installations at the Nigliagvik Bridge piers. Scour was measured with a sounding weight at pier 3, pile A during the direct discharge measurement on June 1. The minimum post-breakup pier scour elevation (-5.5 ft BPSML at pier 4, pile B) is 8.7 feet above the 50-year design scour elevation and 16.3 feet above the 200-year design scour elevation. A comparison of design and observed scour elevations are presented in Table 6.2.

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

Nigliagvik Bridge Pier Scour		
During Breakup		**Elevation (ft BPMSL)[1]**
Pier 3	Pile A	-1.4
Pier 4	-	-
Post-Breakup		**Elevation (ft BPMSL)[2]**
Pier 3	Pile A & B	-4.8
Pier 4	Pile B	-5.5
Design 2013		**Elevation (ft BPMSL)[3,4]**
50-year	**Pier 3-4**	-14.2
200-year	**Pier 3-4**	-21.8

Notes:
1. Scour measurement on upstream side of pile A
2. Minimum channel bed elevations recorded by UMIAQ in August 2017
3. Design values presented in PND 2013
4. Elevations based on LCMF 2008 survey

6.2 BANK EROSION

Maximum incremental and cumulative erosion at the Nigliq Bridge (station 12+00) and Nigliagvik Bridge (station 5+00) and maximum incremental, maximum cumulative, and average erosion along the entire top of bank is presented below in Table 6.3. Photos from the bank erosion survey are presented below in Photo 6.1, Photo 6.2, Photo 6.3, and Photo 6.4. Bank erosion survey drawings and tabulated data are presented in Appendix E.2 (UMIAQ 2017c).

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)
At Bridge	Maximum Incremental Erosion (2016-2017)	12+00	10	--	14+00 [2]	4.2	--	5+00	0.0	--	5+00 [2]	5.3 (deposition)	--
	Maximum Cumulative Erosion (2013-2017)	12+00	9.2	2.3	14+00	4.2	1.1	5+00	20.9	5.2	5+00	2.7	0.7
All Stations	Maximum Incremental Erosion (2016-2017)	0+00	6.6	--	14+00 [2]	4.2	--	2+00	2.1	--	5+23	1.3	--
	Maximum Cumulative Erosion (2013-2017)	0+00	33.2	8.3	14+00	4.2	1.1	5+00	20.9	5.2	4+00	7.3	1.8
	Average Cumulative Erosion (2013-2017)	All	--	1.7	All	--	0.1 (deposition)	All	--	1.5	All	--	0.1

Notes:
1. Stationing begins upstream of bridge
2. No survey data in 2016; erosion noted is between 2015 and 2017

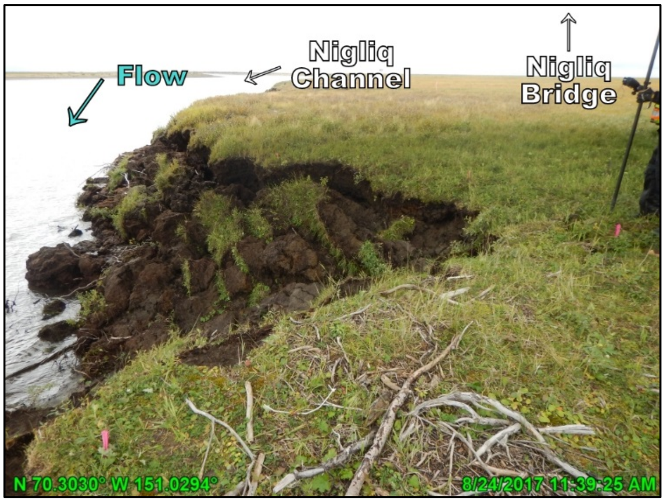


Photo 6.1: West bank of the Nigliq Channel under the Nigliq Bridge, looking south; August 24, 2017

Photo 6.2: East bank of the Nigliq Channel north of the Nigliq Bridge, looking south; August 24, 2017

Photo 6.3: Bank subsidence at the west bank of the Nigliagvik Bridge, looking east; August 24, 2017

Photo 6.4: East bank of Nigliagvik Channel at the Nigliagvik Bridge abutment, looking south; August 24, 2017

6.3 BATHYMETRY

BATHYMETRY AT BRIDGES

The 2017 survey results at each CD5 bridge location were compared with the 2013 and 2016 survey results to obtain maximum incremental scour and deposition between 2017 and 2016, and maximum cumulative scour and deposition between 2017 and 2013 (UMIAQ 2017d) (Table 6.4). Transect profiles and bathymetric cross-sections are provided in Appendix E.3.

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 (2016-2017)	5.4	8+33	9	1.3	1+27	39	1.4	2+32	26
Maximum Cumulative Scour (2013-2017)	12.1	2+67	10	1.3	1+89	36	3.4	1+00	25
Maximum Incremental Deposition (2016-2017)	4.9	8+15	10	0.6	3+95	37	1.5	3+08	26
Maximum Cumulative Deposition (2013-2017)	3.5	8+79	8	0.9	3+49	36	3.5	1+03	26

CHANNEL BATHYMETRY

The 2017 survey results at Nigliq Channel and Nigliagvik Channel were compared with the 2013 and 2016 survey results to obtain maximum incremental scour and deposition between 2017 and 2016, and maximum cumulative scour and deposition between 2017 and 2013 (UMIAQ 2017d) (Table 6.5). Transect profiles and bathymetric cross-sections are provided in Appendix E.3.

Table 6.5: Nigliq Channel and Nigliagvik Channel Scour and Deposition

	Nigliq Channel			Nigliagvik Channel		
	Depth (ft)	Station (STA)	Transect	Depth (ft)	Station (STA)	Transect
Maximum Incremental Scour (2016-2017)	16.6	20+10	6	1.6	2+68	16
Maximum Cumulative Scour (2013-2017)	19.2	39+38	13	3.4	1+00	25
Maximum Incremental Deposition (2016-2017)	8.7	25+10	14	2.0	5+26	35
Maximum Cumulative Deposition (2013-2017)	8.7	37+59	13	3.5	1+03	26

7. ICE ROAD CROSSINGS BREAKUP

Ice roads are constructed annually for ground transportation of supplies and equipment to Alpine facilities. Aerial surveys were conducted during spring breakup to observe and document the progression of melting of the ice road crossings. To facilitate melt and the progression of breakup flooding, ice road crossings are mechanically slotted at the conclusion of the winter season.

In general, ice road crossings melted at a similar rate as channel ice. Aerial surveys showed that slotting was completed and floodwaters were passing freely through the ice road crossings. The majority of the crossings were submerged during the peak of flooding. When flooding receded, the ice road crossings and channel ice had cleared at most locations. Photos of all monitored ice road crossings are presented in Appendix D.2.

8. HISTORICAL BREAKUP TIMING & MAGNITUDE

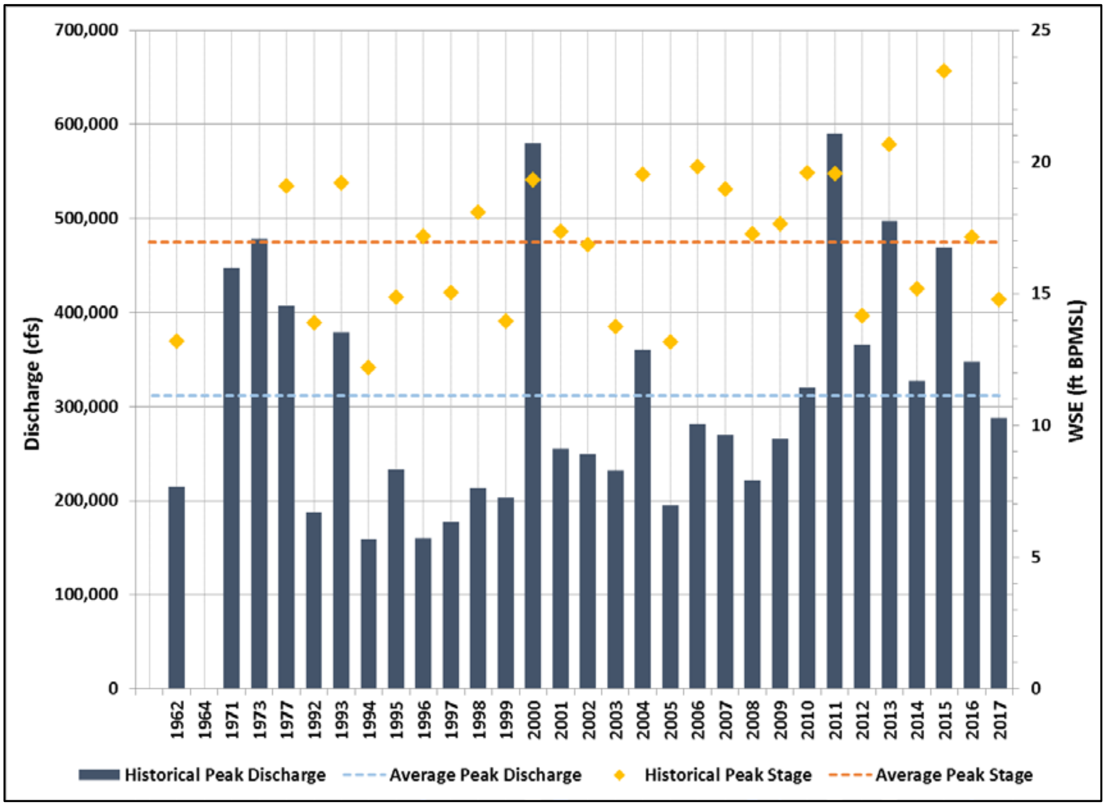
8.1 COLVILLE RIVER – HEAD OF THE DELTA

The historical record of peak stage and peak discharge for the CRD is at MON1C. Annual peak stage and peak discharge at MON1C has been recorded intermittently from 1962 to 1992 and annually from 1992 to 2017 (Table 8.1 and Graph 8.1).

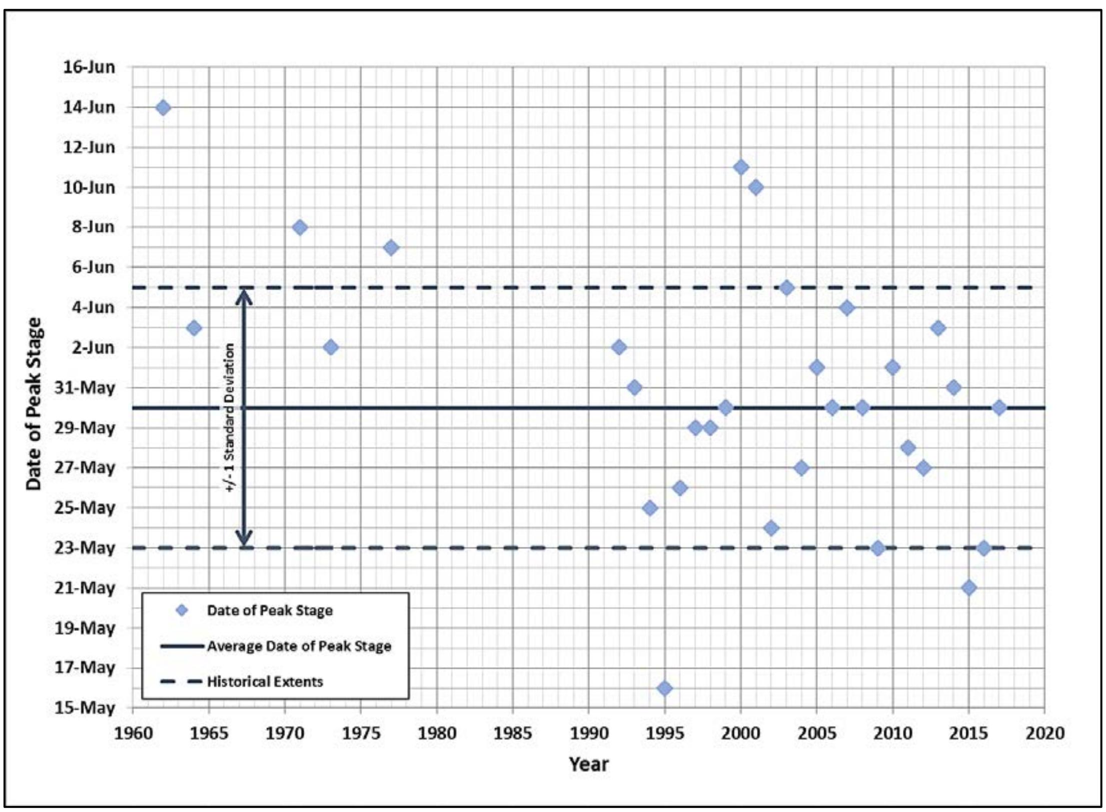
Peak stage and discharge occurred on May 30, coinciding with the historical average (mean) date of peak stage. Statistical analysis of historical peak stage dates shows 77% of the peaks at MON1C occur during a 13-day period from May 23 to June 5.

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	
2017	**288,000**	**30-May**	**14.79**	**30-May**	**This Report**
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

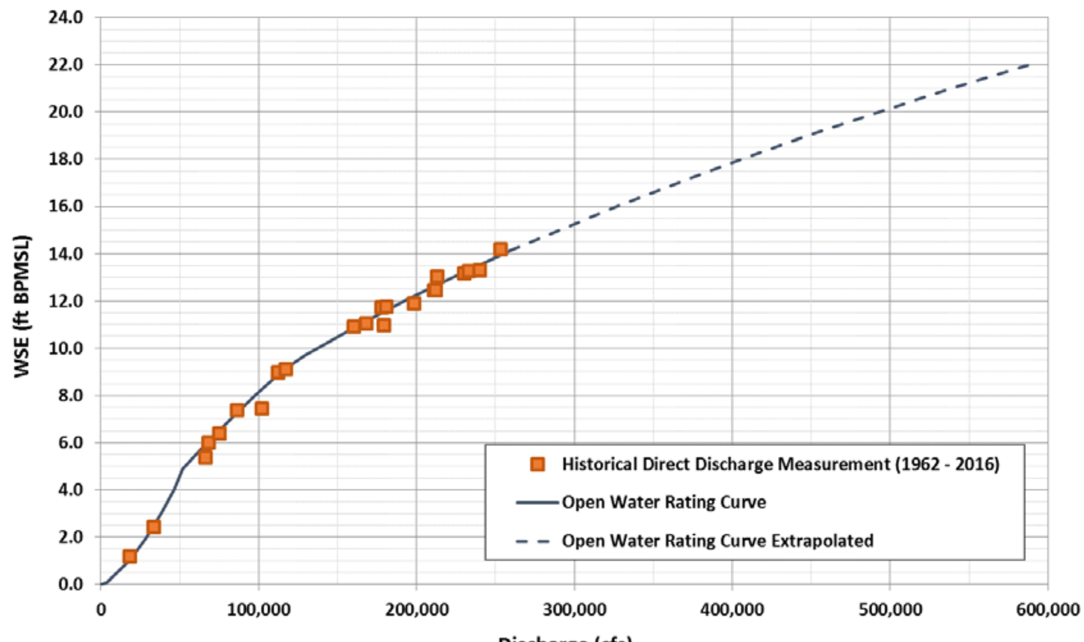


Graph 8.1: Colville River at the Head of the Delta Historical Peak Stage and Peak Discharge



Graph 8.2: Colville River at the Head of the Delta Historical Timing of Peak Stage

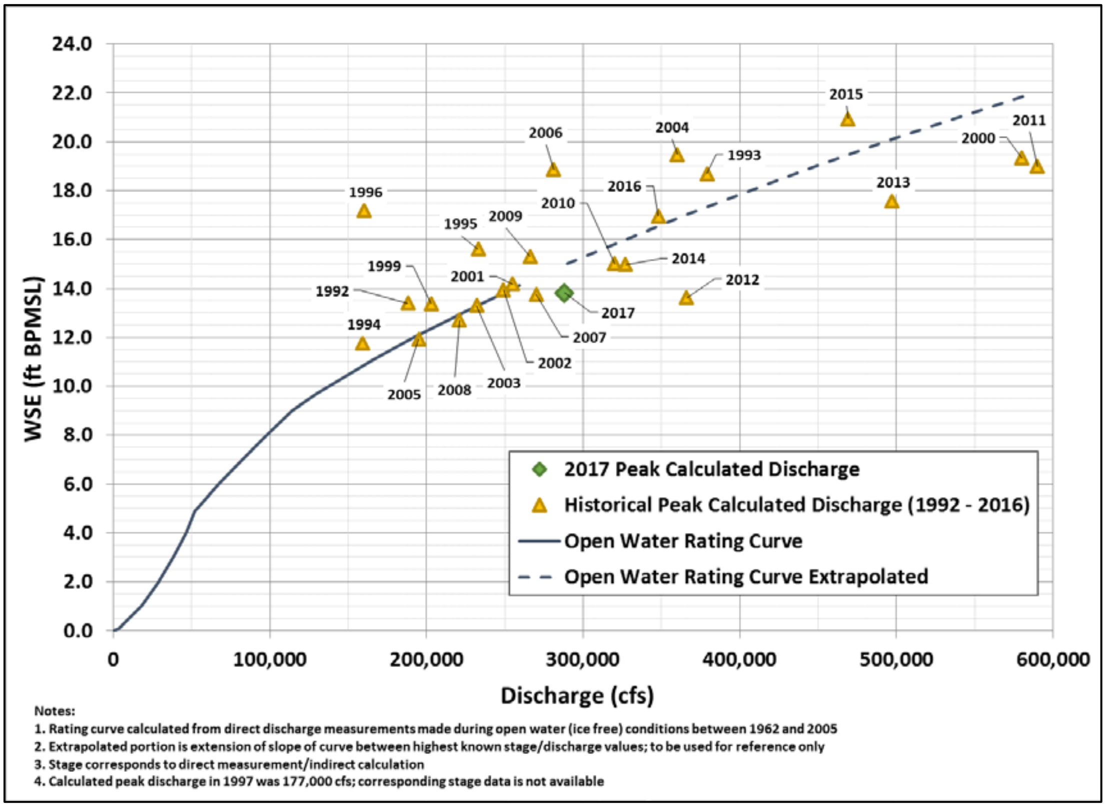
The MON1C stage-discharge rating curve, shown in Graph 8.3, represents a relationship between stage and discharge. The rating curve was calculated from direct discharge measurements taken during ice-free conditions between 1992 and 2016. Colville River discharge can be greatly influenced by channel ice; the rating curve more accurately represents the relationship between stage and discharge at lower stage values when ice-free discharge measurements are possible.



Notes:
1. Rating curve calculated from direct discharge measurements made during open water (ice free) conditions between 1962 and 2005.
2. Extrapolated portion is extension of slope of curve between highest known stage/discharge values, to be used for reference only.
3. Stage corresponds to direct measurement/indirect calculation
4. Historical direct discharge measurements are those collected during open water conditions; direct measurements from 2006, 2007, 2008, and 2009 were ice-affected and are not included.
5. No direct measurement was collected in 2017.

Graph 8.3: Colville River at the Head of the Delta Stage-Discharge Rating Curve with Measured Discharge

Peak discharge between 1992 and 2017 are plotted against the open water rating curve in Graph 8.4. Open water conditions rarely occur (ice is generally present) at or near peak stage 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 2017 falls to the right of the rating curve by 13.2%.



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. A summary of historical discharge measurements at the CD2 road bridges is presented in Table 8.2. Measured flow through the Long Swale Bridge was 24.5% of the average annual measured flow through both bridges (5,300 cfs).

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)										
2017[5]	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**–**	**This Report**
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)										
06/01/17	**5.92**	**0.04**	**445**	**1,505**	**0.86**	**1,290**	**F**	**27**	**Cable**	**This Report**
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

Date	Stage[1] (ft)	Stage Differential[2] (ft)	Width (ft)	Area (ft^2)	Mean Velocity[3] (ft/s)	Discharge (cfs)	Measurement Rating[4]	Number of Sections	Measurement Type	Reference
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

Table 8.3 summarizes the calculated peak annual discharge at the CD2 Long and Short Swale Bridges between 2000 and 2017.

Table 8.3: CD2 Road Bridges Peak 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
			Discharge[4] (cfs)	Mean Velocity (ft/s)	Discharge[4] (cfs)	Mean Velocity (ft/s)	
05/31/17	**6.04**	**0.04**	**1,350**	**0.86**	**– [5]**	**– [5]**	**This Report**
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	– [5]	– [5]	Michael Baker 2009b
05/30/08	6.49	0.26	2,100	0.49	100	0.58	Michael Baker 2008
06/05/07	8.60	0.43	1,500	1.35	400	1.18	Michael Baker 2007b
05/31/06	9.72	0.87	4,400	1.77	1,100	1.59	Michael Baker 2007a
05/31/05	6.48	0.20	1,400	1.37	– [5]	– [5]	Michael Baker 2005b
05/27/04	9.97	0.50	3,400	1.38	900	1.59	Michael Baker 2005a
06/07/03	6.31	0.12	700	0.88	– [5]	– [5]	Michael Baker 2003
05/26/02	7.59	0.69	4,000	3.47	500	1.52	Michael Baker 2002b
06/11/01	7.95	0.73	3,900	2.40	600	1.79	Michael Baker 2001
06/12/00	9.48	0.73	7,100	3.60	1,000	4.30	Michael Baker 2000

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

8.3 CD5 ROAD BRIDGES

Peak annual discharge has been calculated at the Nigliq Bridge since 2009 and at the Nigliagvik, Lake L9341, and Lake L9323 Bridges since 2012. A summary of 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								
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, 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 feet BPMSL at gage G10 (Michael Baker 2006a, 2007b).

Lake L9312 is surrounded by higher tundra than Lake L9313 and is less frequently recharged by floodwater from the Sakoonang Channel. Recharge at this lake relies more on local melt of snow and ice and precipitation. Bankfull elevation of Lake L9312 is 7.8 feet BPMSL 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 L9313 has recharged to bankfull 18 of the last 20 years, and Lake L9312 has recharge to bankfull 14 of the last 20 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 6.5 ft BPMSL[2]
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 performed every three years for the head of the CRD at MON1 to estimate and update flood magnitudes for standard recurrence intervals. The current 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 most recent flood frequency analysis was performed in 2015. These values are presented in Table 9.1 along with the current basis of design.

Table 9.1: Colville River Flood Frequency Analysis Comparison

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

Notes:
1. Michael Baker and Hydroconsult 2002
2. Michael Baker 2015

This year's peak discharge of 288,000 cfs has a recurrence interval of 3.1-years. The flood recurrence interval should be considered with respect to conditions at the time of peak discharge. The ranking of the 2017 peak discharge relative to the historical record (evaluated using current basis of design flood magnitudes) is shown in Table 9.2.

Table 9.2: Colville River at the Head of the CRD Peak Discharge Historical Record

Year	Peak Discharge (cfs)	Recurrence Interval (years)
2011	590,000	22.9
2000	580,000	21.8
2013	497,000	12.9
2015	469,000	10.0
1993	379,000	5.5
2012	366,000	4.9
2004	360,000	4.8
2016	348,000	4.5
2014	327,000	4.0
2010	320,000	3.8
2017	**288,000**	**3.1**
2006	281,000	2.9
2007	270,000	2.7
2009	266,000	2.6
2001	255,000	2.3
2002	249,000	2.2
1995	233,000	<2
2003	232,000	<2
2008	221,000	<2
1998	213,000	<2
1999	203,000	<2
2005	195,000	<2
1997	177,000	<2
1994	165,000	<2
1992	164,000	<2
1996	160,000	<2

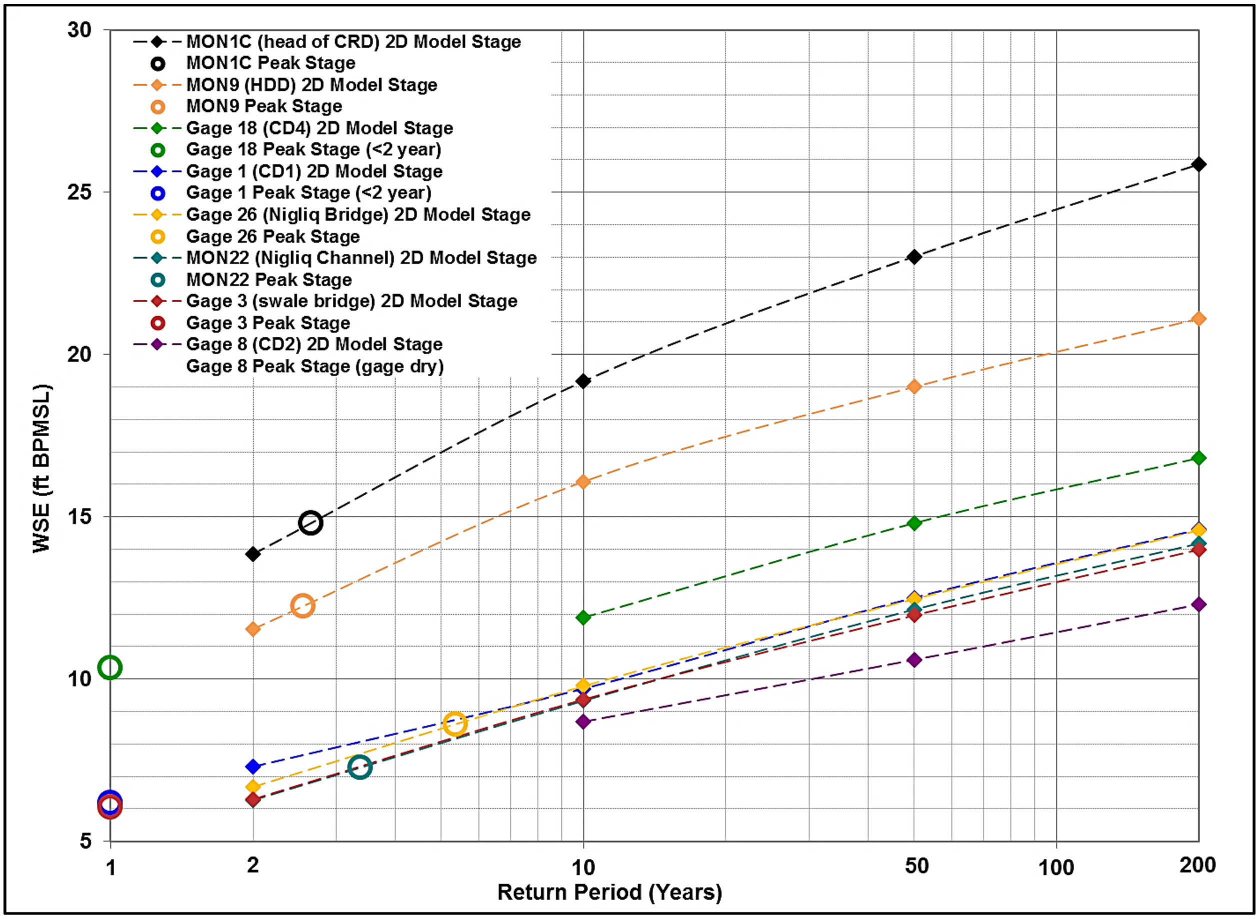
9.2 STAGE FREQUENCY

HIGH MAGNITUDE, LOW FREQUENCY

The CRD 2D surface water model was first created 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. This year's 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 less than 2-years to 11-years. All but one gage station fell below the 10-year recurrence interval. The 11-year recurrence interval at MON28 is attributed to its location at the northern edge of the delta and its close proximity to the downstream boundary of the 2D model. The range of predicted stage at MON28 is very small (1.2 feet) so assigned recurrence intervals can vary widely with small changes in stage. Additionally, influences such as coastal ice and tidal and wind events affect this location.



Graph 9.1: 2D Model 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[3] (years)
	2-year	10-year	50-year	200-year		
Colville River						
MON1C (head of CRD)	13.9	19.2	23.0	25.9	14.8	3
Colville River East Channel						
MON9 (HDD)	11.5	16.1	19.0	21.1	12.2	3
MON35 (Helmericks)	4.3	5.4	6.1	6.5	4.1	<2
Nigliq Channel						
MON20	7.8	11.4	14.6	16.8	8.4	3
MON22	6.3	9.3	12.1	14.2	7.3	3
MON23	5.1	7.4	10.2	12.0	6.3	4
MON28	3.1	3.4	3.9	4.3	3.4	11
CD1 Pad & Drinking Water Lakes						
Gage G1	7.3	9.7	12.5	14.6	6.2	<2
Gage G9 (Lake L9312)	8.3	10.8	13.4	15.7	Dry	-
Gage G10 (Lake L9313)	8.3	10.8	13.4	15.7	7.4	<2
CD2 Pad & Road						
Gage G8 (CD2 pad)	\	8.7	10.6	12.3	Dry	-
Gage G3 (swale bridges)	6.3	9.4	12.0	14.0	6.0	<2
Gage G4 (swale bridges)	6.2	8.5	10.1	11.6	6.0	<2
Gage G6	\	9.5	12.2	14.2	Dry	-
Gage G7	\	8.4	10.0	11.6	Dry	-
Gage G12	\	9.5	12.1	14.1	Dry	-
Gage G13	\	8.4	10.0	11.6	Dry	-
CD3 Pad & Pipeline						
Gage G11	5.2	6.4	6.9	8.0	Dry	-
SAK Gage (Crossing #2)	6.4	8.9	11.2	12.9	6.2	<2
TAM Gage (Crossing #4)	6.7	8.5	9.0	9.8	6.6	<2
ULAM Gage (Crossing #5)	5.5	7.1	7.8	8.7	6.1	4
CD4 Pad & Road						
Gage G19 (CD4 pad)	\	\	14.7	16.8	Dry	-
Gage G20 (CD4 pad)	\	11.1	14.3	16.4	7.5	<10
Gage G15	8.4	10.8	13.5	15.9	7.5	<2
Gage G16	8.4	11.1	14.2	16.3	7.4	<2
Gage G17	\	11.1	14.2	16.3	Dry	-
Gage G18	\	11.9	14.8	16.8	10.3	<10
CD5 Road						
Gage G24 (Lake L9323 Bridge)	\	11.1	14.1	16.0	9.5	<10
Gage G26 (Nigliq Bridge)	6.7	9.8	12.5	14.6	8.6	5
Gage G27 (Nigliq Bridge)	6.7	9.8	12.5	14.5	8.6	5
Gage G30	\	\	13.3	15.5	9.8	<2
Gage G32 (Lake L9341 Bridge)	\	\	13.3	15.1	7.1	<2
Gage G34	\	\	13.3	15.7	Dry	-
Gage G36	\	\	13.3	15.7	Dry	-
Gage G38 (Nigliagvik Bridge)	6.9	10.0	12.8	14.9	6.9	<2

Notes:
1. Sites having dry ground in 2D model are denoted with a backward slash "\"
2. 2D WSEs based on post-CD5 model results
3. Sites that remained dry during 2017 spring breakup are denoted with a dash “-“

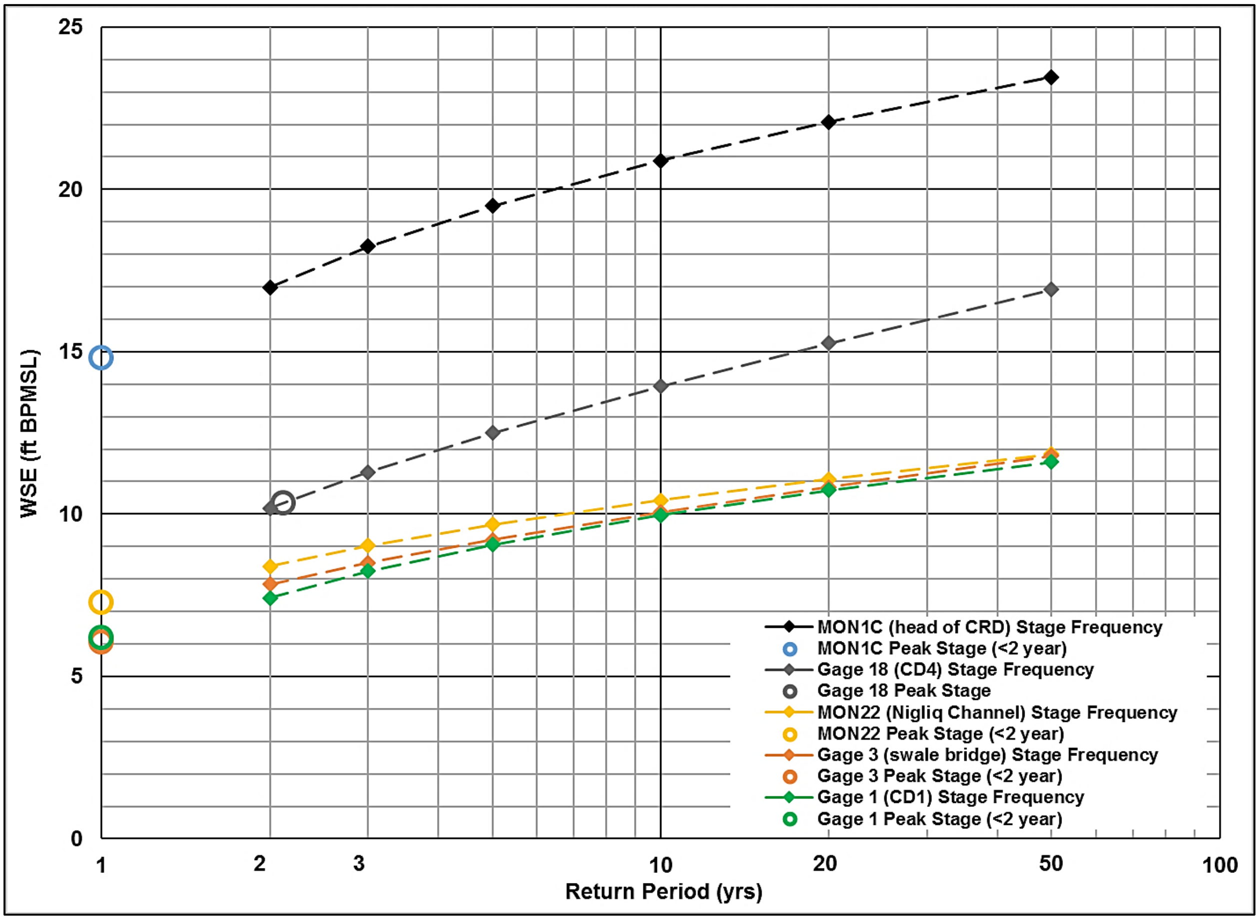
LOW MAGNITUDE, HIGH FREQUENCY

A site-specific stage frequency analysis using the historical record can provide a better estimate of low magnitude recurrence intervals. MON1C, MON22, gage G1, gage G3, and gage G18 have the longest periods of continuous record and are distributed throughout the project area. The maximum period of continuous record is 24 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 2015 (Michael Baker 2015).

It is considered risky to extrapolate stage data for a river impacted by ice and ice jamming beyond the continuous record (USACE 2002; FEMA 2003). This is because of the inherent unpredictability of ice jams, the greater impact ice effects have on lower magnitude events, and the upper limit of stage considering available floodplain storage for overbank flow (i.e. water height can only increase so much once it has crested the banks and spilled into the floodplain). Stage frequency was extrapolated to the 50-year recurrence interval, almost twice the continuous record at MON1C, for comparison to the 2D model because this is where the 2D model results and stage frequency analysis results tend to converge. Unlike the 2D model, the observed data upon which the stage frequency analyses are based reflect ice-affected flooding conditions. Therefore, the stage frequency analysis results can be used to supplement design criteria for low-magnitude, ice impacted flood events. Results from the most recent stage frequency analysis are compared to this year's observed peak stage in Table 9.4 and Graph 9.2. Based on the stage frequency analysis, flood stage recurrence ranged from less than 2-years to 2.1-years.

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)
	2-year	3-year	5-year	10-year	20-year	50-year		
MON1C (head of CRD)	16.99	18.24	19.49	20.88	22.08	23.46	14.8	<2
MON22 (Nigliq Channel)	8.40	9.03	9.68	10.42	11.07	11.85	7.3	<2
Gage G1 (CD1 Pad)	7.41	8.24	9.06	9.97	10.73	11.60	6.2	<2
Gage G3 (CD2 Road)	7.84	8.50	9.21	10.05	10.83	11.80	6.0	<2
Gage G18 (CD4 Road)	10.17	11.30	12.49	13.93	15.26	16.92	10.3	2.1



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
CD2-14N	10.864	N 70.3371°	W 151.0110°	Culvert top	UMIAQ 2016
CD4-10W	12.248	N 70.3275°	W 150.9934°	Culvert top	UMIAQ 2016
CD4-10E	11.799	N 70.3274°	W 150.9930°	Culvert top	UMIAQ 2016
CD4-12W	12.412	N 70.3401°	W 150.9962°	Culvert top	UMIAQ 2016
CD4-12E	11.463	N 70.3235°	W 150.9954°	Culvert top	UMIAQ 2016
CD4-20AE	7.024	N 70.3022°	W 150.9937°	Culvert top	UMIAQ 2016
CD5-35N	13.089	N 70.3063°	W 151.0522°	Culvert top	UMIAQ 2015
CD5-35S	13.256	N 70.3061°	W 151.0526°	Culvert top	UMIAQ 2015
CD5-40S	10.927	N 70.3048°	W 151.0443°	Culvert top	UMIAQ 2015
CP08-11-23	8.524	N 70.3916°	W 150.9079°	Alcap	UMIAQ 2008
CP08-11-35	8.880	N 70.4066°	W 150.8822°	Alcap	BAKER 2015 (UMIAQ 2010)
MONUMENT 1	27.930	N 70.1659°	W 150.9400°	Alcap	UMIAQ 2006
MONUMENT 9	25.060	N 70.2446°	W 150.8583°	Alcap	UMIAQ 2008
MON 12	9.038	N 70.3397°	W 150.0428°	Capped drill stem	UMIAQ 2016
MON 22	11.209	N 70.3423°	W 150.9321°	Capped drill stem	UMIAQ 2015
MONUMENT 22	10.030	N 70.3181°	W 151.0560°	Alcap	BAKER 2010
MONUMENT 23	9.546	N 70.3444°	W 151.0613°	Alcap	BAKER 2009c
MONUMENT 25	17.893	N 70.3024°	W 151.0130°	Capped drill stem	UMIAQ 2016
MONUMENT 27	13.858	N 70.3060°	W 151.0533°	Capped drill stem	UMIAQ 2016
MONUMENT 28 (CD5)	11.365	N 70.4256°	W 151.0670°	Capped drill stem	UMIAQ 2016
MONUMENT 28 (Colville @ Coast)	3.650	N 70.4256°	W 151.0670°	Alcap	UMIAQ GPS 2002
MOUNMENT 29	28.629	N 70.3052°	W 151.1229°	Capped drill stem	UMIAQ 2016
MONUMENT 31	26.897	N 70.3051°	W 151.1992°	Capped drill stem	UMIAQ 2016
MONUMENT 35	5.570	N 70.4325°	W 150.3834°	Alcap	Lounsbury 1996
NANUQ-2	12.926	N 70.3041°	W 150.9974°	Alcap	UMIAQ 2016
NANUQ-5	17.415	N 70.2917°	W 150.9806°	Alcap	UMIAQ 2016
PBM-F	17.862	N 70.3393°	W 151.0468°	PBM in Casing	UMIAQ 2016
PBM-P	20.937	N 70.2914°	W 150.9889°	PBM in Casing	UMIAQ 2016
Pile 08	16.740	-	-	SW Bolt	UMIAQ 2010
Pile 568	23.719	N 70.3639°	W 150.9206°	HSM cap SW bolt	UMIAQ 2010
TBM A	5.890	-	-	Corner of entryway	BAKER 2016
TBM 01-13-09A	12.925	N 70.3401°	W 150.9844°	NE bridge abutment	UMIAQ 2016
TBM L99-32-59	14.605	N 70.3338°	W 150.9522°	Pile Cap SE VSM	UMIAQ 2015

1. North American Datum of 1983 (NAD83)

A.2 CRD GAGE LOCATIONS

Gage Station	Gage Type	Gage Assembly	Latitude (NAD83)	Longitude (NAD83)	Control
MON1U	Indirect-Read	MON1U-A[1]	N 70.1585°	W 150.9450°	MONUMENT 1
		MON1U-A1[2]	N 70.1585°	W 150.9451°	
		MON1U-B	N 70.1585°	W 150.9455°	
		MON1U-C	N 70.1585°	W 150.9461°	
		MON1U-D	N 70.1585°	W 150.9462°	
		MON1U-E	N 70.1585°	W 150.9464°	
		MON1U-F	N 70.1585°	W 150.9465°	
MON1C		MON1C-A[1]	N 70.1657°	W 150.9383°	
		MON1C-A1[2]	N 70.1656°	W 150.9385°	
		MON1C-B	N 70.1658°	W 150.9386°	
		MON1C-C	N 70.1658°	W 150.9392°	
		MON1C-D	N 70.1658°	W 150.9393°	
		MON1C-E	N 70.1658°	W 150.9395°	
		MON1C-F	N 70.1659°	W 150.9397°	
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°	
		MON1D-Z	N 70.1737°	W150.9376°	
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 A
		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°	
MON20	Indirect-Read	MON20-A[1]	N 70.2786°	W 150.9986°	PBM-P
		MON20-B	N 70.2786°	W 150.9985°	
		MON20-C	N 70.2786°	W 150.9983°	
		MON20-D	N 70.2785°	W150.9982°	
		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

Gage Station	Gage Type	Gage Assembly	Latitude (NAD83)	Longitude (NAD83)	Control
G1	Direct-Read	G1[1]	N 70.3428°	W 150.9208°	MON 22
G9		G9[1]	N 70.3336°	W 150.9519°	MON 22
G10		G10[1]	N 70.3425°	W 150.9328°	TBM L99-32-59
G3	Direct-Read	G3[1,2]	N 70.3400°	W 150.9831°	TBM 01-13-09A
G4		G4[1]	N 70.3403°	W 150.9833°	
G6	Direct-Read	G6[1]	N 70.3397°	W 151.0292°	MON 12
G7		G7[1]	N 70.3400°	W 151.0289°	
G12	Indirect-Read	G12[1]	N 70.3367°	W 151.0117°	CD2-14N
G13		G13[1]	N 70.3373°	W 151.0118°	
G8	Indirect-Read	G8	N 70.3393°	W 151.0491°	PBM-F
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
G15	Indirect-Read	G15-A[1]	N 70.3023°	W 150.9929°	CD4-20AE
		G15-B	N 70.3024°	W 150.9939°	
G16		G16-A[1]	N 70.3017°	W 150.9933°	
		G16-B	N 70.3018°	W 150.9943°	
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°	
G20	Indirect-Read	G20-A	N 70.2917°	W 150.9968°	PBM-P
		G20-B	N 70.2917°	W 150.9968°	
G40		G40	N 70.3234°	W 150.9968°	CD4-12W
G41		G41	N 70.3235°	W 150.9949°	
G42		G42	N 70.3276°	W 150.9939°	CD4-10W
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 70.3024°	W 151.0227°	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

Gage Station	Gage Type	Gage Assembly	Latitude (NAD83)	Longitude (NAD83)	Control
G27	Indirect-Read	G27-A[1]	N 70.3033°	W 151.0224°	MONUMENT 25
		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 70.2961°	W 151.0328°	
		G28-B	N 70.2961°	W 151.0331°	
		G28-C	N 70.2961°	W 151.0331°	
		G28-D	N 70.2961°	W 151.0332°	
		G28-E	N 70.2961°	W 151.0335°	
G29		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°	
G30		G30[1]	N 70.3046°	W 151.0443°	CD5-40S
G31		G31[1]	N 70.3051°	W 151.0437°	
G34		G34[1]	N 70.3060°	W 151.0710°	CD5-35S
G35		G35[1]	N 70.3067°	W 151.0711°	
G36		G36[1]	N 70.3055°	W 151.0968°	MONUMENT 28 (CD5)
G37		G37[1]	N 70.3063°	W 151.0971°	
S1		S1-A[1]	N 70.3058°	W 151.1944°	MONUMENT 31
		S1-D[1]	N 70.3066°	W 151.1957°	

Notes:
1. PT, 2. RTFM PT, 3. Baro PT

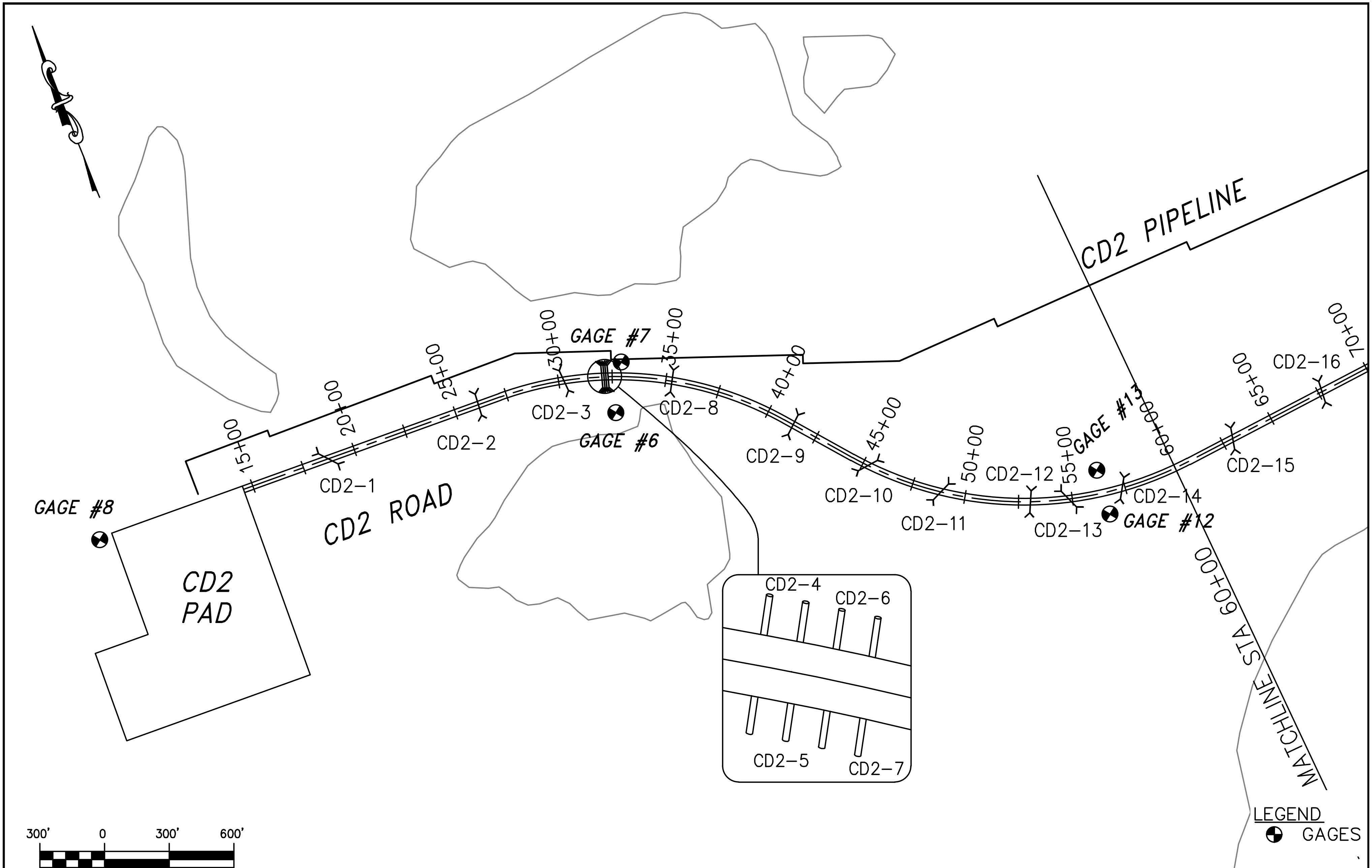
A.4 CULVERT LOCATIONS

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 70.3391	W 150.9678
CD4-02E	13+51	N 70.3383	W 150.9674
CD4-02W		N 70.3383	W 150.9679
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

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
CD4-03E	16+02	N 70.3376	W 150.9672
CD4-03W		N 70.3376	W 150.9676
CD4-04E	18+95	N 70.3368	W 150.9669
CD4-04W		N 70.3369	W 150.9674
CD4-05E	23+08	N 70.3358	W 150.9680
CD4-05W		N 70.3359	W 150.9685
CD4-06E	28+03	N 70.3347	W 150.9707
CD4-06W		N 70.3349	W 150.9711
CD4-07E	34+16	N 70.3336	W 150.9747
CD4-07W		N 70.3338	W 150.9750
CD4-08E	44+28	N 70.3318	W 150.9811
CD4-08W		N 70.3320	W 150.9815
CD4-09E	59+20	N 70.3287	W 150.9886
CD4-09W		N 70.3288	W 150.9890
CD4-10E	66+48	N 70.3273	W 150.9929
CD4-10W		N 70.3274	W 150.9934
CD4-11E	81+24	N 70.3235	W 150.9954
CD4-11W		N 70.3235	W 150.9961
CD4-12E	81+66	N 70.3234	W 150.9954
CD4-12W		N 70.3234	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 150.9960
CD4-15E	102+00	N 70.3179	W 150.9980
CD4-15W		N 70.3179	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 70.3068	W 150.9994
CD4-18E	146+55	N 70.3059	W 150.9985
CD4-18W		N 70.3059	W 150.9989
CD4-19E	154+57	N 70.3038	W 150.9973
CD4-19W		N 70.3037	W 150.9978
CD4-20AE	162+95	N 70.3022	W 150.9937
CD4-20AW		N 70.3019	W 150.9936
CD4-20BE	163+15	N 70.3021	W 150.9934
CD4-20BW		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 70.3019	W 150.9926
CD4-23W		N 70.3017	W 150.9925
CD4-23AE	164+60	N 70.3019	W 150.9924
CD4-23AW		N 70.3016	W 150.9923
CD4-23BE	164+80	N 70.3019	W 150.9923
CD4-23BW		N 70.3016	W 150.9922
CD4-23CE	165+00	N 70.3018	W 150.9921
CD4-23CW		N 70.3016	W 150.9920
CD4-23DE	165+20	N 70.3018	W 150.9920
CD4-23DW		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
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

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
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
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)
CD5-23N	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:	10/11/2017	PROJECT:	159587
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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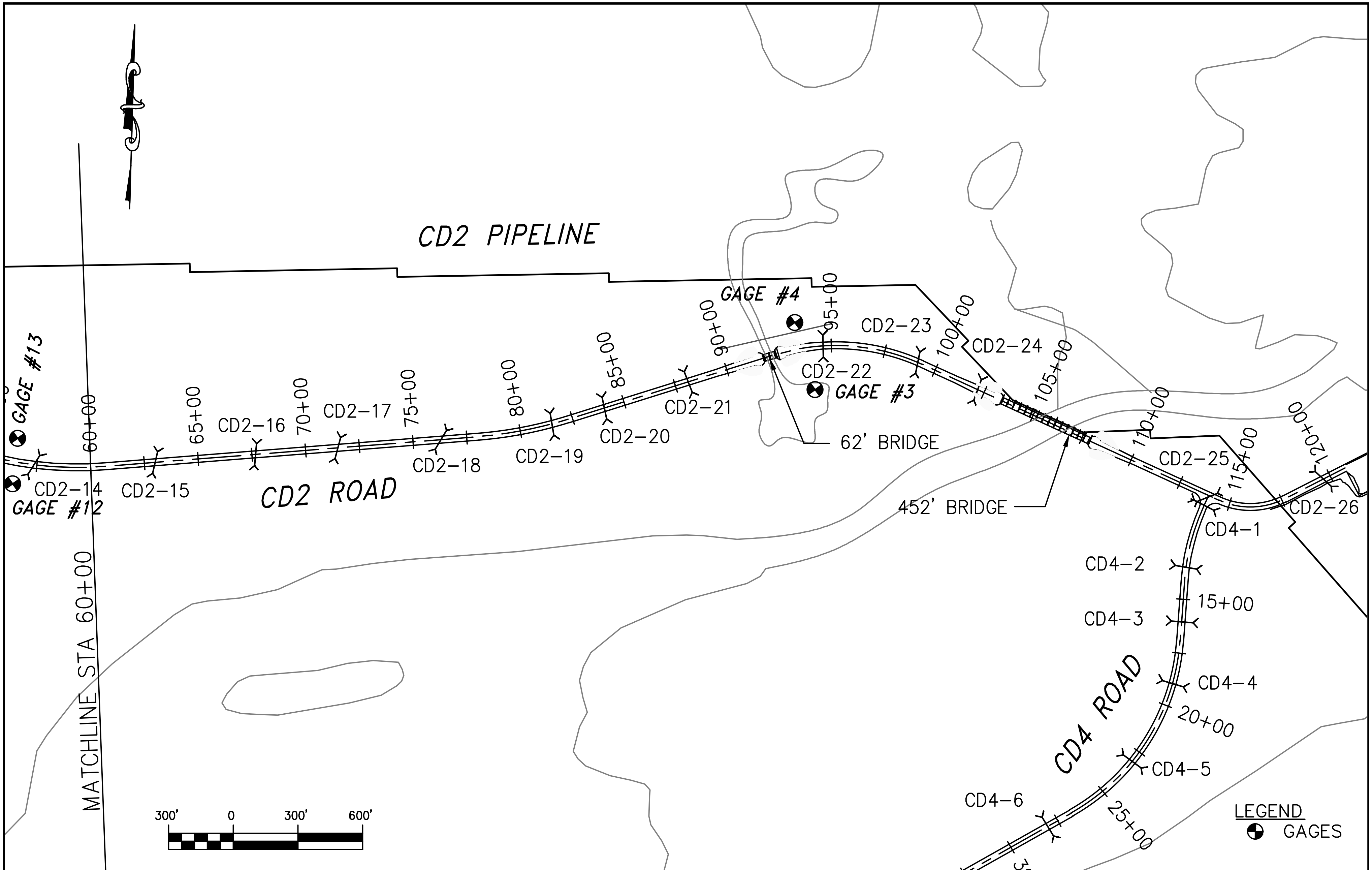
2017 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 1 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	10/11/2017	PROJECT:	159587
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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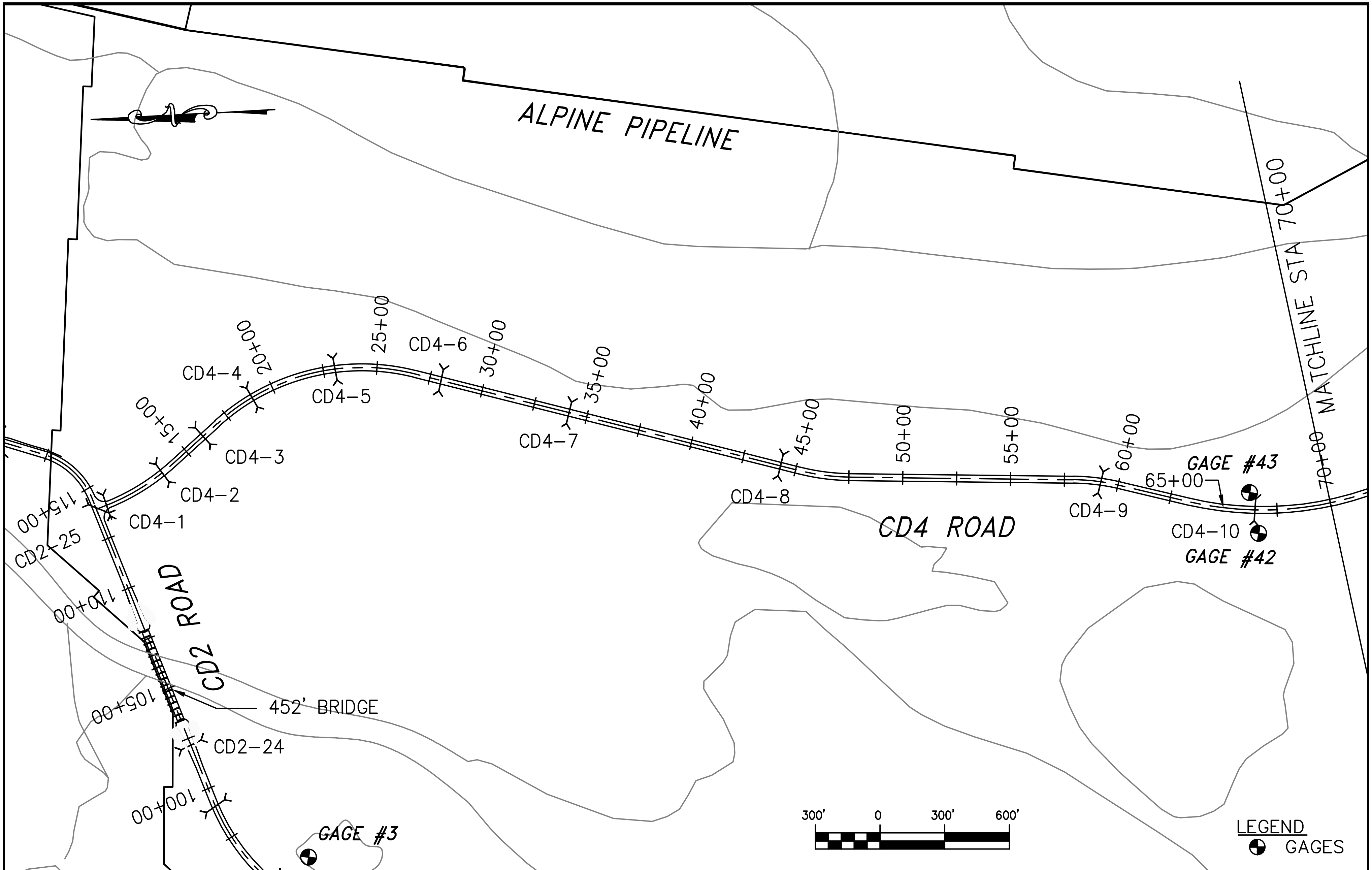
2017 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 2 OF 13)



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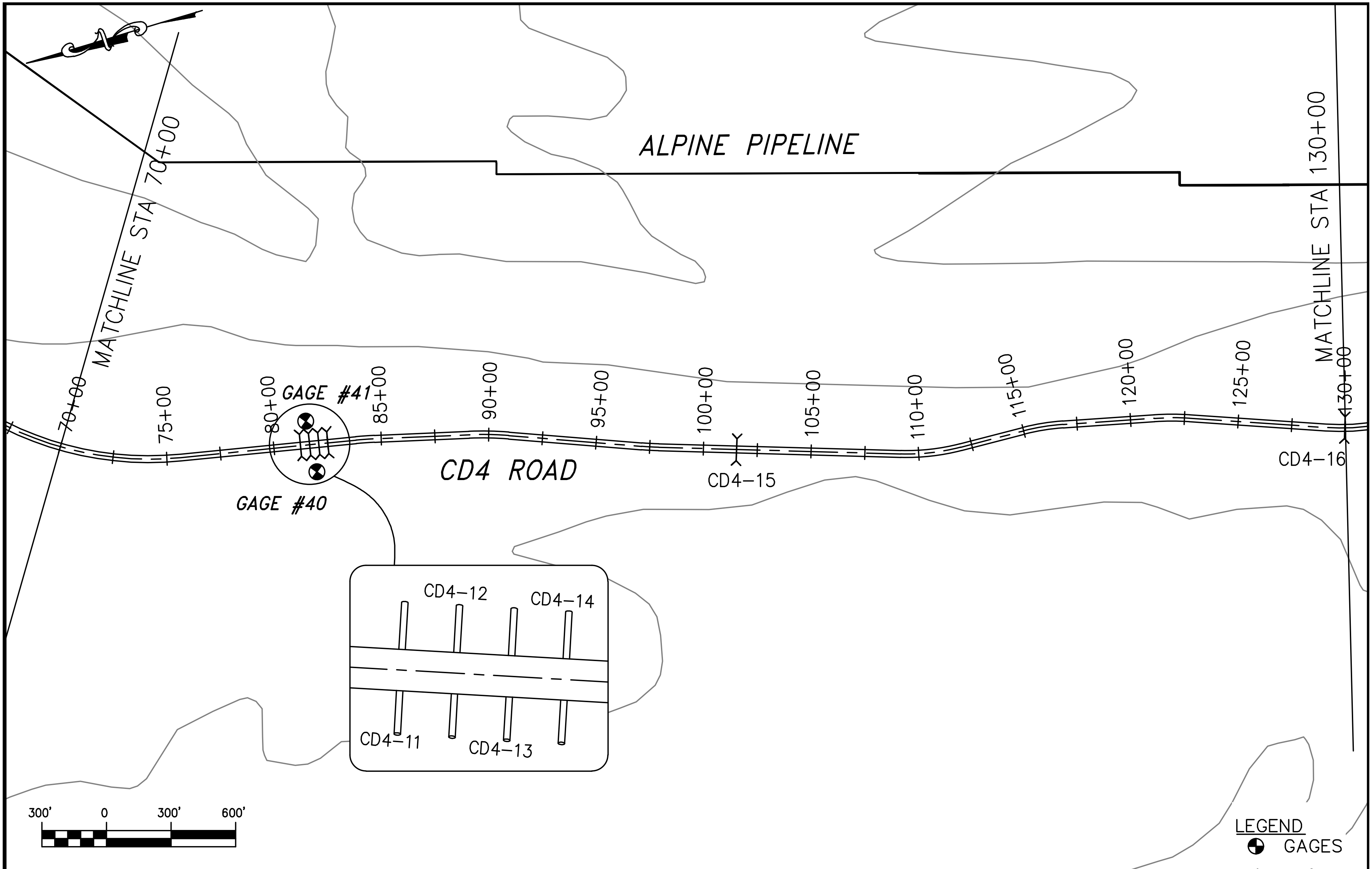
2017 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION



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CHECKED: GCY	SCALE: AS SHOWN

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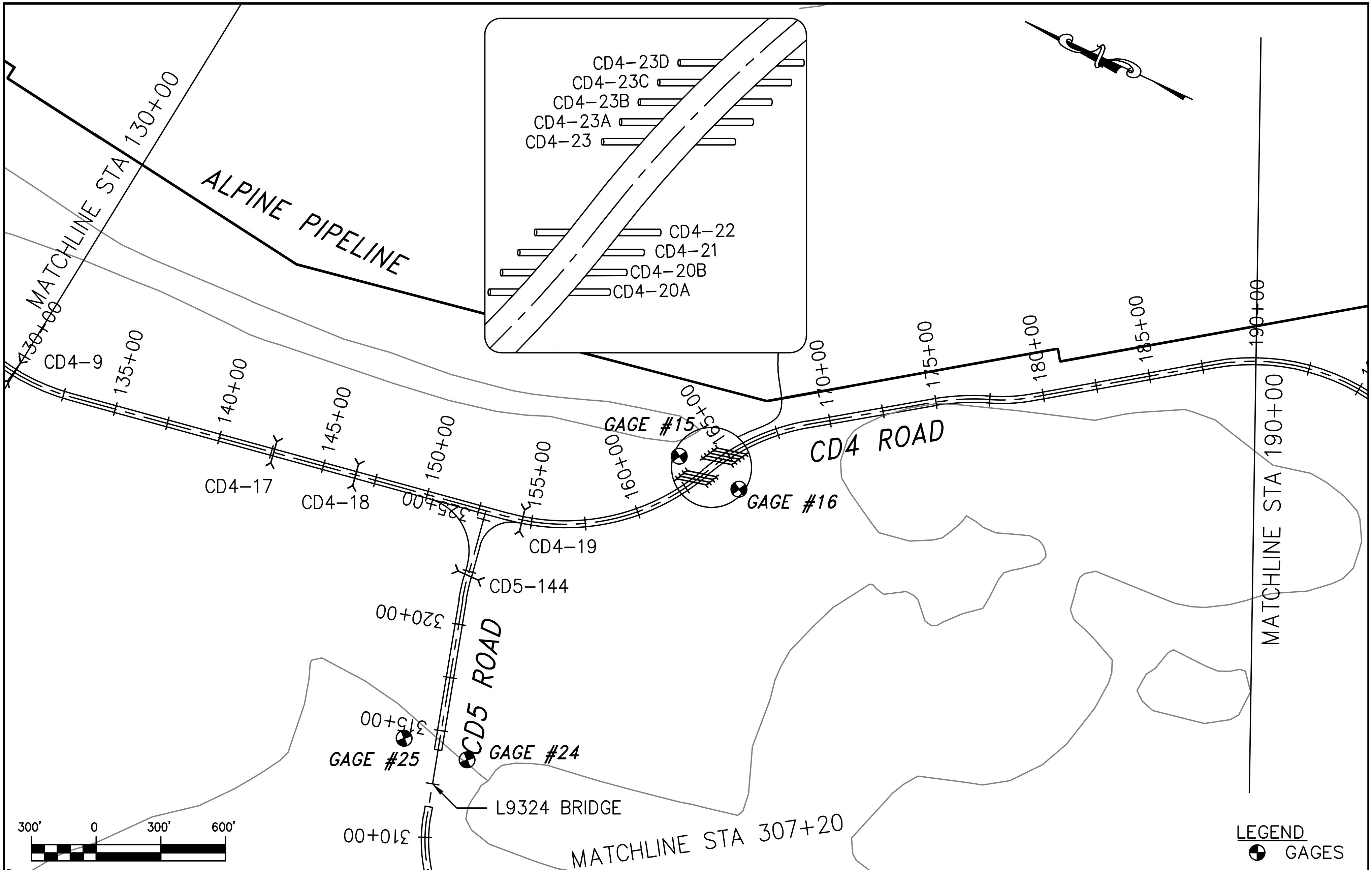
2017 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 4 OF 13)



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DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
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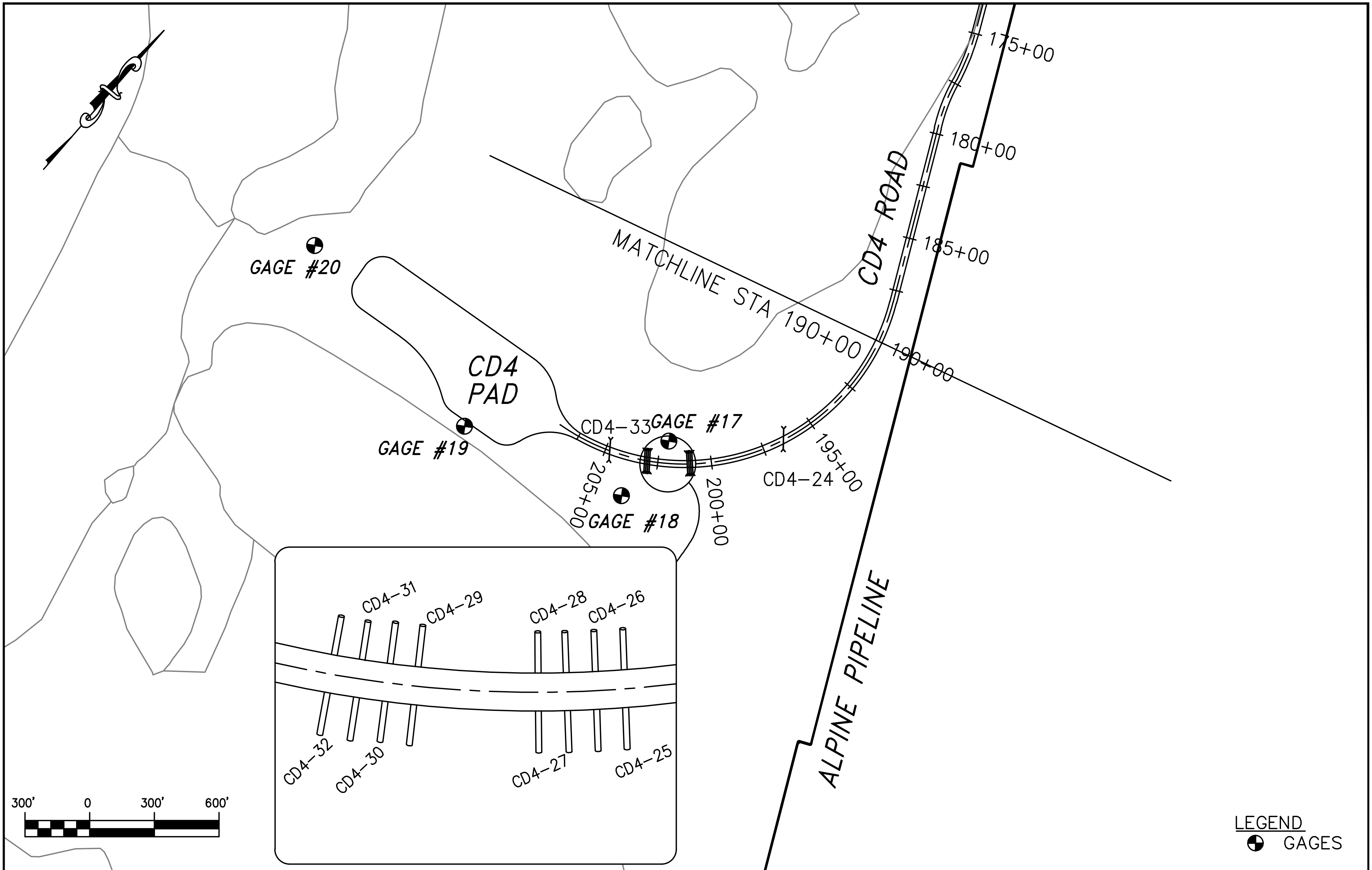
2017 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION



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DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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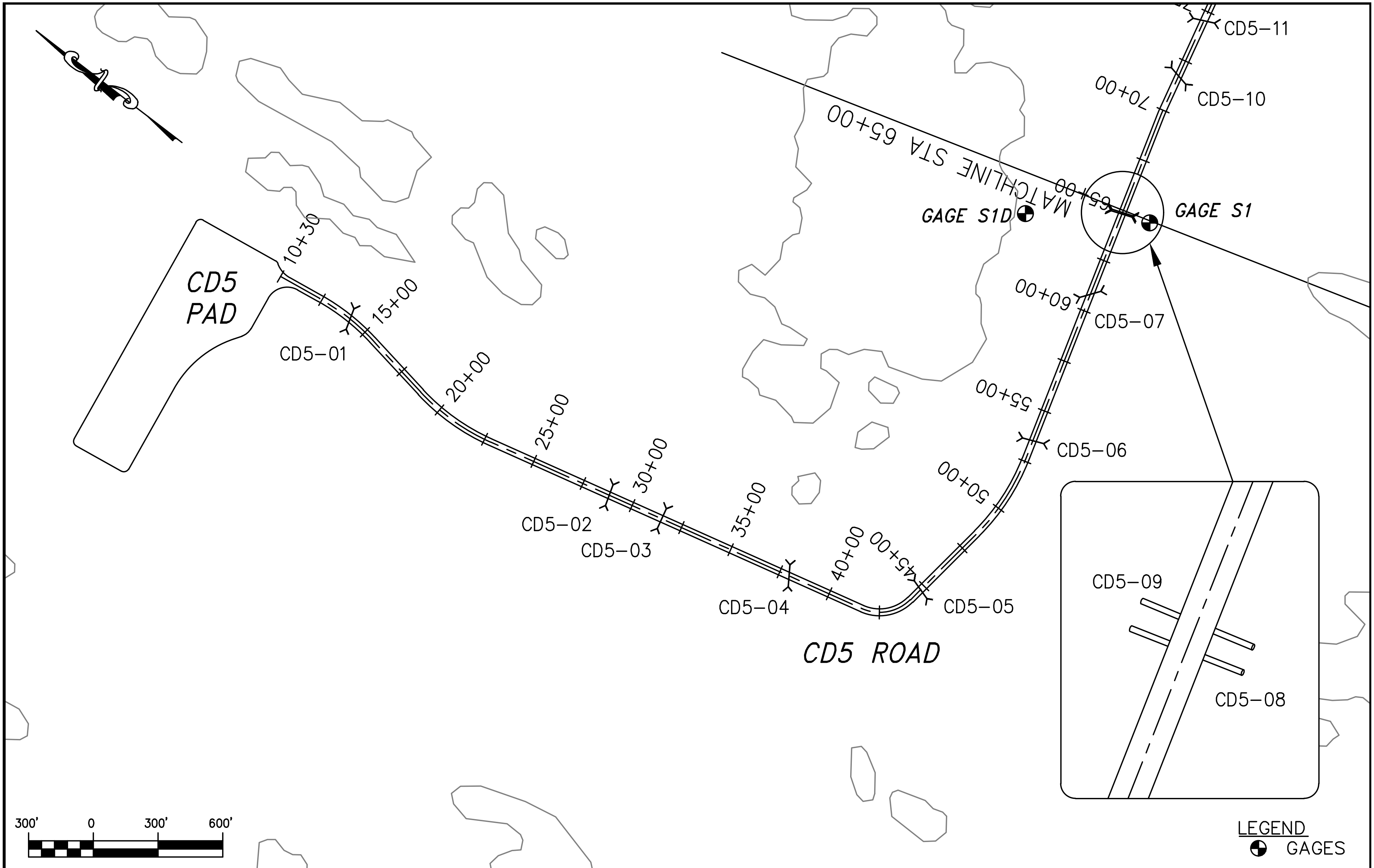
2017 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 6 OF 13)



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DATE:	10/11/2017	PROJECT:	159587
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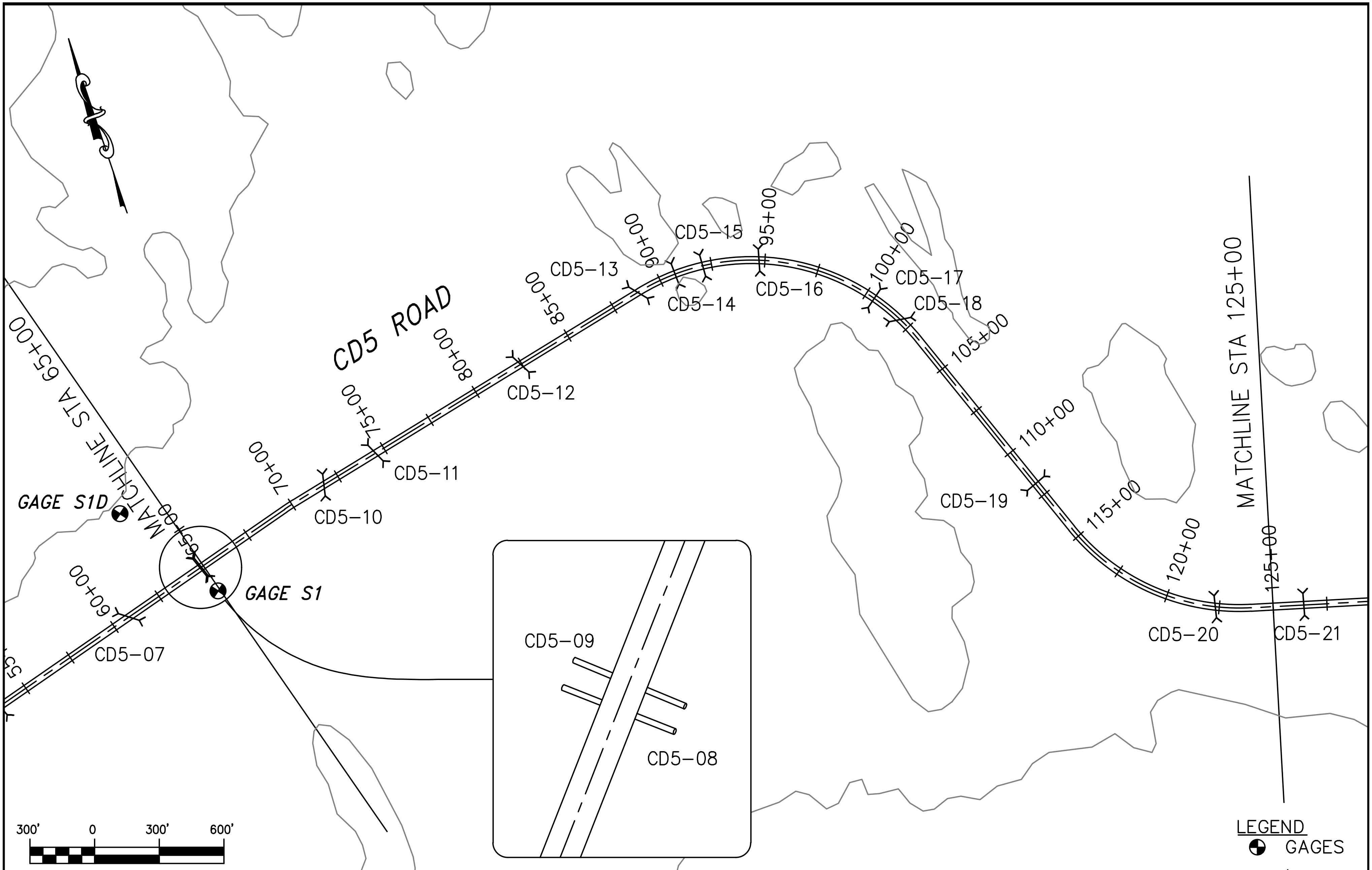
2017 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION



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DATE: 10/11/2017	PROJECT: 159587
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CHECKED: GCY	SCALE: AS SHOWN

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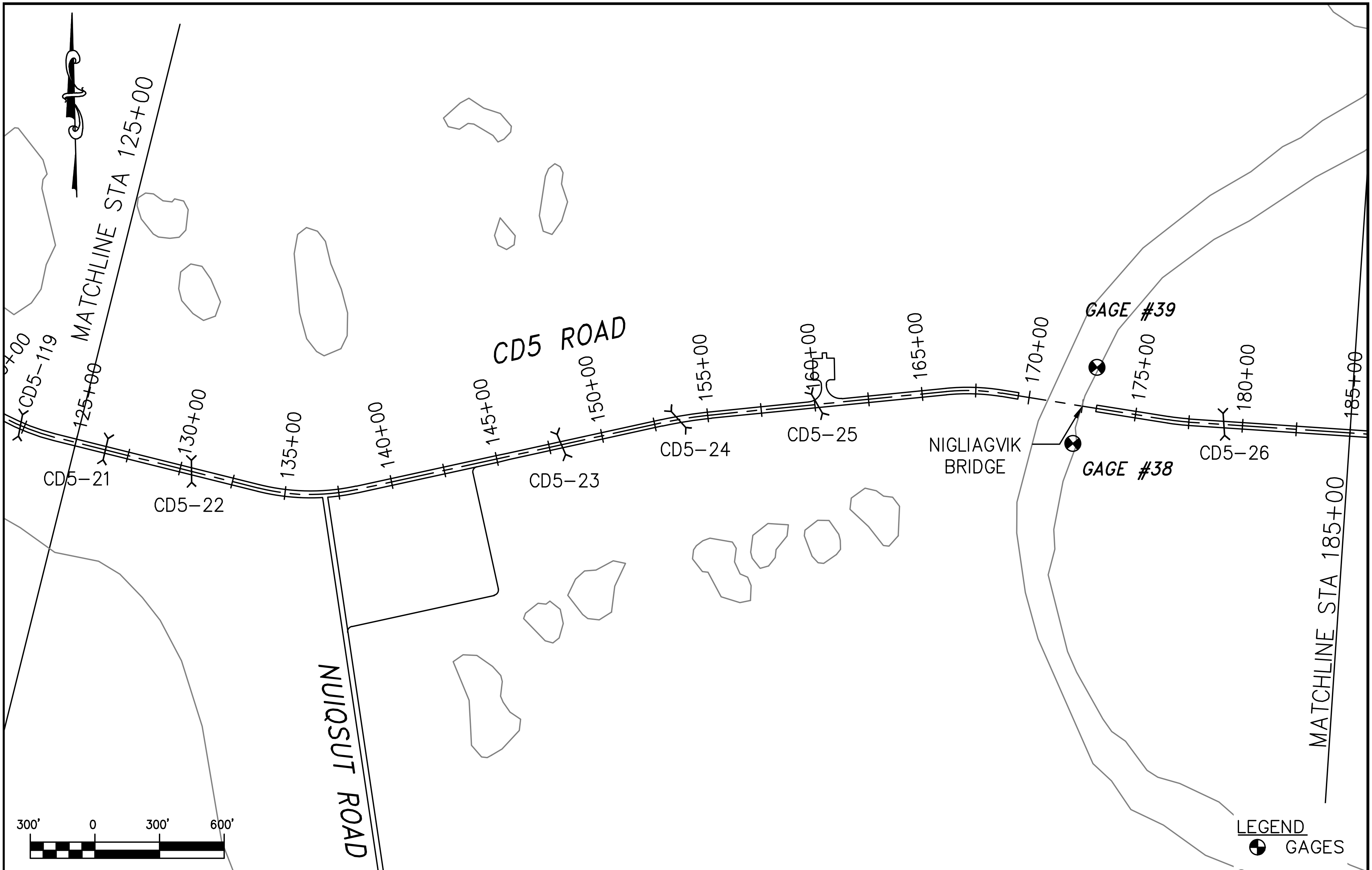
2017 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 8 OF 13)



ConocoPhillips Alaska, Inc.

DATE:	10/11/2017	PROJECT:	159587
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CHECKED:	GCY	SCALE:	AS SHOWN

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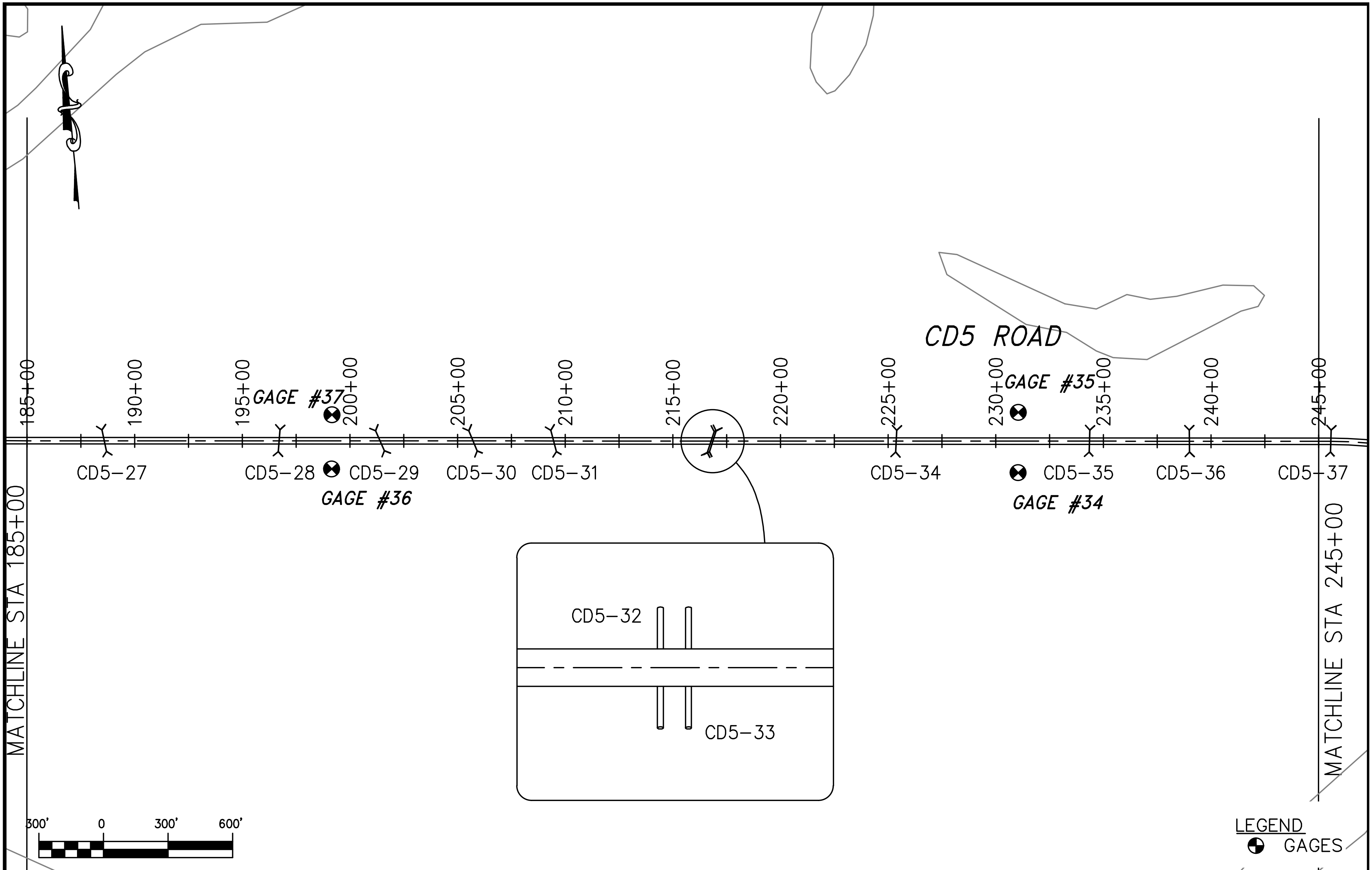
2017 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 9 OF 13)



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DATE:	10/11/2017	PROJECT:	159587
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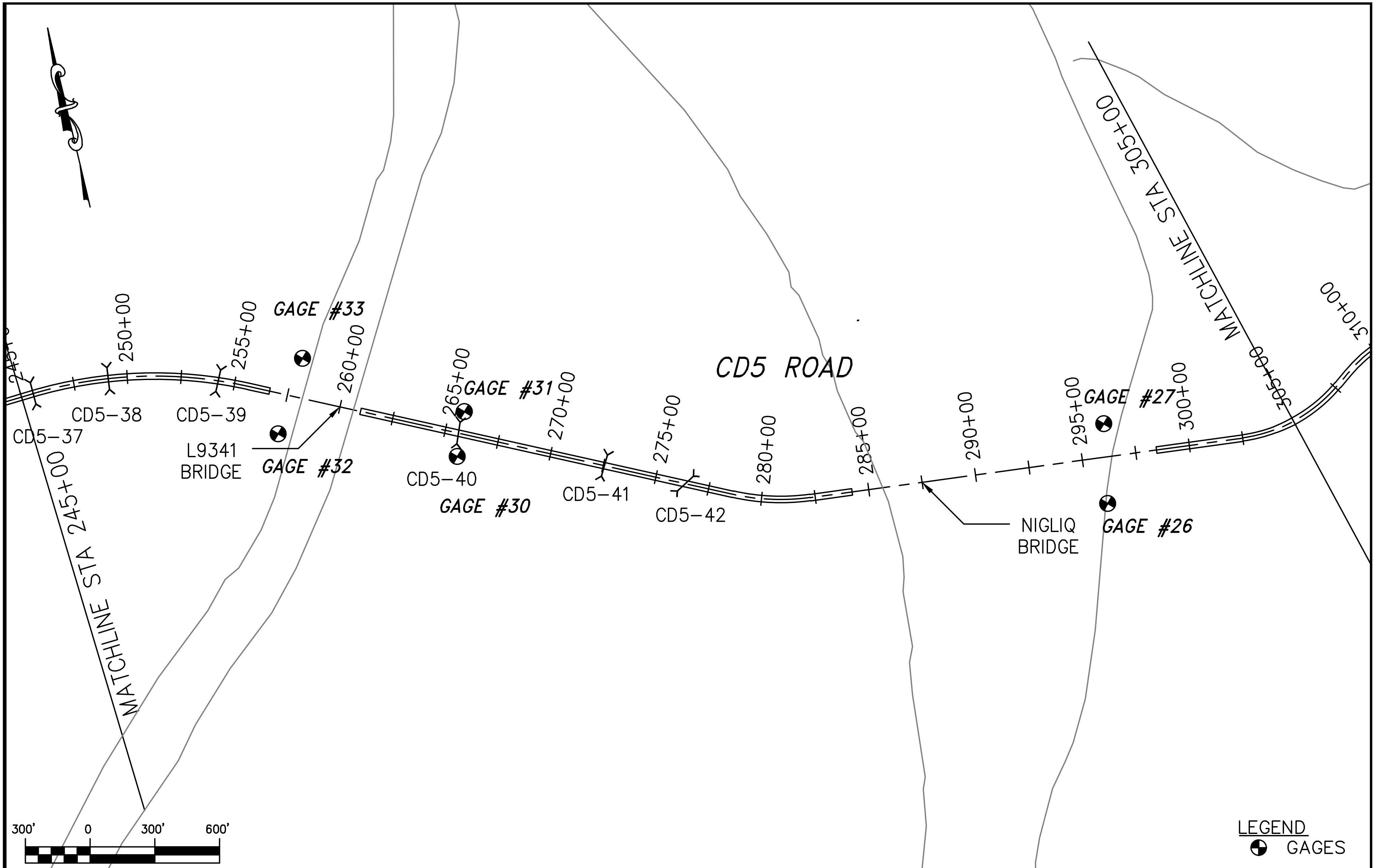
2017 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION



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DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
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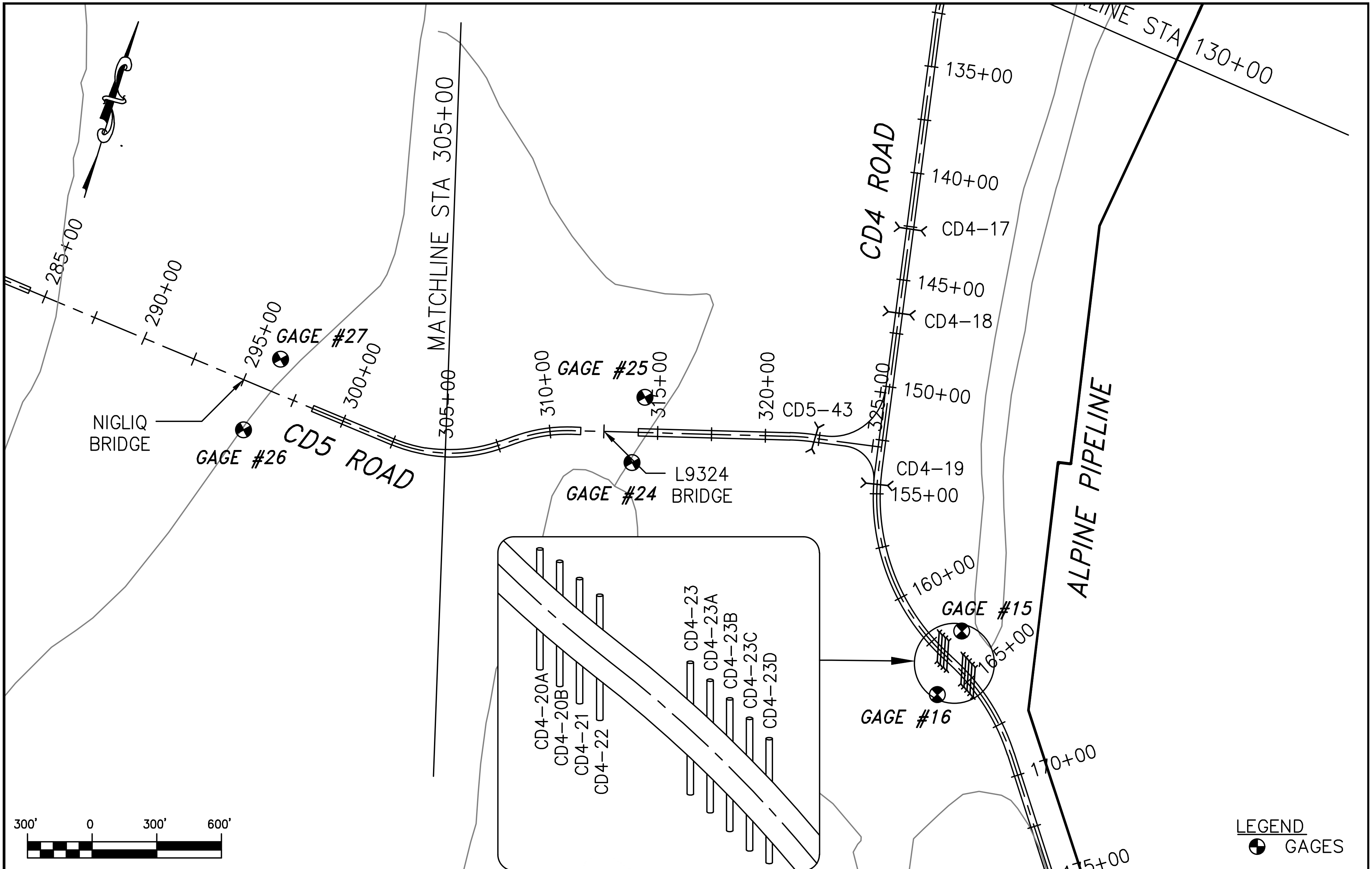
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET11 OF 13)



ConocoPhillips Alaska, Inc.

DATE: 10/11/2017	PROJECT: 159587
DRAWN: DTR	FILE: ALPINE_FACILITES.DWG
CHECKED: GCY	SCALE: AS SHOWN

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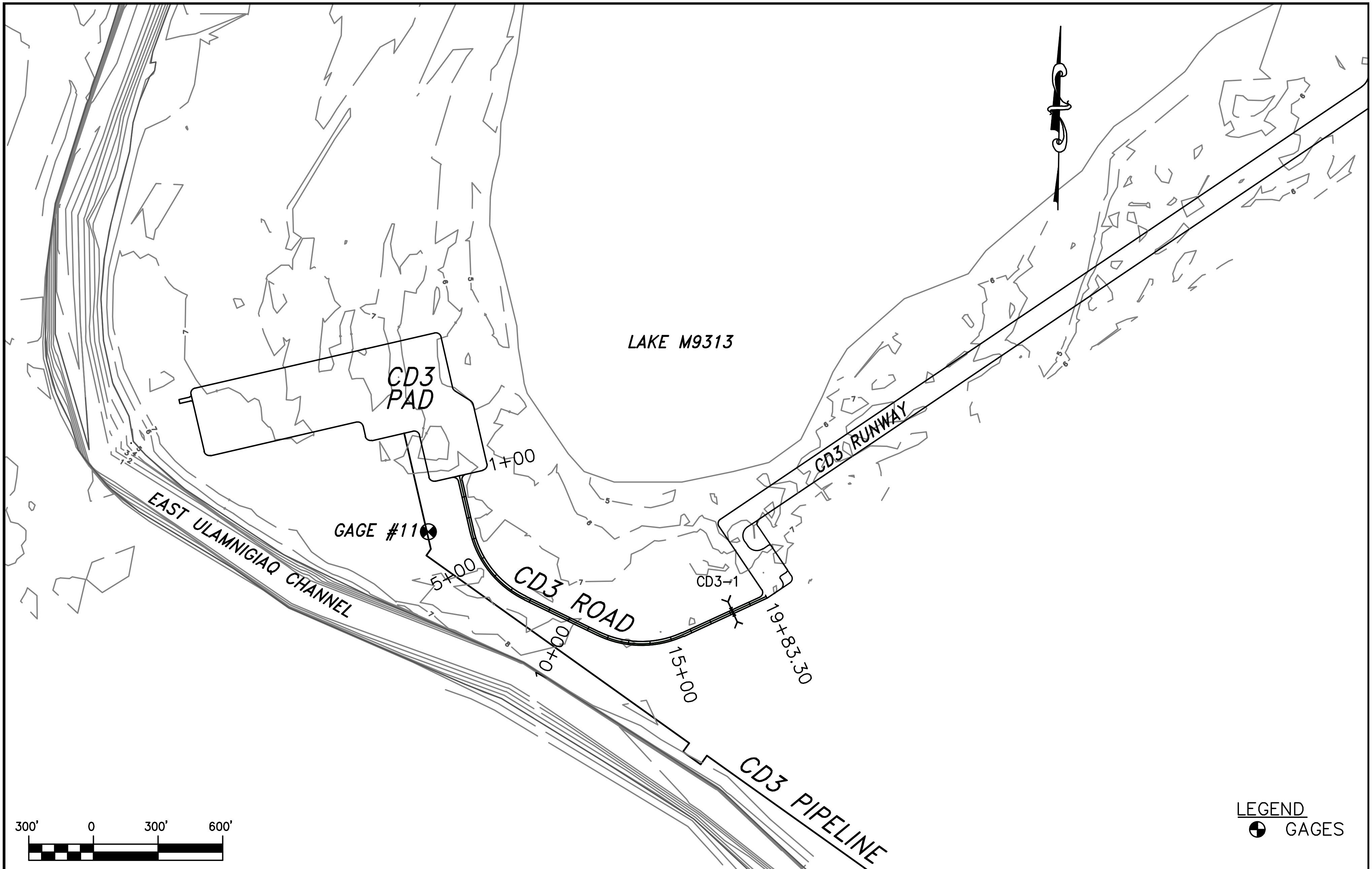
2017 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION



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DATE:	10/11/2017	PROJECT:	159587
DRAWN:	DTR	FILE:	ALPINE_FACILITES.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2017 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 are taken into account, using two independent barometric pressure loggers: In-Situ BaroTROLL® and Solinst Barologger®. A correction of barometric pressure was obtained from the BaroTROLL sensor installed at CD4 pad and the Barologger installed at HDD West near MON9.

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

PT-based stage values were determined by adding the calculated water depth and the surveyed sensor elevation. PTs have the potential to drift and can be affected by ice and sediment. 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

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 each bridge deck 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 counter weight. A tag line was placed along the bridge rail to define the cross section and to delineate measurement subsections within the channel. The standard rating table No.2 for Price AA velocity meters, developed by the USGS Office of Surface Water (OSW) Hydraulic Laboratory as announced in the OSW Technical Memorandum No. 99.05 (OSW 1999a), was used to convert revolutions to stream velocity. The Price AA velocity meter was serviced 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.

C.1.2 PEAK DISCHARGE

Bentley CulvertMaster® software was used to calculate peak discharge through the CD2 road culverts. 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 assumes ice-free open-water conditions and were estimated based on several variables, including:

- Headwater and tailwater elevations at each culvert (hydraulic gradient)
- Culvert diameter and length from UMIAQ as-built surveys (UMIAQ 2002, 2017a)
- Culvert upstream and downstream invert elevations (UMIAQ 2017)
- Culvert Manning's roughness coefficients (0.013 for smooth steel and 0.024 for corrugated metal pipe)

1) Normal Depth

The Normal Depth method (Chow 1959) was used to calculate peak discharge at MON1, MON9, the Nigliq Bridge, and the Nigliagvik Bridge using channel cross section geometry and stage differential between gage sites as an estimate for the energy grade line.

Cross sectional geometry for MON1 is current as of 2004 (UMIAQ 2004), (MON9 is current as of 2014 (UMIAQ 2014d), cross sectional geometry at the Nigliagvik Bridge and Nigliq Bridge is current as of 2016 (UMIAQ 2016b). Because of channel bed morphology, cross sectional geometry becomes less accurate with time, particularly for those CRD channels that are predominantly comprised of fine grained soils or have bottom-fast ice. Stage and energy gradient data were obtained from observations, gage data, and PT data.

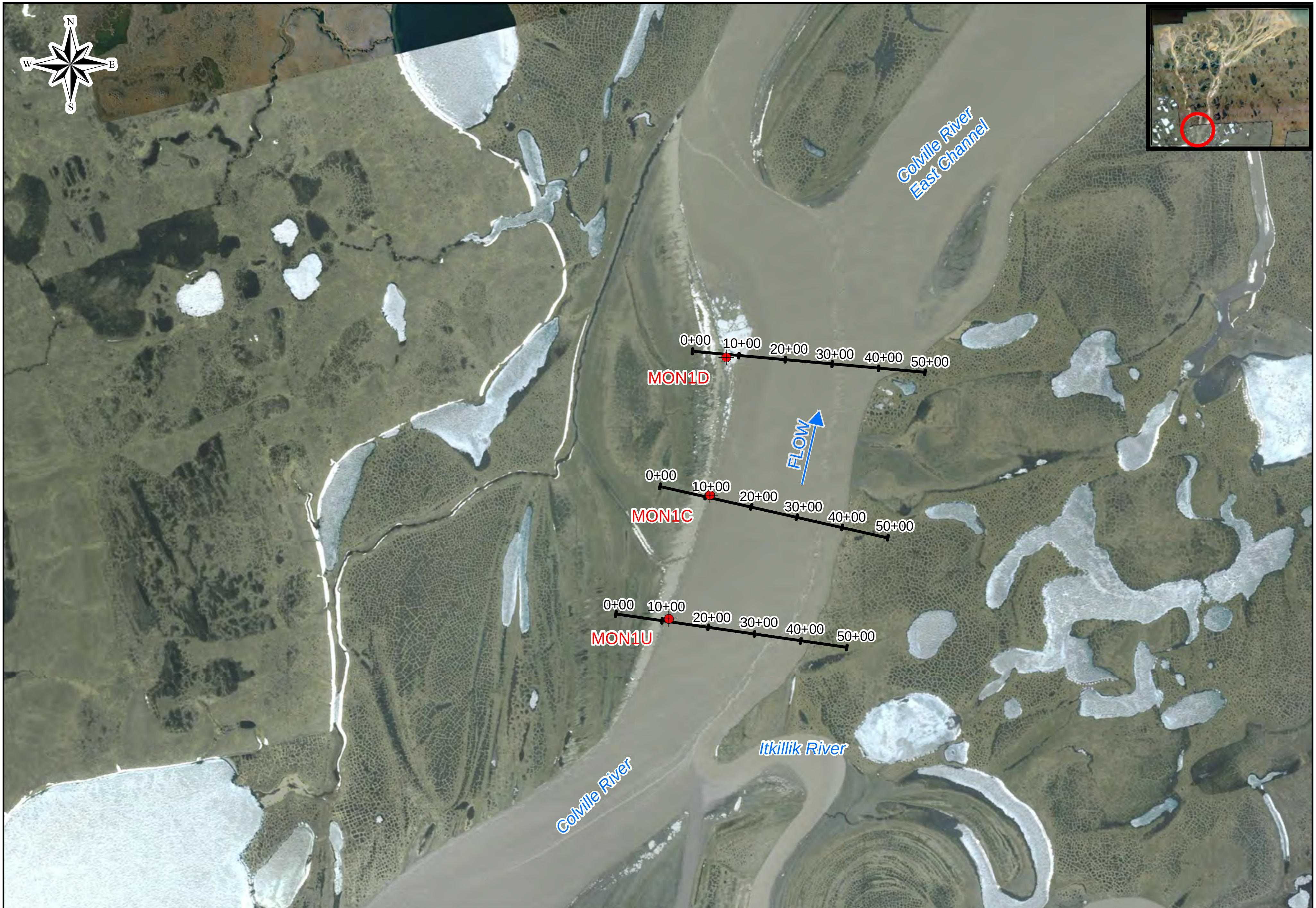
C.2 Data, Plan & Profile Drawings

C.2.1 MON1

1) PEAK DISCHARGE DATA

Peak discharge at MON1 was calculated indirectly using the Normal Depth method. The Slope Area method was not used because of the limited time that stage was high enough to be recorded by the MON1D PT. The energy grade-line was approximated by the average water surface slope between MON1U and MON1C. Manning's n roughness values used were 0.0256 for the main channel and 0.06 for the overbanks, based on 2016 measured discharge and corresponding WSE.

2) PLAN & PROFILES



ConocoPhillips Alaska	Miles 0 0.25 0.5
Date: 10/10/2017	Project: 159587
Drawn: BTG	File: 2017_CRD_8x11L_Mon1.mxd
Checked: GCY	Scale: 1 in = .5 miles

Legend

Gage Location

2004 Cross Section Alignment

Imagery Source: GeoNorth WMS

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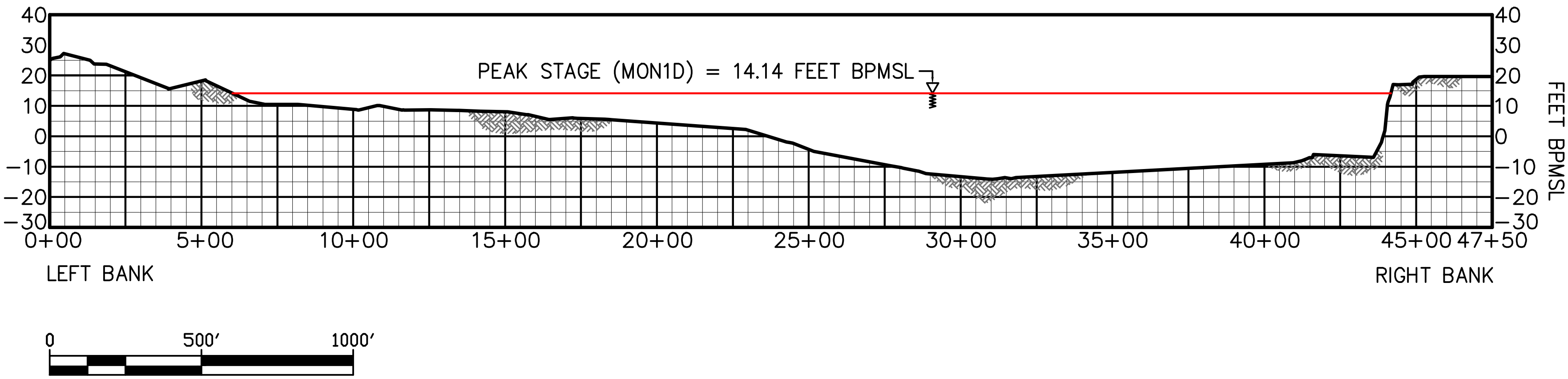
2017 SPRING BREAKUP
MONUMENT 1
PLAN

(SHEET 1 of 4)

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



1D COLVILLE RIVER AT MON1 DOWNSTREAM CROSS−SECTION

ConocoPhillips Alaska, Inc.

DATE:	10/10/2017	PROJECT:	159587
DRAWN:	DTR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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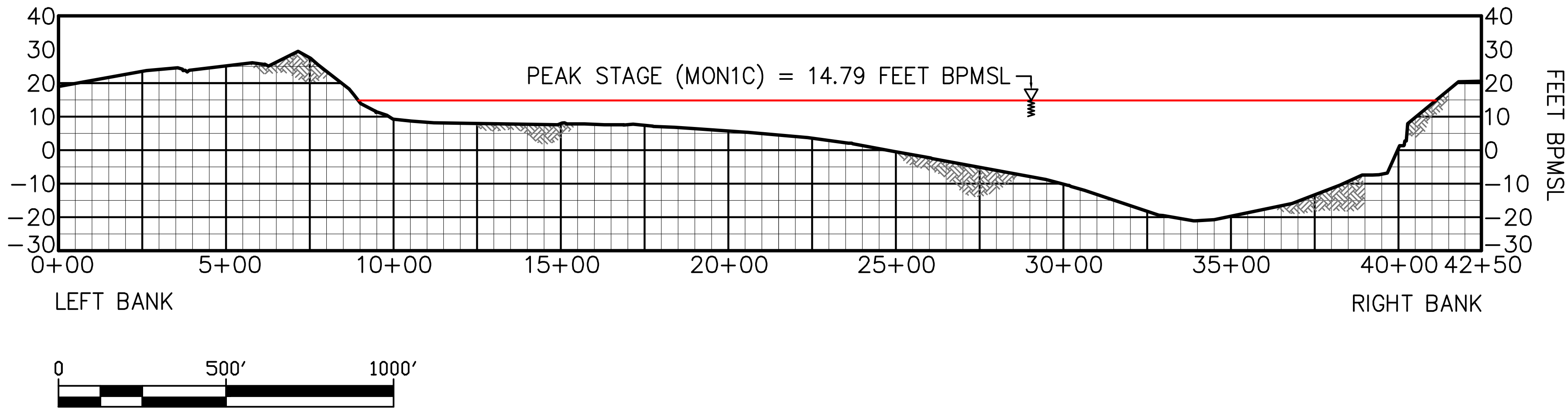
2017 SPRING BREAKUP
MONUMENT 1 DOWNSTREAM
PROFILE

(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

ConocoPhillips Alaska, Inc.

DATE:	10/10/2017	PROJECT:	159587
DRAWN:	DTR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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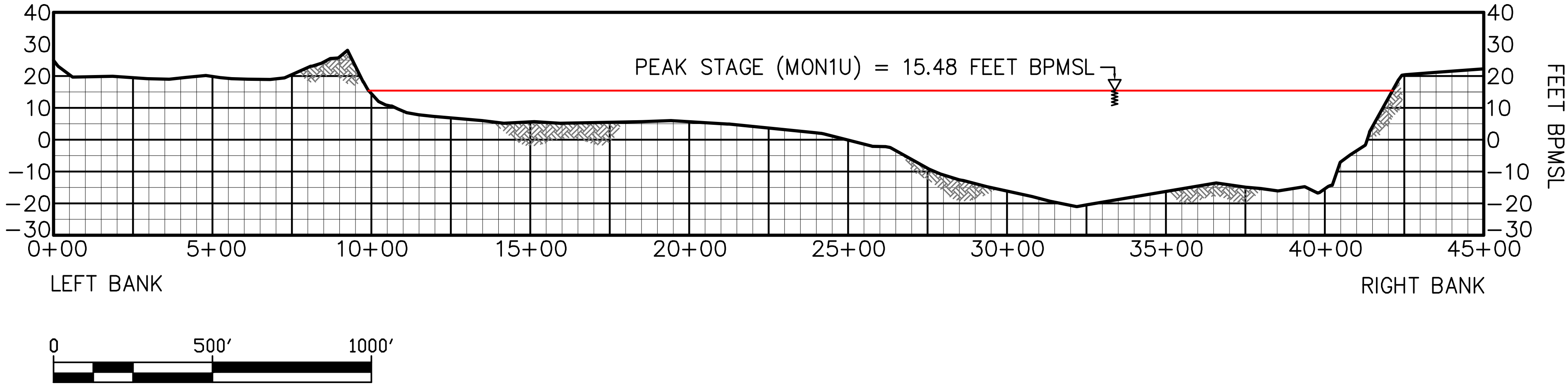
2017 SPRING BREAKUP
MONUMENT 1 CENTERLINE
PROFILE

(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:	10/10/2017	PROJECT:	159587
DRAWN:	DTR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2017 SPRING BREAKUP
MONUMENT 1 UPSTREAM
PROFILE

NUMBER
(SHEET 4 OF 4)

C.2.2 MON9

1) PEAK DISCHARGE DATA

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

ConocoPhillips Alaska	Feet 0 500 1,000		
Date: 10/10/2017	Project: 159587		
Drawn: BTG	File: 2017_CRD_8x11L_Mon9.mxd		
Checked: GCY	Scale: 1 in = 1000 feet		

Legend

- Gage Location
- 2009 Cross Section Alignment
- Pipeline

Imagery Source: ConocoPhillips Alaska, 2015

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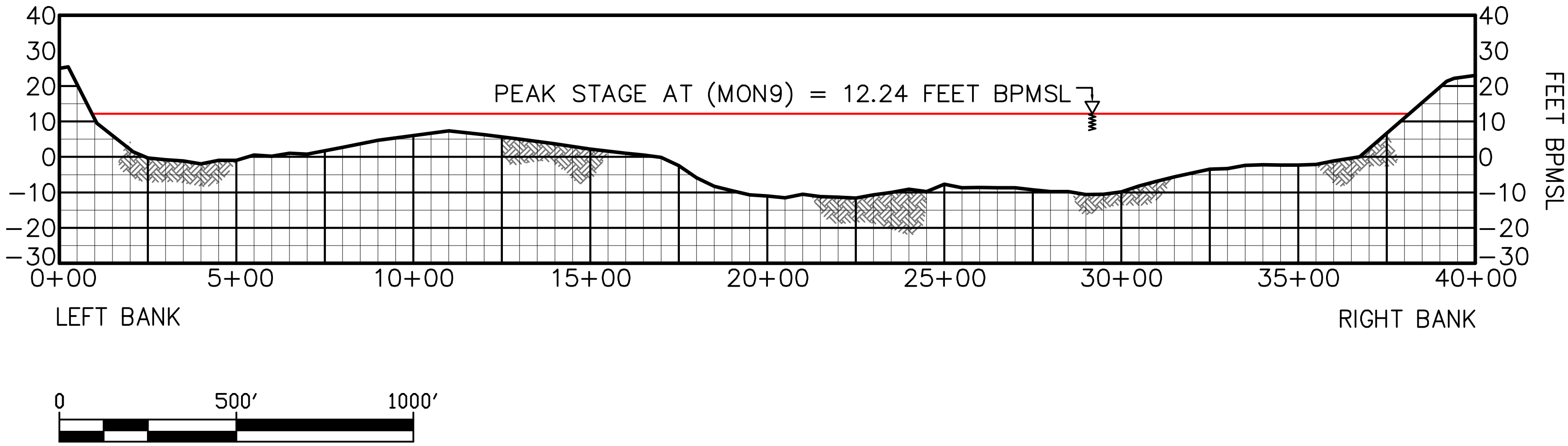
2017 SPRING BREAKUP
Monument 9 / HDD
PLAN

(SHEET 1 of 2)

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



1 COLVILLE EAST CHANNEL AT MON9 CROSS-SECTION

ConocoPhillips
Alaska, Inc.

DATE:	10/10/2017	PROJECT:	159587
DRAWN:	DTR	FILE:	MON9 X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2017 SPRING BREAKUP
MONUMENT 9 / HDD
PROFILE

(SHEET 2 OF 2)

C.2.3 NIGLIQ BRIDGE

1) MEASURED DISCHARGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: June 2, 2017
Computed By: JPM, JMG
Checked By:

Location Name: Nigliq Bridge

Party: JPM, JMG, WAB Start: 6/2/2017 10:19 Finish: 6/2/2017 13:50

Temp: 30 - 35 °F Weather: Overcast, Windy (14-17 mph)

Channel Characteristics:

Width: 736 ft Area: 15741 sq ft Velocity: 1.57 fps Discharge: 24636 cfs

Method: 0.6; 0.2/0.8; S Number of Sections: 33 Count: N/A

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

GAGE READINGS			
Gage	Start	Finish	Change
G26-A	0.45	0.29	0.16
G27-A	1.1	0.95	0.15
G27-C	1.14	0.96	0.18

Meter: 1 ft above bottom of weight

Weight: 50 lbs

Wading **Cable** Ice Boat

Upstream or Downstream side of bridge

GPS Data: W Bridge Abutment
Left Edge of Water: N ° ' " W ° ' "
Right Edge of Water: N ° ' " W ° ' "
E Bridge Abutment

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

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

Descriptions:

Cross Section: Section fairly firm and uniform; about 10 lineal feet of snow on left edge water; streambed soft for 150ft on right edge water

Flow: Falling stage

Remarks: Channel control; some ice floes grounded 600-800 feet downstream, stream banks mostly clear of ice and snow. Very little backwater effect.

Nigliq Bridge
June 2, 2017

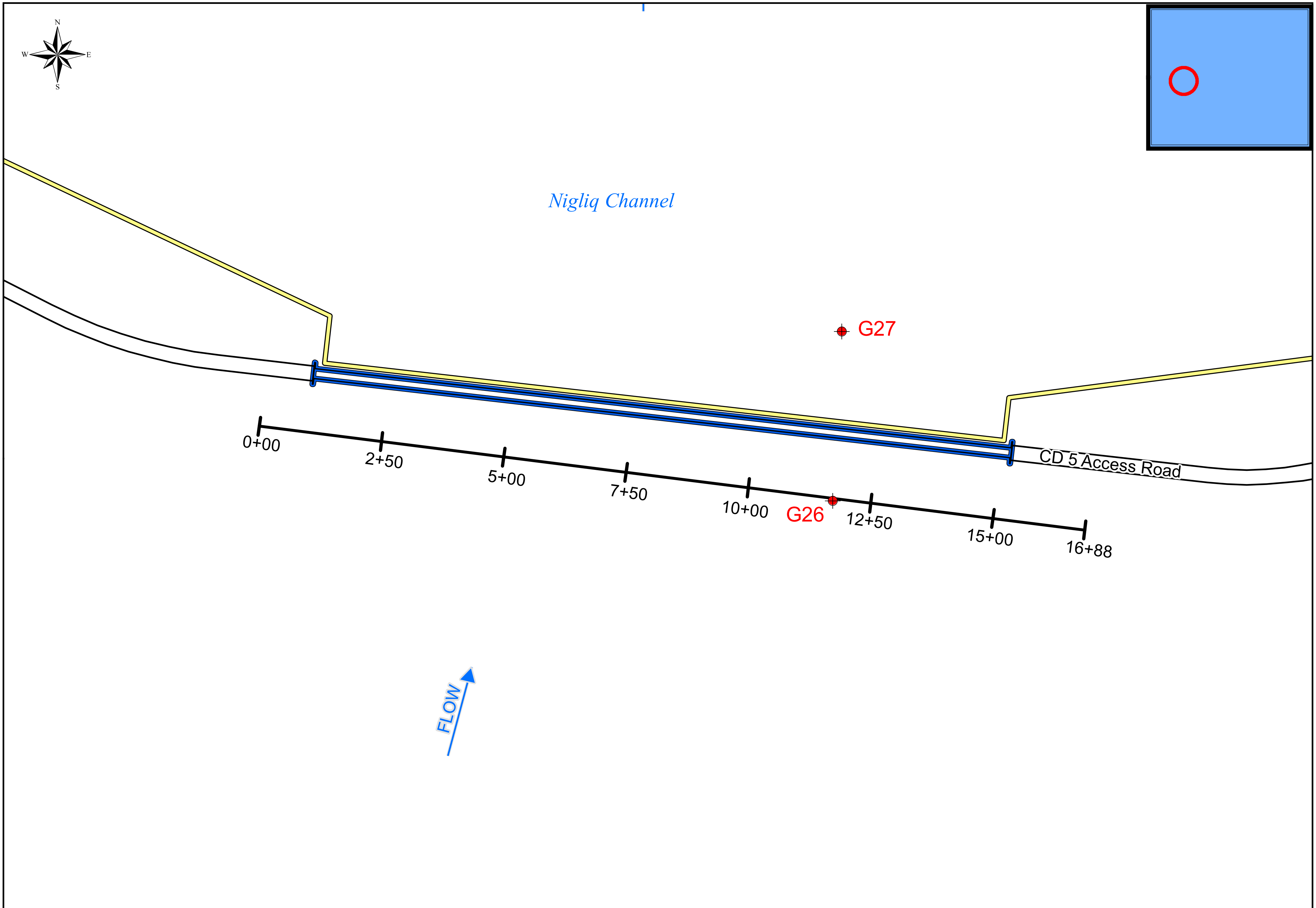
Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
LEW @ 10:20											
	134		0.0								
1	140	16.0	1.6	S	15	43	0.79	0.79	0.79	25.6	20.31
1	160	20.0	19.8	0.2 0.8	30 20	52 43	1.30 1.05	1.18	1.18	396.0	465.70
1	180	17.5	25.8	0.2 0.8	40 30	52 48	1.73 1.41	1.57	1.57	451.5	707.67
1	195	15.0	26.4	0.2 0.8	40 35	42 45	2.13 1.75	1.94	1.94	396.0	768.50
1	210	15.0	27.6	0.2 0.8	40 35	42 45	2.13 1.75	1.94	1.94	414.0	803.43
1	225	15.0	28.4	0.2 0.8	45 40	44 49	2.29 1.83	2.06	2.06	426.0	878.27
1	240	15.0	29.3	0.2 0.8	45 45	47 64	2.15 1.58	1.86	1.86	439.5	818.93
1	255	15.0	29.5	0.2 0.8	40 35	40 43	2.24 1.83	2.03	2.03	442.5	899.94
1	270	15.0	29.4	0.2 0.8	40 35	44 45	2.04 1.75	1.89	1.89	441.0	834.61
1	285	15.0	28.7	0.2 0.8	40 30	41 40	2.19 1.68	1.94	1.94	430.5	833.27
1	300	15.0	29.3	0.2 0.8	45 35	48 41	2.10 1.92	2.01	2.01	439.5	882.71
1	315	15.0	26.5	0.2 0.8	45 30	45 44	2.24 1.53	1.89	1.89	397.5	750.06
1	330	15.0	26.7	0.2 0.8	50 45	54 59	2.08 1.71	1.89	1.89	400.5	758.75
1	345	15.0	28.8	0.2 0.8	30 25	51 48	1.33 1.18	1.25	1.25	432.0	540.21
1	360	15.0	26.6	0.2 0.8	45 40	46 50	2.19 1.80	1.99	1.99	399.0	795.65
1	375	15.0	25.8	0.2 0.8	50 45	51 58	2.20 1.74	1.97	1.97	387.0	762.25
1	390	17.5	25.6	0.2 0.8	55 40	52 55	2.37 1.63	2.00	2.00	448.0	896.70
1	410	20.0	25.5	0.2 0.8	40 45	41 52	2.19 1.94	2.06	2.06	510.0	1052.54
1	430	20.0	25.0	0.2 0.8	40 35	42 45	2.13 1.75	1.94	1.94	500.0	970.33
1	450	20.0	24.1	0.2 0.8	45 30	45 41	2.24 1.64	1.94	1.94	482.0	936.22
1	470	20.0	25.5	0.2 0.8	40 35	43 41	2.09 1.92	2.00	2.00	510.0	1020.18
1	490	20.0	25.8	0.2 0.8	35 40	41 45	1.92 1.99	1.95	1.95	516.0	1008.48
1	510	22.5	26.4	0.2 0.8	40 35	47 45	1.91 1.75	1.83	1.83	594.0	1085.87
1	535	25.0	32.2	0.2 0.8	40 30	54 43	1.66 1.57	1.62	1.62	805.0	1301.26
1	560	25.0	29.0	0.2 0.8	30 45	44 63	1.53 1.61	1.57	1.57	725.0	1137.85
1	585	27.5	23.0	0.2 0.8	35 25	52 41	1.51 1.37	1.44	1.44	632.5	913.07
1	615	32.5	19.5	0.2 0.8	25 25	45 45	1.25 1.25	1.25	1.25	633.8	793.94
1	650	37.5	17.8	0.2 0.8	25 20	49 43	1.15 1.05	1.10	1.10	667.5	735.50
1	690	45.0	22.0	0.2 0.8	15 15	42 65	0.81 1.04	0.93	0.93	990.0	916.12
0.9	740	50.0	22.5	0.2 0.8	3 5	44 79	0.32 0.30	0.31	0.28	1125.0	312.75
0.98	790	65.0	3.7	0.6	3	103	0.15	0.15	0.14	240.5	34.63
	870	40.0	1.1	S	0	70	0.02	0.02	0.00	44.0	0.00
	870	0.0								0.0	0.00
REW @ 01:50 PM											

Total Discharge: 24635.72 cfs

2) PEAK DISCHARGE DATA

Peak discharge was calculated using the Normal Depth method. The channel geometry applied in the Normal Depth calculation was from Transect 10 surveyed for the *Monitoring Plan with an Adaptive Management Strategy* in July 2016. The friction slope used in the Normal Depth calculation was based on WSEs at gages G26 and G29. The channel roughness values used were calibrated from the measured discharge. Manning's n values used were 0.06 for the left and right overbanks, and 0.036 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



Feet

0 125 250

Date:	10/10/2017	Project:	159587
Drawn:	BTG	File:	2016_CRD_8x11L_Nigliq.mxd
Checked:	GCY	Scale:	1 in = 250 feet

Legend

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

Imagery Source: ConocoPhillips Alaska, 2015

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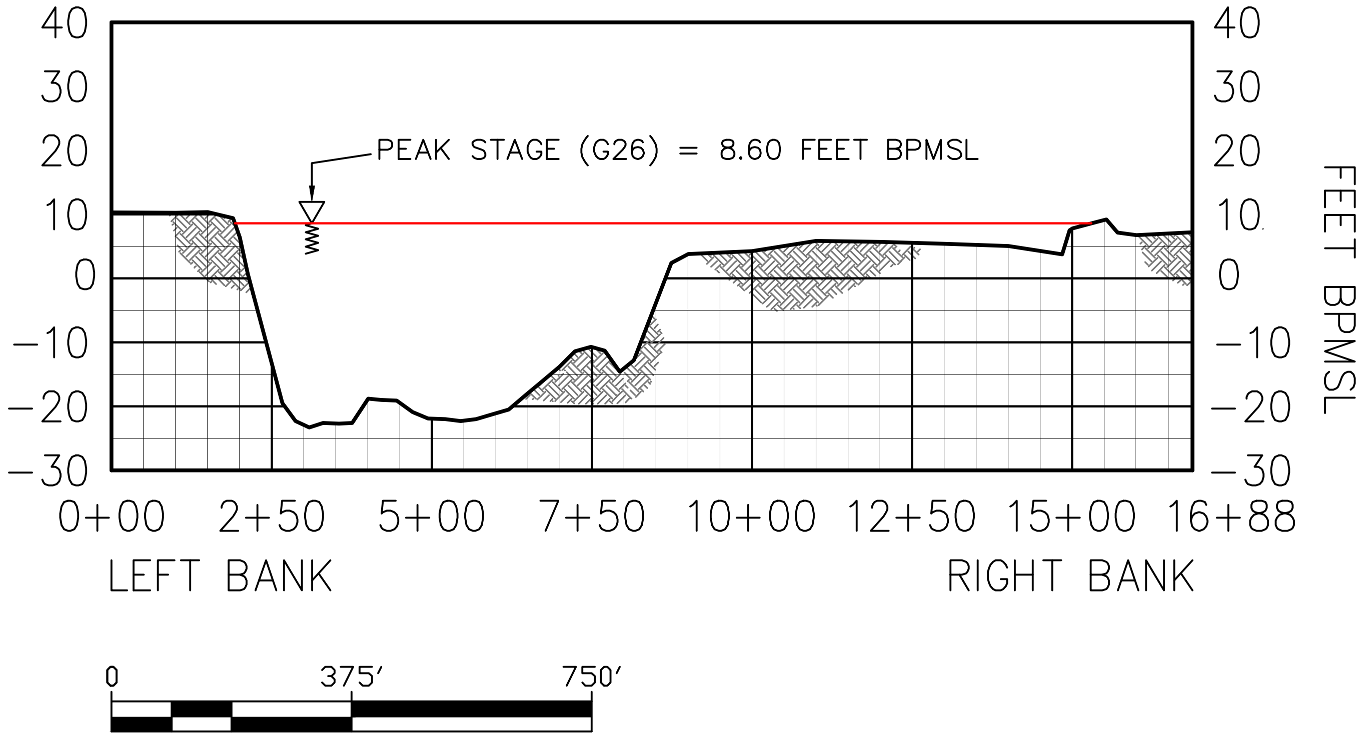
2017 SPRING BREAKUP
NIGLIQ CHANNEL
TRANSECT 10 PLAN

(SHEET 1 of 2)

NOTES

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



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

ConocoPhillips Alaska, Inc.

DATE: 10/10/2017	PROJECT: 159587
DRAWN: DTR	FILE: NIGLIQ X-SECTION.DWG
CHECKED: GCY	SCALE: AS SHOWN

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2017 SPRING BREAKUP
NIGLIQ CHANNEL
TRANSECT 10 PROFILE

(SHEET 2 OF 2)

C.2.4 NIGLIAGVIK BRIDGE

1) MEASURED DISCHARGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: June 1, 2017
Computed By: JPM, MJT
Checked By: JMG

Location Name: Nigliagvik Bridge

Party: MJT, JPM Start: 6/1/2017 11:05 Finish: 6/1/2017 13:45

Temp: 38 °F Weather: Clear - light breeze

Channel Characteristics:

Width: 191.5 ft Area: 963 sq ft Velocity: 1.28 fps Discharge: 1231 cfs

Method: .2 - .8 ; .6; S Number of Sections: 39 Count: N/A

Spin Test: 2.5 minutes after OK seconds Meter: Price AA

GAGE READINGS			
Gage	Start	Finish	Change
G38	6.66	6.61	0.05
G39	6.64	6.59	0.05

Meter: 1 ft above bottom of weight

Weight: 50 lbs

Wading **Cable** Ice Boat

Upstream or Downstream **side of bridge**

GPS Data: W Bridge Abutment

Left Edge of Water: N ° ' " W ° ' "

Right Edge of Water: N ° ' " W ° ' "

E Bridge Abutment

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

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

Descriptions:

Cross Section: Uniform - firm ; No snow or ice

Flow: Falling stage; Variable horizontal angles

Remarks: Channel control - No backwater from snow or ice. Bed and banks clear.

Nigliagvik Bridge
June 1, 2017

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)
	128		0.0				LEW @ 11:05				
0.99	130	2.0	1.8	S	25	46	1.23	1.23	1.21	3.6	4.37
0.99	132	2.5	1.9	S	25	46	1.23	1.23	1.21	4.8	5.76
0.99	135	3.5	2.9	0.6	30	47	1.44	1.44	1.42	10.2	14.44
1	139	4.0	3.3	0.6	30	51	1.33	1.33	1.33	13.2	17.50
1	143	3.5	4.8	0.2 0.8	30 25	42 41	1.61 1.37	1.49	1.49	16.8	25.02
1	146	3.0	5.0	0.2 0.8	30 25	41 40	1.64 1.41	1.53	1.53	15.0	22.89
1	149	3.0	5.1	0.2 0.8	30 25	44 44	1.53 1.28	1.41	1.41	15.3	21.53
1	152	3.5	5.4	0.2 0.8	30 25	40 40	1.68 1.41	1.55	1.55	18.9	29.22
0.99	156	4.0	5.5	0.2 0.8	40 30	53 45	1.70 1.50	1.60	1.58	22.0	34.79
1	160	4.0	5.6	0.2 0.8	30 30	40 44	1.68 1.53	1.61	1.61	22.4	36.04
1	164	4.0	5.5	0.2 0.8	30 30	41 42	1.64 1.61	1.62	1.62	22.0	35.75
1	168	4.0	5.8	0.2 0.8	30 30	40 44	1.68 1.53	1.61	1.61	23.2	37.33
1	172	4.0	6.2	0.2 0.8	30 30	43 46	1.57 1.47	1.52	1.52	24.8	37.65
1	176	4.0	6.3	0.2 0.8	25 25	41 42	1.37 1.34	1.36	1.36	25.2	34.20
1	180	4.0	5.9	0.2 0.8	30 25	45 43	1.50 1.31	1.40	1.40	23.6	33.16
0.99	184	4.0	6.3	0.2 0.8	30 25	42 40	1.61 1.41	1.51	1.49	25.2	37.58
0.99	188	4.0	6.3	0.2 0.8	30 25	43 40	1.57 1.41	1.49	1.47	25.2	37.12
1	192	4.0	6.0	0.2 0.8	30 30	43 48	1.57 1.41	1.49	1.49	24.0	35.71
1	196	4.0	6.0	0.2 0.8	30 25	43 41	1.57 1.37	1.47	1.47	24.0	35.30
1	200	4.0	6.1	0.2 0.8	30 30	45 47	1.50 1.44	1.47	1.47	24.4	35.82
0.99	204	4.0	6.8	0.2 0.8	30 25	46 43	1.47 1.31	1.39	1.37	27.2	37.40
0.99	208	4.0	7.5	0.2 0.8	30 25	47 49	1.44 1.15	1.29	1.28	30.0	38.44
0.99	212	4.0	7.4	0.2 0.8	30 25	47 47	1.44 1.20	1.32	1.31	29.6	38.64
0.99	216	4.0	7.3	0.2 0.8	30 25	46 49	1.47 1.15	1.31	1.30	29.2	37.86
1	220	4.0	7.2	0.2 0.8	30 25	47 47	1.44 1.20	1.32	1.32	28.8	37.97
1	224	4.0	6.6	0.2 0.8	30 25	47 51	1.44 1.11	1.27	1.27	26.4	33.58
1	228	4.5	5.8	0.2 0.8	30 25	49 48	1.38 1.18	1.28	1.28	26.1	33.33
1	233	5.0	5.5	0.2 0.8	25 25	43 48	1.31 1.18	1.24	1.24	27.5	34.18
1	238	5.5	5.5	0.2 0.8	25 25	45 51	1.25 1.11	1.18	1.18	30.3	35.70
1	244	6.0	5.7	0.2 0.8	25 20	47 48	1.20 0.94	1.07	1.07	34.2	36.67
0.99	250	7.0	5.6	0.2 0.8	25 25	46 48	1.23 1.18	1.20	1.19	39.2	46.60
0.99	258	9.0	5.1	0.2 0.8	30 25	49 49	1.38 1.15	1.27	1.25	45.9	57.50
0.99	268	11.0	4.8	0.2 0.8	25 20	42 42	1.34 1.08	1.21	1.20	52.8	63.18
1	280	13.5	4.1	0.6	25	51	1.11	1.11	1.11	55.4	61.30
0.99	295	15.0	3.7	0.6	20	48	0.94	0.94	0.93	55.5	51.87
0.85	310	18.0	2.3	S	7	71	0.45	0.45	0.39	41.4	15.98
	331						REW @ 1:43pm				
										Total Discharge:	1231.38 cfs

2) PEAK DISCHARGE DATA

Peak discharge was calculated using the Normal Depth method. The approach section channel geometry was from Transect 28 surveyed for the *Monitoring Plan with an Adaptive Management Strategy* in July 2016 (LCMF 2016b). The bridge section channel geometry was from the direct discharge measurement on May 26. WSEs at Transect 28 were from gage G38 and WSEs at the bridge section were interpolated between gages G38 and G39. The channel roughness was calibrated from the measured discharge. Manning's n values used were 0.045 for the left and right overbanks, and 0.036 for the main channel. Main channel roughness is relatively high to account for minor obstructions from the bridge piers.

3) PLAN & PROFILE

ConocoPhillips Alaska

Feet
0 125 250

Date: 10/10/2017	Project: 159587
Drawn: BTG	File: 2017_CRD_8x11L_Nigliagvik.mxd
Checked: GCY	Scale: 1 in = 250 feet

Legend

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

Imagery Source: ConocoPhillips Alaska, 2015

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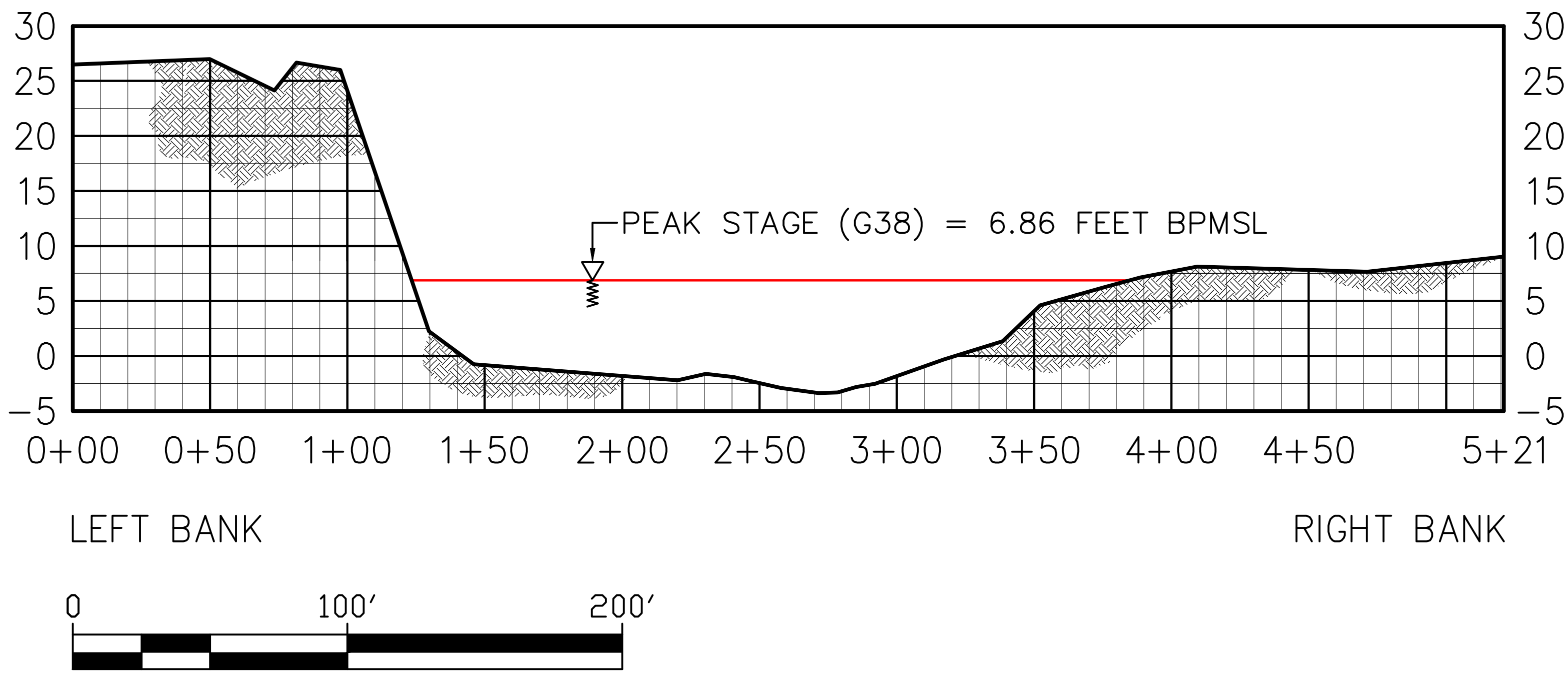
2017 SPRING BREAKUP
NIGLIAGVIK CHANNEL
TRANSECT 27 PLAN

(SHEET 1 of 2)

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



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

ConocoPhillips Alaska, Inc.

DATE:	10/10/2017	PROJECT:	159587
DRAWN:	DTR	FILE:	NIGLIAGVIK X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2017 SPRING BREAKUP
NIGLIAGVIK CHANNEL
TRANSECT 27 PROFILE

(SHEET 2 OF 2)

C.2.5 LONG SWALE BRIDGE

1) MEASURED DISCHARGE

Michael Baker INTERNATIONAL

Discharge Measurement Notes

Date: June 1, 2017
Computed By: BTG
Checked By: GCY

Location Name: Long Swale Bridge

Party: MJT, DR, JPM   Start: 6/1/2017 15:45   Finish: 6/1/2017 17:42

Temp: 38 °F   Weather: Clear, light breeze

Channel Characteristics:

Width: 445 ft   Area: 1505 sq ft   Velocity: 0.86 fps   Discharge: 1290 cfs

Method: 0.6   Number of Sections: 27   Count: N/A

Spin Test: 2.5 minutes after OK seconds   Meter: Price AA

Meter: 1 ft above bottom of weight

Weight: 50 lbs

Wading **Cable** Ice Boat

Upstream or Downstream **side of bridge**

GAGE READINGS			
Gage	Start	Finish	Change
G3	5.91	5.89	-0.02
G4	5.87	5.86	-0.01

GPS Data: W Bridge Abutment

Left Edge of Water: N ° ' " W ° ' "

Right Edge of Water: N ° ' " W ° ' "

E Bridge Abutment

LE Floodplain: ° ' . "

RE Floodplain: ° ' . "

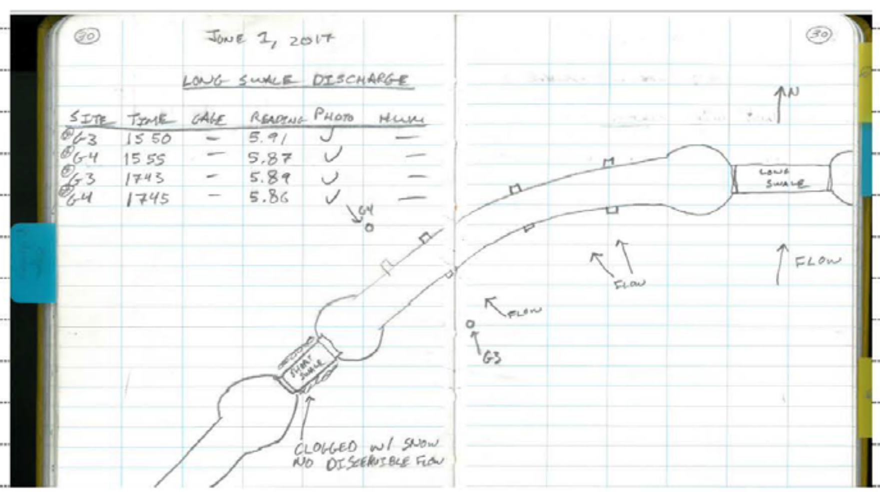
Measurement Rated: Excellent Good **Fair** Poor based on "Descriptions"

Descriptions:

Cross Section: Firm, Uniform, Clear of ice and snow

Flow: Falling stage - Variable horizontal angles

Remarks: Control is lake immediately downstream of bridge. Lake is less than half covered with ice floes. Some back water effect.



Long Swale Bridge
June 1, 2017

Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
LEW @ 15:45											
	1		0.0								
0.75	2	5.0	2.8	0.6	40	51	1.76	1.76	1.32	14.0	18.49
0.87	10	14.0	2.3	0.6	40	50	1.80	1.80	1.56	32.2	50.31
0.92	30	20.0	2.7	0.6	40	62	1.45	1.45	1.34	54.0	72.13
0.94	50	20.0	2.2	0.6	30	56	1.21	1.21	1.14	44.0	49.99
0.99	70	20.0	2.5	0.6	30	65	1.04	1.04	1.03	50.0	51.67
1	90	20.0	2.9	0.6	30	72	0.94	0.94	0.94	58.0	54.76
1	110	20.0	2.3	0.6	20	58	0.78	0.78	0.78	46.0	36.08
1	130	20.0	2.3	0.6	15	59	1.14	1.14	1.14	46.0	52.57
0.94	150	20.0	3.1	0.6	5	51	0.45	0.45	0.42	62.0	26.33
0.7	170	20.0	2.7	0.6	10	55	0.82	0.82	0.58	54.0	31.09
0.75	190	20.0	2.7	0.6	15	49	0.70	0.70	0.52	54.0	28.29
0.85	210	20.0	3.5	0.6	20	58	0.78	0.78	0.67	70.0	46.67
0.92	230	19.0	4.0	0.6	20	52	0.87	0.87	0.80	76.0	61.03
0.94	248	18.0	5.7	0.6	20	60	0.76	0.76	0.71	102.6	73.19
0.96	266	16.0	6.1	0.6	20	52	0.87	0.87	0.84	97.6	81.78
0.97	280	14.5	5.8	0.6	20	59	0.77	0.77	0.75	84.1	62.93
0.96	295	15.0	4.9	0.6	30	60	1.13	1.13	1.08	73.5	79.68
0.92	310	15.0	4.0	0.6	40	72	1.25	1.25	1.15	60.0	69.15
0.7	325	17.5	3.0	0.6	20	53	0.86	0.86	0.60	52.5	31.49
0.7	345	20.0	2.8	0.6	30	58	1.17	1.17	0.82	56.0	45.77
0.86	365	20.0	4.3	0.6	30	54	1.25	1.25	1.08	86.0	92.65
0.85	385	20.0	3.2	0.6	30	64	1.06	1.06	0.90	64.0	57.66
0.7	405	20.0	3.9	0.6	30	68	1.00	1.00	0.70	78.0	54.52
0.85	425	20.0	2.8	0.6	20	56	0.81	0.81	0.69	56.0	38.64
0.99	445	11.0	3.1	0.6	15	51	0.67	0.67	0.67	34.1	22.68
	447		2.0								
REW @ 17:42											

Total Discharge: **1289.57** cfs

C.2.6 CULVERTS

1) MEASURED DISCHARGE

Date	Time	Culvert ID	Flow Conditions[1]	Flow Direction	Total Depth (ft)[2]	Measured Depth (ft)[3]	v1 (ft/s)[3]	v2 (ft/s)[3]	v3 (ft/s)[3]	Upstream Gage	Upstream WSE (ft BPMSL)	Downstream Gage	Downstream WSE (ft BPMSL)	Notes
6/1/2017	16:00	CD2-01	Dry	-		0.00				G6	-	G7	-	
6/1/2017	16:00	CD2-02	Dry	-		0.00				G6	-	G7	-	
6/1/2017	16:00	CD2-03	Dry	-		0.00				G6	-	G7	-	
6/1/2017	16:00	CD2-04	Dry	-		0.00				G6	-	G7	-	
6/1/2017	16:00	CD2-05	Dry	-		0.00				G6	-	G7	-	
6/1/2017	16:00	CD2-06	Dry	-		0.00				G6	-	G7	-	
6/1/2017	16:00	CD2-07	Dry	-		0.00				G6	-	G7	-	
6/1/2017	16:00	CD2-08	Dry	-		0.00				G6	-	G7	-	
6/1/2017	16:00	CD2-09	Dry	-		0.00				G12	-	G13	-	
6/1/2017	16:00	CD2-10	Dry	-		0.00				G12	-	G13	-	
6/1/2017	16:00	CD2-11	Dry	-		0.00				G12	-	G13	-	
6/1/2017	16:00	CD2-12	Dry	-		0.00				G12	-	G13	-	
6/1/2017	16:00	CD2-13	Dry	-		0.00				G12	-	G13	-	
6/1/2017	16:00	CD2-14	Dry	-		0.00				G12	-	G13	-	
6/1/2017	16:00	CD2-15	Dry	-		0.00				G12	-	G13	-	
6/1/2017	16:00	CD2-16	Dry	-		0.00				G12	-	G13	-	
6/1/2017	16:00	CD2-17	Dry	-		0.00				G12	-	G13	-	
6/1/2017	16:00	CD2-18	Dry	-		0.00				G12	-	G13	-	
6/1/2017	16:00	CD2-19	Dry	-		0.00				G3	5.91	G4	5.87	
6/1/2017	16:00	CD2-20	Dry	-		0.00				G3	5.91	G4	5.87	
6/1/2017	16:00	CD2-21	Dry	-		0.00				G3	5.91	G4	5.87	
6/1/2017	17:00	CD2-22	Type 3	South to North	0.60	0.24	1.97	2.05	2.05	G3	5.91	G4	5.87	
6/1/2017	16:50	CD2-23	Type 3	South to North	1.30	0.52	2.43	2.45	2.44	G3	5.91	G4	5.87	
6/1/2017	16:40	CD2-24	Type 3	South to North	1.50	0.60	1.41	1.37	1.35	G3	5.91	G4	5.87	
6/1/2017	16:00	CD2-25	Dry	-		0.00				G3	5.91	G4	5.87	
6/1/2017	16:00	CD2-25	Dry	-		0.00				G3	5.91	G4	5.87	
6/1/2017	16:00	CD2-26	Dry	-		0.00				G3	5.91	G4	5.87	
6/2/2017	17:00	CD4-01	Dry	-		0.00				G3	-	-	-	
6/2/2017	17:00	CD4-02	Dry	-		0.00				G3	-	-	-	
6/2/2017	17:00	CD4-03	Equalized	-		0.00				G3	-	-	-	Ponded west side, 50% full east side, no flow
6/2/2017	17:00	CD4-04	Equalized	-		0.00				G3	-	-	-	Dry west side, 90% full east side
6/2/2017	17:00	CD4-05	Ponded	-		0.00				G3	-	-	-	Ponded west side, dry east side
6/2/2017	17:00	CD4-06	Ponded	-		0.00				G3	-	-	-	Perched east side, ponded west side
6/2/2017	17:00	CD4-07	Dry	-		0.00				G3	-	-	-	
6/2/2017	17:00	CD4-08	Dry	-		0.00				G42	-	G43	-	
6/2/2017	17:00	CD4-09	Dry	-		0.00				G42	-	G43	-	
6/2/2017	17:00	CD4-10	Ponded	-		0.00				G42	-	G43	-	Ponded east side, dry west side

Date	Time	Culvert ID	Flow Conditions[1]	Flow Direction	Total Depth (ft)[2]	Measured Depth (ft)[3]	v1 (ft/s)[3]	v2 (ft/s)[3]	v3 (ft/s)[3]	Upstream Gage	Upstream WSE (ft BPMSL)	Downstream Gage	Downstream WSE (ft BPMSL)	Notes
6/2/2017	17:00	CD4-11	Ponded	-		0.00				G40	-	G41	-	Ponded east side, dry west side
6/2/2017	17:00	CD4-12	Ponded	-		0.00				G40	-	G41	-	Ponded east side, dry west side
6/2/2017	17:00	CD4-13	Ponded	-		0.00				G40	-	G41	-	Ponded east side, dry west side
6/2/2017	17:00	CD4-14	Dry	-		0.00				G40	-	G41	-	
6/2/2017	17:00	CD4-15	Perched	-		0.00				G40	-	G41	-	Dry
6/2/2017	17:00	CD4-16	Perched	-		0.00				G40	-	G41	-	Dry
6/2/2017	17:00	CD4-17	Perched	-		0.00				G40	-	G41	-	Dry
6/2/2017	17:00	CD4-18	Dry	-		0.00				G40	-	G41	-	
6/2/2017	17:00	CD4-19	Ponded	-		0.00				G16	-	G15	-	Ponded west side, dry on east side
6/2/2017	17:00	CD4-20A	Equalized	-		0.00				G16	-	G15	-	Submerged both sides, no flow
6/2/2017	17:00	CD4-20B	Equalized	-		0.00				G16	-	G15	-	Submerged west side, 75% full east side, no flow
6/2/2017	17:00	CD4-21	Equalized	-		0.00				G16	-	G15	-	Submerged west side, 90% full east side, no flow
6/2/2017	17:00	CD4-22	Equalized	-		0.00				G16	-	G15	-	90% full west side, submerged east side, no flow
6/2/2017	17:00	CD4-23	Equalized	-		0.00				G16	-	G15	-	40% full west side, 30% full east side, no flow
6/2/2017	17:00	CD4-23A	Equalized	-		0.00				G16	-	G15	-	50% full west side, 30% full east side, no flow
6/2/2017	17:00	CD4-23B	Equalized	-		0.00				G16	-	G15	-	50% full west side, 30% full east side, no flow
6/2/2017	17:00	CD4-23C	Equalized	-		0.00				G16	-	G15	-	50% full west side, 60% full east side, no flow
6/2/2017	17:00	CD4-23D	Equalized	-		0.00				G16	-	G15	-	50% full both sides, no flow
6/2/2017	16:12	CD4-24	Type 3	West to East	0.50	0.20	0.48	0.49	0.47	G18	Dry	G17	Dry	
6/2/2017	17:00	CD4-25	Dry	-		0.00				G18	Dry	G17	Dry	
6/2/2017	17:00	CD4-26	Dry	-		0.00				G18	Dry	G17	Dry	
6/2/2017	17:00	CD4-27	Dry	-		0.00				G18	Dry	G17	Dry	
6/2/2017	17:00	CD4-28	Dry	-		0.00				G18	Dry	G17	Dry	
6/2/2017	17:00	CD4-29	Dry	-		0.00				G18	Dry	G17	Dry	
6/2/2017	17:00	CD4-30	Dry	-		0.00				G18	Dry	G17	Dry	
6/2/2017	17:00	CD4-31	Dry	-		0.00				G18	Dry	G17	Dry	
6/2/2017	17:00	CD4-32	Dry	-		0.00				G18	Dry	G17	Dry	
6/2/2017	17:00	CD4-33	Ponded	-		0.00				G18	Dry	G17	Dry	Ponded west side, dry east side
6/3/2017	17:00	CD5-01	Perched	-		0.00				-	-	-	-	Dry north side, perched south side
6/3/2017	17:00	CD5-02	Ponded	-		0.00				-	-	-	-	No flow
6/3/2017	17:07	CD5-03	Type 3	North to South	1.80	0.72	1.32	1.29	1.27	-	-	-	-	
6/3/2017	16:57	CD5-04	Type 3	North to South	0.85	0.34	2.14	2.10	2.17	-	-	-	-	
6/3/2017	17:13	CD5-05	Ponded	-	0.80	0.32	0.00	0.00	0.00	-	-	-	-	
6/3/2017	17:00	CD5-06	Ponded	-		0.00				S1	19.35	S1D	19.33	
6/3/2017	17:00	CD5-07	Dry	-		0.00				S1	19.35	S1D	19.33	
6/3/2017	17:20	CD5-08	Type 3	South to North	1.30	0.52	0.04	0.02	0.00	S1	19.35	S1D	19.33	
6/3/2017	17:25	CD5-09	Type 3	South to North	1.40	0.56	0.30	0.33	0.34	S1	19.35	S1D	19.33	
6/3/2017	17:00	CD5-10	Dry	-		0.00				S1	19.35	S1D	19.33	
6/3/2017	17:00	CD5-11	Dry	-		0.00				S1	19.35	S1D	19.33	

Date	Time	Culvert ID	Flow Conditions[1]	Flow Direction	Total Depth (ft)[2]	Measured Depth (ft)[3]	v1 (ft/s)[3]	v2 (ft/s)[3]	v3 (ft/s)[3]	Upstream Gage	Upstream WSE (ft BPMSL)	Downstream Gage	Downstream WSE (ft BPMSL)	Notes
6/3/2017	17:00	CD5-12	Dry	-		0.00				S1	19.35	S1D	19.33	
6/3/2017	17:00	CD5-13	Ponded	-		0.00				S1	19.35	S1D	19.33	No flow
6/3/2017	17:00	CD5-14	Ponded	-		0.00				S1	19.35	S1D	19.33	No flow
6/3/2017	17:00	CD5-15	Ponded	-		0.00				S1	19.35	S1D	19.33	No flow
6/3/2017	17:00	CD5-16	Ponded	-		0.00				S1	19.35	S1D	19.33	No flow
6/3/2017	17:00	CD5-17	Dry	-		0.00				S1	19.35	S1D	19.33	
6/3/2017	17:00	CD5-18	Ponded	-		0.00				S1	19.35	S1D	19.33	No flow
6/3/2017	17:00	CD5-19	Dry	-		0.00				S1	19.35	S1D	19.33	
6/3/2017	17:00	CD5-20	Dry	-		0.00				S1	19.35	S1D	19.33	
6/3/2017	17:00	CD5-21	Submerged	-		0.00				S1	19.35	S1D	19.33	Submerged both sides, no flow
6/3/2017	17:00	CD5-22	Submerged	-		0.00				S1	19.35	S1D	19.33	Submerged both sides, no flow
6/3/2017	17:00	CD5-23	Equalized	-		0.00				S1	19.35	S1D	19.33	75% full north side, dry south side
6/3/2017	17:00	CD5-24	Equalized	-		0.00				S1	19.35	S1D	19.33	60% full both sides, no flow
6/3/2017	17:00	CD5-25	Equalized	-		0.00				S1	19.35	S1D	19.33	25% full both sides, no flow
6/3/2017	17:00	CD5-26	Equalized	-		0.00				G38	-	G39	-	10% full both sides, no flow
6/3/2017	17:00	CD5-27	Equalized	-		0.00				G36	-	G37	-	90% full both sides, no flow
6/3/2017	17:00	CD5-28	Equalized	-		0.00				G36	-	G37	-	50% full both sides, no flow
6/3/2017	17:00	CD5-29	Equalized	-		0.00				G36	-	G37	-	40% full both sides, no flow
6/3/2017	17:00	CD5-30	Submerged	-		0.00				G36	-	G37	-	Submerged both sides, no flow
6/3/2017	17:00	CD5-31	Equalized	-		0.00				G36	-	G37	-	75% full north side, 95% full south side, no flow
6/3/2017	17:00	CD5-32	Submerged	-		0.00				G34	-	G35	-	Submerged north side, 60% full south side, no flow
6/3/2017	17:00	CD5-33	Submerged	-		0.00				G34	-	G35	-	Submerged north side, 30% full south side, no flow
6/3/2017	17:00	CD5-34	Equalized	-		0.00				G34	-	G35	-	50% full both sides, no flow
6/3/2017	17:00	CD5-35	Equalized	-		0.00				G34	-	G35	-	10% full north side, dry south side
6/3/2017	17:00	CD5-36	Ponded	-		0.00				G34	-	G35	-	5% full both sides, no flow
6/3/2017	17:00	CD5-37	Equalized	-		0.00				G32	-	G33	-	10% full north side, 30% full south side
6/3/2017	17:00	CD5-38	Equalized	-		0.00				G32	-	G33	-	20% full north side, 10% full south side
6/3/2017	17:00	CD5-39	Ponded	-		0.00				G32	-	G33	-	No flow
6/3/2017	17:55	CD5-40	Type 3	South to North	1.80	0.72	0.14	0.16	0.17	G30	8.69	G31	8.59	
6/3/2017	17:00	CD5-41	Ponded	-		0.00				G30	8.69	G31	8.59	25% full north side, 25% full of snow/ice south side
6/3/2017	17:00	CD5-42	Ponded	-		0.00				G30	8.69	G31	8.59	50% full south side, 25% full of snow/ice north side
6/3/2017	17:00	CD5-43	Equalized	-		0.00				G24	-	G25	-	10% full north side, 5% full south side, no flow

2) PEAK DISCHARGE

Culvert Calculator Report
CD2-22

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	6.03 ft	Headwater Depth/Height	0.23
Computed Headwater Eleva	6.03 ft	Discharge	2.47 cfs
Inlet Control HW Elev.	5.94 ft	Tailwater Elevation	5.94 ft
Outlet Control HW Elev.	6.03 ft	Control Type	Outlet Control

Grades

Upstream Invert	5.14 ft	Downstream Invert	5.19 ft
Length	72.80 ft	Constructed Slope	-0.000797 ft/ft

Hydraulic Profile

Profile	A2	Depth, Downstream	0.74 ft
Slope Type	Adverse	Normal Depth	0.00 ft
Flow Regime	Subcritical	Critical Depth	0.46 ft
Velocity Downstream	1.57 ft/s	Critical Slope	0.004057 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	3.84 ft
Section Size	48 OD 0.080' WT	Rise	3.84 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	6.03 ft	Upstream Velocity Head	0.03 ft
Ke	0.90	Entrance Loss	0.02 ft

Inlet Control Properties

Inlet Control HW Elev.	5.94 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	11.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Title: 2017 CRD Spring Breakup
...\culvert master files\2017 crd culverts.cvm
10/05/17 10:50:00 AM© Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666
Anchorage Office
Project Engineer: J Gillenwater
CulvertMaster v3.3 [03.03.00.04]
Page 1 of 1

Culvert Calculator Report
CD2-23

Solve For: Discharge

Culvert Summary					
Allowable HW Elevation	6.03	ft	Headwater Depth/Height	0.45	
Computed Headwater Elev:	6.03	ft	Discharge	6.81	cfs
Inlet Control HW Elev.	5.94	ft	Tailwater Elevation	5.94	ft
Outlet Control HW Elev.	6.03	ft	Control Type	Outlet Control	

Grades					
Upstream Invert	4.31	ft	Downstream Invert	4.51	ft
Length	72.80	ft	Constructed Slope	-0.002843	ft/ft

Hydraulic Profile					
Profile	A2		Depth, Downstream	1.42	ft
Slope Type	Adverse		Normal Depth	0.00	ft
Flow Regime	Subcritical		Critical Depth	0.77	ft
Velocity Downstream	1.75	ft/s	Critical Slope	0.003691	ft/ft

Section					
Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Steel		Span	3.84	ft
Section Size	48 OD 0.080' WT		Rise	3.84	ft
Number Sections	1				

Outlet Control Properties					
Outlet Control HW Elev.	6.03	ft	Upstream Velocity Head	0.03	ft
Ke	0.90		Entrance Loss	0.03	ft

Inlet Control Properties					
Inlet Control HW Elev.	5.94	ft	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	11.6	ft²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

Title: 2017 CRD Spring Breakup
...\culvert master files\2017 crd culverts.cvm
10/05/17 10:52:05 AM© Bentley Systems, Inc. Haestad Methods Solution Center Watertown, CT 06795 USA +1-203-755-1666

Project Engineer: J Gillenwater
Anchorage Office
CulvertMaster v3.3 [03.03.00.04]
Page 1 of 1

Culvert Calculator Report
CD2-24

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	6.03 ft	Headwater Depth/Height	0.49
Computed Headwater Eleva	6.03 ft	Discharge	8.22 cfs
Inlet Control HW Elev.	5.94 ft	Tailwater Elevation	5.94 ft
Outlet Control HW Elev.	6.03 ft	Control Type	Outlet Control

Grades

Upstream Invert	4.14 ft	Downstream Invert	4.26 ft
Length	76.00 ft	Constructed Slope	-0.001566 ft/ft

Hydraulic Profile

Profile	A2	Depth, Downstream	1.68 ft
Slope Type	Adverse	Normal Depth	0.00 ft
Flow Regime	Subcritical	Critical Depth	0.84 ft
Velocity Downstream	1.69 ft/s	Critical Slope	0.003648 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	3.84 ft
Section Size	48 OD 0.080' WT	Rise	3.84 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	6.03 ft	Upstream Velocity Head	0.04 ft
Ke	0.90	Entrance Loss	0.03 ft

Inlet Control Properties

Inlet Control HW Elev.	5.94 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	11.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1
Y	0.54000		

Title: 2017 CRD Spring Breakup
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Project Engineer: J Gillenwater
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Page 1 of 1

APPENDIX D ADDITIONAL PHOTOGRAPHS

D.1 EROSION SURVEY

D.1.1 CD2 ROAD & PAD

Photo D.1: North side of CD2 road east of Short Swale Bridge, looking west; June 6, 2017

Photo D.2: South side of CD2 road east of Short Swale Bridge, looking east; June 6, 2017

Photo D.3: South side of CD2 road, looking south; June 6, 2017

Photo D.4: South side of CD2 road west of the Short Swale Bridge, looking northeast; June 6, 2017

Photo D.5: North side of CD2 road east of the Short Swale Bridge, looking southwest; June 6, 2017

Photo D.6: North side of CD2 road west of the Long Swale Bridge, looking east; June 6, 2017

Photo D.7: North side of CD2 road east of Long Swale Bridge, looking west; June 7, 2017

Photo D.8: South side of CD2 road west of the Long Swale Bridge, looking east; June 6, 2017

D.1.2 CD4 ROAD & PAD

Photo D.9: South side of CD4 road east of CD4 pad, looking west; June 5, 2017

Photo D.10: North side of CD4 road east of CD4 pad, looking west; June 5, 2017

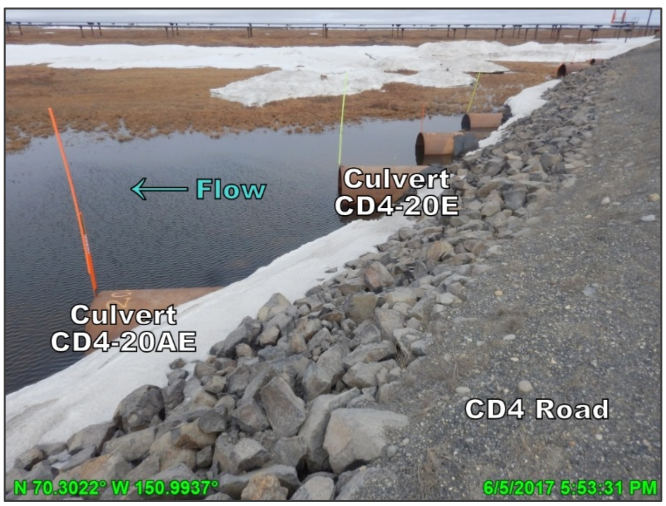


Photo D.11: East side of CD4 road south of CD5 road, looking southeast; June 5, 2017

Photo D.12: West side of CD4 road south of CD5 road, looking north; June 5, 2017

D.1.3 CD5 ROAD

Photo D.13: West side of CD5 road south of CD5 pad, looking south; June 7, 2017

Photo D.14: East side of CD5 road south of CD5 pad near the GMT1 Road, looking south; June7, 2017

D.2 ICE ROAD CROSSINGS BREAKUP

Photo D.15: Colville River East Channel at HDD pre-breakup, looking north (downstream); May 22, 2017

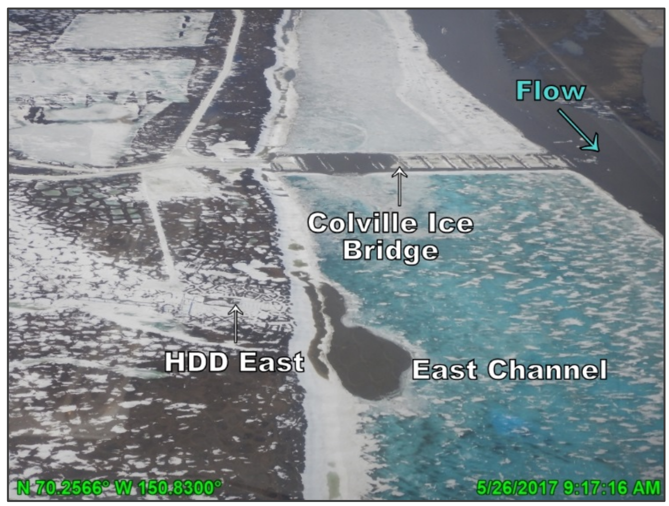


Photo D.16: Colville River East Channel at HDD during breakup, looking southeast (upstream); May 26, 2017

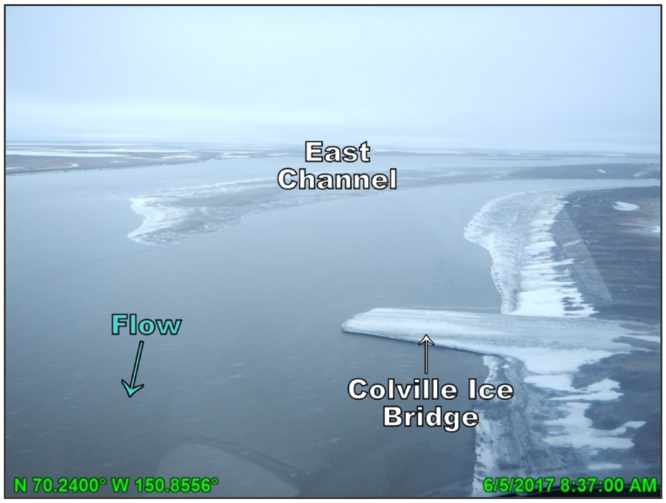


Photo D.17: Colville River East Channel at HDD post-breakup, looking southwest (upstream); June 5, 2017

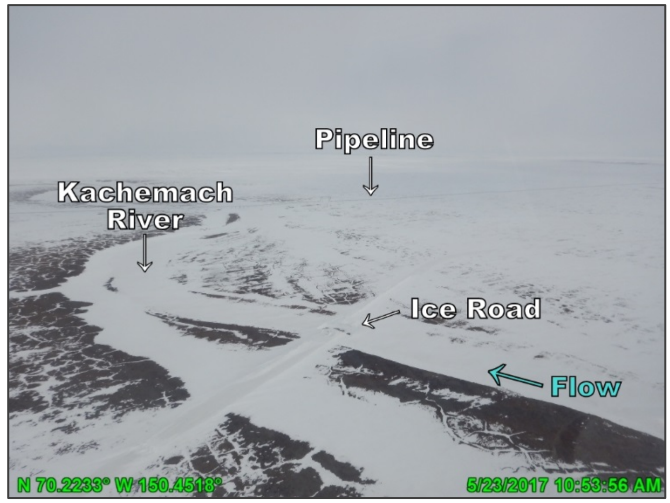


Photo D.18: Kachemach River pre-breakup, looking northeast; May 23, 2017

Photo D.19: Kachemach River during breakup, looking northeast; May 31, 2017

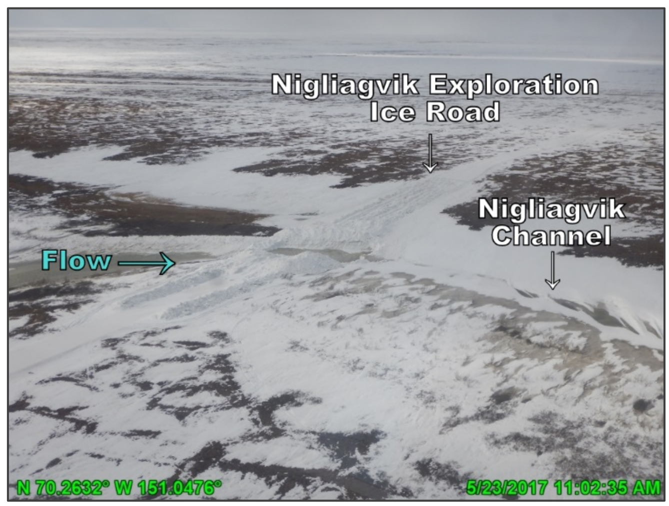


Photo D.20: Nigliagvik Exploration pre-breakup, looking southeast; May 23, 2017

Photo D.21: Nigliagvik Exploration during breakup, looking southeast; May 31, 2017

Photo D.22: Nigliagvik Bridge pre-breakup, looking northeast; May 23, 2017

Photo D.23: Nigliagvik Bridge during breakup, looking east; June 1, 2017

Photo D.24: Nigliagvik Bridge post-breakup, looking southwest; June 7, 2017

Photo D.25: Nigliq Exploration pre-breakup, looking southwest (upstream); May 23, 2017

Photo D.26: Nigliq Exploration during breakup, looking west; May 30, 2017

Photo D.27: Nigliq Exploration post-breakup, looking northeast (downstream); June 4, 2017

Photo D.28: Nigliq Bridge pre-breakup, looking north (downstream); May 22, 2017

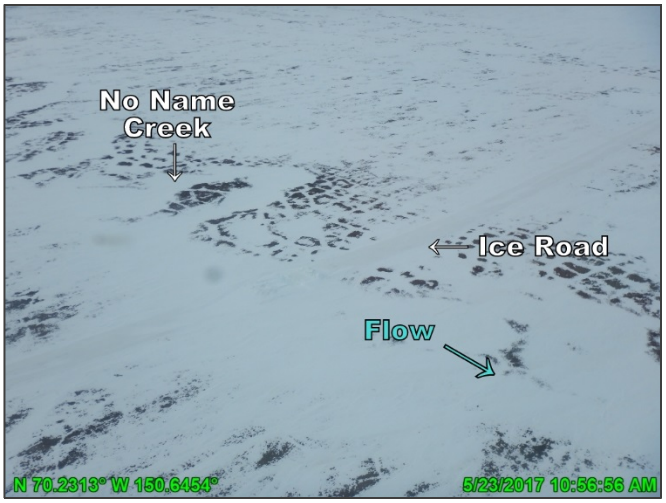


Photo D.29: No Name Creek pre-breakup, looking southwest; May 23, 2017

Photo D.30: No Name Creek during breakup, looking northeast; May 31, 2017

Photo D.31: Pineapple Gulch pre-breakup, looking northeast (downstream); May 23, 2017

Photo D.32: Pineapple Gulch during breakup, looking northeast (downstream); May 30, 2017

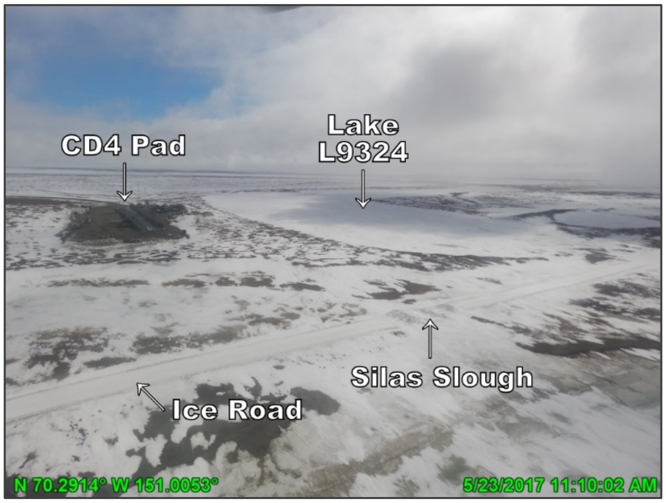


Photo D.33: Silas Slough pre-breakup, looking southeast; May 23, 2017

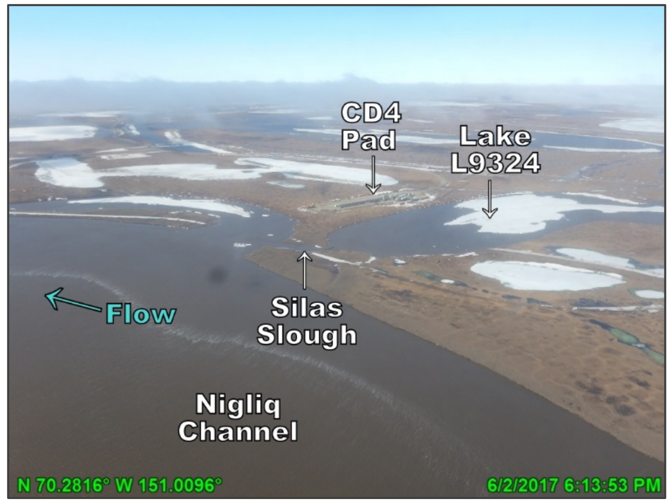


Photo D.34: Silas Slough post-breakup, looking northeast; June 2, 2017

Photo D.35: Slemp Slough pre-breakup, looking northeast; May 23, 2017

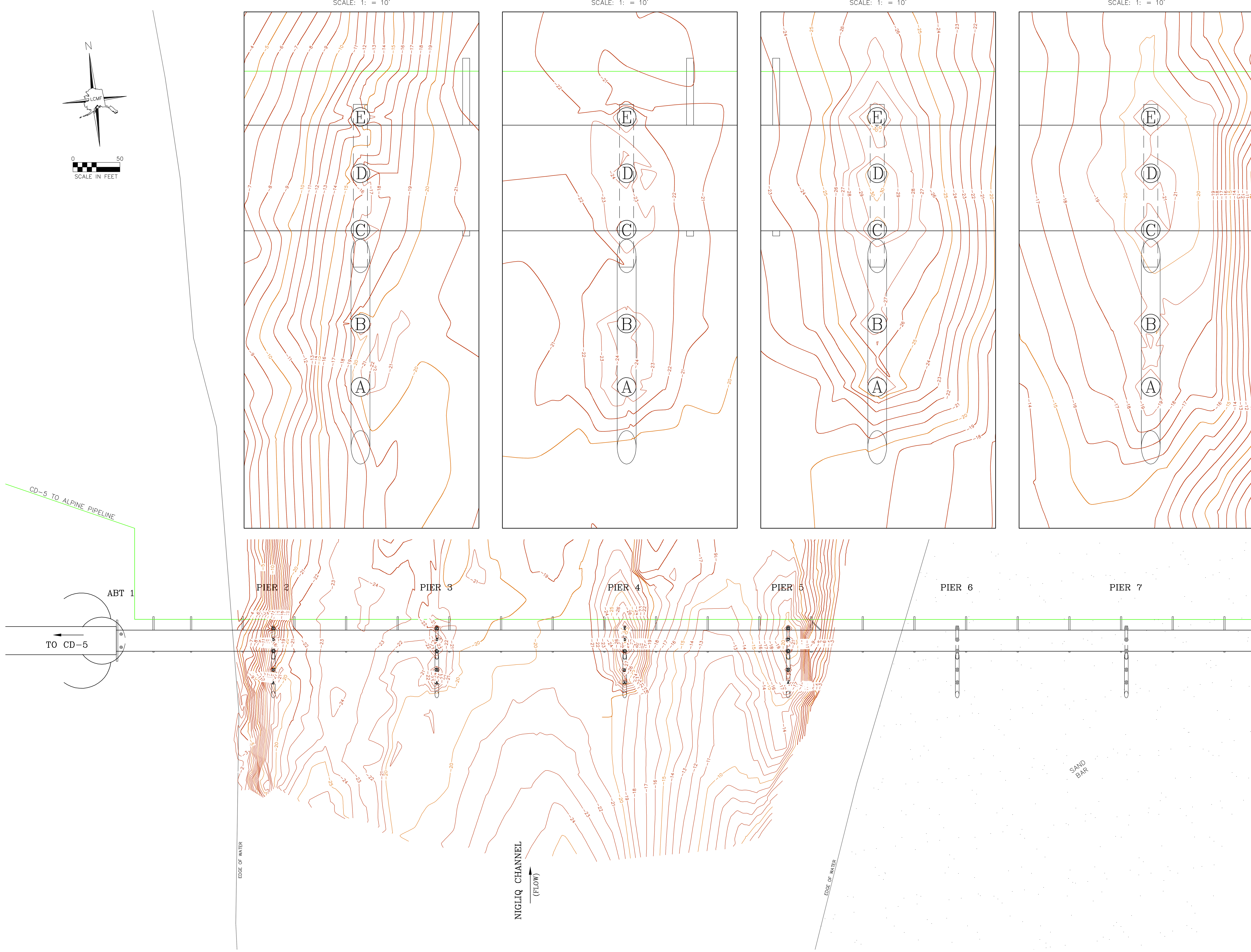
Photo D.36: Tamayayak Channel pre-breakup, looking northeast; May 23, 2017

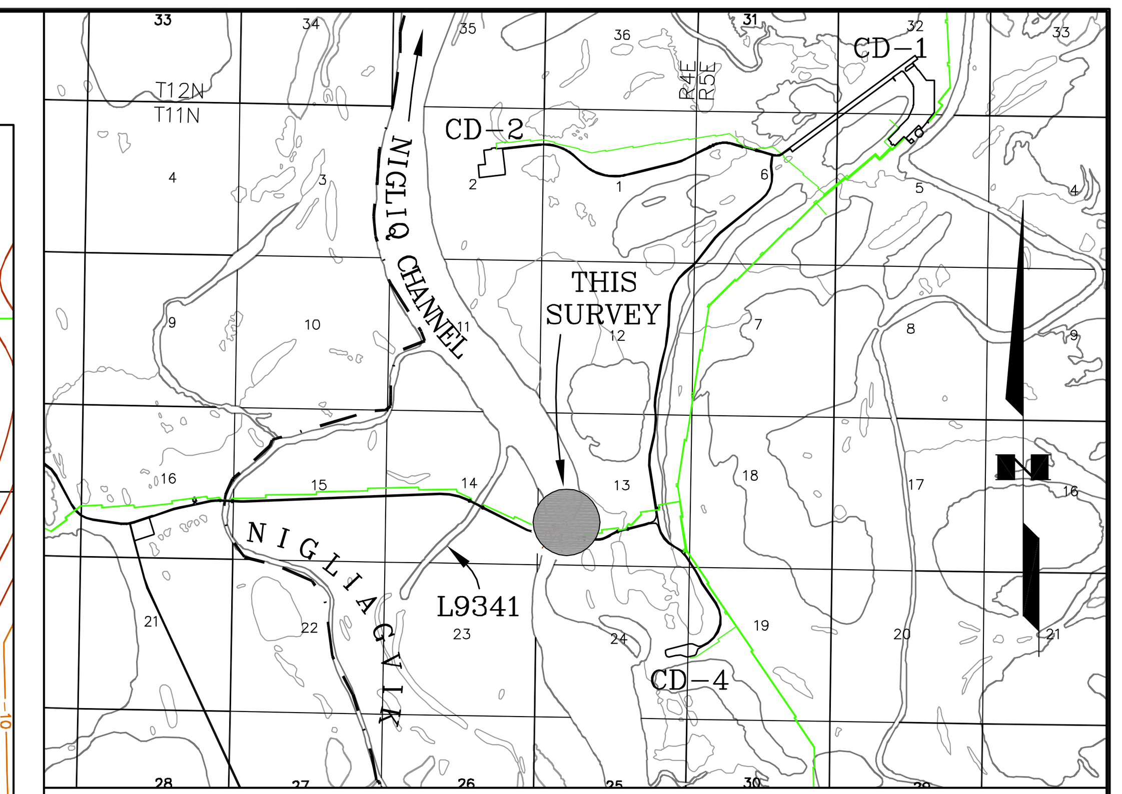
APPENDIX E CD5 PIER SCOUR, BANK EROSION, & BATHYMETRY

E.1 PIER SCOUR

E.1.1 NIGLIQ BRIDGE

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





VICINITY MAP

NOTES:

1. DATES OF SURVEY: AUGUST 2 & 3, 2017.
2. REFERENCE FIELD BOOK: 2017–15, PGS. 4–14.
3. ELEVATIONS ARE BRITISH PETROLEUM MEAN SEAL LEVEL (B.P.M.S.L.)
4. AVERAGE WATER SURFACE ELEVATION DURING SURVEY IS 0.7'.
5. HORIZONTAL DATUM IS NAD 83 ALASKA STATE PLANE ZONE 4.

LEGEND:
- 18 — 1' CONTOUR
- 20 — 5' CONTOUR

KUUKPIK 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: 1" = 50'	CHECKED: –		CC NO: –
	APPROVAL: –		CADD FILE NO. 14–08–12–1AW
JOB NO: –	SUB JOB NO: –	DRAWING NO: CE–CD50–1022	PART: 1 OF 1 / REV: 4

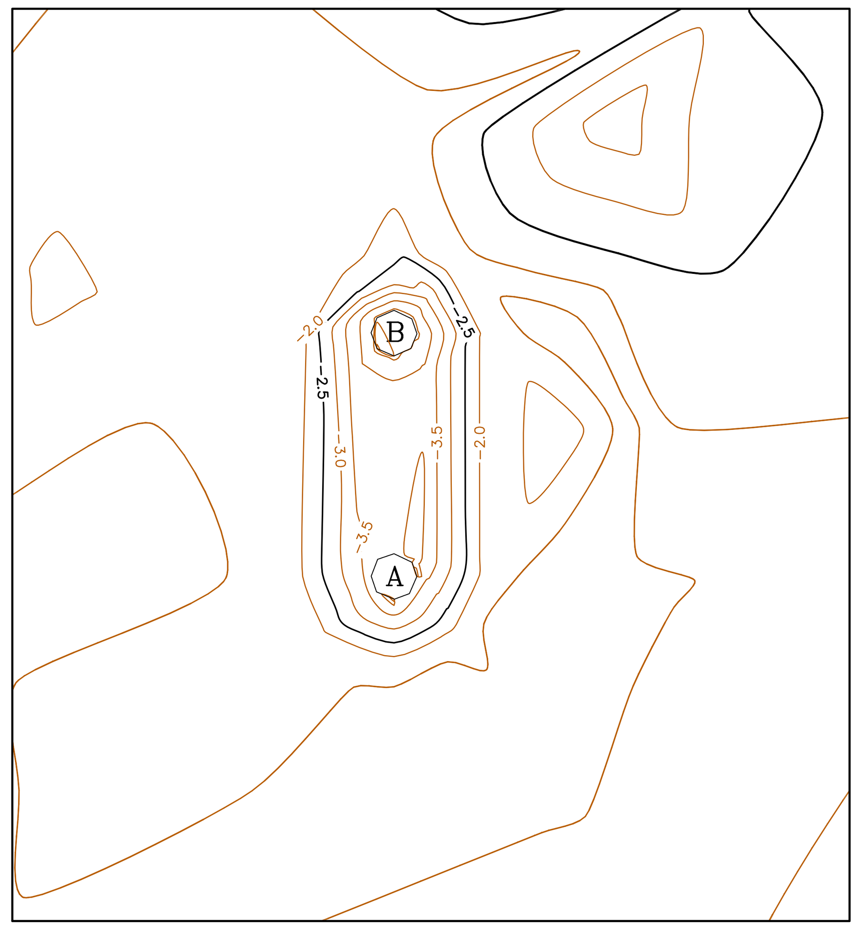
REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
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			

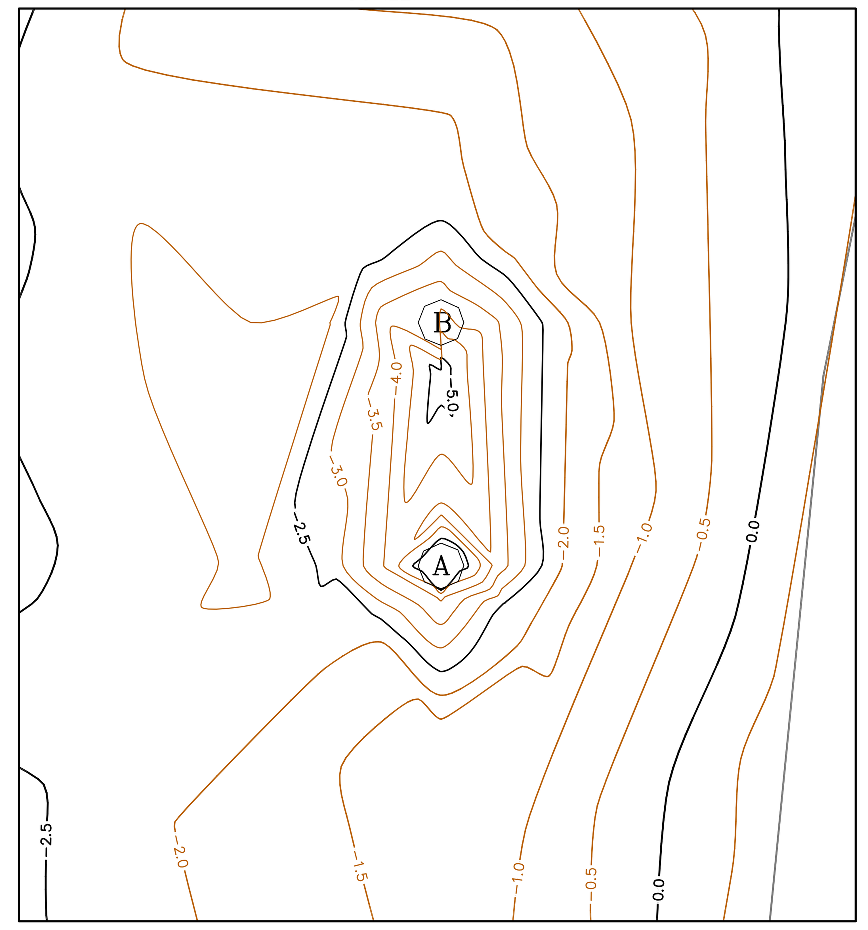
E.1.2 NIGLIAGVIK BRIDGE

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

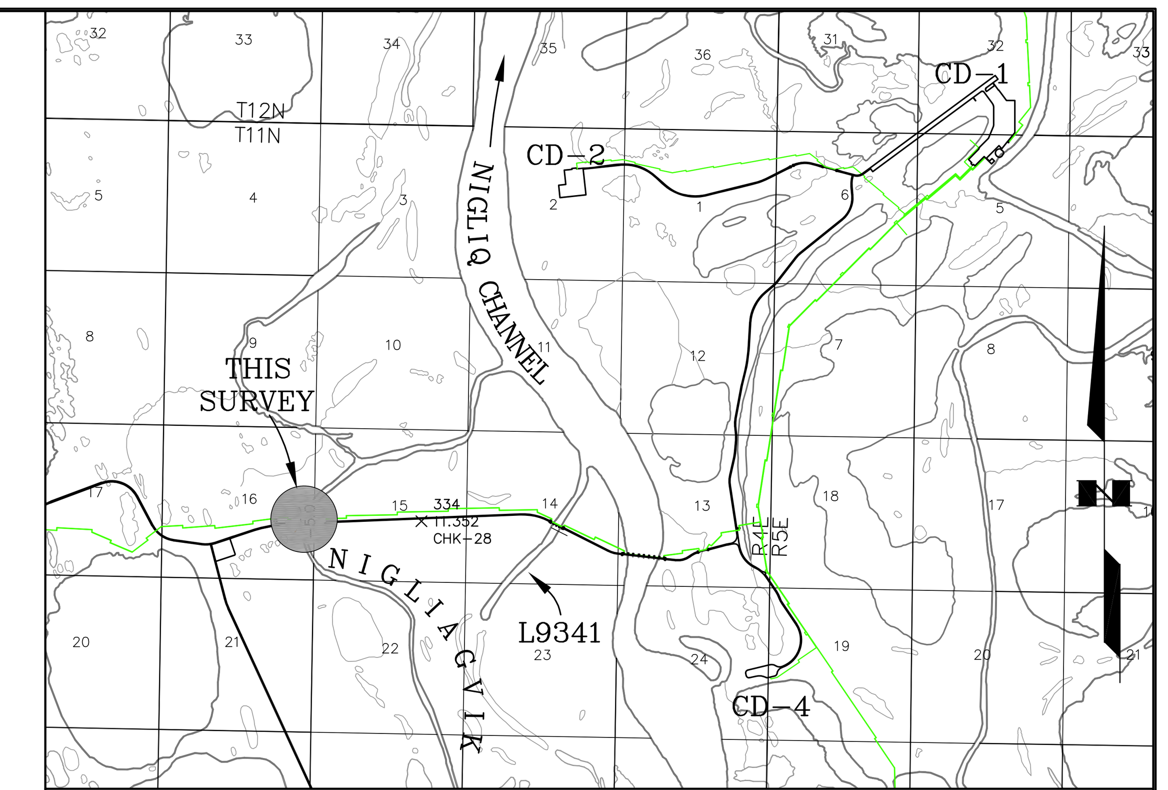
PIER 3
SCALE: 1" = 10'



PIER 4
SCALE: 1" = 10'



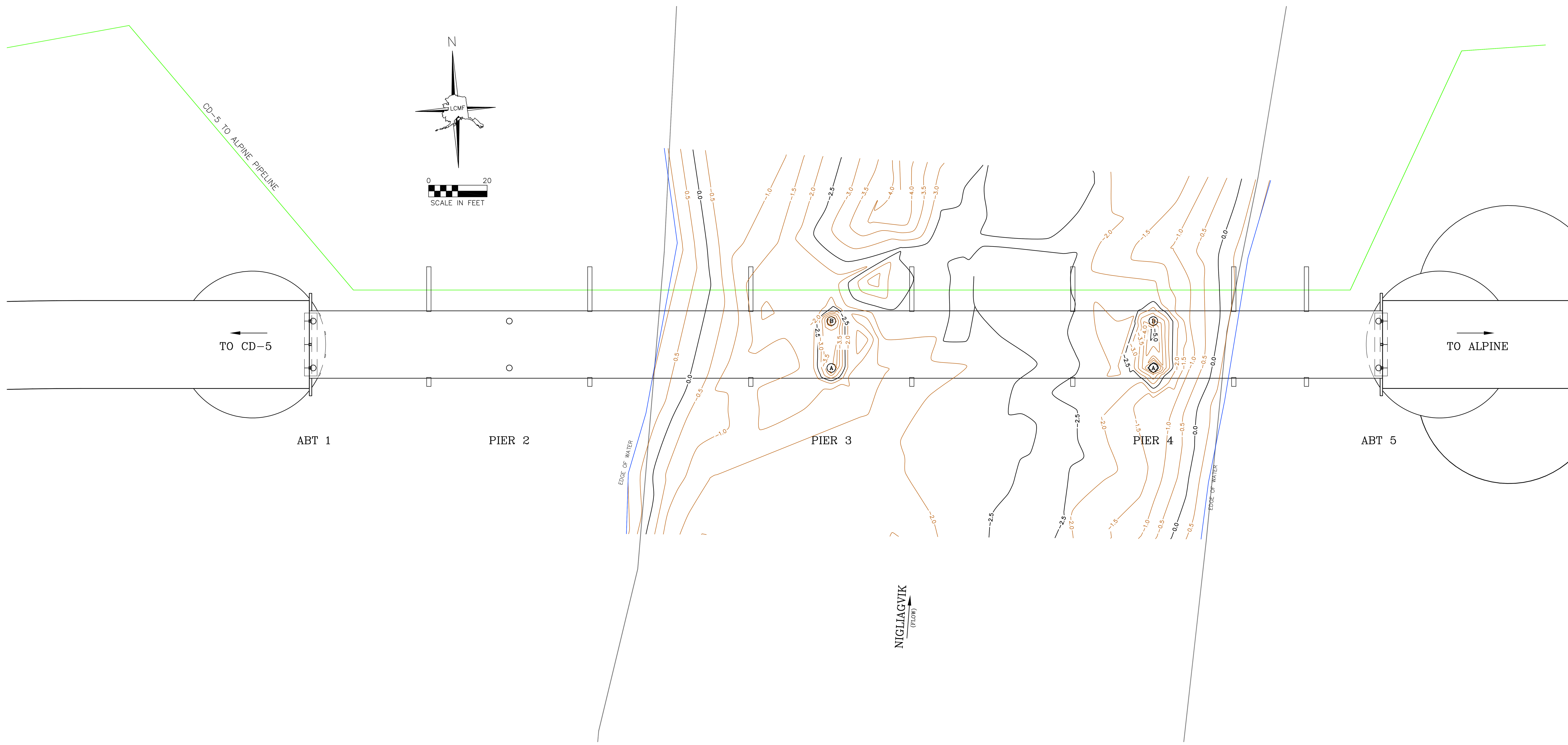
LEGEND:
- 0.5' CONTOUR
- 2.5' CONTOUR



VICINITY MAP

NOTES

1. DATE OF SURVEY: 8/10/17
2. REFERENCE FIELD BOOKS: 2017-15 PGS:24-26
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 LCMF LLC
Alpine Survey Office

ConocoPhillips Alaska, Inc.

ALPINE	MODULE: CD50	UNIT: CD

CD-5 ACCESS ROAD
NIGLIAGVIK BRIDGE
SCOUR MONITORING

REDRAWN FROM:

CONSTRUCTION SHEET OF

DO NOT SCALE — ABOVE SCALE FOR REFERENCE ONLY

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

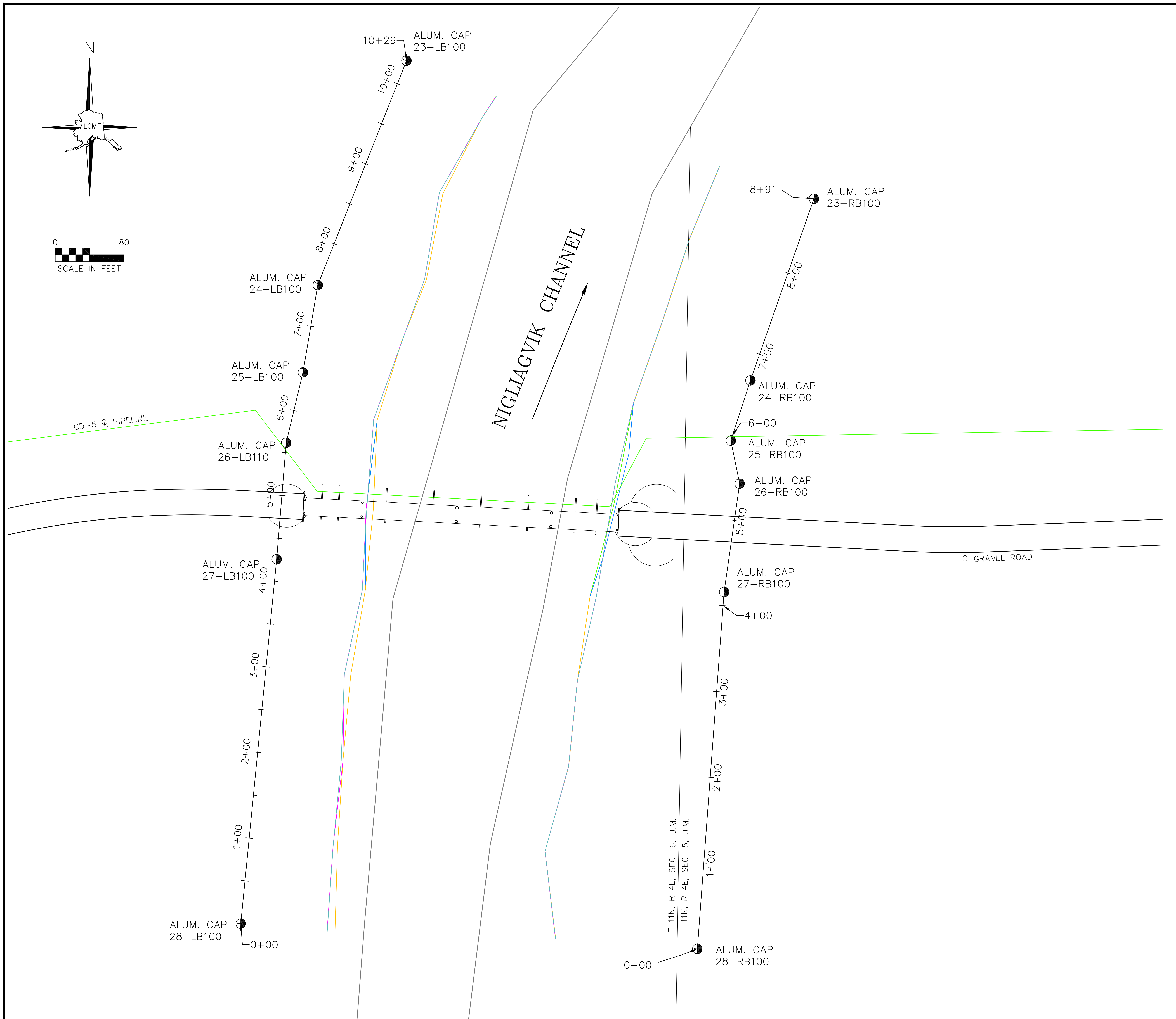
FORM: DSIZE

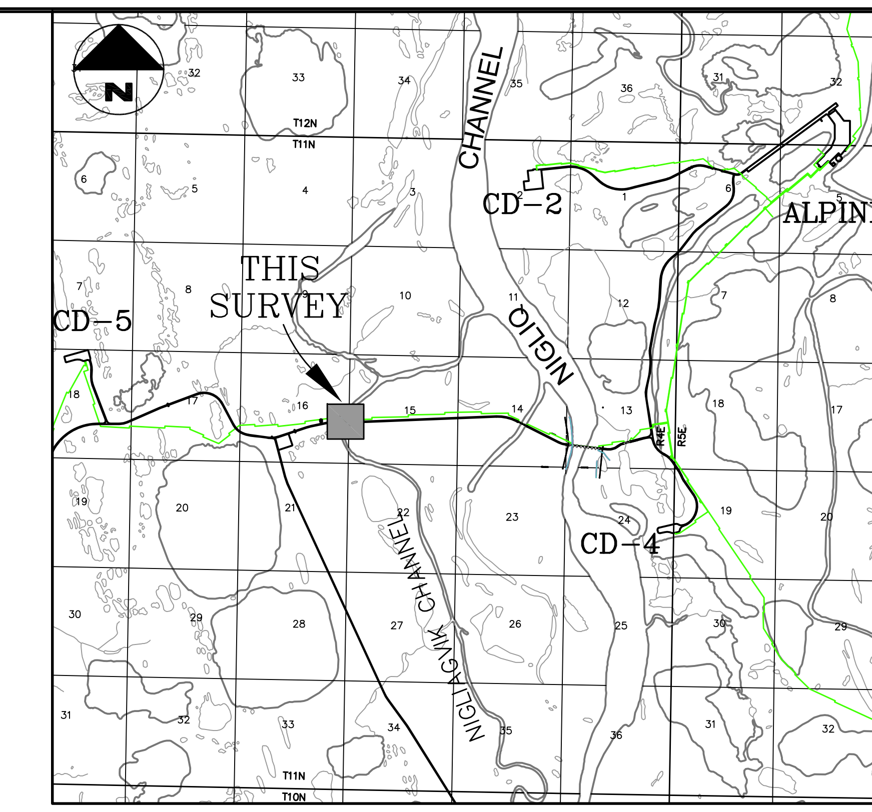
REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
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 & NIGLIAGVIK CHANNEL PLAN VIEW





VICINITY MAP

NOTES

1. DATE OF SURVEY: 8/21/13; 8/24/14; 8/28/15; 7/6/16; 8/24/17.
2. REFERENCE FIELD BOOK: 2013–19, PG. 22; 2014–21, PG. 43; 2015–17, PG. 7; 2016–12, PG.22; 2017–14, PGS. 15 & 17.
3. TOP OF BANK DEFINED BY: MICHAEL BAKER JR.
4. SEE DOCUMENT RPT–CE–CD–111 FOR BANK EROSION BASELINE SURVEY DATA.
5. BASED ON FIELD EVALUATIONS AND REVIEW OF AERIAL IMAGERY, THE 2013 TOP OF BANK POINT AT STATION 3+00 ALONG THE EAST BANK IS CONSIDERED A MISREPRESENTATION OF THE BANK AT THE TIME OF SURVEY. THERE IS NO VISIBLE EROSION AT THIS LOCATION AND THE 2013 TOP OF BANK WAS REPOSITIONED TO ALIGN WITH THE 2016 TOP OF BANK.

LEGEND:

◑ 5/8" REBAR SET WTH 2"ALUMINUM CAP

- TOP OF BANK 8/21/13
- TOP OF BANK 8/24/14
- TOP OF BANK 8/28/15
- TOP OF BANK 7/06/16
- TOP OF BANK 8/24/17

KUUKPIK UMIAQ
ALPINE SURVEY OFFICE
FORM: CSIZE

REFERENCE DWG NO:

REV	DATE	REVISION	BY	CHK	JOB	PROJ
4	12/6/16	UPDATED PER K160003ACS	TRB	DB		
3	9/6/15	UPDATED PER 20968257SACS	CZ	DB		
2	8/26/14	UPDATED PER K140003ACS	CZ	DB		
5	10/02/17	UPDATED PER K170003ACS	CZ	DB		

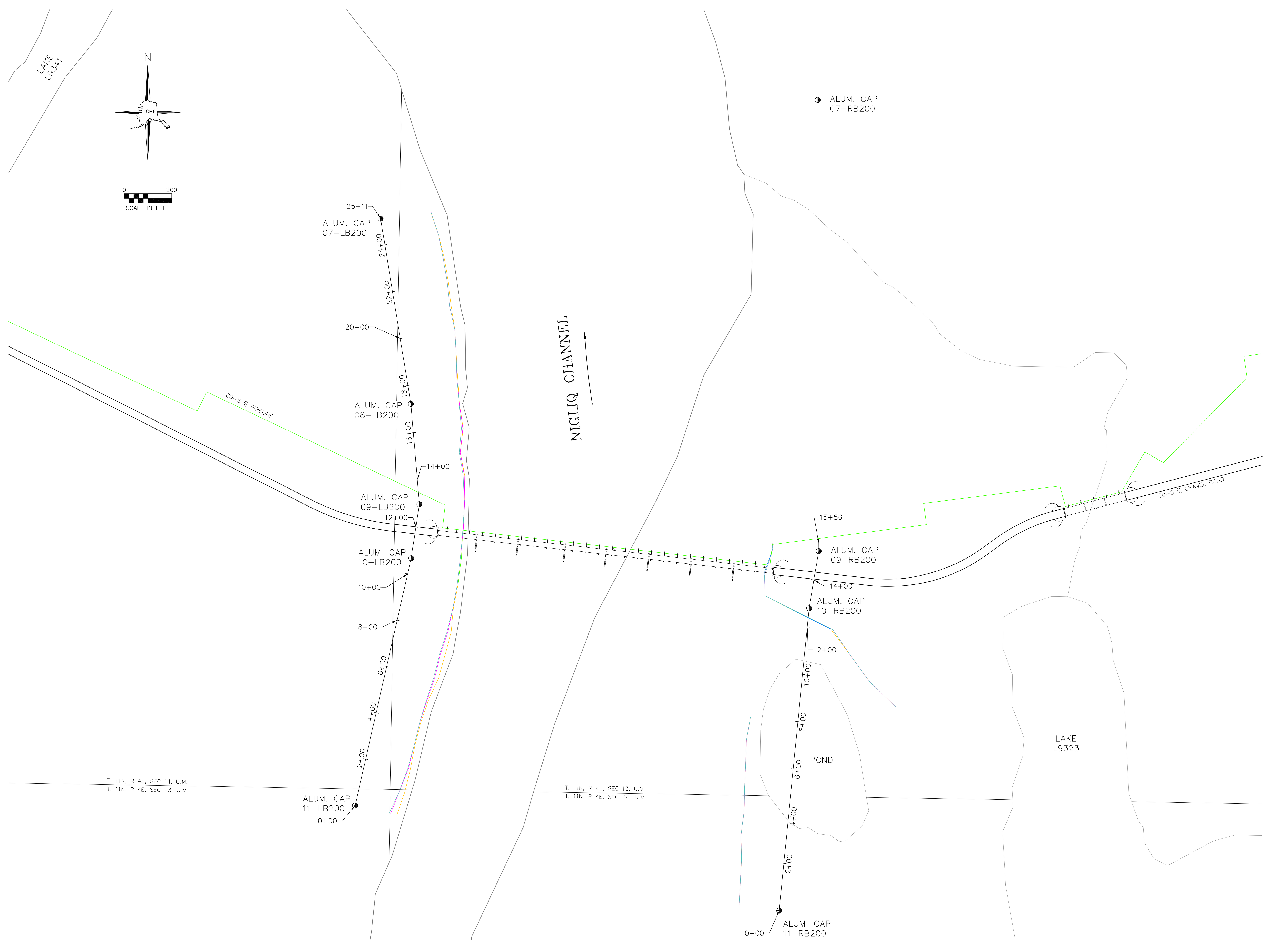
DRAWN: AG	DESIGN: –	ECM NO: K130003ACS
CHECKED: GD	APPROVAL: –	CC NO: K130003ACS
SCALE: 1" = 80'	DATE: 8/29/13	CADD FILENAME: 13-08-07-1 8/29/2013

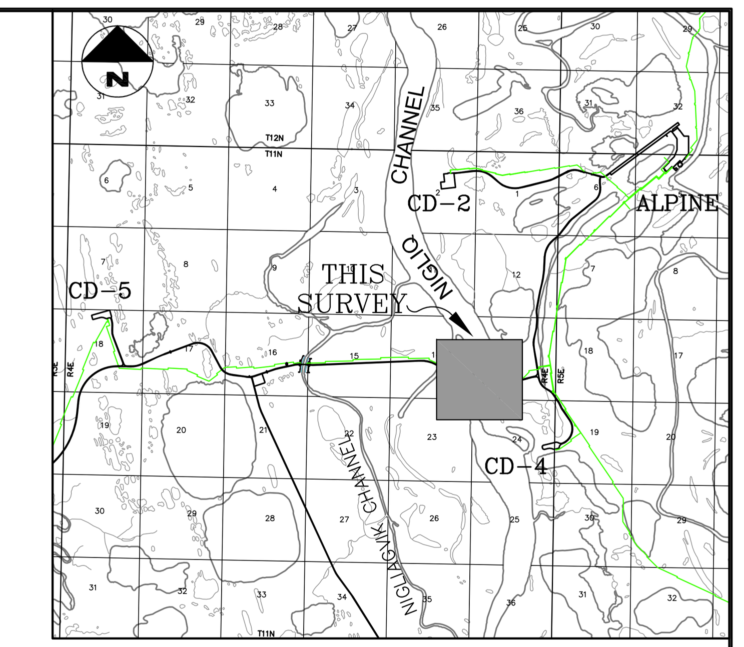
ConocoPhillips Alaska, Inc.

ALPINE | MODULE: AP00 | UNIT: AP

CD-5 MONITORING
TOP OF BANK SURVEY
NIGLIAGVIK CHANNEL

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





VICINITY MAP

NOTES

1. DATE OF SURVEY: 8/22/13; 8/24/14; 8/27/15, 9/3/15; 7/7/168/24/17.
2. REFERENCE FIELD BOOK: 2013-19, PG. 24; 2014-21, PG. 44; 2015-17, PG. 75 & 2015-19, PG. 13; 2016-12 PGS. 23-252017-14, PG. 16.
3. TOP OF BANK DEFINED BY: MICHAEL BAKER JR.
4. SEE DOCUMENT RPT-CE-CD-112 FOR BANK EROSION BASELINE SURVEY DATA.

LEGEND:

◑ 5/8" REBAR SET WTH 2" ALUMINUM CAP

- TOP OF BANK 8/21/13
- TOP OF BANK 8/24/14
- TOP OF BANK 8/28/15
- TOP OF BANK 7/07/16
- TOP OF BANK 8/24/17

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

ConocoPhillips
Alaska, Inc.

ALPINE | MODULE: AP00 | UNIT: AP

CD-5 MONITORING TOP OF BANK SURVEY NIGLIQ CHANNEL

REDRAWN FROM: | CONSTRUCTION SHEET OF

1 2 3 4 5 6
DO NOT SCALE — ABOVE SCALE FOR REFERENCE ONLY

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

REFERENCE DWG NO/SHT NO:

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

FORM: DSIZE

E.2.2 NIGLIQ CHANNEL WEST & EAST BANK TABULATED DATA

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-112 REV5

Alpine AP00
West Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV5

Baseline	**West Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											
	8/21/2013	**8/24/2014**	**8/27/2015**	**7/6/2016**	**8/24/2017**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
0+00	180.2			153.6	147.0							Baseline Offset (In Feet)
0+00				-26.6	-6.6							Incremental Change
0+00				-26.6	-33.2							Cumulative Change
1+00	191.0			168.5	168.5							Baseline Offset (In Feet)
1+00				-22.5	0.0							Incremental Change
1+00				-22.5	-22.5							Cumulative Change
2+00	193.1			184.4	181.6							Baseline Offset (In Feet)
2+00				-8.7	-2.8							Incremental Change
2+00				-8.7	-11.5							Cumulative Change
3+00	189.2			186.1	186.1							Baseline Offset (In Feet)
3+00				-3.1	0.0							Incremental Change
3+00				-3.1	-3.1							Cumulative Change
4+00	192.2			187.7	187.7							Baseline Offset (In Feet)
4+00				-4.5	0.0							Incremental Change
4+00				-4.5	-4.5							Cumulative Change
5+00	202.9			197.1	194.8							Baseline Offset (In Feet)
5+00				-5.8	-2.3							Incremental Change
5+00				-5.8	-8.1							Cumulative Change
6+00	224.0			207.8	203.8							Baseline Offset (In Feet)
6+00				-16.2	-4.0							Incremental Change
6+00				-16.2	-20.2							Cumulative Change

Nigliq Streambank Erosion 1 of 4 West Bank Monitor

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-112 REV5

Alpine AP00

West Bank Nigliq

Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV5

Baseline	West Bank Monitor - Top of Bank Locations											Description
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											
	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	Future	Future	Future	Future	Future	Future	Date
7+00	228.9			209.3	206.0							Baseline Offset (In Feet)
7+00				-19.6	-3.3							Incremental Change
7+00				-19.6	-22.9							Cumulative Change
8+00	232.9			219.1	215.1							Baseline Offset (In Feet)
8+00				-13.8	-4.0							Incremental Change
8+00				-13.8	-17.8							Cumulative Change
9+00	220.0			217.9	217.9							Baseline Offset (In Feet)
9+00				-2.1	0.0							Incremental Change
9+00				-2.1	-2.1							Cumulative Change
10+00	216.8	216.8	213.5	213.5	213.5							Baseline Offset (In Feet)
10+00		0.0	-3.3	0.0	0.0							Incremental Change
10+00		0.0	-3.3	-3.3	-3.3							Cumulative Change
11+00	209.1	209.1	204.9	204.8	204.8							Baseline Offset (In Feet)
11+00		0.0	-4.2	-0.1	0.0							Incremental Change
11+00		0.0	-4.2	-4.3	-4.3							Cumulative Change
12+00	199.0	199.0	199.0	199.8	189.8							Baseline Offset (In Feet)
12+00		0.0	0.0	0.8	-10.0							Incremental Change
12+00		0.0	0.0	0.8	-9.2							Cumulative Change
13+00	192.1	192.1	192.1	192.1	188.3							Baseline Offset (In Feet)
13+00		0.0	0.0	0.0	-3.8							Incremental Change
13+00		0.0	0.0	0.0	-3.8							Cumulative Change

Nigliq Streambank Erosion 2 of 4 West Bank Monitor

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-112 REV5

Alpine AP00
West Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV5

Baseline	West Bank Monitor - Top of Bank Locations											Description
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											
	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	Future	Future	Future	Future	Future	Future	Date
14+00	200.9			198.8	193.7							Baseline Offset (In Feet)
14+00				-2.1	-5.1							Incremental Change
14+00				-2.1	-7.2							Cumulative Change
15+00	190.0			190.0	186.2							Baseline Offset (In Feet)
15+00				0.0	-3.8							Incremental Change
15+00				0.0	-3.8							Cumulative Change
16+00	211.0			209.5	203.3							Baseline Offset (In Feet)
16+00				-1.5	-6.2							Incremental Change
16+00				-1.5	-7.7							Cumulative Change
17+00	204.0			204.0	202.9							Baseline Offset (In Feet)
17+00				0.0	-1.1							Incremental Change
17+00				0.0	-1.1							Cumulative Change
18+00	212.0			208.3	208.3							Baseline Offset (In Feet)
18+00				-3.7	0.0							Incremental Change
18+00				-3.7	-3.7							Cumulative Change
19+00	221.9			221.9	221.9							Baseline Offset (In Feet)
19+00				0.0	0.0							Incremental Change
19+00				0.0	0.0							Cumulative Change
20+00	232.9			232.9	232.9							Baseline Offset (In Feet)
20+00				0.0	0.0							Incremental Change
20+00				0.0	0.0							Cumulative Change

Nigliq Streambank Erosion 3 of 4 West Bank Monitor

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-112 REV5

Alpine AP00

West Bank Nigliq

Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV5

Baseline	**West Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											
	8/21/2013	**8/24/2014**	**8/27/2015**	**7/6/2016**	**8/24/2017**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
21+00	233.9			227.5	227.5							Baseline Offset (In Feet)
21+00				-6.4	0.0							Incremental Change
21+00				-6.4	-6.4							Cumulative Change
22+00	237.8			233.3	233.3							Baseline Offset (In Feet)
22+00				-4.5	0.0							Incremental Change
22+00				-4.5	-4.5							Cumulative Change
23+00	237.9			233.0	233.0							Baseline Offset (In Feet)
23+00				-4.9	0.0							Incremental Change
23+00				-4.9	-4.9							Cumulative Change
24+00	229.9			229.9	229.9							Baseline Offset (In Feet)
24+00				0.0	0.0							Incremental Change
24+00				0.0	0.0							Cumulative Change
25+00	214.1			214.1	214.1							Baseline Offset (In Feet)
25+00				0.0	0.0							Incremental Change
25+00				0.0	0.0							Cumulative Change
25+11	213.9			213.9	213.9							Baseline Offset (In Feet)
25+11				0.0	0.0							Incremental Change
25+11				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.

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-112 REV5

Alpine AP00
East Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV5

Baseline Station	East Bank Monitor - Top of Bank Locations; See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											Description
	8/22/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	Future	Future	Future	Future	Future	Future	Date
0+00	169.9			169.9	169.9							Baseline Offset (In Feet)
0+00				0.0	0.0							Incremental Change
0+00				0.0	0.0							Cumulative Change
1+00	174.0			174.0	174.0							Baseline Offset (In Feet)
1+00				0.0	0.0							Incremental Change
1+00				0.0	0.0							Cumulative Change
2+00	178.9			178.9	178.9							Baseline Offset (In Feet)
2+00				0.0	0.0							Incremental Change
2+00				0.0	0.0							Cumulative Change
3+00	191.0			191.0	191.0							Baseline Offset (In Feet)
3+00				0.0	0.0							Incremental Change
3+00				0.0	0.0							Cumulative Change
4+00	188.0			188.0	188.0							Baseline Offset (In Feet)
4+00				0.0	0.0							Incremental Change
4+00				0.0	0.0							Cumulative Change
5+00	196.1			196.1	196.1							Baseline Offset (In Feet)
5+00				0.0	0.0							Incremental Change
5+00				0.0	0.0							Cumulative Change
6+00	201.1			201.1	201.1							Baseline Offset (In Feet)
6+00				0.0	0.0							Incremental Change
6+00				0.0	0.0							Cumulative Change

Nigliq Streambank Erosion 1 of 3 East Bank Monitor

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-112 REV5

Alpine AP00
East Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV5

Baseline	East Bank Monitor - Top of Bank Locations											Description
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											
	8/22/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	Future	Future	Future	Future	Future	Future	Date
7+00	208.1			208.1	208.2							Baseline Offset (In Feet)
7+00				0.0	0.1							Incremental Change
7+00				0.0	0.1							Cumulative Change
8+00	199.8			199.8	199.9							Baseline Offset (In Feet)
8+00				0.0	0.1							Incremental Change
8+00				0.0	0.1							Cumulative Change
9+00	406.2			406.2	406.0							Baseline Offset (In Feet)
9+00				0.0	-0.2							Incremental Change
9+00				0.0	-0.2							Cumulative Change
10+00	280.9			280.7	280.6							Baseline Offset (In Feet)
10+00				-0.2	-0.1							Incremental Change
10+00				-0.2	-0.3							Cumulative Change
11+00	192.2			192.0	192.0							Baseline Offset (In Feet)
11+00				-0.2	0.0							Incremental Change
11+00				-0.2	-0.2							Cumulative Change
12+00	100.1			107.9	107.6							Baseline Offset (In Feet)
12+00				7.8	-0.3							Incremental Change
12+00				7.8	7.5							Cumulative Change
13+00	192.0	192.0	192.0	192.0	191.8							Baseline Offset (In Feet)
13+00		0.0	0.0	0.0	-0.2							Incremental Change
13+00		0.0	0.0	0.0	-0.2							Cumulative Change

Nigliq Streambank Erosion 2 of 3 East Bank Monitor

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-112 REV5

Alpine AP00
East Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV5

Baseline	**East Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											
	8/22/2013	**8/24/2014**	**8/27/2015**	**7/6/2016**	**8/24/2017**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
13+83.8				208.0	208.0							Baseline Offset (In Feet)
13+83.8					0.0							Incremental Change
13+83.8					0.0							Cumulative Change
14+00	210.0	210.0	210.0	*Unable to	205.8							Baseline Offset (In Feet)
14+00		0.0	0.0									Incremental Change
14+00		0.0	0.0									Cumulative Change
15+00	192.0	192.0	192.0	192.0	192.0							Baseline Offset (In Feet)
15+00		0.0	0.0	0.0	0.0							Incremental Change
15+00		0.0	0.0	0.0	0.0							Cumulative Change
15+56	195.4			195.4	194.6							Baseline Offset (In Feet)
15+56				0.0	-0.8							Incremental Change
15+56				0.0	-0.8							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.												

E.2.3 NIGLIAGVIK CHANNEL WEST & EAST BANK TABULATED DATA

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-111 REV5

Alpine AP00
West Bank Nigliagvik
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-154 REV5

Baseline	**West Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											
	8/21/2013	**8/21/2014**	**8/28/2015**	**7/6/2016**	**8/24/2017**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
0+00	110.0			100.7	100.7							Baseline Offset (In Feet)
0+00				-9.3	0.0							Incremental Change
0+00				-9.3	-9.3							Cumulative Change
1+00	103.0			97.9	97.9							Baseline Offset (In Feet)
1+00				-5.1	0.0							Incremental Change
1+00				-5.1	-5.1							Cumulative Change
2+00	99.6			99.6	97.5							Baseline Offset (In Feet)
2+00				0.0	-2.1							Incremental Change
2+00				0.0	-2.1							Cumulative Change
3+00	98.8			91.3	91.3							Baseline Offset (In Feet)
3+00				-7.5	0.0							Incremental Change
3+00				-7.5	-7.5							Cumulative Change
4+00	106.0	106.0	106.0	102.4	102.4							Baseline Offset (In Feet)
4+00		0.0	0.0	-3.6	0.0							Incremental Change
4+00		0.0	0.0	-3.6	-3.6							Cumulative Change
5+00	102.0	93.5	93.5	81.1	81.1							Baseline Offset (In Feet)
5+00		-8.4	0.0	-12.4	0.0							Incremental Change
5+00		-8.4	-8.4	-20.9	-20.9							Cumulative Change
6+00	92.0	90.4	90.4	87.9	87.9							Baseline Offset (In Feet)
6+00		-1.6	0.0	-2.5	0.0							Incremental Change
6+00		-1.6	-1.6	-4.1	-4.1							Cumulative Change

Nigliagvik Streambank Erosion 1 of 2 West Bank Monitor

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-111 REV5

Alpine AP00
West Bank Nigliagvik
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-154 REV5

Baseline	West Bank Monitor - Top of Bank Locations											Description
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	Future	Future	Future	Future	Future	Future	Date
7+00	107.1			107.1	107.1							Baseline Offset (In Feet)
7+00				0.0	0.0							Incremental Change
7+00				0.0	0.0							Cumulative Change
8+00	115.0			112.8	112.8							Baseline Offset (In Feet)
8+00				-2.2	0.0							Incremental Change
8+00				-2.2	-2.2							Cumulative Change
9+00	96.1			91.8	91.8							Baseline Offset (In Feet)
9+00				-4.3	0.0							Incremental Change
9+00				-4.3	-4.3							Cumulative Change
10+00	106.1			106.1	106.1							Baseline Offset (In Feet)
10+00				0.0	0.0							Incremental Change
10+00				0.0	0.0							Cumulative Change
10+28	112.0			112.0	112.0							Baseline Offset (In Feet)
10+28				0.0	0.0							Incremental Change
10+28				0.0	0.0							Cumulative Change
***Note: Survey completed on 8/21/13 was used for baseline data to compute Incremental/Cumulative Change. Negative numbers indicate erosion.												

Nigliagvik Streambank Erosion 2 of 2 West Bank Monitor

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-111 REV5

Alpine AP00
East Bank Nigliagvik
Streambank Monitor

Umiaq LLC
Alpine Survey Office
Doc.LCMF-154 REV5

Baseline Station	East Bank Monitor - Top of Bank Locations. See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											Description
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	Future	Future	Future	Future	Future	Future	Date
0+00.0	165.1			165.1	165.3							Baseline Offset (In Feet)
0+00.0				0.0	0.2							Incremental Change
0+00.0				0.0	0.2							Cumulative Change
1+00.0	185.0			185.0	185.0							Baseline Offset (In Feet)
1+00.0				0.0	0.0							Incremental Change
1+00.0				0.0	0.0							Cumulative Change
2+00.0	165.0			165.0	165.1							Baseline Offset (In Feet)
2+00.0				0.0	0.1							Incremental Change
2+00.0				0.0	0.1							Cumulative Change
3+00.0	162.3			162.3	162.2							Baseline Offset (In Feet)
3+00.0				0.0	-0.1							Incremental Change
3+00.0				0.0	-0.1							Cumulative Change
4+00.0	154.9	154.9	154.9	147.6	147.6							Baseline Offset (In Feet)
4+00.0		0.0	0.0	-7.3	0.0							Incremental Change
4+00.0		0.0	0.0	-7.3	-7.3							Cumulative Change
5+00.0	141.0	141.0	138.4	Under	143.7							Baseline Offset (In Feet)
5+00.0		0.0	-2.7	Bridge	5.3							Incremental Change
5+00.0		0.0	-2.7		2.7							Cumulative Change
5+23.2				143.2	141.9							Baseline Offset (In Feet)
5+23.2					-1.3							Incremental Change
5+23.2					-1.3							Cumulative Change

Nigliagvik Streambank Erosion 1 of 2 East Bank Monitor

Calc/d By: CZ
Date: 10/02/2017
RPT-CE-CD-111 REV5

Alpine AP00

East Bank Nigliagvik

Streambank Monitor

Umiaq LLC
Alpine Survey Office
Doc.LCMF-154 REV5

Baseline	**East Bank Monitor - Top of Bank Locations**											**Description**
Station	See Drawing CE-AP00-1126 Rev 5 for Survey Baseline Location											
	8/21/2013	**8/21/2014**	**8/28/2015**	**7/6/2016**	**8/24/2017**	**Future**	**Future**	**Future**	**Future**	**Future**	**Future**	**Date**
6+00.0	120.9	120.9	120.9	120.9	121.1							Baseline Offset (In Feet)
6+00.0		0.0	0.0	0.0	0.2							Incremental Change
6+00.0		0.0	0.0	0.0	0.2							Cumulative Change
7+00.0	119.0			119.0	119.5							Baseline Offset (In Feet)
7+00.0				0.0	0.5							Incremental Change
7+00.0				0.0	0.5							Cumulative Change
8+00.0	120.9			120.9	121.3							Baseline Offset (In Feet)
8+00.0				0.0	0.4							Incremental Change
8+00.0				0.0	0.4							Cumulative Change
8+91.0	115.7			115.7	116.1							Baseline Offset (In Feet)
8+91.0				0.0	0.4							Incremental Change
8+91.0				0.0	0.4							Cumulative Change

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

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

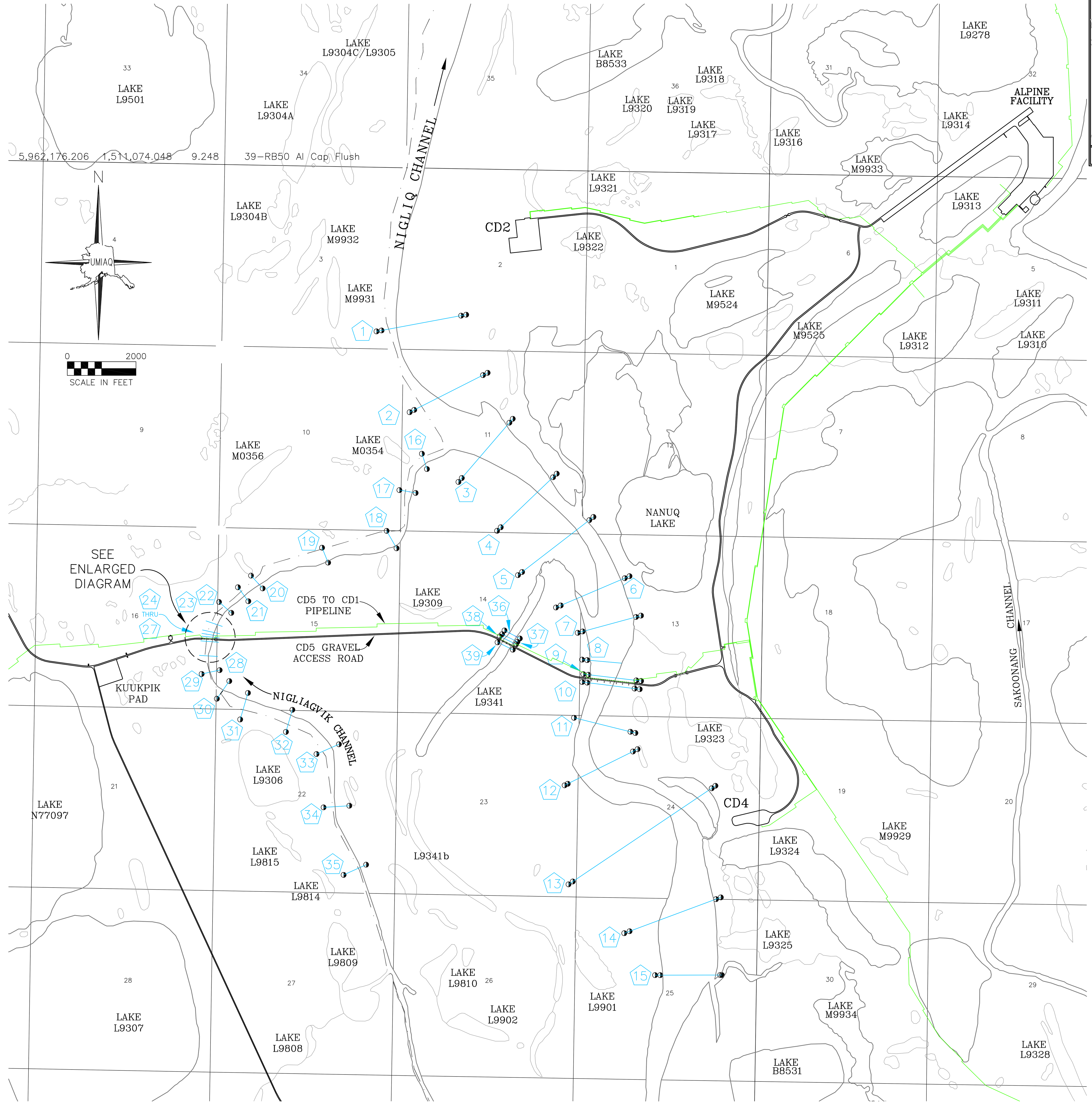
E.3 BATHYMETRY

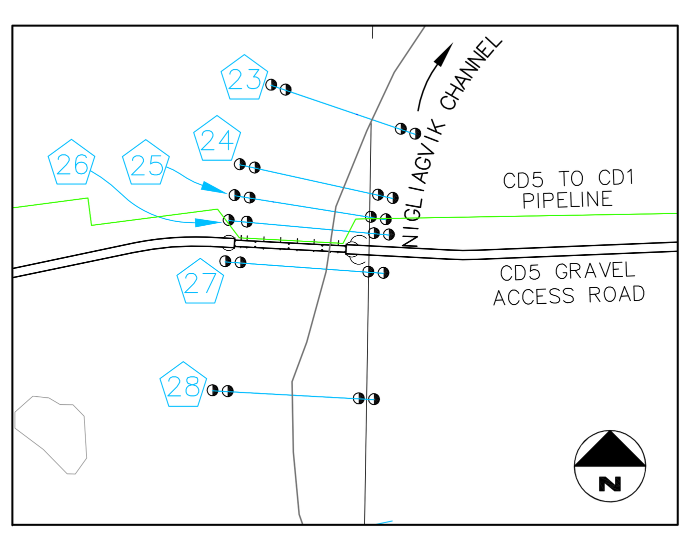
E.3.1 TRANSECT PROFILES

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

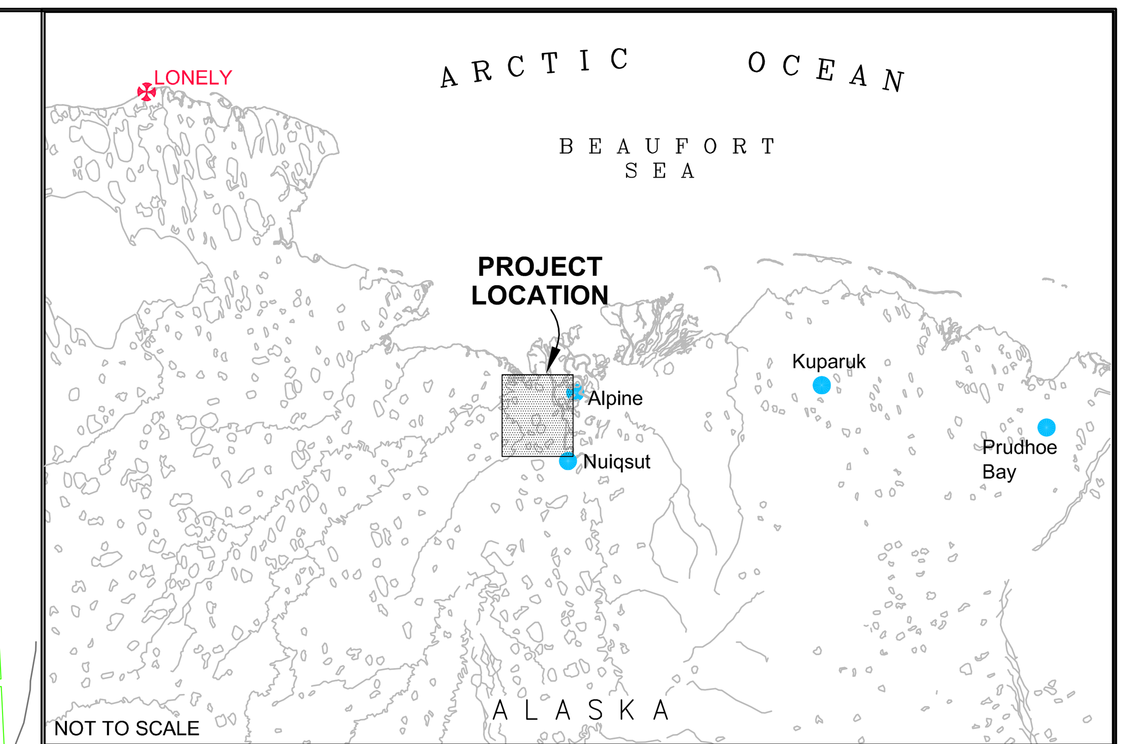
CD5 2017 TRANSECT CONTROL

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	5,962,498.526	1,502,585.637	9.40	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
5,961,214.591	1,513,133.902	10.18	10–LB200 Al Cap Flush	5,961,457.481	1,502,122.198	23.74	29–LB50 Al Cap Flush
5,961,195.839	1,513,282.747	10.25	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
5,966,712.462	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





ENLARGED DIAGRAM



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.
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.

LEGEND:

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

KUUKPIK LCMF LLC
Alpine Survey Office

ConocoPhillips Alaska, Inc.

ALPINE | MODULE: CD50 | UNIT: CD

CD–5 ROAD
MONITORING PLAN BASELINES
ALPINE, ALASKA

REDRAWN FROM: | CONSTRUCTION SHEET OF

DO NOT SCALE | ABOVE SCALE FOR REFERENCE ONLY

FORM: DSIZE

REFERENCE DWG NO/SHT NO:

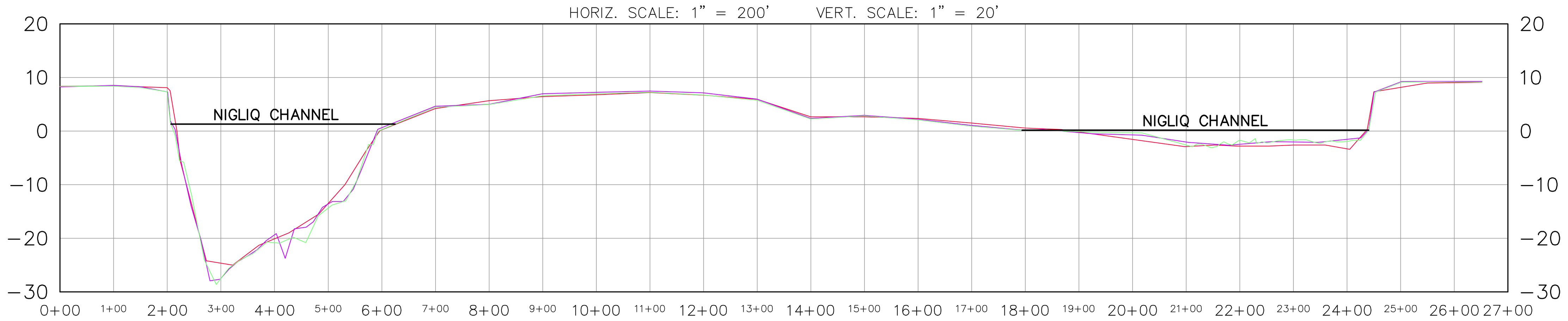
REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
3	10/9/17	UPDATED PER K170003ACS	KD	CZ			
2	7/29/16	UPDATED PER K160003ACS	CZ	DB			
1	10/22/13	ISSUED PER K130003ACS	AG	DB			

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: 3

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

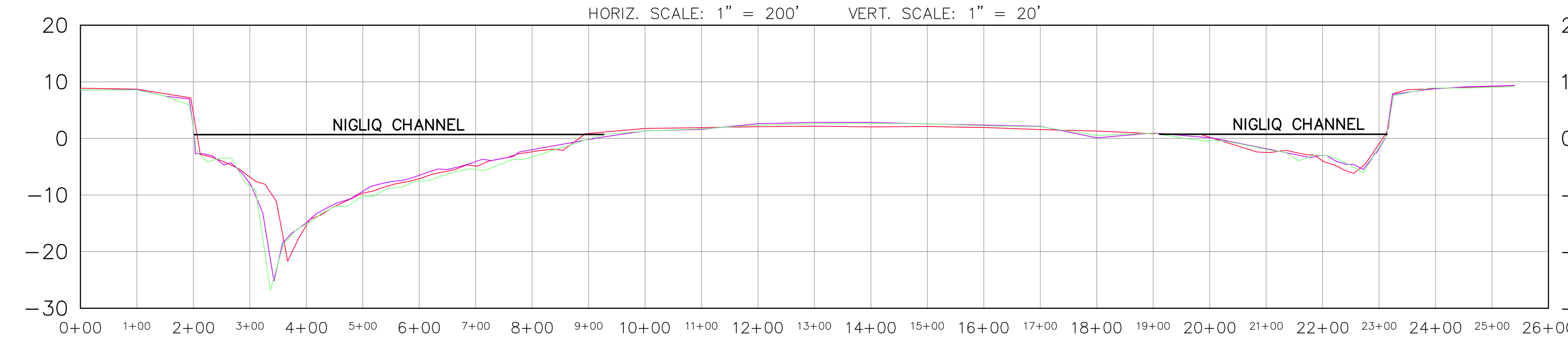
Profile View of Transect-1

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



Profile View of Transect-2

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

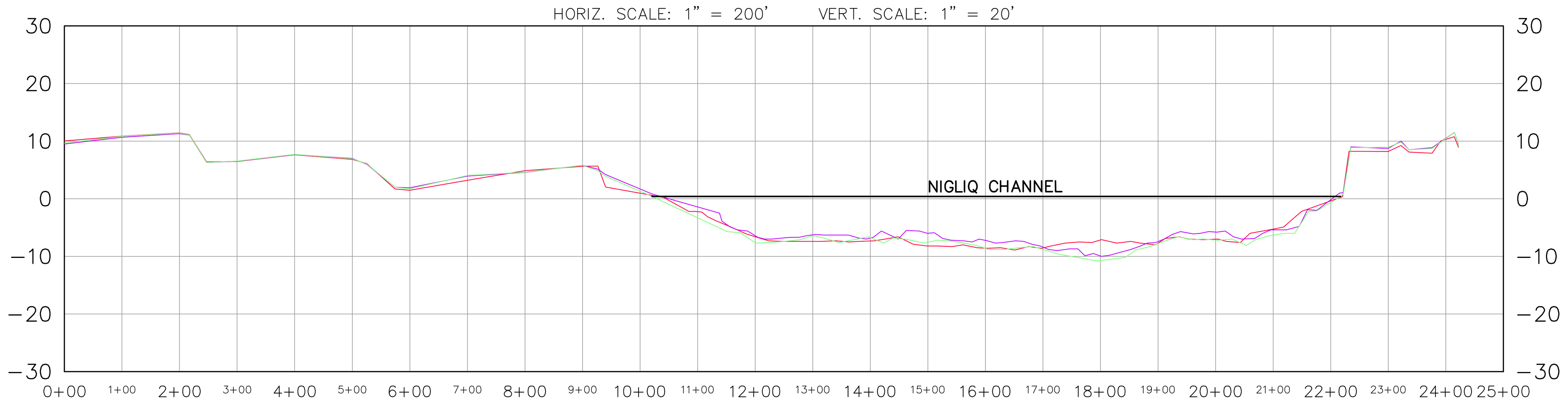


LEGEND:
VIEW LOOKING DOWNSTREAM

- 2013 TRANSECT PROFLIE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE

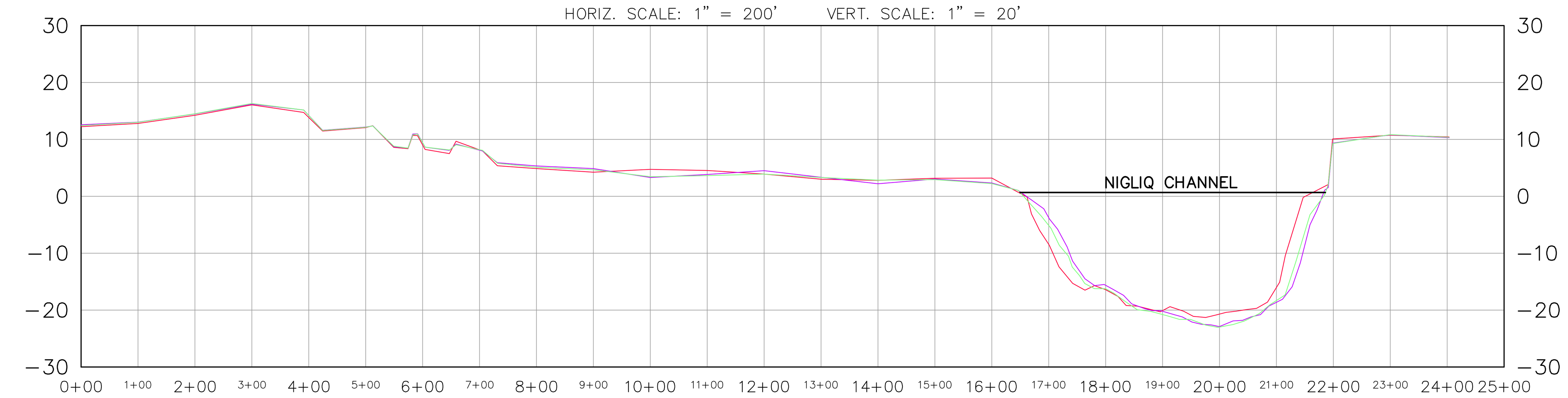
Profile View of Transect-3

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



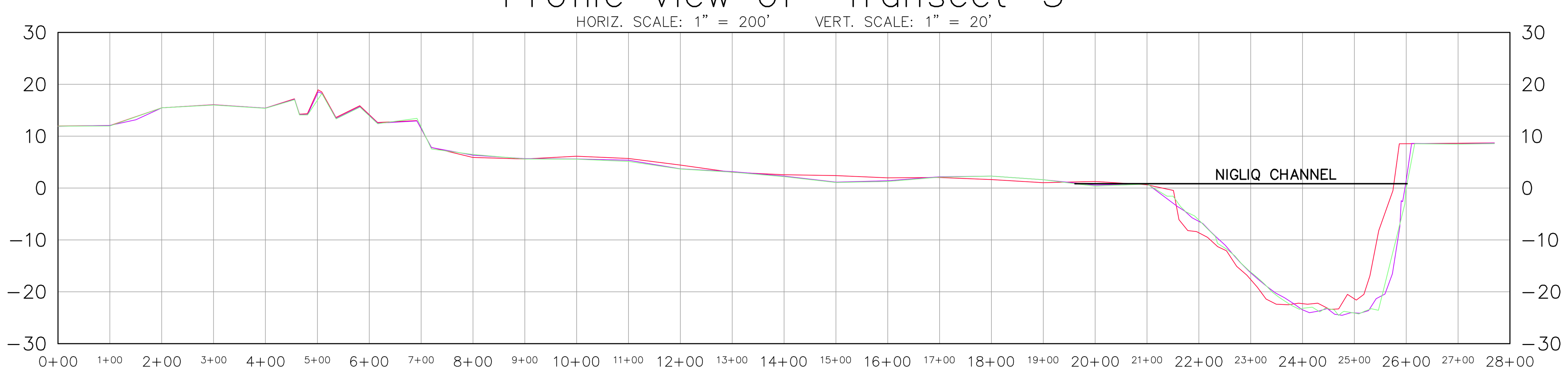
Profile View of Transect-4

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



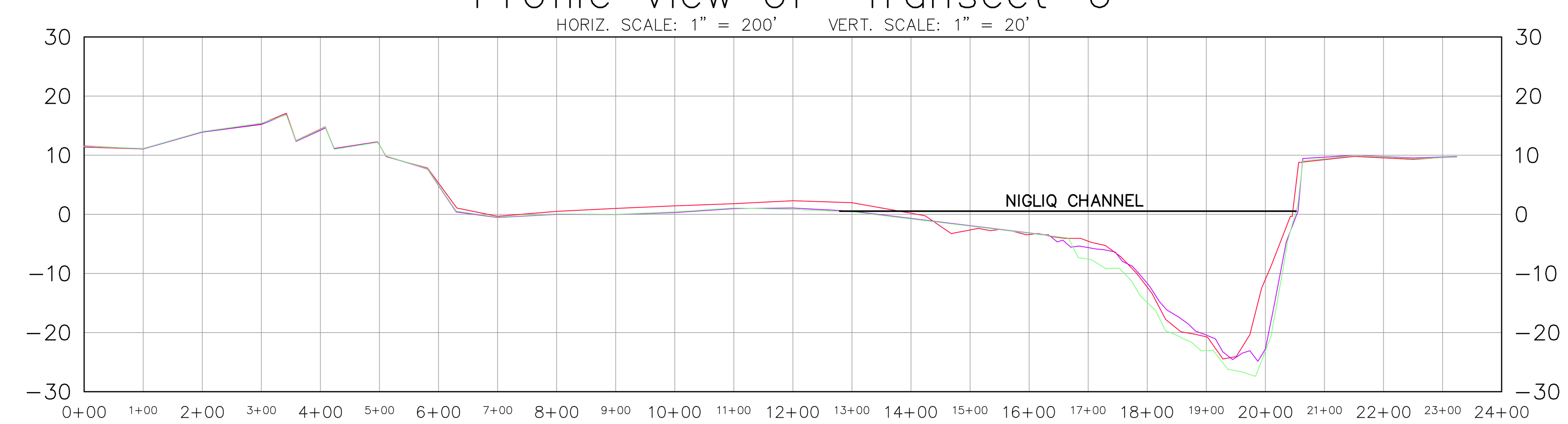
Profile View of Transect-5

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
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: –

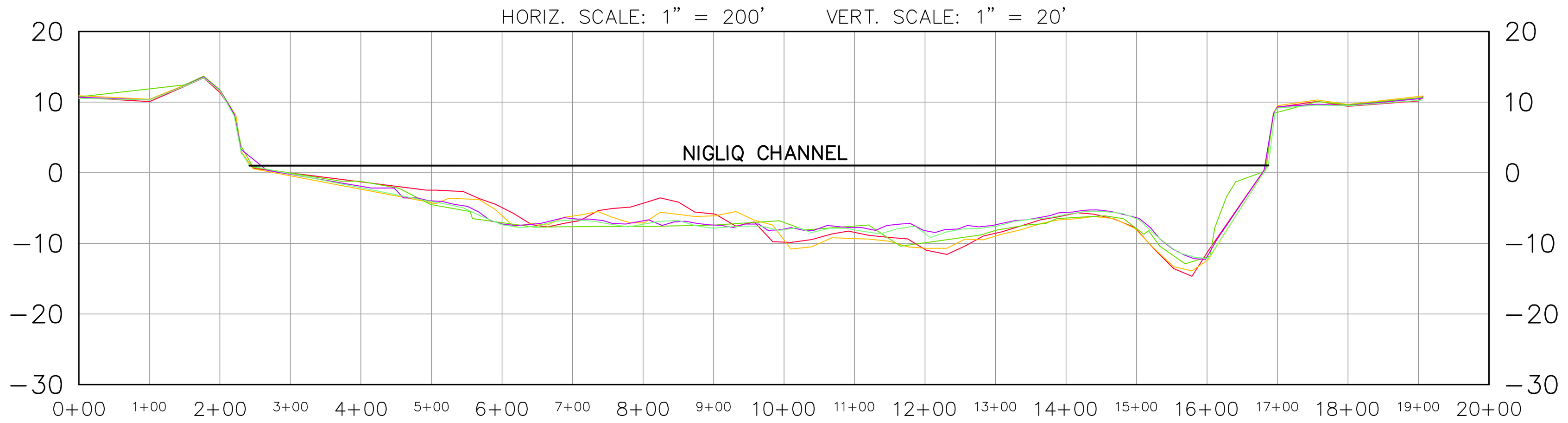
ALPINE
MODULE: CD50
UNIT: CD

CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

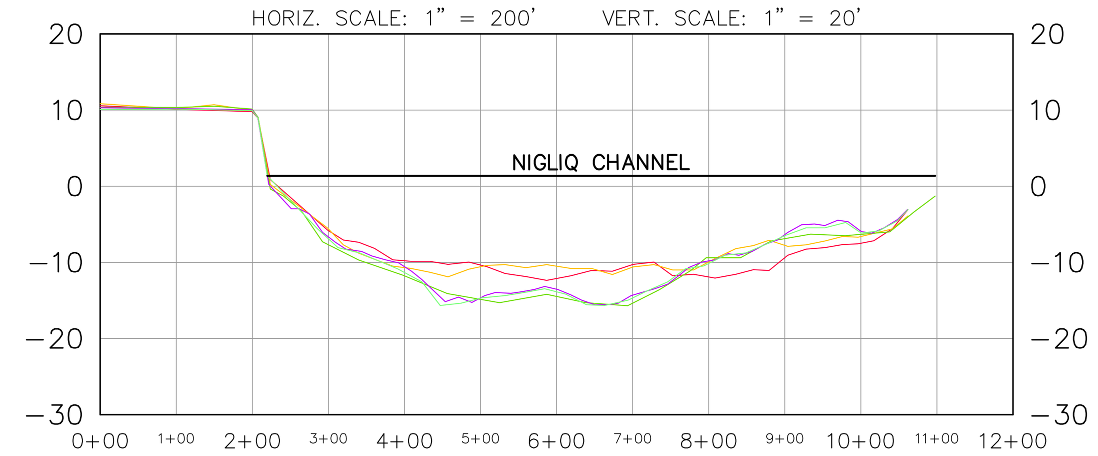
JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	2 of 6	2

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

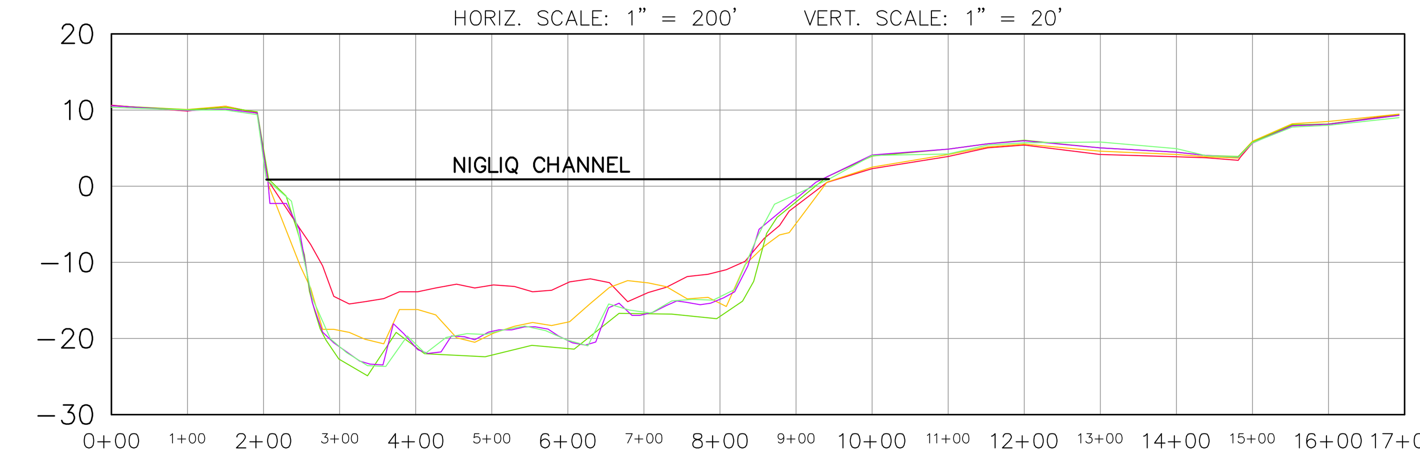
Profile View of Transect-7
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



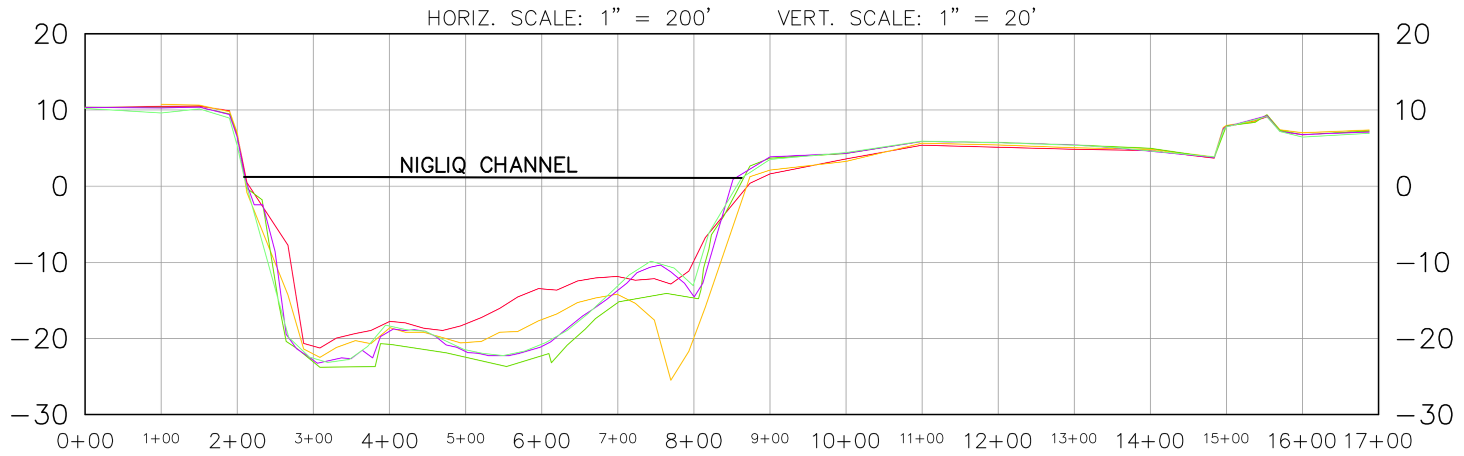
Profile View of Transect-8
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



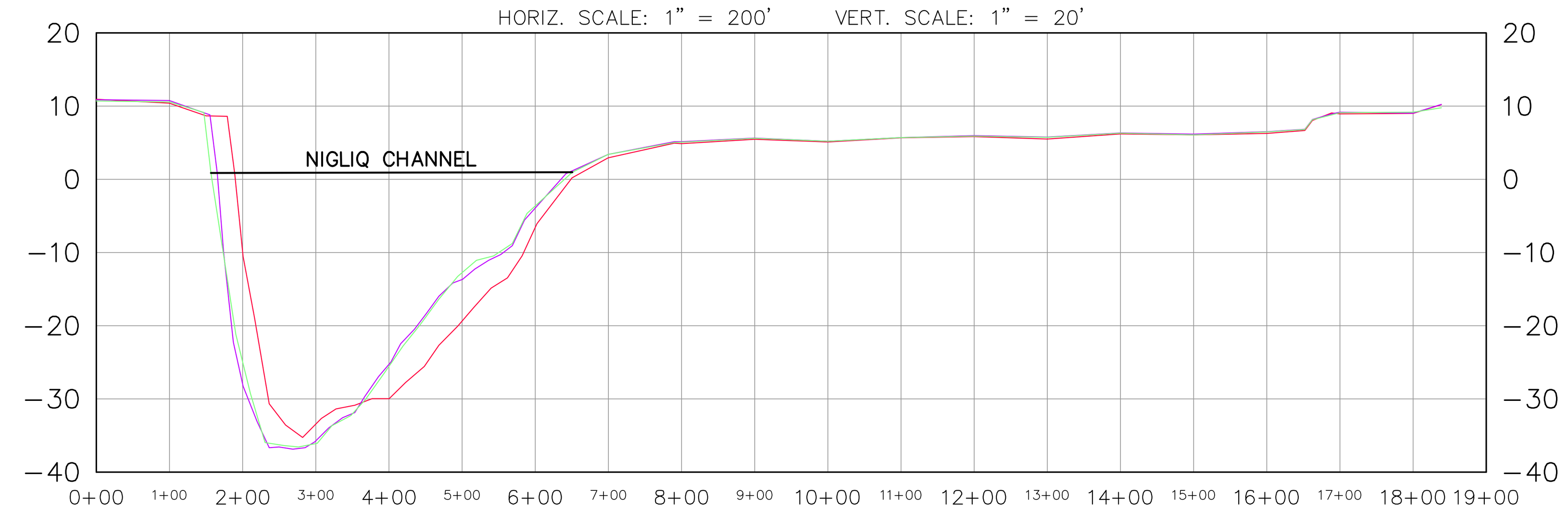
Profile View of Transect-9
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



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

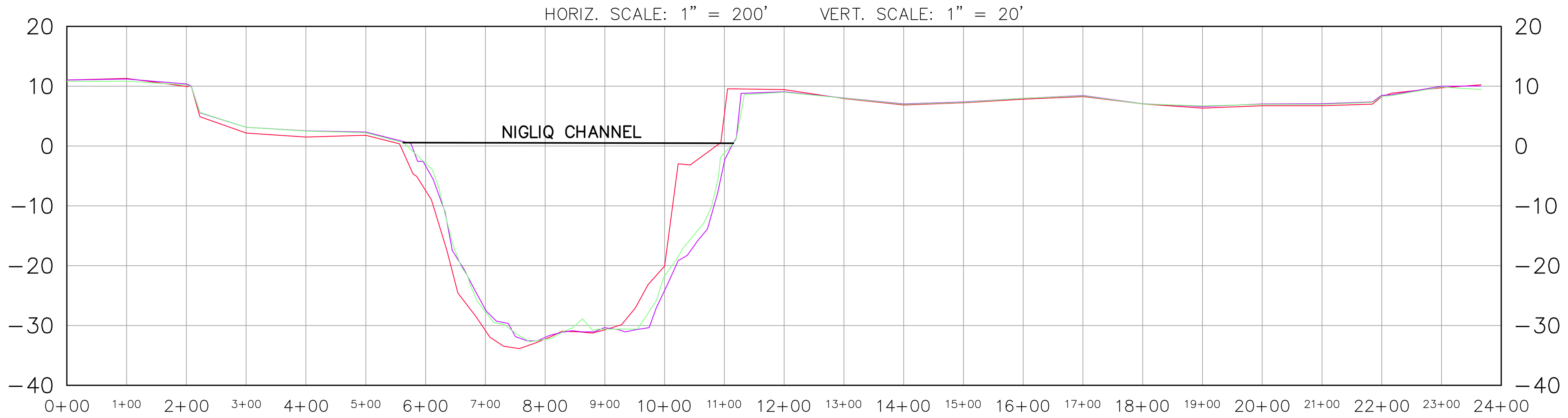


Profile View of Transect-11
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



LEGEND:
VIEW LOOKING DOWNSTREAM
- 2013 TRANSECT PROFLIE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE

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



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

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
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

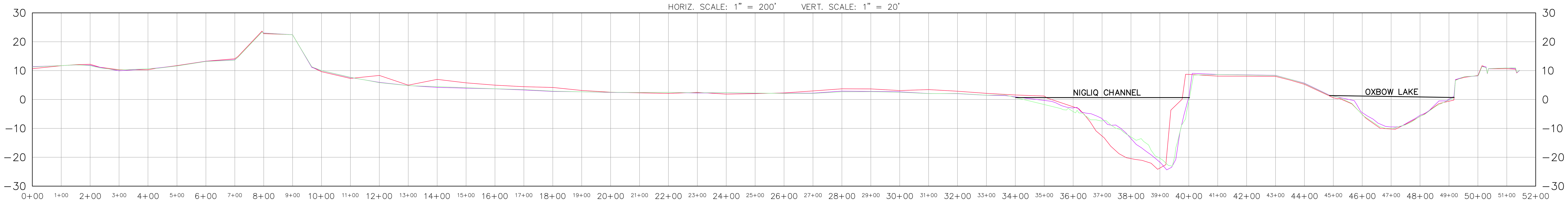
CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	3 of 6	2

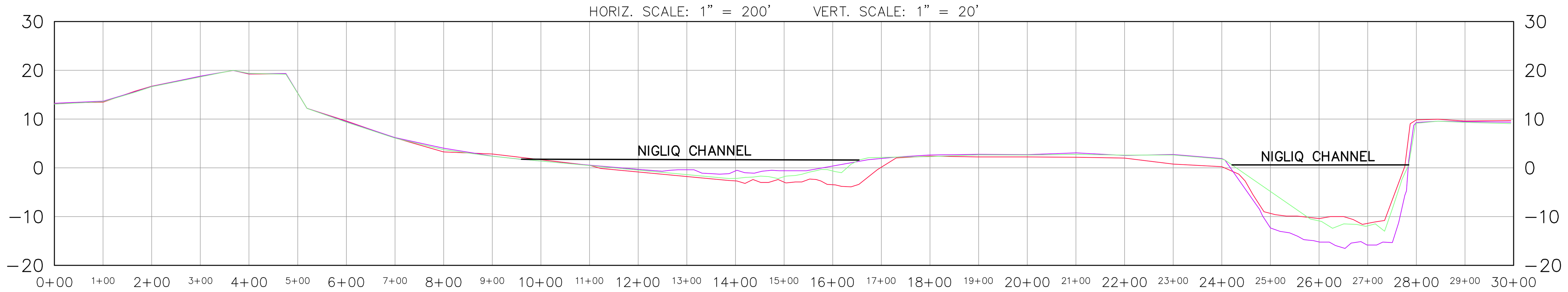
DRAWING NO:	SUB JOB NO:	JOB NO:
CE-CD50-1004	–	–

LEGEND:
VIEW LOOKING DOWNSTREAM
2013 TRANSECT PROFILE
2014 TRANSECT PROFILE
2015 TRANSECT PROFILE
2016 TRANSECT PROFILE
2017 TRANSECT PROFILE

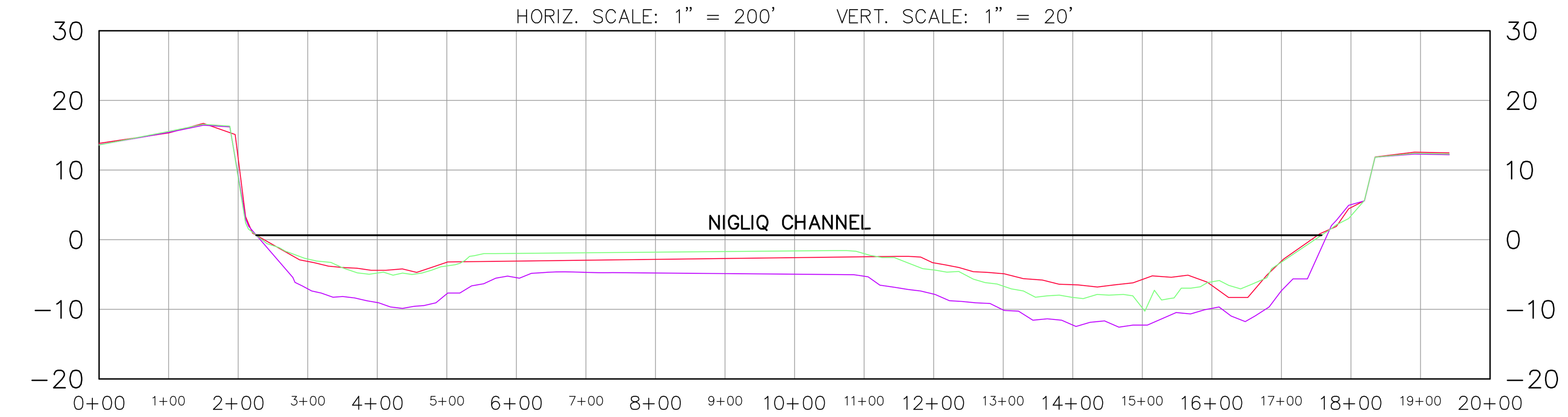
Profile View of Transect-13
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



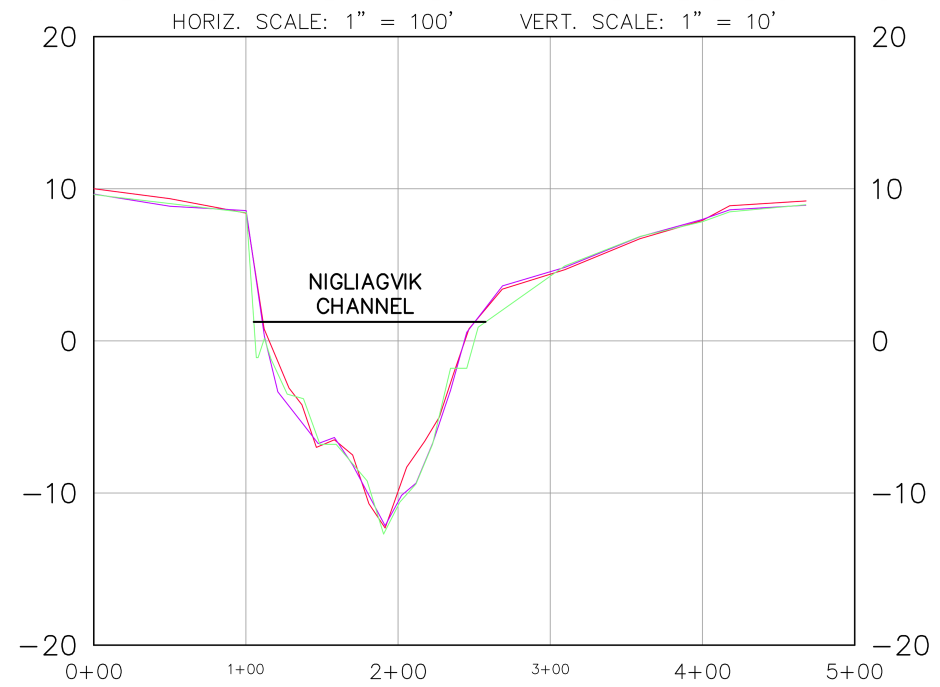
Profile View of Transect-14
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



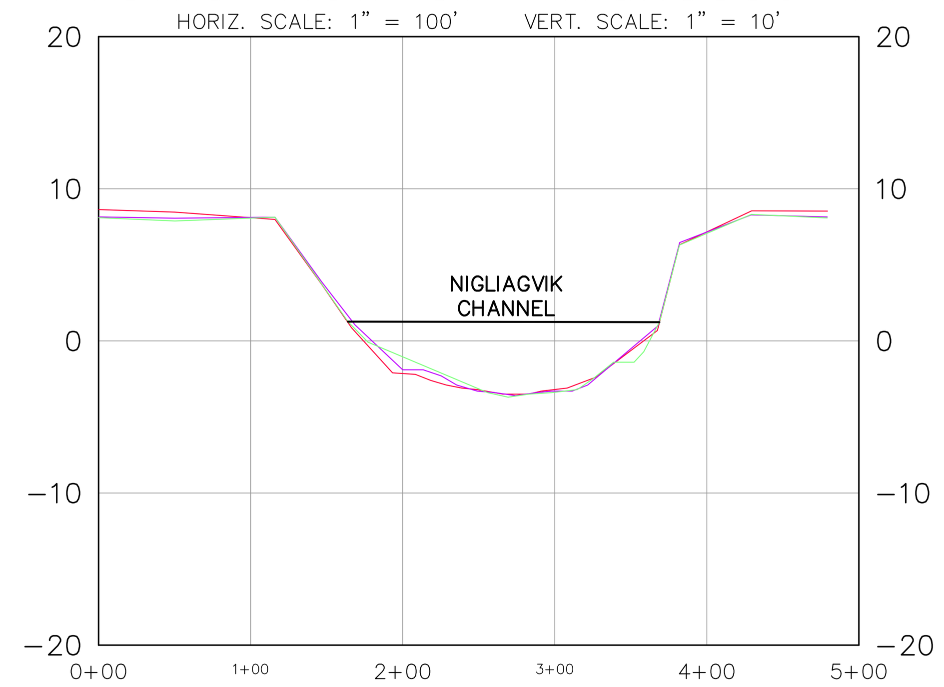
Profile View of Transect-15
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



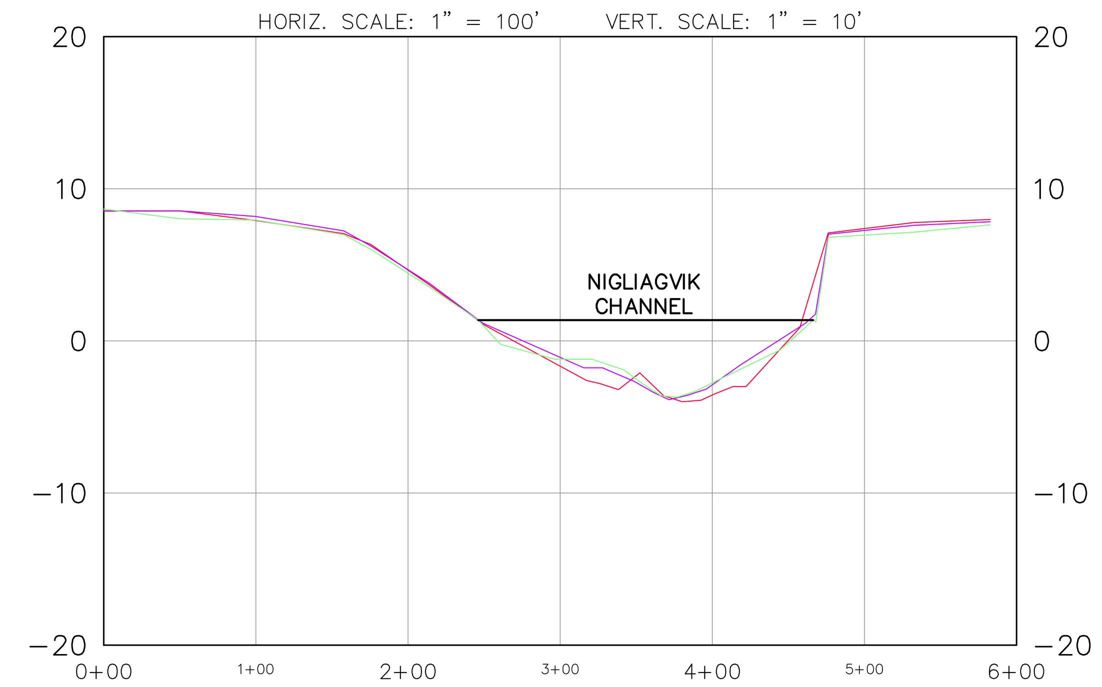
Profile View of Transect-16
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



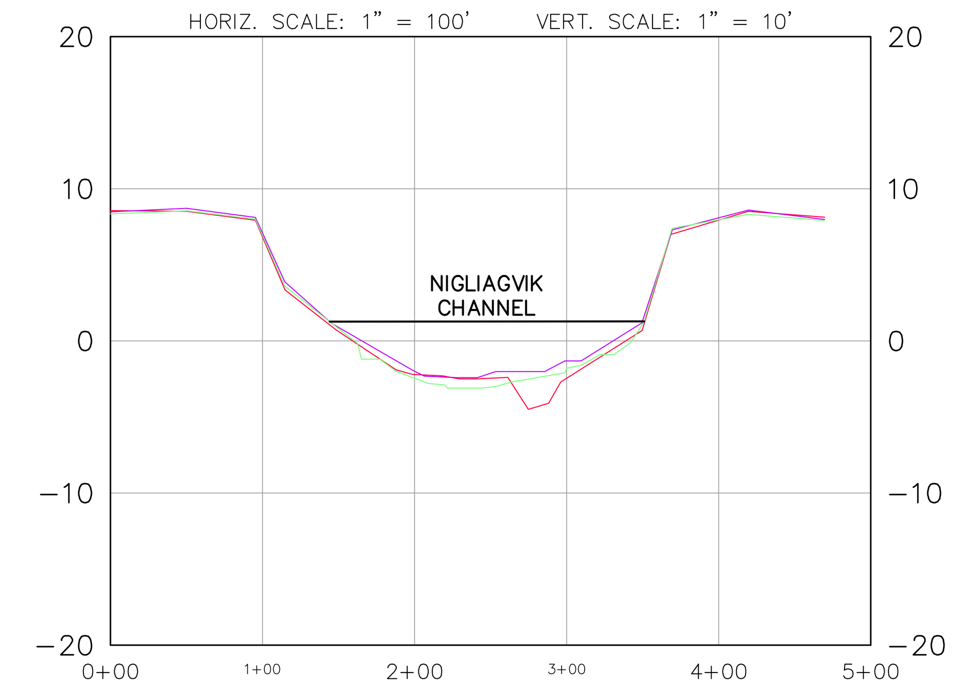
Profile View of Transect-17
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



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
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.

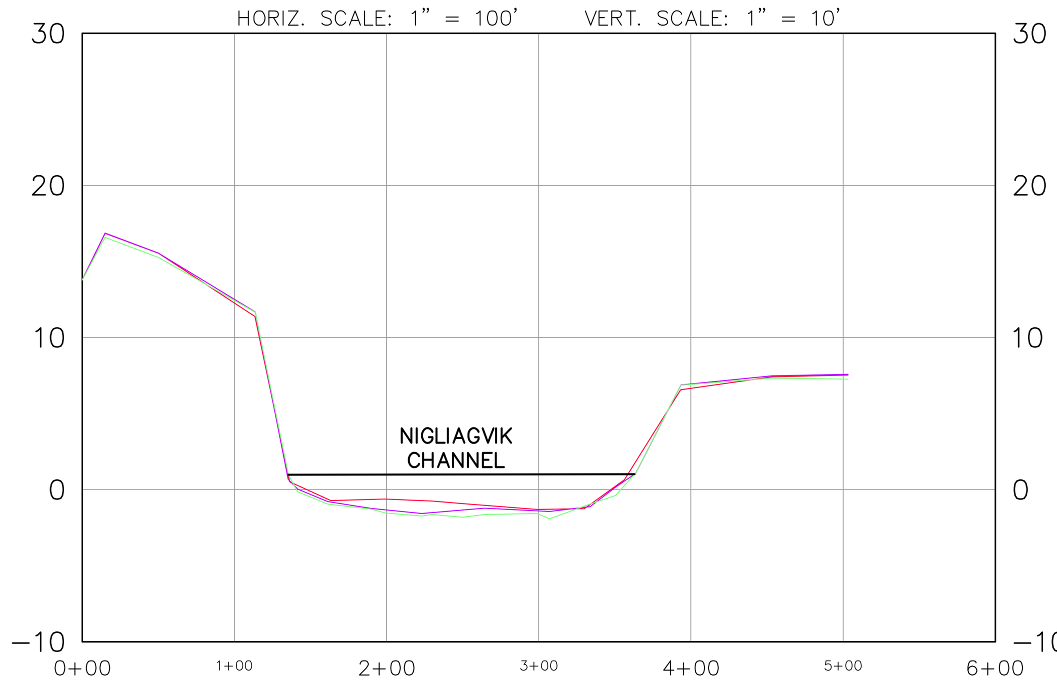
DRAWN: CZ
DESIGN: –
CHECKED: DB
REDRAWN FROM: –
APPROVAL: –

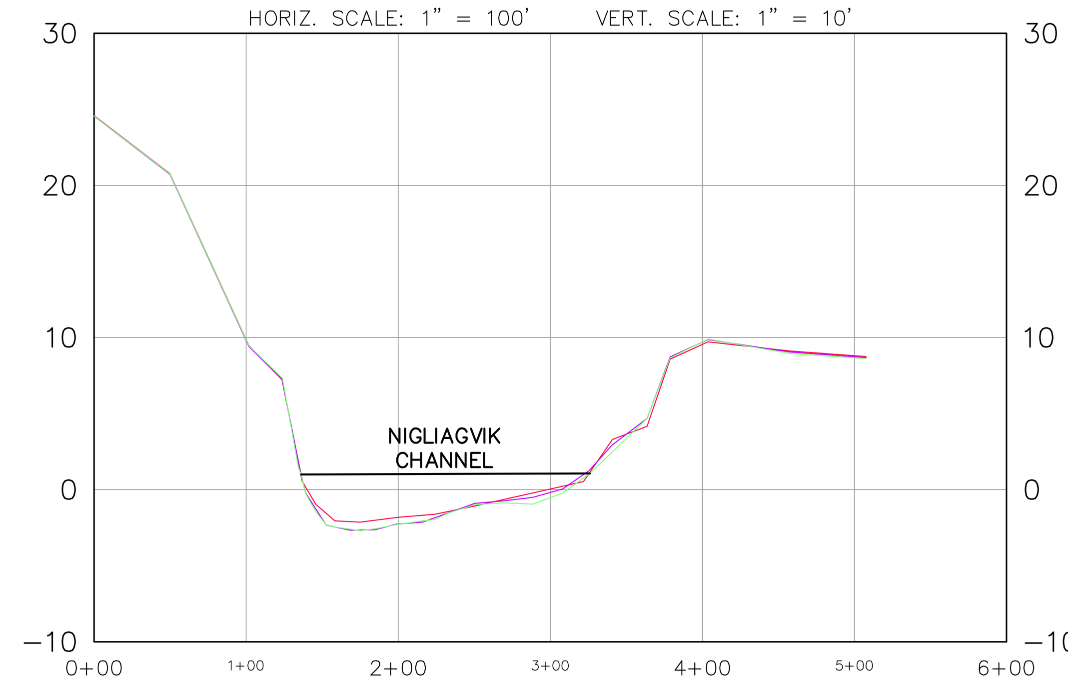
ALPINE
MODULE: CD50
UNIT: CD

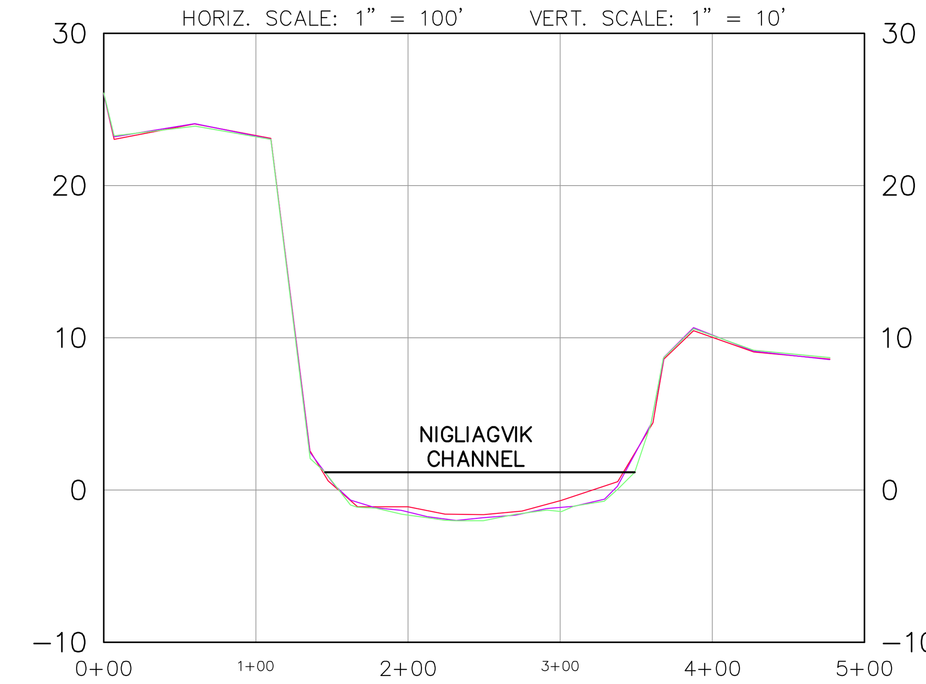
CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

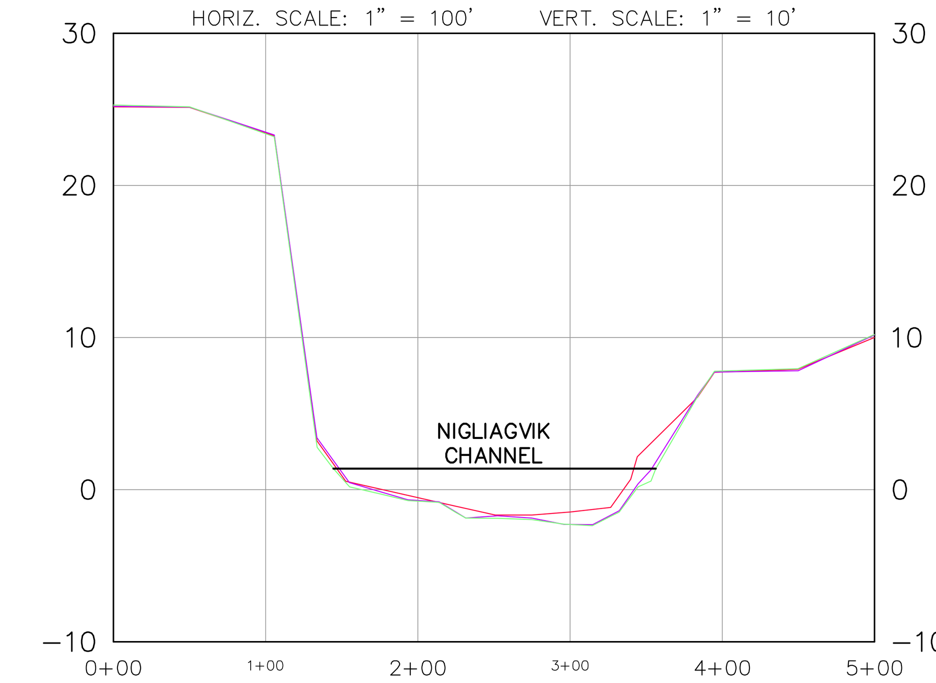
JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	4 of 6	2

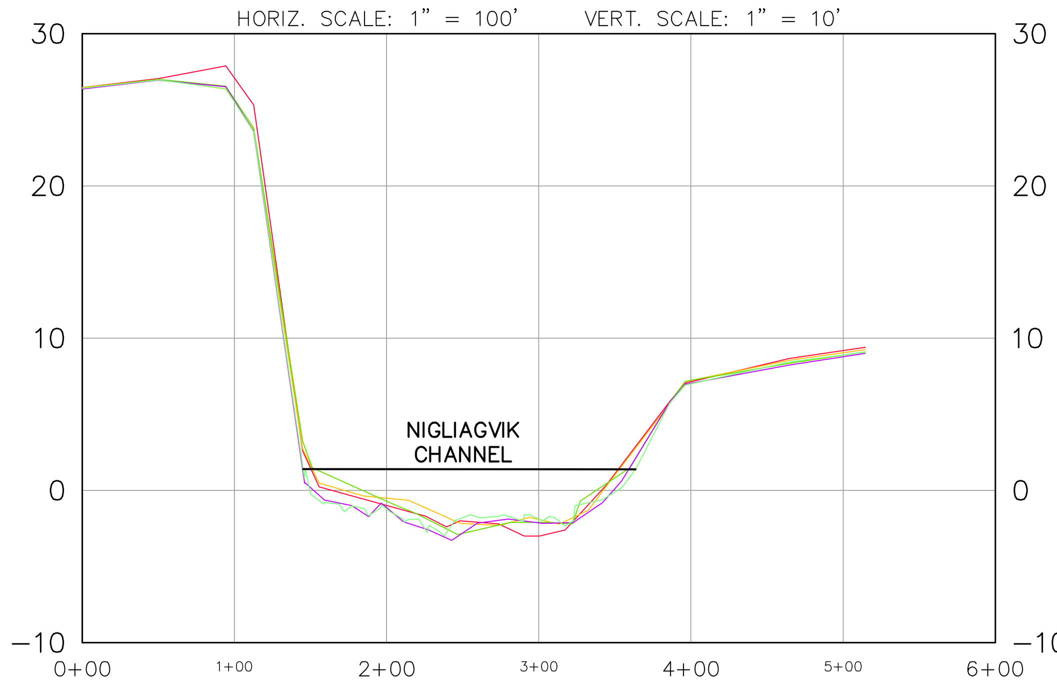
DRAWING NO: CE-CD50-1004 | SUB JOB NO: – | JOB NO: –

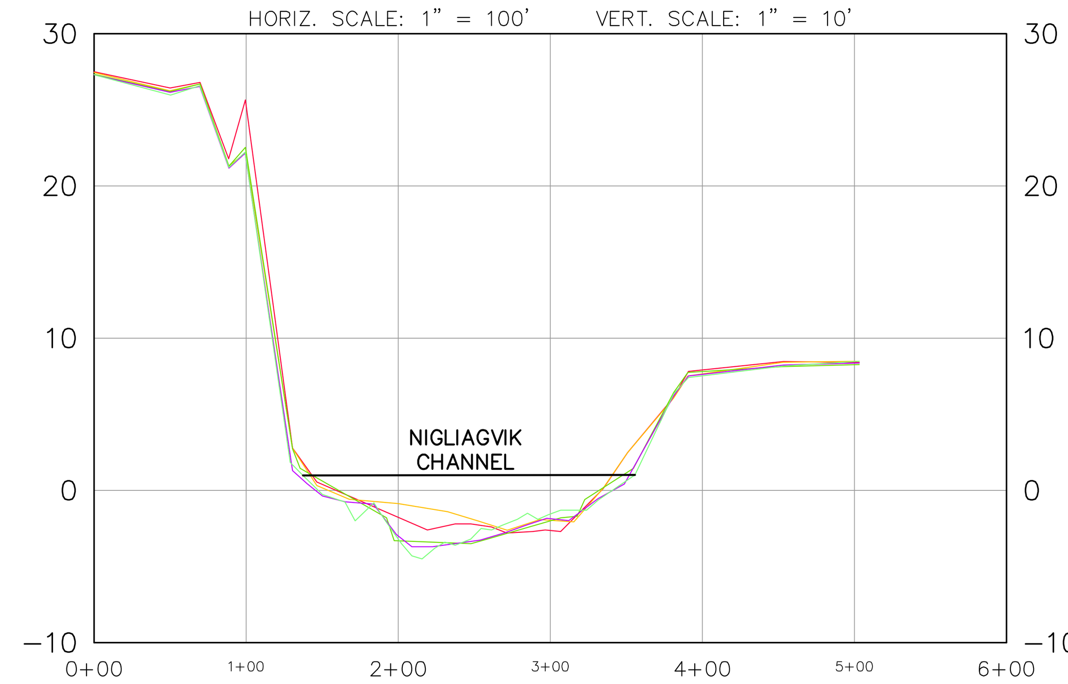
Profile View of Transect-20


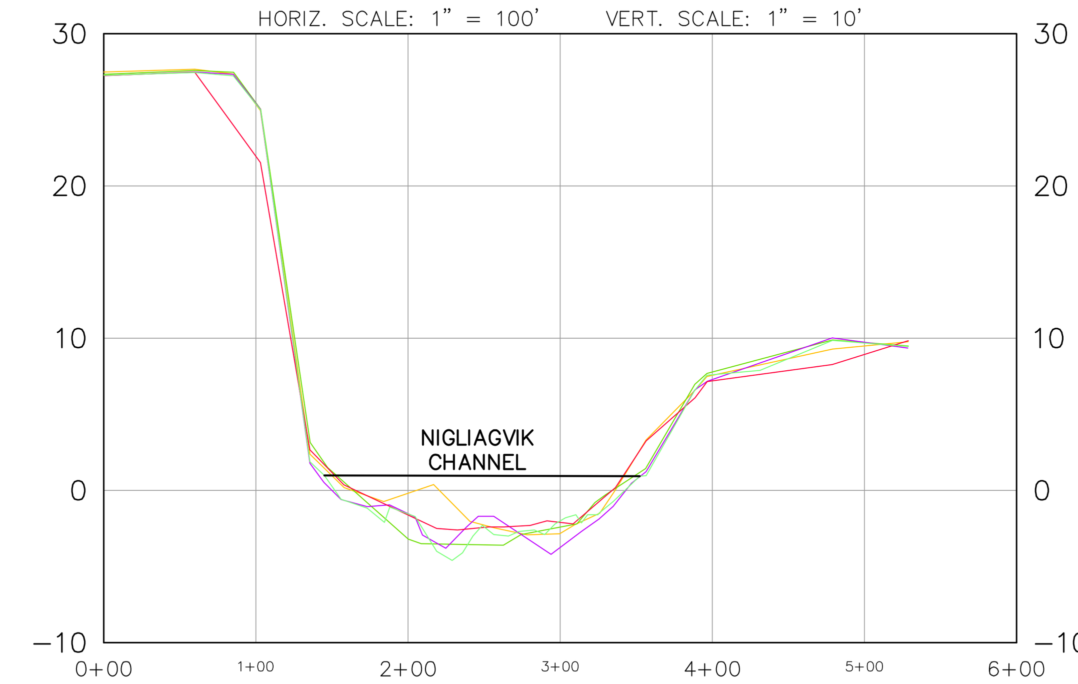
Profile View of Transect-21


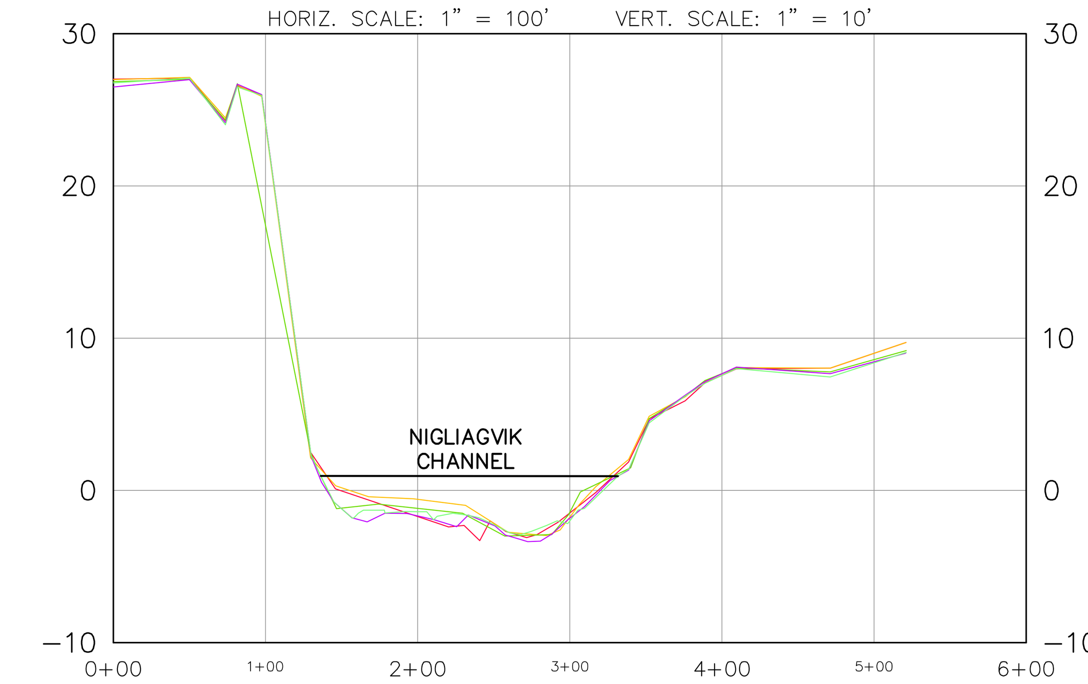
Profile View of Transect-22


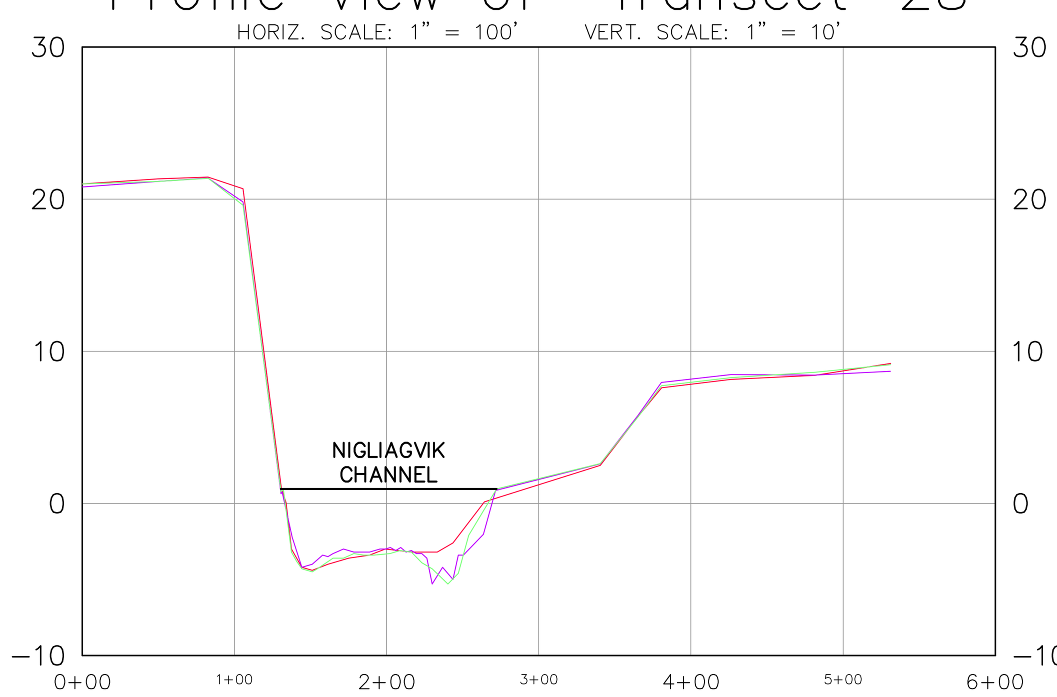
Profile View of Transect-23


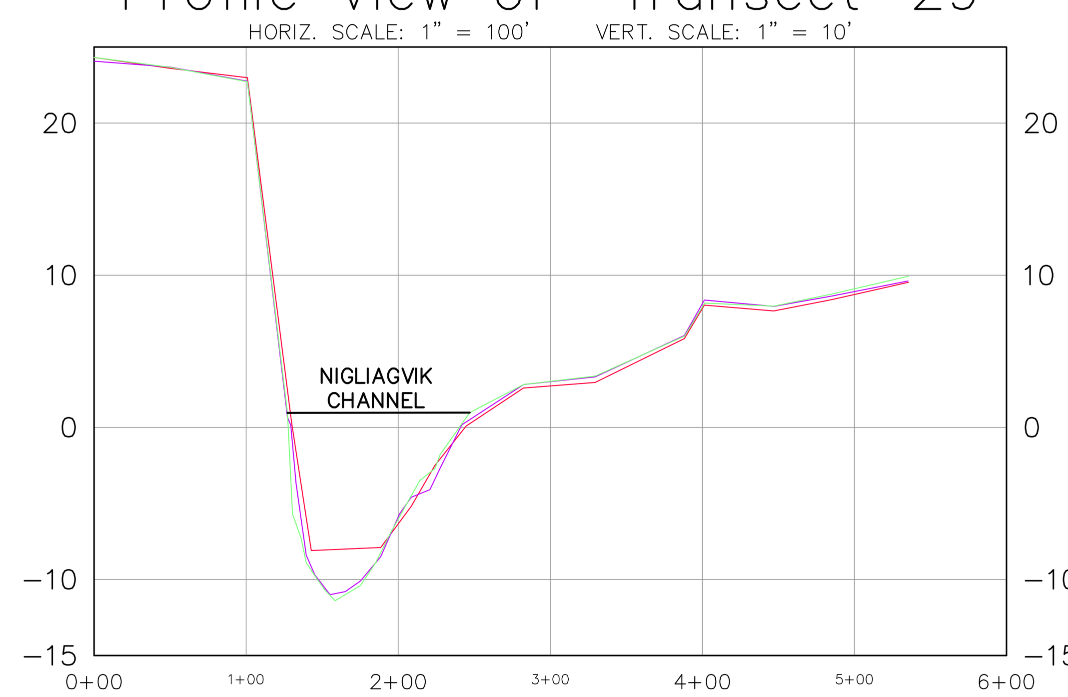
Profile View of Transect-24


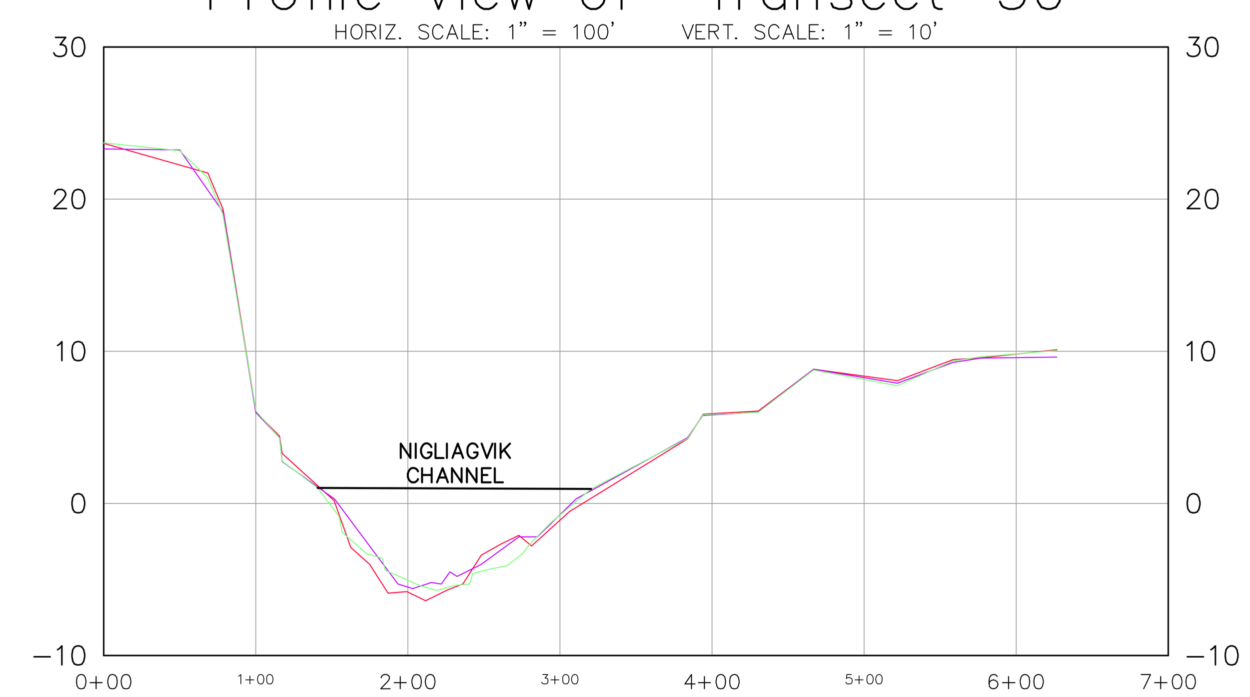
Profile View of Transect-25


Profile View of Transect-26


Profile View of Transect-27


Profile View of Transect-28


Profile View of Transect-29


Profile View of Transect-30


LEGEND:
VIEW LOOKING DOWNSTREAM
- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 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
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: –

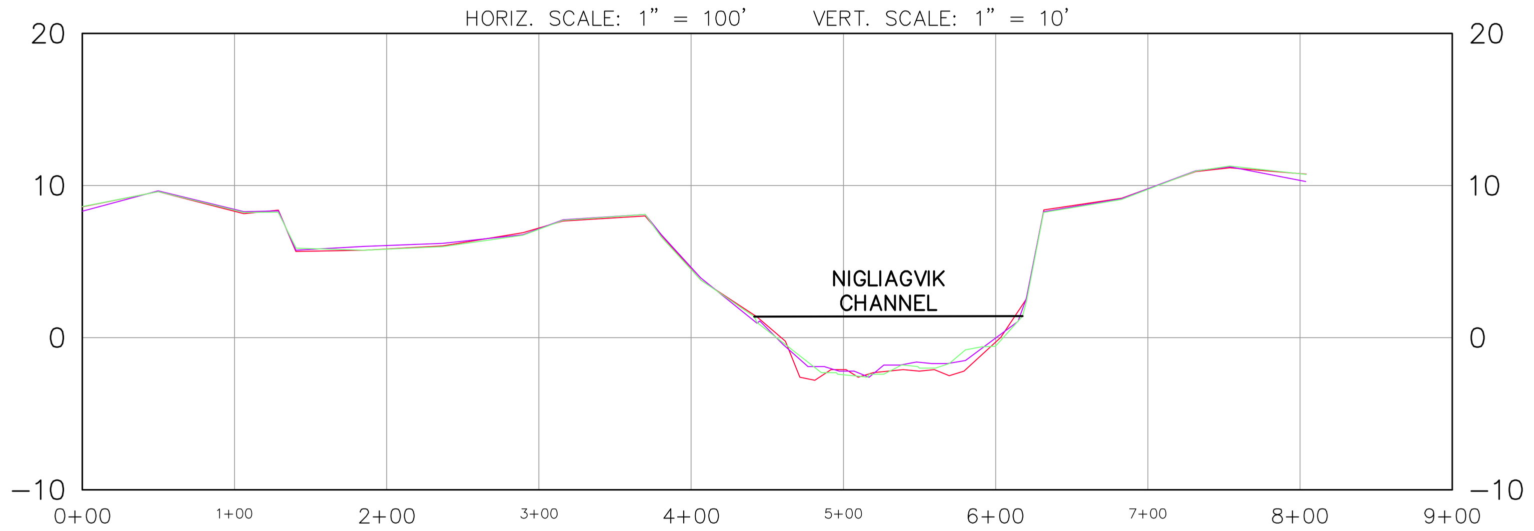
ALPINE | MODULE: CD50 | UNIT: CD

CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

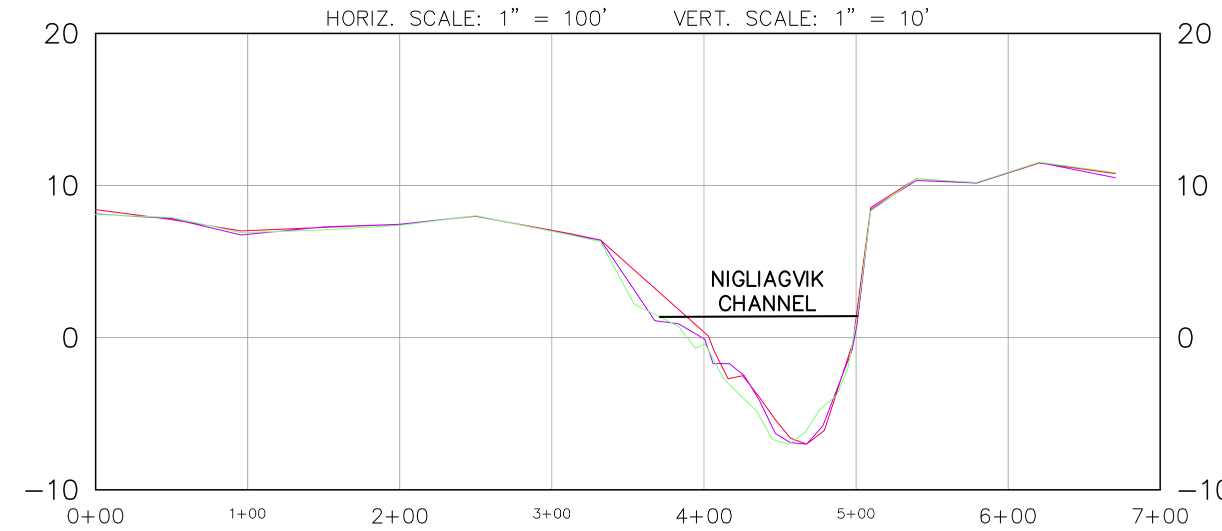
JOB NO:	SUB JOB NO:	DRAWING NO.	PART:	REV:
–	–	CE-CD50-1004	5 of 6	2

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

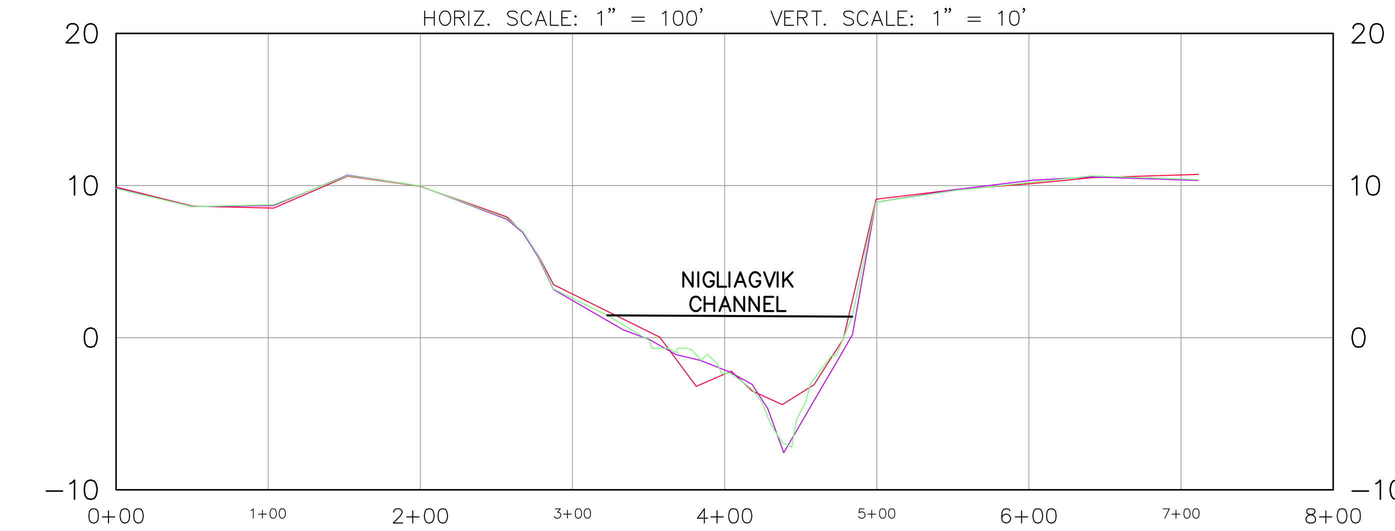
Profile View of Transect-31



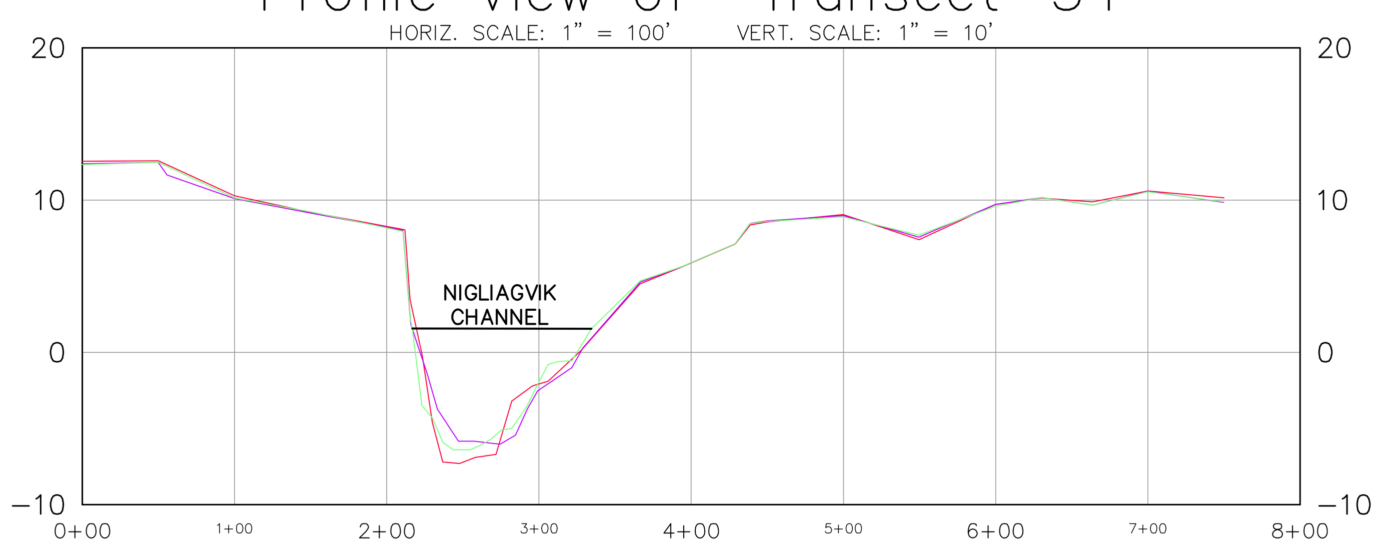
Profile View of Transect-32



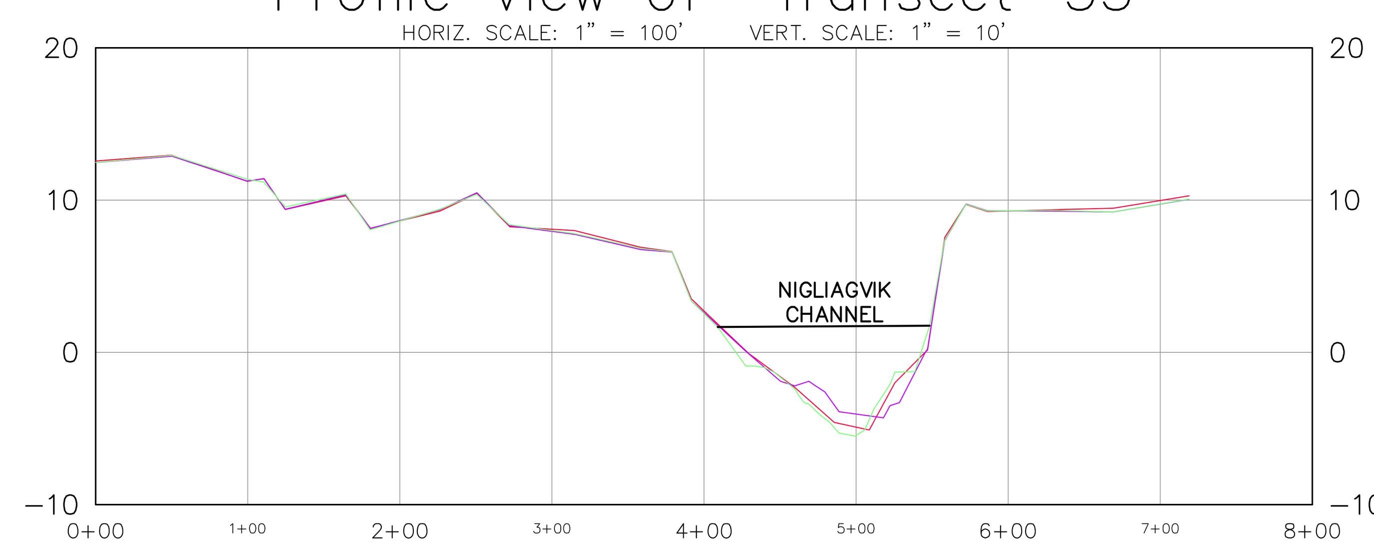
Profile View of Transect-33



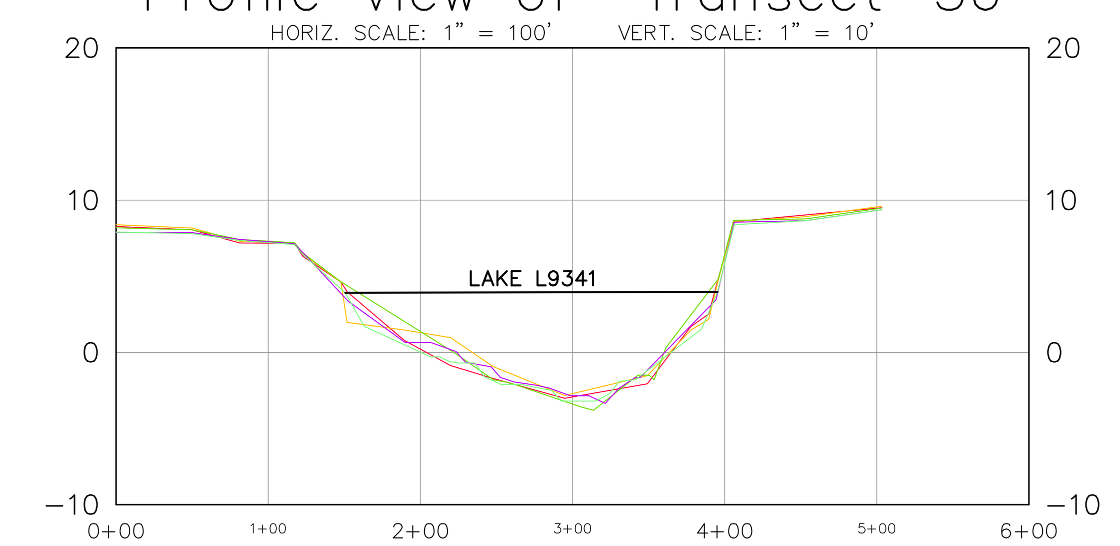
Profile View of Transect-34



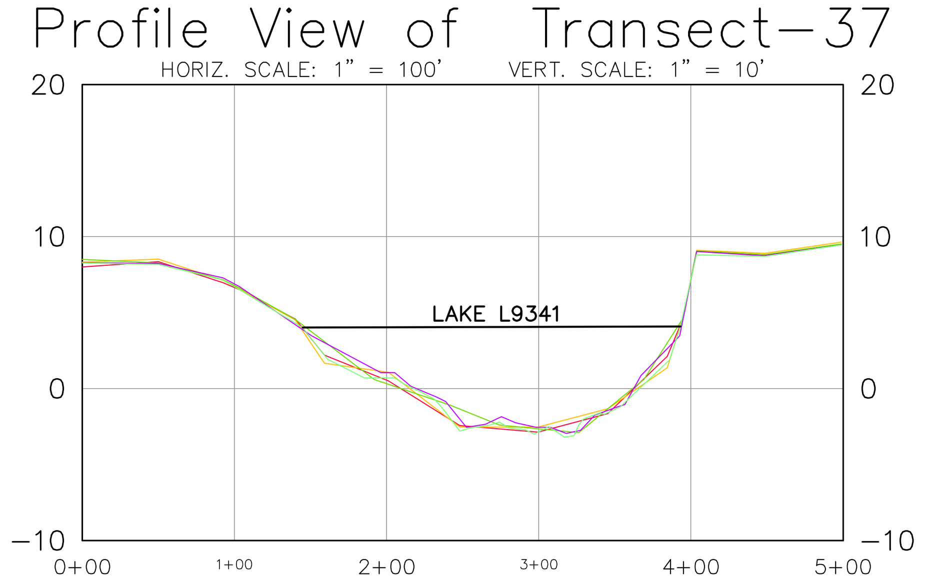
Profile View of Transect-35



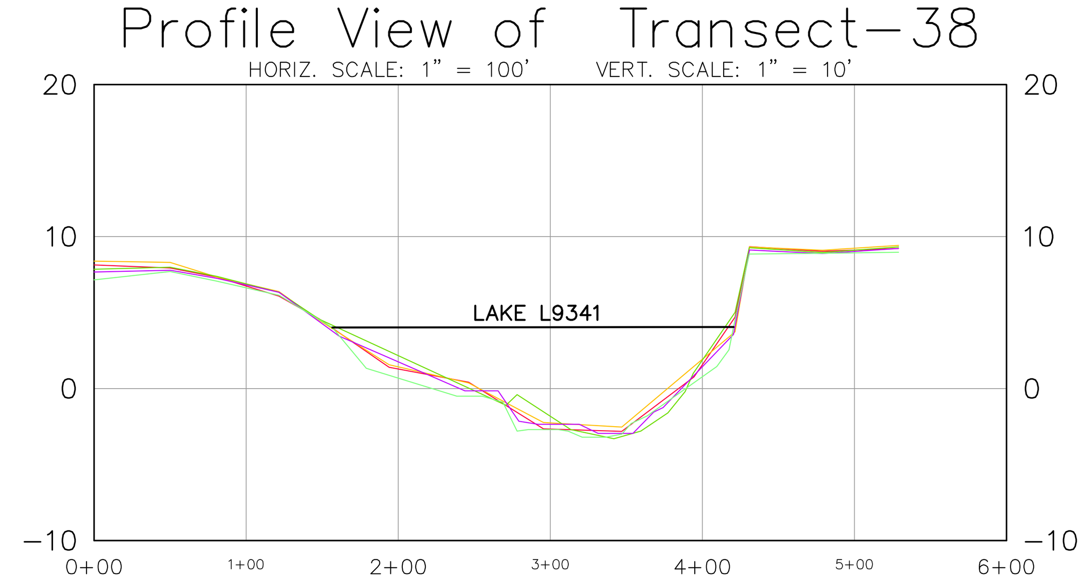
Profile View of Transect-36



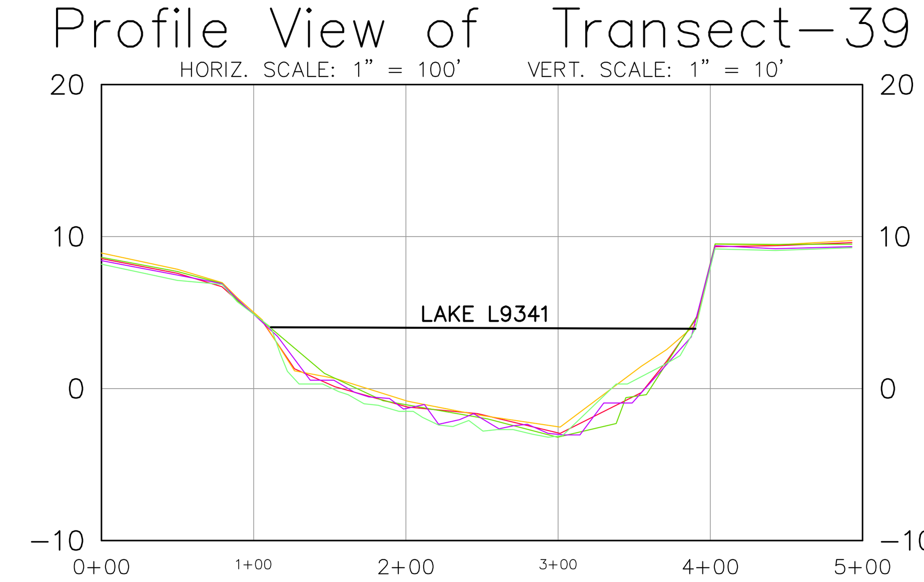
Profile View of Transect-37



Profile View of Transect-38



Profile View of Transect-39



LEGEND:
VIEW LOOKING DOWNSTREAM
- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 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
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	2

E.3.2 NIGLIQ CHANNEL & BRIDGE TABULATED DATA (TRANSECTS 1 – 15)

Calc'd By: CZ
Date: 8/05/2017
RPT-CE-CD-114 REV5

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV5

STATION	2013	2016	2017	DESCRIPTION
0+00	8.4	8.2	8.3	Ground Shot
1+00	8.4	8.5	8.4	Ground Shot
1+50	8.1	-	8.1	Ground Shot
2+00	-	7.3	7.3	Top of Bank
2+05	7.5	-	-	Top of Bank (2013)
2+06	-	1.9	1.6	Toe of Bank
Varies	0.0	0.3	-0.8	Edge of Water
2+24	-5.5	-6.4	-5.5	River Bottom
2+73	-24.2	-24.2	-24.9	River Bottom
3+22	-25.0	-23.2	-24.7	River Bottom
3+71	-21.3	-22.1	-21.9	River Bottom
4+27	-19.0	-21.7	-20.1	River Bottom
4+82	-15.5	-14.2	-15.8	River Bottom
5+31	-10.0	-13.1	-13.1	River Bottom
5+70	-3.7	-6.8	-4.1	River Bottom
Varies	0.1	0.3	-0.1	Edge of Water
7+00	4.2	4.6	4.4	Sand Bar
8+00	5.6	5.0	5.0	Sand Bar
9+00	6.4	7.0	6.6	Sand Bar
10+00	6.8	7.2	6.9	Sand Bar
11+00	7.2	7.5	7.3	Sand Bar
12+00	6.7	7.1	6.7	Sand Bar
13+00	5.9	5.9	5.7	Sand Bar
14+00	2.7	2.3	2.2	Sand Bar
15+00	2.7	2.9	2.8	Sand Bar
16+00	2.4	2.2	2.1	Sand Bar
17+00	1.5	1.0	0.9	Sand Bar
18+00	0.6	0.1	0.1	Sand Bar
Varies	0.3	0.3	0.1	Edge of Water
20+98	-2.9	-2.1	-2.5	River Bottom
21+53	-2.6	-2.6	-3.0	River Bottom
21+96	-2.8	-2.3	-1.9	River Bottom
22+55	-2.8	-2.0	-2.1	River Bottom
23+00	-2.6	-2.0	-1.7	River Bottom
23+59	-2.6	-2.1	-2.0	River Bottom
24+05	-3.4	-1.3	-1.9	River Bottom
Varies	0.3	0.3	0.1	Edge of Water
24+50	7.3	7.3	7.2	Top of Bank
25+02	-	-	9.1	Ground Shot
25+50	8.9	9.2	9.2	Ground Shot
26+51	9.1	9.3	9.1	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev5.xlsx 1 of 22 Transect_01

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

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STATION	2013	2016	2017	DESCRIPTION
0+00	8.9	8.5	8.5	Ground Shot
1+00	8.7	8.6	8.6	Ground Shot
1+50	-	-	7.5	Ground Shot
1+93	-	6.9	5.9	Top of Bank
1+95	7.2	-	-	Top of Bank (2013)
Varies	0.7	0.1	0.7	Edge of Water
2+12	-2.8	-2.7	-3.0	River Bottom
2+35	-3.4	-3.1	-3.9	River Bottom
2+58	-4.3	-4.7	-3.5	River Bottom
2+81	-5.4	-6.1	-5.6	River Bottom
3+10	-7.6	-8.4	-9.2	River Bottom
3+27	-8.1	-13.2	-18.0	River Bottom
3+47	-11.1	-25.2	-22.8	River Bottom
3+67	-21.7	-18.5	-18.1	River Bottom
3+87	-17.6	-16.7	-16.0	River Bottom
4+07	-14.3	-15.1	-14.9	River Bottom
4+27	-13.5	-13.3	-13.2	River Bottom
4+46	-12.2	-11.4	-12.4	River Bottom
4+78	-10.7	-10.7	-12.0	River Bottom
4+98	-9.7	-9.7	-10.4	River Bottom
5+18	-9.3	-8.5	-10.2	River Bottom
5+35	-8.7	-8.0	-9.3	River Bottom
5+55	-8.1	-7.6	-8.8	River Bottom
5+81	-7.6	-7.4	-8.1	River Bottom
6+01	-7.1	-6.8	-7.5	River Bottom
6+24	-6.3	-6.1	-7.2	River Bottom
6+44	-5.9	-5.5	-6.5	River Bottom
6+64	-5.5	-5.0	-5.9	River Bottom
6+83	-4.7	-4.4	-5.5	River Bottom
7+03	-4.9	-3.7	-5.5	River Bottom
7+23	-4.0	-3.9	-5.4	River Bottom
7+55	-3.4	-3.5	-4.3	River Bottom
7+75	-2.7	-2.4	-3.7	River Bottom
7+92	-2.5	-2.1	-3.7	River Bottom
8+09	-2.2	-1.8	-3.3	River Bottom
8+38	-1.9	-1.3	-2.6	River Bottom
8+55	-2.1	-1.0	-2.2	River Bottom
Varies	0.8	0.2	0.7	Edge of Water
10+00	1.8	1.3	1.3	Sand Bar
11+00	1.9	1.6	1.7	Sand Bar
12+00	2.0	2.6	2.3	Sand Bar
13+00	2.2	2.8	2.6	Sand Bar
14+00	2.0	2.8	2.7	Sand Bar
15+00	2.1	2.6	2.6	Sand Bar
16+00	1.9	2.3	2.2	Sand Bar
17+00	1.6	2.1	2.0	Sand Bar
18+00	1.3	0.1	0.5	Sand Bar
19+00	0.8	0.9	0.9	Sand Bar
Varies	0.8	0.0	-0.3	Edge of Water
20+84	-2.4	-1.6	-1.6	River Bottom
21+07	-2.5	-2.0	-2.0	River Bottom
21+36	-2.1	-2.6	-2.5	River Bottom
21+53	-2.5	-2.9	-3.6	River Bottom

Doc LCMF-156 CD5 Bridge Transects Rev5.xlsx 2 of 22 Transect_02

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

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV4

STATION	2013	2016	2017	DESCRIPTION
21+72	-2.9	-3.4	-3.5	River Bottom
21+85	-2.9	-3.3	-3.0	River Bottom
22+01	-4.1	-3.0	-3.0	River Bottom
22+21	-4.7	-4.0	-3.4	River Bottom
22+38	-5.6	-4.6	-4.2	River Bottom
22+55	-6.2	-4.6	-5.0	River Bottom
22+75	-4.6	-5.5	-5.6	River Bottom
Varies	0.7	0.0	0.2	Edge of Water
23+13	-	0.8	0.5	Toe of Bank
23+16	1.8	-	-	Toe of Bank (2103)
23+24	7.8	7.8	-	Top of Bank (2016)
23+26	-	-	7.5	Top of Bank
23+90	8.6	8.7	8.9	Ground Shot
24+50	9.0	9.1	8.9	Ground Shot
25+40	9.3	9.4	9.2	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	10.0	9.5	9.6	Ground Shot
1+00	10.8	10.7	10.8	Ground Shot
2+00	11.4	11.3	11.4	Ground Shot
2+17	11.1	11.0	11.0	Top of Bank
2+47	6.4	6.3	6.3	Toe of Bank
3+00	6.4	6.5	6.5	Ground Shot
4+00	7.6	7.7	7.7	Ground Shot
5+00	6.8	7.0	6.9	Ground Shot
5+25	6.1	6.0	6.0	Top of Bank
5+74	1.7	2.0	2.0	Toe of Bank
6+00	1.5	1.9	1.7	Sand Bar
7+00	3.2	3.9	4.0	Sand Bar
8+00	4.8	4.6	4.6	Sand Bar
9+00	5.6	5.8	5.8	Sand Bar
9+27	5.7	5.1	4.9	Top of Bank
9+40	2.0	4.2	3.9	Toe of Bank
Varies	0.2	0.8	0.4	Edge of Water
10+85	-2.2	-1.0	-2.2	River Bottom
10+95	-2.2	-1.3	-2.6	River Bottom
11+07	-2.3	-1.6	-3.1	River Bottom
11+17	-3.1	-1.9	-3.5	River Bottom
11+31	-3.8	-2.3	-4.1	River Bottom
11+44	-4.3	-3.9	-4.6	River Bottom
11+60	-5.0	-4.9	-5.8	River Bottom
11+85	-6.1	-5.6	-6.5	River Bottom
12+07	-6.8	-6.7	-7.7	River Bottom
12+23	-7.3	-7.0	-7.6	River Bottom
12+48	-7.4	-6.8	-7.4	River Bottom
12+72	-7.4	-6.7	-7.0	River Bottom
12+89	-7.4	-6.4	-6.7	River Bottom
13+15	-7.4	-6.3	-6.8	River Bottom
13+40	-7.3	-6.3	-7.6	River Bottom
13+64	-7.5	-6.3	-7.3	River Bottom
13+81	-7.4	-6.8	-6.9	River Bottom
14+07	-7.3	-6.7	-6.9	River Bottom
14+32	-6.9	-6.3	-7.2	River Bottom
14+48	-6.6	-7.0	-7.0	River Bottom
14+75	-7.9	-5.6	-7.3	River Bottom
14+99	-8.2	-6.0	-7.6	River Bottom
15+16	-8.2	-5.9	-7.2	River Bottom
15+42	-8.3	-7.2	-7.3	River Bottom
15+61	-8.0	-7.3	-7.6	River Bottom
15+86	-8.5	-7.0	-8.1	River Bottom
16+02	-8.6	-7.3	-8.7	River Bottom
16+27	-8.5	-7.6	-8.8	River Bottom
16+51	-8.9	-7.3	-8.6	River Bottom
16+75	-8.3	-7.9	-8.4	River Bottom
16+98	-8.6	-8.2	-8.8	River Bottom
17+14	-8.2	-8.8	-9.2	River Bottom
17+39	-7.7	-8.7	-9.8	River Bottom
17+63	-7.5	-8.7	-10.2	River Bottom
17+85	-7.6	-9.5	-10.5	River Bottom
18+02	-7.1	-10.0	-10.7	River Bottom

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STATION	2013	2016	2017	DESCRIPTION
18+28	-7.7	-9.8	-10.4	River Bottom
18+53	-7.4	-8.8	-9.6	River Bottom
18+69	-7.7	-8.3	-8.6	River Bottom
18+96	-8.0	-7.6	-8.0	River Bottom
19+12	-6.9	-7.0	-7.4	River Bottom
19+37	-6.6	-5.7	-6.6	River Bottom
19+53	-7.0	-6.1	-6.8	River Bottom
19+80	-7.1	-6.0	-7.0	River Bottom
20+04	-7.0	-5.8	-7.2	River Bottom
20+19	-7.4	-5.6	-7.1	River Bottom
20+43	-7.6	-7.0	-7.5	River Bottom
20+60	-6.0	-6.9	-7.9	River Bottom
20+82	-5.6	-6.0	-6.8	River Bottom
21+04	-5.2	-5.4	-6.2	River Bottom
21+19	-4.9	-5.4	-6.0	River Bottom
21+31	-3.8	-4.8	-6.0	River Bottom
21+50	-2.2	-1.9	-4.1	River Bottom
Varies	-0.4	0.9	0.2	Edge of Water
22+21	0.4	-	-	Toe of Bank (2013)
22+22	-	1.0	0.8	Toe of Bank
22+32	8.2	-	-	Top of Bank (2013)
22+35	-	9.0	8.8	Top of Bank
23+00	8.2	8.7	8.9	Ground Shot
23+22	9.2	10.0	9.8	Top of Bank
23+36	8.1	8.5	8.5	Toe of Bank
23+76	7.9	8.9	8.7	Toe of Bank
24+15	10.7	11.5	11.5	Top of Bank
24+22	8.9	9.4	9.3	Toe of Bank

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STATION	2013	2016	2017	DESCRIPTION
0+00	12.2	12.6	12.4	Ground Shot
1+00	12.8	13.0	13.0	Ground Shot
2+00	14.2	14.4	14.5	Ground Shot
3+00	16.1	16.2	16.3	Ground Shot
3+91	14.7	15.2	15.2	Top of Bank
4+24	11.5	11.6	11.6	Toe of Bank
5+00	12.1	12.1	12.1	Ground Shot
5+12	12.4	12.4	12.3	Top of Bank
5+49	8.6	8.7	8.8	Toe of Bank
5+74	8.3	8.4	8.5	Toe of Bank
5+83	10.7	10.9	10.8	Top of Bank
5+91	10.7	11.0	10.9	Top of Bank
6+04	8.2	8.6	8.6	Toe of Bank
6+47	7.5	8.0	8.1	Toe of Bank
6+59	9.7	9.2	9.1	Top of Bank
7+05	8.0	7.9	8.1	Top of Bank
7+31	5.3	5.9	5.8	Toe of Bank
8+00	4.9	5.3	5.1	Sand Bar
9+00	4.2	4.9	4.7	Sand Bar
10+00	4.7	3.3	3.4	Sand Bar
11+00	4.5	3.8	3.6	Sand Bar
12+00	3.9	4.5	3.9	Sand Bar
13+00	3.0	3.3	3.3	Sand Bar
14+00	2.8	2.2	2.8	Sand Bar
15+00	3.1	3.0	2.9	Sand Bar
16+00	3.2	2.3	2.2	Sand Bar
Varies	-0.1	1.0	1.0	Edge of Water
16+70	-3.1	-0.7	-1.6	River Bottom
16+84	-6.0	-1.7	-3.4	River Bottom
17+01	-8.6	-4.0	-8.6	River Bottom
17+18	-12.4	-5.8	-12.4	River Bottom
17+42	-15.3	-11.4	-12.4	River Bottom
17+63	-16.5	-14.5	-15.3	River Bottom
17+80	-15.7	-15.7	-16.2	River Bottom
18+00	-16.4	-15.5	-16.2	River Bottom
18+21	-17.6	-16.3	-17.3	River Bottom
18+36	-19.2	-17.4	-18.4	River Bottom
18+55	-19.3	-18.9	-19.9	River Bottom
18+79	-19.9	-19.7	-20.2	River Bottom
18+96	-20.3	-20.1	-20.7	River Bottom
19+13	-19.4	-20.8	-21.0	River Bottom
19+37	-20.2	-21.2	-21.6	River Bottom
19+54	-21.1	-22.1	-21.8	River Bottom
19+75	-21.3	-22.6	-22.6	River Bottom
19+92	-20.9	-22.9	-22.9	River Bottom
20+12	-20.4	-22.4	-22.8	River Bottom
20+29	-20.2	-21.9	-22.3	River Bottom
20+48	-19.9	-21.8	-21.8	River Bottom
20+65	-19.7	-20.8	-20.8	River Bottom
20+84	-18.6	-19.3	-19.8	River Bottom
21+06	-15.1	-18.1	-18.0	River Bottom
21+15	-10.4	-15.9	-17.3	River Bottom
Varies	-0.2	1.1	0.2	Edge of Water

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STATION	2013	2016	2017	DESCRIPTION
21+91	2.1	1.5	2.0	Toe of Bank
21+98	10.1	9.3	9.3	Top of Bank
22+53	-	-	10.2	Ground Shot
23+00	10.7	10.8	10.8	Ground Shot
24+03	10.4	10.3	10.4	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	11.9	11.9	11.9	Ground Shot
1+00	12.0	12.1	12.0	Ground Shot
2+00	15.5	15.5	15.5	Ground Shot
3+00	16.1	16.0	16.0	Ground Shot
4+00	15.4	15.4	15.4	Ground Shot
4+56	17.2	17.1	17.0	Top of Bank
4+65	14.2	14.2	14.1	Toe of Bank
4+81	14.3	14.1	14.1	Toe of Bank
5+01	18.9	-	-	Top of Bank (2013)
5+08	18.5	18.2	18.2	Top of Bank
5+36	13.6	13.4	13.3	Toe of Bank
5+82	15.9	15.7	15.6	Top of Bank
6+16	12.6	12.5	12.4	Toe of Bank
6+92	13.0	12.9	13.4	Top of Bank
7+20	7.8	7.8	7.5	Toe of Bank
8+00	5.9	6.3	6.5	Sand Bar
9+00	5.6	5.7	5.6	Sand Bar
10+00	6.1	5.6	5.6	Sand Bar
11+00	5.7	5.3	5.1	Sand Bar
12+00	4.4	3.7	3.7	Sand Bar
13+00	3.0	3.1	3.1	Sand Bar
14+00	2.5	2.3	2.2	Sand Bar
15+00	2.4	1.1	1.1	Sand Bar
16+00	1.9	1.4	1.3	Sand Bar
17+00	2.0	2.1	2.1	Sand Bar
18+00	1.6	2.3	2.3	Sand Bar
19+00	1.0	1.6	1.6	Sand Bar
20+00	1.2	0.5	0.3	Sand Bar
21+00	0.6	0.8	0.8	Sand Bar
Varies	-0.5	0.8	0.8	Edge of Water
21+62	-6.1	-3.5	-3.5	River Bottom
21+79	-8.2	-4.4	-4.8	River Bottom
21+96	-8.4	-6.8	-5.8	River Bottom
22+17	-9.5	-8.3	-8.0	River Bottom
22+36	-11.3	-9.7	-10.7	River Bottom
22+53	-12.1	-11.0	-11.7	River Bottom
22+73	-15.1	-14.3	-13.4	River Bottom
22+93	-16.8	-16.0	-15.6	River Bottom
23+13	-19.1	-17.5	-17.3	River Bottom
23+30	-21.4	-18.9	-18.8	River Bottom
23+49	-22.4	-20.2	-20.5	River Bottom
23+73	-22.5	-21.1	-22.2	River Bottom
23+93	-22.2	-23.4	-23.3	River Bottom
24+10	-22.4	-24.0	-23.1	River Bottom
24+29	-22.2	-23.7	-23.5	River Bottom
24+53	-23.4	-23.2	-23.2	River Bottom
24+70	-23.3	-24.3	-23.3	River Bottom
24+87	-20.5	-24.5	-23.9	River Bottom
25+04	-21.6	-24.0	-24.2	River Bottom
25+18	-20.5	-24.1	-23.8	River Bottom
25+30	-16.9	-23.6	-23.4	River Bottom
25+47	-8.2	-21.3	-23.6	River Bottom
Varies	-0.5	0.8	-0.5	Edge of Water

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STATION	2013	2016	2017	DESCRIPTION
25+87	8.5	-	-	Top of Bank (2013)
26+11	-	8.6	-	Top of Bank (2016)
26+17	-	-	8.5	Top of Bank
27+00	8.6	8.5	8.5	Ground Shot
27+70	8.7	8.7	8.6	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	11.4	11.6	11.5	Ground Shot
1+00	11.0	11.1	11.1	Ground Shot
2+00	14.0	13.9	14.0	Ground Shot
3+00	15.3	15.2	15.4	Ground Shot
3+42	17.1	16.9	16.8	Top of Bank
3+59	12.5	12.3	12.4	Toe of Bank
4+08	14.8	14.6	14.7	Top of Bank
4+23	11.1	11.1	11.0	Toe of Bank
4+96	12.3	12.2	12.2	Top of Bank
5+11	9.8	9.8	9.8	Toe of Bank
5+81	7.8	7.7	7.7	Top of Bank
6+31	1.1	0.4	0.5	Edge of Water/Toe of Bank
7+00	-0.3	-0.5	-0.5	Sand Bar
8+00	0.5	0.0	0.1	Sand Bar
9+00	1.0	0.0	0.0	Sand Bar
10+00	1.4	0.3	0.4	Sand Bar
11+00	1.8	1.0	1.1	Sand Bar
12+00	2.3	1.1	0.8	Sand Bar
13+00	2.0	0.5	0.4	Sand Bar
Varies	-0.2	0.5	0.4	Edge of Water
14+68	-3.3	-1.5	-2.1	River Bottom
14+78	-3.1	-1.7	-2.2	River Bottom
14+94	-2.8	-1.9	-2.3	River Bottom
15+14	-2.4	-2.1	-2.5	River Bottom
15+34	-2.8	-2.3	-2.7	River Bottom
15+49	-2.6	-2.5	-2.9	River Bottom
15+72	-2.9	-2.8	-3.1	River Bottom
15+95	-3.5	-3.1	-3.3	River Bottom
16+15	-3.3	-3.5	-3.5	River Bottom
16+38	-3.8	-3.5	-3.7	River Bottom
16+61	-4.1	-4.4	-3.9	River Bottom
16+87	-4.1	-5.4	-7.3	River Bottom
17+06	-4.8	-5.6	-7.7	River Bottom
17+29	-5.3	-5.6	-9.2	River Bottom
17+55	-7.2	-8.0	-9.1	River Bottom
17+82	-10.0	-10.2	-12.5	River Bottom
18+08	-13.4	-12.2	-15.7	River Bottom
18+31	-17.8	-16.2	-19.7	River Bottom
18+57	-19.9	-17.4	-20.8	River Bottom
18+80	-20.3	-19.8	-22.0	River Bottom
19+02	-20.8	-20.4	-23.1	River Bottom
19+28	-24.5	-23.3	-24.7	River Bottom
19+51	-24.1	-23.5	-26.4	River Bottom
19+74	-20.4	-23.1	-26.8	River Bottom
19+93	-12.5	-16.2	-24.0	River Bottom
20+10	-8.6	-4.1	-20.7	River Bottom
Varies	-0.3	0.6	1.6	Edge of Water
20+45	-0.4	-	-	Toe of Bank (2013)
20+56	8.8	-	-	Top of Bank (2013)
20+63	-	9.4	9.0	Top of Bank
21+50	9.8	10.0	9.9	Ground Shot
22+50	9.3	9.5	9.4	Ground Shot
23+24	9.8	9.8	9.7	Ground Shot

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STATION	2013	2014	2015	2016	2017	DESCRIPTION
0+00	10.6	10.9	10.7	10.7	10.5	Ground Shot
1+00	10.1	10.4	10.4	10.3	10.3	Ground Shot
1+50	12.2	12.4	12.4	12.3	12.3	Ground Shot
1+77	13.4	13.7	13.7	13.5	13.5	Grade Break
2+00	11.3	11.6	11.7	11.6	11.6	Ground Shot
2+20	-	-	8.4	8.3	8.0	Top of Bank
2+23	8.1	8.1	-	-	-	Top of Bank (2014)
2+30	2.8	3.0	3.7	3.3	2.9	Toe of Bank
Varies	0.6	0.5	0.8	0.3	1.0	Edge of Water
4+93	-2.5	-4.1	-4.2	-4.0	-4.0	River Bottom
5+06	-2.5	-4.4	-4.6	-4.0	-4.5	River Bottom
5+25	-2.6	-3.6	-5.0	-4.3	-5.0	River Bottom
5+45	-2.7	-3.7	-5.3	-4.7	-5.0	River Bottom
5+68	-3.7	-3.8	-6.6	-5.6	-6.2	River Bottom
5+91	-4.5	-5.2	-7.0	-7.0	-7.0	River Bottom
6+17	-5.8	-7.6	-7.3	-7.5	-7.6	River Bottom
6+42	-7.4	-7.2	-7.7	-7.3	-7.7	River Bottom
6+65	-7.7	-7.4	-7.7	-7.2	-7.2	River Bottom
6+88	-7.2	-6.3	-7.7	-6.4	-6.7	River Bottom
7+11	-6.8	-6.0	-7.6	-6.6	-6.7	River Bottom
7+37	-5.4	-5.5	-7.6	-6.8	-6.9	River Bottom
7+56	-5.1	-6.3	-7.6	-7.2	-7.3	River Bottom
7+82	-4.9	-7.1	-7.6	-7.3	-7.7	River Bottom
8+02	-4.3	-7.1	-7.6	-6.7	-7.3	River Bottom
8+25	-3.6	-5.6	-7.6	-7.5	-6.9	River Bottom
8+50	-4.2	-5.9	-7.5	-7.0	-6.8	River Bottom
8+74	-5.6	-6.2	-7.5	-7.2	-7.5	River Bottom
9+03	-5.9	-6.1	-7.4	-7.5	-7.9	River Bottom
9+32	-7.6	-5.5	-7.2	-7.8	-7.6	River Bottom
9+58	-7.0	-6.7	-7.0	-7.3	-7.6	River Bottom
9+84	-9.8	-7.4	-6.9	-8.2	-7.9	River Bottom
10+10	-9.9	-10.8	-7.4	-7.8	-8.0	River Bottom
10+39	-9.5	-10.5	-8.0	-8.2	-8.5	River Bottom
10+68	-8.7	-9.2	-7.8	-7.5	-7.9	River Bottom
10+91	-8.3	-9.3	-7.6	-7.8	-7.9	River Bottom
11+21	-8.9	-9.4	-7.4	-7.8	-8.4	River Bottom
11+50	-9.2	-9.7	-9.4	-7.5	-8.4	River Bottom
11+76	-9.4	-10.5	-10.3	-7.2	-7.7	River Bottom
12+02	-11.0	-10.7	-9.9	-8.4	-8.6	River Bottom
12+31	-11.6	-10.7	-9.5	-8.1	-8.4	River Bottom
12+57	-10.4	-9.4	-9.1	-7.5	-8.0	River Bottom
12+83	-9.0	-9.5	-8.8	-7.7	-7.9	River Bottom
13+09	-8.4	-8.7	-8.0	-7.2	-7.4	River Bottom
13+35	-7.6	-8.1	-7.6	-6.8	-6.8	River Bottom
13+64	-6.7	-7.2	-7.2	-6.4	-6.5	River Bottom
13+87	-6.3	-6.7	-6.5	-6.1	-6.3	River Bottom
14+17	-5.7	-6.5	-6.3	-5.6	-5.7	River Bottom
14+40	-5.9	-6.2	-6.2	-5.4	-5.5	River Bottom
14+69	-6.6	-6.5	-6.3	-5.7	-5.7	River Bottom
14+98	-7.8	-7.9	-7.8	-6.5	-6.4	River Bottom
15+24	-10.7	-10.6	-9.2	-7.8	-8.6	River Bottom
15+53	-13.6	-13.3	-11.8	-10.9	-10.9	River Bottom
15+79	-14.7	-13.9	-12.6	-12.2	-11.9	River Bottom

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STATION	2013	2014	2015	2016	2017	DESCRIPTION
16+02	-11.1	-12.3	-12.3	-12.3	-12.2	River Bottom
Varies	0.7	0.5	0.2	0.3	1.0	Edge of Water
16+95	8.5	8.4	8.4	8.3	-	Top of Bank (2016)
16+97	-	-	-	-	8.7	Top of Bank
17+00	9.2	9.5	9.4	9.3	9.2	Ground Shot
17+57	10.1	10.3	10.0	9.7	9.6	Ground Shot
18+00	9.4	9.6	9.6	9.5	9.4	Ground Shot
19+00	10.2	10.5	10.6	10.4	10.2	Ground Shot
19+07	10.8	10.9	10.7	10.5	10.3	Ground Shot

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STATION	2013	2014	2015	2016	2017	DESCRIPTION
0+00	10.6	10.8	10.3	10.3	10.1	Ground Shot
1+00	10.1	10.2	10.3	10.2	10.1	Ground Shot
2+00	9.8	10.0	10.1	10.0	9.9	Ground Shot
2+08	8.9	9.0	9.0	9.0	8.9	Top of Bank
Varies	0.9	0.2	-0.4	0.2	1.3	Edge of Water
2+99	-5.8	-5.5	-7.3	-6.6	-6.6	River Bottom
3+20	-7.1	-7.7	-8.7	-8.3	-8.3	River Bottom
3+40	-7.4	-8.8	-9.7	-8.6	-8.8	River Bottom
3+61	-8.2	-9.6	-10.4	-9.2	-9.8	River Bottom
3+85	-9.7	-10.5	-11.2	-9.9	-10.6	River Bottom
4+09	-9.9	-10.8	-12.1	-11.2	-11.6	River Bottom
4+33	-9.9	-11.3	-13.1	-13.6	-13.5	River Bottom
4+57	-10.3	-11.9	-14.1	-15.2	-15.6	River Bottom
4+85	-10.0	-10.9	-14.3	-15.3	-15.2	River Bottom
5+09	-10.6	-10.4	-15.0	-14.4	-14.6	River Bottom
5+33	-11.5	-10.3	-15.2	-14.0	-14.4	River Bottom
5+60	-11.9	-10.7	-14.7	-13.8	-14.0	River Bottom
5+87	-12.4	-10.3	-14.2	-13.2	-13.5	River Bottom
6+19	-11.8	-10.8	-14.9	-14.3	-14.6	River Bottom
6+46	-11.1	-10.8	-15.4	-15.6	-15.6	River Bottom
6+73	-11.2	-11.6	-15.6	-15.5	-15.6	River Bottom
7+01	-10.3	-10.6	-15.3	-14.4	-14.7	River Bottom
7+28	-10.0	-10.3	-13.9	-13.5	-13.5	River Bottom
7+53	-11.8	-11.0	-12.5	-12.4	-12.2	River Bottom
7+80	-11.6	-11.0	-11.1	-10.5	-10.7	River Bottom
8+08	-12.1	-9.5	-9.4	-9.7	-9.8	River Bottom
8+36	-11.6	-8.2	-9.4	-9.1	-9.0	River Bottom
8+59	-11.0	-7.8	-8.5	-8.6	-8.4	River Bottom
8+79	-11.1	-7.1	-7.2	-7.5	-7.6	River Bottom
9+04	-9.1	-7.9	-6.8	-7.1	-6.5	River Bottom
9+28	-8.3	-7.7	-6.3	-5.0	-5.5	River Bottom
9+53	-8.1	-7.2	-6.4	-5.2	-5.5	River Bottom
9+76	-7.7	-6.6	-6.5	-4.6	-4.9	River Bottom
9+96	-7.6	-6.7	-6.4	-5.6	-5.0	River Bottom
10+17	-7.2	-6.2	-6.2	-6.2	-5.8	River Bottom
10+42	-5.6	-5.6	-6.0	-4.8	-4.3	River Bottom
10+62	-3.1	-3.9	-3.4	-3.1	-3.1	River Bottom

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

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

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STATION	2013	2016	2017	DESCRIPTION
0+00	10.9	10.9	10.7	Ground Shot
1+00	10.4	10.7	10.5	Ground Shot
1+47	-	-	9.1	Top of Bank
1+50	8.7	-	-	Ground Shot
1+55	-	8.8	-	Top of Bank (2016)
1+79	8.6	-	-	Top of Bank (2013)
Varies	0.6	0.8	0.9	Edge of Water
2+01	-10.6	-28.3	-25.0	River Bottom
2+16	-19.0	-33.1	-31.0	River Bottom
2+36	-30.7	-36.7	-36.1	River Bottom
2+59	-33.6	-36.6	-36.4	River Bottom
2+82	-35.3	-36.7	-36.4	River Bottom
3+08	-32.7	-35.9	-35.5	River Bottom
3+28	-31.4	-34.0	-33.3	River Bottom
3+54	-30.9	-31.8	-31.8	River Bottom
3+77	-30.0	-29.7	-29.2	River Bottom
4+00	-30.0	-25.0	-25.8	River Bottom
4+23	-27.8	-22.5	-22.5	River Bottom
4+48	-25.6	-18.3	-19.2	River Bottom
4+68	-22.7	-16.0	-16.4	River Bottom
4+94	-20.1	-13.7	-13.3	River Bottom
5+16	-17.5	-12.3	-11.5	River Bottom
5+40	-14.9	-11.1	-10.8	River Bottom
5+62	-13.5	-9.1	-9.1	River Bottom
5+82	-10.5	-5.6	-6.1	River Bottom
6+02	-6.1	-3.6	-3.8	River Bottom
Varies	0.2	0.8	0.9	Edge of Water
7+00	2.9	3.4	3.4	Sand Bar
7+90	4.9	5.1	5.0	Edge of Vegetation
8+00	4.9	5.1	5.0	Ground Shot
9+00	5.5	5.6	5.6	Ground Shot
10+00	5.1	5.2	5.2	Ground Shot
11+00	5.6	5.7	5.7	Ground Shot
12+00	5.8	5.9	5.9	Ground Shot
13+00	5.5	5.8	5.7	Ground Shot
14+00	6.2	6.3	6.3	Ground Shot
15+00	6.1	6.2	6.1	Ground Shot
16+00	6.3	6.5	6.5	Edge of Vegetation
16+52	6.7	6.8	6.8	Grade Break
16+62	8.0	8.2	8.1	Grade Break
16+89	9.1	8.9	8.8	Ground Shot
17+00	8.9	9.1	9.1	Ground Shot
18+00	9.0	9.0	9.2	Ground Shot
18+39	10.2	10.2	9.8	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	11.0	11.0	10.8	Ground Shot
1+00	11.3	11.2	10.8	Ground Shot
2+00	9.9	10.4	10.2	Ground Shot
2+08	10.0	10.0	9.9	Top of Bank
2+22	4.9	5.6	5.6	Toe of Bank
3+00	2.2	3.1	3.1	Sand Bar
4+00	1.5	2.5	2.5	Sand Bar
5+00	1.8	2.3	2.2	Sand Bar
Varies	0.4	0.4	0.6	Edge of Water
5+79	-4.7	0.4	-1.7	River Bottom
5+85	-5.1	-2.6	-2.1	River Bottom
6+10	-9.0	-5.6	-3.9	River Bottom
6+36	-17.5	-11.1	-11.3	River Bottom
6+54	-24.6	-20.7	-18.4	River Bottom
6+85	-28.6	-24.0	-25.9	River Bottom
7+08	-32.0	-29.3	-28.6	River Bottom
7+31	-33.5	-29.7	-29.8	River Bottom
7+57	-33.9	-31.9	-31.6	River Bottom
7+83	-33.0	-32.6	-32.6	River Bottom
8+06	-32.1	-31.7	-32.2	River Bottom
8+29	-31.0	-31.2	-31.1	River Bottom
8+56	-31.1	-31.1	-29.6	River Bottom
8+79	-31.3	-31.1	-30.8	River Bottom
9+02	-30.7	-30.4	-30.6	River Bottom
9+28	-29.9	-30.7	-30.6	River Bottom
9+51	-27.1	-30.7	-30.6	River Bottom
9+72	-23.2	-30.4	-28.1	River Bottom
10+00	-20.1	-22.9	-21.9	River Bottom
10+23	-3.0	-19.2	-19.1	River Bottom
10+43	-3.2	-18.3	-15.9	River Bottom
Varies	0.6	0.5	0.5	Edge of Water
11+05	9.5	-	-	Top of Bank (2013)
11+20	-	1.3	1.2	Toe of Bank
11+28	-	8.8	8.6	Top of Bank
12+00	9.4	9.1	9.0	Ground Shot
13+00	7.9	8.0	8.0	Edge of Vegetation
14+01	6.9	7.0	7.0	Ground Shot
15+01	7.2	7.3	7.3	Ground Shot
16+00	7.8	8.0	8.0	Ground Shot
17+01	8.3	8.4	8.4	Ground Shot
18+00	7.0	7.1	7.0	Ground Shot
19+00	6.3	6.6	6.7	Ground Shot
20+00	6.7	7.0	7.0	Ground Shot
21+00	6.7	7.1	7.0	Ground Shot
21+85	7.0	7.4	7.3	Toe of Bank
22+00	8.2	8.5	8.3	Top of Bank
22+16	8.8	8.6	8.4	Ground Shot
23+00	9.7	10.0	9.9	Ground Shot
23+67	10.2	10.0	9.4	Ground Shot

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Bridge Transects

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STATION	2013	2016	2017	DESCRIPTION
0+00	10.6	11.4	11.2	Ground Shot
1+00	11.7	11.7	11.7	Ground Shot
1+50	12.1	11.9	12.0	Ground Shot
2+00	12.2	11.8	11.7	Ground Shot
2+34	11.2	11.1	10.9	Edge of Vegetation
3+00	10.3	9.9	10.2	Ground Shot
4+00	10.3	10.6	10.6	Ground Shot
4+36	10.9	10.9	10.8	Edge of Vegetation
5+00	11.7	11.6	11.6	Ground Shot
6+00	13.2	13.2	13.1	Ground Shot
7+00	14.1	13.7	13.6	Ground Shot
7+11	14.9	14.6	14.6	Grade Break
7+95	23.7	23.4	23.4	Grade Break
8+00	22.8	23.0	22.9	Ground Shot
9+00	22.4	22.4	22.4	Top of Bank
9+67	11.2	11.1	11.3	Toe of Bank
10+00	9.6	10.0	10.0	Sand Bar
11+00	7.3	7.6	7.7	Sand Bar
12+00	8.3	5.9	5.8	Sand Bar
13+00	5.0	4.8	4.8	Sand Bar
14+00	6.9	4.2	4.4	Sand Bar
15+00	5.8	3.9	4.1	Sand Bar
16+00	4.9	3.7	3.7	Sand Bar
17+00	4.4	3.3	3.4	Sand Bar
18+01	4.2	2.8	2.9	Sand Bar
19+00	3.1	2.6	2.6	Sand Bar
20+00	2.5	2.4	2.5	Sand Bar
21+00	2.3	2.4	2.4	Sand Bar
22+00	2.1	2.5	2.4	Sand Bar
23+00	2.5	2.2	2.3	Sand Bar
24+00	1.8	2.3	2.4	Sand Bar
25+00	2.0	2.2	2.2	Sand Bar
26+00	2.3	2.1	2.1	Sand Bar
27+00	3.0	2.2	2.1	Sand Bar
28+00	3.7	2.9	2.7	Sand Bar
29+00	3.6	2.8	2.7	Sand Bar
30+00	3.1	2.7	2.5	Sand Bar
31+00	3.4	2.1	2.0	Sand Bar
32+00	2.9	2.0	2.1	Sand Bar
33+00	2.1	1.5	1.5	Sand Bar
34+00	1.6	0.9	1.6	Sand Bar
35+00	1.2	-	1.2	Sand Bar
Varies	0.5	1.4	1.6	Edge of Water
36+19	-3.2	-2.8	-4.6	River Bottom
36+39	-5.3	-4.4	-5.4	River Bottom
36+59	-7.8	-5.0	-7.0	River Bottom
36+79	-10.9	-5.8	-7.0	River Bottom
37+07	-13.3	-8.7	-7.3	River Bottom
37+30	-16.2	-9.0	-8.4	River Bottom
37+59	-18.8	-10.0	-10.1	River Bottom
37+84	-20.2	-11.5	-11.8	River Bottom
38+16	-20.8	-15.6	-14.1	River Bottom
38+38	-21.1	-16.7	-13.5	River Bottom

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STATION	2013	2016	2017	DESCRIPTION
38+70	-22.1	-19.2	-17.5	River Bottom
38+92	-24.2	-22.1	-19.8	River Bottom
39+21	-22.6	-24.4	-21.8	River Bottom
39+38	-3.7	-23.5	-22.9	River Bottom
Varies	0.1	1.1	0.3	Edge of Water
39+89	8.7	-	-	Top of Bank (2013)
40+00	8.7	-	-	Ground Shot (2013)
40+12	-	9.1	-	Top of Bank (2016)
40+17	-	-	8.4	Top of Bank
41+00	8.1	8.6	8.6	Ground Shot
42+00	8.1	8.5	8.5	Ground Shot
43+00	8.0	8.4	8.3	Ground Shot
43+53	6.7	7.0	6.9	Edge of Vegetation
44+00	5.2	5.6	5.5	Top of Bank
45+00	0.6	-	-	Sand Bar (2013)
Varies	0.2	1.4	1.4	Edge of Water
45+19	0.4	0.8	0.7	River Bottom
45+64	-1.5	-0.4	-1.4	River Bottom
46+13	-6.5	-5.7	-5.6	River Bottom
46+62	-10.0	-8.8	-9.4	River Bottom
47+14	-10.3	-9.5	-9.8	River Bottom
47+65	-7.8	-7.5	-7.9	River Bottom
48+13	-5.2	-4.8	-5.2	River Bottom
48+65	-1.5	-0.5	-2.2	River Bottom
Varies	-0.2	1.1	0.7	Edge of Water
49+22	6.8	6.9	6.6	Top of Bank
49+53	7.6	7.8	7.9	Grade Break
50+00	8.3	8.2	8.2	Ground Shot
50+14	11.7	11.5	11.4	Ground Shot
50+28	11.2	11.3	11.0	Grade Break
50+33	9.0	8.9	9.0	Grade Break
50+36	10.6	10.6	10.7	Grade Break
51+00	10.7	10.9	10.9	Ground Shot
51+30	10.5	10.7	11.0	Grade Break
51+34	9.2	9.3	9.4	Grade Break
51+44	10.1	10.0	10.1	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	13.2	13.2	13.1	Ground Shot
1+00	13.5	13.7	13.6	Ground Shot
1+65	15.7	15.6	15.5	Ground Shot
2+00	16.7	16.7	16.6	Ground Shot
3+00	18.8	18.8	18.8	Ground Shot
3+67	20.0	20.0	20.0	Grade Break
4+00	19.2	19.3	19.4	Ground Shot
4+76	19.3	19.3	19.2	Top of Bank
5+19	12.2	12.2	12.2	Toe of Bank
6+00	9.6	9.5	9.4	Edge of Vegetation
7+00	6.1	6.2	6.1	Edge of Vegetation
8+00	3.3	4.0	3.7	Sand Bar
9+00	2.8	2.4	2.4	Sand Bar
10+00	1.7	-	1.8	Sand Bar
11+00	0.5	-	0.5	Sand Bar
Varies	-0.1	1.7	1.8	Edge of Water
13+87	-2.6	-1.2	-2.2	River Bottom
14+03	-2.7	-0.5	-2.2	River Bottom
14+20	-3.2	-1.0	-2.0	River Bottom
14+36	-2.4	-1.1	-1.9	River Bottom
14+52	-3.0	-0.7	-1.7	River Bottom
14+68	-3.0	-0.5	-1.8	River Bottom
14+88	-2.4	-0.6	-2.2	River Bottom
15+04	-3.1	-0.6	-1.7	River Bottom
15+24	-2.9	-0.6	-1.6	River Bottom
15+36	-2.9	-0.6	-1.3	River Bottom
15+53	-2.3	-0.5	-0.9	River Bottom
15+66	-2.4	-0.3	-0.6	River Bottom
15+76	-2.7	-0.1	-0.3	River Bottom
15+89	-3.4	0.2	-0.4	River Bottom
16+05	-3.5	0.5	-0.8	River Bottom
16+18	-3.8	0.7	-1.0	River Bottom
16+38	-3.9	1.0	0.7	River Bottom
16+54	-3.4	1.7	1.6	River Bottom
Varies	-0.4	1.7	2.1	Edge of Water
17+31	2.0	2.2	2.2	Sand Bar
18+00	2.4	2.6	2.3	Sand Bar
19+00	2.2	2.8	2.7	Sand Bar
20+00	2.2	2.7	2.7	Sand Bar
21+01	2.2	3.1	2.8	Sand Bar
22+00	2.0	2.5	2.6	Sand Bar
23+00	0.8	2.8	2.6	Sand Bar
24+00	0.2	1.9	1.8	Sand Bar
Varies	-1.3	1.6	1.6	Edge of Water
24+48	-2.7	-4.3	-0.5	River Bottom
24+64	-5.5	-6.5	-1.3	River Bottom
24+87	-9.0	-9.8	-2.5	River Bottom
25+10	-9.6	-12.3	-3.6	River Bottom
25+33	-9.9	-13.0	-4.8	River Bottom
25+56	-9.9	-14.0	-5.9	River Bottom
25+82	-10.2	-14.7	-10.5	River Bottom
26+01	-10.4	-15.2	-10.8	River Bottom
26+24	-10.0	-15.2	-12.2	River Bottom

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STATION	2013	2016	2017	DESCRIPTION
26+50	-10.0	-16.5	-11.5	River Bottom
26+70	-10.6	-15.4	-11.6	River Bottom
26+89	-11.6	-15.1	-11.8	River Bottom
27+15	-11.1	-15.8	-11.5	River Bottom
27+35	-10.8	-15.2	-13.0	River Bottom
Varies	0.3	1.6	0.6	Edge of Water
27+87	9.0	-	-	Top of Bank (2013)
27+95	-	8.7	-	Top of Bank (2016
27+98	-	-	8.8	Top of Bank
28+00	9.8	9.3	9.1	Ground Shot
28+44	10.0	9.6	9.6	Ground Shot
29+00	9.6	9.5	9.3	Ground Shot
29+94	9.7	9.4	9.1	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	13.8	13.6	13.6	Ground Shot
1+00	15.3	15.4	15.5	Ground Shot
1+50	16.7	16.4	16.6	Ground Shot
1+88	-	16.2	16.3	Top of Bank
1+95	15.1	-	-	Top of Bank (2013)
2+11	3.3	3.0	2.4	Toe of Bank
Varies	0.9	1.9	1.5	Edge of Water
2+88	-2.9	-5.4	-2.4	River Bottom
3+09	-3.3	-7.3	-3.0	River Bottom
3+30	-3.8	-7.6	-3.2	River Bottom
3+50	-4.0	-8.1	-4.0	River Bottom
3+71	-4.1	-8.3	-4.8	River Bottom
3+91	-4.4	-8.7	-4.5	River Bottom
4+12	-4.4	-9.0	-4.8	River Bottom
4+36	-4.2	-9.8	-4.8	River Bottom
4+57	-4.7	-9.5	-4.9	River Bottom
4+81	-3.9	-9.0	-4.3	River Bottom
5+01	-3.2	-7.6	-3.8	River Bottom
11+47	-2.4	-6.8	-2.7	River Bottom
11+64	-2.4	-7.1	-3.4	River Bottom
11+81	-2.5	-7.3	-4.0	River Bottom
11+98	-3.3	-7.8	-4.3	River Bottom
12+16	-3.6	-8.7	-4.6	River Bottom
12+36	-4.0	-8.8	-4.5	River Bottom
12+57	-4.6	-9.0	-5.7	River Bottom
12+77	-4.7	-9.1	-6.2	River Bottom
13+01	-4.9	-10.1	-6.7	River Bottom
13+29	-5.6	-10.2	-7.4	River Bottom
13+56	-5.8	-11.3	-8.1	River Bottom
13+80	-6.4	-11.5	-8.0	River Bottom
14+08	-6.5	-12.4	-8.3	River Bottom
14+35	-6.8	-11.8	-7.9	River Bottom
14+59	-6.5	-11.6	-7.9	River Bottom
14+87	-6.2	-12.2	-8.1	River Bottom
15+14	-5.2	-11.3	-8.0	River Bottom
15+42	-5.4	-10.4	-8.4	River Bottom
15+66	-5.1	-10.6	-7.0	River Bottom
15+93	-6.1	-10.0	-6.2	River Bottom
16+24	-8.3	-10.9	-6.6	River Bottom
16+52	-8.3	-11.7	-6.7	River Bottom
16+79	-5.1	-9.6	-5.5	River Bottom
17+03	-2.8	-7.3	-3.0	River Bottom
Varies	0.8	2.0	1.61	Edge of Water
17+79	1.9	2.8	2.13	Sand Bar
17+97	4.4	4.9	3.04	Sand Bar
18+19	5.6	5.6	5.63	Toe of Bank
18+35	11.9	11.8	11.8	Top of Bank
18+91	12.6	12.3	12.4	Ground Shot
19+41	12.5	12.2	12.3	Ground Shot

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E.3.3 NIGLIAGVIK CHANNEL & BRIDGE TABULATED DATA (TRANSECTS 16 – 35)

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STATION	2013	2016	2017	DESCRIPTION
0+00	10.0	9.7	9.6	Ground Shot
0+50	9.4	8.9	9.0	Ground Shot
1+00	8.4	8.6	8.4	Top of Bank
Varies	0.8	0.3	0.2	Edge of Water
1+28	-3.1	-3.4	-3.5	River Bottom
1+37	-4.2	-5.7	-3.8	River Bottom
1+46	-7.0	-6.8	-6.1	River Bottom
1+58	-6.5	-6.4	-6.8	River Bottom
1+70	-7.5	-8.2	-8.1	River Bottom
1+81	-10.7	-10.2	-9.6	River Bottom
1+91	-12.3	-12.2	-12.6	River Bottom
2+06	-8.3	-9.8	10.1	River Bottom
2+17	-6.6	-8.1	-8.1	River Bottom
2+27	-5.0	-6.8	-4.9	River Bottom
2+37	-2.1	-3.3	-1.8	River Bottom
Varies	0.8	0.6	0.9	Edge of Water
2+68	3.4	3.6	2.0	Sand Bar
3+10	4.7	4.8	4.9	Edge of Vegetation
3+59	6.7	6.9	6.9	Edge of Vegetation
4+00	7.9	8.0	7.8	Ground Shot
4+18	8.9	8.6	8.5	Ground Shot
4+68	9.2	8.9	9.0	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	8.6	8.2	8.1	Ground Shot
0+50	8.5	8.1	7.9	Ground Shot
1+16	8.0	8.1	8.1	Top of Bank
1+47	3.7	3.9	3.7	Edge of Vegetation
Varies	0.9	1.0	1.3	Edge of Water
1+93	-2.1	-1.9	-0.8	River Bottom
2+08	-2.2	-1.9	-1.4	River Bottom
2+19	-2.6	-2.3	-1.9	River Bottom
2+29	-2.9	-2.9	-2.3	River Bottom
2+39	-3.1	-3.3	-2.7	River Bottom
2+49	-3.2	-3.4	-3.1	River Bottom
2+66	-3.5	-3.6	-3.6	River Bottom
2+83	-3.5	-3.4	-3.5	River Bottom
2+91	-3.3	-3.3	-3.5	River Bottom
3+08	-3.1	-3.3	-3.3	River Bottom
3+27	-2.4	-2.9	-2.4	River Bottom
Varies	0.7	1.0	1.2	Edge of Water
3+82	6.3	6.5	6.3	Top of Bank
4+29	8.6	8.3	8.3	Ground Shot
4+79	8.5	8.2	8.1	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	8.6	8.5	8.7	Ground Shot
0+50	8.6	8.6	8.0	Ground Shot
1+00	7.9	8.2	8.0	Ground Shot
1+58	7.1	7.2	7.0	Top of Bank
1+76	6.3	6.2	6.0	Edge of Vegetation
2+14	3.7	3.8	3.6	Edge of Vegetation
Varies	1.0	1.2	1.4	Edge of Water
3+17	-2.6	-1.8	-1.2	River Bottom
3+26	-2.8	-1.8	-1.4	River Bottom
3+38	-3.2	-2.7	-1.8	River Bottom
3+52	-2.1	-3.4	-2.7	River Bottom
3+68	-3.6	-3.9	-3.6	River Bottom
3+80	-4.0	-3.6	-3.6	River Bottom
3+93	-3.9	-3.2	-3.1	River Bottom
4+01	-3.5	-2.8	-2.7	River Bottom
4+14	-3.0	-1.9	-2.1	River Bottom
4+22	-3.0	-1.6	-1.7	River Bottom
Varies	0.9	1.2	1.4	Edge of Water
4+68	-	1.8	1.3	Toe of Bank
4+76	7.1	7.0	6.8	Top of Bank
5+33	7.8	7.6	7.1	Ground Shot
5+83	8.0	7.8	7.6	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	8.6	8.5	8.36	Ground Shot
0+50	8.5	8.7	8.6	Ground Shot
0+95	7.9	8.1	8.0	Top of Bank
1+15	3.3	3.9	3.6	Edge of Vegetation
Varies	0.7	1.2	1.3	Edge of Water
1+88	-1.9	-1.3	-2.0	River Bottom
1+99	-2.2	-1.9	-2.4	River Bottom
2+19	-2.3	-2.4	-2.9	River Bottom
2+29	-2.5	-2.4	-3.1	River Bottom
2+40	-2.5	-2.4	-3.1	River Bottom
2+61	-2.4	-2.0	-2.8	River Bottom
2+75	-4.5	-2.0	-2.5	River Bottom
2+88	-4.1	-2.0	-2.3	River Bottom
2+96	-2.7	-1.3	-2.1	River Bottom
Varies	0.7	1.2	1.3	Edge of Water
3+69	7.0	7.3	7.4	Top of Bank
4+20	8.5	8.6	8.3	Ground Shot
4+70	8.1	8.0	7.9	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	13.8	13.8	13.8	Ground Shot
0+15	16.8	16.9	16.6	Grade Break
0+50	15.5	15.5	15.3	Ground Shot
1+13	11.4	11.7	11.7	Top of Bank
1+35	-	0.7	-	Toe of Bank
Varies	0.5	0.0	1.0	Edge of Water
1+63	-0.7	-0.8	-1.0	River Bottom
1+99	-0.6	-1.3	-1.5	River Bottom
2+30	-0.8	-1.5	-1.6	River Bottom
2+50	-0.9	-1.3	-1.8	River Bottom
2+99	-1.3	-1.4	-1.6	River Bottom
3+30	-1.3	-1.1	-1.1	River Bottom
Varies	0.6	0.1	1.0	Edge of Water
3+64	-	1.1	1.08	Toe of Bank
3+93	6.6	6.9	6.9	Top of Bank
4+53	7.4	7.5	7.3	Ground Shot
5+03	7.5	7.6	7.3	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	24.6	24.5	24.54	Ground Shot
0+50	20.8	20.7	20.8	Ground Shot
1+02	9.5	9.4	9.4	Ground Shot
1+24	7.2	7.3	7.3	Top of Bank
1+34	-	1.8	1.5	Toe of Bank
Varies	0.5	1.2	1.0	Edge of Water
1+46	-1.0	-1.3	-1.5	River Bottom
1+58	-2.1	-2.4	-2.4	River Bottom
1+75	-2.1	-2.7	-2.7	River Bottom
2+00	-1.8	-2.3	-2.3	River Bottom
2+24	-1.6	-2.0	-2.0	River Bottom
2+50	-1.1	-1.1	-1.0	River Bottom
Varies	0.5	1.2	1.1	Edge of Water
3+41	3.3	2.9	2.5	Grade Break
3+64	4.2	4.7	4.7	Toe of Bank
3+79	8.6	8.7	8.7	Top of Bank
4+04	9.7	9.9	9.9	Grade Break
4+58	9.1	9.0	8.9	Ground Shot
5+08	8.7	8.7	8.6	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	26.0	26.0	26.07	Ground Shot
0+07	23.0	23.2	23.3	Ground Shot
0+60	24.0	24.1	23.9	Ground Shot
1+10	23.1	23.1	23.0	Top of Bank
1+36	2.6	2.5	2.1	Toe of Bank
Varies	0.6	0.3	1.2	Edge of Water
1+67	-1.1	-0.8	-1.1	River Bottom
2+00	-1.1	-1.5	-1.7	River Bottom
2+24	-1.6	-1.9	-2.0	River Bottom
2+50	-1.6	-1.8	-2.0	River Bottom
2+75	-1.4	-1.6	-1.5	River Bottom
3+01	-0.7	-1.2	-1.4	River Bottom
Varies	0.6	0.2	1.2	Edge of Water
3+61	4.4	4.3	4.3	Toe of Bank
3+68	8.6	8.7	8.7	Top of Bank
3+88	10.5	10.7	10.6	Ground Shot
4+27	9.1	9.1	9.2	Ground Shot
4+77	8.6	8.6	8.7	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	25.2	25.2	25.3	Ground Shot
0+50	25.1	25.1	25.2	Ground Shot
1+06	23.2	23.3	23.2	Top of Bank
1+34	3.2	3.4	2.8	Toe of Bank
Varies	0.5	0.5	1.4	Edge of Water
2+25	-1.1	-1.5	-1.5	River Bottom
2+51	-1.7	-1.7	-1.7	River Bottom
2+75	-1.7	-1.9	-1.7	River Bottom
3+00	-1.5	-2.3	-1.5	River Bottom
3+27	-1.2	-1.7	-1.7	River Bottom
Varies	0.7	0.4	1.4	Edge of Water
3+44	2.2	-	-	Grade Break (2013)
3+53	-	1.3	0.6	Toe of Bank
3+84	6.1	6.2	6.1	Edge of Vegetation
3+95	7.7	7.7	7.8	Top of Bank
4+50	7.9	7.8	7.9	Ground Shot
5+00	10.0	10.2	10.2	Ground Shot

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CD-5 Michael Baker
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STATION	2013	2014	2015	2016	2017	DESCRIPTION
0+00	26.5	26.5	26.4	26.4	26.4	Ground Shot
0+50	27.0	27.0	27.0	26.9	27.0	Ground Shot
0+94	27.9	26.4	26.5	26.5	26.4	Ground Shot
1+13	25.3	23.6	23.8	23.6	23.5	Top of Bank
1+45	2.6	2.7	3.2	0.5	0.8	Toe of Bank
Varies	0.2	0.5	1.5	0.5	1.4	Edge of Water
2+26	-1.7	-1.2	-1.9	-2.6	-2.7	River Bottom
2+39	-2.4	-1.8	-2.6	-3.3	-2.8	River Bottom
2+48	-2.0	-2.2	-2.9	-2.9	-1.9	River Bottom
2+61	-2.1	-2.2	-2.6	-2.2	-1.8	River Bottom
2+74	-2.2	-2.3	-2.3	-2.1	-1.7	River Bottom
2+90	-3.0	-1.9	-2.1	-2.0	-2.0	River Bottom
3+00	-3.0	-1.9	-2.1	-2.2	-1.9	River Bottom
3+17	-2.6	-2.0	-2.2	-2.1	-2.3	River Bottom
Varies	0.3	0.2	1.5	0.6	1.4	Edge of Water
3+86	5.9	5.7	5.8	5.8	5.7	Edge of Vegetation
3+96	7.1	7.2	7.2	7.0	6.9	Top of Bank
4+65	8.7	8.5	8.3	8.2	8.4	Ground Shot
5+15	9.4	9.2	9.1	9.0	9.09	Ground Shot

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STATION	2013	2014	2015	2016	2017	DESCRIPTION
0+00	27.5	27.4	27.3	27.3	27.3	Ground Shot
0+50	26.4	26.2	26.2	26.1	26.0	Ground Shot
0+70	26.8	26.7	26.7	26.5	26.6	Grade Break
0+89	21.8	21.3	21.3	21.2	21.2	Grade Break
1+00	25.7	22.2	22.5	22.1	22.2	Top of Bank
1+29	-	-	-	-	1.8	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	Edge of Water
2+19	-2.6	-1.2	-3.4	-3.7	-3.0	River Bottom
2+38	-2.2	-1.6	-3.5	-3.5	-3.6	River Bottom
2+48	-2.2	-1.9	-3.5	-3.4	-3.2	River Bottom
2+61	-2.4	-2.9	-3.2	-3.1	-2.6	River Bottom
2+72	-2.8	-2.6	-2.8	-2.8	-2.1	River Bottom
2+89	-2.7	-2.1	-2.3	-2.1	-1.7	River Bottom
2+97	-2.6	-1.9	-2.1	-1.8	-1.7	River Bottom
3+07	-2.7	-2.0	-1.8	-1.9	-1.3	River Bottom
Varies	0.1	0.1	1.5	0.4	1.0	Edge of Water
3+51	2.5	2.5	-	-	-	Ground Shot (2014)
3+81	6.1	6.1	6.4	6.2	6.3	Edge of Vegetation
3+91	7.8	7.5	7.7	7.5	7.4	Top of Bank
4+53	8.5	8.3	8.1	8.2	8.2	Ground Shot
5+03	8.4	8.4	8.3	8.4	8.5	Ground Shot

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STATION	2013	2014	2015	2016	2017	DESCRIPTION
0+00	24.0	27.5	27.3	27.3	27.3	Ground Shot
0+60	24.1	27.7	27.6	27.5	27.4	Ground Shot
0+85	24.0	27.3	27.5	27.3	27.2	Ground Shot
1+03	21.5	24.9	25.0	25.0	25.0	Top of Bank
1+36	2.7	2.4	3.1	1.8	1.9	Toe of Bank
Varies	0.4	0.2	1.5	0.5	1.0	Edge of Water
2+19	-2.5	0.2	-3.5	-3.5	-4.0	River Bottom
2+32	-2.6	-1.2	-3.5	-3.0	-4.4	River Bottom
2+43	-2.5	-2.1	-3.6	-1.7	-3.0	River Bottom
2+53	-2.4	-2.4	-3.6	-1.7	-2.6	River Bottom
2+63	-2.4	-2.6	-3.6	-2.1	-3.0	River Bottom
2+80	-2.3	-2.9	-2.8	-3.3	-2.6	River Bottom
2+91	-2.0	-2.9	-2.6	-4.0	-2.8	River Bottom
3+08	-2.2	-2.3	-2.2	-3.2	-1.7	River Bottom
Varies	0.2	0.0	1.4	0.5	0.9	Edge of Water
3+57	3.2	3.3	-	1.2	1.0	Ground Shot
3+89	6.1	6.6	7.0	6.6	6.6	Edge of Vegetation
3+97	7.1	7.5	7.7	7.2	7.6	Top of Bank
4+79	8.3	9.3	9.9	10.0	9.9	Ground Shot
5+29	9.8	9.8	9.5	9.4	9.4	Ground Shot

Station 4+79 falls in Slope of Gravel Road

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

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STATION	2013	2016	2017	DESCRIPTION
0+00	21.0	20.8	21.0	Ground Shot
0+50	21.3	21.2	21.2	Ground Shot
0+83	21.5	21.4	21.4	Ground Shot
1+06	20.7	19.8	19.6	Top of Bank
1+31	1.0	0.6	0.8	Toe of Bank
Varies	0.0	0.8	0.9	Edge of Water
1+37	-3.0	-2.2	-3.1	River Bottom
1+44	-4.2	-4.2	-4.3	River Bottom
1+51	-4.4	-4.0	-4.5	River Bottom
1+61	-4.0	-3.5	-3.9	River Bottom
1+75	-3.6	-3.1	-3.5	River Bottom
1+89	-3.4	-3.2	-3.4	River Bottom
1+99	-3.0	-3.0	-3.3	River Bottom
2+16	-3.2	-3.1	-3.2	River Bottom
2+33	-3.2	-4.8	-4.6	River Bottom
2+44	-2.6	-5.0	-4.9	River Bottom
Varies	0.1	0.9	1.0	Edge of Water
3+40	2.5	2.6	2.6	Ground Shot
3+65	5.7	5.8	5.7	Edge of Vegetation
3+81	7.6	8.0	7.7	Top of Bank
4+26	8.2	8.5	8.3	Ground Shot
4+81	8.4	8.4	8.6	Ground Shot
5+31	9.2	8.7	9.1	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	24.3	24.1	24.3	Ground Shot
0+50	23.6	23.7	23.7	Ground Shot
1+01	23.0	22.7	22.7	Top of Bank
1+27	-	0.7	0.9	Toe of Bank
Varies	0.2	0.1	0.9	Edge of Water
1+43	-8.1	-9.7	-9.4	River Bottom
1+89	-7.9	-8.5	-8.1	River Bottom
2+09	-5.2	-4.6	-4.4	River Bottom
2+24	-2.5	-2.7	-2.7	River Bottom
Varies	0.1	0.2	1.0	Edge of Water
2+82	2.6	2.8	2.8	Ground Shot
3+30	2.9	3.3	3.4	Ground Shot
3+88	5.8	6.0	6.0	Edge of Vegetation
4+01	8.0	8.4	8.2	Top of Bank
4+47	7.7	7.9	8.0	Ground Shot
4+85	8.4	8.6	8.8	Ground Shot
5+36	9.5	9.6	9.9	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	23.7	23.3	23.69	Ground Shot
0+50	-	23.2	23.2	Ground Shot
0+69	21.7	21.5	21.4	Top of Bank
0+79	19.3	19.1	19.0	Grade Break
1+00	6.0	6.0	6.1	Toe of Bank
1+16	4.4	4.3	4.3	Top of Bank
1+17	3.3	2.7	2.8	Toe of Bank
Varies	0.2	0.3	1.0	Edge of Water
1+63	-2.9	-1.2	-2.5	River Bottom
1+75	-4.0	-2.8	-3.4	River Bottom
1+87	-5.9	-4.3	-4.6	River Bottom
1+99	-5.8	-5.5	-5.0	River Bottom
2+12	-6.4	-5.2	-5.5	River Bottom
2+26	-5.7	-4.5	-5.5	River Bottom
2+36	-5.3	-4.6	-5.4	River Bottom
2+48	-3.4	-4.0	-4.5	River Bottom
2+61	-2.7	-3.1	-4.2	River Bottom
2+73	-2.1	-2.2	-3.5	River Bottom
2+81	-2.8	-2.2	-2.5	River Bottom
Varies	-0.5	0.3	1.0	Edge of Water
3+84	4.3	4.3	4.3	Sand Bar
3+94	5.9	5.8	5.8	Grade Break
4+30	6.1	6.0	6.0	Edge of Vegetation
4+67	8.8	8.8	8.8	Grade Break
5+22	8.1	7.9	7.7	Grade Break
5+58	9.4	9.3	9.4	Grade Break/Edge of Veg
5+77	9.6	9.5	9.6	Ground Shot
6+27	10.1	9.6	10.1	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	8.6	8.3	8.6	Ground Shot
0+50	9.6	9.6	9.6	Ground Shot
1+06	8.1	8.3	8.2	Edge of Vegetation
1+29	8.4	8.3	8.2	Top of Bank
1+40	5.7	5.7	5.9	Toe of Bank
1+85	5.7	6.0	5.7	Ground Shot
2+37	6.0	6.2	6.0	Ground Shot
2+89	6.9	6.8	6.7	Ground Shot
3+16	7.7	7.8	7.7	Ground Shot
3+70	8.0	8.1	8.1	Top of Bank
3+80	6.7	6.8	6.6	Grade Break/Edge of Veg
4+06	3.8	3.9	3.8	Sand Bar
4+43	1.4	0.9	1.0	Grade Break
Vaies	-0.2	1.1	1.4	Edge of Water
4+71	-2.6	-1.3	-1.1	River Bottom
4+81	-2.8	-1.9	-1.9	River Bottom
4+92	-2.1	-2.0	-2.3	River Bottom
5+02	-2.1	-2.2	-2.5	River Bottom
5+10	-2.6	-2.3	-2.5	River Bottom
5+20	-2.3	-2.4	-2.4	River Bottom
5+29	-2.2	-1.8	-2.3	River Bottom
5+39	-2.1	-1.8	-1.8	River Bottom
5+50	-2.2	-1.6	-2.0	River Bottom
5+60	-2.1	-1.7	-2.0	River Bottom
5+70	-2.5	-1.7	-1.7	River Bottom
5+79	-2.2	-1.5	-0.9	River Bottom
Vaies	0.0	1.1	1.4	Edge of Water
6+20	2.6	2.6	2.4	Toe of Bank
6+32	8.4	8.3	8.2	Top of Bank
6+83	9.2	9.1	9.1	Grade Break
7+31	10.9	11.0	10.9	Edge of Vegetation
7+54	11.2	11.2	11.3	Ground Shot
8+04	10.7	10.3	10.7	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	8.4	8.1	8.1	Ground Shot
0+50	7.8	7.8	7.9	Ground Shot
0+96	7.0	6.7	6.9	Ground Shot
1+50	7.2	7.3	7.1	Ground Shot
2+00	7.4	7.4	7.4	Ground Shot
2+50	8.0	8.0	8.0	Ground Shot
3+12	6.8	6.8	6.7	Edge of Vegetation
3+32	6.4	6.4	6.3	Top of Bank
3+54	-	3.1	2.2	Ground Shot
3+68	-	1.1	-	Ground Shot
Varies	0.1	0.9	1.4	Edge of Water
4+07	-0.8	-1.7	-1.6	River Bottom
4+16	-2.7	-1.7	-3.0	River Bottom
4+26	-2.5	-2.5	-2.9	River Bottom
4+36	-3.9	-4.1	-5.1	River Bottom
4+47	-5.4	-6.3	-6.7	River Bottom
4+57	-6.6	-6.9	-6.9	River Bottom
4+68	-7.0	-7.0	-6.0	River Bottom
4+79	-6.1	-5.8	-4.5	River Bottom
Varies	-0.4	0.9	1.4	Edge of Water
5+10	8.5	8.4	8.3	Top of Bank
5+40	10.4	10.3	10.4	Ground Shot
5+79	10.2	10.2	10.2	Ground Shot
6+21	11.5	11.5	11.5	Ground Shot
6+71	10.8	10.5	10.8	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	9.9	9.8	9.8	Ground Shot
0+50	8.6	8.6	8.6	Ground Shot
1+03	8.5	8.7	8.7	Edge of Vegetation
1+52	10.6	10.7	10.6	Grade Break
2+00	9.9	10.0	10.0	Ground Shot
2+57	7.9	7.8	7.8	Top of Bank
2+67	6.9	6.9	7.0	Edge of Vegetation
2+78	5.4	5.3	5.4	Sand Bar
2+87	3.5	3.2	3.2	Grade Break
Varies	0.0	0.5	1.5	Edge of Water
3+81	-3.2	-1.5	-1.1	River Bottom
4+04	-2.2	-2.3	-2.4	River Bottom
4+18	-3.5	-3.1	-3.4	River Bottom
4+38	-4.4	-7.5	-6.9	River Bottom
4+59	-3.1	-4.2	-2.7	River Bottom
Varies	-0.1	0.2	1.4	Edge of Water
4+99	9.1	8.9	8.9	Top of Bank
5+53	9.7	9.8	9.7	Edge of Vegetation
6+02	10.1	10.3	10.2	Ground Shot
6+41	10.5	10.6	10.6	Ground Shot
7+11	10.7	10.3	10.4	Ground Shot

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STATION	2013	2016	2017	DESCRIPTION
0+00	12.6	12.4	12.3	Ground Shot
0+50	12.6	12.5	12.5	Ground Shot
1+00	10.3	10.1	10.1	Ground Shot
1+50	9.2	9.2	9.2	Ground Shot
2+12	8.1	8.0	7.9	Top of Bank
2+15	3.5	1.9	2.0	Toe of Bank
Varies	-0.3	0.6	1.6	Edge of Water
2+30	-4.6	-3.7	-4.3	River Bottom
2+37	-7.2	-4.3	-5.9	River Bottom
2+48	-7.3	-5.8	-6.4	River Bottom
2+58	-6.9	-5.8	-6.3	River Bottom
2+72	-6.7	-6.0	-5.4	River Bottom
2+82	-3.2	-5.4	-5.0	River Bottom
2+96	-2.2	-3.1	-2.3	River Bottom
3+06	-1.9	-2.1	-0.8	River Bottom
Varies	0.1	0.3	1.6	Edge of Water
3+66	4.5	4.6	4.7	Grade Break
3+94	5.6	5.6	5.6	Sand Bar
4+29	7.1	7.1	7.1	Edge of Vegetation
4+39	8.4	8.5	8.4	Top of Bank
4+50	8.6	8.6	8.6	Ground Shot
5+00	9.0	9.0	8.9	Ground Shot
5+50	7.4	7.6	7.7	Ground Shot
6+00	9.7	9.7	9.6	Ground Shot
6+30	10.1	10.2	10.2	Edge of Vegetation
6+64	9.9	9.7	9.7	Ground Shot
7+00	10.6	10.6	10.5	Ground Shot
7+50	10.1	9.9	9.9	Ground Shot

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Bridge Transects

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STATION	2013	2016	2017	DESCRIPTION
0+00	12.6	12.5	12.5	Ground Shot
0+50	13.0	12.9	12.9	Ground Shot
1+00	11.2	11.3	11.4	Ground Shot
1+11	11.4	11.4	11.2	Grade Break
1+25	9.4	9.4	9.6	Grade Break
1+65	10.3	10.4	10.4	Grade Break
1+81	8.1	8.1	8.0	Grade Break
2+27	9.3	9.4	9.4	Grade Break
2+51	10.4	10.5	10.4	Grade Break
2+72	8.2	8.3	8.4	Grade Break
3+15	8.0	7.7	7.8	Grade Break
3+59	6.9	6.8	6.8	Edge of Vegetation
3+79	6.6	6.6	6.6	Top of Bank
3+92	3.5	3.4	3.4	Sand Bar
Varies	-0.1	0.1	1.7	Edge of Water
4+60	-2.3	-2.2	-2.4	River Bottom
4+86	-4.6	-3.9	-5.0	River Bottom
5+09	-5.1	-4.2	-4.2	River Bottom
5+26	-2.0	-3.3	-1.3	River Bottom
Varies	-0.2	0.0	1.7	Edge of Water
5+47	0.2	0.2	-	Toe of Bank
5+58	7.6	7.4	7.4	Top of Bank
5+72	9.7	9.7	9.7	Grade Break
5+86	9.2	9.3	9.3	Edge of Vegetation
6+28	9.4	9.3	9.3	Ground Shot
6+69	9.5	9.2	9.2	Ground Shot
7+19	10.3	10.1	10.1	Ground Shot

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E.3.4 LAKE L9341 BRIDGE TABULATED DATA (TRANSECTS 36 – 39)

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STATION	2013	2014	2015	2016	2017	DESCRIPTION
0+00	8.3	8.4	8.2	7.9	7.9	Ground Shot
0+50	8.0	8.2	8.0	7.9	7.8	Ground Shot
0+81	7.2	7.3	7.4	7.4	7.3	Ground Shot
1+17	7.2	7.2	7.2	7.1	7.1	Top of Bank
1+23	6.3	6.5	6.5	6.6	6.4	Edge of Vegetation
Varies	4.6	4.6	4.6	3.4	3.9	Edge of Water
1+52	4.0	2.0	4.4	3.4	3.7	River Bottom
1+89	0.8	1.5	2.1	0.7	-0.5	River Bottom
2+20	-0.9	1.0	0.0	0.1	-0.6	River Bottom
2+48	-1.7	-0.9	-1.8	-1.0	-1.9	River Bottom
2+95	-3.0	-2.8	-3.2	-2.9	-3.2	River Bottom
3+49	-2.1	-1.5	-1.5	-1.2	-1.2	River Bottom
3+78	1.7	1.5	2.5	1.7	1.0	River Bottom
3+90	2.5	2.2	4.1	3.0	2.7	River Bottom
Varies	4.8	4.7	4.8	3.5	4.0	Edge of Water
4+06	8.6	8.6	8.7	8.5	8.4	Top of Bank
5+03	9.5	9.6	9.5	9.4	9.4	Ground Shot

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STATION	2013	2014	2015	2016	2017	DESCRIPTION
0+00	8.0	8.1	8.5	8.3	8.3	Ground Shot
0+50	8.3	8.5	8.3	8.2	8.2	Ground Shot
0+92	7.0	7.1	7.2	7.3	7.1	Top of Bank
1+03	6.5	6.6	6.6	6.7	6.5	Edge of Vegetation
Varies	4.6	4.5	4.6	3.5	4.0	Edge of Water
1+59	2.2	1.7	3.1	3.0	2.2	River Bottom
2+01	0.5	1.1	0.0	1.1	0.7	River Bottom
2+48	-2.4	-2.5	-1.4	-2.0	-2.8	River Bottom
2+99	-2.9	-2.5	-2.6	-2.6	-2.9	River Bottom
3+45	-1.6	-1.3	-1.3	-1.3	-1.7	River Bottom
3+84	2.1	1.4	3.0	2.5	1.6	River Bottom
Varies	4.6	4.7	4.8	3.5	4.1	Edge of Water
4+04	9.1	9.1	9.1	9.0	8.8	Top of Bank
4+49	8.8	8.9	8.8	8.7	8.7	Ground Shot
4+99	9.5	9.6	9.5	9.4	9.5	Ground Shot

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Bridge Transects

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STATION	2013	2014	2015	2016	2017	DESCRIPTION
0+00	8.1	8.4	7.8	7.7	7.1	Ground Shot
0+50	7.9	8.3	8.0	7.8	7.7	Ground Shot
0+81	7.3	7.3	7.4	7.2	7.1	Ground Shot
1+22	6.1	6.4	6.3	6.3	6.1	Edge of Vegetation
Varies	4.6	4.5	4.6	3.5	4.0	Edge of Water
1+94	1.4	1.6	2.4	2.1	0.9	River Bottom
2+46	0.4	0.4	0.0	-0.2	-0.5	River Bottom
2+96	-2.6	-2.2	-1.6	-2.4	-2.7	River Bottom
3+47	-2.8	-2.5	-3.2	-3.0	-3.0	River Bottom
3+95	0.8	1.5	1.0	0.8	0.4	River Bottom
Varies	4.7	3.7	5.0	3.6	4.0	Edge of Water
4+31	9.3	9.3	9.3	9.1	8.9	Top of Bank
4+79	9.0	9.1	9.0	8.9	8.9	Ground Shot
5+29	9.2	9.3	9.3	9.2	9.0	Ground Shot

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CD-5 Michael Baker
Bridge Transects

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STATION	2013	2014	2015	2016	2017	DESCRIPTION
0+00	8.5	8.8	8.6	8.4	8.2	Ground Shot
0+50	7.6	7.8	7.7	7.5	7.1	Ground Shot
0+79	6.7	7.0	6.9	6.9	6.9	Top of Bank
0+89	5.8	6.0	5.8	5.9	5.7	Edge of Vegetation
Varies	4.4	4.5	4.5	3.4	4.0	Edge of Water
1+27	1.3	1.2	2.6	1.9	0.6	River Bottom
1+54	0.1	0.7	0.6	0.6	-0.1	River Bottom
2+01	-1.2	-0.8	-1.1	-1.4	-1.5	River Bottom
2+47	-1.7	-1.7	-2.0	-1.7	-2.4	River Bottom
3+01	-3.0	-2.5	-3.2	-3.1	-3.1	River Bottom
3+55	-0.3	1.5	-0.4	-0.3	-0.8	River Bottom
3+71	1.8	2.6	1.7	1.5	1.6	River Bottom
Varies	4.6	4.3	4.8	3.4	3.9	Edge of Water
4+03	9.3	9.5	9.5	9.4	9.2	Top of Bank
4+43	9.4	9.5	9.5	9.2	9.1	Ground Shot
4+93	9.6	9.7	9.5	9.3	9.3	Ground Shot

2017 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment