ConocoPhillips Alaska

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2018

COLVILLE RIVER DELTA SPRING BREAKUP MONITORING & HYDROLOGICAL ASSESSMENT

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EXECUTIVE SUMMARY

This report presents the observations and results from the 2018 Colville River Delta Spring Breakup Monitoring and Hydrological Assessment conducted by Michael Baker International for ConocoPhillips Alaska. In the Colville River Delta, the breakup and downstream movement of river ice typically occurs during a three-week period in May and June. The spring breakup event historically produces flooding resulting from the rapid rise and fall of stage often attributed to ice jam formations and releases. Annual study and reporting of spring breakup is required by U.S. Army Corps of Engineers Permits 2-960874 Special Condition #6, POA-2004-253 Special Condition #17, and POA-2005-1576 Special Conditions #1 and #17 and Alaska Department of Fish and Game Permits FH04-III-0238, FG97-III-0260, FG99-III-0051, and FG97-III-0190. The analyses provide data to support design, permitting, and operation of oilfield development.

The 2018 monitoring and hydrological assessment is the 27th consecutive year of spring breakup investigations and the 32nd year of historical breakup monitoring in the Colville River Delta. Water surface elevations were monitored throughout the delta at locations of hydrologic importance, including near infrastructure. Discharge was measured, and peak discharge was calculated at key locations. The entire breakup event was documented with visual observations and photography from a helicopter and from roadways. Following breakup, roads, pads, and drainage structures were assessed for erosion and damage.

This year's spring breakup flood was characterized as a protracted, low magnitude event. Initial floodwater arrived in the delta on May 19 and reached the coast by May 21. Cool air temperatures with heavy cloud cover persisted in the delta for the next few weeks and delayed the progression of breakup. On May 23, an ice jam was observed approximately 14 river miles upstream of MON1. This ice jam remained stationary until June 1, when it released and progressed downstream through the MON1 reach and into the east channel. The ice jam and intact channel ice were flushed from the east channel by June 5. Overall, ice jamming effects in the CRD were minimal, as was associated backwater.

Peak conditions throughout the delta occurred between June 1 and June 3. Peak stage at MON1C occurred on June 2 and was 15.90 feet British Petroleum Mean Sea Level having an estimated recurrence interval of less than 2.0-years. Peak discharge at MON1C occurred on June 1 and was estimated at 331,000 cubic feet per second having an estimated 3.4-year recurrence interval.

During peak conditions, floodwater in the delta was generally confined within channels, lakes, and swales and did not reach most infrastructure (roads/pads) in the delta. 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
Baro PT	barometric pressure sensors
BPMSL	British Petroleum Mean Sea Level
CD	Colville Delta
CFDD	cumulative freezing degree days
cfs	cubic feet per second
CPAI	ConocoPhillips Alaska, Inc.
CRD	Colville River Delta
FEMA	Federal Emergency Management Agency
fps	feet per second
ft	feet
gage	hydrologic staff gage
GPS	Global positioning system
HDD	Horizontal directional drill
HWM	High water mark
Michael Baker	Michael Baker International
MON	Monument
MP-AMS	Monitoring Plan with an Adaptive Management Strategy
NOAA	National Atmospheric and Oceanic Administration
NRCS	Natural Resources Conservation Service
NPR-A	National Petroleum Reserve of Alaska
PT	pressure transducer
RM	river mile
RTFM	Real-Time Flood Monitoring
SAK	Sakoonang
TAM	Tamayayak
ULAM	Ulamnigiaq
UMIAQ	Umiaq, LLC (UMIAQ)
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
VSM	Vertical support member
WSE	Water surface elevation

1. INTRODUCTION

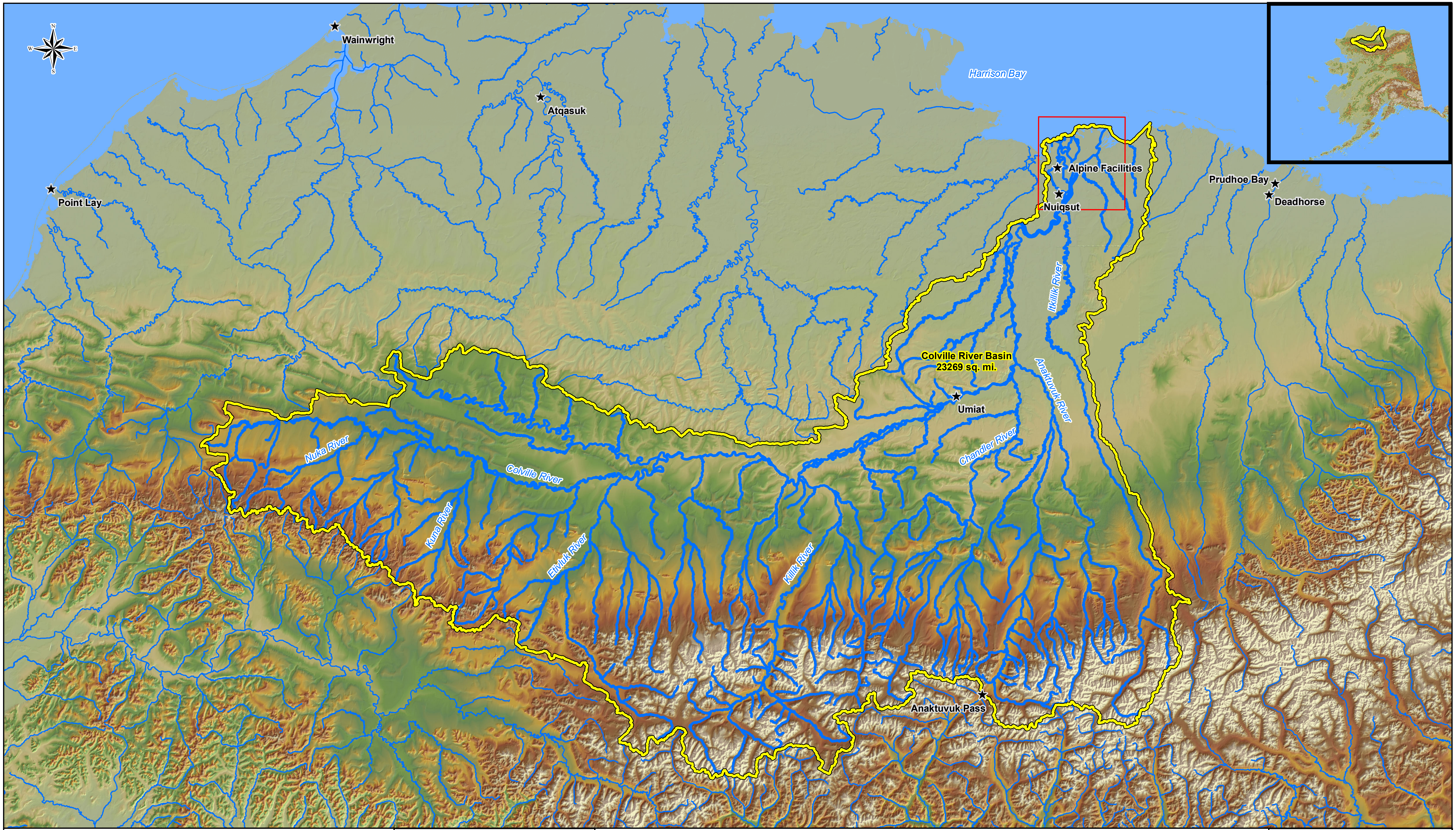
The Colville River is the largest river on the North Slope, initiating in the DeLong Mountains on the north side of the Brooks Range, running north and east through the Arctic Coastal Plain, and forms the Colville River Delta (CRD) where the river empties into the Beaufort Sea. The Colville River drainage basin is approximately 23,269 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, CD5, and Greater Moose's Tooth 1 (GMT1) pads, access roads, and pipelines.

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 2018 monitoring and hydrological assessment is the 27th consecutive year of CRD spring breakup investigations.

The 2018 field program took place from April 23 to June 19. Spring breakup setup began on April 23 and concluded on May 14. Spring breakup monitoring began on May 15 and concluded on June 19. 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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2018 SPRING BREAKUP
COLVILLE RIVER DELTA

Drainage Basin

FIGURE: 1.1

(SHEET 1 of 1)

1.1 MONITORING OBJECTIVES

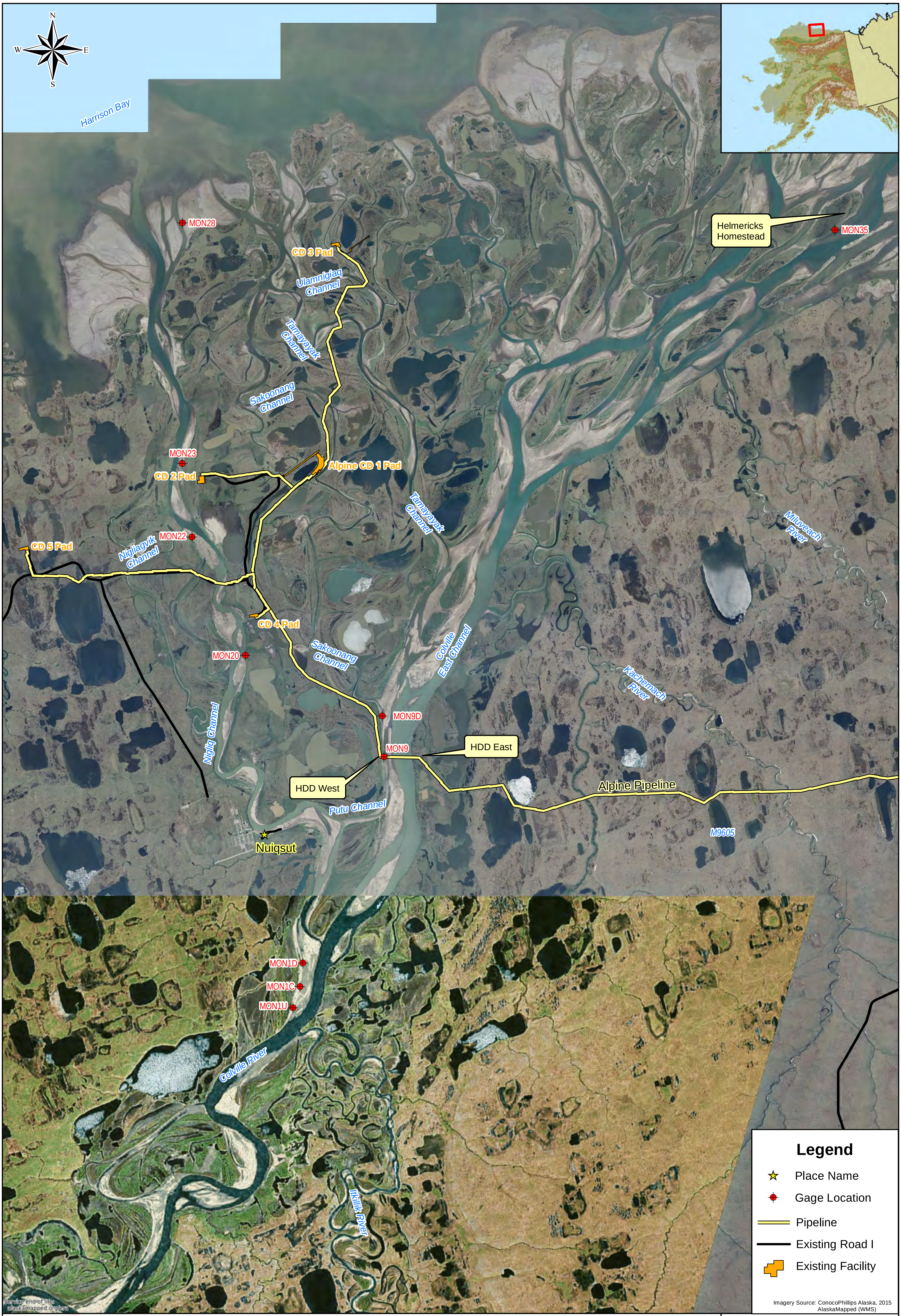
The primary objective of CRD spring breakup monitoring and hydrological assessment is to monitor and estimate the magnitude of breakup flooding within the CRD in relation to Alpine facilities. Water surface elevations (WSE, or stage, used interchangeably in this report), discharge, and observations are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

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

Permit stipulations for USACE Permits 2-960874 Special Condition #6, POA-2004-253-2 Special Condition #17, ADF&G Fish Habitat Permit FH04-III-0238, and USACE Permit POA-2005-1576 Special Conditions #1 and #17 require monitoring Alpine facilities during spring breakup. Permit stipulations include documentation of annual hydrologic conditions, direct measurements and indirect calculations of discharge through drainage structures, and documentation of pad and road erosion caused by spring breakup flooding. USACE Permit POA-2005-1576 Special Condition #1 requires the *Monitoring Plan with an Adaptive Management Strategy* (MP-AMS) (Michael Baker and Alaska Biological Research [ABR] 2013) which includes monitoring channel sedimentation and erosion specific to the CD5 development. Observations of functionality and flooding effects to the CD2 road bridges are recorded to satisfy ADF&G permit FG97-III-0260-Amendment #3. 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 2018 monitoring locations and gage stations are similar to those studied in 2017 (Michael Baker 2017). 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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2018 SPRING BREAKUP
COLVILLE RIVER DELTA

Monitoring Locations

FIGURE: 1.2

(SHEET 1 of 1)

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2018 SPRING BREAKUP
ALPINE AREA FACILITIES

Monitoring Locations

FIGURE: 1.3

(SHEET 1 of 1)

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 G27-C; May 31, 2018

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.

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

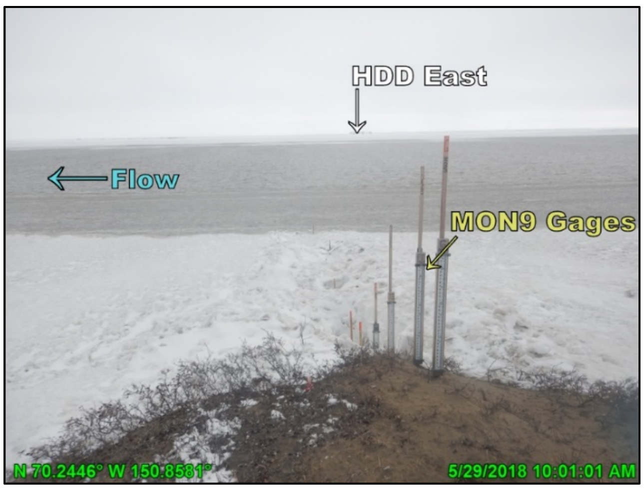


Photo 2.2: Indirect-read gages at Mon9; May 29, 2018

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: Chalked gage at MON20; May 30, 2018

PRESSURE TRANSDUCERS

PTs were used at select gage stations to supplement gage measurements and provide a continuous record of WSEs (Photo 2.4). 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. 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.

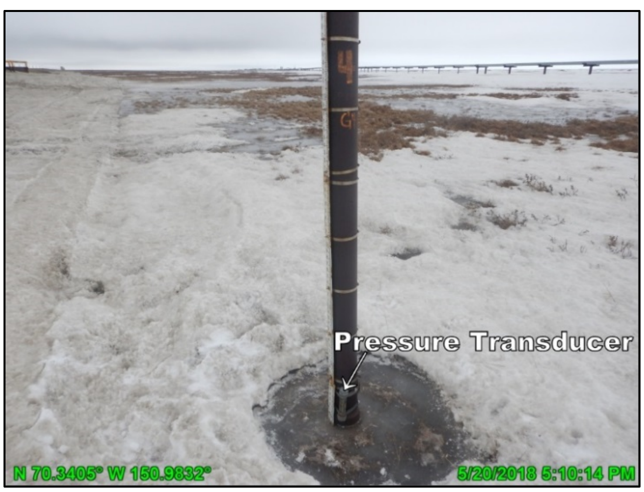


Photo 2.4: PT on direct-read gage G4; May 20, 2018

2.3 DISCHARGE

MEASURED DISCHARGE

Discharge was measured as close to observed peak stage as possible at MON1 and the following drainage structures:

- Nigliq Bridge
- Short Swale 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, and Long Swale and Short Swale bridges 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). Discharge at MON1 was measured using a boat mounted Acoustic Doppler Current Profiler (ADCP, Photo 2.6). Measured discharge methods are further detailed in Appendix C.

Photo 2.5: Measuring discharge at the Nigliq Bridge; June 4, 2018

Photo 2.6: Pre-deployment ADCP testing on the Colville River at MON1; June 3, 2018

PEAK DISCHARGE

Peak discharge was calculated indirectly using the normal depth method 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.

Peak discharge was calculated at the following locations:

- Colville River (MON1)
- Colville River East Channel (MON9)
- Nigliq Bridge
- Long Swale Bridge
- Short 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.

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 satisfy the requirement for annual pier scour measurements during spring breakup and other large flood events at the Nigliq Bridge and Nigliagvik Bridge (Michael Baker and ABR 2013). Maximum scour occurring under the influence of peak velocities is often greater than the final scour measured after flood recession due to sediment deposition in the scour hole associated with lower flow velocities. For this reason, real-time soundings are collected during peak flood conditions.

The Nigliq Bridge is supported by two bridge abutments, abutments 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, abutments 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 presents a plan view of each bridge (UMIAQ 2018a).

A real-time pier scour monitoring system was installed on bridge piers that are the most susceptible to scour. These include piers 2 through 5 of the Nigliq Bridge, installed in the spring of 2016, and pier 3 of the Nigliagvik Bridge, installed in the spring of 2015. 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 all piles at bridge piers within the main channel of the Nigliq Bridge and Nigliagvik Bridge were also completed and contour plots around the piers are provided in Appendix E.

BANK EROSION

The objective of the bank erosion study is to monitor bank migration upstream and downstream of the Nigliq Bridge and Nigliagvik Bridge. This work supports the requirements for visual inspection and documentation of tundra as well as bank erosion monitoring. A detailed edge-of-bank delineation was surveyed in 2013 to establish pre-construction baseline data. Post-construction bank surveys were performed in 2016, 2017 and again this year (UMIAQ 2016, 2017c, 2018). Maximum and average rates of erosion between 2013 and 2018 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 were documented at the following ice road crossings:

- Colville River East Channel at HDD
- Kachemach River
- No Name Creek
- Pineapple Gulch
- Silas Slough
- Slemp Slough
- Tamayayak Channel 1 near coast
- Toolbox Creek

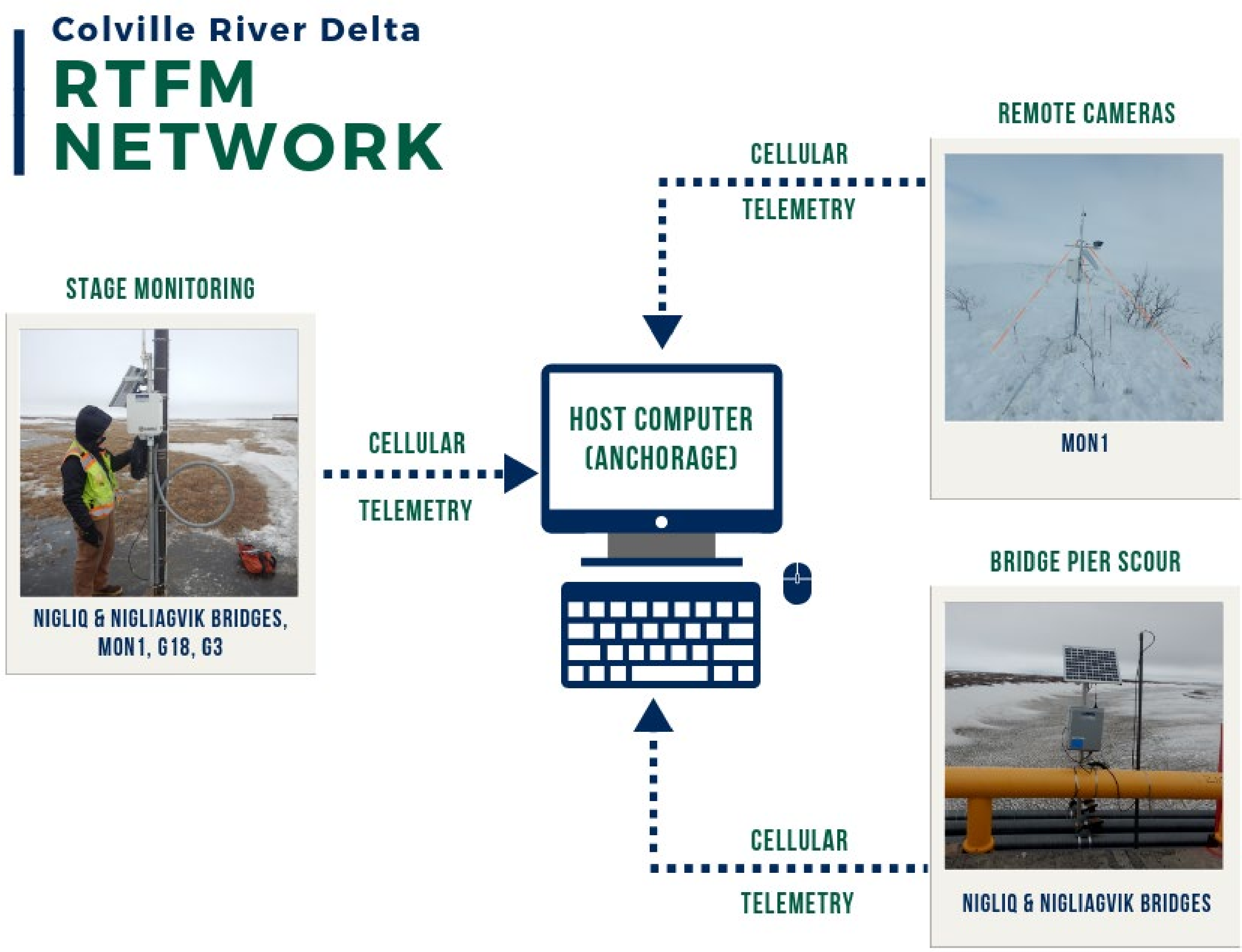
2.7 REAL-TIME FLOOD MONITORING NETWORK

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

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

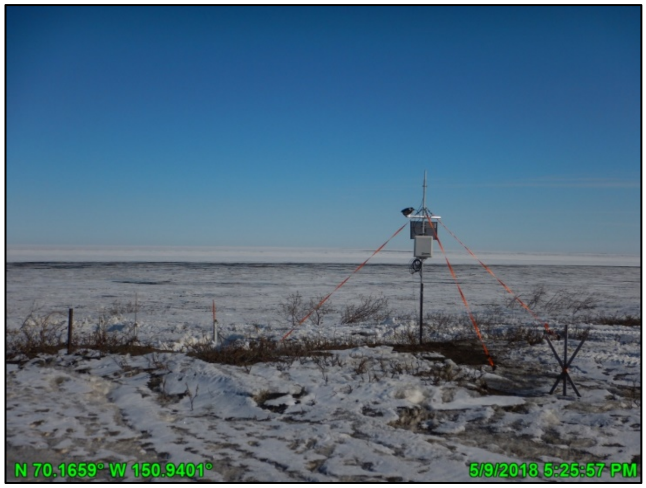


Photo 2.7: Remote camera setup at MON1C; May 9, 2018

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. 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. Systems were powered with 12v DC batteries and charged with onsite solar panels.

HOST COMPUTER, DATA ACCESS, & NOTIFICATIONS

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

2.8 FLOOD & STAGE FREQUENCY ANALYSES

Flood and stage frequency statistical analyses were performed using historic annual peak discharge and stage data to estimate the recurrence interval in a given year. The presence of channel ice and ice jams are common during spring breakup flooding, and the influence of the ice on peak stage and discharge is highly variable. Both ice affected, and non-ice affected peak stage and discharge are grouped together in the analyses to provide results representative of the ranging conditions.

Frequency analyses are completed every three years since a single year of data is unlikely to significantly affect previous findings. When frequency analyses are not performed, peak discharge and stage values are compared to the results of the most current analysis to determine respective returns.

The results of flood and stage frequency analyses provide the design discharge and WSE magnitudes in support of Alpine facility design and operations. The current discharge basis for comparison is the 2002 design-magnitude flood frequency analysis for the Colville River at MON1 (Michael Baker and Hydroconsult 2002). Stage frequency basis of comparison references the 2D surface water model developed during the original design of Alpine Development Project in 2002. The model has been updated throughout the life of the Alpine facilities, most recently in 2012 (Michael Baker 2012b). The most recent flood and stage frequency analyses for the CRD were performed in 2015. Flood frequency findings supported maintaining existing design criteria based on the 2002 analysis; stage frequency findings supported maintaining existing design criteria based on the most current version of the CRD 2D surface water model. Flood and stage frequency analyses were completed again in 2018 and results are presented in this report.

FLOOD FREQUENCY

Flood frequency was analyzed at MON1 using methods outlined in the U.S. Water Resources Council *Guidelines for Determining Flood Flow Frequency,* otherwise known as "Bulletin 17C" (USGS 2018b). A Weibull distribution was applied to determine recurrences of data within the continuous record, and the Hydrologic Engineering Center Statistical Software Package, based on Bulletin 17C was used to statistically fit and extrapolate discharge data for design-magnitude recurrence intervals (USACE 2010).

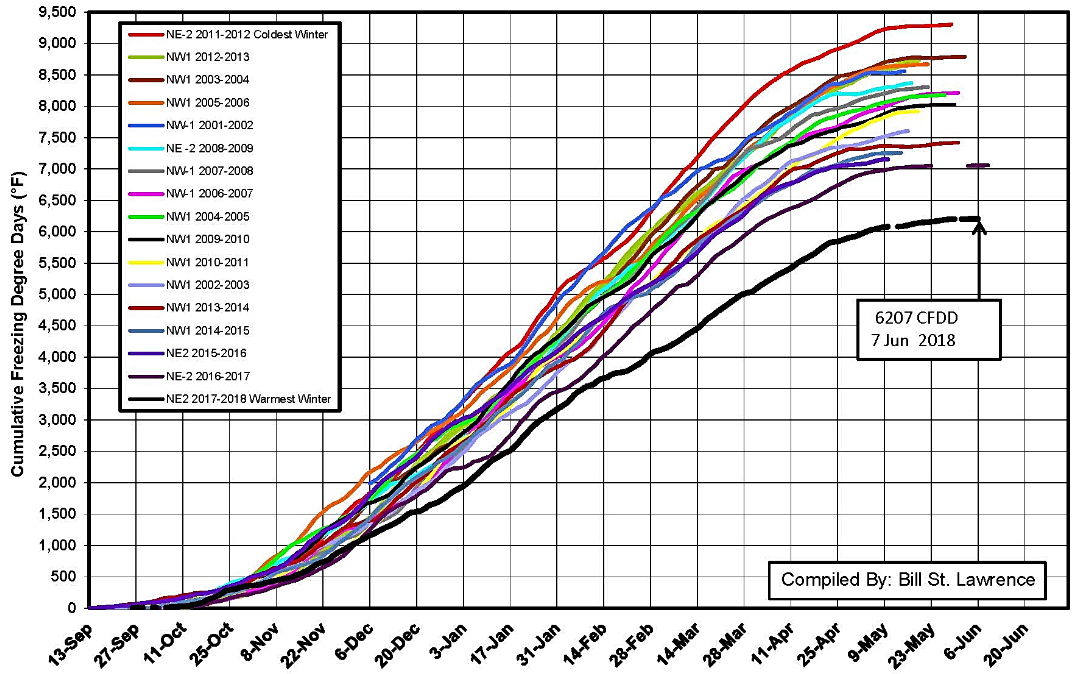
STAGE FREQUENCY

Stage frequency was analyzed at select locations throughout the CRD based on completeness of the historical record and the proximity to Alpine facilities. Using Federal Emergency Management Agency (FEMA) and USACE guidelines (FEMA 2003; USACE 1991, 2002), a Weibull distribution was applied to determine recurrences of data within the continuous record and a Log-Pearson Type III station skew distribution was used to statistically fit and extrapolate stage data for design-magnitude recurrence intervals.

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 2017-2018 (September – May) winter was the warmest on record for the past 17 years (Graph 3.1, ICE 2018).



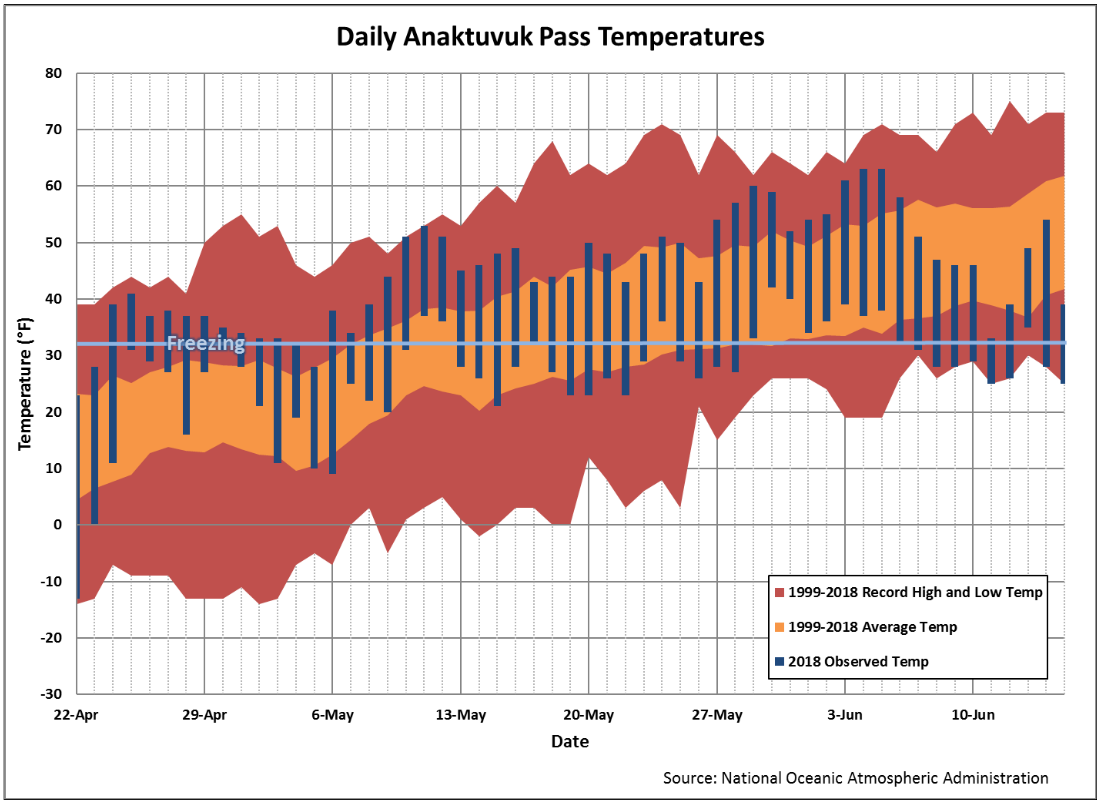
Graph 3.1: NPR-A N. Tundra Monitoring Station, CFDD, Winters 2002-2018 (ICE 2018)

As of April 30, 2018, snowpack in the Brooks Range south of the Colville River basin was reported as approximately 150% of the 1981-2010 median (National Resource Conservation Service [NRCS] 2018). There is no NRCS North Slope snowpack data available for 2018, though general observations indicate snowpack was at or above normal levels.

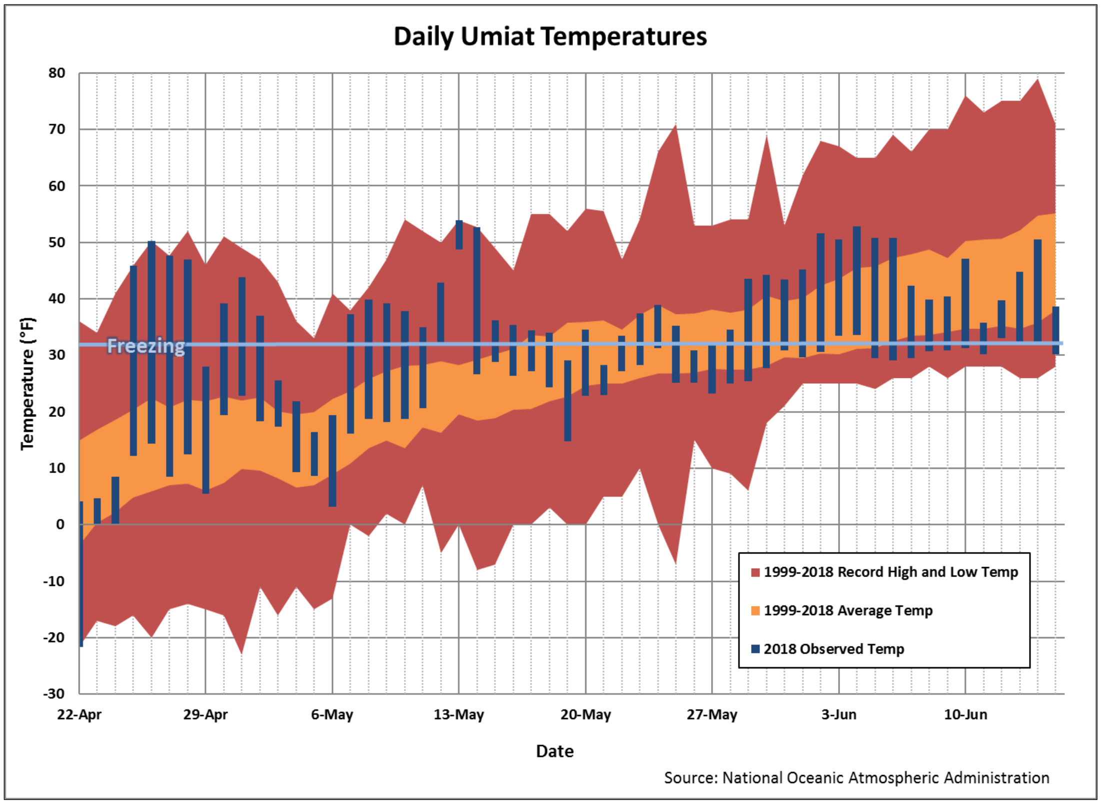
Despite the relatively warm winter and early short-term warm periods in late April and early May, spring in the Colville River watershed was characterized as a delayed and gradual warming trend beginning in late May. This was accompanied by consistent cloud cover over the lower Colville River watershed. A warming period with daily high temperatures above freezing in the upper Colville River watershed (the Brooks Range foothills, as recorded at Umiat) occurred April 25 through April 30 (USGS 2018). Temperatures then cooled to below freezing until May 7. Daily high temperatures at Umiat did not begin consistently recording above freezing until May 27. Daily low temperatures at Umiat began consistently recording above freezing on June 17. Aside from periods in late April and mid-May, daily high air temperatures in the lower Colville River watershed (as recorded at Alpine) did not record above freezing until June 1, after which they were consistently above freezing (National Oceanic and Atmospheric Administration [NOAA] 2018). Daily low temperatures at Alpine began consistently recording above freezing on June 26. At Anaktuvuk Pass, a general warming trend with daily high temperatures consistently exceeding freezing started around May 6 (NOAA 2018). Temperatures routinely reached 45 degrees or more during this warming trend.

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 (NOAA 2018).

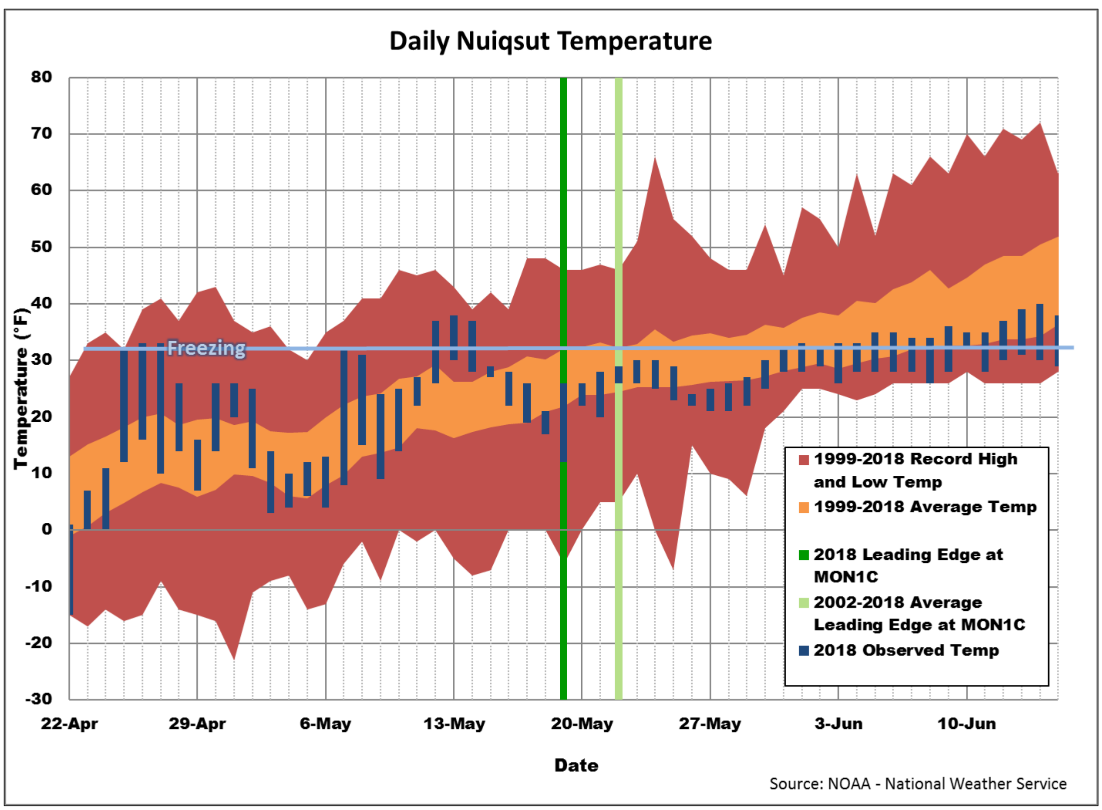
Temperatures for the Alpine area are available from the Nuiqsut weather station, located approximately 9 air miles south (upstream) of Alpine facilities. Daily low ambient air temperatures in the CRD remained at or below freezing throughout breakup. Graph 3.4 illustrates daily high and low ambient air temperatures recorded in Nuiqsut superimposed on the average and record daily highs and lows during the breakup monitoring period (NOAA 2018). The arrival of the leading edge at MON1 was three days before the average arrival.



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



Graph 3.3: Umiat Daily High and Low Ambient Air Temperatures



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

3.2 GENERAL BREAKUP SUMMARY

Crew members began regular reconnaissance flights towards the headwaters of the Colville River drainage on May 15. On May 15, spring runoff was observed flowing down the Anaktuvuk River and into the Colville River. The leading edge of flowing water was observed roughly 10 RM north (downstream) of the confluence of the two rivers (Photo 3.1). Early runoff contributions from the Anaktuvuk River were likely the result of the warm period from May 10 through May 12 when daily low temperatures, measured at Anaktuvuk Pass, were at or exceeded freezing. Daily low temperatures at Umiat during this time were consistently well below freezing, delaying upstream contributions from the Colville River. On May 18, the leading edge of floodwater was observed approximately 5 RM upstream of MON1 (Photo 3.2). The leading edge likely passed MON1 in the morning on May 19. By May 21, floodwater had reached the coast and began to flow over coastal shorefast ice. Cool air temperatures with heavy cloud cover persisted for the next few weeks.

Photo 3.1: Leading edge of water in Colville River, approximately 60 RM upstream of MON1, looking southwest; May 15, 2018

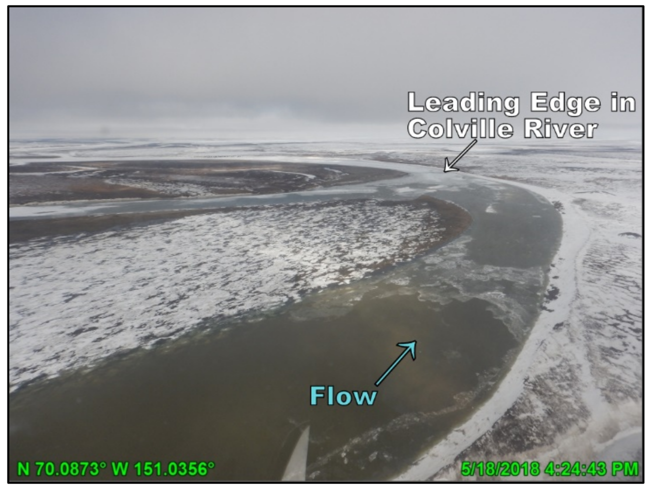


Photo 3.2: Colville River leading edge of water approximately 5 RM upstream of MON1, looking south; May 18, 2018

On May 22, a notable increase in water levels was observed in the Colville River at MON1 and in the East Channel at MON9. Water levels had also increased in the Nigliq Channel but were less pronounced than in the East Channel. Channel ice remained intact throughout the CRD (Photo 3.3 and Photo 3.4). On May 23, an ice jam approximately 2.5 to 3 miles long was observed approximately 14 RM upstream of MON1 (Photo 3.5). Over the next few days, the ice jam decreased in size but remained in place until June 1, when it moved downstream and reformed in the horseshoe bends between Ocean Point and MON1 (Photo 3.6). Some backwater developed behind the jam, filling low flow channels and low-lying areas, but in general, water levels remained near bankfull stage (Photo 3.7). Near Alpine facilities, flow into Nanuq Lake had connected to Lake M9524 and was passing under the Long Swale Bridge (Photo 3.8).

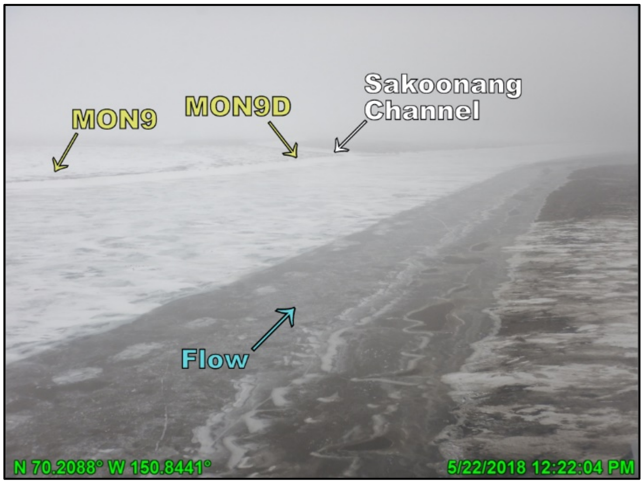


Photo 3.3: **Intact channel ice in the East Channel of the Colville River, looking north (downstream); May 22, 2018**

Photo 3.4: **Channel Ice on the Nigliq Channel, looking north; May 22, 2018**

Photo 3.5: **Ice jam on the Colville River approximately 14 RM upstream of MON1, looking east (downstream); May 23, 2018**

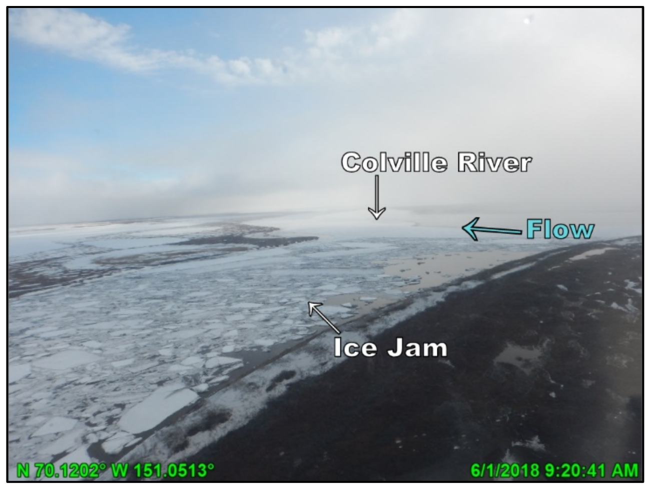


Photo 3.6: **Ice jam near the horseshoe bends on the Colville River, looking northeast; June 1, 2018**

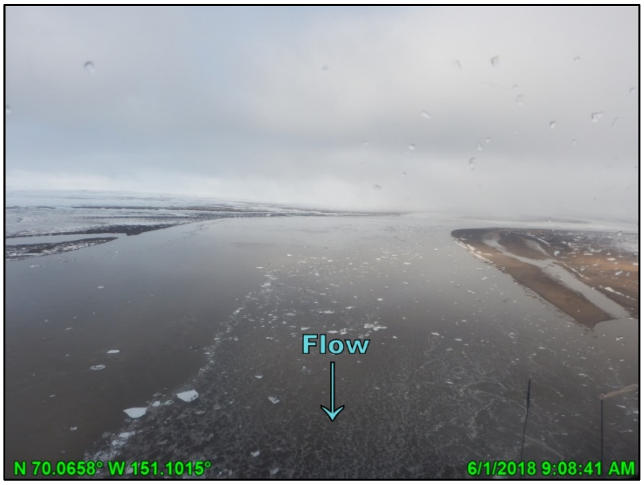


Photo 3.7: Open water conditions upstream of the horseshoe bends on the Colville River, looking southwest (upstream); June 1, 2018

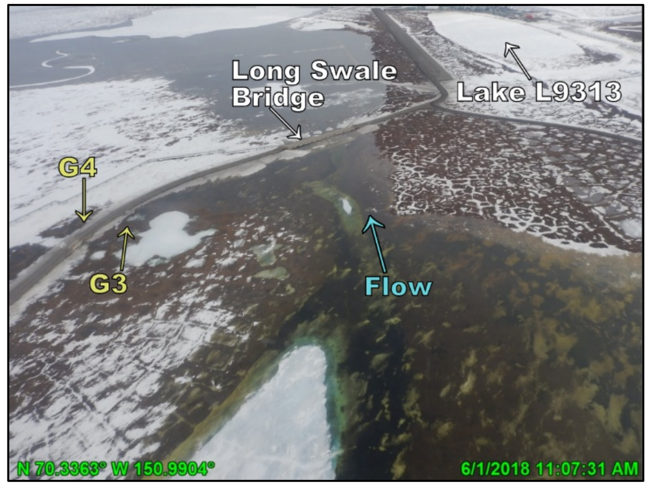


Photo 3.8: Flow under the Long Swale Bridge, looking northeast; June 1, 2018

By June 2, breakup of the Colville River channel ice had progressed through the MON1 reach and an ice jam reformed in the East Channel downstream of MON9D near the Tamayayak River bifurcation (Photo 3.9). A small ice jam was also observed in the Nigliq Channel near MON20 where it formed upstream of intact channel ice (Photo 3.10). Water levels at gages in the Colville River (MON1) and East Channel (MON9) crested in the morning and were decreasing throughout the day. Nigliq Channel water levels at the CD5 bridge also crested in the morning and remained high throughout the day. Flow throughout the CRD remained generally confined within channel banks. Near Alpine facilities, flow through the Large Swale Bridge continued. No flow was observed through the Small Swale Bridge; snow was packed underneath the bridge.

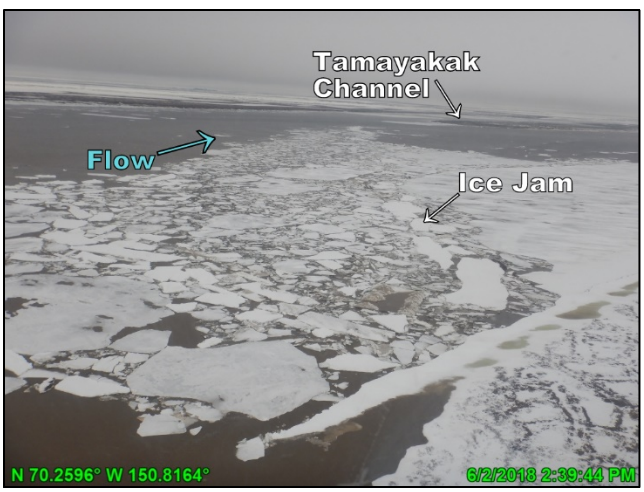


Photo 3.9: Ice jam on the East Channel downstream of MON9, near the Tamayayak tributary, looking north; June 2, 2018

Photo 3.10: Ice jam on the Nigliq Channel near MON20, looking south; June 2, 2018

On June 3, the East Channel ice jam reformed further downstream near the Kachemach River confluence. Stage continued to drop in the Colville River, East Channel, Nigliq Channel, and around Alpine facilities. The Long Swale Bridge continued to convey flow and a small flow path had cut through the snow underneath the Short Swale Bridge. Grounded ice was observed on June 4, indicating stage had receded from peak conditions (Photo 3.11). As of June 6, stage in the Nigliq Channel and East Channel was continuing to drop. Remaining channel ice broke up into floes which progressed with minimal jamming to the outer extents of the CRD (Photo 3.12).

Peak stage was observed at the head of the delta on June 2 and peaked around Alpine facilities on June 2 and June 3. Considerable amounts of snowpack remained in the delta during flooding, impeding flow through low flow channels, swales, and interlake connections. As a result, many hydraulic connections typically observed during spring breakup were either delayed or did not develop. Floodwater did not reach either Lake L9312 or Lake L9313 during spring breakup. Overall, ice jamming effects in the CRD were minimal, as was associated backwater; overbank flooding was generally limited.

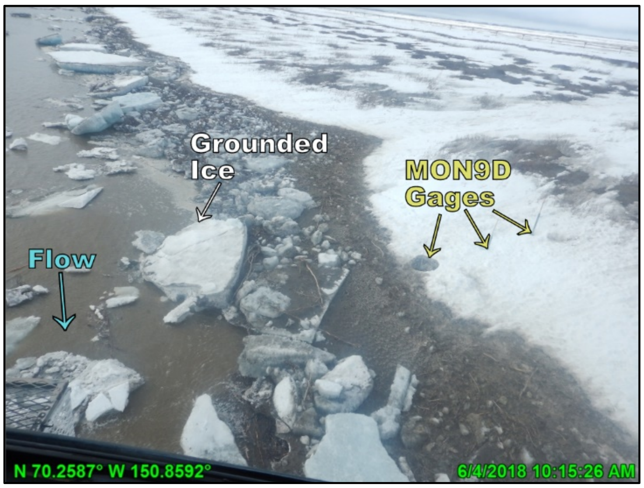
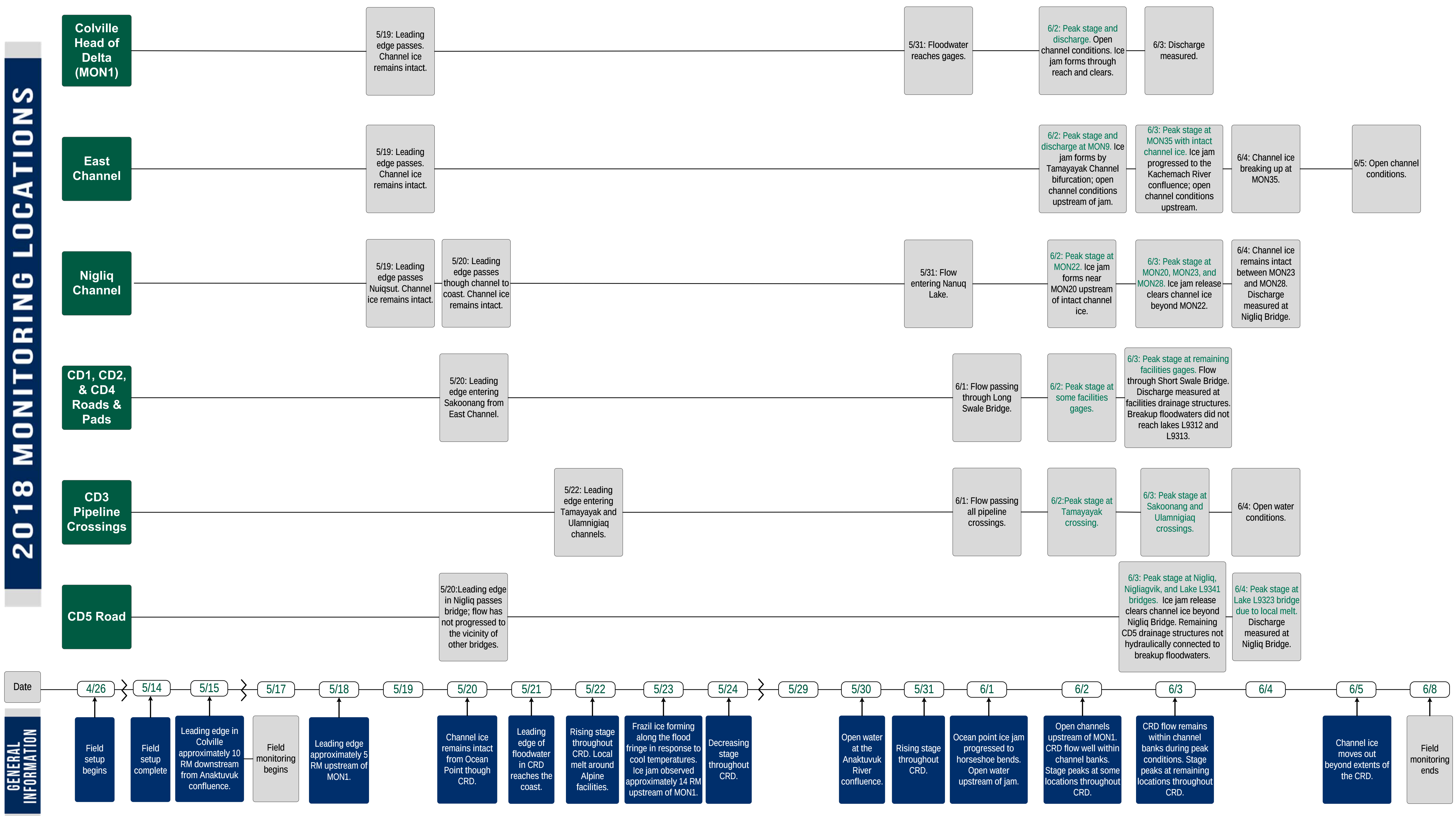


Photo 3.11: Grounded ice at MON9D following stage recession, looking south; June 4, 2018

Photo 3.12: Open channel conditions in the Nigliq Channel downstream of MON23, looking south (upstream); June 6, 2018

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: Stage ft BPMSL	Peak Stage: Date & Time	Measured Discharge: Discharge cfs	Measured Discharge: Stage[1] ft BPMSL	Measured Discharge: Date & Time	Peak Discharge: Discharge cfs	Peak Discharge: Stage ft BPMSL	Peak Discharge: Date & Time
Colville River	Upstream of Anaktuvuk & Chandler River Confluences	Umiat[3]	55.5	6/1, 12:45am	103,000	55.24	6/2, 1:10pm	117,000	55.5	6/1, 12:45am
CRD Monitoring Locations										
Colville River	Head of the CRD	MON1U	15.53	6/2, 4:30am	168,000	12.35	6/3, 3:00PM	331,000	15.79	6/1, 9:00pm
		MON1C	15.90	6/2, 4:15am		12.176			15.19	
		MON1D	16.03	6/2, 4:00am		--			14.84	
Colville River East Channel	East Channel Distributary	MON9	12.97	6/2, 12:00pm	Not measured			236,000	12.59	6/2, 9:45am
		MON9D	12.91	6/2, 12:00pm					12.15	
		MON35	4.21	6/3, 10:30am						
Nigliq Channel	Nigliq Channel Distributary	MON20	8.57	6/3, 2:45am						
		MON22	7.89	6/2, 3:30am						
		MON23	6.73	6/3, 4:00am						
		MON28	3.31	6/3, 7:45am						
Alpine Facilities Monitoring Locations										
CD1 Pad & Drinking Water Lakes	Lake L9312	G9	8.10	6/9, 3:45pm						
	Lake L9313	G10	6.29	7/9, 6:30pm						
	CD1 Pad	G1	5.50	6/3, 10:30am						
CD2 Pad & Road	Short Swale Bridge	G3	7.30	6/2, 5:30am	5.4	6.65	6/3, 4:15pm	12	6.63	6/3, 4:15pm
		G4	7.30	6/2, 5:00am		6.56			6.55	
	Long Swale Bridge	G3	7.30	6/2, 5:30am	3,140	7.05	6/3, 10:20am	3,240	6.96	6/3, 10:20am
		G4	7.30	6/2, 5:00am		6.89			6.82	
	Culverts	G3	7.30	6/2, 5:30am	9	6.53	6/3, 5:00pm	Not calculated		
		G4	7.30	6/2, 5:00am		6.47				
		G6	Dry	--	No flow observed			Not calculated		
		G7	Dry	--						
		G12[4]	7.37	6/1, 5:30pm	No flow observed			Not calculated		
		G13[4]	7.47	6/1, 5:30pm						
	CD2 Pad	G8[4]	9.10	6/2, 9:00am						
CD3 Pad & Pipeline	Pipeline Crossings	SAK	5.78	6/8, 11:15am						
		TAM	7.84	6/2, 1:00pm						
		ULAM	6.88	6/2, 2:00pm						
	CD3 Pad	G11	Dry	--						
CD4 Pad & Road	Culverts	G15[4]	7.77	6/19, 1:45am	No flow observed			Not calculated		
		G16[4]	6.84	6/2, 12:15am						
		G17	Dry	--	No flow observed			Not calculated		
		G18[4]	10.82	6/14, 10:00am						
		G40	Dry	--	No flow observed			Not calculated		
		G41	Dry	--						
		G42	Dry	--	No flow observed			Not calculated		
		G43	Dry	--						
	CD4 Pad	G19	Dry	--						
		G20[2]	9.07	6/2, 9:30am						
CD5 Road	Culverts	G30[2,4]	5.97	6/5, 9:45am	No flow observed			Not calculated		
		G31[2]	Dry	--						
		G34[4]	9.15	6/5, 9:30am	4	9.15	6/5, 9:30am	Not calculated		
		G35	Dry	--		--				
		G36[4]	10.89	6/5, 9:15am	No flow observed			Not calculated		
		G37	Dry	--						
		S1[2]	21.19	6/14, 10:00am	No flow observed			Not calculated		
		S1D[2]	20.70	6/14, 11:00am						
	Lake L9323 Bridge	G24[4]	9.67	6/14, 10:00am	No flow observed			Not calculated		
		G25	10.44	6/4, 10:15pm						
	Nigliq Bridge	G28	8.54	6/3, 12:45am	31,800	--	6/4, 2:00pm	42,200	8.24	6/3, 6:00am
		G26	8.43	6/3, 12:45am		6.01			8.26	
		G27	8.43	6/3, 12:45am		5.97			8.25	
		G29	8.01	6/2, 3:15am		--			7.87	
	Lake L9341 Bridge	G32	8.77	6/2, 8:15pm	No flow observed			Not calculated		
		G33	10.06	6/3, 7:45am						
	Nigliagvik Bridge	G38	7.43	6/3, 4:00am	Not measured			10,400	3.10	5/20, 5:30am
		G39	7.36	6/3, 4:00am					2.08	

Notes:
1. Stage prior to discharge measurement
2. Peak stage date estimated
3. Data obtained from USGS Umiat gage station 15875000 and referenced to NAVD88 vertical datum
4. Peak stage from ponded local melt

Gray cells indicate that measured and calculated discharge at that location are not included within the scope of the program

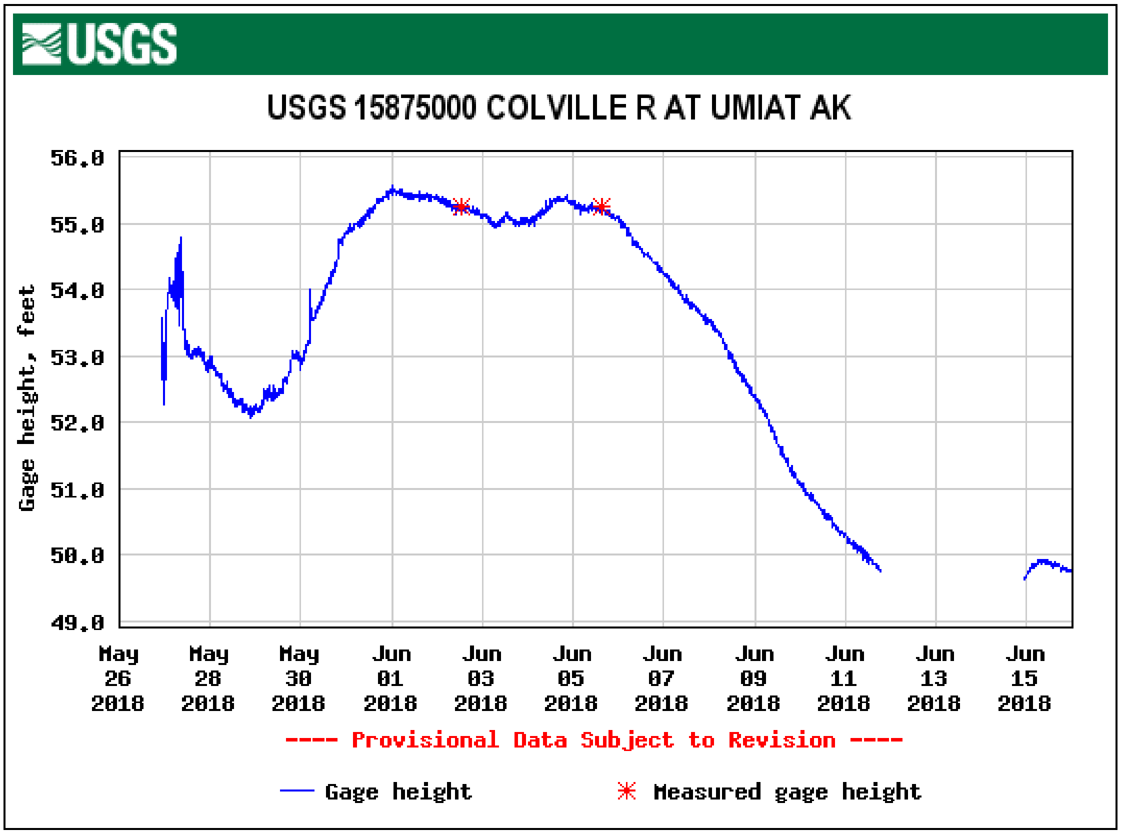
4.1 COLVILLE RIVER

UMIAT

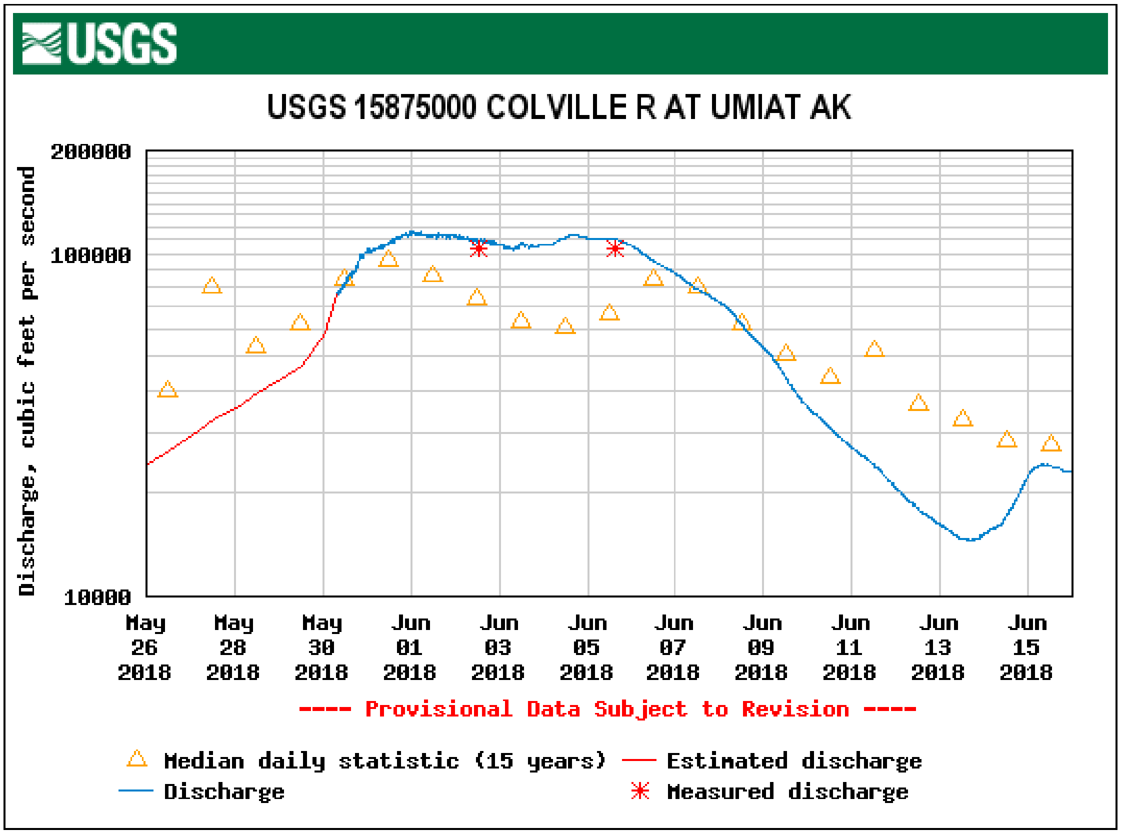
USGS Umiat gage station 15875000 is located approximately 90 RM upstream of the CRD and is monitored throughout breakup to help predict the timing of floodwater and flood crests in the CRD. Umiat is upstream of the Chandler and Anaktuvuk River confluences and Umiat gage data does not account for the 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.

The Umiat gage was offline this year until May 27 and experienced equipment malfunctions between June 11 and June 14. 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 on June 1 at 55.5 ft NAVD88, 3.5 feet below National Weather Service established flood stage of 59.0 ft NAVD88. A slightly lower crest of 55.4 ft NAVD88 was recorded on June 4. Peak discharge of 117,000 cfs occurred on June 1. Discharge was measured on June 4 as 113,000 cfs (USGS 2018a).



Graph 4.1: Colville River at Umiat Stage (USGS 2018a)



Graph 4.2: Colville River at Umiat Discharge (USGS 2018a)

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 where all flow is confined to a single channel and long historical record.

Channel ice remained intact through the MON1 reach until peak discharge and peak stage occurred on June 1 and June 2, respectively (Photo 4.1 and Photo 4.2). Peak conditions at MON1 occurred as the small ice jam and associated backwater released from the upstream horseshoe bends and progressed through the MON1 reach (Photo 4.3). During peak conditions, floodwater was contained within the banks. The estimated peak discharge was assigned a fair quality rating (Table 2.1) because of the ice influences.

Discharge was measured in the Colville River on June 3 with minimal ice and snow interference (Photo 4.4 and Photo 4.5). Stage and discharge results at MON1 are presented in Graph 4.3. Site specific discharge data and plan and profile drawings are provided in Appendix C.

Photo 4.1: Intact channel ice downstream of the MON1 reach the day prior to peak stage, looking northeast (downstream); June 1, 2018

Photo 4.2: Intact channel ice through the MON1 reach the day prior to peak stage at MON1C, looking southwest (upstream); June 1, 2018

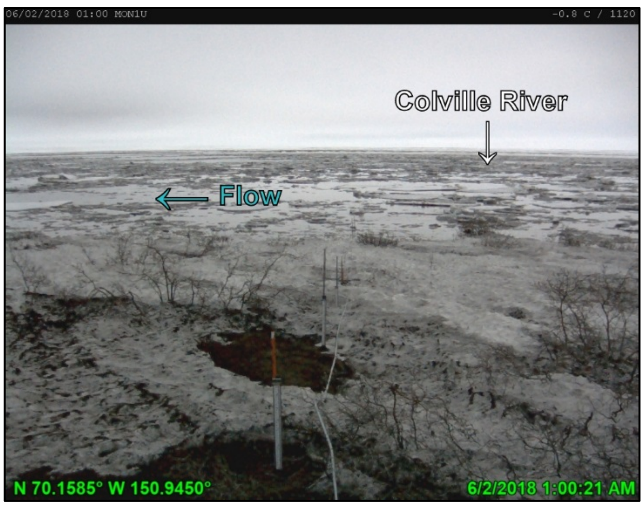


Photo 4.3: Ice jam release through the MON1 reach, the day of peak stage, looking east; June 2, 2018

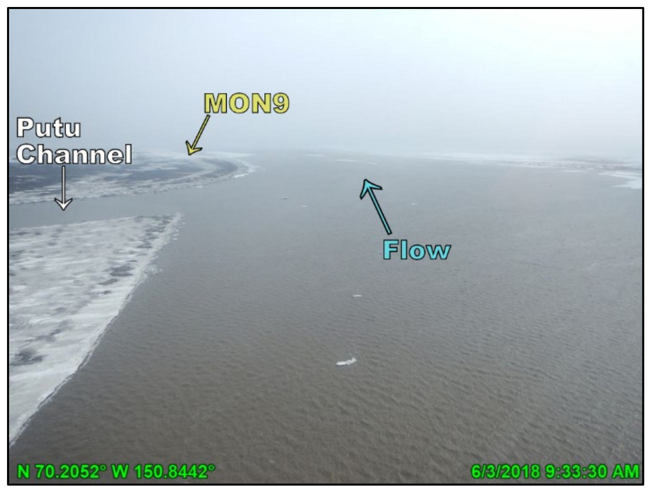
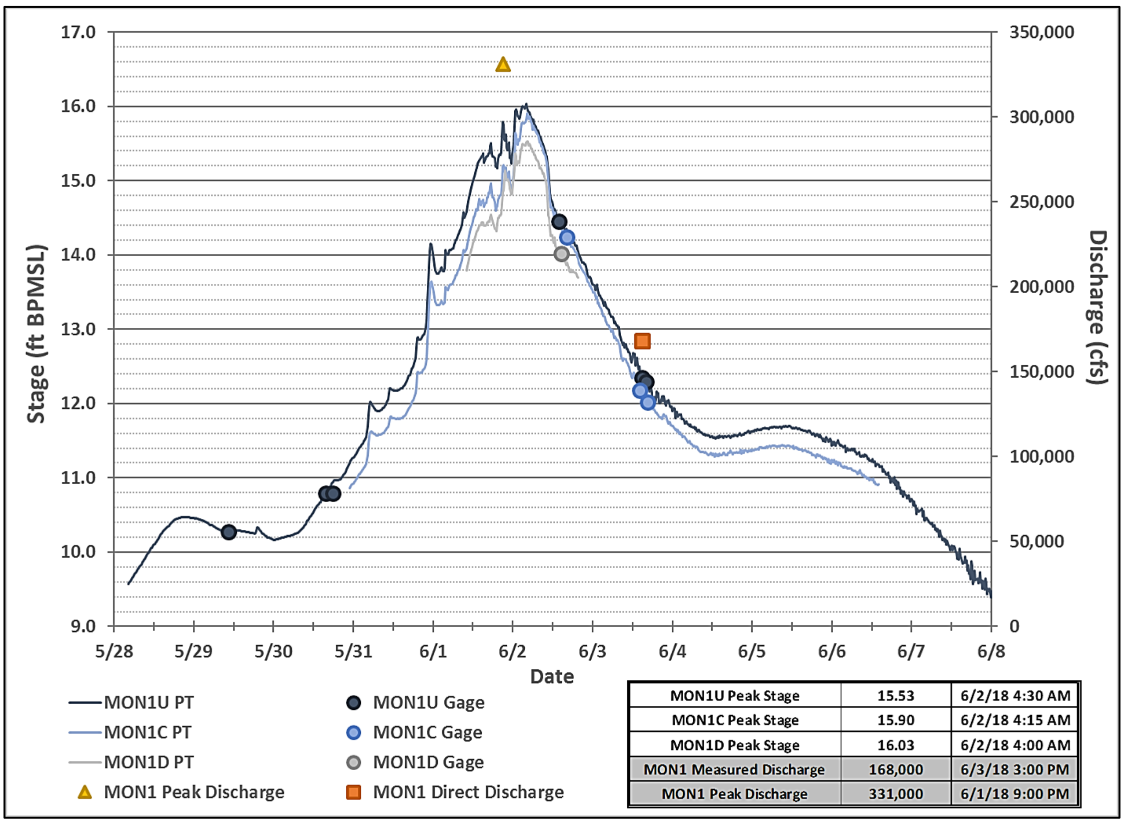


Photo 4.4: Open channel conditions downstream of MON1 on the day of the discharge measurement, looking north (downstream); June 3, 2018

Photo 4.5: Performing discharge measurements at MON1; June 3, 2018



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 and assessing water levels at the HDD pipeline crossing. MON35 has been monitored since 1999 and provides WSEs at the outer extents of the CRD.

Channel ice remained intact in the East Channel through June 1 (Photo 4.6, and Photo 4.6). Peak discharge and peak stage at MON9 and MON9D were the result of an upstream ice jam and associated backwater releasing on June 2 and progressing through the MON9 reach (Photo 4.8). During peak discharge, large ice floes were observed flowing through the reach via remote field camera images (Photo 4.9). The estimated discharge was assigned a fair quality rating (Table 2.1) due to these influences. Site specific discharge data and plan and profile drawings are provided in Appendix C.

All stage observations at MON35 were manually recorded by Jim Helmericks, on average, three times per day. Peak stage at MON35 occurred on June 3 at which time channel ice was still intact. The majority of the channel ice was flushed from the East channel on June 4 and had cleared the MON35 reach on June 5.

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

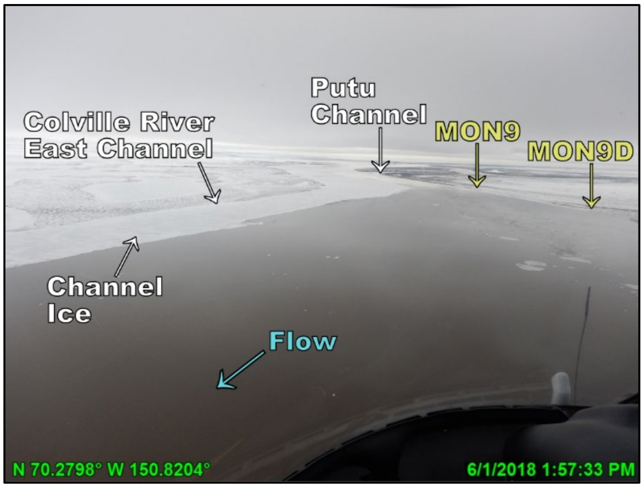


Photo 4.6: Intact channel ice in the East channel, looking south (upstream); June 1, 2018

Photo 4.7: Conditions the day prior to peak stage and discharge at MON9, looking southwest (upstream); June 1, 2018

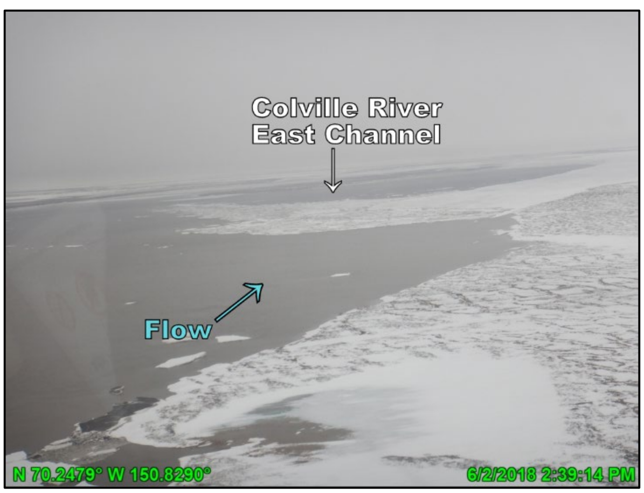
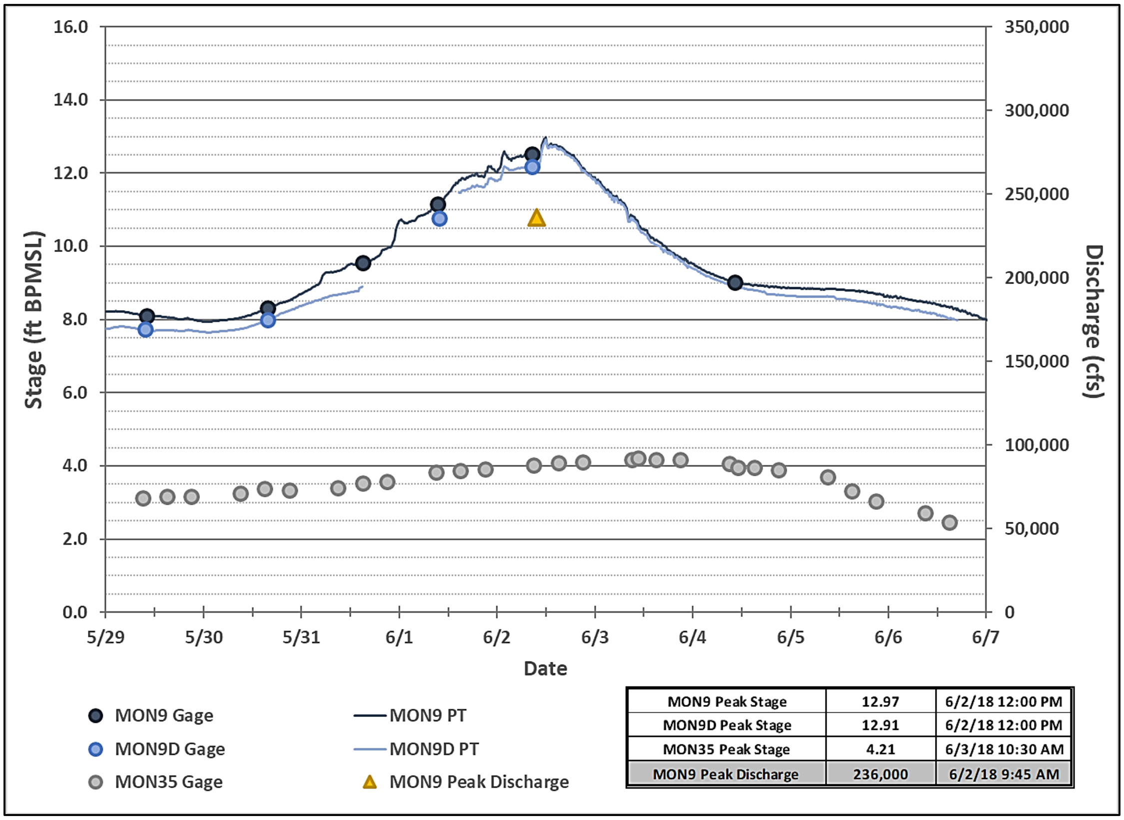


Photo 4.8: Conditions the day of peak stage and discharge at MON9D, looking northwest (downstream); June 2, 2018

Photo 4.9: Ice jam releasing through the MON9 reach, looking east (upstream); June 2, 2018



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.

On May 19, leading edge in the Nigliq Channel was observed passing by Nuiqsut and hinge cracks were observed along intact channel ice indicating a rise in stage. By May 20, visible floodwater was observed at most monitoring locations in the Nigliq Channel. Stage remained low in the Nigliq Channel before slowly increasing around May 30 (Photo 4.10).

Intact channel ice was observed in the Nigliq channel on June 1 (Photo 4.11). Stage initially crested at MON20 and MON23 and peaked at MON22 on June 2 (Photo 4.12). A small ice jam with minimal backwater was observed upstream of MON20, behind channel ice that remained intact through the Nigliq Channel (Photo 4.13). The ice jam released on the morning of June 3, flushing the downstream channel ice through the CD5 bridge. The ice jam release and accompanying backwater produced peak stage at MON20, MON23, and MON28. Open channel conditions were observed throughout the MON20 to MON22 reach by June 4 (Photo 4.14). Channel ice was still observed between MON23 and MON28 on June 4 (Photo 4.15).

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

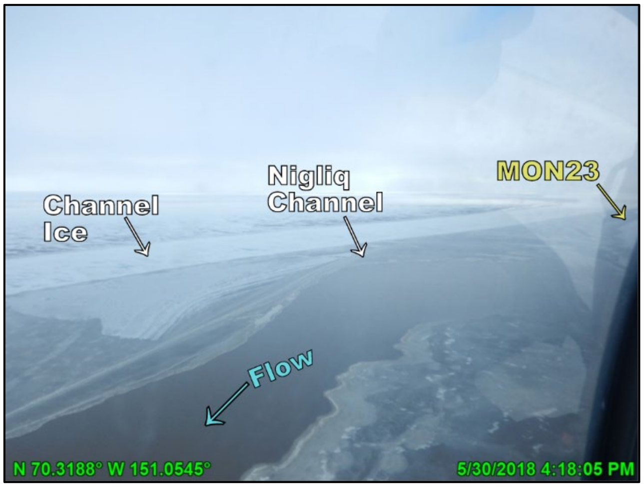


Photo 4.10: MON22 three days before peak stage looking southwest (upstream); May 30, 2018

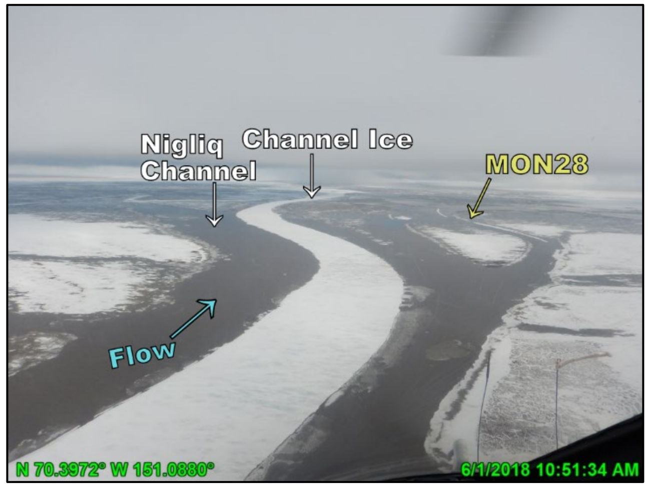


Photo 4.11: Channel ice in the Nigliq Channel between MON23 and MON28, looking north (downstream); June 1, 2018

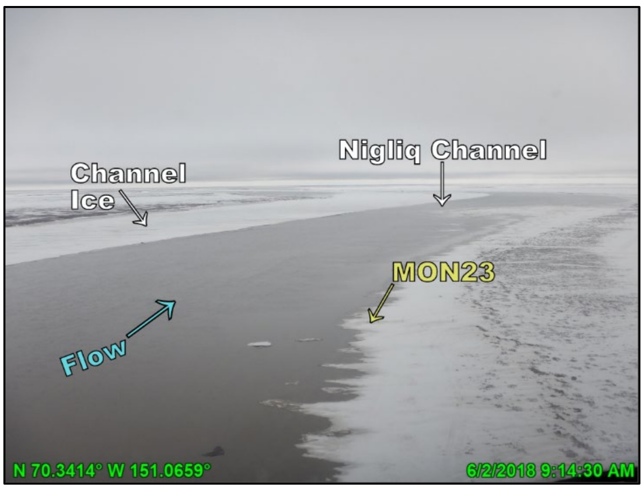


Photo 4.12: Channel ice and conditions prior to peak state at MON23, looking north; June 2, 2018

Photo 4.13: Ice jam and conditions the day prior to peak stage at MON20, looking southwest (upstream); June 2, 2018

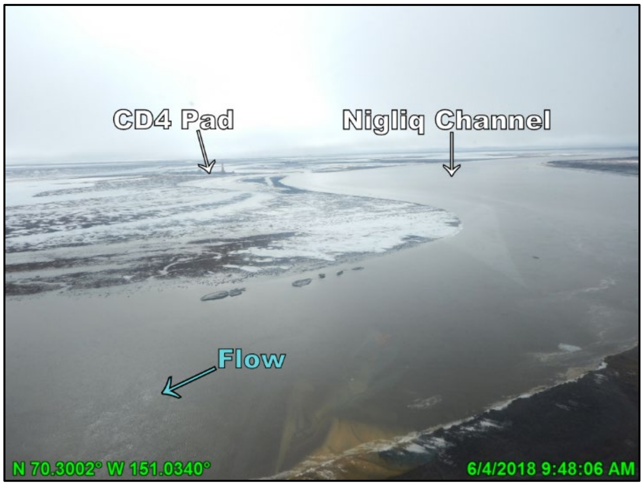


Photo 4.14: Open water conditions the day after to peak stage at MON20, looking southwest (upstream); June 4, 2018

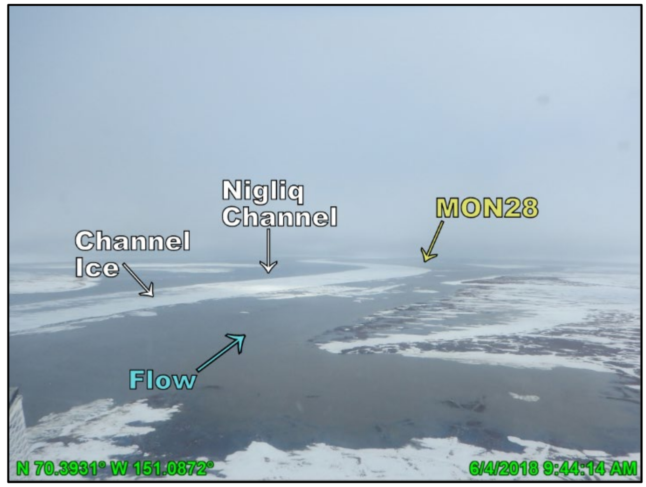
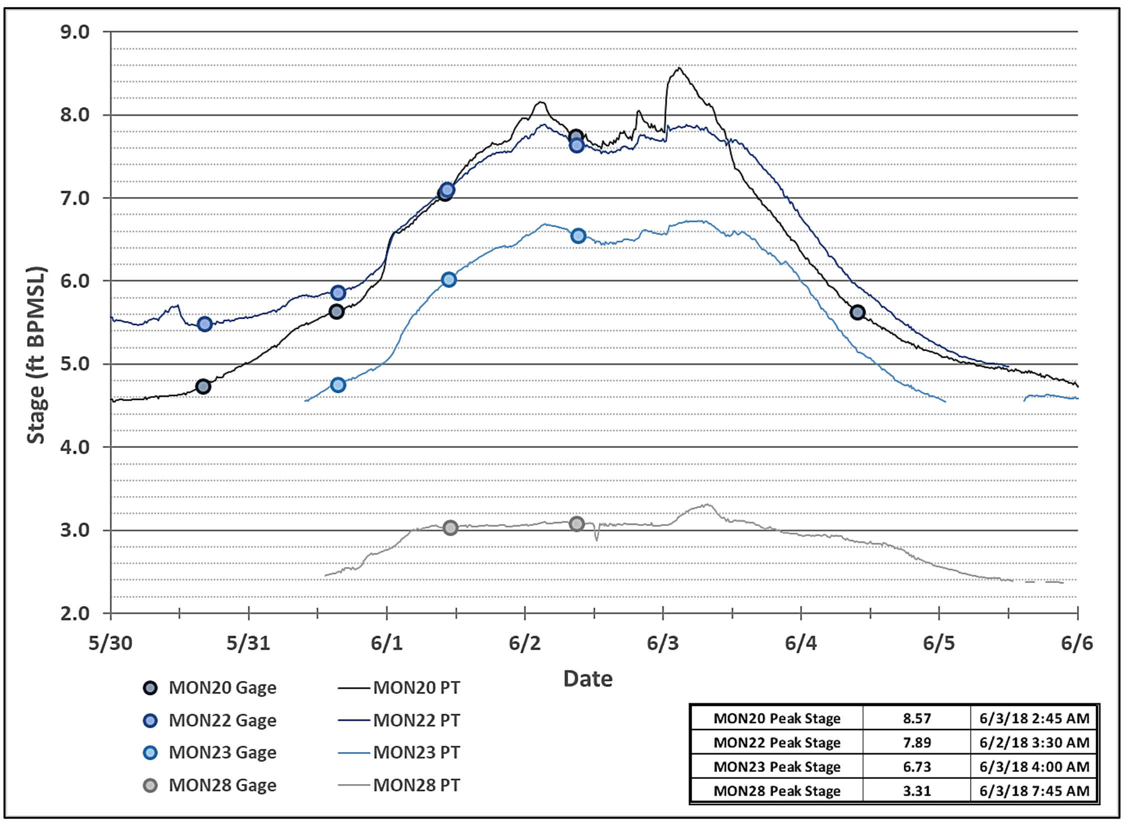


Photo 4.15: Channel ice and conditions the day after peak stage between MON23 and MON28, looking north (downstream); June 4, 2018



MON20 Peak Stage	8.57	6/3/18 2:45 AM
MON22 Peak Stage	7.89	6/2/18 3:30 AM
MON23 Peak Stage	6.73	6/3/18 4:00 AM
MON28 Peak Stage	3.31	6/3/18 7:45 AM

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. Plywood covers are installed at 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 CD2 swale bridges prior to breakup flooding.

Culverts were monitored to assess flow conditions and culvert performance. All culvert covers 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. Detailed culvert discharge measurements, calculations, and performance summary field notes are provided in Appendix C. Snow was cleared from the entrance and exit of CD2 swale bridges prior to the arrival of floodwater, though drifted snow remined immediately beneath the swale bridges.

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). Gage station G1 is situated along the east end of the CD1 pad. Stage data and observations of breakup processes have been collected at gage G1 since 2000. Stage at gage G1 is presented in Graph 4.6.

Spring breakup overbank flow did not reach Lake L9312 or Lake L9313 this year (Photo 4.16). Water levels remained below the gage G9 PT and gage G10 PT throughout the duration of breakup. Snowmelt recharge from within the L9312 lake basin reached bankfull elevation, observed on June 9. Snowmelt recharge from within the L9313 lake basin reached bankfull elevation, based on a hydraulic connection to Lake M9525 observed on July 10 and July 18 (Photo 4.17 through Photo 4.19. Stage at gage G9 (L9313) and gage G10 (L9313) is presented in Graph 4.7.

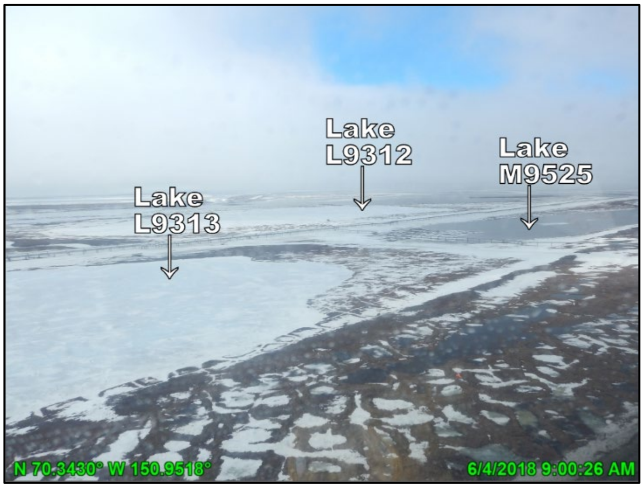
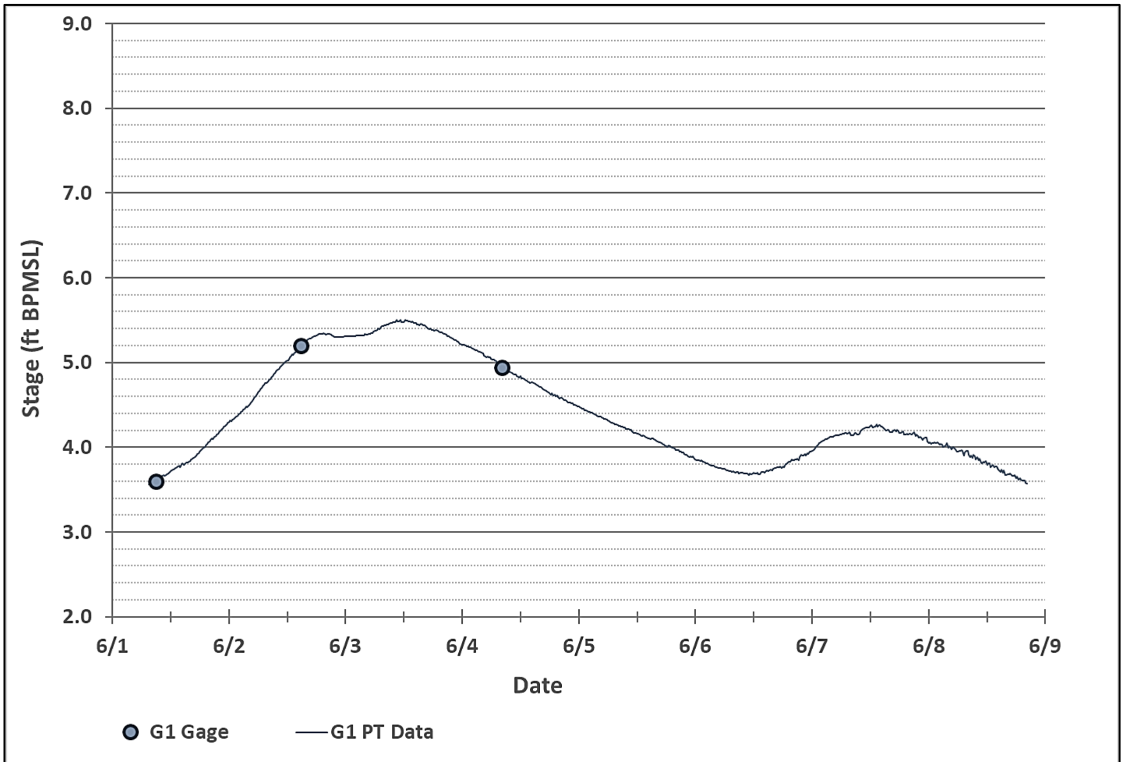


Photo 4.16: Lake L9312 and Lake L9313 hydraulically isolated the day after peak stage, looking south; June 4, 2018

Photo 4.17: Hydraulic connection between Lake M9525 and Lake L9313 looking northwest; July 10, 2018

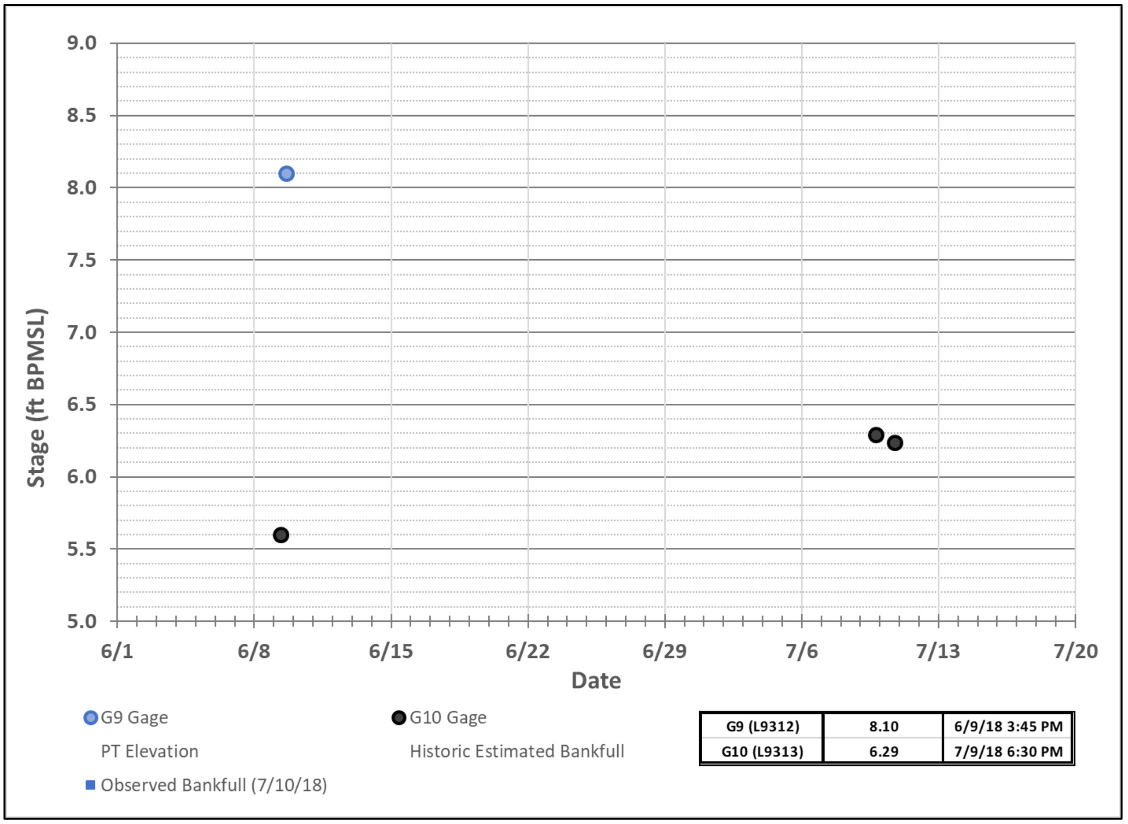
Photo 4.18: Outflow from Lake L9313 looking northeast; July 10, 2018

Photo 4.19: Outflow from Lake L9313 looking north; July 18, 2018



G1 Peak Stage	5.50	6/3/18 10:30 AM

Graph 4.6: CD1 Pad (Gage G1) Stage



G9 (L9312)	8.10	6/9/18 3:45 PM
G10 (L9313)	6.29	7/9/18 6:30 PM

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 around gages G3/G4. Monitoring locations G6/G7, G12/G13, and G8 were either dry or only had local melt. The Long Swale Bridge, the Short Swale Bridge, and three adjacent culverts conveyed flow from the Nigliq Channel into Lake M9524 via Nanuq Lake. Peak stage occurred at G3 and G4 on June 2 (Photo 4.20 and Photo 4.21). Discharge was measured at the Long Swale Bridge and Short Swale Bridge on June 3 approximately 28 hours after peak stage (Photo 4.22). Peak discharge through the G3/G4 culverts was estimated to have occurred approximately 17 hours after peak stage.

The measured average velocity at the Long Swale Bridge was 1.5 feet per second (fps) and the highest depth-averaged velocity within a single section was 3.0 fps. At the time of the measurement, the bridge opening had an ice pan hung up in the middle of the bridge and grounded ice upstream of the bridge producing small eddies effecting velocities at the bridge. Drifted snow was upstream of the bridge abutments, under the bridge, and downstream of the bridge. The quality of the measurement was rated poor because of these factors. 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.

The measured average velocity through the Short Swale Bridge 0.22 fps and the highest velocity was 0.84 fps. At the time of the measurement, a flow path had developed through the snow drift under the bridge. This created a vortex on the upstream side of the bridge. The snow around the abutment contracted the flow under the bridge and back eddies occurred on the downstream side of the bridge as exiting flow expanded.

Stage and total discharge at CD2 bridges and culverts are provided in Graph 4.8. 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.

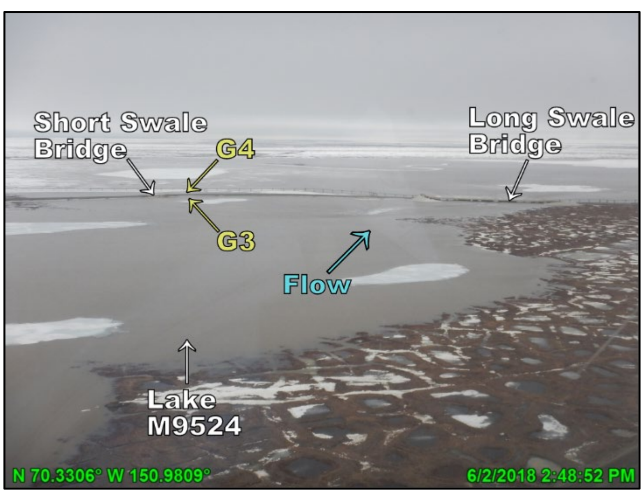
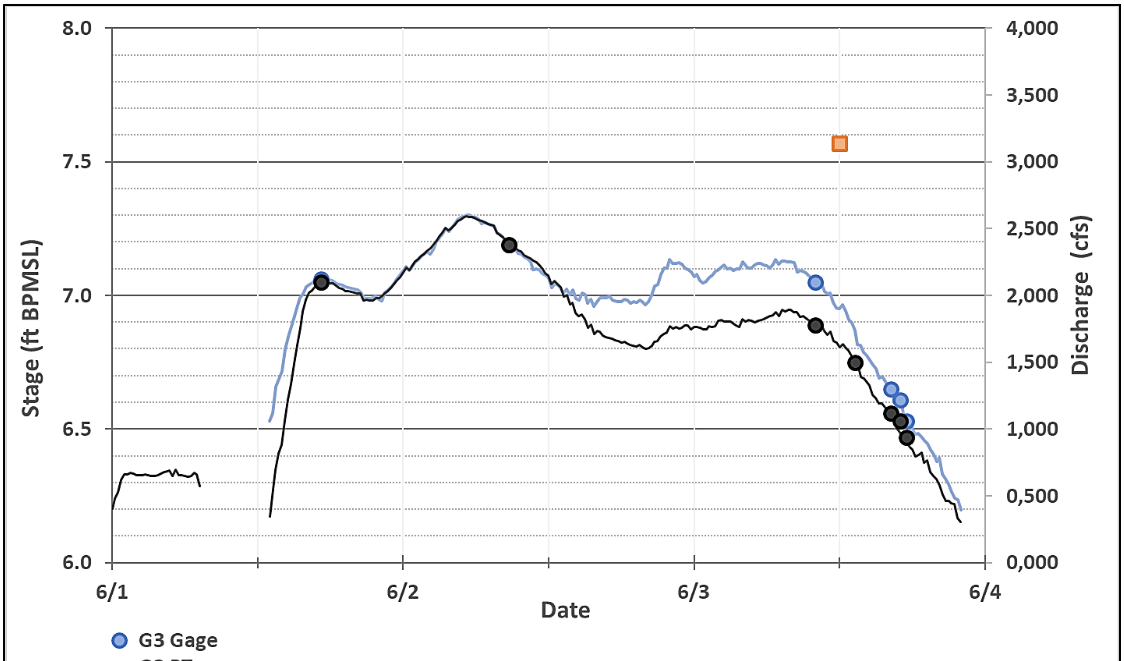


Photo 4.20: CD2 road drainage structures the day of peak stage, looking north (downstream); June 2, 2018

Photo 4.21: CD2 road Short Swale Bridge the day of peak stage, looking northeast (downstream); June 2, 2018

Photo 4.22: Long Swale Bridge the day of the discharge measurement, looking east; June 3, 2018



G3 Peak Stage	7.30	6/2/18 5:30 AM
G4 Peak Stage	7.30	6/2/18 5:00 AM
G3/G4 Bridges + Culverts Measured Discharge	3,140	6/3/18 12:00 PM
G3/G4 Bridges + Culverts Peak Discharge	3,240	6/2/18 10:45 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[3] (cfs)	Total Discharge (cfs)
CD2-20	6/3/18 5:27 PM	0.80	0.32	Less than Half Full	-0.37	-0.7	9
CD2-21	6/3/18 5:20 PM	1.30	0.52	Less than Half Full	0.89	3.2	
CD2-22	6/3/18 5:37 PM	1.20	0.48	Less than Half Full	2.04	6.5	

Note:
1. Measurement taken at 0.6 of total depth of flow
2. Culverts are 48-in diameter
3. Negative values indicate flow moving north to south through culvert.

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

Culvert	Calculated Date & Time	WSE Differential (ft)[1]	Total Depth of Flow (ft)	Flow Depth[2]	Calculated Velocity (ft/s)	Calculated Discharge (cfs)	Total Discharge (cfs)
CD2-20	6/2/18 10:00 PM	0.25	0.92	Less than Half Full	2.48	5	32
CD2-21	6/2/18 10:00 PM		1.68	Less than Half Full	2.55	13	
CD2-22	6/2/18 10:00 PM		1.75	Less than Half Full	2.63	14	

Note:
1. Calculated discharge was based off peak stage differential.
2. 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 before channel ice broke up and moved downstream (Photo 4.23, Photo 4.24, and Photo 4.25). Open channel conditions were observed by June 4.

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

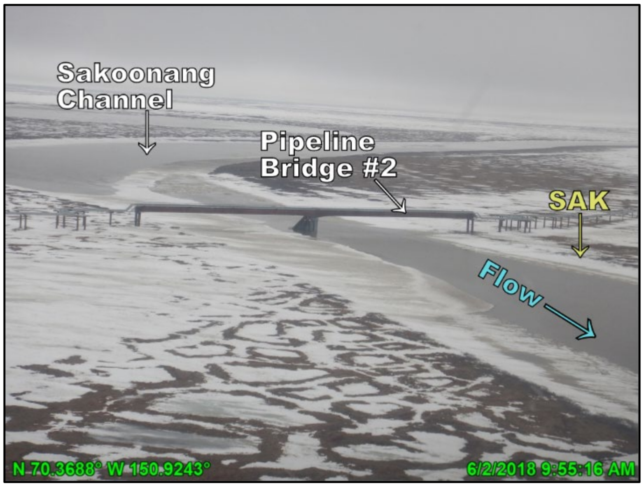


Photo 4.23: Sakoonang Channel the day prior to peak stage at SAK, looking south; June 2, 2018

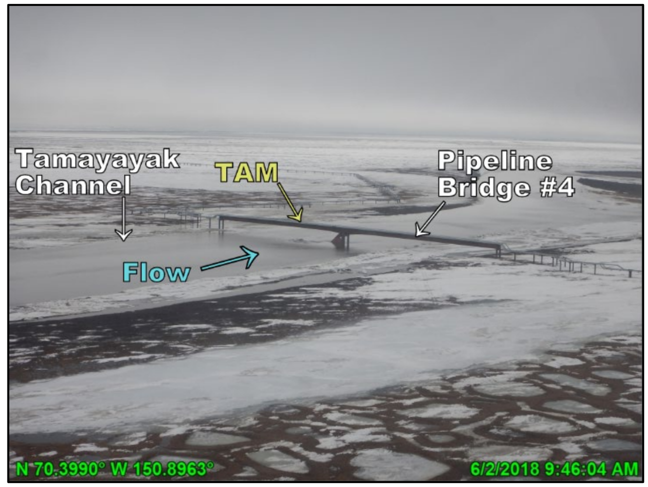


Photo 4.24: Tamayayak Channel the day of peak stage at TAM, looking southwest; June 2, 2018

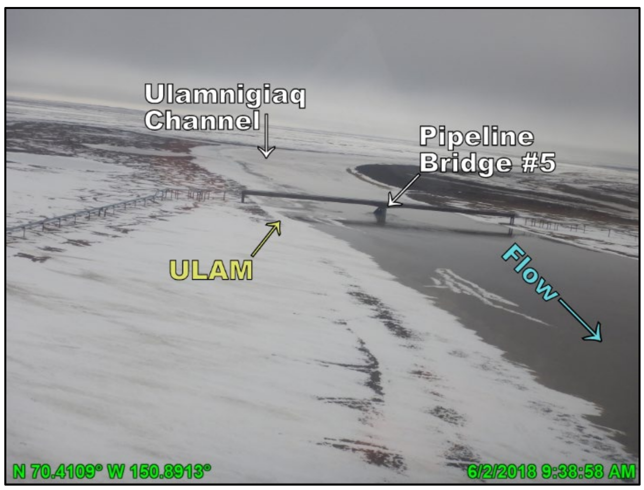
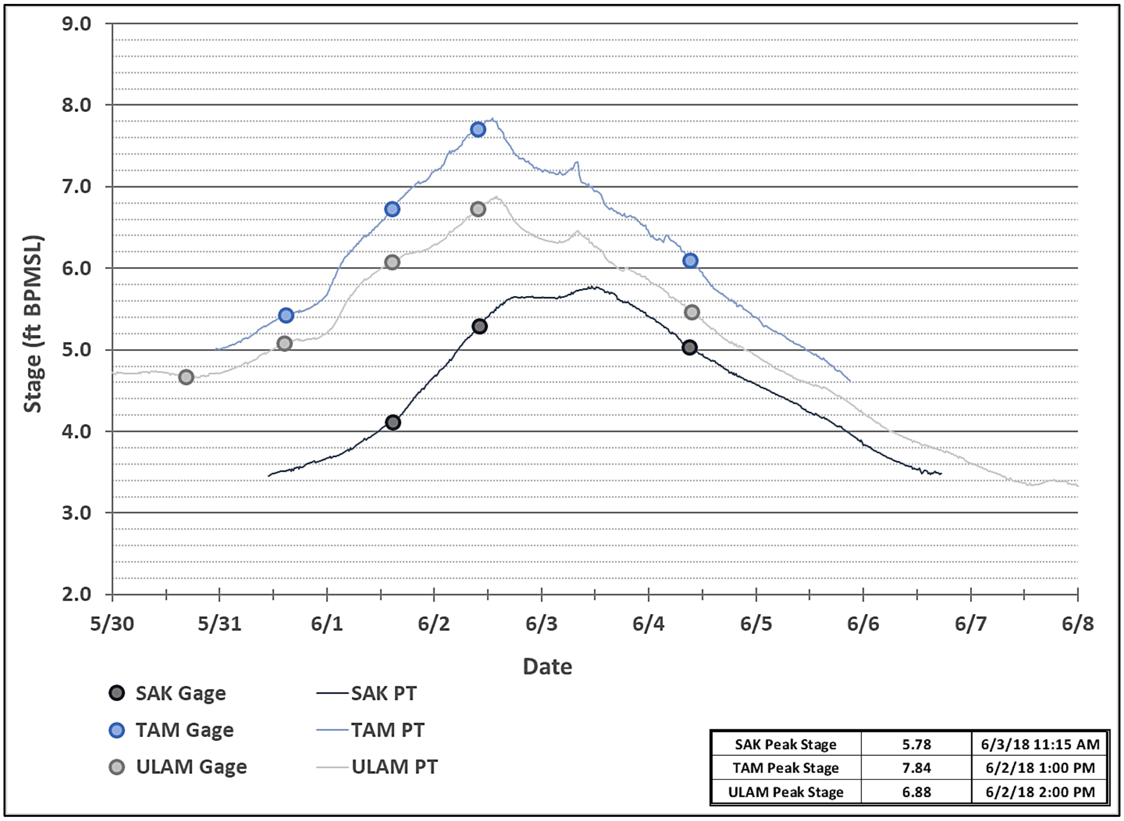


Photo 4.25: Ulamnigiaq Channel the day of peak stage at ULAM, looking southeast; June 2, 2018



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. Local melt was observed at gages G15/G16 (Photo 4.26 and Photo 4.27). No discernable flow was observed at G15/G16 and discharge was not measured or calculated.

Gage G17 remained dry throughout monitoring (Photo 4.28), and local melt was observed at gage G18. Peak discharge was not calculated due to gage G17/G18 remaining dry or only measuring local melt. At the CD4 pad, gage G19 remained dry (Photo 4.29). 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 3.

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 discharge data is summarized in Appendix C.

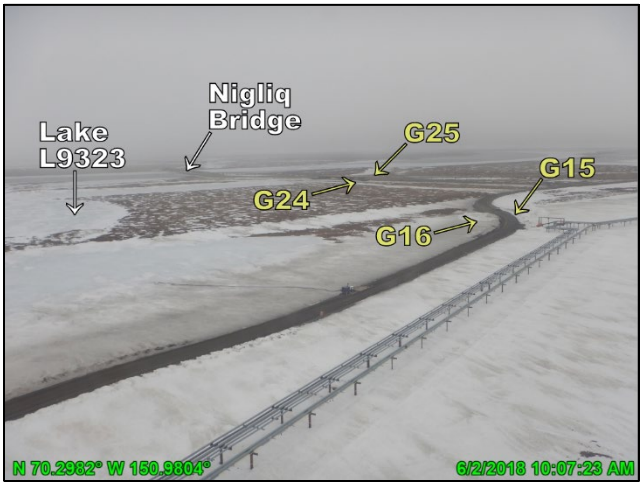


Photo 4.26: North end of CD4 road the day of peak stage at G16, looking north; June 2, 2018

Photo 4.27: CD4 road culvert at gage G16 the day after peak stage, looking south; June 3, 2018

Photo 4.28: CD4 road at gage G17 showing dry conditions, looking northwest; June 2, 2018

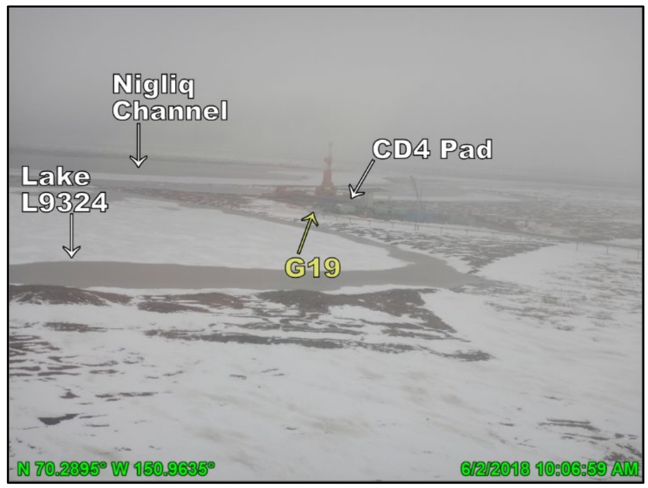
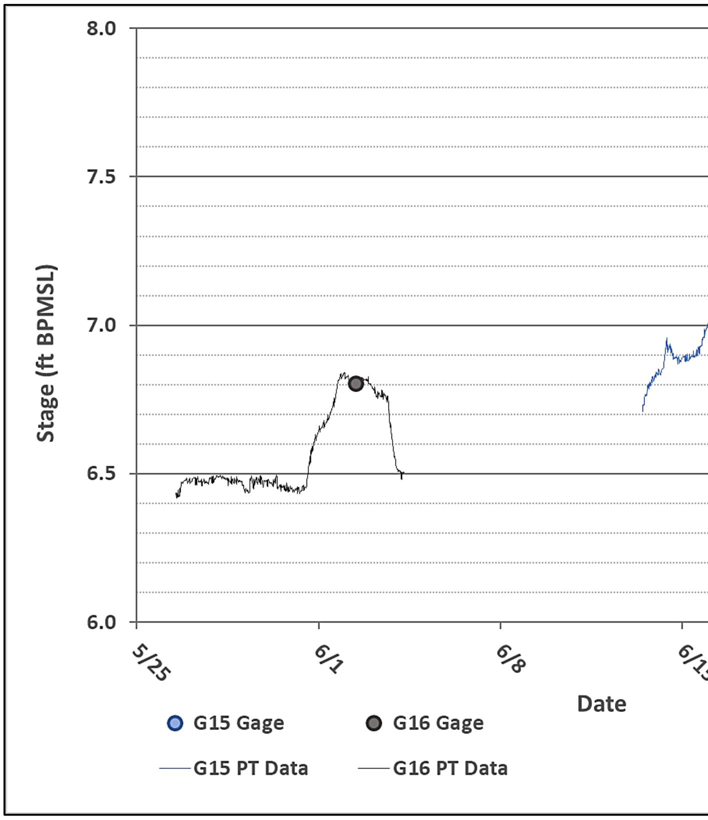
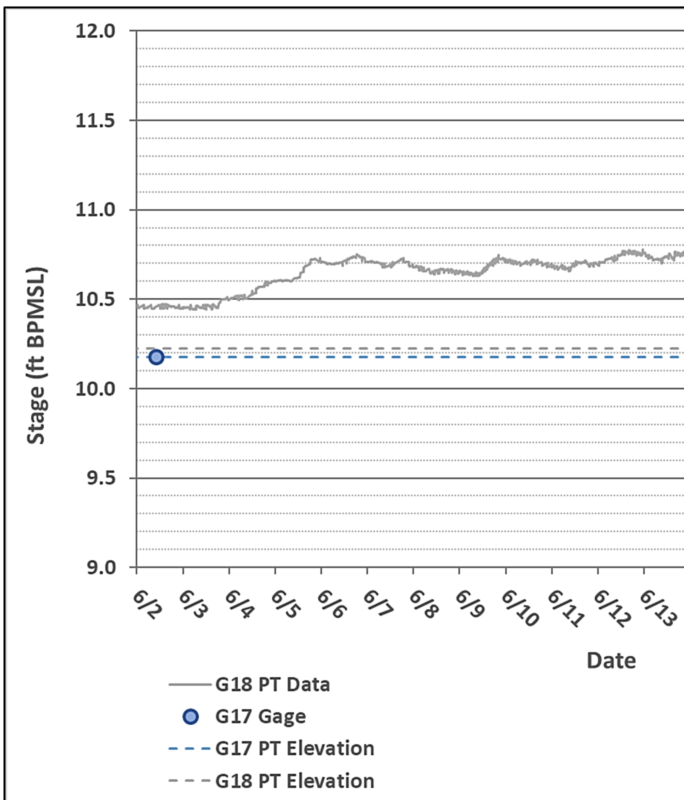


Photo 4.29: CD4 pad at gage G19 showing dry conditions, looking northwest; June 2, 2018



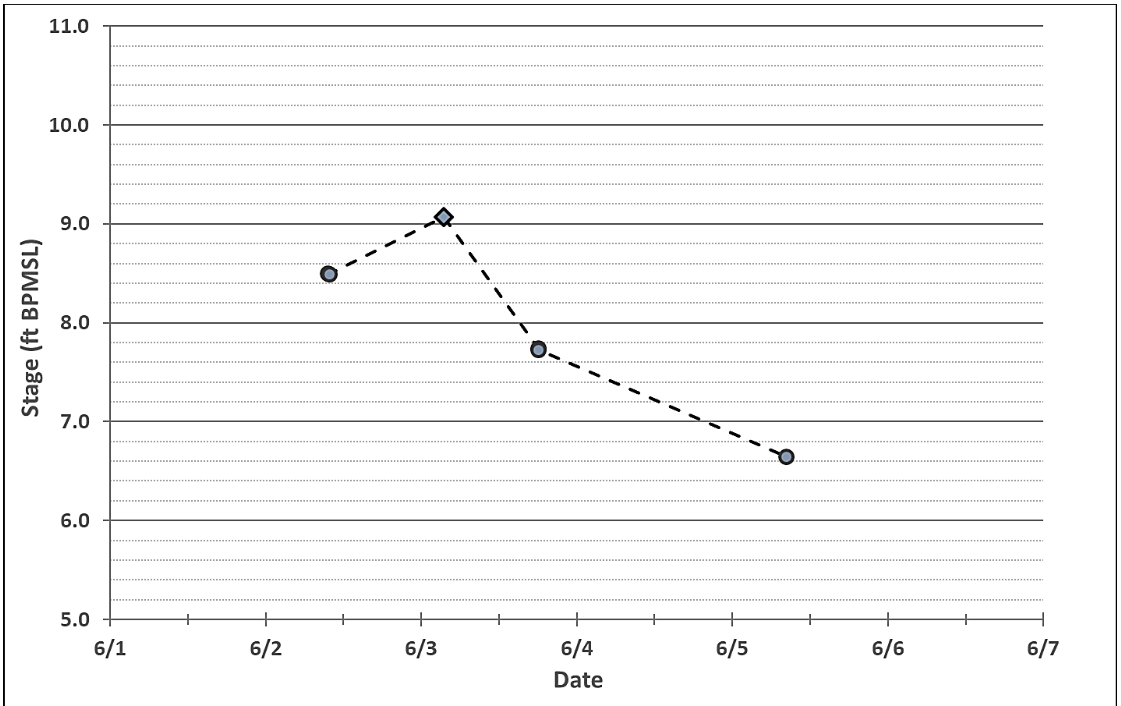
G15 Peak Stage	7.77	6/19/18 1:45 AM
G16 Peak Stage	6.84	6/2/18 12:15 AM

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



G17 Peak Stage	N/A	N/A
G18 Peak Stage*	10.82	6/14/18 10:00 AM
G17/G18 Culverts Peak Discharge	N/A	N/A
*Peak stage attributed to ponded local melt		

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



G19	Dry	Dry
G20 Highest Observed Stage	8.50	6/2/18 9:30 AM
G20 - HWM	9.07	6/3/18 3:30 AM

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. The measured rise in stage at the downstream gage (G25) was from accumulating local melt which peaked on June 4. Drifted snow at the bridge opening initially prevented equalization of the local melt. A sharp drop in stage on June 4 suggests the downstream local melt passed through the drifted snow under the bridge and equalized with the upstream gage.

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.

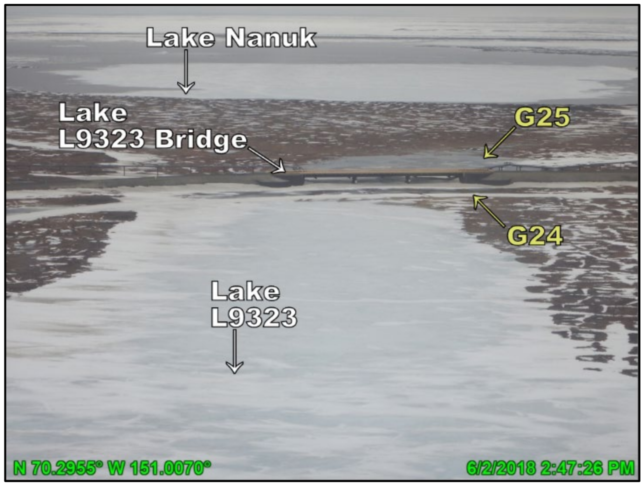
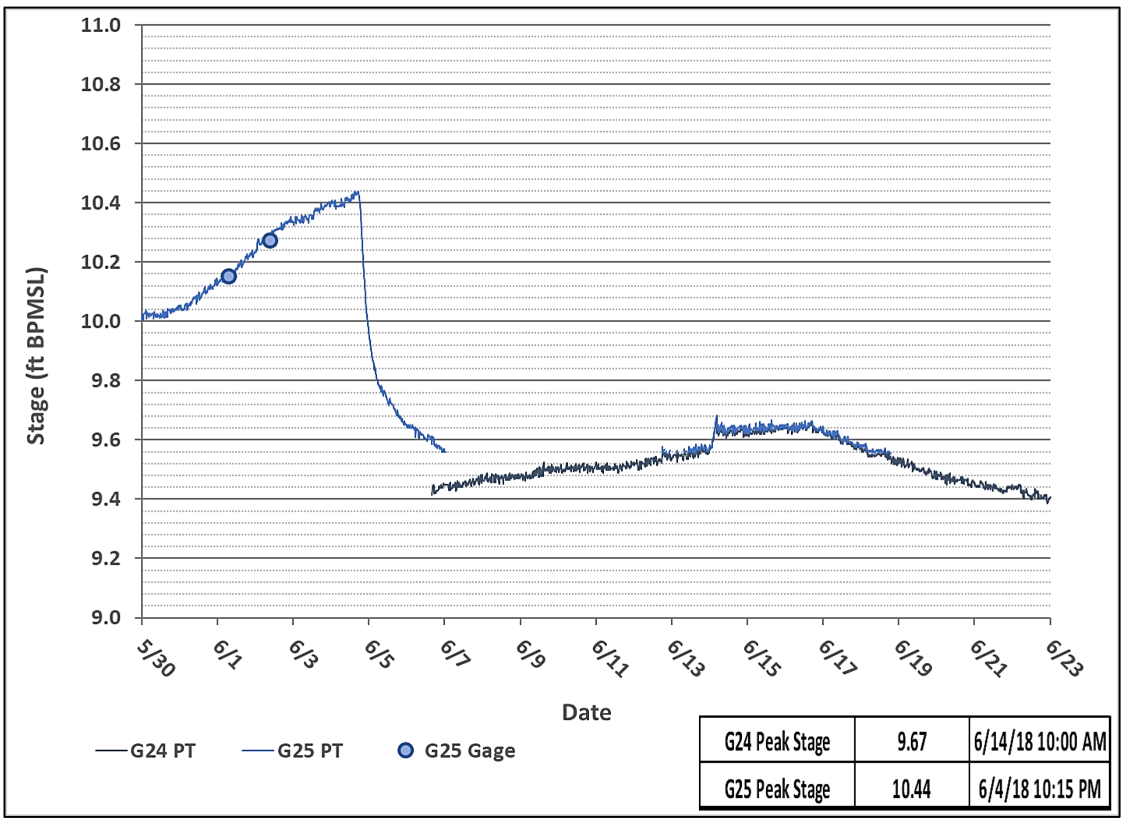


Photo 4.30: CD5 road at gage G24/G25 two days prior to peak stage at G25, looking north; June 2, 2018



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

D. Nigliq Bridge

Leading edge of floodwater passed under the bridge around May 20, and water levels remained low through the end of May. Stage slowly increased from May 30 until cresting on June 1. During this time, the channel ice at the bridge remained intact. Stage dropped slightly on June 1 followed by a series of stage fluctuations associated with the progression of small ice jams upstream of the bridge. On June 2, stage remained elevated and channel ice was observed near the Nigliq bridge (Photo 4.28). Peak stage at the Nigliq bridge occurred early on June 3 and was the result of the ice jam and backwater release at MON20. Game camera images indicate channel ice was still present around the bridge during peak stage but was flushed a few hours afterwards (Photo 4.32).

Discharge was measured from the upstream side of the Nigliq Bridge on June 4. At the time of the measurement, the channel was mostly clear of snow and ice and conditions were considered steady and uniform (Photo 4.33). The average velocity was 1.90 fps and the highest depth-averaged velocity was 2.75 fps. The quality of the measurement was classified as fair. Indirect discharge calculated at the time of direct measurement was 1.9% higher than the measured discharge.

Indirect discharge calculations indicate peak discharge occurred on the morning of June 3 and coincided with the release of channel ice at the bridge opening. Peak discharge was assigned a fair quality rating (Table 2.1) because of these influences.

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.

Photo 4.31: Nigliq Bridge, the day before peak stage, looking west; June 2, 2018

Photo 4.32: Peak conditions at the Nigliq Bridge from remote camera, looking east; June 3, 2018

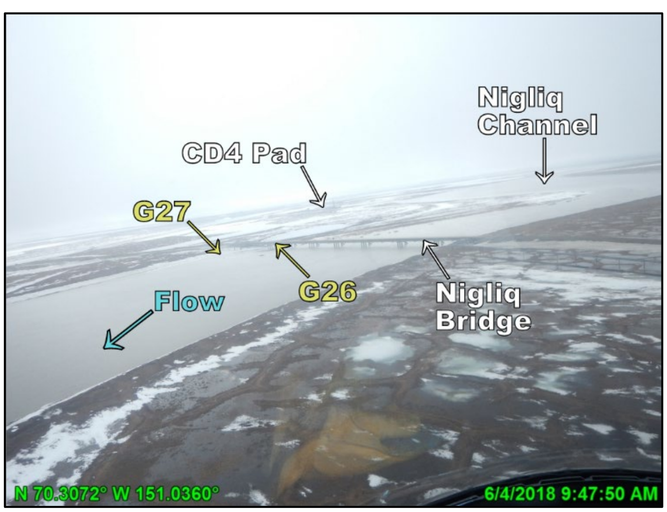
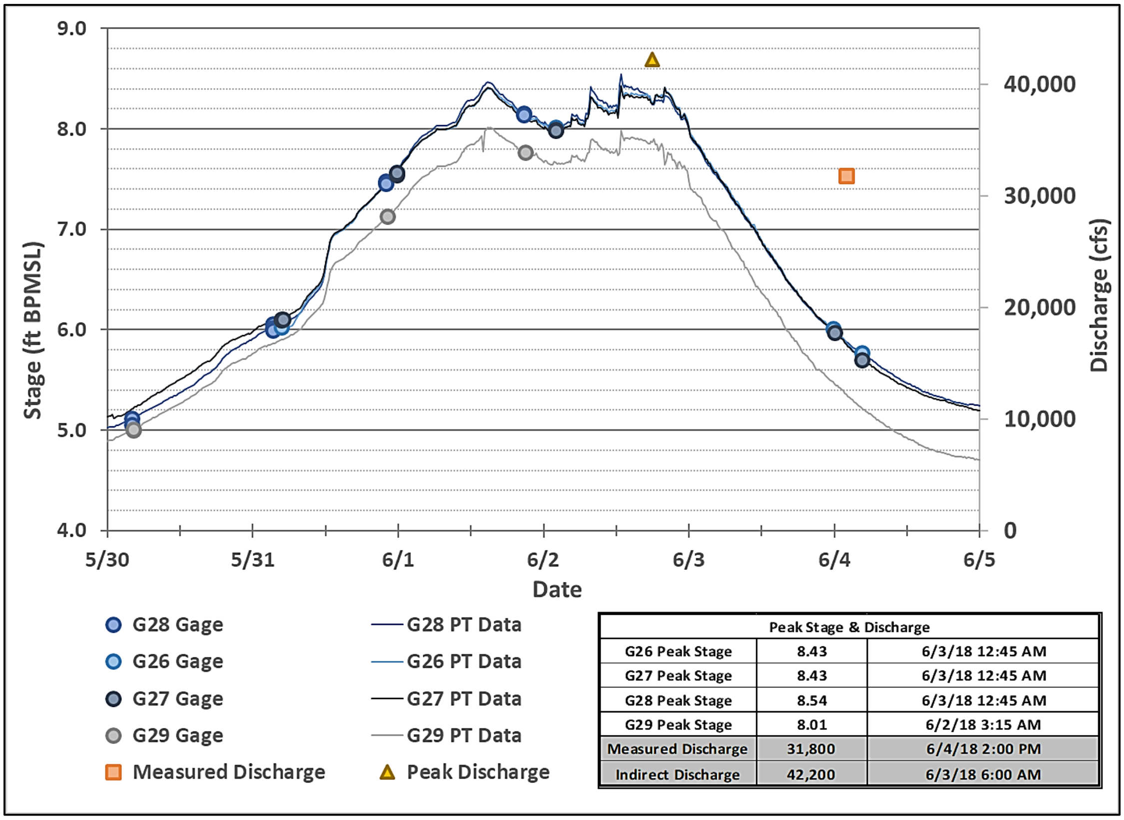


Photo 4.33: Nigliq Bridge the day of discharge measurement, looking south (upstream): June 4, 2018



Peak Stage & Discharge		
G26 Peak Stage	8.43	6/3/18 12:45 AM
G27 Peak Stage	8.43	6/3/18 12:45 AM
G28 Peak Stage	8.54	6/3/18 12:45 AM
G29 Peak Stage	8.01	6/2/18 3:15 AM
Measured Discharge	31,800	6/4/18 2:00 PM
Indirect Discharge	42,200	6/3/18 6:00 AM

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 (Photo 4.34), the influence of which drove peak stage at the downstream gage on June 3. 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.

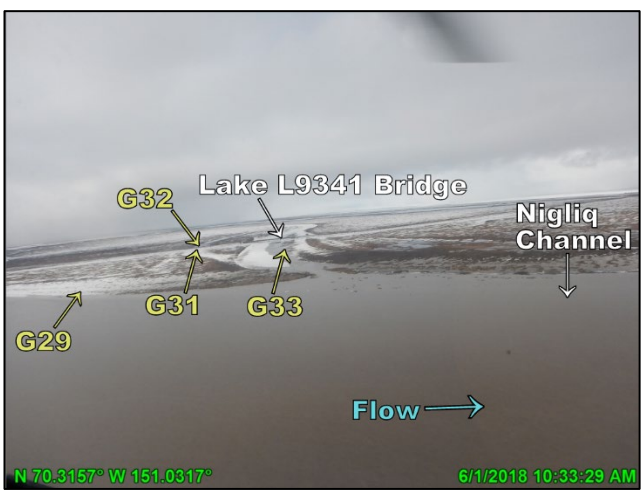
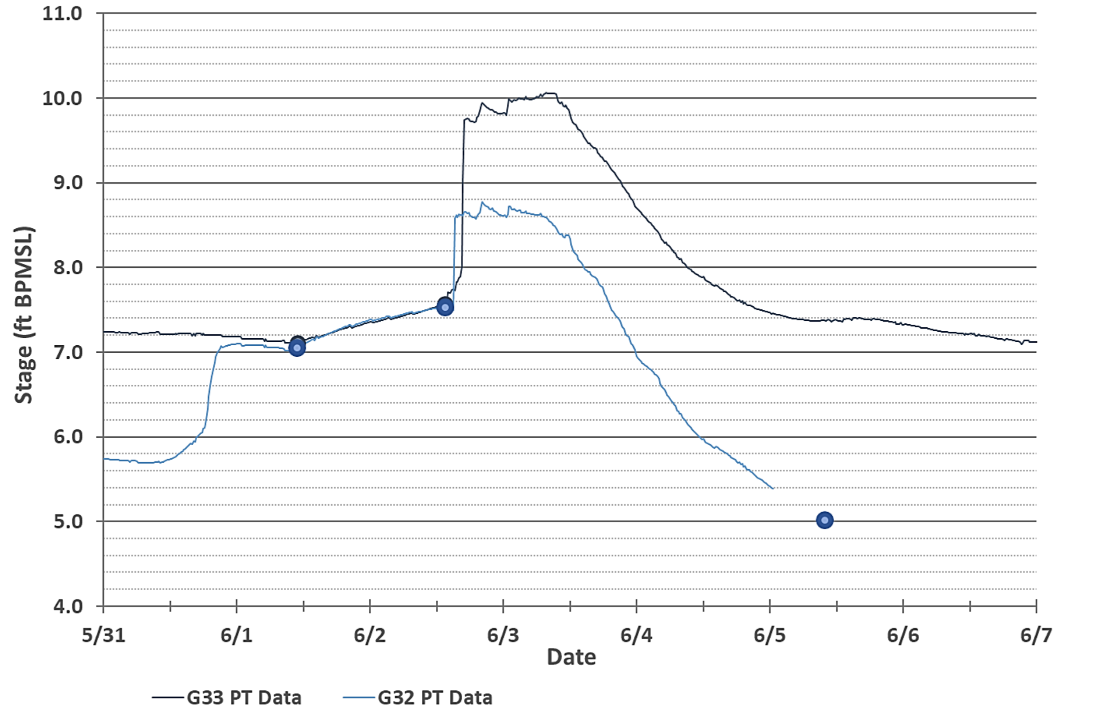


Photo 4.34: North end of Lake L9341 hydraulically connected to the Nigliq Channel two days prior to peak stage, looking southwest; June 1, 2018



G32 Peak Stage	8.77	6/2/18 8:15 PM
G33 Peak Stage	10.06	6/3/18 7:45 AM

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

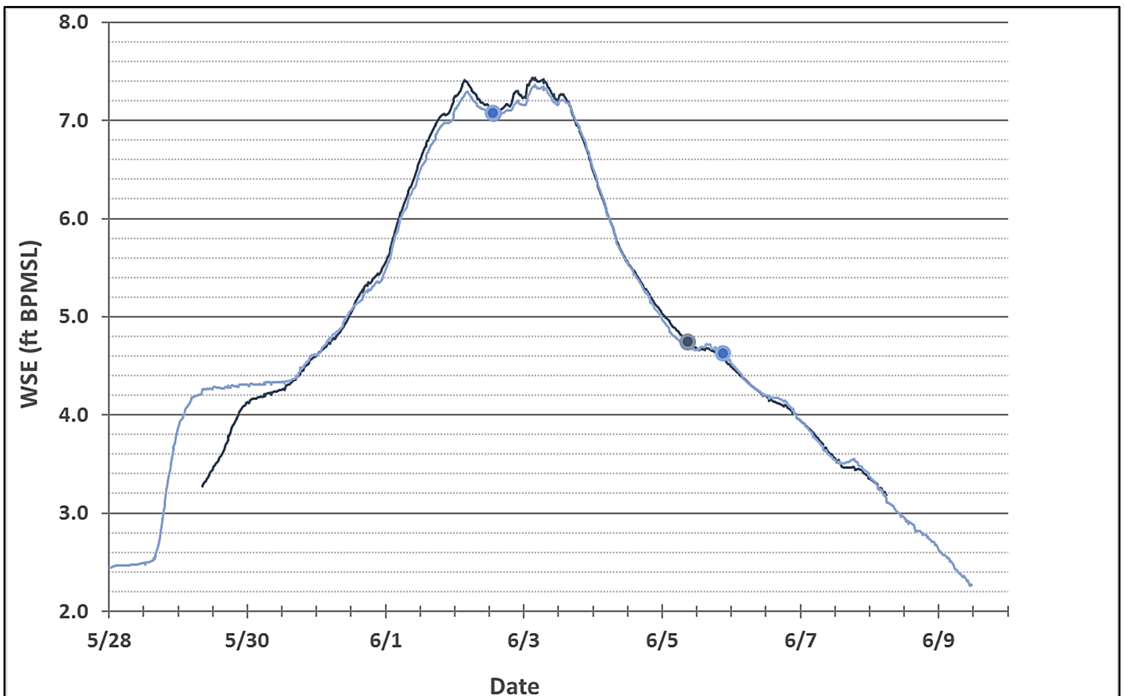
F. NIGLIAGVIK BRIDGE

The Nigliagvik Channel is an anabranch of the Nigliq Channel. The Nigliagvik Channel branches off from the Nigliq Channel approximately 4 RM and 5.5 RM upstream of the Nigliq and Nigliagvik Bridges, respectively, and converges with the Nigliq Channel approximately 2 RM downstream of the Nigliq and Nigliagvik Bridges. Water from the Nigliq Channel diverges into the upstream connection of the Nigliagvik; however, this year, backwater from the Nigliq Channel reached the Nigliagvik Bridge prior to the initiation of downstream flow (Photo 4.32, and Photo 4.33). This can be seen in the stage hydrograph as water levels at the downstream gage were initially higher than water levels at the upstream gage from May 28 through May 30 (Graph 4.16). Upstream and downstream stage equalized at the bridge around May 30. Drifted snow in the Nigliagvik Channel prevented downstream flow from reaching the bridge during breakup and only Nigliq Channel backwater was observed. Because of this, the timing and magnitude of peak stage at the Nigliagvik Bridge were similar to the Nigliq Channel, with peak stage occurring on the morning of June 3.

Since no discernable flow was observed, discharge was not measured, and peak discharge was not calculated. Nigliagvik Bridge stage data is provided in Graph 4.16. Plan and profile drawings at the Nigliagvik Bridge are presented in Appendix C.

Photo 4.35: Nigliagvik Channel the day prior to peak stage, looking south (upstream); June 2, 2018

Photo 4.36: Nigliagvik Channel two days prior to peak stage, looking southwest (upstream); June 1, 2018



Spring		
G38 Peak Stage	7.43	6/3/18 4:00 AM
G39 Peak Stage	7.36	6/3/18 4:00 AM

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

G. Culverts

CD5 culverts east of the Nigliagvik Channel convey overbank floodwater from the Nigliq and Nigliagvik Channels or equalize local meltwater across the CD5 road. 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.

Water levels at gages G30/G31, gages G34/G35, and gages G36/G37 were below PT elevation throughout breakup; these gages only saw ponding of local meltwater. Peak stage at gage G30/G31 was recorded from a HWM due to ponding. Gages G34/G35 stage and discharge data is provided in Graph 4.17. Flow was observed on June 5 and was due to equalization of local melt and surface runoff.

Stage remained below the PT elevation at gages S1/S1D throughout breakup. No water was observed at S1D during the 2018 monitoring season. No hydraulic connections were observed through culverts CD5-33S and CD5-32S on June 1 (Photo 4.34) and culvert CD5-04 on June 4 (Photo 4.38). Discharge through CD5-04 was not calculated due to a lack of measurable WSE at S1D. Gages S1/S1D stage and discharge data is provided in Graph 4.18.

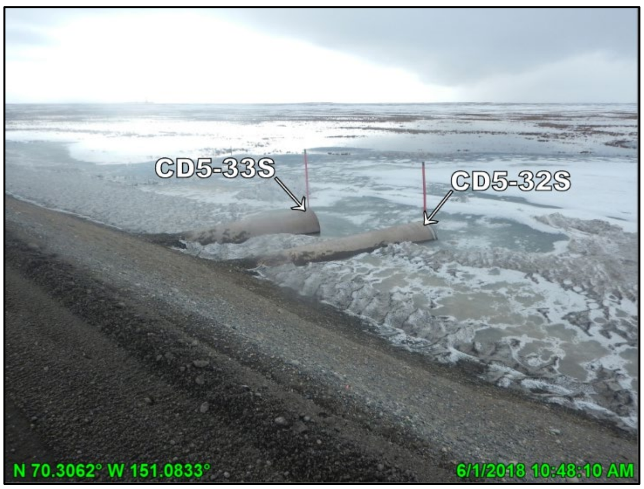
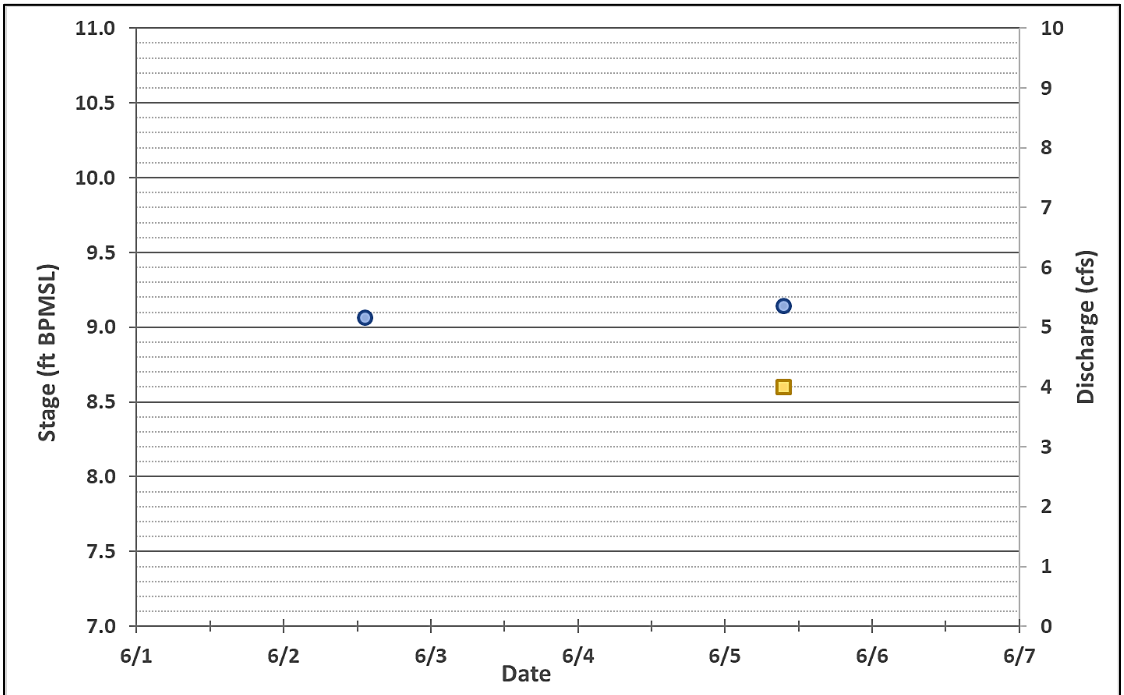


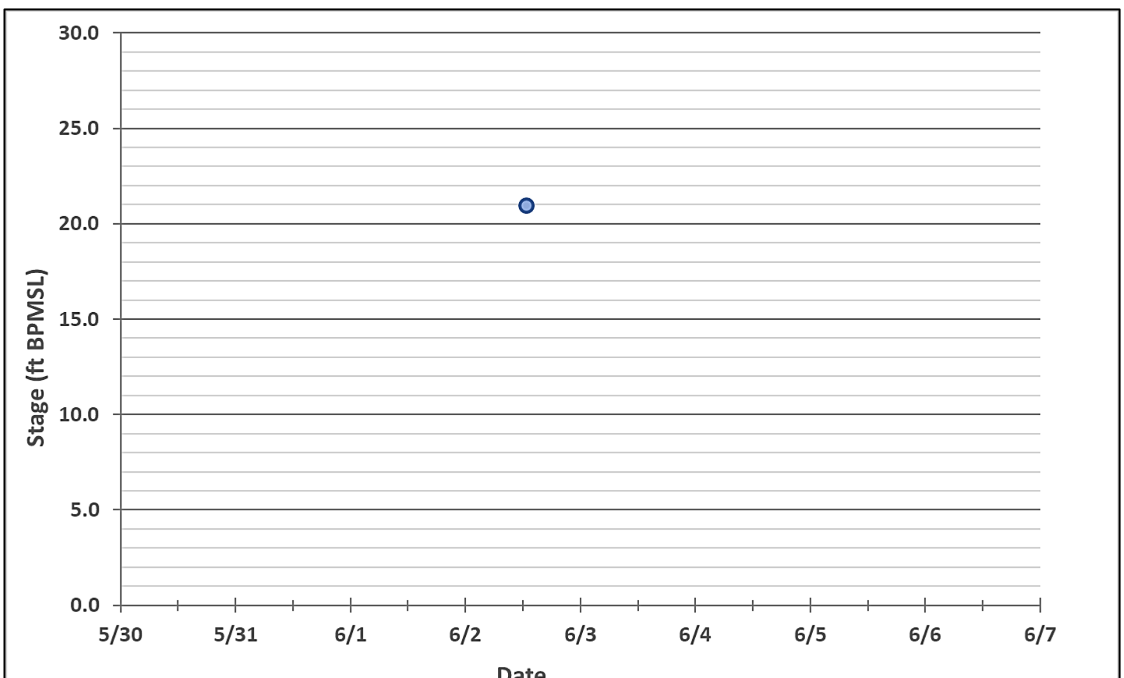
Photo 4.37: Culvert CD5-32S and CD5-33S along the CD5 road, looking southeast; June 1, 2018

Photo 4.38: Hydraulic connection through CD5 culvert CD5-04 looking west, June 4, 2018



G34 Highest Observed Stage	9.15	6/5/18 9:30 AM
G35 Highest Observed Stage	DRY	N/A
G34/G35 Culverts Measured Discharge (cfs)	4	6/5/18 9:30 AM

Graph 4.17: CD5 Road Culverts (Gages G34 & G35) Stage



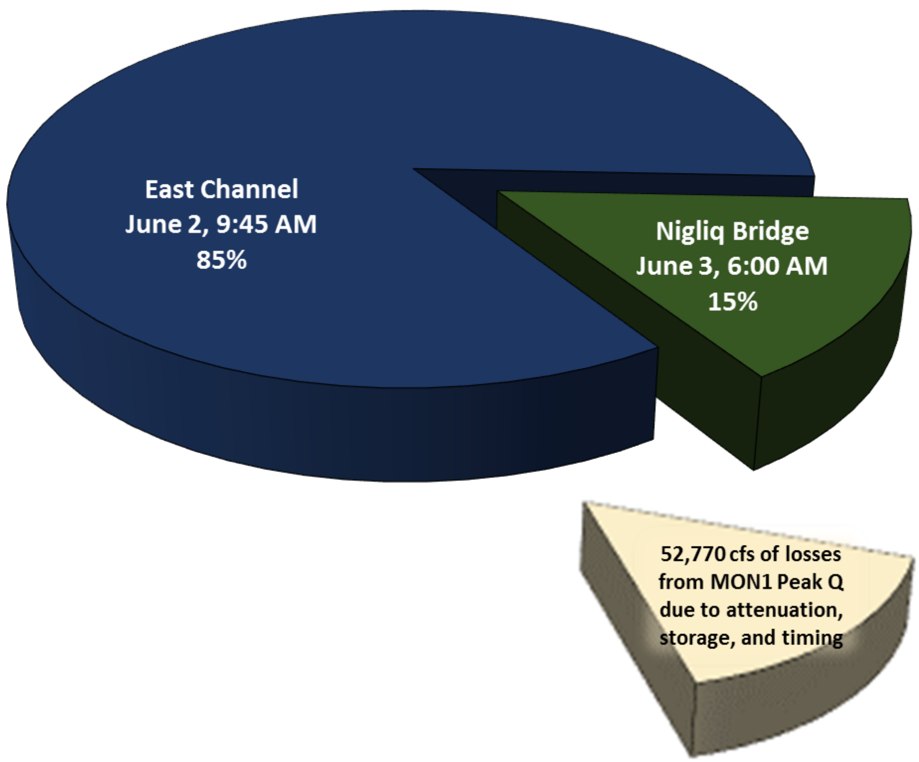
S1 Highest Observed Stage	20.96	6/2/18 12:45 PM
S1D Peak Stage	not recorded	
S1/S1D Culverts Measured Discharge	no flow observed	

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

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 16% when compared to peak discharge calculated for the Colville River at MON1. Hydraulic connections typically seen during breakup were not present or were delayed due to the cold weather and remaining snowpack. Additionally, 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 4 and June 6 (Photo 5.1 through Photo 5.4). Other than minor washlines, no discernable erosion was observed during aerial and ground reconnaissance of the CD2, CD4, and CD5 roads. Floodwaters did not reach CD5 bridge abutments or the CD5 road within the CRD. A prominent washlines 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.

Photo 5.1: North side of CD4 road near CD4 pad, looking west; June 5, 2018

Photo 5.2: West side of CD4 road near CD5 intersection, looking southeast; June 5, 2018

Photo 5.3: South side of CD2 road, looking northwest; June 6, 2018

Photo 5.4: North side of CD5 at the Nigliagvik Channel looking south; June 5, 2018

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 2018. Post-breakup contour plots around the piers and within the main channel of the Nigliq Bridge and Nigliagvik Bridge are provided in Appendix E (UMIAQ 2018a).

NIGLIQ BRIDGE

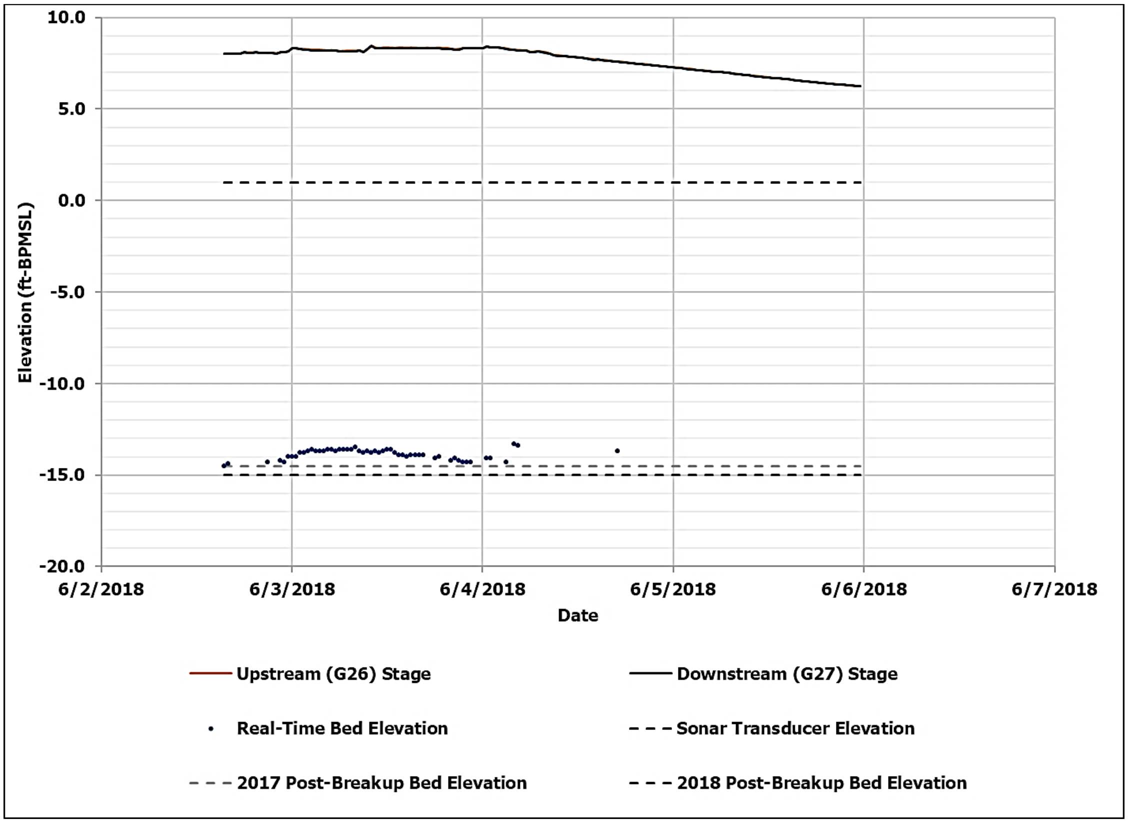
Field crews cleared ice and snow from the pier scour casings, attached to the bridge piers, during spring setup and installed the sonar units. During the freeze thaw cycle, ice plugs had formed around the sonar units, lifting them out of position when stage increased. Field crews were able to de-ice and re-install the sonars into position at the bottom of the casings prior to peak conditions.

The minimum post-breakup scour elevation (-30.2 ft BPMSL at pier 4, pile C) is 1.3 ft below the 50-year design scour elevation and 2.8 ft above the 200-year scour elevation. A comparison of design and observed scour elevations are presented in Table 6.1. Real-time pier scour at piers 2 through 5 and corresponding WSEs during spring breakup monitoring are presented in Graph 6.1 through Graph 6.4. Real-time pier scour measurements indicated little to no active scour during peak conditions. The scatter in sonar measurements during real-time monitoring at some locations may be attributed to a high concentration of near-bed sediments suspended in turbulence associated with eddies converging on the downstream side of the pier. In these cases, the lower readings are interpreted as the true bed elevations.

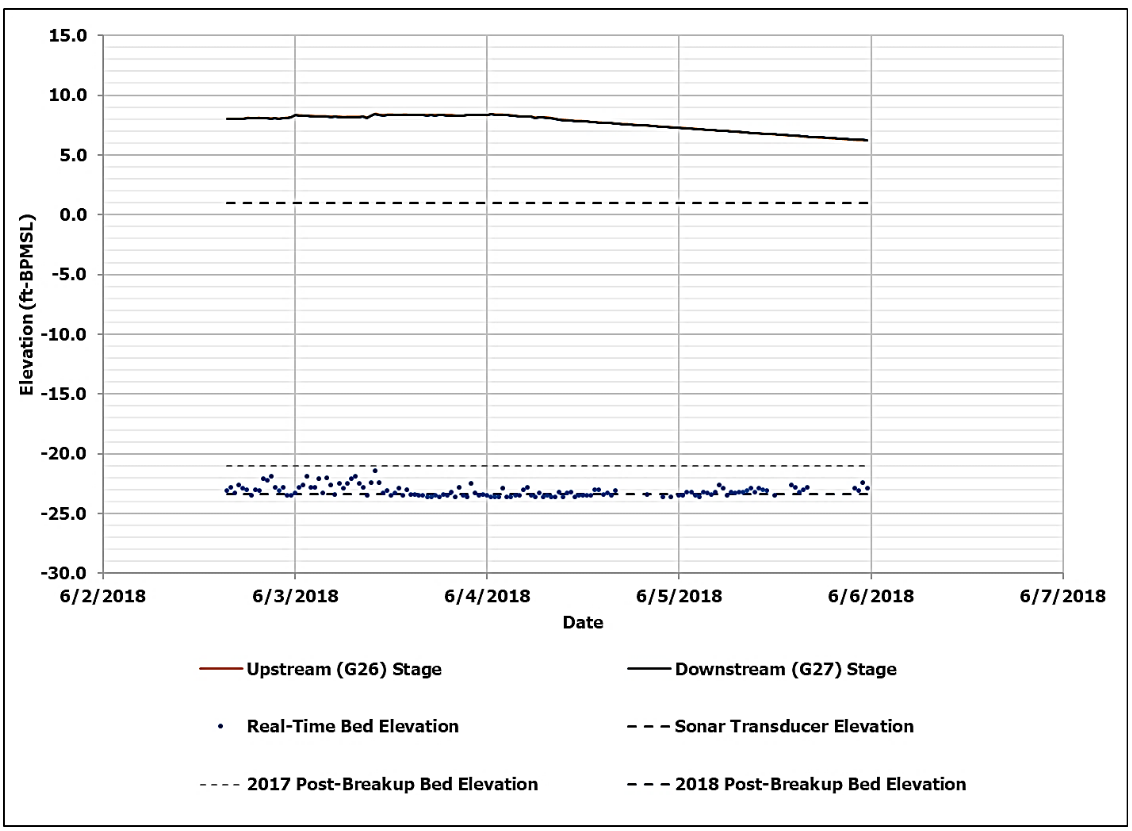
Table 6.1: Nigliq Bridge Comparison of Design and Observed Pier Scour Elevations

Nigliq Bridge Pier Scour		
During Breakup 2018		**Elevation (ft-BPMSL)[1,2]**
Pier 2	Pile E	-14.5
Pier 3	Pile E	-23.6
Pier 4	Pile E	-30.4
Pier 5	Pile E	-22.4
Post-Breakup 2018		**Elevation (ft-BPMSL)[3]**
Pier 2	Pile A on northeast side	-21.7
Pier 3	Pile A on north side	-25.3
Pier 4	Pile C on northwest side	-30.2
Pier 5	Pile E on southeast side	-20.2
Design 2013		**Elevation (ft-BPMSL)[4,5]**
50-year	Pier 2-6	-28.9
	Pier 7-8	-7.1
200-year	Pier 2-6	-33.0
	Pier 7-8	-16.4

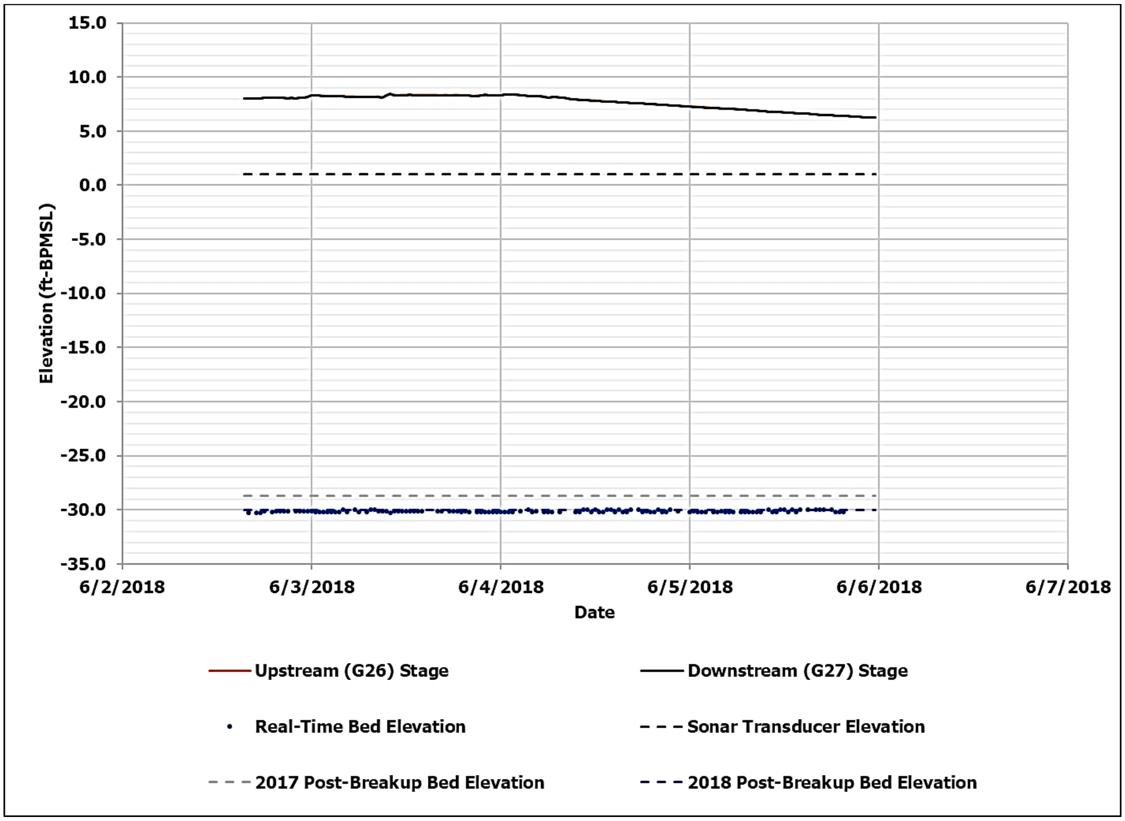
Notes:
1. Minimum channel bed elevations recorded by real-time scour system in June 2018
2. Real-time scour measurements at downstream side of downstream pile
3. Minimum channel bed elevations recorded by LCMF in August 2018
4. Design values presented in PND 2013
5. Elevations based on LCMF 2008 survey



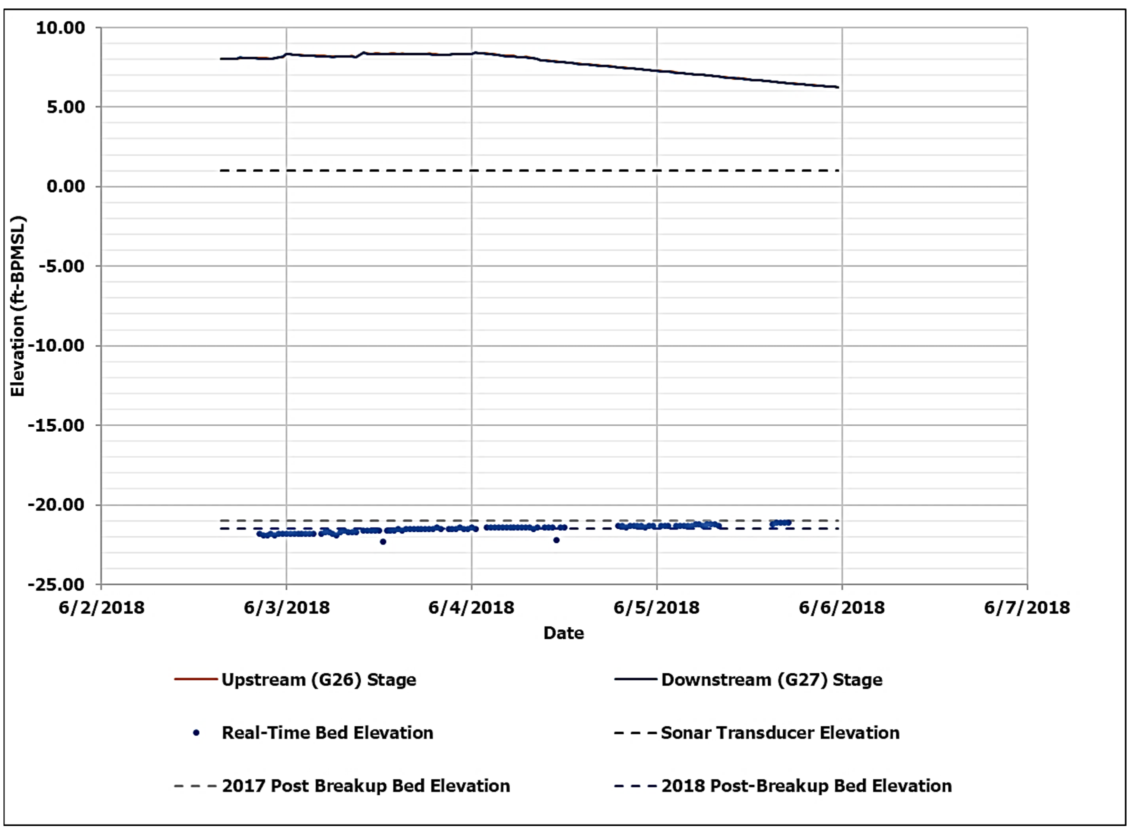
Graph 6.1: Nigliq Bridge Pier 2 (Pile E) Real-Time Scour Elevations



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



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



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

NIGLIAGVIK BRIDGE

The nearly stagnant flow at the Nigliagvik Bridge throughout breakup was ineffective in eroding the bottomfast ice at the base of pier 3. As a result, scour measurements were unattainable during breakup because of insufficient clearance between the sonar transducer and the bottomfast ice (less than 1.5 feet). Therefore, only the post-breakup scour elevations are reported. The minimum post-breakup pier scour elevation (-5.8 ft BPSML at pier 3, pile A) is 8.4 feet above the 50-year design scour elevation and 16 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		
Post-Breakup 2018		Elevation (ft-BPMSL)[1]
Pier 3	Pile A on southwest side	-5.8
Pier 4	Pile A on west-southwest side	-5.6
Design 2013		Elevation (ft-BPMSL)[2,3]
50-year	Pier 3-4	-14.2
200-year	Pier 3-4	-21.8

Notes:
1. Minimum channel bed elevations recorded by LCMF in August 2018
2. Design values presented in PND 2013
3. Elevations based on LCMF 2008 survey

6.2 BANK EROSION

Photos from the bank erosion survey at the Nigliq Bridge and Nigliagvik Bridge are presented in Photo 6.1 through Photo 6.4. Maximum incremental and cumulative erosion at the Nigliq Bridge and Nigliagvik Bridge and maximum incremental, maximum cumulative, and average erosion along the top of bank, upstream and downstream of the bridges, is presented in Table 6.3. Bank erosion tabulated data presented in Appendix E (UMIAQ 2018b).

Photo 6.1: West bank of the Nigliq Channel under the Nigliq Bridge, looking north; September 11, 2018

Photo 6.2: East bank of the Nigliq Channel near the Nigliq Bridge, looking north; September 11, 2018

Photo 6.3: West bank of the Nigliagvik Channel at the Nigliagvik Bridge, looking north; September 11, 2018

Photo 6.4: East bank of the Nigliagvik Channel at the Nigliagvik Bridge abutment, looking north; September 11, 2018

Table 6.3: Nigliq Channel and Nigliagvik Channel Bank Erosion

		Nigliq Channel						Nigliagvik Channel					
		West Bank			East Bank			West Bank			East Bank		
		Station[1] (STA)	Distance (ft)	Rate (ft/yr)	Station[1] (STA)	Distance (ft)	Rate (ft/yr)	Station[1] (STA)	Distance (ft)	Rate (ft/yr)	Station[1] (STA)	Distance (ft)	Rate (ft/yr)
Bridge Stations[2]	Maximum Incremental Erosion (2017-2018)	10+00	2.6	--	None	None	--	None	None	--	None	None	--
	Maximum Cumulative Erosion (2013-2018)	12+00	9.3	1.9	14+00	4.2	0.8	5+00	20.9	4.2	4+00	7.3	1.5
All Stations	Maximum Incremental Erosion[3] (2017-2018)	2+00	3.9	--	None	None	--	10+00	0.9	--	None	None	--
	Maximum Cumulative Erosion[3] (2013-2018)	0+00	33.2	6.6	12+00	7.5	1.5	0+00	9.3	1.9	3+00	0.1	0.0
	Average Cumulative Erosion (2013-2018)	All	--	1.7	All	--	0.1	All	--	1.0	All	--	0.1

Notes:
1. Stationing begins upstream of bridge
2. Nigliq Bridge Stations 10+00 through 13+00 on West Bank and 13+00 through 15+00 on East Bank. Nigliagvik Bridge Stations 4+00 through 6+00 on both banks
3. Excludes bridge transects

6.3 BATHYMETRY

BATHYMETRY AT BRIDGES

The 2018 survey results at each CD5 bridge location were compared with the survey results from 2013-2017 to obtain maximum incremental scour and deposition between 2018 and 2017, and maximum cumulative scour and deposition between 2018 and 2013 (Table 6.4). Transect profiles, bathymetric cross-sections, and tabulated data are provided in Appendix E (UMIAQ 2018c).

Table 6.4: Nigliq Bridge, Lake L9341 Bridge, & Nigliagvik Bridge Scour & 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 (2017-2018)	2	4+26	9	2.8	2+20	36	2.2	2+19	25
Maximum Cumulative Scour (2013-2018)	12.4	2+67	10	2.5	2+20	36	3.4	1+00	25
Maximum Incremental Deposition (2017-2018)	4.9	8+33	9	1.3	1+89	36	1	2+19	26
Maximum Cumulative Deposition (2013-2018)	3.9	8+79	8	0.3	0+00	37	3.4	1+03	26

CHANNEL BATHYMETRY

The 2018 survey results at Nigliq Channel and Nigliagvik Channel were compared with the 2013, 2016, and 2017 survey results to obtain maximum incremental scour and deposition between 2018 and 2017, and maximum cumulative scour and deposition between 2018 and 2013 (Table 6.5). Transect profiles, bathymetric cross-sections, and tabulated data are provided in Appendix E (UMIAQ 2018c).

Table 6.5: Nigliq Channel & Nigliagvik Channel Scour & Deposition

	Nigliq Channel			Nigliagvik Channel		
	Depth (ft)	Station (STA)	Transect	Depth (ft)	Station (STA)	Transect
Maximum Incremental Scour (2017-2018)	7.3	25+33	14	5.6	0+79	30
Maximum Cumulative Scour (2013-2018)	20.7	39+38	13	5.9	0+79	30
Maximum Incremental Deposition (2017-2018)	14.6	16+87	6	2.2	1+37	28
Maximum Cumulative Deposition (2013-2018)	15.2	21+96	5	3.4	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.

8. Historical Breakup Timing & Magnitude

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

8.1 COLVILLE RIVER – HEAD OF THE DELTA

The historical record of peak stage and peak discharge for the CRD is at MON1C, at the head of the delta. Annual peak stage and peak discharge at MON1C has been recorded intermittently from 1962 to 1992 and annually from 1992 to 2018 (Table 8.1 and Graph 8.1).

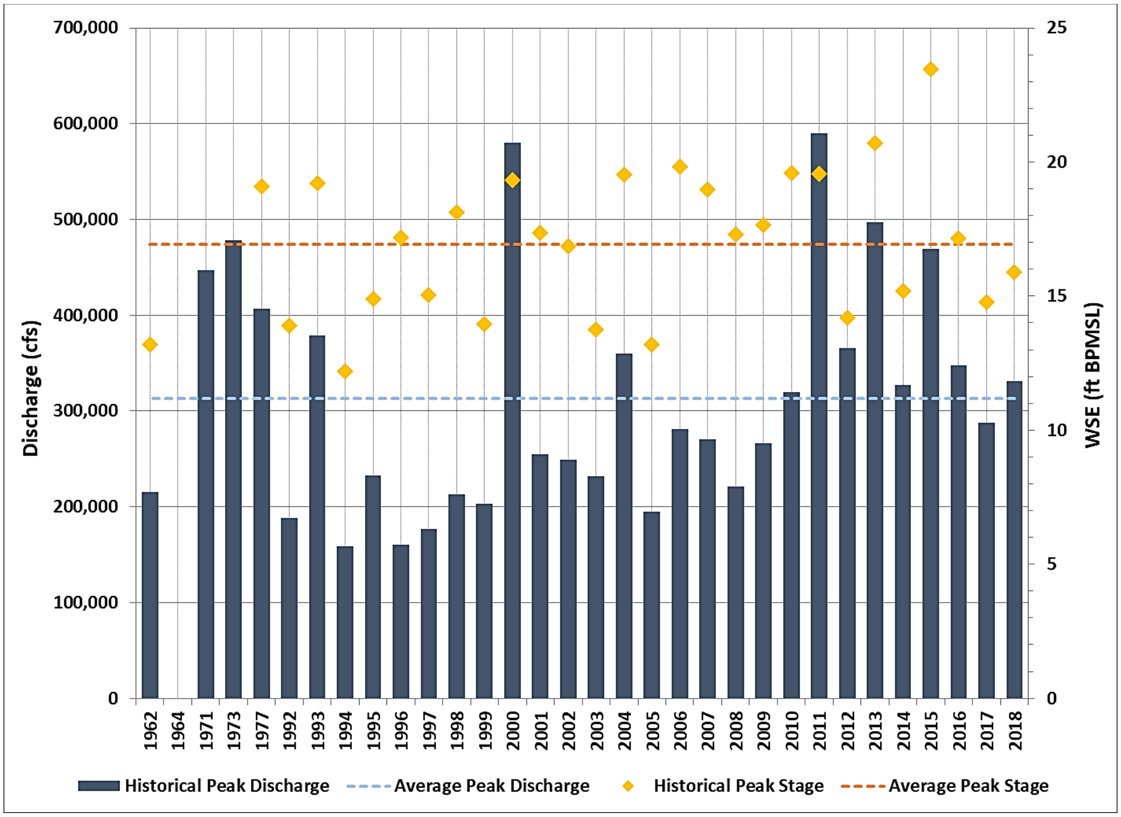
Peak stage at MON1C was 15.90 feet BPMSL and occurred on June 2. The average historical peak stage is 16.93 ft BPMSL and the average date is May 30. The maximum historical peak stage is 23.47 ft BPMSL occurring in 2015.

Peak discharge at MON1C was 331,000 cfs and occurred on June 1. The average historical peak discharge is 313,000 cfs and the average date is May 31. The maximum historical peak discharge is 590,000 cfs occurring in 2011.

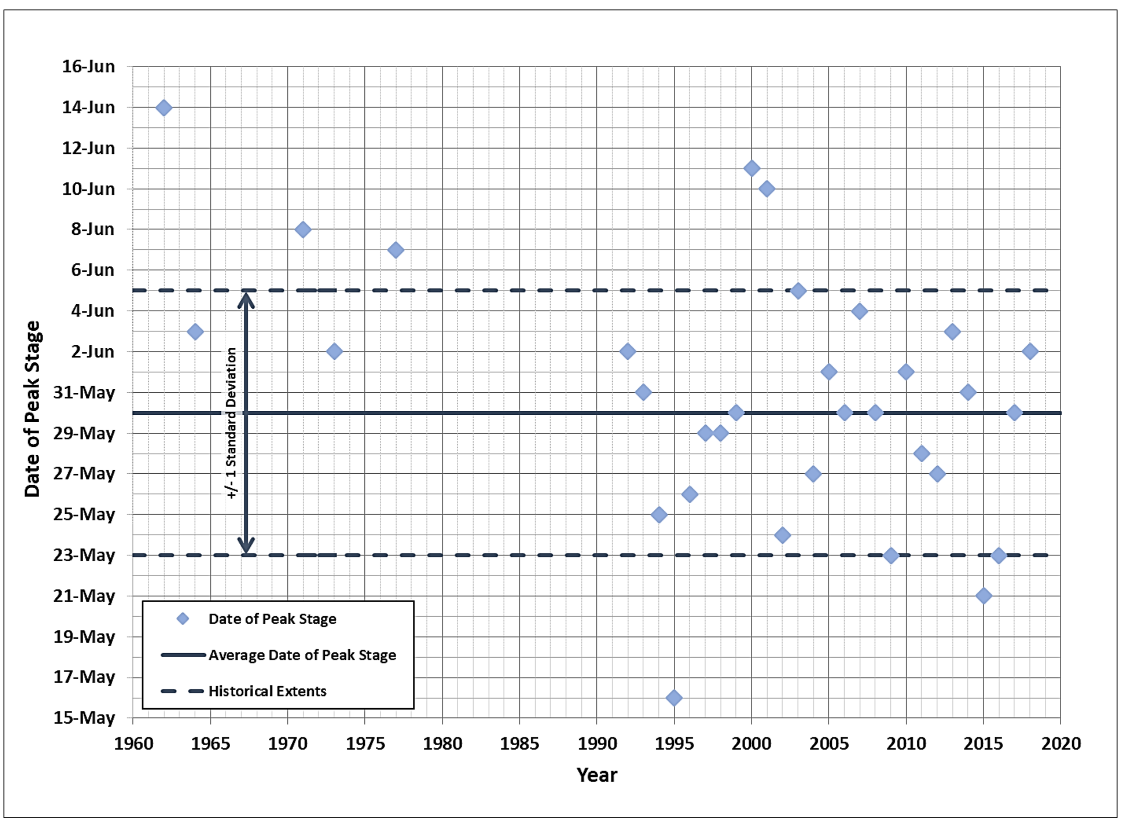
Statistical analysis of historical peak stage dates shows 78% of the peaks at MON1C occur during a 13-day period from May 23 to June 5. This represents one standard deviation of 6.3 days on either side of the average (mean) peak stage date of May 30, based on a normal distribution, as illustrated in Graph 8.2. Peak stage at MON1C this year was three days after the historical average.

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

Year	Discharge		Stage (WSE)		Reference
	Peak Discharge (cfs)	Date	Peak Stage (ft BPMSL)	Date	
2018	**331,000**	**1-Jun**	**15.90**	**2-Jun**	**This Report**
2017	288,000	30-May	14.79	30-May	Michael Baker 2017
2016	348,000	23-May	17.16	23-May	Michael Baker 2016
2015	469,000	22-May	23.47	21-May	Michael Baker 2015
2014	327,000	1-Jun	15.18	31-May	Michael Baker 2014
2013	497,000	3-Jun	20.69	3-Jun	Michael Baker 2013
2012	366,000	1-Jun	14.18	27-May	Michael Baker 2012b
2011	590,000	28-May	19.56	28-May	Michael Baker 2012a
2010	320,000	31-May	19.59	1-Jun	Michael Baker 2010
2009	266,000	23-May	17.65	23-May	Michael Baker 2009b
2008	221,000	28-May	17.29	30-May	Michael Baker 2008
2007	270,000	3-Jun	18.97	4-Jun	Michael Baker 2007b
2006	281,000	30-May	19.83	30-May	Michael Baker 2007a
2005	195,000	9-Jun	13.18	1-Jun	Michael Baker 2005b
2004	360,000	26-May	19.54	27-May	Michael Baker 2005a
2003	232,000	11-Jun	13.76	5-Jun	Michael Baker 2006a
2002	249,000	27-May	16.87	24-May	Michael Baker 2006a
2001	255,000	11-Jun	17.37	10-Jun	Michael Baker 2006a
2000	580,000	11-Jun	19.33	11-Jun	Michael Baker 2000
1999	203,000	30-May	13.97	30-May	Michael Baker 1999
1998	213,000	3-Jun	18.11	29-May	Michael Baker 1998b
1997	177,000	-	15.05	29-May	Michael Baker 2002b
1996	160,000	26-May	17.19	26-May	Shannon & Wilson 1996
1995	233,000	-	14.88	16-May	ABR 1996
1994	159,000	25-May	12.20	25-May	ABR 1996
1993	379,000	31-May	19.20	31-May	ABR 1996
1992	188,000	-	13.90	2-Jun	ABR 1996
1977	407,000	-	19.10	7-Jun	ABR 1996
1973	478,000	-	-	2-Jun	ABR 1996
1971	447,000	8-Jun	-	8-Jun	ABR 1996
1964	-	-	-	3-Jun	ABR 1996
1962	215,000	-	13.20	14-Jun	ABR 1996

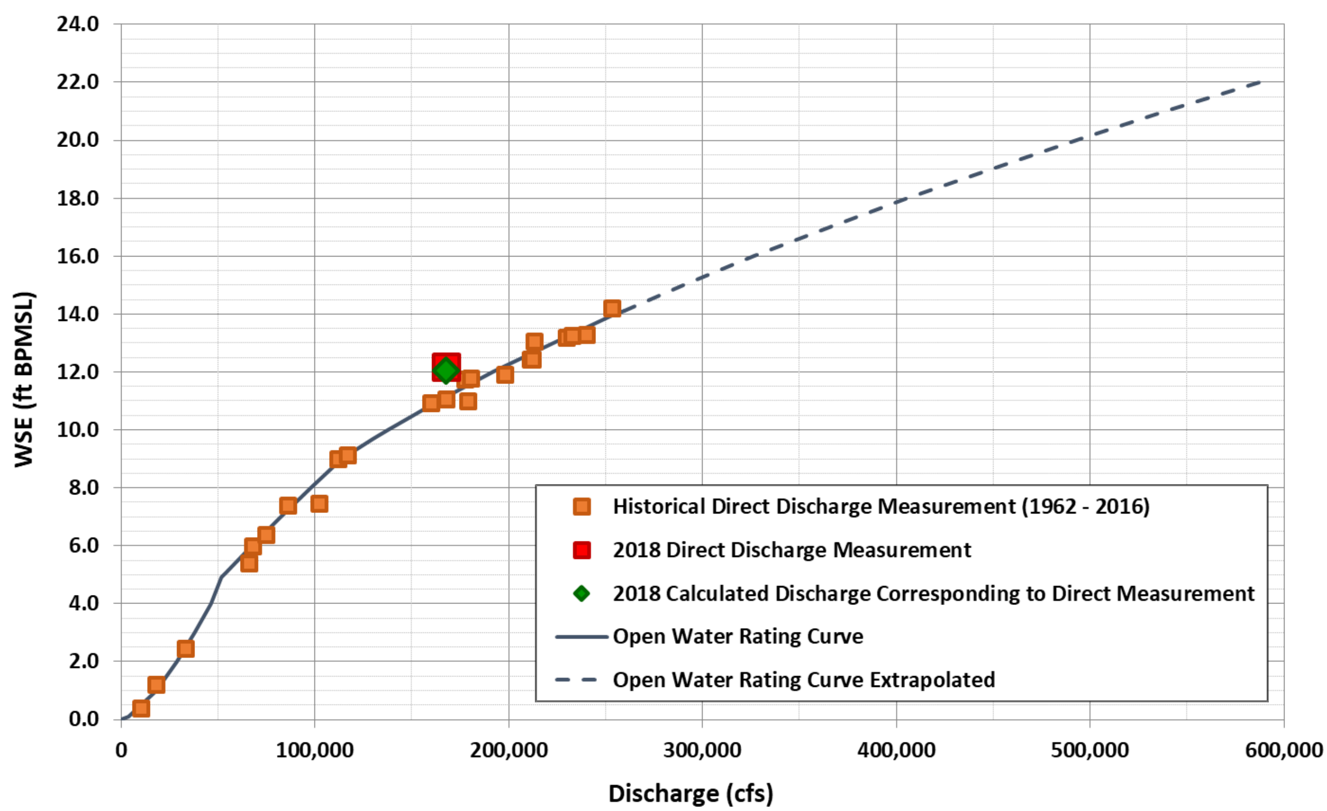


Graph 8.1: Colville River at the Head of the Delta Historical Peak Stage and Peak Discharge



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

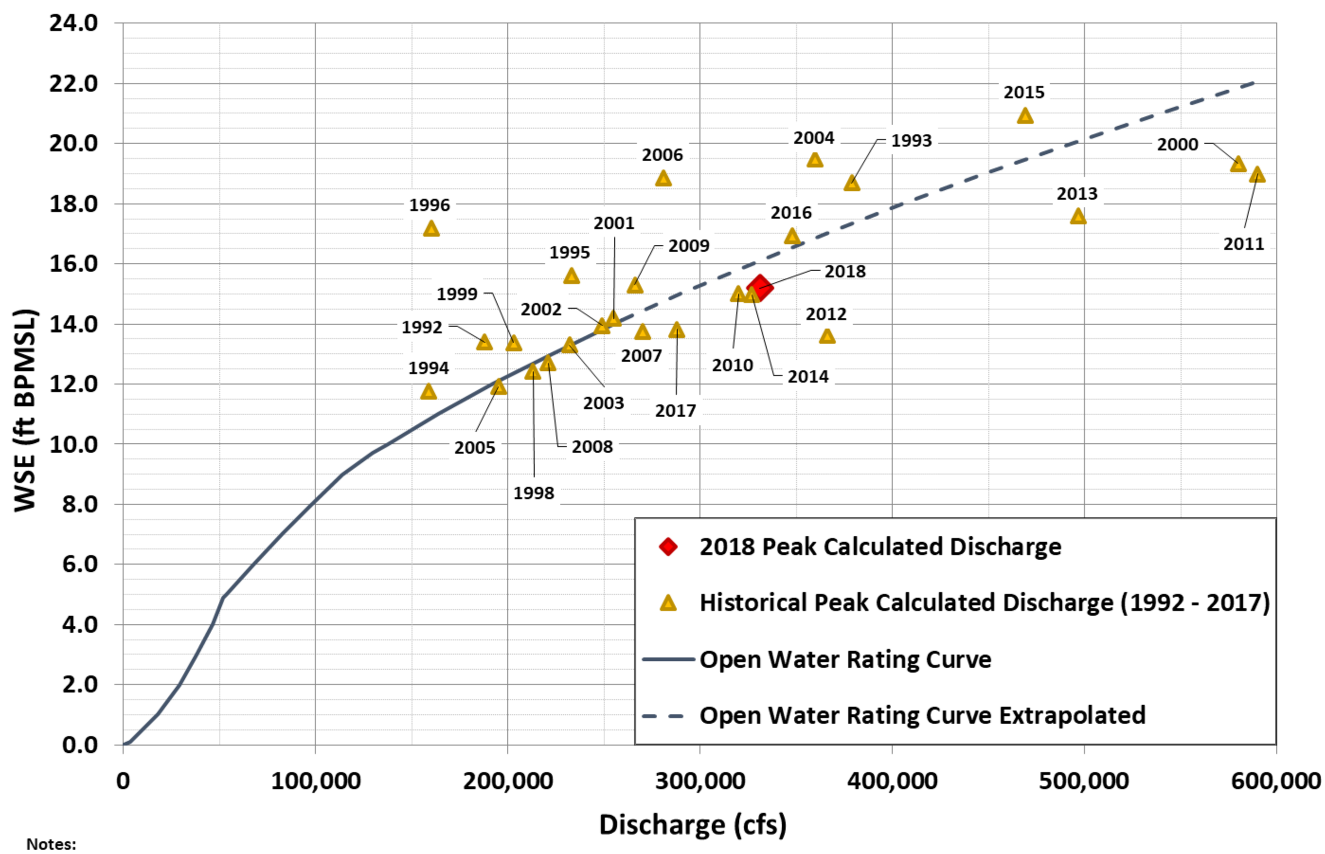
The MON1C stage-discharge rating curve, shown in Graph 8.3, represents a relationship between stage and discharge. The rating curve was calculated from direct discharge measurements taken during ice-free conditions between 1992 and 2016. Colville River discharge can be greatly influenced by channel ice;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

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

Peak discharge between 1992 and 2018 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 2018 falls to the right of the rating curve by 10.3%.



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

Graph 8.4: 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 both the Long Swale Bridge and Short Swale Bridge was 84.2% of the average annual measured flow through both bridges (3,700 cfs).

Table 8.2: CD2 Road Bridges Measured Discharge Historical Summary

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
Short Swale Bridge (62 ft)										
06/03/18	**6.63**	**0.08**	**36**	**32**	**0.22**	**5.40**	**P**	**22**	**Wading**	**This Report**
2017[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2017
05/25/16	7.39	0.32	53	322	2.11	700	G	27	Cable	Michael Baker 2016
05/23/15	7.85	0.05	54	373	0.81	302	F	19	Cable	Michael Baker 2015
06/02/14	7.90	0.12	54	365	1.31	479	F	28	Cable	Michael Baker 2014
06/05/13	9.75	0.46	54	446	3.60	1,608	G	36	Cable	Michael Baker 2013
06/03/12	7.04	0.17	52	306	1.26	386	F	19	Cable	Michael Baker 2012b
05/28/11	8.15	0.43	52	336	2.51	840	F	27	Cable	Michael Baker 2012a
06/03/10	7.58	0.16	55	316	1.79	570	F	28	Cable	Michael Baker 2010
2009[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2009b
05/29/08	6.35	0.18	55	211	0.58	120	P	14	Cable	Michael Baker 2008
06/05/07	7.83	0.09	55	292	1.18	350	F	20	Cable	Michael Baker 2007b
05/31/06	8.49	0.26	55	615	1.59	980	F	20	Cable	Michael Baker 2007a
2005[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2005b
05/29/04	8.34	0.14	55	451	1.60	720	F	17	Cable	Michael Baker 2005a
2003[5]	–	–	–	–	–	–	–	–	–	Michael Baker 2003
05/25/02	6.74	0.22	56	283	1.52	430	G	17	Cable	Michael Baker 2002b
06/11/01	7.64	0.56	56	336	1.79	600	G	15	Cable	Michael Baker 2001
06/10/00	7.87	0.61	47	175	3.30	580	F	13	Cable	Michael Baker 2000
Long Swale Bridge (452 ft)										
06/03/18	**7.05**	**0.16**	**431**	**2,090**	**1.50**	**3,140**	**P**	**-**	**Cable**	**This Report**
06/01/17	5.92	0.04	445	1,505	0.86	1,290	F	27	Cable	Michael Baker 2017
05/25/16	7.48	0.40	445	2,025	2.25	4,800	G/F	28	Cable	Michael Baker 2016
05/22/15	9.93	0.55	447	3,024	3.12	9,440	G	24	Cable	Michael Baker 2015
06/02/14	8.00	0.13	445	2,183	1.30	2,842	G	38	Cable	Michael Baker 2014
06/05/13	9.87	0.42	448	2,947	2.47	7,286	G	36	Cable	Michael Baker 2013
06/03/12	7.10	0.17	445	1,686	1.53	2,582	-	26	Cable	Michael Baker 2012b
05/29/11	8.16	0.38	447	2,027	2.22	4,500	F	26	Cable	Michael Baker 2012a
06/01/10	7.97	0.47	441	1,699	2.66	4,500	G	25	Cable	Michael Baker 2010
05/26/09	5.89	0.09	445	1,592	0.82	730	F	27	Wading	Michael Baker 2009b
05/29/08	6.35	0.18	445	949	2.03	1,930	F	21	Wading	Michael Baker 2008
06/05/07	7.76	0.08	447	1,670	0.74	1,240	F	20	Cable	Michael Baker 2007b
05/31/06	8.42	0.18	409	1,730	1.89	3,260	F	29	Cable	Michael Baker 2007a
06/02/05	6.13	0.08	445	841	1.37	1,100	G	20	Wading	Michael Baker 2005b
05/29/04	8.34	0.14	446	1,700	1.40	2,400	F	18	Cable	Michael Baker 2005a
06/08/03	5.48	-0.05	444	478	0.88	420	G	16	Wading	Michael Baker 2003
05/25/02	6.74	0.22	445	930	3.47	3,200	G	17	Cable	Michael Baker 2002b
06/11/01	7.64	0.56	460	1,538	2.40	3,700	G	16	Cable	Michael Baker 2001
06/09/00	7.34	0.78	437	1,220	3.27	4,000	F	15	Cable	Michael Baker 2000

Notes:
1. Source of stage is G3
2. Stage differential between G3/G4 at time of discharge measurement
3. Mean velocities adjusted with angle of flow coefficient
4. Measurement Rating -
   - E - Excellent: Within 2% of true value
   - G - Good: Within 5% of true value
   - F - Fair: Within 8% of true value
   - P - Poor: Velocity < 0.70 ft/s; Shallow depth for measurement; greater than 8% error
5. Bridge obstructed with snow or ice and/or lack of flow, no measurement made

Calculated peak flow through both bridges was 72.0% of the average annual peak flow through both bridges (4,500 cfs). Table 8.3 summarizes peak stage and peak calculated discharge at the CD2 Long and Short Swale Bridges between 2000 and 2018.

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

Date[1]	Peak Stage[2] (ft BPMSL)	Stage Differential[3] (ft)	Long Swale Bridge (452 ft)		Short Swale Bridge (62 ft)		References
			Peak Discharge (cfs)	Mean Velocity (ft/s)	Peak Discharge (cfs)	Mean Velocity (ft/s)	
06/02/18	**7.12**	**0.25**	**3,240**	**1.50**	**12**	**0.22**	**This Report**
05/31/17	6.04	0.04	1,350	0.86	–[4]	–[4]	Michael Baker 2017
05/25/16	7.50	0.44	4,800	2.35	680	2.06	Michael Baker 2016
05/22/15	11.93	1.54	12,350	3.12	484	0.81	Michael Baker 2015
06/02/14	8.18	0.19	2,971	1.30	501	1.31	Michael Baker 2014
06/04/13	10.27	1.17	7,723	2.47	1,706	3.60	Michael Baker 2013
06/03/12	7.60	0.41	2,940	1.53	425	1.26	Michael Baker 2012b
05/29/11	8.89	0.30	5,200	2.22	940	2.51	Michael Baker 2012a
06/02/10	8.64	0.59	5,300	2.66	670	1.79	Michael Baker 2010
05/25/09	7.63	0.45	1,400	0.82	–[4]	–[4]	Michael Baker 2009b
05/30/08	6.49	0.26	2,100	0.49	130	0.58	Michael Baker 2008
06/05/07	8.60	0.43	1,500	1.35	400	1.18	Michael Baker 2007b
05/31/06	9.72	0.87	4,400	1.77	1,100	1.59	Michael Baker 2007a
05/31/05	6.48	0.20	1,400	1.37	–[4]	–[4]	Michael Baker 2005b
05/27/04	9.97	0.50	3,400	1.38	900	1.59	Michael Baker 2005a
06/07/03	6.31	0.12	700	0.88	–[4]	–[4]	Michael Baker 2003
05/26/02	7.59	0.69	4,000	3.47	500	1.52	Michael Baker 2002b
06/11/01	7.95	0.73	3,900	2.40	600	1.79	Michael Baker 2001
06/12/00	9.48	0.73	7,100	3.60	1,000	4.30	Michael Baker 2000

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

8.3 CD5 ROAD BRIDGES

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

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

Year	Lake L9323 Bridge		Nigliq Bridge		Lake L9341 Bridge		Nigliagvik Bridge	
	Peak Discharge (cfs)	Peak Stage [G24] (ft BPMSL)	Peak Discharge (cfs)	Peak Stage [G26] (ft BPMSL)	Peak Discharge (cfs)	Peak Stage [G32] (ft BPMSL)	Peak Discharge (cfs)	Peak Stage [G38] (ft BPMSL)
Post-Bridge Construction								
2018	**- [1]**	**9.67**	**42,200**	**8.43**	**- [1]**	**8.77**	**10,400**	**7.43**
2017	- [1]	9.54	47,400	8.60	- [1]	7.10	2,550	6.86
2016	- [1]	8.85	65,000	9.05	- [1]	8.65	2,800	8.35
2015[2]	9,100	15.39	112,000	14.50	22,500	14.51	17,300	13.57
2014	- [1]	8.58	66,000	9.38	- [3]	8.48	7,800	8.64
Pre-Bridge Construction								
2013	- [1]	12.40	110,000 [4]	12.42 [5]	5,000 [4]	11.07	7,800 [4]	11.41
2012	- [1]	8.55	94,000 [6]	8.82	6,000 [6]	8.58	11,000 [6]	8.51
2011	- [3]	- [3]	141,000 [6]	9.89 [7]	- [3]	9.5 [8]	- [3]	8.78 [9]
2010	- [3]	- [3]	134,000 [6]	9.65 [7]	- [3]	5.85 [8]	- [3]	8.69 [9]
2009	- [3]	- [3]	57,000 [6]	7.91 [7]	- [3]	7.98 [8]	- [3]	7.71 [9]

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

8.4 ALPINE DRINKING WATER LAKES RECHARGE

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

In most years, Lake L9313 is recharged by overland flow from the Sakoonang Channel via the North Paleo Lake and Lake M9525. The historical record of observed flooding and stage indicates bankfull elevation of Lake L9313 is approximately 6.5 feet BPMSL at gage G10 (Michael Baker 2006a, 2007b). Observations on July 10 and July 18, 2018 indicated a hydraulic connection was established between Lakes L9313 and M9525 (see photos in Section 4.4), implying WSE at Lake L9313 was at or above bankfull elevation. The measured WSE on July 10 was 6.29 feet BPMSL, suggesting actual bankfull elevation at L9313 is lower than 6.5 feet BPMSL. Based on the 2018 observations, the bankfull recharge elevation at Lake L9313 has been revised to 6.29 feet BPMSL.

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 ft BPMSL at gage G9 per the Fish Habitat Permit FG99-III-0051-Amendment #8.

Table 8.5 provides a historical summary of Alpine drinking water lakes stage and bankfull recharge record. Lake L9312 has recharged to bankfull 15 of the last 21 years, and Lake L9313 has recharged to bankfull 18 of the last 21 years.

Table 8.5: Alpine Drinking Water Lakes Historical Recharge Summary

Year	Lake L9312		Lake L9313	
	Peak Stage (ft BPMSL)	Bankfull Recharge to 7.8 ft BPMSL[1]	Peak Stage (ft BPMSL)	Bankfull Recharge to 6.29 ft BPMSL[2]
2018	**8.10**	**Yes[3]**	**6.29**	**Yes[3]**
2017	-	No[3]	7.40	Yes
2016	7.47	No[3]	8.15	Yes
2015	13.32	Yes	12.71	Yes
2014	7.94	Yes	8.59	Yes
2013	8.79	Yes	10.44	Yes
2012	8.23	Yes	8.20	Yes
2011	10.72	Yes	10.67	Yes
2010	7.63	No[3]	7.52	Yes
2009	7.65	No[3]	7.12	Yes
2008	7.45	No[3]	6.95	Yes
2007	9.35	Yes	9.47	Yes
2006	9.55	Yes	9.95	Yes
2005	8.00	Yes	6.12	No[3]
2004	8.37	Yes	9.40	Yes
2003	8.01	Yes	7.12	Yes
2002	8.05	Yes	7.98	Yes
2001	7.55	No[3]	8.31	Yes
2000	-	Yes	-	Yes
1999	7.93	Yes	6.14	No[3]
1998	8.35	Yes	7.35	Yes

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

9. Flood & Stage Frequency Analyses

9.1 FLOOD FREQUENCY

Both continuous record and design-magnitude flood frequency analyses were performed for the Colville River at the head of the delta (MON1) in 2018. These were based on reported annual peak discharge data from 1992 through 2018 and the extrapolated data extending back to 1971, which is recommended for design-magnitude extrapolation with less than 50 years of record. The data was ranked by Weibull distribution for the continuous record and fitted to a Log-Pearson Type III distribution for design-magnitude extrapolation. Results were compared between the 2015 Weibull and Log-Pearson Type III analyses for the period of continuous record; the 2002, 2012, and 2015 Log-Pearson Type III analyses for the period of continuous record; and the 2002, 2012, and 2015 Log-Pearson Type III analyses for design-magnitude returns. The 2002 results are the basis of current design criteria.

Comparison of the 2018 Weibull and Log-Pearson Type III flood frequency analyses for the period of continuous record (1992 to 2018) are presented in Table 9.1, ranked in order (largest to smallest) of peak discharge. As noted, the Weibull analysis limits the return period (also known as recurrence interval) to the number of record years plus one. As a result, the return period for each year is based solely on the ranked position within the continuous record with a maximum return period of 28 years assigned to the event with the largest peak discharge.

Table 9.1: Colville River Flood Frequency Analysis Results

Year	Discharge (cfs)	Weibull Return Period (years)	Log-Pearson Type III Return Period (years)	Difference
2011	590,000	28.0	22.8	-18.7%
2000	580,000	14.0	21.5	53.8%
2013	497,000	9.3	11.3	20.6%
2015	469,000	7.0	9.0	28.9%
1993	379,000	5.6	4.6	-18.2%
2012	366,000	4.7	4.3	-8.8%
2004	360,000	4.0	4.1	2.6%
2016	348,000	3.5	3.8	8.6%
2018	**331,000**	**3.1**	**3.4**	**8.4%**
2014	327,000	2.8	3.3	16.9%
2010	320,000	2.5	3.1	21.6%
2017	288,000	2.3	2.3	-1.1%
2006	281,000	2.2	2.2	2.5%
2007	270,000	2.0	2.1	2.5%
2009	266,000	1.9	2.0	6.9%
2001	255,000	1.8	1.9	7.6%
2002	249,000	1.6	1.8	10.5%
1995	233,000	1.6	1.7	6.5%
2003	232,000	1.5	1.6	11.7%
2008	221,000	1.4	1.5	9.5%
1998	213,000	1.3	1.5	10.1%
1999	203,000	1.3	1.4	10.2%
2005	195,000	1.2	1.3	10.8%
1997	177,000	1.2	1.2	6.1%
1994	165,000	1.1	1.2	6.0%
1992	164,000	1.1	1.2	9.9%
1996	160,000	1.0	1.2	12.5%

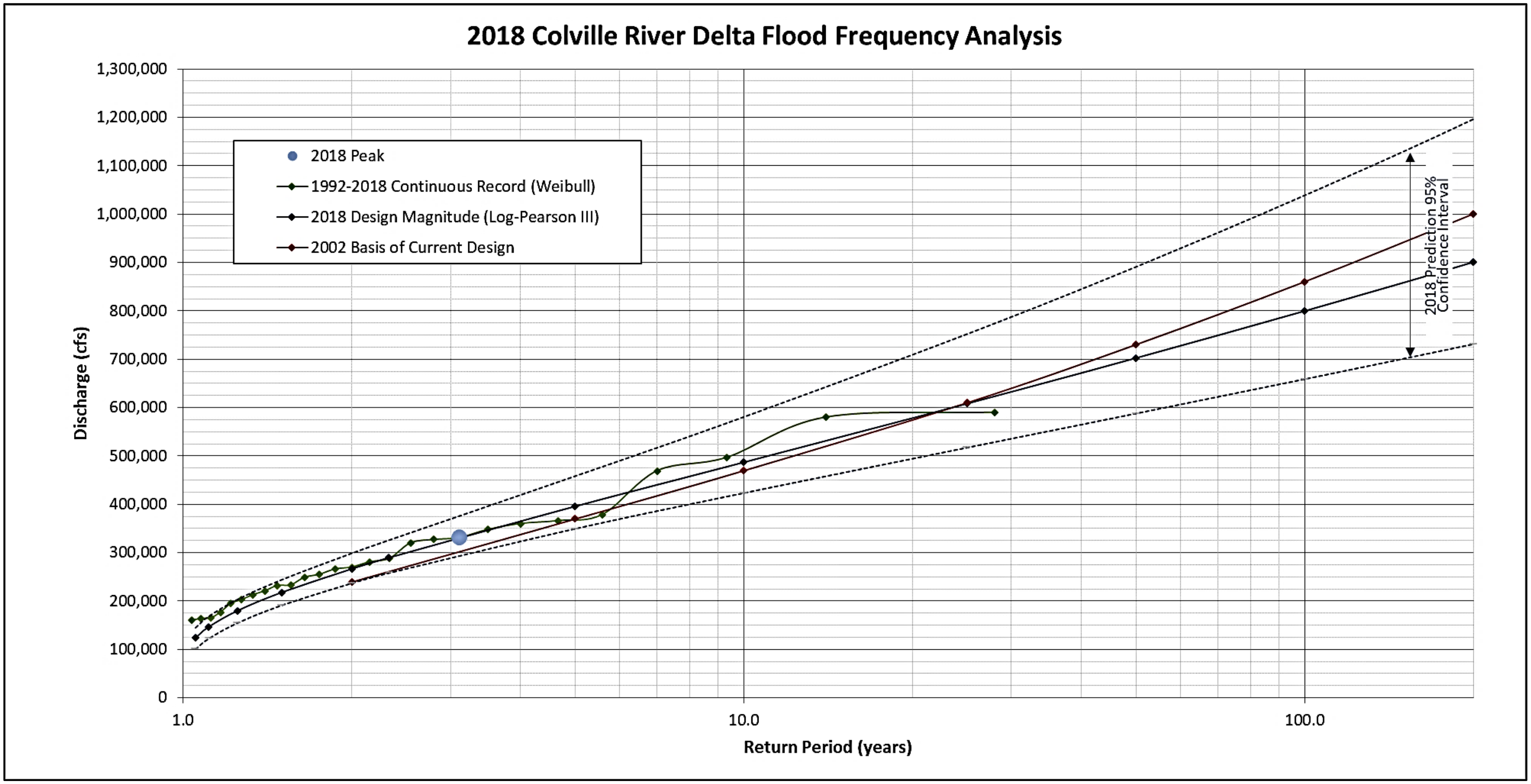
A flood frequency analysis is performed every three years for the head of the CRD at MON1 to estimate and update flood magnitudes for standard recurrence intervals. The current basis of design flood magnitudes are compared with the flood frequency analysis results to ensure the basis of design values are relevant as the body of data grows. These values are presented in Table 9.2 along with the current basis of design. Graph 9.1 provides a plotted comparison of the 2018 continuous record, 2018 design-magnitude, and 2002 design-magnitude flood frequency analysis results.

This year's peak discharge of 331,000 cfs has a recurrence interval of 3.4 years. The flood recurrence interval should be considered with respect to conditions at the time of peak discharge. A comparison of the 2002, 2015, and 2018 Log-Pearson Type III flood frequency results for the period of continuous record (1992 to 2018) is presented in Table 9.3.

Table 9.2: Colville River Flood Frequency Analysis Comparison

Return Period	Basis for Current Design Criteria[1]	2015 Analysis Values[2]	2018 Analysis Values
	Discharge (cfs)	Discharge (cfs)	Discharge (cfs)
2-year	240,000	261,000	266,000
5-year	370,000	394,000	396,000
10-year	470,000	491,000	487,000
25-year	610,000	623,000	608,000
50-year	730,000	727,000	702,000
100-year	860,000	837,000	800,000
200-year	1,000,000	953,000	901,000

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



Graph 9.1: CRD Flood Frequency Analysis Distribution

Table 9.3: Comparison of Colville River 2002, 2015, and 2018 Log-Pearson Type III Analysis Results for the Period of Continuous Record (1992-2018)

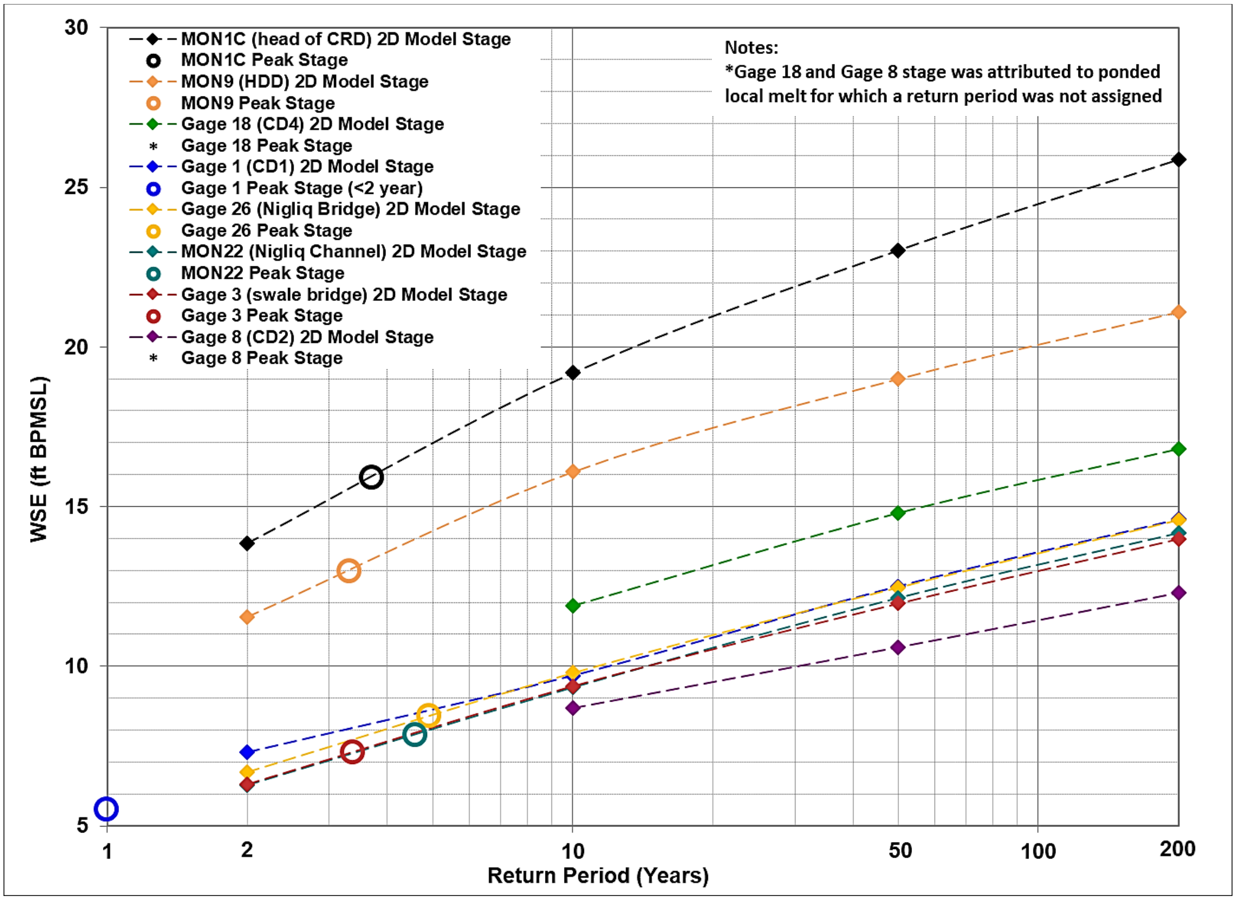
Year	Peak Discharge (cfs)	2002 Return Period (Basis of Current Design Criteria) (years)	2015 Log-Pearson Type III Return Period (years)	2018 Log-Pearson Type III Return Period (years)
2011	590,000	22.9	21.3	22.8
2000	580,000	21.8	20.2	21.5
2013	497,000	12.9	10.7	11.3
2015	469,000	10.0	8.9	9.0
1993	379,000	5.5	4.6	4.6
2012	366,000	4.9	4.3	4.3
2004	360,000	4.8	4.2	4.1
2016	348,000	4.5	3.9	3.8
2018	331,000	4.0	3.4	3.4
2014	327,000	3.8	3.2	3.3
2010	320,000	3.8	3.2	3.1
2017	288,000	3.1	2.4	2.3
2006	281,000	2.9	2.3	2.2
2007	270,000	2.7	2.1	2.1
2009	266,000	2.6	2.1	2.0
2001	255,000	2.3	1.9	<2
2002	249,000	2.2	1.9	<2
1995	233,000	<2	1.7	<2
2003	232,000	<2	1.7	<2
2008	221,000	<2	1.6	<2
1998	213,000	<2	1.5	<2
1999	203,000	<2	1.4	<2
2005	195,000	<2	1.4	<2
1997	177,000	<2	1.3	<2
1994	165,000	<2	1.2	<2
1992	164,000	<2	1.2	<2
1996	160,000	<2	1.2	<2

9.2 STAGE FREQUENCY

HIGH MAGNITUDE, LOW FREQUENCY

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

The 2D model was developed to predict open water flood conditions during low-frequency, high-magnitude events, i.e. design events having 50- and 200-year recurrence intervals. To estimate the relationship between discharge and stage during more frequent, lower magnitude floods, 2- and 10-year recurrence intervals have also been modeled. The 2018 peak stage at select gage stations were assigned a recurrence interval relative to the 2D model predictions (Graph 9.2 and Table 9.4). 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.



Graph 9.2: 2D Model Stage and Peak Stage Recurrence Intervals

Table 9.4: Peak Stage Frequency Relative to 2D Model Stage Frequency Analysis

Gage Station	2D Model Stage Recurrence Intervals[1,2] (ft BPMSL)				Peak Stage (ft BPMSL)	Peak Stage Recurrence Interval (years)
	2-year	10-year	50-year	200-year		
Colville River						
MON1C (head of CRD)	13.9	19.2	23.0	25.9	15.9	4
Colville River East Channel						
MON9 (HDD)	11.5	16.1	19.0	21.1	13.0	3
MON35 (Helmericks)	4.3	5.4	6.1	6.5	4.2	<2
Nigliq Channel						
MON20	7.8	11.4	14.6	16.8	8.6	3
MON22	6.3	9.3	12.1	14.2	7.9	5
MON23	5.1	7.4	10.2	12.0	6.7	6
MON28	3.1	3.4	3.9	4.3	3.3	6
CD1 Pad & Drinking Water Lakes						
Gage G1	7.3	9.7	12.5	14.6	5.5	<2
Gage G9 (Lake L9312)	8.3	10.8	13.4	15.7	8.1	<2
Gage G10 (Lake L9313)	8.3	10.8	13.4	15.7	6.3	<2
CD2 Pad & Road						
Gage G8 (CD2 pad)	\	8.7	10.6	12.3	9.1[3]	-
Gage G3 (swale bridges)	6.3	9.4	12.0	14.0	7.3	3
Gage G4 (swale bridges)	6.2	8.5	10.1	11.6	7.3	4
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	7.4[3]	-
Gage G13	\	8.4	10.0	11.6	7.5[3]	-
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	5.8	<2
TAM Gage (Crossing #4)	6.7	8.5	9.0	9.8	7.8	6
ULAM Gage (Crossing #5)	5.5	7.1	7.8	8.7	6.9	8
CD4 Pad & Road						
Gage G19 (CD4 pad)	\	\	14.7	16.8	Dry	-
Gage G20 (CD4 pad)	\	11.1	14.3	16.4	9.1	<10
Gage G15	8.4	10.8	13.5	15.9	7.8[3]	-
Gage G16	8.4	11.1	14.2	16.3	6.8[3]	-
Gage G17	\	11.1	14.2	16.3	Dry	-
Gage G18	\	11.9	14.8	16.8	10.8[3]	-
CD5 Road						
Gage G24 (Lake L9323 Bridge)	\	11.1	14.1	16.0	9.7[3]	-
Gage G26 (Nigliq Bridge)	6.7	9.8	12.5	14.6	8.4	5
Gage G27 (Nigliq Bridge)	6.7	9.8	12.5	14.5	8.4	5
Gage G30	\	\	13.3	15.5	6.0[3]	-
Gage G32 (Lake L9341 Bridge)	\	\	13.3	15.1	8.8	<2
Gage G34	\	\	13.3	15.7	9.2[3]	-
Gage G36	\	\	13.3	15.7	10.9[3]	-
Gage G38 (Nigliagvik Bridge)	6.9	10.0	12.8	14.9	7.4	3

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. Stage attributed to ponded local melt

LOW MAGNITUDE, HIGH FREQUENCY

A site-specific stage frequency analysis using the historical record can provide a better estimate of low magnitude stage recurrence intervals. Uncertainty increases when extrapolating stage data beyond the continuous record for a river impacted by ice and ice jamming (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, 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.

Stage frequency was performed at MON1, MON22, and gages G1, G3, and G18, which have the longest periods of continuous record and are distributed throughout the project area. The maximum period of continuous record is 25 years at MON1C. Analyses have been performed every three years as the body of data grows (Michael Baker 2007a, 2009a, 2012b, and 2015), and were performed again this year to incorporate the 2016, 2017, and 2018 stage data. Similar to the flood frequency analysis, stage at the select locations was ranked by Weibull distribution for the continuous record and fitted to a Log-Pearson Type III distribution for design-magnitude extrapolation. Measured, estimated, and extrapolated peak annual stage data from 1992 through 2018 for locations used in the stage frequency analysis are presented in Table 9.5.

Table 9.6 and Graph 9.3 presents the Log-Pearson Type III 2018 stage frequency analysis results and the assigned recurrence interval to the 2018 peak stage. Based on the stage frequency analysis, all gage stations fell below the 2-year recurrence interval. Graph 9.4 through Graph 9.8 visually compare the stage frequency analysis and 2D model results to the measured or extrapolated peak annual stage for each selected location.

Table 9.5: Peak Annual Stage for Selected Locations (1992-2018)

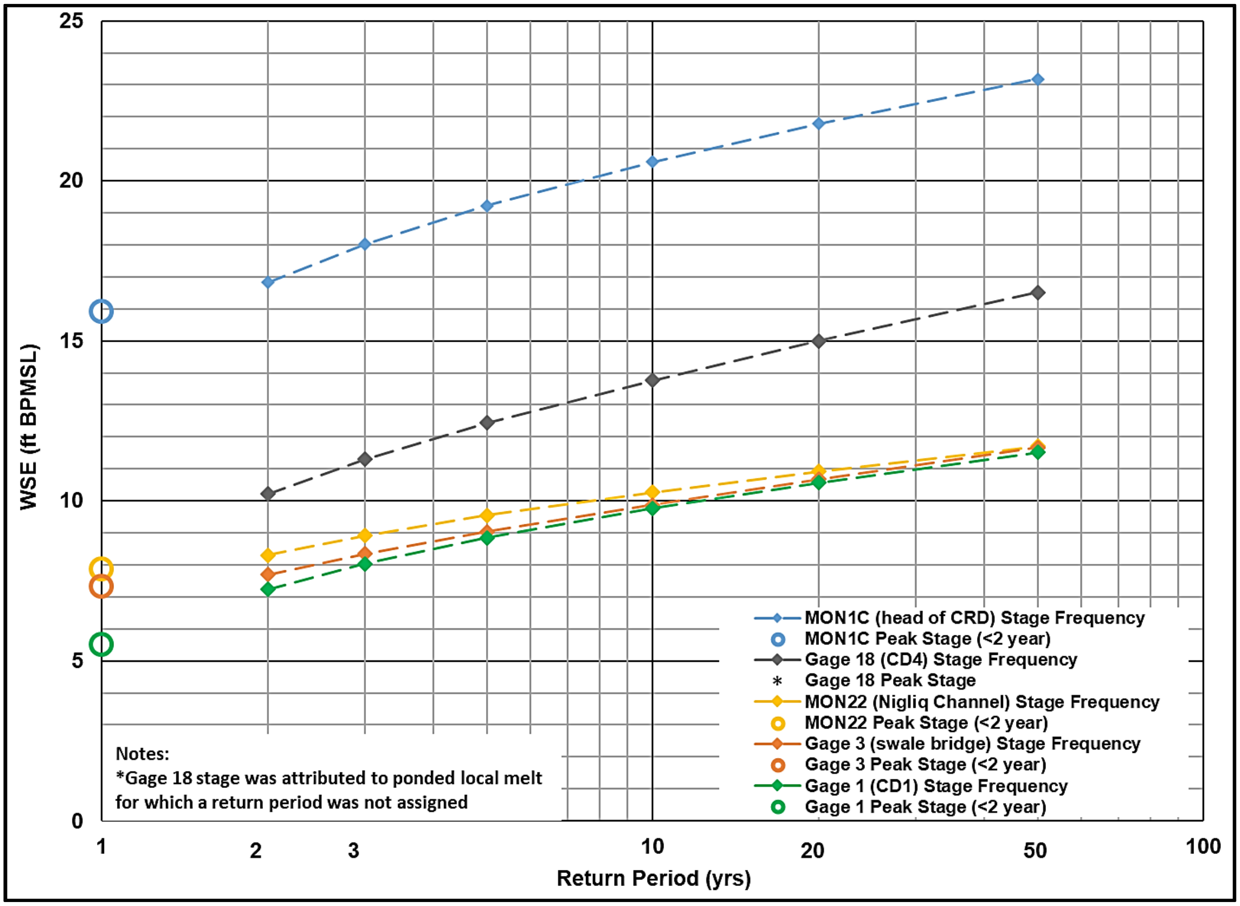
Year	Monument 1 (Head of Delta)	Monument 22 (Nigliq/CD2)	Gage 1 (CD1)	Gage 3 (Swale Bridge)	Gage 18 (CD4)
2018	15.90	7.85	5.50	7.30	10.82[4]
2017	14.79	7.27	6.17	6.04	10.33
2016	17.16	8.52	7.17	7.49	10.84
2015	23.47	11.98	11.26	11.93	16.58
2014	15.18	8.67	8.29	8.18	-
2013	20.69	10.56	9.90	10.27	14.20
2012	14.18	8.17	7.97	7.60	-
2011	19.56	8.97	9.33	8.89	12.84
2010	19.59	8.69	7.15	8.64	11.72
2009	17.65	7.76	6.65	7.63	11.34
2008	17.29	6.78	5.61	8.60	8.60
2007	18.97	9.04	8.64	6.49	10.98
2006	19.83	9.95	9.29	9.72	14.67
2005	13.18	7.65	4.46	6.48	*8.17*
2004	19.54	10.17	8.88	9.97	*11.58*
2003	13.76	7.02	6.07	6.31	*8.03*
2002	16.87	7.94	7.68	7.59	*9.60*
2001	17.37	8.80	6.95	7.95	*10.16*
2000	19.33	9.58	9.10	*9.48*	*10.44*
1999	13.97	5.89	*4.64*	*5.79*	*7.10*
1998	18.11	10.20	*9.51*	*8.02*	*11.39*
1997	15.05	**7.56**	**6.27**	**7.02**	**8.64**
1996	17.19	**8.41**	**7.42**	**7.91**	**10.26**
1995	14.88	**7.49**	**6.18**	**6.94**	**8.52**
1994	12.20	**6.42**	**4.73**	**5.82**	**6.50**
1993	19.20	**9.22**	**8.51**	**8.76**	**11.77**
1992	13.90	**7.10**	**5.65**	**6.53**	**7.78**
Average:	16.99	8.43	7.37	7.90	10.50
Linear Equations:	N/A	y=0.4x+1.5382	y=0.5401x-1.8595	y=0.4203x+0.6897	y=0.7528x-2.6853

Notes:
1. Italicized values were estimated based on linear comparison to peak stage at proximal monitoring locations
2. Bold values were linearly extrapolated based on peak stage at Monument 1
3. Dash "- "indicates no observed WSE
4. Stage attributed to ponded local melt

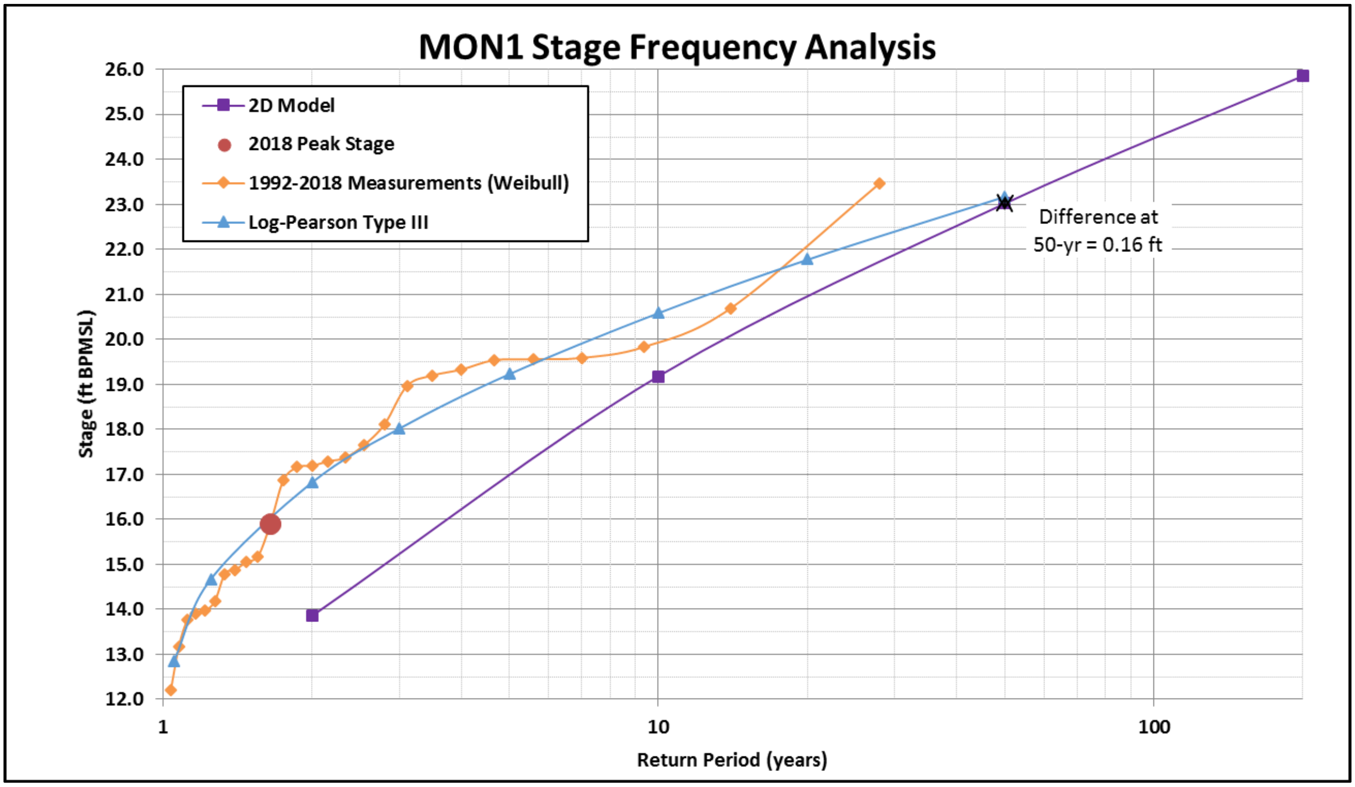
Table 9.6: Peak Stage Frequency Relative to Stage Frequency Analysis

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)	16.82	18.02	19.23	20.59	21.78	23.18	15.90	<2
MON22 (Nigliq Channel)	8.31	8.92	9.55	10.27	10.92	11.70	7.85	<2
Gage G1 (CD1 Pad)	7.24	8.03	8.84	9.77	10.57	11.52	5.50	<2
Gage G3 (CD2 Road)	7.70	8.35	9.04	9.88	10.67	11.67	7.30	<2
Gage G18 (CD4 Road)	10.22	11.30	12.43	13.77	15.00	16.52	10.82[1]	-

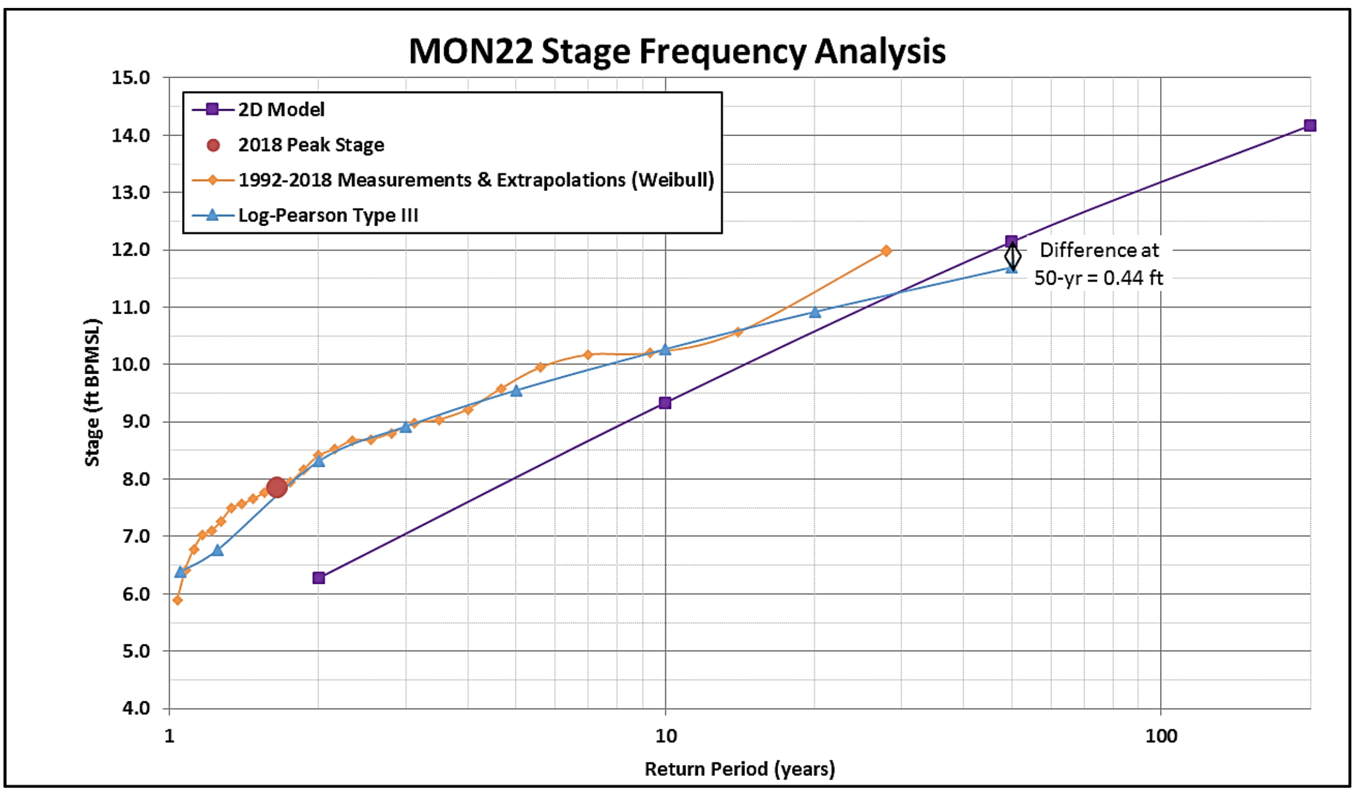
Notes:
1. Stage attributed to ponded local melt



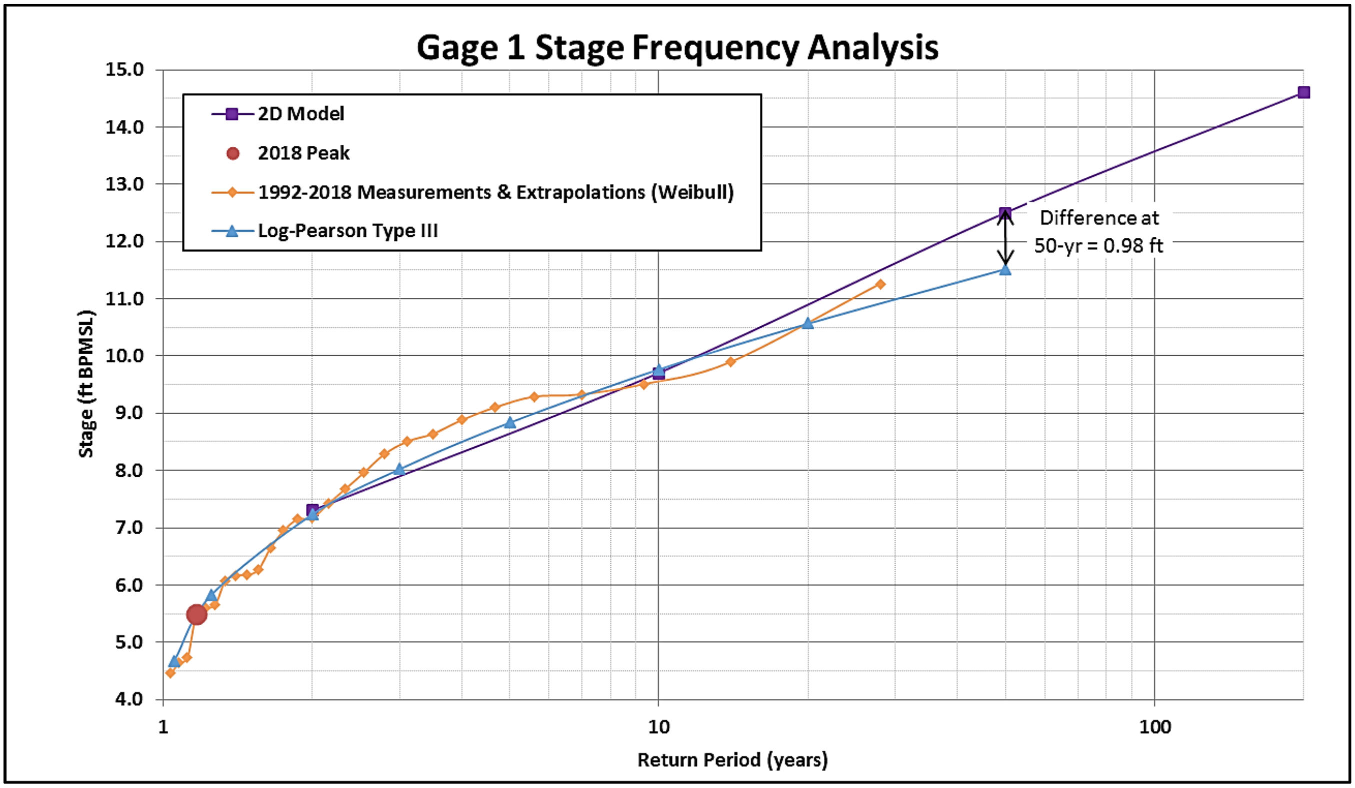
Graph 9.3: Stage Frequency and Peak Stage Recurrence Intervals



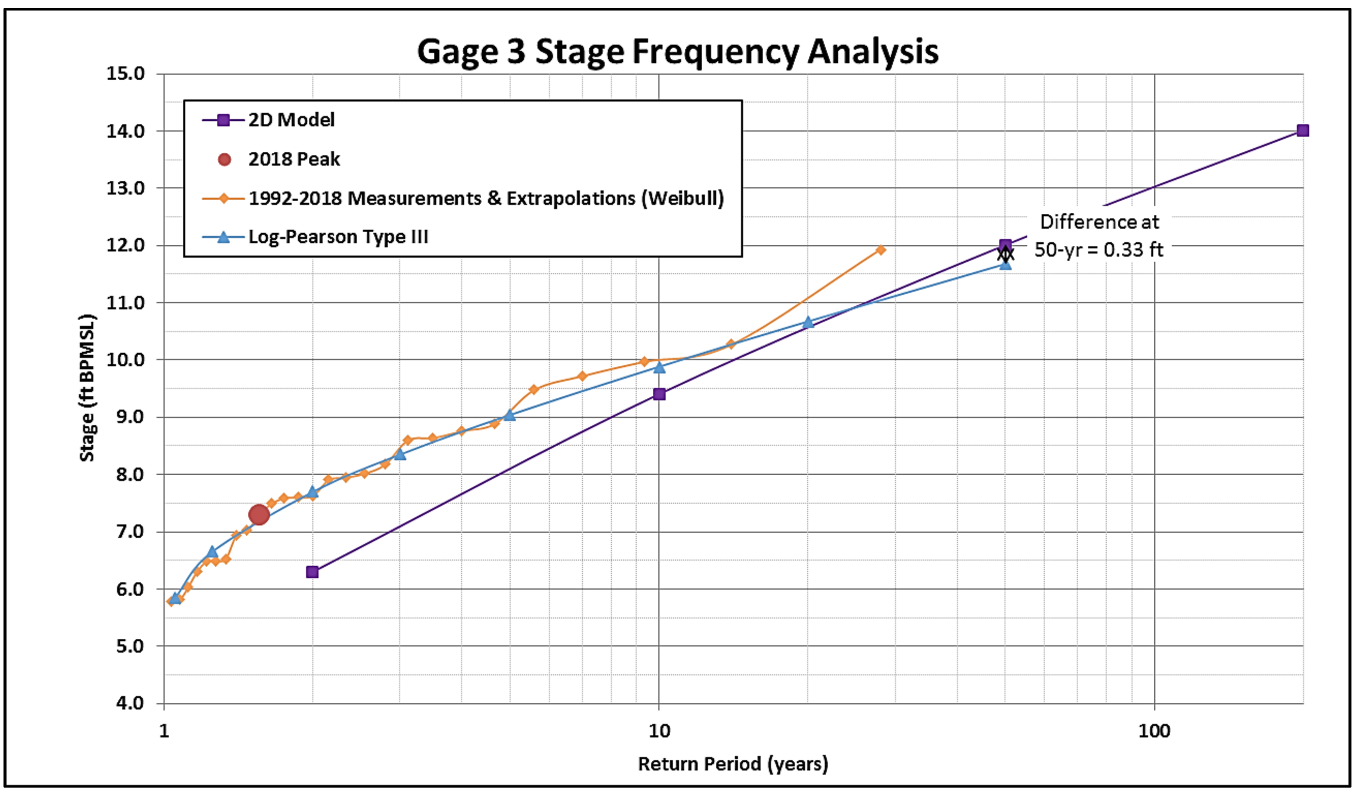
Graph 9.4: MON1 Stage Frequency Analysis, 2D Model Results and Peak Annual Stage Data



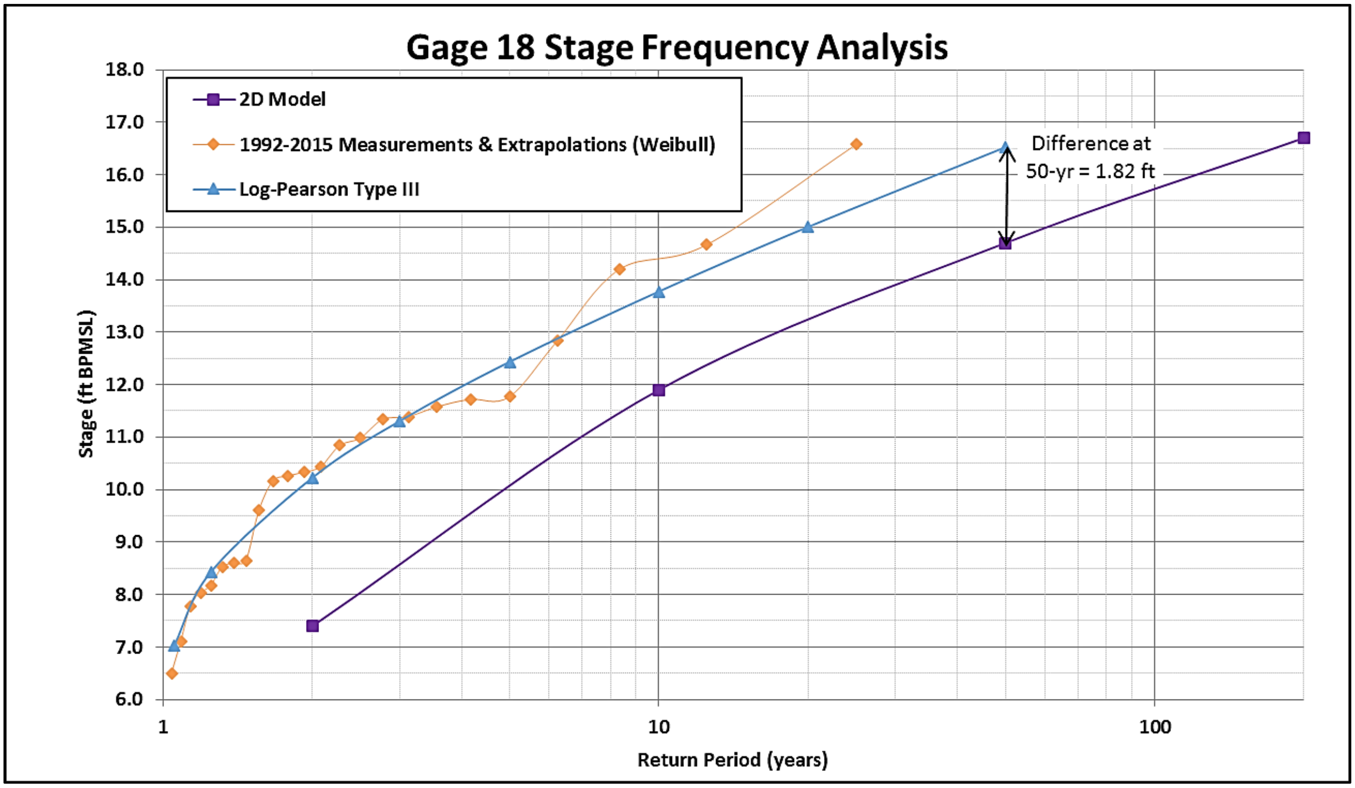
Graph 9.5: MON22 Stage Frequency Analysis, 2D Model Results and Peak Annual Stage Data



Graph 9.6: Gage 1 Stage Frequency Analysis, 2D Model Results and Peak Annual Stage Data



Graph 9.7: Gage 3 Stage Frequency Analysis, 2D Model Results and Peak Annual Stage Data



Graph 9.8: Gage 18 Stage Frequency Analysis, 2D Model Results and Peak Annual Stage Data

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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
CD4-27W		N 70.2934	W 150.9820

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
CD5-23N	148+07	N 70.3043	W 151.1377

Culvert	Station	Latitude (NAD83)	Longitude (NAD83)
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)
CD5-23S		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
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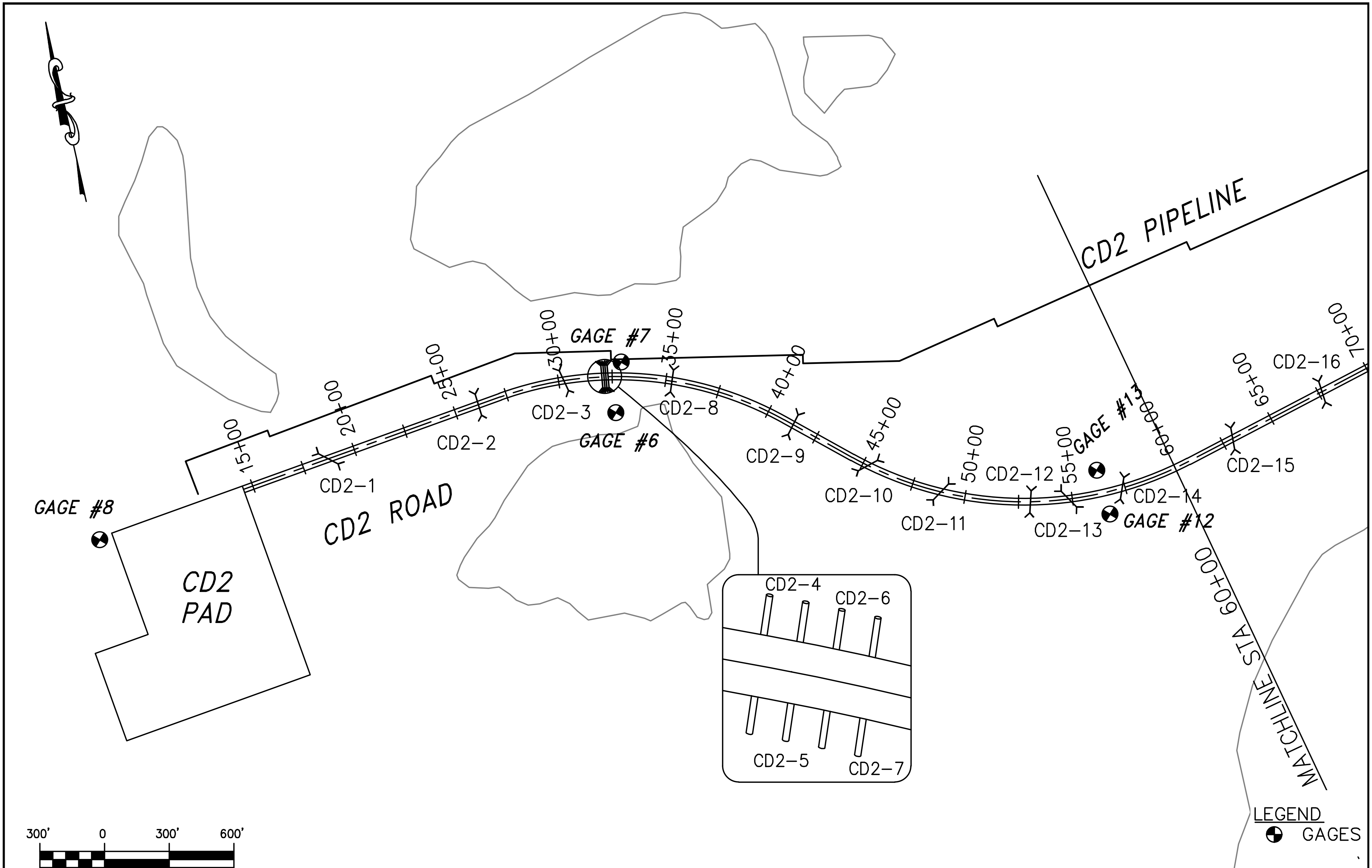

ConocoPhillips Alaska, Inc.

DATE: 10/30/2018	PROJECT: 166417
DRAWN: DTR	FILE: ALPINE_FACILITES.DWG
CHECKED: GCY	SCALE: AS SHOWN

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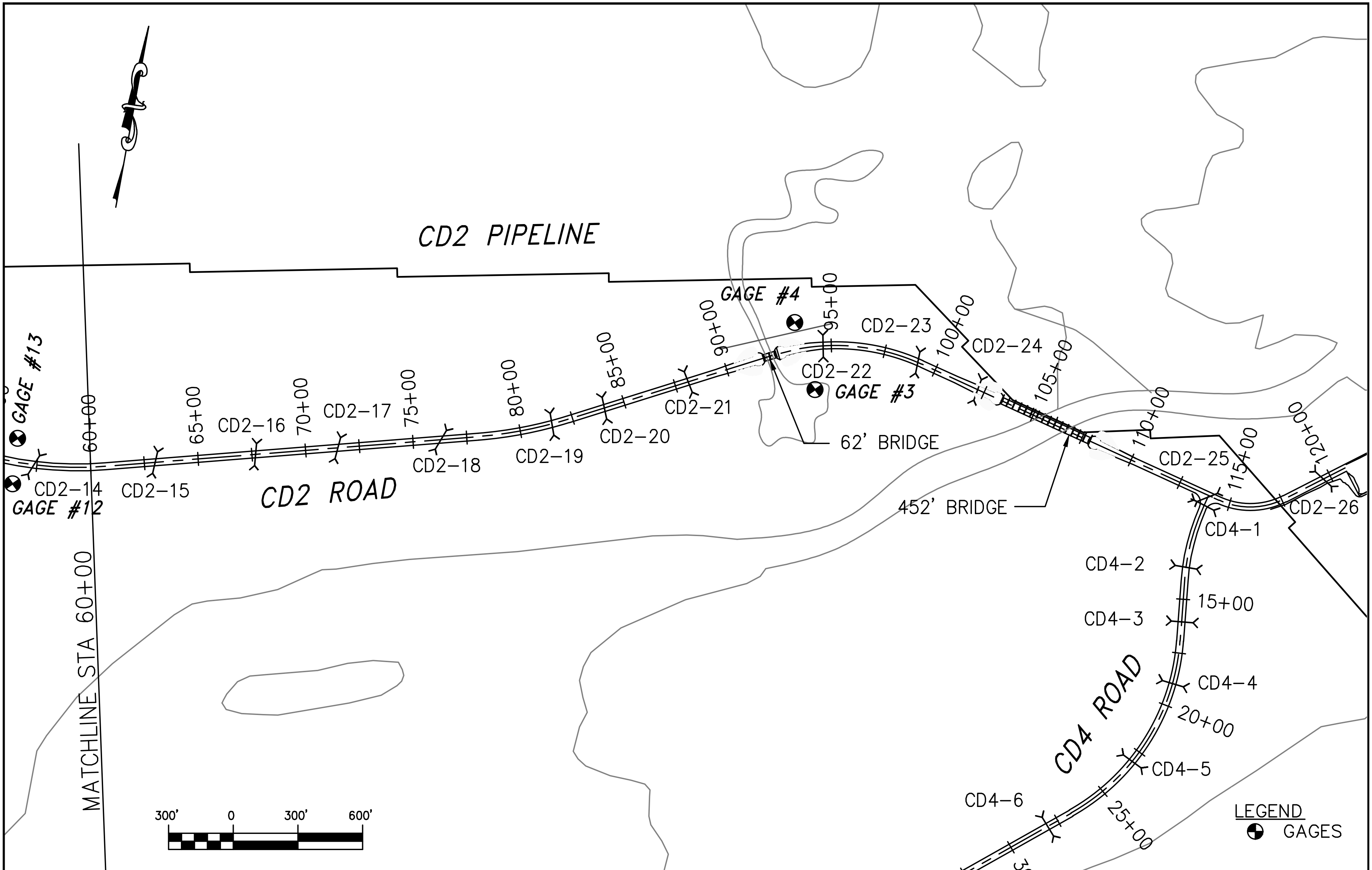
2018 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 1 OF 13)



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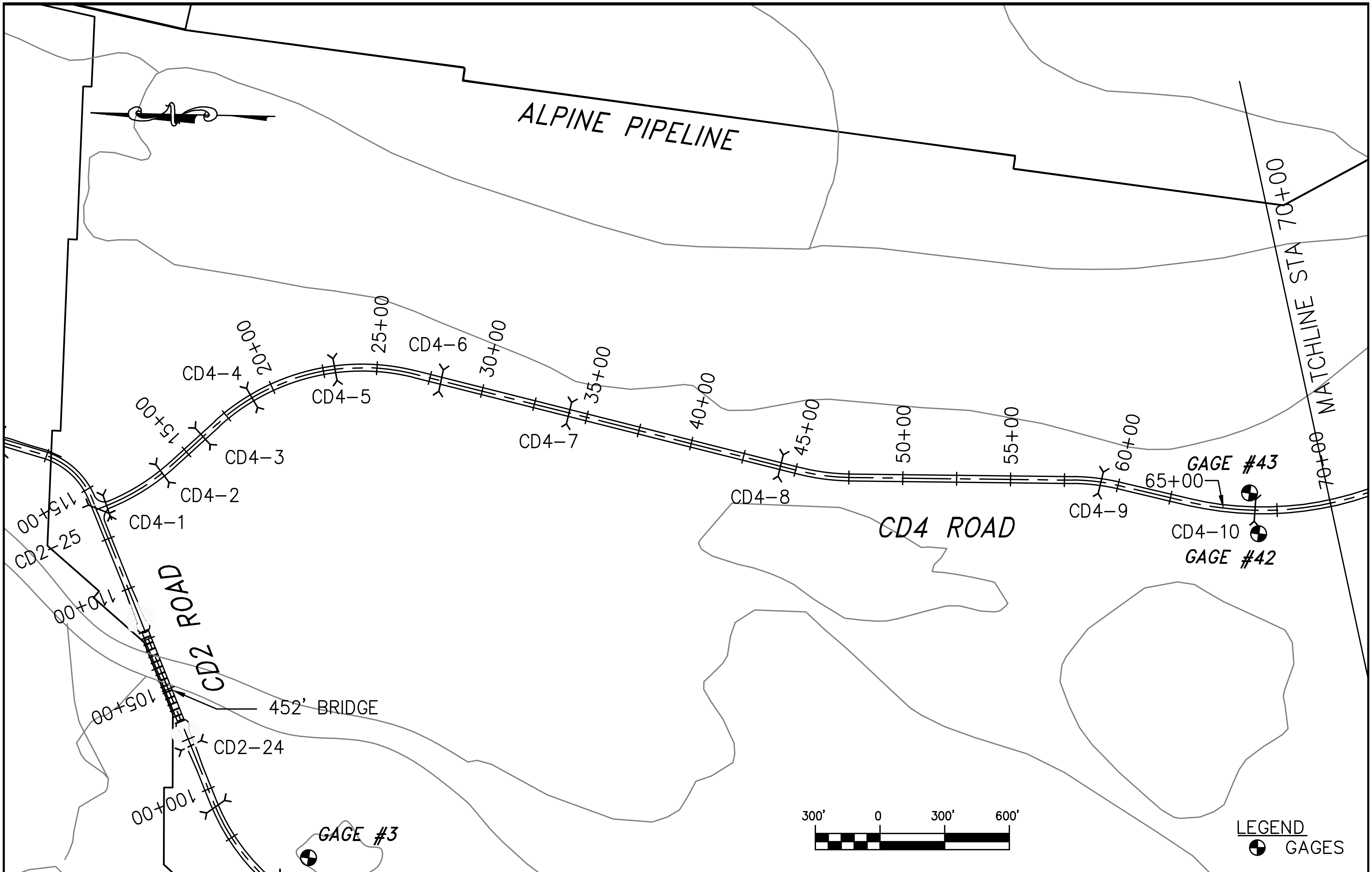
2018 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 2 OF 13)



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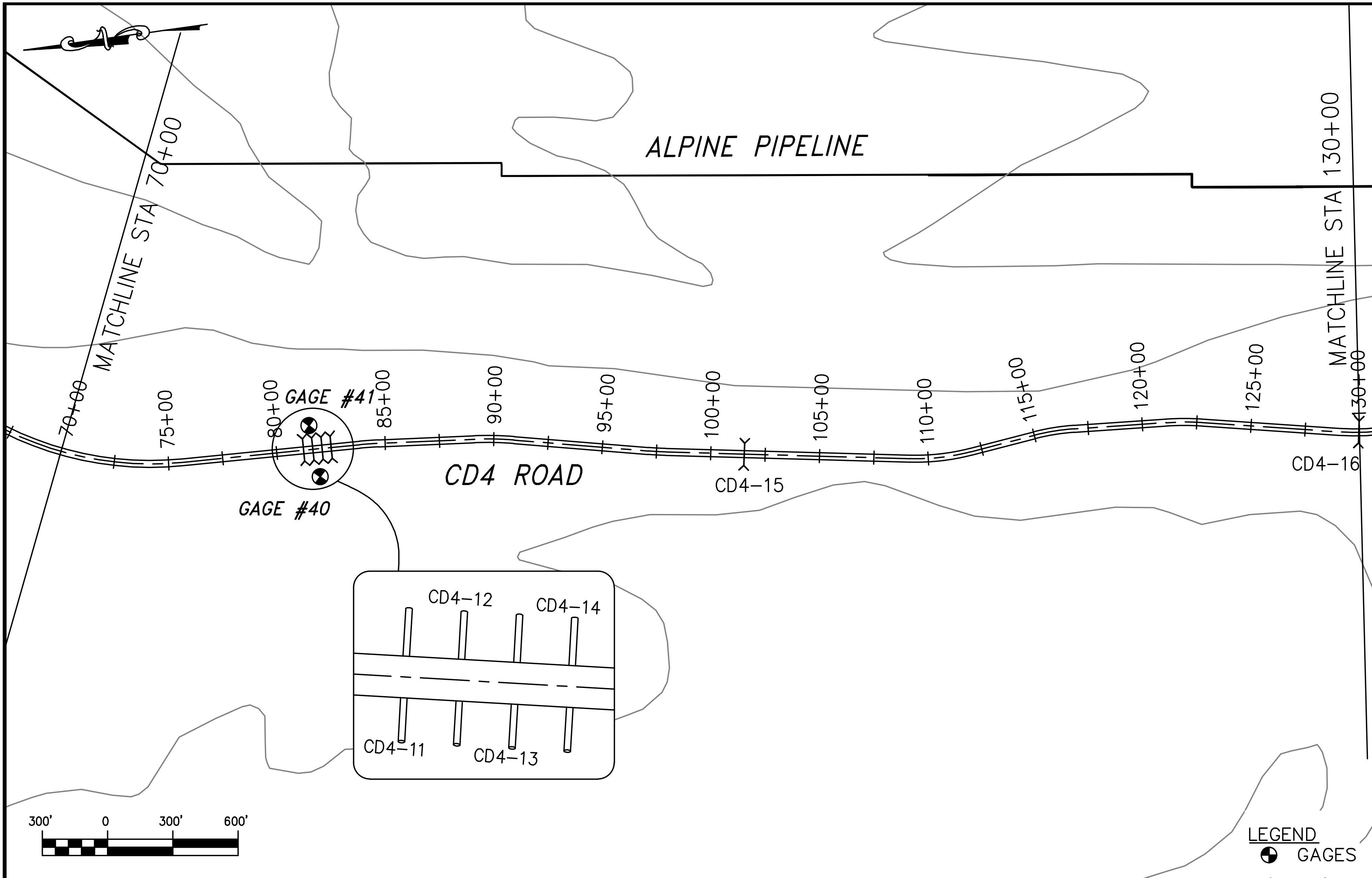
2018 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 3 OF 13)



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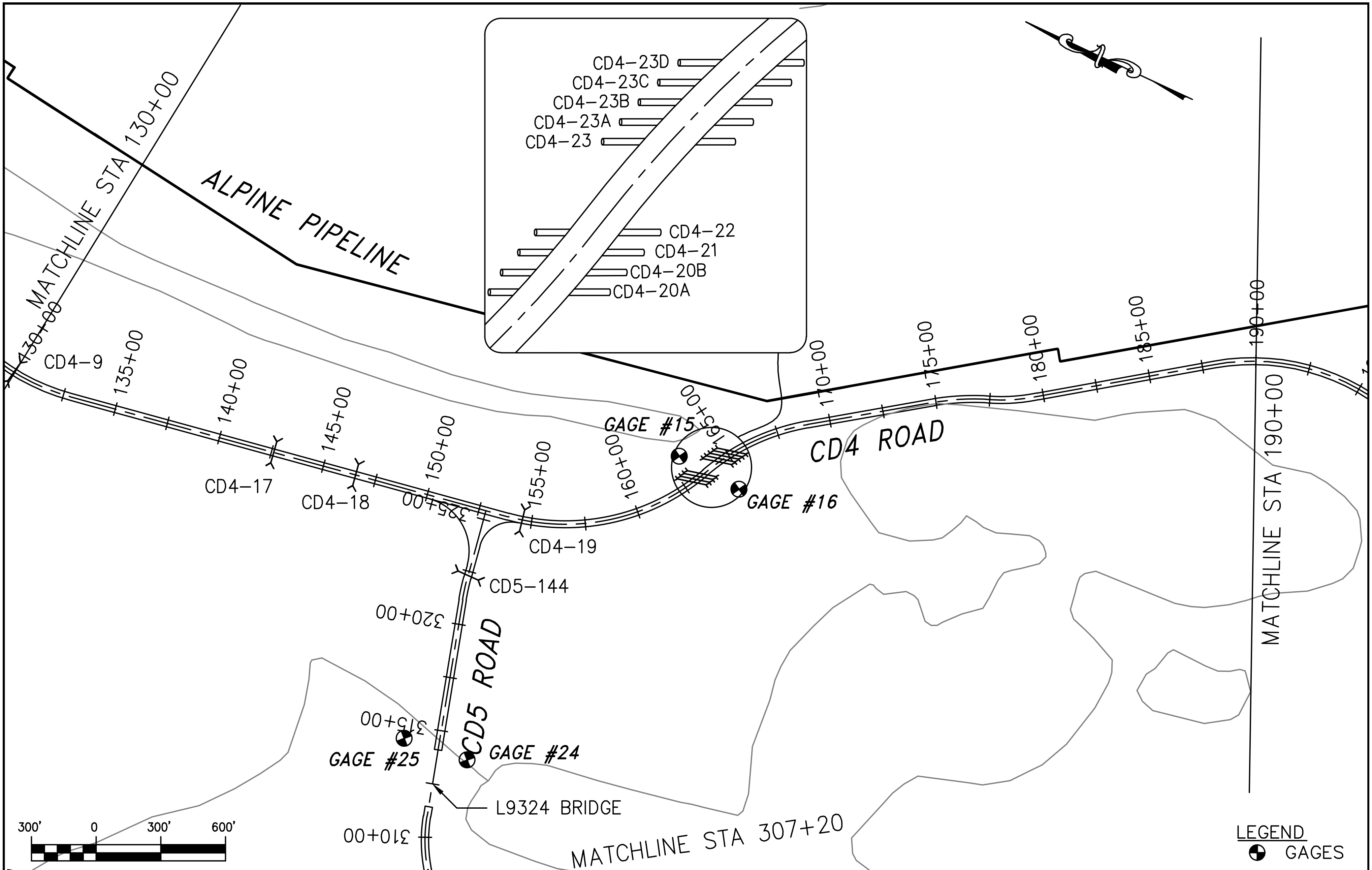
2018 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION



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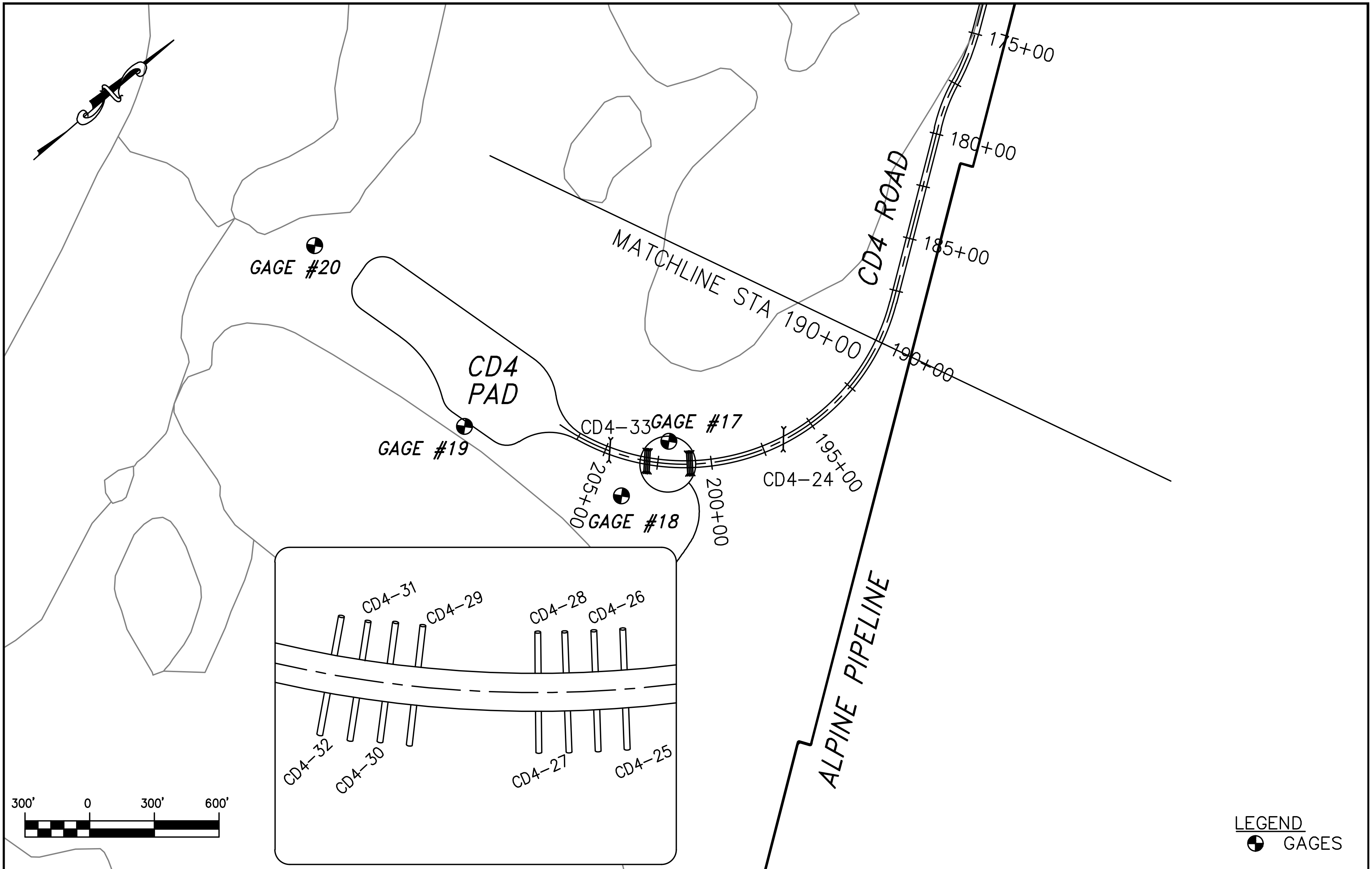
2018 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 5 OF 13)



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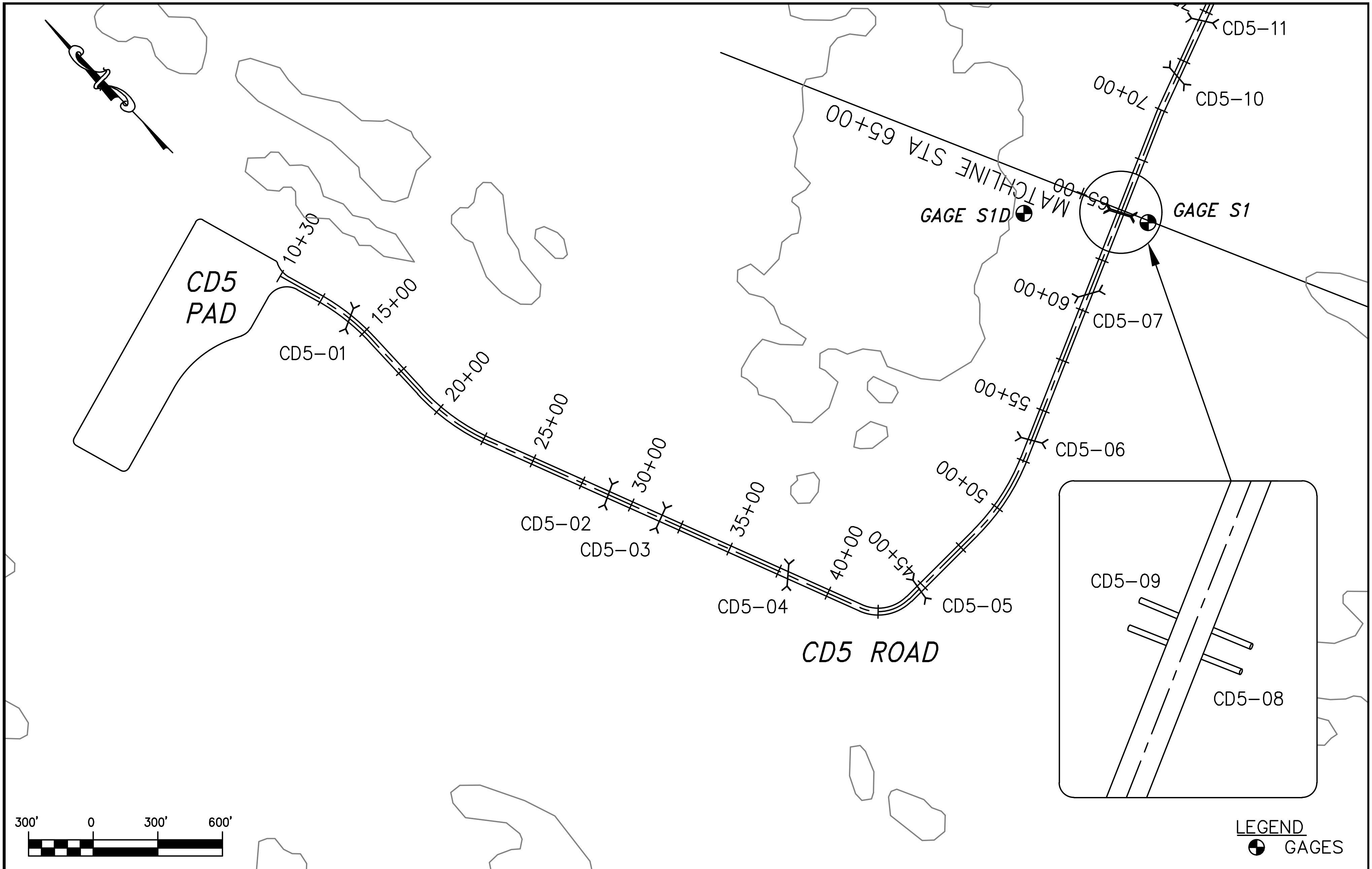
2018 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 6 OF 13)



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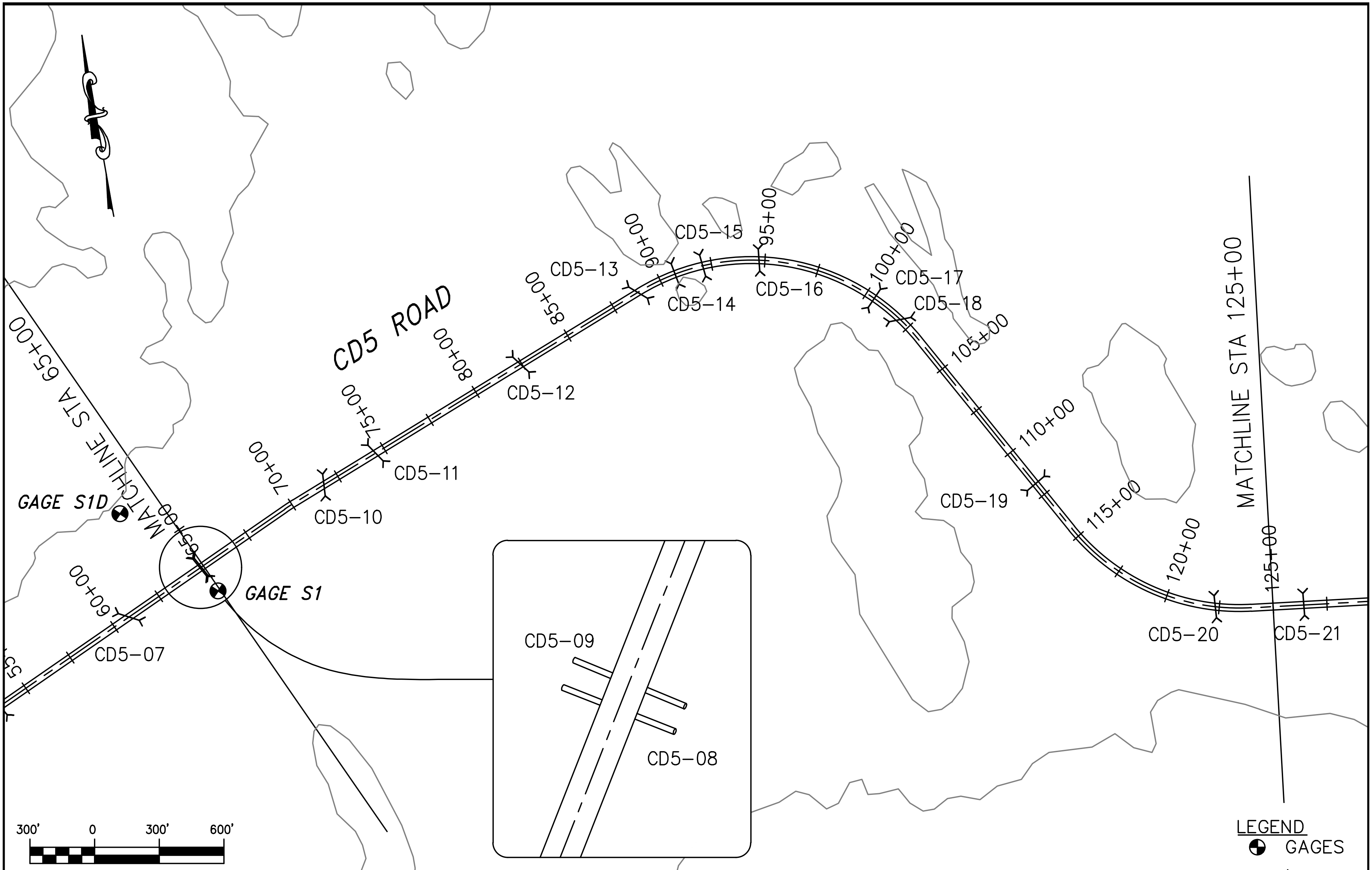
2018 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

(SHEET 7 OF 13)



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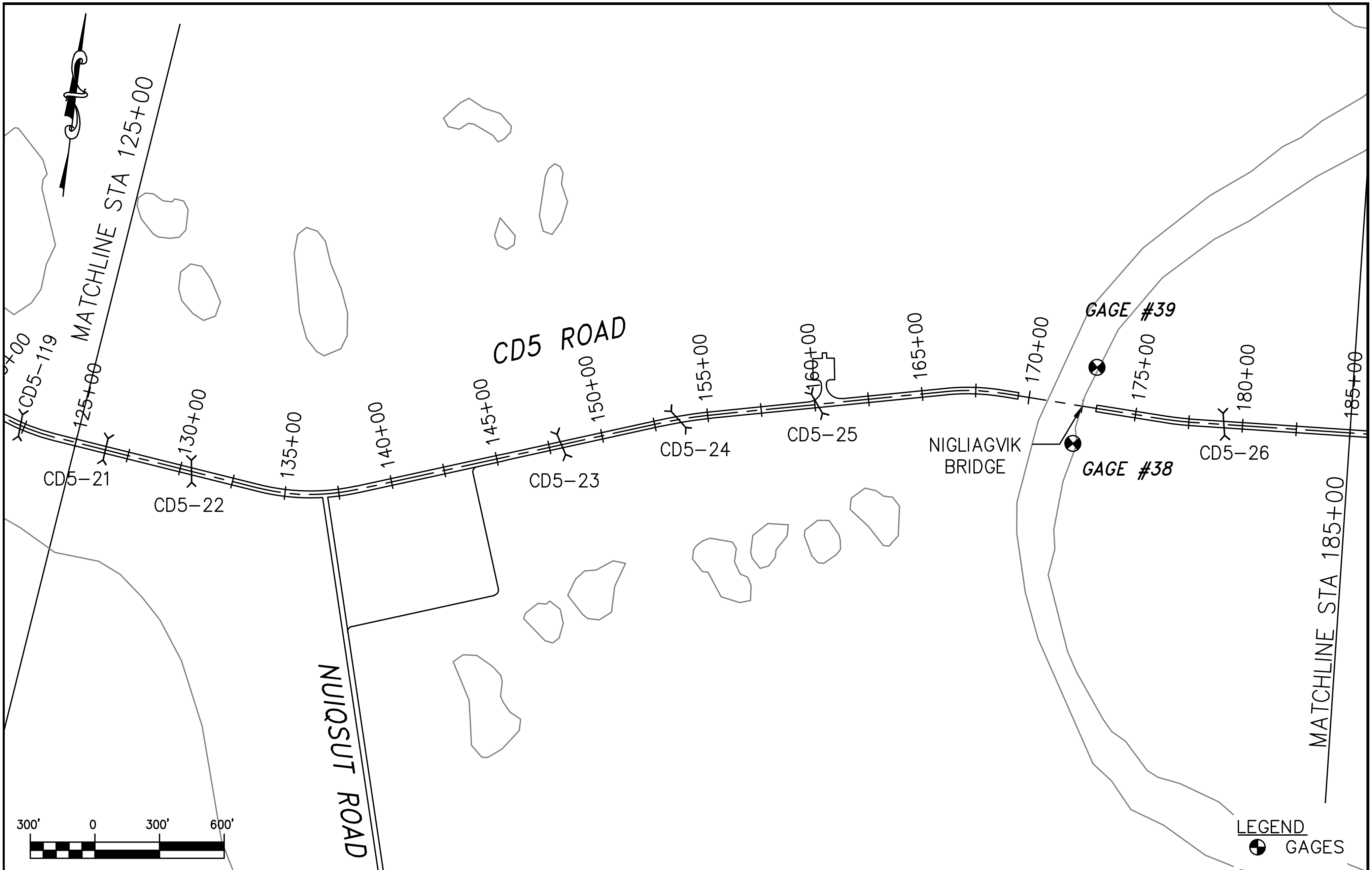
DRAINAGE STRUCTURE LOCATION

(SHEET 8 OF 13)



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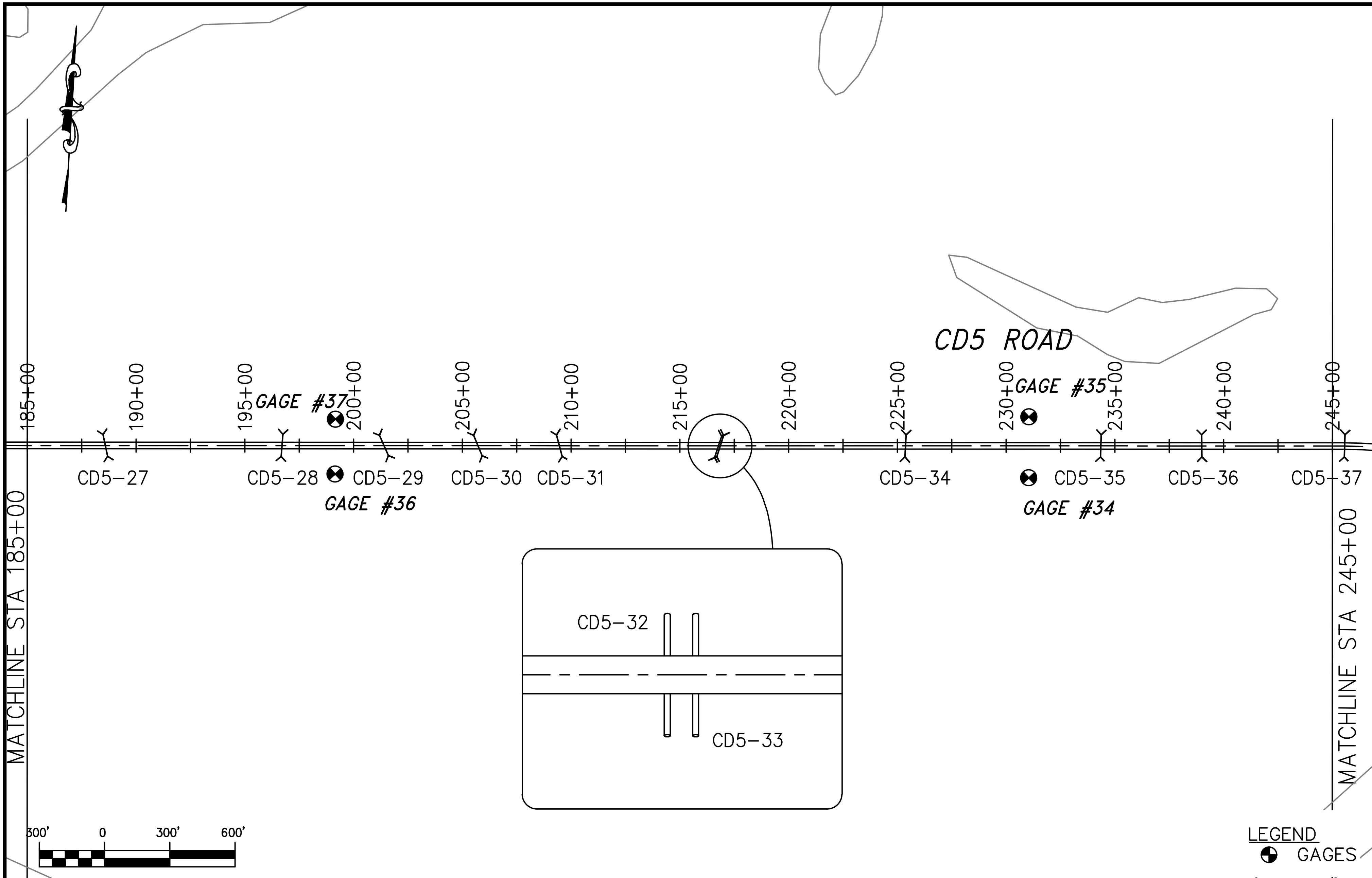
2018 SPRING BREAKUP
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET 9 OF 13)



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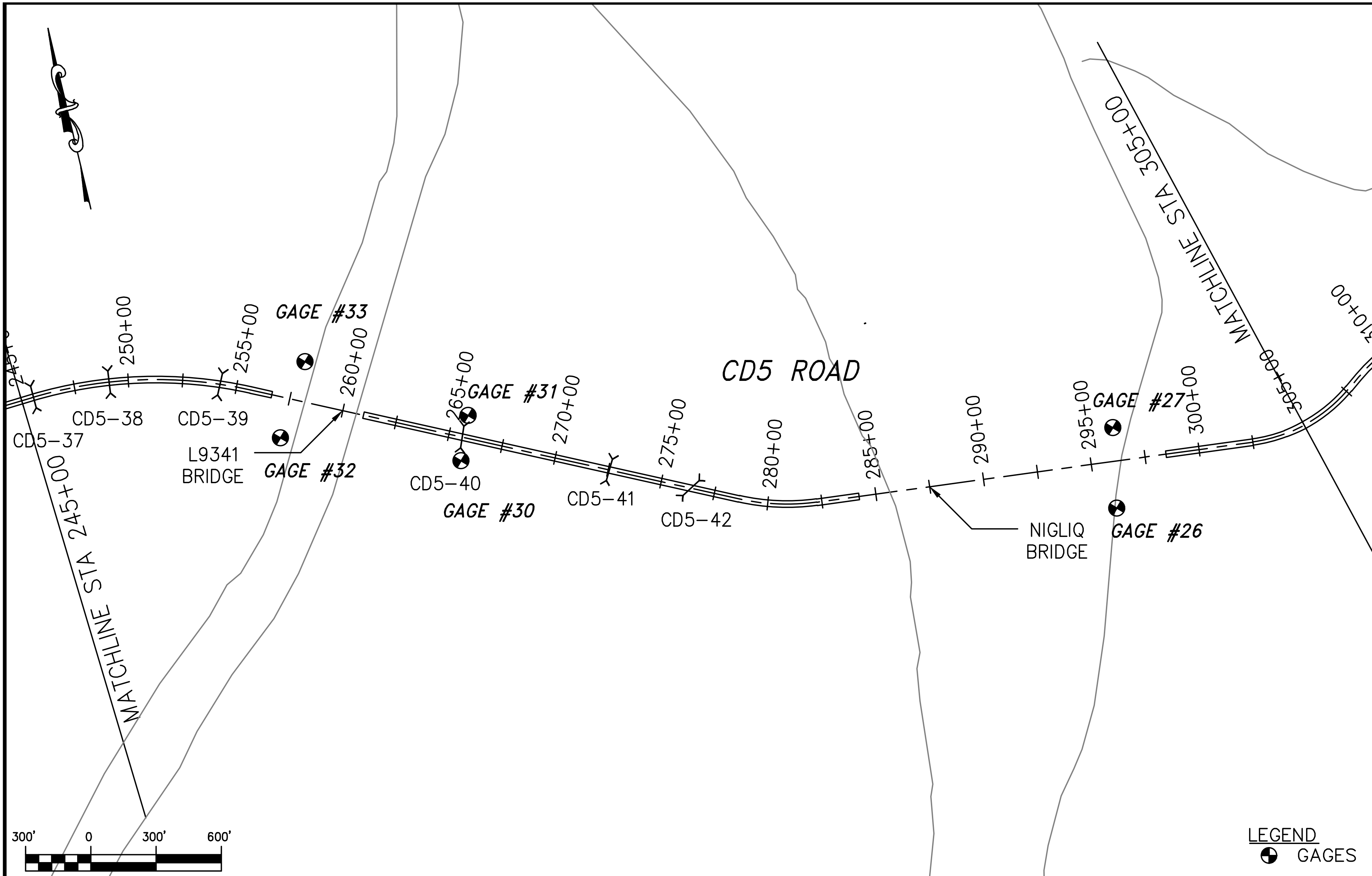

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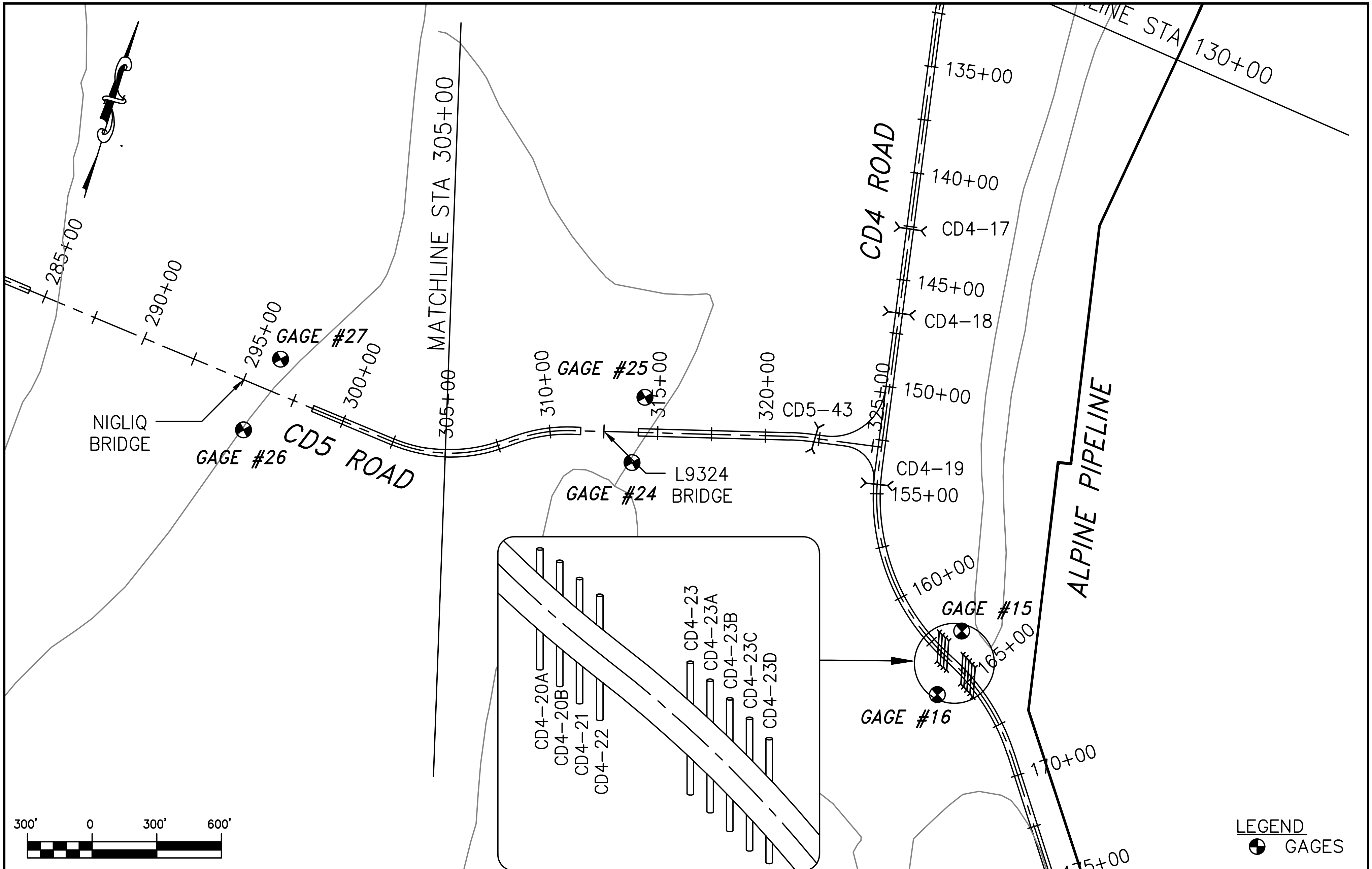
DRAINAGE STRUCTURE LOCATION

(SHEET11 OF 13)



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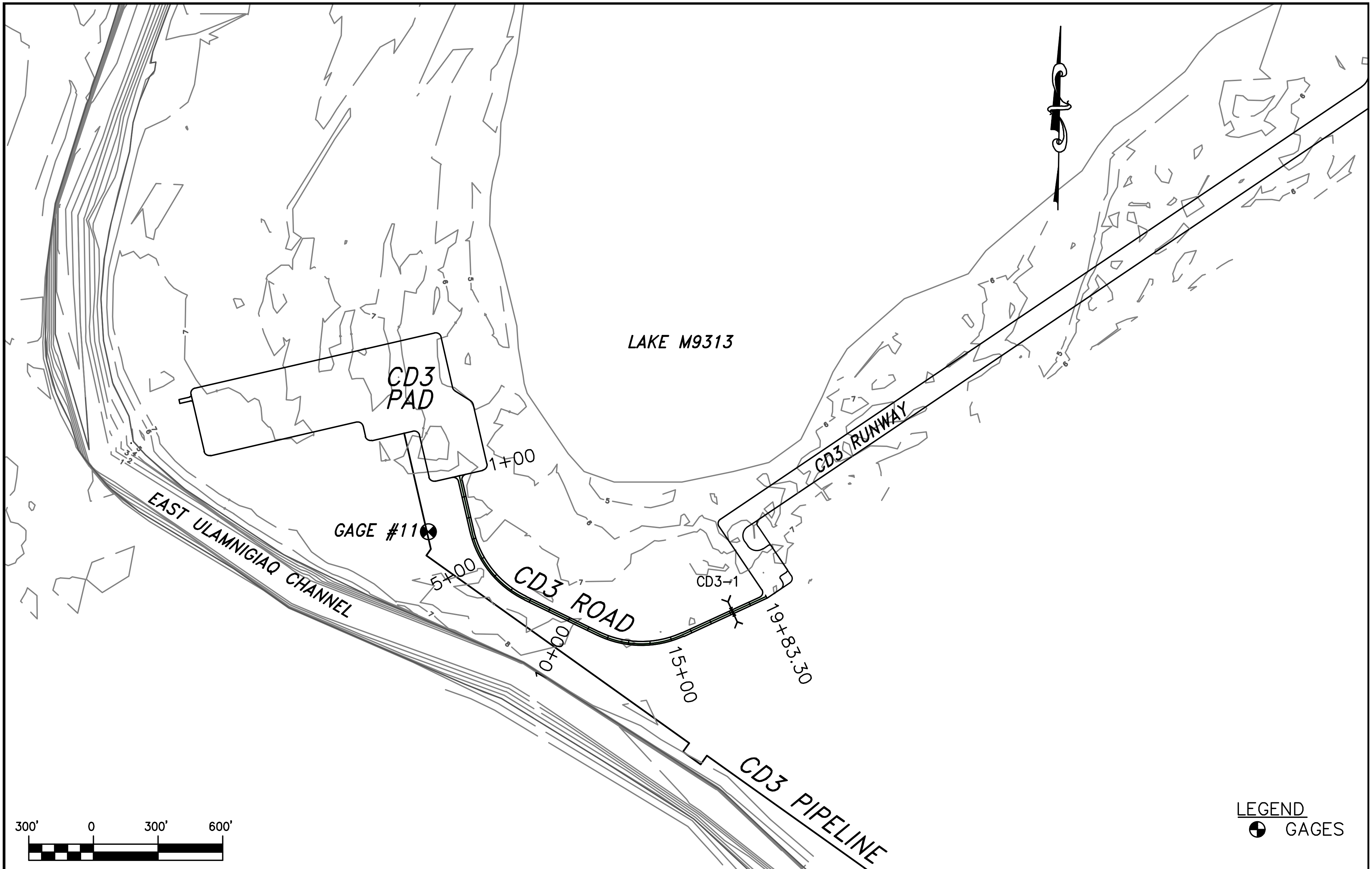
ALPINE FACILITIES
DRAINAGE STRUCTURE LOCATION

(SHEET12 OF 13)



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2018 SPRING BREAKUP

ALPINE FACILITIES

DRAINAGE STRUCTURE LOCATION

APPENDIX B PT SETUP & TESTING METHODS

PTs measure the absolute pressure of the atmosphere and water, allowing the depth of water above the sensor to be calculated. Resulting data yield a comprehensive record of the fluctuations in stage. The reported pressure is the sum of the forces imparted by the water column and atmospheric conditions. Variations in local barometric pressure were taken into account using a Solinst Barologger® barometric pressure logger. A correction of barometric pressure was obtained from the Solinst Levelogger installed at the Tinmiaqsiugvik Bridge.

The PTs were tested before field mobilization. The PTs were configured using Solinst Levelogger® v4.0.3 (for both the Solinst Leveloggers and Barologgers) software prior to placement in the field. Absolute pressure was set to zero. The PT sensor was surveyed during setup to establish a vertical datum using local control.

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

APPENDIX C DISCHARGE METHODS, SITE SPECIFIC INFORMATIN, & PLAN & PROFILE DRAWINGS

C.1 METHODS

C.1.1 MEASURED DISCHARGE

1) USGS Midsection Technique

Bridge flow depth and velocity measurements were taken from the upstream side of 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.

3) ADCP METHODS

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

A. HARDWARE & SOFTWARE

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

BBTalk v3.06, a DOS-based communication program, was used to perform pre-deployment tests. WinRiverII v2.18 was used to configure, initiate, and communicate with the ADCP while on the river. WinRiverII was also used to review and evaluate collected discharge data after returning from the field.

B. PRE-DEPLOYMENT TESTING

Prior to deployment of the ADCP unit, a full suite of tests were run in accordance with the manufacturer's instructions using BBTalk. The tests confirmed the signal path and all major signal processing subsystems were functioning properly. Tests also confirmed accurate tilt and pitch readings. A beam continuity test was performed to verify the transducer beams were connected and operational. Additional diagnostic tests were performed using WinRiverII. Pre-deployment tasks also included compass calibration and verification and a moving bed test. The internal compass was calibrated multiple times until the error was down to 13.19°, which is still outside the specified

5° limit. Additional compass calibration did not decrease the error beyond 13.19° so the overall measurement rating was reduced. A loop test was performed to detect and estimate compensation for a moving bed.

C. ADCP DEPLOYMENT & DATA COLLECTION

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

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

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

D. ADCP BACKGROUND & DATA PROCESSING

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

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

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

C.1.2 PEAK DISCHARGE

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, 2017)
- Culvert upstream and downstream invert elevations (UMIAQ 2017, 2018d)

- 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, and the Nigliq 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 2014), cross sectional geometry at the Nigliagvik Bridge and Nigliq Bridge is current as of 2016 (UMIAQ 2016a). 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.

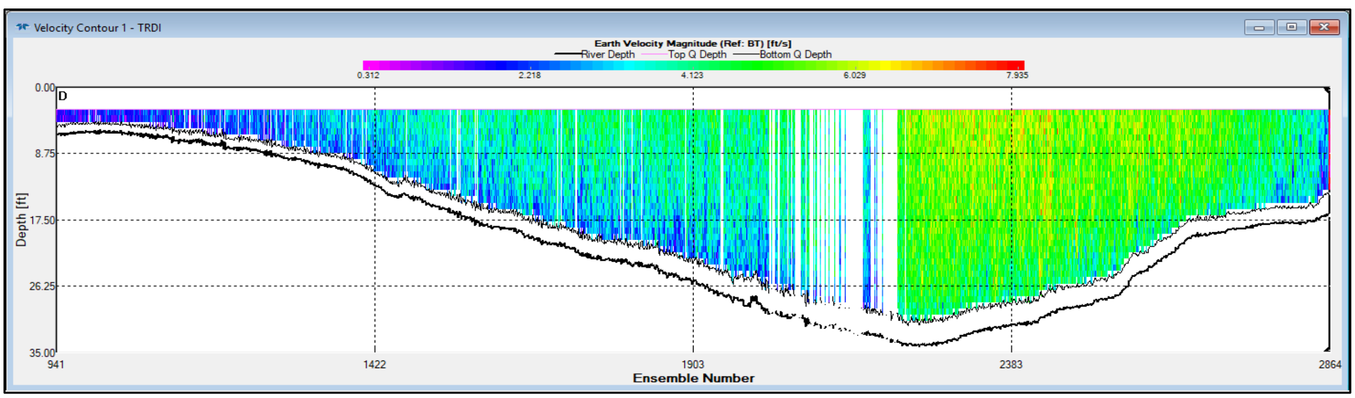
C.2 Site Specific Data & Plan & Profile Drawings

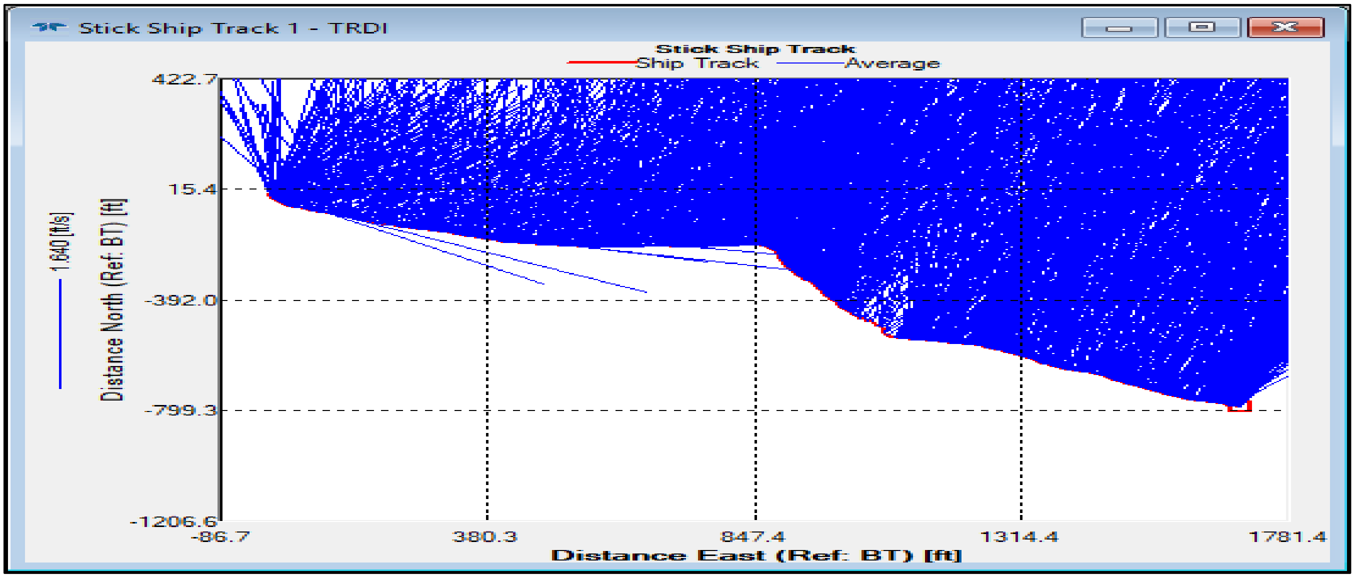
C.2.1 MON1

1) MON1 JUNE 3 SPRING BREAKUP MEASURED DISCHARGE SUMMARY

	Area (ft^2)	Unadjusted Measured Discharge (cfs)	Discharge Correction Attributed to Moving Bed (cfs)	Adjusted Measured Discharge (cfs)	Error	Average Velocity (ft/s)
Transect MON1000 at 18:21	40,184	153,724	13,904	167,628	-0.22%	4.17
Transect MON1001 at 18:36	41,296	155,672	14,288	169,960	1.17%	4.12
Transect MON1002 at 18:50	40,518	152,667	14,019	166,686	-0.78%	4.11
Transect MON1004 at 19:26	40,735	153,644	14,094	167,738	-0.16%	4.12
Average	**40,683**	**153,927**	**14,076**	**168,000**	**--**	**4.13**

E. TRANSECT MON1000 RAW DATA OUTPUT





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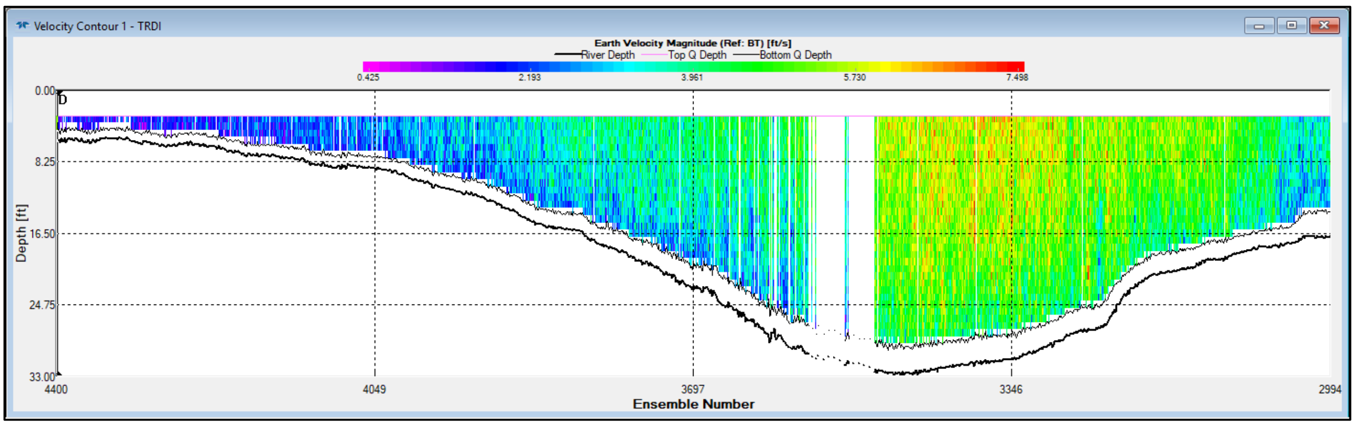

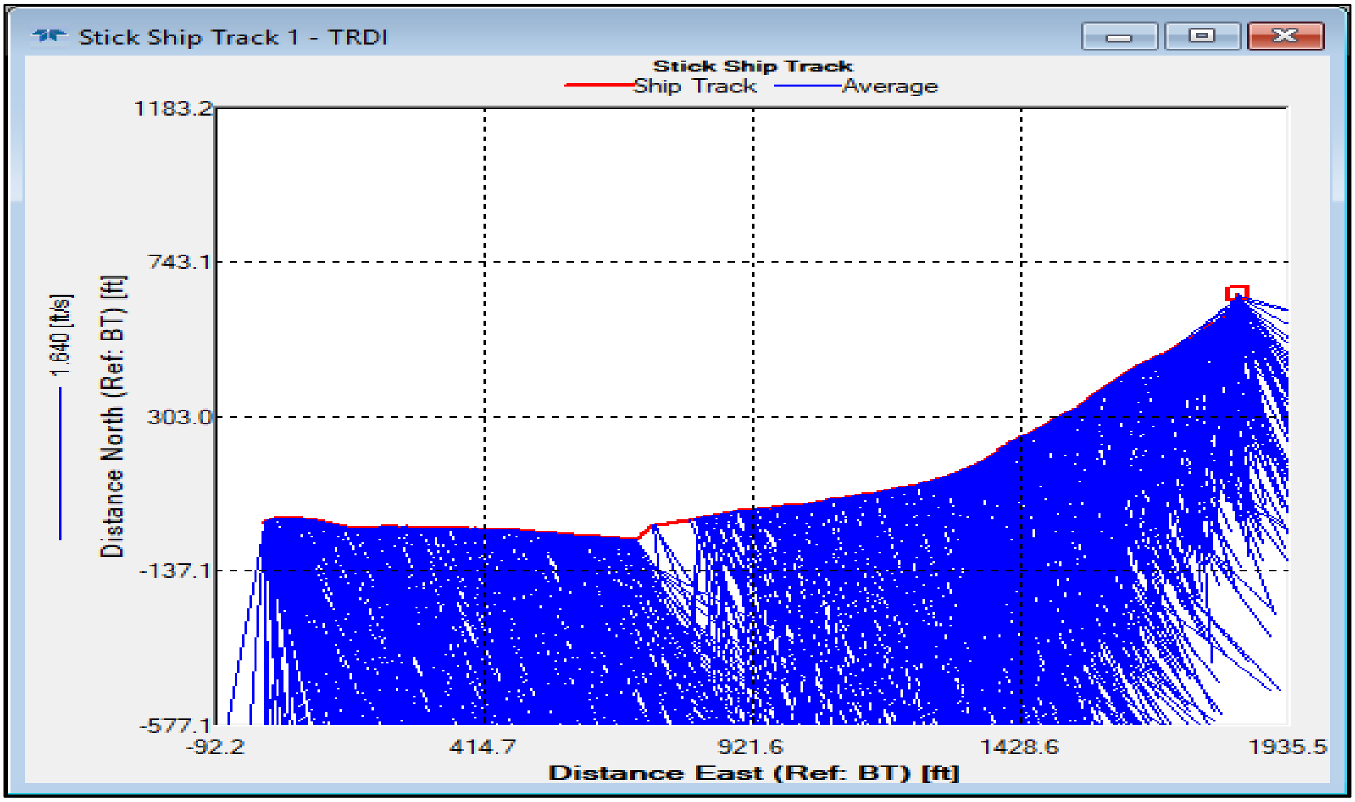

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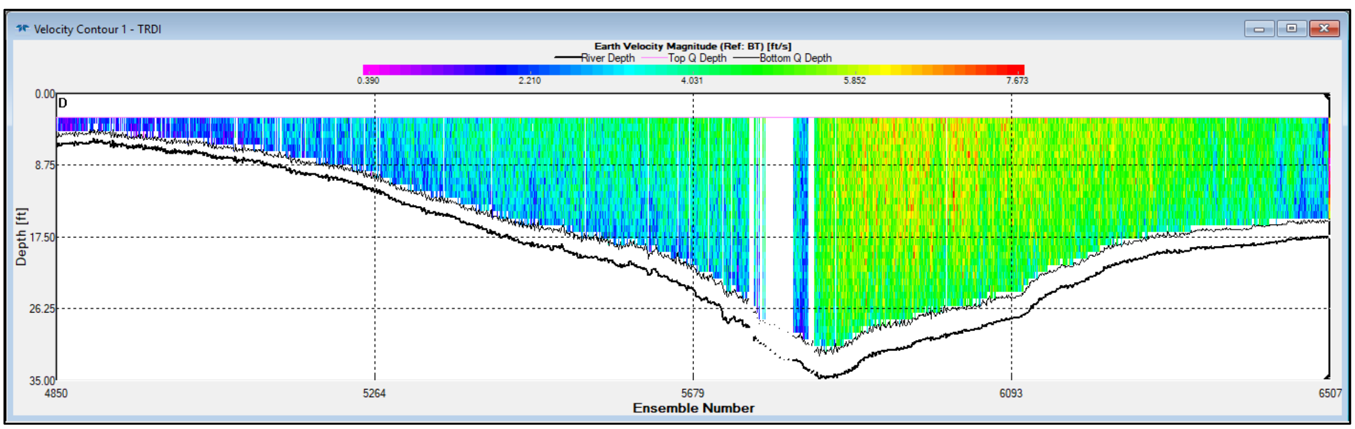

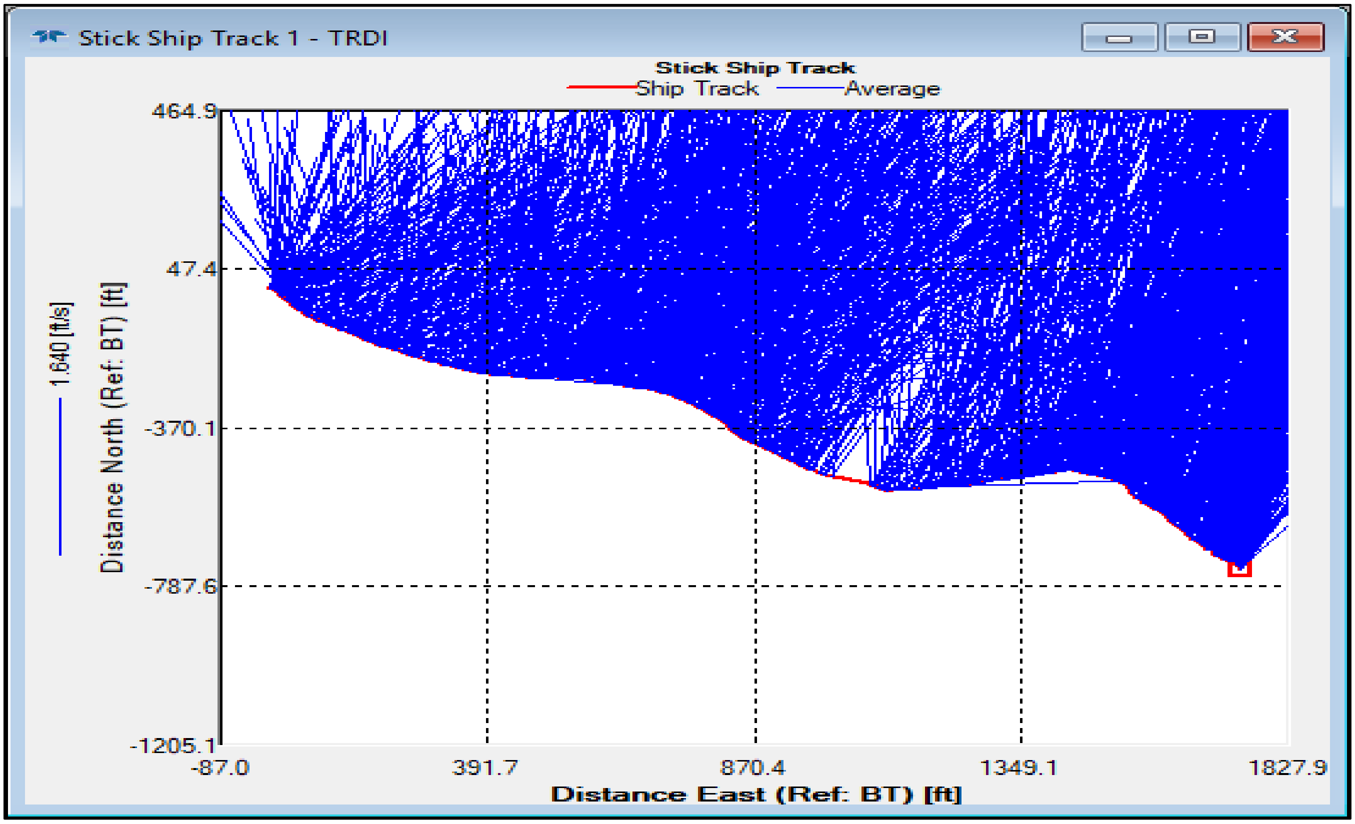

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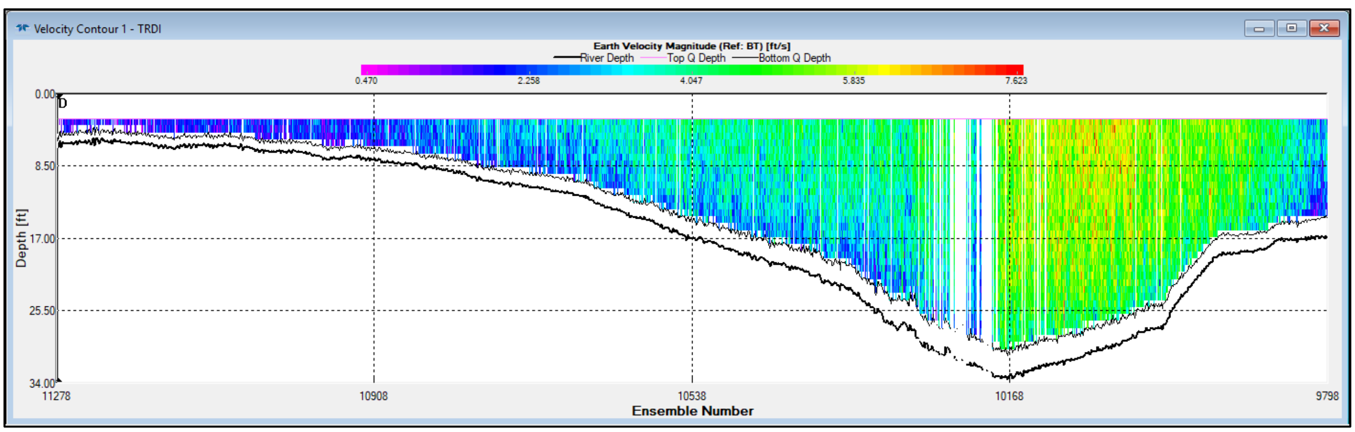
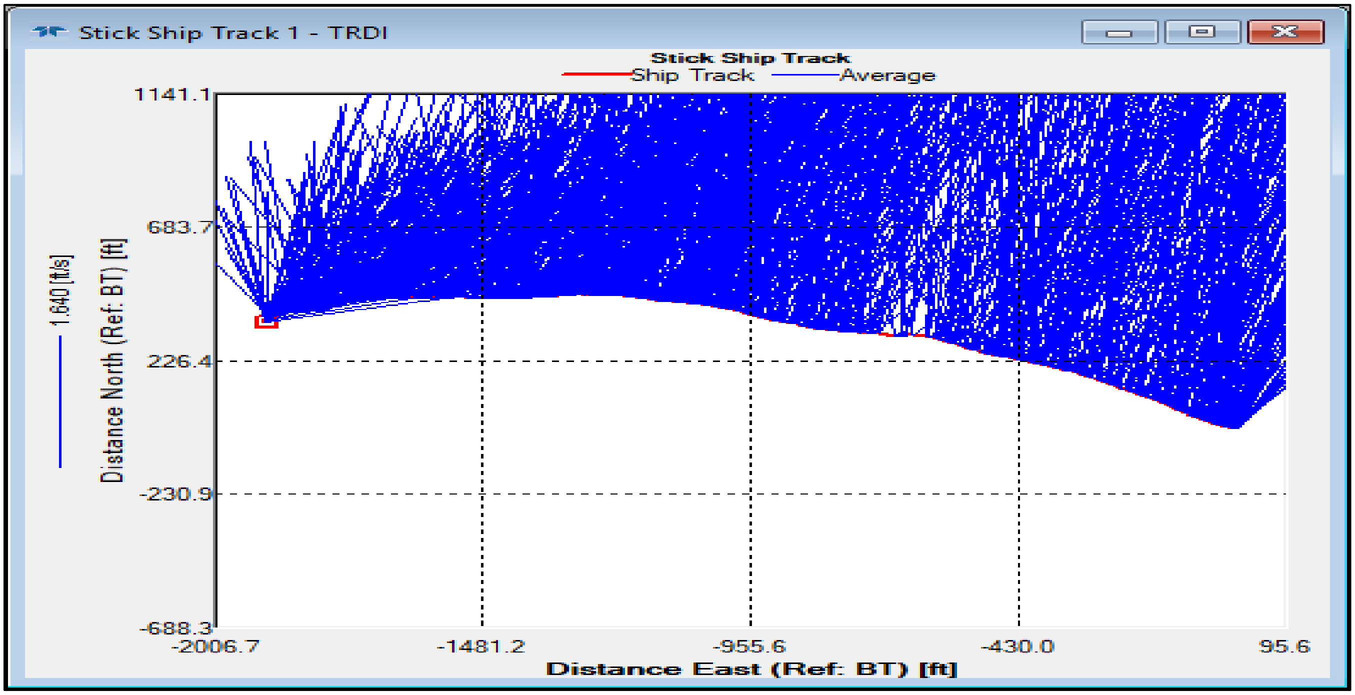
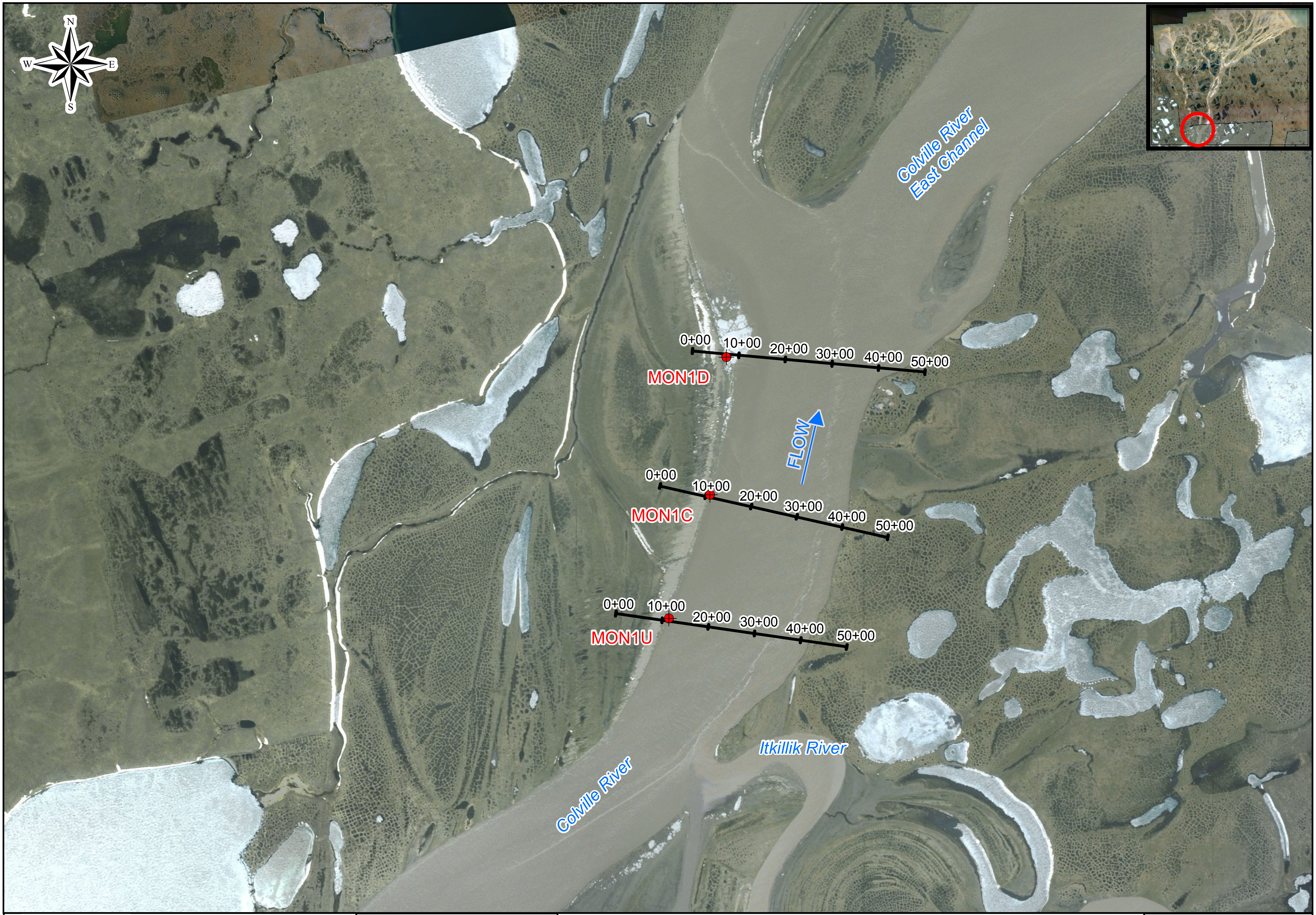




2) PEAK DISCHARGE DATA

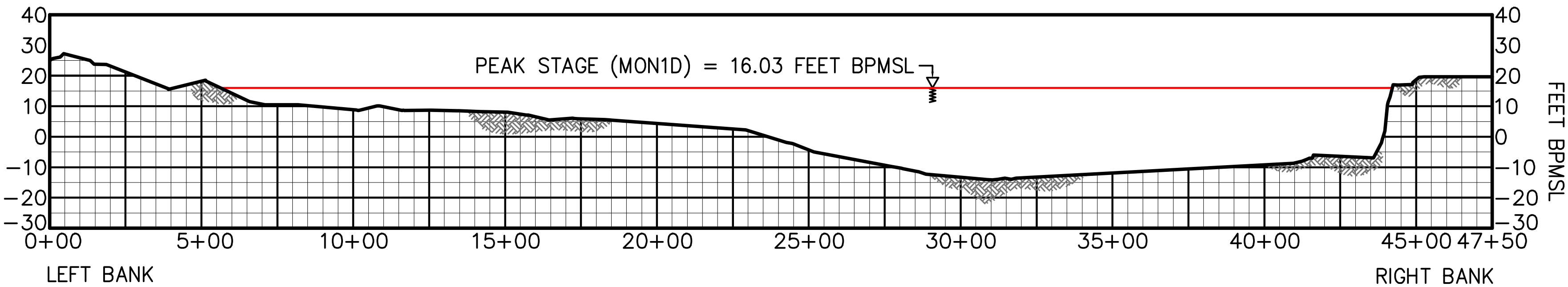
Peak discharge at MON1 was calculated indirectly using the Normal Depth method. The Slope Area method was not used because of the limited time that stage was high enough to be recorded by the MON1D PT. The energy grade-line was approximated by the average water surface slope between MON1U, MON1C, and MON1D. 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.

3) PLAN & PROFILES



ConocoPhillips Alaska	Miles 0 0.25 0.5	Legend		2018 SPRING BREAKUP MONUMENT 1 PLAN
Date: 10/30/2018	Project: 166417	Gage Location	Michael Baker International	
Drawn: BTG	File: 2018_CRD_8x11L_Mon1.mxd	2004 Cross Section Alignment	Michael Baker International 3900 C Street, Suite 900 Anchorage, AK 99503 Phone: (907) 273-1600 Fax: (907) 273-1699	
Checked: GCY	Scale: 1 in = .5 miles	Imagery Source: GeoNorth WMS		(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:	10/30/2018	PROJECT:	166417
DRAWN:	DTR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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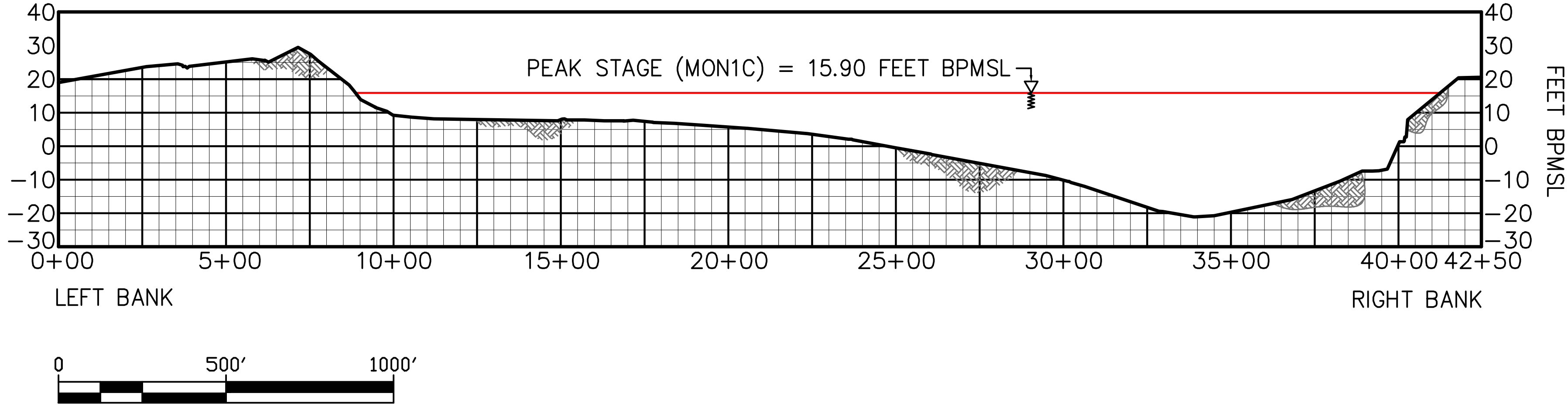
2018 SPRING BREAKUP
MONUMENT 1 DOWNSTREAM
PROFILE

(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:	10/30/2018	PROJECT:	166417
DRAWN:	DTR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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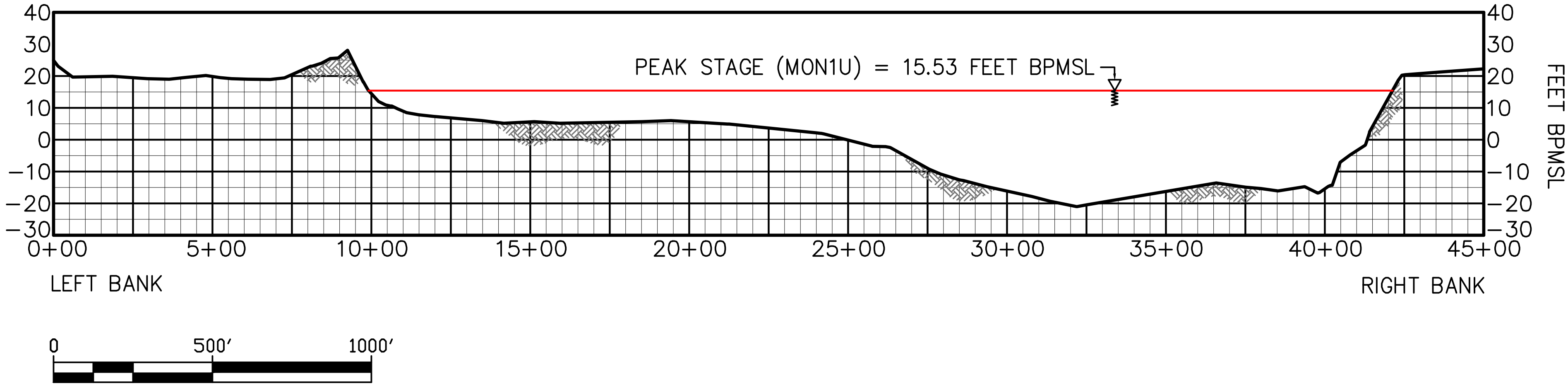
2018 SPRING BREAKUP
MONUMENT 1 CENTERLINE
PROFILE

(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:	10/30/2018	PROJECT:	166417
DRAWN:	DTR	FILE:	MON1 X-SECTIONS.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2018 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:	10/30/2018	Project:	166417
Drawn:	BTG	File:	2018_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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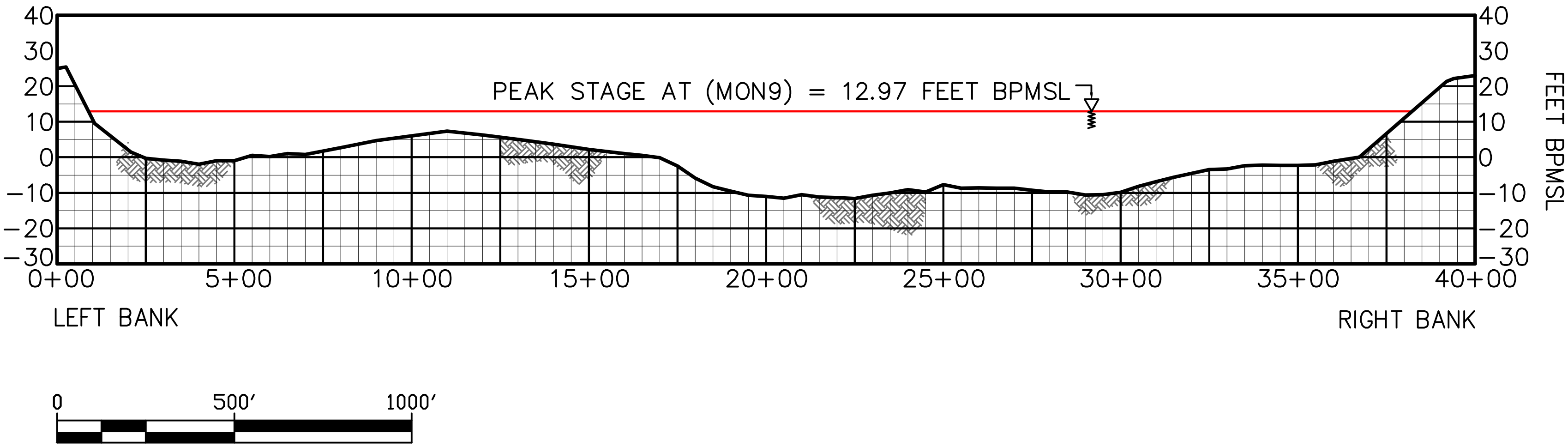
2018 SPRING BREAKUP
Monument 9 / HDD
PLAN

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:	10/10/2018	PROJECT:	166417
DRAWN:	DTR	FILE:	MON9 X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2018 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 4, 2018
Computed By: KDB
Checked By: WAB

Location Name: Nigliq Bridge

Party: SME, GCY, MDM, KDB   Start: 6/4/2018 12:55   Finish: 6/4/2018 16:40

Temp: 31 °F   Weather: CLOUDY/ PARTY CLOUDY

Channel Characteristics:

Width: 750 ft   Area: 15674 sq ft   Velocity: 2.03 fps   Discharge: 31795 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

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
G26	6.01	5.77	0.24
G27	5.97	5.7	0.27

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:

Flow:

Remarks:

Nigliq Bridge
June 4, 2018

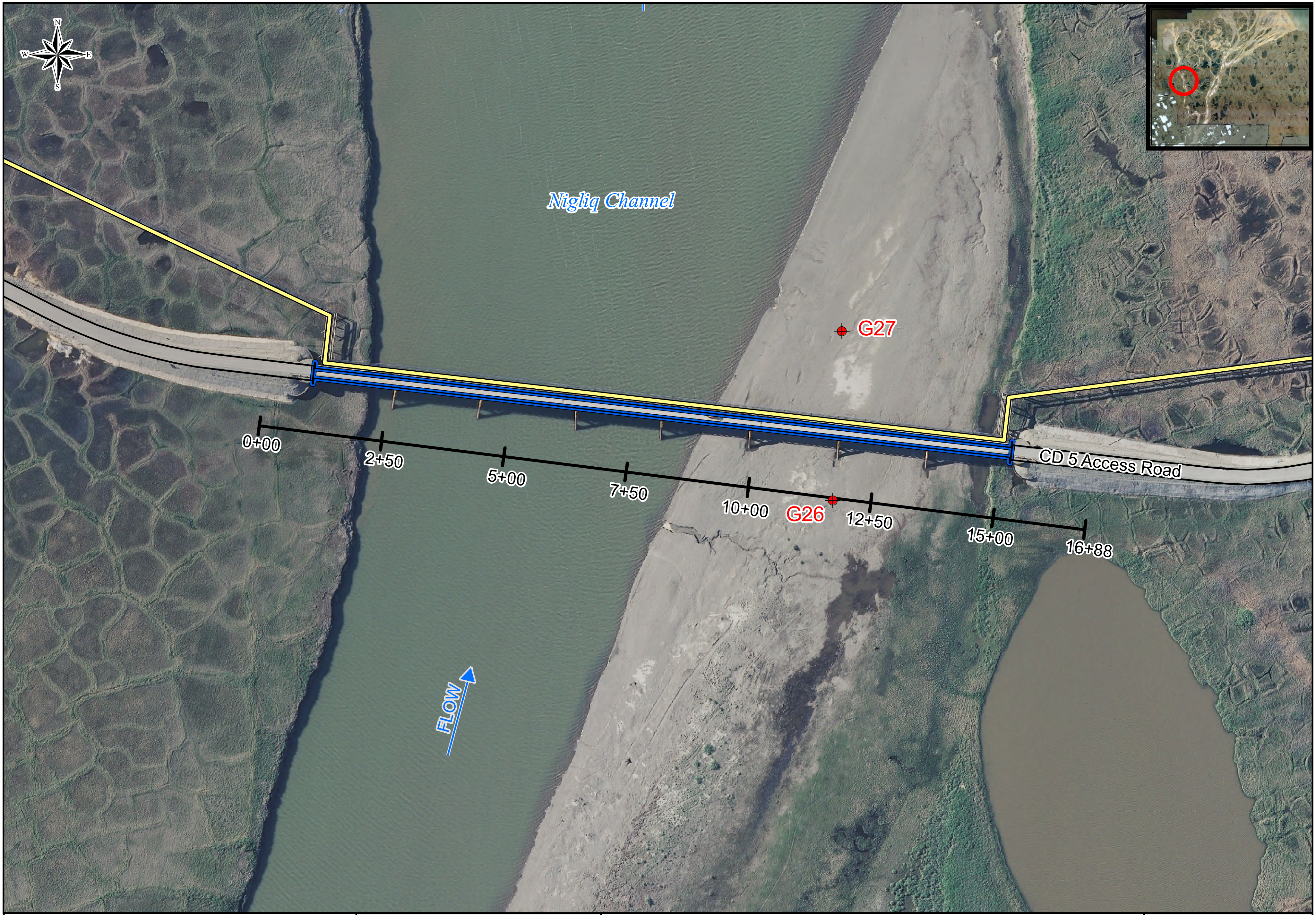
Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	VELOCITY At Point (fps)	VELOCITY Mean in Vertical (fps)	VELOCITY Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
	120										
1	120	10.0	5.5	4.4 1.1	6 7	46 45	0.31 0.36	0.33	0.33	55.0	18.32
0.9	140	20.0	6.9	5.5 1.4	15 20	53 41	0.64 1.09	0.87	0.78	138.0	107.75
1	160	15.0	22.4	17.9 4.5	25 35	48 46	1.17 1.70	1.43	1.43	336.0	480.73
1	170	15.0	23.8	19 4.8	30 40	47 47	1.43 1.89	1.66	1.66	357.0	592.50
1	190	20.0	26.3	21 5.3	50 60	48 49	2.31 2.72	2.52	2.52	526.0	1323.42
1	210	20.0	27.6	22.1 5.5	50 60	48 47	2.31 2.83	2.57	2.57	552.0	1420.55
1	230	20.0	28.8	23 5.8	40 50	41 41	2.17 2.71	2.44	2.44	576.0	1404.12
1	250	20.0	29.6	23.7 5.9	50 60	45 44	2.47 3.02	2.75	2.75	592.0	1625.61
1	270	20.0	29.3	23.4 5.9	50 60	49 42	2.27 3.17	2.72	2.72	586.0	1592.49
1	290	20.0	29.1	23.3 5.8	50 60	49 49	2.27 2.72	2.49	2.49	582.0	1450.68
1	310	20.0	27.9	22.3 5.6	50 60	47 47	2.36 2.83	2.60	2.60	558.0	1449.62
1	330	20.0	28.7	23 5.7	50 60	48 46	2.31 2.89	2.60	2.60	574.0	1494.72
1	350	20.0	27.3	21.8 5.5	40 50	41 44	2.17 2.52	2.35	2.35	546.0	1280.94
1	370	20.0	25.6	20.5 5.1	40 60	41 44	2.17 3.02	2.60	2.60	512.0	1329.45
1	390	20.0	25.2	20.2 5	50 60	49 48	2.27 2.77	2.52	2.52	504.0	1270.43
1	410	20.0	25.0	20 5	40 60	40 45	2.22 2.96	2.59	2.59	500.0	1295.03
1	430	20.0	24.9	19.9 5	50 60	49 47	2.27 2.83	2.55	2.55	498.0	1269.91
1	450	20.0	24.3	19.4 4.9	50 50	47 48	2.36 2.31	2.34	2.34	486.0	1136.71
1	470	20.0	25.1	20.1 5	40 60	42 47	2.12 2.83	2.48	2.48	502.0	1242.46
1	490	20.0	25.5	20.4 5.1	40 60	42 46	2.12 2.89	2.51	2.51	510.0	1277.87
1	510	20.0	25.8	20.6 5.2	50 50	47 40	2.36 2.77	2.57	2.57	516.0	1325.38
1	530	20.0	30.6	24.5 6.1	50 40	47 42	2.36 2.12	2.24	2.24	612.0	1371.17
1	550	20.0	30.8	24.6 6.2	30 40	50 45	1.34 1.98	1.66	1.66	616.0	1022.04
1	570	20.0	24.8	19.8 5	40 50	41 47	2.17 2.36	2.27	2.27	496.0	1123.97
1	590	25.0	21.2	17 4.2	40 40	44 43	2.02 2.07	2.05	2.05	530.0	1084.10
1	620	30.0	18.3	14.6 3.7	40 40	49 46	1.82 1.94	1.88	1.88	549.0	1030.10
1	650	30.0	16.9	13.5 3.4	25 30	42 40	1.33 1.67	1.50	1.50	507.0	760.90
1	680	35.0	20.0	16 4	20 20	51 43	0.88 1.04	0.96	0.96	700.0	674.00
1	720	30.0	25.5	20.4 5.1	7 3	54 55	0.30 0.14	0.22	0.22	765.0	168.94
1	740	25.0	19.7	15.8 3.9	5 5	57 69	0.21 0.18	0.19	0.19	492.5	95.74
1	770	40.0	5.0	4 1	10 7	52 53	0.44 0.31	0.38	0.38	200.0	75.08
1	820	50.0	3.5	2.1	0	0	0.00	0.00	0.00	175.0	0.00
1	870	25.0	1.0	0.0	0.0	0.0	0.00			25.0	0.00

Highest depth averaged velocity 2.75
Average Velocity: 1.90 Total Discharge: 31794.72 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 G28. The channel roughness values used were calibrated from the measured discharge. Manning's n values used were 0.095 for the left overbank, 0.06 for the right overbank, and 0.036 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



ConocoPhillips
Alaska

Feet
0 125 250

Date: 10/30/2018	Project: 166417
Drawn: BTG	File: 2018_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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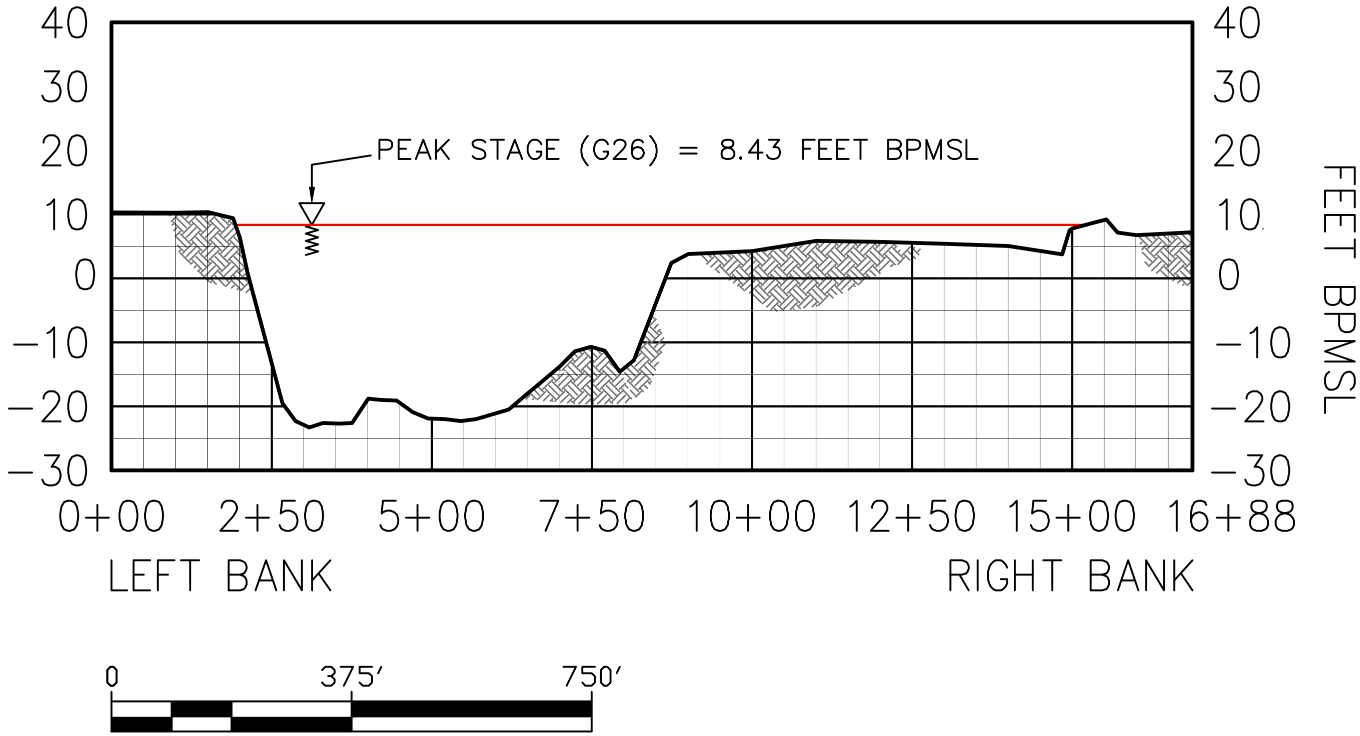
2018 SPRING BREAKUP
NIGLIQ CHANNEL
TRANSECT 10 PLAN

(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:	10/30/2018	PROJECT:	166417
DRAWN:	DTR	FILE:	NIGLIQ X-SECTION.DWG
CHECKED:	GCY	SCALE:	AS SHOWN

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2018 SPRING BREAKUP
NIGLIQ CHANNEL
TRANSECT 10 PROFILE

(SHEET 2 OF 2)

C.2.4 NIGLIAGVIK BRIDGE

1) MEASURED DISCHARGE

Discharge was not measured at the Nigliagvik Bridge as floodwaters were not observed at gages G38/G39.

2) PEAK DISCHARGE DATA

Peak discharge was not calculated at the Nigliagvik Bridge as floodwaters were not observed at gages G38/G39.

3) PLAN & PROFILE

ConocoPhillips Alaska

Feet
0 125 250

Date: 10/30/2018
Project: 166417
Drawn: BTG
File: 2018_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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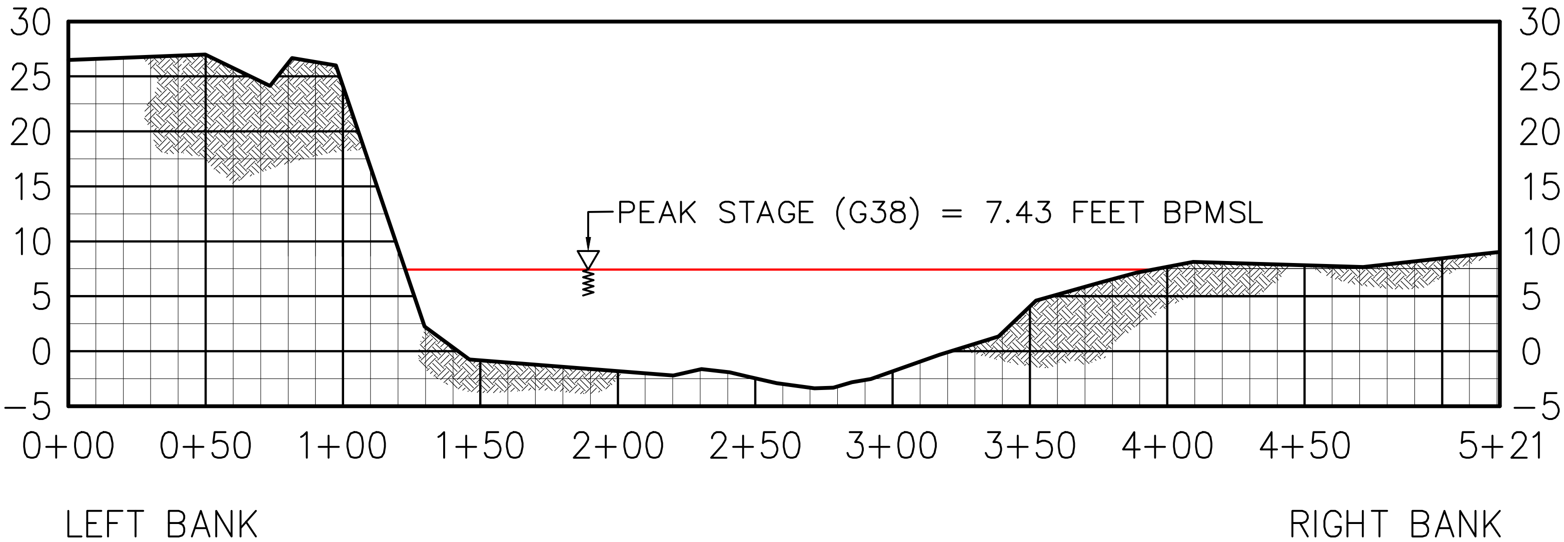
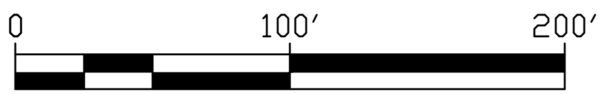
2018 SPRING BREAKUP
NIGLIAGVIK CHANNEL
TRANSECT 27 PLAN

(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: 10/30/2018	PROJECT: 166417
DRAWN: DTR	FILE: NIGLIAGVIK X-SECTION.DWG
CHECKED: GCY	SCALE: AS SHOWN

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2018 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 3, 2018
Computed By: KDB
Checked By: WAB

Location Name: Long Swale Bridge

Party: GCY, SME, KAO   Start: 6/3/2018 10:20   Finish: 6/3/2018 13:15

Temp: 26 °F   Weather: Foggy/Overcast

Channel Characteristics:

Width: 430.5 ft   Area: 2090 sq ft   Velocity: 1.50 fps   Discharge: 3143 cfs

Method: Number of Sections: Count:

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

GAGE READINGS			
Gage	Start	Finish	Change
G3	7.05	6.87	-0.18
G4	6.89	6.75	-0.14

Meter: 0.6 ft above bottom of weight

Weight: 30 lbs

Wading **Cable** Ice Boat

Upstream or Downstream **side of bridge**

GPS Data: W Bridge Abutment
Left Edge of Water: STN 00+15
Right Edge of Water: STN 04+45

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

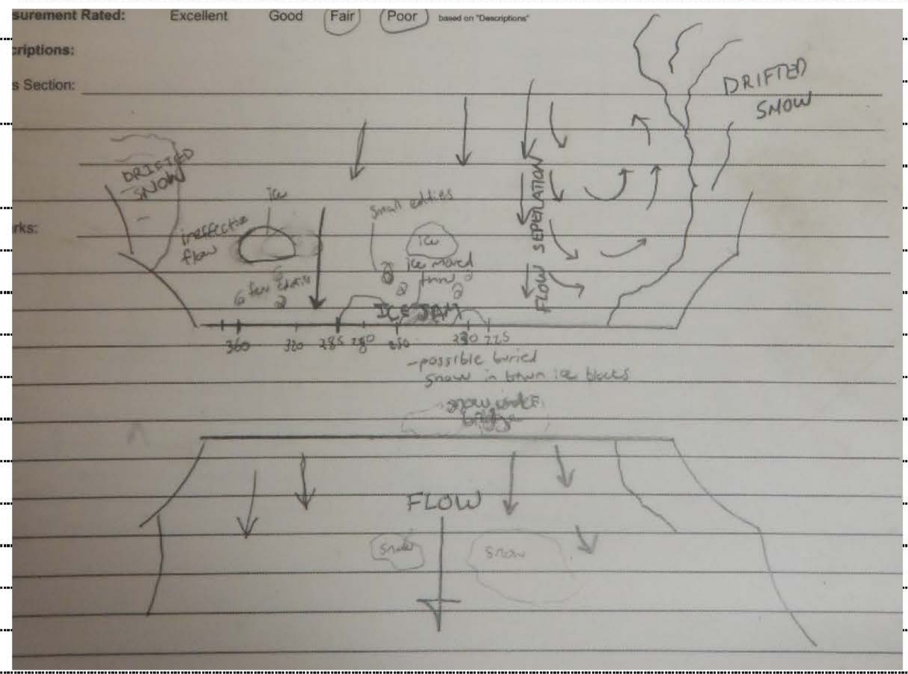
Measurement Rated: Excellent Good Fair **Poor** based on "Descriptions"

Descriptions:

Cross Section:

Flow:

Remarks:



Long Swale Bridge
June 3, 2018

							VELOCITY				
Angle Coeff	Distance from initial point (ft)	Section Width (ft)	Water Depth (ft)	Observed Depth (ft)	Revolution Count	Time Increment (sec)	At Point (fps)	Mean in Vertical (fps)	Adjusted for Angle Coeff (fps)	Area (s.f.)	Discharge (cfs)
1	15		0.0								
1	16	3.0	1.7	1.4	7	51	0.32	0.32	0.32	5.1	1.63
0.99	20	7.0	2.0	1.6	7	42	0.39	0.39	0.38	14.0	5.34
0.9	30	10.0	2.4	1.8	3	90	0.09	0.09	0.08	24.0	1.97
0.9	40	10.0	2.2	1.7	0	0				22.0	0.00
0.7	50	10.0	3.2	1.9	7	93	0.18	0.18	0.13	32.0	4.12
0.5	60	10.0	4.0	2.4	15	61	0.56	0.56	0.28	40.0	11.20
0.99	70	7.5	3.5	2.1	40	45	1.98	1.98	1.96	26.3	51.39
0.99	75	5.0	3.4	2	50	43	2.58	2.58	2.56	17.0	43.45
1	80	5.0	3.5	2.1	60	48	2.77	2.77	2.77	17.5	48.54
1	85	5.0	4.2	3.4 0.8	50 50	47 41	2.36 2.71	2.53	2.53	21.0	53.23
1	90	7.5	4.2	3.4 0.8	40 60	42 45	2.12 2.96	2.54	2.54	31.5	79.93
1	100	10.0	3.6	2.2	50	41	2.71	2.71	2.71	36.0	97.44
1	110	15.0	3.4	2	50	46	2.41	2.41	2.41	51.0	123.13
1	130	20.0	3.5	2.1	40	43	2.07	2.07	2.07	70.0	144.81
1	150	20.0	4.7	3.8 0.9	30 40	43 42	1.56 2.12	1.84	1.84	94.0	172.66
1	170	20.0	4.1	3.3 0.8	25 40	41 44	1.36 2.02	1.69	1.69	82.0	138.76
1	190	20.0	4.1	3.3 0.8	30 40	48 42	1.40 2.12	1.76	1.76	82.0	144.05
1	210	21.0	5.3	4.2 1	20 40	54 41	0.83 2.17	1.50	1.50	111.3	167.13
1	232	15.0	6.3	5 1.3	50 70	41 47	2.71 3.30	3.00	3.00	94.5	283.88
0.75	240	9.0	13.1	10.5 2.6	7 50	97 48	0.18 2.31	1.25	0.93	117.9	110.15
0.7	250	10.0	14.3	11.4 2.9	20 22	47 44	0.96 1.12	1.04	0.73	143.0	103.91
0.8	260	20.0	7.4	5.9 1.5	25 15	41 44	1.36 0.77	1.07	0.85	148.0	126.19
0.98	290	25.0	5.6	4.5 1.1	30 50	47 47	1.43 2.36	1.89	1.86	140.0	259.89
0.96	310	15.0	5.0	4 1	40 60	40 46	2.22 2.89	2.56	2.46	75.0	184.18
0.92	320	10.0	5.0	4 1	40 60	44 45	2.02 2.96	2.49	2.29	50.0	114.53
0.96	330	10.0	4.7	3.8 0.9	50 60	44 45	2.52 2.96	2.74	2.63	47.0	123.65
0.96	340	10.0	4.1	3.3 0.8	50 40	54 44	2.06 2.02	2.04	1.96	41.0	80.32
0.75	350	10.0	4.2	3.4 0.8	30 20	42 45	1.59 1.00	1.30	0.97	42.0	40.80
0.6	360	10.0	5.5	4.4 1.1	10 10	45 46	0.51 0.50	0.50	0.30	55.0	16.58
1	370	10.0	5.5	4.4 1.1	15 25	45 54	0.75 1.04	0.90	0.90	55.0	49.26
1	380	15.0	4.6	3.7 0.9	25 30	43 47	1.30 1.43	1.36	1.36	69.0	94.00
0.99	400	20.0	5.2	4.2 1	20 30	47 42	0.96 1.59	1.27	1.26	104.0	131.21
0.98	420	15.0	4.3	3.4 0.9	20 30	49 43	0.92 1.56	1.24	1.21	64.5	78.18
1	430	7.5	3.6	2.2	25	48	1.17	1.17	1.17	27.0	31.49
0.99	435	5.0	3.4	2	20	40	1.12	1.12	1.11	17.0	18.85
0.98	440	5.0	3.0	1.8	7	42	0.39	0.39	0.38	15.0	5.66
1	445	3.0	2.7	1.6	5.0	64.0	0.19	0.19	0.19	8.1	1.54
	446										

Total Discharge: 3143.08 cfs

ConocoPhillips Alaska
Michael Baker INTERNATIONAL

C.2.6 SHORT SWALE BRIDGE

1) MEASURED DISCHARGE

	Date:	6/3/2018				**Time:**	4:22 PM	**Method:**	USGS cross section
	Location:	Short Swale Bridge				**Crew:**	GCY, SME, KAO	**Observed Depth:**	Water Surface
	Lat:	N 70.3402				**Long:**	W 150.9847	**Equipment:**	HACH METER
Station (ft)	**Depth**	**Channel bottom elvation(ft BPMSL)**	V1	V2	V3	**Average Velocity (ft/s)**	**Section Width (ft)**	**Area (ft^2)**	**Discharge (ft^3/s)**
0+11.0	0	6.63	0	0	0	0.00	-	-	-
0+13.0	0.6	6.03	0	-0.04	-0.04	-0.03	2	1.20	-0.03
0+15.0	0.5	6.13	-0.05	-0.06	-0.06	-0.06	2	1.00	-0.06
0+17.0	0.8	5.83	-0.05	-0.05	-0.06	-0.05	2	1.60	-0.09
0+19.0	0.9	5.73	0.02	0.01	0.02	0.02	2	1.80	0.03
0+21.0	1	5.63	0.06	0.05	0.06	0.06	1.5	1.50	0.09
0+22.0	1	5.63	0.07	0.06	0.07	0.07	1	1.00	0.07
0+23.0	1	5.63	0.32	0.38	0.28	0.33	1	1.00	0.33
0+24.0	1.1	5.53	0.71	0.87	0.94	0.84	1	1.10	0.92
0+25.0	1.2	5.43	0.81	0.82	0.8	0.81	1	1.20	0.97
0+26.0	1.2	5.43	0.77	0.76	0.87	0.80	1	1.20	0.96
0+27.0	1.3	5.33	0.65	0.59	0.58	0.61	1	1.30	0.79
0+28.0	1.3	5.33	0.59	0.66	0.61	0.62	1	1.30	0.81
0+29.0	1.2	5.43	0.44	0.47	0.42	0.44	1	1.20	0.53
0+30.0	1.1	5.53	0.26	0.19	0.17	0.21	1	1.10	0.23
0+31.0	1	5.63	0.03	0.03	0.05	0.04	1	1.00	0.04
0+32.0	1.0	5.63	0.03	0.01	0.01	0.02	1.5	1.50	0.03
0+34.0	1	5.63	-0.02	-0.03	-0.01	-0.02	2	2.00	-0.04
0+36.0	1	5.63	-0.01	-0.01	0	-0.01	2	2.00	-0.01
0+38.0	1	5.63	-0.03	-0.02	-0.01	-0.02	3	3.00	-0.06
0+42.0	0.8	5.83	-0.07	-0.01	-0.01	-0.03	4	3.20	-0.10
0+46.0	0.5	6.13	0	-0.02	-0.01	-0.01	2.5	1.25	-0.01
0+47.0	0	6.63							
Notes:									
1. Measurement performed downstream of Crea Bridge.									
Total Width (ft)	**Average Depth (ft)**					**Average Velocity (ft/s)**	-	**Total Area (ft^2)**	**Total Discharge (ft^3/s)**
36.0	1.0					0.22	-	31.5	5.4

C.2.7 CULVERTS

1) MEASURED DISCHARGE

Date	Time	Culvert ID	Flow Conditions	Flow Direction	Total Depth (ft)	Measured Depth (ft)	v1 (ft/s)	v2 (ft/s)	v3 (ft/s)	Upstream Gage	Upstream WSE (ft BPMSL)	Downstream Gage	Downstream WSE (ft BPMSL)	Notes
6/2/2018	08:30	CD2-22	Flowing	South to North	2.0	0.80	0.32	0.31	0.30	G3	7.21	G4	7.20	
6/3/2018	17:27	CD2-20	Flowing	North to South	0.8	0.32	-0.36	-0.38	-0.37	G3	6.53	G4	6.47	Hydraulic connection may not have been established through culvert at the time of measurement
6/3/2018	17:20	CD2-21	Flowing	South to North	1.3	0.52	0.90	0.88	0.90	G3	6.56	G4	6.46	
6/3/2018	17:37	CD2-22	Flowing	South to North	1.2	0.48	2.04	2.03	2.04	G6	6.53	G7	6.47	

Note: Any culvert not listed was observed to either be stagnant or dry at the time of the discharge measurements (June 2 or June 3).

2) PEAK DISCHARGE

Culvert Calculator Report
CD2-20 Peak Differential

Solve For: Discharge

Culvert Summary			
Allowable HW Elevation	7.14 ft	Headwater Depth/Height	0.28
Computed Headwater Elevation	7.13 ft	Discharge	5.37 cfs
Inlet Control HW Elev.	6.94 ft	Tailwater Elevation	6.89 ft
Outlet Control HW Elev.	7.13 ft	Control Type	Outlet Control

Grades			
Upstream Invert	6.03 ft	Downstream Invert	5.97 ft
Length	72.80 ft	Constructed Slope	0.000824 ft/ft

Hydraulic Profile			
Profile	M2	Depth, Downstream	0.92 ft
Slope Type	Mild	Normal Depth	0.97 ft
Flow Regime	Subcritical	Critical Depth	0.67 ft
Velocity Downstream	2.48 ft/s	Critical Slope	0.003739 ft/ft

Section			
Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties			
Outlet Control HW Elev.	7.13 ft	Upstream Velocity Head	0.09 ft
Ke	0.90	Entrance Loss	0.08 ft

Inlet Control Properties			
Inlet Control HW Elev.	6.94 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1

Title: 2018 CRD Spring Breakup
..\culvert master files\2018 crd culverts.cvm
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Anchorage Office

Project Engineer: K Braun
CulvertMaster v3.3 [03.03.00.04]
Page 1 of 2

Culvert Calculator Report
CD2-21 Peak Differential

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	7.14 ft	Headwater Depth/Height	0.46
Computed Headwater Elevation	7.14 ft	Discharge	12.84 cfs
Inlet Control HW Elev.	6.89 ft	Tailwater Elevation	6.89 ft
Outlet Control HW Elev.	7.14 ft	Control Type	Outlet Control

Grades

Upstream Invert	5.30 ft	Downstream Invert	5.20 ft
Length	76.70 ft	Constructed Slope	0.001304 ft/ft

Hydraulic Profile

Profile	M1	Depth, Downstream	1.68 ft
Slope Type	Mild	Normal Depth	1.36 ft
Flow Regime	Subcritical	Critical Depth	1.05 ft
Velocity Downstream	2.55 ft/s	Critical Slope	0.003551 ft/ft

Section

Section Shape	Circular	Mannings Coefficient	0.013
Section Material	Steel	Span	4.00 ft
Section Size	48 inch	Rise	4.00 ft
Number Sections	1		

Outlet Control Properties

Outlet Control HW Elev.	7.14 ft	Upstream Velocity Head	0.11 ft
Ke	0.90	Entrance Loss	0.10 ft

Inlet Control Properties

Inlet Control HW Elev.	6.89 ft	Flow Control	Unsubmerged
Inlet Type	Projecting	Area Full	12.6 ft²
K	0.03400	HDS 5 Chart	2
M	1.50000	HDS 5 Scale	3
C	0.05530	Equation Form	1

Title: 2018 CRD Spring Breakup
..\culvert master files\2018 crd culverts.cvm
10/29/18 02:32:10 PM
Anchorage Office

Project Engineer: K Braun
CulvertMaster v3.3 [03.03.00.04]
Page 1 of 2

Culvert Calculator Report
CD2-22 Peak Differential

Solve For: Discharge

Culvert Summary

Allowable HW Elevation	7.14	ft	Headwater Depth/Height	0.48	
Computed Headwater Elevation	7.13	ft	Discharge	13.24	cfs
Inlet Control HW Elev.	6.89	ft	Tailwater Elevation	6.89	ft
Outlet Control HW Elev.	7.13	ft	Control Type	Outlet Control	

Grades

Upstream Invert	5.21	ft	Downstream Invert	5.15	ft
Length	72.80	ft	Constructed Slope	0.000549	ft/ft

Hydraulic Profile

Profile	M2		Depth, Downstream	1.73	ft
Slope Type	Mild		Normal Depth	1.74	ft
Flow Regime	Subcritical		Critical Depth	1.06	ft
Velocity Downstream	2.53	ft/s	Critical Slope	0.003548	ft/ft

Section

Section Shape	Circular		Mannings Coefficient	0.013	
Section Material	Steel		Span	4.00	ft
Section Size	48 inch		Rise	4.00	ft
Number Sections	1				

Outlet Control Properties

Outlet Control HW Elev.	7.13	ft	Upstream Velocity Head	0.10	ft
Ke	0.90		Entrance Loss	0.09	ft

Inlet Control Properties

Inlet Control HW Elev.	6.89	ft	Flow Control	Unsubmerged	
Inlet Type	Projecting		Area Full	12.6	ft²
K	0.03400		HDS 5 Chart	2	
M	1.50000		HDS 5 Scale	3	
C	0.05530		Equation Form	1	
Y	0.54000				

APPENDIX D ADDITIONAL PHOTOGRAPHS

D.1 EROSION SURVEY

D.1.1 CD2 & CD4 ROADS & PADS

Photo D.1: CD2 road at the Long Swale Bridge post breakup, looking west; June 18, 2018

Photo D.2: CD4 road near the CD4 Pad, looking west; June 8, 2018

D.1.2 CD5 ROAD

Photo D.3: CD5 road between Lake L9341 and the Nigliagvik Channel, looking southwest; June 17, 2018

Photo D.4: Culverts along the CD5 road, looking south; June 5, 2018

Photo D.5: Culverts along the CD5 road, looking south; June 5, 2018

D.2 ICE ROAD CROSSINGS BREAKUP

Photo D.6: Colville River East Channel at HDD pre-breakup, looking east; May 20, 2018

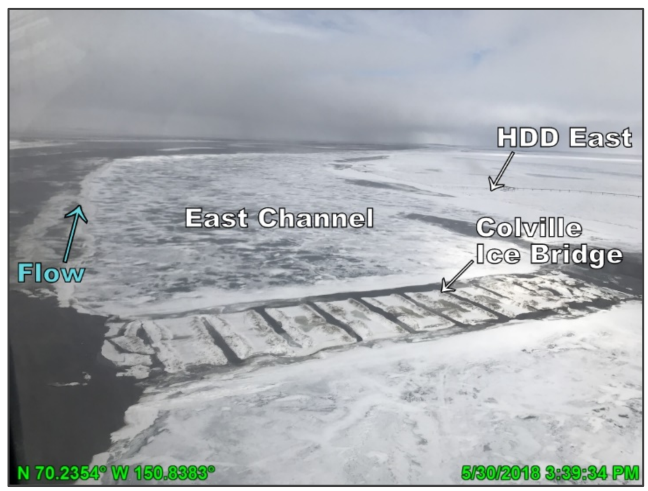


Photo D.7: Colville River East Channel at HDD during breakup, looking north; May 30, 2018

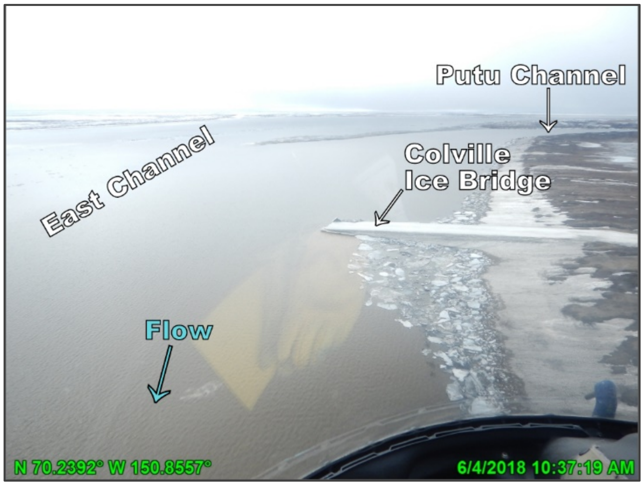


Photo D.8: Colville River East Channel at HDD post-breakup, looking south, June 4, 2018

Photo D.9: Kachemach River during breakup, looking north; June 9, 2018

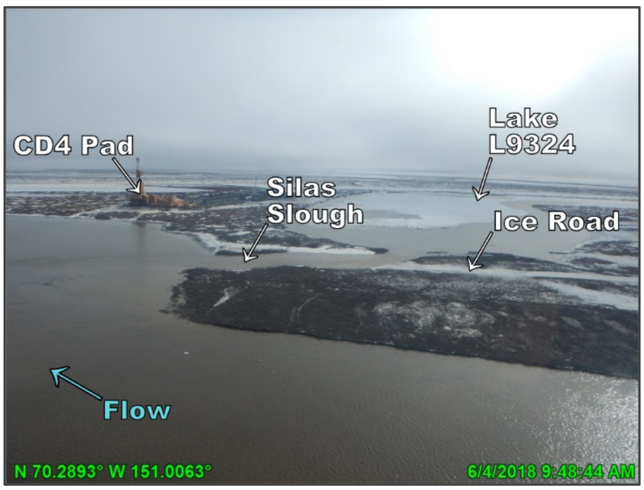


Photo D.10: Silas Slough during breakup, looking east; June 4, 2018

Photo D.11: Silas Slough during breakup, looking south; June 8, 2018

Photo D.12: Toolbox Creek ice road crossing pre-breakup, looking south; May 29, 2018

Photo D.13: Toolbox Creek post-breakup, looking east; June 8, 2018

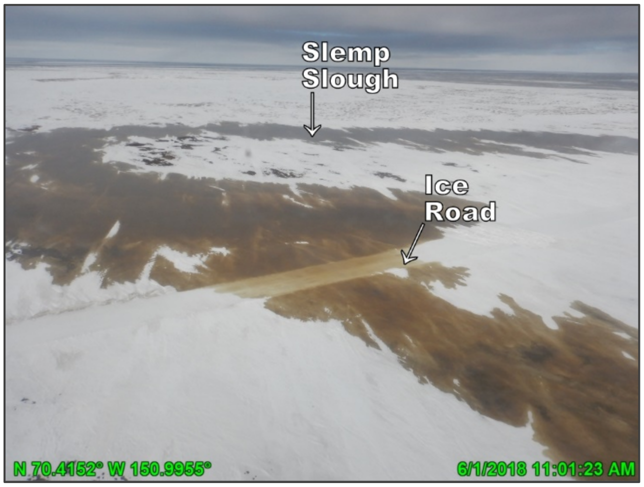


Photo D.14: Slemp Slough pre-breakup, looking northwest; June 1, 2018

Photo D.15: Slemp Slough post-breakup, looking southwest; June 8, 2018

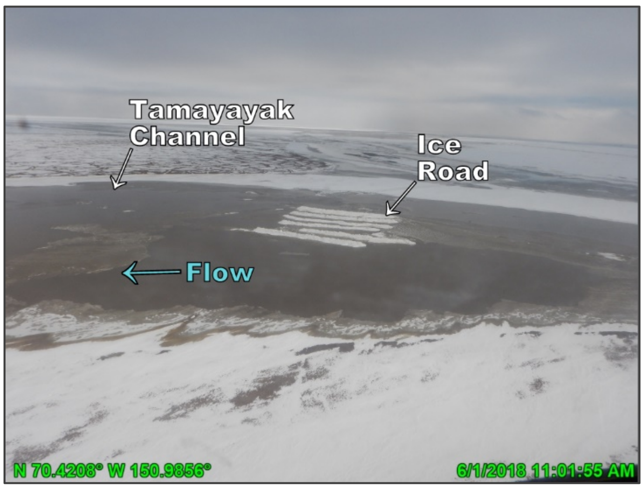


Photo D.16: Tamayayak Channel during breakup, looking west, June 1, 2018

Photo D.17: Tamayayak Channel during breakup, looking northwest; June 8, 2018

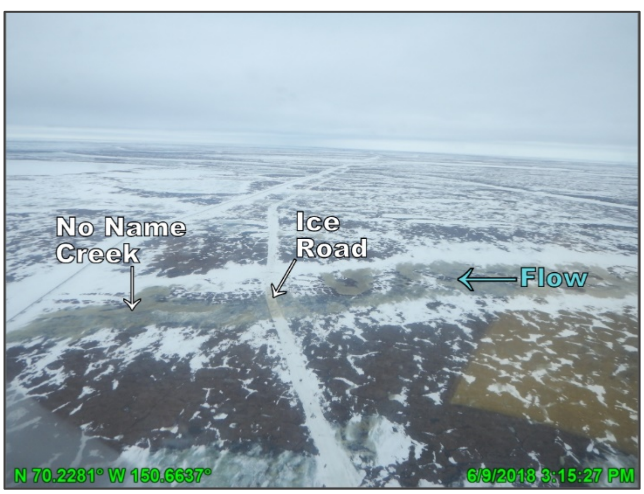


Photo D.18: No Name Creek pre-breakup, looking east; June 4, 2018

Photo D.19: No Name Creek post-breakup, looking northwest; June 15, 2018

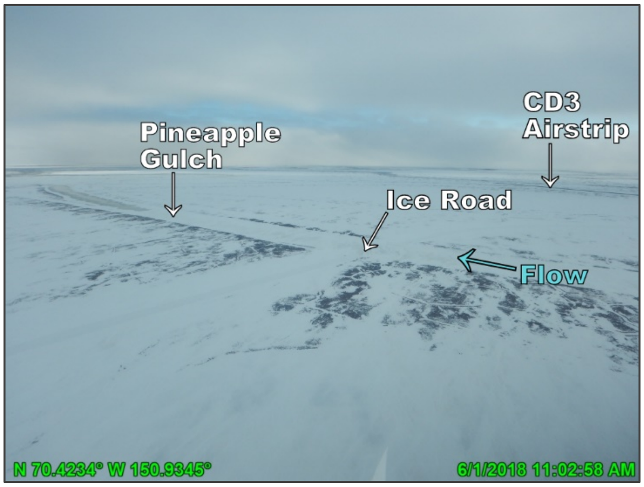


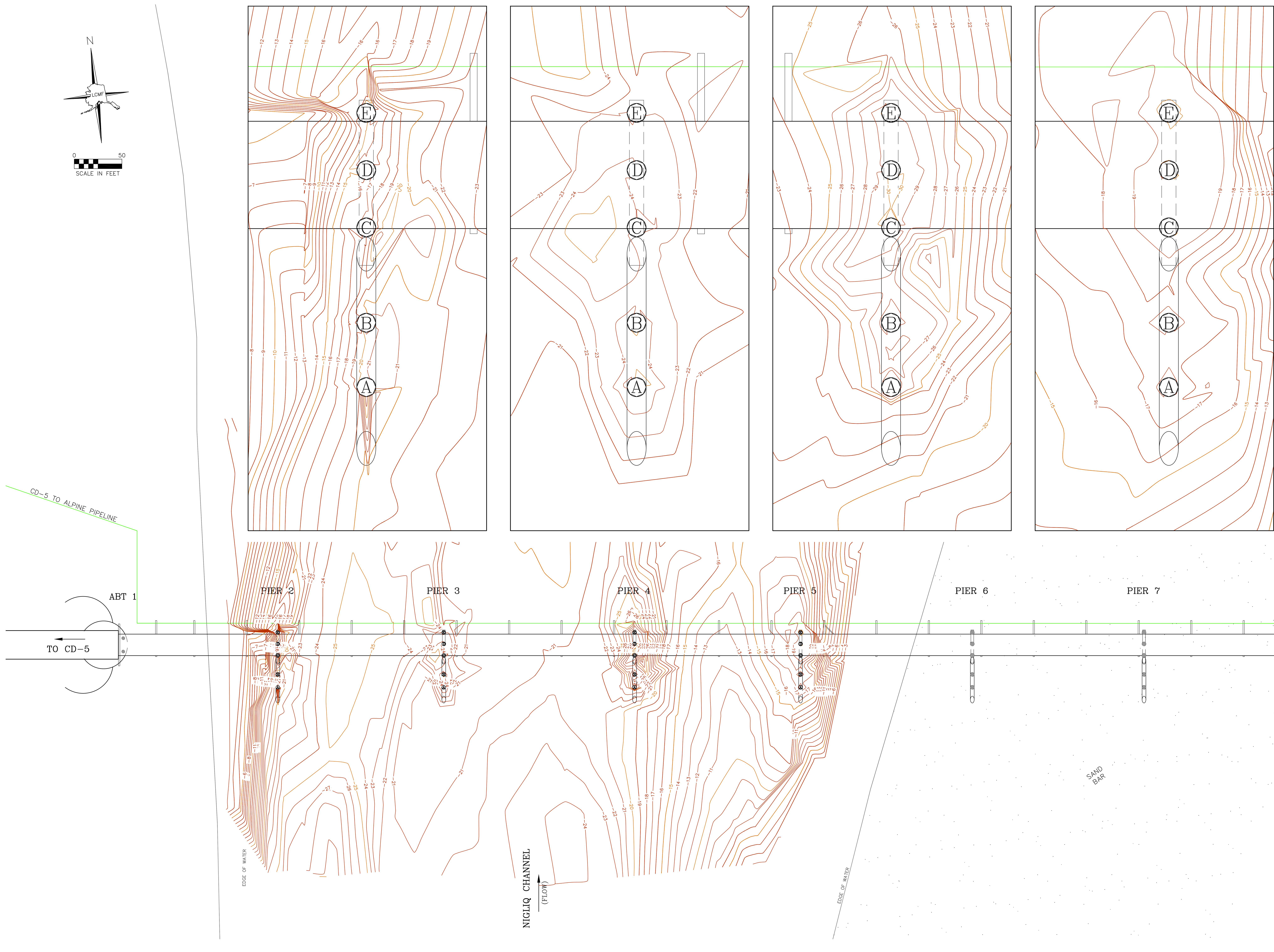
Photo D.20: Pineapple Gulch pre-breakup, looking east; June 1, 2018

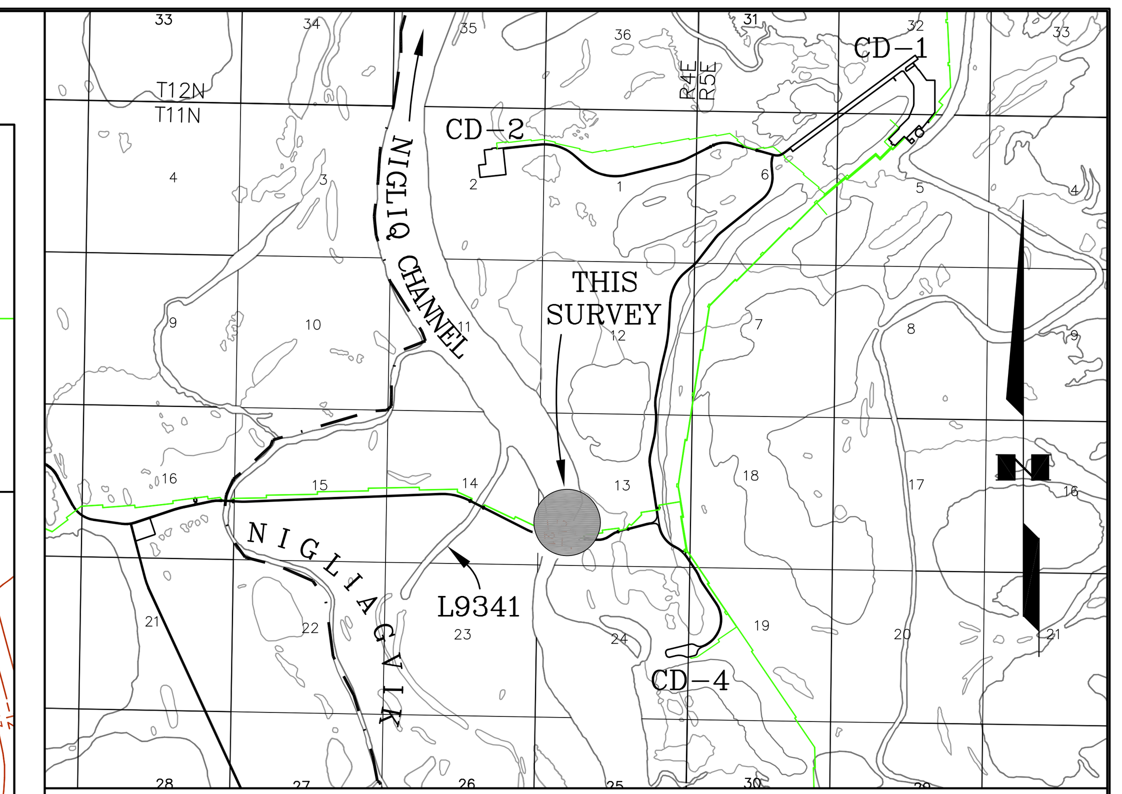
Photo D.21: Pineapple Gulch during breakup, looking northwest; June 8, 2018

APPENDIX E CD5 PIER SCOUR, BANK EROSION, & BATHYMETRY

E.1 PIER SCOUR

E.1.1 NIGLIQ BRIDGE





VICINITY MAP

NOTES:

1. DATES OF SURVEY: AUGUST 22, 2018.
2. REFERENCE FIELD BOOK: 2018-17, PGS. 57.
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:
1' CONTOUR
5' CONTOUR

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

ConocoPhillips
Alaska, Inc.

ALPINE — MODULE: CD50 — UNIT: CD

CD-5 ACCESS ROAD
NIGLIQ BRIDGE
SCOUR MONITORING

REDRAWN FROM: — CONSTRUCTION SHEET OF

DO NOT SCALE — ABOVE SCALE FOR REFERENCE ONLY

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
5	8/21/18	UPDATED PER K180003ACS	SZ	DB			
4	8/4/17	UPDATED PER K170003ACS	CZ	GD			
3	8/10/16	UPDATED PER K160003ACS	TRB	DB			
2	8/30/15	UPDATED PER 20968257ACS	TB	DB			
1	08/25/14	ISSUED PER K140003ACS	CZ	GD			

DATE: 08/23/14	DRAWN: CZ	DESIGN: GD	ECM NO: K140003ACS
	CHECKED: –		CC NO: –
SCALE: 1" = 50'	APPROVAL: –		CADD FILE NO. 14-08-12-1AW
JOB NO: – / SUB JOB NO: –	DRAWING NO: CE-CD50-1022		PART: 1 OF 1 / REV: 5

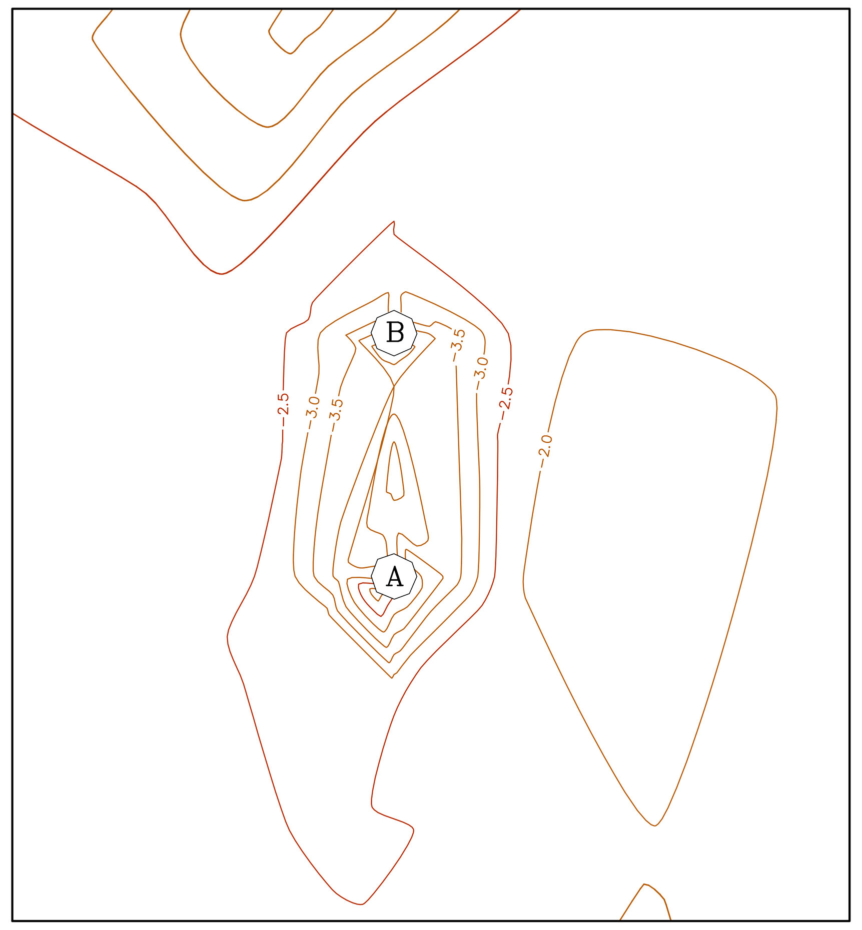
JOB NO: – SUB JOB NO: – DRAWING NO: CE-CD50-1022

FORM: DSIZE

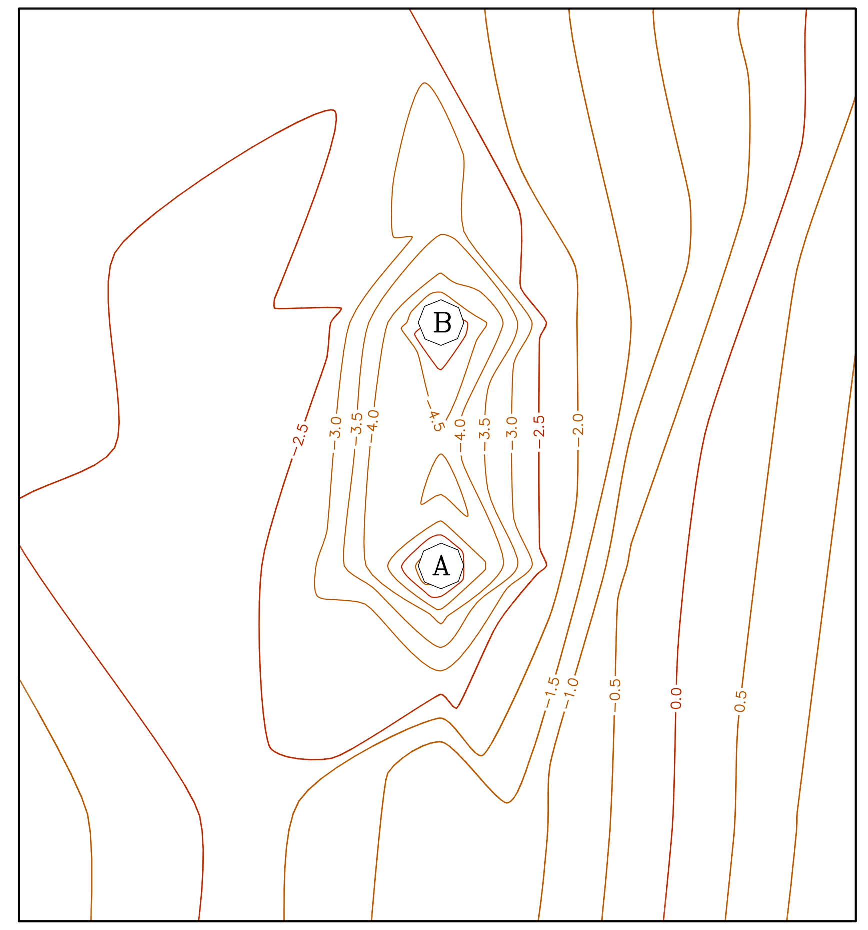
E.1.2 NIGLIAGVIK BRIDGE

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

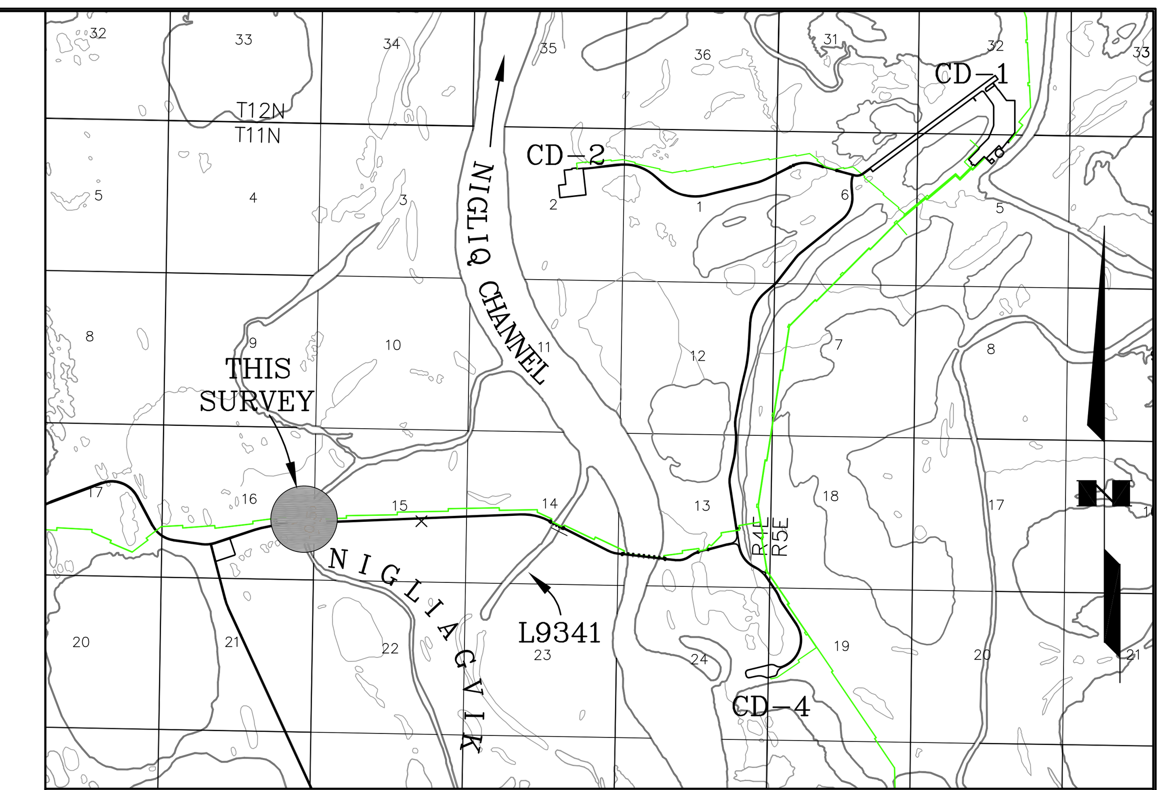
PIER 3
SCALE: 1" = 10'



PIER 4
SCALE: 1" = 10'



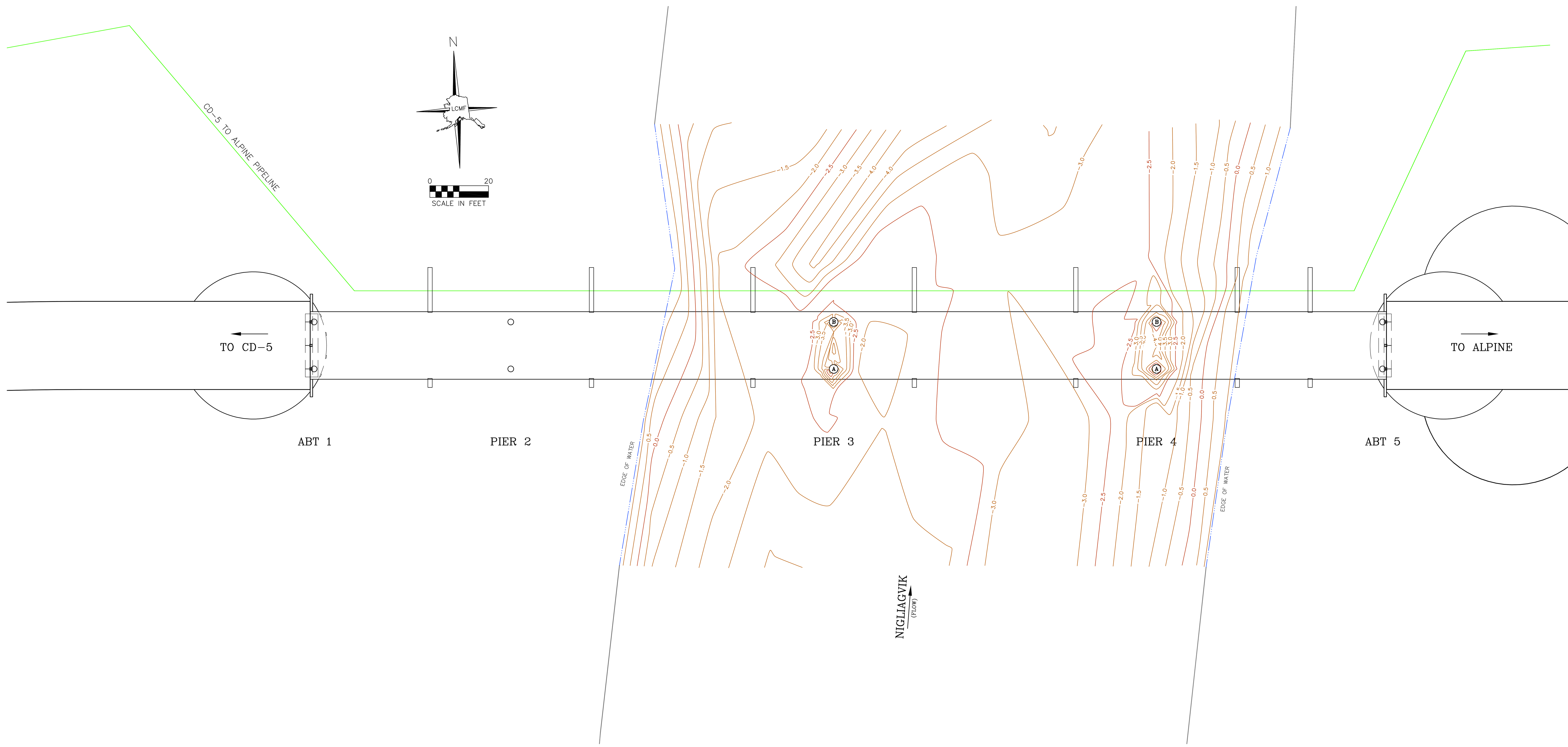
LEGEND:
0.5' CONTOUR
2.5' CONTOUR



VICINITY MAP

NOTES

1. DATE OF SURVEY: 8/11/18
2. REFERENCE FIELD BOOKS: 2018-13 PGS:13-15.
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: 5

FORM: DSIZE

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
5	08/12/18	UPDATED PER K180003ACS	RR	CZ			
4	9/21/17	UPDATER PER K170003ACS	RR	DB			
3	7/31/16	UPDATED PER K160003ACS	CZ	DB			
2	9/8/15	UPDATED PER 20968257ACS	CZ	DB			
1	08/25/14	ISSUED PER K140003ACS	CZ	GD			

E.2 BANK EROSION

E.2.1 NIGLIQ CHANNEL WEST & EAST BANK TABULATED DATA

Calc/d By: TB
Date: 08/25/2018
RPT-CE-CD-112 REV6

Alpine AP00
West Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV6

Baseline Station	West Bank Monitor - Top of Bank Locations						Description
	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	Date
0+00	180.2			153.6	147.0	147.0	Baseline Offset (In Feet)
				-26.6	-6.6	0.0	Incremental Change
				-26.6	-33.2	-33.2	Cumulative Change
1+00	191.0			168.5	168.5	164.8	Baseline Offset (In Feet)
				-22.5	0.0	-3.7	Incremental Change
				-22.5	-22.5	-26.2	Cumulative Change
2+00	193.1			184.4	181.6	177.7	Baseline Offset (In Feet)
				-8.7	-2.8	-3.9	Incremental Change
				-8.7	-11.5	-15.4	Cumulative Change
3+00	189.2			186.1	186.1	183.4	Baseline Offset (In Feet)
				-3.1	0.0	-2.7	Incremental Change
				-3.1	-3.1	-5.8	Cumulative Change
4+00	192.2			187.7	187.7	185.7	Baseline Offset (In Feet)
				-4.5	0.0	-2.0	Incremental Change
				-4.5	-4.5	-6.5	Cumulative Change
5+00	202.9			197.1	194.8	191.3	Baseline Offset (In Feet)
				-5.8	-2.3	-3.5	Incremental Change
				-5.8	-8.1	-11.6	Cumulative Change
6+00	224.0			207.8	203.8	203.8	Baseline Offset (In Feet)
				-16.2	-4.0	0.0	Incremental Change
				-16.2	-20.2	-20.2	Cumulative Change
7+00	228.9			209.3	206.0	202.7	Baseline Offset (In Feet)
				-19.6	-3.3	-3.3	Incremental Change
				-19.6	-22.9	-26.2	Cumulative Change
8+00	232.9			219.1	215.1	212.3	Baseline Offset (In Feet)
				-13.8	-4.0	-2.8	Incremental Change
				-13.8	-17.8	-20.6	Cumulative Change
9+00	220.0			217.9	217.9	217.9	Baseline Offset (In Feet)
				-2.1	0.0	0.0	Incremental Change
				-2.1	-2.1	-2.1	Cumulative Change

Calc/d By: TB
Date: 08/25/2018
RPT-CE-CD-112 REV6

Alpine AP00
West Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV6

Baseline Station	West Bank Monitor - Top of Bank Locations						Description
	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	Date
10+00	216.8	216.8	213.5	213.5	213.5	210.9	Baseline Offset (In Feet)
		0.0	-3.3	0.0	0.0	-2.6	Incremental Change
		0.0	-3.3	-3.3	-3.3	-5.9	Cumulative Change
11+00	209.1	209.1	204.9	204.8	204.8	204.8	Baseline Offset (In Feet)
		0.0	-4.2	-0.1	0.0	0.0	Incremental Change
		0.0	-4.2	-4.3	-4.3	-4.3	Cumulative Change
12+00	199.0	199.0	199.0	199.8	189.8	189.7	Baseline Offset (In Feet)
		0.0	0.0	0.8	-10.0	-0.1	Incremental Change
		0.0	0.0	0.8	-9.2	-9.3	Cumulative Change
13+00	192.1	192.1	192.1	192.1	188.3	188.3	Baseline Offset (In Feet)
		0.0	0.0	0.0	-3.8	0.0	Incremental Change
		0.0	0.0	0.0	-3.8	-3.8	Cumulative Change
14+00	200.9			198.8	193.7	193.7	Baseline Offset (In Feet)
				-2.1	-5.1	0.0	Incremental Change
				-2.1	-7.2	-7.2	Cumulative Change
15+00	190.0			190.0	186.2	186.2	Baseline Offset (In Feet)
				0.0	-3.8	0.0	Incremental Change
				0.0	-3.8	-3.8	Cumulative Change
16+00	211.0			209.5	203.3	203.3	Baseline Offset (In Feet)
				-1.5	-6.2	0.0	Incremental Change
				-1.5	-7.7	-7.7	Cumulative Change
17+00	204.0			204.0	202.9	200.6	Baseline Offset (In Feet)
				0.0	-1.1	-2.3	Incremental Change
				0.0	-1.1	-3.4	Cumulative Change
18+00	212.0			208.3	208.3	208.3	Baseline Offset (In Feet)
				-3.7	0.0	0.0	Incremental Change
				-3.7	-3.7	-3.7	Cumulative Change
19+00	221.9			221.9	221.9	221.9	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change

Doc LCMF-155 Nigliq Bank Monitor Rev6.xlsx 2 of 3 West Bank Monitor

Calc/d By: TB
Date: 08/25/2018
RPT-CE-CD-112 REV6

Alpine AP00
West Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
Doc.LCMF-155 REV6

Baseline Station	West Bank Monitor - Top of Bank Locations						Description
	8/21/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/24/2018	Date
20+00	232.9			232.9	232.9	232.9	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
21+00	233.9			227.5	227.5	227.5	Baseline Offset (In Feet)
				-6.4	0.0	0.0	Incremental Change
				-6.4	-6.4	-6.4	Cumulative Change
22+00	237.8			233.3	233.3	233.3	Baseline Offset (In Feet)
				-4.5	0.0	0.0	Incremental Change
				-4.5	-4.5	-4.5	Cumulative Change
23+00	237.9			233.0	233.0	233.0	Baseline Offset (In Feet)
				-4.9	0.0	0.0	Incremental Change
				-4.9	-4.9	-4.9	Cumulative Change
24+00	229.9			229.9	229.9	229.9	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
25+00	214.1			214.1	214.1	214.1	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
25+11	213.9			213.9	213.9	213.9	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change

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

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East Bank Nigliq
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
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Baseline Station	East Bank Monitor - Top of Bank Locations						Description
	8/22/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/25/2018	Date
0+00	169.9			169.9	169.9	169.9	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
1+00	174.0			174.0	174.0	174.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
2+00	178.9			178.9	178.9	178.9	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
3+00	191.0			191.0	191.0	191.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
4+00	188.0			188.0	188.0	188.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
5+00	196.1			196.1	196.1	196.1	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
6+00	201.1			201.1	201.1	201.1	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
7+00	208.1			208.1	208.2	208.2	Baseline Offset (In Feet)
				0.0	0.1	0.0	Incremental Change
				0.0	0.1	0.1	Cumulative Change
8+00	199.8			199.8	199.9	199.9	Baseline Offset (In Feet)
				0.0	0.1	0.0	Incremental Change
				0.0	0.1	0.1	Cumulative Change
9+00	406.2			406.2	406.0	406.0	Baseline Offset (In Feet)
				0.0	-0.2	0.0	Incremental Change
				0.0	-0.2	-0.2	Cumulative Change

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Baseline Station	East Bank Monitor - Top of Bank Locations						Description
	8/22/2013	8/24/2014	8/27/2015	7/6/2016	8/24/2017	8/25/2018	Date
10+00	280.9			280.7	280.6	280.6	Baseline Offset (In Feet)
				-0.2	-0.1	0.0	Incremental Change
				-0.2	-0.3	-0.3	Cumulative Change
11+00	192.2			192.0	192.0	192.0	Baseline Offset (In Feet)
				-0.2	0.0	0.0	Incremental Change
				-0.2	-0.2	-0.2	Cumulative Change
12+00	100.1			107.9	107.6	107.6	Baseline Offset (In Feet)
				7.8	-0.3	0.0	Incremental Change
				7.8	7.5	7.5	Cumulative Change
13+00	192.0	192.0	192.0	192.0	191.8	191.8	Baseline Offset (In Feet)
		0.0	0.0	0.0	-0.2	0.0	Incremental Change
		0.0	0.0	0.0	-0.2	-0.2	Cumulative Change
14+00	210.0	210.0	210.0	*Unable to Survey - Under Bridge	205.8	205.8	Baseline Offset (In Feet)
		0.0	0.0		-4.2	0.0	Incremental Change
		0.0	0.0		-4.2	-4.2	Cumulative Change
15+00	192.0	192.0	192.0	192.0	192.0	192.0	Baseline Offset (In Feet)
		0.0	0.0	0.0	0.0	0.0	Incremental Change
		0.0	0.0	0.0	0.0	0.0	Cumulative Change
15+56	195.4			195.4	195.4	195.4	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change

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

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E.2.2 NIGLIAGVIK CHANNEL WEST & EAST BANK TABULATED DATA

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Baseline Station	West Bank Monitor - Top of Bank Locations						Description
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/25/2018	Date
0+00	110.0			100.7	100.7	100.7	Baseline Offset (In Feet)
				-9.3	0.0	0.0	Incremental Change
				-9.3	-9.3	-9.3	Cumulative Change
1+00	103.0			97.9	97.9	97.9	Baseline Offset (In Feet)
				-5.1	0.0	0.0	Incremental Change
				-5.1	-5.1	-5.1	Cumulative Change
2+00	99.6			99.6	97.5	97.5	Baseline Offset (In Feet)
				0.0	-2.1	0.0	Incremental Change
				0.0	-2.1	-2.1	Cumulative Change
3+00	98.8			91.3	91.3	91.3	Baseline Offset (In Feet)
				-7.5	0.0	0.0	Incremental Change
				-7.5	-7.5	-7.5	Cumulative Change
4+00	106.0	106.0	106.0	102.4	102.4	102.4	Baseline Offset (In Feet)
		0.0	0.0	-3.6	0.0	0.0	Incremental Change
		0.0	0.0	-3.6	-3.6	-3.6	Cumulative Change
5+00	102.0	93.5	93.5	81.1	81.1	81.1	Baseline Offset (In Feet)
		-8.4	0.0	-12.4	0.0	0.0	Incremental Change
		-8.4	-8.4	-20.9	-20.9	-20.9	Cumulative Change
6+00	92.0	90.4	90.4	87.9	87.9	87.9	Baseline Offset (In Feet)
		-1.6	0.0	-2.5	0.0	0.0	Incremental Change
		-1.6	-1.6	-4.1	-4.1	-4.1	Cumulative Change
7+00	107.1			107.1	107.1	107.1	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
8+00	115.0			112.8	112.8	112.8	Baseline Offset (In Feet)
				-2.2	0.0	0.0	Incremental Change
				-2.2	-2.2	-2.2	Cumulative Change
9+00	96.1			91.8	91.8	91.8	Baseline Offset (In Feet)
				-4.3	0.0	0.0	Incremental Change
				-4.3	-4.3	-4.3	Cumulative Change

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West Bank Nigliagvik
Streambank Monitor

Kuukpik/LCMF
Alpine Survey Office
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Baseline Station	West Bank Monitor - Top of Bank Locations						Description
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/25/2018	Date
10+00	106.1			106.1	106.1	105.2	Baseline Offset (In Feet)
				0.0	0.0	-0.9	Incremental Change
				0.0	0.0	-0.9	Cumulative Change
10+28	112.0			112.0	112.0	112.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	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.

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East Bank Nigliagvik
Streambank Monitor

Umiaq LLC
Alpine Survey Office
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Baseline Station	East Bank Monitor - Top of Bank Locations						Description
	8/21/2013	8/21/2014	8/28/2015	7/6/2016	8/24/2017	8/24/2018	Date
0+00.0	165.1			165.1	165.3	165.3	Baseline Offset (In Feet)
				0.0	0.2	0.0	Incremental Change
				0.0	0.2	0.2	Cumulative Change
1+00.0	185.0			185.0	185.0	185.0	Baseline Offset (In Feet)
				0.0	0.0	0.0	Incremental Change
				0.0	0.0	0.0	Cumulative Change
2+00.0	165.0			165.0	165.1	165.1	Baseline Offset (In Feet)
				0.0	0.1	0.0	Incremental Change
				0.0	0.1	0.1	Cumulative Change
3+00.0	162.3			162.3	162.2	162.2	Baseline Offset (In Feet)
				0.0	-0.1	0.0	Incremental Change
				0.0	-0.1	-0.1	Cumulative Change
4+00.0	154.9	154.9	154.9	147.6	147.6	147.6	Baseline Offset (In Feet)
		0.0	0.0	-7.3	0.0	0.0	Incremental Change
		0.0	0.0	-7.3	-7.3	-7.3	Cumulative Change
5+00.0	141.0	141.0	138.4	Under Bridge	143.7	143.7	Baseline Offset (In Feet)
		0.0	-2.7		5.3	0.0	Incremental Change
		0.0	-2.7		2.7	2.7	Cumulative Change
6+00.0	120.9	120.9	120.9	120.9	121.1	121.1	Baseline Offset (In Feet)
		0.0	0.0	0.0	0.2	0.0	Incremental Change
		0.0	0.0	0.0	0.2	0.2	Cumulative Change
7+00.0	119.0			119.0	119.5	119.5	Baseline Offset (In Feet)
				0.0	0.5	0.0	Incremental Change
				0.0	0.5	0.5	Cumulative Change
8+00.0	120.9			120.9	121.3	121.3	Baseline Offset (In Feet)
				0.0	0.4	0.0	Incremental Change
				0.0	0.4	0.4	Cumulative Change

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East Bank Nigliagvik
Streambank Monitor

Umiaq LLC
Alpine Survey Office
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Baseline Station	East Bank Monitor - Top of Bank Locations						Description
	8/21/2013	**8/21/2014**	**8/28/2015**	**7/6/2016**	**8/24/2017**	**8/24/2018**	**Date**
8+91.0	115.7			115.7	116.1	116.1	Baseline Offset (In Feet)
				0.0	0.4	0.0	Incremental Change
				0.0	0.4	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.

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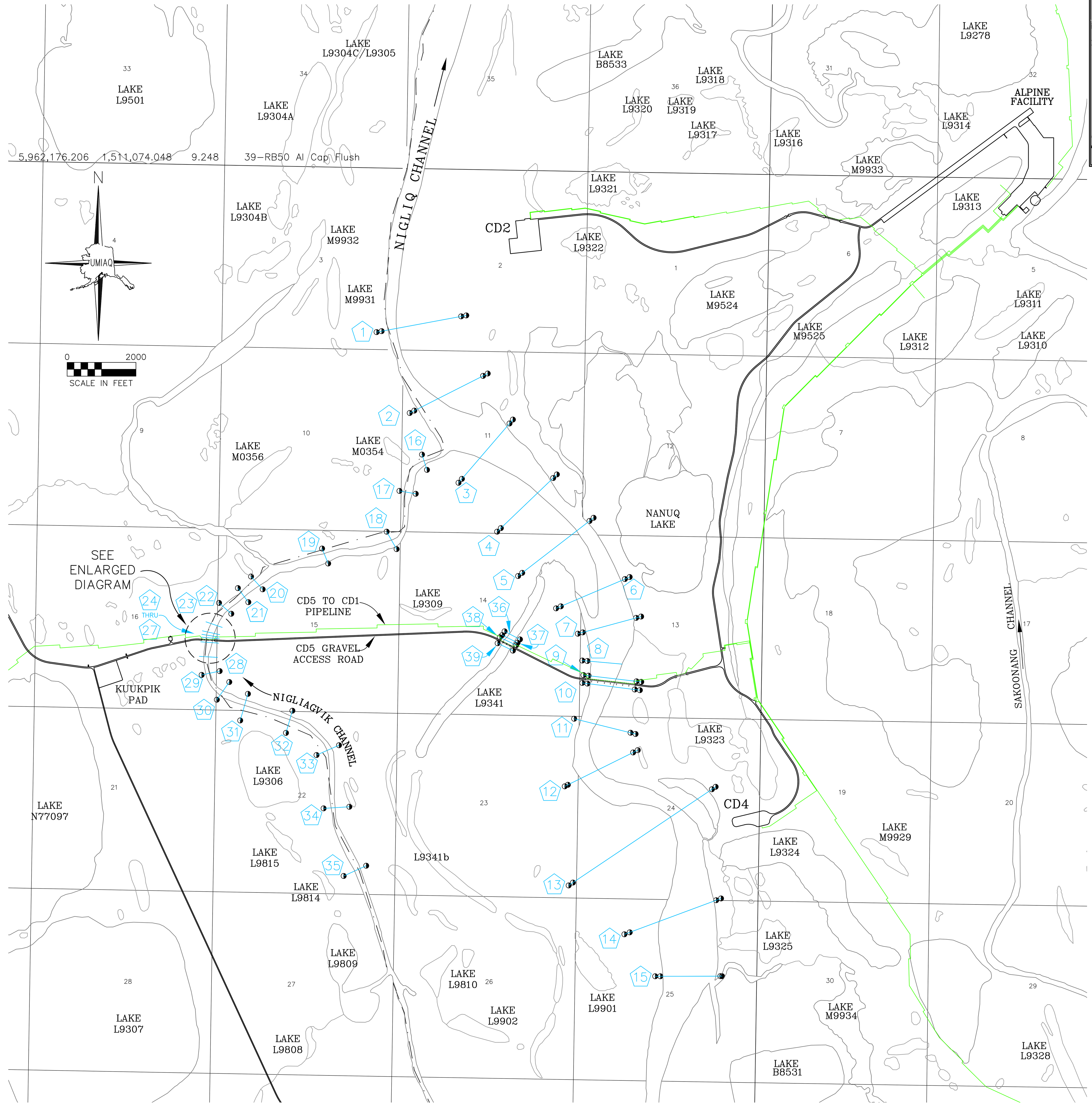
E.3 BATHYMETRY

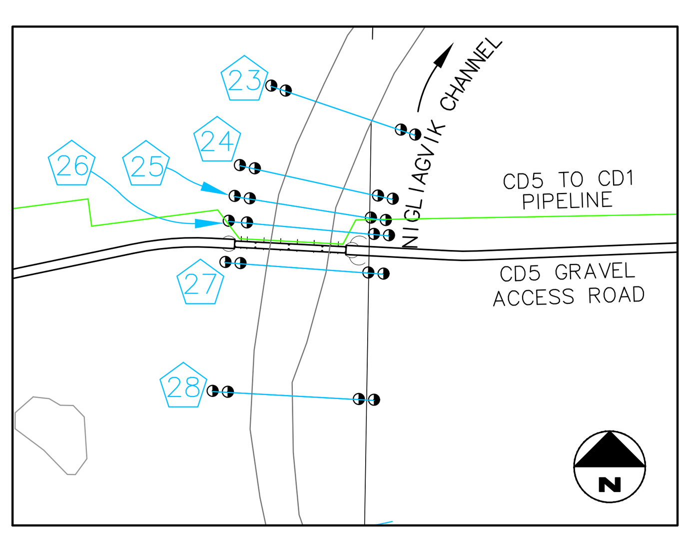
E.3.1 TRANSECT PROFILES

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

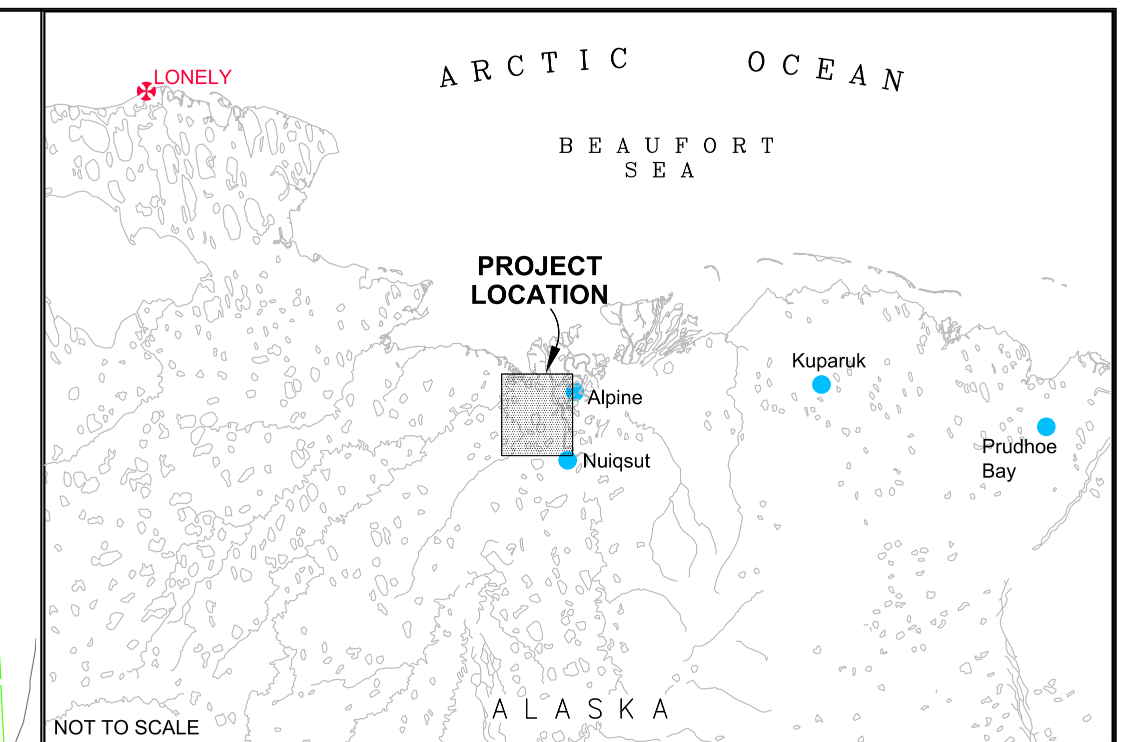
CD5 2017 TRANSECT CONTROL

NORTHING	EASTING	ELEV	DESCRIPTION	NORTHING	EASTING	ELEV	DESCRIPTION
5,971,410.079	1,507,156.531	8.39	01–LB200 Al Cap Flush	5,963,972.572	1,503,814.158	7.59	20–RB50 Al Cap Flush
5,971,437.609	1,507,304.061	8.37	01–LB50 Al Cap Flush	5,963,970.131	1,503,127.991	24.55	21–LB100 Al Cap Flush
5,971,895.666	1,509,763.389	9.13	01–RB200 Al Cap Flush	5,963,929.997	1,503,157.807	20.75	21–LB50 Al Cap Flush
5,971,868.384	1,509,615.796	9.28	01–RB50 Al Cap Flush	5,963,562.385	1,503,430.606	8.83	21–RB100 Al Cap Flush
5,969,060.212	1,508,119.663	8.87	02–LB200 Al Cap Flush	5,963,602.552	1,503,400.707	9.12	21–RB50 Al Cap Flush
5,969,127.986	1,508,253.629	7.65	02–LB50 Al Cap Flush	5,963,540.635	1,502,578.236	26.09	22–LB110 Al Cap Flush
5,970,206.007	1,510,386.350	9.26	02–RB200 Al Cap Flush	5,963,500.929	1,502,623.041	24.05	22–LB50 Al Cap Flush
5,970,138.188	1,510,252.432	8.96	02–RB50 Al Cap Flush	5,963,224.550	1,502,936.061	8.70	22–RB100 Al Cap Flush
5,967,032.227	1,509,538.697	9.67	03–LB200 Al Cap Flush	5,963,257.784	1,502,898.581	9.16	22–RB50 Al Cap Flush
5,967,145.969	1,509,636.499	10.13	03–LB50 Al Cap Flush	5,962,989.540	1,502,198.702	25.27	23–LB100 Al Cap Flsh
5,968,868.865	1,511,117.892	9.41	03–RB200 Al Cap Flush	5,962,973.551	1,502,246.078	25.13	23–LB50 Al Cap Flush
5,968,755.138	1,511,019.833	9.05	03–RB50 Al Cap Flush	5,962,828.919	1,502,671.911	10.17	23–RB100 Al Cap Flush
5,965,610.351	1,510,661.003	12.54	04–LB200 Al Cap Flush	5,962,844.993	1,502,624.671	7.92	23–RB50 Al Cap Flush
5,965,716.677	1,510,772.064	13.71	04–LB50 Al Cap Flush	5,962,728.640	1,502,095.594	26.44	24–LB100 Al Cap Flush
5,967,272.750	1,512,396.862	10.36	04–RB200 Al Cap Flush	5,962,717.858	1,502,144.429	26.95	24–LB50 Al Cap Flush
5,967,169.020	1,512,288.517	10.23	04–RB50 Al Cap Flush	5,962,617.871	1,502,598.118	9.07	24–RB100 Al Cap Flush
5,964,321.998	1,511,269.867	11.98	05–LB200 Al Cap Flush	5,962,628.701	1,502,549.442	8.42	24–RB50 Al Cap Flush
5,964,413.665	1,511,388.462	13.14	05–LB50 Al Cap Flush	5,962,627.134	1,502,078.374	27.30	25–LB100 Al Cap Flush
5,966,013.940	1,513,463.318	8.66	05–RB200 Al Cap Flush	5,962,619.297	1,502,127.805	26.17	25–LB50 Al Cap Flush
5,965,922.233	1,513,344.473	8.66	05–RB50 Al Cap Flush	5,962,548.009	1,502,575.213	8.35	25–RB100 Al Cap Flush
5,963,381.239	1,512,373.965	11.39	06–LB200 Al Cap Flush	5,962,555.885	1,502,525.978	8.2	25–RB50 Al Cap Flush
5,963,439.930	1,512,511.976	13.14	06–LB50 Al Cap Flush	5,962,545.552	1,502,059.146	27.26	26–LB110 Al Cap Flush
5,964,291.972	1,514,511.882	9.79	06–RB250 Al Cap Flush	5,962,540.029	1,502,118.494	27.46	26–LB50 Al Cap Flush
5,964,233.822	1,514,375.381	10.19	06–RB50 Al Cap Flush	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; AUGUST 12 TO AUGUST 19, 2018.
2. COORDINATES SHOWN ARE ALASKA STATE PLANE, ZONE 4 N.A.D. 83, IN FEET.
3. ELEVATIONS SHOWN ARE BRITISH PETROLEUM MEAN SEA LEVEL (B.P.M.S.L.) DATUM.
4. REFERENCE FIELD BOOK 2013–18, PGS. 57–59, 67, 70–72. 2013–20 PGS. 4–14; 2013–21, PG. 29; 2016–11, PG. 76, 2016–12, PGS. 17–20, 26–28, 36–37 & 59; 2017–13, PGS. 70–73, 2017–14, PGS. 15–17, 2017–15, PGS. 3–27; 2018–18, PG. 2–4; 2018–13, PG. 35–38; 2018–17, PG. 19–20.

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

1 2 3 4 5 6

DO NOT SCALE | ABOVE SCALE FOR REFERENCE ONLY

FORM: DSIZE

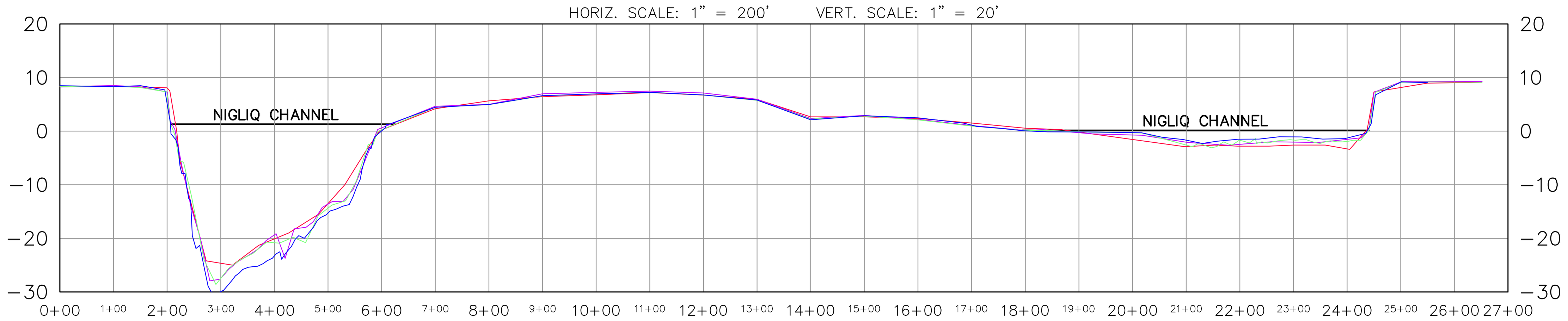
REFERENCE DWG NO/SHT NO:

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

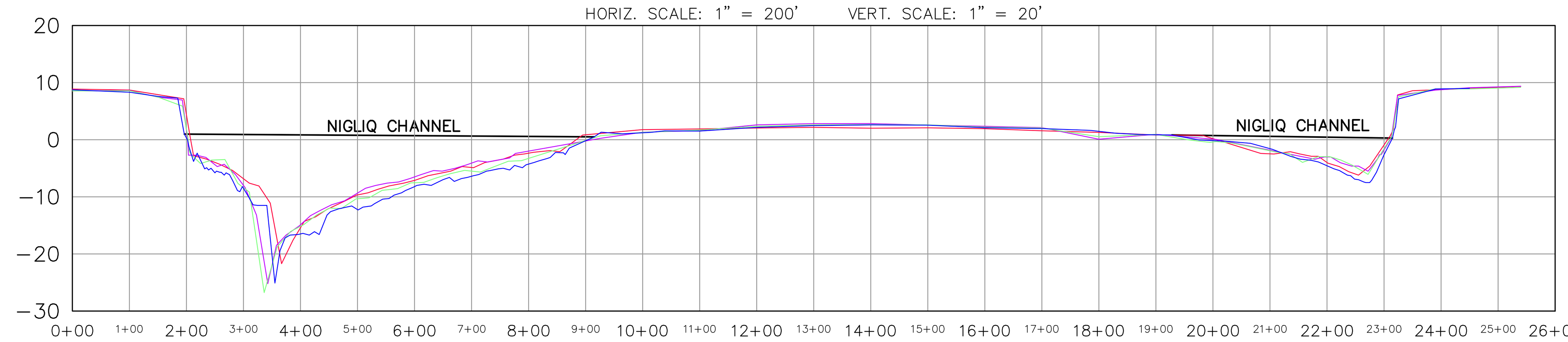
DATE: 8/26/13	DRAWN: CZ	DESIGN: –	ECM NO: –
SCALE: 1" = 2000'	CHECKED: DB		CC NO: –
	APPROVAL: –		CADD FILE NO. 13–08–07–1 –
JOB NO: 02–204	SUB JOB NO: –	DRAWING NO: CE–CD50–1004	PART: 1 OF 6 REV: 4

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

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



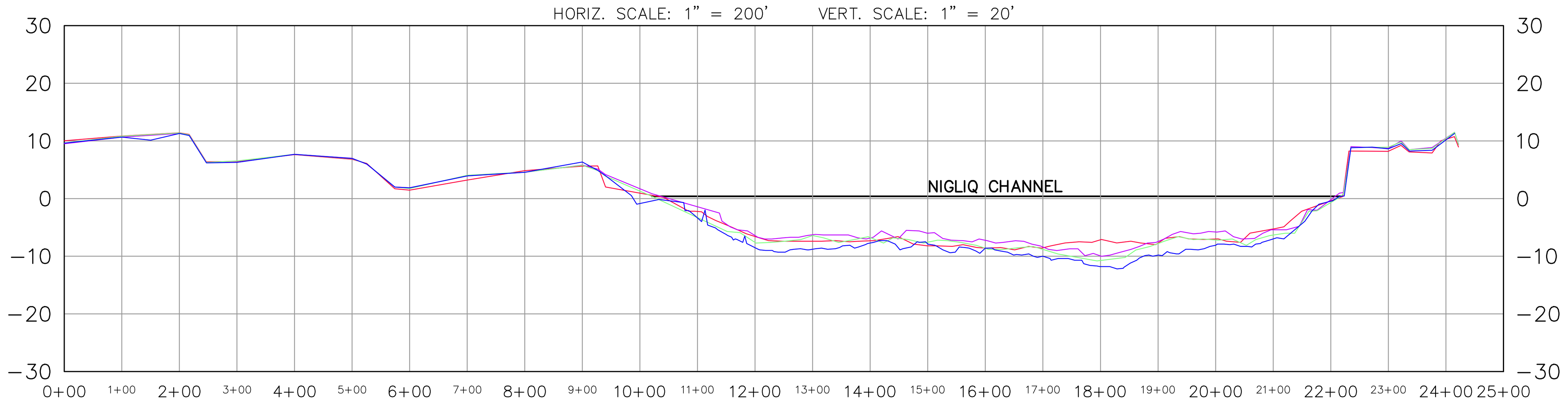
Profile View of Transect–2
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



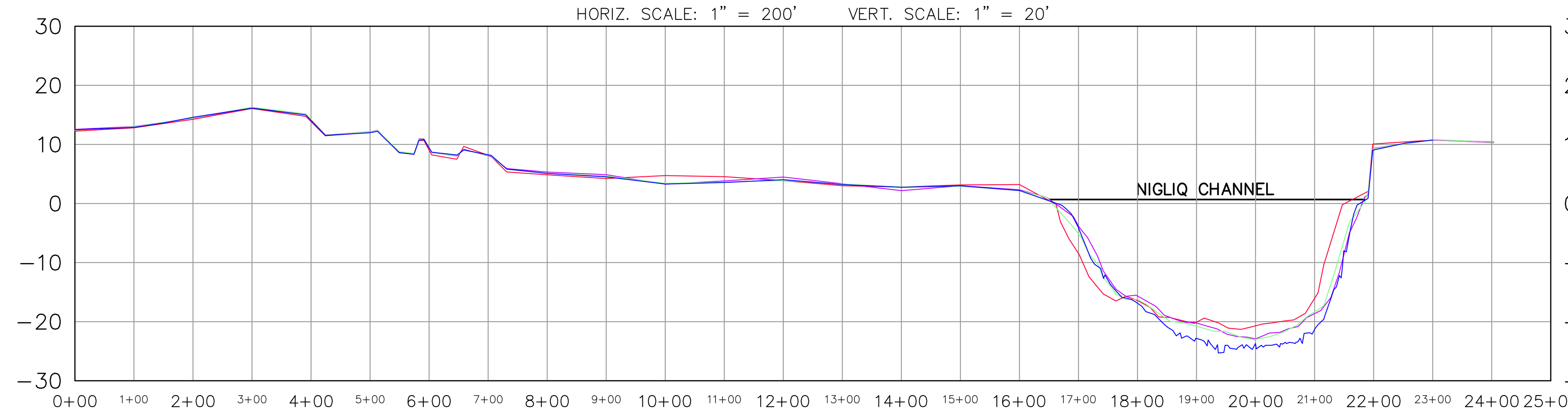
LEGEND:
VIEW LOOKING DOWNSTREAM

- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE
- 2018 TRANSECT PROFILE

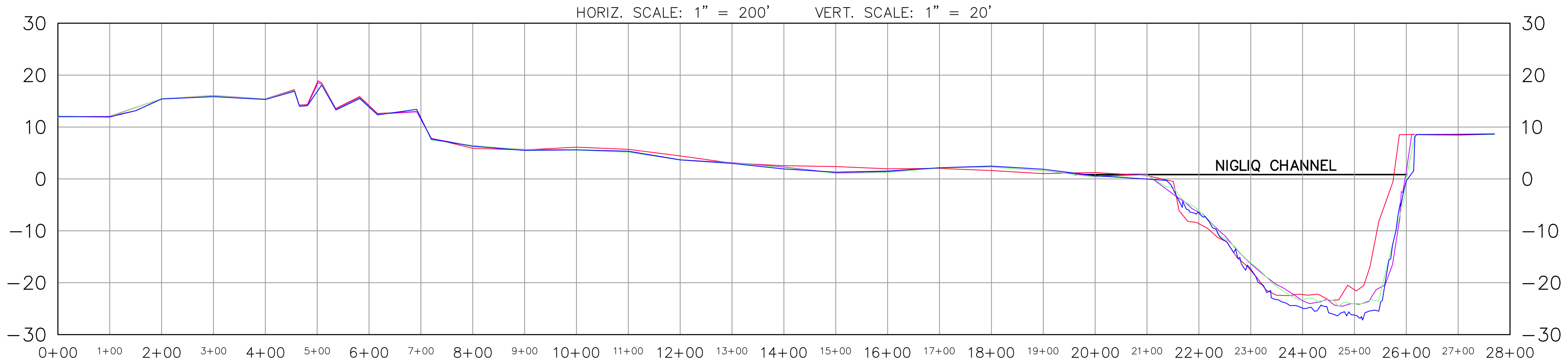
Profile View of Transect–3
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



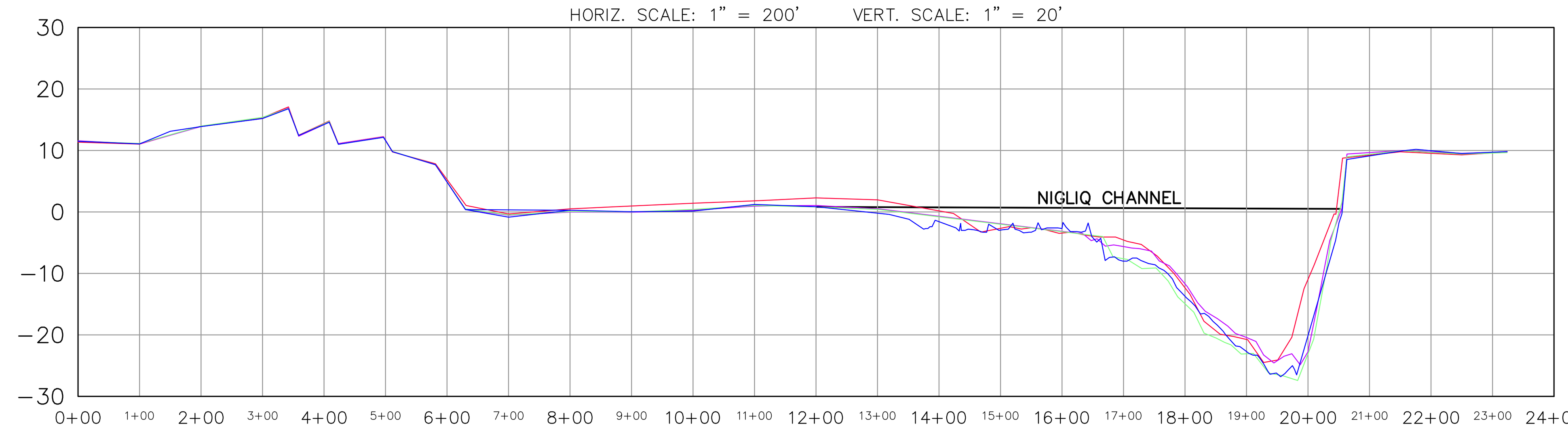
Profile View of Transect–4
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



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
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

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

ConocoPhillips
Alaska, Inc.

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

ALPINE
MODULE: CD50
UNIT: CD

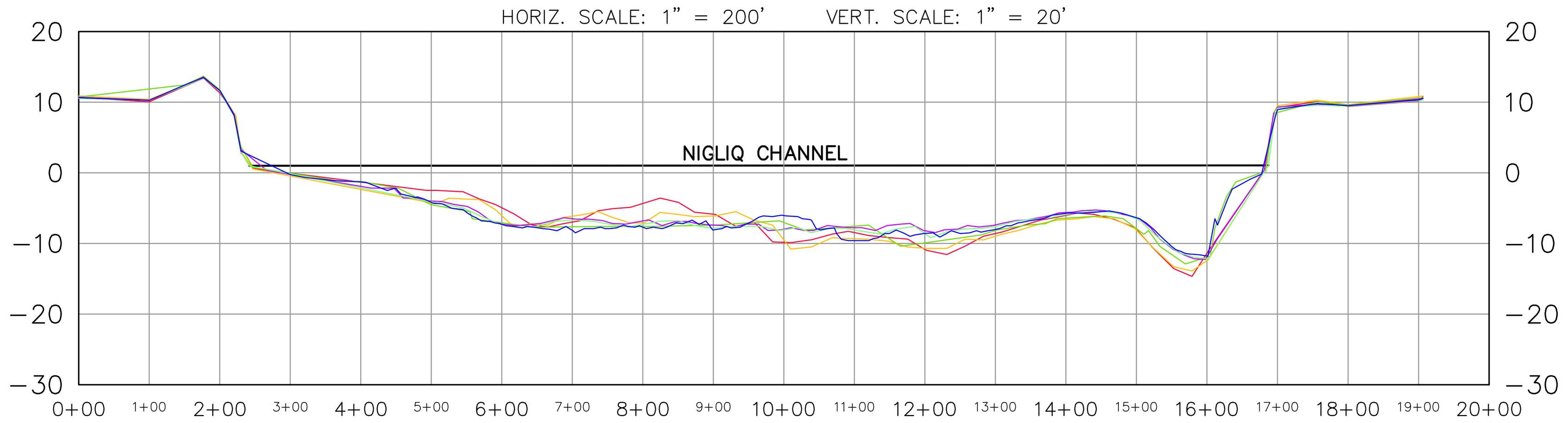
CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

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

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

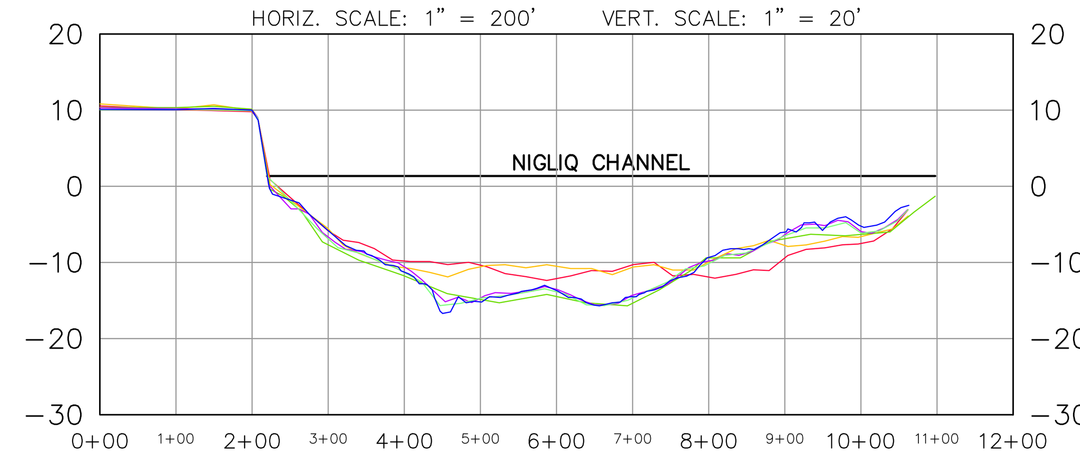
Profile View of Transect–7

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



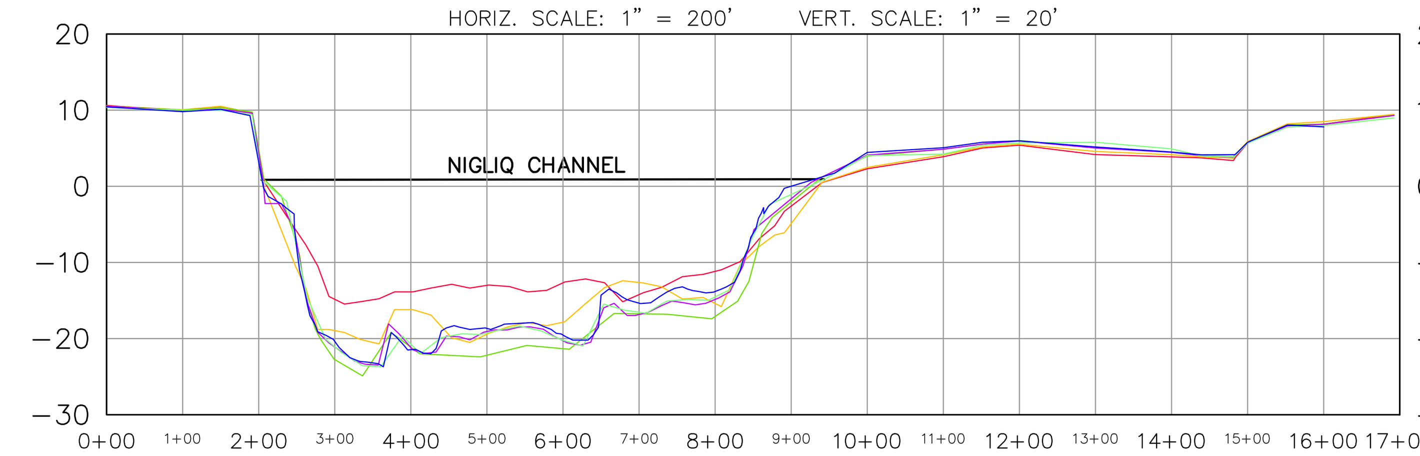
Profile View of Transect–8

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



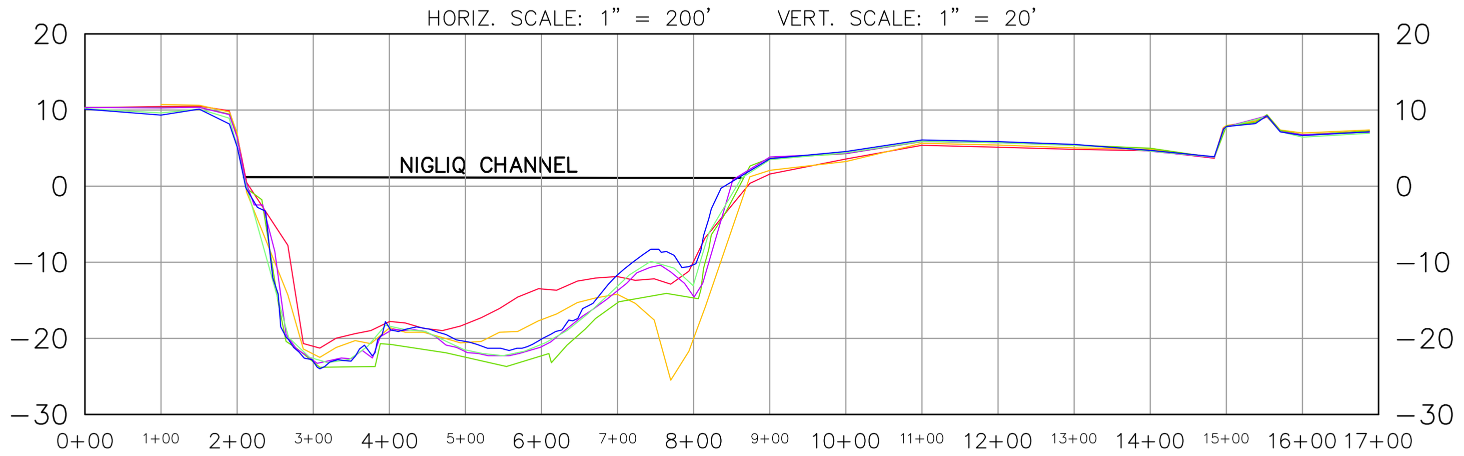
Profile View of Transect–9

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



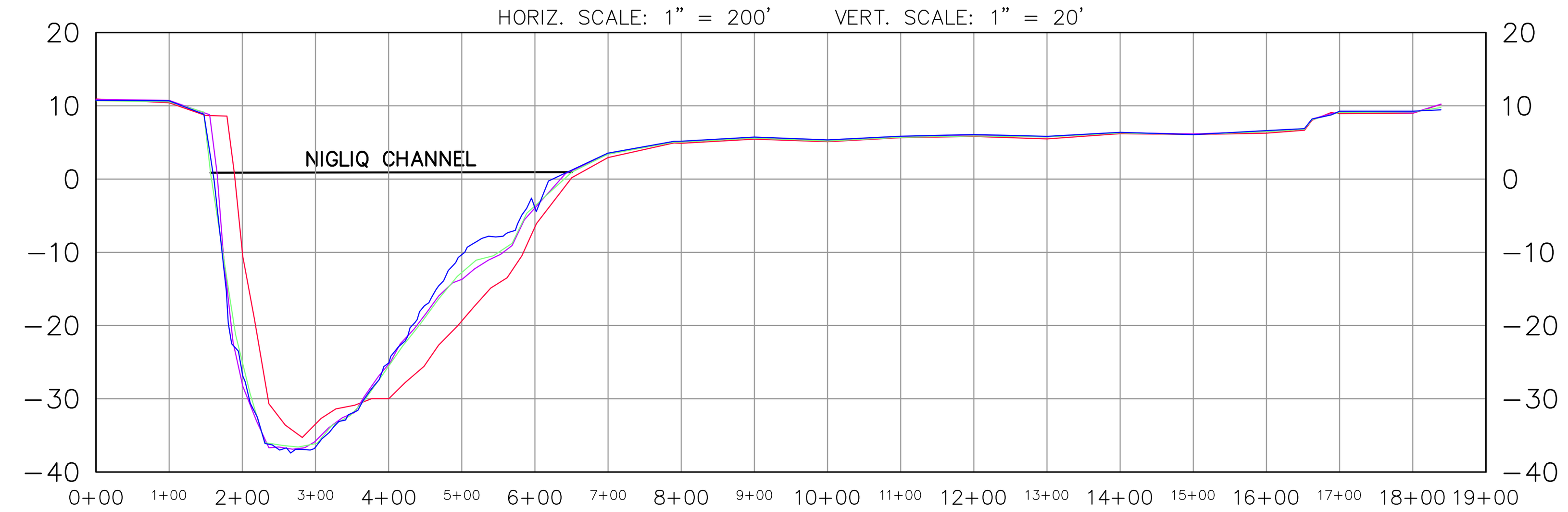
Profile View of Transect–10

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



Profile View of Transect–11

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

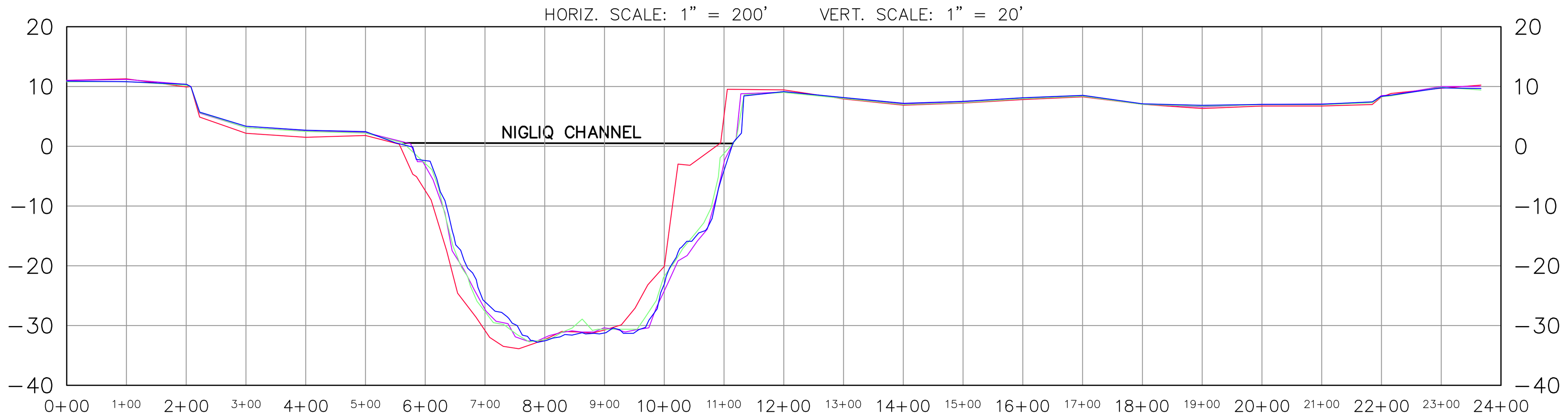


LEGEND:
VIEW LOOKING DOWNSTREAM

- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE
- 2018 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
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

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

ConocoPhillips
Alaska, Inc.

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

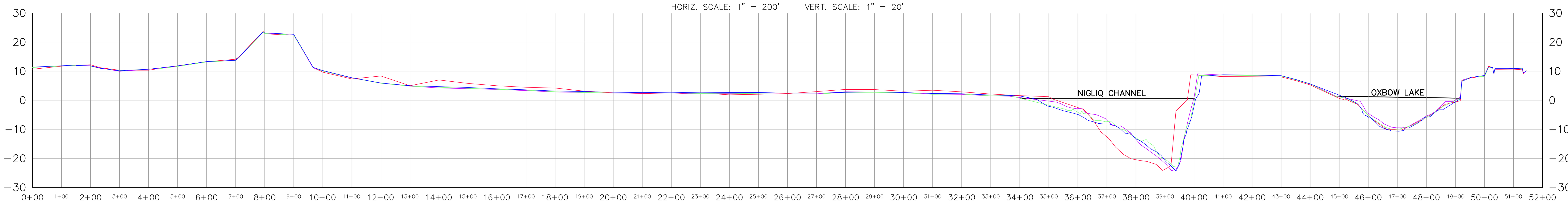
ALPINE
MODULE: CD50
UNIT: CD

CD–5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

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

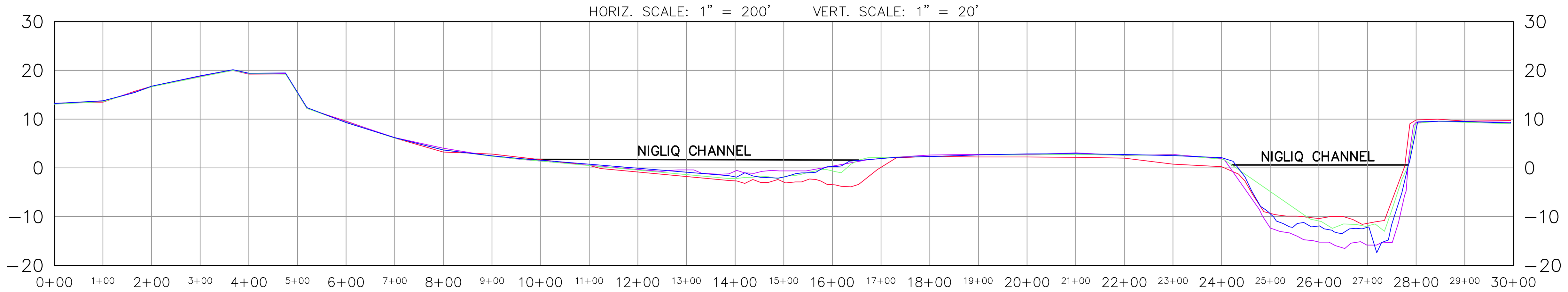
JOB NO:	SUB JOB NO:	DRAWING NO:
–	–	CE-CD50-1004

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

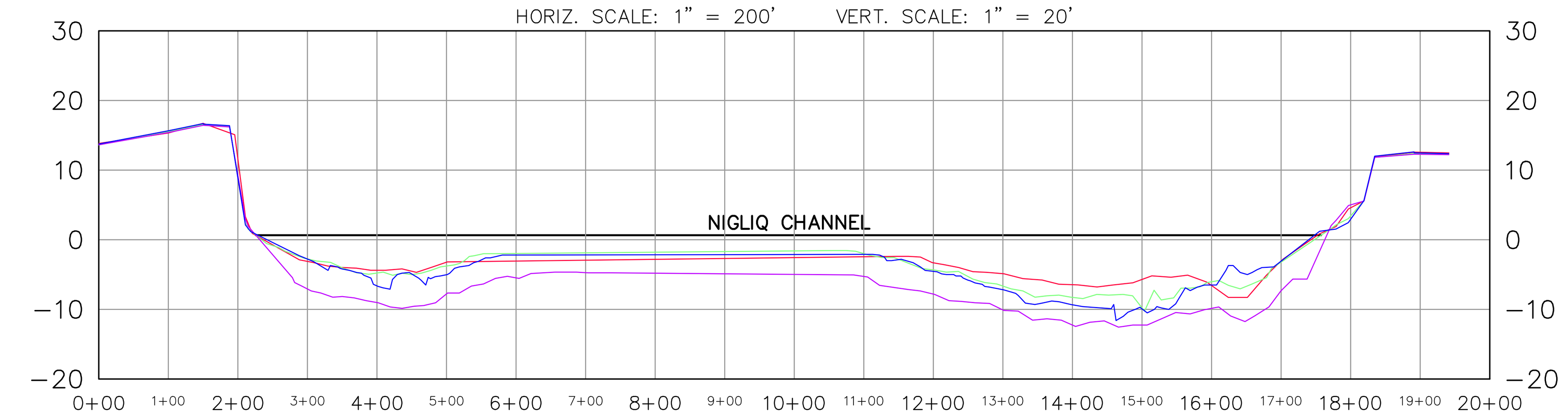


LEGEND:
VIEW LOOKING DOWNSTREAM
2013 TRANSECT PROFILE
2014 TRANSECT PROFILE
2015 TRANSECT PROFILE
2016 TRANSECT PROFILE
2017 TRANSECT PROFILE
2018 TRANSECT PROFILE

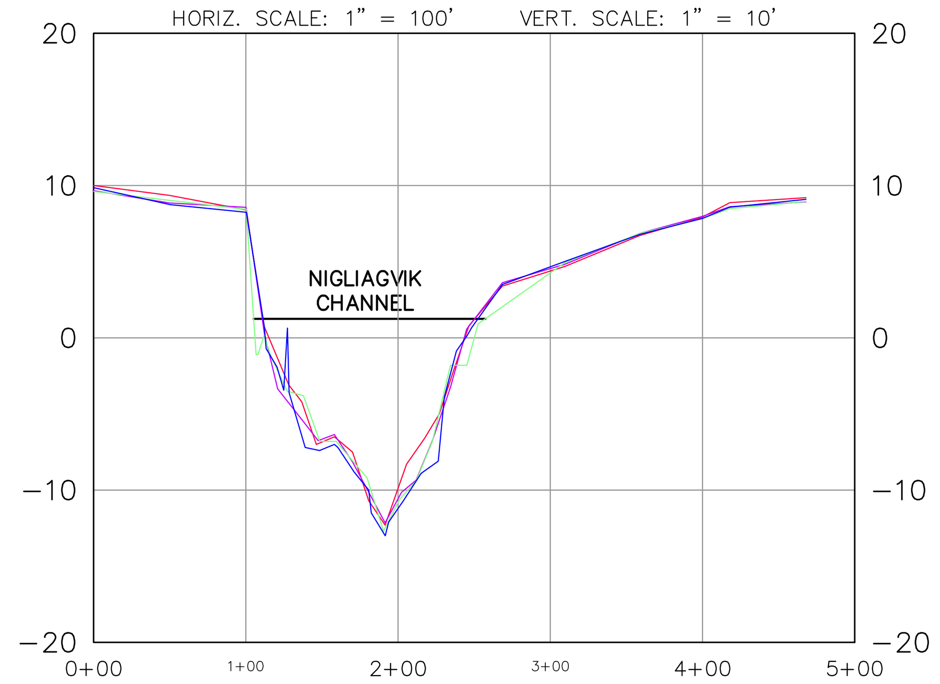
Profile View of Transect-14
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



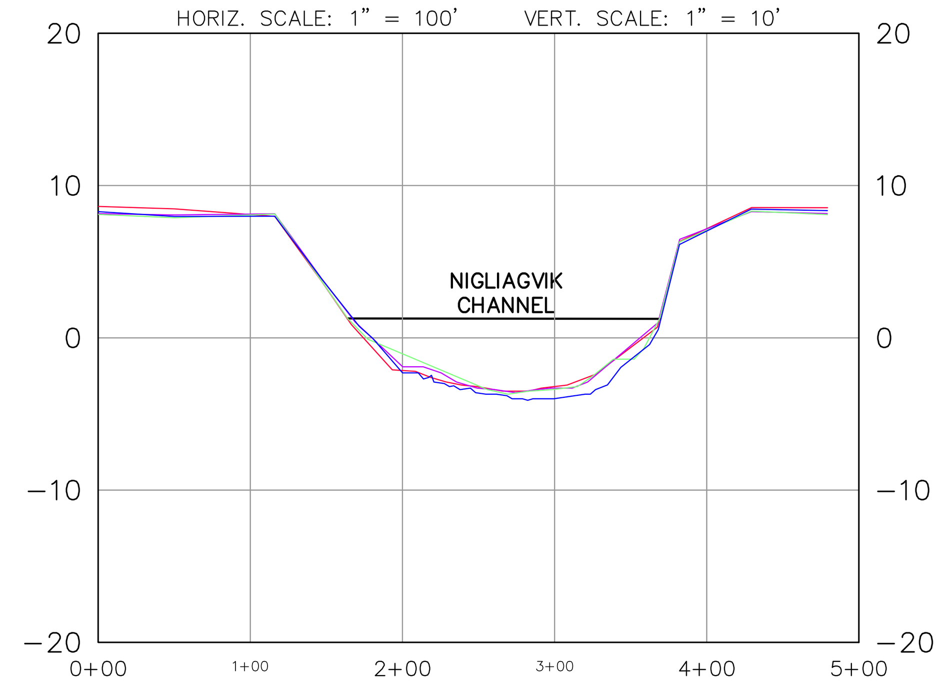
Profile View of Transect-15
HORIZ. SCALE: 1" = 200' VERT. SCALE: 1" = 20'



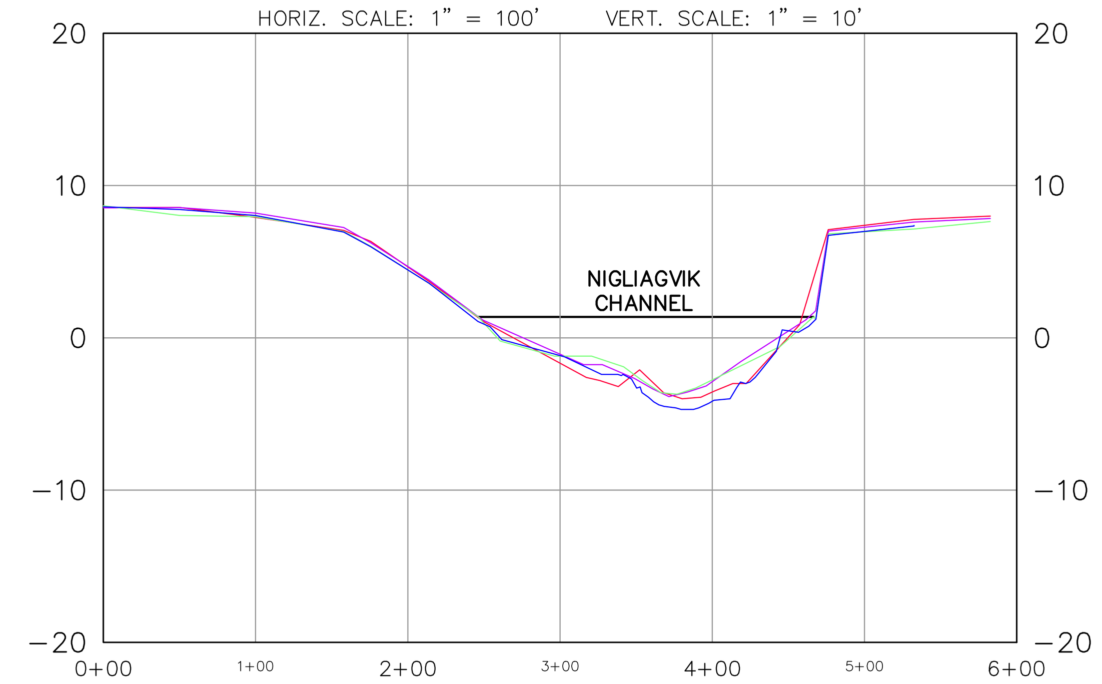
Profile View of Transect-16
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



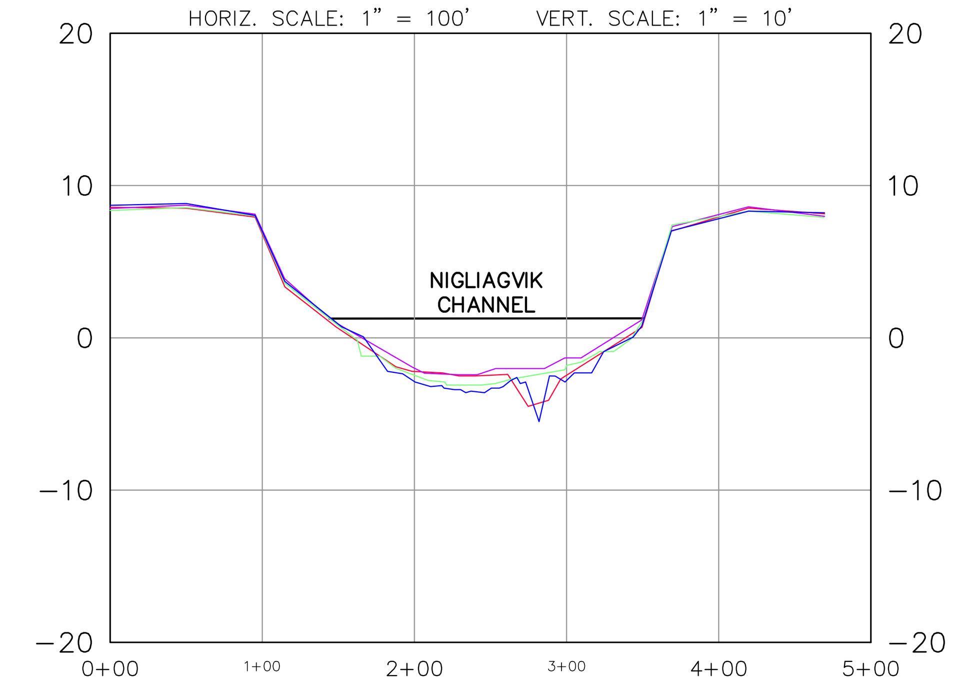
Profile View of Transect-17
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



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



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



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

FORM: DSIZEPID

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

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

ConocoPhillips Alaska, Inc.

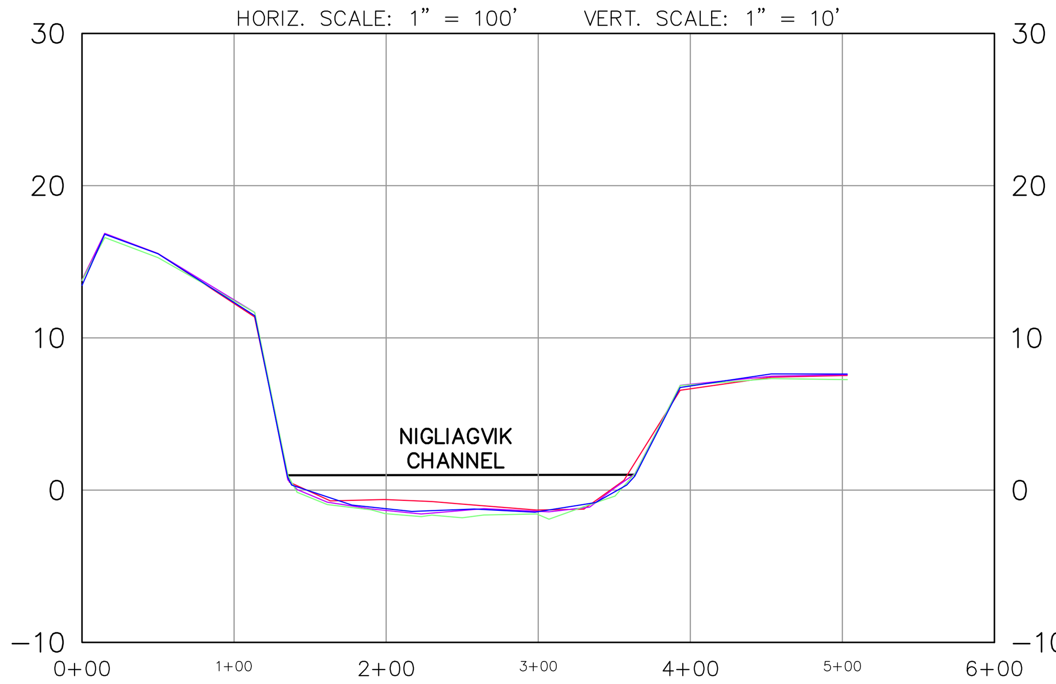
DRAWN: CZ
DESIGN: –
CHECKED: DB
REDRAWN FROM: –
APPROVAL: –

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

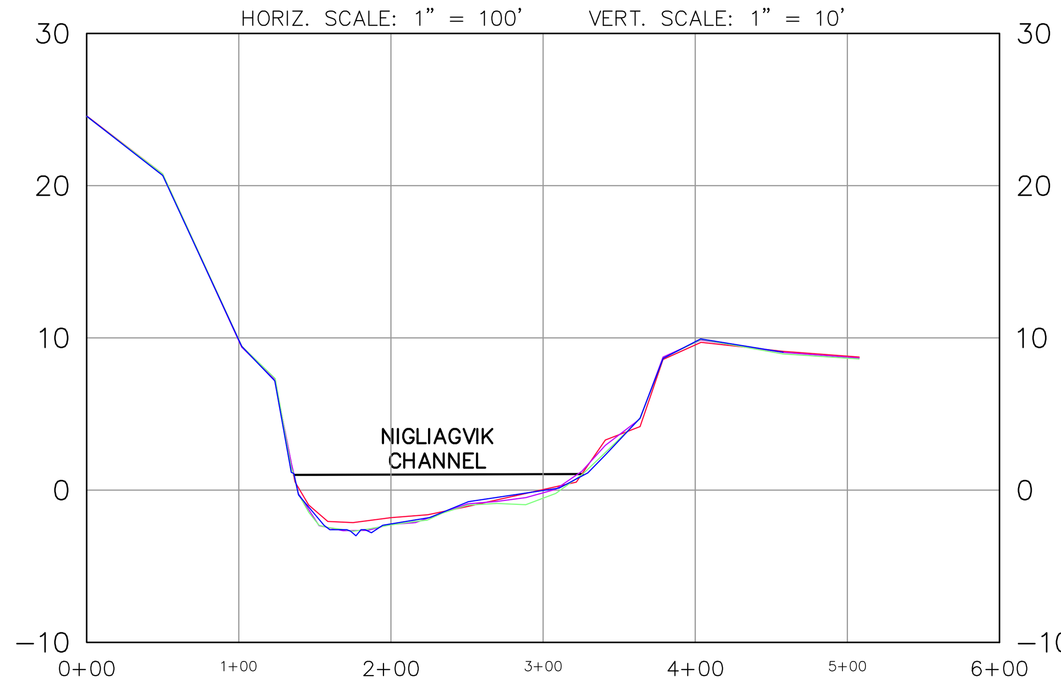
JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	4 of 6	3

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

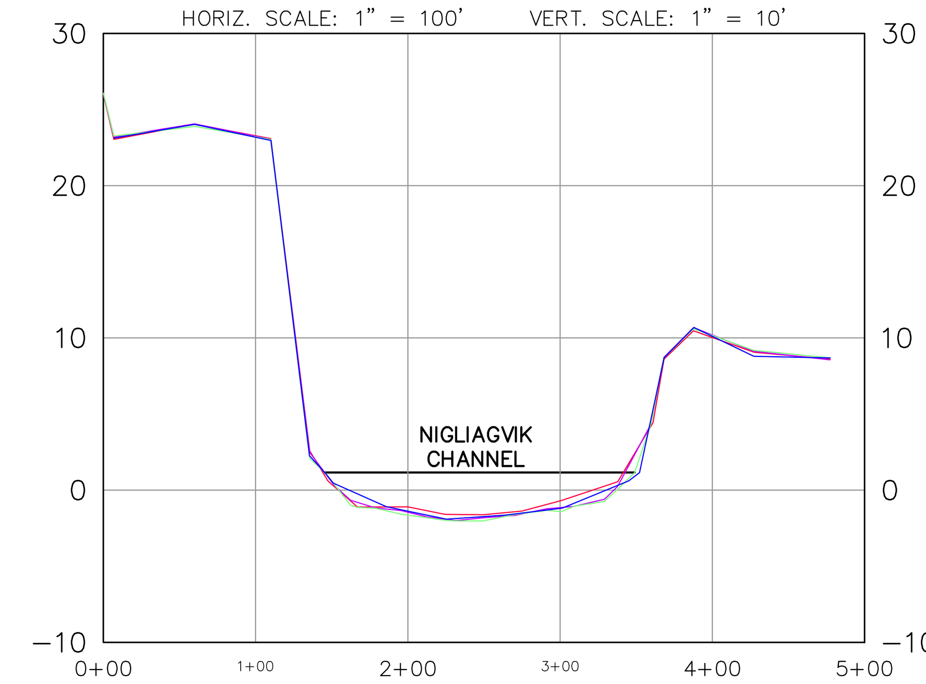
Profile View of Transect-20
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



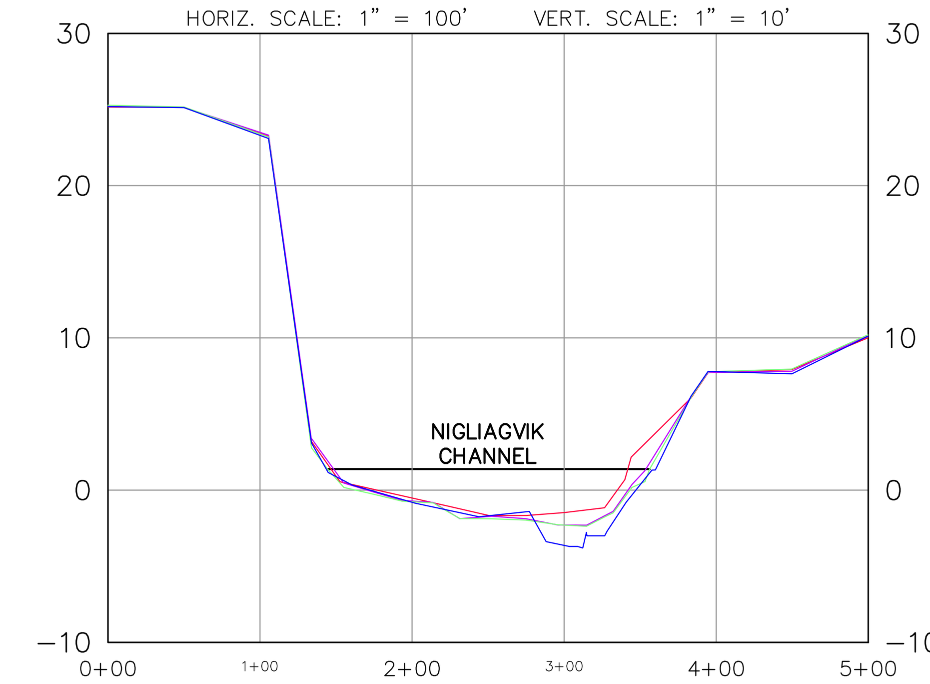
Profile View of Transect-21
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



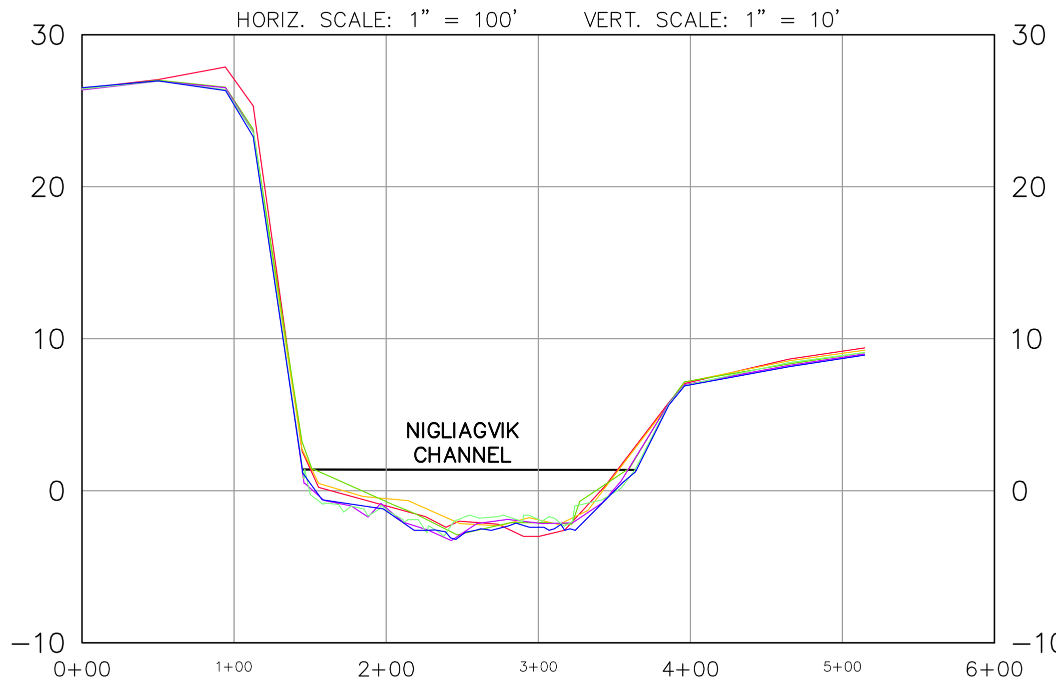
Profile View of Transect-22
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



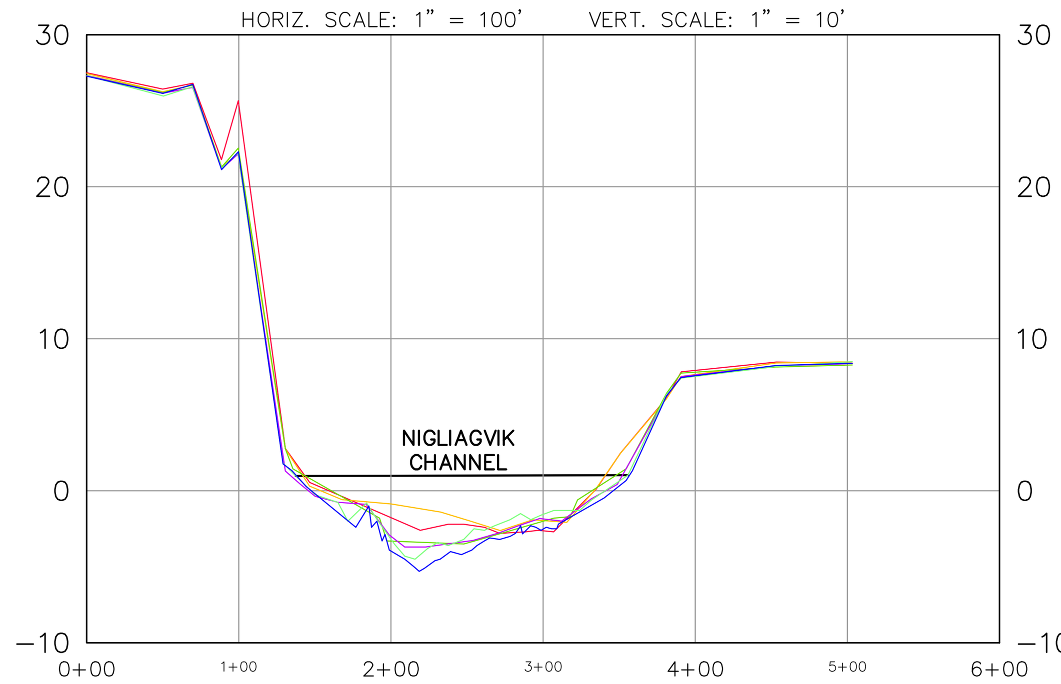
Profile View of Transect-23
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



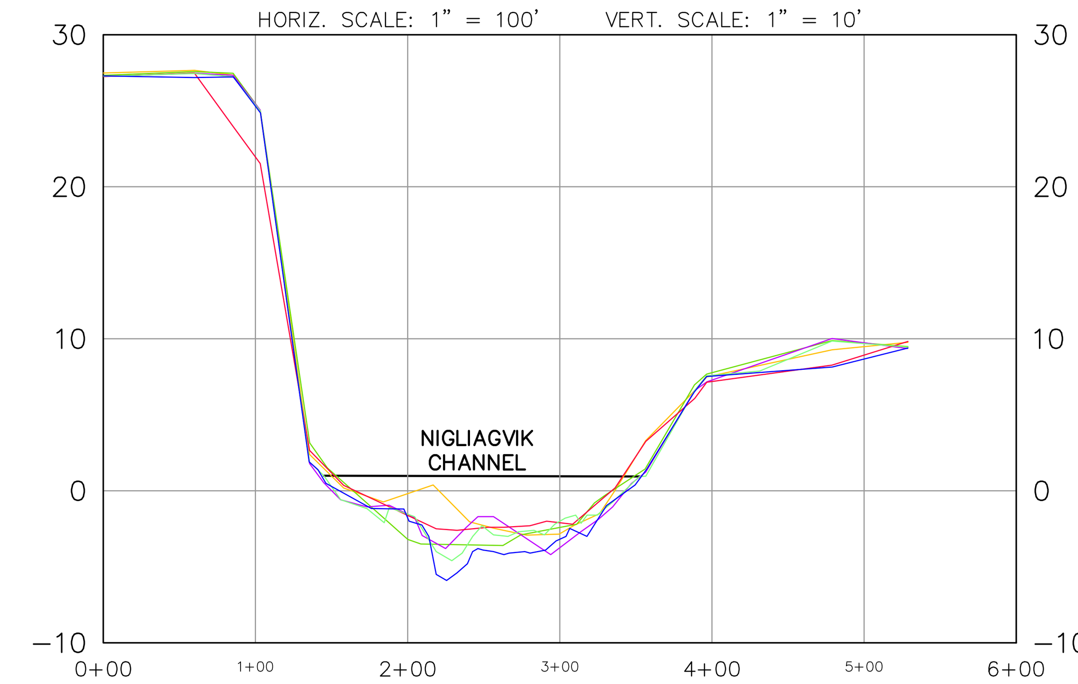
Profile View of Transect-24
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



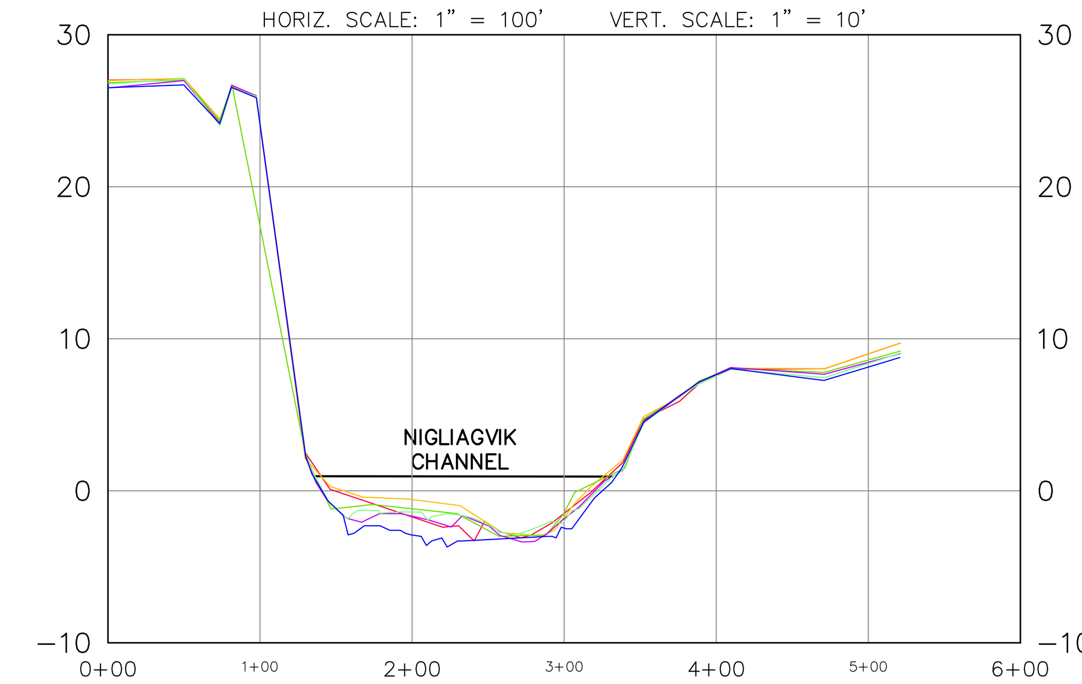
Profile View of Transect-25
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



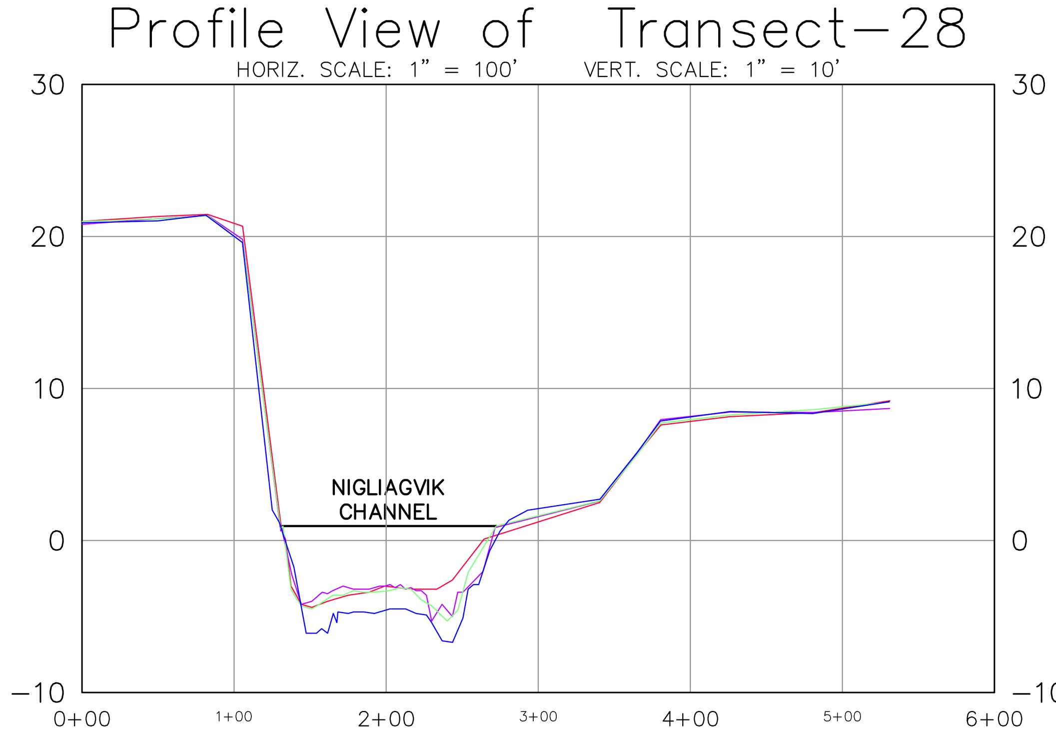
Profile View of Transect-26
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



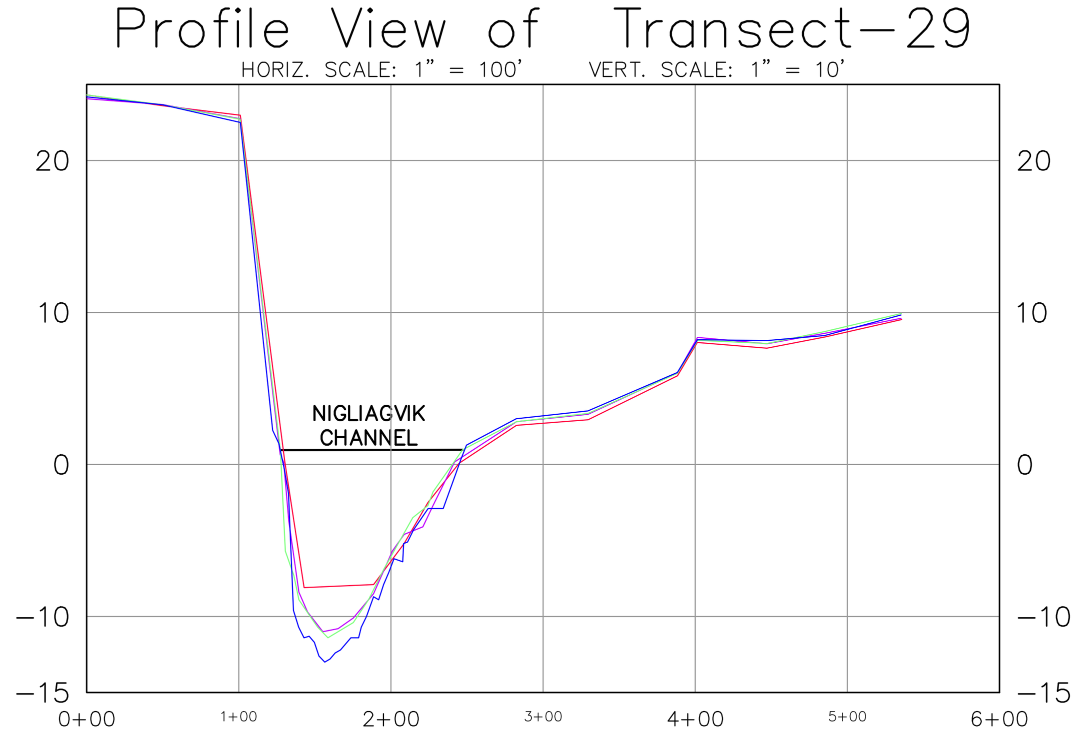
Profile View of Transect-27
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



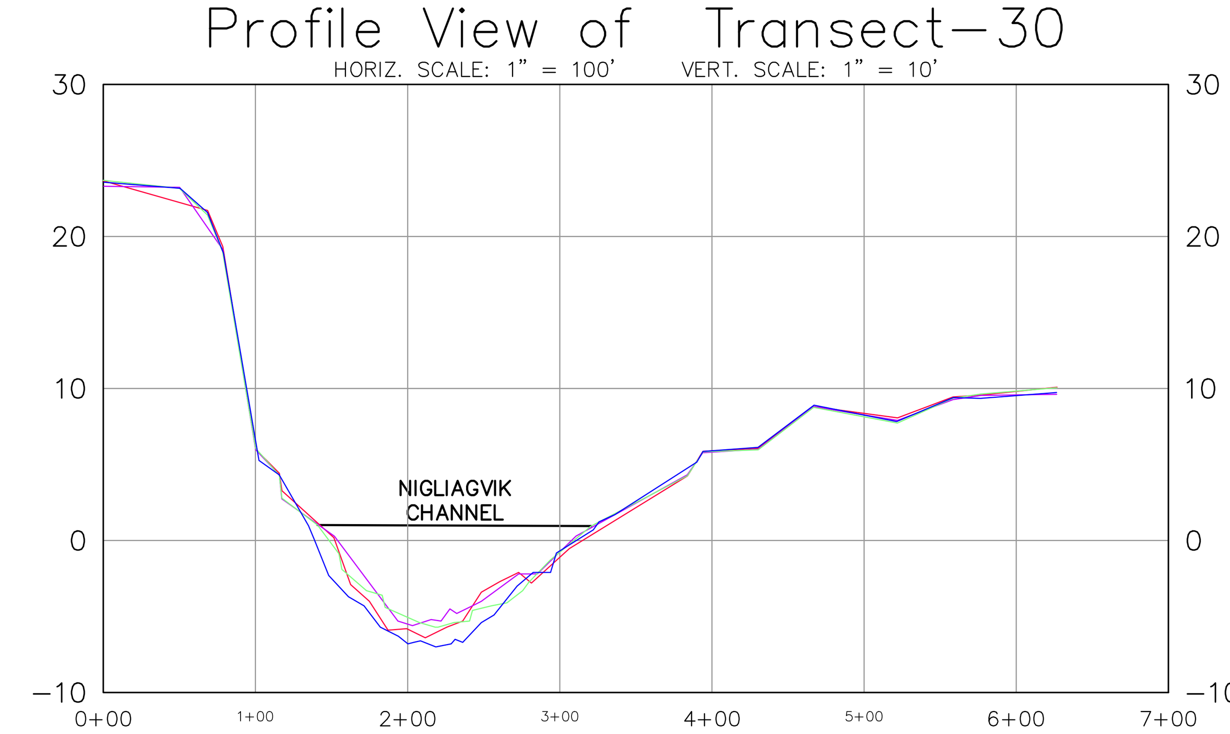
Profile View of Transect-28
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



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



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



LEGEND:
VIEW LOOKING DOWNSTREAM

- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE
- 2018 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
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

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

ConocoPhillips
Alaska, Inc.

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

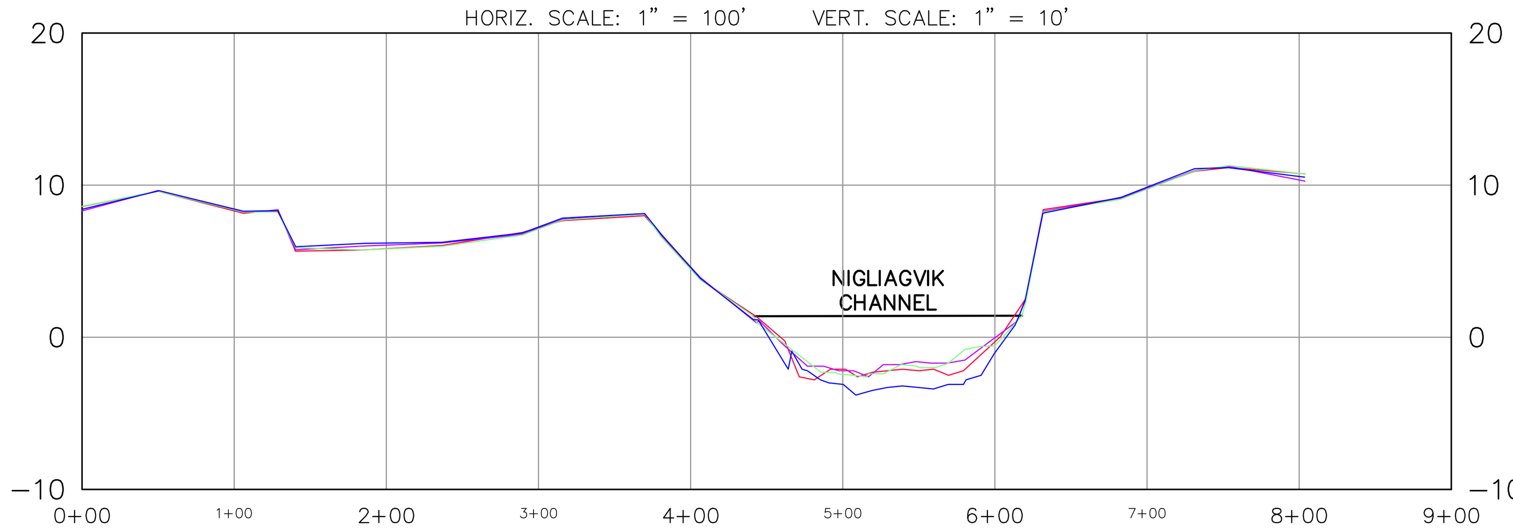
ALPINE
MODULE: CD50
UNIT: CD

CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

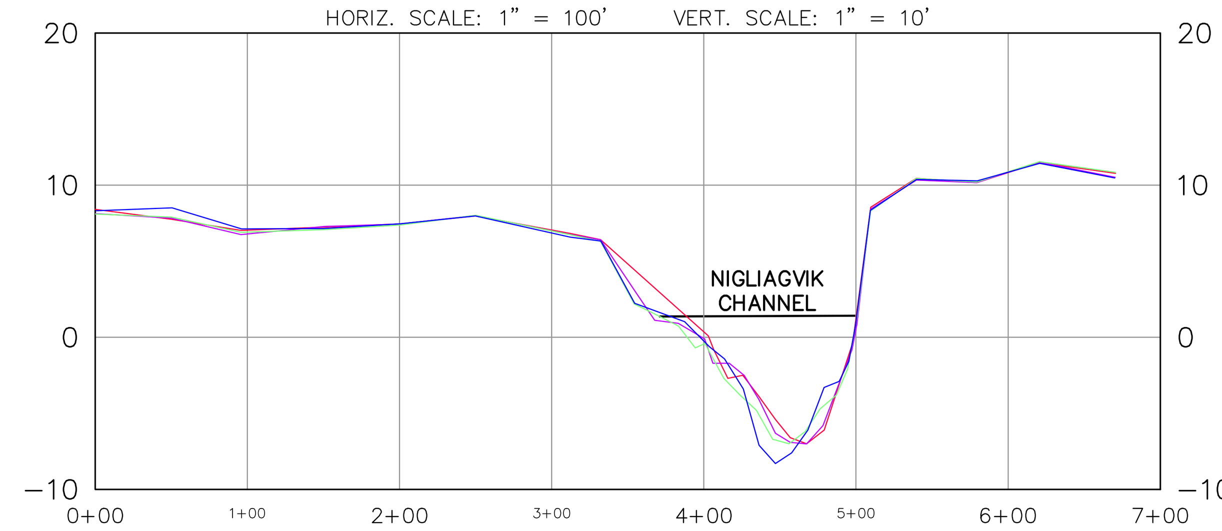
JOB NO:	SUB JOB NO:	DRAWING NO:	PART:	REV:
–	–	CE-CD50-1004	5 of 6	3

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

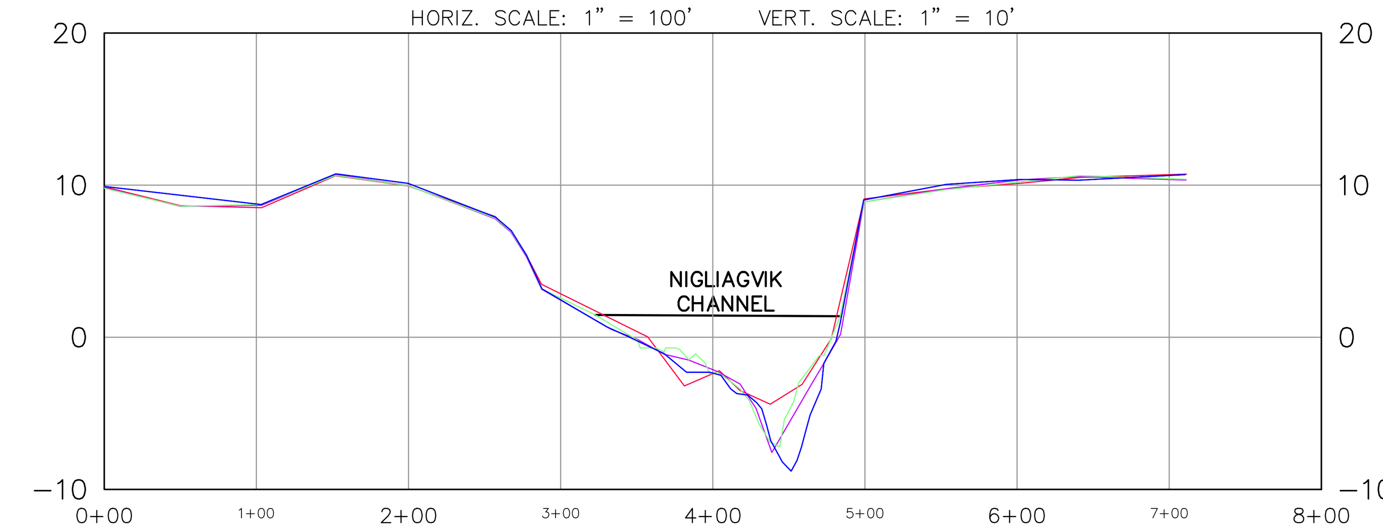
Profile View of Transect–31
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



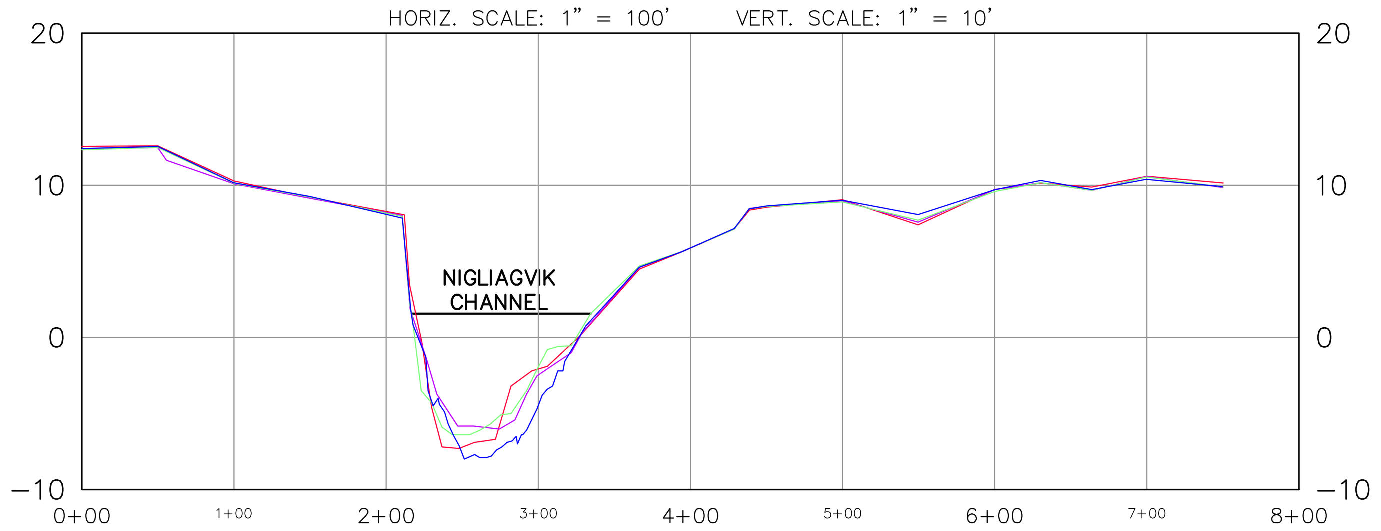
Profile View of Transect–32
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



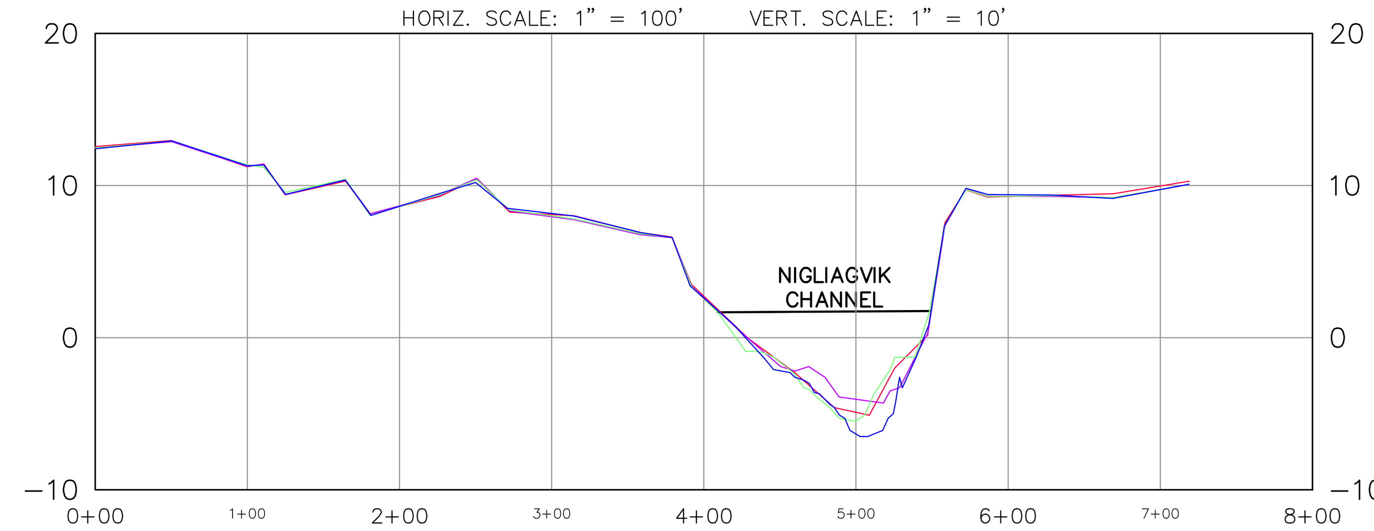
Profile View of Transect–33
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



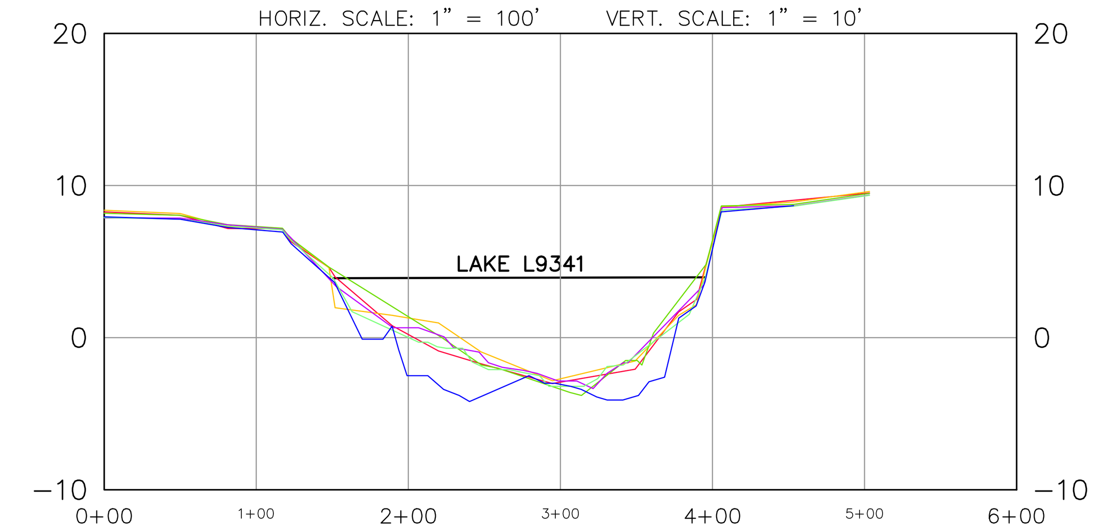
Profile View of Transect–34
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



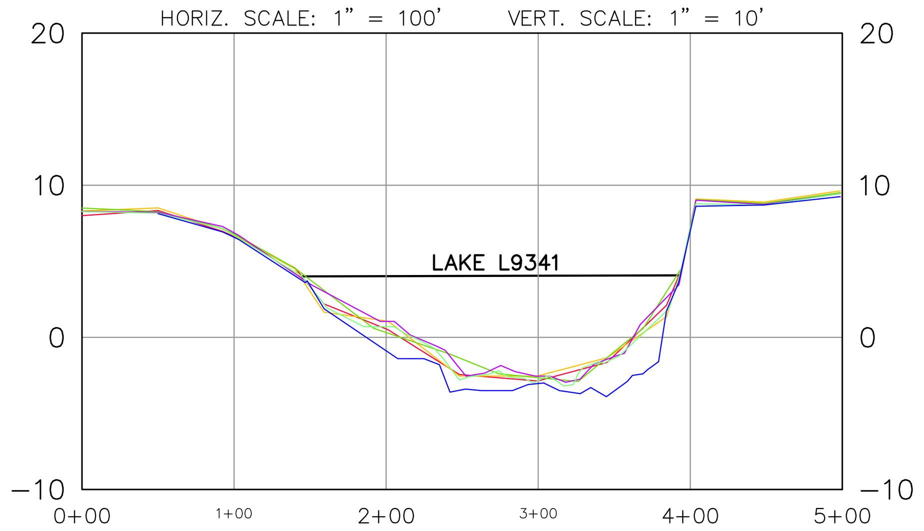
Profile View of Transect–35
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



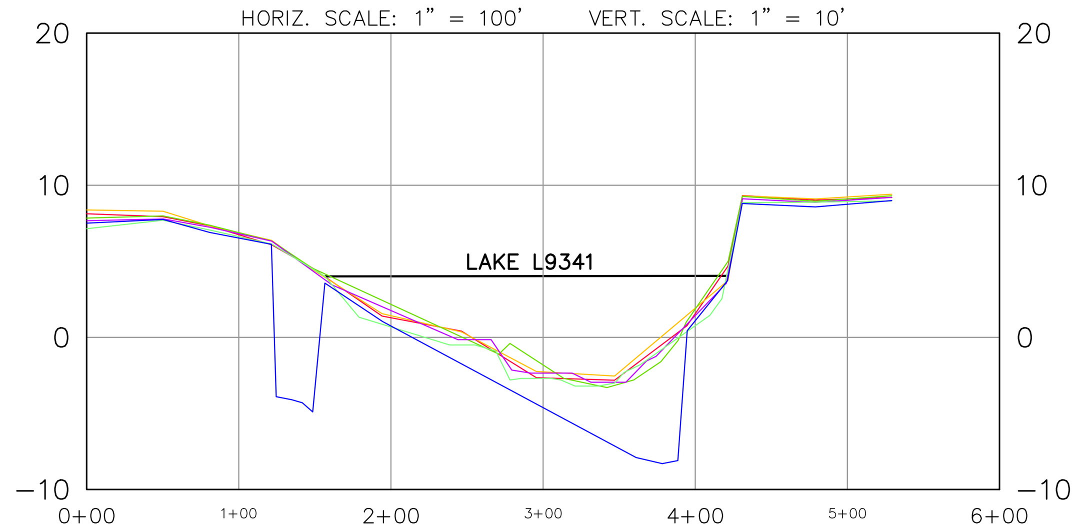
Profile View of Transect–36
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



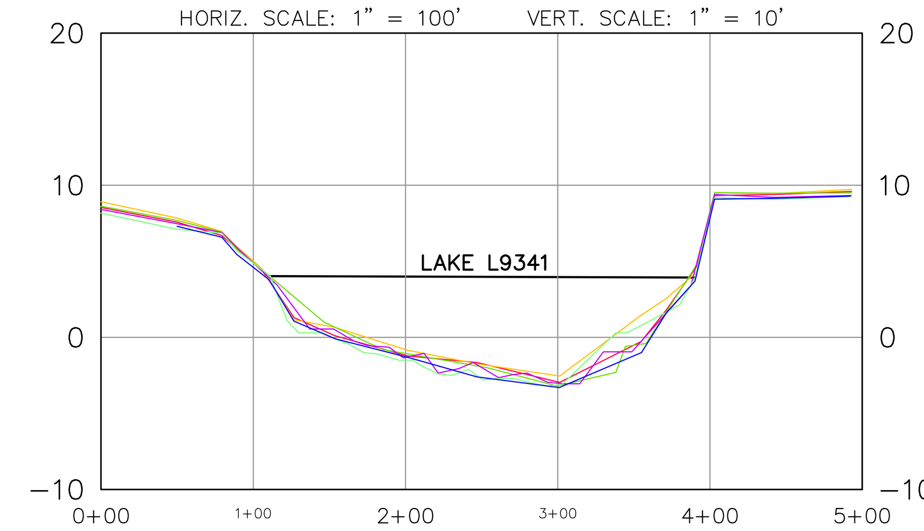
Profile View of Transect–37
HORIZ. SCALE: 1" = 100' VERT. SCALE: 1" = 10'



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



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



LEGEND:
VIEW LOOKING DOWNSTREAM

- 2013 TRANSECT PROFILE
- 2014 TRANSECT PROFILE
- 2015 TRANSECT PROFILE
- 2016 TRANSECT PROFILE
- 2017 TRANSECT PROFILE
- 2018 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
3	8/20/18	UPDATED PER K180003ACS	SZ	CZ			
2	10/9/17	UPDATED PER K170003ACS	KD	CZ			
1	7/29/16	UPDATED PER K160003ACS	CZ	DB			

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

ConocoPhillips Alaska, Inc.

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

ALPINE MODULE: CD50 UNIT: CD

CD-5 ROAD
MONITORING PROFILE BASELINES
ALPINE, ALASKA

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

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

Calc'd By: SZ
Date: 8/20/18
RPT-CE-CD-114 REV6

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV6

STA	2013	2016	2017	2018	Description
0+00	8.4	8.2	8.3	8.5	Ground Shot
1+00	8.4	8.5	8.4	8.3	Ground Shot
1+50	8.1		8.1	8.5	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	1.5	Toe of Bank
Varies	0.0	0.3	-0.8	1.5	Edge of Water
2+24	-5.5	-6.4	-5.5	-3.1	River Bottom
2+73	-24.2	-24.2	-24.9	-25.7	River Bottom
3+22	-25.0	-23.2	-24.7	-27.9	River Bottom
3+71	-21.3	-22.1	-21.9	-25.2	River Bottom
4+27	-19.0	-21.7	-20.1	-22.0	River Bottom
4+82	-15.5	-14.2	-15.8	-16.5	River Bottom
5+31	-10.0	-13.1	-13.1	-13.9	River Bottom
5+70	-3.7	-6.8	-4.1	-4.6	River Bottom
Varies	0.1	0.3	-0.1	1.3	Edge of Water
7+00	4.2	4.6	4.4	4.5	Sand Bar
8+00	5.6	5.0	5.0	5.0	Sand Bar
9+00	6.4	7.0	6.6	6.6	Sand Bar
10+00	6.8	7.2	6.9	6.9	Sand Bar
11+00	7.2	7.5	7.3	7.2	Sand Bar
12+00	6.7	7.1	6.7	6.8	Sand Bar
13+00	5.9	5.9	5.7	5.8	Sand Bar
14+00	2.7	2.3	2.2	2.1	Sand Bar
15+00	2.7	2.9	2.8	2.9	Sand Bar
16+00	2.4	2.2	2.1	2.5	Sand Bar
17+00	1.5	1.0	0.9	0.9	Sand Bar
18+00	0.6	0.1	0.1	0.1	Sand Bar
Varies	0.3	0.3	0.1	1.5	Edge of Water
20+98	-2.9	-2.1	-2.5	-2.3	River Bottom
21+53	-2.6	-2.6	-3.0	-1.9	River Bottom
21+96	-2.8	-2.3	-1.9	-1.5	River Bottom
22+55	-2.8	-2.0	-2.1	-1.1	River Bottom
23+00	-2.6	-2.0	-1.7	-1.1	River Bottom
23+59	-2.6	-2.1	-2.0	-1.5	River Bottom
24+05	-3.4	-1.3	-1.9	-1.3	River Bottom
Varies	0.3	0.3	0.1	1.4	Edge of Water
24+50	7.3	7.3	7.2	6.7	Top of Bank
25+02			9.1	9.2	Ground Shot
25+50	8.9	9.2	9.2	9.0	Ground Shot
26+51	9.1	9.3	9.1	9.2	Ground Shot

Doc LCMF-156 CD5 Bridge Transects Rev6_reformatted.xlsx 1 of 22 Transect_01

Calc'd By: SZ
Date: 8/20/2018
RPT-CE-CD-114 REV6

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV6

STA	2013	2016	2017	2018	Description
0+00	8.9	8.5	8.5	8.7	Ground Shot
1+00	8.7	8.6	8.6	8.3	Ground Shot
1+50			7.5	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	1.5	Edge of Water
2+12	-2.8	-2.7	-3.0	-1.8	River Bottom
2+35	-3.4	-3.1	-3.9	-4.9	River Bottom
2+58	-4.3	-4.7	-3.5	-5.7	River Bottom
2+81	-5.4	-6.1	-5.6	-7.2	River Bottom
3+10	-7.6	-8.4	-9.2	-10.2	River Bottom
3+27	-8.1	-13.2	-18.0	-11.5	River Bottom
3+47	-11.1	-25.2	-22.8	-11.5	River Bottom
3+67	-21.7	-18.5	-18.1	-19.4	River Bottom
3+87	-17.6	-16.7	-16.0	-16.7	River Bottom
4+07	-14.3	-15.1	-14.9	-16.4	River Bottom
4+27	-13.5	-13.3	-13.2	-16.1	River Bottom
4+46	-12.2	-11.4	-12.4	-13.2	River Bottom
4+78	-10.7	-10.7	-12.0	-11.8	River Bottom
4+98	-9.7	-9.7	-10.4	-12.3	River Bottom
5+18	-9.3	-8.5	-10.2	-11.8	River Bottom
5+35	-8.7	-8.0	-9.3	-11.0	River Bottom
5+55	-8.1	-7.6	-8.8	-10.3	River Bottom
5+81	-7.6	-7.4	-8.1	-8.9	River Bottom
6+01	-7.1	-6.8	-7.5	-8.0	River Bottom
6+24	-6.3	-6.1	-7.2	-8.0	River Bottom
6+44	-5.9	-5.5	-6.5	-7.0	River Bottom
6+64	-5.5	-5.0	-5.9	-6.6	River Bottom
6+83	-4.7	-4.4	-5.5	-6.8	River Bottom
7+03	-4.9	-3.7	-5.5	-6.3	River Bottom
7+23	-4.0	-3.9	-5.4	-5.5	River Bottom
7+55	-3.4	-3.5	-4.3	-5.0	River Bottom
7+75	-2.7	-2.4	-3.7	-4.5	River Bottom
7+92	-2.5	-2.1	-3.7	-4.4	River Bottom
8+09	-2.2	-1.8	-3.3	-4.0	River Bottom
8+38	-1.9	-1.3	-2.6	-3.1	River Bottom
8+55	-2.1	-1.0	-2.2	-2.0	River Bottom
Varies	0.8	0.2	0.7	1.5	Edge of Water
10+00	1.8	1.3	1.3	1.3	Sand Bar
11+00	1.9	1.6	1.7	1.5	Sand Bar
12+00	2.0	2.6	2.3	2.2	Sand Bar
13+00	2.2	2.8	2.6	1.2	Sand Bar
14+00	2.0	2.8	2.7	2.5	Sand Bar
15+00	2.1	2.6	2.6	2.6	Sand Bar
16+00	1.9	2.3	2.2	2.5	Sand Bar
17+00	1.6	2.1	2.0	2.1	Sand Bar
18+00	1.3	0.1	0.5	1.0	Sand Bar
19+00	0.8	0.9	0.9	0.8	Sand Bar
Varies	0.8	0.0	-0.3	1.6	Edge of Water
20+84	-2.4	-1.6	-1.6	-0.7	River Bottom
21+07	-2.5	-2.0	-2.0	-1.7	River Bottom
21+36	-2.1	-2.6	-2.5	-2.9	River Bottom
21+53	-2.5	-2.9	-3.6	-3.4	River Bottom

Doc LCMF-156 CD5 Bridge Transects Rev6_reformatted.xlsx 2 of 22 Transect_02

Calc'd By: SZ
Date: 8/20/2018
RPT-CE-CD-114 REV6

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV6

STA	2013	2016	2017	2018	Description
21+72	-2.9	-3.4	-3.5	-3.6	River Bottom
21+85	-2.9	-3.3	-3.0	-3.9	River Bottom
22+01	-4.1	-3.0	-3.0	-5.1	River Bottom
22+21	-4.7	-4.0	-3.4	-5.4	River Bottom
22+38	-5.6	-4.6	-4.2	-6.2	River Bottom
22+55	-6.2	-4.6	-5.0	-7.0	River Bottom
22+75	-4.6	-5.5	-5.6	-7.5	River Bottom
Varies	0.7	0.0	0.2	1.6	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	7.1	Top of Bank
23+90	8.6	8.7	8.9		Ground Shot
24+50	9.0	9.1	8.9	8.9	Ground Shot
25+40	9.3	9.4	9.2	9.0	Ground Shot

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Calc'd By: SZ
Date: 8/20/2018
RPT-CE-CD-114 REV6

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV6

STA	2013	2016	2017	2018	Description
0+00	10.0	9.5	9.6	9.6	Ground Shot
1+00	10.8	10.7	10.8	10.7	Ground Shot
2+00	11.4	11.3	11.4	11.3	Ground Shot
2+17	11.1	11.0	11.0	-	Top of Bank
2+47	6.4	6.3	6.3	6.2	Toe of Bank
3+00	6.4	6.5	6.5	6.3	Ground Shot
4+00	7.6	7.7	7.7	7.7	Ground Shot
5+00	6.8	7.0	6.9	7.0	Ground Shot
5+25	6.1	6.0	6.0	6.0	Top of Bank
5+74	1.7	2.0	2.0	2.0	Toe of Bank
6+00	1.5	1.9	1.7	1.9	Sand Bar
7+00	3.2	3.9	4.0	3.9	Sand Bar
8+00	4.8	4.6	4.6	4.6	Sand Bar
9+00	5.6	5.8	5.8	6.4	Sand Bar
9+27	5.7	5.1	4.9	4.9	Top of Bank
9+40	2.0	4.2	3.9	4.0	Toe of Bank
Varies	0.2	0.8	0.4	0.5	Edge of Water
10+85	-2.2	-1.0	-2.2	-0.8	River Bottom
10+95	-2.2	-1.3	-2.6	-2.9	River Bottom
11+07	-2.3	-1.6	-3.1	-4.0	River Bottom
11+17	-3.1	-1.9	-3.5	-4.6	River Bottom
11+31	-3.8	-2.3	-4.1	-5.1	River Bottom
11+44	-4.3	-3.9	-4.6	-5.9	River Bottom
11+60	-5.0	-4.9	-5.8	-6.7	River Bottom
11+85	-6.1	-5.6	-6.5	-7.8	River Bottom
12+07	-6.8	-6.7	-7.7	-8.9	River Bottom
12+23	-7.3	-7.0	-7.6	-9.0	River Bottom
12+48	-7.4	-6.8	-7.4	-9.3	River Bottom
12+72	-7.4	-6.7	-7.0	-8.8	River Bottom
12+89	-7.4	-6.4	-6.7	-9.9	River Bottom
13+15	-7.4	-6.3	-6.8	-8.6	River Bottom
13+40	-7.3	-6.3	-7.6	-8.7	River Bottom
13+64	-7.5	-6.3	-7.3	-8.1	River Bottom
13+81	-7.4	-6.8	-6.9	-8.4	River Bottom
14+07	-7.3	-6.7	-6.9	-7.6	River Bottom
14+32	-6.9	-6.3	-7.2	-7.4	River Bottom
14+48	-6.6	-7.0	-7.0	-8.9	River Bottom
14+75	-7.9	-5.6	-7.3	-8.1	River Bottom
14+99	-8.2	-6.0	-7.6	-7.5	River Bottom
15+16	-8.2	-5.9	-7.2	-8.2	River Bottom
15+42	-8.3	-7.2	-7.3	-9.3	River Bottom
15+61	-8.0	-7.3	-7.6	-8.5	River Bottom
15+86	-8.5	-7.0	-8.1	-9.3	River Bottom
16+02	-8.6	-7.3	-8.7	-8.6	River Bottom
16+27	-8.5	-7.6	-8.8	-9.1	River Bottom
16+51	-8.9	-7.3	-8.6	-9.7	River Bottom
16+75	-8.3	-7.9	-8.4	-9.6	River Bottom
16+98	-8.6	-8.2	-8.8	-10.1	River Bottom
17+14	-8.2	-8.8	-9.2	-10.7	River Bottom
17+39	-7.7	-8.7	-9.8	-10.4	River Bottom
17+63	-7.5	-8.7	-10.2	-10.7	River Bottom
17+85	-7.6	-9.5	-10.5	-11.6	River Bottom
18+02	-7.1	-10.0	-10.7	-11.8	River Bottom

Doc LCMF-156 CD5 Bridge Transects Rev6_reformatted.xlsx 4 of 22 Transect_03

Calc'd By: SZ
Date: 8/20/2018
RPT-CE-CD-114 REV6

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV6

STA	2013	2016	2017	2018	Description
18+28	-7.7	-9.8	-10.4	-12.2	River Bottom
18+53	-7.4	-8.8	-9.6	-11.2	River Bottom
18+69	-7.7	-8.3	-8.6	-10.3	River Bottom
18+96	-8.0	-7.6	-8.0	-9.9	River Bottom
19+12	-6.9	-7.0	-7.4	-9.6	River Bottom
19+37	-6.6	-5.7	-6.6	-9.6	River Bottom
19+53	-7.0	-6.1	-6.8	-8.8	River Bottom
19+80	-7.1	-6.0	-7.0	-8.7	River Bottom
20+04	-7.0	-5.8	-7.2	-7.9	River Bottom
20+19	-7.4	-5.6	-7.1	-7.9	River Bottom
20+43	-7.6	-7.0	-7.5	-8.3	River Bottom
20+60	-6.0	-6.9	-7.9	-8.4	River Bottom
20+82	-5.6	-6.0	-6.8	-7.6	River Bottom
21+04	-5.2	-5.4	-6.2	-6.8	River Bottom
21+19	-4.9	-5.4	-6.0	-7.0	River Bottom
21+31	-3.8	-4.8	-6.0	-6.0	River Bottom
21+50	-2.2	-1.9	-4.1	-4.0	River Bottom
Varies	-0.4	0.9	0.2	0.4	Edge of Water
22+22	-	1.0	0.8	0.5	Toe of Bank
22+35	-	9.0	8.8	8.8	Top of Bank
23+00	8.2	8.7	8.9	8.6	Ground Shot
23+22	9.2	10.0	9.8	9.5	Top of Bank
23+36	8.1	8.5	8.5	8.2	Toe of Bank
23+76	7.9	8.9	8.7	8.4	Toe of Bank
24+15	10.7	11.5	11.5	11.3	Top of Bank
24+22	8.9	9.4	9.3	9.4	Toe of Bank

Doc LCMF-156 CD5 Bridge Transects Rev6_reformatted.xlsx 5 of 22 Transect_03

Calc'd By: SZ
Date: 8/20/2018
RPT-CE-CD-114 REV6

CD-5 Michael Baker
Bridge Transects

Kuukpik/LCMF
Alpine Survey Office
DOC LCMF-156 REV6

STA	2013	2016	2017	2018	Description
0+00	12.2	12.6	12.4	12.5	Ground Shot
1+00	12.8	13.0	13.0	12.9	Ground Shot
2+00	14.2	14.4	14.5	14.6	Ground Shot
3+00	16.1	16.2	16.3	16.2	Ground Shot
3+91	14.7	15.2	15.2	15.0	Top of Bank
4+24	11.5	11.6	11.6	11.5	Toe of Bank
5+00	12.1	12.1	12.1	12.0	Ground Shot
5+12	12.4	12.4	12.3	12.2	Top of Bank
5+49	8.6	8.7	8.8	8.6	Toe of Bank
5+74	8.3	8.4	8.5	8.3	Toe of Bank
5+83	10.7	10.9	10.8	10.7	Top of Bank
5+91	10.7	11.0	10.9	10.8	Top of Bank
6+04	8.2	8.6	8.6	8.7	Toe of Bank
6+47	7.5	8.0	8.1	8.2	Toe of Bank
6+59	9.7	9.2	9.1	9.1	Top of Bank
7+05	8.0	7.9	8.1	8.2	Top of Bank
7+31	5.3	5.9	5.8	5.8	Toe of Bank
8+00	4.9	5.3	5.1	5.1	Sand Bar
9+00	4.2	4.9	4.7	4.5	Sand Bar
10+00	4.7	3.3	3.4	3.3	Sand Bar
11+00	4.5	3.8	3.6	3.6	Sand Bar
12+00	3.9	4.5	3.9	4.0	Sand Bar
13+00	3.0	3.3	3.3	3.2	Sand Bar
14+00	2.8	2.2	2.8	2.7	Sand Bar
15+00	3.1	3.0	2.9	3.0	Sand Bar
16+00	3.2	2.3	2.2	2.2	Sand Bar
Varies	-0.1	1.0	1.0	-0.3	Edge of Water
16+70	-3.1	-0.7	-1.6	-1.4	River Bottom
16+84	-6.0	-1.7	-3.4	-4.0	River Bottom
17+01	-8.6	-4.0	-8.6	-4.1	River Bottom
17+18	-12.4	-5.8	-12.4	-8.6	River Bottom
17+42	-15.3	-11.4	-12.4	-12.7	River Bottom
17+63	-16.5	-14.5	-15.3	-14.5	River Bottom
17+80	-15.7	-15.7	-16.2	-16.0	River Bottom
18+00	-16.4	-15.5	-16.2	-17.4	River Bottom
18+21	-17.6	-16.3	-17.3	-18.5	River Bottom
18+36	-19.2	-17.4	-18.4	-19.5	River Bottom
18+55	-19.3	-18.9	-19.9	-21.0	River Bottom
18+79	-19.9	-19.7	-20.2	-23.3	River Bottom
18+96	-20.3	-20.1	-20.7	-23.3	River Bottom
19+13	-19.4	-20.8	-21.0	-23.3	River Bottom
19+37	-20.2	-21.2	-21.6	-25.3	River Bottom
19+54	-21.1	-22.1	-21.8	-24.0	River Bottom
19+75	-21.3	-22.6	-22.6	-23.9	River Bottom
19+92	-20.9	-22.9	-22.9	-24.7	River Bottom
20+12	-20.4	-22.4	-22.8	-24.3	River Bottom
20+29	-20.2	-21.9	-22.3	-24.0	River Bottom
20+48	-19.9	-21.8	-21.8	-23.8	River Bottom
20+65	-19.7	-20.8	-20.8	-23.6	River Bottom
20+84	-18.6	-19.3	-19.8	-21.9	River Bottom
21+06	-15.1	-18.1	-18.0	-20.5	River Bottom
21+15	-10.4	-15.9	-17.3	-18.8	River Bottom
Varies	-0.2	1.1	0.2	-0.3	Edge of Water

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STA	2013	2016	2017	2018	Description
21+91	2.1	1.5	2.0	0.9	Toe of Bank
21+98	10.1	9.3	9.3	9.3	Top of Bank
22+53			10.2	10.2	Ground Shot
23+00	10.7	10.8	10.8	10.7	Ground Shot
24+03	10.4	10.3	10.4	10.4	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	11.9	11.9	11.9	12.1	Ground Shot
1+00	12.0	12.1	12.0	11.9	Ground Shot
2+00	15.5	15.5	15.5	15.4	Ground Shot
3+00	16.1	16.0	16.0	15.8	Ground Shot
4+00	15.4	15.4	15.4	15.3	Ground Shot
4+56	17.2	17.1	17.0	16.9	Top of Bank
4+65	14.2	14.2	14.1	14.0	Toe of Bank
4+81	14.3	14.1	14.1	14.1	Toe of Bank
5+08	18.5	18.2	18.2	18.1	Top of Bank
5+36	13.6	13.4	13.3	13.3	Toe of Bank
5+82	15.9	15.7	15.6	15.5	Top of Bank
6+16	12.6	12.5	12.4	12.3	Toe of Bank
6+92	13.0	12.9	13.4	13.4	Top of Bank
7+20	7.8	7.8	7.5	7.7	Toe of Bank
8+00	5.9	6.3	6.5	6.3	Sand Bar
9+00	5.6	5.7	5.6	5.5	Sand Bar
10+00	6.1	5.6	5.6	5.6	Sand Bar
11+00	5.7	5.3	5.1	5.3	Sand Bar
12+00	4.4	3.7	3.7	3.7	Sand Bar
13+00	3.0	3.1	3.1	3.0	Sand Bar
14+00	2.5	2.3	2.2	1.9	Sand Bar
15+00	2.4	1.1	1.1	1.3	Sand Bar
16+00	1.9	1.4	1.3	1.5	Sand Bar
17+00	2.0	2.1	2.1	2.2	Sand Bar
18+00	1.6	2.3	2.3	2.5	Sand Bar
19+00	1.0	1.6	1.6	1.9	Sand Bar
20+00	1.2	0.5	0.3	0.6	Sand Bar
21+00	0.6	0.8	0.8	-0.3	Sand Bar
Varies	-0.5	0.8	0.8	-0.3	Edge of Water
21+62	-6.1	-3.5	-3.5	-3.6	River Bottom
21+79	-8.2	-4.4	-4.8	-5.8	River Bottom
21+96	-8.4	-6.8	-5.8	6.8	River Bottom
22+17	-9.5	-8.3	-8.0	-7.5	River Bottom
22+36	-11.3	-9.7	-10.7	-10.4	River Bottom
22+53	-12.1	-11.0	-11.7	-12.1	River Bottom
22+73	-15.1	-14.3	-13.4	-15.0	River Bottom
22+93	-16.8	-16.0	-15.6	-16.6	River Bottom
23+13	-19.1	-17.5	-17.3	-19.5	River Bottom
23+30	-21.4	-18.9	-18.8	-21.8	River Bottom
23+49	-22.4	-20.2	-20.5	-23.2	River Bottom
23+73	-22.5	-21.1	-22.2	-24.3	River Bottom
23+93	-22.2	-23.4	-23.3	-24.7	River Bottom
24+10	-22.4	-24.0	-23.1	-24.9	River Bottom
24+29	-22.2	-23.7	-23.5	-25.4	River Bottom
24+53	-23.4	-23.2	-23.2	-28.8	River Bottom
24+70	-23.3	-24.3	-23.3	-25.8	River Bottom
24+87	-20.5	-24.5	-23.9	-26.4	River Bottom
25+04	-21.6	-24.0	-24.2	-26.4	River Bottom
25+18	-20.5	-24.1	-23.8	-27.0	River Bottom
25+30	-16.9	-23.6	-23.4	-25.4	River Bottom
25+47	-8.2	-21.3	-23.6	-25.5	River Bottom
Varies	-0.5	0.8	-0.5	-0.3	Edge of Water
25+87	8.5	-	-	-	Top of Bank (2013)

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STA	2013	2016	2017	2018	Description
26+11		8.6	-	-	Top of Bank (2016)
26+17			8.5	8.1	Top of Bank
27+00	8.6	8.5	8.5	8.5	Ground Shot
27+70	8.7	8.7	8.6	8.6	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	11.4	11.6	11.5	11.5	Ground Shot
1+00	11.0	11.1	11.1	11.1	Ground Shot
2+00	14.0	13.9	14.0	13.9	Ground Shot
3+00	15.3	15.2	15.4	15.2	Ground Shot
3+42	17.1	16.9	16.8	16.8	Top of Bank
3+59	12.5	12.3	12.4	12.5	Toe of Bank
4+08	14.8	14.6	14.7	14.6	Top of Bank
4+23	11.1	11.1	11.0	11.0	Toe of Bank
4+96	12.3	12.2	12.2	12.1	Top of Bank
5+11	9.8	9.8	9.8	9.8	Toe of Bank
5+81	7.8	7.7	7.7	7.7	Top of Bank
6+31	1.1	0.4	0.5	0.4	Edge of Water/Toe of Bank
7+00	-0.3	-0.5	-0.5	-0.8	River Bottom
8+00	0.5	0.0	0.1	0.3	Edge of Water
9+00	1.0	0.0	0.0	0.0	Sand Bar
10+00	1.4	0.3	0.4	0.1	Sand Bar
11+00	1.8	1.0	1.1	1.2	Sand Bar
12+00	2.3	1.1	0.8	0.9	Sand Bar
13+00	2.0	0.5	0.4	-0.3	Sand Bar
Varies	-0.2	0.5	0.4	-0.4	Edge of Water
14+68	-3.3	-1.5	-2.1	-3.2	River Bottom
14+78	-3.1	-1.7	-2.2	-2.0	River Bottom
14+94	-2.8	-1.9	-2.3	-2.3	River Bottom
15+14	-2.4	-2.1	-2.5	-2.8	River Bottom
15+34	-2.8	-2.3	-2.7	-3.0	River Bottom
15+49	-2.6	-2.5	-2.9	-3.3	River Bottom
15+72	-2.9	-2.8	-3.1	-2.7	River Bottom
15+95	-3.5	-3.1	-3.3	-2.6	River Bottom
16+15	-3.3	-3.5	-3.5	-3.2	River Bottom
16+38	-3.8	-3.5	-3.7	-3.1	River Bottom
16+61	-4.1	-4.4	-3.9	-4.3	River Bottom
16+87	-4.1	-5.4	-7.3	7.3	River Bottom
17+06	-4.8	-5.6	-7.7	-8.0	River Bottom
17+29	-5.3	-5.6	-9.2	-7.9	River Bottom
17+55	-7.2	-8.0	-9.1	-9.0	River Bottom
17+82	-10.0	-10.2	-12.5	-12.0	River Bottom
18+08	-13.4	-12.2	-15.7	-14.6	River Bottom
18+31	-17.8	-16.2	-19.7	-16.5	River Bottom
18+57	-19.9	-17.4	-20.8	-19.2	River Bottom
18+80	-20.3	-19.8	-22.0	-21.5	River Bottom
19+02	-20.8	-20.4	-23.1	-23.0	River Bottom
19+28	-24.5	-23.3	-24.7	-24.7	River Bottom
19+51	-24.1	-23.5	-26.4	-26.6	River Bottom
19+74	-20.4	-23.1	-26.8	-25.0	River Bottom
19+93	-12.5	-16.2	-24.0	-26.5	River Bottom
20+10	-8.6	-4.1	-20.7	-6.6	River Bottom
Varies	-0.3	0.6	1.6	-0.3	Edge of Water
20+63	-	9.4	9.0	8.5	Top of Bank
21+50	9.8	10.0	9.9	9.9	Ground Shot
22+50	9.3	9.5	9.4	9.5	Ground Shot
23+24	9.8	9.8	9.7	9.8	Ground Shot

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STA	2013	2014	2015	2016	2017	2018	Description
0+00	10.6	10.9	10.7	10.7	10.5	10.6	Ground Shot
1+00	10.1	10.4	10.4	10.3	10.3	10.3	Ground Shot
1+50	12.2	12.4	12.4	12.3	12.3	12.4	Ground Shot
1+77	13.4	13.7	13.7	13.5	13.5	13.5	Grade Break
2+00	11.3	11.6	11.7	11.6	11.6	11.6	Ground Shot
2+20			8.4	8.3	8.0	8.1	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	3.1	Toe of Bank
Varies	0.6	0.5	0.8	0.3	1.0	-0.3	Edge of Water
4+93	-2.5	-4.1	-4.2	-4.0	-4.0	-3.9	River Bottom
5+06	-2.5	-4.4	-4.6	-4.0	-4.5	-4.4	River Bottom
5+25	-2.6	-3.6	-5.0	-4.3	-5.0	-5.0	River Bottom
5+45	-2.7	-3.7	-5.3	-4.7	-5.0	-5.2	River Bottom
5+68	-3.7	-3.8	-6.6	-5.6	-6.2	-6.8	River Bottom
5+91	-4.5	-5.2	-7.0	-7.0	-7.0	-7.1	River Bottom
6+17	-5.8	-7.6	-7.3	-7.5	-7.6	-7.6	River Bottom
6+42	-7.4	-7.2	-7.7	-7.3	-7.7	-7.7	River Bottom
6+65	-7.7	-7.4	-7.7	-7.2	-7.2	-8.0	River Bottom
6+88	-7.2	-6.3	-7.7	-6.4	-6.7	-7.6	River Bottom
7+11	-6.8	-6.0	-7.6	-6.6	-6.7	-8.2	River Bottom
7+37	-5.4	-5.5	-7.6	-6.8	-6.9	-7.8	River Bottom
7+56	-5.1	-6.3	-7.6	-7.2	-7.3	-7.9	River Bottom
7+82	-4.9	-7.1	-7.6	-7.3	-7.7	-7.7	River Bottom
8+02	-4.3	-7.1	-7.6	-6.7	-7.3	-7.8	River Bottom
8+25	-3.6	-5.6	-7.6	-7.5	-6.9	-7.9	River Bottom
8+50	-4.2	-5.9	-7.5	-7.0	-6.8	-7.1	River Bottom
8+74	-5.6	-6.2	-7.5	-7.2	-7.5	-7.0	River Bottom
9+03	-5.9	-6.1	-7.4	-7.5	-7.9	-8.0	River Bottom
9+32	-7.6	-5.5	-7.2	-7.8	-7.6	-7.8	River Bottom
9+58	-7.0	-6.7	-7.0	-7.3	-7.6	-6.6	River Bottom
9+84	-9.8	-7.4	-6.9	-8.2	-7.9	-6.2	River Bottom
10+10	-9.9	-10.8	-7.4	-7.8	-8.0	-6.2	River Bottom
10+39	-9.5	-10.5	-8.0	-8.2	-8.5	-6.7	River Bottom
10+68	-8.7	-9.2	-7.8	-7.5	-7.9	-7.9	River Bottom
10+91	-8.3	-9.3	-7.6	-7.8	-7.9	-9.6	River Bottom
11+21	-8.9	-9.4	-7.4	-7.8	-8.4	-9.3	River Bottom
11+50	-9.2	-9.7	-9.4	-7.5	-8.4	-8.6	River Bottom
11+76	-9.4	-10.5	-10.3	-7.2	-7.7	-9.0	River Bottom
12+02	-11.0	-10.7	-9.9	-8.4	-8.6	-8.6	River Bottom
12+31	-11.6	-10.7	-9.5	-8.1	-8.4	-8.6	River Bottom
12+57	-10.4	-9.4	-9.1	-7.5	-8.0	-8.6	River Bottom
12+83	-9.0	-9.5	-8.8	-7.7	-7.9	-8.4	River Bottom
13+09	-8.4	-8.7	-8.0	-7.2	-7.4	-7.9	River Bottom
13+35	-7.6	-8.1	-7.6	-6.8	-6.8	-7.0	River Bottom
13+64	-6.7	-7.2	-7.2	-6.4	-6.5	-6.5	River Bottom
13+87	-6.3	-6.7	-6.5	-6.1	-6.3	-6.4	River Bottom
14+17	-5.7	-6.5	-6.3	-5.6	-5.7	-5.7	River Bottom
14+40	-5.9	-6.2	-6.2	-5.4	-5.5	-5.6	River Bottom
14+69	-6.6	-6.5	-6.3	-5.7	-5.7	-5.4	River Bottom
14+98	-7.8	-7.9	-7.8	-6.5	-6.4	-6.1	River Bottom
15+24	-10.7	-10.6	-9.2	-7.8	-8.6	-7.9	River Bottom
15+53	-13.6	-13.3	-11.8	-10.9	-10.9	-10.5	River Bottom
15+79	-14.7	-13.9	-12.6	-12.2	-11.9	-11.5	River Bottom

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STA	2013	2014	2015	2016	2017	2018	Description
16+02	-11.1	-12.3	-12.3	-12.3	-12.2	-11.8	River Bottom
Varies	0.7	0.5	0.2	0.3	1.0	-0.2	Edge of Water
16+95	8.5	8.4	8.4	8.3	-	-	Top of Bank (2016)
16+97					8.7	7.9	Top of Bank
17+00	9.2	9.5	9.4	9.3	9.2	8.9	Ground Shot
17+57	10.1	10.3	10.0	9.7	9.6	9.8	Ground Shot
18+00	9.4	9.6	9.6	9.5	9.4	9.5	Ground Shot
19+00	10.2	10.5	10.6	10.4	10.2	10.3	Ground Shot
19+07	10.8	10.9	10.7	10.5	10.3	10.5	Ground Shot

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

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

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

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STA	2013	2016	2017	2018	Description
0+00	10.9	10.9	10.7	10.7	Ground Shot
1+00	10.4	10.7	10.5	10.7	Ground Shot
1+47			9.1	8.8	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	-0.2	Edge of Water
2+01	-10.6	-28.3	-25.0	-26.9	River Bottom
2+16	-19.0	-33.1	-31.0	-32.5	River Bottom
2+36	-30.7	-36.7	-36.1	-36.2	River Bottom
2+59	-33.6	-36.6	-36.4	-36.7	River Bottom
2+82	-35.3	-36.7	-36.4	-36.9	River Bottom
3+08	-32.7	-35.9	-35.5	-35.5	River Bottom
3+28	-31.4	-34.0	-33.3	-33.6	River Bottom
3+54	-30.9	-31.8	-31.8	-31.4	River Bottom
3+77	-30.0	-29.7	-29.2	-28.2	River Bottom
4+00	-30.0	-25.0	-25.8	-25.1	River Bottom
4+23	-27.8	-22.5	-22.5	-22.1	River Bottom
4+48	-25.6	-18.3	-19.2	-17.3	River Bottom
4+68	-22.7	-16.0	-16.4	-14.6	River Bottom
4+94	-20.1	-13.7	-13.3	-10.7	River Bottom
5+16	-17.5	-12.3	-11.5	-8.6	River Bottom
5+40	-14.9	-11.1	-10.8	-7.9	River Bottom
5+62	-13.5	-9.1	-9.1	-7.3	River Bottom
5+82	-10.5	-5.6	-6.1	-4.9	River Bottom
6+02	-6.1	-3.6	-3.8	-4.5	River Bottom
Varies	0.2	0.8	0.9	-0.3	Edge of Water
7+00	2.9	3.4	3.4	3.5	Sand Bar
7+90	4.9	5.1	5.0	5.1	Edge of Vegetation
8+00	4.9	5.1	5.0	5.2	Ground Shot
9+00	5.5	5.6	5.6	5.7	Ground Shot
10+00	5.1	5.2	5.2	5.3	Ground Shot
11+00	5.6	5.7	5.7	5.8	Ground Shot
12+00	5.8	5.9	5.9	6.1	Ground Shot
13+00	5.5	5.8	5.7	5.8	Ground Shot
14+00	6.2	6.3	6.3	6.4	Ground Shot
15+00	6.1	6.2	6.1	6.1	Ground Shot
16+00	6.3	6.5	6.5	6.6	Edge of Vegetation
16+52	6.7	6.8	6.8	6.9	Grade Break
16+62	8.0	8.2	8.1	8.2	Grade Break
16+89	9.1	8.9	8.8	8.8	Ground Shot
17+00	8.9	9.1	9.1	9.3	Ground Shot
18+00	9.0	9.0	9.2	9.3	Ground Shot
18+39	10.2	10.2	9.8	9.4	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	11.0	11.0	10.8	10.9	Ground Shot
1+00	11.3	11.2	10.8	10.8	Ground Shot
2+00	9.9	10.4	10.2	10.4	Ground Shot
2+08	10.0	10.0	9.9	9.9	Top of Bank
2+22	4.9	5.6	5.6	5.7	Toe of Bank
3+00	2.2	3.1	3.1	3.3	Sand Bar
4+00	1.5	2.5	2.5	2.6	Sand Bar
5+00	1.8	2.3	2.2	2.5	Sand Bar
Varies	0.4	0.4	0.6	0.6	Edge of Water
5+79	-4.7	0.4	-1.7	-0.1	River Bottom
5+85	-5.1	-2.6	-2.1	-2.2	River Bottom
6+10	-9.0	-5.6	-3.9	-2.5	River Bottom
6+36	-17.5	-11.1	-11.3	-10.0	River Bottom
6+54	-24.6	-20.7	-18.4	-16.5	River Bottom
6+85	-28.6	-24.0	-25.9	-22.3	River Bottom
7+08	-32.0	-29.3	-28.6	-26.5	River Bottom
7+31	-33.5	-29.7	-29.8	-27.8	River Bottom
7+57	-33.9	-31.9	-31.6	-30.0	River Bottom
7+83	-33.0	-32.6	-32.6	-32.7	River Bottom
8+06	-32.1	-31.7	-32.2	-32.4	River Bottom
8+29	-31.0	-31.2	-31.1	-31.9	River Bottom
8+56	-31.1	-31.1	-29.6	-31.6	River Bottom
8+79	-31.3	-31.1	-30.8	-31.3	River Bottom
9+02	-30.7	-30.4	-30.6	-31.2	River Bottom
9+28	-29.9	-30.7	-30.6	-31.0	River Bottom
9+51	-27.1	-30.7	-30.6	-31.3	River Bottom
9+72	-23.2	-30.4	-28.1	-30.0	River Bottom
10+00	-20.1	-22.9	-21.9	-23.0	River Bottom
10+23	-3.0	-19.2	-19.1	-17.7	River Bottom
10+43	-3.2	-18.3	-15.9	-15.9	River Bottom
Varies	0.6	0.5	0.5	0.6	Edge of Water
11+05	9.5	-	-	-	Top of Bank (2013)
11+20		1.3	1.2	2.2	Toe of Bank
11+28		8.8	8.6	8.4	Top of Bank
12+00	9.4	9.1	9.0	9.1	Ground Shot
13+00	7.9	8.0	8.0	8.1	Edge of Vegetation
14+01	6.9	7.0	7.0	7.2	Ground Shot
15+01	7.2	7.3	7.3	7.5	Ground Shot
16+00	7.8	8.0	8.0	8.1	Ground Shot
17+01	8.3	8.4	8.4	8.5	Ground Shot
18+00	7.0	7.1	7.0	7.1	Ground Shot
19+00	6.3	6.6	6.7	6.9	Ground Shot
20+00	6.7	7.0	7.0	7.0	Ground Shot
21+00	6.7	7.1	7.0	7.0	Ground Shot
21+85	7.0	7.4	7.3	7.4	Toe of Bank
22+00	8.2	8.5	8.3	8.3	Top of Bank
22+16	8.8	8.6	8.4	8.6	Ground Shot
23+00	9.7	10.0	9.9	9.8	Ground Shot
23+67	10.2	10.0	9.4	9.7	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	10.6	11.4	11.2	11.4	Ground Shot
1+00	11.7	11.7	11.7	11.8	Ground Shot
1+50	12.1	11.9	12.0	12.1	Ground Shot
2+00	12.2	11.8	11.7	11.8	Ground Shot
2+34	11.2	11.1	10.9	11.0	Edge of Vegetation
3+00	10.3	9.9	10.2	10.1	Ground Shot
4+00	10.3	10.6	10.6	10.6	Ground Shot
4+36	10.9	10.9	10.8	11.1	Edge of Vegetation
5+00	11.7	11.6	11.6	11.8	Ground Shot
6+00	13.2	13.2	13.1	13.3	Ground Shot
7+00	14.1	13.7	13.6	13.7	Ground Shot
7+11	14.9	14.6	14.6	14.7	Grade Break
7+95	23.7	23.4	23.4	23.6	Grade Break
8+00	22.8	23.0	22.9	23.1	Ground Shot
9+00	22.4	22.4	22.4	22.6	Top of Bank
9+67	11.2	11.1	11.3	11.3	Toe of Bank
10+00	9.6	10.0	10.0	10.2	Sand Bar
11+00	7.3	7.6	7.7	7.7	Sand Bar
12+00	8.3	5.9	5.8	5.9	Sand Bar
13+00	5.0	4.8	4.8	5.0	Sand Bar
14+00	6.9	4.2	4.4	4.7	Sand Bar
15+00	5.8	3.9	4.1	4.4	Sand Bar
16+00	4.9	3.7	3.7	3.9	Sand Bar
17+00	4.4	3.3	3.4	3.6	Sand Bar
18+01	4.2	2.8	2.9	3.2	Sand Bar
19+00	3.1	2.6	2.6	2.9	Sand Bar
20+00	2.5	2.4	2.5	2.7	Sand Bar
21+00	2.3	2.4	2.4	2.6	Sand Bar
22+00	2.1	2.5	2.4	2.7	Sand Bar
23+00	2.5	2.2	2.3	2.5	Sand Bar
24+00	1.8	2.3	2.4	2.6	Sand Bar
25+00	2.0	2.2	2.2	2.6	Sand Bar
26+00	2.3	2.1	2.1	2.4	Sand Bar
27+00	3.0	2.2	2.1	2.4	Sand Bar
28+00	3.7	2.9	2.7	2.7	Sand Bar
29+00	3.6	2.8	2.7	2.8	Sand Bar
30+00	3.1	2.7	2.5	2.6	Sand Bar
31+00	3.4	2.1	2.0	2.3	Sand Bar
32+00	2.9	2.0	2.1	2.2	Sand Bar
33+00	2.1	1.5	1.5	1.8	Sand Bar
34+00	1.6	0.9	1.6	1.4	Sand Bar
35+00	1.2	-	1.2	2.0	Sand Bar
Varies	0.5	1.4	1.6	0.4	Edge of Water
36+19	-3.2	-2.8	-4.6	-5.9	River Bottom
36+39	-5.3	-4.4	-5.4	-7.0	River Bottom
36+59	-7.8	-5.0	-7.0	-7.5	River Bottom
36+79	-10.9	-5.8	-7.0	-8.0	River Bottom
37+07	-13.3	-8.7	-7.3	-8.2	River Bottom
37+30	-16.2	-9.0	-8.4	-8.7	River Bottom
37+59	-18.8	-10.0	-10.1	-10.0	River Bottom
37+84	-20.2	-11.5	-11.8	-11.2	River Bottom
38+16	-20.8	-15.6	-14.1	-14.0	River Bottom
38+38	-21.1	-16.7	-13.5	-15.2	River Bottom
38+70	-22.1	-19.2	-17.5	-17.7	River Bottom
38+92	-24.2	-22.1	-19.8	-19.0	River Bottom

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STA	2013	2016	2017	2018	Description
39+21	-22.6	-24.4	-21.8	-22.6	River Bottom
39+38	-3.7	-23.5	-22.9	-24.4	River Bottom
Varies	0.1	1.1	0.3	0.4	Edge of Water
40+00	8.7	-	-	-	Ground Shot (2013)
40+12		9.1	-	-	Top of Bank (2016)
40+17			8.4		Top of Bank (2017)
40+26			-	8.2	Top of Bank (2018)
41+00	8.1	8.6	8.6	8.7	Ground Shot
42+00	8.1	8.5	8.5	8.7	Ground Shot
43+00	8.0	8.4	8.3	8.4	Ground Shot
43+53	6.7	7.0	6.9	7.1	Edge of Vegetation
44+00	5.2	5.6	5.5	5.6	Top of Bank
Varies	0.2	1.4	1.4	0.5	Edge of Water
45+19	0.4	0.8	0.7	-0.5	River Bottom
45+64	-1.5	-0.4	-1.4	-1.3	River Bottom
46+13	-6.5	-5.7	-5.6	-6.6	River Bottom
46+62	-10.0	-8.8	-9.4	-10.1	River Bottom
47+14	-10.3	-9.5	-9.8	-10.4	River Bottom
47+65	-7.8	-7.5	-7.9	-8.2	River Bottom
48+13	-5.2	-4.8	-5.2	-5.6	River Bottom
48+65	-1.5	-0.5	-2.2	-2.3	River Bottom
Varies	-0.2	1.1	0.7	0.5	Edge of Water
49+22	6.8	6.9	6.6	6.4	Top of Bank
49+53	7.6	7.8	7.9	7.8	Grade Break
50+00	8.3	8.2	8.2	8.5	Ground Shot
50+14	11.7	11.5	11.4	11.4	Ground Shot
50+28	11.2	11.3	11.0	11.2	Grade Break
50+33	9.0	8.9	9.0	9.1	Grade Break
50+36	10.6	10.6	10.7	10.8	Grade Break
51+00	10.7	10.9	10.9	10.9	Ground Shot
51+30	10.5	10.7	11.0	11.0	Grade Break
51+34	9.2	9.3	9.4	9.4	Grade Break
51+44	10.1	10.0	10.1	10.1	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	13.2	13.2	13.1	13.1	Ground Shot
1+00	13.5	13.7	13.6	13.8	Ground Shot
1+65	15.7	15.6	15.5	15.5	Ground Shot
2+00	16.7	16.7	16.6	16.8	Ground Shot
3+00	18.8	18.8	18.8	18.9	Ground Shot
3+67	20.0	20.0	20.0	20.1	Grade Break
4+00	19.2	19.3	19.4	19.4	Ground Shot
4+76	19.3	19.3	19.2	19.5	Top of Bank
5+19	12.2	12.2	12.2	12.4	Toe of Bank
6+00	9.6	9.5	9.4	9.3	Edge of Vegetation
7+00	6.1	6.2	6.1	6.2	Edge of Vegetation
8+00	3.3	4.0	3.7	3.7	Sand Bar
9+00	2.8	2.4	2.4	2.5	Sand Bar
10+00	1.7	-	1.8	1.9	Sand Bar
11+00	0.5	-	0.5	-	Sand Bar
Varies	-0.1	1.7	1.8	1.5	Edge of Water
13+87	-2.6	-1.2	-2.2	-1.6	River Bottom
14+03	-2.7	-0.5	-2.2	-1.9	River Bottom
14+20	-3.2	-1.0	-2.0	-1.0	River Bottom
14+36	-2.4	-1.1	-1.9	-1.7	River Bottom
14+52	-3.0	-0.7	-1.7	-1.9	River Bottom
14+68	-3.0	-0.5	-1.8	-2.0	River Bottom
14+88	-2.4	-0.6	-2.2	-2.1	River Bottom
15+04	-3.1	-0.6	-1.7	-1.5	River Bottom
15+24	-2.9	-0.6	-1.6	-1.2	River Bottom
15+36	-2.9	-0.6	-1.3	-1.0	River Bottom
15+53	-2.3	-0.5	-0.9	-1.0	River Bottom
15+66	-2.4	-0.3	-0.6	-0.9	River Bottom
15+76	-2.7	-0.1	-0.3	-0.3	River Bottom
15+89	-3.4	0.2	-0.4	0.2	River Bottom
16+05	-3.5	0.5	-0.8	0.3	River Bottom
16+18	-3.8	0.7	-1.0	0.4	River Bottom
16+38	-3.9	1.0	0.7	0.4	River Bottom
16+54	-3.4	1.7	1.6	0.9	River Bottom
Varies	-0.4	1.7	2.1	1.4	Edge of Water
17+31	2.0	2.2	2.2	2.2	Sand Bar
18+00	2.4	2.6	2.3	2.3	Sand Bar
19+00	2.2	2.8	2.7	2.7	Sand Bar
20+00	2.2	2.7	2.7	2.9	Sand Bar
21+01	2.2	3.1	2.8	2.9	Sand Bar
22+00	2.0	2.5	2.6	2.7	Sand Bar
23+00	0.8	2.8	2.6	2.5	Sand Bar
24+00	0.2	1.9	1.8	2.1	Sand Bar
Varies	-1.3	1.6	1.6	1.4	Edge of Water
24+48	-2.7	-4.3	-0.5	-1.9	River Bottom
24+64	-5.5	-6.5	-1.3	-4.6	River Bottom
24+87	-9.0	-9.8	-2.5	-8.5	River Bottom
25+10	-9.6	-12.3	-3.6	-10.1	River Bottom
25+33	-9.9	-13.0	-4.8	-12.1	River Bottom
25+56	-9.9	-14.0	-5.9	-11.4	River Bottom
25+82	-10.2	-14.7	-10.5	-12.1	River Bottom
26+01	-10.4	-15.2	-10.8	-11.9	River Bottom
26+24	-10.0	-15.2	-12.2	-12.8	River Bottom
26+50	-10.0	-16.5	-11.5	-13.5	River Bottom
26+70	-10.6	-15.4	-11.6	-12.5	River Bottom

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STA	2013	2016	2017	2018	Description
26+89	-11.6	-15.1	-11.8	-12.5	River Bottom
27+15	-11.1	-15.8	-11.5	-17.4	River Bottom
27+35	-10.8	-15.2	-13.0	-14.5	River Bottom
Varies	0.3	1.6	0.6	1.3	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+03	-	-	-	9.4	Top of Bank (2018)
28+44	10.0	9.6	9.6	9.5	Ground Shot
29+00	9.6	9.5	9.3	9.5	Ground Shot
29+94	9.7	9.4	9.1	9.4	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	13.8	13.6	13.6	13.7	Ground Shot
1+00	15.3	15.4	15.5	15.6	Ground Shot
1+50	16.7	16.4	16.6	15.6	Ground Shot
1+88		16.2	16.3	16.4	Top of Bank
1+95	15.1	-	-	-	Top of Bank (2013)
2+11	3.3	3.0	2.4	2.1	Toe of Bank
Varies	0.9	1.9	1.5	1.2	Edge of Water
2+88	-2.9	-5.4	-2.4	-2.3	River Bottom
3+09	-3.3	-7.3	-3.0	-3.1	River Bottom
3+30	-3.8	-7.6	-3.2	-4.4	River Bottom
3+50	-4.0	-8.1	-4.0	-4.2	River Bottom
3+71	-4.1	-8.3	-4.8	-4.7	River Bottom
3+91	-4.4	-8.7	-4.5	-5.5	River Bottom
4+12	-4.4	-9.0	-4.8	-6.9	River Bottom
4+36	-4.2	-9.8	-4.8	-4.8	River Bottom
4+57	-4.7	-9.5	-4.9	-5.4	River Bottom
4+81	-3.9	-9.0	-4.3	-5.3	River Bottom
5+01	-3.2	-7.6	-3.8	-5.0	River Bottom
11+47	-2.4	-6.8	-2.7	-2.8	River Bottom
11+64	-2.4	-7.1	-3.4	-3.0	River Bottom
11+81	-2.5	-7.3	-4.0	-3.9	River Bottom
11+98	-3.3	-7.8	-4.3	-4.6	River Bottom
12+16	-3.6	-8.7	-4.6	-4.9	River Bottom
12+36	-4.0	-8.8	-4.5	-5.2	River Bottom
12+57	-4.6	-9.0	-5.7	-6.0	River Bottom
12+77	-4.7	-9.1	-6.2	-6.8	River Bottom
13+01	-4.9	-10.1	-6.7	-7.2	River Bottom
13+29	-5.6	-10.2	-7.4	-8.5	River Bottom
13+56	-5.8	-11.3	-8.1	-9.1	River Bottom
13+80	-6.4	-11.5	-8.0	-8.9	River Bottom
14+08	-6.5	-12.4	-8.3	-9.5	River Bottom
14+35	-6.8	-11.8	-7.9	-9.8	River Bottom
14+59	-6.5	-11.6	-7.9	-9.3	River Bottom
14+87	-6.2	-12.2	-8.1	-10.0	River Bottom
15+14	-5.2	-11.3	-8.0	-10.0	River Bottom
15+42	-5.4	-10.4	-8.4	-9.5	River Bottom
15+66	-5.1	-10.6	-7.0	-7.1	River Bottom
15+93	-6.1	-10.0	-6.2	-6.5	River Bottom
16+24	-8.3	-10.9	-6.6	-3.7	River Bottom
16+52	-8.3	-11.7	-6.7	-5.0	River Bottom
16+79	-5.1	-9.6	-5.5	-4.0	River Bottom
17+03	-2.8	-7.3	-3.0	-3.0	River Bottom
Varies	0.8	2.0	1.6	1.2	Edge of Water
17+79	1.9	2.8	2.1	1.5	Sand Bar
17+97	4.4	4.9	3.0	2.5	Sand Bar
18+19	5.6	5.6	5.6	5.6	Toe of Bank
18+35	11.9	11.8	11.8	12.0	Top of Bank
18+91	12.6	12.3	12.4	12.5	Ground Shot
19+41	12.5	12.2	12.3	12.4	Ground Shot

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

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STA	2013	2016	2017	2018	Description
0+00	10.0	9.7	9.6	9.8	Ground Shot
0+50	9.4	8.9	9.0	8.7	Ground Shot
1+00	8.4	8.6	8.4	8.2	Top of Bank
Varies	0.8	0.3	0.2	0.8	Edge of Water
1+28	-3.1	-3.4	-3.5	-3.5	River Bottom
1+37	-4.2	-5.7	-3.8	-7.2	River Bottom
1+46	-7.0	-6.8	-6.1	-7.4	River Bottom
1+58	-6.5	-6.4	-6.8	-7.0	River Bottom
1+70	-7.5	-8.2	-8.1	-8.8	River Bottom
1+81	-10.7	-10.2	-9.6	-10.0	River Bottom
1+91	-12.3	-12.2	-12.6	-13.0	River Bottom
2+06	-8.3	-9.8	-10.1	-10.7	River Bottom
2+17	-6.6	-8.1	-8.1	-8.9	River Bottom
2+27	-5.0	-6.8	-4.9	-4.0	River Bottom
2+37	-2.1	-3.3	-1.8	-0.9	River Bottom
Varies	0.8	0.6	0.9	0.7	Edge of Water
2+68	3.4	3.6	2.0	3.5	Sand Bar
3+10	4.7	4.8	4.9	5.0	Edge of Vegetation
3+59	6.7	6.9	6.9	6.8	Edge of Vegetation
4+00	7.9	8.0	7.8	7.8	Ground Shot
4+18	8.9	8.6	8.5	8.6	Ground Shot
4+68	9.2	8.9	9.0	9.1	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	8.6	8.2	8.1	8.3	Ground Shot
0+50	8.5	8.1	7.9	7.9	Ground Shot
1+16	8.0	8.1	8.1	8.0	Top of Bank
1+47	3.7	3.9	3.7	3.8	Edge of Vegetation
Varies	0.9	1.0	1.3	0.8	Edge of Water
1+93	-2.1	-1.9	-0.8	-2.0	River Bottom
2+08	-2.2	-1.9	-1.4	-2.3	River Bottom
2+19	-2.6	-2.3	-1.9	-2.4	River Bottom
2+29	-2.9	-2.9	-2.3	-2.5	River Bottom
2+39	-3.1	-3.3	-2.7	-3.0	River Bottom
2+49	-3.2	-3.4	-3.1	-3.6	River Bottom
2+66	-3.5	-3.6	-3.6	-3.8	River Bottom
2+83	-3.5	-3.4	-3.5	-4.0	River Bottom
2+91	-3.3	-3.3	-3.5	-4.0	River Bottom
3+08	-3.1	-3.3	-3.3	-3.9	River Bottom
3+27	-2.4	-2.9	-2.4	-3.1	River Bottom
Varies	0.7	1.0	1.2	0.6	Edge of Water
3+82	6.3	6.5	6.3	6.1	Top of Bank
4+29	8.6	8.3	8.3	8.4	Ground Shot
4+79	8.5	8.2	8.1	8.4	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	8.6	8.5	8.7	8.6	Ground Shot
0+50	8.6	8.6	8.0	8.4	Ground Shot
1+00	7.9	8.2	8.0	8.0	Ground Shot
1+58	7.1	7.2	7.0	6.9	Top of Bank
1+76	6.3	6.2	6.0	6.0	Edge of Vegetation
2+14	3.7	3.8	3.6	3.6	Edge of Vegetation
Varies	1.0	1.2	1.4	1.1	Edge of Water
3+17	-2.6	-1.8	-1.2	-1.8	River Bottom
3+26	-2.8	-1.8	-1.4	-2.4	River Bottom
3+38	-3.2	-2.7	-1.8	-2.5	River Bottom
3+52	-2.1	-3.4	-2.7	-3.2	River Bottom
3+68	-3.6	-3.9	-3.6	-4.5	River Bottom
3+80	-4.0	-3.6	-3.6	-4.7	River Bottom
3+93	-3.9	-3.2	-3.1	-4.6	River Bottom
4+01	-3.5	-2.8	-2.7	-4.1	River Bottom
4+14	-3.0	-1.9	-2.1	-3.6	River Bottom
4+22	-3.0	-1.6	-1.7	-3.0	River Bottom
Varies	0.9	1.2	1.4	0.8	Edge of Water
4+68		1.8	1.3	1.2	Toe of Bank
4+76	7.1	7.0	6.8	6.7	Top of Bank
5+33	7.8	7.6	7.1	7.3	Ground Shot
5+83	8.0	7.8	7.6	7.7	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	8.6	8.5	8.36	8.7	Ground Shot
0+50	8.5	8.7	8.6	8.8	Ground Shot
0+95	7.9	8.1	8.0	8.3	Top of Bank
1+15	3.3	3.9	3.6	3.7	Edge of Vegetation
Varies	0.7	1.2	1.3	0.7	Edge of Water
1+88	-1.9	-1.3	-2.0	-2.3	River Bottom
1+99	-2.2	-1.9	-2.4	-2.8	River Bottom
2+19	-2.3	-2.4	-2.9	-3.3	River Bottom
2+29	-2.5	-2.4	-3.1	-3.4	River Bottom
2+40	-2.5	-2.4	-3.1	-3.5	River Bottom
2+61	-2.4	-2.0	-2.8	-2.8	River Bottom
2+75	-4.5	-2.0	-2.5	-5.5	River Bottom
2+88	-4.1	-2.0	-2.3	-2.5	River Bottom
2+96	-2.7	-1.3	-2.1	-2.5	River Bottom
Varies	0.7	1.2	1.3	0.8	Edge of Water
3+69	7.0	7.3	7.4	7.0	Top of Bank
4+20	8.5	8.6	8.3	8.3	Ground Shot
4+70	8.1	8.0	7.9	8.2	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	13.8	13.8	13.8	13.7	Ground Shot
0+15	16.8	16.9	16.6	16.8	Grade Break
0+50	15.5	15.5	15.3	15.5	Ground Shot
1+13	11.4	11.7	11.7	11.5	Top of Bank
1+35		0.7	-	-	Toe of Bank
Varies	0.5	0.0	1.0	0.9	Edge of Water
1+63	-0.7	-0.8	-1.0	-	River Bottom
1+99	-0.6	-1.3	-1.5	-1.0	River Bottom
2+30	-0.8	-1.5	-1.6	-1.4	River Bottom
2+50	-0.9	-1.3	-1.8	-1.2	River Bottom
2+99	-1.3	-1.4	-1.6	-1.5	River Bottom
3+30	-1.3	-1.1	-1.1	-0.8	River Bottom
Varies	0.6	0.1	1.0	0.9	Edge of Water
3+64		1.1	1.08	0.9	Toe of Bank
3+93	6.6	6.9	6.9	6.7	Top of Bank
4+53	7.4	7.5	7.3	7.6	Ground Shot
5+03	7.5	7.6	7.3	7.6	Ground Shot

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STA	*2013*	2016	2017	2018	Description
0+00	24.6	24.5	24.54	24.6	Ground Shot
0+50	20.8	20.7	20.8	20.7	Ground Shot
1+02	9.5	9.4	9.4	9.4	Ground Shot
1+24	7.2	7.3	7.3	7.2	Top of Bank
1+34		1.8	1.5	1.2	Toe of Bank
Varies	0.5	1.2	1.0	1.1	Edge of Water
1+46	-1.0	-1.3	-1.5	-1.3	River Bottom
1+58	-2.1	-2.4	-2.4	-2.3	River Bottom
1+75	-2.1	-2.7	-2.7	-2.7	River Bottom
2+00	-1.8	-2.3	-2.3	-2.3	River Bottom
2+24	-1.6	-2.0	-2.0	-1.8	River Bottom
2+50	-1.1	-1.1	-1.0	-0.8	River Bottom
Varies	0.5	1.2	1.1	1.1	Edge of Water
3+41	3.3	2.9	2.5	2.3	Grade Break
3+64	4.2	4.7	4.7	4.7	Toe of Bank
3+79	8.6	8.7	8.7	8.7	Top of Bank
4+04	9.7	9.9	9.9	9.9	Grade Break
4+58	9.1	9.0	8.9	9.1	Ground Shot
5+08	8.7	8.7	8.6	8.8	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	26.0	26.0	26.07	26.1	Ground Shot
0+07	23.0	23.2	23.3	23.1	Ground Shot
0+60	24.0	24.1	23.9	24.0	Ground Shot
1+10	23.1	23.1	23.0	23.0	Top of Bank
1+36	2.6	2.5	2.1	2.2	Toe of Bank
Varies	0.6	0.3	1.2	1.1	Edge of Water
1+67	-1.1	-0.8	-1.1	-0.3	River Bottom
2+00	-1.1	-1.5	-1.7	-1.9	River Bottom
2+24	-1.6	-1.9	-2.0	-1.9	River Bottom
2+50	-1.6	-1.8	-2.0	-1.2	River Bottom
2+75	-1.4	-1.6	-1.5	-1.4	River Bottom
3+01	-0.7	-1.2	-1.4	-1.2	River Bottom
Varies	0.6	0.2	1.2	1.1	Edge of Water
3+61	4.4	4.3	4.3	5.3	Toe of Bank
3+68	8.6	8.7	8.7	8.7	Top of Bank
3+88	10.5	10.7	10.6	10.7	Ground Shot
4+27	9.1	9.1	9.2	8.8	Ground Shot
4+77	8.6	8.6	8.7	8.7	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	25.2	25.2	25.3	25.2	Ground Shot
0+50	25.1	25.1	25.2	25.1	Ground Shot
1+06	23.2	23.3	23.2	23.1	Top of Bank
1+34	3.2	3.4	2.8	3.1	Toe of Bank
Varies	0.5	0.5	1.4	1.2	Edge of Water
2+25	-1.1	-1.5	-1.5	-1.7	River Bottom
2+51	-1.7	-1.7	-1.7	-1.4	River Bottom
2+75	-1.7	-1.9	-1.7	-2.1	River Bottom
3+00	-1.5	-2.3	-1.5	-1.8	River Bottom
3+27	-1.2	-1.7	-1.7	-2.2	River Bottom
Varies	0.7	0.4	1.4	1.3	Edge of Water
3+44	2.2			-	Grade Break (2013)
3+53	-	1.3	0.6	1.3	Toe of Bank
3+84	6.1	6.2	6.1	6.2	Edge of Vegetation
3+95	7.7	7.7	7.8	7.8	Top of Bank
4+50	7.9	7.8	7.9	7.8	Ground Shot
5+00	10.0	10.2	10.2	10.1	Ground Shot

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Bridge Transects

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

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

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

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

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STA	2013	2016	2017	2018	Description
0+00	21.0	20.8	21.0	20.9	Ground Shot
0+50	21.3	21.2	21.2	21.0	Ground Shot
0+83	21.5	21.4	21.4	21.4	Ground Shot
1+06	20.7	19.8	19.6	19.6	Top of Bank
1+31	1.0	0.6	0.8	2.0	Toe of Bank
Varies	0.0	0.8	0.9	1.2	Edge of Water
1+37	-3.0	-2.2	-3.1	-1.0	River Bottom
1+44	-4.2	-4.2	-4.3	-6.1	River Bottom
1+51	-4.4	-4.0	-4.5	-6.1	River Bottom
1+61	-4.0	-3.5	-3.9	-6.1	River Bottom
1+75	-3.6	-3.1	-3.5	-4.8	River Bottom
1+89	-3.4	-3.2	-3.4	-4.7	River Bottom
1+99	-3.0	-3.0	-3.3	-4.5	River Bottom
2+16	-3.2	-3.1	-3.2	-4.6	River Bottom
2+33	-3.2	-4.8	-4.6	-6.4	River Bottom
2+44	-2.6	-5.0	-4.9	-6.7	River Bottom
Varies	0.1	0.9	1.0	1.3	Edge of Water
3+40	2.5	2.6	2.6	2.7	Ground Shot
3+65	5.7	5.8	5.7	5.8	Edge of Vegetation
3+81	7.6	8.0	7.7	7.9	Top of Bank
4+26	8.2	8.5	8.3	8.4	Ground Shot
4+81	8.4	8.4	8.6	8.4	Ground Shot
5+31	9.2	8.7	9.1	9.1	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	24.3	24.1	24.3	24.2	Ground Shot
0+50	23.6	23.7	23.7	23.7	Ground Shot
1+01	23.0	22.7	22.7	22.5	Top of Bank
1+27		0.7	0.9	2.2	Toe of Bank
Varies	0.2	0.1	0.9	1.4	Edge of Water
1+43	-8.1	-9.7	-9.4	-11.4	River Bottom
1+89	-7.9	-8.5	-8.1	-8.7	River Bottom
2+09	-5.2	-4.6	-4.4	-5.2	River Bottom
2+24	-2.5	-2.7	-2.7	-2.9	River Bottom
Varies	0.1	0.2	1.0	1.3	Edge of Water
2+82	2.6	2.8	2.8	3.0	Ground Shot
3+30	2.9	3.3	3.4	3.5	Ground Shot
3+88	5.8	6.0	6.0	6.0	Edge of Vegetation
4+01	8.0	8.4	8.2	8.2	Top of Bank
4+47	7.7	7.9	8.0	8.2	Ground Shot
4+85	8.4	8.6	8.8	8.5	Ground Shot
5+36	9.5	9.6	9.9	9.8	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	23.7	23.3	23.69	23.6	Ground Shot
0+50		23.2	23.2	23.2	Ground Shot
0+69	21.7	21.5	21.4	21.6	Top of Bank
0+79	19.3	19.1	19.0	13.4	Grade Break
1+00	6.0	6.0	6.1	5.3	Toe of Bank
1+16	4.4	4.3	4.3	4.3	Top of Bank
1+17	3.3	2.7	2.8	4.3	Toe of Bank
Varies	0.2	0.3	1.0	1.0	Edge of Water
1+63	-2.9	-1.2	-2.5	-4.3	River Bottom
1+75	-4.0	-2.8	-3.4	-4.3	River Bottom
1+87	-5.9	-4.3	-4.6	-5.7	River Bottom
1+99	-5.8	-5.5	-5.0	-6.8	River Bottom
2+12	-6.4	-5.2	-5.5	-7.0	River Bottom
2+26	-5.7	-4.5	-5.5	-6.8	River Bottom
2+36	-5.3	-4.6	-5.4	-6.7	River Bottom
2+48	-3.4	-4.0	-4.5	-5.4	River Bottom
2+61	-2.7	-3.1	-4.2	-4.5	River Bottom
2+73	-2.1	-2.2	-3.5	-3.0	River Bottom
2+81	-2.8	-2.2	-2.5	-2.1	River Bottom
Varies	-0.5	0.3	1.0	1.2	Edge of Water
3+84	4.3	4.3	4.3	5.1	Sand Bar
3+94	5.9	5.8	5.8	5.9	Grade Break
4+30	6.1	6.0	6.0	6.1	Edge of Vegetation
4+67	8.8	8.8	8.8	8.9	Grade Break
5+22	8.1	7.9	7.7	7.8	Grade Break
5+58	9.4	9.3	9.4	9.4	Grade Break/Edge of Veg
5+77	9.6	9.5	9.6	9.3	Ground Shot
6+27	10.1	9.6	10.1	9.7	Ground Shot

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Bridge Transects

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STA	2013	2016	2017	2018	Description
0+00	8.6	8.3	8.6	8.4	Ground Shot
0+50	9.6	9.6	9.6	9.6	Ground Shot
1+06	8.1	8.3	8.2	8.3	Edge of Vegetation
1+29	8.4	8.3	8.2	8.3	Top of Bank
1+40	5.7	5.7	5.9	5.9	Toe of Bank
1+85	5.7	6.0	5.7	6.2	Ground Shot
2+37	6.0	6.2	6.0	6.2	Ground Shot
2+89	6.9	6.8	6.7	6.8	Ground Shot
3+16	7.7	7.8	7.7	7.8	Ground Shot
3+70	8.0	8.1	8.1	8.1	Top of Bank
3+80	6.7	6.8	6.6	6.8	Grade Break/Edge of Veg
4+06	3.8	3.9	3.8	3.9	Sand Bar
4+43	1.4	0.9	1.0	1.2	Grade Break
Vaies	-0.2	1.1	1.4	1.1	Edge of Water
4+71	-2.6	-1.3	-1.1	-0.9	River Bottom
4+81	-2.8	-1.9	-1.9	-2.8	River Bottom
4+92	-2.1	-2.0	-2.3	-3.0	River Bottom
5+02	-2.1	-2.2	-2.5	-3.1	River Bottom
5+10	-2.6	-2.3	-2.5	-3.8	River Bottom
5+20	-2.3	-2.4	-2.4	-3.5	River Bottom
5+29	-2.2	-1.8	-2.3	-3.3	River Bottom
5+39	-2.1	-1.8	-1.8	-3.2	River Bottom
5+50	-2.2	-1.6	-2.0	-3.3	River Bottom
5+60	-2.1	-1.7	-2.0	-3.4	River Bottom
5+70	-2.5	-1.7	-1.7	-3.1	River Bottom
5+79	-2.2	-1.5	-0.9	-3.1	River Bottom
Vaies	0.0	1.1	1.4	0.9	Edge of Water
6+20	2.6	2.6	2.4	2.4	Toe of Bank
6+32	8.4	8.3	8.2	8.2	Top of Bank
6+83	9.2	9.1	9.1	9.2	Grade Break
7+31	10.9	11.0	10.9	11.1	Edge of Vegetation
7+54	11.2	11.2	11.3	11.2	Ground Shot
8+04	10.7	10.3	10.7	10.5	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	8.4	8.1	8.1	8.3	Ground Shot
0+50	7.8	7.8	7.9	7.6	Ground Shot
0+96	7.0	6.7	6.9	7.1	Ground Shot
1+50	7.2	7.3	7.1	7.1	Ground Shot
2+00	7.4	7.4	7.4	7.5	Ground Shot
2+50	8.0	8.0	8.0	8.0	Ground Shot
3+12	6.8	6.8	6.7	6.6	Edge of Vegetation
3+32	6.4	6.4	6.3	6.3	Top of Bank
3+54		3.1	2.2	2.2	Ground Shot
3+68		1.1	-	-	Ground Shot
Varies	0.1	0.9	1.4	1.0	Edge of Water
4+07	-0.8	-1.7	-1.6	-0.6	River Bottom
4+16	-2.7	-1.7	-3.0	-1.4	River Bottom
4+26	-2.5	-2.5	-2.9	-3.4	River Bottom
4+36	-3.9	-4.1	-5.1	-7.1	River Bottom
4+47	-5.4	-6.3	-6.7	-8.3	River Bottom
4+57	-6.6	-6.9	-6.9	-7.6	River Bottom
4+68	-7.0	-7.0	-6.0	-6.1	River Bottom
4+79	-6.1	-5.8	-4.5	-3.3	River Bottom
Varies	-0.4	0.9	1.4	0.9	Edge of Water
5+10	8.5	8.4	8.3	8.3	Top of Bank
5+40	10.4	10.3	10.4	10.4	Ground Shot
5+79	10.2	10.2	10.2	10.3	Ground Shot
6+21	11.5	11.5	11.5	11.4	Ground Shot
6+71	10.8	10.5	10.8	10.5	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	9.9	9.8	9.8	9.9	Ground Shot
0+50	8.6	8.6	8.6	8.5	Ground Shot
1+03	8.5	8.7	8.7	8.7	Edge of Vegetation
1+52	10.6	10.7	10.6	10.7	Grade Break
2+00	9.9	10.0	10.0	10.1	Ground Shot
2+57	7.9	7.8	7.8	7.9	Top of Bank
2+67	6.9	6.9	7.0	7.0	Edge of Vegetation
2+78	5.4	5.3	5.4	5.4	Sand Bar
2+87	3.5	3.2	3.2	3.2	Grade Break
Varies	0.0	0.5	1.5	0.7	Edge of Water
3+81	-3.2	-1.5	-1.1	-2.3	River Bottom
4+04	-2.2	-2.3	-2.4	-2.5	River Bottom
4+18	-3.5	-3.1	-3.4	-3.7	River Bottom
4+38	-4.4	-7.5	-6.9	-6.8	River Bottom
4+59	-3.1	-4.2	-2.7	-7.2	River Bottom
Varies	-0.1	0.2	1.4	0.8	Edge of Water
4+99	9.1	8.9	8.9	9.0	Top of Bank
5+53	9.7	9.8	9.7	10.0	Edge of Vegetation
6+02	10.1	10.3	10.2	10.4	Ground Shot
6+41	10.5	10.6	10.6	10.3	Ground Shot
7+11	10.7	10.3	10.4	10.7	Ground Shot

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Bridge Transects

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STA	2013	2016	2017	2018	Description
0+00	12.6	12.4	12.3	12.4	Ground Shot
0+50	12.6	12.5	12.5	12.6	Ground Shot
1+00	10.3	10.1	10.1	10.2	Ground Shot
1+50	9.2	9.2	9.2	9.3	Ground Shot
2+12	8.1	8.0	7.9	7.8	Top of Bank
2+15	3.5	1.9	2.0	1.8	Toe of Bank
Varies	-0.3	0.6	1.6	0.8	Edge of Water
2+30	-4.6	-3.7	-4.3	-4.5	River Bottom
2+37	-7.2	-4.3	-5.9	-4.9	River Bottom
2+48	-7.3	-5.8	-6.4	-7.1	River Bottom
2+58	-6.9	-5.8	-6.3	-7.7	River Bottom
2+72	-6.7	-6.0	-5.4	-7.4	River Bottom
2+82	-3.2	-5.4	-5.0	-6.8	River Bottom
2+96	-2.2	-3.1	-2.3	-5.4	River Bottom
3+06	-1.9	-2.1	-0.8	-3.4	River Bottom
Varies	0.1	0.3	1.6	0.7	Edge of Water
3+66	4.5	4.6	4.7	4.6	Grade Break
3+94	5.6	5.6	5.6	5.6	Sand Bar
4+29	7.1	7.1	7.1	7.2	Edge of Vegetation
4+39	8.4	8.5	8.4	8.4	Top of Bank
4+50	8.6	8.6	8.6	8.6	Ground Shot
5+00	9.0	9.0	8.9	9.0	Ground Shot
5+50	7.4	7.6	7.7	8.1	Ground Shot
6+00	9.7	9.7	9.6	9.7	Ground Shot
6+30	10.1	10.2	10.2	10.3	Edge of Vegetation
6+64	9.9	9.7	9.7	9.7	Ground Shot
7+00	10.6	10.6	10.5	10.4	Ground Shot
7+50	10.1	9.9	9.9	9.9	Ground Shot

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STA	2013	2016	2017	2018	Description
0+00	12.6	12.5	12.5	12.4	Ground Shot
0+50	13.0	12.9	12.9	12.9	Ground Shot
1+00	11.2	11.3	11.4	11.3	Ground Shot
1+11	11.4	11.4	11.2	11.3	Grade Break
1+25	9.4	9.4	9.6	9.4	Grade Break
1+65	10.3	10.4	10.4	10.4	Grade Break
1+81	8.1	8.1	8.0	8.0	Grade Break
2+27	9.3	9.4	9.4	9.5	Grade Break
2+51	10.4	10.5	10.4	10.2	Grade Break
2+72	8.2	8.3	8.4	8.5	Grade Break
3+15	8.0	7.7	7.8	8.0	Grade Break
3+59	6.9	6.8	6.8	6.9	Edge of Vegetation
3+79	6.6	6.6	6.6	6.6	Top of Bank
3+92	3.5	3.4	3.4	3.4	Sand Bar
Varies	-0.1	0.1	1.7	0.8	Edge of Water
4+60	-2.3	-2.2	-2.4	-2.6	River Bottom
4+86	-4.6	-3.9	-5.0	-4.6	River Bottom
5+09	-5.1	-4.2	-4.2	-6.5	River Bottom
5+26	-2.0	-3.3	-1.3	-4.1	River Bottom
Varies	-0.2	0.0	1.7	0.8	Edge of Water
5+47	0.2	0.2	-	1.2	Toe of Bank
5+58	7.6	7.4	7.4	7.3	Top of Bank
5+72	9.7	9.7	9.7	9.8	Grade Break
5+86	9.2	9.3	9.3	9.4	Edge of Vegetation
6+28	9.4	9.3	9.3	9.4	Ground Shot
6+69	9.5	9.2	9.2	9.2	Ground Shot
7+19	10.3	10.1	10.1	10.1	Ground Shot

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

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STA	2013	2014	2015	2016	2017	2018	Description
0+00	8.3	8.4	8.2	7.9	7.9	7.9	Ground Shot
0+50	8.0	8.2	8.0	7.9	7.8	7.8	Ground Shot
0+81	7.2	7.3	7.4	7.4	7.3	7.2	Ground Shot
1+17	7.2	7.2	7.2	7.1	7.1	6.9	Top of Bank
1+23	6.3	6.5	6.5	6.6	6.4	6.2	Edge of Vegetation
Varies	4.6	4.6	4.6	3.4	3.9	3.6	Edge of Water
1+52	4.0	2.0	4.4	3.4	3.7	3.5	River Bottom
1+89	0.8	1.5	2.1	0.7	-0.5	0.8	River Bottom
2+20	-0.9	1.0	0.0	0.1	-0.6	-3.4	River Bottom
2+48	-1.7	-0.9	-1.8	-1.0	-1.9	-4.2	River Bottom
2+95	-3.0	-2.8	-3.2	-2.9	-3.2	-3.0	River Bottom
3+49	-2.1	-1.5	-1.5	-1.2	-1.2	-4.0	River Bottom
3+78	1.7	1.5	2.5	1.7	1.0	1.3	River Bottom
3+90	2.5	2.2	4.1	3.0	2.7	2.1	River Bottom
Varies	4.8	4.7	4.8	3.5	4.0	3.7	Edge of Water
4+06	8.6	8.6	8.7	8.5	8.4	8.3	Top of Bank
5+03	9.5	9.6	9.5	9.4	9.4	9.3	Ground Shot

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STA	2013	2014	2015	2016	2017	2018	Description
0+00	8.0	8.1	8.5	8.3	8.3	8.3	Ground Shot
0+50	8.3	8.5	8.3	8.2	8.2	8.1	Ground Shot
0+92	7.0	7.1	7.2	7.3	7.1	6.9	Top of Bank
1+03	6.5	6.6	6.6	6.7	6.5	6.4	Edge of Vegetation
Varies	4.6	4.5	4.6	3.5	4.0	3.6	Edge of Water
1+59	2.2	1.7	3.1	3.0	2.2	1.9	River Bottom
2+01	0.5	1.1	0.0	1.1	0.7	-1.4	River Bottom
2+48	-2.4	-2.5	-1.4	-2.0	-2.8	-3.6	River Bottom
2+99	-2.9	-2.5	-2.6	-2.6	-2.9	-3.0	River Bottom
3+45	-1.6	-1.3	-1.3	-1.3	-1.7	-3.9	River Bottom
3+84	2.1	1.4	3.0	2.5	1.6	1.7	River Bottom
Varies	4.6	4.7	4.8	3.5	4.1	3.6	Edge of Water
4+04	9.1	9.1	9.1	9.0	8.8	8.6	Top of Bank
4+49	8.8	8.9	8.8	8.7	8.7	8.7	Ground Shot
4+99	9.5	9.6	9.5	9.4	9.5	9.2	Ground Shot

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STA	2013	2014	2015	2016	2017	2018	Description
0+00	8.1	8.4	7.8	7.7	7.1	7.5	Ground Shot
0+50	7.9	8.3	8.0	7.8	7.7	7.8	Ground Shot
0+81	7.3	7.3	7.4	7.2	7.1	6.9	Ground Shot
1+22	6.1	6.4	6.3	6.3	6.1	6.1	Edge of Vegetation
Varies	4.6	4.5	4.6	3.5	4.0	3.6	Edge of Water
1+94	1.4	1.6	2.4	2.1	0.9	1.0	River Bottom
2+46	0.4	0.4	0.0	-0.2	-0.5	-0.5	River Bottom
2+96	-2.6	-2.2	-1.6	-2.4	-2.7	-2.5	River Bottom
3+47	-2.8	-2.5	-3.2	-3.0	-3.0	-3.0	River Bottom
3+95	0.8	1.5	1.0	0.8	0.4	0.4	River Bottom
Varies	4.7	3.7	5.0	3.6	4.0	3.7	Edge of Water
4+31	9.3	9.3	9.3	9.1	8.9	8.8	Top of Bank
4+79	9.0	9.1	9.0	8.9	8.9	8.6	Ground Shot
5+29	9.2	9.3	9.3	9.2	9.0	9.0	Ground Shot

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STA	2013	2014	2015	2016	2017	2018	Description
0+00	8.5	8.8	8.6	8.4	8.2	8.2	Ground Shot
0+50	7.6	7.8	7.7	7.5	7.1	7.3	Ground Shot
0+79	6.7	7.0	6.9	6.9	6.9	6.7	Top of Bank
0+89	5.8	6.0	5.8	5.9	5.7	5.5	Edge of Vegetation
Varies	4.4	4.5	4.5	3.4	4.0	3.8	Edge of Water
1+27	1.3	1.2	2.6	1.9	0.6	1.1	River Bottom
1+54	0.1	0.7	0.6	0.6	-0.1	-0.1	River Bottom
2+01	-1.2	-0.8	-1.1	-1.4	-1.5	-1.3	River Bottom
2+47	-1.7	-1.7	-2.0	-1.7	-2.4	-2.6	River Bottom
3+01	-3.0	-2.5	-3.2	-3.1	-3.1	-3.3	River Bottom
3+55	-0.3	1.5	-0.4	-0.3	-0.8	-1.0	River Bottom
3+71	1.8	2.6	1.7	1.5	1.6	1.6	River Bottom
Varies	4.6	4.3	4.8	3.4	3.9	3.7	Edge of Water
4+03	9.3	9.5	9.5	9.4	9.2	9.1	Top of Bank
4+43	9.4	9.5	9.5	9.2	9.1	9.1	Ground Shot
4+93	9.6	9.7	9.5	9.3	9.3	9.3	Ground Shot

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