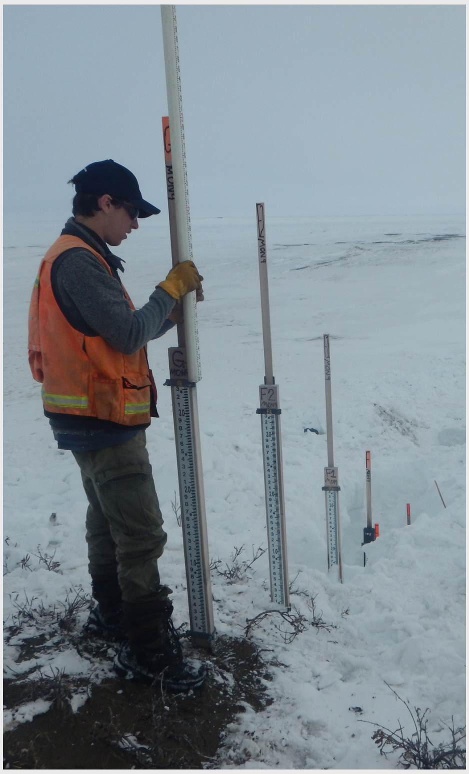
ConocoPhillips
Alaska

JULY 2018

COLVILLE RIVER DELTA SPRING BREAKUP MONITORING & HYDROLOGICAL ASSESSMENT

2018 FIELD REPORT



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ACRONYMS & ABBREVIATIONS

BPMSL	British Petroleum Mean Sea Level
CFDD	Cumulative freezing degree days
CPAI	ConocoPhillips Alaska, Inc.
CRD	Colville River Delta
GPS	Global positioning systems
HWM	High water mark(s)
Michael Baker	Michael Baker International
NPR-A	National Petroleum Reserve Alaska
NRCS	National Resource Conservation Service
PT	Pressure transducer data logger(s)
RM	River miles
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WSE	Water surface elevation(s)

1. INTRODUCTION

Michael Baker International (Michael Baker) provided hydrology monitoring services to ConocoPhillips Alaska, Inc. (CPAI) for the Alpine Development Project in the Colville River Delta (CRD). Alpine facilities include the Colville Delta CD1 processing facility and the CD2, CD3, CD4, and CD5 pads, access roads, and pipelines.

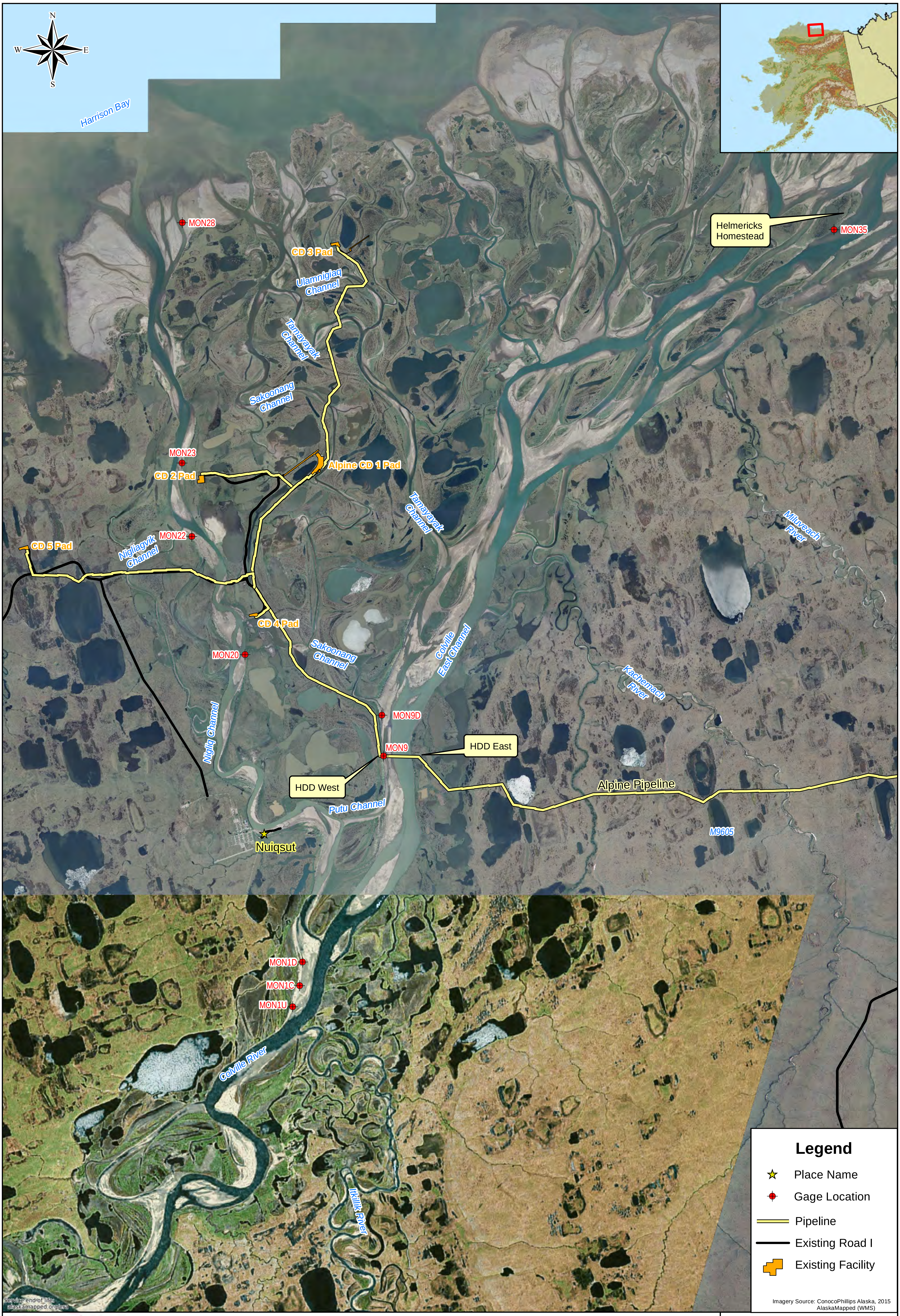
Spring breakup on the North Slope of Alaska is the largest annual flooding event in the region. Hydrology studies are conducted to document the magnitude and extent of flooding. The information acquired through these efforts are integral to understanding the regional hydrology and maintaining the continued safety of the environment, oilfield personnel, and facilities during annual flooding and is important to designing future facilities. This report provides an overview of the 2018 field program and a summary of observations in accordance with the U.S. Army Corps of Engineers (USACE) permit POA-2005-1576 stipulation #17. A comprehensive hydrological assessment report will be submitted by November 30, 2018 to the USACE.

1.1 Study Objective

The objective of the CRD Spring Breakup Monitoring and Hydrological Assessment program is to estimate the magnitude of the 2018 breakup flooding by documenting the distribution of floodwater and measuring water surface elevations (WSE) and flow volume rate (discharge) at preselected locations. Monitoring locations cover the entire CRD (Figure 1) with a focus around oilfield infrastructure, particularly cross-drainage structures (Figure 2).

WSE measurements were collected around facilities, access roads, pipelines, and at other key locations including drinking water lakes and the upstream and downstream extents of the CRD. Discharge was measured at bridges and culverts. Breakup observations included notes and photo documentation of floodwater progression, ice jam effects, ice bridge degradation, and flood impacts to access roads and pads.

Safety was the priority; all field tasks were performed in compliance with Michael Baker's North Slope Water Resources 2018 Health Safety and Environment Plan and project-specific Job Safety Analysis. Toolbox health and safety meetings were conducted by the field crew at the start of work each day and task specific hazard assessments were also completed prior to beginning non-routine tasks. Hazard mitigation, protective equipment, and helicopter, truck, and boat safety were thoroughly evaluated.



ConocoPhillips Alaska

Miles
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Date:	05/16/2018	Project:	166417
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2018 SPRING BREAKUP
COLVILLE RIVER DELTA

Monitoring Locations

FIGURE: 1

(SHEET 1 of 1)

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Miles

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2018 SPRING BREAKUP
ALPINE AREA FACILITIES

Monitoring Locations

FIGURE 2

(SHEET 1 of 1)

2. METHODS

2.1 Observations

The progression of Colville River floodwaters was monitored in the foothills of the Brooks Range, upstream of the CRD with the U.S. Geological Survey (USGS) staff gage and webcam at Umiat. The confluences of the Chandler and Anaktuvuk rivers are downstream of Umiat and contributions are not accounted for in the Umiat gage data. Prior to breakup reaching the CRD, upstream aerial reconnaissance of the Anaktuvuk River and Chandler River tributaries was performed to help forecast breakup timing and resource scheduling.

Field data collection and observations of breakup progression, flow distribution, bank erosion, ice jams, scour, lake recharge, and interactions between floodwaters and infrastructure were recorded in field notebooks. Photographic documentation of breakup conditions was collected using digital cameras with integrated global positioning systems (GPS). The latitude and longitude, date, and time are imprinted onto each photo.

Cameras were positioned at the head of the CRD (MON1) and integrated with telemetry equipment. Real-time access to images provided continuous observations of river conditions and ice jam formations and releases. Remote monitoring of the camera images reduced helicopter activity while increasing situational awareness during breakup flooding.

2.2 Water Surface Elevations

Staff gages (gages) were used to measure changes in WSE. Gage elevations were surveyed to control points referenced to feet British Petroleum Mean Sea Level (ft BPMSL). Most monitoring locations had gage stations consisting of multiple gage assemblies. The number of gage assemblies per gage station depended on the 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. Gages along the road were positioned on both sides of the road to document WSE differential for assessing drainage structure performance. When gages were destroyed by ice, temporary gages were installed or an elevation survey was completed to the water surface.

Pressure transducer data loggers (PTs) were installed at priority gage stations to provide continuous WSE measurements. The depth of water is calculated by subtracting the atmospheric pressure from the absolute pressure recorded by the instrument. PTs were programmed to collect data at 15-minute intervals and were attached to gages at known elevations.

PTs at the head of the CRD (MON1) and at critical locations around Alpine infrastructure were integrated with telemetry equipment and data was accessed remotely to help reduce helicopter activity and provide faster data distribution to operations managers and hydrologists.

2.3 Discharge

Discharge was measured in the Colville River at MON1 using a boat-mounted Acoustic Doppler Current Profiler (ADCP). Discharge was also measured at the CD2 road Long and Short Swale bridges, and the CD5 road Nigliq Bridge using the USGS standard midsection technique. Discharge at the Nigliagvik Bridge was not measured because only backwater was observed. Discharge was also measured at culverts conveying flow in conjunction with monitoring of culvert performance. Analysis of discharge and WSE data is performed post-monitoring to calculate peak discharge at select monitoring locations and estimate magnitude relative to the historical record.

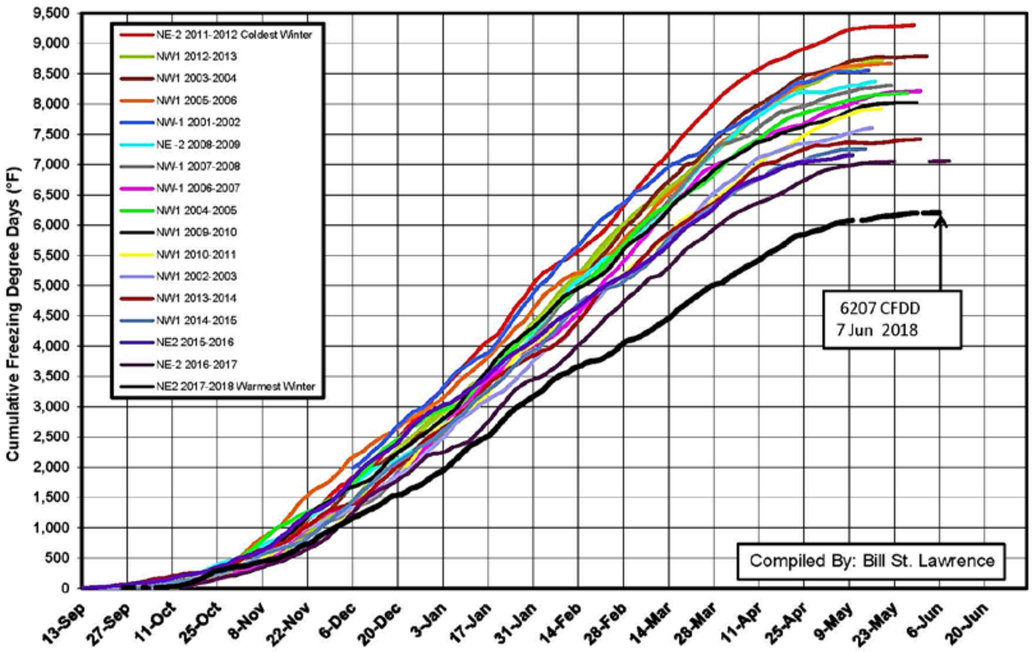
2.4 Field Work Logistics Summary

Spring breakup setup field work began on April 26 via Hägglund tracked vehicles. Setup field work was completed on May 10, after which crews transitioned to monitoring via helicopter and pickup truck. Crew members began departing as floodwaters receded; all field crew were demobilized by June 19.

3. BREAKUP 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: NPRA 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 a consistent cloud cover in 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 began consistently recording above freezing on 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 (Wunderground 2018). Daily low temperatures at Alpine began consistently recording above freezing on June 26.

3.2 Colville River Delta 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 river miles (RM) north (downstream) of the confluence of the two rivers (Photo 1). On May 18, the leading edge of floodwater was observed approximately 5 RM upstream of MON1 (Photo 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 1: Approximate leading edge of observed flowing water, looking south; May 15, 2018

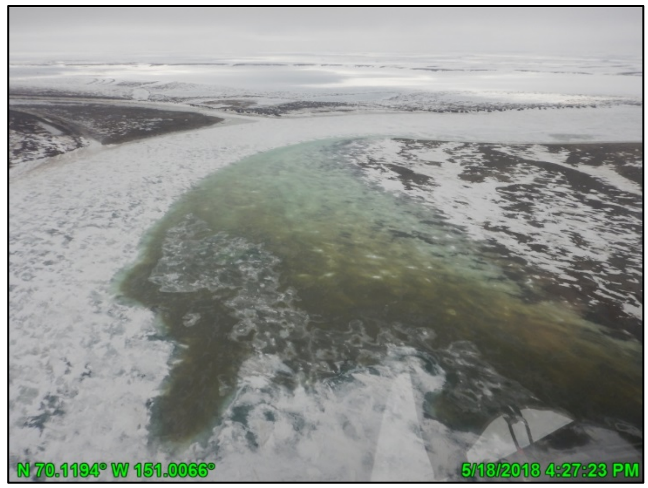


Photo 2: Colville River leading edge approximately 5 RM upstream of MON1, looking north; May 18, 2018

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. On May 23 an ice jam approximately 2.5-3 miles long was observed approximately 14 RM upstream of MON1 (Photo 3). 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. Some backwater developed behind the jam, filling low flow channels and low-lying areas, but in general water levels remained below bankfull stage. Near Alpine facilities, flow into Nanuq Lake had connected to Lake M9524 and was passing through the Long Swale Bridge (Photo 4).

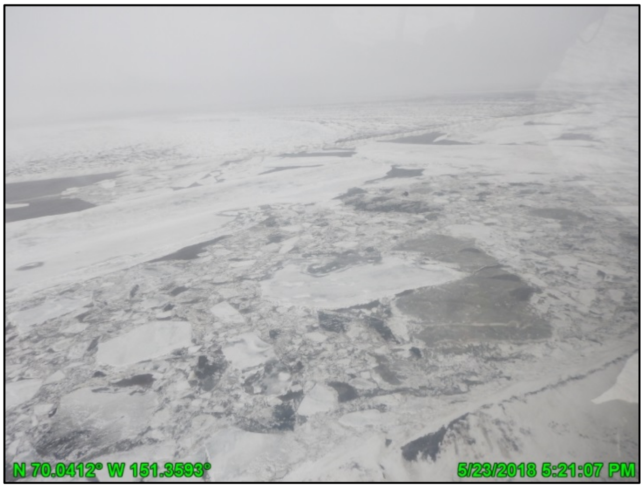


Photo 3: Ice jam on the Colville River approximately 14 RM upstream of MON1, looking south; May 23, 2018

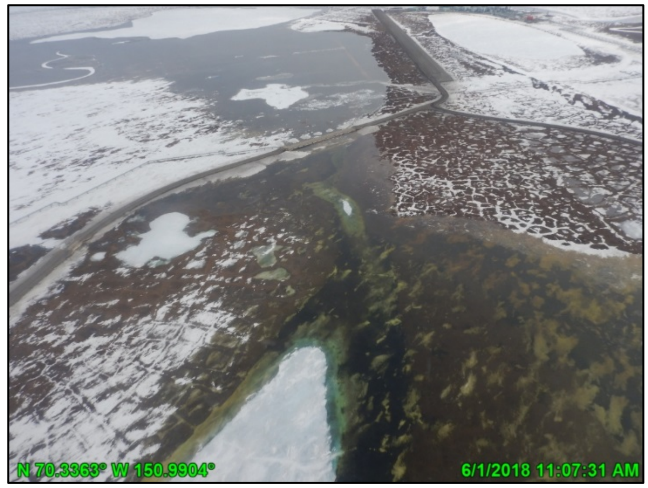


Photo 4: Flow through Long Swale Bridge, looking northwest; June 1, 2018

By June 2, breakup of the Colville River ice had progressed through the MON1 reach and an ice jam reformed in the East Channel downstream of MON9D near the Tamayayak River bifurcation. A small ice jam was also observed in the Nigliq Channel near MON20 where it formed upstream of intact channel ice (Photo 5). Water levels at gages in the Colville River and East Channel 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 through the Small Swale Bridge was observed; snow was packed underneath the bridge.

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 (Photo 6). The Long Swale Bridge continued to convey flow and a small flow path had been cut through the snow underneath the Short Swale Bridge. As of June 5, 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.

Peak stage was observed at the head of the delta and around Alpine facilities on June 2. 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.

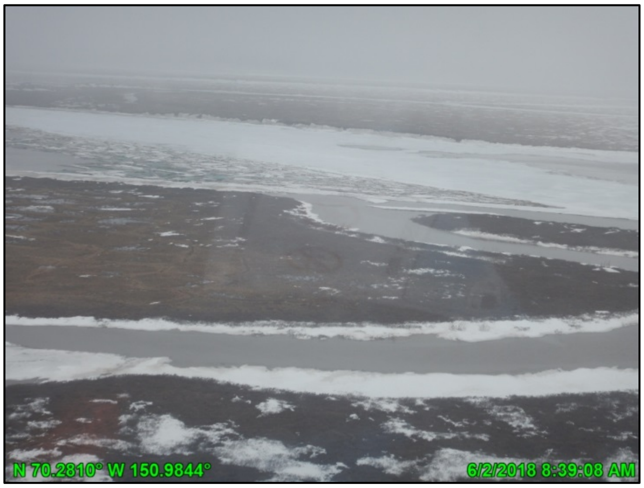


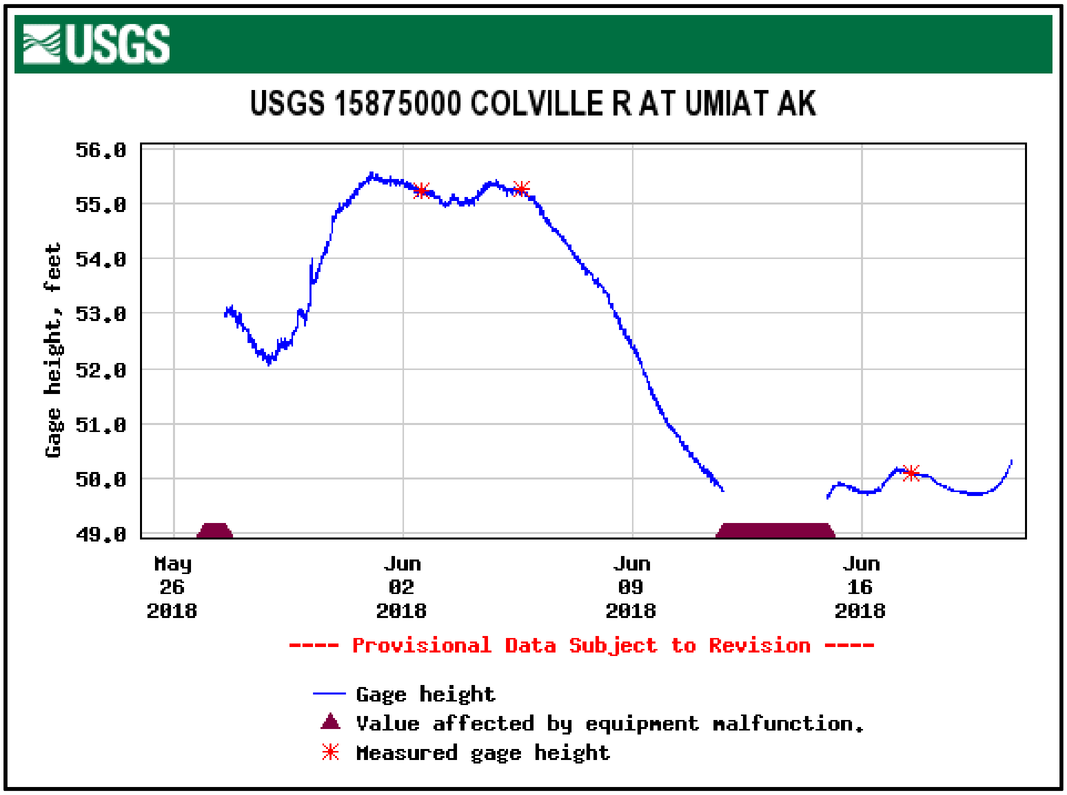
Photo 5: Ice jam on the Nigliq Channel near MON20, looking south; June 2, 2018

Photo 6: Grounded ice at MON9D indicating stage had dropped, looking south; June 4, 2018

3.3 Timing & Magnitude

The 2018 spring breakup flood occurred over a three-week period and was characterized as a protracted, low magnitude event. The USGS gage on the Colville River at Umiat was inoperable until May 27 and experienced equipment malfunctions between June 11 and June 14. Peak stage at Umiat occurred at 12:15 a.m. on June 1 with a gage height of 55.51 feet (Figure 3). National Weather Service (NWS) flood stage at this location is 59 feet. Preliminary PT data and HWMs indicate peak stage in the Colville River at MON1 was 17.0 ft BPMSL and occurred around 4:15 a.m. on June 2. This value falls between the 50% and 20% chance exceedances of occurring in a given year (i.e. between the 2- and 5-year recurrence interval stages), when compared to the historical record (Michael Baker 2017).

Figure 3: Colville River Gage Height at Umiat (USGS 2018)



4. Roads & Facilities Overview

No performance issues were identified at any culverts or bridges conveying flow along the Alpine access roads. The extent where floodwater met Alpine gravel roads and pads was limited to a short section of the CD2 road near the Long and Short Swale bridges. At this location, the road embankment was inspected for erosion. Other than wash lines from previous floods, no discernable erosion was observed during aerial and ground reconnaissance. Floodwaters did not reach any CD5 bridge abutments or the CD5 road within the CRD. There were no signs of sloughing or undermining at any drainage structures. No stream channel changes were observed at access road crossings and bed elevations at bridge piers remained stable during spring breakup flooding.

5. REFERENCES

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