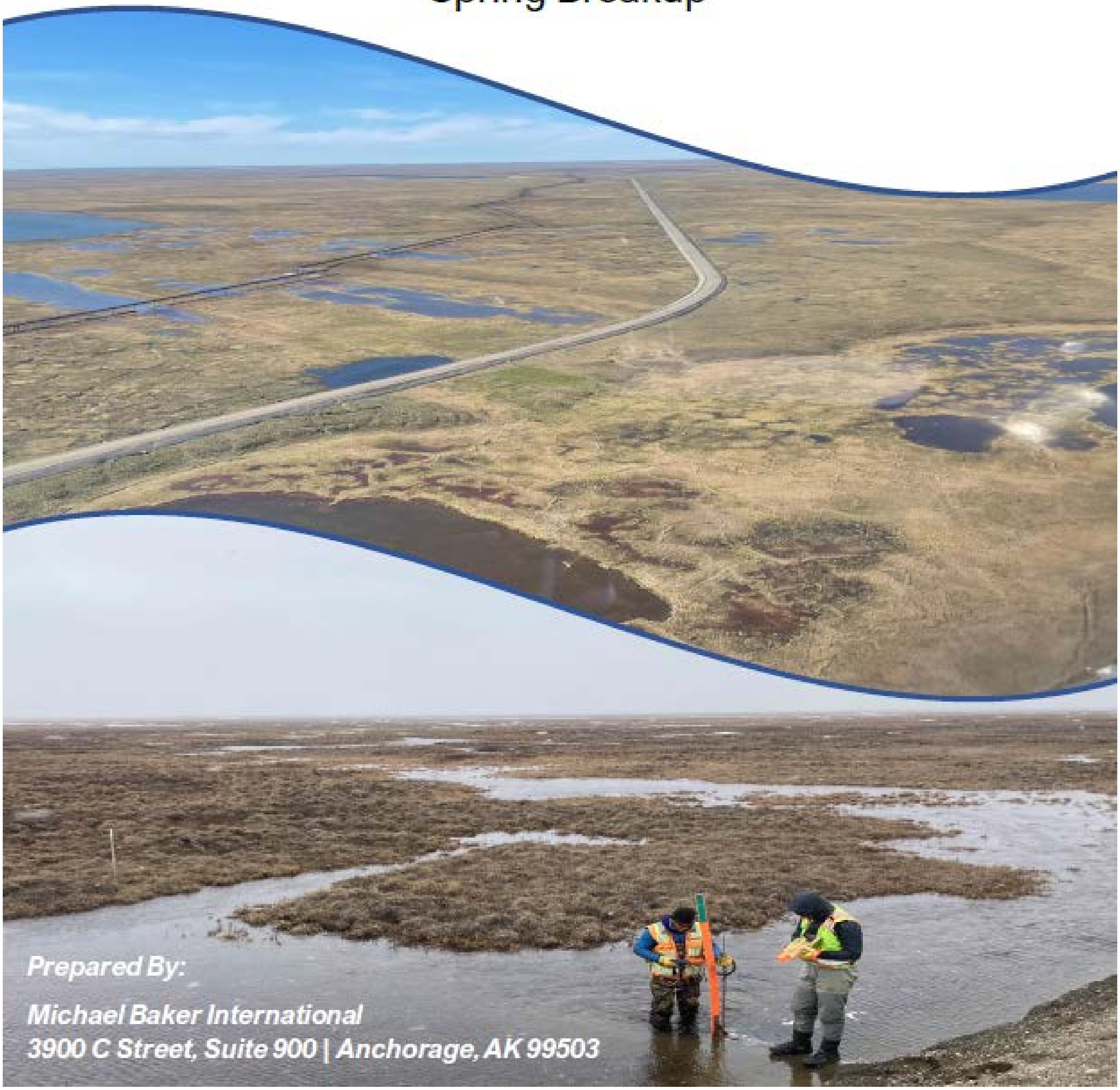
ConocoPhillips
Alaska

Michael Baker
INTERNATIONAL

Culvert Monitoring Report
2021 Greater Moose's Tooth 2
(GMT2/MT7)
Spring Breakup



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ACRONYMS & ABBREVIATIONS

Baro	Barometric
BPMSL	British Petroleum Mean Sea Level
CFDD	cumulative freezing degree days
cfs	cubic feet per second
COPA	ConocoPhillips Alaska
ft	Feet
fps	Feet per second
GMT2/MT7	Greater Mooses Tooth 2
GPS	Global positioning systems
HWM	High water mark(s)
Michael Baker	Michael Baker International
NAD83	North American Datum of 1983
NPR-A	National Petroleum Reserve Alaska
PT	Pressure transducer
UMIAQ	UMIAQ, LLC (formerly LCMF)
USACE	U. S. Army Corps of Engineers
USGS	U.S. Geological Survey
WGS84	World Geodetic System of 1984
WSE	Water surface elevation(s)

1 INTRODUCTION

Greater Moose's Tooth 2 (GMT2/MT7) Spring Breakup Culvert Monitoring supports the ConocoPhillips Alaska (COPA) Environmental group in meeting State of Alaska, federal, and local permit stipulations. GMT2/MT7 facilities include the GMT2 access road and pad. The GMT2 access pad, road, and 80 culverts were installed during the winter of 2018-2019.

The 2021 GMT2/MT7 access road spring breakup culvert monitoring field program was completed in conjunction with the 2021 Colville River Spring Breakup Monitoring and Hydrologic Assessment field program. Spring breakup monitoring began on May 10 and concluded on June 14. An additional site visit was performed on June 26 to retrieve field equipment and document summer conditions. Figure 1 shows the monitoring locations at culverts along the GMT2/MT7 access road. Culvert locations and properties are provided in Appendix A. Hydrologic staff gages (gages) and associated vertical control locations are provided in Appendix B.

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

1.1 Study Objective

The objective of the GMT2/MT7 culvert monitoring program is to monitor and document culvert performance and to evaluate areas where additional culverts or modifications to existing culverts are necessary to maintain natural drainage. Culvert flow is typically limited to the spring breakup season when meltwater is conveyed across the road, generally equalizing ponded water on either side of the road. The hydrology monitoring meets the requirements set forth in the U.S. Army Corps of Engineers (USACE) permit POA-2015-0048. This permit requires annual GMT2/MT7 access road culvert monitoring reports to be submitted for three years post-construction. This is the third year of post-construction reporting.

The following tasks were performed to meet the permit requirements:

- Aerial and ground photo documentation of the GMT2/MT7 access road and pad to demonstrate hydraulic connections during spring breakup and post breakup (summer) conditions
- Identification of areas of differential ponding (ponding on one side of the road), drying, erosion, or stream channel changes adjacent to fill areas
- Demonstration of culvert conveyance of surface water flow based on the maintenance of natural drainage patterns and lack of evidence to the contrary (ponding, drying, erosion, stream channel changes)
- Evaluation of all areas where additional culverts are necessary to maintain natural drainage patterns
- Evaluation of all areas where culvert maintenance, repair, upgrade, setting adjustments, or replacement are necessary to maintain natural drainage patterns

Culvert locations and geometric properties referenced in this report are taken from the As-Built drawings of applicable facilities produced by UMIAQ in August of 2019 and provided in Figure 1.

ConocoPhillips Alaska	0 0.25 0.5 1 mile
Date: 7/7/2021	Scale: 1 inch = 0.5 mile
Drawn: JEM	Project: 183660
Checked: GCY	File: SB2021_GMT2_Culverts.mxd

Legend

- gage(s) + PT
- Culvert
- Pipeline
- Access Ice Road
- GMT2 Pipeline Ice Corridor
- Gravel Road
- Gravel Pad

Imagery Source : Conoco Phillips Alaska 2018 Aerial

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2021 SPRING BREAKUP
GMT2/MT7 Access Road
Culvert Monitoring Locations

FIGURE 1

1.2 Data Collection

Data was collected at the locations provided in Table 1.

Table 1: GMT2/MT7 Access Road Culverts and Associated Gages

Culverts	Associated Gages	Location Description
MT7-01 through MT7-09	S13-A/S13-B	Gage in a depression where flow is conveyed by a network of polygon troughs near the GMT2/MT7 pad location
MT7-10 through MT7-28	-	No defined drainage
MT7-29 through MT7-32	S12-A/S12-B	Gages and culverts in a swale depression between Lake Z06005 and MB0401
MT7-33 through MT7-53	-	No defined drainage
MT7-54 through MT7-58	S11-A/S11-B	Gages and culverts on the southwest corner of a paleolake between Lakes M9923 and M9922
MT7-59 through MT7-66	S10-A/S10-B	Gages and culverts on the east end of a paleolake between Lakes M9923 and M9913
MT7-67 through MT7-69	-	No defined drainage
MT7-70 through MT7-76	S9-A/S9-B	Gages and culverts on the northwest corner of lake M9925 in a shallow depression
MT7-77 through MT7-80	-	No defined drainage; near GMT1 pad location

2 METHODS

2.1 Observations

Gage locations were selected based on topography and hydraulic significance. Field data collection and observations of interactions between floodwaters and infrastructure were recorded in field notebooks and on field sheets. Photographic documentation of spring breakup conditions was collected using iPhone cameras with integrated global positioning systems (GPS). The latitude, longitude, data, and time are imprinted on each photo. The photo locations are referenced to the World Geodetic System of 1984 (WGS84) horizontal datum.

2.2 Water Surface Elevations

Water surface elevation (WSE) data was collected on both sides of the road to document WSE differential for assessing culvert performance. This was completed using hydrologic staff gages with pressure transducers (PTs) attached to each gage. For the purposes of this report, the terms stage and WSE are used interchangeably.

2.2.1 Hydrologic Staff Gages

Gage assemblies (gage and PT) were installed or rehabilitated prior to breakup. The gage stations consist of one gage assembly positioned on both the upstream and downstream sides of the road. Each gage assembly includes a standard U.S. Geological Survey (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 gage support 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. Gage assemblies were identified with alphabetical designations, with the letter ‘A’ representing the gage assembly located on the north side of the GMT2/MT7 access road and the letter ‘B’ representing gage assemblies located on the south side of the GMT2/MT7 access road.

High water marks (HWMs) on the gages were recorded by applying chalk on the angle iron posts and measuring the wash line. HWMs were recorded to document peak stage.

2.2.2 Pressure Transducers

PTs were attached to all gages to supplement gage readings and to provide a continuous record of WSE when the water column is above the PT sensor. PTs were programmed to collect data at 15-minute intervals beginning mid-May. Each PT was housed in a perforated galvanized steel pipe and secured to the base of the gage assembly with hose clamps. The PTs record the absolute pressure of the atmosphere and water column above the PT. A separate barometric (baro) PT was installed nearby and measured the local atmospheric pressure. The depth of water above the sensor was calculated by subtracting the atmospheric pressure from the absolute pressure measured by the site PT. During data processing, the PT measurements were adjusted to WSE readings. PT setup, testing, and processing methods are detailed in Appendix C.

2.3 Discharge Measurements

Site visits and discharge measurements were performed as near to peak flow conditions as possible. Measurements were collected in all culverts observed conveying flow. Culvert velocity and flow depth were measured using a HACH FH950 electromagnetic velocity meter and a wading rod. Discharge was calculated using measured velocity, flow depth, and the inside culvert diameter. Inside culvert diameter was determined based on the outside culvert diameter and wall thickness data provided by UMIAQ (UMIAQ 2019). Discharge methods are detailed in Appendix D.

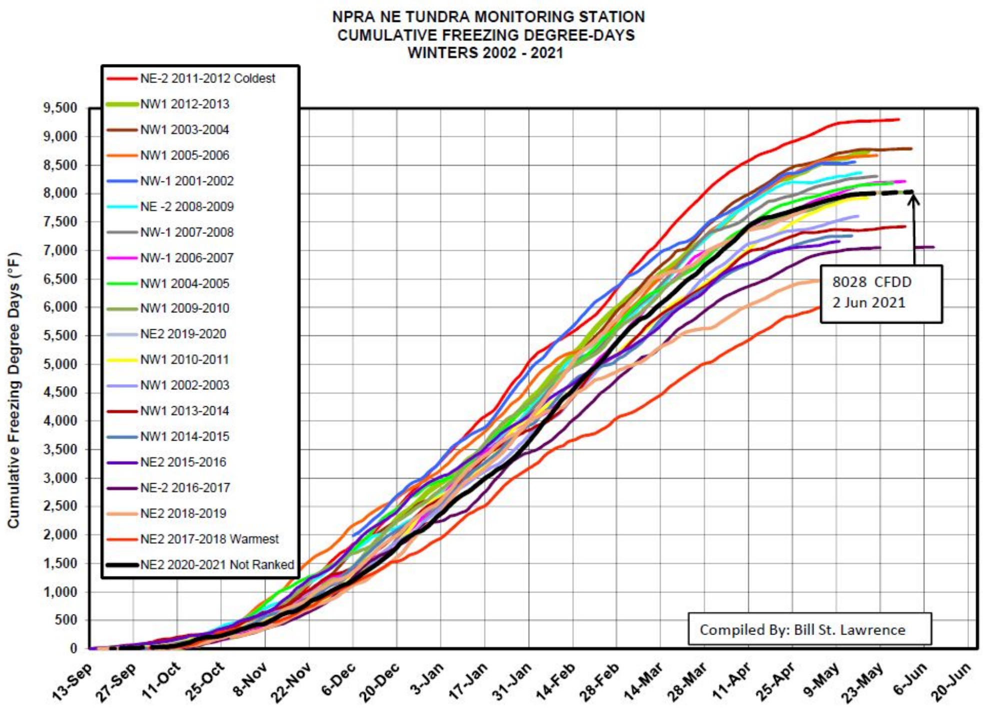
2.4 Culvert Performance Evaluation

Culvert performance was evaluated based on observations, WSE, and discharge measurements with a focus on maintenance, repair, upgrade, setting adjustments, and/or replacement. In addition, the condition of the road fill around the culverts was evaluated to identify areas of erosion or lack thereof.

3 Results

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 2020-2021 (September – June) winter temperature was approximately average compared against the record for the past 20 years (Graph 3.1, ICE 2021).



Graph 3.1: NPRA N. Tundra Monitoring Station CFDD, Winters 2002-2021 (ICE 2021)

There is no NRCS North Slope snowpack data currently available for the 2020-2021 winter season, but general observations indicate snowpack was well below normal levels in the Colville River drainage basin and the GMT2/MT7 surrounding area.

A weather station at the Alpine airstrip at CD1 approximately 20-miles northeast of the GMT2/MT7 pad provided the closest temperature data to the GMT2/MT7 study area. At CD1, daily maximum temperatures consistently exceeded freezing on May 30 and continued through the end of the breakup monitoring period on June 14 (Wundeground, 2021). Daily minimum temperatures remained below freezing until June 11, 3 days before the end of the monitoring period.

3.2 General Observations Summary

Visual inspections performed in mid-May showed that snow had been mechanically cleared from most culvert inlets and outlets prior to spring breakup flooding, although culverts were reburied by drifted snow which accumulated along each embankment prior to breakup (Photo 3.1). Prior to the close out of ice roads, efforts were made to slot and breakup the ice road through general flow paths and over any water body. On May 25, a site visit was performed, and localized meltwater was observed along the GMT2/MT7 access road. Snow cover on the surrounding tundra was approximately 10% and was concentrated along the embankments of the road. By May 26 flow was observed at 12 culverts along the GMT2/MT7 road and discharge was measured at those culverts conveying flow. All other culverts were either dry or blocked by snow and/or ice or inflatable culvert bladders, resulting in differential ponding (Photo 3.2). A site visit on May 27 revealed similar conditions as the day before. Stage had dropped slightly from the prior day and discharge was measured at 4 more culverts conveying flow. Crews pulled bladders from the inlet and outlets of culverts, if safe to do so. Most culverts were found to have ice buildup behind these bladders. Aerial observations showed isolated areas of differential ponding.

Natural drainage patterns continued to improve as culvert blockages melted out through early June. A site visit on June 2 confirmed the equalization of meltwater across most of the GMT2/MT7 road. Remaining areas of differential ponding were caused by culverts still blocked by snow or ice, preventing the conveyance of meltwater across the road. Snow cover on the surrounding tundra was approximately 5% and drifted snow remained along embankments on both sides of the road. By June 26, meltwater was confined to lakes and low-lying areas of drainages, and minimal meltwater remained at the culverts. One area of impounded meltwater remained near culvert MT7-61. All culverts where meltwater was observed properly equalized after snow and ice blockages melted out. Meltwater did not reach culverts situated on higher ground during spring breakup

Photo 3.1: Culvert MT7-29 outlet after mechanical clearing of snow, looking north; May 26, 2021

Photo 3.2: Bladder after being removed from culvert MT7-04 still blocked with ice; May 27, 2021

3.3 Site Specific Observations & Water Surface Elevations

3.3.1 S9 Culverts (MT7-70 through MT7-76)

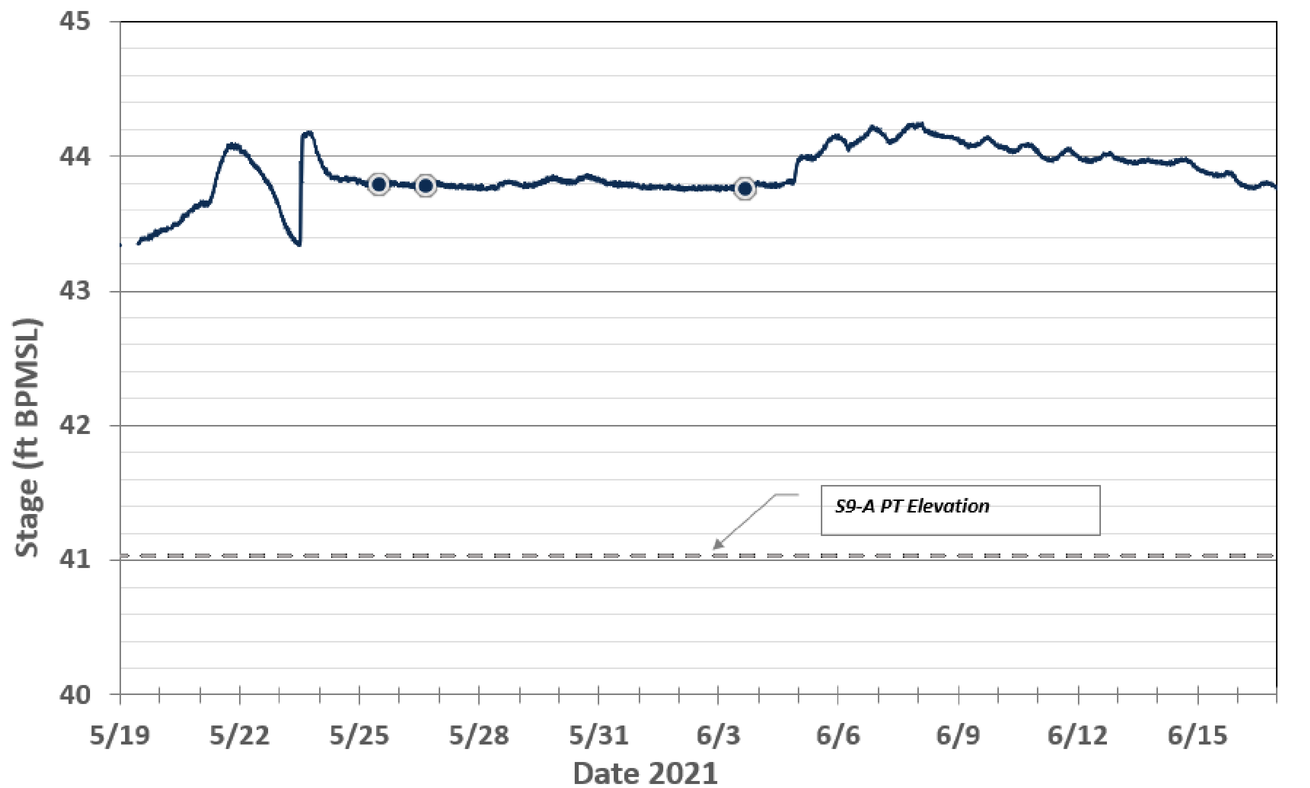
The S9 gages are situated in a low-lying area near the outlet of Lake M9925 near culvert MT7-71. Flow, when present, is conveyed north through surrounding culverts via polygon cracks. During and after breakup, some ponding on the upstream side of the road is expected due to the road being located on the edge of a lower-lying depression within the drainage.

On May 21, isolated pockets of localized meltwater were observed in the drainage near the road embankments (Photo F.1). The ice road along the pipeline alignment, on the south side of the GMT2/MT7 road, remained intact. Meltwater remained impounded on the south side of the gravel road through early June. On June 5, meltwater from Lake M9925 had cut a path through the ice road and was flowing through culvert MT7-70, which is positioned on higher ground than culvert MT7-71 (Photo F.2). Meltwater remained impounded in the low-lying area behind culvert MT7-71 which was blocked by ice and snow.

Peak stage was recorded on the upstream gage, S9-B, on June 8 (Photo F.3). Following peak, stage slowly decreased as meltwater flowed through culvert MT7-70. Aerial observations from June 10 showed impounded water remaining behind culvert MT7-71. Observations from June 26 showed the natural drainage patterns established, with minimal ponding on the upstream side of the road (Photo F.4).

The ice road between the GMT2/MT7 pipeline alignment and the GMT2/MT7 road had negligible impacts to drainage in the area. With the exception of temporary blockages from ice and drifted snow accumulation, all culverts were observed to be functioning as designed and natural drainage patterns in the area were maintained.

S9 spring breakup stage data is provided in Graph 3.2. Measured discharge data is presented in section 3.4. Photos are provided in Appendix F.1.



Spring		
S9-B (US) Peak Stage	44.25	6/8/21 2:15 AM
S9-A (DS) Peak Stage	Dry	

Graph 3.2: S9 Water Surface Elevations

3.3.2 S10 Culverts (MT7-59 through MT7-66)

The S10 gages are in the east end of a paleolake between Lakes M9923 and M9913. Flow, when present, is conveyed north through surrounding culverts via low-lying areas in the paleolake. Culverts MT7-59 through MT7-66 are in this paleolake feature. The S10 gages are positioned to record stage where flow is generally concentrated, near culvert MT7-64.

On May 21, isolated pockets of localized meltwater were observed in the drainage on the south (upstream) side of the road near the embankment (Photo F.5). The ice road along the pipeline alignment on the south side of the GMT2/MT7 road remained intact. After May 21, meltwater increased and accumulated between the ice road and the GMT2/MT7 road. On May 30, two distinct pockets of impounded meltwater were observed along the embankment between culverts MT7-59 and MT7-66 (Photo F.6). One pocket was located directly east of culvert MT7-61, and the other was between culverts MT7-63 and MT7-64 near the S10 gages. This impounded meltwater was hydraulically connected to the paleolake associated with the drainage, and multiple drainage paths had been cut through the ice road.

On June 7, a flow path was established through culvert MT7-63, providing relief to the area of impounded water closest to the S10 gages (Photo F.7). Observations from June 26 showed natural drainage patterns established

(Photo F.8). Meltwater in this study area did not reach sufficient height to measure on the site staff gages, so WSE readings and PT data were unavailable. The precise timing and magnitude of peak stage is unknown.

An ice road between the GMT2/MT7 pipeline alignment and the GMT2/MT7 road had negligible impacts to drainage in the area. With the exception of temporary blockages from ice and drifted snow accumulation, and the area of impounded water near culvert MT7-61, all culverts were observed to be functioning as designed and natural drainage patterns in the area were maintained.

Measured discharge data is presented in section 3.4. Photos are provided in Appendix F.2.

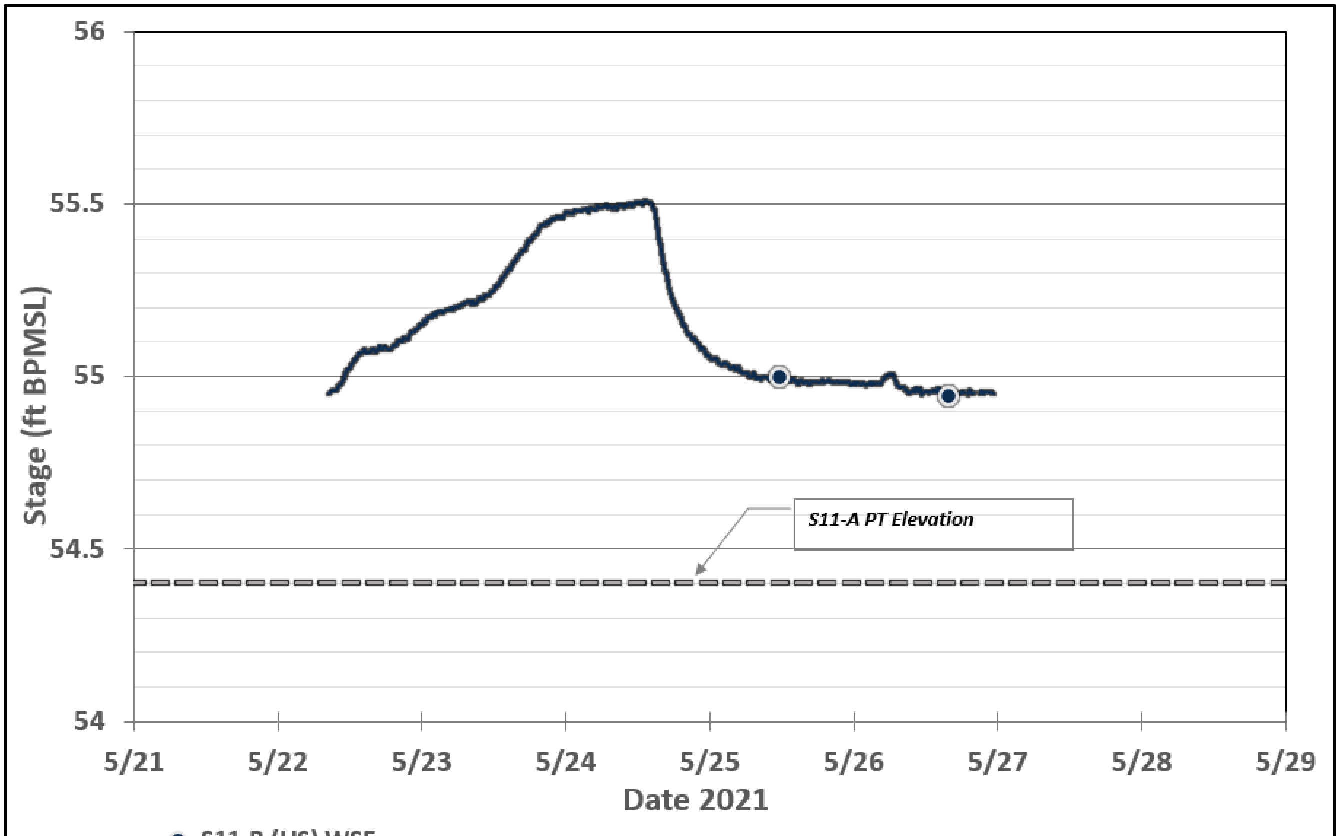
3.3.3 S11 Culverts (MT7-54 through MT7-58)

The S11 gages are in a low-lying area between Lakes M9923 and M9922. Flow, when present, is conveyed north through surrounding culverts via polygon cracks. Culverts MT7-54 through MT7-58 are in this low-lying feature. The S11 gages are positioned to record stage where flow is generally concentrated, near culvert MT7-56.

On May 23, localized meltwater was observed near the GMT2/MT7 road but had not reached the road embankment (Photo F.9). The ice road along the pipeline alignment on the south side of the GMT2/MT7 road remained intact. Meltwater reached the GMT2/MT7 road embankment on May 24 and stage peaked on the upstream gage, S11-B (Photo F.10). Following peak, stage decreased steadily as meltwater flowed through culvert MT7-57. Culvert MT7-56 was blocked with ice and snow. Stage continued to decrease, and minimal meltwater was observed along the road embankments by June 5 (Photo F.11), although some meltwater appeared to be retained behind the ice road. Observations from June 26 showed the natural drainage patterns established (Photo F.12).

An ice road between the GMT2/MT7 pipeline alignment and the GMT2/MT7 road retained some meltwater but had negligible impacts to drainage in the area. In past years, culvert MT7-56 has been observed perched on the north side but drifted snow along the embankments prevented crews from evaluating it this year. With the exception of temporary blockages from ice and drifted snow accumulation, all culverts were observed to be functioning as designed and natural drainage patterns in the area were maintained.

S11 spring breakup stage data is provided in Graph 3.3. Measured discharge data is presented in section 3.4. Photos are provided in Appendix F.3.



Spring		
S11-B (US) Peak Stage	55.51	5/24/21 1:00 PM
S11-A (DS) Peak Stage	Dry	

Graph 3.3: S11 Water Surface Elevations

3.3.4 S12 Culverts (MT7-29 through MT7-32)

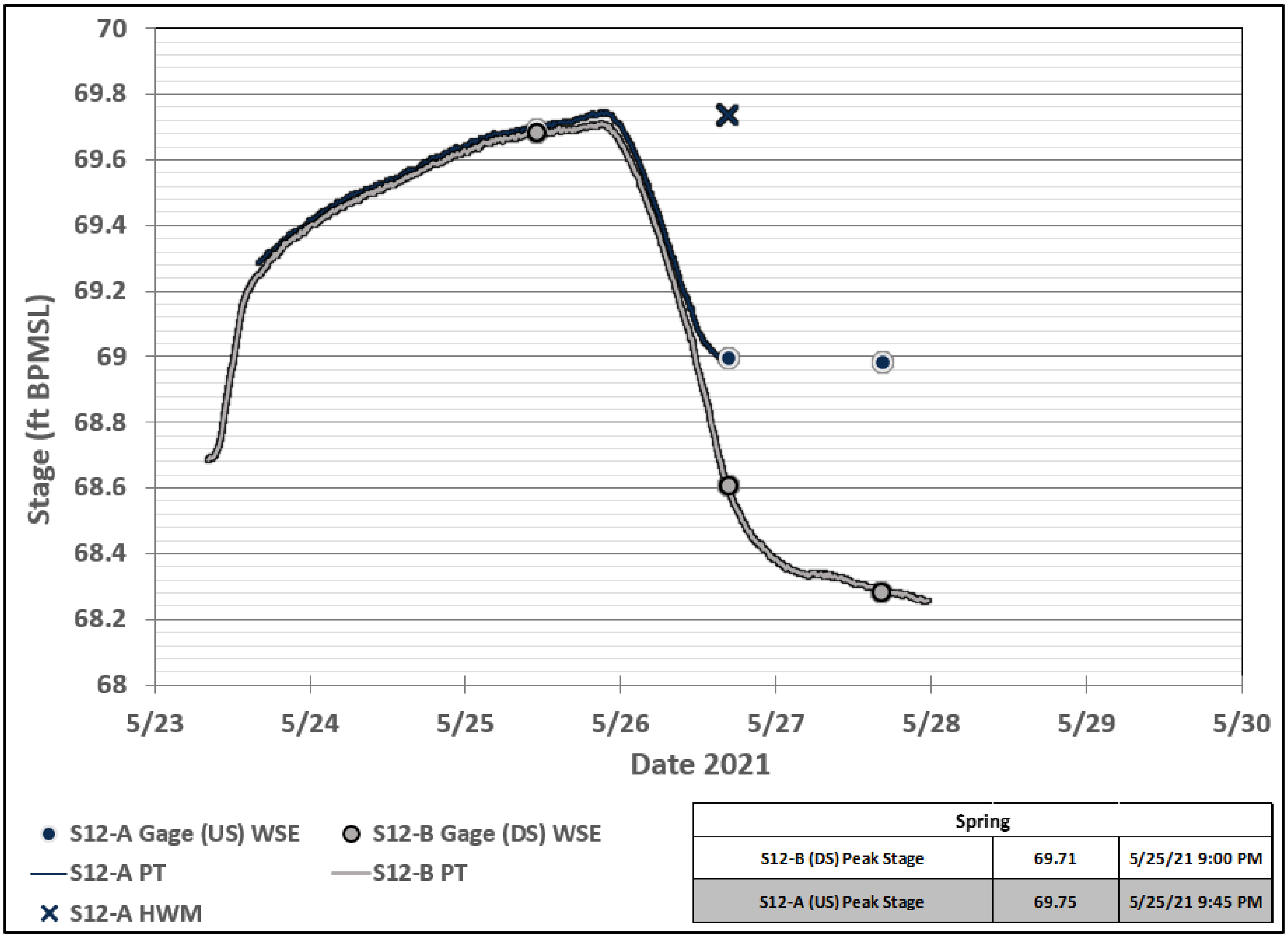
The S12 gages are in a low-lying area between Lake Z06005 and MB0401. Flow, when present, is conveyed south through surrounding culverts via polygon cracks. Culverts MT7-29 through MT7-32 are within the low-lying feature. The S12 gages are positioned to capture flow primarily through culvert MT7-31.

On May 24, meltwater was observed on the east (downstream) side of the road near culverts MT7-30 and MT7-32. This meltwater was impounded by the ice road along the pipeline alignment, with backwater extending to the GMT2/MT7 road embankment (Photo F.13). After the 24th, PT data showed nearly equal water levels on each side of the GMT2/MT7 road, indicating proper conveyance of meltwater through the area culverts. Peak stage occurred on the evening of May 25. After peak, stage receded throughout the rest of the monitoring period.

Disconnected ponding and a channel through the ice road were observed on May 27 during an overflight (Photo F.14). On June 2, minimal meltwater was observed along the road embankments (Photo F.15). Observations from June 26 showed the natural drainage patterns established (Photo F.16).

An ice road between the GMT2/MT7 pipeline alignment and the GMT2/MT7 road temporarily impounded meltwater but had negligible impacts to natural drainage once a channel was established. All culverts were observed to be functioning as designed and natural drainage patterns in the area were maintained.

S12 spring breakup stage data is provided in Graph 3.4. Detailed measured discharge data is presented in section 3.4. Photos are provided in Appendix F.4.



Spring		
S12-B (DS) Peak Stage	69.71	5/25/21 9:00 PM
S12-A (US) Peak Stage	69.75	5/25/21 9:45 PM

Graph 3.4: S12 Water Surface Elevations

3.3.5 S13 Culverts (MT7-01 through MT7-09)

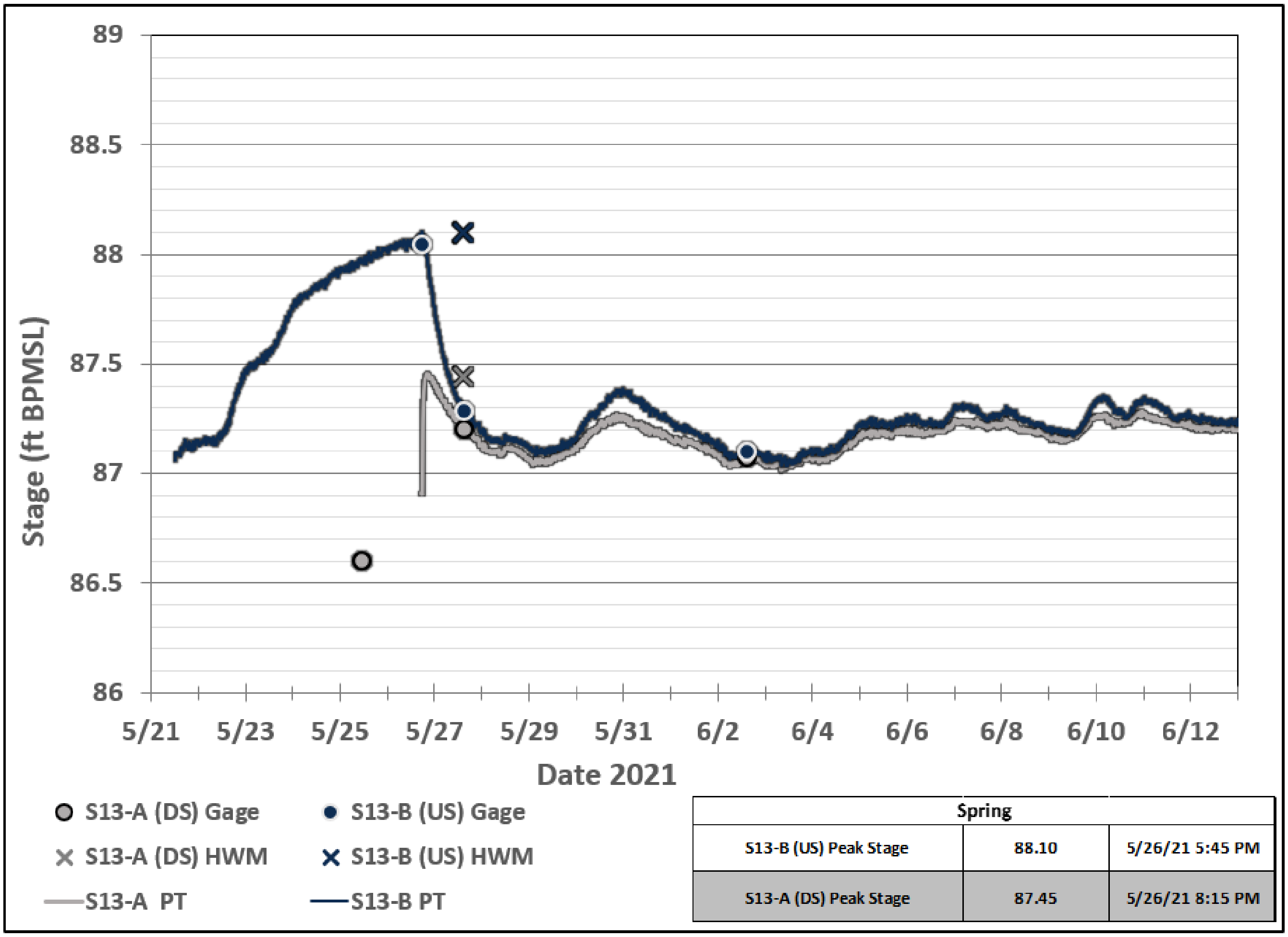
The S13 gages are in a small, poorly defined network of low-lying polygons near the GMT2/MT7 pad location. Flow, when present, is conveyed north through the surrounding culverts via low-lying polygon cracks. Culverts MT7-01 through MT7-09 are within this polygon network. The S13 gages are positioned to capture flow primarily through culvert MT7-02.

On May 21, meltwater was initially observed on the south (upstream) side of the road near S13 (Photo F.17). An observation from on May 26 revealed ponded water on the south embankment of the road, particularly near the turn onto the GMT2/MT7 pad. Peak stage was recorded in the evening of May 26. By May 27, culvert MT7-02 was conveying flow south to north (Photo F.18) and water levels were equalizing at gages S13A and S13B. Culvert bladders were pulled from culverts MT7-03 through MT7-07.

By May 29, water levels had receded. and stage fluctuated slightly throughout the rest of the monitoring period. Aerial observations on June 5 revealed meltwater remaining near the embankments on both sides of the road (Photo F.19). By June 26, observations showed the natural drainage patterns established (Photo F.20).

An ice road between the GMT2/MT7 pipeline alignment the GMT2/MT7 road had negligible impacts on drainage in the area. Also, the newly constructed all-season ice pad along the GMT2/MT7 road east of the GMT2/MT7 pad did not appear to have any impacts on drainage. Culvert MT7-09 was observed slightly perched on the south side but was not impacting drainage, however there is potential for development of a scour hole in the future. With the exception of temporary blockages from ice and drifted snow accumulation, all culverts were observed to be functioning as designed and natural drainage patterns in the area were maintained.

S13 spring breakup stage data is provided in Graph 3.5. Detailed measured discharge data is presented in section 3.4. Photos are provided in Appendix F.5.



Spring		
S13-B (US) Peak Stage	88.10	5/26/21 5:45 PM
S13-A (DS) Peak Stage	87.45	5/26/21 8:15 PM

Graph 3.5: S13 Water Surface Elevations

3.5 Discharge Measurements

Discharge was measured on May 26, May 27, and June 2 at all GMT2/MT7 culverts observed conveying flow. A summary of the discharge measurements is presented in Table 2.

Table 2: GMT2/MT7 Access Road Culvert Discharge

Culvert	Measurement Date & Time	Culvert Inside Diameter (ft)	Flow Area (ft^2)	Total Depth of Flow (ft)	Measured Velocity (fps)	Discharge (cfs)
MT7-08	5/26/2021 17:03	1.9	0.2	0.3	0.22	0.05
MT7-11	5/26/2021 16:53	1.9	1.5	1.0	0.55	0.83
MT7-27	5/26/2021 16:47	1.9	1.7	1.1	0.42	0.71
MT7-31	5/26/2021 16:42	1.9	1.7	1.1	0.27	0.47
MT7-34	5/26/2021 16:27	1.9	0.9	0.7	0.45	0.39
MT7-48	5/26/2021 16:12	1.9	0.9	0.7	0.61	0.58
MT7-53	5/26/2021 16:02	1.9	2.5	1.6	0.56	1.42
MT7-54	5/26/2021 15:57	1.9	0.6	0.5	0.17	0.10
MT7-61	5/26/2021 15:44	1.9	0.5	0.5	0.39	0.20
MT7-63	5/26/2021 15:41	1.9	1.7	1.1	0.92	1.57
MT7-70	5/26/2021 15:30	1.9	0.3	0.3	0.59	0.17
MT7-77	5/26/2021 15:15	1.9	1.9	1.2	0.31	0.58
MT7-02	5/27/2021 14:35	1.9	2.4	1.5	0.42	1.02
MT7-09	5/27/2021 15:45	1.9	1.7	1.1	1.06	1.80
MT7-22	5/27/2021 16:09	1.9	1.3	0.9	0.16	0.22
MT7-26	5/27/2021 16:15	1.9	0.8	0.6	0.31	0.24
MT7-77	6/2/2021 16:30	1.9	1.0	1.6	1.68	4.29

3.6 Culvert Performance Evaluation

No performance issues were identified at any culverts along the GMT2/MT7 access road, besides temporary blockages from ice and drifted snow. Differential ponding was present at several locations along the access road but was mainly attributed to snow and ice impeding flow and not culvert placement (Photo 3.3 and Photo 3.4).

Drifted snow and ice in some culverts persisted through May (Photo 3.5 and Photo 3.6). Once conveyance paths were established by water melting through snow/ice, the culverts all performed as designed and natural drainage patterns were maintained (Photo 3.7 and Photo 3.8). No displacement of gravel fill attributed with spring breakup flooding was observed along the road embankment or around culvert inlets and outlets (Photo 3.9). There were no signs of undermining at drainage structures (Photo 3.10). Besides monitoring perched culverts that were mentioned earlier, no culvert maintenance, repair, upgrade, setting adjustments, and/or replacements are recommended at this time.

Photo 3.3: Culvert MT7-67 outlet partially buried with snow, looking north; May 26, 2021

Photo 3.4: Ponding near culvert MT7-42 looking southwest; May 27, 2021

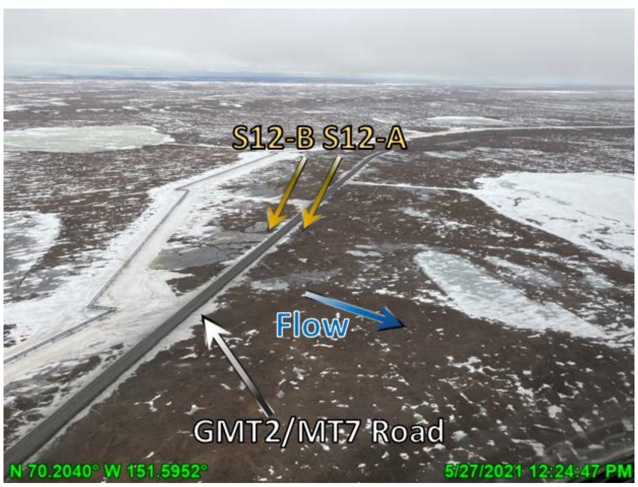


Photo 3.5: Drifted snow blocking flow near S12 gages, looking southwest; May 27, 2021

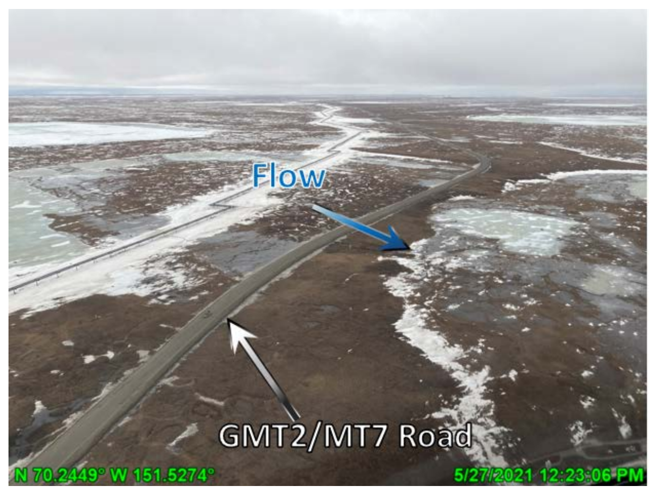


Photo 3.6: Drifted snow along GMT2/MT7 road embankments, looking southwest; May 27, 2021

Photo 3.7: Flow through culvert MT7-27, looking north; May 27, 2021

Photo 3.8: Flow through culvert MT7-63 showing natural drainage pattern cutting through snow, looking north; May 26, 2021

Photo 3.9: Wash line with no sloughing along the south embankment near MT7-05, looking east; May 27, 2021

Photo 3.10: Culvert GMT2-09 showing no undermining of natural drainage on south side of the GMT2/MT7 access road, looking south; May 27, 2021

4 REFERENCES

Bodhaine G. L. 1968. Measurement of Peak Discharge at Culverts by Indirect Methods. Techniques of Water Resources Investigation of the United States Geological Survey, U.S. Geological Survey, Washington.

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

ICE Consult and Design (ICE). 2021 NPR-A North Tundra Monitoring Station. Cumulative Freezing Degree-Days. Winters 2002-2020 Coldest to Warmest Year. June 2, 2021.

UMIAQ, LLC (UMIAQ). 2017. GMT2/MT7 Design Culvert Data. March 2017. Prepared for ConocoPhillips Alaska, Inc.

UMIAQ, LLC (UMIAQ). 2018. Alpine GMT2/MT7 Roads and Pads Civil IFC. August 2018. Prepared for ConocoPhillips Alaska, Inc.

UMIAQ, LLC (UMIAQ). 2019. Alpine GMT2/MT7 Roads and Pads As-Built. October 2019. Prepared for ConocoPhillips Alaska, Inc.

Wunderground. 2021. Temperature data at Alpine Airstrip, AK, April 1 through June 16, 2021. Accessed online at https://www.wunderground.com on June 23, 2021.

Appendix A Culvert Locations & Properties

Culvert	Station	Length (ft)	Latitude (NAD83)	Longitude (NAD83)	Invert Elevation (BPMSL)	Outside Diameter (ft)	Wall Thickness (ft)	Inside Diameter (ft)
MT7-01N	03+06	96.0	70.17499	-151.69089	87.089	2	0.052	1.90
MT7-01S			70.17509	-151.69017	86.545			
MT7-02N	06+91	76.0	70.17593	-151.68926	85.688	2	0.052	1.90
MT7-02S			70.17576	-151.68890	85.175			
MT7-03N	11+97	66.0	70.17655	-151.68552	84.459	2	0.052	1.90
MT7-03S			70.17638	-151.68537	85.140			
MT7-04N	15+58	74.1	70.17688	-151.68268	84.480	2	0.052	1.90
MT7-04S			70.17667	-151.68270	84.257			
MT7-05N	22+49	78.1	70.17737	-151.67753	84.507	2	0.052	1.90
MT7-05S			70.17721	-151.67713	85.221			
MT7-06N	26+34	70.0	70.17767	-151.67441	84.970	2	0.052	1.90
MT7-06S			70.17748	-151.67430	86.060			
MT7-07N	31+64	70.1	70.17806	-151.67036	85.874	2	0.052	1.90
MT7-07S			70.17788	-151.67014	84.238			
MT7-08N	40+82	64.4	70.17873	-151.66318	88.027	2	0.052	1.90
MT7-08S			70.17856	-151.66307	88.329			
MT7-09N	48+59	74.1	70.17932	-151.65717	86.088	2	0.052	1.90
MT7-09S			70.17912	-151.65703	86.471			
MT7-10N	66+45	69.9	70.18063	-151.64332	79.695	2	0.052	1.90
MT7-10S			70.18044	-151.64320	78.269			
MT7-11N	69+00	64.0	70.18082	-151.64134	78.479	2	0.052	1.90
MT7-11S			70.18064	-151.64123	78.069			
MT7-12N	72+69	75.8	70.18110	-151.63834	76.755	2	0.052	1.90
MT7-12S			70.18090	-151.63851	76.771			
MT7-13N	76+50	68.0	70.18137	-151.63552	78.047	2	0.052	1.90
MT7-13S			70.18119	-151.63542	77.595			
MT7-14N	78+37	83.9	70.18153	-151.63390	78.300	2	0.052	1.90
MT7-14S			70.18131	-151.63413	77.022			
MT7-15N	84+25	62.1	70.18194	-151.62951	81.057	2	0.052	1.90
MT7-15S			70.18177	-151.62941	80.840			
MT7-16N	89+18	63.8	70.18230	-151.62570	77.959	2	0.052	1.90
MT7-16S			70.18214	-151.62558	78.102			
MT7-17N	96+57	79.8	70.18308	-151.62010	74.828	2	0.052	1.90
MT7-17S			70.18286	-151.62018	75.574			

Culvert	Station	Length (ft)	Latitude (NAD83)	Longitude (NAD83)	Invert Elevation (BPMSL)	Outside Diameter (ft)	Wall Thickness (ft)	Inside Diameter (ft)
MT7-18N	101+98	69.8	70.18391	-151.61684	77.267	2	0.052	1.90
MT7-18S			70.18378	-151.61643	77.382			
MT7-19N	109+35	81.8	70.18532	-151.61234	72.620	2	0.052	1.90
MT7-19S			70.18510	-151.61219	73.296			
MT7-20N	112+35	67.9	70.18583	-151.61069	71.909	2	0.052	1.90
MT7-20S			70.18570	-151.61030	71.811			
MT7-21N	115+83	64.2	70.18648	-151.60859	70.870	2	0.052	1.90
MT7-21S			70.18634	-151.60826	70.585			
MT7-22N	122+38	74.0	70.18770	-151.60476	71.870	2	0.052	1.90
MT7-22S			70.18755	-151.60434	71.446			
MT7-23N	127+12	68.1	70.18864	-151.60222	76.438	2	0.052	1.90
MT7-23S			70.18853	-151.60177	76.122			
MT7-24N	131+04	80.0	70.18954	-151.60061	70.058	3	0.083	2.83
MT7-24S			70.18944	-151.60003	69.134			
MT7-25N	131+10	79.8	70.18955	-151.60059	70.285	3	0.083	2.83
MT7-25S			70.18946	-151.60001	69.157			
MT7-26N	135+73	70.0	70.19074	-151.59912	68.918	2	0.052	1.90
MT7-26S			70.19061	-151.59869	69.228			
MT7-27N	139+70	65.9	70.19174	-151.59833	69.450	2	0.052	1.90
MT7-27S			70.19170	-151.59782	69.360			
MT7-28N	143+52	72.1	70.19276	-151.59757	68.569	2	0.052	1.90
MT7-28S			70.19271	-151.59700	69.566			
MT7-29N	152+40	68.0	70.19510	-151.59571	72.787	2	0.052	1.90
MT7-29S			70.19505	-151.59519	71.859			
MT7-30N	159+87	72.1	70.19711	-151.59416	67.842	2	0.052	1.90
MT7-30S			70.19699	-151.59369	67.781			
MT7-31N	161+36	70.0	70.19743	-151.59389	67.903	2	0.052	1.90
MT7-31S			70.19745	-151.59333	67.241			
MT7-32N	167+24	66.5	70.19902	-151.59266	71.253	2	0.052	1.90
MT7-32S			70.19897	-151.59215	70.751			
MT7-33N	178+69	72.5	70.20208	-151.59027	74.111	2	0.052	1.90
MT7-33S			70.20196	-151.58982	73.917			
MT7-34N	186+75	80.2	70.20421	-151.58866	71.281	2	0.052	1.90
MT7-34S			70.20409	-151.58812	71.114			
MT7-35N	187+88	89.8	70.20454	-151.58840	71.777	2	0.052	1.90
MT7-35S			70.20436	-151.58792	71.043			

Culvert	Station	Length (ft)	Latitude (NAD83)	Longitude (NAD83)	Invert Elevation (BPMSL)	Outside Diameter (ft)	Wall Thickness (ft)	Inside Diameter (ft)
MT7-36N	190+10	116.1	70.20518	-151.58789	73.886	2	0.052	1.90
MT7-36S			70.20489	-151.58752	72.148			
MT7-37N	196+24	86.2	70.20662	-151.58677	71.771	2	0.052	1.90
MT7-37S			70.20670	-151.58611	71.798			
MT7-38N	198+17	70.1	70.20717	-151.58633	71.453	2	0.052	1.90
MT7-38S			70.20717	-151.58577	72.081			
MT7-39N	207+45	66.3	70.20964	-151.58428	76.703	2	0.052	1.90
MT7-39S			70.20958	-151.58379	76.565			
MT7-40N	212+53	66.2	70.21092	-151.58264	76.120	2	0.052	1.90
MT7-40S			70.21084	-151.58216	76.917			
MT7-41N	220+80	83.9	70.21303	-151.57988	70.639	2	0.052	1.90
MT7-41S			70.21286	-151.57946	71.387			
MT7-42N	228+59	66.3	70.21492	-151.57733	70.759	2	0.052	1.90
MT7-42S			70.21484	-151.57685	71.309			
MT7-43N	235+52	70.2	70.21667	-151.57502	68.095	2	0.052	1.90
MT7-43S			70.21655	-151.57458	67.412			
MT7-44N	241+96	73.8	70.21824	-151.57295	63.278	2	0.052	1.90
MT7-44S			70.21819	-151.57238	63.448			
MT7-45N	250+51	74.1	70.22043	-151.57001	60.025	2	0.052	1.90
MT7-45S			70.22026	-151.56967	60.116			
MT7-46N	252+97	66.2	70.22101	-151.56925	60.334	2	0.052	1.90
MT7-46S			70.22091	-151.56880	60.023			
MT7-47N	257+56	82.1	70.22220	-151.56767	58.601	2	0.052	1.90
MT7-47S			70.22200	-151.56735	57.912			
MT7-48N	264+81	74.1	70.22398	-151.56533	55.432	2	0.052	1.90
MT7-48S			70.22384	-151.56490	56.534			
MT7-49N	271+24	78.0	70.22559	-151.56319	52.422	2	0.052	1.90
MT7-49S			70.22543	-151.56277	52.239			
MT7-50N	274+61	68.0	70.22640	-151.56211	52.142	3	0.083	2.83
MT7-50S			70.22631	-151.56163	52.581			
MT7-51N	280+35	70.0	70.22785	-151.56016	52.679	3	0.083	2.83
MT7-51S			70.22772	-151.55976	52.483			
MT7-52N	282+85	67.9	70.22844	-151.55939	52.027	3	0.083	2.83
MT7-52S			70.22837	-151.55889	52.404			
MT7-53N	288+14	122.2	70.22989	-151.55746	53.010	2	0.052	1.90
MT7-53S			70.22956	-151.55732	53.200			

Culvert	Station	Length (ft)	Latitude (NAD83)	Longitude (NAD83)	Invert Elevation (BPMSL)	Outside Diameter (ft)	Wall Thickness (ft)	Inside Diameter (ft)
MT7-54N	294+05	70.0	70.23126	-151.55563	54.433	2	0.052	1.90
MT7-54S			70.23112	-151.55524	54.218			
MT7-55N	296+83	68.1	70.23193	-151.55476	51.649	2	0.052	1.90
MT7-55S			70.23185	-151.55428	53.594			
MT7-56N	300+38	72.2	70.23281	-151.55360	54.435	2	0.052	1.90
MT7-56S			70.23274	-151.55306	52.445			
MT7-57N	305+96	84.3	70.23416	-151.55184	53.157	2	0.052	1.90
MT7-57S			70.23417	-151.55116	55.112			
MT7-58N	314+66	71.9	70.23640	-151.54880	58.247	2	0.052	1.90
MT7-58S			70.23626	-151.54840	58.404			
MT7-59N	320+54	64.2	70.23782	-151.54669	58.841	2	0.052	1.90
MT7-59S			70.23772	-151.54626	58.853			
MT7-60N	325+88	67.9	70.23886	-151.54363	51.297	2	0.052	1.90
MT7-60S			70.23872	-151.54327	51.427			
MT7-61N	328+82	69.9	70.23933	-151.54153	50.239	2	0.052	1.90
MT7-61S			70.23914	-151.54142	50.505			
MT7-62N	334+52	66.2	70.24017	-151.53777	50.876	2	0.052	1.90
MT7-62S			70.24002	-151.53748	53.522			
MT7-63N	341+20	76.0	70.24117	-151.53333	47.832	2	0.052	1.90
MT7-63S			70.24102	-151.53292	49.002			
MT7-64N	344+85	74.0	70.24181	-151.53106	48.322	2	0.052	1.90
MT7-64S			70.24166	-151.53066	48.996			
MT7-65N	349+75	64.2	70.24280	-151.52848	53.046	2	0.052	1.90
MT7-65S			70.24269	-151.52807	53.910			
MT7-66N	357+06	68.2	70.24437	-151.52483	54.281	2	0.052	1.90
MT7-66S			70.24426	-151.52439	54.583			
MT7-67N	362+88	76.0	70.24563	-151.52191	53.199	2	0.052	1.90
MT7-67S			70.24549	-151.52145	53.121			
MT7-68N	377+03	72.0	70.24865	-151.51482	46.917	2	0.052	1.90
MT7-68S			70.24852	-151.51437	48.819			
MT7-69N	381+62	70.2	70.24963	-151.51248	46.426	2	0.052	1.90
MT7-69S			70.24950	-151.51204	45.078			
MT7-70N	386+01	72.0	70.25058	-151.51025	43.019	2	0.052	1.90
MT7-70S			70.25043	-151.50986	42.461			
MT7-71N	389+31	78.1	70.25127	-151.50835	40.556	2	0.052	1.90
MT7-71S			70.25106	-151.50815	41.757			

Culvert	Station	Length (ft)	Latitude (NAD83)	Longitude (NAD83)	Invert Elevation (BPMSL)	Outside Diameter (ft)	Wall Thickness (ft)	Inside Diameter (ft)
MT7-72N	391+87	66.3	70.25170	-151.50686	40.988	2	0.052	1.90
MT7-72S			70.25156	-151.50654	41.995			
MT7-73N	393+93	66.2	70.25208	-151.50562	40.639	2	0.052	1.90
MT7-73S			70.25193	-151.50528	41.093			
MT7-74N	396+47	84.1	70.25258	-151.50395	40.034	2	0.052	1.90
MT7-74S			70.25235	-151.50388	41.350			
MT7-75N	399+96	68.0	70.25314	-151.50204	41.005	2	0.052	1.90
MT7-75S			70.25305	-151.50158	41.731			
MT7-76N	404+42	66.0	70.25398	-151.49928	42.898	2	0.052	1.90
MT7-76S			70.25384	-151.49894	43.357			
MT7-77N	411+47	72.2	70.25525	-151.49504	38.525	2	0.052	1.90
MT7-77S			70.25511	-151.49465	39.279			
MT7-78N	418+30	96.0	70.25651	-151.49055	39.210	3	0.083	2.83
MT7-78S			70.25625	-151.49067	39.129			
MT7-79N	424+62	70.0	70.25728	-151.48633	38.901	2	0.052	1.90
MT7-79S			70.25714	-151.48596	39.644			
MT7-80N	429+09	70.0	70.25783	-151.48297	39.947	2	0.052	1.90
MT7-80S			70.25765	-151.48282	40.794			

Appendix B Gage & Associated Vertical Control Locations

Monitoring Location	Gage ID	Gage Position Relative to Road	Gage Location		Associated Vertical Control	Vertical Control Location	
			Latitude (NAD83)	Longitude (NAD83)		Latitude (NAD83)	Longitude (NAD83)
S9	S9-A	downstream	70.25133	-151.50848	MT7-72N	70.25170	-151.50686
	S9-B	upstream	70.25102	-151.50821		70.25156	-151.50654
S10	S10-A	downstream	70.24184	-151.53132	MT7-64N	70.24181	-151.53106
	S10-B	upstream	70.24144	-151.53020		70.24166	-151.53066
S11	S11-A	downstream	70.23282	-151.55385	MT7-56N	70.23281	-151.55360
	S11-B	upstream	70.23257	-151.55250		70.23274	-151.55306
S12	S12-A	upstream	70.19744	-151.59401	MT7-31N	70.19743	-151.59389
	S12-B	downstream	70.19742	-151.59284		70.19745	-151.59333
S13	S13-A	downstream	70.17593	-151.68930	PBM-16	70.17510	-151.68830
	S13-B	upstream	70.17558	-151.68858			

Appendix C PT Setup, Testing & Processing Methods

PTs measure the absolute pressure of the atmosphere and water, allowing the depth of water above the sensor to be calculated. Resulting data yield a comprehensive record of the fluctuations in water levels. The reported pressure is the sum of the forces imparted by the water column and atmospheric conditions. Variations in local barometric pressure are taken into account, using two independent barometric pressure loggers: In-Situ BaroTROLL® and Solinst Barologger®. A correction of barometric pressure was obtained from the Barologger installed at the Colville River East Channel horizontal directionally drilled pipeline crossing. The PT sensors were surveyed during spring breakup setup to establish a vertical datum using local control.

All PTs were tested before field mobilization and configured using Win-Situ® LT 5.6.21.0 (for the Level TROLL 500s) or Solinst Levelogger® v4.0.3 (for the Solinst Leveloggers) software prior to placement in the field. Absolute pressure was set to zero.

PT-based water level 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 D Discharge Methods

Standard USGS velocity/area techniques (Bodhaine 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.

Appendix E GMT2 Road Culvert Visual Observation Summary

Observation Date	Time	Culvert ID	Flow Condition	Flow Direction	Notes
6/2/2021	16:45	MT7-80	Dry	-	-
6/2/2021	16:44	MT7-79	Stagnant	-	Culvert blocked by ice and snow on north side. Pond on south side of road.
6/2/2021	16:43	MT7-78	Dry	-	-
6/2/2021	16:32	MT7-77	Flowing	South to North	Measured flow.
6/2/2021	16:29	MT7-76	Dry	-	Air bag iced in on south side of culvert.
6/2/2021	16:26	MT7-75	Flowing	South to North	Minor flow, nearly equalized
6/2/2021	16:24	MT7-74	Dry	-	-
6/2/2021	16:22	MT7-73	Stagnant	-	Air bag iced in on south side of culvert.
6/2/2021	16:20	MT7-72	Dry	-	-
6/2/2021	16:18	MT7-71	Stagnant	-	Blocked by ice and snow in culvert. Pond on south side of road. S9.
6/2/2021	16:18	MT7-70	Flowing	South to North	-
6/2/2021	16:17	MT7-69	Dry	-	-
6/2/2021	16:16	MT7-68	Dry	-	-
6/2/2021	16:15	MT7-67	Stagnant	-	Blocked by ice and snow in south side of culvert.
6/2/2021	16:14	MT7-66	Stagnant	-	Blocked by ice and snow in culvert. Minor pond on south side of road.
6/2/2021	16:13	MT7-65	Dry	-	-
6/2/2021	16:12	MT7-64	Stagnant	-	Blocked by ice and snow in north side of culvert. Minor pond on south side of road. S10 gage dry
6/2/2021	16:11	MT7-63	Flowing	South to North	-
6/2/2021	16:09	MT7-62	Dry	-	-
6/2/2021	16:07	MT7-61	Flowing	South to North	Minor flow, nearly equalized
6/2/2021	16:05	MT7-60	Dry	-	-
6/2/2021	16:02	MT7-59	Dry	-	-
6/2/2021	16:00	MT7-58	Dry	-	-
6/2/2021	15:58	MT7-57	Flowing	North to South	Minor flow, nearly equalized
6/2/2021	15:55	MT7-56	Stagnant	-	Air bag iced in on north side of culvert. Pond on south side of road. S11 gage dry
6/2/2021	15:54	MT7-55	Stagnant	-	Blocked by ice and snow on north side of culvert. Pond on south side of road.
6/2/2021	15:53	MT7-54	Equalized	-	-
6/2/2021	15:52	MT7-53	Flowing	South to North	-
6/2/2021	15:51	MT7-52	Equalized	-	-
6/2/2021	15:50	MT7-51	Stagnant	-	Block by ice and snow in culvert.
6/2/2021	15:48	MT7-50	Equalized	-	-
6/2/2021	15:46	MT7-49	Stagnant	-	Block by ice and snow in culvert. Minor pond on south side of road.
6/2/2021	15:44	MT7-48	Flowing	South to North	Minor flow, nearly equalized
6/2/2021	15:43	MT7-47	Stagnant	-	Culvert blocked by ice and snow on south side. Minor pond on north side of road.
6/2/2021	15:41	MT7-46	Dry	-	-
6/2/2021	15:40	MT7-45	Flowing	South to North	Minor flow
6/2/2021	15:38	MT7-44	Stagnant	-	Culvert blocked by ice and snow on north side. Pond on south side of road.
6/2/2021	15:37	MT7-43	Stagnant	-	Blocked by ice and snow on south side of culvert.

6/2/2021	15:35	MT7-42	Dry	-	-
6/2/2021	15:34	MT7-41	Stagnant	-	Culvert blocked by ice and snow on north side. Pond on south side of road.
6/2/2021	15:33	MT7-40	Dry	-	-
6/2/2021	15:32	MT7-39	Stagnant	-	Blocked by ice and snow in culvert.
6/2/2021	15:31	MT7-38	Stagnant	-	Blocked by ice and snow in culvert.
6/2/2021	15:29	MT7-37	Stagnant	-	Blocked by snow and ice in culvert.
6/2/2021	15:28	MT7-36	Stagnant	-	Blocked by snow and ice in culvert.
6/2/2021	15:26	MT7-35	Stagnant	-	Blocked by ice and snow on north side of culvert.
6/2/2021	15:25	MT7-34	Flowing	North to South	Minor flow, nearly equalized
6/2/2021	15:23	MT7-33	Stagnant	-	Air bag stuck inside culvert on south side. Dry on north side of road and very little stagnant water south side of road
6/2/2021	15:20	MT7-32	Dry	-	-
6/2/2021	15:18	MT7-31	Stagnant	-	Equalized
6/2/2021	15:17	MT7-30	Dry	-	-
6/2/2021	15:16	MT7-29	Dry	-	-
6/2/2021	15:15	MT7-28	Dry	-	-
6/2/2021	15:14	MT7-27	Stagnant	-	Equalized
6/2/2021	15:13	MT7-26	Stagnant	-	Air bag stuck inside culvert on north side. No ponding on either side
6/2/2021	15:12	MT7-25	Stagnant	-	Blocked by ice and snow in culvert. Minor pond both sides of road
6/2/2021	15:12	MT7-24	Stagnant	-	Blocked by ice and snow in culvert. Minor pond both sides of road
6/2/2021	15:11	MT7-23	Dry	-	-
6/2/2021	15:10	MT7-22	Flowing	North to South	-
6/2/2021	15:10	MT7-21	Stagnant	-	Blocked by ice and snow on south side of culvert. Pond on north side of road.
6/2/2021	15:09	MT7-20	Dry	-	-
6/2/2021	15:07	MT7-19	Dry	-	-
6/2/2021	15:05	MT7-18	Dry	-	-
6/2/2021	15:03	MT7-17	Stagnant	-	Equalized
6/2/2021	15:01	MT7-16	Stagnant	-	Equalized
6/2/2021	15:55	MT7-15	Dry	-	-
6/2/2021	14:52	MT7-14	Dry	-	-
6/2/2021	14:51	MT7-13	Dry	-	-
6/2/2021	14:50	MT7-12	Stagnant	-	Air bag removed on north side of culvert. Pond on north side of road.
6/2/2021	14:47	MT7-11	Stagnant	-	Equalized
6/2/2021	14:46	MT7-10	Stagnant	-	Equalized
6/2/2021	14:44	MT7-09	Flowing	South to North	Minor flow, nearly equalized
6/2/2021	14:42	MT7-08	Dry	-	-
6/2/2021	14:40	MT7-07	Stagnant	-	Blocked by ice and snow in culvert. Pond on south side of road.
6/2/2021	14:38	MT7-06	Stagnant	-	Equalized
6/2/2021	14:36	MT7-05	Stagnant	-	Blocked by ice and snow in culvert.
6/2/2021	14:34	MT7-04	Stagnant	-	Blocked by ice and snow in culvert.
6/2/2021	14:32	MT7-03	Stagnant	-	Blocked by ice and snow in culvert.
6/2/2021	14:30	MT7-02	Flowing	South to North	Minor flow, nearly equalized
6/2/2021	14:28	MT7-01	Dry	-	-

Appendix F Monitoring Location Photos

F.1 S9 Monitoring Location

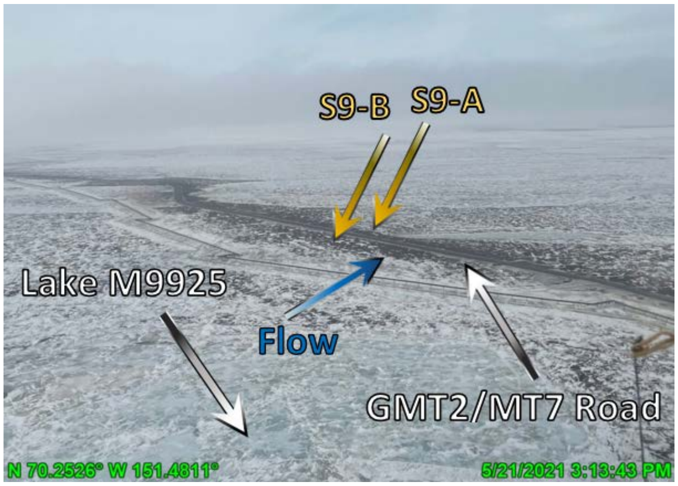


Photo F.1: Local meltwater near S9, looking west; May 21, 2021

Photo F.2: Flow through culvert MT7-70, looking south (upstream); June 5, 2021

Photo F.3: Near peak stage at S9-B, looking northeast; June 7, 2021

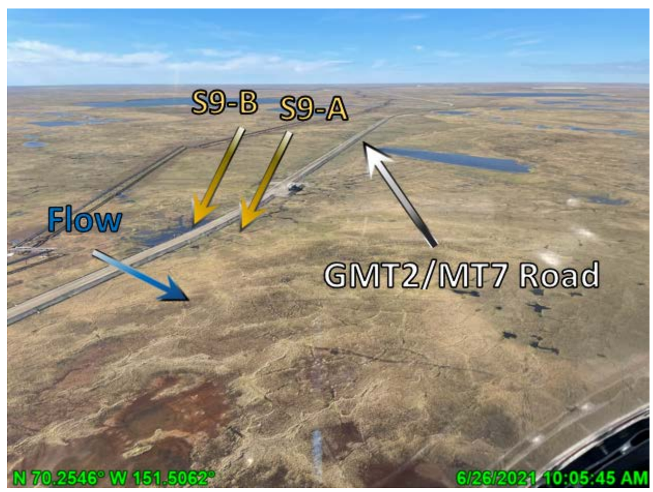


Photo F.4: Summer conditions near S9, looking northeast, June 26, 2021

F.2 S10 Monitoring Location

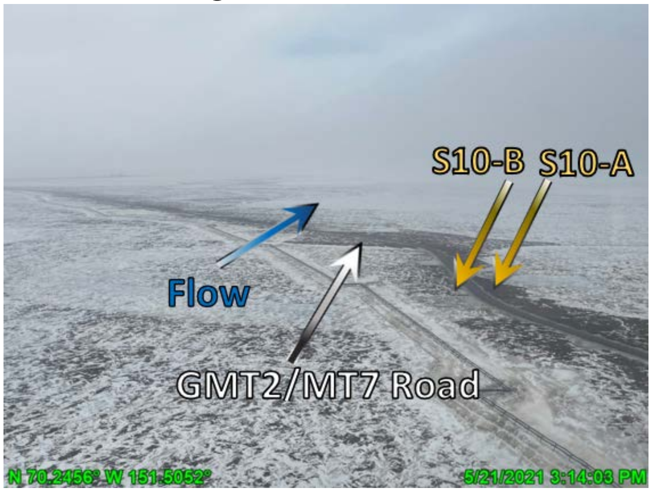


Photo F.5: Local melt near S10, looking west; May 21, 2021

Photo F.6: Increasing meltwater on the upstream (south) side of road, looking northeast; May 30, 2021

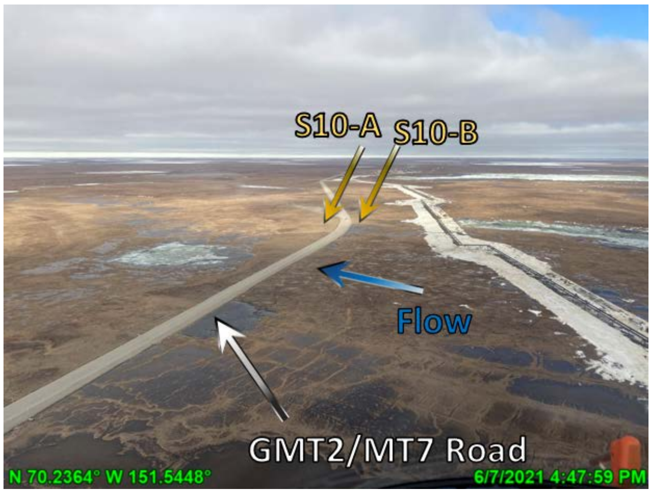


Photo F.7: Decreasing meltwater near S10, looking northeast; June 7, 2021

Photo F.8: Summer conditions near S10, looking southwest; June 26, 2021

F.3 S11 Monitoring Location

Photo F.9: Local meltwater around S11, looking southwest; May 23, 2021

Photo F.10: Peak stage near S11, looking southwest; May 24, 2021

Photo F.11: Receding stage near S11, looking south; June 5, 2021

Photo F.12: Summer conditions near S11, looking southwest; June 26, 2021

F.4 S12 Monitoring Location

Photo F.13: Ponded water on the upstream side of the road near S12, looking south; May 24, 2021

Photo F.14: Decreasing stage near S12 after peak, looking south; May 27, 2021

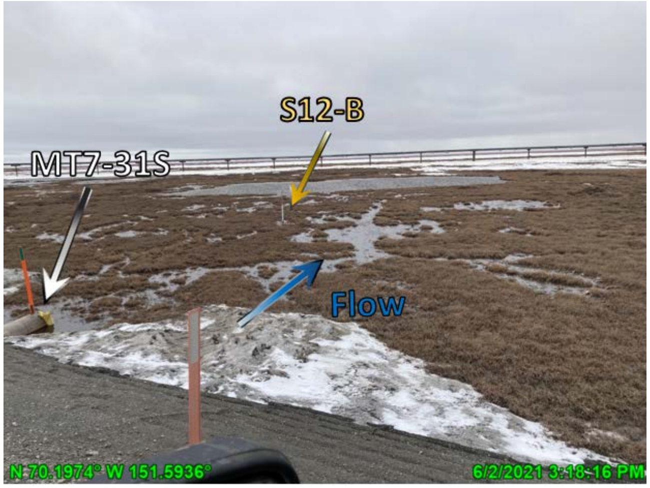


Photo F.15: Minimal ponding along road embankments at S12, looking east (downstream); June 2, 2021

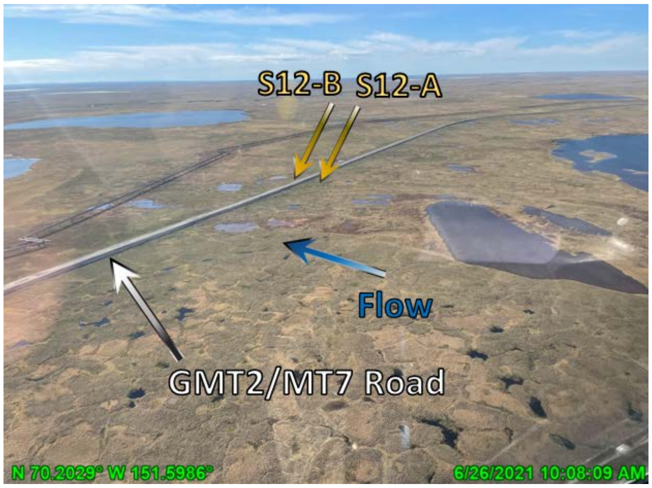


Photo F.16: Summer conditions near S12, looking south; June 26, 2021

F.5 S13 Monitoring Location

Photo F.17: Ponded meltwater on the upstream side of the road near S13, looking southwest; May 21, 2021

Photo F.18: Decreasing stage near S13 after peak, looking south; May 27, 2021

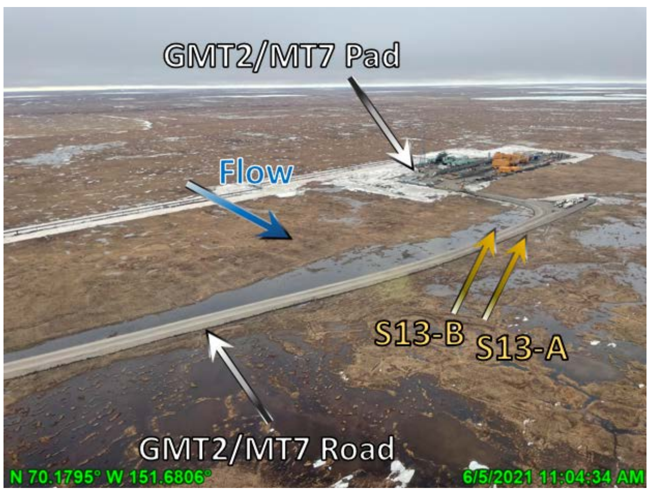


Photo F.19: ponding along road embankments at S13, looking south (upstream); June 5, 2021

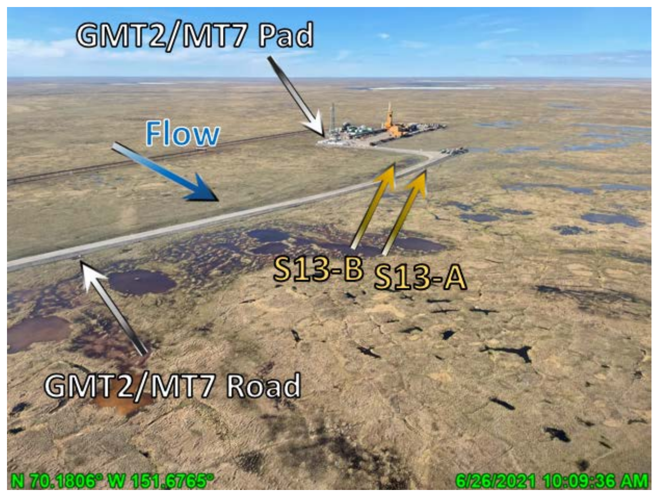


Photo F.20: Summer conditions near S13, looking south (upstream); June 26, 2021