CD-North

Development Project

2002 Spring Breakup and Hydrology Assessment

Submitted to

ConocoPhillips

By

Baker

Michael Baker Jr., Inc.
Anchorage, Alaska 99503
907-273-1600

November 2002

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1.0 Introduction

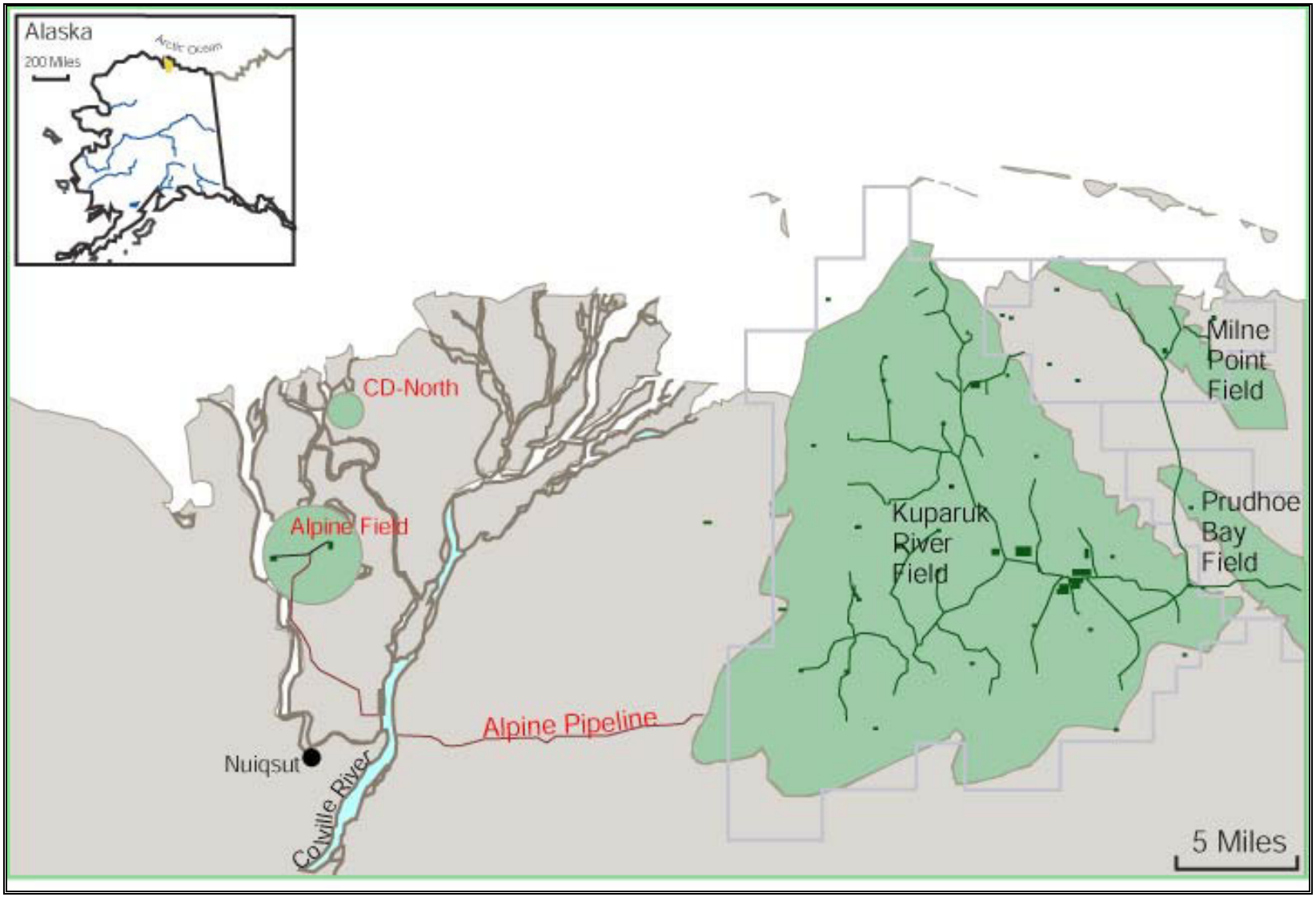
Breakup studies have been conducted on the Colville River Delta since 1992 to further the understanding of the hydrologic characteristics associated with spring breakup flooding events. Historical data for the Colville River Delta and the surrounding region are limited. Continued monitoring efforts are required in order to provide information for the design of oil field facilities that will be safe during large magnitude flood events.

This report summarizes the observations and measurements made during the 2002 spring breakup of the Colville River Delta and its impact on the proposed CD-North satellite development site (Figure 1-1). Breakup field data for the CD-North development were collected in conjunction with those for a breakup study for the existing Alpine development (Michael Baker Jr., 2002a).

Breakup data, observations, and analyses related to the head of the delta, and breakup observations that pertain to the delta as a whole are presented in Section 2 of this report. Breakup data, observations, and analyses related specifically to the proposed CD-North site are presented in Section 3.

All elevations presented in this report are in feet and are referenced to British Petroleum Mean Sea Level (BPMSL) datum unless otherwise noted. All tables, figures, and photographs referenced within a given section are located at the end of that section.

Figure 1-1 Location of Proposed CD-North Satellite



2.0 Colville River

2.1 Water Surface Elevations and Observations at the Head of the Delta

Water surface elevations were monitored at the head of the Colville River delta at three monitoring sites, Monument 01, at temporary benchmark (TBM) 01U and TBM 01D. TBM 01U and TBM 01D were located approximately ½ mile upstream and downstream from Monument 01, respectively. Water surface elevations were measured from either direct observations of temporary staff gages at each monitoring site, high water marks left on the staff gages, or surveyed level loops of water levels or high water marks. The locations of the three monitoring sites at the head of the delta are shown on Figure 2-1. Measurements began on 23 May, the day flowing water was first observed near Monument 01. Measurements continued until 30 May at which time the water levels had receded considerably. All temporary staff gages were removed by 1 June. Water surface elevations and observation records for the temporary staff gages at the head of the delta are presented in Tables 2-1 through 2-3.

2.2 Peak Water Surface Elevation at the Head of the Delta

The peak water surface elevation at Monument 01 occurred in the early afternoon of 24 May at an elevation of 16.87 feet. Following the peak, the water levels receded rapidly and after 36 hours the water surface elevation had decreased to an elevation of 13.96 feet. Discharge at the time of the peak water surface elevation is estimated to have been 231,000 cubic feet per second (cfs). The channel at Monument 01 was free of intact low water channel ice at the time of the peak water surface elevation. Low water channel ice in the East and Nigliq channels was mostly intact (although floating) downstream from the divergence of these channels. Snow blockages were present in many of the smaller channels; however, much of the channel snow had melted and the exposed ice was rotten.

Measured peak water surface elevations at Monument 01 were compared to water surface elevations predicted by the two-dimensional surface water model developed for the Colville River Delta (Michael Baker Jr., Inc., 2002b, 2001a, 1998; and Shannon & Wilson, Inc., 1997). Based on a linear interpolation between the water surface elevations predicted for the 2- and 10-year open water floods, it is estimated that the peak water surface elevations observed this

spring at Monument 01 will likely be equaled or exceeded, on average, about once every 7 years. It should be noted that the difference in peak water surface elevation measured in 2001 versus 2002 is 0.5 feet and that estimated recurrence interval of 7 years (rounded to the nearest whole year) is the same.

2.3 Peak Discharge in the Colville River (Head of the Delta)

Discharge in the Colville River was estimated using the Slope-Area Method as defined by the United States Geological Survey (Dalrymple & Benson 1984). Water surface elevation and slope data were obtained from the measurements made at Monument 01 and TBM 01U and TBM 01D. Cross section geometry was based on three cross sections surveyed in July 2002 by Kuukpik/LCMF (Appendix A). Hydraulic roughness values were estimated based on a 1993 discharge measurement (Alaska Biological Research and Shannon & Wilson, 1994) and on-site investigations of the channel bottom using methods outlined by the United States Geological Survey (Arcement and Schinder, 1989).

The peak discharge at the head of the Colville River Delta is estimated to have been 300,000 cfs, and to have occurred the afternoon of 27 May. It is estimated that this discharge will be equaled or exceeded, on average, approximately once every 4 years (Michael Baker Jr., Inc. and Hydroconsult, 2002). It should be noted that this estimate was based on limited data as weather prevented data collection on 28 and 29 May. The estimated discharge on 30 May is considerably lower than the estimate for 27 May, but the data are not sufficient to determine either the time when the peak discharge began to recede, or if a peak discharge of higher magnitude occurred during that period.

The estimated peak discharge in 2002 is the same as that estimated for 2001. Observations at Monument 01 and other areas of the delta suggest that the discharges were very similar. Thus, the estimated peak discharge is considered a reasonable approximation based on the available data. A hydrograph of water surface elevation and discharge vs. time is presented on Figure 2-2.

2.4 2002 Observations Compared to 2001 Observations

At Monument 01 the peak water surface elevation approximates a 7-year recurrence interval when compared to the predictions of the two-dimensional surface water model. However, using the measured water surface slopes and Slope-Area Method, the magnitude of the peak discharge is estimated to have a recurrence interval of about 4 years (Section 2.2). These are the same conclusions made regarding recurrence intervals that were made for the 2001 spring breakup (Michael Baker Jr. Inc., 2001b).

Water surface elevation and flow pattern observations made in 2002 were very similar to those observed in 2001, although the two breakups exhibited uniquely different characteristics. For example, in 2002 breakup was preceded by warm sunny weather that caused a relatively rapid flood peak. At the head of the delta, the peak water surface elevation has occurred on average (since 1994) seven days after water was first observed on the delta. In 2002, the peak water surface elevation occurred only one day after water was first observed flowing, the fastest recorded time between observed flowing water and peak water surface elevation. In contrast, the 2001 breakup was preceded with cool cloudy weather that caused breakup to occur approximately two weeks later than average. Historically, the average date water has first been observed flowing at the head of the delta is 23 May. In 2001, flowing water was not observed until 5 June, with a peak water surface elevation occurring on 10 June.

Even though breakup occurred differently in 2002 and 2001, the magnitude of the flood peak discharge was estimated to be the same. Observed flow patterns were similar and comparisons to the two-dimensional model were similar. The differences in 2002 and 2001 flood peak recurrence intervals, when comparing estimations based on discharge versus estimations based on water surface elevations (interpolated from the two-dimensional model), are the same 4 year verses 7 year (rounded to the nearest whole year).

The two-dimensional surface water model was constructed to predict conditions during large flood events, i.e. 50-, 100-, and 200-year. It assumes open water, steady state conditions and does not take into account channel ice or ice jams. It was assumed that during a large flood event the presence of snow, ice, and ice jams would have little effect on the overall water surface elevations. This assumption is still valid, however, channel ice and ice jams are likely to always

occur to some extent during breakup in the Colville River Delta. Channel ice and ice jams will restrict flow and cause increases in water surface elevations during smaller flood events when flow is mainly confined to the channels. Thus, the water surface elevation predictions of the model will generally under-predict water surface elevations during small flood events when channel ice and snow are present in the delta. For this reason the water surface elevation return period is higher than the discharge return period during small flood events.

Table 2-1 Monument 01, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	8:15	11.00	Channel is 70% clear. Channel ice intact along the right bank.
5/24/2002	8:00	16.21	Channel ice has cleared. Open channel conditions with floating ice chunks.
High Water Mark		16.87	High water occurred on May 24 between 08:00 and 13:50.
5/24/2002	13:50	16.82	Ice chunks observed floating along right bank.
5/24/2002	14:20	16.63	Majority of floating ice is along right bank.
5/24/2002	14:50	16.21	
5/25/2002	12:19	13.96	Channel is free of ice.
5/26/2002	11:15	13.83	Channel is ice free with occasional small ice chunks flowing through. Reading taken in very windy conditions.
5/27/2002	15:15	13.94	Channel is free of ice.
5/30/2002	16:25	7.77	

Notes:

1. Elevations are based on an elevation of 27.74 feet BPMSL for Monument 01, established by Lounsbury & Associates in 1996.
2. The distance from Monument 01 to TBM 01U is 3,040 feet. The distance from Monument 01 to TBM 01D is 2,960 feet.
3. GPS coordinates for Mounument 01 are N70° 09' 58.3" W150° 56' 12.6" (NAD 27), surveyed by Loundsbury and Associates.

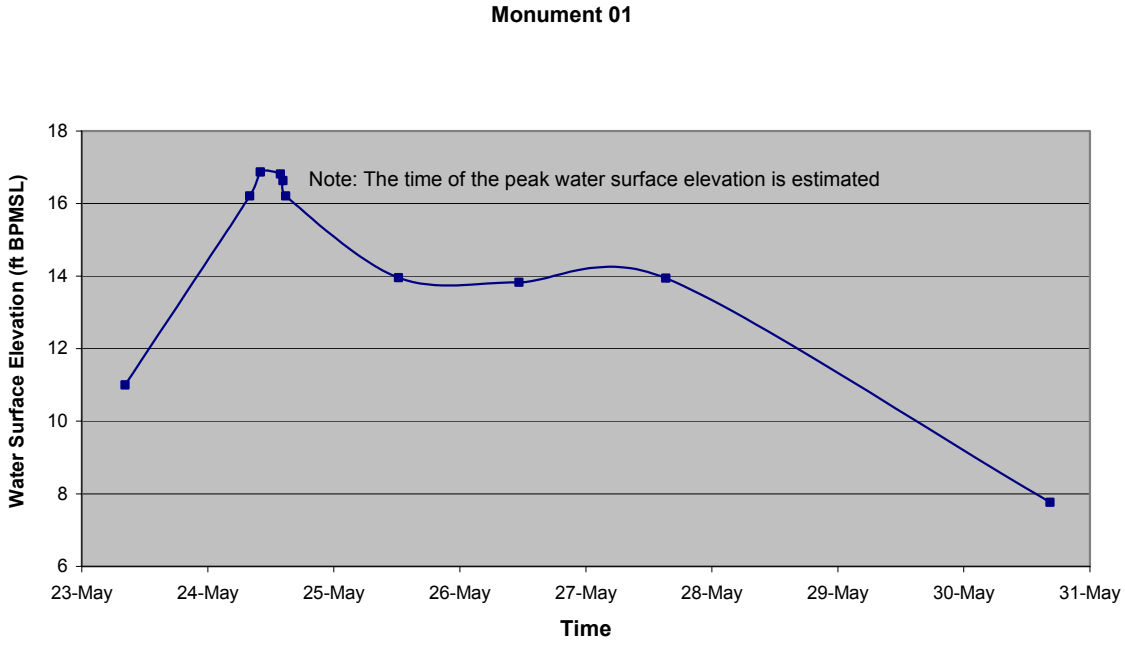


Table 2-2 Temporary Benchmark 01U, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	8:10	11.29	Channel is 70% free of ice. Channel ice intact along the right bank.
5/23/2002	15:25	12.77	Channel is 90% free of ice. Channel ice intact on right bank. Ice chunks floating in open water.
5/24/2002	7:55	16.32	Channel ice has cleared. Open channel conditions with numerous floating ice chunks.
High Water Mark		17.00	High water occurred on May 24 between 07:55 and 14:40.
5/24/2002	14:40	16.47	
5/25/2002	12:38	14.25	Ice chunks floating near left bank.
5/26/2002	10:30	14.16	Reading taken in very windy conditions.
5/27/2002	15:00	14.28	Channel is free of ice.
5/30/2002	15:10	8.13	

Notes:

1. Elevations are based on an elevation of 27.74 feet BPMSL for Monument 01, established by Lounsbury & Associates in 1996.
2. The distance from TBM 01U to Monument 01 is 3,040 feet.
3. GPS coordinates for TBM 01U are N70° 09' 31/4" W150° 56' 36.7" (NAD 27) which were obtained by a Garmin GPS III Plus hand-held global positioning system.

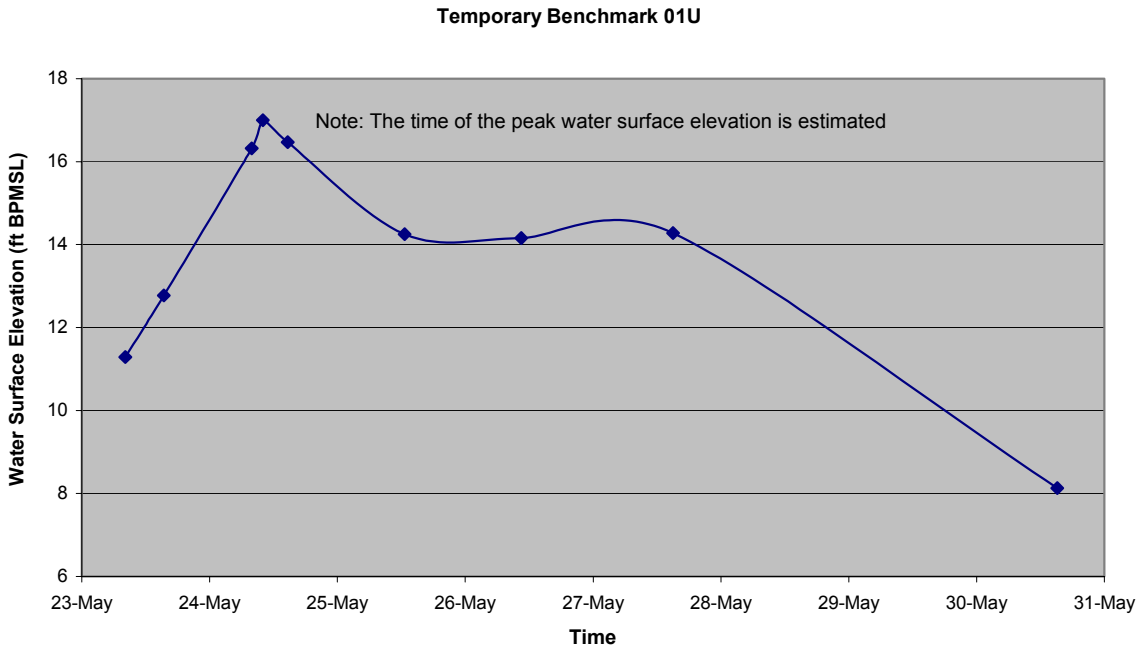


Table 2-3 Temporary Benchmark 01D, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (feet BPMSL)	Observations
5/23/2002	8:20	10.78	Intact channel ice along right bank. Ice breaking into rafts downstream.
5/23/2002	15:55	11.98	Ice chunks passing through channel.
5/24/2002	8:15	16.14	Channel ice has cleared. Open channel conditions with floating ice chunks.
High Water Mark		16.65	High water occurred on May 24 between 08:15 and 14:55.
5/24/2002	14:55	15.74	Stranded ice chunks visible on banks.
5/25/2002	12:52	13.59	Ice less than 5 feet in diamater floating in channel.
5/26/2002	11:20	13.41	Channel is open with occasional small floating ice chunks. Reading taken in very windy conditions.
5/27/2002	15:25	13.39	Channel is free of ice.
5/30/2002	17:57	7.59	

Notes:

1. Elevations are based on an elevation of 27.74 feet BPMSL for Monument 01, established by Lounsbury & Associates in 1996.
2. The distance from Monument 01 to TBM 01D is 2,960 feet.
3. GPS coordinates for TBM 01D are N70° 10' 26.6" W150° 56' 01.6", (NAD 27) which were obtained by a Garmin GPS III Plus hand-held positioning system.

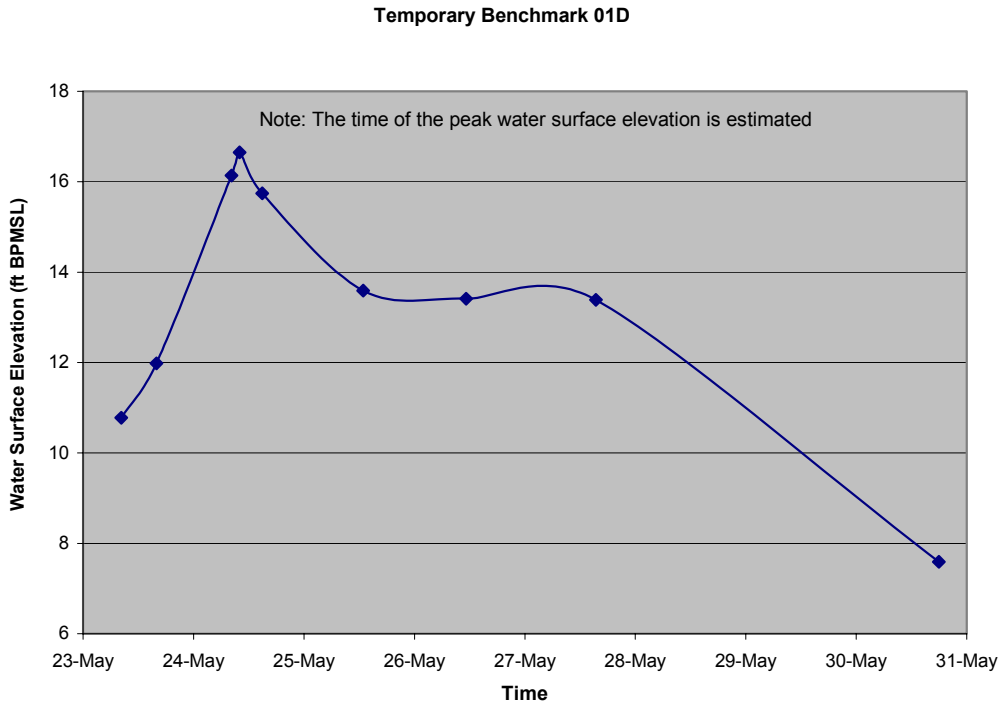


Table 2-4 Summary of Breakup Data Obtained at the Head of the Colville River Delta, 1962 - 2002

Year	Approximate Date Water Began to Flow	Peak Water Surface Elevation (ft)	Date of Peak Water Surface Elevation	Peak Breakup Discharge (cfs)	Notes
2002	23 May	16.87	24 May	300,000	1
2001	5 June	17.37	10 June	300,000	1, 2
2000	8 June	19.33	11 June	580,000	1, 3
1999	22 May	13.97	30 May	203,000	1, 4, 5
1998	21 May	18.11	29 May	213,000	1, 6
1997	20 May	15.05	29 May	177,000	1
1996	15 May	17.19	26 May	160,000	1, 7
1995	8 May	15.7	16 May	233,000	8
1994	16 May	13.0	25 May	159,000	8
1993	–	20.0	31 May	379,000	8
1992	–	14.7	2 June	188,000	8
1977	–	19.9	7 June	407,000	8
1973	25 May	–	8 June	–	8
1971	23 May	–	2 June	–	8
1964	28 May	–	3 June	–	8
1962	19 May	13.2	14 June	215,000	8

Notes:

1. Water surface elevations are based on monuments set by Lounsbury & Associates in 1996 and are based on British Petroleum mean sea level (BPMSL).
2. Data from Michael Baker, Jr., Inc., 2001, Alpine Facilities Spring 2001 Breakup and Hydrologic Assessment. Prepared for Phillips Alaska, Inc., Anchorage.
3. The peak breakup discharge was estimated to range between 570,000 to 590,000 cfs. Data from Michael Baker, Jr., Inc., 2000, Alpine Facilities Spring 2000 Breakup Monitoring and Hydrologic Assessment. Prepared for Phillips Alaska, Inc., Anchorage.
4. Data from Michael Baker Jr., Inc., 1999, 1999 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska. Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
5. Water was flowing in the Colville River at Umiat on this day. It is not known if this was the first day of flow. Therefore, it is not known if water was flowing on the delta prior to this date.
6. Data from Michael Baker Jr., Inc., 1998, 1998 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska. Prepared for ARCO Alaska, Inc., Anchorage, Alaska.
7. Data from Shannon & Wilson, Inc., 1996, 1996 Spring Breakup and Hydrologic Assessment, Colville River Delta, North Slope, Alaska. Prepared for Michael Baker Jr., Inc., Anchorage, Alaska.
8. Data from Jorgenson et al., 1996, Geomorphology and Hydrology of the Colville River Delta, Alaska, 1995. Prepared for ARCO Alaska, Inc., and Kuukpik Unit Owners, Anchorage, Alaska. The water surface elevations presented in this report were based on an elevation of 41.99 feet for the USCGS monument “River.” In 1996 Lounsbury & Associates surveyed USCGS monument “River” and tied it to BPMSL. The elevation of “River,” based on BPMSL, is 41.83 feet. The values presented in this table are based on the elevation for “River” that is based on BPMSL.

Figure 2-1 Temporary Staff Gage Locations

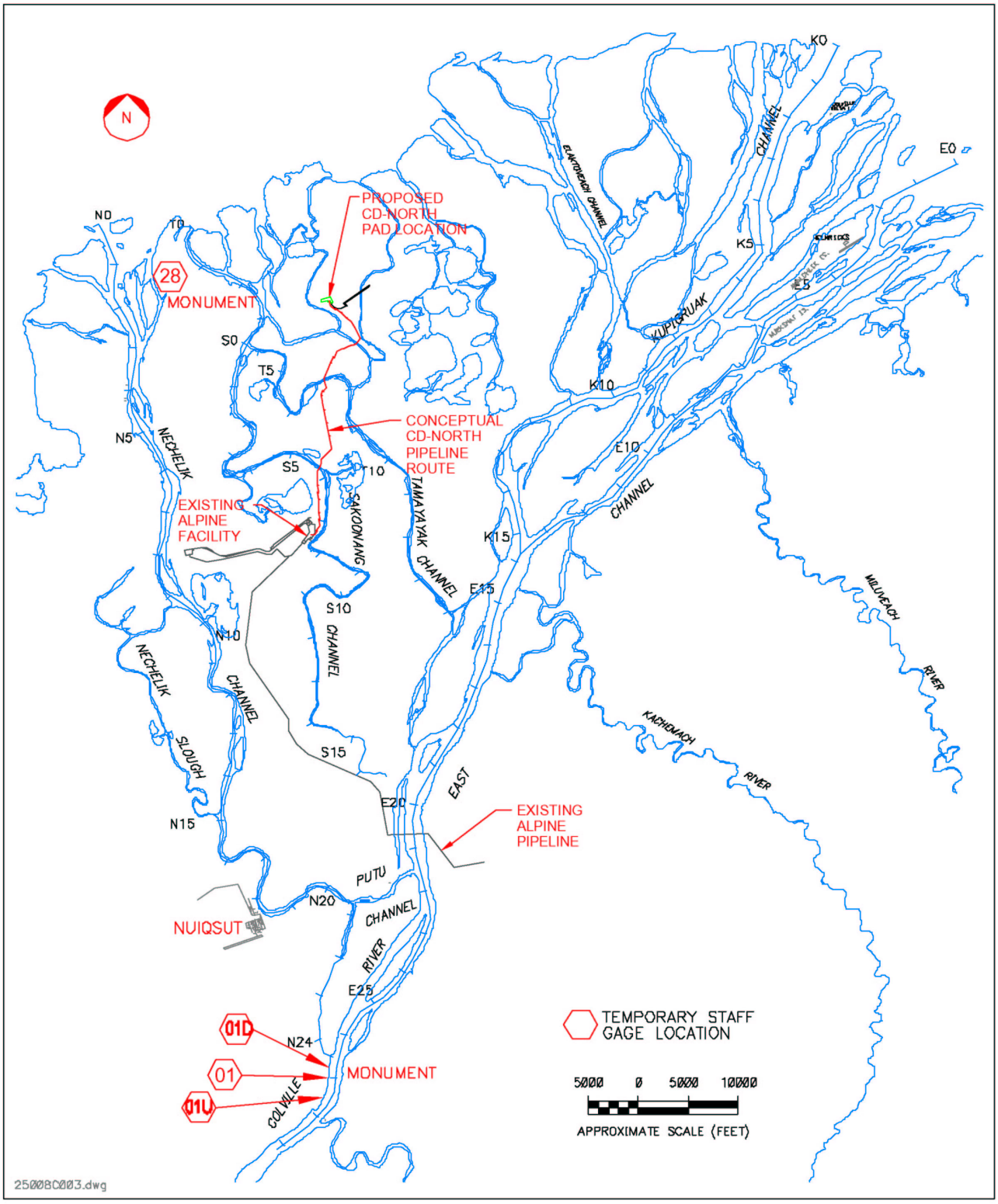
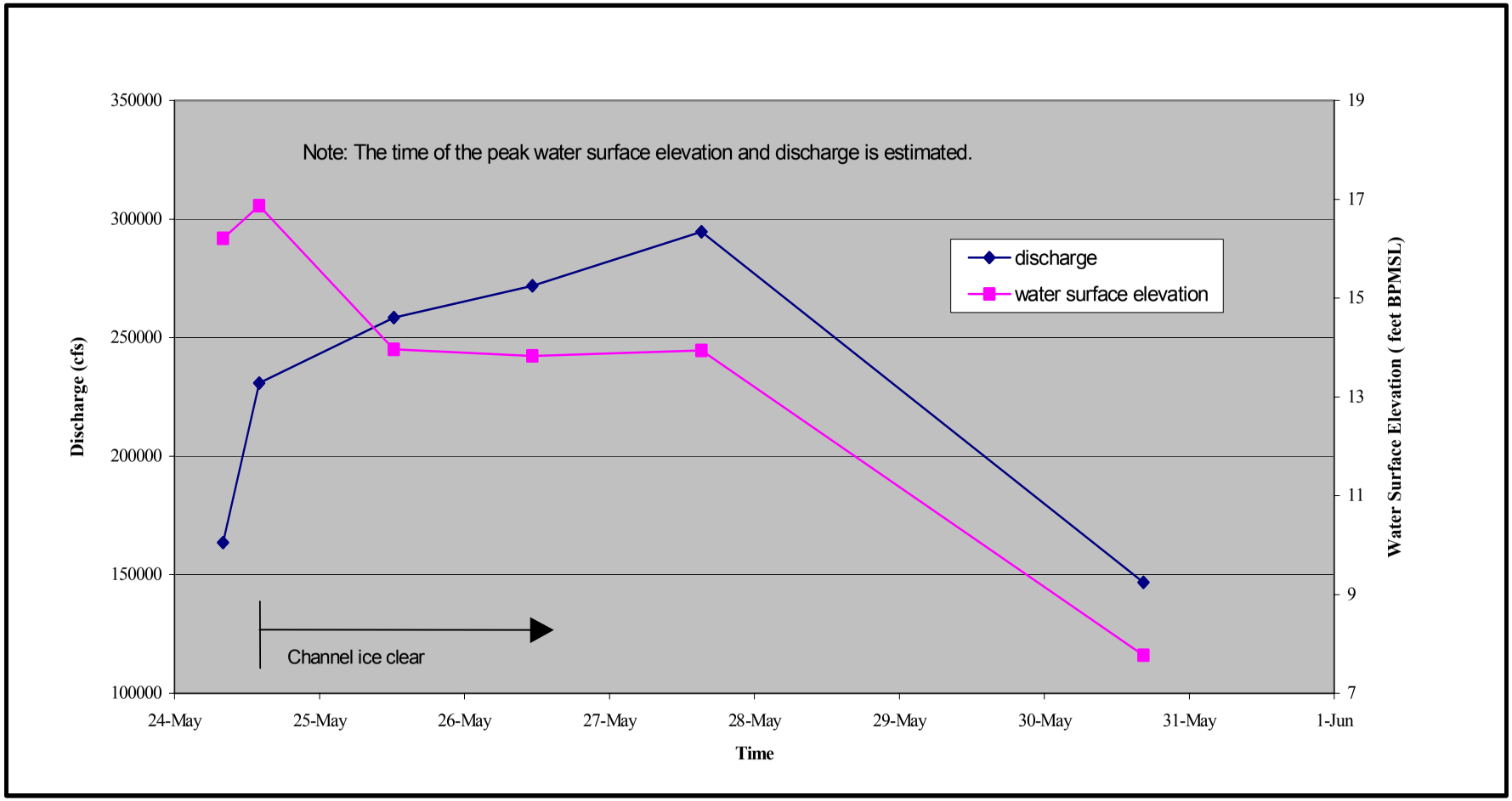


Figure 2-2 Discharge and Water Surface Elevation vs. Time at Monument 01



3.0 CD-North

CD-North is a proposed Colville River Delta satellite development located between the West and East Ulamnigiaq Channels of the Colville River approximately 5 miles north of the existing Alpine facilities. CD-North is proposed as a roadless development consisting of a facilities gravel pad and runway connected by a short gravel road. A 6.5-mile pipeline between CD-North and the existing Alpine facility is planned. The location of the proposed CD-North gravel structures and the proposed pipeline route is presented on Figure 3-1.

To monitor water surface elevations in the CD-North project area, temporary staff gages were installed upstream and downstream of pipeline crossing locations on the Sakoonang, Tamayagiaq, Ulamnigiaq, and West Ulamnigiaq Channels. Temporary gages were also installed on the East Ulamnigiaq Channel in the vicinity of the southeast end of the proposed runway (see Figure 3-2). All temporary gages were referenced to BPMSL elevation. Water surface elevation measurements began on 23 May when flowing water was first observed and continued until 31 May when all staff gages were removed.

Discharge was estimated for all channels that the pipeline crosses as well as the Ulamnigiaq Channel adjacent to the proposed pad location. Channel geometry and flow descriptions are based on cross sections that was surveyed by Kuukpik/LCMF, Incorporated in July 2001. The surveyed cross sections varied in distance from approximately 200 to 1,000 feet from the proposed pipeline crossings. Cross section locations are shown in Figure 3-2 and individual channel cross sections are presented in Appendix B. Site-specific water surface elevations and observations for each of the channels monitored are discussed in the following sections. A summary of channel conditions at the time of the peak water surface elevation is shown on Table 3-1.

3.1 Sakoonang Channel (Crossing 2)

The Sakoonang channel was asymmetrical and generally trapezoidal in shape in the vicinity of the proposed pipeline crossing. During breakup, flow was confined entirely to the active channel. At the time of the peak water surface elevation, the top width of flow was approximately 450 feet and the maximum depth was 11.6 feet, based on the cross section survey in 2001 approximately 420 feet from the proposed crossing location (See Figure B-1).

Water was first observed on the Sakoonang Channel staff gages on 23 May. Water surface elevations peaked at 6.71 feet and 6.11 feet at the upstream and downstream monitoring sites, respectively. In the vicinity of the proposed pipeline crossing, the peak water surface elevation was estimated at 6.7 feet. Peak water surface elevations occurred between 26 May at 1:50 p.m. and 27 May at 11:45 a.m. During the occurrence of the peak water surface elevation, there was no intact channel ice or snow, but grounded ice chunks were observed on the left bank.

Discharge estimates for the Sakoonang Channel were calculated using normal depth computations based on the cross section surveyed in 2001. Channel geometry, streambed material, and Manning roughness coefficients used in estimating 2002 discharge in the channel were identical to those used for 2001 discharge estimates (Michael Baker Jr., 2001b).

It was estimated that at the time the peak water surface elevation, discharge on the Sakoonang channel was approximately 9,800 cfs with an average velocity of 2.7 feet per second (ft/sec). A peak discharge of 10,500 cfs with an average velocity of 3.1 ft/sec, was observed on 24 May. The peak discharge occurred at a water surface elevation of 6.14 feet, and coincided with the steepest water surface slope. Water surface elevations and observations for the Sakoonang channel are summarized in Table 3-2. Photos 3-1, 3-2, and 3-3 show the Sakoonang channel on 23, 24 and 26 May, respectively.

Based on visual observations, the streambed material of the active channel was composed of fine silt and sand, and was relatively free of dunes and other bedforms. The left (looking downstream) overflow bank was relatively smooth and covered with sedge and spare willow. The channel bank is gently sloping from the vegetation line to the active channel. The right overflow bank consisted of rough polygon formations and dense sedge. The right channel bank is a steep cut bank and active erosion was noted. Manning roughness coefficients, n, estimated in 2001 remain the same; coefficients were 0.050 for the left overflow bank, 0.021 for the active channel, and 0.060 for the right overflow bank. Selection of Manning's n at all cross sections was based on the procedures outlined in Arcement and Schnider, 1989.

3.2 Tamayagiaq Channel (Crossing 4)

The Tamayagiaq channel was asymmetrical and generally trapezoidal in shape in the vicinity of the proposed pipeline crossing. At the time of the peak water surface elevation, the top width of water was approximately 630 feet and the maximum depth was 12.2 feet based on the cross section survey in 2001 approximately 200 feet upstream from the proposed crossing location (See Figure B-2).

In the Tamayagiaq channel, flowing water was first observed on 23 May. Water surface elevations peaked at 6.5 feet and 6.0 feet at the upstream and downstream monitoring sites, respectively. In the vicinity of the proposed pipeline crossing the peak water surface elevation was estimated at 6.4 feet. Peak water surface elevations occurred between 26 May at 1:30 p.m. and 27 May at 11:25 a.m. The channel was free of ice at both gage locations on 27 May.

Discharge estimates for the Tamayagiaq Channel were calculated using normal depth computations and the surveyed cross section. Channel geometry, streambed material, and Manning roughness coefficients used in estimating 2002 discharge in the channel were identical to those used for 2001 discharge estimates (Michael Baker Jr., 2001b).

It was estimated that at the time the peak water surface elevation occurred, peak discharge on the Tamayagiaq channel was approximately 10,700 cfs with an average velocity of 2.2 ft/sec. Water surface elevation and observations for the Tamayagiaq channel are summarized in Table 3-3. Photos 3-4, 3-5, and 3-6 shows the Tamayagiaq channel on 23, 26 and 27 May, respectively.

Based on visual observations, the streambed material of the active channel was composed of fine silt and sand, and was relatively smooth and free of bedforms. The left (looking downstream) overflow bank was covered with dense grasses and spare willow. The left channel bank is gently sloping from the vegetation line to the active channel. The right overflow bank consisted of dense grasses and rough polygon formations with relief up to 2 feet. The right channel bank is a steep cut bank approximately 6-8 feet above the normal summertime waterline. Active erosion was noted on this bank. Manning roughness coefficients, *n*, estimated in 2001 remain the same; coefficients were 0.058 for the left overflow bank, 0.021 for the active channel, and 0.065 for the right overflow bank.

3.3 Ulamnigiaq Channel (Crossing 5)

The Ulamnigiaq channel was asymmetrical and generally trapezoidal in shape in the vicinity of the pipeline crossing. At the time of the peak water surface elevation, the top width of water was approximately 690 feet and the maximum depth was 19.0 feet based on the cross section survey in 2001 approximately 1000 feet downstream from the proposed crossing location (See Figure B-3).

Flowing water was first observed on the Ulamnigiaq Channel on 23 May. Water surface elevations peaked between 26 May at 1:00 p.m. and 27 May at 11:00 a.m. at an estimated 6.5 feet at the upstream monitoring site and 6.3 feet at the downstream monitoring site. In the vicinity of the proposed pipeline crossing the peak water surface elevation was estimated to be 6.3 feet. At the time of peak water surface elevation, ice flows were observed at the upstream monitoring location. The channel was free of ice at the downstream monitoring location.

Discharge estimates for the Ulamnigiaq channel were calculated using normal depth computations and the surveyed cross section. Channel geometry, streambed material, and Manning roughness coefficients used in estimating 2002 discharge in the channel were identical to those used for 2001 discharge estimates (Michael Baker Jr., 2001b).

It was estimated that at the time the peak water surface elevation occurred, discharge on the Ulamnigiaq channel at the proposed pipeline crossing was approximately 6,900 cfs with an average velocity of 1.8 ft/sec. A peak discharge of 7,700 cfs, average velocity of 2.7 ft/sec, was observed on 26 May. The peak discharge occurred at a water surface elevation of 4.4 feet. Water surface elevation and observations for the Ulamnigiaq channel are summarized in Table 3-4. Photos 3-7, 3-8, and 3-9 shows conditions at the Ulamnigiaq channel on 23, 26 and 27 May, respectively.

Based on visual observations, the streambed material of the active channel was composed of fine silt and the active channel bed was irregular. The left overflow bank (looking downstream) between the active channel and a paleochannel approximately 700 feet to the south was relatively smooth ground with dense grasses up to approximately 0.5 feet in height. The paleochannel proper was relatively smooth ground with grasses up to 0.8 feet in height. Low sand dunes were noted on the left bank of the paleochannel. The left channel bank is steep and approximately 6

feet above the normal summer waterline. Active erosion was noted as chunks of bank were observed along the base and thermal erosional cracks were noted. The right overflow bank was relatively smooth and covered with dense grasses up to 0.4 feet in height. The right channel bank is sloping and active erosion is not apparent. Manning roughness coefficients, *n*, estimated in 2001 remain the same; coefficients were 0.045 for the paleochannel, 0.042 for the left overflow bank, 0.022 for the active channel, and 0.043 for the right overflow bank.

3.4 West Ulamnigiaq

The West Ulamnigiaq channel adjacent to the proposed CD North facility was asymmetrical and generally trapezoidal in shape. At the time of the peak water surface elevation, the top width of water was approximately 205 feet and the maximum depth was 7.8 feet based on the cross section survey in 2001 (See Figure B-4).

Flowing water was not observed on the West Ulamnigiaq Channel until 25 May. Water surface elevations peaked at 5.79 feet and 5.33 feet at the upstream and downstream monitoring sites, respectively. In the vicinity of the proposed facility water surface elevation was estimated to be 5.6 feet. Peak water surface elevations occurred between 26 May at 12:55 p.m. and 27 May at 10:00 a.m. At the time of peak water surface elevation, ice flows were observed at the upstream monitoring location. The channel was free of ice at the downstream monitoring location.

Discharge estimates for the West Ulamnigiaq channel were calculated using normal depth computations and the surveyed cross section located adjacent to the proposed CD North facility. Channel geometry, streambed material, and Manning roughness coefficients used in estimating 2002 discharge in the channel were identical to those used for 2001 discharge estimates (Michael Baker Jr., 2001b). Manning's roughness coefficients, *n*, estimated for the West Ulamnigiaq Channel were 0.045 for the left and right overflow banks and 0.021 for the active channel.

It was estimated that at the time the peak water surface elevation occurred, peak discharge on the West Ulamnigiaq channel at the proposed facility was approximately 2,200 cfs with an average velocity of 2.4 ft/sec. Water surface elevations and observations for the West Ulamnigiaq channel are summarized in Table 3-5. Photos 3-10, 3-11, and 3-12 show conditions in the West Ulamnigiaq channel on 23, 26, and 27 May, respectively.

3.5 East Ulamnigiaq

A monitoring site was installed in the East Ulamnigiaq channel adjacent to the southeast end of the proposed CD North airstrip. Flowing water was observed on the East Ulamnigiaq channel on 23 May. A peak water surface elevation of 5.64 feet was observed between 26 May at 12:45 p.m. and 27 May at 10:00 a.m. The channel was free of ice at the time of the peak water surface elevation. Water surface elevations and observations for the East Ulamnigiaq channel are summarized in Table 3-6. Photos 3-13 and 3-14 shows conditions in the East Ulamnigiaq channel on 23 and 26 May, respectively.

3.6 Proposed CD-North Gravel Structures Location

The proposed locations of the gravel pad and runway were not impacted by either high water or floating ice during the 2002 breakup. River water was not observed at any time on the floodplain in the vicinity of the proposed gravel pad or in the paleochannel that is crossed by the proposed runway. In addition, ground reconnaissance showed no evidence of inundation by river water.

Peak water surface elevations in the vicinity of the proposed CD-North gravel structures occurred between the morning of 26 May and the afternoon of 27 May. Water surface elevations were monitored on the East and West Ulamnigiaq channels in the vicinity of the CD-North pad location. As previously discussed the water surface elevation in the West Ulamnigiaq channel (adjacent to and west of the proposed pad location) peaked at 5.79 feet. In the East Ulamnigiaq channel (adjacent and to the east of the proposed pad location) the water surface elevation peaked at 5.64 feet.

Measured peak water surface elevations near the CD-North proposed pad location were compared to water surface elevations predicted by the two-dimensional surface water model developed for the Colville River Delta (Michael Baker Jr., Inc., 2002b, 2001 1998, and Shannon & Wilson, Inc., 1997). Based on a linear interpolation between the water surface elevations predicted for the 2- and 10-year open water floods, it is estimated that the peak water surface elevation observed this spring at the proposed CD-North pad site will likely be equaled or exceed on average about once every 7 to 8 years.

Water surface elevations have been monitored in the vicinity of CD-North since 1999. However, water surface elevations have been monitored near the coast at the mouth of the Nigliq and East Channels since 1996. A summary of available data is presented in Table 3-7.

3.7 Channel Ice Observations

Channel ice surveys began on 23 May when water was first observed flowing at the head of the delta and were performed daily until 26 May when all the major channels of the delta were clear of channel ice and ice jams. The progression of the ice clearing and ice jamming is shown in Appendix C, figures C-1 through C-4.

3.7.1 Channel Ice

Unseasonably warm weather and rapidly deteriorating channel ice characterized the early stages of breakup in the main channels of the delta. By 23 May, much of the snow cover in the delta was gone and warm temperatures had resulted in localized melt and standing water in many of the channels.

On the morning of 23 May, the Sakoonang Channel near the proposed CD-North pipeline crossing was between 50 and 80 percent ice-free. Channel ice in smaller channels in the lower portions of the delta was deteriorating rapidly as floodwaters rose and inundated the channels. A small, isolated section of the Ulamnigiaq channel just south of the proposed CD-North facility location was observed to be clear of low water channel ice on the morning of 23 May.

By the morning of 24 May, ice that remained in the smaller channels of the lower delta was, for the most part, floating and rotten, however, intact low water channel ice extended into Harrison Bay from the lower Nigliq Channel. On 25 May, small sections of channel ice remained on the West Ulamnigiaq and Sakoonang Channels, but the majority of the lower channels were clear or contained only floating broken chunk ice. The channel ice on the lower Nigliq extending into Harrison Bay remained intact. With the exception of the East and Nigliq channels, all channels in the lower delta were either clear or contained only discontinuous sections of broken ice by 26 May.

3.7.2 Ice Jams

No ice jams occurred in the immediate vicinity of the proposed CD-North facility, however, ice jams were observed at various other locations in the delta. An ice jam was observed on the Sakoonang channel northeast of Alpine, and on portions of the Nigliq channel. All observed ice jams appeared to be surface ice jams rather that grounded jams. In no case did the observed ice jams appear to cause significant backwater, blockage, or diversions of flow.

An ice jam along the coast near Monument 35 at Colville Village was observed. Here floodwater inundated parts of the local runway and surrounding floodplain. Based on staff gages installed and referenced to Monument 35, the water surface elevation reached a peak of 5.51 feet on the evening of 26 May. The water levels receded rapidly once the ice jam cleared (Helmricks, 2002).

3.8 Sea Ice Observations

A temporary staff gage was installed on the sea ice and tied to the BPMSL datum via Monument 28 on 19 May. The temporary staff gage was located approximately 300 feet north of the coastline and due north of Monument 28. The gage was placed on what appeared to be a small gravel bar visible in the offshore sea ice. On 19 May, the average elevation of the sea ice in the immediate vicinity of the gage location was 1.2 feet based on four surveyed points.

On 22 May, water from the Nigliq channel was observed flowing over the sea ice near the temporary staff gage. Much of the area was inundated and the water surface elevation was 1.1 feet. A peak water surface elevation of approximately 2.65 feet was observed from the helicopter on 24 May. On 25 May, the temporary staff gage could not be located and was presumed destroyed.

Observations made during 2002 and previous breakup investigations on the Colville River Delta indicate that during breakup, the sea ice is generally shore fast and water flows on top of the sea ice as it leaves the delta. Thus, the presence and elevation of the sea ice will likely affect water levels in channels near the coast. The effects of the sea ice will vary from year to year, but will likely have greater effects in years when the flood peak discharge is smaller.

Table 3-1 Summary of Channel Conditions at Peak Flow

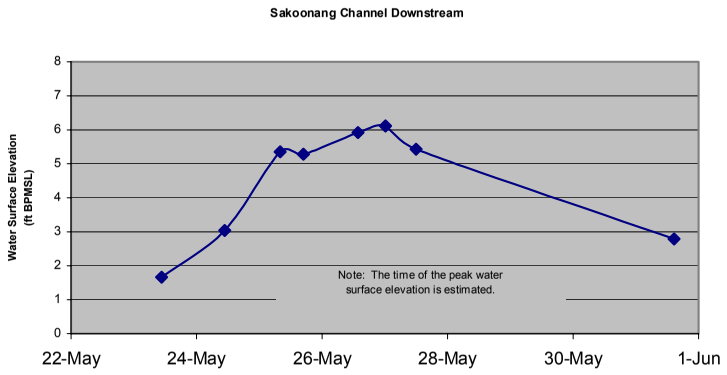
Channel	Estimated Time of Peak Water Surface Elevation	Peak Discharge (cfs)	Estimated Discharge at Peak Water Surface Elevation (cfs)	Width of Flow at Peak Water Surface Elevation (feet)	Maximum Depth at Peak Water Surface Elevation (feet)	Average Velocity at Peak Water Surface Elevation (ft/sec)
Sakoonang (Crossing 2)	Late Evening 26 May	10,500	9,800	450	11.6	2.7
Tamayagiaq (Crossong 4)	Early Morning, 27 May	10,700	10,700	630	12.1	2.0
Ulamnigiaq (Crossing 5)	Early Morning, 27 May	7,700	6,900	690	19.0	1.8
West Ulamnigiaq	Early Morning, 27 May	2,200	2,200	210	7.7	2.4

Note: All values are based on cross sections survey in 2001 by Kuukpik/LCMF Inc. The Sakoonang Channel cross section is approximately 420 feet from the proposed crossing, the Tamayagiaq Channel cross section is approximately 200 feet from the proposed crossing, and the Ulamnigiaq Channel cross section is approximately 1,000 feet from the proposed crossing.

Table 3-2 Sakoonang Channel, Water Surface Elevations and Observations

	Downstream Monitoring Site			Upstream Monitoring Site		
Date	Time	Water Surface Elevation (ft BPMSL)	Observations	Time	Water Surface Elevation (ft BPMSL)	Observations
5/23/2002	10:35	1.66	Channel is approximately 50% free of ice, with ice along the right bank.	10:30	1.56	Channel is approximately 80% free of ice, with ice along the right bank.
5/24/2002	10:45	3.04	Ice on channel bottom.	10:35	3.12	Channel is 80% free of ice, with ice along the right bank beginning to rot.
High Water Mark		5.35	High water mark occurred between May 24 at 10:45 and May 25 at 16:50.	High Water	6.21	High water mark occurred between May 24 at 10:35 and May 25 at 17:05.
5/25/2002	16:50	5.28	Ice flows gathered along left bank.	17:05	6.01	Ice flows in the channel. Stranded ice on the banks.
5/26/2002	13:45	5.92	Channel is free of ice.	13:50	6.23	Channel is free of ice. Grounded ice chunks along left bank at gages.
High Water Mark		6.11	Peak water surface elevation occurred between May 26th at 13:45 and May 27th at 12:00.	High Water	6.71	Peak water surface elevation occurred between May 26th at 13:50 and May 27th at 11:45.
5/27/2002	12:00	5.43	Channel is free of ice.	11:45	5.74	Channel is free of ice. Grounded ice chunks along left bank at gages.
5/31/2002	14:35	2.79	Stranded ice chunks on bank.	14:02	2.99	Stranded ice chunks on bank.

Notes:
1. Elevations are based on an elevation of 11.82 feet BPMSL for TBM 02-14-03 B, established by LCMF in 2002.
2. The distance along the flow path from the upstream site to the downstream site is aproximately 7,170 feet.
3. Coordinates for the upstream and downstream cross sections are N70°21'51.5" W150°55'02.2" and N70°21'59.3" W150°57'57.8" (NAD27), respectively as determined with a Garmin III Plus handheld GPS.



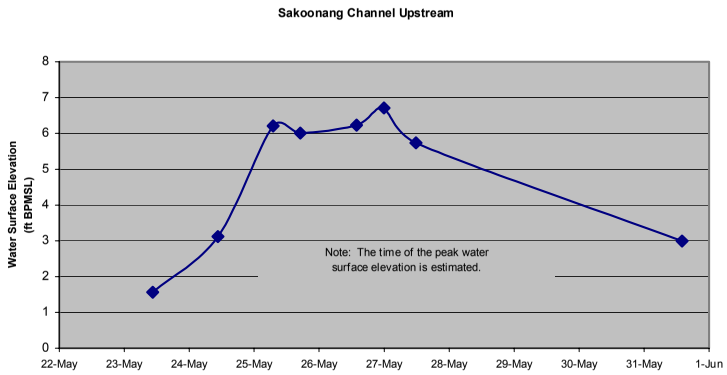
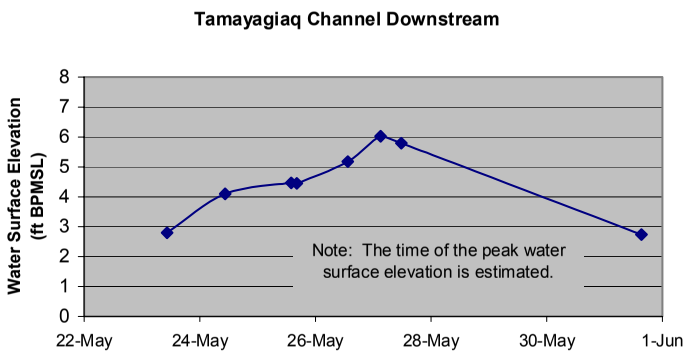


Table 3-3 Tamayagiaq Channel, Water Surface Elevations and Observations

	Downstream Monitoring Site			Upstream Monitoring Site		
Date	Time	Water Surface Elevation (ft BPMSL)	Observations	Time	Water Surface Elevation (ft BPMSL)	Observations
5/22/2002	13:00	1.50	Channel is approximately 70% filled with ice. Water on gage is from local melt.	-	-	-
5/23/2002	10:25	2.80	Channel is approximately 60% clear of ice. Both banks are free of ice.	10:15	3.20	Channel is approximately 60% clear with ice along the right bank.
5/24/2002	10:30	4.10	Channel is 50% clear. Intact ice is rotten and broken.	10:00	4.79	Channel is 50% clear. Intact ice is rotten and broken.
High Water Mark		4.47	High water mark occurred between May 24 at 10:30 and May 25 at 16:15.	High Water	4.92	High water mark occurred between May 24 at 10:00 and May 25 at 15:55.
5/25/2002	16:15	4.45	Intact channel ice remains. Ice is rotten and broken.	15:55	4.71	Broken channel ice, small ice flows visible in channel.
5/26/2002	13:25	5.18	Ice flowing in the middle of the channel. 20% of channel contains ice.	13:30	5.64	Channel is free of ice.
High Water Mark		6.02	Peak water surface elevation occurred between May 26th at 13:25 and May 27th at 11:35.	High Water	6.51	Peak water surface elevation occurred between May 26th at 13:30 and May 27th at 11:25.
5/27/2002	11:35	5.79	Channel is free of ice.	11:25	6.14	Channel is free of ice.
5/31/2002	15:20	2.74	Stranded ice on bank.	14:53	2.81	Stranded ice on bank.

Notes:
1. Elevations for the upstream and downstream gage locations are based on an elevation of 9.68 feet BPMSL for TBM STM LT and 10.06 feet BPMSL for TBM STM RT, respectively, established by LCMF in 2001.
2. The distance along the flow path from the upstream site to the downstream site is aproximately 7,754 feet.
3. Coordinates for the upstream and downstream gage locations are N70°23'29.4" W150°23'29.4" and N70°23'13.1" W150°56'41.3" (NAD27), respectively as determined with a Garmin III Plus handheld GPS.



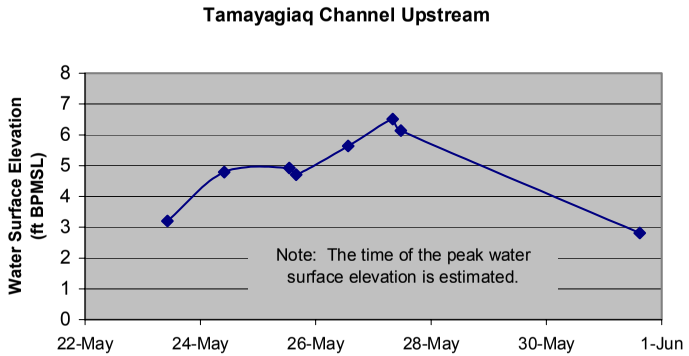
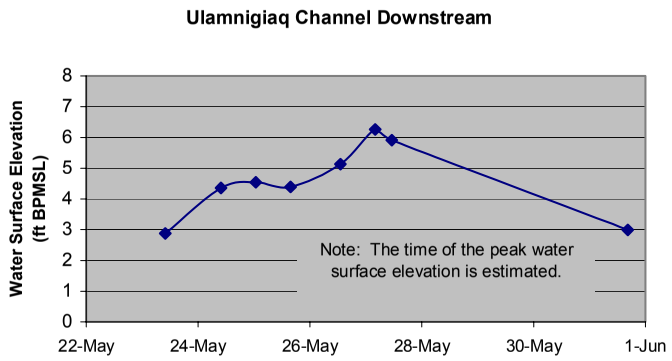


Table 3-4 Ulamnigiaq Channel, Water Surface Elevations and Observations

	Downstream Monitoring Site			Upstream Monitoring Site		
Date	Time	Water Surface Elevation (ft BPMSL)	Observations	Time	Water Surface Elevation (ft BPMSL)	Observations
5/23/2002	9:55	2.88	Channel is free of ice.	10:00	3.35	Channel is approximately 95% free of ice, with ice along the right bank.
5/24/2002	9:50	4.36	Channel at gages is free of ice.	9:55	4.78	Channel is approximately 95% free of ice, with ice along the right bank.
High Water Mark		4.54	High water mark occurred between May 24 at 9:50 and May 25 at 15:40.	High Water	4.94	High water mark occurred between May 24 at 9:55 and May 25 at 15:35.
5/25/2002	15:40	4.39	No channel ice intact at gage location.	15:35	4.65	Channel is approximately 95% free of ice, with ice along the right bank.
5/26/2002	13:05	5.13	Channel is free of intact ice.	13:15	5.49	Channel contains approximately 20% broken ice along right bank.
High Water Mark		6.26	Peak water surface elevation occurred between May 26th at 13:05 and May 27th at 11:07.	High Water	6.47	Peak water surface elevation occurred between May 26th at 13:15 and May 27th at 10:45.
5/27/2002	11:07	5.91	Channel is free of ice.	10:45	6.2	Large ice flows in the middle of the channel.
5/31/2002	16:25	2.99		15:55	3.05	Stranded ice on bank.

Notes:
1. Elevations are based on an elevation of 10.15 feet BPMSL for Fiord 2, established by LCMF in 2000.
2. The distance along the flow path from the upstream site to the downstream site is aproximately 3,467 feet.
3. Coordinates for the upstream and downstream gage locations are N70°23'59.1" W150°52'04.5" and N70°24'28.4" W150°52'54.8" (NAD27), respectively as determined with a Garmin III Plus handheld GPS



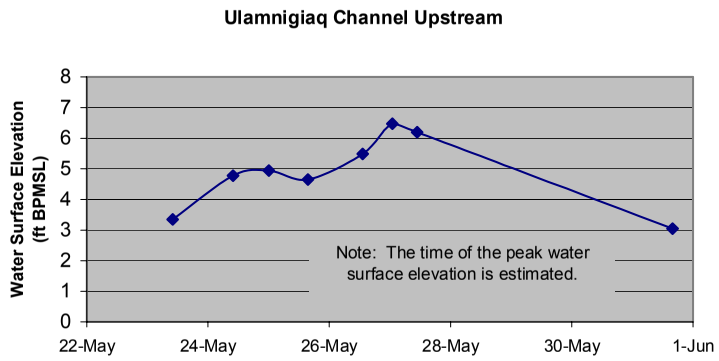
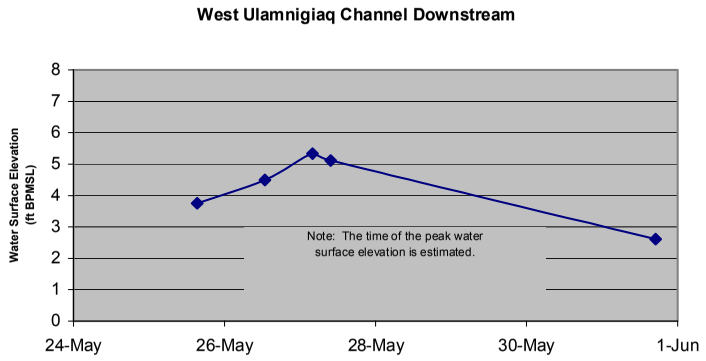


Table 3-5 West Ulamnigiaq Channel, Water Surface Elevations and Observations

	Downstream Monitoring Site			Upstream Monitoring Site		
Date	Time	Water Surface Elevation (ft BPMSL)	Observations	Time	Water Surface Elevation (ft BPMSL)	Observations
5/25/2002	15:22	3.75		15:30	4.05	
5/26/2002	12:50	4.49	One grounded piece of channel ice present mid channel.	12:55	4.70	Channel is about 60% free of ice.
High Water Mark		5.33	Peak water surface elevation occurred between May 26th at 12:50 and May 27th at 09:42.	High Water	5.79	Peak water surface elevation occurred between May 26th at 12:55 and May 27th at 09:59.
5/27/2002	9:42	5.11	Channel is free of ice.	9:59	5.42	Channel is about 80% free of ice.
5/31/2002	17:00	2.61		16:42	2.67	

Notes:
1. Elevations for the upstream and downstream gage locations are based on an elevation of 8.91 feet BPMSL for TBM WUL LT, and 6.84 feet BPMSL for Fiord CP8, respectively, established by LCMF in 2000.
2. The distance along the flow path from the upstream site to the downstream site is aproximately 3,713 feet.
3. Coordinates for the upstream and downstream gage locations are N70°24'46.9" W150°53'40.6" and N70°25'09.1" W150°55'03.1" (NAD27), respectively as determined with a Garmin III Plus handheld GPS.



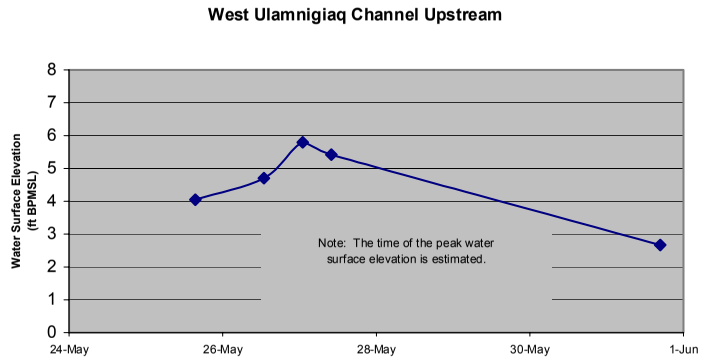


Table 3-6 East Ulamnigiaq Channel, Water Surface Elevations and Observations

Date	Time	Water Surface Elevation (ft BPMSL)	Observations
5/23/2002	11:20	1.73	
High Water Mark		4.12	High water mark occurred between May 23 at 11:20 and May 25 at 14:55.
5/25/2002	14:55	3.94	Channel is free of ice.
5/26/2002	12:45	4.61	Channel is free of ice.
High Water Mark		5.64	Peak water surface elevation occurred between May 26th at 12:45 and May 27th at 10:08.
5/27/2002	10:08	5.22	Channel is free of ice.
5/31/2002	17:25	2.60	

Notes:
1. Elevations are based on an elevation of 7.93 feet BPMSL for Fiord CP-3, established by LCMF in 2000.
2. Coordinates for the gage location are N70°25'21.7" W150°52'12.4" (NAD27) as determined with a Garmin III Plus handheld GPS.

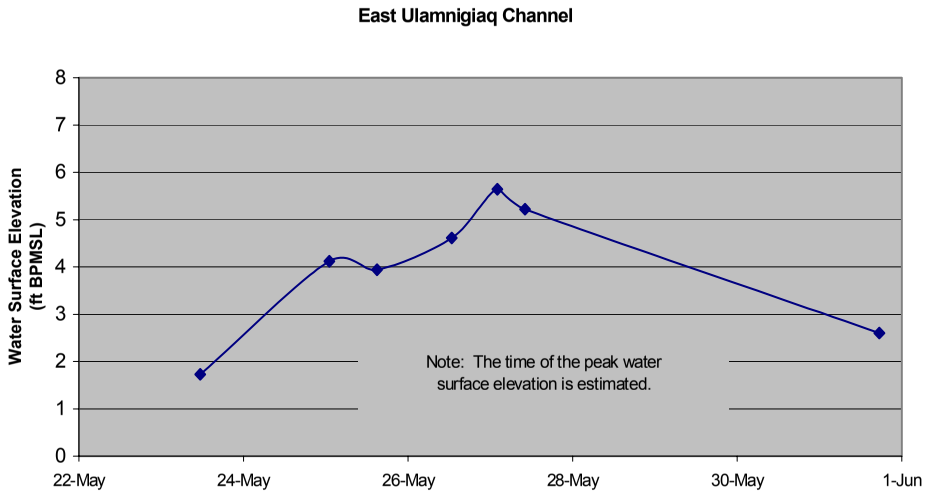


Table 3-7 Spring Peak Water Surface Elevations Near the Colville River Delta Coastline

Year	Location	Elevation (feet, BPMSL)	Peak Discharge at Head of Delta	Recurrence Interval of Peak Discharge (yrs)
2002	West Ulamnigiaq Channel Adjacent to Proposed CD-North Pad Location	5.8	300,000	≅ 4
	East Ulamnigiaq Channel Near TBM FIOSO	5.6		
	Monument 28	3.7		
	Monument 35	5.5		
2001	West Ulamnigiaq Channel Adjacent to Proposed CD-North Pad Location	7.1	300,000	≅ 4
	East Ulamnigiaq Channel Near TBM FIOSO	7.4		
	Monument 28	3.8		
2000	Monument FIORD M1	5.77	580,000	25
	TBM FIOMI	6.32		
	TBM FIOSO	6.63		
	Helmricks' House	7.39		
	Helmricks' Hanger	7.24		
	N. End Helmricks' Runway	7.10		
1999	Monument 28	2.85	203,000	< 2
	Monument FIORD M1	3.00 ± 0.1		
1998	Monument 28	4.51 ± 0.47	213,000	≅ 2
	Monument 35	4.22 ± 0.08		
1997	Monument 28	3.97	173,000	< 2
	Monument 35	4.73		
1996	Monument 28	4.3	160,000	< 2

Notes:

1. Monument 28 is located approximately 2.0 miles upstream from the mouth of the Nigliq Channel.
2. Monument 35 is located approximately 3.0 miles upstream from the mouth of the East Channel.
3. Monument FIORD M1 is located approximately 2.3 miles upstream from the mouth of the Fiord Channel.
4. TBM FIOMILES is located approximately 3.5 miles upstream from the mouth of the Fiord Channel.
5. TBM FIOSO is located approximately 4.2 miles upstream from the mouth of the Fiord Channel.
6. Recurrence intervals are based on the report titled *Colville River Flood-Frequency Analyses, Update* (Baker and Hydroconsult, 2002).

Figure 3-1 Proposed CD-North Location and Conceptual Pipeline Route

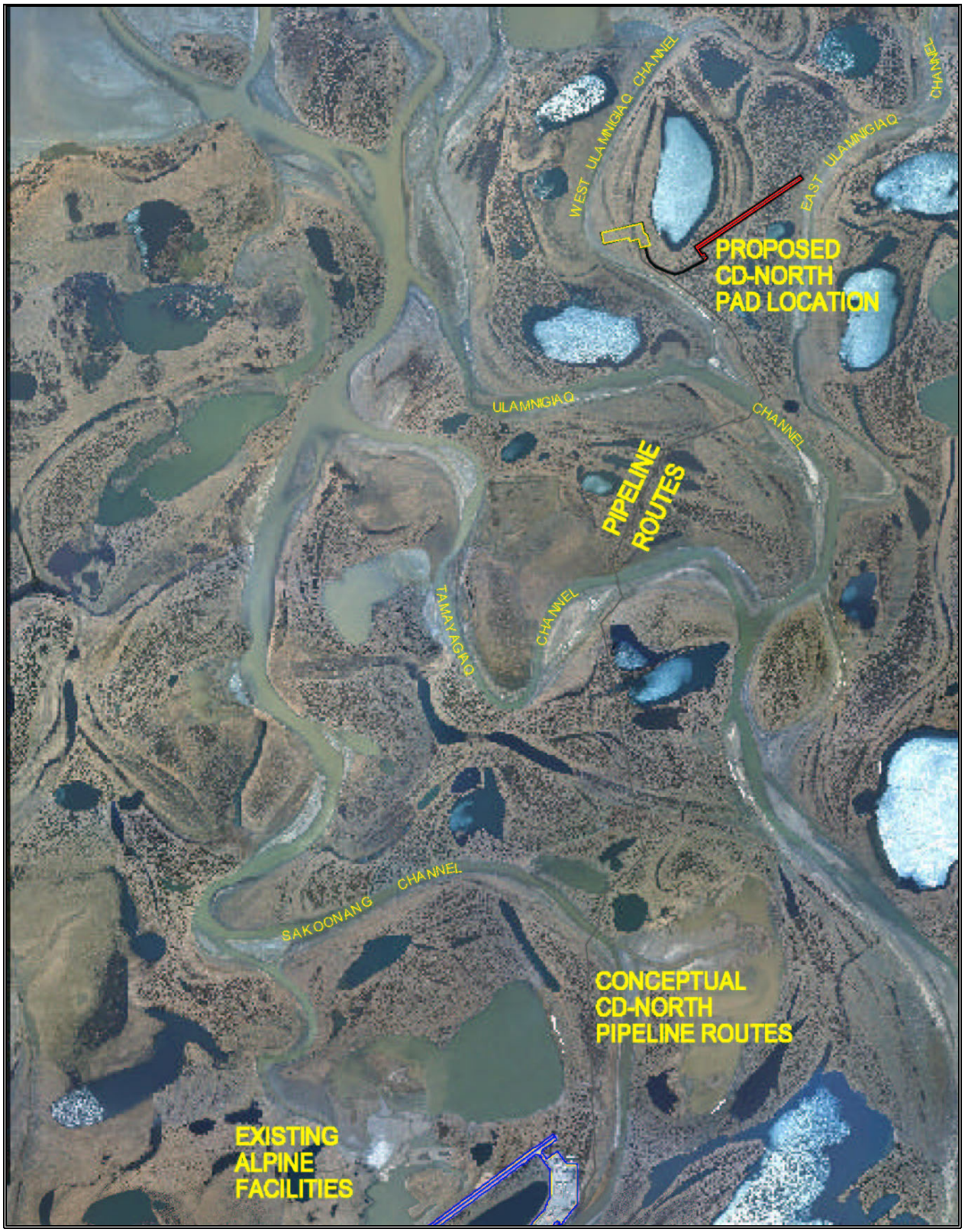
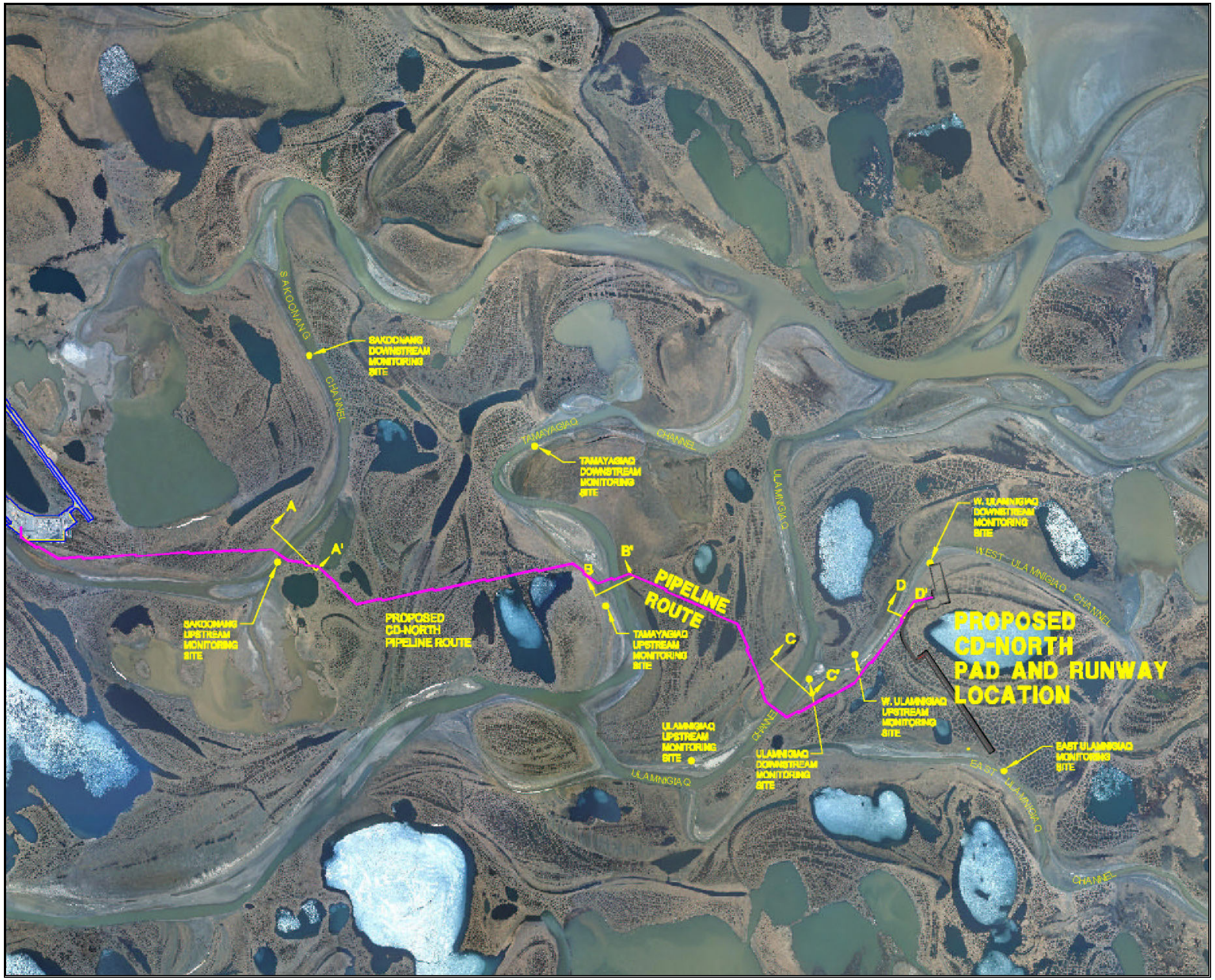


Figure 3-2 CD-North Road Alignment and Breakup Flooding 2002



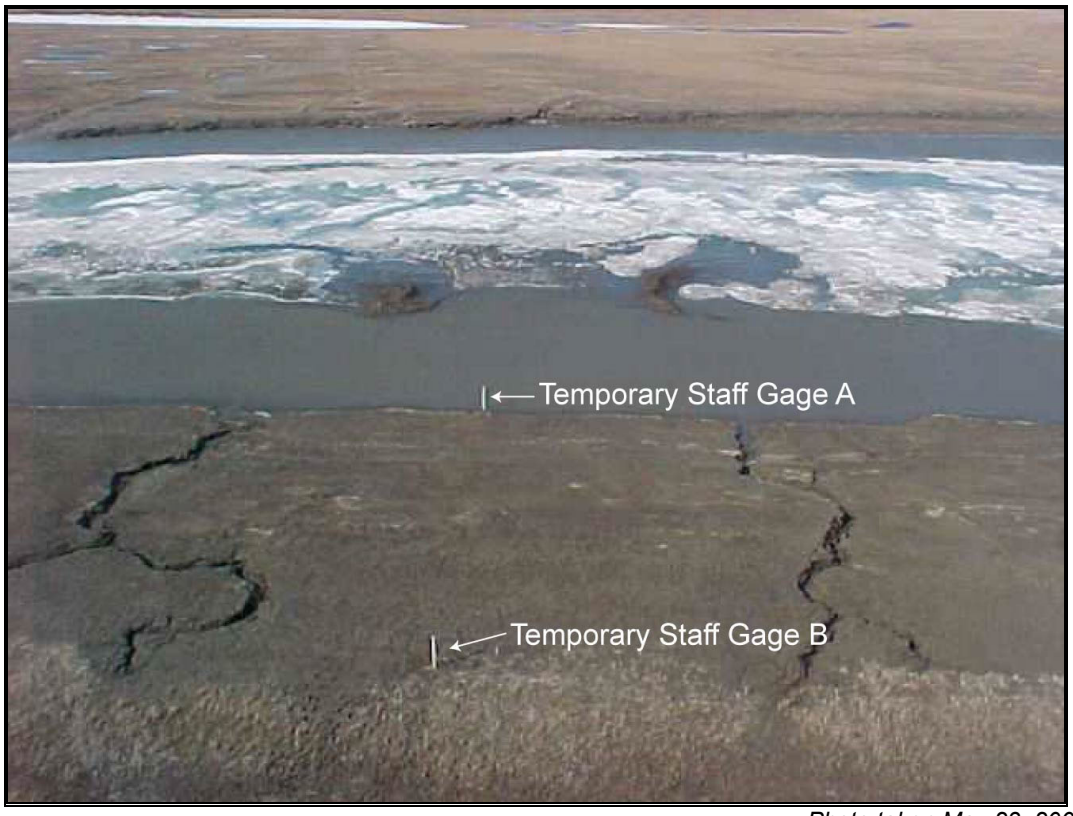


Photo taken May 23, 2002

Photo 3-1 Sakoonang Channel. Looking north at the upstream gages.

Photo taken May 25, 2002

Photo 3-2 Sakoonang Channel. Looking northwest at the downstream gages.

Photo taken May 26, 2002

Photo 3-3 Sakoonang Channel. Looking west at the proposed crossing site.

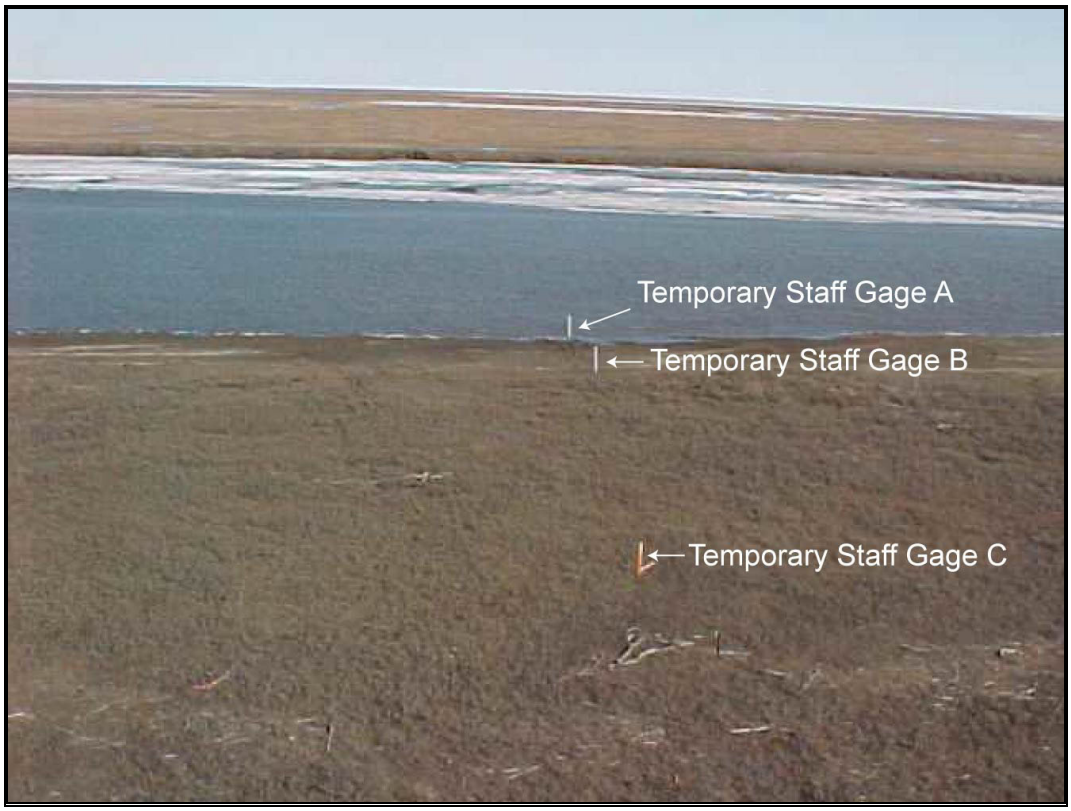


Photo taken May 23, 2002

Photo 3-4 Tamayagiaq Channel. Looking north at the upstream gages.

Photo taken May 26, 2002

Photo 3-5 Tamayagiaq Channel. Looking west (downstream) at the proposed crossing site.

Photo taken May 27, 2002

Photo 3-6 Tamayagiaq Channel. Looking north at the upstream gages.

Photo taken May 23, 2002

Photo 3-7 **Ulamnigiaq Channel. Looking south at the downstream gages.**

Photo taken May 26, 2002

Photo 3-8 **Ulamnigiaq Channel. Looking southeast, upstream from the downstream gages at the proposed crossing site.**

Photo taken May 27, 2002

Photo 3-9 **Ulamnigiaq Channel. Looking south at the downstream gages. Photograph taken near peak high water.**

Photo taken May 23, 2002

Photo 3-10 **West Ulamnigiaq Channel. Looking southwest at the downstream gages.**

Photo taken May 26, 2002

Photo 3-11 **West Ulamnigiaq Channel. Looking northwest, downstream towards the downstream gages.**

Photo taken May 27, 2002

Photo 3-12 **West Ulamnigiaq Channel. Looking southwest at the downstream gages.**

Photo taken May 23, 2002

Photo 3-13 **East Ulamnigiaq Channel. Looking northeast, downstream at the temporary staff gage location.**

Photo taken May 26, 2002

Photo 3-14 **East Ulamnigiaq Channel. Looking south, upstream at the temporary staff gage location.**

4.0 References

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——— 2001b. *CD-North Development Project 2001 Spring Breakup and Hydrologic Assessment.* Prepared for Phillips Alaska, Inc., Anchorage, November 2001.

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Shannon & Wilson. 1997. *Colville River Two-Dimensional Surface Water Model*. Prepared for Michael Baker Jr., Inc., Anchorage Alaska.

Appendix A Cross Section Data — Head of the Delta

Project Note

To: Tony Hoffman, LCMF	Date: July 11, 2002
From: Jeff Baker	Project: Alpine and CD-Satellite Developments
Subject: Colville River Cross Sections	

We would like to have three cross sections of the Colville River near Monument 01 surveyed. The objective is to determine accurate channel geometry to assist with discharge estimates. The existing cross section data was taken in 1995 and I have attached it as a reference. We are requesting that three cross section measurements be made. One is at the same location as the 1995 cross section (x-sec Mon 01), one is upstream of this (x-sec Mon 01U), and one is downstream (x-sec Mon 01D), see attached figure.

Names and coordinates for the cross section end points are:

All coordinates in Alaska State Plane, Zone 4, NAD27

x-sec Mon 01D

x-sec Mon 01D-L	N5,912,928	E383,588
x-sec Mon 01D-R	N5,912,2104	E387,053

x-sec Mon 01

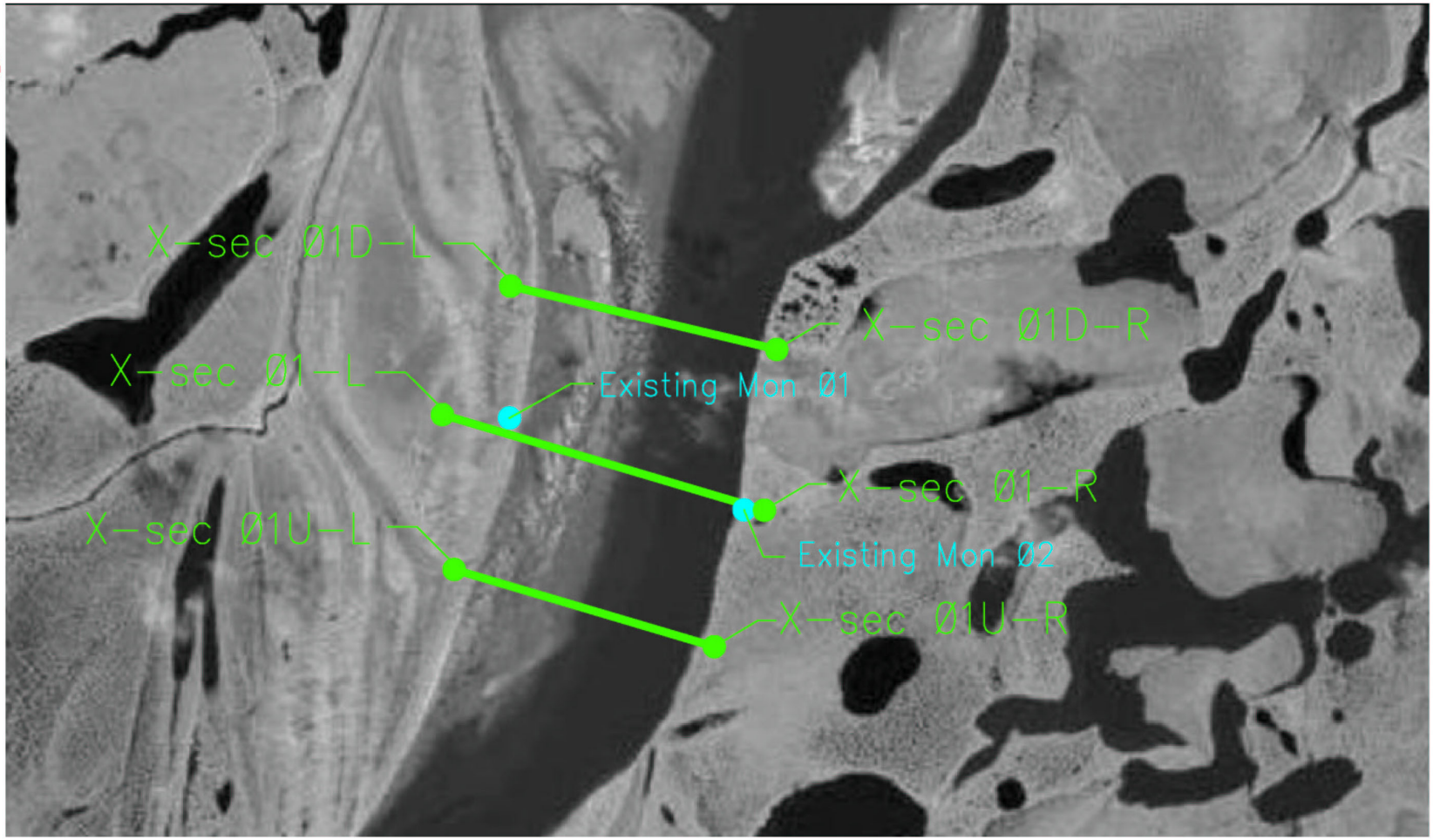
x-sec Mon 01-L	N5,911,257	E382,701
x-sec Mon 01-R	N5,910,016	E386,893

x-sec Mon 01U

x-sec Mon 01U-L	N5,909,245	E382,855
x-sec Mon 01U-R	N5,908,243	E386,240

Cross sections should be run from left bank to right bank (facing downstream). Points shall be taken at a maximum spacing of 50 feet (approximate) but in particular at all grade breaks or changes in soil/vegetation and at edges of water. Note the edge of water and the water surface elevation at the time of the survey. For each point please provide a station offset, ground/channel bottom elevation in BPMSL, northing/easting, and surface description (the same data as the 1995 example). In addition, install monumentation (monument cap with identification) at each cross section end point for future reference.

A spreadsheet file of the data and a description of the data collection procedure will be sufficient for a deliverable.



1000 0 1000 2000

SCALE IN FEET

Baker Michael Baker Jr., Inc.	TITLE: Colville River Monument Ø1 Cross Section Locations		
	FILE NAME: 25ØØ9CØ31	SCALE: As Shown	

Table B-1: Cross Section Data For Cross Section E27.09 (East Channel)

Station (ft)	Elevation (ft)	Northing (ft)	Easting (ft)	Soil Cover Complex
1000	18.4	5911257	382701	Grass covered
1022	18.1	5911251	382722	"
1092	18.6	5911231	382789	"
1133	19.4	5911219	382828	Sand dunes/ willow covered/ sparse grass
1385	23.3	5911148	383070	"
1511	25.2	5911112	383191	"
1708	26.6	5911056	383380	Sand dunes/ sparse willows
1751	30.7	5911044	383421	Top of dunes
1768	30.3	5911039	383438	Sand dunes/ sparse willows
1791	26.1	5911032	383460	"
1812	28.5	5911026	383479	"
1840	24.0	5911018	383507	"
1854	27.2	5911014	383520	"
1871	27.1	5911010	383536	"
1912	19.2	5910998	383576	"
1930	18.6	5910993	383593	"
1937	20.5	5910991	383600	"
1954	14.8	5910986	383616	Edge of dunes
2126	9.9	5910937	383781	Riverbed/sandbar
2429	9.2	5910851	384072	"
2771	7.9	5910754	384400	"
3098	6.3	5910661	384713	"
3321	4.3	5910598	384927	"
3463	2.5	5910558	385063	"
3624	-1.8	5910512	385218	"
3737	-4.2	5910480	385326	"
3842	-6.7	5910450	385427	"
3943	-8.2	5910421	385524	"
4007	-9.7	5910403	385585	"
4074	-10.7	5910384	385649	"
4145	-13.1	5910364	385717	"
4227	-16.0	5910341	385796	"
4318	-20.0	5910315	385883	"
4392	-23.7	5910294	385954	"
4472	-23.1	5910271	386031	"
4532	-22.7	5910254	386089	"
4591	-20.7	5910238	386145	"
4663	-19.2	5910217	386214	"
4719	-18.2	5910201	386268	"
4775	-15.7	5910185	386322	"
4839	-13.7	5910167	386383	"
4888	-13.2	5910153	386430	"
4929	-12.2	5910142	386469	"
4975	-1.9	5910129	386513	"
5001	6.3	5910121	386538	"
5006	9.2	5910120	386543	"

Table B-1: Cross Section Data For Cross Section E27.09 (East Channel)

Station (ft)	Elevation (ft)	Northing (ft)	Easting (ft)	Soil Cover Complex
5011	14.2	5910118	386548	
5016	17.9	5910117	386553	Low-centered polygons/ grass covered/ sparse willows
5022	19.4	5910115	386558	Top of bank
5030	20.1	5910113	386566	Low-centered polygons/ grass covered/ sparse willows
5061	19.4	5910104	386596	"
5080	17.9	5910099	386614	"
5121	18.1	5910087	386653	"
5140	20.3	5910082	386672	"
5200	18.6	5910065	386729	"
5213	18.8	5910061	386742	"
5238	20.1	5910054	386766	"
5370	19.7	5910017	386892	"
5371	19.6	5910016	386893	"

Notes:

1. Elevations are based on British Petroleum Mean Sea Level (BPMSL) datum, coordinate system AK State Plane Zone 4, NAD 27.
2. Ground profile was obtained using a level, theodolite, and sounding weight. The horizontal coordinates for the ends of the cross section were measured with DGPS.
3. In some previous reports, Cross Section E27.09 has been referred to as Cross Section 6.
4. The cross section was measured on 11 Jun 1995. The water-surface elevation on 30 May 1996 was 8.46 feet.

Colville River Channel Cross-Sections

Cross Section Mon 01 Upstream

Station	Offset	Northing	Easting	Elevation	Description
0+00	0	5909266.6	382894.5	27.2	MON-01-UL
0+49	0	5909252.1	382941.5	24.7	Scattered Grass and 3' Willows
0+66	0	5909247.1	382957.7	24.4	Top of Bank
1+12	0	5909233.6	383001.7	18.3	Tundra Ground Shot
1+64	0	5909218.4	383051.0	12.1	Tundra / Edge of Vegetation
2+17	0	5909202.7	383102.0	8.5	Toe of Bank
2+65	0	5909188.7	383147.4	7.4	Ground Shot / Sandy Beach
3+13	0	5909174.5	383193.4	7.1	Ground Shot / Sandy Beach
3+61	0	5909160.4	383239.2	6.8	Ground Shot / Sandy Beach
4+10	0	5909146.0	383286.1	6.6	Ground Shot / Sandy Beach
4+60	0	5909131.3	383333.7	5.6	Ground Shot / Sandy Beach
5+08	0	5909117.1	383380.0	5.4	Ground Shot / Sandy Beach
5+56	0	5909102.8	383426.2	5.4	Ground Shot / Sandy Beach
6+04	0	5909088.9	383471.4	5.1	Ground Shot / Sandy Beach
6+52	0	5909074.7	383517.5	4.6	Ground Shot / Sandy Beach
6+96	0	5909061.6	383560.1	4.9	Ground Shot / Sandy Beach
7+46	0	5909046.9	383607.8	4.7	Ground Shot / Sandy Beach
7+96	0	5909032.4	383655.0	4.6	Ground Shot / Sandy Beach
8+44	0	5909018.0	383701.5	4.0	Ground Shot / Sandy Beach
8+89	0	5909004.9	383744.2	4.1	Ground Shot / Sandy Beach
9+37	0	5908990.9	383789.7	4.7	Ground Shot / Sandy Beach
9+83	0	5908977.2	383834.3	4.8	Ground Shot / Sandy Beach
10+29	0	5908963.8	383877.6	5.3	Ground Shot / Sandy Beach
10+76	0	5908949.8	383923.1	5.1	Ground Shot / Sandy Beach
11+24	0	5908935.9	383968.3	4.9	Ground Shot / Sandy Beach
11+71	0	5908921.9	384013.8	5.1	Ground Shot / Sandy Beach
12+19	0	5908907.9	384059.2	5.1	Ground Shot / Sandy Beach
12+67	0	5908893.8	384105.1	5.2	Ground Shot / Sandy Beach
13+16	0	5908879.2	384152.3	4.9	Ground Shot / Sandy Beach
13+65	0	5908864.7	384199.3	4.2	Ground Shot / Sandy Beach
14+10	0	5908851.4	384242.4	4.1	Ground Shot / Sandy Beach
14+57	0	5908837.6	384287.3	3.5	Ground Shot / Sandy Beach
15+04	0	5908824.0	384331.4	3.1	Ground Shot / Sandy Beach
15+55	0	5908809.0	384380.4	2.4	Ground Shot / Sandy Beach
16+05	0	5908794.0	384428.8	1.4	Edge of Water
16+43	0	5908782.9	384464.9	0.6	River Bed
16+81	0	5908771.7	384501.3	-0.6	River Bed
16+90	4	5908765.2	384508.6	-0.5	River Bed
17+13	8	5908754.7	384529.2	-1.4	River Bed
17+14	0	5908762.0	384532.7	-1.6	River Bed
17+32	0	5908756.6	384549.5	-2.1	River Bed
17+42	0	5908754.0	384559.0	-2.1	River Bed
17+51	-2	5908752.8	384568.7	-2.9	River Bed
17+56	6	5908743.9	384570.5	-2.4	River Bed
17+73	1	5908744.2	384588.8	-3.7	River Bed
17+78	10	5908733.5	384591.0	-3.3	River Bed
17+89	-1	5908740.9	384604.7	-4.3	River Bed
18+01	3	5908733.1	384615.2	-4.4	River Bed
18+28	6	5908722.6	384639.2	-5.6	River Bed
18+47	11	5908712.1	384656.3	-6.5	River Bed

Colville River Channel Cross-Sections

Cross Section Mon 01 Upstream

Station	Offset	Northing	Easting	Elevation	Description
18+73	-3	5908717.8	384685.1	-7.4	River Bed
18+83	-11	5908722.8	384697.5	-7.2	River Bed
18+93	8	5908701.3	384701.1	-7.6	River Bed
19+19	-3	5908704.5	384729.9	-8.6	River Bed
19+45	14	5908680.2	384749.1	-9.5	River Bed
19+65	-9	5908696.5	384774.6	-10.8	River Bed
19+68	18	5908669.7	384769.7	-11.0	River Bed
19+91	12	5908669.4	384793.8	-10.8	River Bed
20+14	5	5908669.0	384818.0	-11.0	River Bed
20+28	-1	5908670.3	384833.3	-10.7	River Bed
20+40	8	5908658.5	384842.0	-10.6	River Bed
20+66	11	5908647.9	384866.0	-11.5	River Bed
20+81	1	5908653.1	384883.1	-12.2	River Bed
20+89	15	5908637.4	384886.6	-12.2	River Bed
21+12	8	5908637.1	384910.8	-13.6	River Bed
21+38	11	5908626.5	384934.8	-14.9	River Bed
21+58	5	5908626.2	384955.5	-15.1	River Bed
21+78	10	5908615.8	384972.6	-15.4	River Bed
22+04	13	5908605.3	384996.6	-16.5	River Bed
22+24	7	5908605.0	385017.4	-17.6	River Bed
22+43	12	5908594.5	385034.5	-18.3	River Bed
22+63	7	5908594.2	385055.2	-18.3	River Bed
22+89	10	5908583.7	385079.2	-18.4	River Bed
23+15	2	5908583.3	385106.8	-18.5	River Bed
23+48	14	5908562.5	385134.1	-18.4	River Bed
23+77	16	5908551.9	385161.6	-18.4	River Bed
24+03	19	5908541.4	385185.6	-18.3	River Bed
24+27	1	5908551.1	385213.4	-17.7	River Bed
24+59	2	5908540.5	385244.3	-16.5	River Bed
24+88	15	5908519.8	385268.2	-15.7	River Bed
25+14	18	5908509.3	385292.2	-15.2	River Bed
25+40	21	5908498.7	385316.2	-15.0	River Bed
25+70	12	5908498.3	385347.3	-14.9	River Bed
25+93	5	5908497.9	385371.5	-14.5	River Bed
26+20	8	5908487.4	385395.5	-14.3	River Bed
26+52	10	5908476.7	385426.4	-14.5	River Bed
26+82	12	5908466.2	385453.9	-15.1	River Bed
27+11	14	5908455.6	385481.4	-15.9	River Bed
27+37	17	5908445.0	385505.4	-17.0	River Bed
27+70	18	5908434.4	385536.3	-18.5	River Bed
27+93	11	5908434.0	385560.5	-19.3	River Bed
28+22	13	5908423.5	385587.9	-20.4	River Bed
28+52	15	5908412.9	385615.4	-22.4	River Bed
28+78	18	5908402.3	385639.4	-23.2	River Bed
29+04	21	5908391.8	385663.5	-23.2	River Bed
29+34	12	5908391.3	385694.5	-23.4	River Bed
29+66	13	5908380.7	385725.5	-23.0	River Bed
29+99	14	5908370.1	385756.4	-22.8	River Bed
30+35	14	5908359.4	385790.8	-19.2	River Bed
30+68	16	5908348.8	385821.7	-18.1	River Bed

Colville River Channel Cross-Sections

Cross Section Mon 01 Upstream

Station	Offset	Northing	Easting	Elevation	Description
30+88	10	5908348.4	385842.4	-17.2	River Bed
31+14	13	5908337.9	385866.4	-16.7	River Bed
31+37	6	5908337.5	385890.6	-15.9	River Bed
31+63	9	5908327.0	385914.6	-13.8	River Bed
31+84	21	5908309.3	385931.7	-7.2	River Bed
31+89	12	5908316.5	385938.6	-5.9	River Bed
32+05	18	5908306.1	385952.3	-2.0	River Bed
32+42	0	5908312.3	385993.0	1.4	Edge of Water
32+50	0	5908310.0	386000.1	1.6	Toe of Bank
32+54	0	5908308.7	386004.6	3.7	Gread Break
32+57	0	5908308.0	386006.8	9.0	Gread Break
32+64	0	5908305.8	386014.0	11.2	Gread Break
32+70	0	5908304.0	386019.7	15.4	Gread Break
32+75	0	5908302.4	386024.8	18.1	Top of Bank
33+25	0	5908287.7	386072.6	18.2	Tundra / Ground Shot
33+75	0	5908273.2	386119.6	19.7	Tundra / Ground Shot
34+24	0	5908258.7	386166.8	19.6	Tundra / Ground Shot
34+75	0	5908243.7	386215.4	19.8	Tundra / Ground Shot
35+08	0	5908234.0	386247.1	20.3	MON-01-UR
Notes:					

1. Elevations are British Petroleum Mean Sea Level Datum, based on the elevation of BM 1at 26.82'.
2. Horizontal Coordinates are Alaska State Plane Zone 4, NAD 27 Datum.
3. Ground profile was surveyed with a conventional total station. River bed depths were obtained with a Garmin GPS Depth Sounder, and spot checked with the total station and rod.
4. Rebar with Aluminum Caps were set at Cross-Section endpoints. Horizontal coordinates of the endpoints are based on found Benchmarks 1 and 2, per GPS survey performed in June 2002.
5. This cross section was surveyed on July 14, 2002. Water surface elevation at time of survey was 1.50' at 5:00 pm.

Colville River Channel Cross-Sections

Cross Section at Mon 01

Station	Offset	Northing	Easting	Elevation	Description
0+00	0	5911257.3	382698.4	18.5	MON-01-L
0+55	0	5911242.1	382751.6	17.6	Sandy Tundra w/ Grass
1+18	-1	5911224.9	382812.3	18.7	Sandy Tundra w/ Grass
1+73	-1	5911209.9	382864.8	18.4	Sandy Tundra w/ Grass
2+29	-1	5911193.7	382918.3	19.6	Sandy Tundra w/ Grass
2+86	-1	5911177.5	382972.6	19.4	Sandy Tundra w/ Grass
3+43	-2	5911162.5	383027.9	20.6	Sandy Tundra w/ Grass
4+00	-1	5911145.4	383082.7	22.7	Sandy Tundra w/ Grass
4+56	-1	5911129.6	383136.0	24.5	Sandy Tundra w/ Grass
5+14	-1	5911112.8	383191.3	24.1	Sandy Tundra w/ Grass
5+69	0	5911096.7	383244.6	23.4	Sandy Tundra w/ Grass
6+27	-1	5911081.3	383299.9	24.1	Sandy Tundra w/ Grass
6+85	0	5911064.0	383355.2	24.4	Sandy Tundra w/ Grass
7+40	0	5911048.3	383408.3	27.1	Sand Dunes w/ Scattered 2' Willows
7+53	0	5911044.6	383420.3	29.1	Sand Dunes w/ Scattered 2' Willows
7+70	0	5911040.1	383437.5	28.2	Sand Dunes w/ Scattered 2' Willows
7+82	0	5911036.7	383448.6	24.7	Sand Dunes w/ Scattered 2' Willows
7+97	0	5911032.0	383463.0	27.5	Sand Dunes w/ Scattered 2' Willows
8+16	1	5911026.2	383481.3	27.3	Sand Dunes w/ Scattered 2' Willows
8+30	0	5911022.6	383494.7	24.4	Sand Dunes w/ Scattered 2' Willows
8+47	0	5911017.7	383511.2	26.5	Sand Dunes w/ Scattered 2' Willows
8+53	-207	5911214.8	383574.5	26.8	BM-01
8+71	0	5911011.3	383534.1	26.2	Sand Dunes w/ Scattered 2' Willows
8+80	0	5911008.9	383542.6	24.4	Sand Dunes w/ Scattered 2' Willows
8+88	0	5911006.8	383549.8	26.1	Top of Bank
8+88	0	5911006.7	383549.9	25.3	Grade Break w/ Scattered Brush
9+08	0	5911000.8	383569.9	20.4	Grade Break w/ Scattered Brush
9+38	0	5910992.4	383598.6	19.2	Grade Break w/ Scattered Brush
9+54	0	5910988.0	383613.4	14.3	Edge of Vegetation
10+34	0	5910965.4	383690.4	9.0	Toe of Bank
10+82	0	5910951.9	383736.3	7.9	Ground Shot / Sandy Beach
11+32	0	5910937.9	383783.9	7.5	Ground Shot / Sandy Beach
11+79	0	5910924.4	383829.7	7.2	Ground Shot / Sandy Beach
12+26	0	5910911.1	383874.9	7.2	Ground Shot / Sandy Beach
12+76	0	5910897.1	383922.3	7.2	Ground Shot / Sandy Beach
13+25	0	5910883.1	383969.9	7.2	Ground Shot / Sandy Beach
13+74	0	5910869.4	384016.4	7.6	Ground Shot / Sandy Beach
14+23	0	5910855.5	384063.9	7.5	Ground Shot / Sandy Beach
14+73	0	5910841.4	384111.5	7.4	Ground Shot / Sandy Beach
15+22	0	5910827.8	384158.0	7.4	Ground Shot / Sandy Beach
15+71	0	5910813.9	384205.2	7.3	Ground Shot / Sandy Beach
16+21	0	5910799.8	384253.1	7.1	Ground Shot / Sandy Beach
16+70	0	5910785.9	384300.2	6.8	Ground Shot / Sandy Beach
17+18	0	5910772.3	384346.5	6.6	Ground Shot / Sandy Beach
17+68	0	5910758.1	384394.6	6.4	Ground Shot / Sandy Beach
18+18	0	5910744.1	384442.4	6.1	Ground Shot / Sandy Beach
18+67	0	5910730.2	384489.7	6.1	Ground Shot / Sandy Beach
19+17	0	5910716.1	384537.5	5.8	Ground Shot / Sandy Beach
19+66	0	5910702.2	384584.6	5.5	Ground Shot / Sandy Beach

Colville River Channel Cross-Sections

Cross Section at Mon 01

Station	Offset	Northing	Easting	Elevation	Description
20+16	0	5910688.3	384631.9	5.2	Ground Shot / Sandy Beach
20+66	0	5910673.9	384680.8	4.9	Ground Shot / Sandy Beach
21+17	0	5910659.8	384728.8	4.6	Ground Shot / Sandy Beach
21+64	0	5910646.3	384774.5	4.4	Ground Shot / Sandy Beach
22+11	0	5910633.0	384819.8	4.2	Ground Shot / Sandy Beach
22+59	0	5910619.7	384865.1	3.5	Ground Shot / Sandy Beach
23+06	0	5910606.4	384910.4	3.0	Ground Shot / Sandy Beach
23+52	0	5910593.2	384955.0	2.7	Ground Shot / Sandy Beach
23+92	0	5910582.1	384992.7	1.8	Edge of Water
24+28	0	5910571.8	385027.8	1.4	River Bed
24+69	0	5910560.2	385067.1	0.6	River Bed
25+02	0	5910551.0	385098.4	-0.1	River Bed
25+34	0	5910542.0	385129.2	0.5	River Bed
25+66	0	5910533.0	385159.8	-0.9	River Bed
25+73	-4	5910534.6	385167.5	-1.2	River Bed
25+76	-5	5910534.5	385171.0	-1.1	River Bed
25+83	-6	5910534.4	385177.9	-1.4	River Bed
25+92	0	5910525.6	385184.9	-2.0	River Bed
26+02	-1	5910524.0	385195.0	-1.8	River Bed
26+22	-7	5910523.7	385215.7	-1.7	River Bed
26+41	-2	5910513.3	385232.8	-2.0	River Bed
26+52	4	5910505.0	385241.0	-2.9	River Bed
26+61	-7	5910512.9	385253.5	-2.8	River Bed
26+81	-2	5910502.5	385270.6	-3.7	River Bed
27+01	-8	5910502.2	385291.3	-4.4	River Bed
27+23	-3	5910491.7	385311.9	-5.0	River Bed
27+34	4	5910481.6	385320.3	-5.3	River Bed
27+40	-8	5910491.5	385329.1	-6.2	River Bed
27+59	-3	5910481.0	385346.3	-6.4	River Bed
27+76	-7	5910480.8	385363.5	-6.8	River Bed
27+95	-2	5910470.4	385380.6	-6.2	River Bed
27+98	5	5910462.5	385381.1	-7.7	River Bed
28+12	-7	5910470.1	385397.9	-7.5	River Bed
28+25	9	5910451.1	385406.0	-8.2	River Bed
28+35	-3	5910459.6	385418.4	-8.3	River Bed
28+58	-9	5910459.2	385442.6	-8.3	River Bed
28+81	-5	5910448.8	385463.2	-8.1	River Bed
28+86	-10	5910452.5	385469.8	-8.4	River Bed
29+01	-10	5910448.5	385483.9	-9.1	River Bed
29+30	-8	5910437.9	385511.3	-9.3	River Bed
29+47	-13	5910437.6	385528.6	-8.7	River Bed
29+51	-17	5910440.3	385533.5	-8.5	River Bed
29+73	-9	5910427.1	385552.6	8.1	River Bed
29+95	-5	5910416.6	385573.2	-8.4	River Bed
30+05	-17	5910425.0	385585.6	-9.3	River Bed
30+19	-12	5910416.2	385597.3	-9.8	River Bed
30+35	-5	5910405.0	385610.7	-9.8	River Bed
30+61	-13	5910405.4	385638.6	-10.0	River Bed
30+87	-9	5910394.9	385662.6	-9.6	River Bed

Colville River Channel Cross-Sections

Cross Section at Mon 01

Station	Offset	Northing	Easting	Elevation	Description
31+04	-14	5910394.6	385679.9	-9.4	River Bed
31+23	-7	5910382.0	385696.1	-11.2	River Bed
31+43	-14	5910383.9	385717.7	-12.7	River Bed
31+63	-20	5910383.6	385738.4	-14.1	River Bed
31+82	-15	5910373.2	385755.5	-14.4	River Bed
32+05	-11	5910362.7	385776.1	-15.5	River Bed
32+22	-15	5910362.4	385793.3	-16.7	River Bed
32+41	-10	5910352.0	385810.5	-18.5	River Bed
32+61	-16	5910351.7	385831.2	-20.5	River Bed
32+80	-10	5910341.3	385848.3	-21.2	River Bed
33+00	-16	5910341.0	385869.0	-22.3	River Bed
33+26	-13	5910330.4	385893.0	-23.5	River Bed
33+43	-17	5910330.2	385910.3	-24.0	River Bed
33+56	-21	5910330.0	385924.1	-24.2	River Bed
33+86	-19	5910319.4	385951.5	-25.4	River Bed
34+25	-19	5910308.6	385989.4	-25.4	River Bed
34+61	-18	5910298.0	386023.7	-24.8	River Bed
34+87	-15	5910287.4	386047.7	-24.6	River Bed
35+04	-20	5910287.2	386065.0	-24.4	River Bed
35+24	-25	5910286.9	386085.7	-23.9	River Bed
35+44	-31	5910286.5	386106.4	-23.8	River Bed
35+60	-35	5910286.3	386123.7	-23.1	River Bed
35+83	-42	5910285.9	386147.9	-22.3	River Bed
36+03	-37	5910275.5	386165.0	-22.3	River Bed
36+29	-33	5910265.0	386189.0	-20.9	River Bed
36+42	-37	5910264.8	386202.8	-20.6	River Bed
36+61	-32	5910254.3	386219.9	-19.9	River Bed
36+75	-36	5910254.1	386233.7	-19.5	River Bed
36+94	-30	5910243.7	386250.8	-19.0	River Bed
37+11	-35	5910243.4	386268.1	-18.7	River Bed
37+33	-31	5910233.0	386288.6	-17.8	River Bed
37+56	-27	5910222.5	386309.2	-16.5	River Bed
37+79	-22	5910212.0	386329.8	-16.5	River Bed
37+95	-27	5910211.7	386347.0	-15.8	River Bed
38+13	-42	5910221.6	386367.9	-15.2	River Bed
38+49	-42	5910210.9	386402.3	-14.8	River Bed
38+65	-36	5910200.5	386415.9	-14.8	River Bed
38+87	-31	5910190.1	386436.5	-13.6	River Bed
39+07	-37	5910189.8	386457.2	-13.3	River Bed
39+30	-33	5910179.3	386477.7	-12.3	River Bed
39+49	-28	5910168.9	386494.9	-11.7	River Bed
39+69	-22	5910158.4	386512.0	-11.3	River Bed
39+78	-25	5910158.5	386521.8	-8.8	River Bed
39+85	-16	5910148.1	386525.6	-5.4	River Bed
39+99	-31	5910158.0	386543.0	-1.7	River Bed
40+02	0	5910127.6	386537.3	1.6	Edge of Water
40+10	0	5910125.3	386545.2	2.3	Toe of Bank
40+17	0	5910123.5	386551.7	4.8	Grade Break
40+24	0	5910121.4	386558.6	9.9	Grade Break

Colville River Channel Cross-Sections

Cross Section at Mon 01

Station	Offset	Northing	Easting	Elevation	Description
40+33	0	5910118.9	386567.1	9.7	Grade Break
40+35	0	5910118.1	386569.7	18.5	Top of Bank
40+84	0	5910104.4	386616.3	17.2	Tundra, Dense 3' Willow Brush
41+19	78	5910020.0	386627.7	20.5	BM-02
41+32	0	5910090.9	386662.0	19.1	Tundra, Dense 3' Willow Brush
41+80	0	5910077.3	386708.4	18.5	Tundra, Dense 3' Willow Brush
42+26	0	5910064.4	386752.0	19.7	Tundra, Dense 3' Willow Brush
42+73	0	5910050.8	386798.0	18.9	Tundra, Dense 3' Willow Brush
43+19	0	5910038.1	386841.3	18.7	Tundra, Dense 3' Willow Brush
43+69	0	5910023.9	386889.7	19.9	MON-01-R
Notes:					

1. Elevations are British Petroleum Mean Sea Level Datum, based on the elevation of BM 1at 26.82'.
2. Horizontal Coordinates are Alaska State Plane Zone 4, NAD 27 Datum.
3. Ground profile was surveyed with a conventional total station. River bed depths were obtained with a Garmin GPS Depth Sounder, and spot checked with the total station and rod.
4. Rebar with Aluminum Caps were set at Cross-Section endpoints. Horizontal coordinates of the endpoints are based on found Benchmarks 1 and 2, per GPS survey performed in June 2002.
5. This cross section was surveyed on July 15, 2002. Water surface elevation at time of survey was 1.60' at 4:40 pm.

Colville River Channel Cross-Sections

Cross Section Mon 01 Downstream

Station	Offset	Northing	Easting	Elevation	Description
0+00	0	5912947.6	383708.9	29.3	MON-01-DL
0+14	0	5912944.2	383722.7	26.3	Grade Break
0+26	0	5912941.3	383733.9	26.9	Grade Break
0+73	0	5912929.6	383779.2	25.7	Grade Break
0+92	0	5912924.7	383798.4	26.5	Grade Break
1+09	0	5912920.6	383814.1	23.4	Grade Break
1+55	0	5912908.9	383859.4	24.9	Grade Break
1+94	0	5912899.3	383896.8	24.4	Top of Bank
2+40	0	5912887.7	383941.2	17.9	Grade Break
2+89	0	5912875.4	383988.9	13.9	Grade Break
3+29	0	5912865.4	384027.7	12.5	Tundra / Edge of Vegetation
3+80	0	5912852.7	384077.3	10.7	Toe of Bank
4+32	0	5912839.9	384127.0	9.6	Ground Shot / Sandy Beach
4+85	0	5912826.6	384178.4	8.8	Ground Shot / Sandy Beach
5+36	0	5912813.9	384227.9	8.0	Ground Shot / Sandy Beach
5+87	0	5912801.2	384277.0	7.8	Ground Shot / Sandy Beach
6+38	0	5912788.5	384326.4	7.1	Ground Shot / Sandy Beach
6+87	0	5912776.2	384374.2	6.9	Ground Shot / Sandy Beach
7+38	0	5912763.6	384423.1	7.1	Ground Shot / Sandy Beach
7+87	0	5912751.1	384471.2	6.7	Ground Shot / Sandy Beach
8+35	0	5912739.2	384517.5	6.7	Ground Shot / Sandy Beach
8+84	0	5912727.0	384564.9	6.8	Ground Shot / Sandy Beach
9+33	0	5912714.8	384612.3	7.1	Ground Shot / Sandy Beach
9+84	0	5912701.9	384662.1	7.1	Ground Shot / Sandy Beach
10+36	0	5912689.1	384711.9	7.0	Ground Shot / Sandy Beach
10+86	0	5912676.6	384760.5	7.0	Ground Shot / Sandy Beach
11+36	0	5912664.0	384809.3	7.0	Ground Shot / Sandy Beach
11+88	0	5912651.1	384859.5	6.8	Ground Shot / Sandy Beach
12+39	0	5912638.3	384909.1	6.5	Ground Shot / Sandy Beach
12+90	0	5912625.6	384958.1	6.4	Ground Shot / Sandy Beach
13+41	0	5912612.8	385007.8	5.9	Ground Shot / Sandy Beach
13+90	0	5912600.6	385055.1	5.5	Ground Shot / Sandy Beach
14+38	0	5912588.7	385101.5	5.2	Ground Shot / Sandy Beach
14+87	0	5912576.6	385148.5	4.4	Ground Shot / Sandy Beach
15+37	0	5912564.0	385197.2	4.2	Ground Shot / Sandy Beach
15+86	0	5912551.7	385244.9	3.9	Ground Shot / Sandy Beach
16+32	0	5912540.3	385289.1	3.3	Ground Shot / Sandy Beach
16+81	0	5912528.2	385336.2	2.7	Ground Shot / Sandy Beach
17+24	0	5912517.3	385378.4	2.4	Ground Shot / Sandy Beach
17+56	0	5912509.3	385409.3	1.6	Edge of Water
17+94	0	5912499.8	385446.5	1.2	River Bed
18+32	0	5912490.3	385483.0	0.7	River Bed
18+69	0	5912481.1	385518.9	-0.2	River Bed
19+04	0	5912472.5	385552.3	-0.7	River Bed
19+35	0	5912464.8	385582.2	-1.1	River Bed
19+47	0	5912461.9	385593.9	-1.6	River Bed
19+62	0	5912457.8	385609.3	-2.1	River Bed
19+75	16	5912439.4	385617.6	-2.0	River Bed
19+95	11	5912439.0	385638.3	-2.3	River Bed
20+18	-1	5912445.2	385663.8	-3.7	River Bed
20+41	10	5912428.2	385683.0	-3.7	River Bed
20+67	15	5912417.7	385707.0	-5.3	River Bed

Colville River Channel Cross-Sections

Cross Section Mon 01 Downstream

Station	Offset	Northing	Easting	Elevation	Description
20+78	-2	5912430.8	385721.3	-5.8	River Bed
20+91	9	5912417.3	385731.1	-5.7	River Bed
21+11	4	5912417.0	385751.9	-6.6	River Bed
21+37	8	5912406.5	385775.9	-6.7	River Bed
21+41	-1	5912413.9	385782.4	-6.8	River Bed
21+59	13	5912396.0	385796.4	-8.0	River Bed
21+82	18	5912385.5	385817.0	-8.7	River Bed
22+05	13	5912385.1	385841.1	-7.8	River Bed
22+29	7	5912384.8	385865.3	-9.0	River Bed
22+53	-1	5912386.7	385890.7	-10.5	River Bed
22+58	10	5912374.2	385892.7	-10.2	River Bed
22+78	5	5912373.9	385913.4	-10.3	River Bed
22+96	-3	5912377.8	385932.8	-11.1	River Bed
23+04	10	5912363.3	385937.5	-11.4	River Bed
23+26	15	5912352.9	385958.0	-12.1	River Bed
23+47	10	5912352.6	385978.7	-11.4	River Bed
23+54	1	5912359.1	385988.0	-11.7	River Bed
23+72	14	5912342.0	386002.7	-12.7	River Bed
23+93	9	5912341.7	386023.4	-12.0	River Bed
24+18	13	5912331.2	386047.4	-12.3	River Bed
24+28	-3	5912345.0	386060.9	-12.9	River Bed
24+42	8	5912330.8	386071.6	-13.3	River Bed
24+64	13	5912320.3	386092.2	-13.7	River Bed
24+87	18	5912309.9	386112.7	-14.2	River Bed
25+10	12	5912309.5	386136.9	-15.0	River Bed
25+31	7	5912309.2	386157.6	-15.1	River Bed
25+54	1	5912308.8	386181.7	-15.8	River Bed
25+80	6	5912298.3	386205.7	-16.5	River Bed
25+97	2	5912298.0	386223.0	-16.9	River Bed
26+23	6	5912287.5	386247.0	-17.9	River Bed
26+45	11	5912277.0	386267.6	-18.3	River Bed
26+65	6	5912276.7	386288.3	-18.4	River Bed
26+91	10	5912266.2	386312.3	-19.5	River Bed
27+15	5	5912265.8	386336.4	-19.8	River Bed
27+35	0	5912265.5	386357.1	-20.0	River Bed
27+58	-6	5912265.2	386381.3	-20.0	River Bed
27+78	-11	5912264.8	386402.0	-20.8	River Bed
28+04	-7	5912254.3	386426.0	-21.5	River Bed
28+33	-3	5912243.7	386453.5	-22.2	River Bed
28+54	-8	5912243.4	386474.2	-22.8	River Bed
28+76	-3	5912233.0	386494.7	-22.9	River Bed
28+99	2	5912222.5	386515.3	-22.9	River Bed
29+25	-5	5912222.1	386542.9	-23.1	River Bed
29+60	8	5912201.3	386573.7	-23.5	River Bed
29+90	11	5912190.7	386601.1	-22.7	River Bed
30+32	11	5912179.9	386642.4	-22.3	River Bed
30+59	5	5912179.5	386670.0	-22.3	River Bed
30+82	10	5912169.0	386690.5	-21.4	River Bed
30+98	6	5912168.8	386707.8	-21.0	River Bed
31+31	8	5912158.1	386738.7	-19.0	River Bed
31+54	3	5912157.8	386762.9	-18.1	River Bed
31+77	8	5912147.3	386783.4	-17.1	River Bed

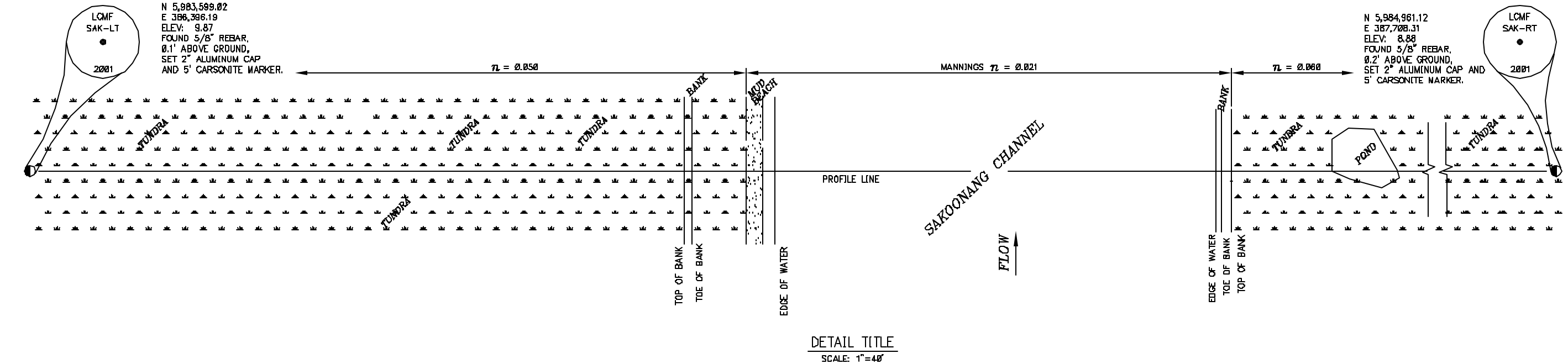
Colville River Channel Cross-Sections

Cross Section Mon 01 Downstream

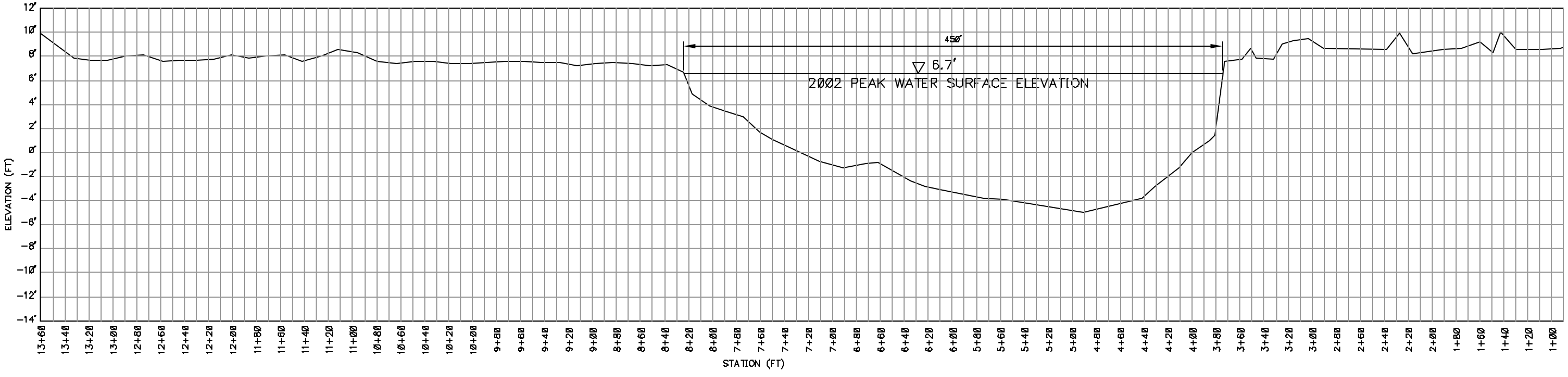
Station	Offset	Northing	Easting	Elevation	Description
31+86	16	5912137.0	386790.2	-16.4	River Bed
31+99	23	5912126.7	386800.4	-15.6	River Bed
32+02	23	5912126.6	386803.8	-15.0	River Bed
32+23	-10	5912152.9	386832.3	-11.2	River Bed
32+33	5	5912136.3	386838.5	-9.0	River Bed
32+43	0	5912138.3	386848.9	1.7	Edge of Water
32+47	-1	5912138.5	386853.3	2.3	Toe of Bank
32+52	0	5912135.9	386858.1	6.2	Grade Break
32+57	0	5912134.7	386862.7	11.0	Grade Break
32+63	0	5912133.2	386868.9	13.8	Grade Break
32+65	0	5912132.8	386870.4	16.6	Top of Bank
33+10	0	5912121.6	386913.7	16.7	Tundra, Dense 3' Willow Brush
33+58	0	5912109.6	386960.3	17.1	Tundra, Dense 3' Willow Brush
34+06	0	5912097.4	387007.5	17.6	Tundra, Dense 3' Willow Brush
34+37	0	5912089.9	387037.1	17.8	MON-01-DR
Notes:					

1. Elevations are British Petroleum Mean Sea Level Datum, based on the elevation of BM 1at 26.82'.
2. Horizontal Coordinates are Alaska State Plane Zone 4, NAD 27 Datum.
3. Ground profile was surveyed with a conventional total station. River bed depths were obtained with a Garmin GPS Depth Sounder, and spot checked with the total station and rod.
4. Rebar with Aluminum Caps were set at Cross-Section endpoints. Horizontal coordinates of the endpoints are based on found Benchmarks 1 and 2, per GPS survey performed in June 2002.
5. This cross section was surveyed on July 15, 2002. Water surface elevation at time of survey was 1.60' at 4:40 pm.

Appendix B CD-North Channel Cross Sections



DETAIL TITLE
SCALE: 1"=40'



CROSS SECTION A-A
SCALE: H 1"=40' V 1"=4'

NOTES:
1. CHANNEL CROSS SECTION SURVEY BY LCMF, JULY 17 2001
2. ELEVATIONS IN FEET, USING BRITISH PETROLEUM MEAN SEA LEVEL (BPMSL) DATUM.
3. HORIZONTAL DATUM IS NAD 27 ALASKA STATE PLANE COORDINATES, ZONE 4, RELATIVE TO THE ALPINE CONTROL NETWORK.
4. SEE BACK OF PAGE.

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	ENGR	PROJ ENGR	QUAL ASR

Baker

Michael Baker Jr, Inc.
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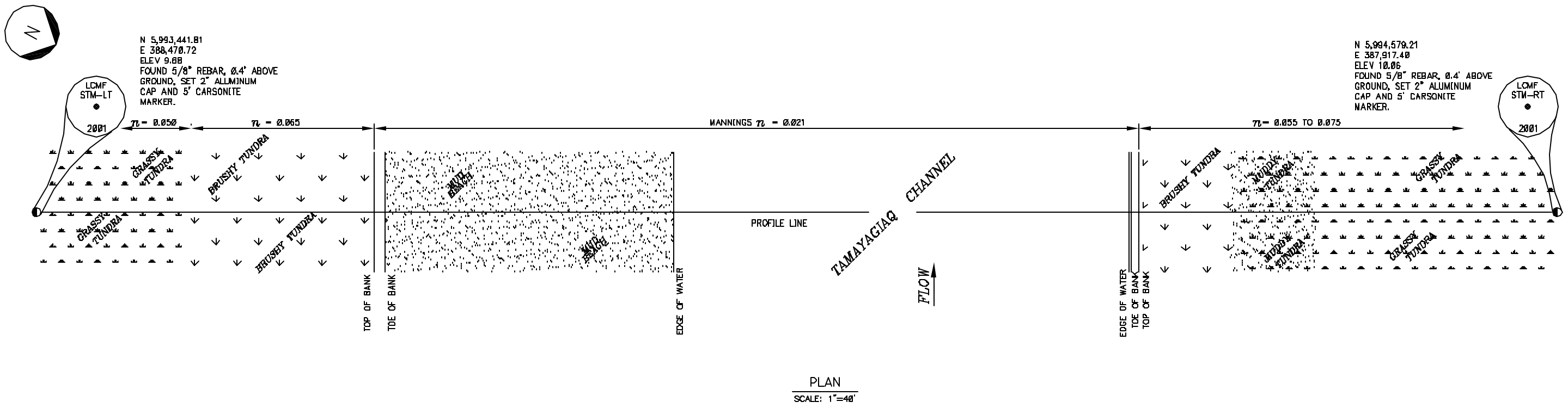
4801 Business Park Blvd., Suite 42
Anchorage, Alaska 99503
Phone: (907) 273-1800
Fax: (907) 273-1699

CADD FILE NO.: 25436D017 | DATE: 11/02 | SCALE: AS SHOWN

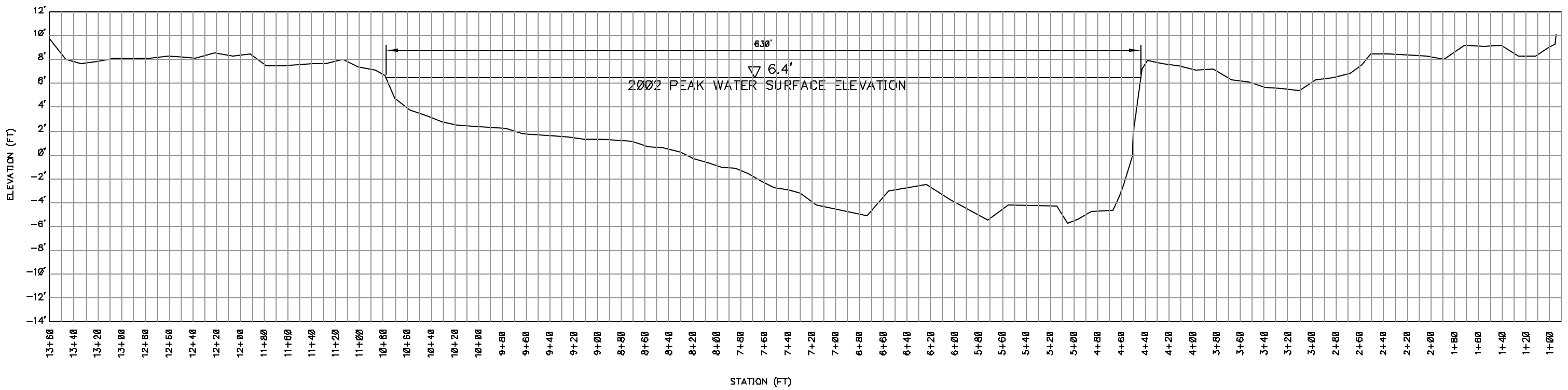
2002 SPRING BREAKUP
COLVILLE RIVER DELTA
SAKOONANG CHANNEL CROSS SECTION

DRAWN	DESIGN	CHECKED	APPROVAL
HMJ	JB	JB	

JOB NO.	DRAWING NO.	SHEET	REV
25436	FIGURE B-1	1 of 1	A



PLAN
SCALE: 1"=4Ø'



CROSS SECTION B-B
SCALE: H 1"=4Ø' V 1"=4'

NOTES:
1. CHANNEL CROSS SECTION SURVEY BY LCMF, JULY 31 2001
2. ELEVATIONS IN FEET, USING BRITISH PETROLEUM MEAN SEA LEVEL (BPMSL) DATUM.
3. HORIZONTAL DATUM IS NAD 27 ALASKA STATE PLANE COORDINATES, ZONE 4, RELATIVE TO THE ALPINE CONTROL NETWORK.
4. SEE BACK OF PAGE.

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB LOGGED	PROJ ENGR	QUALITY APP

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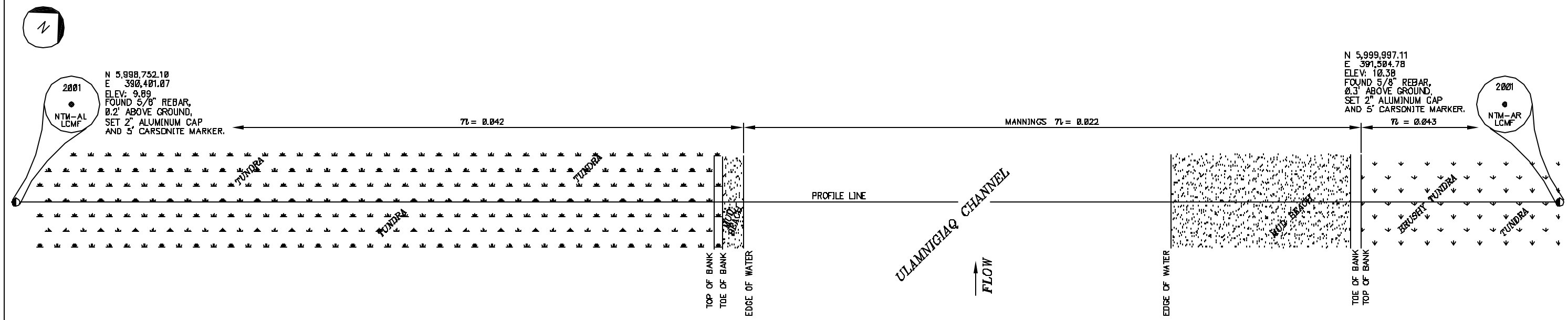
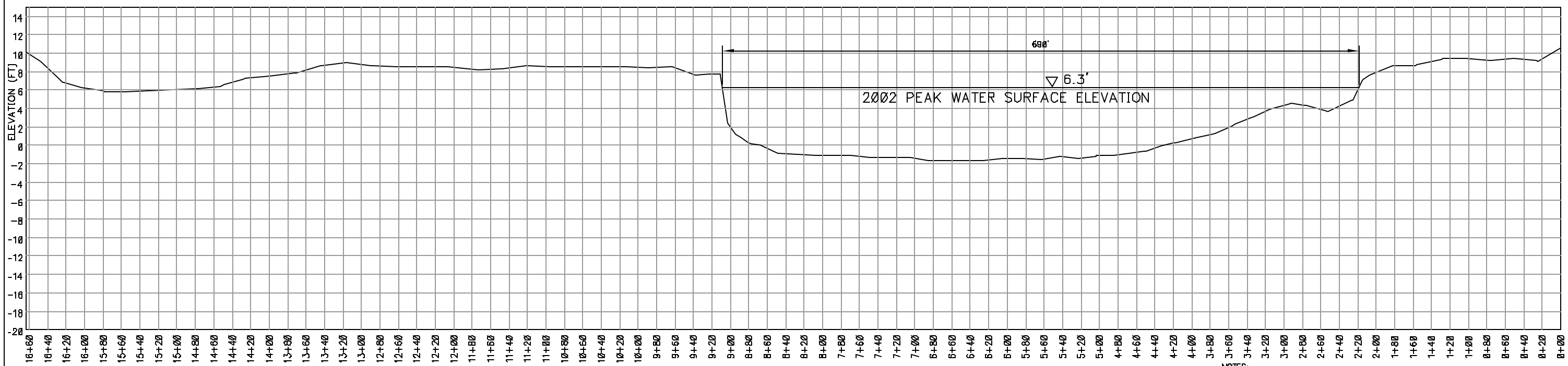
CADD FILE NO.	DATE	SCALE:
25436C017	11/02	AS SHOWN

2ØØ2 SPRING BREAKUP
COLVILLE RIVER DELTA
TAMAYAGIAQ CHANNEL CROSS SECTION

DRAWN:	DESIGN:	CHECKED:	APPROVAL:
HMJ	JB	JB	

JOB NO:	DRAWING NO.	SHEET:	REV:
25436	FIGURE B-2	1 of 1	A





NOTES:
1. CHANNEL CROSS SECTION SURVEY BY LCMF, JULY 17 2001
2. ELEVATIONS IN FEET, USING BRITISH PETROLEUM MEAN SEA LEVEL (BPMSL) DATUM.
3. HORIZONTAL DATUM IS NAD 27 ALASKA STATE PLANE COORDINATES, ZONE 4, RELATIVE TO THE ALPINE CONTROL NETWORK.
4. SEE BACK OF PAGE.

REFERENCE DWG NO/SHT NOs

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	PUBT APP

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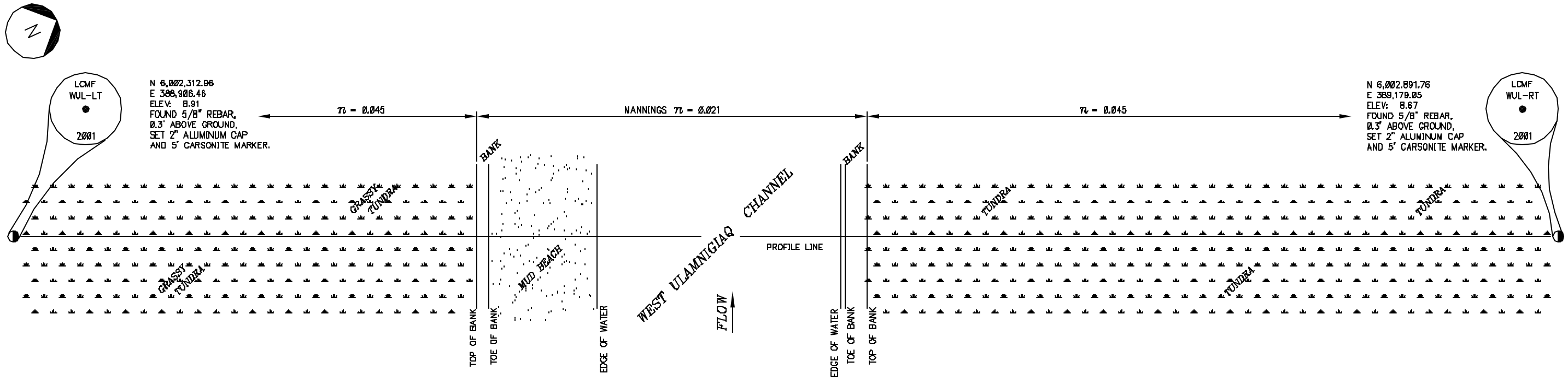
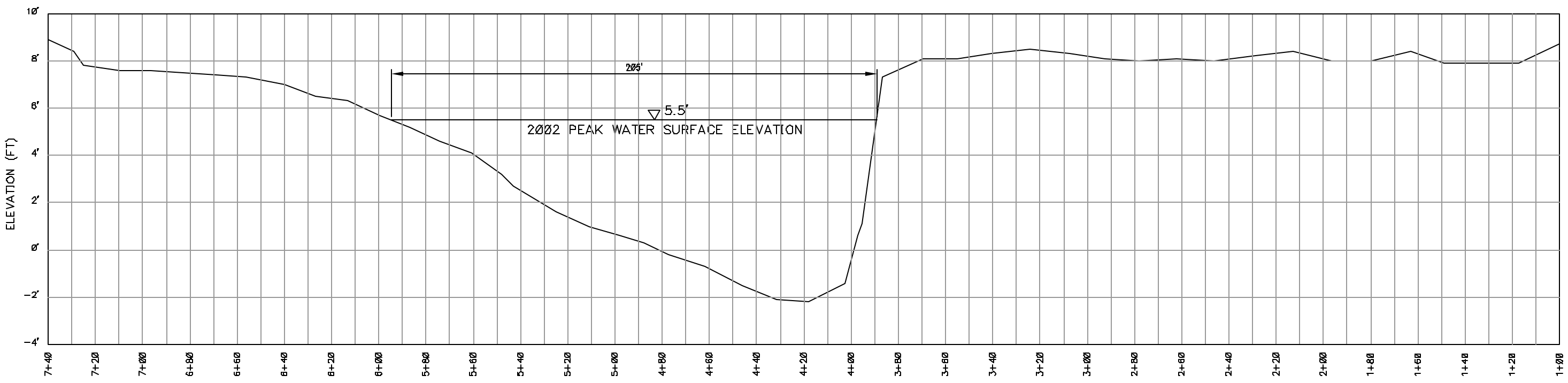
2002 SPRING BREAKUP
COLVILLE RIVER DELTA
ULAMNIGIAQ CHANNEL CROSS SECTION

CADD FILE NO.	DATE	SCALE	DRAWN	DESIGN	CHECKED	APPROVAL
25436C017	11/02	AS SHOWN	HMJ	JB	JB	

JOB NO.	DRAWING NO.	SHEET	REV.
25436	FIGURE B-3	1 of 1	A



PLAN
SCALE: 1"=20'



CROSS SECTION D-D
SCALE: H 1"=20' V 1"=2'

NOTES:
1. CHANNEL CROSS SECTION SURVEY BY LCMF, JULY 30 2001
2. ELEVATIONS IN FEET, USING BRITISH PETROLEUM MEAN SEA LEVEL (BPMSL) DATUM.
3. HORIZONTAL DATUM IS NAD 27 ALASKA STATE PLANE COORDINATES, ZONE 4, RELATIVE TO THE ALPINE CONTROL NETWORK.
4. SEE BACK OF PAGE.

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	DUST APP

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Fax: (907) 273-1699

CADD FILE NO. 25436C017 | DATE: 11/02 | SCALE: AS SHOWN

2002 SPRING BREAKUP
COLVILLE RIVER DELTA
WEST ULAMNIGIAQ CHANNEL CROSS SECTION

DRAWN	DESIGN	CHECKED	APPROVAL
HMJ	JB	JB	

JOB NO	DRAWING NO.	SHEET	REV
25436	FIGURE B-4	1 of 1	A

Appendix C Channel Ice Observations

Figure C- 1 Low Water Channel Ice Survey, May 23, 2002.

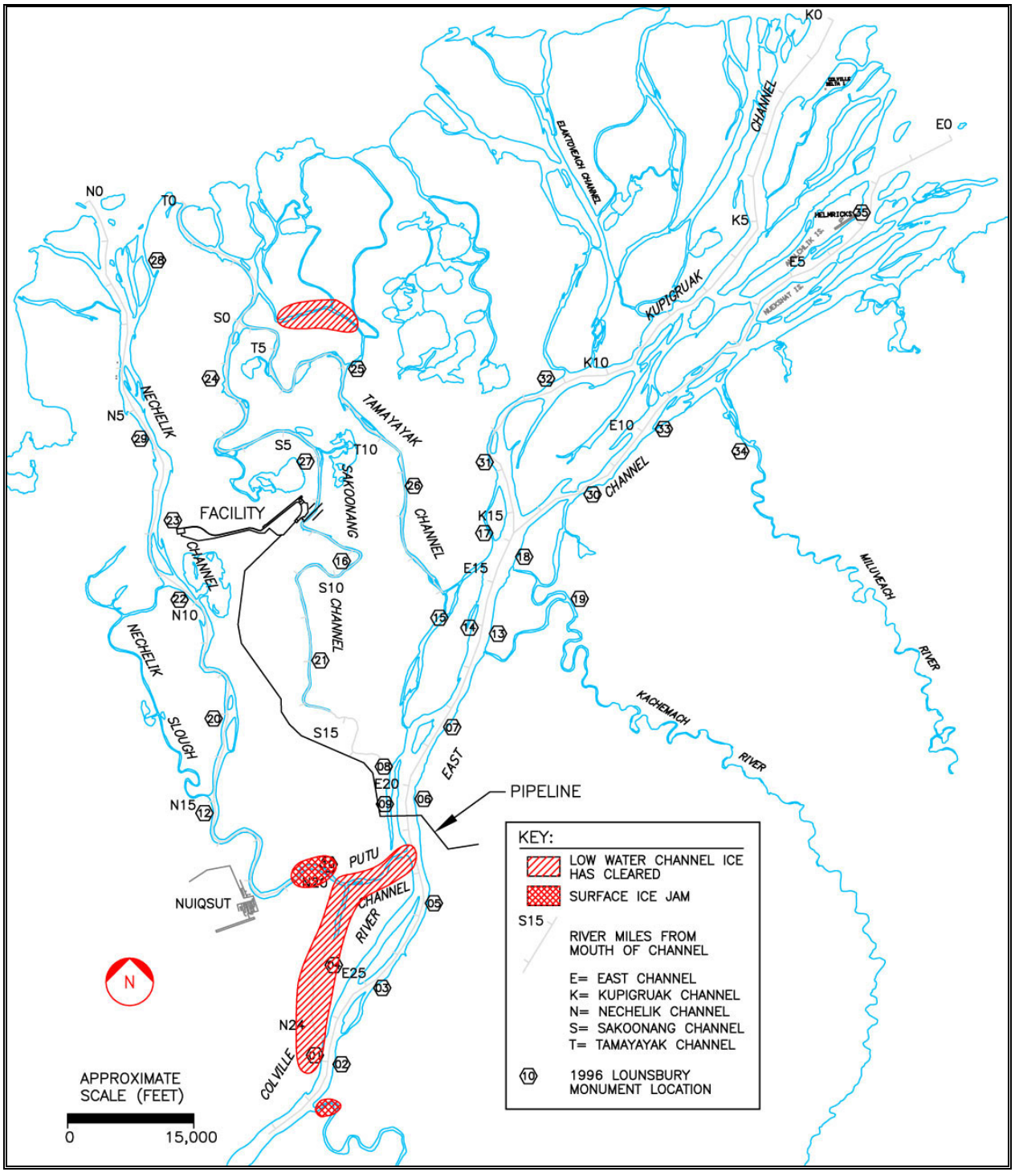


Figure C- 2 Low Water Channel Ice Survey, May 24, 2002.

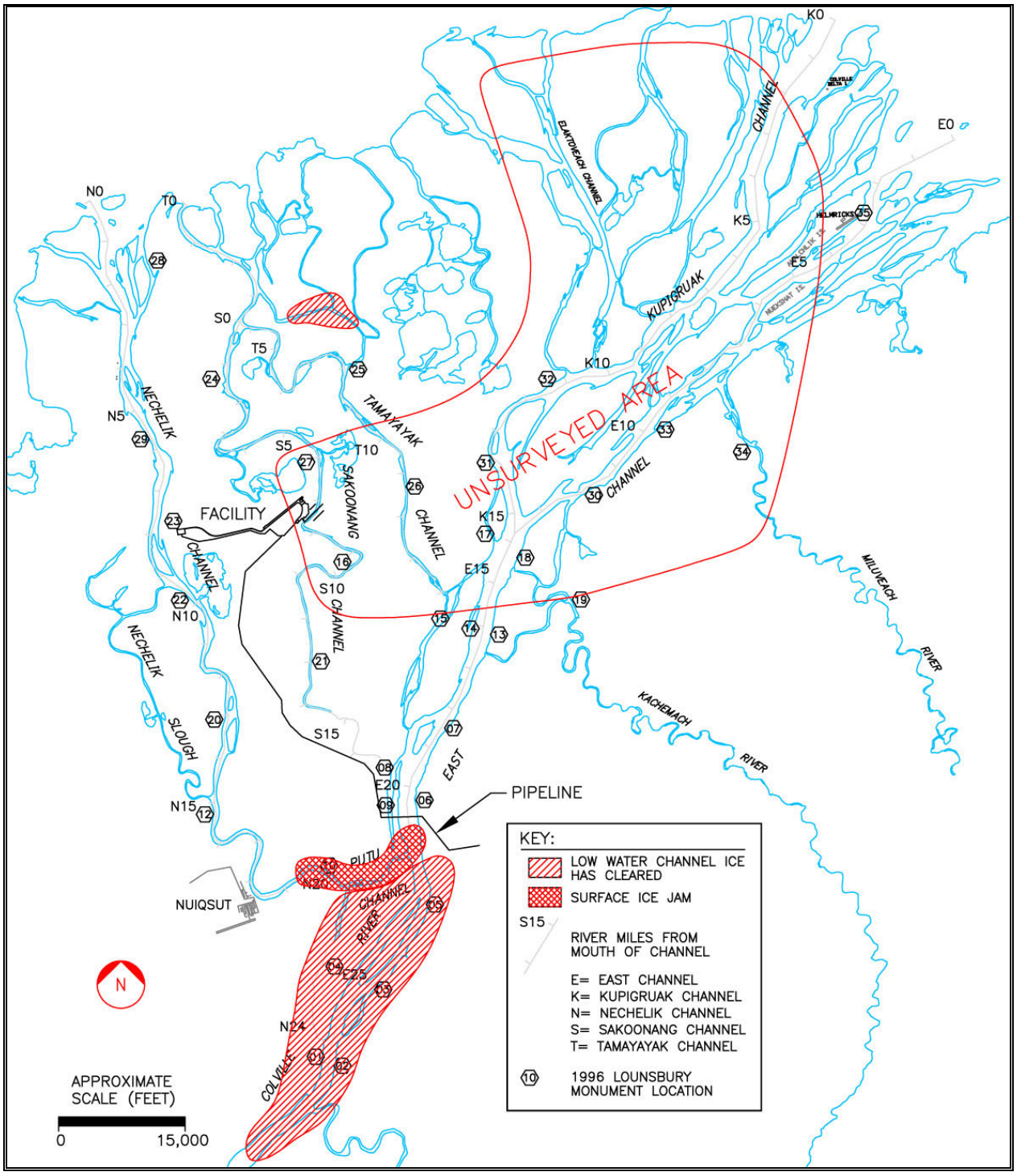


Figure C- 3 Low Water Channel Ice Survey, May 25, 2002.

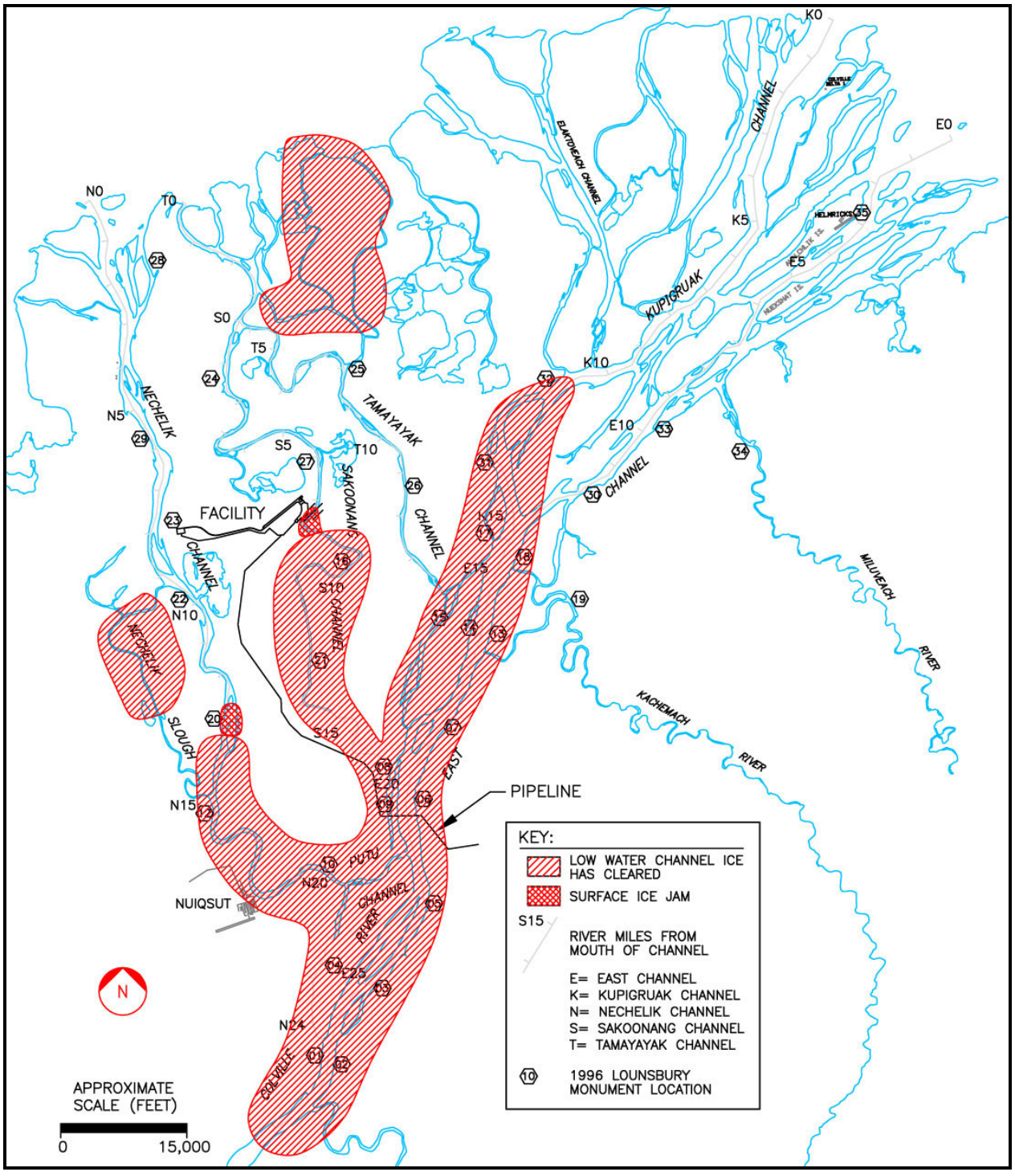
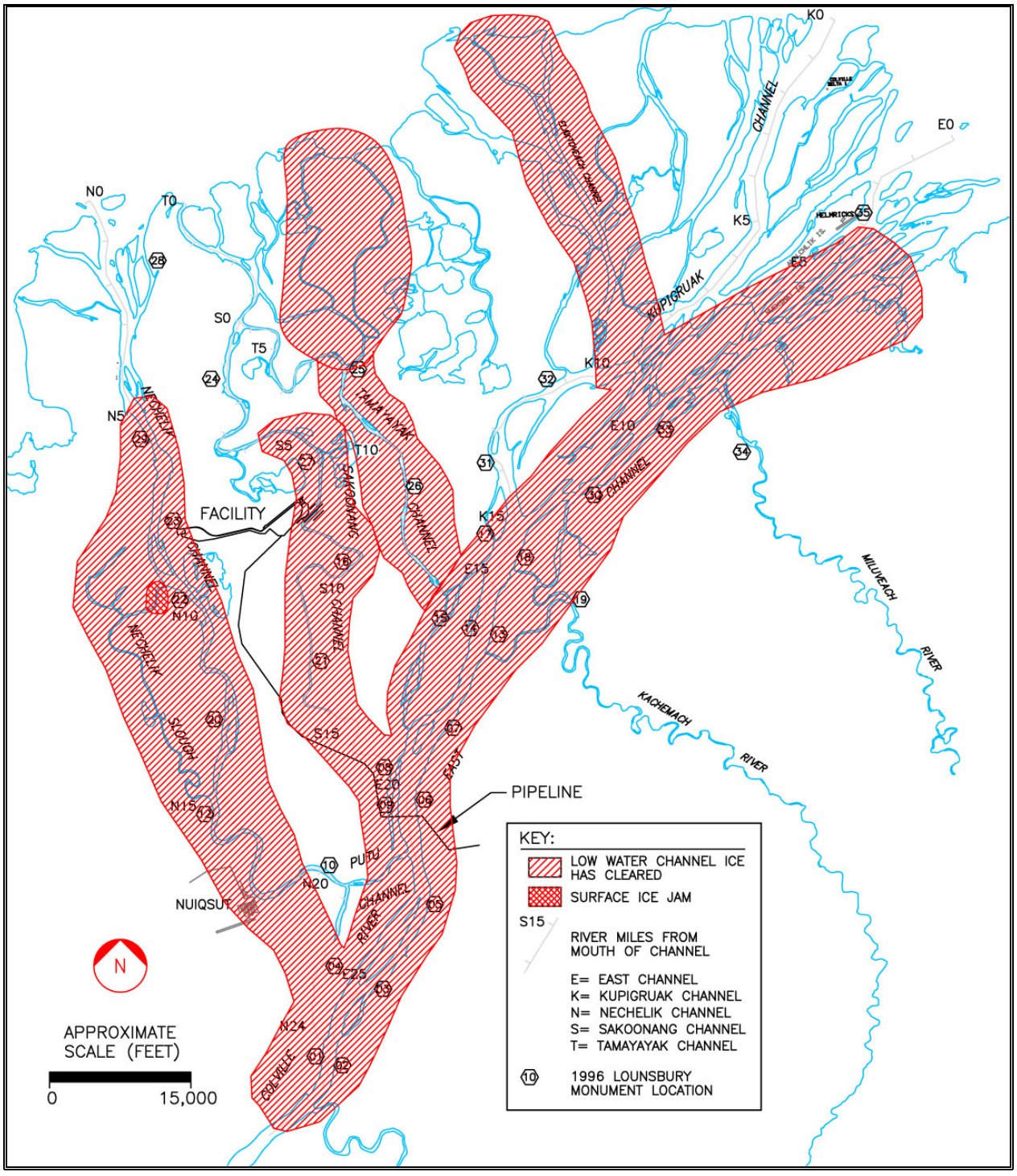


Figure C- 4 Low Water Channel Ice Survey, May 26, 2002.



CD-North 2002 Spring Breakup and Hydrologic Assessment
November 2002

Michael Baker Jr., Inc.
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907-273-1600