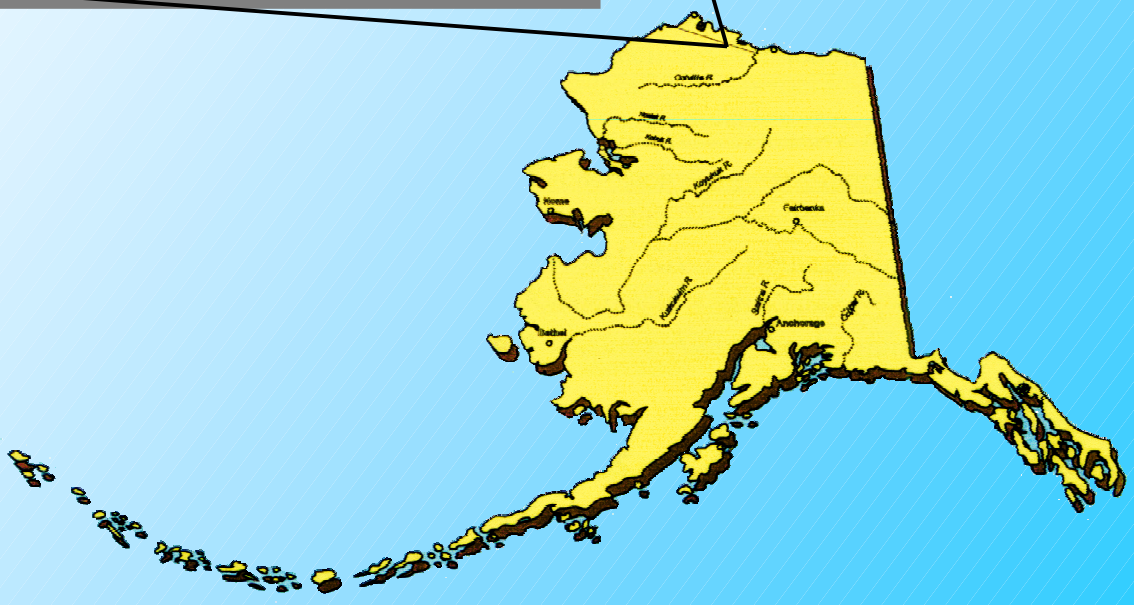
2000 SPRING BREAKUP AND HYDROLOGIC ASSESSMENT

FJORD CHANNEL, COLVILLE RIVER DELTA, ALASKA

for

CD-NORTH DEVELOPMENT PROJECT



January 2001

PHILLIPS Alaska, Inc.
A Subsidiary of PHILLIPS PETROLEUM COMPANY

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24529-MBJ-DCO-001

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Fiord Channel, Colville River Delta, Alaska

For

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PHILLIPS Alaska, Inc.
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By

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1.0 Introduction

This report summarizes the observations and measurements made during the 2000 spring breakup of the Colville River in and around the proposed CD-North Development. The proposed CD-North Development is located in the northwest portion of the Colville River Delta, approximately 60 miles west of Prudhoe Bay and approximately 5 miles north of the Alpine Development, on the North Slope of Alaska (Figure 1-1).

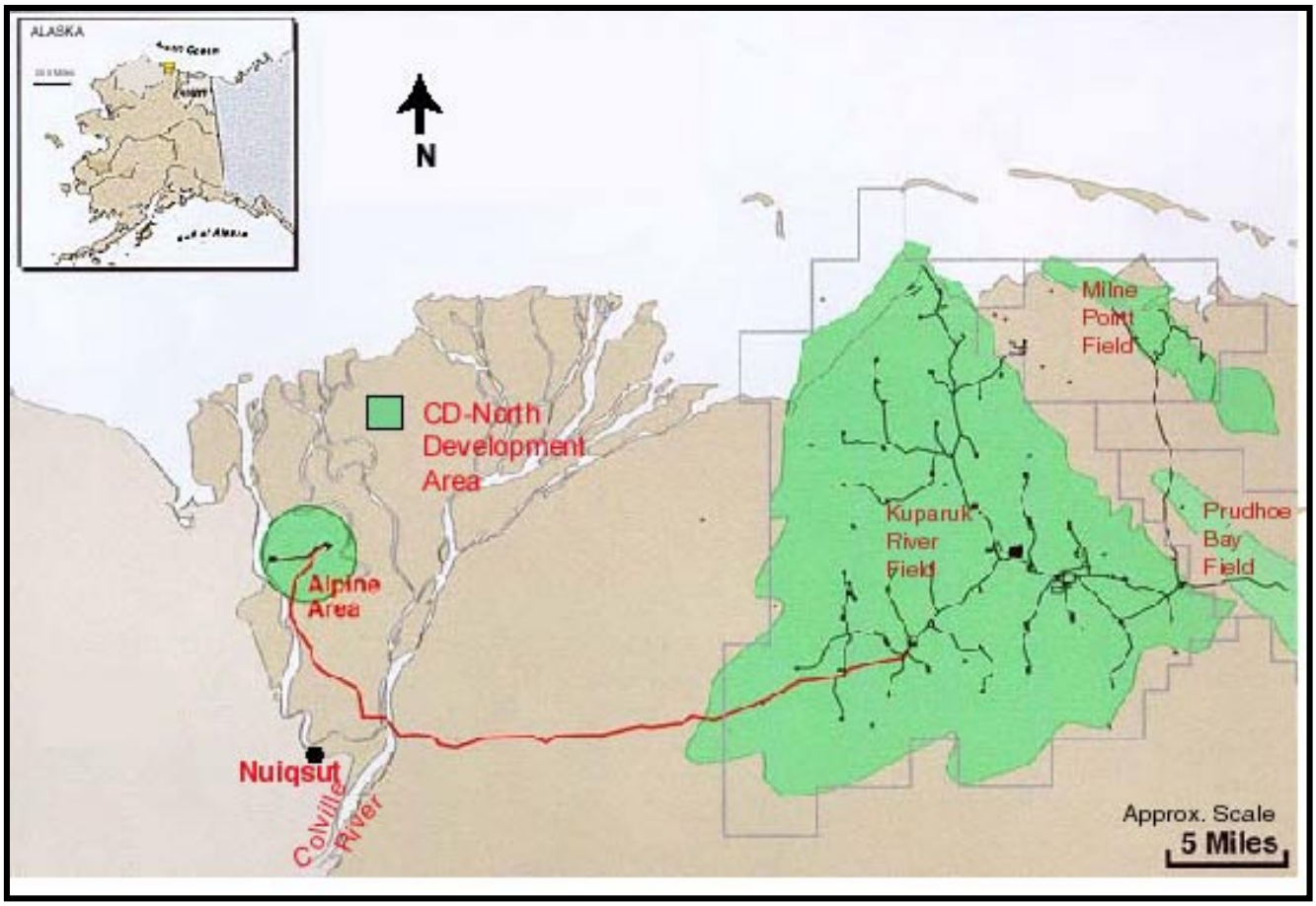

Figure 1-1 Project Location Map

Fieldwork for the 2000 spring breakup was performed between 28 May and 22 June 2000. Water surface elevations were monitored at three locations near the proposed CD-North Development, at the Helmericks' homestead, and at the head of the Colville River Delta. A discharge measurement was made on a distributary of the Tamayayak Channel (referred to as the "Fiord Channel" for this report) to estimate the hydraulic roughness of the channel. The Fiord Channel passes through the

proposed CD-North Development Area. Channel ice observations were made on the main channels of the delta to document the clearing of the low water channel ice sheet and the location of ice jams. Photo documentation of the Fiord Channel monitoring sites was also obtained.

All of the elevations presented in this report are in feet and are based on the British Petroleum mean sea level (BPMSL) datum unless otherwise noted.

2.0 Field Observations and Breakup Summary

2.1 Water Surface Elevations and Observations

On 8 June 2000, we began recording the water surface elevation at the head of the Colville River Delta and near the proposed CD-North Development Area. The water surface elevation peaked at the head of the delta during the night of 9 – 10 June 2000, at an elevation of 19.33 feet. In the lower East Channel (Jim and Tina Helmericks' house, near Monument 35) the water surface elevation peaked on 11 June at approximately 12:30 hours, at an elevation of 7.39 feet. In the Fiord Channel at the Fiord Downstream Site, the water surface elevation probably peaked between 12 and 13 June, at an elevation of 5.77 feet.

To monitor water surface elevations near the head of the delta and the proposed CD-North Development Area, temporary staff gages were established. Three locations at the head of the delta (Survey Monument 1, TBM 01D and TBM 01U) and three locations in the Fiord Channel (FIOSO, FIOMI and FIORD) were monitored. Water-surface elevation data were also collected near the Helmericks' house (near Survey Monument 35). The locations of the monitoring sites are shown in Figure 2-1 and Figure 2-2. The water surface elevation and observation records for these locations are presented in Tables A-1 through A-7 in Appendix A.

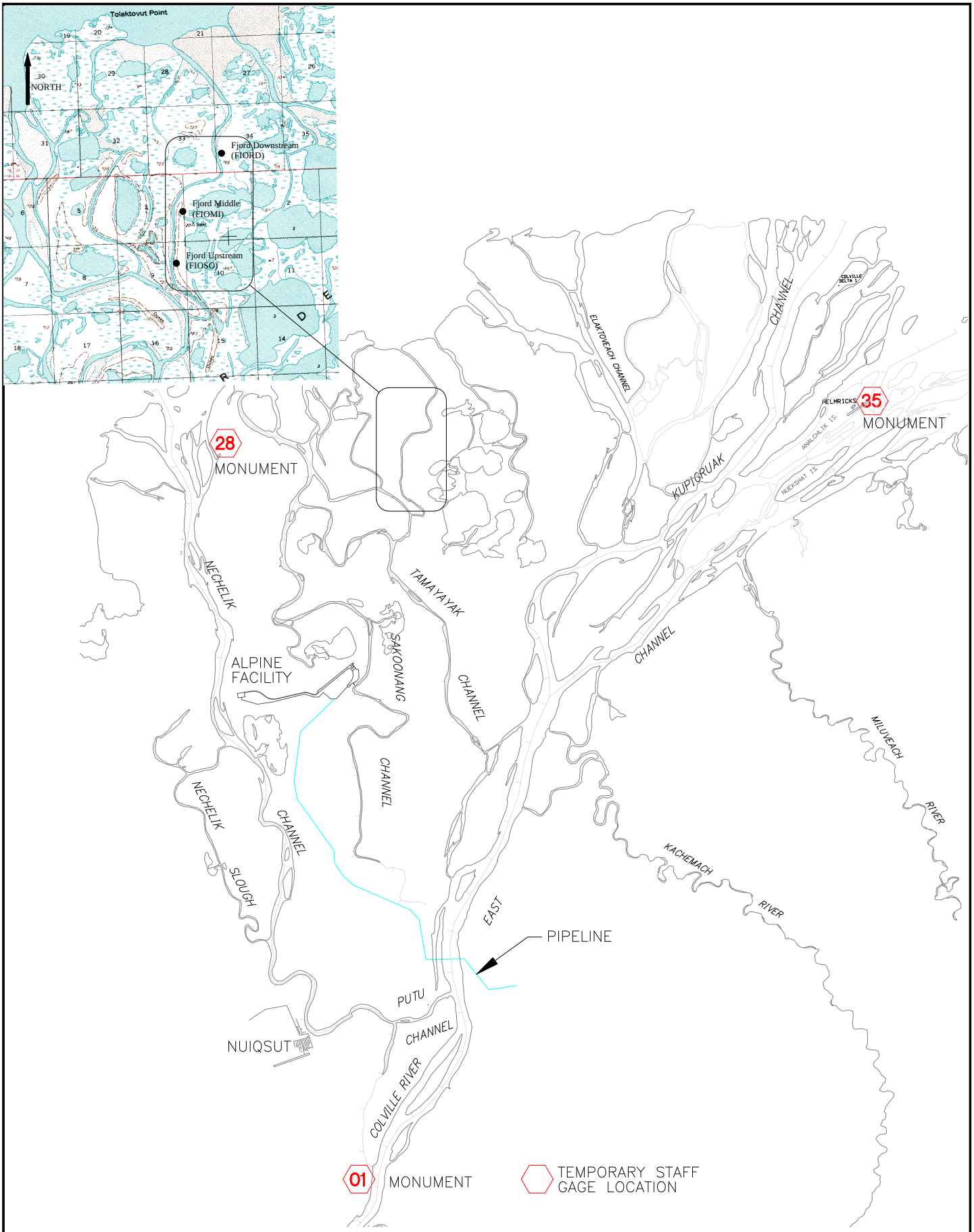

FIGURE 2-1.dwg

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2000 SPRING BREAKUP
COLVILLE RIVER DELTA

TEMPORARY STAFF GAGE LOCATIONS

FIGURE:
2-1

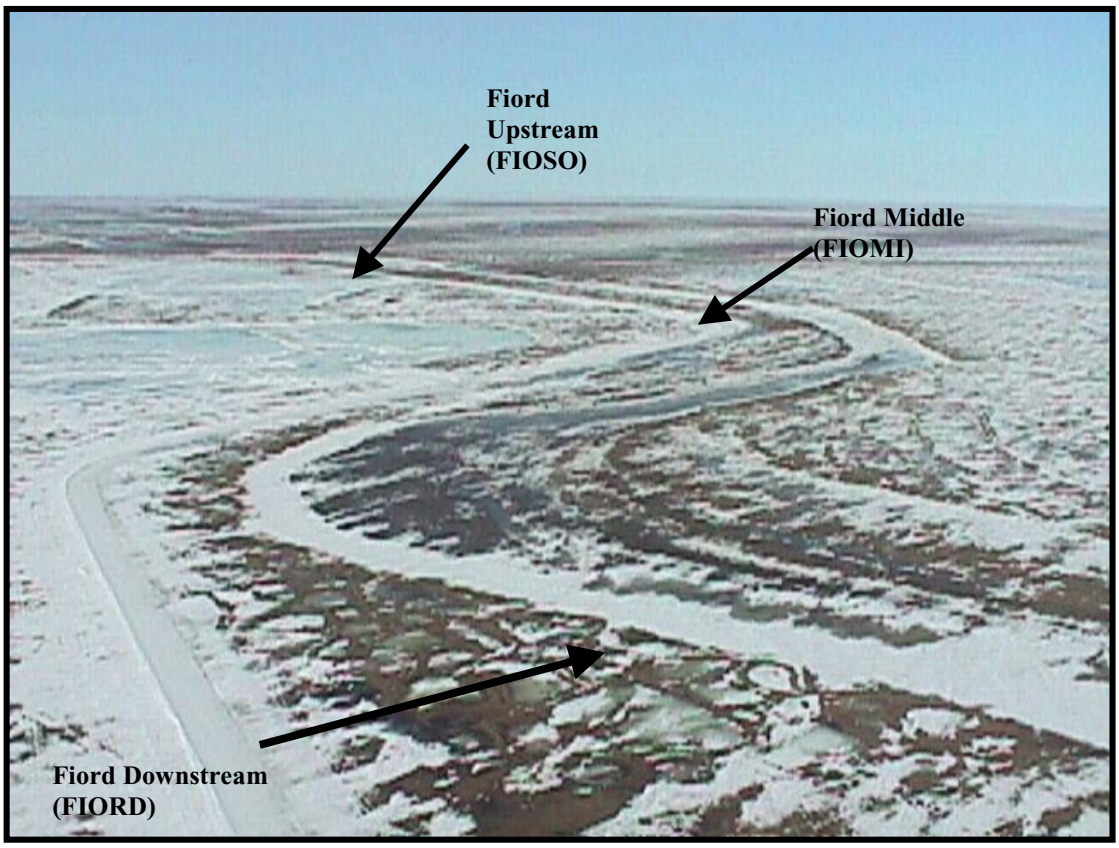


Figure 2-2 Pictorial Site Plan
Fiord Upstream (FIOSO), Middle (FIOMI), and Downstream (FIORD)

At the head of the delta (Monument 1), the water surface elevation peaked during the night of 9 - 10 June 2000, at an elevation of 19.33 feet. In the lower East Channel, at the home of Jim and Tina Helmericks (near Monument 35), the water surface elevation peaked on 11 June at approximately 12:30 hours, at an elevation of 7.39 feet. The peak water-surface elevation at the Helmericks' hanger was 7.24 feet and the peak water-surface elevation at the north end of the runway was 7.10 feet. At the Helmericks' property, the peak water-surface elevation was caused by an offshore ice-jam. It is estimated that the ice jam may have caused the peak water surface elevation at the Helmericks to be on the order of 2.5 feet higher than it would have been if the ice jam had not formed. Due to poor visibility and hindered helicopter travel, it is not known if the ice jam at the mouth of the East Channel affected water surface elevations at the proposed CD-North Development Area. The ice jam may have caused somewhat more water to pass through the Tamayayak and Fiord Channels then would have otherwise passed down those channels. However,

it seems unlikely that the ice jam at the mouth of the East Channel had a large affect on the peak water-surface elevation at the proposed CD-North Development Area.

In the Fiord Channel, the water surface elevation peaked sometime after the morning of 11 June and prior to 15 June 2000. However, based on the measurements and observations at other locations in the delta (Michael Baker Jr., Inc., 2000), it seems most likely that the peak water-surface elevation occurred between 12 and 13 June. The peak water surface elevations recorded at monitoring sites FIOSO, FIOMI, and FIORD are listed in Table 2-1 and compared to water surface elevations predicted by the two-dimensional surface water model developed for the Colville River Delta (Michael Baker Jr., Inc. 1998 and Shannon & Wilson, Inc., 1997). Based on the information it appears that the average recurrence interval associated with the peak water surface elevation at the CD-North Development is probably on the order of 15 to 24 years.

Table 2-1 2000 Water Surface Elevations Compared to Predicted Water Surface Elevations

Monitoring Site	Predicted 10-Year	*2000 Breakup*	Predicted 30-Year	Predicted 50-Year	Predicted 200-Year
FIORD (Downstream Site)	4.6	*5.8 (24-Year)*	6.3	6.6	8.1
FIOMI (Middle Site)	6.0	*6.3 (18-Year)*	6.8	6.9	8.2
FIOSO (Upstream Site)	6.4	*6.6 (15-Year)*	7.2	7.4	8.5
Note: All elevations are presented in feet (BPMSL).					

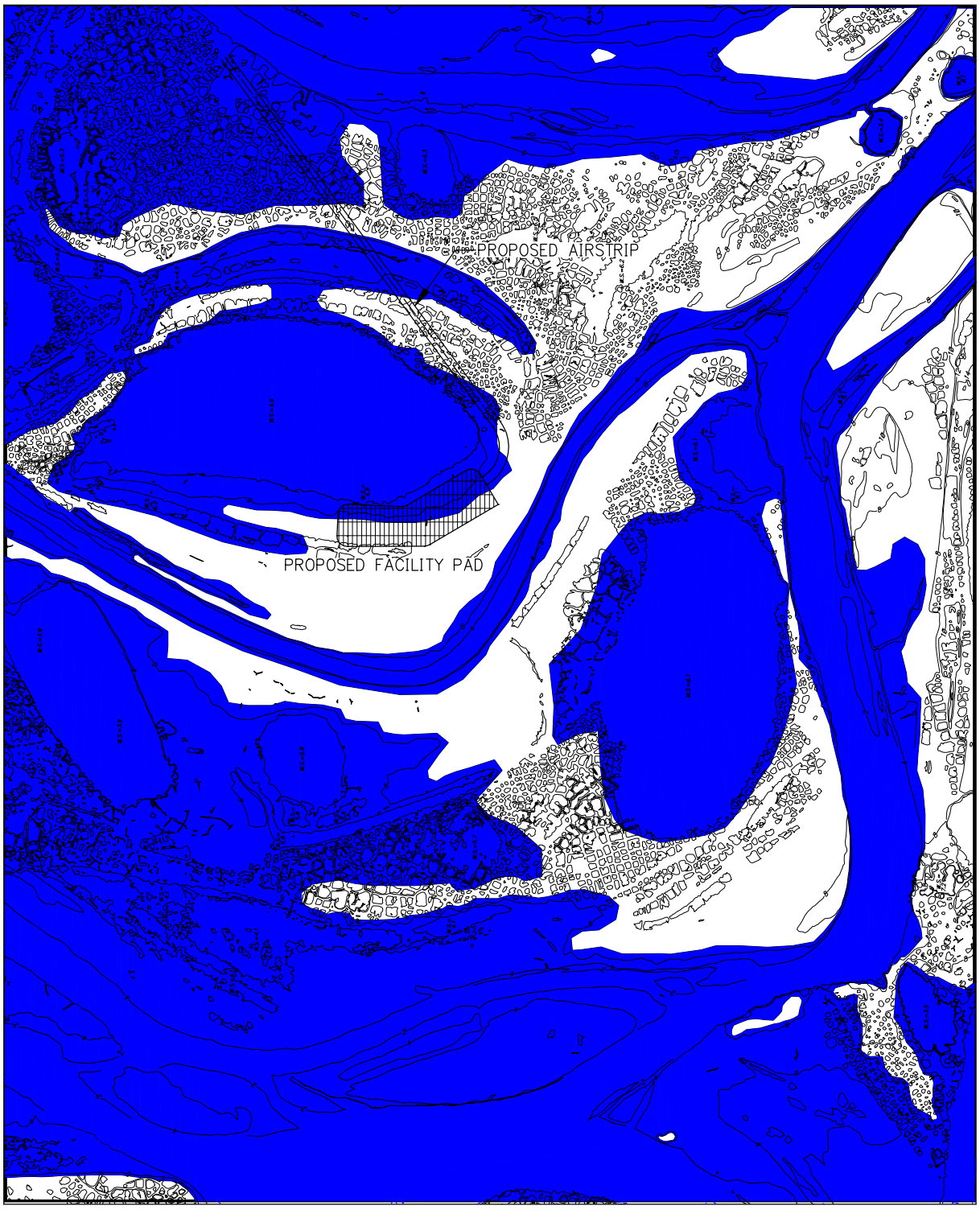
Spring peak water surface elevations were first monitored in the proposed CD-North Development Area in 1999. However, spring peak water surface elevations have been monitored at the mouth of the Nechelik and East Channels since 1996. A summary of the available data is presented in Table 2-2.

In reviewing Table 2-2, it should be noted that the peak water-surface elevation observed this year was probably the highest in at least the last 5 years. Additionally, it should be noted that the water surface elevation observed at the Helmericks' property was the highest since at least 1954 (Helmericks, 2001). It is estimated that the spring 2000 flood-peak discharge at the head of the delta will have an average recurrence interval of about once every 25 years. It is also estimated that the 2000 peak water-surface elevation at the Alpine Development had an average recurrence

interval of about once every 19 years (Michael Baker Jr., Inc., 2000). The difference in return periods between the head of the delta and the Alpine Development is probably due to water storage and subsequent peak attenuation on the delta. Thus, the estimated return period of 15 to 24 years at the proposed CD-North Development appears to be a reasonable estimate of the flood magnitude seen in the spring of 2000.

The ground surface in the CD-North project area that was inundated during the 2000 spring breakup was estimated based on the peak water surface elevation measured along the Fiord Channel. The inundated ground surface is shown on Figure 2-3.

Peak water-surface elevations at the proposed CD-North Development may be caused by storm surge in some years because of the close proximity to the coastline. For this reason, prior to development of this site, a combined storm surge and water-surface frequency analysis should be completed. The combined analysis would provide an estimate of the frequency of occurrence associated with specific water-surface elevations due to spring breakup flooding, storm surge or a combination of the two.



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NOTES:
1. BASE MAP IS COMPILED FROM PHOTOGRAPHY ACQUIRED 6/30/99 BY AEROMAP U.S., ANCHORAGE, ALASKA

2. AREA SHADED IN BLUE IS THE ESTIMATED GROUND SURFACE INUNDATED DURING THE 2000 SPRING BREAKUP.

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2000 SPRING BREAKUP
COLVILLE RIVER DELTA

CD-NORTH PROJECT AREA
ESTIMATED FLOODWATER INUNDATION

FIGURE:
2-3

Table 2-2 Spring Peak Water Surface Elevations Near Colville River Delta Coastline

Year	Location	Elevation (ft, BPMSL)	Peak Discharge at Head of Delta	Recurrence Interval of Peak Discharge (yrs)
2000	Monument FIORD M1	5.77	580,000	25
	TBM FIOMI	6.32		
	TBM FIOSO	6.63		
	Helmericks' House	7.39		
	Helmericks' Hanger	7.24		
	N. End Helmericks' 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 Nechelik 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 FIOMI 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, North Slope, Alaska* (Michael Baker Jr., Inc. and Shannon & Wilson, Inc., 1998)

2.2 Peak Discharge in the Colville River Delta

The peak discharge at the head of the Colville River Delta was approximately 580,000 cubic feet per second (cfs). It is estimated that at the head of the delta this discharge will be equaled or exceeded, on average, approximately once every 25 years (Michael Baker Jr., Inc. et. al, 1998). Discharge on the nights of 9 June, 11 June, and 12 June 2000 was probably within 5 to 10 percent of the estimated peak discharge. The available data does not support a quantitative estimate of the discharge on 10 June 2000. A summary of the flood peak estimates from previous years is presented in Table A-8 in Appendix A.

2.3 Hydraulic Roughness Estimates

A discharge measurement was made at the Fiord Middle Monitoring Site on 16 June 2000, 3 - 4 days after the peak water-surface elevation was estimated to have occurred. The purpose of the discharge measurement was to estimate the hydraulic roughness of the Fiord Channel. The site was free of ice at the time of the measurement, and the discharge was 387 cubic feet per second (Table B-1, Appendix B). The water surface elevation at the Fiord Middle Monitoring Site was

approximately 1.82 feet and the water surface slope between the Fiord Middle and Fiord South Monitoring Sites was 0.0000729 feet/foot. Cross sections at the Fiord Middle Site and the Fiord South Site, the two sites used in the hydraulic roughness estimate, are presented in Figure B-1, Appendix B).

The magnitude of Manning's roughness coefficient was estimated using the U.S. Geological Survey, Slope-Area Method (Dalrymple and Benson, 1976). Based on the conditions observed on 11 June 2000, the value of Manning's roughness coefficient in the Fiord Channel near the proposed CD-North Development is estimated to be 0.031.

2.4 Channel Ice Observations

Ice floe observations began on 6 June 2000 when the ice cover within the Colville River Delta began to break up. By 12 June 2000, all of the major channels on the Colville River Delta had cleared, with the exception of the Nechelik Channel. The Nechelik Channel had cleared to approximately river mile N7, about one mile north of CD-2. It is likely that the ice cleared from most of the rest of the Nechelik Channel by 14 June. The progression of the channel ice breakup is shown on a series of figures presented in Appendix C.

Based on observations since 1992[1], it seems that this year the low water channel ice cleared the delta over a shorter time than in the recent past. It also seemed that a smaller amount of ice hung up along the channel and that more ice reached the coast. In past years, it seemed that the ice in many of the distributaries near the coast rotted in place after the passage of the peak discharge. This year it seemed that much of the ice in the distributaries was moved by the peak discharge. Although the ice did not appear to react as it had over the last several years of observations, it is likely that the difference is due to the lateness of the breakup and the magnitude of the flood peak discharge.

Both the lateness of the breakup and the pattern of ice movement observed this year are probably normal for a flood the size of the one experienced in 2000. It is quite probable that large flood peaks on the Colville are generally produced by late breakups. Additionally, the large discharge

[1] It should be noted that until 1996, a helicopter was not available for transportation around the delta. Thus, widespread observations of breakup and ice jamming were restricted to one or two over flights with a fixed wing aircraft per year.

over a period of days undoubtedly allowed more of the ice to be carried further downstream than typically happens during an average breakup.

2.5 Impacts of Offshore Sea Ice

At the beginning of spring breakup, water often flows over the top of the sea ice and ponds until it can find its way through the sea ice to the water beneath. Based on observations made since 1996 (Table 2.1), it seems that the peak water-surface elevation near the coast often occurs while water is ponding on the sea ice and prior to the peak discharge. This year the peak water-surface elevation probably occurred as a result of the peak discharge or a local ice jam that occurred very close to the peak discharge. Thus, although the offshore sea ice undoubtedly had an impact on water surface elevations near the coast, the impact was probably less than in years when the flood peak discharge was smaller.

2.6 Photographic Documentation

Photographic documentation of the Fiord Channel monitoring sites is presented in Appendix D.

3.0 References

Dalrymple, T. and M.A. Benson. 1976. *Measurement of Peak Discharge by the Slope-Area Method*. Techniques of Water Resources Investigations of the United States Geological Survey, Book 3, Chapter A2. U.S. Government Printing Office. Washington, DC.

Helmericks, J. 2001. Personal Communication. Golden Plover Guiding. Colville River Delta. Alaska.

Michael Baker Jr., Inc. and Shannon & Wilson, Inc. 1998. *Colville River Flood-Frequency Analysis, North Slope, Alaska.* Prepared for: ARCO Alaska, Inc., Anchorage.

Michael Baker Jr., Inc. 2000. *Alpine Facilities Spring 2000 Breakup Monitoring.* Prepared for: Phillips Alaska, Inc., Anchorage.

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

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Appendix A. Water Surface Elevations and Observations

List of Tables:

Table A- 1 Water Surface Elevations and Observations at Fiord Upstream Monitoring Site (FIOSO)

Date	Time	Water Surface Elevation (feet)	Observations
08-Jun-00	08:50	N/A	No visible water flowing in channel. Snow and ice sheet over channel is continuous.
	10:15	N/A	No visible water flowing in channel. Snow and ice sheet over channel is continuous.
	12:22	N/A	No visible water flowing in channel. Snow and ice sheet over channel is continuous.
09-Jun-00	08:51	3.70	Snow bank intact around staff gages and slush/snow present between staff gages and open flow in channel.
	15:50	4.31	Snow bank intact around staff gages and slush/snow present between staff gages and open flow in channel.
10-Jun-00	16:55	6.42	
11-Jun-00	12:05	5.83	
15-Jun-00	11:15	2.85	± 0.01 ft.
High Water Mark		6.63	The peak water-surface elevation probably occurred sometime between the morning of 12 and 13 June based on other local observations.
16-Jun-00	13:54	2.00	
	15:04	1.98	

Notes:

1. Elevations are based on an elevation of 14.14 feet (BPMSL) for Monument "Nehi", which was established by USGS in 1951.
2. Coordinates for Monitoring Site FIOSO are N6001601.82, E 393661.54, NAD 27, Alaska State Plane Zone 4.
3. The distance along the flow path from FIOSO to FIOMI was approximately 2880 feet.

Table A- 2 Water Surface Elevations and Observations at Fiord Middle Monitoring Site (FIOMI)

Date	Time	Water Surface Elevation (feet)	Observations
08-Jun-00	08:51	N/A	No visible water flowing in channel. Snow and ice sheet over channel is continuous.
	10:16	N/A	No visible water flowing in channel. Snow and ice sheet over channel is continuous.
	12:23	N/A	No visible water flowing in channel. Snow and ice sheet over channel is continuous.
09-Jun-00	08:45	N/A	Open water is visible, but has not reached staff gages.
	15:47	N/A	Snow bank intact around staff gages and slush/snow present between staff gages and open flow in channel
10-Jun-00	17:18	6.31	
11-Jun-00	11:55	5.68	
15-Jun-00			
High Water Mark		6.32	The peak water-surface elevation probably occurred sometime between the morning of 12 and 13 June based on other local observations.
16-Jun-00	13:54	1.84	
	15:04	1.81	

Notes:

1. Elevations are based on an elevation of 14.14 feet (BPMSL) for Monument "Nehi", which was established by USGS in 1951
2. Coordinates for Monitoring Site FIOMO are N6004480.32, E 393754.43, NAD 27, Alaska State Plane Zone 4.
3. The distance along the flow path from FIOSO to FIOMI was approximately 2880 feet.

Table A- 3 Water Surface Elevations and Observations at Fiord Downstream Monitoring Site (FIORD)

Date	Time	Water Surface Elevation (feet)	Observations
08-Jun-00	08:51	N/A	No visible water flowing in channel. Snow and ice sheet over channel is continuous.
	10:16	N/A	No visible water flowing in channel. Snow and ice sheet over channel is continuous.
	12:23	N/A	No visible water flowing in channel. Snow and ice sheet over channel is continuous.
09-Jun-00	08:40	3.17	Snow bank intact around staff gages and slush/snow present between staff gages and open flow in channel
	15:47	3.45	Snow bank intact around staff gages and slush/snow present between staff gages and open flow in channel
11-Jun-00	11:47	5.36	
High Water Mark		5.77	The high water mark was identified by rafted grass along a polygon rim. The peak water-surface elevation probably occurred sometime between the morning of 12 and 13 June based on other local observations.
17-Jun-00	09:07	1.01	

Notes:
1. Elevations are based on an elevation of 14.14 feet (BPMSL) for Monument “Nehi”, which was established by USGS in 1951.
2. Coordinates for monument are N70º 25' 56.8" W150º 50' 14.6" which were surveyed by Lounsbury and Associates

Table A-4: Water Surface Elevations and Observations at Survey Monument #1

Date	Time	Water Surface Elevation (feet)	Observations
6-8-00	08:23	11.26	Ice sheet over the channel is continuous and about 1000' across.
	09:42	11.64	Ice sheet over the channel is continuous and about 1000' across.
	11:51	11.75	Ice sheet over the channel is continuous and about 1000' across.
	15:40	12.24	Ice sheet over the channel is continuous and about 1000' across.
6-9-00	06:50	15.68	Ice sheet over the channel is continuous and about 1000' across. Non-moving ice rubble exists for the other 2000'.
	14:37	18.98	Ice sheet over the channel is only along the east bank and about 35' across.
High Water Mark		19.33	
6-10-00	15:20	18.61	Ice sheet over the channel is only along the east bank and about 35' across.
	19:20	18.18	
6-11-00	10:57	15.94	
6-12-00		15.54	
6-13-00		13.21	

Notes:
1. Elevations are based on an elevation of 27.74 feet (BPMSL) for Monument 1, which was established by Lounsbury & Associates in 1996.
2. GPS coordinates for Monument 1 are N 70º 09' 58.3" W 150º 56' 12.6" (NAD 27). The GPS coordinates were obtained with a Garmin GPS II global positioning system.
3. The distance along the flow path from Monument 1 to TBM01D is approximately 2134 feet.
4. The distance along the flow path from Monument 1 to TBM01U is approximately 2010 feet.

Table A-5: Water Surface Elevations and Observations at Temporary Bench Mark 01D

Date	Time	Water Surface Elevation (feet)	Observations
6-8-00	08:27	N/A	Water level had not reached first gauge. Ice sheet over the channel is continuous and about 1000' across.
	09:45	N/A	Water level had not reached first gauge. Ice sheet over the channel is continuous and about 1000' across.
	11:53	N/A	Water level had not reached first gauge. Ice sheet over the channel is continuous and about 1000' across.
6-9-00	07:21	15.49	Ice sheet over the channel is continuous and about 1000' across. Non-moving ice rubble exists for the other 2000'.
	00:29	15.82	Ice sheet over the channel is continuous and about 1000' across. Non-moving ice rubble exists for the other 2000'.
	14:40	18.87	Ice sheet over the channel is only along the east bank and about 35' across.
High Water Mark		18.87	
6-10-00	15:23	18.43	Ice sheet over the channel is only along the east bank and about 35' across.
6-11-00	11:00	N/A	All gages are dry or destroyed.

Notes:
1. The elevations are based on an elevation of 28.62 feet (BPMSL) for TBM01D, which was established by Michael Baker Jr., Inc. in 2000. The elevation of TBM01D was based on an elevation of 27.74 feet (BPMSL) for Monument 1, which was established by Lounsbury and Associates in 1996.
2. The distance along the flow path from Monument 1 to TBM01D is approximately 2134 feet.
3. The distance along the flow path from Monument 1 to TBM01U is approximately 2010 feet.

Table A-6: Water Surface Elevations and Observations at Temporary Bench Mark 01U

Date	Time	Water Surface Elevation (feet)	Observations
6-8-00	08:21	11.46	Ice sheet over the channel is continuous and about 1000' across.
	09:40	11.88	Ice sheet over the channel is continuous and about 1000' across.
	11:45	11.97	Ice sheet over the channel is continuous and about 1000' across.
6-9-00	06:46	16.61	Ice sheet over the channel is continuous and about 1000' across. Non-moving ice rubble exists for the other 2000'.
	09:21	17.56	Ice sheet over the channel is continuous and about 1000' across. Non-moving ice rubble exists for the other 2000'.
	14:34	19.23	Ice sheet over the channel is only along the east bank and about 35' across.
High Water Mark		19.88	
6-10-00	15:15	18.53	Ice sheet over the channel is only along the east bank and about 35' across.
6-11-00	10:55	17.51	
6-12-00	17:15	16.38	

Notes:
1. The elevations are based on an elevation of 28.03 feet (BPMSL) for TBM01U, which was established by Michael Baker Jr., Inc. in 2000. The elevation of TBM01U was based on an elevation of 27.74 feet (BPMSL) for Monument 1, which was established by Lounsbury and Associates in 1996.
2. The distance along the flow path from Monument 1 to TBM01D is approximately 2134 feet.
3. The distance along the flow path from Monument 1 to TBM01U is approximately 2010 feet.

Table A-7: Water Surface Elevations and Observations near Survey Monument #35

Date	Time	Water Surface Elevation (feet)	Observations
6-10-00	22.45	6.26	
6-11-00	01:20	6.30	
	03:30	6.34	
	05:45	6.93	
	06:12	7.01	
	06:45	7.09	
	07:05	7.18	
	07:30	7.26	
	07:50	7.18	
	08:15	7.18	
	08:30	7.26	
	09:00	7.30	
	09:21	7.34	
	10:15	7.34	
	11:30	7.34	
High Water Mark	12:35	7.39	
		7.24	Observation made by Baker crew, inside Helmericks hanger.
		7.10	Observation made by Baker crew, on the north end of the Helmericks runway.
	13:50	7.32	
	14:30	7.22	
	15:45	7.01	
	18:10	7.09	
	19:30	7.01	
	20:15	6.93	
	21:40	6.84	

Table A-7 (continued): Water Surface Elevations and Observations near Survey Monument #35

Date	Time	Water Surface Elevation (feet)	Observations
6-12-00	00:30	6.68	
	06:30	6.26	
	08:00	6.09	
	13:30	5.76	
	16:00	5.59	

Notes:

1. Elevations are based on an elevation of 5.57 feet (BPMSL) for Monument 35, which was established by Lounsbury & Associates in 1996.
2. GPS coordinates for Monument 35 are N 70º 25' 58.1" W 150º 22' 49.1" (NAD 27) which were surveyed by Lounsbury and Associates.
3. Observations made by Jim & Tina Helmericks on the south side of their residence.

Table A-8: Summary of Breakup Data Obtained at the Head of the Colville River Delta, 1962 – 2000

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

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. The peak breakup discharge was estimated to range between 570,000 to 590,000 cfs.
3. 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.
4. 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.
5. 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.
6. 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.
7. 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.

Appendix B. Discharge Measurement on June 16, 2000

List of Tables:

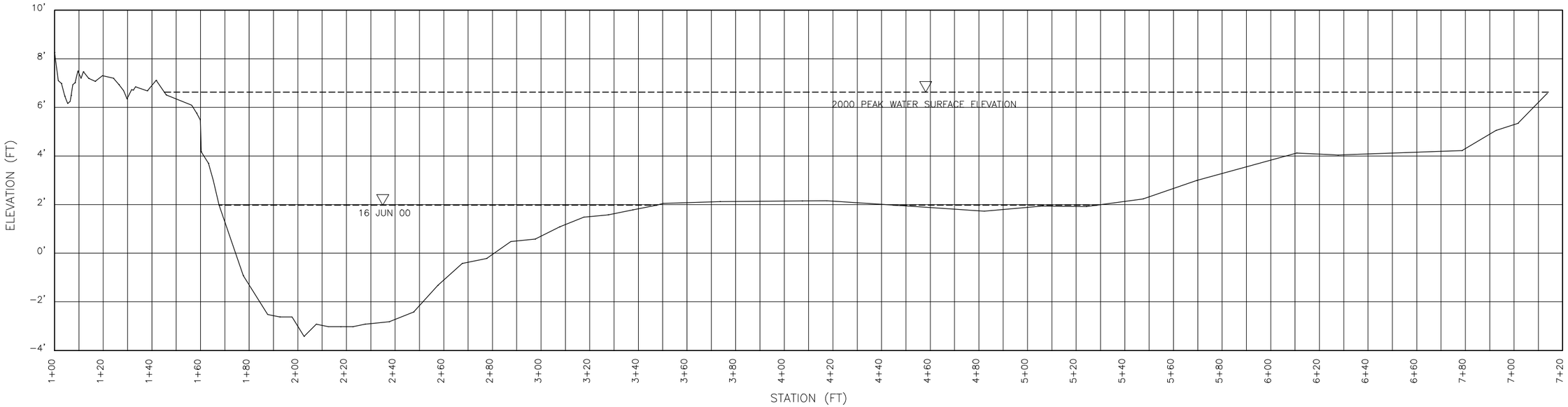
List of Figures:

Table B-1: Fiord Channel Discharge Measurement on June 16, 2000

DISCHARGE MEASUREMENT NOTES													
LOCATION:		FIOMI (Middle Gauging Station of Fiord Channel)											
Date:	16-Jun-00		**Party:**	J. Packer, T. Riopelle									
Width:	217.5	**Area:**	559 sqf.	**Vel:**	1.00	**G.H.:**	1.84			**Disch.:**	387.28	cfs	
No Secs.	13		**G.H. change:**		0.02	in.:	0.93	hrs.:			Susp.:		
Method coef.:				Hor. Angle coef.				**Sus. Coef.:**		**Meter No.**			
Gage Readings								**Type of meter:**		Price AA			
Time		**Recorder**		**Inside**		**Outside**		**Date rated:**		Factory			
13:54		FIOSO-A				W.S.E. = 2.05		**Meter:**	1	ft. above bottom of weight.			
13:54		FIOMI TBM				W.S.E. = 1.84		**Spin before meas.**		2 min 15 sec	**after**	2 min 33 sec	
								Method:	Bridge reel w/ 30 lb sounding weight				
14:06 Start Meas.													
15:02 End Meas.													
15:04		FIOSO-A				W.S.E. = 2.03							
15:04		FIOMI TBM				W.S.E. = 1.81							
Weighted M.G.H.								**Levels obtained**					
G.H. corrections													
Correct M.G.H.													
Measurement rated:								**based on following conditions:**					
Cross section:													
Flow:								**Weather:**	Sunny	**Air °F@:**			
Gage:										**Water °F@:**			
Other:													
Record Removed:								**Intake flushed:**					
Observer													
Control													
Remarks	Water surface elevations are relative to BPMSL.												
G.H. of zero flow:								ft.					
											Page 1 of 2		

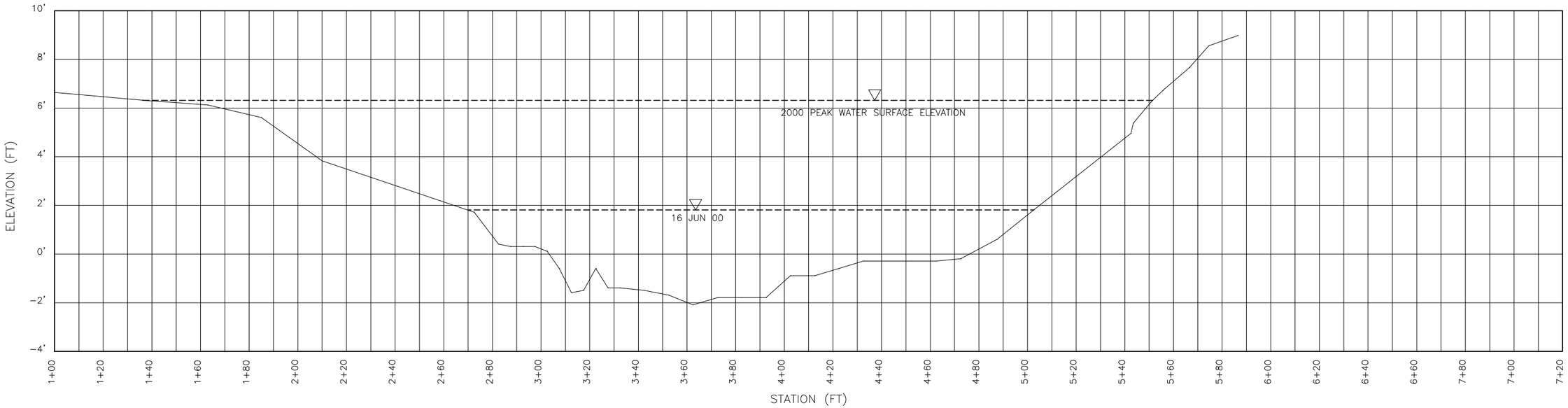
Table B-1 (continued): Fiord Channel Discharge Measurement on June 16, 2000

Angle Coef.	Dist.	Width	Depth	Observ. depth	Revo-lutions	Time In seconds	VELOCITY		Area	Discharge	Description
	From Initial point						At Point	Mean in-vertical			
	(ft)	(ft)	(ft)				(fps)	(fps)	(sf)	(cfs)	
	0		0.00								R.E.W.
	10	7.5	1.40	0.00	16	57	0.64	0.64	10.5	6.7	
	15	5.0	1.50	0.00	16	52	0.70	0.70	7.5	5.2	
	20	5.0	1.50	0.00	16	47	0.77	0.77	7.5	5.8	
	25	5.0	1.50	0.00	16	45	0.80	0.80	7.5	6.0	
	30	5.0	1.70	0.00	16	40	0.90	0.90	8.5	7.6	
	35	5.0	2.40	1.40	16	46	0.78	0.78	12.0	9.4	
	40	5.0	3.40	2.00	20	46	0.97	0.97	17.0	16.5	
	45	5.0	3.30	2.00	25	47	1.18	1.18	16.5	19.5	
	50	5.0	2.40	1.40	20	40	1.12	1.12	12.0	13.4	
	55	5.0	3.20	1.90	20	40	1.12	1.12	16.0	17.8	
	60	7.5	3.20	1.90	25	47	1.18	1.18	24.0	28.4	
	70	10.0	3.30	2.00	25	44	1.26	1.26	33.0	41.7	
	80	10.0	3.50	2.10	25	44	1.26	1.26	35.0	44.2	
	90	10.0	3.90	2.30	25	42	1.32	1.32	39.0	51.5	
	100	10.0	3.60	2.20	25	43	1.29	1.29	36.0	46.5	
	110	10.0	3.60	2.20	25	42	1.32	1.32	36.0	47.6	
	120	10.0	3.60	2.20	25	44	1.26	1.26	36.0	45.5	
	130	10.0	2.70	1.60	20	44	1.02	1.02	27.0	27.4	
	140	10.0	2.70	1.60	20	44	1.02	1.02	27.0	27.4	
	150	10.0	2.40	1.40	20	47	0.95	0.95	24.0	22.9	
	160	10.0	2.10	0.00	20	48	0.93	0.93	21.0	19.6	
	170	10.0	2.10	0.00	20	47	0.95	0.95	21.0	20.0	
	180	10.0	2.10	0.00	20	47	0.95	0.95	21.0	20.0	
	190	10.0	2.10	0.00	20	53	0.85	0.85	21.0	17.8	
	200	12.5	2.00	0.00	20	58	0.78	0.78	25.0	19.5	
	215	15.0	1.20	0.00	12	43	0.64	0.64	18.0	11.4	
	230										L.E.W.
TOTAL		**217.5**							**559.0**	**387.3**	**Page 2 of 2**



CROSS SECTION FIOSO

SCALE: H 1"=20' V 1"=2'



CROSS SECTION FIOMI

SCALE: H 1"=20' V 1"=2'

NOTES:
1. FIOSO IS APPROXIMATELY 2880' UPSTREAM OF FIOMI.
2. ELEVATIONS IN FEET, USING BRITISH PETROLEUM MEAN SEA LEVEL (BPMSL) DATUM.

REFERENCE DWG NO/SHT NO:

REV	DATE	REVISIONS	BY	CHK	JOB ENGR	PROJ ENGR	CUST APP

Baker

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Anchorage, Alaska 99503
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Fax: (907) 273-1699

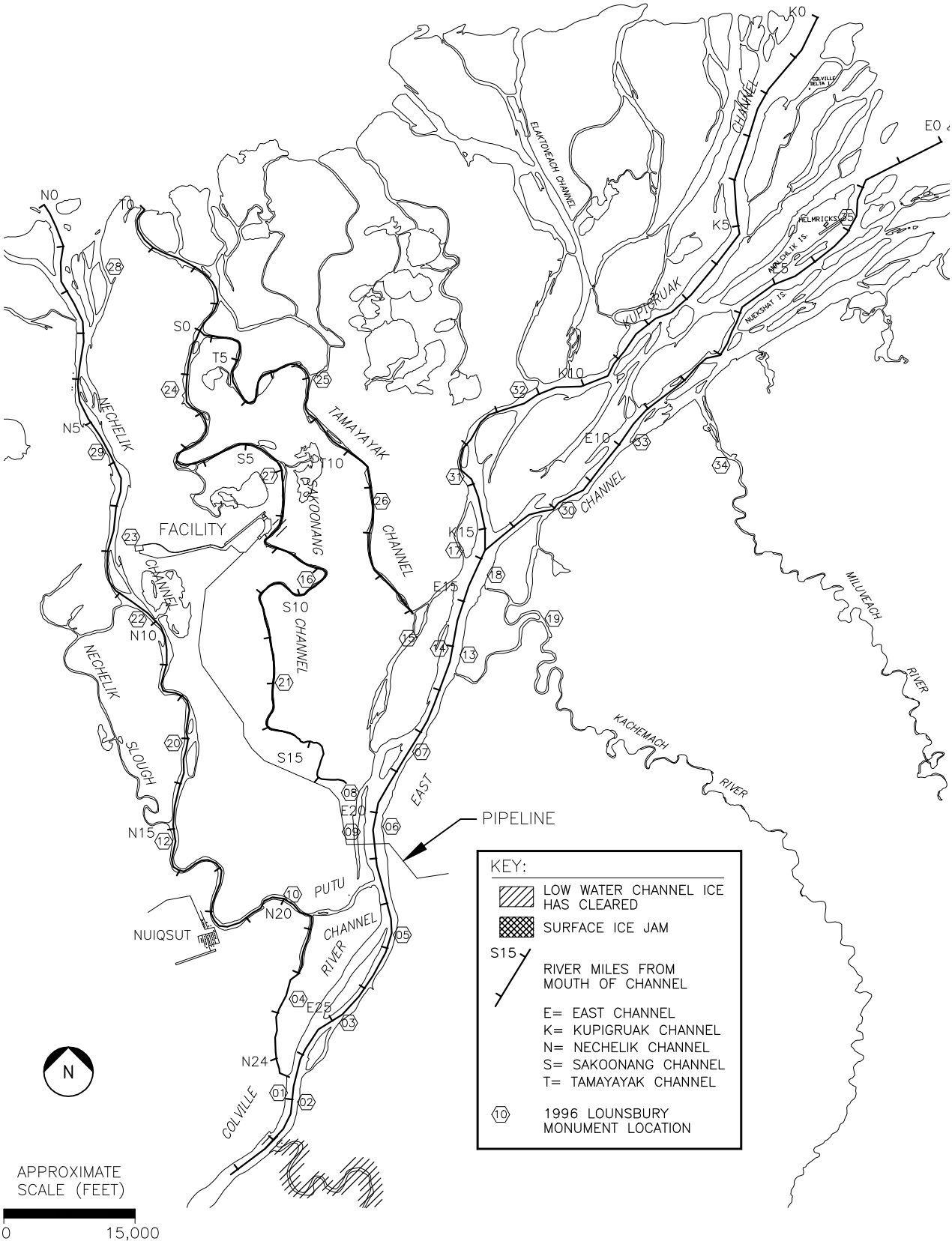
2000 SPRING BREAKUP
COLVILLE RIVER DELTA
FIORD CHANNEL CROSS SECTIONS

CADD FILE NO.	DATE:	SCALE:	JOB NO:	DRAWING NO.	SHEET:	REV:
24529200	08/16/00	AS SHOWN	24529	FIGURE B-1	1 OF 1	A

DRAWN:	DESIGN:	CHECKED:	APPROVAL:
TKM	TR	TR	

Appendix C. Channel Ice Observations

List of Figures:



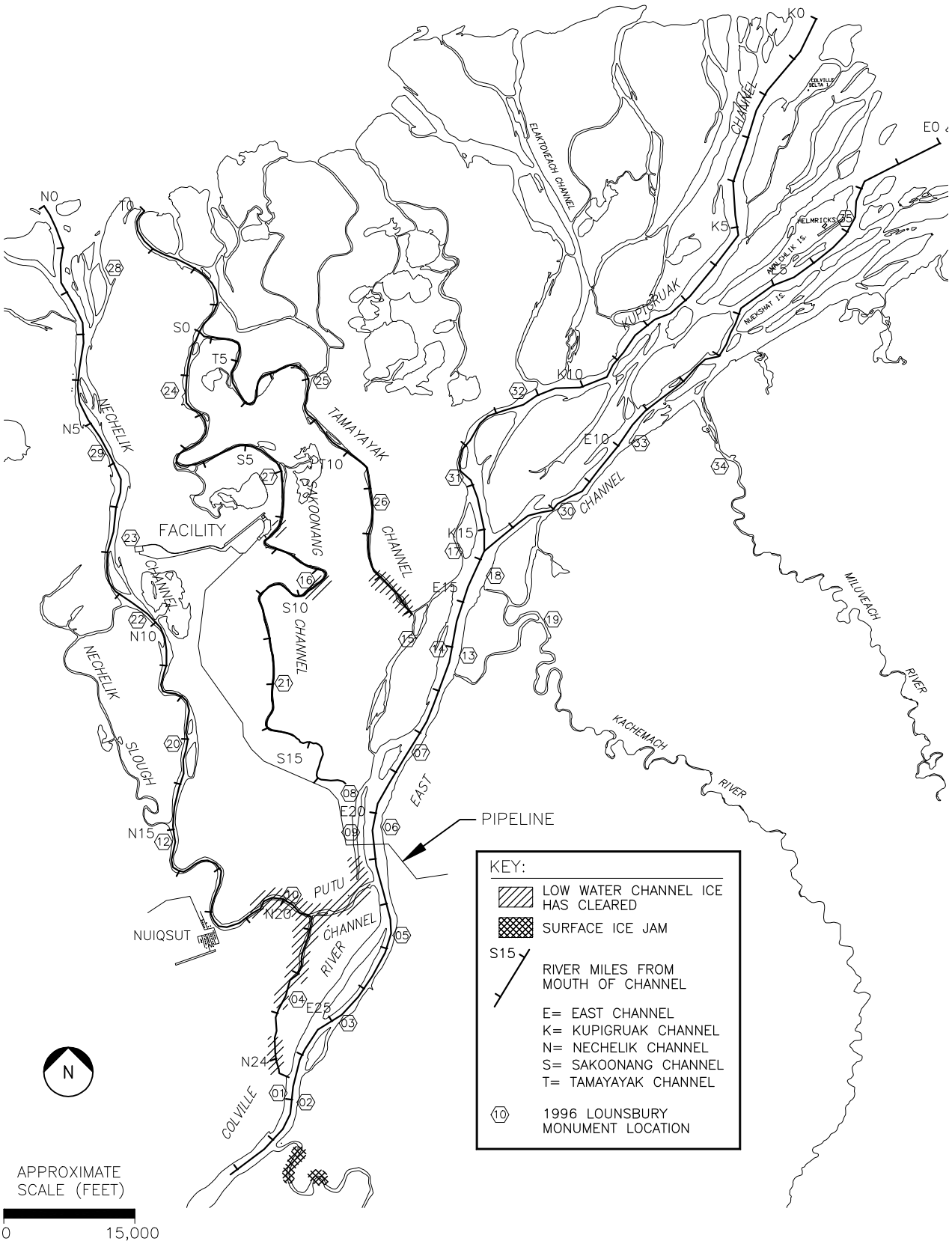
24529M01.dwg

Baker	Michael Baker Jr., Inc.
DATE: 12/26/00	PROJECT: 24529-163-0000
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 6, 2000 AT 15:00 HOURS

FIGURE:
C-1



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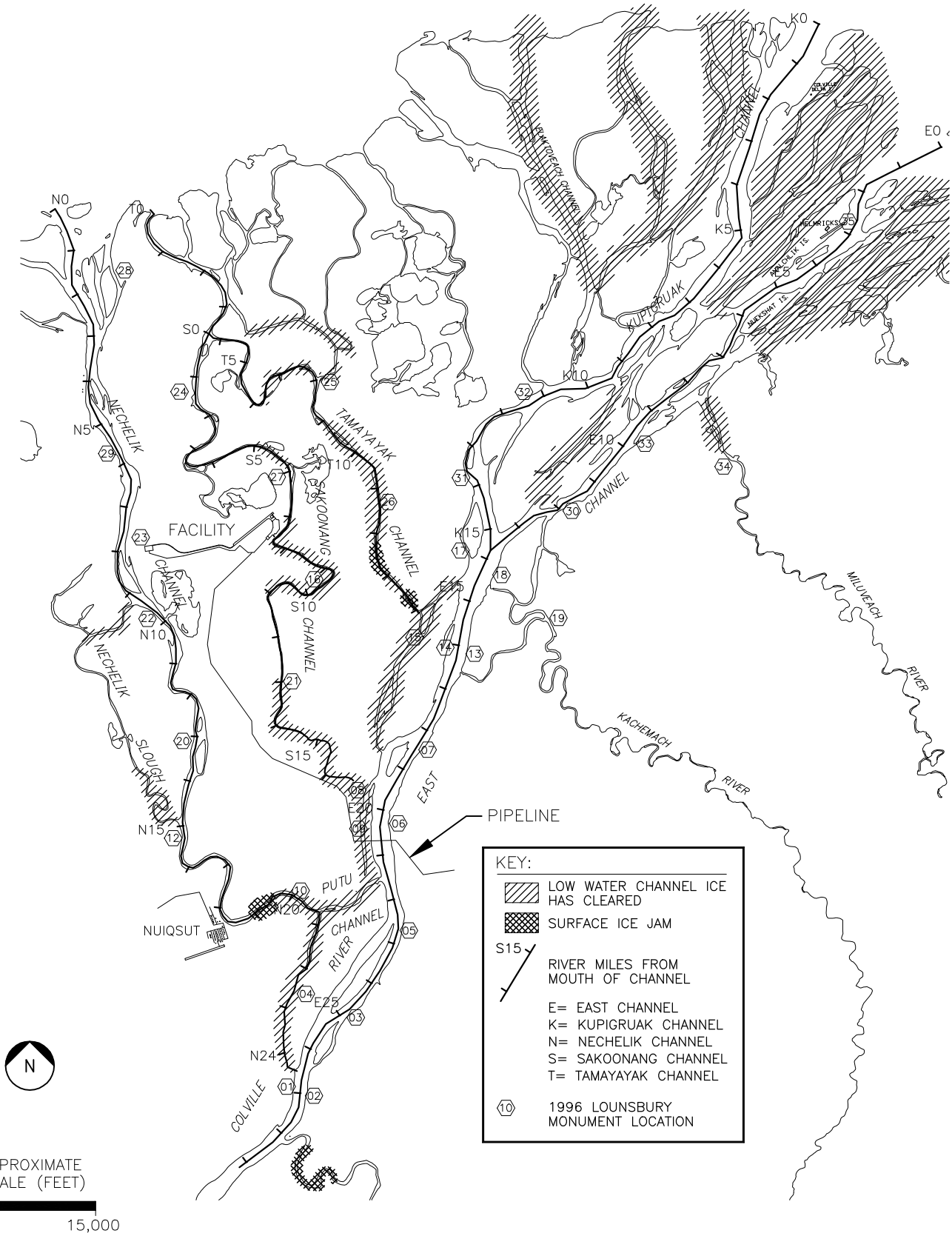
DATE: 12/26/00	PROJECT: 24529-163-0000
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 7, 2000 AT 10:00 HOURS

FIGURE:
C-2



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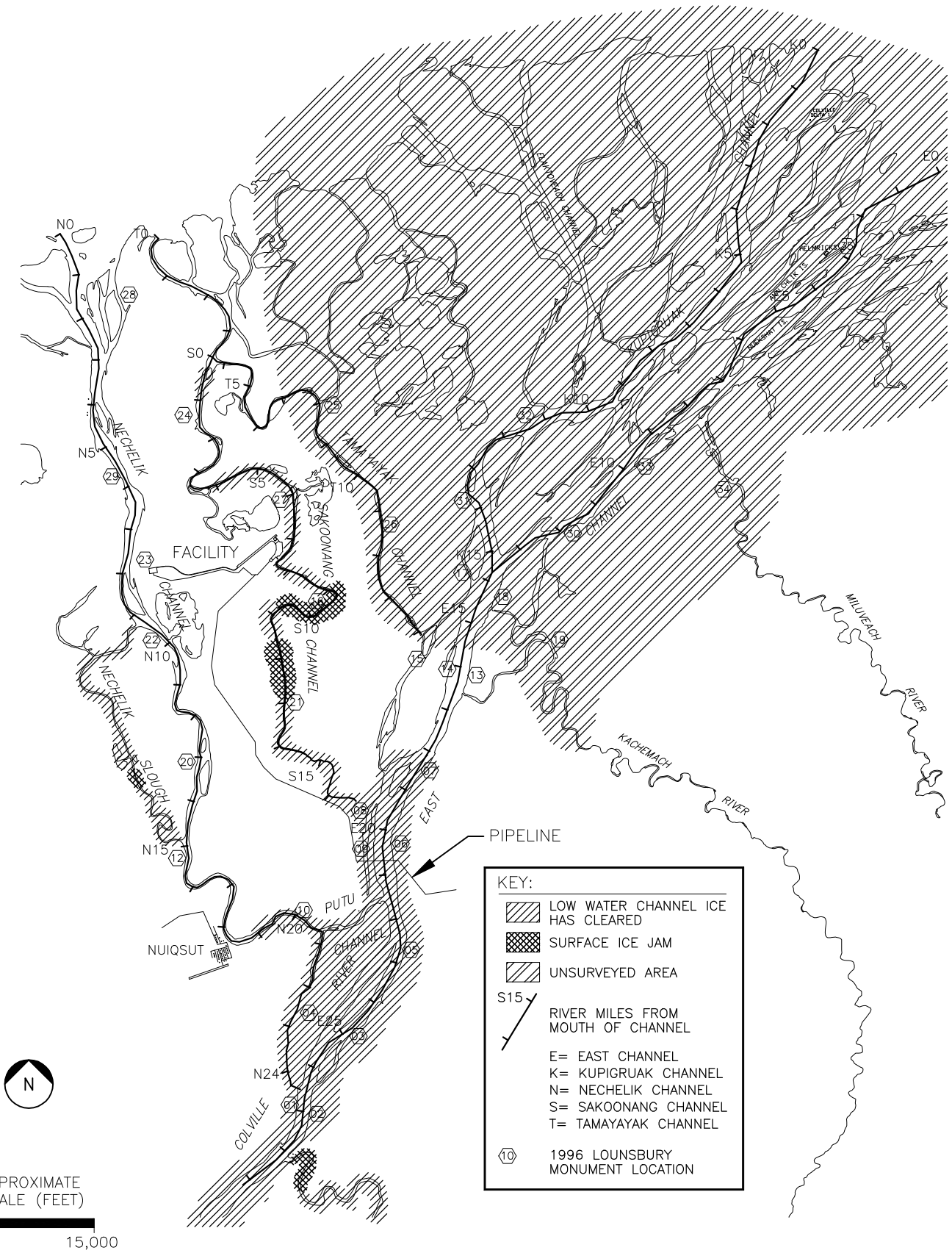
Baker	Michael Baker Jr., Inc.
DATE: 12/26/00	PROJECT: 24529-163-0000
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 8, 2000 AT 15:43 HOURS

FIGURE:
C-3



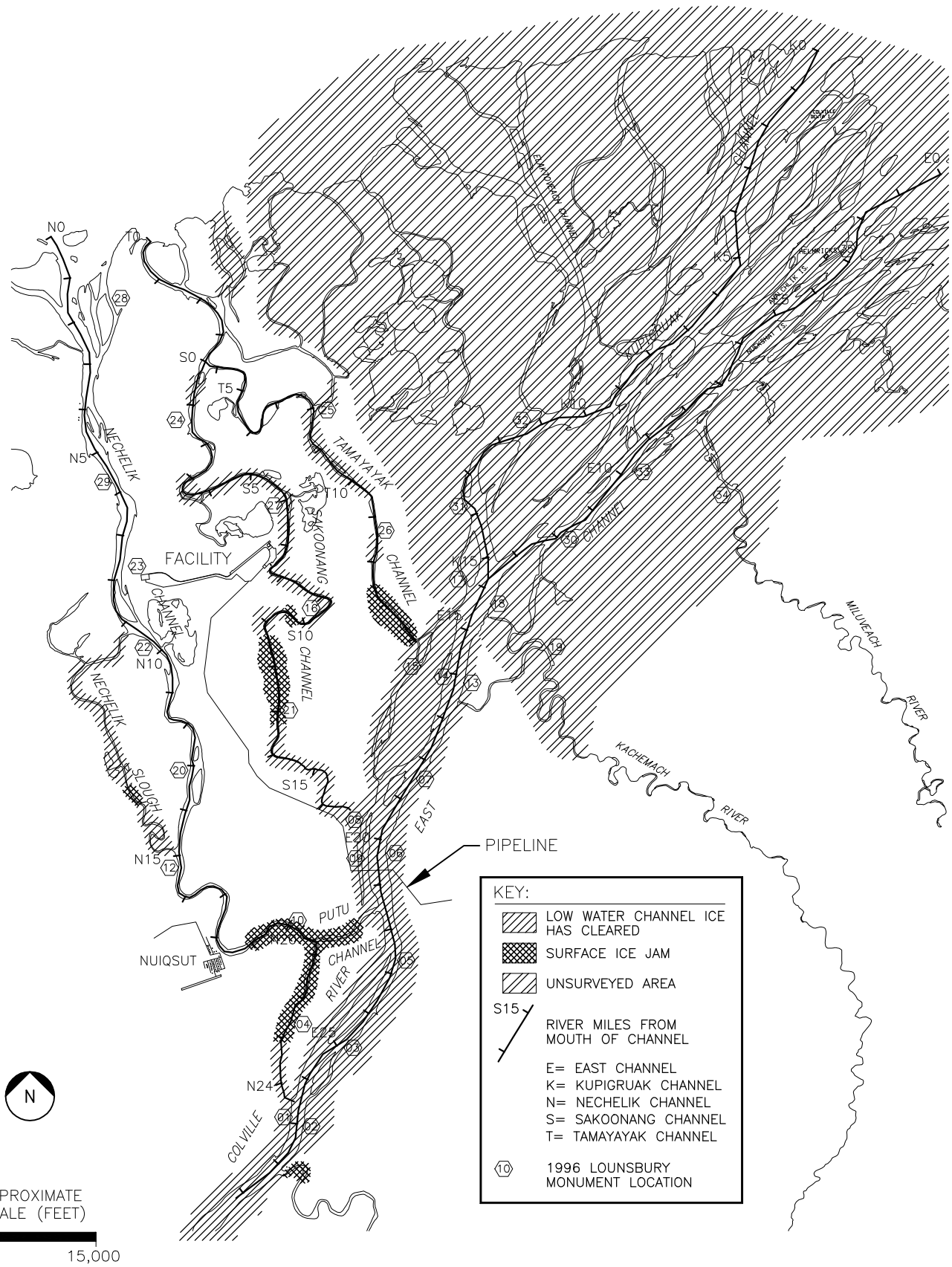
24529M04.dwg

Baker	Michael Baker Jr., Inc.
DATE: 12/26/00	PROJECT: 24529-163-0000
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 9, 2000

FIGURE:
C-4



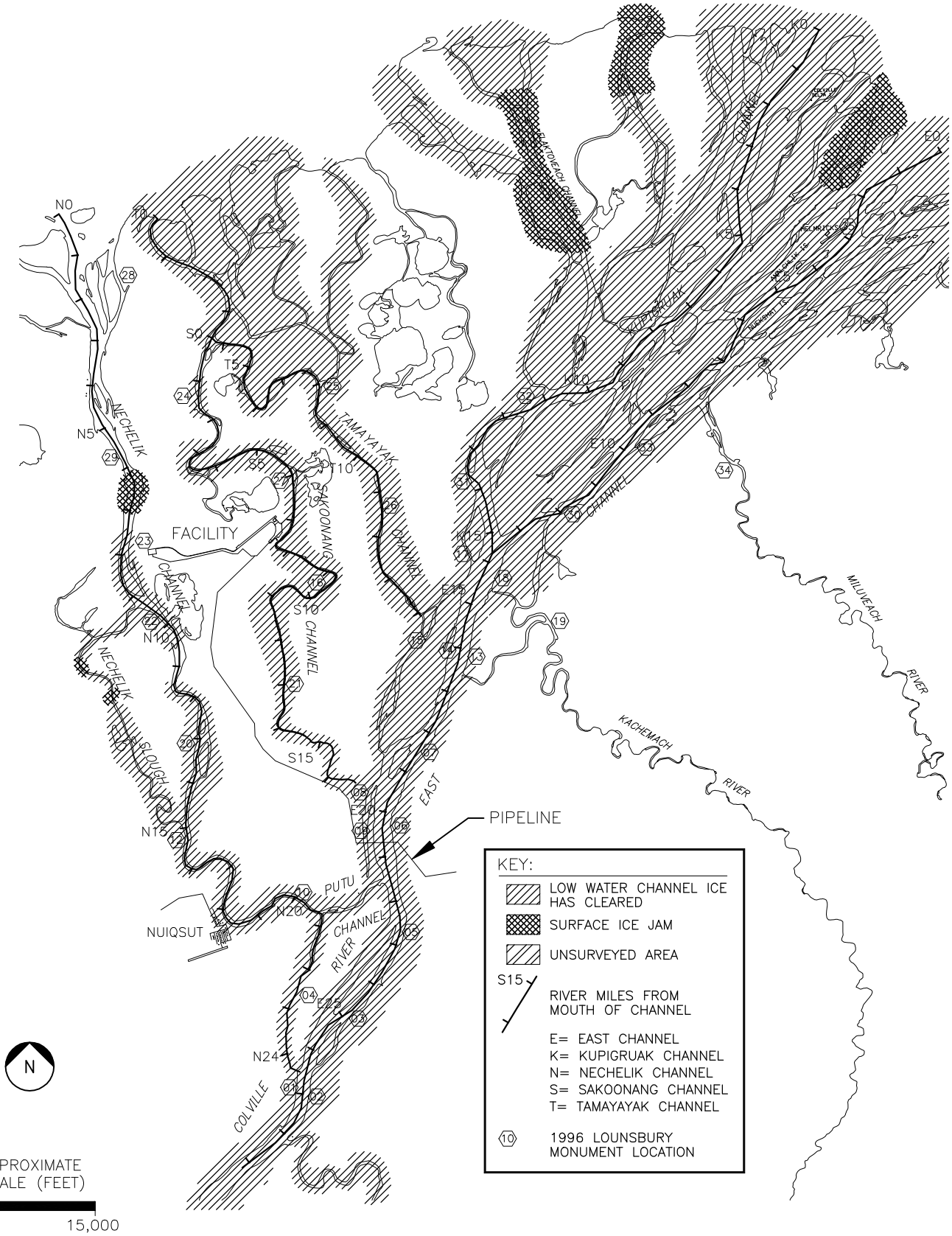
24529MØ5.dwg

Baker	Michael Baker Jr., Inc.
DATE: 12/26/00	PROJECT: 24529-163-0000
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 10, 2000 AT 18:00 HOURS

FIGURE:
C-5



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Baker	Michael Baker Jr., Inc.
DATE: 12/26/00	PROJECT: 24529-163-0000
DRAWN: TM	FILE:
CHECKED: JWA	SCALE: AS NOTED

2000 SPRING BREAKUP
COLVILLE RIVER DELTA

LOW WATER CHANNEL ICE SURVEY
JUNE 12, 2000 AT 15:30 HOURS

FIGURE:
C-6

Appendix D. Photographs

Photo 06/08/00 00060805.jpg

Figure D- 1 Looking South from Fjord Downstream Monitoring Site (FlORD). Photo Taken from Helicopter.

Photo 06/09/00 00060919.jpg

Figure D- 2 Looking West from Fjord Downstream Monitoring Site (FlORD)

Photo 06/09/00 0060921.jpg

Figure D- 3 Looking West from Fjord Upstream Monitoring Site (FIOSO)

Photo 06/10/00 00061027.jpg

Figure D- 4 Looking West from Fjord Upstream Monitoring Site (FIOSO)

Photo 06/10/00 00061029.jpg

Figure D- 5 Looking West from Middle Monitoring Site (FIOMI)

Photo 06/10/00 00061030.jpg

Figure D- 6 Looking Southwest from Fjord Downstream Monitoring Site (FIORD)

Photo 06/11/00 00061124.jpg

Figure D- 7 Looking West from Fjord Downstream Monitoring Site (FIORD)

Photo 06/11/00 00061125.jpg

Figure D- 8 Looking West from Fjord Middle Monitoring Site (FIOMI)

Figure D- 9 Looking Northwest from Fjord Upstream Monitoring Site (FIOSO)